SIEMENS

Optoelectronics

Data Book 1990

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1990

Siemens Components, Inc., *Optoelectronics Division*

Company Overview

Siemens Components, Inc., Optoelectronics Division is headquartered in Cupertino, California – in the heart of Silicon Valley. Siemens is a world leader in light emitting diode (LED) technology, sophisticated CMOS IC design, optics, and packaging. Our product line includes:

- Small Alphanumeric Displays
- Programmable Display™ Devices
- Intelligent Display® Devices
- Military Displays
- Numeric Displays
- Bar Graphs, Light Bars
- LED Lamps
- Optocouplers
- Infrared Emitting Diodes & Photodetectors
- Custom Optoelectronic Products

Our materials technology includes: visible and IR LEDs (GaAsP, GaP or combinations of these, GaAlAs, and Silicon Carbide) and photodetectors. Assembly of final products is done offshore in Malaysia. Our Malaysia plant is a show case of automation and efficiency, featuring the latest automated assembly and test equipment – resulting in high yields and high quality products.

History

Siemens Optoelectronics Division began in 1969 as Litronix to manufacture LED lamps, numeric displays, and optocouplers for the OEM market, as well as calculators and watches for the consumer market. In 1977 Siemens acquired Litronix and refocused priorities toward the basic business of producing and marketing LED materials and components.

Siemens Optoelectronics is a division of Siemens Components, Inc., which is part of Siemens U.S.A. with sales of $3.1 billion and over 27,000 employees. Siemens U.S.A. includes Siemens Corporation, six U.S. operating companies, Siemens affiliates and joint ventures. The six operating companies are Siemens Communications Systems, Siemens Components, Siemens Energy and Automation, Siemens Information Systems, Siemens KWU, and Siemens Medical Systems.

Siemens U.S.A. is a member of the worldwide Siemens organization which has sales of $34 billion, 353,000 employees, and 172 production facilities in 35 countries.

Technology Strengths

Our strengths are in the following areas:

- Continual process development / improvement in LED material
- In-house design of complex CMOS integrated circuits using the latest CAD/CAM and CAE equipment
- Sophisticated optics and packaging capabilities
- State-of-the-art system know how for complex IC/LED hybrids
- Leading supplier of custom optoelectronic products
- A history of innovation:
  - Invented Intelligent Display devices, 1977
  - Invented Programmable Display devices, 1984
    Both feature built-in CMOS IC control circuits for easy interface with microprocessors
    Second sourced by our competitors because of market acceptance

Quality and Reliability

Every aspect of day-to-day production is closely monitored and verified to ensure that all materials, processes, manufacturing, and testing meet precise engineering standards. Rigorous quality control checks are built into each stage of production. The finished product undergoes thorough electrical, optical, dimensional, and visual inspections resulting in products of superior quality. Our overall product quality average is 50 PPM. Our worldwide quality system including PPM and SOC programs, and our flexible manufacturing capabilities, allows us to produce the industry's highest quality products with Just-In-Time deliveries at competitive prices.

Product Applications

Siemens optoelectronic products are used in a broad range of electronic/commercial/industrial/military market segments, such as: test instrumentation, medical equipment, computers and computer peripherals, telecommunications, process/industrial controls, terminals, and power supplies.

Conclusion

Siemens is strategically positioned to concentrate efforts on innovative products and systems offering value-added and cost-effective features to our customers. All our resources and capabilities in the production of LED materials (visible and infrared), R&D engineering, IC design, optics/packaging, automated assembly, and a strong focus on reliability keep Siemens at the leading edge of opto technology.

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SIEMENS

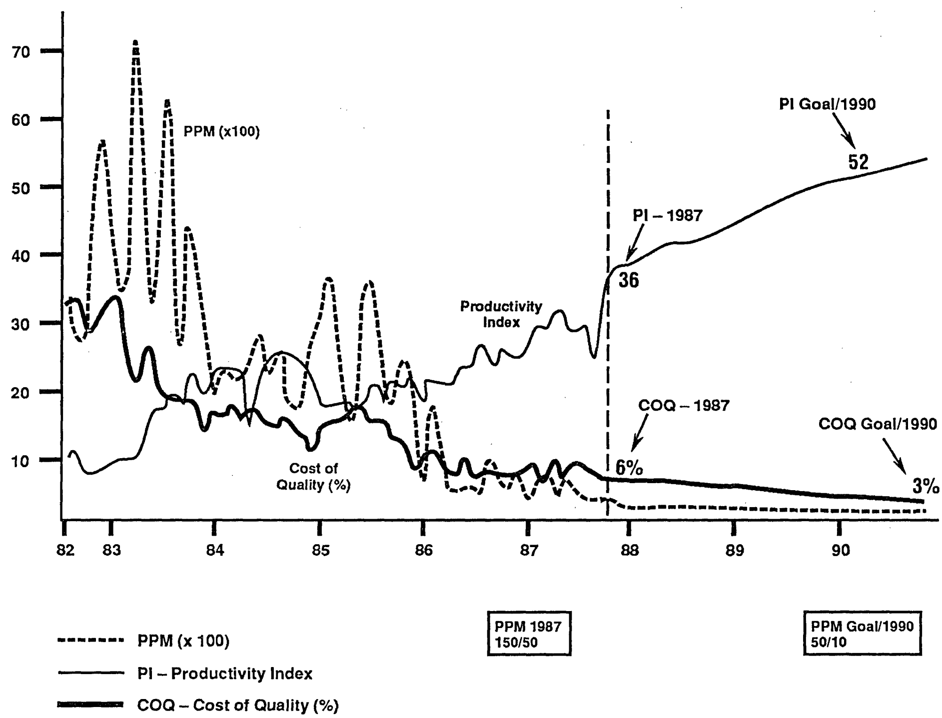
Quality at Siemens Optoelectronics

At Siemens Optoelectronics, quality means more than today's satisfied customer. It means measuring up to our customer's plans for tomorrow.

It means a sophisticated process: Quality manu-facturing and assurance programs, ongoing training and statistical quality control. It means continuously using customer feed-back to build in improvements, ensuring just-in-time delivery. And it means measurable results. During the past decade, we've continually reduced the cost of quality while increasing our productivity and reducing ppm.

In short, quality has become our way of life, permeating everything we do. It's become the art and science of exceeding our customer's expectations.

At Siemens Optoelectronics – Quality Means Measurable Results



Optoelectronics
Quality and Reliability

Introduction

In the technological community as a whole, the terms "quality" and "reliability" are frequently reduced to little more than advertising platitudes—heavily promised, but seldom delivered in the form of highly reliable, precision-made products. At Siemens Optoelectronics Division, however, we strive for continually increasing product excellence through increased quality and reliability reflecting a company-wide commitment of the highest priority.

Our ability to produce quality optoelectronic products offering longterm reliability is directly related to intensive research and development, advanced manufacturing, a quality-oriented work force, and a company wide philosophy attuned to the changing needs of a technologically sophisticated customer base.

Another important facet of our total commitment to manufacturing excellence is a program of quality control and reliability testing, under the Reliability and Quality Assurance (R&QA) Department. R&QA's responsibility is to interface directly with the customers, not only to determine their present satisfaction level, but to assess their future needs as well. In this way, R&QA makes certain that we will successfully meet all current and future quality/reliability requirements of our customers.

Similarly, it is also R&QA's responsibility to maintain open communication with customers, keeping them informed of our latest capabilities and achievements in the areas of product quality and reliability through detailed reports.

Although the concepts of quality and reliability are closely related, they are somewhat divergent, specialized activities. Simply put, **Quality Assurance** makes certain that products are "made right", ranging from rigid inspection and monitoring of all materials used in production processes, to monitoring the actual production processes themselves. **Reliability,** on the other hand, ensures that products "work right" after assembly. At Siemens, component reliability results from an extensive program of routine monitoring and special testing activities which will be detailed later.

Parts Per Million (PPM) Program

The intensive, quality-oriented efforts of every group have enabled us to achieve one of the lowest defect percentages in the industry. Our Parts Per Million (PPM) program meets all industry expectations and is at a level sufficient to supply high-caliber OEM customers including IBM, DELCO, DEC, and SPERRY (UNISYS).

The annual improvement of the PPM level is vital to our ability to remain a cost-effective, on-time supplier of high-quality components to the industry. Our PPM program is at the heart of the quality/reliability "revolution" which has occured in the semiconductor industry during the last few years.

Designed to control and monitor every step of the manufacturing process, as well as to assist in predictability studies, our PPM program represents the key to our long-term success in a highly competitive industry. To this end, we are heavily committed to:

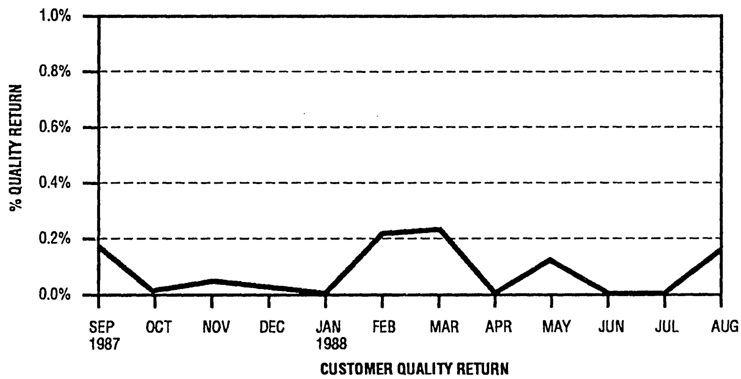
- Maximum automation of processes to obtain consistent, reproducible results.
- A system of stringent process controls to ensure the achievement of expected results.
- Effective quality systems to continuously audit the PPM level actually being achieved.

Customer benefits of the PPM system are numerous:

- A low PPM defect rate enabling you to eliminate incoming QA testing.
- Dependable on-time delivery for a "JUST IN TIME" inventory system, significantly reducing inventory costs.
- Efficient, highly automated manufacturing to keep long term price increases as low as possible.
- Fewer production line failures; lower assembly costs; increased profit margin.
- Fewer field failures on end products; lower warranty and service costs.

The 1988/89 PPM goal for Siemens Optoelectronics is 50 PPM.

Customer Quality Return Performance
September 1987 - August 1988



Statistical Quality Control (SQC)

To achieve our PPM goals efficiently, we have implemented a sophisticated program of Statistical Quality Control (SQC). In effect, SQC ensures highly-reproducible, controlled manufacturing processes and "just-in-time" delivery. It enables us to meet our PPM goals without resorting to a "brute force" approach. SQC is consistent with William E. Deming's principal theory that productivity improves as a product's variability rate decreases.

We recognize the necessity of meeting our customers' ever increasing quality requirements through a carefully developed, well-implemented program of Statistical Quality Control. After considerable research and careful planning, our SQC program was developed using the following 6-point plan for Statistical Process Control:

- Establishment of goals and objectives for company-wide implementation of Quality program
- Assessment of SQC technical capability and quantification of training aids
- Provision for training managers, engineers, supervisors, and analysts in methods and practices of SQC, as needed
- Managerial involvement in gaining statistical evidence pertaining to specific processes
- Identification of examples of successful SQC implementation...to be used as models for emulation
- Monitoring progress toward established goals through a program of periodic self-audits

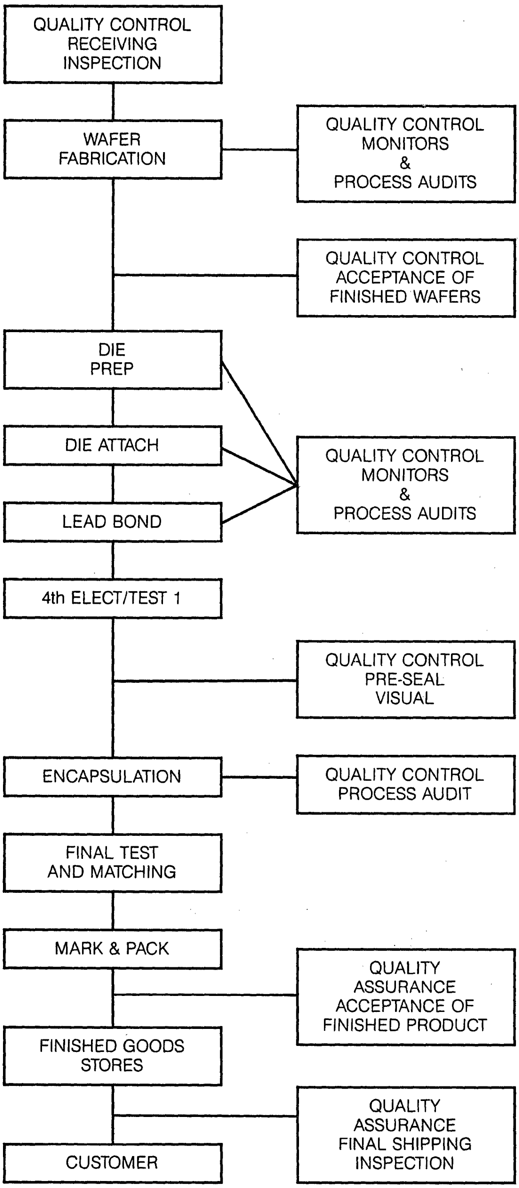
Quality Assurance

At Siemens the Quality Assurance Group serves the vital function of maintaining constant product quality standards. Quality Assurance activities begin with the careful assessment of raw materials, continues through in-process monitoring, and concludes with outgoing audits as outlined below:

- **Raw Material**
  - — Vendor surveys
  - — Vendor qualifications
  - — Incoming inspections
  - — Vendor rating systems
- **In-process Monitors**
  - — Die attach monitors
  - — Lead bond monitors
  - — Encapsulation monitors
  - — Finishing operations monitors
- **Outgoing Audits**
  - — Outgoing audits (all lots)
  - — Finished goods monitor (random)

The flowchart on the right shows the basic quality control procedures employed by Siemens Opto in the production of LEDs.

LED Quality Assurance Flowchart



Reliability

The fundamental objective of our reliability program is to ensure that all our products meet or exceed, quantitatively and qualitatively, the performance requirements of our customers and our Engineering Group. To achieve this goal, the Reliability Group constantly monitors products by generic groups. This monitoring provides continuous updated measurement of product reliability in specific operating environments.

The following are typical Reliability Tests performed for the monitoring program:

- **Temperature Cycle:** 100 Cycles from −40°C to 100°C*
- **Thermal Shock:** 30 Cycles from 0°C to 100°C*
- **Ambient Life Test:** Max rated power for 1000 hours
- **Elevated Life Test:** Max rated power at 70°C for 1000 hours
- **High Temperature Storage:** Max storage temperature, 1000 hours
- **Low Temperature Storage:** Minimum storage temperature, 1000 hours
- **Temperature Humidity:** 85°C – 85% RH, 500 hours
- **Solder Heat Test:** 260°C, 5 seconds

*Typical temp cycle and thermal shock condition. Exact conditions vary with product family.

Reliability Test Data (1982-1988 Monitoring Data)

Type of Test	Lamps	Standard Displays	Intelligent Dispaly® Devices	Opto-couplers
Temperature Cycle (100 CY)				
Sample Size	10,024	6421	7473	18,981
Total Cycles	1002K	642K	747%	1898K
Total Reject	0	0	2	2
Percent Reject	0.0%	0.0%	0.03%	0.01%
Thermal Shock (30 CY)				
Sample Size	8,475	4490	4629	13,269
Total Cycles	254K	134K	138K	398K
Total Reject	2	1	0	2
Percent Reject	0.02%	0.02%	0.0%	0.02%
Room Temperature Burn-In (1000 Hrs)				
Sample Size	3652	1372	3422	4620
Total Hours	3652K	1372K	3421K	4620K
Total Reject	0	0	1	0
FR* (%)	.0%	0.0%	0.03%	0.0%
High Temperature Burn-In (1000 Hrs)				
Sample Size	3838	1048	1088	4620
Total Hours	3838K	1048K	1088K	4619K
Total Reject	0	0	0	1
FR* (%)	0.0%	0.0%	0.0%	0.02%
Solder Heat Test (260°C, 5 sec.)				
Sample Size	2730	2244	2203	10,023
Total Reject	2	0	0	3
Percent Reject	0.0%	0.0%	0.0%	0.03%

*FR = Failure Rate, % per 1000 hours.

Description of Tests - Reliability Monitor Program

Type of Test	Military Standard	Pre Test Readings	Test	Post Test Readings
Temp Cycle (T/C)	MIL STD 883B, Method 1010.2	GO/NO GO	10 cycles per sub group, 15 min. dwell, 5 sec. transfer time, max. storage temp. ranges vary by product	GO/NO GO
Thermal Shock (T/S)	MIL STD 883B, Method 1011.1	GO/NO GO	30 cycles: boiling water; then ice water with 5 min. dwell time at each extreme	GO/NO GO
Life Test (L/T)	MIL STD 833B, Method 1005.2	Read/Record	Room temperature burn-in at max. rated conditions, 1000 hours duration	Read/Record at 168,500 and 1000 hours
High Temp Burn In (HI BI)	MIL STD 883B, Method 1005.2	Read/Record	Maximum rated operating temp. determined from product spec. and derated current as compensation for thermal dissipation, 1000 hours duration	Read/Record at 168,500 and 1000 hours
Solder Heat Test	—	GO/NO GO	Temp = 260 °C, dwell time = 5 seconds	GO/NO GO

Reliability test equipment ranges from multiple burn-in racks and table testers to a scanning electron-beam microscope. We've even designed and produced our own automatic microprocessor-based read/record tester.

Special testing covers a broad spectrum of environmental and life-stress tests. How well a sample performs under these highly-accelerated conditions indicates its reliability potential under service-life conditions.

Special testing affords us vital information in many important areas:

- New product performance
- New processes
- New manufacturing technique
- New material quality
- Special customer specifications
- Long-term reliability prediction

Reliability is also concerned with failure analysis. To determine the cause of failures, we selectively test and section products to localize and identify their failure mechanism. Selective isolation enables us to gauge the precise effects of stresses induced during reliability testing.

Conclusion

Siemens is firmly committed to the design, development and production of innovative optoelectronic components and assemblies of the highest quality and reliability. Working to achieve this goal, every group within the Division—Management, Engineering, Reliability and Quality Assurance, Manufacturing, and Marketing—provides a vital service, enabling us to achieve and maintain the consistent product quality and the high levels of reliability required by our customers in the electronics industry.

Due in large part to the efforts of the Reliability and Quality Assurance Department and to our successful PPM and SQC efforts, we will continue to maintain our leadership position in a highly competitive future-oriented industry.

High Reliability and Military Optoelectronic Devices

Capabilities

High reliability products must function under severe environmental, mechanical, and electrical stress. To meet this challenge Siemens Optoelectronics has established closely monitored product designs and process control techniques, insuring long product life.

Testing

We maintain a well equipped high reliability lab for electrical, mechanical, and environmental tests. All testing for JAN and Hi-rel products is done in Cupertino, California and for Industrial products, in Penang, Malaysia.

Calibration and Quality Control Systems

For calibration systems Siemens complies with the requirements of MIL-S-45662, and for quality control systems, MIL-Q-9858.

Certification

Siemens is a QPL supplier and approved by DESC to supply qualified MIL-D-87157/3 devices in accordance with the requirements of MIL-S-19500G. Electrical, environmental, and mechanical testing is done per MIL-STD-750 and MIL-STD-883 test methods and procedures. Our military lines are staffed by highly trained and experienced people who are certified on a periodic basis as required by DESC.

High Reliability Custom Optoelectronic Products

In addition to our standard displays, Siemens has the capability to design, manufacture and test custom optoelectronic devices—ranging from components to assemblies.

High Reliability Displays

Our Hi-rel, Intelligent Display devices are qualified to quality level A of MIL-D-87157 test levels.

Military Specifications

Siemens Hi-rel and military optoelectronic devices conform to the following Military Specifications:

Military Specifications

MIL-D-87157	General specification for display, light emitting diode, and solid state devices
MIL-S-19500	General specification for semiconductor devices
MIL-Q-9858	Quality program requirements
MIL-STD-105	Standard for sampling procedures and tables for tables for inspection by attributes
MIL-STD-202	Standard for test methods for electronics and electrical components
MIL-STD-750	Standard for test methods for semiconductor devices
MIL-STD-883	Standard for test methods and procedures for microelectronics
MIL-STD-45662	Standard for calibration system requirements
DOD-STD-1686	Electrostatic discharge control program
MIL-HDBK-52A	Evaluation of contractor calibration system handbook
DOD-HDBK-263	Electrostatic discharge control handbook

SIEMENS

RELIABILITY REPORT

DL1414T, DL1416B
DL1814, DL2416T, DL3416
Monolithic Intelligent Display® Devices with CMOS Drivers, Multiplexers, ASCII ROM, Character RAM and Pin Driven Display Attributes

The following summary documents the capability of the above Intelligent Display devices to meet or exceed the reliability standards for the highest level of commercial types of these devices.

I. LIFE TESTS

Test	Test Condition	# of Tests	Total Units Tested	Total Device Hours	Total Fail	Calculated Failure Rate (per 1000 hours)
High Temp Storage	85°C, Non-operating	11	334	334,000	0	2.99×10^{-3}
Low Temp Storage	−40°C, Non-operating	13	382	382,000	0	2.62×10^{-3}
High Temp/High Humidity Storage	85°C/85% RH Non-operating	14	412	412,000	0	2.43×10^{-3}
Ambient Operating Life	25°C, $V_{CC}=5.5$ V Sequencing Char.	11	268	268,000	0	3.73×10^{-3}
Elevated Operating Life	55°C, $V_{CC}=5.5$ V Sequencing Char.	13	372	372,000	0	2.69×10^{-3}
High Temp Operating Life	85°C, $V_{CC}=5.5$ V Sequencing Char.	5	130	130,000	0	7.69×10^{-3}
High Temp/High Humidity Operating Life	85°C/85% RH, $V_{CC}=5.5$ V Sequencing Char.	5	70	70,000	0	14.29×10^{-3}

Note: Assumed one failure on all calculations.

II. ENVIRONMENTAL TESTS

Test	MIL-STD-883 Reference	Test Condition	# of Tests	Total Units Tested	Total Failed
Solder Coverage	2003	260°C, 5 sec.	4	130	0
Solder Heat Resistance		260°C, 5 sec.	4	140	0
Temperature Cycling	1010	−40 to +85°C, 15 min. dwell, 5 min. transfer, 200 cycles.	8	240	0
Temperature Cycling	1010	−40 to +100°C, 15 min. dwell, 5 min. transfer, 100 cycles.	8	493	0
Thermal Shock	1011	0 to +100°C, 5 min. dwell, 3 sec. transfer, liquid to liquid, 50 cycles.	9	75	0
Moisture Resistance	1004	10 days, 90-96% RH, −10 to +65°C, non-operating	1	38	0
Shock	2002	5 blows each X_1, Y_1, Z_1 axis, 1500 G, 0.5 ms	1	22	0
Vibration Fatigue	2005	32±8 hrs. each X_1, Y_1, Y_2, 96 hrs. total, 60 Hz, 20 G	1	38	0
Constant Acceleration	2001	1 min. each axis, X, Y, Z, 5 kg	1	38	0
Terminal Strength	2004	1 lb. for 30 sec., then 8 oz., 3 bends 15°	1	38	0
Salt Atmosphere	1009	35°C fog, 24 hours	1	39	0
Electrostatic Discharge	3015.2	1.5 kΩ, 100 pF, 5 positive and 5 negative voltage discharges, V_Z, applied to all pins vs. GND; $V_Z=1.5$ kV / $V_Z=2.0$ kV / $V_Z=3.0$ kV		10 / 10 / 10	0 / 0 / 0
Solvent Resistance	Immersed at 25°C in solvent for 10 minutes, 5 unit samples, or boiling solvents for 3 minutes, 2 unit samples. *Passed:* Freon TF, Acetone, TA, 111 Trichloroethane *Failed:* Isopropanol, Methanol, Methylene Chloride, TE-35, TP-35, TCM, TMC, TMS + Ethanol, and Carboxylic Acid, TE, and TES.				

Note: Failures are defined as either mechanical or functional failures.

SIEMENS

OPTOCOUPLER MANUFACTURING and RELIABILITY

Single, Dual, and Quad Channel Optocouplers

THE CONCERN FOR OPTOCOUPLER RELIABILITY

Because of the widespread use of optocouplers as an interface device, optocoupler reliability has been a major concern to circuit designers and components engineers. Published studies of comparative tests have indicated a lack of manufacturing consistency with individual manufacturers as well as from manufacturer to manufacturer. This has resulted in user uncertainty about designing in optocouplers despite the fact that these devices often offer the better solution in the circuit.

This report is intended to demonstrate Siemens' concern, efforts, and results in addressing these manufacturing issues to assure users of the quality (out-going) and reliability (long term) of our opto-isolated products. First, aspects of optocoupler characteristics are discussed along with the measures Siemens has taken to assure their quality and reliability. Secondly, the reliability tests used to approximate worst case conditions and the latest results of these tests are described.

OPTOCOUPLER OUTPUT

There are a variety of outputs available in optocouplers. A standard bipolar phototransistor is the most common. They are available with different ratings to fit most applications, including versions without access to the base of the transistor to reduce noise transmission. Darlington transistor outputs offer high gain with reduced input current requirements, but typically trade-off speed. Logic optocouplers provide speed but trade-off working voltage range. Logic couplers are normally only used in data transmission applications. Silicon Controlled Rectifier (SCR) devices allow control of much higher voltages and typically are applied to control AC loads. They are also offered in inverse-parallel (anti-parallel) SCR (triac) configurations that both cycles of an AC sinusoid can be switched. In the Siemens manufacturing flow, all these devices are 100% monitored at a high temperature hot rail (*see Figure 4*) to eliminate potential failures due to marginal die attaches and lead bends, resulting in a more reliable product. Siemens offers all the above types of products.

In optocouplers, especially the transistor, the slow change over several days in the electrical parameters when voltage is applied, is termed the field effect. This process is extreme particularly at high temperatures (100°C) and with a high DC voltage (1kV). Changes in the electrical parameters of the silicon phototransistor can occur due to the release of charge carriers. In this way, a similar effect as takes place in a MOS transistor (inversion at the surface) is caused by the strong electrical field. This may result in changes in the gain, the reverse current, and the reverse voltage. In this case, the direction of the electrical field is a decisive factor.

In Siemens' optocouplers, the pn junctions of the silicon phototransistor are protected by a TRIOS (transparent ion screen) from influences of the electrical field. In this way, changes of electrical parameters by the electrical field are limited to an extremely low value or do not occur at all.

OPTOCOUPLER INPUT

The area of greatest concern in optocoupler reliability has been the IR LED. The decrease in LED light output power over current flow time has been the object of considerable attention in order to reduce its effects. (Circuit designs which have not included allowances for parametric changes with temperature, input current, phototransistor bias, etc. have been attributed to LED degradation. To insure reliable system operation over time, the variation of circuit from data sheet conditions must be considered.)

Siemens has focused on the infrared LED to improve CTR degradation, and consequently achieved a significant improvement in coupler reliability. The improvements have included die geometry to improve coupling efficiency, metalization techniques to increase die shear strength and to increase yields while reducing user cost, and junction coating techniques to protect against mechanical stresses, thus stabilizing long term output.

CURRENT TRANSFER RATIO

The Current Transfer Ratio (CRT) is the amount of output current derived from the amount of input current. CTR is normally expressed as a percent. For example, if 10 mA of input current is applied to the input (LED) and 10 mA of collector current is obtained, then the CTR is 100 or 100%. CTR is affected by a variety of influences: LED output power, Hfe of the transistor, temperature, diode current, and device geometry. If all these factors remain constant, the principle cause of CTR degradation is the degradation of the input LED. As mentioned earlier, Siemens has made tremendous progress in manufacturing techniques to reduce CTR degradation. Figure 1 graphs the CTR degradation of Siemens' optocouplers. The data is presented under two conditions. Both conditions apply a constant stress over the 4000-hour period. This is unlikely to occur in actual application, and therefore can be considered as a worst case condition. The first condition (I_F = 10 mA) is a typical operating point for actual application. The second condition (I_F = 60 mA) stresses the LED at an extremely high, forward current to demonstrate worst case conditions, and magnifies CTR degradation. Siemens' manufacturing techniques maximize coupling efficiency which realize high transfer ratios and low input current requirements. Additionally this allows a large variety of standard CTR values, and the capability of special selection in production volumes.

ISOLATION BREAKDOWN VOLTAGE

Isolation voltage is the maximum voltage which may be applied across the input and output of the device without breaking down. This breakdown will not normally occur inside the package between the LED and the transistor, but rather on the boundary surfaces across which partial discharges can occur. Siemens uses a double mold manufacturing technique where the LED and transistor are encapsulated in an infrared transparent inner mold. The next step in the process is an epoxy over mold. The double mold technique lengthens the leakage path for high voltage discharges appreciably, allowing the device to achieve very high isolation voltages. All of Siemens optocouplers are built using U.L. approved process. A standard line of V.D.E. approved optocouplers is also available.

COLLECTOR TO EMITTER BREAKDOWN VOLTAGE

Collector to emitter breakdown voltage (BV_{CEO}) can be thought of as a transistor's working voltage. When considering the application, the selection should be made to include a safety margin to insure the device is off when it is supposed to be off. Siemens transistor technology in wafer processing offers a variety of BV_{CEO} devices. Each is parametrically (*see Figure 4*) tested to insure proper operation.

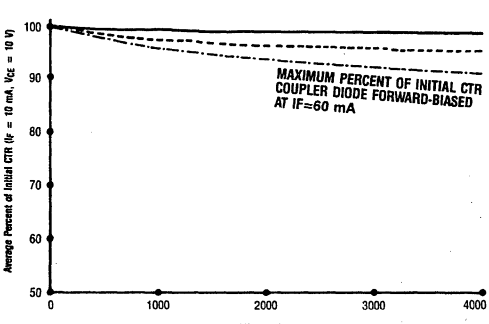
BLOCKING VOLTAGE

Blocking voltage (V_{DRM}, expressed in peak value) is used when describing the working voltage for SCR or triac type devices. Siemens offers products through 600 volts of blocking capability.

DV/DT RATING

DV/DT, an important safety specification, describes a triac type device's capability to withstand a rapidly rising voltage without turning on or false firing. Siemens triac type devices have the highest available DV/DT rating offered on the market. Siemens manufacturing process yields a 10,000 V/µs DV/DT rating. This rating eliminates the need for snubber (RC) networks which negatively affect loads sensitive to leakage currents, while reducing component count for circuit implementation and cost. An example of such a load would be neon indicator lamps. Siemens' triac type devices also carry a load current rating three times the industry standard. This 300 mA current capability allows the device to drive most AC loads without the need for a follow-on triac or interposing an electromechanical relay. Siemens manufactures this device with or without zero crossing detector logic.

Figure 1. CTR Degradation vs. Time



Relative degradation in current-transfer ratio (CTR) over a period of time with the coupler diode forward-biased.

—— Life Test Condition: Coupler diode forward-biased at I_F = 10 mA, T_{amb} = 25°C

---- Life Test Condition: Coupler diode forward-biased at I_F = 60 mA, T_{amb} = 25°C

Figure 2: Reliability Requirements for Optocouplers

MECHANICAL/ENVIRONMENTAL TESTS

Test	MIL-STD-883 Reference	Test Condition
Temperature Cycle	1010	−55°C to +150°C, 100 Cycles
Thermal Shock	1011	0°C to +100°C, 50 Cycles
Solder Heat		260°C, 10 Seconds
Solderability	2003	260°C, 5 Seconds
Pressure Pot	—	15 PSIG ±1, 121°C, Steam 96 Hours
Solvent Resistance	2015	—
Moisture Resistance*	1004	10 Days, 90-98% RH, −10°C to +65°C, Non-Operating
Shock*	2002 Condition B	5 Blows each X_1, Y_1, Z_1, Axis 1500G, 0.5 ms
Vibration Fatigue*	2005 Condition A	32 ±8 Hrs., each X_1, Y_1, Z_1, 96 Hours, 60 Hz, 20G
Constant Acceleration*	2001 Condition A	1 Min. each Axis X,Y,Z, 5KG
Terminal Strength*	2004	1 lb. for 30 Seconds, then 8 oz., 3 Bends 15°

*Monitored periodically.

LIFE TESTS

	Test Conditions			
Tests	Temp (°C)	RH (%)	Bias	Hours
Ambient Life Test	25	≤60%	Max Rating	1000
Elevated Life Test	70	≤60%	Derated Max Rating	1000
High Temp Life Test	150	≤60%	0	1000
Low Temp Life Test	−55	≤60%	0	1000
Temp/Humidity Life	85	85%	0	1000
Intermittent Operating Life	25	≤60%	Max Rating	1000
High Temperature Reverse Bias	125	≤60%	80% of Max Voltage Rating	1000

QUALITY AND RELIABILITY TESTS

The tests in Figure 2 were performed on Siemens optocouplers. The tests allow early detection of weak points, and provide information regarding the reliability characteristics of the component.

From the Life Test information assumptions of useful life expectancy can be obtained. All quality and reliability tests are performed in conditions that either exceed or are equivalent to the limits defined in our data sheets. International standards are also considered. Assuming that no new additional failure mechanisms are created by the stress conditions, the results of the stress test will correlate to conditions in the field and can be used to estimate useful lifetime. The environmental stress tests ensure Siemens manufacturing capabilities will provide package integrity in the most rigorous conditions. The Life Test results highlight our ability in packaging and electrical performance to achieve MTBF hours which meet and exceed the highest expectations for the semiconductor industry.

Figure 3. Environmental and Life Test Results

Single Channel Optocouplers

ENVIRONMENTAL TESTS					
Test	Test Condition	Sample Size	Good	Reject	%Reject
Temperature Cycle	−55°C to +150°C, 100 Cycles	6056	6056	0	0.00%
Thermal Shock	0°C to +100°C, 30 Cycles	4596	4595	1	0.02%
Solder Heat Test	260°C, 10 Seconds	3392	3392	0	0.00%
High Temp Storage	150°C, 1000 Hours	1442	1441	1	0.07%
Low Temp Storage	−55°C, 1000 Hours	1442	1442	0	0.00%
Temp Humidity	+85°C/85% RH, 1000 Hours	454	454	0	0.00%

LIFE TESTS						
Test	Test Condition	Sample Size	Unit Hours (k)	Good	Reject	MTBF* (Unit Hours)
Ambient Life Test	60 mA, 25°C, P_D=255 mW Max.	1442	1442	1442	0	2,030,000
Elevated Life Test	40 mA, 70°C, P_D=104 mW	1442	1442	1442	0	2,030,000
Intermittent Op Test	On=3 Minutes, Off=2 Minutes 60 mA, 25°C, P_D=235 mW Max.	1442	1442	1442	0	2,030,000
	Total	4326	4326	4326	0	6,200,000

*Based on the life test results presented, an overall MTBF of 6,200,000 unit hours can be demonstrated on a "Best Estimate" basis.

Dual Channel Optocouplers

ENVIRONMENTAL TESTS					
Test	Test Condition	Sample Size	Good	Reject	%Reject
Temperature Cycle	−55°C to +150°C, 100 Cycles	6160	6159	1	0.02%
Thermal Shock	0°C to +100°C, 30 Cycles	3969	3968	1	0.03%
Solder Heat Test	260°C, 5 Seconds	2840	2838	2	0.07%
High Temp Storage	150°C, 1000 Hours	1442	1442	0	0.00%
Low Temp Storage	−55°C, 1000 Hours	1442	1442	0	0.00%
Temp Humidity	+85°C/85% RH, 1000 Hours	402	402	0	0.00%

LIFE TESTS						
Test	Test Condition	Sample Size	Unit Hours (k)	Good	Reject	MTBF* (Unit Hours)
Ambient Life Test	37.5 mA/Channel, P_D=388 mW Max., 25°C	1442	1442	1442	0	2,030,000
Elevated Life Test	19.6 mA/Channel, P_D=138 mW Max., 70°C	1442	1442	1442	0	2,030,000
Intermittent Op Life	On=3 Minutes, Off=2 Minutes 37.5 mA/Channel, P_D=388 mW Max., 25°C	1338	1338	1338	0	1,940,000
	Total	4222	4222	4222	0	6,000,000

*Based on the life test results presented, an overall MTBF of 6,000,000 unit hours can be demonstrated on a "Best Estimate" basis.

Quad Channel Optocoupler

ENVIRONMENTAL TESTS					
Test	Test Condition	Sample Size	Good	Reject	%Reject
Temperature Cycle	−55°C to +150°C, 100 Cycles	6056	6055	1	0.02%
Thermal Shock	0°C to +100°C, 30 Cycles	4296	4296	0	0.00%
Solder Heat Test	260°C, 10 Seconds	3406	3405	1	0.03%
High Temp Storage	150°C, 1000 Hours	1442	1442	0	0.00%
Low Temp Storage	−55°C, 1000 Hours	1442	1442	0	0.00%
Temp Humidity	+85°C/85% RH, 1000 Hours	402	402	0	0.00%

LIFE TESTS						
Test	Test Condition	Sample Size	Unit Hours (k)	Good	Reject	MTBF* (Unit Hours)
Ambient Life Test	37.5 mA/Channel, P_D=388 mW Max., 25°C	1442	1442	1442	0	2,030,000
Elevated Life Test	19.6 mA/Channel, P_D=138 mW Max., 70°C	1442	1441	1440	2	530,000
Intermittent Life Test	On=3 Minutes, Off=2 Minutes 37.5 mA/Channel, P_D=138 mW Max., 25°C	1442	1442	1442	0	2,030,000
	Total	4326	4325	4324	2	1,600,000

*Based on the life test results presented (at maximum rated conditions), an overall MTBF of 1,600,000 unit hours can be demonstrated on a "Best Estimate" basis.

PACKAGE INTEGRITY

Although packaged in standard IC configurations, optocouplers have some unique package considerations. The use of two chip and internal light transfer medium require careful selection of materials to insure compatibility under a variety of operating conditions. In addition to the high isolation voltages achieved by Siemens optocouplers, our devices are tested to assure high levels of mechanical integrity and moisture resistance. For example, a ninety-six hour pressure pot test has been recently implemented to more stringently verify moisture resistance. As meaningful test results are accumulated, they will be included in future reports.

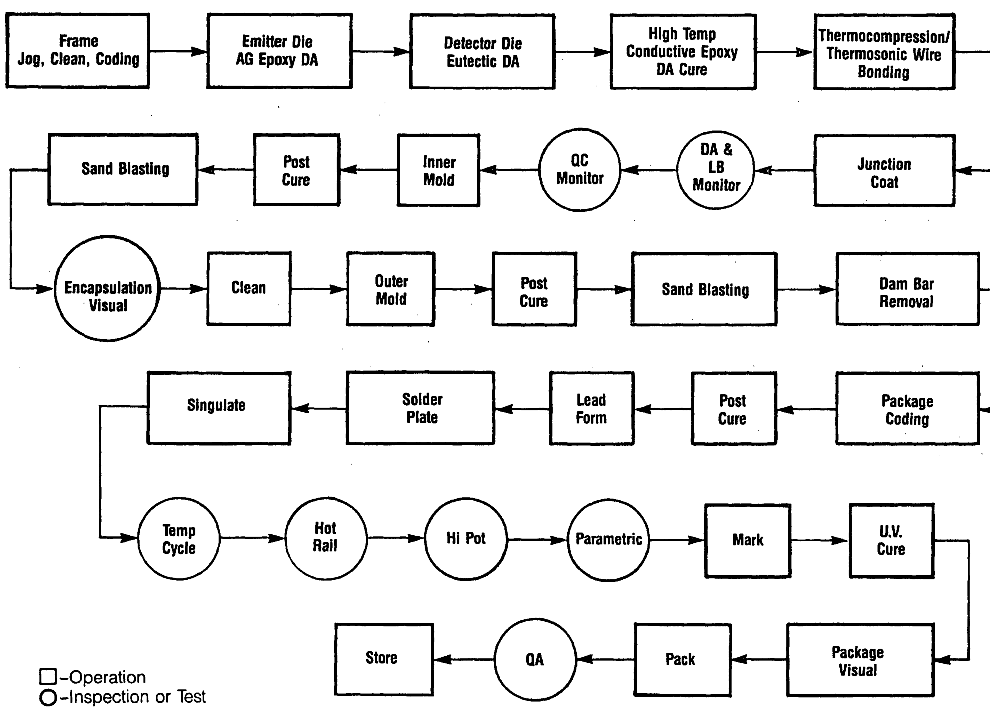
PACKAGE DENSITY

Board space has become increasingly more important in the electronic industry. Siemens uses a plate molding technique to achieve reduction in cost, allowing us to offer a wide selection of packages. These consist of single channel optocouplers in 4, 6, 8, and 16 pin DIP packages, dual channel devices in 8 pin DIP packages, and quad channel devices in 16 pin DIP packages. All of the above devices are available in three surface mount lead configurations, as well as the standard through-the-hole lead. Siemens has also introduced a standard single channel optocoupler in a SOIC-8 footprint package. All of these packages have been designed and tested to meet the highest quality and reliability expectation of the semiconductor industry.

ASSEMBLY QA INSPECTIONS

1. Die Attach and Lead Bond Inspection – Random sampling of die bonding integrity by a shear strength test and wire attach integrity by a wire pull test.
2. Visual QC Monitor – Microscopic inspection of die placement, die and wire bonds, wire loops, damaged die and wire and emitter junction coat coverage.
3. Encapsulation Inspection – Sample lot inspection for molding defects.
4. Temperature Cycle Test – Sample lot temperature cycling from –55°C to +150°C for 10 cycles subjecting the parts to thermal stresses in order to eliminate marginal die attach, wire bonds and misalignments.
5. Hot Rail Test – 100% electrical continuity testing at 100°C to insure removal of thermal intermittent parts.
6. HiPot Test – 100% testing of isolation voltage parameter per UL/VDE requirements.
7. Parametric Tests – 100% electrical tests to data book or customer-selection parameters.
8. QA Final Tests – Lot audits to assure conformance to all product requirements.

Figure 4. Coupler Process Flow & Inspections



RELIABILITY REPORT

IL205-207, IL211-213
IL215-217, IL221-223
Small Outline Surface Mount Optocoupler

The following summary documents the capability of the small outline surface mount optocoupler series to meet and exceed reliability standards for the highest level semiconductor products.

ENVIRONMENTAL

Test	Conditions	Duration	Total Devices Tested	Failures
Temperature Cycling	−55°C to +150°C	200 Cycles	350	0
Thermal Shock	0°C to +100°C	100 Cycles	226	0
Solder Heat Test	260°C	10 Seconds, 3 Times	912	0
Lead Integrity Test	8 oz. Tension	30 Seconds	76	0
Vapor Phase Zone Test	215°C	60 Seconds	76	0

ENVIRONMENTAL LIFE

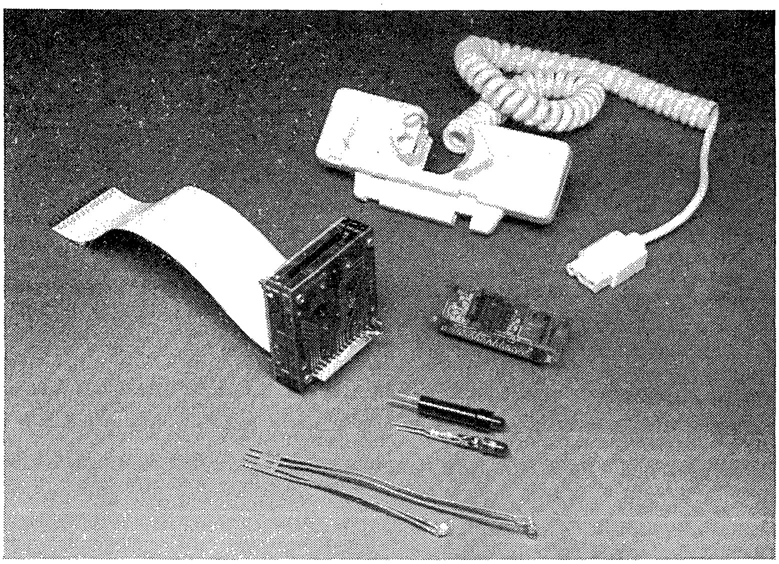
Test	Conditions	Duration	Total Device Hours	Failures
Pressure Pot Test	121°C/15 PSIG Steam	288 Hours	44,640	0
Temperature/Humidity	85°C/85% RH	1000 Hours	240,000	0
High Temperature Storage	150°C	1000 Hours	342,000	0
Low Temperature Storage	-55°C	1000 Hours	208,000	0

OPERATING LIFE

Test	Conditions	Duration	Total Device Hours	Failures
Ambient Life	25°C, I_F=60 mA	1000 Hours	352,000	0
Ambient Life	25°C, I_F=40 mA	1000 Hours	57,000	0
High Temperature Life	70°C, I_F=40 mA	1000 Hours	240,000	0

GENERAL

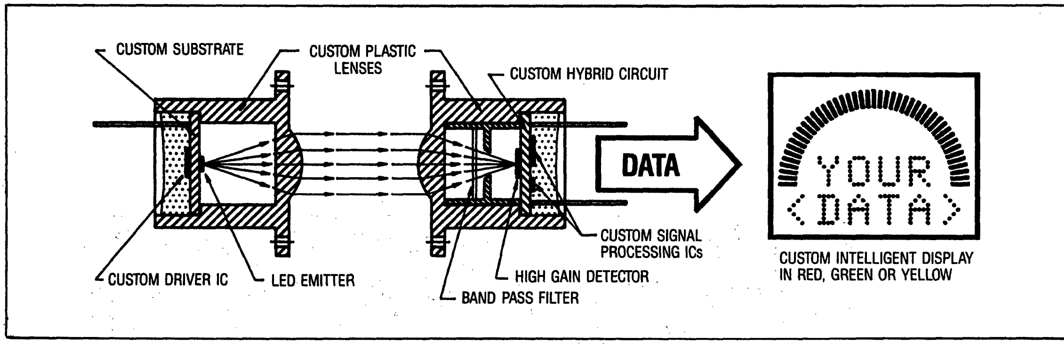
Isolation Breakdown 3KVAC$_{RMS}$ for 1 sec: No Failures
Average Change in CTR Over Pressure Pot Test: 3.6%



Custom Optoelectronic Products
Materials and Die

SIEMENS

CUSTOM OPTOELECTRONIC PRODUCTS



A representative example of our broad custom capabilities described below.

INTRODUCTION

Siemens Custom Optoelectronic Products are designed typically for unique applications or specific performance requirements using optical devices. Because of our over 15 years experience as an optoelectronics supplier, you benefit from this long time experience and tested performance. Our custom engineering resources include an engineering expertise in solid state optical devices and plastic optics, full custom packaging capability, complex hybrid system capabilitly, IC design, and an optical design and measurements lab. Our custom product approach gives you reduced system cost, improved performance, design ownership, improved reliability, high product quality, and many more benefits and features.

OUR CAPABILITIES

- **Optical Design Expertise**
  - — Solid State Optical Device Solutions
  - — Plastic Lens Capabilities
  - — Multi-Element Lens Capability
  - — Multi-Channel Fiber Optic Design Techniques
- **Full Range of Custom Packaging Options**
  - — Modular Assemblies Designed and Built Using:
    - Custom Leadframes
    - Molded Plastic Optics
    - Hybrid Chip-on-Substrate Assemblies
    - Polymer Thick-Film Multilayer Substrates
  - — Transfer Molded Packages
  - — Hermetic Packages
- **Specialize in Hybrid Functional Modules**
  - — Extensive Chip-On-Board Experience
  - — Precise Die Positioning in Single Units or Arrays
  - — Board Component Design
  - — Surface Mount Technology
- **Optical Measurements Facility**
  - — Absolute Characterization of Optical Performance
  - — Fast and Accurate Responses to Customer Requirements
  - — Measurements Traceable to National Bureau of Standards
- **Computer Aided Design Facility**
- **In-House IC Design Capability**
  - — High Speed Silicon Gate CMOS and Bipolar Technology
  - — Complete IC Test, Process and Product Engineering
- **Quality and Reliability Control**
  - — Established QC System
  - — Average Quality Level, under 50 PPM
  - — Extensive Product Characterization
- **State-of-the-Art Materials**
  - — Full Spectrum of Visible LEDs, Infrared Emitters, and Detectors
- **Wafer Fabrication Facility**
  - — Complete Control of Device Fabrication
  - — State-of-the-Art Process and Materials
  - — Custom Die Designs
- **Model, Offshore Assembly Facility**
  - — Latest Automated Assembly Equipment
  - — Test and Burn-in Capability
  - — "Just-in-Time" Philosophy
  - — Over 15 Years Experience in Optical Hybrid Assemblies

CUSTOMER BENEFITS

- **Reduced System and Program Costs**
  - — Higher Level of Integration
  - — Reduction in Components Required
- **Optimum Product Performance**
  - — Use of Latest Technology
  - — Improved Optical Design Techniques
- **Uniquely Competitive Designs**
  - — Special Functions and Features
  - — Proprietary Customer Design
- **Reduced Product Development Time**
  - — Allows Quicker Entry to Market
- **Improved Reliability and Quality**

CUSTOM ENGINEERING RESOURCES

Siemens is an expert in evaluating customer requirements and proposing systems solutions. For example, our engineers are specialists at integrating LED displays with microprocessors to form display subsystems.

Also, our expertise in optical engineering allows us to optimize emitter/detector system designs. This includes: unique plastic lens design, multi-element lens designs, multi-channel fiber optics design techniques as well as the use of other optical elements such as apertures, reflectors, mirrors, etc.

CUSTOM PACKAGING AND HYBRID CAPABILITIES

Custom packaging is another option available to you offering a significant size reduction and resulting cost savings over most existing designs. Our modular assemblies are designed and built using custom leadframes, custom molded plastic lenses, hybrid chip-on-substrate assemblies or polymer thick-film multilayer substrates. We have extensive chip-on-board experience for airgap, concoat, and epoxy encapsulated modules. We support air gap assemblies with metal or plastic housings. We also have the technology to transfer mold epoxy packages. For harsh environmental conditions we offer hermetic processing using glass, ceramic or metal assemblies.

Another area of expertise is in precise die positioning in single units or arrays. Our surface mount technology supports both ceramic and PCB substrates. Our component design capability includes visible LEDs, IR LEDs, Op Amps, Photodiodes, Phototransistors, LSI CMOS Chips, Bipolar ICs, Optocouplers, and Discretes. In summary, we are the optoelectronic specialists in the design of hybrid modules.

OPTICAL DESIGN AND MEASUREMENTS LABORATORY

The Siemens Optics Lab, a versatile and precise optical measurement facility, provides fast and accurate absolute characterization of optical radiation performance. This insures fast and accurate responses to customer requirements and on-site field support available on complex issues. The lab is coordinated with standards organizations worldwide insuring the latest conventions for optical measurement procedures. All measurements are traceable to the National Bureau of Standards.

Listed below are a few of our optical laboratory's capabilities:

- LED spectral irradiance from 280 to 1070 nm.
- LED spectral luminosity from 380 to 780 nm.
- Radiometric and photometric intensity.
- Detector response versus wavelength from 280 to 1070 nm.
- Precise computer based measurement system.
- Other optical capabilities available to support customer needs.

WAFER FABRICATION FACILITIES

For your custom requirements, Siemens wafer fabrication facilities use state-of-the-art materials such as Gallium Arsenide (GaAs), Gallium Aluminum Arsenide (GaAlAs), Gallium Phosphide (GaP), and Gallium Arsenide Phosphide (GaAsP). We can control wavelength in a range from 560 nm to 840 nm. Our quality material gives you higher reliability and more brightness with lower power. We also provide a material foundry service for your custom die requirements.

CAD/CAM: DESIGN AND ASSEMBLY

We design custom assemblies and subassemblies by computer and assemble by computer-controlled automated assembly equipment. This vastly improves the reliability and quality control while offering more features at the lowest possible cost.

AUTOMATED OFFSHORE ASSEMBLY FACILITY

The Siemens assembly plant, in Penang, Malaysia, uses the latest in automated assembly and test equipment allowing effective and flexible approaches to varying technologies and products yielding competitive costs and prices. Our automated computer tracking system supports a "just-in-time" delivery philosophy. A total quality concept includes a statistical process control program, a continuous calibration program a preventive maintenance program, and an employee job awareness enhancement program is an on-going commitment. A complete test and burn-in facility is supported by a failure analysis group and reliability monitors. Production lots are traceable guaranteeing pre-dictability of quality and yield. A dedicated product development group supports a variety of customer needs. We have accumulated a total of over 14 years experience in the assembly and test of high density optoelectronic hybrid assemblies.

CUSTOMER BENEFITS

Your program benefits in many ways, through a combination of the engineering resources and available technology. We can reduce your system and overall program costs through higher levels of integration, reduced component inventory/lower component costs, elimination of in-house assembly labor costs, lower inventory costs, reduction of warranty expenses, and lower administrative costs. We can offer optimum product performance with improved optical design techniques using leading edge technology. Our state-of-the-art packaging techniques offer significant size reductions as well as improved operating conditions. All this leads to improved product quality and reliability characteristics since the final product is 100% tested and guaranteed operational.

Your design will be uniquely competitive since it will use features and technologies not available to your competitors. The design will be your proprietary product. Our ability to dedicate engineering resources to your custom project frees up your resources for other programs enabling your products quicker introduction to the market. You receive only fully tested and quality assured product (100% yield) for improved reliability and quality.

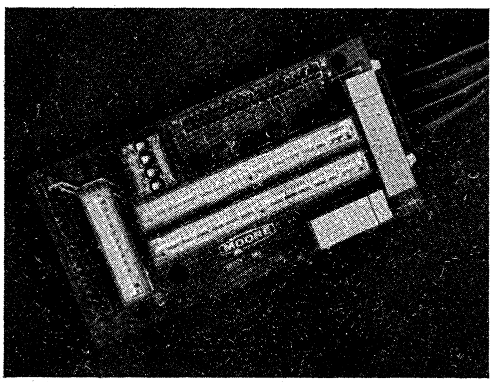
CUSTOM APPLICATIONS AND MARKETS SERVED

Siemens Custom Products have applications in virtually every OEM market. We currently serve the industrial, medical, EDP and computer peripherals, telecommunications, office equipment, and transportation markets. Some high volume applications now in production include: medical fluid flow sensor, medical oximetry probes, electronic coin sensing, industrial controller displays, currency validation, computer touch screen sensing, instrumentation panels, sign boards, information of data terminal displays, and custom lamps and bar graphs.

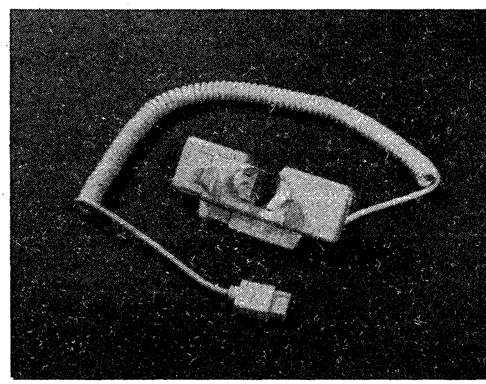
INQUIRIES

Your inquiries should include mechanical, electrical, and environmental requirements. Also include anticipated product volumes, price objectives, and leadtimes since these considerations affect the design and tooling approach.

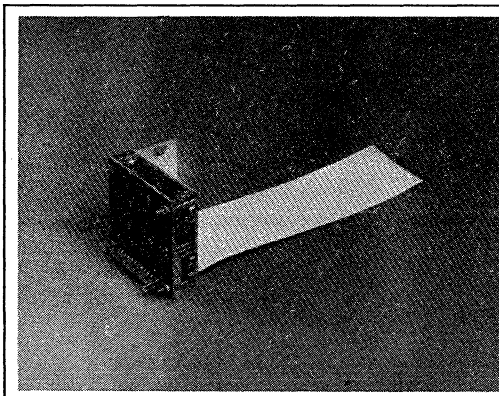
Examples of Products in Production:



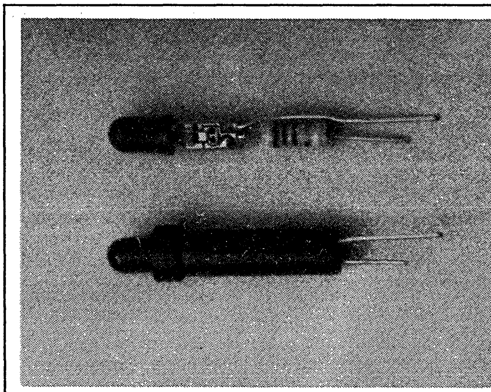
Industrial Display



Fluid Flow Sensor

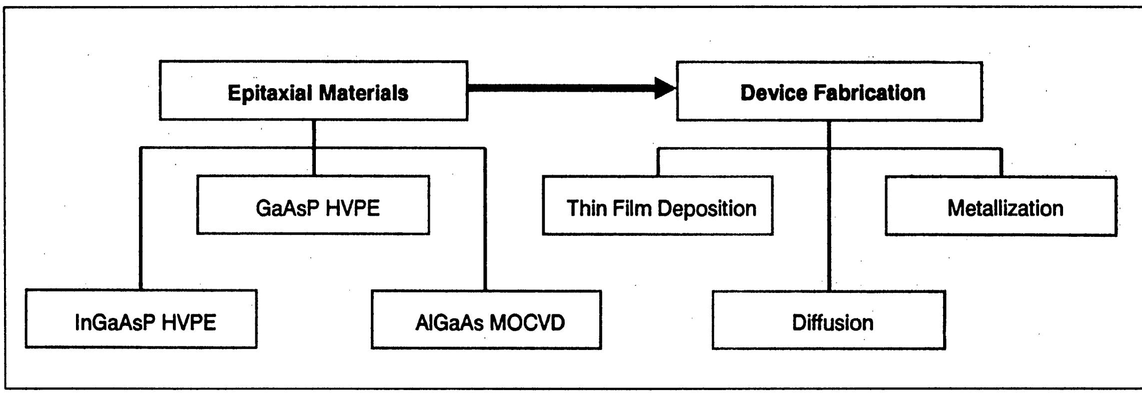


Coin Sensor



Telephone Switch Indicator Lamp

CUSTOM OPTOELECTRONIC MATERIALS AND DIE



Introduction

- **Custom Materials Growth**
  - State-of-the-Art Proprietary Reactor Designs
  - GaAsP, InGaAsP, and AlGaAs Growth Capability
  - Complete Materials Analysis Facility
  - Systems Handle Prototype & Production Volumes
  - 2" and 3" Diameter Wafers and Custom Shapes

- **Custom Device Fabrication**
  - Thermal & Plasma Thin Film Deposition
  - Optimized Diffusions for Each Composition
  - Customized N- and P-Type Metallizations
  - All Processes are DESC/MIL Certified

- **In-House Computer-Aided Device Design**
  - Custom Electro-Optical Devices
  - Library of Point-Source, Multi-Segment, and Fiber Optic Designs Available

- **Optical Measurements Facility**
  - Absolute Characterization of Optical Performance
  - Fast, Accurate Response to Customer Requests
  - All Measurements are NBS-Traceable
  - 100% Analytical Test Capability

- **Modern Testing and Assembly Facility**
  - 42,000 sq. ft. Facility in Penang, Malaysia
  - Latest Automated Assembly Equipment
  - 100% Test and Burn-in Capability
  - "Just-in-Time" Philosophy
  - Over 14 Years Experience in Optical Hybrid Assemblies

- **Additional Product Design Expertise**
  - Multi-Element Lens Capability
  - Multi-Channel Fiber Optic Design Techniques
  - Hermetic Packages
  - Board Component Design
  - Surface Mount Technology

Epitaxial Materials Growth Facility

For your custom materials requirements, Siemens' epitaxial growth facility offers optoelectronic products in several compound semiconductor systems. We have over 15 years of experience in the growth of GaAsP/GaAs materials. Siemens is recognized worldwide for the superior quality and uniformity of our 655nm "Standard Red" materials, but we also produce and have characterized compositions ranging from 560nm pure green through 840nm infrared.

In addition, we are actively developing InGaAsP growth by HVPE and AlGaAs growth by metal-organic chemical vapor deposition (MOCVD). InGaAsP finds application in the visible and infrared regions of the spectrum, while AlGaAs is primarily an infrared material by this growth technique. Both materials are well suited for optical detectors.

An important consideration for our customers is the shape and size of the wafers we produce. To that end, Siemens offers a selection of 2"- and 3"-diameter wafers sized to SEMI specifications or wafers shaped to match your specific needs.

Device Fabrication Facility

Siemens has a fully equipped fabrication facility for processing epitaxial wafers into finished devices. The processes available include thin-film deposition, photolithography, diffusion, metallization, lapping, and parametric testing and analysis. We employ statistical quality control (SQC) to ensure consistency of the most critical processes, and our facility is DESC certified to produce JAN-rated products. In-house control of the fabrication process enables us to select a customized combination of technologies that best match your product needs.

Each application has its own pattern requirements dictated by available drive power, optical output power, human recognition, reliability, etc. Siemens helps you choose from a wide selection of device designs. We maintain a library of extensively characterized standard designs for point-source, multi-segment, and fiber optic emitters, or you can pick your own proprietary configuration. You can apply our design rules to produce your own masks, or give us your mechanical drawing and let us turn it into a working device. We are experienced in the design of large area, high density devices with as many as 240 uniform emitting areas on a single chip!

If you prefer, Siemens can also produce the fully assembled product by computer design of custom assemblies and sub-assemblies and use of automated manufacturing equipment. This vertical integration vastly improves reliability and quality control while offering more features at the lowest possible cost.

Optical Design and Measurements Laboratory

The Siemens Optics Lab, a versatile and precise optical measurement facility, provides fast and accurate characterization of optical radiation performance. This insures prompt and reliable responses to customer requirements. The lab is coordinated with standards organizations worldwide and employs the latest conventions for optical measurement procedures. All measurements are traceable to the National Bureau of Standards.

Automated Offshore Assembly Facility

The Siemens assembly facility in Penang, Malaysia, uses automated test, dicing, and assembly equipment providing both flexibility in device characterization and highest quality/lowest cost for finished products. The test and burn-in operations are supported by a failure analysis group and reliability monitors. The product is fully traceable back to the raw materials, guaranteeing predictability of quality and yield.

Worldwide Technical Commitment

One of our chief strengths lies in Siemens' commitment to establishing leading-edge semiconductor technologies. Divisions throughout the world are involved in the manufacture of optical components for signal processing, ultrahigh-speed communication, and long haul data transmission. Supporting the efforts are the Corporate Research and Technology Laboratories. They are responsible for research in evolving sciences (such as molecular beam epitaxy) and supporting the manufacturing divisions with technical advice, coordinated literature access, the latest process technology, and in-depth material and device analysis.

A Typical Cycle from Plan to Product ...

Your program begins with the "request for quotation (RFQ)" which outlines your product requirements, anticipated delivery and volume, and target price. After review by our technical and manufacturing staffs we will contact you with any additional questions. If we feel that Siemens can adequately service your needs we will submit a program plan, schedule, and quotation. This cycle is typically completed within five working days of receiving the RFQ.

Upon receipt of your order, we will jointly establish milestones and review dates for tracking the progress of your program. This will include a detailed listing of all key deliverables and evaluations, as well as points where reviews and decisions are required. At the end of the development phase of the program a final summary report will be submitted to complete your records and ensure a smooth transition into manufacturing.

How Do Siemens' Customers Benefit?

Successful development and production of optoelectronic devices requires many qualities. Your supplier must deliver:

A FIRM THEORETICAL FOUNDATION ... to guarantee that the latest technology and best equipment put you on the shortest path to the solution,

STABLE PROCESSES ... to ensure that every step of the product evolution is reliable and reproducible,

FLEXIBILITY ... to provide the materials, processing, and degree of integration that are most performance- and cost- effective,

INFORMATION ... to understand how the device will perform in your application,

CONSISTENCY ... to expeditiously and reliably meet your product needs.

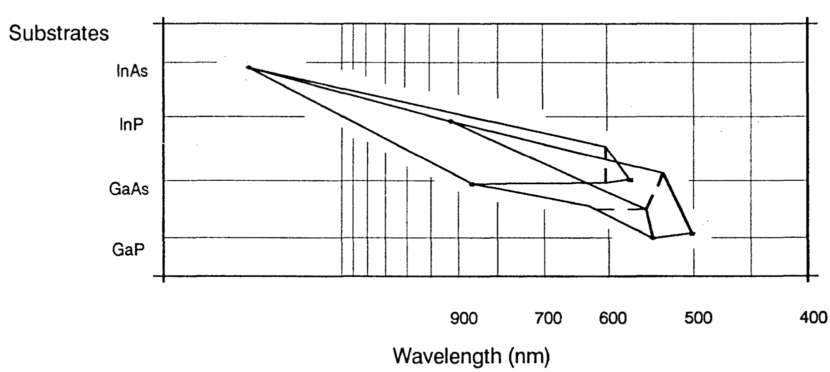
Siemens has been demonstrating these qualities for over 15 years. Whether it is an interactive development of a new product or volume production of an established part, we are the best supplier to service your optoelectronic needs!

Inquiries

Address all correspondence and telephone calls to the "Custom Materials and Devices" organization at:

Siemens Components, Inc.
Optoelectronics Division
19000 Homestead Road
Cupertino, CA 95014 USA
TEL (408) 725-3410
FAX (408) 725-3420
TWX 910-338-0022

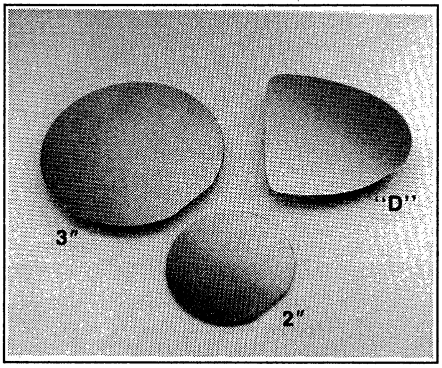
Materials Selection Guide

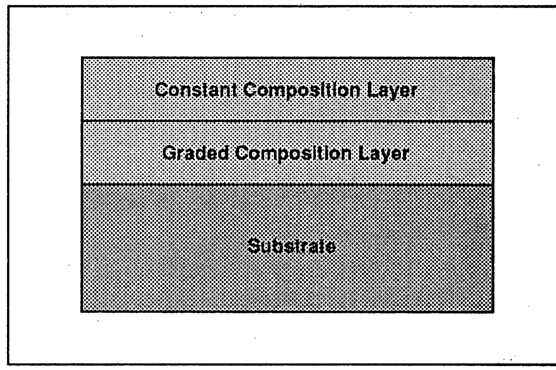


SIEMENS

655 nm D-Shaped GaAsP/GaAs EPITAXIAL WAFER

PART NO. 2600-7048





DESCRIPTION

Siemens epitaxial layers are grown by Hydride Vapor-Phase Epitaxy (HVPE). High quantum efficiencies and uniformity make these wafers ideal for visible displays and solid-state, near-monochromatic light sources.

EPITAXIAL LAYER

Material:	$GaAs_{1\text{-}X}P_X$:Te
Conductivity:	n-type
Carrier Concentration:	$0.5\text{–}3.0 \times 10^{17} cm^{-3}$
Peak PL Wavelength:	655 ±5 nm
Brightness:	0.8 mCd min. at 15 A/cm^2
Graded Layer Thickness:	15 μm min.
Constant Layer Thickness:	15 μm min.

SUBSTRATE

Material:	GaAs:Si or GaAs:Te
Growth Type:	Boat-Grown
Conductivity:	n-type
Resistivity:	<0.007 ohm-cm
Orientation:	(100), off 3 ±0.5° toward the nearest <110>

PHYSICAL PROPERTIES

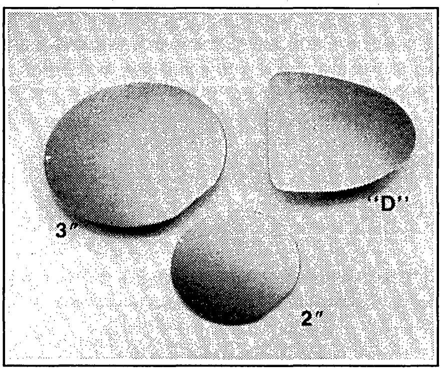
Size:	D-shaped (or partial)
Area:	1.5 sq. inch min.
Thickness:	455 ±51 μm
Bow:	–51 ±76 μm
Orientation Flats:	None
Pits*:	8 per sq. inch max.
Voids*:	3 per wafer max.; none larger than 1 mm diameter
Projections*:	1 per sq. inch max.; none higher than 10 μm
Scratches:	3 per wafer max.; none longer than 10 mm
Chips:	None penetrating further than 2 mm
Cracks:	None
Polycrystal:	None
Broken Lattice:	None
Twin Lines:	None
Contamination:	None, not removable by solvent or ultrasonic cleaning

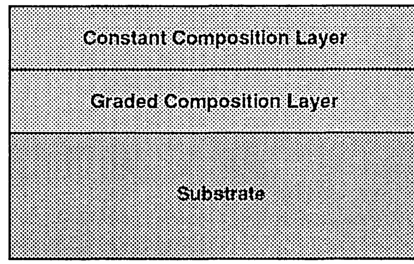
* Excludes outer 2 mm perimeter of wafer.

SIEMENS

655 nm 3″ GaAsP/GaAs EPITAXIAL WAFER

PART NO. 2600-7056





DESCRIPTION

Siemens epitaxial layers are grown by Hydride Vapor-Phase Epitaxy (HVPE). High quantum efficiencies and uniformity make these wafers ideal for visible displays and solid-state, near-monochromatic light sources.

EPITAXIAL LAYER

Material:	$GaAs_{1-X}P_X$:Te
Conductivity:	n-type
Carrier Concentration:	$0.5–5.0 \times 10^{17} cm^{-3}$
Peak PL Wavelength:(1)	655 ±5 nm
Brightness:	0.8 mCd min. at 15 A/cm^2
Graded Layer Thickness:	15 μm min.
Constant Layer Thickness:	10 μm min.

SUBSTRATE

Material:	GaAs
Growth Type:	Czochralski or Boat-Grown
Conductivity:	n-type
Orientation:	(100), off 3 ±0.5° toward the nearest <110>

PHYSICAL PROPERTIES

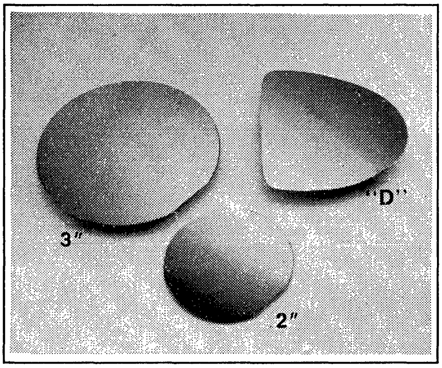
Size:	Grown on 3″ diameter SEMI spec substrate
Thickness:	500 ±50 μm
Bow:	-50 ±100 μm
Pits:(2)	15 per sq. inch max.
Voids:(2)	3 per wafer maximum larger than 1 mm diameter
Projections:(2)	3 per sq. inch maximum higher than 15 μm
Scratches:(2)	3 per wafer max.; none longer than 10 mm
Chips:	None penetrating further than 2 mm
Cracks:	None
Polycrystal:(2)	None
Broken Lattice:(2)	None
Twin Lines:(2)	None

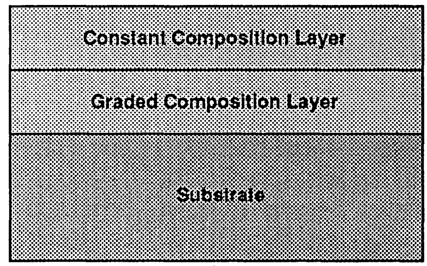
Notes:
1. Other wavelengths also available.
2. Excludes outer 2 mm perimeter of wafer.

SIEMENS

655 nm 2″ GaAsP/GaAs EPITAXIAL WAFER

PART NO. 2600-7057





DESCRIPTION

Siemens epitaxial layers are grown by Hydride Vapor-Phase Epitaxy (HVPE). High quantum efficiencies and uniformity make these wafers ideal for visible displays and solid-state, near-monochromatic light sources.

EPITAXIAL LAYER

Material:	$GaAs_{1-X}P_X$:Te
Conductivity:	n-type
Carrier Concentration:	0.5–5.0 × $10^{17}cm^{-3}$
Peak PL Wavelength:(1)	655 ±5 nm
Brightness:	0.8 mCd min. at 15 A/cm^2
Graded Layer Thickness:	15 μm min.
Constant Layer Thickness:	10 μm min.

SUBSTRATE

Material:	GaAs
Growth Type:	Czochralski or Boat-Grown
Conductivity:	n-type
Orientation:	(100), off 3 ±0.5° toward the nearest <110>

PHYSICAL PROPERTIES

Size:	Grown on 2″ diameter SEMI spec substrate
Thickness:	455 ±50 μm
Bow:	-50 ±100 μm
Pits:(2)	15 per sq. inch max.
Voids:(2)	3 per wafer maximum larger than 1 mm diameter
Projections:(2)	3 per sq. inch maximum higher than 15 μm
Scratches:(2)	3 per wafer max.; none longer than 10 mm
Chips:	None penetrating further than 2 mm
Cracks:	None
Polycrystal:(2)	None
Broken Lattice:(2)	None
Twin Lines:(2)	None

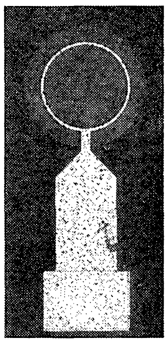
Notes:
1. Other wavelengths also available.
2. Excludes outer 2 mm perimeter of wafer.

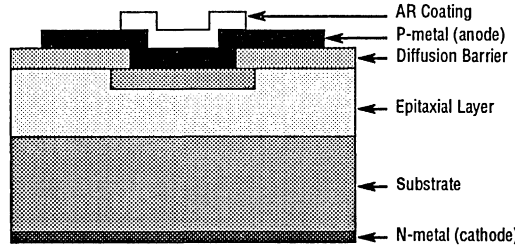
SIEMENS

IP-16A
Mask-Diffused GaAsP LED

PART NO. 2600-7070

Custom Optoelectronic Products





DESCRIPTION

Siemens IP-16A is a mask-diffused GaAsP light-emitting diode. With a bright and uniform 700 nm light-emitting area, this device is ideal for opto-coupler applications.

MATERIAL

Epitaxial Layer:	$GaAs_{1-x}P_x$: Te	
Substrate:	GaAs : Si or GaAs : Te	
Metalizations:	Anode	Aluminum
	Cathode	Gold-Germanium
Dimensions (center to center):	Height	570 µm
	Width	300 µm
	Thickness	200 µm

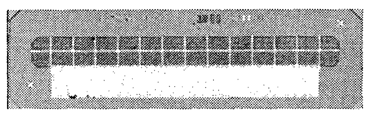
TYPICAL DEVICE PARAMETERS

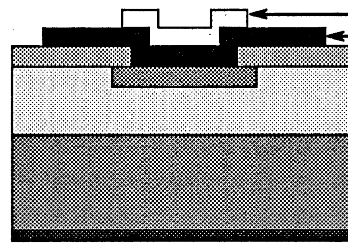
Forward I-V Characteristics	V_{F3}	1.60 V	@ 20 mA
	V_{F2}	1.55 V	@ 10 mA
	V_{F1}	1.40 V	@ 100 µA
Reverse I-V Characteristics	V_{R1}	-10.0 V	@ -10 µA
Peak EL Wavelength	λ	700 nm	@ 20 mA
Spectral Half-Width	FWHM	40 nm	@ 20 mA
Radiant Intensity	RI	35 µW/ster	@ 10 mA

SIEMENS

RB-42B
Mask-Diffused GaAsP LED

PART NO. 2680-0016





DESCRIPTION

Siemens RB-42B is a mask-diffused GaAsP light-emitting diode. With a bright and uniform 655 nm emission, this device is ideal for display applications.

MATERIAL

Epitaxial Layer:	$GaAs_{1-x}P_x$: Te	
Substrate:	GaAs : Si or GaAs : Te	
Metalizations:	Anode	Aluminum
	Cathode	Gold-Germanium
Dimensions (center to center):	Height	0.020″
	Width	0.065″
	Thickness	0.010″

TYPICAL DEVICE PARAMETERS

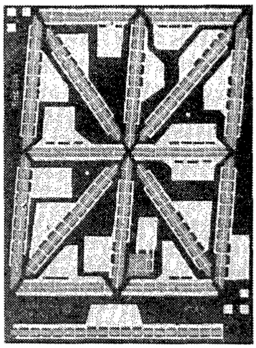
Forward I-V Characteristics	V_{F3}	1.64 V	@ 20 mA
	V_{F2}	1.59 V	@ 10 mA
	V_{F1}	1.42 V	@ 100 µA
Reverse I-V Characteristics	V_{R1}	-25.0 V	@ -10 µA
Peak EL Wavelength	λ	655 nm	@ 20 mA
Spectral Half-Width	FWHM	40 nm	@ 20 mA
Luminous Intensity	LI	500 µCd	@ 10 mA

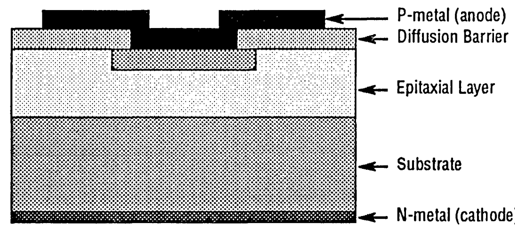
SIEMENS

RM-14A
Mask-Diffused GaAsP Monolithic LED with Cursor

Custom Optoelectronic Products

PART NO. 2680-0117





DESCRIPTION

Siemens RM-14A is a mask-diffused GaAsP monolithic light-emitting diode with cursor. With a bright and uniform 655 nm light-emitting area, this device is ideal for display applications.

MATERIAL

Epitaxial Layer:	$GaAs_{1-x}P_x$: Te	
Substrate:	GaAs : Si or GaAs : Te	
Metalizations:	Anode	Aluminum
	Cathode	Gold-Germanium
Dimensions (center to center):	Height	0.144″
	Width	0.105″
	Thickness	0.010″

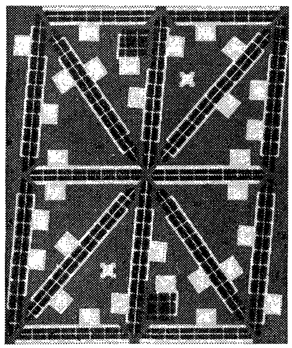
TYPICAL DEVICE PARAMETERS

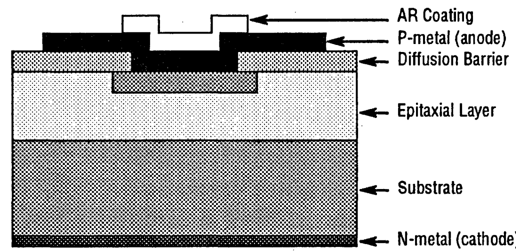
Forward I-V Characteristics	V_{F3}	1.59 V	@ 20 mA
	V_{F2}	1.57 V	@ 10 mA
	V_{F1}	1.40 V	@ 100 µA
Reverse I-V Characteristics	V_{R1}	-23.0 V	@ -10 µA
Peak EL Wavelength	λ	655 nm	@ 20 mA
Spectral Half-Width	FWHM	40 nm	@ 20 mA
Luminous Intensity (Device has no AR coating)	LI	240 µCd	@ 10 mA

SIEMENS

RM-15B Mask-Diffused GaAsP Monolithic LED

PART NO. 2680-0008





DESCRIPTION

Siemens RM-15B is a mask-diffused GaAsP monolithic light-emitting diode. With a bright and uniform 655 nm emission, this device is ideal for display applications.

MATERIAL

Epitaxial Layer:	$GaAs_{1-x}P_x$: Te	
Substrate:	GaAs : Si or GaAs : Te	
Metalizations:	Anode	Aluminum
	Cathode	Gold-Germanium
Dimensions (center to center):	Height	0.159″
	Width	0.133″
	Thickness	0.010″

TYPICAL DEVICE PARAMETERS

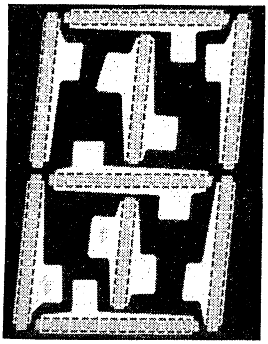
Forward I-V Characteristics	V_{F3}	1.58 V	@ 20 mA
	V_{F2}	1.56 V	@ 10 mA
	V_{F1}	1.39 V	@ 100 µA
Reverse I-V Characteristics	V_{R1}	-23.0 V	@ -10 µA
Peak EL Wavelength	λ	655 nm	@ 20 mA
Spectral Half-Width	FWHM	40 nm	@ 20 mA
Luminous Intensity	LI	350 µCd	@ 10 mA

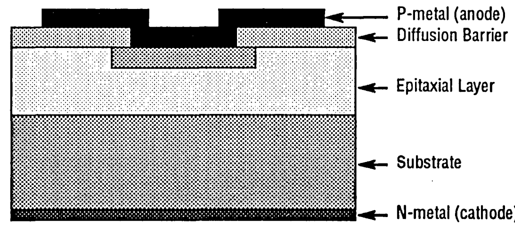
SIEMENS

RM-62A
Mask-Diffused GaAsP Monolithic LED

PART NO. 2680-0031

Custom Optoelectronic Products





DESCRIPTION

Siemens RM-62A is a mask-diffused GaAsP monolithic light-emitting diode. With a bright and uniform 655 nm emission, this device is ideal for display applications.

MATERIAL

Epitaxial Layer:	$GaAs_{1-x}P_x$: Te	
Substrate:	GaAs : Si or GaAs : Te	
Metalizations:	Anode	Aluminum
	Cathode	Gold-Germanium
Dimensions (center to center):	Height	0.107″
	Width	0.079″
	Thickness	0.010″

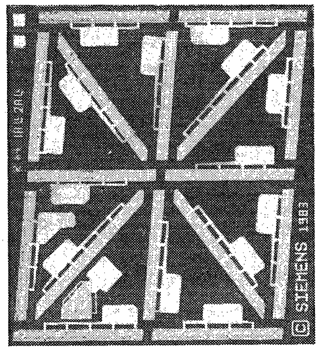
TYPICAL DEVICE PARAMETERS

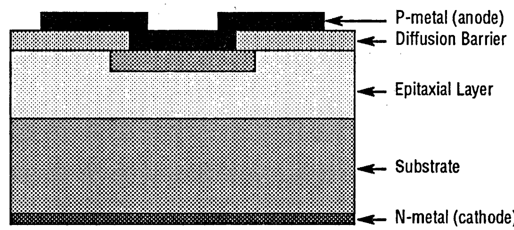
Forward I-V Characteristics	V_{F3}	1.62 V	@ 20 mA
	V_{F2}	1.60 V	@ 10 mA
	V_{F1}	1.41 V	@ 100 µA
Reverse I-V Characteristics	V_{R1}	-23.0 V	@ -10 µA
Peak EL Wavelength	λ	655 nm	@ 20 mA
Spectral Half-Width	FWHM	40 nm	@ 20 mA
Luminous Intensity (Device does not have AR coating)	LI	440 µCd	@ 10 mA

SIEMENS

RM-64A
Mask-Diffused GaAsP Monolithic LED

PART NO. 2680-0038





DESCRIPTION

Siemens RM-64A is a mask-diffused GaAsP monolithic light-emitting diode. With a bright and uniform 655 nm emission, this device is ideal for display applications.

MATERIAL

Epitaxial Layer:	$GaAs_{1-x}P_x$: Te	
Substrate:	GaAs : Si or GaAs : Te	
Metalizations:	Anode	Aluminum
	Cathode	Gold-Germanium
Dimensions (center to center):	Height	0.105″
	Width	0.095″
	Thickness	0.010″

TYPICAL DEVICE PARAMETERS

Forward I-V Characteristics	V_{F3}	1.62 V	@ 20 mA
	V_{F2}	1.60 V	@ 10 mA
	V_{F1}	1.42 V	@ 100 µA
Reverse I-V Characteristics	V_{R1}	-24.0 V	@ -10 µA
Peak EL Wavelength	λ	655 nm	@ 20 mA
Spectral Half-Width	FWHM	40 nm	@ 20 mA
Luminous Intensity (Device does not have AR coating)	LI	350 µCd	@ 10 mA

SIEMENS

RM-73A Mask-Diffused GaAsP Monolithic LED

PART NO. 2680-0003

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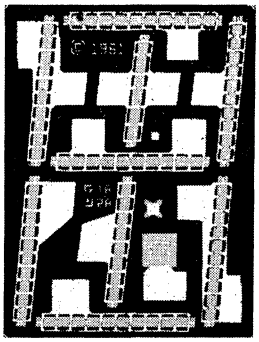
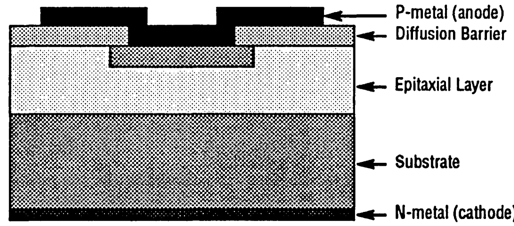




DESCRIPTION

Siemens RM-73A is a mask-diffused GaAsP monolithic light-emitting diode. With a bright and uniform 655 nm emission, this device is ideal for display applications.

MATERIAL

Epitaxial Layer:	$GaAs_{1-x}P_x$: Te	
Substrate:	GaAs : Si or GaAs : Te	
Metalizations:	Anode	Aluminum
	Cathode	Gold-Germanium
Dimensions (center to center):	Height	0.078″
	Width	0.059″
	Thickness	0.010″

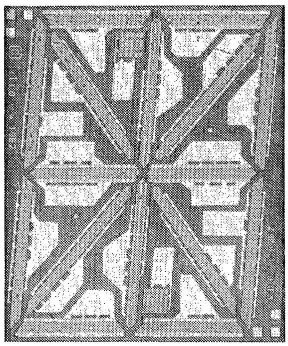
TYPICAL DEVICE PARAMETERS

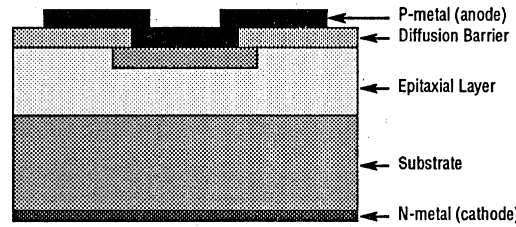
Forward I-V Characteristics	V_{F3}	1.64 V	@ 20 mA
	V_{F2}	1.60 V	@ 10 mA
	V_{F1}	1.42 V	@ 100 µA
Reverse I-V Characteristics	V_{R1}	-23.0 V	@ -10 µA
Peak EL Wavelength	λ	655 nm	@ 20 mA
Spectral Half-Width	FWHM	40 nm	@ 20 mA
Luminous Intensity (Device does not have AR coating)	LI	400 µCd	@ 10 mA

SIEMENS

RM-81B Mask-Diffused GaAsP Monolithic LED

PART NO. 2680-0056





DESCRIPTION

Siemens RM-81B is a mask-diffused GaAsP monolithic light-emitting diode. With a bright and uniform 655 nm emission, this device is ideal for display applications.

MATERIAL

Epitaxial Layer:	$GaAs_{1-x}P_x$: Te	
Substrate:	GaAs : Si or GaAs : Te	
Metalizations:	Anode	Aluminum
	Cathode	Gold-Germanium
Dimensions (center to center):	Height	0.135″
	Width	0.112″
	Thickness	0.010″

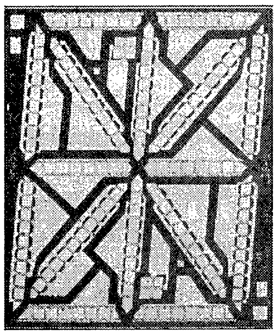
TYPICAL DEVICE PARAMETERS

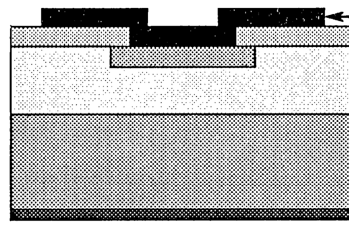
Forward I-V Characteristics	V_{F3}	1.59 V	@ 20 mA
	V_{F2}	1.57 V	@ 10 mA
	V_{F1}	1.40 V	@ 100 μA
Reverse I-V Characteristics	V_{R1}	-23.0 V	@ -10 μA
Peak EL Wavelength	λ	655 nm	@ 20 mA
Spectral Half-Width	FWHM	40 nm	@ 20 mA
Luminous Intensity (Device does not have AR coating)	LI	220 μCd	@ 10 mA

SIEMENS

RM-85D Mask-Diffused GaAsP Monolithic LED

PART NO. 2680-0030





DESCRIPTION

Siemens RM-85D is a mask-diffused GaAsP monolithic light-emitting diode. With a bright and uniform 655 nm emission, this device is ideal for display applications.

MATERIAL

Epitaxial Layer:	$GaAs_{1-x}P_x$: Te	
Substrate:	GaAs : Si or GaAs : Te	
Metalizations:	Anode	Aluminum
	Cathode	Gold-Germanium
Dimensions (center to center):	Height	0.087″
	Width	0.074″
	Thickness	0.010″

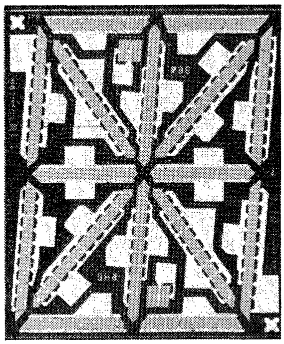
TYPICAL DEVICE PARAMETERS

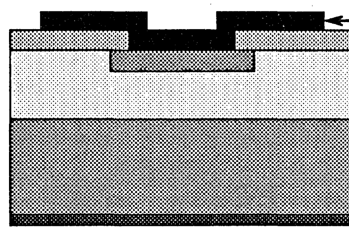
Forward I-V Characteristics	V_{F3}	1.63 V	@ 20 mA
	V_{F2}	1.59 V	@ 10 mA
	V_{F1}	1.42 V	@ 100 µA
Reverse I-V Characteristics	V_{R1}	-23.0 V	@ -10 µA
Peak EL Wavelength	λ	655 nm	@ 20 mA
Spectral Half-Width	FWHM	40 nm	@ 20 mA
Luminous Intensity (Device does not have AR coating)	LI	320 µCd	@ 10 mA

SIEMENS

RM-86A
Mask-Diffused GaAsP Monolithic LED

PART NO. 2680-0114





DESCRIPTION

Siemens RM-86A is a mask-diffused GaAsP monolithic light-emitting diode. With a bright and uniform 655 nm emission, this device is ideal for display applications.

MATERIAL

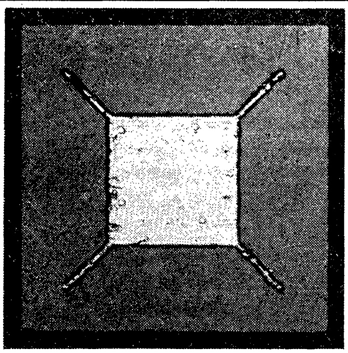
Epitaxial Layer:	$GaAs_{1-x}P_x$: Te	
Substrate:	GaAs : Si or GaAs : Te	
Metalizations:	Anode	Aluminum
	Cathode	Gold-Germanium
Dimensions (center to center):	Height	0.089″
	Width	0.069″
	Thickness	0.010″

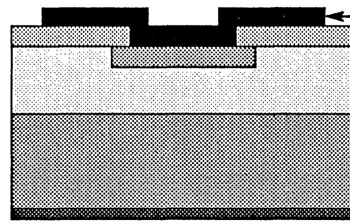
TYPICAL DEVICE PARAMETERS

Forward I-V Characteristics	V_{F3}	1.63 V	@ 20 mA
	V_{F2}	1.60 V	@ 10 mA
	V_{F1}	1.42 V	@ 100 μA
Reverse I-V Characteristics	V_{R1}	-23.0 V	@ -10 μA
Peak EL Wavelength	λ	655 nm	@ 20 mA
Spectral Half-Width	FWHM	40 nm	@ 20 mA
Luminous Intensity (Device does not have AR coating)	LI	280 μCd	@ 10 mA

SIEMENS

RP-12C
Mask-Diffused GaAsP LED
PART NO. 2680-7075





DESCRIPTION

Siemens RP-12C is a mask-diffused GaAsP light-emitting diode. With a bright and uniform 655 nm emission, this device is ideal for lamp and display applications.

MATERIAL

Epitaxial Layer:	$GaAs_{1-x}P_x$: Te	
Substrate:	GaAs : Si or GaAs : Te	
Metalizations:	Anode	Aluminum
	Cathode	Gold-Germanium
Dimensions (center to center):	Height	0.012″
	Width	0.012″
	Thickness	0.010″

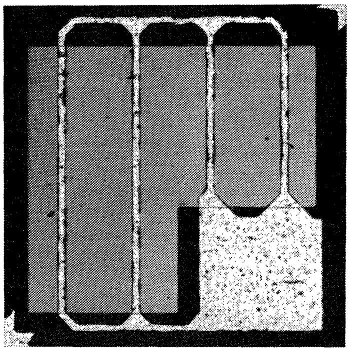
TYPICAL DEVICE PARAMETERS

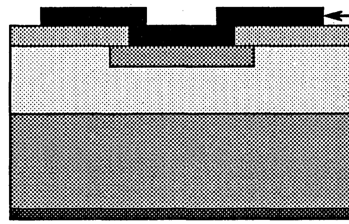
Forward I-V Characteristics	V_{F3}	1.70 V	@ 20 mA
	V_{F2}	1.64 V	@ 10 mA
	V_{F1}	1.45 V	@ 100 µA
Reverse I-V Characteristics	V_{R1}	-25.0 V	@ -10 µA
Peak EL Wavelength	λ	655 nm	@ 20 mA
Spectral Half-Width	FWHM	40 nm	@ 20 mA
Luminous Intensity	LI	500 µCd	@ 10 mA

SIEMENS

RP-13B Mask-Diffused GaAsP Point Source LED

PART NO. 2600-7074





DESCRIPTION

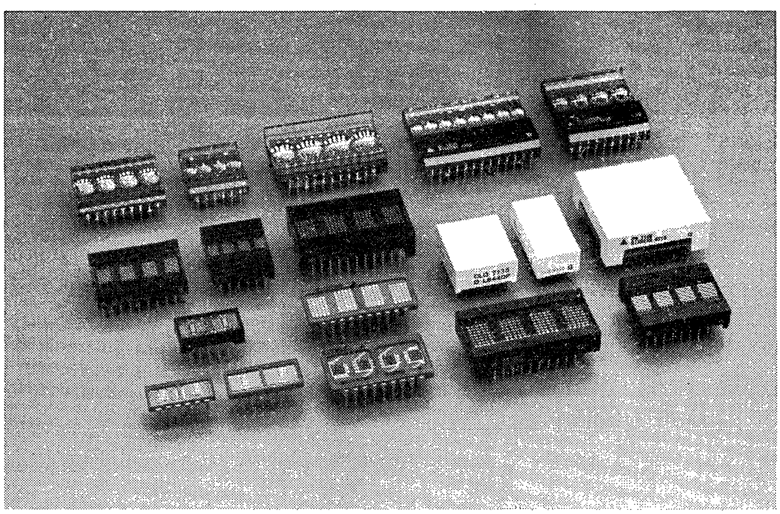
Siemens RP-13B is a mask-diffused GaAsP point source light-emitting diode. With a bright and uniform 655 nm emission, this device is ideal for lamps or dot-matrix displays.

MATERIAL

Epitaxial Layer:	$GaAs_{1-x}P_x$: Te	
Substrate:	GaAs : Si or GaAs : Te	
Metalizations:	Anode	Aluminum
	Cathode	Gold-Germanium
Dimensions (center to center):	Height	0.015"
	Width	0.015"
	Thickness	0.010"

TYPICAL DEVICE PARAMETERS

Forward I-V Characteristics	V_{F3}	1.64 V	@ 20 mA
	V_{F2}	1.59 V	@ 10 mA
	V_{F1}	1.42 V	@ 100 µA
Reverse I-V Characteristics	V_{R1}	-25.0 V	@ -10 µA
Peak EL Wavelength	λ	655 nm	@ 20 mA
Spectral Half-Width	FWHM	40 nm	@ 20 mA
Luminous Intensity (Device does not have AR coating)	LI	450 µCd	@ 10 mA



Intelligent Display® Devices

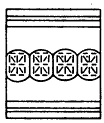
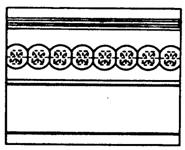
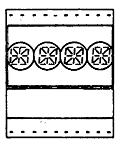
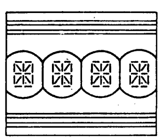
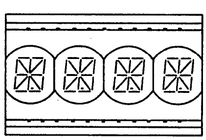
Programmable Display™ Devices

Military Displays

Small Alphanumeric Displays

Intelligent Display Assemblies

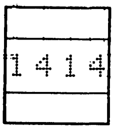
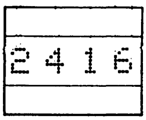
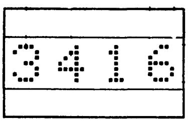
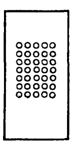
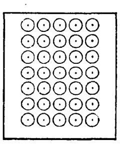
Intelligent Display® Devices - Segmented

Package Outline	Part No./ Color	No. of Characters / Character Height	Viewing Angle	Description	Page
	DL1414T Red	4 .112"	X Axis ±40° Y Axis ±55°	17 segment, 4 character display with built-in CMOS ASCII decoder, multiplexer, memory and driver. Access time: 280 ns. Low power consumption. Portable applications; telecommunications equipment.	2-7
	DL1814 Red	8 .112"	Both Axes ±40°	17 segment, 8 character display with built-in CMOS ASCII decoder, multiplexer, memory and driver. Access time: 525 ns. Low power consumption, dimming capability. Hand held equipment; portable applications; telephone and telecommunications equipment.	2–21
	DL1416B Red DL1416T❋ Red	4 .160"	X Axis ±30° Y Axis ±50°	16 segment, 4 character display with built-in CMOS ASCII decoder, multiplexer, memory and driver. Access time: 350 ns (DL1416B) Independent cursor function. Bench equipment.	2–11 2–16
	DL2416T Red	4 .160"	X Axis ±45° Y Axis ±55°	17 segment, 4 character display with built-in CMOS ASCII decoder, multiplexer, memory and driver. Access time: 300 ns Characters readable up to 8 feet; memory clear function; independent cursor function. Two chip enables for easy system expansion. Medical equipment; instrumentation; table top equipment.	2–25
	DL3416 Red	4 .225"	X Axis ±45° Y Axis ±55°	17 segment, 4 character display with built-in CMOS ASCII decoder, multiplexer, memory and driver. Access time: 300 ns Characters readable up to 12 feet; memory clear function; independent cursor function. Two chip enables for easy system expansion. Telecommunications equipment; instrumentation; table top equipment.	2–31

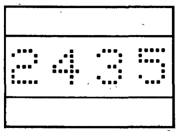
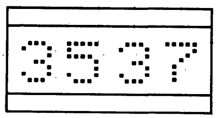
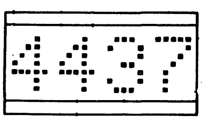
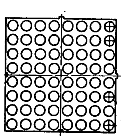
®Intelligent Display is a registered trademark of Siemens

❋ Not recomended for new designs.

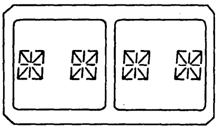
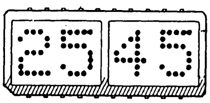
Intelligent Display® Devices - Dot Matrix

Package Outline	Part No./ Color	No. of Characters / Character Height	Viewing Angle	Description	Page
	DLR1414 Red DLO1414 HER DLG1414 Green	4 .145"	X Axis ±50° Y Axis ±75°	Dot matrix drop-in replacement for DL1414T. Four 5x7 dot matrix characters. 128 ASCII characters (English plus 5 other languages). Access time: 110 ns. For portable applications; telecommunications equipment.	2–44
	DLR2416 Red DLO2416 HER DLG2416 Green	4 .200"	X Axis ±50° Y Axis ±75°	Dot matrix drop-in replacement for DL2416T. Four 5x7 dot matrix characters. 128 ASCII characters (English plus 5 other languages). Access time: 110 ns. For bench equipment, instrumentation.	2–49
	DLR3416 Red DLO3416 HER DLG3416 Green	4 .270"	X Axis ±50° Y Axis ±75°	Dot matrix drop-in replacement for DL3416T. Four 5x7 dot matrix characters. 128 ASCII characters (English plus 5 other languages). Access time: 110 ns. For bench equipment, instrumentation.	2–55
	DLO4135 HER DLG4137 Green	1 .43"	±75°	Single 5x7 dot matrix character. Readable to 20 feet plus; wide viewing angle; lamp test; brightness control. One chip-enable for easy system expansion. 96 ASCII character format. Access time: 150 ns. Telecommunications equipment, table top equipment, instrumentation.	2–36
	DLO7135 HER DLG7137 Green	1 .68"	±75°	Single 5x7 dot matrix character. Readable up to 30 feet plus; wide viewing angle; lamp test; brightness control. One chip-enable for easy system expansion. 96 ASCII character format. Access time: 150 ns. Ideal for scales, POS terminals, instrumentation, mainframe peripherals.	2–40

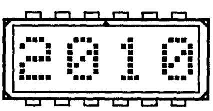
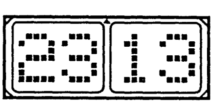
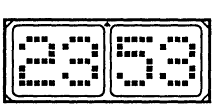
Programmable Display™ Devices - Dot Matrix

Package Outline	Part No./ Color	No. of Characters / Character Height	Viewing Angle	Description	Page
	PD2435 HER PD2436 Red PD2437 Green	4 .200"	X Axis ±55° Y Axis ±65°	Four 5x7 dot matrix characters. Built-in CMOS ASCII decoder, multiplexer, memory and driver. Software driven–true microprocessor peripherals. Additional features over Intelligent Display devices include: control and display memory read/write, dimming (3 levels) and blanking, blinking cursor/character and lamp test. 128 ASCII character format. Extended operating temperature range: -40°C to +85°C.	2–154
	PD3535 HER PD3536 Red PD3537 Green	4 .270"	X Axis ±55° Y Axis ±65°	Four 5x7 dot matrix characters. Built-in CMOS ASCII decoder, multiplexer, memory and driver. Software driven–true microprocessor peripherals. Additional features over Intelligent Display devices include: control and display memory read/write, dimming (3 levels) and blanking, blinking cursor/character and lamp test. 128 ASCII character format. Extended operating temperature range: -40°C to +85°C.	2–164
	PD4435 HER PD4436 Red PD4437 Green	4 .45"	X Axis ±55° Y Axis ±65°	Four 5x7 dot matrix characters. Built-in CMOS ASCII decoder, multiplexer, memory and driver. Software driven–true microprocessor peripherals. Additional features over Intelligent Display devices include: control and display memory read/write, dimming (3 levels) and blanking, blinking cursor/character and lamp test. 128 ASCII character format. Extended operating temperature range: -40°C to +85°C.	2–174
	PD1165 HER PD1167 Green	Display size 1.16" square	±75°	Single 8x8 dot matrix display module with CMOS circuits, and logic interfaces. Each dot is addressable over a TTL compatible, 8 bit bus. Can be alternately programmed to display text or graphics. Software controllable features: 9 intensity levels, memory clear, blanking or blinking, lamp test. Interlocking X-Y stackable package.	2–146

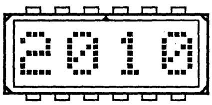
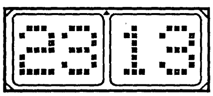
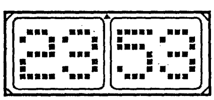
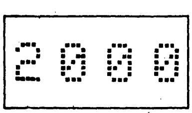
Military Alphanumeric Displays

Package Outline	Part No./ Color	No. of Characters / Character Height	Tempera- ture Range	Description	Page
	MDL2416C MDL2416 TXV/TXVB Red	4 .15"	Operating temperature range: -55°C to +100°C.	**Intelligent Display Device** Four 17 segment characters. Built-in CMOS circuitry - TTL and microprocessor compatible. Rugged ceramic package, hermetically sealed flat glass lens. Low profile package. Conforms to Quality Level A.	2–95
	MPD2545 HER MPD2547 Green MPD2548 Yellow	4 .250"	Operating temperature range: -55°C to +100°C.	**Programmable Display Device** Four 5x7 dot matrix characters. Built-in CMOS ASCII decoder, multiplexer, memory, and driver. 96 character ASCII font. Rugged ceramic package, hermetically sealed flat glass lens. Conforms to Quality Level A.	2–103

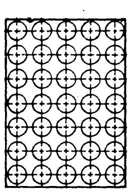
Military Small Alphanumeric Displays

Package Outline	Part No./ Color	No. of Characters / Character Height	Tempera- ture Range	Description	Page
	MSD2010 Red MSD2011 Yellow MSD2012 HER MSD2013 High Efficiency Green	4 .150"	Operating temperature range: -55°C to +100°C.	Four 5x7 dot matrix characters. Available in TXV and TXVB screened versions. Rugged ceramic package, hermetically sealed flat glass lens. Serial input/parallel output. Easily cascaded for multiple displays. Low power on-board CMOS shift registers and constant current LED row drivers. External column strobing allows use of full ASCII and customized fonts. Conforms to Quality Level A.	2–113
	MSD2310 Red MSD2311 Yellow MSD2312 HER MSD2313 High Efficiency Green	4 .200"	Operating temperature range: -55°C to +100°C.	Four 5x7 dot matrix characters. Available in TXV and TXVB screened versions. Rugged ceramic package, hermetically sealed flat glass lens. Serial input/parallel output. Easily cascaded for multiple displays. Low power on-board CMOS shift registers and constant current LED row drivers. External column strobing allows use of full ASCII and customized fonts. Conforms to Quality Level A.	2–124
	MSD2351 Yellow MSD2352 HER MSD2353 High Efficiency Green	4 .200"	Operating temperature range: -55°C to +100°C.	Sunlight viewable. Four 5x7 dot matrix characters. Available in TXV and TXVB screened versions. Rugged ceramic package, hermetically sealed flat glass lens. Serial input/parallel output. Easily cascaded for multiple displays. Low power on-board CMOS shift registers and constant current LED row drivers. External column strobing allows use of full ASCII and customized fonts.	2–135

Hi Rel/Industrial & Commercial Small Alphanumeric Displays

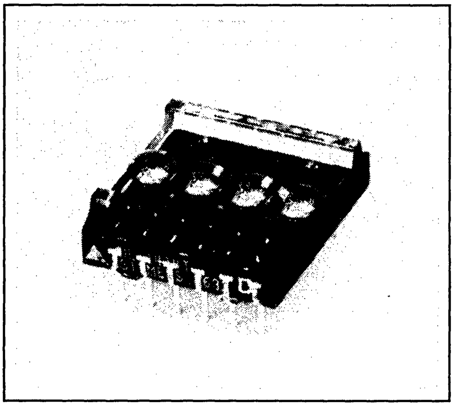
Package Outline	Part No./ Color	No. of Characters / Character Height	Temperature Range	Description	Page
	ISD2010 Red ISD2011 Yellow ISD2012 HER ISD2013 High Efficiency Green	4 .150"	Operating temperature range: -55°C to +100°C.	**Hi Rel/Industrial Displays** Four 5x7 dot matrix characters. Rugged ceramic package, hermetically sealed flat glass lens. Serial input/parallel output. Easily cascaded for multiple displays. Low power on-board CMOS shift registers, constant current LED row drivers. External column strobing allows use of full ASCII and customized fonts.	2–71
	ISD2310 Red ISD2311 Yellow ISD2312 HER ISD2313 High Efficiency Green	4 .200"	Operating temperature range: -55°C to +100°C.	**Hi Rel/Industrial Displays** Four 5x7 dot matrix characters. Rugged ceramic package, hermetically sealed flat glass lens. Serial input/parallel output. Easily cascaded for multiple displays. Low power on-board CMOS shift registers, constant current LED row drivers. External column strobing allows use of full ASCII and customized fonts.	2–79
	ISD2351 Yellow ISD2352 HER ISD2353 High Efficiency Green	4 .200"	Operating temperature range: -55°C to +100°C.	**Hi Rel/Industrial Displays** Sunlight viewable. Four 5x7 dot matrix characters. Rugged ceramic package, hermetically sealed flat glass lens. Serial input/parallel output. Easily cascaded for multiple displays. Low power on-board CMOS shift registers, constant current LED row drivers. External column strobing allows use of full ASCII and customized fonts.	2–87
	HDSP2000LP Red HDSP2001LP Yellow HDSP2002LP HER HDSP2003LP High Efficiency Green	4 .150"	Operating temperature range: -40°C to +85°C.	**Commercial Displays** Four 5x7 dot matrix characters. Plastic package. Serial input/parallel output. Easily cascaded for multiple displays. Low power on-board CMOS shift registers, constant current LED row drivers. External column strobing allows use of full ASCII and customized fonts.	2–63

Alphanumeric Display

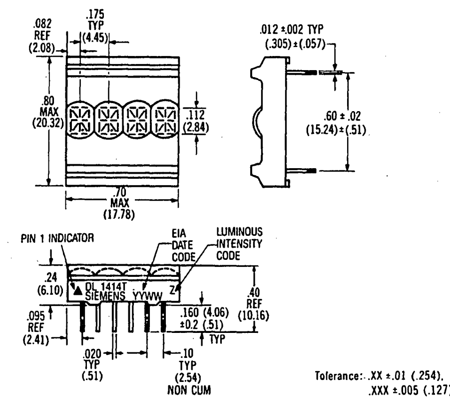
Package Outline	Part No./ Color	No. of Characters / Character Height	Polarity	Luminous Intensity Per Segment Typ. (μcd)	@ mA	Description	Page
	DLR5735 Red DLG5735 Green	1 .69"	Common Cathode Row	200	20	Single 5x7 dot matrix character. No built-in CMOS drive circuitry.	2–61
	DLR5736 Red DLG5736 Green	1 .69"	Common Anode Row	650	10		

SIEMENS DL 1414T

.112" Red, 4-Digit 17-Segment ALPHANUMERIC Intelligent Display® With Memory/Decoder/Driver



Package Dimensions in Inches (mm)



FEATURES

- **0.112" High, Magnified Monolithic Character**
- **Wide Viewing Angle, X Axis ±40°, Y Axis ±55°**
- **Close Vertical Row Spacing, .800"**
- **Rugged Solid Plastic Encapsulated Package**
- **Fast Access Time, 280 ns**
- **Compact Size for Hand Held Equipment**
- **Built-in Memory**
- **Built-in Character Generator**
- **Built-in Multiplex and LED Drive Circuitry**
- **Direct Access to Each Digit Independently & Asynchronously**
- **TTL Compatible, 5 Volt Power**
- **17th Segment for Improved Punctuation Marks**
- **Low Power Consumption, Typically 10 mA per Character**
- **Intensity Coded for Display Uniformity**
- **Extended Operating Temperature Range: −40°C to +85°C**
- **End-Stackable, 4-Character Package**
- **100% Burned In and Tested**
- **Superior ESD Immunity**

DESCRIPTION

The DL 1414T is a four digit display module having 16 bar segments plus a decimal and a built-in CMOS integrated circuit.

The integrated circuit contains memory, ASCII character generator, and LED multiplexing and drive circuitry. Inputs are TTL compatible. A single 5-volt power supply is required. Data entry is asynchronous and random access. A display system can be built using any number of DL 1414Ts since each character in any DL 1414T can be addressed independently and will continue to display the character last written until it is replaced by another.

Loading data into the DL 1414T is straightforward. The desired data code (D_0–D_6) and digit address (A_0, A_1) is presented in parallel and held stable during a write cycle. Data entry may be asynchronous and in random order. (Digit 0 is defined as right hand digit with $A_1 = A_0 = 0 =$ low).

System interconnection is also straightforward. The least significant two address bits (A_0, A_1) are normally connected to the like named inputs of all DL 1414Ts in the system. Data lines are connected to all DL 1414Ts directly and in parallel. Multiple DL 1414T systems usually use an external one-of-N decoder chip. The "write" pulse is connected to the CE of the decoder. A 3-to-8 line decoder multiplexer (74138) or a 4-to-16 line decoder/multiplexer (74154) are possible choices. All higher-order address bits (above A_1) become inputs to the decoder.

All products are 100% burned-in and tested, then subjected to out-going AQL's of .25% for brightness matching, visual alignment and dimensions, .065% for electrical and functional.

Important: Refer to Appnote 18, "Using and Handling Intelligent Displays". Since this is a CMOS device, normal precautions should be taken to avoid static damage.

See Appnote 15 for applications information.

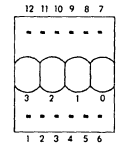
Maximum Ratings

Supply Voltage, V_{CC} . . . . −0.5 to +6.0 Vdc
Voltage, Any Pin Respect to GND . −0.5 to (V_{CC} +0.5) Vdc
Operating Temperature . . . . −40°C to +85°C
Storage Temperature . . . . −40°C to +100°C
Maximum Solder Temperature, 1.59 mm (0.063″)
below Seating Plane, t<5 sec . . . . 260°C
Relative Humidity (non condensing) @85°C 85%

Optical Characteristics @25°C

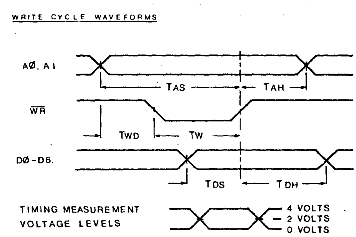
Spectral Peak Wavelength . . . . 660 nm typ.
Magnified digit size . . . . 0.112″×0.085″
Time Averaged Luminous Intensity
(100% brightness, ... 0.40 mcd/digit min.
8 segments/digit, V_{CC}=5 V) . . . . 0.75 mcd/digit typ.
LED to LED Intensity Matching . . . . 1.8:1.0 max.
Device to Device Intensity Matching (one bin) . 1.5:1.0 max.
Bin to Bin Intensity Matching . . . . 1.9:1.0 max.
Viewing Angle (off normal axis)
Horizontal . . . . ±40°
Vertical . . . . ±55°

TOP VIEW



Pin	Function	Pin	Function
1	D5 Data Input	7	Gnd
2	D4 Data Input	8	DØ Data Input (LSB)
3	$\overline{WR}$ Write	9	D1 Data Input
4	A1 Digit Select	10	D2 Data Input
5	AØ Digit Select	11	D3 Data Input
6	V_{CC}	12	D6 Data Input (MSB)

TIMING CHARACTERISTICS



DC CHARACTERISTICS

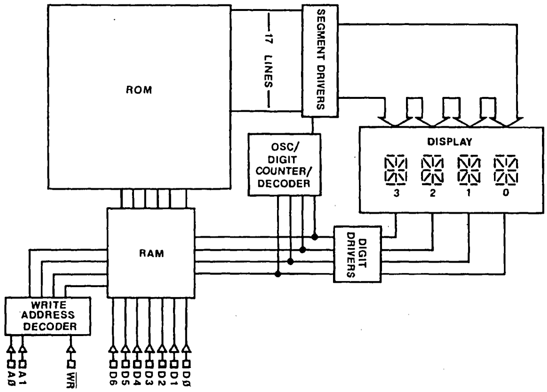
	−40°C			+25°C			+85°C				
Parameter	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	Units	Conditions
I_{CC} 4 Digits on 10 segments/digit		60	75		50	65		40	55	mA	V_{CC}=5 V
I_{CC} Blank		1.5	3.5		1.0	2.7		0.5	2.0	mA	$V_{CC}=\overline{WR}$=5 V, V_{IN}=0 V
I_{IL} (all inputs)		80	180		60	160		45	90	μA	V_{IN}=0.8 V, V_{CC}=5 V
V_{IH}	2.0			2.0			2.0			V	V_{CC}=5 V±0.5 V
V_{IL}			0.8			0.8			0.8	V	V_{CC}=5 V±0.5 V

AC CHARACTERISTICS Guaranteed Minimum Timing Parameters @4.5 V$\leq V_{CC} \leq$5.5 V

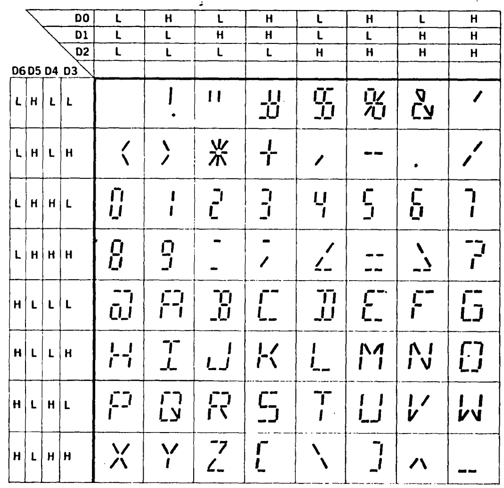
Parameter	Symbol	−40°C (ns)	+25°C (ns)	+85°C (ns)
Address Set Up Time	T_{AS}	175	250	325
Address Hold Time	T_{AH}	30	30	30
Write Delay Time	T_{WD}	25	25	25
Write Time	T_W	150	225	300
Data Set Up Time	T_{DS}	125	175	250
Data Hold Time	T_{DH}	30	30	30
Access Time(2)	T_{ACC}	205	280	355

Notes: 1. Access time $T_{ACC}=T_{AS}+T_{DH}$
2. Digit multiplex frequency may vary from 200 Hz to 1.3 KHz.

DL 1414T BLOCK DIAGRAM



CHARACTER SET



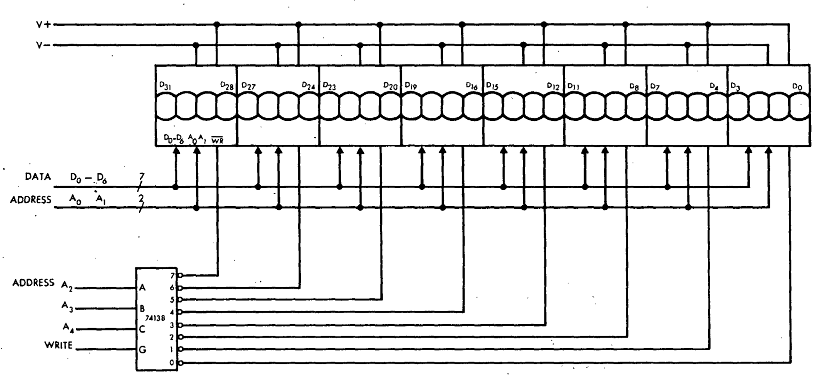
All Other Input Codes Display "Blank"

LOADING DATA STATE TABLE

WR̄	A1	A0	D6	D5	D4	D3	D2	D1	D0	DIGIT 3	2	1	0
H		PREVIOUSLY LOADED DISPLAY								G	R	E	Y
L	L	L	H	L	L	L	H	L	H	G	R	E	E
L	L	H	H	L	H	L	H	L	H	G	R	U	E
L	H	L	H	L	L	H	H	L	L	G	L	U	E
L	H	H	H	L	L	L	L	H	L	B	L	U	E
L	L	H	H	L	L	L	H	L	H	B	L	E	E
L	L	L	H	L	H	L	H	H	H	B	L	E	W
L	X	X	SEE CHARACTER CODE							SEE CHARACTER SET			

X = DON'T CARE

TYPICAL INTERCONNECTION FOR 32 DIGITS



Intelligent Display Devices

DESIGN CONSIDERATIONS

For details on design and applications of the DL 1414T utilizing standard bus configurations in multiple display systems, or parallel I/O devices, such as the 8255 with an 8080 or memory mapped addressing on processors such as the 8080, Z80, 6502, or 6800 refer to Appnote 15 in the current Siemens Optoelectronic Data Book.

ELECTRICAL AND MECHANICAL CONSIDERATIONS

VOLTAGE TRANSIENT SUPPRESSION

It is highly recommended that the display and the components that interface with the display be powered by the same supply to avoid logic inputs higher than V_{CC}. Additionally, the LEDs may cause transients in the power supply line while they change display states. The common practice is to place .01 μF capacitors close to the displays across V_{CC} and GND, one for each display, and one 10 μF capacitor for every second display.

ESD PROTECTION

The metal Gate CMOS IC of the DL 1414T is extremely immune to ESD damage. However, users of these devices are encouraged to take all the standard precautions, normal for CMOS components. These include properly grounding personnel, tools, tables, and transport carriers that come in contact with unshielded parts. If these conditions are not, or cannot be met, keep the leads of the device shorted together or the parts in anti-static packaging.

SOLDERING CONSIDERATIONS

The DL 1414T can be hand soldered with SN63 solder using a grounded iron set to 260°C.

Wave soldering is also possible following these conditions: Preheat that does not exceed 93°C on the solder side of the PC board or a package surface temperature of 85°C. Water soluble organic acid flux (except carboxylic acid) or resin-based RMA flux without alcohol can be used.

Wave temperature of 245°C ±5°C with a dwell between 1.5 sec. to 3.0 sec. Exposure to the wave should not exceed temperatures above 260°C, for 5 seconds at 0.063″ below the seating plane. The packages should not be immersed in the wave.

POST SOLDER CLEANING PROCEDURES

The least offensive cleaning solution is hot D.I. water (60°C) for less than 15 minutes. Addition of mild saponifiers is acceptable. Do not use commercial dishwasher detergents.

For faster cleaning, solvents may be used. Care should be exercised in choosing these as some may chemically attack the nylon package. Maximum exposure should not exceed two minutes at elevated temperatures. Acceptable solvents are TF (trichlorotrifluoroethane), TA, 111 Trichloroethane, and unheated acetone.(1)

Unacceptable solvents contain alcohol, methanol, methylene chloride, ethanol, TP35, TCM, TMC, TMS+, TE, and TES. Since many commercial mixtures exist, you should contact your preferred solvent vendor for chemical composition information. Some major solvent manufacturers are: Allied Chemical Corporation, Specialty Chemical Division, Morristown, NJ; Baron-Blakeslee, Chicago, IL; Dow Chemical, Midland, MI; E.I. DuPont de Nemours & Co., Wilmington, DE.

For further information refer to Appnotes 18 and 19 in the current Siemens Optoelectronic Data Book.

An alternative to soldering and cleaning the display modules is to use sockets. Naturally, 12 pin DIP sockets .600″ wide with .100″ centers work well for single displays. Multiple display assemblies are best handled by longer SIP sockets or DIP sockets when available for uniform package alignment. Socket manufacturers are Aries Electronics, Inc., Frenchtown, NJ; Garry Manufacturing, New Brunswick, NJ; Robinson-Nugent, New Albany, IN; and Samtec Electronic Hardware, New Albany, IN.

For further information refer to Appnote 22 in the current Siemens Optoelectronic Data Book.

OPTICAL CONSIDERATIONS

The .112″ high characters of the DL 1414T allow readability up to 6 feet. Proper filter selection will allow the user to build a display that can be utilized over this distance.

Filters allow the user to enhance the contrast ratio between a lit LED and the character background. This will maximize discrimination of different characters as perceived by the display user. The only limitation is cost. The cost/benefit ratio for filters can be maximized to the user's benefit by first considering the ambient lighting environment.

Incandescent (with almost no green) or fluorescent (with almost no red) lights do not have the flat spectral response of sunlight. Plastic band-pass filters are inexpensive and effective in optimizing contrast ratios. The DL 1414T is a standard red display and should be matched with a long wavelength pass filter in the 600 nm to 620 nm range. For display systems of multiple colors (using other Siemens displays), neutral density grey filters offer the best compromise.

Additional contrast enhancement can be gained through shading the displays. Plastic band-pass filters with built-in louvers offer the "next step up" in contrast improvement. Plastic filters can be further improved with anti-reflective coatings to reduce glare. The trade-off is "fuzzy" characters. Mounting the filters close to the display reduces this effect. Care should be taken not to overheat the plastic filters by allowing for proper air flow.

Optimal filter enhancements for any condition can be gained through the use of circular polarized, anti-reflective, band-pass filters. Circular polarizing further enhances contrast by reducing the light that travels through the filter and reflects back off the display to less than 1%.

Several filter manufacturers supply quality filter materials. Some of them are: Panelgraphic Corporation, W. Caldwell, NJ; SGL Homalite, Wilmington, DE; 3M Company, Visual Products Division, St. Paul, MN; Polaroid Corporation, Polarizer Division, Cambridge, MA; Marks Polarized Corporation, Deer Park, NY; Hoya Optics, Inc., Fremont, CA.

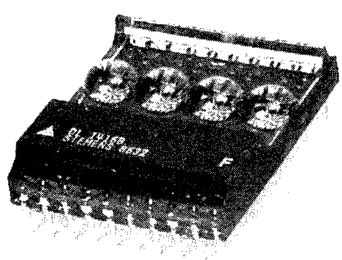
One last note on mounting filters: recessing display and bezel assemblies is an inexpensive way to provide a shading effect in overhead lighting situations. Several Bezel manufacturers are: R.M.F. Products, Batavia, IL; Nobex Components, Griffith Plastic Corp., Burlingame, CA; Photo Chemical Products of California, Santa Monica, CA; I.E.E.-Atlas, Van Nuys, CA.

Refer to Siemens Appnote 23 for further information.

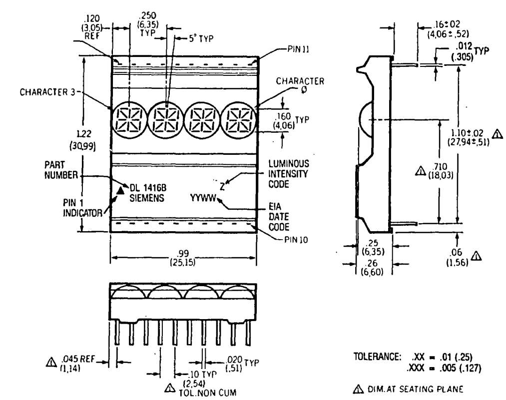
Note: 1. Acceptable commercial solvents are: Basic TF, Arklone P, Genesolve D, Genesolve DA, Blaco-Tron TF, Blaco-Tron TA and, Freon TA.

SIEMENS DL 1416B

.160" Red, 4-Digit 16-Segment Plus Decimal ALPHANUMERIC Intelligent Display® With Memory/Decoder/Driver



Package Dimensions in Inches (mm)



FEATURES

- **0.16" × 0.125", Magnified Monolithic Character**
- **Viewing Angle, X Axis ±30°, Y Axis ±50°**
- **Rugged, Solid Plastic Encapsulated Package**
- **Top Lens Rail for Display Protection**
- **Fast Access Time, 350 ns**
- **Full Size Display for Stationary Equipment**
- **Built-in Memory**
- **Built-in Character Generator**
- **Built-in Multiplex and LED Drive Circuitry**
- **Direct Access to Each Digit Independently & Asynchronously**
- **TTL Compatible, 5 Volt Power**
- **17th Segment (Decimal Point) for Improved Punctuation Marks**
- **Independent Cursor Function**
- **End Stackable, 4 Character Package**
- **Intensity Coded for Display Uniformity**
- **100% Burned In and Tested**
- **Extended Operating Temperature Range: −40°C to +85°C**

DESCRIPTION

The DL 1416B is a four digit display module having 16 segments plus decimal and a built in CMOS integrated circuit.

The integrated circuit contains memory, ASCII ROM decoder, multiplexing circuitry, and drivers. Data entry is asynchronous and can be random. A display system can be built using any number of DL 1416Bs since each digit of each DL 1416B can be addressed independently. Each digit will continue to display the character last "written" until replaced by another.

System interconnection is very straightforward. The least significant two address bits (A_0, A_1) are connected to the like inputs of all DL 1416Bs in a system. In small systems having 16 digits (four DL 1416Bs), the enable ($\overline{CE}$) inputs of the four devices could simply be used directly to select each DL 1416B. In larger display systems, the $\overline{CE}$ inputs would come from a 1 of N decoder integrated circuit. In this case, address lines A_2...A_n would go to the decoder inputs. Data lines (D_0–D_6) would be connected to all DL 1416Bs directly and in parallel. The cursor ($\overline{CU}$) and write ($\overline{WR}$) lines would also be connected directly and in parallel. The display will then behave as a "write only memory".

The cursor function causes all segments of a digit position to illuminate. The cursor is NOT a character, however, and upon removal, the previously displayed character will reappear.

Important: Refer to Appnote 18, "Using and Handling Intelligent Displays". Since this is a CMOS device, normal precautions should be taken to avoid static damage.

Specifications are subject to change without notice.

Maximum Ratings

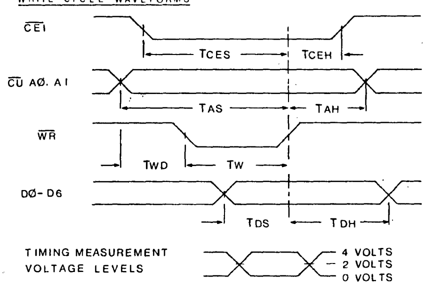
Supply Voltage V_{CC} . . . . −0.5 V to +6.0 Vdc
Voltage, Any Pin Respect to GND . −0.5 to (V_{CC} +0.5) Vdc
Operating Temperature . . . . −40°C to +85°C
Storage Temperature . . . . −40°C to +100°C
Maximum Solder Temperature, 1.59 mm (0.063″)
below Seating Plane, t<5 sec . . . . 260°C
Relative Humidity (non condensing) @85°C 85%

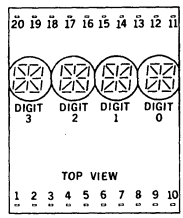
Optical Characteristics

Time Averaged Luminous Intensity
per digit (8 segments) . . . . 0.25 mcd min.
@25°C . . . . 0.75 mcd typ.
Off Axis Viewing Angle:
Horizontal . . . . ±30°
Vertical . . . . ±50°
Digit size . . . . 0.160″×0.125″
Spectral Peak Wavelength . . . . 660 nm
LED to LED Intensity Matching . . . . 1.8:1.0 max.
Average Display Intensity Matching (one bin) . . 1.5:1.0 max.
Bin to Bin Intensity Matching (adjacent bins) . . 1.9:1.0 max.

TIMING CHARACTERISTICS

WRITE CYCLE WAVEFORMS





Pin		Function	Pin		Function
1	D5	Data Input	11	A1	Digit Select
2	D4	Data Input	12	Unused	
3	DØ	Data Input	13	Unused	
4	D1	Data Input	14	Unused	
5	D2	Data Input	15	Unused	
6	D3	Data Input	16	Unused	
7	$\overline{CE}$	Chip Enable	17	Unused	
8	$\overline{WR}$	Write	18	V+	
9	$\overline{CU}$	Cursor Input	19	V−	
10	AØ	Digit Select	20	D6	Data Input

DC CHARACTERISTICS

	−40°C			+25°C			+85°C				
Parameter	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	Units	Conditions
I_{CC} 4 Digits on 10 segments/digit		115	140		80	125		65	100	mA	V_{CC}=5 V
I_{CC} Blank		2.5	4.0		2.0	3.5		1.5	2.5	mA	$V_{CC}=\overline{WR}$=5 V, BL= 0.8 V
I_{IL}		100	120		75	90		60	75	μA	V_{CC}=5 V, V_{IN}=0.8 V
V_{IH}	2.0			2.0			2.0			V	V_{CC}=5 V±0.5 V
V_{IL}			0.8			0.8			0.8	V	V_{CC}=5 V±0.5 V

AC CHARACTERISTICS Minimum at V_{CC}=4.5 V in nanoseconds

Parameter	Symbol	−40°C	+25°C	+85°C
Address Set Up Time	T_{AS}	225	300	400
Cursor Set Up Time	T_{CUS}	225	300	400
Chip Enable Set Up Time	T_{CES}	225	300	400
Data Set Up Time	T_{DS}	100	175	300
Write Time	T_W	150	250	350
Address Hold Time	T_{AH}	30	50	80
Data Hold Time	T_{DH}	30	50	80
Write Delay Time	T_{WD}	30	50	80
Chip Enable Hold	T_{CEH}	30	50	80
Cursor Hold Time	T_{CUH}	30	50	80
Access Time	T_{ACC}	255	350	480

LOADING DATA

The chip enable ($\overline{CE}$) held low and cursor ($\overline{CU}$) held high will enable data loading. The desired data code (D_0-D_6) and selected digit address (A_0-A_1) should be held stable while write ($\overline{W}$) is low for storing new data. The timing parameters in the AC characteristics table are minimum and should be observed. There are no maximum timing requirements. Data entry may be asynchronous and in random order. All undefined data codes (see character set) loaded as data will display a blank.

Digit 0 is defined as the right hand digit with $A_1 = A_0 = 0$ =(low).

LOADING CURSOR

The chip enable ($\overline{CE}$) and Cursor ($\overline{CU}$) are held low. A write ($\overline{W}$) signal will now load a cursor into any digit position addressed by (A_0 - A_1); as defined in data entry. A cursor will be stored if D0 = H and removed if D0 = L. The ($\overline{CU}$) pulse width should not be less than write ($\overline{WR}$) pulse or erroneous data may appear in the display.

Intelligent Display Devices

TYPICAL LOADING DATA STATE TABLE

$\overline{CE}$	$\overline{CU}$	$\overline{W}$	ADDRESS A_1	ADDRESS A_0	DATA INPUT D6	D5	D4	D3	D2	D1	D0	DIGIT 3	DIGIT 2	DIGIT 1	DIGIT 0
H	X	X	X	X	X	X	X	X	X	X	X	NO CHANGE	NO CHANGE	NO CHANGE	NO CHANGE
L	H	L	L	L	H	L	L	L	L	L	H	NO CHANGE	NO CHANGE	NO CHANGE	A
L	H	L	L	H	H	L	L	L	L	H	L	NO CHANGE	NO CHANGE	B	A
L	H	L	H	L	H	L	L	L	L	H	H	NO CHANGE	C	B	A
L	H	L	H	H	H	L	L	L	H	L	L	D	C	B	A
L	H	L	L	L	H	L	L	L	H	L	H	D	C	B	E
L	H	L	H	L	H	L	L	H	L	H	H	D	K	B	E
L	H	L	–	–	–	–	–	–	–	–	–	SEE CHARACTER SET			

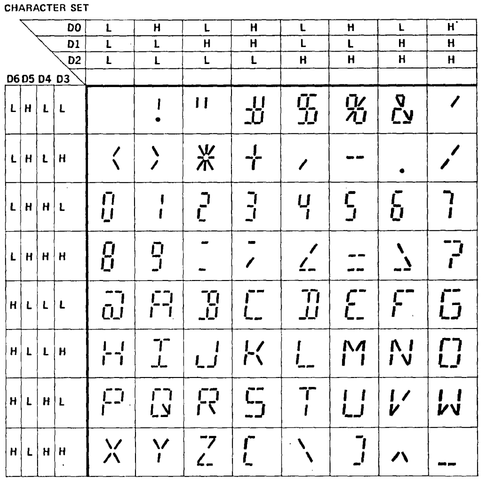
X = DON'T CARE

TYPICAL LOADING CURSOR STATE TABLE

CONTROL $\overline{CE}$	$\overline{CU}$	$\overline{WR}$	ADDRESS A1	A0	DATA D6	D5	D4	D3	D2	D1	D0	DISPLAY DIGIT 3	2	1	0
X	X	H	PREVIOUSLY LOADED DISPLAY									B	E	A	R
X	X	H	DISPLAY PREVIOUSLY STORED CURSORS									B	E	A	R
L	L	L	L	L	X	X	X	X	X	X	H	B	E	A	⊞
L	L	L	L	H	X	X	X	X	X	X	H	B	E	⊞	⊞
L	L	L	H	L	X	X	X	X	X	X	H	B	⊞	⊞	⊞
L	L	L	H	H	X	X	X	X	X	X	H	⊞	⊞	⊞	⊞
L	L	L	H	L	X	X	X	X	X	X	L	⊞	E	⊞	⊞

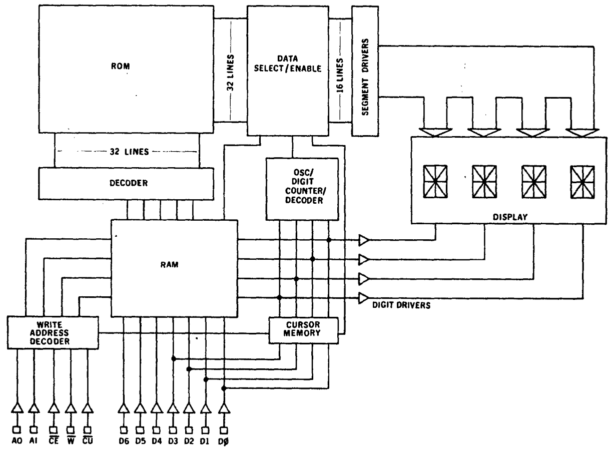
X = DON'T CARE

CHARACTER SET

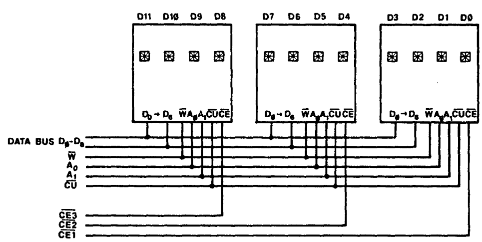


NOTE: All undefined data codes that are loaded or occur on power-up will cause a blank display state.

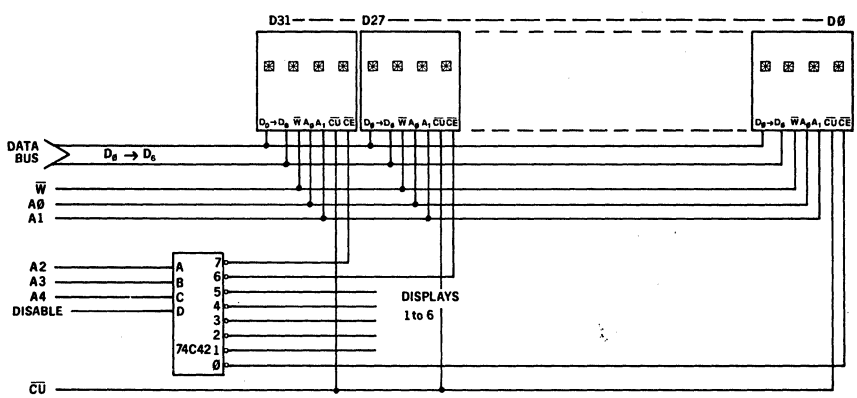
DL 1416B



INTERNAL SCHEMATIC



Typical interconnect for small systems. 12digits



Typical schematic for 32 digit systems

DL 1416B

DESIGN CONSIDERATIONS

For details on design and applications of the DL 1416B utilizing standard bus configurations in multiple display systems, or Parallel I/O devices, such as the 8255 with an 8080 or memory mapped addressing on processors such as the 8080, Z80, or 6800, or non-microprocessor based systems, please refer to Appnote 9A and 13 in our current Optoelectronic Data Book.

ELECTRICAL AND MECHANICAL CONSIDERATIONS

VOLTAGE TRANSIENT SUPPRESSION

It is highly recommended that the display and the components that interface with the display be powered by the same supply to avoid logic inputs higher than V_{CC}. Additionally, the LEDs may cause transients on the power supply line while they change display states. Common practice is to place .01 μF capacitors close to the displays across V_{CC} and GND, one for each display, and one 10 μF capacitor for every second display.

ESD PROTECTION

The metal gate CMOS IC of the DL 1416B is extremely immune to ESD damage. It is capable of withstanding discharges greater than 3KV. However, users of these devices are encouraged to take all the standard precautions, normal for CMOS components. These include properly grounding personnel, tools, tables, and transport carriers that come in contact with un-shielded parts. Where these conditions are not, or cannot be met, keep the leads of the device shorted together or the parts in anti-static packaging.

SOLDERING CONSIDERATIONS

The DL 1416B can be hand soldered with SN63 solder using a grounded iron set to 260°C.

Wave soldering is also possible following these conditions: Preheat that does not exceed 93°C on the solder side of the PC board or a package surface temperature of 85°C. Water soluble organic acid flux (except carboxylic acid) or resin-based RMA flux without alcohol can be used.

Wave temperature of 245°C ±5°C with a dwell between 1.5 sec. to 3.0 sec. Exposure to the wave should not exceed temperatures above 260°C, for 5 seconds at 0.063″ below the seating plane. The packages should not be immersed in the wave.

POST SOLDER CLEANING PROCEDURES

The least offensive cleaning solution is hot D.I. water (60°C) for less than 15 minutes. Addition of mild saponifiers is acceptable. Do not use commercial dishwasher detergents.

For faster cleaning, solvents may be used. Care should be exercised in choosing these as some may chemically attack the nylon package. Maximum exposure should not exceed two minutes at elevated temperatures. Acceptable solvents are TF (trichlorotrifluoroethane), TA, 111 Trichloroethane, and unheated acetone.

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Further information is available in Siemens Appnotes 18 and 19 in our current Optoelectronic Data Book.

An alternative to soldering and cleaning the display modules is to use sockets. Naturally, 20 pin DIP sockets 1.10″ wide with .100″ centers work well for single displays. Multiple display assemblies are best handled by longer SIP sockets or DIP sockets when available for uniform package alignment. Socket manufacturers are Aries Electronics, Inc., Frenchtown, NJ; Garry Manufacturing, New Brunswick, NJ; Robinson-Nugent, New Albany, IN; and Samtec Electronic Hardware, New Albany, IN.

Further information is available in Siemens Appnote 22 in our current Optoelectronic Data Book.

OPTICAL CONSIDERATIONS

The .16″ high characters of the DL 1416B allow readability up to 8 feet. Proper filter selection will allow the user to build a display that can be utilized over this distance.

Filters allow the user to enhance the contrast ratio between a lit LED and the character background. This will maximize discrimination of different characters as perceived by the display user. The only limitation is cost. The cost/benefit ratio for filters can be maximized by first considering the ambient lighting environment.

Incandescent (with almost no green) or fluorescent (with almost no red) lights do not have the flat spectral response of sunlight. Plastic band-pass filters are inexpensive and effective in optimizing contrast ratios. The DL 1416B is a red display and should be matched with a long wavelength pass filter in the 600 nm to 620 nm range. For display systems of multiple colors (using other Siemens displays), neutral density grey filters offer the best compromise.

Additional contrast enhancement can be gained through shading the displays. Plastic band-pass filters with built-in louvers offer the "next step up" in contrast improvement. Plastic filters can be further improved with anti-reflective coatings to reduce glare. The trade-off is "fuzzy" characters, but mounting the filters close to the display reduces this effect. Care should be taken not to overheat the plastic filters by allowing for proper air flow.

Optimal filter enhancements for any condition can be gained through the use of circular polarized, anti-reflective, band-pass filters. The circular polarizing further enhances contrast by reducing the light that travels through the filter and reflects back off the display to less than 1%.

Several filter manufacturers supply quality filter materials. Some of them are: Panelgraphic Corporation, W. Caldwell, NJ; SGL Homalite, Wilmington, DE; 3M Company, Visual Products Division, St. Paul, MN; Polaroid Corporation, Polarizer Division, Cambridge, MA; Marks Polarized Corporation, Deer Park, NY; Hoya Optics, Inc., Fremont, CA.

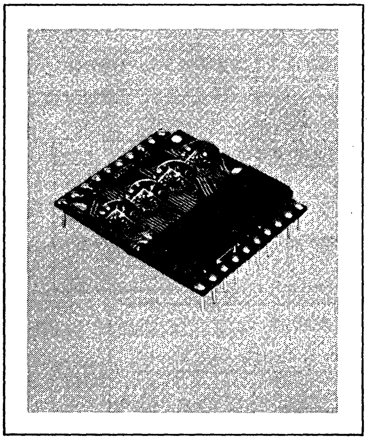
One last note on mounting filters: recessing display and bezel assemblies is an inexpensive way to provide a shading effect in overhead lighting situations. Several Bezel manufacturers are: R.M.F. Products, Batavia, IL; Nobex Components, Griffith Plastic Corp., Burlingame, CA; Photo Chemical Products of California, Santa Monica, CA; I.E.E.-Atlas, Van Nuys, CA.

Please refer to Siemens Appnote 23 for further information.

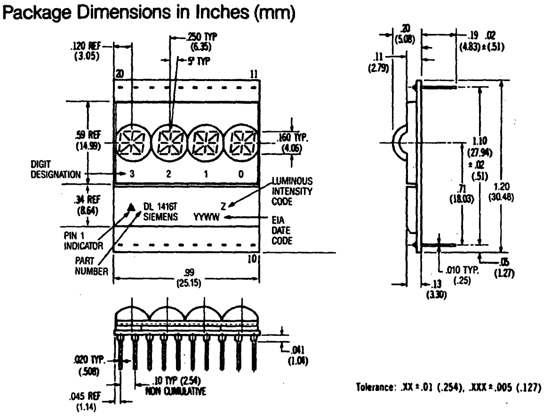
SIEMENS

DL 1416T

.160″ RED, 4-DIGIT 16-SEGMENT ALPHANUMERIC Intelligent Display® WITH MEMORY/DECODER/DRIVER



Package Dimensions in Inches (mm)



NOT FOR NEW DESIGNS

(Refer to the Improved Extended Performance of DL 1416B for Similar Applications.)

FEATURES

- **End-stackable, 4-Character Package**
- **High Contrast, 160 mil High, Magnified Monolithic Characters**
- **Viewing Angle ± 20°**
- **64-Character ASCII Format**
- **Built-in Memory, Decoder, Multiplexer and Drivers**
- **Direct Access to Each Digit Independently and Asynchronously**
- **5 Volt Logic, TTL Compatible**
- **5 Volt Power Supply Only**
- **Independent Cursor Function**
- **Intensity Coded For Display Uniformity**

DESCRIPTION

The DL 1416T Intelligent Display is a four-digit LED display module having a 16-segment font and an on-board CMOS integrated circuit driver.

The CMOS chip includes memory for four digits and cursor, 64 ASCII character generator ROM, and segment/digit drivers with associated multiplexing circuitry. Inputs are TTL compatible as is the power supply requirement. Data entry is asynchronous and random access. A display system can be built using any number of DL 1416Ts since each digit of each DL 1416T can be addressed independently. Each digit will continue to display the character last "written" until replaced by another.

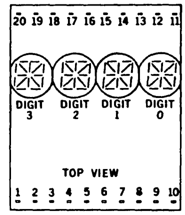
A cursor is defined as all segments of a digit position to be lit. The cursor is *not* a character, however, and upon removal leaves the previously displayed character unchanged. Normally, the cursor would be loaded and unloaded (flash) under software control. This can be used as a pointer in a line of DL 1416T displays or a "lamp test" function is realized by simply storing a cursor in all four digit positions of a display.

System interconnection is very straight forward. The least significant two address bits (A_0, A_1) are connected to the like inputs of all DL 1416Ts in a system. In small systems having 16 digits (4-DL 1416Ts), the enable ($\overline{CE}$) inputs of the four devices could simply be used directly to select each DL 1416T. In larger displays, the $\overline{CE}$ inputs would come from A 1-of-N decoder integrated circuit. In this case, address lines $A_2 \ldots A_n$ would go to the decoder inputs. Data lines (D_0-D_6) would be connected to all DL 1416Ts directly and in parallel. The cursor ($\overline{CU}$) and write ($\overline{W}$) lines would also be connected directly directly and in parallel. The display will then behave as a "write-only memory."

All products are 100% burned-in and tested, then subjected to out-going AQL's of .25% for brightness matching, visual alignment and dimensions, .065% for electrical and functional.

Important: Refer to Appnote 18, "Using and Handling Intelligent Displays". Since this is a CMOS device, normal precautions should be taken to avoid static damage.

Pin		Function	Pin		Function
1	D5	Data Input	11	A1	Digit Select
2	D4	Data Input	12	Unused	
3	DØ	Data Input	13	Unused	
4	D1	Data Input	14	Unused	
5	D2	Data Input	15	Unused	
6	D3	Data Input	16	Unused	
7	$\overline{CE}$	Chip Enable	17	Unused	
8	$\overline{W}$	Write	18	V+	
9	$\overline{CU}$	Cursor Input	19	V−	
10	AØ	Digit Select	20	D6	Data Input



OPTO-ELECTRONIC CHARACTERISTICS @ 25°C

MAXIMUM RATINGS	
V_{CC}	−0.5 V to 6.0 V
Voltage, Any Pin Respect to GND (V-)	−0.5 to Vcc +0.5 VDC
Operating Temperature	−20 to +65°C
Storage Temperautre	−20 to +70°C
Relative Humidity (non condensing) @ 65°C	85%

OPTICAL CHARACTERISTICS (TYPICAL)	
Luminous Intensity per digit/8 segments @5V,	.8 mcd
Viewing Angle	±20°
Digit Size	0.16″×0.125″
Spectral Peak Wavelength	660 nm
LED to LED intensity matching	1.8:1.0 max.
Display to Display intensity matching	1.5:1.0 max.
Bin to bin intensity matching	1.9:1.0 max.

DC CHARACTERISTICS

Parameter	−20°C Typ	+25°C[4]	+65°C Typ	Conditions
I_{CC} 4 digits on (10 seg/digit)		80 mA max[1]		V_{CC} = 5.0 V
I_{CC} Cursor[2]		105 mA max[1]		V_{CC} = 5.0 V
I_{CC} Blank		7 mA max	2.0 mA	V_{IN} = 0 V_{CC} = 5.0 V $\overline{W}$ = 5.0 V
I_{IL}	20 μA	160 μA max	10 μA	V_{IN} = .8 V V_{CC} = 5.0 V
V_{IL}		.8 V Max		V_{CC} = 4.5 V
V_{IH}[3]		2.7 V Min		V_{CC} = 4.5 V
		3.3 V Min		V_{CC} = 5.5 V

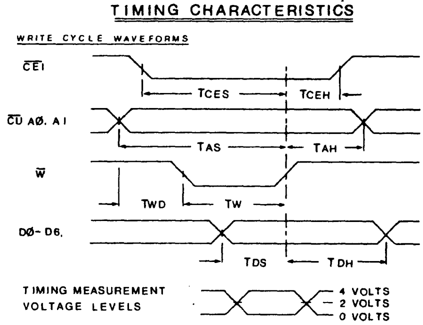
1. Measured at 5 seconds.
2. 60 sec. max. duration.
3. $V_{CC} > V_{IH} > 0.6\ V_{CC}$
4. V_{cc} = +5.0 VDC ±10%

AC CHARACTERISTICS @ 25°C

MINIMUM TIMING PARAMETERS @ 4.5 V (nanoseconds)

T_{AS}	1000
T_{WD}	500
T_W	500
T_{DS}	1000
T_{DH}	400
T_{AH}	400
T_{CEH}	400
T_{CES}	1000
T_{ACC}[4]	1400

TIMING CHARACTERISTICS



Note 1: This display contains a CMOS integrated circuit. Normal CMOS handling precautions should be taken to avoid damage due to high static voltages or electric fields.

Note 2: Unused inputs must be tied to an appropriate logic voltage level (eigher V+ or V−).

Note 3: **Warning** — Do not use solvents containing alcohol.

Note 4: Access time is defined as $T_{AS} + T_{DH}$ (sum of address set up and data hold times).

LOADING DATA

The chip enable ($\overline{CE}$) held low and cursor ($\overline{CU}$) held high will enable data loading. The desired data code (D_0-D_6) and selected digit address (A_0-A_1) should be held stable while write ($\overline{W}$) is low for storing new data. The timing parameters in the AC characteristics table are minimum and should be observed. There are no maximum timing requirements. Data entry may be asynchronous and in random order. All undefined data codes (see character set) loaded as data will display a blank.

Digit 0 is defined as the right hand digit with $A_1 = A_0 = 0 =$ low.

LOADING CURSOR

The chip enable ($\overline{CE}$) and Cursor ($\overline{CU}$) are held low. A write ($\overline{W}$) signal will now load a cursor into any digit position for which the respective first four data lines (D_0, D_1, D_2, D_3) individually or together are held high. If previously stored, the cursors can only be removed if their respective data lines are held low while $\overline{CE}$, $\overline{CU}$ are low and write ($\overline{W}$) occurs.

The cursor ($\overline{CU}$) should *not* be hardwired high (off). During the power-up of DL 1416s the cursor memory will be in a random state. Therefore, it is recommended for the processor-based system to initialize or write out possible cursors during the system initializing portion of the software.

The cursor display will be over ridden by a blank from an undefined code in that digit position.

TYPICAL LOADING DATA STATE TABLE

$\overline{CE}$	$\overline{CU}$	$\overline{W}$	ADDRESS A_1	A_0	DATA INPUT D6	D5	D4	D3	D2	D1	D0	DIGIT 3	DIGIT 2	DIGIT 1	DIGIT 0
H	X	X	X	X	X	X	X	X	X	X	X	NO CHANGE	NO CHANGE	NO CHANGE	NO CHANGE
L	H	L	L	L	H	L	L	L	L	L	H	NO CHANGE	NO CHANGE	NO CHANGE	A
L	H	L	L	H	H	L	L	L	L	H	L	NO CHANGE	NO CHANGE	B	A
L	H	L	H	L	H	L	L	L	L	H	H	NO CHANGE	C	B	A
L	H	L	H	H	H	L	L	L	H	L	L	D	C	B	A
L	H	L	L	L	H	L	L	L	H	L	H	D	C	B	E
L	H	L	H	L	H	L	L	H	L	H	H	D	K	B	E
L	H	L	–	–	–	–	–	–	–	–	–	SEE CHARACTER SET			

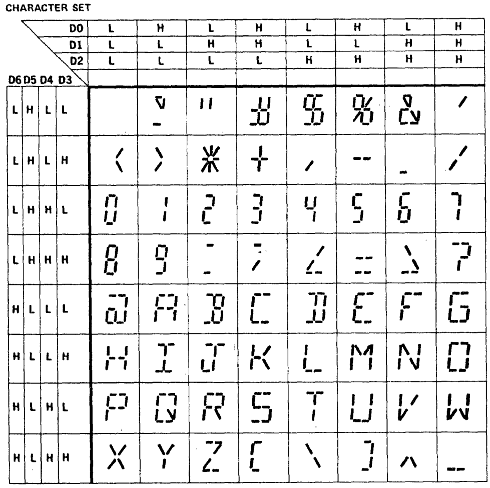
X = DON'T CARE

TYPICAL LOADING CURSOR STATE TABLE

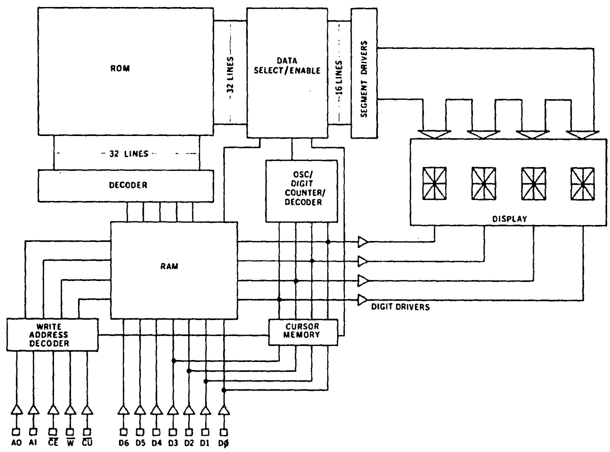
$\overline{CE}$	$\overline{CU}$	$\overline{W}$	ADDRESS A_1	A_0	DATA INPUT D6	D5	D4	D3	D2	D1	D0	DIGIT 3	DIGIT 2	DIGIT 1	DIGIT 0
H	X	X	X	X	X	X	X	X	X	X	X	D	K	B	E
L	L	L	X	X	X	X	X	L	L	L	H	D	K	B	⊞
L	L	L	X	X	X	X	X	L	L	L	L	D	K	B	E
L	L	L	X	X	X	X	X	L	L	H	L	D	K	⊞	E
L	L	L	X	X	X	X	X	L	H	L	L	D	⊞	B	E
L	L	L	X	X	X	X	X	H	L	L	L	⊞	K	B	E
L	L	L	X	X	X	X	X	H	H	H	H	⊞	⊞	⊞	⊞
L	L	L	X	X	X	X	X	L	L	L	L	D	K	B	E

X = DON'T CARE

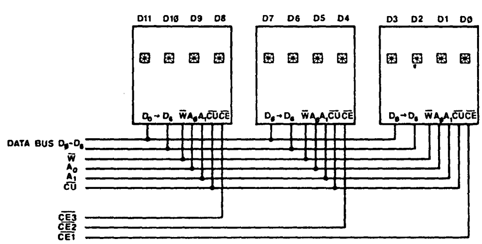
CHARACTER SET



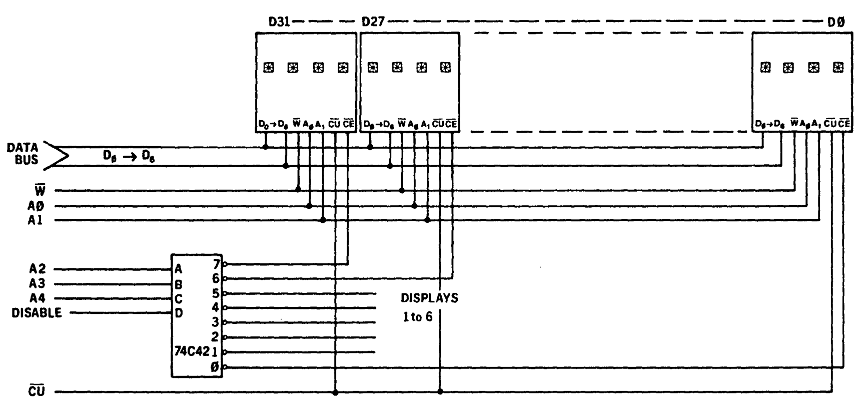
NOTE: All undefined data codes that are loaded or occur on power-up will cause a blank display state.



INTERNAL SCHEMATIC



Typical interconnect
for small systems. 12digits



Typical schematic
for 32 digit systems

DL 1416T

DESIGN CONSIDERATIONS

For details on design and applications of the DL 1416T utilizing standard bus configurations in multiple display systems, or parallel I/O devices, such as the 8255 with an 8080 or memory mapped addressing on processors such as the 8080, Z80, 6800, or non-micro processor based systems, please refer to Appnote 9A and 13 in the current Siemens Optoelectronic Data Book.

ELECTRICAL AND MECHANICAL CONSIDERATIONS

VOLTAGE TRANSIENT SUPPRESSION

It is highly recommended that the display and the components that interface with the display be powered by the same supply to avoid logic inputs higher than V_{CC}. Additionally, the LEDs may cause transients on the power supply line while they change display states. The common practice is to place .01 μF capacitors close to the displays across V_{CC} and GND, one for each display, and one 10 μF capacitor for every second display.

ESD PROTECTION

The metal gate CMOS IC of the DL 1416T is extremely immune to ESD damage. It is capable of withstanding discharges greater than 3KV. However, users of these devices are encouraged to take all the standard precautions, normal for CMOS components. These include properly grounding personnel, tools, tables, and transport carriers that come in contact with unshielded parts. Where these conditions are not, or cannot be met, keep the leads of the device shorted together or the parts in anti-static packaging.

SOLDERING CONSIDERATIONS

The DL 1416T can be hand soldered with SN63 solder using a grounded iron set to 260°C.

Wave soldering is also possible following these conditions: Preheat that does not exceed 93°C on the solder side of the PC board or a package surface temperature of 70°C. Water soluble organic acid flux or (except carboxylic acid) resin-based RMA flux without alcohol can be used.

Wave temperature of 245°C ±5°C with a dwell between 1.5 sec. to 3.0 sec. Exposure to the wave should not exceed temperatures above 260°C, for 5 seconds at 0.063″ below the seating plane. The packages should not be immersed in the wave.

POST SOLDER CLEANING PROCEDURES

The least offensive cleaning solution is hot D.I. water (60°C) for less than 15 minutes. Addition of mild saponifiers is acceptable. Do not use commercial dishwasher detergents.

For faster cleaning, solvents may be used. Care should be exercised in choosing these as some may chemically attack the nylon package. Maximum exposure should not exceed two minutes at elevated temperatures. Acceptable solvents are TF (trichlorotrifluoroethane), TA, 111 Trichloroethane, and unheated acetone.

Unacceptable solvents contain alcohol, methanol, methylene chloride, ethanol, TP35, TCM, TMC, TMS+, TE, and TES. Since many commercial mixtures exist, you should contact your preferred solvent vendor for chemical composition information. Some major solvent manufacturers are: Allied Chemical Corporation, Specialty Chemical Division, Morristown, NJ; Baron-Blakeslee, Chicago, IL; Dow Chemical, Midland, MI; E.I. DuPont de Nemours & Co., Wilmington, DE.

For further information refer to Appnotes 18 and 19 in the current Siemens Optoelectronic Data Book.

An alternative to soldering and cleaning the display modules is to use sockets. Naturally, 20 pin DIP sockets 1.10″ wide with .100″ centers work well for single displays. Multiple display assemblies are best handled by longer SIP sockets or DIP sockets when available for uniform package alignment. Socket manufacturers are Aries Electronics, Inc., Frenchtown, NJ; Garry Manufacturing, New Brunswick, NJ; Robinson-Nugent, New Albany, IN; and Samtec Electronic Hardware, New Albany, IN.

For further information refer to Appnote 22 in the current Siemens Optoelectronic Data Book.

OPTICAL CONSIDERATIONS

The 0.16″ high characters of the DL 1416T allow readability up to six feet. Proper filter selection will allow the user to build a display that can be utilized over this distance.

Filters allow the user to enhance the contrast ratio between a lit LED and the character background. This will maximize discrimination of different characters as perceived by the display user. The only limitation is cost. The cost/benefit ratio for filters can be maximized to the user's benefit by first considering the ambient lighting environment.

Incandescent (with almost no green) or fluorescent (with almost no red) lights do not have the flat spectral response of sunlight. Plastic band-pass filters are inexpensive and effective in optimizing contrast ratios. The DL 1416T is a red display and should be matched with a long wavelength pass filter in the 600 nm to 620 nm range. For display systems of multiple colors (using other Siemens displays), neutral density grey filters offer the best compromise.

Additional contrast enhancement can be gained through shading the displays. Plastic band-pass filters with built-in louvers offer the "next step up" in contrast improvement. Plastic filters can be further improved with anti-reflective coatings to reduce glare. The trade-off is "fuzzy" characters. Mounting the filters close to the display reduces this effect. Care should be taken not to overheat the plastic filters by allowing for proper air flow.

Optimal filter enhancements for any condition can be gained through the use of circular polarized, anti-reflective, band-pass filters. The circular polarizing further enhances contrast by reducing the light that travels through the filter and reflects back off the display to less than 1%.

Several filter manufacturers supply quality filter materials. Some of them are: Panelgraphic Corporation, W. Caldwell, NJ; SGL Homalite, Wilmington, DE; 3M Company, Visual Products Division, St. Paul, MN; Polaroid Corporation, Polarizer Division, Cambridge, MA; Marks Polarized Corporation, Deer Park, NY; Hoya Optics, Inc., Fremont, CA.

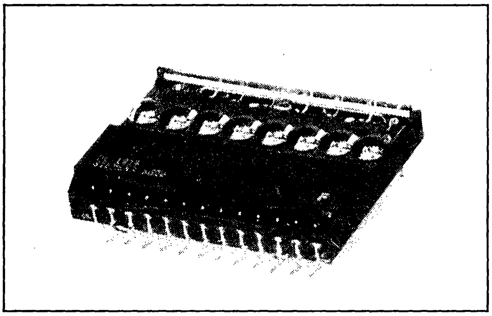
One last note on mounting filters: recessing display and bezel assemblies is an inexpensive way to provide a shading effect in overhead lighting situations. Several Bezel manufacturers are: R.M.F. Products, Batavia, IL; Nobex Components, Griffith Plastic Corp., Burlingame, CA; Photo Chemical Products of California, Santa Monica, CA; I.E.E.-Atlas, Van Nuys, CA.

Refer to Siemens Appnote 23 for further information.

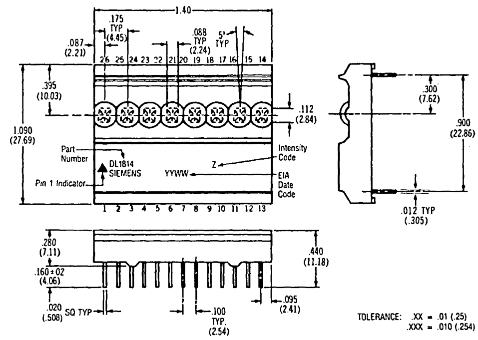
SIEMENS

DL 1814

.112" Red, 8-Digit 17-Segment ALPHANUMERIC Intelligent Display® With Memory/Decoder/Driver



Package Dimensions in Inches (mm)



TOLERANCE: .XX = .01 (.25)
.XXX = .010 (.254)

FEATURES

- 0.112" × 0.088" Magnified Monolithic Character
- Rugged Solid Plastic Encapsulated Package
- Wide Viewing Angle ±40°, Both Axis
- Compact Size for Hand Held Equipment
- Fast Access Time, 525 ns
- Full Integrated CMOS Drive Electronics
- Direct Access to each Digit Independently & Asynchronously
- TTL Compatible, 5 Volt Power
- 17th Segment for Improved Punctuation Marks
- Low Power Consumption, Typically 10 mA per Character
- Display Blank Function
- End-Stackable, Eight Character Package
- Intensity Coded for Display Uniformity
- 100% Burned In and Tested
- Extended Operating Temperature Range: −40°C to +85°C

DESCRIPTION

The DL 1814 is an 8-digit module. Each digit has 16 segments plus a decimal segment and a built-in CMOS integrated circuit.

The integrated circuit contains memory, ASCII character generator, and LED multiplexing and drive circuitry. Inputs are TTL compatible. A single 5 volt power supply is required. Data entry is asynchronous and random access. A display system can be built using any number of DL 1814's since each character in any DL 1814 can be addressed independently and will continue to display the character last written until it is replaced by another.

All products are 100% burned-in and tested, then subjected to out-going AQL's of .25% for brightness matching, visual alignment and dimensions, .065% for electrical and functional.

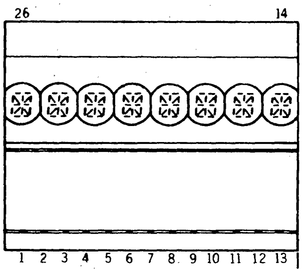
Maximum Ratings

Supply Voltage V_{CC} . . . . −0.5 V to +6.0 Vdc
Voltage, Any Pin Respect
to GND . . . . −0.5 V to (V_{CC} +0.5) Vdc
Operating Temperature . . . . −40°C to +85°C
Storage Temperature . . . . −40°C to +100°C
Relative Humidity (non condensing) @85°C 85%
Maximum Solder Temperature, 1.59 mm (0.063")
below Seating Plane, t<5 sec . . . . 260°C
ESD (MIL-STD-883, method 3015) . . . . V_Z=3 KV

Optical Characteristics

Spectral Peak Wavelength . . . . 660 nm typ.
Magnified digit size . . . . 0.112"×0.088"
Time Averaged Luminous Intensity . . . . . . 0.2 mcd/digit min.
(100% brightness,
8 segments/digit, V_{CC}=5 V) . . . . 0.5 mcd/digit typ.
LED to LED Intensity Matching . . . . 1.8:1.0 max.
Device to Device Intensity Matching (one bin) . 1.5:1.0 max.
Bin to Bin Intensity Matching . . . . 1.9:1.0 max.
Viewing Angle (off normal axis)
Horizontal . . . . ±40°
Vertical . . . . ±40°

TOP VIEW



Pin		Function	Pin	Function
1	D0	Data input	14	$\overline{BL}$ (Blank)
2	D1	Data input	15	NO PIN
3	D2	Data input	16	NO PIN
4	D3	Data input	17	NO PIN
5	D4	Data input	18	NO PIN
6	D5	Data input	19	NO PIN
7	D6	Data input	20	NO PIN
8	GND		21	NO PIN
9	A0	Address	22	NO PIN
10	A1	Address	23	NO PIN
11	A2	Address	24	NO PIN
12	$\overline{WR}$	Write	25	NO PIN
13	VCC		26	$\overline{CE}$ (Chip Enable)

DC CHARACTERISTICS

Parameter	−40°C			+25°C			+85°C			Units	Conditions
	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.		
I_{CC}(1) 8 Digits on 10 segments/digit		130	156		100	120		85	102	mA	$V_{CC}=5$ V
I_{CC} Blank(1)		2.5	5.0		2.0	3.5		1.5	2.0	mA	$V_{CC}=5$ V, $\overline{BL}=0.8$ V
I_{IL} (all inputs)		75	110		55	80		40	55	μA	$V_{IN}=0.8$ V, $V_{CC}=5$ V
V_{IH}	2.7			2.7			2.7			V	$V_{CC}=5$ V$\pm$0.5 V
V_{IL}			0.8			0.8			0.8	V	$V_{CC}=5$ V$\pm$0.5 V

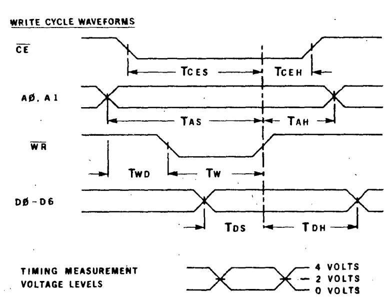
Notes: 1. Measured at 5 sec.

AC CHARACTERISTICS Guaranteed Minimum Timing Parameters @$V_{CC}=4.5$ V

Parameter	Symbol	−40°C (ns)	+25°C (ns)	+85°C (ns)
Chip Enable Set Up Time	T_{CES}	300	450	550
Address Set Up Time	T_{AS}	300	450	575
Chip Enable Hold Time	T_{CEH}	50	75	100
Address Hold Time	T_{AH}	50	75	100
Write Delay Time	T_{WD}	100	150	200
Write Time	T_W	200	300	450
Data Set Up Time	T_{DS}	150	250	350
Data Hold Time	T_{DH}	50	75	100
Access Time	T_{ACC}	350	525	675

Notes:
1. "Off Axis Viewing Angle" is here defined as: "the minimum angle in any direction from the normal to the display surface at which any part of any segment in the display is not visible.
2. This display contains a CMOS integrated circuit. Normal CMOS handling precautions should be taken to avoid damage due to high static voltages or electric fields. See Appnote 18.
3. Unused inputs must be tied to an appropriate logic voltage level (either V+ or V−).
4. **Warning:** Do not use solvents containing alcohol.
5. $V_{CC}=5.0$ VDC $\pm$10%.
6. Access time is defined as $T_{AS}+T_{DH}$ (sum of address set up and data hold time).
7. $V_{CC}=4.5$ V, worst case for all timing parameters.

TIMING CHARACTERISTICS



DL 1814

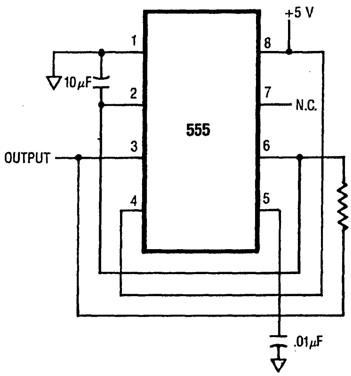
DISPLAY BLANKING

Blanking the display may be accomplished by loading a blank or space into each digit of the display or by using the ($\overline{BL}$) display blank input.

Setting the ($\overline{BL}$) input low does not affect the contents of either data. A flashing display can be realized by pulsing ($\overline{BL}$).

A flashing circuit can easily be constructed using a 555 astable multivibrator. Figure 1 illustrates a circuit in which varying R1 (100K ~ 10K) will have a flash rate of 1 Hz ~ 10 Hz.

FIGURE 1. FLASHING CIRCUIT FOR DL 1814 USING A 555

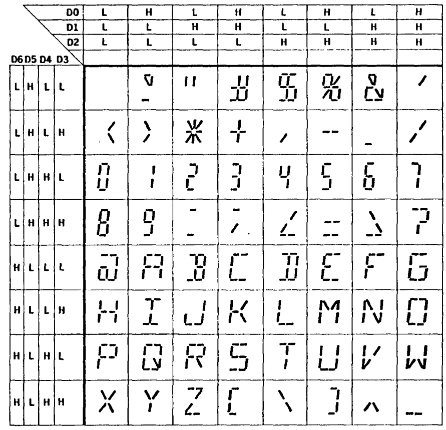


LOADING DATA

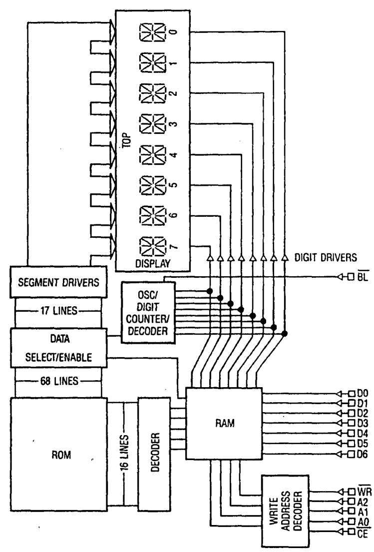
Loading data into the DL1814 is straightforward. The desired data and chip enable should be present and stable during a write pulse. No synchronization is necessary, and each character will continue to be displayed until it is replaced with another. Multiple displays will require an external decoder IC connected to the chip enable input.

Setting the chip enables $\overline{CE}$ to its true state will enable data loading. The desired data code (D0-D6) and digit address (A_0, A_1, A_2) must be held stable during the write cycle for storing new data. Data entry may be asynchronous and random. (Digit 0 is defined as right hand digit with ($A_2 = A_1 = A_0 = 0$.)

CHARACTER SET



BLOCK DIAGRAM



TYPICAL LOADING DATA STATE TABLE

$\overline{BL}$	$\overline{CE}$	$\overline{WR}$	A2	A1	A0	D6	D5	D4	D3	D2	D1	D0	DIGIT 7	6	5	4	3	2	1	0
H	X	H	X	X	X	PREVIOUSLY LOADED DISPLAY							S	I	E	M	E	N	S	
H	H	X	X	X	X	X	X	X	X	X	X	X	S	I	E	M	E	N	S	
H	L	L	L	L	L	H	L	L	L	H	L	H	S	I	E	M	E	N	S	E
H	L	L	L	L	H	H	L	H	L	H	L	H	S	I	E	M	E	N	U	E
H	L	L	L	H	L	H	L	L	H	H	L	L	S	I	E	M	E	L	U	E
H	L	L	L	H	H	H	L	L	L	L	H	L	S	I	E	M	B	L	U	E
H	L	L	H	L	L	H	L	L	L	H	L	H	S	I	E	E	B	L	U	E
H	L	L	H	L	H	H	L	H	L	H	L	H	S	I	U	E	B	L	U	E
H	L	L	H	H	L	H	L	L	H	H	L	L	S	L	U	E	B	L	U	E
H	L	L	H	H	H	H	L	L	L	L	H	L	B	L	U	E	B	L	U	E
L	X	H	X	X	X	BLANK DISPLAY														
H	L	L	L	H	H	H	L	L	L	H	H	H	B	L	U	E	G	L	U	E
H	L	L	X	X	X	SEE CHARACTER CODE								SEE CHARACTER SET						

ELECTRICAL AND MECHANICAL CONSIDERATIONS

VOLTAGE TRANSIENT SUPPRESSION

It is highly recommended that the display and the components that interface with the display be powered by the same supply to avoid logic inputs higher than V_{CC}. Additionally, the LEDs may cause transients in the power supply line while they change display states. Common practice is to place .01 μF capacitors close to the displays across V_{CC} and GND, one for each display, and one 10 μF capacitor for every second display.

ESD PROTECTION

The metal gate CMOS IC of the DL 1814 is extremely immune to ESD damage. It is capable of withstanding discharges greater than 3 KV. However, users of these devices are encouraged to take all the standard precautions, normal for CMOS components. These include properly grounding personnel, tools, tables, and transport carriers that come in contact with un-shielded parts. Where these conditions are not, or cannot be met, keep the leads of the device shorted together or the parts in anti-static packaging.

SOLDERING CONSIDERATIONS

The DL 1814 can be hand soldered with SN63 solder using a grounded iron set to 260°C.

Wave soldering is also possible following these conditions: Preheat that does not exceed 93°C on the solder side of the PC board or a package surface temperature of 85°C. Water soluble organic acid flux (except carboxylic acid) or resin-based RMA flux without alcohol can be used.

Wave temperature of 245°C ±5°C with a dwell between 1.5 sec. to 3.0 sec. Exposure to the wave should not exceed temperatures above 260°C, for 5 seconds at 0.063″ below the seating plane. The packages should not be immersed in the wave.

POST SOLDER CLEANING PROCEDURES

The least offensive cleaning solution is hot D.I. water (60°C) for less than 15 minutes. Addition of mild saponifiers is acceptable. Do not use commercial dishwasher detergents.

For faster cleaning, solvents may be used. Care should be exercised in choosing these as some may chemically attack the nylon package. Maximum exposure should not exceed two minutes at elevated temperatures. Acceptable solvents are TF (trichlorotrifluoroethane), TA, 111 Trichloroethane, and unheated acetone.

Unacceptable solvents contain alcohol, methanol, methylene chloride, ethanol, TP35, TCM, TMC, TMS+, TE, and TES. Since many commercial mixtures exist, you should contact your solvent vendor for chemical composition information. Some major solvent manufacturers are: Allied Chemical Corporation, Specialty Chemical Division, Morristown, NJ; Baron-Blakeslee, Chicago, IL; Dow Chemical, Midland, MI; E.I. DuPont de Nemours & Co., Wilmington, DE.

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An alternative to soldering and cleaning the display modules is to use sockets. Naturally, 26 pin DIP sockets .960″ wide with .100″ centers work well for single displays. Multiple display assemblies are best handled by longer SIP sockets or DIP sockets when available for uniform package alignment. Socket manufacturers are Aries Electronics, Inc., Frenchtown, NJ; Garry Manufacturing, New Brunswick, NJ; Robinson-Nugent, New Albany, IN; and Samtec Electronic Hardware, New Albany, IN.

For further information refer to Appnote 22 in the current Siemens Optoelectronic Data Book.

OPTICAL CONSIDERATIONS

The .112″ high characters of the DL 1814 allow readability up to six feet. Proper filter selection will allow the user to build a display that can be utilized over this distance.

Filters allow the user to enhance the contrast ratio between a lit LED and the character background. This will maximize discrimination of different characters as perceived by the display user. The only limitation is cost. The cost/benefit ratio for filters can be maximized to the user's benefit by first considering the ambient lighting environment.

Incandescent (with almost no green) or fluorescent (with almost no red) lights do not have the flat spectral response of sunlight. Plastic band-pass filters are inexpensive and effective in optimizing contrast ratios. The DL 1814 is a standard red display and should be matched with a long wavelength pass filter in the 600 nm to 620 nm range. For display systems of multiple colors (using other Siemens' displays), neutral density grey filters offer the best compromise.

Additional contrast enhancement can be gained through shading the displays. Plastic band-pass filters with built-in louvers offer the "next step up" in contrast improvement. Plastic filters can be further improved with anti-reflective coatings to reduce glare. The trade-off is "fuzzy" characters. Mounting the filters close to the display reduces this effect. Care should be taken not to overheat the plastic filters by allowing for proper air flow.

Optimal filter enhancements for any condition can be gained through the use of circular polarized, anti-reflective, band-pass filters. The circular polarizing further enhances contrast by reducing the light that travels through the filter and reflects back off the display to less than 1%.

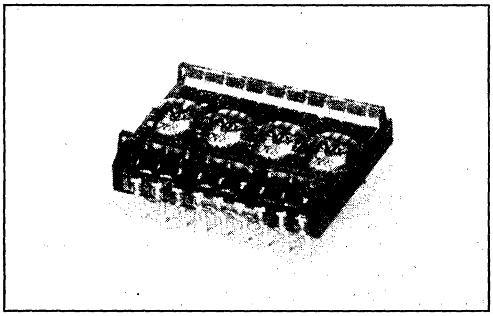
Several filter manufacturers supply quality filter materials. Some of them are: Panelgraphic Corporation, W. Caldwell, NJ; SGL Homalite, Wilmington, DE; 3M Company, Visual Products Division, St. Paul, MN; Polaroid Corporation, Polarizer Division, Cambridge, MA; Marks Polarized Corporation, Deer Park, NY; Hoya Optics, Inc., Fremont, CA.

One last note on mounting filters: recessing display and bezel assemblies is an inexpensive way to provide a shading effect in overhead lighting situations. Several Bezel manufacturers are: R.M.F. Products, Batavia, IL; Nobex Components, Griffith Plastic Corp., Burlingame, CA; Photo Chemical Products of California, Santa Monica, CA; I.E.E.-Atlas, Van Nuys, CA.

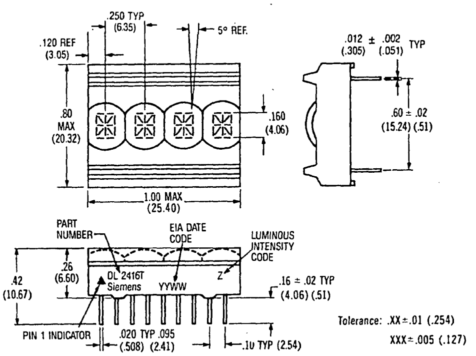
Refer to Siemens Appnote 23 for further information.

SIEMENS DL 2416T

.160″ Red, 4-Digit 16-Segment Plus Decimal ALPHANUMERIC Intelligent Display® With Memory/Decoder/Driver



Package Dimensions in Inches (mm)



FEATURES

- **0.16″ × 0.125″ Magnified Character**
- **Wide Viewing Angle, X Axis ±45°, Y Axis ±55°**
- **Close Multi-line Spacing, 0.8″ Centers**
- **Rugged Solid Plastic Encapsulated Package**
- **Fast Access Time, 300 ns @25°C**
- **Full Size Display for Stationary Equipment**
- **Built-in Memory**
- **Built-in Character Generator**
- **Built-in Multiplex and LED Drive Circuitry**
- **Direct Access to Each Digit Independently & Asynchronously**
- **Independent Cursor Function**
- **17th Segment for Improved Punctuation Marks**
- **Memory Function that Clears Character and Cursor Memory Simultaneously**
- **True Blanking for Intensity Dimming Applications**
- **End-Stackable, 4-Character Package**
- **Intensity Coded for Display Uniformity**
- **Extended Operating Temperature Range: −40°C to +85°C**
- **100% Burned In and Tested**
- **Wave Solderable**
- **TTL Compatible over Operating Temperature Range**
- **Superior ESD Immunity**

DESCRIPTION

The DL 2416T is a four digit display module having 16 segments plus decimal and a built-in CMOS integrated circuit.

The integrated circuit contains memory, ASCII ROM decoder, multiplexing circuitry, and drivers. Data entry is asynchronous and can be random. A display system can be built using any number of DL 2416Ts since each digit of any DL 2416T can be addressed independently and will continue to display the character last stored until replaced by another.

System interconnection is very straightforward. The least significant two address bits (A_0, A_1) are normally connected to the like named inputs of all DL 2416Ts in the system. With two chip enables ($\overline{CE1}$, and $\overline{CE2}$) four DL 2416Ts (16 characters) can easily be interconnected without a decoder.

Data lines are connected to all DL 2416Ts directly and in parallel, as is the write line ($\overline{WR}$). The display will then behave as a write-only memory.

The cursor function causes all segments of a digit position to illuminate. The cursor is *not* a character, however, and upon removal the previously displayed character will reappear.

The DL 2416T has several features superior to competitive devices. The superior ESD immunity afforded by the metal gate CMOS construction and 100% pre-burned in processing assures users of the DL 2416T that the devices will function in more stressful assembly and use environments. The full width character "J" affords better readability under adverse conditions and the "true blanking" allows the designer to dim the display for more flexibility of display presentation. Finally, the CLR clear function will clear the cursor RAM and the ASCII character RAM, simultaneously.

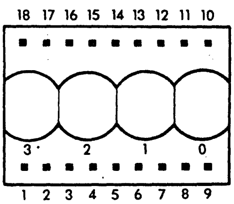
—Continued

DESCRIPTION (Continued)

All products are 100% burned-in and tested, then subjected to out-going AQL's of .25% for brightness matching, visual alignment and dimensions, .065% for electrical and functional.

See Appnote 14 for applications information.

TOP VIEW



Pin	Function	Pin	Function
1	$\overline{CE1}$ Chip Enable	10	Gnd
2	$\overline{CE2}$ Chip Enable	11	DØ Data Input
3	$\overline{CLR}$ Clear	12	D1 Data Input
4	CUE Cursor Enable	13	D2 Data Input
5	$\overline{CU}$ Cursor Select	14	D3 Data Input
6	$\overline{WR}$ Write	15	D6 Data Input
7	A1 Digit Select	16	D5 Data Input
8	AØ Digit Select	17	D4 Data Input
9	V_{CC}	18	$\overline{BL}$ Display Blank

Maximum Ratings

Supply Voltage V_{CC} .... −0.5 V to +6.0 Vdc
Voltage, Any Pin Respect
to GND .... −0.5 V to (V_{CC} +0.5) Vdc
Operating Temperature............... −40°C to +85°C
Storage Temperature .... −40°C to +100°C
Relative Humidity (non condensing) @85°C 85%
Maximum Solder Temperature, 1.59 mm (0.063″)
below Seating Plane, t<5 sec................. 260°C

Optical Characteristics

Spectral Peak Wavelength................. 660 nm typ.
Magnified digit size .... .160″×.125″
Time Averaged Luminous Intensity
(100% brightness, ... 0.5 mcd/digit min.
8 segments/digit, V_{CC}=5 V) .... 1.0 mcd/digit typ.
LED to LED Intensity Matching .... 1.8:1.0 max.
Device to Device Intensity Matching (one bin) . 1.5:1.0 max.
Bin to Bin Intensity Matching............... 1.9:1.0 max.
Viewing Angle (off normal axis)
Horizontal .... ±45°
Vertical .... ±55°

DC CHARACTERISTICS

	−40°C			+25°C			+85°C				
Parameter	**Min.**	**Typ.**	**Max.**	**Min.**	**Typ.**	**Max.**	**Min.**	**Typ.**	**Max.**	**Units**	**Conditions**
I_{CC}(1) 4 Digits on 10 segments/digit		100	130		85	115		70	100	mA	V_{CC}=5 V
I_{CC} Cursor(1, 2)		140	185		120	165		100	145	mA	V_{CC}=5 V
I_{CC} Blank(1)		2.0	5.0		1.5	4.0		1.0	2.7	mA	V_{CC}=5 V, $\overline{BL}$=0.8 V
I_{IL} (all inputs)		80	180		60	160		45	90	μA	V_{IN}=0.8 V, V_{CC}= 5.0 V
V_{IH}	2.0			2.0			2.0			V	V_{CC}=5 V±0.5 V
V_{IL}			0.8			0.8			0.8	V	V_{CC}=5 V±0.5 V

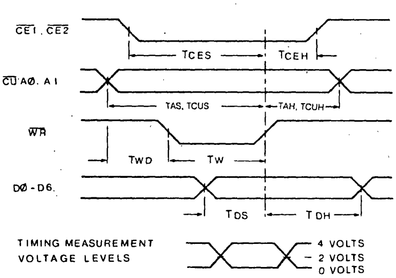
1. Measured at 5 sec.
2. 60 sec max duration.

AC CHARACTERISTICS Guaranteed Minimum Timing Parameters @4.5 V$\leq V_{CC} \leq$5.5 V

Parameter	Symbol	−40°C (ns)	+25°C (ns)	+85°C (ns)
Chip Enable Set Up Time	T_{CES}	175	275	375
Address Set Up Time	T_{AS}	175	275	375
Cursor Set Up Time	T_{CUS}	175	275	375
Chip Enable Hold Time	T_{CEH}	25	25	75
Address Hold Time	T_{AH}	25	25	75
Cursor Hold Time	T_{CUH}	25	25	75
Write Delay Time	T_{WD}	50	50	75
Write Time	T_W	125	225	300
Data Set Up Time	T_{DS}	100	150	225
Data Hold Time	T_{DH}	25	25	75
Clear(3)	T_{CLR}	15 ms	15 ms	15 ms
Access Time(2)	T_{ACC}	200	300	450

Notes: 1. V_{CC}=4.5 V is worst case, all timing parameters improve as V_{CC} increases.
2. Access time $T_{ACC}=T_{AS}+T_{DH}$
3. Clear timing in miliseconds.

TIMING CHARACTERISTICS WRITE CYCLE WAVEFORMS



LOADING DATA

Setting the chip enable ($\overline{CE1}$, $\overline{CE2}$) to their true state will enable data loading. The desired data code (D0-D6) and digit address (A_0, A_1) must be held stable during the write cycle for storing new data.

Data entry may be asynchronous and random. (Digit 0 is defined as a right hand digit with $A_1=A_2=0$.)

Clearing of the entire internal four-digit memory can be accomplished by holding the clear ($\overline{CLR}$) low for one complete display multiplex cycle, 15 mS minimum. The clear function will clear both the ASCII RAM and the cursor RAM. Loading an illegal data code will display a blank.

TYPICAL LOADING DATA STATE TABLE

CONTROL							ADDRESS		DATA							DISPLAY DIGIT			
$\overline{BL}$	$\overline{CE1}$	$\overline{CE2}$	CUE	$\overline{CU}$	$\overline{WR}$	$\overline{CLR}$	A1	A0	D6	D5	D4	D3	D2	D1	D0	3	2	1	0
H	X	X	L	X	H	H	PREVIOUSLY LOADED DISPLAY									G	R	E	Y
H	H	X	L	X	X	H	X	X	X	X	X	X	X	X	X	G	R	E	Y
H	X	H	L	X	X	H	X	X	X	X	X	X	X	X	X	G	R	E	Y
H	L	L	L	H	L	H	L	L	H	L	L	L	H	L	H	G	R	E	E
H	L	L	L	H	L	H	L	H	H	L	H	L	H	L	H	G	R	U	E
H	L	L	L	H	L	H	H	L	H	L	L	H	H	L	L	G	L	U	E
H	L	L	L	H	L	H	H	H	H	L	L	L	L	H	L	B	L	U	E
L	X	X	X	X	H	H	X	X	BLANK DISPLAY										
H	L	L	L	H	L	H	H	H	H	L	L	L	H	H	H	G	L	U	E
H	X	X	L	X	H	L	X	X	CLEARS CHARACTER DISPLAYS										
H	L	L	L	H	L	H	X	X	SEE CHARACTER CODE							SEE CHARACTER SET			

X = DON'T CARE

Intelligent Display Devices

LOADING CURSOR

Setting the chip enables ($\overline{CE1}$, $\overline{CE2}$) and cursor select ($\overline{CU}$) to their true state will enable cursor loading. A write ($\overline{WR}$) pulse will now store or remove a cursor into the digit location addressed by A_0, A_1; as defined in data entry. A cursor will be stored if D0=1; and will be removed if D0=0. The cursor ($\overline{CU}$) pulse width should not be less than the write ($\overline{WR}$) pulse or erroneous data may appear in the display.

For those users not requiring the cursor, the cursor enable signal (CUE) may be tied low to disable the display of the cursor function. A flashing cursor can be realized by simply pulsing CUE. If the cursor has been loaded to any or all positions in the display, then CUE will control whether the cursor(s) or the characters appear. CUE does not affect the contents of cursor memory.

LOADING CURSOR STATE TABLE

CONTROL							ADDRESS		DATA							DISPLAY DIGIT			
$\overline{BL}$	$\overline{CE1}$	$\overline{CE2}$	CUE	$\overline{CU}$	$\overline{WR}$	$\overline{CLR}$	A1	A0	D6	D5	D4	D3	D2	D1	D0	3	2	1	0
H	X	X	L	X	H	H	PREVIOUSLY LOADED DISPLAY									B	E	A	R
H	X	X	H	X	H	H	DISPLAY PREVIOUSLY STORED CURSORS									B	E	A	R
H	L	L	H	L	L	H	L	L	X	X	X	X	X	X	H	B	E	A	▩
H	L	L	H	L	L	H	L	H	X	X	X	X	X	X	H	B	E	▩	▩
H	L	L	H	L	L	H	H	L	X	X	X	X	X	X	H	B	▩	▩	▩
H	L	L	H	L	L	H	H	H	X	X	X	X	X	X	H	▩	▩	▩	▩
H	L	L	H	L	L	H	H	L	X	X	X	X	X	X	L	▩	E	▩	▩
H	X	X	L	X	H	H	DISABLE CURSOR DISPLAY									B	E	A	R
H	L	L	L	L	L	H	H	H	X	X	X	X	X	X	L	B	E	A	R
H	X	X	H	X	H	H	DISPLAY STORED CURSOR									B	E	▩	▩

X = DON'T CARE

DISPLAY BLANKING

Blanking the display may be accomplished by loading a blank or space into each digit of the display or by using the ($\overline{BL}$) display blank input.

Setting the ($\overline{BL}$) input low does not affect the contents of either data or cursor memory. A flashing display can be realized by pulsing ($\overline{BL}$).

A flashing circuit can easily be constructed using a 555 astable multivibrator. Figure 1 illustrates a circuit in which varying R1 (100K ~ 10K) will have a flash rate of 1 Hz ~ 10 Hz.

The display can be dimmed by pulse width modulating the ($\overline{BL}$) at a frequency sufficiently fast to not interfere with the internal clock. This clock frequency may vary from 200 Hz to 1.3 KHz. The dimming signal frequency should be 2.5 KHz or higher. Dimming the display also reduces power consumption.

An example of a simple dimming circuit using a 556 is illustrated in Figure 2. Adjusting potentiometer R2 will dim the display through frequency modulation (2.5 KHz to 4.4 KHz). Adjusting potentiometer R3 will dim the display by increasing the negative pulse width (10% to 50%).

FIGURE 1. FLASHING CIRCUIT FOR DL 2416T USING A 555

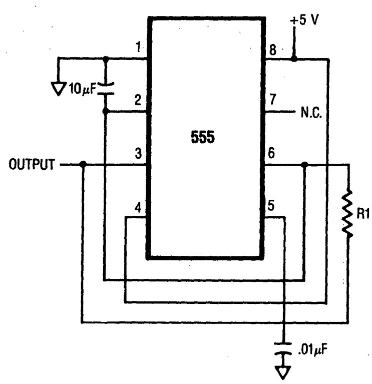
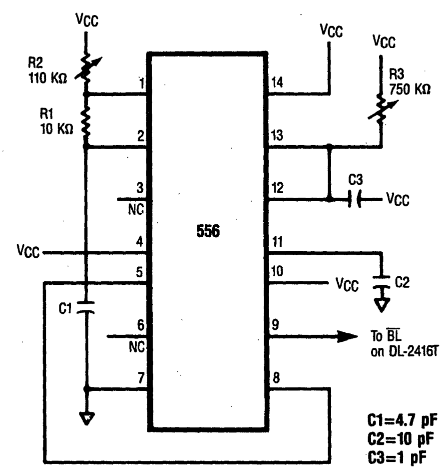


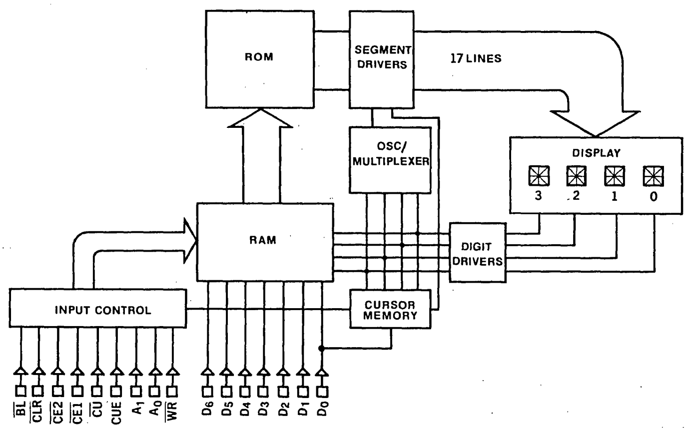
FIGURE 2. DIMMING CIRCUIT FOR DL 2416T USING A 556



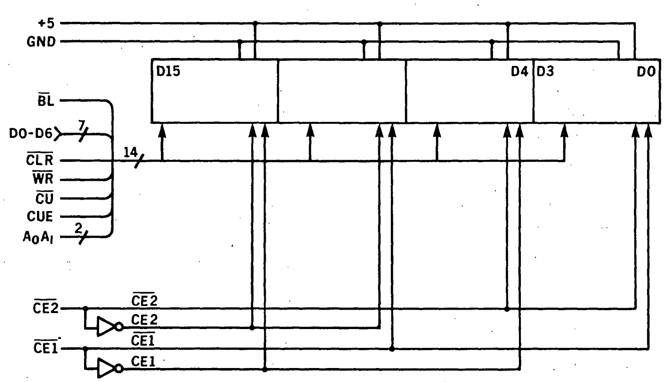
CHARACTER SET

D6	D5	D4																	
			D0	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H
			D1	L	L	H	H	L	L	H	H	L	L	H	H	L	L	H	H
			D2	L	L	L	L	H	H	H	H	L	L	L	L	H	H	H	H
			D3	L	L	L	L	L	L	L	L	H	H	H	H	H	H	H	H
			HEX	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
L	H	L	2		!	"	#	$	%	&	'	(	)	*	+	,	-	.	/
L	H	H	3	0	1	2	3	4	5	6	7	8	9	:	;	<	=	>	?
H	L	L	4	@	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
H	L	H	5	P	Q	R	S	T	U	V	W	X	Y	Z	[	\	]	^	_

All other input codes display "blank"



Internal Block Diagram



Typical Schematic for 16 Digit System

DL 2416T

DESIGN CONSIDERATIONS

For details on design and applications of the DL 2416T utilizing standard bus configurations in multiple display systems, or parallel I/O devices, such as the 8255 with an 8080 or memory mapped addressing on processors such as the 8080, Z80, 6502, 8748, or 6800 refer to Appnote 14, and 20, in the current Siemens Optoelectronic Data Book.

ELECTRICAL AND MECHANICAL CONSIDERATIONS

VOLTAGE TRANSIENT SUPPRESSION

It is highly recommended that the display and the components that interface with the display be powered by the same supply to avoid logic inputs higher than V_{CC}. Additionally, the LEDs may cause transients in the power supply line while they change display states. Common practice is to place .01 μF capacitors close to the displays across V_{CC} and GND, one for each display, and one 10 μF capacitor for every second display.

ESD PROTECTION

The metal gate CMOS IC of the DL 2416T is extremely immune to ESD damage. However, users of these devices are encouraged to take all the standard precautions normal for CMOS components. These include properly grounding personnel, tools, tables, and transport carriers that come in contact with unshielded parts. Where these conditions are not, or cannot be met, keep the leads of the device shorted together or the parts in anti-static packaging.

SOLDERING CONSIDERATIONS

The DL 2416T can be hand soldered with SN63 solder using a grounded iron set to 260°C.

Wave soldering is also possible following these conditions: Preheat that does not exceed 93°C on the solder side of the PC board or a package surface temperature of 85°C. Water soluble organic acid flux (except carboxylic acid) or resin-based RMA flux without alcohol can be used.

Wave temperature of 245°C ±5°C with a dwell between 1.5 sec. to 3.0 sec. Exposure to the wave should not exceed temperatures above 260°C, for 5 seconds at 0.063″ below the seating plane. The packages should not be immersed in the wave.

POST SOLDER CLEANING PROCEDURES

The least offensive cleaning solution is hot D.I. water (60°C) for less than 15 minutes. Addition of mild saponifiers is acceptable. Do not use commercial dishwasher detergents.

For faster cleaning, solvents may be used. Care should be exercised in choosing these as some may chemically attack the nylon package. Maximum exposure should not exceed two minutes at elevated temperatures. Acceptable solvents are TF (trichlorotrifluoroethane), TA, 111 Trichloroethane, and unheated acetone.(1)

Unacceptable solvents contain alcohol, methanol, methylene chloride, ethanol, TP35, TCM, TMC, TMS+, TE, and TES. Since many commercial mixtures exist, you should contact your solvent vendor for chemical composition information. Some major solvent manufacturers are: Allied Chemical Corporation, Specialty Chemical Division, Morristown, NJ; Baron-Blakeslee, Chicago, IL; Dow Chemical, Midland, MI; E.I. DuPont de Nemours & Co., Wilmington, DE.

For further information refer to Appnotes 18 and 19 in the current Siemens Optoelectronic Data Book.

An alternative to soldering and cleaning the display modules is to use sockets. Naturally, 18 pin DIP sockets .600″ wide with .100″ centers work well for single displays. Multiple display assemblies are best handled by longer SIP sockets or DIP sockets when available for uniform package alignment. Socket manufacturers are Aries Electronics, Inc., Frenchtown, NJ; Garry Manufacturing, New Brunswick, NJ; Robinson-Nugent, New Albany, IN; and Samtec Electronic Hardware, New Albany, IN.

For further information refer to Appnote 22 in the current Siemens Optoelectronic Data Book.

OPTICAL CONSIDERATIONS

The .160″ high characters of the DL 2416T allow readability up to eight feet. Proper filter selection will allow the user to build a display that can be utilized over this distance.

Filters allow the user to enhance the contrast ratio between a lit LED and the character background. This will maximize discrimination of different characters as perceived by the display user. The only limitation is cost. The cost/benefit ratio for filters can be maximized to the user's benefit by first considering the ambient lighting environment.

Incandescent (with almost no green) or fluorescent (with almost no red) lights do not have the flat spectral response of sunlight. Plastic band-pass filters are inexpensive and effective in optimizing contrast ratios. The DL 2416T is a standard red display and should be matched with a long wavelength pass filter in the 600 nm to 620 nm range. For display systems of multiple colors (using other Siemens' displays), neutral density grey filters offer the best compromise.

Additional contrast enhancement can be gained through shading the displays. Plastic band-pass filters with built-in louvers offer the "next step up" in contrast improvement. Plastic filters can be further improved with anti-reflective coatings to reduce glare. The trade-off is "fuzzy" characters. Mounting the filters close to the display reduces this effect. Care should be taken not to overheat the plastic filters by allowing for proper air flow.

Optimal filter enhancements for any condition can be gained through the use of circular polarized, anti-reflective, band-pass filters. The circular polarizing further enhances contrast by reducing the light that travels through the filter and reflects back off the display to less than 1%.

Several filter manufacturers supply quality filter materials. Some of them are: Panelgraphic Corporation, W. Caldwell, NJ; SGL Homalite, Wilmington, DE; 3M Company, Visual Products Division, St. Paul, MN; Polaroid Corporation, Polarizer Division, Cambridge, MA; Marks Polarized Corporation, Deer Park, NY; Hoya Optics, Inc., Fremont, CA.

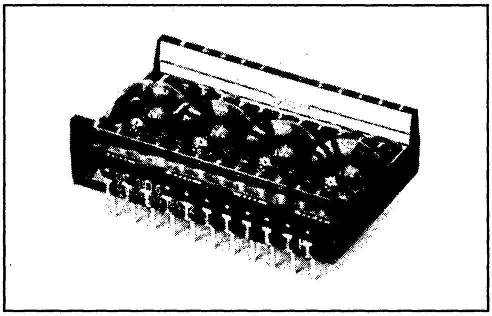
One last note on mounting filters. Recessing display and bezel assemblies is an inexpensive way to provide a shading effect in overhead lighting situations. Several Bezel manufacturers are: R.M.F. Products, Batavia, IL; Nobex Components, Griffith Plastic Corp., Burlingame, CA; Photo Chemical Products of California, Santa Monica, CA; I.E.E.-Atlas, Van Nuys, CA.

Refer to Siemens Appnote 23 for further information.

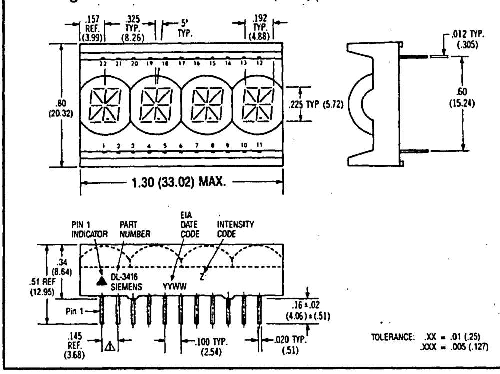
(1)Some commercial names for acceptable compounds are: Basic TF, Arklone P, Genesolve D, Blaco-tron TF, Freon TA, Genesolve DA, and Blaco-tron TA.

SIEMENS DL 3416

.225" Red, 4-Digit 16-Segment Plus Decimal ALPHANUMERIC Intelligent Display® With Memory/Decoder/Driver



Package Dimensions in Inches (mm)



FEATURES

- 0.225" × 0.192" Magnified Monolithic Character
- Wide Viewing Angle, X Axis ±45°, Y Axis ±55°
- Close Vertical Row Spacing, 0.8" centers
- Rugged Solid Plastic Encapsulated Package
- Fast Access Time, 300 ns
- Full Size Display for Stationary Equipment
- Built-in Memory
- Built-in Character Generator
- Built-in Multiplex and LED Drive Circuitry
- Each Digit Independently Addressed
- Independent Cursor Function
- 17th Segment for Improved Punctuation Marks
- Memory Clear Function
- Display Blank Function, for Blinking and Dimming
- End-Stackable, 4-Character Package
- Intensity Coded for Display Uniformity
- Extended Operating Temperature Range: −40°C to +85°C
- Wave Solderable
- 100% Burned In and Tested
- Superior ESD Immunity

DESCRIPTION

The DL 3416 is a four digit display module having 16 segments plus decimal and a built-in CMOS integrated circuit.

The integrated circuit contains memory, ASCII ROM decoder, multiplexing circuitry, and drivers. Data entry is asynchronous and can be random. A display system can be built using any number of DL 3416s since each digit of any DL 3416 can be addressed independently and will continue to display the character last stored until replaced by another.

System interconnection is very straightforward. The least significant two address bits (A_0, A_1) are normally connected to the like named inputs of all DL 3416s in the system. With four chip enables four DL 3416s (16 characters) can easily be interconnected without a decoder.

Alternatively, one-of-n decoder IC's can be used to extend the address for large displays.

Data lines are connected to all DL 3416s directly and in parallel, as is the write line ($\overline{WR}$). The display will then behave as a write-only memory.

The cursor function causes all segments of a digit position to illuminate. The cursor is *not* a character, however, and upon removal the previously displayed character will reappear.

All products are 100% burned-in and tested, then subjected to out-going AQL's of .25% for brightness matching, visual alignment and dimensions, .065% for electrical and functional.

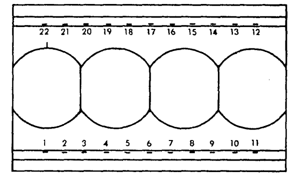
Maximum Ratings

Supply Voltage V_{CC} . . . . −0.5 V to +6.0 Vdc
Voltage, Any Pin Respect
to GND . . . . −0.5 V to (V_{CC} +0.5) Vdc
Operating Temperature. . . . . −40°C to +85°C
Storage Temperature . . . . −40°C to +100°C
Relative Humidity (non condensing) @85°C 85%
Maximum Solder Temperature, 1.59 mm (0.063″)
below Seating Plane, t<5 sec . . . . 260°C

Optical Characteristics

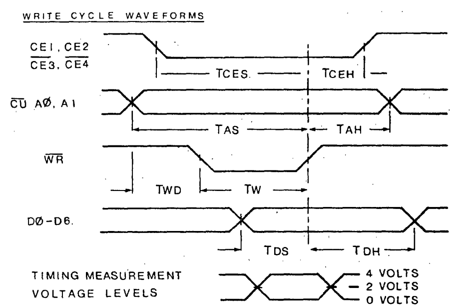
Spectral Peak Wavelength . . . . 660 nm typ.
Magnified digit size . . . . .225″×.192″
Time Averaged Luminous Intensity
(100% brightness,
8 segments/digit, V_{CC}=5 V) . . . . 0.5 mcd/digit min.
. . . . 1.0 mcd/digit typ.
LED to LED Intensity Matching . . . . 1.8:1.0 max.
Device to Device Intensity Matching (one bin) . 1.5:1.0 max.
Bin to Bin Intensity Matching . . . . 1.9:1.0 max.
Viewing Angle (off normal axis)
Horizontal . . . . ±40°
Vertical . . . . ±55°

TOP VIEW



Pin	Function	Pin	Function
1	CE1 Chip Enable	12	GND
2	$\overline{CE2}$ Chip Enable	13	N/C
3	$\overline{CE3}$ Chip Enable	14	$\overline{BL}$ Blanking
4	$\overline{CE4}$ Chip Enable	15	N/C
5	$\overline{CLR}$ Clear	16	D0 Data Input
6	VCC	17	D1 Data Input
7	A0 Digit Select	18	D2 Data Input
8	A1 Digit Select	19	D3 Data Input
9	$\overline{WR}$ Write	20	D4 Data Input
10	$\overline{CU}$ Cursor Select	21	D5 Data Input
11	CUE Cursor Enables	22	D6 Data Input

TIMING CHARACTERISTICS



DC CHARACTERISTICS

Parameter	−40°C Min.	−40°C Typ.	−40°C Max.	+25°C Min.	+25°C Typ.	+25°C Max.	+85°C Min.	+85°C Typ.	+85°C Max.	Units	Conditions
I_{CC}(1) 4 Digits on 10 segments/digit		100	130		85	115		70	100	mA	V_{CC}=5 V
I_{CC} Cursor(1, 2)		140	170		120	150		100	130	mA	V_{CC}=5 V
I_{CC} Blank(1)		2.0	5.0		1.5	4.0		1.0	2.7	mA	V_{CC}=5 V, $\overline{BL}$=0.8 V
I_{IL} (all inputs)		80	180		60	160		45	90	μA	V_{IN}=0.8 V, V_{CC}=5.0 V
V_{IH}	2.7			2.7			2.7			V	V_{CC}=5 V±0.5 V
V_{IL}			0.6			0.6			0.6	V	V_{CC}=5 V±0.5 V

Notes: 1. Measured at 5 sec.
2. 60 sec. max. duration.

DL 3416

AC CHARACTERISTICS Guaranteed Minimum Timing Parameters @4.5 V $\leq V_{CC} \leq$ 5.5 V

Parameter	Symbol	−40°C (ns)	+25°C (ns)	+85°C (ns)
Chip Enable Set Up Time	T_{CES}	175	275	375
Address Set Up Time	T_{AS}	175	275	375
Cursor Set Up Time	T_{CUS}	175	275	375
Chip Enable Hold Time	T_{CEH}	25	25	75
Address Hold Time	T_{AH}	25	25	75
Cursor Hold Time	T_{CUH}	25	25	75
Write Delay Time	T_{WD}	50	50	75
Write Time	T_W	125	225	300
Data Set Up Time	T_{DS}	100	150	225
Data Hold Time	T_{DH}	25	25	75
Clear(3)	T_{CLR}	15 ms	15 ms	16 ms
Access Time(2)	T_{ACC}	200	300	450

Notes: 1. V_{CC}=4.5 V is worst case, all timing parameters improve as V_{CC} increases.
2. Access time $T_{ACC} = T_{AS} + T_{DH}$
3. Clear timing in miliseconds.

LOADING DATA

Setting the chip enable (CE1, CE2, $\overline{CE3}$, $\overline{CE4}$) to their true state will enable loading. The desired data code (D0-D6) and digit address (A_0, A_1) should be held stable during the write cycle for storing new data.

Data entry may be asynchronous and random. (Digit 0 is defined as a right hand digit with $A_1 = A_0 = 0$.)

Clearing of the entire internal four-digit memory can be accomplished by holding the clear ($\overline{CLR}$) low for one complete display multiplex cycle, 15 mS minimum. The clear function will clear both the ASCII RAM and the cursor RAM. Loading an illegal data code will display a blank.

TYPICAL LOADING DATA STATE TABLE

$\overline{BL}$	CE1	CE2	$\overline{CE3}$	$\overline{CE4}$	CUE	$\overline{CU}$	$\overline{WR}$	$\overline{CLR}$	A1	A0	D6	D5	D4	D3	D2	D1	D0	DIGIT 3	2	1	0
H	X	X	X	X	L	X	H	H	PREVIOUSLY LOADED DISPLAY									G	R	E	Y
H	L	X	X	X	L	X	X	H	X	X	X	X	X	X	X	X	X	G	R	E	Y
H	X	L	X	X	L	X	X	H	X	X	X	X	X	X	X	X	X	G	R	E	Y
H	X	X	H	X	L	X	X	H	X	X	X	X	X	X	X	X	X	G	R	E	Y
H	X	X	X	H	L	X	X	H	X	X	X	X	X	X	X	X	X	G	R	E	Y
H	X	X	X	X	L	X	H	H	X	X	X	X	X	X	X	X	X	G	R	E	Y
H	H	H	L	L	L	H	L	H	L	L	H	L	L	L	H	L	H	G	R	E	E
H	H	H	L	L	L	H	L	H	L	H	H	L	H	L	H	L	H	G	R	U	E
H	H	H	L	L	L	H	L	H	H	L	H	L	L	H	H	L	L	G	L	U	E
H	H	H	L	L	L	H	L	H	H	H	H	L	L	L	L	H	L	B	L	U	E
L	X	X	X	X	X	X	H	H	X	X	BLANK DISPLAY										
H	H	H	L	L	L	H	L	H	H	H	H	L	L	L	H	H	H	G	L	U	E
H	X	X	X	X	L	X	X	L	CLEARS CHARACTER DISPLAY												
H	H	H	L	L	L	H	L	H	X	X	SEE CHARACTER CODE							SEE CHARACTER SET			

X = DON'T CARE

LOADING CURSOR

Setting the chip enables (CE1, CE2, $\overline{CE3}$, $\overline{CE4}$) and cursor select ($\overline{CU}$) to their true state will enable cursor loading. A write ($\overline{WR}$) pulse will now store or remove a cursor into the digit location addressed by A_0, A_1; as defined in data entry. A cursor will be stored if D0=1; and will be removed if D0=0. Cursor will not be cleared by the CLR signal. The cursor ($\overline{CU}$) pulse width should not be less than the write pulse ($\overline{WR}$) width or erroneous data may appear in the display.

For those users not requiring the cursor, the cursor enable signal (CUE) may be tied low to disable display of the cursor function. A flashing cursor can be realized by simply pulsing CUE. If the cursor has been loaded to any or all positions in the display, then CUE will control whether the cursor(s) or the characters appear. CUE does not affect the contents of cursor memory.

LOADING CURSOR STATE TABLE

$\overline{BL}$	CE1	CE2	$\overline{CE3}$	$\overline{CE4}$	CUE	$\overline{CU}$	$\overline{WR}$	$\overline{CLR}$	A1	A0	D6	D5	D4	D3	D2	D1	D0	DIGIT 3	2	1	0
H	X	X	X	X	L	X	H	H	PREVIOUSLY LOADED DISPLAY									B	E	A	R
H	X	X	X	X	H	X	H	H	DISPLAY PREVIOUSLY STORED CURSORS									B	E	A	R
H	H	H	L	L	H	L	L	H	L	L	X	X	X	X	X	X	H	B	E	A	⊠
H	H	H	L	L	H	L	L	H	L	H	X	X	X	X	X	X	H	B	E	⊠	⊠
H	H	H	L	L	H	L	L	H	H	L	X	X	X	X	X	X	H	B	⊠	⊠	⊠
H	H	H	L	L	H	L	L	H	H	H	X	X	X	X	X	X	H	⊠	⊠	⊠	⊠
H	H	H	L	L	H	L	L	H	H	L	X	X	X	X	X	X	L	⊠	E	⊠	⊠
H	X	X	X	X	L	X	H	H	DISABLE CURSOR DISPLAY									B	E	A	R
H	H	H	L	L	L	L	L	H	H	H	X	X	X	X	X	X	L	B	E	A	R
H	X	X	X	X	H	X	H	H	DISPLAY STORED CURSORS									B	E	⊠	⊠

X = DON'T CARE

DISPLAY BLANKING

Blanking the display may be accomplished by loading a blank or space into each digit of the display or by using the ($\overline{BL}$) display blank input.

Setting the ($\overline{BL}$) input low does not affect the contents of either data or cursor memory. A flashing display can be realized by pulsing ($\overline{BL}$). A flashing circuit can be constructed using a 555 astable multivibrator.

Figure 1 illustrates a circuit in which varying R1 (100K~10K) will have a flash rate of 1 Hz~10 Hz.

The display can be dimmed by pulsing the ($\overline{BL}$) line at a frequency sufficiently fast to not interfere with the internal clock. This clock frequency may vary from 200 Hz to 1.3 Hz. The dimming signal frequency should be 2.5 Hz or higher. Dimming the display also reduces power consumption.

An example of a simple dimming circuit using a 556 is illustrated in Figure 2. Adjusting potentiometer R2 will dim the display through frequency modulation (2.5 KHz to 4.4 KHz). Adjusting potentiometer R3 will dim the display by increasing the negative pulse width (10% to 50%).

FIGURE 1. FLASHING CIRCUIT FOR DL 3416 USING A 555

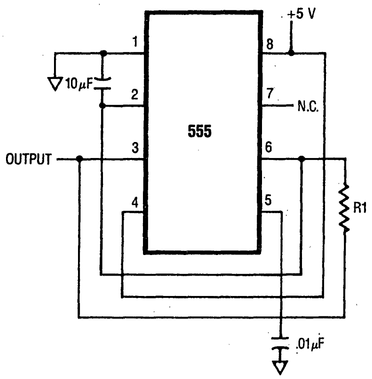
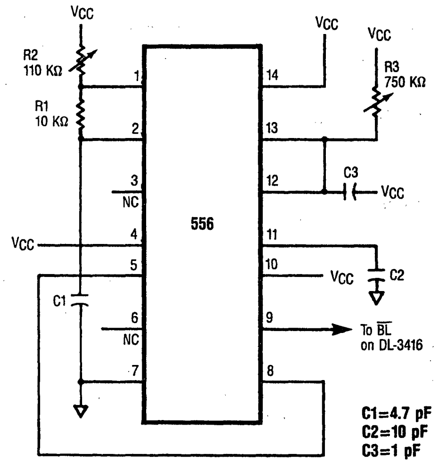
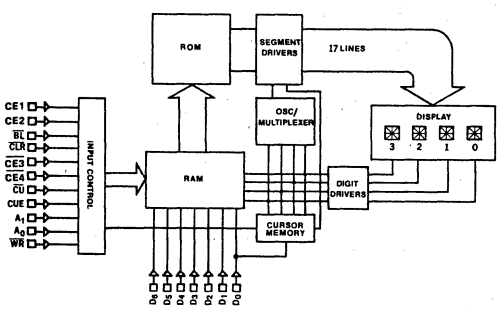


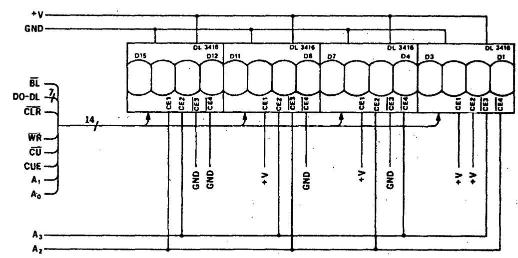
FIGURE 2. DIMMING CIRCUIT FOR DL 3416 USING A 556



Internal Block Diagram



Typical Schematic for 16 Digits



Typical Schematic for 16 Digits

CHARACTER SET

			D0	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H
			D1	L	L	H	H	L	L	H	H	L	L	H	H	L	L	H	H
			D2	L	L	L	L	H	H	H	H	L	L	L	L	H	H	H	H
			D3	L	L	L	L	L	L	L	L	H	H	H	H	H	H	H	H
D6	D5	D4	HEX	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
L	H	L	2		!	"	#	$	%	&	'	(	)	*	+	,	-	.	/
L	H	H	3	0	1	2	3	4	5	6	7	8	9	:	;	<	=	>	?
H	L	L	4	@	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
H	L	H	5	P	Q	R	S	T	U	V	W	X	Y	Z	[	\	]	^	_

ALL OTHER CODES DISPLAY BLANK

DESIGN CONSIDERATIONS

For ideas on design and applications of the DL 3416 utilizing standard bus configurations in multiple display systems, or parallel I/O devices, such as the 8255 with an 8080 or memory mapped addressing on processors such as the 8080, Z80, 6502, 8748, or 6800 refer to Appnote 14, and 20, in the current Siemens Optoelectronic Data Book.

ELECTRICAL AND MECHANICAL CONSIDERATIONS

VOLTAGE TRANSIENT SUPPRESSION

It is highly recommended that the display and the components that interface with the display be powered by the same supply to avoid logic inputs higher than V_{CC}. Additionally, the LEDs may cause transients in the power supply line while they change display states. Common practice is to place .01 μF capacitors close to the displays across V_{CC} and GND, one for each display, and one 10 μF capacitor for every second display.

ESD PROTECTION

The metal Gate CMOS IC of the DL 3416 is extremely immune to ESD damage. However, users of these devices are encouraged to take all the standard precautions, normal for CMOS components. These include properly grounding personnel, tools, tables, and transport carriers that come in contact with unshielded parts. If these conditions are not, or cannot be met, keep the leads of the device shorted together or the parts in anti-static packaging.

SOLDERING CONSIDERATIONS

The DL 3416 can be hand soldered with SN63 solder using a grounded iron set to 260°C.

Wave soldering is also possible following these conditions: Preheat that does not exceed 93°C on the solder side of the PC board or a package surface temperature of 85°C. Water soluble organic acid flux (except carboxylic acid) or resin-based RMA flux without alcohol can be used.

Wave temperature of 245°C ±5°C with a dwell between 1.5 sec. to 3.0 sec. Exposure to the wave should not exceed temperatures above 260°C, for 5 seconds at 0.063″ below the seating plane. The packages should not be immersed in the wave.

POST SOLDER CLEANING PROCEDURES

The least offensive cleaning solution is hot D.I. water (60°C) for less than 15 minutes. Addition of mild saponifiers is acceptable. Do not use commercial dishwasher detergents.

For faster cleaning, solvents may be used. Care should be exercised in choosing these as some may chemically attack the nylon package. Maximum exposure should not exceed two minutes at elevated temperatures. Acceptable solvents are TF (trichlorotrifluoroethane), TA, 111 Trichloroethane, and unheated acetone.

Unacceptable solvents contain alcohol, methanol, methylene chloride, ethanol, TP35, TCM, TMC, TMS+, TE, and TES. Since many commercial mixtures exist, you should contact your solvent vendor for chemical composition information. Some major solvent manufacturers are: Allied Chemical Corporation, Specialty Chemical Division, Morristown, NJ; Baron-Blakeslee, Chicago, IL; Dow Chemical, Midland, MI; E.I. DuPont de Nemours & Co., Wilmington, DE.

For further information refer to Appnotes 18 and 19 in the current Siemens Optoelectronic Data Book.

An alternative to soldering and cleaning the display modules is to use sockets. Naturally, 22-pin DIP sockets .600″ wide with .100″ centers work well for single displays. Multiple display assemblies are best handled by longer SIP sockets or DIP sockets when available for uniform package alignment. Socket manufacturers are Aries Electronics, Inc., Frenchtown, NJ; Garry Manufacturing, New Brunswick, NJ; Robinson-Nugent, New Albany, IN; and Samtec Electronic Hardware, New Albany, IN.

For further information refer to Appnote 22 in the current Siemens Optoelectronic Data Book.

OPTICAL CONSIDERATIONS

The .225″ high characters of the DL 3416 allow readability up to twelve feet. Proper filter selection will allow the user to build a display that can be utilized over this distance.

Filters allow the user to enhance the contrast ratio between a lit LED and the character background. This will maximize discrimination of different characters as perceived by the display user. The only limitation is cost. The cost/benefit ratio for filters can be maximized to the user's benefit by first considering the ambient lighting environment.

Incandescent (with almost no green) or fluorescent (with almost no red) lights do not have the flat spectral response of sunlight. Plastic band-pass filters are inexpensive and effective in optimizing contrast ratios. The DL 3416 is a standard red display and should be matched with a long wavelength pass filter in the 600 nm to 620 nm range. For display systems of multiple colors (using other Siemens' displays), neutral density grey filters offer the best compromise.

Additional contrast enhancement can be gained through shading the displays. Plastic band-pass filters with built-in louvers offer the "next step up" in contrast improvement. Plastic filters can be further improved with anti-reflective coatings to reduce glare. The trade-off is "fuzzy" characters. Mounting the filters close to the display reduces this effect. Care should be taken not to overheat the plastic filters by allowing for proper air flow.

Optimal filter enhancements for any condition can be gained through the use of circular polarized, anti-reflective, band-pass filters. The circular polarizing further enhances contrast by reducing the light that travels through the filter and reflects back off the display to less than 1%.

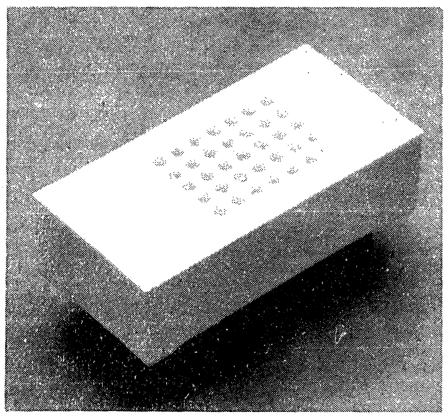
Several filter manufacturers supply quality filter materials. Some of them are: Panelgraphic Corporation, W. Caldwell, NJ; SGL Homalite, Wilmington, DE; 3M Company, Visual Products Division, St. Paul, MN; Polaroid Corporation, Polarizer Division, Cambridge, MA; Marks Polarized Corporation, Deer Park, NY; Hoya Optics, Inc., Fremont, CA.

One last note on mounting filters: recessing display and bezel assemblies is an inexpensive way to provide a shading effect in overhead lighting situations. Several Bezel manufacturers are: R.M.F. Products, Batavia, IL; Nobex Components, Griffith Plastic Corp., Burlingame, CA; Photo Chemical Products of California, Santa Monica, CA; I.E.E.-Atlas, Van Nuys, CA.

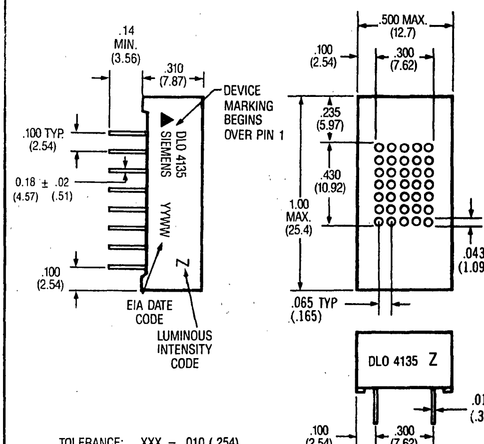
Refer to Siemens Appnote 23 for further information.

SIEMENS

HIGH EFFICIENCY RED DLO 4135
GREEN DLG 4137
.43" SINGLE CHARACTER 5 x 7 DOT MATRIX Intelligent Display® WITH MEMORY/DECODER/DRIVER



Package Dimension in Inches (mm)



TOLERANCE: .XXX = .010 (.254)

FEATURES

- 0.43" High, Dot Matrix Character
- Wide Viewing Angle, ±75°
- 96 Character ASCII Format - Both Upper Case and Lower Case Characters
- Fully Encapsulated, Rugged Solid Plastic Package
- Built-In Memory
- Built-In Character Generator
- Built-In Multiplex and LED Drive Circuitry
- Built-In Lamp Test
- Intensity Control (4 levels)
- Microprocessor Bus Compatible
- Intensity Coded for Display Uniformity
- Single 5-volt Power Supply Required
- X/Y Stackable
- Available in High Efficiency Red and Green

DESCRIPTION

The DLO 4135/DLG 4137 are single digit 5 x 7 dot matrix Intelligent Display devices with 0.43" character height. The built-in CMOS integrated circuit contains memory, ASCII character generator, LED multiplexing and drive circuitry; thereby eliminating the need for additional circuitry. They will display the 96 ASCII characters.

These devices are TTL and microprocessor compatible and offer the possibility of cascading the displays, allowing for multi-character messages. These displays were designed for viewing distances of up to 20 feet. They require a single 5-volt power supply and parallel ASCII input.

All products are 100% burned-in and tested, then subjected to out-going AQL's of .25% for brightness matching, visual alignment and dimensions, .065% for electrical and functional.

Important: Refer to Appnote 18, "Using and Handling Intelligent Displays". Since this is a CMOS device, normal precautions should be taken to avoid static damage.

Maximum Ratings

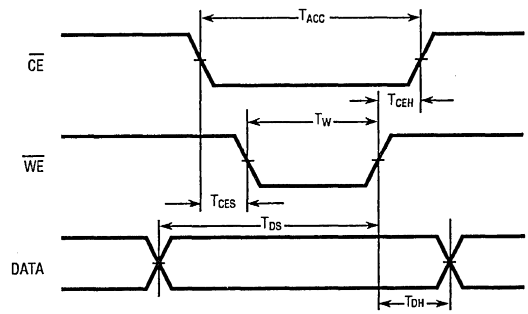
V_{CC} Range (max.) .... -0.5 to 7.0 V
Voltage, Any Pin
Respect to GND .... −0.5 to V_{CC} +0.5 Vdc
Operating Temperature............... -40°C to +85°C
Storage Temperature ....-40°C to +100°C
Maximum Solder Temperature 0.063″
above Seating Plane, t<5 sec ....260°C
Relative Humidity @85°C (non-condensing).........85%

Optical Characteristics (Typical) @25°C

Time Average Luminous Intensity/Dot @5 V
DLO 4135 ....1500 µcd
DLG 4137 ....1500 µcd
Digit Size....................................0.43″
Viewing Angle (Note 1) ....±75°
Spectral Peak Wavelength
DLO 4135 .... 630 nm
DLG 4137 .... 565 nm
Dot to Dot Intensity Ratio..................... 1.8:1.0

TIMING PARAMETERS @25°C, V_{CC}=5.0 V ±0.5 V

Symbol	Parameter	Units (ns)
T_{CES}	Chip Enable Set-Up	10
T_{DS}	Data Set-Up	100
T_W	Write Pulse	120
T_{DH}	Data Hold	20
T_{CEH}	Chip Enable Hold	20
T_{ACC}	Access Time	150



DC CHARACTERISTICS

Parameter	-40°C			+25°C			+85°C			Units	Conditions
	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.		
I_{CC} (20 dots on)		135	180		100	140		85	115	mA	V_{CC}=5 V $\overline{BL0}$=$\overline{BL1}$=5 V
I_{CC} Blank		2.0	5.5		1.5	4.0		0.8	3.5	mA	V_{CC}=$\overline{WR}$=5.0 V $\overline{BL0}$=$\overline{BL1}$=0 V
I_{IL} (all inputs)				25	50	100				µA	V_{IN}=0.8 V V_{CC}=5.0 V ±0.5 V
V_{IH}	2.0			2.0			2.0			V	V_{CC}=5.0 V ±0.5 V
V_{IL}			0.8			0.8			0.8	V	V_{CC}=5.0 V ±0.5 V
V_{CC}	4.5	5.0	5.5	4.5	5.0	5.5	4.5	5.0	5.5	V	

Notes:
1. "Off Axis Viewing Angle" is here defined as: "the minimum angle in any direction from the normal to the display surface at which any part of any dot in the display is not visible."
2. **This display contains a CMOS integrated circuit. Normal CMOS handling precautions should be taken to avoid damage due to high static voltages or electric fields. See Appnote 18.**
3. Unused inputs must be tied to an appropriate logic voltage level (either V+ or GND).
4. V_{CC}=5.0 VDC ±10%.
5. Clean only in water, isopropyl alcohol, freon TF, or TE (or equivalent).

LOADING DATA

Loading data into the DLO 4135/DLG 4137 is straightforward. Chip enable ($\overline{CE}$) should be present and stable during a write pulse ($\overline{WR}$). Parallel data information should be stable for the minimum time (T_W) and held for T_{DH} after write has gone high. No synchronization is necessary and each character will continue to be displayed until it is replaced with another. Multiple displays may be stacked together with only an additional decoder IC for chip enable decoding.

Note 6: Either $\overline{BL0}$ or $\overline{BL1}$ should be held high for display to light up.

LAMP TEST

The lamp test ($\overline{LT}$) when activated causes all dots on the display to be illuminated at 1/7 brightness. The lamp test function is independent of write ($\overline{WR}$) and the settings of the blanking inputs ($\overline{BL0}$, $\overline{BL1}$).

This convenient test gives a visual indication that all dots are functioning properly. Lamp test may also be used as a cursor function or pointer which does not destroy previously displayed characters.

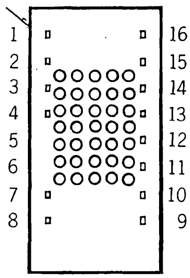
DIMMING AND BLANKING THE DISPLAY

Brightness Level	$\overline{BL1}$	$\overline{BL0}$
Blank	0	0
1/7 Brightness	0	1
1/2 Brightness	1	0
Full Brightness	1	1

DATA LOADING EXAMPLE

$\overline{CE}$	$\overline{WR}$	$\overline{BL0}$	$\overline{BL1}$	$\overline{LT}$	DATA INPUT D6	D5	D4	D3	D2	D1	D0	
H	X	H	X	H	X	X	X	X	X	X	X	NC
X	X	L	L	H	X	X	X	X	X	X	X	BLANK
X	X	X	X	L	X	X	X	X	X	X	X	LMP TEST
L	L	H	H	H	H	L	L	L	L	L	H	A
L	L	H	H	H	H	H	H	L	L	H	L	r
L	L	H	H	H	L	H	H	L	L	H	H	3
L	L	H	H	H	L	H	L	H	L	H	H	+

X = Don't Care
NC = No Change

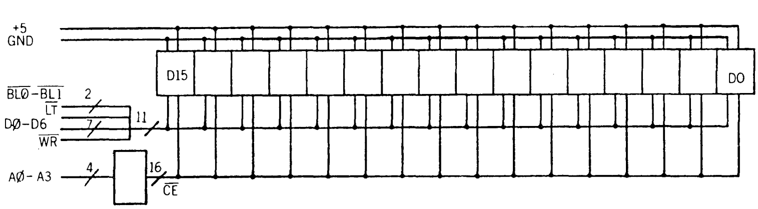


PIN FUNCTIONS			
PIN	FUNCTION	PIN	FUNCTION
1	$\overline{LT}$ LAMP TEST	9	D0 DATA LSB
2	$\overline{WR}$ WRITE	10	D1 DATA
3	$\overline{BL1}$ BRIGHTNESS	11	D2 DATA
4	$\overline{BL0}$ BRIGHTNESS	12	D3 DATA
5	NO PIN	13	D4 DATA
6	NO PIN	14	D5 DATA
7	$\overline{CE}$ CHIP ENABLE	15	D6 DATA MSB
8	GND	16	+ VCC

CHARACTER SET

			D0	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H
			D1	L	L	H	H	L	L	H	H	L	L	H	H	L	L	H	H
			D2	L	L	L	L	H	H	H	H	L	L	L	L	H	H	H	H
			D3	L	L	L	L	L	L	L	L	H	H	H	H	H	H	H	H
D6	D5	D4	HEX	Ø	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
L	L	L	Ø	THESE CODES DISPLAY BLANK															
L	L	H	1																
L	H	L	2		!	"	#	$	%	&	'	(	)	*	+	,	-	.	/
L	H	H	3	0	1	2	3	4	5	6	7	8	9	:	;	<	=	>	?
H	L	L	4	@	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
H	L	H	5	P	Q	R	S	T	U	V	W	X	Y	Z	[	\	]	^	_
H	H	L	6	`	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o
H	H	H	7	p	q	r	s	t	u	v	w	x	y	z	{	|	}	~	▒

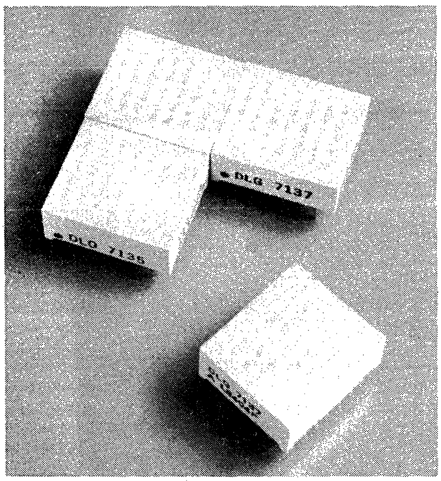
16 Digits Interconnection



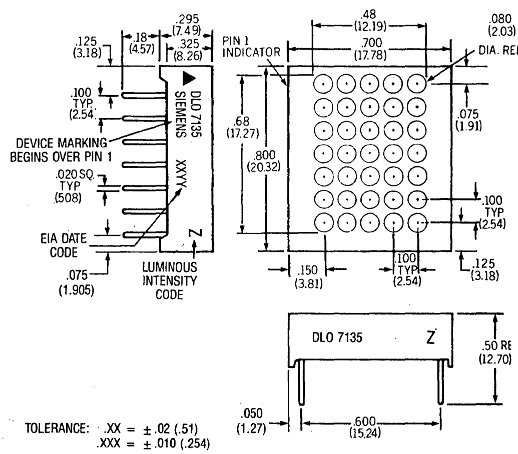
SIEMENS

HIGH EFFICIENCY RED DLO 7135
GREEN DLG 7137

.68" SINGLE CHARACTER 5 x 7 DOT MATRIX Intelligent Display® WITH MEMORY/DECODER/DRIVER



Package Dimensions in Inches (mm)



FEATURES

- 0.68" High, Dot Matrix Character
- Wide Viewing Angle, ±75°
- 96 Character ASCII Format - Both Upper Case and Lower Case Characters
- Fully Encapsulated, Rugged Solid Plastic Package
- Built-In Memory
- Built-In Character Generator
- Built-In Multiplex and LED Drive Circuitry
- Built-In Lamp Test
- Intensity Control (4 levels)
- Microprocessor Bus Compatible
- Intensity Coded for Display Uniformity
- Single 5-volt Power Supply Required
- X/Y Stackable
- Available in High Efficiency Red and Green

DESCRIPTION

The DLO 7135/DLG 7137 are single digit 5 x 7 dot matrix Intelligent Display devices with 0.68" character height. The built-in CMOS integrated circuit contains memory, ASCII character generator, LED multiplexing and drive circuitry; thereby eliminating the need for additional circuitry. They will display the 96 ASCII characters.

These devices are TTL and microprocessor compatible and offer the possibility of cascading the displays, allowing for multi-character messages. These displays were designed for viewing of up to 30 feet. They require a single 5-volt power supply and parallel ASCII input.

All products are 100% burned-in and tested, then subjected to out-going AQL's of .25% for brightness matching, visual alignment and dimensions, .065% for electrical and functional.

Important: Refer to Appnote 18, "Using and Handling Intelligent Displays". Since this is a CMOS device, normal precautions should be taken to avoid static damage.

Intelligent Display Devices

Maximum Ratings

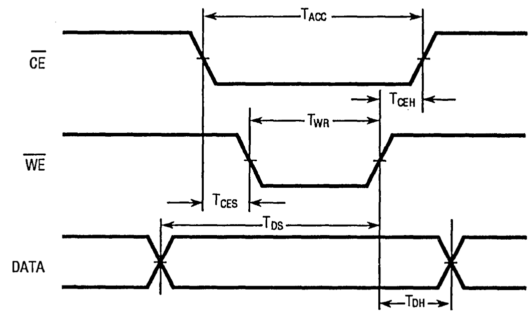
V_{CC} Range (max.) .... −0.5 to 7.0 V
Voltage, Any Pin
  Respect to GND .... −0.5 to V_{CC} +0.5 Vdc
Operating Temperature............... −40 °C to +85 °C
Storage Temperature .... −40 °C to +100 °C
Maximum Solder Temperature 0.063″
  below Seating Plane, t<5 sec................. 260 °C
Relative Humidity @85 °C (non-condensing) 85%

Optical Characteristics (Typical) @25 °C

Time Average Luminous Intensity/Dot @5 V
  DLO 7135 ....1500 μcd
  DLG 7137 ....1500 μcd
Digit Size...................................0.68″
Viewing Angle (Note 1) ....±75°
Spectral Peak Wavelength
  DLO 7135 .... 630 nm
  DLG 7137 .... 565 nm
Dot to Dot Intensity Ratio...................... 1.8:1.0

TIMING PARAMETERS @25 °C, V_{CC} = 5.0 V ±0.5 V

Symbol	Parameter	Units (ns)
T_{CES}	Chip Enable Set-Up	10
T_{DS}	Data Set-Up	100
T_W	Write Pulse	120
T_{DH}	Data Hold	20
T_{CEH}	Chip Enable Hold	20
T_{ACC}	Access Time	150



DC CHARACTERISTICS

Parameter	-40 °C			+25 °C			+85 °C			Units	Conditions
	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.		
I_{CC} (20 dots on)		155	200		125	160		105	135	mA	V_{CC} = 5 V $\overline{BL0}$ = $\overline{BL1}$ = 5 V
I_{CC} Blank		2.0	5.5		1.5	4.5		0.8	3.5	mA	V_{CC} = $\overline{WR}$ = 5.0 V $\overline{BL0}$ = $\overline{BL1}$ = 0 V
I_{IL} (all inputs)				25	50	100				μA	V_{IN} = 0.8 V V_{CC} = 5.0 V ±0.5 V
V_{IH}	2.0			2.0			2.0			V	V_{CC} = 5.0 V ±0.5 V
V_{IL}			0.8			0.8			0.8	V	V_{CC} = 5.0 V ±0.5 V
V_{CC}	4.5	5.0	5.5	4.5	5.0	5.5	4.5	5.0	5.5	V	

Notes:
1. "Off Axis Viewing Angle" is here defined as: "the minimum angle in any direction from the normal to the display surface at which any part of any dot in the display is not visible."
2. **This display contains a CMOS integrated circuit. Normal CMOS handling precautions should be taken to avoid damage due to high static voltages or electric fields. See Appnote 18.**
3. Unused inputs must be tied to an appropriate logic voltage level (either V+ or GND).
4. V_{CC} = 5.0 VDC ±10%.
5. Clean only in water, isopropyl alcohol, freon TF, or TE (or equivalent).

LOADING DATA

Loading data into the DLO 7135/DLG 7137 is straightforward. Chip enable ($\overline{CE}$) should be present and stable during a write pulse ($\overline{WR}$). Parallel data information should be stable for the minimum time (T_W) and held for T_{DH} after write has gone high. No synchronization is necessary and each character will continue to be displayed until it is replaced with another. Multiple displays may be stacked together with only an additional decoder IC for chip enable decoding.

LAMP TEST

The lamp test ($\overline{LT}$) when activated causes all dots on the display to be illuminated at 1/7 brightness. The lamp test function is independent of write ($\overline{WR}$) and the settings of the blanking inputs ($\overline{BL0}$, $\overline{BL1}$).

This convenient test gives a visual indication that all dots are functioning properly. Lamp test may also be used as a cursor function or pointer which does not destroy previously displayed characters.

Note 6: Either $\overline{BL0}$ or $\overline{BL1}$ should be held high for display to light up.

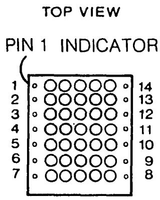
DIMMING AND BLANKING THE DISPLAY

Brightness Level	$\overline{BL1}$	$\overline{BL0}$
Blank	0	0
1/7 Brightness	0	1
1/2 Brightness	1	0
Full Brightness	1	1

DATA LOADING EXAMPLE

					DATA INPUT							
$\overline{CE}$	$\overline{WR}$	$\overline{BL0}$	$\overline{BL1}$	$\overline{LT}$	D6	D5	D4	D3	D2	D1	D0	
H	X	H	X	H	X	X	X	X	X	X	X	NC
X	X	L	L	H	X	X	X	X	X	X	X	BLANK
X	X	X	X	L	X	X	X	X	X	X	X	LMP TEST
L	L	H	H	H	H	L	L	L	L	L	H	A
L	L	H	H	H	H	H	H	L	L	H	L	r
L	L	H	H	H	L	H	H	L	L	H	H	3
L	L	H	H	H	L	H	L	H	L	H	H	+

X = Don't Care
NC = No Change

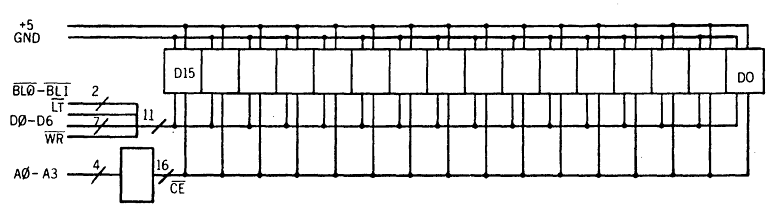


Pin	Function	Pin	Function
1	VCC	14	D6 Data input MSB
2	$\overline{LT}$ Lamp test	13	D5 Data input
3	$\overline{CE}$ Chip enable	12	D4 Data input
4	$\overline{WR}$ Write	11	D3 Data input
5	$\overline{BL1}$ Brightness	10	D2 Data input
6	$\overline{BL0}$ Brightness	9	D1 Data input
7	GND	8	D0 Data input LSB

CHARACTER SET

			D0	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H
			D1	L	L	H	H	L	L	H	H	L	L	H	H	L	L	H	H
			D2	L	L	L	L	H	H	H	H	L	L	L	L	H	H	H	H
			D3	L	L	L	L	L	L	L	L	H	H	H	H	H	H	H	H
D6	D5	D4	HEX	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
L	L	L	0	THESE CODES DISPLAY BLANK															
L	L	H	1																
L	H	L	2		!	"	#	$	%	&	'	(	)	*	+	,	-	.	/
L	H	H	3	0	1	2	3	4	5	6	7	8	9	:	;	<	=	>	?
H	L	L	4	@	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
H	L	H	5	P	Q	R	S	T	U	V	W	X	Y	Z	[	\	]	^	_
H	H	L	6	`	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o
H	H	H	7	p	q	r	s	t	u	v	w	x	y	z	{	|	}	~	▒

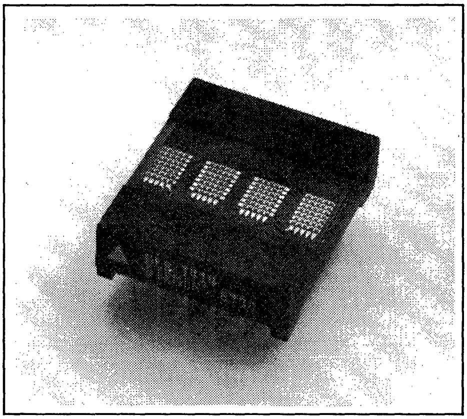
16 Digits Interconnection



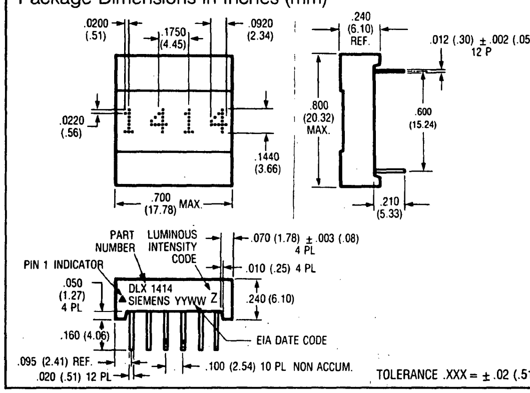
SIEMENS

RED DLR 1414
HIGH EFFICIENCY RED DLO 1414
GREEN DLG 1414

.145″ 4-Digit, Dot Matrix ALPHANUMERIC Intelligent Display® With Memory/Decoder/Driver



Package Dimensions in Inches (mm)



FEATURES

- Dot Matrix Replacement for DL 1414T
- 0.145″ High Dot Matrix Character
- 128 Special ASCII Characters for English, German, Italian, Swedish, Danish, and Norwegian Languages
- Wide Viewing Angle, X Axis ±50°, Y Axis ±75°
- Close Vertical Row Spacing, 0.800″
- Fast Access Time, 110 ns at 25°C
- Compact Size for Hand Held Equipment
- Built-in Memory
- Built-in Character Generator
- Built-in Multiplex and LED Drive Circuitry
- Direct Access to Each Digit Independently and Asynchronously
- TTL Compatible, 5-Volt Power
- Low Power Consumption, Typically 20 mA per Character
- Intensity Coded for Display Uniformity
- Extended Operating Temperature Range: -40°C to +85°C
- End-Stackable, 4-Character Package
- 100% Burned In and Tested

DESCRIPTION

The DLR/DLO/DLG 1414 is a four digit, 5x7 dot matrix display module with a built-in CMOS integrated circuit. This display is a drop-in dot matrix replacement for the segmented DL 1414T.

The integrated circuit contains memory, ASCII ROM decoder, multiplex circuitry and drivers. Data entry is asynchronous and can be random. A display system can be built using any number of DLR/DLO/DLG 1414s since each digit can be addressed independently and will continue to display the character last stored until replaced by another. System interconnection is very straightforward. The least significant two address bits (A_0, A_1) are normally connected to the like-named inputs of all displays in the system. Data lines are connected to all DLR/DLO/DLG 1414s directly and in parallel, as is the write line ($\overline{WR}$). The display then will behave as a write-only memory.

The DLR/DLO/DLG 1414 has several features superior to competitive devices. 100% burn-in processing insures that the DLR/DLO/DLG 1414 will function in more stressful assembly and use environments.

The character set consists of 128 special ASCII characters for English, German, Italian, Swedish, Danish, and Norwegian.

All products are 100% burned-in and tested, then subjected to out-going AQL's of .25% for brightness matching, visual alignment and dimensions, .065% for electrical and functional.

See Appnotes 18, 19, 22, and 23 for additional information.

Maximum Ratings

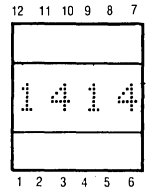
DC Supply Voltage .... −0.5 V to +7.0 Vdc
Input Voltage Levels Relative
  to GND (all inputs) .... −0.5 V to V_{CC} +0.5 Vdc
Operating Temperature .... −40°C to +85°C
Storage Temperature .... −40°C to +100°C
Maximum Solder Temperature, .063″ (1.59 mm)
  below Seating Plane, t<5 sec .... 260°C
Relative Humidity @ 85°C 85%

Optical Characteristics

Spectral Peak Wavelength .... Red 660 nm typ.
HER 630 nm typ.
Green 565 nm typ.
Display Multiplex Rate .... 200 Hz min.
Viewing Angle (off normal axis)
  horizontal .... ±50°
  vertical .... ±75°
Digit Height .... 0.145 inch
Time Averaged Luminous Intensity(1)
  (100% brightness, V_{CC} = 5 Vdc)
  Red .... 50 μcd/LED typ.
  HER .... 60 μcd/LED typ.
  Green .... 70 μcd/LED typ.
LED to LED Intensity Matching .... 1.8:1.0 max.
LED to LED Hue Matching @V_{CC} = 5 V
  (Green only) .... ±2 nm max.

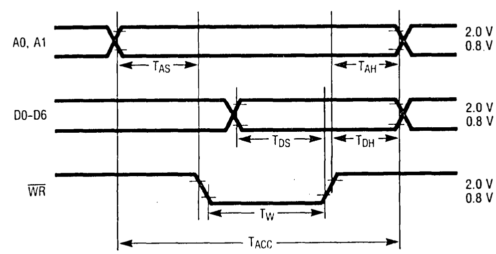
Note: 1. Peak luminous intensity values can be calculated by multiplying these values by 7.

TOP VIEW



Pin	Function
1	D5 Data Input
2	D4 Data Input
3	$\overline{WR}$ Write
4	A1 Digit Select
5	A0 Digit Select
6	V_{CC}
7	GND
8	D0 Data Input (LSB)
9	D1 Data Input
10	D2 Data Input
11	D3 Data Input
12	D6 Data Input (MSB)

TIMING CHARACTERISTICS (V_{CC} = 4.5 V)



Note: These waveforms are not edge triggered.

DC CHARACTERISTICS

Parameter	−40°C			+25°C			+85°C			Units	Conditions
	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.		
I_{CC} 4 Digits on 20 dots/digit		90	120		80	105		70	95	mA	V_{CC} = 5 V
I_{CC} Blank		2.8	4.0		2.3	3.0		2.0	2.5	mA	V_{CC} = $\overline{WR}$ = 5 V, V_{IN} = 0 V
I_{IL} (all inputs)	30	60	120	25	50	100	20	40	80	μA	V_{IN} = 0.8 V, V_{CC} = 5.0 V
V_{IH}	2.0			2.0			2.0			V	V_{CC} = 5.0 V ± 0.5 V
V_{IL}			0.8			0.8			0.8	V	V_{CC} = 5.0 V ± 0.5 V
V_{CC}	4.5	5.0	5.5	4.5	5.0	5.5	4.5	5.0	5.5	V	

AC CHARACTERISTICS Guaranteed Minimum Timing Parameters @V_{CC} = 5.0 V ±0.5 V

Parameter	Symbol	-40°C (ns)	+25°C (ns)	+85°C (ns)
Address Set Up Time	T_{AS}	10	10	10
Data Set Up Time	T_{DS}	20	30	50
Write Pulse Time	T_W	60	70	90
Address Hold Time	T_{AH}	20	30	40
Data Hold Time	T_{DH}	20	30	40
Total Access Time	T_{ACC}(1)	90	110	140

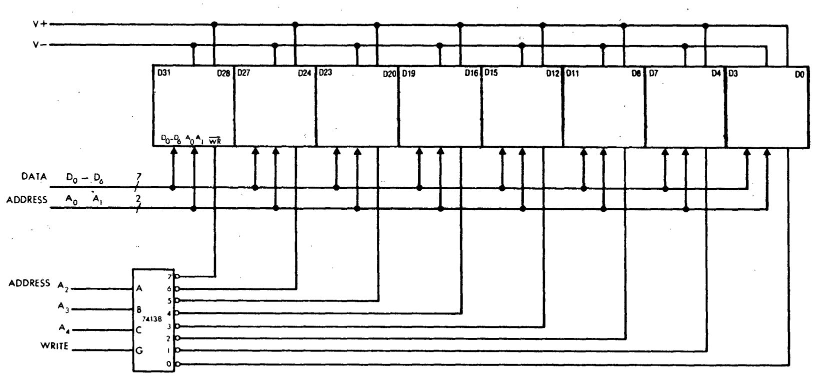
Note: 1. T_{ACC} = Set Up Time + Write Time + Hold Time.

LOADING DATA STATE TABLE

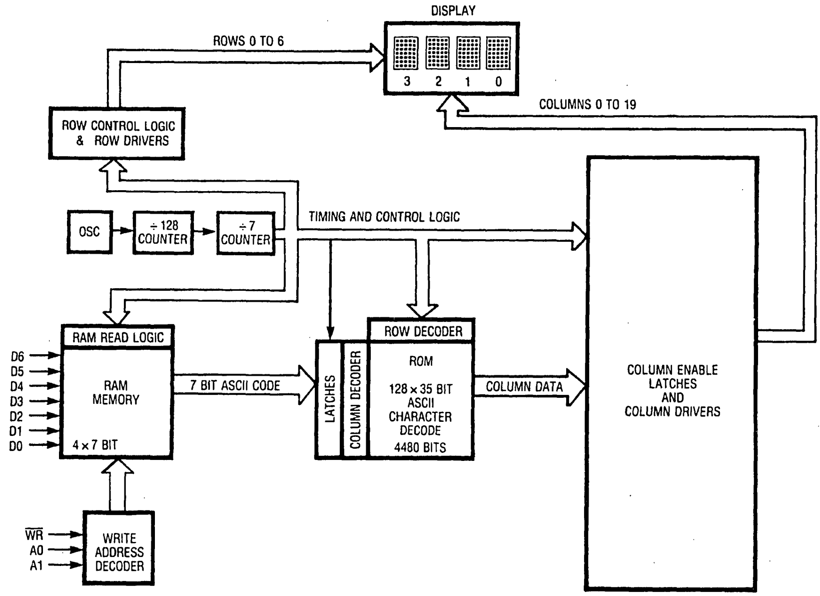
WR	A1	A0	D6	D5	D4	D3	D2	D1	D0	DIGIT 3	DIGIT 2	DIGIT 1	DIGIT 0
H		PREVIOUSLY LOADED DISPLAY								G	R	E	Y
L	L	L	H	L	L	L	H	L	H	G	R	E	E
L	L	H	H	L	H	L	H	L	H	G	R	U	E
L	H	L	H	L	L	H	H	L	L	G	L	U	E
L	H	H	H	L	L	L	L	H	L	B	L	U	E
L	L	H	H	L	L	L	H	L	H	B	L	E	E
L	L	L	H	L	H	L	H	H	H	B	L	E	W
L	X	X	SEE CHARACTER CODE							SEE CHARACTER SET			

X = DON'T CARE

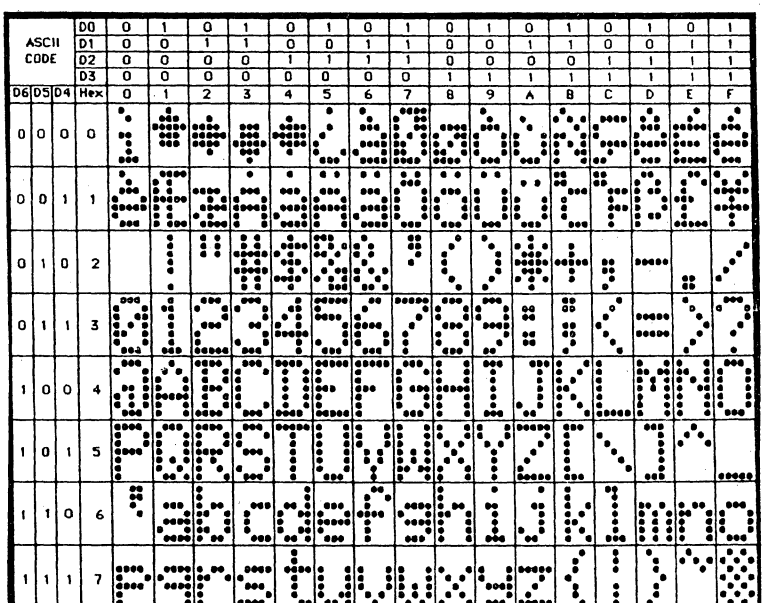
TYPICAL INTERCONNECTION FOR 32 DIGITS



BLOCK DIAGRAM



CHARACTER SET



Notes: 1. High = 1 level.
2. Low = 0 level.
3. Upon power up, the device will initialize in a random state.

DESIGN CONSIDERATIONS

For details on design and applications of the DLR/DLO/DLG 1414 utilizing standard bus configurations in multiple display systems, or parallel I/O devices, such as the 8255 with an 8080 or memory mapped addressing on processors such as the 8080, Z80, 6502, or 6800 refer to Appnote 15 in the current Siemens Optoelectronic Data Book.

ELECTRICAL AND MECHANICAL CONSIDERATIONS

VOLTAGE TRANSIENT SUPPRESSION

For best results power the display and the components that interface with the display with the same supply to avoid logic inputs higher than V_{CC}. Additionally, the LEDs may cause transients in the power supply line while they change display states. The common practice is to place .01 μF capacitors close to the displays across V_{CC} and GND, one for each display, and one 10 μF capacitor for every second display.

ESD PROTECTION

The silicon Gate CMOS IC of the DLR/DLO/DLG 1414 is very strong against ESD damage. It is capable of withstanding discharges greater than 2 KV. However, take all the standard precautions, normal for CMOS components. These include properly grounding personnel, tools, tables, and transport carriers that come in contact with unshielded parts. If these conditions are not, or cannot be met, keep the leads of the device shorted together or the parts in anti-static packaging.

SOLDERING CONSIDERATION

The DLR/DLO/DLG 1414 can be hand soldered with SN63 solder using a grounded iron set to 260°C.

Wave soldering is also possible following these conditions: Preheat that does not exceed 93°C on the solder side of the PC board or a package surface temperature of 85°C. Water soluble organic acid flux (except carboxylic acid) or resin-based RMA flux without alcohol can be used.

Wave temperature of 245°C ±5°C with a dwell between 1.5 sec. to 3.0 sec. Exposure to the wave should not exceed temperatures above 260°C, for 5 seconds at 0.063″ below the seating plane. The packages should not be immersed in the wave.

POST SOLDER CLEANING PROCEDURES

The least offensive cleaning solution is hot D.I. water (60°C) for less than 15 minutes. Addition of mild saponifiers is acceptable. Do not use commercial dishwasher detergents.

For faster cleaning, solvents may be used. Carefully select any solvent as some may chemically attack the nylon package. Maximum exposure should not exceed two minutes at elevated temperatures. Acceptable solvents are TF(trichlorotrifluoroethane), TA, 111 Trichloroethane, and unheated acetone.[1]

Unacceptable solvents contain alcohol, methanol, methylene chloride, ethanol, TP35, TCM, TMC, TMS+, TE, and TES. Since many commercial mixtures exist, you should contact your preferred solvent vendor for chemical composition information. Some major solvent manufacturers are: Allied Chemical Corporation, Specialty Chemical Division, Morristown, NJ; Baron-Blakeslee, Chicago, IL; Dow Chemical, Midland, MI; E.I. DuPont de Nemours & Co., Wilmington, DE.

For further information refer to Appnote 18 and 19 in the current Siemens Optoelectronic Data Book.

An alternative to soldering and cleaning the display modules is to use sockets. Standard pin DIP sockets .600″ wide with .100″ centers work well for single displays. Multiple display assemblies are best handled by longer SIP sockets or DIP sockets when available for uniform package alignment. Socket manufacturers are Aries Electronics, Inc., Frenchtown, NJ; Garry Manufacturing, New Brunswick, NJ; Robinson-Nugent, New Albany, IN; and Samtec Electronic Hardware, New Albany, IN.

For further information refer to Appnote 22 in the current Siemens Optoelectronic Data Book.

OPTICAL CONSIDERATIONS

The .145″ high characters of the DLR/DLO/DLG 1414 are readable up to six feet. To build a display readable from six feet, give careful consideration to proper filter selection. Filters enhance the contrast ratio between a lit LED and the character background, intensifying discrimination of different characters. The only limitation is cost. To maximize the cost/benefit ratio for filters first consider the ambient lighting environment.

Incandescent (with almost no green) or fluorescent (with almost no red) lights do not have the flat spectral response of sunlight. Plastic band-pass filters are inexpensive and effective in optimizing contrast ratios. The DLR 1414 is a standard red display and should be matched with a long wavelength pass filter in the 600 nm to 620 nm range.

The DLO 1414 is a high efficiency red display and should be matched with a long wavelength pass filter in the 570 nm to 590 nm range. The DLG 1414 should be matched with a yellow-green band-pass filter that peaks at 565 nm. For displays of multiple colors, neutral density grey filters offer the best compromise.

Additional contrast enhancement can be gained through shading the displays. Plastic band-pass filters with built-in louvers offer the "next step up" in contrast improvement. Plastic filters can be further improved with anti-reflective coatings to reduce glare. The trade-off is "fuzzy" characters. Mounting the filters close to the display reduces this effect, however to avoid overheating the plastic filters allow for proper air flow.

Optimal filter enhancements for any condition can be gained through the use of circular polarized, anti-reflective, band-pass filters. Circular polarizing further enhances contrast by reducing the light that travels through the filter and reflects back off the display to less than 1%.

Several filter manufacturers supply quality filter materials. Some of them are: Panelgraphic Corporation, W. Caldwell, NJ; SGL Homalite, Wilmington, DE; 3M Company, Visual Products Division, St. Paul, MN; Polaroid Corporation, Polarizer Division, Cambridge, MA; Marks Polarized Corporation, Deer Park, NY; Hoya Optics, Inc., Fremont, CA.

One last note on mounting filters: recessing display and bezel assemblies is an inexpensive way to provide a shading effect in overhead lighting situations. Several Bezel manufacturers are R.M.F. Products, Batavia, IL; Nobex Components, Griffith Plastic Corp., Burlingame, CA; Photo Chemical Products of California, Santa Monica, CA; I.E.E.-Atlas, Van Nuys, CA.

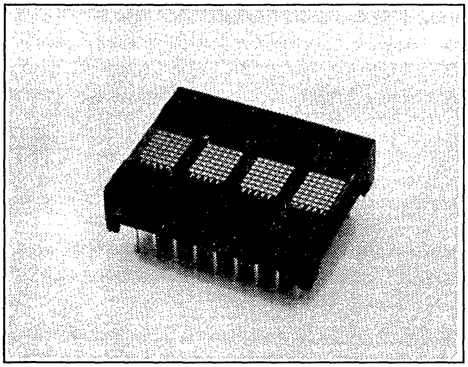
Refer to Siemens Appnote 23 for further information.

Note: 1. Acceptable commercial solvents are Basic TF, Arklone P, Genesolve D, Genesolve DA, Blaco-Tron TF, Blaco-Tron TA, and Freon TA.

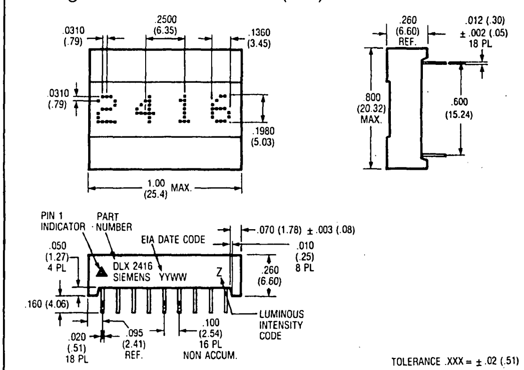
SIEMENS

RED DLR 2416
HIGH EFFICIENCY RED DLO 2416
GREEN DLG 2416

.200″ 4-Digit 5×7 Dot Matrix ALPHANUMERIC Intelligent Display® With Memory/Decoder/Driver



Package Dimensions in Inches (mm)



FEATURES

- **Dot Matrix Replacement for DL 2416T**
- **0.200″ 5 x 7 Dot Matrix Character**
- **128 Special ASCII Characters for English, German, Italian, Swedish, Danish, and Norwegian Languages**
- **Wide Viewing Angle, X Axis ±50° Max., Y Axis ±75° Max.**
- **Close Multi-line Spacing, 0.8″ Centers**
- **Fast Access Time, 110 ns at 25°C**
- **Full Size Display for Stationary Equipment**
- **Built-in Memory**
- **Built-in Character Generator**
- **Built-in Multiplex and LED Drive Circuitry**
- **Direct Access to Each Digit Independently and Asynchronously**
- **Independent Cursor Function**
- **Memory Function that Clears Character and Cursor Memory Simultaneously**
- **True Blanking for Intensity Dimming Applications**
- **End-Stackable, 4-Character Package**
- **Intensity Coded for Display Uniformity**
- **Extended Operating Temperature Range: −40°C to +85°C**
- **Superior ESD Immunity**
- **100% Burned In and Tested**
- **Wave Solderable**
- **TTL Compatible over Operating Temperature Range**
- **Interdigit blanking**

DESCRIPTION

The DLR/DLO/DLG 2416 is a four digit, 5×7 dot matrix display module with a built-in CMOS integrated circuit. This display is a "drop-in" dot matrix replacement for the DL 2416T.

The integrated circuit contains memory, ASCII ROM decoder, multiplexing circuitry, and drivers. Data entry is asynchronous and can be random. A display system can be built using any number of DLR/DLO/DLG 2416 since each digit can be addressed independently and will continue to display the character last stored until replaced by another.

System interconnection is very straightforward. The least significant two address bits (A_0, A_1) are normally connected to the like-named inputs of all displays in the system. With two chip enables ($\overline{CE1}$, and $\overline{CE2}$) four displays (16 characters) can easily be interconnected without a decoder.

Data lines are connected to all DLR/DLO/DLG 2416s directly and in parallel, as is the write line ($\overline{WR}$). The display will then behave as a write-only memory.

The cursor function causes all dots of a digit position to illuminate at half brightness. The cursor is *not* a character, however, and upon removal the previously displayed character will reappear.

The DLR/DLO/DLG 2416 has several features superior to competitive devices. 100% burn-in processing insures that the DLR/DLO/DLG 2416 will function in more stressful assembly and use environments. The "true blanking" allows the designer to dim the display for more flexibility of display presentation. Finally, the $\overline{CLR}$ clear function will clear the cursor RAM and the ASCII character RAM, simultaneously.

—Continued

See Appnotes 18, 19, 22, and 23 for additional information.

DESCRIPTION (Continued)

The character set consists of 128 special ASCII characters for English, German, Italian, Swedish, Danish, and Norwegian.

All products are 100% burned-in and tested, then subjected to out-going AQL's of .25% for brightness matching, visual alignment and dimensions, .065% for electrical and functional.

Maximum Ratings

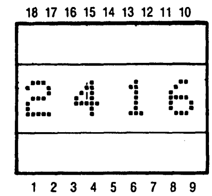
DC Supply Voltage ....−0.5 V to +7.0 Vdc
Input Voltage, Respect to GND
(all inputs) ....−0.5 V to V_{CC} +0.5 Vdc
Operating Temperature ....−40°C to +85°C
Storage Temperature ....−40°C to +100°C
Relative Humidity @ 85°C 85%
Maximum Solder Temperature, 1.59 mm (0.063″)
below Seating Plane, t<5 sec ....260°C

Optical Characteristics

Spectral Peak Wavelength .... Red 660 nm typ.
HER 630 nm typ.
Green 565 nm typ.
Digit Height .... 0.200″ (5.08 mm)
Time Averaged Luminous Intensity(1)
@V_{CC}=5 V
Red .... 60 μcd/LED typ.
HER ....100 μcd/LED typ.
Green ....120 μcd/LED typ.
LED to LED Intensity Matching
@V_{CC}=5 V .... 1.8:1.0 max.
LED to LED Hue Matching (Green only)
@V_{CC}=5 V .... ±2 nm max.
Viewing Angle (off normal axis)
Horizontal .... ±50° max.
Vertical .... ±75° max.

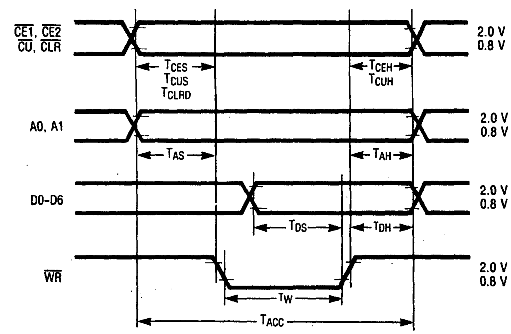
Note: 1. Peak luminous intensity values can be calculated by multiplying these values by 7.

TOP VIEW



Pin	Function	Pin	Function
1	$\overline{\text{CE1}}$ Chip Enable	10	GND
2	$\overline{\text{CE2}}$ Chip Enable	11	D0 Data Input
3	$\overline{\text{CLR}}$ Clear	12	D1 Data Input
4	$\overline{\text{CUE}}$ Cursor Enable	13	D2 Data Input
5	$\overline{\text{CU}}$ Cursor Select	14	D3 Data Input
6	$\overline{\text{WR}}$ Write	15	D6 Data Input
7	A1 Digit Select	16	D5 Data Input
8	A0 Digit Select	17	$\overline{\text{D4}}$ Data Input
9	V_{CC}	18	$\overline{\text{BL}}$ Display Blank

TIMING CHARACTERISTICS WRITE CYCLE WAVEFORMS



Note: These waveforms are not edge triggered.

DC CHARACTERISTICS

	−40°C			+25°C			+85°C				
Parameter	**Min.**	**Typ.**	**Max.**	**Min.**	**Typ.**	**Max.**	**Min.**	**Typ.**	**Max.**	**Units**	**Conditions**
I_{CC} 80 dots on		135	160		110	130		95	115	mA	V_{CC}=5 V
I_{CC} Cursor all dots @50%			135			110			100	mA	V_{CC}=5 V
I_{CC} Blank		2.8	4.0		2.3	3.0		2.0	2.5	mA	V_{CC}=5.0 V $\overline{\text{BL}}$=0.8 V
I_{IL} (all inputs)	30	60	120	25	50	100	20	40	80	μA	V_{IN}=0.8 V V_{CC}=5.0 V
V_{IH} (all inputs)	2.0			2.0			2.0			V	V_{CC}=5.0 V ±0.5 V
V_{IL} (all inputs)			0.8			0.8			0.8	V	V_{CC}=5.0 V ±0.5 V
V_{CC}	4.5	5.0	5.5	4.5	5.0	5.5	4.5	5.0	5.5	V	

FIGURE 1. FLASHING CIRCUIT FOR DLR/DLO/DLG 2416 USING A 555

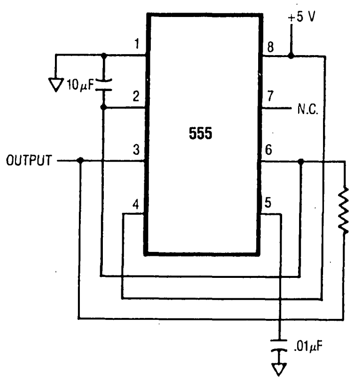
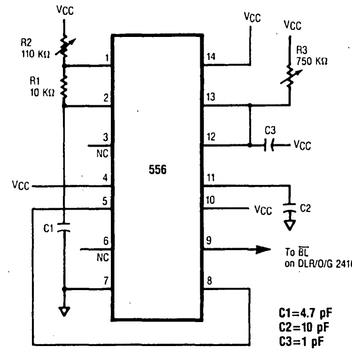
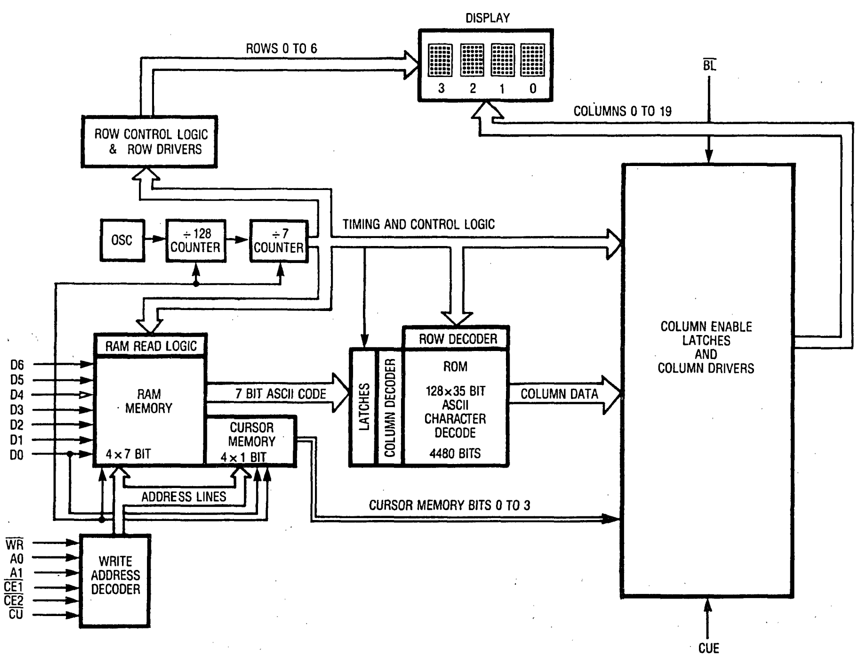


FIGURE 2. DIMMING CIRCUIT FOR DLR/DLO/DLG 2416 USING A 556



BLOCK DIAGRAM



AC CHARACTERISTICS Guaranteed Minimum Timing Parameters @V_{CC} = 5.0 V ±0.5 V

Parameter	Symbol	−40°C (ns)	+25°C (ns)	+85°C (ns)
Chip Enable Set Up Time	T_{CES}	0	0	0
Address Set Up Time	T_{AS}	10	10	10
Cursor Set Up Time	T_{CUS}	10	10	10
Chip Enable Hold Time	T_{CEH}	0	0	0
Address Hold Time	T_{AH}	20	30	40
Cursor Hold Time	T_{CUH}	20	30	40
Clear Disable Time	T_{CLRD}	1 μs	1 μs	1 μs
Write Time	T_W	60	70	90
Data Set Up Time	T_{DS}	20	30	50
Data Hold Time	T_{DH}	20	30	40
Clear Time	T_{CLR}	1 ms	1 ms	1 ms
Access Time	T_{ACC}(1)	90	110	140

Note: 1. T_{ACC} = Set Up Time + Write Time + Hold Time.

LOADING DATA

Setting the chip enable ($\overline{CE1}$, $\overline{CE2}$) to their true state will enable data loading. The desired data code (D0–D6) and digit address (A_0, A_1) must be held stable during the write cycle for storing new data.

Data entry may be asynchronous and random. (Digit 0 is defined as a right hand digit with $A_1 = A_2 = 0$.)

Clearing of the entire internal four-digit memory can be accomplished by holding the clear ($\overline{CLR}$) low for one complete display multiplex cycle, 1 mS minimum. The clear function will clear both the ASCII RAM and the cursor RAM.

TYPICAL LOADING DATA STATE TABLE

CONTROL							ADDRESS		DATA							DISPLAY DIGIT			
$\overline{BL}$	$\overline{CE1}$	$\overline{CE2}$	CUE	$\overline{CU}$	$\overline{WR}$	$\overline{CLR}$	A1	A0	D6	D5	D4	D3	D2	D1	D0	3	2	1	0
H	X	X	L	X	H	H	PREVIOUSLY LOADED DISPLAY									G	R	E	Y
H	H	X	L	X	X	H	X	X	X	X	X	X	X	X	X	G	R	E	Y
H	X	H	L	X	X	H	X	X	X	X	X	X	X	X	X	G	R	E	Y
H	L	L	L	H	L	H	L	L	H	L	L	L	H	L	H	G	R	E	E
H	L	L	L	H	L	H	L	H	H	L	H	L	H	L	H	G	R	U	E
H	L	L	L	H	L	H	H	L	H	L	L	H	H	L	L	G	L	U	E
H	L	L	L	H	L	H	H	H	H	L	L	L	L	H	L	B	L	U	E
L	X	X	X	X	H	H	X	X	BLANK DISPLAY										
H	L	L	L	H	L	H	H	H	H	L	L	L	H	H	H	G	L	U	E
H	X	X	L	X	H	L	X	X	CLEARS CHARACTER DISPLAYS										
H	L	L	L	H	L	H	X	X	SEE CHARACTER CODE							SEE CHARACTER SET			

X = DON'T CARE

LOADING CURSOR

Setting the chip enables ($\overline{CE1}$, $\overline{CE2}$) and cursor select ($\overline{CU}$) to their true state will enable cursor loading. A write ($\overline{WR}$) pulse will now store or remove a cursor into the digit location addressed by A_0, A_1; as defined in data entry. A cursor will be stored if D0 = 1; and will be removed if D0 = 0. The cursor ($\overline{CU}$) pulse width should not be less than the write ($\overline{WR}$) pulse or erroneous data may appear in the display.

If the cursor is not required, the cursor enable signal (CUE) may be tied low to disable the cursor function. For a flashing cursor simply pulse CUE. If the cursor has been loaded to any or all positions in the display, then CUE will control whether the cursor(s) or the characters appear. CUE does not affect the contents of cursor memory.

LOADING CURSOR STATE TABLE

$\overline{BL}$	CE1	CE2	$\overline{CE3}$	$\overline{CE4}$	CUE	$\overline{CU}$	$\overline{WR}$	$\overline{CLR}$	A1	A0	D6	D5	D4	D3	D2	D1	D0	DIGIT 3	2	1	0
H	X	X	X	X	L	X	H	H	PREVIOUSLY LOADED DISPLAY									B	E	A	R
H	X	X	X	X	H	X	H	H	DISPLAY PREVIOUSLY STORED CURSORS									B	E	A	R
H	H	H	L	L	H	L	L	H	L	L	X	X	X	X	X	X	H	B	E	A	■
H	H	H	L	L	H	L	L	H	L	H	X	X	X	X	X	X	H	B	E	■	■
H	H	H	L	L	H	L	L	H	H	L	X	X	X	X	X	X	H	B	■	■	■
H	H	H	L	L	H	L	L	H	H	H	X	X	X	X	X	X	H	■	■	■	■
H	H	H	L	L	H	L	L	H	H	L	X	X	X	X	X	X	L	■	E	■	■
H	X	X	X	X	L	X	H	H	DISABLE CURSOR DISPLAY									B	E	A	R
H	H	H	L	L	L	L	L	H	H	H	X	X	X	X	X	X	L	B	E	A	R
H	X	X	X	X	H	X	H	H	DISPLAY STORED CURSORS									B	E	■	■

X = DON'T CARE

DISPLAY BLANKING

Blanking the display may be accomplished by loading a blank or space into each digit of the display or by using the ($\overline{BL}$) display blank input.

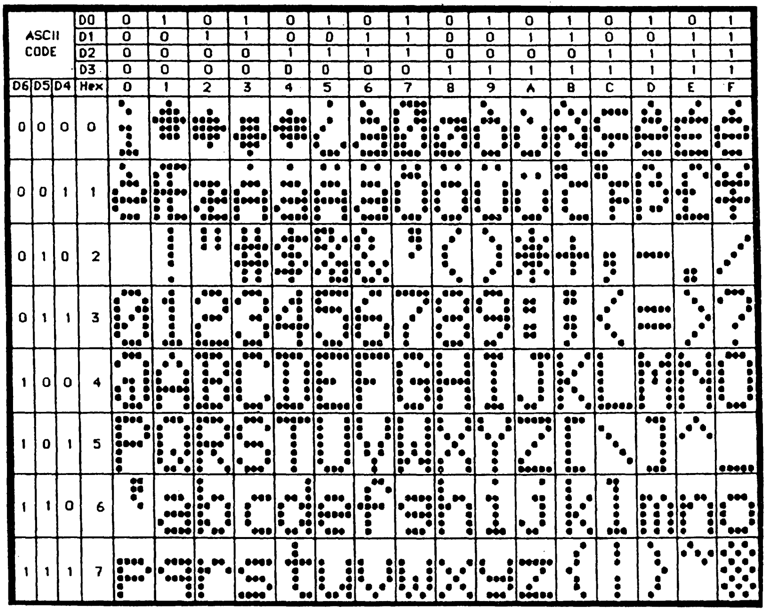
Setting the ($\overline{BL}$) input low does not affect the contents of either data or cursor memory.

A flashing circuit can easily be constructed using a 555 astable multivibrator. Figure 1 illustrates a circuit in which varying R1 (100K∼10K) will have a flash rate of 1 Hz∼10 Hz.

The display can be dimmed by pulse width modulating the ($\overline{BL}$) at a frequency sufficiently fast to not interfere with the internal clock. This clock frequency may vary from 200 Hz to 1.3 KHz. The dimming signal frequency should be 2.5 KHz or higher. Dimming the display also reduces power consumption.

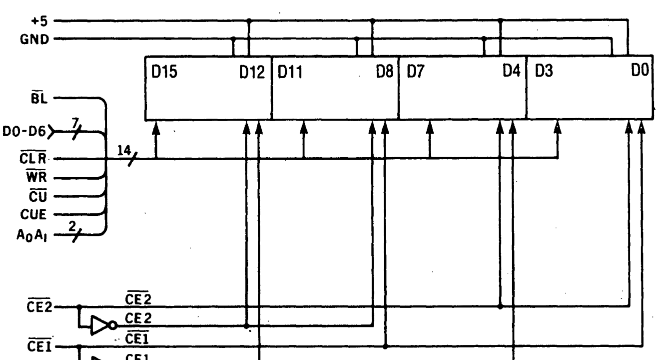
An example of a simple dimming circuit using a 556 is illustrated in Figure 2. Adjusting potentiometer R2 will dim the display through frequency modulation (2.5 KHz to 4.4 KHz). Adjusting potentiometer R3 will dim the display by increasing the negative pulse width (10% to 50%).

CHARACTER SET



Notes: 1. High = 1 level.
2. Low = 0 level.
3. Upon power up, the device will initialize in a random state.

TYPICAL SCHEMATIC FOR 16 DIGIT SYSTEM



Intelligent Display Devices

DESIGN CONSIDERATIONS

For details on design and applications of the DLR/DLO/DLG 2416 utilizing standard bus configurations in multiple display systems, or parallel I/O devices, such as the 8255 with an 8080 or memory mapped addressing on processors such as the 8080, Z80, 6502, or 6800 refer to Appnote 15 in the current Siemens Optoelectronic Data Book.

ELECTRICAL AND MECHANICAL CONSIDERATIONS

VOLTAGE TRANSIENT SUPPRESSION

For best results power the display and the components that interface with the display with the same supply to avoid logic inputs higher than V_{CC}. Additionally, the LEDs may cause transients in the power supply line while they change display states. The common practice is to place .01 μF capacitors close to the displays across V_{CC} and GND, one for each display, and one 10 μF capacitor for every second display.

ESD PROTECTION

The silicon Gate CMOS IC of the DLR/DLO/DLG 2416 is very strong against to ESD damage. It is capable of with-standing discharges greater than 2 KV. However, take all the standard precautions, normal for CMOS components. These include properly grounding personnel, tools, tables, and transport carriers that come in contact with unshielded parts. If these conditions are not, or cannot be met, keep the leads of the device shorted together or the parts in anti-static packaging.

SOLDERING CONSIDERATION

The DLR/DLO/DLG 2416 can be hand soldered with SN63 solder using a grounded iron set to 260°C.

Wave soldering is also possible following these conditions: Preheat that does not exceed 93°C on the solder side of the PC board or a package surface temperature of 85°C. Water soluble organic acid flux (except carboxylic acid) or resin-based RMA flux without alcohol can be used.

Wave temperature of 245°C ±5°C with a dwell between 1.5 sec. to 3.0 sec. Exposure to the wave should not exceed temperatures above 260°C, for 5 seconds at 0.063″ below the seating plane. The packages should not be immersed in the wave.

POST SOLDER CLEANING PROCEDURES

The least offensive cleaning solution is hot D.I. water (60°C) for less than 15 minutes. Addition of mild saponifiers is acceptable. Do not use commercial dishwasher detergents.

For faster cleaning, solvents may be used. Carefully select any solvent as some may chemically attack the nylon package. Maximum exposure should not exceed two minutes at elevated temperatures. Acceptable solvents are TF(trichlorotrifluoroethane), TA, 111 Trichloroethane, and unheated acetone.(1)

Unacceptable solvents contain alcohol, methanol, methylene chloride, ethanol, TP35, TCM, TMC, TMS+, TE, and TES. Since many commercial mixtures exist, contact a solvent vendor for chemical composition information. Some major solvent manufacturers are: Allied Chemical Corporation, Specialty Chemical Division, Morristown, NJ; Baron-Blakeslee, Chicago, IL; Dow Chemical, Midland, MI; E.I. DuPont de Nemours & Co., Wilmington, DE.

For further information refer to Appnote 18 and 19 in the current Siemens Optoelectronic Data Book.

An alternative to soldering and cleaning the display modules is to use sockets. Standard pin DIP sockets .600″ wide with .100″ centers work well for single displays. Multiple display assemblies are best handled by longer SIP sockets or DIP sockets when available for uniform package alignment. Socket manufacturers are Aries Electronics, Inc., Frenchtown, NJ; Garry Manufacturing, New Brunswick, NJ; Robinson-Nugent, New Albany, IN; and Samtec Electronic Hardware, New Albany, IN.

For further information refer to Appnote 22 in the current Siemens Optoelectronic Data Book.

OPTICAL CONSIDERATIONS

The .200″ high characters of the DLR/DLO/DLG 2416 are readable up to eight feet. To build a display readable from eight feet, give careful consideration to proper filter selection. Filters enhance the contrast ratio between a lit LED and the character background, intensifying discrimination of different characters. The only limitation is cost. To maximize the cost/benefit ratio for filters first consider the ambient lighting environment.

Incandescent (with almost no green) or fluorescent (with almost no red) lights do not have the flat spectral response of sunlight. Plastic band-pass filters are inexpensive and effective in optimizing contrast ratios. The DLR 2416 is a standard red display and should be matched with a long wavelength pass filter in the 600 nm to 620 nm range.

The DLO 2416 is a high efficiency red display and should be matched with a long wavelength pass filter in the 570 nm to 590 nm range. The DLG 2416 should be matched with a yellow-green band-pass filter that peaks at 565 nm. For displays of multiple colors, neutral density grey filters offer the best compromise.

Additional contrast enhancement can be gained through shading the displays. Plastic band-pass filters with built-in louvers offer the "next step up" in contrast improvement. Plastic filters can be further improved with anti-reflective coatings to reduce glare. The trade-off is "fuzzy" characters. Mounting the filters close to the display reduces this effect; however to avoid overheating the plastic filters, allow for proper air flow.

Optimal filter enhancements for any condition can be gained through the use of circular polarized, anti-reflective, band-pass filters. Circular polarizing further enhances contrast by reducing the light that travels through the filter and reflects back off the display to less than 1%.

Several filter manufacturers supply quality filter materials. Some of them are: Panelgraphic Corporation, W. Caldwell, NJ; SGL Homalite, Wilmington, DE; 3M Company, Visual Products Division, St. Paul, MN; Polaroid Corporation, Polarizer Division, Cambridge, MA; Marks Polarized Corporation, Deer Park, NY; Hoya Optics, Inc., Fremont, CA.

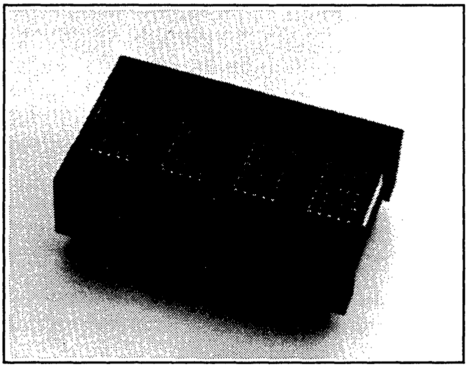
One last note on mounting filters: recessing display and bezel assemblies is an inexpensive way to provide a shading effect in overhead lighting situations. Several Bezel manufacturers are R.M.F. Products, Batavia, IL; Nobex Components, Griffith Plastic Corp., Burlingame, CA; Photo Chemical Products of California, Santa Monica, CA; I.E.E.-Atlas, Van Nuys, CA.

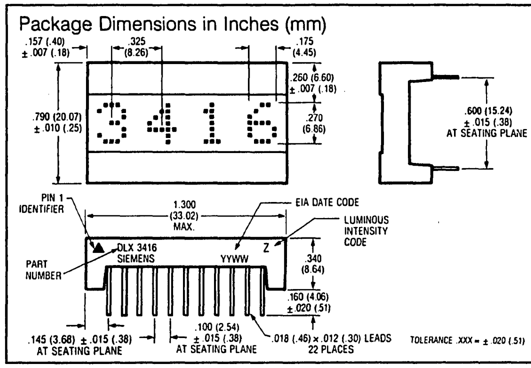
Refer to Siemens Appnote 23 for further information.

Note: 1. Acceptable commercial solvents are Basic TF, Arklone P, Genesolve D, Genesolve DA, Blaco-Tron TF, Blaco-Tron TA, and Freon TA.

RED DLR 3416
HIGH EFFICIENCY RED DLO 3416
GREEN DLG 3416

.270" 4-Digit, Dot Matrix ALPHANUMERIC Intelligent Display® With Memory/Decoder/Driver





FEATURES

- **Dot Matrix Replacement for DL 3416**
- **0.270" High Dot Matrix Character**
- **128 Special ASCII Characters for English, German, Italian, Swedish, Danish, and Norwegian Languages**
- **Wide Viewing Angle, X Axis ±50° Max., Y Axis ±75° Max.**
- **Close Vertical Row Spacing, 0.800" Centers**
- **Fast Access Time, 110 ns at 25°C**
- **Full Size Display for Stationary Equipment**
- **Built-in Memory**
- **Built-in Character Generator**
- **Built-in Multiplex and LED Drive Circuitry**
- **Each Digit Independently Addressed**
- **TTL Compatible, 5-Volt Power, $V_{IH}=2.0$ V, $V_{IL}=0.8$ V**
- **Independent Cursor Function**
- **Memory Clear Function**
- **Display Blank Function, for Blinking and Dimming**
- **End-Stackable, 4-Character Package**
- **Intensity Coded for Display Uniformity**
- **Extended Operating Temperature Range: -40°C to +85°C**
- **Wave Solderable**
- **100% Burned In and Tested**

DESCRIPTION

The DLR/DLO/DLG 3416 is a four digit dot matrix display module with a built-in CMOS integrated circuit. This display is a "drop-in" dot matrix replacement for the DL 3416.

The integrated circuit contains memory, ASCII ROM decoder, multiplexing circuitry, and drivers. Data entry is asynchronous and can be random. A display system can be built using any number of DLR/DLO/DLG 3416s since each digit can be addressed independently and will continue to display the character last stored until replaced by another.

System interconnection is very straightforward. The least significant two address bits (A_0, A_1) are normally connected to the like-named inputs of all displays in the system. With four chip enables, four displays (16 characters) can easily be interconnected without a decoder.

Data lines are connected to all DLR/DLO/DLG 3416s directly and in parallel, as is the write line ($\overline{WR}$). The display will then behave as a write-only memory.

The cursor function causes all dots of a digit position to illuminate at half-brightness. The cursor is *not* a character, however, and upon removal the previously displayed character will reappear.

The DLR/DLO/DLG 3416 has several features superior to competitive devices. 100% burn-in processing insures that the DLR/DLO/DLG 3416 will function in more stressful assembly and use environments. The "true blanking" allows for dimming the display for more flexibility of display presentation. Finally, the $\overline{CLR}$ clear function will clear the cursor RAM and the ASCII character RAM, simultaneously.

The character set consists of 128 special ASCII characters for English, German, Italian, Swedish, Danish, and Norwegian.

See Appnotes 18, 19, 22, and 23 for additional information.

DESCRIPTION (Continued)

All products are 100% burned-in and tested, then subjected to out-going AQL's of .25% for brightness matching, visual alignment and dimensions, .065% for electrical and functional.

Maximum Ratings

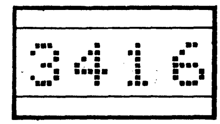
DC Supply Voltage . . . . −0.5 V to +7.0 Vdc
Voltage, Any Pin Respect
to GND . . . . −0.5 V to V_{CC} +0.5 Vdc
Operating Temperature . . . . −40°C to +85°C
Storage Temperature . . . . −40°C to +100°C
Relative Humidity (non condensing) @ 85°C 85%
Maximum Solder Temperature, 1.59 mm (0.063″)
below Seating Plane, t<5 sec . . . . 260°C

Optical Characteristics

Spectral Peak Wavelength . . . . Red 660 nm typ.
HER 630 nm typ.
Green 565 nm typ.
Digit Height . . . . 0.270″ (6.86 mm)
Time Averaged Luminous Intensity(1)
@V_{CC}=5 V
Red . . . . 60 μcd/LED typ.
HER . . . . 120 μcd/LED typ.
Green . . . . 140 μcd/LED typ.
Dot to Dot Intensity Matching
@V_{CC}=5 V . . . . 1.8:1.0 max.
Viewing Angle (off normal axis)
Horizontal . . . . ±50° max.
Vertical . . . . ±75° max.
LED to LED Hue Matching (green only)
@V_{CC}=5 V . . . . ±2 nm max.

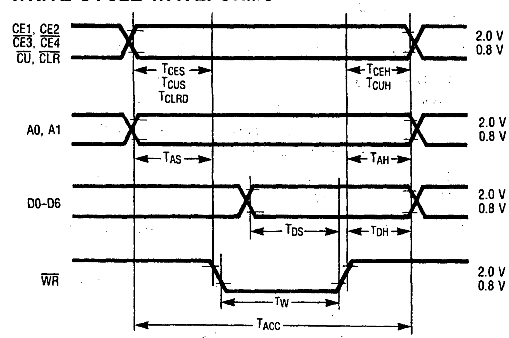
Note: 1. Peak luminous intensity values can be calculated by multiplying these values by 7.

TOP VIEW



Pin	Function	Pin	Function
1	CE1 Chip Enable	12	GND
2	CE2 Chip Enable	13	N/C
3	CE3 Chip Enable	14	BL Blanking
4	CE4 Chip Enable	15	N/C
5	CLR Clear	16	D0 Data Input
6	VCC	17	D1 Data Input
7	A0 Digit Select	18	D2 Data Input
8	A1 Digit Select	19	D3 Data Input
9	WR Write	20	D4 Data Input
10	CU Cursor Select	21	D3 Data Input
11	CUE Cursor Enable	22	D6 Data Input

TIMING CHARACTERISTICS WRITE CYCLE WAVEFORMS



Note: These waveforms are not edge triggered.

DC CHARACTERISTICS

Parameter	-40°C			+25°C			+85°C			Units	Conditions
	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.		
I_{CC} (80 dots on)		150	190		135	165		115	150	mA	V_{CC}=5 V
I_{CC} Cursor (all dots on @50%)			170			140			125	mA	V_{CC}=5 V
I_{CC} Blank		2.8	4.0		2.3	3.0		2.0	2.5	mA	V_{CC}=5 V, $\overline{BL}$=0.8 V
I_{IL} (all inputs)	30	60	120	25	50	100	20	40	80	μA	V_{IN}=0.8 V, V_{CC}=5 V
V_{IH} (all inputs)	2.0			2.0			2.0			V	V_{CC}=5.0 V ±0.5 V
V_{IL} (all inputs)			0.8			0.8			0.8	V	V_{CC}=5.0 V ±0.5 V
V_{CC}	4.5	5.0	5.5	4.5	5.0	5.5	4.5	5.0	5.5	V	

AC CHARACTERISTICS Guaranteed Minimum Timing Parameters @V_{CC} = 5.0 V ±0.5 V

Parameter	Symbol	−40°C (ns)	+25°C (ns)	+85°C (ns)
Chip Enable Set Up Time	T_{CES}	0	0	0
Address Set Up Time	T_{AS}	10	10	10
Cursor Set Up Time	T_{CUS}	10	10	10
Chip Enable Hold Time	T_{CEH}	0	0	0
Address Hold Time	T_{AH}	20	30	40
Cursor Hold Time	T_{CUH}	20	30	40
Write Time	T_W	60	70	90
Data Set Up Time	T_{DS}	20	30	50
Data Hold Time	T_{DH}	20	30	40
Clear Time	T_{CLR}	1 µs	1 µs	1 µs
Clear Disable	T_{CLRD}	1 µs	1 µs	1 µs
Access Time	T_{ACC}(1)	90	110	140

Note: 1. T_{ACC} = Set Up Time + Write Time + Hold Time.

LOADING DATA

Setting the chip enable (CE1, CE2, $\overline{CE3}$, $\overline{CE4}$) to their true state will enable loading. The desired data code (D0–D6) and digit address (A_0, A_1) must be held stable during the write cycle for storing new data.

Data entry may be asynchronous and random. (Digit 0 is defined as a right hand digit with $A_1 = A_0 = 0$.)

Clearing of the entire internal four-digit memory can be accomplished by holding the clear ($\overline{CLR}$) low for one complete display multiplex cycle, 1 mS minimum. The clear function will clear both the ASCII RAM and the cursor RAM.

TYPICAL LOADING DATA STATE TABLE

$\overline{BL}$	CE1	CE2	$\overline{CE3}$	$\overline{CE4}$	CUE	$\overline{CU}$	$\overline{WR}$	$\overline{CLR}$	A1	A0	D6	D5	D4	D3	D2	D1	D0	DIGIT 3	2	1	0
H	X	X	X	X	L	X	H	H	PREVIOUSLY LOADED DISPLAY									G	R	E	Y
H	L	X	X	X	L	X	X	H	X	X	X	X	X	X	X	X	X	G	R	E	Y
H	X	L	X	X	L	X	X	H	X	X	X	X	X	X	X	X	X	G	R	E	Y
H	X	X	H	X	L	X	X	H	X	X	X	X	X	X	X	X	X	G	R	E	Y
H	X	X	X	H	L	X	X	H	X	X	X	X	X	X	X	X	X	G	R	E	Y
H	X	X	X	X	L	X	H	H	X	X	X	X	X	X	X	X	X	G	R	E	Y
H	H	H	L	L	L	H	L	H	L	L	H	L	L	L	H	L	H	G	R	E	E
H	H	H	L	L	L	H	L	H	L	H	H	L	H	L	H	L	H	G	R	U	E
H	H	H	L	L	L	H	L	H	H	L	H	L	L	H	H	L	L	G	L	U	E
H	H	H	L	L	L	H	L	H	H	H	H	L	L	L	L	H	L	B	L	U	E
L	X	X	X	X	X	X	H	H	X	X	BLANK DISPLAY										
H	H	H	L	L	L	H	L	H	H	H	H	L	L	L	H	H	H	G	L	U	E
H	X	X	X	X	L	X	X	L	CLEARS CHARACTER DISPLAY												
H	H	H	L	L	L	H	L	H	X	X	SEE CHARACTER CODE							SEE CHARACTER SET			

X = DON'T CARE

LOADING CURSOR

Setting the chip enables (CE1, CE2, $\overline{CE3}$, $\overline{CE4}$) and cursor select ($\overline{CU}$) to their true state will enable cursor loading. A write ($\overline{WR}$) pulse will now store or remove a cursor into the digit location addressed by A_0, A_1; as defined in data entry. A cursor will be stored if D0 = 1; and will be removed if D0 = 0. Cursor will not be cleared by the CLR signal. The cursor ($\overline{CU}$) pulse width should not be less than the write ($\overline{WR}$) width or erroneous data may appear in the display.

If the cursor is not required, the cursor enable signal (CUE) may be tied low to disable the cursor function. For a flashing cursor simply pulse CUE. If the cursor has been loaded to any or all positions in the display, then CUE will control whether the cursor(s) or the characters appear. CUE does not affect the contents of cursor memory.

LOADING CURSOR STATE TABLE

$\overline{BL}$	CE1	CE2	$\overline{CE3}$	$\overline{CE4}$	CUE	$\overline{CU}$	$\overline{WR}$	$\overline{CLR}$	A1	A0	D6	D5	D4	D3	D2	D1	D0	DIGIT 3	2	1	0
H	X	X	X	X	L	X	H	H	PREVIOUSLY LOADED DISPLAY									B	E	A	R
H	X	X	X	X	H	X	H	H	DISPLAY PREVIOUSLY STORED CURSORS									B	E	A	R
H	H	H	L	L	H	L	L	H	L	L	X	X	X	X	X	X	H	B	E	A	■
H	H	H	L	L	H	L	L	H	L	H	X	X	X	X	X	X	H	B	E	■	■
H	H	H	L	L	H	L	L	H	H	L	X	X	X	X	X	X	H	B	■	■	■
H	H	H	L	L	H	L	L	H	H	H	X	X	X	X	X	X	H	■	■	■	■
H	H	H	L	L	H	L	L	H	H	L	X	X	X	X	X	X	L	■	E	■	■
H	X	X	X	X	L	X	H	H	DISABLE CURSOR DISPLAY									B	E	A	R
H	H	H	L	L	L	L	L	H	H	H	X	X	X	X	X	X	L	B	E	A	R
H	X	X	X	X	H	X	H	H	DISPLAY STORED CURSORS									B	E	■	■

X = DON'T CARE

DISPLAY BLANKING

Blanking the display may be accomplished by loading a blank or space into each digit of the display or by using the ($\overline{BL}$) display blank input.

Setting the ($\overline{BL}$) input low does not affect the contents of either data or cursor memory. A flashing display can be achieved by pulsing ($\overline{BL}$). A flashing circuit can be constructed using a 555 astable multivibrator.

Figure 1 illustrates a circuit in which varying R1 (100K∼10K) will have a flash rate of 1 Hz∼10 Hz.

The display can be dimmed by pulsing the ($\overline{BL}$) line at a frequency sufficiently fast to not interfere with the internal clock. This clock frequency may vary from 200 Hz to 1.3 Hz. The dimming signal frequency should be 2.5 KHz or higher. Dimming the display also reduces power consumption.

An example of a simple dimming circuit using a 556 is illustrated in Figure 2. Adjusting potentiometer R2 will dim the display through frequency modulation (2.5 KHz to 4.4 KHz). Adjusting potentiometer R3 will dim the display by increasing the negative pulse width (10% to 50%).

FIGURE 1. FLASHING CIRCUIT FOR DLR/DLO/DLG 3416 USING A 555

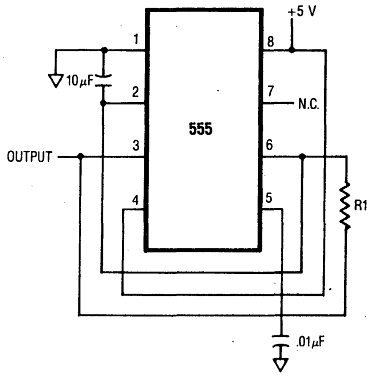
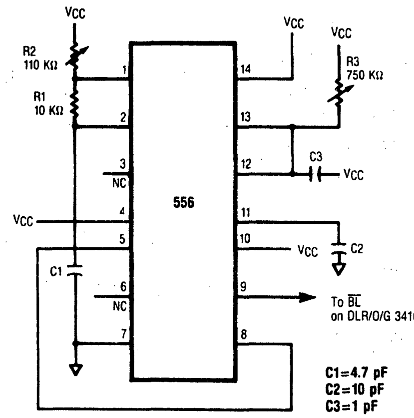
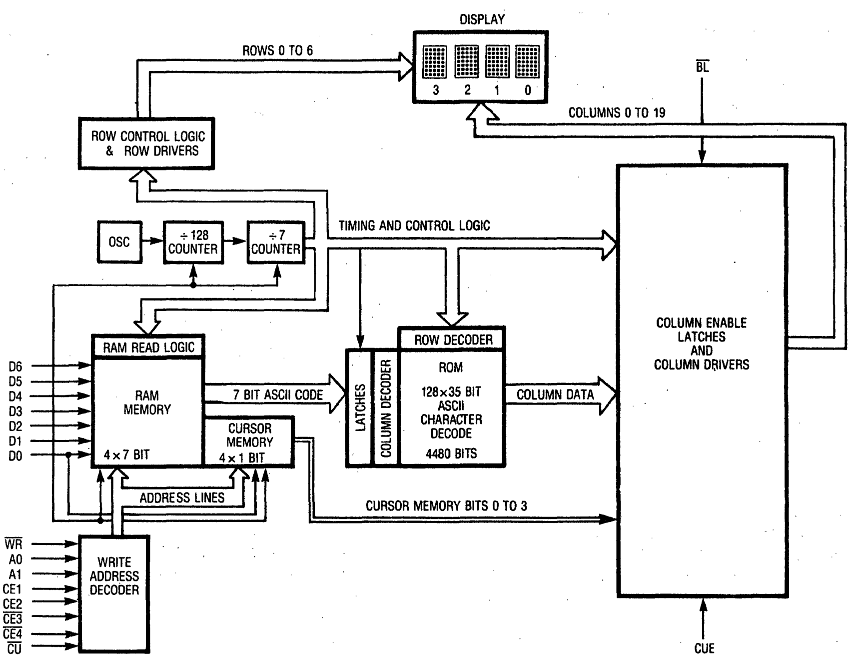


FIGURE 2. DIMMING CIRCUIT FOR DLR/DLO/DLG 3416 USING A 556

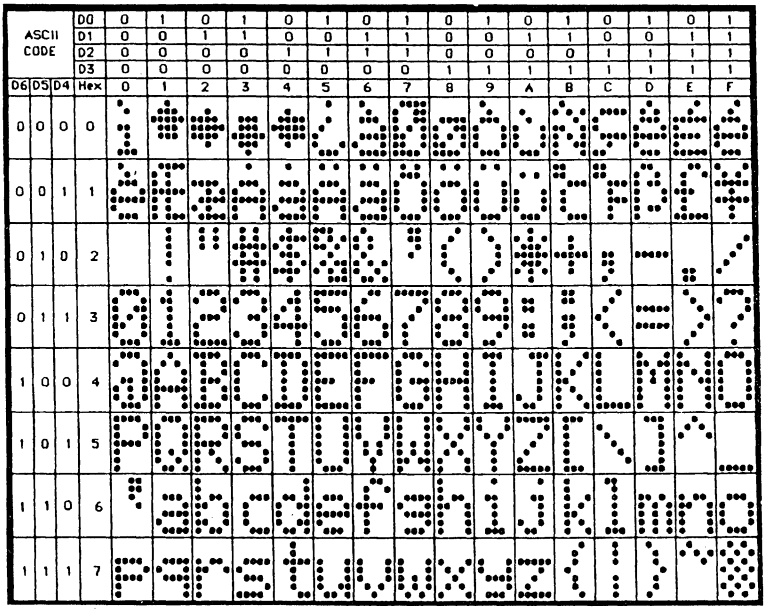


INTERNAL BLOCK DIAGRAM



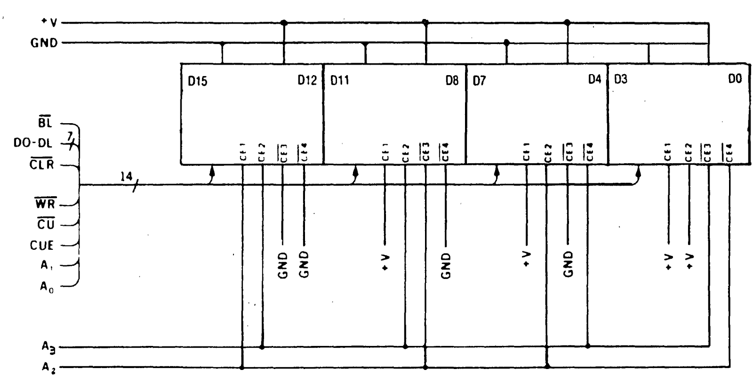
DLR/DLO/DLG 3416

CHARACTER SET



Notes: 1. High = 1 level.
2. Low = 0 level.
3. Upon power up, the device will initialize in a random state.

TYPICAL SCHEMATIC FOR 16 DIGITS



DESIGN CONSIDERATIONS

For details on design and applications of the DLR/DLO/DLG 3416 utilizing standard bus configurations in multiple display systems, or parallel I/O devices, such as the 8255 with an 8080 or memory mapped addressing on processors such as the 8080, Z80, 6502, 8748, or 6800, refer to Appnote 14 and 20, in the current Siemens Optoelectronic Data Book.

ELECTRICAL AND MECHANICAL CONSIDERATIONS

VOLTAGE TRANSIENT SUPPRESSION

For best results power the display and the components that interface with the display with the same supply to avoid logic inputs higher than V_{CC}. Additionally, the LEDs may cause transients in the power supply line while they change display states. The common practice is to place .01 μF capacitors close to the displays across V_{CC} and GND, one for each display, and one 10 μF capacitor for every second display.

ESD PROTECTION

The silicon Gate CMOS IC of the DLR/DLO/DLG 3416 is very strong against ESD damage. It is capable of withstanding discharges greater than 2 KV. However, take all the standard precautions normal for CMOS components. These include properly grounding personnel, tools, tables, and transport carriers that come in contact with unshielded parts. If these conditions are not, or cannot be met, keep the leads of the device shorted together or the parts in anti-static packaging.

SOLDERING CONSIDERATION

The DLR/DLO/DLG 3416 can be hand soldered with SN63 solder using a grounded iron set to 260°C.

Wave soldering is also possible following these conditions: Preheat that does not exceed 93°C on the solder side of the PC board or a package surface temperature of 85°C. Water soluble organic acid flux (except carboxylic acid) or resin-based RMA flux without alcohol can be used.

Wave temperature of 245°C ±5°C with a dwell between 1.5 sec. to 3.0 sec. Exposure to the wave should not exceed temperatures above 260°C, for 5 seconds at 0.063″ below the seating plane. The packages should not be immersed in the wave.

POST SOLDER CLEANING PROCEDURES

The least offensive cleaning solution is hot D.I. water (60°C) for less than 15 minutes. Addition of mild saponifiers is acceptable. Do not use commercial dishwasher detergents.

For faster cleaning, solvents may be used. Carefully select any solvent as some may chemically attack the nylon package. Maximum exposure should not exceed two minutes at elevated temperatures. Acceptable solvents are TF(trichlorotrifluoroethane), TA, 111 Trichloroethane, and unheated acetone.(1)

Unacceptable solvents contain alcohol, methanol, methylene chloride, ethanol, TP35, TCM, TMC, TMS+, TE, and TES. Since many commercial mixtures exist, contact a solvent vendor for chemical composition information. Some major solvent manufacturers are: Allied Chemical Corporation, Specialty Chemical Division, Morristown, NJ; Baron-Blakeslee, Chicago, IL; Dow Chemical, Midland, MI; E.I. DuPont de Nemours & Co., Wilmington, DE.

For further information refer to Appnote 18 and 19 in the current Siemens Optoelectronic Data Book.

An alternative to soldering and cleaning the display modules is to use sockets. Standard pin DIP sockets .600″ wide with .100″ centers work well for single displays. Multiple display assemblies are best handled by longer SIP sockets or DIP sockets when available for uniform package alignment. Socket manufacturers are Aries Electronics, Inc., Frenchtown, NJ; Garry Manufacturing, New Brunswick, NJ; Robinson-Nugent, New Albany, IN; and Samtec Electronic Hardware, New Albany, IN.

For further information refer to Appnote 22 in the current Siemens Optoelectronic Data Book.

OPTICAL CONSIDERATIONS

The .270″ high characters of the DLR/DLO/DLG 3416 are readable up to twelve feet. To build a display readable from twelve feet, carefully select the proper filter. Filters enhance the contrast ratio between a lit LED and the character background, intensifying discrimination between different characters. The only limitation is cost. To maximize the cost/benefit ratio for filters, first consider the ambient lighting environment.

Incandescent (with almost no green) or fluorescent (with almost no red) lights do not have the flat spectral response of sunlight. Plastic band-pass filters are inexpensive and effective in optimizing contrast ratios. The DLR 3416 is a standard red display and should be matched with a long wavelength pass filter in the 600 nm to 620 nm range.

The DLO 3416 is a high efficiency red display and should be matched with a long wavelength pass filter in the 570 nm to 590 nm range. The DLG 3416 should be matched with a yellow-green band-pass filter that peaks at 565 nm. For displays of multiple colors, neutral density grey filters offer the best compromise.

Additional contrast enhancement can be gained through shading the displays. Plastic band-pass filters with built-in louvers offer the "next step up" in contrast improvement. Plastic filters can be further improved with anti-reflective coatings to reduce glare. The trade-off is "fuzzy" characters. Mounting the filters close to the display reduces this effect; however to avoid overheating the plastic filters, allow for air flow.

Optimal filter enhancements for any condition can be gained through the use of circular polarized, anti-reflective, band-pass filters. Circular polarizing further enhances contrast by reducing the light that travels through the filter and reflects back off the display to less than 1%.

Several filter manufacturers supply quality filter materials. Some of them are: Panelgraphic Corporation, W. Caldwell, NJ; SGL Homalite, Wilmington, DE; 3M Company, Visual Products Division, St. Paul, MN; Polaroid Corporation, Polarizer Division, Cambridge, MA; Marks Polarized Corporation, Deer Park, NY; Hoya Optics, Inc., Fremont, CA.

One last note on mounting filters: recessing display and bezel assemblies is an inexpensive way to provide a shading effect in overhead lighting situations. Several Bezel manufacturers are R.M.F. Products, Batavia, IL; Nobex Components, Griffith Plastic Corp., Burlingame, CA; Photo Chemical Products of California, Santa Monica, CA; I.E.E.-Atlas, Van Nuys, CA.

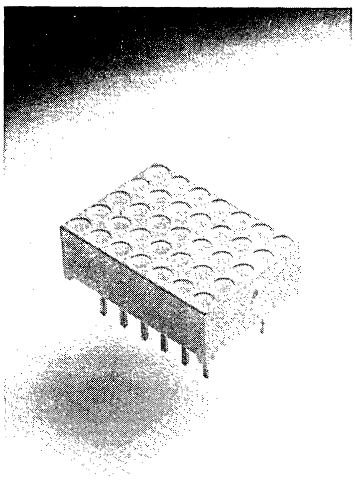
Refer to Siemens Appnote 23 for further information.

Note: 1. Acceptable commercial solvents are Basic TF, Arklone P, Genesolve D, Genesolve DA, Blaco-Tron TF, Blaco-Tron TA, and Freon TA.

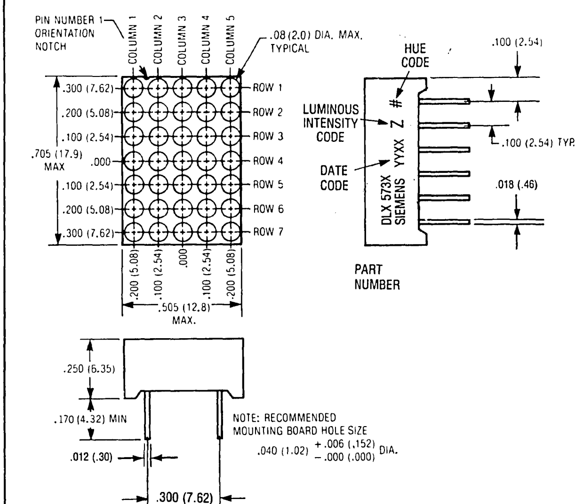
SIEMENS

RED DLR 5735
RED DLR 5736
GREEN DLG 5735
GREEN DLG 5736

.69" (17.5 mm) 5 × 7 ALPHANUMERIC DISPLAY
(No Built-In CMOS Drive Circuitry)



Package Dimensions in Inches (mm)



FEATURES

- **DLR /DLG 5735 Common Row Cathode DLR /DLG 5736 Common Row Anode**
- **5 × 7 Matrix Array with Row-Column Select**
- **End & Side Stackable**
- **Rugged Encapsulation (Filled Reflector Construction)**
- **Compatible with ASCII and EBCDIC Format**
- **Standard 12 pin, 0.3" pin spacing, Dual-Inline Package**
- **Good "OFF" Segment Contrast Grey Face with Clear Segments**

DESCRIPTION

The DLR 5735/5736 Series (gallium arsenide phosphide) and the DLG 5735/5736 Series (gallium phosphide) are 5 × 7 dot matrix light emitting diode alphanumeric displays.

Compatible with ASCII and EBCDIC formats, these displays are well suited for use in keyboard verfiers, computer peripheral equipment, and other applications requiring an alphanumeric display. They are stackable both horizontally and vertically to generate large alphanumeric or even graphic displays.

Maximum Ratings

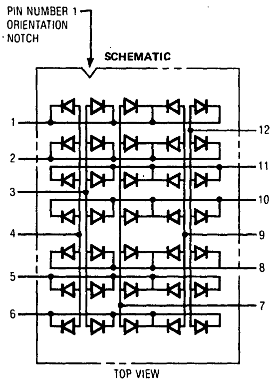
Power Dissipation (Package) .... 750 mW
Derate Linearly from 25°C .... 11.5 mW/°C
Storage Temperature .... −20°C to +70°C
Operating Temperature .... −20°C to +70°C
Continuous Forward Current
  Per Segment .... 20 mA
Pulse Peak Current/Segment
  20% Duty Cycle .... 100 mA
Reverse Voltage
  DLR 5735, 5736 .... 3 V
  DLG 5735, 5736 .... 5 V
Solder Temperature
  1/16" below seating plane for 5 seconds .... 260°C

Electrical/Optical Characteristics ($T_{amb} = 25°C$)

Parameter	Min	Typ	Max	Unit	Test Condition
Luminous Intensity					
Digit Average (Per Dot)					
DLR 5735/5736	100	200		μcd	$I_F = 20$ mA
DLG 5735/5736	320	650		μcd	$I_F = 10$ mA
Forward Voltage					
DLR 5735/5736		1.7	2.0	V	$I_F = 20$ mA
DLG 5735/5736		2.3	3.0	V	$I_F = 20$ mA
Reverse Current					
DLR 5735/5736			100	μA	$V_R = 3$ V
DLG 5735/5736			100	μA	$V_R = 5$ V
Peak Emission Wavelength					
DLR 5735/5736		650		nm	
DLG 5735/5736		565		nm	
Spectral Line Half-Width					
DLR 5735/5736		40		nm	
DLG 5735/5736		30		nm	

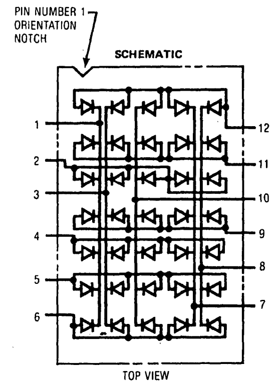
PIN CONFIGURATIONS

DLR 5735
DLG 5735



PIN	FUNCTION
1	ROW 1 CATHODE
2	ROW 2 CATHODE
3	COLUMN 2 ANODE
4	COLUMN 1 ANODE
5	ROW 6 CATHODE
6	ROW 7 CATHODE
7	COLUMN 3 ANODE
8	ROW 5 CATHODE
9	COLUMN 4 ANODE
10	ROW 4 CATHODE
11	ROW 3 CATHODE
12	COLUMN 5 ANODE

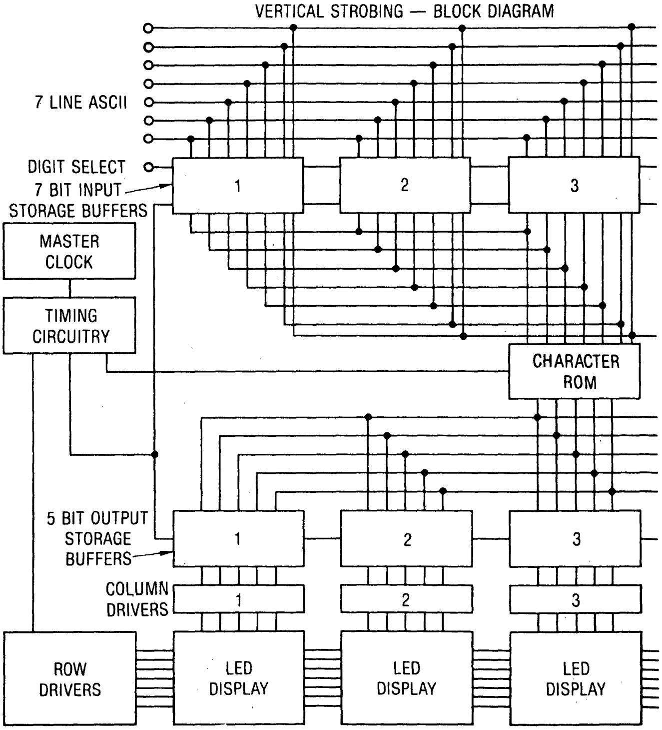
DLR 5736
DLG 5736



PIN	FUNCTION
1	COLUMN 1 CATHODE
2	ROW 3 ANODE
3	COLUMN 2 CATHODE
4	ROW 5 ANODE
5	ROW 6 ANODE
6	ROW 7 ANODE
7	COLUMN 4 CATHODE
8	COLUMN 5 CATHODE
9	ROW 4 ANODE
10	COLUMN 3 CATHODE
11	ROW 2 ANODE
12	ROW 1 ANODE

TYPICAL VERTICAL SCAN DISPLAY SYSTEM

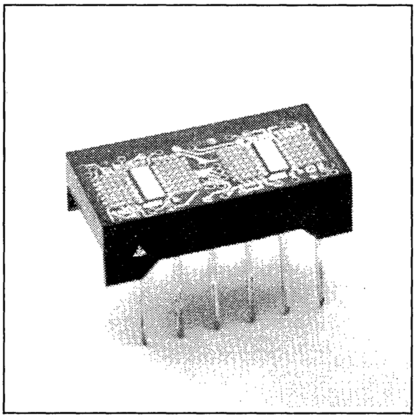
VERTICAL STROBING — BLOCK DIAGRAM



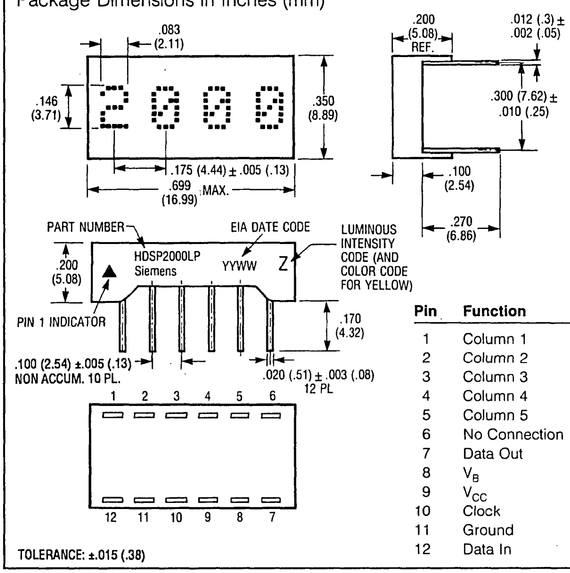
SIEMENS

RED HDSP2000LP
YELLOW HDSP2001LP
HIGH EFFICIENCY RED HDSP2002LP
BRIGHT GREEN HDSP2003LP

.150" 4-Character 5×7 Dot Matrix Serial Input Alphanumeric Display



Package Dimensions in Inches (mm)



Pin	Function
1	Column 1
2	Column 2
3	Column 3
4	Column 4
5	Column 5
6	No Connection
7	Data Out
8	V_B
9	V_{CC}
10	Clock
11	Ground
12	Data In

FEATURES

- **Four 0.150" Dot Matrix Characters**
- **Four Colors: Red, Yellow, High Efficiency Red, Bright Green**
- **Wide Viewing Angle: X Axis ±50° Y Axis ±75°**
- **Built-in CMOS Shift Registers with Constant Current LED Row Drivers**
- **Shift Registers Allow Custom Fonts**
- **Easily Cascaded for Multiple Displays**
- **TTL Compatible**
- **End Stackable**
- **Extended Operating Temperature Range: -40° to +85°C**
- **Categorized for Luminous Intensity**
- **All Displays Color Matched**
- **Compact Plastic Package**
- **100% Burned In and Tested**

DESCRIPTION

The HDSP200XLP are four digit 5×7 dot matrix serial input alphanumeric displays. The displays are available in red, yellow, high efficiency red, or bright green. The package is a standard twelve-pin DIP with a flat plastic lens. The display can be stacked horizontally or vertically to form messages of any length. The HDSP200XLP has two fourteen-bit CMOS shift registers with built-in row drivers. These shift registers drive twenty-eight rows and enable the design of customized fonts. Cascading multiple displays is possible because of the Data In and Data Out pins. Data In and Out are easily input with the clock signal and displayed in parallel on the row drivers. Data Out represents the output of the 7th bit of digit number four shift register. The shift register is level triggered. The like columns of each character in a display cluster are tied to a single pin. (See Block Diagram). High true data in the shift register enables the output current mirror driver stage associated with each row of LEDs in the 5×7 diode array.

The TTL compatible V_B input may either be tied to V_{CC} for maximum display intensity or pulse width modulated to achieve intensity control and reduce power consumption.

—Continued

See Appnote 44 for application information.

DESCRIPTION (Continued)

In the normal mode of operation, input data for digit four, column one is loaded into the seven on-board shift register locations one through seven. Column one data for digits 3, 2, and 1 is shifted into the display shift register locations so that column one input is enabled for an appropriate period of time, T. A similar process is repeated for columns 2, 3, 4, and 5. If the decode time and load data time into the shift register is t, then with five columns, each column of the display is operating at a duty factor of:

$$DF=\frac{T}{5(T+t)}$$

T+t, allotted to each display column, is generally chosen to provide the maximum duty factor consistent with the minimum refresh rate necessary to achieve a flicker free display. For most strobed display systems, each column of the display should be refreshed (turned on) at a minimum rate of 100 times per second.

With columns to be addressed, this refresh rate then gives a value for the time T+t of: 1/[5×(100)]=2 msec. If the device is operated at 5.0 MHz clock rate maximum, it is possible to maintain t<<T. For short display strings, the duty factor will then approach 20%.

Maximum Ratings

Supply Voltage V_{CC} to GND ....-0.5 V to +7.0 V
Inputs, Data Out and V_B ....-0.5 V to V_{CC} +0.5 V
Column Input Voltage, V_{COL} ....-0.5 V to +6.0 V
Operating Temperature Range ....-40°C to +85°C
Storage Temperature Range ....-55°C to +100°C
Maximum Solder Temperature, 0.063″ (1.59 mm)
below Seating Plane, t<5 sec.................260°C
Maximum Allowable Power Dissipation
at T_{amb}=25°C[1] ....0.86 W

Note:
1. Maximum allowable dissipation is derived from V_{CC}=5.25 V, V_B=2.4 V, V_{COL}=3.5 V 20 LEDs on per character, 20% DF.

FIGURE 1. TIMING CHARACTERISTICS

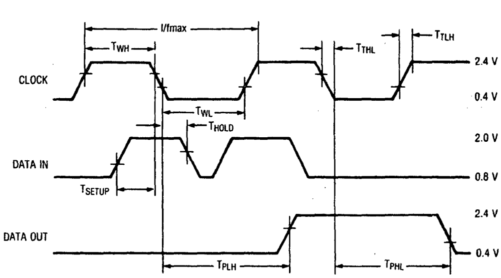
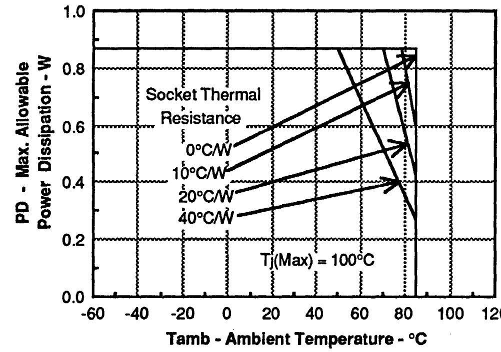


FIGURE 2. MAX. ALLOWABLE POWER DISSIPATION VS. TEMPERATURE



AC ELECTRICAL CHARACTERISTICS
(V_{CC}=4.75 to 5.25 V, T_{amb}=-40°C to 85°C)

Symbol	Description	Min.	Typ.	Max[1]	Units	Fig.
T_{SETUP}	Setup Time	50			ns	1
T_{HOLD}	Hold Time	25			ns	1
T_{WL}	Clock Width Low	75			ns	1
T_{WH}	Clock Width High	75			ns	1
$F_{(CLK)}$	Clock Frequency	0		5	MHz	1
T_{THL}, T_{TLH}	Clock Transition Time			200	ns	1
T_{PHL}, T_{PLH}	Propagation Delay Clock to Data Out			125	ns	1

Note:
1. V_B Pulse Width Modulation Frequency — 50 KHz (max).

CLEANING THE DISPLAYS

IMPORTANT — Do not use cleaning agents containing alcohol of any type with this display. The least offensive cleaning solution is hot D.I. water (60°C) for less than 15 minutes. Addition of mild saponifiers is acceptable. Do not use commercial dishwasher detergents.

For post solder cleaning use water or non-alcohol mixtures formulated for vapor cleaning processing or non-alcohol mixtures formulated for room temperature cleaning. Non-alcohol vapor cleaning processing for up to two minutes in vapors at boiling is permissible. For suggested solvents refer to Siemens Appnote 19.

RECOMMENDED OPERATING CONDITIONS

Parameter	Symbol	Min.	Nom.	Max.	Units
Supply Voltage	V_{CC}	4.75	5.0	5.25	V
Data Out Current, Low State	I_{OL}			1.6	mA
Data Out Current, High State	I_{OH}	-0.5			mA
Column Input Voltage, Column On HDSP2000LP[1]	V_{COL}	2.4		3.5	V
Column Input Voltage, Column On, HDSP2001LP/2002LP/2003LP[1]	V_{COL}	2.75		3.5	V
Setup Time	T_{SETUP}	70			ns
Hold Time	T_{HOLD}	30			ns
Width of Clock	$T_{W(CLK)}$	75			ns
Clock Frequency	T_{CLK}			5	MHz
Clock Transition Time	T_{THL}			200	ns

Note:
1. See Figure 3 – Peak Column Current vs. Column Voltage.

OPTICAL CHARACTERISTICS

Red HDSP2000LP

Description	Symbol	Min.	Typ.[4]	Max.	Units	Test Conditions
Peak Luminous Intensity per LED[1, 3] (Character Average)	I_{VPEAK}	105	200		μcd	$V_{CC}=5.0$ V, $V_{COL}=3.5$ V $T_{amb}=25$ °C, $V_B=2.4$ V
Peak Wavelength	λ_{PEAK}		655		nm	
Dominant Wavelength[2]	λ_D		639		nm	

Yellow HDSP2001LP

Description	Symbol	Min.	Typ.[4]	Max.	Units	Test Conditions
Peak Luminous Intensity per LED[1, 3] (Character Average)	I_{VPEAK}	400	1140		μcd	$V_{CC}=5.0$ V, $V_{COL}=3.5$ V $T_{amb}=25$ °C, $V_B=2.4$ V
Peak Wavelength	λ_{PEAK}		583		nm	
Dominant Wavelength[2]	λ_D		585		nm	

High Efficiency Red HDSP2002LP

Description	Symbol	Min.	Typ.[4]	Max.	Units	Test Conditions
Peak Luminous Intensity per LED[1, 3] (Character Average)	I_{VPEAK}	400	1430		μcd	$V_{CC}=5.0$ V, $V_{COL}=3.5$ V $T_{amb}=25$ °C, $V_B=2.4$ V
Peak Wavelength	λ_{PEAK}		635		nm	
Dominant Wavelength[2]	λ_D		626		nm	

Bright Green HDSP2003LP

Description	Symbol	Min.	Typ.[4]	Max.	Units	Test Conditions
Peak Luminous Intensity per LED[1, 3] (Character Average)	I_{VPEAK}	570	1550		μcd	$V_{CC}=5.0$ V, $V_{COL}=3.5$ V $T_{amb}=25$ °C, $V_B=2.4$ V
Peak Wavelength	λ_{PEAK}		565		nm	
Dominant Wavelength[2]	λ_D		569		nm	

Notes:
1. The displays are categorized for luminous intensity with the intensity category designated by a letter code on the bottom of the package.
2. Dominant wavelength λ_D, is derived from the CIE chromaticity diagram, and represents the single wavelength which defines the color of the device.
3. The luminous sterance of the LED may be calculated using the following relationships:
   L_V (cd/m²) = I_V (Candela)/A (Meter)²
   L_V (Footlamberts) = πI_V (Candela)/A (Foot)²
   HDSP2000LP A = 5.58×10^{-8} m² = 6×10^{-7} ft.²
   HDSP2001/2/3LP A = 7.8×10^{-8} m² = 8.4×10^{-7} ft.²
4. All typical values specified at $V_{CC}=5.0$ V and $T_{amb}=25$ °C unless otherwise noted.

Intelligent Display Devices

ELECTRICAL CHARACTERISTICS (-40°C to +85°C) (unless otherwise specified)

Description	Symbol	Min.	Typ.(1)	Max.	Units	Test Conditions	
Supply Current (quiescent)	I_{CC}		1	5	mA	$V_B = 0.4$ V	$V_{CC} = 5.25$ V, $V_{CLK} = V_{DATA} = 2.4$ V, All SR Stages = Logical 1
			1	5	mA	$V_B = 2.4$ V	
Supply Current (operating)	I_{CC}		1.5	10.0	mA	$F_{CLK} = 5$ MHz	
Column Current at any Column Input(2)	I_{COL} (All)			10	μA	$V_B = 0.4$ V	$V_{CC} = 5.25$ V, $V_{COL} = 3.5$ V, All SR Stages = Logical 1
	I_{COL}		335	410	mA	$V_B = 2.4$ V	
V_B, Clock or Data Input Threshold Low	V_{IL}			0.8	V	$V_{CC} = 4.75$ V - 5.25 V	
V_B, Clock or Data Input Threshold High	V_{IH}	2.0			V		
Data Out Voltage	V_{OH}	2.4			V	$I_{OH} = -0.5$ mA	$V_{CC} = 4.75$ V, $I_{COL} = 0$ mA
	V_{OL}			0.4	V	$I_{OL} = 1.6$ mA	
Input Current Logical 0 V_B only	I_{IL}	-30	-110	-300	μA	$V_{CC} = 4.75$ V - 5.25 V, $V_{IL} = 0.8$ V	
Input Current Logical 0 Data, Clock	I_{IL}		-1	-10	μA		
Input Current Logical 1 Data, Clock	I_{IH}			10	μA	$V_{CC} = 4.75$ V - 5.25 V, $V_{IH} = 2.4$ V	
Input Current Logical 1 V_B	I_{IH}			200	μA		
Power Dissipation per Package(2)	P_D		0.4		W	$V_{CC} = 5.0$ V, $V_{COL} = 3.5$ V, 17.5% DF 15 LEDs on per character, $V_B = 2.4$ V	
Thermal Resistance IC Junction-to-Ambient	$R\theta_{J-A}$		95		°C/W/ Device		

Notes:
1. All typical values specified at $V_{CC} = 5.0$ V and $T_{amb} = 25$°C unless otherwise noted.
2. See Figure 3 – Peak Column Current vs. Column Voltage.

FIGURE 3. PEAK COLUMN CURRENT VS. COLUMN VOLTAGE

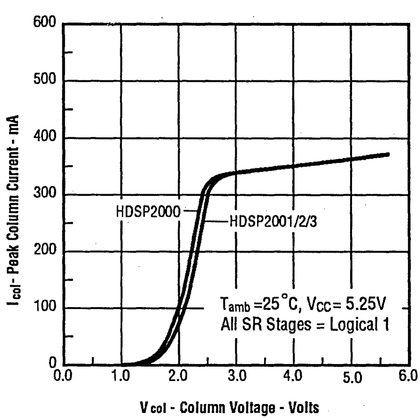
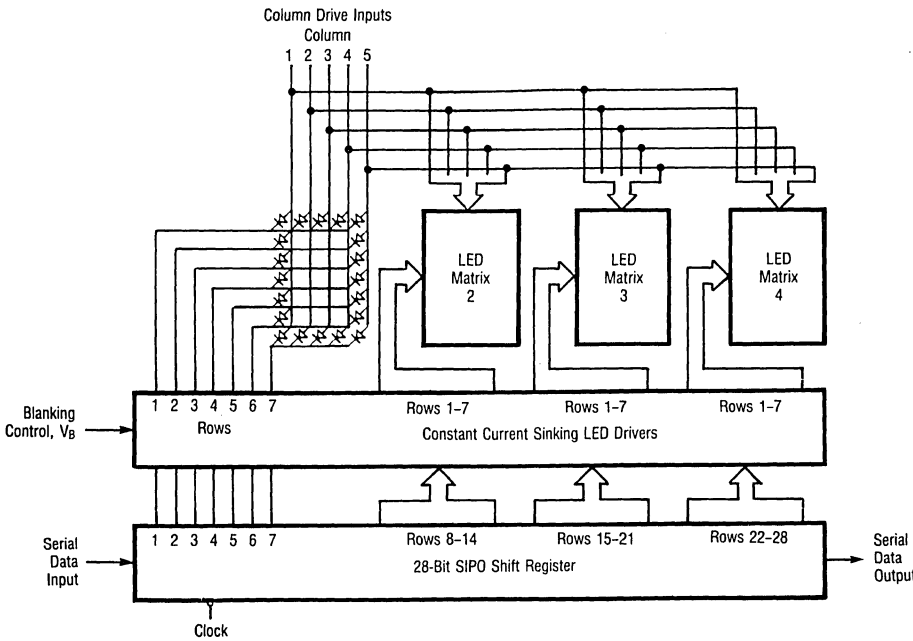


FIGURE 4. BLOCK DIAGRAM



CONTRAST ENHANCEMENT FILTERS

Display Color	Ambient Lighting		
	Dim	Moderate	Bright
HDSP2000LP Red	Panelgraphic Dark Red 63 Panelgraphic Ruby Red 60 Chequers Red 118 Plexiglass 2423	Polaroid HNCP37 3M Light Control Film Panelgraphic Gray 10 Chequers Gray 105	
HDSP2001LP Yellow	Panelgraphic Yellow 27		Polaroid HNCP10-Glass Marks Polarized MPC 30-25C*
HDSP2002LP HER	Panelgraphic Ruby Red 60 Chequers Red 112		Note 1 Polaroid HNCP10-Glass Marks Polarized MPC 20-15C*
HDSP2003LP Bright Green	Panelgraphic Green 48 Chequers Green 107		Polaroid HNCP10-Glass Marks Polarized MPC 50-12C*

Note:
1. Optically coated circular polarized filters, such as Polaroid HNCP10.

*Polaroid Corp.
1 Upland Rd., Bldg. #2
Norwood, MA 02062
800-225-2770

Marks Polarized Corp.
25-B Jefryn Blvd. W.
Deer Park, NY 11729
516-242-1300
FAX (516) 242-1347
Marks Polarized Corp. manufactures to MIL-I-45208 inspection system.

GENERAL QUALITY ASSURANCE LEVELS

Generic data available.

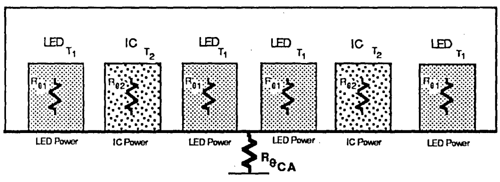
THERMAL CONSIDERATIONS

The small alphanumeric displays are hybrid LED and CMOS assemblies that are designed for reliable operation in commercial, industrial, and military environments. Optimum reliability and optical performance will result when the junction temperature of the LEDs and CMOS ICs are kept as low as possible.

THERMAL MODELING

HDSP200XLP displays consist of two driver ICs and four 5×7 LED matrixes. A thermal model of the display is shown in Figure 5. It illustrates that the junction temperature of the semiconductor = junction self heating + the case temperature rise + the ambient temperature. Equation 1 shows this relationship.

FIGURE 5. THERMAL MODEL



Equation 1.

$$T_{J(LED)} = P_{LED}\, Z_{\theta JC} + P_{CASE}\, (R_{\theta JC} + R_{\theta CA}) + T_A$$

$$T_{J(LED)} = [(I_{COL}/28)\, V_{F(LED)}\, Z_{\theta JC}] + [(n/35)\, I_{COL}\, DF\, (5\, V_{COL}) + V_{CC}\, I_{CC}] \cdot [R_{\theta JC} + R_{\theta CA}] + T_A$$

The junction rise within the LED is the product of the thermal impedance of an individual LED (37 °C/W, DF = 20%, F = 200 Hz), times the forward voltage, $V_{F(LED)}$, and forward current, $I_{F(LED)}$, of 13 - 14.5 mA. This rise averages $T_{J(LED)} = 1$ °C. The table below shows the $V_{F(LED)}$ for the respective displays.

Model Number	V_F		
	Min.	Typ.	Max.
HDSP2000LP	1.6	1.7	2.0
HDSP2001/2/3LP	1.9	2.2	3.0

The junction rise within the LED driver IC is the combination of the power dissipated by the IC quiescent current and the 28 row driver current sinks. The IC junction rise is given in Equation 2.

A thermal resistance of 28 °C/W results in a typical junction rise of 6 °C.

Equation 2.

$$T_{J(IC)} = P_{COL}\, (R_{\theta JC} + R_{\theta CA}) + T_A$$

$$T_{J(IC)} = [5\, (V_{COL} - V_{F(LED)}) \cdot (I_{COL}/2) \cdot (n/35)\, DF + V_{CC} \cdot I_{CC}] \cdot [R_{\theta JC} + R_{\theta CA}] + T_A$$

THERMAL MODELING (Cont.)

For ease of calculations the maximum allowable electrical operating condition is dependent upon the aggregate thermal resistance of the LED matrixes and the two driver ICs. All of the thermal management calculations are based upon the parallel combination of these two networks which is 15°C/W. Maximum allowable power dissipation is given in Equation 3.

Equation 3.

$$P_{DISPLAY} = \frac{T_{J(MAX)} - T_A}{R_{\theta JC} + R_{\theta CA}}$$

$$P_{DISPLAY} = 5\ V_{COL}\ I_{COL}\ (n/35)\ DF + V_{CC}\ I_{CC}$$

For further reference see Figures 2, 7, 8, 9, 10 and 11.

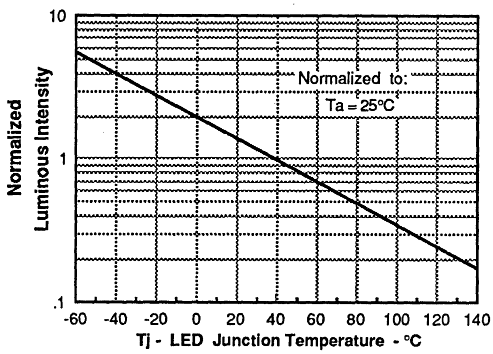
KEY TO EQUATION SYMBOLS

DF	Duty factor
I_{CC}	Quiescent IC current
I_{COL}	Column current
n	Number of LEDs on in a 5×7 array
P_{CASE}	Package power dissipation excluding LED under consideration
P_{COL}	Power dissipation of a column
$P_{DISPLAY}$	Power dissipation of the display
P_{LED}	Power dissipation of an LED
$R_{\theta CA}$	Thermal resistance case to ambient
$R_{\theta JC}$	Thermal resistance junction to case
T_A	Ambient temperature
$T_{J(IC)}$	Junction temperature of an IC
$T_{J(LED)}$	Junction temperature of a LED
$T_{J(MAX)}$	Maximum junction temperature
V_{CC}	IC voltage
V_{COL}	Column voltage
$V_{F(LED)}$	Forward voltage of LED
$Z_{\theta JC}$	Thermal impedance junction to case

OPTICAL CONSIDERATIONS

The light output of the LEDs is inversely related to the LED diode's junction temperature as shown in Figure 6. For optimum light output, keep the thermal resistance of the socket or PC board as low as possible.

FIGURE 6. NORMALIZED LUMINOUS INTENSITY VS. JUNCTION TEMPERATURE



When mounted in a 10 °C/W socket and operated at Absolute Maximum Electrical conditions, the HDSP200XLP will show an LED junction rise of 17 °C. If $T_A = 40$ °C, then the LED's T_J will be 57 °C. Under these conditions Figure 7 shows that the I_V will be 75% of its 25 °C value.

FIGURE 7. MAX. LED JUNCTION TEMPERATURE VS. SOCKET THERMAL RESISTANCE

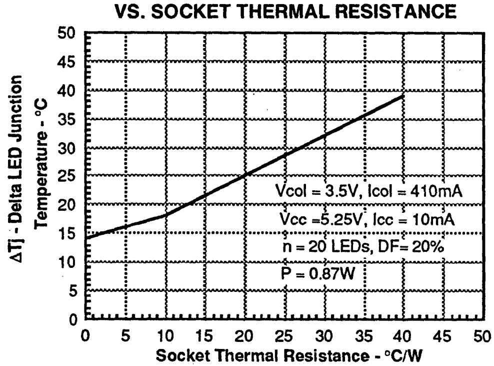


FIGURE 8. MAX. PACKAGE POWER DISSIPATION

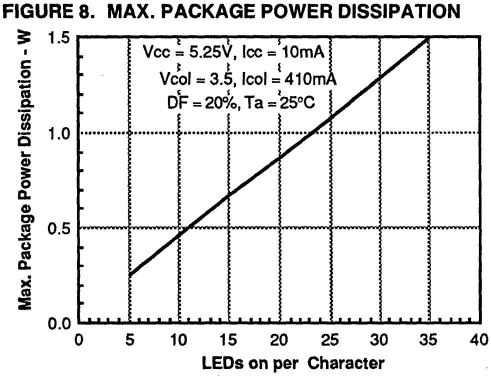


FIGURE 9. PACKAGE POWER DISSIPATION

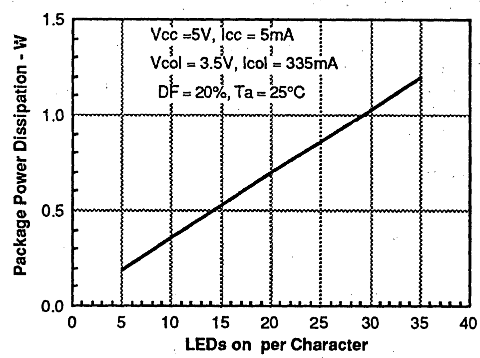


FIGURE 10. MAX. CHARACTER POWER DISSIPATION

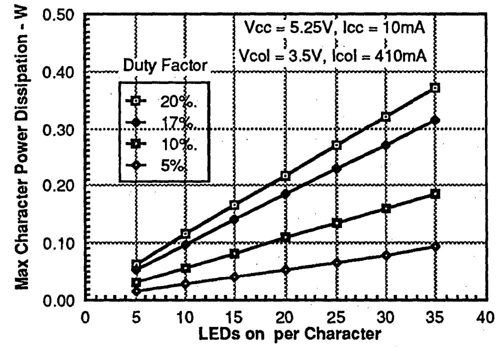
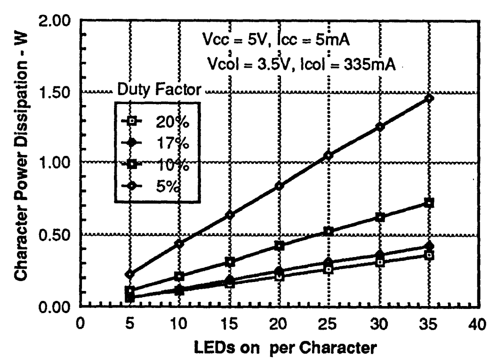


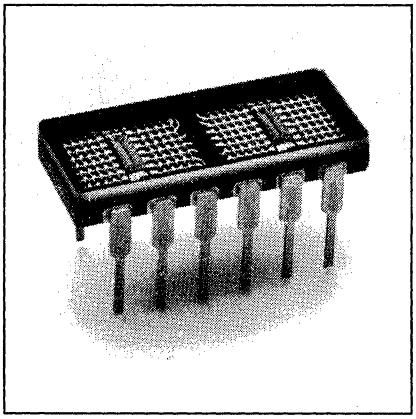
FIGURE 11. CHARACTER POWER DISSIPATION



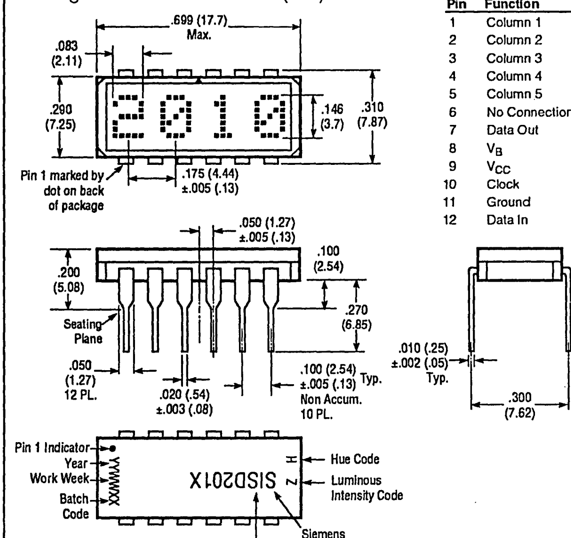
SIEMENS

RED ISD2010
YELLOW ISD2011
HIGH EFFICIENCY RED ISD2012
HIGH EFFICIENCY GREEN ISD2013

.150″ 4-Character 5×7 Dot Matrix Serial Input Alphanumeric Hi Rel/Industrial Display



Package Dimensions in Inches (mm)



Pin	Function
1	Column 1
2	Column 2
3	Column 3
4	Column 4
5	Column 5
6	No Connection
7	Data Out
8	V_B
9	V_{CC}
10	Clock
11	Ground
12	Data In

TOLERANCE: ±.015 (exceptions noted)

FEATURES

- **Four .150″ Dot Matrix Characters**
- **Four Colors: Red, Yellow, High Efficiency Red, High Efficiency Green**
- **Wide Viewing Angle**
- **Built-in CMOS Shift Registers with Constant Current LED Row Drivers**
- **Shift Registers Allow Custom Fonts**
- **Easily Cascaded for Multiple Displays**
- **TTL Compatible**
- **End Stackable**
- **Operating Temperature Range: -55° to +100°C**
- **Categorized for Luminous Intensity**
- **Ceramic Package, Hermetically Sealed Flat Glass Window**

DESCRIPTION

The ISD2010 through ISD2013 are four digit 5×7 dot matrix serial input alphanumeric displays. The displays are available in red, yellow, high efficiency red, or high efficiency green. The package is a standard twelve-pin hermetic DIP package with glass lens. The display can be stacked horizontally or vertically to form messages of any length. The ISD201X has two fourteen-bit CMOS shift registers with built-in row drivers. These shift registers drive twenty-eight rows and enable the design of customized fonts. Cascading multiple displays is possible because of the Data In and Data Out pins. Data In and Out are easily input with the clock signal and displayed in parallel on the row drivers. Data Out represents the output of the 7th bit of digit number four shift register. The shift register is level triggered. The like columns of each character in a display cluster are tied to a single pin. (See Block Diagram). High true data in the shift register enables the output current mirror driver stage associated with each row of LEDs in the 5×7 diode array.

The TTL compatible V_B input may either be tied to V_{CC} for maximum display intensity or pulse width modulated to achieve intensity control and reduce power consumption.

—Continued

See Appnote 44 for application information, and Appnotes 18, 19, 22, and 23 for additional information.

DESCRIPTION (Continued)

In the normal mode of operation, input data for digit four, column one is loaded into the seven on-board shift register locations one through seven. Column one data for digits 3, 2, and 1 is shifted into the display shift register locations. Then column one input is enabled for an appropriate period of time, T. A similar process is repeated for columns 2, 3, 4, and 5. If the decode time and load data time into the shift register is t, then with five columns, each column of the display is operating at a duty factor of:

$$DF=\frac{T}{5(T+t)}$$

T+t, allotted to each display column, is generally chosen to provide the maximum duty factor consistent with the minimum refresh rate necessary to achieve a flicker free display. For most strobed display systems, each column of the display should be refreshed (turned on) at a minimum rate of 100 times per second.

With columns to be addressed, this refresh rate then gives a value for the time T+t of: 1/[5×(100)]=2 msec. If the device is operated at 5.0 MHz clock rate maximum, it is possible to maintain t<<T. For short display strings, the duty factor will then approach 20%.

Maximum Ratings

Supply Voltage V_{CC} to GND .... –0.5 V to +7.0 V
Inputs, Data Out and V_B .... –0.5 V to V_{CC} +0.5 V
Column Input Voltage, V_{COL} .... –0.5 V to +6.0 V
Operating Temperature Range[1, 2] ..... –55°C to +100°C
Storage Temperature Range .... –65°C to +125°C
Maximum Solder Temperature, 0.063″ (1.59 mm) below Seating Plane, t<5 sec .... 260°C
Maximum Power Dissipation at T_{amb}=25°C[2]
Red .... 0.91 W
Yellow, HER, High Eff. Green .... 0.86 W

Notes:
1. Operation above +100°C ambient is possible provided the following condition are met. The junction should not exceed T_J=125°C and the case temperature (as measured at pin 1 or the back of the display) should not exceed T_C=100°C.
2. Maximum dissipation is derived from V_{CC}=5.25 V, V_B=2.4 V, V_{COL}=3.5 V 20 LEDs on per character, 20% DF.

FIGURE 1. TIMING CHARACTERISTICS

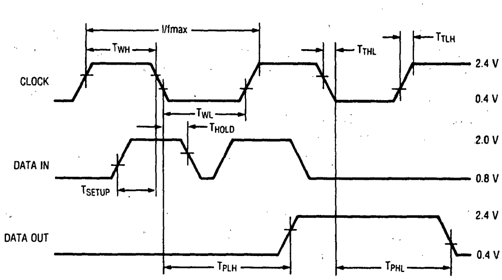
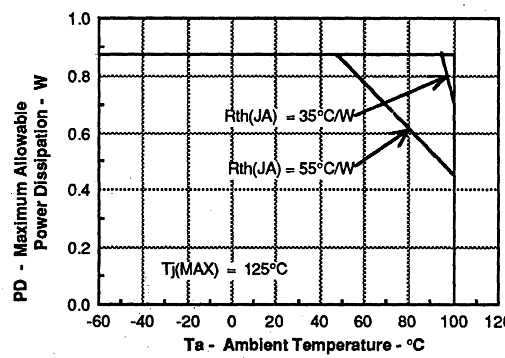


FIGURE 2. MAX. ALLOWABLE POWER DISSIPATION VS. TEMPERATURE



AC ELECTRICAL CHARACTERISTICS

(V_{CC}=4.75 to 5.25 V, T_{amb}=–55°C to +100°C)

Symbol	Description	Min.	Typ.[1]	Max.[2]	Units	Fig.
T_{SETUP}	Setup Time	50	10		ns	1
T_{HOLD}	Hold Time	25	20		ns	1
T_{WL}	Clock Width Low	75	45		ns	1
T_{WH}	Clock Width High	75	45		ns	1
$F_{(CLK)}$	Clock Frequency		6	5	MHz	1
T_{THL}, T_{TLH}	Clock Transition Time		75	200	ns	1
T_{PHL}, T_{PLH}	Propagation Delay Clock to Data Out		50	125	ns	1

Notes:
1. All typical values specified at V_{CC}=5.0 V and T_{amb}=25°C unless otherwise noted.
2. V_B Pulse Width Modulation Frequency — 50 KHz (max).

CLEANING THE DISPLAYS

IMPORTANT — Do not use cleaning agents containing alcohol of any type with this display. The least offensive cleaning solution is hot D.I. water (60°C) for less than 15 minutes. Addition of mild saponifiers is acceptable. Do not use commercial dishwasher detergents.

For post solder cleaning use water or non-alcohol mixtures formulated for vapor cleaning processing or non-alcohol mixtures formulated for room temperature cleaning. Non-alcohol vapor cleaning processing for up to two minutes in vapors at boiling is permissible. For suggested solvents refer to Siemens Appnote 19.

RECOMMENDED OPERATING CONDITIONS (Guaranteed over operating temperature range)

Parameter	Symbol	Min.	Nom.	Max.	Units
Supply Voltage	V_{CC}	4.75	5.0	5.25	V
Data Out Current, Low State	I_{OL}			1.6	mA
Data Out Current, High State	I_{OH}			-0.5	mA
Column Input Voltage, Column On[1]	V_{COL}	2.75		3.5	V
Setup Time	T_{SETUP}	70	45		ns
Hold Time	T_{HOLD}	30			ns
Width of Clock	$T_{W(CLK)}$	75			ns
Clock Frequency	T_{CLK}			5	MHz
Clock Transition Time	T_{THL}			200	ns
Free Air Operating Temperature Range	T_{amb}	-55		+100	°C

Note:
1. See Figure 3 - Peak Column Current vs. Column Voltage.

OPTICAL CHARACTERISTICS

Red ISD2010

Description	Symbol	Min.	Typ.[4]	Max.	Units	Test Conditions
Peak Luminous Intensity per LED[1, 3] (Character Average)	I_{VPEAK}	105	200		μcd	$V_{CC}=5.0$ V, $V_{COL}=3.5$ V T_J[5] = 25°C, $V_B=2.4$ V
Peak Wavelength	λ_{PEAK}		655		nm	
Dominant Wavelength[2]	λ_D		639		nm	

Yellow ISD2011

Description	Symbol	Min.	Typ.[4]	Max.	Units	Test Conditions
Peak Luminous Intensity per LED[1, 3] (Character Average)	I_{VPEAK}	400	750		μcd	$V_{CC}=5.0$ V, $V_{COL}=3.5$ V T_J[5] = 25°C, $V_B=2.4$ V
Peak Wavelength	λ_{PEAK}		583		nm	
Dominant Wavelength[2]	λ_D		585		nm	

High Efficiency Red ISD2012

Description	Symbol	Min.	Typ.[4]	Max.	Units	Test Conditions
Peak Luminous Intensity per LED[1, 3] (Character Average)	I_{VPEAK}	400	1430		μcd	$V_{CC}=5.0$ V, $V_{COL}=3.5$ V T_J[5] = 25°C, $V_B=2.4$ V
Peak Wavelength	λ_{PEAK}		635		nm	
Dominant Wavelength[2]	λ_D		626		nm	

High Efficiency Green ISD2013

Description	Symbol	Min.	Typ.[4]	Max.	Units	Test Conditions
Peak Luminous Intensity per LED[1, 3] (Character Average)	I_{VPEAK}	850	1550		μcd	$V_{CC}=5.0$ V, $V_{COL}=3.5$ V T_J[5] = 25°C, $V_B=2.4$ V
Peak Wavelength	λ_{PEAK}		568		nm	
Dominant Wavelength[2]	λ_D		574		nm	

Notes:
1. The displays are categorized for luminous intensity with the intensity category designated by a letter code on the bottom of the package.
2. Dominant wavelength λ_D, is derived from the CIE chromaticity diagram, and represents the single wavelength which defines the color of the device.
3. The luminous sterance of the LED may be calculated using the following relationships: L_V (cd/m²) = I_V (Candela)/A (Meter)²
   L_V (Footlamberts) = πI_V (Candela)/A (Foot)²
   $A = 5.3 \times 10^{-8}$ M² = 5.8×10^{-7} (Foot)²
4. All typical values specified at $V_{CC}=5.0$ V and $T_{amb}=25$°C unless otherwise noted.
5. The luminous intensity is measured at $T_{amb}=T_J=25$°C. No time is allowed for the device to warm up prior to measurement.

ELECTRICAL CHARACTERISTICS (−55 °C to + 100 °C) (unless otherwise specified)

Description	Symbol	Min.	Typ.(1)	Max.	Units	Test Conditions	
Supply Current (quiescent)	I_{CC}		2	5.0	mA	$V_B = 0.4$ V	$V_{CC} = 5.25$ V, $V_{CLK} = V_{DATA} = 2.4$ V, All SR Stages = Logical 1
			2.5	5.0	mA	$V_B = 2.4$ V	
Supply Current (operating)	I_{CC}		3	10.0	mA	$F_{CLK} = 5$ MHz	
Column Current at any Column Input(2) All	I_{COL}			10	μA	$V_B = 0.4$ V	$V_{CC} = 5.25$ V, $V_{COL} = 3.5$ V, All SR Stages = Logical 1
Red	I_{COL}		350	435	mA	$V_B = 2.4$ V	
Yellow, HER, Green	I_{COL}		335	410	mA		
V_B, Clock or Data Input Threshold Low	V_{IL}			0.8	V	$V_{CC} = 4.75$ V - 5.25 V	
V_B, Clock or Data Input Threshold High	V_{IH}	2.0			V		
Data Out Voltage	V_{OH}	2.4	3.6		V	$I_{OH} = -0.5$ mA	$V_{CC} = 5.25$ V, $I_{COL} = 0$ mA
	V_{OL}		0.2	0.4	V	$I_{OL} = 1.6$ mA	
Input Current Logical 0 V_B only	I_{IL}	−30	−110	−300	μA	$V_{CC} = 4.75$ V − 5.25 V, $V_{IL} = 0.8$ V	
Input Current Logical 0 Data, Clock	I_{IL}		−1	−10	μA		
Input Current Logical 1 Data, Clock	I_{IH}			10	μA	$V_{CC} = 4.75$ V - 5.25 V, $V_{IH} = 2.4$ V	
Input Current Logical 1 V_B	I_{IH}			200	μA		
Power Dissipation per Package	P_D		0.44		W	$V_{CC} = 5.0$ V, $V_{COL} = 3.5$ V, 17.5% DF 15 LEDs on per character, $V_B = 2.4$ V	
Thermal Resistance IC Junction-to-Pin	$R_{\theta J\text{-}PIN}$		30		°C/W/ Device		

Notes:
1. All typical values specified at $V_{CC} = 5.0$ V and $T_{amb} = 25$ °C unless otherwise noted.
2. See Figure 2 – Peak Column Current vs. Column Voltage.

FIGURE 3. PEAK COLUMN CURRENT VS. COLUMN VOLTAGE

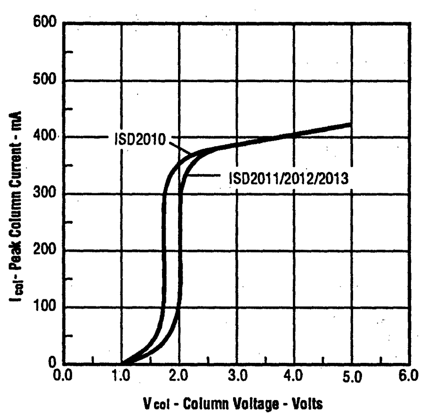
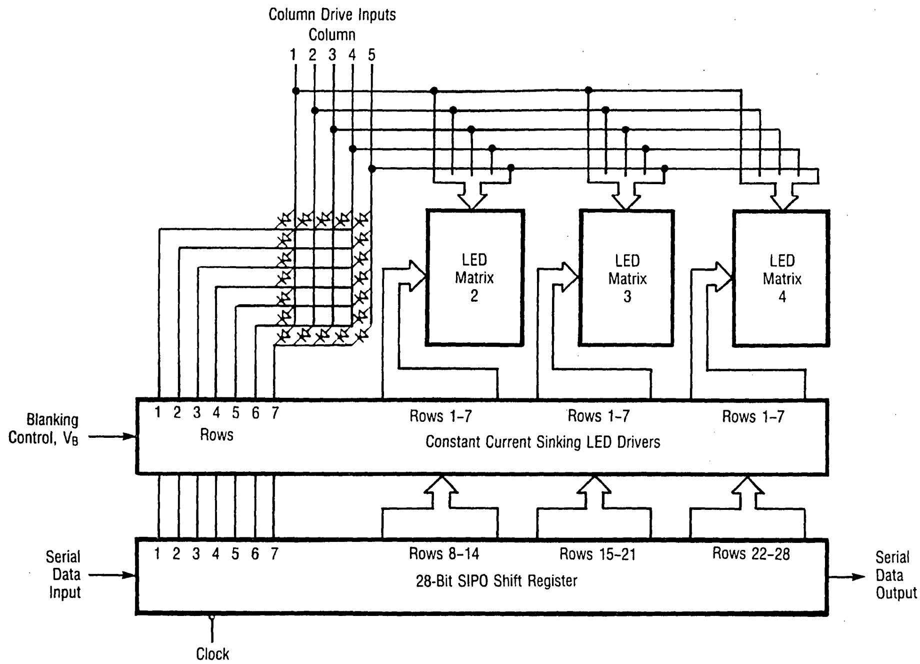


FIGURE 4. BLOCK DIAGRAM



CONTRAST ENHANCEMENT FILTERS FOR SUNLIGHT READABILITY

Display Color Part No.	Filter Color	Marks Polarized Corp.* Filter Series	Optical Characteristics of Filter	
Red, HER ISD2010, 2012	Red	MPC 20-15C	25% @ 635 nm	Circular Polarizer
Yellow ISD2011	Amber	MPC 30-25C	25% @ 583 nm	
Green ISD2013	Yellow/Green	MPC 50-22C	22% @ 568 nm	
Multiple Colors High Ambient Light	Neutral Gray	MPC 80-10C	10% Neutral	
Multiple Colors	Neutral Gray	MPC 80-37C	37% Neutral	

*Marks Polarized Corp.
25-B Jefryn Blvd. W.
Deer Park, NY 11729
516-242-1300
FAX (516) 242-1347
Marks Polarized Corp. manufactures to MIL-I-45208 inspection system.

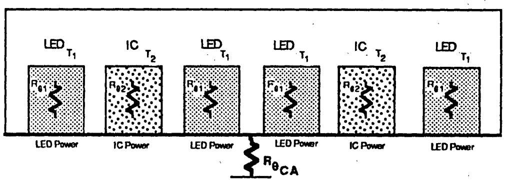
THERMAL CONSIDERATIONS

The small alphanumeric displays are hybrid LED and CMOS assemblies that are designed for reliable operation in commercial, industrial, and military environments. Optimum reliability and optical performance will result when the junction temperature of the LEDs and CMOS ICs are kept as low as possible.

THERMAL MODELING

ISD201X displays consist of two driver ICs and four 5 x 7 LED matrixes. A thermal model of the display is shown in Figure 5. It illustrates that the junction temperature of the semiconductor = junction self heating + the case temperature rise + the ambient temperature. Equation 1 shows this relationship.

FIGURE 5. THERMAL MODEL



Equation 1.

$$T_{J(LED)} = P_{LED}\, Z_{\theta JC} + P_{CASE}\,(R_{\theta JC} + R_{\theta CA}) + T_A$$

$$T_{J(LED)} = [(I_{COL}/28)\, V_{F(LED)}\, Z_{\theta JC}] + [(n/35)\, I_{COL}\, DF\, (5\, V_{COL}) + V_{CC}\, I_{CC}] \cdot [R_{\theta JC} + R_{\theta CA}] + T_A$$

The junction rise within the LED is the product of the thermal impedance of an individual LED (37 °C/W, DF = 20%, F = 200 Hz), times the forward voltage, $V_{F(LED)}$, and forward current, $I_{F(LED)}$, of 13 - 14.5 mA. This rise averages $T_{J(LED)} = 1$ °C. The table below shows the $V_{F(LED)}$ for the respective displays.

Part Number	V_F		
	Min.	**Typ.**	**Max.**
ISD2010	1.6	1.7	2.0
ISD2011/2/3	1.9	2.2	3.0

The junction rise within the LED driver IC is the combination of the power dissipated by the IC quiescent current and the 28 row driver current sinks. The IC junction rise is given in Equation 2.

A thermal resistance of 28 °C/W results in a typical junction rise of 6 °C.

Equation 2.

$$T_{J(IC)} = P_{COL}\,(R_{\theta JC} + R_{\theta CA}) + T_A$$

$$T_{J(IC)} = [5\,(V_{COL} - V_{F(LED)}) \cdot (I_{COL}/2) \cdot (n/35)\, DF + V_{CC} \cdot I_{CC}] \cdot [R_{\theta JC} + R_{\theta CA}] + T_A$$

THERMAL MODELING (Cont.)

For ease of calculations the maximum allowable electrical operating condition is dependent upon the aggregate thermal resistance of the LED matrixes and the two driver ICs. All of the thermal management calculations are based upon the parallel combination of these two networks which is 15°C/W. Maximum allowable power dissipation is given in Equation 3.

Equation 3.

$$P_{DISPLAY} = \frac{T_{J(MAX)} - T_A}{R_{\theta JC} + R_{\theta CA}}$$

$$P_{DISPLAY} = 5\ V_{COL}\ I_{COL}\ (n/35)\ DF + V_{CC}\ I_{CC}$$

For further reference see Figures 2, 7, 8, 9, 10 and 11.

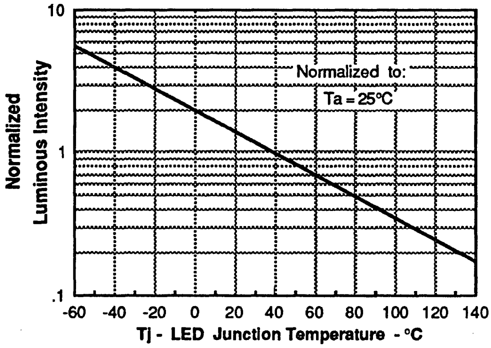
KEY TO EQUATION SYMBOLS

DF	Duty factor
I_{CC}	Quiescent IC current
I_{COL}	Column current
n	Number of LEDs on in a 5×7 array
P_{CASE}	Package power dissipation excluding LED under consideration
P_{COL}	Power dissipation of a column
$P_{DISPLAY}$	Power dissipation of the display
P_{LED}	Power dissipation of an LED
$R_{\theta CA}$	Thermal resistance case to ambient
$R_{\theta JC}$	Thermal resistance junction to case
T_A	Ambient temperature
$T_{J(IC)}$	Junction temperature of an IC
$T_{J(LED)}$	Junction temperature of a LED
$T_{J(MAX)}$	Maximum junction temperature
V_{CC}	IC voltage
V_{COL}	Column voltage
$V_{F(LED)}$	Forward voltage of LED
$Z_{\theta JC}$	Thermal impedance junction to case

OPTICAL CONSIDERATIONS

The light output of the LEDs is inversely related to the LED diode's junction temperature as shown in Figure 6. For optimum light output, keep the thermal resistance of the socket or PC board as low as possible.

FIGURE 6. NORMALIZED LUMINOUS INTENSITY VS. JUNCTION TEMPERATURE



When mounted in a 10 °C/W socket and operated at Absolute Maximum Electrical conditions, the ISD201X will show an LED junction rise of 17 °C. If $T_A = 40$ °C, then the LED's T_J will be 57 °C. Under these conditions Figure 7 shows that the I_V will be 75% of its 25 °C value.

FIGURE 7. MAX. LED JUNCTION TEMPERATURE VS. SOCKET THERMAL RESISTANCE

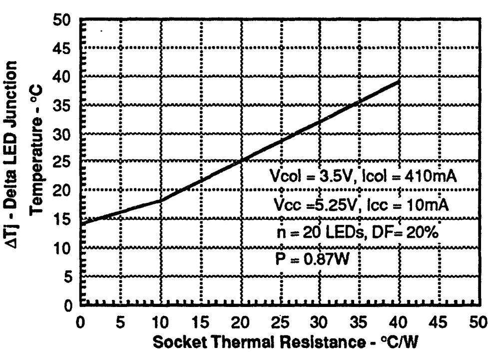


FIGURE 8. MAX. PACKAGE POWER DISSIPATION

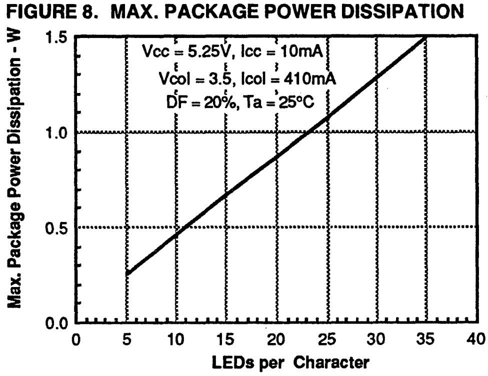


FIGURE 9. PACKAGE POWER DISSIPATION

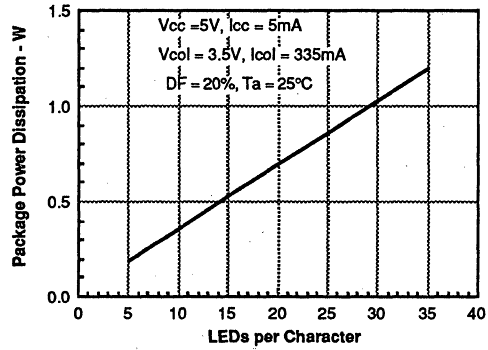


FIGURE 10. MAX. CHARACTER POWER DISSIPATION

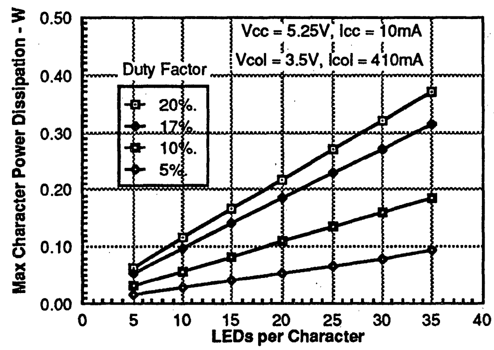
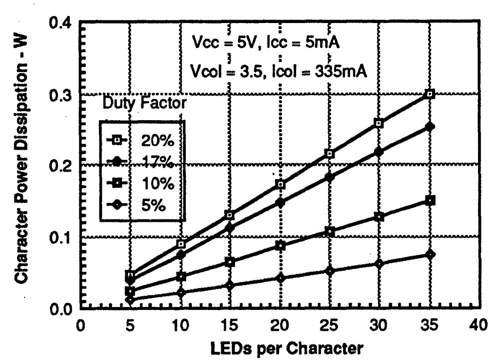


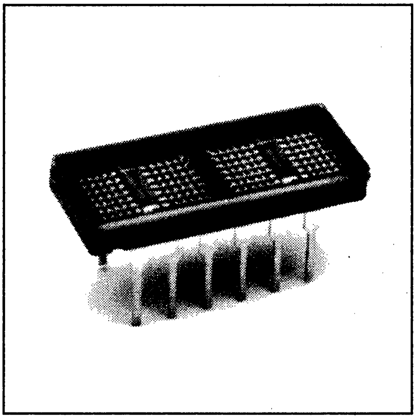
FIGURE 11. CHARACTER POWER DISSIPATION



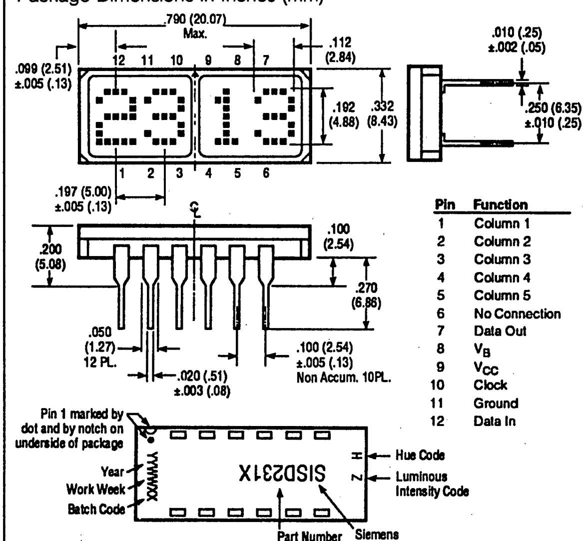
SIEMENS

RED ISD2310
YELLOW ISD2311
HIGH EFFICIENCY RED ISD2312
HIGH EFFICIENCY GREEN ISD2313

.200" 4-Character 5×7 Dot Matrix Serial Input Alphanumeric Hi Rel/Industrial Display



Package Dimensions in Inches (mm)



Pin	Function
1	Column 1
2	Column 2
3	Column 3
4	Column 4
5	Column 5
6	No Connection
7	Data Out
8	V_B
9	V_{CC}
10	Clock
11	Ground
12	Data In

TOLERANCE: ±.015 (exceptions noted)

FEATURES

- **Four .200" Dot Matrix Characters**
- **Four Colors: Red, Yellow, High Efficiency Red, High Efficiency Green**
- **Wide Viewing Angle**
- **Built-in CMOS Shift Registers with Constant Current LED Row Drivers**
- **Shift Registers Allow Custom Fonts**
- **Easily Cascaded for Multiple Displays**
- **TTL Compatible**
- **End Stackable**
- **Operating Temperature Range: -55° to +100°C**
- **Categorized for Luminous Intensity**
- **Ceramic Package, Hermetically Sealed Flat Glass Window**

DESCRIPTION

The ISD2310 through ISD2313 are four digit 5×7 dot matrix serial input alphanumeric displays. The displays are available in red, yellow, high efficiency red, or high efficiency green. The package is a standard twelve-pin hermetic DIP package with glass lens. The display can be stacked horizontally or vertically to form messages of any length. The ISD231X has two fourteen-bit CMOS shift registers with built-in row drivers. These shift registers drive twenty-eight rows and enable the design of customized fonts. Cascading multiple displays is possible because of the Data In and Data Out pins. Data In and Out are easily input with the clock signal and displayed in parallel on the row drivers. Data Out represents the output of the 7th bit of digit number four shift register. The shift register is level triggered. The like columns of each character in a display cluster are tied to a single pin. (See Block Diagram). High true data in the shift register enables the output current mirror driver stage associated with each row of LEDs in the 5×7 diode array.

The TTL compatible V_B input may either be tied to V_{CC} for maximum display intensity or pulse width modulated to achieve intensity control and reduce power consumption.

—Continued

See Appnote 44 for application information, and Appnotes 18, 19, 22, and 23 for additional information.

DESCRIPTION (Continued)

In the normal mode of operation, input data for digit four, column one is loaded into the seven on-board shift register locations one through seven. Column one data for digits 3, 2, and 1 is shifted into the display shift register locations. Then column one input is enabled for an appropriate period of time, T. A similar process is repeated for columns 2, 3, 4, and 5. If the decode time and load data time into the shift register is t, then with five columns, each column of the display is operating at a duty factor of:

$$DF=\frac{T}{5(T+t)}$$

T+t, allotted to each display column, is generally chosen to provide the maximum duty factor consistent with the minimum refresh rate necessary to achieve a flicker free display. For most strobed display systems, each column of the display should be refreshed (turned on) at a minimum rate of 100 times per second.

With columns to be addressed, this refresh rate then gives a value for the time T+t of: 1/[5×(100)]=2 msec. If the device is operated at 5.0 MHz clock rate maximum, it is possible to maintain t<<T. For short display strings, the duty factor will then approach 20%.

Maximum Ratings

Supply Voltage V_{CC} to GND .... −0.5 V to +7.0 V
Inputs, Data Out and V_B .... −0.5 V to V_{CC} +0.5 V
Column Input Voltage, V_{COL} .... −0.5 V to +6.0 V
Operating Temperature Range .... −55°C to +100°C
Storage Temperature Range .... −65°C to +125°C
Maximum Solder Temperature, 0.063″ (1.59 mm) below Seating Plane, t<5 sec .... 260°C
Maximum Power Dissipation at T_{amb}=25°C(2) .... 1.1 W

Notes:
1. Operation above +100°C ambient is possible provided the following condition are met. The junction should not exceed T_J=125°C and the case temperature (as measured at pin 1 or the back of the display) should not exceed T_C=100°C.
2. Maximum dissipation is derived from V_{CC}=5.25 V, V_B=2.4 V, V_{COL}=3.5 V 20 LEDs on per character, 20% DF.

FIGURE 1. TIMING CHARACTERISTICS

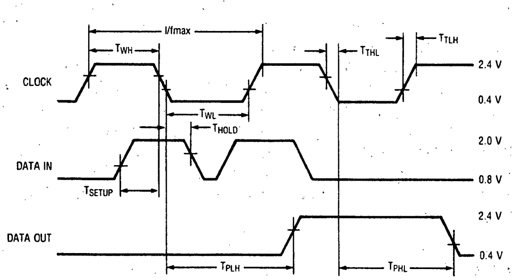
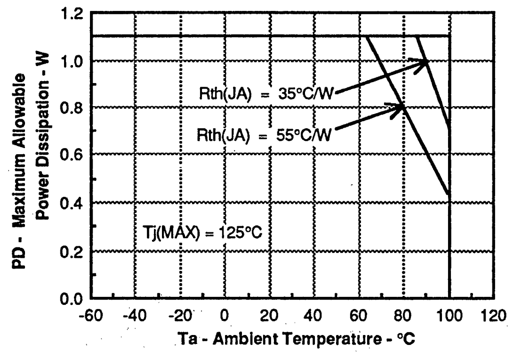


FIGURE 2. MAX. ALLOWABLE POWER DISSIPATION VS. TEMPERATURE



AC ELECTRICAL CHARACTERISTICS

(V_{CC}=4.75 to 5.25 V, T_{amb}=−55°C to +100°C)

Symbol	Description	Min.	Typ.(1)	Max.(2)	Units	Fig.
T_{SETUP}	Setup Time	50	10		ns	1
T_{HOLD}	Hold Time	25	20		ns	1
T_{WL}	Clock Width Low	75	45		ns	1
T_{WH}	Clock Width High	75	45		ns	1
$F_{(CLK)}$	Clock Frequency		6	5	MHz	1
T_{THL}, T_{TLH}	Clock Transition Time		75	200	ns	1
T_{PHL}, T_{PLH}	Propagation Delay Clock to Data Out		50	125	ns	1

Notes:
1. All typical values specified at V_{CC}=5.0 V and T_{amb}=25°C unless otherwise noted.
2. V_B Pulse Width Modulation Frequency — 50 KHz (max).

CLEANING THE DISPLAYS

IMPORTANT — Do not use cleaning agents containing alcohol of any type with this display. The least offensive cleaning solution is hot D.I. water (60°C) for less than 15 minutes. Addition of mild saponifiers is acceptable. Do not use commercial dishwasher detergents.

For post solder cleaning use water or non-alcohol mixtures formulated for vapor cleaning processing or non-alcohol mixtures formulated for room temperature cleaning. Non-alcohol vapor cleaning processing for up to two minutes in vapors at boiling is permissible. For suggested solvents refer to Siemens Appnote 19.

RECOMMENDED OPERATING CONDITIONS (Guaranteed over operating temperature range)

Parameter	Symbol	Min.	Nom.	Max.	Units
Supply Voltage	V_{CC}	4.75	5.0	5.25	V
Data Out Current, Low State	I_{OL}			1.6	mA
Data Out Current, High State	I_{OH}			-0.5	mA
Column Input Voltage, Column On(1)	V_{COL}	2.75		3.5	V
Setup Time	T_{SETUP}	70	45		ns
Hold Time	T_{HOLD}	30			ns
Width of Clock	$T_{W(CLK)}$	75			ns
Clock Frequency	T_{CLK}			5	MHz
Clock Transition Time	T_{THL}			200	ns
Free Air Operating Temperature Range	T_{amb}	-55		+100	°C

Note:
1. See Figure 3 – Peak Column Current vs. Column Voltage.

OPTICAL CHARACTERISTICS

Red ISD2310

Description	Symbol	Min.	Typ.(4)	Max.	Units	Test Conditions
Peak Luminous Intensity per LED(1, 3) (Character Average)	I_{VPEAK}	220	370		μcd	$V_{CC}=5.0$ V, $V_{COL}=3.5$ V T_J(5) = 25°C, $V_B=2.4$ V
Peak Wavelength	λ_{PEAK}		655		nm	
Dominant Wavelength(2)	λ_D		639		nm	

Yellow ISD2311

Description	Symbol	Min.	Typ.(4)	Max.	Units	Test Conditions
Peak Luminous Intensity per LED(1, 3) (Character Average)	I_{VPEAK}	650	1140		μcd	$V_{CC}=5.0$ V, $V_{COL}=3.5$ V T_J(5) = 25°C, $V_B=2.4$ V
Peak Wavelength	λ_{PEAK}		583		nm	
Dominant Wavelength(2)	λ_D		585		nm	

High Efficiency Red ISD2312

Description	Symbol	Min.	Typ.(4)	Max.	Units	Test Conditions
Peak Luminous Intensity per LED(1, 3) (Character Average)	I_{VPEAK}	650	1430		μcd	$V_{CC}=5.0$ V, $V_{COL}=3.5$ V T_J(5) = 25°C, $V_B=2.4$ V
Peak Wavelength	λ_{PEAK}		635		nm	
Dominant Wavelength(2)	λ_D		626		nm	

High Efficiency Green ISD2313

Description	Symbol	Min.	Typ.(4)	Max.	Units	Test Conditions
Peak Luminous Intensity per LED(1, 3) (Character Average)	I_{VPEAK}	1280	2410		μcd	$V_{CC}=5.0$ V, $V_{COL}=3.5$ V T_J(5) = 25°C, $V_B=2.4$ V
Peak Wavelength	λ_{PEAK}		568		nm	
Dominant Wavelength(2)	λ_D		574		nm	

Notes:
1. The displays are categorized for luminous intensity with the intensity category designated by a letter code on the bottom of the package.
2. Dominant wavelength λ_D, is derived from the CIE chromaticity diagram, and represents the single wavelength which defines the color of the device.
3. The luminous sterance of the LED may be calculated using the following relationships: L_V (cd/m²) = I_V (Candela)/A (Meter)²
   L_V (Footlamberts) = πI_V (Candela)/A (Foot)²
   $A = 5.3 \times 10^{-8}\ M^2 = 5.8 \times 10^{-7}$ (Foot)²
4. All typical values specified at $V_{CC}=5.0$ V and $T_{amb}=25°C$ unless otherwise noted.
5. The luminous intensity is measured at $T_{amb}=T_J=25°C$. No time is allowed for the device to warm up prior to measurement.

ELECTRICAL CHARACTERISTICS (-55°C to +100°C) (unless otherwise specified)

Description	Symbol	Min.	Typ.(1)	Max.	Units	Test Conditions	
Supply Current (quiescent)	I_{CC}		2	5.0	mA	$V_B=0.4$ V	$V_{CC}=5.25$ V $V_{CLK}=V_{DATA}=2.4$ V All SR Stages = Logical 1
			2.5	5.0	mA	$V_B=2.4$ V	
Supply Current (operating)	I_{CC}		3	10.0	mA	$F_{CLK}=5$ MHz	
Column Current at any Column Input(2)	I_{COL} (All)			10	μA	$V_B=0.4$ V	$V_{CC}=5.25$ V $V_{COL}=3.5$ V All SR Stages = Logical 1
	I_{COL}		380	520	mA	$V_B=2.4$ V	
V_B, Clock or Data Input Threshold Low	V_{IL}			0.8	V	$V_{CC}=4.75$ V – 5.25 V	
V_B, Clock or Data Input Threshold High	V_{IH}	2.0			V		
Data Out Voltage	V_{OH}	2.4	3.6		V	$I_{OH}=-0.5$ mA	$V_{CC}=5.25$ V $I_{COL}=0$ mA
	V_{OL}		0.2	0.4	V	$I_{OL}=1.6$ mA	
Input Current Logical 0 V_B only	I_{IL}	-30	-110	-300	μA	$V_{CC}=4.75$ V – 5.25 V, $V_{IL}=0.8$ V	
Input Current Logical 0 Data, Clock	I_{IL}		-1	-10	μA		
Input Current Logical 1 Data, Clock	I_{IH}			10	μA	$V_{CC}=4.75$ V – 5.25 V, $V_{IH}=2.4$ V	
Input Current Logical 1 V_B	I_{IH}			200	μA		
Power Dissipation per Package	P_D		0.52		W	$V_{CC}=5.0$ V, $V_{COL}=3.5$ V, 17.5% DF 15 LEDs on per character, $V_B=2.4$ V	
Thermal Resistance IC Junction-to-Pin	$R\theta_{J\text{-}PIN}$		25		°C/W/ Device		

Notes:
1. All typical values specified at $V_{CC}=5.0$ V and $T_{amb}=25$°C unless otherwise noted.
2. See Figure 3 – Peak Column Current vs. Column Voltage.

FIGURE 3. PEAK COLUMN CURRENT VS. COLUMN VOLTAGE

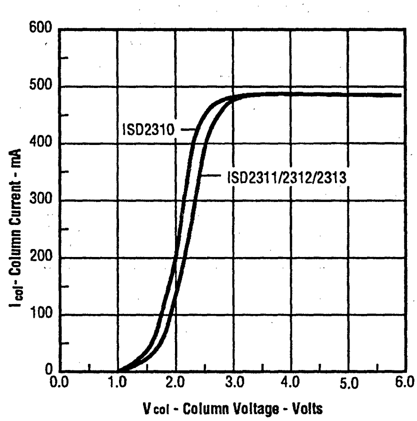
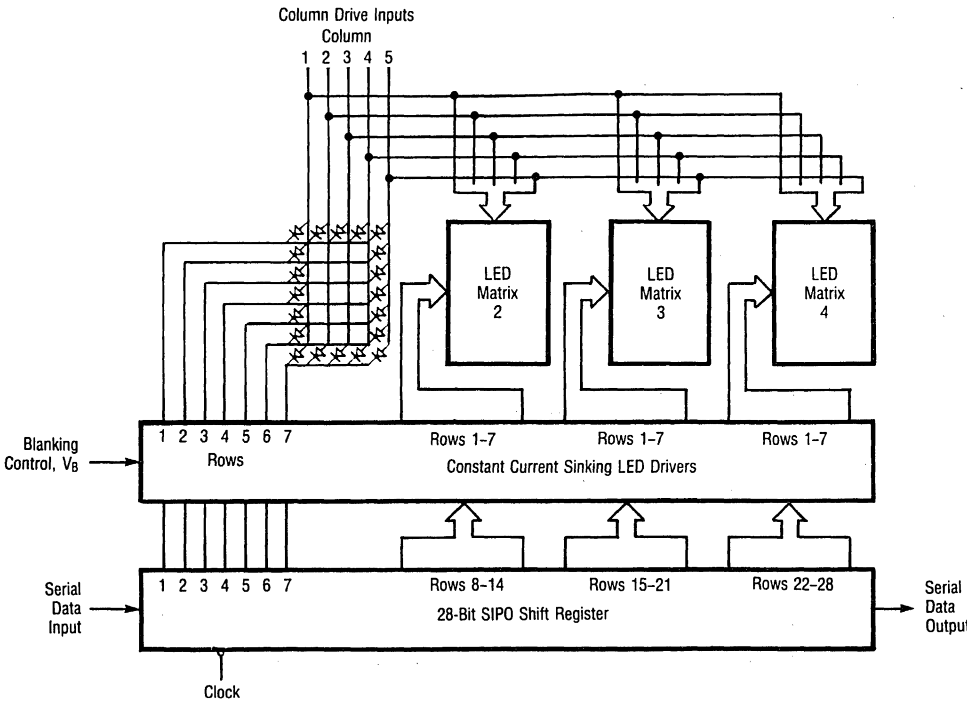


FIGURE 4. BLOCK DIAGRAM



CONTRAST ENHANCEMENT FILTERS FOR SUNLIGHT READABILITY

Display Color Part No.	Filter Color	Marks Polarized Corp.* Filter Series	Optical Characteristics of Filter	
Red, HER ISD2310, 2312	Red	MPC 20-15C	25% @ 635 nm	Circular Polarizer
Yellow ISD2311	Amber	MPC 30-25C	25% @ 583 nm	
Green ISD2313	Yellow/Green	MPC 50-22C	22% @ 568 nm	
Multiple Colors High Ambient Light	Neutral Gray	MPC 80-10C	10% Neutral	
Multiple Colors	Neutral Gray	MPC 80-37C	37% Neutral	

*Marks Polarized Corp.
25-B Jefryn Blvd. W.
Deer Park, NY 11729
516-242-1300
FAX (516) 242-1347
Marks Polarized Corp. manufactures to MIL-I-45208 inspection system.

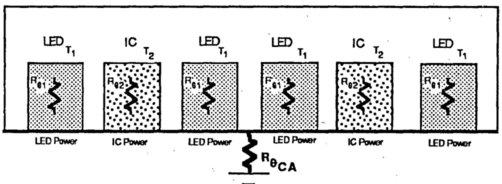
THERMAL CONSIDERATIONS

The small alphanumeric displays are hybrid LED and CMOS assemblies that are designed for reliable operation in commercial, industrial, and military environments. Optimum reliability and optical performance will result when the junction temperature of the LEDs and CMOS ICs are kept as low as possible.

THERMAL MODELING

ISD231X displays consist of two driver ICs and four 5 x 7 LED matrixes. A thermal model of the display is shown in Figure 5. It illustrates that the junction temperature of the semiconductor = junction self heating + the case temperature rise + the ambient temperature. Equation 1 shows this relationship.

FIGURE 5. THERMAL MODEL



Equation 1.

$$T_{J(LED)} = P_{LED}\, Z_{\theta JC} + P_{CASE}\, (R_{\theta JC} + R_{\theta CA}) + T_A$$

$$T_{J(LED)} = [(I_{COL}/28)\, V_{F(LED)}\, Z_{\theta JC}] + [(n/35)\, I_{COL}\, DF\, (5\, V_{COL}) + V_{CC}\, I_{CC}] \cdot [R_{\theta JC} + R_{\theta CA}] + T_A$$

The junction rise within the LED is the product of the thermal impedance of an individual LED (37 °C/W, DF = 20%, F = 200 Hz), times the forward voltage, $V_{F(LED)}$, and forward current, $I_{F(LED)}$, of 13 – 14.5 mA. This rise averages $T_{J(LED)} = 1$ °C. The table below shows the $V_{F(LED)}$ for the respective displays.

Part Number	V_F		
	Min.	Typ.	Max.
ISD2310	1.6	1.7	2.0
ISD2311/2/3	1.9	2.2	3.0

The junction rise within the LED driver IC is the combination of the power dissipated by the IC quiescent current and the 28 row driver current sinks. The IC junction rise is given in Equation 2.

A thermal resistance of 28 °C/W results in a typical junction rise of 6 °C.

Equation 2.

$$T_{J(IC)} = P_{COL}\, (R_{\theta JC} + R_{\theta CA}) + T_A$$

$$T_{J(IC)} = [5\, (V_{COL} - V_{F(LED)}) \cdot (I_{COL}/2) \cdot (n/35)\, DF + V_{CC} \cdot I_{CC}] \cdot [R_{\theta JC} + R_{\theta CA}] + T_A$$

THERMAL MODELING (Cont.)
For ease of calculations the maximum allowable electrical operating condition is dependent upon the aggregate thermal resistance of the LED matrixes and the two driver ICs. All of the thermal management calculations are based upon the parallel combination of these two networks which is 15°C/W. Maximum allowable power dissipation is given in Equation 3.

Equation 3.

$$P_{DISPLAY} = \frac{T_{J(MAX)} - T_A}{R_{\theta JC} + R_{\theta CA}}$$

$$P_{DISPLAY} = 5\ V_{COL}\ I_{COL}\ (n/35)\ DF + V_{CC}\ I_{CC}$$

For further reference see Figures 2, 7, 8, 9, 10 and 11.

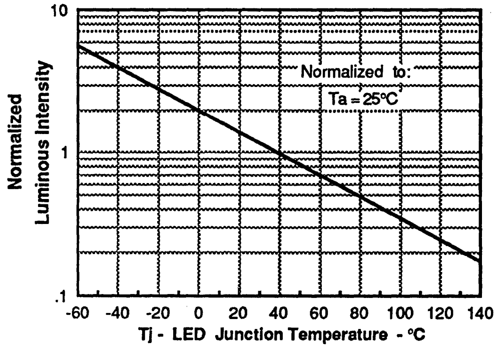
KEY TO EQUATION SYMBOLS

DF	Duty factor
I_{CC}	Quiescent IC current
I_{COL}	Column current
n	Number of LEDs on in a 5×7 array
P_{CASE}	Package power dissipation excluding LED under consideration
P_{COL}	Power dissipation of a column
$P_{DISPLAY}$	Power dissipation of the display
P_{LED}	Power dissipation of an LED
$R_{\theta CA}$	Thermal resistance case to ambient
$R_{\theta JC}$	Thermal resistance junction to case
T_A	Ambient temperature
$T_{J(IC)}$	Junction temperature of an IC
$T_{J(LED)}$	Junction temperature of a LED
$T_{J(MAX)}$	Maximum junction temperature
V_{CC}	IC voltage
V_{COL}	Column voltage
$V_{F(LED)}$	Forward voltage of LED
$Z_{\theta JC}$	Thermal impedance junction to case

OPTICAL CONSIDERATIONS

The light output of the LEDs is inversely related to the LED diode's junction temperature as shown in Figure 6. For optimum light output, keep the thermal resistance of the socket or PC board as low as possible.

FIGURE 6. NORMALIZED LUMINOUS INTENSITY VS. JUNCTION TEMPERATURE



When mounted in a 10°C/W socket and operated at Absolute Maximum Electrical conditions, the ISD231X will show an LED junction rise of 17°C. If $T_A = 40°C$, then the LED's T_J will be 57°C. Under these conditions Figure 7 shows that the I_V will be 75% of its 25°C value.

FIGURE 7. MAX. LED JUNCTION TEMPERATURE VS. SOCKET THERMAL RESISTANCE

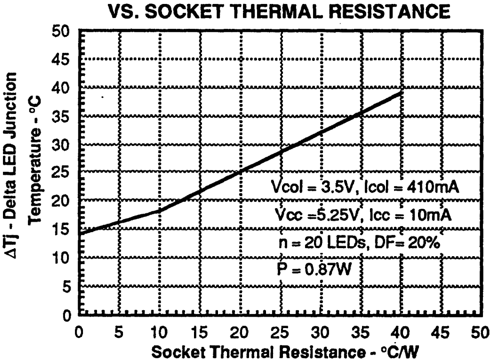


FIGURE 8. MAX. PACKAGE POWER DISSIPATION

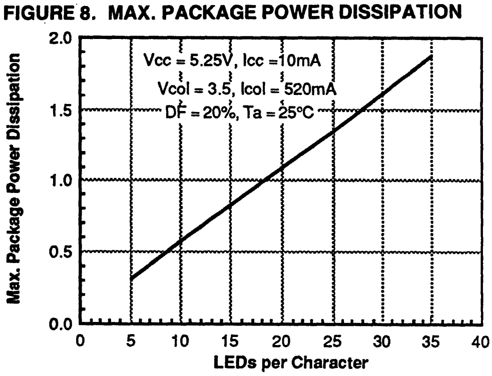


FIGURE 9. PACKAGE POWER DISSIPATION

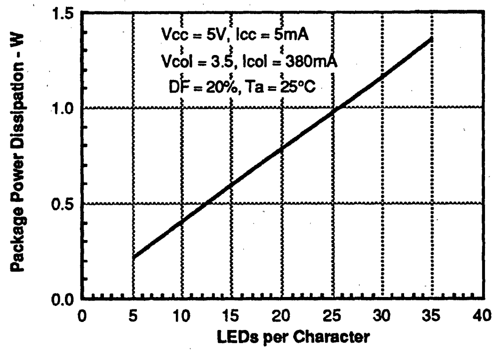


FIGURE 10. MAX. CHARACTER POWER DISSIPATION

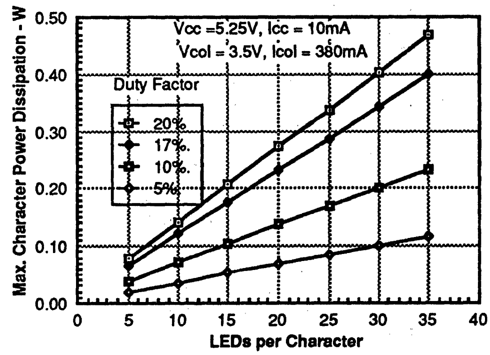
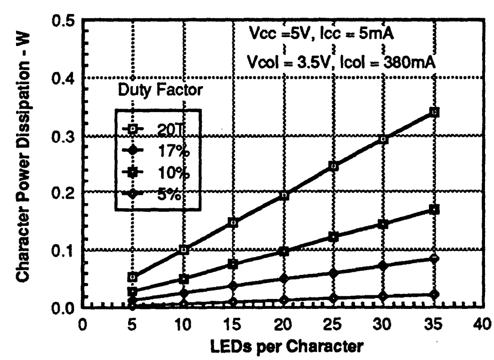


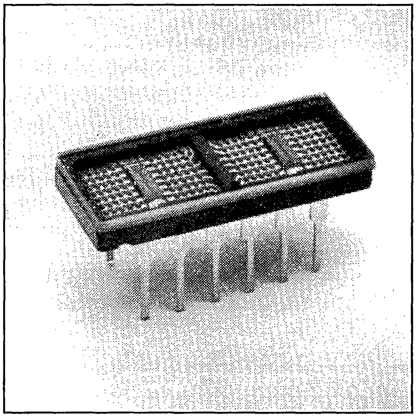
FIGURE 11. CHARACTER POWER DISSIPATION



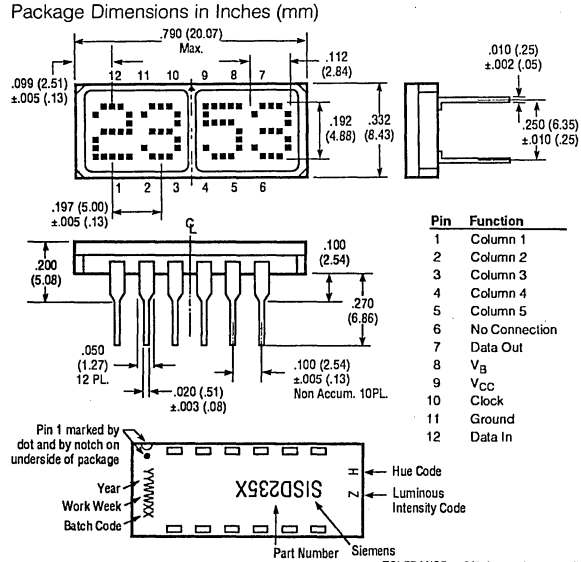
SIEMENS

YELLOW ISD2351
HIGH EFFICIENCY RED ISD2352
HIGH EFFICIENCY GREEN ISD2353

Sunlight Viewable .200″ 4-Character 5×7 Dot Matrix Serial Input Alphanumeric Hi Rel/Industrial Display



Package Dimensions in Inches (mm)



Pin	Function
1	Column 1
2	Column 2
3	Column 3
4	Column 4
5	Column 5
6	No Connection
7	Data Out
8	V_B
9	V_{CC}
10	Clock
11	Ground
12	Data In

TOLERANCE: ±.015 (exceptions noted)

FEATURES

- **Four .200″ Dot Matrix Characters**
- **Three Colors: Yellow, High Efficiency Red, High Efficiency Green**
- **Sunlight Viewable**
- **Wide Viewing Angle**
- **Built-in CMOS Shift Registers with Constant Current LED Row Drivers**
- **Shift Registers Allow Custom Fonts**
- **Easily Cascaded for Multiple Displays**
- **TTL Compatible**
- **End Stackable**
- **Operating Temperature Range: -55° to +100°C**
- **Categorized for Luminous Intensity**
- **Ceramic Package, Hermetically Sealed Flat Glass Window**

DESCRIPTION

The ISD2351 through ISD2353 are four digit 5×7 dot matrix serial input alphanumeric displays. The displays are available in yellow, high efficiency red, or high efficiency green. The package is a standard twelve-pin hermetic package with glass lens. The display can be stacked horizontally or vertically to form messages of any length. The ISD235X has two fourteen-bit CMOS shift registers with built-in row drivers. These shift registers drive twenty-eight rows and enable the design of customized fonts. Cascading multiple displays is possible because of the Data In and Data Out pins. Data In and Out are easily input with the clock signal and displayed in parallel on the row drivers. Data Out represents the output of the 7th bit of digit number four shift register. The shift register is level triggered. The like columns of each character in a display cluster are tied to a single pin. (See Block Diagram). High true data in the shift register enables the output current mirror driver stage associated with each row of LEDs in the 5×7 diode array.

The TTL compatible V_B input may either be tied to V_{CC} for maximum display intensity or pulse width modulated to achieve intensity control and reduce power consumption.

—Continued

See Appnote 44 for application information, and Appnotes 18, 19, 22, and 23 for additional information.

DESCRIPTION (Continued)

In the normal mode of operation, input data for digit four, column one is loaded into the seven on-board shift register locations one through seven. Column one data for digits 3, 2, and 1 is shifted into the display shift register locations. Then column one input is enabled for an appropriate period of time, T. A similar process is repeated for columns 2, 3, 4, and 5. If the decode time and load data time into the shift register is t, then with five columns, each column of the display is operating at a duty factor of:

$$DF = \frac{T}{5(T+t)}$$

T+t, allotted to each display column, is generally chosen to provide the maximum duty factor consistent with the minimum refresh rate necessary to achieve a flicker free display. For most strobed display systems, each column of the display should be refreshed (turned on) at a minimum rate of 100 times per second.

With columns to be addressed, this refresh rate then gives a value for the time T+t of: 1/[5×(100)]=2 msec. If the device is operated at 5.0 MHz clock rate maximum, it is possible to maintain t<<T. For short display strings, the duty factor will then approach 20%.

Maximum Ratings

Supply Voltage V_{CC} to GND .... −0.5 V to +7.0 V
Inputs, Data Out and V_B .... −0.5 V to V_{CC} +0.5 V
Column Input Voltage, V_{COL} .... −0.5 V to +6.0 V
Operating Temperature Range[1, 2] ..... −55°C to +100°C
Storage Temperature Range .... −65°C to +125°C
Maximum Solder Temperature, 0.063″ (1.59 mm) below Seating Plane, t<5 sec .... 260°C
Maximum Power Dissipation at T_{amb}=25°C[2] .... 1.35 W

Notes:
1. Operation above +100°C ambient is possible provided the following condition are met. The junction should not exceed T_J=125°C and the case temperature (as measured at pin 1 or the back of the display) should not exceed T_C=100°C.
2. Maximum dissipation is derived from V_{CC}=5.25 V, V_B=2.4 V, V_{COL}=3.5 V 20 LEDs on per character, 20% DF.

FIGURE 1. TIMING CHARACTERISTICS

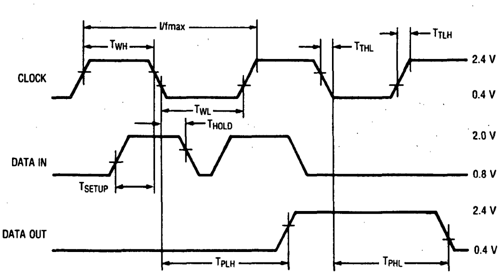
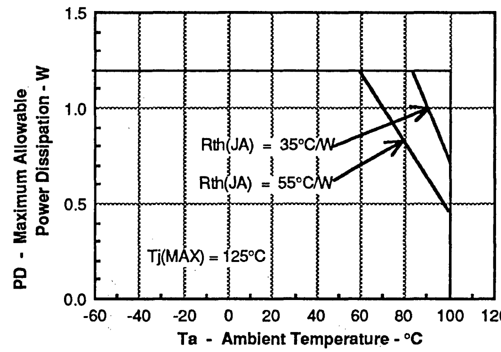


FIGURE 2. MAX. ALLOWABLE POWER DISSIPATION VS. TEMPERATURE



AC ELECTRICAL CHARACTERISTICS

(V_{CC}=4.75 to 5.25 V, T_{amb}=−55°C to +100°C)

Symbol	Description	Min.	Typ.[1]	Max.[2]	Units	Fig.
T_{SETUP}	Setup Time	50	10		ns	1
T_{HOLD}	Hold Time	25	20		ns	1
T_{WL}	Clock Width Low	75	45		ns	1
T_{WH}	Clock Width High	75	45		ns	1
$F_{(CLK)}$	Clock Frequency		6	5	MHz	1
T_{THL}, T_{TLH}	Clock Transition Time		75	200	ns	1
T_{PHL}, T_{PLH}	Propagation Delay Clock to Data Out		50	125	ns	1

Notes:
1. All typical values specified at V_{CC}=5.0 V and T_{amb}=25°C unless otherwise noted.
2. V_B Pulse Width Modulation Frequency — 50 KHz (max).

CLEANING THE DISPLAYS

IMPORTANT — Do not use cleaning agents containing alcohol of any type with this display. The least offensive cleaning solution is hot D.I. water (60°C) for less than 15 minutes. Addition of mild saponifiers is acceptable. Do not use commercial dishwasher detergents.

For post solder cleaning use water or non-alcohol mixtures formulated for vapor cleaning processing or non-alcohol mixtures formulated for room temperature cleaning. Non-alcohol vapor cleaning processing for up to two minutes in vapors at boiling is permissible. For suggested solvents refer to Siemens Appnote 19.

RECOMMENDED OPERATING CONDITIONS (Guaranteed over operating temperature range)

Parameter	Symbol	Min.	Nom.	Max.	Units
Supply Voltage	V_{CC}	4.75	5.0	5.25	V
Data Out Current, Low State	I_{OL}			1.6	mA
Data Out Current, High State	I_{OH}			-0.5	mA
Column Input Voltage, Column On[1]	V_{COL}	2.75		3.5	V
Setup Time	T_{SETUP}	70	45		ns
Hold Time	T_{HOLD}	30			ns
Width of Clock	$T_{W(CLK)}$	75			ns
Clock Frequency	T_{CLK}			5	MHz
Clock Transition Time	T_{THL}			200	ns
Free Air Operating Temperature Range	T_{amb}	-55		+100	°C

Note:
1. See Figure 3 - Peak Column Current vs. Column Voltage.

Intelligent Display Devices

OPTICAL CHARACTERISTICS

Yellow ISD2351

Description	Symbol	Min.	Typ.[4]	Max.	Units	Test Conditions
Peak Luminous Intensity per LED[1, 3] (Character Average)	I_{VPEAK}	2400	3400		μcd	$V_{CC}=5.0$ V, $V_{COL}=3.5$ V $T_J^{(5)}=25°C$, $V_B=2.4$ V
Peak Wavelength	λ_{PEAK}		583		nm	
Dominant Wavelength[2]	λ_D		585		nm	

High Efficiency Red ISD2352

Description	Symbol	Min.	Typ.[4]	Max.	Units	Test Conditions
Peak Luminous Intensity per LED[1, 3] (Character Average)	I_{VPEAK}	1920	2850		μcd	$V_{CC}=5.0$ V, $V_{COL}=3.5$ V $T_J^{(5)}=25°C$, $V_B=2.4$ V
Peak Wavelength	λ_{PEAK}		635		nm	
Dominant Wavelength[2]	λ_D		626		nm	

High Efficiency Green ISD2353

Description	Symbol	Min.	Typ.[4]	Max.	Units	Test Conditions
Peak Luminous Intensity per LED[1, 3] (Character Average)	I_{VPEAK}	2400	3000		μcd	$V_{CC}=5.0$ V, $V_{COL}=3.5$ V $T_J^{(5)}=25°C$, $V_B=2.4$ V
Peak Wavelength	λ_{PEAK}		568		nm	
Dominant Wavelength[2]	λ_D		574		nm	

Notes:
1. The displays are categorized for luminous intensity with the intensity category designated by a letter code on the bottom of the package.
2. Dominant wavelength λ_D, is derived from the CIE chromaticity diagram, and represents the single wavelength which defines the color of the device.
3. The luminous sterance of the LED may be calculated using the following relationships: L_V (cd/m²) = I_V (Candela)/A (Meter)²
   L_V (Footlamberts) = πI_V (Candela)/A (Foot)²
   $A = 5.3 \times 10^{-8}$ M² $= 5.8 \times 10^{-7}$ (Foot)²
4. All typical values specified at $V_{CC}=5.0$ V and $T_{amb}=25°C$ unless otherwise noted.
5. The luminous intensity is measured at $T_{amb}=T_J=25°C$. No time is allowed for the device to warm up prior to measurement.

ELECTRICAL CHARACTERISTICS (–55°C to +100°C) (unless otherwise specified)

Description	Symbol	Min.	Typ.[1]	Max.	Units	Test Conditions	
Supply Current (quiescent)	I_{CC}		2	5.0	mA	$V_B = 0.4$ V	$V_{CC} = 5.25$ V, $V_{CLK} = V_{DATA} = 2.4$ V, All SR Stages = Logical 1
			2.5	5.0	mA	$V_B = 2.4$ V	
Supply Current (operating)	I_{CC}		3	10.0	mA	$F_{CLK} = 5$ MHz	
Column Current at any Column Input[2]	I_{COL} (All)			10	μA	$V_B = 0.4$ V	$V_{CC} = 5.25$ V, $V_{COL} = 3.5$ V, All SR Stages = Logical 1
	I_{COL}		550	650	mA	$V_B = 2.4$ V	
V_B, Clock or Data Input Threshold Low	V_{IL}			0.8	V	$V_{CC} = 4.75$ V – 5.25 V	
V_B, Clock or Data Input Threshold High	V_{IH}	2.0			V		
Data Out Voltage	V_{OH}	2.4	3.6		V	$I_{OH} = -0.5$ mA	$V_{CC} = 5.25$ V, $I_{COL} = 0$ mA
	V_{OL}		0.2	0.4	V	$I_{OL} = 1.6$ mA	
Input Current Logical 0 V_B only	I_{IL}	–30	–110	–300	μA	$V_{CC} = 4.75$ V – 5.25 V, $V_{IL} = 0.8$ V	
Input Current Logical 0 Data, Clock	I_{IL}		–1	–10	μA		
Input Current Logical 1 Data, Clock	I_{IH}			10	μA	$V_{CC} = 4.75$ V – 5.25 V, $V_{IH} = 2.4$ V	
Input Current Logical 1 V_B	I_{IH}			200	μA		
Power Dissipation per Package	P_D		0.74		W	$V_{CC} = 5.0$ V, $V_{COL} = 3.5$ V, 17.5% DF, 15 LEDs on per character, $V_B = 2.4$ V	
Thermal Resistance IC Junction-to-Pin	$R\theta_{J-PIN}$		25		°C/W/ Device		

Notes:
1. All typical values specified at $V_{CC} = 5.0$ V and $T_{amb} = 25$°C unless otherwise noted.
2. See Figure 3 – Peak Column Current vs. Column Voltage.

FIGURE 3. PEAK COLUMN CURRENT VS. COLUMN VOLTAGE

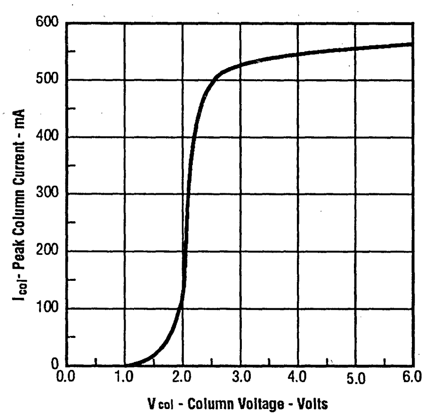
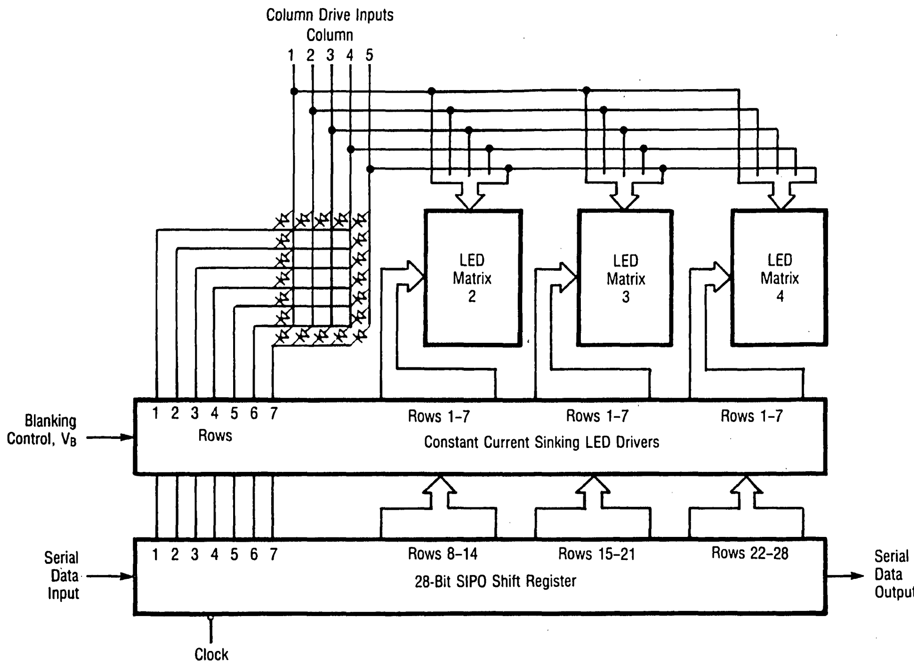


FIGURE 4. BLOCK DIAGRAM



CONTRAST ENHANCEMENT FILTERS FOR SUNLIGHT READABILITY

Display Color Part No.	Filter Color	Marks Polarized Corp.* Filter Series	Optical Characteristics of Filter	
HER ISD2352	Red	MPC 20-15C	25% @ 635 nm	Circular Polarizer
Yellow ISD2351	Amber	MPC 30-25C	25% @ 583 nm	
Green ISD2353	Yellow/Green	MPC 50-22C	22% @ 568 nm	
Multiple Colors High Ambient Light	Neutral Gray	MPC 80-10C	10% Neutral	
Multiple Colors	Neutral Gray	MPC 80-37C	37% Neutral	

*Marks Polarized Corp.
25-B Jefryn Blvd. W.
Deer Park, NY 11729
516-242-1300
FAX (516) 242-1347

Marks Polarized Corp. manufactures to MIL-I-45208 inspection system.

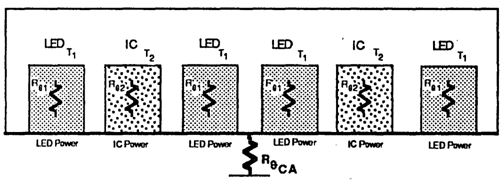
THERMAL CONSIDERATIONS

The small alphanumeric displays are hybrid LED and CMOS assemblies that are designed for reliable operation in commercial, industrial, and military environments. Optimum reliability and optical performance will result when the junction temperature of the LEDs and CMOS ICs are kept as low as possible.

THERMAL MODELING

ISD235X displays consist of two driver ICs and four 5 x 7 LED matrixes. A thermal model of the display is shown in Figure 5. It illustrates that the junction temperature of the semiconductor = junction self heating + the case temperature rise + the ambient temperature. Equation 1 shows this relationship.

FIGURE 5. THERMAL MODEL



Equation 1.

$$T_{J(LED)} = P_{LED}\ Z_{\theta JC} + P_{CASE}\ (R_{\theta JC} + R_{\theta CA}) + T_A$$

$$T_{J(LED)} = [(I_{COL}/28)\ V_{F(LED)}\ Z_{\theta JC}] + [(n/35)\ I_{COL}\ DF\ (5\ V_{COL}) + V_{CC}\ I_{CC}] \cdot [R_{\theta JC} + R_{\theta CA}] + T_A$$

The junction rise within the LED is the product of the thermal impedance of an individual LED (37 °C/W, DF = 20%, F = 200 Hz), times the forward voltage, $V_{F(LED)}$, and forward current, $I_{F(LED)}$, of 13 – 14.5 mA. This rise averages $T_{J(LED)} = 1$ °C. The table below shows the $V_{F(LED)}$ for the respective displays.

Part Number	V_F		
	Min.	**Typ.**	**Max.**
ISD2351/2/3	1.9	2.2	3.0

The junction rise within the LED driver IC is the combination of the power dissipated by the IC quiescent current and the 28 row driver current sinks. The IC junction rise is given in Equation 2.

A thermal resistance of 28 °C/W results in a typical junction rise of 6 °C.

Equation 2.

$$T_{J(IC)} = P_{COL}\ (R_{\theta JC} + R_{\theta CA}) + T_A$$

$$T_{J(IC)} = [5\ (V_{COL} - V_{F(LED)}) \cdot (I_{COL}/2) \cdot (n/35)\ DF + V_{CC} \cdot I_{CC}] \cdot [R_{\theta JC} + R_{\theta CA}] + T_A$$

THERMAL MODELING (Cont.)

For ease of calculations the maximum allowable electrical operating condition is dependent upon the aggregate thermal resistance of the LED matrixes and the two driver ICs. All of the thermal management calculations are based upon the parallel combination of these two networks which is 15°C/W. Maximum allowable power dissipation is given in Equation 3.

Equation 3.

$$P_{DISPLAY} = \frac{T_{J(MAX)} - T_A}{R_{\theta JC} + R_{\theta CA}}$$

$$P_{DISPLAY} = 5\ V_{COL}\ I_{COL}\ (n/35)\ DF + V_{CC}\ I_{CC}$$

For further reference see Figures 2, 7, 8, 9, 10 and 11.

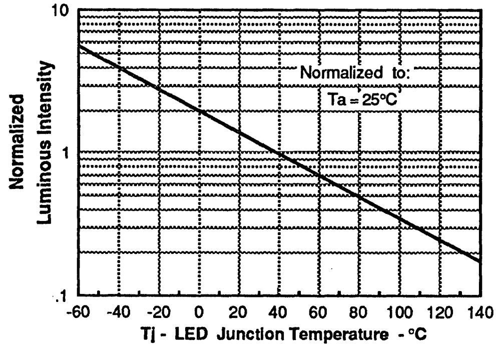
KEY TO EQUATION SYMBOLS

DF	Duty factor
I_{CC}	Quiescent IC current
I_{COL}	Column current
n	Number of LEDs on in a 5×7 array
P_{CASE}	Package power dissipation excluding LED under consideration
P_{COL}	Power dissipation of a column
$P_{DISPLAY}$	Power dissipation of the display
P_{LED}	Power dissipation of an LED
$R_{\theta CA}$	Thermal resistance case to ambient
$R_{\theta JC}$	Thermal resistance junction to case
T_A	Ambient temperature
$T_{J(IC)}$	Junction temperature of an IC
$T_{J(LED)}$	Junction temperature of a LED
$T_{J(MAX)}$	Maximum junction temperature
V_{CC}	IC voltage
V_{COL}	Column voltage
$V_{F(LED)}$	Forward voltage of LED
$Z_{\theta JC}$	Thermal impedance junction to case

OPTICAL CONSIDERATIONS

The light output of the LEDs is inversely related to the LED diode's junction temperature as shown in Figure 6. For optimum light output, keep the thermal resistance of the socket or PC board as low as possible.

FIGURE 6. NORMALIZED LUMINOUS INTENSITY VS. JUNCTION TEMPERATURE



When mounted in a 10 °C/W socket and operated at Absolute Maximum Electrical conditions, the ISD235X will show an LED junction rise of 17 °C. If $T_A = 40\,°C$, then the LED's T_J will be 57 °C. Under these conditions Figure 7 shows that the I_V will be 75% of its 25 °C value.

FIGURE 7. MAX. LED JUNCTION TEMPERATURE VS. SOCKET THERMAL RESISTANCE

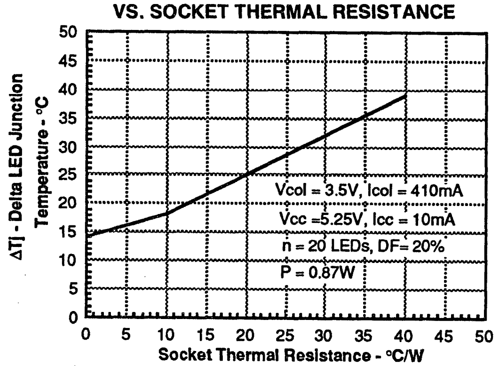


FIGURE 8. MAX. PACKAGE POWER DISSIPATION

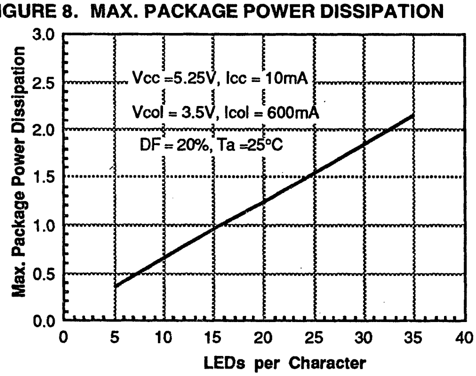


FIGURE 9. PACKAGE POWER DISSIPATION

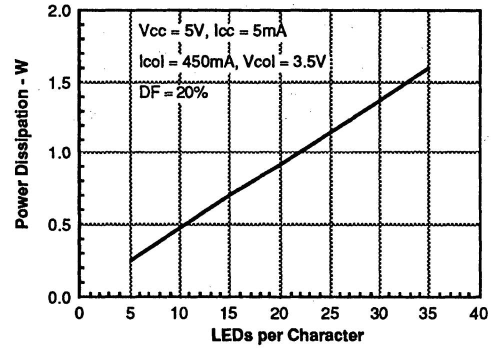


FIGURE 10. MAX. CHARACTER POWER DISSIPATION

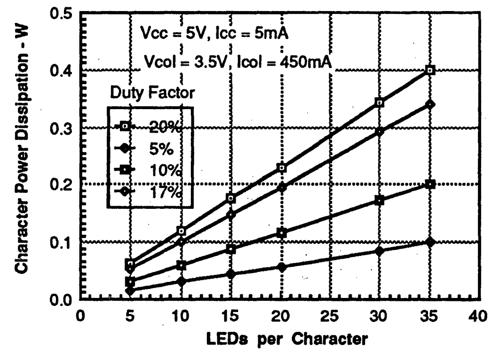
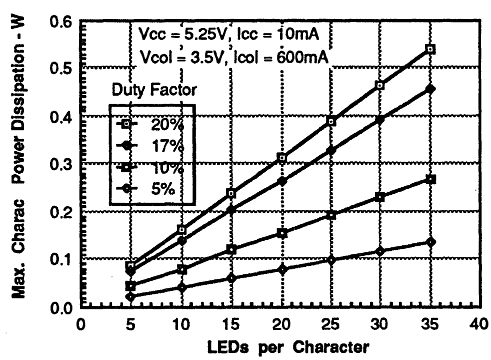


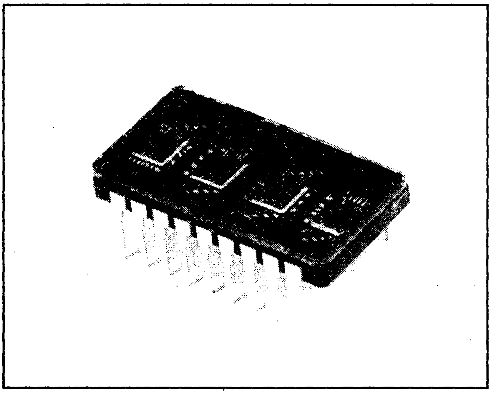
FIGURE 11. CHARACTER POWER DISSIPATION



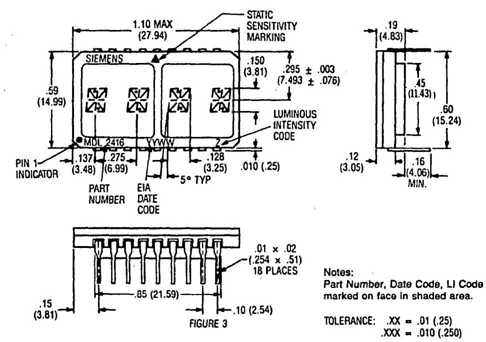
SIEMENS

MDL 2416C
MDL 2416TXV
MDL 2416TXVB

.15″ Red, 4-Digit, 16 Segment plus Decimal HI-REL/Military Alphanumeric Intelligent Display® with Memory/Decoder/Driver



Package Dimensions in Inches (mm)



FEATURES

- 150 Mil High, Non-Magnified Monolithic Character
- Rugged Ceramic Package, Hermetically Sealed Flat Glass Window
- Low Profile Package
- Dual In Line Configuration
- Close Vertical Row Spacing, .600 Inches
- 100 Mil Pin Spacing
- Wide Viewing Angle
- Wide Temperature Operating Range, −55°C to +100°C
- Fully Integrated CMOS Drive Electronics
- Direct Access to Each Digit Independently and Asynchronously
- TTL Compatible, 5 Volt Power Supply
- Independent Cursor Function
- 17th Segment for Improved Punctuation Marks
- Two Chip Enables
- Interdigit Blanking
- Display Blank Function
- Memory Clear Function
- End-Stackable, Four Character Package
- Intensity Coded for Display Uniformity
- TXVB Process Conforms to MIL-D-87157 Quality Level A Test and Tables I, II, IIIa and IV
- TXV Process Conforms to a Modified MIL-D-87157 Quality Level A Test and Table I

DESCRIPTION

The MDL 2416 is a military alphanumeric four digit display having a 17 segment font and built-in CMOS drive circuitry that is TTL and microprocessor compatible. The integrated circuit contains memory, ASCII ROM decoder, multiplexing circuitry, and drivers. The MDL 2416 is designed for use in extremely harsh environments where only the most reliable product is acceptable.

Data entry is asynchronous and can be random. A display system can be built using any number of MDL 2416s since each digit of any MDL 2416 can be addressed independently and will continue to display the character last stored until replaced by another.

System interconnection is straightfoward. The least significant two address bits (A_0, A_1) are normally connected to the like named inputs of all MDL 2416s in the system. With two chips enables, ($\overline{CE1}$, $\overline{CE2}$), four MDL 2416s (16 characters) can easily be interconnected without an external decoder.

Important: Since this is a CMOS device, normal precautions should be taken to avoid static damage.

OPTOELECTRONIC CHARACTERISTICS @ 25°C

ABSOLUTE MAXIMUM RATINGS	
DC Supply	-0.5 to +6.0 VDC
Input Voltage Relative to Gnd (all inputs)	-0.5 to V_{CC} +0.5 VDC
Operating temperature	-55 to +100°C
Storage temperature	-65 to +125°C

OPTICAL CHARACTERISTICS	
Spectral Peak Wavelength	660 nm typ.
Spectral Line Half-Width	40 nm typ.
Viewing Angle (Note 1)	±50°
Digit Size	.15 in.
Luminous Intensity (Typ.)	0.1 mcd/seg @ V_{CC}=5V
Intensity matching, Seg. to Seg.	1.8:1 @ V_{CC}=5V

DC CHARACTERISTICS @25°C

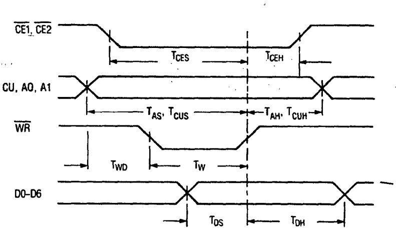
Parameter	Min.	Typ.	Max.	Units	Conditions
V_{CC}	4.5	5.0	5.5	V	25°C
I_{CC} (Blank) (1)	0.10	1.5	4.0	mA	V_{CC}=5 V, $\overline{WR}=V_{CC}$, V_{IN}=0 V All other pins
I_{CC} (10 segments/char. 4 digits on)	65	85	115	mA	V_{CC}=5 V
I_{CC} (all segments on cursor in 4 digits) (1, 2)	85	120	165	mA	V_{CC}=5 V Measured at 5 sec, 60 sec max.
V_{IL} (all inputs)			0.8	V	V_{CC}=5 V ±0.5 V
V_{IH} (all inputs)	2.0			V	V_{CC}=5 V ±0.5 V
I_{IL} (all inputs)		60	160	μA	V_{CC}=5 V, V_{IN}=0.8 V

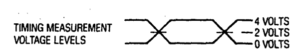
1. Measured at 5 sec.
2. 60 sec. max. duration.

AC CHARACTERISTICS

Parameter	Symbol	−55°C (ns)	+25°C (ns)	+100°C (ns)
Chip Enable Set Up Time	T_{CES}	190	275	410
Address Set Up Time	T_{AS}	190	275	410
Cursor Set Up Time	T_{CUS}	190	275	410
Chip Enable Hold Time	T_{CEH}	25	25	25
Address Hold Time	T_{AH}	25	25	25
Cursor Hold Time	T_{CUH}	25	25	25
Write Delay Time	T_{WD}	40	50	60
Write Pulse	T_W	150	225	350
Data Set Up Time	T_{DS}	100	150	300
Data Hold Time	T_{DH}	25	25	25
Clear	T_{CLR}	12 ms	15 ms	17.5 ms

TIMING CHARACTERISTICS
WRITE CYCLE WAVEFORMS

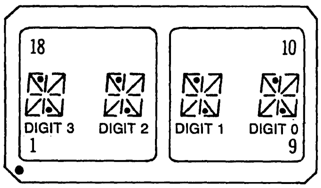




(for tester calibration only)

Notes: 1. "Off Axis Viewing Angle" is here defined as: "the minimum angle in any direction from the normal to the display surface at which any part of any segment in the display is not visible."
2. This display contains a CMOS integrated circuit. Normal CMOS handling precautions should be taken to avoid damage due to high static voltages or electric fields. SEE APPNOTE 18.
3. Unused inputs must be tied to an appropriate logic voltage level (either V+ or V–).

TOP VIEW

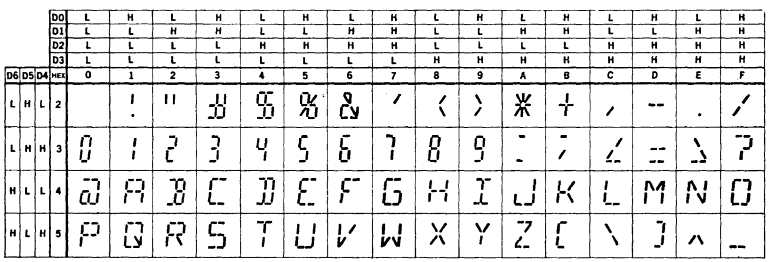


Pin	Function	Pin	Function
1	$\overline{CE1}$ Chip Enable	18	$\overline{BL}$ Display Blank
2	$\overline{CE2}$ Chip Enable	17	D4 Data input
3	$\overline{CLR}$ Clear	16	D5 Data input
4	CUE Cursor Enable	15	D6 Data input
5	$\overline{CU}$ Cursor Select	14	D3 Data input
6	$\overline{WR}$ Write	13	D2 Data input
7	A1 Digit Select	12	D1 Data input
8	A0 Digit Select	11	D0 Data input
9	V_{CC}	10	GND

PIN DEFINITIONS

V_{CC}	Positive power supply.
Gnd	Negative power supply.
D0 thru D6	Data inputs, D0 is the least significant data input and D6 is the most significant data input.
$\overline{WR}$	Write input which must be held low to write data into memory.
$\overline{CE1}$, $\overline{CE2}$	Two chip enable inputs which must be held low to enable the chip.
A0	Least significant address bit.
A1	Next to least significant address bit.
$\overline{CU}$	Cursor load control which must be held high to store data in the RAM and low to store data in the cursor memory.
CUE	Cursor function control, displays the cursor in any positions having an "on" in cursor memory.
$\overline{CLR}$	An input which clears the RAM when held low for 15ms.
$\overline{BL}$	Blanking input. Turns off all segments when held low. Does not affect RAM or cursor memory contents.

CHARACTER SET



All other input codes display "blank"

FUNCTIONAL DESCRIPTION

Referring to the block diagram:

Display Memory—consists of a 4 by 7-bit RAM block. Each 7-bit location holds the 7-bit ASCII data for the four displays.

Cursor Memory—holds the cursor data for all the displays.

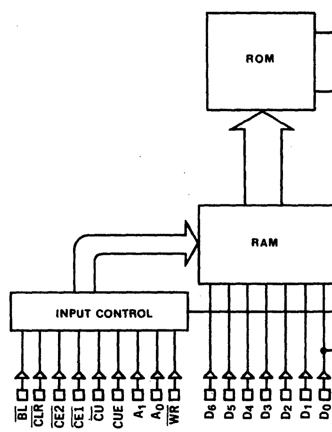
ROM—has a look-up table for the 64 characters.

Oscillator Logic—provides all the necessary timing.

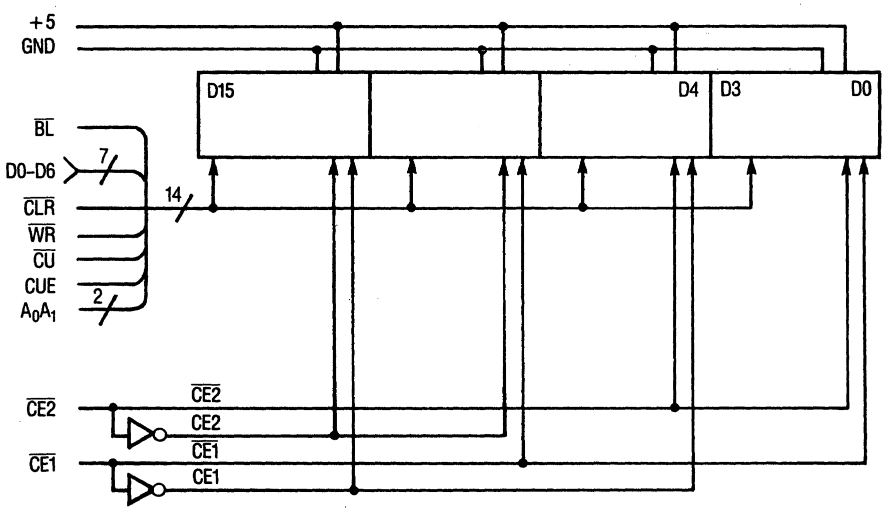
Display Drivers—17 segment drivers and 4 digit drivers.

LED Displays—each display is comprised of 16 segments and one decimal point which make up the alphanumeric characters.

BLOCK DIAGRAM



TYPICAL SCHEMATIC FOR 16 DIGIT SYSTEM



MDL 2416

LOADING DATA

Setting the chip enable ($\overline{CE1}$, $\overline{CE2}$) to their true state will enable data loading. The desired data code (D0-D6) and digit address (A_0, A_1) must be held stable during the write cycle for storing new data.

Data entry may be asynchronous and random. (Digit 0 is defined as a right hand digit with $A_1 = A_0 = 0$.)

Clearing of the entire internal four-digit memory can be accomplished by holding the clear ($\overline{CLR}$) low for one complete display multiplex cycle, 15 mS minimum. The clear function will clear both the ASCII RAM and the cursor RAM. Loading an illegal data code will display a blank.

LOADING CURSOR

Setting the chip enables ($\overline{CE1}$, $\overline{CE2}$) and cursor select ($\overline{CU}$) to their true state will enable cursor loading. A write ($\overline{WR}$) pulse will now store or remove a cursor into the digit location addressed by A_0, A_1; as defined in data entry. A cursor will be stored if D0=1; and will be removed if D0=0. The cursor ($\overline{CU}$) pulse width should not be less than the write ($\overline{WR}$) pulse or erroneous data may appear in the display.

For those users not requiring the cursor, the cursor enable signal (CUE) may be tied low to disable the display of the cursor function. A flashing cursor can be realized by simply pulsing CUE. If the cursor has been loaded to any or all positions in the display, then CUE will control whether the cursor(s) or the characters appear. CUE does not affect the contents of cursor memory.

DISPLAY BLANKING

Blanking the display may be accomplished by loading a blank or space into each digit of the display or by using the ($\overline{BL}$) display blank input.

Setting the ($\overline{BL}$) input low does not affect the contents of either data or cursor memory. A flashing display can be realized by pulsing ($\overline{BL}$).

The display can be dimmed by pulse width modulating the ($\overline{BL}$) at a frequency sufficiently fast to not interfere with the internal clock. Experimentation is encouraged, although 4.5 KHz square wave on the ($\overline{BL}$) pin will have no affect on display brightness. As the low state duty factor is increased, the display will dim, not affecting other device functions.

TYPICAL LOADING DATA STATE TABLE

CONTROL							ADDRESS		DATA							DISPLAY DIGIT			
$\overline{BL}$	$\overline{CE1}$	$\overline{CE2}$	CUE	$\overline{CU}$	$\overline{WR}$	$\overline{CLR}$	A1	A0	D6	D5	D4	D3	D2	D1	D0	3	2	1	0
H	X	X	L	X	H	H	PREVIOUSLY LOADED DISPLAY									G	R	E	Y
H	H	X	L	X	X	H	X	X	X	X	X	X	X	X	X	G	R	E	Y
H	X	H	L	X	X	H	X	X	X	X	X	X	X	X	X	G	R	E	Y
H	L	L	L	H	L	H	L	L	H	L	L	L	H	L	H	G	R	E	E
H	L	L	L	H	L	H	L	H	H	L	H	L	H	L	H	G	R	U	E
H	L	L	L	H	L	H	H	L	H	L	L	H	H	L	L	G	L	U	E
H	L	L	L	H	L	H	H	H	H	L	L	L	L	H	L	B	L	U	E
L	X	X	X	X	H	H	X	X	BLANK DISPLAY										
H	L	L	L	H	L	H	H	H	H	L	L	L	H	H	H	G	L	U	E
H	X	X	L	X	H	L	X	X	CLEARS CHARACTER DISPLAYS										
H	L	L	L	H	L	H	X	X	SEE CHARACTER CODE							SEE CHARACTER SET			

X = DON'T CARE

LOADING CURSOR STATE TABLE

CONTROL							ADDRESS		DATA							DISPLAY DIGIT			
$\overline{BL}$	$\overline{CE1}$	$\overline{CE2}$	CUE	$\overline{CU}$	$\overline{WR}$	$\overline{CLR}$	A1	A0	D6	D5	D4	D3	D2	D1	D0	3	2	1	0
H	X	X	L	X	H	H	PREVIOUSLY LOADED DISPLAY									B	E	A	R
H	X	X	H	X	H	H	DISPLAY PREVIOUSLY STORED CURSORS									B	E	A	R
H	L	L	H	L	L	H	L	L	X	X	X	X	X	X	H	B	E	A	⊠
H	L	L	H	L	L	H	L	H	X	X	X	X	X	X	H	B	E	⊠	⊠
H	L	L	H	L	L	H	H	L	X	X	X	X	X	X	H	B	⊠	⊠	⊠
H	L	L	H	L	L	H	H	H	X	X	X	X	X	X	H	⊠	⊠	⊠	⊠
H	L	L	H	L	L	H	H	L	X	X	X	X	X	X	L	⊠	E	⊠	⊠
H	X	X	L	X	H	H	DISABLE CURSOR DISPLAY									B	E	A	R
H	L	L	L	L	L	H	H	H	X	X	X	X	X	X	L	B	E	A	R
H	X	X	H	X	H	H	DISPLAY STORED CURSOR									B	E	⊠	⊠

X = DON'T CARE

QUALITY ASSURANCE LEVELS

The **MDL 2416TXVBs** are tested in conformance with Quality Level A of MIL-D-87157 for hermetically sealed LED displays with 100% screening. The product is tested to Tables I, II, IIIa and IVa.

The **MDL 2416TXVs** are tested in conformance with Quality Level A, Table I and Group A, Table II.

The **MDL 2416Cs** are tested in conformance with Quality Table I & II, Group A, except delta determinants in Table I.

Table I. Quality Level A of MIL-D-87157

Test Screen	Method	Conditions
1. Precap Visual	2072 MIL-STD-750	
2. High Temperature Storage	1032 MIL-STD-750	T_{amb} = 125°C, Time = 24 hours
3. Temperature Cycling	1051 MIL-STD-750	Condition B, 10 Cycles, 15 min. Dwell T_{amb} = −65°C to +125°C
4. Constant Acceleration	2006 MIL-STD-750	5,000 G's at Y_1 Orientation
5. Fine Leak	1071 MIL-STD-750	Condition H, Leak Rate $\leq 5\times10^{-7}$ cc/s
6. Gross Leak	1071 MIL-STD-750	Condition C
7. Interim Electrical/Optical Tests(2)		I_{CC}, I_V at V_{CC} = 5.0 V, T_{amb} = 25°C.
8. Burn-In(1)	1015 MIL-STD-883	Condition B at V_{CC} = 5.5 V, T_{amb} = 100°C, t = 160 hours
9. Final Electrical Test (2)		Same as Step 7.
10. Delta Determinants		ΔI_V = −20%, ΔI_{CC} = ±10%, T_{amb} = 25°C
11. External Visual	2009 MIL-STD-883	

Notes:
1. MIL-STD-883 test method applies.
2. Limits and conditions are per the Electrical/Optical Characteristics. The I_{OH} and I_{OL} tests are the inverse of V_{OH} and V_{OL} specified in the Electrical Characteristics.

Table II. Group A Electrical Tests – MIL-D-87157

Subgroup/Test	Parameters	LTPD
Subgroup 1 DC Electrical Tests at 25 °C(1)	I_{CC}($), $I_{CC}(\overline{CU})$, $I_{CC}(\overline{BL})$, I_{IL}, I_V and Visual Function at V_{CC} = 5.0 V.	5
Subgroup 2 Selected DC Electrical Tests at High Temperatures(1)	Same as Subgroup 1, except delete I_V Visual Function, T_{amb} = 100 °C	7
Subgroup 3 Selected DC Electrical Tests at Low Temperatures(1)	Same as Subgroup 1, except delete I_V Visual Function, T_{amb} = −55 °C	7
Subgroup 4, 5 and 6 Not Applicable		
Subgroup 7 Optical and Functional Tests at 25 °C	Satisfied by Subgroup 1	5
Subgroup 8 External Visual	MIL-STD-883, Method 2009	7

Note:
1. Limits and conditions are per the Electrical/Optical Characteristics. The I_{OH} and I_{OL} tests are the inverse of V_{OH} and V_{OL} specified in the Electrical Characteristics.

Table IIIa. Group B, Class A and B of MIL-D-87157

Subgroup/Test	MIL-STD-750 Method	Conditions	Sample Size
Subgroup 1 Resistance to Solvents	1022		4 Devices/0 Failures
Internal Visual and Mechanical(3)	2014		1 Device/0 Failures
Subgroup 2(1, 2) Solderability	2026	T_{amb} = 245 °C for 5 seconds	LTPD = 15
Subgroup 3 Thermal Shock (Temp Cycle)	1051	Condition B, 10 Cycles, 15 min. Dwell	LTPD = 15
Moisture Resistance	1021		
Fine Leak	1071	Condition H	
Gross Leak	1071	Condition C	
Electrical/Optical Endpoints(4)		I_{CC}($), $I_{CC}(\overline{CU})$, $I_{CC}(\overline{BL})$, I_{IL}, I_V and Visual Function at T_{amb} = 25 °C.	
Subgroup 4 Operating Life Test (340 Hours)	1027	T_{amb} = +100 °C at V_{CC} = 5.5 V	LTPD = 10
Electrical/Optical Endpoints(4)	1010	Same as Subgroup 3	
Subgroup 5 Non-Operating (Storage) Life Test (340 hours)	1032	T_{amb} = +125 °C	LTPD = 10
Electrical/Optical Endpoints(4)		Same as Subgroup 3	

Notes:
1. Whenever electrical/optical tests are not required as endpoints, electrical rejects may be used.
2. The LTPD applies to the number of leads inspected except in no case shall less than 3 displays be used to provide the number of leads required.
3. MIL-STD-883 test methods apply.
4. Limits and conditions are per the Electrical/Optical Characteristics.
5. Visual requirements shall be as specified in MIL-STD-883, Methods 1011 or 1011.

Table IVa. Group C, Class A and B of MIL-D-87157

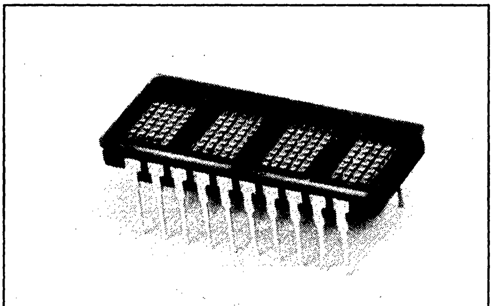
Subgroup/Test	MIL-STD-750 Method	Conditions	Sample Size
Subgroup 1 Physical Dimensions	2066		2 Devices/0 Failures
Subgroup 2[2, 6] Lead Integrity	2004	Condition B2	LTPD = 15
Fine Leak	1071	Condition H	
Gross Leak	1071	Condition C	
Subgroup 3 Shock	2016	1500G, Time = 0.5 ms, 5 Blows in Each Orientation X1, Y1, Z1	LTPD = 15
Vibration, Variable Frequency	2056		
Constant Acceleration	2006	5,000 at Y1 Orientation	
External Visual[4]	1010 or 1011		
Electrical/Optical Endpoints[7]		I_{CC}($), I_{CC}($\overline{CU}$), I_{CC}($\overline{BL}$), I_{IL}, I_V at V_{CC} = 5.0 V and Visual Function T_{amb} = 25 °C.	
Subgroup 4[1, 3] Salt Atmosphere	1041		LTPD = 15
External Visual[4]	1010 or 1011		
Subgroup 5 Bond Strength[5]	2037	Condition A	LTPD = 20 (C = 0)
Subgroup 6 Operating Life Test[8]	1026	T_{amb} = + 100 °C at V_{CC} = 5.50 V	λ = 10
Electrical/Optical Endpoints[8]		Same as Subgroup 3	

Notes:
1. Whenever electrical/optical tests are not required as endpoints, electrical rejects may be used.
2. The LTPD applies to the number of leads inspected except in no case shall less than three displays be used to provide the number of leads required.
3. Solderability samples shall not be used.
4. Visual requirements shall be as specified in MIL-STD-883, Methods 1010 or 1011.
5. Displays may be selected prior to seal.
6. MIL-STD-883 test method applies.
7. Limits and conditions are per the electrical/optical characteristics.
8. Test method or conditions in accordance with detail specification. If a lot undergoing Group B inspection has been selected to satisfy Group C inspection requirements, the 340 hour life tests may be continued on test to 1,000 hours to satisfy the Group C life test requirements. In such cases the 340 hour endpoint measurements shall be made on a basis for Group B lot acceptance or the 1,000 hour endpoint shall be used as the basis for both Group B and Group C acceptance.

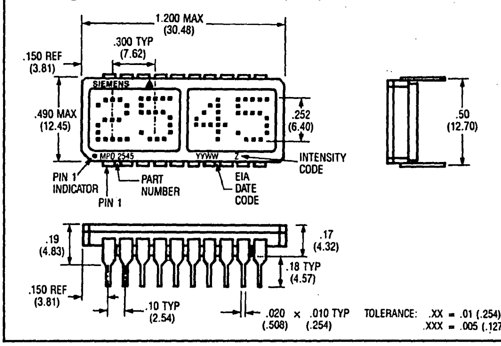
SIEMENS

HIGH EFFICIENCY RED MPD 2545
GREEN MPD 2547
YELLOW MPD 2548

.25" 4-Character, 5×7 Dot Matrix, X-Y Stackable, HI-REL/Military Alphanumeric Programmable Display™ with Built-In CMOS Control Functions



Package Dimensions in Inches (mm)



FEATURES

- **Four .25"Dot Matrix Characters in Hermetic Package**
- **Conforms to MIL-D-87157 Quality Level A Test Table**
- **Built-in Memory, Decoders, Multiplexer and Drivers**
- **Viewing Angle, X Axis ±40°, Y Axis ±75°**
- **96-Character ASCII Format (Both Upper and Lower Case Characters)**
- **Rugged Ceramic Package, Hermetic Sealed Flat Glass Window**
- **Wide Temperature Operating Range for High Reliability Industrial and Military Use, −55°C to +100°C**
- **8-Bit Bidirectional Data BUS**
- **READ/WRITE Capability**
- **Built-In Character Generator ROM**
- **TTL Compatible**
- **Easily Cascaded for Multidisplay Operation**
- **Less CPU Time Required**
- **Software Controlled Features:**
  - **Programmable Highlight Attribute (Blinking, Non-Blinking)**
  - **Asynchronous Memory Clear Function**
  - **Lamp Test**
  - **Display Blank Function**
  - **Single or Multiple Character Blinking Function**
  - **Three Programmabale Brightness Levels**

Important: Refer to Appnote 18, "Using and Handling Intelligent Displays." Since this is a CMOS device, normal precautions should be taken to avoid static damage.

GENERAL DESCRIPTION

The MPD 2545 (high efficiency red/orange), MPD 2547 (green), and MPD 2548 (yellow) are four-digit High Reliability dot matrix Programmable Displays that are aimed at satisfying the most demanding Military display requirements. They are designed for use in extremely harsh environments where only the most reliable product is acceptable. These devices are processed to meet the requirements of HI-REL/Military applications. The devices are constructed in a hermetic package using four .25-inch-high 5×7 dot matrix displays. The devices incorporate the latest in CMOS technology which is the heart of the device intelligence. The CMOS controller chip is controlled by a user-supplied eight-bit data word on the bidirectional BUS. The ASCII data and attribute data are word driven. This approach allows the MPD 2545/2547/2548 to interface using the same techniques as a microprocessor peripheral.

APPLICATIONS

- **Military Control Panels**
- **Night Viewing Applications (Red Light)**
- **Cockpit Monitors**
- **Night Vision Goggle Viewable Displays (Green)**
- **Portable and Vehicle Technology**
- **Industrial Controllers**

Maximum Ratings

DC Supply .... −0.5 V to +6.0 Vdc
Input Voltage Relative
  to GND (all inputs) .... −0.5 V to V_{CC} +0.5 Vdc
Operating Temperature .... −55°C to +100°C
Storage Temperature .... −55°C to +150°C
Thermal Resistance (θ_{JC}) .... 30°C/W

OPTICAL CHARACTERISTICS

High Efficiency Red MPD 2545

Description	Symbol	Min.	Typ.(4)	Max.	Units	Test Conditions
Luminous Intensity per LED(1, 3) (Character Average)	I_{Vave}	75	150		μcd	V_{CC}=5.0 V, # sign "ON" on all digits at full brightness, T_{amb}=25°C
Peak Wavelength	λ_{PEAK}		635		nm	
Dominant Wavelength(2)	λ_D		630		nm	

High Efficiency Green MPD 2547

Description	Symbol	Min.	Typ.(4)	Max.	Units	Test Conditions
Luminous Intensity per LED(1, 3) (Character Average)	I_{Vave}	75	150		μcd	V_{CC}=5.0 V, # sign "ON" on all digits at full brightness, T_{amb}=25°C
Peak Wavelength	λ_{PEAK}		565		nm	
Dominant Wavelength(2)	λ_D		570		nm	

Yellow MPD 2548

Description	Symbol	Min.	Typ.(4)	Max.	Units	Test Conditions
Luminous Intensity per LED(1, 3) (Character Average)	I_{Vave}	75	150		μcd	V_{CC}=5.0 V, # sign "ON" on all digits at full brightness, T_{amb}=25°C
Peak Wavelength	λ_{PEAK}		585		nm	
Dominant Wavelength(2)	λ_D		590		nm	

Notes:
1. The displays are categorized for luminous intensity with the intensity category designated by a letter code on the bottom of the package.
2. Dominant wavelength λ_D, is derived from the CIE chromaticity diagram, and represents the single wavelength which defines the color of the device.
3. The luminous sterance of the LED may be calculated using the following relationships:
   L_V (cd/m²)=I_V (Candela)/A (Meter)²
   L_V (Footlamberts)=πI_V (Candela)/A (Foot)²
   A=8.4×10⁻⁷ ft², 7.8×10⁻⁸ m²
4. All typical values specified at V_{CC}=5.0 V and T_{amb}=25°C unless otherwise noted.

DC CHARACTERISTICS

Parameter	−55°C Min.	−55°C Typ.	−55°C Max.	+25°C Min.	+25°C Typ.	+25°C Max.	+100°C Min.	+100°C Typ.	+100°C Max.	Units	Conditions
I_{CC} Blank (All Inputs Low)		4	10		2.0	5.0		1	2.5	mA	V_{CC}=5 V
I_{CC} 80 dots/unit (100% Brightness)		220	250		160	190		125	160	mA	V_{CC}=5 V
V_{IL} (all inputs)			0.8			0.8			0.8	V	V_{CC}=5 V ±0.5 V
V_{IH} (all inputs)	2.0			2.0			2.0			V	V_{CC}=5 V ±0.5 V
I_{IL} (all inputs)		70	120		60	100		50	80	μA	V_{IN}=0.8 V, V_{CC}=5.0 V

SWITCHING SPECIFICATIONS (@V_{CC}=4.5 V)

WRITE CYCLE TIMING

Parameter	Description	Specification (ns) −55°C	+25°C	+100°C
T_{WD}	Delay time for write pulse after control signals and data (min.)	25	50	75
T_{DH}	Data hold after write pulse (min.)	25	50	75
T_{WR}	Write pulse width	50	100	150
T_{WC}	Total write cycle time (min.)	100	200	300

Notes: 1. TRD=TRC−TAD−(TACC−TDD)
2. TWR=TWC−(TWD+TDH)

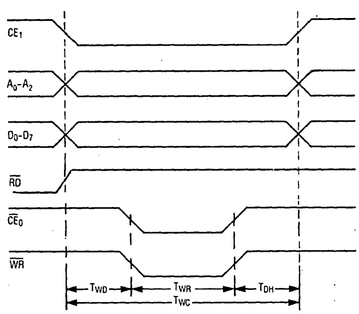
SWITCHING SPECIFICATIONS (@V_{CC} = 4.5 V) (Continued)

READ CYCLE TIMING				
		Specification (ns)		
Parameter	Description	−55°C	+25°C	+100°C
T_{AD}	Address set up delay after CE (min.)	0	0	10
T_{ACC}	Access time for data valid after address (max.)	100	175	200
T_{DD}	Delay time for data valid after read pulse (max.)	100	150	175
T_{DH}	Data valid after end of read pulse (min.)	0	0	0
T_{RD}	Read Pulse (min.)	150	175	200
T_{RC}	Total read cycle time (min.)	150	200	235

Notes: 1. TRD = TRC − TAD − (TACC − TDD)
2. TWR = TWC − (TWD + TDH)

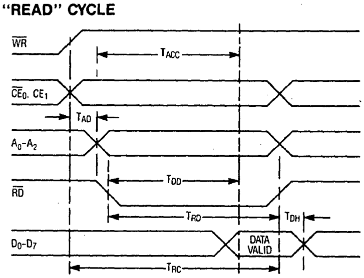
TIMING CHARACTERISTICS @V_{CC} = 4.5 V

DATA "WRITE" CYCLE

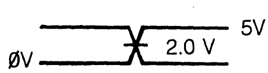


Note: $T_{RD} = T_{RC} - T_{AD} - (T_{ACC} - T_{DD})$

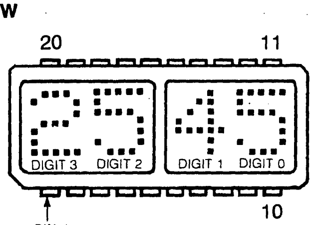
DATA "READ" CYCLE



TIMING MEASUREMENT LEVELS



TOP VIEW



PIN ASSIGNMENTS

PINOUT			
Pin	Function	Pin	Function
1 $\overline{RD}$	READ	11 $\overline{WR}$	WRITE
2 CLK I/O	CLOCK I/O	12 D7	DATA MSB
3 CLKSEL	CLOCK SELECT	13 D6	DATA
4 $\overline{RST}$	RESET	14 D5	DATA
5 CE1	CHIP ENABLE	15 D4	DATA
6 $\overline{CE0}$	CHIP ENABLE	16 D3	DATA
7 A2	ADDRESS MSB	17 D2	DATA
8 A1	ADDRESS	18 D1	DATA
9 A0	ADDRESS LSB	19 D0	DATA LSB
10 GND		20 V_{CC}	

PIN DEFINITIONS

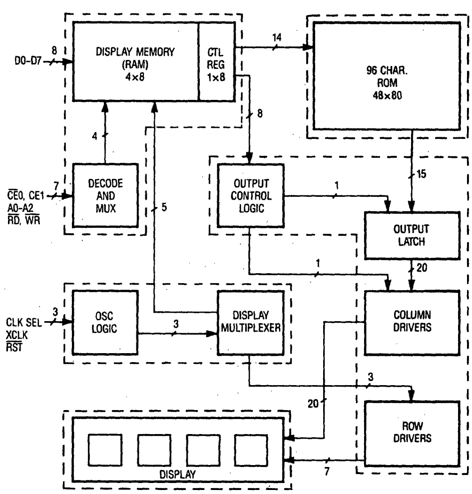
Pin	
1. $\overline{RD}$	Active low, will enable a processor to read all registers in the MPD 2545/7/8.
2. CLK I/O	If CLK SEL (pin 3) is low, then expect an external clock source into this pin. If CLK SEL is high, then this pin will be the master or source for all other devices which have CLK SEL low.
3. CLK SEL	CLocK SELect, determines the action of pin 2. CLK I/O, see the section on Cascading for an example.
4. $\overline{RST}$	Reset. Must be held low until $V_{CC} > 4.5$ volts. Reset is used only to synchronize blinking and will not clear the display.
5. CE1	Chip enable (active high).
6. $\overline{CE0}$	Chip enable (active low).
7. A2	Address input (MSB).
8. A1	Address input.
9. A0	Address input (LSB).
10. GND	Ground.
11. $\overline{WR}$	Write. Active Low. If the device is selected, a low on the write input loads the data into memory.
12. D7	Data Bus bit 7 (MSB).
13. D6	Data Bus bit 6.
14. D5	Data Bus bit 5.
15. D4	Data Bus bit 4.
16. D3	Data Bus bit 3.
17. D2	Data Bus bit 2.
18. D1	Data Bus bit 1.
19. D0	Data Bus bit 0 (LSB).
20. V_{CC}	Plus 5 volts power pin.

DATA INPUT COMMANDS															
$\overline{CE0}$	CE1	$\overline{RD}$	$\overline{WR}$	A2	A1	A0	D7	D6	D5	D4	D3	D2	D1	D0	OPERATION
1	0	X	X	X	X	X	X	X	X	X	X	X	X	X	No Change
0	1	0	1	1	0	0	X	X	X	X	X	X	X	X	Read Digit 0 Data To Bus
0	1	1	0	1	0	0	X	0	1	0	0	1	0	0	($) Written To Digit 0
0	1	1	0	1	0	1	X	1	0	1	0	1	1	1	(W) Written to Digit 1
0	1	1	0	1	1	0	X	1	1	0	0	1	1	0	(f) Written To Digit 2
0	1	1	0	1	1	1	X	0	1	1	0	0	1	1	(3) Written to Digit 3
0	1	1	0	1	0	0	1	X	X	X	X	X	X	X	Char. Written To Digit 0 And Cursor Enabled

MODE SELECTION				
$\overline{CE0}$	CE1	$\overline{RD}$	$\overline{WR}$	OPERATION
0	1	0	0	Illegal
1	X	X	X	No Change
X	0	X	X	No Change
X	X	1	1	No Change

NOTE: 0 = Low Logic Level, 1 = High Logic Level, X = Don't Care.

BLOCK DIAGRAM



FUNCTIONAL DESCRIPTION

The MPD 2545/7/8 block diagram includes 5 major blocks and internal registers (indicated by dotted lines).

Display Memory consists of a 5x8 bit RAM block. Each of the four 8-bit words holds the 7-bit ASCII data (bits D0–D6). The fifth 8-bit memory word is used as a control word register. A detailed description of the control register and its functions can be found under the heading Control Word. Each 8-bit word is addressable and can be read from or written to.

The **Control Logic** dictates all of the features of the display device and is discussed in the Control Word section of this data sheet.

The **Character Generator** converts the 7-bit ASCII data into the proper dot pattern for the 96 characters shown in the character set chart.

The **Clock Source** can originate either from the internal oscillator clock or from an external source—usually from the output of another MPD 2545/7/8 in a multiple module display.

The **Display Multiplexer** controls all display output to the digit drivers so no additional logic is required for a display system.

The **Column Drivers** are connected directly to the display.

The **Display** has four digits. Each of the four digits is comprised of 35 LEDs in a 5x7 dot array which makes up the alphanumeric characters.

The intensity of the display can be varied by the Control Word in steps of 0% (Blank), 25%, 50%, and full brightness.

MICROPROCESSOR INTERFACE

The interface to the microprocessor is through the address lines (A0–A2), the data bus (D0–D7), two chip select lines ($\overline{CE0}$, CE1), and read ($\overline{RD}$) and write ($\overline{WR}$) lines.

To derive the appropriate enable signal, the $\overline{WR}$ and $\overline{RD}$ lines should be "NANDED" into the CE1 input. The $\overline{CE0}$ should be held low when executing a read, or write operation.

The read and write lines are both active low. During a valid read the data input lines (D0–D7) become outputs. A valid write will enable the data as input lines.

INPUT BUFFERING

If a cable length of 6 inches or more is used, all inputs to the display should be buffered with a tri-state non-inverting buffer mounted as close to the display as conveniently possible. Recommended buffers are: 74LS245 for the data lines and 74LS244 for the control lines.

PROGRAMMING THE MPD 2545/7/8

There are five registers within the MPD 2545/7/8. Four of these registers are used to hold the ASCII code of the four display characters. The fifth register is the Control Word, which is used to blink, blank, clear or dim the entire display, or to change the presentation (attributes) of individual characters.

ADDRESSING

The addresses within the display device are shown below. Digit 0 is the rightmost digit of the display, while digit 3 is on the left. Although there is only one Control Word, it is duplicated at the four address locations 0-3. Data can be read from any of these locations. When one of these locations is written to, all of them will change together.

Address	Contents
0	Control Word
1	Control Word (Duplicate)
2	Control Word (Duplicate)
3	Control Word (Duplicate)
4	Digit 0 (rightmost)
5	Digit 1
6	Digit 2
7	Digit 3 (leftmost)

Bit D7 of any of the display digit locations is used to allow an attribute to be assigned to that digit. The attributes are discussed in the next section. If bit D7 is set to a one, that character will be displayed using the attribute. If bit D7 is cleared, the character will display normally.

CONTROL WORD

When address bit A2 is taken low, the Control Word is accessed. The same Control Word appears in all four of the lower address spaces of the display. Through the Control Word, the display can be cleared, the lamps can be tested, display brightness can be selected, and attributes can be set for any characters which have been loaded with their most significant bit (D7) set high.

Brightness (D0, D1): The state of the lower two bits of the Control Word are used to set the brightness of the entire display, from 0% to 100%. The table below shows the correspondence of these bits to the brightness.

D7	D6	D5	D4	D3	D2	D1	D0	Operation
0	0	X	X	X	X	0	0	Blank
0	0	X	X	X	X	0	1	25% brightness
0	0	X	X	X	X	1	0	50% brightness
0	0	X	X	X	X	1	1	Full brightness

X = don't care

Attributes (D2-D4): Bits D2, D3, and D4 control the visual attributes (i.e., blinking, alternate) of those display digits which have been written with bit D7 set high. In order to use any of the four attributes, the Cursor Enable bit (D4 in the Control Word) must be set. When the Cursor Enable bit is

CONTROL WORD FORMAT

D7	D6	D5	D4	D3	D2	D1	D0
CLEAR	LAMP TEST	BLINK	ATTRIBUTE ENABLE	ATTRIBUTES		BRIGHTNESS	

D1	D0	BRIGHTNESS
0	0	0% (Blank)
0	1	25%
1	0	50%
1	1	100%

D3	D2	ATTRIBUTE
0	0	Display Cursor Instead Of Character
0	1	Blink Character
1	0	Display Blinking Cursor Instead Of Character
1	1	Alternate Character With Cursor

D4	ATTRIBUTE ENABLE
0	Disable Above Attributes
1	Enable Above Attributes

D5	BLINK
0	Blink-Attribute Disabled
1	Blink Entire Display

D6	LAMP TEST
0	Standard Operation
1	Display All Dots At 50% Brightness

D7	CLEAR
0	Standard Operation
1	Clear Entire Display

set, and bit D7 in a character location is set, the character will take on one of the following display attributes.

D7	D6	D5	D4	D3	D2	D1	D0	Operation
0	0	0	0	X	X	B	B	Disable highlight attribute
0	0	0	1	0	0	B	B	Display cursor* instead of character
0	0	0	1	0	1	B	B	Blink single character
0	0	0	1	1	0	B	B	Display blinking cursor* instead of character
0	0	0	1	1	1	B	B	Alternate character with cursor*

*"Cursor" refers to a condition when all dots in a single character space are lit to half brightness.
X = don't care
B = depends on the selected brightness

Attributes are non-destructive. If a character with bit D7 set is replaced by a cursor (Control Word bit D4 is set, and D3=D2=0) the character will remain in memory and can be revealed again by clearing D4 in the Control Word.

Blink (D5): The entire display can be caused to blink at a rate of approximately 2Hz by setting bit D5 in the Control Word. This blinking is independent of the state of D7 in all character locations.

In order to synchronize the blink rate in a bank of these devices, it is necessary to tie all devices' clocks and resets together as described in a later section of this data sheet.

D7	D6	D5	D4	D3	D2	D1	D0	Operation
0	0	1	X	X	X	B	B	Blinking display

Lamp Test (D6): When the Lamp Test bit is set, all dots in the entire display are lit at half brightness. When this bit is cleared, the display returns to the characters that were showing before the lamp test.

D7	D6	D5	D4	D3	D2	D1	D0	Operation
0	1	0	X	X	X	X	X	Lamp test

Clear Data (7): When D7 is set in the Control Word all character and Control Word memory bits are reset to zero. This causes total erasure of the display, and returns all digits to a non-blink, the preset brightness, non-cursor status.

D7	D6	D5	D4	D3	D2	D1	D0	Operation
1	0	0	0	X	X	%	%	Clear

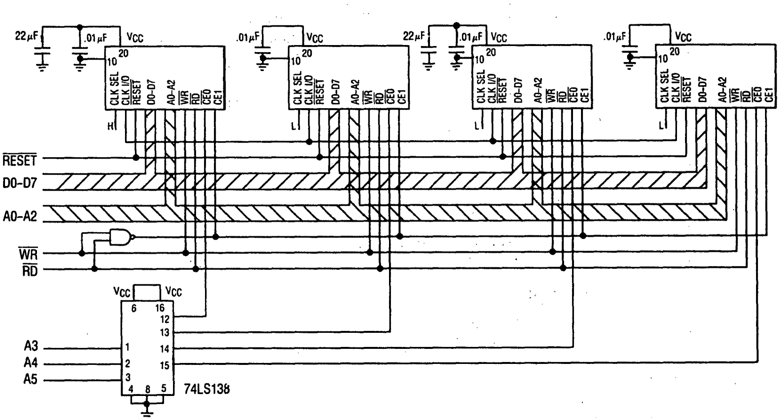
CASCADING

Cascading the MPD 2545/7/8 is a simple operation. The requirements for cascading are: 1) decoding the correct address to determine the chip select for each additional device, 2) assuring that all devices are reset simultaneously, and 3) selecting one display as the clock source and setting all others to accept clock input (the reason for cascading the clock is to synchronize the flashing of multiple displays). One display as a source is capable of driving six other MPD 2545/7/8s. If more displays are required, a buffer will be necessary. The source display must have pin 3 tied high to output clock signals. All other displays must have pin 3 tied low.

VOLTAGE TRANSIENTS

It has become common practice to provide 0.01 μf bypass capacitors liberally in digital systems. Like other CMOS circuitry, the Intelligent Display controller chip has very low power consumption and the usual 0.01 μf would be adequate were it not for the LEDs. The module itself can, in some conditions, use up to 100 mA (multiplexed). In order to prevent power supply transients, capacitors with low inductance and high capacitance at high frequencies are required. This suggests a solid tantalum or ceramic disc for high frequency bypass. For larger displays, distribute the bypass capacitors evenly, keeping capacitors as close to the power pins as possible. We recommend a 10 μf and 0.01 μf for every Intelligent Display to decouple the displays themselves, at the display.

CASCADING THE MPD 2545/7/8



HOW TO LOAD INFORMATION INTO THE MPD 2545/7/8

Information loaded into the MPD 2545/7/8 can be either ASCII data or Control Word data. The following procedure (see also typical loading sequence) will demonstrate a typical loading sequence and the resulting visual display. The word STOP is used in all of the following examples.

SET BRIGHTNESS

Step 1 Set the brightness level of the entire display to your preference (example: 100%)

LOAD FOUR CHARACTERS

Step 2 Load an "S" in the left-hand digit.

Step 3 Load a "T" in the next digit.

Step 4 Load an "O" in the next digit.

Step 5 Load a "P" in the right-hand digit.

If you loaded the information correctly, the MPD 2545 should now show the word "STOP."

BLINK A SINGLE CHARACTER

Step 6 Into the digit, second from the right, load the hex code "CF," which is the code for an "O" with the D7 bit added as a control bit.

NOTE: the "O" is the only digit which has the control bit (D7) added to normal ASCII data.

Step 7 Load enable blinking character into the control word register.

The MPD 2545 should now display "STOP" with a flashing "O."

ADD ANOTHER BLINKING CHARACTER

Step 8 Into the left hand digit, load the hex code "D3" which is for an "S" with the D7 bit added as a control bit.

The MPD 2545 should display "STOP" with a flashing "O" and a flashing "S."

ALTERNATE CHARACTER/CURSOR ENABLE

Step 9 Load enable alternate character/cursor into the control word register.

The MPD 2545 should now display "STOP" with the "O" and the "S" alternating between the letter and a cursor (all dots lit).

INITIATE FOUR-CHARACTER BLINKING
(Regardless of Control Bit setting)

Step 10 Load enable display blinking.

The MPD 2545 should now display the entire word "STOP" blinking.

ELECTRICAL AND MECHANICAL CONSIDERATIONS

The CMOS IC of the MPD 2545/7/8 is designed to provide resistance to both Electrostatic and Discharge Damage and Latch Up due to voltage or current surges. Several precautions are strongly recommended for the user, to avoid overstressing these built-in safeguards.

ESD PROTECTION

Users of the MPD 2545/7/8 should be careful to handle the devices consistent with Standard ESD protection procedures. Operators should wear appropriate wrist, ankle or feet ground straps and avoid clothing that collects static charges. Work surfaces, tools and transport carriers that come into contract with unshielded devices or assemblies should also be appropriately grounded.

LATCH UP PROTECTION

Latch up is a condition that occurs in CMOS ICs after the input protection diodes have been broken down. These diodes can be reversed through several means:

V_{IN} < GND, V_{IN} > V_{CC} +0.5 V, or through excessive currents begin forced on the inputs. When these situations exist, the IC may develop the response of an SCR and begin conducting as much as one amp through the V_{CC} pin. This destructive condition will persist (latched) until device failure or the device is turned off.

The Voltage Transient Suppression Techniques and buffer interfaces for longer cable runs help considerably to prevent latch conditions from occuring. Additionally, the following Power Up and Power Down sequence should be observed.

POWER UP SEQUENCE

1. Float all active signals by tri-stating the inputs to the displays.
2. Apply V_{CC} and GND to the display.
3. Apply active signals to the displays by enabling all input signals per application.

POWER DOWN SEQUENCE

1. Float all active signals by tri-stating the inputs to the display.
2. Turn off the power to the display.

TYPICAL LOADING SEQUENCE

	$\overline{CE0}$	CE1	$\overline{RD}$	$\overline{WR}$	A2	A1	A0	D7	D6	D5	D4	D3	D2	D1	D0	DISPLAY
1.	L	H	H	L	L	X	X	0	0	0	0	0	0	1	1	
2.	L	H	H	L	H	H	H	0	1	0	1	0	0	1	1	S
3.	L	H	H	L	H	H	L	0	1	0	1	0	1	0	0	ST
4.	L	H	H	L	H	L	H	0	1	0	0	1	1	1	1	STO
5.	L	H	H	L	H	L	L	0	1	0	1	0	0	0	0	STOP
6.	L	H	H	L	H	L	H	1	1	0	0	1	1	1	1	STOP
7.	L	H	H	L	L	X	X	0	0	0	1	0	1	1	1	STO*P
8.	L	H	H	L	H	H	H	1	1	0	1	0	0	1	1	S*TO*P
9.	L	H	H	L	L	X	X	0	0	0	1	1	1	1	1	S†TO†P
10.	L	H	H	L	L	X	X	0	0	1	0	0	0	1	1	S*T*O*P*

*Blinking Character
†Character alternating with cursor (all dots lit)

CHARACTER SET

			D0	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H
			D1	L	L	H	H	L	L	H	H	L	L	H	H	L	L	H	H
			D2	L	L	L	L	H	H	H	H	L	L	L	L	H	H	H	H
			D3	L	L	L	L	L	L	L	L	H	H	H	H	H	H	H	H
D6	D5	D4	HEX	Ø	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
L	L	L	Ø	THESE CODES DISPLAY BLANK															
L	L	H	1																
L	H	L	2		!	"	#	$	%	&	'	(	)	*	+	,	-	.	/
L	H	H	3	0	1	2	3	4	5	6	7	8	9	:	;	<	=	>	?
H	L	L	4	@	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
H	L	H	5	P	Q	R	S	T	U	V	W	X	Y	Z	[	\	]	^	_
H	H	L	6	`	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o
H	H	H	7	p	q	r	s	t	u	v	w	x	y	z	{	|	}	~	▒

Notes: 1. A2 must be held high for ASCII data.
2. Bit D7 = 1 enables attributes for the assigned digit.

GENERAL QUALITY ASSURANCE LEVELS

The parts are tested in conformance with Quality Level A of MIL-D-87157 for hermetically sealed LED displays with 100% screening. The product is tested to Tables I, II, IIIa and IVa.

Table I. Quality Level A of MIL-D-87157

Test Screen	Method	Conditions
1. Precap Visual	2072 MIL-STD-750	
2. High Temperature Storage	1032 MIL-STD-750	T_{amb} = 125°C, Time = 24 hours
3. Temperature Cycling	1051 MIL-STD-750	Condition B, 10 Cycles, 15 min. Dwell
4. Constant Acceleration	2006 MIL-STD-750	5,000 G's at Y_1 Orientation
5. Fine Leak	1071 MIL-STD-750	Condition G or H
6. Gross Leak	1071 MIL-STD-750	Condition C
7. Interim Electrical/Optical Tests		Limits and conditions are per the Electrical/Optical Characteristics. The I_{OH} and I_{OL} tests are the inverse of V_{OH} and V_{OL} specified in the Electrical Characteristics. T_{amb} = 25°C.
8. Burn-In[1]	1015 MIL-STD-883	Condition B at V_{CC} = 5.5 V, T_{amb} = 100°C. t = 160 hours.
9. Final Electrical Test		Same as Step 7.
10. External Visual	2009 MIL-STD-883	

Note:
1. MIL-STD-883 test method applies.

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Table II. Group A Electrical Tests – MIL-D-87157

Subgroup/Test	Parameters	LTPD
Subgroup 1 DC Electrical Tests at 25°C	Limits and conditions are per the Electrical/Optical Characteristics. The I_{OH} and I_{OL} tests are the inverse of V_{OH} and V_{OL} specified in the Electrical Characteristics.	5
Subgroup 2 Selected DC Electrical Tests at High Temperatures		7
Subgroup 3 Selected DC Electrical Tests at Low Temperatures		7
Subgroup 4, 5 and 6 Not Applicable		
Subgroup 7 Optical and Functional Tests at 25°C	Satisfied by Subgroup 1	5
Subgroup 8 External Visual		7

Table IIIa. Group B, Class A and B of MIL-D-87157

Subgroup/Test	MIL-STD-750 Method	Conditions	Sample Size
Subgroup 1 Resistance to Solvents	1022		4 Devices/0 Failures
Internal Visual and Mechanical[3]	2014		1 Device/0 Failures
Subgroup 2[1, 2] Solderability	2026	T_{amb} = 245°C for 5 seconds	LTPD = 15
Subgroup 3 Thermal Shock (Temp Cycle)	1051	Condition B, 10 Cycles, 15 min. Dwell	LTPD = 15
Moisture Resistance	1021		
Fine Leak	1071	Condition G or H	
Gross Leak	1071	Condition C	
Electrical/Optical Endpoints		Limits and conditions are per the Electrical/Optical Characteristics. The I_{OH} and I_{OL} tests are the inverse of V_{OH} and V_{OL} specified in the Electrical Characteristics. T_{amb} = 25°C.	
Subgroup 4[1] Operating Life Test (340 hours)	1027	T_{amb} = 100°C @ V_{CC} = 5.5 V	LTPD = 10
Electrical/Optical Endpoints		Same as Subgroup 3	
Subgroup 5 Non-Operating (Storage) Life Test (340 hours)	1032	T_{amb} = +125°C	LTPD = 10
Electrical/Optical Endpoints		Same as Subgroup 3	

Notes:
1. Whenever electrical/optical tests are not required as endpoints, electrical rejects may be used.
2. The LTPD applies to the number of leads inspected except in no case shall less than 3 displays be used to provide the number of leads required.
3. MIL-STD-883 test methods apply.
4. Visual requirements shall be as specified in MIL-STD-883, Methods 1010 or 1011.

Intelligent Display Devices

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Table IVa. Group C, Class A and B of MIL-D-87157

Subgroup/Test	MIL-STD-750 Method	Conditions	Sample Size
Subgroup 1			
Physical Dimensions	2066		2 Devices/0 Failures
Subgroup 2[2, 6]			
Lead Integrity	2004	Condition B2	LTPD = 15
Fine Leak	1071	Condition G or H	
Gross Leak	1071	Condition C	
Subgroup 3			
Shock	2016	1500G, Time = 0.5 ms, 5 Blows in Each Orientation X1, Y1, Y2	LTPD = 15
Vibration, Variable Frequency	2056		
Constant Acceleration	2006	5,000G at Y1 Orientation	
External Visual[4]	1001 or 1011		
Electrical/Optical Endpoints		Limits and conditions are per the Electrical/Optical Characteristics. The I_{OH} and I_{OL} tests are the inverse of V_{OH} and V_{OL} specified in the Electrical Characteristics. $T_{amb} = 25\,°C$.	
Subgroup 4[1, 3]			
Salt Atmosphere	1041		LTPD = 15
External Visual[4]	1010 or 1011		LTPD = 20 (C = 0)
Subgroup 5			
Bond Strength[5]	2037	Condition A	
Subgroup 6			
Operating Life Test[7]	1026	$T_{amb} = 100\,°C$ @ $V_{CC} = 5.5$ V	λ = 10
Electrical/Optical Endpoints[7]	1026	Same as Subgroup 3	

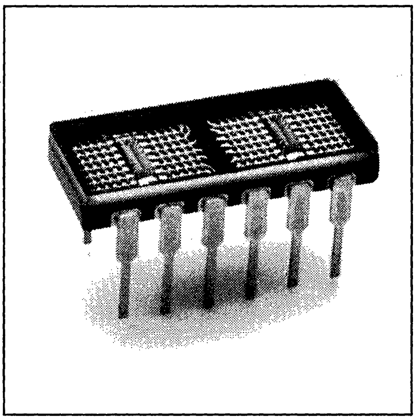
Notes:
1. Whenever electrical/optical tests are not required as endpoints, electrical rejects may be used.
2. The LTPD applies to the number of leads inspected except in no case shall less than three displays be used to provide the number of leads required.
3. Solderability samples shall not be used.
4. Visual requirements shall be as specified in MIL-STD-883, Methods 1010 or 1011.
5. Displays may be selected prior to seal.
6. MIL-STD-883 test method applies.
7. Test method or conditions in accordance with detail specification.

MPD 2545/7/8

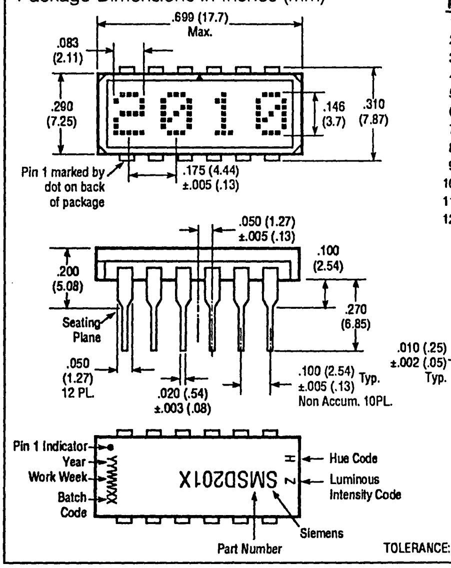
SIEMENS

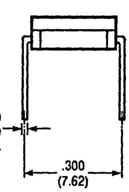
RED MSD2010TXV/TXVB
YELLOW MSD2011TXV/TXVB
HIGH EFF. RED MSD2012TXV/TXVB
HIGH EFF. GREEN MSD2013TXV/TXVB

.150" 4-Character 5×7 Dot Matrix Serial Input Alphanumeric Military Display



Package Dimensions in Inches (mm)





Pin	Function
1	Column 1
2	Column 2
3	Column 3
4	Column 4
5	Column 5
6	No Connection
7	Data Out
8	V_B
9	V_{CC}
10	Clock
11	Ground
12	Data In

TOLERANCE: ±.015 (exceptions noted)

FEATURES

- **Four .150" Dot Matrix Characters**
- **Four Colors: Red, Yellow, High Efficiency Red, High Efficiency Green**
- **Wide Viewing Angle**
- **Built-in CMOS Shift Registers with Constant Current LED Row Drivers**
- **Shift Registers Allow Custom Fonts**
- **Easily Cascaded for Multiple Displays**
- **TTL Compatible**
- **End Stackable**
- **Military Operating Temperature Range: −55° to +100°C**
- **Categorized for Luminous Intensity**
- **Ceramic Package, Hermetically Sealed Flat Glass Window**
- **TXVB Process Conforms to MIL-D-87157 Quality Level A Test and Tables I, II, IIIa and IVa**
- **TXV Process Conforms to a Modified MIL-D-87157 Quality Level A Test and Table I**

DESCRIPTION

The MSD2010 through MSD2013TXV/TXVB are four digit 5×7 dot matrix serial input alphanumeric displays. The displays are available in red, yellow, high efficiency red, or high efficiency green. The package is a standard twelve-pin hermetic DIP package with glass lens. The display can be stacked horizontally or vertically to form messages of any length. The MSD201X has two fourteen-bit CMOS shift registers with built-in row drivers. These shift registers drive twenty-eight rows and enable the design of customized fonts. Cascading multiple displays is possible because of the Data In and Data Out pins. Data In and Out are easily input with the clock signal and displayed in parallel on the row drivers. Data Out represents the output of the 7th bit of digit number four shift register. The shift register is level triggered. The like columns of each character in a display cluster are tied to a single pin. (See Block Diagram). High true data in the shift register enables the output current mirror driver stage associated with each row of LEDs in the 5×7 diode array.

The TTL compatible V_B input may either be tied to V_{CC} for maximum display intensity or pulse width modulated to achieve intensity control and reduce power consumption.

—Continued

See Appnote 44 for application information, and Appnotes 18, 19, 22, and 23 for additional information.

DESCRIPTION (Continued)

In the normal mode of operation, input data for digit four, column one is loaded into the seven on-board shift register locations one through seven. Column one data for digits 3, 2, and 1 is shifted into the display shift register locations. Then column one input is enabled for an appropriate period of time, T. A similar process is repeated for columns 2, 3, 4, and 5. If the decode time and load data time into the shift register is t, then with five columns, each column of the display is operating at a duty factor of:

$$DF = \frac{T}{5(T+t)}$$

T+t, allotted to each display column, is generally chosen to provide the maximum duty factor consistent with the minimum refresh rate necessary to achieve a flicker free display. For most strobed display systems, each column of the display should be refreshed (turned on) at a minimum rate of 100 times per second.

With columns to be addressed, this refresh rate then gives a value for the time T+t of: 1/[5×(100)]=2 msec. If the device is operated at 5.0 MHz clock rate maximum, it is possible to maintain t<<T. For short display strings, the duty factor will then approach 20%.

Maximum Ratings

Supply Voltage V_{CC} to GND .... –0.5 V to +7.0 V
Inputs, Data Out and V_B .... –0.5 V to V_{CC} +0.5 V
Column Input Voltage, V_{COL} .... –0.5 V to +6.0 V
Operating Temperature Range[1, 2] ..... –55°C to +100°C
Storage Temperature Range .... –65°C to +125°C
Maximum Solder Temperature, 0.063″ (1.59 mm)
below Seating Plane, t<5 sec .... 260°C
Maximum Power Dissipation
at T_{amb}=25°C[2]
Red .... 0.91 W
Yellow, HER, High Eff. Green .... 0.86 W

Notes:
1. Operation above +100°C ambient is possible provided the following condition are met. The junction should not exceed T_J=125°C and the case temperature (as measured at pin 1 or the back of the display) should not exceed T_C=100°C.
2. Maximum dissipation is derived from V_{CC}=5.25 V, V_B=2.4 V, V_{COL}=3.5 V 20 LEDs on per character, 20% DF.

FIGURE 1. TIMING CHARACTERISTICS

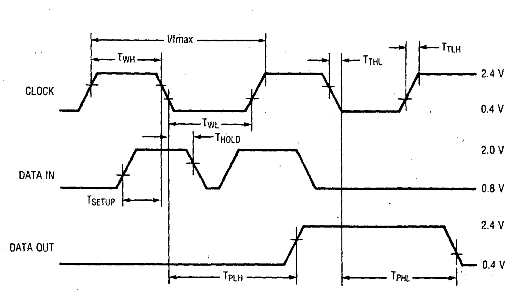
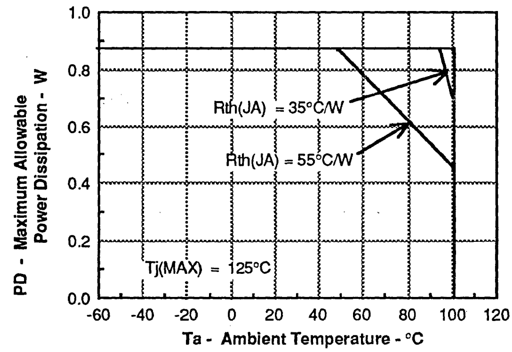


FIGURE 2. MAX. ALLOWABLE POWER DISSIPATION VS. TEMPERATURE



AC ELECTRICAL CHARACTERISTICS

(V_{CC}=4.75 to 5.25 V, T_{amb}=–55°C to +100°C)

Symbol	Description	Min.	Typ.[1]	Max.[2]	Units	Fig.
T_{SETUP}	Setup Time	50	10		ns	1
T_{HOLD}	Hold Time	25	20		ns	1
T_{WL}	Clock Width Low	75	45		ns	1
T_{WH}	Clock Width High	75	45		ns	1
$F_{(CLK)}$	Clock Frequency		6	5	MHz	1
T_{THL}, T_{TLH}	Clock Transition Time		75	200	ns	1
T_{PHL}, T_{PLH}	Propagation Delay Clock to Data Out		50	125	ns	1

Notes:
1. All typical values specified at V_{CC}=5.0 V and T_{amb}=25°C unless otherwise noted.
2. V_B Pulse Width Modulation Frequency — 50 KHz (max).

CLEANING THE DISPLAYS

IMPORTANT — Do not use cleaning agents containing alcohol of any type with this display. The least offensive cleaning solution is hot D.I. water (60°C) for less than 15 minutes. Addition of mild saponifiers is acceptable. Do not use commercial dishwasher detergents.

For post solder cleaning use water or non-alcohol mixtures formulated for vapor cleaning processing or non-alcohol mixtures formulated for room temperature cleaning. Non-alcohol vapor cleaning processing for up to two minutes in vapors at boiling is permissible. For suggested solvents refer to Siemens Appnote 19.

RECOMMENDED OPERATING CONDITIONS

Parameter	Symbol	Min.	Nom.	Max.	Units
Supply Voltage	V_{CC}	4.75	5.0	5.25	V
Data Out Current, Low State	I_{OL}			1.6	mA
Data Out Current, High State	I_{OH}			-0.5	mA
Column Input Voltage, Column On[1]	V_{COL}	2.75		3.5	V
Setup Time	T_{SETUP}	70	45		ns
Hold Time	T_{HOLD}	30			ns
Width of Clock	$T_{W(CLK)}$	75			ns
Clock Frequency	T_{CLK}			5	MHz
Clock Transition Time	T_{THL}			200	ns
Free Air Operating Temperature Range	T_{amb}	-55		+100	°C

Note:
1. See Figure 3 - Peak Column Current vs. Column Voltage.

Intelligent Display Devices

OPTICAL CHARACTERISTICS

Red MSD2010

Description	Symbol	Min.	Typ.[4]	Max.	Units	Test Conditions
Peak Luminous Intensity per LED[1, 3] (Character Average)	I_{VPEAK}	105	200		μcd	$V_{CC}=5.0$ V, $V_{COL}=3.5$ V $T_J{}^{(5)}=25°C$, $V_B=2.4$ V
Peak Wavelength	λ_{PEAK}		655		nm	
Dominant Wavelength[2]	λ_D		639		nm	

Yellow MSD2011

Description	Symbol	Min.	Typ.[4]	Max.	Units	Test Conditions
Peak Luminous Intensity per LED[1, 3] (Character Average)	I_{VPEAK}	400	750		μcd	$V_{CC}=5.0$ V, $V_{COL}=3.5$ V $T_J{}^{(5)}=25°C$, $V_B=2.4$ V
Peak Wavelength	λ_{PEAK}		583		nm	
Dominant Wavelength[2]	λ_D		585		nm	

High Efficiency Red MSD2012

Description	Symbol	Min.	Typ.[4]	Max.	Units	Test Conditions
Peak Luminous Intensity per LED[1, 3] (Character Average)	I_{VPEAK}	400	1430		μcd	$V_{CC}=5.0$ V, $V_{COL}=3.5$ V $T_J{}^{(5)}=25°C$, $V_B=2.4$ V
Peak Wavelength	λ_{PEAK}		635		nm	
Dominant Wavelength[2]	λ_D		626		nm	

High Efficiency Green MSD2013

Description	Symbol	Min.	Typ.[4]	Max.	Units	Test Conditions
Peak Luminous Intensity per LED[1, 3] (Character Average)	I_{VPEAK}	850	1550		μcd	$V_{CC}=5.0$ V, $V_{COL}=3.5$ V $T_J{}^{(5)}=25°C$, $V_B=2.4$ V
Peak Wavelength	λ_{PEAK}		568		nm	
Dominant Wavelength[2]	λ_D		574		nm	

Notes:
1. The displays are categorized for luminous intensity with the intensity category designated by a letter code on the bottom of the package.
2. Dominant wavelength λ_D, is derived from the CIE chromaticity diagram, and represents the single wavelength which defines the color of the device.
3. The luminous sterance of the LED may be calculated using the following relationships: L_V (cd/m²) = I_V (Candela)/A (Meter)²
   L_V (Footlamberts) = πI_V (Candela)/A (Foot)²
   $A = 5.3 \times 10^{-8}$ M² = 5.8×10^{-7} (Foot)²
4. All typical values specified at $V_{CC}=5.0$ V and $T_{amb}=25°C$ unless otherwise noted.
5. The luminous intensity is measured at $T_{amb}=T_J=25°C$. No time is allowed for the device to warm up prior to measurement.

ELECTRICAL CHARACTERISTICS (–55 °C to + 100 °C) (unless otherwise specified)

Description	Symbol	Min.	Typ.[1]	Max.	Units	Test Conditions	
Supply Current (quiescent)	I_{CC}		2	5.0	mA	$V_B = 0.4$ V	$V_{CC} = 5.25$ V $V_{CLK} = V_{DATA} = 2.4$ V All SR Stages = Logical 1
			2.5	5.0	mA	$V_B = 2.4$ V	
Supply Current (operating)	I_{CC}		3	10.0	mA	$F_{CLK} = 5$ MHz	
Column Current at any Column Input[2] All	I_{COL}			10	μA	$V_B = 0.4$ V	$V_{CC} = 5.25$ V $V_{COL} = 3.5$ V All SR Stages = Logical 1
Red	I_{COL}		350	435	mA	$V_B = 2.4$ V	
Yellow, HER, Green	I_{COL}		335	410	mA		
V_B, Clock or Data Input Threshold Low	V_{IL}			0.8	V	$V_{CC} = 4.75$ V – 5.25 V	
V_B, Clock or Data Input Threshold High	V_{IH}	2.0			V		
Data Out Voltage	V_{OH}	2.4	3.6		V	$I_{OH} = -0.5$ mA	$V_{CC} = 5.25$ V $I_{COL} = 0$ mA
	V_{OL}		0.2	0.4	V	$I_{OL} = 1.6$ mA	
Input Current Logical 0 V_B only	I_{IL}	–30	–110	–300	μA	$V_{CC} = 4.75$ V – 5.25 V, $V_{IL} = 0.8$ V	
Input Current Logical 0 Data, Clock	I_{IL}		–1	–10	μA		
Input Current Logical 1 Data, Clock	I_{IH}			10	μA	$V_{CC} = 4.75$ V – 5.25 V, $V_{IH} = 2.4$ V	
Input Current Logical 1 V_B	I_{IH}			200	μA		
Power Dissipation per Package	P_D		0.44		W	$V_{CC} = 5.0$ V, $V_{COL} = 3.5$ V, 17.5% DF 15 LEDs on per character, $V_B = 2.4$ V	
Thermal Resistance IC Junction-to-Pin	$R_{\theta J\text{-}PIN}$		30		°C/W/ Device		

Notes:
1. All typical values specified at $V_{CC} = 5.0$ V and $T_{amb} = 25$ °C unless otherwise noted.
2. See Figure 3 – Peak Column Current vs. Column Voltage.

FIGURE 3. PEAK COLUMN CURRENT VS. COLUMN VOLTAGE

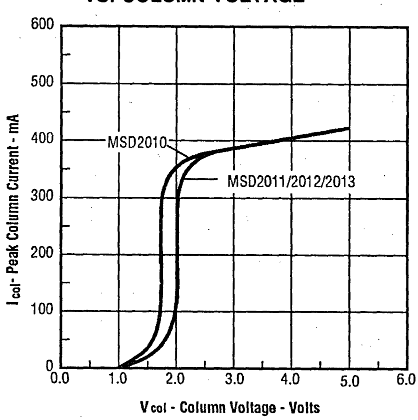
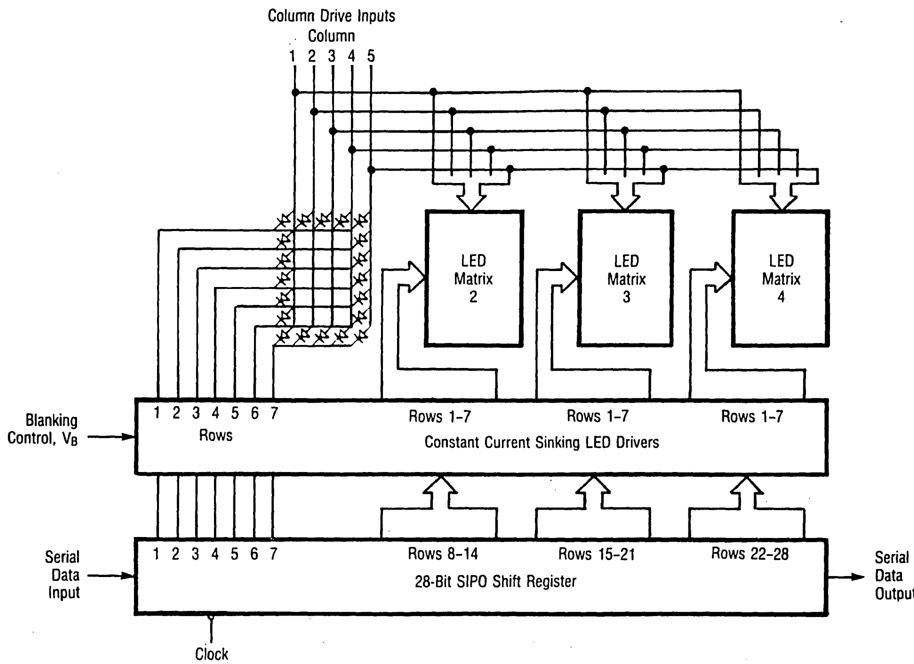


FIGURE 4. BLOCK DIAGRAM



CONTRAST ENHANCEMENT FILTERS FOR SUNLIGHT READABILITY

Display Color Part No.	Filter Color	Marks Polarized Corp.* Filter Series	Optical Characteristics of Filter	
Red, HER MSD2010, 2012	Red	MPC 20-15C	25% @ 635 nm	Circular Polarizer
Yellow MSD2011	Amber	MPC 30-25C	25% @ 583 nm	
Green MSD2013	Yellow/Green	MPC 50-22C	22% @ 568 nm	
Multiple Colors High Ambient Light	Neutral Gray	MPC 80-10C	10% Neutral	
Multiple Colors	Neutral Gray	MPC 80-37C	37% Neutral	

*Marks Polarized Corp.
25-B Jefryn Blvd. W.
Deer Park, NY 11729
516-242-1300
FAX (516) 242-1347
Marks Polarized Corp. manufactures to MIL-I-45208 inspection system.

GENERAL QUALITY ASSURANCE LEVELS

The parts are tested in conformance with Quality Level A of MIL-D-87157 for hermetically sealed LED displays with 100% screening. The product is tested to Tables I, II, IIIa and IVa.

Table I. Quality Level A of MIL-D-87157

Test Screen	Method	Conditions
1. Precap Visual	2072 MIL-STD-750	
2. High Temperature Storage	1032 MIL-STD-750	T_{amb} = 125°C, Time = 24 hours
3. Temperature Cycling	1051 MIL-STD-750	Condition B, 10 Cycles, 15 min. Dwell T_{amb} = –65°C to +125°C
4. Constant Acceleration	2006 MIL-STD-750	10,000 G's at Y_1 Orientation
5. Fine Leak	1071 MIL-STD-750	Condition H, Leak Rate $\leq 5 \times 10^{-7}$ cc/s
6. Gross Leak	1071 MIL-STD-750	Condition C
7. Interim Electrical/Optical Tests[(2)]		I_{CC} (at V_B = 0.4 V and 2.4 V), I_{COL} (at V_B = 0.4 V and 2.4 V), I_{IH} (V_B, Clock and Data In), I_{IL} (V_B, Clock and Data In), I_{OH}, I_{OL}, Visual Function and I_V Peak. V_{IH} and V_{IL} inputs are guaranteed by the electronic shift register test. T_{amb} = 25°C.
8. Burn-In[(1)]	1015 MIL-STD-883	Condition B at V_{CC} = V_B = 5.25 V, V_{COL} = 3.5 V, T_{amb} = 100°C. LED On-Time Duty Factor = 5%, t = 160 hours
9. Final Electrical Test[(2)]		Same as Step 7.
10. Delta Determinants		ΔI_{CC} = +/–1 mA, ΔI_{IH} = +/–10 mA (Clock and Data In), ΔI_{OH} = +/–10% of initial value, ΔI_V = –20%
11. External Visual	2009 MIL-STD-883	

Table II. Group A Electrical Tests – MIL-D-87157

Subgroup/Test	Parameters	LTPD
Subgroup 1 DC Electrical Tests at 25°C	I_{CC} (at V_B = 0.4 V and 2.4 V), I_{COL} (at V_B = 0.4 V and 2.4 V), I_{IH} (V_B, Clock and Data In), I_{IL} (V_B, Clock and Data In), I_{OH}, I_{OL}, Visual Function and I_V Peak. V_{IH} and V_{IL} inputs are guaranteed by the electronic shift register test.	5
Subgroup 2 Selected DC Electrical Tests at High Temperatures[(2)]	Same as Subgroup 1, except delete I_V and Visual Function, T_{amb} = 100°C	7
Subgroup 3 Selected DC Electrical Tests at Low Temperatures[(2)]	Same as Subgroup 1, except delete I_V and Visual Function, T_{amb} = –55°C	7
Subgroup 4, 5 and 6 Not Tested		
Subgroup 7 Optical and Functional Tests at 25°C	Satisfied by Subgroup 1	5
Subgroup 8 External Visual	MIL-STD-883, Method 2009	7

Notes:
1. MIL-STD-883 test method applies.
2. Limits and conditions are per the Electrical/Optical Characteristics. The I_{OH} and I_{OL} tests are the inverse of V_{OH} and V_{OL} specified in the Electrical Characteristics.

Table IIIa. Group B, Classes A and B of MIL-D-87157

Subgroup/Test	MIL-STD-750 Method	Conditions	Sample Size
Subgroup 1			
Resistance to Solvents	1022		4 Devices/0 Failures
Internal Visual and Mechanical	2075	Inspection may be performed through glass cover, includes front and back cavities	1 Device/0 Failures
Subgroup 2[1, 2]			
Solderability	2026	$T_{amb} = 245°C$ for 5 seconds	LTPD = 15
Subgroup 3			
Thermal Shock (Temp Cycle)	1051	Condition B1, 15 min. Dwell	LTPD = 15
Moisture Resistance[3] Visual Inspection Endpoints	1021	Within 24 hours after completion of moisture resistance test	
Hermetic Seal	1071		
Fine Leak	1071	Condition G or H	
Gross Leak	1071	Condition C	
Electrical/Optical Endpoints[4]		I_{CC} (at $V_B = 0.4$ V and 2.4 V), I_{COL} (at $V_B = 0.4$ V and 2.4 V), I_{IH} (V_B, Clock and Data In), I_{IL} (V_B, Clock and Data In), I_{OH}, I_{OL}, Visual Function and I_V Peak. V_{IH} and V_{IL} inputs are guaranteed by the electronic shift register test. $T_{amb} = 25°C$.	
Subgroup 4			
Operating Life Test (340 Hours)	1027	$T_{amb} = +100°C$ at $V_{CC} = V_B = 5.25$ V, $V_{COL} = 3.5$ V, LED on time DF = 5%	LTPD = 10
Electrical/Optical Endpoints[4]		Same as Subgroup 3	
Subgroup 5			
Non-Operating (Storage) Life Test (340 hours)	1032	$T_{amb} = +125°C$	LTPD = 10
Electrical/Optical Endpoints[4]		Same as Subgroup 3	

Notes:
1. Whenever electrical/optical tests are not required as endpoints, electrical rejects may be used.
2. The LTPD applies to the number of leads inspected except in no case shall less than 3 displays be used to provide the number of leads required.
3. Initial conditioning shall be a 15 degree inward bend and back to original position, one cycle.
4. Limits and conditions are per the Electrical/Optical Characteristics. The I_{OH} and I_{OL} tests are the inverse of V_{OH} and V_{OL} specified in the Electrical Characteristics.

Table IVa. Group C, Classes A and B of MIL-D-87157

Subgroup/Test	MIL-STD-750 Method	Conditions	Sample Size
Subgroup 1[1] Physical Dimensions	2066		2 Devices/0 Failures
Subgroup 2[1, 2] Lead Integrity	2004	Condition B2	LTPD = 15
Hermetic Seal	1071		
Fine Leak	1071	Condition G or H	
Gross Leak	1071	Condition C	
Subgroup 3 Shock	2016	1500G's, Time = 0.5 ms, 5 Blows in Each Orientation X1, Y1, Y2	LTPD = 15
Vibration, Variable Frequency	2056		
Constant Acceleration	2006	10,000G's at Y1 Orientation	
External Visual[3]	1010 or 1011		
Electrical/Optical Endpoints		I_{CC} (at $V_B = 0.4$ V and 2.4 V), I_{COL} (at $V_B = 0.4$ V and 2.4 V), I_{IH} (V_B, Clock and Data In), I_{OL} (V_B, Clock and Data In), I_{OH}, I_{OL}, Visual Function and I_V Peak. V_{IH} and V_{IL} inputs are guaranteed by the electronic shift register test. $T_{amb} = 25°C$.	
Subgroup 4[5, 6] Salt Atmosphere	1041		LTPD = 15
External Visual[3]	1010 or 1011		
Subgroup 5 Bond Strength[7]	2037	Condition A	LTPD = 20 (C = 0)
Subgroup 6 Operating Life Test[8]	1026	$T_{amb} = +100°C$ at $V_{CC} = V_B = 5.25$ V, $V_{COL} = 3.5$ V, LED on time DF = 5%	$\lambda = 10$
Electrical/Optical Endpoints[4]		Same as Subgroup 3	

Notes:
1. The LTPD applies to the number of leads inspected except in no case shall less than three displays be used to provide the number of leads required.
2. MIL-STD-883 test method applies.
3. Visual requirements shall be as specified in MIL-STD-883, Methods 1010 or 1011.
4. Limits and conditions are per the electrical/optical characteristics.
5. Whenever electrical/optical tests are not required as endpoints, electrical rejects may be used.
6. Solderability samples shall not be used.
7. Displays may be selected prior to seal.
8. If any given inspection lot undergoing Group B inspection has been selected to satisfy Group C inspection requirements, the 340-hour life tests may be continued on test to 1000 hours in order to satisfy the Group C Life Test requirements. In such cases, either the 340-hour endpoint measurement shall be made a basis for Group B lot acceptance or the 1000-hour endpoint measurement shall be used as the basis for both Group B and Group C acceptance.

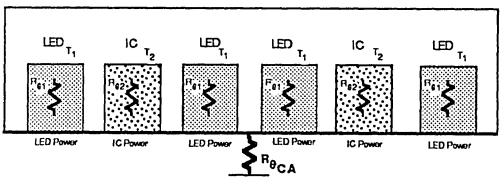
THERMAL CONSIDERATIONS

The small alphanumeric displays are hybrid LED and CMOS assemblies that are designed for reliable operation in commercial, industrial, and military environments. Optimum reliability and optical performance will result when the junction temperature of the LEDs and CMOS ICs are kept as low as possible.

THERMAL MODELING

MSD201X displays consist of two driver ICs and four 5 × 7 LED matrixes. A thermal model of the display is shown in Figure 5. It illustrates that the junction temperature of the semiconductor = junction self heating + the case temperature rise + the ambient temperature. Equation 1 shows this relationship.

FIGURE 5. THERMAL MODEL



Equation 1.

$$T_{J(LED)} = P_{LED}\, Z_{\theta JC} + P_{CASE}\,(R_{\theta JC} + R_{\theta CA}) + T_A$$

$$T_{J(LED)} = [(I_{COL}/28)\, V_{F(LED)}\, Z_{\theta JC}] + [(n/35)\, I_{COL}\, DF\,(5\, V_{COL}) + V_{CC}\, I_{CC}] \cdot [R_{\theta JC} + R_{\theta CA}] + T_A$$

The junction rise within the LED is the product of the thermal impedance of an individual LED (37 °C/W, DF = 20%, F = 200 Hz), times the forward voltage, $V_{F(LED)}$, and forward current, $I_{F(LED)}$, of 13 - 14.5 mA. This rise averages $T_{J(LED)} = 1$ °C. The table below shows the $V_{F(LED)}$ for the respective displays.

Part Number	V_F		
	Min.	**Typ.**	**Max.**
MSD2010	1.6	1.7	2.0
MSD2011/2/3	1.9	2.2	3.0

The junction rise within the LED driver IC is the combination of the power dissipated by the IC quiescent current and the 28 row driver current sinks. The IC junction rise is given in Equation 2.

A thermal resistance of 28 °C/W results in a typical junction rise of 6 °C.

Equation 2.

$$T_{J(IC)} = P_{COL}\,(R_{\theta JC} + R_{\theta CA}) + T_A$$

$$T_{J(IC)} = [5\,(V_{COL} - V_{F(LED)}) \cdot (I_{COL}/2) \cdot (n/35)\, DF + V_{CC} \cdot I_{CC}] \cdot [R_{\theta JC} + R_{\theta CA}] + T_A$$

THERMAL MODELING (Cont.)

For ease of calculations the maximum allowable electrical operating condition is dependent upon the aggregate thermal resistance of the LED matrixes and the two driver ICs. All of the thermal management calculations are based upon the parallel combination of these two networks which is 15°C/W. Maximum allowable power dissipation is given in Equation 3.

Equation 3.

$$P_{DISPLAY} = \frac{T_{J(MAX)} - T_A}{R_{\theta JC} + R_{\theta CA}}$$

$$P_{DISPLAY} = 5\ V_{COL}\ I_{COL}\ (n/35)\ DF + V_{CC}\ I_{CC}$$

For further reference see Figures 2, 7, 8, 9, 10 and 11.

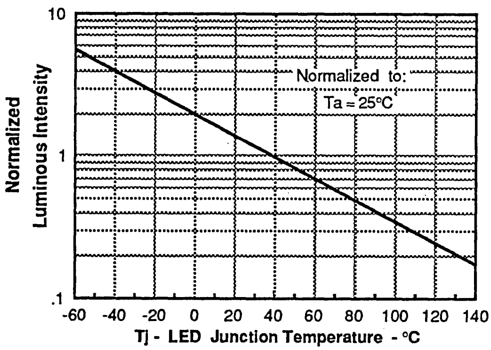
KEY TO EQUATION SYMBOLS

DF	Duty factor
I_{CC}	Quiescent IC current
I_{COL}	Column current
n	Number of LEDs on in a 5 × 7 array
P_{CASE}	Package power dissipation excluding LED under consideration
P_{COL}	Power dissipation of a column
$P_{DISPLAY}$	Power dissipation of the display
P_{LED}	Power dissipation of an LED
$R_{\theta CA}$	Thermal resistance case to ambient
$R_{\theta JC}$	Thermal resistance junction to case
T_A	Ambient temperature
$T_{J(IC)}$	Junction temperature of an IC
$T_{J(LED)}$	Junction temperature of a LED
$T_{J(MAX)}$	Maximum junction temperature
V_{CC}	IC voltage
V_{COL}	Column voltage
$V_{F(LED)}$	Forward voltage of LED
$Z_{\theta JC}$	Thermal impedance junction to case

OPTICAL CONSIDERATIONS

The light output of the LEDs is inversely related to the LED diode's junction temperature as shown in Figure 6. For optimum light output, keep the thermal resistance of the socket or PC board as low as possible.

FIGURE 6. NORMALIZED LUMINOUS INTENSITY VS. JUNCTION TEMPERATURE



When mounted in a 10 °C/W socket and operated at Absolute Maximum Electrical conditions, the MSD201X will show an LED junction rise of 17 °C. If $T_A = 40$ °C, then the LED's T_J will be 57 °C. Under these conditions Figure 7 shows that the I_V will be 75% of its 25 °C value.

FIGURE 7. MAX. LED JUNCTION TEMPERATURE VS. SOCKET THERMAL RESISTANCE

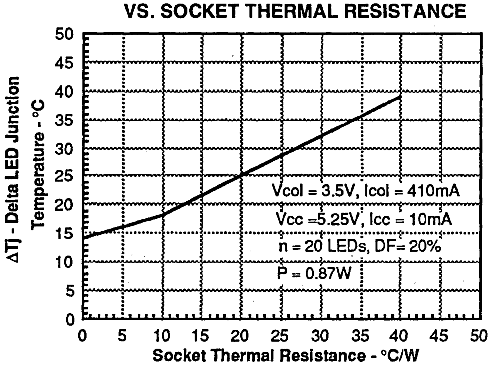


FIGURE 8. MAX. PACKAGE POWER DISSIPATION

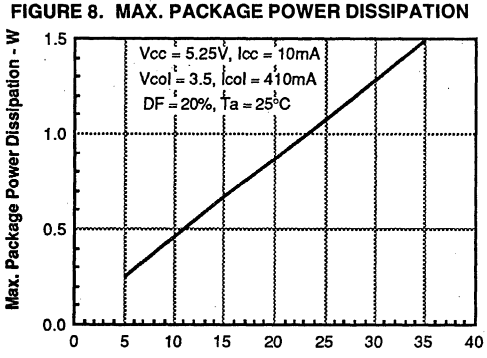


FIGURE 9. PACKAGE POWER DISSIPATION

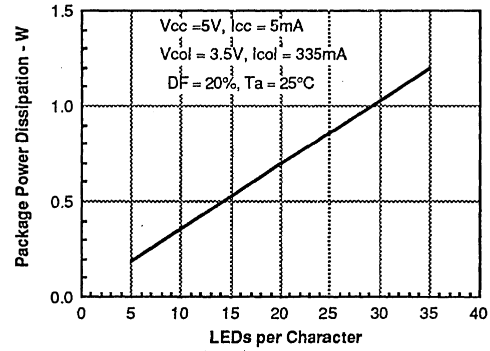


FIGURE 10. MAX. CHARACTER POWER DISSIPATION

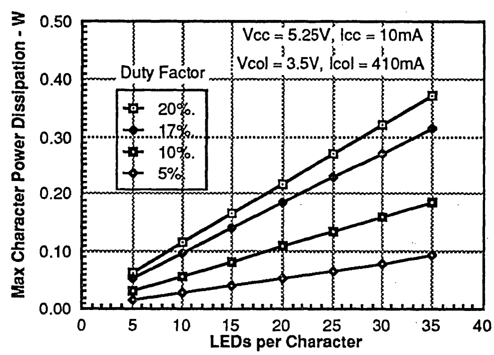
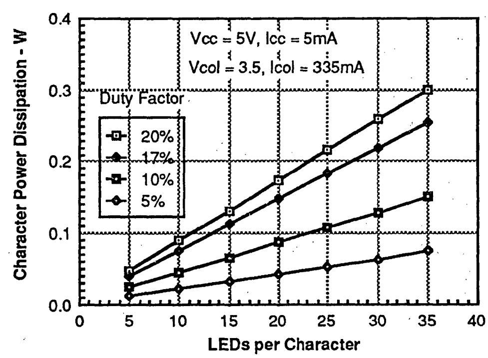


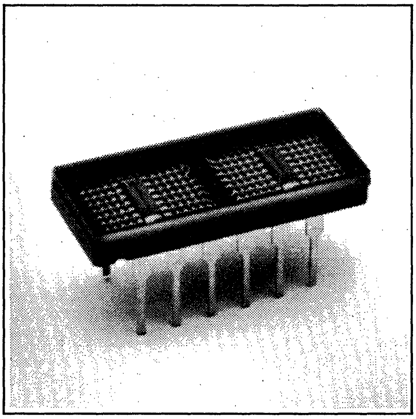
FIGURE 11. CHARACTER POWER DISSIPATION

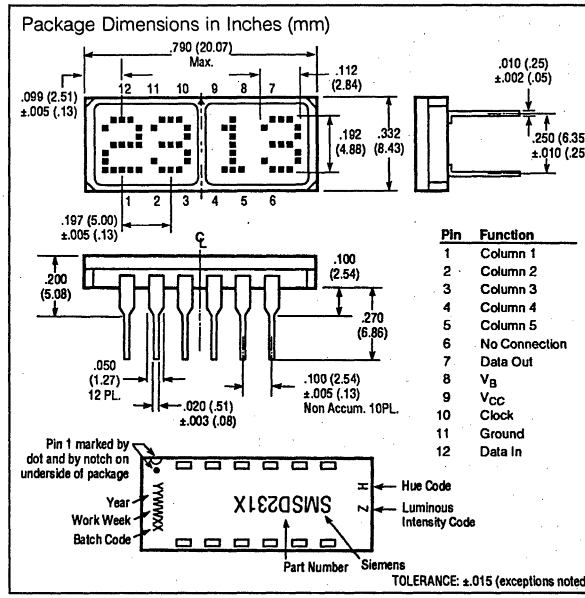


SIEMENS

RED MSD2310TXV/TXVB
YELLOW MSD2311TXV/TXVB
HIGH EFF. RED MSD2312TXV/TXVB
HIGH EFF. GREEN MSD2313TXV/TXVB

.200" 4-Character 5×7 Dot Matrix Serial Input Alphanumeric Military Display





Pin	Function
1	Column 1
2	Column 2
3	Column 3
4	Column 4
5	Column 5
6	No Connection
7	Data Out
8	V_B
9	V_{CC}
10	Clock
11	Ground
12	Data In

FEATURES

- Four .200" Dot Matrix Characters
- Four Colors: Red, Yellow, High Efficiency Red, High Efficiency Green
- Wide Viewing Angle
- Built-in CMOS Shift Registers with Constant Current LED Row Drivers
- Shift Registers Allow Custom Fonts
- Easily Cascaded for Multiple Displays
- TTL Compatible
- End Stackable
- Military Operating Temperature Range: −55° to +100°C
- Categorized for Luminous Intensity
- Ceramic Package, Hermetical Solder-Glass Flat Glass Window
- TXVB Process Conforms to MIL-D-87157 Quality Level A Test and Tables I, II, IIIa and IVa
- TXV Process Conforms to a Modified MIL-D-87157 Quality Level A Test and Table I

DESCRIPTION

The MSD2310 through MSD2313TXV/TXVB are four digit 5×7 dot matrix serial input alphanumeric displays. The displays are available in red, yellow, high efficiency red, or high efficiency green. The package is a standard twelve-pin hermetic DIP package with glass lens. The display can be stacked horizontally or vertically to form messages of any length. The MSD231X has two fourteen-bit CMOS shift registers with built-in row drivers. These shift registers drive twenty-eight rows and enable the design of customized fonts. Cascading multiple displays is possible because of the Data In and Data Out pins. Data In and Out are easily input with the clock signal and displayed in parallel on the row drivers. Data Out represents the output of the 7th bit of digit number four shift register. The shift register is level triggered. The like columns of each character in a display cluster are tied to a single pin. (See Block Diagram). High true data in the shift register enables the output current mirror driver stage associated with each row of LEDs in the 5×7 diode array.

The TTL compatible V_B input may either be tied to V_{CC} for maximum display intensity or pulse width modulated to achieve intensity control and reduce power consumption.

—Continued

See Appnote 44 for application information, and Appnotes 18, 19, 22, and 23 for additional information.

DESCRIPTION (Continued)

In the normal mode of operation, input data for digit four, column one is loaded into the seven on-board shift register locations one through seven. Column one data for digits 3, 2, and 1 is shifted into the display shift register locations. Then column one input is enabled for an appropriate period of time, T. A similar process is repeated for columns 2, 3, 4, and 5. If the decode time and load data time into the shift register is t, then with five columns, each column of the display is operating at a duty factor of:

$$DF=\frac{T}{5(T+t)}$$

T+t, allotted to each display column, is generally chosen to provide the maximum duty factor consistent with the minimum refresh rate necessary to achieve a flicker free display. For most strobed display systems, each column of the display should be refreshed (turned on) at a minimum rate of 100 times per second.

With columns to be addressed, this refresh rate then gives a value for the time T+t of: $1/[5\times(100)]=2$ msec. If the device is operated at 5.0 MHz clock rate maximum, it is possible to maintain t<<T. For short display strings, the duty factor will then approach 20%.

Maximum Ratings

Supply Voltage V_{CC} to GND .... −0.5 V to +7.0 V
Inputs, Data Out and V_B .... −0.5 V to V_{CC} +0.5 V
Column Input Voltage, V_{COL} .... −0.5 V to +6.0 V
Operating Temperature Range(1, 2) ..... −55°C to +100°C
Storage Temperature Range .... −65°C to +125°C
Maximum Solder Temperature, 0.063″ (1.59 mm) below Seating Plane, t<5 sec .... 260°C
Maximum Power Dissipation at T_{amb}=25°C(2) .... 1.1 W

Notes:
1. Operation above +100°C ambient is possible provided the following condition are met. The junction should not exceed T_J=125°C and the case temperature (as measured at pin 1 or the back of the display) should not exceed T_C=100°C.
2. Maximum dissipation is derived from V_{CC}=5.25 V, V_B=2.4 V, V_{COL}=3.5 V 20 LEDs on per character, 20% DF.

FIGURE 1. TIMING CHARACTERISTICS

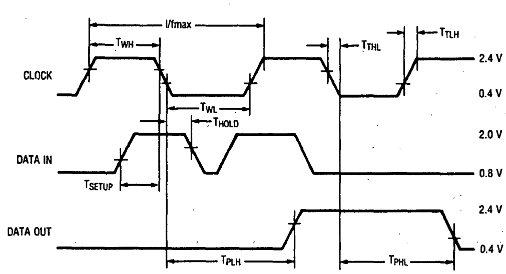
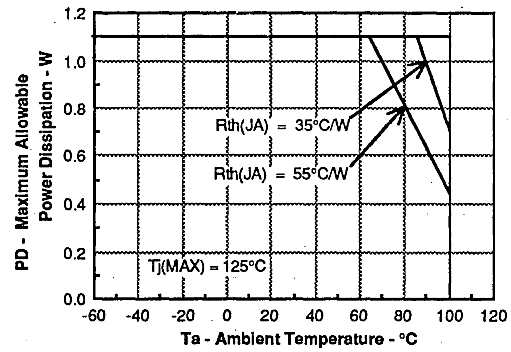


FIGURE 2. MAX. ALLOWABLE POWER DISSIPATION VS. TEMPERATURE



AC ELECTRICAL CHARACTERISTICS

(V_{CC}=4.75 to 5.25 V, T_{amb}=−55°C to +100°C)

Symbol	Description	Min.	Typ.(1)	Max.(2)	Units	Fig.
T_{SETUP}	Setup Time	50	10		ns	1
T_{HOLD}	Hold Time	25	20		ns	1
T_{WL}	Clock Width Low	75	45		ns	1
T_{WH}	Clock Width High	75	45		ns	1
$F_{(CLK)}$	Clock Frequency		6	5	MHz	1
T_{THL}, T_{TLH}	Clock Transition Time		75	200	ns	1
T_{PHL}, T_{PLH}	Propagation Delay Clock to Data Out		50	125	ns	1

Notes:
1. All typical values specified at V_{CC}=5.0 V and T_{amb}=25°C unless otherwise noted.
2. V_B Pulse Width Modulation Frequency — 50 KHz (max).

CLEANING THE DISPLAYS

IMPORTANT — Do not use cleaning agents containing alcohol of any type with this display. The least offensive cleaning solution is hot D.I. water (60°C) for less than 15 minutes. Addition of mild saponifiers is acceptable. Do not use commercial dishwasher detergents.

For post solder cleaning use water or non-alcohol mixtures formulated for vapor cleaning processing or non-alcohol mixtures formulated for room temperature cleaning. Non-alcohol vapor cleaning processing for up to two minutes in vapors at boiling is permissible. For suggested solvents refer to Siemens Appnote 19.

RECOMMENDED OPERATING CONDITIONS (Guaranteed over operating temperature range)

Parameter	Symbol	Min.	Nom.	Max.	Units
Supply Voltage	V_{CC}	4.75	5.0	5.25	V
Data Out Current, Low State	I_{OL}			1.6	mA
Data Out Current, High State	I_{OH}			−0.5	mA
Column Input Voltage, Column On(1)	V_{COL}	2.75		3.5	V
Setup Time	T_{SETUP}	70	45		ns
Hold Time	T_{HOLD}	30			ns
Width of Clock	$T_{W(CLK)}$	75			ns
Clock Frequency	T_{CLK}			5	MHz
Clock Transition Time	T_{THL}			200	ns
Free Air Operating Temperature Range	T_{amb}	−55		+100	°C

Note:
1. See Figure 3 – Peak Column Current vs. Column Voltage.

OPTICAL CHARACTERISTICS

Red MSD2310

Description	Symbol	Min.	Typ.(4)	Max.	Units	Test Conditions
Peak Luminous Intensity per LED(1, 3) (Character Average)	I_{VPEAK}	220	370		μcd	$V_{CC}=5.0$ V, $V_{COL}=3.5$ V, T_J(5) = 25 °C, $V_B=2.4$ V
Peak Wavelength	λ_{PEAK}		655		nm	
Dominant Wavelength(2)	λ_D		639		nm	

Yellow MSD2311

Description	Symbol	Min.	Typ.(4)	Max.	Units	Test Conditions
Peak Luminous Intensity per LED(1, 3) (Character Average)	I_{VPEAK}	650	1140		μcd	$V_{CC}=5.0$ V, $V_{COL}=3.5$ V, T_J(5) = 25 °C, $V_B=2.4$ V
Peak Wavelength	λ_{PEAK}		583		nm	
Dominant Wavelength	λ_D		585		nm	

High Efficiency Red MSD2312

Description	Symbol	Min.	Typ.(4)	Max.	Units	Test Conditions
Peak Luminous Intensity per LED(1, 3) (Character Average)	I_{VPEAK}	650	1430		μcd	$V_{CC}=5.0$ V, $V_{COL}=3.5$ V, T_J(5) = 25 °C, $V_B=2.4$ V
Peak Wavelength	λ_{PEAK}		635		nm	
Dominant Wavelength(2)	λ_D		626		nm	

High Efficiency Green MSD2313

Description	Symbol	Min.	Typ.(4)	Max.	Units	Test Conditions
Peak Luminous Intensity per LED(1, 3) (Character Average)	I_{VPEAK}	1280	2410		μcd	$V_{CC}=5.0$ V, $V_{COL}=3.5$ V, T_J(5) = 25 °C, $V_B=2.4$ V
Peak Wavelength	λ_{PEAK}		568		nm	
Dominant Wavelength(2)	λ_D		574		nm	

Notes:
1. The displays are categorized for luminous intensity with the intensity category designated by a letter code on the bottom of the package.
2. Dominant wavelength λ_D, is derived from the CIE chromaticity diagram, and represents the single wavelength which defines the color of the device.
3. The luminous sterance of the LED may be calculated using the following relationships: L_V (cd/m²) = I_V (Candela)/A (Meter)²
   L_V (Footlamberts) = πI_V (Candela)/A (Foot)²
   $A = 5.3 \times 10^{-8}$ M² $= 5.8 \times 10^{-7}$ (Foot)²
4. All typical values specified at $V_{CC}=5.0$ V and $T_{amb}=25$ °C unless otherwise noted.
5. The luminous intensity is measured at $T_{amb}=T_J=25$ °C. No time is allowed for the device to warm up prior to measurement.

ELECTRICAL CHARACTERISTICS (-55 °C to +100 °C) (unless otherwise specified)

Description	Symbol	Min.	Typ.[1]	Max.	Units	Test Conditions	
Supply Current (quiescent)	I_{CC}		2	5.0	mA	$V_B = 0.4$ V	$V_{CC} = 5.25$ V, $V_{CLK} = V_{DATA} = 2.4$ V, All SR Stages = Logical 1
			2.5	5.0	mA	$V_B = 2.4$ V	
Supply Current (operating)	I_{CC}		3	10.0	mA	$F_{CLK} = 5$ MHz	
Column Current at any Column Input[2]	I_{COL} (All)			10	μA	$V_B = 0.4$ V	$V_{CC} = 5.25$ V, $V_{COL} = 3.5$ V, All SR Stages = Logical 1
	I_{COL}		380	520	mA	$V_B = 2.4$ V	
V_B, Clock or Data Input Threshold Low	V_{IL}			0.8	V	$V_{CC} = 4.75$ V - 5.25 V	
V_B, Clock or Data Input Threshold High	V_{IH}	2.0			V		
Data Out Voltage	V_{OH}	2.4	3.6		V	$I_{OH} = -0.5$ mA	$V_{CC} = 5.25$ V, $I_{COL} = 0$ mA
	V_{OL}		0.2	0.4	V	$I_{OL} = 1.6$ mA	
Input Current Logical 0 V_B only	I_{IL}	-30	-110	-300	μA	$V_{CC} = 4.75$ V – 5.25 V, $V_{IL} = 0.8$ V	
Input Current Logical 0 Data, Clock	I_{IL}		-1	-10	μA		
Input Current Logical 1 Data, Clock	I_{IH}			10	μA	$V_{CC} = 4.75$ V - 5.25 V, $V_{IH} = 2.4$ V	
Input Current Logical 1 V_B	I_{IH}			200	μA		
Power Dissipation per Package	P_D		0.52		W	$V_{CC} = 5.0$ V, $V_{COL} = 3.5$ V, 17.5% DF, 15 LEDs on per character, $V_B = 2.4$ V	
Thermal Resistance IC Junction-to-Pin	$R\theta_{J-PIN}$		25		°C/W/ Device		

Notes:
1. All typical values specified at $V_{CC} = 5.0$ V and $T_{amb} = 25$ °C unless otherwise noted.
2. See Figure 3 – Peak Column Current vs. Column Voltage.

FIGURE 3. PEAK COLUMN CURRENT VS. COLUMN VOLTAGE

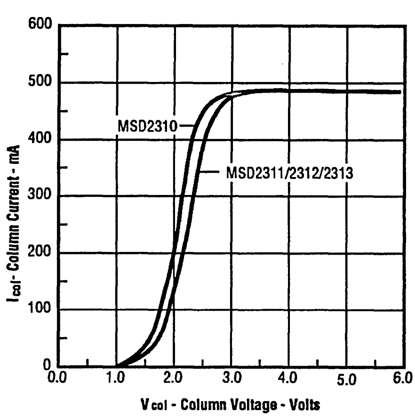
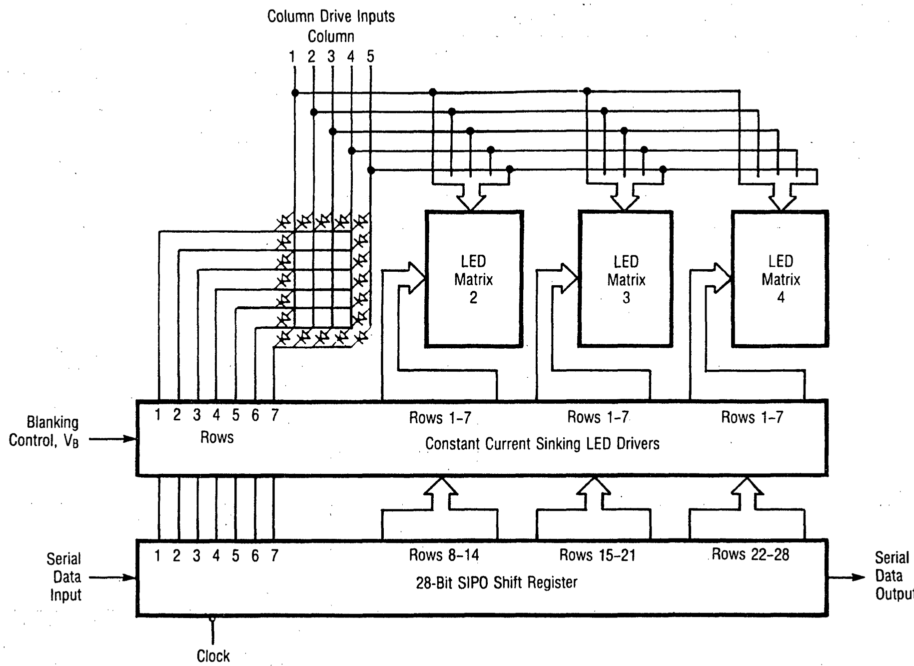


FIGURE 4. BLOCK DIAGRAM



CONTRAST ENHANCEMENT FILTERS FOR SUNLIGHT READABILITY

Display Color Part No.	Filter Color	Marks Polarized Corp.* Filter Series	Optical Characteristics of Filter	
Red, HER MSD2310, 2312	Red	MPC 20-15C	25% @ 635 nm	Circular Polarizer
Yellow MSD2311	Amber	MPC 30-25C	25% @ 583 nm	
Green MSD2313	Yellow/Green	MPC 50-22C	22% @ 568 nm	
Multiple Colors High Ambient Light	Neutral Gray	MPC 80-10C	10% Neutral	
Multiple Colors	Neutral Gray	MPC 80-37C	37% Neutral	

*Marks Polarized Corp.
25-B Jefryn Blvd. W.
Deer Park, NY 11729
516-242-1300
FAX (516) 242-1347

Marks Polarized Corp. manufactures to MIL-I-45208 inspection system.

GENERAL QUALITY ASSURANCE LEVELS

The parts are tested in conformance with Quality Level A of MIL-D-87157 for hermetically sealed LED displays with 100% screening. The product is tested to Tables I, II, IIIa and IVa.

Table I. Quality Level A of MIL-D-87157

Test Screen	Method	Conditions
1. Precap Visual	2072 MIL-STD-750	
2. High Temperature Storage	1032 MIL-STD-750	T_{amb} = 125 °C, Time = 24 hours
3. Temperature Cycling	1051 MIL-STD-750	Condition B, 10 Cycles, 15 min. Dwell T_{amb} = −65 °C to +125 °C
4. Constant Acceleration	2006 MIL-STD-750	10,000 G's at Y_1 Orientation
5. Fine Leak	1071 MIL-STD-750	Condition H, Leak Rate $\leq 5 \times 10^{-7}$ cc/s
6. Gross Leak	1071 MIL-STD-750	Condition C
7. Interim Electrical/Optical Tests(2)		I_{CC} (at V_B = 0.4 V and 2.4 V), I_{COL} (at V_B = 0.4 V and 2.4 V), I_{IH} (V_B, Clock and Data In), I_{IL} (V_B, Clock and Data In), I_{OH}, I_{OL}, Visual Function and I_V Peak. V_{IH} and V_{IL} inputs are guaranteed by the electronic shift register test. T_{amb} = 25 °C.
8. Burn-In(1)	1015 MIL-STD-883	Condition B at $V_{CC} = V_B$ = 5.25 V, V_{COL} = 3.5 V, T_{amb} = 100 °C. LED On-Time Duty Factor = 5%, t = 160 hours
9. Final Electrical Test (2)		Same as Step 7.
10. Delta Determinants		ΔI_{CC} = +/−1 mA, ΔI_{IH} = +/−10 mA (Clock and Data In), ΔI_{OH} = +/−10% of initial value, ΔI_V = −20%
11. External Visual	2009 MIL-STD-883	

Table II. Group A Electrical Tests – MIL-D-87157

Subgroup/Test	Parameters	LTPD
Subgroup 1 DC Electrical Tests at 25 °C	I_{CC} (at V_B = 0.4 V and 2.4 V), I_{COL} (at V_B = 0.4 V and 2.4 V), I_{IH} (V_B, Clock and Data In), I_{IL} (V_B, Clock and Data In), I_{OH}, I_{OL}, Visual Function and I_V Peak. V_{IH} and V_{IL} inputs are guaranteed by the electronic shift register test.	5
Subgroup 2 Selected DC Electrical Tests at High Temperatures(2)	Same as Subgroup 1, except delete I_V and Visual Function, T_{amb} = 100 °C	7
Subgroup 3 Selected DC Electrical Tests at Low Temperatures(2)	Same as Subgroup 1, except delete I_V and Visual Function, T_{amb} = −55 °C	7
Subgroup 4, 5 and 6 Not Tested		
Subgroup 7 Optical and Functional Tests at 25 °C	Satisfied by Subgroup 1	5
Subgroup 8 External Visual	MIL-STD-883, Method 2009	7

Notes:
1. MIL-STD-883 test method applies.
2. Limits and conditions are per the Electrical/Optical Characteristics. The I_{OH} and I_{OL} tests are the inverse of V_{OH} and V_{OL} specified in the Electrical Characteristics.

Table IIIa. Group B, Classes A and B of MIL-D-87157

Subgroup/Test	MIL-STD-750 Method	Conditions	Sample Size
Subgroup 1 Resistance to Solvents	1022		4 Devices/0 Failures
Internal Visual and Mechanical	2075	Inspection may be performed through glass cover, includes front and back cavities	1 Device/0 Failures
Subgroup 2[1, 2] Solderability	2026	$T_{amb}=245°C$ for 5 seconds	LTPD = 15
Subgroup 3 Thermal Shock (Temp Cycle)	1051	Condition B1, 15 min. Dwell	LTPD = 15
Moisture Resistance[3] Visual Inspection Endpoints	1021	Within 24 hours after completion of moisture resistance test	
Hermetic Seal	1071		
Fine Leak	1071	Condition G or H	
Gross Leak	1071	Condition C	
Electrical/Optical Endpoints[4]		I_{CC} (at $V_B=0.4$ V and 2.4 V), I_{COL} (at $V_B=0.4$ V and 2.4 V), I_{IH} (V_B, Clock and Data In), I_{IL} (V_B, Clock and Data In), I_{OH}, I_{OL}, Visual Function and I_V Peak. V_{IH} and V_{IL} inputs are guaranteed by the electronic shift register test. $T_{amb}=25°C$.	
Subgroup 4 Operating Life Test (340 Hours)	1027	$T_{amb}=+100°C$ at $V_{CC}=V_B=5.25$ V, $V_{COL}=3.5$ V, LED on time DF = 5%	LTPD = 10
Electrical/Optical Endpoints[4]		Same as Subgroup 3	
Subgroup 5 Non-Operating (Storage) Life Test (340 hours)	1032	$T_{amb}=+125°C$	LTPD = 10
Electrical/Optical Endpoints[4]		Same as Subgroup 3	

Notes:
1. Whenever electrical/optical tests are not required as endpoints, electrical rejects may be used.
2. The LTPD applies to the number of leads inspected except in no case shall less than 3 displays be used to provide the number of leads required.
3. Initial conditioning shall be a 15 degree inward bend and back to original position, one cycle.
4. Limits and conditions are per the Electrical/Optical Characteristics. The I_{OH} and I_{OL} tests are the inverse of V_{OH} and V_{OL} specified in the Electrical Characteristics.

Table IVa. Group C, Classes A and B of MIL-D-87157

Subgroup/Test	MIL-STD-750 Method	Conditions	Sample Size
Subgroup 1[1]			
Physical Dimensions	2066		2 Devices/0 Failures
Subgroup 2[1, 2]			
Lead Integrity	2004	Condition B2	LTPD = 15
Hermetic Seal	1071		
Fine Leak	1071	Condition G or H	
Gross Leak	1071	Condition C	
Subgroup 3			
Shock	2016	1500G's, Time = 0.5 ms, 5 Blows in Each Orientation X1, Y1, Y2	LTPD = 15
Vibration, Variable Frequency	2056		
Constant Acceleration	2006	10,000G's at Y1 Orientation	
External Visual[3]	1010 or 1011		
Electrical/Optical Endpoints		I_{CC} (at $V_B = 0.4$ V and 2.4 V), I_{COL} (at $V_B = 0.4$ V and 2.4 V), I_{IH} (V_B, Clock and Data In), I_{OL} (V_B, Clock and Data In), I_{OH}, I_{OL}, Visual Function and I_V Peak. V_{IH} and V_{IL} inputs are guaranteed by the electronic shift register test. $T_{amb} = 25°C$.	
Subgroup 4[5, 6]			
Salt Atmosphere	1041		LTPD = 15
External Visual[3]	1010 or 1011		
Subgroup 5			
Bond Strength[7]	2037	Condition A	LTPD = 20 (C = 0)
Subgroup 6			
Operating Life Test[8]	1026	$T_{amb} = +100°C$ at $V_{CC} = V_B = 5.25$ V, $V_{COL} = 3.5$ V, LED on time DF = 5%	$\lambda = 10$
Electrical/Optical Endpoints[4]		Same as Subgroup 3	

Notes:
1. The LTPD applies to the number of leads inspected except in no case shall less than three displays be used to provide the number of leads required.
2. MIL-STD-883 test method applies.
3. Visual requirements shall be as specified in MIL-STD-883, Methods 1010 or 1011.
4. Limits and conditions are per the electrical/optical characteristics. The I_{OH} and I_{OL} tests are the inverse of V_{OH} and V_{OL} specified in the Electrical Characteristics.
5. Whenever electrical/optical tests are not required as endpoints, electrical rejects may be used.
6. Solderability samples shall not be used.
7. Displays may be selected prior to seal.
8. If any given inspection lot undergoing Group B inspection has been selected to satisfy Group C inspection requirements, the 340-hour life tests may be continued on test to 1000 hours in order to satisfy the Group C Life Test requirements. In such cases, either the 340-hour endpoint measurement shall be made a basis for Group B lot acceptance or the 1000-hour endpoint measurement shall be used as the basis for both Group B and Group C acceptance.

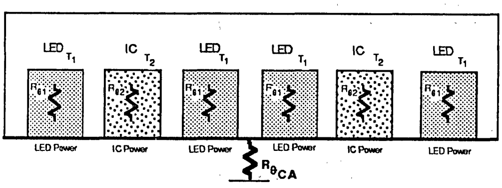
THERMAL CONSIDERATIONS

The small alphanumeric displays are hybrid LED and CMOS assemblies that are designed for reliable operation in commercial, industrial, and military environments. Optimum reliability and optical performance will result when the junction temperature of the LEDs and CMOS ICs are kept as low as possible.

THERMAL MODELING

MSD231X displays consist of two driver ICs and four 5×7 LED matrixes. A thermal model of the display is shown in Figure 5. It illustrates that the junction temperature of the semiconductor = junction self heating + the case temperature rise + the ambient temperature. Equation 1 shows this relationship.

FIGURE 5. THERMAL MODEL



Equation 1.

$$T_{J(LED)} = P_{LED}\ Z_{\theta JC} + P_{CASE}\ (R_{\theta JC} + R_{\theta CA}) + T_A$$

$$T_{J(LED)} = [(I_{COL}/28)\ V_{F(LED)}\ Z_{\theta JC}] + [(n/35)\ I_{COL}\ DF\ (5\ V_{COL}) + V_{CC}\ I_{CC}] \cdot [R_{\theta JC} + R_{\theta CA}] + T_A$$

The junction rise within the LED is the product of the thermal impedance of an individual LED (37 °C/W, DF = 20%, F = 200 Hz), times the forward voltage, $V_{F(LED)}$, and forward current, $I_{F(LED)}$, of 13 – 14.5 mA. This rise averages $T_{J(LED)} = 1$ °C. The table below shows the $V_{F(LED)}$ for the respective displays.

Part Number	V_F		
	Min.	Typ.	Max.
MSD2310	1.6	1.7	2.0
MSD2311/2/3	1.9	2.2	3.0

The junction rise within the LED driver IC is the combination of the power dissipated by the IC quiescent current and the 28 row driver current sinks. The IC junction rise is given in Equation 2.

A thermal resistance of 28 °C/W results in a typical junction rise of 6 °C.

Equation 2.

$$T_{J(IC)} = P_{COL}\ (R_{\theta JC} + R_{\theta CA}) + T_A$$

$$T_{J(IC)} = [5\ (V_{COL} - V_{F(LED)}) \cdot (I_{COL}/2) \cdot (n/35)\ DF + V_{CC} \cdot I_{CC}] \cdot [R_{\theta JC} + R_{\theta CA}] + T_A$$

THERMAL MODELING (Cont.)

For ease of calculations the maximum allowable electrical operating condition is dependent upon the aggregate thermal resistance of the LED matrixes and the two driver ICs. All of the thermal management calculations are based upon the parallel combination of these two networks which is 15°C/W. Maximum allowable power dissipation is given in Equation 3.

Equation 3.

$$P_{DISPLAY} = \frac{T_{J(MAX)} - T_A}{R_{\theta JC} + R_{\theta CA}}$$

$$P_{DISPLAY} = 5\ V_{COL}\ I_{COL}\ (n/35)\ DF + V_{CC}\ I_{CC}$$

For further reference see Figures 2, 7, 8, 9, 10 and 11.

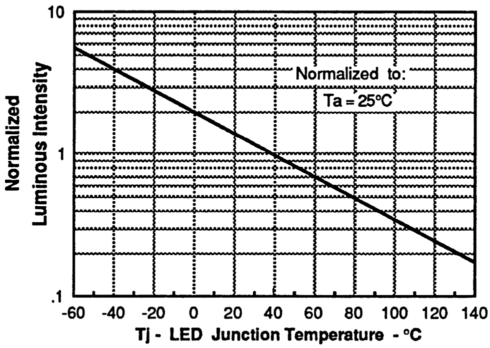
KEY TO EQUATION SYMBOLS

DF	Duty factor
I_{CC}	Quiescent IC current
I_{COL}	Column current
n	Number of LEDs on in a 5×7 array
P_{CASE}	Package power dissipation excluding LED under consideration
P_{COL}	Power dissipation of a column
$P_{DISPLAY}$	Power dissipation of the display
P_{LED}	Power dissipation of an LED
$R_{\theta CA}$	Thermal resistance case to ambient
$R_{\theta JC}$	Thermal resistance junction to case
T_A	Ambient temperature
$T_{J(IC)}$	Junction temperature of an IC
$T_{J(LED)}$	Junction temperature of a LED
$T_{J(MAX)}$	Maximum junction temperature
V_{CC}	IC voltage
V_{COL}	Column voltage
$V_{F(LED)}$	Forward voltage of LED
$Z_{\theta JC}$	Thermal impedance junction to case

OPTICAL CONSIDERATIONS

The light output of the LEDs is inversely related to the LED diode's junction temperature as shown in Figure 6. For optimum light output, keep the thermal resistance of the socket or PC board as low as possible.

FIGURE 6. NORMALIZED LUMINOUS INTENSITY VS. JUNCTION TEMPERATURE



When mounted in a 10 °C/W socket and operated at Absolute Maximum Electrical conditions, the MSD231X will show an LED junction rise of 17 °C. If $T_A = 40$ °C, then the LED's T_J will be 57 °C. Under these conditions Figure 7 shows that the I_V will be 75% of its 25 °C value.

FIGURE 7. MAX. LED JUNCTION TEMPERATURE VS. SOCKET THERMAL RESISTANCE

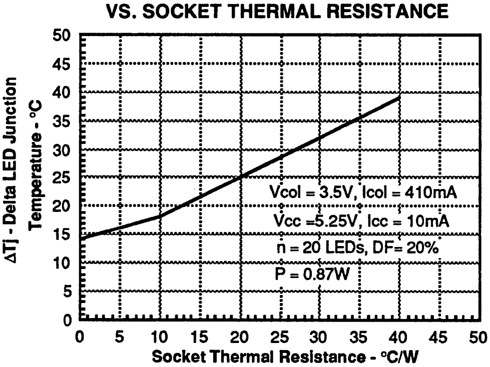


FIGURE 8. MAX. PACKAGE POWER DISSIPATION

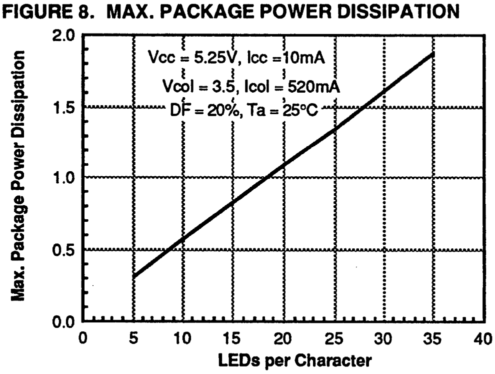


FIGURE 9. PACKAGE POWER DISSIPATION

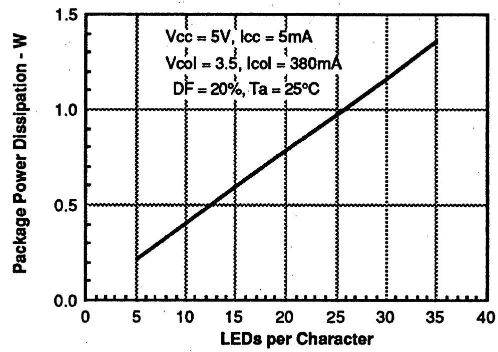


FIGURE 10. MAX. CHARACTER POWER DISSIPATION

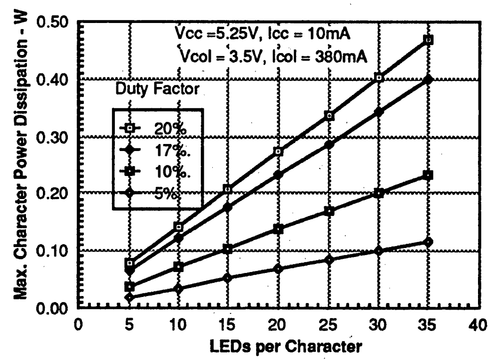
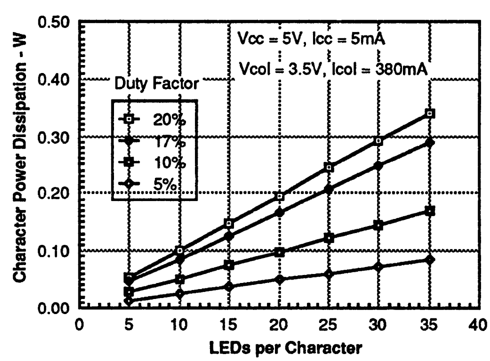


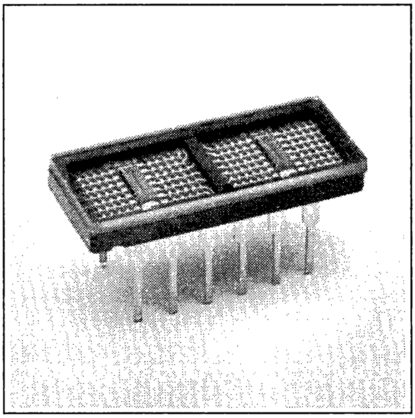
FIGURE 11. CHARACTER POWER DISSIPATION

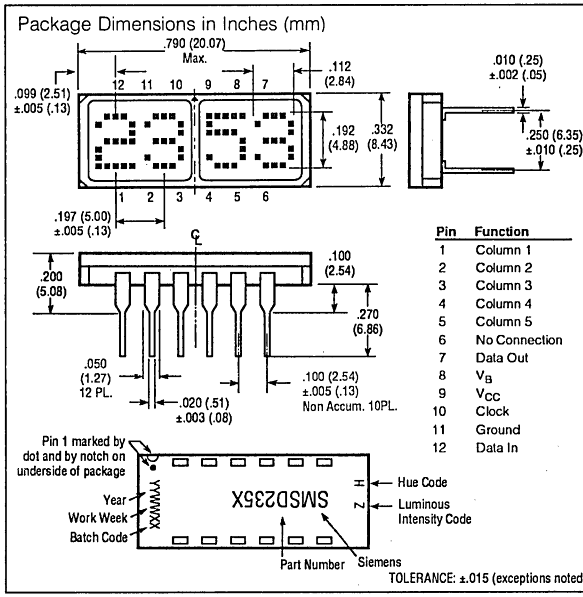


SIEMENS

YELLOW MSD2351TXV/TXVB
HIGH EFF. RED MSD2352TXV/TXVB
HIGH EFF. GREEN MSD2353TXV/TXVB

Sunlight Viewable .200″ 4-Character 5×7 Dot Matrix Serial Input Alphanumeric Military Display





Pin	Function
1	Column 1
2	Column 2
3	Column 3
4	Column 4
5	Column 5
6	No Connection
7	Data Out
8	V_B
9	V_{CC}
10	Clock
11	Ground
12	Data In

FEATURES

- **Four .200″ Dot Matrix Characters**
- **Three Colors: Yellow, High Efficiency Red, High Efficiency Green**
- **Sunlight Viewable**
- **Wide Viewing Angle**
- **Built-in CMOS Shift Registers with Constant Current LED Row Drivers**
- **Shift Registers Allow Custom Fonts**
- **Easily Cascaded for Multiple Displays**
- **TTL Compatible**
- **End Stackable**
- **Military Operating Temperature Range: −55° to +100°C**
- **Categorized for Luminous Intensity**
- **Ceramic Package, Hermetically Sealed Flat Glass Window**
- **TXVB Process Conforms to MIL-D-87157 Quality Level A Test and Tables I, II, IIIa and IV**
- **TXV Process Conforms to a Modified MIL-D-87157 Quality Level A Test and Table I**

DESCRIPTION

The MSD2351 through MSD2353TXV/TXVB are four digit 5×7 dot matrix serial input alphanumeric displays. The displays are available in yellow, high efficiency red, or high efficiency green. The package is a standard twelve-pin hermetic package with glass lens. The display can be stacked horizontally or vertically to form messages of any length. The MSD235X has two fourteen-bit CMOS shift registers with built-in row drivers. These shift registers drive twenty-eight rows and enable the design of customized fonts. Cascading multiple displays is possible because of the Data In and Data Out pins. Data In and Out are easily input with the clock signal and displayed in parallel on the row drivers. Data Out represents the output of the 7th bit of digit number four shift register. The shift register is level triggered. The like columns of each character in a display cluster are tied to a single pin. (See Block Diagram). High true data in the shift register enables the output current mirror driver stage associated with each row of LEDs in the 5×7 diode array.

The TTL compatible V_B input may either be tied to V_{CC} for maximum display intensity or pulse width modulated to achieve intensity control and reduce power consumption.

—Continued

See Appnote 44 for application information, and Appnotes 18, 19, 22, and 23 for additional information.

DESCRIPTION (Continued)

In the normal mode of operation, input data for digit four, column one is loaded into the seven on-board shift register locations one through seven. Column one data for digits 3, 2, and 1 is shifted into the display shift register locations. Then column one input is enabled for an appropriate period of time, T. A similar process is repeated for columns 2, 3, 4, and 5. If the decode time and load data time into the shift register is t, then with five columns, each column of the display is operating at a duty factor of:

$$DF=\frac{T}{5(T+t)}$$

T+t, allotted to each display column, is generally chosen to provide the maximum duty factor consistent with the minimum refresh rate necessary to achieve a flicker free display. For most strobed display systems, each column of the display should be refreshed (turned on) at a minimum rate of 100 times per second.

With columns to be addressed, this refresh rate then gives a value for the time T+t of: 1/[5×(100)]=2 msec. If the device is operated at 5.0 MHz clock rate maximum, it is possible to maintain t<<T. For short display strings, the duty factor will then approach 20%.

Maximum Ratings

Supply Voltage V_{CC} to GND .... −0.5 V to +7.0 V
Inputs, Data Out and V_B .... −0.5 V to V_{CC} +0.5 V
Column Input Voltage, V_{COL} .... −0.5 V to +6.0 V
Operating Temperature Range .... −55°C to +100°C
Storage Temperature Range .... −65°C to +125°C
Maximum Solder Temperature, 0.063″ (1.59 mm) below Seating Plane, t<5 sec .... 260°C
Maximum Power Dissipation at T_{amb}=25°C .... 1.35 W

Notes:
1. Operation above +100°C ambient is possible provided the following condition are met. The junction should not exceed T_J=125°C and the case temperature (as measured at pin 1 or the back of the display) should not exceed T_C=100°C.
2. Maximum dissipation is derived from V_{CC}=5.25 V, V_B=2.4 V, V_{COL}=3.5 V 20 LEDs on per character, 20% DF.

FIGURE 1. TIMING CHARACTERISTICS

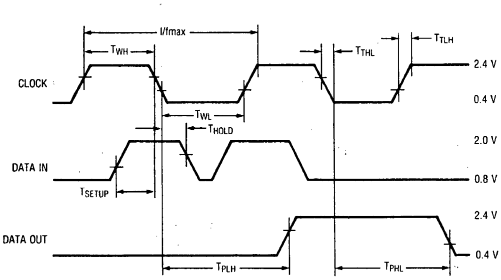
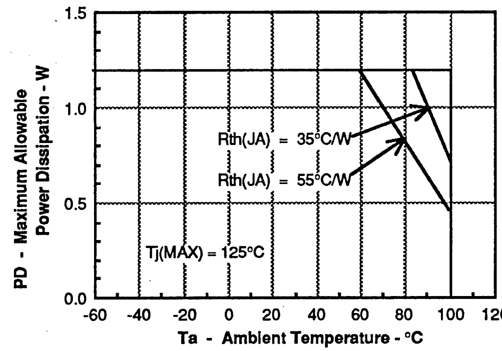


FIGURE 2. MAX. ALLOWABLE POWER DISSIPATION VS. TEMPERATURE



AC ELECTRICAL CHARACTERISTICS

(V_{CC}=4.75 to 5.25 V, T_{amb}=−55°C to +100°C)

Symbol	Description	Min.	Typ.[1]	Max.[2]	Units	Fig.
T_{SETUP}	Setup Time	50	10		ns	1
T_{HOLD}	Hold Time	25	20		ns	1
T_{WL}	Clock Width Low	75	45		ns	1
T_{WH}	Clock Width High	75	45		ns	1
$F_{(CLK)}$	Clock Frequency		6	5	MHz	1
T_{THL}, T_{TLH}	Clock Transition Time		75	200	ns	1
T_{PHL}, T_{PLH}	Propagation Delay Clock to Data Out		50	125	ns	1

Notes:
1. All typical values specified at V_{CC}=5.0 V and T_{amb}=25°C unless otherwise noted.
2. V_B Pulse Width Modulation Frequency — 50 KHz (max).

CLEANING THE DISPLAYS

IMPORTANT — Do not use cleaning agents containing alcohol of any type with this display. The least offensive cleaning solution is hot D.I. water (60°C) for less than 15 minutes. Addition of mild saponifiers is acceptable. Do not use commercial dishwasher detergents.

For post solder cleaning use water or non-alcohol mixtures formulated for vapor cleaning processing or non-alcohol mixtures formulated for room temperature cleaning. Non-alcohol vapor cleaning processing for up to two minutes in vapors at boiling is permissible. For suggested solvents refer to Siemens Appnote 19.

RECOMMENDED OPERATING CONDITIONS

Parameter	Symbol	Min.	Nom.	Max.	Units
Supply Voltage	V_{CC}	4.75	5.0	5.25	V
Data Out Current, Low State	I_{OL}			1.6	mA
Data Out Current, High State	I_{OH}			-0.5	mA
Column Input Voltage, Column On[1]	V_{COL}	2.75		3.5	V
Setup Time	T_{SETUP}	70	45		ns
Hold Time	T_{HOLD}	30			ns
Width of Clock	$T_{W(CLK)}$	75			ns
Clock Frequency	T_{CLK}			5	MHz
Clock Transition Time	T_{THL}			200	ns
Free Air Operating Temperature Range	T_{amb}	-55		+100	°C

Note:
1. See Figure 3 - Peak Column Current vs. Column Voltage.

OPTICAL CHARACTERISTICS

Yellow MSD2351

Description	Symbol	Min.	Typ.[4]	Max.	Units	Test Conditions
Peak Luminous Intensity per LED[1, 3] (Character Average)	I_{VPEAK}	2400	3400		μcd	$V_{CC}=5.0$ V, $V_{COL}=3.5$ V T_J[5] $=25°C$, $V_B=2.4$ V
Peak Wavelength	λ_{PEAK}		583		nm	
Dominant Wavelength[2]	λ_D		585		nm	

High Efficiency Red MSD2352

Description	Symbol	Min.	Typ.[4]	Max.	Units	Test Conditions
Peak Luminous Intensity per LED[1, 3] (Character Average)	I_{VPEAK}	1920	2850		μcd	$V_{CC}=5.0$ V, $V_{COL}=3.5$ V T_J[5] $=25°C$, $V_B=2.4$ V
Peak Wavelength	λ_{PEAK}		635		nm	
Dominant Wavelength[2]	λ_D		626		nm	

High Efficiency Green MSD2353

Description	Symbol	Min.	Typ.[4]	Max.	Units	Test Conditions
Peak Luminous Intensity per LED[1, 3] (Character Average)	I_{VPEAK}	2400	3000		μcd	$V_{CC}=5.0$ V, $V_{COL}=3.5$ V T_J[5] $=25°C$, $V_B=2.4$ V
Peak Wavelength	λ_{PEAK}		568		nm	
Dominant Wavelength[2]	λ_D		574		nm	

Notes:
1. The displays are categorized for luminous intensity with the intensity category designated by a letter code on the bottom of the package.
2. Dominant wavelength λ_D, is derived from the CIE chromaticity diagram, and represents the single wavelength which defines the color of the device.
3. The luminous sterance of the LED may be calculated using the following relationships: L_V (cd/m²) = I_V (Candela)/A (Meter)²
   L_V (Footlamberts) = πI_V (Candela)/A (Foot)²
   $A = 5.3 \times 10^{-8}$ M² $= 5.8 \times 10^{-7}$ (Foot)²
4. All typical values specified at $V_{CC}=5.0$ V and $T_{amb}=25°C$ unless otherwise noted.
5. The luminous intensity is measured at $T_{amb}=T_J=25°C$. No time is allowed for the device to warm up prior to measurement.

Intelligent Display Devices

ELECTRICAL CHARACTERISTICS (−55°C to +100°C) (unless otherwise specified)

Description	Symbol	Min.	Typ.	Max.	Units	Test Conditions	
Supply Current (quiescent)	I_{CC}			5.0	mA	$V_B = 0.4$ V	$V_{CC} = 5.25$ V $V_{CLK} = V_{DATA} = 2.4$ V All SR Stages = Logical 1
				5.0	mA	$V_B = 2.4$ V	
Supply Current (operating)	I_{CC}			10.0	mA	$F_{CLK} = 5$ MHz	
Column Current at any Column Input[1]	I_{COL} (All)			10	μA	$V_B = 0.4$ V	$V_{CC} = 5.25$ V $V_{COL} = 3.5$ V All SR Stages = Logical 1
	I_{COL}		550	650	mA	$V_B = 2.4$ V	
V_B, Clock or Data Input Threshold Low	V_{IL}			0.8	V	$V_{CC} = 4.75$ V − 5.25 V	
V_B, Clock or Data Input Threshold High	V_{IH}	2.0			V		
Data Out Voltage	V_{OH}	2.4			V	$I_{OH} = 0.2$ mA	$V_{CC} = 4.75$ V $I_{COL} = 0$ mA
	V_{OL}			0.4	V	$I_{OL} = 1.6$ mA	
Input Current Logical 0 V_B only	I_{IL}	−30	−110	−300	μA	$V_{CC} = 4.75$ V − 5.25 V, $V_{IL} = 0.8$ V	
Input Current Logical 0 Data, Clock	I_{IL}			−10	μA		
Input Current Logical 1 Data, Clock	I_{IH}			10	μA	$V_{CC} = 4.75$ V − 5.25 V, $V_{IH} = 2.4$ V	
Input Current Logical 1 V_B	I_{IH}			200	μA		
Power Dissipation per Package	P_D		0.74		W	$V_{CC} = 5.0$ V, $V_{COL} = 3.5$ V, 17.5% DF 15 LEDs on per character, $V_B = 2.4$ V	
Thermal Resistance IC Junction-to-Pin	$R\theta_{J-PIN}$		25		°C/W/ Device		

Note:
1. See Figure 3 – Peak Column Current vs. Column Voltage.

FIGURE 3. PEAK COLUMN CURRENT VS. COLUMN VOLTAGE

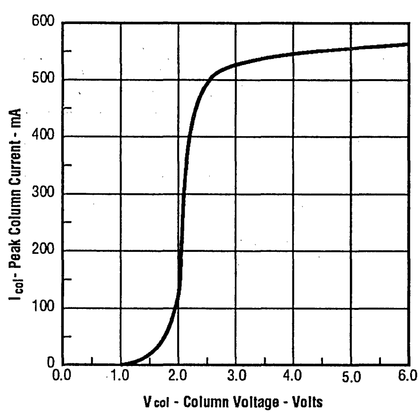
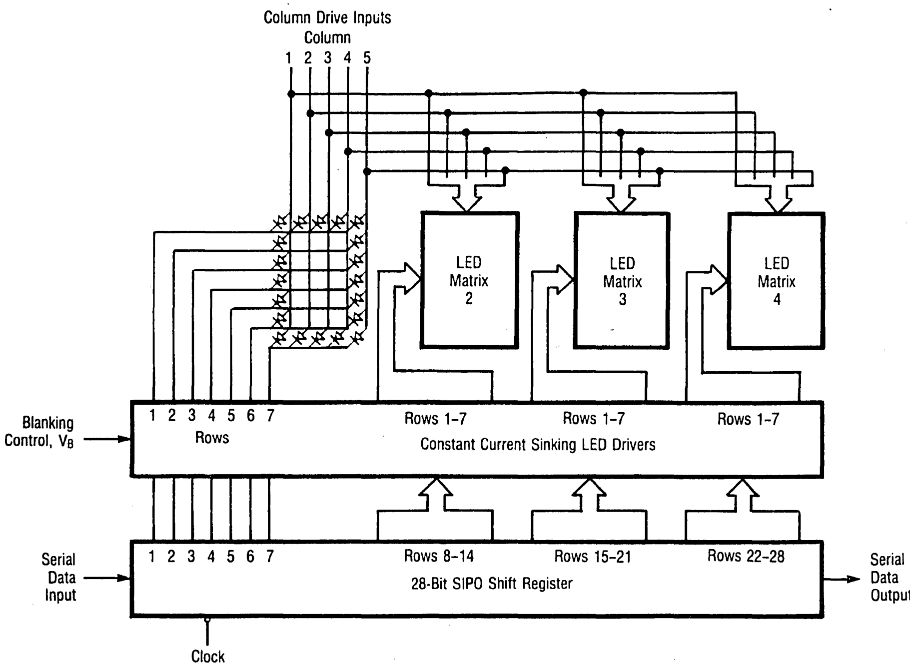


FIGURE 4. BLOCK DIAGRAM



CONTRAST ENHANCEMENT FILTERS FOR SUNLIGHT READABILITY

Display Color Part No.	Filter Color	Marks Polarized Corp.* Filter Series	Optical Characteristics of Filter	
HER MSD2352	Red	MPC 20-15C	25% @ 635 nm	Circular Polarizer
Yellow MSD2351	Amber	MPC 30-25C	25% @ 583 nm	
Green MSD2353	Yellow/Green	MPC 50-22C	22% @ 568 nm	
Multiple Colors High Ambient Light	Neutral Gray	MPC 80-10C	10% Neutral	
Multiple Colors	Neutral Gray	MPC 80-37C	37% Neutral	

*Marks Polarized Corp.
25-B Jefryn Blvd. W.
Deer Park, NY 11729
516-242-1300
FAX (516) 242-1347
Marks Polarized Corp. manufactures to MIL-I-45208 inspection system.

GENERAL QUALITY ASSURANCE LEVELS

The parts are tested in conformance with Quality Level A of MIL-D-87157 for hermetically sealed LED displays with 100% screening. The product is tested to Tables I, II, IIIa and IVa.

Table I. Quality Level A of MIL-D-87157

Test Screen	Method	Conditions
1. Precap Visual	2072 MIL-STD-750	
2. High Temperature Storage	1032 MIL-STD-750	T_{amb} = 125 °C, Time = 24 hours
3. Temperature Cycling	1051 MIL-STD-750	Condition B, 10 Cycles, 15 min. Dwell T_{amb} = −65 °C to +125 °C
4. Constant Acceleration	2006 MIL-STD-750	10,000 G's at Y_1 Orientation
5. Fine Leak	1071 MIL-STD-750	Condition H, Leak Rate $\leq 5 \times 10^{-7}$ cc/s
6. Gross Leak	1071 MIL-STD-750	Condition C
7. Interim Electrical/Optical Tests(2)		I_{CC} (at V_B = 0.4 V and 2.4 V), I_{COL} (at V_B = 0.4 V and 2.4 V), I_{IH} (V_B, Clock and Data In), I_{IL} (V_B, Clock and Data In), I_{OH}, I_{OL}, Visual Function and I_V Peak. V_{IH} and V_{IL} inputs are guaranteed by the electronic shift register test. T_{amb} = 25 °C.
8. Burn-In(1)	1015 MIL-STD-883	Condition B at $V_{CC} = V_B$ = 5.25 V, V_{COL} = 3.5 V, T_{amb} = 100 °C. LED On-Time Duty Factor = 5%, t = 160 hours
9. Final Electrical Test (2)		Same as Step 7.
10. Delta Determinants		ΔI_{CC} = +/−1 mA, ΔI_{IH} = +/−10 mA (Clock and Data In), ΔI_{OH} = +/−10% of initial value, ΔI_V = −20%
11. External Visual	2009 MIL-STD-883	

Table II. Group A Electrical Tests – MIL-D-87157

Subgroup/Test	Parameters	LTPD
Subgroup 1 DC Electrical Tests at 25 °C	I_{CC} (at V_B = 0.4 V and 2.4 V), I_{COL} (at V_B = 0.4 V and 2.4 V), I_{IH} (V_B, Clock and Data In), I_{IL} (V_B, Clock and Data In), I_{OH}, I_{OL}, Visual Function and I_V Peak. V_{IH} and V_{IL} inputs are guaranteed by the electronic shift register test.	5
Subgroup 2 Selected DC Electrical Tests at High Temperatures(2)	Same as Subgroup 1, except delete I_V and Visual Function, T_{amb} = 100 °C	7
Subgroup 3 Selected DC Electrical Tests at Low Temperatures(2)	Same as Subgroup 1, except delete I_V and Visual Function, T_{amb} = −55 °C	7
Subgroup 4, 5 and 6 Not Tested		
Subgroup 7 Optical and Functional Tests at 25 °C	Satisfied by Subgroup 1	5
Subgroup 8 External Visual	MIL-STD-883, Method 2009	7

Notes:
1. MIL-STD-883 test method applies.
2. Limits and conditions are per the Electrical/Optical Characteristics. The I_{OH} and I_{OL} tests are the inverse of V_{OH} and V_{OL} specified in the Electrical Characteristics.

Table IIIa. Group B, Classes A and B of MIL-D-87157

Subgroup/Test	MIL-STD-750 Method	Conditions	Sample Size
Subgroup 1 Resistance to Solvents	1022		4 Devices/0 Failures
Internal Visual and Mechanical	2075	Inspection may be performed through glass cover, includes front and back cavities	1 Device/0 Failures
Subgroup 2[1, 2] Solderability	2026	$T_{amb} = 245°C$ for 5 seconds	LTPD = 15
Subgroup 3 Thermal Shock (Temp Cycle)	1051	Condition B1, 15 min. Dwell	LTPD = 15
Moisture Resistance[3] Visual Inspection Endpoints	1021	Within 24 hours after completion of moisture resistance test	
Hermetic Seal	1071		
Fine Leak	1071	Condition G or H	
Gross Leak	1071	Condition C	
Electrical/Optical Endpoints[4]		I_{CC} (at $V_B = 0.4$ V and 2.4 V), I_{COL} (at $V_B = 0.4$ V and 2.4 V), I_{IH} (V_B, Clock and Data In), I_{IL} (V_B, Clock and Data In), I_{OH}, I_{OL}, Visual Function and I_V Peak. V_{IH} and V_{IL} inputs are guaranteed by the electronic shift register test. $T_{amb} = 25°C$.	
Subgroup 4 Operating Life Test (340 Hours)	1027	$T_{amb} = +100°C$ at $V_{CC} = V_B = 5.25$ V, $V_{COL} = 3.5$ V, LED on time DF = 5%	LTPD = 10
Electrical/Optical Endpoints[4]		Same as Subgroup 3	
Subgroup 5 Non-Operating (Storage) Life Test (340 hours)	1032	$T_{amb} = +125°C$	LTPD = 10
Electrical/Optical Endpoints[4]		Same as Subgroup 3	

Notes:
1. Whenever electrical/optical tests are not required as endpoints, electrical rejects may be used.
2. The LTPD applies to the number of leads inspected except in no case shall less than 3 displays be used to provide the number of leads required.
3. Initial conditioning shall be a 15 degree inward bend and back to original position, one cycle.
4. Limits and conditions are per the Electrical/Optical Characteristics. The I_{OH} and I_{OL} tests are the inverse of V_{OH} and V_{OL} specified in the Electrical Characteristics.

Table IVa. Group C, Classes A and B of MIL-D-87157

Subgroup/Test	MIL-STD-750 Method	Conditions	Sample Size
Subgroup 1[1]			
Physical Dimensions	2066		2 Devices/0 Failures
Subgroup 2[1, 2]			
Lead Integrity	2004	Condition B2	LTPD = 15
Hermetic Seal	1071		
Fine Leak	1071	Condition G or H	
Gross Leak	1071	Condition C	
Subgroup 3			
Shock	2016	1500G's, Time = 0.5 ms, 5 Blows in Each Orientation X1, Y1, Y2	LTPD = 15
Vibration, Variable Frequency	2056		
Constant Acceleration	2006	10,000G's at Y1 Orientation	
External Visual[3]	1010 or 1011		
Electrical/Optical Endpoints		I_{CC} (at $V_B = 0.4$ V and 2.4 V), I_{COL} (at $V_B = 0.4$ V and 2.4 V), I_{IH} (V_B, Clock and Data In), I_{OL} (V_B, Clock and Data In), I_{OH}, I_{OL}, Visual Function and I_V Peak. V_{IH} and V_{IL} inputs are guaranteed by the electronic shift register test. $T_{amb} = 25°C$.	
Subgroup 4[5, 6]			
Salt Atmosphere	1041		LTPD = 15
External Visual[3]	1010 or 1011		
Subgroup 5			
Bond Strength[7]	2037	Condition A	LTPD = 20 (C = 0)
Subgroup 6			
Operating Life Test[8]	1026	$T_{amb} = +100°C$ at $V_{CC} = V_B = 5.25$ V, $V_{COL} = 3.5$ V, LED on time DF = 5%	$\lambda = 10$
Electrical/Optical Endpoints[4]		Same as Subgroup 3	

Notes:
1. The LTPD applies to the number of leads inspected except in no case shall less than three displays be used to provide the number of leads required.
2. MIL-STD-883 test method applies.
3. Visual requirements shall be as specified in MIL-STD-883, Methods 1010 or 1011.
4. Limits and conditions are per the electrical/optical characteristics.
5. Whenever electrical/optical tests are not required as endpoints, electrical rejects may be used.
6. Solderability samples shall not be used.
7. Displays may be selected prior to seal.
8. If any given inspection lot undergoing Group B inspection has been selected to satisfy Group C inspection requirements, the 340-hour life tests may be continued on test to 1000 hours in order to satisfy the Group C Life Test requirements. In such cases, either the 340-hour endpoint measurement shall be made a basis for Group B lot acceptance or the 1000-hour endpoint measurement shall be used as the basis for both Group B and Group C acceptance.

THERMAL CONSIDERATIONS

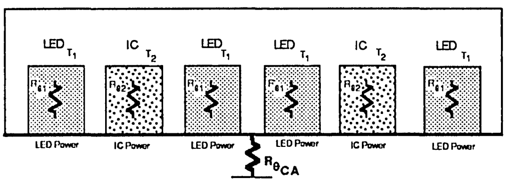
The small alphanumeric displays are hybrid LED and CMOS assemblies that are designed for reliable operation in commercial, industrial, and military environments. Optimum reliability and optical performance will result when the junction temperature of the LEDs and CMOS ICs are kept as low as possible.

Intelligent Display Devices

THERMAL MODELING

MSD235X displays consist of two driver ICs and four 5×7 LED matrixes. A thermal model of the display is shown in Figure 5. It illustrates that the junction temperature of the semiconductor = junction self heating + the case temperature rise + the ambient temperature. Equation 1 shows this relationship.

FIGURE 5. THERMAL MODEL



Equation 1.

$$T_{J(LED)} = P_{LED}\ Z_{\theta JC} + P_{CASE}\ (R_{\theta JC} + R_{\theta CA}) + T_A$$

$$T_{J(LED)} = [(I_{COL}/28)\ V_{F(LED)}\ Z_{\theta JC}] + [(n/35)\ I_{COL}\ DF\ (5\ V_{COL}) + V_{CC}\ I_{CC}] \cdot [R_{\theta JC} + R_{\theta CA}] + T_A$$

The junction rise within the LED is the product of the thermal impedance of an individual LED (37 °C/W, DF = 20%, F = 200 Hz), times the forward voltage, $V_{F(LED)}$, and forward current, $I_{F(LED)}$, of 13 - 14.5 mA. This rise averages $T_{J(LED)} = 1$ °C. The table below shows the $V_{F(LED)}$ for the respective displays.

Part Number	V_F		
	Min.	Typ.	Max.
MSD2351/2/3	1.9	2.2	3.0

The junction rise within the LED driver IC is the combination of the power dissipated by the IC quiescent current and the 28 row driver current sinks. The IC junction rise is given in Equation 2.

A thermal resistance of 28 °C/W results in a typical junction rise of 6 °C.

Equation 2.

$$T_{J(IC)} = P_{COL}\ (R_{\theta JC} + R_{\theta CA}) + T_A$$

$$T_{J(IC)} = [5\ (V_{COL} - V_{F(LED)}) \cdot (I_{COL}/2) \cdot (n/35)\ DF + V_{CC} \cdot I_{CC}] \cdot [R_{\theta JC} + R_{\theta CA}] + T_A$$

THERMAL MODELING (Cont.)

For ease of calculations the maximum allowable electrical operating condition is dependent upon the aggregate thermal resistance of the LED matrixes and the two driver ICs. All of the thermal management calculations are based upon the parallel combination of these two networks which is 15°C/W. Maximum allowable power dissipation is given in Equation 3.

Equation 3.

$$P_{DISPLAY} = \frac{T_{J(MAX)} - T_A}{R_{\theta JC} + R_{\theta CA}}$$

$$P_{DISPLAY} = 5\ V_{COL}\ I_{COL}\ (n/35)\ DF + V_{CC}\ I_{CC}$$

For further reference see Figures 2, 7, 8, 9, 10 and 11.

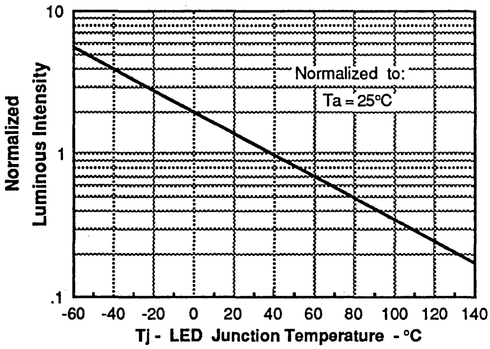
KEY TO EQUATION SYMBOLS

DF	Duty factor
I_{CC}	Quiescent IC current
I_{COL}	Column current
n	Number of LEDs on in a 5×7 array
P_{CASE}	Package power dissipation excluding LED under consideration
P_{COL}	Power dissipation of a column
$P_{DISPLAY}$	Power dissipation of the display
P_{LED}	Power dissipation of an LED
$R_{\theta CA}$	Thermal resistance case to ambient
$R_{\theta JC}$	Thermal resistance junction to case
T_A	Ambient temperature
$T_{J(IC)}$	Junction temperature of an IC
$T_{J(LED)}$	Junction temperature of a LED
$T_{J(MAX)}$	Maximum junction temperature
V_{CC}	IC voltage
V_{COL}	Column voltage
$V_{F(LED)}$	Forward voltage of LED
$Z_{\theta JC}$	Thermal impedance junction to case

OPTICAL CONSIDERATIONS

The light output of the LEDs is inversely related to the LED diode's junction temperature as shown in Figure 6. For optimum light output, keep the thermal resistance of the socket or PC board as low as possible.

FIGURE 6. NORMALIZED LUMINOUS INTENSITY VS. JUNCTION TEMPERATURE



When mounted in a 10°C/W socket and operated at Absolute Maximum Electrical conditions, the MSD235X will show an LED junction rise of 17°C. If $T_A = 40°C$, then the LED's T_J will be 57°C. Under these conditions Figure 7 shows that the I_V will be 75% of its 25°C value.

FIGURE 7. MAX. LED JUNCTION TEMPERATURE VS. SOCKET THERMAL RESISTANCE

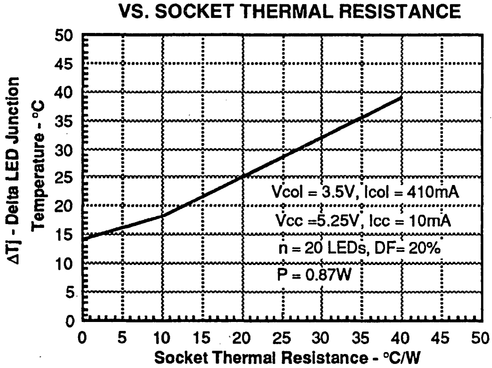


FIGURE 8. MAX. PACKAGE POWER DISSIPATION

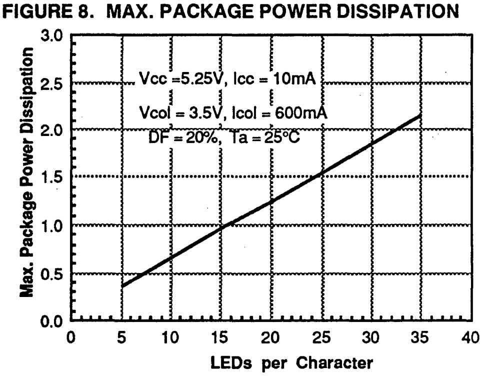


FIGURE 9. PACKAGE POWER DISSIPATION

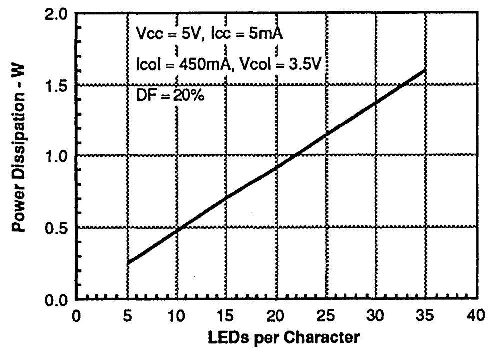


FIGURE 10. MAX. CHARACTER POWER DISSIPATION

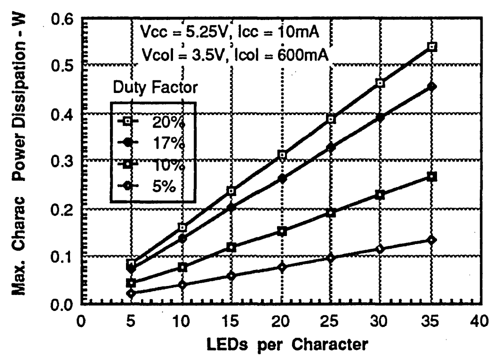
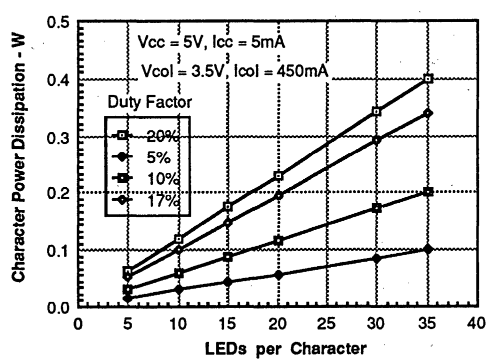


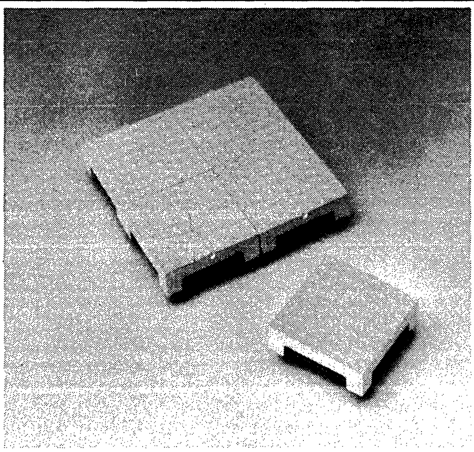
FIGURE 11. CHARACTER POWER DISSIPATION



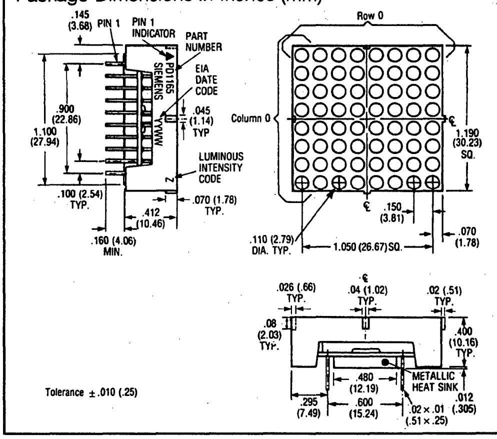
SIEMENS

HIGH EFFICIENCY RED PD1165
VERY BRIGHT GREEN PD1167

1.16″ Square 8 × 8 Dot Matrix Programmable Display™ Module With On Board Drivers, Built-In RAM and Software Controllable Features



Package Dimensions in Inches (mm)



FEATURES

- Active Display Size 1.16″ Square
- 0.11″ Diam. Dots on 0.15″ Centers
- Very Bright Green or High Efficiency Red
- Intensity Matched and Binned
- Readable from 35 Feet
- Viewing Angle ±75°
- Interlocking X-Y Stackable Packages for Larger Displays
- On board CMOS Circuits with Complete Drive Circuits and Logic Interfaces
- Each Dot Addressable Over TTL Compatible, 8 Bit BUS
- Alternate Language & Graphics Programming Capability
- Cascadable-Synchronizable Logic for Expanded Display Systems
- Software Controlled Attributes:
  9 Levels of Intensity Settings
  Memory Clear
  Blanking or Blinking
  Built-In Lamp Test
- 100% Burned In Prior to Final Test
- 20 Pin DIP Package: 0.6″ Wide Rows, 0.1″ Pin Spacing
- Wave Solderable
- −20°C to +70°C Operating Range

DESCRIPTION

The high efficiency red PD 1165 and very bright green PD 1167 are modular 8x8 dot matrix Programmable Displays. They are constructed with highly efficient III/V material LEDs, packaged in a reflector package for maximum dot illumination. Further optimizing light output are built-in CMOS drive circuits. These circuits strobe the LEDs at peak currents that give the best time averaged luminous intensity for the power required. The user has complete control of the display through further built-in CMOS circuitry. The display appearance can be set by programming an 8 bit RAM.

Features such as blinking, synchronizing, blanking, one of nine intensity levels or lamp tests are easily programmed through a control word. Additional external connections are available for clock inputs, clock outputs and total intensity control through an external resistor.

All products are 100% burned-in and tested, then subjected to out-going AQL's of .25% for brightness matching, visual alignment and dimensions, .065% for electrical and functional.

The display is constructed of epoxy filled polycarbonate with two interconnected pcbs. A heat sink is attached to cool the device with its 20 pin dip lead construction. The package is wave solderable and has been fully qualified for operation and storage over a temperature range from −20°C to +70°C.

Maximum Ratings

V_{CC}, DC Supply Voltage .... −0.5 to +6.0 Vdc
V_{IN}, Input Voltage Levels Relative to GND (all inputs) .... −0.5 to (V_{CC} +0.5) Vdc
Operating Temperature .... −20°C to +70°C
Storage Temperature .... −20°C to +70°C
Relative Humidity (non condensing) @65°C 90%
Power Dissipation @V_{CC}=5.0 V, T_A= −20°C .... 1.6 W
Junction Temperature @70°C (Θ_{JA}=25°C/W) .... 95°C
Maximum Solder Temperature .063″ (1.59 mm) below the Seating Plane, t<5 sec .... 260°C

Recommended Operating Conditions −20°C to +70°C

Parameter	Min.	Nom.	Max.	Units
V_{CC}, Supply Voltage	4.5	5.0	5.5	V
V_{IH}, Input Voltage High	2.7			V
V_{IL}, Input Voltage Low			0.8	V
Clock Fan Out(1)		8	15	Disp.

Note: 1. The number of displays that can be synchronized by one "master" display clock depends on how "clean" the line is. The maximum can only be achieved in very "clean" electrical environments. A buffer is required for larger systems or noisy environments.

Optical Characteristics @25°C

Spectral Peak Wavelength .... (HER) 630 nm typ.
.... (Green) 565 nm typ.
Viewing Angle, both axis (off normal axis) .... ±75°
Active Display Size .... 1.16″ square
Dot Size .... 0.11″ diam.
Pitch (center to center dot spacing) .... 0.15″
Time Averaged Luminous Intensity (100% bright) .... 0.5 mcd/dot min.
1.7 mcd/dot typ.
Dot to Dot Intensity Matching Ratio .... 1.8:1.0 max.
Display Average Intensity Matching Ratio (per bin) .... 1.5:1.0 max.
Bin to Bin Matching Ratio (adjacent bin) .... 1.9:1.0 max.

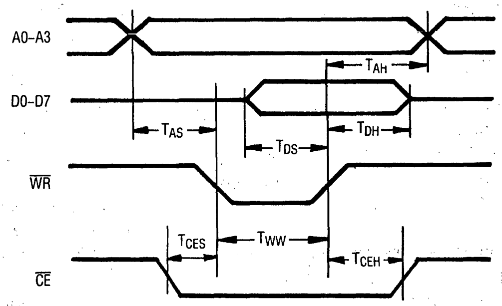
Intelligent Display Devices

DC CHARACTERISTICS

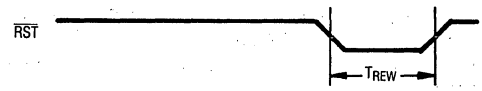
Parameter	−20°C			+25°C			+70°C			Units	Conditions
	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.		
I_{CC} Blank		3.0	4.0		2.0	3.0		1.0	2.0	mA	$\overline{WR}=V_{CC}=5.0$ V $V_{IN}=0.8$ V
I_{CC} Lamp Test		115	130		105	115		95	105	mA	$V_{CC}=5.0$ V
I_{CC} 64 dots on at full intensity(1, 2)		235	265		205	230		185	200	mA	$V_{CC}=5.0$ V
I_{IL}		12	24		10	20		8	16	μA	$V_{CC}=5.0$ V
V_{IH}	2.7			2.7			2.7			V	4.5 V $\leq V_{CC} \leq$ 5.5 V
V_{IL}			0.8			0.8			0.8	V	4.5 V $\leq V_{CC} \leq$ 5.5 V

Notes: 1. Average LED drive current is 3 mA. Peak current at 1/8 duty cycle is typically 25 mA.
2. RDIM can be used to reduce I_{CC} and subsequently lower the nominal display intensity level. See figure (2) for typical brightness reductions with the use of R_{EXT}.

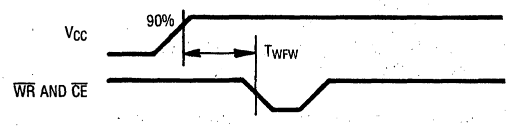
WRITE CYCLE



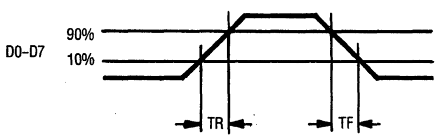
RESET TIMING



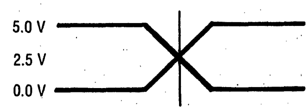
POWER ON TO FIRST WRITE TIMING



DATA BUS TRANSITIONS AT CL = 150 pF



TIMING MEASUREMENT LEVELS



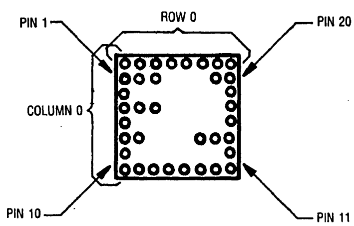
AC CHARACTERISTICS Over Operating Temperature Range at V_{CC} = 4.5 V

Parameter	Symbol	−20°C (t_{MIN})	+25°C (t_{MIN})	+70°C (t_{MIN})	Units
Chip Enable Set Up Time	T_{CES}	0	5	5	ns
Address Set Up Time	T_{AS}	10	10	10	ns
Write Pulse Width	T_{WW}	20	30	30	ns(2)
Data Set Up Time	T_{DS}	40	55	55	ns(2)
Chip Enable Hold Time	T_{CEH}	0	0	0	ns
Address Hold Time	T_{AH}	5	5	5	ns
Data Hold Time	T_{DH}	20	20	20	ns
Reset Pulse Width	T_{REW}	50	50	50	μs(1)
Minimum Time Between Power Up and the First Write Operation	T_{WFW}	2	2	2	ms
Total Write Time (T_{AS} + T_{WW} + T_{DH})	T_{WR}	35	45	45	ns

Notes: 1. 50 μs or 2 clock cycles minimum. The internal clock frequency is between 50 and 80 kHz. If an external clock is supplied, it should be held between 50 and 60 kHz.
2. T_{WW} must be less than T_{DS}.

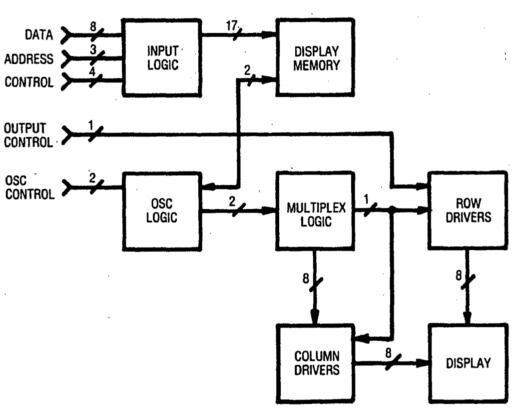
PD 1165

TOP VIEW



PD 1165, PD 1167 PINOUT			
1	$\overline{RST}$	20	GND
2	CLK OUT	19	D7
3	$\overline{WR}$	18	D6
4	$\overline{CE}$	17	D5
5	A0	16	D4
6	A1	15	D3
7	A2	14	D2
8	A3	13	D1
9	CLK IN	12	D0
10	R DIM	11	V_{CC}

PD 1165 (PD 1167) BLOCK DIAGRAM



PIN DEFINITIONS

Pin		
1.	$\overline{RST}$	Resets the System. Active low.
2.	CLK_{OUT}	Clock output for daisy chaining
3.	$\overline{WR}$	Writes data into the display. Active low.
4.	$\overline{CE}$	Chip Enable. Active low.
5.	A0	Address Input (LSB)
6.	A1	Address Input
7.	A2	Address Input (MSB)
8.	A3	Address Input for control words.
9.	CLK_{IN}	Clock Input for daisy chaining
10.	R_{DIM}	Controls Brightness through R_{EXT}
11.	V_{CC}	Plus 5 volts power pin
12.	D0	Data Bus Bit 0 (LSB)
13.	D1	Data Bus Bit 1
14.	D2	Data Bus Bit 2
15.	D3	Data Bus Bit 3
16.	D4	Data Bus Bit 4
17.	D5	Data Bus Bit 5
18.	D6	Data Bus Bit 6
19.	D7	Data Bus Bit 7 (MSB)
20.	GND	Ground

FUNCTIONAL DESCRIPTION

The PD 1165 (PD 1167) block diagram includes the major blocks and internal registers.

Display Memory consists of a 8×8 bit RAM block for the display columns and rows. Each one of the eight bit corres-pond to a LED and each eight bit cluster corresponds to a column. It also contains a 1×8 bit block to serve as Control Word Register.

The **Input Logic** consists of Data Buffers, Control Logic and Address Decode Logic.

The **Oscillator (OSC) Logic** generates clock for internal and external use. Reset function is a part of this block.

The **Multiplex Logic** generates multiplex scheme for column and row drivers, intensity control and blinking.

The **Row Drivers** drive 8 rows of eight LEDs each. The row drive currents could be trimmed using an external resistor (R_{DIM}) to set the nominal display brightness.

The **Column Drivers** drive 8 columns of eight LEDs each.

The **Display** consists of 64 LEDs connected in clusters of 8 to form columns and rows.

USING THE PD 1165 (PD 1167)

POWER ON AND RESET

Each PD 1165 (PD 1167) series part is equivalent to a miniaturized hybrid display system. Careful consideration of power supply capabilities and applications should always be exercised. It is important that $GND \leq V_{IN} < (V_{CC} + 0.5\ V)$ always be maintained during use.

POWER SUPPLY REQUIREMENTS

A 5 volt power supply with no more than 10% tolerance should be used. Each display, depending on programming can switch very large loads. To keep transients on V_{CC} above (V_{IN} −0.5 V), a 0.01 μF mica capacitor and a 22 μF tantalum capacitor should be located as close as conveniently possible to the V_{CC} and GND pins.(1)

To avoid malfunction during Power Up and Power Down, follow the sequences listed below.

POWER UP SEQUENCE

1. Float (tri-state) all display inputs.
2. Apply V_{CC} and GND to the display.
3. Activate inputs as required enabling the display. (Observe T_{WRW} restrictions.)

POWER DOWN SEQUENCE

1. Float (tri-state) all active input signals to the display.
2. Turn off power to the display.

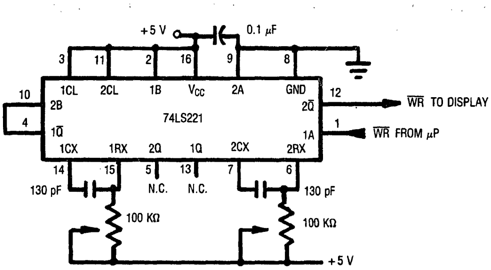
Once the display is powered up or following a hard reset using (RST), the display will initialize in a blinking lamp test control state. All LEDs will be on at 50% intensity blinking at about 2 Hz. Software control words can then be input initializing the displays configuring them for intensity and blinking attributes as well as clock control and timing synchronization.

SIGNAL CONDITIONING/INPUT BUFFERING

If cable lengths of 18 inches or more are used between the microprocessor and displays, the inputs should be buffered with tri-state non-inverting buffers. The buffers should be mounted as close to the displays as practical. Suggested buffers are the 74HCT244 or 74HC541.

The PD 1165 (PD 1167) accepts programming on the falling edge of the write pulse (WR). Interfacing the displays to microprocessors that write on the rising edge (such as the 8035) will require the pulse from the microprocessor to be delayed. A dual one-shot circuit such as the one illustrated in figure (1) below is recommended.

FIGURE 1. WRITE DELAY CIRCUIT FOR μP's THAT WRITE ON RISING EDGE OF WR



PROGRAMMING THE PD 1165 (PD 1167)

As described earlier, each display has 1 byte of RAM for a control word and 8 bytes for the display state of each LED.(2)

ADDRESSING LEDs AND CONTROL WORDS

Addressing the LEDs is managed through the A0-A2 address lines and D0-D7 data lines. Each data line corresponds to an LED row location with the address lines identifying a binary representation for the LED columns. The control word RAM address is identified by A3. WR and CE must also be low to input valid data.

Address State				Location
A3	A2	A1	A0	
0	0	0	0	First Column
0	0	0	1	Second Column
0	0	1	0	Third Column
0	0	1	1	Fourth Column
0	1	0	0	Fifth Column
0	1	0	1	Sixth Column
0	1	1	0	Seventh Column
0	1	1	1	Eighth Column
1	0	0	0	Control Word

When the appropriate column is addressed, a specific LED can be "written" on or off by identifying the appropriate row. Some examples are:

D7	D6	D5	D4	D3	D2	D1	D0	Operation
0	0	0	0	0	0	0	1	1st Row On
0	0	1	0	0	0	0	0	6th Row On
0	0	0	1	0	0	0	1	1st & 5th Rows On

High Signals turn on LEDs, low turn off LEDs. Patterns remain until re-written or cleared.

CONTROL WORD OPERATION

When address bit A3 is taken high, the control word RAM is accessed. The same control word appears at all eight LED address locations of the display. These words determine display functions such as clearing, blanking, blinking, brightness to nine levels, selecting internal or external clock sources, resetting timing for synchronizing blinking and implementing a lamp test. These instructions are implemented in the following manner.

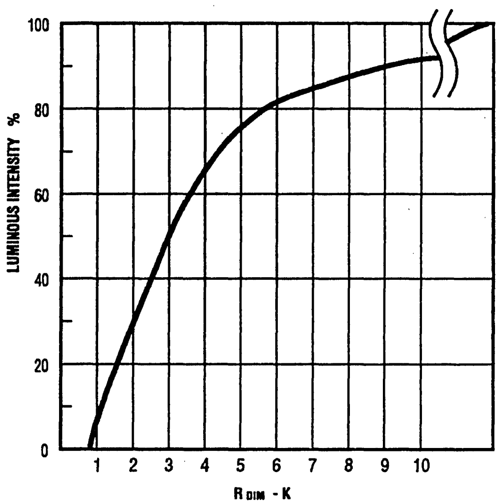
Brightness (D0-D2, RDIM): Display intensity must be set at one of the following levels. Increments of 12.5% are possible.

D7	D6	D5	D4	D3	D2	D1	D0	Intensity Level
X	X	X	X	X	0	0	0	12.5%
X	X	X	X	X	0	0	1	25.0%
X	X	X	X	X	0	1	0	37.5%
X	X	X	X	X	0	1	1	50.0%
X	X	X	X	X	1	0	0	62.5%
X	X	X	X	X	1	0	1	75.0%
X	X	X	X	X	1	1	0	87.5%
X	X	X	X	X	1	1	1	100.0%

Note 1. The device heatsink is tied to V_{CC}. It should be electrically insulated from all data and ground lines.
Note 2. 0=Low, 1=High, X=Don't Care, $=appropriate intensity code.

These intensity levels are proportional to the total display brightness. Each device is intensity categorized, however, this maximum brightness category can be lowered through an external resistor. See figure (2) for the characteristic relationship of intensity to R_{EXT}. A 4K resistor would be equivalent to one intensity category shift.

Figure 2. Luminous Intensity vs. R_{DIM}



Display Blank (D3): The D3 bit will visually clear the display, blank it, without affecting the display RAM LED pattern.(1)

D7	D6	D5	D4	D3	D2	D1	D0	Operation
0	X	X	X	1	$	$	$	Blank

Note: 1. Although it is not recommended, the display can be dimmed by strobing the blank instruction on and off. If this is done, frequencies of 1 KHz or more should be utilized to avoid flickering.

Clock Select (D4): The appropriate clock selection should be included in the control word. For multiple display systems, external synchronized clocks should be used when blinking is required for uniform display appearance. One display can act as a master clock for up to 15 other displays provided the D4 bit is properly set.

D7	D6	D5	D4	D3	D2	D1	D0	Operation
X	X	X	0	X	$	$	$	Internal Clock
X	X	X	1	X	$	$	$	External Clock

Blink Control D5

D7	D6	D5	D4	D3	D2	D1	D0	Operation
0	X	1	X	0	$	$	$	Blink Display at 2 Hz

Lamp Test D6, D2, D1, D0

The lamp test is only functional with the intensity level set to 50%. This does not affect display RAM.

D7	D6	D5	D4	D3	D2	D1	D0	Operation
0	1	X	X	0	0	1	1	Turn all LEDs on at 50% brightness

Memory Clear D7, D6

D7	D6	D5	D4	D3	D2	D1	D0	Operation
1	0	X	X	X	$	$	$	Clear Display RAM, turn off LEDs

Reset Timing D7, D6

Timing reset is necessary for synchronizing display blinking for multiple display systems. It has no effect on display RAM.

D7	D6	D5	D4	D3	D2	D1	D0	Operation
1	1	X	X	X	$	$	$	Internal Timing Reset

DESIGN CONSIDERATIONS

MULTIPLE DISPLAY SYSTEMS

The PD 1165 (PD 1167) parts may be cascaded for flat panel displays of any size. If blinking is to be used, up to 15 displays can be synchronized to one "master" display clock as described earlier. Additional displays will require a buffer to drive the clock load.

The connection scheme is straight forward as illustrated in figure (3) below.

1. Buss together: Data lines, Address lines, Write Enable lines, Reset lines, V_{CC} (with proper capacitors for power supply conditioning) and GND lines.
2. Terminate the Data, Address and Write lines of the "master" display to the microprocessor interface.
3. Terminate the CE lines of the "slave" displays to the appropriate microprocessor address decoders.
4. Connect the clock out (pin 2) of the "master" display to the buffer for/or clock in (pin 9), of the "slave" displays.

This flat panel sub assembly can then be interfaced easily with microprocessors, such as the 8035, as illustrated in figure (4) below.

For systems with synchronized blinking, an initializing control softword reset should precede the instructions for clearing, brightness, clock selection, etc.

INTENSITY MATCHING

For best matching, displays from one bin should be used. It is often acceptable, under normal viewing conditions, to use displays from two neighboring bins. The RDIM connection allows users to set intensity levels to match displays of all intensity levels.

ESD PROTECTION

The silicon gate CMOS IC of the PD 1165 (PD 1167) is sensitive to ESD damage. Users of these devices are encouraged to take all the standard precautions, normal for CMOS components. These include properly grounding personnel, tools, tables, and transport carriers that come in contact with unshielded parts. Where these conditions are not or cannot be met, keep the leads of the device shorted together or the parts in anti-static packaging.

SOLDERING CONSIDERATIONS

The PD 1165 (PD 1167) can be hand soldered with SN63 solder using a grounded iron set to 260°C.

Wave soldering is also possible following these conditions: Preheat that does not exceed 93°C on the solder side of the PC board or a package surface temperature of 70°C. Water soluble organic acid flux or resin-based RMA flux can be used.

Wave temperature of 245°C ±5°C with a dwell between 1.5 sec. to 3.0 sec. Exposure to the wave should not exceed temperatures above 260°C, for 5 seconds at 0.063″ below the seating plane. The packages should not be immersed in the wave.

POST SOLDER CLEANING PROCEDURES

The least offensive cleaning solution is hot D.I. water (60°C) for less than 15 minutes. Addition of mild saponifiers is acceptable. Do not use commercial dishwasher detergents.

For faster cleaning, solvents may be used. Care should be exercised in choosing these as some may chemically attack the polycarbonate package. Maximum exposure should not exceed two minutes at elevated temperatures. Acceptable solvents are TF (trichlorotrifluoroethane), TP35, TMS+, TE, and Isopropyl Alcohol.

Unacceptable solvents contain TCM, TMC, TA, TES, Acetone, and III Trichloroethane. Since many commercial mixtures exist, you should contact your preferred solvent vendor for chemical composition information. Some major solvent manufacturers are: Allied Chemical Corporation, Specialty Chemical Division, Morristown, NJ; Baron-Blakeslee, Chicago, IL; Dow Chemical, Midland, MI; E.I. DuPont de Nemours & Co., Wilmington, DE.

For further information refer to Appnotes 18 and 19 in the current Siemens Optoelectronic Data Book.

An alternative to soldering and cleaning the display modules is to use sockets. Naturally, 20 pin DIP sockets .600″ wide with .100″ centers work well for single displays. Multiple display assemblies are best handled by longer SIP sockets or DIP sockets when available for uniform package alignment. Socket manufacturers are Aries Electronics, Inc., Frenchtown, NJ; Garry Manufacturing, New Brunswick, NJ; Robinson-Nugent, New Albany, IN; and Samtec Electronic Hardware, New Albany, IN.

For further information refer to Appnote 22 in the current Siemens Optoelectronic Data Book.

FIGURE 3. GENERAL INTERFACE CIRCUIT

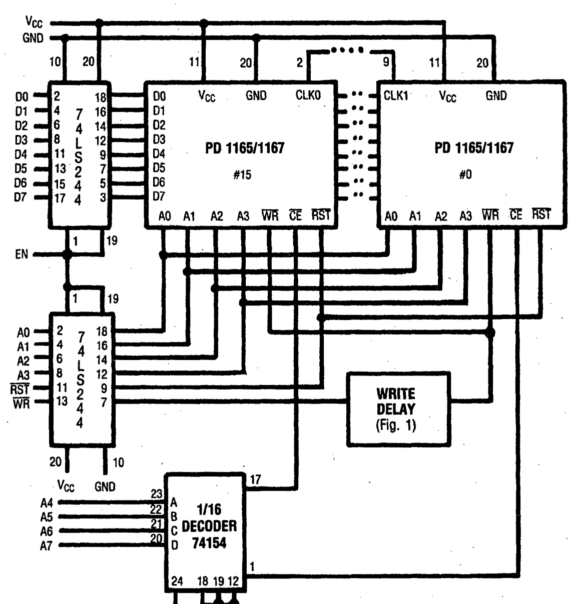
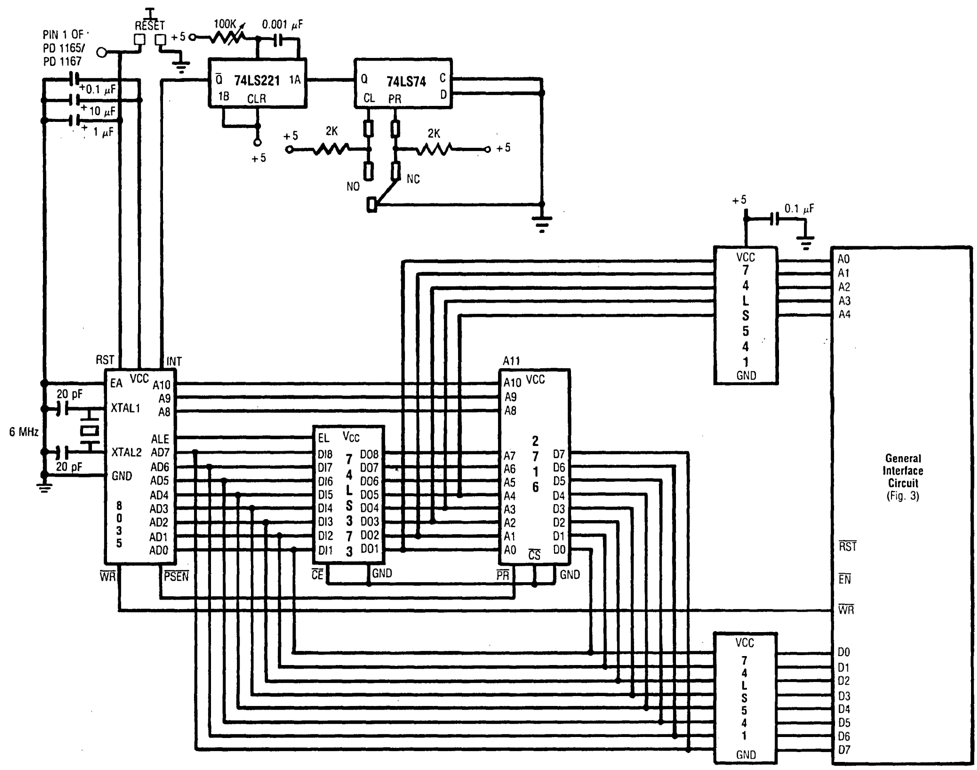


FIGURE 4. MICROPROCESSOR INTERFACE CIRCUIT



OPTICAL CONSIDERATIONS

The 1.19″ high character of the PD 1165 (PD 1167) allows readability up to 35 feet. Proper filter selection will allow the user to build a display that can be utilized over this distance.

Filters enhance the contrast ratio between a lit LED and the character background. The only limitation is cost. The cost/benefit ratio for filters can be maximized by first considering the ambient lighting environment.

Incandescent (with almost no green) or fluorescent (with almost no red) lights do not have the flat spectral response of sunlight. Plastic band-pass filters are inexpensive and effective in optimizing contrast ratios. The PD 1165 is a high efficiency red display and should be matched with a long wavelength pass filter in the 570 nm to 590 nm range. The PD 1167 should be matched with a yellow-green band-pass filter that peaks at 565 nm. For display systems of multiple colors (using other Siemens displays), neutral density grey filters offer the best compromise.

Additional contrast enhancement can be gained through shading the displays. Plastic band-pass filters with built-in louvers offer the "next step up" in contrast improvement. Also, plastic filters can be further improved with anti-reflective coatings to reduce glare. The trade-off is "fuzzy" characters. Mounting the filters close to the display reduces this effect. Care should be taken not to overheat the plastic filters by allowing for proper air flow.

Optimal filter enhancements for any condition can be gained through the use of circular polarized, anti-reflective, band-pass filters. The circular polarizing further enhances contrast by reducing the light that travels through the filter and reflects back off the display to less than 1%.

Several filter manufacturers supply quality filter materials. Some of them are: Panelgraphic Corporation, W. Caldwell, NJ; SGL Homelite, Wilmington, DE; 3M Company, Visual Products Division, St. Paul, MN; Polaroid Corporation, Polarizer Division, Cambridge, MA; Marks Polarized Corporation, Deer Park, NY; Hoya Optics, Inc., Fremont, CA.

One final note on mounting filters. Recessing display and bezel assemblies is an inexpensive way to provide a shading effect in overhead lighting situations. Several Bezel manufacturers are: R.M.F. Products, Batavia, IL; Nobex Components, Griffith Plastic Corp., Burlingame, CA; Photo Chemical Products of California, Santa Monica, CA; I.E.E.-Atlas, Van Nuys, CA.

Refer to Siemens Appnote 23 for further information.

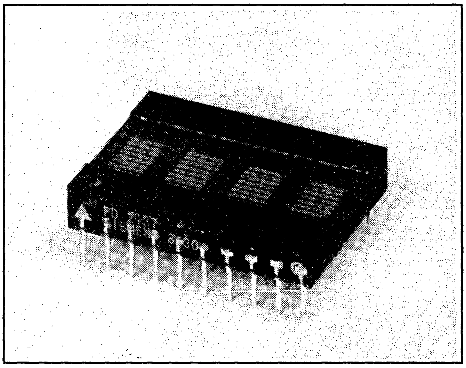
REPLACEMENT

Should a display nested within a panel be damaged, replacement can be made by trimming the tabs off the neighboring displays adjacent to the damaged displays Row # 0 and Column # 0 (typically above and to the left). Once the interlocking tabs are trimmed (using a razor blade-type cut), the damaged device may be removed and replaced.

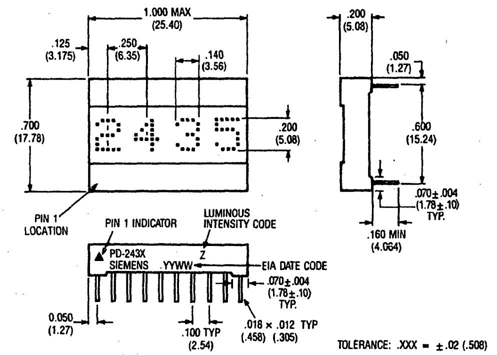
SIEMENS

HIGH EFFICIENCY RED PD2435
RED PD2436
BRIGHT GREEN PD2437

.200" 4-Character, 5×7 Dot Matrix Alphanumeric Programmable Display™ with Built-In CMOS Control Functions



Package Dimensions in Inches (mm)



FEATURES

- **Four 0.200" Dot Matrix Characters in High Efficiency Red, Red, and Bright Green**
- **Built-in Memory, Decoders, Multiplexer and Drivers**
- **Wide Viewing Angle, X Axis ±55°, Y Axis ±65°**
- **Categorized for Luminous Intensity**
- **128-Character ASCII Format (Both Upper and Lower Case Characters)**
- **8-Bit Bidirectional Data BUS**
- **READ/WRITE Capability**
- **100% Burned In and Tested**
- **Dual In-Line Package Configuration, .600" Wide, .100" Pin Centers**
- **End-Stackable Package**
- **Internal or External Clock**
- **Built-in Character Generator ROM**
- **TTL Compatible**
- **Easily Cascaded for Multidisplay Operation**
- **Less CPU Time Required**
- **Software Controlled Features:**
  - **Programmable Highlight Attribute (Blinking, Non-Blinking)**
  - **Asynchronous Memory Clear Function**
  - **Lamp Test**
  - **Display Blank Function**
  - **Single or Multiple Character Blinking Function**
  - **Programmable Intensity, Three Brightness Levels**
- **Extended Operating Temperature Range: -40°C to +85°C**

DESCRIPTION

The PD 2435/6/7 are four digit display system modules. The digits are 0.20" by 0.14" 5×7 dot matrix arrays constructed with the latest solid state technology in light emitting diodes. Driving and controlling the LED arrays is a silicon gate CMOS integrated circuit. This integrated circuit provides all necessary LED drivers and complete multiplexing control logic.

Additionally, the IC has the necessary ROM to decode 128 ASCII alphanumeric characters and enough RAM to store the display's complete four digit ASCII message with special attributes. These attributes, all software programmable at the user's discretion, include a lamp test, brightness control, displaying cursors, alternating cursors and characters, and flashing cursors or characters. The CMOS IC also incorporates special interface control circuitry to allow the user to control the module as a fully supported microprocessor peripheral. The module, under internal or external clock control, has asynchronous read, write, and memory clear over an eight bit parallel, TTL compatible, bi-directional data bus. Each module is fully encapsulated within a package 1.0"×0.7"×0.2". The standard 20 pin DIP construction with two 0.6" rows on 0.1" centers is wave solderable and has been fully tested with over one million total device hours to operate over a temperature range from -40°C to +85°C.

All products are 100% burned-in and tested, then subjected to out-going AQL's of .25% for brightness matching, visual alignment and dimensions, .065% for electrical and functional. All the devices are intensity binned to allow users to construct a uniform display of any length.

See the end of this data sheet or refer to Appnotes 18, 19, 22, and 23 for further details on handling and assembling Siemens Programmable Displays.

Maximum Ratings

DC Supply Voltage . . . . -0.5 V to +7.0 Vdc
Input Voltage Levels Relative
to GND (all inputs) . . . . -0.5 V to V_{CC} +0.5 Vdc
Operating Temperature . . . . -40°C to +85°C
Storage Temperature . . . . -40°C to +100°C
Maximum Solder Temperature, .063″ (1.59 mm)
below Seating Plane, t<5 sec . . . . 260°C

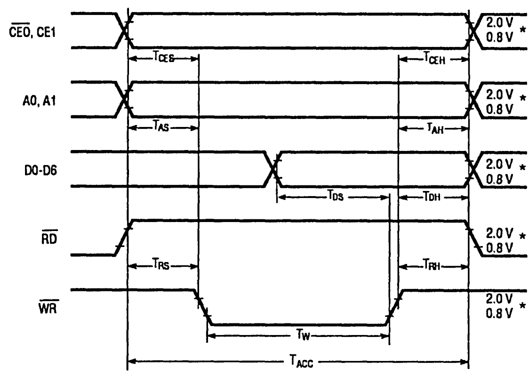
Optical Characteristics @25°C

Spectral Peak Wavelength . . . . (HER) 630 nm typ.
. . . . (Red) 660 nm typ.
. . . . (Green) 565 nm typ.
Viewing Angle
horizontal . . . . ±55°
(off normal axis) vertical . . . . ±65°
Digit Height . . . . 0.200 inch (5.08 mm)
Time Averaged Luminous Intensity[1]
Red . . . . 30 μcd/LED min.
HER/Green . . . . 90 μcd/LED min.
LED to LED Intensity Matching . . . . 1.8:1.0 max.
Device to Device (one bin) . . . . 1.5:1.0 max.
Bin to Bin (adjacent bin) . . . . 1.9:1.0 max.

Note: 1. Peak luminous intensity values can be calculated by multiplying these values by 7.

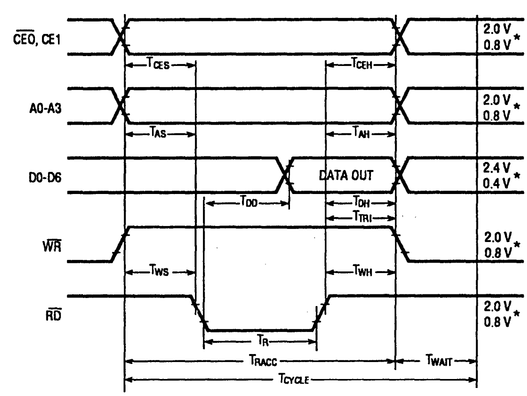
TIMING CHARACTERISTICS
(@V_{CC}=4.5 V, Temp=25°C)

Data WRITE Cycle



*Notes: 1. All input voltage are (V_{IL} = 0.8 V, V_{IH} = 2.0 V.)
2. These waveforms are not edge triggered.

Data READ Cycle



Intelligent Display Devices

PD 2435/6/7

SWITCHING SPECIFICATIONS (V_{CC} = 4.5 V)

READ CYCLE TIMING					
		Specification Minimum			
Parameter	Description	-40°C	25°C	85°C	Units
T_{AS}	Address Setup	0	0	0	ns
T_{CES}	Chip Enable	0	0	0	ns
T_{WS}	Write Enable Setup	20	30	40	ns
T_{DD}	Data Delay Time	100	150	175	ns
T_{R}	Read Pulse	150	175	200	ns
T_{AH}	Address Hold	0	0	0	ns
T_{DH}	Data Hold	0	0	0	ns
T_{TRI}	Time to Tristate (Max time)	30	40	50	ns
T_{CEH}	Chip Enable Hold	0	0	0	ns
T_{WH}	Write Enable Hold	30	40	50	ns
T_{ACC}	Total Access Time = Setup Time + Write Time + Time to Tristate	200	245	290	ns
T_{WAIT}(1)	Wait Time between Reads	0	0	0	ns
T_{CYCLE}	Read Cycle Time = T_{RACC} + T_{WAIT}	200	245	290	ns

Notes:
1. Wait 1 μs between any Reads or Writes after writing a Control Word with a Clear (D7 = 1). Wait 1μs between any Reads or Writes after Clearing a Control Word with a Clear (D7 = 0). All other Reads and Writes can be back to back.
2. All input voltages are (V_{IL} = 0.8 V, V_{IH} = 2.0 V).
3. Data out voltages are measured with 100 pF on the data bus and the ability to source = -40 μA and sink = 1.6 mA. The rise and fall times are 60 ns. V_{OL} = 0.4 V, V_{OH} = 2.4 V.

SWITCHING SPECIFICATIONS (V_{CC} = 4.5 V)

WRITE CYCLE TIMING					
		Specification Minimum			
Parameter	Description	-40°C	25°C	85°C	Units
T_{CLR}*	Clear RAM	1	1	1	μs
T_{CLRD}*	Clear RAM Disable	1	1	1	μs
T_{AS}	Address Setup	10	10	10	ns
T_{CES}	Chip Enable Setup	0	0	0	ns
T_{RS}	Read Enable Setup	10	10	10	ns
T_{DS}	Data Setup	20	30	50	ns
T_{W}	Write Pulse	60	70	90	ns
T_{AH}	Address Hold	20	30	40	ns
T_{DH}	Data Hold	20	30	40	ns
T_{CEH}	Chip Enable Hold	0	0	0	ns
T_{RH}	Read Enable Hold	20	30	40	ns
T_{ACC}	Total Access Time = Setup Time + Write Time + Hold Time	90	110	140	ns

* Wait 1 μs between any Reads or Writes after writing a Control Word with a Clear (D7 = 1). Wait 1μs between any Reads or Writes after Clearing a Control Word with a Clear (D7 = 0). All other Reads and Writes can be back to back.

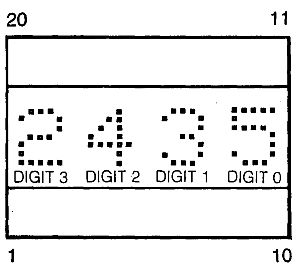
PD 2435/6/7

DC CHARACTERISTICS @25°C

Parameter	Limits Min.	Typ.	Max.	Units	Conditions
V_{CC}	4.5	5.0	5.5	Volts	Nominal
I_{CC} Blank (All Inputs Low)		2.5	3.5	mA	V_{CC} = 5 V, All inputs = 0.8 V
I_{CC} 80 LEDs/unit (100% Bright)		115	130	mA	V_{CC} = 5 V
V_{IL} (All Inputs)	-0.5		0.8	Volts	V_{CC} = 4.5 V to 5.5 V
V_{IH} (All Inputs)	2.0			Volts	V_{CC} = 4.5 V to 5.5 V
I_{IL} (All Inputs)	25		100	μA	V_{CC} = 4.5 V to 5.5 V, V_{IN} = 0.8 V
V_{OL} (D0–D7)			0.4	Volts	V_{CC} = 4.5 V to 5.5 V
V_{OH} (D0–D7)	2.4			Volts	V_{CC} = 4.5 V to 5.5 V
I_{OH} (D0–D7)	-8.9			mA	V_{CC} = 4.5 V, V_{OH} = 2.4 V
I_{OL} (D0–D7)	1.6			mA	V_{CC} = 4.5 V, V_{OL} = 0.4 V
Data I/O Bus Loading			100	pF	
Clock I/O Bus Loading			240	pF	

Note: 1. Typical average LED drive current is 1.9 mA. Peak current at 1/7 duty cycle is 13.1 mA.

TOP VIEW



PIN ASSIGNMENTS

Pin	Function	Pin	Function
1 $\overline{RD}$	READ	11 $\overline{WR}$	WRITE
2 CLK I/O	CLOCK I/O	12 D7	DATA MSB
3 CLKSEL	CLOCK SELECT	13 D6	DATA
4 $\overline{RST}$	RESET	14 D5	DATA
5 CE1	CHIP ENABLE	15 D4	DATA
6 $\overline{CE0}$	CHIP ENABLE	16 D3	DATA
7 A2	ADDRESS MSB	17 D2	DATA
8 A1	ADDRESS	18 D1	DATA
9 A0	ADDRESS LSB	19 D0	DATA LSB
10 GND		20 V_{CC}	

PIN DEFINITIONS

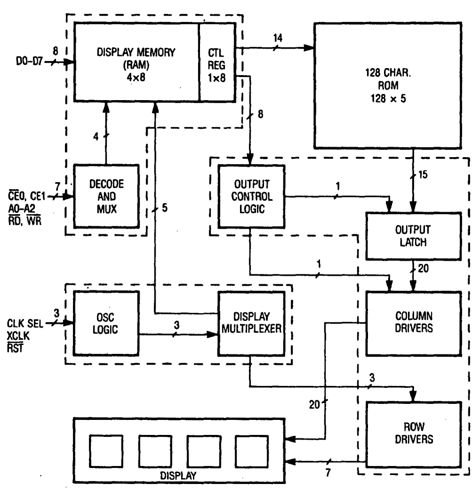
Pin		
1.	$\overline{RD}$	Active low, will enable a processor to read all registers in the PD 2435/6/7
2.	CLK I/O	If CLK SEL (pin 3) is low, then expect an external clock source into this pin. If CLK SEL is high, then this pin will be the master or source for all other devices which have CLK SEL low.
3.	CLK SEL	CLocK SELect, determines the action of pin 2. CLK I/O, see the section on Cascading for an example.
4.	$\overline{RST}$	Reset. Must be held low until $V_{CC} > 4.5$ volts. Reset is used only to synchronize blinking, and will not clear the display.
5.	CE1	Chip enable (active high).
6.	$\overline{CE0}$	Chip enable (active low).
7.	A2	Address input (MSB).
8.	A1	Address input.
9.	A0	Address input (LSB).
10.	GND	Ground.
11.	$\overline{WR}$	Write. Active Low. If the device is selected, a low on the write input loads the data into the PD 2435/6/7's memory.
12.	D7	Data Bus bit 7 (MSB).
13.	D6	Data Bus bit 6.
14.	D5	Data Bus bit 5.
15.	D4	Data Bus bit 4.
16.	D3	Data Bus bit 3.
17.	D2	Data Bus bit 2.
18.	D1	Data Bus bit 1.
19.	D0	Data Bus bit 0 (LSB).
20.	V_{CC}	Plus 5 volts power pin.

DATA INPUT COMMANDS															
$\overline{CE0}$	CE1	$\overline{RD}$	$\overline{WR}$	A2	A1	A0	D7	D6	D5	D4	D3	D2	D1	D0	OPERATION
1	0	X	X	X	X	X	X	X	X	X	X	X	X	X	No Change
0	1	0	1	1	0	0	X	X	X	X	X	X	X	X	Read Digit 0 Data To Bus
0	1	1	0	1	0	0	X	0	1	0	0	1	0	0	($) Written To Digit 0
0	1	1	0	1	0	1	X	1	0	1	0	1	1	1	(W) Written to Digit 1
0	1	1	0	1	1	0	X	1	1	0	0	1	1	0	(f) Written To Digit 2
0	1	1	0	1	1	1	X	0	1	1	0	0	1	1	(3) Written to Digit 3
0	1	1	0	1	0	0	1	X	X	X	X	X	X	X	Char. Written To Digit 0 And Cursor Enabled

MODE SELECTION				
$\overline{CE0}$	CE1	$\overline{RD}$	$\overline{WR}$	OPERATION
0	1	0	0	Illegal
1	X	X	X	No Change
X	0	X	X	No Change
X	X	1	1	No Change

NOTE: 0 = Low Logic Level, 1 = High Logic Level, X = Don't Care.

BLOCK DIAGRAM



FUNCTIONAL DESCRIPTION

The PD 2435/6/7 block diagram includes the major blocks and internal registers.

Display Memory consists of a 5×8 bit RAM block. Each of the four 8-bit words holds the 7-bit ASCII data (bits D0–D6). The fifth 8-bit memory word is used as a control word register. A detailed description of the control register and its functions can be found under the heading Control Word. Each 8-bit word is addressable and can be read from or written to.

The **Control Logic** dictates all of the features of the display device and is discussed in the Control Word section of this data sheet.

The **Character Generator** converts the 7-bit ASCII data into the proper dot pattern for the 128 characters shown in the character set chart.

The **Clock Source** can originate either from the internal oscillator clock or from an external source—usually from the output of another PD 2435/6/7 in a multiple module display.

The **Display Multiplexer** controls all display output to the digit drivers so no additional logic is required for a display system.

The **Column Drivers** are connected directly to the display.

The **Display** has four digits. Each of the four digits is comprised of 35 LEDs in a 5×7 dot array which makes up the alphanumeric characters.

The intensity of the display can be varied by the Control Word in steps of 0% (Blank), 25%, 50%, and full brightness.

MICROPROCESSOR INTERFACE

The interface to the microprocessor is through the address lines (A0–A2), the data bus (D0–D7), two chip select lines ($\overline{CE0}$, CE1), and read ($\overline{RD}$) and write ($\overline{WR}$) lines.

The $\overline{CE0}$ should be held low when executing a read, or write operation.

The read and write lines are both active low. During a valid read the data input lines (D0–D7) become outputs. A valid write will enable the data as input lines.

INPUT BUFFERING

If a cable length of 6 inches of more is used, all inputs to the display should be buffered with a tri-state non-inverting buffer mounted as close to the display as conveniently possible. Recommended buffers are: 74LS245 for the data lines and 74LS244 for the control lines.

PROGRAMMING THE PD 2435/6/7

There are five registers within the PD 2435/6/7. Four of these registers are used to hold the ASCII code of the four display characters. The fifth register is the Control Word, which is used to blink, blank, clear or dim the entire display, or to change the presentation (attributes) of individual characters.

ADDRESSING

The addresses within the display device are shown below. Digit 0 is the rightmost digit of the display, while digit 3 is on the left. Although there is only one Control Word, it is duplicated at the four address locations 0–3. Data can be read from any of these locations. When one of these locations is written to, all of them will change together.

Address	Contents
0	Control Word
1	Control Word (Duplicate)
2	Control Word (Duplicate)
3	Control Word (Duplicate)
4	Digit 0 (rightmost)
5	Digit 1
6	Digit 2
7	Digit 3 (leftmost)

Bit D7 of any of the display digit locations is used to allow an attribute to be assigned to that digit. The attributes are discussed in the next section. If bit D7 is set to a one, that character will be displayed using the attribute. If bit D7 is cleared, the character will display normally.

CONTROL WORD

When address bit A2 is taken low, the Control Word is accessed. The same Control Word appears in all four of the lower address spaces of the display. Through the Control Word, the display can be cleared, the lamps can be tested, display brightness can be selected, and attributes can be set for any characters which have been loaded with their most significant bit (D7) set high.

Brightness (D0, D1): The state of the lower two bits of the Control Word are used to set the brightness of the entire display, from 0% to 100%. The table below shows the correspondence of these bits to the brightness.

D7	D6	D5	D4	D3	D2	D1	D0	Operation
0	0	X	X	X	X	0	0	Blank
0	0	X	X	X	X	0	1	25% brightness
0	0	X	X	X	X	1	0	50% brightness
0	0	X	X	X	X	1	1	Full brightness

X = don't care

CONTROL WORD FORMAT

D7	D6	D5	D4	D3	D2	D1	D0
CLEAR	LAMP TEST	BLINK	ATTRIBUTE ENABLE	ATTRIBUTES		BRIGHTNESS	

D1	D0	BRIGHTNESS
0	0	0% (Blank)
0	1	25%
1	0	50%
1	1	100%

D3	D2	ATTRIBUTE
0	0	Display Cursor Instead Of Character
0	1	Blink Character
1	0	Display Blinking Cursor Instead Of Character
1	1	Alternate Character With Cursor

D4	ATTRIBUTE ENABLE
0	Disable Above Attributes
1	Enable Above Attributes

D5	BLINK
0	Blink-Attribute Disabled
1	Blink Entire Display

D6	LAMP TEST
0	Standard Operation
1	Display All Dots At 50% Brightness

D7	CLEAR
0	Standard Operation
1	Clear Entire Display

Attributes (D2-D4): Bits D2, D3, and D4 control the visual attributes (i.e., blinking) of those display digits which have been written with bit D7 set high. In order to use any of the four attributes, the Cursor Enable bit (D4 in the Control Word) must be set. When the Cursor Enable bit is set, and bit D7 in a character location is set, the character will take on one of the following display attributes.

D7	D6	D5	D4	D3	D2	D1	D0	Operation
0	0	0	0	X	X	B	B	Disable highlight attribute
0	0	0	1	0	0	B	B	Display cursor* instead of character
0	0	0	1	0	1	B	B	Blink single character
0	0	0	1	1	0	B	B	Display blinking cursor* instead of character
0	0	0	1	1	1	B	B	Alternate character with cursor*

*"Cursor" refers to a condition when all dots in a single character space are lit to half brightness.
X = don't care
B = depends on the selected brightness

Attributes are non-destructive. If a character with bit D7 set is replaced by a cursor (Control Word bit D4 is set, and D3=D2=0) the character will remain in memory and can be revealed again by clearing D4 in the Control Word.

Blink (D5): The entire display can be caused to blink at a rate of approximately 2Hz by setting bit D5 in the Control Word. This blinking is independent of the state of D7 in all character locations.

In order to synchronize the blink rate in a bank of these devices, it is necessary to tie all devices' clocks and resets together as described in a later section of this data sheet.

D7	D6	D5	D4	D3	D2	D1	D0	Operation
0	0	1	X	X	X	B	B	Blinking display

Lamp Test (D6): When the Lamp Test bit is set, all dots in the entire display are lit at half brightness. When this bit is cleared, the display returns to the characters that were showing before the lamp test. The lamp test will remain if implemented simultaneously with a clear instruction.

D7	D6	D5	D4	D3	D2	D1	D0	Operation
0	1	0	X	X	X	X	X	Lamp test

Clear Data (D7): When D7 is set in the Control Word, all character and Control Word memory bits are reset to zero. This causes total erasure of the display, and returns all digits to a non-blink, full brightness, non-cursor status.

D7	D6	D5	D4	D3	D2	D1	D0	Operation
1	0	X	X	X	X	X	X	Clear

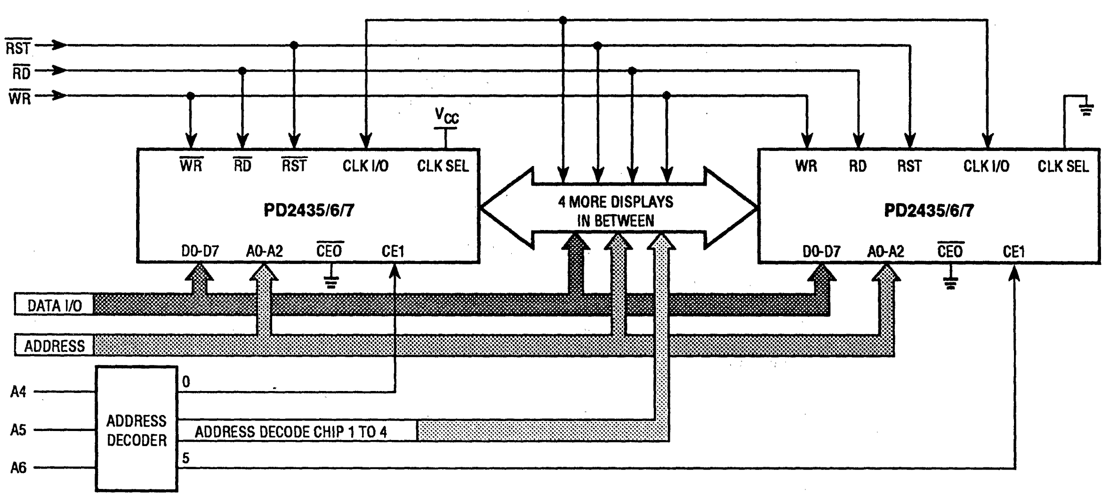
CASCADING

The SMC-4740 oscillator is designed to drive up to 16 PD 2435/6/7s with input loading of 15 pF each.

The general requirements for cascading 16 displays together are:

1. Determine the correct address for each display.
2. Tie $\overline{CE0}$ to ground and use CE1 from an address decoder to select the correct display.
3. Select one of the Displays to provide the Clock for the other displays.
4. Tie CLK SEL to ground on other displays.
5. Use $\overline{RST}$ to synchronize the blinking between the displays.

CASCADING DIAGRAM



VOLTAGE TRANSIENT SUPPRESSION

It has become common practice to provide 0.01 μf bypass capacitors liberally in digital systems. Like other CMOS circuitry, the Intelligent Display controller chip has very low power consumption and the usual 0.01 μf would be adequate were it not for the LEDs. The module itself can, in some conditions, use up to 100 mA. In order to prevent power supply transients, capacitors with low inductance and high capacitance at high frequencies are required. This suggests a solid tantalum or ceramic disc for high frequency bypass. For multiple display module systems, distribute the bypass capacitors evenly, keeping capacitors as close to the power pins as possible. Use a 0.01 μF capacitor for each display module and a 22 μF for every third display module.

HOW TO LOAD INFORMATION INTO THE PD 2435/6/7

Information loaded into the PD 2435/6/7 can be either ASCII data or Control Word data. The following procedure (see also typical loading sequence) will demonstrate a typical loading sequence and the resulting visual display. The word STOP is used in all of the following examples.

SET BRIGHTNESS

Step 1 Set the brightness level of the entire display to your preference (example: 100%)

LOAD FOUR CHARACTERS

Step 2 Load an "S" in the left-hand digit.

Step 3 Load a "T" in the next digit.

Step 4 Load an "O" in the next digit.

Step 5 Load a "P" in the right-hand digit.

If you loaded the information correctly, the PD 2435/6/7 would now show the word "STOP."

BLINK A SINGLE CHARACTER

Step 6 Into the digit, second from the right, load the hex code "CF," which is the code for an "O" with the D7 bit added as a control bit.

NOTE: The "O" is the only digit which has the control bit (D7) added to normal ASCII data.

Step 7 Load enable blinking character into the control word register.

The PD 2435/6/7 should now display "STOP" with a flashing "O".

ADD ANOTHER BLINKING CHARACTER

Step 8 Into the left hand digit, load the hex code "D3" which is for an "S" with the D7 bit added as a control bit.

The PD 2435/6/7 should now display "STOP" with a flashing "O" and a flashing "S."

ALTERNATE CHARACTER/ CURSOR ENABLE

Step 9 Load enable alternate character/cursor into the control word register.

The PD 2435/6/7 should now display "STOP" with "O" and the "S" alternating between the letter and a cursor (which is all dots lit).

INITIATE FOUR-CHARACTER BLINKING

Regardless of Control Bit setting)

Step 10 Load enable display blinking.

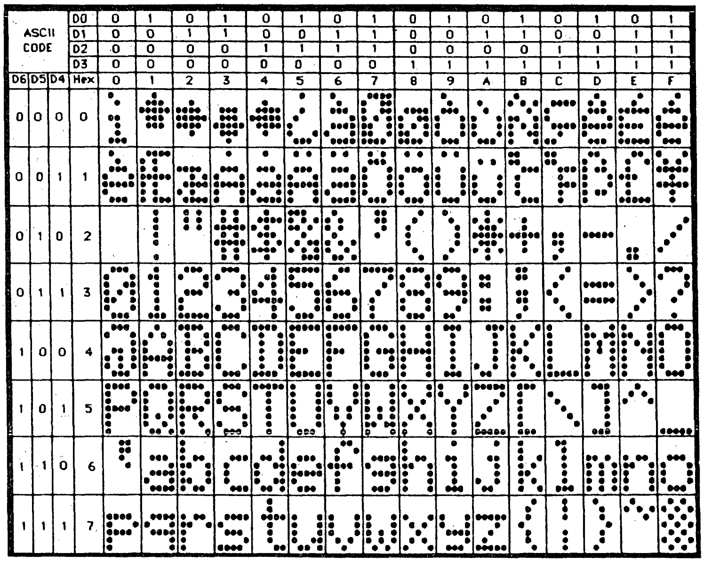
The PD 2435/6/7 should now display the entire word "STOP" blinking.

TYPICAL LOADING SEQUENCE

	$\overline{CE0}$	CE1	$\overline{RD}$	$\overline{WR}$	A2	A1	A0	D7	D6	D5	D4	D3	D2	D1	D0	DISPLAY
1.	L	H	H	L	L	X	X	0	0	0	0	0	0	1	1	
2.	L	H	H	L	H	H	H	0	1	0	1	0	0	1	1	S
3.	L	H	H	L	H	H	L	0	1	0	1	0	1	0	0	ST
4.	L	H	H	L	H	L	H	0	1	0	0	1	1	1	1	STO
5.	L	H	H	L	H	L	L	0	1	0	1	0	0	0	0	STOP
6.	L	H	H	L	H	L	H	1	1	0	0	1	1	1	1	STOP
7.	L	H	H	L	L	X	X	0	0	0	1	0	1	1	1	STO*P
8.	L	H	H	L	H	H	H	1	1	0	1	0	0	1	1	S*TO*P
9.	L	H	H	L	L	X	X	0	0	0	1	1	1	1	1	S†TO†P
10.	L	H	H	L	L	X	X	0	0	1	0	0	0	1	1	S*T*O*P*

*Blinking Character
†Character alternating with cursor (all dots lit)

CHARACTER SET



Notes: 1. High = 1 level.
2. Low = 0 level.
3. Upon power up, the device will initialize in a random state.

ELECTRICAL AND MECHANICAL CONSIDERATIONS

The CMOS IC of the PD 2435/6/7 is designed to provide resistance to both Electrostatic Discharge Damage and Latch Up due to voltage or current surges. Several precautions are strongly recommended for the user, to avoid overstressing these built-in safeguards.

ESD PROTECTION

Users of the PD 2435/6/7 should be careful to handle the devices consistent with Standard ESD protection procedures. Operators should wear appropriate wrist, ankle or feet ground straps and avoid clothing that collects static charges. Work surfaces, tools and transport carriers that come into contact with unshielded devices or assemblies should also be appropriately grounded.

LATCH UP PROTECTION

Latch up is a condition that occurs in CMOS ICs after the input protection diodes have been broken down. These diodes can be reversed through several means:

V_{IN} < GND, $V_{IN} > V_{CC}$ +0.5 V, or through excessive currents begin forced on the inputs. When these situations exist, the IC may develop the response of an SCR and begin conducting as much as one amp through the V_{CC} pin. This destructive condition will persist (latched) until device failure or the device is turned off.

The Voltage Transient Suppression Techniques and buffer interfaces for longer cable runs help considerably to prevent latch conditions from occuring. Additionally, the following Power Up and Power Down sequence should be observed.

POWER UP SEQUENCE

1. Float all active signals by tri-stating the inputs to the displays.
2. Apply V_{CC} and GND to the display.
3. Apply active signals to the displays by enabling all input signals per application.

POWER DOWN SEQUENCE

1. Float all active signals by tri-stating the inputs to the display.
2. Turn off the power to the display.

SOLDERING CONSIDERATIONS

PD 2435/6/7s can be hand soldered with SN63 solder using a grounded iron set to 160°C.

Wave soldering is also possible following these conditions: Preheat that does not exceed 93°C on the solder side of the PC board or a package surface temperature of 85°C. Water soluble organic acid flux (except Carboxylic acid) or resin-based RMA flux without alcohol can be used.

Wave temperature of 245°C ±5°C with a dwell between 1.5 sec. to 3.0 sec. Exposure to the wave should not exceed temperatures above 260°C, for 5 seconds at 0.063″ below the seating plane. The packages should not be immersed in the wave.

POST SOLDER CLEANING PROCEDURES

The least offensive cleaning solution is hot D.I. water (60°C) for less than 15 minutes. Addition of mild saponifiers is acceptable. Do not use commercial dishwasher detergents.

For faster cleaning, solvents may be used. Care should be exercised in choosing these as some may chemically attack the nylon package. Maximum exposure should not exceed two minutes at elevated temperatures. Acceptable solvents are TF (trichlorotrifluoroethane), TA, 111 Trichloroethane, and unheated acetone.(1)

Note: 1. Acceptable commercial solvents are: Basic TF, Arklone P, Genesolv D, Genesolv DA, Blaco-Tron TF, Blaco-Tron TA and, Freon TA.

Do not use solvents containing alcohol, methanol, methylene chloride, ethanol, TP35, TCM, TMC, TMS+, TE, and TES. Since many commercial mixtures exist, you should contact your preferred solvent vendor for chemical composition information. Some major solvent manufacturers are: Allied Chemical Corporation, Specialty Chemical Division, Morristown, NJ; Baron-Blakeslee, Chicago, IL; Dow Chemical, Midland, MI; E.I. DuPont de Nemours & Co., Wilmington, DE.

For further information refer to Appnotes 18 and 19 in the current Siemens Optoelectronic Data Book.

An alternative to soldering and cleaning the display modules is to use sockets. Naturally, 20 pin DIP sockets .600" wide with .100" centers work well for single displays. Multiple display assemblies are best handled by longer SIP sockets or DIP sockets when available for uniform package alignment. Socket manufacturers are Aries Electronics, Inc., Frenchtown, NJ; Garry Manufacturing, New Brunswick, NJ; Robinson-Nugent, New Albany, IN; and Samtec Electronic Hardware, New Albany, IN.

For further information refer to Appnote 22 in the current Siemens Optoelectronic Data Book.

OPTICAL CONSIDERATIONS

The .200" high character of the PD 2435/6/7 allows readability up to eight feet. Proper filter selection will allow the user to build a display that can be utilized over this distance.

Filters allow the user to enhance the contrast ratio between a lit LED and the character background. This will maximize discrimination of different characters as perceived by the display user. The only limitation is cost. The cost/benefit ratio for filters can be maximized to the user's benefit by first considering the ambient lighting environment.

Incandescent (with almost no green) or fluorescent (with almost no red) lights do not have the flat spectral response of sunlight. Plastic band-pass filters are inexpensive and effective in optimizing contrast ratios. The PD 2435 is a high efficiency red display and should be matched with a long wavelength pass filter in the 570 nm to 590 nm range. The PD 2436 is a standard red display and should be matched with a long wavelength pass filter in the 600 nm to 620 nm range. The PD 2437 should be matched with a yellow-green band-pass filter that peaks at 565 nm. For displays of multiple colors, neutral density grey filters offer the best compromise.

Additional contrast enhancement can be gained through shading the displays. Plastic band-pass filters with built-in louvers offer the "next step up" in contrast improvement. Plastic filters can be further improved with anti-reflective coatings to reduce glare. The trade-off is "fuzzy" characters. Mounting the filters close to the display reduces this effect. Care should be taken not to overheat the plastic filters by allowing for proper air flow.

Optimal filter enhancements for any condition can be gained through the use of circular polarized, anti-reflective, band-pass filters. The circular polarizing further enhances contrast by reducing the light that travels through the filter and reflects back off the display to less than 1%. Proper intensity selection of the displays will allow 10,000 foot candle sunlight viewability.

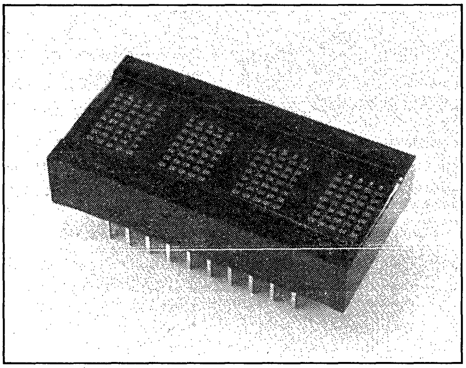
Several filter manufacturers supply quality filter materials. Some of them are: Panelgraphic Corporation, W. Caldwell, NJ; SGL Homalite, Wilmington, DE; 3M Company, Visual Products Division, St. Paul, MN; Polaroid Corporation, Polarizer Division, Cambridge, MA; Marks Polarized Corporation, Deer Park, NY; Hoya Optics, Inc., Fremont, CA.

One last note on mounting filters: recessing display and bezel assemblies is an inexpensive way to provide a shading effect in overhead lighting situations. Several Bezel manufacturers are: R.M.F. Products, Batavia, IL; Nobex Components, Griffith Plastic Corp., Burlingame, CA; Photo Chemical Products of California, Santa Monica, CA; I.E.E.-Atlas, Van Nuys, CA.

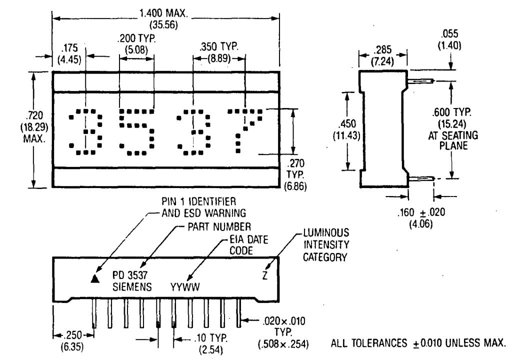
See Siemens Appnote 23 for further information.

HIGH EFFICIENCY RED PD3535
RED PD3536
BRIGHT GREEN PD3537

.270″ 4-Character, 5×7 Dot Matrix Alphanumeric Programmable Display™ with Built-In CMOS Control Functions



Package Dimensions in Inches (mm)



FEATURES

- **Four 0.270″ Dot Matrix Characters in High Efficiency Red, Red, or Bright Green**
- **Built-in Memory, Decoders, Multiplexer and Drivers**
- **Wide Viewing Angle, X Axis ±55°, Y Axis ±65°**
- **Categorized for Luminous Intensity**
- **128-Character ASCII Format (Both Upper and Lower Case Characters)**
- **8-Bit Bidirectional Data BUS**
- **READ/WRITE Capability**
- **100% Burned In and Tested**
- **Dual In-Line Package Configuration, .600″ Wide, .100″ Pin Centers**
- **End-Stackable Package**
- **Internal or External Clock**
- **Built-in Character Generator ROM**
- **TTL Compatible**
- **Easily Cascaded for Multidisplay Operation**
- **Less CPU Time Required**
- **Software Controlled Features:**
  - **Programmable Highlight Attribute (Blinking, Non-Blinking)**
  - **Asynchronous Memory Clear Function**
  - **Lamp Test**
  - **Display Blank Function**
  - **Single or Multiple Character Blinking Function**
  - **Programmable Intensity, Three Brightness Levels**
- **Extended Operating Temperature Range: -40°C to +85°C**

DESCRIPTION

The PD 3535/6/7 are four digit display system modules. The digits are 0.27″ by 0.20″ 5×7 dot matrix arrays constructed with the latest solid state technology in light emitting diodes. Driving and controlling the LED arrays is a silicon gate CMOS integrated circuit. This integrated circuit provides all necessary LED drivers and complete multiplexing control logic.

Additionally, the IC has the necessary ROM to decode 128 ASCII alphanumeric characters and enough RAM to store the display's complete four digit ASCII message with special attributes. These attributes, all software programmable at the user's discretion, include a lamp test, brightness control, displaying cursors, alternating cursors and characters, and flashing cursors or characters. The CMOS IC also incorporates special interface control circuitry to allow the user to control the module as a fully supported microprocessor peripheral. The module, under internal or external clock control, has asynchronous read, write, and memory clear over an eight bit parallel, TTL compatible, bi-directional data bus. Each module is fully encapsulated within a package 1.4″×0.72″×0.295″. The standard 20 pin DIP construction with two 0.6″ rows on 0.1″ centers is wave solderable and has been fully tested with over one million total device hours to operate over a temperature range from −40°C to +85°C.

All products are 100% burned-in and tested, then subjected to out-going AQL's of .25% for brightness matching, visual alignment and dimensions, .065% for electrical and functional. All the devices are intensity binned to allow users to construct a uniform display of any length.

See the end of this data sheet or refer to Appnotes 18, 19, 22, and 23 for further details on handling and assembling Siemens Programmable Displays.

Maximum Ratings

DC Supply Voltage . . . . -0.5 V to +7.0 Vdc
Input Voltage Levels Relative
to GND (all inputs) . . . . -0.5 V to V_{CC} +0.5 Vdc
Operating Temperature . . . . -40°C to +85°C
Storage Temperature . . . . -40°C to +100°C
Maximum Solder Temperature, .063″ (1.59 mm)
below Seating Plane, t<5 sec . . . . 260°C

Optical Characteristics @25°C

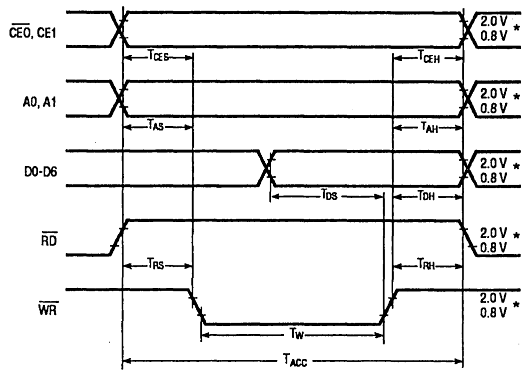
Spectral Peak Wavelength . . . . (HER) 630 nm typ.
. . . . (Red) 660 nm typ.
. . . . (Green) 565 nm typ.
Viewing Angle
horizontal . . . . ±55°
(off normal axis) vertical . . . . ±65°
Digit Height . . . . 0.270 inch (6.86 mm)
Time Averaged Luminous Intensity(1)
Red . . . . 30 μcd/LED min.
HER/Green . . . . 90 μcd/LED min.
LED to LED Intensity Matching . . . . 1.8:1.0 max.
Device to Device (one bin) . . . . 1.5:1.0 max.
Bin to Bin (adjacent bin) . . . . 1.9:1.0 max.

Note: 1. Peak luminous intensity values can be calculated by multiplying these values by 7.

TIMING CHARACTERISTICS

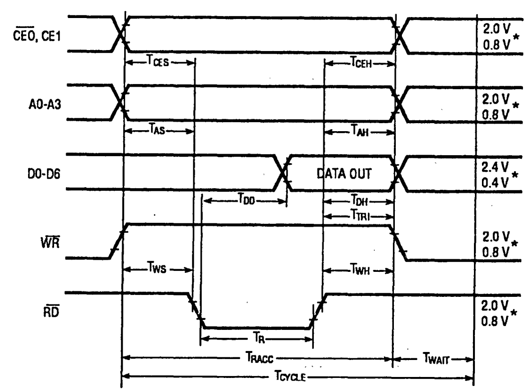
(@V_{CC}=4.5 V, Temp=25°C)

Data WRITE Cycle



*Notes: 1. All input voltage are (V_{IL} = 0.8 V, V_{IH} = 2.0 V.)
2. These waveforms are not edge triggered.

Data READ Cycle



SWITCHING SPECIFICATIONS (V_{CC} = 4.5 V)

READ CYCLE TIMING					
		Specification Minimum			
Parameter	Description	-40°C	25°C	85°C	Units
T_{AS}	Address Setup	0	0	0	ns
T_{CES}	Chip Enable	0	0	0	ns
T_{WS}	Write Enable Setup	20	30	40	ns
T_{DD}	Data Delay Time	100	150	175	ns
T_R	Read Pulse	150	175	200	ns
T_{AH}	Address Hold	0	0	0	ns
T_{DH}	Data Hold	0	0	0	ns
T_{TRI}	Time to Tristate (Max time)	30	40	50	ns
T_{CEH}	Chip Enable Hold	0	0	0	ns
T_{WH}	Write Enable Hold	30	40	50	ns
T_{ACC}	Total Access Time = Setup Time + Write Time + Time to Tristate	200	245	290	ns
T_{WAIT}(1)	Wait Time between Reads	0	0	0	ns
T_{CYCLE}	Read Cycle Time = T_{RACC} + T_{WAIT}	200	245	290	ns

Notes:

1. Wait 1 μs between any Reads or Writes after writing a Control Word with a Clear (D7 = 1). Wait 1μs between any Reads or Writes after Clearing a Control Word with a Clear (D7 = 0). All other Reads and Writes can be back to back.
2. All input voltages are (V_{IL} = 0.8 V, V_{IH} = 2.0 V).
3. Data out voltages are measured with 100 pF on the data bus and the ability to source = -40 μA and sink = 1.6 mA. The rise and fall times are 60 ns. V_{OL} = 0.4 V, V_{OH} = 2.4 V.

SWITCHING SPECIFICATIONS (V_{CC} = 4.5 V)

WRITE CYCLE TIMING					
		Specification Minimum			
Parameter	Description	-40°C	25°C	85°C	Units
T_{CLR}*	Clear RAM	1	1	1	μs
T_{CLRD}*	Clear RAM Disable	1	1	1	μs
T_{AS}	Address Setup	10	10	10	ns
T_{CES}	Chip Enable Setup	0	0	0	ns
T_{RS}	Read Enable Setup	10	10	10	ns
T_{DS}	Data Setup	20	30	50	ns
T_W	Write Pulse	60	70	90	ns
T_{AH}	Address Hold	20	30	40	ns
T_{DH}	Data Hold	20	30	40	ns
T_{CEH}	Chip Enable Hold	0	0	0	ns
T_{RH}	Read Enable Hold	20	30	40	ns
T_{ACC}	Total Access Time = Setup Time + Write Time + Hold Time	90	110	140	ns

*Wait 1 μs between any Reads or Writes after writing a Control Word with a Clear (D7 = 1). Wait 1μs between any Reads or Writes after Clearing a Control Word with a Clear (D7 = 0). All other Reads and Writes can be back to back.

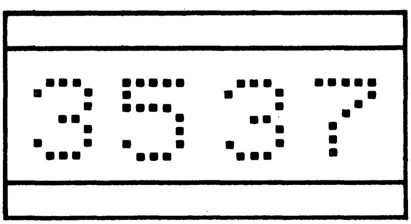
PD 3535/6/7

DC CHARACTERISTICS @25°C

Parameter	Limits Min.	Typ.	Max.	Units	Conditions
V_{CC}	4.5	5.0	5.5	Volts	Nominal
I_{CC} Blank (All Inputs Low)		2.5	5	mA	$V_{CC}=5$ V, All inputs $=0.8$ V
I_{CC} 80 LEDs/unit (100% Bright)		145	165	mA	$V_{CC}=5$ V
V_{IL} (All Inputs)	-0.5		0.8	Volts	$V_{CC}=4.5$ V to 5.5 V
V_{IH} (All Inputs)	2.0			Volts	$V_{CC}=4.5$ V to 5.5 V
I_{IL} (All Inputs)	25		100	μA	$V_{CC}=4.5$ V to 5.5 V, $V_{IN}=0.8$ V
V_{OL} (D0–D7)			0.4	Volts	$V_{CC}=4.5$ V to 5.5 V
V_{OH} (D0–D7)	2.4			Volts	$V_{CC}=4.5$ V to 5.5 V
I_{OH} (D0–D7)	-8.9			mA	$V_{CC}=4.5$ V, $V_{OH}=2.4$ V
I_{OL} (D0–D7)	1.6			mA	$V_{CC}=4.5$ V, $V_{OL}=0.4$ V
Data I/O Bus Loading			100	pF	
Clock I/O Bus Loading			240	pF	

Note: 1. Typical average LED drive current is 1.9 mA. Peak current at 1/7 duty cycle is 13.1 mA.

TOP VIEW



PIN ASSIGNMENTS

Pin	Function	Pin	Function
1 $\overline{RD}$	READ	11 $\overline{WR}$	WRITE
2 CLK I/O	CLOCK I/O	12 D7	DATA MSB
3 CLKSEL	CLOCK SELECT	13 D6	DATA
4 $\overline{RST}$	RESET	14 D5	DATA
5 CE1	CHIP ENABLE	15 D4	DATA
6 $\overline{CE0}$	CHIP ENABLE	16 D3	DATA
7 A2	ADDRESS MSB	17 D2	DATA
8 A1	ADDRESS	18 D1	DATA
9 A0	ADDRESS LSB	19 D0	DATA LSB
10 GND		20 V_{CC}	

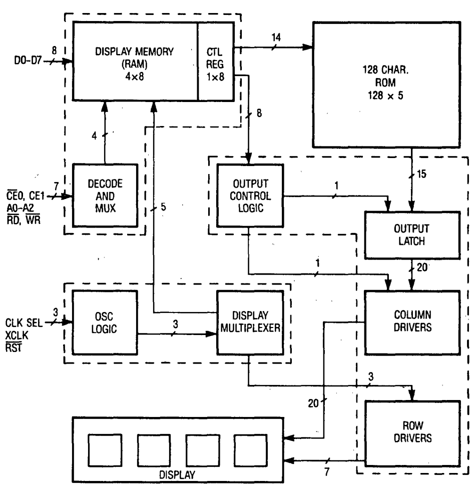
PIN DEFINITIONS

Pin	
1. $\overline{RD}$	Active low, will enable a processor to read all registers in the PD 3535/6/7
2. CLK I/O	If CLK SEL (pin 3) is low, then expect an external clock source into this pin. If CLK SEL is high, then this pin will be the master or source for all other devices which have CLK SEL low.
3. CLK SEL	CLocK SELect, determines the action of pin 2. CLK I/O, see the section on Cascading for an example.
4. $\overline{RST}$	Reset. Must be held low until $V_{CC} > 4.5$ volts. Reset is used only to synchronize blinking, and will not clear the display.
5. CE1	Chip enable (active high).
6. $\overline{CE0}$	Chip enable (active low).
7. A2	Address input (MSB).
8. A1	Address input.
9. A0	Address input (LSB).
10. GND	Ground.
11. $\overline{WR}$	Write. Active Low. If the device is selected, a low on the write input loads the data into the PD 3535/6/7's memory.
12. D7	Data Bus bit 7 (MSB).
13. D6	Data Bus bit 6.
14. D5	Data Bus bit 5.
15. D4	Data Bus bit 4.
16. D3	Data Bus bit 3.
17. D2	Data Bus bit 2.
18. D1	Data Bus bit 1.
19. D0	Data Bus bit 0 (LSB).
20. V_{CC}	Plus 5 volts power pin.

DATA INPUT COMMANDS															
$\overline{\text{CE0}}$	CE1	$\overline{\text{RD}}$	$\overline{\text{WR}}$	A2	A1	A0	D7	D6	D5	D4	D3	D2	D1	D0	OPERATION
1	0	X	X	X	X	X	X	X	X	X	X	X	X	X	No Change
0	1	0	1	1	0	0	X	X	X	X	X	X	X	X	Read Digit 0 Data To Bus
0	1	1	0	1	0	0	X	0	1	0	0	1	0	0	($) Written To Digit 0
0	1	1	0	1	0	1	X	1	0	1	0	1	1	1	(W) Written to Digit 1
0	1	1	0	1	1	0	X	1	1	0	0	1	1	0	(f) Written To Digit 2
0	1	1	0	1	1	1	X	0	1	1	0	0	1	1	(3) Written to Digit 3
0	1	1	0	1	0	0	1	X	X	X	X	X	X	X	Char. Written To Digit 0 And Cursor Enabled

MODE SELECTION				
$\overline{\text{CE0}}$	CE1	$\overline{\text{RD}}$	$\overline{\text{WR}}$	OPERATION
0	1	0	0	Illegal
1	X	X	X	No Change
X	0	X	X	No Change
X	X	1	1	No Change

BLOCK DIAGRAM



FUNCTIONAL DESCRIPTION

The PD 3535/6/7 block diagram includes the major blocks and internal registers.

Display Memory consists of a 5×8 bit RAM block. Each of the four 8-bit words holds the 7-bit ASCII data (bits D0–D6). The fifth 8-bit memory word is used as a control word register. A detailed description of the control register and its functions can be found under the heading Control Word. Each 8-bit word is addressable and can be read from or written to.

The **Control Logic** dictates all of the features of the display device and is discussed in the Control Word section of this data sheet.

The **Character Generator** converts the 7-bit ASCII data into the proper dot pattern for the 128 characters shown in the character set chart.

The **Clock Source** can originate either from the internal oscillator clock or from an external source—usually from the output of another PD 3535/6/7 in a multiple module display.

The **Display Multiplexer** controls all display output to the digit drivers so no additional logic is required for a display system.

The **Column Drivers** are connected directly to the display.

The **Display** has four digits. Each of the four digits is comprised of 35 LEDs in a 5×7 dot array which makes up the alphanumeric characters.

The intensity of the display can be varied by the Control Word in steps of 0% (Blank), 25%, 50%, and full brightness.

MICROPROCESSOR INTERFACE

The interface to the microprocessor is through the address lines (A0–A2), the data bus (D0–D7), two chip select lines ($\overline{\text{CE0}}$, CE1), and read ($\overline{\text{RD}}$) and write ($\overline{\text{WR}}$) lines.

The $\overline{\text{CE0}}$ should be held low when executing a read, or write operation.

The read and write lines are both active low. During a valid read the data input lines (D0–D7) become outputs. A valid write will enable the data as input lines.

INPUT BUFFERING

If a cable length of 6 inches of more is used, all inputs to the display should be buffered with a tri-state non-inverting buffer mounted as close to the display as conveniently possible. Recommended buffers are: 74LS245 for the data lines and 74LS244 for the control lines.

PROGRAMMING THE PD 3535/6/7

There are five registers within the PD 3535/6/7. Four of these registers are used to hold the ASCII code of the four display characters. The fifth register is the Control Word, which is used to blink, blank, clear or dim the entire display, or to change the presentation (attributes) of individual characters.

ADDRESSING

The addresses within the display device are shown below. Digit 0 is the rightmost digit of the display, while digit 3 is on the left. Although there is only one Control Word, it is duplicated at the four address locations 0–3. Data can be read from any of these locations. When one of these locations is written to, all of them will change together.

Address	Contents
0	Control Word
1	Control Word (Duplicate)
2	Control Word (Duplicate)
3	Control Word (Duplicate)
4	Digit 0 (rightmost)
5	Digit 1
6	Digit 2
7	Digit 3 (leftmost)

Bit D7 of any of the display digit locations is used to allow an attribute to be assigned to that digit. The attributes are discussed in the next section. If bit D7 is set to a one, that character will be displayed using the attribute. If bit D7 is cleared, the character will display normally.

CONTROL WORD

When address bit A2 is taken low, the Control Word is accessed. The same Control Word appears in all four of the lower address spaces of the display. Through the Control Word, the display can be cleared, the lamps can be tested, display brightness can be selected, and attributes can be set for any characters which have been loaded with their most significant bit (D7) set high.

Brightness (D0, D1): The state of the lower two bits of the Control Word are used to set the brightness of the entire display, from 0% to 100%. The table below shows the correspondence of these bits to the brightness.

D7	D6	D5	D4	D3	D2	D1	D0	Operation
0	0	X	X	X	X	0	0	Blank
0	0	X	X	X	X	0	1	25% brightness
0	0	X	X	X	X	1	0	50% brightness
0	0	X	X	X	X	1	1	Full brightness

X = don't care

CONTROL WORD FORMAT

D7	D6	D5	D4	D3	D2	D1	D0
CLEAR	LAMP TEST	BLINK	ATTRIBUTE ENABLE	ATTRIBUTES		BRIGHTNESS	

D1 D0 BRIGHTNESS
- 0 0 0% (Blank)
- 0 1 25%
- 1 0 50%
- 1 1 100%

D3 D2 ATTRIBUTE
- 0 0 Display Cursor Instead Of Character
- 0 1 Blink Character
- 1 0 Display Blinking Cursor Instead Of Character
- 1 1 Alternate Character With Cursor

D4 ATTRIBUTE ENABLE
- 0 Disable Above Attributes
- 1 Enable Above Attributes

D5 BLINK
- 0 Blink-Attribute Disabled
- 1 Blink Entire Display

D6 LAMP TEST
- 0 Standard Operation
- 1 Display All Dots At 50% Brightness

D7 CLEAR
- 0 Standard Operation
- 1 Clear Entire Display

Attributes (D2-D4): Bits D2, D3, and D4 control the visual attributes (i.e., blinking) of those display digits which have been written with bit D7 set high. In order to use any of the four attributes, the Cursor Enable bit (D4 in the Control Word) must be set. When the Cursor Enable bit is set, and bit D7 in a character location is set, the character will take on one of the following display attributes.

D7	D6	D5	D4	D3	D2	D1	D0	Operation
0	0	0	0	X	X	B	B	Disable highlight attribute
0	0	0	1	0	0	B	B	Display cursor* instead of character
0	0	0	1	0	1	B	B	Blink single character
0	0	0	1	1	0	B	B	Display blinking cursor* instead of character
0	0	0	1	1	1	B	B	Alternate character with cursor*

*"Cursor" refers to a condition when all dots in a single character space are lit to half brightness.
X = don't care
B = depends on the selected brightness

Attributes are non-destructive. If a character with bit D7 set is replaced by a cursor (Control Word bit D4 is set, and D3=D2=0) the character will remain in memory and can be revealed again by clearing D4 in the Control Word.

Blink (D5): The entire display can be caused to blink at a rate of approximately 2Hz by setting bit D5 in the Control Word. This blinking is independent of the state of D7 in all character locations.

In order to synchronize the blink rate in a bank of these devices, it is necessary to tie all devices' clocks and resets together as described in a later section of this data sheet.

D7	D6	D5	D4	D3	D2	D1	D0	Operation
0	0	1	X	X	X	B	B	Blinking display

Lamp Test (D6): When the Lamp Test bit is set, all dots in the entire display are lit at half brightness. When this bit is cleared, the display returns to the characters that were showing before the lamp test. The lamp test will remain if implemented silmutaneously with a clear instruction.

D7	D6	D5	D4	D3	D2	D1	D0	Operation
0	1	0	X	X	X	X	X	Lamp test

Clear Data (D7): When D7 is set in the Control Word, all character and Control Word memory bits are reset to zero. This causes total erasure of the display, and returns all digits to a non-blink, full brightness, non-cursor status.

D7	D6	D5	D4	D3	D2	D1	D0	Operation
1	0	X	X	X	X	X	X	Clear

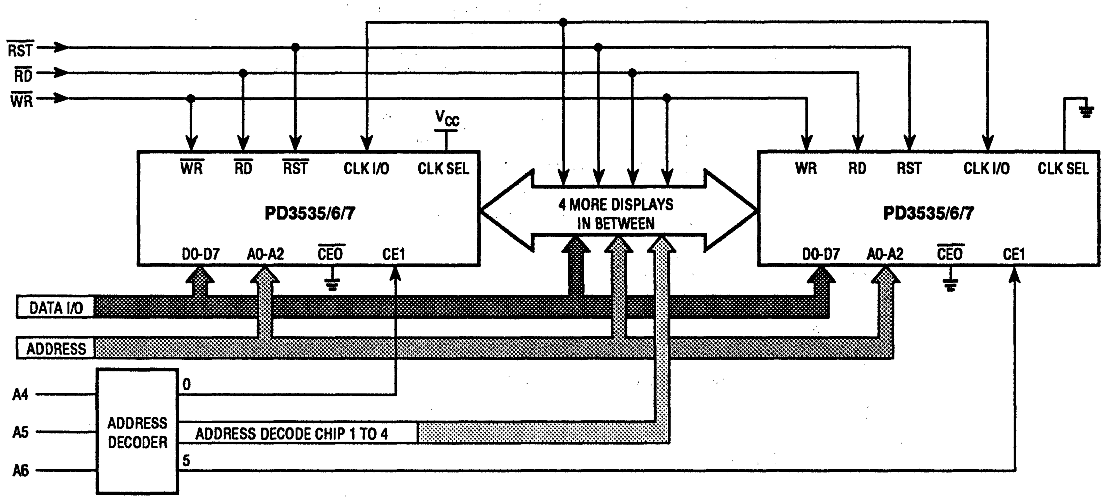
CASCADING

The SMC-4740 oscillator is designed to drive up to 16 PD 3535/6/7s with input loading of 15 pF each.

The general requirements for cascading 16 displays together are:

1. Determine the correct address for each display.
2. Tie $\overline{CE0}$ to ground and use CE1 from an address decoder to select the correct display.
3. Select one of the Displays to provide the Clock for the other displays.
4. Tie CLK SEL to ground on other displays.
5. Use $\overline{RST}$ to synchronize the blinking between the displays.

CASCADING DIAGRAM



VOLTAGE TRANSIENT SUPPRESSION

It has become common practice to provide 0.01 μf bypass capacitors liberally in digital systems. Like other CMOS circuitry, the Intelligent Display controller chip has very low power consumption and the usual 0.01 μf would be adequate were it not for the LEDs. The module itself can, in some conditions, use up to 100 mA. In order to prevent power supply transients, capacitors with low inductance and high capacitance at high frequencies are required. This suggests a solid tantalum or ceramic disc for high frequency bypass. For multiple display module systems, distribute the bypass capacitors evenly, keeping capacitors as close to the power pins as possible. Use a 0.01 μF capacitor for each display module and a 22 μF capacitor for every third display module.

HOW TO LOAD INFORMATION INTO THE PD 3535/6/7

Information loaded into the PD 3535/6/7 can be either ASCII data or Control Word data. The following procedure (see also typical loading sequence) will demonstrate a typical loading sequence and the resulting visual display. The word STOP is used in all of the following examples.

SET BRIGHTNESS

Step 1 Set the brightness level of the entire display to your preference (example: 100%)

LOAD FOUR CHARACTERS

Step 2 Load an "S" in the left-hand digit.

Step 3 Load a "T" in the next digit.

Step 4 Load an "O" in the next digit.

Step 5 Load a "P" in the right-hand digit.

If you loaded the information correctly, the PD 3535/6/7 would now show the word "STOP."

BLINK A SINGLE CHARACTER

Step 6 Into the digit, second from the right, load the hex code "CF," which is the code for an "O" with the D7 bit added as a control bit.

NOTE: The "O" is the only digit which has the control bit (D7) added to normal ASCII data.

Step 7 Load enable blinking character into the control word register.

The PD 3535/6/7 should now display "STOP" with a flashing "O".

ADD ANOTHER BLINKING CHARACTER

Step 8 Into the left hand digit, load the hex code "D3" which is for an "S" with the D7 bit added as a control bit.

The PD 3535/6/7 should now display "STOP" with a flashing "O" and a flashing "S."

ALTERNATE CHARACTER/ CURSOR ENABLE

Step 9 Load enable alternate character/cursor into the control word register.

The PD 3535/6/7 should now display "STOP" with "O" and the "S" alternating between the letter and a cursor (which is all dots lit).

INITIATE FOUR-CHARACTER BLINKING

Regardless of Control Bit setting)

Step 10 Load enable display blinking.

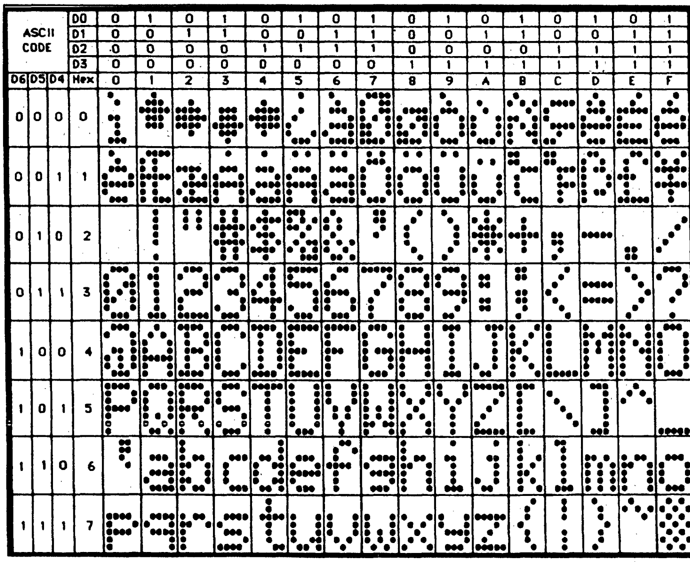
The PD 3535/6/7 should now display the entire word "STOP" blinking.

TYPICAL LOADING SEQUENCE

	$\overline{CE0}$	CE1	$\overline{RD}$	$\overline{WR}$	A2	A1	AØ	D7	D6	D5	D4	D3	D2	D1	D0	DISPLAY
1.	L	H	H	L	L	X	X	0	0	0	0	0	0	1	1	
2.	L	H	H	L	H	H	H	0	1	0	1	0	0	1	1	S
3.	L	H	H	L	H	H	L	0	1	0	1	0	1	0	0	ST
4.	L	H	H	L	H	L	H	0	1	0	0	1	1	1	1	STO
5.	L	H	H	L	H	L	L	0	1	0	1	0	0	0	0	STOP
6.	L	H	H	L	H	L	H	1	1	0	0	1	1	1	1	STOP
7.	L	H	H	L	L	X	X	0	0	0	1	0	1	1	1	STO*P
8.	L	H	H	L	H	H	H	1	1	0	1	0	0	1	1	S*TO*P
9.	L	H	H	L	L	X	X	0	0	0	1	1	1	1	1	S†TO†P
10.	L	H	H	L	L	X	X	0	0	1	0	0	0	1	1	S*T*O*P*

*Blinking Character
†Character alternating with cursor (all dots lit)

CHARACTER SET



Notes: 1. High = 1 level.
2. Low = 0 level.
3. Upon power up, the device will initialize in a random state.

ELECTRICAL AND MECHANICAL CONSIDERATIONS

The CMOS IC of the PD 3535/6/7 is designed to provide resistance to both Electrostatic Discharge Damage and Latch Up due to voltage or current surges. Several precautions are strongly recommended for the user, to avoid overstressing these built-in safeguards.

ESD PROTECTION

Users of the PD 3535/6/7 should be careful to handle the devices consistent with Standard ESD protection procedures. Operators should wear appropriate wrist, ankle or feet ground straps and avoid clothing that collects static charges. Work surfaces, tools and transport carriers that come into contact with unshielded devices or assemblies should also be appropriately grounded.

LATCH UP PROTECTION

Latch up is a condition that occurs in CMOS ICs after the input protection diodes have been broken down. These diodes can be reversed through several means:

$V_{IN} < GND$, $V_{IN} > V_{CC} + 0.5$ V, or through excessive currents begin forced on the inputs. When these situations exist, the IC may develop the response of an SCR and begin conducting as much as one amp through the V_{CC} pin. This destructive condition will persist (latched) until device failure or the device is turned off.

The Voltage Transient Suppression Techniques and buffer interfaces for longer cable runs help considerably to prevent latch conditions from occuring. Additionally, the following Power Up and Power Down sequence should be observed.

POWER UP SEQUENCE

1. Float all active signals by tri-stating the inputs to the displays.
2. Apply V_{CC} and GND to the display.
3. Apply active signals to the displays by enabling all input signals per application.

POWER DOWN SEQUENCE

1. Float all active signals by tri-stating the inputs to the display.
2. Turn off the power to the display.

SOLDERING CONSIDERATIONS

PD 3535/6/7s can be hand soldered with SN63 solder using a grounded iron set to 160 °C.

Wave soldering is also possible following these conditions: Preheat that does not exceed 93 °C on the solder side of the PC board or a package surface temperature of 85 °C. Water soluble organic acid flux (except Carboxylic acid) or resin-based RMA flux without alcohol can be used.

Wave temperature of 245 °C ±5 °C with a dwell between 1.5 sec. to 3.0 sec. Exposure to the wave should not exceed temperatures above 260 °C, for five seconds at 0.063″ below the seating plane. The packages should not be immersed in the wave.

POST SOLDER CLEANING PROCEDURES

The least offensive cleaning solution is hot D.I. water (60°C) for less than 15 minutes. Addition of mild saponifiers is acceptable. Do not use commercial dishwasher detergents.

For faster cleaning, solvents may be used. Care should be exercised in choosing these as some may chemically attack the nylon package. Maximum exposure should not exceed two minutes at elevated temperatures. Acceptable solvents are TF (trichlorotrifluoroethane), TA, 111 Trichloroethane, and unheated acetone.(1)

Note: 1. Acceptable commercial solvents are: Basic TF, Arklone P, Genesolv D, Genesolv DA, Blaco-Tron TF, Blaco-Tron TA and, Freon TA.

Do not use solvents containing alcohol, methanol, methylene chloride, ethanol, TP35, TCM, TMC, TMS+, TE, and TES. Since many commercial mixtures exist, you should contact your preferred solvent vendor for chemical composition information. Some major solvent manufacturers are: Allied Chemical Corporation, Specialty Chemical Division, Morristown, NJ; Baron-Blakeslee, Chicago, IL; Dow Chemical, Midland, MI; E.I. DuPont de Nemours & Co., Wilmington, DE.

For further information refer to Appnotes 18 and 19 in the current Siemens Optoelectronic Data Book.

An alternative to soldering and cleaning the display modules is to use sockets. Naturally, 20 pin DIP sockets .600″ wide with .100″ centers work well for single displays. Multiple display assemblies are best handled by longer SIP sockets or DIP sockets when available for uniform package alignment. Socket manufacturers are Aries Electronics, Inc., Frenchtown, NJ; Garry Manufacturing, New Brunswick, NJ; Robinson-Nugent, New Albany, IN; and Samtec Electronic Hardware, New Albany, IN.

For further information refer to Appnote 22 in the current Siemens Optoelectronic Data Book.

OPTICAL CONSIDERATIONS

The .270″ high character of the PD 3535/6/7 allows readability up to eight feet. Proper filter selection will allow the user to build a display that can be utilized over this distance.

Filters allow the user to enhance the contrast ratio between a lit LED and the character background. This will maximize discrimination of different characters as perceived by the display user. The only limitation is cost. The cost/benefit ratio for filters can be maximized to the user's benefit by first considering the ambient lighting environment.

Incandescent (with almost no green) or fluorescent (with almost no red) lights do not have the flat spectral response of sunlight. Plastic band-pass filters are inexpensive and effective in optimizing contrast ratios. The PD 3535 is a high efficiency red display and should be matched with a long wavelength pass filter in the 570 nm to 590 nm range. The PD 3536 is a standard red display and should be matched with a long wavelength pass filter in the 600 nm to 620 nm range. The PD 3537 should be matched with a yellow-green band-pass filter that peaks at 565 nm. For displays of multiple colors, neutral density grey filters offer the best compromise.

Additional contrast enhancement can be gained through shading the displays. Plastic band-pass filters with built-in louvers offer the "next step up" in contrast improvement. Plastic filters can be further improved with anti-reflective coatings to reduce glare. The trade-off is "fuzzy" characters. Mounting the filters close to the display reduces this effect. Care should be taken not to overheat the plastic filters by allowing for proper air flow.

Optimal filter enhancements for any condition can be gained through the use of circular polarized, anti-reflective, band-pass filters. The circular polarizing further enhances contrast by reducing the light that travels through the filter and reflects back off the display to less than 1%. Proper intensity selection of the displays will allow 10,000 foot candle sunlight viewability.

Several filter manufacturers supply quality filter materials. Some of them are: Panelgraphic Corporation, W. Caldwell, NJ; SGL Homalite, Wilmington, DE; 3M Company, Visual Products Division, St. Paul, MN; Polaroid Corporation, Polarizer Division, Cambridge, MA; Marks Polarized Corporation, Deer Park, NY; Hoya Optics, Inc., Fremont, CA.

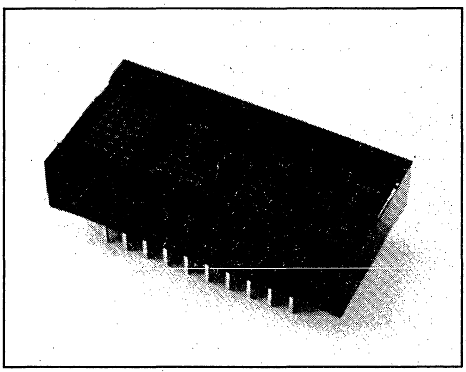
One last note on mounting filters: recessing display and bezel assemblies is an inexpensive way to provide a shading effect in overhead lighting situations. Several Bezel manufacturers are: R.M.F. Products, Batavia, IL; Nobex Components, Griffith Plastic Corp., Burlingame, CA; Photo Chemical Products of California, Santa Monica, CA; I.E.E.-Atlas, Van Nuys, CA.

See Siemens Appnote 23 for further information.

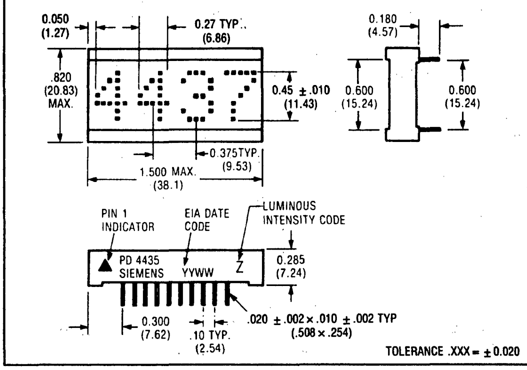
SIEMENS

HIGH EFFICIENCY RED PD4435
RED PD4436
BRIGHT GREEN PD4437

.45″ 4-Character, 5×7 Dot Matrix Alphanumeric Programmable Display™ with Built-In CMOS Control Functions



Package Dimensions in Inches (mm)



FEATURES

- **Four 0.45″ Dot Matrix Characters in High Efficiency Red, Red, or Bright Green**
- **Built-in Memory, Decoders, Multiplexer and Drivers**
- **Wide Viewing Angle, X Axis ±55°, Y Axis ±65°**
- **Categorized for Luminous Intensity**
- **128-Character ASCII Format (Both Upper and Lower Case Characters)**
- **8-Bit Bidirectional Data BUS**
- **READ/WRITE Capability**
- **100% Burned In and Tested**
- **Dual In-Line Package Configuration, Pin Rows .600″ Wide, .100″ Pin Centers**
- **End-Stackable Package**
- **Internal or External Clock**
- **Built-in Character Generator ROM**
- **TTL Compatible**
- **Easily Cascaded for Multidisplay Operation**
- **Less CPU Time Required**
- **Software Controlled Features:**
  - **Programmable Highlight Attribute (Blinking, Non-Blinking)**
  - **Asynchronous Memory Clear Function**
  - **Lamp Test**
  - **Display Blank Function**
  - **Single or Multiple Character Blinking Function**
  - **Programmable Intensity, Three Brightness Levels**
- **Extended Operating Temperature Range: -40°C to +85°C**

DESCRIPTION

The PD 4435, PD 4436, and PD 4437 are four digit display system modules. The digits are 0.45″ by 0.27″ 5×7 dot matrix arrays constructed with the latest solid state technology in light emitting diodes. Driving and controlling the LED arrays is a silicon gate CMOS integrated circuit. This integrated circuit provides all necessary LED drivers and complete multiplexing control logic.

Additionally, the IC has the necessary ROM to decode 128 ASCII alphanumeric characters and enough RAM to store the display's complete four digit ASCII message with special attributes. These attributes, all software programmable at the user's discretion, include a lamp test, brightness control, displaying cursors, alternating cursors and characters, and flashing cursors or characters. The CMOS IC also incorporates special interface control circuitry to allow the user to control the module as a fully supported microprocessor peripheral. The module, under internal or external clock control, has asynchronous read, write, and memory clear over an eight bit parallel, TTL compatible, bi-directional data bus. Each module is fully encapsulated within a package 1.5″×0.8″×0.285″. The standard 20 pin DIP construction with two 0.6″ rows on 0.1″ centers is wave solderable and has been fully tested with over one million total device hours to operate over a temperature range from -40°C to +85°C.

All products are 100% burned-in and tested, then subjected to out-going AQL's of .25% for brightness matching, visual alignment and dimensions, .065% for electrical and functional. All the devices are intensity binned to allow users to construct a uniform display of any length.

See the end of this data sheet or refer to Appnotes 18, 19, 22, and 23 for further details on handling and assembling Siemens Programmable Displays.

Maximum Ratings

DC Supply Voltage .... −0.5 V to +7.0 Vdc
Input Voltage Levels Relative
  to GND (all inputs) .... −0.5 V to V_{CC} +0.5 Vdc
Operating Temperature .... −40°C to +85°C
Storage Temperature .... −40°C to +100°C
Maximum Solder Temperature, .063″ (1.59 mm)
  below Seating Plane, t<5 sec .... 260°C

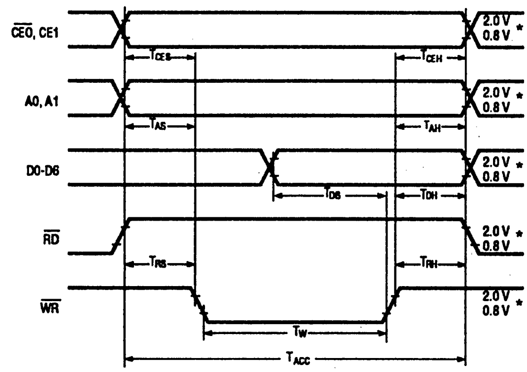
Optical Characteristics @25°C

Spectral Peak Wavelength .... (4435) 630 nm typ.
.... (4436) 660 nm typ.
.... (4437) 565 nm typ.
Viewing Angle
  horizontal .... ±55°
  (off normal axis) vertical .... ±65°
Digit Height .... 0.420 inch (10.6 mm)
Time Averaged Luminous Intensity(1)
  Red .... 75 μcd/LED min.
  HER/Green .... 100 μcd/LED min.
LED to LED Intensity Matching .... 1.8:1.0 max.
Device to Device (one bin) .... 1.5:1.0 max.
Bin to Bin (adjacent bin) .... 1.9:1.0 max.

Note: 1. Peak luminous intensity values can be calculated by multiplying these values by 7.

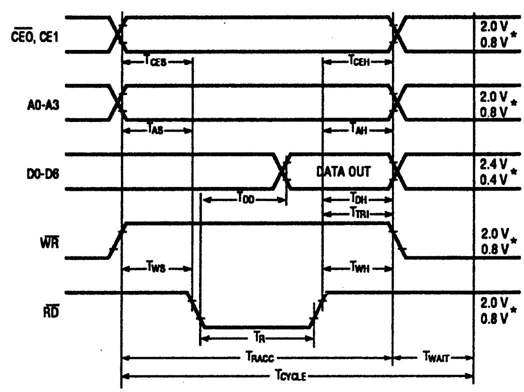
TIMING CHARACTERISTICS
(@V_{CC} = 4.5 V, Temp = 25°C)

Data WRITE Cycle



*Notes: 1. All input voltage are (V_{IL} = 0.8 V, V_{IH} = 2.0 V.)
2. These waveforms are not edge triggered.

Data READ Cycle



SWITCHING SPECIFICATIONS (V_{CC} = 4.5 V)

READ CYCLE TIMING					
		Specification Minimum			
Parameter	Description	-40°C	25°C	85°C	Units
T_{AS}	Address Setup	0	0	0	ns
T_{CES}	Chip Enable	0	0	0	ns
T_{WS}	Write Enable Setup	20	30	40	ns
T_{DD}	Data Delay Time	100	150	175	ns
T_R	Read Pulse	150	175	200	ns
T_{AH}	Address Hold	0	0	0	ns
T_{DH}	Data Hold	0	0	0	ns
T_{TRI}	Time to Tristate (Max time)	30	40	50	ns
T_{CEH}	Chip Enable Hold	0	0	0	ns
T_{WH}	Write Enable Hold	30	40	50	ns
T_{ACC}	Total Access Time = Setup Time + Write Time + Time to Tristate	200	245	290	ns
T_{WAIT}(1)	Wait Time between Reads	0	0	0	ns
T_{CYCLE}	Read Cycle Time = T_{RACC} + T_{WAIT}	200	245	290	ns

Notes:
1. Wait 1 μs between any Reads or Writes after writing a Control Word with a Clear (D7 = 1). Wait 1μs between any Reads or Writes after Clearing a Control Word with a Clear (D7 = 0). All other Reads and Writes can be back to back.
2. All input voltages are (V_{IL} = 0.8 V, V_{IH} = 2.0 V).
3. Data out voltages are measured with 100 pF on the data bus and the ability to source = −40 μA and sink = 1.6 mA. The rise and fall times are 60 ns. V_{OL} = 0.4 V, V_{OH} = 2.4 V.

SWITCHING SPECIFICATIONS (V_{CC} = 4.5 V)

WRITE CYCLE TIMING					
		Specification Minimum			
Parameter	Description	-40°C	25°C	85°C	Units
T_{CLR}*	Clear RAM	1	1	1	μs
T_{CLRD}*	Clear RAM Disable	1	1	1	μs
T_{AS}	Address Setup	10	10	10	ns
T_{CES}	Chip Enable Setup	0	0	0	ns
T_{RS}	Read Enable Setup	10	10	10	ns
T_{DS}	Data Setup	20	30	50	ns
T_W	Write Pulse	60	70	90	ns
T_{AH}	Address Hold	20	30	40	ns
T_{DH}	Data Hold	20	30	40	ns
T_{CEH}	Chip Enable Hold	0	0	0	ns
T_{RH}	Read Enable Hold	20	30	40	ns
T_{ACC}	Total Access Time = Setup Time + Write Time + Hold Time	90	110	140	ns

* Wait 1 μs between any Reads or Writes after writing a Control Word with a Clear (D7 = 1). Wait 1 μs between any Reads or Writes after Clearing a Control Word with a Clear (D7 = 0). All other Reads and Writes can be back to back.

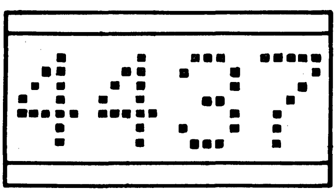
PD 4435/6/7

DC CHARACTERISTICS @25°C

Parameter	Limits Min.	Limits Typ.	Limits Max.	Units	Conditions
V_{CC}	4.5	5.0	5.5	Volts	Nominal
I_{CC} Blank (All Inputs Low)		2.5	5	mA	$V_{CC}=5$ V, All inputs $=0.8$ V
I_{CC} 80 LEDs/unit (100% Bright)	130	150(1)	170(2)	mA	$V_{CC}=5$ V
V_{IL} (All Inputs)	-0.5		0.8	Volts	$V_{CC}=4.5$ V to 5.5 V
V_{IH} (All Inputs)	2.0			Volts	$V_{CC}=4.5$ V to 5.5 V
I_{IL} (All Inputs)	25		100	μA	$V_{CC}=4.5$ V to 5.5 V, $V_{IN}=0.8$ V
V_{OL} (D0–D7)			0.4	Volts	$V_{CC}=4.5$ V to 5.5 V
V_{OH} (D0–D7)	2.4			Volts	$V_{CC}=4.5$ V to 5.5 V
I_{OH} (D0–D7)	-8.9			mA	$V_{CC}=4.5$ V, $V_{OH}=2.4$ V
I_{OL} (D0–D7)	1.6			mA	$V_{CC}=4.5$ V, $V_{OL}=0.4$ V
Data I/O Bus Loading			100	pF	
Clock I/O Bus Loading			240	pF	

Notes: 1. Typical average LED drive current is 1.9 mA. Peak current at 1/7 duty cycle is 13.1 mA.
2. Characterization data indicates max I_{CC} will vary from 200 mA at -40°C to 130 mA at 85°C.

TOP VIEW



PIN ASSIGNMENTS

PD 4435/6/7 PINOUT

Pin		Function	Pin		Function
1	$\overline{RD}$	READ	11	$\overline{WR}$	WRITE
2	CLK I/O	CLOCK I/O	12	D7	DATA MSB
3	CLKSEL	CLOCK SELECT	13	D6	DATA
4	$\overline{RST}$	RESET	14	D5	DATA
5	CE1	CHIP ENABLE	15	D4	DATA
6	$\overline{CE0}$	CHIP ENABLE	16	D3	DATA
7	A2	ADDRESS MSB	17	D2	DATA
8	A1	ADDRESS	18	D1	DATA
9	A0	ADDRESS LSB	19	D0	DATA LSB
10	GND		20	V_{CC}	

PIN DEFINITIONS

Pin		
1.	$\overline{RD}$	Active low, will enable a processor to read all registers in the PD 4435/6/7.
2.	CLK I/O	If CLK SEL (pin 3) is low, then expect an external clock source into this pin. If CLK SEL is high, then this pin will be the master or source for all other devices which have CLK SEL low.
3.	CLK SEL	CLocK SELect, determines the action of pin 2. CLK I/O, see the section on Cascading for an example.
4.	$\overline{RST}$	Reset. Must be held low until $V_{CC} > 4.5$ volts. Reset is used only to synchronize blinking, and will not clear the display.
5.	CE1	Chip enable (active high).
6.	$\overline{CE0}$	Chip enable (active low).
7.	A2	Address input (MSB).
8.	A1	Address input.
9.	A0	Address input (LSB).
10.	GND	Ground.
11.	$\overline{WR}$	Write. Active Low. If the device is selected, a low on the write input loads the data into the PD 4435/6/7s. memory.
12.	D7	Data Bus bit 7 (MSB).
13.	D6	Data Bus bit 6.
14.	D5	Data Bus bit 5.
15.	D4	Data Bus bit 4.
16.	D3	Data Bus bit 3.
17.	D2	Data Bus bit 2.
18.	D1	Data Bus bit 1.
19.	D0	Data Bus bit 0 (LSB).
20.	V_{CC}	Plus 5 volts power pin.

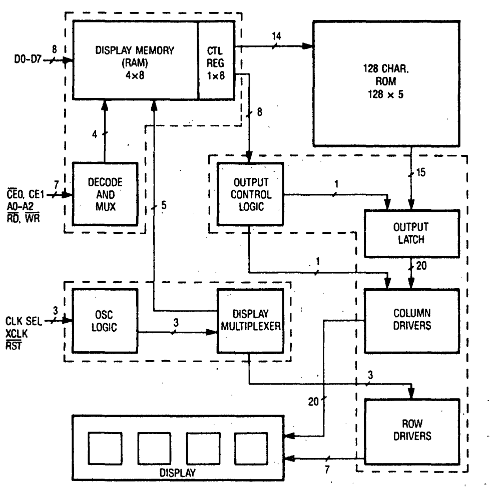
DATA INPUT COMMANDS

$\overline{CE0}$	CE1	$\overline{RD}$	$\overline{WR}$	A2	A1	A0	D7	D6	D5	D4	D3	D2	D1	D0	OPERATION
1	0	X	X	X	X	X	X	X	X	X	X	X	X	X	No Change
0	1	0	1	1	0	0	X	X	X	X	X	X	X	X	Read Digit 0 Data To Bus
0	1	1	0	1	0	0	X	0	1	0	0	1	0	0	($) Written To Digit 0
0	1	1	0	1	0	1	X	1	0	1	0	1	1	1	(W) Written to Digit 1
0	1	1	0	1	1	0	X	1	1	0	0	1	1	0	(f) Written To Digit 2
0	1	1	0	1	1	1	X	0	1	1	0	0	1	1	(3) Written to Digit 3
0	1	1	0	1	0	0	1	X	X	X	X	X	X	X	Char. Written To Digit 0 And Cursor Enabled

MODE SELECTION

$\overline{CE0}$	CE1	$\overline{RD}$	$\overline{WR}$	OPERATION
0	1	0	0	Illegal
1	X	X	X	No Change
X	0	X	X	No Change
X	X	1	1	No Change

BLOCK DIAGRAM



FUNCTIONAL DESCRIPTION

The PD 4435/6/7 block diagram includes the major blocks and internal registers.

Display Memory consists of a 5×8 bit RAM block. Each of the four 8-bit words holds the 7-bit ASCII data (bits D0–D6). The fifth 8-bit memory word is used as a control word register. A detailed description of the control register and its functions can be found under the heading Control Word. Each 8-bit word is addressable and can be read from or written to.

The **Control Logic** dictates all of the features of the display device and is discussed in the Control Word section of this data sheet.

The **Character Generator** converts the 7-bit ASCII data into the proper dot pattern for the 128 characters shown in the character set chart.

The **Clock Source** can originate either from the internal oscillator clock or from an external source—usually from the output of another PD 4435/6/7 in a multiple module display.

The **Display Multiplexer** controls all display output to the digit drivers so no additional logic is required for a display system.

The **Column Drivers** are connected directly to the display.

The **Display** has four digits. Each of the four digits is comprised of 35 LEDs in a 5×7 dot array which makes up the alphanumeric characters.

The intensity of the display can be varied by the Control Word at settings of 0% (Blank), 25%, 50%, and full brightness.

MICROPROCESSOR INTERFACE

The interface to the microprocessor is through the address lines (A0–A2), the data bus (D0–D7), two chip select lines ($\overline{CE0}$, CE1), and read ($\overline{RD}$) and write ($\overline{WR}$) lines.

The read and write lines are both active low. During a valid read the data input lines (D0–D7) become outputs. A valid write will enable the data as input lines.

INPUT BUFFERING

If a cable length of 6 inches of more is used, all inputs to the display should be buffered with a tri-state non-inverting buffer mounted as close to the display as conveniently possible. Recommended buffers are: 74LS245 for the data lines and 74LS244 for the control lines.

VOLTAGE TRANSIENT SUPPRESSION

It has become common practice to provide 0.01 μf bypass capacitors liberally in digital systems. Like other CMOS circuitry, the Programmable Display controller chip has a very low power consumption and the usual 0.01 μf would be adequate were it not for the LEDs. The module itself can, in some conditions, use up to 100 mA. In order to prevent power supply transients, capacitors with low inductance and high capacitance at high frequencies are required. This suggests a solid tantalum or ceramic disc for high frequency bypass. For multiple display module systems, distribute the bypass capacitors evenly, keeping capacitors as close to the power pins as possible. Use a 0.01 μF capacitor for each display module and a 22 μF capacitor for every third display module.

HOW TO LOAD INFORMATION INTO THE PD 4435/6/7

Information loaded into the PD 4435/6/7 can be either ASCII data or Control Word data. The following procedure (see also typical loading sequence) will demonstrate a typical loading sequence and the resulting visual display. The word STOP is used in all of the following examples.

SET BRIGHTNESS

Step 1 Set the brightness level of the entire display to your preference (example: 100%)

LOAD FOUR CHARACTERS

Step 2 Load an "S" in the left-hand digit.

Step 3 Load a "T" in the next digit.

Step 4 Load an "O" in the next digit.

Step 5 Load a "P" in the right-hand digit.

If you loaded the information correctly, the PD 4435/6/7 should now show the word "STOP."

BLINK A SINGLE CHARACTER

Step 6 Into the digit, second from the right, load the hex code "CF," which is the code for an "O" with the D7 bit added as a control bit.

NOTE: the "O" is the only digit which has the control bit (D7) added to normal ASCII data.

Step 7 Load enable blinking character into the control word register.

The PD 4435/6/7 should now display "STOP" with a flashing "O."

ADD ANOTHER BLINKING CHARACTER

Step 8 Into the left hand digit, load the hex code "D3" which is for an "S" with the D7 bit added as a control bit.

The PD 4435/6/7 should display "STOP" with a flashing "O" and a flashing "S."

ALTERNATE CHARACTER/ CURSOR ENABLE

Step 9 Load enable alternate character/cursor into the control word register.

The PD 4435/6/7 should now display "STOP" with the "O" and the "S" alternating between the letter and a cursor (which is all dots lit).

INITIATE FOUR-CHARACTER BLINKING
(Regardless of Control Bit setting)

Step 10 Load enable display blinking.

The PD 4435/6/7 should now display the entire word "STOP" blinking.

TYPICAL LOADING SEQUENCE

	$\overline{CE0}$	CE1	$\overline{RD}$	$\overline{WR}$	A2	A1	AØ	D7	D6	D5	D4	D3	D2	D1	D0	DISPLAY
1.	L	H	H	L	L	X	X	0	0	0	0	0	0	1	1	
2.	L	H	H	L	H	H	H	0	1	0	1	0	0	1	1	S
3.	L	H	H	L	H	H	L	0	1	0	1	0	1	0	0	ST
4.	L	H	H	L	H	L	H	0	1	0	0	1	1	1	1	STO
5.	L	H	H	L	H	L	L	0	1	0	1	0	0	0	0	STOP
6.	L	H	H	L	H	L	H	1	1	0	0	1	1	1	1	STOP
7.	L	H	H	L	L	X	X	0	0	0	1	0	1	1	1	STO*P
8.	L	H	H	L	H	H	H	1	1	0	1	0	0	1	1	S*TO*P
9.	L	H	H	L	L	X	X	0	0	0	1	1	1	1	1	S†TO†P
10.	L	H	H	L	L	X	X	0	0	1	0	0	0	1	1	S*T*O*P*

*Blinking Character

†Character alternating with cursor (all dots lit)

Intelligent Display Devices

Attributes (D2-D4): Bits D2, D3, and D4 control the visual attributes (i.e., blinking) of those display digits which have been written with bit D7 set high. In order to use any of the four attributes, the Cursor Enable bit (D4 in the Control Word) must be set. When the Cursor Enable bit is set, and bit D7 in a character location is set, the character will take on one of the following display attributes.

D7	D6	D5	D4	D3	D2	D1	D0	Operation
0	0	0	0	X	X	B	B	Disable highlight attribute
0	0	0	1	0	0	B	B	Display cursor* instead of character
0	0	0	1	0	1	B	B	Blink single character
0	0	0	1	1	0	B	B	Display blinking cursor* instead of character
0	0	0	1	1	1	B	B	Alternate character with cursor*

*"Cursor" refers to a condition when all dots in a single character space are lit to half brightness.
X = don't care
B = depends on the selected brightness

Attributes are non-destructive. If a character with bit D7 set is replaced by a cursor (Control Word bit D4 is set, and D3=D2=0) the character will remain in memory and can be revealed again by clearing D4 in the Control Word.

Blink (D5): The entire display can be caused to blink at a rate of approximately 2Hz by setting bit D5 in the Control Word. This blinking is independent of the state of D7 in all character locations.

In order to synchronize the blink rate in a bank of these devices, it is necessary to tie all devices' clocks and resets together as described in a later section of this data sheet.

D7	D6	D5	D4	D3	D2	D1	D0	Operation
0	0	1	X	X	X	B	B	Blinking display

Lamp Test (D6): When the Lamp Test bit is set, all dots in the entire display are lit at half brightness. When this bit is cleared, the display returns to the characters that were showing before the lamp test. The lamp test will remain if implemented silmutaneously with a clear instruction.

D7	D6	D5	D4	D3	D2	D1	D0	Operation
0	1	0	X	X	X	X	X	Lamp test

Clear Data (D7): When D7 is set in the Control Word, all character and Control Word memory bits are reset to zero. This causes total erasure of the display, and returns all digits to a non-blink, full brightness, non-cursor status.

D7	D6	D5	D4	D3	D2	D1	D0	Operation
1	0	X	X	X	X	X	X	Clear

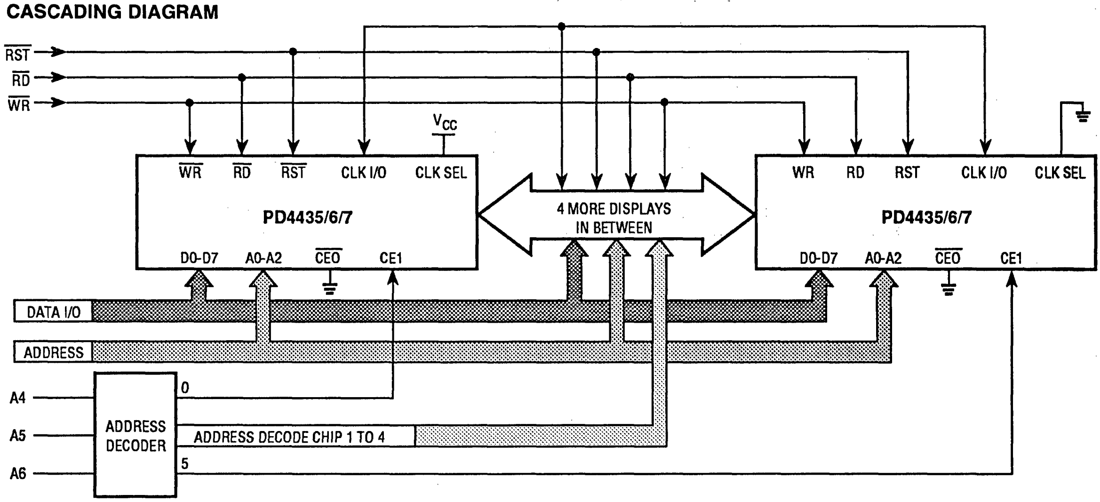
DATA PROTOCOL

The display module continuously executes all control words programmed in the registers. Randomly, before new control works are completely defined, valid unitentional transient control words may be executed. This may present a problem if the memory clear instruction is one of the transients. To avoid the inadvertant clearing of display memory, it is suggested that display data be loaded after changes in control word programming. Alternatively, D7 must be stable in the low state throughout the complete write cycle.

CASCADING

Cascading the PD 4435/6/7 is a simple operation. The requirements for cascading are: 1) decoding the correct address to determine the chip select for each additional device, 2) assuring that all devices are reset simultaneously, and 3) selecting one display as the clock source and setting all others to accept clock input (the reason for cascading the clock is to synchronize the flashing of multiple displays). One display as a source is capable of driving six other PD 4435/6/7s. If more displays are required, a buffer will be necessary. The source display must have pin 3 tied high to output clock signals. All other displays must have pin 3 tied low. External clock frequencies should not exceed 100 KHz, norminally it should be 30 KHz.

CASCADING DIAGRAM



PROGRAMMING THE PD 4435/6/7

There are five registers within the PD 4435/6/7. Four of these registers are used to hold the ASCII code of the four display characters. The fifth register is the Control Word, which is used to blink, blank, clear or dim the entire display, or to change the presentation (attributes) of individual characters.

ADDRESSING

The addresses within the display device are shown below. Digit 0 is the rightmost digit of the display, while digit 3 is on the left. Although there is only one Control Word, it is duplicated at the four address locations 0-3. Data can be read from any of these locations. When one of these locations is written to, all of them will change together.

Address	Contents
0	Control Word
1	Control Word (Duplicate)
2	Control Word (Duplicate)
3	Control Word (Duplicate)
4	Digit 0 (rightmost)
5	Digit 1
6	Digit 2
7	Digit 3 (leftmost)

Bit D7 of any of the display digit locations is used to allow an attribute to be assigned to that digit. The attributes are discussed in the next section. If bit D7 is set to a one, that character will be displayed using the attribute. If bit D7 is cleared, the character will display normally.

CONTROL WORD

When address bit A2 is taken low, the Control Word is accessed. The same Control Word appears in all four of the lower address spaces of the display. Through the Control Word, the display can be cleared, the lamps can be tested, display brightness can be selected, and attributes can be set for any characters which have been loaded with their most significant bit (D7) set high. (1)

Brightness (D0, D1): The state of the lower two bits of the Control Word are used to set the brightness of the entire display, from 0% to 100%. The table below shows the correspondence of these bits to the brightness.

D7	D6	D5	D4	D3	D2	D1	D0	Operation
0	0	X	X	X	X	0	0	Blank
0	0	X	X	X	X	0	1	25% brightness
0	0	X	X	X	X	1	0	50% brightness
0	0	X	X	X	X	1	1	Full brightness

X = don't care

Note: 1. The control word should be stable on the bus when A2 is taken low. Failure to do this may result in inadvertently clearing the display RAM.

CONTROL WORD FORMAT

D7	D6	D5	D4	D3	D2	D1	D0
CLEAR	LAMP TEST	BLINK	ATTRIBUTE ENABLE	ATTRIBUTES		BRIGHTNESS	

D1	D0	BRIGHTNESS
0	0	0% (Blank)
0	1	25%
1	0	50%
1	1	100%

D3	D2	ATTRIBUTE
0	0	Display Cursor Instead Of Character
0	1	Blink Character
1	0	Display Blinking Cursor Instead Of Character
1	1	Alternate Character With Cursor

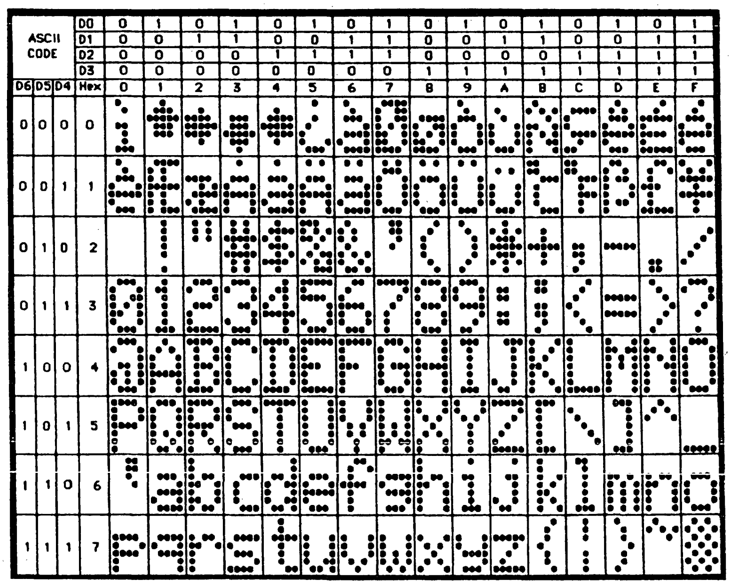
D4	ATTRIBUTE ENABLE
0	Disable Above Attributes
1	Enable Above Attributes

D5	BLINK
0	Blink-Attribute Disabled
1	Blink Entire Display

D6	LAMP TEST
0	Standard Operation
1	Display All Dots At 50% Brightness

D7	CLEAR
0	Standard Operation
1	Clear Entire Display

CHARACTER SET



Notes: 1. A2 must be held high for ASCII data.
2. Bit D7 = 1 enables attributes for the assigned digit.
3. High = 1 level.
Low = 0 level.

ELECTRICAL AND MECHANICAL CONSIDERATIONS

The CMOS IC of the PD 4435/6/7 is designed to provide resistance to both Electrostatic Discharge Damage and Latch Up due to voltage or current surges. Several precautions are strongly recommended for the user, to avoid overstressing these built-in safeguards.

ESD PROTECTION

Users of the PD 4435/6/7 should be careful to handle the devices consistent with Standard ESD protection procedures. Operators should wear appropriate wrist, ankle or feet ground straps and avoid clothing that collects static charges. Work surfaces, tools and transport carriers that come into contract with unshielded devices or assemblies should also be appropriately grounded.

LATCH UP PROTECTION

Latch up is a condition that occurs in CMOS ICs after the input protection diodes have been broken down. These diodes can be reversed through several means:

V_{IN} < GND, V_{IN} > V_{CC} +0.5 V, or through excessive currents begin forced on the inputs. When these situations exist, the IC may develop the response of an SCR and begin conducting as much as one amp through the V_{CC} pin. This destructive condition will persist (latched) until device failure or the device is turned off.

The Voltage Transient Suppression Techniques and buffer interfaces for longer cable runs help considerably to prevent latch conditions from occuring. Additionally, the following Power Up and Power Down sequence should be observed.

POWER UP SEQUENCE

1. Float all active signals by tri-stating the inputs to the displays.
2. Apply V_{CC} and GND to the display.
3. Apply active signals to the displays by enabling all input signals per application.

POWER DOWN SEQUENCE

1. Float all active signals by tri-stating the inputs to the display.
2. Turn off the power to the display.

SOLDERING CONSIDERATIONS

PD 4435/6/7 can be hand soldered with SN63 solder using a grounded iron set to 260°C.

Wave soldering is also possible following these conditions: Preheat that does not exceed 93°C on the solder side of the PC board or a package surface temperature of 85°C. Water soluble organic acid flux (except Carboxylic acid) or resin-based RMA flux without alcohol can be used.

Wave temperature of 245°C ±5°C with a dwell between 1.5 sec. to 3.0 sec. Exposure to the wave should not exceed temperatures above 260°C, for five seconds at 0.063″ below the seating plane. The packages should not be immersed in the wave.

POST SOLDER CLEANING PROCEDURES

The least offensive cleaning solution is hot D.I. water (60°C) for less than 15 minutes. Addition of mild saponifiers is acceptable. Do not use commercial dishwasher detergents.

For faster cleaning, solvents may be used. Care should be exercised in choosing these as some may chemically attack the nylon package. Maximum exposure should not exceed two minutes at elevated temperatures. Acceptable solvents are TF (trichlorotrifluoroethane), TA, 111 Trichloroethane, and unheated acetone.(1)

Do not use solvents containing alcohol, methanol, methylene chloride, ethanol, TP35, TCM, TMC, TMS+, TE, or TES. Since many commercial mixtures exist, you should contact your preferred solvent vendor for chemical composition information. Some major solvent manufacturers are: Allied Chemical Corporation, Specialty Chemical Division, Morristown, NJ; Baron-Blakeslee, Chicago, IL; Dow Chemical, Midland, MI; E.I. DuPont de Nemours & Co., Wilmington, DE.

For further information refer to Appnote 18 and 19 in the current Siemens Optoelectronic Data Book.

An alternative to soldering and cleaning the display modules is to use sockets. Naturally, 20 pin DIP sockets .600″ wide with .100″ centers work well for single displays. Multiple display assemblies are best handled by longer SIP sockets or DIP sockets when available for uniform package alignment. Socket manufacturers are Aries Electronics, Inc., Frenchtown, NJ; Garry Manufacturing, New Brunswick, NJ; Robinson-Nugent, New Albany, IN; and Samtec Electronic Hardware, New Albany, IN.

For further information refer to Appnote 22 in the current Siemens Optoelectronic Data Book.

OPTICAL CONSIDERATIONS

The .450″ high character of the PD 4435/6/7 allows readability up to eight feet. Proper filter selection will allow the user to build a display that can be utilized over this distance.

Filters allow the user to enhance the contrast ratio between a lit LED and the character background. This will maximize discrimination of different characters as perceived by the display user. The only limitation is cost. The cost/benefit ratio for filters can be maximized to the user's benefit by first considering the ambient lighting environment.

Incandescent (with almost no green) or fluorescent (with almost no red) lights do not have the flat spectral response of sunlight. Plastic band-pass filters are inexpensive and effective in optimizing contrast ratios. The PD 4435 is a high efficiency red display and should be matched with a long wavelength pass filter in the 570 nm to 590 nm range. The PD 4436 is a standard red display and should be matched with a long wavelength pass filter in the 600 nm to 620 nm range. The PD 4437 should be matched with a yellow-green band-pass filter that peaks at 565 nm. For displays of multiple colors, neutral density grey filters offer the best compromise.

Additional contrast enhancement can be gained through shading the displays. Plastic band-pass filters with built-in louvers offer the "next step up" in contrast improvement. Plastic filters can be further improved with anti-reflective coatings to reduce glare. The trade-off is "fuzzy" characters. Mounting the filters close to the display reduces this effect. Care should be taken not to overheat the plastic filters by allowing for proper air flow.

Optimal filter enhancements for any condition can be gained through the use of circular polarized, anti-reflective, band-pass filters. The circular polarizing further enhances contrast by reducing the light that travels through the filter and reflects back off the display to less than 1%. Proper intensity selection of the displays will allow 10,000 foot candle sunlight viewability.

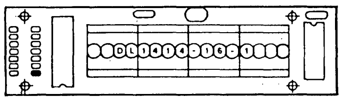
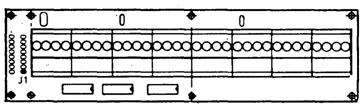
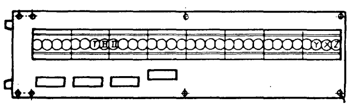
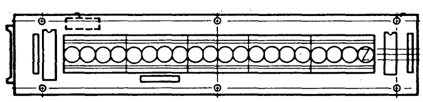
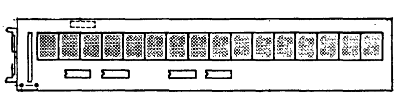
Several filter manufacturers supply quality filter materials. Some of them are: Panelgraphic Corporation, W. Caldwell, NJ; SGL Homalite, Wilmington, DE; 3M Company, Visual Products Division, St. Paul, MN; Polaroid Corporation, Polarizer Division, Cambridge, MA; Marks Polarized Corporation, Deer Park, NY; Hoya Optics, Inc., Fremont, CA.

One last note on mounting filters: recessing display and bezel assemblies is an inexpensive way to provide a shading effect in overhead lighting situations. Several Bezel manufacturers are: R.M.F. Products, Batavia, IL; Nobex Components, Griffith Plastic Corp., Burlingame, CA; Photo Chemical Products of California, Santa Monica, CA; I.E.E.-Atlas, Van Nuys, CA.

See Siemens Appnote 23 for further information.

Note: 1. Acceptable commercial solvents are: Basic TF, Arklone P, Genesolve D, Genesolve DA, Blaco-Tron TF, Blaco-Tron TA, and Freon TA.

Intelligent Display Assemblies

Package Outline	Part No./ Color	No. of Characters / Character Height	Description	Page
	IDA1414-16-1 IDA1414-16-2 Red	16 .112"	Intelligent Display assembly with four segmented DL1414 displays, decoder, and interface buffer on a single circuit board. IDA141-16-1 buffered input data lines. IDA1414-16-2 Non-buffered input data lines.	2–185
	IDA1416-32 Red	32 .160"	Intelligent Display assembly with four segmented DL1416 displays, decoder, and interface buffer on a single circuit board..	2–189
	IDA2416-16 Red	16 .160"	Intelligent Display assembly with four segmented DL2416 displays, decoder, and interface buffer on a single circuit board..	2–193
	IDA2416-32 Red	32 .160"	Intelligent Display assembly with eight segmented DL2416 displays, decoder, and interface buffer on a single circuit board..	
	IDA3416-16 Red	16 .225"	Intelligent Display assembly with four segmented DL3416 displays, decoder, and interface buffer on a single circuit board..	2–197
	IDA3416-20 Red	20 .225"	Intelligent Display assembly with five segmented DL3416 displays, decoder, and interface buffer on a single circuit board..	
	IDA3416-32 Red	32 .225"	Intelligent Display assembly with eight segmented DL3416 displays, decoder, and interface buffer on a single circuit board..	
	IDA7135-16 HER IDA7137-16 Green	16 .68"	Intelligent Display assembly with sixteen dot matrix DLO7135 or DLG7137 displays, decoder, and interface buffer on a single circuit board..	2–201
	IDA7135-20 HER IDA7137-20 Green	20 .68"	Intelligent Display assembly with twenty dot matrix DLO7135 or DLG7137 displays, decoder, and interface buffer on a single circuit board..	

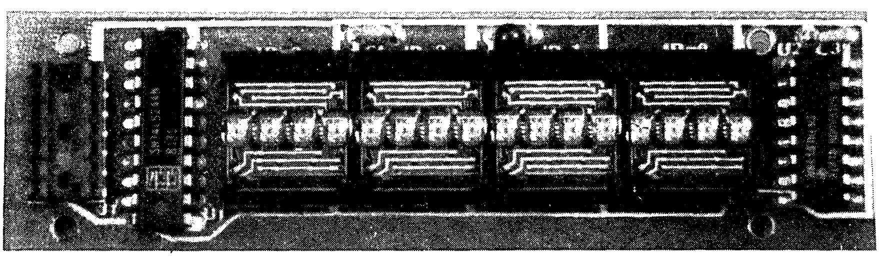
For non-standard requirements, see Custom Optoelectronic Products on page 1–2.

SIEMENS

IDA 1414-16

.112″ Red, 17 Segment, 16 Character DL 1414 Intelligent Display®ASSEMBLY

IDA-1414-16-1 Buffered Input Data Lines
IDA 1416-16-2 Non-buffered Input Data Lines



FEATURES

- 112 Mil High, Magnified Monolithic Character
- Wide Viewing Angle, ± 40°
- Complete Alphanumeric Display Assembly Utilizing the DL 1414
  - Built-in Multiplex and LED Drive Circuitry
  - Built-in Memory
  - Built-in Character Generator
- Displays 64 Character ASCII Set
- Direct Access to Each Digit Independently
- Single 5.0 Volt Power Supply
- TTL Compatible
- Easily Interfaced to a Microprocessor
- IDA 1414-16-1 Input Data Lines Are Buffered
- IDA 1414-16-2 Input Lines Are Not Buffered

DESCRIPTION

The IDA 1414-16 Assembly is an extension of the very easy-to-use DL 1414 Intelligent Display. This product provides the designer with circuitry for display maintenance. It also minimizes interaction and interface normally required between the user's system and a multiplexed alphanumeric display.

The assembly consists of four DL 1414's in a single row, together with decoder and interface buffer on a single printed circuit board. Each DL 1414 provides its own memory, ASCII ROM character decoder, multiplexing circuitry, and drivers for its four 17- segment LED's.

Intelligent Display Assemblies can be used for applications such as data terminals, controllers, instruments, and other products which require an easy to use alpha-numeric display.

Maximum Ratings

V_{CC}	6.0 V
Voltage applied to any input	-0.5 to V_{CC}+0.5 VDC
Operating Temperature	0 to +65° C
Storage Temperature	-20 to +70° C
Relative Humidity (non-condensing) @ 65° C	85%

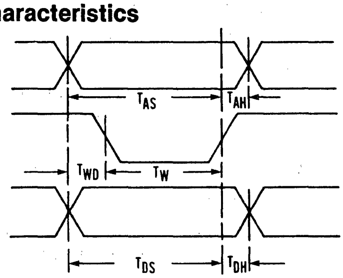
Optoelectronic Characteristics @ 25° C

Parameter	Symbol	Min	Typ	Max	Units	Test Conditions
Supply Voltage	V_{CC}	4.75		5.25	V	
Supply Current (Total)	I_{CC}					V_{CC}=5.0 V (10 Segments/Digit)
Supply Current -1				400	mA	
Supply Current -2				380	mA	
Supply Current (Display Blank)	$I_{CC_{BLANK}}$					V_{CC}=5.0 V V_{IN}=0
Supply Current -1				75	mA	
Supply Current -2				25	mA	
Input Voltage — High	V_{IH}					
-1 (D_0-D_6, A_2, A_3, $\overline{WR}$)		2.0			V	
-1 (A_0, A_1)		2.7			V	V_{CC}=4.5 V
		3.5			V	V_{CC}=5.5 V
-2 (D_0-D_6, A_0, A_1)	V_{IH}	2.7			V	V_{CC}=4.5 V
		3.5			V	V_{CC}=5.5 V
-2 (A_2, A_3, $\overline{WR}$)		2.0			V	
Input Voltage — Low	V_{IL}					
All inputs				0.8	V	V_{CC}=4.5 V
Input Current — High	I_{IH}					
Any input				20	μA	V_{CC}=5.5 V, V_I=2.7 V
Input Current — Low	I_{IL}					
Any input				400	μA	V_{CC}=5.5 V, V_I=0.4 V
Luminous Intensity						
Average Per Digit	I_V		0.5		mcd	V_{CC}=5.0 V (8 Segments/Digit)
Peak Emission Wavelength	λpk		660		nm	
Viewing Angle			±40		Deg	

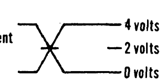
Switching Characteristics @ 5 V

Parameter	Symbol	(Typ) @ 0°C	(Min) @ 25°C	(Typ) @ 65°C	Units
Write Pulse	T_W	300	325	350	nS
Address/DE Setup Time	T_{AS}	350	400	450	nS
Data Setup Time	T_{DS}	350	400	450	nS
Write Setup	T_{WD}	50	75	100	nS
Data Hold Time	T_{DH}	50	75	100	nS
Address/DE Hold Time	T_{AH}	50	75	100	nS

Timing Characteristics



Timing Measurement Voltage Levels



IDA 1414-16

System Overview

The Intelligent Display Assembly offers the designer 16 alphanumeric characters and operates from just a 5V supply. Based on the DL1414 four character Intelligent Display, the IDA 1414-16 adds all the support logic required for direct connection to most microprocessor buses. The system interface takes place through a 14 hole dual in line pattern. The user may solder wires directly into these holes or use a ribbon cable and connectors.

System Power Requirements

Operating from a single +5V power supply, the IDA 1414-16 requires a maximum operating current of 400 mA with ten of the segments lit on each character. With the display blanked, the board circuitry draws 75 mA maximum.

Display Interface

The display interface available on the 14 pin dual in line hole pattern consists of seven data lines (D0 to D6), four address lines (A0 to A3), write pulse, V_{CC}, and GND.

$\overline{WR}$ (Write, active low): To store a character in the display memory, this line must be pulsed low for a minimum of 325 ns. See timing diagram for timing and relationships to other signals.

Address lines A0 to A3 are set up so that the right-most character is the lowest address. The left-most character is the highest address. Data lines are set up so that D0 is the least significant bit and D6 is the most significant bit.

Using the Display Interface

Through the use of memory-mapped I/O techniques, the IDA can be treated almost like a memory location—supply the data, address and proper control signals and the characters appear, with each character location independently addressable. The basic signal flow sequence to load a character would start with the address lines going to the desired address. After the address has stabilized, the data can change to the desired values. After the data have stabilized, the $\overline{WR}$ pulse is started, and must remain low for at least 325 ns. Signals must be held stable for 75 ns, minimum, after the rising edge of the $\overline{WR}$ pulse to ensure correct loading, while the addresses must be stable for 400 ns preceding the same rising edge of the $\overline{WR}$ pulse. See the timing diagram for a pictorial explanation.

System Design Considerations

It is often necessary, because of the nature of displays, to use ribbon cable from the CPU board. We have provided a 14 pin dual-in-line hole pattern for this purpose. In those circumstances for cables over 12 inches, use IDA 1414-16-1 (buffered version) instead of IDA 1414-16-2 (non-buffered version). Voltage transients from noisy systems may couple through the cables into the Intelligent Display and can cause serious damage.

Avoid handling the assembly other than by the edges of the PCB. Static damage can still be a problem, so take the necessary precautions. Keep in conductive material, grounded work areas, etc.

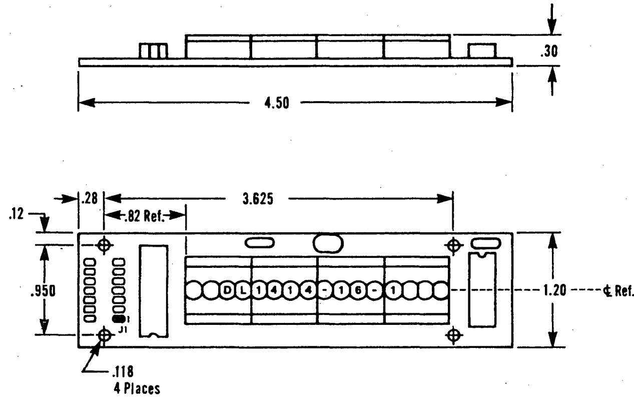
The IDA 1414 assemblies should need minimal cleaning. A gentle wiping with a soft damp cloth should be its only requirement. The solvent that cannot be used on any Intelligent Display product is alcohol. Therefore, if a solvent is used, first check chemical composition before application.

CHARACTER SET

			D0	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H
			D1	L	L	H	H	L	L	H	H	L	L	H	H	L	L	H	H
			D2	L	L	L	L	H	H	H	H	L	L	L	L	H	H	H	H
			D3	L	L	L	L	L	L	L	L	H	H	H	H	H	H	H	H
D6	D5	D4	HEX	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
L	H	L	2		!	"	#	$	%	&	'	(	)	*	+	,	-	.	/
L	H	H	3	0	1	2	3	4	5	6	7	8	9	:	;	<	=	>	?
H	L	L	4	@	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
H	L	H	5	P	Q	R	S	T	U	V	W	X	Y	Z	[	\	]	^	_

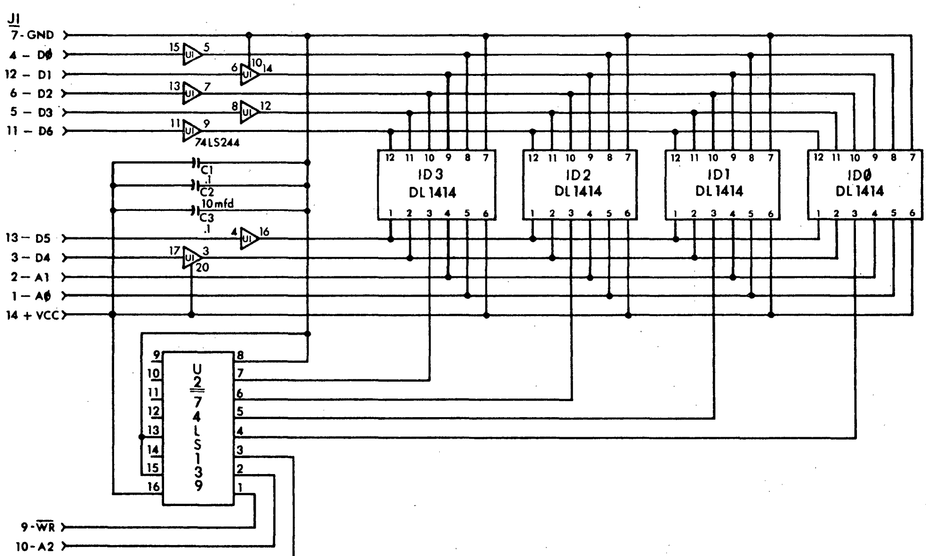
ALL OTHER INPUT CODES DISPLAY BLANKS

Physical Dimensions (in inches)



PIN	FUNCTION
1	A0 DIGIT SELECT
2	A1 DIGIT SELECT
3	D4 DATA INPUT
4	D0 DATA INPUT (LSB)
5	D3 DATA INPUT
6	D2 DATA INPUT
7	GND
8	A3 DIGIT SELECT
9	WR WRITE
10	A2 DIGIT SELECT
11	D6 DATA INPUT (MSB)
12	D1 DATA INPUT
13	D5 DATA INPUT
14	+ VCC

Wires may be soldered direct to 14 hole dual in line position or contact can be made with ribbon cable and connector such as Berg 65493-006 or Amp 86838-1/86838-2.

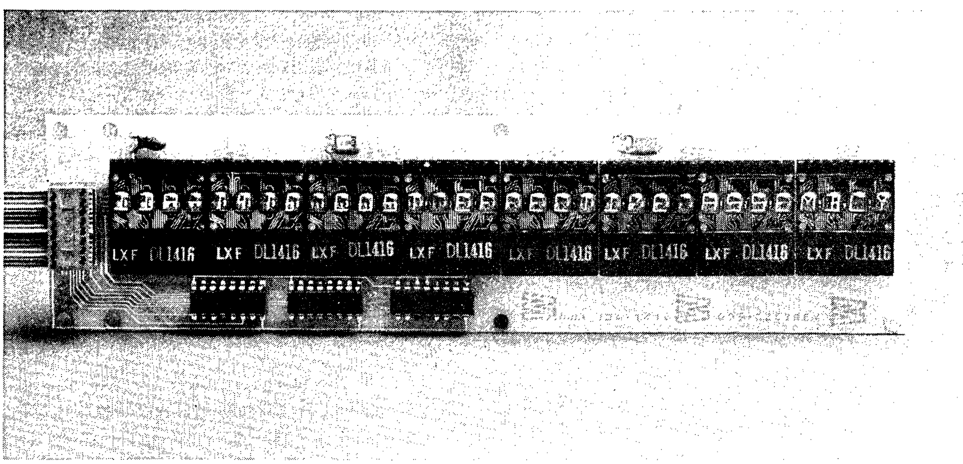


IDA 1414-16

SIEMENS

IDA 1416-32

.160", Red, 16 Segment, 32 Character DL 1416 Intelligent Display®ASSEMBLY with Memory/Decoder/Driver



FEATURES

- **160 MIL High Magnified Monolithic Character**
- **Complete Alphanumeric Display Assembly Utilizing the DL 1416**
  - **Built-in Multiplex and LED Drive Circuitry**
  - **Built-in Memory**
  - **Built-in Character Generator**
- **Displays 64 Character ASCII Set**
- **Direct Access to Each Digit Independently**
- **All Inputs are Buffered**
- **Cursor Function**
- **Single 5.0 Volt Power Supply**
- **TTL Compatible**
- **Easily Interfaced to a Microprocessor**

DESCRIPTION

The IDA 1416-32 Assembly is an extension of the very easy-to-use DL 1416 Intelligent Display. This product provides the designer with circuitry for display maintenance. It also minimizes interaction and interface normally required between the user's system and a multiplexed alphanumeric display.

The assembly consists of eight DL 1416's in a single row together with decoder and interface buffers on a single printed circuit board. Each DL 1416 provides its own memory, ASCII ROM character decoder, multiplexing circuitry, and drivers for its four 16-segment LED's.

Intelligent Display Assemblies can be used for applications such as data terminals, controllers, instruments, and other products which require an easy to use alphanumeric display.

System Overview

The IDA 1416-32 Intelligent Display Assembly offers the designer 32 alphanumeric characters and operates from just a +5 volt supply. Based on the previously introduced DL 1416 four character Intelligent Display. The IDA 1416-32 adds all the support logic required for direct connection to a host system.

System Power Requirements

Operating from a single +5 volt power supply, the IDA 1416-32 requires a typical operating current of 390mA with ten segments lit for each digit. The maximum operating current with all segments lit for all digits will be 900mA maximum.

Display Interface Signals

The system interface takes place through a 16 hole dual-in-line pattern. The user may solder wires directly into these holes or use a ribbon cable connector. The interface signals available at the 16 holes consist of seven data lines (DØ to D6), five address (AØ-A4), write and cursor input.

- $\overline{WR}$ (Write, active low): To store a character in the display memory must meet minimum write cycle waveform.
- $\overline{CU}$ (Cursor select, active low): This input must be held high during a write cycle to load ASCII data into memory; and held low during a write cycle to load cursor data into memory. The cursor ($\overline{CU}$) should *not* be hardwired high (off). During the power-up of the DL 1416's the cursor memory will be in a random state. Therefore, it is recommended for the host system to initialize or write out all possible cursors during system initialization. Also, the cursor display will be overridden by a blank from an undefined code in that digit position.

Address lines AØ to A4 are set up so that the right-most character is the lowest address location. The left-most character is the highest address. Data lines are set up so that DØ is the least significant bit and D6 is the most significant bit.

Using the Display Assembly

Through the use of memory-mapped I/O techniques, the IDA can be treated almost like a memory location—supply the data, address, proper control signals and the characters appear, with each character location independently addressable. The basic signal flow sequence to load a character would start with the address lines going to the desired address. Data can change to the desired values (including cursor). After the data has stabilized, the write ($\overline{WR}$) pulse is started. See specifications and timing diagram for times and pictorial explanation.

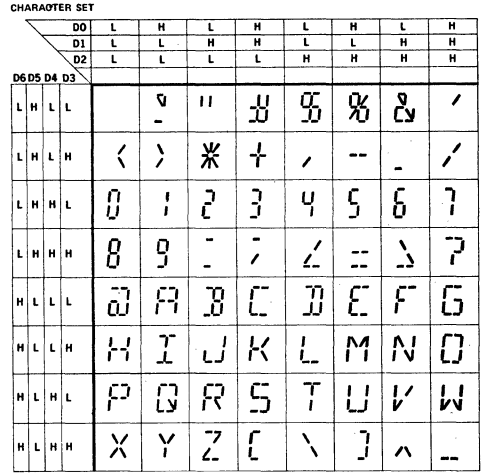
System Design Considerations

It is often necessary, because of the nature of displays, to use cables. Avoid excessively long cables; try to keep them short. Because of current steps due to internal multiplexing, wire length and size will affect load regulation which may cause an incorrect display.

Avoid handling the assembly other than by the edges of the PCB. Static damage can still be a problem, so take the necessary precautions. Keep in conductive material, grounded work areas, etc.

The IDA 1416-32 requires minimal cleaning. A gentle wiping with a soft damp cloth should be its only requirement. The solvent that *cannot* be used on any Intelligent Display product is alcohol, therefore, if a solvent is used, first check chemical composition before application.

CHARACTER SET



NOTE: All undefined data codes that are loaded or occur on power-up will cause a blank display state.

IDA 1416-32

Maximum Ratings

V_{CC} 6.0V
Voltage applied to any input . . . . − 0.5 V to V_{CC} + 0.5V
Operating Temperature . . . . 0° to +65°C
Storage Temperature . . . . − 20° to +70°C

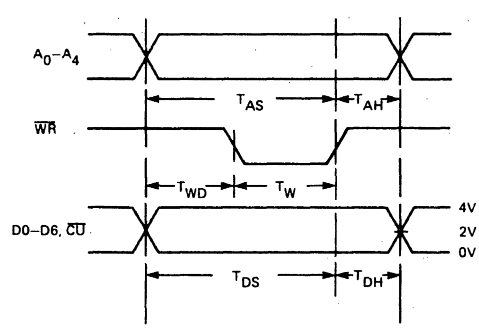
Optoelectronic Characteristic @ 25°C

Parameter	Symbol	Min	Typ	Max	Units	Test Conditions
Supply Voltage	V_{CC}	4.75		5.25	V	
Supply Current	I_{CC}					
Cursor				1250	mA	V_{CC} = 5V-All segments on.
Blank (Total)				100	mA	V_{CC} = 5V Inputs low.
Typical/Digit			390		mA	V_{cc} = 5V (10 segments/digit)
Input Voltage High	V_{IH}	2			V	V_{CC} = 5V
Input Voltage Low	V_{IL}			0.8	V	V_{CC} = 5V
Input Current High	I_{IH}			40	μA	V_{CC} = 5.25 V_I = 2.4V
Input Current Low	I_{IL}			− 1.6	mA	V_{CC} = 5.25 V_I = 0.4V
Luminous Intensity Average per digit	I_V		0.5		mcd	V_{CC} = 5V (8 segment digit)
Peak Emission Wavelength			660		mm	
Viewing Angle			± 20		Deg	

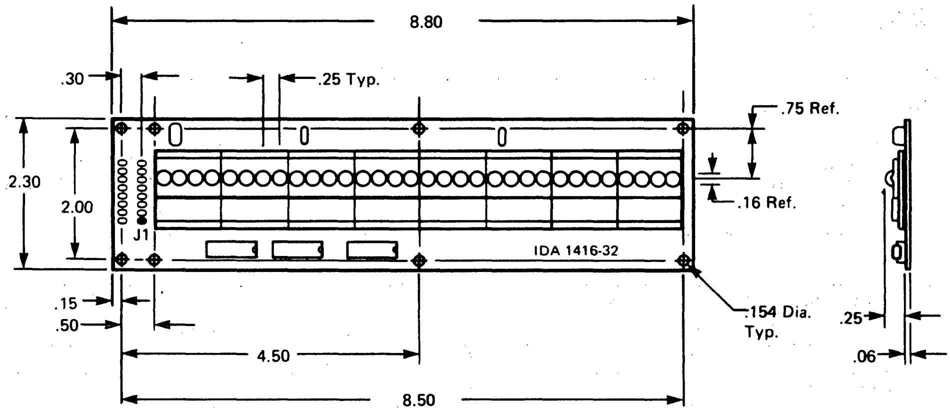
Switching Characteristics

Parameters	Symbol	0°C (Typ)	25°C (Min)	65°C (Typ)	Units
Write Pulse	T_W	475	560	675	nS
Data Setup time	T_{DS}	950	1100	1300	nS
Data hold time	T_{DH}	400	500	600	nS
Address setup time	T_{AS}	950	1100	1300	nS
Address hold time	T_{AH}	400	500	600	nS
Write delay time	T_{WD}	475	540	625	nS

TIMING CHARACTERISTICS

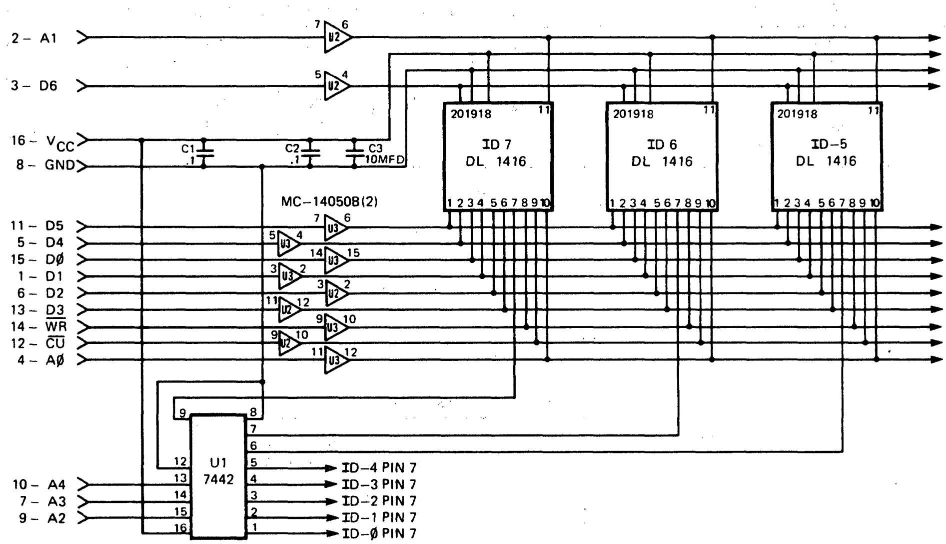


Physical Dimensions (in inches)



PIN	FUNCTION
1	D1 DATA INPUT
2	A1 CHARACTER ADDRESS
3	D6 DATA INPUT
4	AØ CHARACTER ADDRESS
5	D4 DATA INPUT
6	D2 DATA INPUT
7	A3 CHARACTER ADDRESS
8	GND
9	A2 CHARACTER ADDRESS
10	A4 CHARACTER ADDRESS
11	D5 DATA INPUT
12	CU CURSOR INPUT
13	D3 DATA INPUT
14	W WRITE
15	DØ DATA INPUT
16	VCC

Wires may be soldered directly to 16 hole dual in-line position or contact can be made with ribbon cable and connector such as Berg 65493-008 or Amp 86839-1/86839-2.

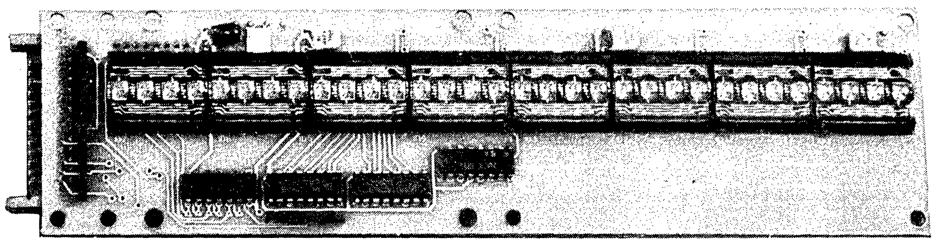


IDA 1416-32

SIEMENS

IDA 2416 Series

.160", RED 17 SEGMENT
DL-2416 Intelligent Display ASSEMBLY



FEATURES

- **160 Mil High Magnified Monolithic Character Wide Viewing Angle ± 40°**
- **Complete Alphanumeric Display Assembly Utilizing the DL 2416**
  - **Built-in Multiplex and LED Drive Circuitry**
  - **Built-in Memory**
  - **Built-in Character Generator**
- **Displays 64 Character ASCII Set**
- **Direct Access to Each Digit Independently**
- **Display Blank Function**
- **Memory Clear Function**
- **Cursor Function**
- **Choice of 16 or 32 Character Display Length (Other lengths optional)**
- **Single 5.0 Volt Power Supply**
- **TTL Compatible**
- **Easily Interfaced to a Microprocessor**
- **Tri-State or Open-Collector Input Circuitry**
- **Schmitt Trigger Inputs on Control Lines**

The IDA 2416 Series Assembly is an extension of the very easy-to-use DL 2416 Intelligent Display. This product provides the designer with circuitry for display maintenance. It also minimizes interaction and interface normally required between the user's system and a multiplexed alphanumeric display.

The assembly consists of DL 2416's in a single row together with decoder and interface buffers on a single printed circuit board. Each DL 2416 provides its own memory, ASCII ROM character decoder, multiplexing circuitry, and drivers for its four 17-segment LED's.

Intelligent Display Assemblies can be used for applications such as data terminals, controllers, instruments, and other products which require an easy to use alphanumeric display.

Part Number	Description
IDA 2416-16	Single Line 16 Character Alphanumeric Display Utilizing the DL 2416
IDA 2416-32	Single Line 32 Character Alphanumeric Display Utilizing the DL 2416
	For custom lengths in increments of four characters, consult factory

System Overview

The Intelligent Display Assembly offers the designer a choice of either 16 or 32 alphanumeric characters (the IDA 2416-16 and IDA 2416-32, respectively), and operates from just a +5V supply. Based on the DL 2416 four-character Intelligent Display, the IDA 2416 adds all the support logic required for direct connection to most microprocessor buses. The system interface takes place through a 26-pin connector, which has available on it the data and address lines as well as the control signals needed. Two additional connectors are included on the IDA 2416—one of them is used for the power and ground connections, and the other is used to implement display enable selection.

System Power Requirements

Operating from a single +5-V power supply, the IDA 2416-16 requires a typical operating current of 450 mA with eight of the segments lit on each character. For the 32 character display, the current increases to 850 mA, typical. For the worst-case condition with all segments lit, the 16 character display draws 650 mA and the 32 character display requires 1250 mA. With the display blanked, the board circuitry draws about 70 mA.

Display Interface

The display interface available on the 26-pin connector consists of seven data lines (DØ to D6), five address lines (AØ to A4), four display-enable lines ($\overline{DE1}$ to $\overline{DE4}$), several unused pins, and various control signals. All address, data, and control lines have either pull-up or pull-down 1K ohm resistors.

$\overline{BL}$ (Blanking, active low): When this line is pulled low, it causes the entire IDA display to go blank without affecting the contents of the display memory on the DL 2416s. $\overline{BL}$ is active regardless of address or display enable lines. A flashing display can be realized by pulsing this line.

$\overline{WR}$ (Write, active low): To store a character in the display memory, this line must be pulsed low for a minimum of 350 ns. See timing diagram for timing & relationships to other signals. The $\overline{WR}$ input drives a schmitt-trigger.

CUE (Cursor Enable, active high): When high, this line permits the cursor to be displayed, and when brought low, it disables the cursor function without affecting the stored value. CUE is active regardless of address or display enable lines. A flashing cursor can be created by pulsing the CUE line low.

$\overline{CU}$ (Cursor Select, active low): The cursor function (character with all segments lit) is loaded by selecting the digit address and holding $\overline{CU}$ true. A "1" on DØ writes the cursor. A "Ø" on DØ removes the cursor. The change occurs during the next write pulse per the timing diagram.

$\overline{CLR}$ (Clear, active low): When held low for one display multiplex cycle (see DL 2416 data sheet for more information) of 15 ms, this line will cause all stored characters in the display, except for the cursor, to be cleared. $\overline{CLR}$ is active regardless of address or display enable lines. The $\overline{CLR}$ input drives a schmitt-trigger.

$\overline{DE1}$ to $\overline{DE4}$ (Display Enable, active low): There are four jumper selectable lines, any one of which can be selected to provide one of four board addresses that can be used when multiple IDAs are built into a system. When low, this line enables the selected display to permit data loading. The display enable input drives a schmitt-trigger.

Address lines AØ to A4 are set up so that the right-most character is the lowest address. The left-most character is the highest address. Data lines are set up so that DØ is the least significant bit and D6 is the most significant bit.

Using the Display Interface

Through the use of memory-mapped I/O techniques, the IDA can be treated almost like a memory location — supply the data, address and proper control signals and the characters appear, with each character location independently addressable. The basic signal flow sequence to load a character would start with the address lines going to the desired address while the $\overline{CLR}$ and $\overline{BL}$ lines are high to permit the data to be loaded in and displayed. After the address has stabilized, the data can change to the desired values (including the cursor). After the data has stabilized, the $\overline{WR}$ pulse is started, and must remain low for at least 350 ns. Signals must be held stable for 75 ns, minimum, after the rising edge of the $\overline{WR}$ pulse to ensure correct loading, while the addresses must be stable for 650 ns preceding the same rising edge of the $\overline{WR}$ pulse. See the timing diagram for a pictorial explanation.

Enable Selection

For board enable (the $\overline{DE1}$ through $\overline{DE4}$ lines) the user can choose any one of the four enable signals he has provided on the cable. This signal will be used to provide a master enable to each IDA. All that need be done is to insert the shorting plug in the appropriate position on the pins provided. This allows the user to make the system display the same information on two or more different IDAs or display different information on each of up to four groups of IDA's.

IDA 2416 Series

Maximum Ratings

V_{CC}	6.0 V
Voltage applied to any input	-0.5 to V_{CC} +0.5 VDC
Operating Temperature	Ø to +65°C
Storage Temperature	Ø to +70°C
Relative Humidity (non condensing) @ 65°C	85%

Optoelectronic Characteristics @ 25°C

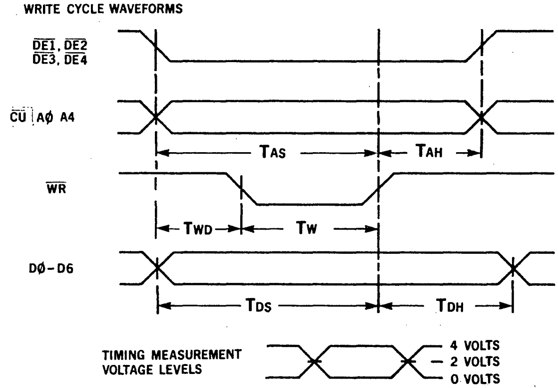
Parameter	Symbol	Min	Typ	Max	Units	Test Conditions
Supply Current/Digit	I_{CC}		25		mA	V_{CC} = 5.0 V (8 Segments/Digit)
Total (IDA-2416-16)	I_{CC}			650	mA	V_{CC} = 5.0 V (All Segments/Digit)
Total (IDA-2416-32)	I_{CC}			1250	mA	V_{CC} = 5.0 V (All Segments/Digit)
Supply Voltage	V_{CC}	4.75	5.00	5.25	V	
Input Voltage — High (All inputs)	V_{IH}	3.3			V	V_{CC} = 5.0 V ± .25 V
Input Voltage — Low (All inputs)	V_{IL}			0.8	V	V_{CC} = 5
Input Current — High (All inputs)	I_{IH}			40	μA	V_{CC} = 5.5 V, V_I = 2.4 V
Input Current — Low (All inputs)	I_{IL}			2.2	mA	V_{CC} = 5.5 V, V_I = 0.4 V
Luminous Intensity Average Per Digit	I_V		0.5		mcd	V_{CC} = 5.0 V (8 Segments/Digit)
Peak Wavelength	λ_{peak}		660		nm	
Viewing Angle			±45		Deg	Vertical & Horizontal From Normal To Display Plane

Switching Characteristics @ 5 V

Parameter @ 25°C	Symbol	Min	Units
Write Pulse	T_W	350	nS
Address/DE Setup Time	T_{AS}	550	nS
Data Setup Time	T_{DS}	550	nS
Write Setup	T_{WD}	200	nS
Data Hold Time	T_{DH}	75	nS
Address/DE Hold Time	T_{AH}	75	nS
Clear Time	T_{CLR}	15	mS

TIMING CHARACTERISTICS

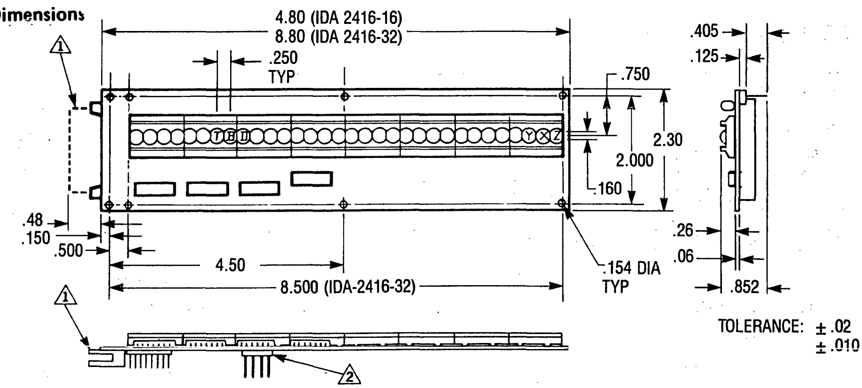
WRITE CYCLE WAVEFORMS



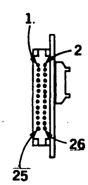
IDA 2416

Intelligent Display Devices

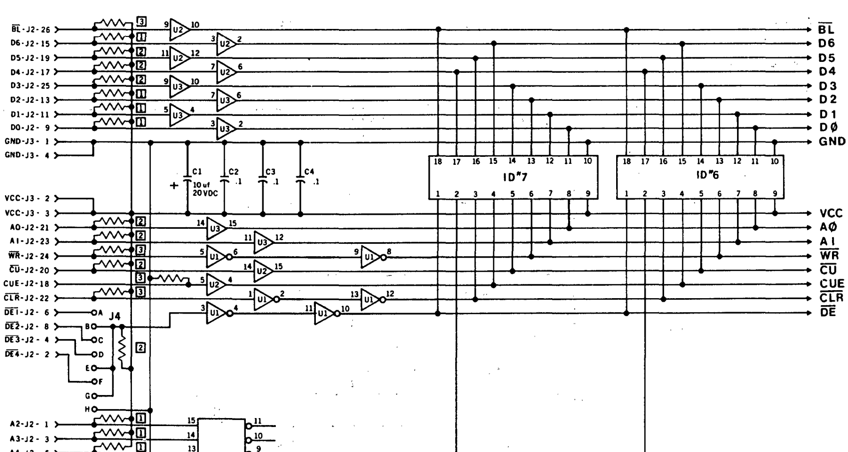
Physical Dimensions



RECOMMENDED MATING CONNECTOR			
Connector	**Function**	**Type**	**Suggested Mfg.**
△1 J2	Control/Data	26-Pin Ribbon	BERG P/N 65484-011
△2 J3	Power	AMP	PIN P/N 87026-2 HOUSING P/N 1-87025-3



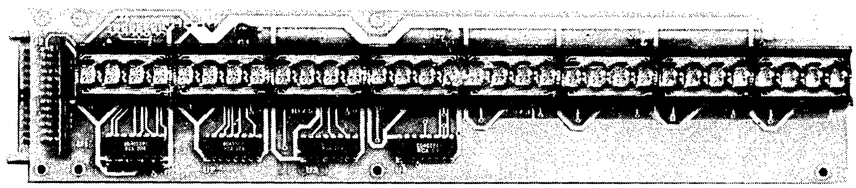
PIN	FUNCTION	PIN	FUNCTION
J2-1	A2 ADDRESS LINE	J2-14	NO CONNECTION
J2-2	$\overline{DE4}$ DISPLAY ENABLE	J2-15	D6 DATA LINE
J2-3	A3 ADDRESS LINE	J2-16	NO CONNECTION
J2-4	$\overline{DE3}$ DISPLAY ENABLE	J2-17	D4 DATA LINE
J2-5	A4 ADDRESS LINE	J2-18	CUE CURSOR ENABLE
J2-6	$\overline{DE1}$ DISPLAY ENABLE	J2-19	D5 DATA LINE
J2-7	NO CONNECTION	J2-20	$\overline{CU}$ CURSOR SELECT
J2-8	$\overline{DE2}$ DISPLAY ENABLE	J2-21	AØ ADDRESS LINE
J2-9	DØ DATA LINE	J2-22	$\overline{CLR}$ CLEAR
J2-10	NO CONNECTION	J2-23	A1 ADDRESS LINE
J2-11	D1 DATA LINE	J2-24	$\overline{WR}$ WRITE
J2-12	NO CONNECTION	J2-25	D3 DATA LINE
J2-13	D2 DATA LINE	J2-26	$\overline{BL}$ BLANKING
J3-1	GND	J3-3	VCC
J3-2	VCC	J3-4	GND



Note:
1. RESISTOR PART OF PACK R1 (1K)
2. RESISTOR PART OF PACK R2 (1K)
3. RESISTOR PART OF PACK R3 (1K)
5: UNUSED PINS OF J2 ARE: 7, 10, 12, 14 AND 16

IDA 2416

IDA 3416 Series
.225'' Red 17 Segment
DL 3416 Intelligent Display® ASSEMBLY



FEATURES

- 225 Mil High Magnified Monolithic Character
- Wide Viewing Angle ± 40°
- Complete Alphanumeric Display Assembly Utilizing the DL 3416
  - Built-in Multiplex and LED Drive Circuitry
  - Built-in Memory
  - Built-in Character Generator
- Displays 64 Character ASCII Set
- Direct Access to Each Digit Independently
- Display Blank Function
- Memory Clear Function
- Cursor Function
- Choice of 16, 20 or 32 Character Display Length (Other lengths optional)
- Single 5.0 Volt Power Supply
- TTL Compatible
- Easily Interfaced to a Microprocessor
- Schmitt Trigger Inputs on Data and Write Lines

The IDA 3416 Series Assembly is an extension of the very easy-to-use DL 3416 Intelligent Display. This product provides the designer with circuitry for display maintenance. It also minimizes interaction and interface normally required between the user's system and a multiplexed alphanumeric display.

The assembly consists of DL 3416's in a single row together with decoder and interface buffers on a single printed circuit board. Each DL 3416 provides its own memory, ASCII ROM character decoder, multiplexing circuitry, and drivers for its four 17-segment LED's.

Intelligent Display Assemblies can be used for applications such as data terminals, controllers, instruments, and other products which require an easy to use alphanumeric display.

Specifications are subject to change without notice.

Part Number	Description
IDA 3416-16	Single Line 16 Character Alphanumeric Display Utilizing the DL 3416
IDA 3416-20	Single Line 20 Character Alphanumeric Display Utilizing the DL 3416
IDA 3416-32	Single Line 32 Character Alphanumeric Display Utilizing the DL 3416

For Custom Lengths, in Increments of 4 Characters, Consult the Factory.

IDA 3416 Series

Maximum Ratings	
V_{CC}	6.0 V
Voltage applied to any input	-0.5 to V_{CC} +0.5 VDC
Operating Temperature	0 to +65°C
Storage Temperature	-20 to +70°C

Optoelectronic Characteristics @ 25°C

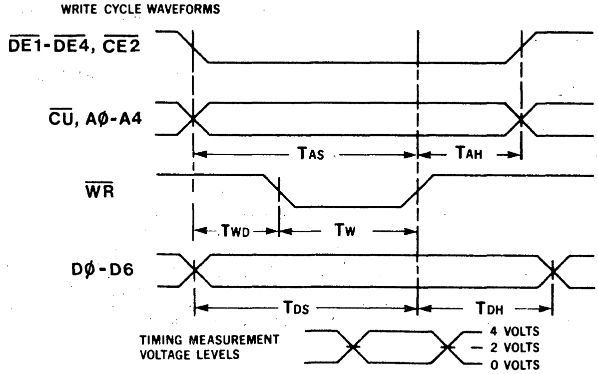
Parameter	Symbol	Min	Typ	Max	Units	Test Conditions
Supply Current/Digit	I_{CC}		25		mA	V_{CC} = 5.0 V (8 Segments/Digit)
Supply Current/Digit	I_{CC}			6	mA	V_{CC} = 5.0 V (Display Blank) V_{IN} = 0V, $\overline{WR}$ = 5V
Total (IDA-3416-16)	I_{CC}			850	mA	V_{CC} = 5.0 V (All Segments/Digit) (See Note 2)
Total (IDA-3416-20)	I_{CC}			1050		V_{CC} = 5.0 V (All Segments/Digit) (See Note 2)
Total (IDA-3416-32)	I_{CC}			1680	mA	V_{CC} = 5.0 V (All Segments/Digit) (See Note 2)
Supply Voltage	V_{CC}	4.75	5.00	5.25	V	
Input Voltage — High (All inputs)	V_{IH}	3.5			V	V_{CC} = 5.0 V ± .25 V
Input Voltage — Low (All inputs)	V_{IL}			0.8	V	V_{CC} = 5
Input Current — High (All inputs)	I_{IH}			40	µA	V_{CC} = 5.5 V, V_I = 2.4 V
Input Current — Low (All inputs)	I_{IL}			6.4	mA	V_{CC} = 5.5 V, V_I = 0.4 V
Luminous Intensity Average Per Digit	I_V		0.8		mcd	V_{CC} = 5.0 V (8 Segments/Digit)
Peak Wavelength	λ_{peak}		660		nm	
Viewing Angle			±40		Deg	Vertical & Horizontal From Normal To Display Plane

Switching Characteristics @ 5 V

Parameter @ 25°C	Symbol	Min	Units
Write Pulse	T_W	350	nS
Address/DE Setup Time	T_{AS}	550	nS
Data Setup Time	T_{DS}	550	nS
Write Setup	T_{WD}	200	nS
Data Hold Time	T_{DH}	75	nS
Address/DE Hold Time	T_{AH}	75	nS
Clear Time	T_{CLR}	15	mS

TIMING CHARACTERISTICS

WRITE CYCLE WAVEFORMS



IDA 3416

System Overview

The Intelligent Display Assembly offers the designer a choice of either 16, 20 or 32 alphanumeric characters and operates from just a +5V supply. Based on the DL 3416 four-character Intelligent Display, the IDA 3416 adds all the support logic required for direct connection to most microprocessor buses. The system interface takes place through a 20 or 26-pin connector, which has available on it the data and address lines as well as the control signals needed. One additional connector is used for the power and ground connections.

System Power Requirements

Operating from a single +5-V power supply, the IDA 3416 Series Assembly requires a typical operating current of 30 mA per digit with eight of the segments lit on each character. For the worst case condition with all segments lit, the current is 52 mA per digit and with the display blank the current is 6 mA per digit.

Display Interface

The display interface available on the 20 or 26-pin connector consists of seven data lines (DØ to D6), five address lines (AØ to A4), and various control signals. All address, data, and control lines have either pull-up or pull-down 1K ohm resistors. $\overline{BL}$ (Blanking, active low): When this line is pulled low, it causes the entire IDA display to go blank without affecting the contents of the display memory on the DL 3416s. $\overline{BL}$ is active regardless of address or display enable lines. A flashing display can be realized by pulsing this line. $\overline{WR}$ (Write, active low): To store a character in the display memory, this line must be pulsed low for a minimum write time. See timing diagram for timing & relationships to other signals.

CUE (Cursor Enable, active high): When high, this line permits the cursor to be displayed (see Note 2), and when brought low, it disables the cursor function without affecting the stored value. CUE is active regardless of address or display enable lines. A flashing cursor can be created by pulsing the CUE line low.

$\overline{CU}$ (Cursor Select, active low): The cursor function (character with all segments lit) is loaded by selecting the digit address and holding $\overline{CU}$ true. A "1" on DØ inserts the cursor. A "Ø" on DØ removes the cursor. The change occurs during a write pulse per the timing diagram.

$\overline{CLR}$ (Clear, active low): When held low for one display multiplex cycle (see DL 3416 data sheet for more information) of 15 ms, this line will cause all stored characters in the display, except for the cursor, to be cleared. $\overline{CLR}$ is active regardless of address or display enable lines.

$\overline{CE2}$ (Chip Enable, Active Low): To store a character in the display memory, this line must be held low at least 550 nanoseconds preceding the leading edge of the $\overline{WR}$ pulse.

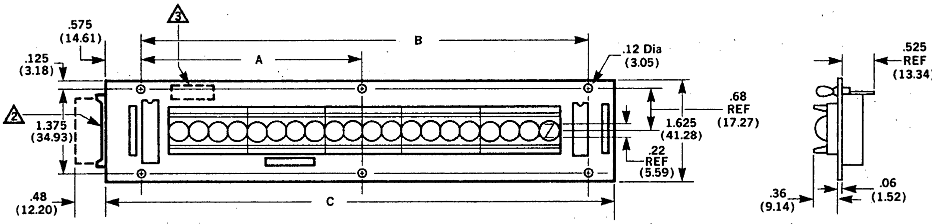
Address lines AØ to A4 are set up so that the right-most character is the lowest address. The left-most character is the highest address. Data lines are set up so that DØ is the least significant bit and D6 is the most significant bit.

Using the Display Interface

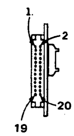
Through the use of memory-mapped I/O techniques, the IDA can be treated almost like a memory location — supply the data, address and proper control signals and the characters appear, with each character location independently addressable. The basic signal flow sequence to load a character would start with the address lines going to the desired address while the $\overline{CLR}$ and $\overline{BL}$ lines are high to permit the data to be loaded in and displayed. After the address has stabilized, the data can change to the desired values (including the cursor). After the data have stabilized, the $\overline{WR}$ pulse is started, and must remain low for at least 350 ns. Signals must be held stable for 75 ns, minimum, after the rising edge of the $\overline{WR}$ pulse to ensure correct loading, while the addresses must be stable for 550 ns preceding the same rising edge of the $\overline{WR}$ pulse. See the timing diagram for a pictorial explanation.

Notes:
1) CMOS Handling precaution — App Note 18
2) Cursor should not be on longer than 60 sec.
3) Cleaning solvents — use NO alcohol

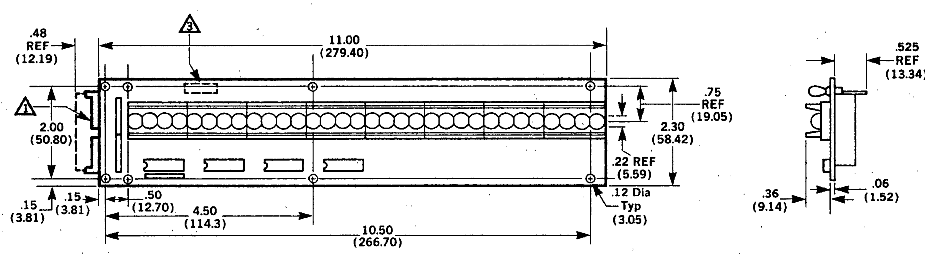
IDA3416 Physical Dimensions

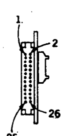


PRODUCT	A	B	C
IDA 3416-16	3.00 (76.20)	6.00 (152.40)	6.95 (176.58)
IDA 3416-20	3.65 (92.71)	7.30 (185.42)	8.25 (209.55)



PIN	FUNCTION	PIN	FUNCTION
J2-1	D6 DATA LINE	J2-11	D1 DATA LINE
J2-2	BL BLANKING	J2-12	CE2 CHIP ENABLE
J2-3	D5 DATA LINE	J2-13	D0 DATA LINE
J2-4	UNUSED	J2-14	CU CURSOR SELECT
J2-5	D4 DATA LINE	J2-15	WR WRITE
J2-6	A1 ADDRESS LINE	J2-16	CUE CUSOR ENABLE
J2-7	D3 DATA LINE	J2-17	A3 ADDRESS LINE
J2-8	A0 ADDRESS LINE	J2-18	UNUSED
J2-9	D2 DATA LINE	J2-19	A4 ADDRESS LINE
J2-10	CLR CLEAR	J2-20	A2 ADDRESS LINE
J3-1	GND	J3-3	VCC
J3-2	VCC	J3-4	GND





PIN	FUNCTION	PIN	FUNCTION
J2-1	A2 ADDRESS LINE	J2-14	NO CONNECTION
J2-2	DE4 DISPLAY ENABLE	J2-15	D6 DATA LINE
J2-3	A3 ADDRESS LINE	J2-16	NO CONNECTION
J2-4	DE3 DISPLAY ENABLE	J2-17	D4 DATA LINE
J2-5	A4 ADDRESS LINE	J2-18	CUE CURSOR ENABLE
J2-6	DE1 DISPLAY ENABLE	J2-19	D5 DATA LINE
J2-7	NO CONNECTION	J2-20	CU CURSOR SELECT
J2-8	DE2 DISPLAY ENABLE	J2-21	A0 ADDRESS LINE
J2-9	D0 DATA LINE	J2-22	CLR CLEAR
J2-10	NO CONNECTION	J2-23	A1 ADDRESS LINE
J2-11	D1 DATA LINE	J2-24	WR WRITE
J2-12	NO CONNECTION	J2-25	D3 DATA LINE
J2-13	D2 DATA LINE	J2-26	BL BLANKING
J3-1	GND	J3-3	VCC
J3-2	VCC	J3-4	GND

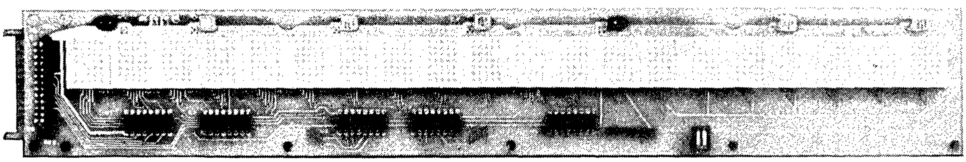
RECOMMENDED MATING CONNECTOR

Connector	Function	Type	Suggested Mfg.
1 J2	Control/Data	20 Pin Ribbon	BERG P/N 65496-007
2 J2	Control Data	26 Pin Ribbon	BERG P/N 65484-011
3 J3	Power	AMP	PIN P/N 87026-2 HOUSING P/N 1-87025-3

SIEMENS

HIGH EFFICIENCY RED IDA 7135 Series
Green IDA 7137 Series

.68" HIGH, 5×7 DOT MATRIX Intelligent Display® ASSEMBLY



FEATURES

- **A Complete Alphanumeric Display Assembly Utilizing the DLX713X Series 5 x 7 Dot Matrix Display**
  - **Built-in Multiplex and LED Drive Circuitry**
  - **Built-in Memory**
  - **Built-in Character Generator**
- **Displays 96 Character ASCII Set, Including Both Upper and Lower Case Characters**
- **Direct Access to Each Digit Independently**
- **Three Brightness Levels**
- **Display Blank Function**
- **Lamp Test Function**
- **Wide Viewing Angle, ±50°**
- **Readable in High Ambient Lighting**
- **Available in High Efficiency Red and Green**
- **Choice of 16 or 20 Character Display Lengths**
- **Single 5.0 Volt Power Supply Requirement**
- **Easily Interfaced to a Microprocessor**
- **TTL Compatible**
- **Fully Buffered Inputs**

DESCRIPTION

The IDA 713X Series Assembly is an extension of the single character DLX 713X, 5×7 fully intelligent dot matrix display. This display assembly provides the designer with circuitry for display maintenance, while minimizing the interaction and interface normally required between the user's system and a multiplexed alphanumeric display.

The assembly consists of DLX 713X's in a single row, together with the necessary address decoders and interface buffers, on a single printed circuit board. Each DLX 713X provides its own memory, ASCII ROM character generator, multiplexing circuitry, and drivers for the 35 LED dots.

Intelligent Display Assemblies can be used for applications such as P.O.S. terminals, message systems, industrial equipment, instrumentation, and any other products requiring a large, easily readable, "user friendly", alphanumeric display.

For additional information refer to Appnote 25.
For cleaning we recommend De-ionized water, Isopropyl Alcohol, Freon TE or Freon TF.

Important: Refer to Appnote 18, "Using and Handling Intelligent Displays." Since this is a CMOS device, normal precautions should be taken to avoid static damage.

Specifications are subject to change without notice.

Part Number	COLOR	Description
IDA 7135-16	Hi. Effi. Red	Single Line, 16 Character Alphanumeric Display Utilizing the DLO 7135
IDA 7137-16	Green	Single Line, 16 Character Alphanumeric Display Utilizing the DLG 7137
IDA 7135-20	Hi. Effi. Red	Single Line, 20 Character Alphanumeric Display Utilizing the DLO 7135
IDA 7137-20	Green	Single Line, 20 Character Alphanumeric Display Utilizing the DLG 7137

MAXIMUM RATINGS

V_{CC} .... 6.0 V
Voltage applied to
any input .... − 0.5 to V_{CC} + 0.5VDC
Operating Temperature .... 0 °C to + 65 °C
Storage Temperature .... − 20 °C to + 65 °C
Relative Humidity
(non condensing) @ 65 °C 85%

SWITCHING CHARACTERISTICS @ 5V

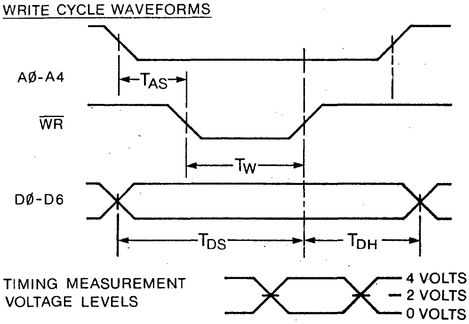
Parameter @ 25°C	Symbol	Minimum	Units
Write Pulse	T_W	200	ns
Data Setup Time	T_{DS}	230	ns
Hold Time	T_{DH}	100	ns
Address Setup	T_{AS}	30	ns

OPTOELECTRONIC CHARACTERISTICS AT 25°C

Parameter	Symbol	Min	Typ	Max	Units	Test Conditions
Supply Current/Digit	I_{CC}		170	220	mA	V_{CC} = 5.0 V, $\overline{BL0}$ = $\overline{BL1}$ = 1
Supply Current/Digit (Blank)	I_{CC}		5	10	mA	V_{CC} = 5.0 V, $\overline{BL0}$ = $\overline{BL1}$ = 0
Supply Current/Digit	I_{CC}		85		mA	V_{CC} = 5.0 V, $\overline{BL0}$ = 0, $\overline{BL1}$ = 1
Supply Current/Digit	I_{CC}		42		mA	V_{CC} = 5.0 V, $\overline{BL0}$ = 1, $\overline{BL1}$ = 0
Supply Voltage	V_{CC}	4.75		5.25	VDC	
Input Voltage-High (All inputs)	VIH	2.7			VDC	V_{CC} = 5.0V ± .25V
Input Voltage-Low (All inputs)	V_{IL}			1.0	VDC	V_{CC} = 5.0V
Input Current	I_{IL}			160	uA	V_{CC} = 5.0V
Luminous Intensity/Dot Average	I_V		250		μCD	V_{CC} = 5.0V
Peak Wave Length						
IDA 7137			565 (Green)		nm	
IDA 7135			640 (Hi. Effi. Red)		nm	
Viewing Angle			±50°		Deg	

TIMING CHARACTERISTICS

WRITE CYCLE WAVEFORMS



SYSTEM OVERVIEW

The Intelligent Display Assembly offers the designer a choice of either 16 (IDA 713X-16) or 20 (IDA 713X-20) alphanumeric characters. Based on the DLX713X intelligent dot matrix display, the IDA 713X adds all the support logic required for direct connection to most microprocessor buses. The system interface takes place through a 26 pin connector, which has the data and address lines as well as the control signals available on it. One additional connector is used for the power and ground connections.

SYSTEM POWER REQUIREMENTS

Operating from a single + 5V power supply, the IDA 713X-16 requires a typical operating current of 2720 mA at brightest level. For the 20 character assembly, typical operating current is 3400 mA. For worst case conditions, the 16 character assembly draws 3520 mA, while the 20 character assembly draws 4400 mA. With the display blanked, the board circuitry for the 16 character assembly draws 80 mA, and the 20 character assembly draws 100 mA.

DISPLAY INTERFACE

The display interface available on the 26 pin connector consists of seven data lines (D0 to D6),* five address lines (A0 to A4, see Note 3), two brightness inputs ($\overline{BL0}$ to $\overline{BL1}$), lamp test ($\overline{LT}$), the Chip Enable ($\overline{CE}$), and the Write line ($\overline{WR}$). All address and data lines have 1K ohm pull up resistors.

$\overline{BL0}$ and $\overline{BL1}$ (Brightness, active low): When both of these are pulled low, it causes the entire IDA display to go blank without affecting the contents of the display memory on the DLX713X's. $\overline{BL}$ is active regardless of address or display enable lines. These two lines are used to vary the intensity of the display to one of four levels.

$\overline{WR}$ (Write, active low): To store a character in the display memory, this line must be pulsed low for a minimum of 200 ns. See timing diagram for timing and relationships to other signals.

$\overline{LT}$ (Lamp test, active low): This line can be activated to light all display dots.

*For IDA 713X-16 only.
Four address bits are used.

DIMMING AND BLANKING THE DISPLAY

Brightness Level	$\overline{BL1}$	$\overline{BL0}$
Blank	0	0
¼ Brightness	0	1
½ Brightness	1	0
Full Brightness	1	1

USING THE DISPLAY INTERFACE

Through the use of memory-mapped I/O techniques, the IDA can be treated almost like a memory location—supply the data, address and proper control signals and the characters appear, with each character location independently addressable. The basic signal flow sequence to load a character would start with the address lines going to the desired address. After the address has stabilized, the data can change to the desired values. After the data has stabilized, the $\overline{WR}$ pulse is started and must remain low for at least 200 ns to ensure correct loading. See the timing diagram for a pictorial explanation. Either $\overline{BL0}$ or $\overline{BL1}$ should be held high for displays to light up.

LAMP TEST

The lamp test ($\overline{LT}$) when activated causes all dots on the display to be illuminated at half brightness. The lamp test function is independent of write ($\overline{WR}$) and the settings of the blanking inputs ($\overline{BL0}$), $\overline{BL1}$).

This convenient test gives a visual indication that all dots are functioning properly. Lamp test may also be used as a cursor function or pointer which does not destroy previously displayed characters.

IDA 713X XX* DIGIT ADDRESSING TRUTH TABLE

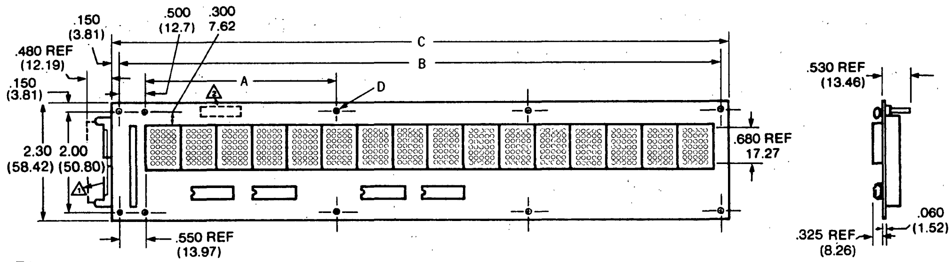
Address Bit					Device Addressed
A4	A3	A2	A1	A0	
0	0	0	0	0	0
0	0	0	0	1	1
0	0	0	1	0	2
0	0	0	1	1	3
0	0	1	0	0	4
0	0	1	0	1	5
0	0	1	1	0	6
0	0	1	1	1	7
0	1	0	0	0	8
0	1	0	0	1	9
0	1	0	1	0	10
0	1	0	1	1	11
0	1	1	0	0	12
0	1	1	0	1	13
0	1	1	1	0	14
0	1	1	1	1	15
1	0	0	0	0	16
1	0	0	0	1	17
1	0	0	1	0	18
1	0	0	1	1	19

*Entire area is for 20 characters, smaller portion is for 16 characters.

Rightmost character is digit 0.

CHARACTER SET

			D0	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H
			D1	L	L	H	H	L	L	H	H	L	L	H	H	L	L	H	H
			D2	L	L	L	L	H	H	H	H	L	L	L	L	H	H	H	H
			D3	L	L	L	L	L	L	L	L	H	H	H	H	H	H	H	H
D6	D5	D4	HEX	Ø	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
L	L	L	Ø	THESE CODES DISPLAY BLANK															
L	L	H	1																
L	H	L	2		!	"	#	$	%	&	'	(	)	*	+	,	-	.	/
L	H	H	3	0	1	2	3	4	5	6	7	8	9	:	;	<	=	>	?
H	L	L	4	@	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
H	L	H	5	P	Q	R	S	T	U	V	W	X	Y	Z	[	\	]	^	_
H	H	L	6	`	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o
H	H	H	7	p	q	r	s	t	u	v	w	x	y	z	{	|	}	~	▒



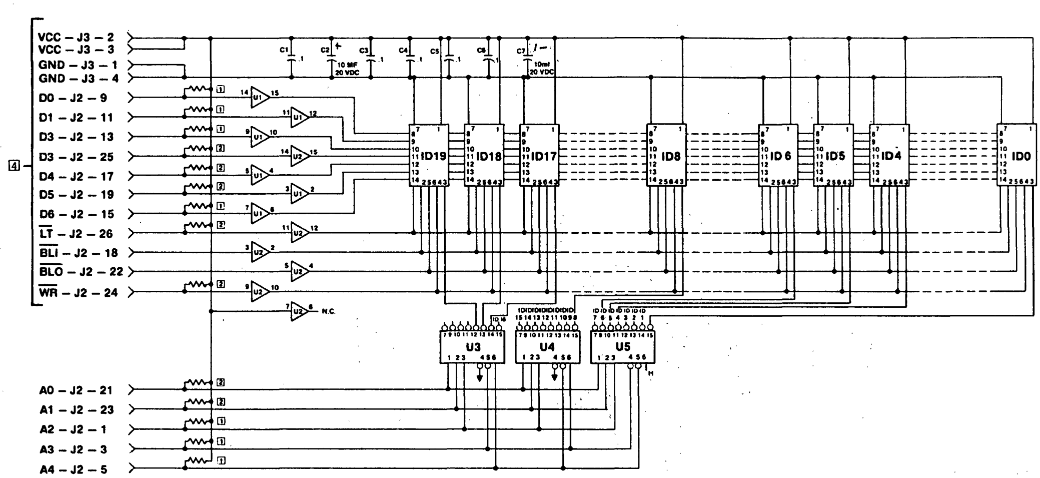
(Tolerance ± .01)

Pin	Function	Pin	Function
J2-1	A2 Address Line	J2-14	No Connection
J2-2	No Connection	J2-15	D6 Data Line
J2-3	A3 Address Line	J2-16	No Connection
J2-4	No Connection	J2-17	D4 Data Line
J2-5	A4 Address Line	J2-18	BL1 Brightness
J2-6	No Connection	J2-19	D5 Data Line
J2-7	No Connection	J2-20	No Connection
J2-8	No Connection	J2-21	A0 Address Line
J2-9	D0 Data Line	J2-22	BLO Brightness
J2-10	No Connection	J2-23	A1 Address Line
J2-11	D1 Data Line	J2-24	WR Write
J2-12	No Connection	J2-25	D3 Data Line
J2-13	D2 Data Line	J2-26	LT Lamp Test
J3-1	GND Ground	J3-3	V_{CC}
J3-2	V_{CC}	J3-4	GND Ground

Product	A	B	C	D
IDA 7135-16 IDA 7137-16	3.80 Typ. (96.52)	11.90 (302.26)	12.20 (309.88)	.120 Typ 10 places (3.05)
IDA 7135-20 IDA 7137-20	3.55 Typ (90.17)	14.70 (373.38)	15.00 (381.00)	.155 Typ 12 places (3.94)

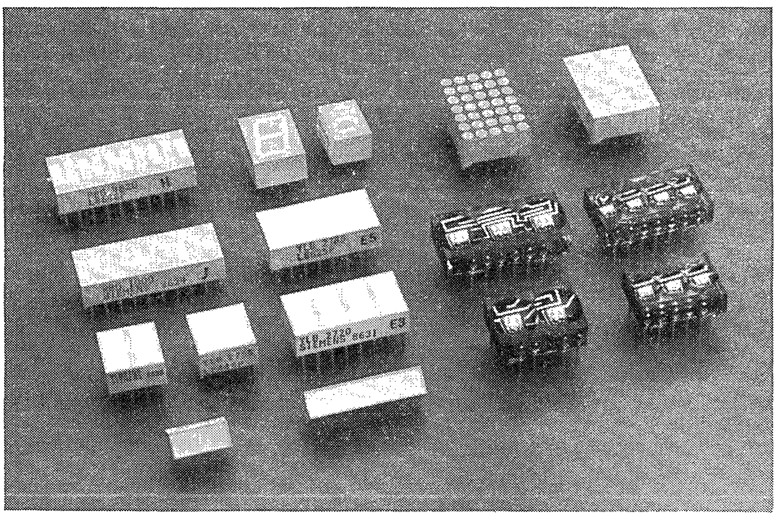
RECOMMENDED MATING CONNECTOR

Connector	Function	Type	Suggest Mfg.
△1 J2	Control/Data	26-Pin Ribbon	BERG P/N 65948-011
△2 J3	Power	AMP	PIN P/N 87026-2 HOUSING P/N 1-87025-3



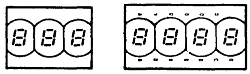
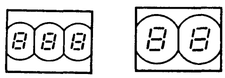
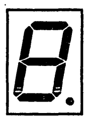
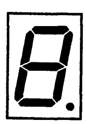
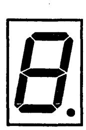
NOTE: 1 Part of Resistor Pack RP1 (IK SIP)
2 Part of Resistor Pack RP2 (IK SIP)
3 Address bits A0–A4 are decoded by ICs, U3–U5 to enable ID0–ID19.
4 All like lines on all displays are tied together; e.g., LT, WR, BL1, BLO, etc.

IDA 7135

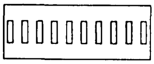
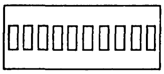


Numeric Displays
Bar Graphs
Light Bars

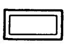
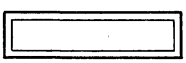
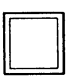
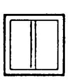
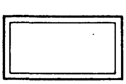
LED Numeric Displays

Package Type	Package Outline	Part Number	Character Height	Description	Polarity	Color	Luminous Intensity per Segment µcd (typ.)	Luminous Intensity per Segment mA	Page
Multi-digit magnified monolithic		DL-330M	.11" (2.8mm)	7 seg. 3 digit	C.C. Multiplex	Red	2500 per digit	5	3–4
		DL-340M		7 seg. 4 digit					
		DL-430M	.15" (3.8mm)	7 seg. 3 digit					
		DL-440M		7 seg. 2 digit					
Compact single digit encapsu-lated (filled reflector)		HD1075R	.28" (7mm)	7 segment, D.P. right	C.A	Red	800	20	3–6
		HD1077R			C.C.				
		HD1075O			C.A.	High Eff.Red	1000	15	
		HD1077O			C.C.				
		HD1075Y			C.A.	Yellow	900		
		HD1077Y			C.C.				
		HD1075G			C.A.	Green	1000		
		HD1077G			C.C.				
Compact single digit encapsu-lated (filled reflector)		HD1105R	.39" (10 mm)	7 segment, D.P. right	C.A	Red	1000	25	3–8
		HD1107R			C.C.				
		HD1105O			C.A.	High Eff.Red		15	
		HD1107O			C.C.				
		HD1105Y			C.A.	Yellow	900		
		HD1107Y			C.C.				
		HD1105G			C.A.	Green	1000		
		HD1107G			C.C.				
Compact single digit encapsu-lated (filled reflector)		HD1131R	.53" (13.5 mm)	7 segment, D.P. right	C.A	Red	1400	35	3–10
		HD1133R			C.C.				
		HD1131O			C.A.	High Eff.Red		20	
		HD1133O			C.C.				
		HD1131Y			C.A.	Yellow	1300		
		HD1133Y			C.C.				
		HD1131G			C.A.	Green	1400		
		HD1133G			C.C.				

Bar Graphs

Package Type	Package Outline	Part Number	Color	Light Emitting Area	Polarity	Luminous Intensity Per Segment µcd (typ.)	mA	Page
10 Element Encapsu-lated (filled reflector DIP)		RBG-1000	Red	.04 x .15"	Separately address-able anode and cathode	500	20	3–18
		OBG-1000	High Eff.Red			2500		
		YBG-1000	Yellow			2000		
		GBG-1000	Green					
		RBG-4820	Red	.06 x .20"		500		3–20
		OBG-4830	High Eff.Red			2500		
		YBG-4840	Yellow			2000		
		GBG-4850	Green					

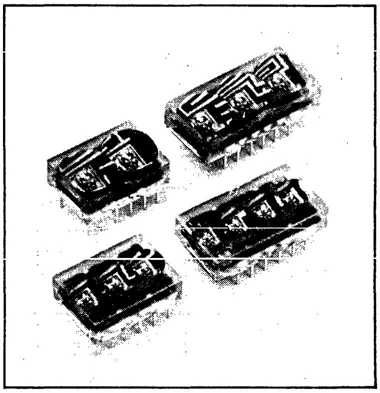
Light Bars

Package Type	Package Outline	Part Number	Color	Light Emitting Area	Description	Luminous Intensity mcd (typ.)	mA	Page
Small rec-tangular. Rugged encapsu-lated.		OLB-2300	High Eff. Red	.15 x .35"	Two die light bar.	10	20 per each die	3–12
		YLB-2400	Yellow			6		
		GLB-2500	Green			10		
Large rec-tangular. Rugged encapsu-lated.		OLB-2350	High Eff. Red	.15 x .75"	Four die light bar (1x4).	20	20 per each die	3–13
		YLB-2450	Yellow			12		
		GLB-2550	Green			20		
Square. Rugged encapsu-lated.		OLB-2655	High Eff. Red	.35 x .35"	Four die light bar.	20	20	3–16
		YLB-2755	Yellow			12		
		GLB-2855	Green			20		
Square. Rugged encapsu-lated.		OLB-2600	High Eff. Red	.15 x .35"	Four die light bar with mechanical barrier creating 2 isolated rectangular light emitting areas (2x2).	10	20 per each die	3–14
		YLB-2700	Yellow			6		
		GLB-2800	Green			10		
Large rec-tangular. Rugged encapsu-lated.		OLB-2685	High Eff. Red	.35 x .75"	Eight die light bar .	40	20	3–17
		YLB-2785	Yellow			24		
		GLB-2885	Green			40		
Large rec-tangular, 4 section Rugged encapsu-lated.		OLB-2620	High Eff. Red	.15 x .35"	Eight die light bar with mechanical barrier creating 4 isolated rectangu-lar light emitting areas (2x4).	10	20 per each die	3–15
		YLB-2720	Yellow			6		
		GLB-2820	Green			10		

SIEMENS

.11″ 3 DIGIT DL-330M
.11″ 4 DIGIT DL-340M
.15″ 3 DIGIT DL-430M
.15″ 2 DIGIT DL-440M

RED SEVEN SEGMENT MAGNIFIED MONOLITHIC NUMERIC DISPLAY



FEATURES

- **Rugged Encapsulated Package**
- **Integrated Magnifier Lens**
- **Monolithic Construction for Maximum Brightness at Minimum Power**
- **Common Cathode for Simplicity of Multiplexing**
- **Standard Dual-In-Line Package**
- **Categorized for Brightness Uniformity**

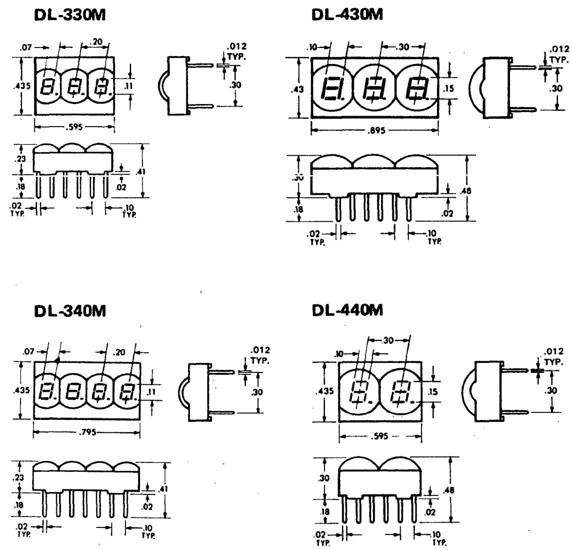
DESCRIPTION

The DL-330M/340M and DL-430M/440M are red numeric LED displays. Low cost is achieved through minimum use of monolithic GaAsP material and magnification to full height using a simple integrated lens construction. A red plexiglass or circularly polarized filter is recommended to enhance visibility and to eliminate glare from the surface of the package.

These displays are designed for multiplex operation, the desired digit being displayed by selecting the appropriate cathode. A right hand decimal point is provided.

All devices are optimized for low power portable battery operated equipment using MOS and CMOS integrated logic circuits such as DMM's and digital thermometers.

Package Dimensions in Inches (mm)

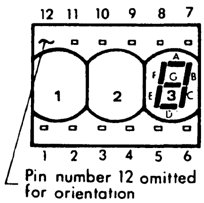


Maximum Ratings: (at 25°C)

Power Dissipation	320 mW
Derating Factor from 25°C/Digit	4.3 mW/ °C
Storage and Operating Temperature	−20°C to +70°C
Continuous Forward Current Per Segment and Decimal	7 mA
Peak Inverse Voltage per Segment and Decimal	3 V
Peak Pulse Current (10μS)	50 mA

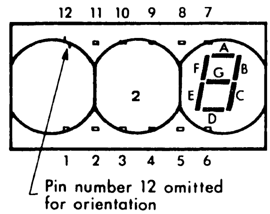
Optoelectronic Characteristics (at 25°C)

Parameter	Min	Typ	Max	Unit	Test Condition
Luminous Intensity (Total Digit)	1.0	2.5		mcd	I_F = 5 mA/seg.
Emission Peak Wavelength			660	nm	
Line Half-Width	40			nm	
Forward Voltage		1.7	2.0		I_F = 20 mA/digit
					V = 0
Reverse Current			100	μA	V_R = 3.0 V



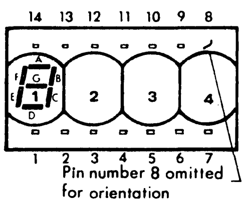
DL-330M

Pin	Function
1	Cathode D1
2	Anode E
3	Anode D
4	Cathode D2
5	Anode C
6	Anode DP
7	Cathode D3
8	Anode B
9	Anode G
10	Anode A
11	Anode F
12	No Pin



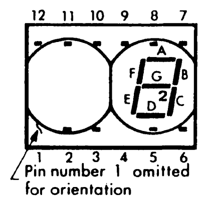
DL-430M

Pin	Function
1	Cathode D1
2	Anode E
3	Anode D
4	Cathode D2
5	Anode C
6	Anode DP
7	Cathode D3
8	Anode B
9	Anode G
10	Anode A
11	Anode F
12	No Pin



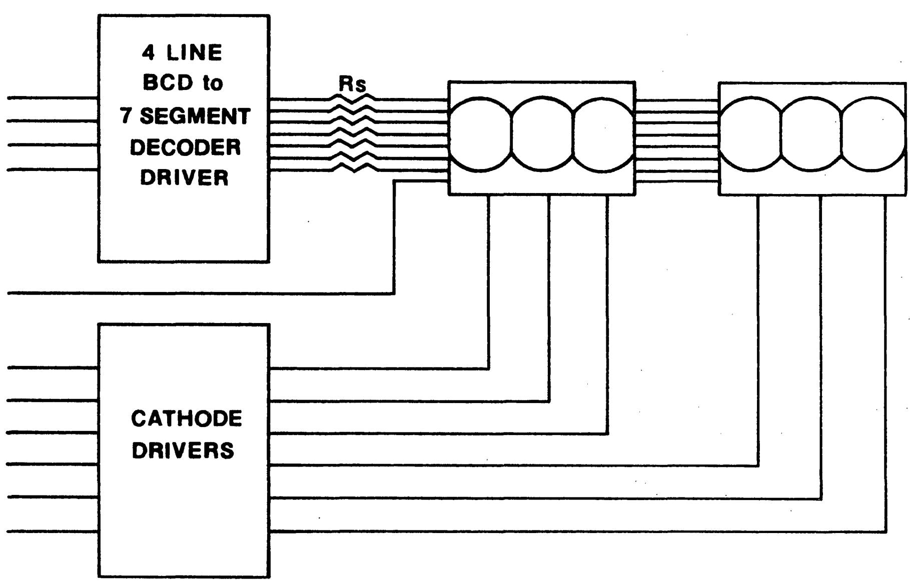
DL-340M

Pin	Function
1	No Connection
2	Anode E
3	Anode D
4	Anode C
5	Anode DP
6	Anode G
7	Cathode 4
8	No Pin
9	Anode B
10	Cathode 3
11	Anode F
12	Cathode 2
13	Anode A
14	Cathode 1



DL-440M

Pin	Function
1	No Pin
2	Anode E
3	Anode D
4	No Pin
5	Anode C
6	Anode DP
7	Cathode D2
8	Anode B
9	Anode G
10	Anode A
11	Anode F
12	Cathode D1

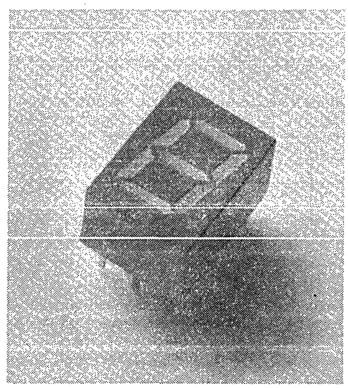


BLOCK DIAGRAM FOR TYPICAL DISPLAY DRIVE CIRCUITRY

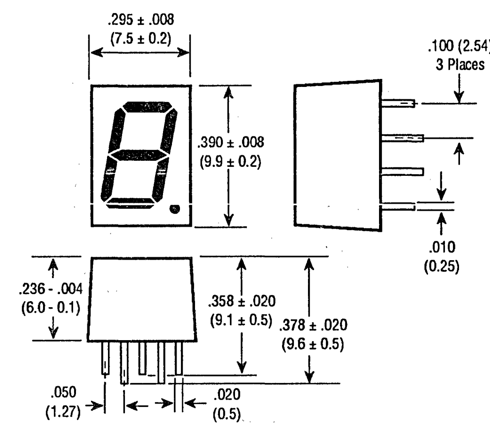
SIEMENS

RED HD1075R/1077R
HIGH EFFICIENCY RED HD1075O/1077O
YELLOW HD1075Y/1077Y
GREEN HD1075G/1077G

0.28″ (7 mm) SEVEN SEGMENT NUMERIC DISPLAY



Package Dimensions in Inches (mm)



FEATURES

- Rugged Encapsulated Package
- 0.28 Inch (7 mm) Digit Height
- Choice of Colors
- Common Anode or Common Cathode
- Wide Viewing
- Intensity Coded for Display Uniformity

DESCRIPTION

The HD1075X/1077X are displays with 0.28 inch (7 mm) digits with either a common anode or common cathode and a right hand decimal point.

These displays have good viewing and can be used in electronic instruments, point-of-sale systems, clocks, and other general industrial and consumer applications. All displays have a light grey face.

Contrast enhancement filters are recommended for use with all displays.

Product	Color	Description
HD1075R	Red	Common Anode, Right Decimal
HD1077R	Red	Common Cathode, Right Decimal
HD1075O	High Efficiency Red	Common Anode, Right Decimal
HD1077O	High Efficiency Red	Common Cathode, Right Decimal
HD1075Y	Yellow	Common Anode, Right Decimal
HD1077Y	Yellow	Common Cathode, Right Decimal
HD1075G	Green	Common Anode, Right Decimal
HD1077G	Green	Common Cathode, Right Decimal

Maximum Ratings

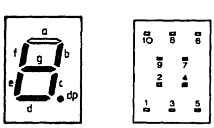
Power Dissipation per Segment (T_{amb}=45°C) .... 40 mW
Operating and Storage Temperature .... -40°C to +85°C
DC Forward Current per Segment (T_{amb}=45°C)
Red .... 15 mA
HER, Yellow, Green .... 20 mA
Surge Forward Current per segment (t_p≤10 µs, T_{amb}=45°C) .... 150 mA
Reverse Voltage .... 6 V
Thermal Resistance .... 170 K/W
Junction Temperature (less than 5 sec @ min distance of 2 mm) .... 100°C

See graph numbers 1, 2, 3A, 4, 5, 6A, 7, 8, 9, 10 on pages 22 and 23.

Optoelectronic Characteristics @25°C

Parameter	Symbol	Typ.	Max.	Units	Conditions
Luminous Intensity per segment [1]					
Red	I_V	450		µcd	I_F=10 mA
HER	I_V	1800		µcd	I_F=10 mA
Yellow	I_V	600		µcd	I_F=10 mA
Green	I_V	900		µcd	I_F=10 mA
Forward Voltage					
Red	V_F	1.6	2.0	V	I_F=10 mA
HER, Yellow, Green	V_F	2.0	2.6	V	I_F=10 mA
Reverse Current per segment	I_R	0.01	10	µA	V_R=6 V
Peak Emission Wavelength					
Red	λ_{PEAK}	660		nm	
HER	λ_{PEAK}	635		nm	
Yellow	λ_{PEAK}	586		nm	
Green	λ_{PEAK}	565		nm	
Dominant Wavelength					
Red	λ_{DOM}	645		nm	
HER	λ_{DOM}	628		nm	
Yellow	λ_{DOM}	590		nm	
Green	λ_{DOM}	567		nm	
Rise Time					
Red	t_R	120		ns	
HER, Yellow	t_R	300		ns	
Green	t_R	450		ns	
Fall Time					
Red	t_F	50		ns	
HER, Yellow	t_F	150		ns	
Green	t_F	200		ns	
Spectral Bandwidth @50% I_V					
Red	Δ_λ	35		nm	I_F=10 mA
HER, Yellow	Δ_λ	45		nm	I_F=10 mA
Green	Δ_λ	25		nm	I_F=10 mA
Capacitance per segment					
Red	C_0	25		pF	V_R=0 V, f=1 MHz
HER	C_0	12		pF	V_R=0 V, f=1 MHz
Yellow	C_0	10		pF	V_R=0 V, f=1 MHz
Green	C_0	15		pF	V_R=0 V, f=1 MHz

HD1075/1077



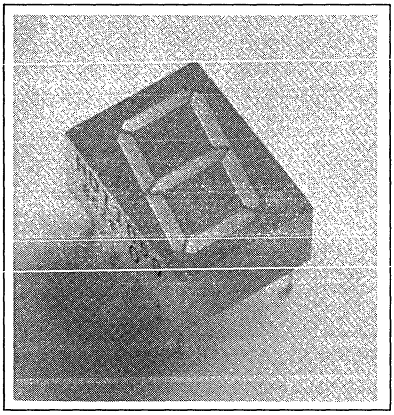
Pin	HD1075	Pin	HD1077
1	Cathode E	1	Anode E
2	Cathode D	2	Anode D
3	Common Anode	3	Common Cathode
4	Cathode C	4	Anode C
5	Cathode DP	5	Anode DP
6	Cathode B	6	Anode B
7	Cathode A	7	Anode A
8	Common Anode	8	Common Cathode
9	Cathode G	9	Anode G
10	Cathode F	10	Anode F

Note:
1. Deviation of the absolute values within one digit $I_{V MAX}/I_{V MIN} \leq 2$.

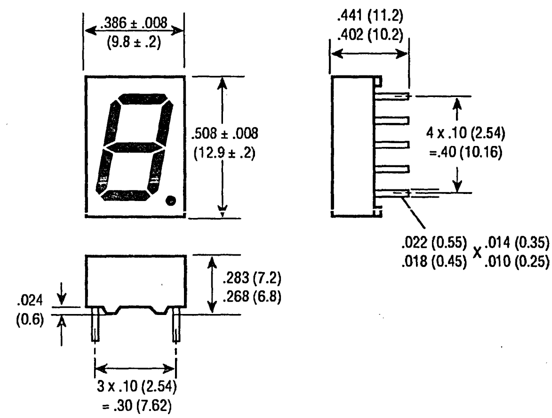
SIEMENS

RED HD1105R/1107R
HIGH EFFICIENCY RED HD1105O/1107O
YELLOW HD1105Y/1107Y
GREEN HD1105G/1107G

0.39″ (10 mm) SEVEN SEGMENT NUMERIC DISPLAY



Package Dimensions in Inches (mm)



FEATURES

- Rugged Encapsulated Package
- Large 0.39 Inch (10 mm) Digit Height
- Choice of Colors
- Common Anode or Common Cathode
- Wide Viewing
- Intensity Coded for Display Uniformity

DESCRIPTION

The HD1105X/1107X are displays with 0.39″ (10 mm) digits with either a common anode or common cathode and a right hand decimal point.

These displays were designed for viewing distances of up to 10 feet and can be used in electronic instruments, point-of-sale systems, clocks, and other general industrial and consumer applications. All displays have a light grey face.

Contrast enhancement filters are recommended for use with all displays.

Product	Color	Description
HD1105R	Red	Common Anode, Right Decimal
HD1107R	Red	Common Cathode, Right Decimal
HD1105O	High Efficiency Red	Common Anode, Right Decimal
HD1107O	High Efficiency Red	Common Cathode, Right Decimal
HD1105Y	Yellow	Common Anode, Right Decimal
HD1107Y	Yellow	Common Cathode, Right Decimal
HD1105G	Green	Common Anode, Right Decimal
HD1107G	Green	Common Cathode, Right Decimal

Maximum Ratings

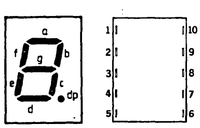
Power Dissipation per Segment (T_{amb}=45°C)	50 mW
Operating and Storage Temperature	-40°C to +85°C
DC Forward Current per Segment (T_{amb}=45°C)	17.5 mA
Peak Forward Current (t_p≤10 µs, T_{amb}=45°C)	150 mA
Reverse Voltage	6 V
Thermal Resistance (Junction to Air)	135 K/W
Junction Temperature	100°C

See graph numbers 1, 2, 3B, 4, 5, 6B, 7, 8, 9, 10 on pages 22 and 23.

Optoelectronic Characteristics @25°C

Parameter	Symbol	Typ.	Max.	Units	Conditions
Luminous Intensity per segment [1]					
Red	I_V	600		µcd	I_F=10 mA
HER	I_V	2300		µcd	I_F=10 mA
Yellow	I_V	900		µcd	I_F=10 mA
Green	I_V	1200		µcd	I_F=10 mA
Forward Voltage					
Red	V_F	1.6	2.0	V	I_F=10 mA
HER, Yellow, Green	V_F	2.0	2.6	V	I_F=10 mA
Reverse Current per segment	I_R	0.01	10	µA	V_R=6 V
Peak Emission Wavelength					
Red	λ_{PEAK}	660		nm	
HER	λ_{PEAK}	635		nm	
Yellow	λ_{PEAK}	586		nm	
Green	λ_{PEAK}	565		nm	
Dominant Wavelength					
Red	λ_{DOM}	645		nm	
HER	λ_{DOM}	628		nm	
Yellow	λ_{DOM}	590		nm	
Green	λ_{DOM}	567		nm	
Rise Time					
Red	t_R	120		ns	
HER, Yellow	t_R	300		ns	
Green	t_R	450		ns	
Fall Time					
Red	t_F	50		ns	
HER, Yellow	t_F	150		ns	
Green	t_F	200		ns	
Spectral Bandwidth @50% I_V					
Red	Δ_λ	35		nm	I_F=10 mA
HER, Yellow	Δ_λ	45		nm	I_F=10 mA
Green	Δ_λ	25		nm	I_F=10 mA
Capacitance per segment					
Red	C_0	25		pF	V_R=0 V, f=1 MHz
HER	C_0	12		pF	V_R=0 V, f=1 MHz
Yellow	C_0	10		pF	V_R=0 V, f=1 MHz
Green	C_0	15		pF	V_R=0 V, f=1 MHz

TOP VIEW



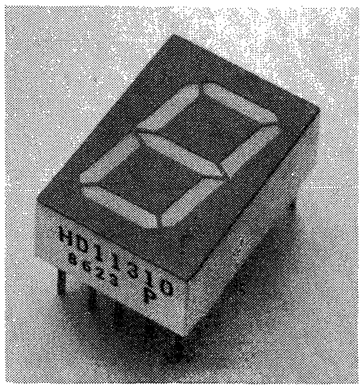
	HD1105		HD1107
1	Cathode G	1	Anode G
2	Cathode F	2	Anode F
3	Common Anode	3	Common Cathode
4	Cathode E	4	Anode E
5	Cathode D	5	Anode D
6	Cathode DP	6	Anode DP
7	Cathode C	7	Anode C
8	Common Anode	8	Common Cathode
9	Cathode B	9	Anode B
10	Cathode A	10	Anode A

Note:
1. Deviation of the absolute values within one digit $I_{V MAX}/I_{V MIN} \leq 2$.

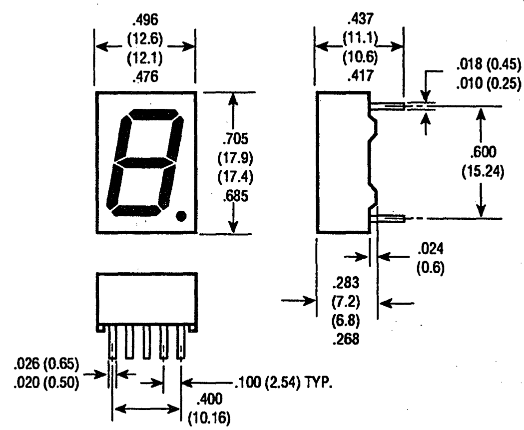
SIEMENS

RED HD1131R/1133R
HIGH EFFICIENCY RED HD1131O/1133O
YELLOW HD1131Y/1133Y
GREEN HD1131G/1133G

0.53″ (13.5 mm) SEVEN SEGMENT NUMERIC DISPLAY



Package Dimensions in Inches (mm)



FEATURES

- Rugged Encapsulated Package
- Large 0.53 Inch (13.5 mm) Digit Height
- Choice of Colors
- Common Anode or Common Cathode
- Wide Viewing
- Intensity Coded for Display Uniformity

DESCRIPTION

The 0.53 inch (13.5 mm) digit height series of HD1131/1133 Seven Segment Displays offer the choice of common anode or common cathode versions with right hand decimal point.

These displays were designed for viewing distances of up to 20 feet and can be used in electronic instruments, point-of-sale systems, clocks, and other general industrial and consumer applications. All displays have a light grey face.

Contrast enhancement filters are recommended for use with all displays.

Product	Color	Description
HD1131R	Red	Common Anode, Right Decimal
HD1133R	Red	Common Cathode, Right Decimal
HD1131O	High Efficiency Red	Common Anode, Right Decimal
HD1133O	High Efficiency Red	Common Cathode, Right Decimal
HD1131Y	Yellow	Common Anode, Right Decimal
HD1133Y	Yellow	Common Cathode ,Right Decimal
HD1131G	Green	Common Anode, Right Decimal
HD1133G	Green	Common Cathode, Right Decimal

Maximum Ratings

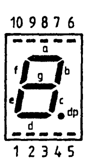
Power Dissipation per Segment (T_{amb}=45°C) .... 60 mW
Operating and Storage Temperature .... -40°C to +85°C
DC Forward Current per Segment (T_{amb}=45°C)
Red .... 35 mA
HER, Yellow, Green .... 20 mA
Peak Forward Current (t≤10 µs, T_{amb}=45°C)
Red .... 400 mA
HER, Yellow, Green .... 150 mA
Reverse Voltage .... 6 V
Thermal Resistance (Junction to Air) .... 115 K/W
Soldering Temperature (less than 5 sec @ min distance of 2 mm) .... 230°C

See graph numbers 1, 2, 3A, 4, 5, 6C, 7, 8, 9, 10 on pages 22 and 23.

Optoelectronic Characteristics @25°C

Parameter	Symbol	Typ.	Max.	Units	Conditions
Luminous Intensity per segment[1]					
Red	I_V	750		µcd	I_F=10 mA
HER	I_V	2900		µcd	I_F=10 mA
Yellow, Green	I_V	1500		µcd	I_F=10 mA
Forward Voltage					
Red	V_F	1.6	2.0	V	I_F=10 mA
HER, Yellow, Green	V_F	2.0	2.6	V	I_F=10 mA
Reverse Current per segment	I_R	0.01	10	µA	V_R=6 V
Peak Emission Wavelength					
Red	λ_{PEAK}	660		nm	
HER	λ_{PEAK}	635		nm	
Yellow	λ_{PEAK}	586		nm	
Green	λ_{PEAK}	565		nm	
Dominant Wavelength					
Red	λ_{DOM}	645		nm	
HER	λ_{DOM}	628		nm	
Yellow	λ_{DOM}	590		nm	
Green	λ_{DOM}	567		nm	
Rise Time					
Red	t_R	120		ns	
HER, Yellow	t_R	300		ns	
Green	t_R	450		ns	
Fall Time					
Red	t_F	50		ns	
HER, Yellow	t_F	150		ns	
Green	t_F	200		ns	
Spectral Bandwidth @50% I_V					
Red	Δ_λ	35		nm	I_F=10 mA
HER, Yellow	Δ_λ	45		nm	I_F=10 mA
Green	Δ_λ	25		nm	I_F=10 mA
Capacitance per segment					
Red	C_0	25		pF	V_R=0 V, f=1 MHz
HER	C_0	12		pF	V_R=0 V, f=1 MHz
Yellow	C_0	10		pF	V_R=0 V, f=1 MHz
Green	C_0	15		pF	V_R=0 V, f=1 MHz

HD1131/1133



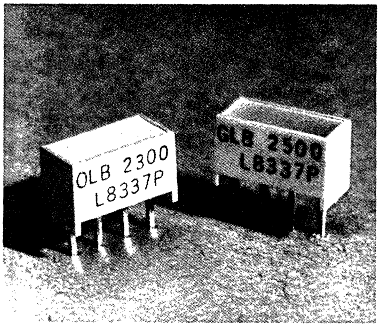
Pin	HD1131	Pin	HD1133
1	Cathode E	1	Anode E
2	Cathode D	2	Anode D
3	Common Anode	3	Common Cathode
4	Cathode C	4	Anode C
5	Cathode DP	5	Anode DP
6	Cathode B	6	Anode B
7	Cathode A	7	Anode A
8	Common Anode	8	Common Cathode
9	Cathode F	9	Anode F
10	Cathode G	10	Anode G

Num. Displays Bar Graphs Light Bars

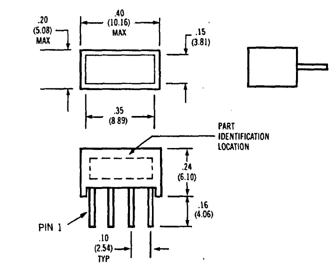
Note:
1. Deviation of the absolute values within one digit $I_{V MAX}/I_{V MIN} \leq 2$.

SIEMENS

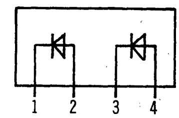
HIGH EFFICIENCY RED OLB 2300
YELLOW YLB 2400
GREEN GLB 2500
LIGHT BARS



Package Dimensions in Inches (mm)



PIN	PIN FUNCTION
1	Cathode — a
2	Anode — a
3	Cathode — b
4	Anode — b



FEATURES

- **Small Rectangular Package**
- **Uniform Light Emitting Area**
- **Excellent ON/OFF Contrast**
- **Choice of Three Colors**
- **Categorized for Light Output**
- **Yellow and Green Categorized for Dominant Wavelength**
- **Panel or Legend Mountable**
- **Can be Mounted on P.C. Boards or SIP/DFP Sockets**
- **X-Y Stackable**
- **Suitable for Multiplexing**
- **IC Compatible**

APPLICATIONS

These devices are ideally suited for:

- **Message Annunciators**
- **Positions/Status Indicators**
- **Telecommunications Indicators**
- **Bar Graphs**

DESCRIPTION

The OLB 2300/YLB 2400/GLB 2500 series light bars are rectangular displays designed for applications requiring a large light emitting area. They are configured in a single in-line package and contain a single light emitting area. The OLB 2300 and YLB 2400 devices utilize two LED chips which are made from GaAsP on a transparent GaP substrate. The GLB 2500 device utilizes two chips made from GaP on a transparent GaP substrate.

Maximum Ratings

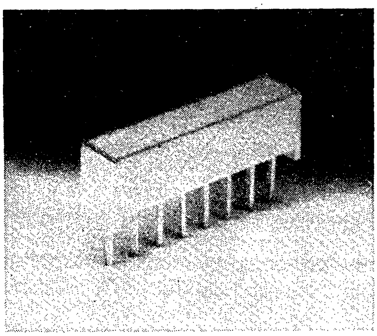
	OLB 2300 & GLB 2500	YLB 2400
Average Power Dissipation per LED chip	135mW	85mW
Peak Forward Current per LED chip Ta = 50°C (max pulse width = 2ms)	90mA	60mA
Average Forward Current per LED Pulsed conditions (Ta = 50°C)	25mA	20mA
DC Forward Current Per LED (Ta = 50°C)	30mA	25mA
Reverse Voltage per LED chip	6V	
Operating Temperature	−40°C to +85°C	
Storage Temperature	−40°C to +85°C	
Lead Soldering Temperature, 1/16 inch below seating plane	260°C for 3 sec.	
Junction Temperature	100°C	

Electrical/Optical Characteristics (@ 25°C)

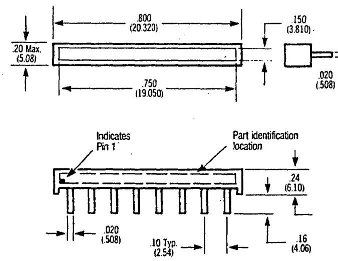
Parameters	Min.	Typ.	Max.	Units	Test Conditions
Luminous Intensity					
OLB2300	4.5	10		mcd	20mA DC
YLB2400	4	6		mcd	20mA DC
GLB2500	3.7	10		mcd	20mA DC
Peak Wavelength					
OLB2300		635		nm	
YLB2400		583		nm	
GLB2500		565		nm	
Dominant Wavelength					
OLB2300		626		nm	
YLB2400		585		nm	
GLB2500		572		nm	
Forward Voltage					
OLB2300		1.9	2.6	V	$I_F = 20mA$
YLB2400		2	2.6	V	$I_F = 20mA$
GLB2500		2.1	2.6	V	$I_F = 20mA$
Reverse Voltage					
OLB2300	6	15		V	$I_R = 100\mu A$
YLB2400	6	15		V	$I_R = 100\mu A$
GLB2500	6	15		V	$I_R = 100\mu A$

SIEMENS

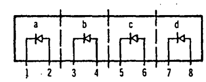
HIGH EFFICIENCY RED OLB 2350
YELLOW YLB 2450
GREEN GLB 2550
LIGHT BARS



Package Dimensions in Inches (mm)



PIN	FUNCTION
1	Cathode — a
2	Anode — a
3	Cathode — b
4	Anode — b
5	Cathode — c
6	Anode — c
7	Cathode — d
8	Anode — d



Num. Displays
Bar Graphs
Light Bars

FEATURES

- **Small Rectangular Package**
- **Uniform Light Emitting Area**
- **Excellent ON/OFF Contrast**
- **Choice of Three Colors**
- **Categorized for Light Output**
- **Yellow and Green Categorized for Dominant Wavelength**
- **Panel or Legend Mountable**
- **Can be Mounted on P.C. Boards or SIP/DFP Sockets**
- **X-Y Stackable**
- **Suitable for Multiplexing**
- **IC Compatible**

APPLICATIONS

These devices are ideally suited for:

- **Message Annunciators**
- **Positions/Status Indicators**
- **Telecommunications Indicators**
- **Bar Graphs**

DESCRIPTION

The OLB 2350/YLB 2450/GLB 2550 light bars are rectangular displays designed for applications requiring a large light emitting area. They are configured in a single in-line package and contain a single light emitting area. The OLB 2350 and YLB 2450 devices utilize four LED chips which are made from GaAsP on a transparent GaP substrate. The GLB 2550 device utilizes four chips made from GaP on a transparent GaP substrate.

Maximum Ratings

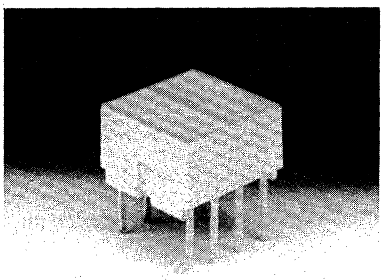
	OLB 2350 & GLB 2550	YLB 2450
Average Power Dissipation per LED chip	135mW	85mW
Peak Forward Current per LED chip Ta = 50°C (max pulse width = 2ms)	90mA	60mA
Average Forward Current per LED Pulsed conditions (Ta = 50°C)	25mA	20mA
DC Forward Current Per LED (Ta = 50°C)	30mA	25mA
Reverse Voltage per LED chip	6V	
Operating Temperature	−40°C to +85°C	
Storage Temperature	−40°C to +85°C	
Lead Soldering Temperature, 1/16 inch below seating plane	260°C for 3 sec.	
Junction Temperature	100°C	

Electrical/Optical Characteristics (@ 25°C)

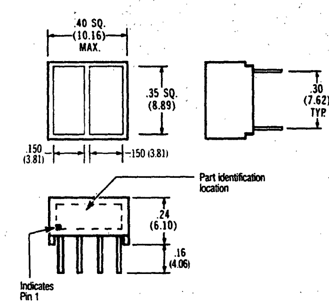
Parameters	Min.	Typ.	Max.	Units	Test Conditions
Luminous Intensity					
OLB2350	9	20		mcd	20mA DC
YLB2450	8	12		mcd	20mA DC
GLB2550	7.5	20		mcd	20mA DC
Peak Wavelength					
OLB2350		635		nm	
YLB2450		583		nm	
GLB2550		565		nm	
Dominant Wavelength					
OLB2350		626		nm	
YLB2450		585		nm	
GLB2550		572		nm	
Forward Voltage					
OLB2350		1.9	2.6	V	$I_F = 20mA$
YLB2450		2	2.6	V	$I_F = 20mA$
GLB2550		2.1	2.6	V	$I_F = 20mA$
Reverse Voltage					
OLB2350	6	15		V	$I_R = 100\mu A$
YLB2450	6	15		V	$I_R = 100\mu A$
GLB2550	6	15		V	$I_R = 100\mu A$

SIEMENS

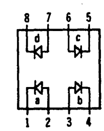
HIGH EFFICIENCY RED OLB 2600
YELLOW YLB 2700
GREEN GLB 2800
LIGHT BARS



Package Dimensions in Inches (mm)



PIN	PIN FUNCTION
1	Cathode a
2	Anode a
3	Anode b
4	Cathode b
5	Cathode c
6	Anode c
7	Anode d
8	Cathode d



FEATURES

- **Square Package**
- **Mechanical barrier creating two isolated rectangular light emitting areas**
- **Uniform Light Emitting Area**
- **Excellent ON/OFF Contrast**
- **Choice of Three Colors**
- **Categorized for Light Output**
- **Yellow and Green Categorized for Dominant Wavelength**
- **Panel or Legend Mountable**
- **Can be Mounted on P.C. Boards or DIP Sockets**
- **X-Y Stackable**
- **Suitable for Multiplexing**
- **IC Compatible**

APPLICATIONS

These devices are ideally suited for:
- **Message Annunciators**
- **Positions/Status Indicators**
- **Telecommunications Indicators**
- **Bar Graphs**

DESCRIPTION

The OLB 2600/YLB 2700/GLB 2800 series light bars are square displays. They are configured in a dual in-line package with a mechanical barrier creating two isolated rectangular light emitting areas. The OLB 2600 and YLB 2700 devices utilize four LED chips which are made from GaAsP on a transparent GaP substrate. The GLB 2800 device utilizes four chips made from GaP on a transparent GaP substrate.

Maximum Ratings

	OLB 2600 & GLB 2800	YLB 2700
Average Power Dissipation per LED chip	135mW	85mW
Peak Forward Current per LED chip Ta = 50°C (max pulse width = 2ms)	90mA	60mA
Average Forward Current per LED Pulsed conditions (Ta = 50°C)	25mA	20mA
DC Forward Current Per LED (Ta = 50°C)	30mA	25mA
Reverse Voltage per LED chip	6V	
Operating Temperature	−40°C to +85°C	
Storage Temperature	−40°C to +85°C	
Lead Soldering Temperature, 1/16 inch below seating plane	260°C for 3 sec.	
Junction Temperature	100°C	

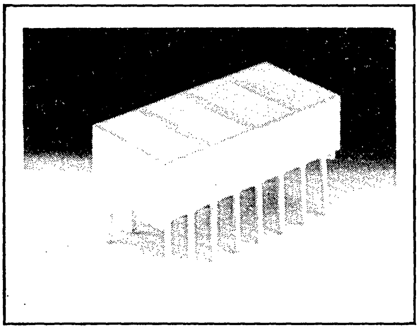
Electrical/Optical Characteristics (@ 25°C)

Parameters	Min.	Typ.	Max.	Units	Test Conditions
Luminous Intensity (per light emitting area)					
OLB2600	4.5	10		mcd	20mA DC
YLB2700	4	6		mcd	20mA DC
GLB2800	3.7	10		mcd	20mA DC
Peak Wavelength					
OLB2600		635		nm	
YLB2700		583		nm	
GLB2800		565		nm	
Dominant Wavelength					
OLB2600		626		nm	
YLB2700		585		nm	
GLB2800		572		nm	
Forward Voltage					
OLB2600		2.1	2.6	V	$I_F = 20mA$
YLB2700		2.2	2.6	V	$I_F = 20mA$
GLB2800		2.2	2.6	V	$I_F = 20mA$
Reverse Voltage					
OLB2600	6	15		V	$I_R = 100\mu A$
YLB2700	6	15		V	$I_R = 100\mu A$
GLB2800	6	15		V	$I_R = 100\mu A$

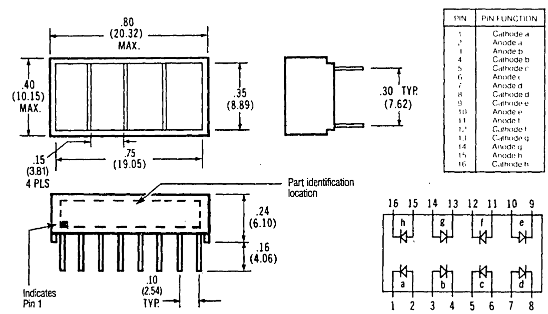
SIEMENS

HIGH EFFICIENCY RED OLB 2620
YELLOW YLB 2720
GREEN GLB 2820
LIGHT BARS

Num. Displays
Bar Graphs
Light Bars



Package Dimensions in Inches (mm)



FEATURES

- Large Rectangular Package
- Mechanical barrier creating four isolated rectangular light emitting areas
- Uniform Light Emitting Area
- Excellent ON/OFF Contrast
- Choice of Three Colors
- Categorized for Light Output
- Yellow and Green Categorized for Dominant Wavelength
- Panel or Legend Mountable
- Can be Mounted on P.C. Boards or DIP Sockets
- X-Y Stackable
- Suitable for Multiplexing
- IC Compatible

APPLICATIONS

These devices are ideally suited for:

- Message Annunciators
- Positions/Status Indicators
- Telecommunications Indicators
- Bar Graphs

DESCRIPTION

The OLB 2620/YLB 2720/GLB 2820 series light bars are rectangular displays. They are configured in a dual in-line package with a mechanical barrier creating four isolated rectangular light emitting areas. The OLB 2620 and YLB 2720 devices utilize eight LED chips which are made from GaAsP on a transparent GaP substrate. The GLB 2820 device utilizes eight chips made from GaP on a transparent GaP substrate.

Maximum Ratings

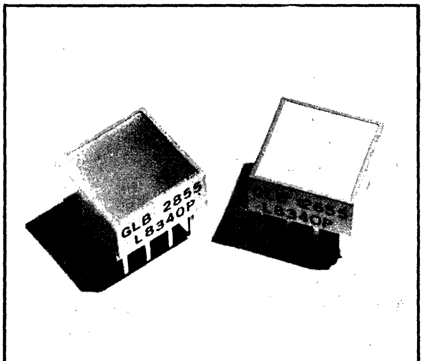
	OLB 2620 & GLB 2820	YLB 2720
Average Power Dissipation per LED chip	135mW	85mW
Peak Forward Current per LED chip Ta = 50°C (max pulse width = 2ms)	90mA	60mA
Average Forward Current per LED Pulsed conditions (Ta = 50°C)	25mA	20mA
DC Forward Current Per LED (Ta = 50°C)	30mA	25mA
Reverse Voltage per LED chip	6V	6V
Operating Temperature	−40°C to +85°C	
Storage Temperature	−40°C to +85°C	
Lead Soldering Temperature, 1/16 inch below seating plane	260°C for 3 sec.	
Junction Temperature	100°C	

Electrical/Optical Characteristics (@ 25°C)

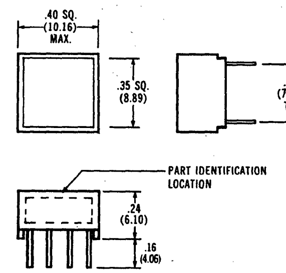
Parameters	Min.	Typ.	Max.	Units	Test Conditions
Luminous Intensity (per light emitting area)					
OLB2620	4.5	10		mcd	20mA DC
YLB2720	4	6		mcd	20mA DC
GLB2820	3.7	10		mcd	20mA DC
Peak Wavelength					
OLB2620		635		nm	
YLB2720		583		nm	
GLB2820		565		nm	
Dominant Wavelength					
OLB2620		626		nm	
YLB2720		585		nm	
GLB2820		572		nm	
Forward Voltage					
OLB2620		2.1	2.6	V	$I_F = 20mA$
YLB2720		2.2	2.6	V	$I_F = 20mA$
GLB2820		2.2	2.6	V	$I_F = 20mA$
Reverse Voltage					
OLB2620	6	15		V	$I_R = 100\mu A$
YLB2720	6	15		V	$I_R = 100\mu A$
GLB2820	6	15		V	$I_R = 100\mu A$

SIEMENS

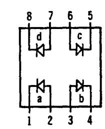
HIGH EFFICIENCY RED OLB 2655
YELLOW YLB 2755
GREEN GLB 2855
LIGHT BARS



Package Dimensions in Inches (mm)



PIN	PIN FUNCTION
1	Cathode a
2	Anode a
3	Anode b
4	Cathode b
5	Cathode c
6	Anode c
7	Anode d
8	Cathode d



FEATURES

- **Square Package**
- **Uniform Light Emitting Area**
- **Excellent ON/OFF Contrast**
- **Choice of Three Colors**
- **Categorized for Light Output**
- **Yellow and Green Categorized for Dominant Wavelength**
- **Panel or Legend Mountable**
- **Can be Mounted on P.C. Boards or DIP Sockets**
- **X-Y Stackable**
- **Suitable for Multiplexing**
- **IC Compatible**

APPLICATIONS

These devices are ideally suited for:

- **Message Annunciators**
- **Positions/Status Indicators**
- **Telecommunications Indicators**
- **Bar Graphs**

DESCRIPTION

The OLB 2655/YLB 2755/GLB 2855 series light bars are square displays designed for application requiring a large light emitting area. They are configured in a dual in-line package and contain a single light emitting area. The OLB 2655 and YLB 2755 devices utilize four LED chips which are made from GaAsP on a transparent GaP substrate. The GLB 2855 device utilizes four chips made from GaP on a transparent GaP substrate.

Maximum Ratings

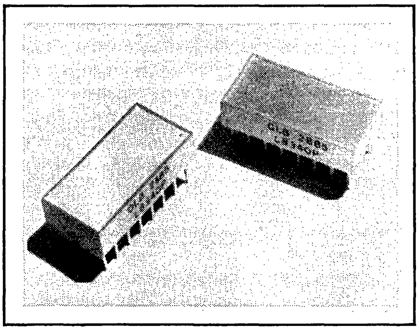
	OLB 2655 & GLB 2855	YLB 2755
Average Power Dissipation per LED chip	135mW	85mW
Peak Forward Current per LED chip Ta = 50°C (max pulse width = 2ms)	90mA	60mA
Average Forward Current per LED Pulsed conditions (Ta = 50°C)	25mA	20mA
DC Forward Current Per LED (Ta = 50°C)	30mA	25mA
Reverse Voltage per LED chip	6V	
Operating Temperature	−40°C to +85°C	
Storage Temperature	−40°C to +85°C	
Lead Soldering Temperature, 1/16 inch below seating plane	260°C for 3 sec.	
Junction Temperature	100°C	

Electrical/Optical Characteristics (@ 25°C)

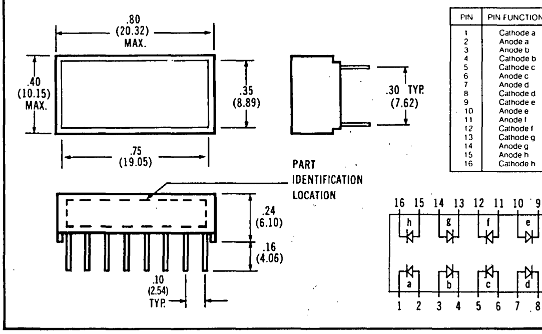
Parameters	Min.	Typ.	Max.	Units	Test Conditions
Luminous Intensity					
OLB2655	9	20		mcd	20mA DC
YLB2755	8	12		mcd	20mA DC
GLB2855	7.5	20		mcd	20mA DC
Peak Wavelength					
OLB2655		635		nm	
YLB2755		583		nm	
GLB2855		565		nm	
Dominant Wavelength					
OLB2655		626		nm	
YLB2755		585		nm	
GLB2855		572		nm	
Forward Voltage					
OLB2655		2.1	2.6	V	$I_F = 20mA$
YLB2755		2.2	2.6	V	$I_F = 20mA$
GLB2855		2.2	2.6	V	$I_F = 20mA$
Reverse Voltage					
OLB2655	6	15		V	$I_R = 100\mu A$
YLB2755	6	15		V	$I_R = 100\mu A$
GLB2855	6	15		V	$I_R = 100\mu A$

SIEMENS

HIGH EFFICIENCY RED OLB 2685
YELLOW YLB 2785
GREEN GLB 2885
LIGHT BARS



Package Dimensions in Inches (mm)



PIN	PIN FUNCTION
1	Cathode a
2	Anode a
3	Anode b
4	Cathode b
5	Cathode c
6	Anode c
7	Anode d
8	Cathode d
9	Cathode e
10	Anode e
11	Anode f
12	Cathode f
13	Cathode g
14	Anode g
15	Anode h
16	Cathode h

FEATURES
- **Large Rectangular Package**
- **Uniform Light Emitting Area**
- **Excellent ON/OFF Contrast**
- **Choice of Three Colors**
- **Categorized for Light Output**
- **Yellow and Green Categorized for Dominant Wavelength**
- **Panel or Legend Mountable**
- **Can be Mounted on P.C. Boards or DIP Sockets**
- **X-Y Stackable**
- **Suitable for Multiplexing**
- **IC Compatible**

APPLICATIONS
These devices are ideally suited for:
- **Message Annunciators**
- **Positions/Status Indicators**
- **Telecommunications Indicators**
- **Bar Graphs**

DESCRIPTION
The OLB 2685/YLB 2785/GLB 2885 series light bars are rectangular displays designed for applications requiring a large light emitting area. They are configured in a dual in-line package and contain a single light emitting area. The OLB 2685 and YLB 2785 devices utilize eight LED chips which are made from GaAsP on a transparent GaP substrate. The GLB 2885 device utilizes eight chips made from GaP on a transparent GaP substrate.

Maximum Ratings

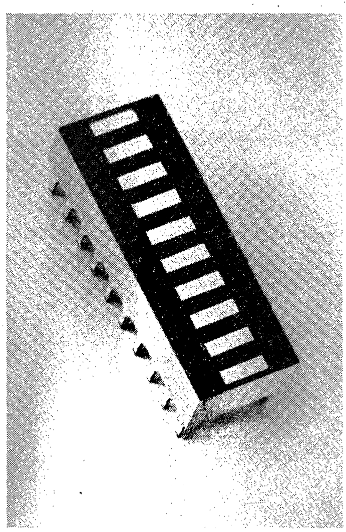
	OLB 2685 & GLB 2885	YLB 2785
Average Power Dissipation per LED chip	135mW	85mW
Peak Forward Current per LED chip Ta = 50°C (max pulse width = 2ms)	90mA	60mA
Average Forward Current per LED Pulsed conditions (Ta = 50°C)	25mA	20mA
DC Forward Current Per LED (Ta = 50°C)	30mA	25mA
Reverse Voltage per LED chip	6V	6V
Operating Temperature	−40°C to +85°C	
Storage Temperature	−40°C to +85°C	
Lead Soldering Temperature, 1/16 inch below seating plane	260°C for 3 sec.	
Junction Temperature	100°C	

Electrical/Optical Characteristics (T_{amb} = 25°C)

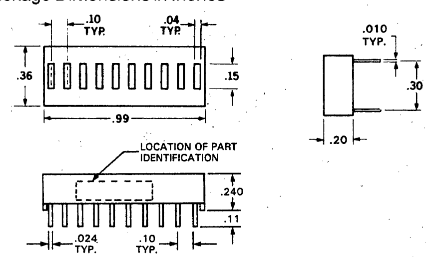
Parameters	Min.	Typ.	Max.	Units	Test Conditions
Luminous Intensity					
OLB2685	18	40		mcd	20mA DC
YLB2785	16	24		mcd	20mA DC
GLB2885	15	40		mcd	20mA DC
Peak Wavelength					
OLB2685		635		nm	
YLB2785		583		nm	
GLB2885		565		nm	
Dominant Wavelength					
OLB2685		626		nm	
YLB2785		585		nm	
GLB2885		572		nm	
Forward Voltage					
OLB2685		2.1	2.6	V	I_F = 20mA
YLB2785		2.2	2.6	V	I_F = 20mA
GLB2885		2.2	2.6	V	I_F = 20mA
Reverse Voltage					
OLB2685	6	15		V	I_R = 100µA
YLB2785	6	15		V	I_R = 100µA
GLB2885	6	15		V	I_R = 100µA

SIEMENS

RED RBG-1000
HIGH EFFICIENCY RED OBG-1000
YELLOW YBG-1000
GREEN GBG-1000
10 ELEMENT BAR GRAPH



Package Dimensions in Inches



FEATURES

- 10 Element Display
- End Stackable Module
- Individual Addressable Anode and Cathode
- Intensity Coded for Display Uniformity
- Rugged Encapsulation
- Choice of Colors

DESCRIPTION

The Red RBG-1000, Hi-efficiency Red OBG-1000, Yellow YBG-1000, and Green GBG-1000 are 10 individual element bar graphs. They are contained in a 1 inch long, 20 pin dual-in-line package that can be end stacked as bar-graph displays of various lengths. Applications include: bar graph, solid-state meter movement, position indicator, etc.

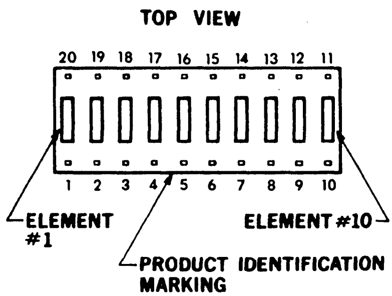
Maximum Ratings

Storage Temperature		−20° to +85°C
Operating Temperature		−20° to +85°C
Power Dissipation @25°C		450 mW
Derating Factor from 25°C		7.5 mW/°C
Continous Forward Current		
RBG-1000	per display	200 mA
	per element	20 mA
OBG-1000 YBG-1000 GBG-1000	per display	156 mA
	per element	20 mA
Peak Inverse Voltage per Element		3 V

Opto-Electronic Characteristics (@25°C)

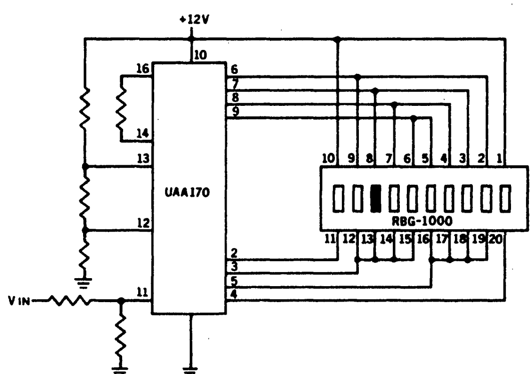
Parameter	Typ	Max	Unit	Test Condition
Luminous Intensity/ Element (Display Average)				
RBG-1000	.5		mcd	$I_F = 20$ mA/ Segment
OBG-1000	2.5		mcd	$I_F = 20$ mA/ Segment
YBG-1000	2.0		mcd	$I_F = 20$ mA/ Segment
GBG-1000	2.0		mcd	$I_F = 20$ mA/ Segment
Forward Voltage				
RBG-1000	1.7	2.0	V	$I_F = 20$ mA
OBG-1000	2.2	2.8	V	$I_F = 20$ mA
YBG-1000	2.4	3.0	V	$I_F = 20$ mA
GBG-1000	2.4	3.0	V	$I_F = 20$ mA
Reverse Leakage	0.1	100	μA	$V_R = 3$ V
Emission Peak Wavelength				
RBG-1000	660		nm	
OBG-1000	630		nm	
YBG-1000	585		nm	
GBG-1000	565		nm	

RBG-1000, OBG-1000, YBG-1000 AND GBG-1000



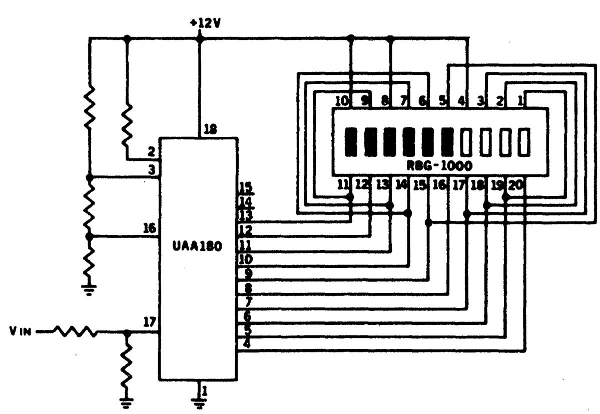
PIN	FUNCTION	PIN	FUNCTION
1	ANODE 1	11	CATHODE 10
2	ANODE 2	12	CATHODE 9
3	ANODE 3	13	CATHODE 8
4	ANODE 4	14	CATHODE 7
5	ANODE 5	15	CATHODE 6
6	ANODE 6	16	CATHODE 5
7	ANODE 7	17	CATHODE 4
8	ANODE 8	18	CATHODE 3
9	ANODE 9	19	CATHODE 2
10	ANODE 10	20	CATHODE 1

TYPICAL APPLICATIONS



LIGHT SPOT DISPLAY

LINEAR DISPLAY DRIVERS
Siemens UAA170
Siemens UAA180
National LM3914
National LM3915
Sharp IR2406



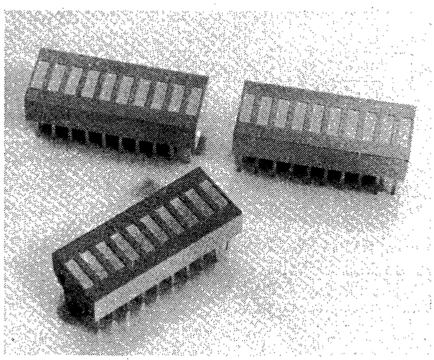
LIGHT BAND DISPLAY

No endorsement or warranty of other manufacturer's products is intended

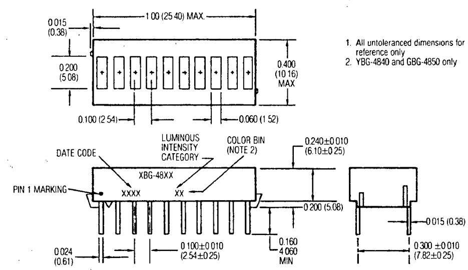
SIEMENS

RED RBG-4820
HIGH EFFICIENCY RED OBG-4830
YELLOW YBG-4840
GREEN GBG-4850

10 ELEMENT LINEAR DISPLAY



Package Dimensions in Inches (mm)



FEATURES

- **10 Element Array**
- **End Stackable With Package Interlock to Assure Alignment**
- **Matched LED's for Uniform Display**
- **Individually Addressable Anode and Cathode**
- **Intensity Coded for Display Uniformity**
- **Wide Viewing Angle**
- **Rugged Encapsulated Construction**
- **Standard Dual-In-Line Package**
- **High On-Off Contrast, Segment to Segment Hue Coded For Uniformity**
- **Choice of Colors**

DESCRIPTION

The Red RBG-4820, Hi-efficiency Red, OBG-4830, Yellow YBG-4840 and Green GBG-4850 are 10 individual element linear bar displays and are designed to display information in easily recognizable bar graph form. They are end stackable for expanded display lengths. The package interlock ensures that each bargraph will align accurately and correctly with the next one. Applications include solid state meters, position indicators, and instrumentation.

Maximum Ratings

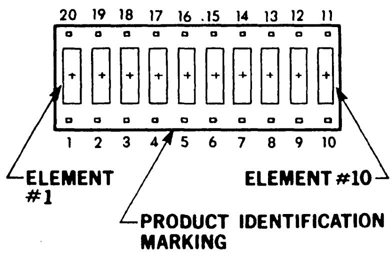
Storage Temperature	-20°C to +85°C
Operating Temperature	-20°C to +85°C
Power Dissipation @ 25°C	450 mW
Derating Factor from 25°C	7.5 mW/°C
Lead Soldering Temperature (1/16 below seating plane)	260°C for 3 sec.
Peak Reverse Voltage Per Led	3V
Continuous Forward Current	
RBG-4820	30mA
OBG-4830	30mA
YBG-4840	20mA
GBG-4850	30mA

Optoelectronic Characteristics (@ 25°C)

Parameters	Min.	Typ.	Max.	Units	Test Conditions
Luminous Intensity Per Element					
RBG-4820		500		µcd	I_F=20mA
OBG-4830		2500		µcd	I_F=20mA
YBG-4840		2000		µcd	I_F=20mA
GBG-4850		2000		µcd	I_F=20mA
Peak Wavelength					
RBG-4820		655		nm	
OBG-4830		635		nm	
YBG-4840		583		nm	
GBG-4850		566		nm	
Dominant Wavelength					
RBG-4820		645		nm	
OBG-4830		626		nm	
YBG-4840		585		nm	
GBG-4850		571		nm	
Forward Voltage Per LED					
RBG-4820		1.6	2.0	V	I_F=20mA
OBG-4830		2.1	2.5	V	I_F=20mA
YBG-4840		2.2	2.6	V	I_F=20mA
GBG-4850		2.1	2.5	V	I_F=10mA
Reverse Voltage Per LED					
RBG-4820	3	12		V	I_R=100uA
OBG-4830	3	30		V	I_R=100uA
YBG-4840	3	50		V	I_R=100uA
GBG-4850	3	50		V	I_R=100uA

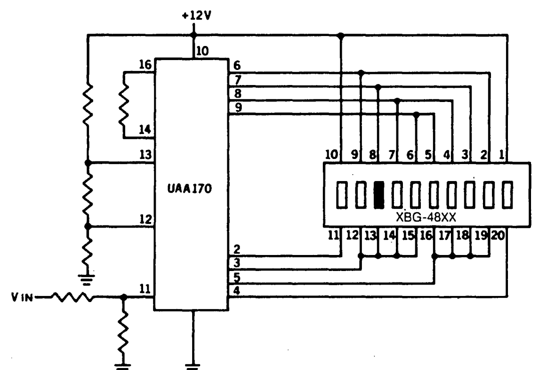
RBG-4820 OBG-4830 YBG-4840 and GBG-4850

TOP VIEW



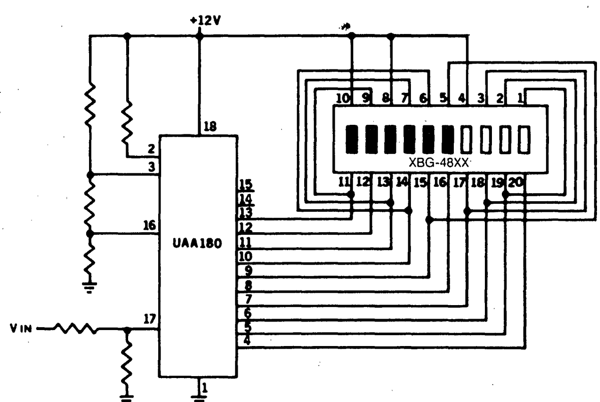
PIN	FUNCTION	PIN	FUNCTION
1	ANODE 1	11	CATHODE 10
2	ANODE 2	12	CATHODE 9
3	ANODE 3	13	CATHODE 8
4	ANODE 4	14	CATHODE 7
5	ANODE 5	15	CATHODE 6
6	ANODE 6	16	CATHODE 5
7	ANODE 7	17	CATHODE 4
8	ANODE 8	18	CATHODE 3
9	ANODE 9	19	CATHODE 2
10	ANODE 10	20	CATHODE 1

TYPICAL APPLICATIONS



LIGHT SPOT DISPLAY

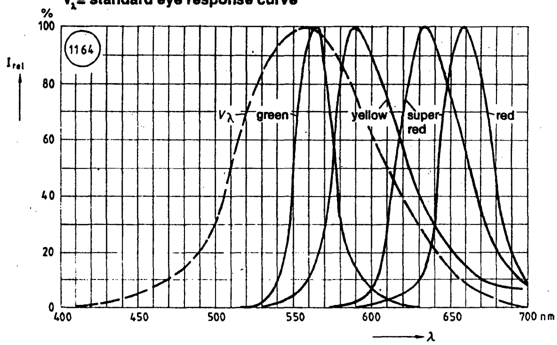
LINEAR DISPLAY DRIVERS
Siemens UAA170
Siemens UAA180
National LM3914
National LM3915
Sharp IR2406



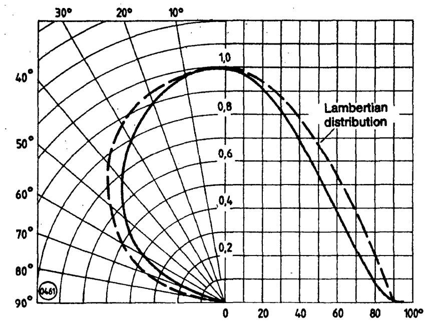
LIGHT BAND DISPLAY

No endorsement or warranty of other manufacturer's products is intended

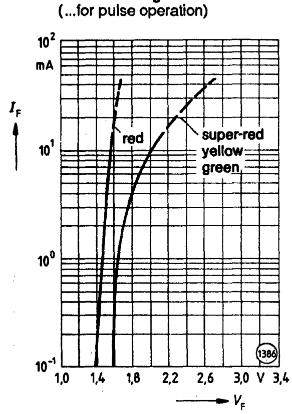
1.
Relative spectral emission versus wavelength
V_λ = standard eye response curve



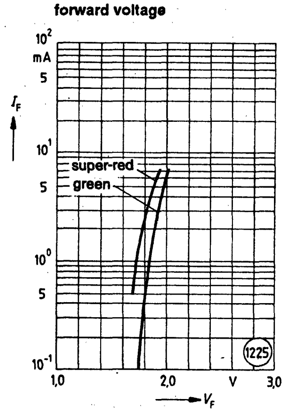
2.
Radiation characteristic
Relative spectral emission versus half angle



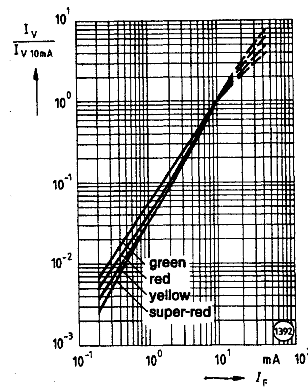
3A.
Forward current versus forward voltage
(...for pulse operation)



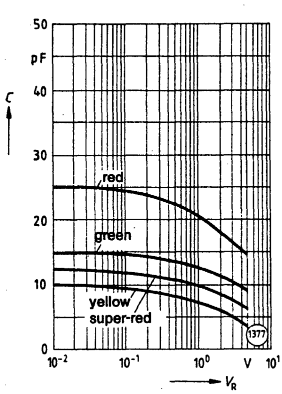
3B.
Forward current versus forward voltage



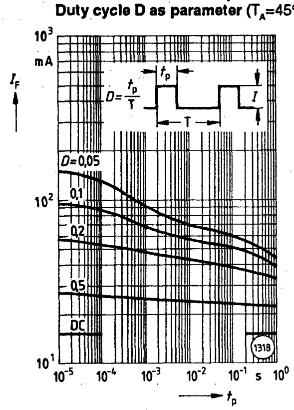
4.
Relative luminous intensity versus forward current
(...for pulse operation)



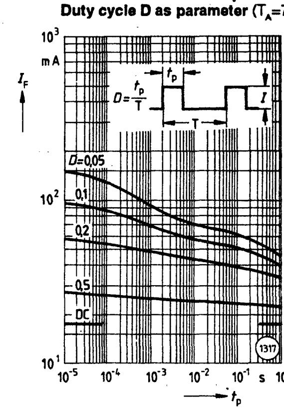
5.
Capacitance versus reverse voltage



6A.
Permissible pulse handling capability per segment
Forward current versus pulse width
Duty cycle D as parameter (T_A=45°C)

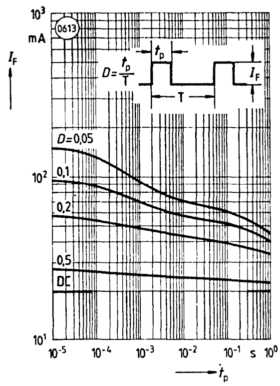


6B.
Permissible pulse handling capability per segment
Forward current versus pulse width
Duty cycle D as parameter (T_A=70°C)

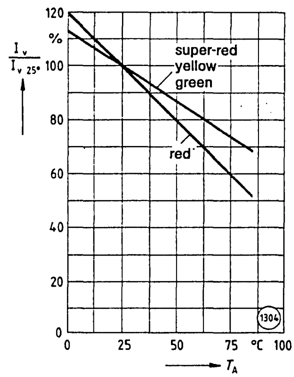


GRAPHS FOR DISPLAYS (*Cont.*)

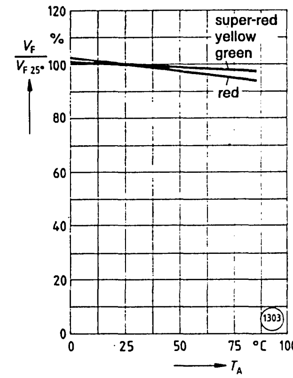
6C.
Permissible pulse handling capability per segment
Forward current versus pulse width
Duty cycle D as parameter (T_A=45°C)



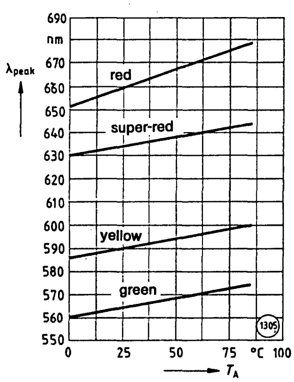
7.
Luminous intensity versus ambient temperature



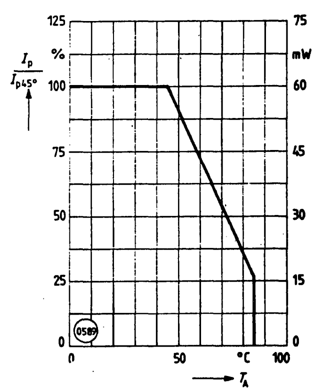
8.
Forward voltage versus ambient temperature

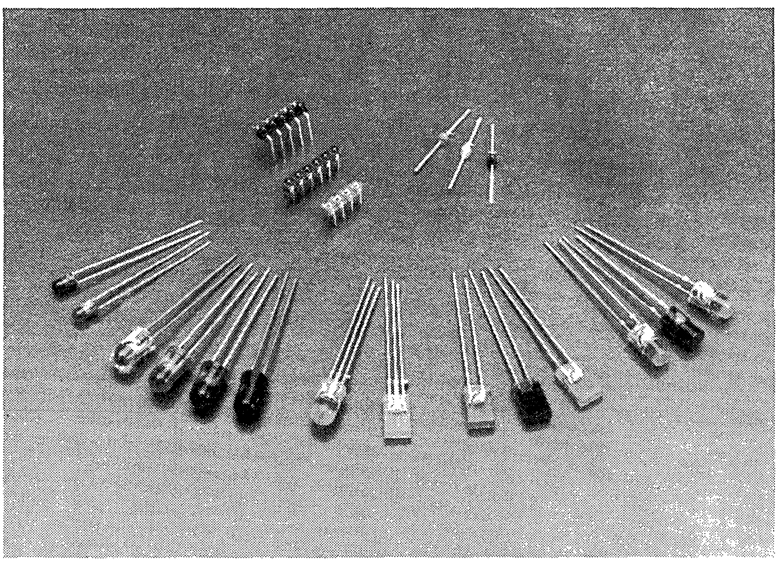


9.
Wavelength at peak emission versus ambient temperature



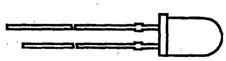
10.
Permissible continuous power dissipation and pulse current per segment versus ambient temperature



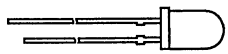
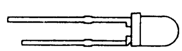
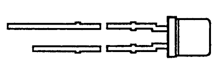
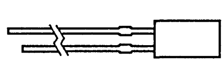


LED Lamps

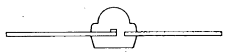
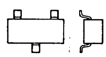
LED Lamps

Package Type	Package Outline	Part Number	Color	Lens	Viewing Angle	Luminous Intensity (min.) mcd	Luminous Intensity (min.) mA	Max. Fwd. Current (mA)	Page
T1 3/4 5mm 1" leads 100 mil lead spacing, no standoffs		LDR5091	Red	Red Clear	24°	2.5	20	100	4–12
		LDR5092				4.0			
		LDR5093				10			
		LDH5191	High Efficiency Red	Orange Clear		10	10	60	
		LDH5192				20			
		LDH5193				30			
		LDY5391	Yellow	Yellow Clear		10			
		LDY5392				20			
		LDY5393				30			
		LDG5591	Green	Water Clear		40	20		
		LDG5592				80			
		LDB5410	Blue		16°	2.5		25	4–8
T1 3/4 5mm 1" leads 100 mil lead spacing, no standoffs		LDR5101	Red	Red Diffused	70°	1.0	20	100	4–13
		LDR5102				2.5			
		LDR5103				4.0			
		LDH5121	High Efficiency Red			2.0	10	60	
		LDH5122				4.0			
		LDH5123				6.0			
		LDY5161	Yellow	Yellow Diffused		1.0			
		LDY5162				2.5			
		LDY5163				4.0			
		LDG5171	Green	Green Diffused		2.5	20		
		LDG5172							
T1 3/4 5mm 1" leads 100 mil lead spacing with standoffs		LS5421-MO	High Efficiency Red	Orange Tinted	20°	16	10	45	4–15
		LS5421-PO				40			
		LS5421-QO				63			
		LY5421-MO	Yellow	Yellow Tinted		16			
		LY5421-PO				40			
		LY5421-QO				63			
		LG5411-LO	Green	Water Clear		10			
		LG5411-NO				25			
		LG5411-PO				40			
		LS5469-EO	High Efficiency Red	Diffused	50°	0.63	2	7.5	4–16
		LS5469-FO				1.0			
		LY5469-EO	Yellow			0.63			
		LY5469-FO				1.0			
		LG5469-EO	Green			0.63			
		LG5469-FO				1.0			

LED Lamps

Package Type	Package Outline	Part Number	Color	Lens	Viewing Angle	Luminous Intensity (min.) mcd	Luminous Intensity (min.) mA	Max. Fwd. Current (mA)	Page
T1 3/4 5mm 1" leads 100 mil lead spacing with standoffs		LDR5001	Red	Red Diffused	70°	1.0	20	100	4–11
		LDR5002				2.5			
		LDR5003				4.0			
		LDH5021	High Efficiency Red			2.0	10	60	
		LDH5022				4.0			
		LDH5023				6.0			
		LDY5061	Yellow	Yellow Diffused		1.0			
		LDY5062				2.5			
		LDG5071	Green	Green Diffused		2.5	20		
		LDG5072				6.0			
T1 5mm 1" leads 100 mil lead spacing, no standoffs		LS3369-EO	High Efficiency Red	Diffused	60°	0.63	2	75	4–14
		LS3369-FO				1.0			
		LY3369-EO	Yellow			0.63			
		LY3369-FO				1.0			
		LG3369-EO	Green			0.63			
		LG3369-FO				1.0			
		LDR1101	Red	Red Diffused	70°	1.0	20	100	4–9
		LDR1102				2.0			
		LDR1103				4.0			
		LDH1111	High Efficiency Red			2.5	10	60	
		LDH1112				4.0			
		LDH1113				6.0			
		LDY1131	Yellow	Yellow Diffused		1.0			
		LDY1132				2.0			
		LDY1133				4.0			
		LDG1151	Green	Green Diffused		2.5	20		
		LDG1152				6.0			
		LDG1153				10			
						Luminous Flux			
Flat top. T1 3mm, 1" leads 100 mil lead spacing, no standoffs.		LSK380	High Eff. Red	Tinted Trans-parent	Not appli-cable	32 (10)	15 m/m	45	4–17
		LYK380	Yellow						
		LGK380	Green						
Rectan-gular 5mm 1" leads		LDR3701	Red	Red Diffused	100°	0.4	20	60	4–10
		LDR3702				0.63			
		LDH3601	High Efficiency Red			1.6			
		LDH3602				2.5			
		LDH3603				4.0			
		LDY3801	Yellow	Yellow Diffused		1.0			
		LDY3802				1.6			
		LDY3803				2.5			
		LDG3901	Green	Green Diffused		1.0			
		LDG3902				1.6			
		LDG3903				2.5			

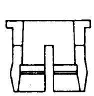
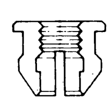
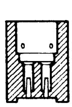
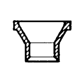
LED Lamps

Package Type	Package Outline	Part Number	Color	Lens	Viewing Angle	Luminous Intensity (min.) mcd	Luminous Intensity (min.) mA	Max. Fwd. Current (mA)	Page
Miniature Axial Lead		RL-50	Red	Water Clear	90°	0.5	10	40	4–21
		RL-54		Red Diffused		0.4			
Miniature Axial Lead. High dome lens.		RL-55	Red	Red Diffused	50°	2.0	10	40	4–23
		YL-56	Yellow	Yellow Diffused	40°			25	
		GL-56	Green	Green Diffused		1.0			
SOT23 Subminiature 1.3mm by 3mm by 1mm high		LS S260-DO	High Efficiency Red	Water Clear	140°	1.0	20	12.5 (30 on ceramic substrate)	4–18
		LY S260-DO	High Efficiency Yellow	Red Diffused					
		LG S260-DO	Green	Green Diffused					
		LU S250-DO	Red and Green	Colorless Diffused					

Multicolor LED Lamps

Package Type	Package Outline	Part Number	Color	Lens	Viewing Angle	Luminous Intensity (min.) mcd	Luminous Intensity (min.) mA	Max. Fwd. Current (mA)	Page
T1 3/4 5mm 1" Leads		LD1005	Red and Green	Clear Diffused	100°	2.5	20	60	4–6
		LD1006				4.0			
		LD1007				6.3			
T1 3/4 5mm 1" Leads		LD1103		Colorless Diffused		1.0			4–7
		LD1104				1.6			
		LD1105				2.5			

Lamp Accessories (pgs. 25-26)

	Mounting Clip and Collar for T13/4 LEDs Part Number: 2004-9002 - Black 2004-9003 - Clear		Mounting Clip and Collar for T1 LEDs Part Number: 2004-9015 - Black 2004-9016 - Clear
	Right Angle Mount Part Number: 2004-9019 - Black		Reflector Part Number: 2004-9020 - Polished

Packaging of LEDs on continuous tapes

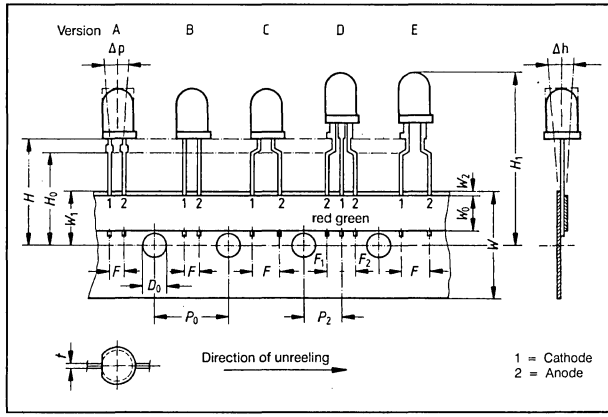
Light emitting diodes are available now in taped form. Packaging of **unidirectional** LEDs on continuous tapes is based on the **IEC publication 40 (secretariat) 451**.

The component tapes are wound on reels and supplied in boxes containing two reels each. One reel comprises 1000 items of the 5 mm types or 2000 items of the 3 mm types.

The **ordering codes** for taped components with unidirectional leads packaged on reels are as follows:

For components with 2.54 mm lead spacing (version A, B, and D), "E7500" is added to the last position of the type number.
Example: LDR1101 E7500

For components with 5.08 mm spacing (version C and E) "E7501" is added to the last position of the type number.
Example: LDG5171 E7501



LED Lamps

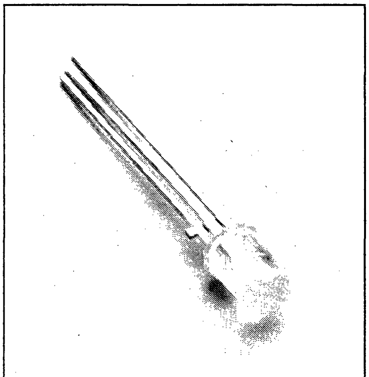
Dimensional table for radial tape

Description	Symbol	Dimensions in inches (mm)
Overall Tape Width	W	$.709 {+.039 \atop -.020}$ $\left(18 {+1 \atop -0.5}\right)$
Hold Down Tape Width	W_0	.236 ± .012 (6 ± 0.3)
Feed Hole Location	W_1	$.354 {+.030 \atop -.020}$ $\left(9 {+0.75 \atop -0.5}\right)$
Hold Down Tape Position	W_2	≦ .118 (≦ 3)
Overall Taped Package Thickness	t	.035 max. (0.9)
Tape Feed Hole Diameter	D_0	.157 ± .008 (4 ± 0.2)
Feed Hole to Bottom of Component	H	.709 + .079 (18 + 2)
Height of Seating Plane	H_0	.630 ± .020 (16 ± 0.5)
Feed Hole to Overall Component Height	H_1	1.268 max. (32.2)
Feed Hole Pitch	P_0	.500 ± .012 (12.7 ± 0.3)
Feed Hole-Component Center Distance	P_2	.250 ± .028 (6.35 ± 0.7)
Component Lead Pitch	F	$\left.{.100 \atop .200}\right\}$ $\begin{matrix}+.024 \\ -.004\end{matrix}$ $\left(\begin{matrix}2.54 + 0.6 \\ 5.08 - 0.1\end{matrix}\right)$
Component Lead Pitch	F_1, F_2	ea. $.100 {+.016 \atop -.004}$ $\left(2.54 {+0.4 \atop -0.1}\right)$
Deflection Left or Right	Δp	± .040 (± 1)
Deflection Front or Rear	Δh	± .079 (± 2)

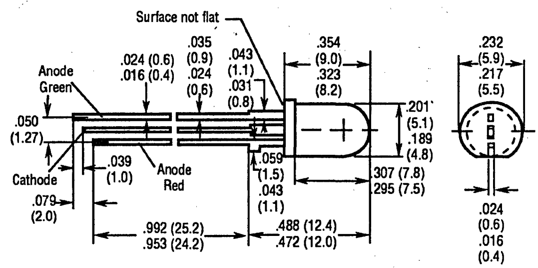
SIEMENS

LD 1005/1006/1007

TWO-COLOR, RED AND GREEN T1 ¾ LED LAMP



Package Dimensions in Inches (mm)



FEATURES

- **T1 ¾ Package Size**
- **Colorless Lens**
- **Two-Color Operation, Red and Green**
- **Three Leads, One of Which Is Common Cathode**
- **Minimum Lead Length 1″**
- **.05″ Lead Spacing**

DESCRIPTION

The LD 100X series has a colorless round, 5 mm case with diffuser layer. Two chips (GaP-green and TSN-red) allow use as optical indicator with two functions.

Because of its very low current consumption and hence low inherent heating as well as high vibration resistance and long service life, this LED is suitable for applications where signal lamps are not or only inadequately useful. Moreover, the LED can be driven by TTL ICs.

Maximum Ratings

Reverse Voltage (V_R)	5 V
Forward Current* (I_F)	60 mA
Surge Current* (i_{FS}), $t \leq 10\ \mu s$	1 A
Storage Temperature (T_{stg})	−55 to +100 °C
Junction Temperature (T_j)	100 °C
Power Dissipation (P_{tot}) $T_{amb} = 25\ °C$	200 mW
Thermal Resistance (R_{thJA}) Junction-to-Air	375 K/W

Characteristics ($T_{amb} = 25\ °C$)

Parameter	Symbol	TSN-red	GaP-green	Unit
Wavelength of the Emitted Light	λ_{peak}	645 ± 15	560 ± 15	nm
Dominant Wavelength	λ_{dom}	638	561	nm
Half Angle (Limits for 50% of Luminous Intensity I_v)	φ	50		Deg.
Forward Voltage ($I_F = 20$ mA)	V_F	2.4 (≤3.0)		V
Reverse Current ($V_R = 5$ V)	I_R	0.01 (≤10)		μA
Rise Time	t_r	100	50	ns
Fall Time	t_f	100	50	ns
Capacitance ($V_R = 0$ V, f = 1 MHz)	C_O	12	45	pF

Luminous Intensity

Part Number	Min	Unit	Test Condition
LD 1005	2.5	mcd	10 mA
LD 1006	4.0	mcd	10 mA
LD 1007	6.3	mcd	10 mA

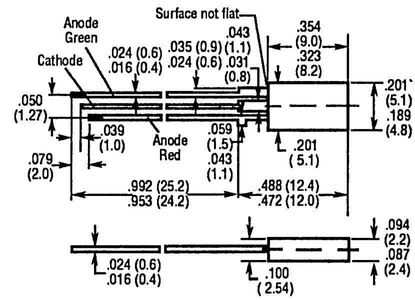
***The ratings indicated for the forward current I_F or the surge current i_{FS}, respectively, are maximum ratings of the component. If both chips are operated simultaneously, the sum of the forward current ratings is not allowed to exceed the indicated maximum value.**

See graph numbers 1A, 2A, 3A (HER), 3B (green), 4A, 5A, 6A, 7A, 8A, 9A, 10A on pages 4-27 – 4-34.

LD 1103/1104/1105

TWO-COLOR RED AND GREEN RECTANGULAR LED LAMP

Package Dimension in Inches (mm)



FEATURES

- **Rectangular Shape**
- **Colorless Lens**
- **Two-Color Operation, Red and Green**
- **Three Leads, One of Which Is Common Cathode**
- **Minimum Lead Length 1″**
- **.05″ Lead Spacing**

DESCRIPTION

The LD 1103 series has a colorless case with rectangular, luminous area and diffuser layer. Two chips (GaP-green and TSN-red) enable the use as optical indicator with two functions.

Because of its very low current consumption and hence low inherent heating as well as high vibration resistance and long service life, this LED is suitable for applications where signal lamps are not or only inadequately useful. Moreover, the LED can be driven by TTL ICs.

Maximum Ratings

Reverse Voltage (V_R)	5 V
Forward Current* (I_F)	60 mA
Surge Current (i_{FS}), $t \leq 10\ \mu s$*	1 A
Storage Temperature (T_{stg})	−55 to +100 °C
Junction Temperature (T_j)	100 °C
Power Dissipation (P_{tot}), $T_{amb} = 25$ °C	200 mW
Thermal Resistance Junction-Air (R_{thJA})	375 K/W

Characteristics ($T_{amb} = 25$ °C)

Parameter	Symbol	TSN-red	GaP-green	Unit
Wavelength of the Emitted Light	λ_{peak}	645 ± 15	560 ± 15	nm
Dominant Wavelength	λ_{dom}	638	561	nm
Aperture Cone (Half Angle) (Limits for 50% of Luminous Intensity I_V) Lateral Emission of Light Screened	φ	50		Deg.
Forward Voltage ($I_F = 20$ mA)	V_F	2.4 (≤3.0)		V
Reverse Current ($V_R = 5$ V)	I_R	0.01 (≤ 10)		μA
Rise Time	t_r	100	50	ns
Fall Time	t_f	100	50	ns
Capacitance ($V_R = 0$ V, f = 1 MHz)	C_O	12	45	pF

Luminous Intensity

Type	Min	Unit	Test Condition
LD 1103	1.0	mcd	20 mA
LD 1104	1.6	mcd	20 mA
LD 1105	2 5	mcd	20 mA

*The ratings indicated for the forward current I_F or the surge current i_{FS}, respectively, are maximum ratings of the component. If both chips are operated simultaneously, the sum of the forward current ratings is not allowed to exceed the indicated maximum value.

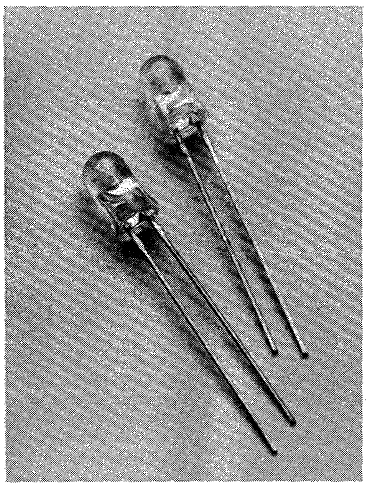
See graph numbers 1A, 2B, 3A (HER), 3B (green), 4A, 5A, 6A, 7A, 8A, 9A, 10A on pages 4-27 – 4-34.

SIEMENS

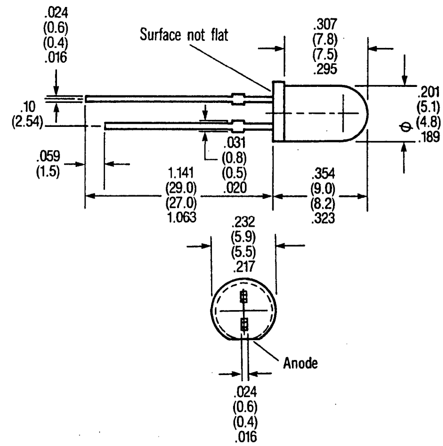
LDB5410

BLUE T1¾ LED LAMP

Preliminary Data Sheet



Package Dimensions in Inches (mm)



FEATURES

- **Pure Blue Light (480 nm)**
- **Clear T-1¾ Plastic Package**
- **1″ Min. Lead Length**
- **High Brightness**
- **TTL Compatible**

DESCRIPTION

The LDB5410 is a Silicon Carbide (SiC) LED, emitting a pure blue light from a clear T-1¾ plastic package. The LDB5410 is ideal for such applications as: spectroscopy, calibration, and light sources in medical equipment.

Maximum Ratings

Reverse voltage	V_R	1	V
Forward current	I_F	25	mA
Storage temperature range	T_{stor}	−55 to +100	°C
Junction temperature	T_j	100	°C
Total power dissipation (T_{amb} = 25°C)	P_{tot}	150	mW
Thermal resistance Junction to Air	$R_{th}J_{amb}$	500	K/W

Characteristics (T_{amb} = 25°C)

		Min.	Typ.	Unit
Wavelength at peak emission		λpeak	480	nm
Dominant wavelength		dom	480	nm
Viewing angle			16	Deg.
Forward voltage (I_F = 20 mA)		V_F	4(≦8)	V
Reverse current (V_R = IV)		I_R	0.01(≦10)	μA
Capacitance (V_R = 0 V; f = 1 MHz)		C_o	160	pF
Luminous intensity (I_F = 20 mA)		2.5	6.0	mcd

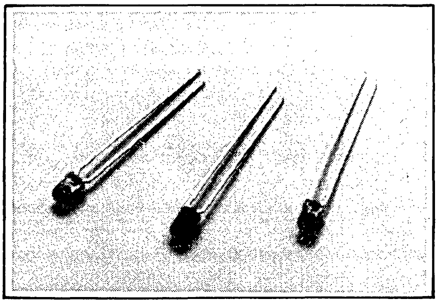
CAUTION: Because of low reverse voltage, the polarity of the LDB5410 should be checked before inserting into a circuit.

See Appnote 31 for further information.

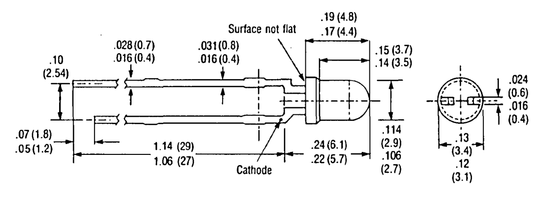
See graph numbers 1C, 2C, 3C, 4B, 6B on pages 4-27–4-34.

SIEMENS

RED LDR 1101/1102/1103
HIGH EFFICIENCY RED LDH 1111/1112/1113
HIGH EFFICIENCY YELLOW LDY 1131/1132/1133
HIGH EFFICIENCY GREEN LDG 1151/1152/1153
T1 LED LAMP



Package Dimension in Inches (mm)



FEATURES
- **High Light Output**
- **Diffused Lens**
- **Wide Viewing Angle 70°**
- **T 1 Size**
- **1″ Lead Length**
- **Front Panel Mounting**
  Snap-in Mounting Clips Available
  Clip/Collar #2004-9016 Clear
  #2004-9015 Black
- **I/C Compatible**

DESCRIPTION

The LDR 110X Series is a standard red gallium arsenide phosphide (GaAsP) LED lamp. The LDH111X high efficiency red and LDY13X yellow are premium high efficiency light emitting diode lamps fabricated with TSN (transparent substrate nitrogen) technology. The LDG 115X green Series is a gallium phosphide (GaP) lamp. All have a diffused plastic lens which emits a full flooded intense light.

See graph numbers on pages 4-27 – 4-34.
Red: 1D, 2D, 3D, 5B, 6C, 7B, 8B, 9B, 10B
HER: 1A, 2E, 3A, 5A, 6A, 7A, 8A, 9A, 10A
Yellow: 1A, 2E, 3A, 5A, 6A, 7A, 8A, 9B, 10A
Green: 1A, 2F, 3B, 5A, 6A, 7C, 8A, 9A, 10A

Maximum Ratings

		LDR 110X	LDH 111X LDY 113X LDG 115X	
Reverse voltage	V_R	5	5	V
Forward current	I_F	100	60	mA
Surge current (≤10µs)	i_{FS}	2	1	A
Storage temperature range	T_{stg}	-55 to +100		°C
Junction temperature	T_j	100	100	°C
Total power dissipation (T_{amb}=25°C)	P_{tot}	200	200	mW
Thermal resistance junction to air	R_{thJA}	375	375	K/W

Characteristics (T_{amb}=25°)

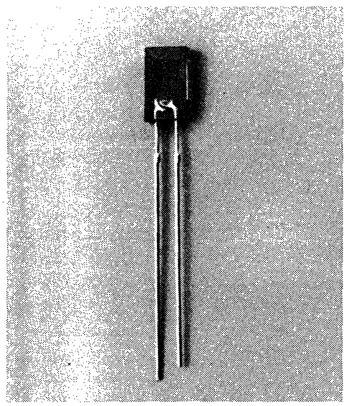
		LDR 110X	LDH 111X	LDY 113X	LDG 115X	
Wavelength at peak emission	λ_{peak}	665±15	645±15	590±10	560±15	nm
Dominant wavelength	λ_{dom}	645	638	592	561	nm
Viewing angle (Limits for 50% of luminous intensity I_v)	φ	70	70	70	70	Deg.
Forward voltage (I_F = 20mA)	V_F	1.6(≤2.0)		2.4(≤3.0)		V
Reverse current (V_R = 5 V)	I_R			0.01 (≤10)		µA
Rise time	t_r	5	100	200	50	ns
Fall time	t_f	5	100	200	50	ns
Capacitance (V_R = 0 V; f = 1 MHz)	C_0	40	12	10	45	pF

Luminous Intensity

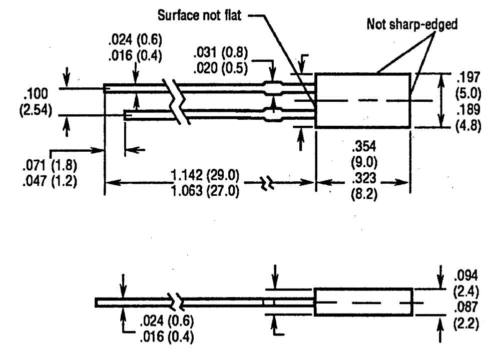
P/N	mcd (MIN)	Test conditions
LDR 1101	1.0	20mA
LDR 1102	2.0	20mA
LDR 1103	4.0	20mA
LDH 1111	2.5	10mA
LDH 1112	4.0	10mA
LDH 1113	6.0	10mA
LDY 1131	1.0	10mA
LDY 1132	2.0	10mA
LDY 1133	4.0	10mA
LDG 1151	2.5	20mA
LDG 1152	6.0	20mA
LDG 1153	10	20mA

SIEMENS

RED LDR 3701/3702
HIGH EFFICIENCY RED LDH 3601/3602/3603
YELLOW LDY 3801/3802/3803
GREEN LDG 3901/3902/3903
RECTANGULAR LED LAMP



Package Dimensions in Inches (mm)



FEATURES

- **Red Diffused Lens, LDR 370X**
  Red Diffused Lens, LDH 360X
  Yellow Diffused Lens, LDY 380X
  Green Diffused Lens, LDG 390X
- **T1¾ Size Rectangular Shape**
- **Minimum Lead Length 1″**
- **1/10″ Lead Spacing**
- **I/C Compatible**

DESCRIPTION

The LDR 370X is a standard red GaAsP LED lamp. The LDH 360X high efficiency red and LDY 380X yellow are light emitting diode lamps fabricated with TSN (transparent substrate nitrogen) technology. The LDG 390X green is a gallium phosphide LED lamp. All these lamps have a diffused lens which forms an evenly dispersed rectangular head-on light. They can be used singly as indicators or stacked together to form arrays.

See graph numbers on pages 4-27 – 4-34.
Red: 1D, 2B, 3D, 5B, 6C, 7B, 8B, 9B, 10B
HER: 1A, 2B, 3A, 5A, 6A, 7A, 8A, 9A, 10A
Yellow: 1A, 2B, 3E, 5A, 6A, 7A, 8A, 9A, 10A
Green: 1A, 2B, 3A, 5A, 6D, 7C, 8A, 9A, 10A

Maximum Ratings

Reverse voltage	V_R	5	V
Forward current	I_F	60	mA
Surge current ($t \leq 10$ s)	i_{FS}	1	A
Storage temperature	T_s	−55 to +100	°C
Junction temperature	T_j	100	°C
Power dissipation (T_{amb} = 25°C)	P_{tot}	200	mW
Thermal resistance junction to air	R_{thJamb}	375	K/W

Characteristics T_{amb} = 25°C)

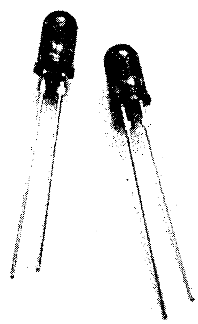
		LDR 370X	LDH 360X	LDY 380X	LDG 390X	
Wave length of emitted light	λ_{peak}	665 ± 15	645 ± 15	590 ± 10	560 ± 15	nm
Dominant wave length	λ_{dom}	645	638	592	561	nm
Viewing Angle (Limits for 50% of luminous intensity I_V) shielded against lateral emission of light	φ	100	100	100	100	Deg.
Forward voltage (I_F = 20 mA)	V_F		1.6 (≤2.0)	2.4 (≤3.0)		V
Reverse current (V_R = 5 V)	I_R		0.01 (≤10)	0.01 (≤10)		μA
Rise time	t_r	5	5	100	50	ns
Fall time	t_f	5	5	100	50	ns
Capacitance (V_R = 0 V)	C_0	40	40	10	45	pF

Luminous Intensity

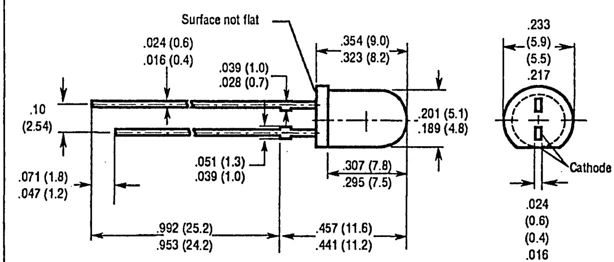
P/N	Min.	Unit	Test Condition
LDR 3701	.4	mcd	20 mA
LDR 3702	.63	mcd	20 mA
LDH 3601	1.6	mcd	20 mA
LDH 3602	2.5	mcd	20 mA
LDH 3603	4.0	mcd	20 mA
LDY 3801	1.0	mcd	20 mA
LDY 3802	1.6	mcd	20 mA
LDY 3803	2.5	mcd	20 mA
LDG 3901	1.0	mcd	20 mA
LDG 3902	1.6	mcd	20 mA
LDG 3903	2.5	mcd	20 mA

SIEMENS

RED LDR 5001/5002/5003
HIGH EFFICIENCY RED LDH 5021/5022/5023
HIGH EFFICIENCY YELLOW LDY 5061/5062
HIGH EFFICIENCY GREEN LDG 5071/5072
T1¾ LED LAMP



Package Dimensions in Inches (mm)



FEATURES

- High Light Output
- Diffused Lens
- Wide Viewing Angle 70°
- With Standoffs
- T1¾ Package Size
- 1″ Lead Length
- Front Panel Mounting
  Snap-in Mounting Clips Available
  Clip/Collar #2004-9002 Black
  #2004-9003 Clear
- I/C Compatible

DESCRIPTION

The LDR 500X is a standard red gallium arsenide phosphide (GaAsP) LED lamp. The LDH 502X high efficiency red and LDY 506X yellow are premium high efficiency light emitting diode lamps fabricated with TSN (transparent substrate nitrogen) technology. The LDG 507X green is a gallium phosphide (GaP) lamp. All have a diffused plastic lens which emits a full flooded intense light.

See graph numbers on pages 4-27 – 4-34.
Red: 1D, 2G, 3D, 5B, 6C, 7B, 8B, 9A, 10B
HER: 1A, 2G, 3A, 5A, 6A, 7A, 8A, 9A, 10A
Yellow: 1A, 2G, 3E, 5A, 6A, 7A, 8A, 9A, 10A
Green: 1A, 2G, 3B, 5A, 6D, 7C, 8A, 9A, 10A

Maximum Ratings

		LDR 500X	LDH 502X LDY 506X LDG 507X	
Reverse voltage	V_R	5	5	V
Forward current	I_F	100	60	mA
Surge current ($\tau \leq 10 \mu s$)	i_{FS}	2	1	A
Storage temperature range	T_{stg}	-55 to +100		°C
Junction temperature	T_j	100	100	°C
Total power dissipation (T_{amb} = 25°C)	P_{tot}	200	200	mW
Thermal resistance junction to air	R_{thJA}	375	375	K/W

Characteristics (T_{amb} = 25°C)

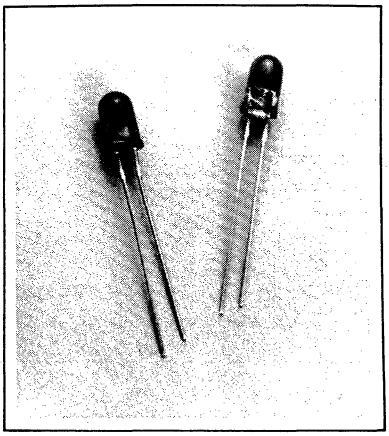
		LDR 500X	LDH 502X	LDY 506X	LDG 507X	
Wavelength at peak emission	λ_{peak}	665±15	645±15	590±10	560±15	nm
Dominant wavelength	λ_{dom}	645	638	592	561	nm
Half angle (Limits for 50% of luminous intensity I_v	φ	35	35	35	35	Deg.
Forward voltage (I_F = 20mA)	V_F	1.6 (≤2.0)	2.4(≤3.0)			V
Reverse current (V_R = 5 V)	I_R		0.01 (≤10)			μA
Rise time	t_r	5	100	200	50	ns
Fall time	t_f	5	100	200	50	ns
Capacitance (V_R = 0 V; f = 1MHz)	C_0	40	12	10	45	pF

Luminous Intensity Grouping

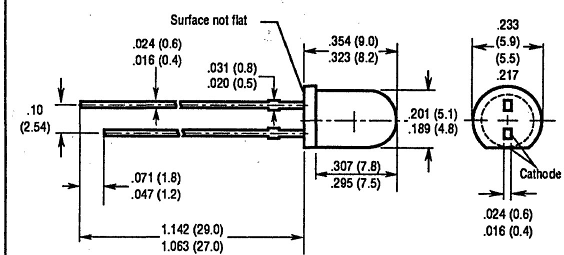
P/N	mcd (Min)	Test conditions
LDR 5001	1.0	20mA
LDR 5002	2.5	20mA
LDR 5003	4.0	20mA
LDH 5021	2.0	10mA
LDH 5022	4.0	10mA
LDH 5023	6.0	10mA
LDY 5061	1.0	10mA
LDY 5062	2.5	10mA
LDG 5071	2.5	20mA
LDG 5072	6.0	20mA

SIEMENS

RED LDR 5091/5092/5093
HIGH EFFICIENCY RED LDH 5191/5192/5193
YELLOW LDY 5391/5392/5393
GREEN LDG 5591/5592
T1¾ LED LAMP



Package Dimensions in Inches (mm)



FEATURES

- **High Light Output**
- **Lightly Tinted Clear Lens**
- **Wide Viewing Angle, 24°**
- **T1¾ Package Size**
- **1″ Lead Length**
- **Front Panel Mounting**
  Snap-in Mounting Clips Available
  Clip/Collar #2004-9002 Black
  #2004-9003 Clear
- **I/C Compatible**

DESCRIPTION

The LDR 509X is a standard red GaAsP light emitting diode lamp. The LDH 519X high efficiency red and LDY 539X yellow lamps are fabricated with TSN (transparent substrate nitrogen) technology. The LDG 559X is a gallium phosphide LED lamp. All four have a lightly tinted clear lens with a narrow viewing angle for the concentration of intense brightness in a head-on position. This is particularly desirable for legend back lighting applications.

See graph numbers on pages 4-27– 4-34.
Red: 1D, 2H, 3D, 5B, 6C, 7B, 8B, 9B, 10A
HER: 1A, 2I, 3A, 5A, 6A, 7A, 8A, 9A, 10C
Yellow: 1A, 2I, 3E, 5A, 6A, 7A, 8A, 9A, 10C
Green: 1A, 2I, 3B, 5A, 6D, 7C, 8A, 9A, 10A

Maximum Ratings

		LDR 509X	LDH 519X LDY 539X LDG 559X	
Reverse voltage	V_R	5	5	V
Forward current	I_F	100	60	mA
Surge current ($\tau \leq 10\ \mu s$)	i_{FS}	2	1	A
Storage temperature range	T_{stg}	– 55 to + 100		°C
Junction temperature	T_j	100		°C
Total power dissipation (T_{amb} = 25°C)	P_{tot}	200		mW
Thermal resistance, junction to air	R_{thJA}	375		K/W

Characteristics (T_{amb} = 25°C)

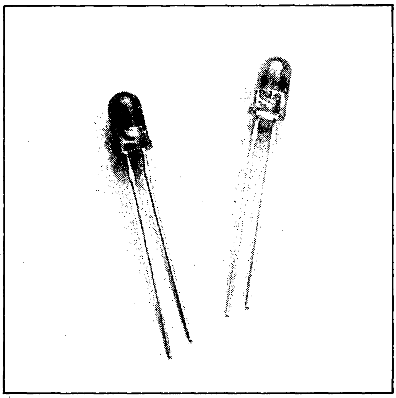
		LDR 509X	LDH 519X	LDY 539X	LDG 559X	
Wavelength at peak emmision	λ_{peak}	665 ± 15	645 ± 15	590 ± 10	560 ± 15	nm
Dominant wavelength	λ_{dom}	645	638	592	561	nm
Viewing angle (Limits for 50% of luminous intensity I_v)	φ	24	24	24	24	Deg.
Forward voltage (I_F = 20mA)	V_F	1.6(≤2.0)		2.4(≤3.0)		V
Reverse current (V_R = 5 V)	I_R			0.01(≤10)		μA
Rise time	t_r	5	100	100	50	ns
Fall time	t_f	5	100	100	50	ns
Capacitance (V_r = 0 V; f = 1 MHz)	C_o	40	12	10	45	pF

Luminous Intensity Grouping

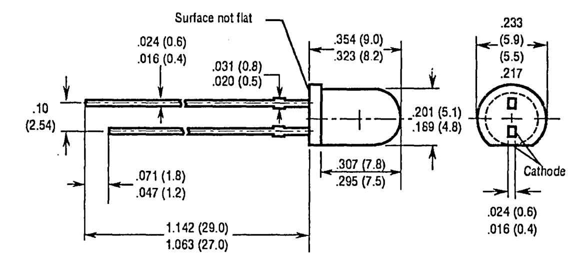
P/N	Min Mcd	Test Current
LDR 5091	2.5	20 mA
LDR 5092	4.0	20 mA
LDR 5093	10	20 mA
LDH 5191	10	10 mA
LDH 5192	20	10 mA
LDH 5193	30	10 mA
LDY 5391	10	10 mA
LDY 5392	20	10 mA
LDY 5393	30	10 mA
LDG 5591	40	20 mA
LDG 5592	80	20 mA

SIEMENS

RED LDR 5101/5102/5103
HIGH EFFICIENCY RED LDH 5121/5122/5123
HIGH EFFICIENCY YELLOW LDY 5161/5162/5163
HIGH EFFICIENCY GREEN LDG 5171/5172
T1¾ LED LAMP



Package Dimensions in Inches (mm)



FEATURES

- **High Light Output**
- **Diffused Lens**
- **Wide Viewing Angle 70°**
- **With Standoffs**
- **T1 ¾ Package Size**
- **1″ Lead Length**
- **Front Panel Mounting**
  Snap-in Mounting Clips Available
  Clip/Collar #2004-9002 Black
  #2004-9003 Clear
- **I/C Compatible**

DESCRIPTION

The LDR 510X Series is a standard red gallium arsenide phosphide (GaAsP) LED lamp. The LDH 512X high efficiency red and LDY 516X yellow are premium high efficiency light emitting diode lamps fabricated with TSN (transparent substrate nitrogen) technology. The LDG 517X green is a gallium phosphide (GaP) lamp. All have a diffused plastic lens which emits a full flooded intense light.

See graph numbers on pages 4-27 – 4-34.
Red: 1A, 2G, 3D, 5B, 6C, 7B, 8B, 9B, 10B
HER: 1A, 2G, 3A, 5A, 6A, 7A, 8A, 9A, 10A
Yellow: 1A, 2G, 3E, 5A, 6A, 7A, 8A, 9A, 10A
Green: 1A, 2G, 3B, 5A, 6D, 7C, 8A, 9A, 10A

Maximum Ratings

		LDR 510X	LDH 512X LDY 516X LDG 517X	
Reverse voltage	V_R	5	5	V
Forward current	I_F	100	60	mA
Surge current ($\tau \leq 10\mu s$)	i_{FS}	2	1	A
Storage temperature range	T_{stg}	-55 to +100		°C
Junction temperature	T_j	100	100	°C
Total power dissipation (T_{amb} = 25°C)	P_{tot}	200	200	mW
Thermal resistance junction to air	R_{thJA}	375	375	K/W

Characteristics (T_{amb} = 25°)

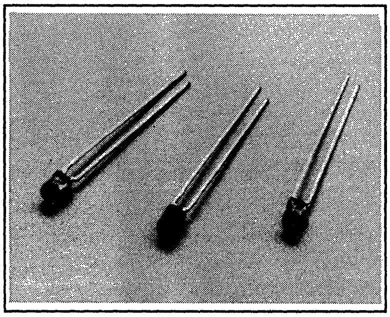
		LDR 510X	LDH 512X	LDY 516X	LDG 517X	
Wavelength at peak emission	λ_{peak}	665±15	645±15	590±10	560±15	nm
Dominant wavelength	λ_{dom}	645	638	592	561	nm
Viewing angle (Limits for 50% of luminous intensity I_v	φ	70	70	70	70	Deg.
Forward voltage (I_F = 20mA)	V_F	1.6(≤2.0)	2.4(≤3.0)			V
Reverse current (V_R = 5 V)	I_R		0.01 (≤10)			µA
Rise time	t_r	5	100	200	50	ns
Fall time	t_f	5	100	200	50	ns
Capacitance (V_R = 0 V; f = 1MHz)	C_0	40	12	10	45	pF

Luminous Intensity Grouping

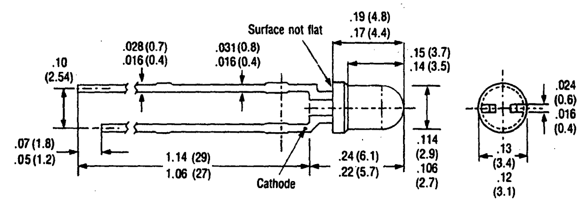
P/N	mcd (Min)	Test Conditions
LDR 5101	1.0	20mA
LDR 5102	2.5	20mA
LDR 5103	4.0	20mA
LDH 5121	2.0	10mA
LDH 5122	4.0	10mA
LDH 5123	6.0	10mA
LDY 5161	1.0	10mA
LDY 5162	2.5	10mA
LDY 5163	4.0	10mA
LDG 5171	2.5	20mA
LDG 5172	6.0	20mA

SIEMENS

HIGH EFFICIENCY RED LS3369-EO/-FO
YELLOW LY3369-EO/-FO
GREEN LG3369-EO/-FO
LOW CURRENT T1 LED LAMP



Package Dimensions in Inches (mm)



FEATURES

- **Low Power Requirement**
- **60° Viewing Angle**
- **Diffused Lens**
- **1" Lead Length**
- **I/C Compatible**

DESCRIPTION

The 3369 series are low current LED lamps that have been designed to optimize light output at very low currents. These parts are ideally suited for applications where power is at a premium, such as portable equipment.

See graph numbers 2J, 3F and 4C (HER), 3G and 4D (yellow), 3H and 4E (green), 6F on pages 4-27 – 4-34.

Maximum Ratings

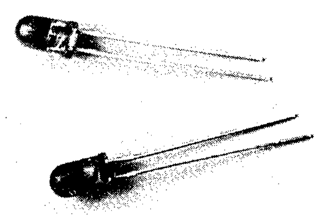
Reverse Voltage (V_R)	5 V
Forward Current (I_F)	7.5 mA
Surge Current ($\tau \leq 10\ \mu s/D \leq .005$) ($I_{FS}$)	100 mA
Storage Temperature Range (T_{stg})	-55 to +100°C
Junction Temperature (T_j)	100°C
Total Power Dissipation (T_{amb} = 25°C) (P_{tot})	20 mW
Thermal Resistance Junction-air (R_{thJA})	500 K/W

Electrical/Optical Characteristics (T_{amb} = 25°C)

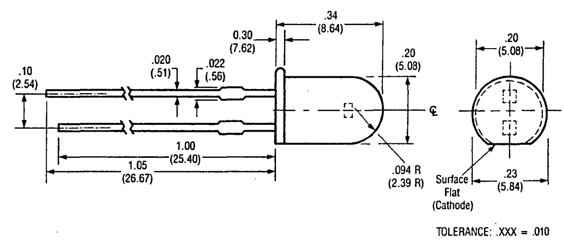
	Min	Typ	Max	Unit	Test Condition
Luminous Intensity					
HER, Yellow, Grn (-EO)	0.63	2		mcd	I_F = 2 mA
HER, Yellow, Grn (-FO)	1	2		mcd	I_F = 2 mA
Peak Wavelength					
HER		635		nm	I_F = 2 mA
Yellow		590		nm	I_F = 2 mA
Green		565		nm	I_F = 2 mA
Dominant Wavelength					
HER		625		nm	I_F = 2 mA
Yellow		592		nm	I_F = 2 mA
Green		564		nm	I_F = 2 mA
Half Angle		60		Deg.	
Forward Voltage V_F					
HER		1.8	2.5	V	I_F = 2 mA
Yellow, Green		1.9	2.7	V	I_F = 2 mA
Reverse Current I_R		.010	10	μA	V_R = 5 V
Response Time (Rise Time) t_r I_V from 10% to 90%					
HER, Yellow		200		ns	I_F = 25 mA, T = 1 μsec
Green		450		ns	I_F = 25 mA, T = 1 μsec
Response Time (Fall Time) t_f I_V from 90% to 10%					
HER, Yellow		150		ns	I_F = 25 mA, T = 1 μsec
Green		200		ns	I_F = 25 mA, T = 1 μsec
Capacitance C_0					
HER, Yellow		3		pF	V_R = 0 V, f = 1 MHz
Green		12		pF	V_R = 0 V, f = 1 MHz
Spectral Line Halfwidth					
HER		45		nm	I_F = 2 mA
Yellow		50		nm	I_F = 2 mA
Green		25		nm	I_F = 2 mA

SIEMENS

HIGH EFFICIENCY RED LS5421-MO/-PO/-QO
YELLOW LY5421-MO/-PO/-QO
GREEN LG5411-LO/-NO/-PO
SUPERBRIGHT T1¾ LED LAMPS



Package Dimensions in Inches (mm)



FEATURES
- High Light Output
- New Lens to Optimize Output
- 20° Viewing Angle
- HER Lamp, Orange Tinted Lens
  Yellow Lamp, Yellow Tinted Lens
  Green Lamp, Water Clear Lens
- 1″ Lead Length

DESCRIPTION
The 5421/5411 series are superbright T1¾ LED lamps. Improvements in materials and optimization of lens and reflectors have resulted in a dramatic increase in luminous intensity.

Maximum Ratings
Power Dissipation (T_{amb} = 25°C) .... 150 mW
Storage and Operating Temperature .... –55 to +100°C
Continuous Forward Current .... 45 mA
Reverse Voltage .... 5 V
Surge Current ($\tau \leq 10\ \mu s$) .... 1 A

Electrical/Optical Characteristics (T_{amb} = 25°C)

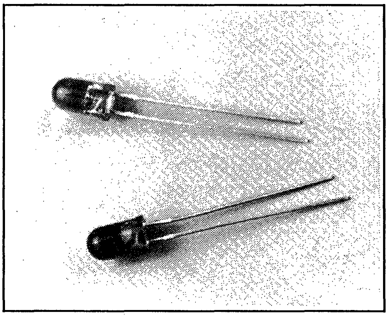
	Min	Typ	Max	Unit	Test Condition
Luminous Intensity					
HER, Yellow (-MO)	16	40		mcd	I_F = 10 mA
HER, Yellow, Green (-PO)	40	60		mcd	I_F = 10 mA
HER, Yellow (-QO)	63	100		mcd	I_F = 10 mA
Green (-LO)	10	40		mcd	I_F = 10 mA
Green (-NO)	25	40		mcd	I_F = 10 mA
Peak Wavelength					
HER		635		nm	I_F = 10 mA
Yellow		590		nm	I_F = 10 mA
Green		560		nm	I_F = 10 mA
Half Angle		20		Deg.	
Forward Voltage		2.2	3.0	V	I_F = 10 mA
Reverse Current I_R		0.1	100	μA	I_R = 5 V

See graph numbers 1B, 2N, 3I, 4F, 5C, 6E, 7E, 8A, 9A, 10B on pages 4-27–4-34.

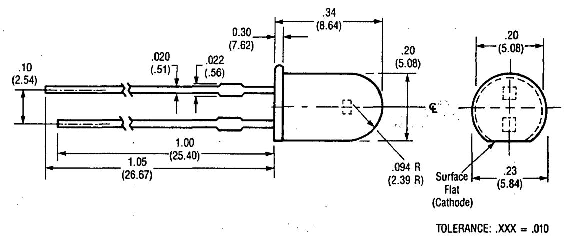
SIEMENS

HIGH EFFICIENCY RED LS5469-EO/-FO
YELLOW LY5469-EO/-FO
GREEN LG5469-EO/-FO

LOW CURRENT T1¾ LED LAMP



Package Dimensions in Inches (mm)



FEATURES

- **Low Power Requirement**
- **50° Viewing Angle**
- **Diffused Lens**
- **1″ Lead Length**
- **I/C Compatible**

DESCRIPTION

The 5469 series are low current LED lamps that have been designed to optimize light output at very low currents. These parts are ideally suited for applications where power is at a premium, such as portable equipment.

Both the HER and yellow lamps utilize GaAsP on GaP semiconductor materials while the green lamps utilize GaP on GaP.

See graph numbers 2K, 3F and 4C (HER), 3G and 4D (yellow), 3H and 4E (green), 6F on pages 4-27 – 4-34.

Maximum Ratings

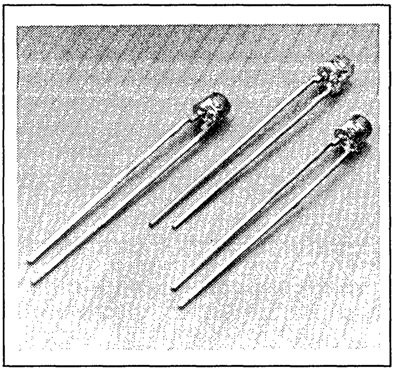
Reverse Voltage (V_R)	5 V
Forward Current (I_F)	7.5 mA
Surge Current ($\tau \leq 10$ µs/D ≤ .005) (I_{FS})	100 mA
Storage Temperature Range (T_{stg})	–55 to +100°C
Junction Temperature (T_j)	100°C
Total Power Dissipation (T_{amb} = 25°C) (P_{tot})	20 mW
Thermal Resistance Junction-air (R_{thJA})	500 K/W

Electrical/Optical Characteristics (T_{amb} = 25°C)

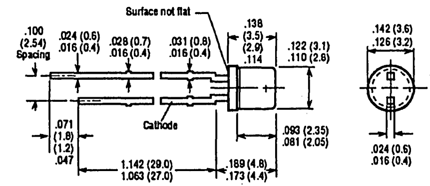
	Min	Typ	Max	Unit	Test Condition
Luminous Intensity					
HER, Yellow, Grn (-EO)	0.63	2		mcd	I_F = 2 mA
HER, Yellow, Grn (-FO)	1	2		mcd	I_F = 2 mA
Peak Wavelength					
HER		635		nm	I_F = 2 mA
Yellow		590		nm	I_F = 2 mA
Green		565		nm	I_F = 2 mA
Dominant Wavelength					
HER		625		nm	I_F = 2 mA
Yellow		592		nm	I_F = 2 mA
Green		564		nm	I_F = 2 mA
Half Angle		50		Deg.	
Forward Voltage V_F					
HER		1.8	2.5	V	I_F = 2 mA
Yellow, Green		1.9	2.7	V	I_F = 2 mA
Reverse Current I_R		010	10	µA	V_R = 5 V
Response Time (Rise Time) t_r I_V from 10% to 90%					
HER, Yellow		200		ns	I_F= 25 mA T = 1 µsec
Green		450		ns	I_F = 25 mA T = 1 µsec
Response Time (Fall Time) t_f I_V from 90% to 10%					
HER, Yellow		150		ns	I_F= 25 mA T = 1 µsec
Green		200		ns	I_F = 25 mA T = 1 µsec
Capacitance C_0					
HER, Yellow		3		pF	V_R = 0 V f = 1 MHz
Green		12		pF	V_R = 0 V f = 1 MHz
Spectral Line Halfwidth					
HER		45		nm	I_F = 2 mA
Yellow		50		nm	I_F = 2 mA
Green		25		nm	I_F = 2 mA

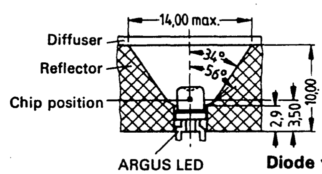
SIEMENS

HIGH EFFICIENCY RED LS K380
YELLOW LY K380
GREEN LG K380
T1 ARGUS LED LAMP



Package Dimensions in Inches (mm)





Diode with reflector and diffuser

LED Lamps

FEATURES

- Colors: HER, Yellow, Green
- Lens: Tinted Transparent
- Low Power Dissipation
- Low Self-Heating
- Rugged Design
- Optimal for Backlighting Applications
- Cathode: Shorter Solder Tab

DESCRIPTION

The LS/LY/LG K380 are T1 (3 mm) ARGUS LED lamps. ARGUS lamps can be used only with an additional, custom-built reflector (i.e., white plastic, such as Pocan B7375). The front end of the reflector is covered by a diffuser (see illustration). Uniform illumination can be enhanced by the reflector design tailored to the LED and/or by the use of appropriate diffuser material. If the diffuser is tinted, the spectral transmission must be adjusted to the wavelength emitted by the LED.

Applications include backlighting of display panels, e.g. front panels, graphic control and display boards, sealed keyboards, large-scale displays, dot matrix displays.

Maximum Ratings

Reverse Voltage (V_R) .... 5 V
Forward Current (I_F) .... 45 mA
Surge Current t_p = 10 µs, (I_{FM}) .... 1 A
Operating Temperature Range (T_{amb}) .... -55°C to +100°C
Storage Temperature Range (T_{STG}) .... -55°C to +100°C
Junction Temperature (T_J) .... +100°C
Total Power Dissipation (P_{TOT}) T_{amb}=25°C .... 150 mW
Thermal Resistance Junction to Air (R_{THJA}) .... 500 K/W

Characteristics (T_{amb}=25°C)

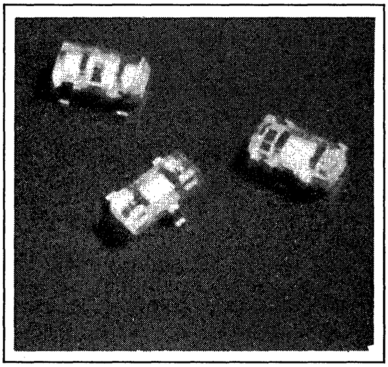
Parameter	Symbol	LS K380 HER	LY K380 Yellow	LG K380 Green	Unit
Wavelength at Peak Emission (I_F=20 mA)	λ_{PEAK}	635 (typ.)	586 (typ.)	565 (typ.)	nm
Dominant Wavelength	λ_{DOM}	628	590	567	nm
Spectral Bandwidth at 50% ϕ_V (I_F=20 mA)	$\Delta\lambda$	45	45	25	nm
Forward Voltage (I_F=10 mA)	V_F	2.0 (≤2.6)	2.0 (≤2.6)	2.0 (≤2.6)	V
Reverse Current (V_R=5 V)	I_R	0.01 (≤10)	0.01 (≤10)	0.01 (≤10)	µA
Capacitance (V_R=0 V, f=1 MHz)	C_0	12	10	15	pF
Switching Times (I_F=100 mA, t_p=10 µs)					
Rise Time from 10% to 90%	t_R	300	300	300	ns
Fall Time from 90% to 10%	t_F	150	150	450	ns
Luminous Flux (I_F=15 mA)	ϕ_V	32 (≥10)	32 (≥10)	32 (≥10)	lm

* Luminous flux factor of ϕ_V in one packaging unit $\frac{\phi_{V\,MAX}}{\phi_{V\,MIN}} \leq 2$.

See graph numbers 1B, 2L, 3I, 5C, 6E, 7E, 8A, 9C, 10B on pages 4-27 – 4-34.

SIEMENS

HIGH EFFICIENCY RED LS S260-DO
HIGH EFFICIENCY YELLOW LY S260-DO
HIGH EFFICIENCY GREEN LG S260-DO
HIGH EFFICIENCY RED/GREEN LU S250-DO
SOT23
SURFACE MOUNT LED LAMP



FEATURES

- **Available in:**
  High Efficiency Red, LS S260-DO
  High Efficiency Yellow, LY S260-DO
  High Efficiency Green, LG S260-DO
  High Efficiency Red and Green (Two Chip), LU S250-DO
- **Colored Diffused Plastic Package (Except for LU S250-DO which is Colorless Diffused)**
- **Rectangular Package, 1.3 mm by 3 mm by 1mm Thick**
- **Wide Viewing Angle, 140°**
- **Ideal for Use as Failure Indicators Mounted on Printed Circuit Boards**
- **IC Compatible**

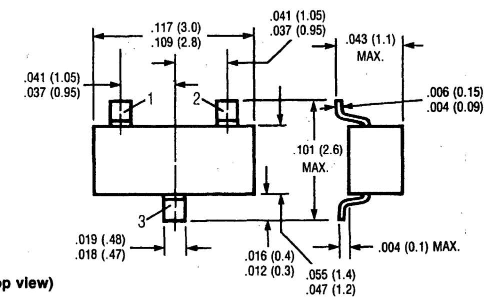
DESCRIPTION

These surface mount LED lamps (SOT23) are available in high efficiency red, yellow, green, and red/green combination. The lamps are supplied in bulk or on 8 mm wide tape on standard 18 cm diameter reels with 3000 components per reel. The packaging conforms to IEC standards and can be used on all commercial automatic surface mount insertion equipment. Add E7502 at the end of the part number, i.e., LS S260-DO E7502, to order the lamps on tape and reel.

Special 38 cm reels with 10,000 components per reel are available. Contact the factory for ordering information on 10,000 units per reel.

See Appnote 38 for surface mount information.

Package Dimensions in Inches (mm)



Pinouts (top view)

Pin	Function	
	LS/LY/LG S260-DO	**LU S250-DO**
1	NC	Red
2	Anode	Green
3	Cathode	Common Anode

Maximum Ratings (All Devices)

Note: For the LU S250-DO the following operating conditions apply when one diode is on while the other diode is off.

Reverse Voltage (V_R) . . . . . 5 V
Forward Current (I_F) . . . . . 12.5 mA
Ceramic Substrate[1] (I_F) . . . . . 30 mA
Surge Current ($\tau = 10\ \mu s$) (I_{FS}) . . . . . 1 A
Ceramic Substrate[1] ($\tau = 10\ \mu s$) (I_{FS}) . . . . . 1 A
Junction Temperature (T_J) . . . . . 100°C
Storage Temperature (T_S) . . . . . −55 to +100°C
Power Dissipation (P_{TOT}) . . . . . 70 mW
Ceramic Substrate[1] (P_{TOT}) . . . . . 200 mW
Thermal Resistance Junction to Air (R_{THJV}) . . . . . 1050 K/W
Thermal Resistance Junction to Ceramic (R_{THJSR}) . . . . . 375 K/W

Electrical/Optical Characteristics ($T_{amb} = 25°C$)

Wavelength of Emitted Light			
LS S260-DO	λ_{PEAK}	635 ±15	nm
LY S260-DO	λ_{PEAK}	590 ±10	nm
LG S260-DO	λ_{PEAK}	565 ±15	nm
Dominant Wavelength			
LS S260-DO	λ_{DOM}	628	nm
LY S260-DO	λ_{DOM}	592	nm
LG S260-DO	λ_{DOM}	564	nm
Aperture Cone (½<) (Limits for 50% of luminous intensity (IV) shielded against lateral emission of light)	φ	70	Deg.
Forward Voltage ($I_F = 10$ mA)	V_F	2.0 (≤2.6)	V
Reverse Current ($V_R = 5$ V)	I_R	0.1 (≤10)	μA
Luminous Intensity ($I_F = 10$ mA)	I_V	0.75 (≥0.4) Typ.	mcd

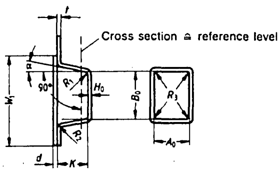
1. Ceramic substrate 2.5 cm² surface area, 0.7 mm thick.

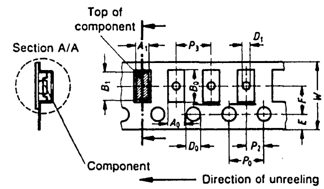
See graph numbers 1A, 2M, 3A (HER), 3E (yellow), 3B (green), 4G, 5A, 7F, 8C, 9A, 10A on pages 4-27–4-34.

PACKAGING OF SURFACE MOUNT LEDs

LEDs in **SOT23 packages** are available on continuous tapes. In this case, the **IEC publication 40 (secretariat) 458** applies.

The 8 mm broad tape is wound on an 18 cm or 33 cm film reel and is equipped with 3000 or 10,000 components.





Blister Tape

Dimensional table for blister tape

Designation	**Symbol**	**Dimensions in inches (mm)** SOT 23	**Notes**
Tape width	W	.315 ± .012 (8 ± 0.3)	
Carrier tape thickness	t	.012 max. (0.3)	
Pitch of sprocket holes	P_0	.157 ± .004 (4 ± 0.1)	Cumulative pitch error + 0.2 mm/10 pitches
Diameter of sprocket holes	D_0	.039 + .008 (1 + 0.2)	
Distance of sprocket holes	E	.069 ± .004 (1.75 ± 0.1)	
Distance of components	F	.138 ± .002 (3.5 ± 0.05)	Center hole to center compartment
	P_2	.079 ± .002 (2 ± 0.05)	
Distance compartment to compartment	P_3	.157 (4)	
Compartment dimensions	K	.098 max. (2.5)	Exact dimensions are given with the component dimensions
	a	15° max.	
	R_1, R_2	.012 max. (0.3)	
	H_0	$.012 {}^{+.004}_{-.002} \left(0.3 {}^{+0.1}_{-0.05}\right)$	Between inner side of the compartment bottom and the reference level for measuring A_0, B_0
Compartment	A_0 B_0	The tolerances are chosen such that the components can change their orientation only within permissible tolerances, but can easily be removed from the tape.	
Hole in compartment	D_1	$.039 {}^{+.008}_{-.002} \left(1 {}^{+0.2}_{-0.05}\right)$	Tolerance to the center of the sprocket hole: 0.1 mm
Width of fixing tape	W_1 d	.217 typ. (5.5) .004 max. (0.1)	The fixing tape shall not cover the sprocket holes, nor protrude beyond the carrier tape so that the max. tape width will not be exceeded.
Device tilt in the compartment	-	15° max.	
Minimum bending radius	-	1.181 min. (30)	

SOLDERING CONSIDERATIONS

Semiconductor components in plastic packages (SOT23) are designated as active components for thin and thick film integrated circuits. These soldering directions refer to the use of resistors and LED lamps on PCB substrates with interconnecting conductors which are tin-lead plated through dip soldering.

To achieve reliable bonding, the following criteria should be considered:

1. The right soldering temperature and appropriate soldering flux are important. The soldering flux is not to affect or attack the plastic package. The solvents should easily remove the flux residues and not affect or attack the plastic package.
2. Temperature (240 degree C max for 5 sec max) and rapid temperature changes during the soldering apply high mechanical stress to the substrate and should be avoided to prevent breaking or cracking of the substrate.
3. Placement of the semiconductor components onto the substrate is to be done with the highest precision. The soldering pads must be placed exactly on the conductor traces because there is a high risk of cracking if the hot soldering pads touch the package.

SOLDERING METHODS

The soldering method selection should be made according to production volume, amount of semiconductor components per circuit board, required precision placement, and possibility of exchanging/replacing semiconductor components. Listed below are four mounting methods.

METHOD 1 Wave or Dip Soldering

The components in the SOT23 housing are first glued onto the thick film substrate (glass, ceramic) or the etched printed circuit board (glass fiber) with silicon glue. The glue can be applied by silk screen printing. Care should be taken that the glue does not cover the contact surfaces. The components are pressed onto the substrate. A film of 60-80 um glue results in excellent adhesion, and when the components are attached, the contact surfaces are not contaminated. Soldering can be done through wave or dip soldering. A good soldering material is Sn-Pb mixture in eutectic proximity with a 3.5-4% Ag additive agent, i.e. Solidanol (170 Sn/Pb/Ag:60/35/4). The bath temperature is to be 225+/−10 degrees C and the maximum soldering time of 5 seconds. The recommended soldering flux is a non-activated colophonium resin 45%, dissolved in the ethyl alcohol 55% plus glycerin additive agent. After soldering the components, the solder flux residues are to be removed; cleaning baths containing isopropyl alcohol as a washing agent are suitable.

Method 2 Reflow Soldering

Here soldering flux is added to the powdered solder and then applied in paste form to the printed circuit board. This procedure is most effective using silk screenprinting. The thickness should be 80 um. The substrate with the components is heated for 5 seconds to 240 degrees C by means of a conveyer band or a heating plate. The paste is melted and the soldering process takes place. Further information can be obtained from the reflow soldering paste manufacturer's instructions.

METHOD 3 Pin Soldering

The substrate is placed on a heating plate with a temperature of 100 degrees C. A magnified view of the semiconductor component is used to place it into the right position. It is placed on the substrate by means of a minimum pressure valve. Simultaneously three (still cold) micro soldering pins are placed under pressure on the leads of the component to improve thermal resistance. The soldering pins have to be structured in a way that the thermal conductance takes place only on its peak. The soldering pins will be briefly charged (8 seconds) with 20 W each. Within this time span the solder becomes liquid for about 3 seconds which achieves a complete covering. Because of the low thermal capacity the soldering pins cool off rapidly after turn-off. The flux can, while soldering pins are still attached, cool off below their melting temperature. The soldering pins should be made of steel, (18% Cr, 8% N) because this material will not be adhesive to solder and has a good resistance against corrosion. Flux colophonium is suitable, which residues have to be removed after soldering with isopropyl alcohol. Using this method, the plastic package will not be heated more than the preheating plate. Provided the preheating plate temperature does not exceed 100 degrees C and the soldering time is not longer than 5 seconds, the risk of substrate cracking beneath the conductor wiring is lowered. The junction temperature will increase to about 250 degrees C with this method.

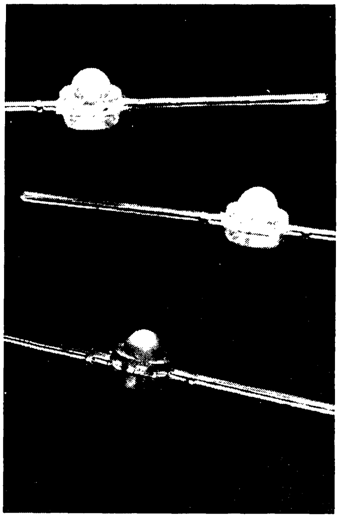
METHOD 4 Iron Soldering

Manual soldering using a miniature soldering has the following disadvantages.

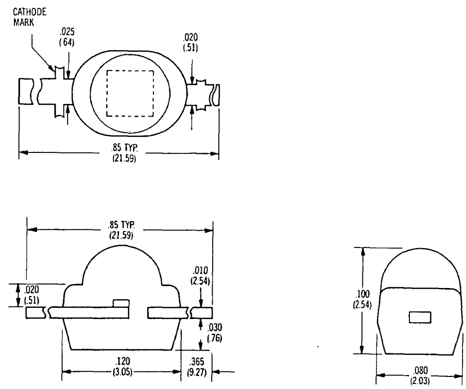
The placement of the component cannot be done very accurately in places where its leads directly touch the subtrate as stubsrate cracks during soldering can occur. Because of the sequential soldering of the leads, mechanical stress can cause substrate damage and consequently disrupt interconnections inside a component. Furthermore, the plastic package can be damaged by the soldering iron. Therefore, this method is only suitable for inserting single semiconductor components.

SIEMENS

WATER CLEAR LENS RL-50
RED DIFFUSED LENS RL-54
RED MINIATURE AXIAL LED LAMP



Package Dimensions in Inches (mm)



LED Lamps

FEATURES

- **High Luminance—typically 1.0 mcd @ 10 mA**
- **Optimum Packaging Design for Maximum Strength at Minimum Linear Spacing**
- **Operates from 5 V IC Logic Supply**
- **Small Size**
- **High Reliability**
- **Lens**
  RL-50: Water Clear
  RL-54: Red Diffused

DESCRIPTION

The RL-50 and RL-54 are intended for high volume usage in array and indicator light applications. Major advantages of these devices are high luminance at low currents, long life and low cost.

Maximum Ratings

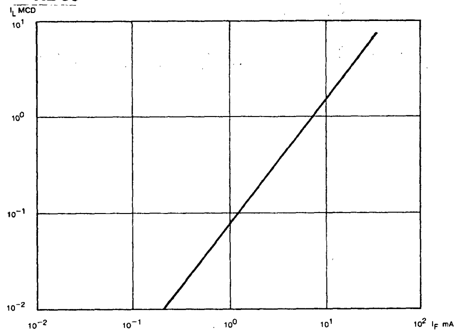
Power Dissipation @25° Ambient .... 80 mW
Derate Linearly from 25°C .... –1.1 mW/°C
Storage and Operating Temp. Range .... –55°C to +100°C
Continuous Forward Current .... 40 mA
Lead Solder Time@260°C (1/16″ from lens) .... 5 sec.
Peak Inverse Voltage .... 3.0 V

Electrical/Optical Characteristics (T_{amb} = 25°C)

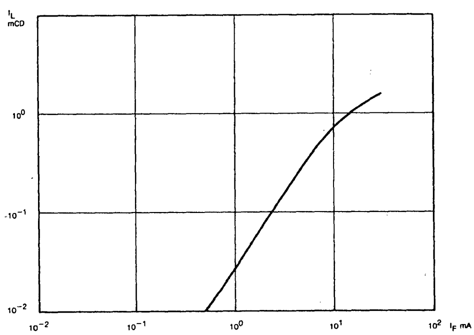
Parameter	Min	Typ	Max	Unit	Test Condition
Luminous Intensity					
RL-50	0.5	1.0		mcd	I_F = 20 mA
RL-54	0.4	0.6		mcd	I_F = 20 mA
Forward Voltage		1.6	2.0	V	I_F = 20 mA
Viewing Angle		90		Deg.	
Reverse Current			100	μA	3.0 V
Peak Emission Wavelength		660		nm	

Specifications are subject to change without notice.

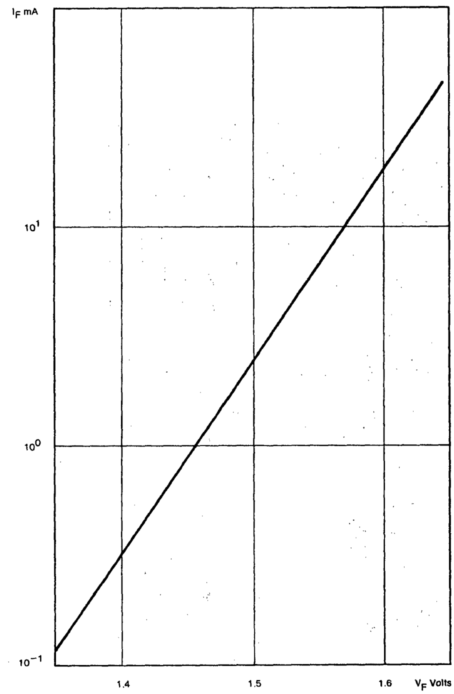
Luminous Intensity vs. Forward Current RL-50



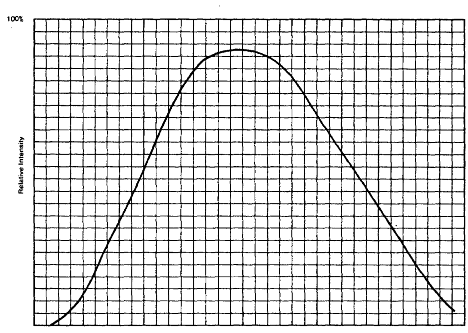
Luminous Intensity vs. Forward Current RL-54



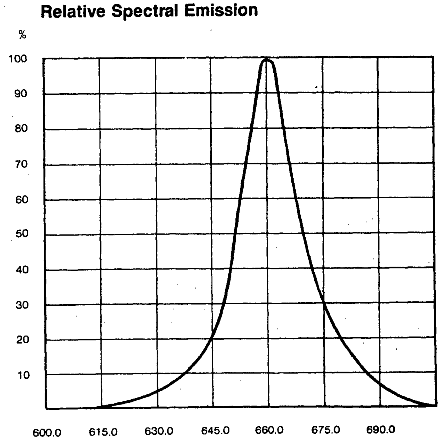
Forward Current vs. Forward Voltage



Radiation Characteristics

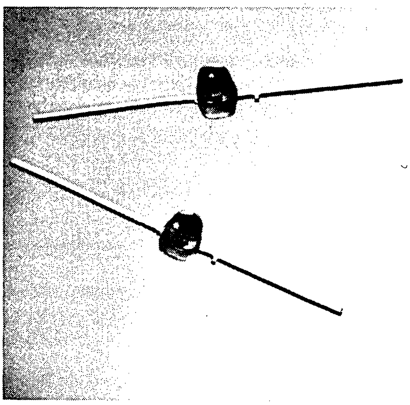


Relative Spectral Emission

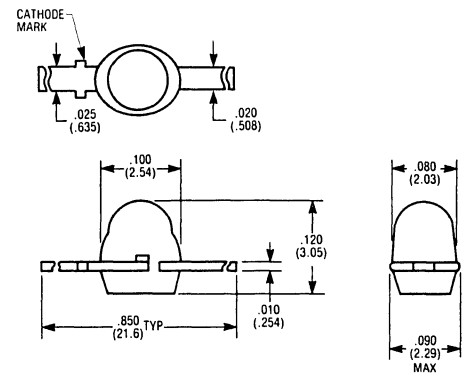


SIEMENS

RED RL-55 YELLOW YL-56 GREEN GL-56
MINIATURE AXIAL LEAD LED LAMP



Package Dimensions in Inches (mm)



FEATURES

- **2 Gate Load Bright Light: 0.4 mcd at 3 mA**
- **High on Axis Intensity**
- **Optimum Packaging Design for Maximum Strength at Minimum Linear Spacing**
- **Operates from 5 V IC Logic Supply**
- **Miniature Axial Lead**
- **High Reliability**
- **Low Cost Version (Red): RL-55-5**

DESCRIPTION

The RL-55 is a Gallium Arsenide Phosphide and GL-56/YL-56 are Gallium Phosphide LED lamps that have high on-axis intensity, long life and low cost. They are diffused lenses and provide a full 0.080″ flooded light with good contrast. Applications include mounting on PC boards at low current as diagnostic and circuit status indicators.

Maximum Ratings

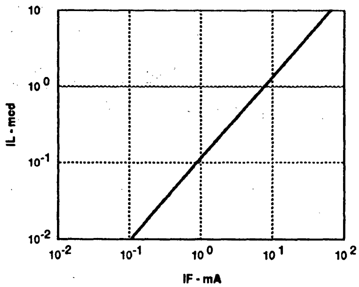
Power Dissipation @25°C Ambient	80 mW
Derate Linearly From 25°C	−1.1 mW/°C
Storage and Operating Temperature	−55°C to +100°C
Continuous Forward Current	
RL-55	40 mA
YL-56, GL-56	25 mA
Lead Solder Time@260°C (1/16″ from case)	5 sec.
Peak Inverse Voltage	3 V
Peak Forward Current	
(1 μs pulse, 0.1% duty cycle)	250 mA

Electrical/Optical Characteristics (T_{amb} = 25°C)

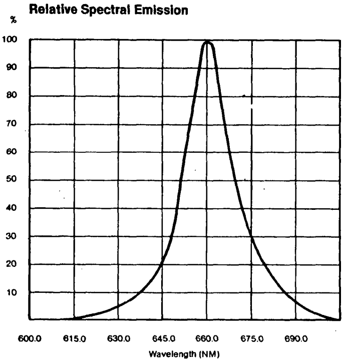
Parameter	Min	Typ	Max	Unit	Test Conditions
Luminous Intensity					
RL-55	2.0	2.2		mcd	I_F = 10 mA
YL-56	2.0	2.0		mcd	I_F = 10 mA
GL-56	1.0	1.3		mcd	I_F = 10 mA
Forward Voltage					
RL-55		1.6	2.0	V	I_F = 20 mA
YL-56		2.4	3.5	V	I_F = 20 mA
GL-56		2.2	3.5	V	I_F = 20 mA
Viewing Angle					
RL-55		50		Deg.	
YL-56, GL-56		40		Deg.	
Reverse Current		0.15	10	μA	V_R = 3 V
Peak Emission Wavelength					
RL-55		660		nm	
YL-56		585		nm	
GL-56		565		nm	
Spectral Line Half Width		40		nm	

Red RL-55

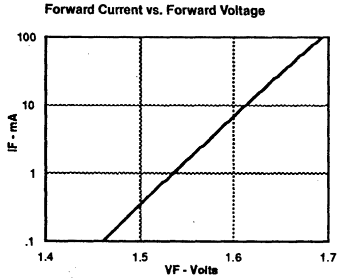
Luminuous Intensity vs. Forward Current



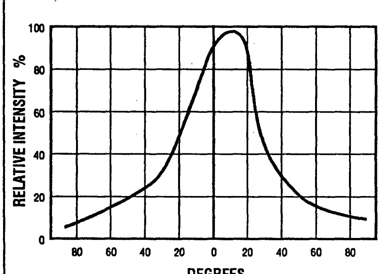
Relative Spectral Emission



Forward Current vs. Forward Voltage

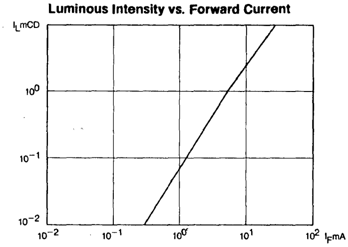


Radiation Characteristics

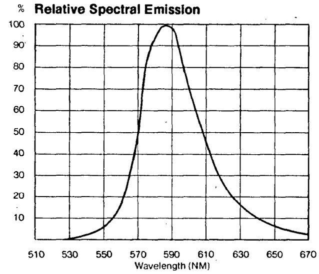


Yellow YL-56

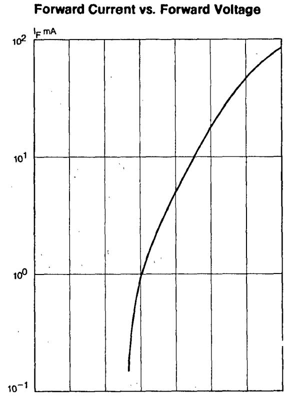
Luminous Intensity vs. Forward Current



% Relative Spectral Emission

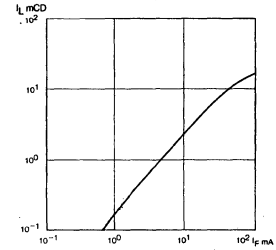


Forward Current vs. Forward Voltage

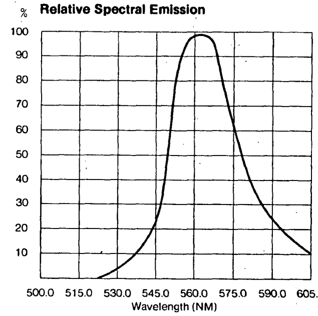


Green GL-56

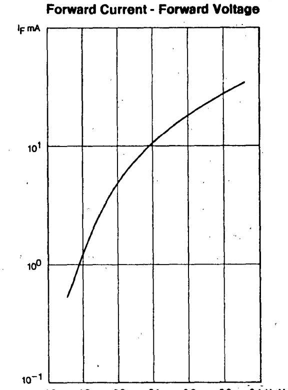
Luminous Intensity vs. Forward Current



% Relative Spectral Emission

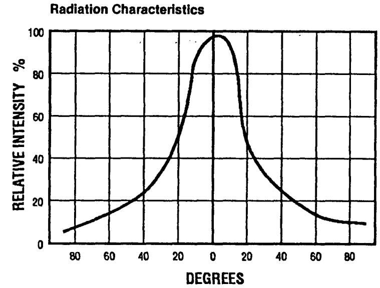


Forward Current - Forward Voltage

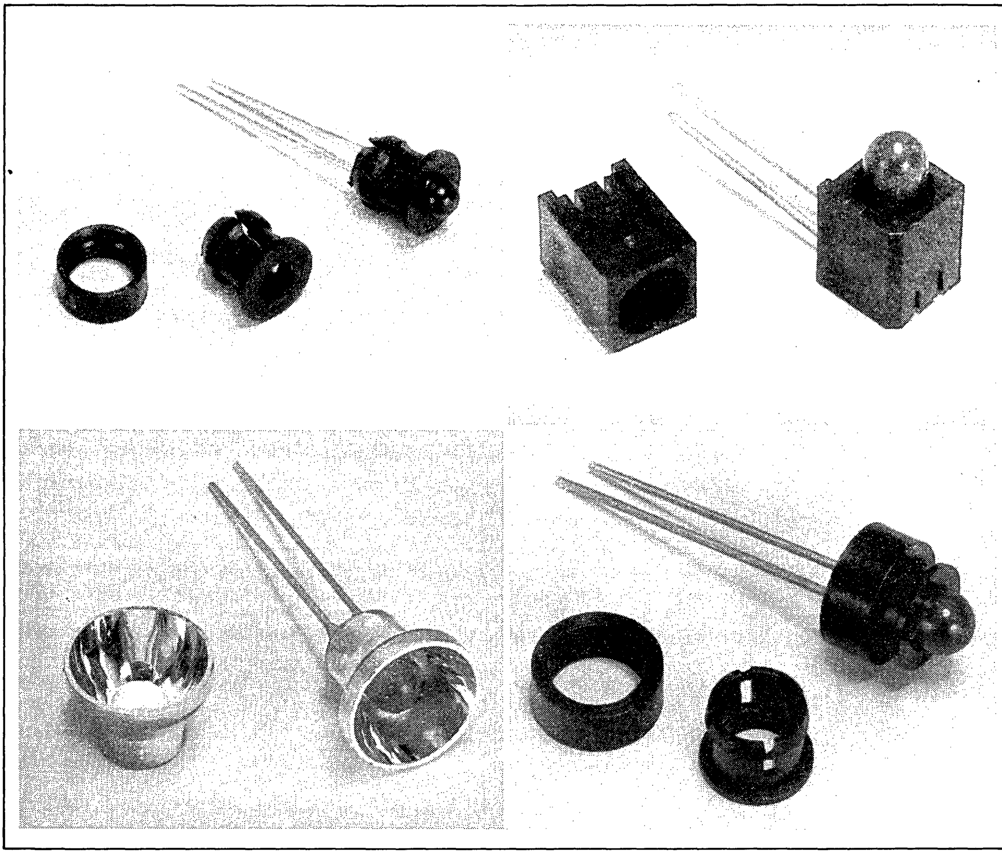


Yellow & Green YL-56 & GL-56

Radiation Characteristics

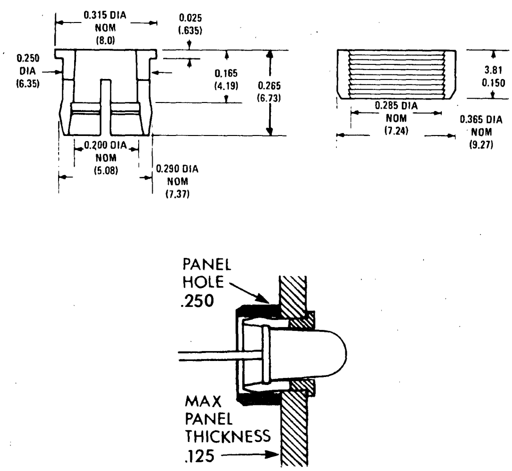


Lamp Accessories

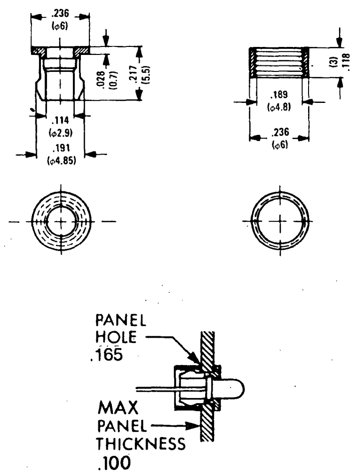


Part Number	Description	Color
2004-9002	Mounting Clip & Collar for T1 ¾ LED's	Black
2004-9003		Clear
2004-9015	Mounting Clip & Collar for T1 LED's	Clear
2004-9016		Black
2004-9019	Right Angle Mounting Part Designed to allow right angle mounting of lamps to PC Boards and other surfaces.	Black
2004-9020	Reflector This highly polished reflector greatly increases lighted area and enhances overall brightness of low profile and T1 ¾ LED's	Polished

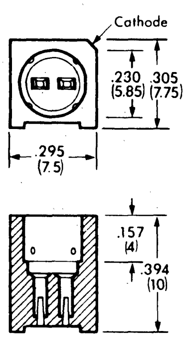
2004-9002
2004-9003



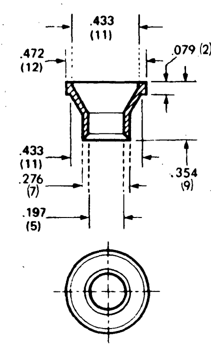
2004-9015
2004-9016



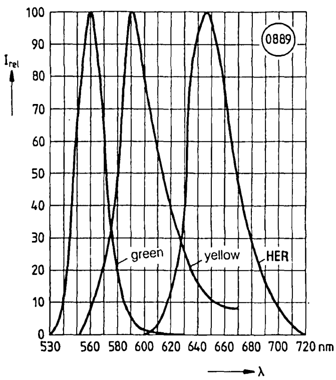
2004-9019 Right Angle Mounting Part



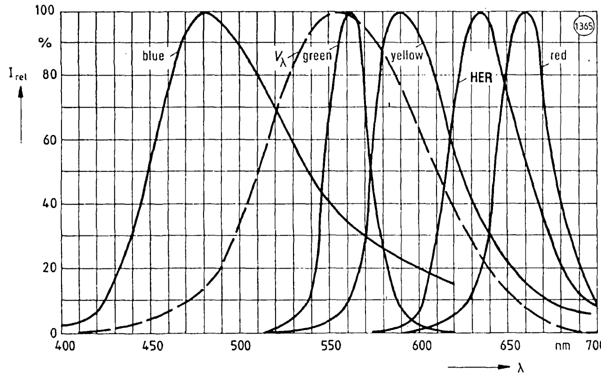
2004-9020 Reflector



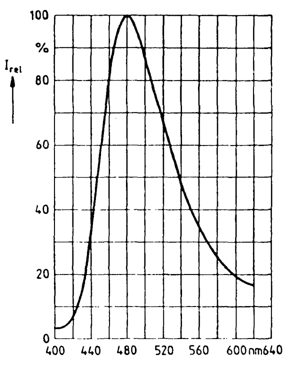
1A.
Relative spectral emission
I_{REL}=f (λ)



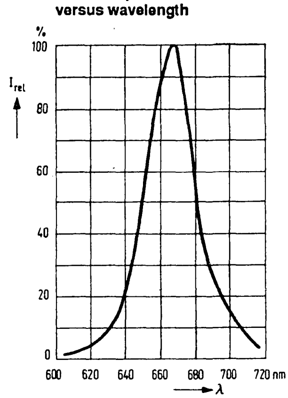
1B.
Relative spectral emission versus wavelength
$V_λ$= standard eye response curve



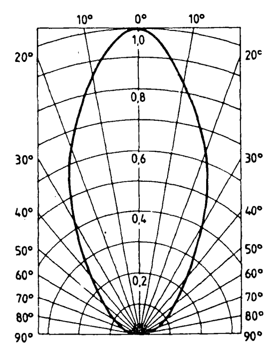
1C.
Relative spectral emission versus wavelength



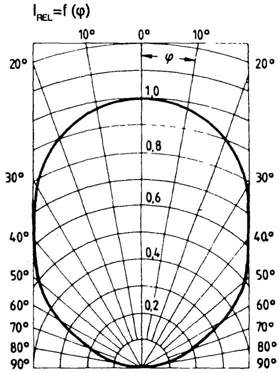
1D.
Relative spectral emission versus wavelength



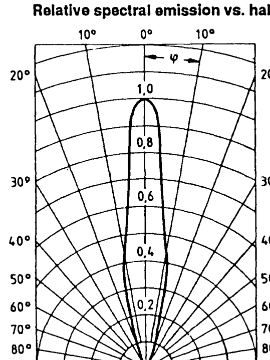
2A.
Radiation characteristic
I_{REL}=f (φ)



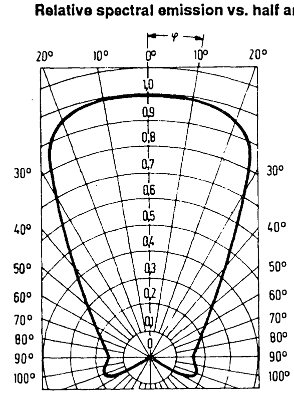
2B.
Radiation characteristic
I_{REL}=f (φ)



2C.
Radiation characteristic
Relative spectral emission vs. half angle

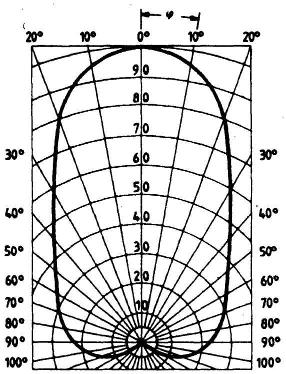


2D.
Radiation characteristic
Relative spectral emission vs. half angle

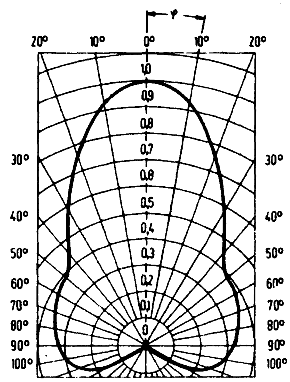


GRAPHS FOR LAMPS (*Cont.*)

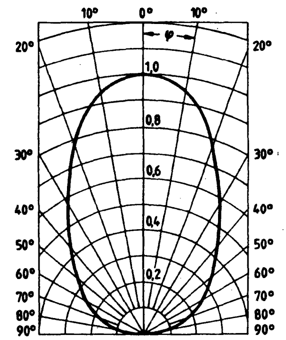
2E.
Radiation characteristic
Relative spectral emission vs. half angle



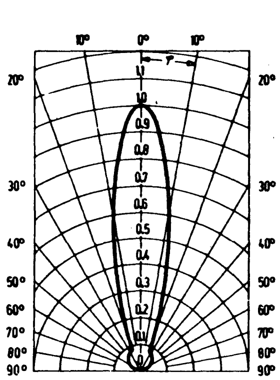
2F.
Radiation characteristic
Relative spectral emission vs. half angle



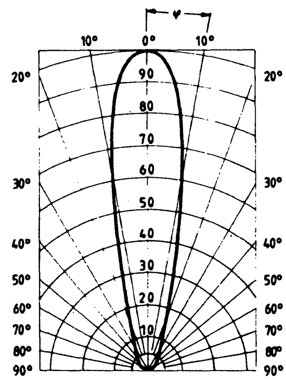
2G.
Radiation characteristic
Relative spectral emission vs. half angle



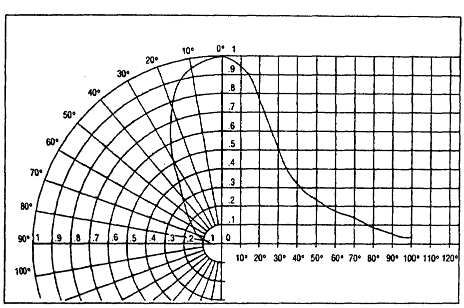
2H.
Radiation characteristic
$I_{REL}=f(\varphi)$



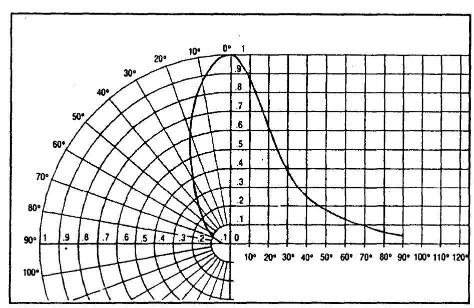
2I.
Radiation characteristic
$I_{REL}=f(\varphi)$



2J.
Relative luminous intensity vs. angular displacement

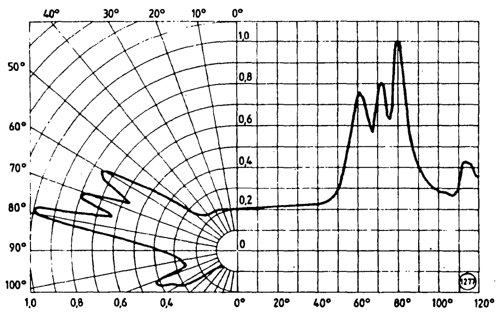


2K.
Relative luminous intensity vs. angular displacement

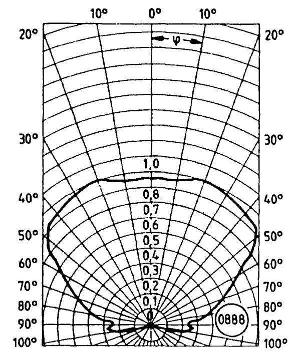


GRAPHS FOR LAMPS (*Cont.*)

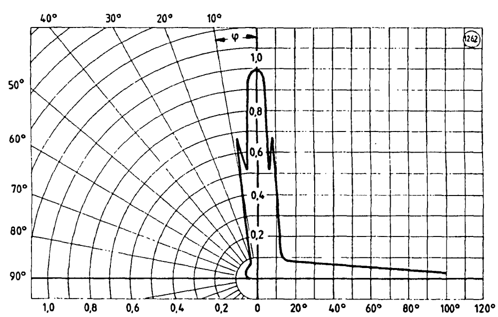
2L.
Radiation characteristic
Relative spectral emission vs. half angle



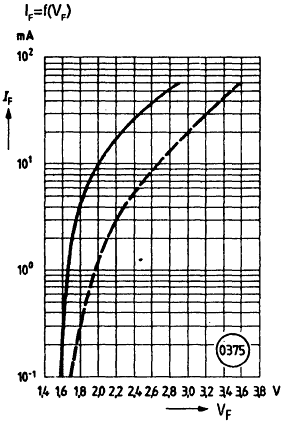
2M.
Radiation characteristic
$I_{REL}=f(\varphi)$



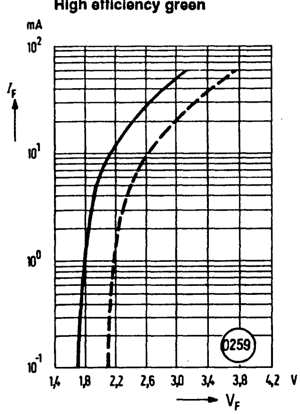
2N.
Radiation characteristic
Relative spectral emission vs. half angle



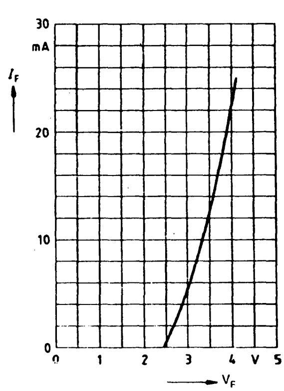
3A.
Forward current
$I_F=f(V_F)$



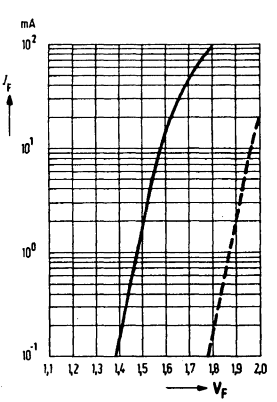
3B.
Forward current $I_F=f(V_F)$
High efficiency green



3C.
Forward current vs. forward voltage



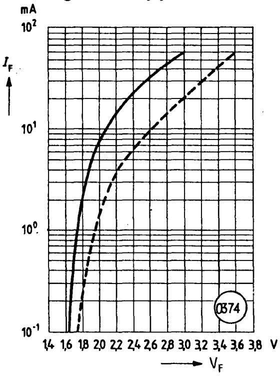
3D.
Forward current vs. forward voltage



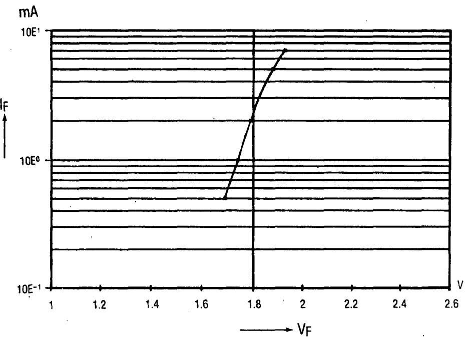
LED Lamps

GRAPHS FOR LAMPS (*Cont.*)

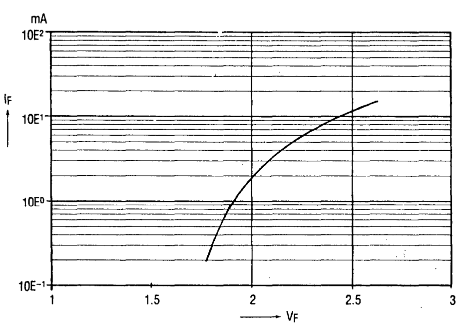
3E.
Forward current $I_F=f(V_F)$
High efficiency yellow



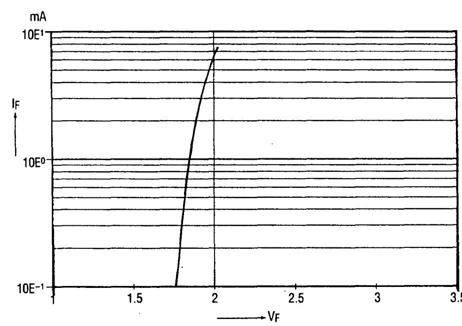
3F.
Forward current vs. forward voltage $I_F=f(V_F)$
HER



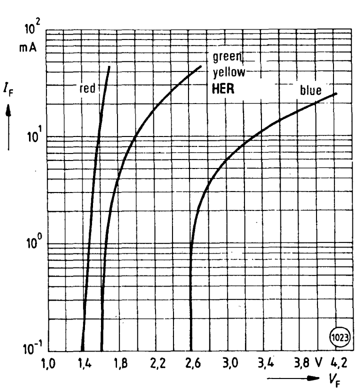
3G.
Forward current versus forward voltage $I_F=f(V_F)$
Yellow



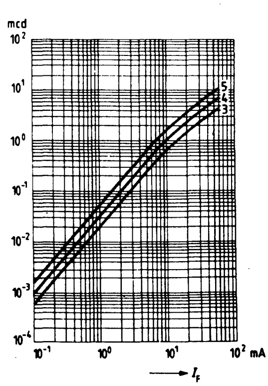
3H.
Forward current versus forward voltage $I_F=f(V_F)$
Green



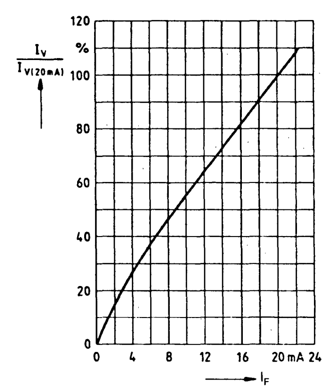
3I.
Forward current versus forward voltage



4A.
Luminous intensity $I_V=f(I_F)$

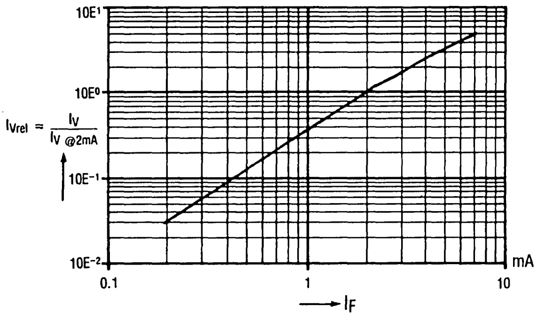


4B.
Relative luminous intensity
versus forward current

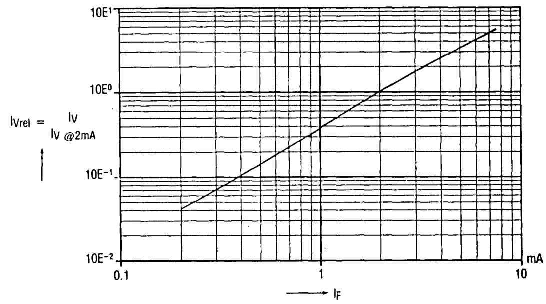


GRAPHS FOR LAMPS (*Cont.*)

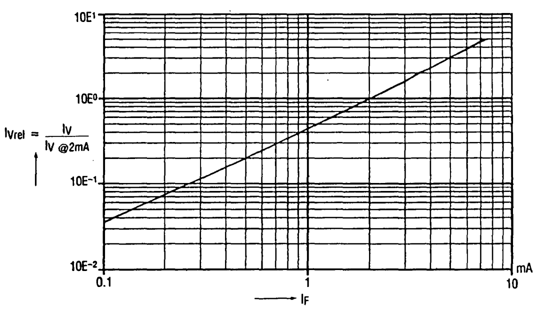
4C.
Relative luminous intensity versus forward current $I_{Vrel}=f(I_F)$
HER



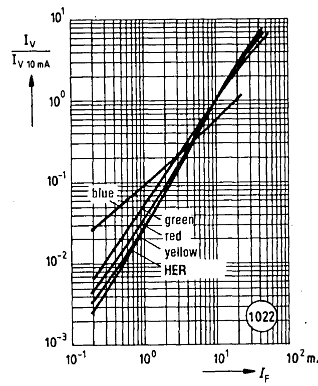
4D.
Relative luminous intensity versus forward current $I_{Vrel}=f(I_F)$
Yellow



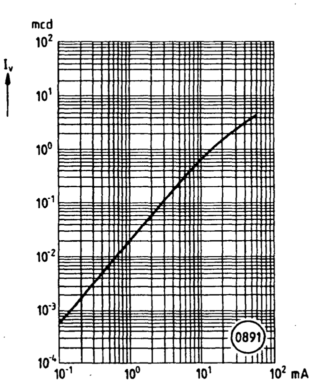
4E.
Relative luminous intensity versus forward current $I_{Vrel}=f(I_F)$
Green



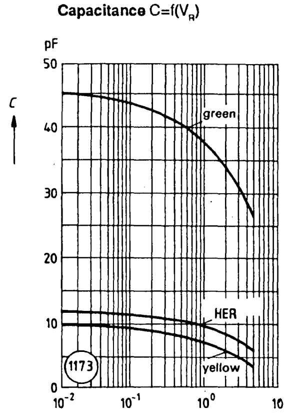
4F.
Relative luminous intensity versus forward current



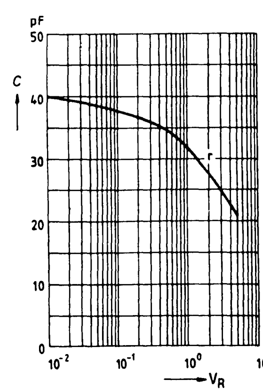
4G.
Luminous intensity $I_V=f(I_F)$



5A.
Capacitance $C=f(V_R)$

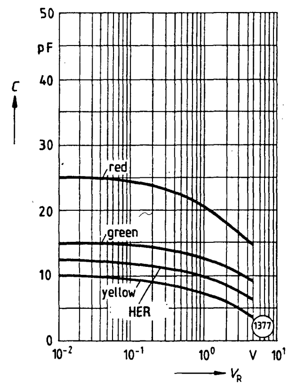


5B.
Capacitance versus reverse voltage

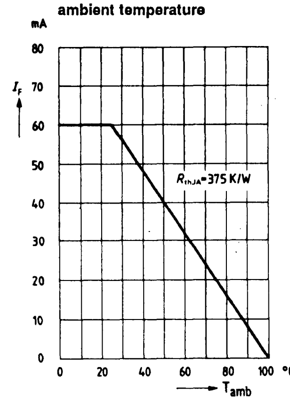


GRAPHS FOR LAMPS (*Cont.*)

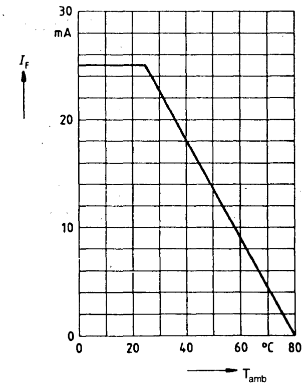
5C.
Capacitance $C=f(V_R)$



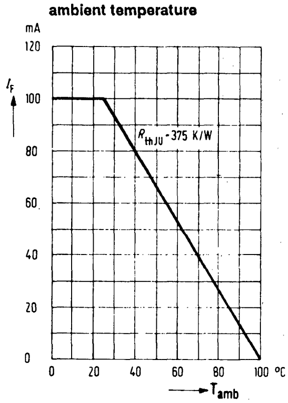
6A.
Forward current versus ambient temperature



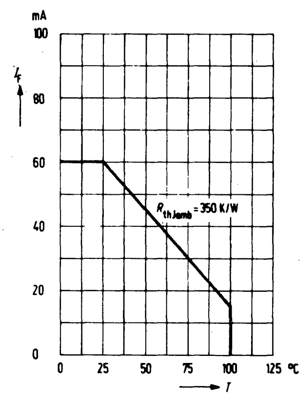
6B.
Forward current versus ambient temperature



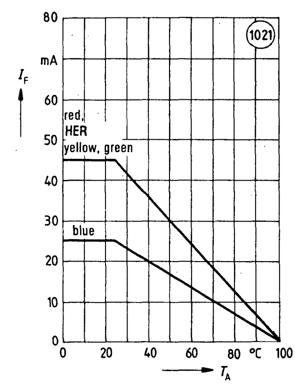
6C.
Forward current versus ambient temperature



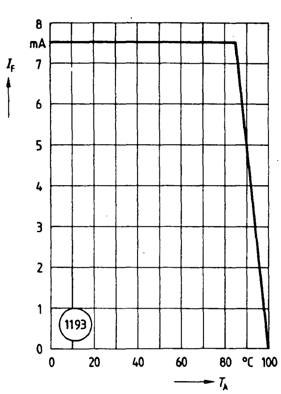
6D.
Maximum permissible forward current
$I_F=f(T)$



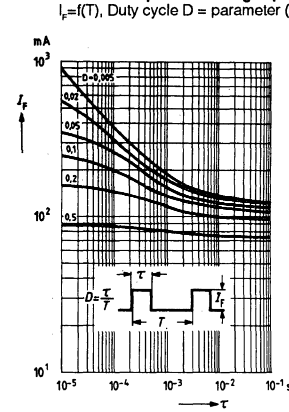
6E.
Maximum permissible forward current versus ambient temperature



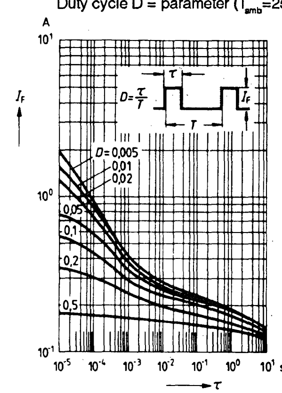
6F.
Maximum permissible forward current versus ambient temperature



7A.
Permissible pulse handling capability
$I_F=f(T)$, Duty cycle D = parameter (T_{amb}=25°C)

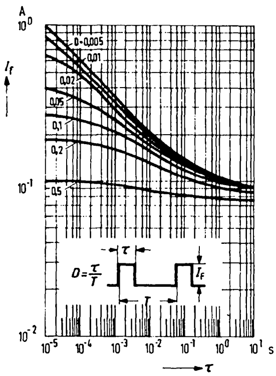


7B.
Permissible pulse handling capability
Forward current versus cycle duration
Duty cycle D = parameter (T_{amb}=25°C)

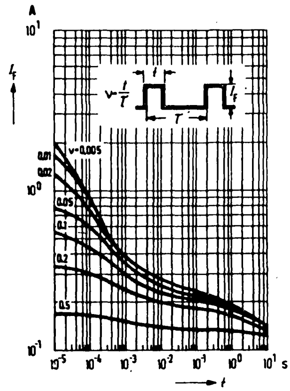


GRAPHS FOR LAMPS (*Cont.*)

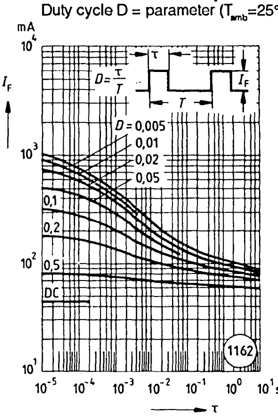
7C.
Permissible pulse handling capability
Forward current versus cycle duration
Duty cycle D = parameter (T_{amb}=25°C)



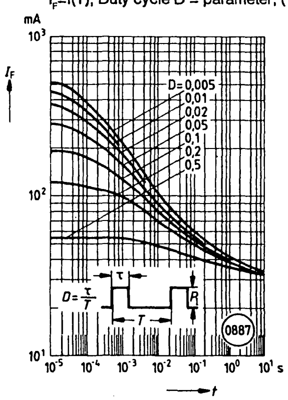
7D.
Permissible pulse handling capability
I_F=f(T), V = parameter (T_{amb}=25°C)



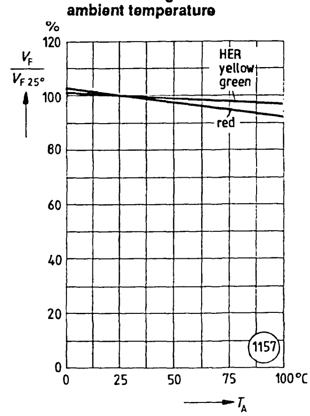
7E.
Permissible pulse handling capability
Forward current versus pulse width
Duty cycle D = parameter (T_{amb}=25°C)



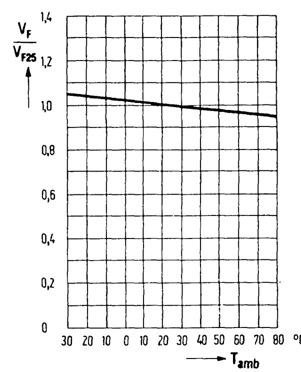
7F.
Permissible pulse handling capability
I_F=f(T), Duty cycle D = parameter, (T_{amb}=25°C)



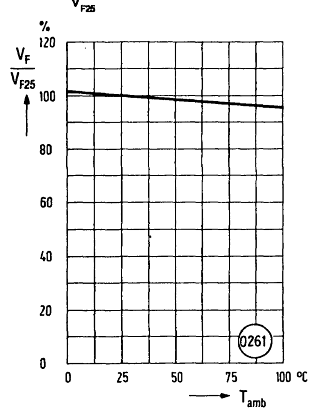
8A.
Forward voltage versus
ambient temperature



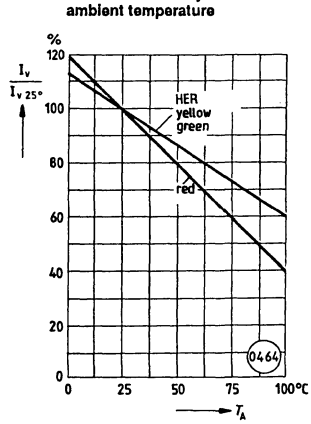
8B.
Forward voltage versus
ambient temperature



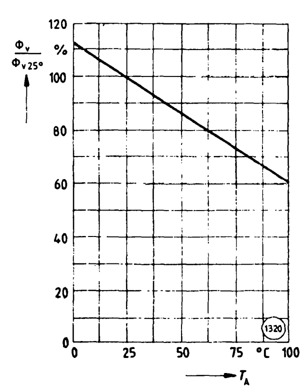
8C.
Forward voltage versus ambient temperature
$\frac{V_F}{V_{F25}}$=f (T_{amb})



9A.
Luminous intensity versus
ambient temperature



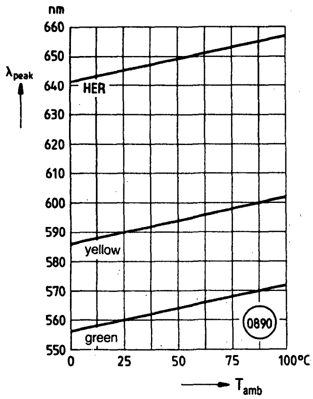
9B.
Luminous flux versus
ambient temperature



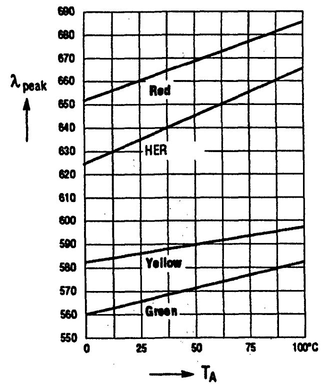
LED Lamps

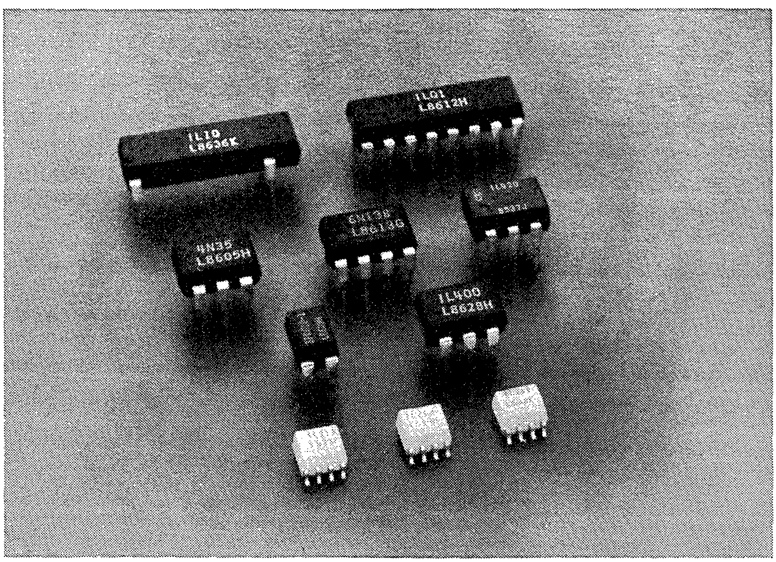
GRAPHS FOR LAMPS (*Cont.*)

10A.
Wavelength of emission $\lambda_{PEAK}=f(T_{amb})$



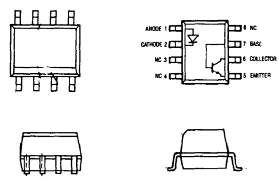
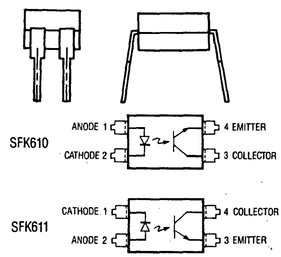
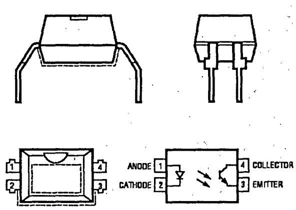
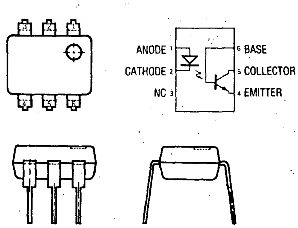
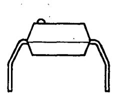
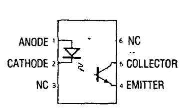
10B.
Wavelength of peak emission versus ambient temperature





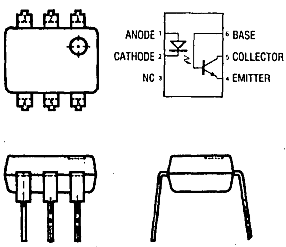
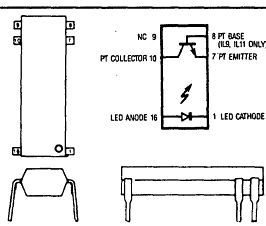
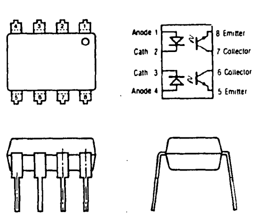
Optocouplers

Optocouplers

Package and Type	Package Outline	Part Number	Features	Current Transfer Ratio (%) I_F = 10 mA	(V_{DC})[1] Isolation Breakdown Voltage	BV_{CEO}	Page
8 Pin SOIC-8 DIP, photo-transister		IL205	Small outline surface mount SOIC-8 footprint. .05″ standard lead spacing. Available on tape and reel.	40 - 80	2500 V_{RMS}	70	5–49
		IL206		63 - 125			
		IL207		100 - 200			
		IL211		20 Min.		30	5–51
		IL212		50 Min.			
		IL213		100 Min.			
		IL215		20 Min. (IF = 1 mA)			5–53
		IL216		50Min. (IF = 1 mA)			
		IL217		100 Min. (IF = 1 mA)			
Miniature 4 Pin DIP single channel, photo-transister		SFK610-1	CTR groupings. 100% burn-in.	40 - 80	7500[2]	70	5–121
		SFK610-2		63 - 125			
		SFK610-3		100 - 200			
		SFK610-4		160 - 320			
		SFK611-1		40 - 80			
		SFK611-2		63 - 125			
		SFK611-3		100 - 200			
		SFK611-4		160 - 320			
4 Pin DIP single channel, photo-transister		SFH617G-1	TRIOS (Transparent Ion Shield). VDE #0884 and #0883 applied for. 8 mm lead spacing, input to output.	40 - 80	5300[3]	70	5–113
		SFH617G-2		63 - 125			
		SFH617G-3		100 - 200			
6 Pin DIP single channel, photo-transister		CNY17-1	CTR groupings. VDE approved #0883. 100% burn-in. (VDE 0884 optional with option 1)	40 - 80	5300[3]	70	5–16
		CNY17-2		63 - 125			
		CNY17-3		100 - 200			
		CNY17-4		160 - 320			
		SFH600-0		40 - 80			5–93
		SFH600-1		63 - 125			
		SFH600-2		100 - 200			
		SFH600-3		160 - 320			
		SFH601-1		40 - 80			5–97
		SFH601-2		63 - 125			
		SFH601-3		100 - 200			
		SFH601-4		160 - 320			
	This view for SFH601G series only. 	SFH601G-1	CTR groupings. VDE approved #0883, #0805, #0806. 100% burn-in. (VDE 0884 optional with option 1)	40 - 80			5–101
		SFH601G-2		63 - 125			
		SFH601G-3		100 - 200			
		SFH601G-4		160 - 320			
		SFH609-1	CTR groupings. High BV_{CEO} VDE approved #0883. 100% burn-in.	40 - 80		90	5–109
		SFH609-2		63 - 125			
		SFH609-3		100 - 200			
	This diagram for CNY17F series only. 	CNY17F/GF-1	No base pin connection. CTR groupings. 100% burn-in. VDE approved #0883. (VDE 0884 optional w/option 1)	40 - 80		70	5–20
		CNY17F/GF-2		63 - 125			
		CNY17F/GF-3		100 - 200			

1. 1 sec. unless otherwise specified.
2. UL qualified voltage.
3. According to VDE #0883.

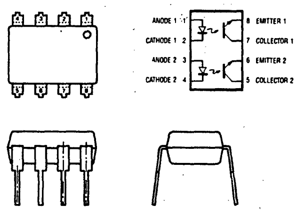
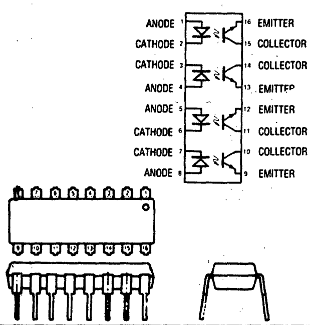
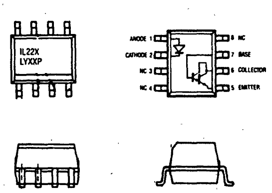
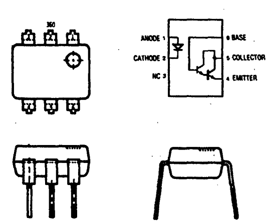
Optocouplers

Package and Type	Package Outline	Part Number	Features	Current Transfer Ratio (%) I_F = 10 mA	(V_{DC})[1] Isolation Breakdown Voltage	BV_{CEO}	Page
6 pin DIP single channel, photo-transistor		IL1	VDE approved #0883 and #0804.	20 Min.	7500[2] 5300[3]	50	5–32
		IL2		100 Min.		70	
		IL5		50 Min.			
		IL74		12.5 Min.		20	5–42
		4N25	Low cost industry standard. VDE approved #0883 and #0804.	20 Min.		30	5–9
		4N26					
		4N27		10 Min.			
		4N28					
		4N35		100 Min.			5–12
		4N36					
		4N37					
		H11A1		50 Min.			5–24
		H11A2		20 Min.			
		H11A3		20 Min.			
		H11A4		10 Min.			
		H11A5		30 Min.			
		MCT2		20 Min.			5–87
		MCT2E		20 Min.			
		MCT270		50 Min.			5–91
		MCT271		45 Min.			
		MCT272		75 Min.			
		MCT273		125 Min.			
		MCT274		225 Min.			
		MCT275		70 Min.			
		MCT276		15 Min.			
		MCT277		100 Min.			
		IL201	Low input forward current. VDE approved #0883 and #0804.	10 Min. (IF = 1 mA)			5–47
		IL202		30 Min. (IF = 1 mA)			
		IL203		50 Min. (IF = 1 mA)			
		SFH606	TRIOS (TRansparent IOn Shield). High reliability.	63 Min.	5300[3]	70	5–105
		SFH6011					5–117
16 pin DIP package, single channel, photo-transistor		IL8 (4 pin)	Very high isolation breakdown voltage. VDE approved #0700, #0883, #0804, #0860. IEC#601/VDE#0750, IEC#380/VDE#0806, IEC#435/VDE#0805.	20 Min.	8 KV_{RMS}[2] (1 Min.) 7 KV_{RMS}[3] 10 KV_{DC}	30	5–38
		IL9 (6 pin)					
		IL10 (4 pin)		50 Min.			5–39
		IL11 (6 pin)					
8 pin DIP dual channel, photo-transistor		ILCT6	VDE approved #0883 and #0804.	20 Min.	7500[2] 5300[3]	30	5–72
		ILD1				50	5–74
		ILD2		100 Min.		70	
		ILD5		50 Min.			
		ILD74		12.5 Min.		20	5–42

1. 1 sec. unless otherwise specified.
2. UL qualified voltage.
3. According to VDE #0883.

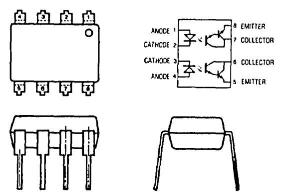
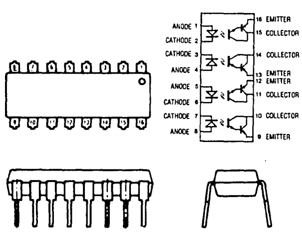
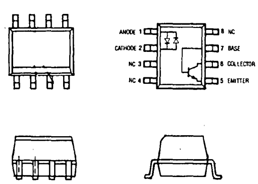
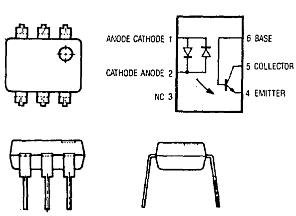
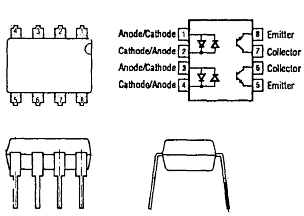
Optocouplers (Optoisolators)

Optocouplers

Package and Type	Package Outline	Part Number	Features	Current Transfer Ratio (%) I_F = 10 mA	(V_{DC})[1] Isolation Breakdown Voltage	BV_{CEO}	Page
8 pin DIP dual channel, photo-transistor		MCT6	Low cost industry standard. VDE approved #0883 and #0804.	20 Min.	7500[2]	70	5–89
		ILD610-1	Pinout of emitter and detector is repetitive. 100% burn-in, CTR groupings.	40 - 80			5–82
		ILD610-2		63 - 125			
		ILD610-3		100 - 200			
		ILD610-4		160 - 320			
16 pin DIP quad channel, photo-transistor		ILQ1	VDE approved #0883 and #0804.	20 Min.	7500[2] 5300[3]	50	5–74
		ILQ2		100 Min.		70	
		ILQ5		50 Min.			
		ILQ74		12.5 Min.		20	5–42
8 pin SOIC-8 DIP, photo-darlington		IL221	.05″ standard lead spacing. Available on tape and reel.	100 Min. (IF = 1 mA)	2500 V_{RMS}	30	5–55
		IL222		200 Min.			
		IL223		500 Min.			
6 pin DIP single channel, photo-darlington		IL31	High gain. VDE approved #0883 and #0804.	200 Min., 400 Typ.	7500[2] 5300[3]	30	5–40
		IL30		100 Min., 400 Typ.			
		IL55				55	
		4N32		500 Min.		30	5–11
		4N33					
		H11B1	High gain. Low cost industry standard.	500 Min. (IF = 1 mA)		25	5–28
		H11B2		200 Min.			
		H11B3		100 Min.			
		MCA230		100 Min.		30	5–85
		MCA231		200 Min.			
		MCA255		100 Min.		55	

1. 1 sec. unless otherwise specified.
2. UL qualified voltage.
3. According to VDE #0883.

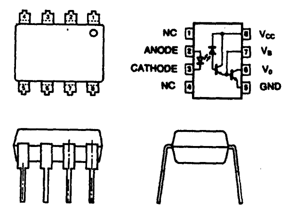
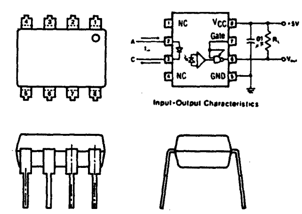
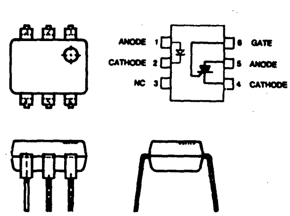
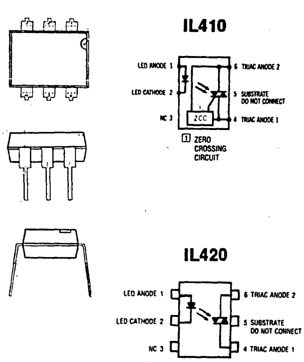
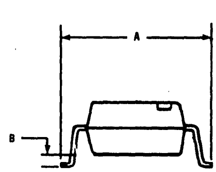
Optocouplers

Package and Type	Package Outline	Part Number	Features	Current Transfer Ratio (%) $I_F = 10$ mA	(V_{DC})[1] Isolation Breakdown Voltage	BV_{CEO}	Page
8 pin DIP dual channel, photo-darlington		ILD31		200 Min., 400 Typ.		30	5–40
		ILD30	High gain.	100 Min., 400 Typ.			
		ILD55	VDE approved #0883 and #0804.		7500[2] 5300[3]	55	
		ILD32		500 Min.		30	5–80
16 pin DIP quad channel, photo-darlington		ILQ31		200 Min., 400 Typ.		30	5–40
		ILQ30	High gain.	100 Min., 400 Typ.			
		ILQ55	VDE approved #0883 and #0804.		7500[2] 5300[3]	55	
		ILQ32		500 Min.		30	5–80
8 pin SOIC-8 DIP, AC/bi-directional		IL256	.05″ standard lead spacing. Available on tape and reel.	20 Min.	2500 V_{RMS}	30	5–60
6 pin DIP single channel, AC/bi-directional		H11AA1	3:1 CTR matching. VDE approved #0883 and #0804.	20 Min.			5–26
		IL250	2:1 CTR matching.	50 Min.	7500[2] 5300[3]	30	
		IL251	VDE approved #0883 and #0804.	20 Min.			5–58
		IL252		100 Min.			
8 pin DIP dual channel, AC/bi-directional		ILD250	2:1 CTR matching.	50 Min.			
		ILD251	VDE approved #0883 and #0804.	20 Min.	7500	30	5–58
		ILD252		100 Min.			

1. 1 sec. unless otherwise specified.
2. UL qualified voltage.
3. According to VDE #0883.

Optocouplers (Optoisolators)

Optocouplers

Package and Type	Package Outline	Part Number	Features	Current Transfer Ratio (%) I_F = 10 mA	$(V_{DC})^1$ Isolation Breakdown Voltage	BV_{CEO}	Page
8 pin DIP single channel, low input current		6N138	High gain. Low input forward current.	300 Min., 600 Typ.	6000	Input current (mA) 1.6	5–14
		6N139	High gain. Low input forward current. Low saturation voltage.	400 Min., 800 Typ.		0.5	
8 pin DIP single channel, high speed		IL101B	High speed. Tri-state output. Schmitt trigger.	Typical propagation delay time: tpd(0)=70 ns tpd(1)=175 ns	6000	Thres-hold current (mA) 5	5–45
6 pin DIP single channel, SCR output		H11C4	Optically coupled SCR.	LED Trigger Current: 11 mA	7500	Fwd. blocking voltage V_{DRM}= 400 V	5–30
		H11C5		11 mA			
		H11C6		14 mA			
		IL400		10 mA 5 mA Typ.			5–63
6 pin DIP single channel, Triac output		IL410	Optically coupled triac driver. Zero crossing detector. High dv/dt. Very low input required.	LED trigger current 10 mA 2 mA (1 mA typ.)	7500	Fwd. blocking voltage V_{DRM}= 600 V	5–64
		IL420	Optically coupled triac driver. High dv/dt. Very low input required.				5–68
Surface mount, lead bend option (for all standard 4, 6, 8 & 16 pin DIPs)		See dimensions below					5–8

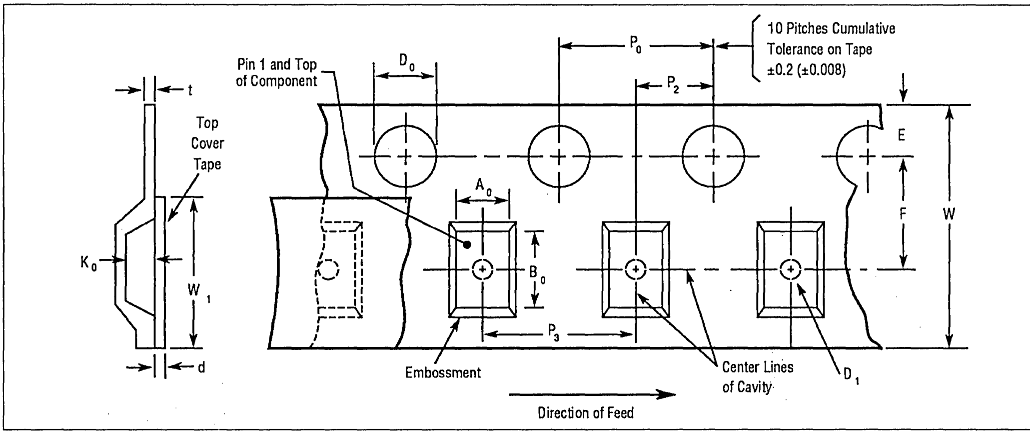
Dimension \ Version	–004 Min.	–004 Max.	–009 Min.	–009 Max.
A	.373 (9.47)	.393 (9.98)	.375 (9.53)	.395 (10.03)
B	.0005 (.013)	.0040 (.102)	.0045 (.102)	.0098 (.249)

1. 1 sec. unless otherwise specified.
2. UL qualified voltage.
3. According to VDE #0883.

Tape and Reel Packaging for SOIC8 Optocouplers

All SOIC8 optocouplers are available in tape and reel format. To order any surface mount IL2XX optocoupler on tape and reel, add a suffix "T" to the part number.

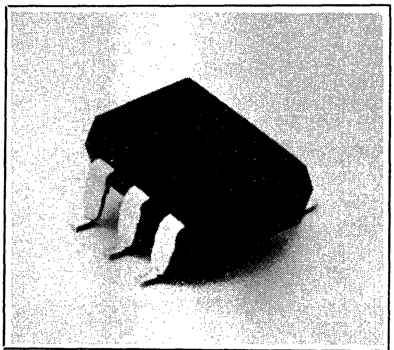
The tape is 12mm and is wound on a 33 cm reel. There are 2000 parts per reel. Taped and reeled SOIC8 optocouplers conform to EIA-481.



Description	Symbol	Dimensions in Inches (mm) SOIC8	Notes
Tape width	W	.472 ±.012 (12 ±.3)	
Carrier tape thickness	t	.012 (0.3) max.	
Pitch of sprocket holes	P_0	.157 ±.004 (4 ±0.1)	Cummulative pitch error +0.2mm/10 pitches
Diameter of sprocket holes	D_0	.059 (1.5) min.	
Distance of sprocket holes	E	.069 ±.004 (1.75 ±0.1)	
Distance of compartment	F	.217 ±.002 (5.5 ±.005)	Center hole to center compartment
	P_2	.079 ±.002 (2 ±0.05)	
Distance compartment to compartment	P_3	.157 (4)	
Compartment	K_0 A_0 B_0	.140 (3.5) .252 (6.4) .205 (5.2)	
Hole in compartment	D_1	.054 (1.5)	
Width of fixing tage	W_1 d	.325 (8.3) tape .004 (0.1) max.	The fixing tape shall not cover the sprocket holes, nor protrude beyond the carrier tape so not to exceed max. tape width
Device tilt in the compartment		15° max.	
Minimum bending radius		1.18 (30)	

SIEMENS

SURFACE MOUNT LEAD BEND OPTIONS –004 –009



The entire optocoupler line is available with a lead bend for surface mounting.

FEATURES

- **Surface Mountable**
- **Available for all 4, 6, 8 & 16 Pin Plastic Packages with 0.1" Lead Spacing**
- **All Electrical Parameters Remain Unchanged from Standard Packages**
- **Two Stand-off Heights (.004" and .009")**

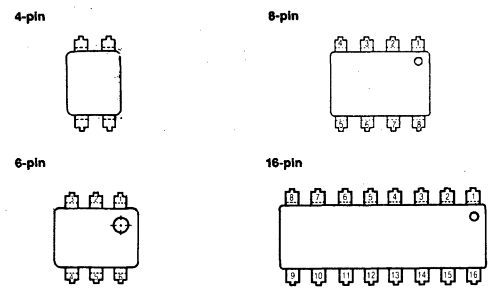
ORDERING INFORMATION

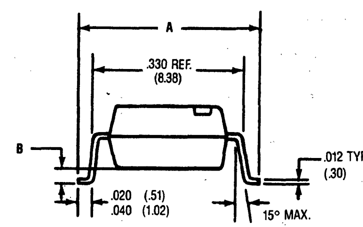
To order any standard optocoupler with a surface mount lead bend, add: –004 or –009 to the standard part number.

Example:
Standard part number: ILD1
Surface Mount: ILD1-004 or ILD1-009

Dimensions in inches (mm)

Standard Packages (0.1" lead spacing)





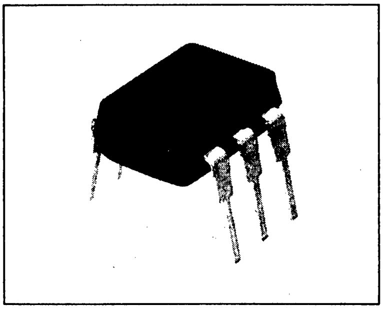
Dimension \ Version	–004		–009	
	Min.	**Max.**	**Min.**	**Max.**
A	(9.47) .373	(9.98) .393	(9.53) .375	(10.03) .395
B	(.013) .0005	(.102) .0040	(.102) .0040	(.249) .0098

All other package dimensions remain unchanged.

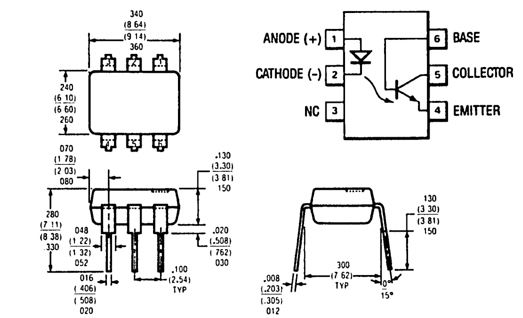
SIEMENS

4N25/4N26
4N27/4N28

PHOTOTRANSISTOR OPTOCOUPLER



Package Dimensions in Inches (mm)



Optocouplers (Optoisolators)

FEATURES

- **I/O Compatible with Integrated Circuits**
- **0.5 pF Coupling Capacitance**
- **Underwriters Lab Approval #E52744**
- **VDE Approvals 0883/6.80, 0804/1.83**

DESCRIPTION

The 4N25, 4N26, 4N27, and 4N28 are optically coupled isolated pairs, each consisting of a Gallium Arsenide infrared LED and a silicon NPN phototransistor. Signal information, including a DC level, can be transmitted by the device while maintaining a high degree of electrical isolation between input and output. They can be used to replace relays and transformers in many digital interface applications. They have excellent frequency response when used in analog applications.

Maximum Ratings

Gallium Arsenide LED
- Power Dissipation at 25°C .... 150 mW
- Derate Linearly from 25°C .... 2.0 mW/°C
- Continuous Forward Current .... 80 mA
- Forward Current Peak (1µs pulse, 300 pps) .... 3.0 A
- Peak Reverse Voltage .... 3.0 V

Detector (Silicon Phototransistor)
- Power Dissipation at 25°C .... 150 mW
- Derate Linearly from 25°C .... 2.0 mW/°C
- Collector-Emitter Breakdown Voltage (BV_{CEO}) .... 30 V
- Emitter-Collector Breakdown Voltage (BV_{ECO}) .... 7.0 V
- Collector-Base Breakdown Voltage (BV_{CBO}) .... 70 V

Package
- Total Package Dissipation at 25°C Ambient (equal power in each element) .... 250 mW
- Derate Linearly from 25°C .... 3.3 mW/°C
- Isolation Test Voltage in Accordance with DIN57883/6.80 ... 3750 VAC/5300 VDC
- Creepage Path .... 8 mm min.
- Clearance Path .... 7 mm min.
- Tracking Index According to VDE 0303 .... KB100/A

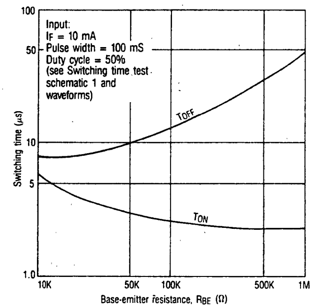
Storage Temperature .... –55 to +150°C
Operating Temperature .... –55 to +100°C
Lead Soldering Time at 260 °C .... 10 sec

Electrical Characteristics (T_{amb} = 25°C)

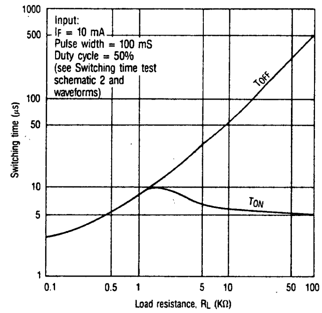
Parameter	Min	Typ	Max	Unit	Test Condition
Gallium Arsenide LED					
*Forward Voltage		1.3	1.5	V	I_F = 50 mA
*Reverse Current		0.1	100	µA	V_R = 3.0 V
Capacitance		100		pF	V_R = 0
Phototransistor Detector					
H_{FE}		150			V_{CE} = 5.0 V
*BV_{CEO}	30			V	I_C = 1 mA
*BV_{ECO}	7			V	I_E = 100 µA
*BV_{CBO}	70			V	I_C = 100 µA
*I_{CEO} (dark)					
4N25, 4N26, 4N27		5	50	nA	V_{CE} = 10 V
4N28		10	100	nA	(base open)
*I_{CBO} (dark)		2	20	nA	V_{CB} = 10 V (emitter open)
Collector-Emitter Capacitance		2		pF	V_{CE} = 0
Coupled Characteristics					
*DC Current Transfer Ratio					
4N25, 4N26	0.2	0.5			I_F = 10 mA, V_{CE} = 10 V
4N27, 4N28	0.1	0.3			I_F = 10 mA, V_{CE} = 10 V
Capacitance, Input to Output		0.5		pF	
Breakdown Voltage					
*4N25	2500			V	Peak, 60 Hz
*4N26, 4N27	1500			V	Peak, 60 Hz
*4N28	500			V	Peak, 60 Hz
UL Qualified for	7500			VDC	
*Resistance, Input to Output	100			GΩ	
Rise and Fall Times		2		µs	I_F = 10 mA, V_{CE} = 10 V
*Collector-Emitter Saturation Voltage			0.5	V	I_F = 50 mA, I_C = 2.0 mA

*Indicates JEDEC registered values

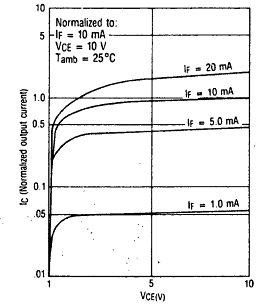
Typical switching characteristics versus base resistance
(Saturated operation)



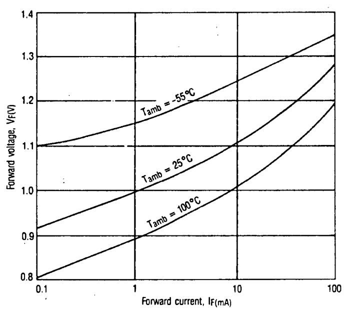
Typical switching times versus load resistance



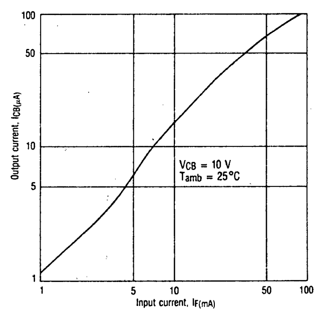
Collector current versus collector voltage



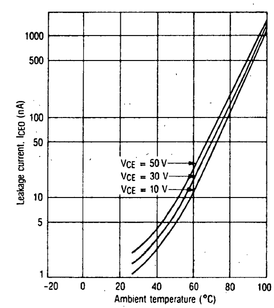
Typical forward voltage versus forward current



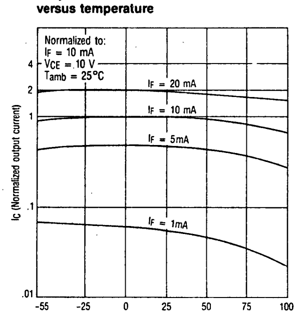
Typical output current (I_{CB}) versus input current



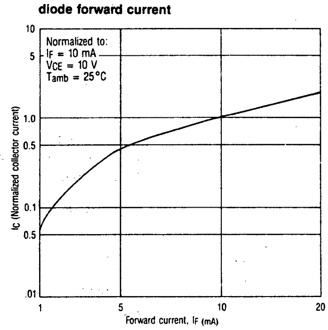
Typical leakage current versus ambient temperature



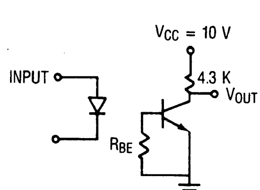
Output current versus temperature



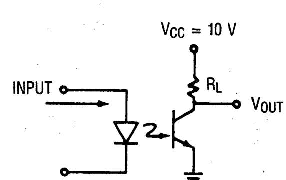
Collector current versus diode forward current



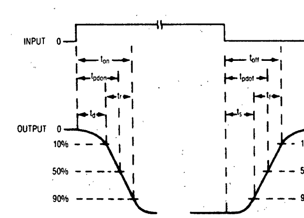
Switching time test schematic and waveforms



Switching time test schematic 1



Switching time test schematic 2

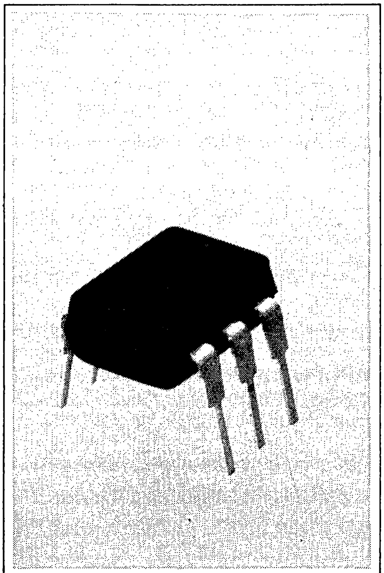


4N25/4N26

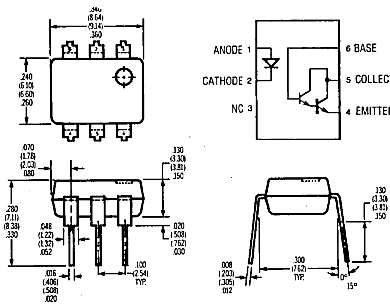
SIEMENS

4N32/4N33

PHOTODARLINGTON OPTOCOUPLER



Package Dimensions in Inches (mm)



Optocouplers (Optoisolators)

FEATURES

- **Very High Current Transfer Ratio (500% Min.)**
- **High Isolation Resistance (10^{11} Ω Typical)**
- **Low Coupling Capacitance**
- **Standard Plastic Dip Package**
- **Underwriters Lab Approval #E52744**
- **VDE Approvals 0883/6.80, 0804/1.83**

DESCRIPTION

The 4N32 and 4N33 are optically coupled isolators employing a gallium arsenide infrared emitter and a silicon photo darlington sensor. Switching can be accomplished while maintaining a high degree of isolation between driving and load circuits. They can be used to replace reed and mercury relays with advantages of long life, high speed switching and elimination of magnetic fields.

Maximum Ratings

Gallium Arsenide LED (Drive Circuit)
- Power Dissipation at 25°C .... 150 mW
- Derate Linearly from 55°C .... 2 mW/°C
- Continuous Forward Current .... 80 mA
- Peak Reverse Voltage .... 3 V

Photodarlington Sensor (Load Circuit)
- Power Dissipation at 25°C Ambient .... 150 mW
- Derate Linearly from 25°C .... 2.0 mW/°C
- Collector (load) Current .... 125 mA
- Collector-Emitter Breakdown Voltage (BV_{CEO}) .... 30 V
- Collector Base Breakdown Voltage (BV_{CBO}) .... 50 V
- Emitter-Base Breakdown Voltage (BV_{EBO}) .... 8 V
- Emitter-Collector Breakdown Voltage (BV_{ECO}) .... 5 V

Package
- Total Dissipation at 25°C .... 250 mW
- Derate Linearly from 25°C* .... 3.3 mW/°C
- Isolation Test Voltage
  - in Accordance with DIN57883/6.80 .... 3750 VAC/5300 VDC
- Creepage Path .... 8 mm min.
- Clearance Path .... 7 mm min.
- Tracking Index According to VDE 0303 .... KB100/A

Storage Temperature .... –55 to +150°C
Operating Temperature .... –55 to +100°C
Lead Soldering Time at 260 °C .... 10 sec

Electrical Characteristics (T_{amb} = 25°C)

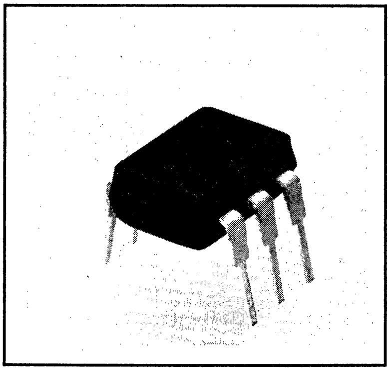
	Min	Typ	Max	Unit	Conditions
GaAS Emitter					
Forward Voltage*		1.25	1.5	V	I_F = 50 mA
Reverse Current*		0.1	100	μA	V_R = 3.0 V
Capacitance		100		pF	V_R = 0 V
Sensor					
H_{FE}		13K		V	V_{CE} = 5 V, I_C = 0.5 mA
BV_{CEO}*	30			V	I_C = 100 μA, I_F = 0
BV_{CBO}*	50			V	I_C = 100 μA, I_F = 0
BV_{EBO}*	8			V	I_C = 100 μA, I_F = 0
BV_{ECO}*	5			V	I_E = 100 μA
I_{CEO}*		1.0	100	nA	V_{CE} = 10 V, I_F = 0
Coupled Characteristics					
Current Transfer Ratio*	500			%	I_F = 10 mA, V_{CE} = 10 V
$V_{CE\ (SAT)}$		1.0		V	I_C = 2 mA, I_F = 8 mA
Isolation Resistance*		10^{11}		Ω	V_{IO} = 500 V
Isolation Capacitance		1.5		pF	
Turn-on Time			5	μs	V_{CC} = 10 V, I_C = 50 mA
Turn-off Time			100	μs	I_F = 200 mA, R_L = 180 Ω
Isolation Voltage					Pulse Width = 8ms
4N32*	1500			V	Peak, 60 Hz
4N33*	6000			V	Peak, 60 Hz
4N32/33 UL Qualified for	7500			VDC	

*Indicates JEDEC registered data.

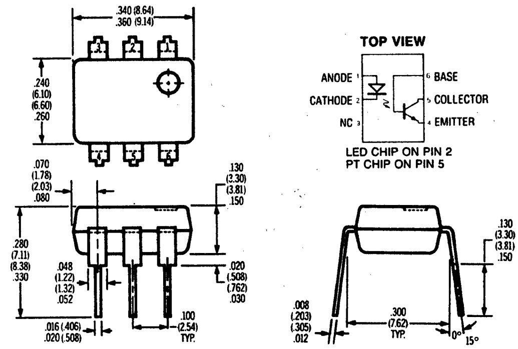
SIEMENS

4N35/4N36/4N37

PHOTOTRANSISTOR OPTOCOUPLER



Package Dimensions in Inches (mm)



FEATURES

- High Current-Transfer-Ratio (100% Min)
- Standard Dual-In-Line
- 0.5 pF Coupling Capacitance
- Underwriters Lab Approval #E52744
- VDE Approvals 0883/6.80, 0804/1.83

DESCRIPTION

4N35, 4N36, 4N37 are optically coupled pairs employing a Gallium Arsenide infrared LED and a silicon NPN phototransistor. Signal information, including a DC level, can be transmitted by the device while maintaining a high degree of electrical isolation between input and output. The 4N35, 4N36, 4N37 can be used to replace relays and transformers in many digital interface applications, as well as analog applications such as CRT modulation.

Maximum Ratings

Gallium Arsenide LED
- Power Dissipation at 25°C .... 100 mW
- Derate Linearly from 55°C .... 1.33 mW/°C
- Continuous Forward Current .... 60 mA
- Peak Reverse Voltage .... 6.0 V

Detector (Silicon Phototransistor)
- Power Dissipation at 25°C .... 300 mW
- Derate Linearly from 25°C .... 4.0 mW/°C
- Collector-Emitter Breakdown Voltage (BV_{CEO}) .... 30 V
- Emitter-Collector Breakdown Voltage (BV_{ECO}) ..... 7 V
- Collector-Base Breakdown Voltage (BV_{CBO}) ...... 70 V

Package
- Isolation Test Voltage in Accordance with DIN57883/6.80 .... 3750 VAC/5300 VDC
- Creepage Path .... 8 mm min.
- Clearance Path .... 7 mm min.
- Tracking Index According to VDE 0303 ..... KB100/A

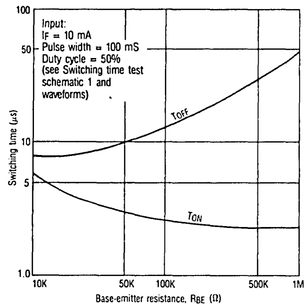
Storage Temperature* .... -55 to +150°C
Operating Temperature* .... -55 to +100°C
Lead Soldering Time at 260 °C* .... 10 sec
Relative Humidity at 85°C 85%

Electrical Characteristics (T_{amb} = 25°C)

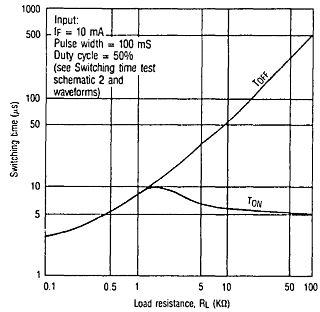
	Min	Typ	Max	Unit	Conditions
Gallium Arsenide LED					
Forward Voltage*		1.3	1.5	V	I_F = 10 mA
	0.9		1.7	V	I_F = 10 mA, T_A = -55°C
	0.7		1.4	V	I_F = 10 mA, T_A = 100°C
Reverse Current*		.1	10	μA	V_R = 6.0 V
Capacitance		100		pF	V_R = 0, f = 1 MHz
Phototransistor Detector					
H_{FE}	100	150			V_{CE} = 5.0 V, I_C = 100 μA
BV_{CEO}*	30			V	I_C = 1 mA
BV_{CEO}*	7			V	I_E = 100 μA
I_{CEO} (dark)		5	50	nA	V_{CE} = 10 V, I_F = 0
I_{CEO} (dark)*			500	μA	V_{CE} = 30 V, I_F = 0 TA = 100°C
BV_{CBO}*	70			V	I_C = 100 μA
Collector-Emitter Capacitance		2		pF	V_{CE} = 0
Coupled Characteristics					
DC Current Transfer Ratio*	100			%	I_F = 10 mA, T_A = 25°C V_{CE} = 10 V
DC Current Transfer Ratio*	40			%	I_F = 10 mA, V_{CE} = 10 V T_A = 55° to 100°C
Capacitance, Input to Output*		2.5		pF	f = 1.0 MHz
Resistance, Input to Output*		10^{11}		Ω	V_{IO} = 500 V
T_{ON}, T_{OFF}*			10	μs	I_C = 2 mA, R_E = 100 Ω V_{CC} = 10 V
Collector-Emitter Saturation Voltage $V_{CE(sat)}$*			0.3	V	I_F = 10 mA, I_C = 0.5 mA
Input to Output Isolation Current (Pulse Width = 8 m. sec)*					
4N35			100	μA	V_{IO} = 2500 VRMS
4N36			100	μA	V_{IO} = 1750 VRMS
4N37			100	μA	V_{IO} = 1050 VRMS
4N35/36/37 UL Qualified for	7500			VDC	

*Indicates JEDEC registered data.

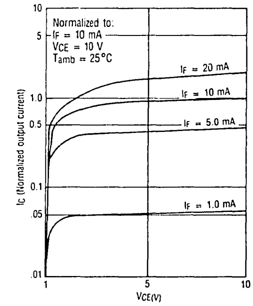
Typical switching characteristics versus base resistance
(Saturated operation)



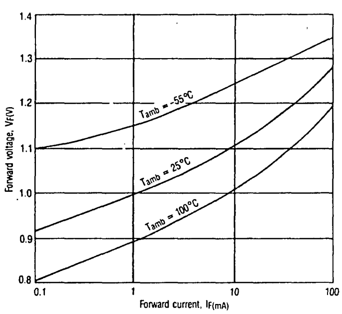
Typical switching times versus load resistance



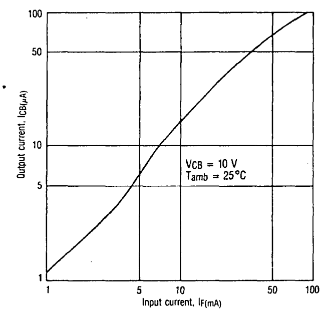
Collector current versus collector voltage



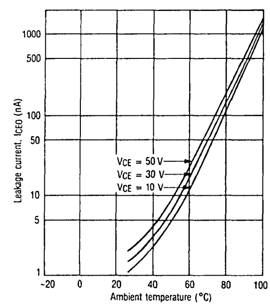
Typical forward voltage versus forward current



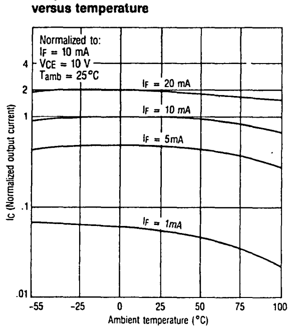
Typical output current (I_{CB}) versus input current



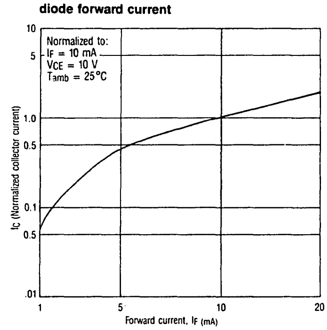
Typical leakage current versus ambient temperature



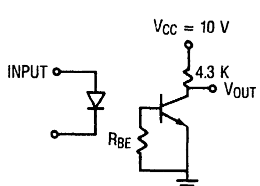
Output current versus temperature



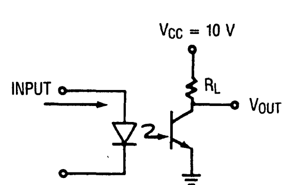
Collector current versus diode forward current



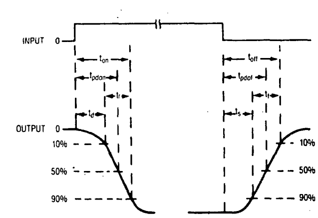
Switching time test schematic and waveforms



Switching time test schematic 1



Switching time test schematic 2

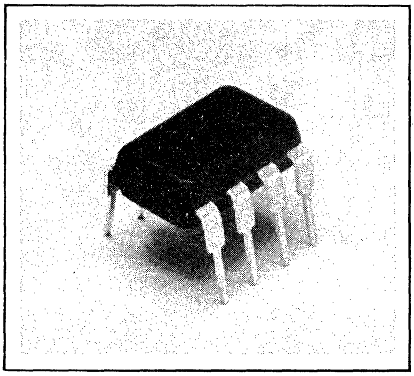


Optocouplers (Optoisolators)

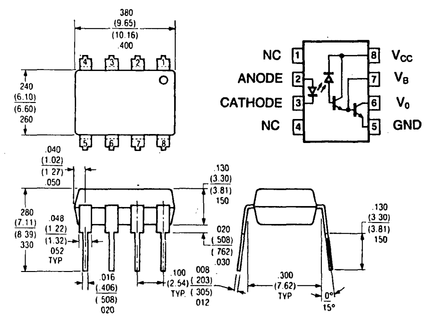
SIEMENS

6N138
6N139

LOW INPUT CURRENT, HIGH GAIN OPTOCOUPLER



Package Dimensions in Inches (mm)



FEATURES

- **6000 Volt Isolation Voltage**
- **High Current Transfer Ratio 800%**
- **Low Input Current Requirement - 0.5mA**
- **TTL Compatible Output - 0.1V V_{OL}**
- **High Common Mode Rejection - 500V/μsec.**
- **High Output Current - 60mA**
- **DC to 1 Megabit / Sec. Operation**
- **Adjustable Bandwidth - Access to Base**
- **Standard Molded Dip Plastic Package**
- **UL Approval # E52744**

DESCRIPTION

High common mode transient immunity and very high current transfer ratio together with 6000 volts DC insulation are achieved by coupling an LED with an integrated high gain photon detector in an 8 pin dual inline package. Separate pins for the photodiode and output stage enable TTL compatible saturation voltages with high speed operation. Photo Darlington operation is achieved by tying the Vcc and Vo terminals together. Access to the base terminal allows adjustment to the gain bandwidth.

The 6N138 is ideal for TTL applications since the 300% minimum current transfer ratio with an LED current of 1.6mA enables operation with 1 unit load in and 1 unit load out with a 2.2K Ω pull-up resistor.

The 6N139 is best suited for low power logic applications involving CMOS and low power TTL. A 400% current transfer ratio with only 0.5mA of LED current is guaranteed from 0°C to 70°C.

APPLICATIONS

- Logic ground isolation – TTL/TTL, TTL/CMOS, CMOS/CMOS, CMOS/TTL
- EIA RS 232C Line Receiver
- Low Input Current Line Receiver – Long Lines, Party Lines
- Telephone Ring Detector
- 117 VAC Line Voltage Status Indication–Low Input Power Dissipation
- Low Power Systems – Ground Isolation

Maximum Ratings

Maximum Temperatures	
Storage Temperatures	−55° to +125°C
Operating Temperatures	0°C to +70°C
Lead Temperature (soldering, 10 sec.)	260°C
Average Input Current (I_F)	20mA
Peak Input Current (I_F) (50% Duty Cycle — 1ms pulse width)	40mA
Reverse Input Voltage (V_R)	5v
Input Power Dissipation	35mW
(Derate linearly above 50% in free air temperature at 0.7mW/°C)	
Output Current — I_o (Pin 6)	60mA
(Derate linearly above 25°C in free air temperature at 0.7mA/°C)	
Emitter-Base Reverse Voltage (Pin 5-7)	0.5V
Supply and Outage Voltage — V_{CC} (Pin 8-5), V_o (Pin 6-5)	
6N138	−0.5 to 7V
6N139	−0.5 to 18V
Output Power Dissipation	100mW
(Derate Linearly Above 25°C in Free Air Temperature at 2.0mW/°C)	

Caution:
Due to the small geometries of this device it should be handled with Electrostatic Discharge (ESD) precautions. Proper grounding would further prevent damage and/or degradation which may be induced by ESD.

Electro-Optical Characteristics (T_A = 0°C to 70°C, Unless Otherwise Specified)

Parameter	Device	Min	Typ	Max	Units	Test Conditions	Note
Current Transfer Ratio (CTR)	6N139	400 500	800 900		%	$I_F = 0.5mA$, $V_o = 0.4V$, $V_{CC} = 4.5V$ $I_F = 1.6mA$, $V_o = 0.4V$, $V_{CC} = 4.5V$	5,6
	6N138	300	600		%	$I_F = 1.6mA$, $V_o = 0.4V$, $V_{CC} = 4.5V$	
Logic Low Output Voltage (VOL)	6N139 6N139 6N139		0.1 0.1 0.2	0.4 0.4 0.4	V	$I_F = 1.6mA$, $I_o = 6.4mA$, $V_{CC} = 4.5V$ $I_F = 5mA$, $I_o = 15mA$, $V_{CC} = 4.5V$ $I_F = 12mA$, $I_o = 24mA$, $V_{CC} = 4.5V$	6
	6N138		0.1	0.4	V	$I_F = 1.6mA$, $I_o = 4.8mA$, $V_{CC} = 4.5V$	6
Logic High	6N139		0.05	100	μA	$I_F = 0mA$, $V_o = V_{CC} = 18V$	6
Output Current (I_{OH})	6N138		0.1	250	μA	$I_F = 0mA$, $V_o = V_{CC} = 7V$	
Logic Low Supply Current (ICCL)				0.2	mA	$I_F = 1.6mA$, V_o = OPEN, $V_{CC} = 5v$	6
Logic High Supply Current (ICCH)				10	mA	$I_F = 0mA$, V_o = OPEN, $V_{CC} = 5v$	6
Input Forward Voltage (VF)			1.4	1.7	V	$I_F = 1.6mA$, $T_A = 25°C$	
Input Reverse Breakdown Voltage (BVR)		5			V	$I_R = 10uA$, $T_A = 25°C$	
Temperature Coefficient of Forward Voltage			−1.8		mV/°c	$I_F = 1.6mA$	
Input Capacitance (C_{IN})			60		pF	$f = 1MH_z$, $V_F = 0$	
Input-Output Insulation Leakage Current ($I_{1\text{-}0}$)				1.0	μA	45% Relative Humidity, $T_A = 25°C$ $t = 5_S$, $V_{1\text{-}0}$ = 3000VDC	7
Resistance Input-Output) ($R_{1\text{-}0}$)			10^{12}		Ω	$V_{1\text{-}0}$ = 500V_{DC}	7
Capacitance (Input-Output) ($C_{1\text{-}0}$)			0.6		pF	$f = 1MH_z$	7

Switching Specifications (TA = 25°C)

Parameter	Device	Min	Typ	Max	Units	Test Conditions	Note
Propagation Delay Time	6N139	—	5 0.2	25 1	μs	$I_F = 0.5mA$, $R_L = 4.7kΩ$ $I_F = 12mA$, $R_L = 270Ω$	6,8
To Logic Low at Output tPHL	6N138		1	10	μs	$I_F = 1.6mA$, $R_L = 2.2kΩ$	
Propagation Delay Time	6N139		5 1	60 7	μs	$I_F = 0.5mA$, $R_L = 4.7kΩ$ $I_F = 12mA$, $R_L = 270mAΩ$	6,8
To Logic High at Output tPLH	6N138		4	35	μs	$I_F = 1.6mA$, $R_L = 2.2kΩ$	
Common Mode Transient Immunity at Logic High Level (CM_H) Output			500		v/μs	$I_F = 0mA$, $R_L = 2.2kΩ$ $R_{CC} = 0$,/V_{cm}/ = 10$V_{p\text{-}p}$	9,10
Common Mode Transient Immunity at Logic Low Level (CM_L) Output			−500		v/μs	$I_F = 1.6mA$, $R_L = 2.2kΩ$ $R_{CC} = 0$,/V_{CM}/ = 10$V_{p\text{-}p}$	9,10

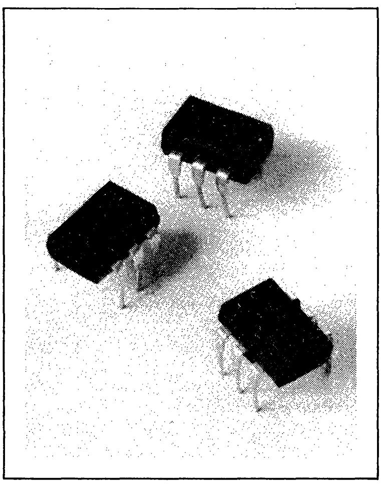
Notes

1. Derate linearly above 50°C free-air temperature at a rate of 0.4mA/°C.
2. Derate linearly above 50°C free-air temperature at a rate of 0.7mW/°C.
3. Derate linearly above 25°C free-air temperature at a rate of 0.7mA/°C.
4. Derate linearly above 25°C free-air temperature at a rate of 2.0mW/°C.
5. DC current transfer ratio is defined as the ratio of output collector current, I_O, to the forward LED input current, $I_F$times 100%
6. Pin 7 open.
7. Device considered a two-terminal device: pins 1,2,3 and 4 shorted together and pins 5,6,7, and 8 shorted together.
8. Use of a resistor between pin 5 and 7 will decrease gain and delay time.
9. Common mode transient immunity in logic high level is the maximum tolerable (positive) dVcm/dt on the leading edge of the common mode pulse, V_{cm}, to assure that the output will remain in a logic high state (i.e. $V_o > 2.0V$) common mode transient immunity in logic low level is the maximum tolerable (negative) dVcm/dt on the trailing edge of the common mode pulse signal, V_{cm}, to assure that the output will remain in a logic low state (i.e. $V_p < 0.8V$).
10. In applications where dv/dt may exceed 50,000v/us (such as state discharge) a series resistor, R_{CC} should be included to protect I_C from destructively high surge currents. The recommended value us $R_{CC} \approx \frac{1V}{0.15\, I_F\,(mA)}$ kΩ.

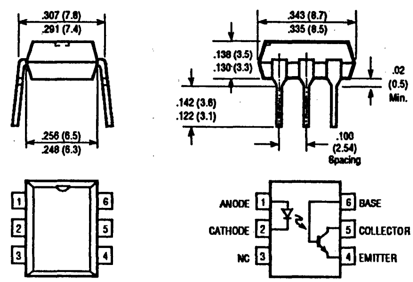
SIEMENS

CNY17 SERIES

SINGLE CHANNEL PHOTOTRANSISTOR OPTOCOUPLER



Package Dimensions in Inches (mm)



FEATURES

- **5300 Volt Breakdown Voltage**
- **High Current Transfer Ratio, 4 Groups**
  - CNY 17-1, 40 to 80%
  - CNY 17-2, 63 to 125%
  - CNY 17-3, 100 to 200%
  - CNY 17-4, 160 to 320%
- **Long Term Stability**
- **Industry Standard Dual-in-Line**
- **Underwriters Lab Approval #E52744**
- **VDE Approval #0883**
- **VDE Approval #0884 (Optional with Option 1, add -X001 suffix)**

DESCRIPTION

The CNY 17 is an optically coupled pair employing a gallium arsenide infrared LED and a silicon NPN phototransistor. Signal information, including a DC level, can be transmitted by the device while maintaining a high degree of electrical isolation between input and output. The CNY 17 can be used to replace relays and transformers in many digital interface applications, as well as analog applications such as CRT modulation.

Maximum Ratings

Emitter (GaAs infrared emitting diode)			
Reverse voltage	V_R	6	V
Forward current	I_F	60	mA
Surge current ($t \leq 10\ \mu s$)	i_{FS}	2.5	A
Power dissipation	P_{tot}	100	mW
Detector (Si phototransistor)			
Collector-emitter reverse voltage	V_{CEO}	70	V
Emitter-base reverse voltage	V_{EBO}	7	V
Collector current	I_C	50	mA
Collector current (t<1 ms)	I_{CSM}	100	mA
Power dissipation	P_{tot}	150	mW
Coupler			
Storage temperature	T_{stor}	−40 to +150	°C
Operating temperature	T_{amb}	−40 to +100	°C
Junction temperature	T_j	100	°C
Soldering temperature in a 2 mm distance from the case bottom ($t \leq 3$ s)	T_s	260	°C
Isolation voltage	V_{is}	5300	V
(between emitter and detector referred to standard climate 23/50 DIN 50014;			
leakage path, DIN 57883, 6.80		8.2 MIN.	mm
air path, VDE 0883, 6.80		7.3 MIN.	mm

Tracking resistance: Group III (KC≥ 600 in accordance with VDE 110 § 6, table 3 and DIN 53 480/VDE 0330, part 1.

Isolation voltage @ V_{is} = 500 V	R_{is}	10^{11}	Ω

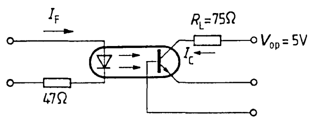
Characteristics (T_{amb} = 25°C)

Emitter (GaAs infrared emitting diode)			
Forward voltage (I_F = 60 mA)	V_F	1.25 (≤ 1.65)	V
Breakdown voltage (I_R = 10 μA)	V_{BR}	30 (≥ 6)	V
Reverse current (V_R = 6 V)	I_R	0.01 (≤ 10)	μA
Capacitance (V_R = 0 V; f = 1 MHz)	C_O	40	pF
Thermal Resistance	R_{thJamb}	750	K/W
Detector (Si phototransistor)			
Capacitance (V_{CE} = 5 V; f = 1 MHz)	C_{CE}	6.8	pF
(V_{CB} = 5 V; f = 1 μHz)	C_{CB}	8.5	pF
(V_{CB} = 5 V; f = 1 μHz)	C_{EB}	11	pF
Thermal Resistance	R_{thJamb}	500	K/W
Coupler			
Collector-emitter saturation voltage (I_F = 10 mA; I_C = 2.5 mA)	V_{CEsat}	.25 (≤ .4)	V
Coupling capacitance	C_K	.55	pF

The optocouplers are grouped according to their current transfer ratio I_C/I_F at V_{CE}=5 V, marked by dash numbers.

	–1	–2	–3	–4	
I_C/I_F (I_F=10 mA)	40–80	63–125	100–200	160–320	%
I_C/I_F (I_F=1 mA)	30 (>13)	45 (>22)	70 (>34)	90 (>56)	%
Collector-Emitter Leakage Current (V_{CE}=10 V) (I_{CEO})	2 (≤50)	2 (≤50)	5 (≤100)	5 (≤100)	nA

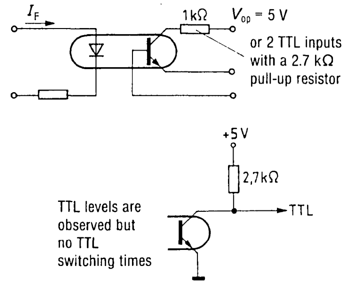
Linear Operation (without saturation)



I_F=10 mA, V_{OP}=5 V, T_{amb}=25°C

Load Resistance	R_L	75	Ω
Turn-On Time	t_{ON}	3.0 (≤5.6)	µs
Rise Time	t_R	2.0 (≤4.0)	µs
Turn-Off Time	t_{OFF}	2.3 (≤4.1)	µs
Fall Time	t_F	2.0 (≤3.5)	µs
Cut-Off Frequency	F_{CO}	250	kHz

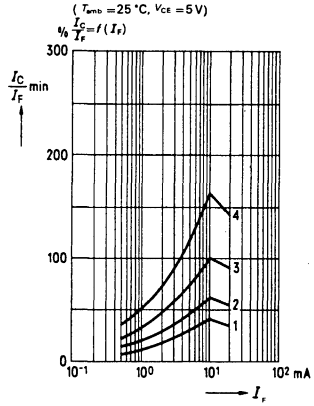
Switching Operation (with saturation)



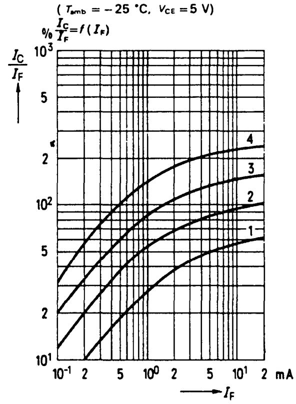
Group	–1 (I_F=20 mA)	–2 and –3 (I_F=10 mA)	–4 (I_F=5 mA)	
Turn-On Time t_{ON}	3.0 (≤5.5)	4.2 (≤8.0)	6.0 (≤10.5)	µs
Rise Time t_R	2.0 (≤4.0)	3.0 (≤6.0)	4.6 (≤8.0)	µs
Turn-Off Time t_{OFF}	18 (≤34)	23 (≤39)	25 (≤43)	µs
Fall Time t_F	11 (≤20)	14 (≤24)	15 (≤26)	µs
V_{CESAT}	0.25 (≤0.4)			V

Optocouplers (Optoisolators)

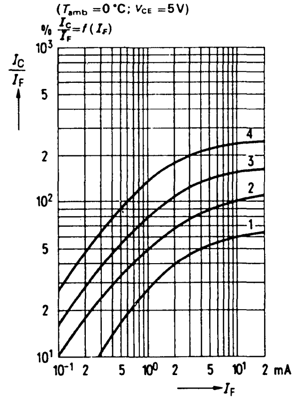
Minimum current transfer ratio as a function of diode current
(T_{amb} =25 °C, V_{CE} =5 V)



Current transfer ratio as a function of diode current
(T_{amb} = –25 °C, V_{CE} =5 V)



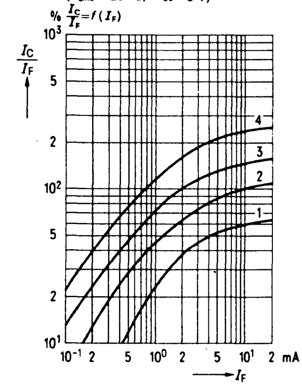
Current transfer ratio as a function of diode current
(T_{amb} =0 °C; V_{CE} =5V)



Current transfer ratio as a function of diode current

(T_{amb} = 25 °C, V_{CE} = 5 V)

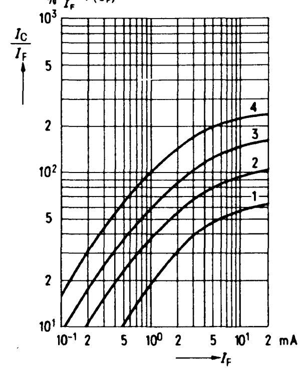
% $\frac{I_C}{I_F} = f(I_F)$



Current transfer ratio as a function of diode current

(T_{amb} = 50 °C; V_{CE} = 5 V)

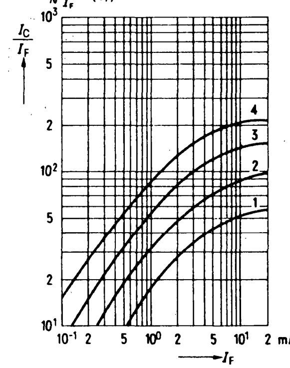
% $\frac{I_C}{I_F} = f(I_F)$



Current transfer ratio as a function of diode current

(T_{amb} = 75 °C; V_{CE} = 5 V)

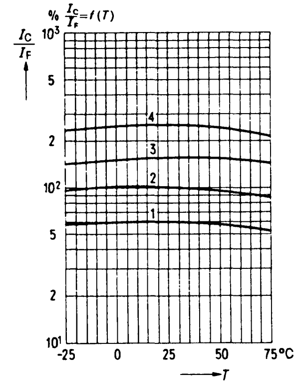
% $\frac{I_C}{I_F} = f(I_F)$



Current transfer ratio as a function of temperature

(I_F = 10 mA, V_{CE} = 5 V)

% $\frac{I_C}{I_F} = f(T)$

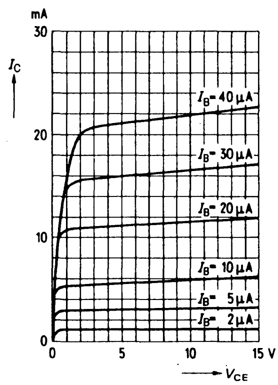


Transistor characteristics

(Current gain B=550)

(T_{amb} = 25 °C; I_F = 0)

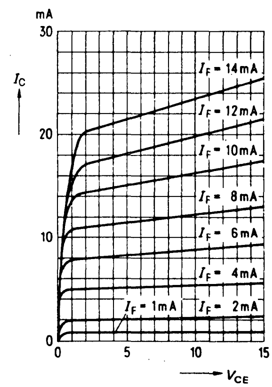
$I_C = f(V_{CE})$



Output characteristics

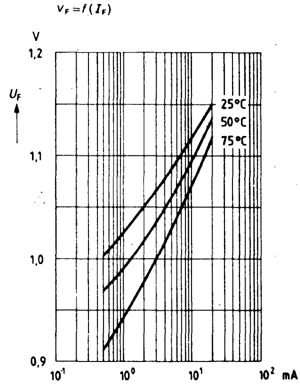
(T_{amb} = 25 °C)

$I_C = f(V_{CE})$



Forward voltage

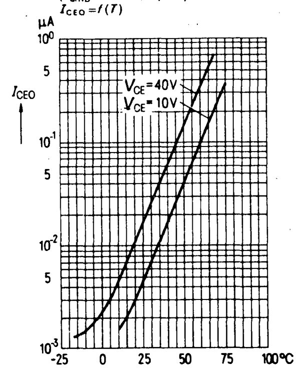
$V_F = f(I_F)$



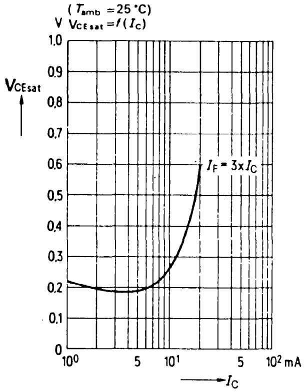
Collector-emitter off-state current

(T_{amb} = 25 °C; I_F = 0)

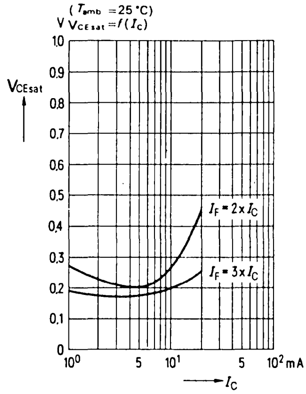
$I_{CEO} = f(T)$



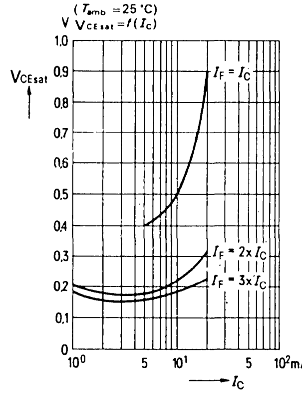
Saturation voltage as a function of collector current and modulation depth for CNY17-1



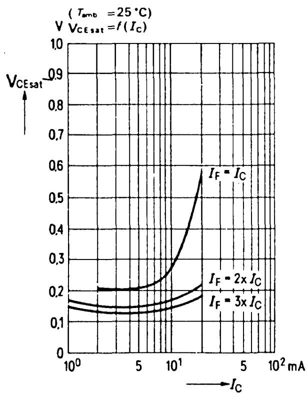
Handling same except for CNY17-2



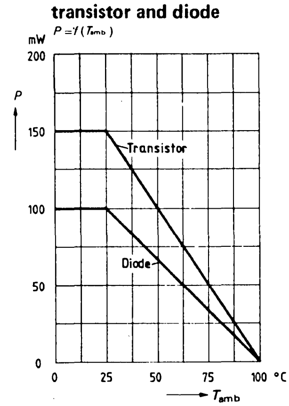
CNY17-3



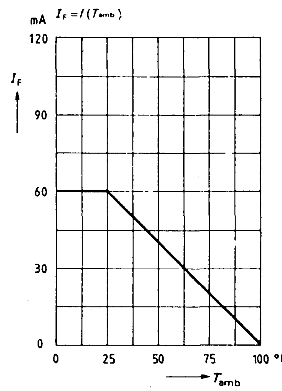
CNY17-4



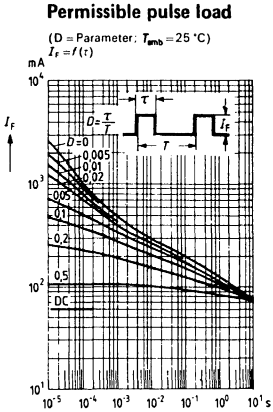
Permissible loss transistor and diode



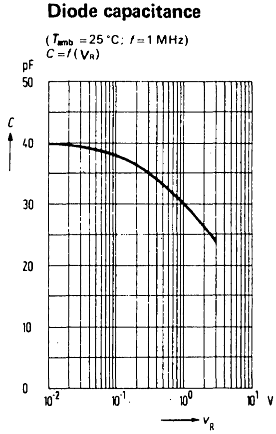
Permissible loss diode



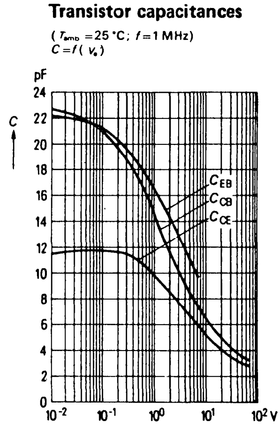
Permissible pulse load



Diode capacitance



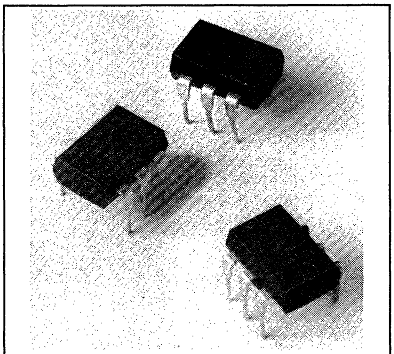
Transistor capacitances



Optocouplers (Optoisolators)

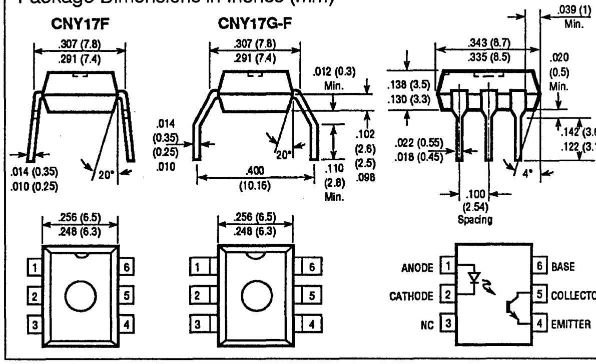
SIEMENS

CNY17F SERIES
VDE LEAD BEND CNY17G F SERIES
SINGLE CHANNEL PHOTOTRANSISTOR OPTOCOUPLER NO BASE CONNECTION



CNY17F

Package Dimensions in Inches (mm)



FEATURES

- **CNY17F G Lead Bend in Accordance with VDE 0805/0806**
- **5300 Volt Breakdown Voltage**
- **Base Terminal not connected for improved Common Mode Interface Immunity**
- **High Current Transfer Ratio, 3 Groups CNY17F/G F-1, 40 to 80% CNY17F/G F-2, 63 to 125% CNY17F/G F-3, 100 to 200%**
- **Low CTR Degradation**
- **High Collector-emitter Voltage $V_{CEO} = 70V$**
- **100% Burn-in**
- **VDE Approval #0883**
- **VDE Approval #0884 (Optional with Option 1, add -X001 suffix)**

DESCRIPTION

The CNY17F/G F is an optocoupler that employs a GaAs infrared emitting diode optically coupled to a silicon planar phototransistor detector. The component is incorporated in a plastic plug-in DIP-6 package. The coupling device is suitable for signal transmission between two electrically separated circuits. The potential difference between the circuits to be coupled is not allowed to exceed the maximum permissible reference voltages.

In contrast to the CNY17 Series, the base terminal of the F/G F type is not connected. This results in a substantially improved common-mode interference immunity.

Maximum Ratings:

Emitter (GaAs infrared emitter)			
Reverse voltage	V_R	6	V
DC forward current	I_F	60	mA
Surge forward current ($t \le 10$ µs)	I_{FSM}	2.5	A
Total power dissipation	P_{tot}	100	mW
Detector (silicon phototransistor)			
Collector-emitter reverse voltage	V_{CEO}	70	V
Collector current	I_C	50	mA
Collector current ($t \le 1$ ms)	I_{CSM}	100	mA
Total power dissipation	P_{tot}	150	mW
Optocoupler			
Storage temperature range	T_{stg}	–40 ... + 150	°C
Ambient temperature range	T_{amb}	–40 ... + 100	°C
Junction temperature	T_j	100	°C
Soldering temperature (max. 10s)[1]	T_s	260	°C
Isolation test voltage[2] between emitter and detector referred to standard climate 23/50 DIN 50014	V_{IO}	5300	Vdc
Leakage path		>8.0	mm
Air Path			
CNY17F		>7.3	mm
CNY17G-F		>8.0	mm
Tracking resistance			
in acc. with VDE 0110 § 6, table 3 and DIN 53480/VDE 0303, part 1.	KB	≥ 100 (group 3)	
Isolation resistance (V_{IO} = 500 V)	R_{IO}	10^{11}	Ω

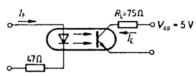
Characteristics (T_{amb} = 25°C)

Emitter (GaAs infrared emitter)			
Forward voltage (I_F = 60 mA)	V_F	1.25 (≤ 1.65)	V
Breakdown voltage (I_R = 10 µA)	BV	30 (≥ 6)	V
Reverse current (V_R = 6 V)	I_R	0.01 (≤ 10)	µA
Capacitance (V_R = 0 V; f = 1 MHz)	C_0	40	pF
Thermal resistance[1]	R_{thJA}	750	K/W
Detector (silicon phototransistor)			
Capacitance (V_{CE} = 5 V; f = 1 MHz)	C_{CE}	6.8	pF
Thermal resistance[1]	R_{thJA}	500	K/W
Optocoupler			
Collector-emitter saturation voltage (I_F = 10 mA; I_C = 2.5 mA)	V_{CEsat}	0.25 (≤ 0.4)	V
Coupling capacitance	C_K	0.5	pF

The optocouplers are grouped according to their current transfer ratio I_C/I_F at V_{CE} = 5 V, and marked by Arabic numerals.

Group	-1	-2	-3	
I_C/I_F (I_F = 10 mA)	40 ... 80	63 ... 125	100 ... 200	%
I_C/I_F (I_F = 1 mA)	30 (> 13)	45 (> 22)	70 (> 34)	%
Collector-emitter leakage current (V_{CE} = 10 V) I_{CEO}	2 (≤ 50)	2 (≤ 50)	5 (≤ 100)	nA

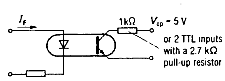
Linear operation (without saturation)

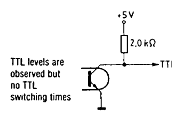


Load resistance	R_L	75	Ω
Turn-on time	t_{on}	3.0 (≤ 5.6)	µs
Rise time	t_r	2.0 (≤ 4.0)	µs
Turn-off time	t_{off}	2.3 (≤ 4.1)	µs
Fall time	t_f	2.0 (≤ 3.5)	µs
Cut-off frequency	f_{co}	250	kHz

I_F = 10 mA
V_{op} = 5 V
T_{amb} = 25 °C

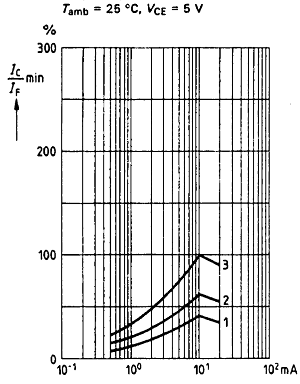
Switching operation (with saturation)



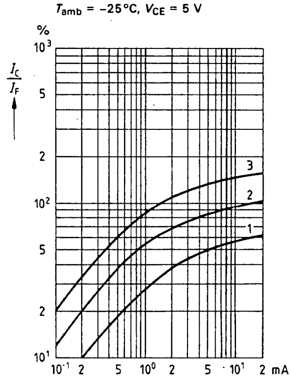


Group		1 I_F = 20 mA	2 and 3 I_F = 10 mA	
Turn-on time	t_{on}	3.0 (≤ 5.5)	4.2 (≤ 8.0)	µs
Rise time	t_r	2.0 (≤ 4.0)	3.0 (≤ 6.0)	µs
Turn-off time	t_{off}	18 (≤ 34)	23 (≤ 39)	µs
Fall time	t_f	11 (≤ 20)	14 (≤ 24)	µs
	V_{CEsat}	0.25 (≤ 0.4)		V

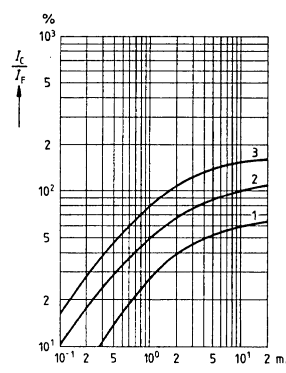
Minimum current transfer ratio versus diode forward current
T_{amb} = 25 °C, V_{CE} = 5 V



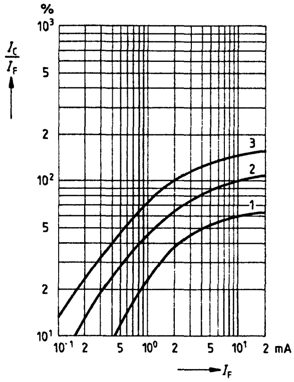
Current transfer ratio (typ.) versus diode forward current
T_{amb} = −25 °C, V_{CE} = 5 V



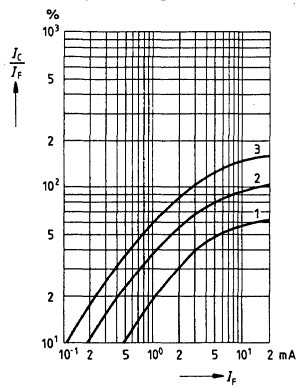
Current transfer ratio (typ.) versus diode forward current
T_{amb} = 0 °C; V_{CE} = 5 V



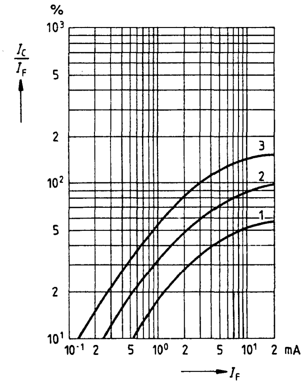
Current transfer ratio (typ.) versus diode forward current
T_{amb} = 25 °C; V_{CE} = 5 V



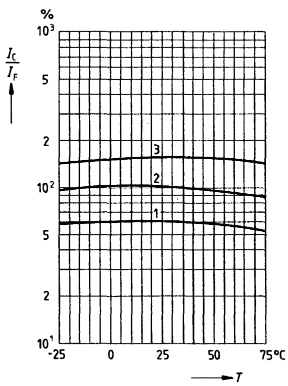
Current transfer ratio (typ.) versus diode forward current
T_{amb} = 50 °C, V_{CE} = 5 V



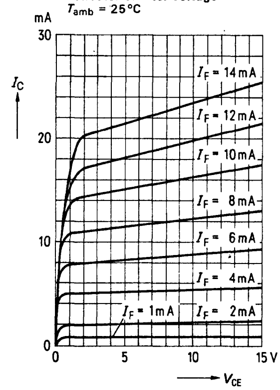
Current transfer ratio (typ.) versus diode forward current
T_{amb} = 75 °C, V_{CE} = 5 V



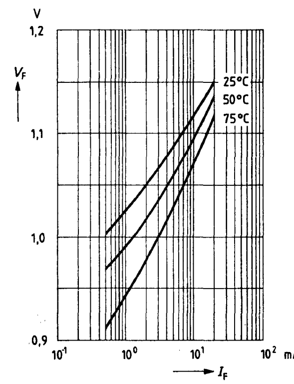
Current transfer ratio (typ.) versus temperature
I_F = 10 mA; V_{CE} = 5 V



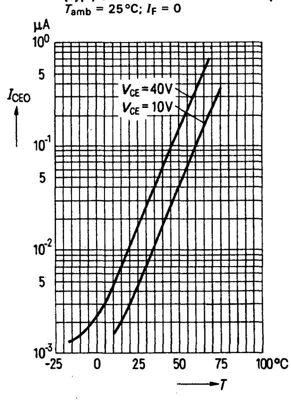
Output characteristics (typ.) Collector current versus collector-emitter voltage
T_{amb} = 25 °C



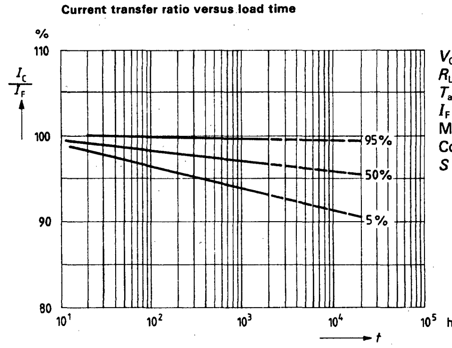
Forward voltage (typ.) of the diode versus forward current



Collector-emitter leakage current (typ.) of the transistor versus temperature
T_{amb} = 25 °C; I_F = 0

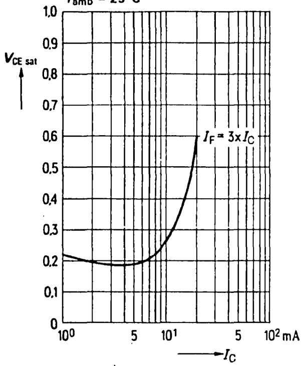


Current transfer ratio versus load time

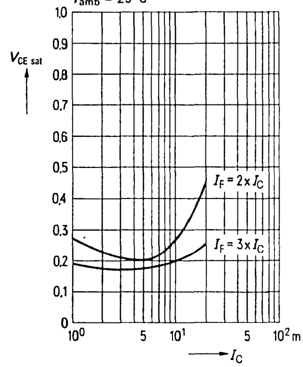


V_{CE} = 5 V
R_L = 1 kΩ
T_{amb} = 25 °C
I_F = 60 mA
Measuring current = 10 mA
Confidence coefficient
S = 60 %

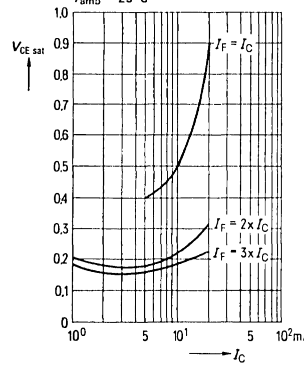
Collector-emitter saturation voltage (typ.) versus collector current and control range[1]
for group 1
T_{amb} = 25°C



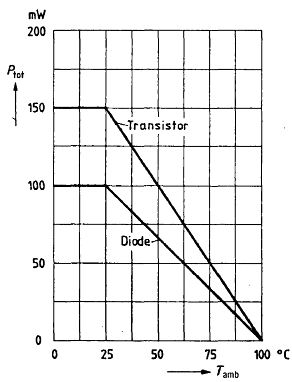
Collector-emitter saturation voltage (typ.) versus collector current and control range[1]
for group 2
T_{amb} = 25°C



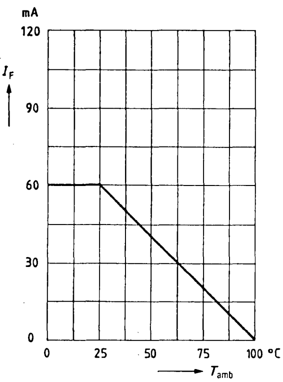
Collector-emitter saturation voltage (typ.) versus collector current and control range[1]
for group 3
T_{amb} = 25°C



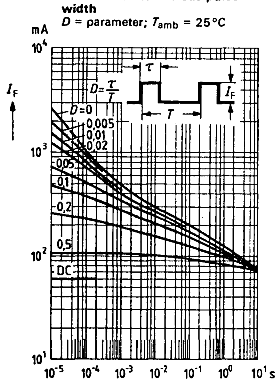
Permissible power dissipation for transistor and diode versus ambient temperature



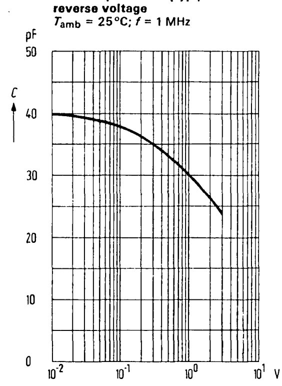
Permissible forward current of the diode versus ambient temperature



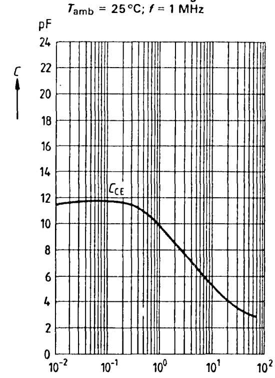
Permissible pulse handling capability
Forward current versus pulse width
D = parameter; T_{amb} = 25°C



Diode capacitance (typ.) versus reverse voltage
T_{amb} = 25°C; *f* = 1 MHz

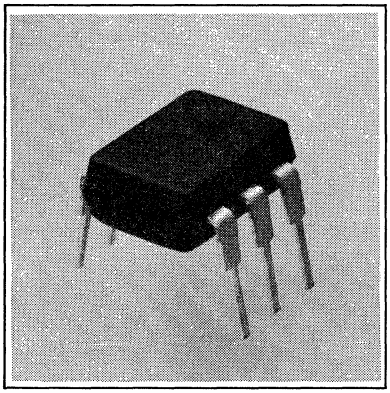


Transistor capacitances (typ.) versus emitter voltage
T_{amb} = 25°C; *f* = 1 MHz

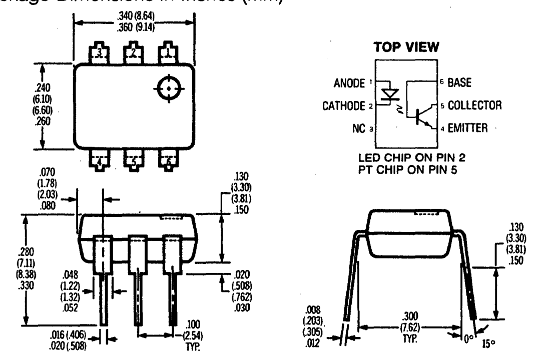


SIEMENS

H11A1 thru H11A5
PHOTOTRANSISTOR OPTOCOUPLER



Package Dimensions in Inches (mm)



FEATURES

- **7500 Volt Withstand Test Voltage**
- **0.5 pF Coupling Capacitance**
- **CTR Minimum: H11A1 - 50%**
  H11A2, H11A3 - 20%
  H11A4 - 10%
  H11A5 - 30%
- **Underwriters Lab Approval #E52744**

DESCRIPTION

The H11A1 thru H11A5 are industry standard optocouplers, consisting of a GaAs infrared LED and a silicon phototransistor. These optocouplers are constructed with a high voltage insulation, double molded packaging process which offers 7.5 KV withstand test capability.

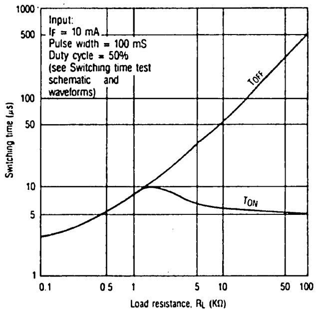
Maximum Ratings

Gallium Arsenide LED	
Power Dissipation at 25°C	100 mW
Derate Linearly from 25°C	1.33 mW/°C
Continuous Forward Current	60 mA
Reverse Voltage	3 V
Detector Silicon Phototransistor	
Power Dissipation at 25°C	150 mW
Derate Linearly from 25°C	3.3 mW/°C
Collector-Emitter Breakdown	30 V
Emitter-Collector Breakdown	7 V
Collector-Base Breakdown	70 V
Package	
Total Package Dissipation at 25°C (LED plus Detector)	250 mW
Derate Linearly from 25°C	3.3 mW/°C
Storage Temperature	–55 to +150°C
Operating Temperature	–55 to +100°C
Lead Soldering Time at 260 °C	10 sec

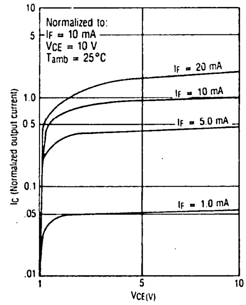
Electrical Characteristics (T_{amb} = 25°C)

	Min	Typ	Max	Unit	Conditions
Gallium Arsenide LED					
Forward Voltage		1.1	1.5	V	I_F = 10 mA
Forward Voltage (H11A5 only)		1.1	1.7	V	"
Reverse Current			10	μA	V_F = 3 V
Junction Capacitance		50		pF	V_F = 0 V, f = 1 MHz
Phototransistor Detector					
BV_{CEO}	30			V	I_C = 10 mA, I_F = 0 mA
BV_{ECO}	7			V	I_E = 100 μA, I_F = 0 mA
BV_{CBO}	70			V	I_C = 10 μA
I_{CEO}		5	50	nA	V_{CE} = 10 V, I_F = 0 mA
Collector-Emitter Capacitance		2		pF	V_{CE} = 0
Coupled Characteristics					
$V_{CE\ (sat)}$			0.4	V	I_{CE} = 0.5 mA, I_F = 10 mA
DC Current Transfer Ratio					
H11A1	50			%	V_{CE} = 10 V, I_F = 10 mA
H11A2, H11A3	20			%	"
H11A4	10			%	"
H11A5	30			%	"
Capacitance Input to Output		0.5		pF	
Withstand Test Voltage	7500			VDC	t = 1 sec.
	5300			VAC_{RMS}	t = 1 sec.
Resistance Input to Output		100		GΩ	
Switching Times					
t_{on}		3.0		μs	R_E = 100 Ω, V_{CE} = 10 V
t_{off}		3.0		μs	I_C = 2 mA

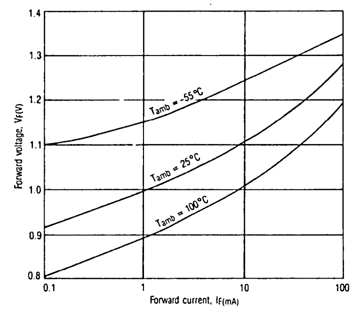
Typical switching times versus load resistance



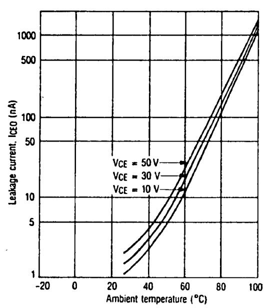
Collector current versus collector voltage



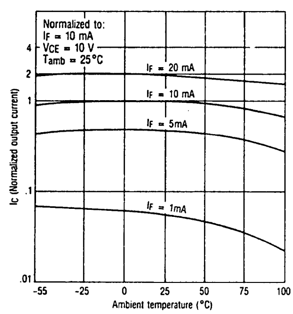
Typical forward voltage versus forward current



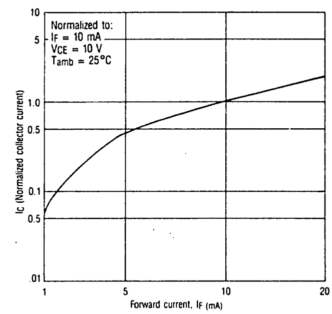
Typical leakage current versus ambient temperature



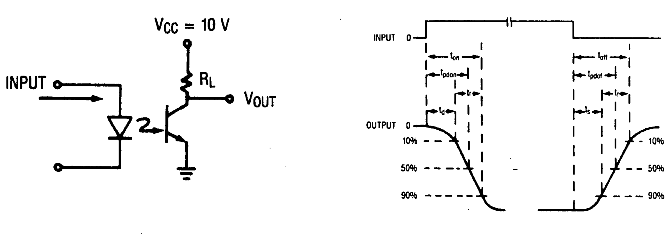
Output current versus temperature



Collector current versus diode forward current



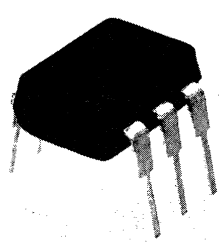
Switching time test schematic and waveforms



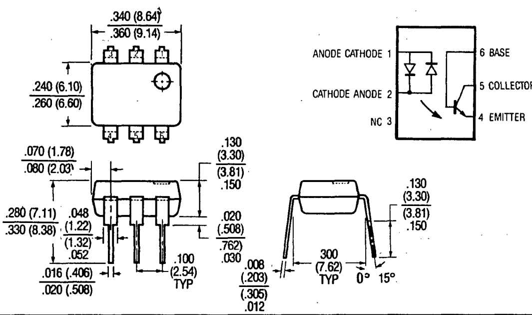
Optocouplers (Optoisolators)

H11AA1

BIDIRECTIONAL INPUT OPTOCOUPLER



Package Dimensions in Inches (mm)



FEATURES

- **AC or Polarity Insensitive Input**
- **Current Transfer Ratio 20% Min.**
- **Industry Standard Dual-In-Line**
- **Built-in Reverse Polarity Input Protection**
- **I/O compatible with integrated circuits**
- **Underwriters' Lab Approval #E52744**
- **VDE Approvals 0883/6.80, 0804/1.83**

DESCRIPTION

The H11AA1 is a bidirectional input optically coupled isolator. It consists of two gallium arsenide infrared emitting diodes coupled to a silicon NPN phototransistor in a 6-pin dual in-line package. The H11AA1 has a minimum CTR of 20% and a CTR symmetry of 1:3. It is designed for applications requiring detection or monitoring of AC signals.

Maximum Ratings

Gallium Arsenide LED
- Power Dissipation @ 25°C .... 200 mW
- Derate Linearly from 25°C .... 2.6 mW/°C
- Continuous Forward Current .... 100 mA
- Peak Reverse Voltage .... 3.0 V

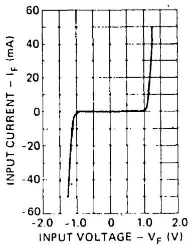
Detector (Silicon Phototransistor)
- Power Dissipation @ 25°C .... 200 mW
- Derate Linearly from 25°C .... 2.6 mW/°C
- Collector-Emitter Breakdown Voltage (BV_{CEO}) .... 30 V
- Emitter-Base Breakdown Voltage (BV_{ECO}) .... 5 V
- Collector-Base Breakdown Voltage (BV_{CBO}) .... 70 V

Package
- Total Package Dissipation at 25°C Ambient (LED Plus Detector) .... 250 mW
- Derate Linearly from 25°C .... 3.3 mW/°C
- Isolation Test Voltage in Accordance with DIN57883/6.80 .... 3750 VAC/5300 VDC
- Creepage Path .... 8 mm min.
- Clearance Path .... 7 mm min.
- Tracking Index According to VDE 0303 .... KB100/A
- Storage Temperature .... −55 to +150°C
- Operating Temperature .... −55 to +100°C
- Lead Soldering time @ 260°C .... 10 sec
- UL Qualified for .... 7500 VDC

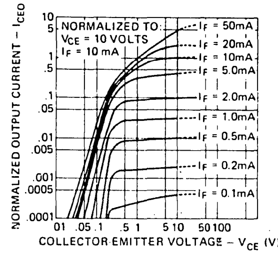
Electrical Characteristics (T_{amb} = 25°C)

Parameter	Min	Typ	Max	Unit	Test Condition
Gallium Arsenide LED					
Forward Voltage V_F	—	1.2	1.5	V	$I_F = \pm 10$ mA
Phototransistor Detector					
BV_{CEO}	30	50	—	V	$I_C = 1$ mA
BV_{ECO}	7	10	—	V	$I_E = 100\ \mu A$
BV_{CBO}	70	90	—	V	$I_C = 100\ \mu A$
I_{CEO}	—	5	100	nA	$V_{CE} = 10$ V
Coupled Characteristics					
$V_{CE(sat)}$	—	—	0.4	V	$I_F = \pm 10$ mA, $I_C = 0.5$ mA
DC Current Transfer Ratio CTR	20	—	—	%	$I_F = \pm 10$ mA, $V_{CE} = 10$ V
Symmetry $\frac{CTR\ @\ +10\ mA}{CTR\ @\ -10\ mA}$	0.33	1.0	3.0	—	

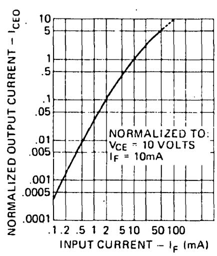
INPUT CHARACTERISTICS



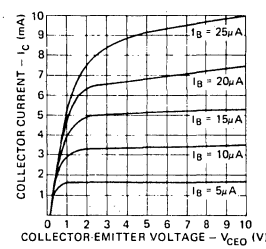
TRANSFER CHARACTERISTICS



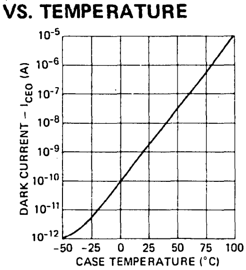
OUTPUT VS. INPUT CURRENT



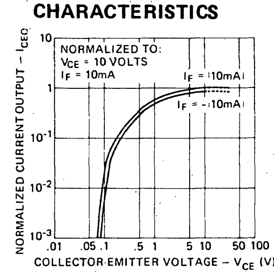
OUTPUT CHARACTERISTICS



DARK CURRENT VS. TEMPERATURE



SYMMETRY CHARACTERISTICS

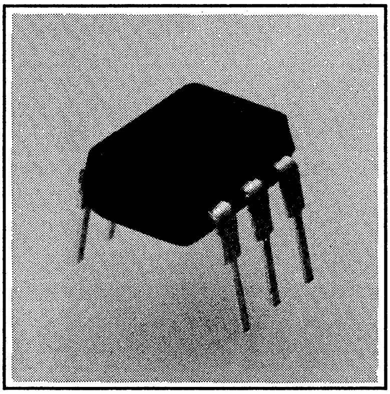


Optocouplers (Optoisolators)

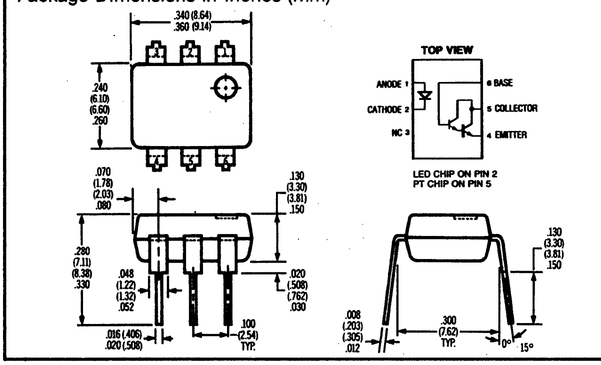
SIEMENS

H11B1/H11B2/H11B3

PHOTODARLINGTON OPTOCOUPLER



Package Dimensions in Inches (mm)



FEATURES

- **7500 Volt Withstand Test Voltage**
- **0.5 pF Coupling Capacitance**
- **CTR Minimum at $I_F = 1$ mA:**
  H11B1 500%
  H11B2 200%
  H11B3 100%
- **Underwriters Lab Approval #E52744**

DESCRIPTION

The H11B1/H11B2/H11B3 are industry standard optocouplers, consisting of a GaAs infrared LED and a silicon photodarlington transistor. These optocouplers are constructed with a high voltage insulation, double molded packaging process which offers 7.5 KV withstand test capability.

Maximum Ratings

Gallium Arsenide LED
- Power Dissipation at 25°C .... 100 mW
- Derate Linearly from 25°C .... 1.33 mW/°C
- Continuous Forward Current .... 60 mA
- Reverse Voltage .... 3 V

Detector Silicon Phototransistor
- Power Dissipation at 25°C .... 150 mW
- Derate Linearly from 25°C .... 2.0 mW/°C
- Collector-Emitter Breakdown .... 25 V
- Emitter-Collector Breakdown .... 7 V
- Collector-Base Breakdown .... 30 V
- Collector-Current (Continuous) .... 100 mA

Package
- Total Package Dissipation at 25°C (LED plus Detector) .... 260 mW
- Derate Linearly from 25°C .... 3.5 mW/°C

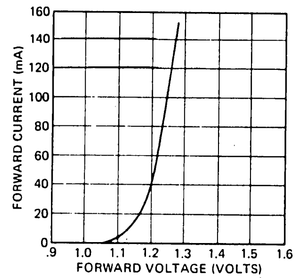
Storage Temperature .... –55 to +150°C
Operating Temperature .... –55 to +100°C
Lead Soldering Time at 260°C .... 10 sec

Electrical Characteristics ($T_{amb} = 25°C$)

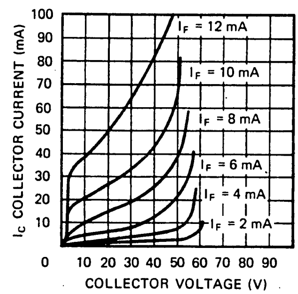
	Min	Typ	Max	Unit	Conditions
Gallium Arsenide LED					
Forward Voltage					
H11B1, B2		1.1	1.5	V	$I_F = 10$ mA
H11B3		1.1	1.5	V	$I_F = 50$ mA
Reverse Current			10	μA	$V_F = 3$ V
Junction Capacitance		50		pF	$V_F = 0$ V, f = 1 MHz
Phototransistor Detector					
BV_{CEO}	25			V	$I_C = 1.0$ mA, $I_F = 0$ mA
BV_{ECO}	7			V	$I_E = 100$ μA, $I_F = 0$ mA
BV_{CBO}	30			V	$I_C = 100$ μA, $I_F = 0$ mA
I_{CEO}			100	nA	$V_{CE} = 10$ V, $I_F = 0$ mA
Coupled Characteristics					
$V_{CE\ (SAT)}$			1.0	V	$I_F = 1$ mA, $I_C = 1$ mA
DC Current Transfer Ratio					
H11B1	500			%	$V_{CE} = 5$ V, $I_F = 1$ mA
H11B2	200			%	$V_{CE} = 5$ V, $I_F = 1$ mA
H11B3	100			%	$V_{CE} = 5$ V, $I_F = 1$ mA
Capacitance Input to Output		0.5		pF	
Withstand Test Voltage	7500			VDC	t = 1 sec
	5300			VAC_{RMS}	t = 1 sec
Resistance Input to Output		100		GΩ	
Switching Times					
t_{on}		125		μs	$R_E = 100$ Ω, $V_{CE} = 10$ V,
t_{off}		100		μs	$I_C = 10$ mA

TYPICAL OPTOELECTRONIC CHARACTERISTIC CURVES

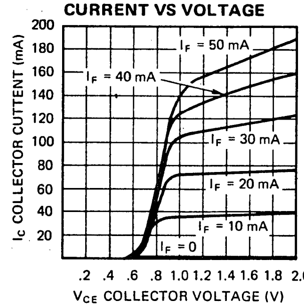
GaAs EMITTER: FORWARD CURRENT – VOLTAGE CHARACTERISTICS



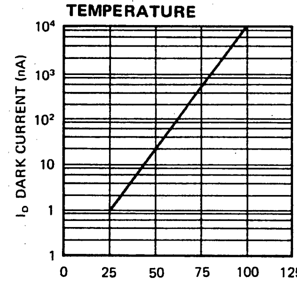
DARLINGTON TRANSISTOR CURRENT VS VOLTAGE



DARLINGTON TRANSISTOR OUTPUT CURRENT VS VOLTAGE



DARK CURRENT VS TEMPERATURE



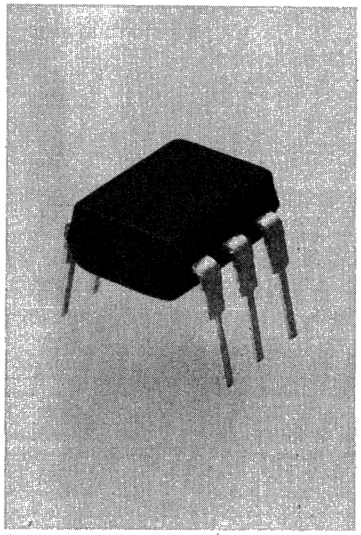
Optocouplers (Optoisolators)

SIEMENS

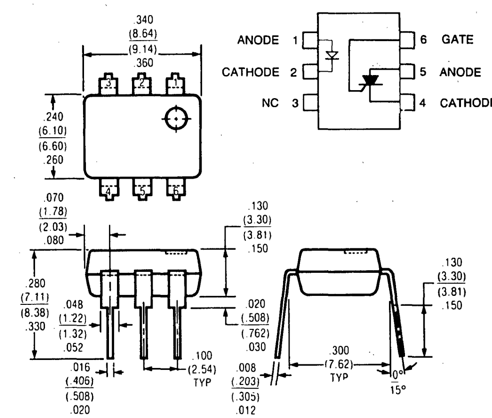
H11C4/H11C5/H11C6

PHOTO SCR OPTOCOUPLER

Advance Data Sheet



Package Dimensions in Inches (mm)



FEATURES

- **400 Volts Blocking Voltage**
- **Turn On Current (I_{FT}) 5.0 mA Typical**
- **Gate Trigger Current (I_{GT}) – 20μA Typical**
- **Gate Trigger Voltage (V_{GT}) – 0.6 Volt Typical**
- **7500 Volt Isolation Voltage**
- **Surge Anode Current – 5.0 Amp**
- **Solid State Reliability**
- **Standard Dip Package**
- **Underwriters Lab Approval #E52744**

DESCRIPTION

The H11C4, H11C5, H11C6 are optically coupled SCRs employing a GaAs infrared emitter and a silicon photo SCR sensor. Switching can be accomplished while maintaining a high degree of isolation between triggering and load circuits. It can be used in SCR triac and solid state relay applications where high blocking voltages and low input current sensitivity is required.

The H11C4 and H11C5 has a maximum turn-on-current of 11 mA. The H11C6 has a maximum of 14 mA.

Maximum Ratings

Gallium Arsenide LED (Drive Circuit)	
Power Dissipation at 25°C	100 mW
Derate Linearly from 25°C	1.33 mW/ °C
Continuous Forward Current	60 mA
Peak Reverse Voltage	6.0 V
Peak Forward Current (1 μs, 1% Duty Cycle)	3.0 A
SCR Detector (Load Circuit)	
Power Dissipation (25°C case)	1000 mW
Derate Linearly from 25°C	13.3 mW/ °C
RMS Forward Current	300 mA
Surge Anode Current (10 ms duration)	5.0 A
Peak Forward Current (100 μs, 1% Duty Cycle)	10 A
Surge Gate Current (5 ms duration)	200 mA
Reverse Gate Voltage	6.0 V
Anode Voltage (DC or AC Peak)	400 V
Coupled	
Isolation Voltage (H11C4/H11C5/H11C6) (t = 1 sec.)	7500 VDC 5300 VAC (RMS)
Total Package Power Dissipation	400 mW
Derate Linearly from 25°	5.3 mW/ °C
Operating Temperature Range	-55°C to +100°C
Storage Temperature Range	-55°C to +150°C
Lead Soldering Time at 260°C	10 sec

Electrical Characteristics (T_{amb} = 25°C)

Parameter	Min	Typ	Max	Unit	Test Condition
Input Diode					
Forward Voltage		1.2	1.5	V	I_F = 10 mA
Reverse Current			10	μA	V_R = 3 V
Capacitance		50		pF	V = 0, f = 1 μHz
Photo - SCR					
Forward Leakage Current (I_D)			150	μA	R_{GK} = 10 Kohm, I_F = 0 V_{DM} = 400 V TA = 100°C
Reverse Leakage Current (I_R)			150	μA	R_{GK} = 10 Kohm, I_F = 0 V_{RM} = 400 V TA = 100°C
Forward Blocking Voltage (V_{DM})	400			V	R_{GK} = 10 Kohm TA = 100°C I_d = 150 μA
Reverse Blocking Voltage (V_{DM})	400			V	R_{GK} = 10 Kohm TA = 100°C I_d = 150 μA
On-state Voltage (V_t)	–	1.1	1.3	V	I_T = 300 mA
Holding Current (I_H)	–	–	500	μA	R_{GK} = 27 Kohm, V_{FX} = 50 V
Gate Trigger Voltage (V_{GT})	–	0.6	1.0	V	V_{FX} = 100 V R_{GK} = 27 Kohm R_L = 10 Kohm
Gate Trigger Current (I_{GT})		20	50	μA	V_{FX} = 100 V R_L = 10 Kohm R_{GK} = 27 Kohm
Capacitance					
Anode to Gate		20		pF	V = 0, f = 1 μHz
Gate to Cathode		350		pF	
Coupled					
Turn-on Current (I_{FT})					
— H11C4/H11C5			20	mA	V_{DM} = 50 V
— H11C6			30	mA	R_{GK} = 10 Kohm
— H11C4/H11C5		5	11	mA	V_{DM} = 100 V
— H11C6		7	14	mA	R_{GK} = 27 Kohm
Isolation Voltage	7500			V_{DC}	1 second 5300 VAC (RMS)
Isolation Resistance	100			G-ohm	V_{iso} = 500 V
Isolation Capacitance			2	pF	f = 1 MHz, V = 0

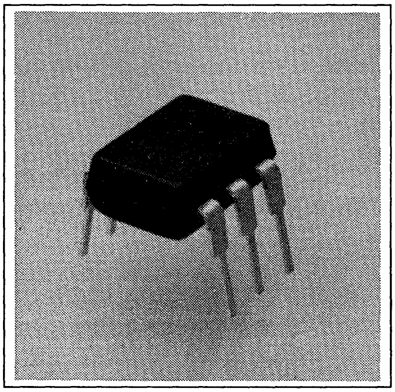
Optocouplers (Optoisolators)

H11C4

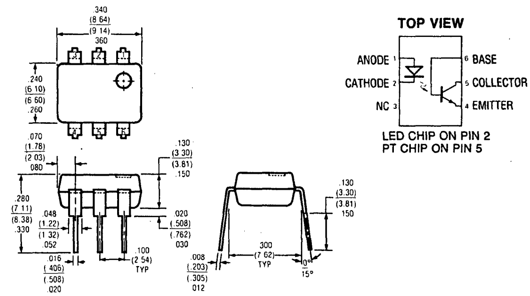
SIEMENS

IL1/2/5

PHOTOTRANSISTOR OPTOCOUPLER



Package Dimensions in Inches (mm)



FEATURES

- **Current Transfer Ratio @ I_F = 10 mA**
  IL1 – 20% Min.
  IL2 – 100% Min.
  IL5 – 50% Min.
- **High Collector-Emitter Voltage**
  IL1 – BV_{CEO} = 50 V
  IL2, IL5 – BV_{CEO} = 70 V
- **Field-Effect Stable by TRansparent IOn Shield (TRIOS)***
- **Double Molded Package Offers Withstand Test Voltage**
  7500 VAC_{PEAK}, 1 sec.
  4420 VAC_{RMS}, 1 min.
- **UL Approval #E52744**
- **VDE Approvals 0883/6.80, 0804/1.83**

DESCRIPTION

The IL1/2/5 are optically coupled isolated pairs employing GaAs infrared LEDs and silicon NPN phototransistor. Signal information, including a DC level, can be transmitted by the drive while maintaining a high degree of electrical isolation between input and output. The IL1/2/5 are especially designed for driving medium-speed logic and can be used to eliminate troublesome ground loop and noise problems. These couplers can be used also to replace relays and transformers in many digital interface applications such as CRT modulation.

See Appnote 45, "How to Use Optocoupler Normalized Curves."

TRansparent **IO**n **S**hield.

Maximum Ratings

Emitter	
Reverse Voltage	6 V
Forward Current	100 mA
Surge Current	2.5 A
Power Dissipation	200 mW
Derate Linearly from 25°C	2.6 mW/°C
Detector	
Collector-Emitter Reverse Voltage	
IL1	50 V
IL2, IL5	70 V
Emitter-Base Reverse Voltage	7 V
Collector-Base Reverse Voltage	70 V
Collector Current	50 mA
Collector Current (t<1 ms)	400 mA
Power Dissipation	200 mW
Derate Linearly from 25°C	2.6 mW/°C
Package	
Storage Temperature	-40°C to +150°C
Operating Temperature	-40°C to +100°C
Junction Temperature	100°C
Soldering Temperature (in a 2 mm distance from case bottom)	260°C
Package Power Dissipation	250 mW
Derate Linearly from 25°C	3.3 mW/°C
UL Withstand Test Voltage (PK) (t=1 sec.)	7500 VDC/5300 VAC_{RMS}
VDE Isolation Test Voltage in Accordance with DIN 57883/6.80	5300 VDC/3750 VAC_{RMS}
Creepage Path	8 min mm
Clearance Path	7 min mm
Tracking Index According to VDE 0303	KB100/A
Working Voltage	1700 VAC_{RMS}
Insulation Resistance	10^{11} Ω

Characteristics

	Symbol	Min.	Typ.	Max.	Unit
Emitter					
Forward Voltage (I_F=60 mA)	V_F		1.25	1.65	V
Breakdown Voltage (I_R=10 μA)	V_{BR}	6	30		V
Reverse Current (V_R=6 V)	I_R		0.01	10	μA
Capacitance (V_R=0 V, f=1 MHz)	C_0		40		pF
Thermal Resistance Junction to Lead	R_{THJL}		750		°C/W
Detector					
Capacitance (V_{CE}=5 V, f=1 MHz)	C_{CE}		6.8		pF
(V_{CB}=5 V, f=1 MHz)	C_{CB}		8.5		pF
(V_{EB}=5 V, f=1 MHz)	C_{EB}		11		pF
Collector-Emitter Leakage Current (V_{CE}=10 V)	I_{CEO}		5	50	nA
Collector-Emitter Saturation Voltage (I_{CE}=1 mA, I_B=20 μA)	$V_{CE(SAT)}$		0.25	0.4	
Base-Emitter Voltage (V_{CE}=10 V, I_B=20 μA)	V_{BE}		0.65		V
DC Forward Current Gain (V_{CE}= 10 V, I_B=20 μA)	HFE	200	650	1800	
Saturated DC Forward Current Gain (V_{CE}= 0.4 V, I_B=20 μA)	HFE_{SAT}	120	400	600	
Thermal Resistance Junction to Lead	R_{THJL}		500		C°/W
Package Transfer Characteristics					
IL1					
Saturated Current Transfer Ratio (Collector-Emitter) (I_F=10 mA, V_{CE}=0.4 V)	CTR_{CESAT}		75		%
Current Transfer Ratio (Collector-Emitter) (I_F=10 mA, V_{CE}=10 V)	CTR_{CE}	20	80	300	%
Current Transfer Ratio (Collector-Base) (I_F=10 mA, V_{CB}=9.3 V)	CTR_{CB}		0.25		%

Characteristics (Cont.)

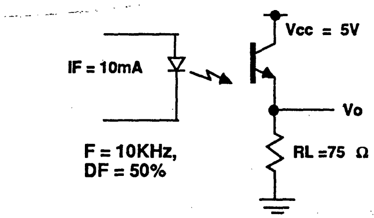
	Symbol	Min.	Typ.	Max.	Unit
Package Transfer Characteristics (Cont.)					
IL2					
Saturated Current Transfer Ratio (Collector-Emitter) (I_F=10 mA, V_{CE}=0.4 V)	CTR_{CESAT}		170		%
Current Transfer Ratio (Collector-Emitter) (I_F=10 mA, V_{CE}=10 V)	CTR_{CE}	100	200	500	%
Current Transfer Ratio (I_F=10 mA, V_{CB}=9.3 V)	CTR_{CB}		0.35		%
IL5					
Saturated Current Transfer Ratio (Collector-Emitter) (I_F=10 mA, V_{CE}=0.4 V)	CTR_{CESAT}		100		%
Current Transfer Ratio (Collector-Emitter) (I_F=10 mA, V_{CE}=10 V)	CTR_{CE}	50	130	400	%
Current Transfer Ratio (I_F=10 mA, V_{CB}=9.3 V)	CTR_{CB}		0.3		%
Isolation and Insulation					
Common Mode Rejection Output High (V_{CM}=50 V_{P-P}, R_L=1 kΩ, I_F=0 mA)	CMH		5000		V/μs
Common Mode Rejection Output Low (V_{CM}=50 V_{P-P}, R_L=1 kΩ, I_F=10 mA)	CML		5000		V/μs
Common Mode Coupling Capacitance	C_{CM}		0.01		pF
Package Capacitance (V_{I-O}=0 V, f=1 MHz.)	C_{I-O}	0.8			pF
Insulation Resistance (V_{I-O}=500 V)	R_S	5^{+10}	10^{+14}		Ω
Dielectric Leakage Current (V_{IO}=4420 $AC_{(RMS)}$, 1 min., 60 Hz)	I_{I-O}		3.3	10	μA
(V_{IO}=6250 VDC, 1 min.)			0.5	10	μA
(V_{IO}=5304 $AC_{(RMS)}$, 1 sec., 60 Hz)			4	10	μA
(V_{IO}=7500 VDC, 1 sec.)			0.6	12	μA

Optocouplers (Optoisolators)

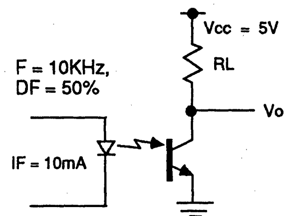
IL1/2/5

SWITCHING TIMES

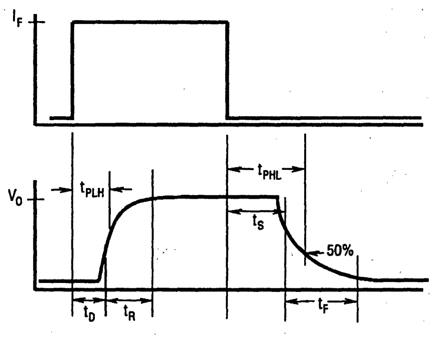
Non-Saturated Switching



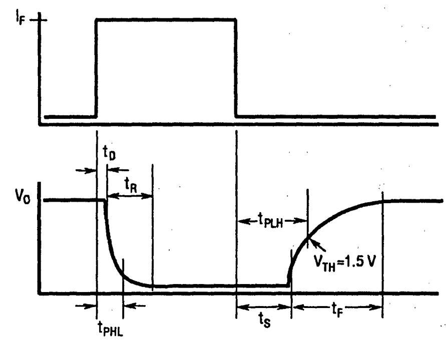
Saturated Switching



Non-Saturated Switching Timing



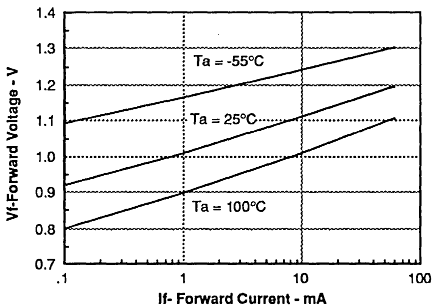
Saturated Switching Timing



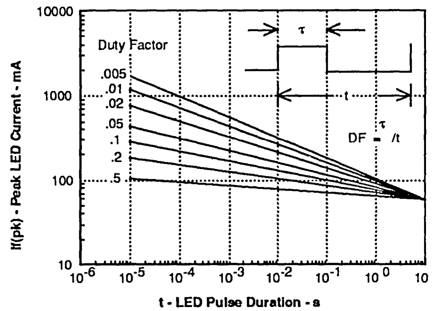
Characteristic		IL1 I_F=20 mA	IL2 I_F=5 mA	IL5 I_F=10 mA	Unit
Delay	T_D	0.8	1.7	1.7	µs
Rise Time (V_{CC}=5 V)	t_R	1.9	2.6	2.6	µs
Storage (R_L=75 Ω)	t_S	0.2	0.4	0.4	µs
Fall Time	t_F	1.4	2.2	2.2	µs
Propagation H-L (50% of V_{PP})	t_{PHL}	0.7	1.2	1.1	µs
Propagation L-H	t_{PLH}	1.4	2.3	2.5	µs

Characteristic		IL1 I_F=20 mA	IL2 I_F=5 mA	IL5 I_F=10 mA	Unit
Delay	T_D	0.8	1	1.7	µs
Rise Time (V_{CE}=0.4 V)	t_R	1.2	2	7	µs
Storage (R_L=1 kΩ)	t_S	7.4	5.4	4.6	µs
Fall Time (V_{CC}=5 V)	t_F	7.6	13.5	20	µs
Propagation H-L (V_{TH}=1.5 V)	t_{PHL}	1.6	5.4	2.6	µs
Propagation L-H	t_{PLH}	8.6	7.4	7.2	µs

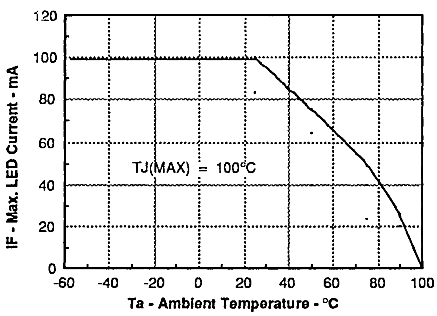
Forward voltage versus forward current



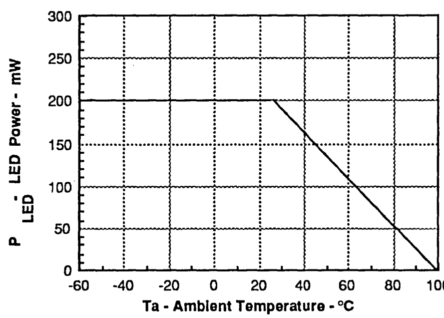
Peak LED current versus duty factor, Tau



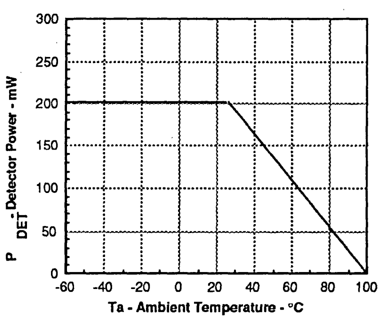
Maximum LED current versus ambient temperature



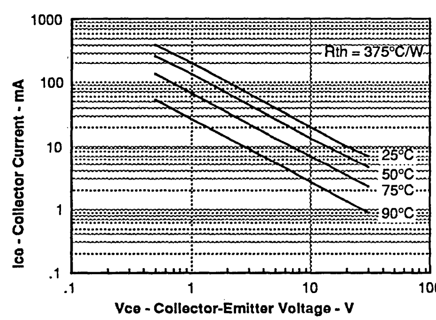
Maximum LED power dissipation



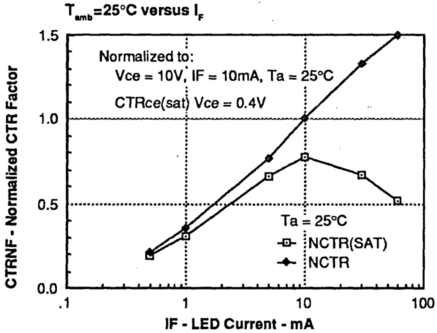
Maximum detector power dissipation



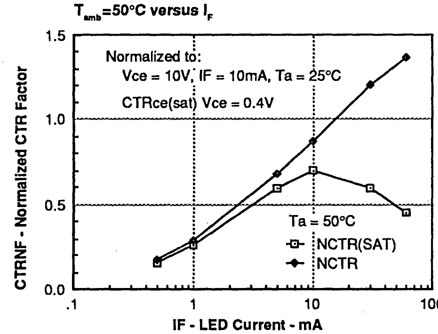
IL1 Maximum collector current versus collector voltage



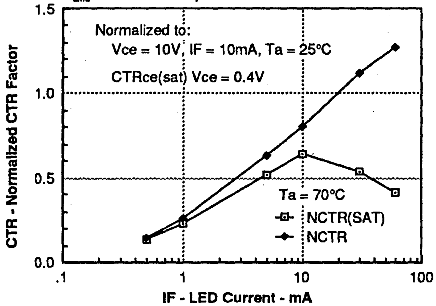
Normalization factor for non-saturated and saturated CTR
T_{amb}=25°C versus I_F



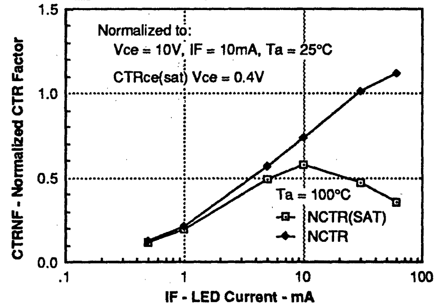
Normalization factor for non-saturated and saturated CTR
T_{amb}=50°C versus I_F



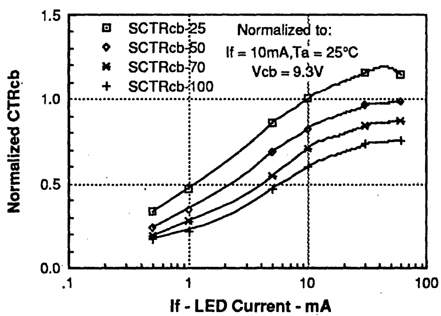
Normalization factor for non-saturated and saturated CTR T_{amb}=70°C versus I_F



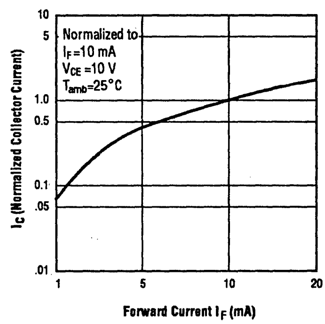
Normalization factor for non-saturated and saturated CTR T_{amb}=100°C versus I_F



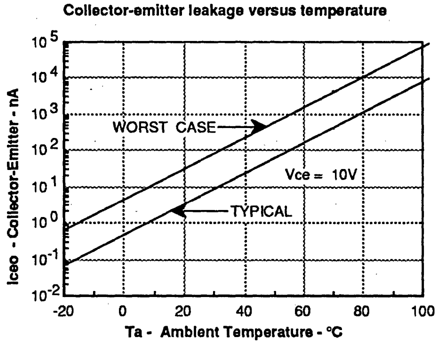
Normalized CTR_{CB} versus LED Current



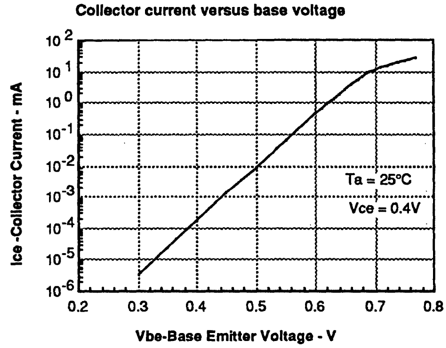
Collector current versus diode forward current



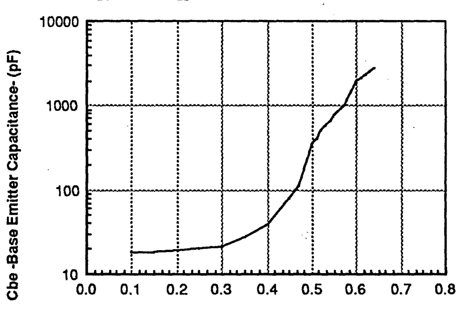
Collector-emitter leakage versus temperature



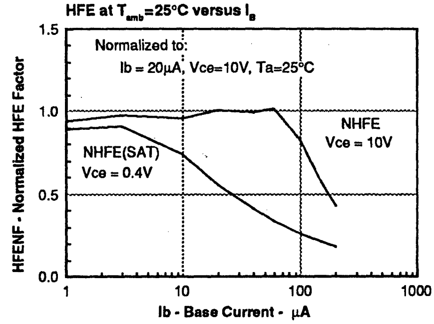
Collector current versus base voltage



C_{BE} versus V_{BE}

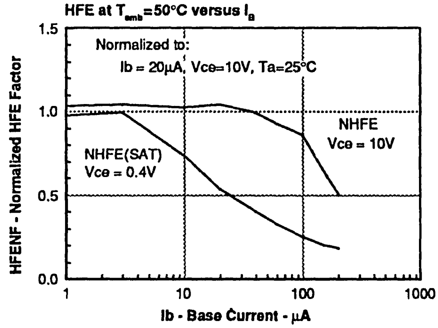


Normalization factor for non-saturated and saturated HFE at T_{amb}=25°C versus I_B

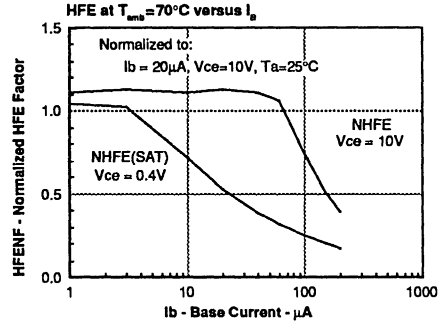


IL1/2/5

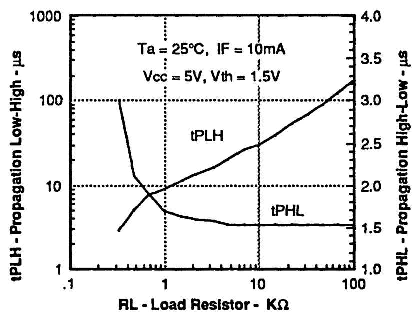
Normalization factor for non-saturated and saturated HFE at T_{amb}=50°C versus I_B



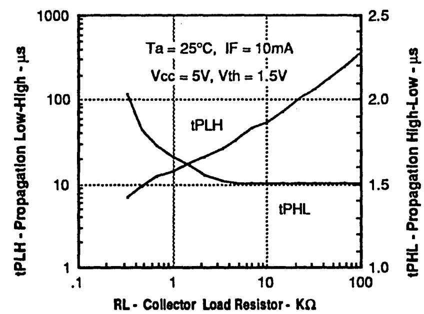
Normalization factor for non-saturated and saturated HFE at T_{amb}=70°C versus I_B



IL1 propagation delay versus collector load resistor

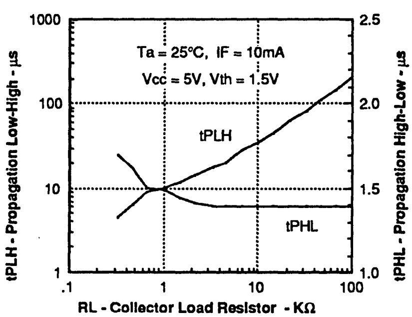


IL2 propagation delay versus collector load resistor



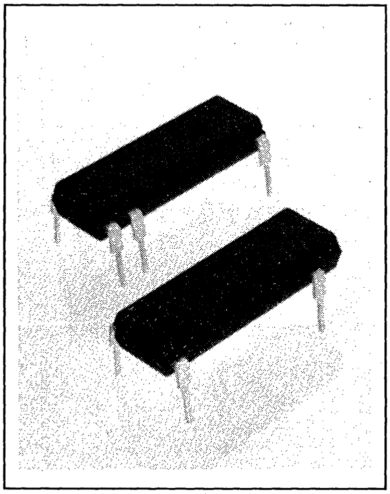
Optocouplers
(Optoisolators)

IL5 propagation delay versus collector load resistor

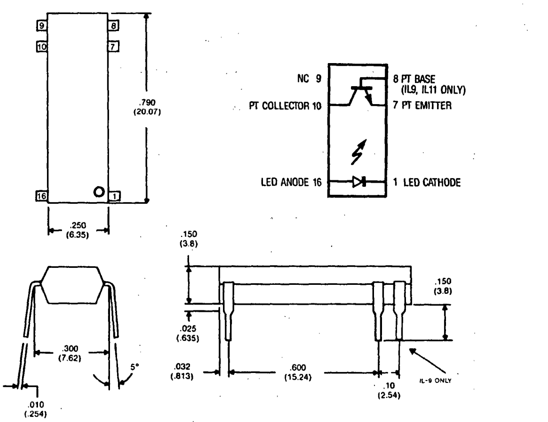


IL8/IL9

PHOTOTRANSISTOR OPTOCOUPLER



Package Dimensions in Inches (mm)



FEATURES

- **Minimum Internal Separation of 2.0 mm between Conductive Parts**
- **Minimum External Separation of Leads and Creepage Distance of 13 mm**
- **Standard DIP Profile on Leads and Package**
- **Machine Insertable on PCB**
- **IL8 is Four Lead Product**
- **IL9 is Six Lead with Base Contact**
- **Underwriters Lab Approval #E52744**
- **VDE and IEC Approvals 0700, 0883/6.80, 0804/1.83, 0860/8.86, IEC601/VDE0750, IEC380/VDE806/8.81, IEC435/VDE0805**

DESCRIPTION

The IL8 and IL9 are optically coupled isolators employing a gallium arsenide infrared emitter and a silicon phototransistor.

Absolute Maximum Ratings

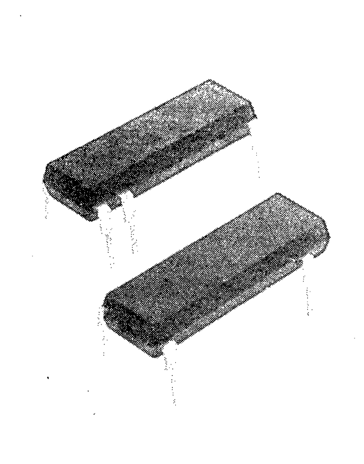
Storage Temperature	–55 to 100°C
Operating Temperature	–55 to 100°C
Lead Solder Temperature (1.6 mm from cast for t = 5 sec)	260°C
Isolation Test Voltage in Accordance with DIN57883/6.80	7070 VAC/10 K VDC
Creepage Path	13 mm
Clearance Path	13 mm
Tracking Index According to VDE 0303	KB100/A
UL Qualified for	8000 VRMS
LED	
Forward DC Current	60 mA
Peak Forward Current (1 μsec pulse, 300 pps)	3.0 A
Reverse Voltage	5.0 V
Power Dissipation	100 mW
Derate Linearly from 25°C	1.33 mW/°C
Phototransistor	
Collector Emitter Voltage	30 V
Emitter Base Voltage	7 V
Collector Current	100 mA
Power Dissipation	300 mW
Derate Linearly from 25°C	4.0 mW/°C

Electrical Characteristics (25°C unless otherwise noted)

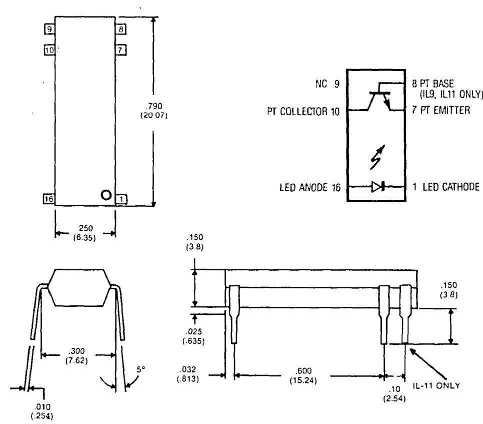
LED	
V_F (I_F = 10 mA)	1.5 V max.
I_R (V_R = 5 V)	10 μA max.
Phototransistor	
BV_{CEO} (I_C = 1.0 mA)	30 V min.
BV_{EBO} (I_E = 10 μA)	7 V min.
I_{CEO} (V_{CE} = 10 V)	50 nA max.
Coupled	
DC Current Transfer Ratio (I_F = 10 mA, V_{CE} = 10 V)	20% min.
Saturation Voltage-Collector to Emitter (I_F = 20 mA, I_C = 2 mA)	0.4 V max.
T_{ON} = (I_C = 2 mA, R_E = 100 Ω, 100 μs Pulsewidth, 1% Duty Cycle)	14 μs typ.
T_{OFF} = (I_C = 2 mA, R_E = 100 Ω, 100 μs Pulsewidth, 1% Duty Cycle)	11 μs typ.
Input to Output Resistance at 500 VDC	10^{10} Ω

IL10/IL11

PHOTOTRANSISTOR OPTOCOUPLER



Package Dimensions in Inches (mm)



FEATURES

- **Minimum Internal Separation of 2.0 mm between Conductive Parts**
- **Minimum External Separation of Leads and Creepage Distance of 13 mm**
- **Standard DIP Profile on Leads and Package**
- **Machine Insertable on PCB**
- **IL10 is Four Lead Product**
- **IL11 is Six Lead with Base Contact**
- **Underwriters Lab Approval #E52744**
- **VDE and IEC Approvals 0700, 0883/6.80, 0804/1.83, 0860/8.86, IEC601/VDE0750, IEC380/VDE806/8.81, IEC435/VDE0805**

DESCRIPTION

The IL10 and IL11 are optically coupled isolators employing a gallium arsenide infrared emitter and a silicon phototransistor.

Absolute Maximum Ratings

Storage Temperature	–55 to 100°C
Operating Temperature	–55 to 100°C
Lead Solder Temperature (1.6 mm from cast for t = 5 sec)	260°C
Isolation Test Voltage in Accordance with DIN57883/6.80	7070 VAC/10 K VDC
Creepage Path	13 mm
Clearance Path	13 mm
Tracking Index According to VDE 0303	KB100/A
UL Qualified for	8000 VRMS

LED

Forward DC Current	60 mA
Peak Forward Current (1 µsec pulse, 300 pps)	3.0 A
Reverse Voltage	5.0 V
Power Dissipation	100 mW
Derate Linearly from 25°C	1.33 mW/°C

Phototransistor

Collector Emitter Voltage	30 V
Emitter Base Voltage	7 V
Collector Current	100 mA
Power Dissipation	300 mW
Derate Linearly from 25°C	4.0 mW/°C

Electrical Characteristics (25°C unless otherwise noted)

LED

V_F (I_F = 10 mA)	1.5 V max.
I_R (V_R = 5 V)	10 µA max.

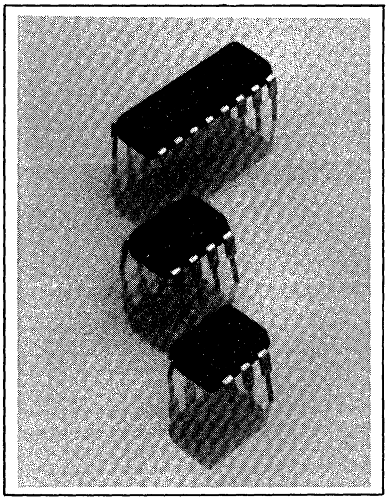
Phototransistor

BV_{CEO} (I_C = 1.0 mA)	30 V min.
BV_{EBO} (I_E = 10 µA)	7 V min.
I_{CEO} (V_{CE} = 10 V)	50 nA max.

Coupled

DC Current Transfer Ratio (I_F = 10 mA, V_{CE} = 10 V)	50% min.
Saturation Voltage-Collector to Emitter (I_F = 20 mA, I_C = 2 mA)	0.4 V max.
T_{ON} = (I_C = 2 mA, R_E = 100 Ω, 100 µs Pulsewidth, 1% Duty Cycle)	14 µs typ.
T_{OFF} = (I_C = 2 mA, R_E = 100 Ω, 100 µs Pulsewidth, 1% Duty Cycle)	11 µs typ.
Input to Output Resistance at 500 VDC	10^{10} Ω

SIEMENS IL30/IL31/IL55 SINGLE CHANNEL
ILD30/ILD31/ILD55 DUAL CHANNEL
ILQ30/ILQ31/ILQ55 QUAD CHANNEL
PHOTODARLINGTON OPTOCOUPLER



FEATURES

- **125 mA Load Current Rating**
- **Fast Rise Time—10 μs**
- **Fast Fall Time—35 μs**
- **Current Transfer Ratio**
  100% Min.
  200% Min. (IL31, ILD31, ILQ31 only)
- **Solid State Reliability**
- **Standard Dip Package**
- **Underv'riter Lab Approval #E52744**
- **VDE Approvals 0883/6.80, 0804/1.83**

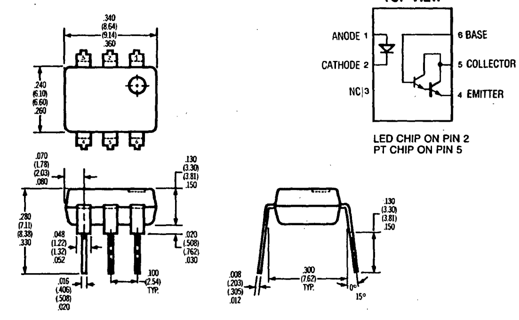
DESCRIPTION

IL30/IL31/IL55, ILD30/ILD31/ILD55 and ILQ30/ILQ31/ILQ55 are optically coupled isolators employing a Gallium Arsenide infrared emitter and a silicon photodarlington sensor. Switching can be accomplished while maintaining a high degree of isolation between driving and load circuits, with no crosstalk between channels. They can be used to replace reed and mercury relays with advantages of long life, high speed switching and elimination of magnetic fields.

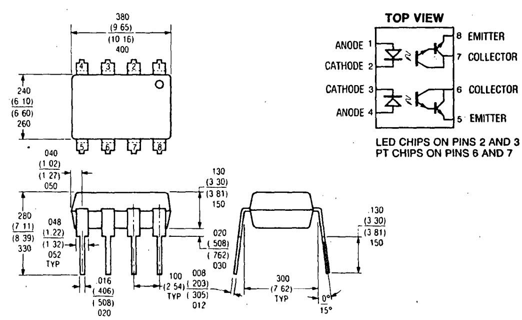
The IL30/IL31/IL55 are equivalent to MCA2-30/MCA2-31/MCA2-55. ILD30/ILD31/ILD55 are designed to reduce board space requirements in high density applications.

Package Dimensions in Inches (mm)

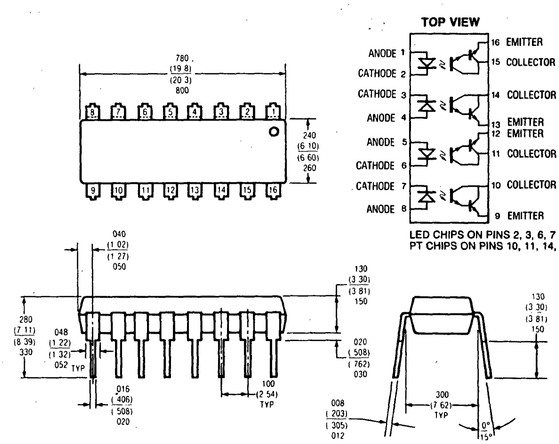
IL30/IL31/IL55 (Single Channel)



ILD30/ILD31/ILD55 (Dual Channel)



ILQ30/ILQ31/ILQ55 (Quad Channel)



Maximum Ratings

Gallium Arsenide LED (each channel)
- Power Dissipation @25°C . . . . 75 mW
- Derate Linearly from 25°C . . . . 10 mW/°C
- Continuous Forward Current . . . . 50 mA
- Peak Reverse Voltage . . . . 3 V

	ILD 30 ILQ 30	ILD55 ILQ55
Photodarlington Sensor (Each Channel)		
Power Dissipation at 25°C Ambient	150 mW	150 mW
Derate Linearly From 25°C	2.0 mW/°C	2.0 mW/°C
Collector (load) Current	125 mA	125 mA
Collector Emitter Breakdown Voltage (BV_{CEO})	30V	55V

Package
- Storage Temperature . . . . −55°C to +125°C
- Operating Temperature . . . . −55°C to +100°C
- Lead Soldering Time at 260°C . . . . 10 sec

Total Package Power Dissipation @25°C
- IL30/IL31/IL55 . . . . 250 mW
- ILD30/ILD31/ILD55 . . . . 400 mW
- ILQ30/ILQ31/ILQ55 . . . . 500 mW

Derate Linearly from 25°C
- IL30/IL31/IL55 . . . . 3.3 mW/°C
- ILD30/ILD31/ILD55 . . . . 5.33 mW/°C
- ILQ30/ILQ31/ILQ55 . . . . 5.67 mW/°C

Isolation Test Voltage
- in Accordance with DIN57883/6.80 . . . . 3750 VAC/5300 VDC

Creepage Path
- IL30/31/55 . . . . 8 mm min.
- ILD30/31/55, ILQ30/31/55 . . . . 7 mm min.

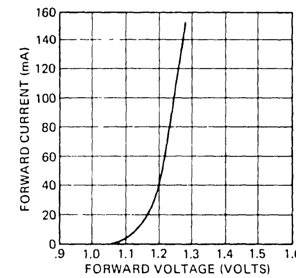
Clearance Path . . . . 7 mm min.
Tracking Index According to VDE 0303 . . . . KB100/A

Electrical Characteristics (T_{amb} = 25°C)

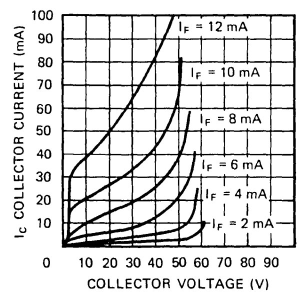
Parameter	Min	Typ	Max	Unit	Test Condition
GaAs Emitter					
Forward Voltage		1.25	1.5	V	I_F = 20mA
Reverse Current		0.1	10	μA	V_R = 3.0V
Capacitance		50		pF	V_R = 0
Sensor					
BV_{CEO}	30/55			V	I_C = 100μA I_F = 0
I_{CEO}		1.0	100	nA	V_{CE} = 10V I_F = 0
Capacitance Collector-Emitter		3.4		pF	V_{CE} = 10V
Coupled Characteristics					
Current Transfer Ratio	100	400		%	I_F = 10mA V_{CE} = 5V
Current Transfer Ratio IL31, ILD31, ILQ31 only	200	400			
$V_{CE(SAT)}$		0.9	1.0	V	I_C = 50mA I_F = 50mA
Rise Time		10		μs	V_{CC} = 13.5V
Fall Time		35		μs	I_F = 50mA R_C = 100Ω
UL Qualified for	7500			VDC	
Isolation Resistance		10^{12}		ohm	
Isolation Capacitance		0.5		pF	

TYPICAL OPTOELECTRONIC CHARACTERISTIC CURVES

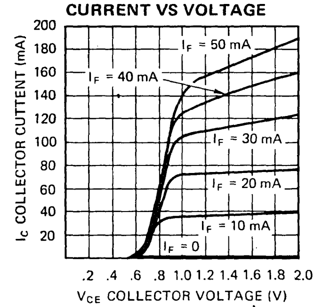
GaAs EMITTER: FORWARD CURRENT – VOLTAGE CHARACTERISTICS



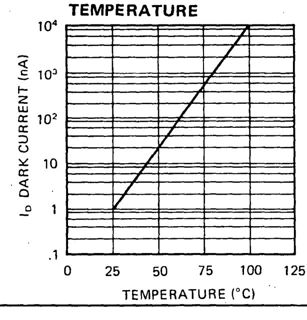
DARLINGTON TRANSISTOR CURRENT VS VOLTAGE



DARLINGTON TRANSISTOR OUTPUT CURRENT VS VOLTAGE



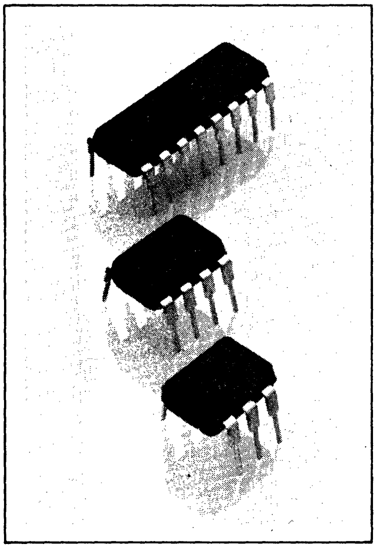
DARK CURRENT VS TEMPERATURE



Optocouplers (Optoisolators)

SIEMENS

IL 74 SINGLE CHANNEL
ILD 74 DUAL CHANNEL
ILQ 74 QUAD CHANNEL
PHOTOTRANSISTOR OPTOCOUPLER



FEATURES

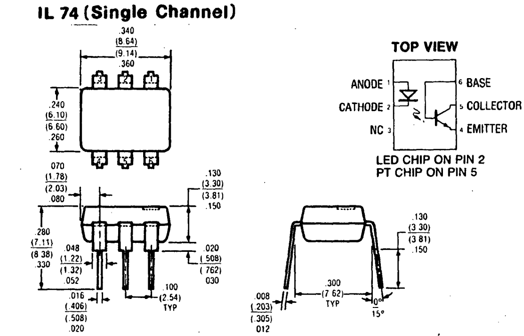
- **7400 Series T²L Compatible**
- **35% typical transfer ratio**
- **0.5 pF coupling capacitance**
- **Industry standard dual-in-line package**
- **Single channel, dual, and quad configurations**
- **Underwriters Lab Approval #E52744**
- **VDE Approvals 0883/6.80, 0804/1.83**

DESCRIPTION

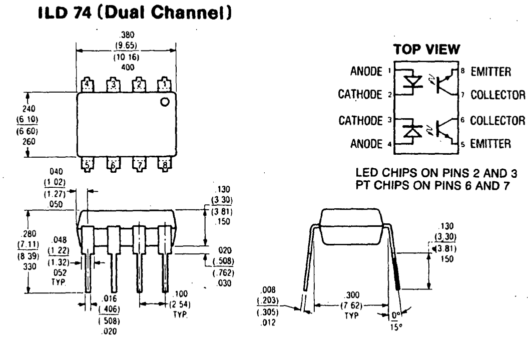
IL74 is an optically coupled pair employing a Gallium Arsenide infrared LED and a silicon NPN phototransistor. Signal information, including a DC level, can be transmitted by the device while maintaining a high degree of electrical isolation between input and output. The IL74 is especially designed for driving medium-speed logic, where it may be used to eliminate troublesome ground loop and noise problems. It can also be used to replace relays and transformers in many digital interface applications, as well as analog applications such as CRT modulation. The ILD74 offers two isolated channels in a single DIP package while the ILQ74 provides four isolated channels per package.

Package Dimensions in Inches (mm)

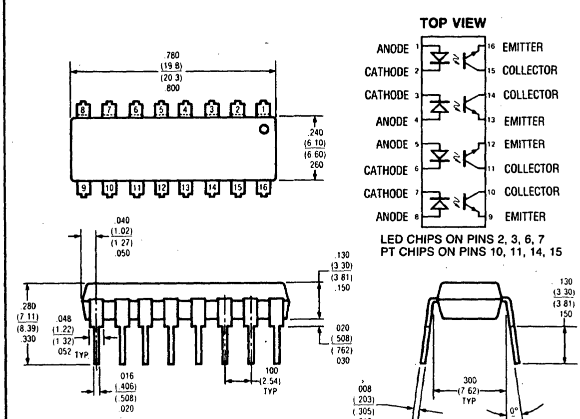
IL 74 (Single Channel)



ILD 74 (Dual Channel)



ILQ 74 (Quad Channel)



Maximum Ratings

Gallium Arsenide LED (Each channel)
- Power Dissipation at 25°C .... 150 mW
- Derate Linearly from 25°C .... 1.33 mW/°C
- Continuous Forward Current .... 60 mA
- Peak Reverse Voltage .... 3.0 V

Detector-Silicon Phototransistor (Each channel)
- Power Dissipation at 25°C .... 150 mW
- Derate Linearly from 25°C .... 2.0 mW/°C
- Collector-Emitter Breakdown Voltage (BV_{CEO}) .... 20 V
- Emitter-Base Breakdown Voltage (BV_{ECO}) .... 5 V
- Collector-Base Breakdown Voltage (BV_{CBO}) .... 70 V

Storage Temperature .... –55 to +150°C
Operating Temperature .... –55 to +100°C
Lead Soldering Time at 260°C .... 10 sec
UL Qualified for .... 7500 VDC

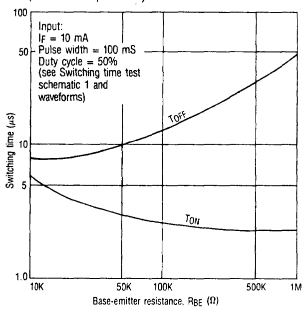
	IL74	ILD74	ILQ74
Package			
Total Package Dissipation at 25°C Ambient (LED Plus Detector)	200 mW	400 mW	500 mW
Derate Linearly from 25°C	3.3 mW/°C	5.33 mW/°C	6.67 mW/°C
Isolation Test Voltage in Accordance with DIN57883/6.80	3750 VAC/ 5300 VDC	3750 VAC/ 5300 VDC	3750 VAC/ 5300 VDC
Creepage Path	8 mm min.	7 mm min.	7 mm min.
Clearance Path	7 mm min.	7 mm min.	7 mm min.
Tracking Index According to VDE 0303	KB100/A	KB100/A	KB100/A

Electrical Characteristics Per Channel (T_{amb} = 25°C)

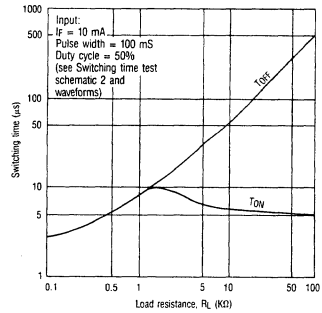
Parameter	Min	Typ	Max	Unit	Test Conditions
Gallium Arsenide LED					
Forward Voltage		1.3	1.5	V	I_F = 20 mA
Reverse Current		0.1	100	μA	V_R = 3.0 V
Capacitance		100		pF	V_R = 0
Phototransistor Detector					
BV_{CEO}	20	50		V	I_C = 1 mA
I_{CEO}		5.0	500	nA	V_{CE} = 5V, I_F = 0
Collector-Emmitter Capacitance		2.0		pF	V_{CE} = 0
Coupled Characteristics					
DC Current Transfer Ratio	12.5	35		%	I_F = 16 mA, V_{CE} = 5 V
V_{SAT}		0.3	0.5	V	I_C = 2 mA, I_F = 16 mA
Capacitance, Input to Output		0.5		pF	
Resistance, Input to Output		100		GΩ	
Switching Times					
t_{ON}		3.0		μs	R_E = 100 Ω, V_{CE} = 10 V
t_{OFF}		3.0		μs	I_C = 2 mA

Optocouplers (Optoisolators)

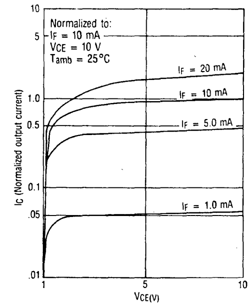
IL74 Single Channel
Typical switching characteristics versus base resistance
(Saturated operation)



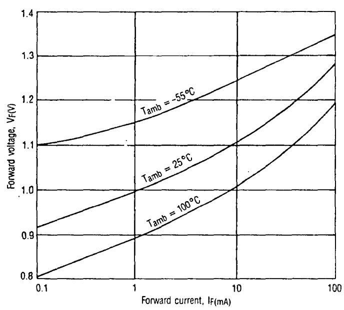
Typical switching times versus load resistance



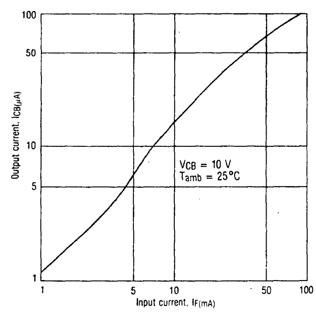
Collector current versus collector voltage



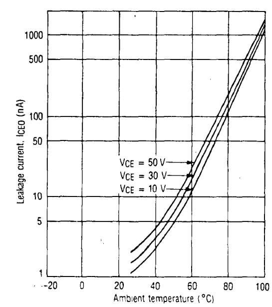
Typical forward voltage versus forward current



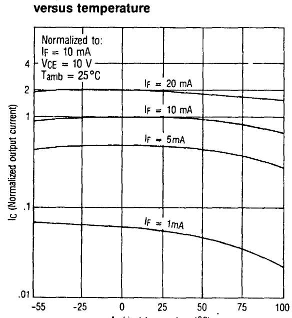
IL74 Single Channel
Typical output current (I_{CB}) versus input current



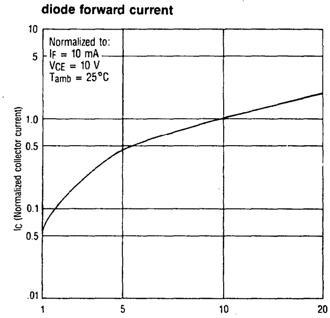
Typical leakage current versus ambient temperature



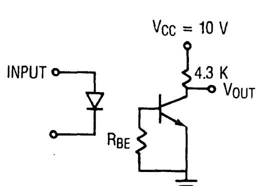
Output current versus temperature



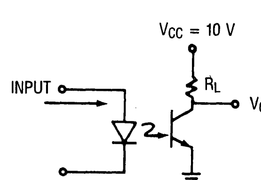
Collector current versus diode forward current



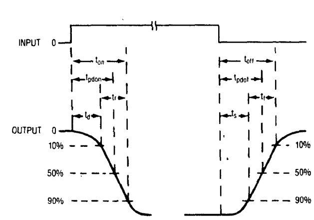
Switching time test schematic and waveforms



Switching time test schematic 1



Switching time test schematic 2



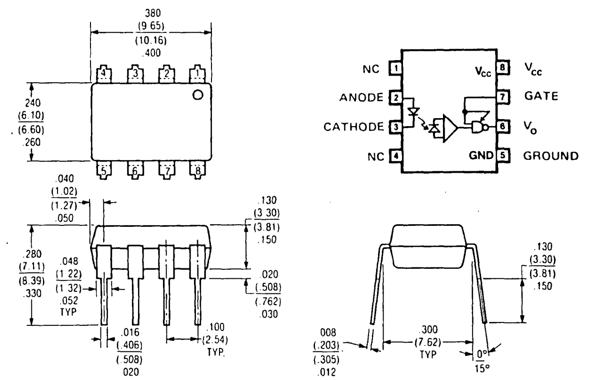
IL/D/Q74

SIEMENS

IL101B

HIGH SPEED THREE STATE OPTOCOUPLER

Package Dimensions in Inches (mm)



FEATURES

- **High Speed**
- **Faraday Shielded Photodetector Improves Common Mode Rejection**
- **DTL/TTL Compatible, 5 V Supply**
- **Three State Output Logic for Multiplexing**
- **Built-in Schmitt Trigger Avoids Oscillation**
- **UL Approval #E52744**

DESCRIPTION

IL101B is an optically coupled pair with a Gallium Arsenide Phosphide LED and a silicon monolithic integrated circuit including a photodetector. High speed digital information can be transmitted while maintaining a high degree of electrical isolation between input and output. The IL101B can be used to replace pulse transformers in many digital interface applications. A built-in Schmitt Trigger provides hysteresis reducing oscillation possibility.

Maximum Ratings

Input Diode

Forward DC Current .... 25 mA
Reverse Voltage .... 5 V

Output IC

Supply Voltage (V_{CC}) .... 7 V
Enable Input Voltage (V_E)
(not to exceed V_{CC} by more than 500 mV) .... 5.5 V
Output Collector Current (I_C) .... 100 mA
Output Collector Power Dissipation .... 100 mW
Output Collector Voltage (V_{OUT}) .... 7 V
Isolation Voltage (Input-Output), DC .... 6000 V

Package

Storage Temperature .... 55°C to +125°C
Operating Temperature .... 0°C to +70°C
Lead Solder Temperature .... 260°C for 10 sec.

Electrical Characteristics (T_{amb}=0°C to 70°C)

Parameter	Min.	Typ.	Max.	Unit	Test Condition
I_{in} (1) – Logic (1) Input Current for Logic (0) Output (Figure 1)	12			mA	
I_{in} (0) – Logic (0) Input Current for Logic (1) Output (Figure 1)			250	mA	
V_G (1) – Logic (1) Gate Voltage	2.0			V	
V_G (0) – Logic (0) Gate Voltage			.8	V	
V_{OUT} (0) – Logic (0) Output Voltage		.35	.6	V	V_{CC}=5.5 V, V_G=2.4 V, I_{in}=12 mA, I_{out} (sinking) =16 mA
I_{CC}		18	22	mA	V_{CC}= 5.5 V, V_G=0.5 V, I_{in}=0. 10 mA

Switching Characteristics (T_{amb}=25°C, V_{CC}=5 V)

Parameter	Min.	Typ.	Max.	Unit	Test Condition
t_{pd} (1) – Propagation Delay Time to Logic Level (1) (Fig. 1, Note 1)		175	300	ns	R_L=350 Ω, C_L=15 pF, I_{in}=12 mA
t_{pd} (0) – Propagation Delay Time to Logic Level (0) (Fig. 1, Note 2)		70	300	ns	R_L = 350 Ω, C_L=15 pF, I_{in}=12 mA
t_R- t_F(0) – Output Rise-Fall Time (10-90%)		15		ns	R_L=350 Ω, C_L=15 pF, I_{in}=12 mA

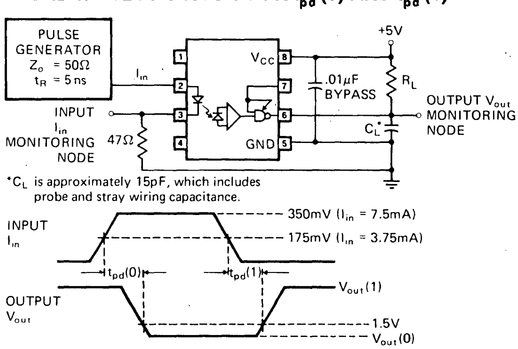
Electrical Characteristics (T_{amb}=25°C) – Input to Output

Parameter	Min.	Typ.	Max.	Unit	Test Condition
Insulation Voltage Input-Output (BV_{IO}) (Note 3)	6000	7500		VDC	t = 1 sec.
Resistance, Input-Output (R_{I-O}) (Note 3)	10^{12}			Ω	V_{I-O}= 500 V
Capacitance Input-Output (C_{I-O}) (Note 3)	0.5	0.8		pF	f = 1 MHz

Electrical Characteristics (T_{amb}=25°C) – Input Diode

Parameter	Min.	Typ.	Max.	Unit	Test Condition
Forward Voltage (V_F)		1.5	1.75	V	I_{in}=10 mA
Reverse Breakdown Voltage (V_{BR})	5			V	I_R=10 mA
Capacitance (I_{in})		10		pF	V = 0, f = 1MHz

FIGURE 1. TEST CIRCUIT FOR t_{pd} (0) AND t_{pd} (1)



Notes:
1. The t_{pd}(1) propagation delay is measured from the 3.75 mA point on the trailing edge of the input pulse to the 1.5 V point on the trailing edge of the output pulse.
2. The t_{pd}(0) propagation delay is measured from the 3.75 mA point on the input pulse to the 1.5 V point on the leading edge of the output pulse.
3. Pins 2 and 3 are shorted together, and pins 5, 6, 7, and 8 shorted together.
4. At 10 mA V_F decreases with increasing temperature at the rate of 1.6 mV/°C.

OPERATING PROCEDURES AND DEFINITIONS

Logic Convention: The IL101B is defined in terms of positive logic.

Bypassing: A ceramic capacitor (.01mF min.) should be connected from pin 8 to pin 5 to stabilize the switching amplifier operation. Switching properties may be impaired by not providing for bypassing.

Polarities: All voltages are referenced to network ground (pin 5). Current flowing toward a terminal is considered positive.

Gate input: No external pull-up required for a logic (1).

TRUTH TABLE (Positive Logic)

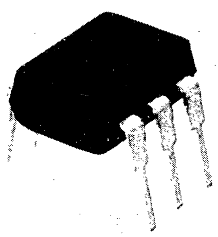
Input*	Enable	Output
1	1	0
0	1	1
1	0	off
0	0	off

*See definition of terms for logic state.

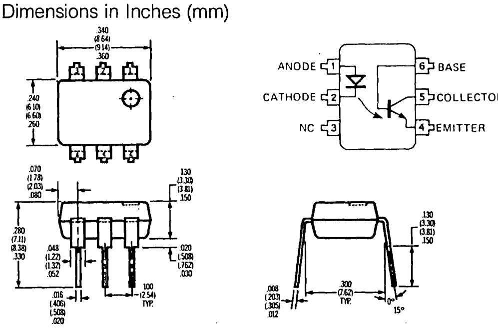
SIEMENS

IL201/IL202/IL203

PHOTOTRANSISTOR OPTOCOUPLER



Package Dimensions in Inches (mm)



Optocouplers (Optoisolators)

FEATURES

- **High Current Transfer-Ratio (75%–450%)**
- **High Collector-Emitter Voltage BV_{CEO} = 70 V**
- **Long Term Stability**
- **Industry Standard Dual-In-Line**
- **Min 10% Current-Transfer-Ratio Guaranteed @I_F = 1 mA**
- **Underwriters Lab Approval #E52744**
- **VDE Approvals 0883/6.80, 0804/1.83**

DESCRIPTION

The IL201, IL202, IL203 are optically coupled pairs employing a Gallium Arsenide infrared LED and a silicon NPN phototransistor. Signal information, including a DC level, can be transmitted by the device while maintaining a high degree of electrical isolation between input and output. The IL201, IL202, IL203 can be used to replace relays and transformers in many digital interface applications, as well as analog applications such as CRT modulation.

Maximum Ratings

Gallium Arsenide LED
- Power Dissipation @ 25°C . . . . 200 mW
- Derate Linearly from 25°C . . . . 2.6 mW/°C
- Continuous Forward Current . . . . 100 mA
- Peak Reverse Voltage . . . . 6.0 V

Detector (Silicon Phototransistor)
- Power Dissipation @ 25°C . . . . 200 mW
- Derate Linearly From 25°C . . . . 2.6 mW/°C
- Collector-Emitter Breakdown Voltage (BV_{CEO}) . . . . 30 V
- Emitter-Collector Breakdown Voltage (BV_{ECO}) . . . . 7 V
- Collector-Base Breakdown Voltage (BV_{CBO}) . . . . 70 V

Package
- Total Package Dissipation at 25°C Ambient (LED Plus Detector) . . . . 250 mW
- Derate Linearly From 25°C . . . . 3.3 mW/°C

Isolation Test Voltage in Accordance with DIN57883/6.80 . . . . 3750 VAC/5300 VDC

Creepage Path . . . . 8 mm min.

Clearance Path . . . . 7 mm min.

Tracking Index According to VDE 0303 . . . . KB100/A

Storage Temperature . . . . −55 to +150°C

Operating Temperature . . . . −55 to +100°C

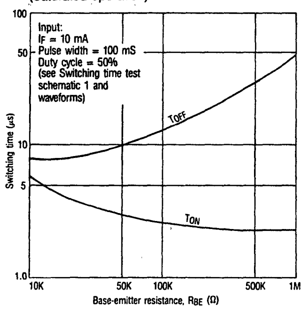
Lead Soldering Time @ 260°C . . . . 10 sec

UL Qualified for . . . . 7500 VDC

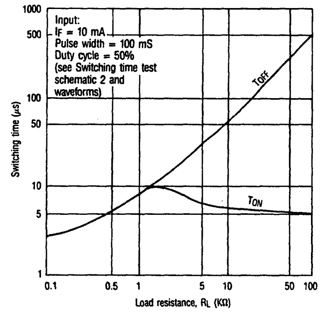
Electrical Characteristics (0°C – 70°C unless otherwise specified)

Parameter	Min	Typ	Max	Unit	Test Condition
Gallium Arsenide LED					
Forward Voltage V_F		1.2	1.5	V	I_F = 20 mA
Forward Voltage V_F		1.0	1.2	V	I_F = 1 mA
Reverse Current I_R		0.1	10	μA	V_R = 6 V, T_A = 25°C
Breakdown Voltage V_R	6	20		V	I_R = 10 μA
Phototransistor Detector					
H_{FE}	100	200			V_{CE} = 5V, I_C = 100 μA
BV_{CEO}	70			V	I_C = 1 mA
BV_{ECO}	7	10		V	I_E = 100 μA
BV_{CBO}	70	90		V	I_C = 10 μA
I_{CEO}		5	50	nA	V_{CE} = 10 V, T_A = 25°C
Coupled Characteristics					
Base Current Transfer Ratio (BTR)	0.15			%	I_F = 10 mA, V_{CB} = 10 V
$V_{CE\ (sat)}$			0.4	V	I_F = 10 mA, I_C = 2 mA
DC Current Transfer Ratio (CTR)					
IL201	75	100	150	%	I_F = 10 mA
IL202	125	200	250	%	V_{CE} = 10 V
IL203	225	300	450	%	
DC Current Transfer Ratio (CTR)					
IL201	10			%	I_F = 1 mA
IL202	30			%	V_{CE} = 10 V
IL203	50			%	
Input to Output					

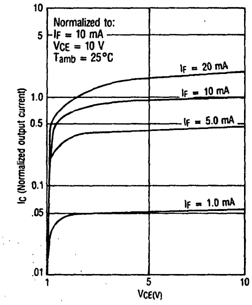
Typical switching characteristics versus base resistance
(Saturated operation)



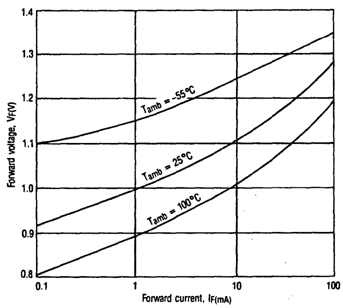
Typical switching times versus load resistance



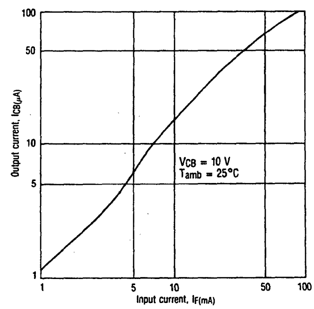
Collector current versus collector voltage



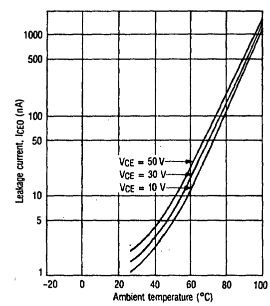
Typical forward voltage versus forward current



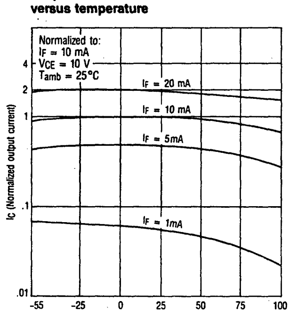
Typical output current (I_{CB}) versus input current



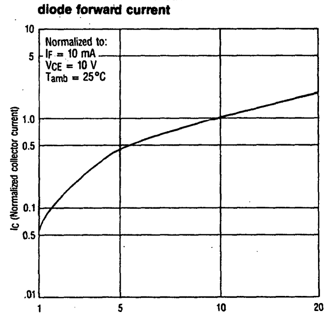
Typical leakage current versus ambient temperature



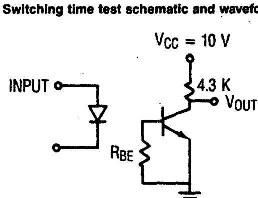
Output current versus temperature



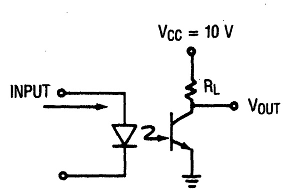
Collector current versus diode forward current



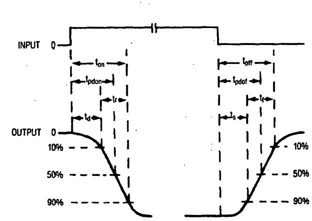
Switching time test schematic and waveforms



Switching time test schematic 1



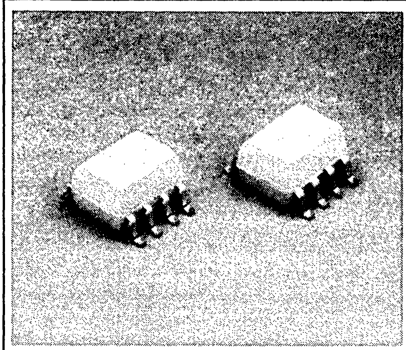
Switching time test schematic 2



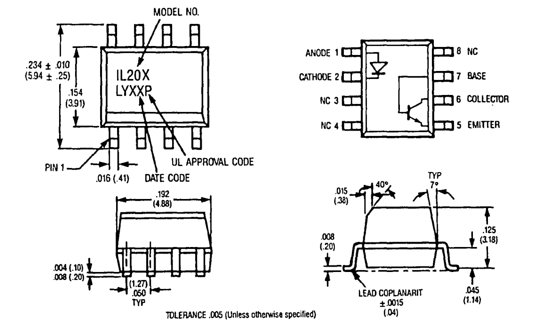
SIEMENS

IL205/IL206/IL207

PHOTOTRANSISTOR SMALL OUTLINE SURFACE MOUNT OPTOCOUPLER



Package Dimensions in Inches (mm)



FEATURES

- **Industry Standard SOIC-8 Surface Mountable Package**
- **Standard Lead Spacing of .05"**
- **Available in Tape and Reel Option (Conforms to EIA Standard RS481A)**
- **2500 VRMS, Isolation Voltage**
- **High Current Transfer Ratios, 3 Groups: IL205, 40 - 80% IL206, 63 - 125% IL207, 100 - 200%**
- **High BV_{CEO}, 70 V**
- **Underwriters Lab Approval #E52744 (Code Letter P)**
- **Compatible with Dual Wave, Vapor Phase and IR Reflow Soldering**

DESCRIPTION

IL205/206/207 are optically coupled pairs employing a GaAs infrared LED and a silicon NPN phototransistor. Signal information, including a DC level, can be transmitted by the device while maintaining a high degree of electrical isolation between input and output. The IL205/206/207 come in a standard SOIC-8 small outline package for surface mounting which makes them ideally suited for high density applications with limited space. In addition to eliminating through-holes requirements, this package conforms to standards for surface mounted devices.

A specified minimum and maximum CTR allows a narrow tolerance in the electrical design of the adjacent circuits. The high BV_{CEO} of 70 V gives a higher safety margin compared to the industry standard 30 V.

See Appnote 39 for solderability information.

Maximum Ratings

Gallium Arsenide LED
- Power Dissipation @25°C .... 90 mW
- Derate Linearly from 25°C .... 0.8 mW/°C
- Continuous Forward Current .... 60 mA
- Peak Reverse Voltage .... 6.0 V

Detector (Silicon Phototransistor)
- Power Dissipation @25°C .... 150 mW
- Derate Linearly from 25°C .... 2.0 mW/°C
- Collector-Emitter Breakdown Voltage (BV_{CEO}) .... 70 V
- Emitter-Collector Breakdown Voltage (BV_{ECO}) .... 7 V
- Collector-Base Breakdown Voltage (BV_{CBO}) .... 70 V

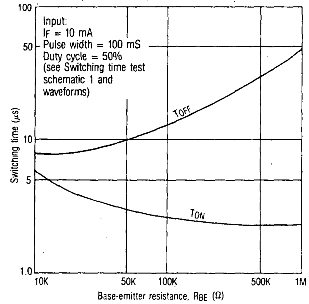
Package
- Total Package Dissipation at 25°C Ambient (LED Plus Detector) .... 250 mW
- Derate Linearly from 25°C .... 3.3 mW/°C
- Storage Temperature .... −55 to +150 °C
- Operating Temperature .... −55 to +100 °C
- Soldering Time @260°C .... 10 sec

(See Application Note 39 for a detailed report on solderability tests using dual wave, vapor phase and IR reflow soldering processes.)

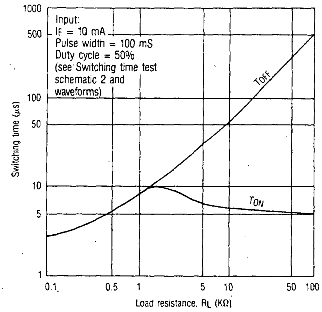
Electrical Characteristics (T_{amb} = 25°C)

Parameter	Min	Typ	Max	Unit	Test Condition
Gallium Arsenide LED					
Forward Voltage		1.3	1.5	V	I_F = 60 mA
Reverse Current		.1	100	µA	V_R = 6.0
Capacitance		100		pF	V_R = 0
Phototransistor Detector					
BV_{CEO}	70			V	I_C = 100 µA
BV_{ECO}	7	10		V	I_E = 100 µA
I_{CEO} (dark)		5	50	nA	V_{CE} = 10 V, I_F = 0
Collector-Emitter Capacitance		2		pF	V_{CE} = 0
Coupled Characteristics					
DC Current Transfer					
IL205	40		80	%	I_F = 10 mA, V_{CE} = 10 V
IL206	63		125		
IL207	100		200		
Collector-Emitter Saturation Voltage $V_{CE\ (sat)}$			0.4	V	I_F = 10 mA, I_C = 2.0 mA
Capacitance, Input to Output		.5		pF	
Breakdown Voltage	2500			VAC_{RMS}	t = 1 min.
Equivalent DC Isolation Voltage	3535			VDC	
Resistance, Input to Output		100		GΩ	
t_{on}		3.0		µs	I_C = 2 mA, R_E = 100 Ω
t_{off}		3.0		µs	V_{CE} = 10 V

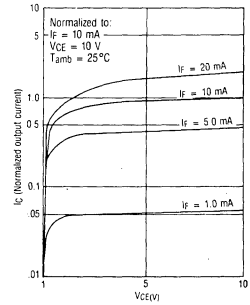
Typical switching characteristics versus base resistance
(Saturated operation)



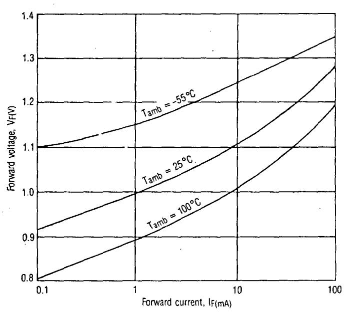
Typical switching times versus load resistance



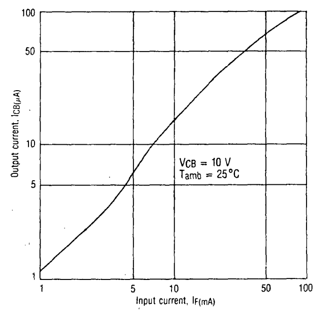
Collector current versus collector voltage



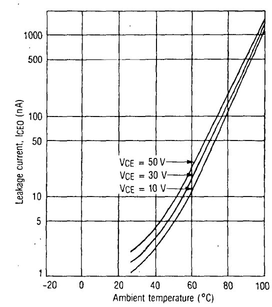
Typical forward voltage versus forward current



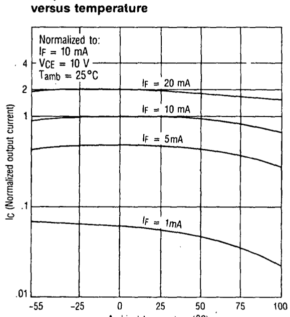
Typical output current (I_{CB}) versus input current



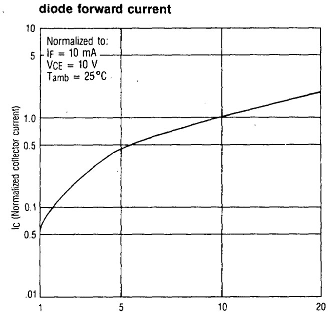
Typical leakage current versus ambient temperature



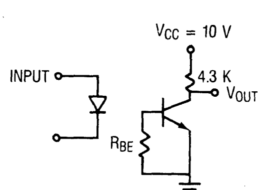
Output current versus temperature



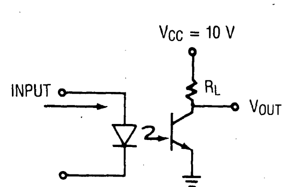
Collector current versus diode forward current



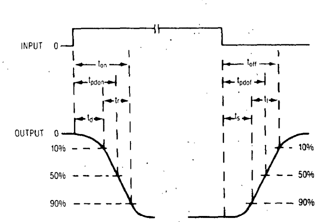
Switching time test schematic and waveforms



Switching time test schematic 1



Switching time test schematic 2

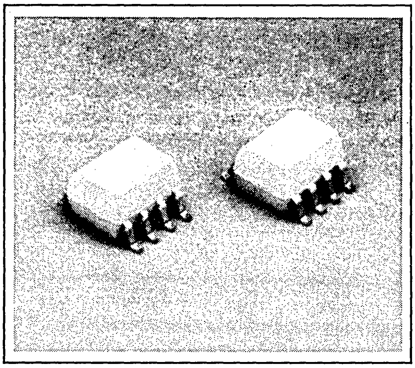


IL205/206/207

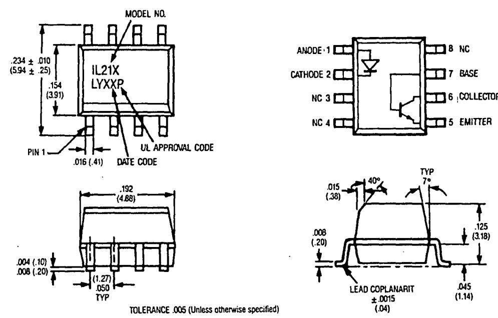
SIEMENS

IL211/IL212/IL213

PHOTOTRANSISTOR SMALL OUTLINE SURFACE MOUNT OPTOCOUPLER



Package Dimensions in Inches (mm)



Optocouplers (Optoisolators)

FEATURES

- Industry Standard SOIC-8 Surface Mountable Package
- Standard Lead Spacing of .05″
- Available in Tape and Reel Option (Conforms to EIA Standard RS481A)
- 2500 VRMS, Isolation Voltage
- 20, 50, and 100% min. CTR @I_F = 10 mA
- Electrical Specifications Similar to Standard 6 Pin Coupler
- Underwriters Lab Approval #E52744 (Code Letter P)
- Compatible with Dual Wave, Vapor Phase and IR Reflow Soldering

DESCRIPTION

IL211/212/213 are optically coupled pairs employing a GaAs infrared LED and a silicon NPN phototransistor. Signal information, including a DC level, can be transmitted by the device while maintaining a high degree of electrical isolation between input and output. The IL211/212/213 come in a standard SOIC-8 small outline package for surface mounting which makes them ideally suited for high density applications with limited space. In addition to eliminating through-holes requirements, this package conforms to standards for surface mounted devices.

A choice of 20, 50, and 100% minimum CTR (IL211/IL212/IL213 respectively) at I_F = 10 mA makes them suitable for a variety of different applications.

See Appnote 39 for solderability information.

Maximum Ratings

Gallium Arsenide LED
- Power Dissipation @25°C .... 90 mW
- Derate Linearly from 25°C .... 0.8 mW/°C
- Continuous Forward Current .... 60 mA
- Peak Reverse Voltage .... 6.0 V

Detector (Silicon Phototransistor)
- Power Dissipation @25°C .... 150 mW
- Derate Linearly from 25°C .... 2.0 mW/°C
- Collector-Emitter Breakdown Voltage (BV_{CEO}) .... 30 V
- Emitter-Collector Breakdown Voltage (BV_{ECO}) .... 7 V
- Collector-Base Breakdown Voltage (BV_{CBO}) .... 70 V

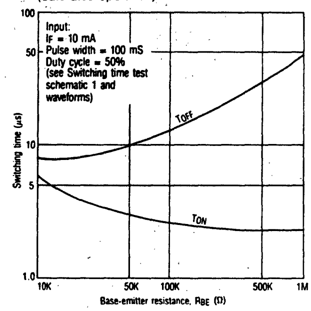
Package
- Total Package Dissipation at 25°C Ambient (LED Plus Detector) .... 250 mW
- Derate Linearly from 25°C .... 3.3 mW/°C
- Storage Temperature .... –55 to +150 °C
- Operating Temperature .... –55 to +100 °C
- Soldering Time @260°C .... 10 sec

(See Application Note 39 for a detailed report on solderability tests using dual wave, vapor phase and IR reflow soldering processes.)

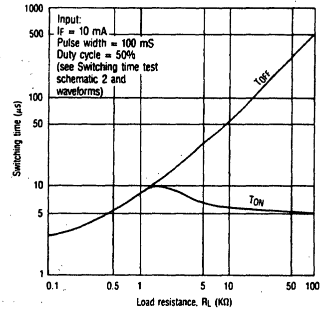
Electrical Characteristics (T_{amb} = 25°C)

Parameter	Min	Typ	Max	Unit	Test Condition
Gallium Arsenide LED					
Forward Voltage		1.3	1.5	V	I_F = 10 mA
Reverse Current		.1	100	μA	V_R = 6.0
Capacitance		100		pF	V_R = 0
Phototransistor Detector					
BV_{CEO}	30	90		V	I_C = 1 μA
BV_{ECO}	7	10		V	I_E = 10 μA
I_{CEO} (dark)		5	50	nA	V_{CE} = 10 V, I_F = 0
Collector-Emitter Capacitance		2		pF	V_{CE} = 0
Coupled Characteristics					
DC Current Transfer					
IL211	20	50		%	I_F = 10 mA,
IL212	50	80			V_{CE} = 10 V
IL213	100	130			
Collector-Emitter Saturation Voltage $V_{CE\ (sat)}$			0.4	V	I_F = 10 mA, I_C = 2.0 mA
Capacitance, Input to Output		.5		pF	
Breakdown Voltage	2500			VAC_{RMS}	t = 1 min.
Equivalent DC Isolation Voltage	3535			VDC	
Resistance, Input to Output		100		GΩ	
t_{on}		3.0		μs	I_C = 2 mA, R_E = 100 Ω
t_{off}		3.0		μs	V_{CE} = 10 V

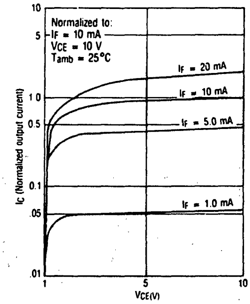
Typical switching characteristics versus base resistance
(Saturated operation)



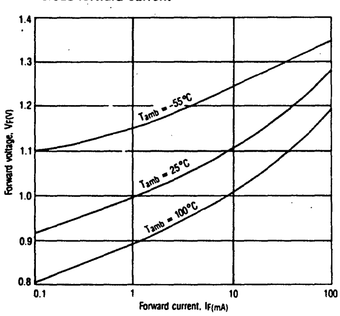
Typical switching times versus load resistance



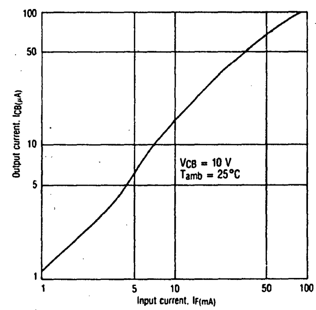
Collector current versus collector voltage



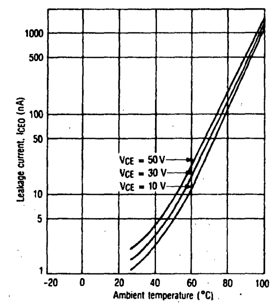
Typical forward voltage versus forward current



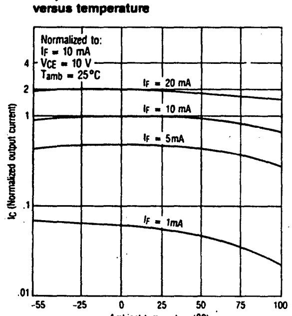
Typical output current (I_{CB}) versus input current



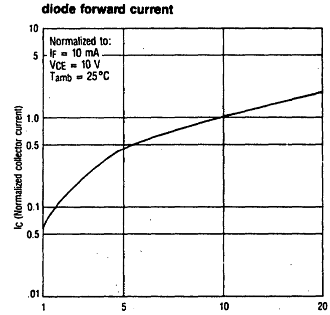
Typical leakage current versus ambient temperature



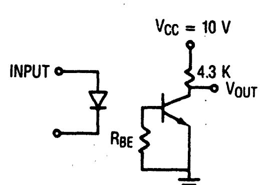
Output current versus temperature



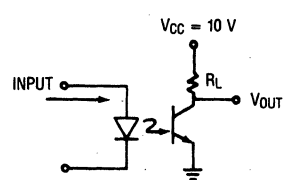
Collector current versus diode forward current



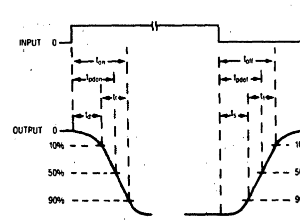
Switching time test schematic and waveforms



Switching time test schematic 1



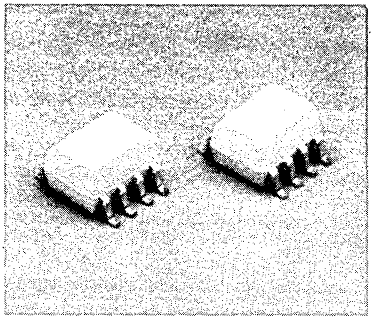
Switching time test schematic 2



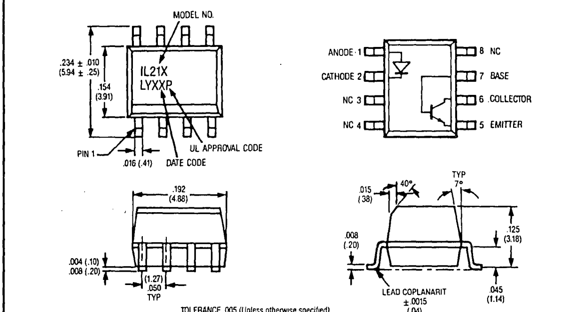
SIEMENS

IL215/IL216/IL217

PHOTOTRANSISTOR SMALL OUTLINE SURFACE MOUNT OPTOCOUPLER



Package Dimensions in Inches (mm)



Optocouplers (Optoisolators)

FEATURES

- **Industry Standard SOIC-8 Surface Mountable Package**
- **Standard Lead Spacing of .05″**
- **Available in Tape and Reel Option (Conforms to EIA Standard RS481A)**
- **2500 VRMS, Isolation Voltage**
- **Low Input Current Required**
- **20, 50, 100% CTR @I_F = 1 mA**
- **Electrical Specifications Similar to Standard 6 Pin Couplers**
- **Underwriters Lab Approval #E52744 (Code Letter P)**
- **Compatible with Dual Wave, Vapor Phase and IR Reflow Soldering**

DESCRIPTION

IL215/216/217 are optically coupled pairs employing a GaAs infrared LED and a silicon NPN phototransistor. Signal information, including a DC level, can be transmitted by the device while maintaining a high degree of electrical isolation between input and output. The IL215/216/217 come in a standard SOIC-8 small outline package for surface mounting which makes them ideally suited for high density applications with limited space. In addition to eliminating through-holes requirements, this package conforms to standards for surface mounted devices.

The high CTR at low input current is designed for low power consumption requirements such as CMOS microprocessor interfaces.

See Appnote 39 for solderability information.

Maximum Ratings

Gallium Arsenide LED
- Power Dissipation @25°C .... 90 mW
- Derate Linearly from 25°C .... 0.8 mW/°C
- Continuous Forward Current .... 60 mA
- Peak Reverse Voltage .... 6.0 V

Detector (Silicon Phototransistor)
- Power Dissipation @25°C .... 150 mW
- Derate Linearly from 25°C .... 2.0 mW/°C
- Collector-Emitter Breakdown Voltage (BV_{CEO}) .... 30 V
- Emitter-Collector Breakdown Voltage (BV_{ECO}) .... 7 V
- Collector-Base Breakdown Voltage (BV_{CBO}) .... 70 V

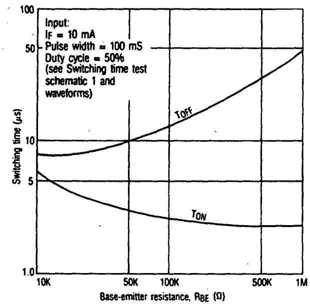
Package
- Total Package Dissipation at 25°C Ambient (LED Plus Detector) .... 250 mW
- Derate Linearly from 25°C .... 3.3 mW/°C
- Storage Temperature .... −55 to +150 °C
- Operating Temperature .... −55 to +100 °C
- Soldering Time @260°C .... 10 sec

(See Application Note 39 for a detailed report on solderability tests using dual wave, vapor phase and IR reflow soldering processes.)

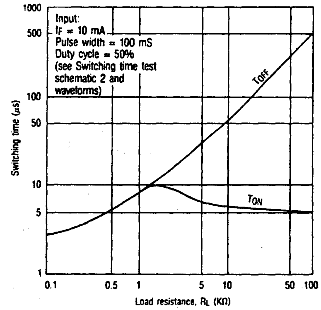
Electrical Characteristics (T_{amb} = 25°C)

Parameter	Min	Typ	Max	Unit	Test Condition
Gallium Arsenide LED					
Forward Voltage			1.3	V	I_F = 1 mA
Reverse Current		.1	100	µA	V_R = 6.0
Capacitance		100		pF	V_R = 0
Phototransistor Detector					
BV_{CEO}	30	90		V	I_C = 1 mA
BV_{ECO}	7	10		V	I_E = 10 µA
I_{CEO} (dark)		5	50	nA	V_{CE} = 5 V, I_F = 0
Collector-Emitter Capacitance		2		pF	V_{CE} = 0
Coupled Characteristics					
DC Current Transfer					
IL215	20	50		%	I_F = 1 mA,
IL216	50	80			V_{CE} = 5 V
IL217	100	130			
Collector-Emitter Saturation Voltage $V_{CE\,(sat)}$		.35	.4	V	I_F = 1 mA, I_C = 0.1 mA
Capacitance, Input to Output		.5		pF	
Breakdown Voltage	2500			VAC_{RMS}	t = 1 min.
Equivalent DC Isolation Voltage	3535			VDC	
Resistance, Input to Output		100		GΩ	
t_{on}		3.0		µs	I_C = 2 mA, R_E = 100 Ω
t_{off}		3.0		µs	V_{CE} = 10 V

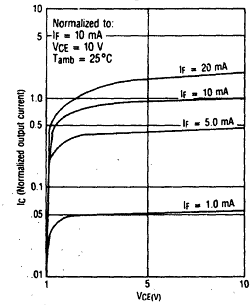
Typical switching characteristics versus base resistance
(Saturated operation)



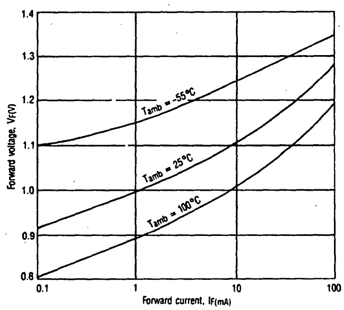
Typical switching times versus load resistance



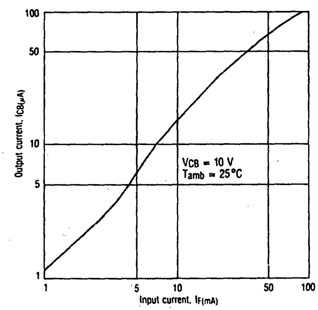
Collector current versus collector voltage



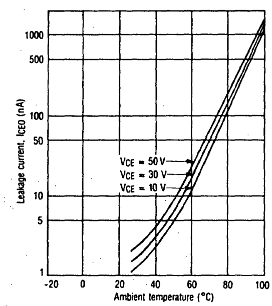
Typical forward voltage versus forward current



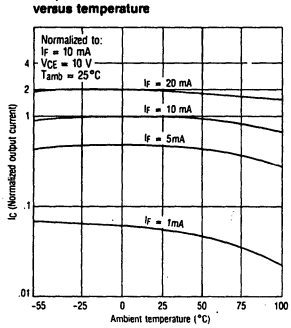
Typical output current (I_{CB}) versus input current



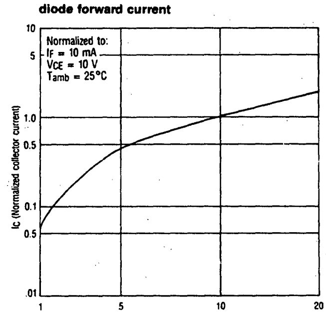
Typical leakage current versus ambient temperature



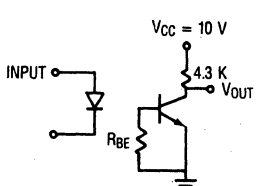
Output current versus temperature



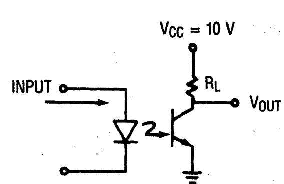
Collector current versus diode forward current



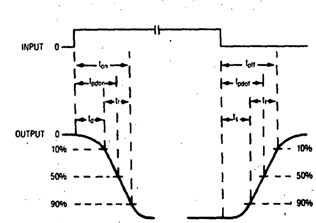
Switching time test schematic and waveforms



Switching time test schematic 1

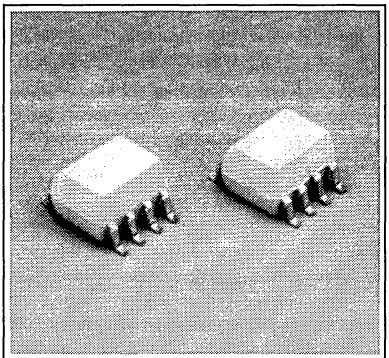


Switching time test schematic 2

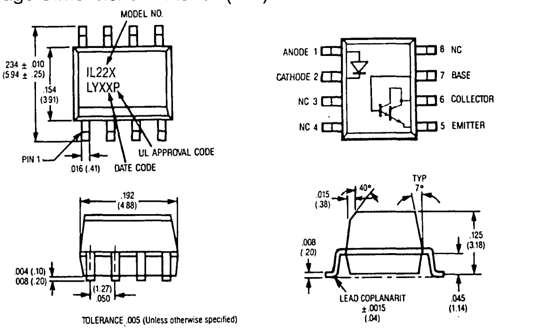


IL221/IL222/IL223

PHOTODARLINGTON SMALL OUTLINE SURFACE MOUNT OPTOCOUPLER



Package Dimensions in Inches (mm)



Optocouplers (Optoisolators)

FEATURES

- **Industry Standard SOIC-8 Surface Mountable Package**
- **Standard Lead Spacing of .05"**
- **Available in Tape and Reel Option (Conforms to EIA Standard RS481A)**
- **2500 VRMS, Withstand Test Voltage**
- **High Current Transfer Ratios @ I_F = 1 mA: IL221 - 100% Min. IL222 - 200% Min. IL223 - 500% Min.**
- **Electrical Specifications Similar to Standard 6 Pin Couplers**
- **Underwriters Lab Approval #E52744 (Code Letter P)**
- **Compatible with Dual Wave, Vapor Phase and IR Reflow Soldering**

DESCRIPTION

The IL221/222/223 family of devices are high current transfer ratio (CTR) optocouplers. They employ a GaAs infrared LED emitter and a silicon NPN photodarlington transistor detector.

These devices are offered with CTRs tested at an LED current of 1 mA. This low drive current permits easy interfacing from CMOS to LSTTL or TTL.

These optocouplers are constructed in a standard SOIC-8 foot print. This package makes them ideally suited for high density applications. In addition to eliminating through-hole requirements, this package conforms to standards for surface mounted devices.

Maximum Ratings

Gallium Arsenide LED
- Power Dissipation at 25°C .... 90 mW
- Derate Linearly from 25°C .... 0.8 mW/°C
- Continuous Forward Current .... 60 mA
- Peak Reverse Voltage .... 6.0 V

Detector (Silicon Phototransistor)
- Power Dissipation at 25°C .... 150 mW
- Derate Linearly from 25°C .... 2.0 mW/°C
- Collector-Emitter Breakdown Voltage (BV_{CEO}) .... 30 V
- Emitter-Collector Breakdown Voltage (BV_{ECO}) .... 5 V

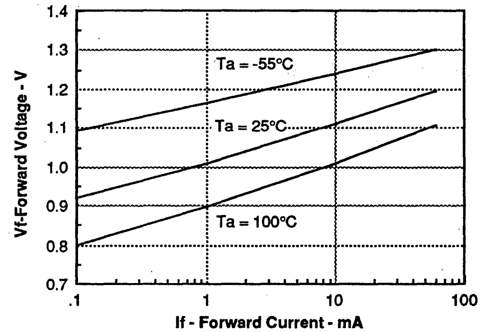
Package
- Total Package Dissipation at 25°C Ambient (LED Plus Detector) .... 250 mW
- Derate Linearly from 25°C .... 3.3 mW/°C

Storage Temperature .... -55 to +150°C
Operating Temperature .... -55 to +100°C
Soldering Time at 260 °C .... 10 sec
(See Application Note 39 for a detailed report on solderability tests using dual wave, vapor phase and IR reflow soldering processes.)

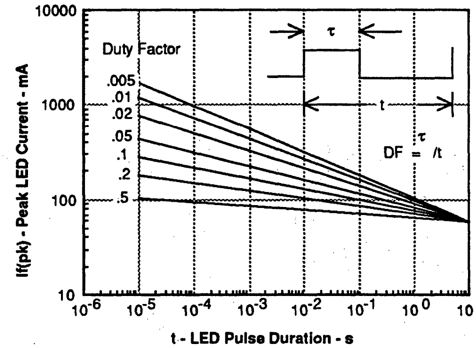
Electrical Characteristics (T_{amb} = 25°C)

Parameter	Min	Typ	Max	Unit	Test Conditions
Gallium Arsenide LED					
Forward Voltage			1.3	V	I_F = 1 mA
Reverse Current		0.1	100	μA	V_R = 6.0
Capacitance		100		pF	V_F = 0 V, F = 1 MHz
Photodarlington Transistor					
BV_{CEO}	30			V	I_C = 100 μA
BV_{ECO}	5			V	I_E = 100 μA
I_{CEO}			50	nA	V_{CE} = 5 V, I_F = 0 A
Collector-Emitter Capacitance		3.4		pF	V_{CE} = 10 V
Coupled Characteristics					
DC Current Transfer Ratio @ I_F = 1 mA					
IL221	100			%	I_F = 1.0 mA, V_{CE} = 5 V
IL222	200			%	I_F = 1.0 mA, V_{CE} = 5 V
IL223	500			%	I_F = 1.0 mA, V_{CE} = 5 V
Collector-Emitter Saturation					
Voltage $V_{CE\ (sat)}$			1	V	I_F = 1 mA, I_{CE} = 0.5 mA
Capacitance, Input to Output		0.5		pF	
Withstand Test Voltage	2500			VAC_{RMS}	t = 1 min.
Resistance Input to Output		100		GΩ	

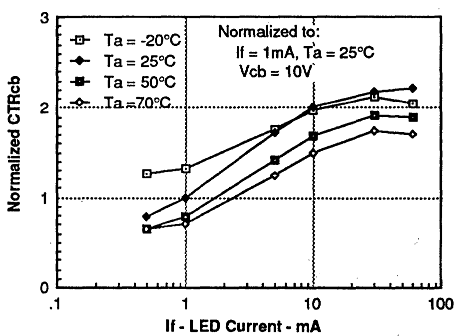
Forward voltage versus forward current



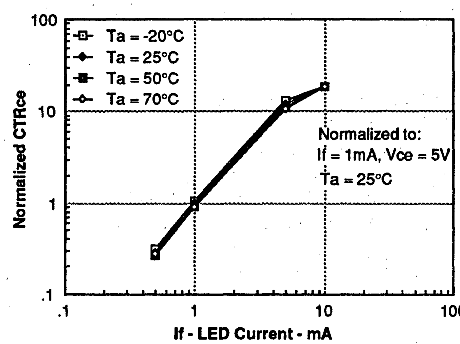
Peak LED current versus duty factor, Tau



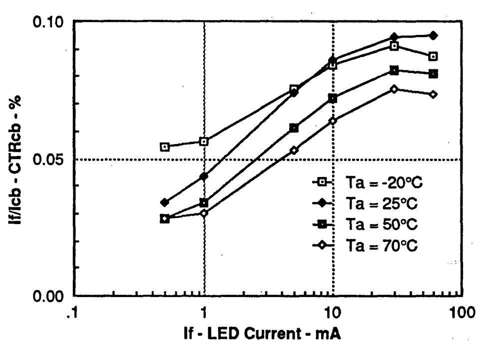
Normalized CTR_{CB} versus I_F



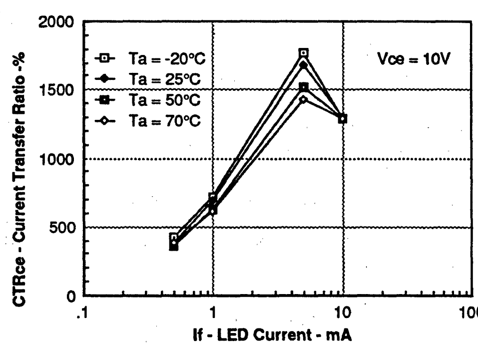
Normalized CTR_{CE} versus LED current



CTR_{CB} versus LED current

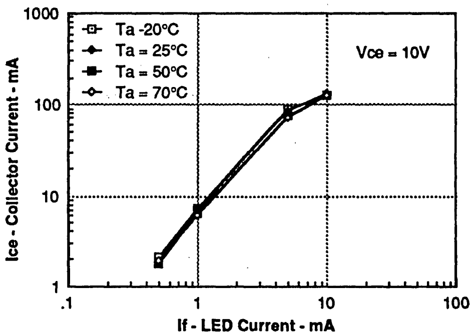


CTR versus LED current

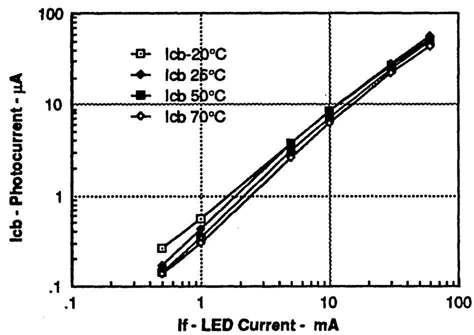


IL221/2/3

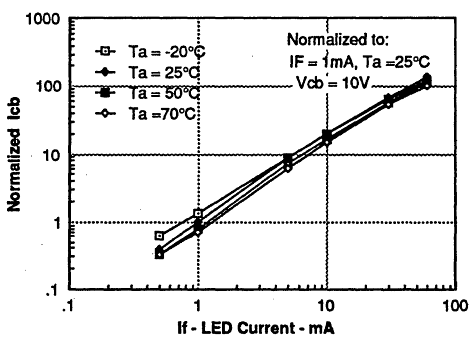
Collector current versus LED current



Photocurrent versus LED current



Normalized I_{CB} versus I_F

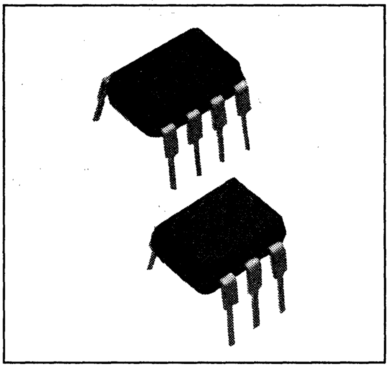


Optocouplers (Optoisolators)

IL221/2/3

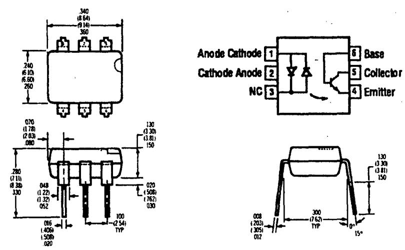
SIEMENS

SINGLE CHANNEL IL250/251/252
DUAL CHANNEL ILD250/251/252
BIDIRECTIONAL INPUT OPTOCOUPLERS

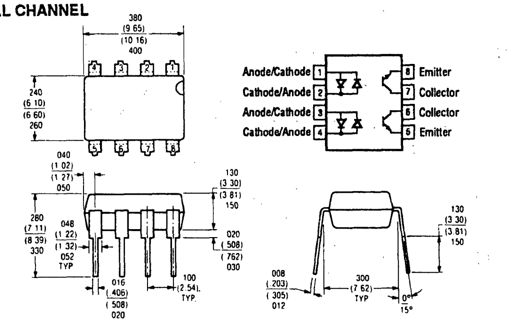


Package Dimensions in Inches (mm)

SINGLE CHANNEL



DUAL CHANNEL



FEATURES

- **AC or Polarity Insensitive Inputs**
- **Selected Current Transfer Ratios (20%, 50%, 100% Min.)**
- **Industry Standard Dual-In-Line**
- **Built-In Reverse Polarity Input Protection**
- **Improved CTR Symmetry**
- **Underwriters Lab Approval #E52744**
- **VDE Approvals 0883/6.80, 0804/1.83 - IL250/251/252 only**

DESCRIPTION

The IL/ILD250/251/252 are bidirectional input optically coupled isolators. They consist of two gallium arsenide infrared emitting diodes coupled to a silicon NPN photo-transistor per channel.

The IL/ILD250 has a minimum CTR of 50%, the IL/ILD251 has a minimum CTR of 20%, and the IL/ILD252 has a minimum CTR of 100%.

The IL250/1/2 are single channel opto-couplers. The ILD250/1/2 has two isolated channels in a single DIP package.

They are designed for applications requiring detection or monitoring of AC signals.

Maximum Ratings

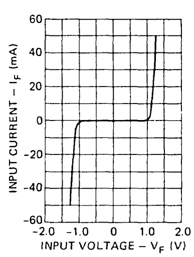
	IL250/1/2	ILD250/1/2	IL250/1/2 ILD250/1/2
Gallium Arsenide LED (Each channel)			
Power Dissipation at 25°C	200 mW	90 mW	
Derate Linearly from 25°C	2.6 mW/°C	1.2 mW/°C	
Continuous Forward Current	100 mA	60 mA	
Peak Reverse Voltage			3.0 V
Detector-Silicon Phototransistor (Each channel)			
Power Dissipation at 25°C	200 mW	150 mW	
Derate Linearly from 25°C	2.6 mW/°C	2.0 mW/°C	
Collector-Emitter Breakdown Voltage (BV_{CEO})			30 V
Emitter-Base Breakdown Voltage (BV_{ECO})			5 V
Collector-Base Breakdown Voltage (BV_{CBO})			70 V
Package			
Total Package Dissipation at 25°C Ambient (LED Plus Detector)	250 mW	400 mW	
Derate Linearly from 25°C	3.3 mW/°C	5.3 mW/°C	
UL Withstand Test Voltage (PK) (t = 1 sec)			7500 VDC/ 5300 VAC_{RMS}
VDE Isolation Test Voltage in Accordance with DIN57883/6.80			3750 VAC/ 5300 VDC
Creepage Path			8 mm min.
Clearance Path			7 mm min.
Tracking Index According to VDE 0303			KB100/A
Storage Temperature			-55 to +150°C
Operating Temperature			-55 to +100°C
Lead Soldering Time at 260 °C			10 sec

Electrical Characteristics ($T_{amb} = 25°C$)

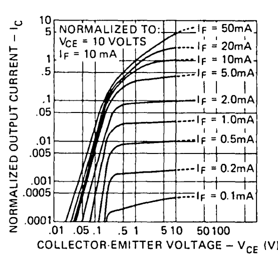
Parameter	Min	Typ	Max	Unit	Test Condition
Gallium Arsenide LED					
Forward Voltage V_F		1.2	1.5	V	$I_F = \pm 10$ mA
Phototransistor Detector					
BV_{CEO}	30	50		V	$I_C = 1$ mA
BV_{ECO}	7	10		V	$I_C = 100\ \mu A$
BV_{CBO}	70	90		V	$I_C = 10\ \mu A$
I_{CEO}		5	50	nA	$V_{CE} = 10$ V
Coupled Characteristics					
$V_{CE}(sat)$			0.4	V	$I_F = \pm 16$ mA, $I_C = 2$ mA
DC Current Transfer Ratio (CTR)					
IL250/ILD250	50			%	$I_F = \pm 10$ mA, $V_{CE} = 10$ V
IL251/ILD251	20			%	
IL252/ILD252	100			%	
Symmetry $\frac{\text{CTR @ +10 mA}}{\text{CTR @ −10 mA}}$	0.50	1.0	2.0		

Typical Optocoupler Characteristic Curves

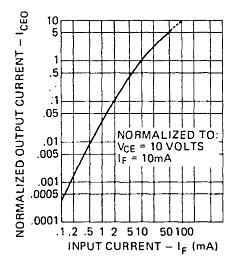
Input characteristics



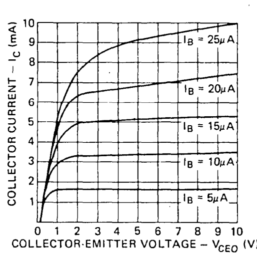
Transfer characteristics



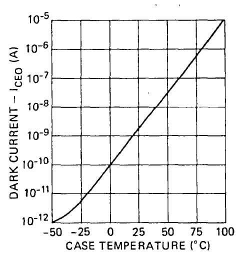
Output vs. input current



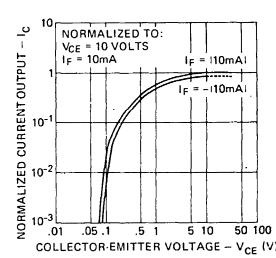
Output characteristics



Dark current vs. temperature



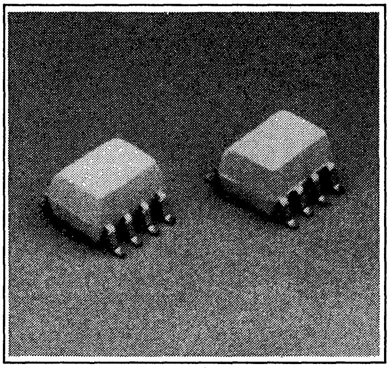
Symmetry characteristics



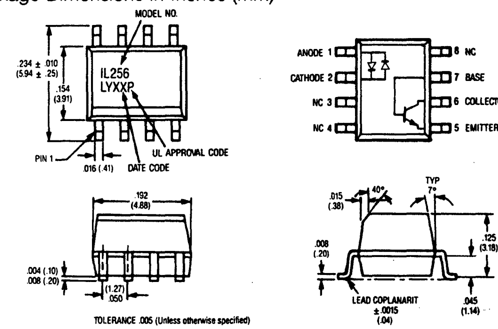
SIEMENS

IL256

AC INPUT PHOTOTRANSISTOR SMALL OUTLINE SURFACE MOUNT OPTOCOUPLER



Package Dimensions in Inches (mm)



FEATURES

- **Industry Standard SOIC-8 Surface Mountable Package**
- **Standard Lead Spacing of .05″**
- **Available in Tape and Reel Option (Conforms to EIA Standard RS481A)**
- **Bidirectional AC Input**
- **Guaranteed CTR Symmetry of 2:1 Maximum**

DESCRIPTION

The IL256 is an AC input phototransistor optocoupler. The device consists of two infrared emitters connected in anti-parallel and coupled to a silicon NPN phototransistor detector.

These circuit elements are constructed with a standard SOIC-8 foot print. Soldering and assembly with this optocoupler is covered in detail in Appnote 39.

The product is well suited for telecom application such as ring detection or off/on hook status, given its bidirectional LED input and guaranteed current transfer ratio CTR of 20% at $I_F = 10$ mA.

Maximum Ratings

Gallium Arsenide LED
- Power Dissipation at 25°C .... 90 mW
- Derate Linearly from 25°C .... 0.8 mW/°C
- Continuous Forward Current .... 60 mA

Detector (Silicon Phototransistor)
- Power Dissipation at 25°C .... 150 mW
- Derate Linearly from 25°C .... 2.0 mW/°C
- Collector-Emitter Breakdown Voltage (BV_{CEO}) .... 30 V
- Emitter-Base Breakdown Voltage (BV_{ECO}) .... 5 V
- Collector-Base Breakdown Voltage (BV_{CBO}) .... 70 V

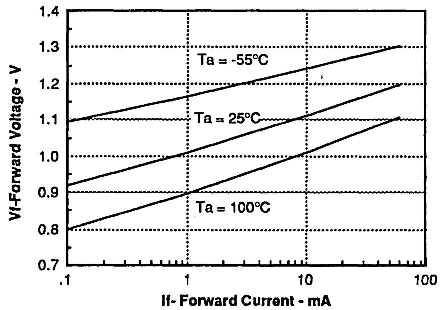
Package
- Total Package Dissipation at 25°C Ambient (LED Plus Detector) .... 240 mW
- Derate Linearly from 25°C .... 3.1 mW/°C

Storage Temperature .... –55 to +150°C
Operating Temperature .... –55 to +100°C

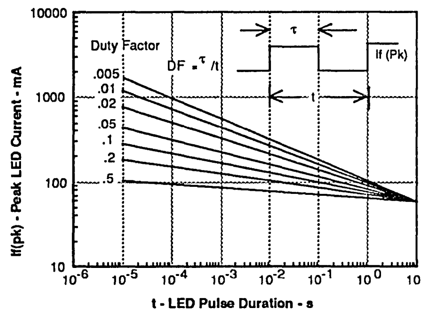
Electrical Characteristics ($T_{amb} = 25$°C)

Parameter	Min	Typ	Max	Unit	Test Conditions
Gallium Arsenide LED					
Forward Voltage V_F		1.2	1.5	V	$I_F = \pm 10$ mA
Phototransistor Detector					
BV_{CEO}	30	50		V	$I_C = 1$ mA
BV_{ECO}	5	10		V	$I_C = 100$ μA
BV_{CBO}	70	90		V	$I_C = 100$ μA
I_{CEO}		5	50	nA	$V_{CE} = 10$ V
Coupled Characteristics					
$V_{CE(sat)}$			0.4	V	$I_F = \pm 16$ mA, $I_C = 2$ mA
DC Current Transfer Ratio (CTR)	20			%	$I_F = \pm 10$ mA, $V_{CE} = 10$ V
Symmetry $\frac{CTR\ @\ +10\ mA}{CTR\ @\ -10\ mA}$	0.5	1.0	2.0		
Input to Output Withstand Test Voltage	2500			VAC_{RMS}	t = 1 min.

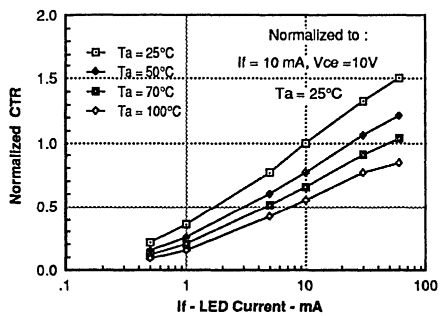
Forward voltage versus forward current



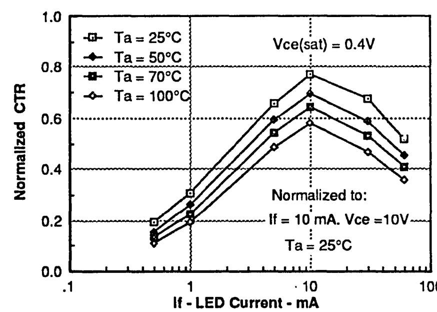
Peak LED current versus duty factor, Tau



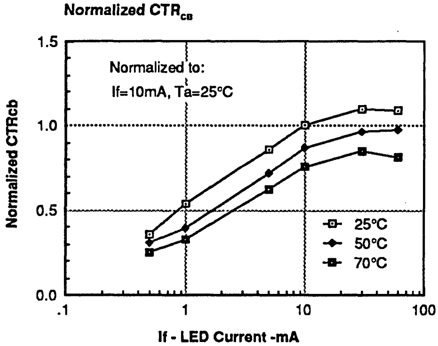
Normalized CTR versus I_F and T_{amb}



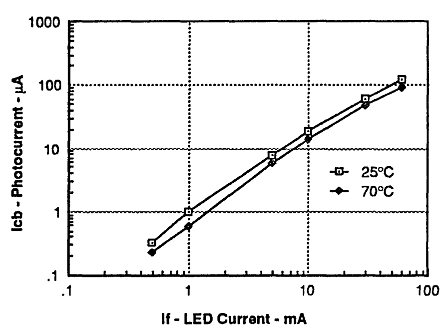
Normalized saturated CTR



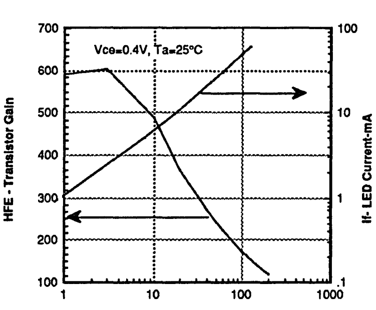
Normalized CTR_{cb}



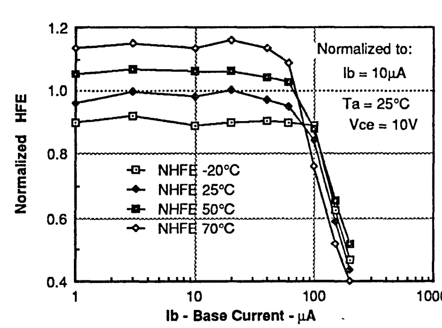
Photocurrent versus LED current



Base current versus I_F and HFE



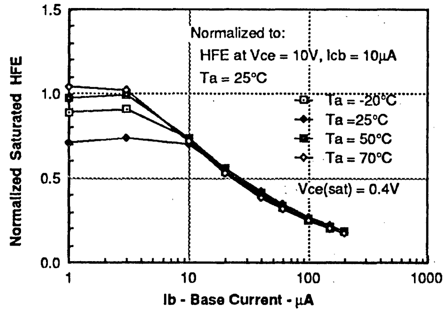
Normalized HFE versus I_B, T_{amb}



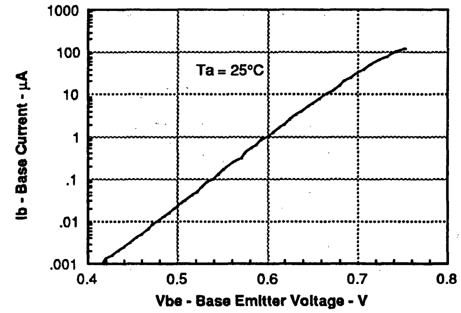
Optocouplers (Optoisolators)

IL256

Normalized saturated HFE versus I_B



Base emitter voltage versus base current

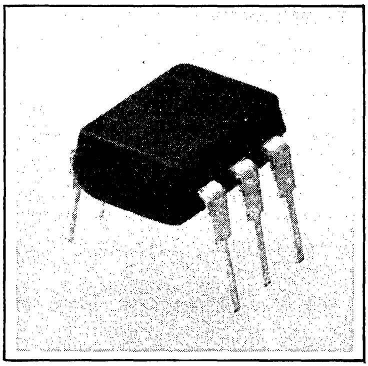


SIEMENS

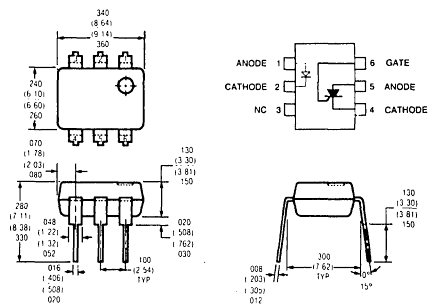
IL400

PHOTO SCR OPTOCOUPLER

Advance Data Sheet



Package Dimensions in Inches (mm)



FEATURES

- **400 Volts Blocking Voltage**
- **Turn On Current (I_ft) 5.0 mA Typical**
- **Gate Trigger Current (I_{GT}) - 20μA**
- **Gate Trigger Voltage (t_{GT}) - 0.6 Volt**
- **7500 Volt Isolation Voltage**
- **Surge Anode Current - 1.0 Amp**
- **Solid State Reliability**
- **Standard Dip Package**
- **Underwriters Lab Approval #E52744**

DESCRIPTION

The IL400 is an optically coupled SCR employing a GaAs infrared emitter and a silicon photo SCR sensor. Switching can be accomplished while maintaining a high degree of isolation between triggering and load circuits. It can be used in SCR triac and solid state relay applications where high blocking voltages and low input current sensitivity is required.

Gallium Arsenide LED (Drive Circuit)
- Power Dissipation at 25°C .... 100 mW
- Derate Linearly from 25°C .... 1.05 mW/°C
- Continuous Forward Current .... 60 mA
- Peak Reverse Voltage .... 6.0 V
- Peak Forward Current (100 μs, 1% Duty Cycle) .... 1.0 A

SCR Detector (Load Circuit)
- Power Dissipation at 25°C ambient .... 200 mW
- Derate Linearly from 25°C .... 2.11 mW/°C
- Anode Current .... 100 mA
- Surge Anode Current (5 ms duration) .... 1.0 A
- Surge Gate Current (5 ms duration) .... 200 mA
- Reverse Gate Voltage .... 6.0 V
- Anode Voltage (DC or AC Peak) .... 400 V

Coupled
- Isolation Voltage .... 6000 VDC
- Total Package Power Dissipation .... 250 mW
- Derate Linearly from 25° .... 2.63 mW/°C
- Operating Temperature Range .... -55°C to +100°C
- Storage Temperature Range .... -55°C to +150°C

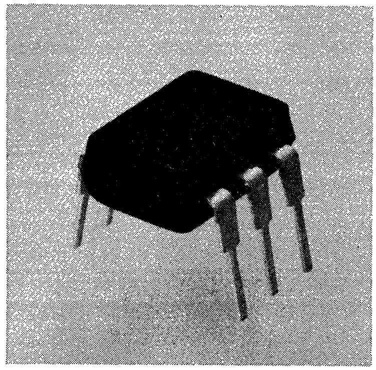
Electrical Characteristics (T_{amb} = 25°C)

Parameter	Min	Typ	Max	Unit	Test Condition
Input Diode					
Forward Voltage		1.2	1.5	V	I_F = 20 mA
Reverse Voltage	5.0			V	I_R = 10 μA
Reverse Current			10	μA	V_R = 5 V
Photo - SCR					
Forward Leakage Current (I_D)		0.2	2.0	μA	R_{GK} = 27 Kohm, I_F = 0 V_{RX} = 400 V, TA = 25°C
Reverse Leakage Current (I_R)		0.2	2.0	μA	R_{GK} = 27 Kohm, I_F = 0 V_{RX} = 400 V, TA = 25°C
Forward Blocking Voltage (V_{DM})	400			V	R_{GK} = 10 Kohm TA = 100°C I_d = 150 μA
Reverse Blocking Voltage (V_{DM})	400			V	R_{GK} = 10 Kohm TA = 100°C I_d = 150 μA
On Voltage (V_t)	-	-	1.2	V	I_T = 100 mA
Holding Current (I_H)	-	-	500	μA	R_{GK} = 27 Kohm, V_{FX} = 50 V
Gate Trigger Voltage (V_{GT})	-	0.6	1.0	V	V_{FX} = 100 V R_{GK} = 27 Kohm R_L = 10 Kohm
Gate Trigger Current (I_{GT})		20	50	μA	V_{FX} = 100 V R_L = 10 Kohm R_{GK} = 27 Kohm
Coupled					
Turn-on Current (I_{FT})	0.5	5.0	10.0	mA	V_{FX} = 100 V R_{GK} = 27 Kohm
Isolation Voltage	7500			V_{DC}	t = 1 sec.
Isolation Resistance	100			G-ohm	V_{iso} = 500 V
Isolation Capacitance			2	pF	f = 1 MHz

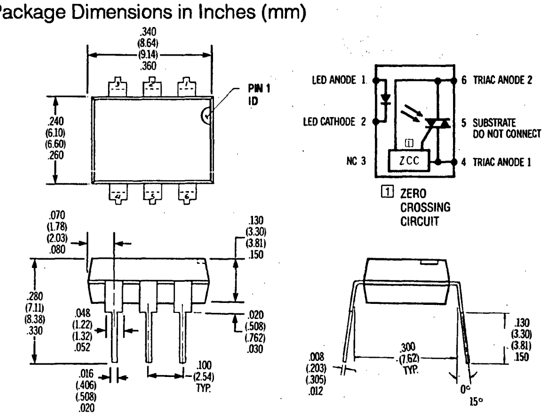
SIEMENS

IL410

ZERO VOLTAGE CROSSING 600 V TRIAC DRIVER OPTOCOUPLER



Package Dimensions in Inches (mm)



FEATURES

- **High Input Sensitivity**
  I_{FT} = 2 mA, PF = 1.0
  I_{FT} = 5 mA, Typical PF ≤ 1.0
- **Zero Voltage Crossing**
- **600 V Blocking Voltage**
- **300 mA On-State Current**
- **High Static dv/dt 10,000 V/µs**
- **Inverse Parallel SCRs Provide Commutating dv/dt >10K V/µs**
- **Very Low Leakage <10K µA**
- **Withstand Test Voltage from Double Molded Package 7500 VAC_{PEAK}**
- **Small 6-Pin DIP Package**
- **UL Approval #E52744**

DESCRIPTION

The IL410 consists of a GaAs IRLED optically coupled to a photosensitive zero crossing TRIAC network. The TRIAC consists of two inverse parallel connected monolithic SCRs. These three semiconductors are assembled in a six pin 0.3 inch dual in-line package, using high insulation double molded, over/under leadframe construction.

High input sensitivity is achieved by using an emitter follower phototransistor and a cascaded SCR predriver resulting in an LED trigger current of less than 2 mA(DC).

The IL410 uses two discrete SCRs resulting in a commutating dV/dt greater than 10KV/µs. The use of a proprietary dv/dt clamp results in a static dV/dt of greater than 10KV/µs. This clamp circuit has a MOSFET that is enhanced when high dV/dt spikes occur between MT1 and MT2 of the TRIAC. When conducting, the FET clamps the base of the phototransistor, disabling the first stage SCR predriver.

The zero cross line voltage detection circuit consists of two enhancement MOSFETS and a photodiode. The inhibit voltage of the network is determined by the enhancement voltage of the N-channel FET. The P-channel FET is enabled by a photocurrent source that permits the FET to conduct the main voltage to gate on the N-channel FET. Once the main voltage can enable the N-channel, it clamps the base of the phototransistor, disabling the first stage SCR predriver.

The 600V blocking voltage permits control of off-line voltages up to 240VAC, with a safety factor of more than two, and is sufficient for as much as 380VAC.

The IL410 isolates low-voltage logic from 120, 240, and 380 VAC lines to control resistive, inductive, or capacitive loads including motors, solenoids, high current thyristors or TRIAC and relays.

Applications include solid-state relays, industrial controls, office equipment, and consumer appliances.

Maximum Ratings

Emitter

Reverse Voltage .... 6 V
Forward Current .... 60 mA
Surge Current .... 2.5 A
Power Dissipation .... 100 mW
Derate from 25°C .... 1.33 mW/°C
Thermal Resistance .... 750 °C/W

Detector

Peak Off-State Voltage .... 600 V
Peak Reverse Voltage .... 600 V
RMS On-State Current .... 300 mA
Single Cycle Surge .... 3 A
Total Power Dissipation .... 500 mW
Derate from 25°C .... 6.6 mW/°C
Thermal Resistance .... 150 °C/W

Package

Storage Temperature .... -55°C to +150°C
Operating Temperature .... -55°C to +100°C
Lead Soldering Temperature .... 260°C/5 sec.
Withstand Test Voltage .... 7500 VAC_{PEAK} /5300 VAC_{RMS}

Characteristics

	Symbol	Min.	Typ.	Max	Unit
Emitter					
Forward Voltage (I_F=60 mA)	V_F		1.3	1.5	V
Breakdown Voltage (I_R=10 µA)	V_{BR}	6	30		V
Reverse Current (V_R=6 V)	I_R		0.1	10	µA
Capacitance (V_F=0 V, f=1 MHz)	C_O		40		pF
Thermal Resistance Junction to Lead	R_{THJL}		750		°C/W
Output Detector					
Repetitive Peak Off-State Voltage (I_{DRM}=100 µA)	V_{DRM}	600	650		V
Off-State Voltage ($I_{D(RMS)}$=70 µA)	$V_{D(RMS)}$	424	460		V
Off-State Current (V_D=600 V, T_{amb}=100°C, I_F=0 mA)	$I_{D(RMS)1}$		10	100	µA
Off-State Current (V_D=120 V, I_F=Rated I_{FT})	$I_{D(RMS)2}$			20	µA
On-State Voltage (I_T=300 mA)	V_{TM}		1.7	3	V
On-State Current (PF=1.0, $V_{T(RMS)}$=1.7 V)	I_{TM}			300	mA
Surge (Non-Repetitive) On-State Current (f=50 Hz)	I_{TSM}			3	A

Characteristics (Cont.)

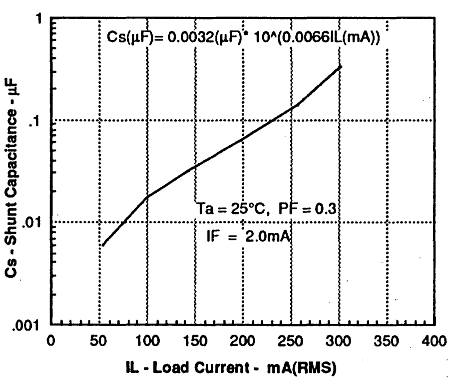
	Symbol	Min.	Typ.	Max	Unit
Output Detector (Cont.)					
Holding Current (V_T=3 V)	I_H		65	200	µA
Latching Current (V_T=2.2 V)	I_L		5		mA
LED Trigger Current (V_{AK}=5 V)	I_{FT}		1	2	mA
Zero Cross Inhibit Voltage (I_F=Rated I_{FT})	V_{IH}		15	25	
Turn-On Time (V_{RM}=V_{DM}=424 VAC)	t_{ON}		35		µs
Turn-Off Time (PF=1.0, I_T=300 mA)	t_{OFF}		50		µs
Critical Rate of Rise of Off-State Voltage (V_{RM}=V_{DM}=424 VAC)	$dv_{(MT)}/dt$	10000			V/µs
(T_{amb}=80°C)			2000		V/µs
Critical Rate of Rise of Commutating Voltage (V_{RM}=V_{DM}=424 VAC)	$dv_{(COM)}/dt$	10000			V/µs
(T_{amb}=80°C)			2000		V/µs
Critical Rate of Rise of Commutating Current (I_T=300 mA)	di/dt		100		A/ms
Thermal Resistance Junction to Lead	R_{THJL}		150		°C/W
Insulation and Isolation					
Critical Rate of Rise of Coupled Input/Output Voltage (I_T=0 A, V_{RM}=V_{DM}=424 VAC)	$dv_{(IO)}/dt$		10000		V/µs
Common Mode Coupling Capacitor	C_{CM}		0.01		pF
Package Capacitance (f=1 MHz, V_{IO}=0 V)	C_{IO}		0.8		pF
Insulation Resistance	R_S				Ω
Withstand Test Voltage Input-Output (Relative Humidity ≤50%)	WTV	4420			VAC_{RMS}
(I_{IO}≤10 µA, 1 min.)	WTV	6250			VAC_{PEAK}
Relative Humidity ≤50%)	WTV	5300			VAC_{RMS}
(I_{IO}≤10 µA, 1 sec.)	WTV	7500			VAC_{PEAK}

POWER FACTOR CONSIDERATIONS

A snubber isn't needed to eliminate false operation of the TRIAC driver because of the IL410's high static and commutating dv/dt with loads between 1 and 0.8 power factors. When inductive loads with power factors less than 0.8 are being driven, include a RC snubber or a single capacitor directly across the device to damp the peak commutating dv/dt spike. Normally a commutating dv/dt causes a turning-off device to stay on due to the stored energy remaining in the turning-off device.

But in the case of a zero voltage crossing optotriac, the commutating dv/dt spikes can inhibit one half of the TRIAC from turning on. If the spike potential exceeds the inhibit voltage of the zero cross detection circuit, half of the TRIAC will be held-off and not turn-on. This hold-off condition can be eliminated by using a snubber or capacitor placed directly across the optotriac as shown in Figure 1. Note that the value of the capacitor increases as a function of the load current.

FIGURE 1. SHUNT CAPACITANCE VS. LOAD CURRENT



The hold-off condition also can be eliminated by providing a higher level of LED drive current. The higher LED drive provides a larger photocurrent which causes the phototransistor to turn-on before the commutating spike has activated the zero cross network. Figure 2 shows the relationship of the LED drive for power factors of less than 1.0. The curve shows that if a device requires 1.5 mA for a resistive load, then 1.8 times (2.7 mA) that amount would be required to control an inductive load whose power factor is less than 0.3.

FIGURE 2. NORMALIZED LED TRIGGER CURRENT VS. POWER FACTOR

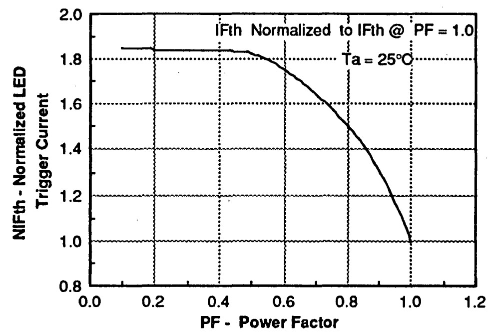
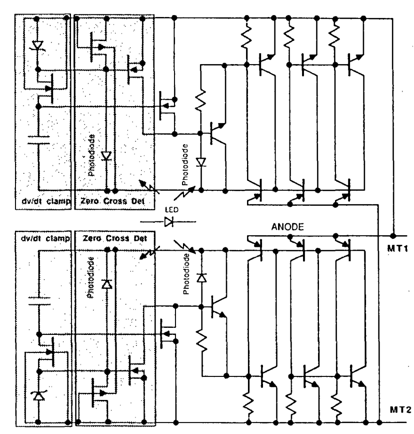
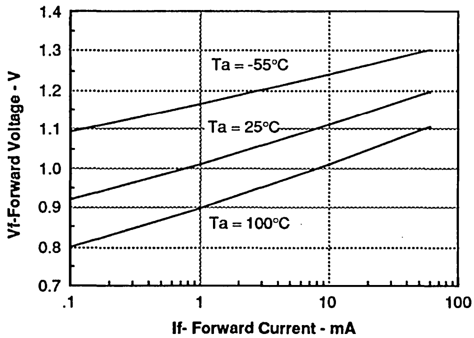


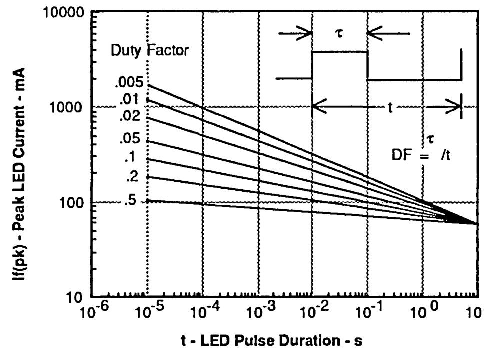
FIGURE 3. SCHEMATIC



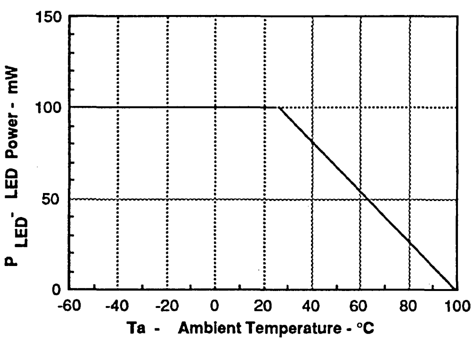
Forward voltage versus forward current



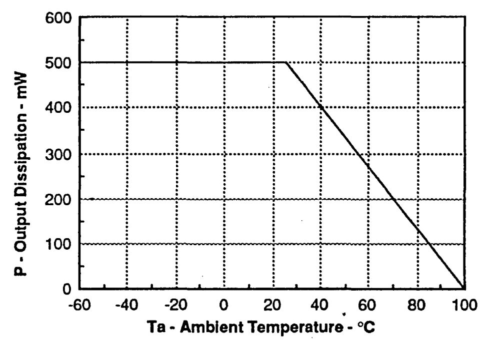
Peak LED current versus duty factor, Tau



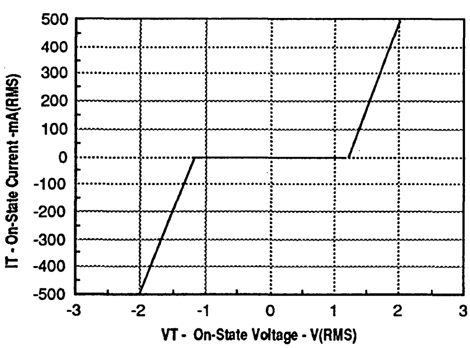
Maximum LED power dissipation



Maximum output power dissipation

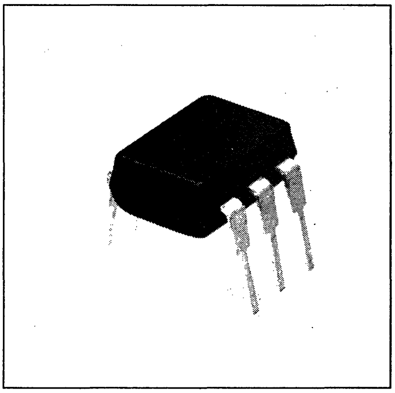


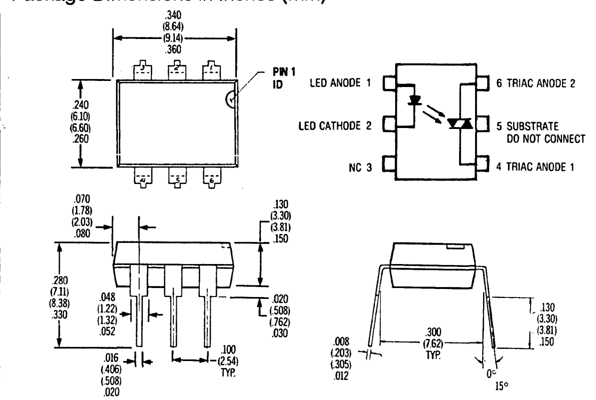
On-state terminal voltage versus terminal current



IL420

600 V TRIAC DRIVER OPTOCOUPLER





FEATURES

- High Input Sensitivity I_{FT} = 2 mA
- 600 V Blocking Voltage
- 300 mA On-State Current
- High Static dv/dt 10,000 V/µs
- Inverse Parallel SCRs Provide Commutating dv/dt >2K V/µs
- Very Low Leakage <10K µA
- Withstand Test Voltage from Double Molded Package 7500 VAC_{PEAK}
- Small 6-Pin DIP Package
- UL Approval #E52744

DESCRIPTION

The IL420 consists of a GaAs IRLED optically coupled to a photosensitive non-zero crossing TRIAC network. The TRIAC consists of two inverse parallel connected monolithic SCRs. These three semiconductors are assembled in a six pin 0.3 inch dual in-line package, using high insulation double molded, over/under leadframe construction.

High input sensitivity is achieved by using an emitter follower phototransistor and a cascaded SCR predriver resulting in an LED trigger current of less than 2 mA(DC).

The IL420 uses two discrete SCRs resulting in a commutating dV/dt of greater than 10KV/ms. The use of a proprietary *dv/dt clamp* results in a static dV/dt of greater than 10KV/ms. This clamp circuit has a MOSFET that is enhanced when high dV/dt spikes occur between MT1 and MT2 of the TRIAC. When conducting, the FET clamps the base of the phototransistor, disabling the first stage SCR predriver.

The 600V blocking voltage permits control of off-line voltages up to 240VAC, with a safety factor of more than two, and is sufficient for as much as 380VAC.

The IL420 isolates low-voltage logic from 120, 240, and 380 VAC lines to control resistive, inductive, or capacitive loads including motors, solenoids, high current thyristors or TRIAC and relays.

Applications include solid-state relays, industrial controls, office equipment, and consumer appliances.

Maximum Ratings

Emitter

Reverse Voltage .... 6 V
Forward Current .... 60 mA
Surge Current .... 2.5 A
Power Dissipation .... 100 mW
Derate from 25°C .... 1.33 mW/°C
Thermal Resistance .... 750 °C/W

Detector

Peak Off-State Voltage .... 600 V
Peak Reverse Voltage .... 600 V
RMS On-State Current .... 300 mA
Single Cycle Surge .... 3 A
Total Power Dissipation .... 500 mW
Derate from 25°C .... 6.6 mW/°C
Thermal Resistance .... 150 °C/W

Package

Storage Temperature .... -55°C to +150°C
Operating Temperature .... -55°C to +100°C
Lead Soldering Temperature .... 260°C/5 sec.
Withstand Test Voltage .... 7500 VAC_{PEAK} / 5300 VAC_{RMS}

Characteristics

	Symbol	Min.	Typ.	Max	Unit
Emitter					
Forward Voltage (I_F=60 mA)	V_F		1.3	1.5	V
Breakdown Voltage (I_R=10 µA)	V_{BR}	6	30		V
Reverse Current (V_R=6 V)	I_R		0.1	10	µA
Capacitance (V_F=0 V, f=1 MHz)	C_0		40		pF
Thermal Resistance Junction to Lead	R_{THJL}		750		°C/W
Output Detector					
Repetitive Peak Off-State Voltage (I_{DRM}=100 µA)	V_{DRM}	600	650		V
Repetitive Peak Reverse Voltage (I_{RM}=100 µA)	V_{RRM}	600	650		V
Off-State Voltage ($I_{D(RMS)}$=70 µA)	$V_{D(RMS)}$	424	460		V
Reverse Voltage ($I_{R(RMS)}$=70 µA)	V_R	424	460		V
Off-State Current (V_D=600 V, T_{amb}=100°C)	$I_{D(RMS)}$		10	100	µA
Reverse Current (V_R=600 V, T_{amb}=100°C)	$I_{R(RMS)}$		10	100	µA

Characteristics (Cont.)

	Symbol	Min.	Typ.	Max	Unit
Output Detector (Cont.)					
On-State Voltage (I_T=300 mA)	V_{TM}		1.7	3	V
On-State Current (PF=1.0, $V_{T(RMS)}$=1.7 V)	I_{TM}			300	mA
Surge (Non-Repetitive) On-State Current (f=50 Hz)	I_{TSM}			3	A
Holding Current (V_T=3 V)	I_H		65	200	µA
Latching Current (V_T=2.2 V)	I_L		5		mA
LED Trigger Current (V_{AK}=5 V)	I_{FT}		1	2	mA
Turn-On Time (V_{RM}=V_{DM}=424 VAC)	t_{ON}		35		µs
Turn-Off Time (PF=1.0, I_T=300 mA)	t_{OFF}		50		µs
Critical Rate of Rise of Off-State Voltage (V_{RM}=V_{DM}=424 VAC)	$dv_{(MT)}/dt$	10000			V/µs
(T_{amb}=80°C)			2000		V/µs
Critical Rate of Rise of Commutating Voltage (V_{RM}=V_{DM}=424 VAC)	$dv_{(COM)}/dt$	10000			V/µs
(T_{amb}=80°C)			2000		V/µs
Critical Rate of Rise of Commutating Current (I_T=300 mA)	di/dt		100		A/ms
Thermal Resistance Junction to Lead	R_{THJL}		150		°C/W
Insulation and Isolation					
Critical Rate of Rise of Coupled Input/Output Voltage (I_T=0 A, V_{RM}=V_{DM}=424 VAC)	$dv_{(IO)}/dt$		5000		V/µs
Common Mode Coupling Capacitor	C_{CM}		0.01		pF
Package Capacitance (f=1 MHz, V_{IO}=0 V)	C_{IO}		0.8		pF
Insulation Resistance	R_S				Ω
Withstand Test Voltage Input-Output (Relative Humidity ≤50%)	WTV	4420			VAC_{RMS}
(I_{IO}≤10 µA, 1 min.)	WTV	6250			VAC_{PEAK}
Relative Humidity ≤50%)	WTV	5300			VAC_{RMS}
(I_{IO}≤10 µA, 1 sec.)	WTV	7500			VAC_{PEAK}

FIGURE 1. NORMALIZED LED TRIGGER CURRENT VS. POWER FACTOR

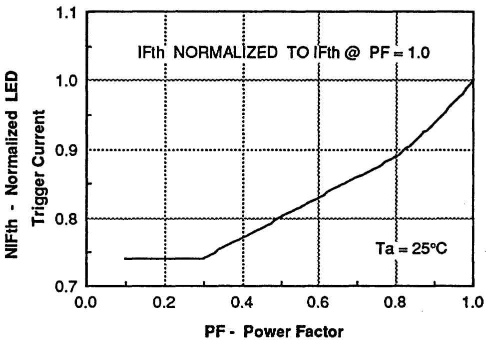


FIGURE 2. LED TRIGGER CURRENT VS. LOAD CURRENT

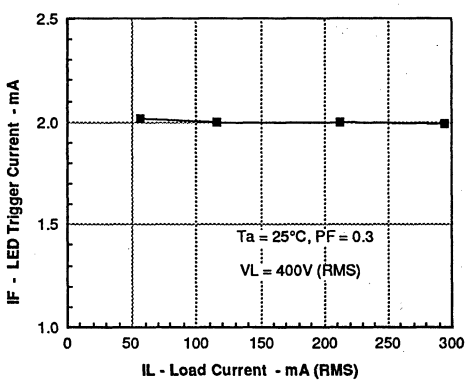
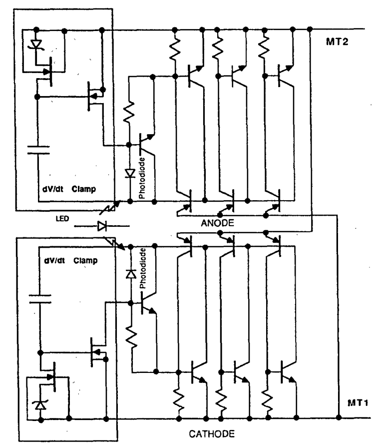
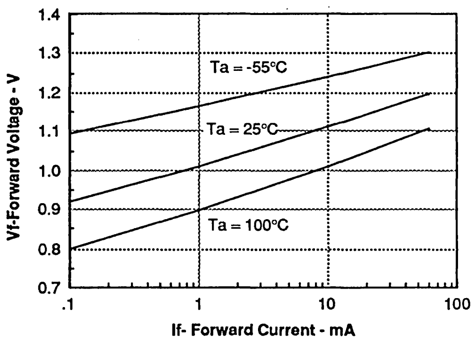


FIGURE 3. SCHEMATIC

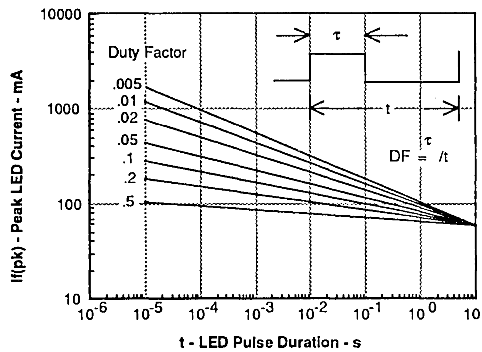


The IL420 uses two discrete SCRs resulting in a commutating dV/dt of greater than 10KV/µs. The use of a proprietary dv/dt clamp results in a static dV/dt of greater than 10KV/µs.

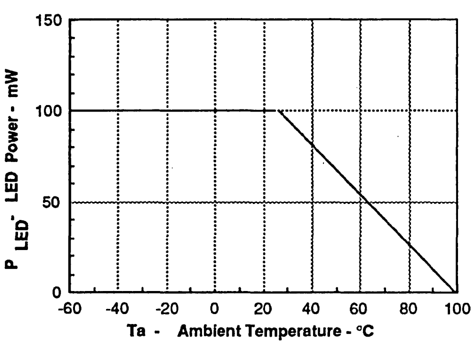
Forward voltage versus forward current



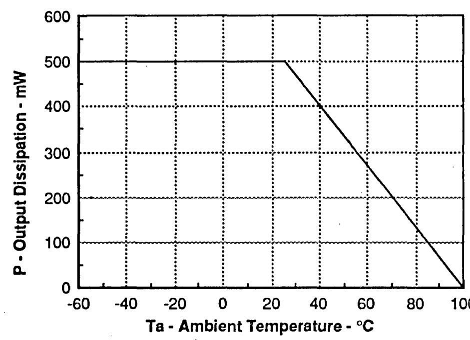
Peak LED current versus duty factor, Tau



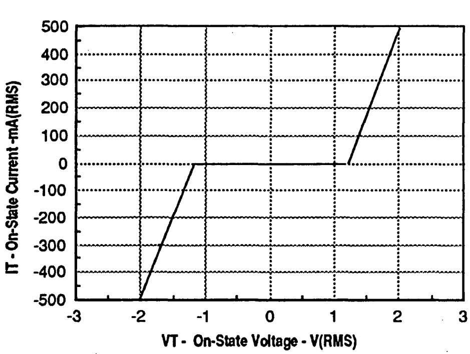
Maximum LED power dissipation



Maximum output power dissipation



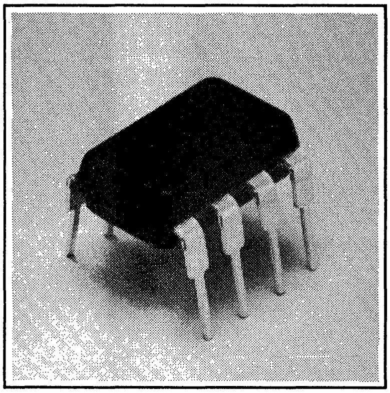
On-state terminal voltage versus terminal current



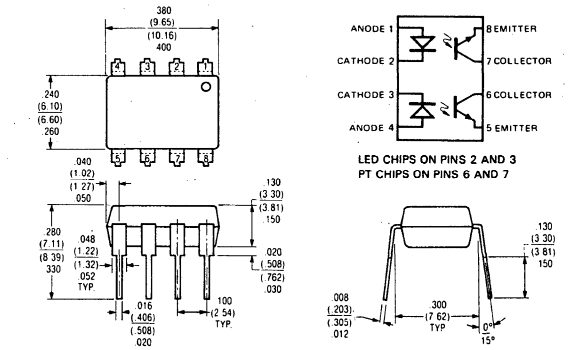
SIEMENS

ILCT6

DUAL PHOTOTRANSISTOR OPTOCOUPLER



Package Dimensions in Inches (mm)



FEATURES

- **Two Isolated Channels Per Package**
- **50% Typical Current Transfer Ratio**
- **1 nA Typical Leakage Current**
- **Direct Replacement For MCT6**
- **Underwriter Lab Approval #E52744**
- **VDE Approvals 0883/6.80, 0804/1.83**

DESCRIPTION

The ILCT6 is a two channel opto isolator for high density applications. Each channel consists of an optically coupled pair employing a Gallium Arsenide infrared LED and a silicon NPN phototransistor. Signal information, including a DC level, can be transmitted by the device while maintaining a high degree of electrical isolation between input and output. The ILCT6 is especially designed for driving medium-speed logic, where it may be used to eliminate troublesome ground loop and noise problems. It can also be used to replace relays and transformers in many digital interface applications, as well as analog applications such as CRT modulation.

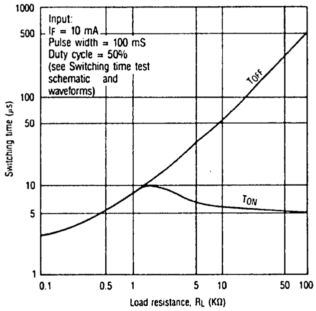
Maximum Ratings

Maximum Temperatures	
Storage Temperature	–55°C to +150°C
Operating Temperature	–55°C to +100°C
Lead Temperature (Soldering, 10 seconds)	260°C
Input Diode (each channel)	
Rated Forward Current, DC	60 mA
Peak Forward Current, DC (1μs pulse, 300 pps)	3 A
Power Dissipation at 25°C Ambient	100 mW
Derate Linearly from 25°C	1.3 mW/°C
Output Transistor (each channel)	
Power Dissipation at 25°C Ambient	150 mW
Derate Linearly from 25°C	2 mW/°C
Collector Current	30 mA
Coupled	
Isolation Test Voltage in Accordance with DIN57883/6.80	3750 VAC/5300 VDC
Creepage Path	7 mm min.
Clearance Path	7 mm min.
Tracking Index According to VDE 0303	KB100/A
Total Package Dissipation at 25°C Ambient	400 mW
Derate Linearly from 25°C	5.33 mW/°C
UL Qualified for	7500 VDC

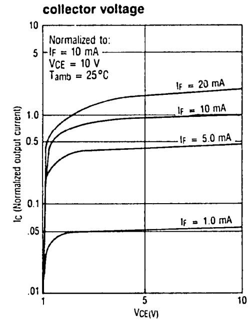
Electrical Characteristics (T_{amb} = 25°C)

	Min	Typ	Max	Unit	Conditions
Input Diode					
Rated Forward Voltage		1.25	1.50	V	I_F = 20 mA
Reverse Voltage	3.0	8.0		V	I_R = 10μA
Reverse Current		0.1	10	μA	V_R = 3.0 V
Junction Capacitance		100		pF	V_F = 0 V
Output Transistor					
Breakdown Voltage					
Collector to Emitter	30	65		V	I_C = 1.0 mA
Emitter to Collector	7.0	10		V	I_E = 100 μA
Leakage Current					
Collector to Emitter		1.0	100	nA	V_{CE} = 10 V
Capacitance Collector to Emitter		8.0		pF	V_{CE} = 0 V
Coupled					
DC Current Transfer Ratio (I_C/I_F)	20	50		%	V_{CE} = 10 V, I_F = 10 mA
Saturation Voltage					
Collector to Emitter			0.40	V	I_C = 2.0 mA, I_F = 16 mA
Isolation Resistance		10^{12}		Ω	V_{IO} = 500 V
Isolation Capacitance		0.5		pF	f = 1.0 MHz
Breakdown Voltage					
Channel-to-Channel		1500		VDC	Relative Humidity = 40%
Capacitance Between Channels		0.4		pF	f = 1.0 MHz
Bandwidth		150		KHz	I_C = 2.0 mA, V_{CC} = 10 V, R_L = 100 Ω
Switching Times					
Output Transistor t_{on}		3.0		μs	I_C = 2 mA, R_E = 100 Ω
t_{off}		3.0		μs	V_{CE} = 10 V

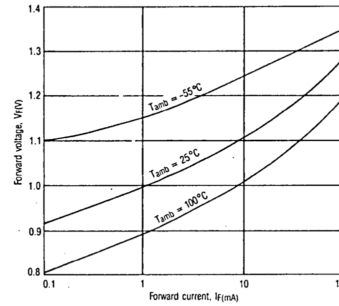
Typical switching times versus load resistance



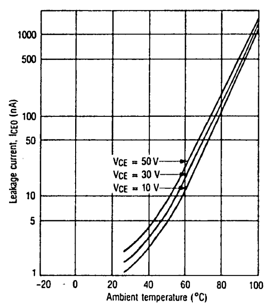
Collector current versus collector voltage



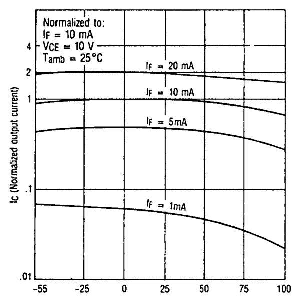
Typical forward voltage versus forward current



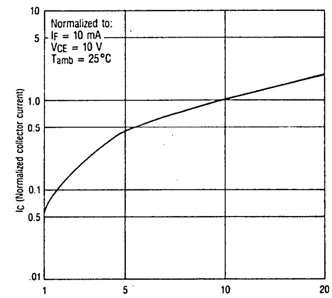
Typical leakage current versus ambient temperature



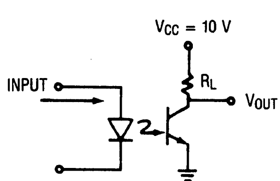
Output current versus temperature

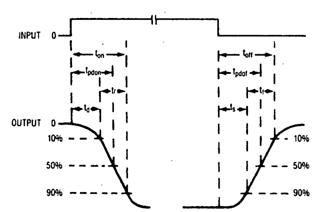


Collector current versus diode forward current



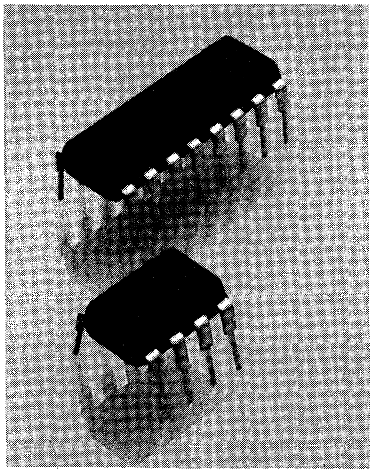
Switching time test schematic and waveforms





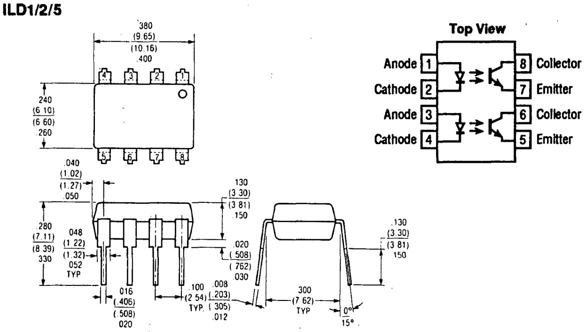
SIEMENS

DUAL CHANNEL ILD1/2/5
QUAD CHANNEL ILQ1/2/5
PHOTOTRANSISTOR OPTOCOUPLER

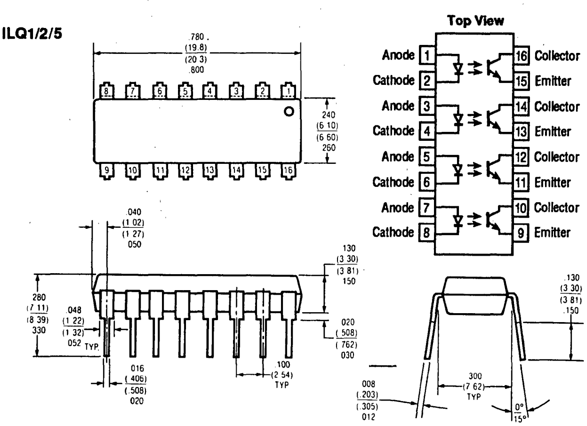


Package Dimensions in Inches (mm)

ILD1/2/5



ILQ1/2/5



FEATURES

- Current Transfer Ratio @ I_F = 10 mA
  ILD/Q1 – 20% Min.
  ILD/Q2 – 100% Min.
  ILD/Q5 – 50% Min.
- High Collector-Emitter Voltage
  ILD/Q1 – BV_{CEO} = 50 V
  ILD/Q2, ILD/Q5 – BV_{CEO} = 70 V
- Field-Effect Stable by TRansparent IOn Shield (TRIOS)*
- Double Molded Package Offers Withstand Test Voltage
  7500 VAC_{PEAK}, 1 sec.
  4420 VAC_{RMS}, 1 min.
- UL Approval #E52744
- VDE Approval #0883

DESCRIPTION

The ILD/Q1/2/5 are optically coupled isolated pairs employing GaAs infrared LEDs and silicon NPN phototransistor. Signal information, including a DC level, can be transmitted by the drive while maintaining a high degree of electrical isolation between input and output. The ILD/Q1/2/5 are especially designed for driving medium-speed logic and can be used to eliminate troublesome ground loop and noise problems. Also these couplers can be used to replace relays and transformers in many digital interface applications such as CRT modulation. The ILD1/2/5 has two isolated channels in a single DIP package and the ILQ1/2/5 has four isolated channels per package.

See Appnote 45, "How to Use Optocoupler Normalized Curves."

*TRansparent IOn Shield.

Maximum Ratings

Emitter

Reverse Voltage .... 6 V
Forward Current .... 100 mA
Surge Current .... 2.5 A
Power Dissipation .... 200 mW
Derate Linearly from 25°C .... 2.6 mW/°C

Detector

Collector-Emitter Reverse Voltage
ILD/Q1 .... 50 V
ILD/Q2, ILD/Q5 .... 70 V
Emitter-Base Reverse Voltage .... 7 V
Collector-Base Reverse Voltage .... 70 V
Collector Current .... 50 mA
Collector Current (t<1 ms) .... 400 mA
Power Dissipation .... 200 mW
Derate Linearly from 25°C .... 2.6 mW/°C

Package

Storage Temperature .... -40°C to +150°C
Operating Temperature .... -40°C to +100°C
Junction Temperature .... 100°C
Soldering Temperature (in a 2 mm distance from case bottom) .... 260°C
Package Power Dissipation .... 250 mW
Derate Linearly from 25°C .... 3.3 mW/°C
UL Withstand Test Voltage (PK) (t=1 sec.) .... 7500 VDC/5300 VAC_{RMS}
VDE Isolation Test Voltage in Accordance with DIN 57883/6.80 .... 5300 VDC/3750 VAC_{RMS}
Creepage Path .... 8 min mm
Clearance Path .... 7 min mm
Tracking Index According to VDE 0303 .... KB100/A
Working Voltage .... 1700 VAC_{RMS}
Insulation Resistance .... 10^{11} Ω

Characteristics

	Symbol	Min.	Typ.	Max.	Unit
Emitter					
Forward Voltage (I_F=60 mA)	V_F		1.25	1.65	V
Breakdown Voltage (I_R=10 µA)	V_{BR}	6	30		V
Reverse Current (V_R=6 V)	I_R		0.01	10	µA
Capacitance (V_R=0 V, f=1 MHz)	C_0		40		pF
Thermal Resistance Junction to Lead	R_{THJL}		750		°C/W
Detector					
Capacitance (V_{CE}=5 V, f=1 MHz)	C_{CE}		6.8		pF
(V_{CB}=5 V, f=1 MHz)	C_{CB}		8.5		pF
(V_{EB}=5 V, f=1 MHz)	C_{EB}		11		pF
Collector-Emitter Leakage Current (V_{CE}=10 V)	I_{CEO}		5	50	nA
Collector-Emitter Saturation Voltage (I_{CE}=1 mA, I_B=20 µA)	$V_{CE(SAT)}$		0.25	0.4	
Base-Emitter Voltage (V_{CE}=10 V, I_B=20 µA)	V_{BE}		0.65		V
DC Forward Current Gain (V_{CE}= 10 V, I_B=20 µA)	HFE	200	650	1800	
Saturated DC Forward Current Gain (V_{CE}= 0.4 V, I_B=20 µA)	HFE_{SAT}	120	400	600	
Thermal Resistance Junction to Lead	R_{THJL}		500		C°/W

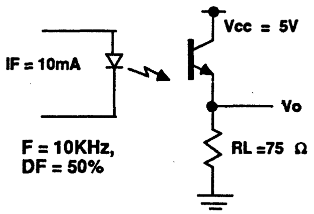
Characteristics (Cont.)

	Symbol	Min.	Typ.	Max.	Unit
Package Transfer Characteristics					
ILD/Q1					
Saturated Current Transfer Ratio (Collector-Emitter) (I_F=10 mA, V_{CE}=0.4 V)	CTR_{CESAT}		75		%
Current Transfer Ratio (Collector-Emitter) (I_F=10 mA, V_{CE}=10 V)	CTR_{CE}	20	80	300	%
Current Transfer Ratio (Collector-Base) (I_F=10 mA, V_{CB}=9.3 V)	CTR_{CB}		0.25		%
ILD/Q2					
Saturated Current Transfer Ratio (Collector-Emitter) (I_F=10 mA, V_{CE}=0.4 V)	CTR_{CESAT}		170		%
Current Transfer Ratio (Collector-Emitter) (I_F=10 mA, V_{CE}=10 V)	CTR_{CE}	100	200	500	%
Current Transfer Ratio (I_F=10 mA, V_{CB}=9.3 V)	CTR_{CB}		0.35		%
ILD/Q5					
Saturated Current Transfer Ratio (Collector-Emitter) (I_F=10 mA, V_{CE}=0.4 V)	CTR_{CESAT}		100		%
Current Transfer Ratio (Collector-Emitter) (I_F=10 mA, V_{CE}=10 V)	CTR_{CE}	50	130	400	%
Current Transfer Ratio (I_F=10 mA, V_{CB}=9.3 V)	CTR_{CB}		0.3		%
Isolation and Insulation					
Common Mode Rejection Output High (V_{CM}=50 V_{P-P}, R_L=1 kΩ, I_F=0 mA)	CMH		5000		V/µs
Common Mode Rejection Output Low (V_{CM}=50 V_{P-P}, R_L=1 kΩ, I_F=10 mA)	CML		5000		V/µs
Common Mode Coupling Capacitance	C_{CM}		0.01		pF
Package Capacitance (V_{I-O}=0 V, f=1 MHz.)	C_{I-O}	0.8			pF
Insulation Resistance (V_{I-O}=500 V)	R_S	5^{+10}	10^{+14}		Ω
Dielectric Leakage Current (V_{IO}=4420 $AC_{(RMS)}$, 1 min., 60 Hz)	I_{I-O}		3.3	10	µA
(V_{IO}=6250 VDC, 1 min.)			0.5	10	µA
(V_{IO}=5304 $AC_{(RMS)}$, 1 sec., 60 Hz)			4	10	µA
(V_{IO}=7500 VDC, 1 sec.)			0.6	12	µA

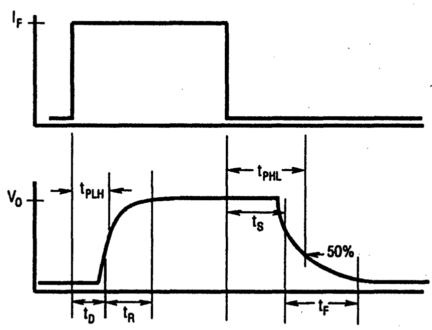
Optocouplers (Optoisolators)

SWITCHING TIMES

Non-Saturated Switching

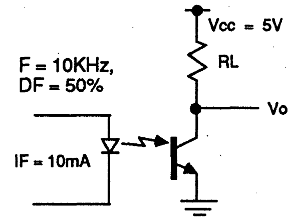


Non-Saturated Switching Timing

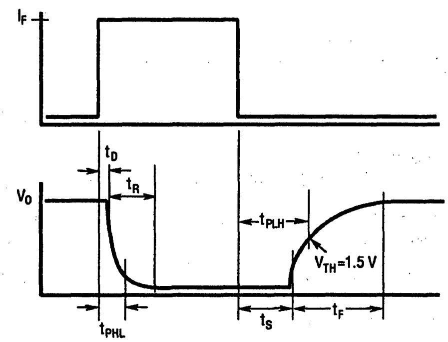


Characteristic		ILD/Q1 I_F=20 mA	ILD/Q2 I_F=5 mA	ILD/Q5 I_F=10 mA	Unit
Delay	T_D	0.8	1.7	1.7	µs
Rise Time (V_{CC}=5 V)	t_R	1.9	2.6	2.6	µs
Storage (R_L=75 Ω)	t_S	0.2	0.4	0.4	µs
Fall Time	t_F	1.4	2.2	2.2	µs
Propagation H- L (50% of V_{PP})	t_{PHL}	0.7	1.2	1.1	µs
Propagation L- H	t_{PLH}	1.4	2.3	2.5	µs

Saturated Switching

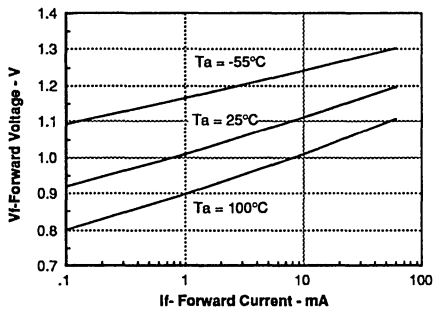


Saturated Switching Timing

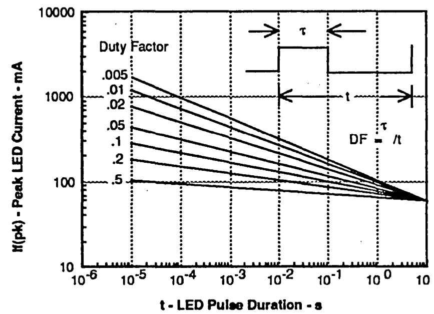


Characteristic		ILD/Q1 I_F=20 mA	ILD/Q2 I_F=5 mA	ILD/Q5 I_F=10 mA	Unit
Delay	T_D	0.8	1	1.7	µs
Rise Time (V_{CE}=0.4 V)	t_R	1.2	2	7	µs
Storage (R_L=1 kΩ)	t_S	7.4	5.4	4.6	µs
Fall Time (V_{CC}=5 V)	t_F	7.6	13.5	20	µs
Propagation H- L (V_{TH}=1.5 V)	t_{PHL}	1.6	5.4	2.6	µs
Propagation L- H	t_{PLH}	8.6	7.4	7.2	µs

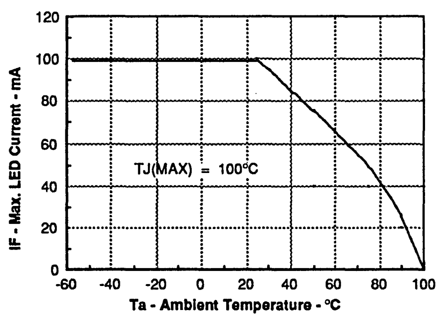
Forward voltage versus forward current



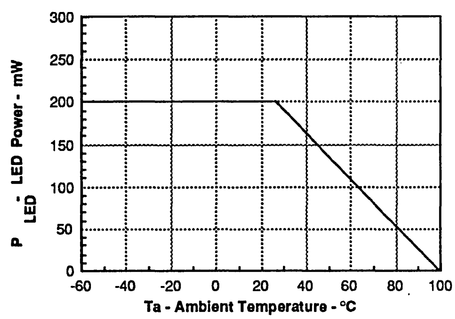
Peak LED current versus duty factor, Tau



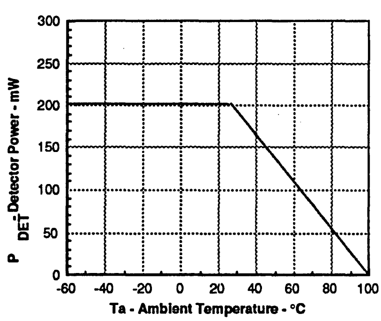
Maximum LED current versus ambient temperature



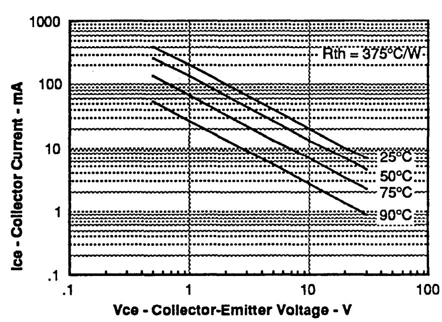
Maximum LED power dissipation



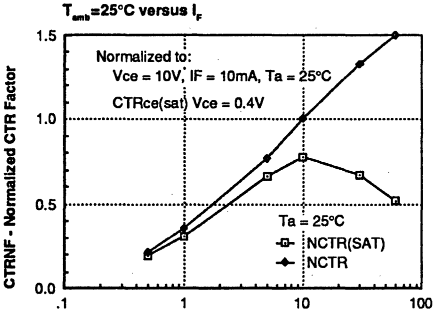
Maximum detector power dissipation



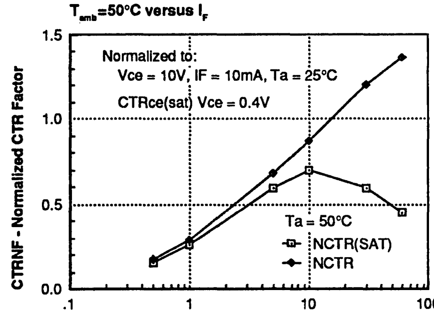
Maximum collector current versus collector voltage



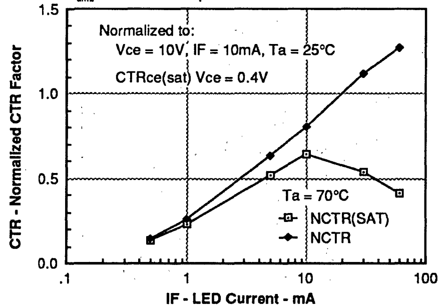
Normalization factor for non-saturated and saturated CTR T_{amb}=25°C versus I_F



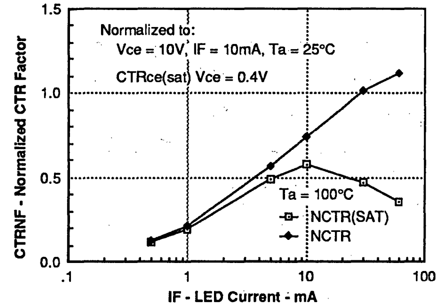
Normalization factor for non-saturated and saturated CTR T_{amb}=50°C versus I_F



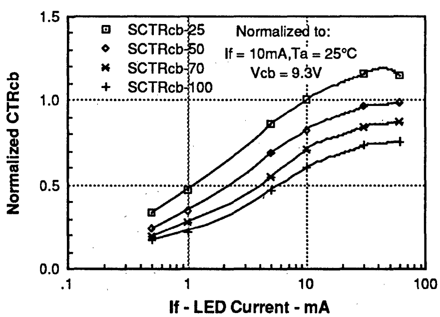
Normalization factor for non-saturated and saturated CTR T_{amb}=70°C versus I_F



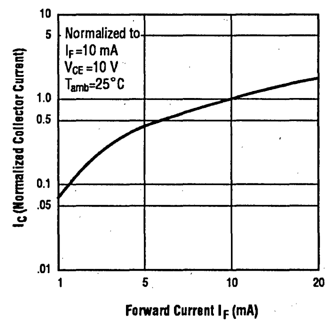
Normalization factor for non-saturated and saturated CTR T_{amb}=100°C versus I_F



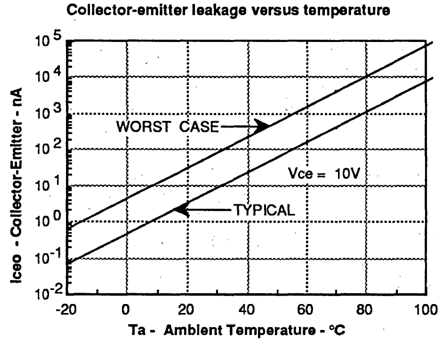
Normalized CTR_{CB} versus LED Current



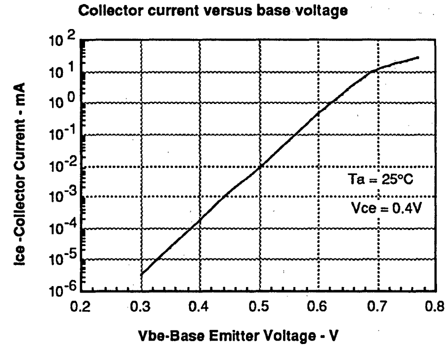
Collector current versus diode forward current



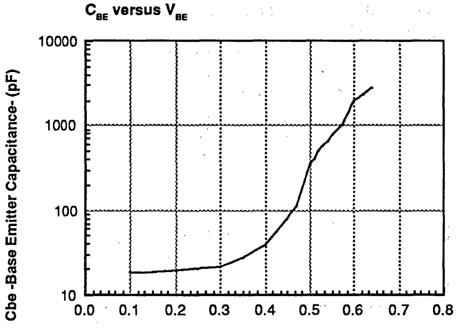
Collector-emitter leakage versus temperature



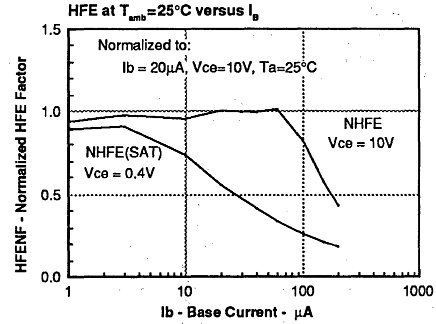
Collector current versus base voltage



C_{BE} versus V_{BE}

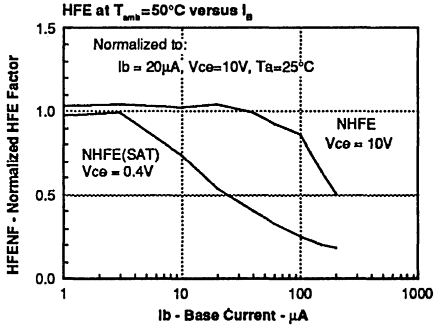


Normalization factor for non-saturated and saturated HFE at T_{amb}=25°C versus I_B

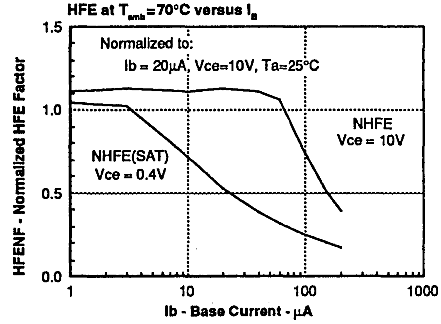


ILD/Q1/2/5

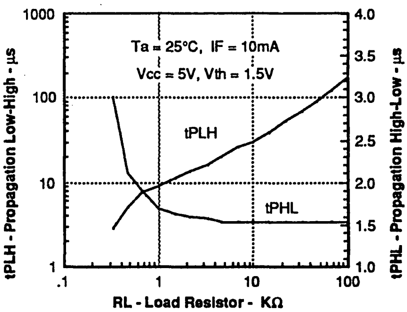
Normalization factor for non-saturated and saturated HFE at T_{amb}=50°C versus I_B



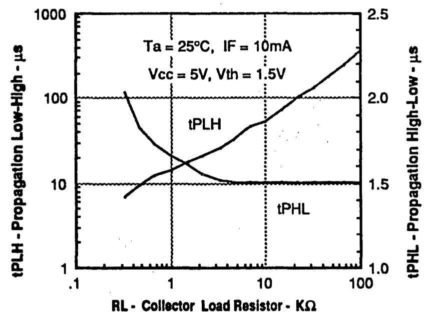
Normalization factor for non-saturated and saturated HFE at T_{amb}=70°C versus I_B



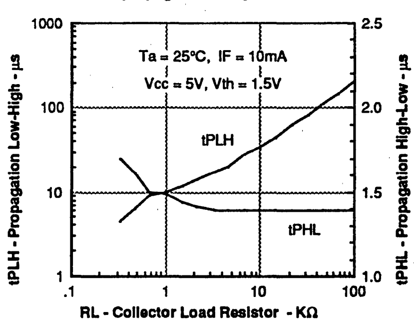
ILD/Q1 propagation delay versus collector load resistor



ILD/Q2 propagation delay versus collector load resistor



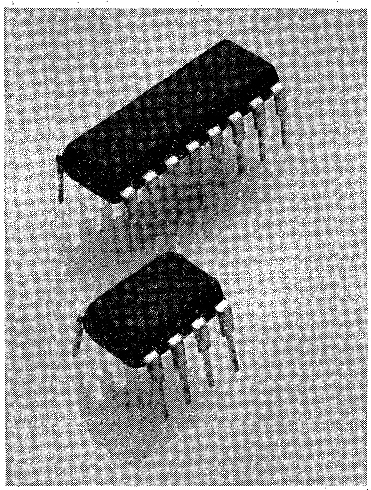
ILD/Q5 propagation delay versus collector load resistor



SIEMENS

ILD32/ILQ32

MULTI-CHANNEL PHOTODARLINGTON OPTOCOUPLER



FEATURES

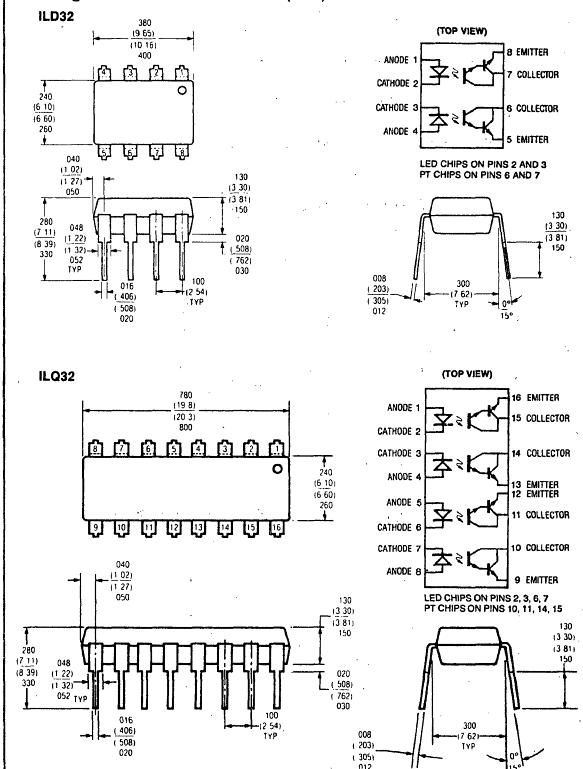
- **7500 Volt Isolation Voltage**
- **Very High Current Transfer Ratio (500% Min.)**
- **High Isolation Resistance (10^{11} Ω Typical)**
- **Low Coupling Capacitance**
- **Standard Plastic Dip Package**
- **Underwriters Lab Approval #E52744**
- **VDE Approval #0883**

DESCRIPTION

The ILD32 and ILQ32 are optically coupled isolators employing a gallium arsenide infrared emitter and a silicon photodarlington sensor. Switching can be accomplished while maintaining a high degree of isolation between driving and load circuits. They can be used to replace reed and mercury relays with advantages of long life, high speed switching, and elimination of magnetic fields.

The ILD32 offers two isolated channels in a DIP package and the ILQ32 has 4 channels. These devices can be used to replace 4N32's or 4N33's in applications calling for several single-channel couplers on a board.

Package Dimensions in Inches (mm)



Maximum Ratings: (At 25°C)

Gallium Arsenide LED (Drive Circuit)	
Power Dissipation at 25°C	150 mW
Derate Linearly from 25°C	2 mW/°C
Continuous Forward Current	80 mA
Peak Reverse Voltage	3 V
Photodarlington Sensor (Load Circuit)	
Power Dissipation at 25°C Ambient	150 mW
Derate Linearly from 25°C	2.0 mW/°C
Collector (Load) Current	125 mA
Collector-Emitter Breakdown Voltage (BV_{CEO})	30 V
Emitter-Collector Breakdown Voltage (BV_{ECO})	5 V
Package	
Total Dissipation ILD32	400 mW
ILQ32	500 mW
Derate Linearly from 25°C — ILD32	5.33 mW/°C
— ILQ32	6.67 mW/°C
Storage Temperature	−55°C to +150°C
Operating Temperature	−55°C to +100°C
Lead Soldering Time at 260°C	10 sec

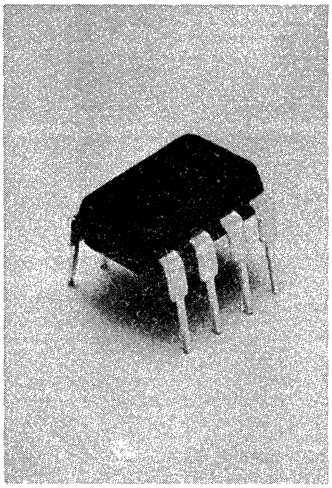
Electrical Characteristics (T_{amb} = 25°C)

Parameter	Min	Typ	Max	Unit	Test Condition
GaAs Emitter					
Forward Voltage		1.25	1.5	V	I_F = 10 mA
Reverse Current		0.1	100	μA	V_R = 3.0 V
Capacitance		100		pF	V_R = 0
Sensor					
BV_{CEO}	30			V	I_C = 100 μA, I_F = 0
BV_{ECO}	5			V	I_E = 100 μA
I_{CEO}		1.0	100	nA	V_{CE} = 10 V, I_F = 0
Coupled Characteristics					
Current Transfer Ratio	500			%	I_F = 10 mA, V_{CE} = 10 V
$V_{CE(SAT)}$			1.0	V	I_C = 2 mA, I_F = 8 mA
Isolation Resistance		10^{11}		ohm	V_{IO} = 500 V
Isolation Capacitance		1.5		pF	
Turn-on Time			5	μs	{ V_{CC} = 10 V, I_C = 50 mA
Turn-off Time			100	μs	{ I_F = 200 mA, R_L = 180 Ω
Isolation Voltage	7500			VDC	
(t = 1 sec)	5300			VAC_{RMS}	
VDE Isolation Test Voltage in Accordance with DIN 57 883/6.80	5300			VDC	
	3750			VAC_{RMS}	

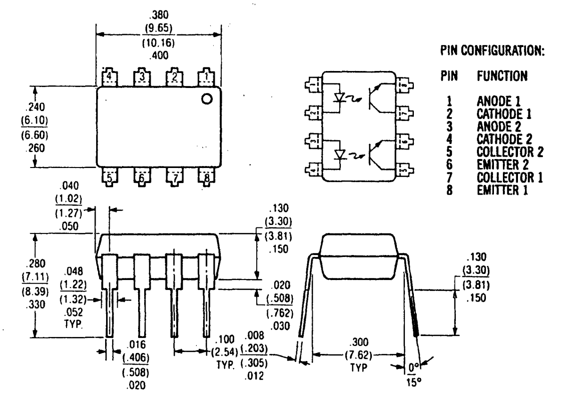
Optocouplers (Optoisolators)

SIEMENS

ILD 610 SERIES
DUAL PHOTOTRANSISTOR OPTOCOUPLER



Package Dimensions in Inches (mm)



FEATURES

- **Dual Version of SFK 610/611 Series**
- **High Current Transfer Ratios, 4 Groups**
  - **ILD 610-1 40 to 80%**
  - **ILD 610-2 63 to 125%**
  - **ILD 610-3 100 to 200%**
  - **ILD 610-4 160 to 320%**
- **7500 Volt Isolation**
- **$V_{CE\,sat}$ 0.25 (≤0.4) Volt I_F = 10 mA; I_c = 2.5 mA**
- **V_{CEO} 70 Volt**
- **100% Burn-in**
- **UL Approval #52744**

DESCRIPTION

The ILD 610 Series is a two-channel optocoupler series for high density applications. Each channel consists of an optically coupled pair employing a Gallium Arsenide infrared LED and a silicon NPN phototransistor. Signal information, including a DC level, can be transmitted by the device while maintaining a high degree of electrical isolation between input and output. The ILD 610 Series is the dual version of the SFK 610/611 Series and uses a repetitive pin-out configuration instead of more common alternating pin-out used in most dual couplers.

Maximum Ratings

Emitter (GaAs LED)			
Reverse Voltage	V_R	6	V
DC forward current	I_F	60	mA
Surge forward current (t≤10 µs)	I_{FSM}	1.5	A
Total power dissipation	P_{tot}	100	mW
Detector (silicon phototransistor)			
Collector-emitter voltage	V_{CEO}	70	V
Collector current	I_C	50	mA
Collector current (t≤1 ms)	I_{CSM}	100	mA
Total power dissipation	P_{tot}	150	mW
Optocoupler			
Storage temperature range	T_{stg}	−55... +150 °C	
Ambient temperature range	T_{amb}	−55... +100 °C	
Junction temperature	T_j	100	°C
Soldering temperature (max. 10 sec)[1]	T_{sold}	260	°C
Isolation test voltage (t = 1sec)	V_{IS}	7500	VDC
		5300	VAC (RMS)
Isolation resistance	R_{ISO}	10^{11}	Ω

[1] Dip soldering: Insertion depth <3.6 mm

CHARACTERISTICS @ T_{amb} 25°C			
Emitter (GaAs infared emitter)			
Forward voltage ($I_F = 60$ mA)	V_F	1.25 (≤1.65)	V
Breakdown voltage ($I_R = 10$ μA)	V_{BR}	30 (≥6)	V
Reverse current ($V_R = 6$ V)	I_R	0.01 (≤10)	μA
Capacitance ($V_R = 0$ V; f = 1 MHz)	C_O	25	pF
Detector (silicon phototransistor)			
Collector—emitter dark current	I_{CEO}	2	nA
Collector—emitter breakdown voltage	BV_{CEO}	70	V
Emitter—collector breakdown voltage	BV_{ECO}	7.5	V
Capacitance ($V_{CE} = 5$ V; f = 1 μHz)	C_{CE}	7	pF
Coupled			
Collector—emitter saturation voltage ($I_F = 10$ mA, $I_C = 2.5$ mA)	$V_{CE\ (sat)}$	0.25 (<0.40)	V
Coupling capacitance	C_C	0.35	pF

Group	ILD 610-1	ILD 610-2	ILD 610-3	ILD 610-4	
Current transfer ratio[1] $I_F = 10$ mA, $V_{CE} = 5$ V	40–80	63–125	100–200	160–320	%
Current transfer ratio[1] $I_F = 1$ ma, $V_{CE} = 5$ V	13 min.	22 min.	34 min.	56 min.	%
I_{CEO} ($V_{CE} = 10$ V)	2 (≤50)	2 (≤50)	5 (≤100)	5 (≤100)	nA

CTR will match within a ratio of 1.7:1

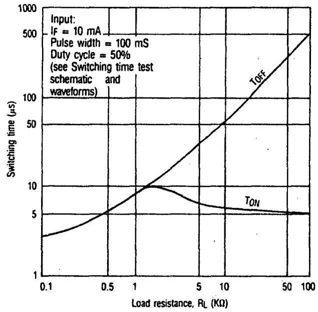
Switching Characteristics
Linear Operation (without saturation) I_F10 mA, $V_{CC} = 5$ V, $R_C = 75\ \Omega$

Group		ILD 610-1	ILD 610-2	ILD 610-3	ILD 610-4	
Turn on time	t_{on}	3.0 (<5.6)	3.2 (<5.6)	3.6 (<5.6)	4.1 (<5.6)	μs
Rise time	t_r	2.0 (<4.0)	2.5 (<4.0)	2.9 (<4.0)	3.3 (<4.0)	μs
Turn off time	t_{off}	2.3 (<4.1)	2.9 (<4.1)	3.4 (<4.1)	3.7 (<4.1)	μs
Fall time	t_f	2.0 (<3.5)	2.6 (<3.5)	3.1 (<3.5)	3.5 (<3.5)	μs

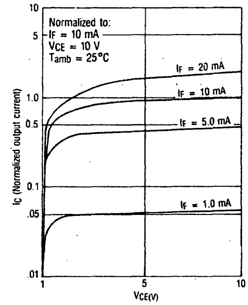
Switching operation (with saturation) $V_{CC} = 5$ V, $R_C = 1$ KΩ

Group		ILD 610-1 $I_F = 20$ mA	ILD 610-2 $I_F = 10$ mA	ILD 610-3 $I_F = 10$ mA	ILD 610-4 $I_F = 5$ mA	
Turn on time	t_{on}	3.0 (<5.5)	4.3 (<8.0)	4.6 (<8.0)	6.0 (<10.5)	μs
Rise time	t_r	2.0 (<4.0)	2.8 (<6.0)	3.3 (<6.0)	4.6 (<8.0)	μs
Turn off time	t_{off}	18 (<34)	24 (<39)	25 (<39)	25 (<43)	μs
Fall time	t_f	11 (<20)	11 (<24)	15 (<24)	15 (<26)	μs

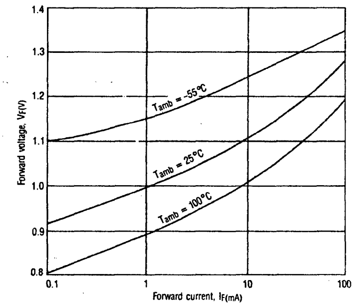
Typical switching times versus load resistance



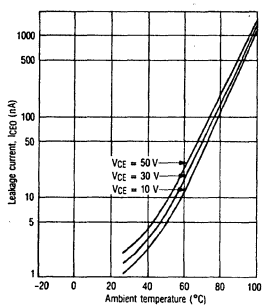
Collector current versus collector voltage



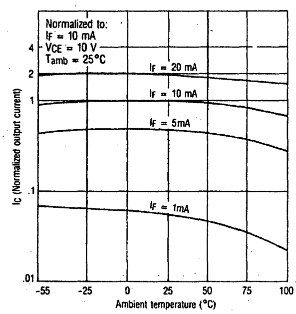
Typical forward voltage versus forward current



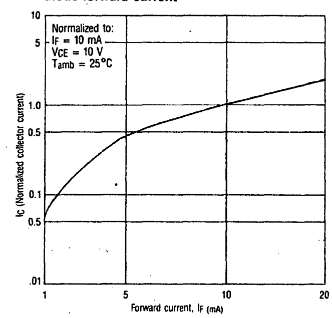
Typical leakage current versus ambient temperature



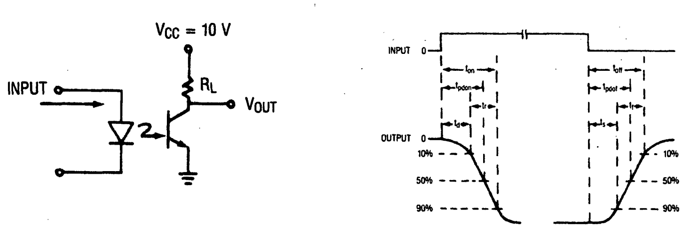
Output current versus temperature



Collector current versus diode forward current



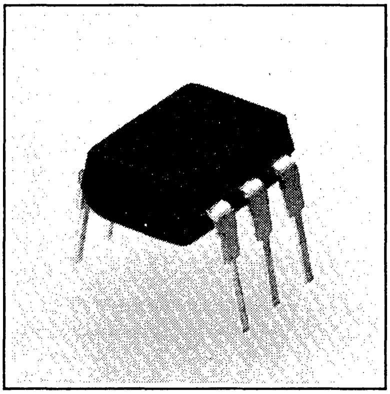
Switching time test schematic and waveforms



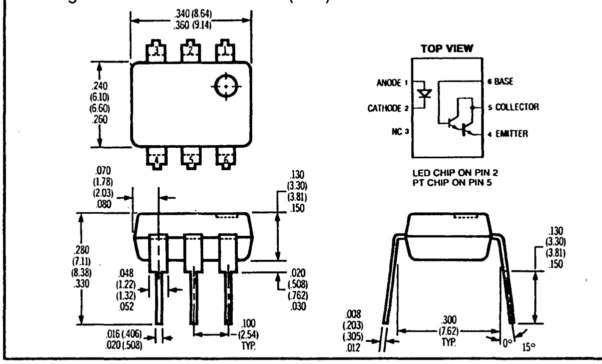
SIEMENS

MCA230/231/255

PHOTODARLINGTON OPTOCOUPLER



Package Dimensions in Inches (mm)



FEATURES

- **7500 Volt Withstand Test Voltage**
- **0.5 pF Coupling Capacitance**
- **CTR Minimum: MCA230/255 -100%**
  MCA231 - 200%
- **Fast Rise Time - 10 μs**
- **Fast Fall Time - 35 μs**
- **Underwriters Lab Approval #E52744**

DESCRIPTION

The MCA230/231/255 are industry standard optocouplers, consisting of a GaAs infrared LED and a silicon photo Darlington transistor. These optocouplers are constructed with a high voltage insulation, double molded packaging process which offers 7.5 KV withstand test capability.

Maximum Ratings

Gallium Arsenide LED	
Power Dissipation at 25°C	135 mW
Derate Linearly from 25°C	1.8 mW/°C
Continuous Forward Current	60 mA
Reverse Voltage	6 V
Detector Silicon Phototransistor	
Power Dissipation at 25°C	210 mW
Derate Linearly from 25°C	2.8 mW/°C
Collector-Emitter Breakdown	
MCA230	30 V
MCA231	30 V
MCA255	55 V
Emitter-Collector Breakdown	7 V
Collector-Base Breakdown	
MCA230	30 V
MCA231	30 V
MCA255	55 V
Package	
Total Package Dissipation at 25°C (LED plus Detector)	260 mW
Derate Linearly from 25°C	3.5 mW/°C
Storage Temperature	–55 to +150°C
Operating Temperature	–55 to +100°C
Lead Soldering Time at 260 °C	10 sec

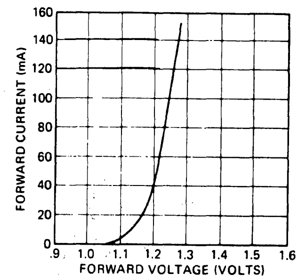
Electrical Characteristics ($T_{amb}=25°C$)

	Min	Typ	Max	Unit	Conditions
Gallium Arsenide LED					
Forward Voltage		1.1	1.5	V	$I_F=20$ mA
Reverse Current			10	μA	$V_F=3$ V
Junction Capacitance		50		pF	$V_F=0$ V, f=1 MHz
Phototransistor Detector					
BV_{CEO}					
MCA230	30			V	$I_C=100$ μA, $I_F=0$ mA
MCA231	30			V	$I_C=100$ μA, $I_F=0$ mA
MCA255	55			V	$I_C=100$ μA, $I_F=0$ mA
BV_{ECO}	5			V	$I_E=10$ μA, $I_F=0$ mA
BV_{CBO}					
MCA230	30			V	$I_C=10$ μA, $I_F=0$ mA
MCA231	30			V	$I_C=10$ μA, $I_F=0$ mA
MCA255	55			V	$I_C=10$ μA, $I_F=0$ mA
I_{CEO}			100	nA	$V_{CE}=10$ V, $I_F=0$ mA
Coupled Characteristics					
$V_{CE\ (sat)}$				V	$I_{CE}=2$ mA, $I_F=16$ mA
MCA230/231/255			1.0	V	$I_C=I_F=50$ mA
			1.0	V	$I_C=2$ mA, $I_F=1$ mA
			1.0	V	$I_C=10$ mA, $I_F=5$ mA
			1.2	V	$I_C=50$ mA, $I_F=10$ mA
DC Current Transfer Ratio					
MCA230, MCA255	100			%	$V_{CE}=5$ V, $I_F=10$ mA
MCA231	200			%	$V_{CE}=5$ V, $I_F=10$ mA
Capacitance Input to Output		0.5		pF	
Withstand Test Voltage	7500			VDC	t=1 sec
	5300			VAC_{RMS}	t=1 sec
Resistance Input to Output		100		GΩ	
Switching Times					
t_{on}		10		μs	$R_E=100$ Ω, $V_{CE}=10$ V
t_{off}		35		μs	

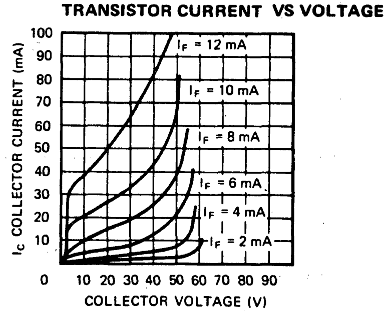
Specifications are subject to change without notice.

TYPICAL OPTOELECTRONIC CHARACTERISTIC CURVES

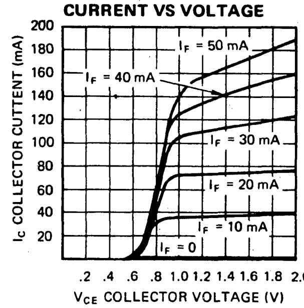
GaAs EMITTER: FORWARD CURRENT – VOLTAGE CHARACTERISTICS



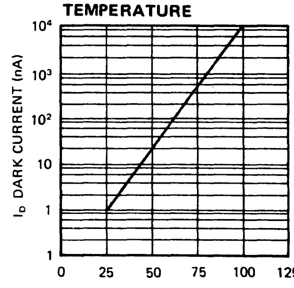
DARLINGTON TRANSISTOR CURRENT VS VOLTAGE



DARLINGTON TRANSISTOR OUTPUT CURRENT VS VOLTAGE



DARK CURRENT VS TEMPERATURE

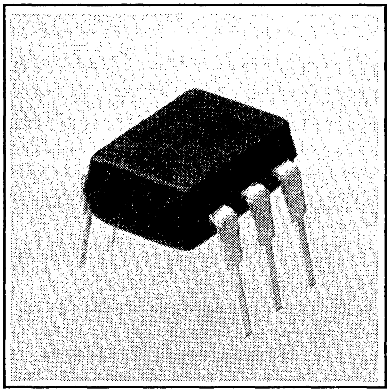


MCA230/231/255

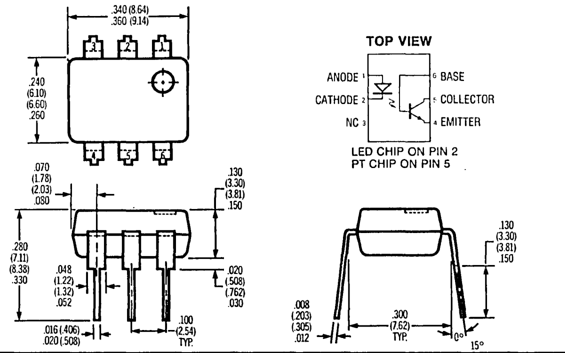
SIEMENS

MCT2/MCT2E

PHOTOTRANSISTOR OPTOCOUPLER



Package Dimensions in Inches (mm)



FEATURES

- **7500 Volt Withstand Test Voltage**
- **0.5 pF Coupling Capacitance**
- **CTR Minimum: 20%**
- **Underwriters Lab Approval #E52744**

DESCRIPTION

The MCT2 and MCT2E are industry standard optocouplers, consisting of a GaAs infrared LED and a silicon phototransistor. These optocouplers are constructed with a high voltage insulation, double molded packaging process which offers 7.5 KV withstand test capability.

Maximum Ratings

Gallium Arsenide LED
- Power Dissipation at 25°C .... 200 mW
- Derate Linearly from 25°C .... 2.6 mW/°C
- Continuous Forward Current .... 60 mA
- Reverse Voltage .... 3 V

Detector Silicon Phototransistor (each channel)
- Power Dissipation at 25°C .... 200 mW
- Derate Linearly from 25°C .... 2.6 mW/°C
- Collector-Emitter Breakdown .... 30 V
- Emitter-Collector Breakdown .... 7 V
- Collector-Base Breakdown .... 70 V

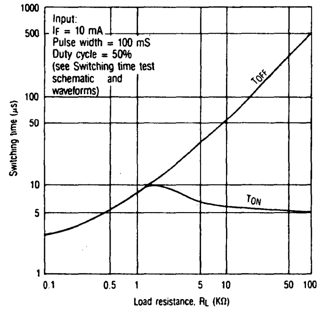
Package
- Total Package Dissipation at 25°C (LED plus Detector) .... 250 mW
- Derate Linearly from 25°C .... 3.3 mW/°C

Storage Temperature .... –55 to +150°C
Operating Temperature .... –55 to +100°C
Lead Soldering Time at 260 °C .... 10 sec

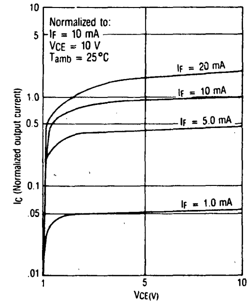
Electrical Characteristics (T_{amb} = 25°C)

	Min	Typ	Max	Unit	Conditions
Gallium Arsenide LED					
Forward Voltage		1.1	1.5	V	I_F = 20 mA
Reverse Current			10	μA	V_F = 3 V
Junction Capacitance		50		pF	V_F = 0 V, f = 1 MHz
Phototransistor Detector					
BV_{CEO}	30			V	I_C = 1 mA, I_F = 0 mA
BV_{ECO}	7			V	I_E = 100 μA, I_F = 0 mA
BV_{CBO}	70			V	I_C = 10 μA, I_F = 0 mA
I_{CEO}		5	50	nA	V_{CE} = 10 V, I_F = 0 mA
I_{CBO}			20	nA	V_{CE} = 10 V, I_F = 0 mA
Collector-Emitter Capacitance		2		pF	V_{CB} = 0
Coupled Characteristics					
$V_{CE\ (sat)}$		0.1	0.4	V	I_{CE} = 2 mA, I_F = 16 mA
DC Current Transfer Ratio	20	60		%	V_{CE} = 10 V, I_F = 10 mA
Capacitance Input to Output		0.5		pF	
Withstand Test Voltage	7500			VDC	t = 1 sec
Resistance Input to Output		100		GΩ	
Switching Times					
t_{on}		3.0		μs	R_E = 100 Ω, V_{CE} = 10 V
t_{off}		3.0		μs	I_C = 2 mA

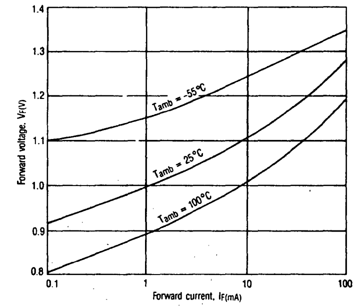
Typical switching times versus load resistance



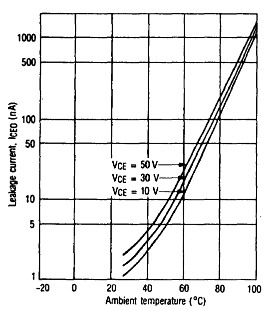
Collector current versus collector voltage



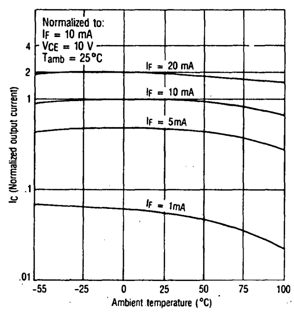
Typical forward voltage versus forward current



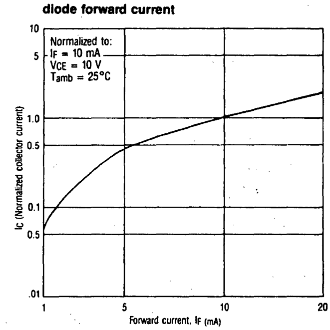
Typical leakage current versus ambient temperature



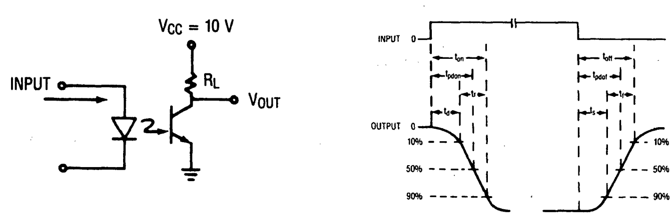
Output current versus temperature



Collector current versus diode forward current



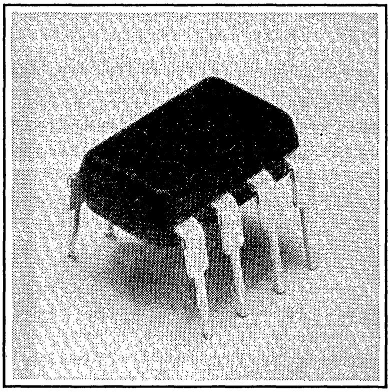
Switching time test schematic and waveforms



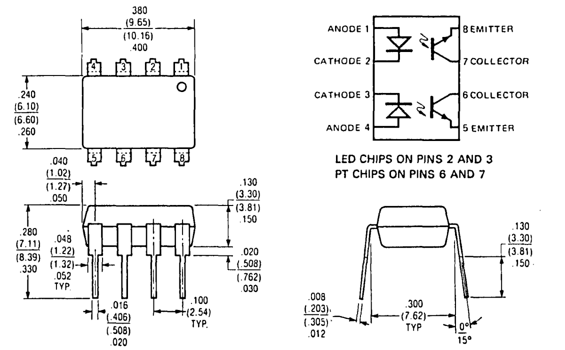
SIEMENS

MCT6

DUAL PHOTOTRANSISTOR OPTOCOUPLER



Package Dimensions in Inches (mm)



FEATURES

- **Two Isolated Channels per Package**
- **7500 Volt Withstand Test Voltage**
- **CTR Minimum: 20%**
- **Underwriters Lab Approval #E52744**

DESCRIPTION

The MCT6 is an industry standard dual optocoupler, consisting of a GaAs infrared LED and a silicon phototransistor per channel. The MCT6 is constructed with a high voltage insulation, double molded packaging process which offers 7.5 KV withstand test capability.

Maximum Ratings

Gallium Arsenide LED (each channel)
- Power Dissipation at 25°C . . . . 100 mW
- Derate Linearly from 25°C . . . . 1.3 mW/°C
- Continuous Forward Current . . . . 60 mA
- Reverse Voltage . . . . 3 V

Detector Silicon Phototransistor (each channel)
- Power Dissipation at 25°C . . . . 150 mW
- Derate Linearly from 25°C . . . . 2 mW/°C
- Collector-Emitter Breakdown . . . . 30 V
- Emitter-Collector Breakdown . . . . 6 V
- Collector-Base Breakdown . . . . 30 V

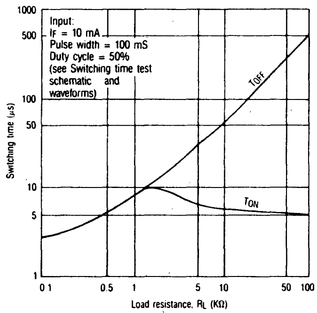
Package
- Total Package Dissipation at 25°C (LED plus Detector) . . . . 400 mW
- Derate Linearly from 25°C . . . . 5.33 mW/°C

Storage Temperature . . . . –55 to +150°C
Operating Temperature . . . . –55 to +100°C
Lead Soldering Time at 260 °C . . . . 10 sec

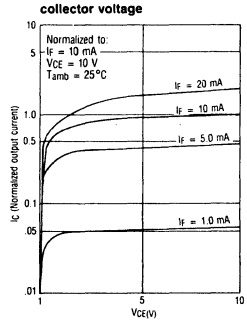
Electrical Characteristics (T_{amb}=25°C)

	Min	Typ	Max	Unit	Conditions
Gallium Arsenide LED					
Forward Voltage		1.1	1.5	V	I_F=20 mA
Reverse Current			10	μA	V_F=3 V
Junction Capacitance		50		pF	V_F=0 V, f=1 MHz
Phototransistor Detector					
BV_{CEO}	30			V	I_C=100 μA, I_F=0 mA
BV_{ECO}	6			V	I_E=100 μA, I_F=0 mA
BV_{CBO}	30			V	I_C=10 μA, I_F=0 mA
I_{CEO}			100	nA	V_{CE}=10 V, I_F=0 mA
Coupled Characteristics					
$V_{CE\ (sat)}$			0.4	V	I_{CE}=2 mA, I_F=16 mA
DC Current Transfer Ratio	20	50		%	V_{CE}=10 V, I_F=10 mA
Capacitance Input to Output		0.5		pF	
Withstand Test Voltage	7500			VDC	t=1 sec
	5300			VAC_{RMS}	t=1 sec
Resistance Input to Output		100		GΩ	
Switching Times					
t_{on}		3		μs	R_E=100 Ω, V_{CE}=10 V
t_{off}		15		μs	I_C=2 mA

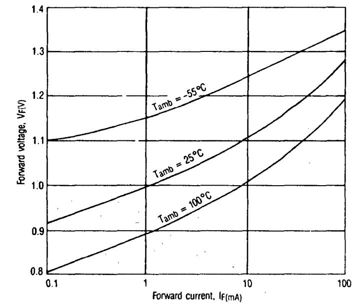
Typical switching times versus load resistance



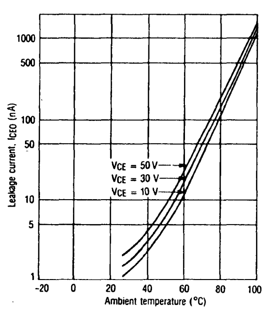
Collector current versus collector voltage



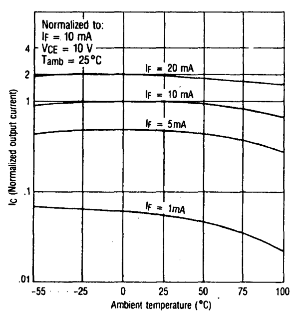
Typical forward voltage versus forward current



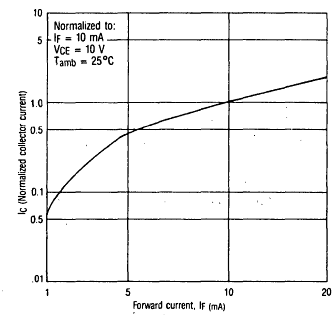
Typical leakage current versus ambient temperature



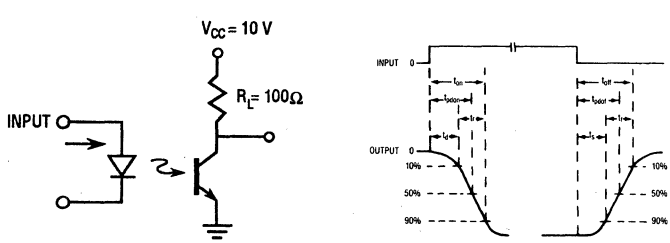
Output current versus temperature



Collector current versus diode forward current



Switching time test schematic and waveforms

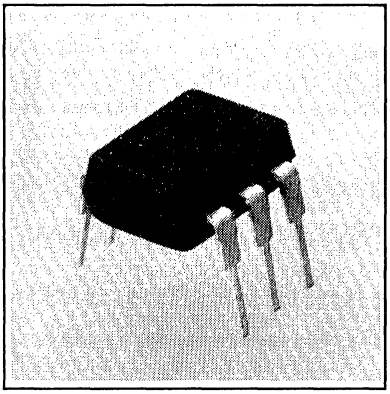


MCT6

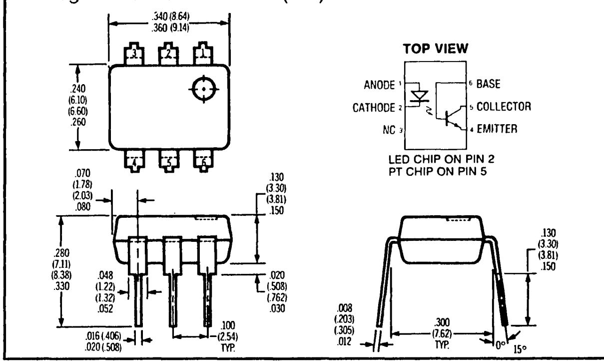
SIEMENS

MCT270 thru MCT277

PHOTOTRANSISTOR OPTOCOUPLER



Package Dimensions in Inches (mm)



FEATURES

- **7500 Volt Withstand Test Voltage**
- **0.5 pF Coupling Capacitance**
- **CTR Minimum: MCT270 – 50%**
  MCT271 – 45%
  MCT272 – 75%
  MCT273 – 125%
  MCT274 – 225%
  MCT275 – 70%
  MCT276 – 15%
  MCT277 – 100%
- **Underwriters Lab Approval #E52744**

DESCRIPTION

The MCT270 through MCT277 are industry standard optocouplers, consisting of a GaAs infrared LED and a silicon phototransistor. These optocouplers are constructed with a high voltage insulation, double molded packaging process which offers 7.5 KV withstand test capability.

Maximum Ratings

Gallium Arsenide LED
- Power Dissipation at 25°C .... 100 mW
- Derate Linearly from 25°C .... 1.33 mW/°C
- Continuous Forward Current .... 60 mA
- Reverse Voltage .... 3 V

Detector Silicon Phototransistor
- Power Dissipation at 25°C .... 150 mW
- Derate Linearly from 25°C .... 2 mW/°C
- Collector-Emitter Breakdown .... 30 V
- Emitter-Collector Breakdown .... 7 V
- Collector-Base Breakdown .... 70 V

Package
- Total Package Dissipation at 25°C (LED plus Detector) .... 250 mW
- Derate Linearly from 25°C .... 3.3 mW/°C

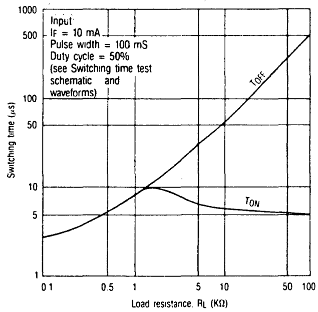
Storage Temperature .... -55 to +150°C
Operating Temperature .... -55 to +100°C
Lead Soldering Time at 260 °C .... 10 sec

Electrical Characteristics (T_{amb} = 25°C)

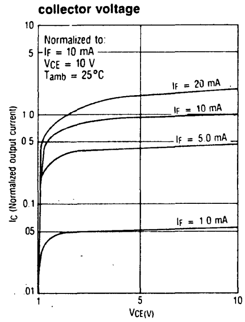
	Min	Typ	Max	Unit	Conditions
Gallium Arsenide LED					
Forward Voltage			1.5	V	I_F = 20 mA
Reverse Current			10	μA	V_F = 3 V
Junction Capacitance		50		pF	V_F = 0 V, f = 1 MHz
Phototransistor Detector					
BV_{CEO}	30			V	I_C = 1.0 mA, I_F = 0 mA
BV_{EBO}	5			V	I_E = 100 μA, I_F = 0 mA
BV_{CBO}	70			V	I_C = 10 μA, I_F = 0 mA
I_{CEO}			50	nA	V_{CE} = 10 V, I_F = 0 mA
Coupled Characteristics					
$V_{CE\,(sat)}$			0.4	V	I_C = 2 mA, I_F = 16 mA
DC Current Transfer Ratio				%	V_{CE} = 10 V, I_F = 10 mA
MCT270	50				
MCT271	45		90		
MCT272	75		150		
MCT273	125		250		
MCT274	225		400		
MCT275	70		210		
MCT276	15		60		
MCT277	100				
CTR_{CE} min. = 12.5% @V_{CE} = 0.4 V, I_F = 16 mA MCT271-276					
CTR_{CE} min. = 40% @V_{CE} = 0.4 V, I_F = 16 mA MCT277					
Capacitance Input to Output		0.5		pF	f = 1 MHz
Withstand Test Voltage	7500			VAC_{PEAK}	I_{IO} ≤ 10μA, t = 5 sec.,
	5300			VAC_{RMS}	RH ≤ 50%
Resistance Input to Output		100		GΩ	V_{I-O} = 500 VDC
Switching Times t_{on}, t_{off}:				μs	R_L = 100 Ω, V_{CC} = 5 V
MCT270, 272			10		I_C = 2 mA
MCT271			7		
MCT273			20		
MCT274			25		
MCT275, 277			15		
MCT276			3.5		

Optocouplers (Optoisolators)

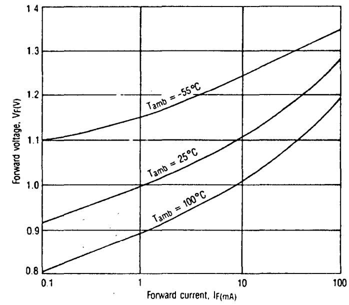
Typical switching times versus load resistance



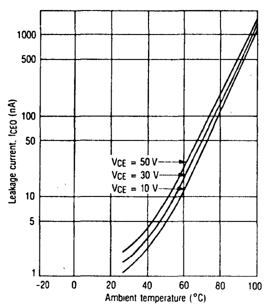
Collector current versus collector voltage



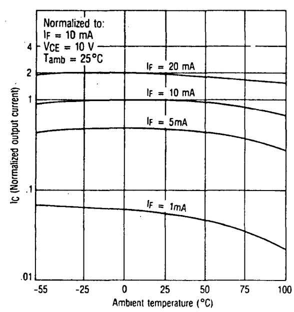
Typical forward voltage versus forward current



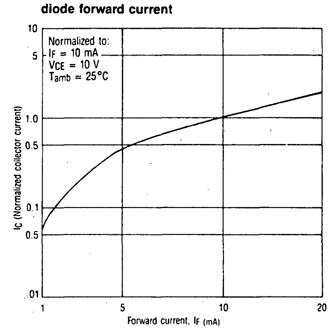
Typical leakage current versus ambient temperature



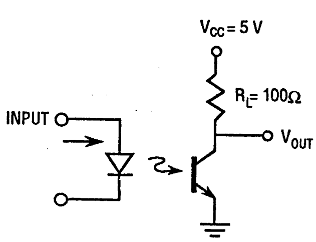
Output current versus temperature

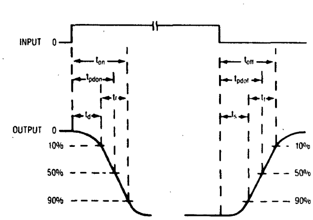


Collector current versus diode forward current



Switching time test schematic and waveforms



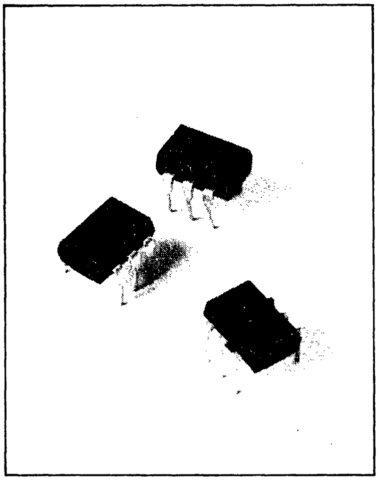


Pulse width = 100 µs
Duty Cycle = 10%

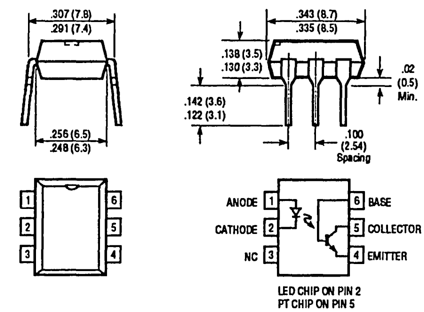
SIEMENS

SFH600 SERIES

PHOTOTRANSISTOR OPTOCOUPLER



Package Dimension in Inches (mm)



Optocouplers (Optoisolators)

FEATURES

- High Quality Premium Device
- Long Term Stability
- High Current Transfer Ratio, 4 Groups
  SFH 600-0, 40 to 80%
  SFH 600-1, 63 to 125%
  SFH 600-2, 100 to 200%
  SFH 600-3, 160 to 320%
- 5300 Volt Isolation (1 Minute)
- Storage Temperature −55 to +150° C
- VCE SAT 0.25 (<0.4) Volt
  I_F = 10 mA, I_C = 2.5 mA
- UL Approval #E52744
- VDE Approval #0883
- VDE Approval #0884 (Optional with Option 1, add -X001 suffix)

DESCRIPTION

The optoelectronic coupler SFH 600 comprises a GaAs LED as the emitter which is optically coupled with a silicon planar phototransistor as the detector. The component is located in a plastic plug-in case 20 AB DIN 41866.

The coupler allows to transfer signals between two electrically isolated circuits. The potential difference between the circuits to be coupled is not allowed to exceed the maximum permissable insulating voltage.

Maximum Ratings

Reverse Voltage (V_R)	6 V
Forward Current (I_F)	60 mA
Surge Current (I_{FS}), t_p = 10 μs	2.5 A
Power Dissipation (P_{tot})	100 mW
Detector (Silicon Phototransistor)	
Collector-Emitter Voltage (V_{CEO})	70 V
Emitter-Base Reverse Voltage (V_{EBO})	7 V
Collector Current (I_C)	50 mA
Collector Current (I_{CS}), t = 1 ms	100 mA
Power Dissipation (P_{tot})	150 mW
Coupler	
Storage Temperature (T_{stor})	−55 to +150°C
Ambient Temperature (T_{amb})	−55 to +100°C
Junction Temperature (T_j)	100°C
Soldering Temperature (T_L), 1 Min.	260°C
Isolation Test Voltage (1 Min.) (V_{is}) (between emitter and detector referred to standard climate 23/50 DIN 50014)	5300 V
Tracking Resistance	Min. 8.2 mm
Air Path	Min. 7.3 mm

Tracking Resistance
Group III (KC = >600) in accordance with VDE0110 § 6
Table 3 and DIN 53480/VDE0303, Part 1
As to nominal isolation voltage VDE 0883 applies.

Isolation Resistance (R_{is}) at V_{is} = 500 V .... 10^{11} Ω

Climatic Conditions
DIN 40040, Humidity Class F

Flammability
DIN57471 or VDE0471, Part 2, of April 1975 or MIL-202E, Method 11A

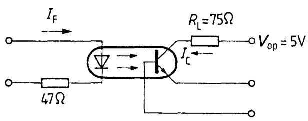
Characteristics (T_{amb} = 25 °C)

Emitter (GaAs LED)	
Forward Voltage (V_F), I_F = 60 mA	1.25 (≤1.65) V
Breakdown Voltage (V_{BR}), I_R = 100 μA	30 (≥6) V
Reverse Current (I_R), V_R = 3 V	0.01 (≤10) μA
Capacitance (C_O), V_R = 0V, f = 1 MHz	40 pF
Thermal Resistance ($R_{th\ Jamb}$)	750 K/W
Detector (Silicon Phototransistor)	
Capacitance, (V_{CE} = 5 V, f = 1 MHz)	
C_{CE}	5.2 pF
C_{CB}	6.5 pF
C_{EB}	9.5 pF
Thermal Resistance ($R_{th\ Jamb}$)	500 K/W
Coupler	
Collector-Emitter Saturation Voltage ($V_{CE\ sat}$) I_f = 10 mA, I_C = 2.5 mA	0.25 (≤0.4) V
Coupling Capacitance (C_K)	0.55 pF

The optocouplers are grouped according to their current transfer ratio I_C/I_F at V_{CE}=5 V, marked by dash numbers.

	–0	–1	–2	–3	
I_C/I_F (I_F=10 mA)	40–80	63–125	100–200	160–320	%
I_C/I_F (I_F=1 mA)	30 (>13)	45 (>22)	70 (>34)	90 (>56)	%
Collector-Emitter Leakage Current (V_{CE}=10 V) (I_{CEO})	2 (≤35)	2 (≤35)	5 (≤35)	5 (≤70)	nA

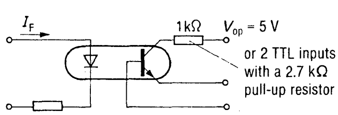
Linear Operation (without saturation)

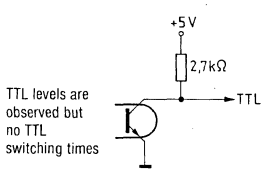


I_F=10 mA, V_{OP}=5 V, T_{amb}=25°C

Load Resistance	R_L	75	Ω
Turn-On Time	t_{ON}	3.2 (≤4.6)	µs
Rise Time	t_R	2.0 (≤3.0)	µs
Turn-Off Time	t_{OFF}	3.0 (≤4.0)	µs
Fall Time	t_F	2.5 (≤3.3)	µs
Cut-Off Frequency	F_{CO}	250	kHz

Switching Operation (with saturation)

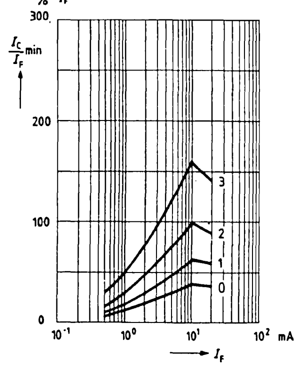




Group	–0 (I_F=20 mA)	–1 and –2 (I_F=10 mA)	–3 (I_F=5 mA)	
Turn-On Time t_{ON}	3.7 (≤5.8)	4.5 (≤6.2)	5.8 (≤8.0)	µs
Rise Time t_R	2.5 (≤4.0)	3.0 (≤4.2)	4.0 (≤5.5)	µs
Turn-Off Time t_{OFF}	19 (≤25)	21 (≤27)	24 (≤31)	µs
Fall Time t_F	11 (≤14)	12 (≤15)	14 (≤18)	µs
V_{CESAT}	0.25 (≤0.4)			V

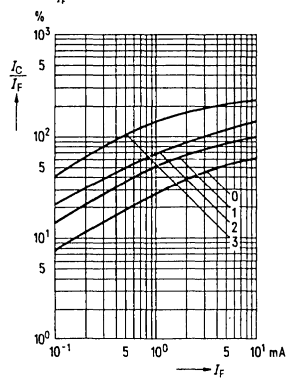
Minimum current transfer ratio as a function of diode current (T_{amb} = 25°C, V_{CE} = 5 V)

$\frac{I_C}{I_F} = f(I_F)$



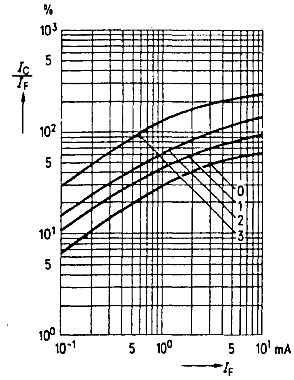
Current transfer ratio as a function of diode current (T_{amb} = −25°C)

$\frac{I_C}{I_F} = f(I_F)$ V_{CE} = 5 V



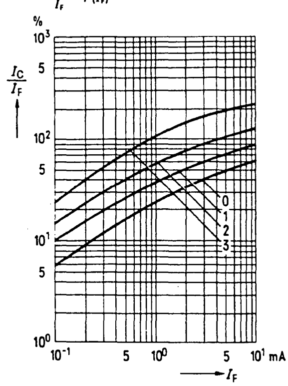
Current transfer ratio as a function of diode current (T_{amb} = 0°C)

$\frac{I_C}{I_F} = f(I_F)$ V_{CE} = 5 V



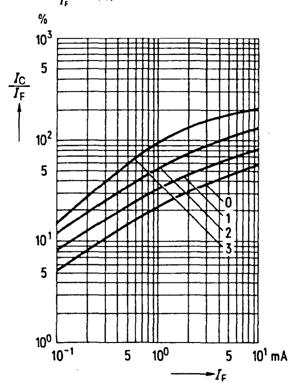
Current transfer ratio as a function of diode current (T_{amb} = 25°C)

$\frac{I_C}{I_F} = f(I_F)$ V_{CE} = 5 V



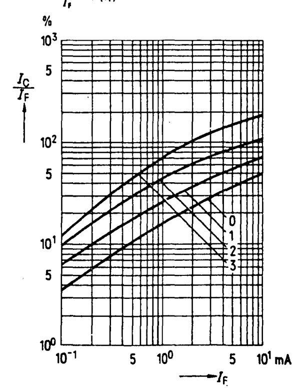
Current transfer ratio as a function of diode current (T_{amb} = 50°C)

$\frac{I_C}{I_F} = f(I_F)$ V_{CE} = 5 V



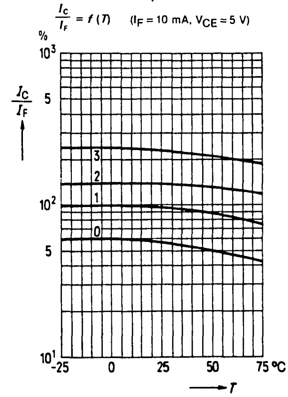
Current transfer ratio as a function of diode current (T_{amb} = 75°C)

$\frac{I_C}{I_F} = f(I_F)$ V_{CE} = 5 V



Current transfer ratio as a function of temperature

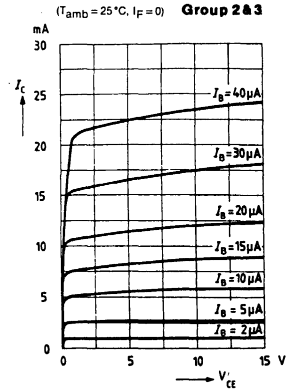
$\frac{I_C}{I_F} = f(T)$ (I_F = 10 mA, V_{CE} = 5 V)



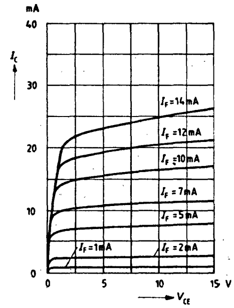
Transistor characteristics (B = 550)

$I_C = f(V_{CE})$

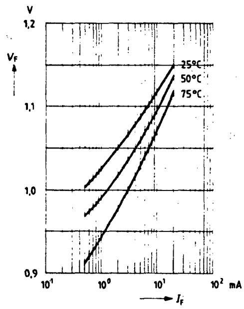
(T_{amb} = 25°C, I_F = 0) **Group 2&3**



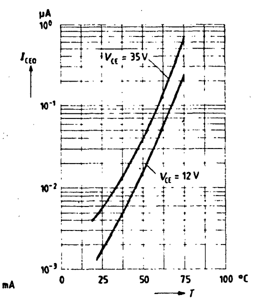
Output characteristics $I_C = f(V_{CE})$ ($T_{amb} = 25\,°C$) Group 2 & 3



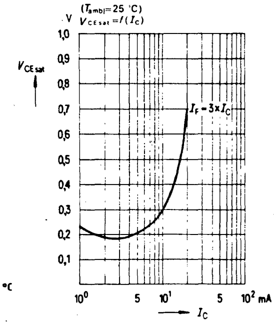
Forward voltage $V_F = f(I_F)$



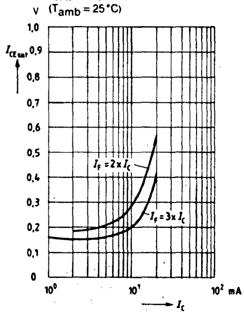
Collector-emitter off-state current $I_{CEO} = f(V, T)$ ($T_{amb} = 25\,°C$, $I_F = 0$)



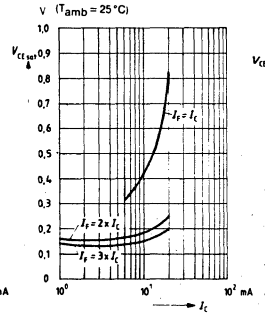
Saturation voltage as a function of collector current and modulation depth for SFH 600-0 ($T_{amb} = 25\,°C$) $V_{CEsat} = f(I_C)$



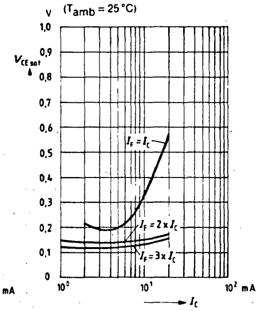
Saturation voltage as a function of collector current and modulation depth for SFH 600-1 $V_{CEsat} = f(I_C)$ ($T_{amb} = 25\,°C$)



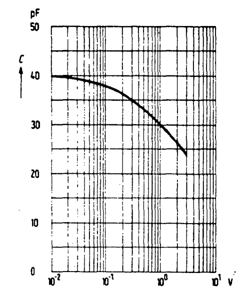
Saturation voltage as a function of collector current and modulation depth for SFH 600-2 $V_{CEsat} = f(I_C)$ ($T_{amb} = 25\,°C$)



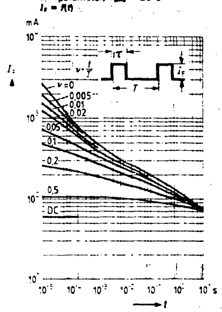
Saturation voltage as a function of collector current and modulation depth for SFH 600-3 $V_{CEsat} = f(I_C)$ ($T_{amb} = 25\,°C$)



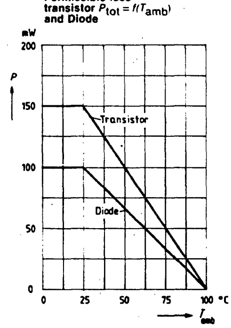
Diode capacitance $C = f(V_R)$ ($T_{amb} = 25\,°C$, f = 1 MHz)



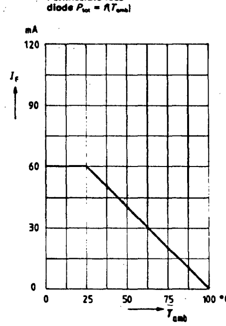
Permissible pulse load v = parameter, $T_{amb} = 25\,°C$ $I_F = f(t)$



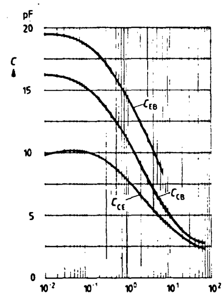
Permissible loss transistor $P_{tot} = f(T_{amb})$ and Diode



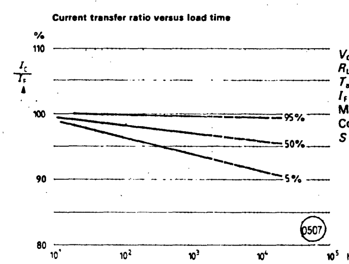
Permissible loss diode $P_{tot} = f(T_{amb})$



Transistor capacitances $C = f(V_0)$ ($T_{amb} = 25\,°C$; f = 1 MHz)



Current transfer ratio versus load time

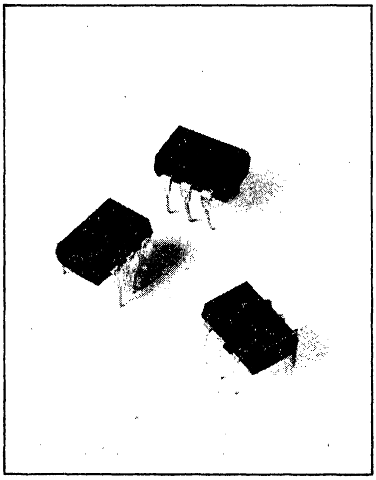


V_{CE} = 5 V
R_L = 1 kΩ
T_{amb} = 60 °C
I_F = 60 mA
Measuring current = 10 mA
Confidence coefficient
S = 60%

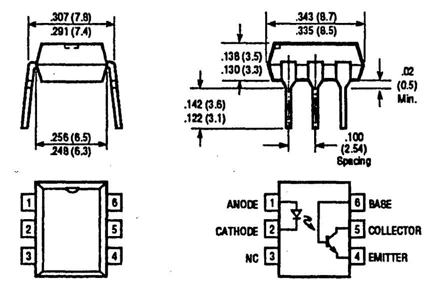
SIEMENS

SFH601 SERIES

PHOTOTRANSISTOR OPTOCOUPLER



Package Dimension in Inches (mm)



FEATURES

- Highest Quality Premium Device
- Built to Conform to VDE Requirements
- Long Term Stability
- High Current Transfer Ratios, 4 Groups
  SFH 601-1, 40 to 80%
  SFH 601-2, 63 to 125%
  SFH 601-3, 100 to 200%
  SFH 601-4, 160 to 320%
- 5300 Volt Isolation (1 Minute)
- Storage Temperature −40° to +150°C
- VCE_{sat} 0.25 (<0.4) Volt at I_F = 10 mA, I_C = 2.5 mA
- UL Approval #E52744
- VDE Approval #0883
- VDE Approval #0884 (Optional with Option 1, add -X001 suffix)
- CECC Approved

DESCRIPTION

The SFH601 is an optocoupler that is comprised of a GaAs LED emitter which is optically coupled with a silicon planar phototransistor detector. The component is packaged in a plastic plug-in case 20 AB DIN 41866. The coupler transmits signals between two electrically isolated circuits. The potential difference between the circuits to be coupled is not allowed to exceed the maximum permissible insulating voltage.

Maximum Ratings

Reverse Voltage (V_R) .... 6 V
Forward Current (I_F) .... 60 mA
Surge Current (I_{FS}), t_p = 10 μs .... 2.5 A
Power Dissipation (P_{tot}) .... 100 mW

Detector (Silicon Phototransistor)

Collector-Emitter Voltage (V_{CEO}) .... 70 V
Emitter-Base Reverse Voltage (V_{EBO}) .... 7 V
Collector Current (I_C) .... 50 mA
Collector Current (I_{CS}), t = 1 ms .... 100 mA
Power Dissipation (P_{tot}) .... 150 mW

Coupler

Storage Temperature (T_{stor}) .... −40 to +150°C
Ambient Temperature (T_{amb}) .... −40 to +100°C
Junction Temperature (T_j) .... 100°C
Soldering Temperature (T_L), 10 s Max. .... 260°C
Isolation Test Voltage (V_{is}), 1 Min per VDE 0883 .... 5300 VDC
(between emitter and detector referred to standard climate 23/50 DIN 50014)
Tracking Resistance .... Min. 8.2 mm
Air Path .... Min. 7.3 mm

Tracking Resistance

Group III (KC = >600) in accordance with VDE 0110 § 6 Table 3 and DIN 53480/VDE 0303, Part 1.
As to nominal isolation voltage DIN 57883 or VDE 0883 applies.
Isolation Resistance (R_{is}) at V_{is} = 500 V .... 10^{11} Ω

Climatic Conditions

DIN 40040, humidity Class F

Flammability

DIN 57471 or VDE 0471, Part 2, of April 1975 or MIL202E, Method 11 A

Characteristics ($T_{amb} = 25\,°C$)

Emitter (GaAs LED)

Forward Voltage (V_F), $I_F = 60$ mA .... 1.25 (≤ 1.65) V
Breakdown Voltage (V_{BR}), $I_R = 100\,\mu A$ .... 30 (≥ 6) V
Reverse Current (I_R), $V_R = 3$ V .... 0.01 (≤ 10) µA
Capacitance (C_O)
($V_R = 0$ V; f = 1 MHz) .... 40 pF
Thermal Resistance (R_{thJamb}) .... 750 K/W

Detector (Silicon Phototransistor)

Capacitance ($V_{CE} = 5$ V; f = 1 MHz)
C_{CE} .... 6.8 pF
C_{CB} .... 8.5 pF
C_{EB} .... 11 pF
Thermal Resistance (R_{thJamb}) .... 500 K/W

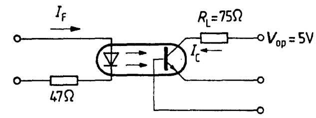
Coupler

Collector-Emitter Saturation Voltage (V_{CEsat})
($I_F = 10$ mA, $I_C = 2.5$ mA) .... 0.25 (< 0.4) V
Coupling Capacitance (C_K) .... 0.30 pF

The optocouplers are grouped according to their current transfer ratio I_C/I_F at V_{CE}=5 V, marked by dash numbers.

	–1	–2	–3	–4	
I_C/I_F (I_F=10 mA)	40–80	63–125	100–200	160–320	%
I_C/I_F (I_F=1 mA)	30 (>13)	45 (>22)	70 (>34)	90 (>56)	%
Collector-Emitter Leakage Current (V_{CE}=10 V) (I_{CEO})	2 (≤50)	2 (≤50)	5 (≤100)	5 (≤100)	nA

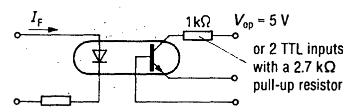
Linear Operation (without saturation)

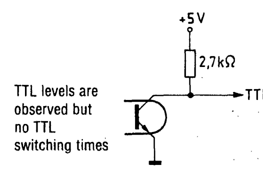


I_F=10 mA, V_{OP}=5 V, T_{amb}=25°C

Load Resistance	R_L	75	Ω
Turn-On Time	t_{ON}	3.0 (≤5.6)	µs
Rise Time	t_R	2.0 (≤4.0)	µs
Turn-Off Time	t_{OFF}	2.3 (≤4.1)	µs
Fall Time	t_F	2.0 (≤3.5)	µs
Cut-Off Frequency	F_{CO}	250	kHz

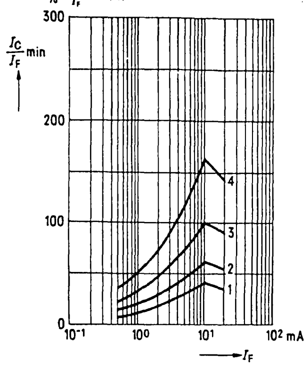
Switching Operation (with saturation)



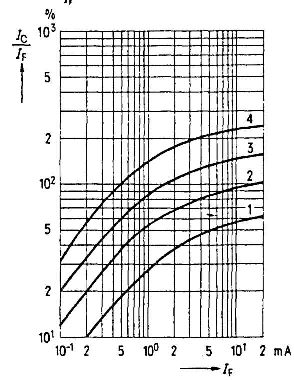


Group	–1 (I_F=20 mA)	–2 and –3 (I_F=10 mA)	–4 (I_F=5 mA)	
Turn-On Time t_{ON}	3.0 (≤5.5)	4.2 (≤8.0)	6.0 (≤10.5)	µs
Rise Time t_R	2.0 (≤4.0)	3.0 (≤6.0)	4.6 (≤8.0)	µs
Turn-Off Time t_{OFF}	18 (≤34)	23 (≤39)	25 (≤43)	µs
Fall Time t_F	11 (≤20)	14 (≤24)	15 (≤26)	µs
V_{CESAT}	0.25 (≤0.4)			V

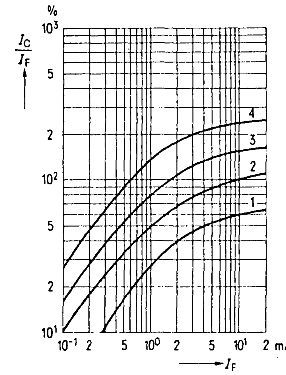
Minimum current transfer ratio as a function of diode current
(T_{amb} = 25°C, V_{CE} = 5 V)
$\frac{I_C}{I_F} = f(I_F)$



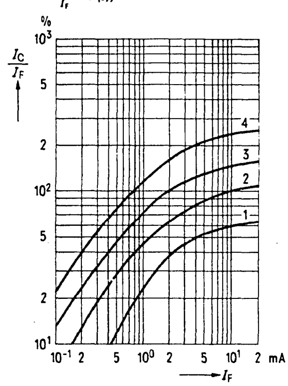
Current transfer ratio as a function of diode current (T_{amb} = –25°C)
$\frac{I_C}{I_F} = f(I_F)$ V_{CE} = 5 V



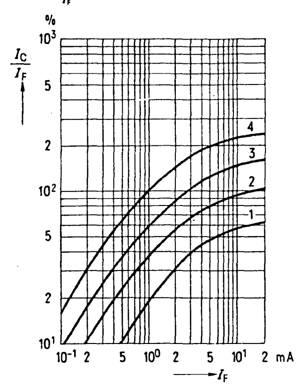
Current transfer ratio as a function of diode current (T_{amb} = 0°C)
$\frac{I_C}{I_F} = f(I_F)$ V_{CE} = 5 V



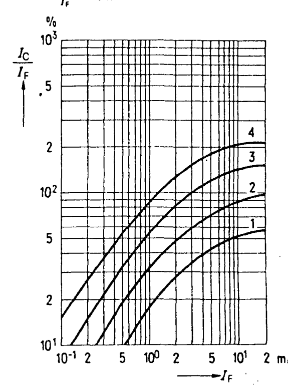
Current transfer ratio as a function of diode current (T_{amb} = 25°C)
$\frac{I_C}{I_F} = f(I_F)$ V_{CE} = 5 V



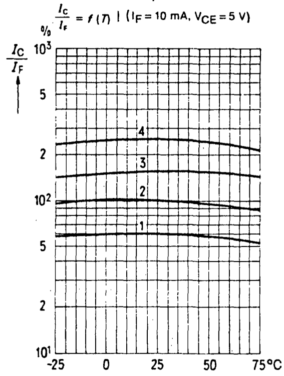
Current transfer ratio as a function of diode current (T_{amb} = 50°C)
$\frac{I_C}{I_F} = f(I_F)$ V_{CE} = 5 V



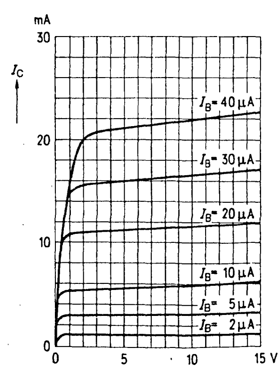
Current transfer ratio as a function of diode current (T_{amb} = 75°C)
$\frac{I_C}{I_F} = f(I_F)$ V_{CE} = 5 V



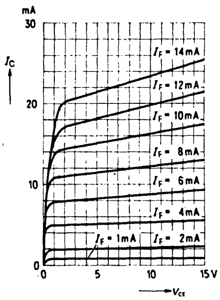
Current transfer ratio as a function of temperature
$\frac{I_C}{I_F} = f(T)$ | (I_F = 10 mA, V_{CE} = 5 V)



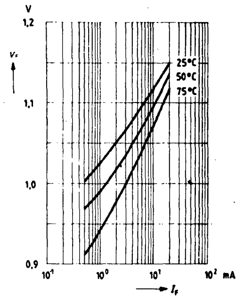
Transistor characteristics (B = 550)
$I_C = f(V_{CE})$ (T_{amb} = 25°C, I_F = 0)



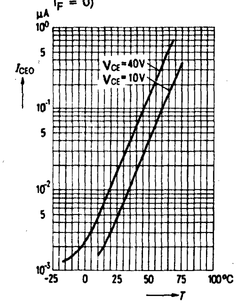
Output characteristics $I_C = f(V_{CE})$
(T_{amb} = 25°C)



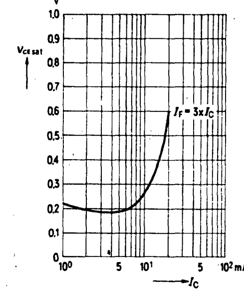
Forward voltage $V_F = f(I_F)$



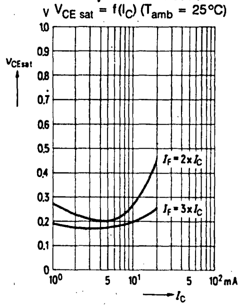
Collector-emitter off-state current
$I_{CEO} = f(V, T)$ (T_{amb} = 25°C, I_F = 0)



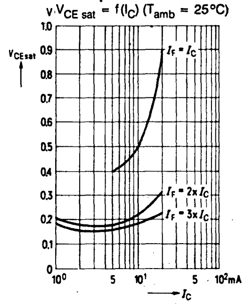
Saturation voltage as a function of collector current and modulation depth for SFH 601-1
$V_{CE\,sat} = f(I_C)$ (T_{amb} = 25°C)



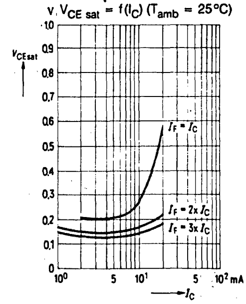
Saturation voltage as a function of collector current and modulation depth for SFH 601-2
$V_{CE\,sat} = f(I_C)$ (T_{amb} = 25°C)



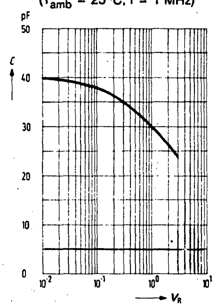
Saturation voltage as a function of collector current and modulation depth for SFH 601-3
$V_{CE\,sat} = f(I_C)$ (T_{amb} = 25°C)



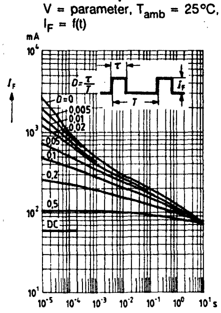
Saturation voltage as a function of collector current and modulation depth for SFH 601-4
$V_{CE\,sat} = f(I_C)$ (T_{amb} = 25°C)



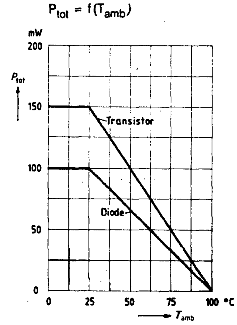
Diode capacitance $C = f(V_R)$
(T_{amb} = 25°C, f = 1 MHz)



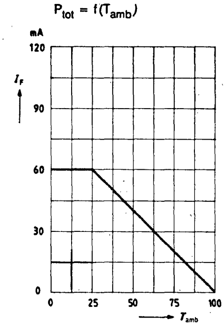
Permissible pulse load
V = parameter, T_{amb} = 25°C,
$I_F = f(t)$



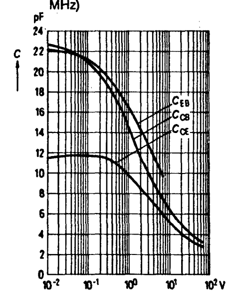
Permissible loss transistor
$P_{tot} = f(T_{amb})$



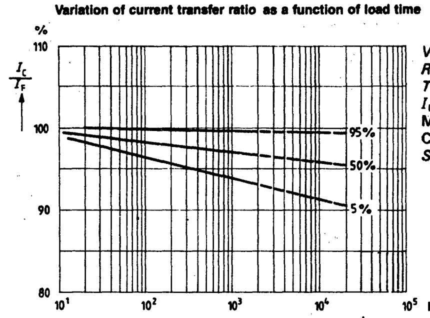
Permissible loss diode
$P_{tot} = f(T_{amb})$



Transistor capacitances
$C = f(V_O)$ (T_{amb} = 25°C; f = 1 MHz)



Variation of current transfer ratio as a function of load time $\frac{I_C}{I_F} = f(t)$

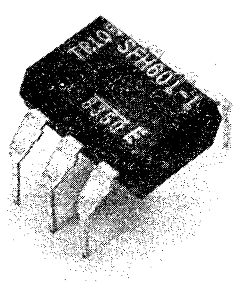


V_{CE} = 5 V
R_L = 1 kΩ
T_{amb} = 25°C
I_F = 60 mA
Measuring current = 10 mA
Confidence coefficient
S = 60%

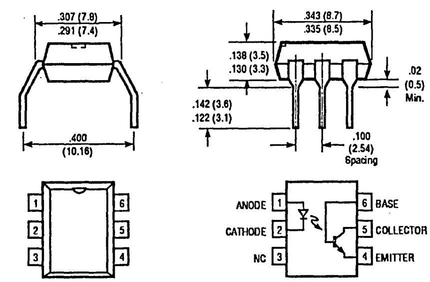
SIEMENS

SFH 601G SERIES

PHOTOTRANSISTOR OPTOCOUPLER



Package Dimensions in Inches (mm)



FEATURES

- Wide Lead Spacing
- Highest Quality Premium Device
- Long Term Stability
- High Current Transfer Ratios, 4 Groups
  SFH 601G-1, 40 to 80%
  SFH 601G-2, 63 to 125%
  SFH 601G-3, 100 to 200%
  SFH 601G-4, 160 to 320%
- 5300 Volt Isolation (1 Minute)
- Storage Temperature −40° to +150°C
- V_{CEsat} 0.25 (<0.4) Volt
  I_F = 10 mA, I_C = 2.5 mA
- UL Approval #E52744
- VDE Approval #0883, #0805, #0806
- VDE Approval #0884 (Optional with Option 1, add -X001 suffix)
- CECC Approved

DESCRIPTION

The SFH 601G is an optocoupler that is comprised of a GaAs LED emitter which is optically coupled with a silicon planar phototransistor detector. The component is packaged in a plastic plug-in case 20 AB DIN 41866. The coupler transmits signals between two electrically isolated circuits. The potential difference between the circuits to be coupled is not allowed to exceed the maximum permissible insulating voltage.

Maximum Ratings

Reverse Voltage (V_R)	6 V
Forward Current (I_F)	60 mA
Surge Current (I_{FS}), t_p = 10 μs	2.5 A
Power Dissipation (P_{tot})	100 mW
Detector (Silicon Phototransistor)	
Collector-Emitter Voltage (V_{CEO})	70 V
Emitter-Base Reverse Voltage (V_{EBO})	7 V
Collector Current (I_C)	50 mA
Collector Current (I_{CS}), t = 1 ms	100 mA
Power Dissipation (P_{tot})	150 mW
Coupler	
Storage Temperature (T_{stor})	−40 to +150°C
Ambient Temperature (T_{amb})	−40 to +100°C
Junction Temperature (T_j)	100°C
Soldering Temperature (T_L), 10 s Max.	260°C
Isolation Test Voltage (V_{is}), 1 Min. (between emitter and detector referred to standard climate 23/50 DIN 50014)	5300 VDC
Tracking Resistance	Min. 8.2 mm
Air Path	Min. 8 mm

Tracking Resistance
Group III (KC = >600) in accordance with VDE 0110 § 6 Table 3 and DIN 53480/VDE 0303, Part 1.
As to nominal isolation voltage DIN 57883 or VDE 0883 applies.

Isolation Resistance (R_{is}), @ V_{is} = 500 V .... 10^{11} Ω

Climatic Conditions
DIN 40040, humidity Class F

Flammability
DIN 57471 or VDE 0471, Part 2, of April 1975 or MIL202E, Method 11 A

Characteristics (T_{amb} = 25°C)

Emitter (GaAs LED)	
Forward Voltage (V_F), I_F = 60 mA	1.25 (≤1.65) V
Breakdown Voltage (V_{BR}), I_R = 100 μA	30 (≥6) V
Reverse Current (I_R), V_R = 6 V	0.01 (≤10) μA
Capacitance (C_O) (V_R = 0 V; f = 1 MHz)	40 pF
Thermal Resistance (R_{thJamb})	750 K/W
Detector (Silicon Phototransistor)	
Capacitance (V_{CE} = 5 V; f = 1 MHz)	
C_{CE}	6.8 pF
C_{CB}	8.5 pF
C_{EB}	11 pF
Thermal Resistance (R_{thJamb})	500 K/W

Characteristics (Continued)

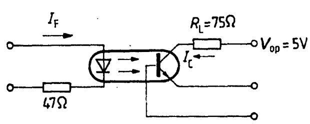
Coupler

Collector-Emitter Saturation Voltage (V_{CEsat})
(I_F = 10 mA, I_C = 2.5 mA) . . . . 0.25 (<0.4) V
Coupling Capacitance (C_K) . . . . 0.30 pF

The optocouplers are grouped according to their current transfer ratio I_C/I_F at V_{CE}=5 V, marked by dash numbers.

	–1	–2	–3	–4	
I_C/I_F (I_F=10 mA)	40–80	63–125	100–200	160–320	%
I_C/I_F (I_F=1 mA)	30 (>13)	45 (>22)	70 (>34)	90 (>56)	%
Collector-Emitter Leakage Current (V_{CE}=10 V) (I_{CEO})	2 (≤50)	2 (≤50)	5 (≤100)	5 (≤100)	nA

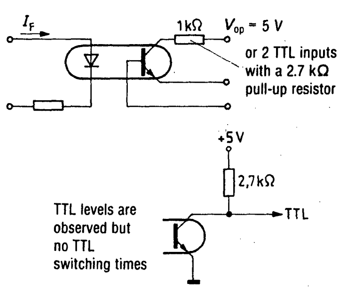
Linear Operation (without saturation)



I_F=10 mA, V_{OP}=5 V, T_{amb}=25°C

Load Resistance	R_L	75	Ω
Turn-On Time	t_{ON}	3.0 (≤5.6)	µs
Rise Time	t_R	2.0 (≤4.0)	µs
Turn-Off Time	t_{OFF}	2.3 (≤4.1)	µs
Fall Time	t_F	2.0 (≤3.5)	µs
Cut-Off Frequency	F_{CO}	250	kHz

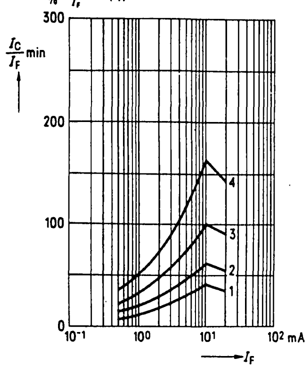
Switching Operation (with saturation)



Group	–1 (I_F=20 mA)	–2 and –3 (I_F=10 mA)	–4 (I_F=5 mA)	
Turn-On Time t_{ON}	3.0 (≤5.5)	4.2 (≤8.0)	6.0 (≤10.5)	µs
Rise Time t_R	2.0 (≤4.0)	3.0 (≤6.0)	4.6 (≤8.0)	µs
Turn-Off Time t_{OFF}	18 (≤34)	23 (≤39)	25 (≤43)	µs
Fall Time t_F	11 (≤20)	14 (≤24)	15 (≤26)	µs
V_{CESAT}	0.25 (≤0.4)			V

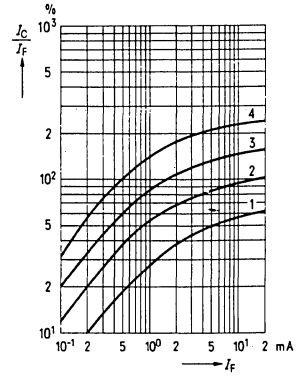
Minimum current transfer ratio as a function of diode current (T_{amb} = 25°C, V_{CE} = 5 V)

$\frac{I_C}{I_F} = f(I_F)$



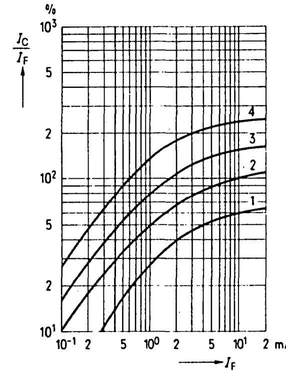
Current transfer ratio as a function of diode current (T_{amb} = −25°C)

$\frac{I_C}{I_F} = f(I_F)$ V_{CE} = 5 V



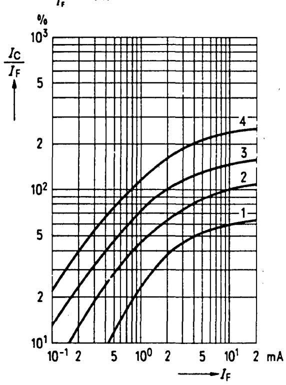
Current transfer ratio as a function of diode current (T_{amb} = 0°C)

$\frac{I_C}{I_F} = f(I_F)$ V_{CE} = 5 V



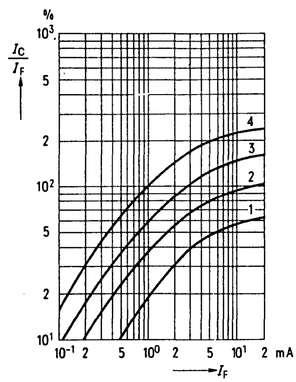
Current transfer ratio as a function of diode current (T_{amb} = 25°C)

$\frac{I_C}{I_F} = f(I_F)$ V_{CE} = 5 V



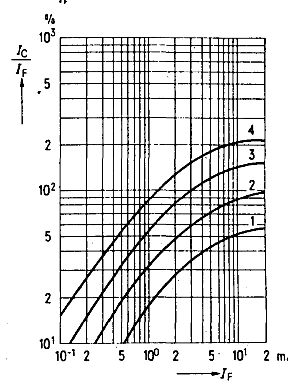
Current transfer ratio as a function of diode current (T_{amb} = 50°C)

$\frac{I_C}{I_F} = f(I_F)$ V_{CE} = 5 V



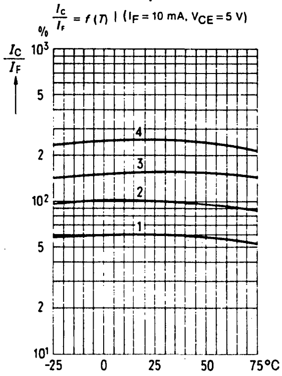
Current transfer ratio as a function of diode current (T_{amb} = 75°C)

$\frac{I_C}{I_F} = f(I_F)$ V_{CE} = 5 V



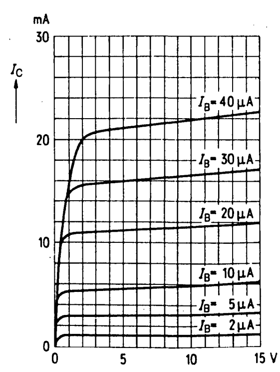
Current transfer ratio as a function of temperature

$\frac{I_C}{I_F} = f(T)$ | (I_F = 10 mA, V_{CE} = 5 V)

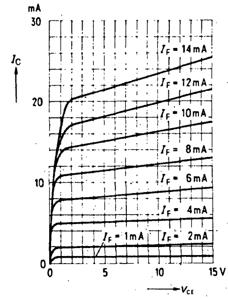


Transistor characteristics (B = 550)

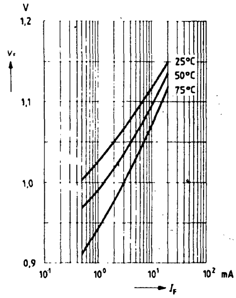
$I_C = f(V_{CE})$ (T_{amb} = 25°C, I_F = 0)



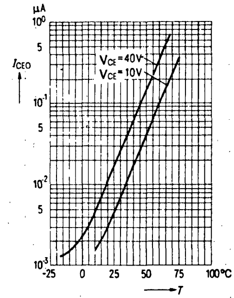
Output characteristics $I_C = f(V_{CE})$
($T_{amb} = 25\,°C$)



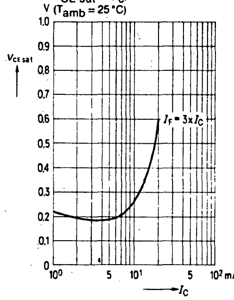
Forward voltage $V_F = f(I_F)$



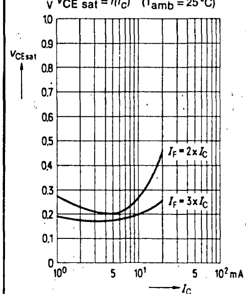
Collector-emitter off-state current
$I_{CEO} = f(V, T)$ ($T_{amb} = 25\,°C$, $I_F = 0$)



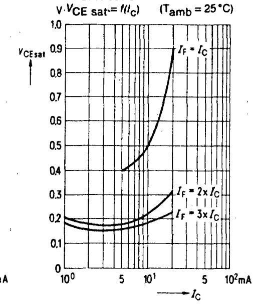
Saturation voltage as a function of collector current and modulation depth for SFH 601-1
$V_{CE\,sat} = f(I_C)$
($T_{amb} = 25\,°C$)



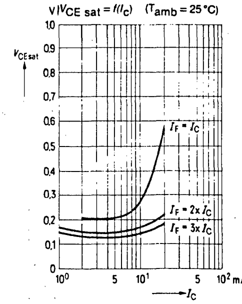
Saturation voltage as a function of collector current and modulation depth for SFH 601-2
$V_{CE\,sat} = f(I_C)$ ($T_{amb} = 25\,°C$)



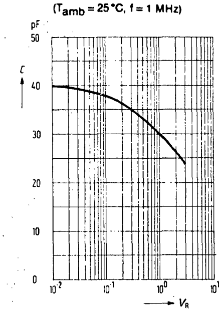
Saturation voltage as a function of collector current and modulation depth for SFH 601-3
$V_{CE\,sat} = f(I_C)$ ($T_{amb} = 25\,°C$)



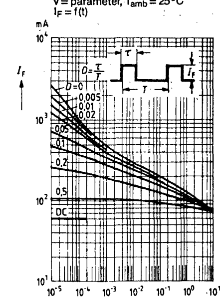
Saturation voltage as a function of collector current and modulation depth for SFH 601-4
$V_{CE\,sat} = f(I_C)$ ($T_{amb} = 25\,°C$)



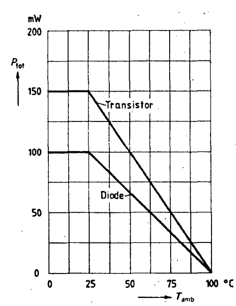
Diode capacitance $C = f(V_R)$
($T_{amb} = 25\,°C$, f = 1 MHz)



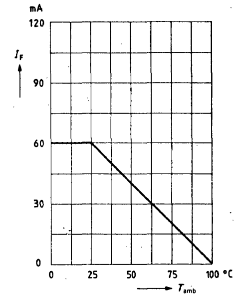
Permissible pulse load
v = parameter, $T_{amb} = 25\,°C$
$I_F = f(t)$



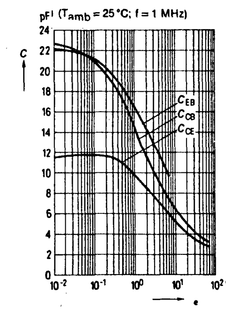
Permissible loss transistor $P_{tot} = f(T_{amb})$



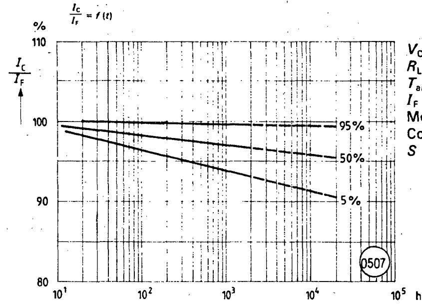
Permissible loss diode $P_{tot} = f(T_{amb})$



Transistor capacitances $C = f(V_0)$
($T_{amb} = 25\,°C$; f = 1 MHz)



Variation of current transfer ratio as a function of load time
$\frac{I_C}{I_F} = f(t)$



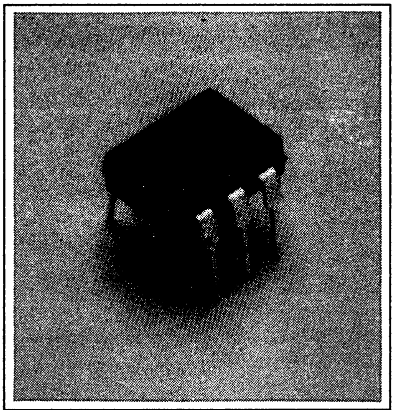
V_{CE} = 5 V
R_L = 1 kΩ
T_{amb} = 25 °C
I_F = 60 mA
Measuring current = 10 mA
Confidence coefficient
S = 60%

SFH 601G

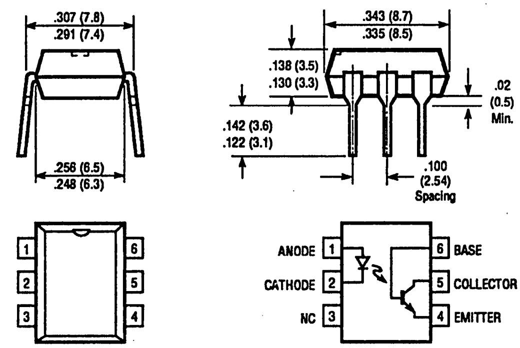
SIEMENS

SFH 606

5.3 kV TRIOS*® OPTOCOUPLER HIGH REL/FAST TRANSISTOR



Package Dimensions in Inches (mm)



Optocouplers (Optoisolators)

FEATURES

- **Isolation Test Voltage: 5300 V**
- **High Current Transfer Ratios at 10 mA: 63-125% at 1 mA: >22%**
- **Fast Switching Times**
- **Minor CTR Degradation**
- **100% Burn-In**
- **Field-Effect Stable by TRIOS**
- **Temperature Stable**
- **Good CTR Linearity Depending on Forward Current**
- **High Collector-Emitter Voltage V_{CEO}=70 V**
- **Low Saturation Voltage**
- **Low Coupling Capacitance**
- **External Base Wiring Possible**
- **VDE Approval Applied For**

DESCRIPTION

The optically coupled isolator SFH 606 features a high current transfer ratio as well as a high isolation voltage. It employs a GaAs infrared emitting diode as emitter, which is optically coupled to a silicon planar phototransistor acting as detector. The component is incorporated in a plastic plug-in DIP-6 package.

The coupling device is suitable for signal transmission between two electrically separated circuits. The difference in potential between the circuits to be coupled must not exceed the maximum permissible reference voltages.

*TRansparent IOn Shield.

Maximum Ratings

Emitter (GaAs Infrared Emitter)
Reverse Voltage .... 6 V
DC Forward Current .... 60 mA
Surge Forward Current ($t \leq 10$ µs) .... 2.5 A
Total Power Dissipation .... 100 mW

Detector (Silicon Phototransistor)
Collector-Emitter Voltage .... 70 V
Emitter-Base Voltage .... 7 V
Collector Current .... 50 mA
Collector Current ($t \leq 1$ ms) .... 100 mA
Total Power Dissipation .... 150 mW

Optocoupler
Storage Temperature Range .... -55°C to +150°C
Ambient Temperature Range .... -55°C to +100°C
Junction Temperature .... 100°C
Soldering Temperature (max. 10 s)[1] .... 260°C
Isolation Test Voltage[2]
(between emitter and detector referred to standard climate 23/50 DIN 50014) .... 5300 VDC
Leakage Path .... ≥8.2 mm
Air path .... ≥7.3 mm

Tracking Resistance
In Accordance with VDE 0110 §6, table 3, and DIN 53480/VDE 0303, part 1 .... ≥100(group 3)
Isolation Resistance (V_{IO}=500 V) .... 10^{11} Ω

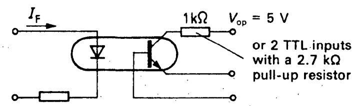
Notes:
1. Dip soldering: Insertion depth ≤3.6 mm.
2. DC test voltage in accordance with DIN 57883, draft 6/80.

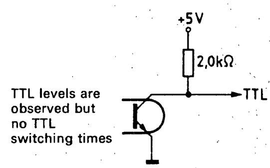
Characteristics (T_A=25°C)

Emitter (GaAs Infrared Emitter)			
Forward Voltage (I_F=60 mA)	V_F	1.25 (≤1.65)	V
Breakdown Voltage (I_R=10 µA)	BV	30 (≥6)	V
Reverse Current (V_R=6 V)	I_R	0.01 (≤10)	µA
Capacitance (V_R=0 V, f=1 MHz)	C_0	25	pF
Thermal Resistance	R_{THJA}	750	K/W
Detector (Silicon Phototransistor)			
Capacitance			
(V_{CE}=5 V, f=1 MHz)	C_{CE}	5.2	pF
(V_{CB}=5 V, f=1 MHz)	C_{CB}	6.5	pF
(V_{EB}=5 V, f=1 MHz)	C_{EB}	9.5	pF
Thermal Resistance	R_{THJA}	500	K/W
Optocoupler			
Collector-Emitter Saturation Voltage			
(I_F=10 mA, I_C=2.5 mA)	V_{CESAT}	0.25 (≤0.4)	V
Coupling Capacitance	C_K	0.5	pF
Current Transfer Ratio			
(I_F=10 mA)	I_C, I_F	63 –125	%
(I_F=1 mA)	I_C, I_F	45 (>22)	%
Collector-Emitter Leakage Current			
(V_{CE}=10 V)	I_{CEO}	2 (≤35)	nA

SWITCHING TIME

Switching Operation (with saturation)

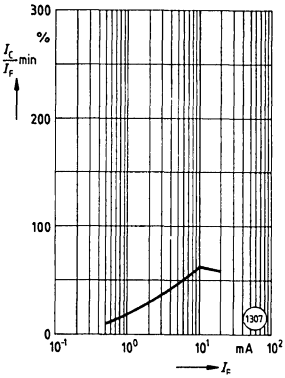




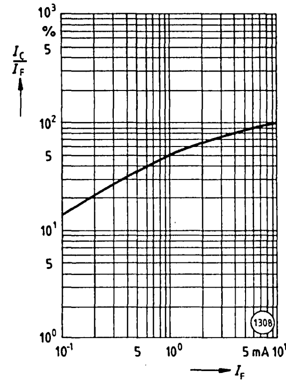
I_F=10 mA

Turn-On Time	t_{ON}	3.8 (≤4.5)	µs
Rise Time	t_R	2.5 (≤3.0)	µs
Turn-Off Time	t_{OFF}	11 (≤14)	µs
Fall Time	t_F	8 (≤10)	µs
	V_{CESAT}	≤0.4	V

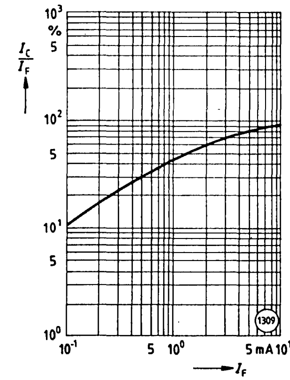
Minimum current transfer ratio versus diode forward current
(T_A=25°C, V_{CE}=5 V)



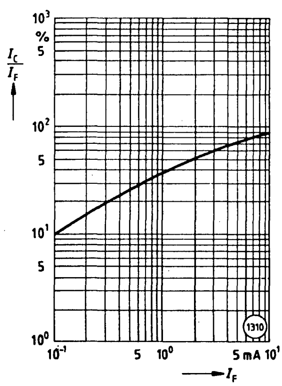
Current transfer ratio (typ.) versus diode forward current
(T_A=25°C, V_{CE}=5 V)



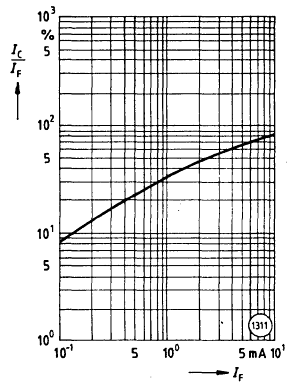
Current transfer ratio (typ.) versus diode forward current
(T_A=0°C, V_{CE}=5 V)



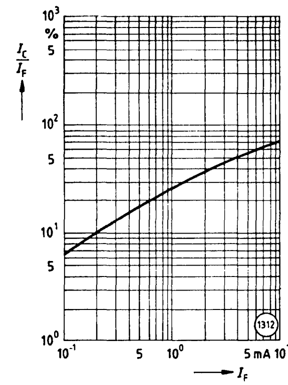
Current transfer ratio (typ.) versus diode forward current
(T_A=25°C, V_{CE}=5 V)



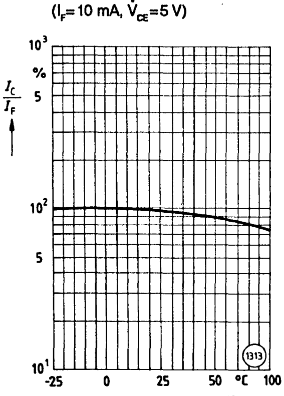
Current transfer ratio (typ.) versus diode forward current
(T_A=50°C, V_{CE}=5 V)



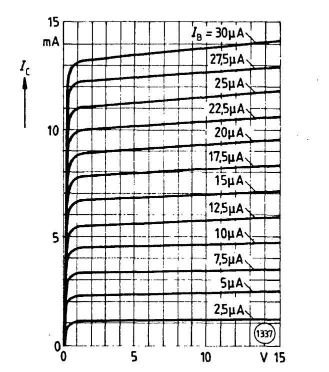
Current transfer ratio (typ.) versus diode forward current
(T_A=75°C, V_{CE}=5 V)



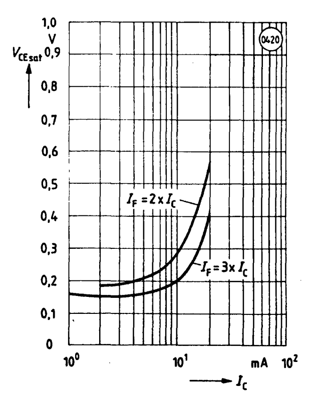
Current transfer ratio (typ.) versus temperature
(I_F=10 mA, V_{CE}=5 V)



Collector current versus collector-emitter voltage
(Current gain B=550, T_A=25°C, V_F≤0.6 V)

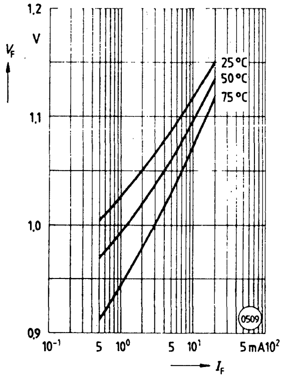


Collector-emitter saturation voltage (typ.) versus collector current and control range (T_A=25°C)

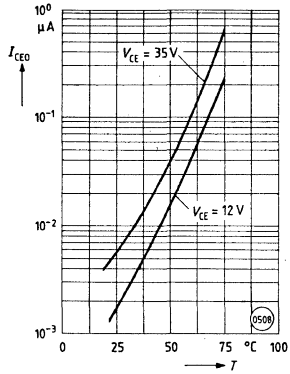


Optocouplers (Optoisolators)

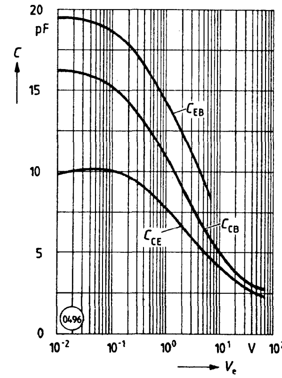
Diode forward voltage (typ.) versus forward current



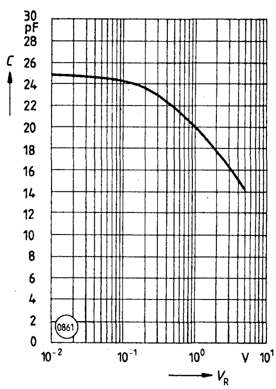
Collector-emitter leakage current (typ.) of the transistor versus temperature (I_F=0)



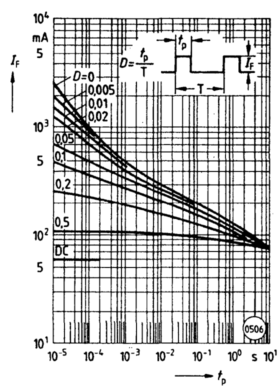
Transistor capacitance (typ.) versus emitter voltage (T_A=25°C, f =1 MHz)



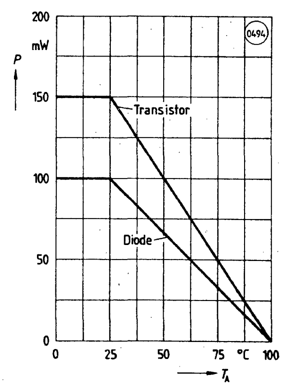
Diode capacitance (typ.) versus reverse voltage (T_A=25°C, f =1 MHz)



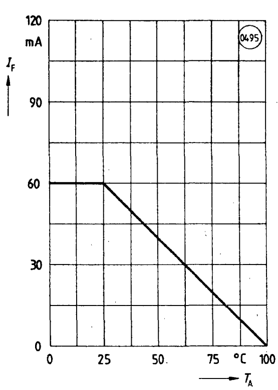
Permissible pulse handling capability Forward current versus pulse width (D=parameter, T_A=25°C)



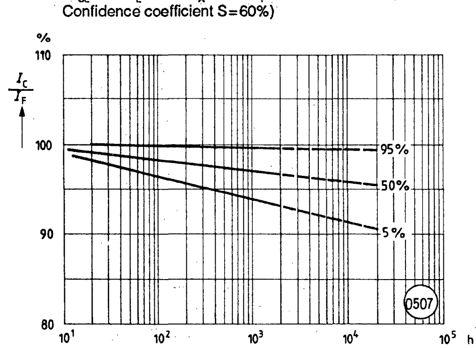
Permissible power dissipation for transistor and diode versus ambient temperature



Permissible forward current of the diode versus ambient temperature



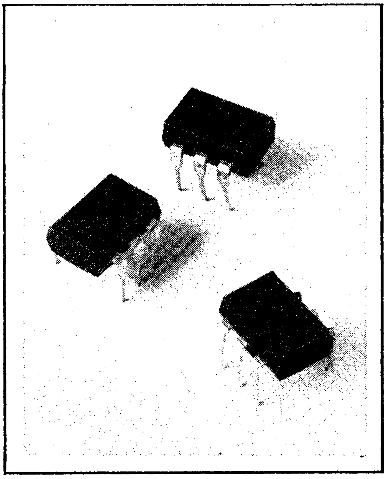
Current transfer ratio versus load time
(V_{CE}=5 V, R_L=1 kΩ, T_A=60°C, I_F=60 mA, Measuring current=10 mA, Confidence coefficient S=60%)



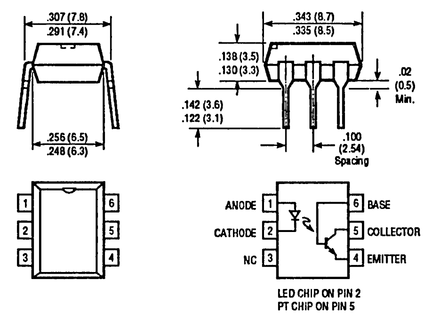
SIEMENS

SFH609 SERIES

HIGH RELIABILITY PHOTOTRANSISTOR OPTOCOUPLER



Package Dimensions in Inches(mm)



Optocouplers (Optoisolators)

FEATURES

- **Highest Quality Premium Device**
- **Built to Conform to VDE Requirements**
- **Long Term Stability**
- **High Current Transfer Ratios, 3 Groups**
  SFH 609-1, 40 to 80%
  SFH 609-2, 63 to 125%
  SFH 609-3, 100 to 200%
- **5300 Volt Isolation (1 Minute)**
- **Storage Temperature −40° to +150°C**
- **V_{CEsat} 0.25 (<0.4) Volt**
  I_F = 10 mA, I_C = 2.5 mA
- **V_{CEO} 90V**
- **UL Approval #E52744**
- **VDE Approval #0883**

DESCRIPTION

The optically coupled isolator SFH 609 features a high current transfer ratio as well as high isolation voltage, and uses as emitter a GaAs infrared emitting diode which is optically coupled with a silicon planar phototransistor acting as detector. The component is incorporated in a plastic plug-in package 20 A 6 DIN 41866.

The coupling device is suitable for signal transmission between two electrically separated circuits. The potential difference between the circuits to be coupled is not allowed to exceed the maximum permissible isolation voltage.

Maximum Ratings

Emitter (GaAs infrared emitter)			
Reverse voltage	V_R	6	V
DC forward current	I_F	60	mA
Surge forward current ($t \leq 10$ µs)	I_{FSM}	2.5	A
Total power dissipation	P_{tot}	100	mW
Detector (silicon phototransistor)			
Collector-emitter voltage (I_s = 0)	V_{CEO}	90	V
Emitter-base voltage (I_C = 0)	V_{EBO}	7	V
Collector current	I_C	50	mA
Collector current ($t \leq 1$ ms)	I_{CSM}	100	mA
Total power dissipation	P_{tot}	150	mW
Optocoupler			
Storage temperature range	T_{stg}	−40 to +150	°C
Ambient temperature range	T_{amb}	−40 to +100	°C
Junction temperature	T_j	100	°C
Soldering temperature (max. 10 sec)¹)	T_{sold}	260	°C
Isolation voltage (1 min)²) between emitter and detector referred to standard climate 23/50 DIN 50014	V_{is}	5300	Vdc

AC reference voltage, DC reference voltage } in acc. with DIN 57883, 6.80 and/or VDE 0883, 6.80

Leakage path	min 8.2	mm
Air path	min 7.3	mm

¹) Dip soldering: Insertion depth 3.6 mm
²) DC test voltage in accordance with DIN 57883, draft 4/78

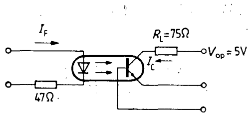
CHARACTERISTICS @25°C

Emitter			
Forward voltage (I_F = 60 mA)	V_F	1.25 (≤1.65)	V
Breakdown voltage (I_R = 10 μA)	$V_{(BR)}$	30 (≥6)	V
Reverse current (V_R = 6 V)	I_R	0.01 (≤10)	μA
Capacitance (V_R = 0 V; f = 1 MHz)	C_O	40	pF
Thermal resistance	R_{thJA}	750	K/W
Detector (silicon phototransistor)			
Capacitance (V_{CE} = 5 V; f = 1 MHz)	C_{CE}	6.8	pF
(V_{CB} = 5 V; f = 1 MHz)	C_{CB}	8.5	pF
(V_{EB} = 5 V; f = 1 MHz)	C_{EB}	11	pF
Thermal resistance	R_{thJA}	500	K/W
Optocoupler			
Collector-emitter saturation voltage (I_F = 10 mA, I_C = 2.5 mA)	V_{CEsat}	0.25 (≤0.4)	V
Coupling capacitance	C_K	0.30	pF

The optocouplers are grouped according to their current transfer ratio I_C/I_F at V_{CE}=5 V and marked by dash numbers.

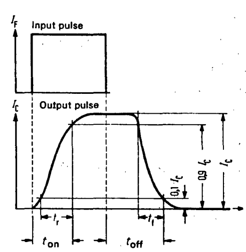
Group	–1	–2	–3	
I_C/I_F (I_F=10 mA)	40–80	63–125	100–200	%
I_C/I_F (I_F=1 mA)	30 (>13)	45 (>22)	70 (>34)	%
Collector-Emitter Leakage Current (I_{CEO}) (V_{CE}=10 V)	2 (≤50)	2 (≤50)	5 (≤100)	nA

Linear operation (without saturation)



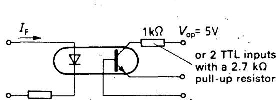
I_F = 10 mA
V_{op} = 5 V
T_{amb} = 25°C

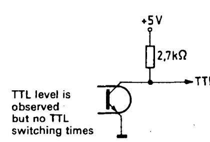
Switching times



Load resistance	R_L	75	Ω
Turn-on time	t_{on}	3.0 (≦ 5.6)	μs
Rise time	t_r	2.0 (≦ 4.0)	μs
Turn-off time	t_{off}	2.3 (≦ 4.1)	μs
Fall time	t_f	2.0 (≦ 3.5)	μs
Cut-off frequency	f_{co}	250	kHz

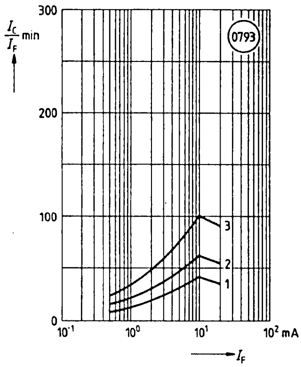
Switching operation (with saturation)



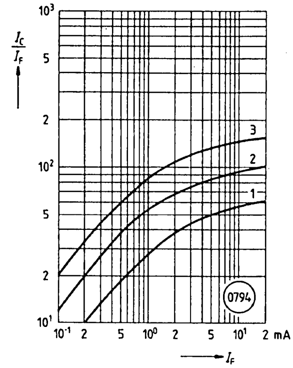


Group		1 I_F = 20 mA	2 and 3 I_F = 10 mA	
Turn-on time	t_{on}	3.0 (≦ 5.5)	4.2 (≦ 8.0)	μs
Rise time	t_r	2.0 (≦ 4.0)	3.0 (≦ 6.0)	μs
Turn-off time	t_{off}	18 (≦ 34)	23 (≦ 39)	μs
Fall time	t_f	11 (≦ 20)	14 (≦ 24)	μs
	V_{CEsat}	0.25 (≦ 0.4)		V

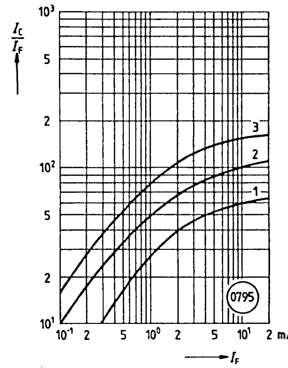
Minimum current transfer ratio versus diode forward current
T_{amb} = 25°C; V_{CE} = 5 V



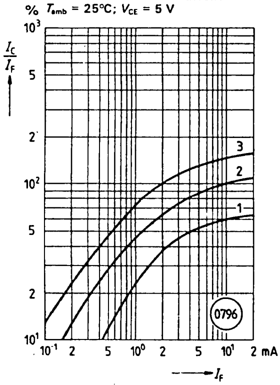
Current transfer ratio (typ.) versus diode forward current
T_{amb} = −25°C; V_{CE} = 5 V



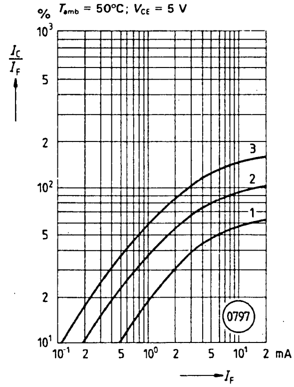
Current transfer ratio (typ.) versus diode forward current
T_{amb} = 0°C; V_{CE} = 5 V



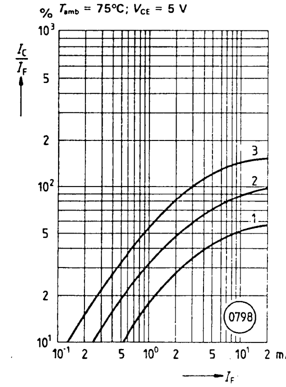
Current transfer ratio (typ.) versus diode forward current
T_{amb} = 25°C; V_{CE} = 5 V



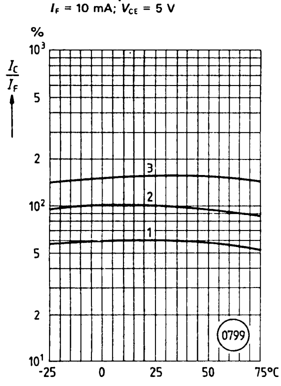
Current transfer ratio (typ.) versus diode forward current
T_{amb} = 50°C; V_{CE} = 5 V



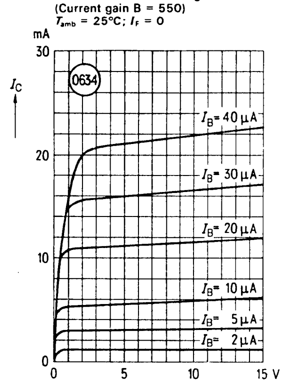
Current transfer ratio (typ.) versus diode forward current
T_{amb} = 75°C; V_{CE} = 5 V



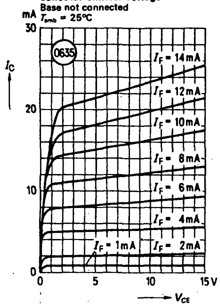
Current transfer ratio (typ.) versus temperature
I_F = 10 mA; V_{CE} = 5 V



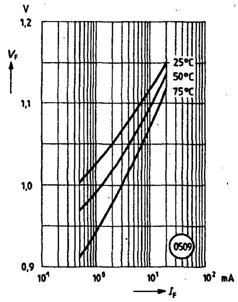
Collector current versus collector-emitter voltage
(Current gain B = 550)
T_{amb} = 25°C; I_F = 0



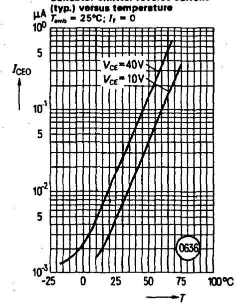
Output characteristics (typ.)
Collector current versus collector-emitter voltage
Base not connected
T_{amb} = 25°C



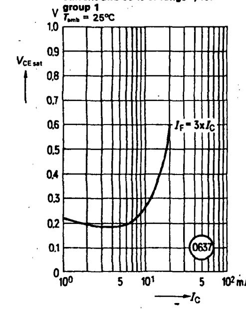
Forward voltage (typ.) of the diode versus forward current



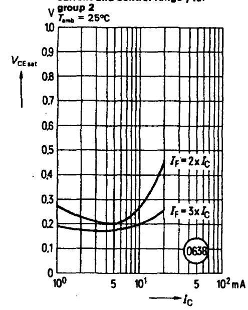
Collector-emitter reverse current (typ.) versus temperature
T_{amb} = 25°C; I_F = 0



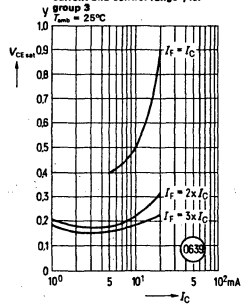
Collector-emitter saturation voltage (typ.) versus collector current and control range [1] for group 1
T_{amb} = 25°C



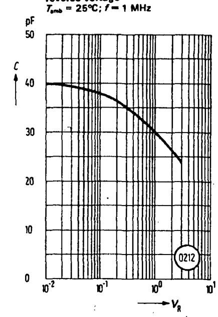
Collector-emitter saturation voltage (typ.) versus collector current and control range [1] for group 2
T_{amb} = 25°C



Collector-emitter saturation voltage (typ.) versus collector current and control range [1] for group 3
T_{amb} = 25°C

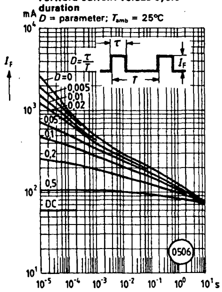


Diode capacitance (typ.) versus reverse voltage
T_{amb} = 25°C; f = 1 MHz

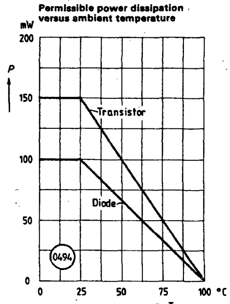


[1] I_F = 2 x I_C means that the current flow of the diode has to be adjusted to the doubled value of the collector current.

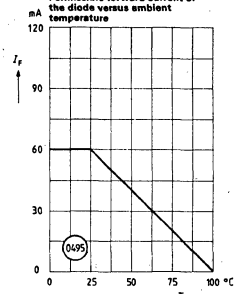
Permissible pulse handling capability
Forward current versus cycle duration
D = parameter; T_{amb} = 25°C



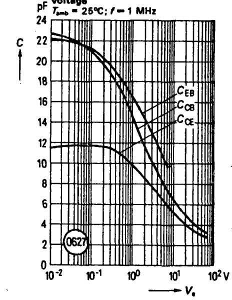
Permissible power dissipation versus ambient temperature



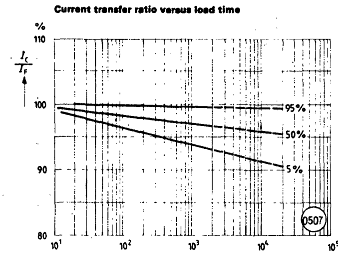
Permissible forward current of the diode versus ambient temperature



Capacitance (typ.) versus emitter voltage
T_{amb} = 25°C; f = 1 MHz



Current transfer ratio versus load time

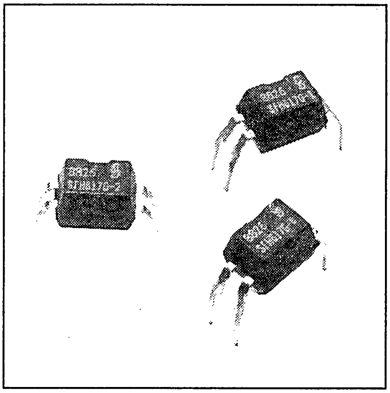


V_{CE} = 5 V
R_L = 1 kΩ
T_{amb} = 25°C
I_F = 60 mA
Measuring current = 10 mA
Confidence coefficient
S = 60%

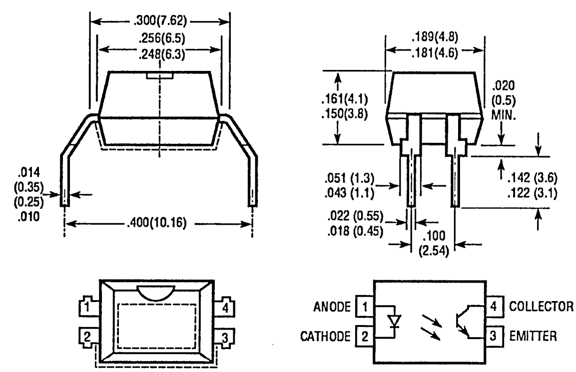
SIEMENS

SFH 617G SERIES

5.3 kV TRIOS*® OPTOCOUPLER



Package Dimensions in Inches (mm)



Optocouplers (Optoisolators)

FEATURES

- **Creepage Distances and Clearances to VDE 0110b**
- **Fulfills the VDE Standards: 0804/0805/0806/0860**
- **VDE 0884 Approval Applied for**
- **UL 1409 Approval Applied for**
- **Insulation Thickness ≥0.8 mm**
- **Creepage Distance ≤8 mm**
- **High Common-Mode Rejection**
- **Current Transfer Ratios:**
  SFH 617G-1 40–80%
  SFH 617G-2 63–125%
  SFH 617G-3 100–200%

DESCRIPTION

The SFH 617G line isolating optocoupler has been designed for especially demanding applications. The reflective coupler without base connection and a 0.80 mm separation between electrically conducting parts results in an excellent high-voltage safety. Despite the small size of the package, modified pins ensure a creepage distance of 8 mm. The pins have been bent up to a spacing of 0.4″, which also maintains a creepage distance ≥8 mm on the PC board. For use in circuits requiring safe electrical isolation in accordance with protection class II.

Maximum Ratings

Emitter (IR GaAs Diode)	
Reverse Voltage	6 V
DC Forward Current	60 mA
Surge Forward Current (t≤10 μs)	2.5 A
Total Power Dissipation	100 mW
Detector (Silicon Phototransistor)	
Collector-Emitter Voltage	70 V
Emitter-Base Voltage	7 V
Collector Current	50 mA
Collector Current (t≤1 ms)	100 mA
Total Power Dissipation	150 mW
Optocoupler	
Storage Temperature Range	–55 to +150°C
Operating Temperature Range	–55 to +100°C
Junction Temperature	100°C
Soldering Temperature (max. 10 s)[1]	260°C
Isolation Test Voltage[2] (between emitter and detector referred to standard climate 23/50 DIN 50014)	5300 VDC
Creepage Distance	≥8.0 mm
Clearance	≥8.0 mm
Tracking Resistance	
In Accordance with VDE 0110, §6, table 3 and DIN 53480/VDE 0303, part 1	≥100
Isolation Resistance (V_{IO}=500 V)	10^{11}Ω

Notes:
1. Dip soldering: Distance to case bottom edge ≥0.5 mm
2. DC test voltage in accordance with DIN 57883, draft 4/78

***TR**ansparent **IO**n **S**creen.

Characteristics ($T_{amb} = 25°C$)

Emitter (IR GaAs Emitter Diode)			
Forward Voltage ($I_F = 60$ mA)	V_F	1.25 (≤1.65)	V
Breakdown Voltage ($I_R = 10$ μA)	V_{BR}	30 (≥6)	V
Reverse Current ($V_R = 6$ V)	I_R	0.01 (≤1.65)	μA
Capacitance ($V_R = 0$ V, f = 1 MHz)	C_O	25	pF
Thermal Resistance[1]	R_{THJA}	750	K/W
Detector (Silicon Phototransistor)			
Capacitance ($V_{CE} = 5$ V, f = 1 MHz)	C_{CE}	6.8	pF
Thermal Resistance[1]	R_{THJA}	500	K/W
Optocoupler			
Collector-Emitter Saturation Voltage ($I_F = 10$ mA, $I_C = 2.5$ mA	V_{CESAT}	0.25 (≤0.4)	V
Coupling Capacitance	C_K	0.25	pF

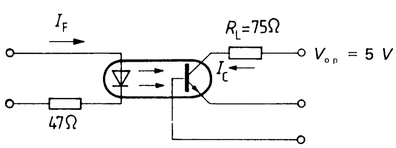
Note:
1. Static air, coupler soldered in PCB or inserted in base.

Current Transfer Ratio by dash number. I_C/I_F at $V_{CE} = 5$ V

	-1	-2	-3	
I_C/I_F ($I_F = 10$ mA	40–80	63–125	100–200	%
I_C/I_F ($I_F = 1$ mA	30 (>13)	45 (>22)	70 (>34)	%
Collector-Emitter Leakage Current (I_{CEO}) ($V_{CE} = 10$ V)	2 (≤50)	2 (≤50)	5 (≤100)	nA

SWITCHING TIMES

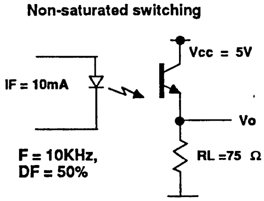
Linear Operation (without saturation)



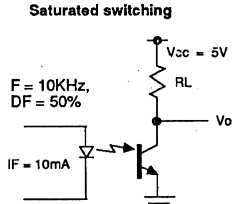
$I_F = 10$ mA; $V_{CC} = 5$ V; $T_{amb} = 25°C$

Dash Number		-1	-2, -3	
Load Resistance	R_L	75		Ω
Turn-On-Time	t_{ON}	3.0 (<5.6)	3.2 (<5.6)	μs
Rise Time	t_R	2.0 (<4.0)	2.5 (<4.0)	μs
Turn-Off-Time	t_{OFF}	2.3 (<4.1)	2.9 (<4.1)	μs
Fall Time	t_F	2.0 (<3.5)	2.6 (<3.5)	μs

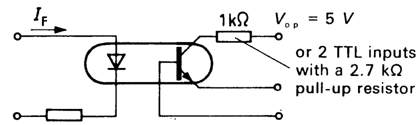
Non-saturated switching

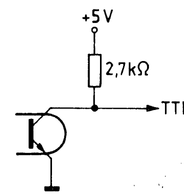


Saturated switching



Switching Operation (with saturation)

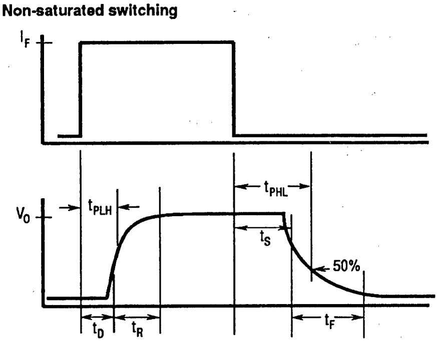




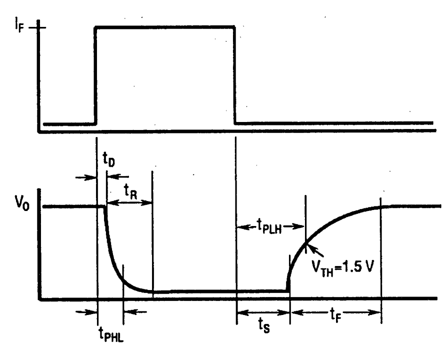
TTL levels are observed but no TTL switching times

		-1 $I_F = 20$ mA	-2, -3 $I_F = 10$ mA	
Turn-On-Time	t_{ON}	3.0 (<5.5)	4.2 (<8.0)	μs
Rise Time	t_R	2.0 (<4.0)	3.0 (<6.0)	μs
Turn-Off-Time	t_{OFF}	18 (<34)	23 (<39)	μs
Fall Time	t_F	11 (<20)	14 (<24)	μs
	V_{CESAT}	0.25 (<0.4)	0.25 (<0.4)	V

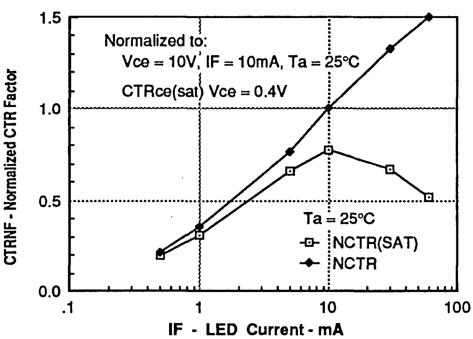
Non-saturated switching



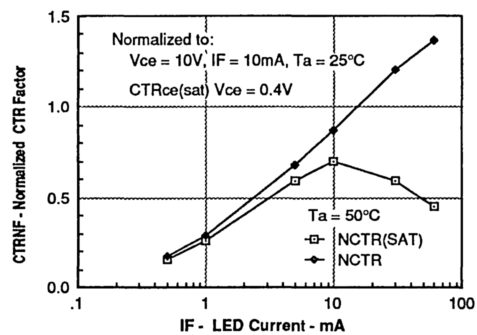
Saturated switching



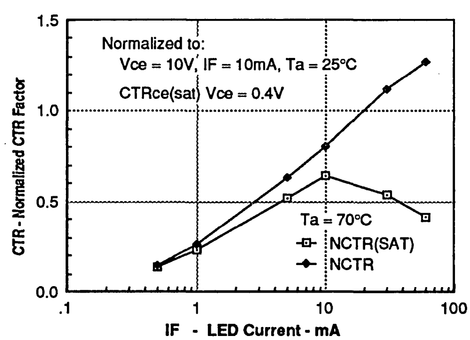
Normalization factor for non-saturated and saturated CTR T_{amb}=25°C versus I_F



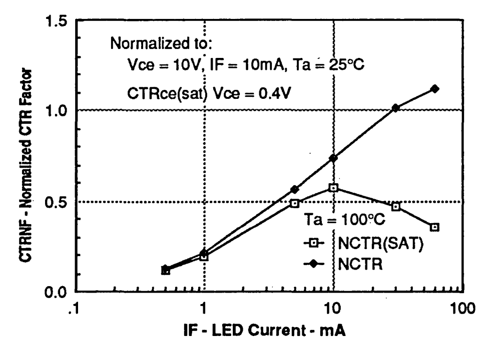
Normalization factor for non-saturated and saturated CTR T_{amb}=50°C versus I_F



Normalization factor for non-saturated and saturated CTR T_{amb}=70°C versus I_F

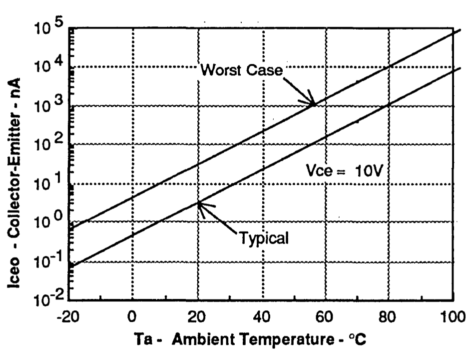


Normalization factor for non-saturated and saturated CTR T_{amb}=100°C versus I_F

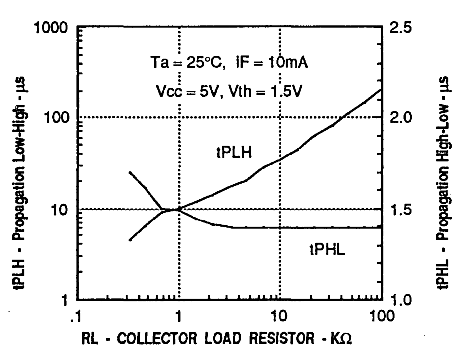


Optocouplers (Optoisolators)

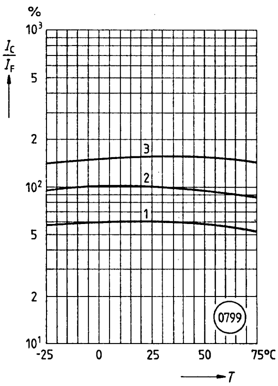
Collector-emitter leakage versus temperature



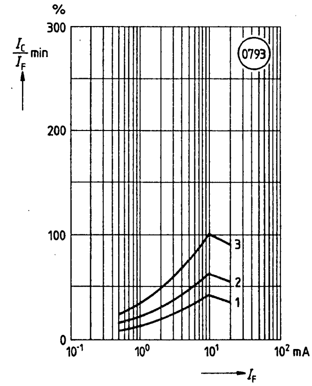
Propagation delay versus collector load resistor



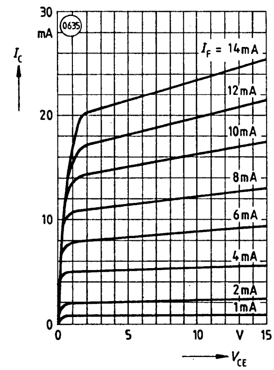
Current transfer ratio (typ.) versus temperature
(I_F = 10 mA, V_{CE} = 5 V)



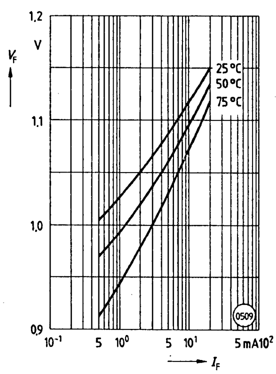
Minimum current transfer ratio versus diode forward current
(T_{amb} = 25 °C, V_{CE} = 5 V)



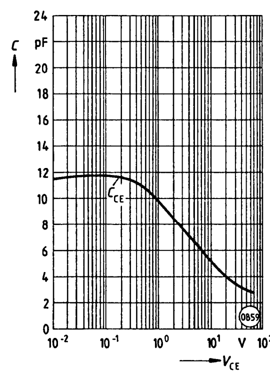
Output characteristics (typ.) Collector current versus collector-emitter voltage
(T_{amb} = 25 °C)



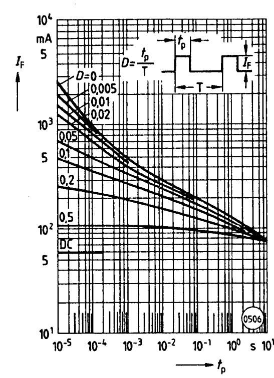
Diode forward voltage (typ.) Forward voltage versus forward current



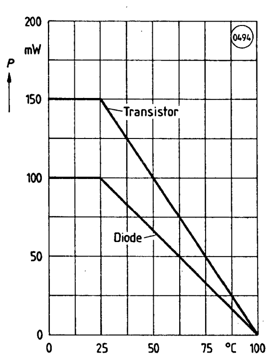
Transistor capacitances (typ.) Capacitance versus collector-emitter voltage
(T_{amb} = 25 °C, f = 1 MHz)



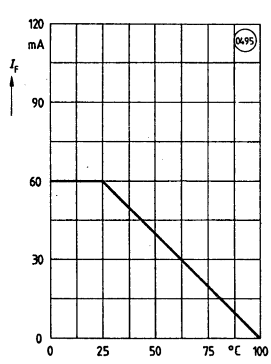
Permissible pulse handling capability Forward current versus pulse width
(Pulse duty factor D = parameter, T_{amb} = 25 °C)



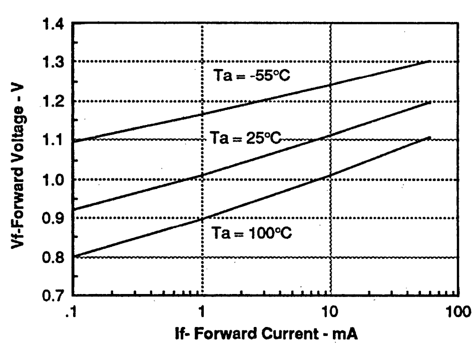
Permissible power dissipation for transistor and diode versus ambient temperature



Permissible forward current of the diode versus ambient temperature



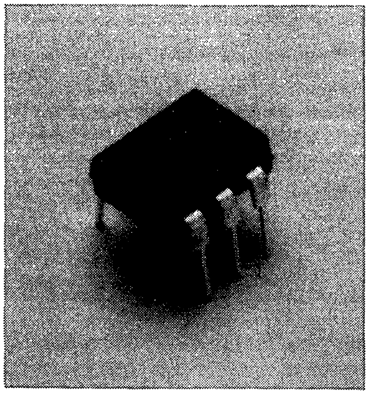
Forward voltage versus forward current



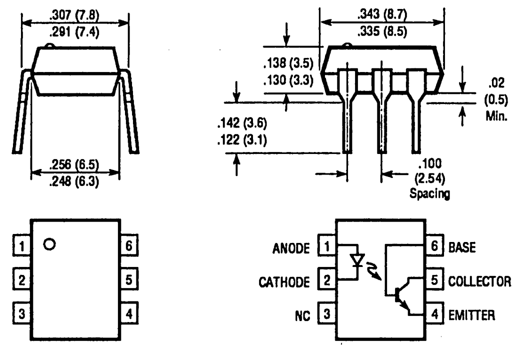
SIEMENS

SFH 6011

5.3 kV TRIOS*® OPTOCOUPLER HIGH RELIABILITY



Package Dimensions in Inches (mm)



FEATURES

- **Isolation Test Voltage: 5300 V**
- **High Current Transfer Ratios at 10 mA: 63-200% at 1 mA: 50% typ. (>22)**
- **Fast Switching Times**
- **Minor CTR Degradation**
- **100% Burn-In of Emitting Diode to Stabilize Radiant Intensity**
- **Field-Effect Stable by TRIOS**
- **Temperature Stable**
- **Good CTR Linearity Depending on Forward Current**
- **High Collector-Emitter Voltage V_{CEO}=70 V**
- **Low Saturation Voltage**
- **Low Coupling Capacitance**
- **External Base Wiring Possible**
- **High Security Against Premature Failure**
- **VDE Approval Applied For**

DESCRIPTION

The optically coupled isolator SFH 6011 features a high current transfer ratio as well as high isolation voltage. It has a GaAs infrared emitting diode as emitter, which is optically coupled to a silicon planar phototransistor detector. The component is incorporated in a plastic plug-in DIP-6 package.

The coupling device is suitable for signal transmission between two electrically separated circuits. The potential difference between the circuits to be coupled is not allowed to exceed the maximum permissible reference voltages.

This optocoupler exhibits a high standard of quality and great reliability.

Quality assurance is implemented by a repeated 100% test and by a subsequent random-sample testing, in which the basic AQL is 0.065 for major faults.

The second 100% test is performed at an extended temperture of 70°C with more severe test-limits. Thus reliability is considerably increased with the following failure rates: Up to 1000 hours in service (premature failure phase): a failure rate of <100 fit. After 1000 service hours: a constant failure rate of <10 fit. (1 fit=1 failure per 10^9 component hours.)

*TRansparent IOn Shield.

Maximum Ratings

Emitter (GaAs Infrared Emitter)
Reverse Voltage .... 6 V
DC Forward Current .... 60 mA
Surge Forward Current (t≤10 µs) .... 2.5 mA
Total Power Dissipation .... 100 mW

Detector (Silicon Phototransistor)
Collector-Emitter Voltage .... 70 V
Emitter-Base Voltage .... 7 V
Collector Current .... 50 mA
Collector Current (t ≤1 ms) .... 100 mA
Total Power Dissipation .... 150 mW

Optocoupler
Storage Temperature Range .... -55°C to +150°C
Ambient Temperature Range .... -55°C to +100°C
Junction Temperature Range .... 100°C
Soldering Temperature (max. 10 s)[1] .... 260°C
Isolation Test Voltage[2]
(between emitter and detector referred to standard climate 23/50 DIN 50014) .... 5300 VDC
Leakage Path .... ≥8.2 mm
Air path .... ≥7.3 mm

Tracking Resistance
In Accordance with VDE 0110 §6, table 3, and DIN 53480/VDE 0303, part 1 .... ≥100
Isolation Resistance (V_{IO}=500 V) .... 10^{11} Ω

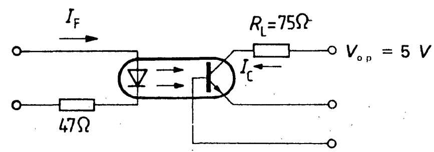
Notes:
1. Dip soldering: 0.5 mm clearance from package.
2. DC test voltage in accordance with DIN 57883, draft 6.80.

Characteristics (T_{amb}=25°C)

Emitter (GaAs Infrared Emitter)			
Forward Voltage (I_F=60 mA)	V_F	1.25 (≤1.65)	V
Breakdown Voltage (I_R=100 µA)	BV	30 (≥6)	V
Reverse Current (V_R=6 V)	I_R	0.01 (≤10)	µA
Capacitance (V_R=0 V, f=1 MHz)	C_0	25	pF
Thermal Resistance	R_{THJA}	750	K/W
Detector (Silicon Phototransistor)			
Capacitance			
(V_{CE}=5 V, f=1 MHz)	C_{CE}	6.8	pF
(V_{CB}=5 V, f=1 MHz)	C_{CB}	8.5	pF
(V_{EB}=5 V, f=1 MHz)	C_{EB}	11	pF
Thermal Resistance	R_{THJA}	500	K/W
Optocoupler			
Collector-Emitter Saturation Voltage			
(I_F=10 mA, I_C=2.5 mA)	V_{CESAT}	0.25 (≤0.4)	V
Coupling Capacitance	C_K	0.55	pF
Current Transfer Ratio			
(I_F=10 mA, V_{CE}=5 V)	I_C, I_F	63 – 200	%
(I_F=1 mA, V_{CE}=5 V)	I_C, I_F	50 (>22)	%
Collector-Emitter Leakage Current			
(V_{CE}=10 V)	I_{CEO}	2 (≤50)	nA

SWITCHING TIMES

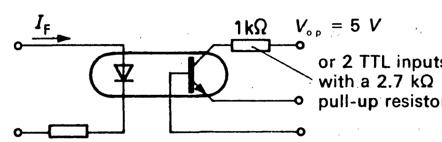
Linear Operation (without saturation)

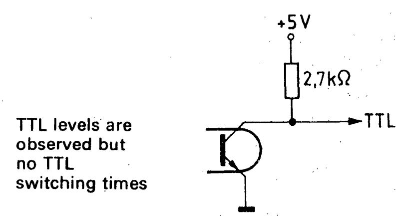


I_F=10 mA, V_{OP}=5 V, T_{amb}=25°C

Load Resistance	R_L	75	Ω
Turn-On Time	t_{ON}	3.0 (≤5.6)	µs
Rise Time	t_R	2.0 (≤4.0)	µs
Turn-Off Time	t_{OFF}	2.3 (≤4.1)	µs
Fall Time	t_F	2.0 (≤3.5)	µs
Cut-Off Frequency	F_{CO}	250	kHz

Switching Operation (with saturation)

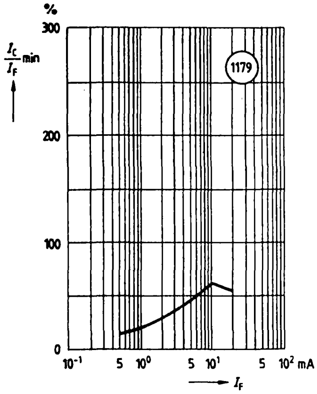




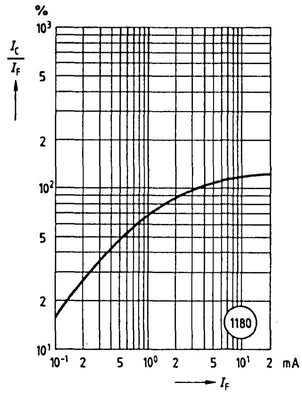
I_F=10 mA

Turn-On Time	t_{ON}	4.2 (≤8.0)	µs
Rise Time	t_R	3.0 (≤6.0)	µs
Turn-Off Time	t_{OFF}	23 (≤39)	µs
Fall Time	t_F	14 (≤24)	µs
	V_{CESAT}	0.25 (≤0.4)	V

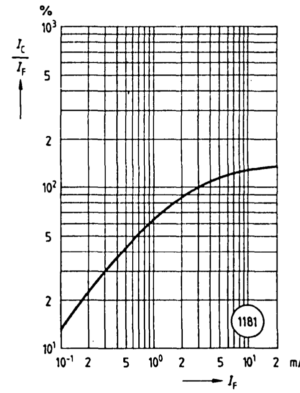
Minimum current transfer ratio versus diode forward current
(T_A=25°C, V_{CE}=5 V)



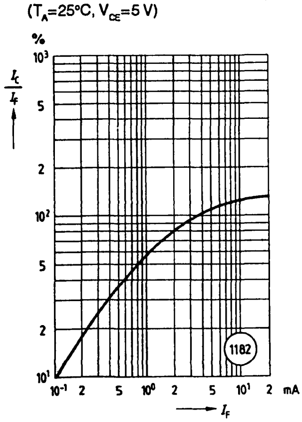
Current transfer ratio (typ.) versus diode forward current
(T_A=25°C, V_{CE}=5 V)



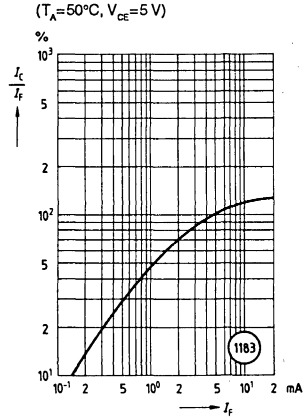
Current transfer ratio (typ.) versus diode forward current
(T_A=0°C, V_{CE}=5 V)



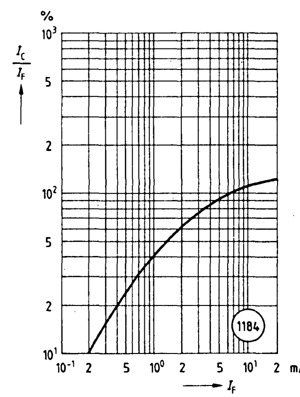
Current transfer ratio (typ.) versus diode forward current
(T_A=25°C, V_{CE}=5 V)



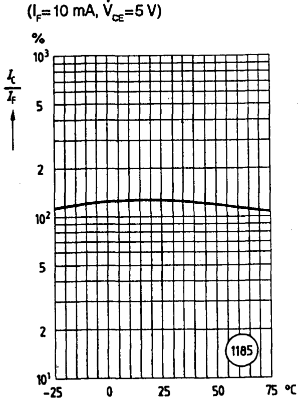
Current transfer ratio (typ.) versus diode forward current
(T_A=50°C, V_{CE}=5 V)



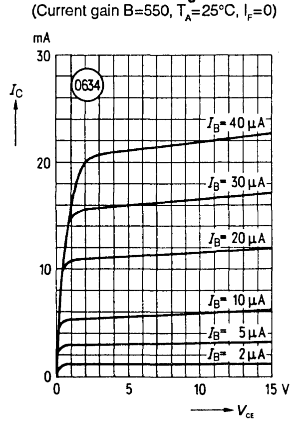
Current transfer ratio (typ.) versus diode forward current
(T_A=75°C, V_{CE}=5 V)



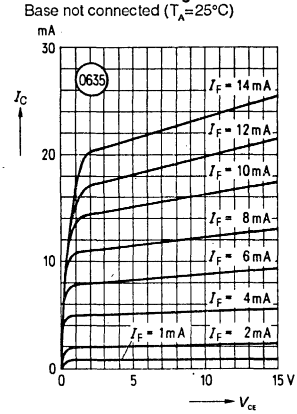
Current transfer ratio (typ.) versus temperature
(I_F=10 mA, V_{CE}=5 V)



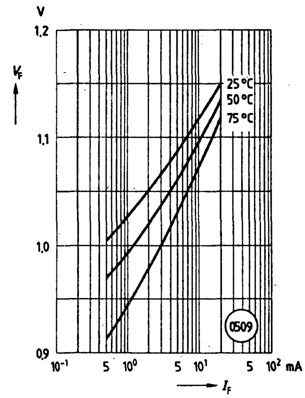
Collector current versus collector-emitter voltage
(Current gain B=550, T_A=25°C, I_F=0)



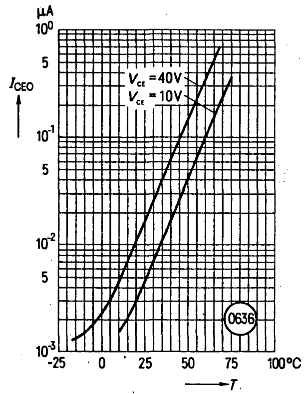
Output characteristics (typ.) Collector current versus collector-emitter voltage
Base not connected (T_A=25°C)



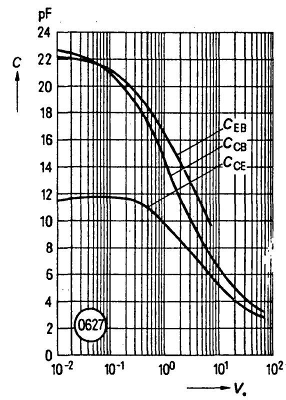
Diode forward voltage (typ.) versus forward current



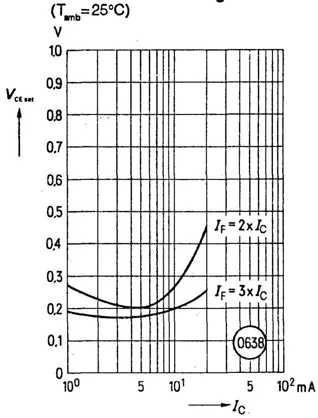
Collector-emitter leakage current (typ.) of the transistor versus temperature
(T_{amb}=25°C, I_F=0)



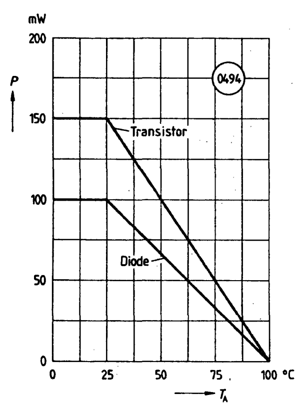
Transistor capacitance (typ.) versus emitter voltage
(T_{amb}=25°C, f =1 MHz)



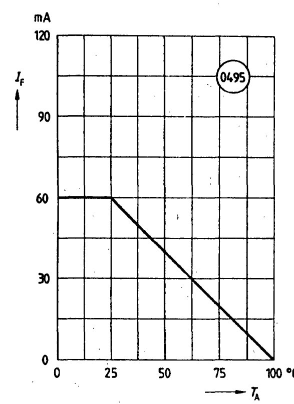
Collector-emitter saturation voltage (typ.) versus collector current and control range [1]
(T_{amb}=25°C)



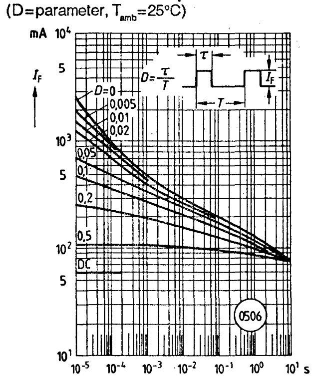
Permissible power dissipation for transistor and diode versus ambient temperature



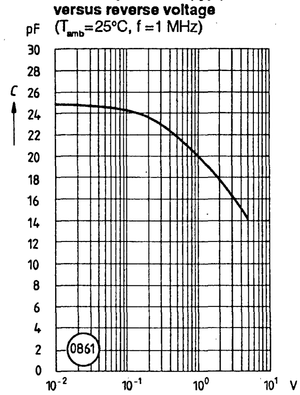
Permissible forward current of the diode versus ambient temperature



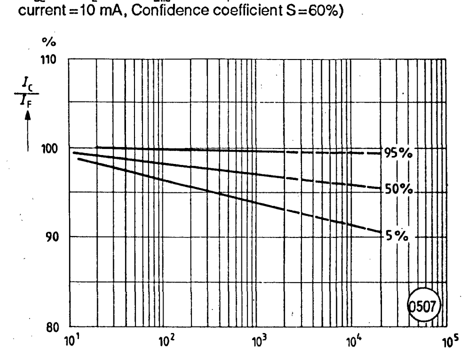
Permissible pulse handling capability Forward current versus pulse width
(D=parameter, T_{amb}=25°C)



Diode capacitance (typ.) versus reverse voltage
(T_{amb}=25°C, f =1 MHz)



Current transfer ratio versus load time
(V_{CE}=5 V,R_L=1 kΩ, T_{amb}=60°C, I_F=60 mA, Measuring current =10 mA, Confidence coefficient S=60%)

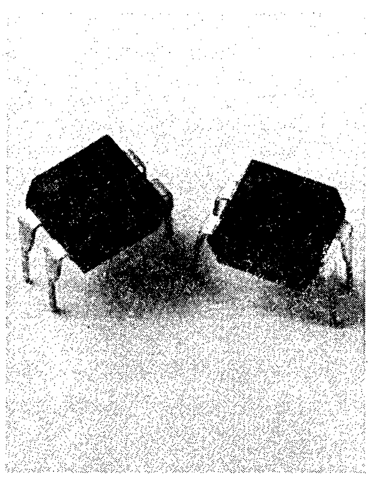


Note:
1. I_F=2 × I_C means that the current flow of the diode has to be adjusted to twice the value of the collector current.

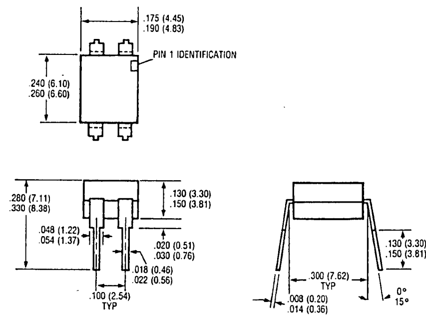
SIEMENS

SFK610/611 SERIES

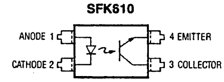
SINGLE PHOTOTRANSISTOR OPTOCOUPLER



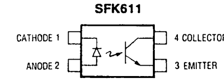
Package Dimensions in Inches (mm)



SFK610



SFK611



Optocouplers (Optoisolators)

FEATURES

- **High Current Transfer Ratios, 4 Groups**
  SFK610/611-1 40 to 80%
  SFK610/611-2 63 to 125%
  SFK610/611-3 100 to 200%
  SFK610/611-4 160 to 320%
- **7500 Volt DC Isolation**
- **Low Saturation Voltage**
- **V_{CEO} = 70 Volt**
- **100% Burn-In at I_F = 50 mA T_{amb} = 60°C, t = 24h**
- **UL Approval #52744**
- **Trios**

DESCRIPTION

The SFK610/611 series is a single-channel optocoupler series for high density applications. Each coupler consists of an optically coupled pair employing a Gallium Arsenide infrared LED and a silicon NPN phototransistor. Signal information, including a DC level, can be transmitted by the device while maintaining a high degree of electrical isolation between input and output.

The SFK610/611 series offers an additional level of reliability with 100% burn-in of the LED emitter at elevated temperature.

Maximum Ratings

Emitter (GaAs LED)			
Reverse Voltage	V_R	6	V
DC forward current	I_F	60	mA
Surge forward current (t≤10 μs)	I_{FSM}	2.5	A
Total power dissipation	P_{tot}	100	mW
Detector (silicon phototransistor)			
Collector-emitter voltage	V_{CEO}	70	V
Collector current	I_C	50	mA
Collector current (t≤1 ms)	I_{CSM}	100	mA
Total power dissipation	P_{tot}	150	mW
Optocoupler			
Storage temperature range	T_{stg}	−55... +150 °C	
Ambient temperature range	T_{amb}	−55... +100 °C	
Junction temperature	T_j	100	°C
Soldering temperature (max. 10 sec)[1]	T_{sold}	260	°C
Isolation test voltage (t = 1sec)	V_{IS}	7500	VDC
		5300	VAC (RMS)
Isolation resistance	R_{ISO}	10^{11}	Ω

[1] Dip soldering: Insertion depth <3.6 mm

CHARACTERISTICS @ T_{amb} 25°C			
Emitter (GaAs infared emitter)			
Forward voltage ($I_F = 60$ mA)	V_F	1.25 (≤1.65)	V
Breakdown voltage ($I_R = 10$ μA)	V_{BR}	30 (≥6)	V
Reverse current ($V_R = 6$ V)	I_R	0.01 (≤10)	μA
Capacitance ($V_R = 0$ V; f = 1 MHz)	C_O	25	pF
Detector (silicon phototransistor)			
Collector—emitter breakdown voltage	BV_{CEO}	70	V
Emitter—collector breakdown voltage	BV_{ECO}	7.5	V
Capacitance ($V_{CE} = 5$ V; f = 1 μHz)	C_{CE}	6.8	pF
Coupled			
Collector—emitter saturation voltage ($I_F = 10$ mA, $I_C = 2.5$ mA)	$V_{CE\ (sat)}$	0.25 (<0.40)	V
Coupling capacitance	C_C	0.35	pF

Group	SFK610/611-1	SFK610/611-2	SFK610/611-3	SFK610/611-4	
Current transfer ratio[1] $I_F = 10$ mA, $V_{CE} = 5$ V	40–80	63–125	100–200	160–320	%
Current transfer ratio[1] $I_F = 1$ ma, $V_{CE} = 5$ V	13 min.	22 min.	34 min.	56 min.	%
I_{CEO} ($V_{CE} = 10$ V)	2 (≤50)	2 (≤50)	5 (≤100)	5 (≤100)	nA

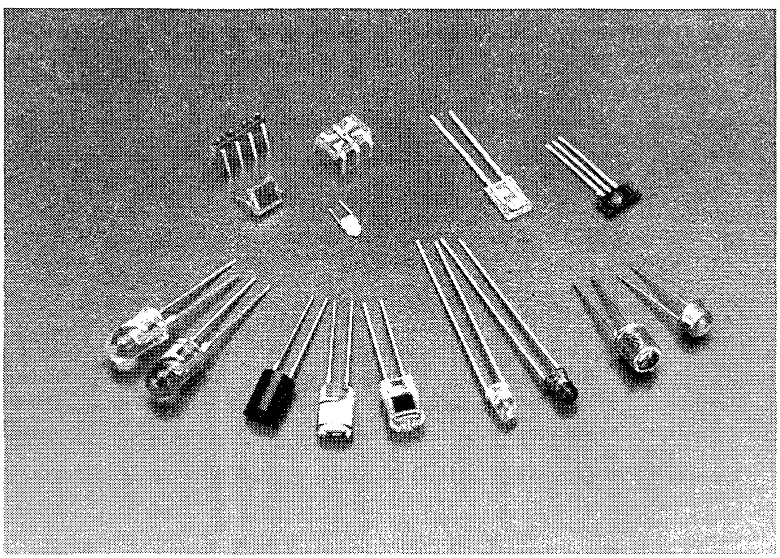
CTR will match within a ratio of 1.7:1

Switching Characteristics
Linear Operation (without saturation) I_F10 mA, $V_{CC} = 5$ V, $R_C = 75\ \Omega$

Group		SFK610/611-1	SFK610/611-2	SFK610/611-3	SFK610/611-4	
Turn on time	t_{on}	3.0 (<5.6)	3.2 (<5.6)	3.6 (<5.6)	4.1 (<5.6)	μs
Rise time	t_r	2.0 (<4.0)	2.5 (<4.0)	2.9 (<4.0)	3.3 (<4.0)	μs
Turn off time	t_{off}	2.3 (<4.1)	2.9 (<4.1)	3.4 (<4.1)	3.7 (<4.1)	μs
Fall time	t_f	2.0 (<3.5)	2.6 (<3.5)	3.1 (<3.5)	3.5 (<3.5)	μs

Switching operation (with saturation) $V_{CC} = 5$ V, $R_C = 1$ KΩ

Group		SFK610/611-1 $I_F = 20$ mA	SFK610/611-2 $I_F = 10$ mA	SFK610/611-3 $I_F = 10$ mA	SFK610/611-4 $I_F = 5$ mA	
Turn on time	t_{on}	3.0 (<5.5)	4.3 (<8.0)	4.6 (<8.0)	6.0 (<10.5)	μs
Rise time	t_r	2.0 (<4.0)	2.8 (<6.0)	3.3 (<6.0)	4.6 (<8.0)	μs
Turn off time	t_{off}	18 (<34)	24 (<39)	25 (<39)	25 (<43)	μs
Fall time	t_f	11 (<20)	11 (<24)	15 (<24)	15 (<26)	μs



Fiber Optic Devices

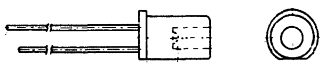
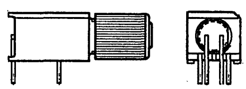
Infrared Emitters

Photodiodes

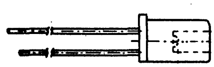
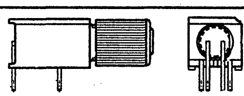
Phototransistors

Photovoltaic Cells

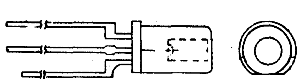
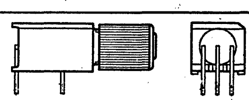
Fiber Optic Emitters

Package Outline	Part Number	Package Type	Infrared/ Visible (Color)	Maximum Wavelength nm	Surge Current (t<10μS) A	Features	Page
	SFH450	T1³/4 Light grey plastic	Infrared	950 GaAs	3.5	Fiber optic short distance data transmission. 2.3mm aperture holds 1000 micron plastic fiber. Matches with SFH250/F/V or SFH350/F/V.	6–11
	SFH750	T1³/4 Red plastic	Visible (Red)	660 GaAsP	1.5		
	SFH751	T1³/4 Green plastic	Visible (Green)	560 GaAsP	1.0		
	SFH450V	Grey plastic connector housing.	Infrared	950 GaAs	3.5		6–13
	SFH451V SFH452V			840			
	SFH750V		Visible (Red)	660	1.5		
	SFH752V		Visible (Hyper-red)	650			

Fiber Optic Photodiodes

Package Outline	Part Number	Package Type	Aperture	Dark Current V_R=20V nA	Max. Wave-length nm	Features	Page
	SFH250	T1³/4 Plastic SFH250, clear SFH250F, daylight filter	2.3mm	1(≤10) 20V	950	PIN type. Fiber optic short distance data transmission. 2.3mm aperture holds 1000 micron plastic fiber.	6–3
	SFH250F				900		
	SFH250V	Black plastic connector housing.			850	Matches with SFH450/V, 451V, 452V, 750/V.	6–5

Fiber Optic Phototransitors

Package Outline	Part Number	Package Type	Aperture	Photocurrent λ=950nm VCE=5V mA	Collector Emitter Voltage V	Features	Page
	SFH350	T1³/4 Plastic SFH350, clear SFH350F, daylight filter	2.3mm	0.7	50	Fiber optic short distance data transmission. 2.3mm aperture holds 1000 micron plastic fiber. Matches with SFH450/V, 451V, 452V, 750/V, SFH751, SFH752V.	6–7
	SFH350F			0.55			
	SFH350V	Black plastic connector housing.		0.7			6–9

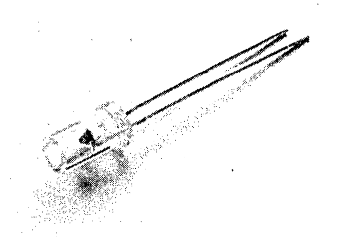
Fiber Optic Kit

Part Number: PFOK–1 Design-in kit for fiber optic devices. Contains: 1) Emitters–SFH450, SFH750, SFH751, SFH750V; 2) Photodiodes–SFH250, SFH250F, SFH250V; 3) Phototransistors–SFH350, SFH350F; 4) Fiber–7' long & 15' long; 5) Application Note; and 6) Data Book.	6–15

SIEMENS

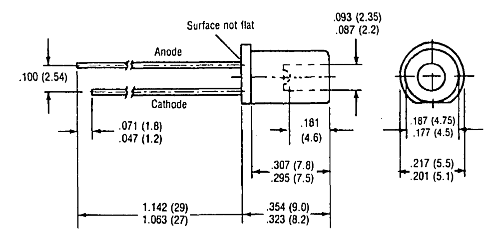
SFH250
WITH IR FILTER SFH250F
PLASTIC FIBER OPTIC PHOTODIODE DETECTOR

Preliminary Data Sheet



SFH250

Package Dimensions in Inches (mm)



FEATURES

- **2.3 mm Aperture Holds Standard 1000 Micron Plastic Fiber**
- **No Fiber Stripping Required**
- **Daylight Rejection Filter (SFH250F)**
- **High Reliability**
- **Low Noise**
- **Fast Switching Times**
- **Low Capacitance**
- **Very Good Linearity**
- **Sensitive in the Visible (SFH250) and Near IR Range (SFH250 & 250F)**
- **Molded Microlens for Efficient Coupling**

DESCRIPTION

The SFH250/250F are fast silicon PIN photodiodes in a low cost plastic package for use in short distance data transmission using 1000 micron plastic fibers. Both come in a 5 mm (T1¾) plastic package featuring a tubular aperture which is wide enough to accommodate fiber and cladding. A microlens on the bottom of the aperture improves the light coupling efficiency of the fiber output into the photodiode.

The SFH250 has a clear plastic housing; the SFH250F has a black plastic housing.

Typical applications include: automotive wiring, isolation interconnects, medical instruments, robotics, electronic games, and copy machines.

For application information see Appnote 40.

Maximum Ratings

Operating and Storage Temperature Range (T) .... –55 to +100°C
Soldering Temperature (Distance from solder to package = 2 mm)
Dip Soldering Time, t≤5 sec (T_S) .... 260°C
Reverse Voltage (V_R) .... 30 V
Power Dissipation (P_{TOT}) .... 100 mW
Thermal Resistance (R_{THJA}) .... 750 K/W

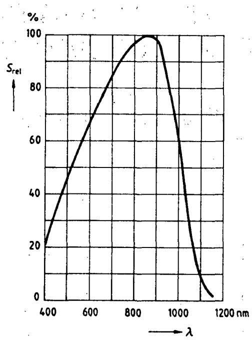
Characteristics (T_{amb} = 25°C)

Wavelength of Max. Photosensitivity			
SFH250	λ_{MAX}	850	nm
SFH250F	λ_{MAX}	900	nm
Spectral Range of Photosensitivity ($S = 10\%$ of S_{MAX})			
SFH250	λ	400 to 1100	nm
SFH250F	λ	800 to 1100	nm
Dark Current ($V_R = 20$ V)	I_R	1 (≤10)	nA
Quantum Efficiency ($\lambda = 850$ nm)	η	0.89	Electrons / Photon
Rise and Fall Time of the Photocurrent from 10% to 90%, respectively, and from 90% to 10% of its Peak Value ($R_L = 50\Omega$, $V_R = 30$ V, $\lambda = 880$ nm)	t_R, t_F	10	ns
Capacitance ($V_R = 0$ V, f = 1 MHz, $E_V = 0$ lx)	C_0	11	pF
Noise Equivalent Power	NEP	2.9×10^{-14}	$\frac{W}{\sqrt{Hz}}$
Detection Limit ($V_R = 20$ V)	D_L	3.5×10^{12}	$\frac{cm\sqrt{Hz}}{W}$
Photocurrent ($V_R = 5$ V) (Note 1)			
SFH250/250F $\lambda = 950$ nm	I_{PH}	4.0	μA
SFH250 $\lambda = 660$ nm	I_{PH}	3.0	μA

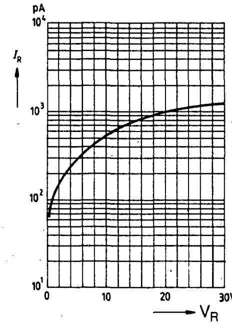
[1] Photocurrent generated at 10 μW light incidence through plastic 1000 micron fiber (distance lens-fiber ≤0.1 mm, fiber type ESKA EH4001, fiber face polished).

SFH250

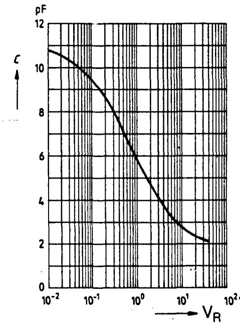
Relative spectral sensitivity
$S_{rel} = f(\lambda)$



Dark current $I_R = f(V_R)$
$T_{amb} = 25°C$



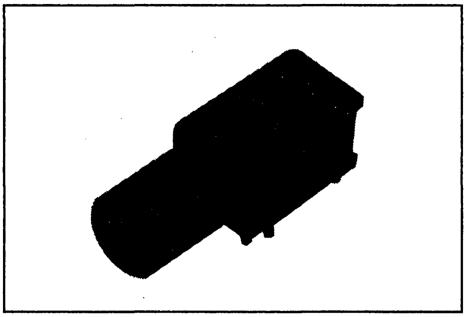
Capacitance $C = f(V_R)$
$T_{amb} = 25°C$



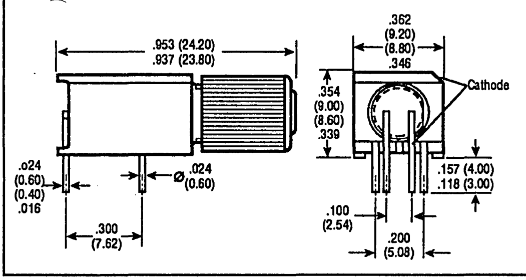
SFH250V

PLASTIC FIBER OPTIC PHOTODIODE DETECTOR

Preliminary Data Sheet



Package Dimensions in Inches (mm)



FEATURES

- **2.3 mm Aperture Holds Standard 1000 Micron Plastic Fiber**
- **No Fiber Stripping Required**
- **Connect Fiber without Twisting**
- **Plastic Connector Housing**
- **Mounting Screw Attached to Connector**
- **Interference-Free Transmission because of Light-Tight Housing**
- **Transmitter and Receiver Can Be Flexibly Positioned**
- **No Cross Talk**
- **Auto Insertable and Wave Solderable**
- **Supplied in Tubes**
- **Molded Microlens for Efficient Coupling**
- **Fast Switching Time**
- **Sensitive in Visible and Near IR Range**
- **Very Good Linearity**

DESCRIPTION

The SFH250V is a fast silicon PIN photodiode for use in short distance data transmission using 1000 micron plastic fibers. The photodiode is part of a family of light link components for applications requiring a low cost fiber optic link. The device is housed in a plastic connector with a mounting screw permanently attached to the thread and designed to house a 1000 micron plastic fiber with cladding. A microlens improves the light coupling efficiency of the fiber output into the photodiode.

Typical applications include: Remote photointerrupter/sensing; Fast optocoupler with extremely high isolation voltage; Transmission of analog/digital signals, data buses; Feedback loop in switch mode power supplies; Isolation in test/measurement/medical instruments; Noise immune data transmission in electrically noisy environments (motors, relays, solenoids, etc.).

For application information see Appnotes 40, 41, 42, 43.

See SFH250/F for component without plastic housing.

Maximum Ratings

Operating and Storage Temperature Range (T) .... −55 to +100°C
Soldering Temperature (Distance from solder to package = 2 mm)
Dip Soldering Time, t≤5 sec (T_S) .... 260°C
Reverse Voltage (V_R) .... 30 V
Power Dissipation (P_{TOT}) .... 100 mW
Thermal Resistance (R_{THJA}) .... 750 K/W

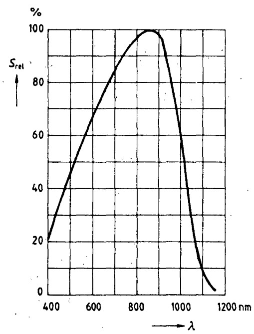
Characteristics (T_{amb} = 25°C)

Wavelength of Max. Photosensitivity	λ_{MAX}	850	nm
Spectral Range of Photosensitivity (S = 10% of S_{MAX})	λ	400 to 1100	nm
Dark Current (V_R = 20 V)	I_R	1 (≤10)	nA
Quantum Efficiency (λ = 850 nm)	η	0.89	Electrons / Photon
Rise and Fall Time of the Photocurrent from 10% to 90%, respectively, and from 90% to 10% of its Peak Value (R_L = 50Ω, V_R = 30 V, λ = 880 nm)	t_R, t_F	10	ns
Capacitance (V_R = 0 V, f = 1 MHz, E_V = 0 lx)	C_0	11	pF
Noise Equivalent Power	NEP	2.9×10^{-14}	$\frac{W}{\sqrt{Hz}}$
Detection Limit (V_R = 20 V)	D_L	3.5×10^{12}	$\frac{cm \sqrt{Hz}}{W}$
Photocurrent (V_R = 5 V) (Note 1) λ = 660 nm (red)	I_{PH}	3.0	µA

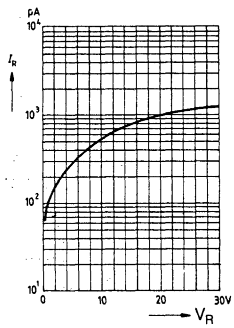
[1] Photocurrent generated at 10 µW light incidence through plastic 1000 micron fiber (distance lens-fiber ≤0.1 mm, fiber type ESKA EH4001, fiber ends polished).

SFH250V

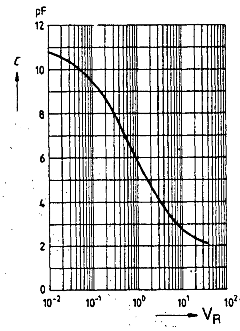
Relative spectral sensitivity
$S_{rel} = f(\lambda)$



Dark current $I_R = f(V_R)$
$T_{amb} = 25°C$



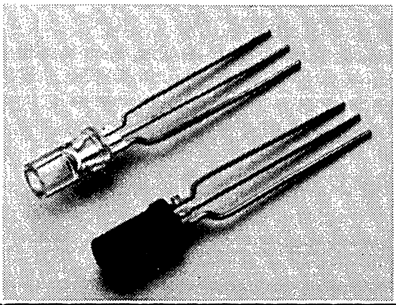
Capacitance $C = f(V_R)$
$T_{amb} = 25°C$



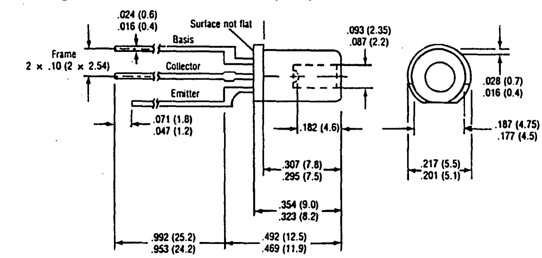
SIEMENS

SFH350
WITH IR FILTER SFH350F
PLASTIC FIBER OPTIC PHOTOTRANSISTOR DETECTOR

Preliminary Data Sheet



Package Dimensions in Inches (mm)



FEATURES

- **2.3 mm Aperture Holds Standard 1000 Micron Plastic Fiber**
- **No Fiber Stripping Required**
- **Daylight Rejection Filter (SFH350F)**
- **High Reliability**
- **Good Linearity**
- **Sensitive in the Visible (SFH350) and Near IR Range (SFH350 & 350F)**
- **Three Lead Phototransistor**
- **Molded Microlens for Efficient Coupling**

DESCRIPTION

The SFH350/350F are NPN silicon phototransistors in a low cost plastic package for use in short distance data transmission using 1000 micron plastic fibers. Both come in a 5 mm (T1¾) plastic package featuring a tubular aperture. It is wide enough to accommodate fiber and cladding. A microlens on the bottom improves the light coupling efficiency—fiber output to PTX.

The SFH350 has a clear plastic housing; the SFH350F has a black plastic housing.

Typical applications include: automotive wiring, isolation interconnects, medical applications, robotics, electronic games, etc.

For application information see Appnote 40.

Maximum Ratings

Operating and Storage Temperature Range (T) .... –55 to +100°C
Soldering Temperature (Distance from solder to package = 2 mm)
Dip Soldering Time, t≤5 sec (T_S) .... 260°C
Collector-Emitter Voltage (V_{CE}) .... 50 V
Collector Current (I_C) .... 50 mA
Collector Peak Current, t≤10 sec (I_{CP}) .... 100 mA
Emitter Base Voltage (V_{EB}) .... 7 V
Power Dissipation (T_{amb} = 25°C) (P_{TOT}) .... 200 mW
Thermal Resistance (R_{THJA}) .... 375 K/W

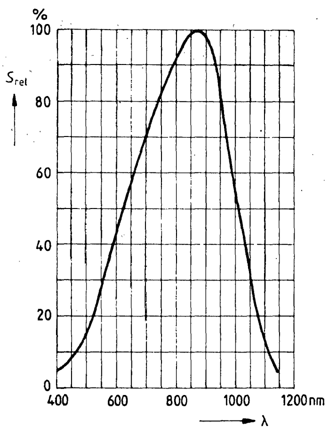
Characteristics (T_{amb} = 25°C)

Wavelength of Max. Photosensitivity			
SFH350	λ_{MAX}	850	nm
SFH350F	λ_{MAX}	900	nm
Spectral Range of Photosensitivity (S = 10% of S_{MAX})			
SFH350	λ	400 to 1100	nm
SFH350F	λ	800 to 1100	nm
Capacitance			
(V_{CE} = 0 V, f = 1 MHz, E = 0 lx)	C_{CE}	9	pF
(V_{CB} = 0 V, f = 1 MHz, E = 0 lx)	C_{CB}	22	pF
(V_{EB} = 0 V, f = 1 MHz, E = 0 lx)	C_{EB}	20	pF
Rise and Fall Time			
(I_C = 1.0 mA, V_{CE} = 5 V, R_L = 1 kΩ)	t_R, t_F	15	µs
Current Gain			
(V_{CE} = 5 V, I_{CE} = 2 mA)	β	500	Typ.
Photocurrent (V_{CE} = 5 V) (Note 1)			
SFH350F λ = 950 nm	I_{CE}	1.0	mA
SFH350 λ = 660 nm	I_{CE}	0.8	mA

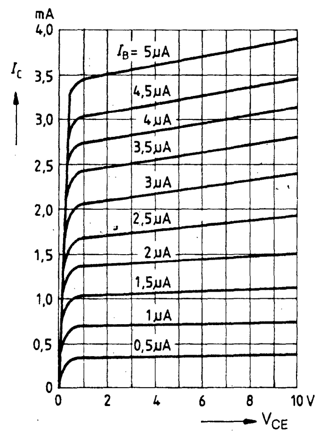
[1] Photocurrent generated at 10 µW light incidence through plastic 1000 micron fiber (distance lens-fiber ≤0.1 mm, fiber type ESKA EH4001, fiber face polished).

SFH350

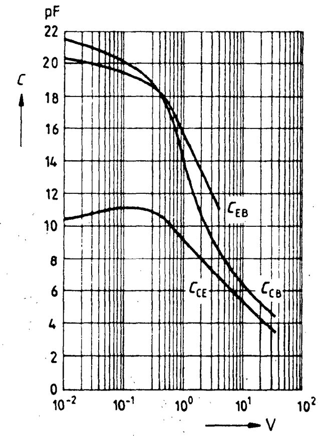
Relative spectral sensitivity
$S_{rel} = f(\lambda)$



Output characteristics
$I_C = f(V_{CE})$; I_B = Parameter



Capacitance C = f(V)

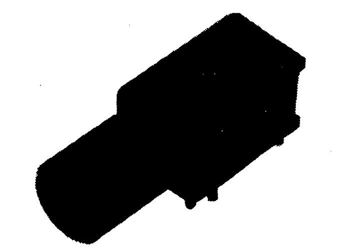


SIEMENS

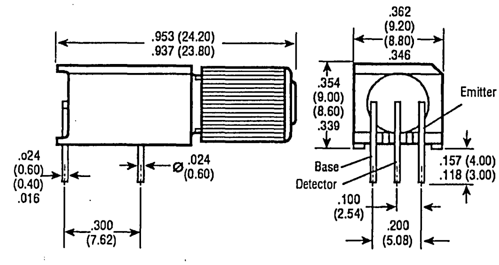
SFH350V

PLASTIC FIBER OPTIC PHOTOTRANSISTOR DETECTOR

Preliminary Data Sheet



Package Dimensions in Inches (mm)



FEATURES

- **2.3 mm Aperture Holds Standard 1000 Micron Plastic Fiber**
- **No Fiber Stripping Required**
- **Connect Fiber without Twisting**
- **Plastic Connector Housing**
- **Mounting Screw Attached to Connector**
- **Interference-Free Transmission because of Light-Tight Housing**
- **Transmitter and Receiver Can Be Flexibly Positioned**
- **No Cross Talk**
- **Auto Insertable and Wave Solderable**
- **Supplied in Tubes**
- **Good Linearity**
- **Molded Microlens for Efficient Coupling**
- **Sensitive in the Visible and Near IR Range**
- **Base Lead Connection for External Biasing**

DESCRIPTION

The SFH350V is a NPN silicon phototransistor in a low cost plastic package for use in short distance data transmission using 1000 micron plastic fibers. The phototransistor is part of a family of light link components for applications requiring a low cost fiber optic link. The device is housed in a plastic connector with a mounting screw permanently attached to the thread and designed to house a 1000 micron plastic fiber with cladding. A microlens improves the light coupling efficiency of the fiber output into the phototransistor.

Typical applications include: Remote photointerrupter/sensing; Fast optocoupler with extremely high isolation voltage; Transmission of analog/digital signals, data buses; Feedback loop in switch mode power supplies; Isolation in test/measurement/medical instruments; Noise immune data transmission in electrically noisy environments (motors, relays, solenoids, etc.).

Maximum Ratings

Operating and Storage Temperature Range (T)	–55 to +100°C
Soldering Temperature (Distance from solder to package = 2 mm)	
Dip Soldering Time, $t \leq 5$ sec (T_S)	260°C
Collector-Emitter Voltage (V_{CE})	50 V
Collector Current (I_C)	50 mA
Collector Peak Current, $t \leq 10$ sec (I_{CP})	100 mA
Emitter Base Voltage (V_{EB})	7 V
Power Dissipation (T_{amb} = 25°C) (P_{TOT})	200 mW
Thermal Resistance (R_{THJA})	375 K/W

Characteristics (T_{amb} = 25°C)

Wavelength of Max. Photosensitivity	λ_{MAX}	850	nm
Spectral Range of Photosensitivity			
(S = 10% of S_{MAX})	λ	400 to 1100	nm
Capacitance			
(V_{CE} = 0 V, f = 1 MHz, E = 0 lx)	C_{CE}	9	pF
(V_{CB} = 0 V, f = 1 MHz, E = 0 lx)	C_{CB}	22	pF
(V_{EB} = 0 V, f = 1 MHz, E = 0 lx)	C_{EB}	20	pF
Rise and Fall Time			
(I_C = 1.0 mA, V_{CE} = 5 V, R_L = 1 kΩ)	t_R, t_F	15	µs
Current Gain			
(V_{CE} = 5 V, I_{CE} = 2 mA)	β	500	Typ.
Photocurrent (V_{CE} = 5 V) (Note 1)			
λ = 660 nm (red)	I_{CE}	0.8	mA

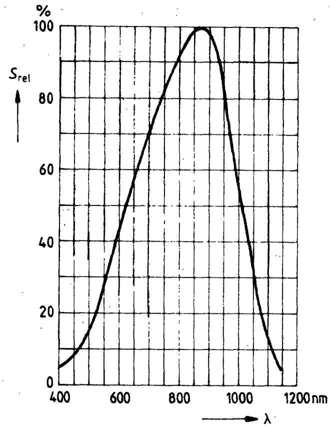
[1] Photocurrent generated at 10 µW light incidence through plastic 1000 micron fiber (distance lens-fiber ≤0.1 mm, fiber type ESKA EH4001, fiber ends polished).

For application information see Appnotes 40, 41, 42, 43.

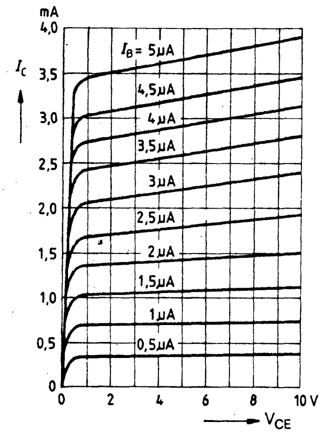
See SFH350/F for component without plastic housing.

SFH350V

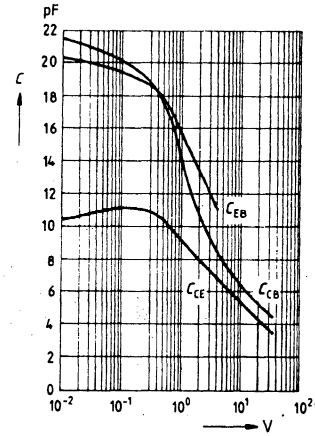
Relative spectral sensitivity
$S_{rel} = f(\lambda)$



Output characteristics
$I_C = f(V_{CE})$; I_B = Parameter



Capacitance C = f(V)

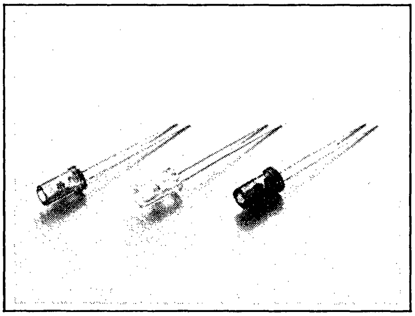


SIEMENS

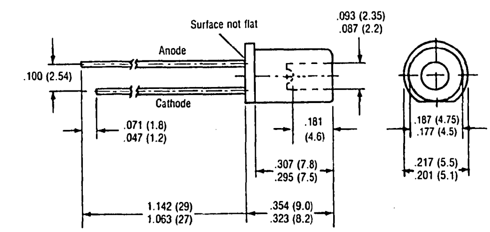
SFH450/750/751

PLASTIC FIBER OPTIC TRANSMITTER DIODE

Preliminary Data Sheet



Package Dimensions in Inches (mm)



FEATURES

- **2.3 mm Aperture Holds 1000 Micron Plastic Fiber**
- **No Fiber Stripping Required**
- **SFH450 – Infrared, Light Grey Plastic Package**
- **SFH750 – Visible Red, Red Plastic Package**
- **SFH751 – Visible Green, Green Plastic Package**
- **High Reliability**
- **Long Life Time**
- **Fast Switching Times**
- **Molded Microlens for Efficient Coupling**

DESCRIPTION

The SFH450 is a gallium arsenide (GaAs) infrared emitter. The SFH750 is a gallium arsenide phosphide (GaAsP), visible red emitter; the SFH751 is a gallium phosphide (GaP) visible green emitter. These three devices form a new family of low cost fiber optic components designed for short distance data transmission using 1000 micron core plastic fiber. The devices come in a 5 mm (T1¾) plastic package featuring a tubular aperture which is wide enough to accommodate fiber and cladding. A microlens on the bottom of the aperture improves the light coupling efficiency into an inserted plastic fiber.

Typical applications include: automotive wiring, isolation interconnects, medical equipment, robotics, electronic games, and copy machines.

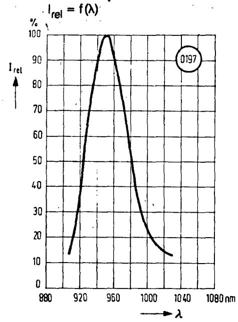
Maximum Ratings

		SFH450	SHF750	SFH751	
Operating and Storage Temperature	T		-55 to +100		°C
Junction Temperature	T_j		100		°C
Soldering Temperature (Distance from solder to package =2 mm) Dip Soldering Time t ≤ 5 sec	T_S	260	260	260	°C
Reverse Voltage	V_R	5	5	5	V
Forward Current (DC)	I_F	130	75	45	mA
Surge Current (t≤10 μs, D = 0)	I_{FS}	3.5	1.5	1	A
Power Dissipation	P_{tot}	210	150	150	mW
Thermal Resistance Junction/Air	R_{thjA}	350	500	500	K/W

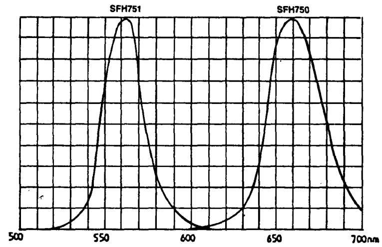
Electrical Characteristics (T_{amb} = 25°C)

		SFH450	**SHF750**	**SFH751**	
Wavelength	λ	950 ±20	660 ±15	560 ±15	nm
Spectral Bandwidth	Δλ	55	35	25	nm
Switching Times					
t_{ON} (10 – 90%)	t_r	1	0.12	0.5	μsec
t_{OFF} (90 – 10%)	t_f	1	0.05	0.2	μsec
Capacitance	C_0	40	40	11	pF
Forward Voltage	V_F				
I_F = 100 mA		1.3 (≤1.5)			V
I_F = 10 mA			1.6 (≤2.0)	2.0 (≤2.6)	V
Coupling Characteristics into a 1000 Micron Core Plastic Fiber (ESKA EH4001) Distance Fiber to Lens ≤0.1 mm, polished ends. (I_F = 10 mA)	P_{in}	90	9	3	μW

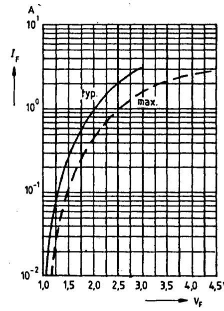
SFH450
Relative spectral emission
$I_{rel} = f(\lambda)$



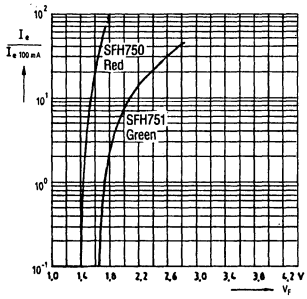
SFH750/751
Relative spectral emission
$I_{rel} = f(\lambda)$



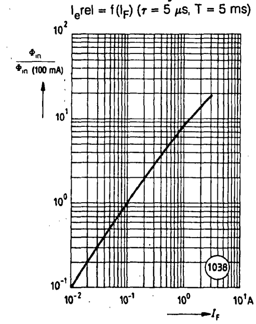
SFH450
Forward current $I_F = f(V_F)$



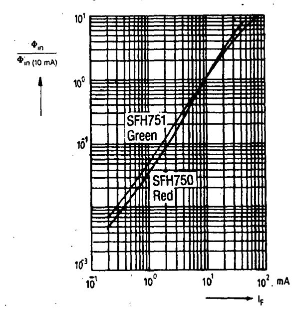
SFH750/751
Forward current $I_F = f(V_F)$



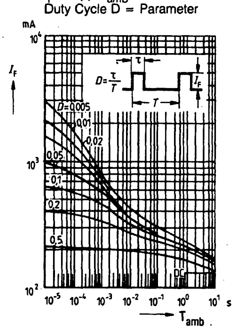
SFH450
Radiant intensity
$I_e rel = f(I_F)$ ($\tau = 5\ \mu s$, T = 5 ms)



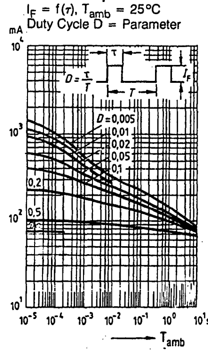
SFH750/751
Radiant intensity
$I_e rel = f(I_F)$ ($\tau = 5\ \mu s$, T = 5 ms)



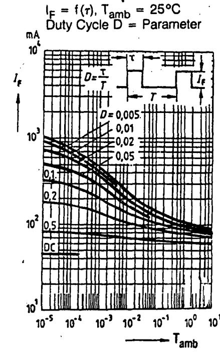
SFH450
Permissible pulse load
$I_F = f(\tau)$, $T_{amb} = 25°C$
Duty Cycle D = Parameter



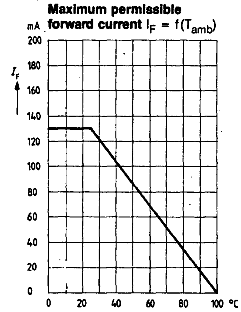
SFH750
Permissible pulse load
$I_F = f(\tau)$, $T_{amb} = 25°C$
Duty Cycle D = Parameter



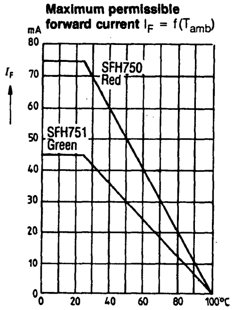
SFH751
Permissible pulse load
$I_F = f(\tau)$, $T_{amb} = 25°C$
Duty Cycle D = Parameter



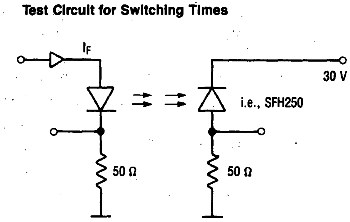
SFH450
Maximum permissible
forward current $I_F = f(T_{amb})$



SFH750/751
Maximum permissible
forward current $I_F = f(T_{amb})$



SFH450/750/751
Test Circuit for Switching Times

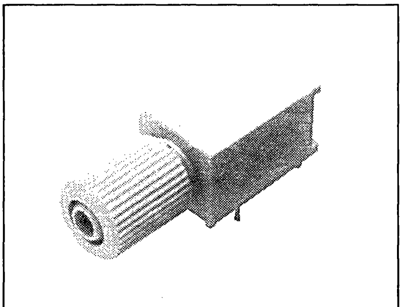


SIEMENS

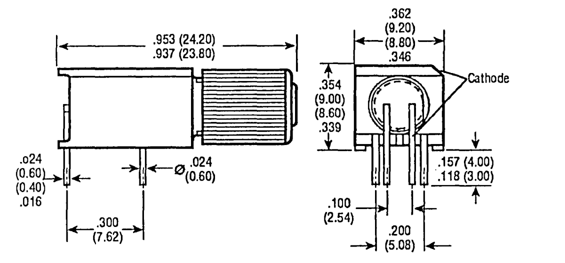
SFH450V/451V/452V
SFH750V/752V

PLASTIC FIBER OPTIC TRANSMITTER DIODE

Preliminary Data Sheet



Package Dimensions in Inches (mm)



FEATURES

- **2.3 mm Aperture Holds 1000 Micron Plastic Fiber**
- **No Fiber Stripping Required**
- **Connect Fiber without Twisting**
- **Plastic Connector Housing**
- **Mounting Screw Attached to Connector**
- **Interference-Free Transmission because of Light-Tight Housing**
- **No Cross Talk**
- **Auto Insertable and Wave Solderable**
- **Supplied in Tubes**
- **Molded Microlens for Efficient Coupling**

DESCRIPTION

The SFH450V, SFH451V, and SFH452V are infrared emitters, the SFH450V is a gallium arsenide (GaAs) emitter, the SFH451V, a gallium aluminum arsenide (GaAlAs) emitter, and the SFH452V, a very fast infrared emitter. The SFH750V is a gallium arsenide phosphide (GaAsP), visible red emitter and the SFH752V, hyper-red emitter. These devices are part of a family of low cost fiber optic components designed for short distance data transmission using 1000 micron core plastic fiber. The devices are housed in a plastic connector with a mounting screw permanently attached to the thread and a tubular aperture wide enough to accommodate fiber and cladding. A microlens on the bottom of the aperture improves the light coupling efficiency into an inserted plastic fiber.

Typical applications include: Remote photo-interrupter/sensing; Fast optocoupler with extremely high isolation voltage; Transmission of analog/digital signals, data buses; Feed-back loop in switch mode power supplies; Isolation in test/measurement/medical instruments; Noise immune data transmission in electrically noisy environments (motors, relays, solenoids, etc.).

Maximum Ratings

Operating and Storage Temperature (T) . . . . −55 to +100°C
Junction Temperature (T_J) . . . . 100°C
Soldering Temperture (Distance from solder to package = 2 mm)
Dip Soldering Time t ≤ 5 sec (T_S) . . . . 260°C
Reverse Voltage (V_R) . . . . 5 V

		SFH450V SFH451V SFH452V	SFH750V	SFH752V	
Forward Current (DC)	I_F	130	75	45	mA
Surge Current (t ≤ 10 μs, D = 0)	I_{FS}	3.5	1.5	1.5	A
Power Dissipation	P_{TOT}	210	150	150	mW
Thermal Resistance Junction/Air	R_{THJA}	350	500	500	K/W

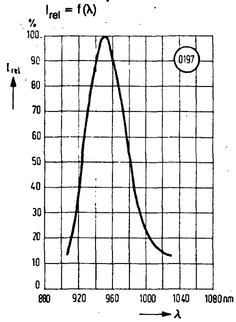
Electrical Characteristics (T_{amb} = 25°C)

		SFH450V	SFH451V	SFH452V	SFH750V	SFH752V	
Wavelength	λ	950	830	770	660	665	nm
Spectral Bandwidth	Δλ	55	80	80	35	35	nm
Switching Times t_{ON} (10–90%)	t_r	1	0.1	0.05	0.12	0.07	μsec
t_{OFF} (90–10%)	t_f	1	0.1	0.05	0.05	0.01	μsec
Capacitance	C_0	40	40	40	40	40	pF
Forward Voltage I_F = 100 mA	V_F	1.3 (≤1.5)	1.4 (≤1.6)	1.4 (≤1.6)	1.6 (≤2.0)	1.6 (≤2.0)	V
Coupling Characteristics into a 1000 Micron Core Plastic Fiber (ESKA EH4001) Distance Fiber to Lens ≤0.1 mm, polished ends. (I_F = 10 mA)	P_{IN}	90	40	40	5	40	μW

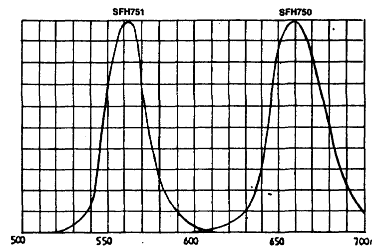
For application information see Appnotes 40, 41, 42, 43.

See SFH450/451/750/751 for components without plastic housing.

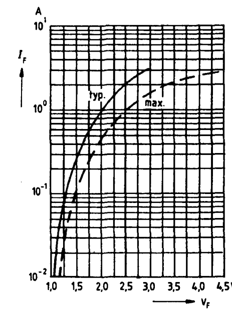
SFH450V
Relative spectral emission
$I_{rel} = f(\lambda)$



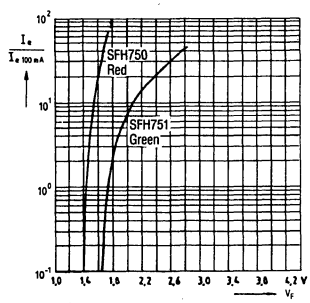
SFH750V
Relative spectral emission
$I_{rel} = f(\lambda)$



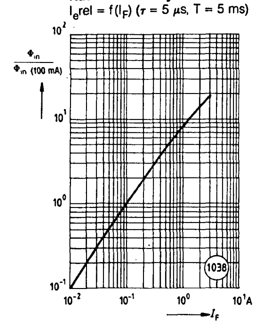
SFH450V
Forward current $I_F = f(V_F)$



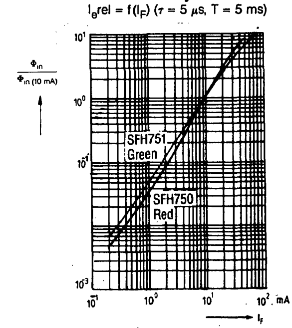
SFH750V
Forward current $I_F = f(V_F)$



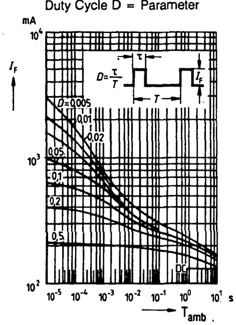
SFH450V
Radiant intensity
$I_e rel = f(I_F)$ ($\tau = 5\ \mu s$, T = 5 ms)



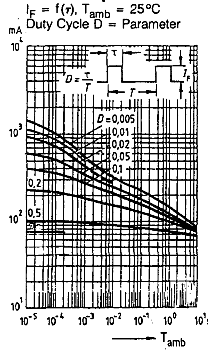
SFH750V
Radiant intensity
$I_e rel = f(I_F)$ ($\tau = 5\ \mu s$, T = 5 ms)



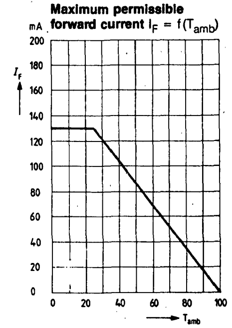
SFH450V
Permissible pulse load
$I_F = f(\tau)$, $T_{amb} = 25°C$
Duty Cycle D = Parameter



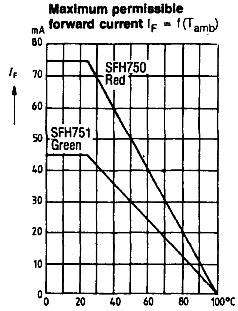
SFH750V
Permissible pulse load
$I_F = f(\tau)$, $T_{amb} = 25°C$
Duty Cycle D = Parameter



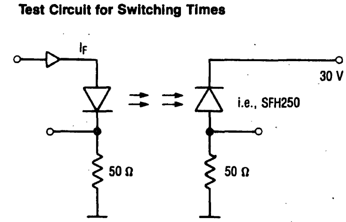
SFH450V/451V
Maximum permissible
forward current $I_F = f(T_{amb})$



SFH750V
Maximum permissible
forward current $I_F = f(T_{amb})$



SFH450V/451V/750V
Test Circuit for Switching Times



SIEMENS

PFOK-1

PLASTIC FIBER OPTIC KIT

DESCRIPTION

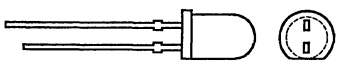
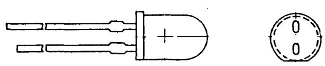
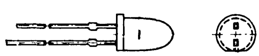
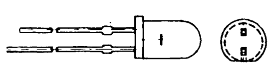
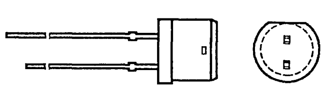
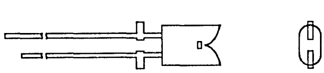
The plastic fiber optic kit is intended to be a comprehensive design-in tool for potential customers that have already received data sheets or samples of our discrete fiber optic components. The kit contains all necessary components and literature for a designer to set up an optical link and test our components in a system.

Kit Contents

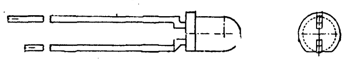
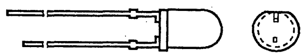
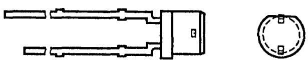
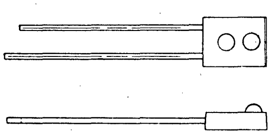
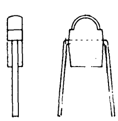
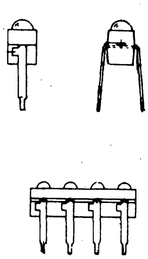
SFH250	Photodiode
SFH250F	Photodiode with daylight filter
SFH250V	Photodiode in connector housing
SFH350	Phototransistor
SFH350F	Phototransistor with daylight filter
SFH450	IR Emitter
SFH750	Red Emitter
SFH750V	Red Emitter in connector housing
SFH751	Green Emitter
Fiber*	15 feet, approx.
Fiber*	7 inches, approx.
Data Book	
Application Note	

* Siemens will not supply samples or production quantities. Fiber cables are only available in this kit.

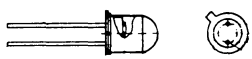
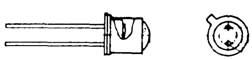
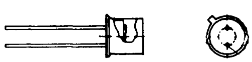
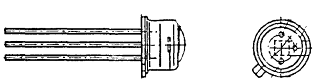
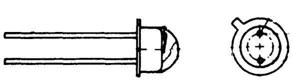
Infrared Emitters

Package Outline	Part Number	Package Type	Half Angle	Radiant Intensity mW/sr	Radiant Intensity mA	Surge Current t<10µS A	Features	Page
	LD271	T1³/4 5mm grey plastic	±25°	15(≥10)	100	3.5	IR remote control. Most commonly used IR emitters. Low cost. Wide angle high power GaAs, 950nm. Matches with SFH205 or BP104 photodiode or BP103 phototransistor.	7–12
	LD271H			≥16				
	LD271L (1" Leads)			15(≥10)				
	LD271LH (1" Leads)			≥16				
	LD275-1		±18°	10-20		3.0		7–18
	LD275-2			16-32				
	LD275-3			≥25				
	LD274-1	T1³/4 5mm grey plastic	±10°	30-60	100	3.0	IR remote control GaAs, 950 nm. very high intensity, narrow angle. Matches with SFH205, BP104 and BP103B phototransistor	7–16
	LD274-2			50-100				
	LD274-3			≥80				
	SFH484-1	T1³/4 5mm clear blue-tinted plastic	±8°	50-100	100	2.5	IR remote control GaAlAs, 880nm. Extremely high intensity, narrow angle.	7–40
	SFH484-2			80-160				
	SFH484-3			≥125				
	SFH485-1	T1³/4 5mm clear blue-tinted plastic	±20°	16-32	100	2.5	IR remote control GaAlAs, 880nm. High intensity, medium angle.	7–42
	SFH485-2			25-50				
	SFH485-3			≥40				
	SFH485P-1	T1³/4 5mm clear plastic	±40°	3.15-6.3	100	2.5	IR remote control GaAlAs, 880 nm. Wide angle IR remote control. Shaft encoder IR sound transmission. Low cost replacement for metal can package.	7–44
	SFH485P-2			≥5				
	LD273	Modified T1 ³/4, 5mm grey plastic	±25°	≥25	100	3.2	IR remote control Space saving. Two IR chips in series. GaAs, 950nm. Matches with SFH205 or BP104 photodiode or BP103B phototransistor.	7–14
	SFH435	Special case. Grey epoxy resin.	±8°	8 typ.	100	3.0	GaAs. Two beam with one chip. Diametrical radiation.	7–31

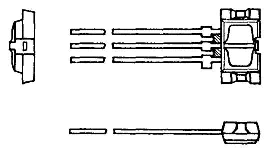
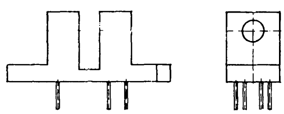
Infrared Emitters

Package Outline	Part Number	Package Type	Half Angle	Radiant Intensity mW/sr	Radiant Intensity mA	Surge Current t<10μS A	Features	Page
	SFH409-1	T1, 3mm grey plastic	±20°	6.3-12.5	100	3	IR remote control. GaAs, 950nm. Matches with SFH309 phototransistor.	7–28
	SFH409-2			10-20				
	SFH409-3			≥16				
	SFH487-1	T1, 3mm clear blue-tinted plastic		12.5-25		2.5	IR remote control. GaAs, 880nm. High intensity, medium angle.	7–46
	SFH487-2			20-40				
	SFH487-3			≥32				
	SFH487P-1	T1, 3mm clear blue-tinted plastic	±65°	2-4	100	2.5	Wide angle IR remote control. GaAs, 880 nm. Shaft encoder IR sound transmission. Low cost replacement for metal can package.	7–48
	SFH487P-2			≥3.15				
	IRL80A	Miniature. Clear plastic, side-facing.	±30°	≥0.4	20	3	Sidefacing. IRL80A: GaAs, 950nm. IRL81A: GaAlAs, 880nm. Matches with LPT80A, phototransistor or LPD80A, photodarlington.	7-5
	IRL81A		±25°	≥1.0		2.5		7-6
	SFH405-2	Miniature, 1mm wide. Radial leads.	±16°	1.6-3.2	40	1.6	Ideal for very short range light barriers Extremely thin, .039" (1mm) package width. Radial lead/ GaAs. 950nm. Matches with SFH305 phototransistor.	7–26
	SFH405-3			≥2.5				
	LD261-4	Miniature. 2mm wide. Single unit.	±30°	2.0-4.0	50	1.6	GaAs, 950nm. Small package size, radial lead. Ideal for card readers. Matches with BPX81 (LD261-x) or BPX80 series phototransistors (LD260, 261-9)	7–10
	LD261-5			3.2-6.3				
	LD262	2 diode array		2.5-8				
	LD263	3 diode array						
	LD264	4 diode array						
	LD265	5 diode array						
	LD266	6 diode array						
	LD267	7 diode array						
	LD268	8 diode array						
	LD269	9 diode array						
	LD260	10 diode array						

Infrared Emitters

Package Outline	Part Number	Package Type	Half Angle	Radiant Intensity mW/sr	Radiant Intensity mA	Surge Current t<10µS A	Features	Page
	SFH400-2	TO-18, round glass lens.	±6°	20-40	100	3	Hermetic seal for high rel use. Very narrow angle. GaAs, 950nm. Matches with BPX43 phototransistor.	7–20
	SFH400-3			≥32				
	SFH480-1			25-50		2.5	Hermetic seal for high rel use. Narrow angle, very high intensity. GaAlAs, 880nm.	7–34
	SFH480-2			40-80				
	SFH480-3			≥63				
	SFH401-2	TO-18, dome glass lens.	±15°	10-20	100	3	Hermetic seal for high rel use. Very narrow angle, GaAs, 950nm. Matches with BPY62 phototransistor.	7–22
	SFH401-3			16-32				
	SFH401-4			>25				
	SFH481-1			10-20		2.5	Hermetic seal for high rel use. Narrow angle, GaAlAs, 880nm.	7–36
	SFH481-2			16-32				
	SFH481-3			≥35				
	SFH402-2	TO-18, flat glass lens.	±40°	2.5-5.0	100	3	Hermetic seal for high rel use. Wide angle, GaAs, 950nm. Matches with BPX38 phototransistor orBPX65/66 photodiodes.	7–24
	SFH402-3			≥4.0				
	SFH482-1		±30°	3.15-6.3		2.5	Hermetic seal for high rel rel use. Wide angle, GaAlAs, 880nm.	7–38
	SFH482-2			5-10				
	SFH482-3			≥8				
	SFH431-1	TO-18, dome glass lens.	±8°	10-20	100	3	Hermetic seal for high rel rel use. 3-leaded. Narrow beam. GaAs, 950nm. Reversed polarity as compared to SFH401.	7–30
	SFH431-2			16-32				
	SFH431-3			≥25				
	LD242-2	Modified TO-18, plastic lens.	±40°	4.8-8.0	100	5	Suitable for sound transmission. Ideal for short range light barriers. Very wide angle. GaAs, 950nm. Matches with BP103 phototransistor & BPX63 photodiode.	7-8
	LD242-3			≥6.3				

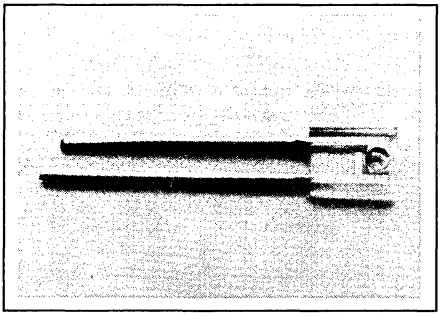
Infrared Assemblies

Package Outline	Part Number	Package Type	$V_{CE}sat$ I_F=10mA	Current Transfer Ratio mA	Surge Current t<10µS A	Features	Page
	SFH900-1	Miniature plastic with daylight filter.	.2(≤.6)	0.25-0.5	1.5	Reflective light barrier for short (up to 5mm) distances.	7–50
	SFH900-2			0.4-.08			
	SFH900-3			.63-1.25			
	SFH900-4			≥1.0			
	SFH905-1			40-125µA			
	SFH905-2			≥100µA			
	SFH910	Plastc with daylight filter	Output: Counting pulse Z Directional signal R Resolution ≥0.33"		1	Differential photo interrupter.	7–54
	2004-9053	Plastic disc with 96 slots.				Disc for SFH910. Can be ordered separately.	

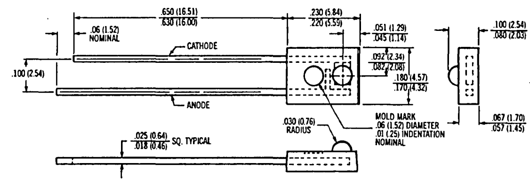
SIEMENS

IRL-80A

GaAs INFRARED EMITTER



Package Dimensions in Inches (mm)



FEATURES

- **Low Cost Plastic Package**
- **Long Term Stability**
- **Wide Beam, 60°**
- **Matches Phototransistor LPT-80A**

DESCRIPTION

The IRL-80A is a high power GaAs emitter diode, emitting radiation in the near infrared range. It is mounted in a clear miniature plastic side-facing package and was designed for a variety of applications which require beam interruption.

Maximum Ratings:

Reverse voltage	V_R	3	V
Forward current ($T_{amb}=25°C$)	I_F	60	mA
Operating/storage temperature	T	−40 to +100	°C
Power dissipation ($T_{amb}=25°C$)	P_{tot}	100	mW
Derate above 25°C		1.33	mW/°C
Lead soldering temp (1/16 inch from plastic package) for 5 sec.	T_s	240	°C

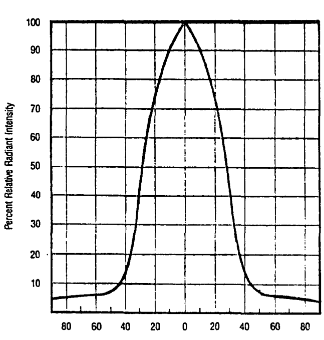
Characteristics ($T_{amb}=25°C$)

Wavelength of radiation at I_{max}		950	nm
Spectral bandwidth at 50% of I_{max}		±20	nm
Radiant intensity (Note 1) $I_F=20$ mA	I_e	(≥0.4)	mW/sr
Half angle (limits for 50% of radiant intensity I_e)	φ	±30	Deg.
Forward voltage ($I_F=20$ mA)	V_F	1.5 max	V
Breakdown voltage ($I_R=10$ µA)	V_{BR}	(≥3)	V

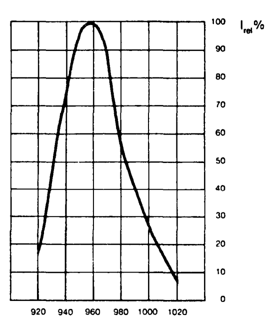
Note 1: A 1 cm² silicon detector is aligned with the mechanical axis. No aperture is used.

Infrared Emitters

Radiation Characteristics



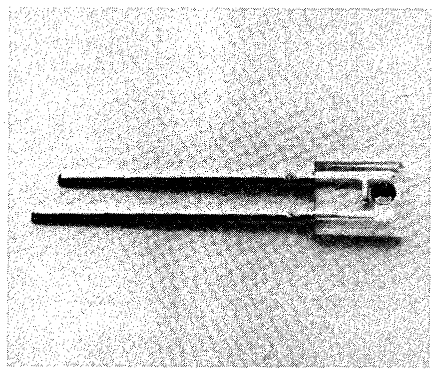
Relative Spectral Emission (Typ)



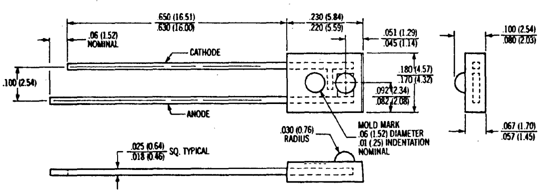
SIEMENS

IRL-81A

GaAlAs INFRARED EMITTER



Package Dimensions in Inches (mm)



FEATURES

- **GaAlAS Infrared Emitting Diode**
- **Low Cost**
- **Miniature Side Facing Package**
- **Clear Plastic**
- **Long Term Stability**
- **Wide Beam, 50°**
- **Matches Phototransistor LPT-80A or Photodarlington LPD-80A**

DESCRIPTION

The GaAlAs infrared emitting diode IRL-81A is designed to emit radiation at a wavelength in the near infrared range. The chip is positioned to emit radiation from the side of the clear plastic miniature package. It operates efficiently with the matching LPT-80A phototransistor, or LPD-80A photodarlington.

Maximum Ratings

Reverse Voltage (≤25°C)	V_R	5	V
Forward Current (≤25°C)	I_F	100	mA
Operating and Storage Temperature	T	−40 to +100	°C
Power Dissipation (T_{amb}≤25°C)	P_{tot}	200	mW
Derate Above 25°C		2.67	mW/°C

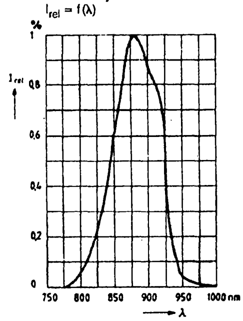
Characteristics (T_{amb} = 25°C)

Wavelength of Radiation at I_{max}	λ_{peak}	880	nm
Spectral Bandwidth at 50% of I_{max}	$\Delta\lambda$	−36...+44	nm
Forward Voltage (I_F = 20 mA)	V_F	1.5 (≤2.0)	V
Breakdown Voltage (I_R = 10 µA)	V_{BR}	30 (≥5)	V
Radiant Intensity (I_F = 20 mA, Note 1)	I_e	≥1.0	mW/sr
Radiant Power Output (I_F = 20 mA)	P_O	1.5	mW
Half Angle	φ	±25	Deg.

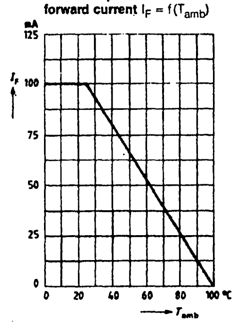
[1] A 1 cm² silicon detector with a radiometric filter is aligned with the mechanical axis of the DUT. No aperature is used.

TYPICAL OPTOELECTRONIC CHARACTERISTICS

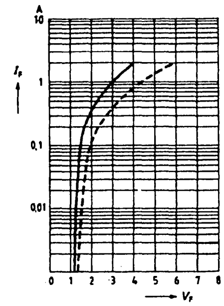
Relative spectral emission
$I_{rel} = f(\lambda)$



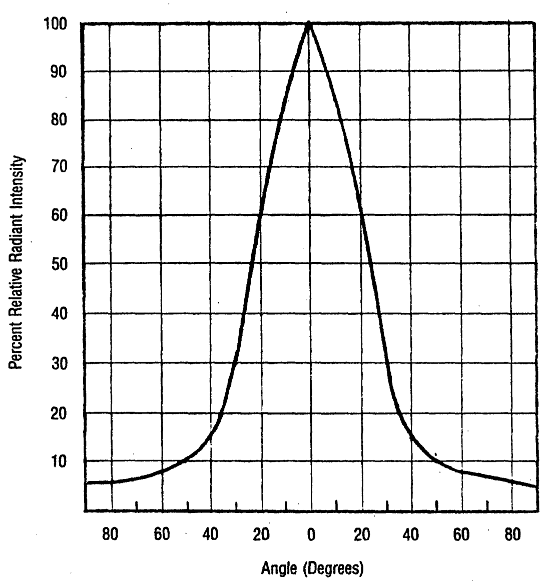
Maximum permissible
forward current $I_F = f(T_{amb})$



Forward current $I_F = f(V_F)$



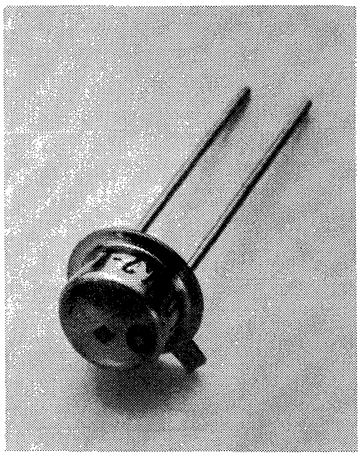
Radiation Characteristics



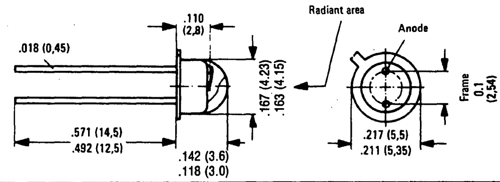
Infrared Emitters

SIEMENS

LD 242 SERIES
INFRARED EMITTER



Package Dimensions in Inches (mm)



FEATURES

- Modified TO-18 Size Metal Case
- Rounded Plastic Lens
- Long Term Stability
- Very Wide Beam, 80°
- Matches with Phototransistor BP103 and Photodiode BPX63

DESCRIPTION

The GaAs infrared emitting diode LD 242 is designed to emit radiation at a wavelength in the near infrared range. The radiation emitted is excited by current flowing in forward direction and can be modulated. The plastic cover permits wide-angle radiation. The anode terminal is marked by the adjacent projection on the rim of the case bottom. The cathode is electrically connected to the case. The LD 242 is particularly suitable for use as emitter for IR sound transmission in radio and TV sets.

Maximum Ratings

Storage Temperature	T	−40 to +80	°C
Soldering Temperature (Distance from soldering joint to package ≥2 mm, soldering time t ≤ 3 s)	T_S	230	°C
Junction Temperature	T_j	100	°C
Reverse Voltage	V_R	5	V
Forward Current	I_F	250	mA
Surge Current (t = 10 μs, D = 0)	I_{FS}	3	A
Power Dissipation	P_{tot}	470	mW
Thermal Resistance	R_{thJamb}	450	K/W
	R_{thJL}	160	K/W

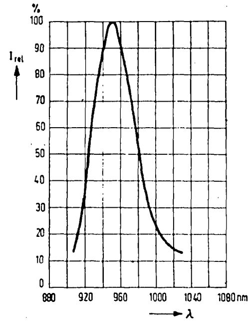
Characteristics (T_{amb} = 25°C)

Wavelength (I_F = 100 mA, t_p = 20 ms)	λ	950±20	nm
Spectral Bandwidth (I_F = 100 mA, t_p = 20 ms)	Δλ	55	nm
Half Angle	φ	±40	Deg.
Active Area	A	0.25	mm²
Active Die Area per Die	L × W	0.5 × 0.5	mm
Distance Die Surface to Package Surface	H	0.3 to 0.7	mm
Switching Time (I_e from 10% to 90% and from 90% to 10% at I_F = 100 mA)	t_r, t_f	1	μs
Capacitance (V_R = 0 V)	C_0	40	pF
Forward Voltage (I_F = 100 mA)	V_F	1.3 (≤1.5)	V
(I_F = 1A, t_p = 100μs)	V_F	1.9 (≤2.5)	V
Breakdown Voltage (I_R = 10 μA)	V_{BR}	30 (≥5)	V
Reverse Current (V_R = 5 V)	I_R	0.01 (≤1)	μA
Temperature Coefficient of I_e or Φ_e	TC_I	−0.55	%/K
Temperature Coefficient of V_F	TC_V	−1.5	mV/K
Temperature Coefficient of λpeak	TC_λ	0.3	nm/K

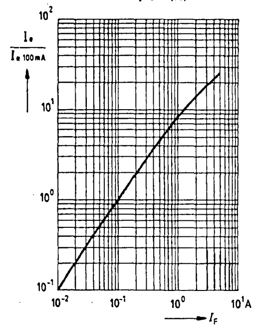
Radiant Intensity I_e in Axial Direction Measured at a Solid Angle of Ω = 0.01 sr

Group	LD242-2	LD242-3	
Radiant Intensity (I_F = 100 mA, t_p = 20 ms) I_e	4...8	≥6.3	mW/sr
(I_F = 1 A, t_p = 100 μs) I_e	45	60	mW/sr
Radiant Power (I_F = 100 mA t_p = 20 ms) Φ_e	13	16	mW

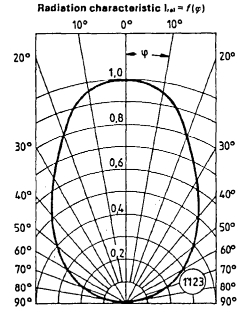
Relative spectral emission $I_{rel} = f(\lambda)$



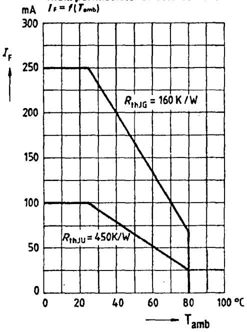
Radiant intensity $I_e = f(I_F)$



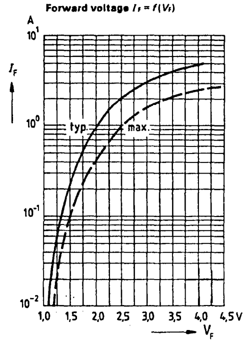
Radiation characteristic $I_{rel} = f(\varphi)$



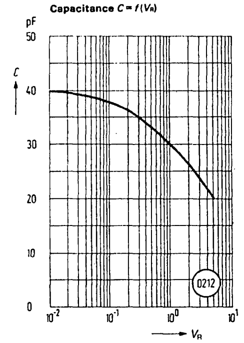
Max. permissible forward current $I_F = f(T_{amb})$



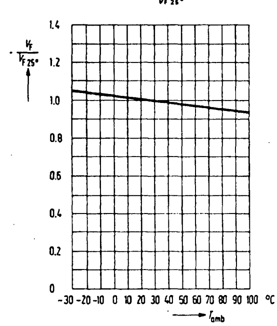
Forward voltage $I_F = f(V_F)$



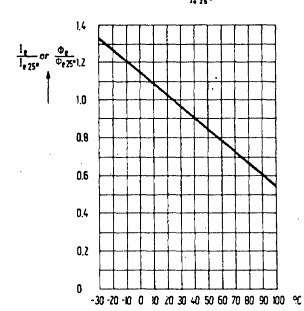
Capacitance $C = f(V_R)$



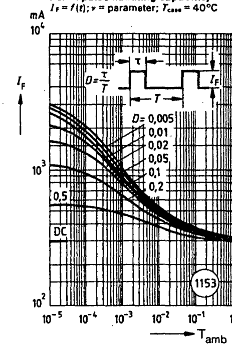
Forward voltage $\frac{V_F}{V_{F\,25°}} = f(T_{amb})$



Radiant intensity $\frac{I_e}{I_{e\,25°}} = f(T_{amb})$



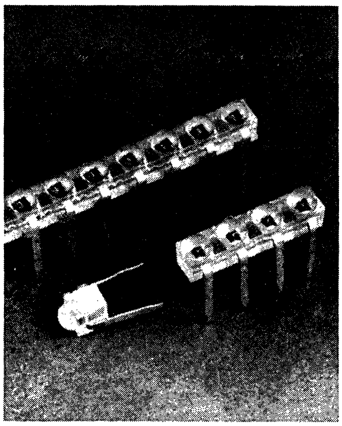
Perm. pulse handling capability
$I_F = f(t)$; v = parameter; $T_{case} = 40°C$



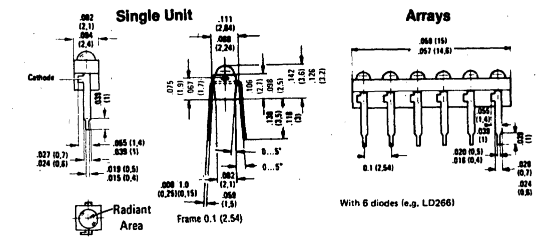
Infrared Emitters

SIEMENS

LD 261 SERIES
INFRARED EMITTER
SINGLE AND ARRAYS



Package Dimensions in Inches (mm)



FEATURES
- **Low Cost**
- **Miniature Size**
- **Available As Single Unit, LD 261 and Arrays:**
  Two Diodes, LD 262
  Three Diodes, LD 263
  Four Diodes, LD 264
  Five Diodes, LD 265
  Six Diodes, LD 266
  Seven Diodes, LD 267
  Eight Diodes, LD 268
  Nine Diodes, LD 269
  Ten Diodes, LD 260
- **Medium Wide Beam, 60°**

DESCRIPTION
The LD 261 series, GaAs infrared emitting diodes, emit radiation at a wavelength in the near infrared range. This miniature device comes in a grey plastic package and is available as a single emitter as well as two through ten element arrays. The terminals are solder pins with .10″ lead spacing. The LD 261 series is designed for use with the BPX 81 series phototransistor when the spacing between each is approximately 10mm. These devices can easily be mounted on PC boards and in thick film circuits for simple or complex scanning systems.

Maximum Ratings

Storage Temperature	T	−40 to +80	°C
Soldering Temperature (Distance from soldering joint to package ≥2 mm, soldering time t ≤ 3 s)	T_S	230	°C
Junction Temperature	T_j	80	°C
Reverse Voltage	V_R	5	V
Forward Current	I_F	60	mA
Surge Current (t = 10 μs, D = 0)	I_{FS}	1.6	A
Power Dissipation	P_{tot}	85	mW
Thermal Resistance	R_{thJamb}	750	K/W
	R_{thJL}	650	K/W

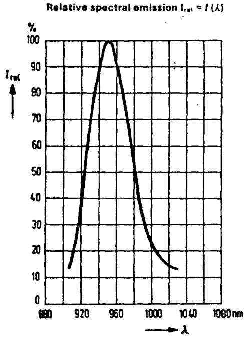
Characteristics (T_{amb} = 25°C)

Wavelength (I_F = 50 mA, t_P = 20 ms)	λ	950±20	nm
Spectral Bandwidth (I_F = 50 mA, t_p = 20 ms)	Δλ	55	nm
Half Angle	φ	±30	Deg.
Active Area	A	0.25	mm²
Active Die Area per Die	L × W	0.5 × 0.5	mm
Distance Die Surface to Package Surface	H	1.3 to 1.9	mm
Switching Time (I_e from 10% to 90% and from 90% to 10% at I_F = 50 mA)	t_r, t_f	1	μs
Capacitance (V_R = 0 V)	C_0	40	pF
Forward Voltage (I_F = 50 mA, t_p = 20 ms)	V_F	1.25 (≤1.4)	V
Breakdown Voltage (I_R = 10 μA)	V_{BR}	30 (≥5)	V
Reverse Current (V_R=5 V)	I_R	0.01 (≤1)	μA
Temperature Coefficient of I_e or Φ_e	TC_I	−0.55	%/K
Temperature Coefficient of V_F	TC_V	−1.5	mV/K
Temperature Coefficient of λpeak	TC_λ	0.3	nm/K

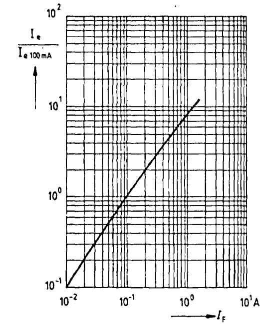
Radiant Intensity I_e in Axial Direction Measured at a Solid Angle of Ω = 0.01 sr

Group	LD261-4	LD261-5	260, 262-269	
Radiant Intensity (I_F = 50 mA, t_p = 20 ms) I_e	2 to 4	3.2 to 6.3	2.5 to 8	mW/sr
Radiant Power (I_F = 50 mA, t_p = 20 ms) Φ_e	5	6.5	8	mW

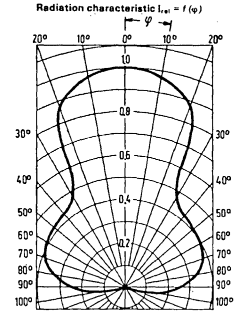
Relative spectral emission $I_{rel} = f(\lambda)$



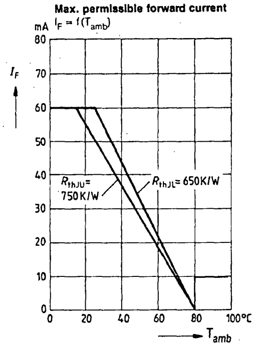
Radiant intensity $I_e = f(I_F)$



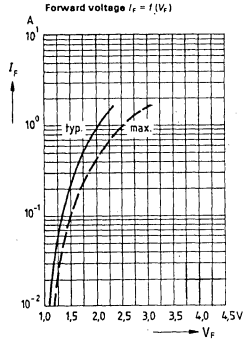
Radiation characteristic $I_{rel} = f(\varphi)$



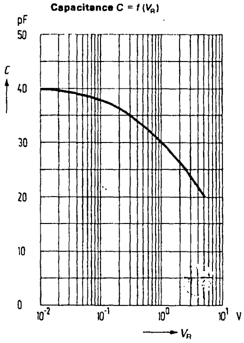
Max. permissible forward current



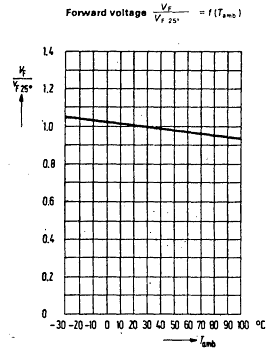
Forward voltage $I_F = f(V_F)$



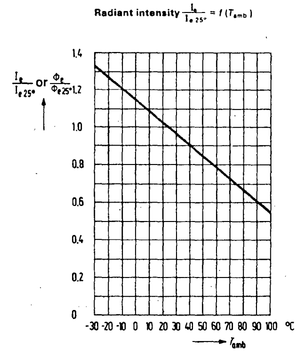
Capacitance $C = f(V_R)$



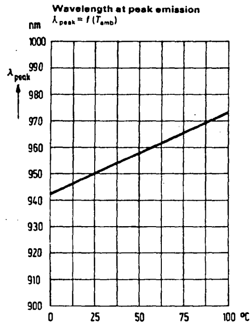
Forward voltage $\frac{V_F}{V_{F\,25°}} = f(T_{amb})$



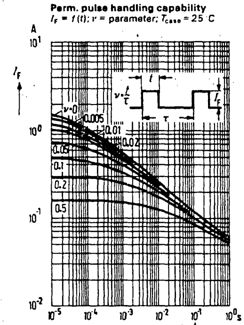
Radiant intensity $\frac{I_e}{I_{e\,25°}} = f(T_{amb})$



Wavelength at peak emission



Perm. pulse handling capability
$I_F = f(t)$; ν = parameter; T_{case} = 25 °C

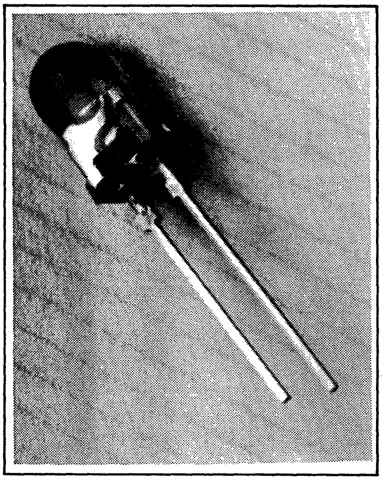


Infrared Emitters

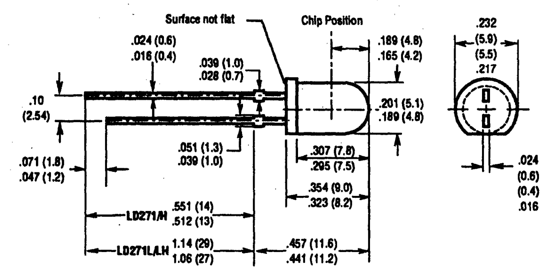
LD 261

SIEMENS

LD 271/271H
1" LEADS LD 271L/271LH
INFRARED EMITTER



Package Dimensions in Inches (mm)



FEATURES

- Low Cost
- T-1¾ Package
- Lightly Diffused Gray Plastic Lens
- LD 271L/LD 271LH 1-inch Leads
- Long Term Stability
- Medium Wide Beam, 50°
- Very High Power
- High Intensity
- Matches with Photodiodes SFH 205 or BP104 or Phototransistors BP103B

DESCRIPTION

LD 271/H/L/LH an infrared emitting diode, emits radiation in the near infrared range (950 nm peak). The emitted radiation, which can be modulated, is generated by forward flowing current. The device is enclosed in a 5 mm plastic package. An application for the LD 271 family is remote control of color TV receivers.

Maximum Ratings

Storage Temperature	T	–55 to +100	°C
Soldering Temperature (Distance from soldering joint to package ≥10 mm, soldering time t ≤ 3 s)	T_S	260	°C
Junction Temperature	T_j	100	°C
Reverse Voltage	V_R	5	V
Forward Current	I_F	130	mA
Surge Current (t = 10 µs, D = 0)	I_{FS}	3.5	A
Power Dissipation	P_{tot}	210	mW
Thermal Resistance	R_{thJamb}	350	K/W

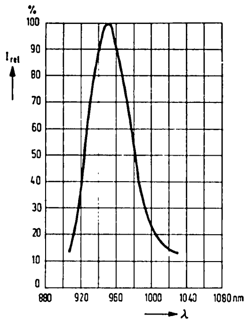
Characteristics (T_{amb} = 25°C)

Wavelength (I_F = 100 mA, t_p = 20 ms)	λ	950±20	nm
Spectral Bandwidth (I_F = 100 mA, t_p = 20 ms)	Δλ	55	nm
Half Angle	φ	±25	Deg.
Active Area	A	0.25	mm²
Active Die Area per Die	L × W	0.5 × 0.5	mm
Distance Die Surface to Package Surface	H	4.0 to 4.6	mm
Switching Time (I_e from 10% to 90% and from 90% to 10% at I_F = 100 mA)	t_r, t_f	1	µs
Capacitance (V_R = 0 V)	C_0	40	pF
Forward Voltage (I_F = 100 mA)	V_F	1.30 (≤1.5)	V
(I_F = 1A, t_p = 100µs)	V_F	1.9 (≤2.5)	V
Breakdown Voltage (I_R = 10 µA)	V_{BR}	30 (≥5)	V
Reverse Current (V_R = 5 V)	I_R	0.01 (≤1)	µA
Temperature Coefficient of I_e or Φ_e	TC_I	–0.55	%/K
Temperature Coefficient of V_F	TC_V	–1.5	mV/K
Temperature Coefficient of λpeak	TC_λ	+0.3	nm/K

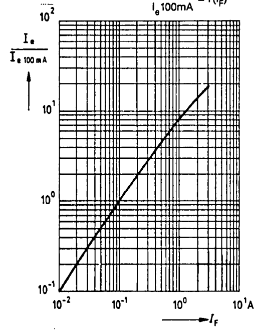
Radiant Intensity I_e in Axial Direction Measured at a Solid Angle of Ω = 0.01 sr

Group	LD 271 & LD 271L	LD 271H & LD 271 LH	
Radiant Intensity (I_F = 100 mA, t_p = 20 ms) I_e	15 (≥10)	≥16	mW/sr
(I_F = 1 A, t_p = 100 µs) I_e	100	120	mW/sr
Radiant Power (I_F = 100 mA t_p = 20 ms) Φ_e	12	16	mW

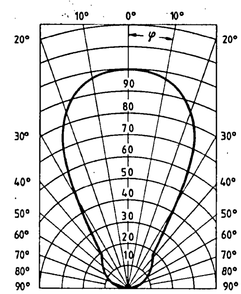
Relative spectral emission $I_{rel} = f(\lambda)$



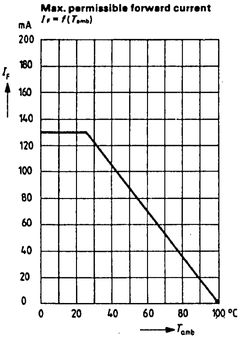
Radiant intensity $\frac{I_e}{I_{e\,100mA}} = f(I_F)$



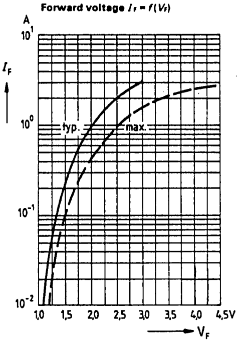
Radiation characteristic $I_{rel} = f(\varphi)$



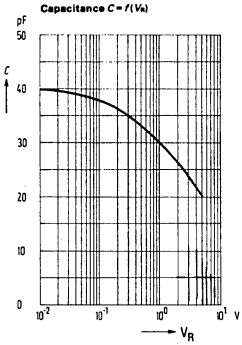
Max. permissible forward current $I_F = f(T_{amb})$



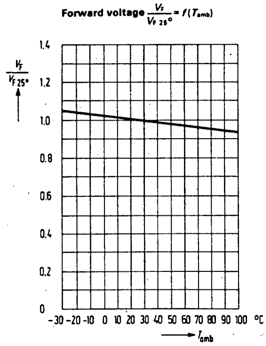
Forward voltage $I_F = f(V_F)$



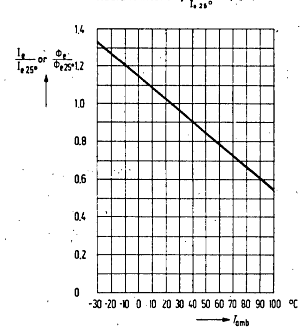
Capacitance $C = f(V_R)$



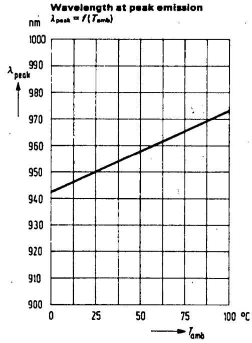
Forward voltage $\frac{V_F}{V_{F\,25°}} = f(T_{amb})$



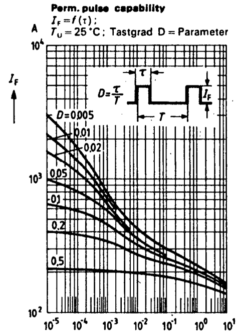
Radiant intensity $\frac{I_e}{I_{e\,25°}} = f(T_{amb})$



Wavelength at peak emission $\lambda_{peak} = f(T_{amb})$



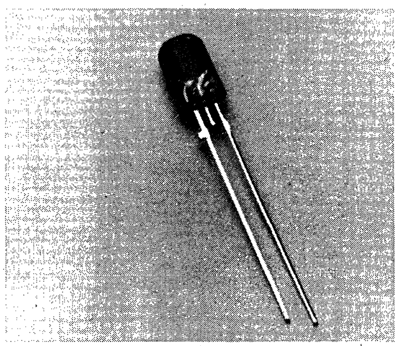
Perm. pulse capability $I_F = f(\tau)$; $T_U = 25°C$; Tastgrad D = Parameter



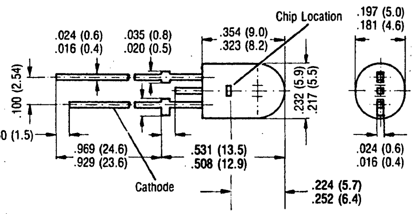
Infrared Emitters

SIEMENS

LD 273
TWO CHIP INFRARED EMITTER



Package Dimensions in Inches (mm)



FEATURES

- **Very High Radiant Intensity**
- **Two Chip Device**
- **Grey Oval Plastic Package**
- **Equivalent to T1¾ Size**
- **Matches with Photodiodes SFH 205 or BP104 or Phototransistors BP103B**

DESCRIPTION

The LD 273 is an infrared emitter consisting of two GaAs-IRLED chips connected in a series. This provides a very high radiant intensity of greater than 25 mW/sr at 100 mA. Radiation is emitted in the axial (0°) direction from a smoke colored oval plastic package. This device serves particularly well as a powerful emitter of increased range in remote control applications.

Mounting Instruction

In order not to damage the system when soldering in the emitting diodes, the soldering distance to the plastic package has to be dimensioned as large as possible. We recommend a minimum distance of 10 mm between package and soldering point for the usual soldering conditions (260°C/3 sec).

Maximum Ratings

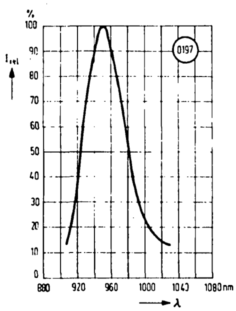
Storage Temperature	T	−55 to +100	°C
Soldering Temperature (Distance from soldering joint to package ≥10 mm, soldering time t ≤ 3 s)	T_S	260	°C
Junction Temperature	T_j	100	°C
Reverse Voltage	V_R	10	V
Forward Current	I_F	100	mA
Surge Current (t = 10 μs, D = 0)	I_{FS}	3.2	A
Power Dissipation	P_{tot}	260	mW
Thermal Resistance	R_{thJamb}	280	K/W

Characteristics (T_{amb} = 25°C)

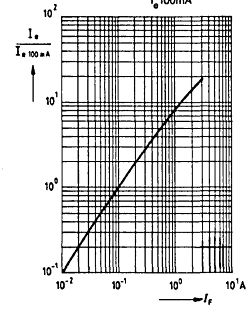
Wavelength (I_F = 100 mA, t_p = 20 ms)	λ	950±20	nm
Spectral Bandwidth (I_F = 100 mA, t_p = 20 ms)	Δλ	55	nm
Half Angle (Horizontal to terminal plane)	φ_H	±25	Deg.
Half Angle (Vertical to terminal plane)	φ_V	±15	Deg.
Active Area (2 die)	A	0.09	mm²
Active Die Area per Die	L × W	0.3 × 0.3	mm
Distance Die Surface to Package Surface	H	4.8 to 5.4	mm
Switching Time (I_e from 10% to 90% and from 90% to 10% at I_F = 100 mA)	t_r, t_f	1	μs
Capacitance (V_R = 0 V)	C_0	10	pF
Forward Voltage (I_F = 100 mA)	V_F	2.6 (≤3.0)	V
(I_F = 1A, t_p = 100μs)	V_F	3.8 (≤5.2)	V
Breakdown Voltage (I_R = 10 μA)	V_{BR}	50 (≥10)	V
Reverse Current (V_R = 10 V)	I_R	0.01 (≤1)	μA
Temperature Coefficient of I_e or Φ_e	TC_I	−0.55	%/K
Temperature Coefficient of V_F	TC_V	−3	mV/K
Temperature Coefficient of λpeak	TC_λ	+0.3	nm/K
Radiant Intensity in Axial Direction Measured at a Solid Angle of Ω = 0.01 sr (I_F = 100 mA, t_p = 20 ms)	I_e	≥25	mW/sr
(I_F = 1 A, t_p = 100 μs)	I_e	220	mW/sr
Radiant Power (I_F = 100 mA t_p = 20 ms)	Φ_e	26	mW

1-24-86 2-4-86/2

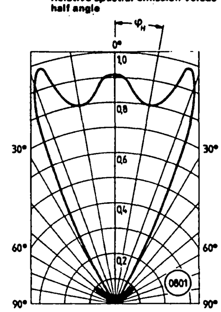
Relative spectral emission versus wavelength



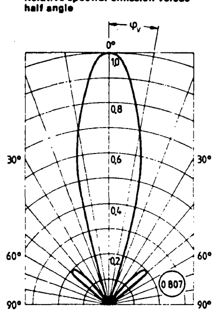
Radiant Intensity $\frac{I_e}{I_{e\,100mA}} = f(I_F)$



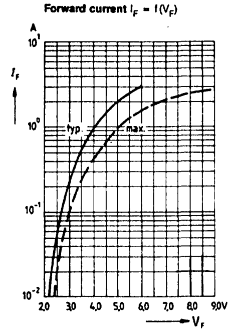
Radiation characteristic horizontally to pin terminal plane Relative spectral emission versus half angle



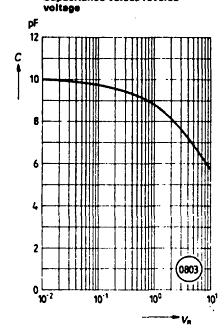
Radiation characteristic vertically to pin terminal plane Relative spectral emission versus half angle



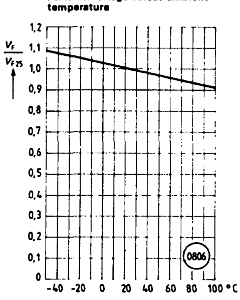
Forward current $I_F = f(V_F)$



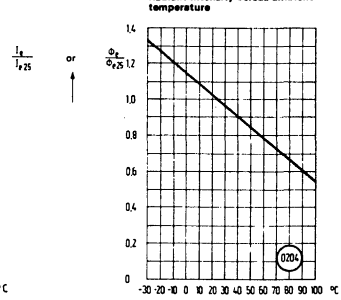
Capacitance versus reverse voltage



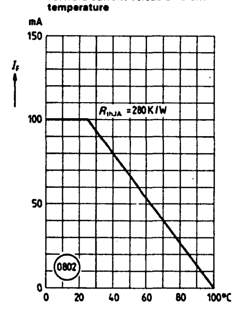
Forward voltage versus ambient temperature



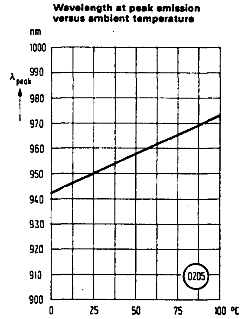
Radiant intensity versus ambient temperature



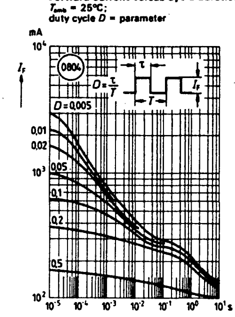
Forward current versus ambient temperature



Wavelength at peak emission versus ambient temperature



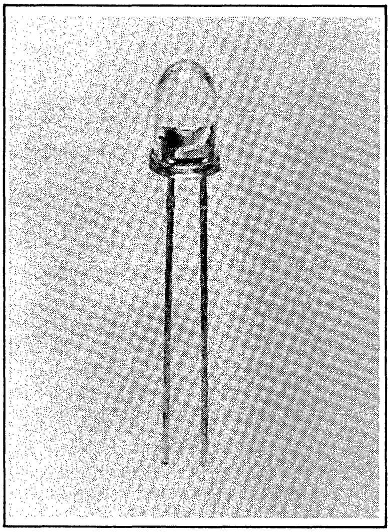
Permissible pulse handling capability Forward current versus cycle duration T_{amb} = 25°C; duty cycle D = parameter



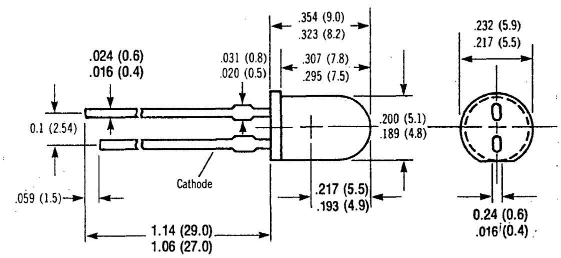
Infrared Emitters

SIEMENS

LD 274
INFRARED EMITTER



Package Dimensions in Inches (mm)



FEATURES

- **Three Radiant Intensity Groupings**
- **Low Cost**
- **T1¾ Package**
- **Lightly Diffused Gray Plastic Lens**
- **Long Term Stability**
- **Narrow Beam, 20°**
- **Excellent Match to Silicon Photo-detector BP103B**

DESCRIPTION

The GaAs infrared emitting diode LD 274 emits radiation at a wavelength in the near infrared range. It is enclosed in a T 1¾ plastic package of 5 mm diameter. This device is designed for remote control applications requiring extremely high power.

Maximum Ratings

Storage temperature	T	−55 to +100	°C
Soldering temperature			
Distance from casing-solder tab ⩾2mm			
Dip soldering time ⩽5s	T_{sold}	260	°C
Iron soldering time ⩽3s	T_{sold}	300	°C
Junction temperature	T_j	100	°C
Reverse voltage	V_R	5	V
Forward current	I_F	100	mA
Surge current ($\tau = 10\mu s$)	i_{FS}	3	A
Power dissipation (T = 25 °C)	P_{tot}	165	mW
Thermal Resistance	R_{thA}	450	K/W

Characteristics ($T_{amb} = 25°$)

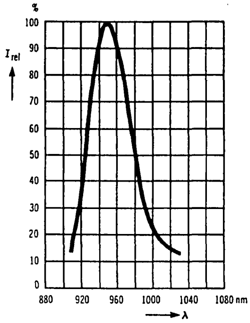
Wavelength at peak emission at $I_F = 100$ mA, tp = 20ms	λpeak	950 ± 20	nm
Spectral bandwidth at 50% of I_{max} at $I_F = 100$mA, $t_p = 20$ ms	Δλ	55	nm
Half angle	φ	±10	Deg.
Active chip area	A	0.09	mm²
Dimensions of active chip area	L×W	0.3 × 0.3	mm
Distance chip surface to case surface	D	4.9 to 5.5	mm
Switching time: (I_e from 10% to 90%; $I_F = 100$mA)	t_r, t_f	1	µs
Capacity ($V_R = 0$ V)	C_o	25	pF
Forward Voltage ($I_F = 100$mA)	V_F	1.30 (≤1.5)	V
($I_F = 1$A; $t_p = 100\mu s$)	V_F	1.9 (≤2.5)	V
Breakdown voltage ($I_R = 100\ \mu A$)	V_{BR}	30 (⩾5)	V
Reverse current ($V_R = 5$V)	I_R	0.01 (≤1)	µA
Temperature coefficient of I_e or Φ_e	TC	−0.55	%/K
Temperature coefficient of V_F	TC	−1.5	mV/K
Temperature coefficient of λpeak	TC	+0.3	nm/K

Radiant intensity I_e in axial direction at a steradian Ω = 0.01 sr, or 6,65°.

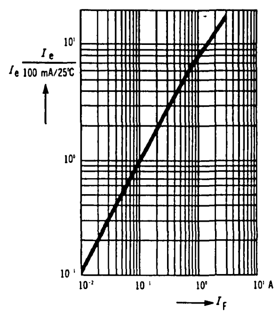
Radiant Intensity I_E in Axial Direction Measured at a Solid Angle of Ω = 0.01sr

Group	LD 274-1	LD 274-2	LD 274-3	
Radiant Intensity I_E				
($I_F = 100$ mA, $T_P = 20$ ms)	30-60	50-100	≥80	mW/sr
($I_F = 1$ A, $T_P = 100\ \mu s$)	335	560	675	mW/sr
Total Radiant Flux Φ_E				
($I_F = 100$ mA, $T_P = 20$ ms)	10	12	14	mW

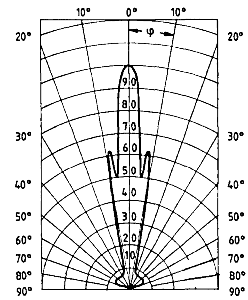
Relative spectral emission
$I_{rel} = f(\lambda)$



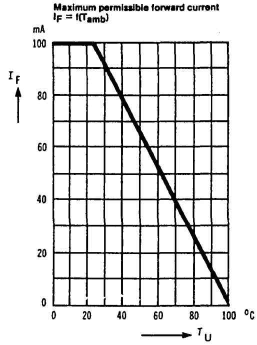
Radiant intensity
$I_{e rel} = f(I_F)$ (τ = 5 μs, T = 5ms)



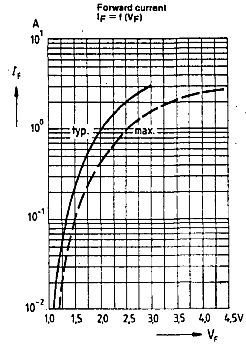
Radiant characteristics
$I_{rel} = f(\varphi)$



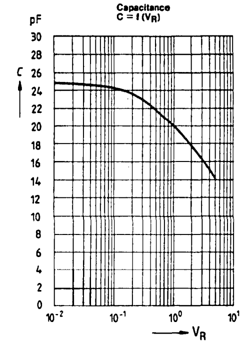
Maximum permissible forward current
$I_F = f(T_{amb})$



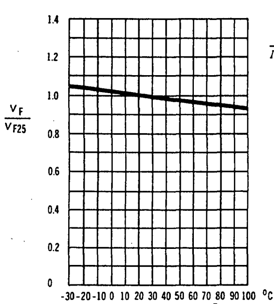
Forward current
$I_F = f(V_F)$



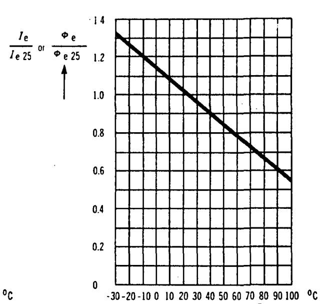
Capacitance
$C = f(V_R)$



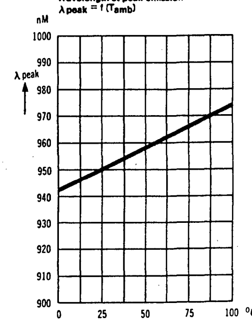
Forward voltage $\frac{V_F}{V_{F\,25}} = f(T_{amb})$



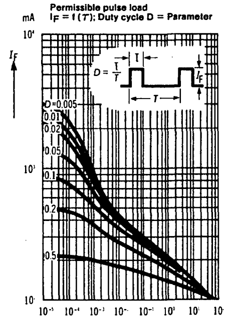
Radiant intensity $\frac{I_e}{I_{e\,25}} = f(T_{amb})$



Wavelength at peak emission
$\lambda_{peak} = f(T_{amb})$



Permissible pulse load
$I_F = f(\tau)$; Duty cycle D = Parameter



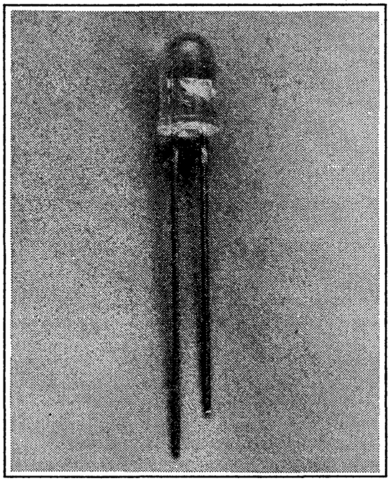
Infrared Emitters

LD 274

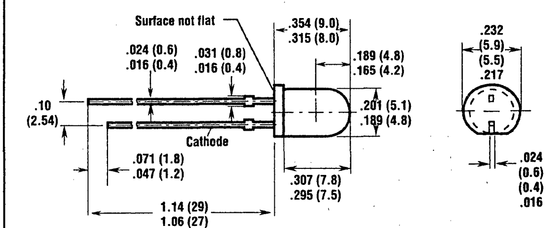
SIEMENS

LD275

INFRARED EMITTER
1" LEADS



Package Dimensions in Inches (mm)



FEATURES

- **Three Radiant Intensity Ranges**
- **Low Cost**
- **T1¾ Package**
- **Lightly Diffused Gray Plastic Lens**
- **1 Inch Leads**
- **Medium Wide Beam, 36°**
- **High Radiant Intensity**
- **Matches with Photodiodes SFH205 or BP104 or Phototransistors BP103B**

DESCRIPTION

LD275 an infrared emitting diode, emits radiation in the near infrared range (950 nm peak). The emitted radiation, which can be modulated, is generated by forward flowing current. The device is enclosed in a 5 mm plastic package. A typical application for the LD275 is remote control of TV receivers and VCRs as well as other consumer products.

Maximum Ratings

Storage Temperature (T) .... –55 to +100°C
Soldering Temperature
(Distance from soldering joint to package ≥10 mm,
soldering time t≤3 s) (T_S) .... 260°C
Junction Temperature (T_J) .... 100°C
Reverse Voltage (V_R) .... 5 V
Forward Current (I_F) .... 100 mA
Surge Current (t = 10 µs, D = 0) (I_{FS}) .... 3 A
Power Dissipation (P_{TOT}) .... 165 mW
Thermal Resistance (R_{THJAMB}) .... 450 K/W

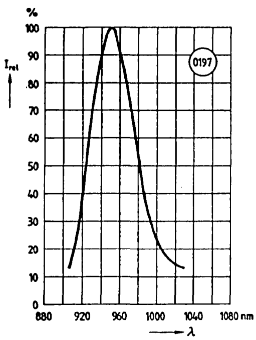
Characteristics (T_{amb} = 25°C)

Wavelength (I_F = 100 mA, t_P = 20 ms)	λ	950 ±20	nm
Spectral Bandwidth (I_F = 100 mA, t_P = 20 ms)	Δλ	55	nm
Half Angle	φ	±18	Deg.
Active Area	A	0.09	mm²
Active Die Area per Die	L×W	0.3×0.3	mm
Distande Die Surface to Package Surface	H	4.2 to 4.8	mm
Switching Time (I_E from 10% to 90% and from 90% to 10% at I_F = 100 mA)	t_R, t_F	1	µs
Capacitance (V_R = 0 V)	C_0	25	pF
Forward Voltage (I_F = 100 mA)	V_F	1.3 (≤1.5)	V
(I_F = 1 A, t_P = 100 µs)	V_F	1.9 (≤2.5)	V
Breakdown Voltage (I_R = 10 µA)	V_{BR}	30 (≥5)	V
Reverse Current (V_R = 5 V)	I_R	0.01 (≤1)	µA
Temperature Coefficient of I_E or Φ_E	TC_I	–0.55	%/K
Temperature Coefficient of V_F	TC_V	–1.5	mV/K
Temperature Coefficient of λpeak	TC_λ	+0.3	nm/K

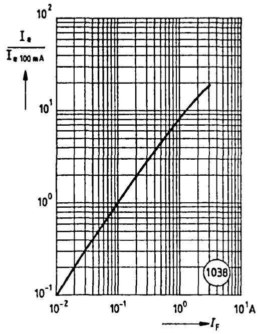
Radiant Intensity I_E in Axial Direction Measured at a Solid Angle of Ω = 0.01sr

Group	LD 275-1	LD 275-2	LD 275-3	
Radiant Intensity I_E				
(I_F = 100 mA, T_P = 20 ms)	10–20	16–32	≥25	mW/sr
(I_F = 1 A, T_P = 100 µs)	110	180	≥225	mW/sr
Total Radiant Flux Φ_E				
(I_F = 100 mA, T_P = 20 ms)	10	12	14	mW

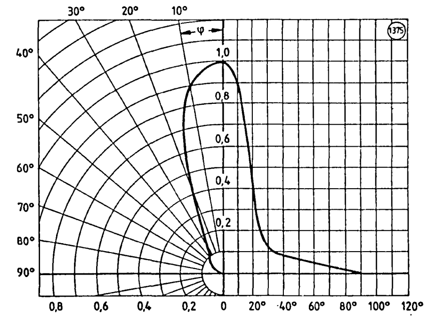
Relative spectral emission $I_{REL} = f(\lambda)$



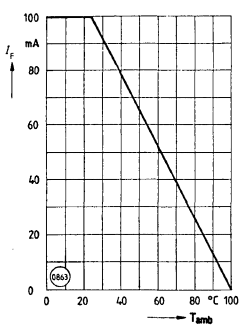
Relative radiant intensity $\frac{I_E}{I_{E\,100\,mA}} = f(I_F)$



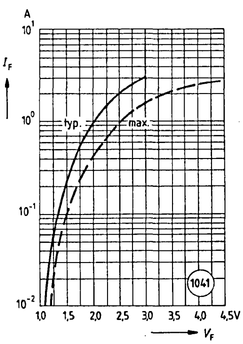
Radiation Characteristic $I_{REL} = f(\varphi)$



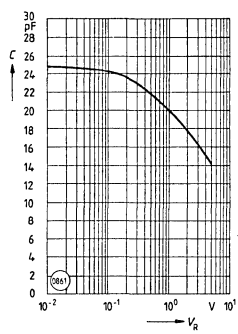
Forward current $I_F = f(T_{amb})$



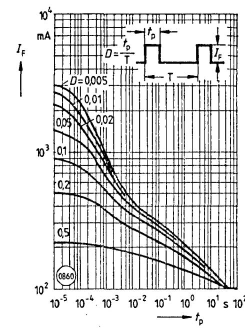
Forward current $I_F = f(V_F)$



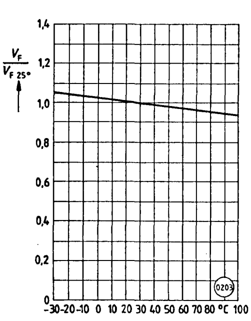
Capacitance $C = f(V_R)$



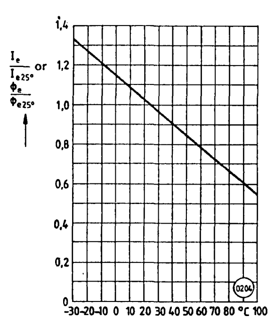
Permissible pulse load $I_F = f(t_P)$
duty cycle D = parameter



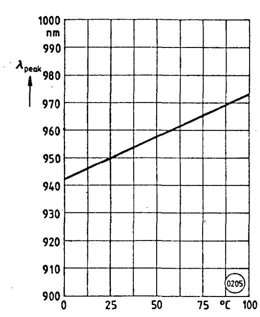
Forward voltage $\frac{V_F}{V_{F\,25}} = f(T_{amb})$



Radiant intensity $\frac{I_E}{I_{E\,25}} = f(T_{amb})$



Wavelength at peak emission
$\lambda_{PEAK} = f(T_{amb})$

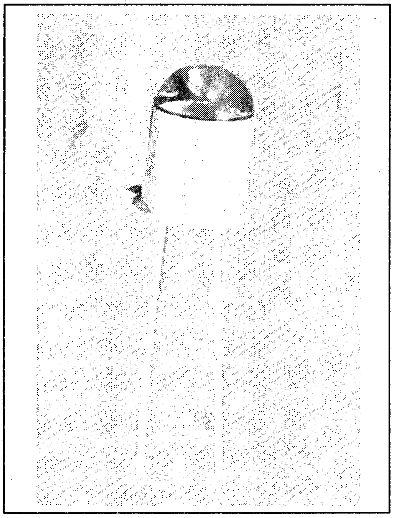


Infrared Emitters

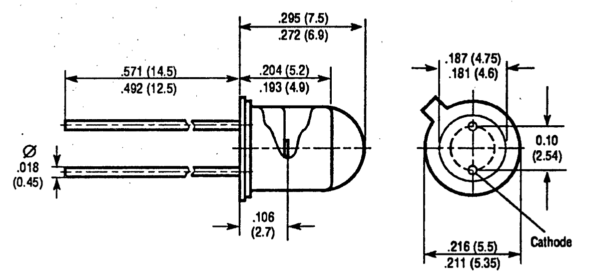
SIEMENS

SFH 400 SERIES

GaAs INFRARED EMITTER



Package Dimensions in Inches (mm)



FEATURES

- **Package: 18 A 3 DIN 41 876 (TO 18), Glass Lens, Hermetically Sealed, Solder Tabs, Lead Spacing 2.54 mm (1/10")**
- **Anode Marking: Tab at Case Bottom**
- **High Reliability**
- **Long Life**
- **Very High Radiant Intensity, Narrow Beam**
- **High Pulse Power**
- **Two Radiant Intensity Ranges**
- **Same Package as SFH 480, SFH 216**

DESCRIPTION

The GaAs infrared emitting diode SFH 400, fabricated in a liquid phase epitaxy process, features high efficiency and emits radiation at a wavelength in the near infrared range. The radiation is activated by dc or pulse operation in forward direction; simultaneous modulation is possible. The cathode is electrically connected to the case.

The applications include light-reflecting switches for steady and varying intensity, IR-remote control, industrial electronics, "measuring and controlling".

Maximum Ratings

Storage and Operating Temperature (T_{STG}, T_{OP}) ....-55°C to +100°C
Soldering Temperature at Dip Soldering (≥2 mm distance
from case bottom) (t ≤5 sec.) (T_S) ....260°C
Soldering Temperature at Iron Soldering (≥2 mm distance
from case bottom) (t ≤ 3 sec.) (T_S) ....300°C
Junction Temperature (T_J) ....100°C
Reverse Voltage (V_R) ....5 V
Forward Current (I_F) T_C= 25°C ....300 mA
Surge Current (t ≤ 10 µs, D=0) (I_{FS}) ....3 A
Power Dissipation (P_{TOT}) T_C = 25°C ....470 mW
Thermal Resistance (R_{thJA}) ....450 K/W
(R_{thJC}) ....160 K/W

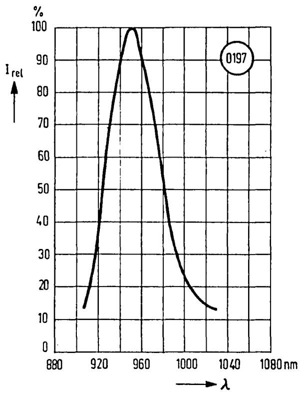
Characteristics (T_A=25°C)

Parameter	Symbol		Unit
Wavelength at Peak Emission (I_F=100 mA, t_p=20 ms)	λ_{PEAK}	950 ±20	nm
Spectral Bandwidth at 50% of I_{MAX} (I_F=100 mA, t_p=20 ms)	$\Delta\lambda$	55	nm
Half Angle	φ	±6	Deg.
Active Chip Area	A	0.25	mm²
Dimensions of Active Chip Area	L × W	0.5 × 0.5	mm
Distance Chip Surface to Case Surface	D	4.0 – 4.8	mm
Switching Times (I_E from 10% to 90%, and from 90% to 10%, I_F =100 mA)	t_R, t_F	1	µs
Capacitance (V_R=0 V, f=1 MHz)	C_0	40	pF
Forward Voltage (I_F=100 mA)	V_F	1.30 (≤1.5)	V
(I_F=1 A, t_p=100 µs)	V_F	1.9 (≤2.5)	V
Breakdown Voltage (I_R=10 µA)	V_{BR}	30 (≥5)	V
Reverse Current (V_R=5 V)	I_R	0.01 (≤1)	µA
Temperature Coefficient of I_E or ϕ_E	TC_I	–0.55	%/K
Temperature Coefficient of V_F	TC_V	–1.5	mV/K
Temperature Coefficient of λ_{PEAK}	TC_λ	0.3	nm/K

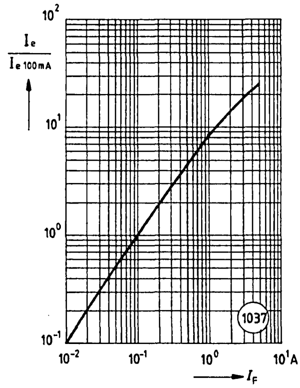
Radiant Intensity I_E in Axial Direction at a Steradian Ω ≥0.01 sr or 6.5 degrees

		SFH400-2	SFH400-3	
(I_F=100 mA, t_p=20 ms)	I_E	20 – 40	≥32	mW/sr
(I_F=1 A, t_p=100 µs)	I_E	220	270	mW/sr
Radiant Flux (total) (I_F=100 mA, t_p=20 ms)	ϕ_E	5.5	7	mW

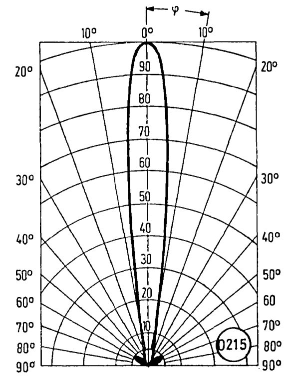
Relative spectral emission versus wavelength



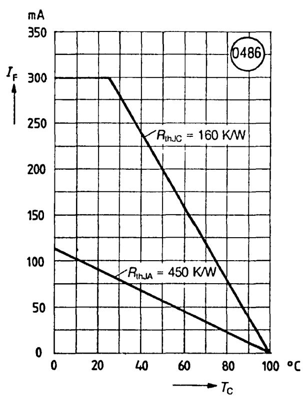
Radiant intensity versus forward current



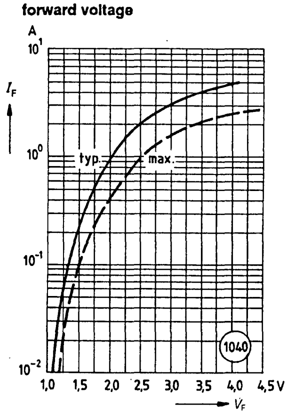
Radiation characteristic
Relative spectral emission versus half angle



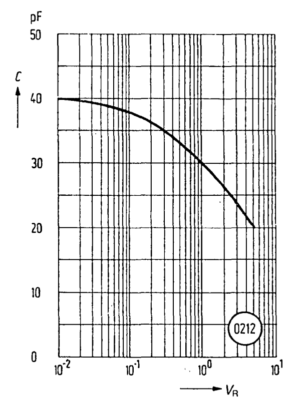
Forward current versus case temperature



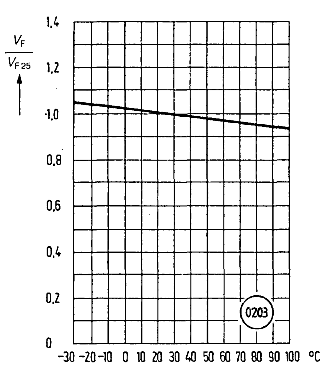
Forward current versus forward voltage



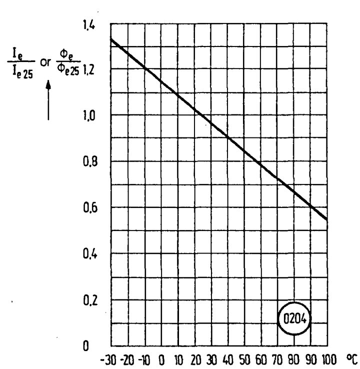
Capacitance versus reverse voltage



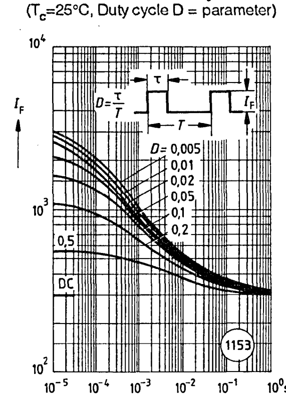
Forward voltage versus ambient temperature



Radiant intensity versus ambient temperature



Permissible pulse handling capability
Forward current versus cycle duration
(T_C=25°C, Duty cycle D = parameter)

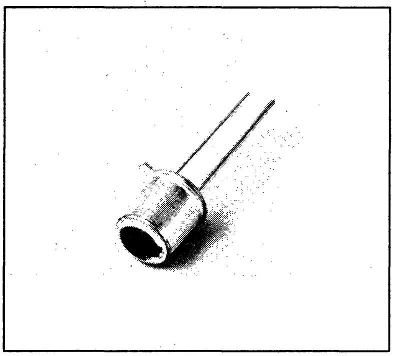


Infrared Emitters

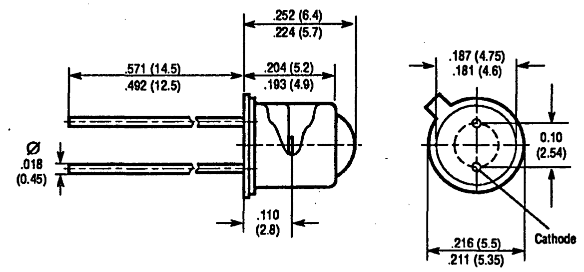
SIEMENS

SFH 401 SERIES

GaAs INFRARED EMITTER



Package Dimensions in Inches (mm)



FEATURES

- **Package: 18 A 3 DIN 41 876 (TO 18), Glass Lens, Hermetically Sealed, Solder Tabs, Lead Spacing 2.54 mm (1/10")**
- **Anode Marking: Tab at Case Bottom**
- **High Reliability**
- **Long Life**
- **Very High Radiant Intensity, Narrow Beam**
- **High Pulse Power**
- **Two Radiant Intensity Ranges**
- **Same Package as SFH 481**

DESCRIPTION

The GaAs infrared emitting diode SFH 401, fabricated in a liquid phase epitaxy process, features high efficiency and emits radiation at a wavelength in the near infrared range. The radiation is activated by dc or pulse operation in forward direction; simultaneous modulation is possible. The cathode is electrically connected to the case.

The applications include light-reflecting switches for steady and varying intensity, IR-remote control, industrial electronics, "measuring and controlling".

Maximum Ratings

Storage and Operating Temperature (T_{STG}, T_{OP}) .... -55°C to +100°C
Soldering Temperature at Dip Soldering (≥2 mm distance from case bottom) (t ≤5 sec.) (T_S) .... 260°C
Soldering Temperature at Iron Soldering (≥2 mm distance from case bottom) (t ≤ 3 sec.) (T_S) .... 300°C
Junction Temperature (T_J) .... 100°C
Reverse Voltage (V_R) .... 5 V
Forward Current (I_F) T_C= 25°C .... 300 mA
Surge Current (t ≤ 10 µs, D=0) (I_{FS}) .... 3 A
Power Dissipation (P_{TOT}) T_C = 25°C .... 470 mW
Thermal Resistance (R_{THJA}) .... 450 K/W
(R_{THJC}) .... 160 K/W

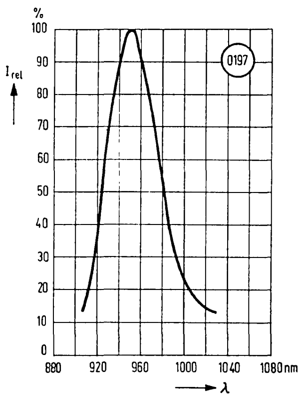
Characteristics (T_A=25°C)

Parameter	Symbol		Unit
Wavelength at Peak Emission			
(I_F=100 mA, t_p=20 ms)	λ_{PEAK}	950 ±20	nm
Spectral Bandwidth at 50% of I_{MAX}			
(I_F=100 mA, t_p=20 ms)	Δλ	±55	nm
Half Angle	φ	±15	Deg.
Active Chip Area	A	0.25	mm²
Dimensions of Active Chip Area	L x W	0.5 x 0.5	mm
Distance Chip Surface to Case Surface	D	2.8 – 3.7	mm
Switching Times			
(I_E from 10% to 90%,			
and from 90% to 10%, I_F =100 mA)	t_R, t_F	1	µs
Capacitance (V_R=0 V, f=1 MHz)	C_0	40	pF
Forward Voltage			
(I_F=100 mA)	V_F	1.30 (≤1.5)	V
(I_F=1 A, t_p=100 µs)	V_F	1.9 (≤2.5)	V
Breakdown Voltage (I_R=10 µA)	V_{BR}	30 (≥5)	V
Reverse Current (V_R=5 V)	I_R	0.01 (≤1)	µA
Temperature Coefficient of I_E or ϕ_E	TC_I	–0.55	%/K
Temperature Coefficient of V_F	TC_V	–1.5	mV/K
Temperature Coefficient of λ_{PEAK}	TC_λ	0.3	nm/K

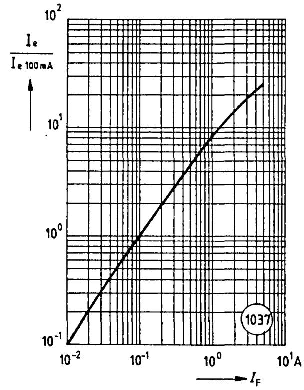
Radiant Intensity I_E in Axial Direction at a Steradian Ω ≥0.01 sr or 6.5 degrees

		SFH401-2	SFH401-3	SFH401-4	
(I_F=100 mA, t_p=20 ms)	I_E	10 – 20	16 – 32	>25	mW/sr
(I_F=1 A, t_p=100 µs)	I_E	100	120	225	mW/sr
Radiant Flux (total) (I_F=100 mA, t_p=20 ms)	ϕ_E	5.5	7	8.5	mW

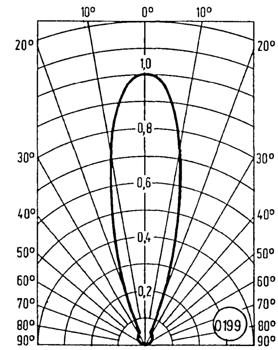
Relative spectral emission versus wavelength



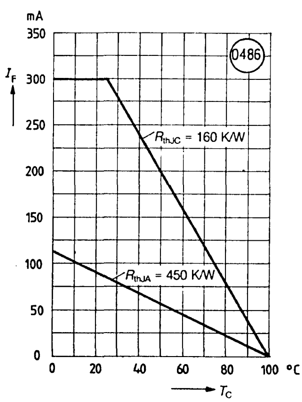
Radiant intensity versus forward current



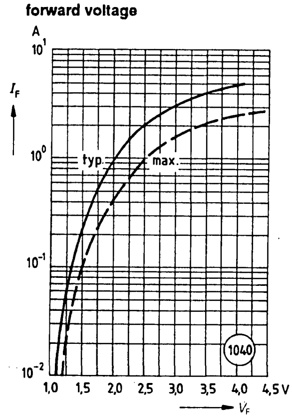
Radiation characteristic Relative spectral emission versus half angle



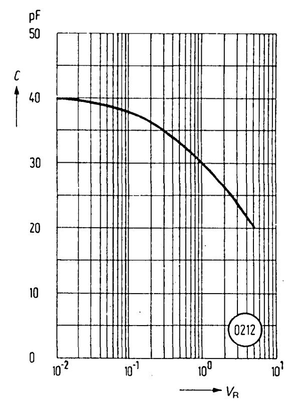
Forward current versus case temperature



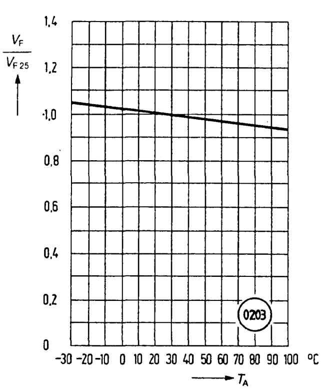
Forward current versus forward voltage



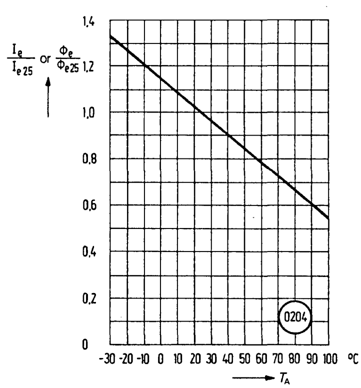
Capacitance versus reverse voltage



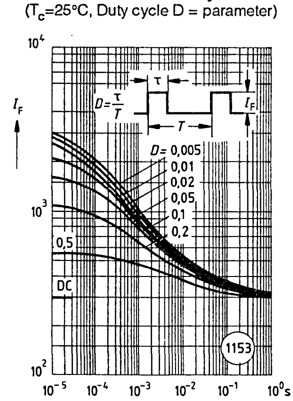
Forward voltage versus ambient temperature



Radiant intensity versus ambient temperature



Permissible pulse handling capability Forward current versus cycle duration
(T_c=25°C, Duty cycle D = parameter)



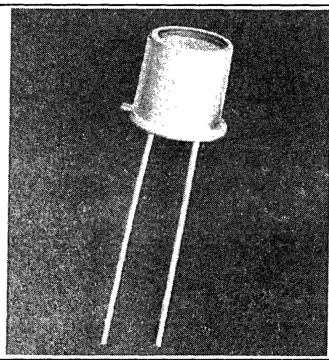
Infrared Emitters

SFH 401

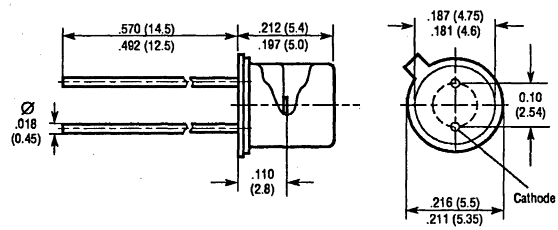
SIEMENS

SFH 402 SERIES

GaAs INFRARED EMITTER



Package Dimensions in Inches (mm)



FEATURES

- **Package: 18 A 3 DIN 41 876 (TO 18), Glass Lens, Hermetically Sealed, Solder Tabs, Lead Spacing 2.54 mm (1/10")**
- **Anode Marking: Tab at Case Bottom**
- **High Reliability**
- **Long Life**
- **Wide Beam**
- **High Pulse Power**
- **Two Radiant Intensity Ranges**
- **Same Package as SFH 482, BPX38/65/66**

DESCRIPTION

The GaAs infrared emitting diode SFH 402, fabricated in a liquid phase epitaxy process, features high efficiency and emits radiation at a wavelength in the near infrared range. The radiation is activated by dc or pulse operation in forward direction; simultaneous modulation is possible. The cathode is electrically connected to the case.

The applications include light-reflecting switches for steady and varying intensity, IR-remote control, industrial electronics, "measuring and controlling".

Maximum Ratings

Storage and Operating Temperature (T_{STG}, T_{OP})	-55°C to +100°C
Soldering Temperature at Dip Soldering (≥2 mm distance from case bottom) (t ≤5 sec.) (T_S)	260°C
Soldering Temperature at Iron Soldering (≥2 mm distance from case bottom) (t ≤ 3 sec.) (T_S)	300°C
Junction Temperature (T_J)	100°C
Reverse Voltage (V_R)	5 V
Forward Current (I_F) T_C= 25°C	300 mA
Surge Current (t ≤ 10 µs, D=0) (I_{FS})	3 A
Power Dissipation (P_{TOT}) T_C = 25°C	470 mW
Thermal Resistance (R_{THJA})	450 K/W
(R_{THJC})	160 K/W

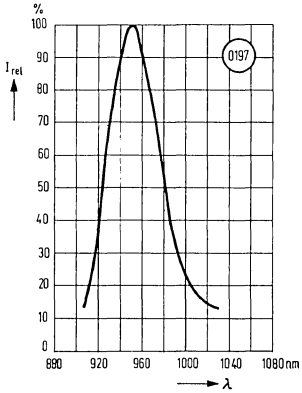
Characteristics (T_A=25°C)

Parameter	Symbol		Unit
Wavelength at Peak Emission (I_F=100 mA, t_p=20 ms)	λ_{PEAK}	950 ±20	nm
Spectral Bandwidth at 50% of I_{MAX} (I_F=100 mA, t_p=20 ms)	Δλ	±55	nm
Half Angle	φ	±40	Deg.
Active Chip Area	A	0.25	mm²
Dimensions of Active Chip Area	L x W	0.5 x 0.5	mm
Distance Chip Surface to Case Surface	D	2.1 – 2.7	mm
Switching Times (I_E from 10% to 90%, and from 90% to 10%, I_F =100 mA)	t_R, t_F	1	µs
Capacitance (V_R=0 V, f=1 MHz)	C_0	40	pF
Forward Voltage (I_F=100 mA)	V_F	1.30 (≤1.5)	V
(I_F=1 A, t_p=100 µs)	V_F	1.9 (≤2.5)	V
Breakdown Voltage (I_R=10 µA)	V_{BR}	30 (≥5)	V
Reverse Current (V_R=5 V)	I_R	0.01 (≤1)	µA
Temperature Coefficient of I_E or ϕ_E	TC_I	–0.55	%/K
Temperature Coefficient of V_F	TC_V	–1.5	mV/K
Temperature Coefficient of λ_{PEAK}	TC_λ	0.3	nm/K

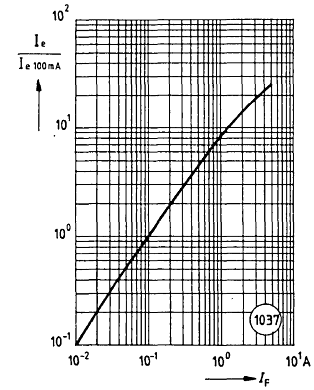
Radiant Intensity I_E in Axial Direction at a Steradian Ω ≥0.01 sr or 6.5 degrees

		SFH402-2	SFH402-3	
(I_F=100 mA, t_p=20 ms)	I_E	2.5 – 5	≥4	mW/sr
(I_F=1 A, t_p=100 µs)	I_E	28	35	mW/sr
Radiant Flux (total) (I_F=100 mA, t_p=20 ms)	ϕ_E	5.5	7	mW

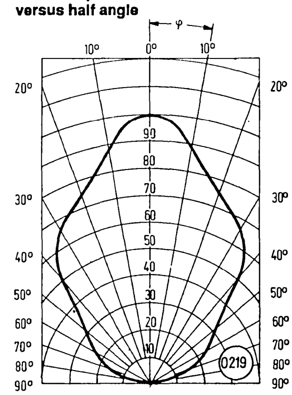
Relative spectral emission versus wavelength



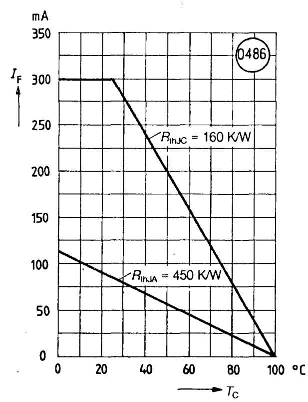
Radiant intensity versus forward current



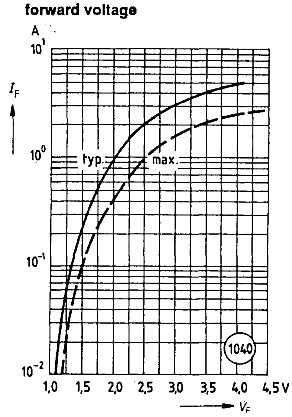
Radiation characteristic Relative spectral emission versus half angle



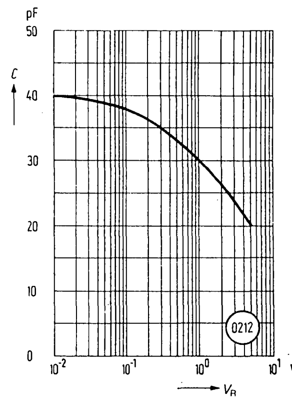
Forward current versus case temperature



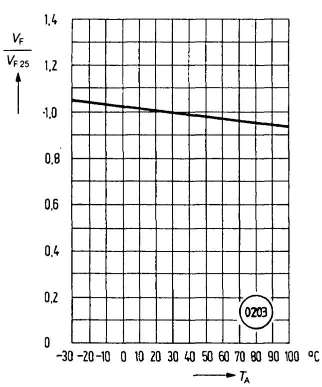
Forward current versus forward voltage



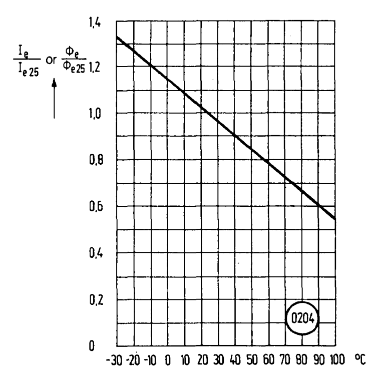
Capacitance versus reverse voltage



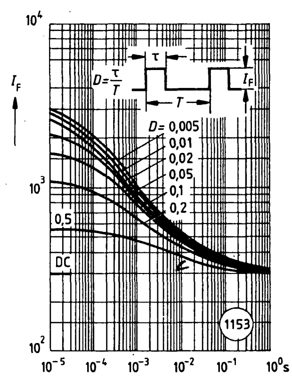
Forward voltage versus ambient temperature



Radiant intensity versus ambient temperature



Permissible pulse handling capability Forward current versus cycle duration
(T_C=25°C, Duty cycle D = parameter)



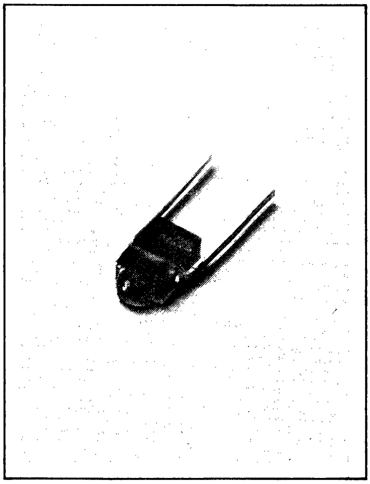
Infrared Emitters

SFH 402

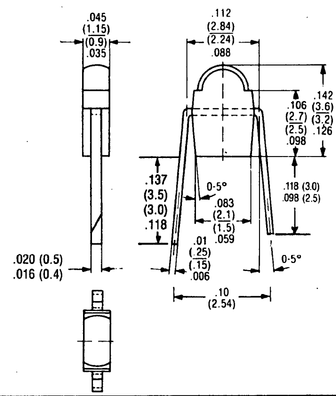
SIEMENS

SFH 405 SERIES

INFRARED EMITTER



Package Dimensions in Inches (mm)



FEATURES

- **Miniature Plastic Package**
- **1/10″ (2.54 mm) Lead Spacing**
- **Emitter for SFH-305 Phototransistor Detector**
- **Two Radiant Intensity Groups**

DESCRIPTION

The SFH 405 is a GaAs infrared diode which emits radiation at a wavelength in the near infrared. The radiation emitted is excited by current flowing in the forward direction.

The case is transparent plastic with a lens shaped light output. The plastic is slightly smoke colored in order to differentiate between phototransistors of the same type (SFH 305). The terminals are solder pins in 1/10″ (2.54 mm) lead spacing. The infrared emitting diodes are grouped according to radiation intensity. SFH 405 is suitable for use as emitter with the phototransistor SFH 305. The cathode is marked with a color dot.

They can be used effectively in miniature light barriers with close spacing between emitter and receiver.

Maximum Ratings

Operating and Storage Temperature	T	−40 to +80	°C
Soldering Temperature (Distance from soldering joint to package ≥2 mm			
Dip soldering time t ≤ 3 s	T_S	230	°C
Iron soldering time t ≤ 3 s)	T_S	300	°C
Junction Temperature	T_j	80	°C
Reverse Voltage	V_R	5	V
Forward Current	I_F	40	mA
Surge Current (t = 10 µs, D = 0)	I_{FS}	1.6	A
Power Dissipation	P_{tot}	65	mW
Thermal Resistance	R_{thJamb}	950	K/W
	R_{thJL}	850	K/W

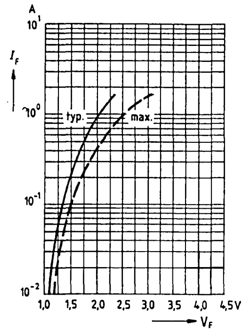
Characteristics (T_{amb} = 25°C)

Wavelength (I_F = 40 mA, t_P = 20 ms)	λ	950±20	nm
Spectral Bandwidth (I_F = 40 mA, t_p = 20 ms)	Δλ	55	nm
Half Angle	φ	±16	Deg.
Active Area	A	0.25	mm²
Active Die Area per Die	L × W	0.5 × 0.5	mm
Distance Die Surface to Package Surface	H	1.3 to 1.9	mm
Switching Time (I_e from 10% to 90% and from 90% to 10% at I_F = 40 mA)	t_r, t_f	1	µs
Capacitance (V_R = 0 V)	C_0	40	pF
Forward Voltage (I_F = 40 mA)	V_F	1.25 (≤1.4)	V
Breakdown Voltage (I_R = 10 µA)	V_{BR}	30 (≥5)	V
Reverse Current (V_R = 5 V)	I_R	0.01 (≤1)	µA
Temperature Coefficient of I_e or Φ_e	TC_I	−0.55	%/K
Temperature Coefficient of V_F	TC_V	−1.5	mV/K
Temperature Coefficient of λpeak	TC_λ	+0.3	nm/K

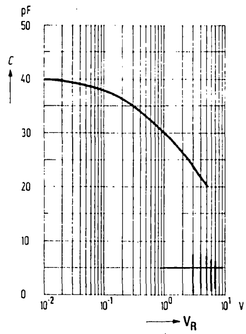
Radiant Intensity I_e in Axial Direction Measured at a Solid Angle of Ω = 0.01 sr

Group	SFH 405-2	SFH 405-3	
Radiant Intensity (I_F = 40 mA, t_p = 20 ms) I_e	1.6–3.2	≥2.5	mW/sr
Radiant Power (I_F = 40 mA t_p = 20 ms) Φ_e	2.5	4	mW

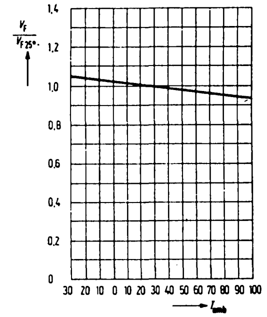
FORWARD CURRENT
$I_F = f(V_F)$



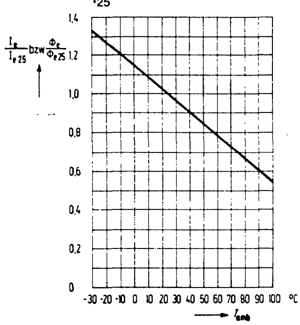
CAPACITANCE
$C = f(V_R)$



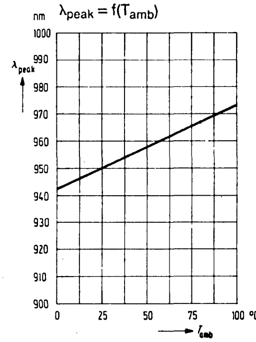
FORWARD VOLTAGE
$\frac{V_F}{V_{F25}} = (T_{amb})$



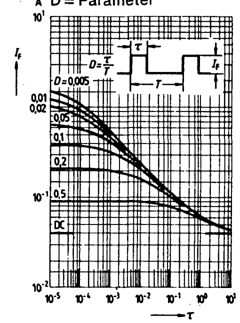
RADIANT INTENSITY
$\frac{I_e}{I_{25}} = f(T_{amb})$



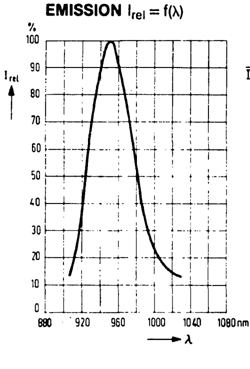
WAVELENGTH AT PEAK EMISSION
$\lambda_{peak} = f(T_{amb})$



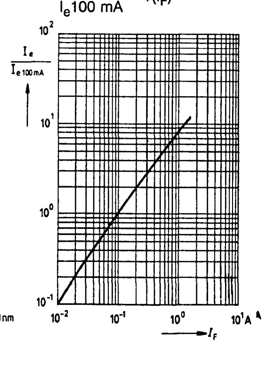
PERMISSIBLE PULSE LOAD
$I_F = f(\tau)$; $T_{amb} = 25\,°C$;
Duty Cycle
D = Parameter



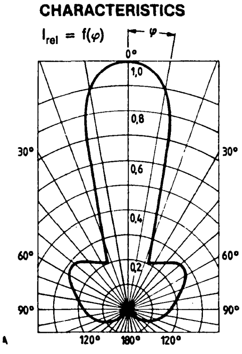
RELATIVE SPECTRAL EMISSION $I_{rel} = f(\lambda)$



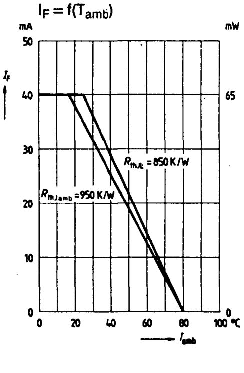
RADIANT INTENSITY
$\frac{I_e}{I_e 100\ mA} = f(I_F)$



RADIATION CHARACTERISTICS
$I_{rel} = f(\varphi)$



MAXIMUM PERMISSIBLE FORWARD CURRENT
$I_F = f(T_{amb})$

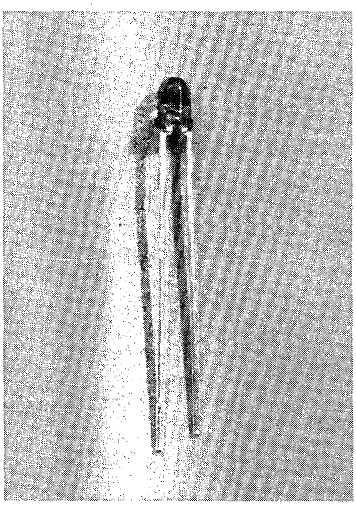


Infrared Emitters

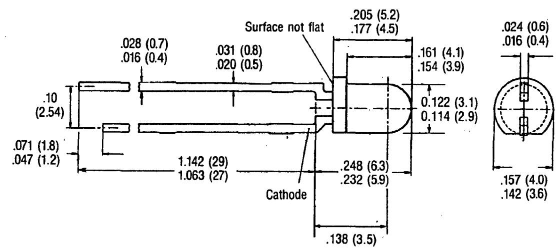
SFH 405

SIEMENS

SFH 409
INFRARED EMITTER



Package Dimensions in Inches (mm)



FEATURES

- **Radiant Intensity Selections**
  SFH409-1 6.3–12.5
  SFH409-2 10–20
  SFH409-3 ≥16
- **High Reliability**
- **3 mm (T1) Size Package**
- **1/10″ (2.54 mm)Lead Spacing**
- **Low Cost**
- **High Pulse Power**
- **Long Term Stability**
- **Medium Wide Beam, 40°**
- **Excellent Match with SFH-309 Photodetector**

DESCRIPTION

The SFH-409 is a GaAs Infrared Emitting Diode in a standard T1 size plastic package. It is designed for a variety of low cost, high volume applications such as IR remote control and other consumer and entertainment products.

Maximum Ratings:

Storage temperature	T_{stg}	−55 to +100	°C
Soldering temperature			
Distance from casing-solder tab≥2mm			
Dip soldering time ≤5s	T_{sold}	260	°C
Iron soldering time≤3s	T_{sold}	300	°C
Junction temperature	T_j	100	°C
Reverse voltage	V_R	5	V
Forward current	I_F	100	mA
Surge current (τ = 10μs)	i_{FS}	3	A
Power dissipation (T = 25 °C)	P_{tot}	165	mW
Thermal Resistance	$R_{th\,JA}$	450	K/W

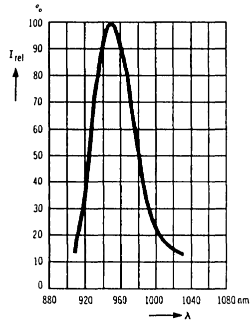
Characteristics (T_{amb} = 25 °)

Wave length at peak emission at I_F = 100 mA tp = 20ms	λpeak	950 ± 20	nm
Spectral bandwidth at 50% of I_{max} at I_F = 100mA, t_p = 20 ms	Δλ	55	nm
Half angle	φ	±20	Deg.
Active chip area	A	0.09	mm²
Dimensions of active chip area	L×W	0.3 × 0.3	mm
Distance chip surface to leadframe standoff	D	3.5	mm
Switching time: (I_e from 10% to 90%; I_F = 100mA)	t_r,t_f	1	μs
Capacity (V_R = 0 V)	C_0	25	pF
Forward Voltage (I_F = 100mA)	V_F	1.30 (≤1.5)	V
(I_F = 1A; t_p = 100μs)	V_F	1.9 (≤2.5)	V
Breakdown voltage (I_R = 100 μA)	V_{BR}	30 (≥5)	V
Reverse current (V_R = 5V)	I_R	0.01 (≤1)	μA
Temperature coefficient of I_e or Φ_e	TC	−0,55	%/K
Temperature coefficient of V_F	TC	−1,5	mV/K
Temperature coefficient of λpeak	TC	+0,3	nm/K

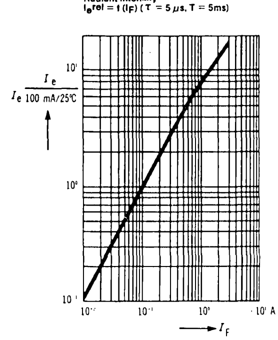
Radiant Intensity I_E in Axial Direction Measured at a Solid Angle of Ω = 0.01sr

Group	SFH 409-1	SFH 409-2	SFH 409-3	
Radiant Intensity I_E				
(I_F = 100 mA, T_P = 20 ms)	6.3–12.5	10–20	≥16	mW/sr
(I_F = 1 A, T_P = 100 μs)	70	110	150	mW/sr
Total Radiant Flux Φ_E				
(I_F = 100 mA, T_P = 20 ms)	10	12	14	mW

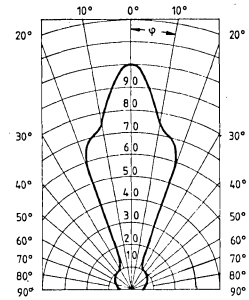
Relative spectral emission
$I_{rel} = f(\lambda)$



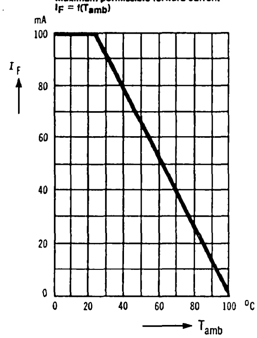
Radiant intensity
$I_{e rel} = f(I_F)$ (τ = 5 µs, T = 5ms)



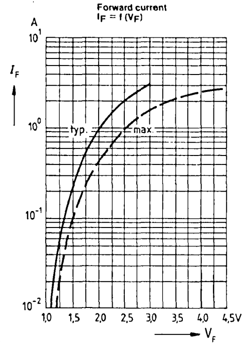
Radiant characteristics
$I_{rel} = f(\varphi)$



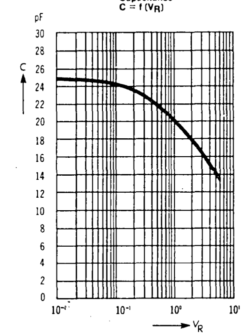
Maximum permissible forward current
$I_F = f(T_{amb})$



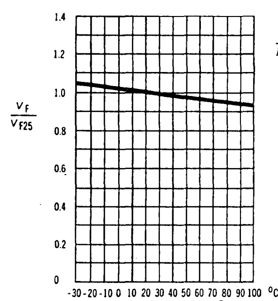
Forward current
$I_F = f(V_F)$



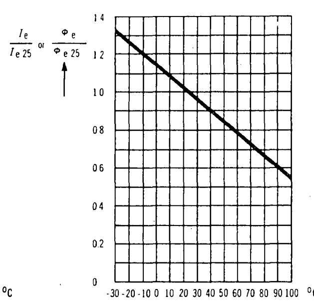
Capacitance
$C = f(V_R)$



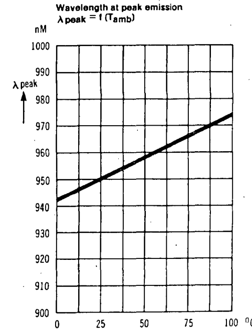
Forward voltage $\frac{V_F}{V_{F\,25}} = f(T_{amb})$



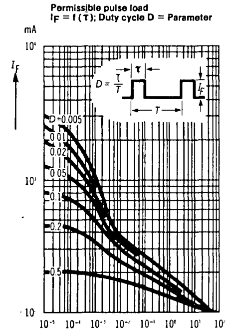
Radiant intensity $\frac{I_e}{I_{e\,25}} = f(T_{amb})$



Wavelength at peak emission
$\lambda_{peak} = f(T_{amb})$



Permissible pulse load
$I_F = f(\tau)$; Duty cycle D = Parameter

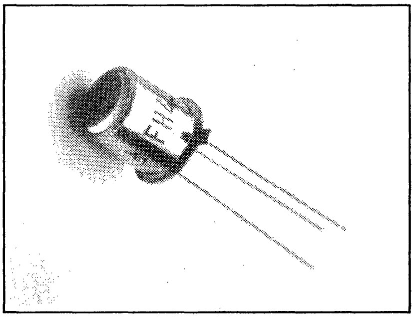


Infrared Emitters

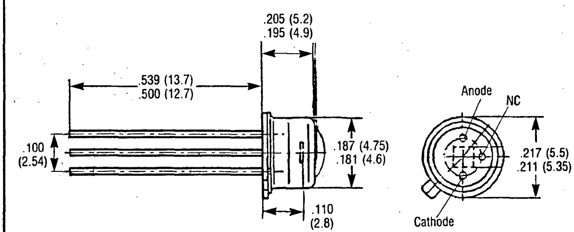
SFH 409

SFH 431 SERIES

INFRARED EMITTER



Package Dimensions in Inches (mm)



Cathode is connected to case.

FEATURES

- **TO-18 Hermetic Package, 3-Leaded**
- **Dome Glass Lens**
- **Very Narrow Beam, ±8°**
- **Three High Power Intensity Ranges**
  SFH 431 10 mW/Sr
  SFH 431-1 10–20 mW/Sr
  SFH 431-2 16–32 mW/Sr
  SFH 431-3 ≥25 mW/Sr
- **Reversed Polarity Compared to SFH 401**
- **GaAs Material**

DESCRIPTION

The SFH 431 is a GaAs infrared emitting diode which emits radiation in the near infrared range. The emitted radiation, which can be modulated, is caused by current in the forward direction. The SFH 431 comes in a 3-leaded TO-18 package and has a glass lens to provide a narrow emitting beam. The cathode lead is the lead closest to the tab. The cathode is electrically connected to the case. The SFH 431 is electrically similar to the SFH 401 series, but has a reversed pin out and case polarity.

Absolute Maximum Ratings

Parameter	Symbol	Min	Max	Unit
Power Dissipation			470	mW
DC Forward Current	I_F		300	mA
Surge Current (t<10 μs, D=0)			3.0	A
Reverse Voltage	V_R		5.0	V
Storage Temperature	T_S	−55	100	°C
Operating Temperature	T_A	−55	100	°C
Junction Temperature	T_J		100	°C
Lead Soldering Temperature (1/8 inch from case)				260°C for 5 sec.

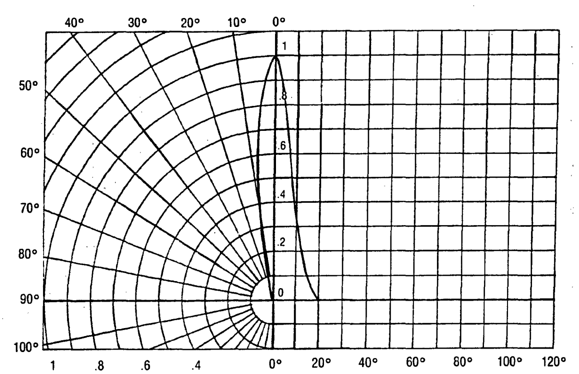
Electrical Characteristics (T_{amb} = 25°C)

Parameter	Symbol	Min	Typ	Max	Unit	Test Conditions
Forward Voltage	V_F		1.3	1.5	V	I_F = 100 mA
Forward Voltage	V_F		1.9	2.5	V	I_F = 1 A
Reverse Current	I_R		0.01	10	μA	V_R = 5 V
Peak Wavelength	λp	930	950	970	nm	I_F = 100 mA
Half Angle	φ		±8		Deg.	

The diodes are grouped according to their radiant intensity I_e in axial direction (at I_F = 100 mA, t_P = 20 ms).

Dash Number	SFH431	−1	−2	−3	Unit
Radiant Intensity I_e	10	10–20	16–32	≥25	mW/Sr
Φ_e (Total) typ.	6	5	6	7	mW

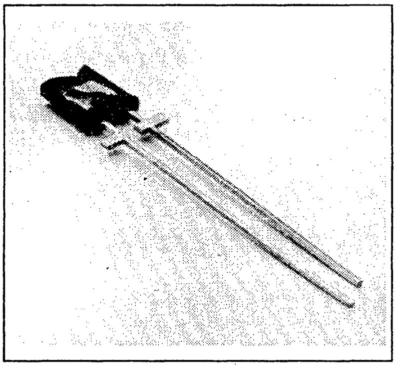
Radiant Characteristics I_{rel} = f (φ)



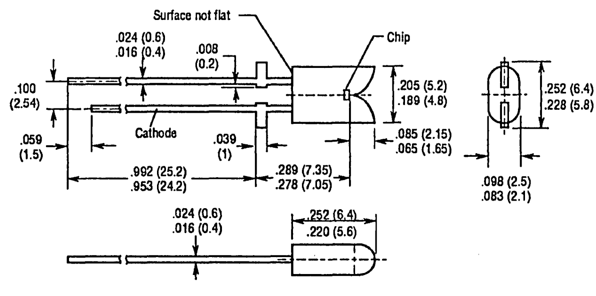
SIEMENS

SFH 435

GaAs INFRARED EMITTER DOUBLE EMITTING DIODE



Package Dimensions in Inches (mm)



FEATURES

- **Package: Special Case, Grey Tinted Epoxy Resin, Solder Tabs, 2.54 mm (1/10″) Lead Spacing**
- **Cathode Marking: Short Solder Tab**
- **High Reliability**
- **Long Life**
- **Diametrical Radiation**
- **High Pulse Handling Capability**
- **Good Spectral Matching with Silicon Photodetectors**

DESCRIPTION

The SFH 435 is a two-beam GaAs infrared emitting diode with one chip. The beams emerge diametrically from the diode in a half angle of 8 degrees.

The radiation is emitted in the near infrared range. It is excited by a current flowing in forward direction; dc as well as pulse operation with simultaneous modulation are possible.

The SFH 435 is especially suitable for application in dual photo interrupters, i.e., light reflection switches, tape end control.

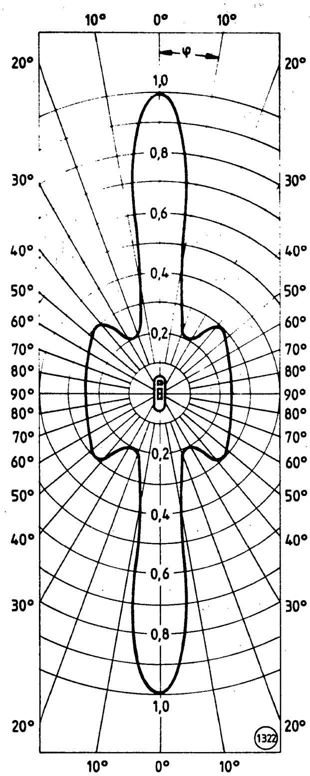
Maximum Ratings

Reverse Voltage (V_R) .... 5 V
Forward Current (I_F) .... 100 mA
Surge Current ($t_p \le 10\ \mu s$) (I_{FS}) .... 3 A
Junction Temperature (T_J) .... 100°C
Storage Temperature Range (T_{STG}) .... -55°C to +100°C
Soldering Temperature at Dip Soldering (≥2 mm distance
from case bottom) (t ≤5 sec.) (T_S) .... 260°C
Soldering Temperature at Iron Soldering (≥2 mm distance
from case bottom) (t ≤3 sec.) (T_S) .... 300°C
Total Power Dissipation (P_{TOT}) $T_{amb} \le 25°C$ .... 165 mW
Thermal Resistance (R_{thJA}) .... 450 K/W

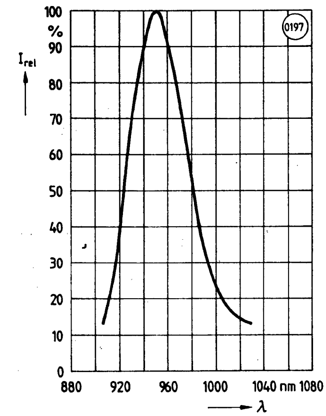
Characteristics (T_{amb}=25°C)

Parameter	Symbol		Unit
Wavelength at Peak Emission			
(I_F=100 mA, t_p=20 ms; t_{OFF}=180 ms)	λ_{PEAK}	950 ±20	nm
Spectral Bandwidth at 50% of I_{REL}			
(I_F=100 mA, t_p=20 ms)	$\Delta\lambda$	70	nm
Half Angle per Major Lobe	φ	8	Deg.
Active Chip Area	A	0.09	mm²
Dimensions of Active Chip Area	L × W	0.3 × 0.3	mm²
Switching Times			
(I_E from 10% to 90%, I_F =100 mA)	t_R, t_F	1	µs
Capacitance (V_R=0 V)	C_0	25	pF
Forward Voltage			
(I_F=100 mA)	V_F	1.35 (≤1.65)	V
(I_F=1 A, t_p=100 µs)	V_F	2.0 (≤2.7)	V
Breakdown Voltage (I_R=100 µA)	V_{BR}	30 (≥5)	V
Reverse Current (V_R=5 V)	I_R	0.01 (≤10)	µA
Temperature Coefficient of I_E or ϕ_E	T_C	–0.55	%/K
Temperature Coefficient of V_F	T_C	–1.5	mV/K
Temperature Coefficient of λ_{PEAK}	T_C	+0.3	nm/K
Radiant Intensity in Axial Direction at			
a Steradian Ω≥0.01 sr or 6.5 degrees			
(measured in direction of major lobes)			
(I_F=100 mA, t_p=20 ms)	I_E	8 (typ.)	mW/sr
(I_F=1 A, t_p=100 µs)	I_E	60 (typ.)	mW/sr
Radiant Flux, Total			
(I_F=100 mA, t_p=20 ms)	ϕ_E	13 (typ.)	mW

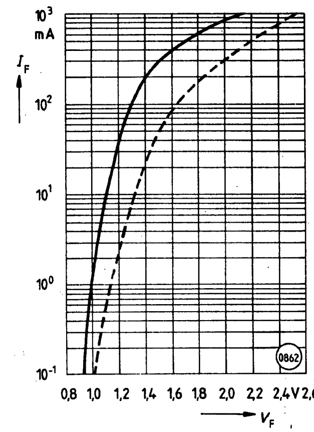
Radiation characteristic
Relative spectral emission
versus half angle



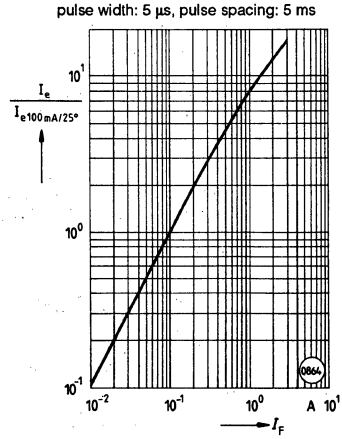
Relative spectral emission
versus wavelength



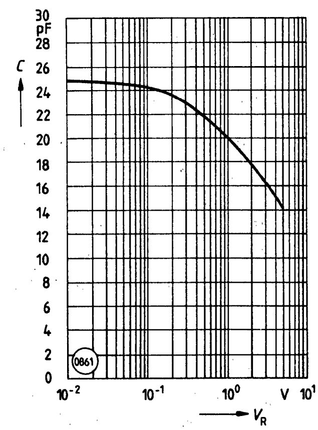
Forward current versus
forward voltage



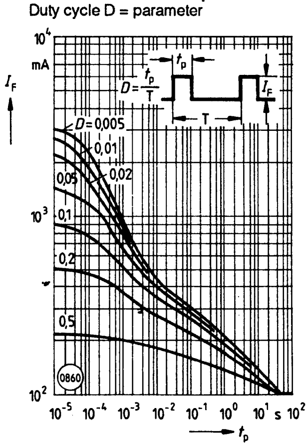
Radiant intensity versus
forward current
pulse width: 5 µs, pulse spacing: 5 ms



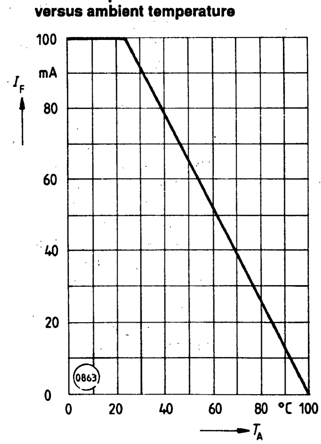
Capacitance versus reverse voltage



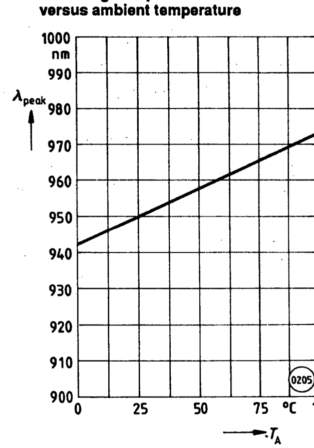
Permissible pulse handling capability
Forward current versus pulse width
Duty cycle D = parameter



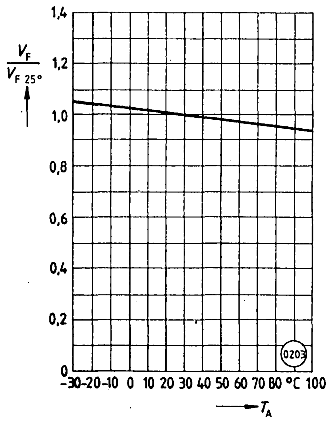
Maximum permissible forward current
versus ambient temperature



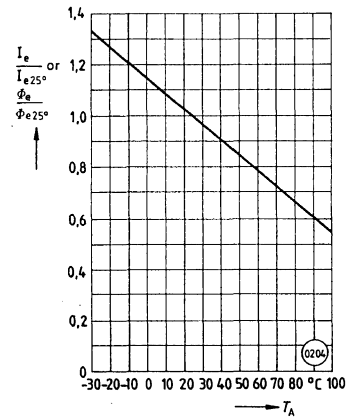
Wavelength at peak emission
versus ambient temperature



Forward voltage versus ambient temperature



Radiant intensity versus ambient temperature



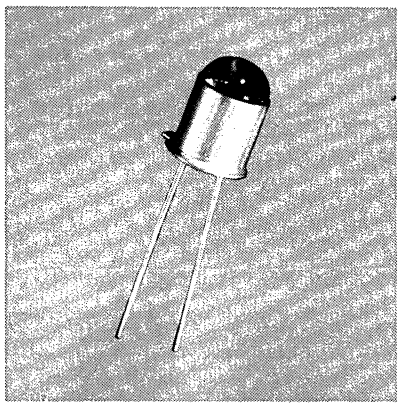
Infrared Emitters

SFH 435

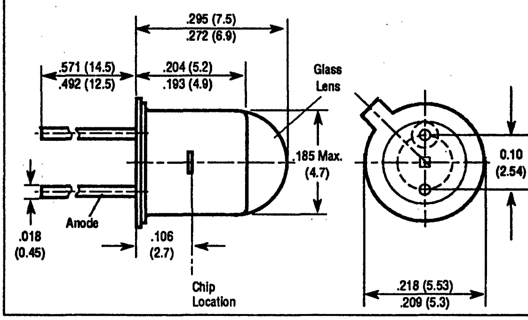
SIEMENS

SFH480 SERIES

GaAlAs INFRARED EMITTER



Package Dimensions in Inches (mm)



FEATURES

- **TO-18 Hermetic Package**
- **Round Glass Lens**
- **Very Narrow Beam, 12°**
- **Very High Power, 10 mW Typical at 100 mA**
- **Three Radiant Intensity Selections**
  SFH480-1, ≥25 mW/sr
  SFH480-2, ≥40 mW/sr
  SFH480-3, ≥63 mW/sr

DESCRIPTION

The SFH 480 series are infrared emitting diodes which emit radiation in the near infrared range (880 nm peak). The emitted radiation, which can be modulated, is generated by forward flowing current. The case (18A 2 DIN 41876—similar to TO-18) is topped by a glass lens. The cathode lead is nearest the tab on the rim of the case. The anode is electrically connected to the case.

Maximum Ratings

Reverse Voltage	V_R	5	V
Forward Current ($T_c \leq 25°C$)	I_F	200	mA
Surge Current ($\tau \leq 10 \mu s$)	i_{FS}	2.5	A
Junction Temperature	T_j	100	°C
Storage Temperature	T_S	−55 to +100	°C
Power Dissipation ($T_c \leq 25°C$)	P_{tot}	470	mW
Thermal Resistance:			
Junction to Air	R_{thJamb}	450	K/W
Junction to Case	R_{thJG}	160	K/W
Soldering Temperature (Distance from casing-solder tab ≥2 mm)			
Dip Soldering Time ≤ 5 sec	T_{SOLD}	260	°C
Iron Soldering Time < 3 sec	T_{SOLD}	300	°C

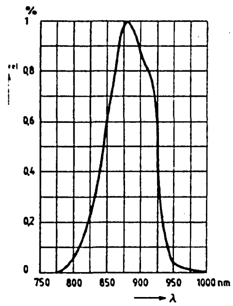
Characteristics ($T_{amb} = 25°C$)

Wavelength at peak emission at $I_F = 10$ mA;	λpeak	880	nm
Wavelength at peak emission at $I_F = 100$ mA; $t_{pulse} = 20$ ms; Duty cycle = 1:12	λpeak	883	nm
Wavelength at peak emission at $I_F = 1$A $t_{pulse} = 100$ µs; Duty cycle = 1:200	λpeak	886	nm
Spectral bandwidth at 50% of I_{max} at $I_F = 10$ mA	Δλ	80	nm
Half angle	φ	±6	Deg.
Active chip area	A	0.16	mm²
Dimensions of active chip area	L x W	0.4 x 0.4	mm
Distance chip surface to case surface	D	4 0...4.8	mm
Switching time: (I_e from 10% to 90%; and from 90% to 10% $I_F = 100$ mA)	t_r, t_f	0.6/0.5	µs
Capacitance ($V_R = 0$ V; f = 1 MHz)	C_o	25	pF
Forward voltage ($I_F = 100$ mA; $t_{pulse} = 20$ ms)	V_F	1.5(≤1.8)	V
($I_F = 1$ A; $t_{pulse} = 100$ µs)	V_F	3.0(≤3.8)	V
Breakdown voltage ($I_R = 10$ µA)	V_{BR}	30(≥5)	V
Reverse current ($V_R = 5$ V)	I_R	0.01 (≤1)	µA
Temperature coefficient of I_e or Φ_e	TC	−0.5	%/K
Temperature coefficient of V_F	TC	−0.2	%/K
Temperature coefficient of λpeak	TC	0.25	nm/K
Typical Radiant Flux ($I_F = 100$ mA, $T_P = 20$ ms)	Φ_E	10	mW

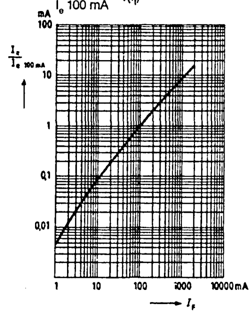
Radiant Intensity I_E in Axial Direction Measured at a Solid Angle of Ω = 0.01sr

Group	SFH 480-1	SFH 480-2	SFH 480-3	
Radiant Intensity I_E				
($I_F = 100$ mA, $T_P = 20$ ms)	25-50	40-80	≥63	mW/sr
($I_F = 1$ A, $T_P = 100$ µs)	280	450	525	mW/sr

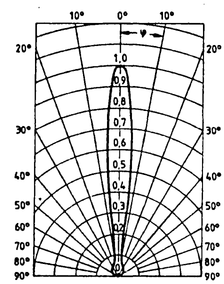
Relative spectral emission
$I_{rel} = f(\lambda)$



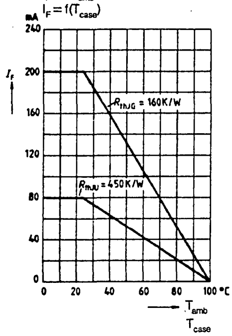
Radiant intensity
$\frac{I_e}{I_e\ 100\ mA} = f(I_F)$



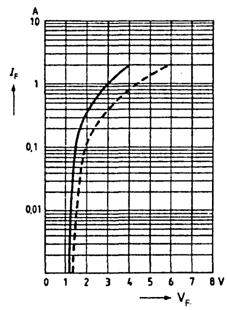
Radiant characteristics
$I_{rel} = f(\varphi)$



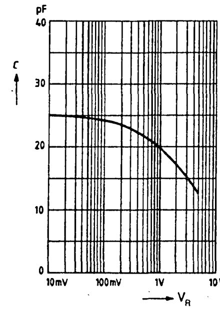
Maximum permissable forward current
$I_F = f(T_{amb})$
$I_F = f(T_{case})$



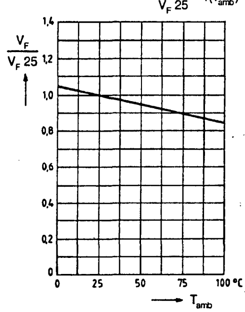
Forward current
$I_F = f(V_F)$



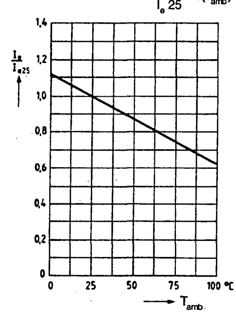
Capacitance
$C = f(V_R)$



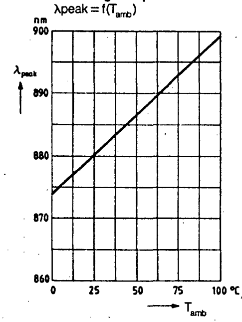
Forward voltage $\frac{V_F}{V_F\ 25} = f(T_{amb})$



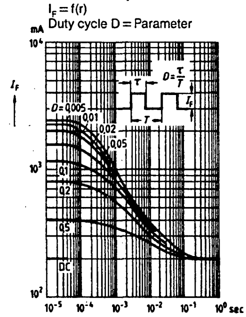
Radiant intensity $\frac{I_e}{I_e\ 25} = f(T_{amb})$



Wavelength at peak emission
$\lambda peak = f(T_{amb})$



Permissable pulse load
$I_F = f(\tau)$
Duty cycle D = Parameter

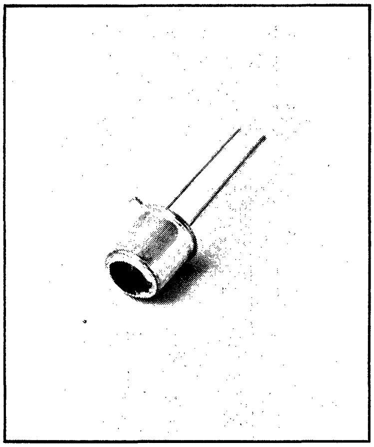


Infrared Emitters

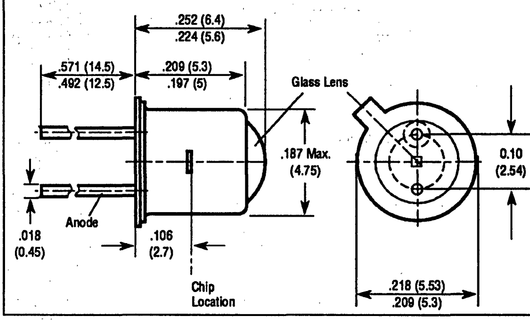
SIEMENS

SFH481 SERIES

GaAlAs INFRARED EMITTER



Package Dimensions in Inches (mm)



FEATURES

- **TO-18 Hermetic Package**
- **Dome Glass Lens**
- **Narrow Beam, 30°**
- **Very High Power, 10 mW Typical at 100 mA**
- **Radiant Intensity Selections**
  SFH481-1, ≥10 mW/sr
  SFH481-2, ≥16 mW/sr
  SFH481-3, ≥35 mW/sr

DESCRIPTION

The SFH 481 series are emitting diodes which emit radiation in the near infrared range (880 nm peak). The emitted radiation, which can be modulated, is generated by forward flowing current. The case (18A 2 DIN 41876—similar to TO-18) has a domed glass lens top. The cathode lead is nearest the tab on the rim of the case bottom. The anode is electrically connected to the case.

Maximum Ratings

Reverse Voltage	V_R	5	V
Forward Current ($T_C \leq 25°C$)	I_F	200	mA
Surge Current ($\tau \leq 10$ µs)	i_{FS}	2.5	A
Junction Temperature	T_j	100	°C
Storage Temperature Range	T_s	−55 to +100	°C
Power Dissipation ($T_C \leq 25°C$)	P_{tot}	470	mW
Thermal Resistance:			
Junction to Air	R_{thJamb}	450	K/W
Junction to Case	R_{thJC}	160	K/W
Soldering Temperature (Distance from casing-solder tab ≥2 mm)			
Dip Soldering Time ≤ 5 sec	T_{SOLD}	260	°C
Iron Soldering Time ≤ 3 sec	T_{SOLD}	300	°C

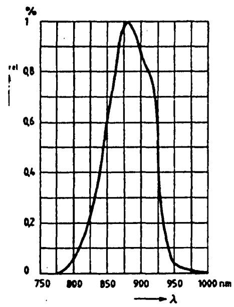
Characteristics ($T_{amb} = 25°C$)

Wavelength at peak emission at $I_F = 10$ mA	λpeak	880	nm
Wavelength at peak emission at $I_F = 100$ mA, $t_{pulse} = 20$ms, Duty cycle = 1:12	λpeak	883	nm
Wavelength at peak emission at $I_F = 1$A, $t_{pulse} = 100$µs, Duty cycle = 1:100	λpeak	886	nm
Spectral bandwidth at 50% of I_{max} at $I_F = 10$ mA	Δλ	80	nm
Half angle	φ	±15	Deg.
Active chip area	A	0.16	mm²
Dimensions of active chip area	L×W	0.4×0.4	mm
Distance chip surface to case surface	D	2.8...3.7	mm
Switching time: (I_e from 10% to 90%; and from 90% to 10% $I_F = 100$ mA)	t_r, t_f	0.6/0.5	µs
Capacitance ($V_R = 0$ V, f = 1 MHz)	C_o	25	pF
Forward voltage ($I_F = 100$ mA; $t_{pulse} = 20$ ms)	V_F	1.5 (≤1.8)	V
($I_F = 1$ A; $t_{pulse} = 100$ µs)	V_F	3.0 (≤3.8)	V
Breakdown voltage ($I_R = 10$ µA)	V_{BR}	30 (≥5)	V
Reverse current ($V_R = 5$ V)	I_R	0.01 (≤1)	µA
Temperature coefficient of I_e or Φ_e	TC	−0.5	%/K
Temperature coefficient of V_F	TC	−0.2	%/K
Temperature coefficient of λpeak	TC	0.25	nm/K
Typical Radiant Flux ($I_F = 100$ mA, $T_P = 20$ ms)	Φ_E	10	mW

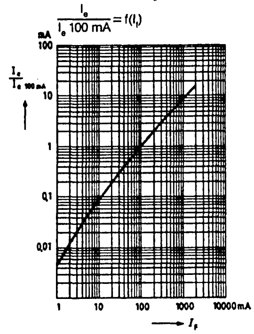
Radiant Intensity I_E in Axial Direction Measured at a Solid Angle of Ω = 0.01sr

Group	SFH 481-1	SFH 481-2	SFH 481-3	
Radiant Intensity I_E				
($I_F = 100$ mA, $T_P = 20$ ms)	10–20	16–32	≥35	mW/sr
($I_F = 1$ A, $T_P = 100$ µs)	110	180	300	mW/sr

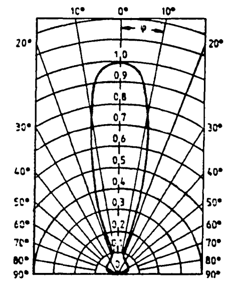
Relative spectral emission
$I_{rel} = f(\lambda)$



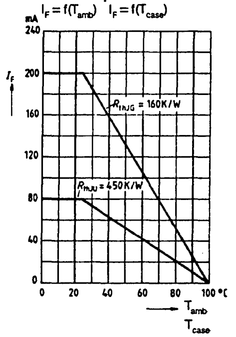
Radiant intensity
$\frac{I_e}{I_e\ 100\ mA} = f(I_F)$



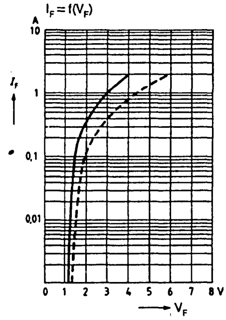
Radiant characteristics
$I_{rel} = f(\varphi)$



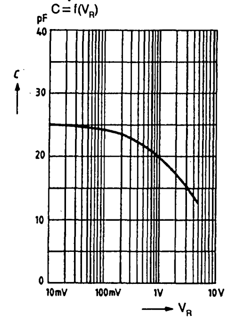
Maximum permissable forward current
$I_F = f(T_{amb})$ $I_F = f(T_{case})$



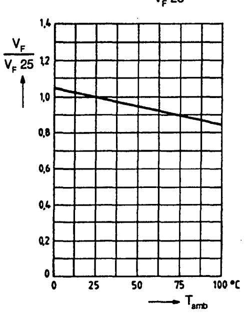
Forward current
$I_F = f(V_F)$



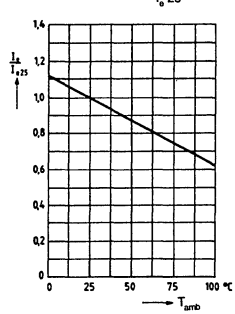
Capacitance
$C = f(V_R)$



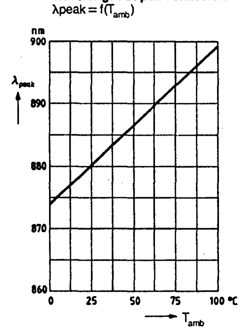
Forward voltage $\frac{V_F}{V_F\ 25} = f(T_{amb})$



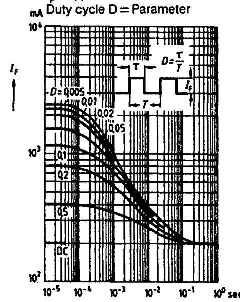
Radiant intensity $\frac{I_e}{I_e\ 25} = f(T_{amb})$



Wavelength at peak emission
$\lambda peak = f(T_{amb})$



Permissable Pulse Load
$I_F = f(\tau)$
Duty cycle D = Parameter



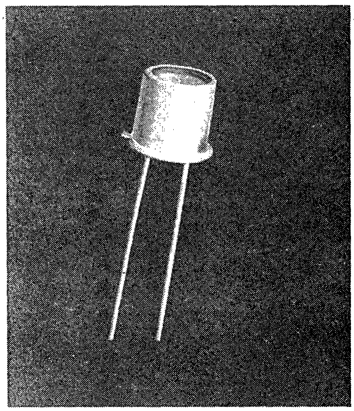
Infrared Emitters

SFH 481

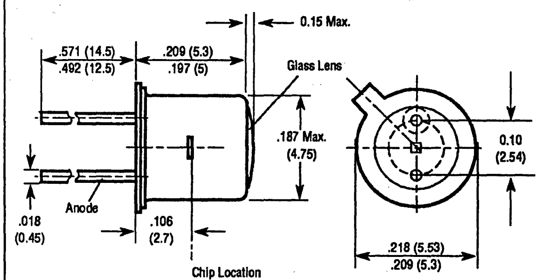
SIEMENS

SFH482 SERIES

GaAlAs INFRARED EMITTER



Package Dimensions in Inches (mm)



FEATURES

- **TO-18 Hermetic Package**
- **Flat Glass Lens**
- **Wide Beam, 60°**
- **Very High Power, 10 mW Typical at 100 mA**
- **Radiant Intensity Selections**
  SFH482-1, ≥3.15 mW/sr
  SFH482-2, ≥5 mW/sr
  SFH482-3, ≥8 mW/sr

DESCRIPTION

The SFH 482 series are infrared emitting diodes which emit radiation in the near infrared range (880 nm peak). The emitted radiation, which can be modulated, is generated by forward flowing current. The case, which is similar to TO-18, is topped by a flat glass lens. The cathode lead is nearest the tab on the rim of the case bottom. The anode is electrically connected to the case.

Maximum Ratings

Reverse Voltage	V_R	5	V
Forward Current ($T_c \leq 25°C$)	I_F	200	mA
Surge Current ($\tau \leq 10$ µs)	i_{FS}	2.5	A
Junction Temperature	T_j	100	°C
Storage Temperature	T_s	−55 to +100	°C
Power Dissipation ($T_c \leq 25°C$)	P_{tot}	470	mW
Thermal Resistance:			
Junction to Air	R_{thJamb}	450	K/W
Junction to Case	R_{thJG}	160	K/W
Soldering Temperature (Distance from casing-solder tab ≥2 mm)			
Dip Soldering Time ≤ 5 sec	T_{SOLD}	260	°C
Iron Soldering Time ≤ 3 sec	T_{SOLD}	300	°C

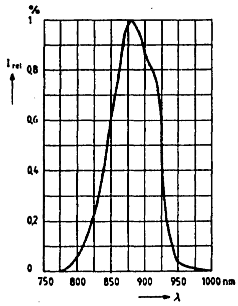
Characteristics ($T_{amb} = 25°C$)

Wavelength at peak emission at $I_F = 10$ mA	λpeak	880	nm
Wavelength at peak emission at $I_F = 100$ mA; $t_{pulse} = 20$ ms; Duty cycle = 1:12	λpeak	883	nm
Wavelength at peak emission at $I_F = 1$ A; $t_{pulse} = 100$ µs; Duty cycle = 1:200	λpeak	886	nm
Spectral bandwidth at 50% of I_{max} at $I_F = 10$ mA	Δλ	80	nm
Half angle	φ	±30	Deg.
Active chip area	A	0.16	mm²
Dimensions of active chip area	L x W	0.4 x 0.4	mm
Distance chip surface to case surface	D	2.1...2.7	mm
Switching time: (I_e from 10% to 90%; and from 90% to 10% $I_F = 100$ mA)	t_r, t_f	0.6/0.5	µs
Capacitance ($V_R = 0$ V; f = 1 MHz)	C_o	25	pF
Forward Voltage ($I_F = 100$ mA; $t_{pulse} = 20$ ms)	V_F	1.5 (≤1.8)	V
($I_F = 1$ A; $t_{pulse} = 100$ µs)	V_F	3.0(≤3.8)	V
Breakdown voltage ($I_R = 10$ µA)	V_{BR}	30(≥5)	V
Reverse current ($V_R = 5$ V)	I_R	0.01 (≤1)	µA
Temperature coefficient of I_e or Φ_e	TC	−0.5	%/K
Temperature coefficient of V_F	TC	−0.2	%/K
Temperature coefficient of λpeak	TC	0.25	nm/K
Typical Radiant Flux ($I_F = 100$ mA, $T_P = 20$ ms)	Φ_E	10	mW

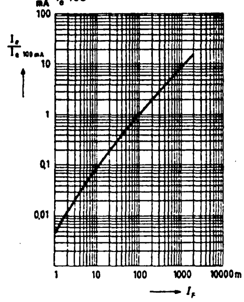
Radiant Intensity I_E in Axial Direction Measured at a Solid Angle of Ω = 0.01sr

Group	SFH 482-1	SFH 482-2	SFH 482-3	
Radiant Intensity I_E				
($I_F = 100$ mA, $T_P = 20$ ms)	3.15-6.3	5-10	≥8	mW/sr
($I_F = 1$ A, $T_P = 100$ µs)	35	56	75	mW/sr

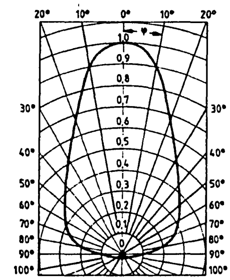
Relative spectral emission
$I_{rel} = f(\lambda)$



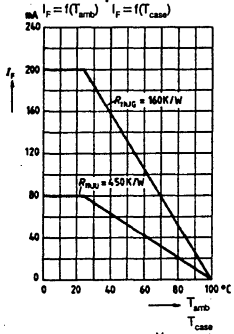
Radiant intensity
$\frac{I_e}{I_e\,100} = f(I_F)$



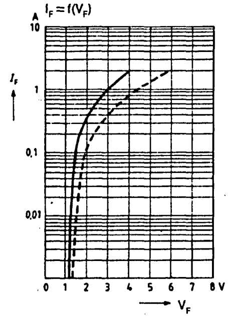
Radiant characteristics
$I_{rel} = f(\varphi)$



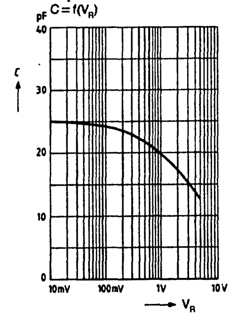
Maximum permissable forward current
$I_F = f(T_{amb})$ $I_F = f(T_{case})$



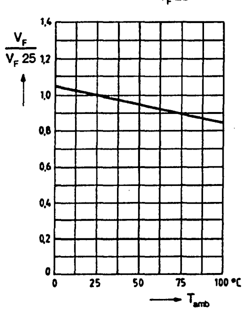
Forward current
$I_F = f(V_F)$



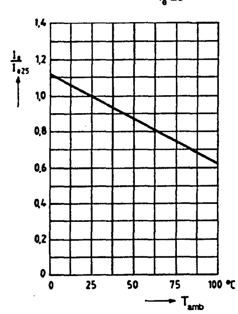
Capacitance
$C = f(V_R)$



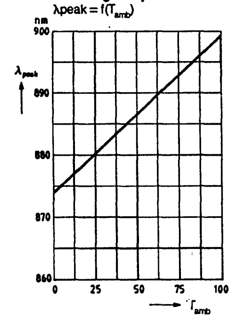
Forward voltage $\frac{V_F}{V_F\,25} = f(T_{amb})$



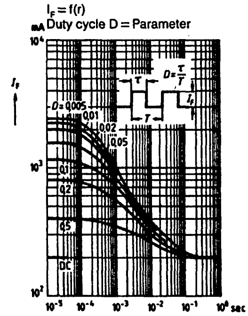
Radiant intensity $\frac{I_e}{I_e\,25} = f(T_{amb})$



Wavelength at peak emission
$\lambda peak = f(T_{amb})$



Permissable Pulse Load
$I_F = f(\tau)$
Duty cycle D = Parameter

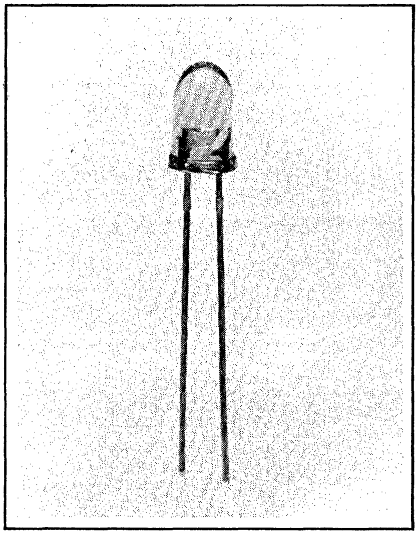


Infrared Emitters

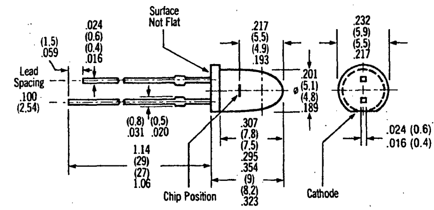
SIEMENS

SFH 484

GaAlAs INFRARED EMITTER



Package Dimensions in Inches (mm)



FEATURES

- **Three Radiant Intensity Selections**
  SFH484-1 50–100
  SFH484-2 80–160
  SFH484-3 ≥125
- **Good Spectral Match with Silicon Photo Detector**
- **Gallium Aluminum Arsenide Material**
- **Low Cost**
- **T-1¾ Package**
- **Clear Plastic Lens**
- **Long Term Stability**
- **Narrow Beam, 16°**
- **Very High Power, 20 mW Typical at 100 mA**
- **High Intensity, 100 mW/sr at 100 mA**
- **For Smoke Detection Application: Use SFH484-E7517**

DESCRIPTION

SFH 484, an infrared emitting diode, emits radiation in the near infrared range (880 nm peak). The emitted radiation, which can be modulated, is generated by forward flowing current. The device is enclosed in a 5mm plastic package. Uses for SFH 484 include: IR remote control of color TV receivers, smoke detectors, and other applications requiring very high power, such as IR touch screens.

Maximum Ratings

Storage temperature	T_{stg}	–55 to +100	°C
Soldering temperature at dip soldering: (≥2 mm distance from the case bottom; soldering time t≤5 sec)	T_{sold}	260	°C
Soldering temperature at iron soldering: (≥2 mm distance from the case bottom; soldering time t≤3 sec)	T_{sold}	300	°C
Junction temperature	T_j	100	°C
Reverse voltage	V_R	5	V
Forward current	I_F	100	mA
Surge current ($\tau = 10$ µs)	i_{SC}	2.5	A
Power dissipation (T = 25°C)	P_{tot}	200	mW
Thermal Resistance*	R_{thA}	375	K/W

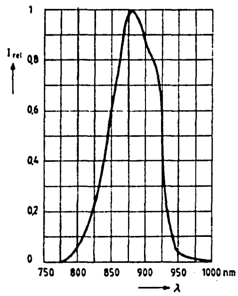
Characteristics ($T_{amb} = 25°C$)

Wavelength at peak emission at $I_F = 10$ mA	λpeak	880	nm
Wavelength at peak emission at $I_F = 100$ mA; $t_{pulse} = 20$ ms, Duty cycle = 1:12	λpeak	883	nm
Wavelength at peak emission at $I_F = 1$ A; $t_{pulse} = 100$ µs, Duty cycle = 1:100	λpeak	886	nm
Spectral bandwidth at $I_F = 10$ mA	Δλ	80	nm
Half angle	φ	±8	Deg.
Active chip area	A	0.16	mm²
Dimensions of active chip area	L×W	0.4×0.4	mm
Distance chip surface to case surface	D	4.9...5.5	mm
Switching time: (I_e from 10% to 90%; and from 90% to 10% $I_F = 100$ mA)	t_r, t_f	0.6/0.5	µs
Capacitance ($V_R = 0$ V, f = 1 MHz)	C_o	25	pF
Forward Voltage ($I_F = 100$ mA; $t_{pulse} = 20$ ms)	V_F	1.5 (≤1.8)	V
($I_F = 1$ A; $t_{pulse} = 100$ µs)	V_F	3.0 (≤3.8)	V
Breakdown voltage ($I_R = 10$ µA)	V_{BR}	30 (≥5)	V
Reverse current ($V_R = 5$ V)	I_R	0.01 (≤1)	µA
Temperature coefficient of I_e or Φ_e	TC	–0.5	%/K
Temperature coefficient of V_F	TC	–0.2	%/K
Temperature coefficient of λpeak	TC	0.25	nm/K

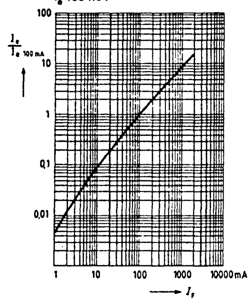
Radiant Intensity I_E in Axial Direction Measured at a Solid Angle of $\Omega = 0.01$sr

Group	SFH 484-1	SFH 484-2	SFH 484-3	
Radiant Intensity I_E ($I_F = 100$ mA, $T_P = 20$ ms)	50–100	80–160	≥125	mW/sr
($I_F = 1$ A, $T_P = 100$ µs)	560	900	975	mW/sr
Total Radiant Flux Φ_E ($I_F = 100$ mA, $T_P = 20$ ms)	21	23	25	mW

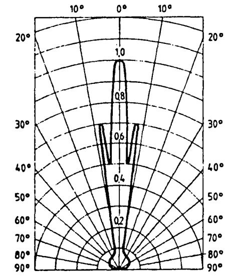
Relative spectral emission
$I_{rel} = f(\lambda)$



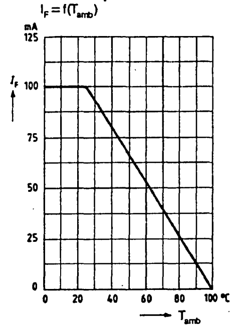
Radiant intensity
$\frac{I_e}{I_e\ 100\ mA} = f(I_F)$



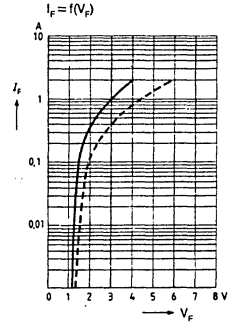
Radiant characteristics
$I_{rel} = f(\varphi)$



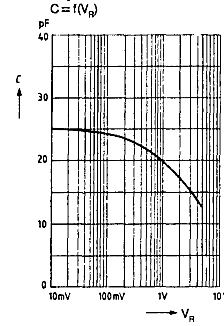
Maximum permissable forward current
$I_F = f(T_{amb})$



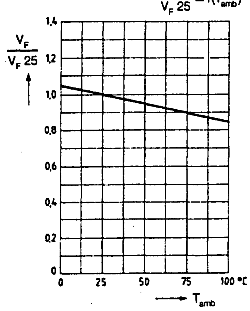
Forward current
$I_F = f(V_F)$



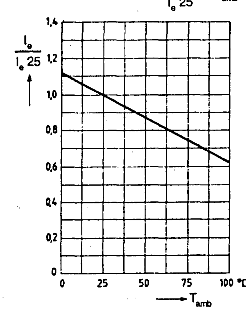
Capacitance
$C = f(V_R)$



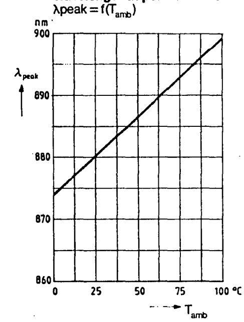
Forward voltage $\frac{V_F}{V_F\ 25} = f(T_{amb})$



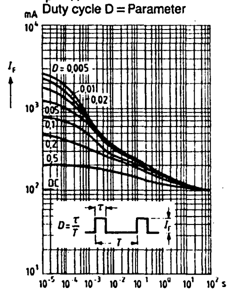
Radiant intensity $\frac{I_e}{I_e\ 25} = f(T_{amb})$



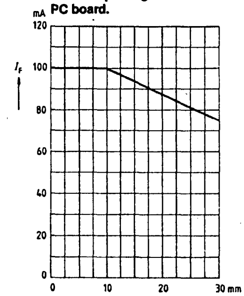
Wavelength at peak emission
$\lambda peak = f(T_{amb})$



Permissable pulse load
$I_F = f(\tau)$
Duty cycle D = Parameter



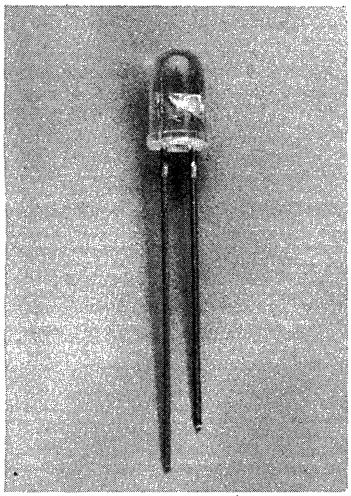
Forward current (max): dependent upon the lead length from the package bottom to the PC board.



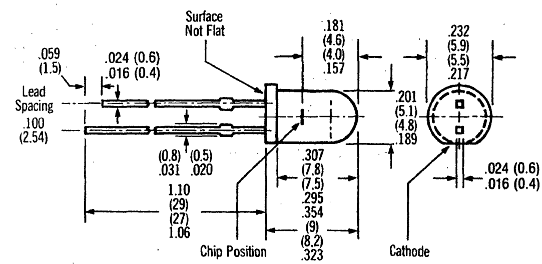
SIEMENS

SFH 485

GaAlAs INFRARED EMITTER



Package Dimensions in Inches (mm)



FEATURES

- **Radiant Intensity Selections**
  SFH485-1 16–32
  SFH485-2 25–50
  SFH485-3 ≥40
- **Perfect Spectral Match with Silicon Photodetectors**
- **Gallium Aluminum Arsenide Material**
- **Low Cost**
- **T1¾ Package**
- **Clear Blue Tinted Plastic Lens**
- **Long Term Stability**
- **Medium Wide Beam, 40°**
- **Very High Power, 20 mW Typical at 100 mA**
- **High Intensity, 40 mW/sr at 100 mA**

DESCRIPTION

SFH 485, an infrared emitting diode, emits radiation in the near infrared range (880 nm peak). The emitted radiation, which can be modulated, is generated by forward flowing current. The device is enclosed in a 5 mm plastic package. Uses for SFH 485 include: IR remote control of color TV receivers, smoke detectors, and other applications requiring very high power, such as IR touch screens.

Maximum Ratings

Storage temperature	T_{stg}	−55 to +100	°C
Soldering temperature at dip soldering: (≥2mm distance from the case bottom; soldering time t≤5 sec)	T_{sold}	260	°C
Soldering temperature at iron soldering: (≥2mm distance from the case bottom; soldering time t≤3 sec)	T_{sold}	300	°C
Junction temperature	T_j	100	°C
Reverse voltage	V_R	5	V
Forward current	I_F	100	mA
Surge current ($\tau = 10$ µsec)	i_{FS}	2.5	A
Power dissipation ($T_{amb} = 25$°C)	P_{tot}	200	mW
Thermal resistance*	$R_{th}JA$	375	K/W

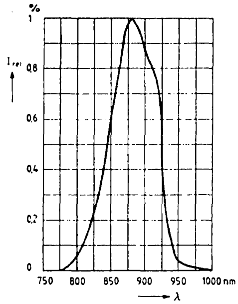
Characteristics ($T_{amb} = 25$°C)

Wavelength at peak emission at $I_F = 10$mA	λpeak	880	nm
Wavelength at peak emission at $I_F = 100$ mA, $t_{pulse} = 20$ ms, Duty cycle = 1:12	λpeak	883	nm
Wavelength at peak emission at $I_F = 1$A, $t_{pulse} = 100$ µs, Duty cycle = 1:100	λpeak	886	nm
Spectral bandwidth at $I_F = 10$mA	Δλ	80	nm
Half angle	ϑ	±20	Deg.
Active chip area	A	0.16	mm^2
Dimensions of active chip area	L×W	0.4×0.4	mm
Distance chip surface to case surface	D	4.0 to 4.6	mm
Switching time: (I_e from 10% to 90%; and from 90% to 10% $I_F = 100$ mA)	t_r, t_f	0.6/0.5	µs
Capacitance ($V_R = 0$V, f = 1MHz)	C_o	25	pF
Forward voltage ($I_F = 100$ mA; $t_{pulse} = 20$ ms)	V_F	1.5 (≤1.8)	V
($I_F = 1$ A; $t_{pulse} = 100$ µs)	V_F	3.0 (≤3.8)	V
Breakdown voltage ($I_R = 10$ µA)	V_{BR}	30 (≥5)	V
Reverse current ($V_R = 5$V)	I_R	0.01 (≤1)	µA
Temperature coefficient of I_e or Φ_e	TC	−0.5	%/K
Temperature coefficient of V_F	TC	−0.2	%/K
Temperature coefficient of λpeak	TC	0.25	nm/K

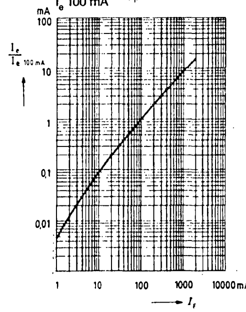
Radiant Intensity I_E in Axial Direction Measured at a Solid Angle of $\Omega = 0.01$sr

Group	SFH 485-1	SFH 485-2	SFH 485-3	
Radiant Intensity I_E				
($I_F = 100$ mA, $T_P = 20$ ms)	16-32	25-50	≥40	mW/sr
($I_F = 1$ A, $T_P = 100$ µs)	180	280	340	mW/sr
Total Radiant Flux Φ_E				
($I_F = 100$ mA, $T_P = 20$ ms)	21	23	25	mW

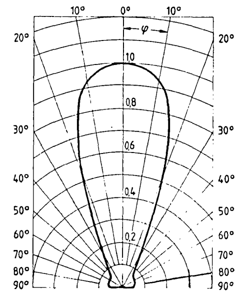
Relative spectral emission
$I_{rel} = f(\lambda)$



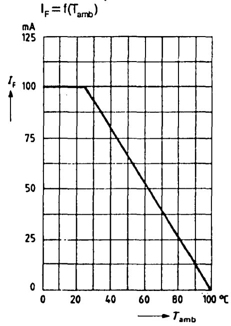
Radiant intensity
$\frac{I_e}{I_e\ 100\ mA} = f(I_F)$



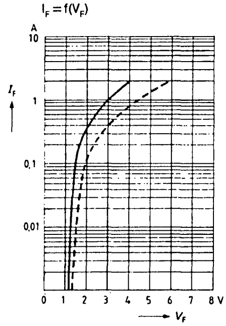
Radiation characteristic
$I_{rel} = f(\varphi)$



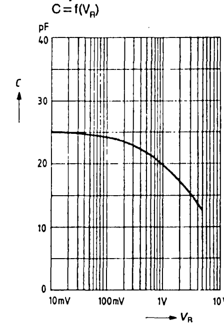
Maximum permissable forward current
$I_F = f(T_{amb})$



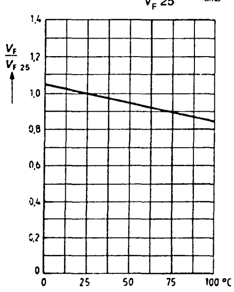
Forward current
$I_F = f(V_F)$



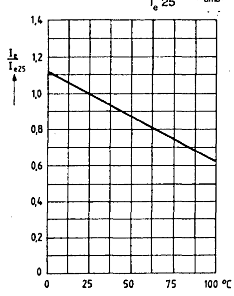
Capacitance
$C = f(V_R)$



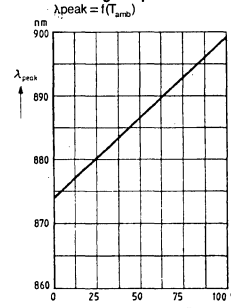
Forward voltage $\frac{V_F}{V_F\ 25} = f(T_{amb})$



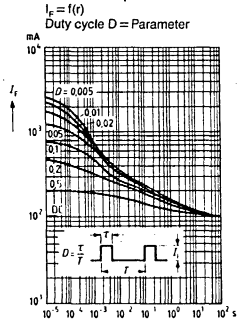
Radiant intensity $\frac{I_e}{I_e\ 25} = f(T_{amb})$



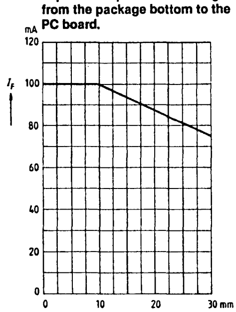
Wavelength at peak emission
$\lambda peak = f(T_{amb})$



Permissable pulse load
$I_F = f(\tau)$
Duty cycle D = Parameter



Forward current (max): dependent upon the lead length from the package bottom to the PC board.

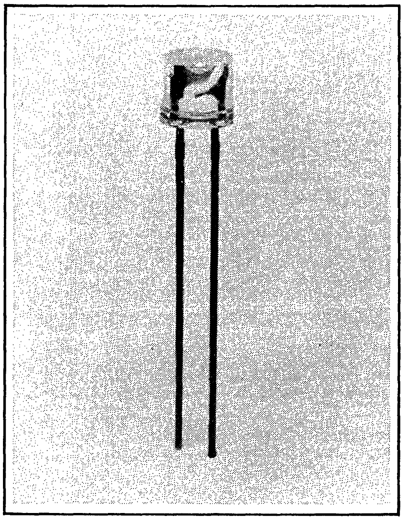


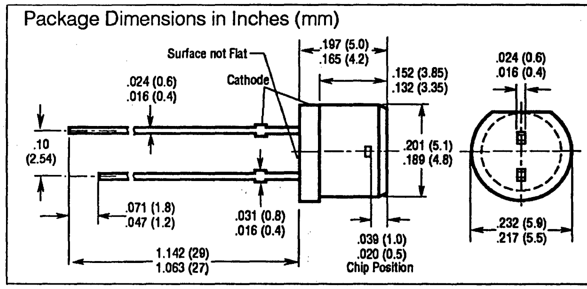
Infrared Emitters

SIEMENS

SFH 485P

GaAlAs INFRARED EMITTER





FEATURES

- **Radiant Intensity Selections**
  SFH485P-1 3.15–6.3
  SFH485P-2 ≥5
- **Good Spectral Matching to Silicon Photo Detector**
- **Gallium Aluminum Arsenide Material**
- **Low Cost**
- **T-1¾ Base Package**
- **Flat Lens**
- **Long Term Stability**
- **Wide Beam, 80°**
- **Very High Power, 20 mW Typical at 100 mA**

DESCRIPTION

SFH 485P, an infrared emitting diode, emits radiation in the near infrared range (880 nm peak). The emitted radiation, which can be modulated, is generated by forward flowing current. The device is enclosed in a 5mm diameter plastic package. Uses for the SFH 485P include: IR remotre control of color TV receivers, smoke detectors, and other applications requiring very high power, such IR touch screens.

Maximum Ratings

Storage temperature	T_{stg}	−55 to +100	°C
Soldering temperature at dip soldering: (≥2 mm distance from the case bottom; soldering time t≤5 sec)	T_{sold}	260	°C
Soldering temperature at iron soldering: (≥2 mm distance from the case bottom; soldering time t≤3 sec)	T_{sold}	300	°C
Junction temperature	T_j	100	°C
Reverse voltage	V_R	5	V
Forward current	I_F	100	mA
Surge current (τ = 10 µs)	i_{FS}	2.5	A
Power dissipation (T = 25°C)	P_{tot}	200	mW
Thermal resistance	R_{thA}	375	K/W

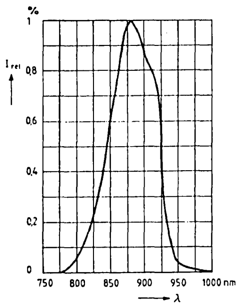
Characteristics (T_{amb} = 25°C)

Wavelength at peak emission at I_F = 10 mA	λpeak	880	nm
Wavelength at peak emission at I_F = 100 mA; t_{pulse} = 20 ms, Duty cycle = 1:12	λpeak	883	nm
Wavelength at peak emission at I_F = 1 A; t_{pulse} = 100 µs, Duty cycle = 1:100	λpeak	886	nm
Spectral bandwidth at I_F = 10 mA	Δλ	80	nm
Half angle	φ	±40	Deg.
Active chip area	A	0.16	mm²
Dimensions of active chip area	L×W	0.4×0.4	mm
Distance chip surface to case surface	D	0.5 to 1.0	mm
Switching time: (I_e from 10% to 90%; and from 90% to 10% I_F = 100 mA)	t_r, t_f	0.6/0.5	µs
Capacitance (V_R = 0 V, f = 1 MHz)	C_o	25	pF
Forward Voltage (I_F = 100 mA; t_{pulse} = 20 ms)	V_F	1.5 (≤1.8)	V
(I_F = 1 A; t_{pulse} = 100 µs)	V_F	3.0 (≤3.8)	V
Breakdown voltage (I_R = 10 µA)	V_{BR}	30 (≥5)	V
Reverse current (V_R = 5 V)	I_R	0.01 (≤1)	µA
Temperature coefficient of I_e or Φ_e	TC	−0.5	%/K
Temperature coefficient of V_F	TC	−0.2	%/K
Temperature coefficient of λpeak	TC	0.25	nm/K

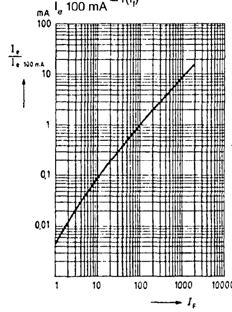
Radiant Intensity I_E in Axial Direction Measured at a Solid Angle of Ω = 0.01sr

Group	SFH 485P-1	SFH 485P-2	
Radiant Intensity I_E			
(I_F = 100 mA, T_P = 20 ms)	3.15–6.3	≥5	mW/sr
(I_F = 1 A, T_P = 100 µs)	35	56	mW/sr
Total Radiant Flux Φ_E			
(I_F = 100 mA, T_P = 20 ms)	21	23	mW

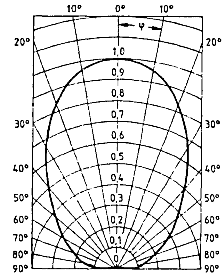
Relative spectral emission
$I_{rel} = f(\lambda)$



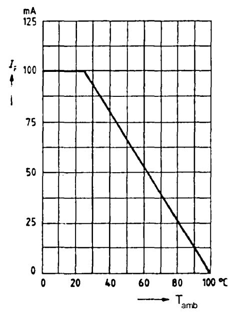
Radiant intensity
$\frac{I_e}{I_e\ 100\ mA} = f(I_f)$



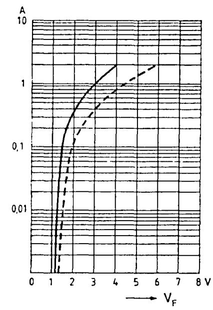
Radiant characteristics
$I_{rel} = f(\varphi)$



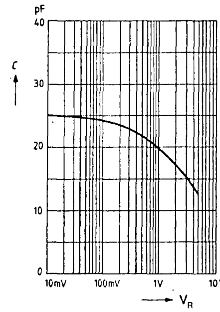
Maximum permissable forward current
$I_F = f(T_{amb})$



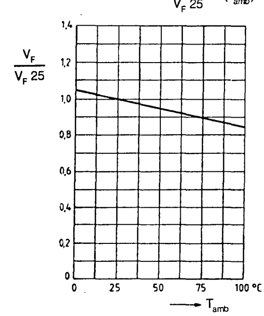
Forward current
$I_F = f(V_F)$



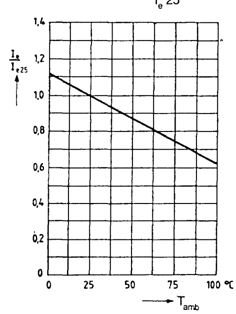
Capacitance
$C = f(V_R)$



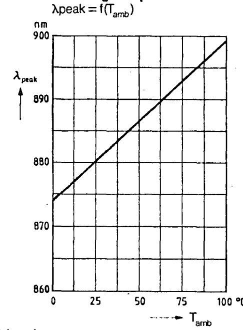
Forward voltage $\frac{V_F}{V_F\ 25} = f(T_{amb})$



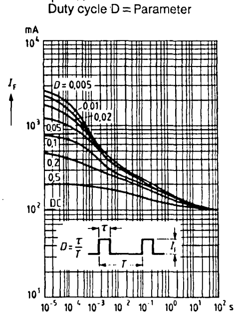
Radiant intensity $\frac{I_e}{I_e\ 25} = f(T_{amb})$



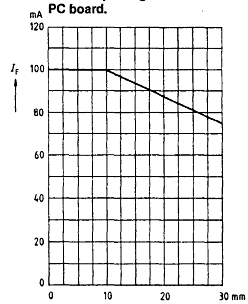
Wavelength at peak emission
$\lambda peak = f(T_{amb})$



Permissable pulse load
$I_F = f(\tau)$
Duty cycle D = Parameter



Forward current (max): dependent upon the lead length from the package bottom to the PC board.



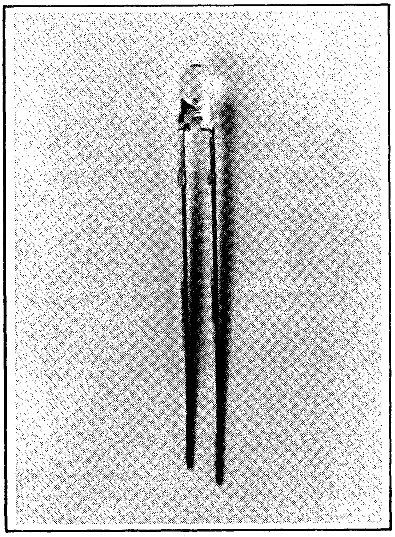
Infrared Emitters

SFH 485P

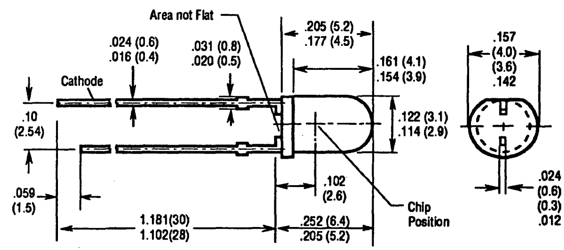
SIEMENS

SFH 487

GaAlAs INFRARED EMITTER



Package Dimensions in Inches (mm)



FEATURES

- **Radiant Intensity Selections**
  SFH487-1 12.5–25
  SFH487-2 20–40
  SFH487-3 ≥32
- **Good Spectral Match to Silicon Photo Detector**
- **Gallium Aluminum Arsenide Material**
- **Low Cost**
- **T-1 Package**
- **Clear Blue Tinted Plastic Lens**
- **Long-Term Stability**
- **Medium Wide Beam, 40°**
- **Very High Power, 20 mW Typical at 100 mA**
- **High Intensity, 30 mW/sr at 100 mA**

DESCRIPTION

SFH 487, an infrared emitting diode, emits radiation in the near infrared range (880 nm peak). The emitted radiation, which can be modulated, is generated by forward flowing current. The device is enclosed in a 3mm plastic package. Uses for SFH 487 include: IR remote control of color TV receivers, smoke detectors, and other applications requiring very high power, such as IR touch screens.

Maximum Ratings

Storage temperature	T_{stg}	–55 to +100	°C
Soldering temperature at dip soldering: (≥2 mm distance from the case bottom; soldering time t≤5 sec)	T_{sold}	260	°C
Soldering temperature at iron soldering: (≥2 mm distance from the case bottom; soldering time t≤3 sec)	T_{sold}	300	°C
Junction temperature	T_j	100	°C
Reverse voltage	V_R	5	V
Forward current	I_F	100	mA
Surge current (τ = 10 µs)	i_{FS}	2.5	A
Power dissipation (T = 25°C)	P_{tot}	200	mW
Thermal resistance	R_{thA}	375	K/W

Characteristics (T_{amb} = 25°C)

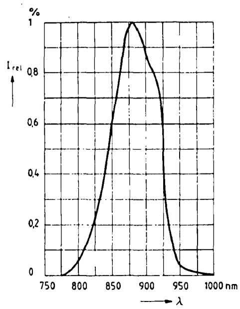
Wavelength at peak emission at I_F = 10 mA	λpeak	880	nm
Wavelength at peak emission at I_F = 100 mA, t_{pulse} = 20ms, Duty cycle = 1:12	λpeak	883	nm
Wavelength at peak emission at I_F = 1A, t_{pulse} = 100µs, Duty cycle = 1:100	λpeak	886	nm
Spectral bandwidth at I_F = 10 mA	Δλ	80	nm
Half angle	φ	±20	Deg.
Active chip area	A	0.16	mm²
Dimensions of active chip area	L×W	0.4×0.4	mm
Distance chip surface to stand off	D	2.6	mm
Switching time: (I_e from 10% to 90%; and from 90% to 10% I_F = 100 mA)	t_r, t_f	0.6/0.5	µs
Capacitance (V_R = 0 V, f = 1 MHz)	C_o	25	pF
Forward voltage (I_F = 100 mA; t_{pulse} = 20 ms)	V_F	1.5 (≤1.8)	V
(I_F = 1 A; t_{pulse} = 100 µs)	V_F	3.0 (≤3.8)	V
Breakdown voltage (I_R = 10 µA)	V_{BR}	30 (≥5)	V
Reverse current (V_R = 5 V)	I_R	0.01 (≤1)	µA
Temperature coefficient of I_e or Φ_e	TC	–0.5	%/K
Temperature coefficient of V_F	TC	–0.2	%/K
Temperature coefficient of λpeak	TC	0.25	nm/K

Radiant Intensity I_E in Axial Direction Measured at a Solid Angle of Ω = 0.01sr

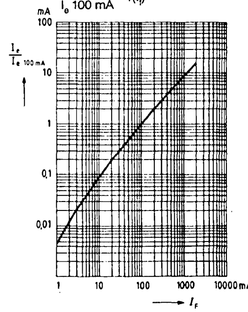
Group	SFH 487-1	SFH 487-2	SFH 487-3	
Radiant Intensity I_E				
(I_F = 100 mA, T_P = 20 ms)	12.5–25	20–40	≥32	mW/sr
(I_F = 1 A, T_P = 100 µs)	140	270	300	mW/sr
Total Radiant Flux Φ_E				
(I_F = 100 mA, T_P = 20 ms)	21	23	25	mW

Infrared Emitters

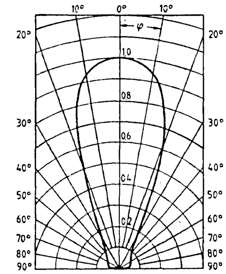
Relative spectral emission
$I_{rel} = f(\lambda)$



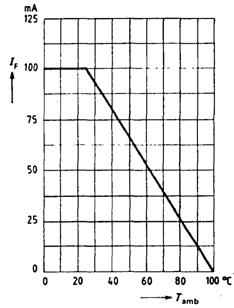
Radiant intensity
$\frac{I_e}{I_e\ 100\ mA} = f(I_F)$



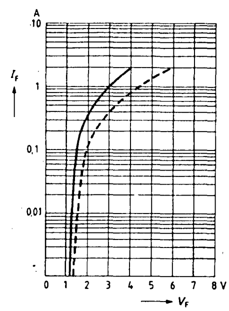
Radiant characteristics
$I_{rel} = f(\varphi)$



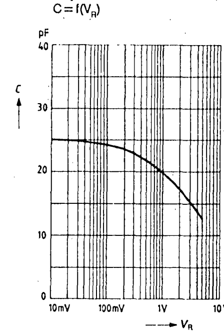
Maximum permissable forward current
$I_F = f(T_{amb})$



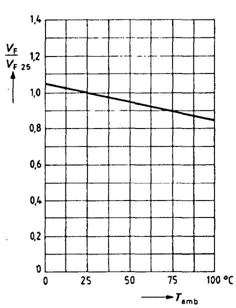
Forward current
$I_F = f(V_F)$



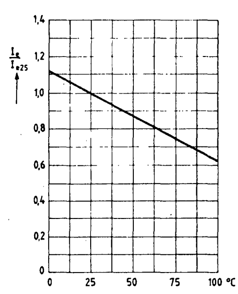
Capacitance
$C = f(V_R)$



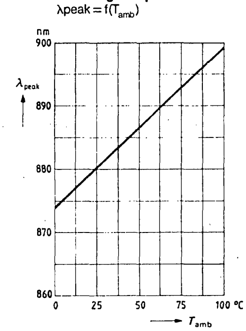
Forward voltage $\frac{V_F}{V_F\ 25} = f(T_{amb})$



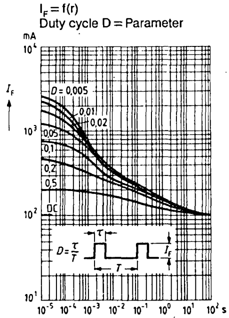
Radiant intensity $\frac{I_e}{I_e\ 25} = f(T_{amb})$



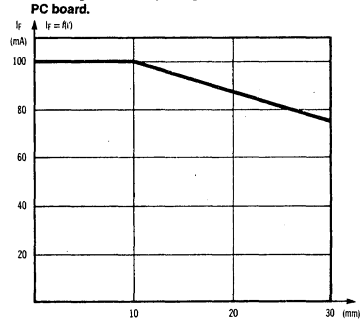
Wavelength at peak emission
$\lambda peak = f(T_{amb})$



Permissable Pulse Load
$I_F = f(\tau)$
Duty cycle D = Parameter



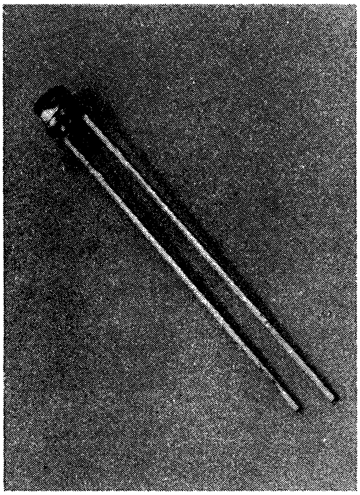
Forward current (max): dependent upon the lead length from the package bottom to the PC board.



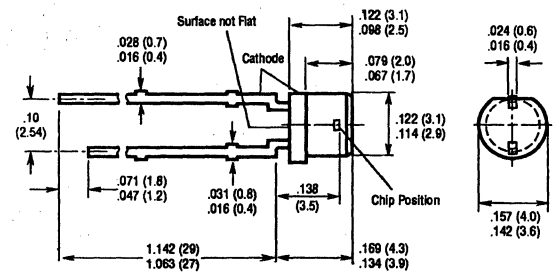
SIEMENS

SFH 487P

GaAlAs INFRARED EMITTER



Package Dimensions in Inches (mm)



FEATURES

- **Radiant Intensity Selections**
  SFH487P-1 2–4
  SFH487P-2 ≥3.15
- **Perfect Spectral Match with Silicon Photo Detector**
- **Gallium Aluminum Arsenide Material**
- **Low Cost**
- **T1 Package**
- **Flat Plastic Lens**
- **Long-Term Stability**
- **Very Wide Beam, 130°**
- **Very High Power, 20 mW Typical at 100 mA**

DESCRIPTION

SFH 487P, an infrared emitting diode, emits radiation in the near infrared range (880 nm peak). The emitted radiation, which can be modulated, is generated by forward flowing current. The device is enclosed in a 3 mm diameter plastic package with a flat lens. Typical applications are in digital shaft encoders and light interruptors for DC and AC operation.

Maximum Ratings

Storage temperature	T_{stg}	−55 to +100	°C
Soldering temperature at dip soldering: (≥2 mm distance from the case bottom; soldering time t≤5 sec)	T_{sold}	260	°C
Soldering temperature at iron soldering: (≥2 mm distance from the case bottom; soldering time t≤3 sec)	T_{sold}	300	°C
Junction temperature	T_j	100	°C
Reverse voltage	V_R	5	V
Forward current	I_F	100	mA
Surge current (τ = 10 µs)	I_{FS}	2.5	A
Power dissipation (T = 25°C)	P_{tot}	200	mW
Thermal resistance*	R_{thA}	375	K/W

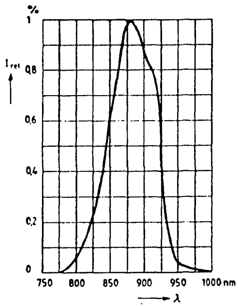
Characteristics (T_{amb} = 25°C)

Wavelength at peak emission at I_F = 10 mA	λpeak	880	nm
Wavelength at peak emission at I_F = 100 mA; t_{pulse} = 20 ms, Duty cycle = 1:12	λpeak	883	nm
Wavelength at peak emission at I_F = 1 A; t_{pulse} = 100 µs, Duty cycle = 1:100	λpeak	886	nm
Spectral bandwidth at I_F = 10 mA	Δλ	80	nm
Half angle	φ	±65	Deg.
Active chip area	A	0.16	mm²
Dimensions of active chip area	L×W	0.4×0.4	mm
Distance chip surface to case surface	D	0.4 to 0.7	mm
Switching time: (I_e from 10% to 90%; and from 90% to 10% I_F ≙ 100 mA)	t_r, t_f	0.6/0.5	µs
Capacitance (V_R = 0 V, f = 1 MHz)	C_o	25	pF
Forward Voltage (I_F = 100 mA; t_{pulse} = 20 ms)	V_F	1.5 (≤1.8)	V
(I_F = 1 A; t_{pulse} = 100 µs)	V_F	3.0 (≤3.8)	V
Breakdown voltage (I_R = 10 µA)	V_{BR}	30 (≥5)	V
Reverse current (V_R = 5 V)	I_R	0.01 (≤1)	µA
Temperature coefficient of I_e or Φ_e	TC	−0.5	%/K
Temperature coefficient of V_F	TC	−0.2	%/K
Temperature coefficient of λpeak	TC	0.25	nm/K

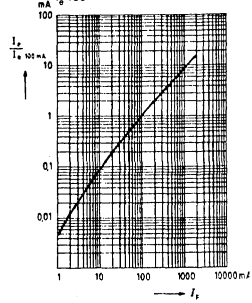
Radiant Intensity I_E in Axial Direction Measured at a Solid Angle of Ω = 0.01sr

Group	SFH 487P-1	SFH 487P-2	
Radiant Intensity I_E			
(I_F = 100 mA, T_P = 20 ms)	2–4	≥3.15	mW/sr
(I_F = 1 A, T_P = 100 µs)	25	35	mW/sr
Total Radiant Flux Φ_E			
(I_F = 100 mA, T_P = 20 ms)	21	23	mW

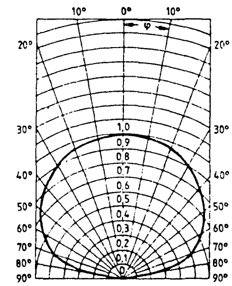
Relative spectral emission
$I_{rel} = f(\lambda)$



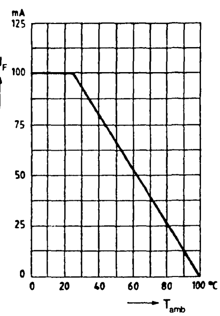
Radiant intensity
$\frac{I_e}{I_e\,100} = f(I_F)$



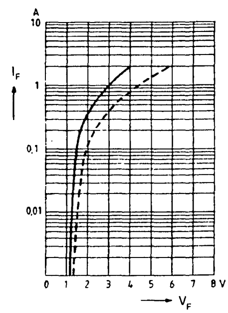
Radiant characteristics
$I_{rel} = f(\varphi)$



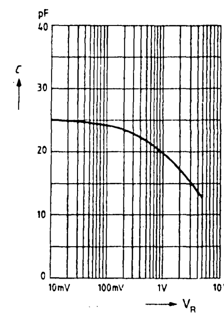
Maximum permissable forward current
$I_F = f(T_{amb})$



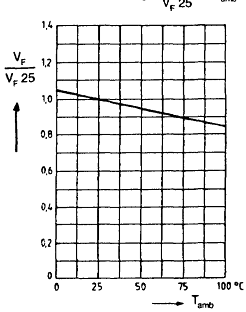
Forward current
$I_F = f(V_F)$



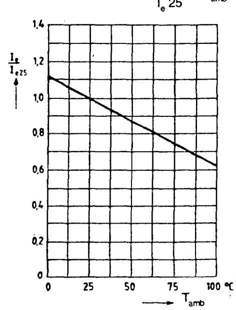
Capacitance
$C = f(V_R)$



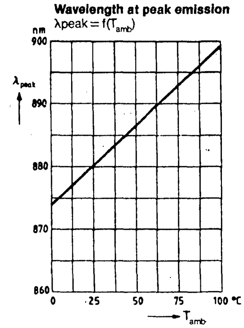
Forward voltage $\frac{V_F}{V_F\,25} = f(T_{amb})$



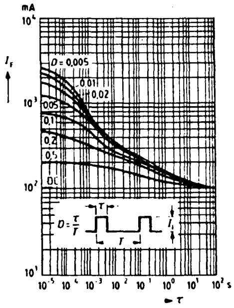
Radiant intensity $\frac{I_e}{I_e\,25} = f(T_{amb})$



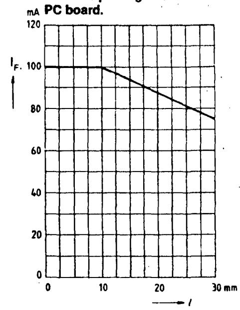
Wavelength at peak emission
$\lambda peak = f(T_{amb})$



Permissable Pulse Load
$I_F = f(\tau)$
Duty cycle D = Parameter



Forward current (max): dependent upon the lead length from the PC package bottom to the PC board.

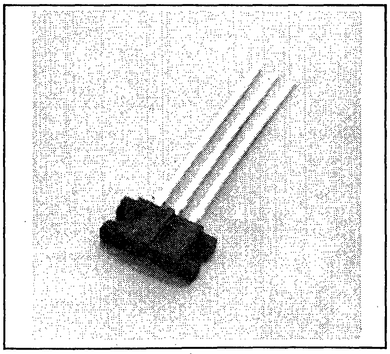


Infrared Emitters

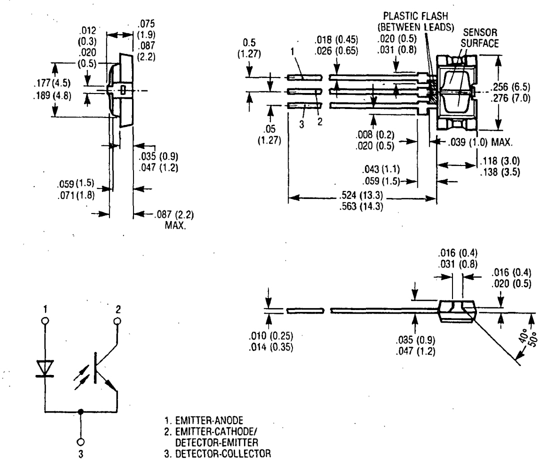
SIEMENS

SFH900 SERIES
SFH905 SERIES

MINIATURE LIGHT REFLECTION EMITTER/SENSOR



Package Dimensions in Inches (mm)



FEATURES

- **IR Emitter and NPN Phototransistor Detector**
- **High Sensitivity (SFH900)**
- **Low Saturation Voltage**
- **No Cross Talk (SFH900) Negligible Cross Talk (SFH905)**
- **Designed for Short Distances Up to 5 mm**
- **Current Transfer Ratio Groups**
  SFH900-1 — I_{CE} 0.25 to 0.5 mA
  SFH900-2 — I_{CE} 0.4 to 0.8 mA
  SFH900-3 — I_{CE} 0.63 to 1.25 mA
  SFH900-4 — I_{CE} ≥1.0 mA
  SFH905-1 — I_{CE} 40 to 125 μA
  SFH905-2 — I_{CE} ≥100 μA

DESCRIPTION

The SFH900/SFH905 are light reflection switches for short distances, operating in the infrared range, which includes a GaAs IRLED transmitter and an NPN phototransistor with a high photosensitive receiver. Both components are manufactured in modern strip-line technique and are mounted side-by-side in a plastic package. A daylight filter screens against undesired light effects. The SFH905 has lower current transfer ratios than the SFH900.

The SFH900/905 are designed for applications in industrial and entertainment electronics, e.g., as position reporting devices and end position switches, for speed monitoring or in general, as sensor elements in various types of motion transmitters.

For applications information see Appnote 26.

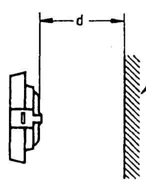
Maximum Ratings

Emitter (GaAs infrared diode)	
Reverse Voltage (V_R)	6 V
Forward DC Current (I_F)	50 mA
Surge Current (T_P≤10 μs, T_{amb}=40°C) (I_{FSM})	1.5 A
Total Power Dissipation (T_{amb}=40°C) (P_{TOT})	80 mW
Thermal Resistance (R_{THJA})	750 K/W
Detector (silicon phototransistor)	
Collector-Emitter Voltage (V_{CEO})	30 V
Emitter-Collector Voltage (V_{ECO})	7 V
Collector Current (I_C)	10 mA
Power Dissipation (T_{amb}=40°C) (P_{TOT})	100 mW
Thermal Resistance (R_{THJA})	600 K/W
Light Reflection Switch	
Storage Temperature Range (T_{STG})	−40 to +85°C
Ambient Temperature Range (T_{amb})	−40 to +85°C
Junction Temperature (T_J)	100°C
Soldering Temperature (3 s max.)[1] (T_S)	235°C
With heat sink between case and soldering (T_S)	260°C
Total Power Dissipation (T_{amb}=40°C) (P_{TOT})	150 mW

1. Dip soldering: 3 mm from case bottom.

Characteristics

Emitter (GaAs infrared diode)			
Forward Voltage (I_F = 50 mA)	V_F	1.25 (≤1.65)	V
Breakdown Voltage (I_R = 10 μA)	V_{BR}	30 (≥6)	V
Reverse Current (V_R = 6 V)	I_R	0.01 (≤10)	μA
Capacitance (V_R = 0 V; f = 1 MHz)			
SFH900	C_0	40	pF
SFH905	C_0	25	pF
Detector (silicon phototransistor)			
Capacitance (V_{CE} = 5 V; f = 1 MHz)			
SFH900	C_{CE}	11	pF
SFH905	C_{CE}	7	pF
Collector-Emitter Leakage Current (V_{CE} = 10 V)			
SFH900	I_{CEO}	20 (≤200)	nA
SFH905	I_{CEO}	20 (≤100)	nA
Photocurrent (outside light sensitivity) (V_{CE} = 5 V; E_V = 1000 Lx)			
SFH900	I_P	≤3	mA
SFH905	I_P	≤0.5	mA
Light Reflection Switch			
Collector-Emitter Current (I_F = 10 mA; V_{CE} = 5 V; D = 1 mm)			
SFH900-1	I_{CE}	0.25 to 0.50	mA
SFH900-2	I_{CE}	0.40 to 0.80	mA
SFH900-3	I_{CE}	0.63 to 1.25	mA
SFH900-4	I_{CE}	≥1.0	mA
SFH905-1	I_{CE}	40 to 125	μA
SFH905-2	I_{CE}	≥100	μA
Collector-Emitter Saturation Voltage (I_F = 10 mA; D = 1 mm)			
(I_C = 85 μA) SFH900-1	VCE_{SAT}	0.2 (≤0.6)	V
(I_C = 135 μA) SFH900-2	VCE_{SAT}	0.2 (≤0.6)	V
(I_C = 215 μA) SFH900-3	VCE_{SAT}	0.2 (≤0.6)	V
(I_C = 335 μA) SFH900-4	VCE_{SAT}	0.2 (≤0.6)	V
(I_C = 13 μA) SFH905-1	VCE_{SAT}	0.2 (≤0.6)	V
(I_C = 34 μA) SFH905-2	VCE_{SAT}	0.2 (≤0.6)	V



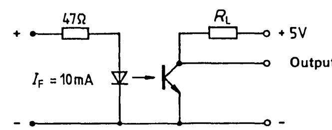
Reflector with 90% reflection (Kodak neutral white test card)

SFH900

Load Resistance (R_L)	1	kΩ
Turn-On Time (T_{ON})	65	μs
Rise Time (T_R)	50	μs
Turn-Off Time (T_{OFF})	55	μs
Fall Time (T_F)	50	μs

Note: I_C = 1 mA.

TEST CIRCUIT

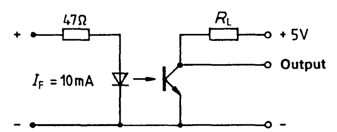


SFH905

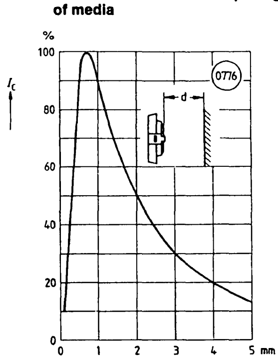
Load Resistance (R_L)	1	kΩ
Turn-On Time (T_{ON})	40	μs
Rise Time (T_R)	30	μs
Turn-Off Time (T_{OFF})	45	μs
Fall Time (T_F)	40	μs

Note: I_C = 100 μA; V_S = 5 V; I_F = 10 mA.

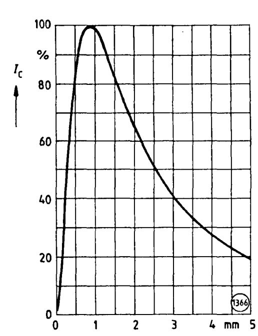
TEST CIRCUIT



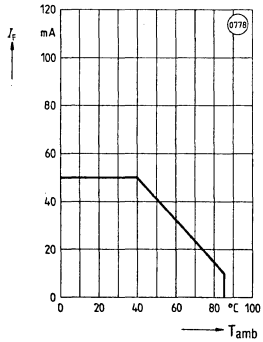
SFH900
Collector current versus spacing of media



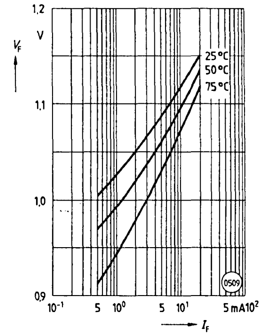
SFH905
Collector current versus spacing of media



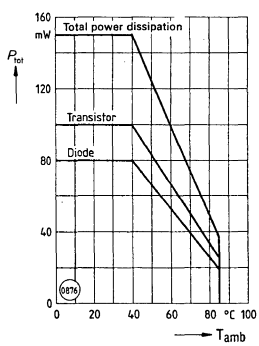
SFH900/905
Max. permissible forward current versus ambient temperature



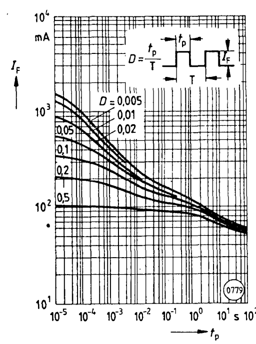
SFH900/905
Forward voltage (typ.) of diode versus forward current



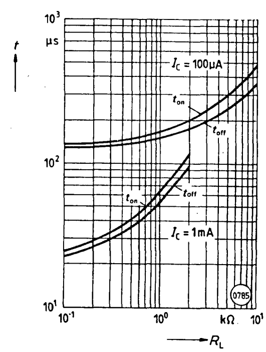
SFH900/905
Permissible power dissipation for diode and transistor versus ambient temperature



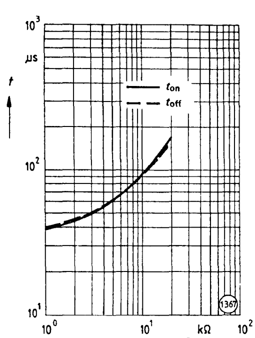
SFH900/905
Permissible pulse handling capability
Forward current versus pulse width
(D=parameter, T_{amb}=25°C)



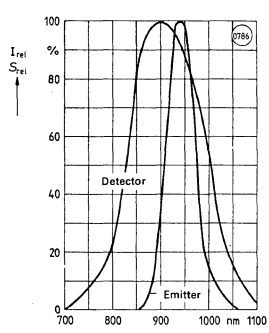
SFH900
Switching characteristics t_{ON} and t_{OFF} versus load resistance
(T_{amb}=25°C, I_F=10 mA)



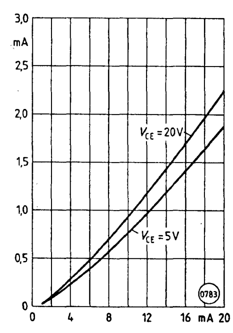
SFH905
Switching characteristics t_{ON} and t_{OFF} versus load resistance
(T_{amb}=25°C, I_F=10 mA)



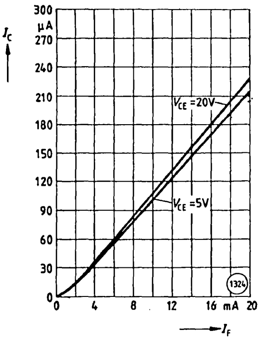
SFH900/905
Relative spectral emission of emitter (GaAs) and detector (Si) versus wavelength



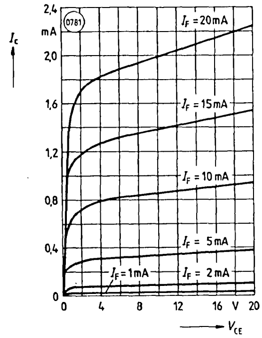
SFH900
Collector current versus forward current (spacing d to reflector=1 mm; 90% reflection)



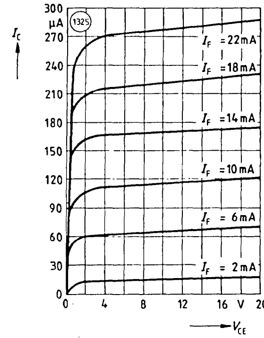
SFH905
Collector current versus forward current (spacing d to reflector=1 mm; 90% reflection)



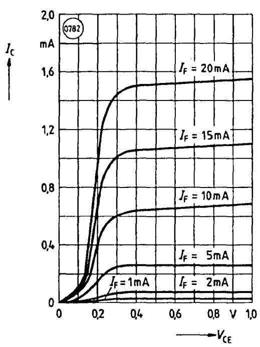
SFH900
Output characteristics
Collector current versus collector-emitter voltage (spacing to reflector: d=1 mm; T_{amb}=25°C; 90% reflection)



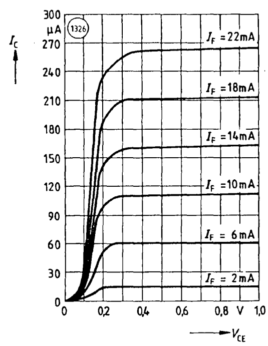
SFH905
Output characteristics
Collector current versus collector-emitter voltage (spacing to reflector: d=1 mm; T_{amb}=25°C; 90% reflection)



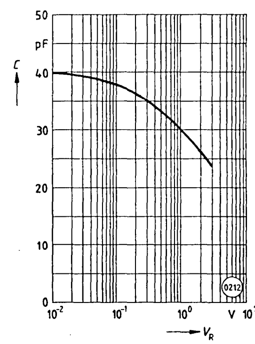
SFH900
Output characteristics (typ.)
Collector current versus collector-emitter voltage (spacing to reflector: d=1 mm; T_{amb}=25°C; 90% reflection)



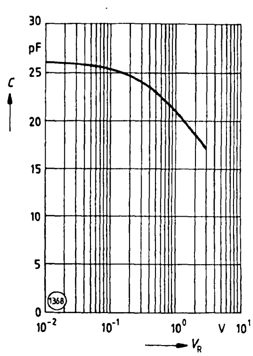
SFH905
Output characteristics (typ.)
Collector current versus collector-emitter voltage (spacing to reflector: d=1 mm; T_{amb}=25°C; 90% reflection)



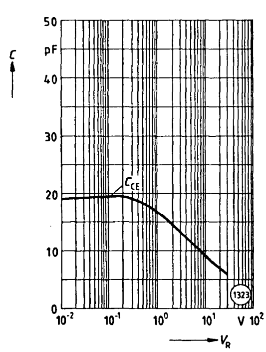
SFH900
Diode capacitance (typ.) versus reverse voltage (T_{amb}=25°C; f=1 MHz)



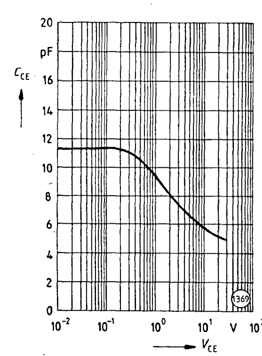
SFH905
Diode capacitance (typ.) versus reverse voltage (T_{amb}=25°C; f=1 MHz)



SFH900
Transistor capacitance (typ.) versus reverse voltage (T_{amb}=25°C; f=1 MHz)



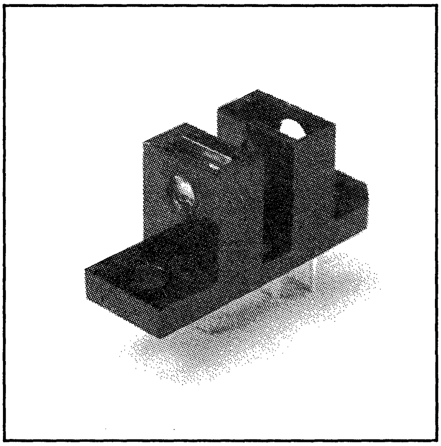
SFH905
Transistor capacitance (typ.) versus reverse voltage (T_{amb}=25°C; f=1 MHz)



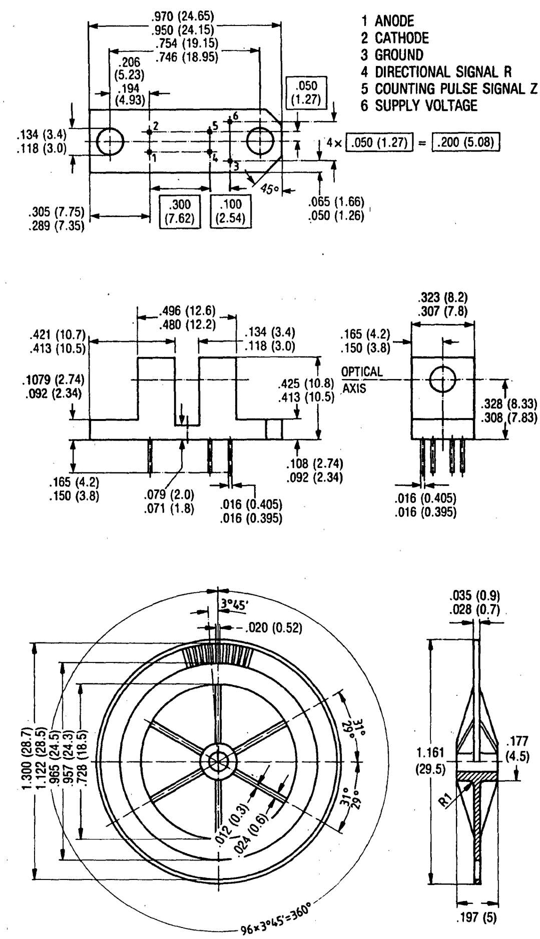
SIEMENS

SFH 910

Differential Photo Interrupter w/Counting Pulse & Direction Recognition



Package Dimensions in Inches (mm)



FEATURES

- **Counting Mechanism**
- **Movement Direction Display**
- **Slot Width: 1.26_0 (3.2 mm)**
- **Typical Operating Range of the Logic: 5 mA $< I_F <$ 50 mA**
- **Max. Output Current I_{OL}: 20 mA**
- **Switching Times t_r, t_f: 0.3 μs**
- **96 Slot Code Wheel Available (P/N 2004-9053)**

DESCRIPTION

The SFH 910 is a differential photo interrupter with daylight-suppression filter and spherical lens, operating in the infrared range.

A GaAlAs-IRED is used as an emitter.

The receiver circuit consists of two narrow photodiodes, next to each other, with amplifiers and Schmitt triggers, and a logic which produces a counting pulse signal and a directional signal. The width of the counting pulse remains constant. The counting pulse (Z) and the directional recognition (R) outputs are open NPN collectors, which are TTL-compatible.

The SFH 910 is used to encode mechanical shaft rotational speed and direction. The Differential Photo Interrupter will accept code wheels with slot widths as small as 0.033″ (0.85 mm). An optional 96 slot code wheel as described in the data sheet is available.

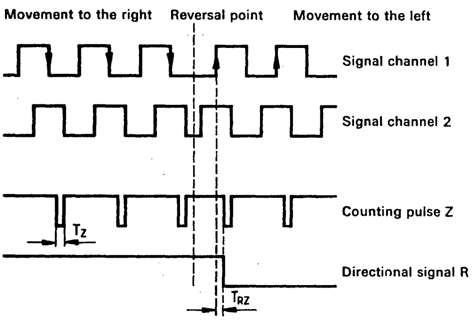
Maximum Ratings

Emitter (GaAlAs IRED)
Reverse Voltage (V_R) .... 5 V
Forward Current (I_F) .... 50 mA
Surge Forward Current (T_{amb} = 25°C) (I_{FSM}) .... 1 A
Total Power Dissipation (T_{amb} = 25°C) (P_{tot}) .... 85 mW
Thermal Resistance (R_{thJA}) .... 500 K/W

Detector (Detector IC)
Supply Voltage (V_S) .... 4...18 V
Output Current (Output/Low) (I_{OL}) .... 20 mA
Output Voltage (Output/High) (V_{OH}) .... 16 V
Total Power Dissipation (T_{amb} = 25°C) (P_{tot}) .... 200 mW
Thermal Resistance (R_{thJA}) .... 375 K/W

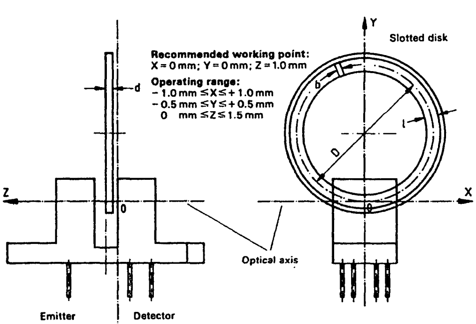
Photo Interrupter
Operating Temperature (T_{OP}) .... –20 to +85°C
Storage Temperature (T_{stg}) .... –40 to +100°C
Junction Temperature (T_J) .... –100°C
Soldering Temperature (1 mm soldering distance from the case bottom; soldering time max. 5 sec.) (T_{sold}) .... 260°C

Pulse diagram



Channels 1 and 2 represent the out-of-phase signals after the Schmitt triggers (see block diagram.) This diagram is for reference only and can't be verified by using the output pins of the device.

Positioning of the slotted disk within the photo interrupter



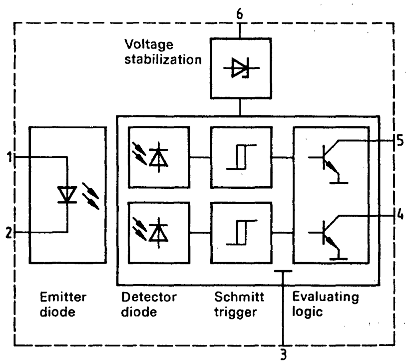
Number of slots on the slotted disk	n = 96
Thickness of the slotted disk	d = .031 (0.8 mm)
Width of the slot center	b = .015 (0.38 mm)
Slot length	l = .079 (2.0 mm)
Diameter of the slotted disk (from slot center to slot center)	D = 1.043 (26.50 mm)

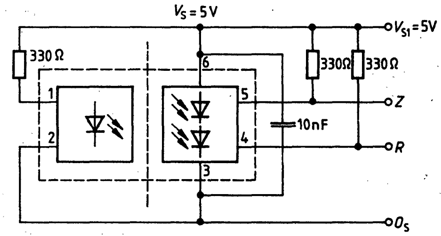
Characteristics (T_{amb} = 25°C)[1]

Parameter	Symbol	Value	Unit
Emitter (GaAlAs IRED)			
Forward Voltage (I_F = 10 mA)	V_F	1.25 (≤1.5)	V
Breakdown Voltage (I_R = 10 µA)	V_{BR}	30 (≥5)	V
Reverse Current (V_R = 5 V)	I_R	0.01 (≤10)	µA
Capacitance (V_R = 0 V; f = 1 MHz	C_0	25	pF
Detector (Detector IC)			
Supply Voltage	V_S	4.5...16	V
Current Consumption (V_S = 5 V; outputs open)	I_S	5 (≤10)	mA
Output Voltage (counting pulse) (I_{OLZ} = 16 mA; V_S = 5 V; I_F = 10 mA)	V_{OLZ}	0.2 (≤0.4)	V
Output Voltage (direction) (I_{OLR} = 16 mA; V_S = 5 V; I_F = 10 mA)	V_{OLR}	0.2 (≤0.4)	V
Output Current[2] (counting pulse) (V_{OHZ} = V_S = 16 V; I_F = 0)	I_{OHZ}	0.01 (≤10)	µA
Output Current[2] (direction) (V_{OHR} = V_S = 16 V; I_F = 0)	I_{OHR}	0.01 (≥10)	µA
Photo Interrupter			
Minimum Operating Range	I_F	10...30	mA
Typical Operating Range	I_F	5...50	mA
Rise Time, Fall Time (R_L = 280Ω; V_S = V_{S1} = 5 V; I_F = 20 mA)	t_r, t_f	0.3	µs
Counting Pulse Width	T_Z	10 (≤20)	µs
Delay Time (change of direction/counting pulse)	T_{RZ}	1	µs
Hysteresis of Schmitt Triggers	P_H	25	%

1. All characteristics have been measured by means of a slotted disk, as described previously.
2. Without ambient light.

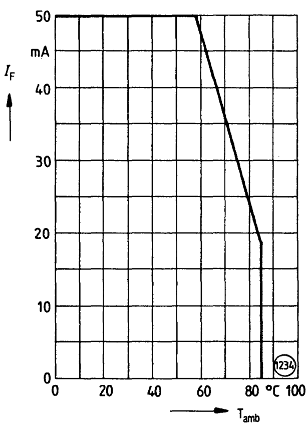
Block diagram



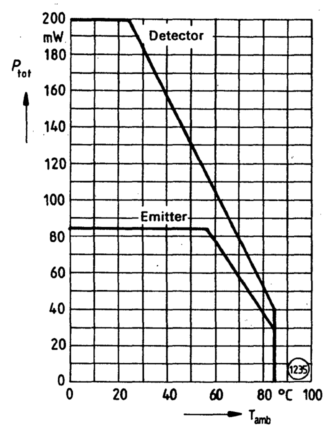


1 ANODE
2 CATHODE
3 GROUND
4 DIRECTIONAL SIGNAL R
5 COUNTING PULSE SIGNAL Z
6 SUPPLY VOLTAGE

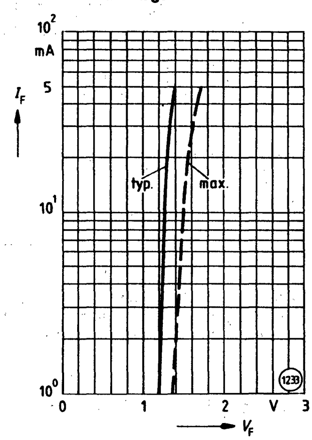
Max. permissible forward current versus ambient temperature (emitter)



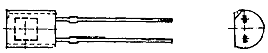
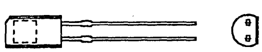
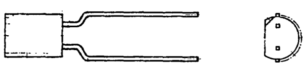
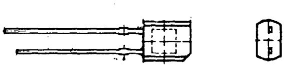
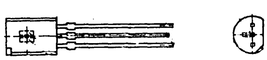
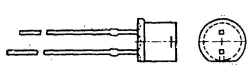
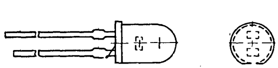
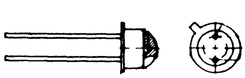
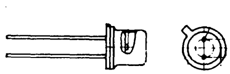
Permissible power dissipation versus ambient temperature



Forward current versus forward voltage

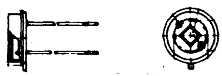
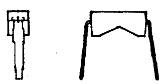
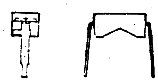
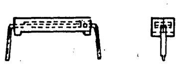


Photodiodes

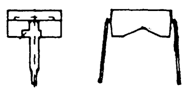
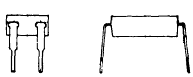
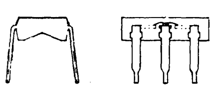
Package Outline		Package Type	Half Angle	Dark Current V_R=10V nA	Photosensitivity λ=950nm 0.5mW/cm² nA	Radiant Sensitive Area mm²	Peak Wave-length nm	Features	Page
	SFH205	Plastic w/ daylight filter. Solder tabs.	±70°	2(≤30)	25(≥15) μA	7.00	950	PIN type, built in filter. Superior S/N ratio at low luminance.	8–44
	SFH206				25(≥16) μA				8–48
	SFH206K	Plastic, clear. Solder tabs.			80(≥50)		850		8–50
	SFH205Q2	Plastic w/ daylight filter. Solder tabs.	±70°	2(≤30)	25(≥15) μA	7.00	950	PIN type, built in filter. Curved surface. Superior s/n ratio at low luminance.	8–46
	SFH225	Plastic w/ daylight filter.	±60°	2(≤30)	17(≥12.5) μA	4.84	950	PIN type, short switching time. Matches with emitters SFH484/485, LD271/274.	8–54
	SFH248	TO-92 Clear plastic	±60°	100 (≤200)	24 (≥15)	1.54	850	Low noise. Short switching time. Low capacitance.	8–56
	SFH248F	TO-92 Plastic w/ daylight filter.			7.5(≥4)) μA		950		
	SFH217	T1³/4 flat. Clear plastic.	±60°	1(≤10) 20V	9.5(≥5)	1		PIN type. Low cost diode for fiber optics. Transmission over 560 m/bits.	8–52
	SFH217F	T1³/4 flat. Plastic w/ daylight filter.			3(≥1.8) μA		900		
	SFH2030	T1³/4 Clear-plastic.	±20°	1(≤5) 20V	80(≥50)	1	850	Low noise. Short switching time. Low capacitance.	8–58
	SFH2030F	T1³/4 Plastic w/ daylight filter.			25(≥15) μA		900		
	BPX63	TO-18 plastic lens.	±75°	5 (≤20) pA 1V	10(≥8)	1	800	Extremely low dark current. For exposure meters. Matches with emitter, LD242.	8–26
	BPX65	TO-18 flat plastic lens.	±40°	1(≤5) 20V	10(≥5.5)	.097	850	PIN type. Very high speed, 5nS. Low dark current, 1mA.	8–28
	BPX66			0.15 (≤0.3) 1V				PIN type. Very high speed, 5nS. Very low dark current, 15mA.	8–30

Photodiodes

Photodiodes

Package Outline	Part Number	Package Type	Half Angle	Dark Current V_R=10V nA	Photosensitivity λ=950nm 0.5mWcm² nA	Radiant Sensitive Area mm²	Peak Wavelength nm	Features	Page
	BPW21	Similar to TO-5. Fla glass lens. Hermeti-cally sealed lens.	±60°	2(≤30) 5V	10(≥5.5)	7.34	850	High reliability. V_2 filter, 550mn.	8-8
	BPX60		±55°	7(≤300)	70(≥35)			High reliability. Superior S/N ratio at low luminance.	8-22
	BPX61			2(≤30)	70(≥50) µA	7.00		High reliability. PIN type. Superior S/N ratio at low luminance.	8-24
	BP104BS	Plastic with daylight filter.	±60°	2(≤30)	25(≥15) µA	7.00	920	IR remote control. PIN type. Surface mount.	8-6
	BPX92	Plastic. Solder tabs.	±60°	1(≤100)	9.5 (≥4)	1.0	850	High reliability. PIN type. Superior S/N ratio at low luminance.	8-36
	BPW32	Plastic, clear. Solder tabs.	±60°	5 (≤20) pA IV	10(≥7)	0.97	800	Low dark current, 5 pA.	8-10
	BPX90			5 (≤200)	45(≥25)	5.5	850	High sensitivity. Superior signal to noise ratio at low luminance.	8-32
	BPX90K	Plastic with daylight filter.			13(≥8) µA	5.0	950		
	SFH200	Plastic, clear. Solder tabs.		5 (<40) pA 1V	20 (≥14)	2.0	800	High sensitivity. High zero crossover.	8-40
	SFH100	Plastic, clear, solder tabs.	±60°	0.4(≤10)	175 (≥150)	21.8	850	High sensitivity. Superior signal to noise ratio at low luminance.	8-38

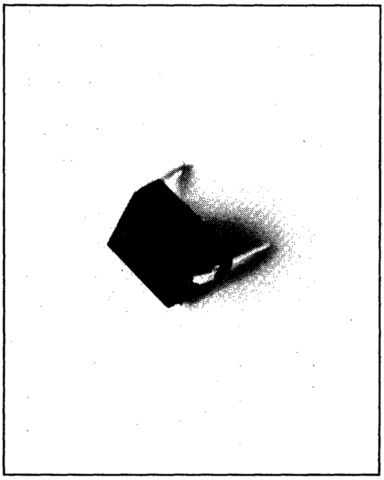
Photodiodes

Package Outline	Part Number	Package Type	Half Angle	Dark Current V_R=10V nA	Photosensitivity λ=950nm 0.5mW/cm² nA	Radiant Sensitive Area mm²	Peak Wavelength nm	Features	Page
	BP104	Plastic w/ daylight filter.		2(≤30)	17(≥12.5) µA	4.84	950	IR remote control. PIN type.	8–4
	BPW33	Plastic, clear, solder tabs.		20 (≤100) pA 1V	75(≥35)	7.34	800	Light measuring applications. Low dark current.	8–12
	BPW34		±60°	2(≤30)	80(≥50) µA	7.00	850	PIN type. Low junction capacitance.	8–14
	BPW34B			2(≤30)	75(≥50)	7.45	850	PIN type. High blue sensitivity.	8–16
	BPW34F	Plastic w/ daylight filter.			25(≥15) µA	7.00	800	PIN type.	8–18
	BPX91B	Plastic, clear, solder tabs.		7(≤300)	65(≥35)	7.45	850	High blue sensitivity.	8–34
	BPX48	Plastic, clear, solder tabs.	±60°	100 (≤200)	24 (≥15)	2 x1.54	850	Fast response, differential type photodiode, 90µm apart. Precision applications.	8–20
	SFH204	6 pin DIP.	Not applicable.	.01 (≤2)	.13 (≥.08)	4 x .01	850	Four quadrant photodiodes, 12µm apart. Precision measurement applications.	8–42

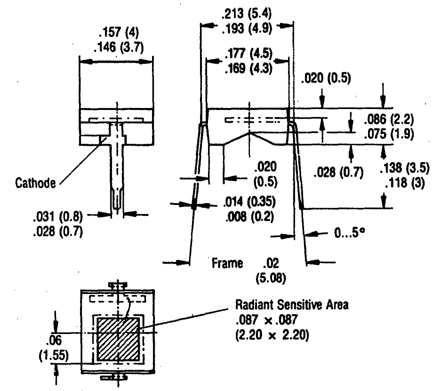
SIEMENS

BP 104

SILICON PIN PHOTODIODE WITH DAYLIGHT FILTER



Package Dimensions in Inches (mm)



FEATURES

- **Daylight Filter**
- **Silicon Planar PIN Photodiode**
- **Plastic Package**
- **2/10″ Lead Spacing**
- **High Speed**
- **Lead Bend Option (for SMD)**

DESCRIPTION

BP 104 is a silicon planar PIN photodiode, encapsulated in a plastic package, which simultaneously serves as filter and is transparent to IR radiation. Its terminals are soldering tabs spaced 5.08 mm (2/10″) apart. Due to its design the diode can easily be mounted, even on PC boards. The flat back of the epoxy resin case makes rigid fixing of the component feasible. Arrays can be realized by multiple arrangements. This universal photodetector is suitable for diode as well as voltaic cell operation. The signal/noise ratio is particularly favorable, even at low illuminances.

The PIN photodiode is outstanding for its low junction capacitance, high maximum frequency, and fast switching times. It is particularly suitable for IR sound transmission

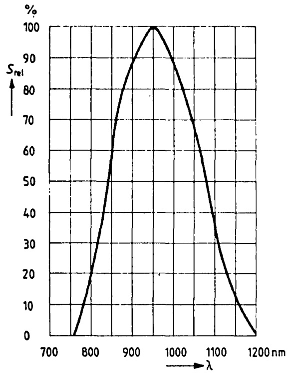
Maximum Ratings

Reverse Voltage (V_R) .... 20 V
Operating and Storage Temperature Range .... −40 to +80°C
Soldering Temperature in a 2 mm Distance from the Case Bottom ($t \leq 3$ s) (T_S) .... 230°C
Power Dissipation (T_{amb} = 25°C) (P_{tot}) .... 150 mW

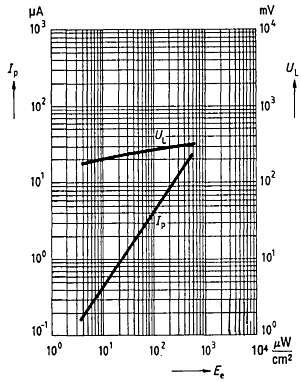
Characteristics (T_{amb} = 25°C)

Photosensitivity (V_R = 5 V, λ = 950 nm, E_e = 0.5 mW/cm²)	S	17 (≥12.5)	μA
Wavelength of Max. Photosensitivity	λ_{Smax}	950	nm
Spectral Range of Photosensitivity (S = 10% of Smax)	λ	800...1100	nm
Radiant Sensitive Area	A	4.84	mm²
Dimensions of the Radiant Sensitive Area	L × W	2.20 × 2.20	mm
Distance Between Chip Surface and Package Surface	H	0.5	mm
Half Angle	φ	±60	Deg.
Dark Current (V_R = 10 V)	I_R	2 (≤30)	nA
Spectral Photosensitivity (λ = 950 nm)	S_λ	0.70	A/W
Quantum Efficiency (λ = 950 nm)	η	0.90	$\frac{\text{Electrons}}{\text{Photon}}$
Open Circuit Voltage (E_e = 0.5 mW/cm², λ = 950 nm)	V_O	327 (≥250)	mV
Short Circuit Current (E_e = 0.5 mW/cm², λ = 950 nm)	I_{SC}	17 (≥12.5)	μA
Rise and Fall Time of the Photocurrent from 10% to 90% and from 90% to 10% of the Final Value (R_L = 1 KΩ, V_R = 5 V, λ = 830 nm, I_P = 17 μA)	t_r, t_f	125	ns
Forward Voltage (I_F = 100 mA, E_e = 0)	V_F	1.3	V
Capacitance (V_R = 0 V, f = 1 MHz, E_V = 0 lx)	C_0	48	pF
Temperature Coefficient V_O	TC_V	-2.6	mV/K
Temperature Coefficient I_S	TC_I	0.18	%/K
Noise Equivalent Power (V_R = 1 V)	NEP	3.6×10^{-14}	$\frac{W}{\sqrt{Hz}}$
Detection Limit (V_R = 1 V)	D	6.1×10^{12}	$\frac{cm\sqrt{Hz}}{W}$

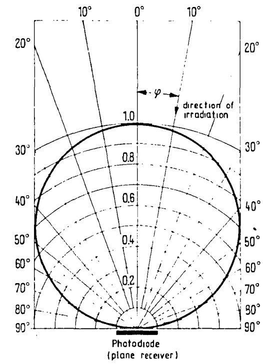
Relative spectral sensitivity
$S_{rel} = f(\lambda)$



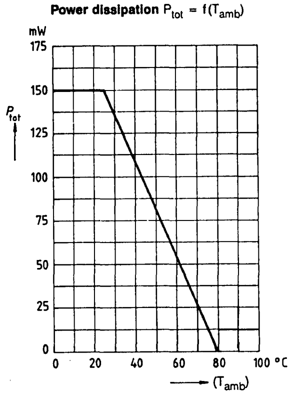
Photocurrent $I_P = f(E_e)$
Open circuit current $V_L = f(E_e)$



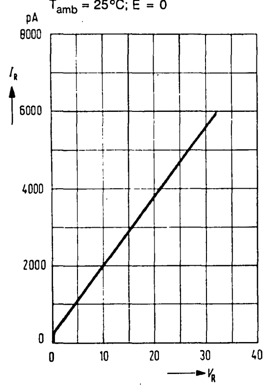
Directional characteristic
$S_{rel} = f(\varphi)$



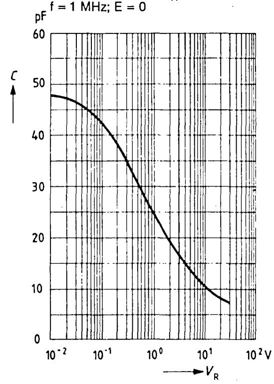
Power dissipation $P_{tot} = f(T_{amb})$



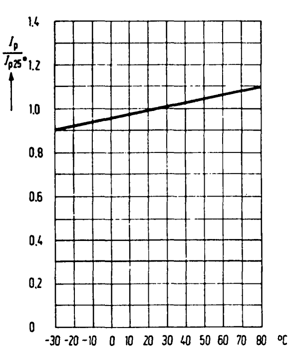
Dark current $I_R = f(V_R)$
$T_{amb} = 25°C$; $E = 0$



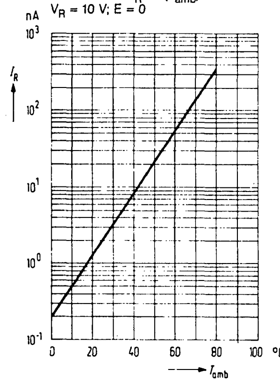
Capacitance $C = f(V_R)$
$f = 1$ MHz; $E = 0$



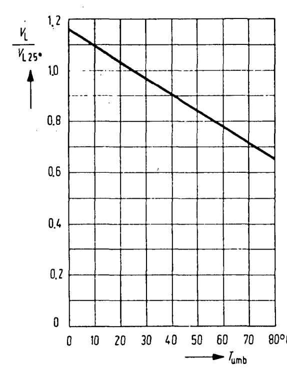
Photocurrent $\frac{I_P}{I_{P25°}} = f(T_{amb})$



Dark current $I_R = f(T_{amb})$
$V_R = 10$ V; $E = 0$



Open circuit voltage $\frac{V_L}{V_{L25°}} = f(T_{amb})$

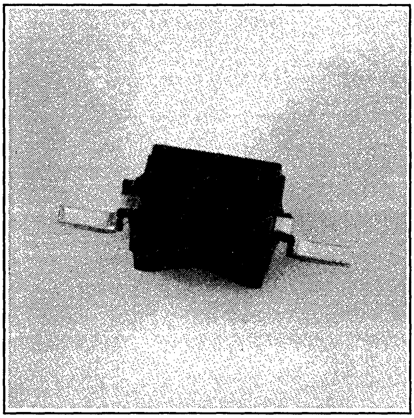


Photodiodes

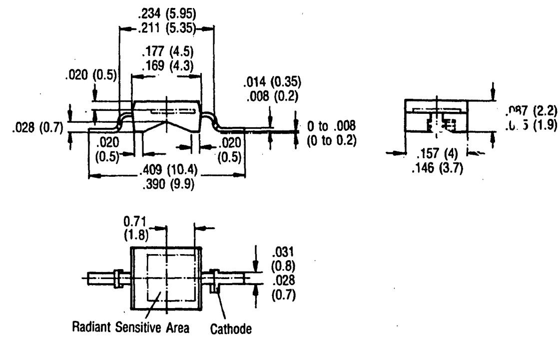
SIEMENS

BP 104BS

SILICON PIN PHOTODIODE WITH DAYLIGHT FILTER



Package Dimensions in Inches (mm)



FEATURES

- **Silicon Planar Pin Photodiode**
- **Plastic Package**
- **2/10″ Lead Spacing**
- **Low Junction Capacitance**
- **Short Switching Time**
- **High Sensitivity**
- **Daylight Filter**
- **Lead Bend (for SMD)**

DESCRIPTION

The BP104BS is a silicon planar PIN photodiode in a plastic package. Because the terminals are soldering tabs bent for surface mounting the diode can easily be assembled on PC boards. The flat back of the epoxy resin case makes rigid fixing of the component feasible. The cathode is marked by a blue dot.

These devices can be arrayed. This versatile photodetector can be used as a diode as well as a voltaic cell. The signal/noise ratio is particularly favorable, even at low illuminances. The open circuit voltage at low illuminances is higher than with comparable mesa photovoltaic cells. The PIN photodiode is outstanding for low junction capacitance, high cut-off frequency and short switching times. An application is IR sound transmission.

Maximum Ratings

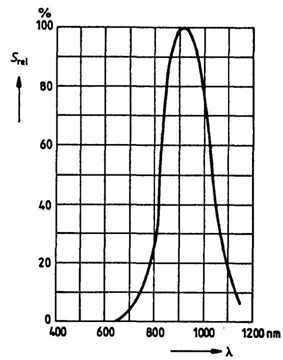
Reverse Voltage (V_R) .... 20 V
Operating and Storage Temperature Range .... −40 to +80°C
Soldering Temperature in a 2 mm Distance from the Case Bottom ($t \leq 3$ s) (T_S) .... 230°C
Power Dissipation (T_{amb} = 25°C) (P_{tot}) .... 15 mW

Characteristics (T_{amb} = 25°C)

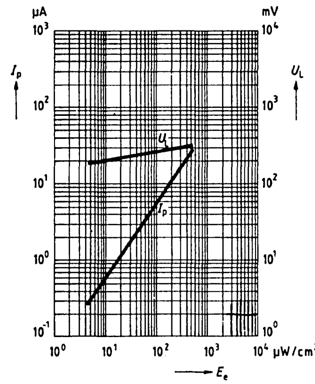
Photosensitivity (V_R = 5 V, λ = 950 nm E_e = 0.5 mW/cm²)	S	25 (≥15)	μA
Wavelength of Max. Photosensitivity	λ_{Smax}	920	nm
Spectral Range of Photosensitivity (S = 10% of Smax)	λ	800... 1100	nm
Radiant Sensitive Area	A	7.00	mm²
Dimensions of the Radiant Sensitive Area	L × W	2.65 × 2.65	mm
Distance Between Chip Surface and Package Surface	H	0.5	mm
Half Angle	φ	±60	Deg.
Dark Current (V_R = 10 V)	I_R	2 (≤30)	nA
Spectral Photosensitivity (λ = 950 nm)	S_λ	0.68	A/W
Quantum Yield (λ = 950 nm)	η	0.90	Electrons / Photon
Open Circuit Voltage (E_e = 0.5 mW/cm², λ = 950 nm)	V_O	327 (≥275)	mV
Short Circuit Current (E_e = 0.5 mW/cm², λ = 950 nm)	I_{SC}	25 (≥15)	μA
Rise and Fall Time of the Photocurrent from 10% to 90% and from 90% to 10% of the Final Value (R_L = 1 KΩ, V_R = 5 V, λ = 830 nm I_P = 25 μA)	t_r, t_f	400	ns
Forward Voltage (I_F = 100 mA, E_e = 0, T_{amb} = 25°C)	V_F	1.3	V
Capacitance (V_R = 0 V, E = 0, f = 1 MHz)	C_0	72	pF
Temperature Coefficient of V_O	TC_V	−2.6	mV/K
Temperature Coefficient of I_S	TC_I	0.18	%/K
Noise Equivalent Power (V_R = 10 V)	NEP	3.7×10^{-14}	$\frac{W}{\sqrt{Hz}}$
Detection Limit (V_R = 10 V)	D	7.3×10^{12}	$\frac{cm \sqrt{Hz}}{W}$

[1] The illuminance indicated refers to unfiltered radiation of a tungsten filament lamp at a color temperature of 2856 K (standard light A in accordance with DIN 5030 and IEC publ. 306-1).

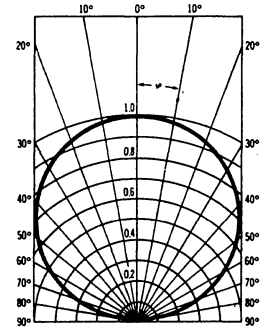
Relative spectral sensitivity versus wavelength



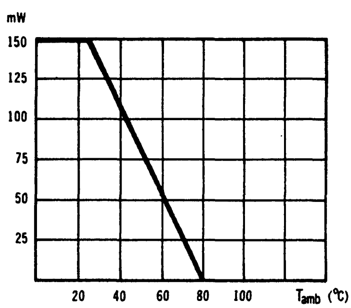
Photocurrent $I_P = f(E_e)$
Open circuit voltage $V_L = f(E_V)$



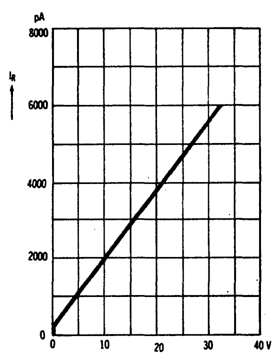
Directional characteristic
$S_{rel} = f(\varphi)$



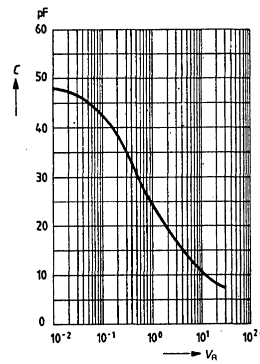
Power dissipation $P_{tot} = f(T_{amb})$



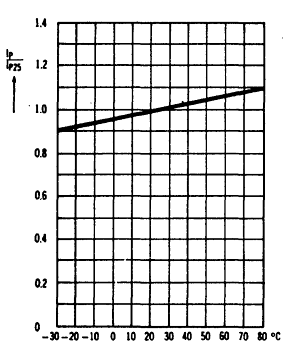
Dark current $I_R = f(V_R)$
$T_{amb} = 25°C$; $E = 0$



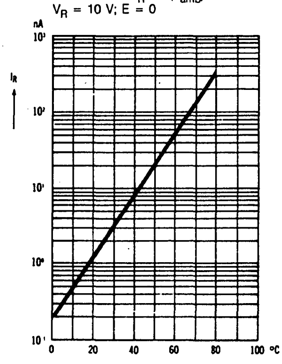
Capacitance versus reverse voltage
$f = 1$ MHz; $E = 0$



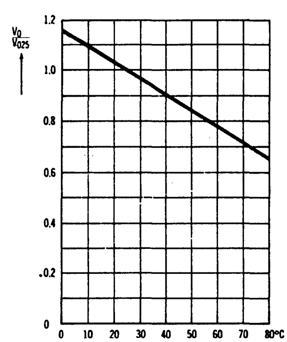
Photocurrent $\frac{I_P}{I_{P25}} = f(T_{amb})$



Dark current $I_R = f(T_{amb})$
$V_R = 10$ V; $E = 0$



Open circuit voltage $\frac{V_O}{V_{O25}} = f(T_{amb})$

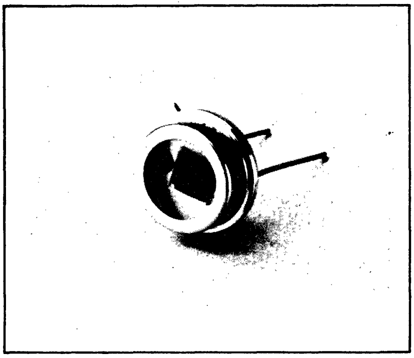


Photodiodes

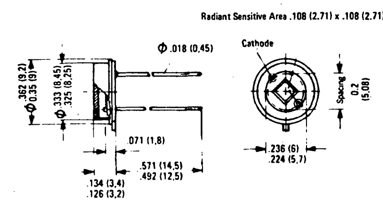
SIEMENS

BPW 21

SILICON PHOTODIODE WITH Vλ FILTER



Package Dimension in Inches (mm)



FEATURES

- **Incorporates, Vλ Filter**
- **High Reliability**
- **Hermetically Sealed, Glass Lens Package, Similar to TO-5**
- **Low Noise**
- **High Open-circuit Voltage as Photovoltaic Cells**
- **Detector for Low Illuminance**
- **Short Switching Time**
- **High Photosensitivity**
- **Linear Relation Between I_s and Illuminance of 10^{-2} to 10^5 lx**
- **Wide Temperature Range**
- **Suitable in the Range of Visible Light**

DESCRIPTION

BPW 21 is a Planar Silicon Photodiode. The N-Si material results in a positive front and negative back contact. These photodetectors can be operated as photodiodes with reverse voltage or as photovoltaic cells. Applications include exposure meters for daylight as well as artificial light of high color temperature in photographic fields and color analysis.

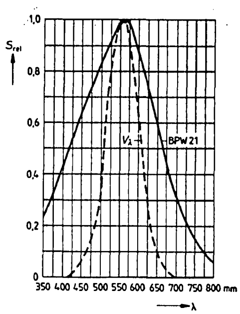
Maximum Ratings

Operating temperature range	T_{amb}	−40...+80	°C
Storage temperature range	T_{stg}	−40...+80	°C
Soldering temperature in a 1.5 mm distance from the case bottom (t≤5 sec)	T_{sold}	235	°C
Reverse voltage	V_R	10	V
Total power dissipation	P_{tot}	250	mW
Thermal resistance	$R_{th\ JA}$	300	K/W
	$R_{th\ JC}$	80	K/w

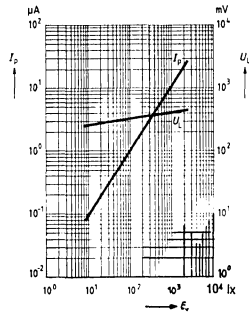
Characteristics (T_{amb} = 25 °C)

Photosensitivity (V_R = 5 V, standard light A, T = 2856K)	S	10 (≥5.5)	nA/lx
Wavelength of max. photosensitivity	$\lambda_{s\ max}$	550	nm
Spectral range of photosensitivity (S = 10% of S_{max})	λ	350...775	nm
Radiant sensitive area	A	7.34	mm²
Dimension of radiant sensitive area	L × W	2.71 × 2.71	mm
Distance chip surface to case top edge	H	1.9...2.3	mm
Half angle	φ	±60	Deg.
Dark current (V_R = 5 V)	I_R	2(≤30)	nA
(V_R = 10 mV)	I_R	8 (≤200)	pA
Spectral photosensitivity (σ = 550 nm)	S_σ	0.34	A/W
Quantum yield (σ = 550 nm)	η	0.80	Electrons/Photon
Open-circuit voltage (E_V = 1000 lx, standard light A, T = 2856 K)	V_O	400 (≥320)	mV
Short-circuit current (E_V = 1000 lx, standard light A, T = 2856 K) (Deviation of I_S linearity in the range of 3 ·10^{-2} to 10^4 lx: max. 12%)	I_{SC}	10 (≥5.5)	µA
Rise and fall time of photocurrent from 10% to 90% and from 90% to 10% of final value (R_L = 1 KΩ, V_R = 5 V, λ = 550 nm, I_P = 10 µA)	t_r, t_f	1.5	µs
Forward voltage (I_F = 100 mA, E_e = O)	V_F	1.2	V
Capacitance (V_R = 0 V, f = 1 MHz, E_V = 0 lx)	C_O	580	pF
Temperature coefficient of V_o	TC	−2.6	mV/K
Temperature coefficient of I_S	TC	0.12	%K
Noise Equivalent Power (V_R = 1 V)	NEP	7.2×10^{-14}	$\frac{W}{\sqrt{Hz}}$
Detection Limit (V_R = 1 V)	D	1×10^{12}	$\frac{cm \cdot \sqrt{Hz}}{W}$

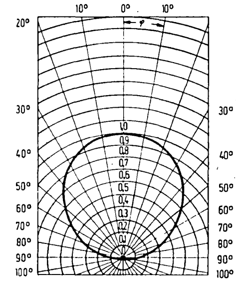
Relative spectral photosensitivity versus wavelength



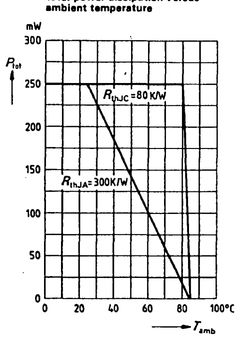
Photocurrent $I_P = f(E_V)$
Open circuit voltage $V_O = f(E_V)$



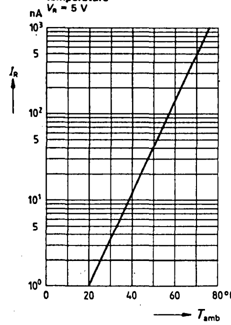
Directional characteristic
$S_{rel} = f(φ)$



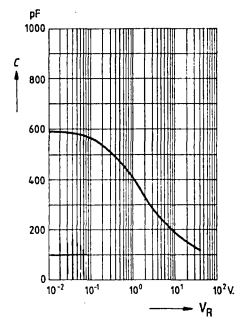
Total power dissipation versus ambient temperature



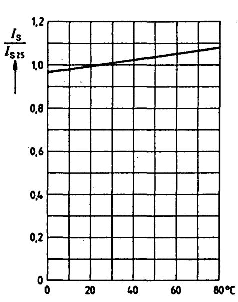
Dark current versus ambient temperature
$V_R = 5$ V



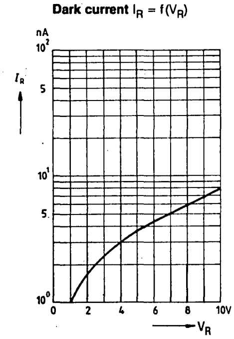
Capacitance $C = f(V_R)$, f = 1 MHz



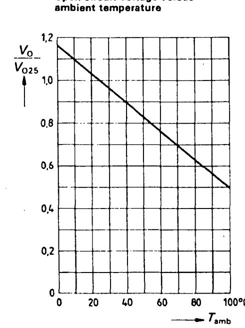
Short-circuit current versus ambient temperature



Dark current $I_R = f(V_R)$



Open-circuit voltage versus ambient temperature

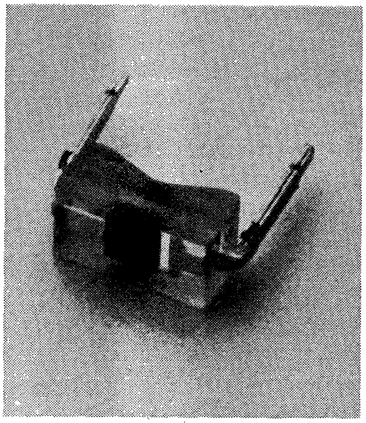


Photodiodes

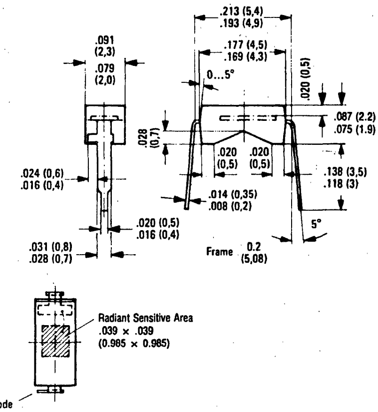
SIEMENS

BPW 32

SILICON PHOTODIODE



Package Dimensions in Inches (mm)



FEATURES

- **Very Low Dark Current**
- **Silicon Planar Photodiode**
- **Transparent Plastic Package**
- **2/10″ Lead Spacing**
- **Low Illuminances Usage, i.e., Light Sensor**
- **Lead Bend Option (for SMD)**

DESCRIPTION

The BPW 32 is a silicon planar photodiode, which is incorporated in a transparent plastic package. Its terminals are soldering tabs, arranged in 5.08 mm (2/10″) lead spacing. Because of this design, the diodes can also very easily be assembled on PC boards. The flat back of the epoxy resin case makes rigid fixing of the component feasible.

The BPW 32 has been developed as a detector for low illuminances and is intended for use as a sensor in exposure meters and automatic exposure timers. The component is outstanding for low dark currents and—when used as a voltaic cell—for a high open circuit voltage at low illuminances. The cathode is marked by an orange dot.

Maximum Ratings

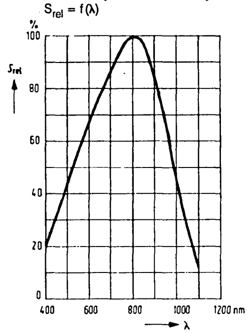
Reverse Voltage (V_R)	7 V
Operating and Storage Temperature Range	−40 to +80°C
Soldering Temperature in a 2 mm Distance from the Case Bottom ($t \leq 3$ s) (T_S)	230°C
Power Dissipation (T_{amb} = 25°C) (P_{tot})	100 mW

Characteristics (T_{amb} = 25°C)

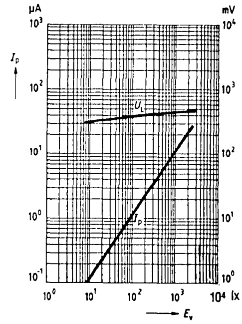
Photosensitivity (V_R = 5 V, Note 1)	S	10 (≥7)	nA/lx
Wavelength of Max. Photosensitivity	λ_{Smax}	800	nm
Spectral Range of Photosensitivity (S = 10% of Smax)	λ	350...1100	nm
Radiant Sensitive Area	A	0.97	mm^2
Dimensions of the Radiant Sensitive Area	L × W	0.985 × 0.985	mm
Distance Between Chip Surface and Package Surface	H	0.5	mm
Half Angle	φ	±60	Deg.
Dark Current (V_R = 1 V)	I_R	5 (≤20)	pA
Zero Crossing (E_e = 0, T_{amb} = 50°C)	S_O	≥ 2	pA/mV
Spectral Photosensitivity (λ = 800 nm)	S_λ	0.5	A/W
Quantum Efficiency (λ = 800 nm)	η	0.73	$\frac{\text{Electrons}}{\text{Photon}}$
Open Circuit Voltage (E_V = 1000 lx, Note 1)	V_O	450 (≥380)	mV
Short Circuit Current (E_V = 1000 lx, Note 1)	I_{SC}	10 (≥7)	μA
Rise and Fall Time of the Photocurrent from 10% to 90% and from 90% to 10% of the Final Value (R_L = 1 KΩ, V_R = 5 V, λ = 830 nm, I_P = 10 μA)	t_r, t_f	1.3	μsec
Forward Voltage (I_F = 100 mA, E_e = 0, T_{amb} = 25°C)	V_F	1.3	V
Capacitance (V_R = 0 V, f = 1 MHz, E_V = 0 lx)	C_0	100	pF
Temperature Coefficient V_O	TC_V	-2.6	mV/K
Temperature Coefficient I_O	TC_I	0.2	%/K
Noise Equivalent Power (V_R = 1 V)	NEP	2.5×10^{-15}	$\frac{W}{\sqrt{Hz}}$
Detection Limit (V_R = 1 V)	D	3.9×10^{13}	$\frac{cm\sqrt{Hz}}{W}$

[1] The illuminance indicated refers to unfiltered radiation of a tungsten filament lamp at a color temperature of 2856 K (standard light A in accordance with DIN 5033 and IEC publ. 306-1.)

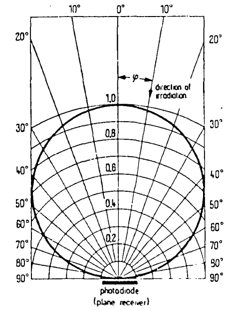
Relative spectral sensitivity
$S_{rel} = f(\lambda)$



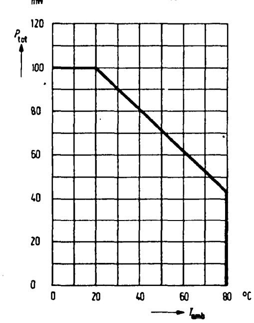
Photocurrent $I_P = f(E_V)$
Open circuit voltage $V_L = f(E_V)$



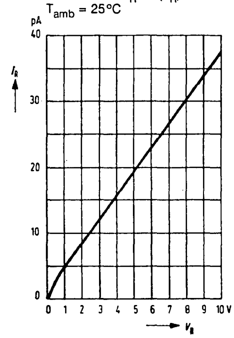
Directional characteristic
$S_{rel} = f(\varphi)$



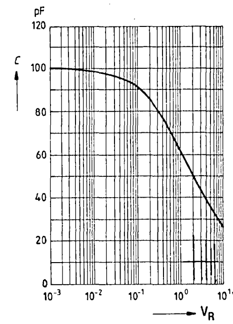
Power dissipation $P_{tot} = f(T_{amb})$



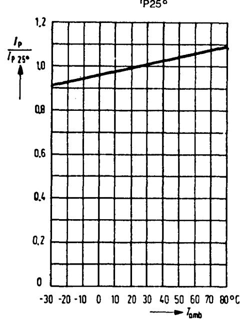
Dark current $I_R = f(V_R)$
$T_{amb} = 25°C$



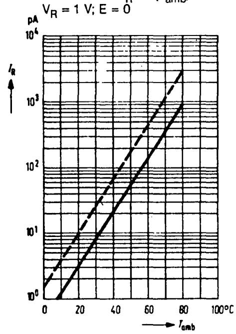
Capacitance $C = f(V_R)$, $E = 0$



Photocurrent $\frac{I_P}{I_{P25°}} = f(T_{amb})$



Dark current $I_R = f(T_{amb})$
$V_R = 1$ V; $E = 0$



Open circuit voltage $\frac{V_L}{V_{L25°}} = f(T_{amb})$

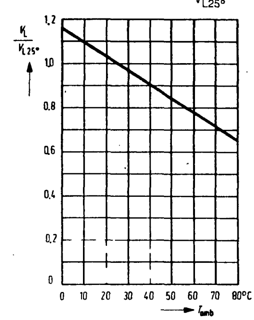
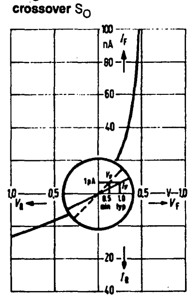


Diagram of the zero crossover S_O

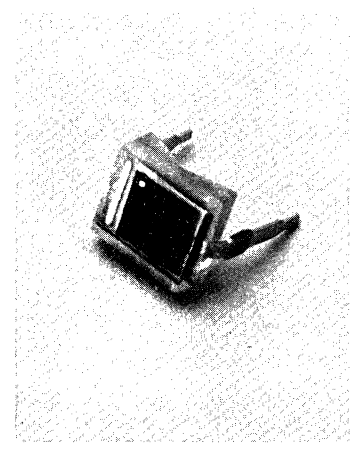


Photodiodes

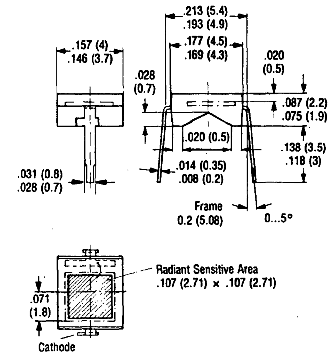
SIEMENS

BPW 33

SILICON PHOTODIODE



Package Dimensions in Inches (mm)



FEATURES

- **Very Low Dark Current, 20 pA**
- **Silicon Planar Photodiode**
- **Transparent Plastic Package**
- **2/10" Lead Spacing**
- **High Sensitivity, 75 nA/lx**
- **Light Measuring Applications**
- **Lead Bend Option (for SMD)**

DESCRIPTION

The BPW 33 is a large area silicon planar photodiode, which is incorporated in a transparent plastic package. Its terminals are soldering tabs, arranged in 5.08 mm (2/10") lead spacing. Because of its design the diodes can also very easily be assembled on PC boards. The flat back of the epoxy resin case makes rigid fixing of the component feasible.

The BPW 33 has been developed as a detector for low illuminances and is intended for use as a sensor in exposure meters and automatic exposure timers. The component is outstanding for high open circuit voltage at low illuminances. The cathode is marked by an orange dot.

Maximum Ratings

Reverse Voltage (V_R) .... 7 V
Storage Temperature Range .... −40 to +80°C
Soldering Temperature in a 2 mm Distance from the Case Bottom ($t \leq 3$ s) (T_S) .... 230°C
Power Dissipation (T_{amb} = 25°C) (P_{tot}) .... 150 mW

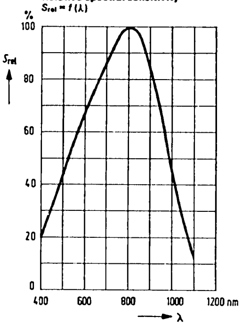
Characteristics (T_{amb} = 25°C)

Photosensitivity (V_R = 5 V, Note 1)	S	75 (≥35)	nA/lx
Wavelength of Max. Photosensitivity	λ_{Smax}	800	nm
Spectral Range of Photosensitivity	λ	350...1100	nm
Radiant Sensitive Area	A	7.34	mm²
Dimensions of the Radiant Sensitive Area	L × W	2.71 × 2.71	mm
Distance Between Chip Surface and Package Surface	H	0.5	mm
Half Angle	φ	±60	Deg.
Dark Current (V_R = 1 V)	I_R	20 (≤100)	pA
Zero Cross Over (E_V = 0 T_{amb} = 50°C, Note 2)	S_O	≥ 20	pA/mV
Spectral Photosensitivity (λ = 850 nm)	S	0.59	A/W
Quantum Yield (λ = 800 nm)	η	0.86	Electrons/Photon
Open Circuit Voltage (E_V = 1000 lx, Note 1)	V_O	440 (≥375)	mV
Short Circuit Current (E_V = 1000 lx, Note 1)	I_{SC}	72 (≥35)	μA
Rise and Fall Time of the Photocurrent from 10% to 90% and from 90% to 10% of the Final Value (R_L = 1 KΩ, V_R = 5 V, λ = 830 nm I_P = 70 μA)	t_r, t_f	1.5	μs
Forward Voltage (I_F = 100 mA, E_e = 0 T_{amb} = 25°C)	V_F	1.3	V
Capacitance (V_R = 0 V, E = 0, f = 1 MHz)	C_O	630	pF
Temperature Coefficient of V_O	TC_V	−2.6	mV/K
Temperature Coefficient I_K	TC_I	0.2	%/K
Noise Equivalent Power (V_R = 1 V)	NEP	4.3×10^{-15}	$\frac{W}{\sqrt{Hz}}$
Detection Limit (V_R = 1 V)	D	6.3×10^{13}	$\frac{cm \sqrt{Hz}}{W}$

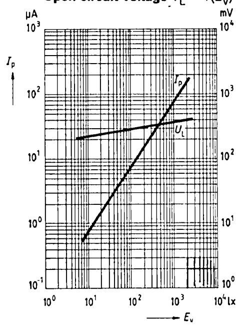
[1] The illuminance indicated refers to unfiltered radiation of a tungsten filament lamp at a color temperature of 2856 K (standard light A in accordance with DIN 5040 and IEC publ. 306-1).

[2] S_O is a measure for the lower spectral sensitivity when the photodiode is used in exposure meters. The zero cross over S_O is defined in the diagram.

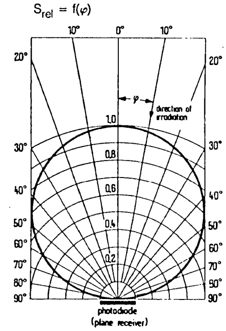
Relative spectral sensitivity $S_{rel} = f(\lambda)$



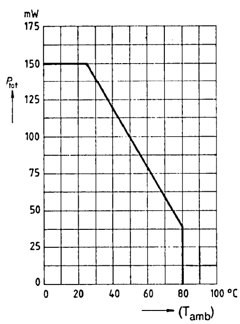
Photocurrent $I_P = f(E_V)$
Open circuit voltage $V_L = f(E_V)$



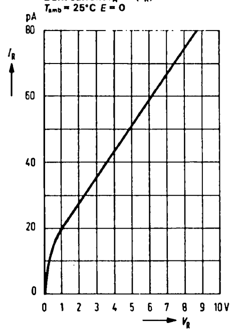
Directional characteristic $S_{rel} = f(\varphi)$



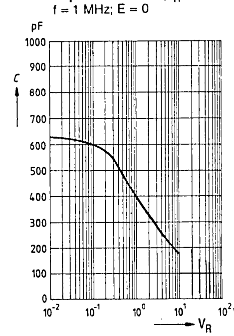
Power dissipation $P_{tot} = f(T_{amb})$



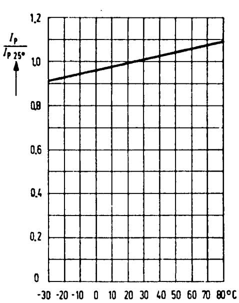
Dark current $I_R = f(V_R)$
$T_{amb} = 25°C$ $E = 0$



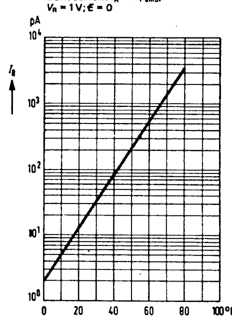
Capacitance $C = f(V_R)$
f = 1 MHz; E = 0



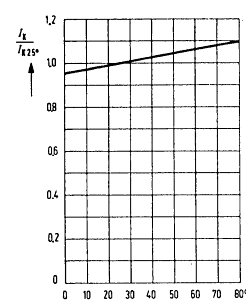
Photocurrent $\frac{I_P}{I_{P\,25°}} = f(T_{amb})$



Dark current $I_R = f(T_{amb})$
$V_R = 1\,V$; $E = 0$



Short circuit current $I_K = f(T_{amb})$



Open circuit voltage $V_L = f(T_{amb})$

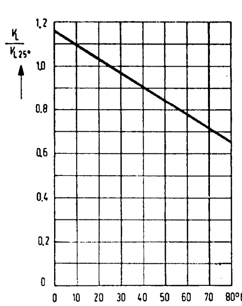
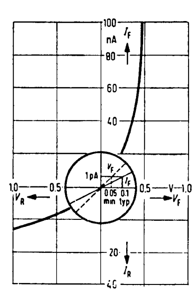


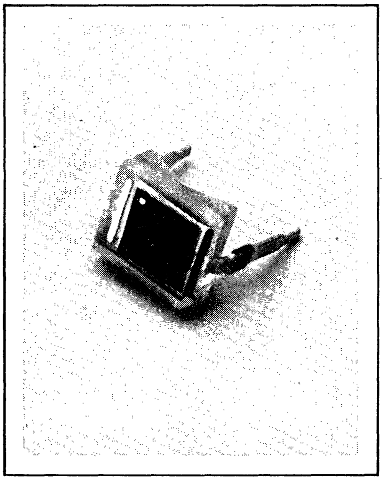
Diagram of the zero cross over S_0



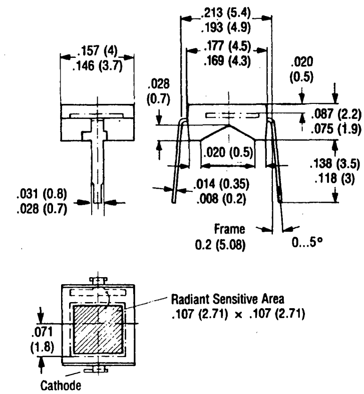
SIEMENS

BPW 34

SILICON PIN PHOTODIODE



Package Dimensions in Inches (mm)



FEATURES

- **Silicon Planar PIN Photodiode**
- **Transparent Plastic Package**
- **2/10″ Lead Spacing**
- **Low Junction Capacitance**
- **Short Switching Time**
- **High Sensitivity**
- **Lead Bend Option (for SMD)**

DESCRIPTION

The BPW 34 is a silicon planar PIN photodiode, which is incorporated in a transparent plastic package. Its terminals are soldering tabs arranged in 5.08 mm (2/10″) lead spacing. Due to its design the diode can also very easily be assembled on PC boards. The flat back of the epoxy resin case makes rigid fixing of the component feasible.

Arrays can be realized by multiple arrangements. This versatile photodetector can be used as a diode as well as a voltaic cell. The signal/noise ratio is particularly favorable, even at low illuminances. The open circuit voltage at low illuminances is higher than with comparable mesa photovoltaic cells. The PIN photodiode is outstanding for low junction capacitance, high cut-off frequency and short switching times. The photodiode is particularly suitable for IR sound transmission.

Maximum Ratings

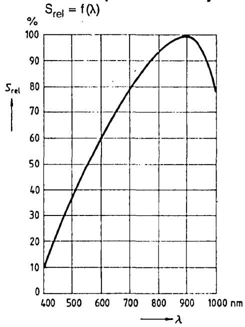
Reverse Voltage (V_R)	32 V
Operating and Storage Temperature Range	−40 to +80°C
Soldering Temperature in a 2 mm Distance from the Case Bottom ($t \leq 3$ s) (T_S)	230°C
Power Dissipation (T_{amb} = 25°C) (P_{tot})	150 mW

Characteristics (T_{amb} = 25°C)

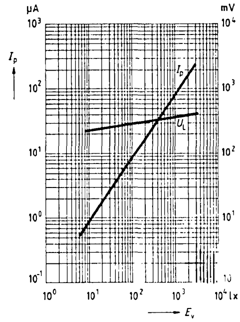
Photosensitivity (V_R = 5 V, Note 1)	S	80 (≥50)	nA/lx
Wavelength of Max. Photosensitivity	λ_{Smax}	880	nm
Spectral Range of Photosensitivity (S = 10% of Smax)	λ	400... 1100	nm
Radiant Sensitive Area	A	7.00	mm²
Dimensions of the Radiant Sensitive Area	L × W	2.65 ×2.65	mm
Distance Between Chip Surface and Package Surface	H	0.5	mm
Half Angle	φ	±60	Deg.
Dark Current (V_R = 10 V)	I_R	2 (≤30)	nA
Spectral Photosensitivity (λ = 850 nm)	S	0.62	A/W
Quantum Yield (λ = 850 nm)	η	0.90	Electrons / Photon
Open Circuit Voltage (E_V = 1000 lx, Note 1)	V_O	365 (≥300)	mV
Short Circuit Current (E_V = 1000 lx, Note 1)	I_{SC}	80 (≥50)	μA
Rise and Fall Time of the Photocurrent from 10% to 90% and from 90% to 10% of the Final Value (R_L = 1 KΩ, V_R = 5 V, λ = 830 nm I_P = 70 μA)	t_r, t_f	350	ns
Forward Voltage (I_F = 100 mA, E_e = 0 T_{amb} = 25°C)	V_F	1.3	V
Capacitance (V_R = 0 V, E = 0, f = 1 MHz)	C_0	72	pF
Temperature Coefficient of V_O	TC_V	-2.6	mV/K
Temperature Coefficient of I_K or I_P	TC_I	0.18	%/K
Noise Equivalent Power (V_R = 10 V)	NEP	4.1×10^{-14}	$\frac{W}{\sqrt{Hz}}$
Detection Limit (V_R = 10 V)	D	6.6×10^{12}	$\frac{cm \sqrt{Hz}}{W}$

[1] The illuminance indicated refers to unfiltered radiation of a tungsten filament lamp at a color temperature of 2856 K (standard light A in accordance with DIN 5030 and IEC publ. 306-1).

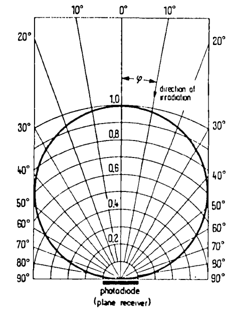
Relative spectral sensitivity
$S_{rel} = f(\lambda)$



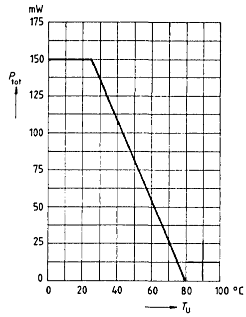
Photocurrent $I_P = f(E_V)$
Open circuit voltage $V_L = f(E_V)$



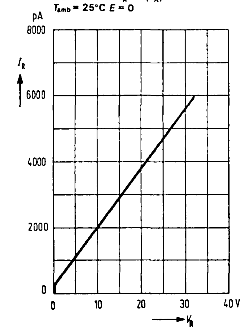
Directional characteristic $S_{rel} = f(\varphi)$



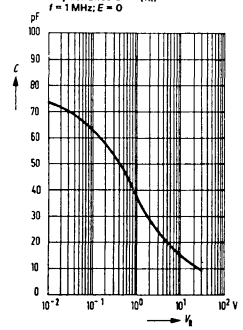
Power dissipation $P_{tot} = f(T_{amb})$



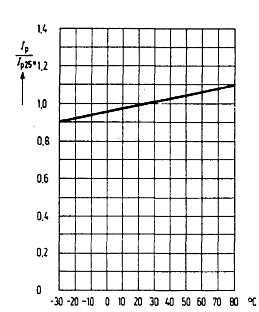
Dark current $I_R = f(V_R)$
$T_{amb} = 25°C$ $E = 0$



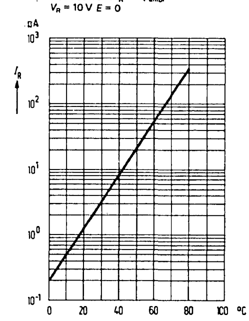
Capacitance $C = f(V_R)$
$f = 1$ MHz; $E = 0$



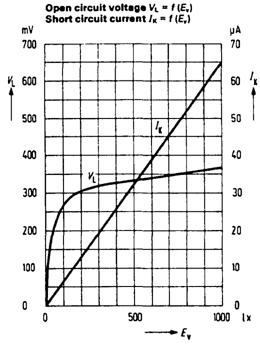
Photocurrent $\frac{I_P}{I_{P\,25°}} = f(T_{amb})$



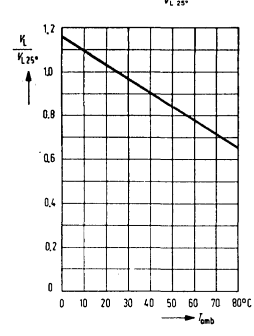
Dark current $I_R = f(T_{amb})$
$V_R = 10$ V $E = 0$



Open circuit voltage $V_L = f(E_v)$
Short circuit current $I_K = f(E_v)$



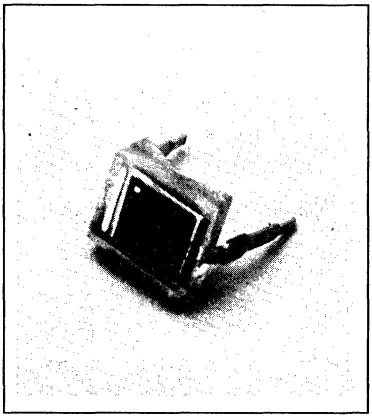
Open circuit voltage $\frac{V_L}{V_{L\,25°}} = f(T_{amb})$



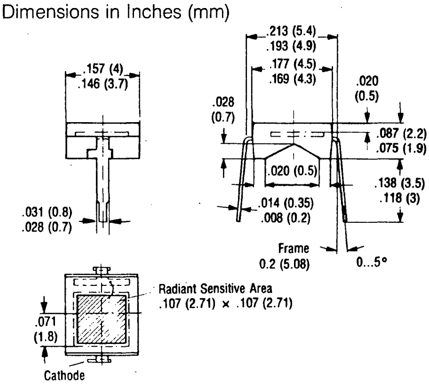
SIEMENS

BPW 34B

SILICON PIN PHOTODIODE



Package Dimensions in Inches (mm)



FEATURES

- **High Blue Sensitivity, 400 mm = 30% Srel**
- **Transparent Plastic Package**
- **2/10″ (5.08 mm) Lead Spacing**
- **Very Low Dark Current, 30 nA**

DESCRIPTION

The BPW34B is a planar silicon photodiode in a transparent plastic package. Its terminals are soldering tabs arranged in 2/10″ (5.08 mm) lead spacing. Due to its design, the diode can also very easily be assembled on PC boards. The flat back of the epoxy resin case makes rigid fixing of the component feasible. Arrays can be realized by multiple arrangements. The increased blue sensitivity with short wavelength makes the BPW34B particularly suitable for application with high blue light source.

This versatile photodetector is suitable for diode as well as a voltaic cell operation. The signal/noise ratio is particularly favorable, even at low illuminances. The open circuit voltage at low illuminances is higher than with comparable mesa photovoltaic cells. The cathode is marked by a tab on the solder lead.

Maximum Ratings

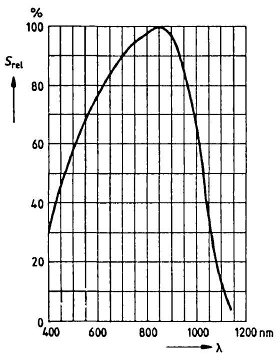
Reverse Voltage (V_R)	32 V
Operating and Storage Temperature Range	−40 to +80°C
Soldering Temperature in a 2 mm Distance from the Case Bottom ($t \leq 3$ s) (T_S)	230°C
Power Dissipation (T_{amb} = 25°C) (P_{tot})	150 mW

Characteristics (T_{amb} = 25°C)

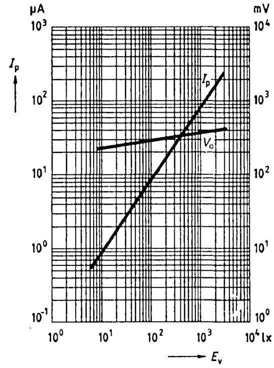
Photosensitivity (V_R = 5 V)	S	75 (≥50)	nA/lx
Wavelength of Max. Photosensitivity	λ_{Smax}	850	nm
Spectral Range of Photosensitivity (S = 10% of Smax)	λ	350...1100	nm
Radiant Sensitive Area	A	7.45	mm²
Dimensions of the Radiant Sensitive Area	L x W	2.73 x 2.73	mm
Distance Between Chip Surface and Package Surface	H	0.5	mm
Half Angle	φ	±60	Deg.
Dark Current (V_R = 10 V, E = 0)	I_R	2 (≤30)	nA
Spectral Photosensitivity (λ = 850 nm)	S_λ	0.62	A/W
Quantum Yield	η	0.90	Electrons / Photon
Open Circuit Voltage (E_V = 1000 lx, Note 1)	V_O	390 (≥320)	mV
Short Circuit Current (E_V = 1000 lx, Note 1)	I_{SC}	75 (≥50)	µA
Rise and Fall Time of the Photocurrent (R_L = 1 KΩ, V_R = 5 V, λ = 830 nm, I_P = 70 µA)	t_r, t_f	350	ns
Forward Voltage (I_F = 100 mA, E_e = 0, T_{amb} = 25°C)	V_F	1.3	V
Capacitance (V_R = 0 V, f = 1 MHz, E = 0)	C_0	72	pF
Temperature Coefficient V_O	TC_V	−2.6	mV/K
Temperature Coefficient I_{SC}	TC_I	0.18	%/K
Noise equivalent power (V_R =10 V)	NEP	4.2 x10⁻¹⁴	$\frac{W}{\sqrt{Hz}}$
Detection Limit (V_R = 10 V)	D	6.3 x 10¹²	$\frac{cm\sqrt{Hz}}{W}$

[1] The illuminance indicated refers to unfiltered radiation of a tungsten filament lamp at a color temperature of 2856 K (standard light A in accordance with DIN 5033 and IEC publ. 306-1).

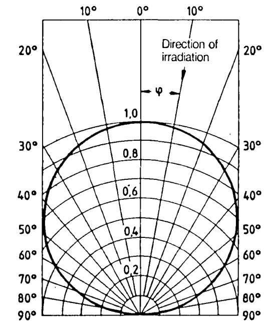
Relative spectral sensitivity
$S_{rel} = f(\lambda)$



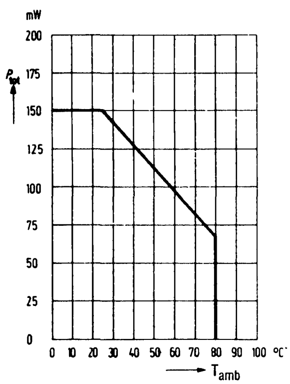
Photocurrent $I_P = f(E_V)$
Open circuit voltage $V_L = f(E_V)$



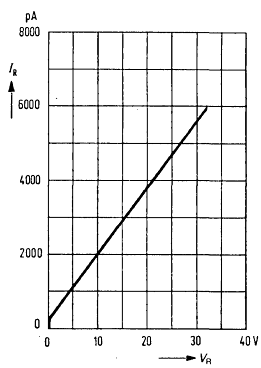
Directional characteristic
$S_{rel} = f(\varphi)$



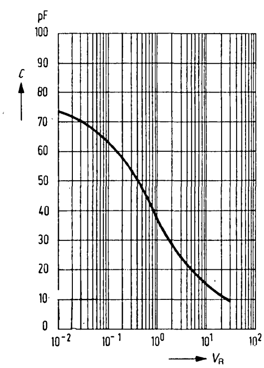
Power dissipation $P_{tot} = f(T_{amb})$



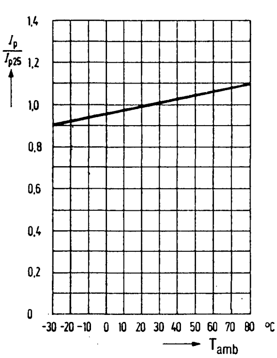
Dark current $I_R = f(V_R)$



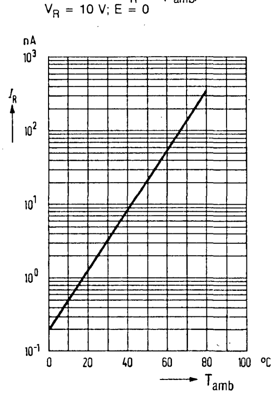
Capacitance $C = f(V_R)$



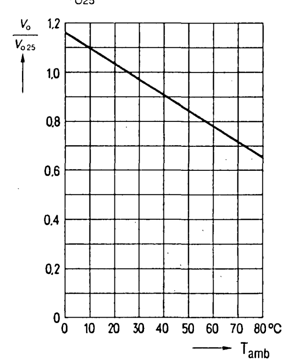
Photocurrent $\frac{I_P}{I_{P25}} = f(T_{amb})$



Dark current $I_R = f(T_{amb})$
$V_R = 10$ V; $E = 0$



Open circuit voltage versus ambient temperature
$\frac{V_O}{V_{O25}} = f(T_{amb})$

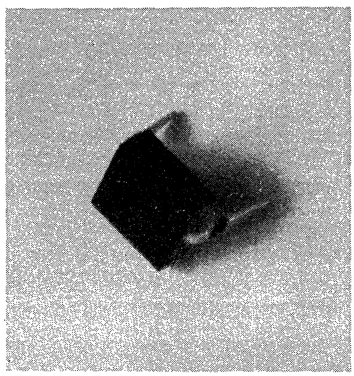


Photodiodes

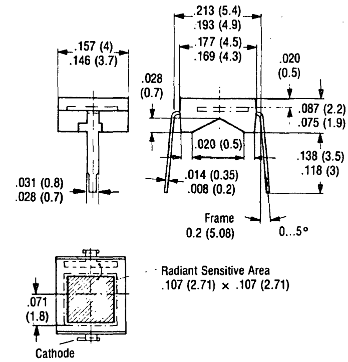
SIEMENS

BPW 34F

SILICON PIN PHOTODIODE WITH DAYLIGHT FILTER



Package Dimensions in Inches (mm)



FEATURES

- **Silicon Planar Pin Photodiode**
- **Plastic Package**
- **2/10" Lead Spacing**
- **Low Junction Capacitance**
- **Short Switching Time**
- **High Sensitivity**
- **Daylight Filter**
- **Lead Bend Option (for SMD)**

DESCRIPTION

The BPW 34F is a silicon planar PIN photodiode, which is incorporated in a plastic package. Its terminals are soldering tabs arranged in 5.08 mm (2/10") lead spacing. due to its design the diode can also very easily be assembled on PC boards. The flat back of the epoxy resin case makes rigid fixing of the component feasible.

Arrays can be realized by multiple arrangements. This versatile photodetector can be used as a diode as well as a voltaic cell. The signal/noise ratio is particularly favorable, even at low illuminances. The open circuit voltage at low illuminances is higher than with comparable mesa photovoltaic cells. The PIN photodiode is outstanding for low junction capacitance, high cut-off frequency and short switching times. The photodiode is particularly suitable for IR sound transmission. The cathode is marked by a blue dot.

Maximum Ratings

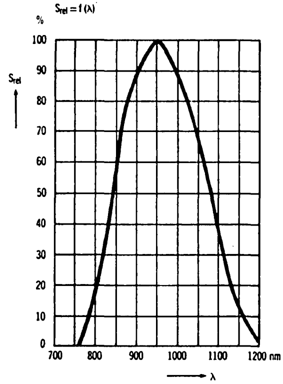
Reverse Voltage (V_R) .... 32 V
Operating and Storage Temperature Range .... −40 to +80°C
Soldering Temperature in a 2 mm Distance
from the Case Bottom (t ≤ 3 s) (T_S) .... 230°C
Power Dissipation (T_{amb} = 25°C) (P_{tot}) .... 150 mW

Characteristics (T_{amb} = 25°C)

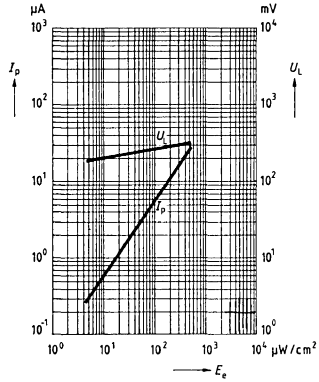
Photosensitivity (V_R = 5 V, λ = 950 nm E_e = 0.5 mW/cm²)	S	25 (≥15)	µA
Wavelength of Max. Photosensitivity	λ_{Smax}	950	nm
Spectral Range of Photosensitivity (S = 10% of Smax)	λ	800... 1100	nm
Radiant Sensitive Area	A	7.00	mm²
Dimensions of the Radiant Sensitive Area	L × W	2.65 × 2.65	mm
Distance Between Chip Surface and Package Surface	H	0.5	mm
Half Angle	φ	±60	Deg.
Dark Current (V_R = 10 V)	I_R	2 (≤30)	nA
Spectral Photosensitivity (λ = 950 nm)	S_λ	0.68	A/W
Quantum Yield (λ = 950 nm)	η	0.90	Electrons / Photon
Open Circuit Voltage (E_e = 0.5 mW/cm², λ = 950 nm)	V_O	327 (≥275)	mV
Short Circuit Current (E_e = 0.5 mW/cm², λ = 950 nm)	I_{SC}	25 (≥15)	µA
Rise and Fall Time of the Photocurrent from 10% to 90% and from 90% to 10% of the Final Value (R_L = 1 KΩ, V_R = 5 V, λ = 830 nm I_P = 25 µA)	t_r, t_f	400	ns
Forward Voltage (I_F = 100 mA, E_e = 0 T_{amb} = 25°C)	V_F	1.3	V
Capacitance (V_R = 0 V, E = 0, f = 1 MHz)	C_0	72	pF
Temperature Coefficient of V_O	TC_V	-2.6	mV/K
Temperature Coefficient of I_S	TC_I	0.18	%/K
Noise Equivalent Power (V_R = 10 V)	NEP	3.7×10^{-14}	$\frac{W}{\sqrt{Hz}}$
Detection Limit (V_R = 10 V)	D	7.3×10^{12}	$\frac{cm \sqrt{Hz}}{W}$

[1] The illuminance indicated refers to unfiltered radiation of a tungsten filament lamp at a color temperature of 2856 K (standard light A in accordance with DIN 5030 and IEC publ. 306-1).

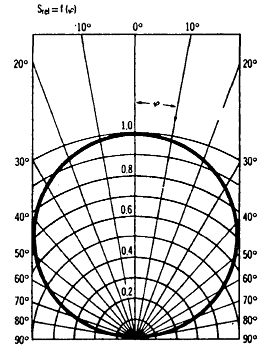
RELATIVE SPECTRAL SENSITIVITY
$S_{rel} = f(\lambda)$



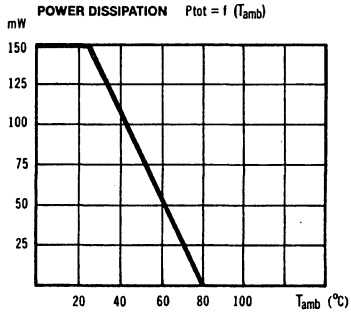
Photocurrent $I_P = f(E_e)$
Open circuit voltage $V_L = f(E_V)$



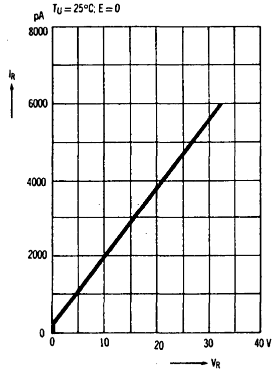
DIRECTIONAL CHARACTERISTIC.
$S_{rel} = f(\varphi)$



POWER DISSIPATION Ptot = f (T_{amb})



DARK CURRENT $I_R = f(V_R)$
$T_U = 25°C$; $E = 0$



CAPACITANCE $C = f(V_R)$
$f = 1$ MHz; $E = 0$

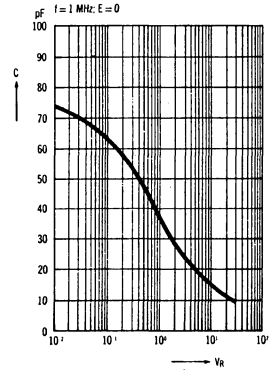
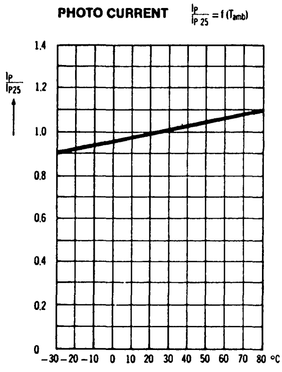
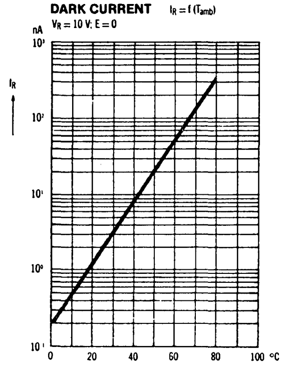


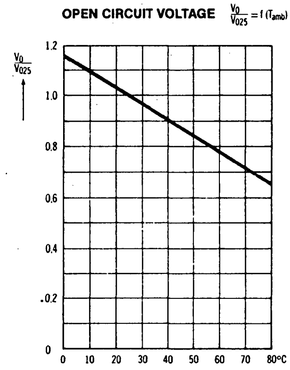
PHOTO CURRENT $\frac{I_P}{I_{P25}} = f(T_{amb})$



DARK CURRENT $I_R = f(T_{amb})$
$V_R = 10$ V; $E = 0$



OPEN CIRCUIT VOLTAGE $\frac{V_O}{V_{O25}} = f(T_{amb})$

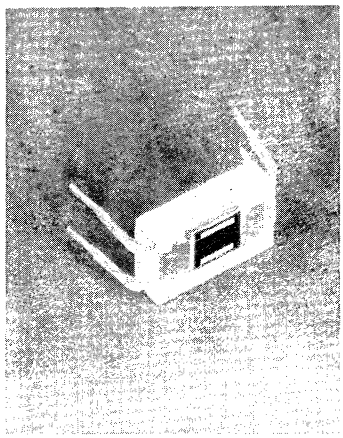


Photodiodes

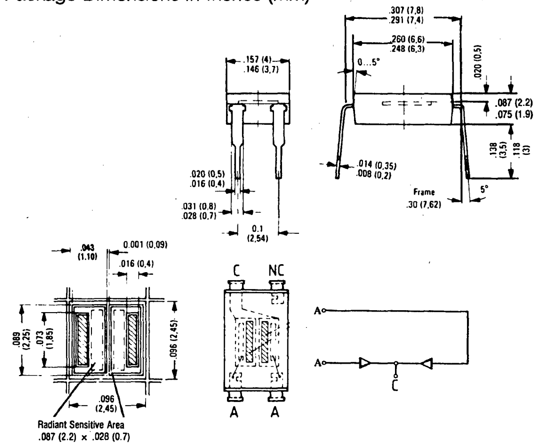
SIEMENS

BPX 48

SILICON DIFFERENTIAL PHOTODIODE



Package Dimensions in Inches (mm)



FEATURES

- **Differential Photodiode**
- **Plastic Encapsulated, Strip Line Technique**
- **Tightly Spaced Diodes for Precise Positional Indication**
- **Lead Bend Option (for SMD)**

DESCRIPTION

The differential photodiode BPX 48 is designed for special industrial electronic applications, such as follow-up control, edge control, path and angle scanning, respectively. The individual diodes are spaced 90 µm apart, thus resulting in a highly precise positional indication. The rise and fall times of the photocurrent are so short that control systems with small down times can be built up. The silicon planar method ensures a low dark current level, low noise and thus very favorable signal relationships.

Maximum Ratings

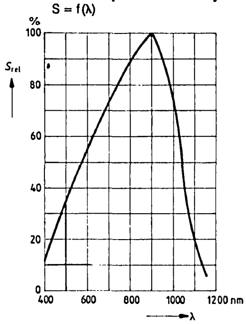
Reverse Voltage (V_R) .... 10 V
Storage Temperature Range .... –40 to +80°C
Soldering Temperature in a 2 mm Distance from the Case Bottom (t ≤ 3 s) (T_S) .... 230°C
Power Dissipation (P_{tot}) .... 50 mW

Characteristics (T_{amb} = 25°C) (Single Diode)

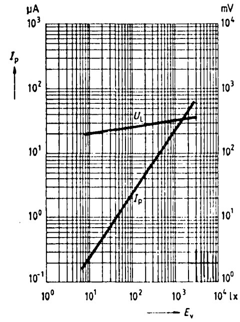
Photosensitivity (V_R = 5 V, Note 1)	S	24 (≥15)	nA/lx
Wavelength of Max. Photosensitivity	λ_{Smax}	850	nm
Spectral Range of Photosensitivity (S = 10% of Smax)	λ	430...1150	nm
Radiant Sensitive Area	A	1.54	mm^2
Dimensions of the Radiant Sensitive Area	L × W	0.7 × 2.2	mm
Distance Between Chip Surface and Package Surface	H	0.5	mm
Half Angle	φ	±60	Deg.
Dark Current (V_R = 10 V)	I_R	100 (≤200)	nA
Spectral Photosensitivity (λ = 850 nm)	S_λ	0.55	A/W
Max. Deviation of Photosensitivity Between Diodes	Δ	±5	%
Quantum Efficiency (λ = 850 nm)	η	0.80	Electrons / Photon
Open Circuit Voltage (E_V = 1000 lx, Note 1)	V_O	330 (≥280)	mV
Short Circuit Current (E_V = 1000 lx, Note 1)	I_{SC}	24 (≥15)	µA
Rise and Fall Time of the Photocurrent from 10% to 90% and from 90% to 10% of the Final Value (R_L = 1 KΩ, V_R = 5 V, λ = 830 nm I_P = 20 µA)	t_r, t_f	500	ns
Forward Voltage (I_F = 100 mA, E_e = 0 T_{amb} = 25°C)	V_F	1.3	V
Capacitance (V_R = 0 V, f = 1 MHz, E_V = 0 lx)	C_0	25	pF
(V_R = 10 V, f = 1 MHz E_V = 0 lx)	C_{10}	6	pF
Temperature Coefficient V_O	TC_V	–2.6	mV/K
Temperature Coefficient I_O	TC_I	0.18	%/K

[1] The illuminance indicated refers to unfiltered radiation of a tungsten filament lamp at a color temperature of 2856 K (standard light A in accordance with DIN 5033 and IEC publ. 306-1).

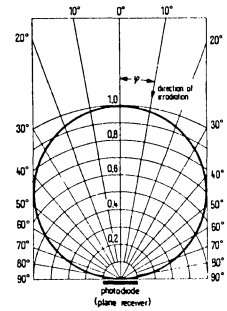
Relative spectral sensitivity
S = f(λ)



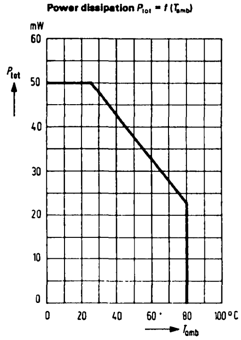
Photocurrent $I_P = f(E_V)$
Open circuit voltage $V_L = f(E_V)$



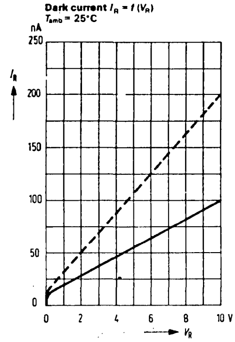
Directional characteristic $S_{rel} = f(\varphi)$



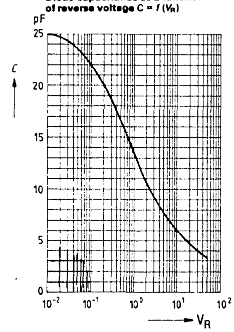
Power dissipation $P_{tot} = f(T_{amb})$



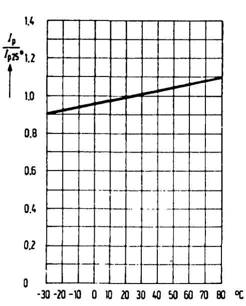
Dark current $I_R = f(V_R)$
T_{amb} = 25 °C



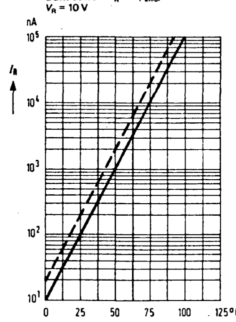
Diode capacitance as a function of reverse voltage $C = f(V_R)$



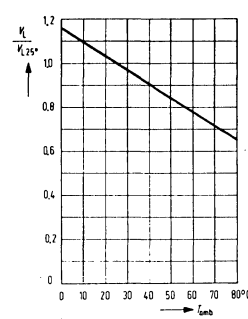
Photocurrent $\frac{I_P}{I_{P25°}} = f(T_{amb})$



Dark current $I_R = f(T_{amb})$
V_R = 10 V



Open circuit voltage $V_L = f(T_{amb})$

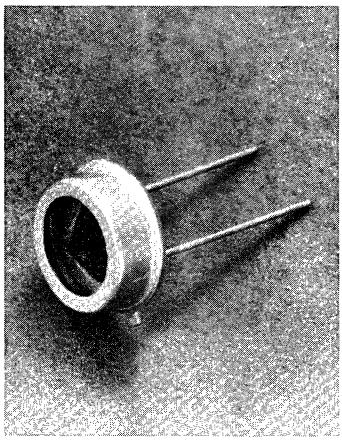


Photodiodes

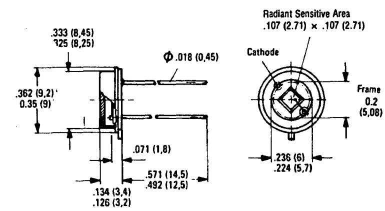
SIEMENS

BPX 60

SILICON PHOTODIODE



Package Dimensions in Inches (mm)



FEATURES

- **Silicon Planar Photodiode**
- **Premium Hi-Rel Device**
- **Modified TO-5 Hermetic Case**
- **Flat Glass Lens**
- **Large Photosensitive Area**
- **Suitable for Visible as well as IR Range**

DESCRIPTION

The BPX 60 is a planar silicon photodiode. The large area photosensitive system is suitable for cell as well as diode operation at a very low reverse current level. The hermetically sealed case—a TO-5 modification with flat glass window—allows application at extreme operating conditions. The signal/noise ratio is particularly favorable even at low illuminances. The open circuit voltage at low illuminances is higher than with comparable mesa photovoltaic cells.

Maximum Ratings

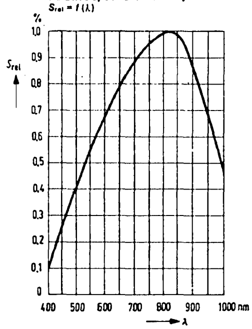
Reverse Voltage (V_R) .... 32 V
Operating and Storage Temperature Range .... −40 to +80°C
Soldering Temperature in a 2 mm Distance
from the Case Bottom ($t \leq 3$ s) (T_S) .... 230°C
Power Dissipation (P_{tot}) .... 325 mW
Thermal Resistance (R_{thJamb}) .... 300 K/W
($R_{thJcase}$) .... 80 K/W

Characteristics (T_{amb} = 25°C)

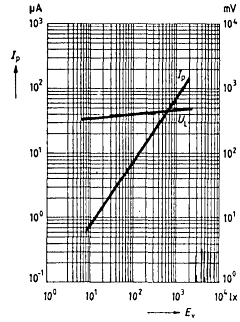
Photosensitivity (V_R = 5 V, Note 1)	S	70 (≥35)	nA/lx
Wavelength of Max. Photosensitivity	λ_{Smax}	850	nm
Spectral Range of Photosensitivity (S = 10% of Smax)	λ	400...1100	nm
Radiant Sensitive Area	A	7.34	mm^2
Dimensions of the Radiant Sensitive Area	L × W	2.71 × 2.71	mm
Distance Between Chip Surface and Package Surface	H	1.9...2.3	mm
Half Angle	φ	±55	Deg.
Dark Current (V_R = 10 V)	I_R	7 (≤300)	nA
Spectral Photosensitivity (λ = 850 nm)	S_λ	0.50	A/W
Quantum Efficiency (λ = 850 nm)	η	0.73	$\frac{\text{Electrons}}{\text{Photon}}$
Open Circuit Voltage (E_V = 1000 lx, Note 1)	V_O	460 (≥390)	mV
Short Circuit Current (E_V = 1000 lx, Note 1)	I_{SC}	70 (≥35)	μA
Rise and Fall Time of the Photocurrent from 10% to 90% and from 90% to 10% of the Final Value (R_L = 1 KΩ, V_R = 5 V, λ = 830 nm, I_P = 70 μA)	t_r, t_f	3.0	μs
Forward Voltage (I_F = 100 mA, E_e = 0, T_{amb} = 25°C)	V_F	1.3	V
Capacitance (V_R = 0 V, f = 1 MHz, E_V = 0 lx)	C_0	580	pF
Temperature Coefficient V_O	TC_V	−2.6	mV/K
Temperature Coefficient I_S	TC_I	0.18	%/K
Noise Equivalent Power (V_R = 1 V)	NEP	9.5×10^{-14}	$\frac{W}{\sqrt{Hz}}$
Detection limit (V_R = 1 V)	D*	2.9×10^{12}	$\frac{cm \cdot \sqrt{Hz}}{W}$

[1] The illuminance indicated refers to unfiltered radiation of a tungsten filament lamp at a color temperature of 2856 K (standard light A in accordance with DIN 5033 and IEC publ. 306-1).

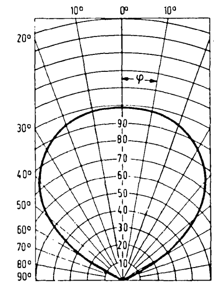
Relative spectral sensitivity $S_{rel} = f(\lambda)$



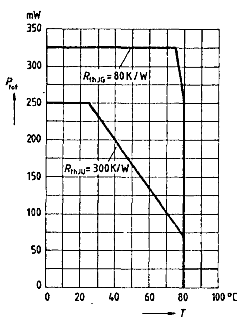
Photocurrent $I_P = f(E_V)$
Open circuit voltage $V_L = f(E_V)$



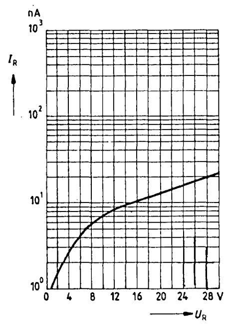
Directional characteristic $S_{rel} = f(\varphi)$



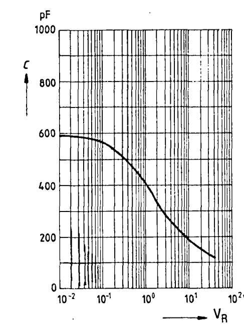
Power dissipation $P_{tot} = f(T_{amb})$



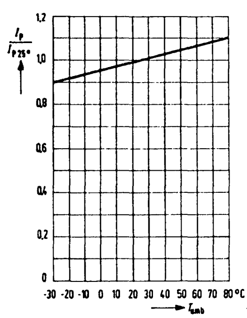
Dark current $I_R = f(V_R)$



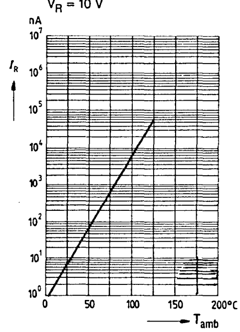
Capacitance $C = f(V_R)$; $f = 1$ MHz



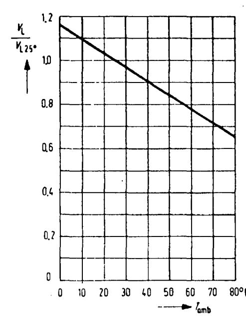
Photocurrent $\frac{I_P}{I_{P\,25°}} = f(T_{amb})$



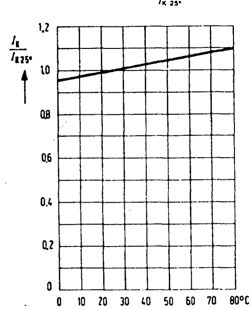
Dark current $I_R = f(T_{amb})$
$V_R = 10$ V



Open circuit voltage $\frac{V_L}{V_{L\,25°}} = f(T_{amb})$



Short circuit current $\frac{I_K}{I_{K\,25°}} = f(T_{amb})$



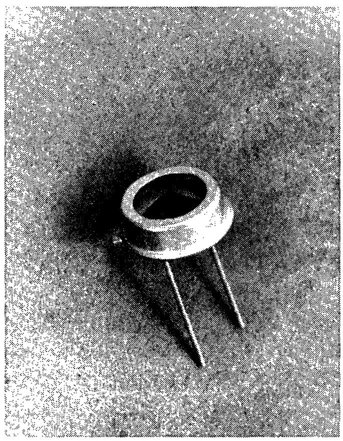
BPX 60

Photodiodes

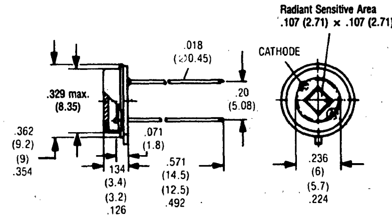
SIEMENS

BPX 61

SILICON PIN PHOTODIODE



Package Dimensions in Inches (mm)



FEATURES

- **Silicon Planar PIN Photodiode**
- **Premium Hi-Rel Device**
- **Modified TO-5 Hermetic Case**
- **Flat Glass Lens**
- **Large Photosensitive Area**
- **Low Dark Current**
- **Short Switching Time**
- **Suitable for Visible as well as IR Range**

DESCRIPTION

The BPX 61 is a planar silicon photodiode with low reverse current. Its low capacitance permits use up to 10 MHz. The large area photosensitive system is suitable for cell as well as diode operation at a very low reverse current level. The hermetically sealed case—a TO-5 modification with flat glass window—allows application at extreme operating conditions. The signal/noise ratio is particularly favorable even at low illuminances. The open circuit voltage at low illuminances is higher than with comparable mesa photovoltaic cells. The PIN photodiode is outstanding for low junction capacitance, high cut-off frequency and short switching times.

Maximum Ratings

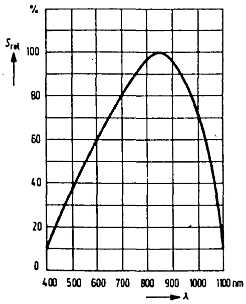
Reverse Voltage (V_R)	32 V
Operating and Storage Temperature Range	−40 to +80°C
Soldering Temperature in a 2 mm Distance from the Case Bottom ($t \leq 3$ s) (T_S)	230°C
Power Dissipation (T_{amb} = 25°C) (P_{tot})	325 mW
Thermal Resistance (R_{thJamb})	300 K/W
($R_{thJcase}$)	80 K/W

Characteristics (T_{amb} = 25°C)

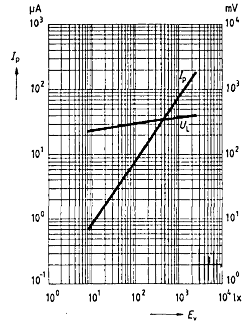
Photosensitivity (V_R = 5 V, Note 1)	S	70 (≥50)	nA/lx
Wavelength of Max. Photosensitivity	λ_{Smax}	850	nm
Spectral Range of Photosensitivity (S = 10% of Smax)	λ	400... 1100	nm
Radiant Sensitive Area	A	7.00	mm²
Dimensions of the Radiant Sensitive Area	L × W	2.65 × 2.65	mm
Distance Between Chip Surface and Package Surface	H	1.9...2.3	mm
Half Angle	φ	±55	Deg.
Dark Current (V_R = 10 V)	I_R	2 (≤30)	nA
Spectral Photosensitivity (λ = 850 nm)	S_λ	0.62	A/W
Quantum Efficiency (λ = 850 nm)	η	0.90	$\frac{\text{Electrons}}{\text{Photon}}$
Open Circuit Voltage (E_V = 1000 lx, Note 1)	V_O	375 (≥320)	mV
Short Circuit Current (E_V = 1000 lx, Note 1)	I_{SC}	70 (≥50)	µA
Rise and Fall Time of the Photocurrent from 10% to 90% and from 90% to 10% of the Final Value (R_L = 1 KΩ, V_R = 5 V, λ = 830 nm, I_P = 70 µA)	t_r, t_f	350	ns
Forward Voltage (I_F = 100 mA, E_e = 0, T_{amb} = 25°C)	V_F	1.3	V
Capacitance (V_R = 0 V, f = 1 MHz, E_V = 0 lx)	C_0	72	pF
Temperature Coefficient V_O	TC_V	−2.6	mV/K
Temperature Coefficient I_S	TC_I	0.18	%/K
Noise Equivalent Power (V_R = 10 V)	NEP	4.1×10^{-14}	$\frac{W}{\sqrt{Hz}}$
Detection Limit (V_R = 10 V)	D	6.6×10^{12}	$\frac{cm\sqrt{Hz}}{W}$

[1] The illuminance indicated refers to unfiltered radiation of a tungsten filament lamp at a color temperature of 2856 K (standard light A in accordance with DIN 5033 and IEC publ. 306-1).

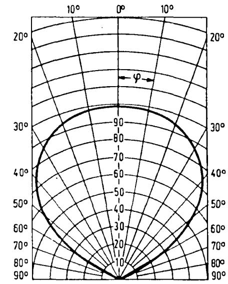
Relative spectral sensitivity
$S_{rel} = f(\lambda)$



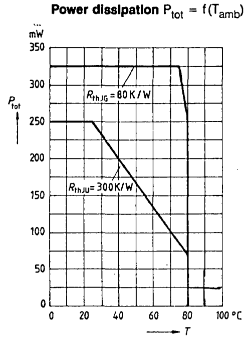
Photocurrent $I_P = f(E_V)$
Open circuit voltage $V_O = f(E_V)$



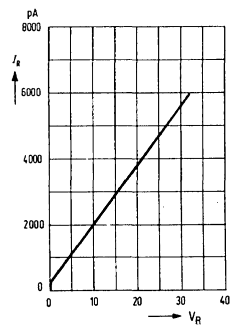
Directional characteristic $S_{rel} = f(\varphi)$



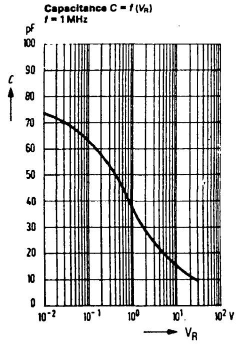
Power dissipation $P_{tot} = f(T_{amb})$



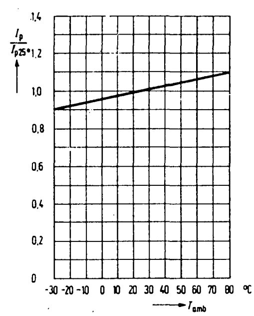
Dark current $I_R = f(V_R)$



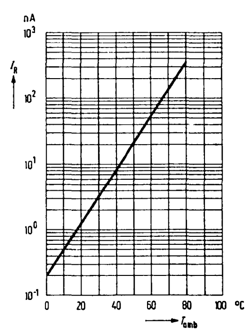
Capacitance $C = f(V_R)$
$f = 1$ MHz



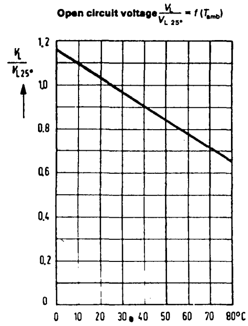
Photocurrent $\frac{I_P}{I_{P\,25°}} = f(T_{amb})$



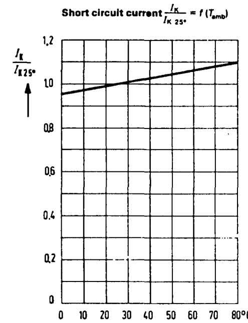
Dark current $I_R = f(T_{amb})$



Open circuit voltage $\frac{V_L}{V_{L\,25°}} = f(T_{amb})$



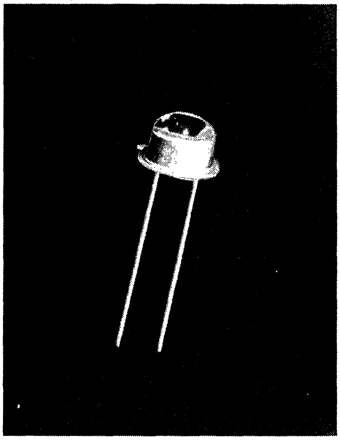
Short circuit current $\frac{I_K}{I_{K\,25°}} = f(T_{amb})$



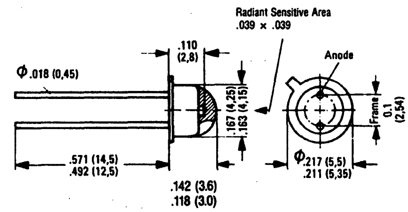
SIEMENS

BPX 63

SILICON PHOTODIODE



Package Dimensions in Inches (mm)



FEATURES

- **Very Low Dark Current**
- **Silicon Planar Photodiode**
- **Modified TO-18 Package**
- **Metal Case and Plastic Lens**

DESCRIPTION

The BPX 63 is a planar silicon photodiode, mounted on a TO-18 base plate and covered with transparent plastic material. The BPX 63 has been developed as a detector for low illuminances and is intended for use as a sensor for exposure meters and automatic exposure meters. The component is outstanding for low dark currents and—when used as a voltaic cell—for a high open circuit voltage at low illuminances. The cathode of the BPX 63 is electrically connected to the case.

Maximum Ratings

Reverse Voltage (V_R)	7 V
Operating and Storage Temperature Range	−40 to +80°C
Soldering Temperature in a 2 mm Distance from the Case Bottom ($t \leq 3$ s) (T_S)	230°C
Power Dissipation (T_{amb} = 25°C) (P_{tot})	200 mW

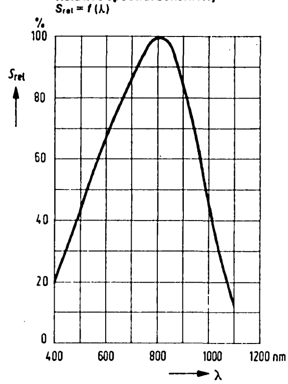
Characteristics (T_{amb} = 25°C)

Photosensitivity (V_R = 5 V, Note 1)	S	10 (≥8)	nA/lx
Wavelength of Max. Photosensitivity	λ_{Smax}	800	nm
Spectral Range of Photosensitivity (S = 10% of Smax)	λ	350...1100	nm
Radiant Sensitive Area	A	0.97	mm^2
Dimensions of the Radiant Sensitive Area	L × W	0.985 × 0.985	mm
Distance Between Chip Surface and Package Surface	H	0.2...0.8	mm
Half Angle	φ	±75	Deg.
Dark Current (V_R = 1 V)	I_R	5 (≤20)	pA
Zero Cross Over (E_V = 0 T_{amb} = 50°C, Note 2)	S_o	≥20	pA/mV
Spectral Photosensitivity (λ = 850 nm)	S_λ	0.50	A/W
Quantum Efficiency (λ = 800 nm)	η	0.73	$\frac{Electrons}{Photon}$
Open Circuit Voltage (E_V = 1000 lx, Note 1)	V_O	450 (≥380)	mV
Short Circuit Current (E_V = 1000 lx, Note 1)	I_{SC}	10 (≥8)	µA
Rise and Fall Time of the Photocurrent from 10% to 90% and from 90% to 10% of the Final Value (R_L = 1 KΩ, V_R = 5 V, λ = 830 nm, I_P = 10 µA)	t_r, t_f	1.3	µs
Forward Voltage (I_F = 100 mA, E_e = 0 T_{amb} = 25°C)	V_F	1.3	V
Capacitance (V_R = 0 V, f = 1 MHz, E_V = 0 lx)	C_0	100	pF
Temperature Coefficient V_O	TC_V	−2.6	mV/K
Temperature Coefficient I_S	TC_I	0.16	%/K
Noise Equivalent Power (V_R = 1 V)	NEP	2.5×10^{-15}	$\frac{W}{\sqrt{Hz}}$
Detection Limit (V_R = 1 V)	D	3.9×10^{13}	$\frac{cm\sqrt{Hz}}{W}$

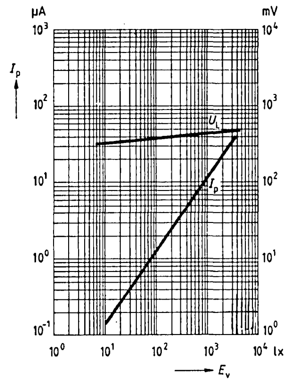
[1] The illuminance indicated refers to unfiltered radiation of a tungsten filament lamp at a color temperature of 2856 K (standard light A in accordance with DIN 5033 and IEC publ. 306-1).

[2] S_O is a measure for the lowest spectral sensitivity when the photodiode is used in exposure meters. The zero cross over S_O is defined in the diagram.

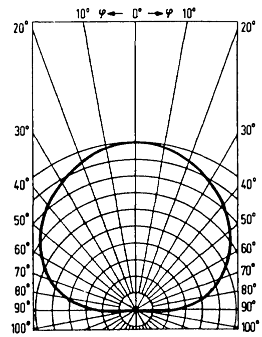
Relative spectral sensitivity
$S_{rel} = f(\lambda)$



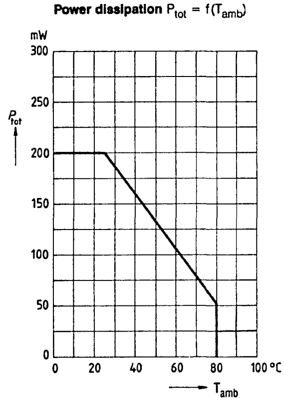
Photocurrent $I_P = f(E_V)$
Open circuit voltage $V_O = f(E_V)$



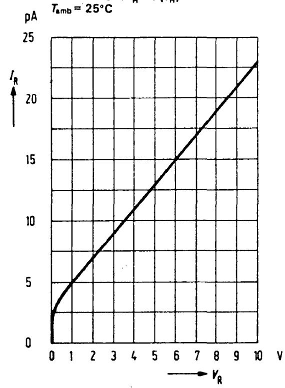
Directional characteristic $S_{rel} = f(\varphi)$



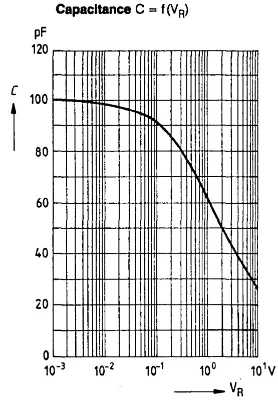
Power dissipation $P_{tot} = f(T_{amb})$



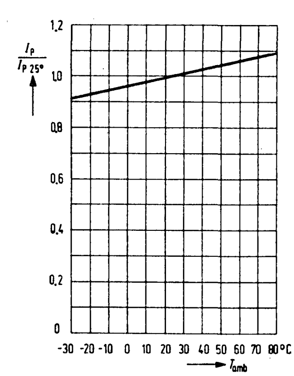
Dark current $I_R = f(V_R)$
$T_{amb} = 25°C$



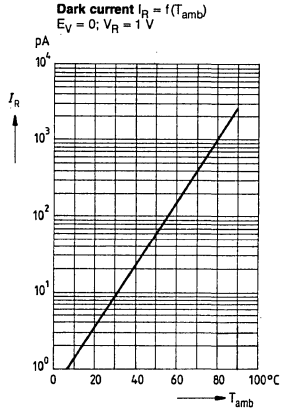
Capacitance $C = f(V_R)$



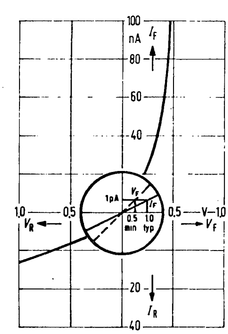
Photocurrent $\frac{I_P}{I_{P\,25°}} = f(T_{amb})$



Dark current $I_R = f(T_{amb})$
$E_V = 0$; $V_R = 1$ V



Zero cross over $S_0 = \frac{V_F}{I_F}$

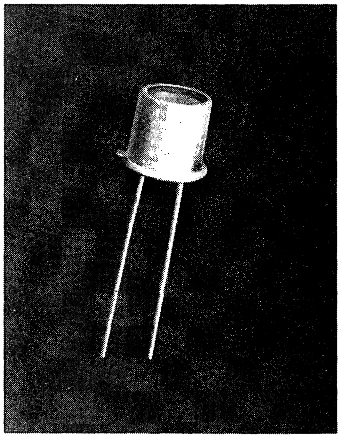


Photodiodes

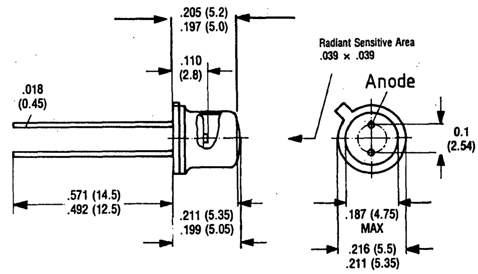
SIEMENS

BPX 65

SILICON PIN PHOTODIODE



Package Dimensions in Inches (mm)



FEATURES

- **Silicon Planar PIN Photodiode**
- **Premium Hi-Rel Device**
- **TO-18 Size Package**
- **Flat Glass Lens**
- **High Speed**
- **Low Dark Current**
- **Suitable for the Visible as well as IR Range**

DESCRIPTION

The BPX 65 is a planar silicon PIN photodiode in a case 18 A 2 DIN 41876 (sim. to TO-18) with a flat window. The cathode is electrically connected to the case. The flat window has no influence on the beam path of optical lens systems. Because of its high cut-off frequency this diode is particularly suitable for use as optical sensor of high modulation bandwidth.

The PIN photodiode is outstanding for low junction capacitance and short switching times.

Maximum Ratings

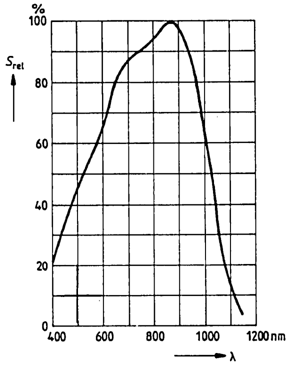
Reverse Voltage (V_R)	50 V
Operating and Storage Temperature Range	−40 to +80°C
Soldering Temperature in a 2 mm Distance from the Case Bottom ($t \leq 3$ s) (T_S)	230°C
Power Dissipation (P_{tot})	230 mW

Characteristics (T_{amb} = 25°C)

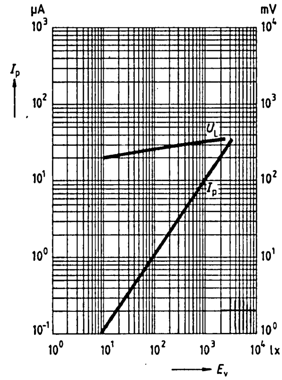
Photosensitivity (V_R = 5 V, Note 1)	S	10 (≥5.5)	nA/lx
Wavelength of Max. Photosensitivity	λ_{Smax}	850	nm
Spectral Range of Photosensitivity (S = 10% of Smax)	λ	350... 1100	nm
Radiant Sensitive Area	A	1.00	mm²
Dimensions of the Radiant Sensitive Area	L × W	1 × 1	mm
Distance Between Chip Surface and Package Surface	H	2.25...2.55	mm
Half Angle	φ	±40	Deg.
Dark Current (V_R = 20 V)	I_R	1 (≤5)	nA
Spectral Photosensitivity (λ = 850 nm)	S_λ	0.55	A/W
Quantum Efficiency (λ = 850 nm)	η	0.80	$\frac{\text{Electrons}}{\text{Photon}}$
Open Circuit Voltage (E_V = 1000 lx, Note 1)	V_O	320 (≥270)	mV
Short Circuit Current (E_V = 1000 lx, Note 1)	I_{SC}	10 (≥5.5)	μA
Rise and Fall Time of the Photocurrent from 10% to 90% and from 90% to 10% of the Final Value (R_L = 50Ω, V_R = 5 V, λ = 880 nm, I_P = 15 μA)	t_r, t_f	30/80	ns
Forward Voltage (I_F = 100 mA, E_e = 0, T_{amb} = 25°C)	V_F	1.3	V
Capacitance			
(V_R = 0 V, f = 1 MHz, E_V = 0 lx)	C_0	11	pF
(V_R = 1 V, f = 1 MHz, E_V = 0 lx)	C_1	6.4	pF
(V_R = 20 V, f = 1 MHz, E_V = 0 lx)	C_{20}	2.4	pF
Temperature Coefficient V_O	TC_V	-2.6	mV/K
Temperature Coefficient I_O	TC_I	0.2	%/K
Noise Equivalent Power (V_R = 20 V)	NEP	3.3×10^{-14}	$\frac{W}{\sqrt{Hz}}$
Detection Limit (V_R = 20 V)	D	3.1×10^{12}	$\frac{cm\sqrt{Hz}}{W}$

[1] The illuminance indicated refers to unfiltered radiation of a tungsten filament lamp at a color temperature of 2856 K (standard light A in accordance with DIN 5033 and IEC publ. 306-1).

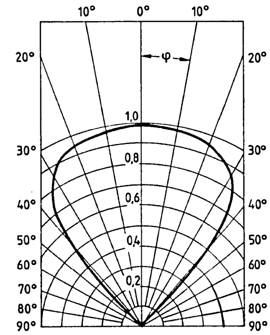
Relative spectral sensitivity
$S_{rel} = f(\lambda)$



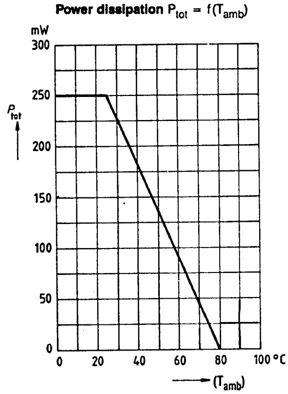
Photocurrent $I_P = f(E_V)$
Open circuit voltage $V_L = f(E_V)$



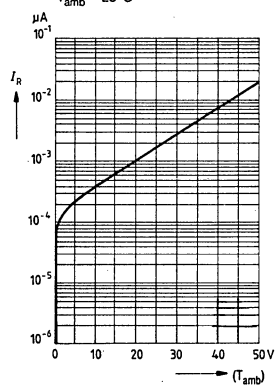
Directional characteristic
$S_{rel} = f(\varphi)$



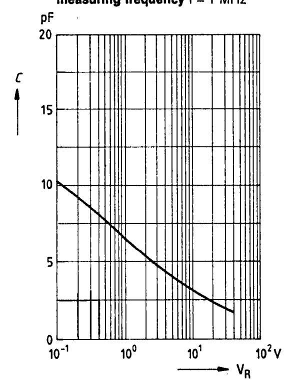
Power dissipation $P_{tot} = f(T_{amb})$



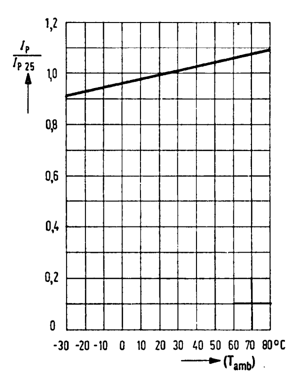
Dark current $I_R = f(T_{amb})$; E = 0
$T_{amb} = 25°C$



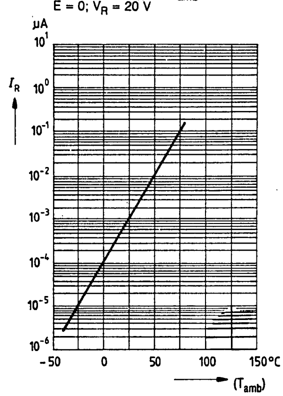
Junction capacitance
$C = f(V_R)$; E = 0
measuring frequency f = 1 MHz



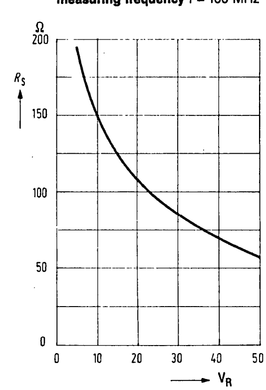
Photocurrent $\frac{I_P}{I_{P25°}} = f(T_{amb})$



Dark current $I_R = f(T_{amb})$
$E = 0$; $V_R = 20$ V



Series resistance
$R_S = f(V_R)$; E = 0
measuring frequency f = 100 MHz

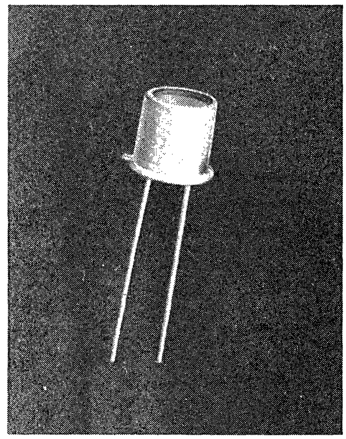


Photodiodes

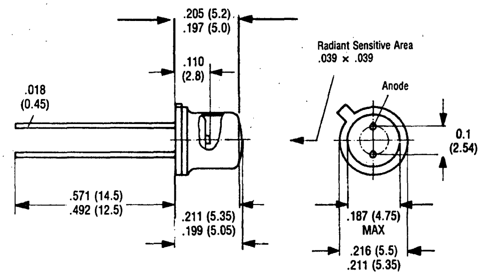
SIEMENS

BPX 66

SILICON PIN PHOTODIODE



Package Dimensions in Inches (mm)



FEATURES

- Silicon Planar PIN Photodiode
- Premium Hi-Rel Device
- TO-18 Size Package
- Flat Glass Lens
- High Speed
- Very Low Dark Current
- Suitable for the Visible as well as IR Range

DESCRIPTION

The BPX 66 is a planar silicon PIN photodiode in a case 18 A 2 DIN 41876 (sim. to TO-18) with a flat window and extremely low dark current. The cathode is electrically connected to the case. The flat window has no influence on the beam path of optical lens systems. Because of its high cut-off frequency, this diode is particularly suitable for use as optical sensor of high modulation bandwidth.

The PIN photodiode is outstanding for low junction capacitance and short switching times.

Maximum Ratings

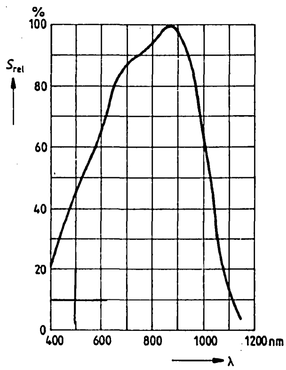
Reverse Voltage (V_R) .... 50 V
Storage Temperature Range .... −40 to +80°C
Soldering Temperature in a 2 mm Distance from the Case Bottom ($t \leq 3$ s) (T_S) .... 230°C
Power Dissipation (P_{tot}) .... 250 mW

Characteristics (T_{amb} = 25°C)

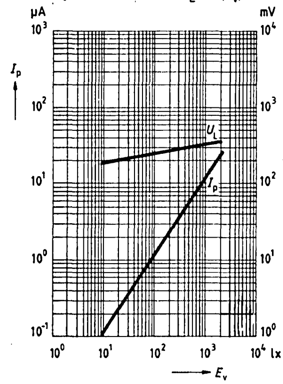
Photosensitivity (V_R = 5 V, Note 1)	S	10 (≥5.5)	nA/lx
Wavelength of Max. Photosensitivity	λ_{Smax}	850	nm
Spectral Range of Photosensitivity (S = 10% of Smax)	λ	350... 1100	nm
Radiant Sensitive Area	A	1.00	mm²
Dimensions of the Radiant Sensitive Area	L × W	1 × 1	mm
Distance Between Chip Surface and Package Surface	H	2.25...2.55	mm
Half Angle	φ	±40	Deg.
Dark Current (V_R = 1 V)	I_R	0.15 (≤0.3)	nA
Spectral Photosensitivity (λ = 850 nm)	S_λ	0.55	A/W
Quantum Efficiency (λ = 850 nm)	η	0.80	Electrons/Photon
Open Circuit Voltage (E_V = 1000 lx, Note 1)	V_O	330 (≥280)	mV
Short Circuit Current (E_V = 1000 lx, Note 1)	I_{SC}	10 (≥5.5)	µA
Rise and Fall Time of the Photocurrent from 10% to 90% and from 90% to 10% of the Final Value. (R_L = 50Ω, V_R = 5 V, λ = 880 nm, I_P = 10 µA)	t_r, t_f	30/80	ns
Forward Voltage (I_F = 100 mA, E_e = 0, T_{amb} = 25°C)	V_F	1.3	V
Capacitance (V_R = 0 V, f = 1 MHz, E_V = 0 lx)	C_0	11	pF
(V_R = 1 V, f = 1 MHz, E_V = 0 lx)	C_1	6.4	pF
(V_R = 20 V, f = 1 MHz, E_V = 0 lx)	C_{20}	2.4	pF
Temperature Coefficient V_O	TC_V	-2.6	mV/K
Temperature Coefficient I_S	TC_I	0.2	%/K
Noise Equivalent Power (V_R = 20 V)	NEP	3.3×10^{-14}	$\frac{W}{\sqrt{Hz}}$
Detection Limit (V_R = 20 V)	D	3.1×10^{12}	$\frac{cm\sqrt{Hz}}{W}$

[1] The illuminance indicated refers to unfiltered radiation of a tungsten filament lamp at a color temperature of 2856 K (standard light A in accordance with DIN 5033 and IEC publ. 306-1).

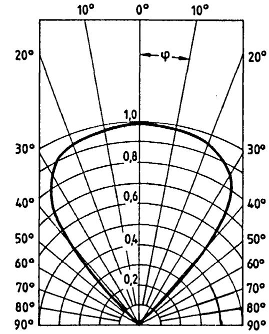
Relative spectral sensitivity
$S_{rel} = f(\lambda)$



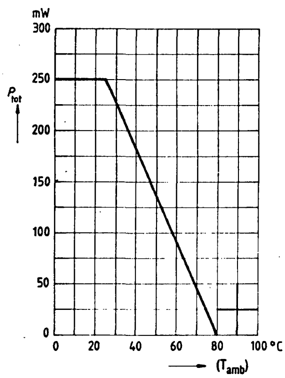
Photocurrent $I_P = f(E_V)$
Open circuit current $V_L = f(E_V)$



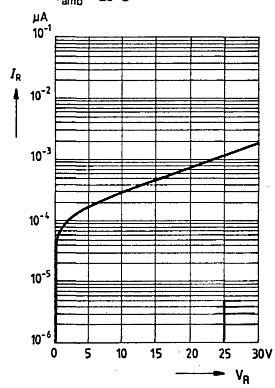
Directional characteristic
$S_{rel} = f(\varphi)$



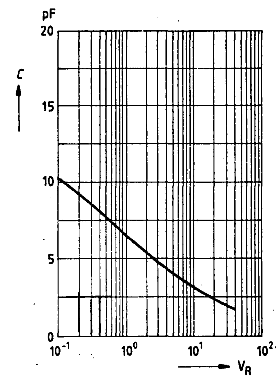
Power dissipation $P_{tot} = f(T_{amb})$



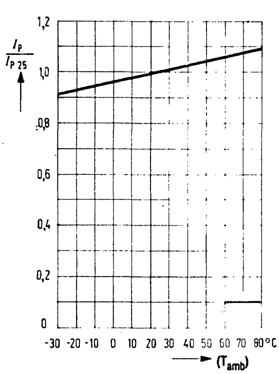
Dark current $I_R = f(V_R)$; E = 0
T_{amb} = 25°C



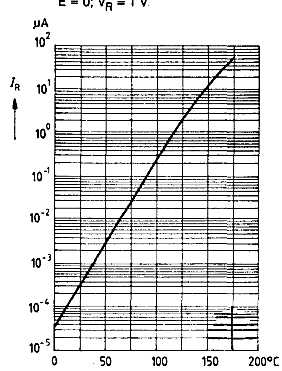
Junction capacitance
$C = f(V_R)$; E = 0
measuring frequency f = 1 MHz



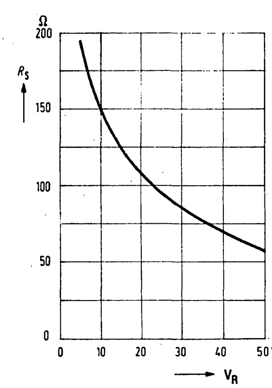
Photocurrent $\frac{I_P}{I_{P25°}} = f(T_{amb})$



Dark current $I_R = f(T_{amb})$
E = 0; V_R = 1 V



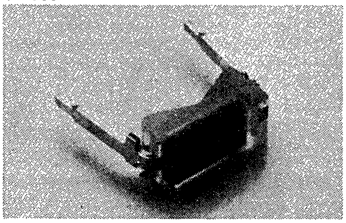
Series resistance
$R_S = f(V_R)$; E = 0
measuring frequency f = 100 MHz



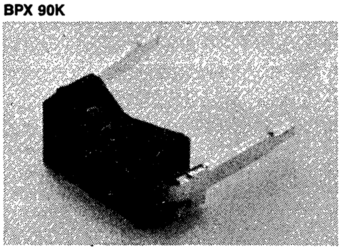
SIEMENS

BPX 90
WITH DAYLIGHT FILTER BPX 90K
PLANAR SILICON PHOTODIODE

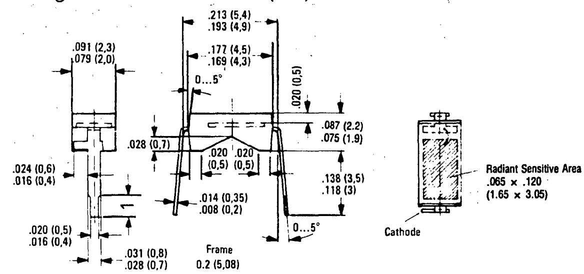
BPX 90



BPX 90K



Package Dimensions in Inches (mm)



FEATURES

- **Transparent Plastic Package – BPX 90**
- **Daylight Filter – BPX 90K**
- **Silicon Planar Photodiode**
- **0.2″ Lead Spacing**
- **High Sensitivity, BPX 90: 45 nA/lx; BPX 90K: 13 nA/lx**
- **Lead Bend Option (for SMD)**

DESCRIPTION

The BPX90 and BPX90K are planar silicon photodiodes. The BPX90 is in a transparent plastic package. The BPX90K is in a black plastic package with IR filter. Its terminals are soldering tabs arranged in 0.2″ (5.08 mm) lead spacing. Due to its design, the diode can be easily assembled on PC boards. The flat back of the epoxy resin case makes rigid fixing of the component feasible. Arrays can be realized by multiple arrangements.

This versatile photodetector is suitable for diode as well as voltaic cell operation. The signal/noise ratio is particularly favorable, even at low illuminances. The open circuit voltage at low illuminances is higher than with comparable mesa photovoltaic cells.

Maximum Ratings

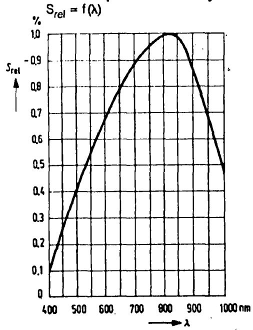
Reverse Voltage (V_R) ....32 V
Operating and Storage
Temperature Range ....−40 to +80°C
Soldering Temperature in a 2 mm Distance
from the Case Bottom (t≤3 s) (T_S)........230°C
Power Dissipation (P_{tot})..................100 mW

Characteristics (T_{amb} = 25°C)

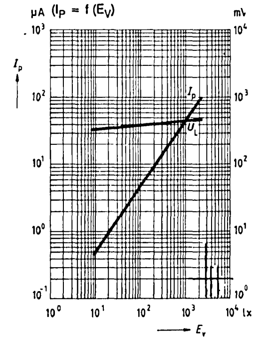
	Symbol	BPX90	BPX90K	Unit
Photosensitivity (V_R = 5 V, Note 1)	S	45 (≥25)	—	nA/lx
(V_R = 5 V, λ=950 nm, E_e=0.5 mW/cm²)		—	13 (≥8)	μA
Wavelength of Max. Photosensitivity	λ_{Smax}	850	950	nm
Spectral Range of Photosensitivity (S = 10% of Smax)	λ	400...1100	800...1150	nm
Radiant Sensitive Area	A	5.5	5	mm²
Dimensions of the Radiant Sensitive Area	L x W	1.75 x 3.15	1.65 x 3.05	mm
Distance Between Chip Surface and Package Surface	H	0.5	0.5	mm
Half Angle	φ	±60	±60	Deg.
Dark Current (V_R = 10 V)	I_R	5 (≤200)	5 (≤200)	nA
Spectral Photosensitivity (λ = 850 nm)	S_λ	0.50	0.48	A/W
Quantum Efficiency (λ = 850 nm)	η	0.73	0.62	Electrons / Photon
Open Circuit Voltage (E_e = 0.5 mW/cm², λ = 950 nm)	V_O	450 (≥380)	400 (≥340)	mV
Short Circuit Current (E_e = 0.5 mW/cm², λ =950 nm)	I_{SC}	45 (≥25)	13 (≥8)	μA
Rise and Fall Time of the Photocurrent from 10% to 90% and from 90% to 10% of the Final Value (R_L = 1 KΩ, V_R = 5 V, λ = 830 nm, I_P = 45 μA/BPX90, I_P = 30 μA/BPX90K)	t_r, t_f	1.3	1.3	μsec
Forward Voltage (I_F = 100 mA, E_e = 0, T_{amb} = 25°C)	V_F	1.3	1.3	V
Capacitance (V_R = 0 V, f = 1 MHz, E_V = 0 lx)	C_O	430	430	pF
(V_R = 10 V, f = 1 MHz, E_V = 0 lx)	C_{10}	100	100	pF
Temperature Coefficient V_O	TC_V	-2.6	-2.6	mV/K
Temperature Coefficient I_S	TC_I	0.18	0.18	%/K
Noise Equivalent Power (V_R=1 V)	NEP	8 x 10^{-14}	8 x 10^{-14}	$\frac{W}{\sqrt{Hz}}$
Detection Limit (V_R=1 V)	D	2.9 x 10^{12}	2.9 x 10^{12}	$\frac{cm \cdot \sqrt{Hz}}{W}$

[1]The illuminance indicated refers to unfiltered radiation of a tungsten-filament lamp at a color temperature of 2856 K. (Standard light A in accordance with DIN 5033 and IEC publ. 306-1.)

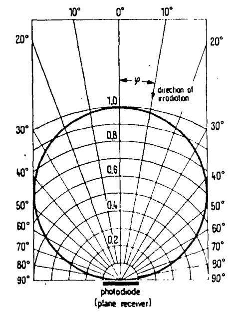
BPX90
Relative spectral sensitivity
$S_{rel} = f(\lambda)$



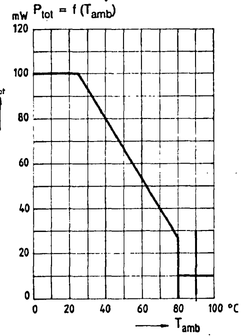
BPX90
Photocurrent
$(I_P = f(E_V))$



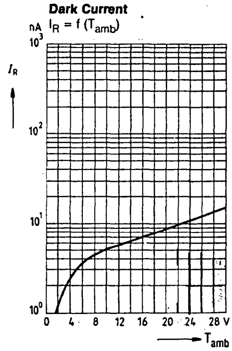
Directional characteristic $S_{rel} = f(\varphi)$



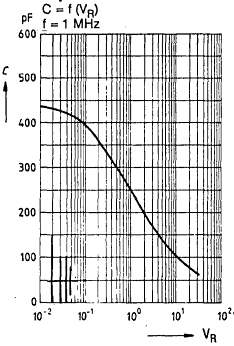
Power Dissipation
$P_{tot} = f(T_{amb})$



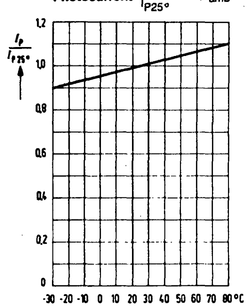
Dark Current
$I_R = f(T_{amb})$



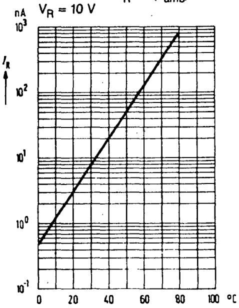
Capacitance
$C = f(V_R)$
f = 1 MHz



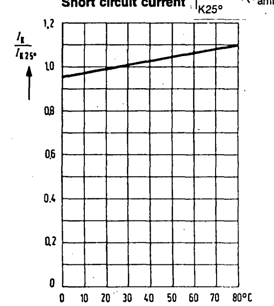
Photocurrent $\frac{I_P}{I_{P25°}} = f(T_{amb})$



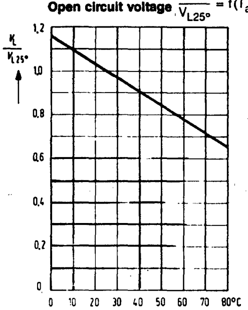
Dark current $I_R = f(T_{amb})$
$V_R = 10\ V$



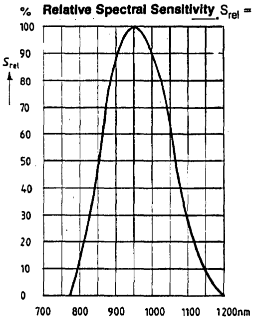
Short circuit current $\frac{I_K}{I_{K25°}} = f(T_{amb})$



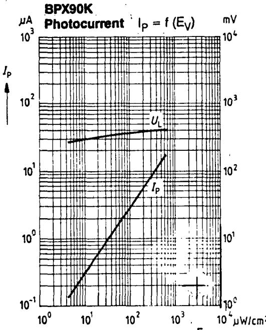
Open circuit voltage $\frac{V_L}{V_{L25°}} = f(T_{amb})$



BPX90K
Relative Spectral Sensitivity $S_{rel} = f(\lambda)$



BPX90K
Photocurrent $I_P = f(E_V)$

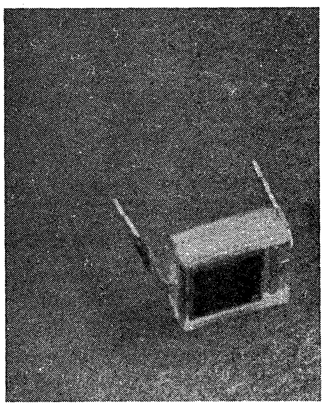


Photodiodes

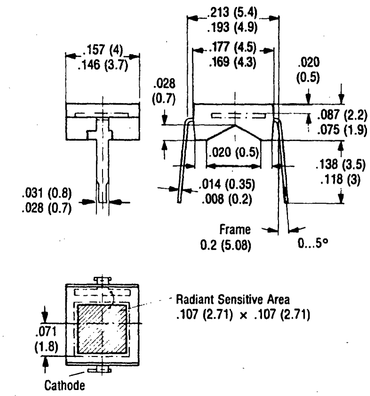
SIEMENS

BPX 91B

SILICON PHOTODIODE



Package Dimensions in Inches (mm)



Supercedes BPX 91

FEATURES

- **High Blue Sensitivity, 400 mm = 30% Srel**
- **Low Dark Current**
- **Transparent Plastic Package**
- **2/10″ (5.08 mm) Lead Spacing**
- **Lead Bend Option (for SMD)**

DESCRIPTION

The BPX 91B is a planar silicon photodiode, which is incorporated in a transparent plastic package. Its terminals are soldering tabs arranged in 2/10″ (5.08 mm) lead spacing. Due to its design, the diode can also very easily be assembled on PC boards. The flat back of the epoxy resin case makes rigid fixing of the component feasible. Arrays can be realized by multiple arrangements. The increased blue sensitivity with short wavelength makes the BPX 91B particularly suitable for application with high blue light source.

This versatile photodetector is suitable for diode as well as voltaic cell operation. The signal/noise ratio is particularly favorable, even at low illuminances. The open circuit voltage at low illuminances is higher than with comparable mesa photovoltaic cells. The cathode is marked by a tab on the solder lead.

Maximum Ratings

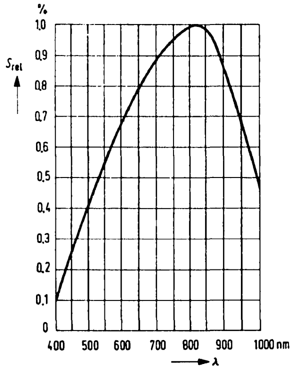
Reverse Voltage (V_R) .... 10 V
Operating and Storage Temperature Range .... −40 to +80°C
Soldering Temperature in a 2 mm Distance from the Case Bottom ($t \leq 3$ s) (T_S) .... 230°C
Power Dissipation (T_{amb} = 25°C) (P_{tot}) .... 150 mW

Characteristics (T_{amb} = 25°C)

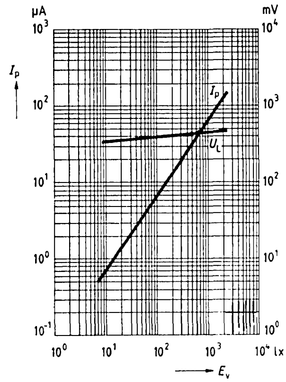
Photosensitivity	S	65 (≥35)	nA/lx
Wavelength of Max. Photosensitivity	λ_{Smax}	850	nm
Spectral Range of Photosensitivity (S = 10% of Smax)	λ	320... 1100	nm
Radiant Sensitive Area	A	7.45	mm²
Dimensions of the Radiant Sensitive Area	L × W	2.73 × 2.73	mm
Distance Between Chip Surface and Package Surface	H	0.5	mm
Half Angle	φ	±60	Deg.
Dark Current (V_R = 10 V, E = 0)	I_R	7 (≤300)	nA
Spectral Photosensitivity (λ = 850 nm)	S_λ	0.60	A/W
Quantum Yield	η	0.86	Electrons/Photon
Open Circuit Voltage (E_V = 1000 lx, Note 1)	V_O	450 (≥380)	mV
Short Circuit Current (E_V = 1000 lx, Note 1)	I_{SC}	65 (≥35)	μA
Rise and Fall Time of the Photocurrent (R_L = 1 KΩ, V_R = 5 V, λ = 830 nm, I_P = 65 μA)	t_r, t_f	1.6	μs
Forward Voltage (I_F = 100 mA, E_e = 0, T_{amb} = 25°C)	V_F	1.3	V
Capacitance (V_R = 0 V, f = 1 MHz, E = 0)	C_0	580	pF
(V_R = 10 V, f = 1 MHz, E = 0)	C_{10}	180	pF
Temperature Coefficient V_O	TC_V	-2.6	mV/K
Temperature Coefficient I_S	TC_I	0.2	%/K
Noise Equivalent Power (V_R = 1 V)	NEP	7.9×10^{-14}	$\frac{W}{\sqrt{Hz}}$
Detection Limit (V_R = 1 V)	D	3.5×10^{12}	$\frac{cm \cdot \sqrt{Hz}}{W}$

[1] The illuminance indicated refers to unfiltered radiation of a tungsten filament lamp at a color temperature of 2856 K (standard light A in accordance with DIN 5033 and IEC publ. 306-1).

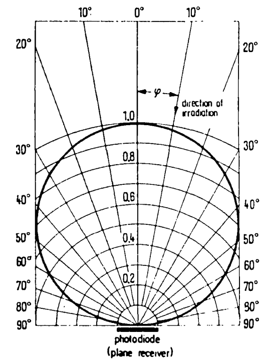
Relative spectral sensitivity
$S_{rel} = f(\lambda)$



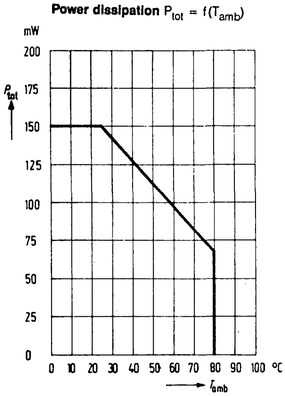
Photocurrent $I_P = f(E_V)$
Open circuit voltage $V_L = f(E_V)$



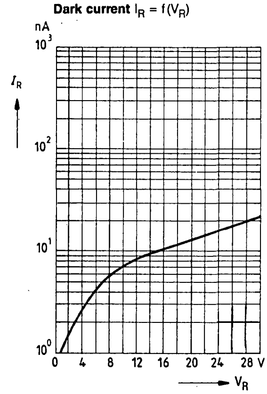
Directional characteristic
$S_{rel} = f(\varphi)$



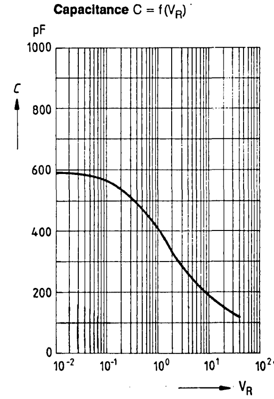
Power dissipation $P_{tot} = f(T_{amb})$



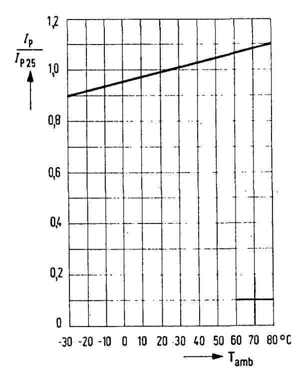
Dark current $I_R = f(V_R)$



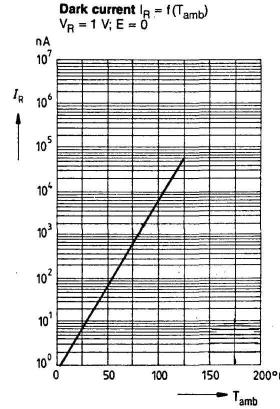
Capacitance $C = f(V_R)$



Photocurrent $\frac{I_P}{I_{P25°}} = f(T_{amb})$

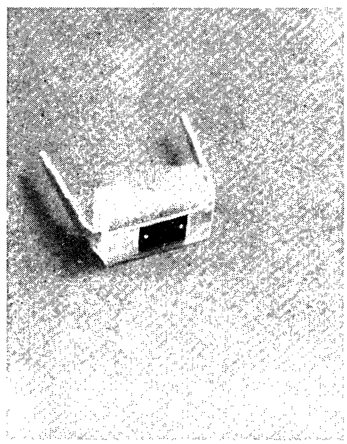


Dark current $I_R = f(T_{amb})$
$V_R = 1$ V; $E = 0$

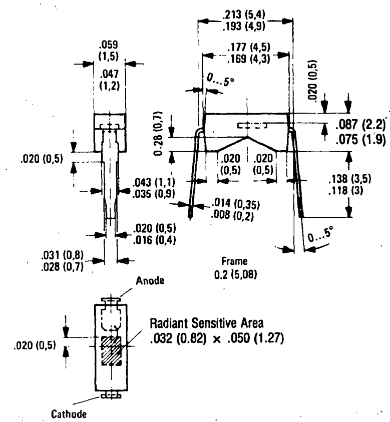


SIEMENS

BPX 92
PHOTODIODE



Package Dimensions in Inches (mm)



FEATURES

- **Silicon Planar Photodiode**
- **Transparent Plastic Package**
- **2/10" Lead Spacing**
- **Low Dark Current, 1 nA**
- **Lead Bend Option (for SMD)**

DESCRIPTION

The BPX 92 is a planar silicon photodiode, which is incorporated in a transparent plastic package. Its terminals are soldering tabs arranged in 5.08 mm (2/10") lead spacing. Due to its design the diode can also very easily be assembled on PC boards. The flat back of the epoxy resin case makes rigid fixing of the component feasible. Arrays can be realized by multiple arrangements.

This versatile photodetector is suitable for diode as well as voltaic cell operation. The signal/noise ratio is particularly favorable, even at low illuminances. The open circuit voltage at low illuminances is higher than with comparable mesa photovoltaic cells.

Maximum Ratings

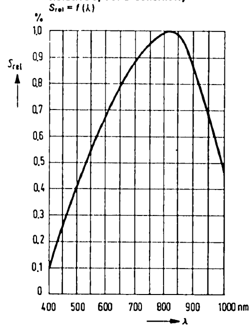
Reverse Voltage (V_R) .... 32 V
Operating and Storage Temperature Range .... −40 to +80°C
Soldering Temperature in a 2 mm Distance from the Case Bottom ($t \leq 3$ s) (T_S) .... 230°C
Power Dissipation (T_{amb} = 25°C) (P_{tot}) .... 50 mW

Characteristics (T_{amb} = 25°C)

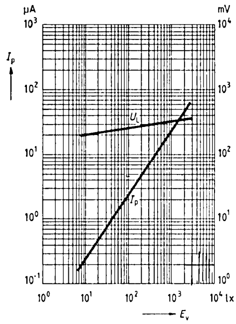
Photosensitivity (V_R = 5 V, Note 1)	S	9.5 (≥4)	nA/lx
Wavelength of Max. Photosensitivity	λ_{Smax}	850	nm
Spectral Range of Photosensitivity (S = 10% of Smax)	λ	400...1100	nm
Radiant Sensitive Area	A	1	mm²
Dimensions of the Radiant Sensitive Area	L × W	0.82 × 1.27	mm
Distance Between Chip Surface and Package Surface	H	0.5	mm
Half Angle	φ	±60	Deg.
Dark Current (V_R = 10 V)	I_R	1 (≤100)	nA
Spectral Photosensitivity (λ = 850 nm)	S_λ	0.50	A/W
Quantum Efficiency (λ = 850 nm)	η	0.73	$\frac{\text{Electrons}}{\text{Photon}}$
Open Circuit Voltage (E_V = 1000 lx, Note 1)	V_O	440 (≥370)	mV
Short Circuit Current (E_V = 1000 lx, Note 1)	I_{SC}	9.5 (≥4)	μA
Rise and Fall Time of the Photocurrent from 10% to 90% and from 90% to 10% of the Final Value (R_L = 1 KΩ, V_R = 5 V, λ = 830 nm, I_P = 20 μA)	t_r, t_f	1.2	μs
Forward Voltage (I_F = 100 mA, E_e = 0, T_{amb} = 25°C)	V_F	1.3	V
Capacitance (V_R = 0 V, f = 1 MHz, E_V = 0 lx)	C_0	90	pF
(V_R = 10 V, f = 1 MHz, E_V = 0 lx)	C_{10}	23	pF
Temperature Coefficient V_O	TC_V	-2.6	mV/K
Temperature Coefficient I_O	TC_I	0.2	%/K
Noise Equivalent Power (V_R = 1 V)	NEP	3.6×10^{-14}	$\frac{W}{\sqrt{Hz}}$
Detection Limit (V_R = 1 V)	D	2.8×10^{12}	$\frac{cm \cdot \sqrt{Hz}}{W}$

[1] The illuminance indicated refers to unfiltered radiation of a tungsten filament lamp at a color temperature of 2856 K (standard light A in accordance with DIN 5033 and IEC publ. 306-1).

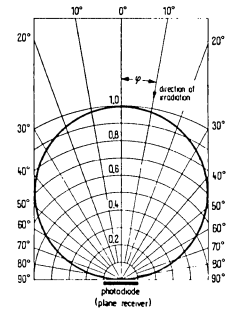
Relative spectral sensitivity $S_{rel} = f(\lambda)$



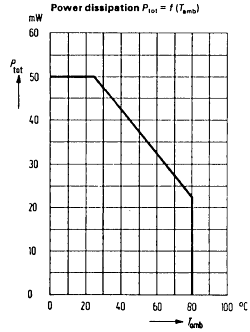
Photocurrent $I_P = f(E_V)$
Open circuit voltage $V_L = f(E_V)$



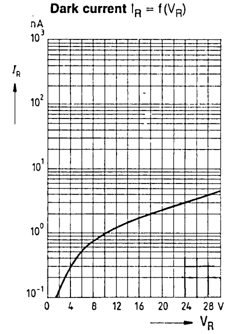
Directional characteristic $S_{rel} = f(\varphi)$



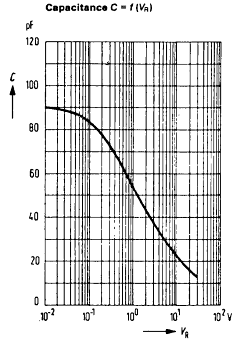
Power dissipation $P_{tot} = f(T_{amb})$



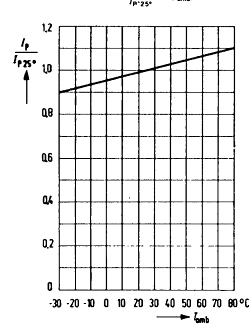
Dark current $I_R = f(V_R)$



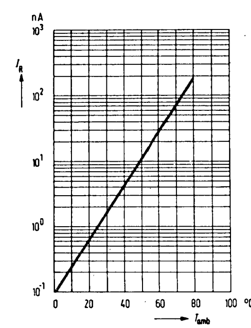
Capacitance $C = f(V_R)$



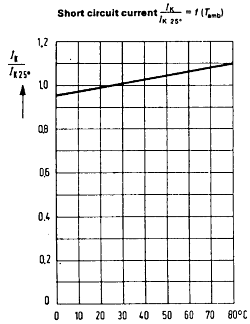
Photocurrent $\frac{I_P}{I_{P\,25°}} = f(T_{amb})$



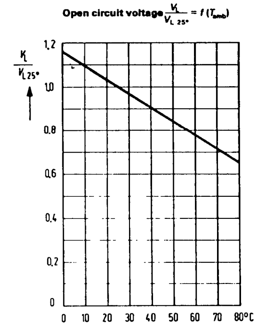
Dark current $I_R = f(T_{amb})$



Short circuit current $\frac{I_K}{I_{K\,25°}} = f(T_{amb})$



Open circuit voltage $\frac{V_L}{V_{L\,25°}} = f(T_{amb})$

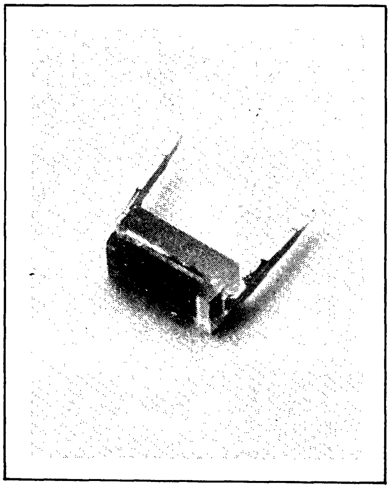


Photodiodes

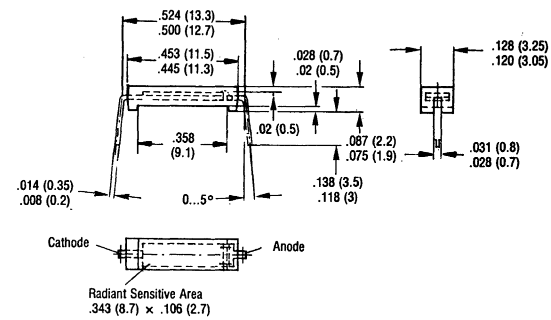
SIEMENS

SFH 100

SILICON PHOTODIODE



Package Dimensions in Inches (mm)



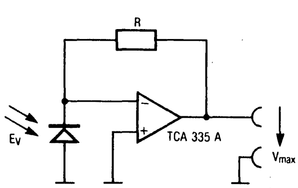
FEATURES

- High Blue Sensitivity
- Very Low Dark Current
- Transparent Plastic Package
- 12.7 mm Lead Spacing
- Low Reverse Voltage
- Lead Bend Option (for SMD)

DESCRIPTION

The SFH100 silicon planar photodiode is supplied for universal applications. It is especially suitable for operation with small reverse voltage (approx. 0.1 V) for the detection of very limited illumination. The increased blue sensitivity of the diode lightens application with luminous source, which has a short wave emission spectrum. The component is built in a transparent plastic package and contains solder tab leads spaced at 12.7 mm.

Switching Applications



A type with small input current should be used as operational amplifier.

$R = \frac{V_{max}}{I_{K\,max}}$

$I_K = E_{V\,max} \times 175$
($E_{V\,max}$ in Lux → $I_{V\,max}$ in nA)

Maximum Ratings

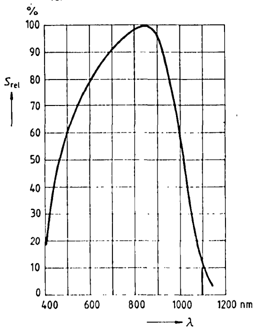
Reverse Voltage (V_R) .... 7 V
Operating and Storage Temperature Range .... −40 to +80°C
Soldering Temperature in a 2 mm Distance from the Case Bottom ($t \leq 3$ s) (T_S) .... 230°C
Power Dissipation (P_{tot}) .... 100 mW

Characteristics (T_{amb} = 25°C)

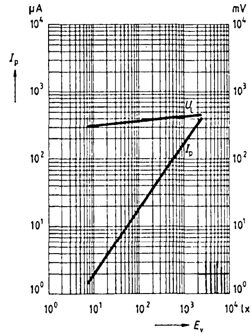
Photosensitivity (V_R = 5 V, Note 1)	S	175 (≥150)	nA/lx
Wavelength of Max. Photosensitivity	λ_{Smax}	850	nm
Spectral Range of Photosensitivity (S = 10% of Smax)	λ	300... 1100	nm
Radiant Sensitive Area	A	21.8	mm²
Dimensions of the Radiant Sensitive Area	L × W	8.5 × 2.5	mm
Distance Between Chip Surface and Package Surface	H	0.5	mm
Half Angle	φ	±60	Deg.
Dark Current (V_R = 10 V)	I_R	0.4 (≤10)	nA
Spectral Photosensitivity (λ = 850 nm)	S_λ	0.5	A/W
Quantum Efficiency (λ = 850 nm)	η	0.88	Electrons / Photon
Open Circuit Voltage (E_V = 1000 lx, Note 1)	V_O	430 (≥350)	mV
Short Circuit Current (E_V = 1000 lx, Note 1)	I_{SC}	175 (≥150)	µA
Rise and Fall Time of the Photocurrent from 10% to 90% and from 90% to 10% of the Final Value (R_L = 1 KΩ, V_R = 5 V, λ = 830 nm, I_P = 200 µA)	t_r, t_f	1.8	µs
Forward Voltage (I_F = 100 mA, E_e = 0, T_{amb} = 25°C)	V_F	1.3	V
Capacitance (V_R = 0 V, f = 1 MHz, E_V = 0 lx)	C_0	1000	pF
Temperature Coefficient V_O	TC_V	−2.6	mV/K
Temperature Coefficient I_O	TC_I	0.2	%/K
Noise Equivalent Power (V_R = 1 V)	NEP	2.3×10^{-14}	$\frac{W}{\sqrt{Hz}}$
Detection Limit (V_R = 1 V)	D	2.0×10^{13}	$\frac{cm \cdot \sqrt{Hz}}{W}$

[1] The illuminance indicated refers to unfiltered radiation of a tungsten filament lamp at a color temperature of 2856 K (standard light A in accordance with DIN 5033 and IEC publ. 306-1).

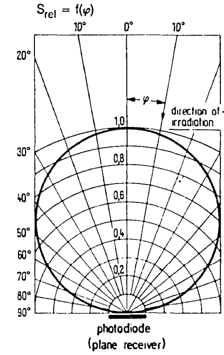
Relative spectral sensitivity
$S_{rel} = f(\lambda)$



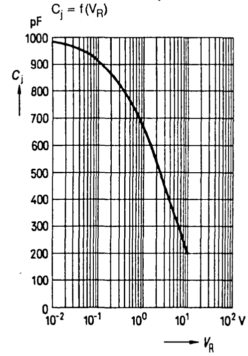
Photocurrent $I_P = f(E_V)$
Open circuit voltage $V_L = f(E_V)$



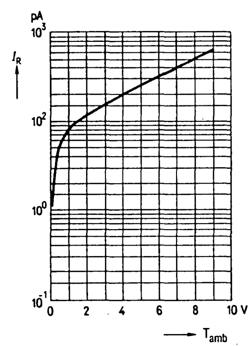
Directional characteristic
$S_{rel} = f(\varphi)$



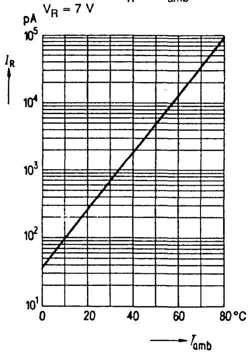
Collector-base capacitance
$C_j = f(V_R)$



Dark current $I_R = f(T_{amb})$

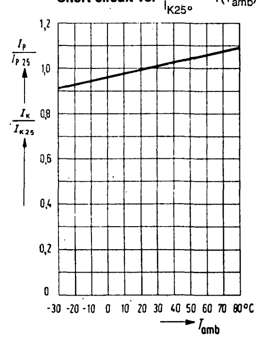


Dark current $I_R = f(T_{amb})$
$V_R = 7$ V

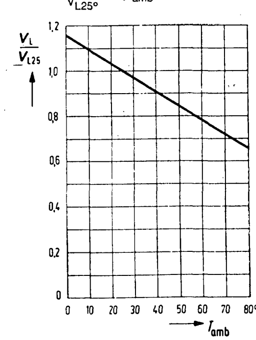


Photocurrent $\frac{I_P}{I_{P25°}} = f(T_{amb})$

Short circuit vol $\frac{I_K}{I_{K25°}} = f(T_{amb})$



Open circuit voltage
$\frac{V_L}{V_{L25°}} = f(T_{amb})$

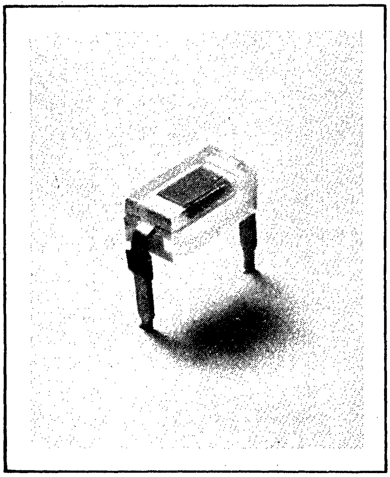


Photodiodes

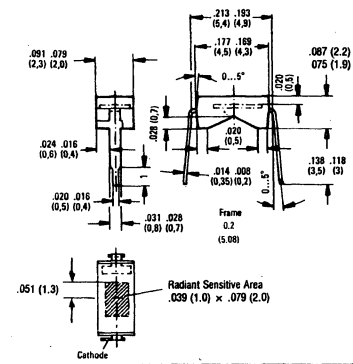
SIEMENS

SFH 200

SILICON PHOTODIODE



Package Dimensions in Inches (mm)



FEATURES

- **Very Large Zero Crossover, 1 mV/pA**
- **Transparent Plastic Case**
- **5.08 mm (2/10") Lead Spacing**
- **Lead Bend Option (for SMD)**

DESCRIPTION

SFH 200 is a planar silicon photodiode incorporated in a transparent plastic package. Its terminals are solder tabs arranged in 5.08 mm (2/10 inch) lead spacing. The diode can also very easily be mounted on PC boards. The SFH 200 is developed for low luminescence as receiver for such applications as exposure meters. The photo component distinguishes itself by large zero point divisions and by high open circuit voltage with low luminescence.

Type Characterization: notch with blue point. The cathode is marked by a tab on solder lead.

Maximum Ratings

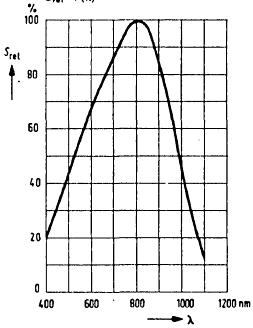
Reverse Voltage (V_R)	1 V
Operating and Storage Temperature Range	-55 to +80°C
Soldering Temperature in a 2 mm Distance from the Case Bottom ($t \leq 3$ s) (T_S)	230°C
Power Dissipation (T_{amb} = 25°C) (P_{tot})	100 mW

Characteristics (T_{amb} = 25°C)

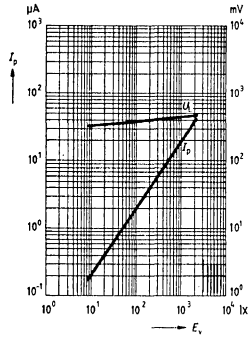
Photosensitivity (V_R = 5 V, Note 1)	S	20 (≥14)	nA/lx
Wavelength of Max. Photosensitivity	λ_{Smax}	800	nm
Spectral Range of Photosensitivity (S = 10% of Smax)	λ	350...1100	nm
Radiant Sensitive Area	A	2	mm²
Dimensions of the Radiant Sensitive Area	L × W	1 × 2	mm
Distance Between Chip Surface and Package Surface	H	0.5	mm
Half Angle	φ	±60	Deg.
Dark Current (V_R = 1V)	I_R	5 (≤40)	pA
Spectral Photosensitivity (λ = 850 nm)	S_λ	0.5	A/W
Zero Crossing (E_e = 0, T_{amb} = 40°C)	S_O	≤1	pA/mV
Quantum Efficiency (λ = 850 nm)	η	0.73	Electrons / Photon
Open Circuit Voltage (E_V = 1000 lx, Note 1)	V_O	450 (≥380)	mV
Short Circuit Current (E_V = 1000 lx, Note 1)	I_{SC}	20 (≥14)	μA
Rise and Fall Time of the Photocurrent from 10% to 90% and from 90% to 10% of the Final Value (R_L = 1 KΩ, V_R = 5 V, λ = 830 nm, I_P = 20 μA)	t_r, t_f	1.5	μs
Forward Voltage (I_F = 100 mA, E_e = 0 T_{amb} = 25°C)	V_F	1.3	V
Capacitance (V_R = 0 V, f = 1 MHz, E_V = 0 lx)	C_0	180	pF
(V_R = 3 V, f = 1 MHz, E_V = 0 lx)	C_3	70	pF
Temperature Coefficient V_O	TC_V	-2.6	mV/K
Temperature Coefficient I_O	TC_I	0.2	%/K
Noise Equivalent Power (V_R = 1 V)	NEP	2.5×10^{-14}	$\frac{W}{\sqrt{Hz}}$
Detection Limit (V_R = 1 V)	D	5.6×10^{13}	$\frac{cm \cdot \sqrt{Hz}}{W}$

[1] The illuminance indicated refers to unfiltered radiation of a tungsten filament lamp at a color temperature of 2856 K (standard light A in accordance with DIN 5033 and IEC publ. 306-1).

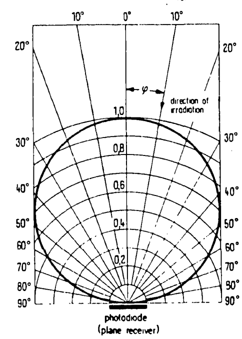
Relative spectral sensitivity
$S_{rel} = f(\lambda)$



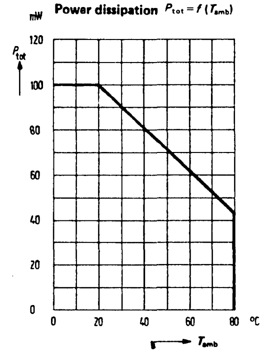
Photocurrent $I_P = f(E_V)$
Open circuit voltage $V_L = f(E_V)$



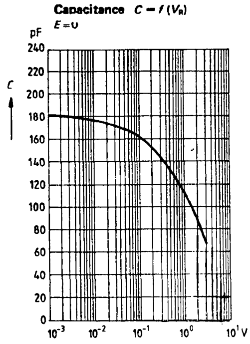
Directional characteristic $S_{rel} = f(\varphi)$



Power dissipation $P_{tot} = f(T_{amb})$



Capacitance $C = f(V_R)$
$E = 0$



Photocurrent $\frac{I_P}{I_{P\,25}} = f(T_{amb})$

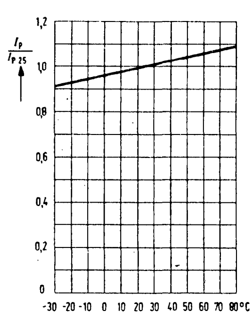
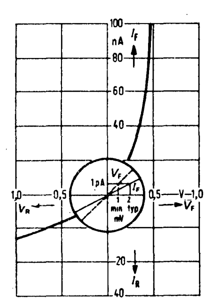


Diagram of zero crossover S_0



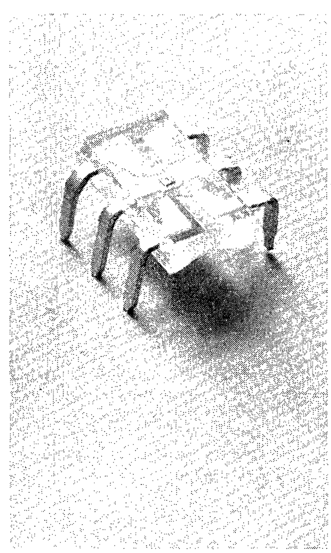
Photodiodes

SFH 200

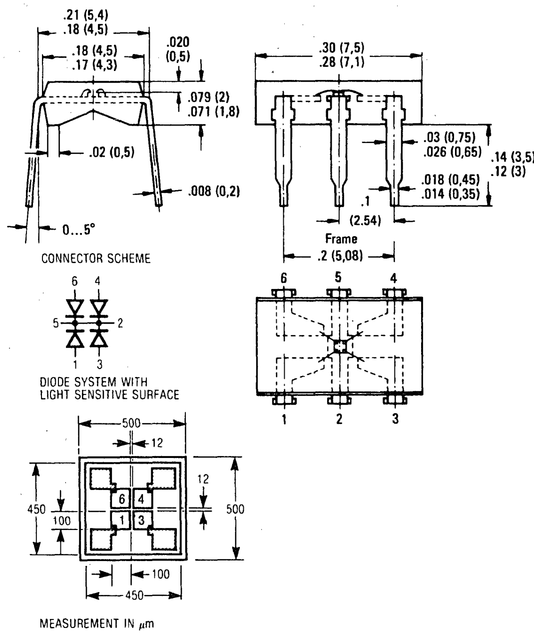
SIEMENS

SFH 204

SILICON FOUR QUADRANT PHOTODIODE



Package Dimensions in Inches (mm)



FEATURES

- **Miniature Size**
- **Four Quadrant Active Sections**
- **Close Spacing of Contacts, 12 μm**
- **Can Determine If and By How Much a Light Source Has Deviated**
- **SMD Package Optional**

DESCRIPTION

The SFH 204 silicon planar miniature four quadrant photodiode has application in edge drive, positioning, and path and corner scanning control devices. The active units are spaced at only 12 μm apart from individual contacts. It is therefore possible to get exact positioning with high definition.

Maximum Ratings

Reverse Voltage (V_R) .... 12 V
Operating and Storage Temperature Range (T , T_O) .... −40 to +80°C
Soldering Temperature in a 2 mm Distance
from the Case Bottom (t ≤ 3 s) (T_S) .... 230°C
Power Dissipation (P_{tot}) .... 40 mW

Characteristics (T_{amb} = 25°C)

Photosensitivity (V_R = .5 V, Note 1)	S	0.13 (≥0.08)	nA/lx
Wavelength of Max. Photosensitivity	λ_{Smax}	850	nm
Spectral Range of Photosensitivity (S = 10% of Smax)	λ	400...1100	nm
Radiant Sensitive Area	A	4 × 0.01	mm²
Dimensions of the Radiant Sensitive Area	L × W	100 × 100	mm
Distance Between Chip Surface and Package Surface	H	0.5	mm
Half Angle	φ	60	Deg.
Dark Current (V_R = 10 V)	I_R	0.1 (≤2)	nA
Spectral Photosensitivity (λ = 850 nm)	S_λ	0.35	A/W
Max. Deviation of Photosensitivity Between Diodes	Δ	±10	%
Quantum Efficiency (λ = 950 nm)	η	0.45	Electrons/Photon

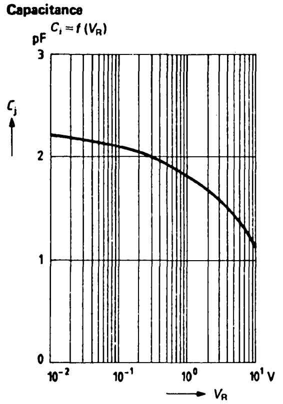
—Continued

Characteristics (T_{amb} = 25°C)

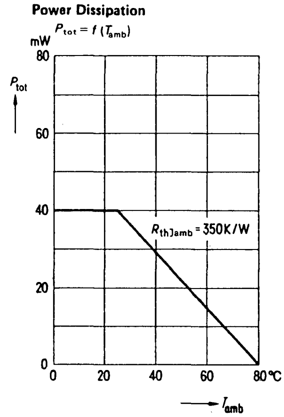
Open Circuit Voltage (E_V = 1000 lx, Note 1)	V_O	450 (≥380)	mV
Short Circuit Current (E_V = 1000 lx, Note 1)	I_K	130 (≥80)	nA
Rise and Fall Time of the Photocurrent from 10% to 90% and from 90% to 10% of the Final Value (R_L = 1 KΩ, V_R = 5 V, λ = 830 nm I_P = 45 μA)	t_r, t_f	3	μs
Forward Voltage (I_F = 100 mA, E_e = 0 T_{amb} = 25°C)	V_F	1.3	V
Capacitance (V_R = 0 V, f = 1 MHz, E_V = 0 lx)	C_0	2.0	pF
(V_R = 10 V, f = 1 MHz, E_V = 0 lx)	C_{10}	1.0	pF
Temperature Coefficient V_O	TC_V	-2.6	mV/K
Temperature Coefficient I_O	TC_I	0.18	%/K

[1] The illuminance indicated refers to unfiltered radiation of a tungsten filament lamp at a color temperature of 2856 K (standard light A in accordance with DIN 5033 and IEC publ. 306-1).

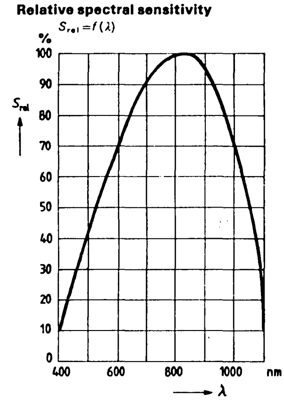
Capacitance



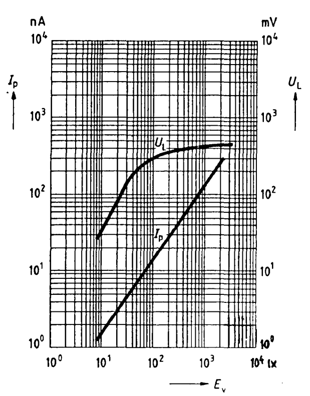
Power Dissipation



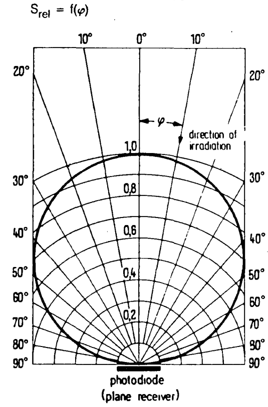
Relative spectral sensitivity



Photocurrent $I_P = f(E_V)$
Open circuit voltage $V_L = f(E_V)$



Directional characteristic
$S_{rel} = f(\varphi)$

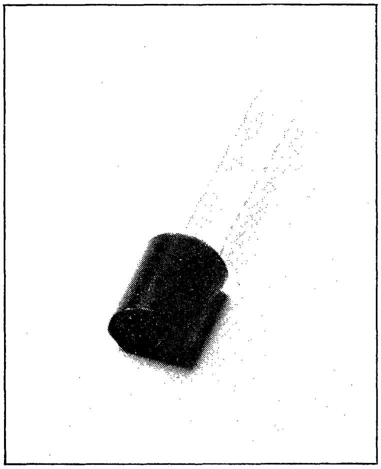


Photodiodes

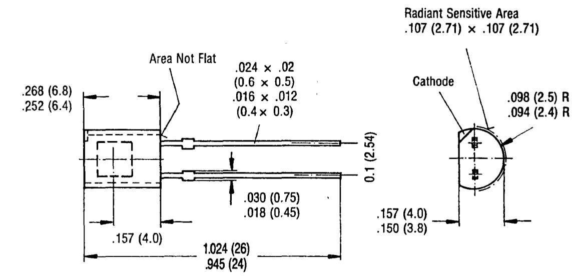
SIEMENS

SFH 205

SILICON PIN PHOTODIODE WITH DAYLIGHT FILTER



Package Dimensions in Inches (mm)



FEATURES

- **Black Plastic Encapsulated Package**
- **0.1″ (2.54 mm) Lead Spacing**
- **Built-in Daylight Filter**
- **Suitable for IR Sound Transmission**

DESCRIPTION

The SFH 205 is a silicon planar PIN photodiode, which is incorporated in a plastic package which simultaneously serves as filter and is also transparent for infrared emission. Its terminals are soldering tabs arranged in 0.1″ (2.54 mm) lead spacing. Due to its design, the diode can vertically be assembled on PC boards. Arrays can be realized by multiple arrangements. This versatile photodetector can be used as a diode as well as a voltaic cell. The signal/noise ratio is particularly favorable, even at low illuminances.

The PIN photodiode is outstanding for low junction capacitance, high cut-off frequency and short switching times. The photodiode is particularly suitable for IR sound transmission and remote control. The cathode is marked by stamping at the case edge.

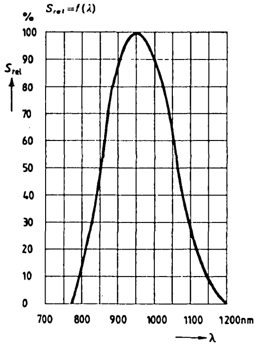
Maximum Ratings

Reverse Voltage (V_R) .... 20 V
Operating and Storage Temperature Range .... –40 to +80°C
Soldering Temperature in a 2 mm Distance
from the Case Bottom (t ≤ 3 s) (T_S) .... 230°C
Power Dissipation (T_{amb} = 25°C) (P_{tot}) .... 150 mW

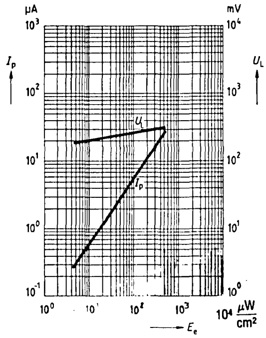
Characteristics (T_{amb} = 25°C)

Photosensitivity (V_R = 5 V, λ = 950 nm, E_e = 0.5 mW/cm²)	S	25 (≥15)	μA
Wavelength of Max. Photosensitivity	λ_{Smax}	950	nm
Spectral Range of Photosensitivity (S = 10% of Smax)	λ	800... 1100	nm
Radiant Sensitive Area	A	7.00	mm²
Dimensions of the Radiant Sensitive Area	L × W	2.65 × 2.65	mm
Distance Between Chip Surface and Package Surface	H	2.3...2.5	mm
Half Angle	φ	±70	Deg.
Dark Current (V_R = 10 V)	I_R	2 (≤30)	nA
Spectral Photosensitivity (λ = 850 nm)	S_λ	0.68	A/W
Quantum Efficiency (λ = 850 nm)	η	0.90	Electrons / Photon
Open Circuit Voltage (E_e = 0.5 mW/cm², λ = 950 nm)	V_O	327 (≤250)	mV
Short Circuit Current (E_e = 0.5 mW/cm², λ = 950 nm)	I_{SC}	25 (≥15)	μA
Rise and Fall Time of the Photocurrent from 10% to 90% and from 90% to 10% of the Final Value (R_L = 1 KΩ, V_R = 5 V, λ = 830 nm, I_P = 25 μA)	t_r, t_f	350	ns
Forward Voltage (I_F = 100 mA, E_e = 0, T_{amb} = 25°C)	V_F	1.3	V
Capacitance (V_R = 0 V, f = 1 MHz, E_V = 0 lx)	C_0	72	pF
Temperature Coefficient V_O	TC_V	-2.6	mV/K
Temperature Coefficient I_O	TC_I	0.18	%/K
Noise Equivalent Power (V_R = 10 V)	NEP	3.7×10^{-14}	$\frac{W}{\sqrt{Hz}}$
Detection Limit (V_R = 10 V)	D	7.3×10^{12}	$\frac{cm\sqrt{Hz}}{W}$

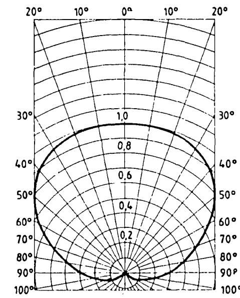
Relative spectral sensitivity
$S_{rel} = f(\lambda)$



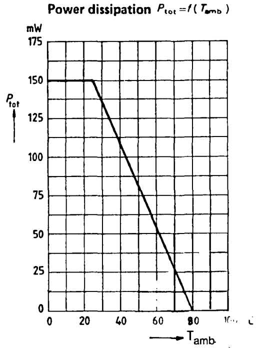
Photocurrent
$I_P = f(E_e)$; λ = 950 nm
Open circuit voltage $V_L = f(E_e)$



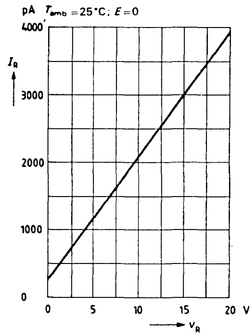
Directional characteristic
$S_{rel} = f(\varphi)$



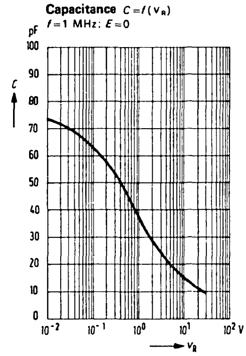
Power dissipation $P_{tot} = f(T_{amb})$



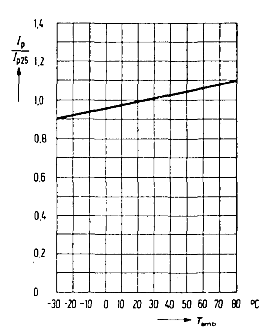
Dark current $I_R = f(V_R)$



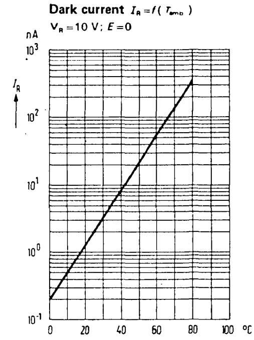
Capacitance $C = f(V_R)$



Photocurrent $\frac{I_P}{I_{P25}} = f(T_{amb})$



Dark current $I_R = f(T_{amb})$

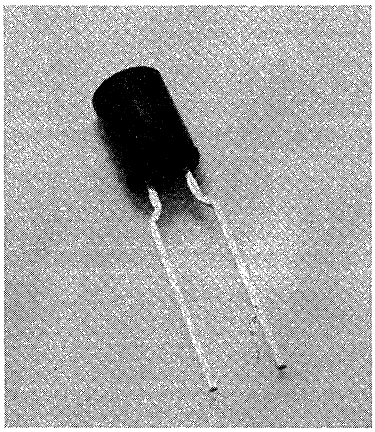


Photodiodes

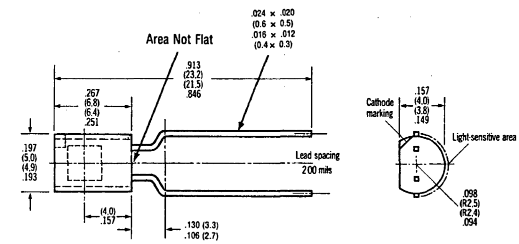
SIEMENS

SFH 205Q2

SILICON PIN PHOTODIODE WITH DAYLIGHT FILTER



Package Dimensions in Inches (mm)



FEATURES

- **Black Plastic Encapsulated Package**
- **5.08 mm (.20") Lead Spacing**
- **Built-in Daylight Filter**
- **Suitable for IR Sound Transmission**

DESCRIPTION

The SFH 205Q2 is a silicon planar PIN photodiode, which is incorporated in a plastic package which simultaneously serves as filter and is also transparent for infrared emission. Its terminals are soldering tabs arranged in 5.08 mm (.20") lead spacing. Due to its design, the diode can vertically and automatically be assembled on PC boards. Arrays can be realized by multiple arrangements. This versatile photodetector can be used as a diode as well as a voltaic cell. The signal/noise ratio is particularly favorable, even at low illuminances.

The PIN photodiode is outstanding for low junction capacitance, high cut-off frequency and short switching times. The photodiode is particularly suitable for IR sound transmission and remote control. The cathode is marked by stamping at the case edge.

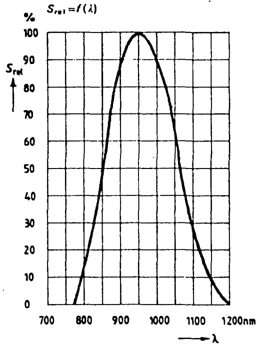
Maximum Ratings

Reverse Voltage (V_R) .... 20 V
Operating and Storage Temperature Range .... −40 to +80°C
Soldering Temperature in a 1 mm Distance
from the Case Bottom ($t \leq 3$ s) (T_S) .... 230°C
Power Dissipation (T_{amb} = 25°C) (P_{tot}) .... 150 mW

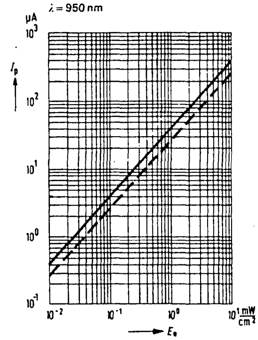
Characteristics (T_{amb} = 25°C)

Photosensitivity (V_R = 5 V, λ = 950 nm, E_e = 0.5 mW/cm²)	S	25 (≥15)	μA
Wavelength of Max. Photosensitivity	λ_{Smax}	950	nm
Spectral Range of Photosensitivity (S = 10% of Smax)	λ	800... 1100	nm
Radiant Sensitive Area	A	7.00	mm²
Dimensions of the Radiant Sensitive Area	L x W	2.65 x 2.65	mm
Distance Between Chip Surface and Package Surface	H	2.3...2.5	mm
Half Angle	φ	±70	Deg.
Dark Current (V_R = 10 V)	I_R	2 (≤30)	nA
Spectral Photosensitivity (λ = 850 nm)	S_λ	0.68	A/W
Quantum Efficiency (λ = 850 nm)	η	0.90	Electrons / Photon
Open Circuit Voltage (E_e = 0.5 mW/cm², λ = 950 nm)	V_O	327 (≤250)	mV
Short Circuit Current (E_e = 0.5 mW/cm², λ = 950 nm)	I_{SC}	25 (≥15)	μA
Rise and Fall Time of the Photocurrent from 10% to 90% and from 90% to 10% of the Final Value (R_L = 1 KΩ, V_R = 5 V, λ = 830 nm, I_P = 25 μA)	t_r, t_f	350	ns
Forward Voltage (I_F = 100 mA, E_e = 0, T_{amb} = 25°C)	V_F	1.3	V
Capacitance (V_R = 0 V, f = 1 MHz, E_V = 0 lx)	C_0	72	pF
Temperature Coefficient V_O	TC_V	-2.6	mV/K
Temperature Coefficient I_O	TC_I	0.18	%/K
Noise Equivalent Power (V_R = 10 V)	NEP	3.7×10^{-14}	$\frac{W}{\sqrt{Hz}}$
Detection Limit (V_R = 10 V)	D	7.3×10^{12}	$\frac{cm \sqrt{Hz}}{W}$

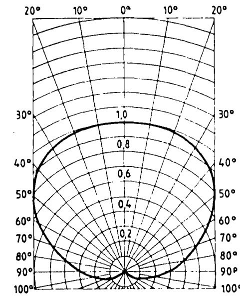
Relative spectral sensitivity
$S_{rel} = f(\lambda)$



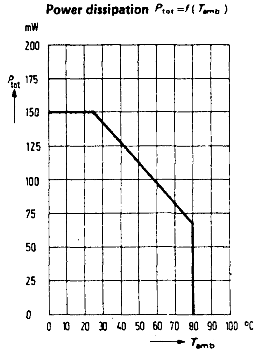
Photocurrent $I_P = f(E_e)$
$\lambda = 950$ nm



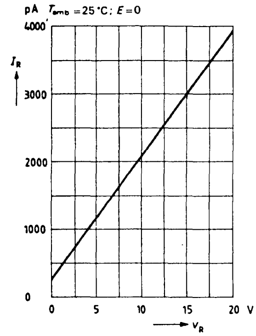
Directional characteristic
$S_{rel} = f(\varphi)$



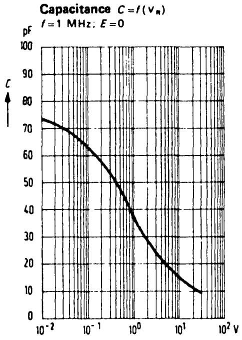
Power dissipation $P_{tot} = f(T_{amb})$



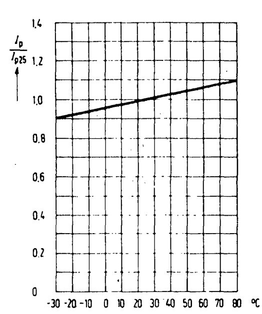
Dark current $I_R = f(V_R)$
pA $T_{amb} = 25$ °C; $E = 0$



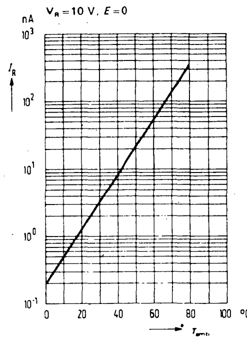
Capacitance $C = f(V_R)$
$f = 1$ MHz; $E = 0$



Photocurrent $\frac{I_P}{I_{P25}} = f(T_{amb})$



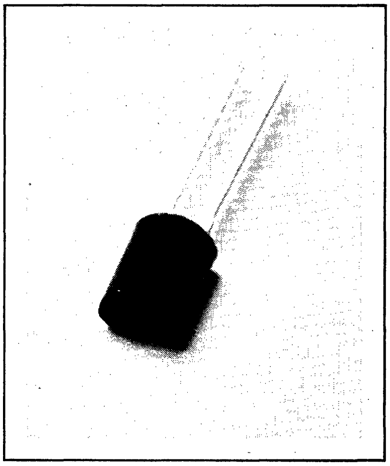
Dark current $I_R = f(T_{amb})$
$V_R = 10$ V, $E = 0$



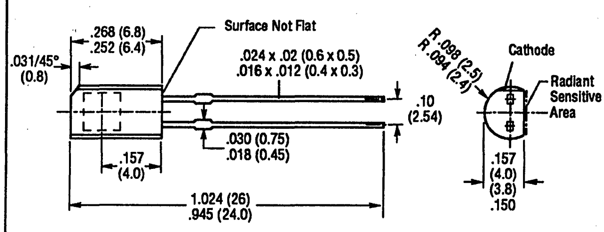
SIEMENS

SFH 206

SILICON PIN PHOTODIODE WITH DAYLIGHT FILTER



Package Dimensions in Inches (mm)



FEATURES

- **Black Plastic Package**
- **0.1″ (2.54mm) Lead Spacing**
- **Built in Daylight Filter**

DESCRIPTION

The SFH 206 is a silicon planar PIN photodiode in a black plastic package that serves as a filter for infrared radiation. Its terminals are solder tabs with 0.1″ (2.54 mm) spacing. Due to its design the diode can vertically be assembled on PC boards. Arrays can be realized by multiple arrangements. This versatile photodetector can be used as a diode as well as a voltaic cell. The signal/noise ratio is particularly favorable, especially at low light levels.

The PIN photodiode is outstanding for low junction capacitance, high cut off frequency and short switching times. Applications include IR sound transmission and remote control. The anode is marked by stamping at the case edge.

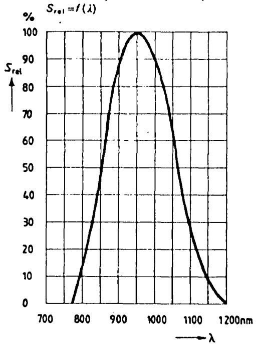
Maximum Ratings

Reverse Voltage (V_R) .... 20 V
Operating and Storage Temperature Range .... –40 to +80°C
Soldering Temperature in a 1 mm Distance from the Case Bottom ($t \leq 3$ s) (T_S) .... 230°C
Power Dissipation (T_{amb} = 25°C) (P_{tot}) .... 150 mW

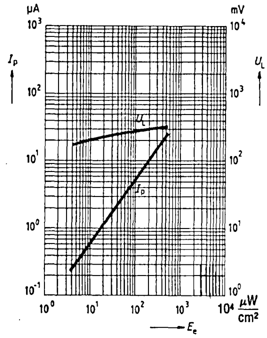
Characteristics (T_{amb} = 25°C)

Photosensitivity (V_R = 5 V, λ = 950 nm, E_e = 0.5 mW/cm²)	S	25 (≥16)	μA
Wavelength of Max. Photosensitivity	λ_{Smax}	950	nm
Spectral Range of Photosensitivity (S = 10% of Smax)	λ	800... 1100	nm
Radiant Sensitive Area	A	7.00	mm²
Dimensions of the Radiant Sensitive Area	L × W	2.65 × 2.65	mm
Distance Between Chip Surface and Package Surface	H	1.2...1.4	mm
Half Angle	φ	±70	Deg.
Dark Current (V_R = 10 V)	I_R	2 (≤30)	nA
Spectral Photosensitivity (λ = 850 nm)	S_λ	0.68	A/W
Quantum Efficiency (λ = 850 nm)	η	0.90	$\frac{\text{Electrons}}{\text{Photon}}$
Open Circuit Voltage (E_e = 0.5 mW/cm², λ = 950 nm)	V_O	327 (≥250)	mV
Short Circuit Current (E_e = 0.5 mW/cm², λ = 950 nm)	I_{SC}	25 (≥16)	μA
Rise and Fall Time of the Photocurrent from 10% to 90% and from 90% to 10% of the Final Value (R_L = 1 KΩ, V_R = 5 V, λ = 830 nm, I_P = 25 μA)	t_r, t_f	350	ns
Forward Voltage (I_F = 100 mA, E_e = 0, T_{amb} = 25°C)	V_F	1.3	V
Capacitance (V_R = 0 V, f = 1 MHz, E_V = 0 lx)	C_0	72	pF
Temperature Coefficient V_O	TC_V	–2.6	mV/K
Temperature Coefficient I_O	TC_I	0.18	%/K
Noise Equivalent Power (V_R = 10 V)	NEP	3.7×10^{-14}	$\frac{W}{\sqrt{Hz}}$
Detection Limit (V_R = 10 V)	D	7.3×10^{12}	$\frac{cm\sqrt{Hz}}{W}$

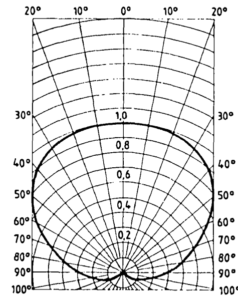
Relative spectral sensitivity $S_{rel} = f(\lambda)$



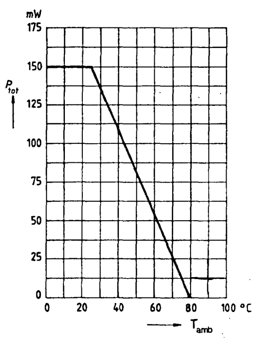
Photocurrent $I_P = f(E_e)$
Open circuit voltage $V_L = f(E_e)$



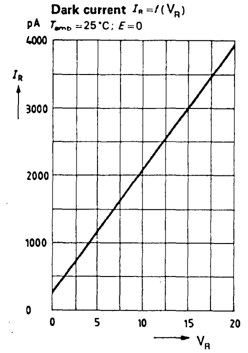
Directional characteristic $S_{rel} = f(\varphi)$



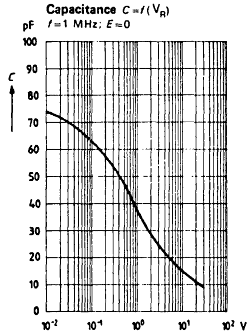
Power dissipation $P_{tot} = f(T_{amb})$



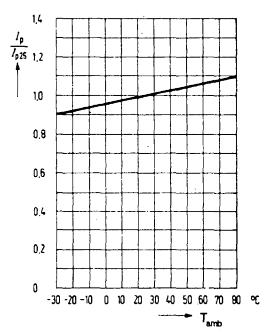
Dark current $I_R = f(V_R)$
$T_{amb} = 25\,°C$; $E = 0$



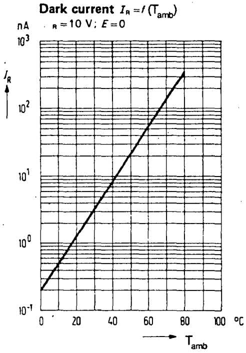
Capacitance $C = f(V_R)$
$f = 1$ MHz; $E = 0$



Photocurrent $\frac{I_P}{I_{P\,25}} = f(T_{amb})$



Dark current $I_R = f(T_{amb})$
$V_R = 10$ V; $E = 0$



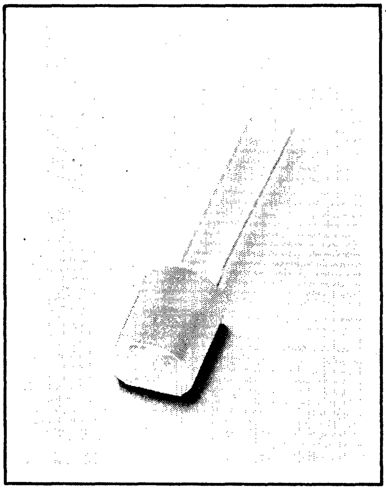
Photodiodes

SFH 206

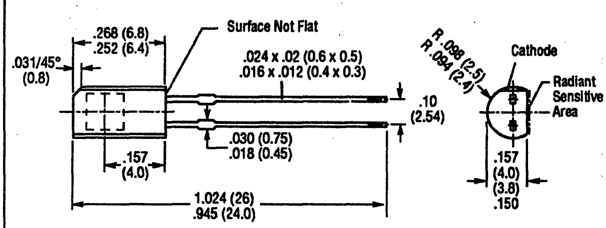
SIEMENS

SFH 206K

PIN PHOTODIODE



Package Dimensions in Inches (mm)



FEATURES

- **Waterclear Plastic Package**
- **0.1" (2.54 mm) Lead Spacing**
- **Suitable for IR Sound Transmission**

DESCRIPTION

The SFH 206K is a silicon planar PIN photodiode which is incorporated in a colorless plastic package. The terminals are solder tabs with 0.1" (2.54 mm) spacing. Due to its design the diode can be assembled vertically on PC boards. Arrays can be realized by multiple arrangements. This versatile photodetector can be used as a diode as well as a voltaic cell. The signal/noise ratio is particularly favorable, even at low illuminances.

The PIN photodiode is outstanding for low junction capacitance, high cut off frequency and short switching times. It is particularly suitable for IR sound transmission and remote control. The anode is marked by stamping at the case edge.

Maximum Ratings

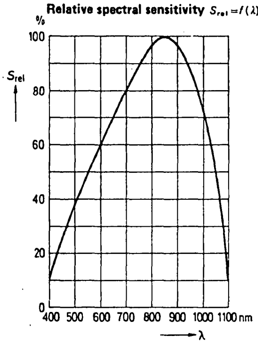
Operating and Storage Temperature Range .... –40 to +80°C
Soldering Temperature in a 2 mm Distance
from the Case Bottom ($t \leq 3$ s) (T_S) .... 230°C
Reverse Voltage (V_R) .... 20 V
Power Dissipation (T_{amb} = 25°C) (P_{tot}) .... 150 mW

Characteristics (T_{amb} = 25°C)

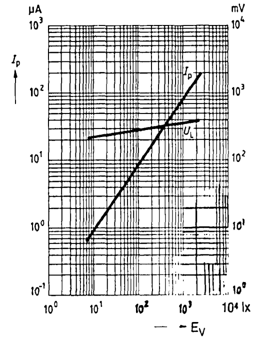
Spectral Sensitivity (V_R = 5 V, standard light A, T= 2856K)	S	80 (≥50)	nA/lx
Wavelength of Max. Photosensitivity	λ_{Smax}	850	nm
Spectral Range of Sensitivity (S = 10% of Smax)	λ	400... 1100	nm
Radiant Sensitive Area	A	7.00	mm²
Dimensions of the Radiant Sensitive Area	L × W	2.65 × 2.65	mm
Distance Between Chip Surface and Package Surface	H	1.2...1.4	mm
Half Angle	φ	±70	Deg.
Dark Current (V_R = 10 V)	I_R	2 (≤30)	nA
Quantum Efficiency (λ = 850 nm)	η	0.88	Electrons/Photon
Open Circuit Voltage (E_V = 1000 lx, Note 1)	V_O	365 (≥310)	mV
Short Circuit Current (E_V = 1000 lx, Note 1)	I_{SC}	80 (≥50)	µA
Rise and Fall Time of the Photocurrent from 10% to 90% and from 90% to 10% of the Final Value (R_L = 1 KΩ, V_R = 5 V, λ = 830 nm I_P = 80 µA)	t_r, t_f	350	ns
Forward Voltage (I_F = 100 mA, E_e = 0 T_{amb} = 25°C)	V_F	1.3	V
Capacitance (V_R = 0 V, f = 1 MHz, E_V = 0 lx)	C_0	72	pF
Temperature Coefficient V_O	TC_V	-2.6	mV/K
Temperature Coefficient I_O	TC_I	0.18	%/K
Noise Equivalent Power (V_R = 10 V)	NEP	4.2×10^{-14}	$\frac{W}{\sqrt{Hz}}$
Detection Limit (V_R = 10 V)	D	6.3×10^{12}	$\frac{cm\sqrt{Hz}}{W}$

[1] The illuminance indicated refers to unfiltered radiation of a tungsten filament lamp at color temperature of 2856 K (standard light A in accordance with DIN 5030 and IEC publ. 306-1).

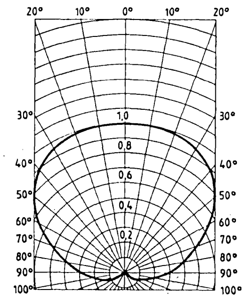
Relative spectral sensitivity $S_{rel} = f(\lambda)$



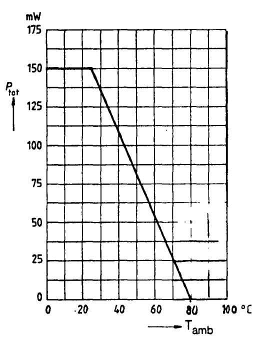
Photocurrent $I_P = f(E_V)$
Open circuit voltage $V_L = f(E_V)$



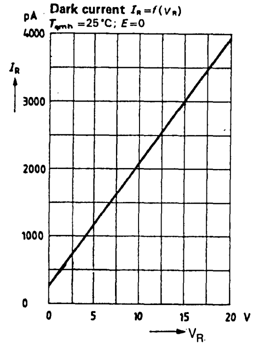
Directional characteristic $S_{rel} = f(\varphi)$



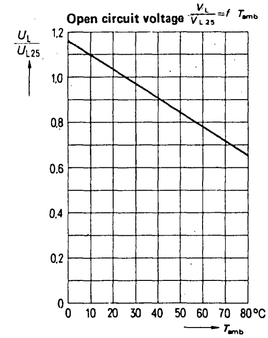
Power dissipation $P_{tot} = f(T_{amb})$



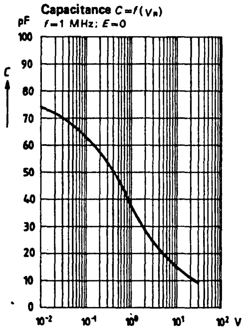
Dark current $I_R = f(V_R)$
$T_{amb} = 25\,°C$; $E = 0$



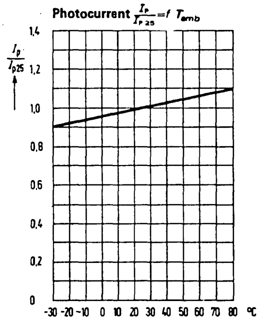
Open circuit voltage $\frac{V_L}{V_{L25}} = f\ T_{amb}$



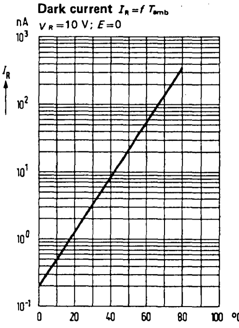
Capacitance $C = f(V_R)$
$f = 1$ MHz; $E = 0$



Photocurrent $\frac{I_P}{I_{P25}} = f\ T_{amb}$



Dark current $I_R = f\ T_{amb}$
$V_R = 10$ V; $E = 0$

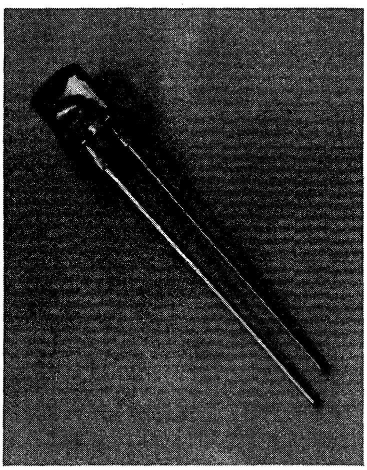


Photodiodes

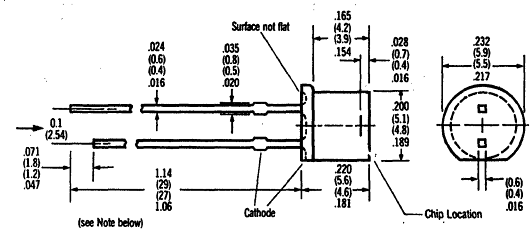
SIEMENS

SFH 217
SFH 217F

SILICON PIN PHOTODIODE WITH DAYLIGHT FILTER



Package Dimensions in Inches (mm)



Note: Temporarily these devices may be supplied with lead lengths of $\frac{.65\ (16.6)}{.62\ (15.8)}$

FEATURES

- **Silicon Planar Pin Photodiode**
- **Cost Effective Device**
- **T-1¾ Package**
- **Flat Top**
- **High Speed, 1 ns**
- **Low Dark Current, 1 nA**
- **IR Filter (SFH217F)**

DESCRIPTION

The SFH217 and SFH217F are planar PIN photodiodes in a plastic T-1¾ package with a flat lens. The flat window has no effect on the beam path of optical lens systems. It is characterized by its low junction capacitance and fast switching speeds.

Because of its high cut-off frequency, this diode is particularly suitable for use as an optical sensor of high modulation bandwidth.

Maximum Ratings

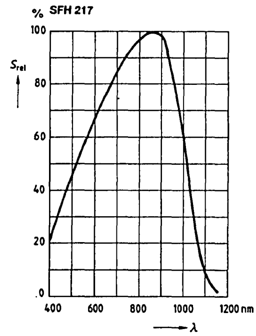
Reverse voltage	V_R	30	V
Storage/operating temperature range	T	−55 to +100	°C
Power dissipation	P_{tot}	100	mW
Soldering temperature (Solder 2 mm distance from case t≤3 sec)	T_L	300	°C

Electrical/Optical Characteristics (T_{amb} = 25°C)

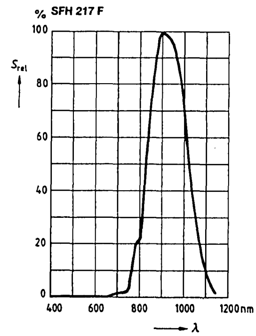
		SFH217	SFH217F	
Radiant sensitive area	A	1	1	mm²
Dimensions of radiant sensitive area	LxW	1 × 1	1 × 1	mm
Distance chip surface to package surface	H	0.4 . . . 0.7	0.4 . . . 0.7	mm
Wavelength of the max. sensitivity	$\lambda_{S\,max}$	850	900	nm
Quantum yield (Electrons per photon) (λ = 850 nm)	η	0.89	0.89	Electrons/Photon
Spectral sensitivity (λ = 850 nm)	S	0.62	0.62	A/W
Rise time of the photocurrent (load resistance R_L = 50 Ω; V_R = 5 V; λ = 880 nm, I_P = 14 μA)	t_r	2	2	ns
Forward voltage (I_F = 100 mZ, E_e = 0, T_A = 25°C)	V_F	1.3	1.3	V
Capacitance (V_R = 0 V, f = 1 MHz, E = 0 lx)	C_0	11	11	pF
Dark current (V_R = 20 V; E = 0)	I_R	1 (≤10)	1 (≤10)	nA
Photosensitivity (V_R = 5 V, standard light A, T = 2856 k)	S	9.5 (≥5)	—	nA/lx
Photosensitivity (V_R = 5 V, λ = 950 nm, E_e = 0.5 mW/cm²)	S	—	3.0 (≥1.8)	μA
Spectral range of photosensitivity (S = 10% of S_{max})	λ	400 . . . 1100	800 . . . 1100	nm
Open circuit voltage (E_V = 1000 lx, standard light A, T = 2856 K)	V_O	350 (≥300)	—	mV
(E_e = 0.5 mW/cm², λ = 950 nm)	V_O	—	300 (≥250)	mV
Short circuit current (E_V = 1000 lx, standard light A, T = 2856 K)	I_S	9.3 (≥5)	—	μA
(E_e = 0.5 mW/cm², λ = 950 nm)	I_S	—	3.1 (≥1.8)	μA
Noise equivalent power (V_R = 20 V)	NEP	2.9 x 10⁻¹⁴	2.9 x 10⁻¹⁴	$\frac{W}{\sqrt{Hz}}$
Detection limit (V_R = 20 V)	D*	3.5 x 10¹²	3.5 x 10¹²	$\frac{cm\sqrt{Hz}}{W}$
Temperature coefficient for I_S	TC	0.2	0.2	%/K
Temperature coefficient for U_O	TC	−2.6	−2.6	mV/k

1) The illuminance indicated refers to unfiltered radiation of a tungsten filament lamp at a color temperature of 2856 K (standard light A in accordance with DIN 5033 and IEC publ. 306-1).

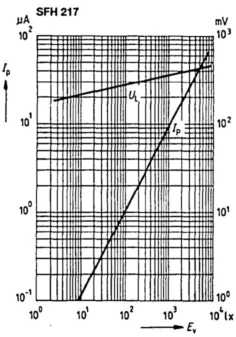
Relative Spectral Sensitivity
$S_{rel} = f(\lambda)$



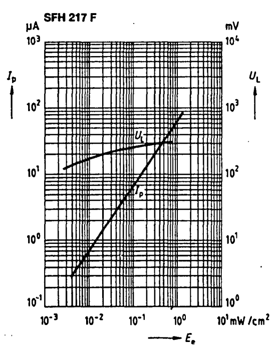
Relative Spectral Sensitivity
$S_{rel} = f(\lambda)$



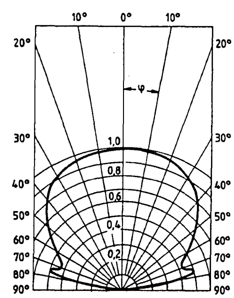
Photocurrent $I_P = f(E_V)$



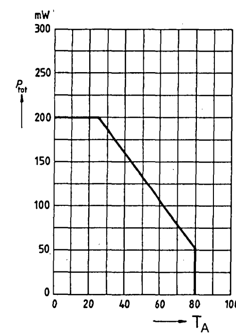
Photocurrent $I_P = f(E_e)$



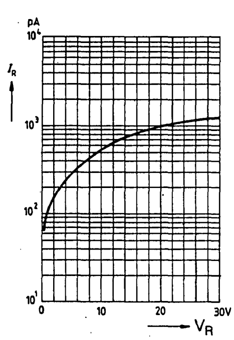
Directional Characteristics
$S_{rel} = f(\varphi)$



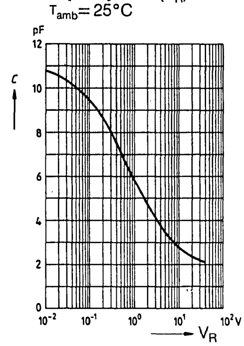
Power Dissipation
$P_{tot} = f(T_A)$



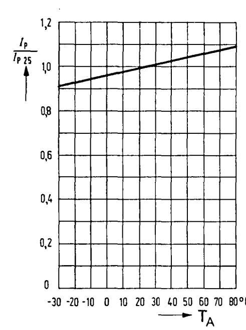
Dark Current $I_R = f(V_R)$



Capacity $C = f(V_R)$
$T_{amb} = 25°C$



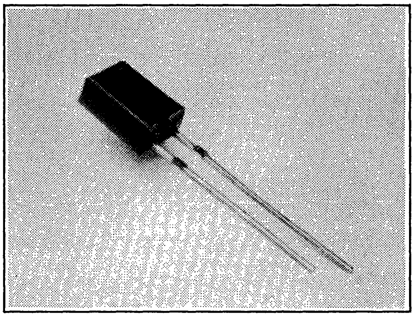
Photocurrent $\frac{I_P}{I_{P\,25}} = f(T_A)$

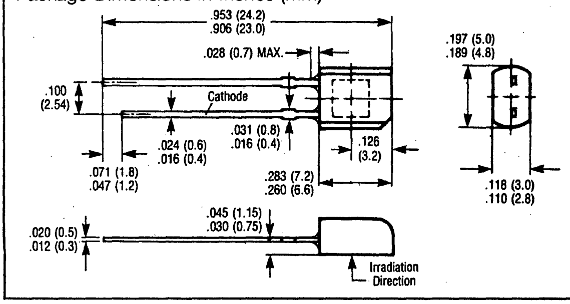


SIEMENS

SFH 225

PIN PHOTODIODE





FEATURES

- **Built In IR Filter**
- **Short Switching Time —125 ns Typical**
- **Spectrally Matched to Emitters SFH484/485 and LD271/274**
- **Flattened Black Epoxy Package**

DESCRIPTION

The SFH 225 is a silicon planar PIN photodiode. It is housed in a black epoxy package that acts as a daylight rejection filter. Due to its small package and 2.54 mm (0.1 inch) lead spacing, it is suitable for high density packaging. The SFH 225 can be used in a reversed (photodiode) or forward biased (photo cell) mode. Its low signal/noise ratio and IR filter make it especially suitable at low light levels.

The PIN photodiode is outstanding for low junction capacitance, short switching times and high cut off frequency. Applications include remote control, IR sound transmission, dimmers and light reflective switches.

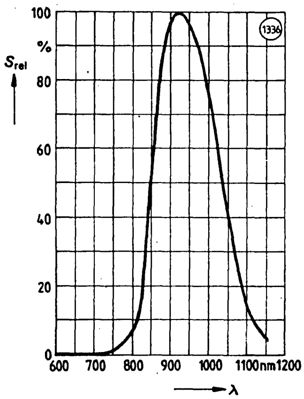
Maximum Ratings

Operating and Storage Temperature Range (T) .... −40 to +80°C
Soldering Temperature (2 mm distance from case bottom; soldering time t≤3 s) (T_S) .... 230°C
Reverse Voltage (V_R) .... 20 V
Total Power Dissipation (T_{amb}=25°C) (P_{TOT}) .... 150 mW

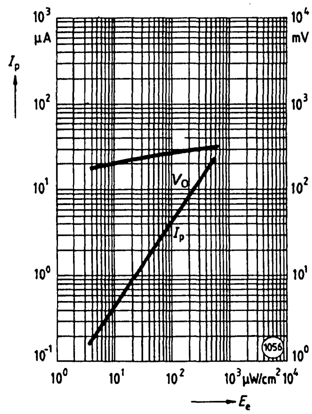
Characteristics (T_{amb} = 25°C)

Photosensitivity (V_R=5 V, λ=950 nm E_E=0.5 mW/cm²)	S	17 (≥12.5)	µA
Wavelength of Max. Photosensitivity	λ_{SMAX}	950	nm
Spectral Range of Photosensitivity (S=10% of S_{MAX})	λ	800 to 1100	nm
Radiant Sensitive Area	A	4.84	mm²
Dimensions of Radiant Sensitive Area	L×W	2.20×2.20	mm
Distance Chip Surface to Case Surface	H	0.6 to 0.8	mm
Half Angle	φ	±60	Deg.
Dark Current (V_R=10 V)	I_R	2 (≤30)	nA
Spectral Sensitivity (λ=950 nm)	S_λ	0.70	A/W
Quantum Yield (λ=950 nm)	η	0.90	Electrons/Photon
Open-Circuit Voltage (E_E=0.5 mW/cm²; λ=950 nm)	V_O	327 (≥250)	mV
Short-Circuit Current (E_E=0.5 mW/cm²; λ=950 nm)	I_{SC}	17 (≥12.5)	µA
Rise and Fall Time of Photocurrent from 10% to 90%, or from 90% to 10% of final value (R_L=1 kΩ, V_R=5 V, λ=830 nm, I_P=17 µA)	t_R, t_F	125	ns
Forward Voltage (I_F=100 mA, E_E=0, T_{amb}=25°C)	V_F	1.3	V
Capacitance (V_R=0 V, f=1 MHz, E_V=0 lx)	C_0	48	pF
Temperature Coefficient of V_O	TC_V	-2.6	mV/K
Temperature Coefficient of I_{SH}	TC_I	0.18	%/K
Noise Equivalent Power (V_R=10 V)	NEP	3.6×10^{-14}	$\frac{W}{\sqrt{Hz}}$
Detection Limit (V_R=10 V)	D	6.1×10^{12}	$\frac{cm\sqrt{Hz}}{W}$

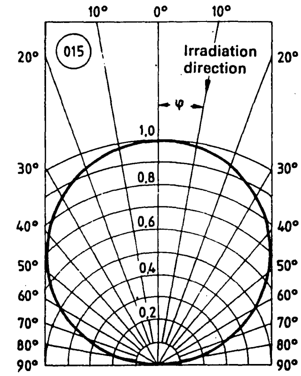
Relative spectral sensitivity versus wavelength



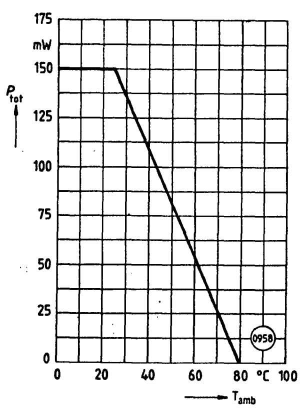
Photocurrent and open-circuit voltage versus irradiance



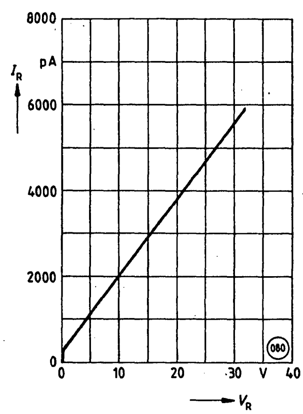
Directional characteristic relative spectral sensitivity versus half angle



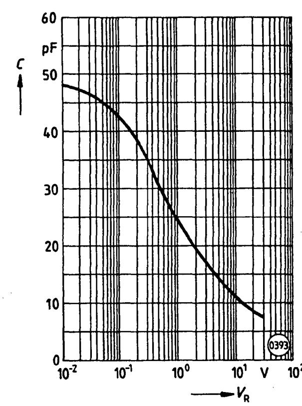
Total power dissipation versus ambient temperature



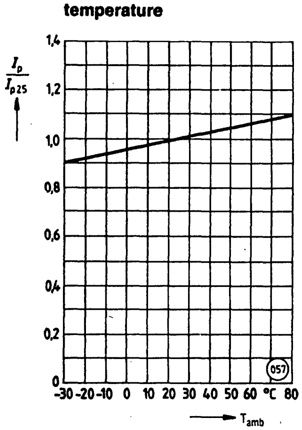
Dark current versus reverse voltage
T_{amb} = 25 °C; E = 0



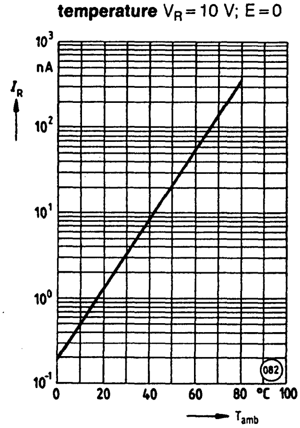
Capacitance versus reverse voltage
f = 1 MHz; E = 0



Photocurrent versus ambient temperature



Dark current versus ambient temperature V_R = 10 V; E = 0

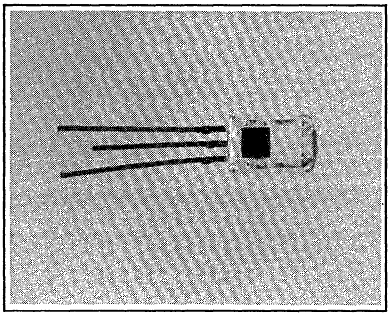


Photodiodes

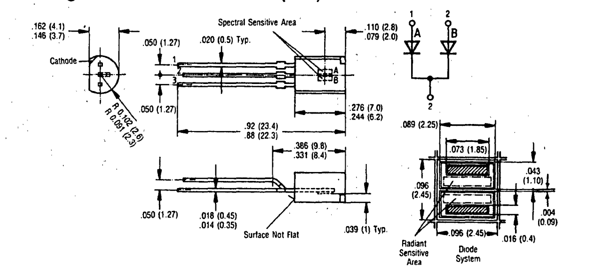
SFH 225

SIEMENS

SFH 248
WITH DAYLIGHT FILTER SFH 248F
SILICON DIFFERENTIAL PHOTODIODE



Package Dimensions in Inches (mm)



FEATURES

- High Reliability
- Low Noise
- High Open-Circuit Voltage as Photovoltaic Cells
- Detector For Low Illuminance
- Short Switching Time
- Low Capacitance
- High Spectral Sensitivity
- Cathode Marking: Middle Solder Tab
- Suitable for Use in the Visible Light and Near Infrared Range
- Daylight Filter Option, SFH248F

DESCRIPTION

SFH248 and SFH248F are silicon differential photodiodes fabricated in planar technology. The devices are packaged in a plastic case similar to a TO92. The terminals are solder tabs with .01″ (2.54 mm) lead spacing. These photodetectors can be used as photodiodes with reverse voltage or as photovoltaic cells.

Applications include: edge control, path and corner scanning, industrial electronics, measuring and controlling devices.

Maximum Ratings

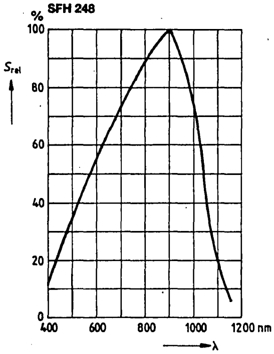
Reverse Voltage (V_R) . . . . 10 V
Storage and Operating Temperature . . . . –40 to +80°C
Soldering Temperature in a 2 mm Distance from the Case Bottom ($t \leq 3$ s) (t_S) . . . . 230°C
Power Dissipation (P_{tot}) . . . . 50 mW

Characteristics (T_{amb} = 25°C)

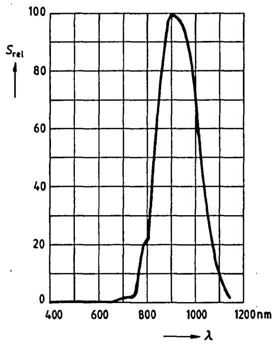
	Symbol	SFH248	SFH248F	Unit
Spectral Sensitivity (V_R = 5 V, Note 1)	S	24 (≥15)		nA/lx
Spectral Sensitivity (V_R =5 V; λ = 950 nm E_e = 0.5 mW/cm²)	S		7.5 (≥4)	μA
Wavelength of Max. Sensitivity	λ_{Smax}	850	950	nm
Spectral Range of Photosensitivity (S = 10% of Smax)	λ	430 to 1150	800 to 1150	nm
Radiant Sensitive Area	A	1.54	1.54	mm²
Dimensions of the Radiant Sensitive Area	L × W	0.7 × 2.2	0.7 × 2.2	mm
Distance Between Chip Surface and Package Surface	D	1	1	mm
Half Angle	φ	±60	±60	Deg.
Dark Current (V_R = 10 V)	I_R	100 (≤200)	100 (≤200)	nA
Spectral Sensitivity (λ = 850 nm)	S_λ	0.55	0.55	A/W
Quantum Yield (λ = 850 nm)	η	0.80	0.80	Electrons / Photon
Open Circuit Voltage (E_e =1000 lx, Note 1)	V_O	390 (≥320)		mV
(E_e = 0.5 mW/cm² λ = 950 nm)	V_O		340 (≥280)	mV
Short Circuit Current (E_e =1000 lx, Note 1)	I_K	24 (≥15)		μA
(E_e = 0.5 mW/cm² λ =950 nm)	I_K		7.5 (≥4)	μA
Rise and Fall Time of the Photocurrent from 10% to 90% and from 90% to 10% of the Final Value (R_L = 1 Ω, V_R = 0 V λ = 830 nm, I_P = 20 μA)	t_r, t_f	500	500	ns
Forward Voltage (I_F = 100 mA, E_e = 0 T_{amb} = 25°C)	V_F	1.3	1.3	V
Capacitance (V_R = 0 V, f = 1 MHz E_V = 0 lx)	C_0	40	40	pF
(V_R = 10 V, f = 1 MHz E_V = 0 lx)	C_{10}	10	10	pF
Temperature Coefficient V_O	TC_V	-2.6	-2.6	mV/K
Temperature Coefficient I_S	TC_I	0.18	0.18	%/K

[1]The illuminance indicated refers to unfiltered radiation of a tungsten-filament lamp at a color temperature of 2856 K. (Standard light A in accordance with DIN 5033 and IEC publ. 306-1.)

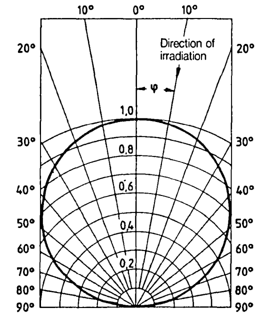
Relative spectral sensitivity versus wavelength
SFH 248



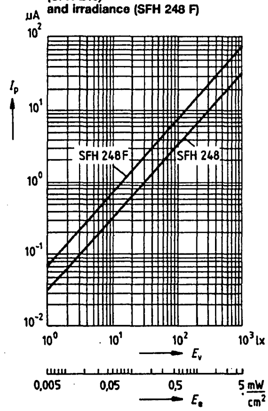
Relative spectral sensitivity versus wavelength
SFH 248 F



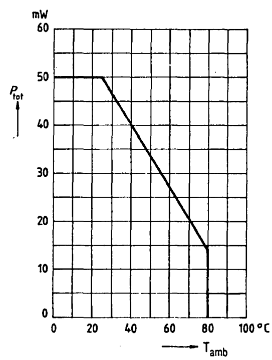
Directional characteristic
Relative spectral sensitivity versus half angle



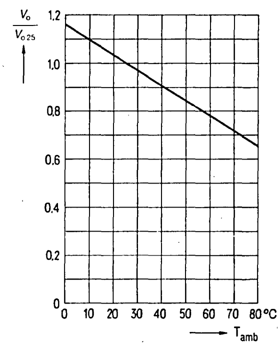
Photocurrent versus illuminance (SFH 248) and irradiance (SFH 248 F)



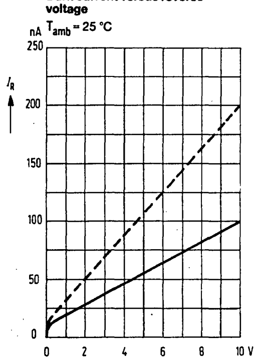
Total power dissipation versus ambient temperature



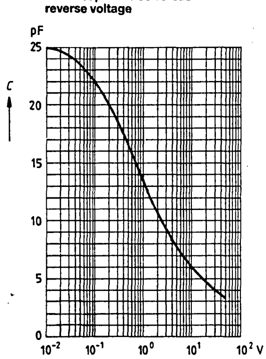
Open-circuit voltage versus ambient temperature



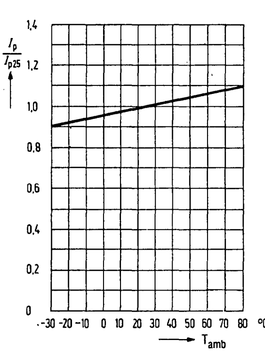
Dark current versus reverse voltage
T_{amb} = 25 °C



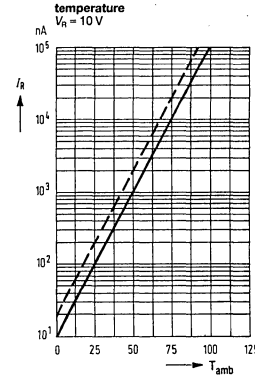
Diode capacitance versus reverse voltage



Photocurrent versus ambient temperature



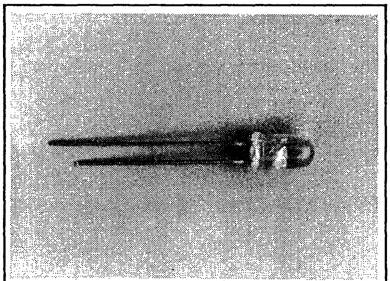
Dark current versus ambient temperature
V_R = 10 V



Photodiodes

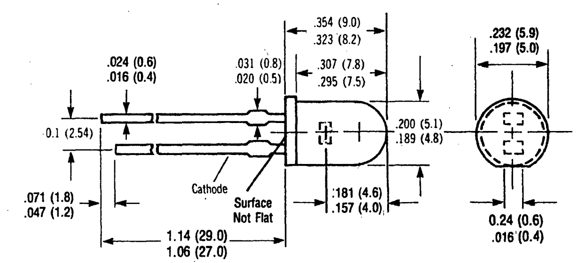
SIEMENS

SFH 2030
WITH DAYLIGHT FILTER SFH 2030F
SILICON PIN PHOTODIODE



SFH2030

Package Dimensions in Inches (mm)



FEATURES

- **High Reliability**
- **Low Noise**
- **High Open-Circuit Voltage as Photovoltaic Cells**
- **Short Switching Time**
- **Low Capacitance**
- **High Spectral Sensitivity**
- **Suitable for Use in the Visible Light and Near Infrared Range**
- **Clear Plastic Lens, SFH2030**
- **Daylight Filter Option, SFH2030F**

DESCRIPTION

SFH2030 and SFH2030F are silicon photodiodes fabricated in PIN planar technology. The devices are in T1¾ packages. The terminals are solder tabs with 0.1″ (2.54 mm) lead spacing. These photodetectors can be operated either as photodiodes with reverse voltage or as photovoltaic cells.

Applications include: industrial electronics, measuring and controlling devices, light-activated switches, fiber optic transmission systems.

Maximum Ratings

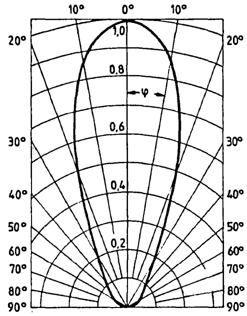
Reverse Voltage (V_R) .... 30 V
Storage and Operating Temperature .... −40 to +80°C
Soldering Temperature in a 2 mm Distance from the Case Bottom (t ≤ 3 s) (t_S) .... 300°C
Power Dissipation (P_{tot}) .... 100 mW

Characteristics (T_{amb} = 25°C)

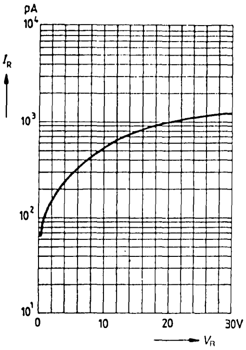
	Symbol	SFH2030	SFH2030F	Unit
Spectral Sensitivity (V_R = 5 V, Note 1)	S	80 (≥50)		nA/lx
Spectral Sensitivity (V_R = 5 V; λ = 950 nm E_e = 0.5 mW/cm²)	S		25 (≥15)	μA
Wavelength of Max. Sensitivity	λ_{Smax}	850	900	nm
Spectral Range of Photosensitivity (S = 10% of Smax)	λ	400 to 1100	800 to 1100	nm
Radiant Sensitive Area	A	1	1	mm²
Dimensions of the Radiant Sensitive Area	L × W	1 × 1	1 × 1	mm
Distance Between Chip Surface and Package Surface	H	4.0 to 4.6	4.0 to 4.6	mm
Half Angle	φ	±20	±20	Deg.
Dark Current (V_R = 20 V)	I_R	1 (≤5)	1 (≤5)	nA
Spectral Sensitivity (λ = 850 nm)	S_λ	0.62	0.62	A/W
Quantum Yield (λ = 850 nm)	η	0.89	0.89	Electrons/Photon
Open Circuit Voltage (E_e = 1000 lx, Note 1)	V_O	420 (≥350)		mV
(E_e = 0.5 mW/cm² λ = 950 nm)	V_O		370 (≥300)	mV
Short Circuit Current (E_e = 1000 lx, Note 1)	I_S	80 (≥50)		μA
(E_e = 0.5 mW/cm² λ = 950 nm)	I_S		25 (≥15)	μA
Rise and Fall Time of the Photocurrent from 10% to 90% and from 90% to 10% of the Final Value (R_L = 50 Ω, V_R = 5 V λ = 880 nm, I_P = 14 μA)	t_r, t_f	2	2	ns
Forward Voltage (I_F = 100 mA, E_e = 0 T_{amb} = 25°C)	V_F	1.3	1.3	V
Capacitance (V_R = 0 V, f = 1 MHz E_V = 0 lx)	C_0	11	11	pF
Temperature Coefficient V_O	TC_V	−2.6	−2.6	mV/K
Temperature Coefficient I_S	TC_I	0.2	0.2	%/K
Noise Equivalent Power (V_R = 20 V)	NEP	2.9×10^{-14}	2.9×10^{-14}	$\frac{W}{\sqrt{Hz}}$
Detection Limit (V_R = 20 V)	D_L	3.5×10^{12}	3.5×10^{12}	$\frac{cm \sqrt{Hz}}{W}$

[1]The illuminance indicated refers to unfiltered radiation of a tungsten-filament lamp at a color temperature of 2856 K. (Standard light A in accordance with DIN 5033 and IEC publ. 306-1.)

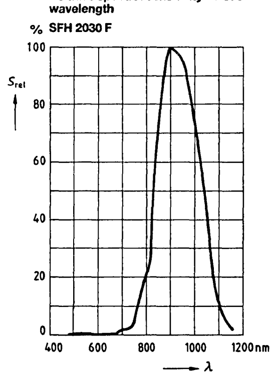
Directional characteristic
Relative spectral sensitivity versus half angle



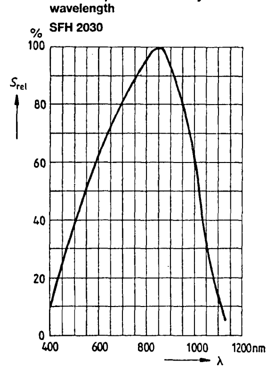
Dark current versus reverse voltage



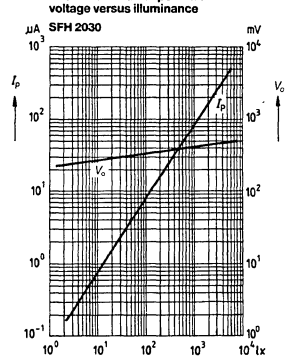
Relative spectral sensitivity versus wavelength



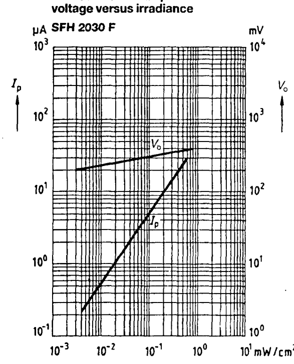
Relative spectral sensitivity versus wavelength



Photocurrent and open-circuit voltage versus illuminance

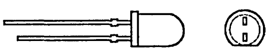
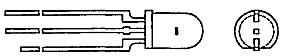
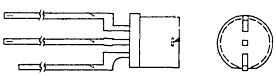
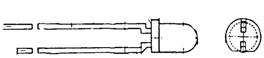
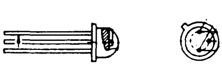


Photocurrent and open-circuit voltage versus irradiance

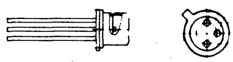
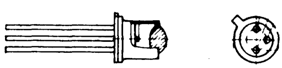
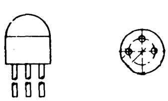
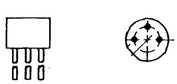
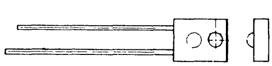


Photodiodes

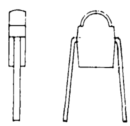
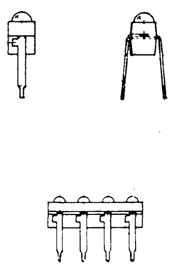
Phototransistors

Package Outline	Part Number	Package Type	Half Angle	Photocurrent λ=950nm V_{CE}=5V mA	Collector Emitter Voltage V	Radiant Sensitive Area mm²	Features	Page
	BP103B-2	T1³/4 Clear plastic.	±25°	0.63-1.25	35	.12	IR remote control. High gain. λsmax 850nm. Matches with IR emitter LD271, LD273, SFH484, or SFH485.	9-6
	BP103B-3			1.0-2.0				
	BP103B-4			≥1.6				
	SFH303-2	T1³/4 Clear plastic.	±20°	1.0-2.0	50	.30	Good linearity. High photosensitivity. Suitable for visual and near IR range.	9-23
	SFH303-3			1.6-3.2				
	SFH303-4			≥2.5				
	SFH303F-2	T1³/4 Plastic with daylight filter.		1.0-2.0				
	SFH303F-3			1.6-3.2				
	SFH303F-4			≥2.5				
	SFH317-2	T1³/4 Flat clear plastic lens.	±60°	0.16-0.32	50	.30	Good linearity. High photosensitivity. Fast rise and fall times.	9-29
	SFH317-3			0.25-0.5				
	SFH317-4			≥0.4				
	SFH317F-2	T1³/4 Flat plastic lens with daylight filter.		0.16-0.32				
	SFH317F-3			0.25-0.5				
	SFH317F-4			≥0.4				
	SFH309-2	T1 Clear plastic.	±16°	0.5-1.0	35	.045	IR remote control. Narrow acceptance angle. Matches with IR emitter SFH409.	9-27
	SFH309-3			0.63-1.25				
	SFH309-4			1.0-2.0				
	SFH309-5			≥1.6				
	SFH309F-2	T1 Plastic with daylight filter.		0.5-1.0				
	SFH309F-3			0.63-1.25				
	SFH309F-4			1.0-2.0				
	SFH309F-5			≥1.6				
	BP103-2	Similiar to TO-18. Clear plastic lens.	±55°	0.08-0.16	50	.12	IR remote control. λsmax 850nm. Matches with IR emitter LD242.	9-4
	BP103-3			0.125-0.25				
	BP103-4			0.2-0.4				
	BP103-5			0.32-0.63				
	BP103-6			≥0.50				

Phototransistors

Package Outline	Part Number	Package Type	Half Angle	Photocurrent λ=950nm V_{CE}=5V mA	Collector Emitter Voltage V	Radiant Sensitive Area mm²	Features	Page
	BPX38-2	TO-18 Hermetic package. Flat glass lens.	±40°	0.2-0.4	50	.675	Wide acceptance angle 80 . Matches with IR emitter SFH402. λsmax 870nm.	9-8
	BPX38-3			0.32-0.63				
	BPX38-4			0.5-1.0				
	BPX38-5			0.8-1.6				
	BPX38-6			≥1.25				
	BPX43-2	TO-18 Hermetic package. Glass lens.	±15°	0.8-1.6	50	.675	Narrow acceptance angle 30°. Matches with IR emitter SFH401. λsmax 870nm.	9–10
	BPX43-3			1.25-2.5				
	BPX43-4			2.0-4.0				
	BPX43-5			3.2-6.3				
	BPX43-6			≥5				
	BPY62-2		±8°	0.5-1.0	32	.12	Very narrow acceptance angle 16°. Matches with IR emitter SFH400. λsmax 850nm.	9–14
	BPY62-3			0.8-1.6				
	BPY62-4			1.25-2.5				
	BPY62-5			2.0-4.0				
	BPY62-6			≥3.2				
	LPT100	Ceramic. Plastic lens.	±25°	4.2 H=5mW/cm²	30	—	Position detector. Intrusion alarm sensor. Optical tachometer.	9–21
	LPT100A							
	LPT100B							
	LPT110		±45°	2.7 H=5mW/cm²				
	LPT110A							
	LPT110B							
	LPD80A Photodarlington	Rectangular clear plastic. Side-facing.	±40°	0.5–4.0 H=5mW/cm²	30	—	λsmax 810nm. Matches with IR emitters IRL80A/81A.	9–16
	LPT80A			≥0.2 H=5mW/cm²			λsmax 870nm. Matches with IR emitters IRL80A/81A.	9–17
	LPT85A			≥0.9 H=5mW/cm²				9–19

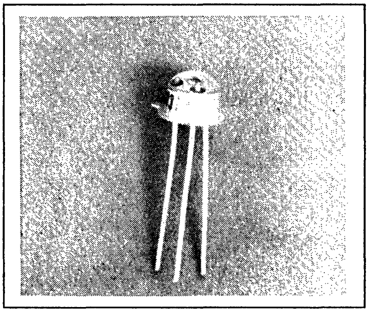
Phototransistors

Package Outline	Part Number	Package Type	Half Angle	Photocurrent λ=950nm V_{CE}=5V mA	Collector Emitter Voltage V	Radiant Sensitive Area mm^2	Features	Page
	SFH305-2	Miniature. Thin package. Clear plastic. Axial lead.	±16°	0.25-0.5	32	.17	Narrow acceptance angle 32° λsmax 850nm. Matches with IR emitter SFH405.	9–25
	SFH305-3			0.4-0.8				
	BPX81-2	Miniature. Clear plastic. Single unit.	±18°	0.25-0.5	32	.17	Axial leads. λsmax 850nm. BPX81: Matches with IR emitters LD261. BPX82-89, 80: Matches with IR emitters LD262-9, LD260.	9–12
	BPX81-3			0.4-0.8				
	BPX81-4			≥0.63				
	BPX82	2 diode array		0.32-0.8		.17 per diode		
	BPX83	3 diode array						
	BPX84	4 diode array						
	BPX85	5 diode array						
	BPX86	6 diode array						
	BPX87	7 diode array						
	BPX88	8 diode array						
	BPX89	9 diode array						
	BPX80	10 diode array						

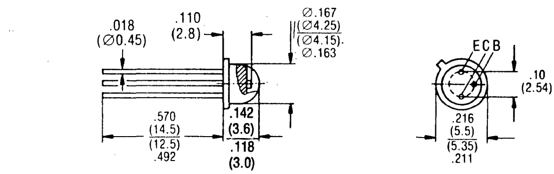
SIEMENS

BP103 SERIES

SILICON PHOTOTRANSISTOR



Package Dimensions in Inches (mm)



FEATURES

- **Silicon NPN Epitaxial Phototransistor**
- **Modified TO-18 Package**
- **Clear Plastic Lens**
- **Wide Acceptance Angle, 110°**
- **Five Sensitivity Ranges**
- **Matches LD242 Emitter**

DESCRIPTION

The BP103 is an epitaxial NPN silicon planar phototransistor in a case similar to 18 A 3 DIN 41876 (TO-18) with glass-clear plastic encapsulation. The plastic lens provides a wide angle for incident light. This angle can also be reduced by mounting a diaphragm. The emitter terminal is marked by a tab on the case bottom. The collector is electrically connected to the metallic case parts.

Applications include: automatic electronic flashes with base integrating circuit and self-excited (high-frequency) breakdown voltage generators (see circuit diagram) and in high Q electronic instructional toys used in filament lamp light and daylight, as well as in combination with GaAs infrared emitting diodes in small light barriers.

Maximum Ratings

Operating and Storage Temperature (T_{STG}, T_{OP}) .... -40°C to +80°C
Soldering Temperature (distance from soldering joint to package ≥2 mm)
Dip Soldering Time (t ≤5 sec.) (T_S) .... 260°C
Iron Soldering Time (t ≤3 sec.) (T_S) .... 300°C
Collector Emitter Voltage (V_{CEO}) .... 50 V
Collector Current (I_C) .... 100 mA
Collector Peak Current (t <10 µs) (I_{PK}) .... 200 mA
Emitter Base Voltage (V_{EB}) .... 7 V
Power Dissipation (P_{TOT}) T_{amb}=25°C .... 300 mW
Thermal Resistance (R_{thJA}) .... 500 K/W

Characteristics (T_{amb}=25°C)

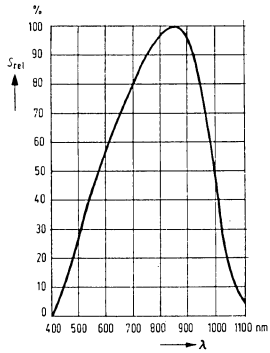
Wavelength of Max. Photosensitivity	λ_{Smax}	850	nm
Spectral Range of Photosensitivity	λ	440–1100	nm
Radiant Sensitive Area	A	0.12	mm²
Die Area	L x W	0.5 x 0.5	mm
Distance Die Surface to Package Surface	H	0.2–0.8	mm
Half Angle	φ	±55	Deg.
Photocurrent of the Collector, Base Diode			
(E_E=0.5 mW/cm², λ=950 nm, V_{CB}=5 V)	I_{PCB}	0.9	µA
(E_V=1000 lx, standard light A, V_{CB}=5 V)	I_{PCB}	2.7	µA
Capacitance			
(V_{CE}=0 V, f=1 MHz, E=0)	C_{CE}	8	pF
(V_{CB}=0 V, f=1 MHz, E=0)	C_{CB}	11	pF
(V_{EB}=0 V, f=1 MHz, E=0)	C_{EB}	19	pF
Collector Emitter Leakage Current			
(V_{CEO}=35 V, E=0 lx)	I_{CEO}	5 (≤100)	nA

		–2	–3	–4	–5	–6 [2]	
Photocurrent, Collector to Emitter (Note 1) (E_V=1000 lx, standard light A, V_{CE}=5 V)	I_{PCE}	0.38	0.60	0.95	1.4	1.8	mA
(E_E=0.5 mW/cm², λ=950 nm, V_{CE}=5 V)	I_{PCE}	.08 –.16	.125 –.25	.20 –.40	.32 –.63	≥.50	mA
Rise/Fall Time (I_C=1 mA, V_{CE}=5 V, R_L=1 kΩ, λ=830 nm)	t_R,t_F	5	7	9	12	15	µs
Collector Emitter Saturation Voltage (I_C=I_{PCEmin} • 0.3, E=1000 lx)	V_{CEsat}	150	150	150	150	150	mV
Current Gain (E_E=0.5 mW/cm², λ=950 nm, V_{CE}=5 V)	$\frac{I_{PCE}}{I_{PCB}}$	140	210	340	530	800	

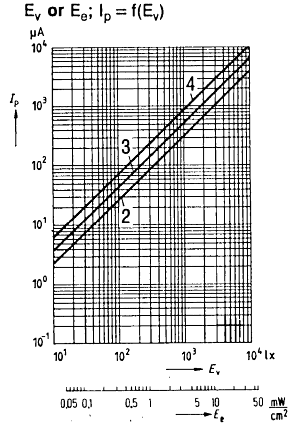
The illuminances refer to unfiltered radiation of a tungsten filament lamp at a color temperature of 2856K (standard light A in accordance with DIN 5033 and IEC publ. 306-11). Irradiance E_E measured with HP radiant flux meter 8334A with option 013.

Notes:
1. Measured with LED λ= 950 nm. I_{PCE}= Photocurrent of transistors; I_{PCB}= Photocurrent of Collector-Base-Diode.
2. Supplies of this group cannot be guaranteed due to unforeseeable spread of yield. In this case we will reserve us the right of delivering a substitute group.

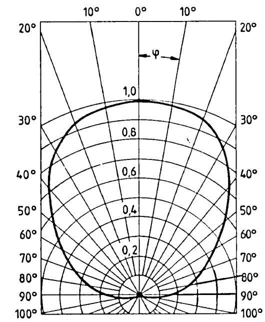
Relative Spectral Sensitivity
$S_{rel} = f(\lambda)$



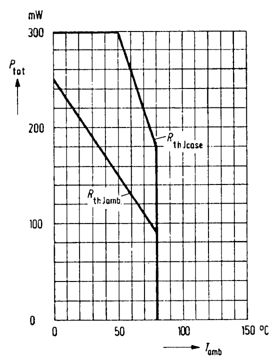
Photocurrent as a Function of E_v or E_e; $I_p = f(E_v)$



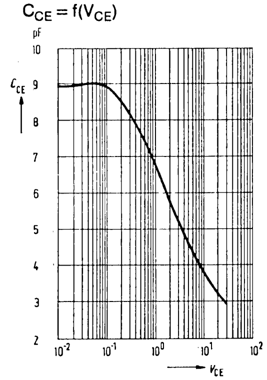
Directional Characteristic
$S_{rel} = f(\varphi)$



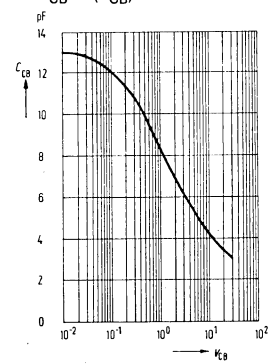
Power Dissipation $P_{tot} = f(T_{amb})$



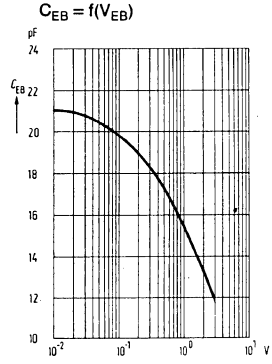
Collector-Emitter Capacitance
$C_{CE} = f(V_{CE})$



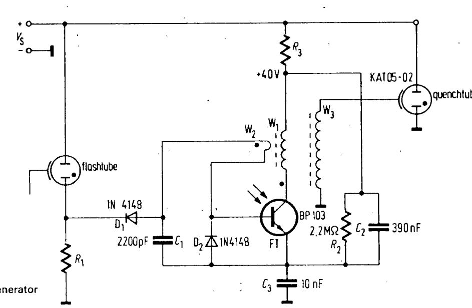
Collector-Base Capacitance
$C_{CB} = f(V_{CB})$



Emitter-Base Capacitance
$C_{EB} = f(V_{EB})$



Application Example



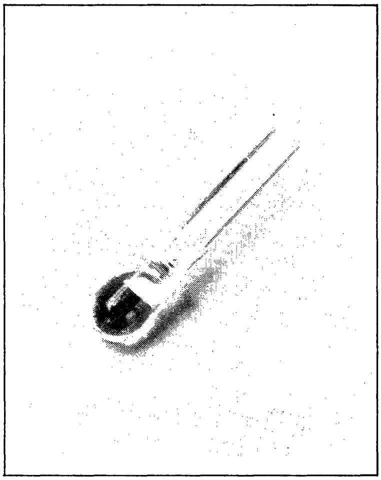
Breakdown voltage generator for measuring circuit
W_1 : 4 turns 0.15 Ø CuLS
W_2 : 1 turns 0.25 Ø CuL
W_3 : 140 turn 0.15 Ø CuLS

Interior space of the coil with SIFERRIT cylindrical core, material M 25, inner coil diameter: 11 mm

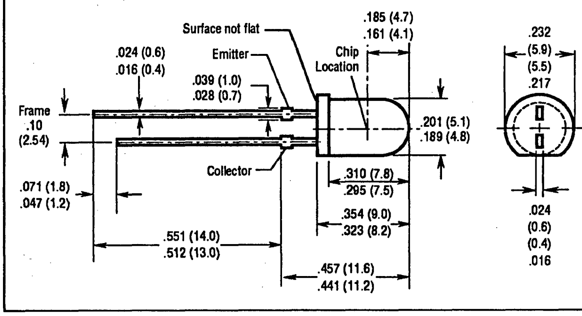
Phototransistors/ Photodarlington

SIEMENS

BP 103B SERIES
PHOTOTRANSISTOR



Package Dimensions in Inches (mm)



FEATURES

- **Silicon NPN Epitaxial Phototransistor**
- **Low Cost**
- **T 1¾ Package**
- **Clear Plastic Lens**
- **Acceptance Angle 50°**
- **Very High Gain**
- **Matches with Infrared Emitters LD271, LD 273, SFH484 or 485**

DESCRIPTION

BP103B is an epitaxial NPN silicon phototransistor of high sensitivity. It is enclosed in a tubular 5 mm all-plastic package.

The base terminal is not contacted, control is performed by the incident light. The collector is characterized by a flattening on the package base.

The phototransistor is mainly intended for standard applications and for use in automatic electronic flashes. Due to the tubular plastic shape, it can easily be mounted into holes and preformed plastic sleeves; e.g. LED mounting assemblies.

Maximum Ratings

Operating and Storage Temperature	T	−55 to +100	°C
Soldering Temperature (Distance from soldering joint to package ≥2 mm			
Dip Soldering Time t ≤ 5 s	T_S	260	°C
Iron Soldering Time t ≤3 s)	T_S	300	°C
Collector Emitter Voltage	V_{CEO}	35	V
Collector Current	I_C	50	mA
Collector Peak Current (t < 10 µs)	I_{PK}	100	mA
Emitter Base Voltage	V_{EB}	7	V
Power Dissipation (T_{amb} = 25°C)	P_{tot}	200	mW
Thermal Resistance	R_{thJA}	375	K/W

Characteristics (T_{amb} = 25°C)

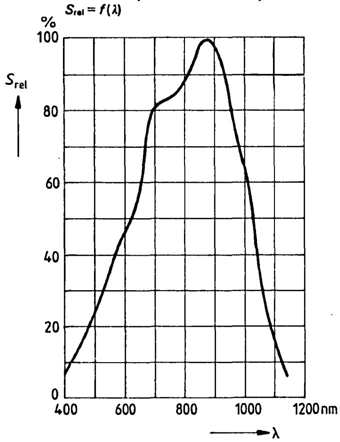
Wavelength of Max. Photosensitivity	λ_{Smax}	850	nm
Spectral Range of Photosensitivity	λ	420 to 1100	nm
Radiant Sensitive Area	A	0.12	mm²
Die Area	L × W	0.5 × 0.5	mm
Distance Die Surface to Package Surface	H	4.1 to 4.7	mm
Half Angle	φ	±25	Deg.
Capacitance (V_{CE} = 0 V, f = 1 MHz, E = 0 lx)	C_{CE}	6.5	pF
Collector Emitter Leakage Current (V_{CEO} = 35 V, E = 0 lx)	I_{CEO}	5 (≤100)	nA

Group	BP103B-2	BP103B-3	BP103B-4	
Photocurrent of the Transistor, Collector to Emitter (Note 1) (E_V = 1000 lx, V_{CE} = 5 V) I_{PCE}	2.5 to 5.0	4.0 to 8.0	≥6.3	mA
(E_e = 0.5 mW/cm² λ = 950 nm, V_{CE} = 5 V) I_{PCE}	0.63 to 1.25	1 to 2	≥1.6	mA
Rise/Fall Time (I_C = 1 mA, V_{CE} = 5 V R_L = 1 kΩ) t_r, t_f	7.5	10	10	µs
Collector Emitter Saturation Voltage (I_C = I_{PCEmin} • 0.3 E = 1000 lx) V_{CEsat}	130	140	150	mV
Current Gain (E_V = 1000 lx, V_{CE} = 5 V) $\frac{I_{PCE}}{I_{PCB}}$	350	550	650	

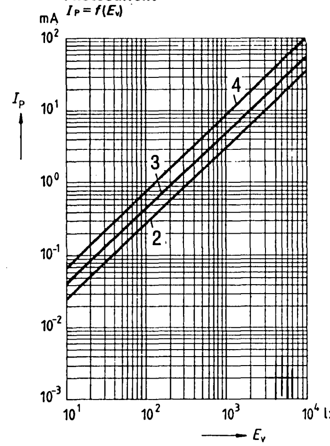
The illuminances refer to unfiltered radiation of a tungsten filament lamp at a color temperature of 2856 K (standard light A in accordance with DIN 5033 and IEC 306-1). Irradiance E_e measured with HP radiant flux meter 8334A with option 013.

[1] Measured with LED λ = 950 nm. I_{PCE} = Photocurrent of transistors; I_{PCB} = Photocurrent of Collector-Base-Diode.

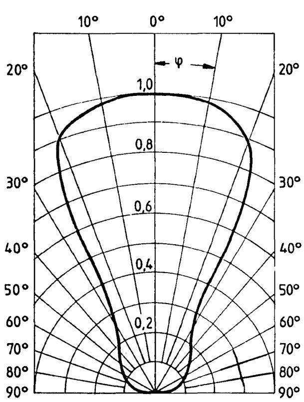
Relative spectral sensitivity
$S_{rel} = f(\lambda)$



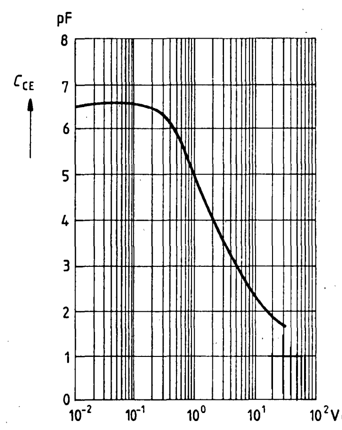
Photocurrent
$I_P = f(E_v)$



Directional characteristic $S_{rel} = f(\varphi)$



Collector-emitter capacitance
$C_{CE} = f(V_{CE})$

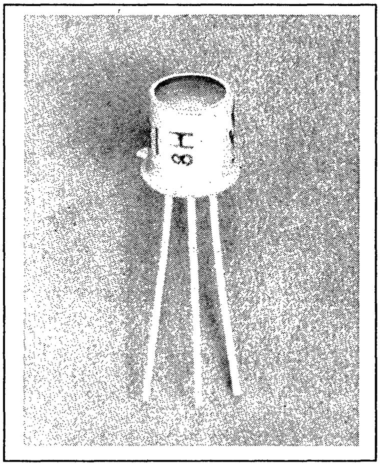


Phototransistors/
Photodarlington

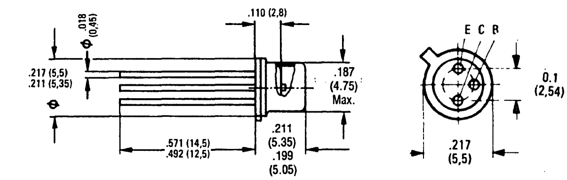
SIEMENS

BPX38 SERIES

PHOTOTRANSISTOR



Package Dimensions in Inches (mm)



FEATURES

- **Silicon NPN Epitaxial Phototransistor**
- **TO-18 Hermetic Package**
- **Flat Glass Lens**
- **Premium Hi-Rel Device**
- **Moderate Gain**
- **Wide Acceptance Angle, 80°**
- **Five Sensitivity Ranges**

DESCRIPTION

The BPX38 is a silicon epitaxial planar phototransistor in an 18 A 3 DIN 41876 (TO-18) case with a flat window and high radiant sensitivity for front irradiance. The flat window has no influence on light paths. The collector terminal is electrically connected to the case.

The BPX38 is suitable for industrial applications where lens systems are used.

Maximum Ratings

Operating and Storage Temperature (T_{STG}, T_{OP}) .... -55°C to +125°C
Soldering Temperature (distance from soldering joint to package ≥2 mm)
Dip Soldering Time (t ≤5 sec.) (T_S) .... 260°C
Iron Soldering Time (t ≤3 sec.) (T_S) .... 300°C
Collector Emitter Voltage (V_{CEO}) .... 50 V
Collector Current (I_C) .... 50 mA
Collector Peak Current (t <10 µs) (I_{PK}) .... 200 mA
Emitter Base Voltage (V_{EB}) .... 7 V
Power Dissipation (P_{TOT}) T_{amb}= 25°C .... 330 mW
Thermal Resistance (R_{THJA}) .... 450 K/W

Characteristics (T_{amb}=25°C)

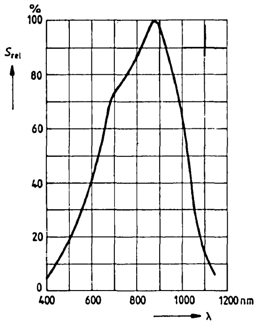
Wavelength of Max. Photosensitivity	λ_{SMAX}	880	nm
Spectral Range of Photosensitivity	λ	450–1150	nm
Radiant Sensitive Area	A	0.675	mm^2
Die Area	L x W	1 x 1	mm
Distance Die Surface to Package Surface	H	2.25–2.55	mm
Half Angle	φ	±40	Deg.
Photocurrent of the Collector, Base Diode			
(E_V=1000 lx, V_{CE}=5 V)	I_{PCB}	5.5	µA
(E_E=0.5 mW/cm^2, λ=950 nm, V_{CB}=5 V)	I_{PCB}	1.8	µA
Capacitance			
(V_{CE}=0 V, f=1 MHz, E=0)	C_{CE}	23	pF
(V_{CB}=0 V, f=1 MHz, E=0)	C_{CB}	39	pF
(V_{EB}=0 V, f=1 MHz, E=0)	C_{EB}	47	pF
Collector Emitter Leakage Current			
(V_{CE}=25 V, E=0)	I_{CEO}	20 (≤300)	nA

		–2	–3	–4	–5	–6 (2)	
Photocurrent, Collector to Emitter (Note 1) (E_V=1000 lx, standard light A, V_{CE}=5 V)	I_{PCE}	0.95	1.5	2.3	3.6	4.6	mA
(E_E=0.5 mW/cm^2, λ=950 nm, V_{CE}=5 V)	I_{PCE}	0.2–0.4	0.32–0.63	0.5–1.0	0.8–1.6	≥1.25	mA
Rise/Fall Time (I_C=1 mA, V_{CE}=5 V, R_L=1 kΩ, λ=830 nm)	t_R,t_F	9	12	15	18	22	µs
Collector Emitter Saturation Voltage (I_C=I_{PCEmin} • 0.3, λ=950 nm, V_{CE}=5 V)	V_{CEsat}	200	200	200	200	200	mV
Current Gain (E_E=0.5 mW/cm^2, λ=950 nm, V_{CE}=5 V)	$\frac{I_{PCE}}{I_{PCB}}$	170	280	420	650	840	

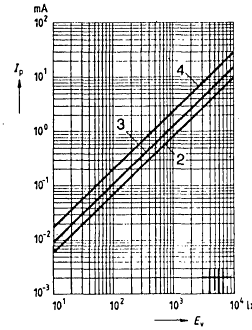
The illuminances refer to unfiltered radiation of a tungsten filament lamp at a color temperature of 2856K (standard light A in accordance with DIN 5033 and IEC publ. 306-11). Irradiance E_E measured with HP radiant flux meter 8334A with option 013.

Notes:
1. Measured with LED λ= 950 nm. I_{PCE}= Photocurrent of transistors; I_{PCB}= Photocurrent of Collector-Base-Diode.
2. Supplies of this group cannot be guaranteed due to unforeseeable spread of yield. In this case we will reserve us the right of delivering a substitute group.

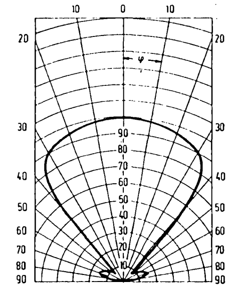
Relative spectral sensitivity $S_{rel} = f(\lambda)$



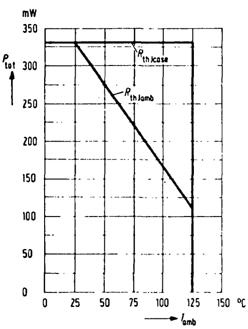
Photocurrent $I_P = f(E_v)$



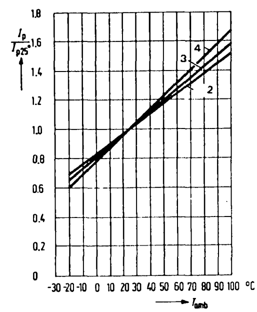
Directional characteristics $S_{rel} = f(\varphi)$



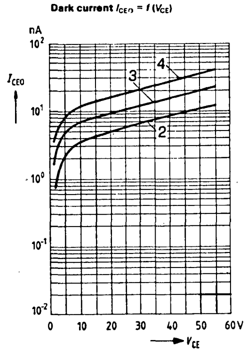
Power dissipation $P_{tot} = f(T_{amb})$



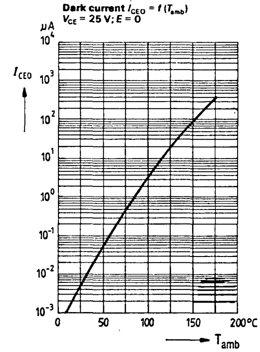
Photocurrent $\frac{I_P}{I_{P\,25°}} = f(T_{amb})$



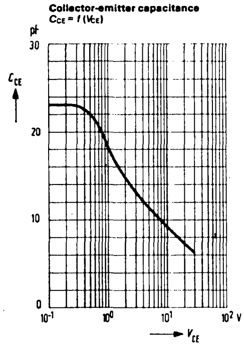
Dark current $I_{CEO} = f(V_{CE})$



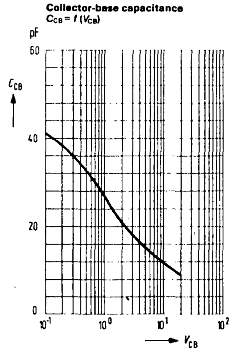
Dark current $I_{CEO} = f(T_{amb})$
$V_{CE} = 25$ V; $E = 0$



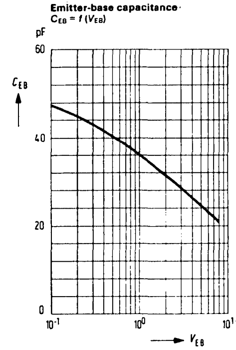
Collector-emitter capacitance
$C_{CE} = f(V_{CE})$



Collector-base capacitance
$C_{CB} = f(V_{CB})$



Emitter-base capacitance
$C_{EB} = f(V_{EB})$

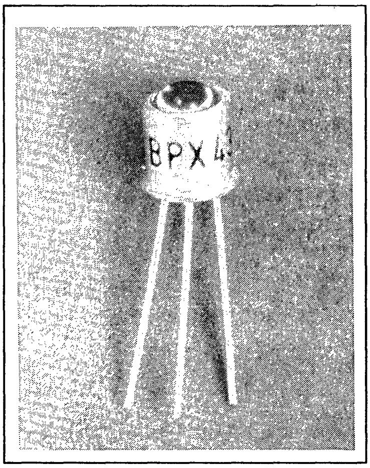


Phototransistors/ Photodarlington

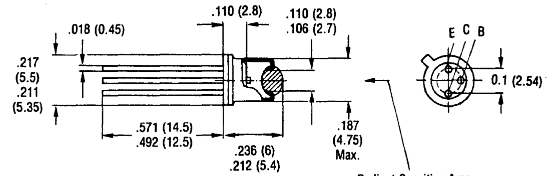
SIEMENS

BPX43 SERIES

PHOTOTRANSISTOR



Package Dimensions in Inches (mm)



FEATURES

- **Silicon NPN Epitaxial Phototransistor**
- **TO-18 Hermetic Package**
- **Rounded Glass Lens**
- **Premium Hi-Rel Device**
- **Very High Gain**
- **Narrow Acceptance Angle, 30°**
- **Five Sensitivity Ranges**

DESCRIPTION

The BPX43 is a silicon NPN epitaxial planar phototransistor in an 18 A 3 DIN 41876 (TO-18) case with lens-shaped window for front irradiance. The special transistor system in connection with the lens shaped window provides a high spectral sensitivity. The collector terminal is electrically connected to the case.

The BPX43 is suitable for industrial applications at low illuminances.

Maximum Ratings

Operating and Storage Temperature (T_{STG}, T_{OP}) .... -55°C to +125°C
Soldering Temperature (distance from soldering joint to package ≥2 mm)
Dip Soldering Time (t ≤5 sec.) (T_S) .... 260°C
Iron Soldering Time (t ≤3 sec.) (T_S) .... 300°C
Collector Emitter Voltage (V_{CEO}) .... 50 V
Collector Current (I_C) .... 50 mA
Collector Peak Current (t <10 µs) (I_{FK}) .... 200 mA
Emitter Base Voltage (V_{EB}) .... 7 V
Power Dissipation (P_{TOT}) T_{amb}= 25°C .... 330 mW
Thermal Resistance (R_{THJA}) .... 450 K/W

Characteristics (T_{amb}=25°C)

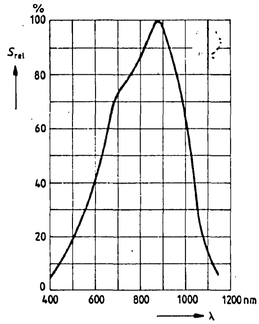
Wavelength of Max. Photosensitivity	λ_{SMAX}	880	nm
Spectral Range of Photosensitivity	λ	450–1100	nm
Radiant Sensitive Area	A	0.675	mm^2
Die Area	L x W	1 x 1	mm
Distance Die Surface to Package Surface	H	2.25–2.55	mm
Half Angle	φ	±15	Deg.
Photocurrent of the Collector, Base Diode			
(E_V=1000 lx, V_{CE}=5 V)	I_{PCB}	35	µA
(E_E=0.5 mW/cm^2, λ=950 nm, V_{CB}=5 V)	I_{PCB}	11	µA
Capacitance			
(V_{CE}=0 V, f=1 MHz, E=0)	C_{CE}	23	pF
(V_{CB}=0 V, f=1 MHz, E=0)	C_{CB}	39	pF
(V_{EB}=0 V, f=1 MHz, E=0)	C_{EB}	47	pF
Collector Emitter Leakage Current			
(V_{CE}=25 V, E=0)	I_{CEO}	20 (≤300)	nA

		–2	–3	–4	–5	–6 [2]	
Photocurrent, Collector to Emitter (Note 1) (E_V=1000 lx, standard light A, V_{CE}=5 V)	I_{PCE}	3.8	6.0	9.5	15.0	22.5	mA
(E_E=0.5 mW/cm^2, λ=950 nm, V_{CE}=5 V)	I_{PCE}	0.8–1.6	1.25–2.5	2–4	3.2–6.3	≥5	mA
Rise/Fall Time (I_C=1 mA, V_{CE}=5 V, R_L=1 kΩ, λ=830 nm)	t_R,t_F	9	12	15	18	22	µs
Collector Emitter Saturation Voltage (I_C=I_{PCEmin} • 0.3, λ=950 nm, V_{CE}=5 V)	V_{CEsat}	200	220	240	260	290	mV
Current Gain (E_E=0.5 mW/cm^2, λ=950 nm, V_{CE}=5 V)	$\frac{I_{PCE}}{I_{PCB}}$	110	170	270	430	640	

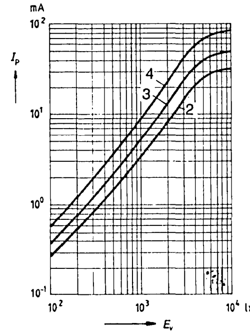
The illuminances refer to unfiltered radiation of a tungsten filament lamp at a color temperature of 2856K (standard light A in accordance with DIN 5033 and IEC publ. 306-11). Irradiance E_E measured with HP radiant flux meter 8334A with option 013.

Notes:
1. Measured with LED λ= 950 nm. I_{PCE}= Photocurrent of transistors; I_{PCB}= Photocurrent of Collector-Base-Diode.
2. Supplies of this group cannot be guaranteed due to unforeseeable spread of yield. In this case we will reserve us the right of delivering a substitute group.

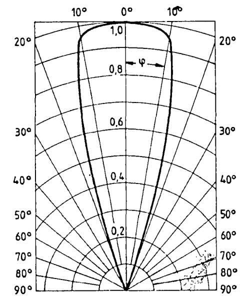
Relative spectral sensitivity
$S_{rel} = f(\lambda)$



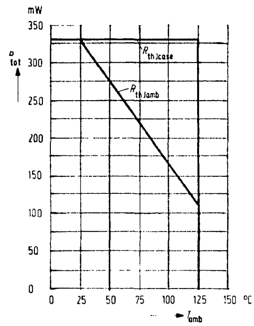
Photocurrent $I_P = f(E_v)$
(V_{CE} = 5 V)



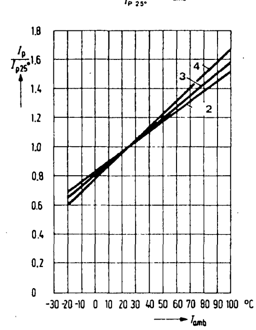
Directional characteristic $S_{rel} = f(\varphi)$



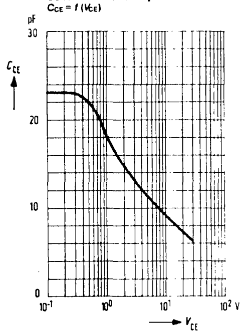
Power dissipation $P_{tot} = f(T_{amb})$



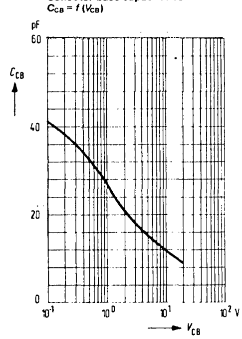
Photocurrent $\frac{I_P}{I_{P\,25°}} = f(T_{amb})$



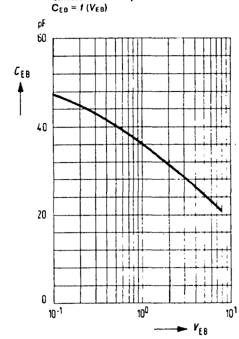
Collector-emitter capacitance
$C_{CE} = f(V_{CE})$



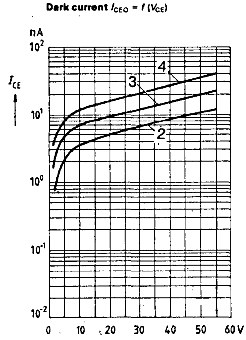
Collector-base capacitance
$C_{CB} = f(V_{CB})$



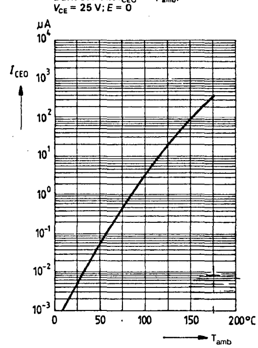
Emitter-base capacitance
$C_{EB} = f(V_{EB})$



Dark current $I_{CEO} = f(V_{CE})$

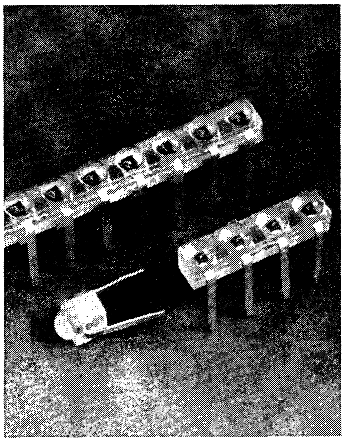


Dark current $I_{CEO} = f(T_{amb})$
V_{CE} = 25 V; E = 0

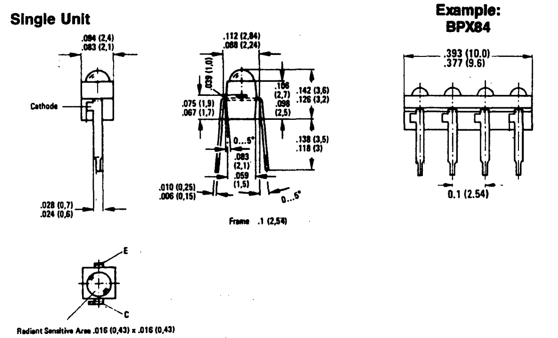


SIEMENS

BPX 81 SERIES
PHOTOTRANSISTOR SINGLE AND ARRAYS



Package Dimensions in Inches (mm)



FEATURES

- Silicon NPN Planar Phototransistor
- Low Cost
- Miniature Size
- Available as Single Unit, BPX 81 and Arrays:
  - Two Chip, BPX 82
  - Three Chip, BPX 83
  - Four Chip, BPX 84
  - Five Chip, BPX 85
  - Six Chip, BPX 86
  - Seven Chip, BPX 87
  - Eight Chip, BPX 88
  - Nine Chip, BPX 89
  - Ten Chip, BPX 80
- Narrow Acceptance Angle, 36°
- High Gain, Up to 5 mA

DESCRIPTION

The types BPX 80 to BPX 89 are plastic encapsulated phototransistor arrays consisting of an arrangement of max. 10 silicon NPN epitaxial planar phototransistors. The individual photoelectric detectors are spaced apart according to the standard lead spacing of 2.54 mm (1/10″). A small angle of the lens-shaped light window avoids optical "cross modulation" from the adjacent system. The collector terminals are marked by small projections arranged at the sides of the solder pins. The phototransistor is suitable for versatile applications in conjunction with filament lamps and infrared light. The BPX 81 can be mounted on PC boards and is also provided for use as detector of the light emitting diode LD 261 (same type as BPX 81) in miniature light barriers.

Maximum Ratings

Operating and Storage Temperature	T	-40 to +80	°C
Soldering Temperature (Distance from soldering joint to package ≥2 mm			
Dip Soldering Time t ≤ 5 s	T_S	230	°C
Iron Soldering Time t ≤3 s)	T_S	300	°C
Collector Emitter Voltage	V_{CEO}	32	V
Collector Current	I_C	50	mA
Collector Peak Current (t < 10 µs)	I_{PK}	200	mA
Power Dissipation (T_{amb} = 25°C)	P_{tot}	100	mW
Thermal Resistance	R_{thJA}	750	K/W
	R_{thJG}	650	K/W

Characteristics (T_{amb} = 25°C)

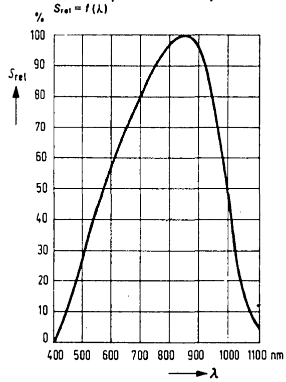
Wavelength of Max. Photosensitivity	λ_{Smax}	850	nm
Spectral Range of Photosensitivity	λ	440 to 1070	nm
Radiant Sensitive Area	A	0.17	mm²
Die Area	L × W	0.6 × 0.6	mm
Distance Die Surface to Package Surface	H	1.3 to 1.9	mm
Half Angle	φ	±18	Deg.
Capacitance (V_{CE} = 0 V, f = 1 MHz, E = 0 lx)	C_{CE}	6	pF
Collector Emitter Leakage Current (V_{CEO} = 25 V, E = 0 lx)	I_{CEO}	25 (≤200)	nA

Group		BPX81-2	BPX81-3	BPX81-4	BPX82-89 BPX80	
Photocurrent of the Transistor, Collector to Emitter (Note 1) (E_V = 1000 lx, V_{CE} = 5 V)	I_P	1.0 to 2.0	1.6 to 3.2	≥2.5	1.25 to 3.2	mA
(E_e = 0.5 mW/cm², λ = 950 nm, V_{CE} = 5 V)	I_P	.25 to .50	.40 to .80	≥.63	.32 to .80	mA
Rise/Fall Time (I_C = 1 mA, V_{CE} = 5 V, R_L = 1 kΩ)	t_r, t_f	5.5	6	8	5.5 to 8	µs
Collector Emitter Saturation Voltage ($I_C = I_{PCEmin} \bullet 0.3$, E = 1000 lx)	V_{CEsat}	150	150	150	150	mV
Current Gain (E_V = 1000 lx, V_{CE} = 5 V)	$\frac{I_{PCE}}{I_{PCB}}$	190	300	450	450	

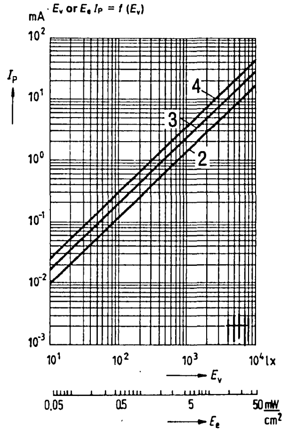
The illuminances refer to unfiltered radiation of a tungsten filament lamp at a color temperature of 2856 K (standard light A in accordance with DIN 5033 and IEC 306-1). Irradiance E_e measured with HP radiant flux meter 8334A with option 013.

[1] Measured with LED λ = 950 nm. I_{PCE} = Photocurrent of transistors; I_{PCB} = Photocurrent of Collector-Base-Diode.

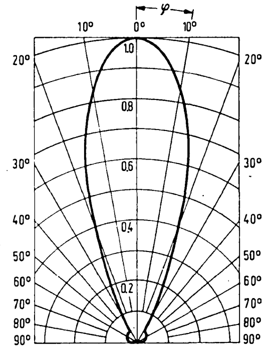
Relative spectral sensitivity
$S_{rel} = f(\lambda)$



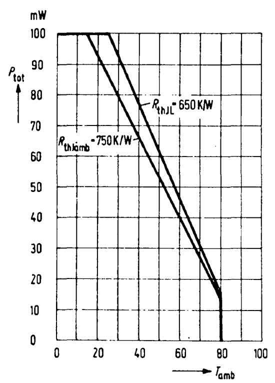
Photocurrent as a function of E_v **or** E_e $I_P = f(E_v)$



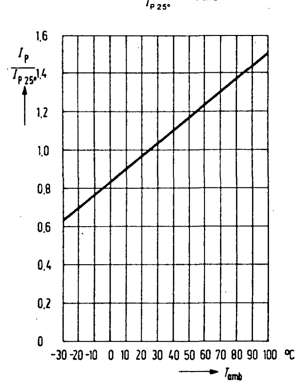
Directional characteristic $S_{rel} = f(\varphi)$



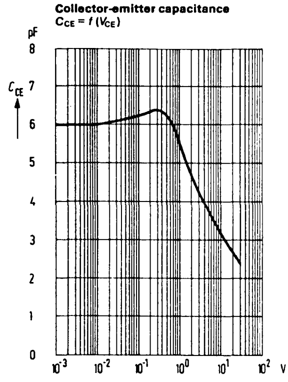
Power dissipation $P_{tot} = f(T_{amb})$



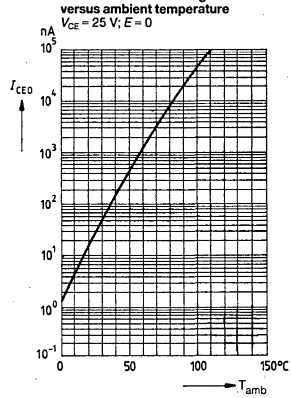
Photocurrent $\frac{I_P}{I_{P\,25°}} = f(T_{amb})$



Collector-emitter capacitance
$C_{CE} = f(V_{CE})$



Collector-emitter leakage current versus ambient temperature
$V_{CE} = 25$ V; $E = 0$

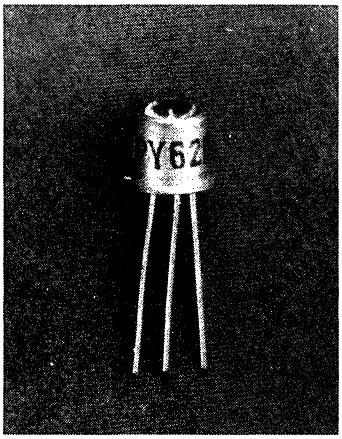


Phototransistors/ Photodarlington

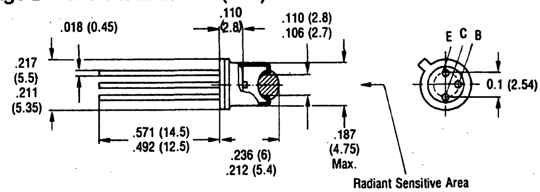
SIEMENS

BPY62 SERIES

PHOTOTRANSISTOR



Package Dimensions in Inches (mm)



FEATURES

- **Silicon NPN Epitaxial Phototransistor**
- **TO-18 Hermetic Package**
- **Rounded Glass Lens**
- **Premium Hi-Rel Device**
- **High Gain**
- **Very Narrow Acceptance Angle, 16°**
- **Five Sensitivity Ranges**

DESCRIPTION

The BPY62 is a silicon NPN epitaxial phototransistor in an 18 A 3 DIN 41876 (TO-18) package with a light window for front irradiance. The base connection is brought out and the emitter is marked by a tab on the case bottom. The collector is electrically connected to the case.

The BPY62 is suitable for versatile applications in connection with filament lamp light where sensitive photoelectric detectors are required.

Maximum Ratings

Operating and Storage Temperature (T_{STG}, T_{OP}) .... -55°C to +125°C
Soldering Temperature (distance from soldering joint to package ≥2 mm)
Dip Soldering Time (t ≤5 sec.) (T_S) .... 260°C
Iron Soldering Time (t ≤3 sec.) (T_S) .... 300°C
Collector Emitter Voltage (V_{CEO}) .... 50 V
Collector Current (I_C) .... 100 mA
Collector Peak Current (t <10 µs) (I_{PK}) .... 200 mA
Emitter Base Voltage (V_{EB}) .... 7 V
Power Dissipation (P_{TOT}) T_{amb}= 25°C .... 300 mW
Thermal Resistance (R_{THJA}) .... 450 K/W

Characteristics (T_{amb}=25°C)

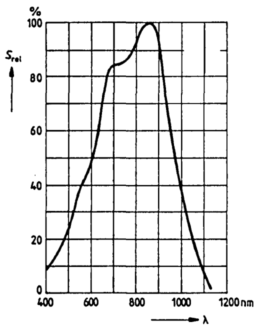
Wavelength of Max. Photosensitivity	λ_{SMAX}	850	nm
Spectral Range of Photosensitivity	λ	400–1100	nm
Radiant Sensitive Area	A	0.12	mm²
Die Area	L x W	0.5 x 0.5	mm
Distance Die Surface to Package Surface	H	2.6–3.2	mm
Half Angle	φ	±8	Deg.
Photocurrent of the Collector, Base Diode			
(E_V=1000 lx, V_{CE}=5 V)	I_{PCB}	17	µA
(E_E=0.5 mW/cm², λ=950 nm, V_{CB}=5 V)	I_{PCB}	4.5	µA
Capacitance			
(V_{CE}=0 V, f=1 MHz, E=0)	C_{CE}	6	pF
(V_{CB}=0 V, f=1 MHz, E=0)	C_{CB}	11	pF
(V_{EB}=0 V, f=1 MHz, E=0)	C_{EB}	19	pF
Collector Emitter Leakage Current			
(V_{CE}=25 V, E=0)	I_{CEO}	5 (≤100)	nA

		–2	–3	–4	–5	–6 (2)	
Photocurrent, Collector to Emitter (Note 1) (E_V=1000 lx, standard light A, V_{CE}=5 V)	I_{PCE}	3.0	4.6	7.2	11.4	15.3	mA
(E_E=0.5 mW/cm², λ=950 nm, V_{CE}=5 V)	I_{PCE}	0.5–1	0.8–1.6	1.25–2.5	2–4	≥3.2	mA
Rise/Fall Time (I_C=1 mA, V_{CE}=5 V, R_L=1 kΩ, λ=830 nm)	t_R,t_F	5	7	9	12	15	µs
Collector Emitter Saturation Voltage (I_C=I_{PCEmin} • 0.3, λ=950 nm, V_{CE}=5 V)	V_{CEsat}	150	150	160	180	200	mV
Current Gain (E_E=0.5 mW/cm², λ=950 nm, V_{CE}=5 V)	$\frac{I_{PCE}}{I_{PCB}}$	170	270	420	670	880	

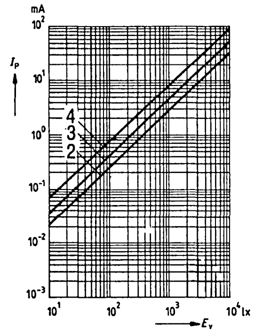
The illuminances refer to unfiltered radiation of a tungsten filament lamp at a color temperature of 2856K (standard light A in accordance with DIN 5033 and IEC publ. 306-11). Irradiance E_E measured with HP radiant flux meter 8334A with option 013.

Notes:
1. Measured with LED λ= 950 nm. I_{PCE}= Photocurrent of transistors; I_{PCB}= Photocurrent of Collector-Base-Diode.
2. Supplies of this group cannot be guaranteed due to unforeseeable spread of yield. In this case we will reserve us the right of delivering a substitute group.

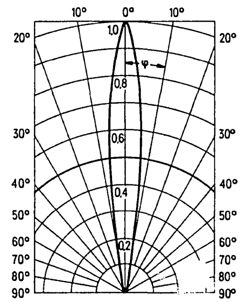
Relative spectral sensitivity
$S_{rel} = f(\varphi)$



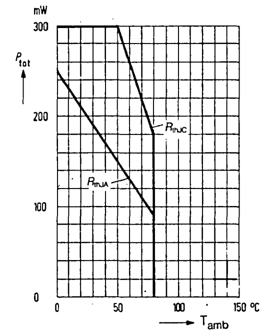
Photocurrent as a function of
E_V or E_e; $I_P = f(E_V)$



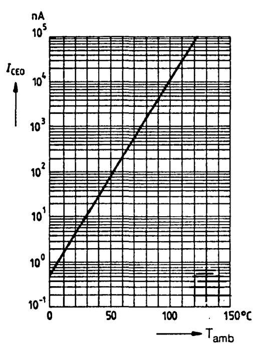
Directional characteristic
$S_{rel} = f(\varphi)$



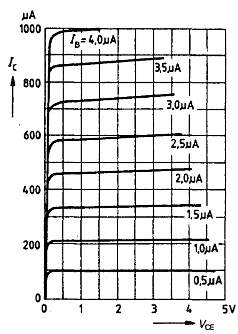
Power dissipation $P_{tot} = f(T_{amb})$
R_{th} = parameter



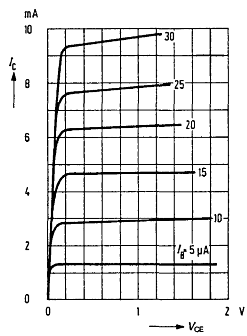
Leakage current (CEO = $f(T_{amb})$
V_{CE} = 25 V, E = 0



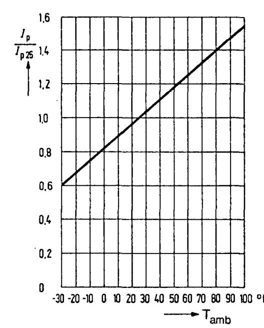
Output characteristics $I_C = f(V_{CE})$
I_S = parameter



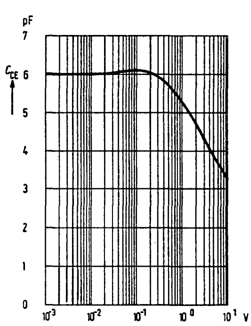
Output characteristics $I_C = f(V_{CE})$
I_R = parameter (emitter circuit)



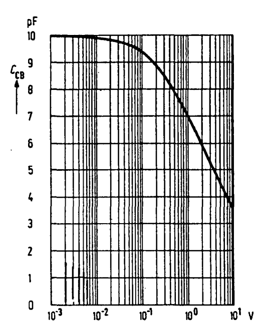
Photocurrent $\frac{I_P}{I_{P25°}} = f(T_{amb})$



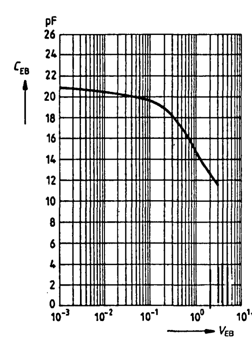
Collector-emitter capacitance
$C_{CE} = f(V_{CE})$



Collector-base capacitance
$C_{CB} = f(V_{CB})$



Emitter-base capacitance
$C_{EB} = f(V_{EB})$

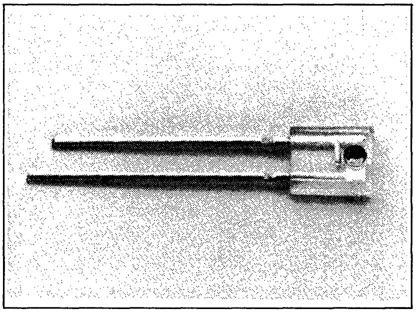


SIEMENS

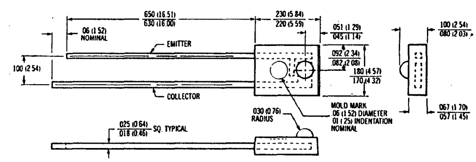
LPD-80A

PHOTODARLINGTON

Advance Data Sheet



Package Dimensions in Inches (mm)



FEATURES

- **Silicon NPN Photodarlington**
- **Miniature Side-Facing Package**
- **Low Cost**
- **High Sensitivity**
- **Matches IRL-80A Infrared Emitter**

DESCRIPTION

The LPD-80A is an epitaxial NPN silicon photo-darlington. The chip is positioned to accept radiation from the side of the clear miniature package. It efficiently receives infrared radiation from the matching IRL-80A.

Maximum Ratings

Collector Emitter Voltage	V_{CE}	30	V
Emitter Collector Voltage	V_{EC}	5	V
Operating and Storage Temperature	T	-40 to +100	°C
Power Dissipation @ 25°C	P_{tot}	100	mW
Deviation Above 25°C		1.33	mW/°C

Characteristics (T_{amb} = 25°C)

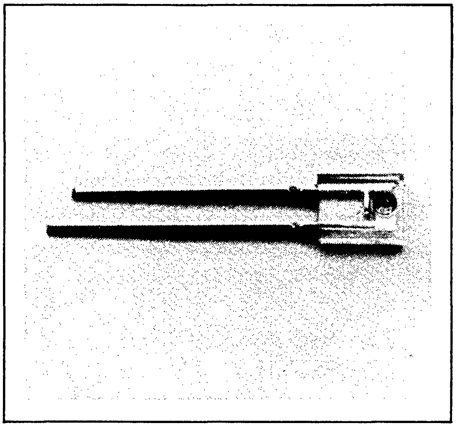
Photocurrent (Note 1) (V_{CE} = 5 V, H = 0.5 mW/cm²)	I_{CE}	.5	4	mA
Dark Current (V_{CE} = 10 V, H = 0)	I_{CEO}		100	nA
Saturation Voltage (I_C = 250 μA H = 0.5 mW/cm²)	V_{CEsat}		1.1	V

[1] The light source is a tungsten filament bulb used in conjunction with a 950 ±30 nm filter. The mechanical axis of the DUT is aligned with the light source.

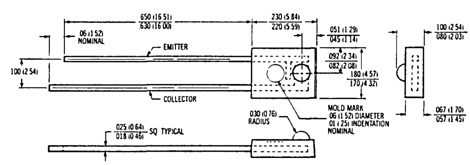
Specifications are subject to change without notice.

SIEMENS

LPT-80A
PHOTOTRANSISTOR



Package Dimensions in Inches (mm)



FEATURES

- **Low Cost Plastic Package**
- **High Sensitivity**
- **Matches Infrared Emitter IRL-80A**

DESCRIPTION

The LPT-80A is a plastic, NPN phototransistor. It comes in a lensed, clear plastic, side-facing, miniature package. Its spheric lens was designed to accept light from very wide angles (±40°). This sensitive detector is ideal for a wide variety of industrial processing and control applications which require a beam interruption.

Maximum Ratings:

Collector-emitter voltage	V_{CEO}	30	V
Emitter-Collector voltage	V_{ECO}	5	V
Collector current	I_C	50	mA
Collector peak current (t = lms)	I_{CM}	100	mA
Storage and operating temperature	T	−40 to +100	°C
Maximum permissible soldering temperature (t≤5 sec)	T_s	240	°C
Power dissipation (T_{amb} = 25°C)	P_{tot}	100	mW*
*Derate above 25°C linearly		1.33	mW/°C

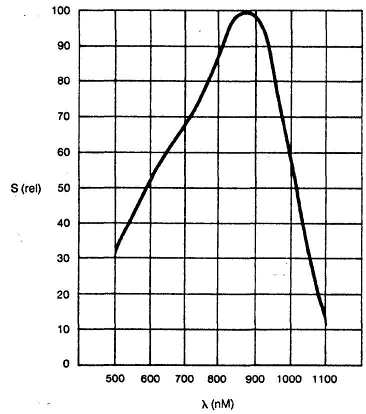
Characteristics (T_{amb} = 25°C)

Collector-emitter leakage current (V_{CE} = 15 V; H = 0)	I_{CEO}	≤100	nA
Wavelength of the max. sensitivity		870	nm
Acceptance half angle	φ	±40	Deg.
Breakdown voltage	BV_{CEO}	30 V min. @ I_C = 1 mA	
	BV_{ECO}	5 V min. @ I_C = 100 µA	
Photocurrent (Note 1) (V_{CE} = 5 V, H = 0.5 mW/cm²)	I_p	≥200	µA
Saturation voltage (I_C = 250 µA, H = 0.5 mW/cm²)	$V_{CE\,(sat)}$	0.15V typ	0.4 V max.

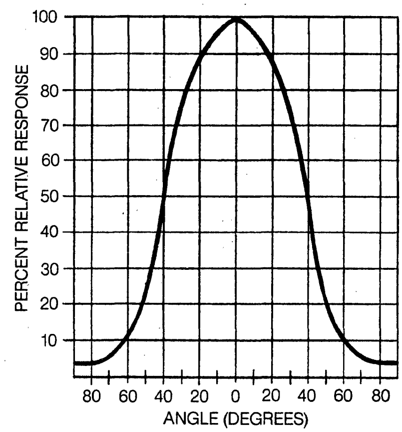
Note 1: The light source is a tungsten filament bulb used in conjunction with a 950 ±30 nm filter. The mechanical axis of the DUT is aligned with the light source.

TYPICAL OPTOELECTRONIC CHARACTERISTICS

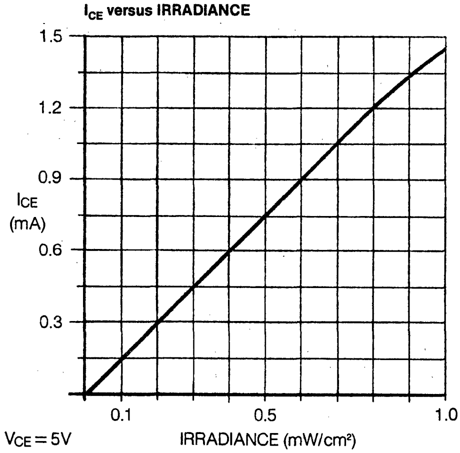
RELATIVE SPECTRAL SENSITIVITY



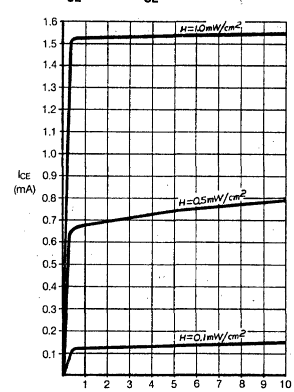
ANGULAR RESPONSE



I_{CE} versus IRRADIANCE



I_{CE} versus V_{CE}

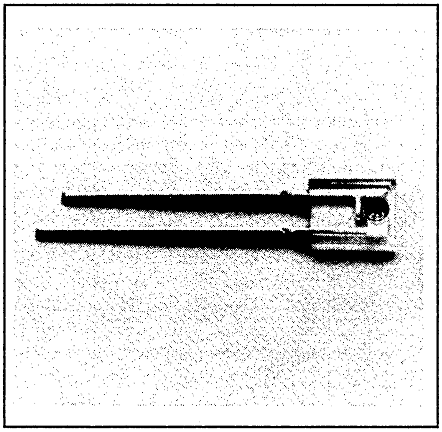


LPT-80A

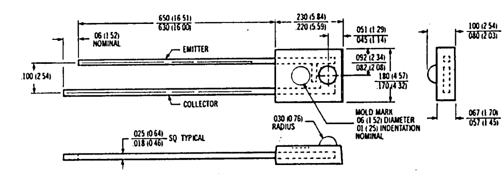
SIEMENS

LPT85A

PHOTOTRANSISTOR



Package Dimensions in Inches (mm)



FEATURES

- **Low Cost Plastic Package**
- **Very High Sensitivity**
- **Matches Infrared Emitter IRL80A and IRL81A**

DESCRIPTION

The LPT85A is a plastic, NPN phototransistor. It comes in a lensed, clear plastic, side-facing, miniature package. Its spheric lens was designed to accept light from very wide angles (±40°). This sensitive detector is ideal for a wide variety of industrial processing and control applications which require a beam interruption.

Maximum Ratings

Collector-Emitter Voltage	V_{CEO}	30	V
Emitter-Collector Voltage	V_{ECO}	5	V
Collector Current	I_C	50	mA
Storage and Operating Temperature	T	-40 to +100	°C
Maximum Permissible Soldering Temperature Range (t≤5 sec)	T_S	240	°C
Power Dissipation (T_{amb}=25°C)	P_{TOT}	100	mW*
*Derate above 25°C Linearly		1.33	mW/°C

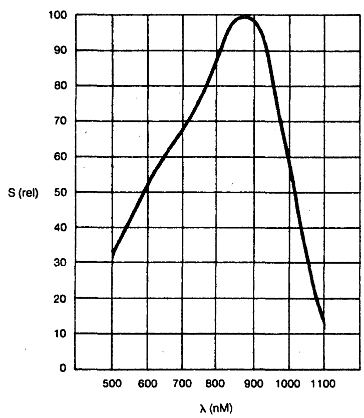
Characteristics (T_{amb}=25°C)

Collector-Emitter Leakage Current (V_{CE}=15 V; H=0)	I_{CEO}	≤100	nA
Wavelength of the Max. Sensitivity		870	nm
Acceptance Half Angle	φ	±40	Deg.
Breakdown Voltage (I_C=100 μA, H=0 mW/cm²)	BV_{CEO}	5 V min.	@I_C=100μA
Photocurrent(1) (V_{CE}=5 V, H=0.5 mW/cm²)	I_P	0.9	-mA
Saturation Voltage (I_C=250 μA, H=0.5 mW/cm²)	$V_{CE(SAT)}$	0.15 V typ.	0.4 V max.

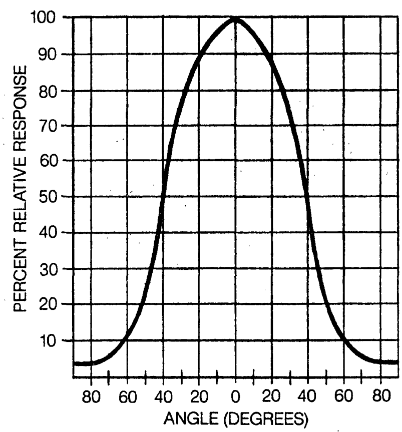
Note 1:
The light source is a tungsten filament bulb used in conjunction with a 950 ±3 nm filter. The mechanical axis of the DUT is aligned with the light source.

Typical Optoelectronic Characteristics

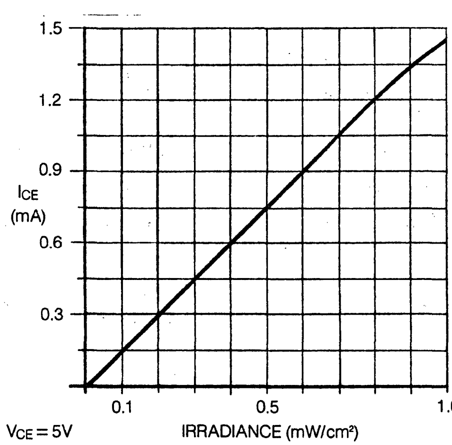
Relative Spectral Sensitivity



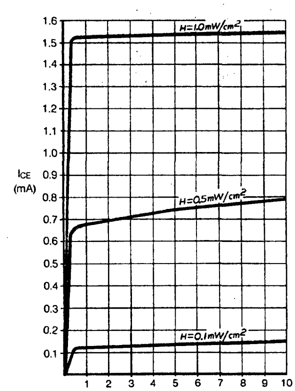
Angular Response



I_{CE} versus Irradiance



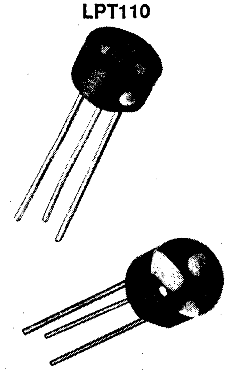
I_{CE} versus V_{CE})



SIEMENS

LPT100/100A/100B
LPT110/110A/110B
PHOTOTRANSISTOR

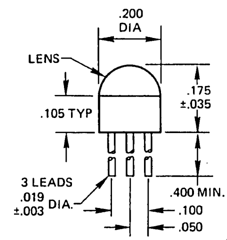
LPT110



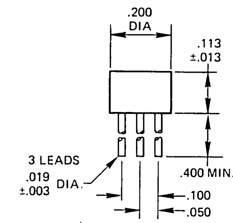
LPT100

Package Dimensions in Inches

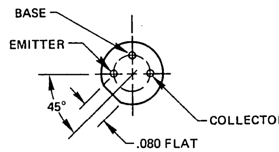
LPT100/A/B



LPT110/A/B



LPT100/A/B and LPT110/A/B



Notes:
1. All leads electrically isolated from case.
2. Flatness variation of top of cup is ±.015.
3. Photosensitive area is a .030 diameter circle within the center of the package.

FEATURES

- **Collector Dark Current 0.25 nA Typ.**
- **Responsivity**
  0.6 µA/mW/cm² Min (Tungsten)
  1.8 µA/mW/cm² Min (GaAs)
- **Photo Current**
  0.2 mA Min (Tungsten)
  0.6 mA Min (GaAs)
- **Rise and Fall Time 2.8 µs Typ**
- **Applications**
  Position Detector, Intrusion Alarm Sensor, Optical Tachometer

Maximum Ratings

Maximum Temperature/Humidity
- Storage Temperature .... -55°C to +100°C
- Operating Junction Temperature .... -55°C to +85°C
- Relative Humidity at Temperature .... 98% at +65°C

Maximum Power Dissipation (1, 2)
- Total Dissipation at +25°C Case Temperature .... 200 mW
- Total Dissipation at +25°C Ambient Temperature .... 100 mW

Maximum Voltages (5)
- BV_{CBO} Collector to Base Voltage .... 50 V
- LV_{CEO} Collector to Emitter Sustaining Voltage .... 30 V

Maximum Current
- I_C Collector Current .... 100 mA

Notes:
1. These are steady state limits. The factory should be consulted on applications involving pulsed or low duty cycle operations.
2. These ratings give a maximum junction temperature of +85°C and junction to case thermal resistance of +300°C/W (derating factor of 3.33 mW/°C) and a junction to ambient thermal resistance of +600°C/W (derating factor of 1.67 mW/°C).
3. Measured with radiation flux intensity of less than 0.1 µW/cm² over the spectrum from 100 to 1500 nm.
4. Measured at noted irradiance as emitted from a tungsten filament lamp at a color temperature of 2854° K.
5. No electrical connection to emitter lead.
6. Measured with a tungsten lamp (2854° K) with a 950 nm filter.
7. No electrical connection to base lead.
8. Rise time is defined as the time required for I_{CE} to rise from 10% to 90% peak value. Fall time is defined as the time required for I_{CE} to decrease from 90% to 10% of peak value. Test conditions are: I_{CE}=4.0 mA, V_{CE}=5.0 V, R_L=100 Ohms, GaAs Source.

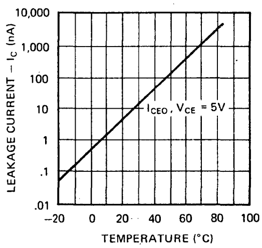
Characteristics (T_{amb}=25°C)

		Min.	Typ.	Max.	
Collector Dark Current (3) (V_{CB}=10 V)	I_{CBO}		0.25	25	nA
Collector Dark Current (3) (65°C) (V_{CB}=10 V)	I_{CBO}		0.025	0.5	µA
Collector Dark Current (3) (V_{CE}=5.0 V)	I_{CEO}		2.0	100	nA
Responsivity (Tungsten) (4, 5) (V_{CB}=10 V)	R_{CB}				µA/mW/cm²
LPT100/A/B		0.6	1.6		
LPT110/A/B		0.6	1.0		
Responsivity (GaAs) (5, 6) (V_{CB}=10 V)	R_{CB}				µA/mW/cm²
LPT100/A/B		1.8	4.8		
LPT110/A/B		1.8	3.0		
Photocurrent (Tungsten) (4, 7) (V_{CE}=5.0 V, H=5.0 mW/cm²)	$I_{CE(L)}$				mA
LPT100		0.2	1.4		
LPT110		0.2	2.1		
LPT100A		1.0	2.0	3.0	
LPT110A		0.6	1.2	1.8	
LPT100B		1.3	2.0	2.6	
LPT110B		0.8	1.2	1.6	
Photocurrent (GaAs) (6, 7) (V_{CE}=5.0 V, H=5.0 mW/cm²)	$I_{CE(L)}$				mA
LPT100/A/B		0.6	4.2		
LPT110/A/B		0.6	2.7		
Light Current Rise Time (8)	t_R, t_F		2.8		µs
Collector to Emitter (4) Saturation Voltage (I_C=500 µA, H=20 mW/Cm²)	$V_{CE(SAT)}$		0.16	0.4	
Collector to Base Breakdown (3) Voltage (I_C=100 µA)		50	120		V
Collector to Emitter (3) Sustaining Voltage (I_C=1.0 mA)	LV_{CEO}	30	50		V
Emitter to Collector (3) Breakdown (I_{EC}=100 µA)	BV_{ECO}		7.0		V

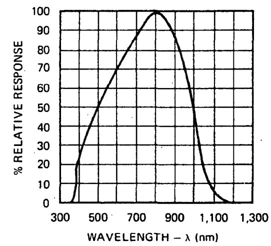
Phototransistors/ Photodarlington

TYPICAL OPTOELECTRONIC CHARACTERISTICS

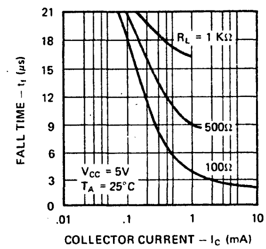
COLLECTOR DARK CURRENT VS TEMPERATURE



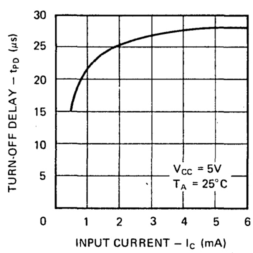
SPECTRAL CHARACTERISTICS



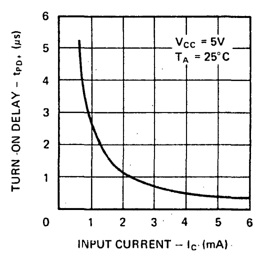
RISE AND FALL TIME VS COLLECTOR CURRENT



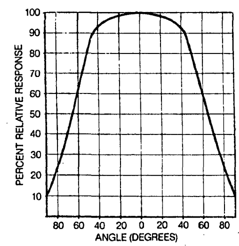
TURN-OFF DELAY TIMES FOR CURRENT



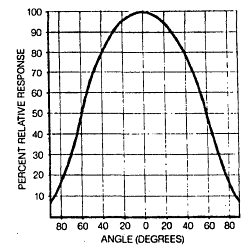
TURN-ON DELAY TIMES FOR CURRENT



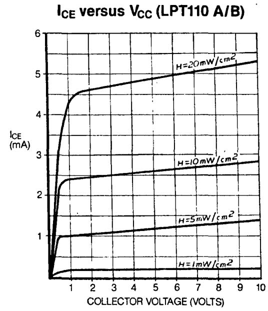
ANGULAR RESPONSE (LPT100 A/B)



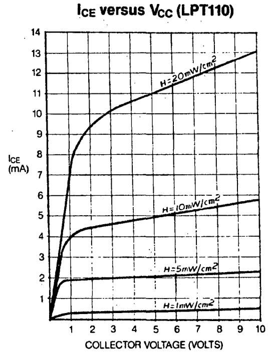
ANGULAR RESPONSE (LPT110 A/B)



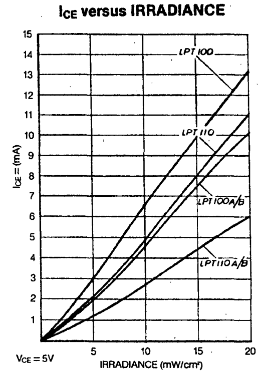
I_{CE} versus V_{CC} (LPT110 A/B)



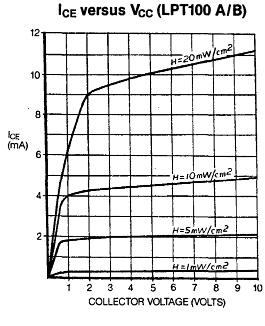
I_{CE} versus V_{CC} (LPT110)



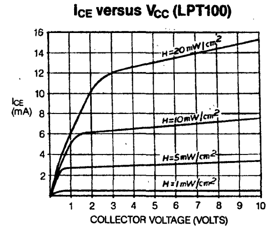
I_{CE} versus IRRADIANCE



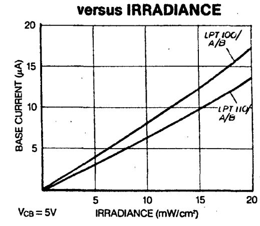
I_{CE} versus V_{CC} (LPT100 A/B)



I_{CE} versus V_{CC} (LPT100)

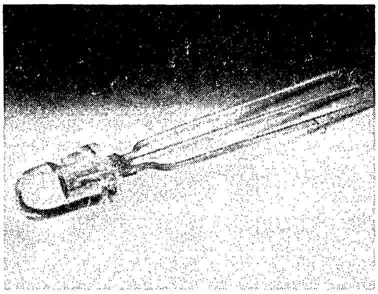


BASE CURRENT versus IRRADIANCE

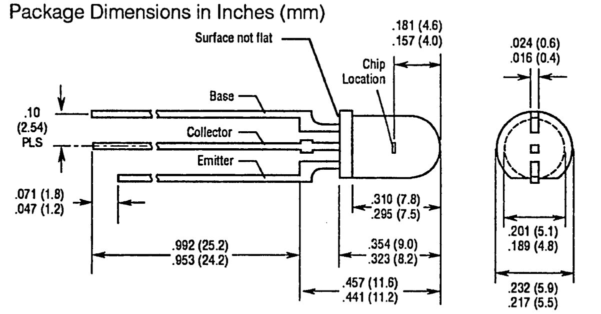


SIEMENS

SFH303
WITH DAYLIGHT FILTER SFH303F
NPN SILICON PHOTOTRANSISTOR


SFH303

Package Dimensions in Inches (mm)



FEATURES

- **High Reliability**
- **Good Linearity**
- **Suitable for the Visual and Near IR Range**
- **Daylight Filter–SFH303F**
- **Detection Angle, 40°**
- **High Photosensitivity**

DESCRIPTION

The SFH303/303F are silicon phototransistors with external base connection. The SFH303 comes in a standard T1¾ (5 mm) water clear package. The SFH303F has a black daylight filter. The three leaded device has a tab to indicate the emitter. The collector lead is the center lead.

The devices are suitable for use in industrial control applications, light barriers in DC and AC operation, etc.

Maximum Ratings

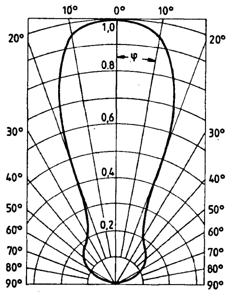
Operating and Storage Temperature (T_{STG}, T_{OP}) .... -55°C to +100°C
Soldering Temperature (distance from soldering joint to package ≥2 mm)
Dip Soldering Time (t ≤5 sec.) (T_S) .... 260°C
Iron Soldering Time (t ≤ 3 sec.) (T_S) .... 300°C
Collector Emitter Voltage (V_{CEO}) .... 50 V
Collector Current (I_C) .... 50 mA
Collector Peak Current (t<10 µs) (I_{CP}) .... 100 mA
Emitter Base Voltage (V_{EB}) .... 7 V
Power Dissipation (P_{TOT}) T_{amb} = 25°C .... 200 mW
Thermal Resistance (R_{THJA}) .... 375 K/W

Characteristics (T_{amb} = 25°C)

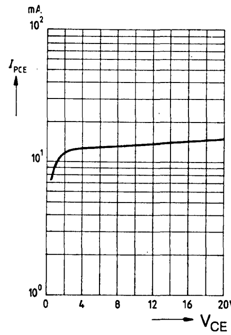
		SFH303	SFH303F	
Wavelength at the max. photosensitivity	S_{max}	850	900	nm
Range of spectral photosensitivity (S = 10% of S_{max})		400–1100	800–1100	nm
Radiant sensitive area	A	0.30		mm²
Dimensions of the radiant sensitive area	W x L	0.75 x 0.75		mm
Half angle	φ	± 20		Deg.
Photocurrent of the collector base diode (E_V = 1000 lux, V_{CB} = 5 V)	I_{PCB}	27		µA
(E_e = 0.5 mW/cm², λ = 950 nm, V_{CB} = 5 V)	I_{PCB}	5		µA
Capacitance (V_{CE} = 0 V, f = 1 MHz, E = 0 lux)	C_{CE}	9		pF
(V_{CB} = 0 V, f = 1 MHz, E = 0 lux)	C_{CB}	19		pF
(V_{EB} = 0 V, f = 1 MHz, E = 0 lux)	C_{EB}	20		pF
Photocurrent (E_V = 1000 lux, V_{CE} = 5 V)	I_p	(≥4) 13 typ	–	mA
(E_e = 0.5 mW/cm², = 950 nm, V_{CE} = 5 V)	I_p	–	(≥0.8) 2 typ	mA
Rise/Fall Time (I_C = 2 mA, λ = 830 nm, V_{CE} = 5 V, R_L = 1 K)	T_r/T_f	15	15	µs
Collector/Emitter Saturation Voltage (I_C = 2 ma, E = 1000 lux)	V_{CE} (sat)	140	–	mV
(I_C = 250 µA, λ = 950 nm, E_e = 0.5 mW/cm²)	V_{CE}(sat)	–	130	mV
Current Gain E_V = 1000 lux, V_{CE} = 5 V, E_e = 0.5 mW/cm²	I_{PCE}	500 typ	500 typ	
λ = 880 nm, V_{CE} = 5 V	I_{PCB}			
Collector Dark Current (V_{CEO} = 10 V, E = 0 lux)	I_{CEO}	2 (≤50)	2 (≤50)	nA

SFH303/F	–2	–3	–4	
Photocurrent, Collector to Emitter (E_E=0.5 mW/cm², λ=950 nm, V_{CE}=5 V) I_{PCE}	1–2	1.6–3.2	≥2.5	mA

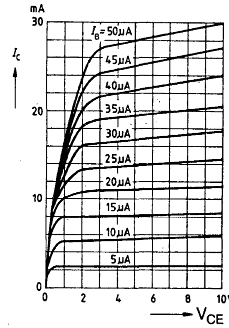
Radiation Characteristics
$S_{rel} = f(\varphi)$



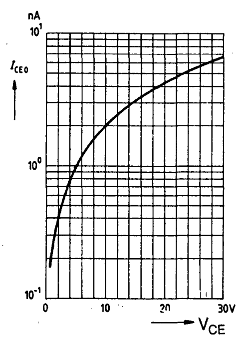
Photocurrent
$I_{PCE} = f(V_{CE})$



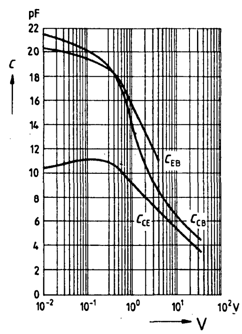
Output Characteristics $I_C = f(V_{CE})$
I_B = Parameter



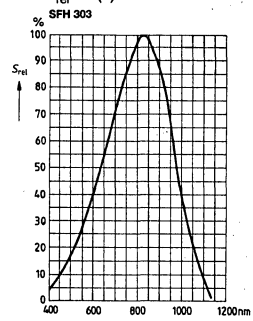
Dark Current $I_{CEO} = f(V_{CE})$



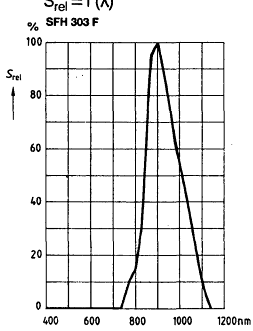
Capacitance $C = f(V)$



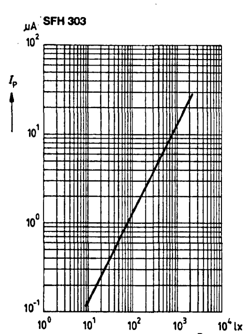
Relative Spectral Sensitivity
$S_{rel} = f(\lambda)$



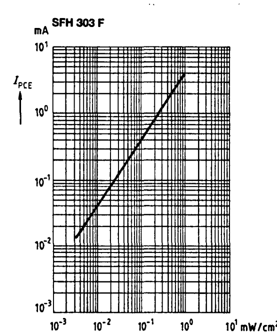
Relative Spectral Sensitivity
$S_{rel} = f(\lambda)$



Photocurrent $I_P = f(E_V)$



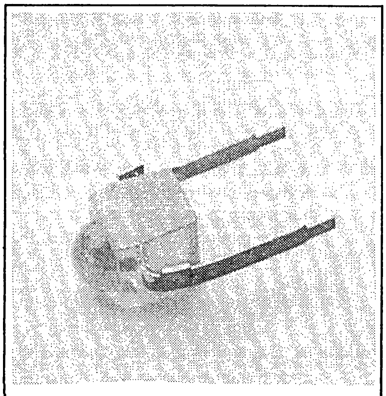
Photocurrent $I_P = f(E_e)$



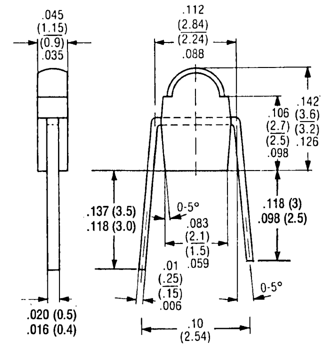
SIEMENS

SFH 305 SERIES

PHOTOTRANSISTOR



Package Dimensions in Inches (mm)



FEATURES

- **Miniature Plastic Package**
- **2.54 mm (1/10") Lead Spacing**
- **Detector for SFH 405 Infrared Emitter**
- **Narrow Acceptance Angle, 32°**
- **Designed for Maximum Spacing of 10 mm Between Emitter & Detector**

DESCRIPTION

The SFH 305 is a NPN silicon planar photo transistor in clear plastic encapsulation with solder PIN terminals. The connectors in the form of solder tabls are spaced 2.54 mm (1/10 inch). The photo transistors are grouped according to photo sensitivity. The SFH 305 is suitable for use as detector for the infrared diode SFH 405 to effect miniature light barriers with close spacing between sender and receiver up to 10 mm maximum. Also, the SFH 305 is suitable for application with glow-lamp light, i.e. daylight. The collector is marked with a colored dot.

Maximum Ratings

Operating and Storage Temperature	T	−40 to +80	°C
Soldering Temperature (Distance from soldering joint to package ≥2 mm)			
Dip Soldering Time t ≤ 5 s	T_S	230	°C
Iron Soldering Time t ≤3 s)	T_S	300	°C
Collector Emitter Voltage	V_{CEO}	32	V
Collector Current	I_C	50	mA
Collector Peak Current (t < 10 µs)	I_{PK}	200	mA
Power Dissipation (T_{amb} = 25°C)	P_{tot}	75	mW
Thermal Resistance	R_{thJA}	950	K/W
	R_{thJG}	850	K/W

Characteristics (T_{amb} = 25°C)

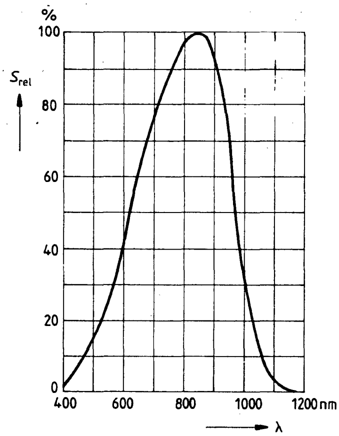
Wavelength of Max. Photosensitivity	λ_{Smax}	850	nm
Spectral Range of Photosensitivity	λ	460 to 1060	nm
Radiant Sensitive Area	A	0.17	mm²
Die Area	L × W	0.6 × 0.6	mm
Distance Die Surface to Package Surface	H	1.3 to 1.9	mm
Half Angle	φ	±16	Deg.
Photocurrent of the Collector Base Diode (E_V = 1000 lx, V_{CE} = 5 V)	I_{PCB}		µA
Capacitance (V_{CE} = 0 V, f = 1 MHz, E = 0 lx)	C_{CE}	5.5	pF
Collector Emitter Leakage Current (V_{CEO} = 25 V, E = 0 lx)	I_{CEO}	3 (≤20)	nA

Group		SFH305-2	SFH305-3	
Photocurrent of the Transistor, Collector to Emitter (Note 1) (E_V = 1000 lx, V_{CE} = 5 V)	I_P	1 to 2	1.6 to 3.2	mA
(E_e = 0.5 mW/cm² λ = 950 nm, V_{CE} = 5 V)	I_P	.25 to .5	.4 to .8	mA
Rise/Fall Time (I_C = 1 mA, V_{CE} = 5 V R_L = 1 kΩ)	t_r, t_f	5.5	6	µs
Collector Emitter Saturation Voltage (I_C = I_{PCEmin} • 0.3 E = 1000 lx)	V_{CEsat}	150	150	mV
Current Gain (E_V = 1000 lx, V_{CE} = 5 V)	$\frac{I_{PCE}}{I_{PCB}}$	190	300	

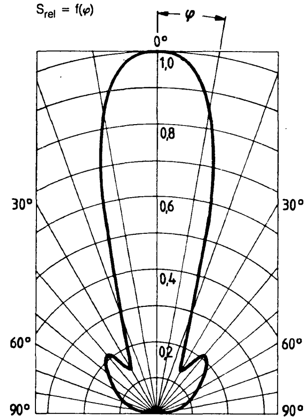
The illuminances refer to unfiltered radiation of a tungsten filament lamp at a color temperature of 2856 K (standard light A in accordance with DIN 5033 and IEC 306-1). Irradiance E_e measured with HP radiant flux meter 8334A with option 013.

[1] Measured with LED λ = 950 nm. I_{PCE} = Photocurrent of transistors; I_{PCB} = Photocurrent of Collector-Base-Diode.

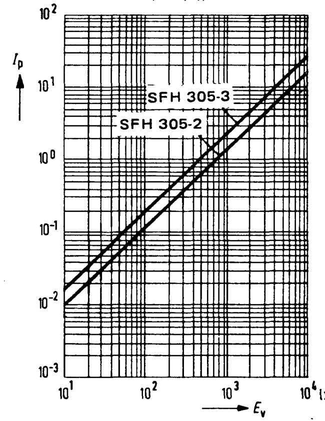
Relative spectral sensitivity $S_{rel} = f(\lambda)$



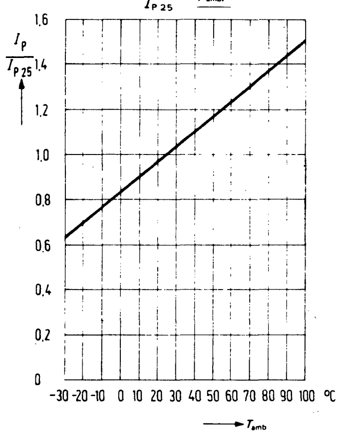
Directional characteristic
$S_{rel} = f(\varphi)$



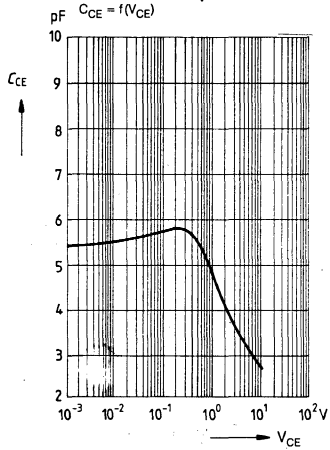
mA **Photocurrent** $I_P = f(E_v)$



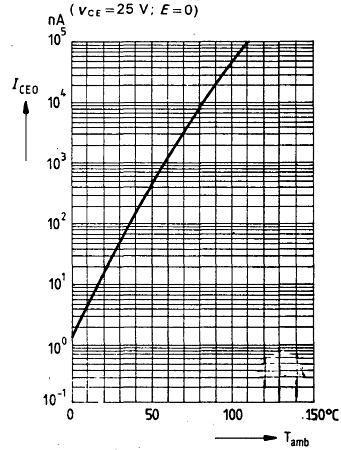
Photocurrent $\frac{I_P}{I_{P\,25}} = f(T_{amb})$



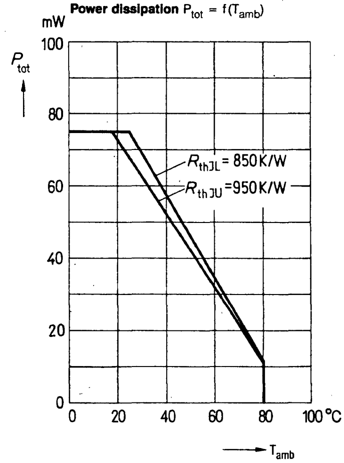
Collector emitter capacitance
$C_{CE} = f(V_{CE})$



Leakage current $I_{CEO} = f(T_{amb})$
$(V_{CE} = 25\ V;\ E = 0)$

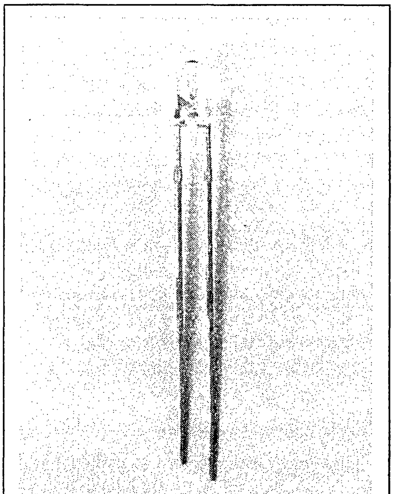


Power dissipation $P_{tot} = f(T_{amb})$



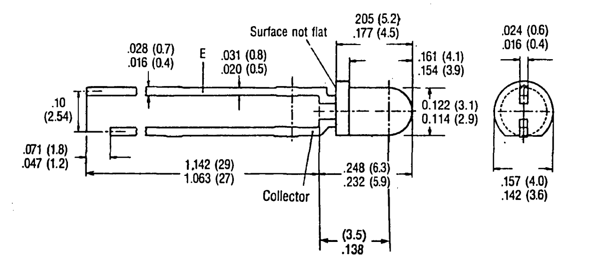
SIEMENS

SFH309
WITH DAYLIGHT FILTER SFH309F
PHOTOTRANSISTOR



SFH309

Package Dimensions in Inches (mm)



Maximum Ratings

Operating and Storage Temperature (T_{STG}, T_{OP}) .... -55°C to +100°C
Soldering Temperature (distance from soldering joint to package ≥2 mm)
Dip Soldering Time (t ≤5 sec.) (T_S) .... 260°C
Iron Soldering Time (t ≤ 3 sec.) (T_S) .... 300°C
Collector Emitter Voltage (V_{CEO}) .... 35 V
Collector Current (I_C) .... 15 mA
Collector Peak Current (t<10 µs) (I_{CP}) .... 75 mA
Power Dissipation (P_{TOT}) T_{amb}= 25°C .... 165 mW
Thermal Resistance (R_{thJA}) .... 450 K/W

FEATURES

- **High Reliability**
- **T1 (3 mm) Package**
- **0.10 Inch (2.54 mm) Lead Spacing**
- **Low Cost**
- **Good Linearity**
- **Daylight Filter–SFH309F**
- **Narrow Acceptance Angle, 32°**
- **Matches with SFH409 Infrared Emitter**

DESCRIPTION

The SFH309/309F are silicon NPN phototransistors in a standard T1 (3 mm) size plastic package. The SFH309F has a black daylight filter.

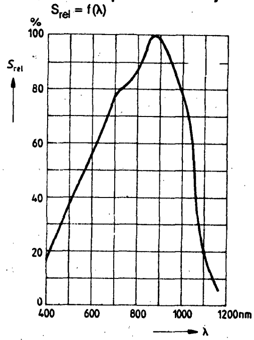
The devices are suitable for use in a variety of low cost, high volume applications such as IR remote control and other consumer and entertainment products.

Characteristics (T_{amb}=25°C)

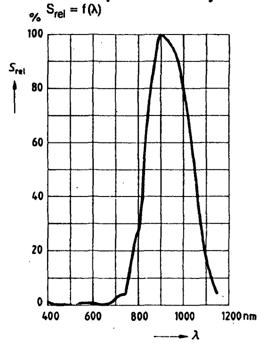
		SFH309	SFH309F	
Wavelength of Max. Photosensitivity	λ_{SMAX}	880	900	nm
Spectral Range of Photosensitivity	λ	380-1125	800–1100	nm
Radiant Sensitive Area	A	0.045	0.045	mm²
Diameter of the Die Area	D	0.24	0.24	mm
Distance between Chip Surface and Lead Frame Standoff	H	3.5	3.5	mm
Half Angle	φ	±16	±16	Deg.
Capacitance (V_{CE}=0 V, f=1 MHz, E=0 lx)	C_{CE}	5.3	5.3	pF
Photocurrent, Collector to Emitter (E_V=1000 lx, V_{CE}=5 V)	I_{PCE}	5(≥1.6)Typ.	–	mA
(E_E=0.5 mW/cm², λ=950 nm, V_{CE}=5 V)	I_{PCE}	1.3(≥0.4)Typ.	2(≥0.5)Typ.	mA
Rise/Fall Time (I_C=2 mA, λ=830 nm, V_{CE}=5 V, R_L=1 kΩ)	t_R,t_F	10	10	µs
Collector Emitter Saturation Voltage (I_C=2 mA, I_B=50 µA, E=0 lx)	V_{CEsat}	200	–	mV
(I_C=0.25 mA, λ=950 nm, E_E=0.5 mW/cm²)	V_{CEsat}	–	130	mV
Leakage Current (V_{CEO}=25 V, E=0 lx)	I_{CEO}	60(≤200)	60(≤200)	nA

SFH309/F		–2	–3	–4	–5	
Photocurrent, Collector to Emitter (E_E=0.5 mW/cm², λ=950 nm, V_{CE}=5 V)	I_{PCE}	0.5–1	0.63–1.25	1–2	≥1.6	mA

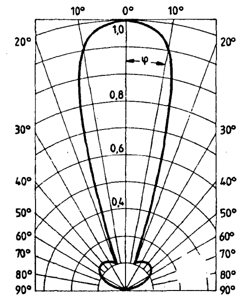
SFH 309
Relative spectral sensitivity
$S_{rel} = f(\lambda)$



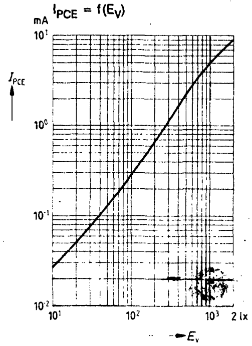
SFH 309F
Relative spectral sensitivity
$S_{rel} = f(\lambda)$



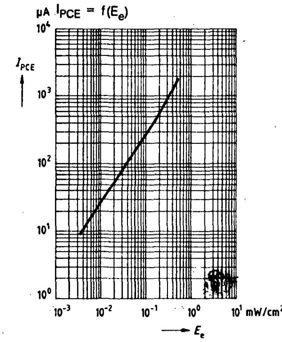
Directional characteristic
$S_{rel} = f(\varphi)$



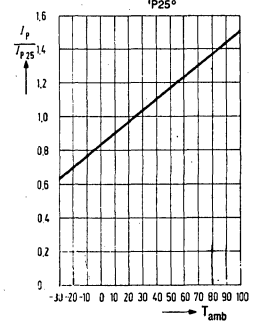
SFH 309
Photocurrent
$I_{PCE} = f(E_V)$



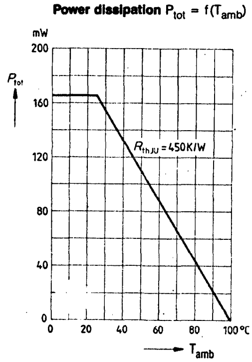
SFH 309F
Photocurrent
$I_{PCE} = f(E_e)$



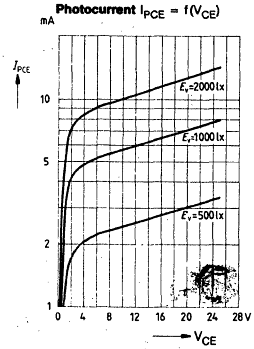
Photocurrent $\frac{I_P}{I_{P25°}} = f(T_{amb})$



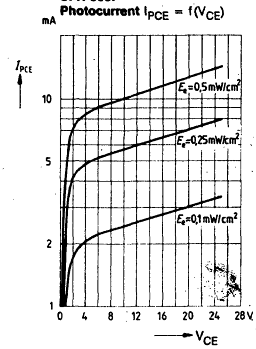
Power dissipation $P_{tot} = f(T_{amb})$



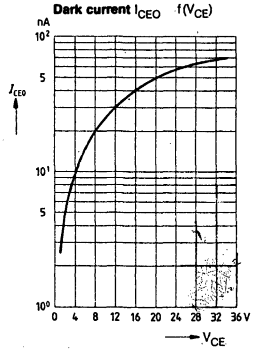
SFH 309
Photocurrent $I_{PCE} = f(V_{CE})$



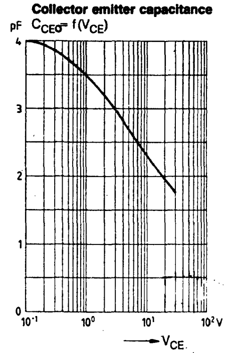
SFH 309F
Photocurrent $I_{PCE} = f(V_{CE})$



Dark current $I_{CEO} = f(V_{CE})$

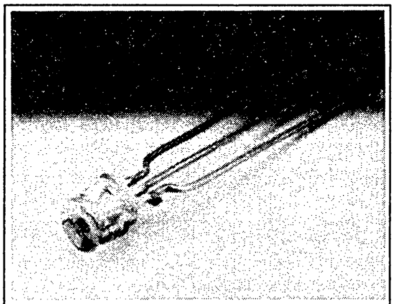


Collector emitter capacitance
$C_{CEO} = f(V_{CE})$



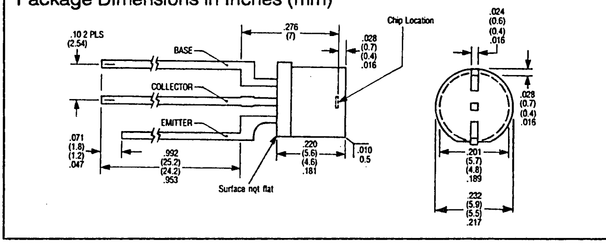
SIEMENS

SFH317
WITH DAYLIGHT FILTER SFH317F
PHOTOTRANSISTOR



SFH 317

Package Dimensions in Inches (mm)



FEATURES

- High Reliability
- Fast Rise and Fall Times
- Good Linearity
- High Photosensitivity
- Daylight Filter–SFH317F
- Wide Acceptance Angle, 120°

DESCRIPTION

The SFH309/309F are highly sensitive silicon planar phototransistors with base connection in a T1³/₄ (5 mm) package. The SFH317 comes in a water-clear, no lens package. The SFH317F is housed in a black epoxy package. A tab at the leadframe indicates the emitter. The collector lead is in the middle.

Maximum Ratings

Storage Temperature (T_{STG}) ....-55°C to +100°C
Soldering Temperature (distance from casing-solder tab ≥2 mm)
Dip Soldering Time (t ≤5 sec.) (T_S) .... 260°C
Iron Soldering Time (t ≤ 3 sec.) (T_S) .... 300°C
Collector Emitter Voltage (V_{CEO}) .... 50 V
Collector Current (I_C) .... 50 mA
Collector Peak Current (t<10 µs) (I_{CP}) .... 100 mA
Emitter Base Voltage (V_{EB}) .... 7 V
Power Dissipation (P_{TOT}) T_{amb}= 25°C .... 200 mW
Thermal Resistance (R_{THJA}) .... 375 K/W

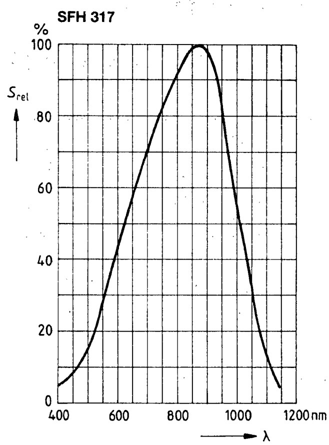
Characteristics (T_{amb}=25°C)

		SFH317		SFH317F	
Wavelength at the max. photosensitivity	S_{max}	850		900	nm
Range of spectral photo sensitivity (S = 10% of S_{max})		400–1100		800–1100	nm
Radiant sensitive area	A		0.30		mm²
Dimensions of the radiant sensitive area	W x L		0.75 x 0.75		mm
Distance chip surface to package surface	H		0.4–0.7		mm
Half angle	φ		±60		Deg.
Photocurrent of the collector base photo diode (E_V = 1000 lux, V_{CB} = 5 V)	I_{PCB}		2.6		µA
(E_e = 0, 5 mW/cm², λ = 950 nm, V_{CB} = 5 V)	I_{PCB}		0.65		µA
Capacitance (V_{CE} = 0 V, f = 1 MHz, E = 0 lux)	C_{CE}		9		pF
(V_{CB} = 0 V, f = 1 MHz, E = 0 lux)	C_{CB}		19		pF
(V_{EB} = 0 V, f = 1 MHz, E = 0 lux)	C_{EB}		20		pF
Photocurrent (E_V = 1000 lux, V_{CE} = 5 V)	I_P	(≥0.5) 1.8		–	mA
(E_e = 0, 5 mW/cm², λ = 950 nm, V_{CE} = 5 V)		–		(≥0.1) 0.2	mA
Rise/Fall Time (I_C = 0.2 mA, V_{CE} = 5 V, R_L = 1 Kohm)	T_r/T_f		15		µs
Collector/Emitter Saturation Voltage (I_C = 2 mA, E = 1000 lux)	V_{CE}(sat)	140		–	mV
(I_C = 30 µA, λ = 950 nm, E_e = 0.5 mW/cm²)	V_{CE}(sat)	–		130	mV
Current Gain (E_V = 1000 lux, V_{CE} = 5 V) (E_e = 0, 5 mW/cm², λ = 950 nm, V_{CE} = 5 V)	I_{PCE}/I_{PCB}	500 typ		500 typ	
Collector Dark Current (V_{CEO} = 10 V, E = 0 lux)	I_{CEO}	2 (≤50)		2 (≤50)	nA

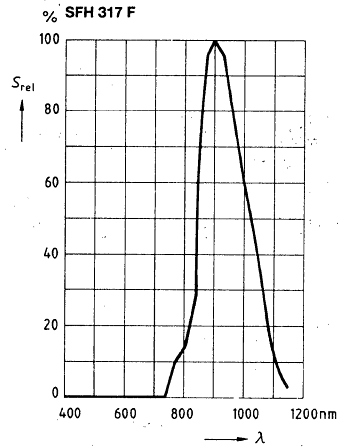
SFH317/F		–2	–3	–4	
Photocurrent (E_E=0.5 mW/cm², λ=950 nm, V_{CE}=5 V)	I_{PCE}	0.16–0.32	0.25–0.55	≥0.4	mA

Phototransistors/ Photodarlington

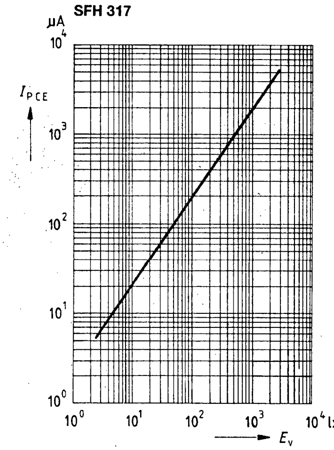
Relative Spectral Sensitivity
$S_{rel} = f(\lambda)$



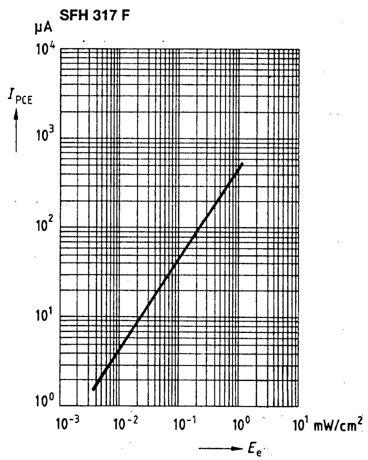
Relative Spectral Sensitivity
$S_{rel} = f(\lambda)$



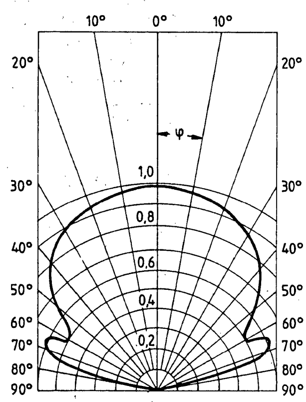
Photocurrent $I_{PCE} = f(E_v)$



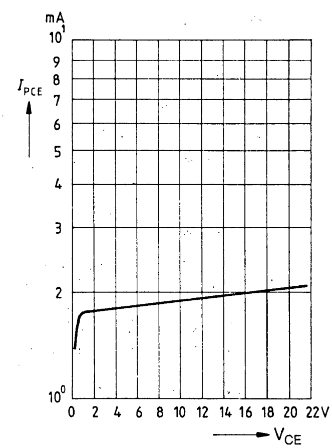
Photocurrent $I_{PCE} = f(E_e)$



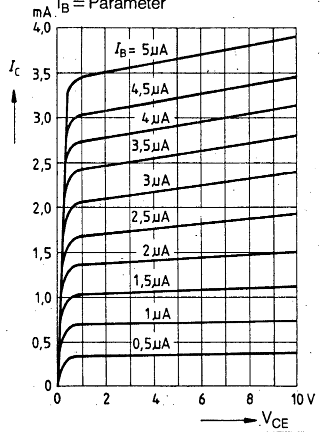
Radiation Characteristics $S_{rel} = f(\varphi)$



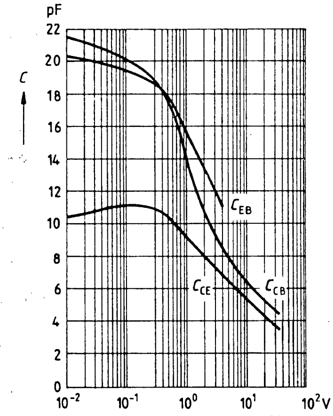
Photocurrent $I_{PCE} = f(V_{CE})$



Output Characteristics $I_C = f(V_{CE})$
I_B = Parameter

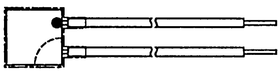
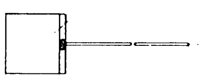
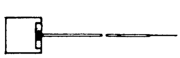
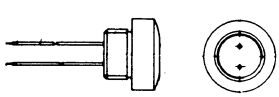
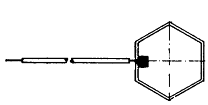


Capacitance $C = f(V)$



SFH317/F

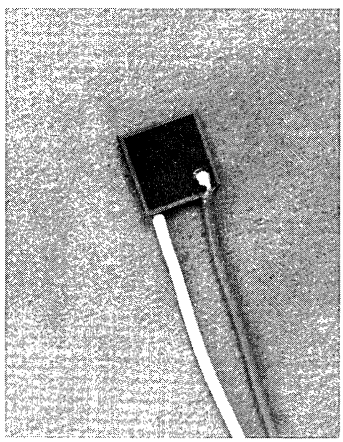
Photovoltaic Cells

Package Outline	Part Number	Package Type	Half Angle	Sensitivity s(µA/lx) Typical	Dark Current V_R=1V, E=0 µA	Radiant Sensitive Area mm^2	Peak Wave-length	Capacitance V_R=0V, E=0 nF	Page
	BPX79	Chip with wires.	±60°	170 (≥100) nA/lx	0.3 (<50)	20	800	2500pF	10–2
	BPY11P-4	Chip with wires.	±60°	47-63	1(≥10)	8.7	850	.8	10–4
	BPY11P-5			≥56					
	BPY63P	Chip with wires.	±60°	.65(≥0.45)	10	0.9	850	8	10–6
	BPY64P	Chip with wires.	±60°	.25(≥0.18) nA.lx	4	0.36	850	3	10–8
	TP60P	Plastic, threaded. Anode marked by red lead.	±60°	1(≥0.7)	0.1(≥2)	1.3	850	3	10–10
	TP61P	Chip with wires. Anode marked by red lead.							

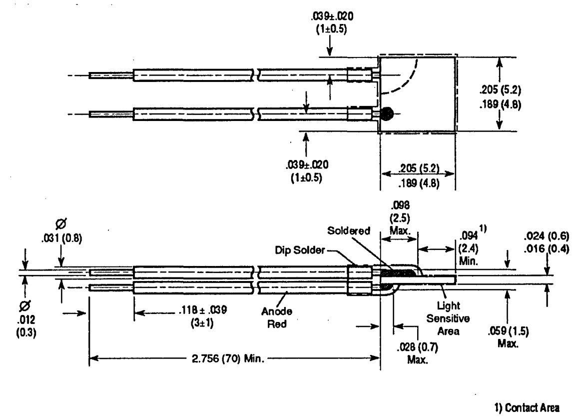
SIEMENS

BPX 79

SILICON PHOTOVOLTAIC CELL



Package Dimensions in Inches (mm)



FEATURES

- **Silicon Planar Photovoltaic Cell**
- **Medium Size Radiation Sensitive Surface**
- **Decreased Blue Sensitivity**

DESCRIPTION

The BPX 79 is a silicon planar photovoltaic cell. The increased sensitivity with shorter wavelengths makes it particularly suitable for applications with light sources having a high share of blue. The planar method ensures a low reverse current level and low noise. The photovoltaic cell is nitride-passivated and has an anti-reflection coating for a wavelength of λ = 450 nm.

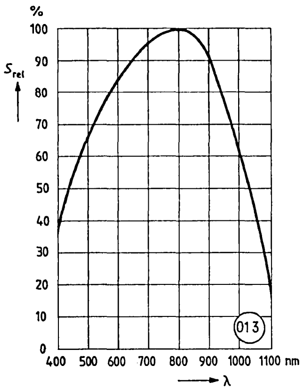
Maximum Ratings

Reverse voltage	V_R	1	V
Storage temperature and operating temperature	T_{amb}	– 55 to + 100	°C

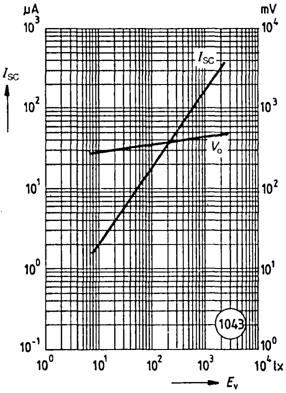
Characteristics (T_{amb} = 25°C)

Photosensitivity (standard light A, T = 2856 K)	S	170 (≥100)	nA/lx
Wavelength of Max. Photosensitivity	λ_{Smax}	800	nm
Spectral Range of Photosensitivity (S = 10% of Smax)	λ	350 to 1100	nm
Radiant Sensitive Area	A	20	mm²
Dimensions of the Radiant Sensitive Area	L × W	4.47 × 4.47	mm
Half Angle	φ	±60	Deg.
Dark Current (V_R = 1 V, E = 0)	I_R	0.3 (≤50)	μA
Spectral Photosensitivity (λ = 850 nm)	S_λ	0.55	A/W
Quantum Efficiency (λ = 850 nm)	η	0.80	Electrons / Photon
Open Circuit Voltage (E_V = 1000 lx, standard light A T = 2856 K)	V_L	450 (≥310)	mV
Short Circuit Current (E_V = 1000 lx, standard light A T = 2856 K)	I_{SC}	170 (≥100)	μA
Rise and Fall Time of the Photo-current from 10% to 90% and from 90% to 10% of the Final Value (R_L = 1 KΩ, V_R = 1 V, λ = 950 nm I_P = 150 μA)	t_r, t_f	6	μs
Capacitance (V_R = 0 V, f = 1 MHz, E_V = 0 lx)	C_0	2500	pF
(V_R = 1 V, f = 1 MHz, E_V = 0 lx)	C_1	1800	pF
Temperature Coefficient V_L	TC	-2.6	mV/K
Temperature Coefficient I_K	TC	0.2	%/K

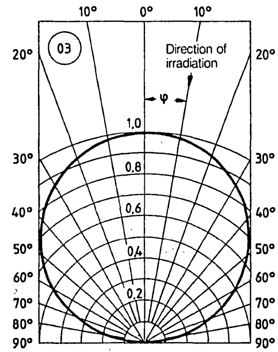
Relative spectral sensitivity versus wavelength



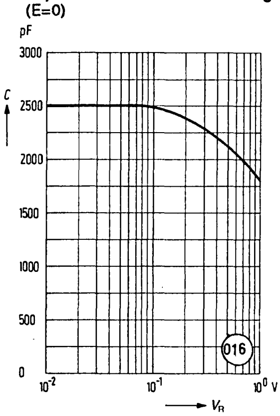
Open circuit voltage and short circuit current versus illuminance



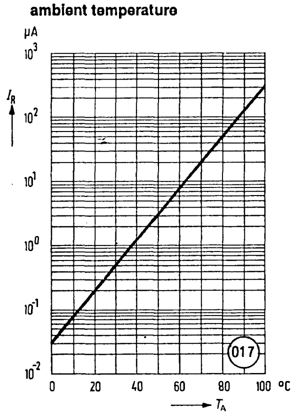
Directional characteristic
Relative spectral sensitivity versus half angle



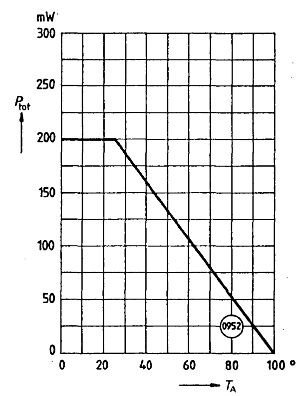
Capacitance versus reverse voltage (E=0)



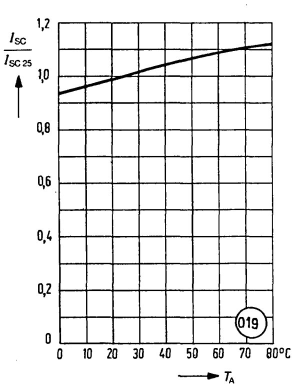
Dark current versus ambient temperature



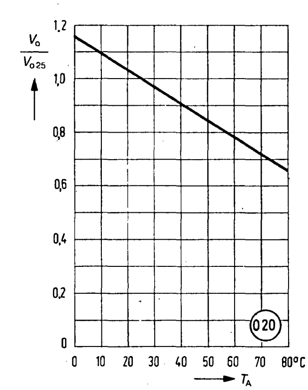
Total power dissipation versus ambient temperature



Short-circuit current versus ambient temperature



Open-circuit voltage versus ambient temperature

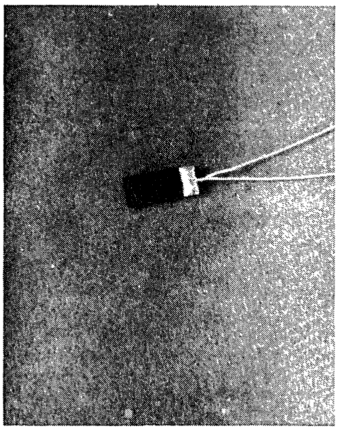


Photovoltaic Cells

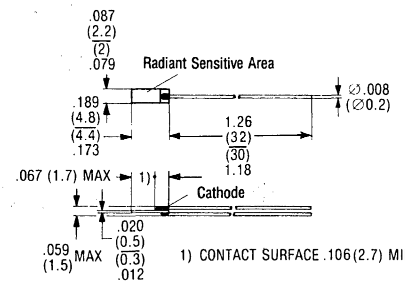
SIEMENS

BPY 11P SERIES

SILICON PHOTOVOLTAIC CELL



Package Dimensions in Inches (mm)



FEATURES

- **Small Package**
- **May Be Stacked Tightly Together**
- **Choice of 2 Sensitivity Groups**
- **Fast Response Time**

DESCRIPTION

BPY 11 P is a photovoltaic cell, fabricated with planar technology.

The silicon protovoltaic cell is suitable for use in control and drive circuits, for light pulse scanning, and for quantitative light measurements. Its rapid response, small dimensions, and high permissible operating temperature make universal application feasible.

Since this cell is not encased, the assembly of high efficient scanning systems can be realized. For this purpose the cells may be cemented closely together on suitable mounting assemblies.

Maximum Ratings

Ambient temperature	T_{amb}	−55 to 100	°C
Reverse voltage (positive pole to cathode)	V_R	1	V

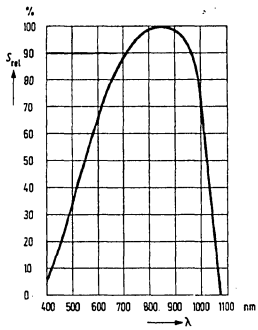
Characteristics (T_{amb} = 25°C)

Photosensitivity (standard light A, T = 2856 K)	S	60 (≥47)	μA/lx
Wavelength of Max. Photosensitivity	λ_{Smax}	850	nm
Spectral Range of Photosensitivity (S = 10% of Smax)	λ	420 to 1060	nm
Radiant Sensitive Area	A	8.7	mm²
Dimensions of the Radiant Sensitive Area	L × W	1.95 × 4.45	mm
Half Angle	φ	±60	Deg.
Dark Current (V_R = 1 V, E = 0)	I_R	1 (≥10)	μA
(V_R = 1 V, E = 0, T_{amb} = 50°C)	I_R	2.5	μA
Spectral Photosensitivity (λ = 850 nm)	S_λ	0.55	A/W
Quantum Efficiency (λ = 850 nm)	η	0.80	Electrons / Photon
Open Circuit Voltage (E_V = 1000 lx, standard light A T = 2856 K)	V_L	440 (≥260)	mV
Short Circuit Current (E_V = 1000 lx, standard light A T = 2856 K)	I_{SC}	60 (≥28)	μA
Rise and Fall Time of the Photocurrent from 10% to 90% and from 90% to 10% of the Final Value (R_L = 1 KΩ, V_R = 1 V, λ = 840 nm I_P = 250 μA)	t_r, t_f	3	μs
Capacitance (V_R = 0 V, f = 1 MHz, E_V = 0 lx)	C_0	0.8	nF
Temperature Coefficient V_L	TC	−2.9	mV/K
Temperature Coefficient I_K	TC	0.12	%/K

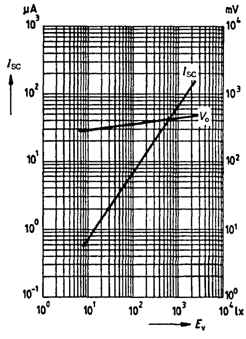
Spectral Photosensitivity

Group		BPY 11P-4	BPY 11P-5	
Short Circuit Current (E_V = 1000 lx, standard light A T = 2856 K)	I_K	47 to 63	≥56	μA

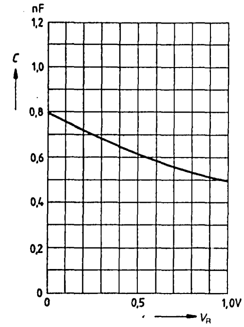
Relative spectral sensitivity
$S_{rel} = f(\lambda)$



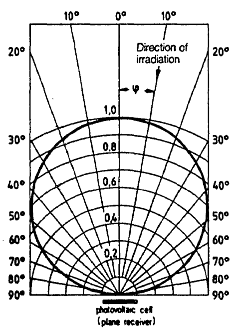
Open circuit voltage $V_L = f(E_V)$
Short circuit voltage $I_K = f(E_V)$



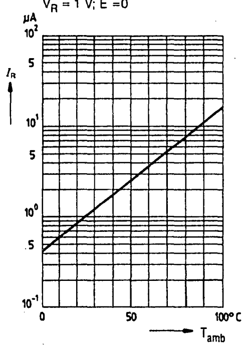
Capacitance $C = f(V_R)$; $E = 0$



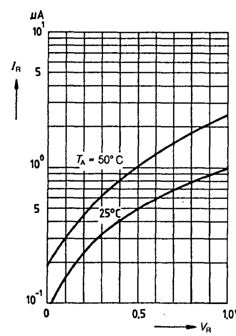
Directional characteristic
$S_{rel} = f(\varphi)$



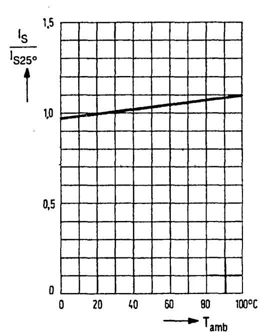
Dark current as a function of temperature $I_R = f(T_{amb})$
$V_R = 1$ V; E =0



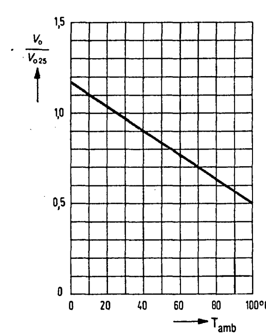
Dark current $I_R = f(V_R)$
T_{amb} = Parameter; E = 0



Short circuit current as a function of temperature



Open circuit voltage as a function of temperature

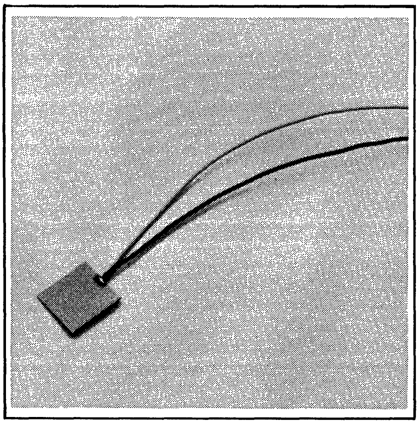


Photovoltaic Cells

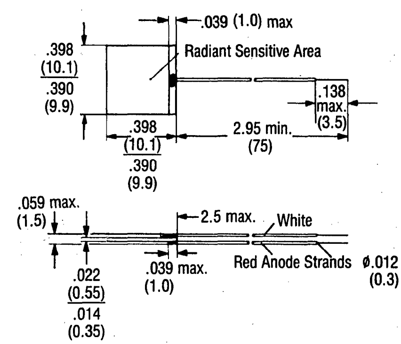
SIEMENS

BPY 63P

PHOTOVOLTAIC CELL



Package Dimensions in Inches (mm)



FEATURES

- **High Sensitivity**
- **Cost Effective Package**

DESCRIPTION

BPY 63P is a silicon photovoltaic cell (photoelement) fabricated with planar technology. The silicon chip comes with two leads and is covered with a hydro protective layer. BPY 63P is suitable for use in control and regulation circuits. Also, as a photoelement, it can be used as a detector of incandescent light and daylight.

Maximum Ratings

Reverse Voltage (V_R, Note 2) .... 1.0 V
Temperature Range (T_A) .... –55 to +100°C

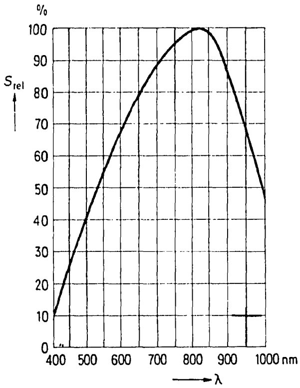
Characteristics (T_{amb} = 25°C)

Photosensitivity	S	0.65 (≥0.45)	µA/lx
Wavelength of Max. Photosensitivity	λ_{Smax}	850	nm
Spectral Range of Photosensitivity (S = 10% of Smax)	λ	400 to 1100	nm
Radiant Sensitive Area	A	0.94	cm²
Dimensions of the Radiant Sensitive Area	L × W	9.69 × 9.69	mm
Half Angle	φ	±60°	Deg.
Dark Current (V_R = 1 V, E = 0)	I_R	10	µA
Spectral Photosensitivity (λ = 850 nm)	S_λ	0.5	A/W
Quantum Efficiency (λ = 850 nm)	S_λ	0.72	Electrons / Photon
Open Circuit Voltage (E_V = 1000 lx, Note 1)	V_O	430 (≥280)	mV
Short Circuit Current (E_V = 1000 lx, Note 1)	I_{SC}	0.65 (≥0.45)	mA
Switching Times (R_L = 1 KΩ, V_R = 1 V, λ = 840 nm, I_P = 500 µA)	t_r, t_f	11	µs
Capacitance (V_R = 0 V, f = 1 MHz, E_V = 0 lx)	C_0	8	nF
Temperature Efficiency of V_O	TK	-2.6	mV/K
Temperature Efficiency of I_S	TK	0.2	%/K

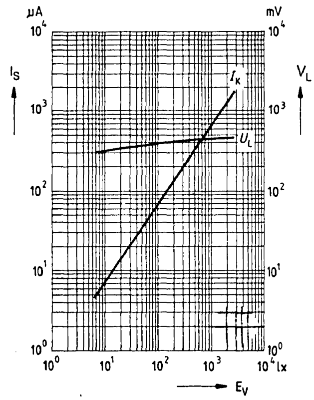
[1] The illuminance indicated refers to unfiltered radiation of a tungsten filament lamp at a color temperature of 2856K.

[2] Plus port of the voltage source to be connected to white strands.

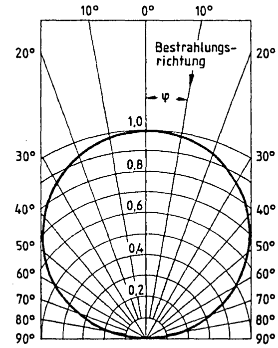
Relative spectral sensitivity
$S_{rel} = f(\lambda)$



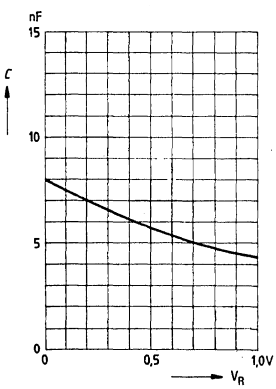
Open circuit voltage $V_L = f(E_V)$
Short circuit voltage $I_S = f(E_V)$



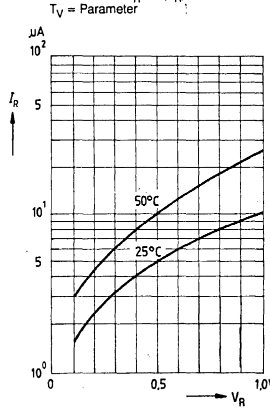
Directional characteristics
$S_{rel} = f(\varphi)$



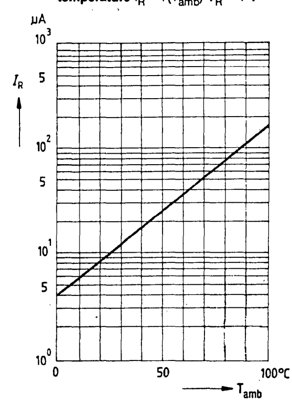
Capacitance $C = f(V_R)$; $E = 0$ lx



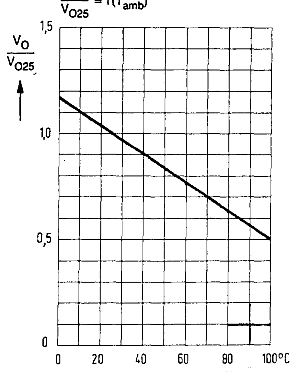
Dark current $I_R = f(V_R)$
T_V = Parameter



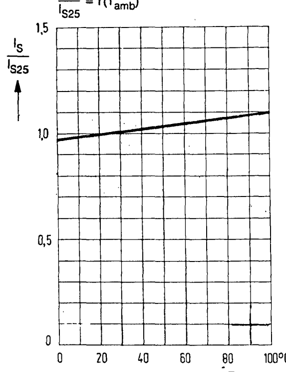
Dark current I_R versus temperature $I_R = f(T_{amb})$ $V_R = 1$ V



Open circuit voltage V_O versus temperature
$\frac{V_O}{V_{O25}} = f(T_{amb})$



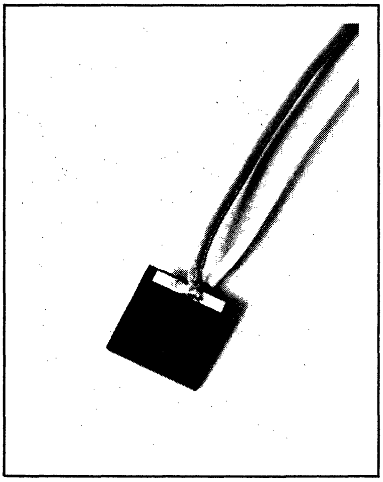
Short circuit current I_S versus temperature
$\frac{I_S}{I_{S25}} = f(T_{amb})$



SIEMENS

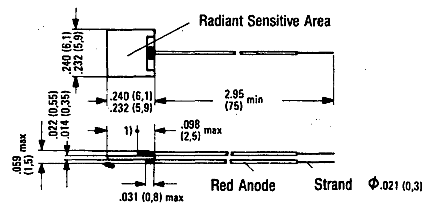
BPY 64P

PHOTOVOLTAIC CELL



Supercedes BPY 64

Package Dimensions in Inches (mm)



1) CONTACT SURFACE .138 (3.5) MIN.

Maximum Ratings

Reverse voltage	V_R	1	V
Temperature range	T_{amb}	− 55 to + 100	°C

FEATURES

- **Silicon Photovoltaic Cell**
- **Medium Size Radiation Sensitive Surface**

DESCRIPTION

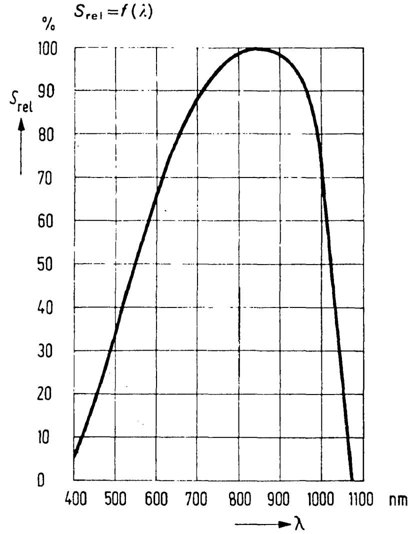
The BPY 64P is suitable for versatile applications in control and drive circuits. It can be used, like all silicon photovoltaic cells, as detector for light of filament lamps or daylight.

Characteristics (T_{amb} = 25°C)

Photosensitivity (standard light A, T = 2856 K)	S	0.25 (≥0.18)	nA/lx
Wavelength of Max. Photosensitivity	λ_{Smax}	850	nm
Spectral Range of Photosensitivity (S = 10% of Smax)	λ	420 to 1060	nm
Radiant Sensitive Area	A	0.36	cm²
Dimensions of the Radiant Sensitive Area	L × W	5.98 × 5.98	mm
Half Angle	φ	±60	Deg.
Dark Current (V_R = 1 V, E = 0)	I_R	4	μA
(V_R = 1 V, E = 0, T_{amb} = 50°C)	I_R	10	μA
Spectral Photosensitivity (λ = 850 nm)	S_λ	0.50	A/W
Quantum Efficiency (λ = 850 nm)	η	0.72	Electrons / Photon
Open Circuit Voltage (E_V = 1000 lx, standard light A T = 2856 K)	V_L	450 (≥280)	mV
Short Circuit Current (E_V = 1000 lx, standard light A T = 2856 K)	I_{SC}	0.25 (≥0.18)	mA
Rise and Fall Time of the Photocurrent from 10% to 90% and from 90% to 10% of the Final Value (R_L = 1 KΩ, V_R = 1 V, λ = 840 nm I_P = 250 μA)	t_r, t_f	5	μs
Capacitance (V_R = 0 V, f = 1 MHz, E_V = 0 lx)	C_0	3	nF
Temperature Coefficient V_L	TC	-2.6	mV/K
Temperature Coefficient I_K	TC	0.2	%/K

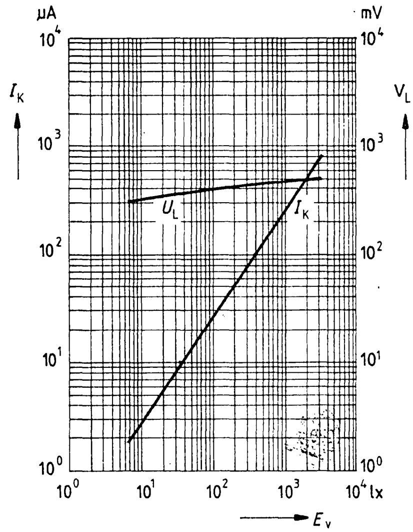
Relative spectral sensitivity

$S_{rel} = f(\lambda)$

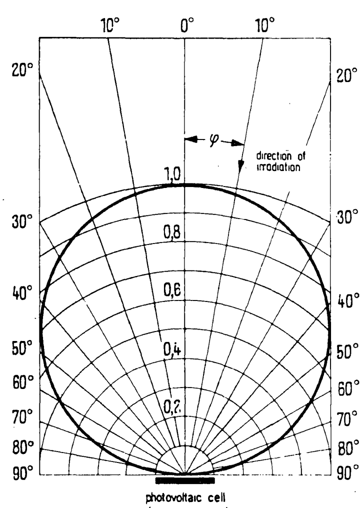


Open circuit voltage $V_L = f(E_v)$

Short circuit voltage $I_K = f(E_v)$

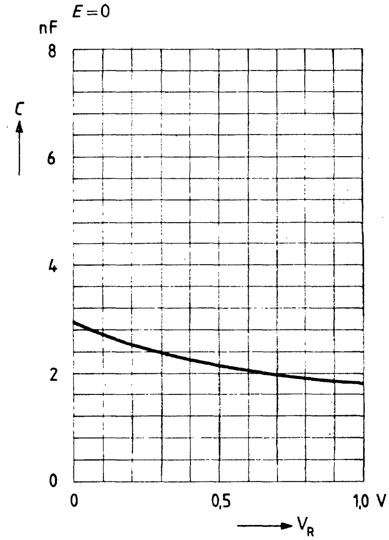


Directional characteristic $S_{rel} = f(\varphi)$



Capacitance $C = f(V_R)$;

$E = 0$

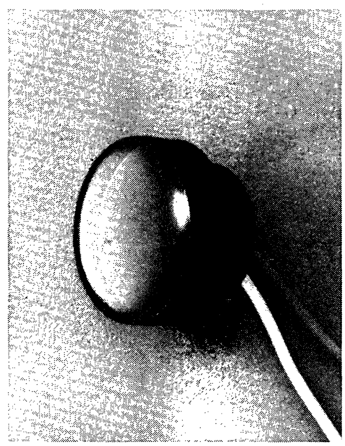


Photovoltaic Cells

SIEMENS

TP 60P
TP 61P

SILICON PHOTOVOLTAIC CELLS



TP 60P

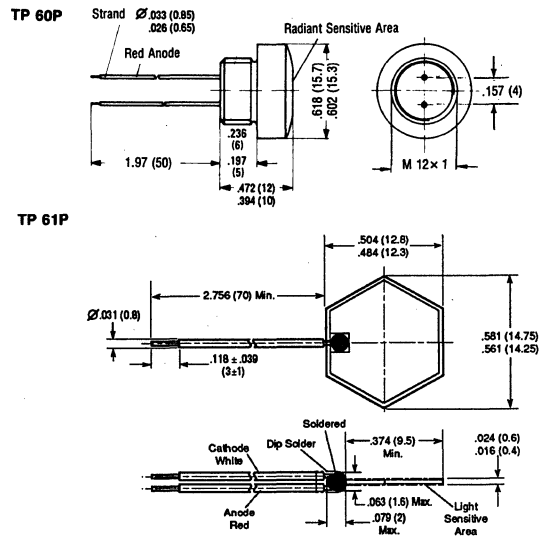
FEATURES

- **Silicon Photovoltaic Cell**
- **Stud Package, TP 60P**
- **Wide Temperature Range, -55° to +100°, TP 61P**
- **Very High Sensitivity, 1000 nA/lx Typ.**

DESCRIPTION

The silicon photovoltaic cells TP 60 P and TP 61P are suitable for use in drive and control circuits. Featuring the same electrical characteristics, they differ only in design. The anode (positive pole of the cell) is marked by a red lead.

Package Dimensions in Inches (mm)



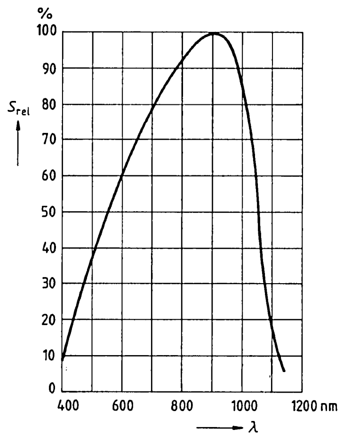
Maximum Ratings

		TP 60P	TP 61P	
Operating and storage temperature range	T_{amb}	− 40 to + 80	− 55 to + 100	°C
Reverse voltage [1]	V_R	1.0	1.0	V

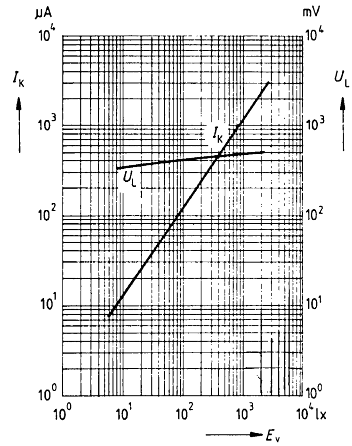
Characteristics (T_{amb} = 25°C)

Photosensitivity (standard light A, T = 2856 K)	S	1 (≥0.7)	µA/lx
Wavelength of Max. Photosensitivity	λ_{Smax}	850	nm
Spectral Range of Photosensitivity (S = 10% of Smax)	λ	400 to 1100	nm
Radiant Sensitive Area	A	1.3	cm²
Half Angle	φ	±60	Deg.
Dark Current (V_R = 1 V, E = 0)	I_R	0.1 (≥2)	µA
(V_R = 1 V, E = 0, T_{amb} = 50°C)	I_R		µA
Spectral Photosensitivity (λ = 850 nm)	S_λ	0.55	A/W
Quantum Efficiency (λ = 850 nm)	η	0.80	Electrons/Photon
Open Circuit Voltage (E_V = 1000 lx, standard light A T = 2856 K)	V_L	450 (≥270)	mV
(E_e = 0.5 mW/cm², λ = 850 nm)	V_L	430 (≥250)	mV
Short Circuit Current (E_V = 1000 lx, standard light A T = 2856 K)	I_{SC}	1 (≥.7)	mA
Rise and Fall Time of the Photocurrent from 10% to 90% and from 90% to 10% of the Final Value (R_L = 1 KΩ, V_R = 1 V, λ = 840 nm I_P = 1 mA)	t_r, t_f	5	µs
Capacitance (V_R = 0 V, f = 1 MHz, E_V = 0 lx)	C_0	3	nF
Temperature Coefficient V_L	TC	-2.6	mV/K
Temperature Coefficient I_K	TC	0.2	%/K

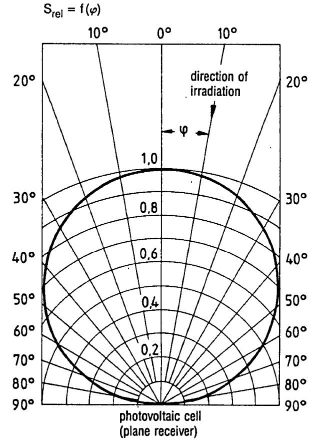
Relative spectral sensitivity
$S_{rel} = f(\lambda)$



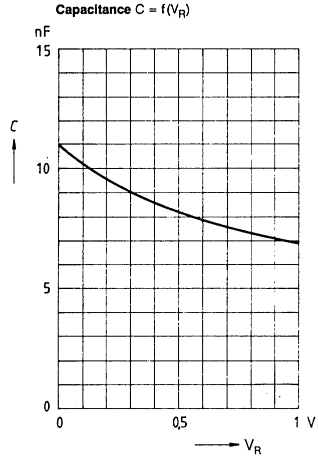
Open circuit voltage $V_L = f(E_V)$
short circuit current $I_K = f(E_V)$



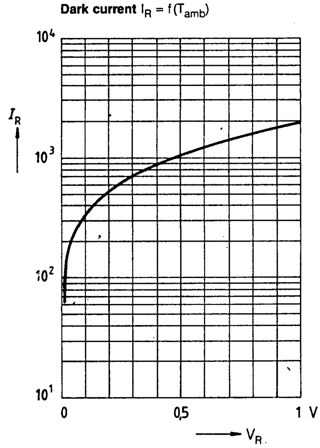
Directional characteristic
$S_{rel} = f(\varphi)$



Capacitance $C = f(V_R)$



Dark current $I_R = f(T_{amb})$



Photovoltaic Cells

LIST OF APPLICATION NOTES

SIEMENS

LEDs & Photometry Appnote 1

by George Smith

The observed spectrum of electromagnetic radiations, extends from a few Hz, to beyond 10^{24} Hz, covering some 80 octaves. The narrow channel from 430 THz to 750 THz would be entirely negligible, except for the fact that more information is communicated to human beings, in this channel, than is obtained from the rest of the spectrum. This radiation has a wavelength ranging from 400nm to 700nm, and is detectable by the sensory mechanisms of the human eye. Radiation observable by the human eye is commonly called light.

Measurements of the physical properties of light and light sources, can be described in the same terms as any other form of electromagnetic energy. Such measurements are commonly called Radiometric Measurements.

Measurements of the psychophysical attributes of the electromagnetic radiation we call light, are made in terms of units, other than these radiometric units. Those attributes which relate to the luminosity (sometimes called visibility) of light and light sources, are called photometric quantities, and the measurement of these aspects is the subject of Photometry.

The electronics engineer who is starting to apply light emitting diodes and other opto-electronic devices to perform useful tasks, will find the subject of photometry to be a confused mass of strange units, confusing names for photometric quantities, and general disagreement as to what the important requirements are for his application.

The photometric quantities are related to the corresponding radiometric quantities by the C.I.E. Standard Luminosity Function (Fig. 1), which we may colloquially refer to as the standard eyeball. We can think of the luminosity function, as the transfer function of a filter which approximates the behavior of the average human eye under good lighting conditions.

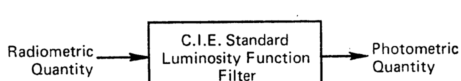


Figure 1. Relationship between radiometric units and photometric units.

The eye responds to the rate at which radiant energy falls on the retina, i.e., on the radiant flux density expressed as Watts/m^2. The corresponding photometric quantity is Lumens/m^2. The standard luminosity function is then, a plot of Lumens/Watt as a function of wavelength.

The function has a maximum value of 680 Lumens/Watt at 555nm and the ½ power points occur at 510nm and 610nm (Fig. 2).

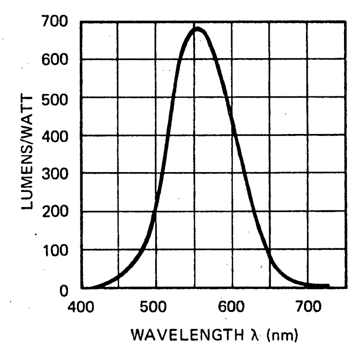


Figure 2. CIE standard photopic luminosity function.

The LUMEN is the unit of LUMINOUS FLUX and corresponds to the watt as the unit of radiant flux.

Thus the total luminous flux emitted by a light source in all directions is measured in lumens, and can be traced back to the power consumed by the source to obtain an efficiency number.

Since it is generally not practical to collect all the flux from a light source, and direct it in some desired direction, it is desirable to know how the flux is distributed spatially about the source. If we treat the source as a point (far field measurement), we can divide the space around the source into elements of solid angle (dω), and inquire as to the luminous flux (dF) contained in each element of solid angle ($\frac{df}{d\omega}$). The resulting quantity is Lumens/Steradian and is called LUMINOUS INTENSITY (I), (Fig. 3). The unit of Luminous intensity is called the CANDELA, sometimes loosely called the candle, or candle power.

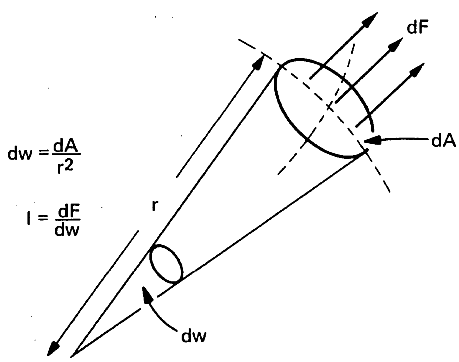


Figure 3. Solid angles and luminous intensity.

Since the space surrounding a point contains 4 π steradians, it is apparent that an isotropic radiator of one candela intensity, emits a total luminous flux of 4 π Lumens.

No real light source is isotropic, so it is quite common to show a plot of Luminous intensity versus angle off the axis (Fig. 4). If the source has no axis of symmetry, a more complex diagram is required.

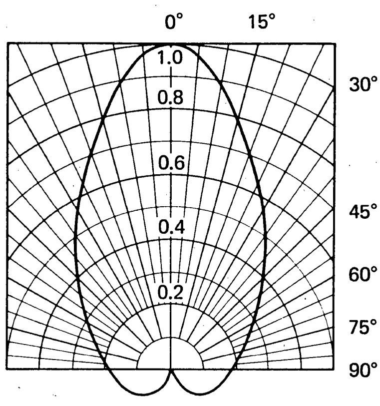


Figure 4. Spatial distribution pattern.

For an extended radiating surface, (such as an LED chip), each element of area contributes to the luminous intensity of the source, in any given direction. The luminous intensity contribution in the given direction, divided by the projected area of the surface element in that direction, is called the LUMINANCE (B) of the source (in that direction), (Fig. 5). The quantity is sometimes called photometric brightness, or simply brightness. The use of the term brightness on its own, should be discouraged, as this involves various subjective properties such as texture, color, sparkle, apparent size, etc. that have psychological implications.

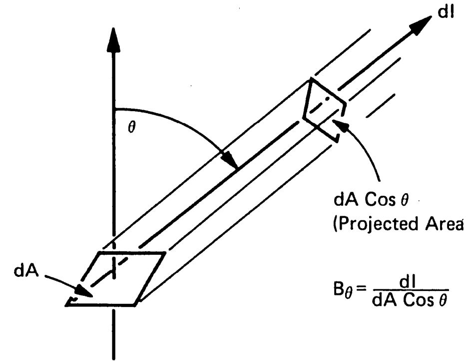


Figure 5. Definition of luminance.

The fundamental quantitative standard of the photometric system of units is the standard of luminance.

The luminance of a black body radiator at the temperature of freezing platinum (2043.8°K) is 60 candela per square centimeter. [A blackbody radiator is a perfect absorber of all electromagnetic energy incident on it. In thermal equilibrium at a given temperature, it emits radiation, spectrally distributed according to Plancks Formula

$$(W_\lambda = \frac{c_1 \lambda^{-5}}{\exp(\frac{c_2}{\lambda}) - 1})]$$

The units of Luminance in present use are an engineering nightmare.

1 candela/cm^2 is called a *Stilb*
1/π candela/cm^2 is called a *Lambert*
1 candela/m^2 is called a *Nit*
1/π candela/m^2 is called an *Apostilb*
1/π candela/ft^2 is called a *foot-Lambert*

The foot Lambert is the most commonly used unit in this country.

Of particular interest is a source whose angular distribution pattern is a circle (Fig. 6). For such a source we have $I_\theta = I_o \cos\theta$, the luminance of such a source in a given direction θ, is then given by

$$B_\theta = \frac{d\, I_\theta}{d\, A \cos\theta} = \frac{d\, I_o \cos\theta}{d\, A \cos\theta} = \frac{d\, I_o}{dA}$$

The luminance is seen to be the same in all directions. Such a source is called a LAMBERTIAN SOURCE. It can be shown that a perfectly diffusing surface behaves in this fashion. The formula governing a diffusing surface $I_\theta = I_o \cos\theta$ is called Lambert's Cosine Law.

It can be shown that a flat LED chip is a very good approximation to a Lambertian Source.

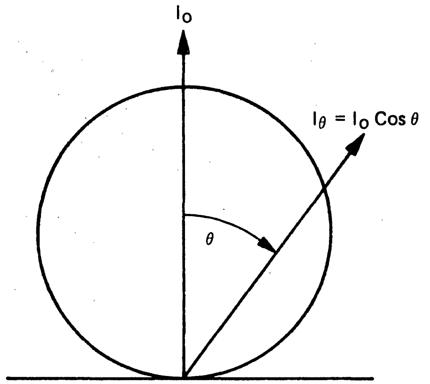


Figure 6. Lambertian radiation pattern.

If we now take a surface element (dA) and determine the intensity contribution in each direction we can determine the total flux (dF) emitted by the surface element. The resultant ratio ($\frac{dF}{dA}$) Lumens/m^2 is called the LUMINOUS EMITTANCE (L). For a flat surface we may calculate L from

$$L = 2\pi \int_{0}^{\pi/2} B(\theta) \, S_{IN}\,\theta \, \text{Cos}\,\theta \, d\,\theta$$

The corresponding radiant emittance in watts/m^2 is of considerable interest for GaAs infrared LED's where total output power is an important parameter.

The total luminous flux emitted by a light source can then be calculated from $F_{total} = \int LdA$.

These photometric quantities are sufficient to describe the properties of light sources such as light emitting diodes.

When light falls on a receiving surface, it is either partially reflected in the case of a purely passive surface, or partly converted into some other form of energy by what we may describe as an active surface (such as a phototransistor or photomultiplier cathode). In either case we are interested in how much flux falls on each element of the surface; Lumens/m^2 in the case of a passive surface which we wish to illuminate, or the eye; and Watts/m^2 in the case of other active surfaces. The quantity Lumens/m^2 in this case is called the ILLUMINANCE sometimes loosely referred to as the illumination. The unit of illuminance is the LUX also referred to as the metercandle. Another commonly used unit of illuminance, in the U.S. is the FOOT CANDLE, equal to one lumen per square foot. One lumen per square cm is called a PHOT.

Many of these photometric quantities and units are in common use in the field of illumination engineering. While English units are the most common in this country, a mixed system of units is involved in common usage.

APPLICATION TO LIGHT EMITTING DIODES

The above description of photometric quantities should indicate that there are many ways in which the photometric properties of LEDs can be stated. There is no general agreement among LED makers and users, as to the best way to specify LED performance, and this has led to much confusion and misunderstanding.

Many factors must be taken into account when evaluating LED specifications for a particular application, and electronic engineers will need to develop a knowledge of these factors to put LEDs to effective use in new designs.

Presently available light emitting diodes are made from III-V, II-VI, and IV semiconductors, with Gallium Arsenide Phosphide and Gallium Phosphide being the major materials. Gallium Aluminum Arsenide is also used but is less common. Gallium Arsenide is commonly included in this group, but GaAs emits only infrared radiation around 900 nm, which is not visible to the eye, and is thus not properly called light. All specifications of non-visible emitters must be in radiametric units.

GaP emits green light between 520 and 570 nm peaking at 550 nm, very close to the peak eye sensitivity. It also can emit red light between 630 and 790 nm peaking at 690 nm.

$GaAs_{(1-x)} P_x$ emits light over a broad range from green to infrared depending on the percentage of phosphorus in the material (x). For x in the 0.4 region, red light between 640 and 700 nm peaking at 660 nm, is obtained. For x = 0.5, amber light peaking around 610 nm is obtained.

$Ga_{(1-x)} Al_x A_s$ as presently available emits red light between 650 and 700 nm peaking at 670 nm. It also emits into the infrared.

The efficiency of these materials is very dependent on the emitted wavelength, with drastic fall off in efficiency as the wavelength gets shorter. Fortunately the standard eyeball filter favors the shorter wavelength (down to 555nm) and gives some measure of compensation. Some typical efficiencies reported by device makers, and the resulting overall luminous efficiency (Lumens/electrical watt) are as follows:

GaP.red	.72% @ 20Lum/Watt = .14 Lum/Watt overall
$GaAs_{.6}P_{.4}$red	.3% @ 50Lum/Watt = .15 Lum/Watt overall
GaAlAs red	1.5% @ 40Lum/Watt = .024 Lum/Watt overall
GaP green	.006% @ 675Lum/Watt = .04 Lum/Watt overall
$GaAs_{.5}P_{.5}$amber	.0044% @ 340Lum/Watt – .015 Lum/Watt overall

For simple status indicator applications, front panel lamps and similar applications, several factors must be taken into account:

(1) Color. Generally the designer has Henry Ford's color choice; various similar shades of red. Amber and green are available in smaller quantity, because of availability of suitable raw material.

(2) Apparent source size. Various combinations of chip size and optical systems are available so that apparent source sizes from about 5 mils to about 300 mils diameter are available as standard products. Other things being equal, a larger source size is more visible.

(3) Angular distribution. GaAsP diode chips are nearly Lambertian, but GaP are nearly isotropic. With suitable optical design, the angular distribution pattern can be changed from very broad to quite narrow. By placing the chip at the focus of the lens system a narrow high intensity beam is obtained. The off axis visibility is drastically reduced. By using diffusing lens materials, a large area source with good off axis visibility is obtained. In this case the luminance is reduced.

(4) Luminous intensity. This will govern the visibility under optimum background contrast conditions, when viewed at normal distances. 1 millicandela is typical for red lamps of either GaAsP or GaP at normal operating conditions.

(5) Luminance. When it is not possible to provide a dark contrasting background, or when the source is viewed at very close distances, the luminance becomes important. Values from 100 ft-L to 5000 ft-L are typical.

These factors are all related to the design of the device and the user should understand the trade offs. High luminance values in excess of 10,000 ft-L are easily obtained by running very high current densities in the LED chip, but this can lead to shortened life if carried too far.

For a given drive current the luminous intensity of two different chips will be similar, while the luminance will be inversely proportional to the active area of the chip.

If the designer can use filter screens or circularly polarizing filters in front of the light source, excellent protection from background illumination can be obtained. In this case a diffusive lens giving a large apparent source with lower luminance, is more visible than a high luminance point source.

When a LED is used with an optical system to activate a remote sensor such as a cadmium sulphide or cadmium selenide cell (red light), or a GaAs IR emitter is used with a silicon photo detector, the performance requirements are somewhat different. It can be shown that for a given optical arrangement the irradiance of the detector determines the detected signal and this is proportional to the radiance of the source, which is comparable to the luminance (brightness) of the source. The intensity of the source will not be a factor unless the detector active area is larger than the incident beam.

When average power consumption must be minimized but good visibility is required, or detection at a considerable distance is required, pulsed operation can be used. With GaAs and GaAsP emitters using low duty cycle short pulses, very high peak intensity levels can be reached permitting communication over considerable distances. This technique is not useful with GaP diodes since they do not exhibit a linear relationship between optical output and instantaneous forward current, becoming saturated at moderate current levels. GaP also has a 50% higher rate of fall off in light output with temperature increase, than GaAsP which further inhibits high power applications.

The use of LED's to give a "Heads Up" projected display, such as for an automobile speedometer readout, or aircraft cockpit application, places severe requirements on the display luminance. For easy visibility, the projected image must be sufficiently contrasted with the ambient illumination. This requires very high luminance values for the LED's together with the use of photochromic windshields and probably polarizing screens.

The foregoing is a necessarily simplified description of a very complex subject. The reader should avail himself of the standard textbook literature on these subjects.

References:

R. Kingslake, *Applied Optics & Optical Engineering*
Committee on Colorimetry of the O.S.A., *The Science of Color.*
Warren J. Smith, *Modern Optical Engineering.*

SIEMENS

Applications of Optocouplers Appnote 2

by George Smith

The IL1 is the first in a family of optocouplers. These products are also called photon coupled isolators, photocouplers, photo-coupled pairs and optically coupled pairs. All of the characteristics of the IL1 are electrical: it has no external optical properties. Hence opto-isolators are not OPTOELECTRONIC DEVICES; they are in fact one of the simplest of all ELECTRO-OPTICAL SYSTEMS.

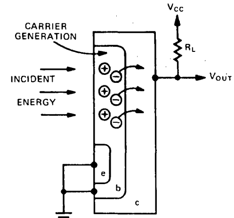
The IL1 consists of a Gallium Arsenide infrared emitting diode, and a silicon phototransistor mounted together in a DIP package.

When forward current (I_F) is passed through the Gallium Arsenide diode, it emits infrared radiation peaking at about 900nm wavelength. This radiant energy is transmitted through an optical coupling medium and falls on the surface of the NPN phototransistor.

Photo-transistors are designed to have large base areas; and hence a large base-collector junction area; and a small emitter area. Some fraction of the photons that strike the base area cause the formation of electron-hole pairs in the base region. This fraction is called the QUANTUM EFFICIENCY of the photodetector.

If we ground the base and emitter, and apply a positive voltage to the collector of the photo-transistor, the device operates as a photo diode.

The high field across the collector base junction quickly draws the electrons across into the collector region. The holes drift towards the base terminal attracting electrons from the terminal.

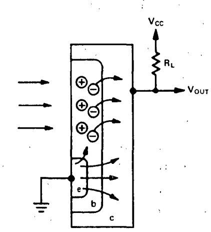


Thus a current flows from collector to base, causing a voltage drop across the load resistance (R_L).

The high junction capacitance, C_{cb}, results in an output circuit time constant R_LC_{cb}, with a corresponding output voltage rise time.

The output current in this configuration is quite small and hence this connection is not normally used.

The commonest circuit configuration is to leave the base connection open. With this connection, the holes generated in the base region cause the base potential to rise, forward biasing the base-emitter junction. Electrons are then injected into the base from the emitter, to try to neutralize the excess holes. Because of the close proximity of the collector junction, the probability of an electron recombining with a hole is small and most of the injected electrons are immediately swept into the collector region. As a result, the total collector current is much higher than the photo-generated current, and is in fact β times as great.



The total collector current is then several hundred times greater than for the previous connection.

This gain comes with a penalty of much slower operation. Any drop in collector voltage is coupled to the base via the collector-base capacitance tending to turn off the injected current. The only current available to charge this junction capacitance is the original photo-current. Thus, the rate of change of the output voltage is the same for both the diode and transistor connections. In the latter case, the voltage swing is β times as great, so the total rise time is β times as great as for the diode connection. Thus the effective output time constant is $\beta\ R_LC_{cb}$.

For the IL1 this results in a typical 2µs rise time for 100Ω load.

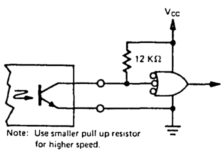
The ratio of the output current from the photo-transistor (I_C or I_E), to the input current in the Gallium Arsenide diode, is called the Current Transfer Ratio (CTR). For the IL1, CTR is specified at 20% minimum with 35% being typical at $I_F = 10$ mA.* Thus for 10 mA input current the minimum output current is 2 mA. Other important parameters are V_F typically 1.3V at 100 mA I_F.

DIGITAL INTERFACES

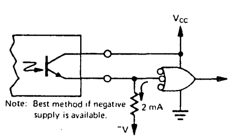
Output Sensing Circuits

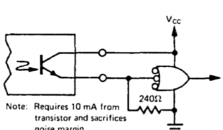
The output of the phototransistor can directly drive the input of standard logic circuits such as the 7400 TTL families. The worst case input current for the 74 series gate is −1.6 mA for $V_{IN} = 0.4$ Volts. This can be easily supplied by the IL1, with 10 mA input to the infrared diode.

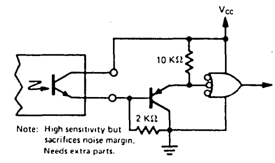
TTL Active Level Low (7400)

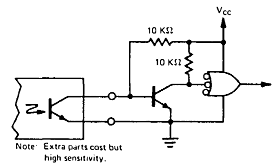


It is more difficult to operate into TTL gates in the active level high configuration. Some possible methods are as follows;

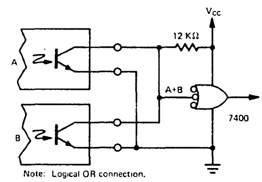


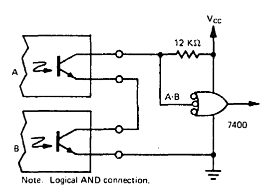






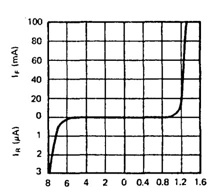
Obviously, several optocoupler output transistors can be connected to perform logical functions.





Input Driving Circuits

The input side of the IL1 has a diode characteristic as shown.

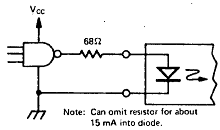


The forward current must be controlled to provide the desired operating condition.

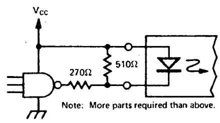
Application Notes

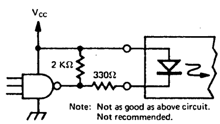
The input can be conveniently driven by integrated circuit logic elements in a number of different ways.

TTL Active Level High (7400 Series)



TTL Active Level Low (7400 Series)





There are obviously many other ways to drive the device with logic signals, but the commonest needs can be met with the above circuits. All provide 10 mA into the LED giving 2 mA minimum out of the photo-transistor. The 1 Volt diode knee and its high capacitance (typically 100 pF), provides good noise immunity. The rise time and propagation delay can be reduced by biasing the diode on to perhaps 1 mA forward current, but the noise performance will be worse.

All previous configurations show medium speed digital interfaces. These circuits have various advantages over other ways of doing the task.

(1) They can replace relays and reed relays, giving much faster switching speeds, no contact bounce, better reliability, and usually better electrical isolation exçept for special configurations. However relays have high current capability, higher output voltage, lower on resistance and offset voltage and higher off resistance.

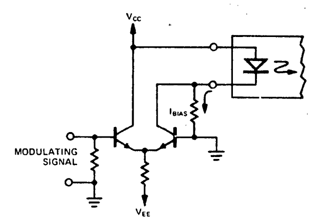
(2) **They can replace pulse transformers in many floating applications. Opto-isolators can transmit DC signal components and low frequency AC, whereas pulse transformers couple only the high frequency components, and a latch is required to restore the DC information. Pulse transformers have faster rise time than photo-transistor optocouplers.**

(3) **Integrated circuit line drivers and receivers are used to transmit digital information over long lines in the presence of common mode noise. The maximum common mode noise voltage permissible is usually in the 30 Volt range. There are many practical situations where common mode noise voltages of several hundred Volts can be induced in long lines. For these applications, optocouplers provide protection against several thousand Volts.**

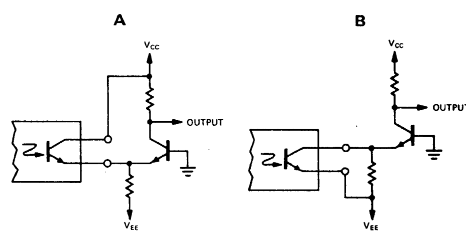
LINEAR APPLICATIONS

The curve of input current versus output current for the IL1 is somewhat non-linear, because of the variation of β with current for the photo-transistor, and the variation of infrared radiation out versus forward current in the GaAs diode. The useful range of input current is about 1 mA to 100 mA, but higher currents may be used for short duty cycles.

For linear applications the LED must be forward biased to some suitable current (usually 5 mA to 20 mA). Modulating signals can then be impressed on this DC bias. A differential amplifier is a good way to accomplish this.

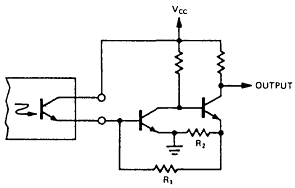


Sensing in linear applications can be done in several ways depending on the requirements. For high frequency performance, the photo-transistor should be operated into a low impedance input current amplifier. The simplest such scheme is a grounded base amplifier.



The circuit will work equally well either way, with a phase inversion between the two. Obviously a PNP transistor would work as well.

A feedback amplifier could also be used to get a low impedance input.



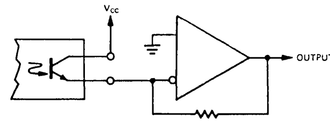
The current gain is $\left(1 + \frac{R_1}{R_2}\right)$.

The input impedance is approximately

$$\left(\frac{R_1}{1 + \frac{V_{CC} - 2V_{BE}}{.026}}\right)$$

For example if R_1 = 900Ω, R_2 = 100Ω, V_{CC} = 5V; we would have a current gain of 10 and an input impedance of about 6.3Ω. This would give a considerable speed improvement over a 100Ω load.

A high speed operational amplifier could be used to give excellent performance.



Note that in all cases the output can be taken from either the collector, or the emitter of the photo-transistor depending on the polarity desired. The operating speed is the same in either case.

CONCLUSION

This appnote covers the most commonly used ways of applying photo-transistor optocouplers. The design engineer will see many ways to expand on these circuits to achieve his end goals. The devices are extremely versatile, and can provide better solutions to many systems problems than other competing components. Special designs are possible to optimize certain parameters such as coupling capacitance, or transfer ratio.

SUMMARY OF PROPERTIES OF SIGNAL COUPLING DEVICES

Device	Advantages	Disadvantages
Optocoupler	Economical. Solid state reliability. Medium to high speed signal transmission. DC & low frequency transmission. High voltage isolation. High isolation impedance. Small size DIP Package. No contact bounce Low power operation.	Finite ON Resistance Finite OFF Resistance. Limited ON state current. Limited OFF state voltage. Low transmission efficiency. (Low CTR)
Relays	High power capability. Low ON resistance. DC transmission. High voltage isolation.	High cost. High power consumption. Unreliable. Very slow operation. Physically large.
Pulse Transformers	High speed signal transmission. Moderate size. Good transmission efficiency.	No DC or low frequency transmission. Expensive for high isolation impedance or voltage.
Differential line Drivers and Receivers	Solid state reliability. Small size DIP package. High speed transmission. DC transmission. Low cost.	Very low breakdown Voltage. Low isolation impedance.

SIEMENS

Multiplexing LED Displays Appnote 3

by George Smith

In digital displays, such as would be used in a D.V.M. or counter of conventional design, all digits are operated in parallel, with a separate decoder-driver for each digit operated from data generally stored in a quad latch.

In many cases, a reduction in cost can be effected by operating the display in a time division multiplexed mode. The question of cost effectiveness depends on the particular application. As a general rule, the greater the number of digits in the display, the more advantageous the multiplex system becomes from the cost standpoint. Because of the great variety of situations possible, it is difficult to say at what number of digits the change should be made. In some circumstances, non-multiplexed operation of less than 8 digits is more economical. On the other hand, there are circumstances under which multiplexing is used for three and four digit displays at a cost saving. This application note attempts to show some of the many ways of multiplexing digits, and it is left to the designer to decide whether his own system application would be lower in cost if he used a multiplex scheme.

The properties of light emitting diodes (LED) make them particularly suitable for multiplexed operation, and hence it is the preferred method to use, if a scheme can be designed which is cost competitive with non-multiplexed operation.

Throughout this paper, it will be generally assumed that we are talking of a system using TTL type logic families, with MSI functions being used where applicable. In most production situations this will be the most economical approach. There will be some cases where discrete gates and flip-flops may yield a lower cost. There are also cases where a single MOS chip contains all the necessary logic functions, and only interface driver circuits are required.

The seven segment numeric displays with a common anode connection made by Siemens provide compatibility with the most widely available decoder-drivers, which are active level low outputs. The commonest device is SN7447 or similar. Any of these is suitable for driving the HD107XX, HD110XX, or HD1131XX Series type dipslay. For common cathode displays, such as the Siemens DL330M, DL340M, DL430M, or DL440M, SN7448 decoder can be used, and anode drivers become cathode drivers.

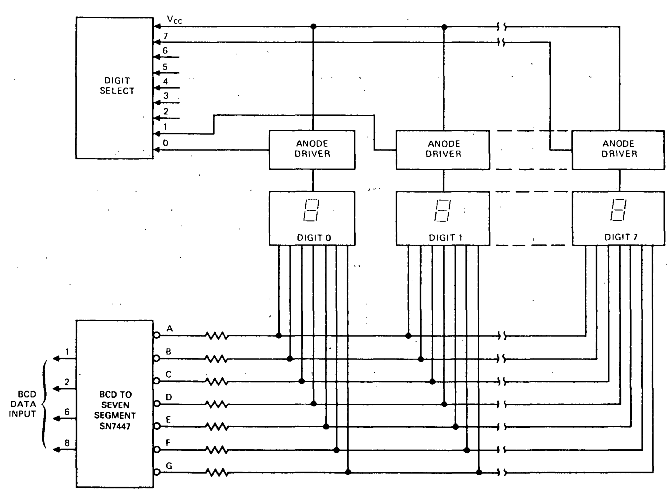


Figure 1

In a multiplex system, the corresponding cathodes of each digit are bussed together, and driven from one seven segment decoder-driver, via the usual current limiting resistors. The display data is presented serially by digit, to the decoder-driver, together with an enable signal to the appropriate digit anode Figure 1.

Each digit anode is driven by a switch, capable of passing the full current of all segments. The simplest switch would be a PNP high current switch or amplifier transistor, such as a core driver type.

In operation, the anode switches are activated one at a time, in the desired sequence, while the appropriate digital data is presented at the input to the decoder-driver. The amount of circuitry required in Figure 1 is much less than that used in the non-multiplexed scheme. The question of overall economy is dependent on the amount of circuitry required to sequence the anodes and present the data at the decoder input. Let us consider some typical situations.

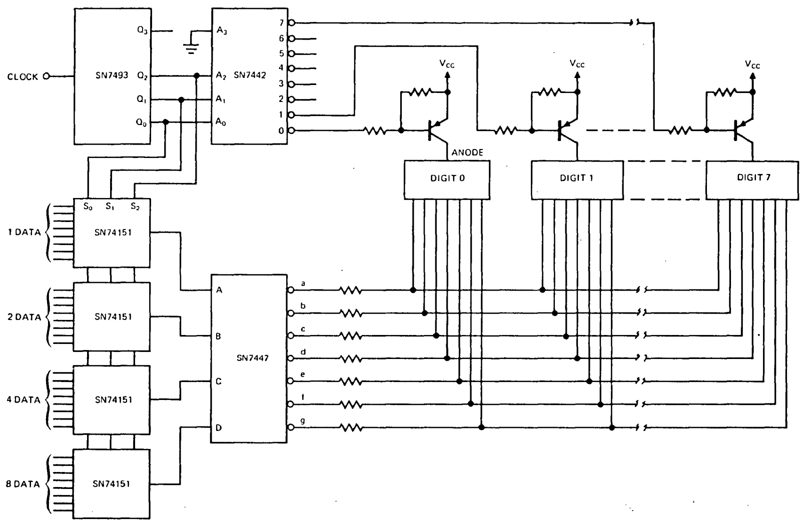


Figure 2

CASE 1:

An 8-digit counter-timer display, with the data stored in multiple latch circuits. This is the most common situation present in a counter-timer of conventional design. A quad latch (SN7475) is used to store each digit, and this data is periodically updated. To scan this data, a 4 pole 8 position switch is required (SN74151). To select the appropriate digit, an octal counter (SN7493) and a BCD decoder (SN7442) are required. The complete circuit is as shown in Figure 2.

The total package count is about the same for this arrangement, as for non-multiplexed operation, but most of the packages are lower cost than the seven segment decoder. The scheme shown is a 20% cost reduction over non-multiplexed operation, based on O.E.M. prices for the components. For less than eight digits, it would be difficult to compete with non-multiplexed operation using this scheme.

CASE 2:

Multiplexing becomes more attractive, when the data is stored in a shift register, rather than in latches. In this case the data is circulated around the register, at some suitable rate, and is sequentially presented at the input of the seven-segment decoder-driver. The anode drive can be obtained from a counter and decoder as in Figure 2, or from a parallel output shift register – Figure 3.

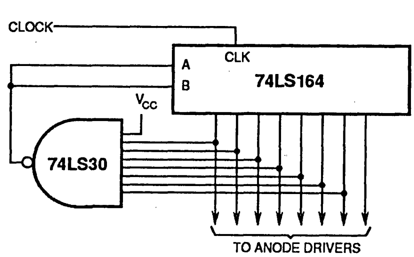


Figure 3

Application Notes

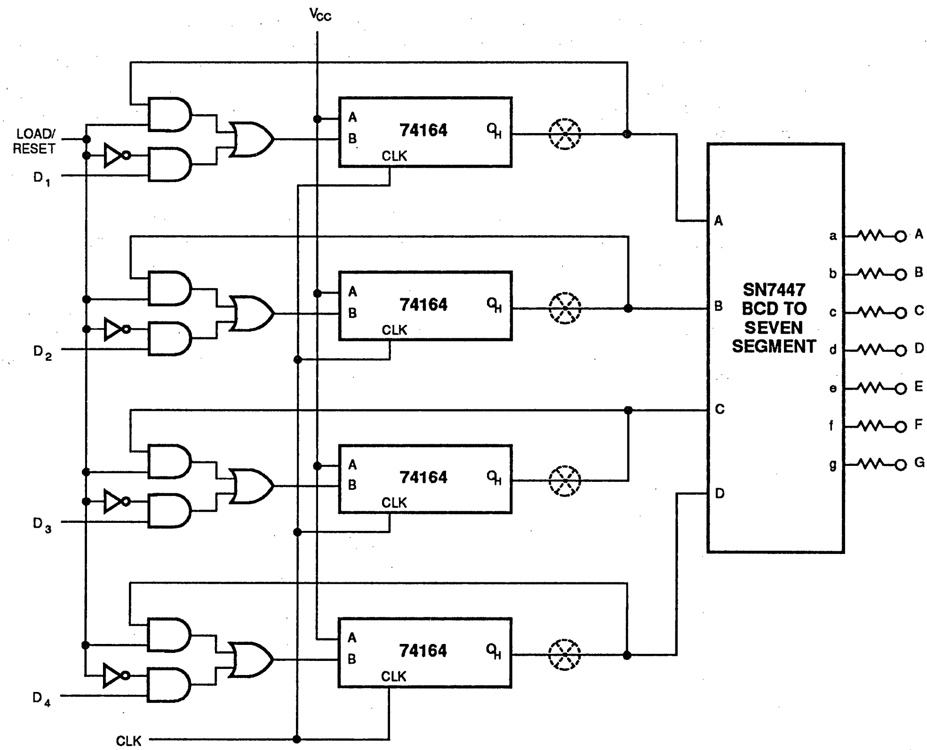


Figure 4

This circuit, which can be expanded to any number of digits, circulates a single zero, and thus can directly drive the PNP anode switches. Systems using recirculating memories generally require this digit timing circuitry for other reasons, so it is generally available in the system already.

For displays of 8 digits; a very common number in counter-timer instruments, the 74164 8 bit shift register makes a very good circulating shift register.

The scheme can be extended to more digits by adding a 4 bit shift register, such as the 7494; the extra shift bits are inserted at the points marked ⊗ in Figure 4. The same circuit can be used for less than 8 digits, if a 12½% duty cycle is satisfactory.

The preceding schemes demonstrate that systems containing recirculating data are very effectively coupled to multiplexed LED displays. Many multi-digit systems such as calculating machines use L.S.I. MOS circuits to provide their logic, and these naturally lend themselves to recirculating data. It is now practical to use microprocessors in instruments, which lend themselves nicely with Siemens Intelligent Display devices.

Apart from the strictly logical problems involved in a multiplexed display, the designer must choose suitable operating conditions for the LED's. Peak forward current, current pulse width, duty cycle and repetition rate, are all factors which the designer must determine.

The luminous intensity, or the luminance of GaAsP LED's, is essentially proportional to forward current over a wide range, but certain phenomena modify this condition. At low currents, the presence of non-radiative recombination processes, results in less light output than the linear relationship would predict. This effect is noticeable in the region below about 5 mA per segment (for 1/4 inch characters). The result is that noticeable difference in luminance from segment to segment can occur at low currents. At high currents, the power dissipation in the chip causes substantial temperature rise, and this reduces the efficiency of the chip. As a result the light output versus forward current curve falls below the straight

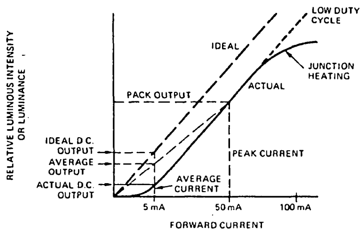


Figure 5

line, at high currents (Figure 5). It should be emphasized that this latter effect is entirely due to self heating. If the power dissipation is limited, by running short pulses at low duty cycle, the output follows the straight line up to very high current densities. Whereas 100 A/cm^2 may be used in DC operation, as much as 10^4 A/cm^2 can be used under pulsed conditions, with a proportionate increase in peak intensity. (If this did not occur, GaAsP lasers could not be built.) Gallium Phosphide, however, has an inherent saturation mechanism that causes a drastic reduction in efficiency at high current densities even if the junction temperature remains constant. This effect is due to competing non-radiative recombination mechanisms at high current density.

As a first approximation the brightness of a pulsed LED will be similar to that when operated at a DC forward current equal to the average pulsed current. For example, for 40 mA peak current at 25% duty cycle, the brightness will be similar to DC operation at 10 mA. The actual brightness comparison will depend on the actual pulsing conditions. Under most legitimate conditions the brightness will be greater for pulsed operation.

Figure 5 shows how the actual light output at 5 mA DC is substantially less than expected from the ideal curve, because of the "foot" on the curve at low currents. Operation at 50 mA peak current and 10% duty cycle yields a high peak output as shown, and an integrated average output that is much closer to the ideal value. It should be obvious that variations in the "foot" from segment to segment cause a significant variation in light output at a low DC current, but a much smaller variation in the average output when operated in a pulsed mode. As well as an increase in luminance, or luminous intensity due to pulsing, there is an increase in brightness because of the behavior of the eye. The eye does not behave as an integrating photometer, but as a partially integrating and partially peak reading photometer. As a result, the eye perceives a brightness that is somewhere between the peak and the average brightness.

The net result is that a low duty cycle high intensity pulse of light looks brighter than a DC signal equal to the average of the pulsed signal. The practical benefit of multiplexed operation then, is an improvement in display visibility for a given average power consumption besides the lower cost. The brightness variation from segment to segment and digit to digit is also reduced by time-sharing. The gain in brightness over DC operation can be as much as a factor of 5 at low duty cycles of 1 or 2 percent, and peak currents of 50 to 100 mA.

A number of factors must be taken into account when deciding on the design of a multiplexed display. Besides the optical output, thermal considerations are very important.

Most 1/4" size LED numerics are rated at 30 mA DC max per segment. Under pulsed operation, higher currents can be used provided several thermal considerations are taken into account.

(1) The average power dissipation must not exceed the maximum rated power.

(2) The power pulse width must be short enough to prevent the junction from overheating during the pulse. This implies that the pulse width must get shorter as the amplitude increases.

Present experience indicates that for pulses of 10 μs, the amplitude should be limited to 100 mA max. Shorter pulses of higher amplitude may be used but the circuit problems become severe if the pulse width is very short.

Application Notes

SIEMENS

Driving High-Level Loads With Optocouplers Appnote 4

by David M. Barton

Frequently a load to be driven by an optocoupler requires more current, voltage, or both, than an optocoupler can provide at its output.

Available optocoupler output current, of course, is found by multiplying input (LED section) current by the "CTR" or current-transfer-ratio. For worst-case design, the minimum specified value would be used. The minimum CTR of the IL1 is 20%. Temperature derating is not usually necessary over the 0 to +60 degree Celcius range because the LED light output and transistor beta have approximately compensating coefficients.

Multiplying the minimum CTR by 0.9 would ensure a safe design over this temperature range. Over a wide range, more margin would be required.

The LED source current is limited by its rated power dissipation. Table I shows maximum allowable I_F vs maximum ambient temperature.

Values for Table I are based on a 1.33 mW/°C derate from the 100 mW at 25°C power rating.

Table I

MAXIMUM TEMPERATURE	I_F MAXIMUM
40°C	65 mA
60°C	48 mA
80°C	25 mA

Obviously, one can increase the available output current then by either choosing a higher CTR-rated optocoupler, by providing more current, or both. Table II shows the minimum available output current of each device assuming 60 °C derating (from Table I) and a 10 percent margin for temperature effects.

Table II

P/N	I_{CE}(MIN) mA
IL1	8.6

If the IL1 is being operated from logic with 5 volt driving transistor and 0.2 volt V_{CE} saturation is assumed for the driving transistor, a 75 ohm R_{IF} resistor will provide the 48 mA. The forward voltage of the IR-emitting LED is about 1.2 volts. Figures 1A and 1B show two such drive circuits.

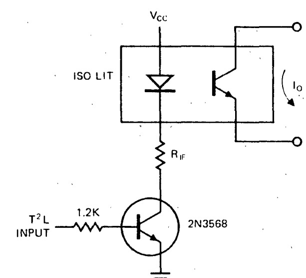


Figure 1A. NPN Driver

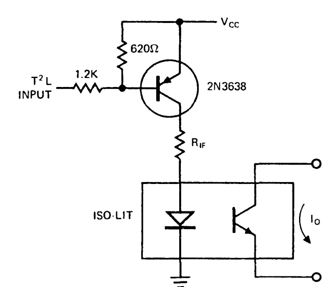


Figure 1B. PNP Driver

A "buffer-gate," such as the SN7440 provides a very good alternative to discrete transistor drivers. Figure 2 shows how this is done. Note that the gate is used in the "current-sinking" rather than the "current-sourcing" mode. In other words, conventional current flows *into* the buffer-gate to turn on the LED. This makes use of the fact that a T²L gate will sink more current than it will source. The SN7440 is specified to drive thirty 1.6 mA loads or 48 mA. Changing R_{IF} from 75 to 68 ohms adjusts for the higher saturation voltage of the monolithic device.

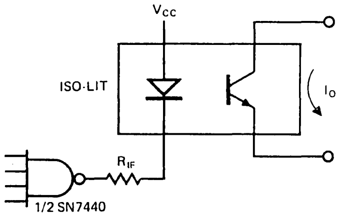


Figure 2. Buffer-Gate Drive

MORE CURRENT

For load currents greater than 8.6 mA, a current amplifier is required. Figures 3A and 3B show two simple one-transistor current amplifier circuits.

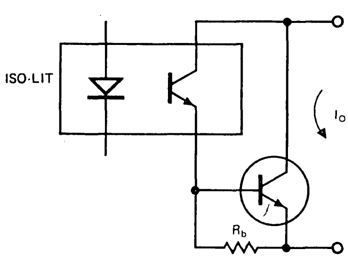


Figure 3A. NPN Current Booster

Since the transistor in the optocoupler is treated as a two-terminal device, no operational difference exists between the NPN and the PNP circuits. R_b provides a return path for I_{CBO} of the output transistor. Its value is: R_b = 400 mV/I_{CBO} (T) where I_{CBO}(T) is found for the highest *junction* temperature expected.

Assume that leakage currents double every ten degrees. Use the maximum dissipated power, the specified maximum junction-to-ambient thermal resistance,

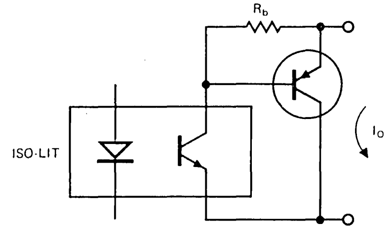


Figure 3B. PNP Current Booster

and the maximum design ambient temperature in conjunction with the specified maximum 25 degree I_{CBO} to calculate I_{CBO}(T).

As an example, suppose a 2N3568 is used to provide a 100 mA load current. Also assume a maximum steady-state transistor power dissipation of 100 mW and a 60°C maximum ambient. The transistor junction-to-ambient thermal resistance is 333°C/watt, so a maximum junction temperature of 60 + 33 or 93°C is expected. This is about 7 decades above 25°C. Therefore, $I_{CBO}(T) = I_{CBO}(max) \times 2^7 = 50$ nA x 128 = 6.5 μA. A safe value for R_b is 400 mV/6.5 μA = 62 kilohms.

Working backwards, maximum base current under load will be $I_O/h_{FE}(min) = 100$ mA/100 = 1 mA. Current in R_b is V_{BE}/R_b = 600 mV/60k = 10μA, which is negligible. An IL1 with 9 mA drive would operate effectively.

If the load requires more current than can be obtained with the highest beta transistor available, then more than one transistor must be used in cascade. For example, suppose 3 amperes load current and 10 watt dissipation are needed. A Motorola MJE3055 might be used for the output transistor, driven by a MJE205 as shown in Figure 4. Using a 5°/watt heat sink and the rated MJE3055 junction-to-case thermal resistance of 1.4°/watt, we find that junction temperature rise is 6.4 x 10, or 64°. Therefore maximum junction temperature is 124°C. This is 10 decades above 25°C making $I_{CBO}(T) = 2^{10} I_{CBO}(max) = 10^3 I_{CBO}(max)$.

I_{CBO}(max) at 30 volts or less is not given, but I_{CEO} is. Using (for safety) a value of 20 for the minimum low-current h_{FE} of the device, I_{CBO} could be as large as

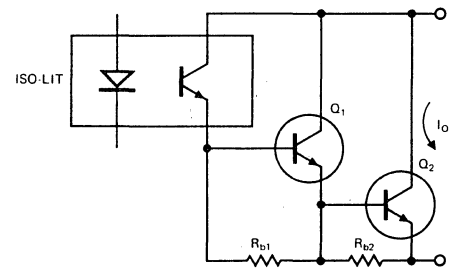


Figure 4. Two-NPN Current Booster

$I_{CEO}/20 = 35\ \mu A$. Then $I_{CBO}(T)$ is 35 mA and $R_{b2} = 400\ mV/35\ mA = 11$ ohms. For I_b use I_o/h_{FE}(min @ 4A) = 3A/20 = 150 mA. $I_{Rb2} = 600\ mV/10$ ohms = 60 mA, so $I_{e(Q1)} = 210$ mA.

Maximum Power in Q_1 will be about 1/14 the power in Q_2 since its current is lower by that ratio and the two collector-to-emitter voltages are nearly the same. This means Q_1 must dissipate 700 mW.

Assuming a small "flag" heat sink having 50°/watt thermal resistance, we find the junction at about 95°C. The 150°C case temperature I_{CBO} rating for this device is 2 mA, so one can work backwards and assume about 1/30 of this value, or 70 μA. On the other hand, the 25° rated I_{CBO} is 100 μA. Choosing the larger of these contradictory specifications, $R_{b1} = 400\ mV/0.1\ mA = 4k \approx 3.9k$. Q_1 base current is $I_{E(Q1)}/h_{FE(Q1\text{-}min)} = 210\ mA/50^* = 4.2$ mA. Total current is $I_{b(Q1)} + I_{Rb1} = 4.2 + 0.24 = 4.5$ mA. Table II shows that an IL1 could be used here.

MORE LOAD VOLTAGES

All of the current-gain circuits shown so far have one common feature: load voltage is limited by the 30 volt rating of the IL1 not by the voltage or power rating of the transistor(s). Figure 5A shows a method of overcoming this limitation. This circuit will stand off BV_{CEO} of Q_1. The voltage rating of the phototransistor is irrelevant since its maximum collector-emitter voltage is the base-emitter voltage of Q_1 (about 0.7 volts).

Unlike the "Darlington" configurations shown previously, this circuit operates "normally-ON." When no current flows in the LED the phototransistor, being OFF, allows R_2 current to flow into the base of Q_1, turning Q_1 ON. When the optocoupler is energized, its phototransistor "shorts out" the R_2 current turning Q_1 OFF.

*Minimum h_{FE} is obtained using the specification at I_{CE} = 2A and the "Normalized DC Current Gain" graph given in the Motorola "Semiconductor Data Book," 5th Edition, pp. 7 – 232, 3.

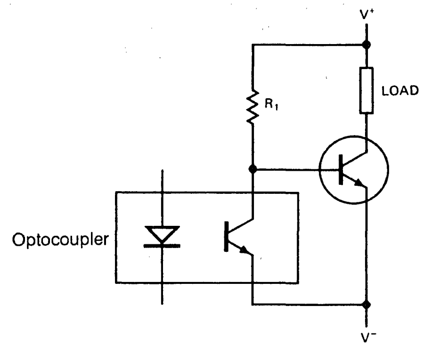


Figure 5A. NPN HV Booster

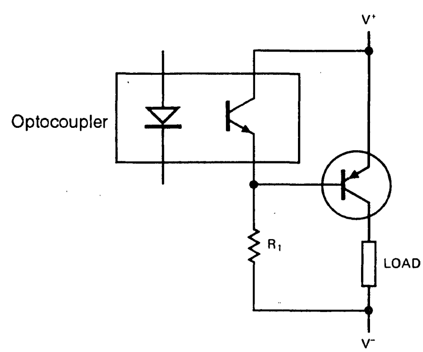


Figure 5B. PNP HV Booster

The value of R_1 depends only on the load-supply voltage $V^+ - V^-$, and the *maximum* required Q_1 base current. This is derived from the minimum beta of Q_1 at minimum temperature and the load current. The required current-drive capability is the same as I_{R1}, since I_{R1} changes negligibly when the circuit goes between its "ON" and "OFF" states.

In some applications either more current gain will be required than one transistor can provide or the power dissipated in R_1 will be objectionable. In these cases, simply use the Darlington high-voltage booster shown in Figure 6A.

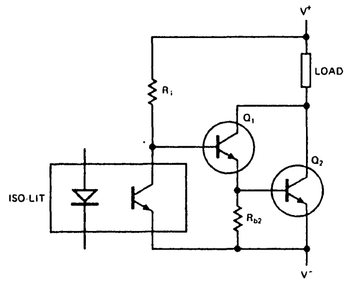


Figure 6A. NPN Darlington HV Booster

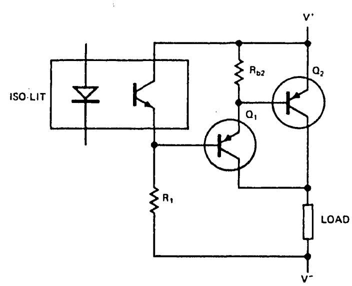


Figure 6B. PNP Darlington HV Booster

If more than one load is being driven and their negative terminals must be in common, use the PNP circuit, Figure 6B. Otherwise, the NPN is better because the transistors cost less. Of course performance characteristics of the NPN and PNP versions are identical if the device parameters are also the same.

APPLICATIONS

Optocoupler isolated circuits are useful wherever ground loop problems exist in systems, or where dc voltage level translations are needed. In many systems so-called interpose relays are used between a logic circuit section (which may be a mini-computer) and the devices being controlled. Sometimes *two levels* of interpose relays are used in cascade either because of the load power level or because of extreme difficulties with EMI. Optocouplers aided by booster circuits such as those described, can replace many of the relays in these systems.

The reed relays, typically used as the first level of interpose and mounted on the interface logic cards in the electronic part of the system, are almost always replaceable by optocouplers since their load is just the coil of a larger relay. This relay may have a coil power of 1/2 to 5 watts and operate on 12, 24 or 48 volts dc.

Assuming worst-case design techniques are carefully followed, system reliability should improve in proportion to the number of relays replaced.

SIEMENS

More Speed from Optocouplers Appnote 5

by David M. Barton

Figure 1 shows a typical circuit employing an optocoupler to transmit logic signals between electrically isolated parts of a system. In the circuit shown, the optocoupler must "sink" the current from one T^2L load plus a pull-up resistor to V_{CC}. The resistor in series with the LED half of the optocoupler must supply the worst-case load current divided by the "current transfer ratio" or CTR of the optocoupler. If an IL1 is used, having a min CTR of 0.2, and 30 percent variation in the load is allowed. 8.1 mA is required. This is supplied by the 430Ω resistor.

The maximum repetition rate at which this circuit will operate is only about 3 kHz. The severe speed limitation is due entirely to the characteristics of the phototransistor half of the optocoupler. This device has a large base-collector junction area and a very thick base region in order to make it sensitive to light. C_{ob} is typically 25 pF. This capacitance is, in the circuit of Figure 1, effectively multiplied by a large factor due to the "Miller effect." Also, because the base region volume is large, so is base storage time.

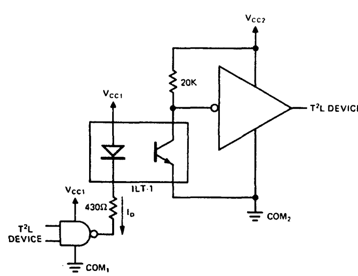


Figure 1

A very simple method of reducing both of these effects is to add a resistor between the base and emitter as shown in Figure 2. This resistor helps by reducing the time constant due to C_{ob} and by removing stored charge from the base region faster than recombination can. When a base-emitter resistor is used, of course, the required LED drive is increased since much of the photo-current generated in the base-collector junction is now deliberately "dumped."

Using this method does not usually result in a large power supply current drain since *average* repetition rate is low in most applications.

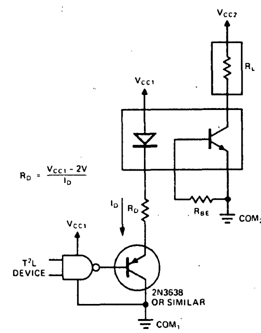


Figure 2

As drive is increased and R_{BE} reduced, turn-on time and turn-off time both decrease. The total amount of charge stored can also be reduced by decreasing the LED drive pulse duration. Also, as higher drive levels are used, the load resistance, R_L can be reduced to further enhance the speed of the circuit. These parameters are related to each other such that all should be changed together for best results.

One important generalization can be made concerning their interdependence. The LED drive pulse duration, T_{in}, output fall time, t_f, output rise time, t_r and propagation delay, t_p, should occur in a 1.5:1:1:1 ratio, approximately. If this relationship does not occur, the circuit will not operate at as high a repetition rate as it could at the same drive level. T_{out} equals T_{in} at low currents but stretches out at high currents.

Figure 3 is a graph relating the important parameters for a typical IL1 whose CTR is 0.25. The optimum values of T_{in}, R_{BE}, and R_L are shown versus LED pulse current as are the resultant output pulse width and maximum full-swing frequency. Rise, fall and propagation time can be read as 2/3 of Tin.

Figure 3 shows that increasing drive to 200 mA and using optimum R_{BE} and R_L will increase the maximum repetition rate from 3 kHz to 500 kHz, a 167:1 improvement.

Lower grade optocouplers will behave similarly if the LED drive level is scaled appropriately to allow for a lower CTR.

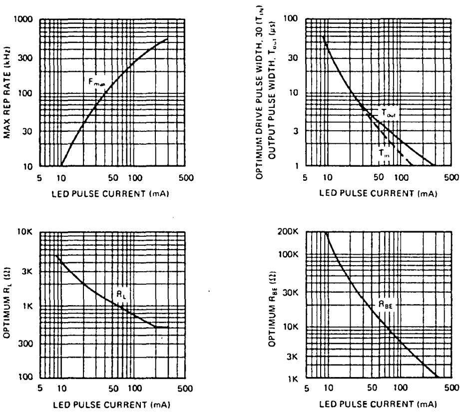


Figure 3. Parameters vs LED Pulse Current

Another method of increasing speed is to operate the photo-transistor as a photo-diode. In this method, bias voltage is supplied between the collector and base terminal, the emitter being unused. Operation to at least 10 MHz is possible this way, but the price is the need for external amplification. Figure 4 is a graph

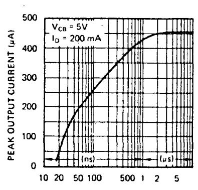


Figure 4. Diode Mode Output Current vs Drive Pulse Duration

showing peak output current versus drive pulse duration for 200 mA peak drive current.

Since output current is small, some type of wide-bandwidth amplifier must be employed in order to drive T^2L loads.

One simple solution for intermediate speed operation is the use of MOS inverter (1/6 74HC04). (Figure 5)

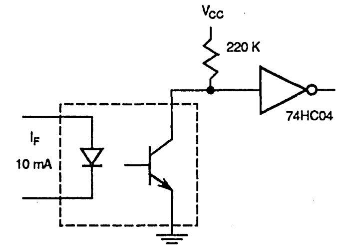


Figure 5

Another device which will provide a good interface is an integrated comparator amplifier. The photo-transistor collector goes to V_{CC}. Its base has a 200Ω load resistor to ground and goes to one input of the comparator. Also, a resistor goes from this node to the minus supply. This resistor is chosen to supply 50 μA. The other comparator input is grounded. The voltage at the comparator input will switch from −10 mV to +10 mV or more when the diode turns on and the output will drive the T^2L loads.

Of course discrete-component amplifiers could be used and may be best in some applications.

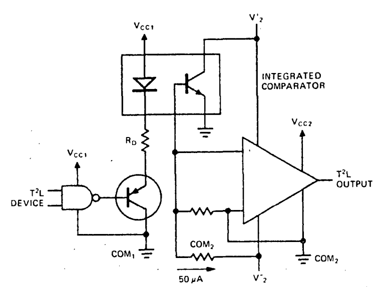


Figure 6

CONCLUSIONS

For operation to 500 kHz, the addition of a base-emitter resistor and a high-current driver is probably the best method of increasing optocoupler speed. Above 500 kHz one must revert to photodiode mode and use an external amplifier to drive most loads, particularly T^2L.

SIEMENS

Operating LEDs on AC Power
Appnote 6

by David M. Barton

Introduction

Frequently it is desirable to operate LEDs on AC power rather than DC. Typically, the power source is 120 VRMS 60 Hz. The most obvious method is to rectify this power with a series diode and use a resistor to limit LED current as shown in Figure 1.

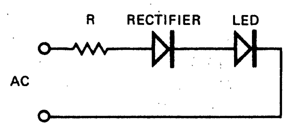


FIGURE 1. The Power Resistor Method

This method, though sound, results in very high power dissipation in the resistor since the LED operates on only 1.6 volts.

The Method

Figure 2 shows a better method. Here a capacitor is used to control LED current and a shunt silicon diode provides rectification.

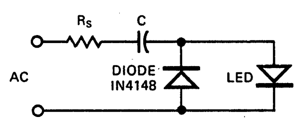


FIGURE 2.

Since, for current in either direction, voltage drop across the LED or rectifier is a negligible part of the supply voltage, current in the capacitor is almost exactly equal to the AC supply voltage divided by the reactance of the capacitor. Average capacitor current is then

1. $I_C\ (AV) = .9 \times VRMS/X_C$

   and average half-cycle LED or rectifier current is

2. $I_{LED\ (AV)} = 1/2\ I_D\ (AV) = .45\ VRMS/X_C$

   or, for 120 VRMS, 60 Hz operation,

3. $I_{LED\ (AV)} = 20\ mA \times C\mu F$

   or $C\mu F = \dfrac{I_{LED\ (AV)}}{20\ mA}$

Figure 3 shows the value of the series capacitor needed for a range of average LED currents assuming 60 Hz, 120 volt power.

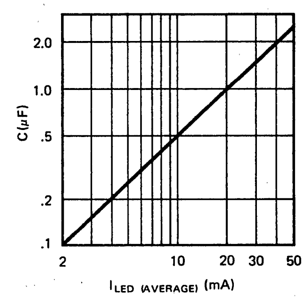


FIGURE 3. Series Capacitor Value vs Average LED Current for 120 VRMS 60 Hz.

A resistor is necessary in series with the capacitor to limit turn-on transient currents. A value of 100 ohms will be adequate in most cases.

The current in the LED, of course, flows almost exactly in quadrature with the line voltage. For this reason, power dissipation is low, being limited to the expected LED and rectifier power loss, the loss in series resistor and to losses in the capacitor. The latter term will be extremely low if high quality capacitors are used. Although power consumption of a circuit may not be of much significance in terms of the cost of the power, it certainly can be important to reduce heat generation within an enclosure.

If more than one LED is to be operated from the same source, simply put the LEDs in series in the same circuit, as shown in Figure 4. For small numbers of LEDs the current will be, for practical purposes, the same as for one.

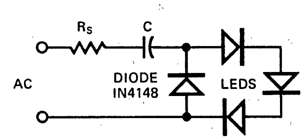


FIGURE 4.

Conclusion

Cost of the series capacitor (mylar) will be similar to the cost of a series power resistor. The shunt diode, a IN4148 or similar, will cost about two cents; much less than a series rectifier which must have a several hundred volt PIV rating.

So, the capacitor method is both lower in cost and lower in heat generation and power consumption than the resistor method.

SIEMENS

Applying the DL 1416B Intelligent Display® device Appnote 9B

by Dave Takagishi

This application note is intended to serve as design and application guide for users of the DL 1416B Intelligent Display. The information presented covers: device electrical description and operation, considerations for general circuit designs, multi-digit display systems and interfacing to the 6800, Z80, and 8080 microprocessors.

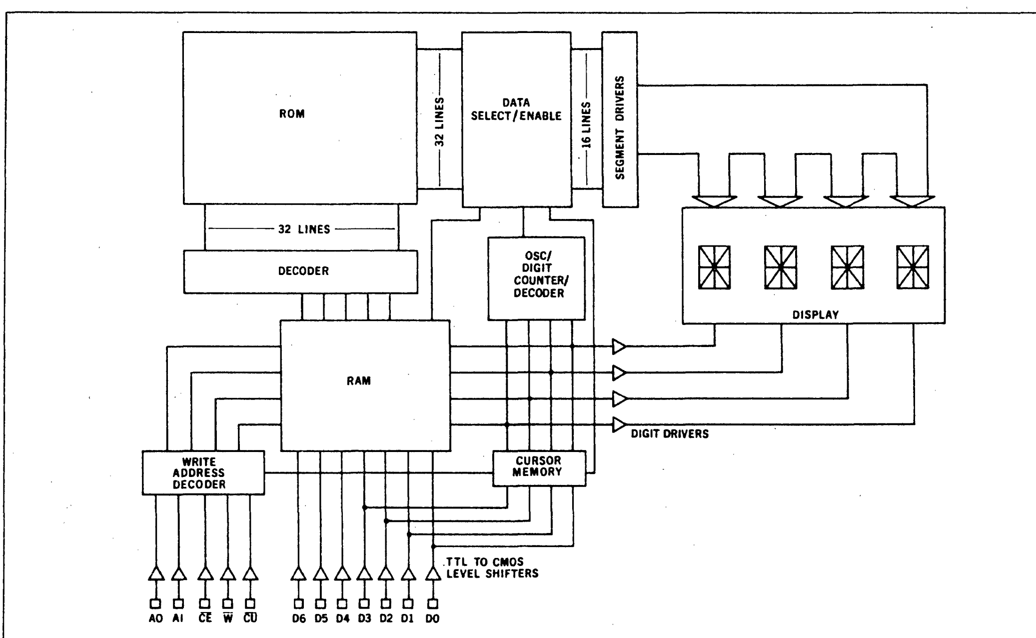
The DL 1416B was designed to provide an easy-to-use alphanumeric display for the 64 character ASCII systems. Only twelve interconnect pins plus power and ground are needed to drive a single four digit display. The overall package is designed to allow end stacking of the DL 1416B to form any desired character length display.

Electrical Description

The on-board electronics of the DL 1416B eliminates all the traditional difficulties of using displays – segment decoding, driving, and multiplexing. The DL 1416B has gone further and provided internal memory for the four digits. This approach allows the user to address one of four digits, load the desired data asynchronously to the multiplex rate and continue.

Figure 1 is a block diagram of the circuitry in the DL 1416B. The unit consists of a display and a single integrated circuit chip. The display is four 16-segment alphanumeric monolithic LED die magnified to a height of 160 mils. The

Figure 1. Block Diagram



Application Notes

IC chip contains the 16 segment drivers, 4 digit drivers, 64-character ROM, four-word 7-bit RAM, internal oscillator for multiplexing, multiplex counter/decoder, cursor RAM, write address decoder, and level shifters for the inputs.

The inputs to the DL 1416B are:

$\overline{CE}$ CHIP ENABLE (active low)
This determines which device in an array will actually execute the loading of data. When the chip enable is in the high state, all inputs are inhibited.

A_0, A_1 DIGIT ADDRESS
The address to the DL 1416B determines the digit in which the data will be written. Address order is right-to-left for positive-true address.

D_0-D_6 DATA LINES
The seven data input lines are designed to accept the 64 ASCII code set. See Table 1 for character set.

$\overline{W}$ WRITE (active low)
Data to be written into the DL 1416B must be present before the leading edge of write. The data and address must be stable until after the trailing edge.

$\overline{CU}$ CURSOR (active low)
When the $\overline{CU}$ is held low, the DL 1416B enables the user to write or remove a cursor in any digit position. The cursor function lights all 16 segments in the selected digits without erasing the data. After the cursor is removed, the digit will again display the previously written character.

V+ POSITIVE SUPPLY
TTL compatible +5 volts

V- NEGATIVE SUPPLY
Ground

Table 1. Character Set

D6 D5 D4 D3 \ D0 D1 D2	L L L	H L L	L H L	H H L	L L H	H L H	L H H	H H H
L H L L		!	"	#	$	%	&	'
L H L H	(	)	*	+	,	-	.	/
L H H L	0	1	2	3	4	5	6	7
L H H H	8	9	:	;	<	=	>	?
H L L L	@	A	B	C	D	E	F	G
H L L H	H	I	J	K	L	M	N	O
H L H L	P	Q	R	S	T	U	V	W
H L H H	X	Y	Z	[	\	]	^	_

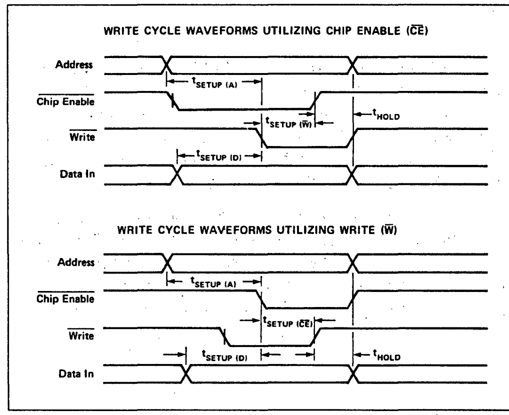
Note:
1. All undefined codes will display a blank.

Operation

Loading data into the DL 1416B is similar to writing into a RAM. The data and address must be present before the leading edge of the write signal ($\overline{W}$) and must be present until after the trailing edge. The waveforms of Figure 2 demonstrate the relationship of the signals required to generate a write cycle utilizing chip enable ($\overline{CE}$) and write ($\overline{W}$) (Check data sheet for minimum values).

As can be seen from the waveforms, $\overline{CE}$ and $\overline{W}$ are interchangeable. The true internal "write" function is formed by the "and-of-the-nots".

Figure 2. Address Table



Multiplexed display systems sequentially read and display data from a memory device. In *synchronous* systems, control circuitry must compare the location of data to be read and displayed to the location of new data to be stored, i.e. synchronize, before a write can be done. This can be slow if there are many memory locations. It can also be cumbersome.

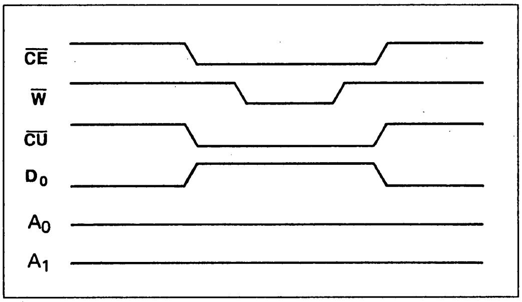
Data entry of the DL 1416B is *asynchronous* and data may be stored in random order. Each digit will continue to display the character last "written" until replaced by another.

The cursor function causes all 16 segments of a digit to light. The cursor can indicate the position in the display of the next character to be entered. The cursor *is not* a character but overrides display of the stored character. Upon removal of the cursor, the display will again show the character stored in memory.

The cursor can be written into any digit position by setting the digit position address (A_1, A_0), enabling chip enable ($\overline{CE}$), cursor select ($\overline{CU}$), write ($\overline{WR}$) data (D_0). A high on data line D_0 will place a cursor into position set by the address A_0, A_1. Conversely, a low on D_0 will remove the cursor.

The cursor will remain displayed after the cursor ($\overline{CU}$) and write ($\overline{W}$) signals have been removed. The waveforms in Figure 3 show a cursor being placed in Digit 0.

Figure 3. Cursor Write Cycle



Hardwiring the cursor ($\overline{CU}$) line high is not recommended. This internal cursor memory will be randomly loaded on power-up and all positions must be cleared before a cursor-free display is ensured.

General Circuit Design Considerations

Using positive-true address logic, address order is from right to left. For left to right address order, use the "ones-complement" or simple inversion of the addresses.

For systems with only a 6 bit ASCII code format, data line D_6 cannot be left open. Data D_6 must be the complement of data line D_5. If an illegal code is loaded into the DL 1416B, it will display a blank in the digit accessed.

A "display test" function can be realized by simply storing a cursor in all digits.

Because of the random state of the cursor RAM after power up, it is necessary to clear it initially to assure that all the cursors are off.

When using DL 1416Bs on a separate display board having more than 6 inches of cable length, it may be necessary to buffer all DL 1416B inputs. This is most easily achieved with hex-non-inverting buffers such as 74365 ICs. The object is to prevent transient current in the DL 1416B protection diodes. The buffers should be located on the display board near the DL 1416Bs. Local power supply bypass capacitors are also needed in many cases. These should be 6 or 10 volt tantalum type having 10 µF or greater capacitance. Low internal resistance is important to eliminate voltage transients due to the current steps which result from the internal multiplexing of the DL 1416B.

If small wire cables are used, it is good engineering practice to calculate the wire resistance of the ground plus the +5 volt wires. More than 0.1 volt drop (at 25 mA per digit worst case) should be avoided, since this loss is in addition to any inaccuracies or load regulation limitations of the power supply.

General Interface

The most general and straight-forward interface approach would be to use the parallel I/O device of a microprocessor. This interface scheme can be completely software dependent. One eight bit output port can handle the seven input data bits and the cursor. Another eight bit output port can contain the address and chip enable information with one bit reserved for the write signal.

An 8080 system shown in Figure 4 illustrates a 16 character display using a 8255 programmable peripheral interface I/O device with a 7442 one-of-ten decoder added for ease of programming. The following program will display a simple 16 character message using the parallel I/O interface.

```
INIT:    MVI A, 80H       ;CONTROL DATA MODE 0
         OUT CONTROL      ;LOAD CONTROL REGISTER
CUSR:    MVI A, 00H       ;CLEAR CURSOR DATA
         OUT PORTA        ;LOAD DATA PORT
         MVI B, OFH       ;SET COUNTER
CUSR1:   MOV A, B
         CALL DSPWT       ;WRITE SUBROUTINE
         DCR B            ;DECREMENT COUNTER
         JNZ CUSR1        ;16 CHARACTERS
DISP:    LXI H, TABLE     ;SET TABLE
DISP1:   MOV A, M
         OUT PORTA        ;LOAD DATA OUTPUT
         MOV A, B
         CALL DSPWT       ;LOAD ADDRESS & WRITE
         INX H            ;INCREMENT TABLE ADDRESS
         INR B            ;INCREMENT COUNTER
         MVI A, 10H       ;SET # OF DIGITS
         CMP B
         JNZ DISP1        ;16 CHARACTERS
         HLT              ;END OF PROGRAM
DSPWT:   ORI 80H          ;SET WRITE BIT OFF
         OUT PORTB        ;LOAD ADDRESS
         ANI 7FH          ;SET WRITE BIT ON
         OUT PORTB        ;LOAD WRITE
         ORI 80H          ;SET WRITE BIT OFF
         OUT PORTB        ;LOAD WRITE
         RET
TABLE:   DB               OC3H
         DB               OC9H
         DB               OD4H
         DB               OD3H
         DB               OC1H
         DB               OD4H
         DB               OCEH
         DB               OC1H
         DB               OC6H
         DB               OA0H
         DB               OD3H
         DB               OD4H
         DB               OC8H
         DB               OC7H
         DB               OC9H
         DB               OCCH
```

I/O or Memory Mapped Addressing

Some designers may wish to avoid the additional cost of a parallel I/O in their system. Structuring the addressing achitecture for the DL 1416B to look like a set of peripheral or output devices (I/O mapped) or RAMs and ROMs (memory mapped), is very easy. Figure 5 shows the simplicity of interfacing to microprocessors, such as 8080, Z80 and 6502 as examples.

The interface with the 6800 microprocessor in Figure 6 illustrates the need for designers to check the timing requirements of the DL 1416B and the µP. The typical data output hold time is only 30 ns for DBE =Ø2 timing; two inverters in the DBE line are added to increase the data output hold time for compatibility with the 50 nS minimum spec of the DL 1416B.

Conclusion

Note that although other manufacturer's products are used in examples, this application note does not imply specific endorsement, or recommendation or warranty of other manufacturer's products by Siemens.

The interface schemes shown demonstrate the simplicity of using the DL 1416B with microprocessors. The slight differences encountered with various microprocessors to interface with the DL 1416B are similar to those encountered when using different RAMs. The techniques used in the examples were shown for their generality. The user will undoubtedly invent other schemes to optimize his particular system to its requirements.

Figure 4.

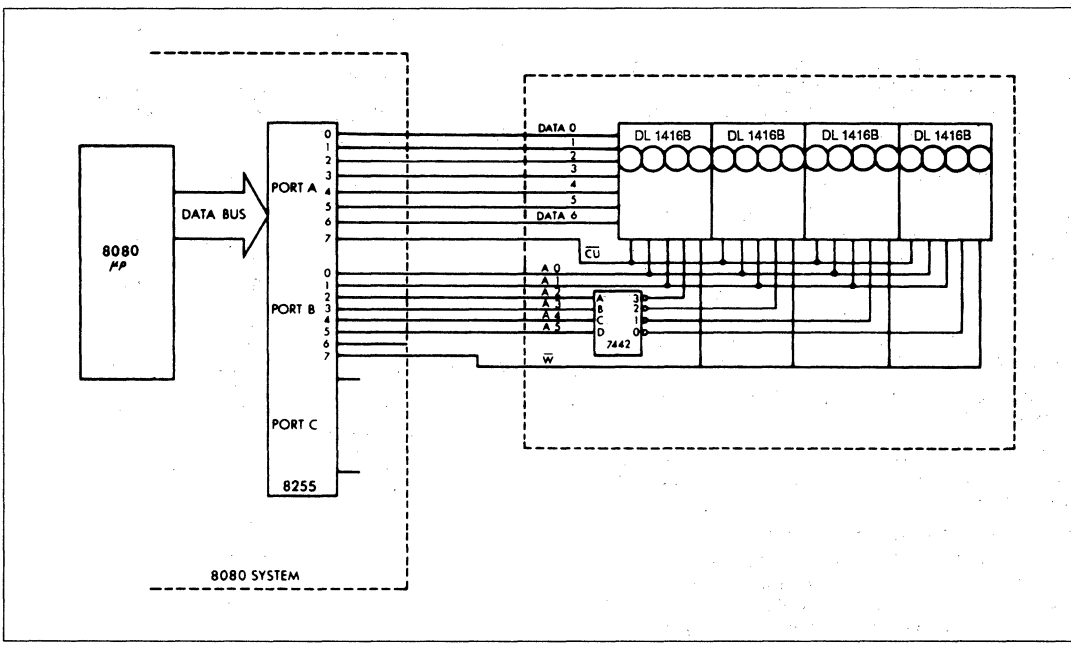


Figure 5. Mapped Interface

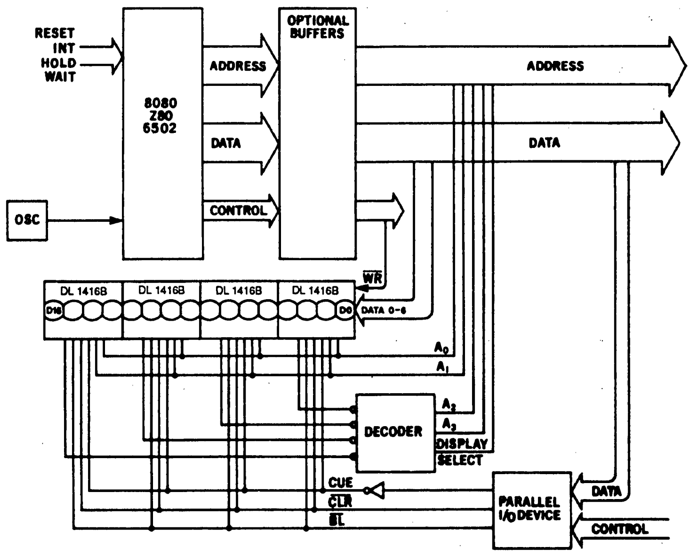
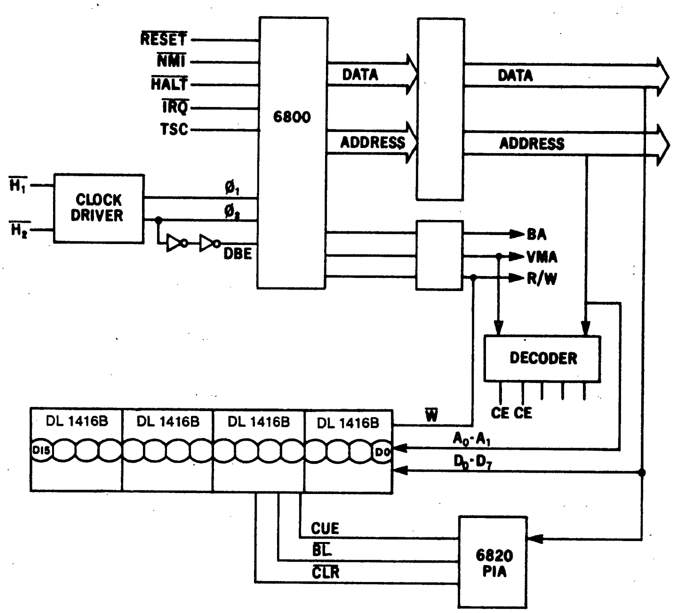


Figure 6.



Application Notes

SIEMENS

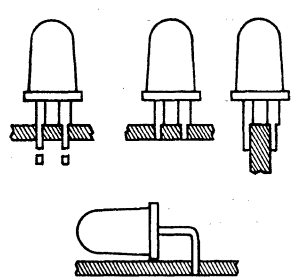
Mounting Considerations for LED Lamps and Displays Appnote 11

by Dave Takagishi

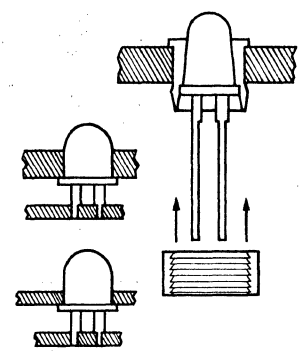
There are numerous ways to mount an LED lamp into a panel or a piece of equipment and this application note is written as an aid to designers and engineers when using LED lamps and displays.

MOUNTING TECHNIQUES:

There are several ways to mount LED lamps such as the Siemens LDR5001 by soldering directly into PCB's, plugging into sockets, or panel mounting with or without clips. Bending of the leads is allowed bearing the following guidelines in mind. Leads must not be bent closer than .065 inches from the base of case when leads are not in excess of .020 inch in diameter. Leads should be clamped next to the case during bending of leads to relieve stresses. Under no circumstances must any mechanical force be applied to case while bending the leads. Also, incorrectly spaced holes in the printed circuit board will place mechanical stress on the plastic case which can cause failure during soldering.



Displays of the HD11XXX type can be soldered directly into a printed circuit board or be plugged into sockets. Many displays can be end-stacked (butted end-to-end) to obtain longer displays with more digits. This usually causes no break in digit spacing. In applications using screw-down mounting, a flexible washer should be used to avoid strain from misalignment or board warpage.



Connector/Socket Suppliers	(Partial List)
Aries	Frenchtown, NJ
Augat	Attleboro, MA
Berg	New Cumberland, PA
EMC	Woonsocket, RI
Robinson Nugent	New Albany, IND
Precision Concept, Inc.	Bohemia, NY

THERMAL CONSIDERATIONS:

Most LED failures can be traced to excess thermal stress. A typical LED chip is mounted on a substrate or lead frame with a wire bond from the top of the chip to a metallized trace on the substrate and is encapsulated in epoxy. Temperature changes cause these various materials to expand and contract at different rates. Extreme low temperatures are most likely to cause structural failure. High temperatures, usually cause reduced lifetime rather than immediate failures.

The internal LED junction temperature depends on ambient temperature, power applied to the LED, and the thermal resistance, LED chip-to-ambient.

Long-term degradation of the LED chips, causing reduced light output, will occur if junction temperature exceeds 125 deg. C. Also the epoxy material overcoating the LED chips may gradually become opaque if it is subjected to temperatures above 125 deg. C.

For these reasons, all Siemens LED products carry derating specifications designed to limit LED junction temperature to 100 deg. C.

Particular care is needed in designing multiplexed systems. Here, increased forward voltage and the effects of the thermal time constant, chip to ambient (about 10mS typical) can cause "thermal ripple" peak excursions above 100 deg. C while calculated average temperature is much lower.

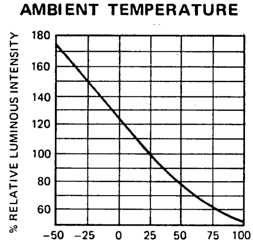
A separate reason for keeping LED chip temperature down is the reduced light output, shown in Figure 1. One can reach a point of diminishing returns, particularly in multiplexed systems, in which an increase in current reduces reliability while actually resulting in little or no increase in display visibility. In such cases, one would be well advised to put his money in higher brightness-grade displays.

A well-designed display system, especially if high power levels or multiplexed operations are involved, should:

1. Allow for convection airflow around the display.
2. Place other heat-generating components* either away from or above, but never below the display (*Display current-control resistors, for example).
3. Take the increased forward voltage and "thermal ripple" peaks into account, in multiplexed systems, and not allow peak temperature to exceed 100 deg. C.

In common with many semiconductor products, LED displays offer the user the most reliable and longest lifetime product available. These good properties do depend, however, on proper usage. Semiconductor products are well-known to be rather unforgiving of abuse when compared to the older technologies. LED's are not different, they are, in fact, hybrid integrated circuits.

LUMINOUS INTENSITY VS AMBIENT TEMPERATURE



SOLDERING CONSIDERATIONS:

Care should be taken not to overheat LED's when soldering. Effectiveness and safety in soldering are related to three basic parameters: temperature, time, and distance. In general, soldering time should not exceed 3 seconds at 1/16 inch from case at 260°C. Some packages allow greater latitude, as indicated on individual data sheets.

OPTICAL CONSIDERATIONS:

Siemens recommends the use of a contrast enhancing filter in front of LED displays. This filter will increase the contrast ratio of digit to surrounding area and help remove reflected light and glare from the PCB and components around the display. Insetting the display to reduce direct ambient light on the display should also be considered.

ROHM & HAAS red "Plexiglass" #2423 makes a good general purpose filter for the 640-660 nm Peak Emission Wavelength of red LEDs. A 1/16 inch thick sheet of this inexpensive material is quite effective. Additional information on this and other filter materials may be obtained by contacting the following suppliers:

ROHM & HAAS	Philadelphia, PA
HOMALITE	Wilmington, DE
PANELGRAPHIC	West Caldwell, NJ
3M	St. Paul, MN
POLAROID	Cambridge, MA
FOR RED LEDS	
ROHM & HAAS	Plexiglass 2423
HOMALITE	1670, 1605
PANELGRAPHIC	Red 60, Red 63, Red 65, Purple 90
POLAROID	HRCP
FOR GREEN LEDS	
ROHM & HAAS	Plexiglas 38168
PANELGRAPHIC	Green 48
HOMALITE	1425, 1440
FOR YELLOW LEDS	
PANELGRAPHICS	Yellow 25, Amber 23
HOMALITE	1720, 1726
NEUTRAL DENSITY FILTER	
HOMALITE	Neutral Gray 10

SIEMENS

Displaying Message Systems Without a Microprocessor Appnote 13

by Dave Takagishi

Any Siemens 4 digit, alphanumeric Intelligent Display device has on board memory, decoder and drive circuitry. This makes it particularly well suited to marry directly to a microprocessor. However, small multi-message systems of 4, 8, 12, 16 character length need not have a microprocessor to drive the Intelligent Display. With the aid of PROM Intelligent Display devices can combine lighted indicators, status displays, annunciator messages or symbols, or a "canned message" into a single display.

Annunciator Displays

An automobile, for example, has several switches each lighting its own status or annunciator indicator. A single Intelligent Display could easily display messages alternately upon interrogation of the appropriate switches.

Figures 1, 2, and 3 show a DL 1416 but any of our Intelligent Display devices can be substituted. The circuit shown in Figure 1 will display four character messages sequentially for each open switch and continue to display until switches are returned to their normally closed positions. The Counters U4 and U5 address the PROM U6 and select switches on U1. The Data Selector, U1, sequentially selects one of eight switches (oil, temperature, catalytic, generator, brake, door, belt, and null), The eighth switch or null state can display a blank for a normal or off condition. The output of U1 enables the display's $\overline{CE}$. When this signal goes high, the Monostable, U2, will fire and inhibit the Oscillator U3 for approximately a two second display time. The PROM, U6, generates the ASCII code data for each word. Expansion of the display can easily be achieved by adding a PROM for each additional display.

Another annunciator type display is shown in Figure 2. This display has a message of up to 16 characters and will continue to display the same line until the 6 bit input code changes state. With this scheme, it can be seen that the 16 character X64 line message PROM can easily be adapted for other message and character length combinations.

Figure 1.

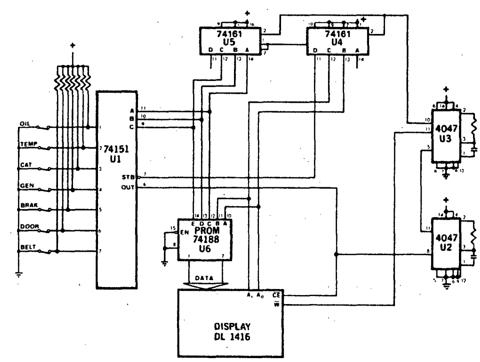
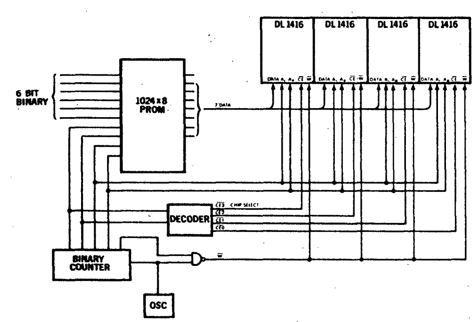


Figure 2. Typical Circuit for 64 Messages of 16 Characters Long



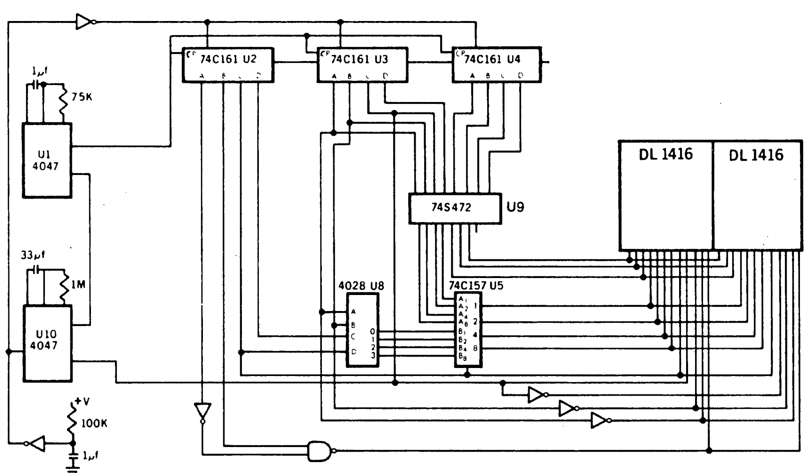
Canned Messages

The canned message type display can be an ideal sales, marketing or instructional aid. The message can be altered by replacing the PROM.

The technique for this display would be to sequentially display a word or group of words, depending on the character length of the display, through the entire message. The system could either continue to repeat itself or could go through the complete sequence once each time a switch is operated.

Figure 3 is the schematic for a sales demo box for the DL 1416. A 256X8 PROM was used to display an 8 digit-32 word message. The oscillator, U1, increments the counters U2, U3, U4 providing the address for the DL1416's and PROM U9. After eight counts the monostable U10 is fired, inhibiting the oscillator for a two second display time. Devices U5 and U8 were added for cursor control. Decoder U8 will alternately enable or disable a data bit for a cursor to proceed writing new data into each digit. The multiplexer U5 will select the character data or the cursor data for the D0-D3 data lines. Inverters on the address lines cause data entry to occur from the left rather than from the right.

Figure 3.



Application Notes

SIEMENS

Applying the DL 2416T/DLX 2416* Intelligent Display® device Appnote 14

by Dave Takagishi

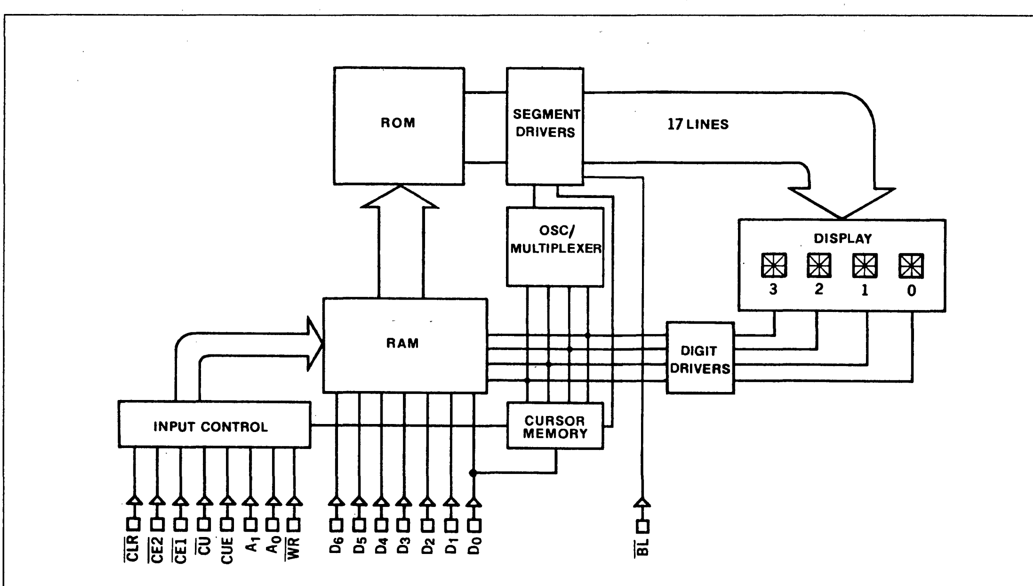
This application note is intended to serve as a design and application guide for the DL 2416T/DLX 2416 (hereafter referred to as 2416) alphanumeric Intelligent Displays. The information presented covers device electrical description and operation, considerations for general circuit design, and interfacing the 2416 to microprocessors. Refer to the specific data sheet and other Siemens Appnotes for more details.

Electrical & Mechanical Description

The internal electronics in these Intelligent Displays eliminates all the traditional difficulties of using multi-digit light emitting displays (segment decoding, drivers, and multiplexing). The Intelligent Display also provides internal memory for the four digits. This approach allows the user to asynchronously address one of four digits, and load new data without regard to the LED multiplex timing.

Figure 1a is a block diagram of the DL 2416T. The unit consists of four 17-segment monolithic LED dies and a single CMOS integrated circuit chip. The LED dies are magnified to a height of 160 mils by built-in lenses. The IC chip contains 17 segment drivers, four digit drivers, 64 character ROM, four word x 7 bit Random Access Memory, oscillator for multiplexing, multiplex counter/decoder, cursor memory, address decoder, and miscellaneous control logic.

Figure 1a. Block Diagram – DL 2416T



*DL 2416T – segmented display.
DLX 2416 (DLR 2416, DLG 2416, or DLO 2416) – dot matrix displays.

Figure 1b is a block diagram of the DLX 2416. The unit consists of 4 (5x7) LEDs and a single CMOS integrated chip. The IC chip contains the column drivers and row drivers, 128 character ROM, four word x 7 bit Random Access Memory, oscillator for multiplexing, multiplex counter/decoder, cursor memory, address decoder, and miscellaneous control logic.

Packaging

Packaging consists of a transfer-molded nylon lens which also serves as an "encapsulation shell" since it covers five of the six "faces". The assembled and tested substrate ("PTF" multilayer), is placed within the shell and the entire assembly is then filled with a water-clear IC-grade epoxy.

This yields a very rugged part, which is quite impervious to moisture, shock and vibration, Although not "hermetic", the device will easily withstand total immersion in water/detergent solutions.

Figure 1b. Block Diagram – DLX 2416

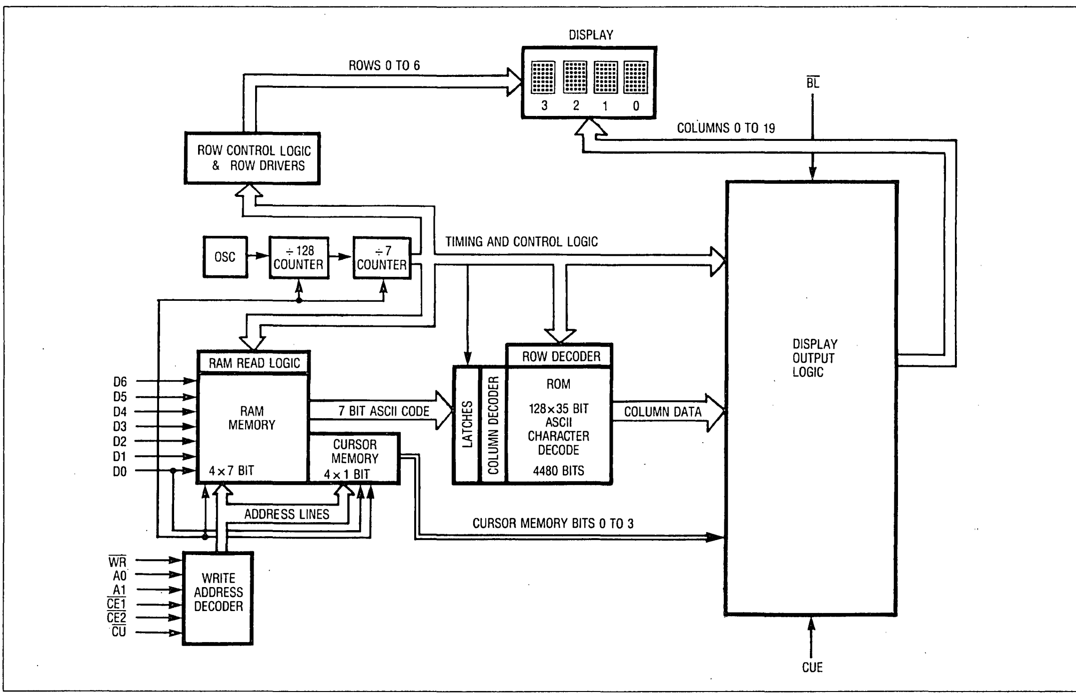
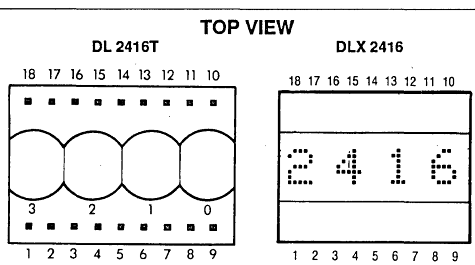


Figure 2.



Pin	Function	Pin	Function
1	$\overline{CE1}$ Chip Enable	10	GND
2	$\overline{CE2}$ Chip Enable	11	D_0 Data Input
3	$\overline{CLR}$ Clear	12	D_1 Data Input
4	CUE Cursor Enable	13	D_2 Data Input
5	$\overline{CU}$ Cursor Select	14	D_3 Data Input
6	$\overline{WR}$ Write	15	D_6 Data Input
7	A_1 Digit Select	16	D_5 Data Input
8	A_0 Digit Select	17	D_4 Data Input
9	V_{cc}	18	$\overline{BL}$ Display Blank

Electrical Inputs to the 2416

V_{CC} — Positive supply +5 volts

GND — Ground

D_0-D_6 — Data Lines
The seven data input lines are designed to accept the first 64 ASCII characters, See Figure 3a for character set. (The DL 2416T interprets all undefined codes as a blank). See Figure 3b for character set for DLX 2416.

A_0, A_1 — Address Lines
The address determines the digit position to which the data will be written. Address order is right to left for positive-true logic.

$\overline{WR}$ — Write (Active Low)
Data and address to be loaded must be present and stable before and after the trailing edge of write. (See data sheet for timing information).

$\overline{CE1}$, $\overline{CE2}$ — Chip Enable (Active Low)
This determines which device in an array will actually accept data. When either or both chip enable is in the high state, all inputs are inhibited.

$\overline{CLR}$ — Clear (Active Low)
The data RAM and cursor RAM for DL 2416T will be cleared when held low for 15 mS. For the DLX 2416 the minimum for $\overline{CLR}$ is 1 mS.

CUE — Cursor Enable. Activates Cursor function. Cursor will not be displayed regardless of cursor memory contents when cue is Low.

CU — Cursor Select (Active Low)
This input must be held high to store data in data memory and low to store data into the cursor memory.

$\overline{BL}$ — Display Blank (Active Low)
Blanking the entire display may be accomplished by holding the $\overline{BL}$ input low. This is not a stored function, however. When $\overline{BL}$ is released, the stored characters are again displayed. $\overline{BL}$ can be used for flashing or dimming.

Figure 3a. Character Set – DL 2416T

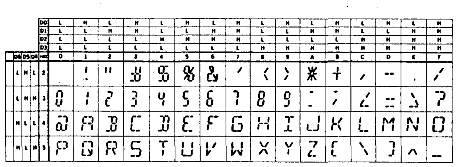
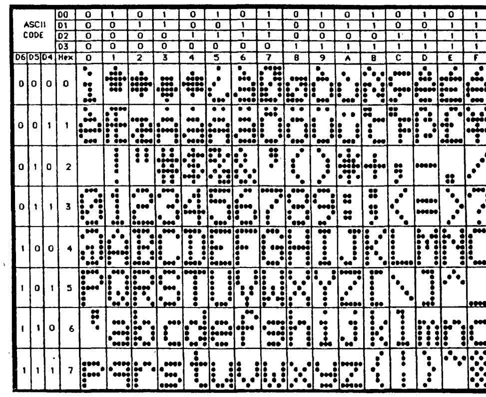


Figure 3b. Character Set – DLX 2416



Notes:
1. High =1 level.
2. Low =0 level.
3. Upon power up, the device will initialize in a random state.

Clear Memory

Clearing of the entire internal four-digit memory may be accomplished by holding the clear line ($\overline{CLR}$) low for one complete internal display multiplex cycle, 15 mS minimum for DL 2416T, 1 mS for DLX 2416; less time may leave some data uncleared. $\overline{CLR}$ also clears the cursor memory.

Display Blanking

Blanking the display may be accomplished by loading a blank, space or illegal code into each digit of the display or by using the ($\overline{BL}$) display blank input. Setting the ($\overline{BL}$) input low does not affect the contents of either data or cursor memory. A flashing display can be realized by pulsing ($\overline{BL}$).

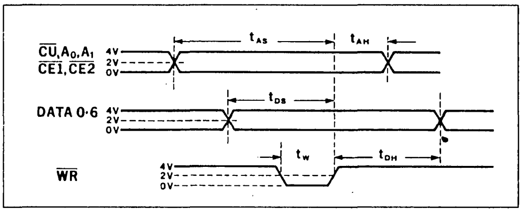
Operation

Multiplexed display systems sequentially read and display data from a memory device. In synchronous systems, control circuitry must compare the location of data to be read to the location or position of new data to be stored or displayed, i.e., synchronize before a Write can be done. This can be slow and cumbersome.

Data entry in "intelligent displays" is asynchronous and may be done in any random order. Loading data is similar to writing into a RAM. Each digit has its own memory location and will display until replaced by another code.

The waveforms of Figure 4 demonstrate the relationships of the signals required to generate a write cycle.

Figure 4.



(Check individual data sheet for minimum values). As can be seen from the waveforms, all signals are referenced from the rising or trailing edge of write.

Cursor

The cursor function of the DL 2416T causes all 16 line-segments of a digit to light. For the DLX 2416 the cursor function causes all dots to light at 50% brightness. The cursor can be used to indicate the position in the display of the next character to be entered. The cursor is not a character but overrides the display of a stored character. Upon removal of the cursor, the display will again show the character stored in memory.

The cursor can be written into any digit position by setting the cursor enable (CUE) high, setting the digit address (A_1, A_0), enabling Chip Enable, ($\overline{CE1}$, $\overline{CE2}$), cursor select ($\overline{CU}$), Write ($\overline{WR}$) and Data (D_0). A high on data line D_0 will place a cursor into the position set by the address A_0 and A_1. Conversely, a low on D_0 will remove the cursor. The cursor will remain displayed after the cursor ($\overline{CU}$) and write ($\overline{WR}$) signals have been removed. During the cursor-write sequence, data lines D_1 through D_6 are ignored by the 2416.

Figure 5.

LOADING DATA

$\overline{BL}$	$\overline{CE1}$	$\overline{CE2}$	CUE	$\overline{CU}$	$\overline{WR}$	$\overline{CLR}$	A_1	A_0	D6	D5	D4	D3	D2	D1	D0	DIGIT 3	DIGIT 2	DIGIT 1	DIGIT 0
L	X	X	X	H	X	H	X	X	X	X	X	X	X	X	X	BLANK			
H	H	X	L	H	X	H	X	X	X	X	X	X	X	X	X	PREVIOUS CHARACTERS			
H	X	H	L	H	X	H	X	X	X	X	X	X	X	X	X	NC	NC	NC	NC
H	X	X	L	H	H	H	X	X	X	X	X	X	X	X	X	NC	NC	NC	NC
H	L	L	L	H	L	H	L	L	H	L	L	L	L	L	H	NC	NC	NC	A
H	L	L	L	H	L	H	L	H	H	L	L	L	L	H	L	NC	NC	B	A
H	L	L	L	H	L	H	H	L	H	L	L	L	L	H	H	NC	C	B	NC
H	L	L	L	H	L	H	H	H	H	L	L	L	H	L	L	D	C	NC	A
H	L	L	L	H	L	H	L	L	H	L	L	L	H	L	H	D	C	B	E
H	L	L	L	H	L	H	H	L	H	L	L	H	L	H	H	D	K	B	E
H	L	L	L	H	L	H	–	–	–	–	–	–	–	–	–	SEE CHARACTER SET			
LOADING CURSOR																			
H	L	L	L	H	X	H	X	X	X	X	X	X	X	X	X	Normal Data Entry			
H	L	L	H	H	H	H	X	X	X	X	X	X	X	X	X	Enable Previous Stored Cursors			
H	L	L	H	L	L	H	L	L	X	X	X	X	X	X	H	NC	NC	NC	⊞
H	L	L	H	L	L	H	L	H	X	X	X	X	X	X	H	NC	NC	⊞	⊞
H	L	L	H	L	L	H	H	L	X	X	X	X	X	X	H	NC	⊞	⊞	⊞
H	L	L	H	L	L	H	H	H	X	X	X	X	X	X	H	⊞	⊞	⊞	⊞
H	L	L	L	H	H	H	X	X	X	X	X	X	X	X	X	D	K	B	E
H	L	L	L	L	L	H	L	L	X	X	X	X	X	X	L	D	K	B	E
H	L	L	H	H	H	H	X	X	X	X	X	X	X	X	X	⊞	⊞	⊞	E

X = Don't care
NC = No change from previously displayed characters

If the user does not wish to utilize the cursor function, the cursor enable (CUE) can be tied low to disable the cursor function. A flashing cursor can be realized by simply pulsing the CUE line after cursor data has been stored.

General Design Considerations

Using Positive true logic, address order is from right to left. For left to right address order, use the "ones complement" or simple inversion of the addresses.

For systems with only a 6-bit (abbreviated ASCII) code format, Data Line D_6 cannot be left open. Data D_6 must be the complement of Data Line D_5.

A "display test" or "lamp test" function can be realized by simply storing a cursor into all digits.

Because of the random state of the cursor RAM after power up, if the cursor function is to be used, it will be necessary to clear cursors initially to assure that all cursor memories contain its zero state. This is easily accomplished with the $\overline{CLR}$ input.

When using the 2416 on a separate display board having more than 6 inches of cable length, it may be necessary to buffer all inputs. This is most easily achieved with Hex non-inverting buffers such as the 74365. The object is to prevent transient current in the protection diodes. The buffers should be located on the display board near the displays.

Local power supply bypass capacitors are also needed in many cases. These should be 6 or 10 volt, tantalum type having 10 µF or greater capacitance. Low internal resistance is important due to current steps which result from the internal multiplexing of the displays.

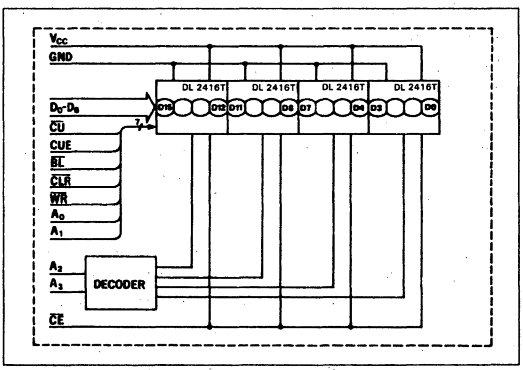
If small wire cables are used, it is good engineering practice to calculate the wire resistance of the ground plus the +5 volt wires. More than 0.1 volt drop, (at 25 mA per digit worst cast) should be avoided, since this loss is in addition to any inaccuracies or load regulation limitations of the power supply.

The 5-volt power supply for the displays should be the same one supplying V_{CC} to all logic devices which drive the display devices. If a separate supply must be used, then local buffers using hex non-inverting gates should be used on all displays inputs and these buffers should be powered from the display power supply. This precaution is to avoid logic inputs higher than display V_{CC} during power up or line transients.

Interfacing the 2416

A general and straight-forward interface circuit is shown in Figure 6 using the DL 2416T, but any 2416 display can be used interchangeably in these examples (also applies to Figure 7, 8, and 9). This scheme can easily interface to µP systems or any other systems which can provide the seven data lines, appropriate address and control lines.

Figure 6. General Interface Circuit



Parallel I/O

The parallel I/O device of a microprocessor can easily be connected to the circuit in Figure 6. One eight bit output port can provide the seven input data bits and the cursor (CU). Another eight bit output port can contain the address and chip enable information and the other control signals.

Figure 7. 16-Digit Parallel I/O System

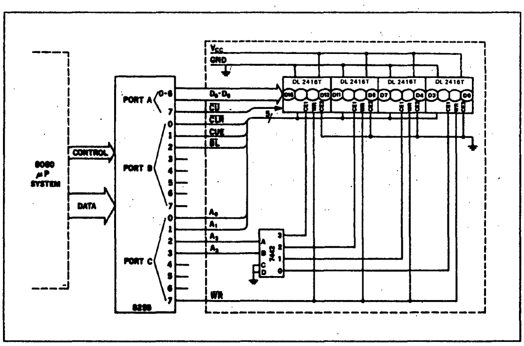


Figure 7 illustrates a 16-character display with an 8080 system using the 8255 programmable peripheral interface I/O device. The following program will display a simple 16-character message using this interface.

```
INIT:    MVI A,80H        ;CONTROL DATA MODE
         OUT CONTROL      ;LOAD CONTROL REGISTER
CUSR:    MVI A,00H        ;CLEAR CURSOR DATA
         OUT PORT A       ;LOAD DATA PORT
         MVI B, 0FH       ;SET CHARACTER COUNTER
CUSRI:   MOV A, B         ;
         CALL DSPWT       ;WRITE SUBROUTINE
         DCR B            ;DECREMENT COUNTER
         JNZ CUSRI        ;DIGIT 0?
         MOV A, B         ;
         CALL DSPWT       ;
         MVI A, FFH       ;SET DATA FOR CONTROL
         OUT PORT B       ;LOAD CONTROL LINES
DISP:    LXI H, TABLE     ;SET TABLE ADDRESS
DISP1:   MOV A, M         ;MOVE TABLE DATA INTO
                           ACCUMULATOR
         OUT PORT A       ;LOAD DATA PORT
         MOV A, B         ;
         CALL DSPWT       ;LOAD ADDRESS AND
                           CONTROL
         INX H            ;INCREMENT TABLE ADDRESS
         INR B            ;INCREMENT COUNTER
         MVI A, 10H       ;SET # OF DIGITS
         CMP B            ;
         JNZ DISP1        ;16 CHARACTERS?
         HALT             ;END OF PROGRAM
DSPWT:   ORI F0H          ;SET CONTROL BITS OFF
         OUT PORT C       ;LOAD CONTROL
         ANI 7FH          ;SET WRITE BIT ON
         OUT PORT C       ;LOAD WRITE
         ORI F0H          ;SET WRITE BIT OFF
         OUT PORT C       ;LOAD CONTROL
         RET
TABLE:   DB               ;0C3H
         DB               ;0C9H
         DB               ;0D4H
         DB               ;0D3H
         DB               ;0C1H
         DB               ;0D4H
         DB               ;0CEH
         DB               ;0C1H
         DB               ;0C6H
         DB               ;0A0H
         DB               ;0D3H
         DB               ;0D4H
         DB               ;0C8H
         DB               ;0C7H
         DB               ;0C9H
         DB               ;0CCH
```

Figure 8. Mapped Interface

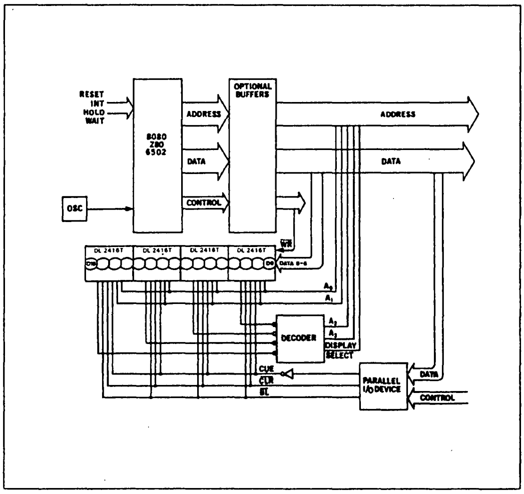
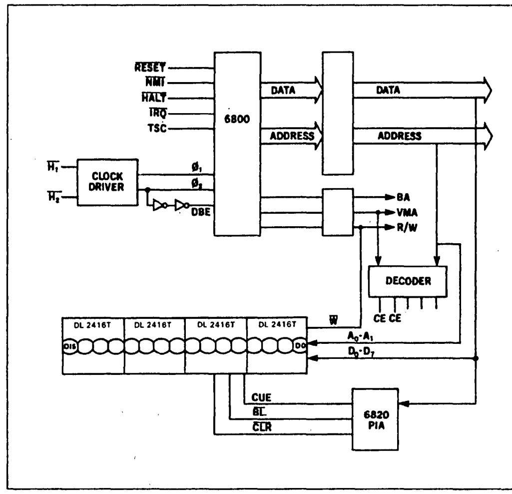


Figure 9.



I/O or Memory Mapped Addressing

Some designers may wish to avoid the additional cost of a parallel I/O in their system. Structuring the addressing achitecture for the 2416 to look like a set of peripheral or output devices (I/O mapped) or RAM's and ROM's (memory mapped) is very easy. Figure 8 shows the simplicity of interfacing to microprocessors, such as 8080, Z80 and 6502 as examples.

The interface with the 6800 microprocessor in Figure 9 illustrates the need for designers to check the timing requirements of the DL 2416T and the μP. The typical data output hold time is only 30 ns for DBE =Ø2 timing; two inverters in the DBE line are added to increase the data output hold time for compatibility with the 50 nS minimum spec of the DL 2416T.

Conclusion

Note that although other manufacturer's products are used in examples, this application note does not imply specific endorsement, or recommendation or warranty of other manufacturer's products by Siemens.

The interface schemes shown demonstrate the simplicity of using the 2416 with microprocessors. The slight differences encountered with various microprocessors to interface with the 2416 are similar to those encountered when using different RAMs. The techniques used in the examples were shown for their generality. The user will undoubtedly invent other schemes to optimize his particular system to its requirements.

SIEMENS

Applying the DL 1414/DLX 1414* Intelligent Display® Device Appnote 15

by Dave Takagishi

This application note is intended to serve as a design and application guide for users of the DL 1414/DLX 1414 (referred to as 1414 hereafter) alphanumeric Intelligent Display. The information presented covers device electrical description and operation, considerations for general circuit design, and interfacing the 1414 to microprocessors.

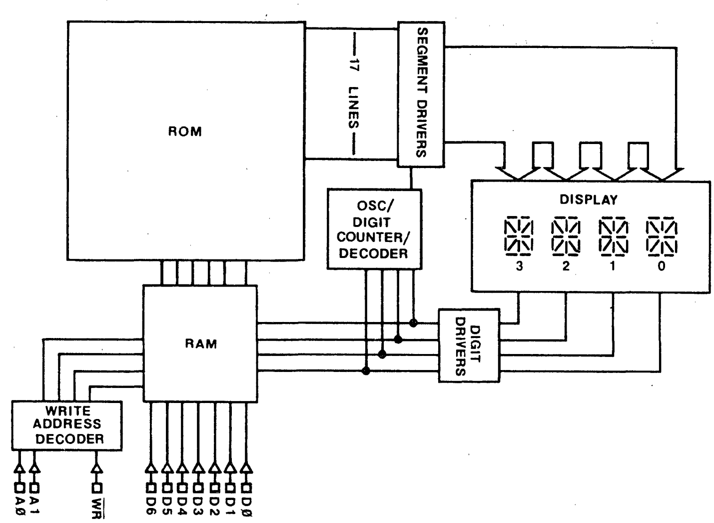
Electrical & Mechanical Description

General

The internal electronics in these Intelligent Displays eliminates all the traditional difficulties of using multi-digit light emitting displays (segment decoding, drivers and multiplexing). The Intelligent Display also provides internal memory for the four digits. This approach allows the user to asynchronously address one of four digits, and load new data without regard to the LED multiplex timing.

Figure 1a is a block diagram of the DL 1414. The unit consists of four 17 segment monolithic LED die and a single CMOS integrated circuit chip. The LED die are magnified to a height of 112 mils by the built-in lenses. The IC chip contains 17 segment drivers, four digit drivers, 64 character ROM, four word x 7 bit Random Access Memory, oscillator for multiplexing, multiplex counter/decoder, address decoder and miscellaneous control logic.

Figure 1a. Block Diagram – DL 1414



*DL 1414 – segmented display.
DLX 1414 (DLR 1414, DLG 1414, or DLO 1414) – dot matrix displays.

Figure 1b is a block diagram of the DLX 1414. The unit consists of four (5x7) LED arrays and a single CMOS integrated chip. The IC chip contains the column drivers and row drivers, 128 character ROM, four word x 7 bit Random Access Memory, oscillator for multiplexing, multiplex counter/decoder, cursor memory, address decoder, and miscellaneous control logic.

Packaging

Packaging consists of an injection-molded plastic lens which also serves as an "encapsulation shell" since it covers five of the six "faces". The assembled and tested substrate (ceramic or "PTF" multilayer) is placed within the shell and the entire assembly is then filled with a water-clear IC-grade epoxy.

This yields a very rugged part which is quite impervious to moisture, shock and vibration. Although not "hermetic", the device will easily withstand total immersion in water/detergent solutions.

Figure 1b. Block Diagram – DLX 1414

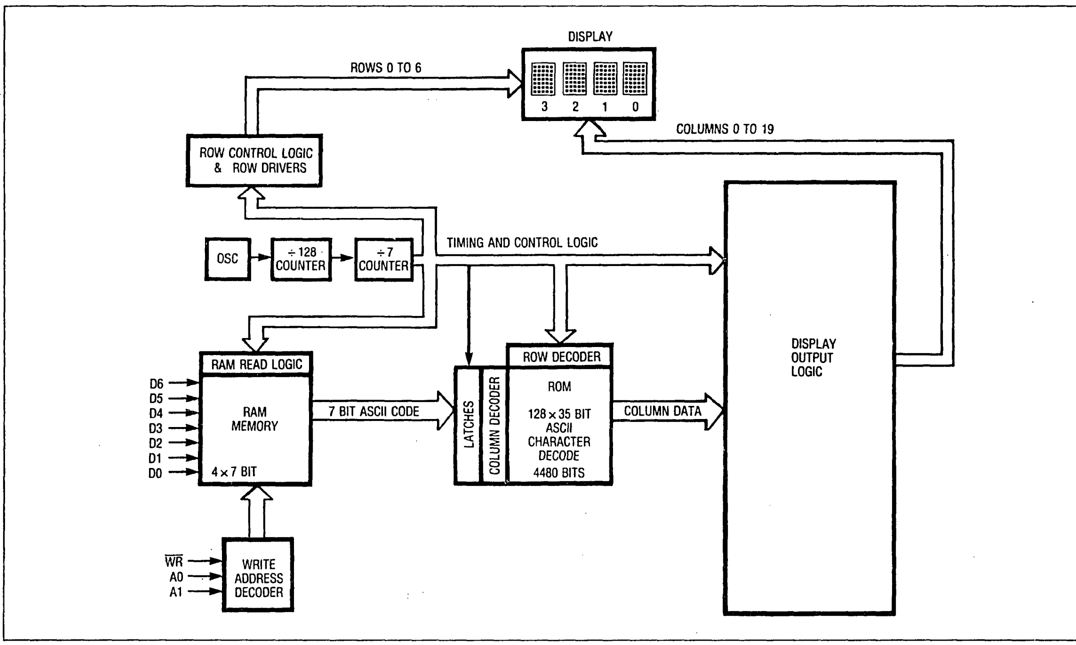
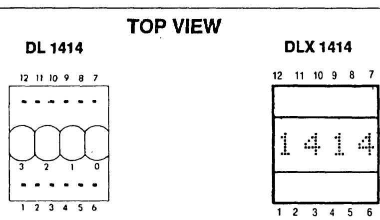


Figure 2.



Pin	Function	Pin	Function
1	D_5 Data Input	7	GND
2	D_4 Data Input	8	D_0 Data Input (LSB)
3	$\overline{WR}$ Write	9	D_1 Data Input
4	A_1 Digit Select	10	D_2 Data Input
5	A_0 Digit Select	11	D_3 Data Input
6	V_{CC}	12	D_6 Data Input (MSB)

Electrical Inputs to the DL 1414

V_{CC} POSITIVE SUPPLY +5 volts

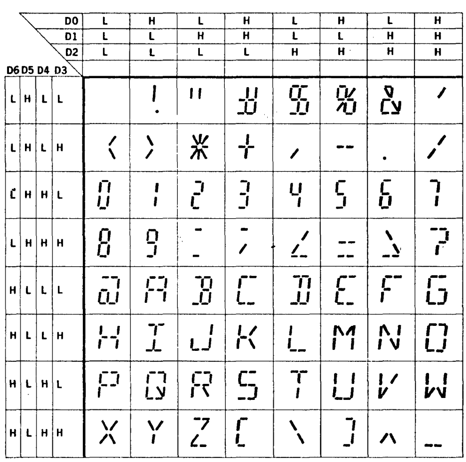
GND GROUND

D_0-D_6 DATA LINES
The seven data input lines are designed to accept the first 64 ASCII characters. See Figure 3a for the character set for DL 1414 and Figure 3b for the character set for DLX 1414. (The DL 1414 interprets all undefined codes as a blank).

A_0, A_1 ADDRESS LINES
The address determines the digit position to which the data will be written. Address order is right to left for positive-true logic.

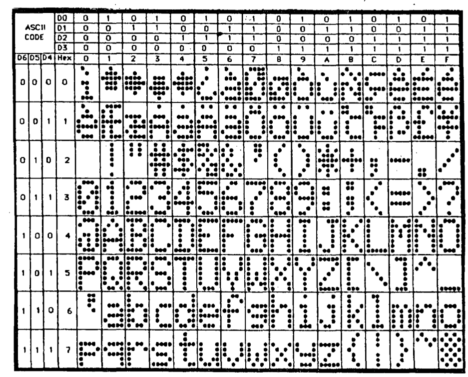
$\overline{WR}$ WRITE (Active Low).
Data and address to be loaded must be present and stable before and after the trailing edge of write. (See data sheet for timing info).

Figure 3a. Character Set – DL 1414



All Other Input Codes Display "Blank"

Figure 3b. Character Set – DLX 1414



Notes:
1. High =1 level.
2. Low =0 level.
3. Upon power up, the device will initialize in a random state.

Operation

Multiplexed display systems sequentially read and display data from a memory device. In synchronous systems, control circuitry must compare the location of data to be read to the location or position of new data to be stored or displayed, i.e., synchronize before a Write can be done. This can be slow and cumbersome.

Data entry in Intelligent Displays is asynchronous and may be done in any random order. Loading data is similar to writing into a RAM. Each digit has its own memory location and will display until replaced by another code.

The waveforms of Figure 4 demonstrate the relationships of the signals required to generate a Write cycle. (Check individual data sheet for minimum values.) As can be seen from the waveforms, all signals are referenced from the rising or trailing edge of Write.

Figure 4. Write Cycle Waveform

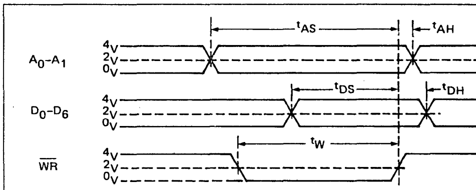
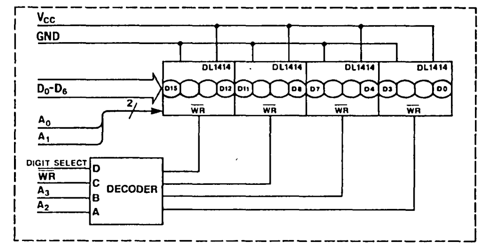


Figure 5. Data Loading Table

$\overline{WR}$	ADDRESS A_1	ADDRESS A_0	DATA INPUT D6	D5	D4	D3	D2	D1	D0	DIGIT 3	DIGIT 2	DIGIT 1	DIGIT 0
H	X	X	X	X	X	X	X	X	X	NO CHANGE	NO CHANGE	NO CHANGE	NO CHANGE
L	L	L	H	L	L	L	L	L	H	NO CHANGE	NO CHANGE	NO CHANGE	A
L	L	H	H	L	L	L	L	H	L	NO CHANGE	NO CHANGE	B	A
L	H	L	H	L	L	L	L	H	H	NO CHANGE	C	B	A
L	H	H	H	L	L	L	H	L	L	D	C	B	A
L	L	L	H	L	L	L	H	L	H	D	C	B	E
L	H	L	H	L	L	H	L	H	H	D	K	B	E
L	–	–	–	–	–	–	–	–	–	SEE CHARACTER SET			

X = DON'T CARE

Figure 6. General Interface Circuit



General Design Considerations

Using positive true logic, address order is from right to left. For left to right address order, use the "ones complement" or simple inversion of the addresses.

For systems with only a 6-bit (abbreviated ASCII) code format, Data Line D_6 cannot be left open. Data D_6 must be the complement of Data Line D_5.

When using the 1414 on a separate display board having more than 6 inches of cable length, it may be necessary to buffer all inputs. This is most easily achieved with Hex non-inverting buffers such as the 74365. The object is to prevent transient current in the protection diodes. The buffers should be located on the display board near the displays.

Local power supply bypass capacitors are also needed in many cases. These should be 6 or 10 volt, tantalum type having 10 µF or greater capacitance. Low internal resistance is important due to current steps which result from the internal multiplexing of the displays.

If small wire cables are used, it is good engineering practice to calculate the wire resistance of the ground plus the +5 volt wires. More than 0.1 volt drop, (at 25 mA per digit worst case) should be avoided, since this loss is in addition to any inaccuracies or load regulation limitations of the power supply.

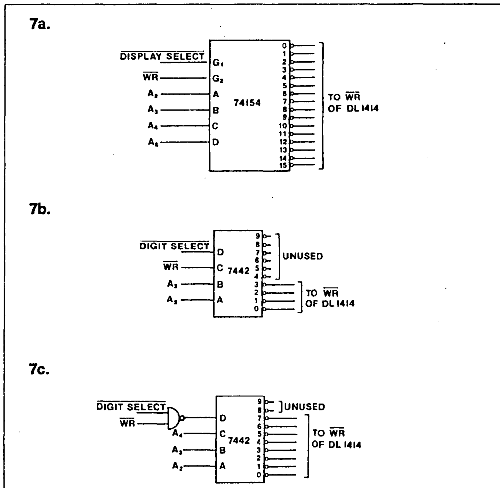
The 5-volt power supply for the displays should be the same one supplying V_{CC} to all logic devices which drive the display devices. If a separate supply must be used, then local buffers using hex, non-inverting gates should be used on all inputs and these buffers should be powered from the display power supply. This precaution is to avoid logic inputs higher than display V_{CC} during power up or line transients.

Interfacing the 1414

A general and straight-forward interface circuit is shown in Figure 6 (using DL 1414s but any 1414 display can be used interchangeably in Figures 8, 9, and 10). This scheme can easily interface to µP systems or any other systems which can provide the seven data lines, appropriate address and control lines.

The 1414 does not have a chip enable input. Therefore, each display in a system requires its Write pulse be gated with appropriate address signals. Figure 7a shows the use of a 74154 decoder (4 line to 16 line) for up to a 64 character display. Using the G1 input for display select (address select in a memory mapped system) and the G2 input to gate the Write signal. Another approach (Figure 7b and 7c) which minimizes logic for a 16 or 32 digit display takes advantage of decoding scheme of the 7442 decoder.

Figure 7. Gating the Write Pulse



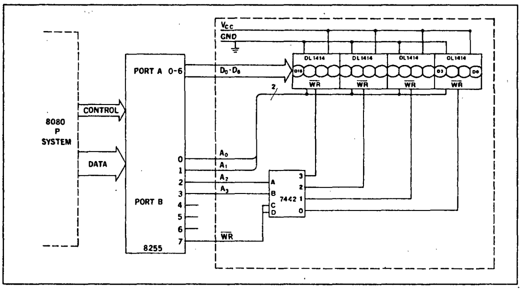
Parallel I/O

The parallel I/O device of a microprocessor can easily be connected to the circuit in Figure 6. One eight bit output port can provide the seven input data bits. Another eight bit output port can contain the address and control signals.

Figure 8 illustrates a 16-character display with an 8080 system using the 8255 programmable peripheral interface

I/O device. The following program will display a simple 16-character message using this interface.

Figure 8. 16-Digit Parallel I/O



Sample I/O Program

```
INIT:    MVI A, 80H       ;CONTROL DATA MODE 0
         OUT CONTROL      ;LOAD CONTROL REGISTER
         MVI B,00H        ;SET COUNTER = 0
DISP:    LXI H, TABLE     ;SET TABLE ADDRESS
DISP1:   MOV A,M          ;MOVE TABLE DATA TO
                           ACCUMULATOR
         OUT PORTA        ;LOAD DATA PORT
         MOV A, B
         CALL DSPWT       ;LOAD ADDRESS AND CONTROL
         INX H            ;INCREMENT TABLE ADDRESS
         INR B            ;INCREMENT COUNTER
         MVI A, 10H       ;SET # OF DIGITS
         CMP B
         JNZ DISP1        ;16 CHARACTERS ?
         HALT             ;END OF PROGRAM
DSPWT:   ORI F0H          ;SET CONTROL BITS OFF
         OUT PORTB        ;LOAD CONTROL
         ANI 7FH          ;SET WRITE BIT ON
         OUT PORTB        ;LOAD WRITE
         ORI F0H          ;SET WRITE BIT OFF
         OUT PORTB        ;LOAD CONTROL
         RET
TABLE:   DL               ;0C3H
         DB               ;0C9H
         DB               ;0D4H
         DB               ;0D3H
         DB               ;0C1H
         DB               ;0D4H
         DB               ;0CEH
         DB               ;0C1H
         DB               ;0C6H
         DB               ;0A0H
         DB               ;0D3H
         DB               ;0D4H
         DB               ;0C8H
         DB               ;0C7H
         DB               ;0C9H
         DB               ;0CCH
```

I/O or Memory Mapped Addressing

Some designers may wish to avoid the additional cost of a parallel I/O in their system. Structuring the addressing architecture for the 1414 to look like a set of peripheral or output devices (I/O mapped) or RAMs and ROMs (memory mapped), is very easy. Figure 9 shows the simplicity of interfacing to microprocessors, such as 8080, Z80 and 6502 as examples.

The interface with the 6800 microprocessor in Figure 10 illustrates the need for designers to check the timing requirements of the 1414 and the μP. The typical data output hold time is only 30 ns for DBE=Ø2 timing; two inverters in the DBE line are added to increase the data output hold time for compatibility with the 50 ns minimum spec of the 1414.

Conclusion

Note that although other manufacturer's products are used in examples, this application note does not imply specific endorsement, or recommendation or warranty of other manufacturer's products by Siemens.

The interface schemes shown demonstrate the simplicity of using the 1414 with microprocessors. The slight differences encountered with different microprocessors to interface with the 1414 are similar to those encountered when using different RAMs. The techniques used in the examples were shown for their generality. The user will undoubtedly invent other schemes to optimize his particular system to its requirements.

Figure 9. Mapped Interface

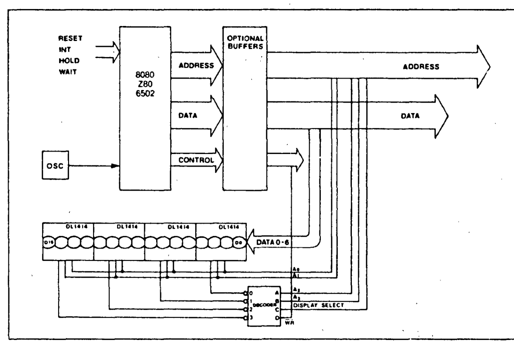
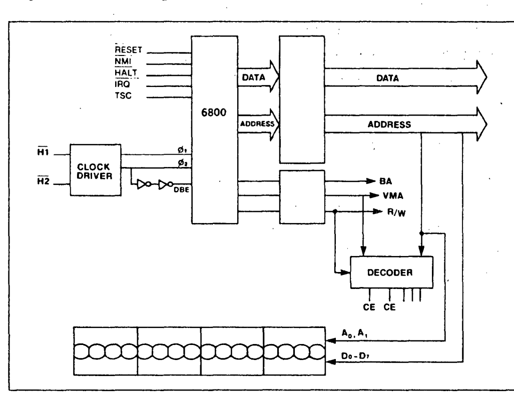


Figure 10. Gating the Write Pulse



SIEMENS

Silicon Photovoltaic Cells, Silicon Photodiodes and Phototransistors Appnote 16

Optoelectronic components are increasingly used in modern electronics. Main fields of application are light barriers for production control and safety devices, light control and regulating equipment like twilight switches, fire detectors and facilities for optical heat supervision, scanning of punched cards and perforated tapes, positioning of machine tools (for measuring length, angle and position), of optical apparatus and ignition processes, for signal transmission at electrically separated input and output, as well as conversion of light into electrical energy.

Lately, new fields of application opened up for optoelectronic components in the photo industry in form of exposure and aperture control and for automatic electronic flashes. IR sound transmission and IR remote control are new modes in the radio industry. Computer diagnosis and LED displays in instrument panels are possible applications in the automotive industry.

Depending upon the application either photovoltaic cells or photodiodes are used. Wherever amplifiers with high input impedance are required, photodiodes are to be preferred.

Phototransistors are predominantly used in connection with transistor circuits or to drive integrated circuits, whereas photovoltaic cells are preferred to scan large surfaces, if a strictly linear relation between light and signal level or optimum reliability is required.

PHOTOVOLTAIC CELLS

Photovoltaic cells are active two-poles with a comparably low resistance that has its cause in the voltage of the voltaic cell, which may only be some tenth of a volt. For practical application, this characteristic requires special attention.

The open circuit voltage V_L rises almost logarithmically as a function of the illuminance and, particularly in case of planar photovoltaic cells, reaches high values already at very low illuminances. It is independent of the size of the photovoltaic cell.

The short circuit current I_K increases linearly with the illuminance. It is proportional to the size of the exposed photosensitive area at uniform illuminance.

The maximum energy of the photovoltaic cell is yielded in a load resistance R_L of approx $\frac{V_L}{I_K}$.

Practical short circuit operation and thus proportionality between optical and electrical signal is given at load resistance up to $\frac{V_L}{2\,I_K}$. This relation can be applied to an open circuit voltage of $\geqq 100$ mV.

In any type of application the highest value of I_K has to be used. A simple procedure to gain information on the load resistance required is to measure V_L and I_K at given illumination conditions, irrespective of the radiation source.

In case the voltage yielded by the photovoltaic cell is insufficient it can also be used in diode operation at reverse voltages up to 1 V. In such case the flowing dark current has to be taken into consideration.

The rise time of a signal voltage delivered to a load resistor by the voltaic cell primarily depends on the operating conditions. There are two distinctive borderline cases:

1. Load resistor smaller than the matching resistor (tendency toward short circuit operation).
2. Load resistor larger than the matching resistor (tendency to open circuit operation).

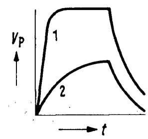
In case 1) the photovoltage rise is analogous to the charging of a capacitor via a resistor from a constant voltage source. In photovoltaic cells the junction capacitance C_j must be charged. The rise occurs by the time constant $r = R_L \cdot C_j$, R_L being the load resistor (the low ohmic resistance of the photovoltaic cell is considered negligible).

In case 2) the photovoltage rise is similar to the charging of a capacitor by a constant current mode. The rise time t_r of the photovoltage follows the equation:

$$t_r = \frac{V_P \cdot C_j}{I_K}$$

I_K is the short-circuit current under given illumination conditions. This relation only holds true for values of V_P less than 80% of the final value of the open circuit voltage.

The principal characteristic of the rise time of photovoltaic cells is shown in the following diagram:



Case 1) Rise time according to the equation

$$V_P = I_K \cdot R_L \cdot \left(1 - e^{-\frac{t}{R_L \cdot C_j}}\right)$$

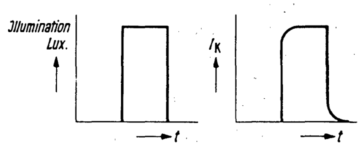
Time constant $\tau = R_L \cdot C_j$.

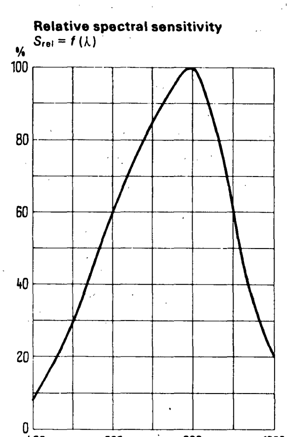
Case 2) Rise time $t_r = \frac{V_P \cdot C_j}{I_K}$

fall time in both cases $\tau = R_L \cdot C_j$

Modulation transients can, under certain conditions, lead to a modification of the above diagram.

E.g. At very low time constants (particularly in short circuit operation) the actual pulse shape of the short circuit current that deviates from an ideal square pulse has to be noted. See diagram.





SILICON PHOTODIODES

These photodiodes have a PN junction poled by a reversed bias. The capacitance which decreases with a growing reverse voltage reduces the switching times. The PN junction is of easy access to the light. Without illumination a very small reverse current flows, the so-called dark current. Light falling onto the surrounding of the PN junction generates charge carrier pairs there that lead to an increase of the reverse current. This photocurrent is proportional to the illuminance. Therefore, photodiodes are particularly well suited for quantitative light measurements. The planar technique has 2 essential advantages: The dark currents are considerably smaller than for comparable photo electric components in non-planar technique. This leads to a reduction of the current noise and thus to a decisive improvement of the signal/noise ratio.

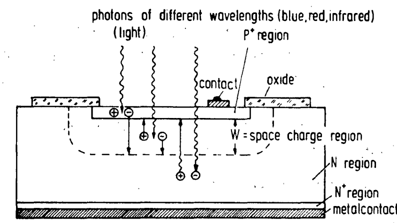


Figure 1

Figure 1 shows the basic design of a photodiode. The limit of the space charge region is indicated by a dashed line.

Without illumination only a small dark current I_D flows through the PN junction as a result of thermally generated carriers.

With light, additional charge carrier pairs (hole electron pairs) are generated in the P and N region by the radiation quantum (internal photo effect). Carriers originating in the space charge region are immediately extracted because of the electrical field present there, i.e. the holes in the P and the electrons in the N direction. Carriers from the remaining field must first diffuse into the space charge region in order to be separated there. If holes and electrons recombine before, they do not contribute to the photocurrent. Thus, the photocurrent I_P is a combination of the drift current of the space charge region and the diffusion current of the P and N area.

I_P is proportional to the incident radiation intensity. Since I_D is very small for diodes, it can be neglected in the equation $I_P = I_P + I_D$. Subsequently one gets a linear correlation between I_P and the incident radiation intensity over a very wide range.

Diodes with a small space charge width are termed PN diodes, diodes with a large space charge width PIN diodes.

PN diodes have the diffusion current as dominating part of the photocurrent whereas it is the drift current in the case of PIN diodes.

As the capacitance of the space charge width W is inversely proportional, the PIN diode is characterized by a smaller capacitance than a PN diode of identical surface. The capacitance of (most of) the diodes reads:

$$C_D \sim \sqrt{\frac{N}{V}}$$

The less the doping N of the basic material and the higher the applied voltage V, the lower the capacitance.

Fig. 2 shows the capacitance as function of the voltage for a PIN diode, e.g. BPY 12.

Junction capacitance as a function of reverse voltage $C = f(V_R)$

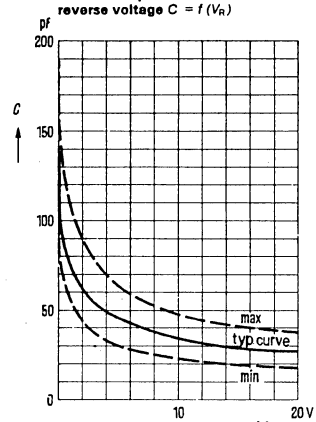


Figure 2

SILICON PHOTOTRANSISTORS

The introduction of the planar technique allows to produce phototransistors of small dimensions. They are used as photoelectric detectors in control and regulating devices. The photoelectric transistors are excellently suited as receivers for incandescent lamp light, as their maximal photosensitivity lies near the infrared limit of the light wave spectrum.

In its mode of operation a photoelectric transistor corresponds to that of a photodiode with built-in amplifier. It has a 100 to 500 times higher photosensitivity than a comparable photoelectric diode.

The photoelectric transistor is preferably operated in an emitter circuit and acts similar to an AF transistor.

Unilluminated only a small collector-emitter leakage current flows. It amounts to appròximately $I_d = B \cdot I_{CBO}$, B standing for the current amplification and I_{CBO} for the reverse current of the base diode.

At illumination the reverse current of the base diode I_{CBO} increases by the photocurrent I_P'. Thus, one receives for the photocurrent $I_P \sim B(I_{CBO} + I_P')$.

Consequently, the photocurrent of a transistor is a function of the photocurrent I_P' of the base diode and the current amplification B. As B cannot be increased indefinitely, an as high as possible photosensitivity of the base diode is aimed at.

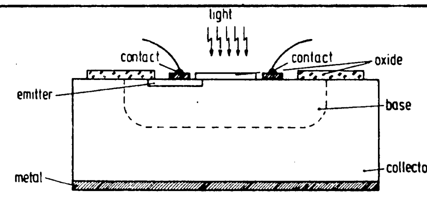


Figure 3

Figure 3 shows the design of a phototransistor. The emitter and base leads are affixed laterally to make the base diode most easily accessible to light. The large collector zone ensures that the most possible radiation quanta are abosrbed there and will contribute to the photocurrent.

Contrary to a photodiode, a linear interconnection between the incident radiation intensity and the photocurrent I_P exists only in a small region, since the current gain B depends on the current. Figure 4 shows typical current voltage characteristics of a phototransistor.

Since the reverse current I_{CBO} of the base diode is amplified in the same way as the photocurrent I_P, the signal/noise ratio of the phototransistor is the same as that of the photodiode.

Photocurrent as a function of the collector-emitter voltage
$I_P = f(V_{CE})$
E_v = parameter e.g. **BPX 38**

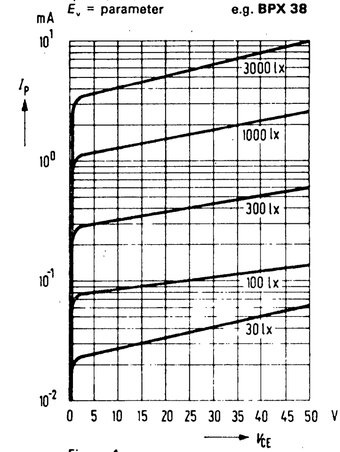


Figure 4

For the versatile applications, special type phototransistors are available. BPY 62, BPX 43, BP 101 and BP 102 requiring no lens on the receiver side are suitable for general applications.

BPY 62 is outstanding for a higher cut off frequency, BPX 43 for a higher photo-sensitivity.

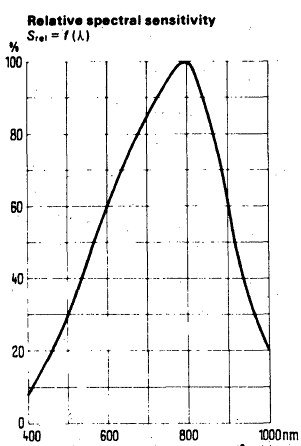
In case the application demands a lens on the detector side, this requirement is met by BPX 38. The flat window of this phototransistor makes a precise reproduction of the focal spot on the photosensitive surface of the transmitter system possible. On account of the larger system surface, the adjustment and alignment of the transistor case to the light emitter causes less difficulties.

At the types mentioned, the user may preset the operating point of the phototransistor by wiring the base leads. The rapidity of response may thus be increased and the photosensitivity reduced. A fixed bias can reverse the phototransistor. Coincidence circuits can be realized by scanning this bias.

The phototransistor BPY 61 meets the requirement for high packing density. It is enclosed in a miniature glass case of 13 mm x 2.1 mm Ø and its photosensitivity is by the factor 500 to 1000 higher than small-surface silicon photovoltaic cells. Also the BPX 62 in micro ceramic case is provided for use on PC boards at minimum space requirements. The tolerance range of the light sensitivity is subdivided into four sensitivity groups. There is no base contact. Light is the controlling element which produces a correspondingly high collector current via the emitter-base path of the transmitter system, multiplied by the factor of the current gain. The rise and fall times depend on the illuminance and decrease with rising intensity.

Main applications are scanning of binary coded discs, films and punched cards.

Under limited mounting conditions the following amplifier must often be connected by relatively long leads. There is only little danger of interference pick-up since a sufficiently large signal to noise ratio is ensured by high photoelectric currents.



Mounting Instructions For Silicon Voltaic Cells and Photodiodes, open design without casing

As silicon is an inherently brittle material, the photoelectronic component should be shielded from pressure or tension. Contact points are particularly endangered. Should tension come to bear on the solid wire leads which, for technological reasons, are alloyed to a very thin P layer it should only be parallel to the surface and must not exceed 200 p (pond). Leads may only be bent 3 mm off the outer edge of the photoelectric component. Photoelectric components can be cemented onto metallic or plastic supports but the expansion coefficient of the material has to be taken into consideration to prevent mechanical strain between support and photoelectric component at change of temperature. An epoxy resin is to be used to cement or encapsulate the photoelectric component. It has to be colourless and should not grow darker with time. After curing, the epoxy resin must not have any gas occlusions (filter effect). The epoxy resin EPICOTE 162[1] together with the hardener LAROMIN-C 260[2] are particularly suited for the encapsulation of photoelectric components. 100 weight parts EPICOTE 162, 38 weight parts LAROMIN-C 260 are to be mixed well and remain workable for about 30 minutes. After that period of time the epoxy becomes viscid. All material to be encapsulated has to be dry, dust- and grease-free. Should bubbles form after the encapsulation it is advisable to raise the curing process temperature to 100°C for a short time. It makes the bubbles come to the surface and burst. The normal curing temperature lies between 60 and 80°C. The curing time is 1 hour, it lessens with higher temperature. When working with epoxy great care should be taken that neither the resin nor the hardener touches the skin. The quickly binding glue SICOMET 85[3] proves adequate to cement open-design Si diodes or photovoltaic cells. The light sensitive surface of the photovoltaic cell is coated with a protective lacquer and should not be contaminated while cementing.

1) Registered trademark (Shell Chemical)
2) Registered trademark (BASF)
3) Registered trademart (Sichel-Werke, Hannover)

SIEMENS

Applying the DL 3416/DLX 3416* Intelligent Display® device Appnote 17

by Dave Takagishi

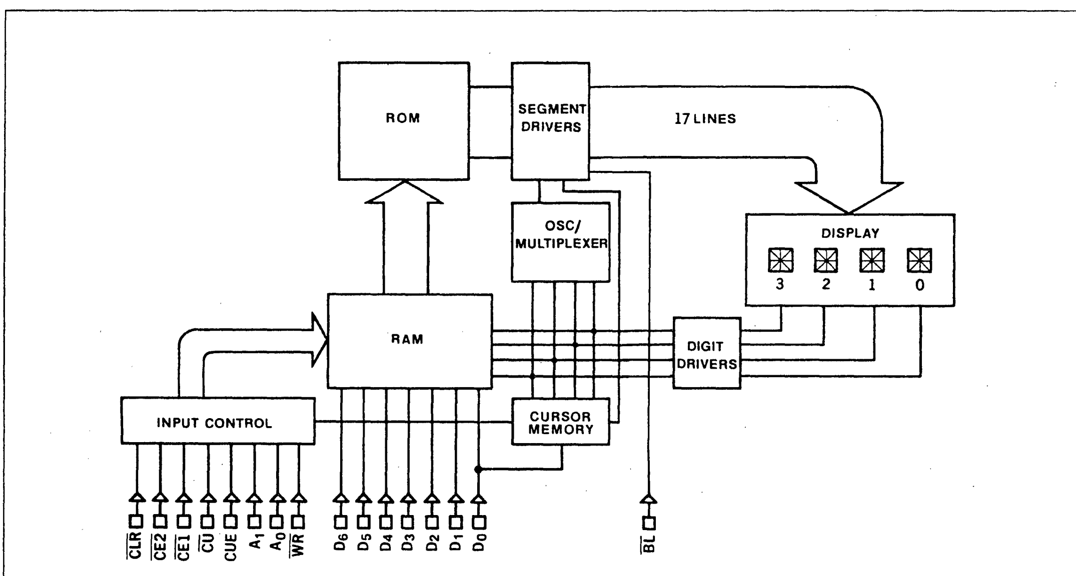
This application note is intended to serve as a design and application guide for users of the DL 3416/DLX 3416 (referred to as 3416 hereafter) alphanumeric Intelligent Displays. The information presented covers device electrical description and operation, considerations for general circuit design, and interfacing the 3416 to microprocessors. Refer to the specific data sheet and other Siemens Appnotes for more details.

Electrical & Mechanical Description

The internal electronics in these Intelligent Displays eliminates all the traditional difficulties of using multi-digit light emitting displays (segment decoding, drivers, and multiplexing). The Intelligent Display also provides internal memory for the four digits. This approach allows the user to asynchronously address one of four digits, and load new data without regard to the LED multiplex timing.

Figure 1a is a block diagram of the DL 3416. The unit consists of four 17-segment monolithic LED dies and a single CMOS integrated circuit chip. The LED dies are magnified to a height of 225 mils by built-in lenses. The IC chip contains 17 segment drivers, four digit drivers, 64 character ROM, four word x 7 bit Random Access Memory, oscillator for multiplexing, multiplex counter/decoder, cursor memory, address decoder, and miscellaneous control logic.

Figure 1a. Block Diagram – DL 3416



*DL 3416 – segmented display.
DLX 3416 (DLR 3416, DLG 3416, or DLO 3416) – dot matrix displays.

Figure 1b is a block diagram of the DLX 3416. The unit consists of four (5x7) LED arrays and a single CMOS integrated chip. The IC chip contains the column and row drivers, 128 character ROM, four word x 7 bit Random Access Memory, oscillator for multiplexing, multiplex counter/decoder, cursor memory, address decoder, and miscellaneous control logic.

Packaging

Packaging consists of a transfer-molded nylon lens which also serves as an "encapsulation shell" since it covers five of the six "faces". The assembled and tested substrate ("PTF" multilayer), is placed within the shell and the entire assembly is then filled with a water-clear IC-grade epoxy.

This yields a very rugged part, which is quite impervious to moisture, shock and vibration. Although not "hermetic", the device will easily withstand total immersion in water/detergent solutions.

Figure 1b. Block Diagram – DLX 3416

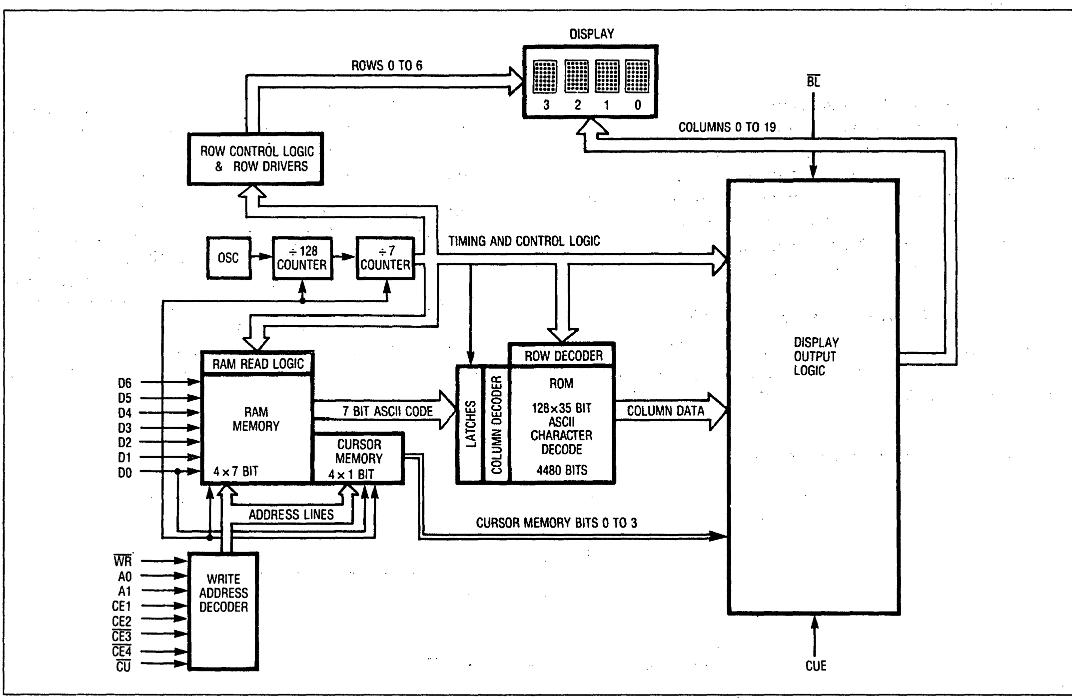
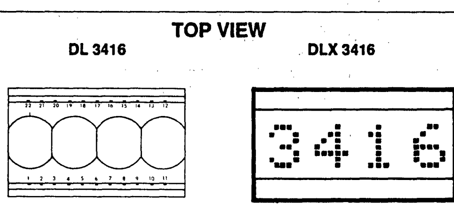


Figure 2.



Pin	Function	Pin	Function
1	CE1 Chip Enable	10	GND
2	CE2 Chip Enable	11	D_0 Data Input
3	CLR Clear	12	D_1 Data Input
4	CUE Cursor Enable	13	D_2 Data Input
5	CU Cursor Select	14	D_3 Data Input
6	WR Write	15	D_6 Data Input
7	A_1 Digit Select	16	D_5 Data Input
8	A_0 Digit Select	17	D_4 Data Input
9	V_{cc}	18	BL Display Blank

Electrical Inputs to the 3416

V_{CC} — Positive supply +5 volts

GND — Ground

D_0-D_6 — Data Lines
The seven data input lines are designed to accept the first 64 ASCII characters. See Figure 3a for character set. (The DL 3416 interprets all undefined codes as a blank). See Figure 3b for character set for DLX 3416.

A_0, A_1 — Address Lines
The address determines the digit position to which the data will be written. Address order is right to left for positive-true logic.

$\overline{WR}$ — Write (Active Low)
Data and address to be loaded must be present and stable before and after the trailing edge of write. (See data sheet for timing information).

$\overline{CE1}$, $\overline{CE2}$ — Chip Enable (Active High)
$\overline{CE3}$, $\overline{CE4}$ — Chip Enable (Active Low)
This determines which device in an array will actually accept data. When either or both chip enable is in the high state, all inputs are inhibited.

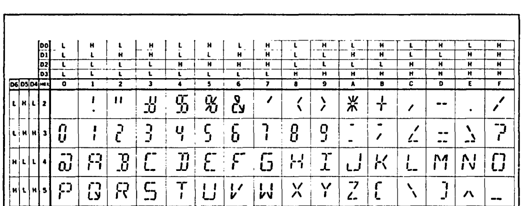
$\overline{CLR}$ — Clear (Active Low)
The data RAM and cursor RAM of the DL 3416 will be cleared when held low for 15 mS. The minimum for the $\overline{CLR}$ is 1 mS for the DLX 3416.

CUE — Cursor Enable. Activates Cursor function. Cursor will not be displayed regardless of cursor memory contents when cue is Low.

$\overline{CU}$ — Cursor Select (Active Low)
This input must be held high to store data in data memory and low to store data into the cursor memory.

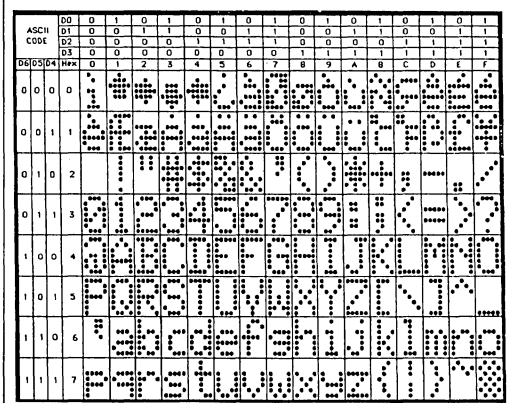
$\overline{BL}$ — Display Blank (Active Low)
Blanking the entire display may be accomplished by holding the $\overline{BL}$ input low. This is not a stored function, however. When $\overline{BL}$ is released, the stored characters are again displayed. $\overline{BL}$ can be used for flashing or dimming.

Figure 3a. Character Set – DL 3416



ALL OTHER CODES DISPLAY BLANK

Figure 3b. Character Set – DLX 3416



Notes:
1. High =1 level.
2. Low =0 level.
3. Upon power up, the device will initialize in a random state.

Clear Memory

Clearing of the entire internal four-digit memory may be accomplished by holding the clear line ($\overline{CLR}$) low for one complete internal display multiplex cycle, 15 mS minimum for DL 3416, 1 mS for DLX 3416. Less time may leave some data uncleared. $\overline{CLR}$ also clears the cursor memory.

Display Blanking

Blanking the display may be accomplished by loading a blank, space or illegal code into each digit of the display or by using the ($\overline{BL}$) display blank input. Setting the ($\overline{BL}$) input low does not affect the contents of either data or cursor memory. A flashing display can be realized by pulsing ($\overline{BL}$).

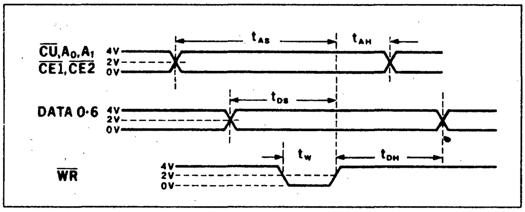
Operation

Multiplexed display systems sequentially read and display data from a memory device. In synchronous systems, control circuitry must compare the location of data to be read to the location or position of new data to be stored or displayed, i.e., synchronize before a Write can be done. This can be slow and cumbersome.

Data entry in "intelligent displays" is asynchronous and may be done in any random order. Loading data is similar to writing into a RAM. Each digit has its own memory location and will display until replaced by another code.

The waveforms of Figure 4 demonstrate the relationships of the signals required to generate a write cycle.

Figure 4.



(Check individual data sheet for minimum values). As can be seen from the waveforms, all signals are referenced from the rising or trailing edge of write.

Cursor

For the DL 3416 the cursor function causes all 16 line-segments of a digit to light. For the DLX 3416 the cursor function causes all dots to light at 50% brightness. The cursor can be used to indicate the position in the display of the next character to be entered. The cursor is not a character but overrides the display of a stored character. Upon removal of the cursor, the display will again show the character stored in memory.

The cursor can be written into any digit position by setting the cursor enable (CUE) high, setting the digit address (A_1, A_0), enabling Chip Enable, ($\overline{CE1}$, $\overline{CE2}$), cursor select ($\overline{CU}$), Write ($\overline{WR}$) and Data (D_0). A high on data line D_0 will place a cursor into the position set by the address A_0 and A_1. Conversely, a low on D_0 will remove the cursor. The cursor will remain displayed after the cursor ($\overline{CU}$) and write ($\overline{WR}$) signals have been removed. During the cursor-write sequence, data lines D_1 through D_6 are ignored by the 3416.

Figure 5.

LOADING DATA

$\overline{BL}$	$\overline{CE1}$	$\overline{CE2}$	CUE	$\overline{CU}$	$\overline{WR}$	$\overline{CLR}$	A_1	A_0	D6	D5	D4	D3	D2	D1	D0	DIGIT 3	DIGIT 2	DIGIT 1	DIGIT 0
L	X	X	X	H	X	H	X	X	X	X	X	X	X	X	X	BLANK			
H	H	X	L	H	X	H	X	X	X	X	X	X	X	X	X	PREVIOUS CHARACTERS			
H	X	H	L	H	X	H	X	X	X	X	X	X	X	X	X	NC	NC	NC	NC
H	X	X	L	H	H	H	X	X	X	X	X	X	X	X	X	NC	NC	NC	NC
H	L	L	L	H	L	H	L	L	H	L	L	L	L	L	H	NC	NC	NC	A
H	L	L	L	H	L	H	L	H	H	L	L	L	L	H	L	NC	NC	B	A
H	L	L	L	H	L	H	H	L	H	L	L	L	L	H	H	NC	C	B	NC
H	L	L	L	H	L	H	H	H	H	L	L	L	H	L	L	D	C	NC	A
H	L	L	L	H	L	H	L	L	H	L	L	L	H	L	H	D	C	B	E
H	L	L	L	H	L	H	H	L	H	L	L	H	L	H	H	D	K	B	E
H	L	L	L	H	L	H	–	–	–	–	–	–	–	–	–	SEE CHARACTER SET			

LOADING CURSOR

H	L	L	L	H	X	H	X	X	X	X	X	X	X	X	X	Normal Data Entry			
H	L	L	H	H	H	H	X	X	X	X	X	X	X	X	X	Enable Previous Stored Cursors			
H	L	L	H	L	L	H	L	L	X	X	X	X	X	X	H	NC	NC	NC	▦
H	L	L	H	L	L	H	L	H	X	X	X	X	X	X	H	NC	NC	▦	▦
H	L	L	H	L	L	H	H	L	X	X	X	X	X	X	H	NC	▦	▦	▦
H	L	L	H	L	L	H	H	H	X	X	X	X	X	X	H	▦	▦	▦	▦
H	L	L	L	H	H	H	X	X	X	X	X	X	X	X	X	D	K	B	E
H	L	L	L	L	L	H	L	L	X	X	X	X	X	X	L	D	K	B	E
H	L	L	H	H	H	H	X	X	X	X	X	X	X	X	X	▦	▦	▦	E

X = Don't care
NC = No change from previously displayed characters

If the user does not wish to utilize the cursor function, the cursor enable (CUE) can be tied low to disable the cursor function. A flashing cursor can be realized by simply pulsing the CUE line after cursor data has been stored.

General Design Considerations

Using Positive true logic, address order is from right to left. For left to right address order, use the "ones complement" or simple inversion of the addresses.

For systems with only a 6-bit (abbreviated ASCII) code format, Data Line D_6 cannot be left open. Data D_6 must be the complement of Data Line D_5.

A "display test" or "lamp test" function can be realized by simply storing a cursor into all digits.

Because of the random state of the cursor RAM after power up, if the cursor function is to be used, it will be necessary to clear cursors initially to assure that all cursor memories contain its zero state. This is easily accomplished with the $\overline{CLR}$ input.

When using the 3416 on a separate display board having more than 6 inches of cable length, it may be necessary to buffer all inputs. This is most easily achieved with Hex non-inverting buffers such as the 74365. The object is to prevent transient current in the protection diodes. The buffers should be located on the display board near the displays.

Local power supply bypass capacitors are also needed in many cases. These should be 6 or 10 volt, tantalum type having 10 µF or greater capacitance. Low internal resistance is important due to current steps which result from the internal multiplexing of the displays.

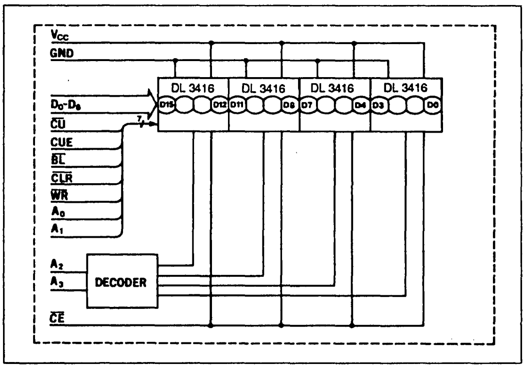
If small wire cables are used, it is good engineering practice to calculate the wire resistance of the ground plus the +5 volt wires. More than 0.1 volt drop, (at 25 mA per digit worst cast) should be avoided, since this loss is in addition to any inaccuracies or load regulation limitations of the power supply.

The 5-volt power supply for the displays should be the same one supplying V_{CC} to all logic devices which drive the display devices. If a separate supply must be used, then local buffers using hex non-inverting gates should be used on all inputs and these buffers should be powered from the display power supply. This precaution is to avoid logic inputs higher than display V_{CC} during power up or line transients.

Interfacing the 3416

A general and straight-forward interface circuit is shown in Figure 6. Figures 6, 7, 8, and 9 show DL 3416's being used, but any displays from the 3416 family can be used interchangeably in these examples. This scheme can easily interface to µP systems or any other systems which can provide the seven data lines, appropriate address and control lines.

Figure 6. General Interface Circuit



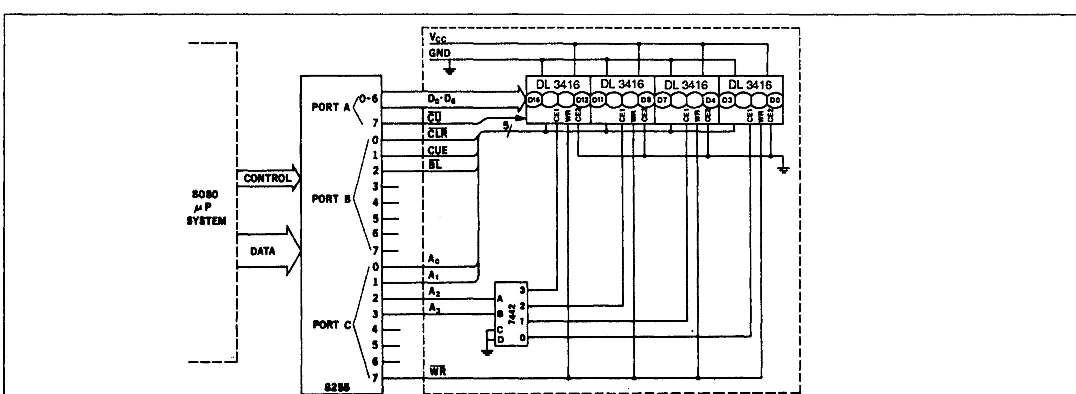
Parallel I/O

The parallel I/O device of a microprocessor can easily be connected to the circuit in Figure 6. One eight bit output port can provide the seven input data bits and the cursor (CU). Another eight bit output port can contain the address and chip enable information and the other control signals.

Figure 7 illustrates a 16-character display with an 8080 system using the 8255 programmable peripheral interface I/O device. The following program will display a simple 16-character message using this interface.

```
INIT:    MVI A,80H       ;CONTROL DATA MODE 0
         OUT CONTROL     ;LOAD CONTROL REGISTER
CUSR:    MVI A,00H       ;CLEAR CURSOR DATA
         OUT PORT A      ;LOAD DATA PORT
         MVI B, 0FH      ;SET CHARACTER COUNTER
CUSRI:   MOV A, B        ;
         CALL DSPWT      ;WRITE SUBROUTINE
         DCR B           ;DECREMENT COUNTER
         JNZ CUSRI       ;DIGIT 0?
         MOV A, B        ;
         CALL DSPWT      ;
         MVI A, FFH      ;SET DATA FOR CONTROL
         OUT PORT B      ;LOAD CONTROL LINES
DISP:    LXI H, TABLE    ;SET TABLE ADDRESS
DISP1:   MOV A, M        ;MOVE TABLE DATA INTO
                          ACCUMULATOR
         OUT PORT A      ;LOAD DATA PORT
         MOV A, B        ;
         CALL DSPWT      ;LOAD ADDRESS AND
                          CONTROL
         INX H           ;INCREMENT TABLE ADDRESS
         INR B           ;INCREMENT COUNTER
         MVI A, 10H      ;SET # OF DIGITS
         CMP B           ;
         JNZ DISP1       ;16 CHARACTERS?
         HALT            ;END OF PROGRAM
DSPWT:   ORI F0H         ;SET CONTROL BITS OFF
         OUT PORT C      ;LOAD CONTROL
         ANI 7FH         ;SET WRITE BIT ON
         OUT PORT C      ;LOAD WRITE
         ORI F0H         ;SET WRITE BIT OFF
         OUT PORT C      ;LOAD CONTROL
         RET
TABLE:   DB              ;0C3H
         DB              ;0C9H
         DB              ;0D4H
         DB              ;0D3H
         DB              ;0C1H
         DB              ;0D4H
         DB              ;0CEH
         DB              ;0C1H
         DB              ;0C6H
         DB              ;0A0H
         DB              ;0D3H
         DB              ;0D4H
         DB              ;0C8H
         DB              ;0C7H
         DB              ;0C9H
         DB              ;0CCH
```

Figure 7. 16-Digit Parallel I/O System



Application Notes

Figure 8. Mapped Interface

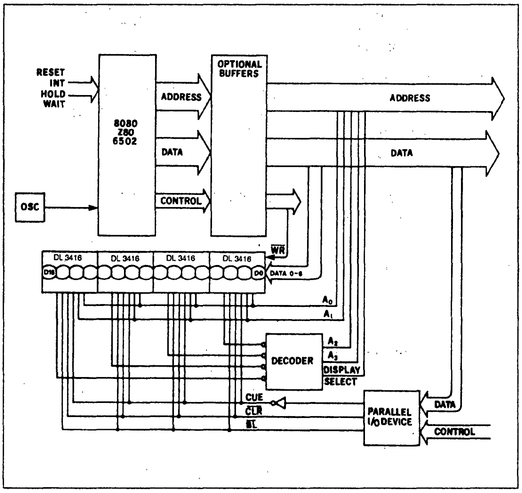
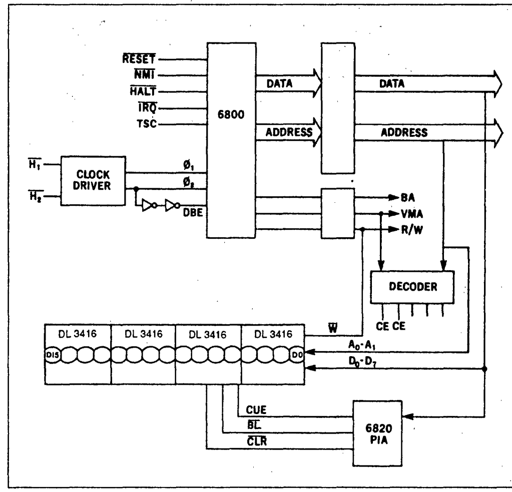


Figure 9.



I/O or Memory Mapped Addressing

Some designers may wish to avoid the additional cost of a parallel I/O in their system. Structuring the addressing achitecture for the 3416 to look like a set of peripheral or output devices (I/O mapped) or RAM's and ROM's (memory mapped) is very easy. Figure 8 shows the simplicity of interfacing to microprocessors, such as 8080, Z80 and 6502 as examples.

The interface with the 6800 microprocessor in Figure 9 illustrates the need for designers to check the timing requirements of the DL 3416 and the µP. The typical data output hold time is only 30 ns for DBE =Ø2 timing; two inverters in the DBE line are added to increase the data output hold time for compatibility with the 50 nS minimum spec of the DL 3416.

Conclusion

Note that although other manufacturer's products are used in examples, this application note does not imply specific endorsement, or recommendation or warranty of other manufacturer's products by Siemens.

The interface schemes shown demonstrate the simplicity of using the 3416 with microprocessors. The slight differences encountered with various microprocessors to interface with the 3416 are similar to those encountered when using different RAMs. The techniques used in the examples were shown for their generality, and any display of this family are interchangeable in these examples. The user will undoubtedly invent other schemes to optimize his particular system to its requirements.

SIEMENS

Guidelines for Handling and Using Intelligent Displays® Appnote 18

by Malcolm Howard
Dave Takagishi

IMPORTANT!

This appnote contains vital information for optimum design and performance of Intelligent Displays.

Siemens Opto Intelligent Displays and Programmable Displays are one, four or eight-digit LED display modules, having 16, 17 segment or 5x7 dot matrix fonts and on-board CMOS integrated circuits. The CMOS chip provides segment decoding, drivers, multiplexing and memory for easy interfacing to most microprocessors.

Since Siemens first began manufacturing Intelligent Displays, questions concerning their use have arisen. This application note is a guide for the design and handling considerations of these products.

System Design Consideration

In the practical circuit (i.e., design of PCB, etc.) the voltage to any input must never exceed the power inputs (i.e., $GND<V_{IN}<V_{CC}$). If these conditions are not met, then malfunction, or at worst, device destruction can occur. The most common cause of these conditions is circuit noise on the inputs and transient power supply changes.

Good Circuit Layout

The principles of good circuit layout are identical to any logic circuitry, but the deviation tolerance of MOS devices is much less than that of bipolar logic. To reduce the coupling effect between signals, it is important to keep the signal path lengths as short as possible.

Buffering

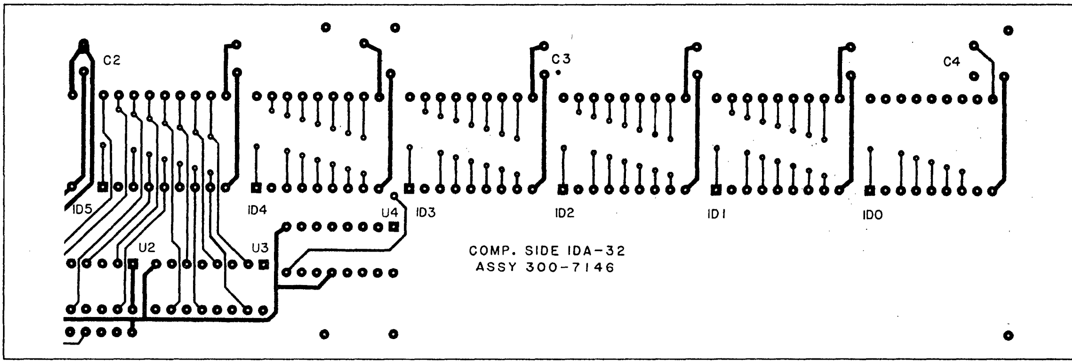
Although the use of parallel tracking is usually considered good design practice, avoid PCB designs which allow an interconnection track to run parallel to another. This is particularly true if one of the tracks is a high power bus when the fluctuations of power supply current can cause inductive or capacitive coupled charge onto an adjacent input signal.

Possibly the worst example of parallel tracking is the ribbon cable. While physically neat and convenient, ribbon cables can be electrically destructive for the MOS circuits, It is often necessary, because of the very nature of the Intelligent Display, to use ribbon cable from the CPU board to the display assembly board. In those circumstances for PCB trace lengths plus cable lengths over 15.5 cm (6 inches), use a buffer for each input. This is especially true for noisy systems which have motors, relays, etc. The buffers should be physically as close as possible to the displays; thus maintaining a minimum distance between their outputs and the display inputs. Long cables can be poor transmission lines for speed pulses. Line drivers, line receivers, or Schmidt trigger gates may be required to shape pulses.

Voltage Transients

It has become common practice to provide 0.01 µf bypass capacitors liberally in digital systems. For Intelligent Displays, the emphasis is on adequate decoupling. Like other CMOS circuitry, the Intelligent Display controller chip has a very low power consumption and the usual 0.01 µf capacitor would be adequate were it not for the LEDs. The module can, in some conditions (depending on the displayed characters), use up to 100 mA (average, multiplexed). To prevent power supply transients, use capacitors with low inductance and high capacitance at high frequencies, i.e., a solid tantalum or ceramic disc for high frequency bypass. For longer display lengths, distribute the bypass capacitors evenly keeping capacitors as close to display power pins as possible. Do not rely on into the board decoupling, use a 10 µf and a 0.01 µf capacitor for every three or four Intelligent Displays to decouple the displays themselves, at the displays. See Figure 1.

Figure 1.



An actual PCB layout for a line of DL 2416 Intelligent Displays. Capacitors are spaced evenly and close to the displays with room for addtional capacitors should the system require them.

Functional Limitations

Several parameters in an Intelligent Display data sheet which may affect your design are listed below. While some parameters may not be destructive, some may affect reliability and/or functional operation. (Check latest data sheets.)

1. The length of ***time that all cursors may be lit*** (on the DL 1416B, DL 2416T, DL 3416) should be ***1 minute max.***
2. The timing parameters at 25°C will increase (slower) with increased temperature.
3. The timing parameters will decrease (faster) with increased V_{CC}.

Manufacturing Considerations

Handling

The static voltages generated by friction with synthetic materials (i.e., carpets, clothing, device carriers, etc.) are often measured in thousands of volts. Although these static charges usually have little energy, it is sufficient to cause destruction to CMOS circuitry if applied to circuit inputs. Our CMOS circuits have input protection diodes which can minimize their vulnerability to these static voltages, but there is a limit to their protection capabilities. Under certain conditions, static charges can exceed that limit. The most effective protection is to avoid the generation of static charges. When static charges are unavoidable, prevent that charge from coming into contact with the device pins.

1. ***Avoid touching the pins, handle the body only.***
2. ***Keep the devices in anti-static tubes or conductive material when transporting.***
3. ***Use conductive and grounded working area*** (conductive flooring, conductive workbench tops, conductive individual wrist straps, etc.).

Intensity Brightness Codes

Display uniformity is a concern when two or more displays are in a system. SIEMENS has adopted a letter code (indicating a brightness range) to maintain a uniform display. It is recommended a single letter code be used per system. Because this may be difficult to always achieve due to yield and delivery, adjacent codes (i.e., D with E or E with F) can be used with minimal problems. Jumping over a code (i.e., D with F) may be noticeable.

Soldering

Because of the plastic housing of the Intelligent Displays, it is necessary to control the solder temperature, soldering time, and soldering distance. A maximum of 260°C for three seconds at a distance greater than 1/16 inch is recommended. An additional requirement during wave soldering: the temperature of the plastic package should not exceed 70°C.

Cleaning

For the DL 1414, DL 1416B, DL 1814, DL 2416T, and DL 3416. To maintain the optical performance of the plastic housing, the cleaning process for the Intelligent Displays is crucial. Because of the clear plastic magnifying bubbles, any solvent containing some form of alcohol cannot be used. Alcohol will attack the lens material causing cracking, crazing, and destruction of the clear optical properties of the lens.

Solvents in the ***suggested category*** are the chlorinated hydrocarbons (Acetone, 1.1.1 Trichloroethane, etc.), Freon TF, Freon TA or warm DI water. One note of caution: do not use a Freon solvent without first determining the chemical composition. Some manufacturers use some form of alcohol as an additive to enhance cleaning, so beware.

For the DL 1414T, DL 1416B, DL1814, DL 2416T, DL 3416, DLX 1414, DLX 2416, DLX 3416, PD 243X, PD 353X, PD 443X, HDSP 200XLP, IDA 1414, IDA 1416, IDA 2416, IDA 3416: Solvents in the suggested category are TF and III Trichloethane or warm water.

SIEMENS

Cleaning LED Opto Products Appnote 19

by Dave Takagishi
Rick Rachford

Now that you have selected the right optoelectronic device for your application and designed the circuitry, the next step is to install the devices. This application note is a cleaning solvent selection guide for Siemens products.

PURPOSE OF CLEANING

In the manufacturing of your product, the components will be handled and soldered. It is important to clean the board and remove both flux rosin and ionic residues after soldering to insure a reliable product operation.

Opto products have to be treated differently than other semiconductor devices with respect to cleaning. LED devices for visual applications require special materials for their optical properties. Exposure to a cleaning solvent must not degrade these properties in any way. For this reason, only certain cleaning solvents and their applications may be used for LED components.

Optoelectronic products are built using differing manufacturing packaging techniques depending upon the device and cost. (See Table 1). For this reason, different types of solvents and cleaning techniques may be required. (See Table 3 for solvent summary).

CLEANING TECHNIQUES

The most common cleaning techniques used in the electronic industry are:

1. Brush/wipe
2. Immerse/spray
3. Vapor degreaser

Dipping a short hard bristle brush into a solvent and applying to the area desired is used mostly for touch-up or rework areas where localized cleaning is required. This technique can be used on all optoelectronic products if care is taken to maintain their optical properties.

Immersing the printed circuit board into a pan of solvent with slight agitation is another method of cleaning. Spraying the cleaner, in a dishwasher type machine, is a method for removing water soluble type flux.

The most common technique is the vapor degreaser. This method elevates the solvent to its vapor state. The object is placed into this vapor area allowing condensation into a liquid solvent and dissolving the soil.

Table 1.

OPTOELECTRONIC PACKAGING

1. Without housing (photovoltaic, etc.)
2. Cast or molded
3. Housed (lensed or flat)
4. Reflector (filled)

SOLVENTS

There are many different solvents today. Some may be used only at room temperature; some are more effective with a vapor degreaser. Table 2 is a list of major solvent manufacturers.

Table 2.

MAJOR SOLVENT MANUFACTURERS

Allied Chemical Corporation
Specialty Chemical Division
PO Box 1087
Morristown, N.J. 07960

Baron-Blakeslee
1620 S. Laramie Avenue
Chicago, Ill 60650

Dow Chemical
2020 Dow Center
Midland, MI 48640

El DuPont de Nemours & Co.
1007 Market Street
Wilmington, DE 19898

Cost should not be the only criteria for choosing a specific cleaning solvent. Any assembly that has a variety of components makes it mandatory to analyze the effects of any given solvent on all components. The component likely to be affected the most by any solvent should control your choice of solvent.

CONCLUSION

The list of suitable/not suitable solvents in Table 3 represents a small part of available solvents. Some others may be compatible, but more likely, most will not be compatible. Another area of concern is that solvent manufacturers make comparable products, not exact products. Additives and concentrations are slightly different from manufacturer to manufacturer which may affect a solvent's acceptability.

Siemens does not assume any responsibility for damage caused to product/s by use of solvents mentioned. This application note is only a guide to solvents that have been found satisfactory when tested under our own controlled conditons. We recommend that components be evaluated under your solvent conditions before committing to use on a production basis.

Table 3. Suitable and Unsuitable Solvents for Siemens Optoelectronic Products

	Solvents										
Product Types	**TF**	**TP-35**	**TCM**	**TMC**	**TMS+**	**TE**	**TA**	**TES**	**Acetone**	**Isopropyl Alcohol**	**III Tri-chloethane**
Visible Lamp All Types	S	S	N	N	S	S	N	N	N	S	N
IR Emitter/Detector All Types	S	S	N	N	S	S	N	N	N	S	N
Optocoupler All Types	S	S	N	N	S	S	N	N	N	S	N
Displays – Group 1 (All devices listed below are in Group 1) HD XXXX DLX 413X DLX 477X DLX 573X DLX 713X XBG 1000 XLB 2XXX XBG 48X0	S	S	N	N	S	S	N	N	N	S	N
Displays – Group 2 (All devices listed below are in Group 2) DL 3XXM/DL 4XXM DL 1414T, DLX 1414 DL 1416T DL 1416B DL 1814 DL 2416T, DLX 2416 DL 3416, DLX 3416 HDSP200XLP IDA 1414 IDA 1416 IDA 2416 IDA 3416 PD 243X PD 353X PD 443X	S	N	N	N	N	N	S	N	S	N	S

S = Suitable
N = Not Suitable
X = Substitute for specific part designation

SIEMENS

Moving Messages Using Intelligent Display® devices and 8748 Microprocessor Appnote 20

Reprinted from Siemens Design Examples of Integrated Circuits Edition 1980/81

Output and display of texts including an important operator information are not only limited to devices of data processing systems but they are more and more applied in other fields of electronics, e.g. in industrial and consumer as well as control engineering. If data of different kinds (e.g. program results, error indications, decision criteria, test results, etc.) are displayed as moving news, they have a striking effect calling the operator's attention.

The text can easily be read when each character remains for 0.25 s on the display. A special advantage of a moving news panel being controlled by a microcomputer is in that the information can immediately be modified. The described circuit of **Fig. 1** operates with SAB 8748. Its program memory capacity (EPROM) is 1K Byte and up to 900 characters can be stored. If the microcomputer is replaced by another one incorporating a different program, the information which is to be displayed is also exchanged.

The described circuit offers the advantage in requiring a minimum of components. The single-chip microcomputer SAB 8748 operates in conjunction with an alphanumeric 16-segment-LED-display DL-2416. It incorporates memory decoder and driver.

Hardware

The ASCII-coded data is transferred from the SAB 8748 to the display ICs via the bus port (DBØ to DB6) and via the $\overline{WR}$-output (strobe). The information at pins P20 and P21 addresses the specific digits of the display-IC DL2416.
The signals at P22 to P26 select the individual ICs via the chip enable input $\overline{CE1}$. When one pin of port 1 is connected to ground, the microcomputer supplies the corresponding text. An output of 4 different texts is possible.

The text may have any length as long as the memory capacity of 900 bytes is not exceeded. There are no additional components required than indicated in the circuit of **Fig. 2.**

Software

The first 100 bytes of the EPROM are reserved for the program. As the program counter can only be read as data memory within 256 bytes, additional instructions are necessary (see listing). At the beginning of the program port 1 is read. If a signal with low level is available at one of the pins, the starting address of the corresponding text is loaded to register 2 (low address) and 3 (high address). Now output registers 20H to 32H have to be filled with blanks. Then the first letter is transfered from text memory to data memory. Now the microprocessor operates in a waiting loop, determining the speed of the moving news. At an oscillator frequency of 3 MHz the timer has an overflow after $\frac{1}{3} \times 10^{-6}\ \mu s \times 15 \times 32 \times 256 = 40.96$ ms. The moving-news text is stepping four times per second after 6 overflows have occurred, that means the 900 characters need in total 3¾ minutes. If the 8-bit-word zero (figure Ø, not the ASCII-character for Ø) is read as character, the text end is recognized by the program. Therefore a counting is not necessary, that means all characters have been transferred. Now the program returns to read port 1.

The flowchart is shown in **Fig. 3** and **Fig. 4** presents the complete listing.

Components for circuit 2

1	8-bit single chip microcomputer (1-KByte-EPROM, 3-MHz-version)	SAB 8748-8-D
5	4-digit alphanumeric LED-displays with memory, decoder and driver, (4 mm character height, 16 segments)	DL 2416
1	Crystal	3 MHz
4	Push buttons for pc board mounting, 2 break-make contacts, lateral operation	

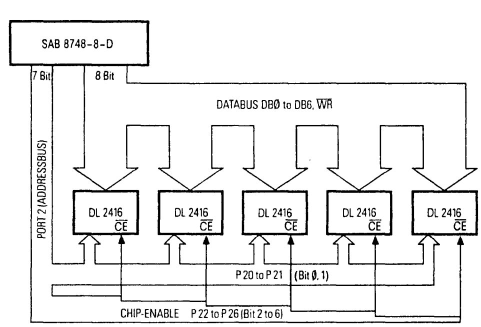


Fig. 1

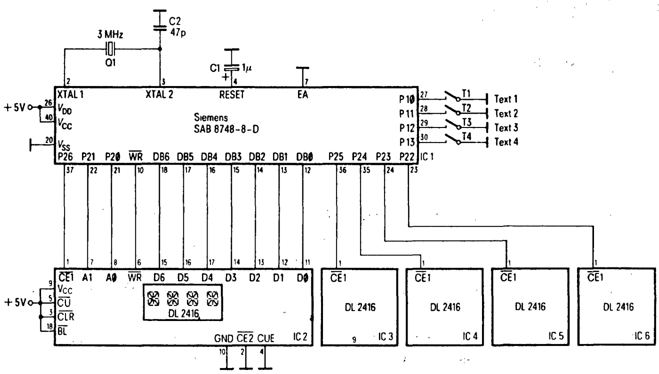


Fig. 2

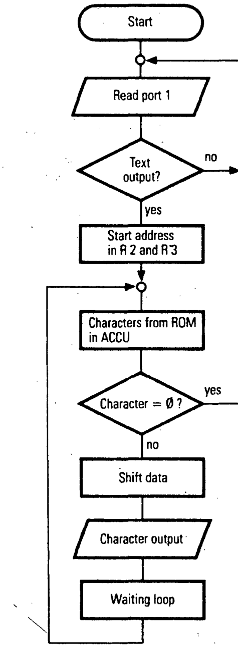


Fig. 3

```
ASM48 APP20

ISIS-II MCS-48/UPI-41 MACRO ASSEMBLER, V3.0                PAGE     1
APPNOTE 20 MOVING MESSAGE USING DL-2416S

  LOC  OBJ         LINE        SOURCE STATEMENT

                      1 $LIST PAGING SYMBOLS XREF MACROFILE DEBUG
                      2 $TITLE('APPNOTE 20 MOVING MESSAGE USING DL-2416S')
                      3         ;
                      4         ;**********************************************************
                      5         ;* THIS PROGRAM WILL DISPLAY FOUR-32 CHARACTER MESSAGES   *
                      6         ;* IN A "TIMES-SQUARE" MOVING MESSAGE FORMAT. IT USES     *
                      7         ;* FIVE OF THE TIME TESTED SIEMENS/LITRONIX DL-2416       *
                      8         ;* INTELLIGENT DISPLAYS(R)                                *
                      9         ;**********************************************************
                     10         ;17 FEBRUARY 1982
  0000 0A            11         IN      A,P2                    ;KEY POLLING
  0001 37            12         CPL     A
  0002 120C          13         JB0     AUS1
  0004 3212          14         JB1     AUS2
  0006 5218          15         JB2     AUS3
  0008 721E          16         JB3     AUS4
  000A 0400          17         JMP     0
  000C BA80          18 AUS1:   MOV     R2,#LOW(TEXT1-1)
  000E BB00          19         MOV     R3,#HIGH(TEXT1-1)       ;ADDRESS TEXT 1
  0010 0422          20         JMP     ANFANG
  0012 BAA1          21 AUS2:   MOV     R2,#LOW(TEXT2-1)
  0014 BB00          22         MOV     R3,#HIGH(TEXT2-1)       ;ADDRESS TEXT 2
  0016 0422          23         JMP     ANFANG
  0018 BAC2          24 AUS3:   MOV     R2,#LOW(TEXT3-1)
  001A BB00          25         MOV     R3,#HIGH(TEXT3-1)       ;ADDRESS TEXT 3
  001C 0422          26         JMP     ANFANG
  001E BAE3          27 AUS4:   MOV     R2,#LOW(TEXT4-1)
  0020 BB00          28         MOV     R3,#HIGH(TEXT4-1)       ;ADDRESS TEXT 4
                     29
  0022 55            30 ANFANG: STRT T
  0023 B820          31         MOV     R0,#20H
  0025 BD14          32         MOV     R5,#20
  0027 2320          33         MOV     A,#20H                  ;BLANK
  0029 A0            34 LOECH:  MOV     @R0,A
  002A 18            35         INC     R0
  002B ED29          36         DJNZ    R5,LOECH                ;BLANK IN RAM 20H-32H
  002D 1464          37 SCHL:   CALL    EINFUE                  ;NEXT CHARACTER
  002F C600          38 HALT:   JZ      0                       ;LAST CHARACTER
  0031 BD14          39         MOV     R5,#20
  0033 B820          40         MOV     R0,#20H
  0035 20            41 SCHL1:  XCH     A,@R0                   ;SHIFT
  0036 18            42         INC     R0
  0037 ED35          43         DJNZ    R5,SCHL1
  0039 B820          44         MOV     R0,#20H
  003B BCF8          45         MOV     R4,#0F8H                ;CHIP SELECT 1 DISPLAY
  003D 1459          46         CALL    AUS4BY                  ;OUTPUT 4 DIGITS
  003F BCF4          47         MOV     R4,#0F4H                ;CHIP SELECT 2 DISPLAY
  0041 1459          48         CALL    AUS4BY
  0043 BCEC          49         MOV     R4,#0ECH                ;CHIP SELECT 3 DISPLAY
  0045 1459          50         CALL    AUS4BY
  0047 BCDC          51         MOV     R4,#11011100B           ;CHIP SELECT 4 DISPLAY
  0049 1459          52         CALL    AUS4BY
  004B BCBC          53         MOV     R4,#10111100B           ;CHIP SELECT 5 DISPLAY
  004D 1459          54         CALL    AUS4BY
  004F BD0A          55         MOV     R5,#10
  0051 1655          56 WARTE:  JTF     WEITER                  ;WAIT 240 MS
  0053 0451          57         JMP     WARTE
  0055 ED51          58 WEITER: DJNZ    R5,WARTE
  0057 042D          59         JMP     SCHL
                     60
                     61         ;OUTPUT 4 DIGITS SUBROUTINE
                     62         ;R0 OUTPUT DIGIT POINTER
                     63         ;R4 CHIP SELECT & 2 BIT ADDRESS
                     64         ;R5 LOOP COUNTER
                     65
  0059 BD04          66 AUS4BY: MOV     R5,#4
  005B FC            67 AUS4B1: MOV     A,R4
  005C 39            68         OUTL    P1,A
  005D 1C            69         INC     R4
  005E F0            70         MOV     A,@R0
  005F 02            71         OUTL    BUS,A
  0060 18            72         INC     R0
  0061 ED5B          73         DJNZ    R5,AUS4B1
  0063 83            74         RET
                     75
                     76         ;FETCH NEXT CHARACTER SUBROUTINE
                     77         ;ADDRESS R2(LOW) & R3(HIGH)
                     78         ;JUMPS TO CORRECT PAGE FOR TEXT
                     79         ;& RETURNS TO MAIN PROGRAM
                     80
  0064 1A            81 EINFUE: INC     R2
  0065 FA            82         MOV     A,R2
  0066 966B          83         JNZ     UMGEH
  0068 BA02          84         MOV     R2,#2
  006A 1B            85         INC     R3
  006B FB            86 UMGEH:  MOV     A,R3
  006C 036F          87         ADD     A,#JMPADR
  006E B3            88         JMPP    @A
  006F 73            89 JMPADR: DB      JMPADR +4
  0070 76            90         DB      JMPADR +7
  0071 79            91         DB      JMPADR +10
  0072 7C            92         DB      JMPADR +13
  0073 FA            93         MOV     A,R2
  0074 047F          94         JMP     DATEN           ;PAGE 0
  0076 FA            95         MOV     A,R2
  0077 2400          96         JMP     100H            ;PAGE 1
  0079 FA            97         MOV     A,R2
  007A 4400          98         JMP     200H            ;PAGE 2
  007C FA            99         MOV     A,R2
  007D 6400         100         JMP     300H            ;PAGE 3
                    101
  007F A3           102 DATEN:  MOVP    A,@A
  0080 83           103         RET
  0081 54455854     104 TEXT1:  DB      'TEXTAUSGABE 1                     ',0
  0085 41555347
  0089 41424520
  008D 31202020
  0091 20202020
  0095 20202020
  0099 20202020
  009D 20202020
  00A1 00
  00A2 54455854     105 TEXT2:  DB      'TEXTAUSGABE 2                     ',0
  00A6 41555347
  00AA 41424520
  00AE 32202020
  00B2 20202020
  00B6 20202020
  00BA 20202020
  00BE 20202020
  00C2 00
  00C3 54455854     106 TEXT3:  DB      'TEXTAUSGABE 3                     ',0
  00C7 41555347
  00CB 41424520
  00CF 33202020
  00D3 20202020
  00D7 20202020
  00DB 20202020
  00DF 20202020
  00E3 00
  00E4 54455854     107 TEXT4:  DB      'TEXTAUSGABE 4                  '
  00E8 41555347
  00EC 41424520
  00F0 34202020
  00F4 20202020
  00F8 20202020
  00FC 20202020
  0100 A3           108         MOVP    A,@A            ;THIS INSTRUCTION
  0101 83           109         RET                     ;MUST BE INSERTED
  0102 20202020     110         DB      '    ',0        ;@100H,200H,300H
  0106 00
                    111                                 ;BEFORE EACH PAGE
                    112         END

USER SYMBOLS
ANFANG 0022   AUS1   000C   AUS2   0012   AUS3   0018   AUS4   001E
EINFUE 0064   HALT   002F   JMPADR 006F   LOECH  0029   SCHL   002D
TEXT3  00C3   TEXT4  00E4   UMGEH  006B   WARTE  0051   WEITER 0055

AUS4B1 005B   AUS4BY 0059   DATEN  007F
SCHL1  0035   TEXT1  0081   TEXT2  00A2

ASSEMBLY COMPLETE,   NO ERRORS
```

Fig. 4

SIEMENS

Silver Plated Tarnished Leads Appnote 21

by Dave Takagishi

Silver plating, as an alternative to gold plating, has excellent electrical conductivity, LED die attach, and wire bonding properties. But tarnished leads can cause soldering difficulties. This application note will discuss silver tarnish and solderability.

Effects of Tarnish

Solderability means the metals or surfaces to be soldered must be types that will go into solution with tin-lead alloys.

When exposed to the atmosphere, all metals form oxides or tarnish of varying degree which reduce the ability of solder alloys to adhere to the metals. Silver tarnish is formed when silver chemically reacts with sulfur to form silver sulfide (Ag_2S). This tarnish is the reason for poor solderability of silver plated products. However, the amount of tarnish and the kind of solder flux used actually determine the solderability. As the tarnish increases, a more active flux must be used to penetrate and remove the tarnish.

Prevention and Handling

Prevention is the best method for inhibiting the formation of tarnish and insuring good solderability of silver plated devices. To inhibit silver tarnish, do not expose the silver plating to sulfur and sulfur compounds. One source of sulfur is free air. Another is paper products such as bags and cardboard.

Listed below are a few suggestions for storing silver plated products.

1. Store the unused devices in polyethylene sheet to keep out free air.
2. Loose devices may be stored in zip-lock or sealed plastic bags.
3. For long term storage, place petroleum napthalene (mothballs) with product inside plastic packages to help keep out free air.
4. The silver leads may be wrapped in "Silver Saver" paper for protection. "Silver Saver" is manufactured by:
   Daubert Coated Products
   1200 Jorie Drive
   Oak Brook, Ill. 60521
   (312) 582-1000
5. Tapes such as adhesive, electrical, and masking should not be used because the adhesive may leave a film and will need to be removed before soldering.

The best defense against the formation of tarnish is to keep silver plated devices in protective packaging until just prior to soldering.

Fluxes

Depending on the amount of tarnish, different types of flux may be required. Below is a list of flux in order of increasing strength.

Type R: Un-activated Rosin Flux
: A pure water-white gum rosin without any additives. Flux and its residue are non-conductive and non-corrosive.

Type RMA: Mildly Activated Rosin Flux
: A WW rosin flux with a small amount of activating agent. Flux its residue are non-conductive and non-corrosive.

Type RA: Activated Rosin Flux
: Similar to RMA flux but with greater amounts of activating agents. Flux and its residue are non-conductive & non-corrosive.

Types AC: Organic Acid Flux
: A fully active organic flux with greater flux ability than a rosin flux. Due to its organic nature, the flux residues decompose at soldering temperatures but must be removed to prevent conductive and corrosive aftereffects.

Recommended flux types with respect to the various tarnish amount:

1. Tarnish free may be soldered with Alpha 100, Kester 135, or equivalent Type R flux. (Identified by a bright surface)
2. Minor tarnish will require Alpha 611, Kester 197, or equivalent Type RMA flux. (Identified by a medium bright surface)
3. Mild tarnish will require Alpha 711, Kester 1544, or equivalent Type RA flux. (Identified by a light tint surface)
4. Moderate tarnish will require Alpha 830, Kester 1429, or equivalent Type AC flux. (Identified by a light tan color on the surface)
5. If severe tarnish is present, as identified by a dark tan to black color, a cleaner/surface conditioner Alpha 140, Kester 5560, or equivalent must be used. A few seconds and at room temperature is all that is required. These conditioners are acidic; therefore, a thorough wash and rinse is recommended. Care is advised to only immerse the leads and not the body, because optical properties may be damaged.

Soldering

To obtain reliable circuit operation, good soldering is necessary. For wave soldering, Sn60 is the most commonly used solder for electronic components. Two alternatives are Sn63 and Sn62 solder. A high quality rosin core flux is recommended for hand solder operations. Typically the core is an RMA type flux.

Two major soldering suppliers are:

Alpha Metals
600 Rt 440
Jersey City, NJ 07304
(201) 434-6778

Kester Solder
4201 Wrightwood Ave.
Chicago, Ill 60639
(312) 235-1600

Regardless of the flux and solder technique used, care should be taken to assure the optical properties of the optoelectronic product are not degraded in any manner.

Siemens does not assume any responsibility for damage caused by products mentioned above.

SIEMENS

Socket Selection Guide Appnote 22

by Dave Takagishi

This application note is a guide to locate a suitable socket for various Siemens products.

The selection of a socket is first based on the number of pins and the pin spacing required. Sockets for displays require an orientation and sometimes stackability. Other requirements may be:

- Contact type (i.e., side vs. edge)
- Plating type (i.e., tin vs. gold)
- PCB mounting (i.e., solder vs. wirewrap)
- Height of socket

To use this guide, (1) Find Siemens product part number in Table 1, (2) Note number of pins, (3) Note spacing and orientation... (Example 300 H), (4) Go to Table 2, find # of pin with corresponding spacing/orientation and follow to suggested socket.

The purpose of this application note is to guide you to possible vendors and suggest one out of many possible socket choices. It is recommended that the part numbers given be used as a starting point with a vendor for choosing a socket. The part number will depend on your requirement and application.

This guide is not intended to imply specific endorsement or warranty of other manufacturer's products by Siemens.

Table 1.

Part Number	# of Pins	Spacing
DL330M	12	.300 H
DL340M	14	.300 H
DL430M	12	.300 H
DL440M	12	.300 H
HD1075X	10	(SPC)
HD1077X	10	(SPC)
HD1105X	10	.300 V
HD1107X	10	.300 V
HD1131X	10	.600 H
HD1132X	10	.600 H
HD1133X	10	.600 H
HD1134X	10	.600 H
DLX573X	12	.300 V
HDSP200XLP	12	.300 H
ISD235X	12	.250 H
ISD231X	12	.250 H
ISD201X	12	.300 H
Optocouplers: 6 pin	6	.300 B
8 pin	8	.300 B
16 pin	16	.300 B
Arrays	2–20	.100 B

Table 2.

# of Pins	Row-Row Spacing	ARIES New Jersey	GARRY MFG. New Jersey	ROBINSON-NUGENT, Indiana	SAMTEC Indiana
12	.300 H	12-513-10	(2)102-06-X	(2)ICN-063-X	
14	.300 H	14-511-10	102-14-X-X-X	ICL-143-S6-X	ICC-314-T
18	.600 V	18-6511-10	300-18-X-X-X		IC-618-X
22	.600 V	24-6513-10	300-22-XX-X		ICC-624-X
22	SPC	—	—	—	—
13	SPC	—	—	—	—
12	.300 V	12-513-10			
14	.300 V	14-511-10	102-14-X-X-X	ICL-143-S6-X	ICC-314
14	.600 V	14-6511-10	300-14-X-X-X		IC-614-X
20	.300 H	20-511-10	102-20-CC-X-X	ICL-203-S6-X	ICC-320
10	SPC	—	—	—	—
10	.300 V				IC-310-X
10	.600 V	10-6511-10			IC-610-X
18	.300 V	18-511-10	102-18-X-X-X		ICC-318
6	.300 B	6-513-10	102-06-X	ICN-063-S3-X	IC-306-X
8	.300 B	8-511-10	102-8-X-X-X	ICN-083-S3-X	IC-308
16	.300 B				
2-20	.100 B	PIN-LINE SERIES	SERIES 200 SERIES 2002	SB-25-100X	SSA-1XX-XSERIES ICK-1XX-XSERIES
Others		Yes	Yes	Yes	

List of Possible Vendors

Aries Electronics Co.
P.O. Box 130
Frenchtown, NJ 08825
201-996-6841

Garry Manufacturing
1010 Jersey Ave.
New Brunswick, NJ 08902
201-545-2424

Robinson-Nugent
800 E. Eighth St.
New Albany, IN 47150
812-945-0211

Samtec
810 Progress Blvd.
New Albany, IN 47150
812-944-6733

Notes:
1. All sockets are 0.100 pin-to-pin spacing.
2. Products listed are generally tin plated PCB solder type. Contact vendor for other types.
3. Row-row spacing of pins: (H)-pins are horizontal with respect to viewing of display; (V)-pins are vertical with respect to viewing of display; (B)-pins can be either horizontal or vertical; (SPC)-pins not standard 0.100 or row-row spacing.
4. Others — Special sockets for display such as right angle, etc. Contact vendor for details.
5. Consult vendor for stackability.
6. Strip in-line sockets may be used. (Cut to length required.)
7. Vendor may have other products also suitable for your application.

SIEMENS

LED Filter Selection Guide Appnote 23

By Dave Takagishi

The most important design consideration for a piece of equipment using LED products is the ability to display information to an observer clearly. This information must be easily and accurately recognized in various ambient light conditions. This application note will discuss the design considerations and recommendations for filtering.

Since the quality of readability is very subjective, the best judge of the performance of a product is the human eye and in the user's conditions. To improve the readability of a display it will be necessary to employ certain techniques such as contrast enhancement, wavelength filtering, special filtering, and mounting.

Contrast Enhancement

The objective of contrast enhancement is to maximize the contrast between the display segments 'ON' and 'OFF' states. This is done by reducing the ambient light reflected from the surface of the display and allowing as much of the emitted light to reach the observer. This can be accomplished by painting the front surface of the display to match as close as possible the color of an 'OFF' segment. This reduces the distracting areas around the display and therefore enhances the 'ON' segments.

Contrast enhancement may be improved further by the use of selected wavelength filters. Under bright ambient conditions, contrast enhancement is more difficult and additional techniques such as louvered filters and/or shading may be necessary.

Filters

The majority of display applications use plastic filter material for their low cost and ease of assembly. The filter requirements for different ambient lighting conditions and different color displays make it necessary to become familiar with the various relative transmittance characteristics. Most filter manufacturers will provide transmittance curves for their products.

When selecting a filter, the shape of the transmittance curve vs wavelength should be considered in relationship to the LED radiated spectrum to obtain maximum contrast enhancement. For standard red displays, a long wavelength pass filter having a sharp cutoff in the 600nm to 620nm range is ideal. The same applies for high efficiency red displays with a long wavelength pass filter in the 570nm to 590nm range. The yellow and green displays are more difficult to filter effectively. The most effective filter for yellow displays is a yellow-orange or amber filter. Yellow-only filters are very poor for contrast enhancement. Green displays will require a band-pass yellow-green filter which peaks at 565nm.

A choice among available filters must be made on the basis of which filter and LED combination is most effective, but experimentation with each choice must be made to choose the most esthetic combination.

Effectiveness of Wavelength Filters with Different Lighting

Contrast is very dependent upon the ambient lighting. If the ambient light is outside the spectrum of the LED, then it is very easy to reduce the reflected light. This is the case for a red LED display in fluorescent lighting or a green LED in incandescent lighting. Bright sunlight has a flat spectral distribution curve and when it is directly incident upon a display the background may meet or exceed the light output of the display. It should be obvious that a wavelength filter alone is not sufficient in daylight ambient conditions.

Other Techniques

An acceptable contrast is difficult to achieve if high ambient light is parallel to the viewing axis (the incident light is perpendicular to the face of the display). If the incident light is not parallel to the viewing axis, the use of louvered filters or shading and recessing is recommended. It is the shading of louvered filters that reduces the incident light to allow for more contrast. The drawback to this filter is the restricted viewing angle.

Circular polarizing filters are effective in reducing the reflected light from the highly reflective (glossy) surfaces of bubble lensed products, such as the Intelligent Displays.

Glare can still be present from the surface of filters, therefore, an anti-reflection surface is recommended. This can be incorporated into the filter. The trade-off is that both ambient and display light are diffused and the display may appear fuzzy if not mounted close enough to the filter.

Care should be taken to design the printed circuit board to keep all reflective surfaces away from display area or display side of the board or consider a dark coating on the reflective surfaces.

Mounting Considerations

The designer should consider recessing the display and bezel assembly to add some shading effect. The shading will reduce the indirect lighting for better contrast.

It is essential to design the unit to allow sufficient air flow for circulation and mount current limiting resistors on another board or any heat generating components away from the displays.

Filter Recommendations

Visible Filters

Manufacturer	Red	Hi-Eff	Ylw	Grn	Spcls
Homalite	1605	1670	1720 1726	1425 1440	
Panelgraphic	Red 60 Red 63	Red 65	Ylw 25 Amb 23	Grn 48	Gray 10
Rohm & Haas	2423	2444			2412
3-M					Louvered Filters
Polaroid					Circular Polarizing

Near IR Filter

Rohm & Haas	Red #2711

Filter Material Manufacturers

Panelgraphic Corporation
10 Henderson Drive
West Caldwell, New Jersey 07006
201-227-1500

SGL Homalite
11 Brookside Drive
Wilmington, Delaware 19804
302-652-3686

3M Company
Visual Products Division
3M Center, Bldg 220-10W
St. Paul, Minnesota 55101
612-733-0128

Rohm and Haas
Independence Mall West
Philadelphia, Penn 19105
215-592-3000

Polaroid Corporation
Polarizer Division
549 Technology Square
Cambridge, Mass 02139
617-864-6000

Dontech Inc.
P.O. Box 889
Doylestown, PA 18901
215-348-5010

ESCO Products Inc.
171 Oak Ridge Road
Oak Ridge, NJ 07438
201-697-3700

Bezel & Filter Assembly Manufacturers

R.M.F. PRODUCTS
P.O. Box 413
Batavia, IL 60510
312-879-0020

NOBEX COMPONENTS
Nobex Division
Griffith Plastic Corp.
1027 California Dr.
Burlingame, CA 94010
415-342-8170

PHOTO CHEMICAL PRODUCTS
OF CALIFORNIA
1715 Berkeley St.
Santa Monica, CA 90404
213-828-9561

I.E.E.-Atlas
Industrial Electronic Engrs Inc.
7740 Lemona Avenue
Van Nuys, CA 91405
213-787-0311

SIEMENS

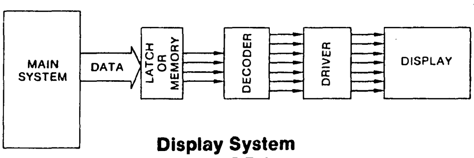
Drivers For Light Emitting Displays Appnote 24

by Dave Takagishi

The purpose of this application note is to provide some information on the integrated circuits presently available to drive Light Emitting Diodes (LED) displays and how to interface them to the various displays.

Background

LED displays come in various sizes (0.1" to 0.8"), colors (red, high-efficiency red, green, yellow), fonts (7/9/14/16 segment, dot-matrix, or bar graph), and types (common anode, common cathode, multi-digit). The brightness is essentially proportional to the current through an LED and each element within a display should have the same current or a brightness variation may be apparent. A display subsystem can be made up from several elements.



Display System
FIGURE 1

The partitioning of these elements are dependent on the drivers used; therefore, the display driver chosen is dependent on the specifications of the display and the application.

Also some types of displays require using a multiplexing technique because of the internal interconnections. This is only applicable for multi-digit displays.

Typical Circuits

Figure 2 shows a very basic circuit for driving an LED. The series resistance can be easily calculated from the following formula.

$$Rs = \frac{Vb - Vf}{If}$$

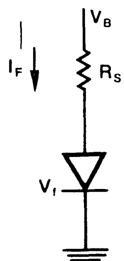
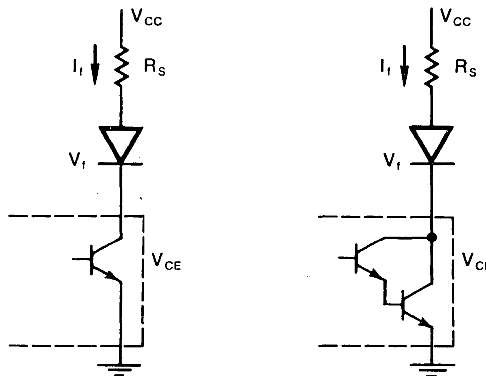


FIGURE 2

For circuits using TTL Logic or transistors (fig 3).

$$Rs = \frac{Vcc - Vce - Vf}{If}$$



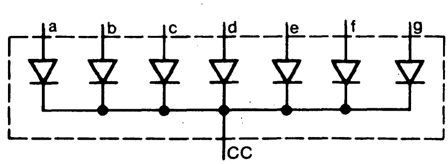
TTL or Transistor **Darlington Transistor**

FIGURE 3

It can be seen that the term Vce(saturation voltage) for the driver is going to be a factor in determining the series limiting resistor. Therefore, a darlington vs a single output transistor will have different current limiting resistor values to maintain a constant current through the LED.

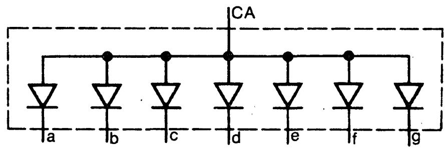
Selection

One factor in choosing the display and/or driver will be whether the display is a common cathode or common anode type display.



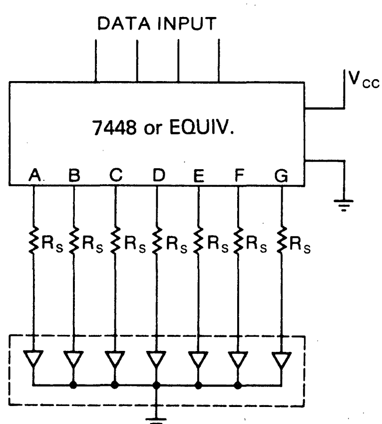
Common Cathode Display
FIGURE 4

Application Notes

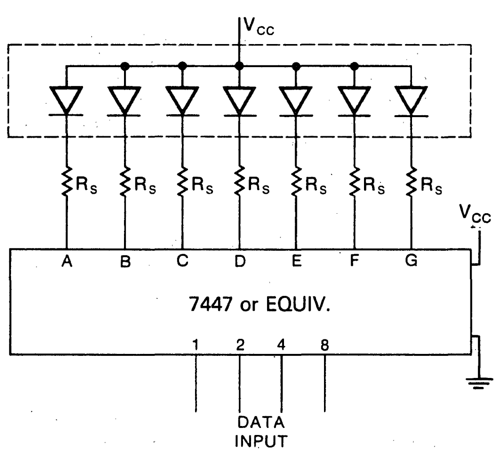


Common Anode Display
FIGURE 5

Another factor is the different drivers go low or high,

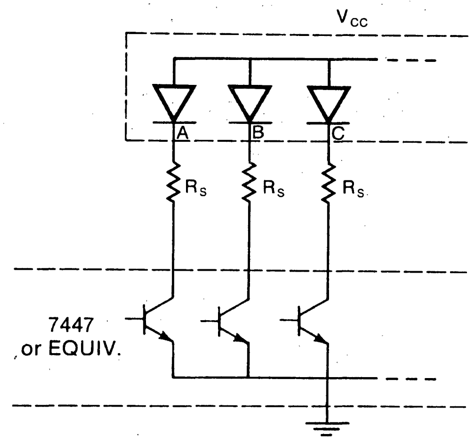


Common Cathode Display w/Driver
FIGURE 6

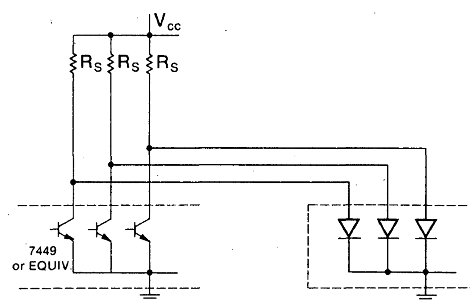


Common Anode Display w/Driver
FIGURE 7

or can be wired into different configurations.



Open Collector Type Driver
w/Common Anode Display
FIGURE 8



Open Collector Type Driver
w/Common Cathode Display
FIGURE 9

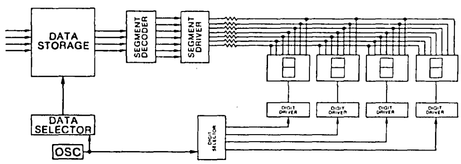
From figures 6/7/8/9, it may appear obvious to combine the seven (7) series resistors (Rs) into one common resistor in the common line. However this should not be done because of the possible variation in Vf from segment to segment. This variation in Vf can cause a variation in current, resulting in segment brightness differences.

Table 1 is a list of some of the most common LED drivers available. Besides having different current drive capabilities, one product may have a feature which may make them easier to use in a particular application.

- Serial vs parallel input data
- Data latching type drivers
- Blanking
  - Drive the ripple blanking input (rbo) with pulse width modulation to vary brightness.
- Multi-digit drivers
- Constant current drivers
- Advantage of a constant current driver is the change of Vf will not affect the brightness. This is important with different color LED's.

Multiplexing

In a multiplex system, the corresponding segment of each digit is bussed together and driven from one segment drive via the usual current limiting resistors. The display data is presented serially by digit to the decoder driver together with the appropriate digit signal (figure 10). For more information on multiplexing, see Appnote #3 (Multiplexing LED Displays).



Block Diagram of a 4-Digit Multiplexed Display
FIGURE 10

One way to simplify the design procedure for alphanumeric displays would be to consider the Siemens Intelligent Displays®. This device family incorporates all necessary interface control with drivers and memory built-in with the display. This means the designer need not be concerned about the memory, multiplex circuitry, character generator, or drivers for these are provided inside a modular unit. More information on these products is available in the Siemens Opto Short Form Catalog or general catalog.

Circuits herein mentioned are not the responsibility of Siemens Opto and are for reference only. Products are continually being improved by vendors and/or are obsoleted; therefore, consultation with the factory is recommended.

TABLE 1

Single Digit Decoder/Drivers

PART #	MFGR	If/seg	TYPE	COMMENTS
7447 74247 7446	Fairchild Hitachi Motorola National Signetics Teledyne TI	40 ma	CA	BCD-to-7 seg, open coll, ripple blnkng
7448 74248	Fairchild Hitachi Motorola National Signetics TI	6 ma	CC	BCD-to-7 seg, int pull-up, ripple blnkng
7449 74249	Fairchild Hitachi Motorola National Signetics TI	8 ma	CC	BCD-to-7 seg, open coll, blnkng input
DS8857	National	60 ma	CA	BCD-to-7 seg decoder, ripple blnkng
DS8858	National	50 ma	CC	BCD-to-7 seg decoder, ripple blnkng
CD4511 4511B MC14511	Fairchild National Motorola	25 ma	CC	BCD-to-7 seg, latched, blnkng
DS8647 DS8648	National	10 ma	CC	9 seg drivers
NE587	Signetics	50 ma	CA	BCD-to-7 seg, latched, ripple blnkng, vari current
NE589	Signetics	50 ma	CC	BCD-to-7 seg, latched, ripple blnkng, vari current
CA3161E	RCA	25 ma	CA	BCD-to-7 seg, constant current drivers
9368	Fairchild	20 ma	CC	BCD-to-7 seg, ripple blnkng
9374	Fairchild	15 ma	CA	BCD-to-7 seg, ripple blnkng

TABLE 1, Continued

Multi-Digit Display Drivers:

MM5450	National	25 ma	CA	34 seg serial input, brightness control
MM5451	National	25 ma	CA	35 seg serial input, brightnes control
MM74C912	National	100 ma	CC	6 digit, 7 seg+decimal, BCD decoder, output enble
MM74C911	National	100 ma	CC	4 digit, 8 seg controller/seg driver
MM74917	National	100 ma	CC	6 digit, 7 seg+decimal, Hex decoder, output enble
DS8669	National	25 ma	CA	Dual BCD-to-7 seg decoder/driver
CA3168E	RCA	25 ma	CA	Dual BCD-to-7 seg decoder/driver
ICM7212 ICM7212A ICM7212M ICM7212AM	Intersil	8 ma	CA	4 digit, latched, 28 seg drivers, brightness cntl
ICM7218A	Intersil	20 ma	CA	8 digit, 8 seg (decoded/spcl), w/mem/drivers
ICM7218B	Intersil	10 ma	CC	8 digit, 8 seg (decoded/spcl), w/mem/drivers
ICM7218C	Intersil	20 ma	CA	8 digit, 8 seg(hex/bcd), w/mem drivers
ICM7218D	Intersil	10 ma	CC	8 digit, 8 seg(hex/bcd), w/mem/drivers
ICM7218E	Intersil	20 ma	CA	8 digit, 8 seg (decoded/spcl), w/mem drivers, cntls avble
TSC700A	Teledyne	11 ma	CA	4 digit decoder/driver, parallel output, brightness cntl
TSC7212A	Teledyne	5 ma	CA	4 digit decoder/driver, parallel output, brightness cntl
SAA1060	Signetics	40 ma	CA	16 element serial in/parallel out driver
SDA2014	Siemens	12 ma	CC	2 or 4 digit, serial bcd input
SDA2131	Siemens	20 ma	CA	16 element, serial input

Other Drivers:

XR-2000	Exar	400 ma	sink	5 darlington transistors, MOS-to-LED
XR-2201 XR-2202 XR-2203 XR-2204	Exar	500 ma	sink	7 darlington transistors, open collector w/diodes TTL-to-LED, compatible to Sprague (ULN-xxxx)
CA3081	RCA	100 ma	sink	7 common emitter transistor array
CA3082	RCA	100 ma	source	7 common collector transistor array
9665 9667	Fairchild	250 ma	sink	7 common emitter darlington transistor array

Bar Graph Drivers:

UAA180	Siemens	10 ma	n.a.	12 element bar driver
LM3914	National	2-20 ma	n.a.	10 element dot/bar linear output driver
LM3915	National	1-30 ma	n.a.	10 element dot/bar log output driver

SIEMENS

The DLX 713X, 5 x 7 Dot Matrix Intelligent Display® Device Appnote 25

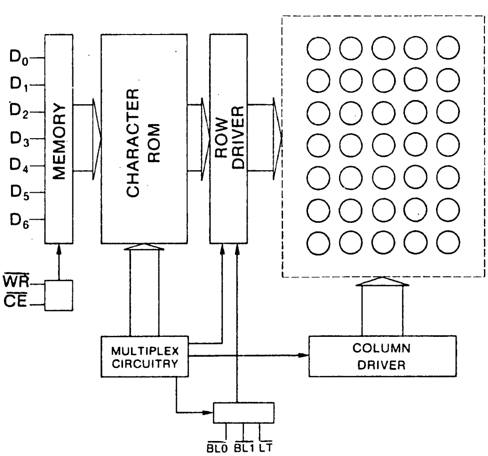
by Dave Takagishi

This application note is intended to serve as a design and application guide for users of the DLO 7135, and DLG 7137 Siemens Optoelectronics Division Intelligent Displays. The information presented covers device electrical description, operation, general circuit design considerations, and interfacing to microprocessors.

Electrical Description

The DLX 713X Intelligent Alphanumeric 5 x 7 Dot Matrix Display contains memory, character generator, multiplexing circuits, and drivers built into a single package.

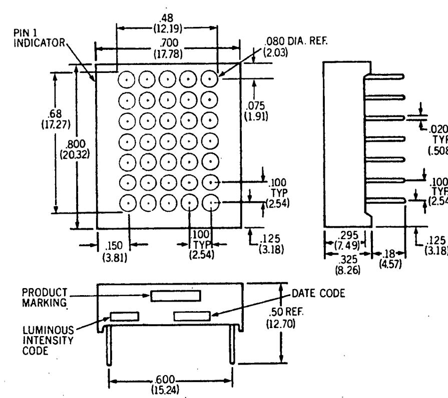
Figure 1 is a block diagram of the DLX 713x. The unit consists of 35 LED die arranged in a 5x7 pattern and a single CMOS integrated circuit chip. The IC chip contains the column drivers, row drivers, 96 character generator ROM, memory, multiplex and blanking circuitry.



DLX-713x Block Diagram
FIGURE 1

Package

The 35 dots form a 0.48 x 0.68 inch overall character size in a 0.700 x 0.800 inch dual-in-line package. The ±50 degree wide viewing angle complements the large display and is the ideal display for the industrial control application. Display construction is a filled reflector type with the intregrated circuit in the back and then filled with IC-grade epoxy. This results in a very rugged part which is quite impervious to moisture, shock, and vibration.



Physical Dimension Inches
FIGURE 2

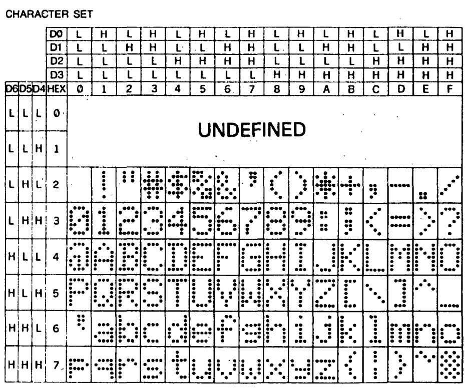
Electrical Inputs

PIN	Name	PIN	Name
1	Vcc	14	D6 data input (msd)
2	$\overline{LT}$ lamp test	13	D5 data input
3	$\overline{CE}$ chip enable	12	D4 data input
4	$\overline{WR}$ write	11	D3 data input
5	$\overline{BL1}$ brightness	10	D2 data input
6	$\overline{BL0}$ brightness	9	D1 data input
7	GND	8	D0 data input (lsd)

Application Notes

Pin Description

Vcc	Positive Supply +5 volts
GND	Ground
D0-D6	Data Lines see figure 3 for character set
$\overline{CE}$	Chip Enable (active low) This determines which device in an array will accept data
$\overline{WR}$	Write (active low) Data and chip enable must be present and stable before and after the write pulse (see data sheet for timing)
$\overline{BL0}$,$\overline{BL1}$	Blanking Control Input (active low) Used to control the level of display brightness
$\overline{LT}$	Lamp Test (active low) Causes all dots to light at ½ brightness



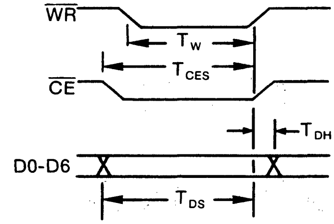
Character Set
Figure 3

Operation

In a dot matrix display system, it is advantageous to use a multiplexed approach with 12 drivers (5 digit + 7 segments) rather than 35 segment drivers. This obviously reduces the number of drivers and interconnections required. A multiplexed system must be a synchronous system or the digits or elements may have different on (lit) times and therefore varying brightness.

The DL*X* 713*x* is an internally multiplexed display but the data entry is asynchronous. Loading data is similar to writing into a RAM. Present the data, select the chip, and give a write signal. For a multi-digit system, each digit has its own unique location and will display its contents until replaced by another code.

The waveforms of figure 4 demonstrates the relationship of the signals required to generate a write cycle. Check the data sheet for minimum values required for each signal.



Timing Characteristics
Figure 4

Display Blanking and Dimming

The DL*X* 713*x* Intelligent Display has the capability of three levels of brightness plus blank. Figure 5 shows the combination of $\overline{BL0}$ and $\overline{BL1}$ for the different levels of brightness. The $\overline{BL0}$ and $\overline{BL1}$ inputs are independent of write and chip enable and does not affect thecontents of the internal memory. A flashing display can be achieved by pulsing the blanking pins at a 1-2 hertz rate. Either $\overline{BL0}$ or $\overline{BL1}$ should be held high to light up the display.

Dimming and Blanking Control

Brightness Level	$\overline{BL1}$	$\overline{BL0}$
Blank	0	0
¼ brightness	0	1
½ brightness	1	0
full brightness	1	1

Figure 5

Lamp Test

The lamp test when activated causes all dots on the display to be illuminated at half brightness. It does not destroy any previously stored characters. The lamp test function is independent of chip enable, write, and the settings of the blanking inputs.

This convenient test gives a visual indication that all dots are functioning properly. Because of the lamp test not affecting the display memory, it can be used as a cursor or pointer in a line of displays.

General Design Considerations

When using the DLX 713*x* on a separate display board having more than 6 inches of cable length, it may be necessary to buffer all of the input lines. A non-inverting 74365 hex buffer can be used. The object is to prevent transient current into the DLX 713*x* protection diodes. The buffers should be located on the display board and as close to the displays as possible.

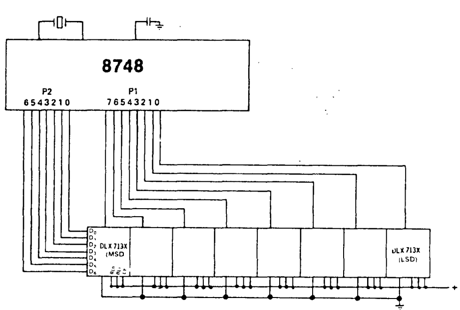
Because of high switching currents caused by the multiplexing, local power supply by-pass capacitors are also needed in many cases. These should be 6 or 10 volt, tantalum type having 5 - 10 uf capacitance. The capacitors may only be required every 6-7 displays depending on the line regulation and other noise generators.

If small wire cables are used, it is good engineering practice to calculate the wire resistance of the ground and the +5 volt wires. More than 0.2 volt drop (at 100ma per digit) should be avoided, since this loss is in addition to any inaccuracies or load regulation of the power supply.

The 5 volt power supply for the DLX 713*x* should be the same one supplying the Vcc to all logic devices. If a separate supply must be used, then local buffers should be used on all the inputs and these buffers should be powered from the display power supply. This precaution is to avoid line transients or any logic signals to be higher than Vcc during power up.

Interfacing

For an eight digit display using the DLX 713x, interfacing to a single chip microprocessor such as the 8748 is easy and straight forward. One approach may be to dedicate one port for the seven data signals and another 8-bit port for the write signals. The schematic is shown in Figure 6.

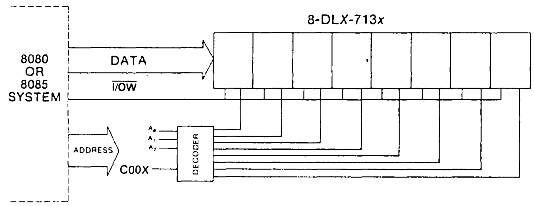


DLX 713x with 8748
Figure 6

```
                          ; SUBROUTINE TO LOAD AN 8-DIGIT
                          ; DISPLAY USING THE DL7135
                          ; DATA IN RAM 10H-17H (MSD-LSD)
INIT:   ORL   P1,#0FFH    ; PORT 1 ALL HIGH (WRITE)
        ORL   P2,#00H     ; PORT 2 ALL LOW (DATA)
        MOV   R1,#0FH     ; RAM ADDRESS — 1
        MOV   R2,#0FEH    ; WRITE PULSE
        MOV   R3,#08H     ; COUNTER
START:  INC   R1          ; INCREMENT RAM POINTER
DATA:   MOV   A,@R1       ; FETCH DATA FROM RAM
        OUTL  P2,A        ; LOAD PORT 2
        MOV   A,R2        ; RECALL WRITE
        RR    A           ; SHIFT A TO NEXT WRITE
        MOV   R2,A        ; SAVE WRITE
WRITE:  OUTL  P1,A        ; SEND WRITE PULSE
        MOV   A,#0FFH     ; WAIT
        OUTL  P1,A        ; RESET WRITE PULSE
        DJNZ  R3, START   ; LOAD COMPLETE?
        RET               ; RETURN TO MAIN PROGRAM
```

I/O or Memory Mapped System

For a memory mapped system using a processor such as the 8080 or 8085, the interfacing is also straight-forward. Each display is treated as a memory location with its own address, like another I/O or RAM location. See Figure 7.



Block Diagram for 8-Digit DLX 713*x* Dot Matrix Display
Figure 7

```
                          ; ROUTINE FOR AN 8 DIGIT DISPLAY
                          ; USING THE DLX 713x AND
                          ; 8085 OR 8080 MICROPROCESSOR
                          ;
                          ; DATA TO BE DISPLAYED IS IN
                          ; A0(LSD) THRU A8(MSD)
                          ;
                          ; DISPLAY ADDRESS C00X
                          ; LSD IS RIGHT MOST DIGIT
                          ;
                          ; DOES NOT SAVE REG A,B,H,L,D,E
                          ;
DADD    EQU   0A000H      ; DATA ADDRESS LOCATION
DPAD    EQU   0C000H      ; DISPLAY ADDRESS LOCATION
LEN     EQU   08H         ; DISPLAY LENGTH
                          ;
ORG     100H
                          ;
DISP:   LXI   H,DADD      ; LOAD DATA ADDRESS
        LXI   D,DPAD      ; LOAD DISPLAY ADDRESS
        MVI   B,LEN       ; LOAD DISPLAY LENGTH
DISP1:  MOV   A,M         ; GET DATA
        XCHG              ; XCHG H/L & D/E
        MOV   M,A         ; LOAD DISPLAY FROM REG A
        XCHG              ; RESTORE H/L & D/E
        INX   D           ; INCREMENT DISPLAY ADDRESS
        INX   H           ; INCREMENT DATA ADDRESS
        DCR   B           ; DECREMENT LENGTH COUNTER
        JNZ   DISP1       ; END OF DISPLAY?
        RET               ; RETURN TO MAIN PROGRAM
```

Conclusion

Note that although other manufacturer's products are used in the examples, this application note does not imply specific endorsement, or warranty of other manufacturer's products by Siemens. The interface schemes shown demonstrate the simplicity of using the DLX 713*x* Dot Matrix Intelligent Display. Slight timing differences may be encountered for various microprocessors, but can be resolved similar to those encountered when using different RAM's. The techniques used in the examples were shown for their generality. The user will undoubtedly invent other schemes to optimize his particular system to its requirements.

SIEMENS

SFH 900 — A Low-Cost Miniature Reflex Optical Sensor Appnote 26

Whether for an industrial plant or a hobbyists' drilling machine, an electric drive will hardly be acceptable nowadays without speed control. Incremental bar patterns simply applied to rotating shafts can be detected by the new Siemens reflex optical sensor, the SFH 900. The information can be processed with a minimum of circuitry, whether for a high rate of black-to-white transitions or just single, slow transitions.

Construction

The SFH 900 optical sensor is a remarkable component even by virtue of its shape alone. Its maximum height of 2.2 mm is in the trend of today's electronics, of putting a large number of functions into a very small space. The small dimensions allow it to be used where ordinary optical sensors run into space or other problems. **Fig. 1** is an enlarged picture of the device. Dimensions and pin configuration are shown in **Fig. 2.**

Fabricated by lead frame technique in a thermoplastic package, the sensor uses a GaAs infra-red diode as a radiation emitter and a large-area phototransistor as the detector. High sensitivity is ensured by a 1 mm² radiation sensitive area and a current gain of almost 1000. The effect of unwanted ambient light is almost screened out by a filter.

Two fixing notches are a help in mounting the device. Lead frame technology accurately locates the optically active areas relative to these notches and thus to the component body. **Fig. 3** is an example of one form of mounting.

Fig. 1 SFH 900 reflex optical sensor, front and back view, shown here three times normal size

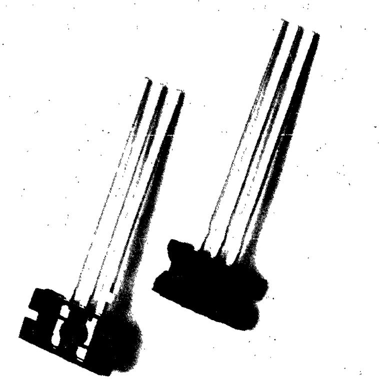
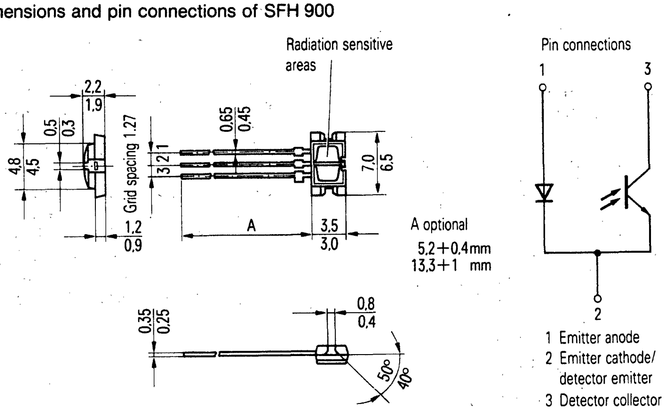


Fig. 2 Outline dimensions and pin connections of SFH 900



Characteristics

Main technical data are given in the **Table**. Turn-on and turn-off times are also important. These depend essentially on the collector current I_C and the load resistance R_L. Typical switching times for I_C = 1 mA and R_L = 1 kΩ are 50 to 70 µs.

The user will be mainly concerned with the following points:

- What collector current, I_C, can be expected under given static conditions?
- What are the signal amplitudes when scanning bar patterns of different pitches?
- What is the temperature dependence of the collector current and what is the repeatability of the measured values?

Collector current

Dependence of collector current on emitter diode forward current I_F is almost linear at forward currents above 10 mA, as can be seen from **Fig. 4.** At currents below 1 mA the dependency shows almost a square law. The measurement was made with a standard reflector (Kodak neutral white test card, r = 90%) at a distance of 1 mm. **Fig. 5** shows I_C characteristics for distances of 0.2 to 10 mm at a constant forward current of 10 mA. The curves are for four different reflecting materials: two standard Kodak reflectors with 15% and 90% reflection, polished aluminium and a strongly absorbing foil. DC-fix adhesive tapes and other tapes commonly used for printed circuit layouts proved particularly suitable. It should be mentioned that the curve for polished aluminium in **Fig. 5** is very similar to the Kodak reflector response with r = 90%, in spite of the reflection being mirrored by the metal and diffused by the standard reflector, as a result of the wide directional characteristics of the emitter and detector.

At short distances (e. g. d = 0.25 mm) very large changes of current per unit distance are obtained. Because of these steep edges, which can only be used dynamically, the SFH 900 may also be utilized as a microphone.

Fig. 3 Suggestion for mounting the SFH 900. Projections N in the flexible plastic clamp locate in corresponding notches in the body of the optical sensor

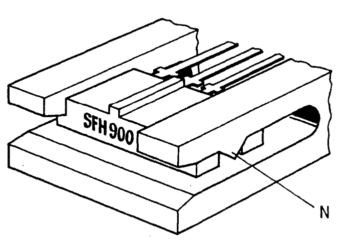


Fig. 4 SFH 900 collector current I_C as a function of forward current I_F with 90% diffuse reflectin at distance d = 1 mm and with U_S = 5 V

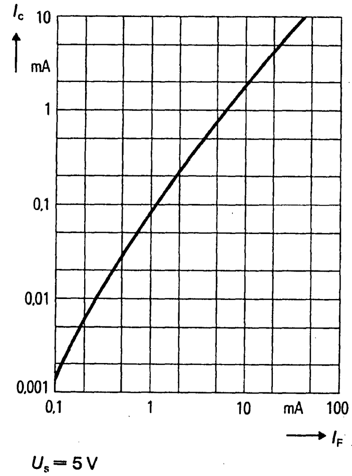
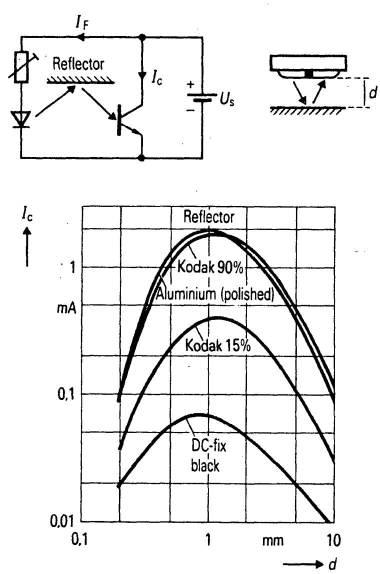


Fig. 5 SFH 900 collector current I_C as a function of reflector distance d with different reflector materials



Forward current I_F = 10 mA
Operating voltage U_S = 5 V.

Emitter (GaAs infra-red diode)				
Reverse voltage		U_R	6	V
Forward dc current		I_F	50	mA
Surge current ($t \leq 10$ µs)		i_{FSM}	1.5	A
Power dissipation (T_{amb} = 40 °C)		P_{tot}	80	mW
Thermal resistance		R_{thJU}	750	K/W
Detector (silicon phototransistor)				
Collector-emitter voltage		U_{CEO}	30	V
Emitter-collector voltage		U_{ECO}	7	V
Collector current		I_C	10	mA
Total power dissipation (T_{amb} = 40 °C)		P_{tot}	100	mW
Collector-emitter leakage current (U_{CE} = 10 V)		I_{CEO}	20 (≤ 200)	nA
Photocurrent under ambient light (U_{CE} = 5 V) (E_E = 0.5 mW/cm²)		I_P	≤ 3	mA
Reflex optical sensor				
Storage temperature range		T_S	−40 to +85	°C
Ambient temperature range		T_U	−40 to +85	°C
Junction temperature		T_j	100	°C
Total power dissipation (T_{amb} = 40 °C)		P_{tot}	150	mW
Collector current	SFH 900-1	I_{CE}	≥ 0.3	mA
(I_F = 10 mA; U_{CE} = 5 V; d= 1 mm)	SFH 900-2	I_{CE}	≥ 0.5	mA

Table Selective characteristics of SFH 900

Resolution of black-and-white patterns

As can be seen from **Fig. 5**, strongly reflecting and badly reflecting materials give collector currents differing by a factor of about 25. Strongly reflecting means »white«, badly reflecting »black«.

If a black-to-white transition is scanned, the displacement distance between the »fully white« signal and the »fully black« signal is 4 to 5 mm **(Fig. 6).**

If, in contrast, a regular bar pattern is scanned, the signal amplitude becomes smaller the smaller the bar width. **Fig. 7** shows clearly how the excursion is affected: the maximum white signal becomes smaller with decreasing bar width, while the minimum black signal becomes larger. **Fig. 8** shows the signal excursion itself, to make it clearer. Here a regular pattern and a single white bar are compared. The excursion is referred to a single black-to-white transition corresponding to a 100% signal excursion.

A bar width of 3 mm can thus be detected without significant loss of sensitivity. The signal excursion, however, drops to as low as 10% using a grid of 1 mm bar

Fig. 7 Maximum and minimum collector current when scanning a black-white pattern

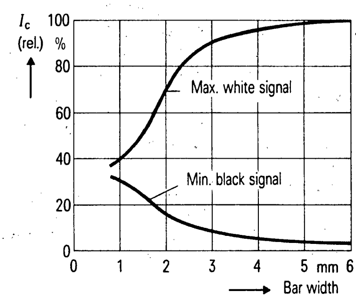
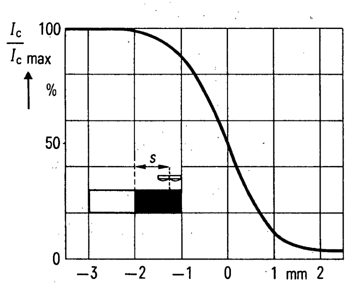


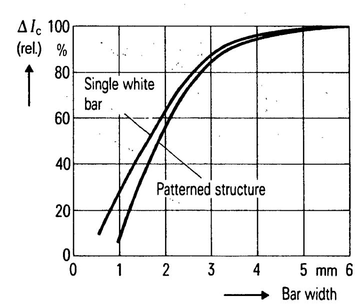
Fig. 6 Resolution of a black-to-white transition. Relative collector current as a function of sensor position s



Reflector distance d = 1 mm
Emitter diode current I_F = 10 mA

Fig. 8 Relative signal excursion as a function of white bar width

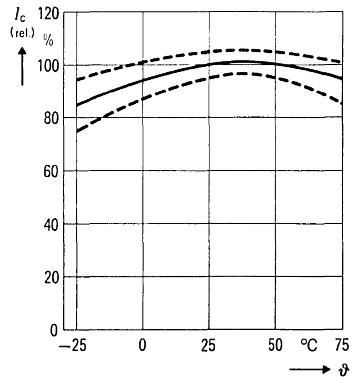
I_F = 10 mA, d = 1 mm



width. An apparently higher signal excursion is obtained when a single 1 mm wide white bar on a black background is scanned. The result is then about a 30%, as shown in **Fig. 8.**
The optical sensor can be used for scanning in any position, regardless of whether the emitter-detector axis is at right-angles to the scanning direction. Tests have shown that the device sensitivity is independent of direction. If a white spot on a black background (or vice-versa) is to be detected without loss of sensitivity, this should have a minimum area of 5×5 mm. From this we can conclude that a pattern bar must not be larger than 5 mm.
Thus the resolution capability of the SFH 900 seems to be limited to bar widths of 1 to 2 mm minimum. In fact, however, considerably higher resolutions can be obtained when gratings are used. An example is given below.

Temperature dependence
The temperature dependence of the output signal is shown in **Fig. 9.** This fortunately very small dependence results from the combination of the temperature dependent diode emission (approx. −0.55%/K) with the temperature dependent current gain of the phototransistor (approx. +0.9%/K). As these two parameters partly compensate for each other the temperature dependence of the output signal is fairly small.
There is a spread of characteristics in the different devices but they remain within the specified tolerance range, allowing for ageing, with a probability of at least 95%.

Fig. 9 Relative collector current as a function of temperature



U_s = 5 V d = 1 mm
I_F = 10 mA r = 90%
—— typical response
---- spread of characteristics
(including long-term effects)

Applications

Speed control for dc motors
A simple speed regulator circuit for small dc motors can be designed using the TCA 955 device. **Fig. 10** is an example. The teeth of a toothed wheel on the motor shaft serve as reflectors (40 teeth on a wheel of approx. 60 mm diameter). Pulses from the optical sensor are converted by the TCA 955 into a dc voltage proportional to speed. The pulse signal is first amplified, then frequency doubled, then fed to a monostable which produces a square wave with a constant pulse duration determined by the R_1 C_1 product. The mean value of this pulse train is determined by capacitor C2 and an 8.7 kΩ internal resistor.
The voltage present at C2, still with a slight triangular modulation, is compared with an internal set value. The difference is amplified and determines the duty cycle in the subsequent mark-to-space ratio converter. The motor is connected to the operating voltage via a BD 675 switching stage, which runs to the rhythm of the duty cycle. A larger mark-to-space ratio causes the speed to increase. The desired frequency can be set by P1 over a wide range.

Speed control for ac motors
This is mainly intended for use in the consumer field, in such things as kitchen appliances and drilling machines. It is important that the speed indicator should have a very low current consumption as it is supplied from a simple line rectifier circuit using a series resistor. The specimen circuit in **Fig. 11** has an emitter diode current of only 2 mA. Signal processing and triac triggering are done by the new TLB 3101 phase control IC. Total current needed for control is around 7 mA, including the SFH 900.
Pulses from the optical sensor are first amplified, then converted by a monostable to constant pulse width and finally filtered to give a mean value. By comparison with a sawtooth voltage the gate trigger time for the triac is fixed. A soft start is given by transistor T1.
The range of speed regulation is 5000 to 15000 rpm. The reflector is a disc mounted on the motor shaft, and at its periphery this disc has, as an example, 5 pairs of black and white segments.

Shaft encoder with direction sensing
This example shows how gratings can be used to give a considerable increase in resolution. A transparent disc of about 130 mm diameter has an array of 200 opaque bars at its periphery **(Fig. 12a).** The bar width is thus about 1 mm. A second grating with reflecting white bars is placed under the disc. If the disc pattern and the grating beneath are set gap to gap, the detector »sees« 100% black. If the bars of the two gratings are on top of each other the image appears as 50% white. So, when the disc is rotating the useful amplitude is therefore about 50% of the full black-to-white excursion.
The grating pattern is constructed so that one half is displaced by 90° of a grid period with respect to the other half. If a reflex optical sensor is assigned to each half, on rotation of the disc the output signals will be roughly sinusoidal and displaced by 90° from each other. This means that patterns of half bar width can be successfully resolved.
In further processing both sinewave voltages are converted into square waveforms, also phase-shifted by 90° **(Fig. 13).**

Fig. 10 Speed regulator using SFH 900 reflex optical sensor and TCA 955 integrated speed control

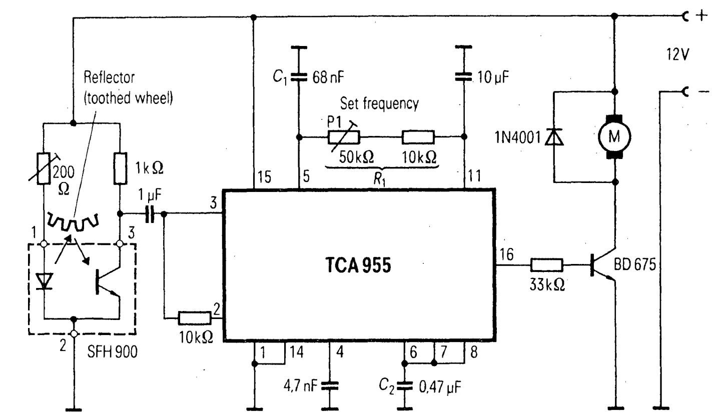
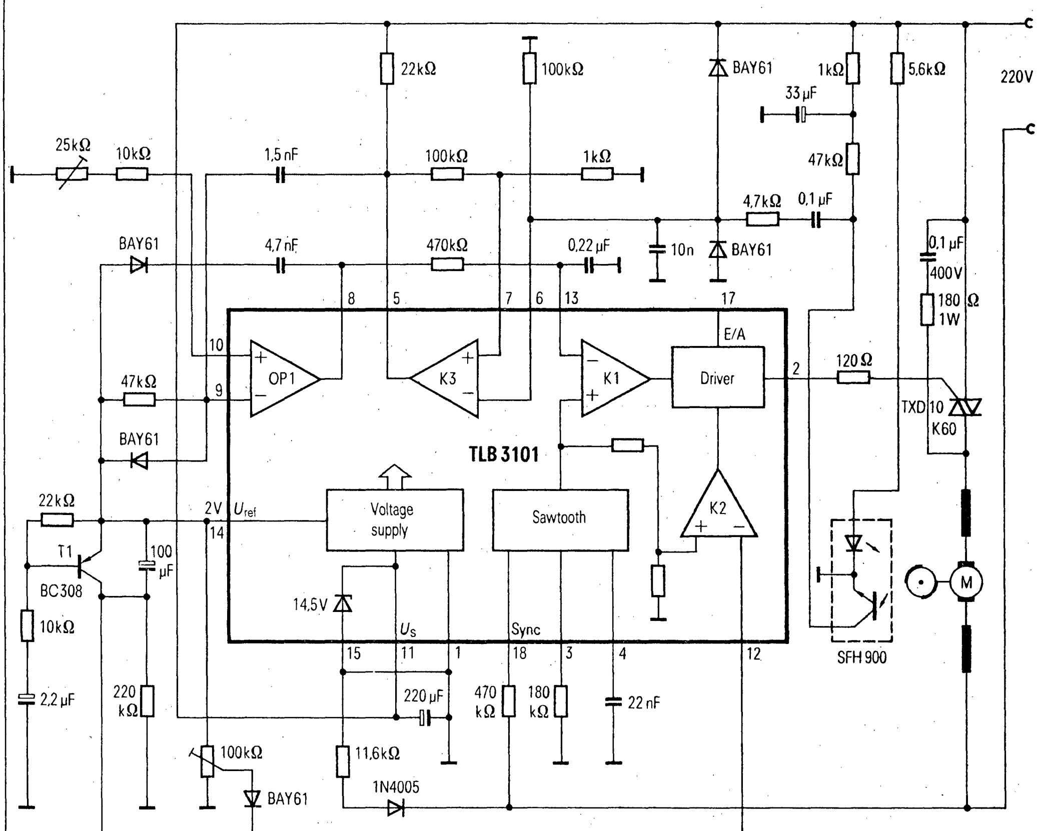


Fig. 11 Speed regulator for an ac motor using SFH 900 and TLB 3101



The rising edge of on square-wave (signal 1) is used for counting. It triggers a monoflop which generates a pulse of short duration relative to the square-wave period. The other, 90° shifted, square-wave controls the direction of the counter (Low = forward, High = backward).
According to the direction command, the conditions in **Fig. 13** come into effect. The active clock edge coincides with either the low level or the high level of signal 2. Counting therefore takes place in accordance with forward or backward rotation of the shaft. **Fig. 14** gives the detailed circuit diagram of the shaft encoder.
The counter used has a range of two decades and gives the BCD separately for each digit.
A 7-segment decoder-driver follows this for each of the two LED displays. The number of digits can be increased by cascading several stages.
For the purposes of explanation any bar in the pattern can be considered as the starting point and the counter reset to zero using the reset key. If now the disc is turned at any speed in either direction with respect to the stationary mark, the counter indicates the bar number difference with respect to the starting point. As only dc voltage coupling is used the rotational speed may have any arbitrary minimum value.

Fig. 13 Waveforms showing the operation of a shaft encoder with direction sensing

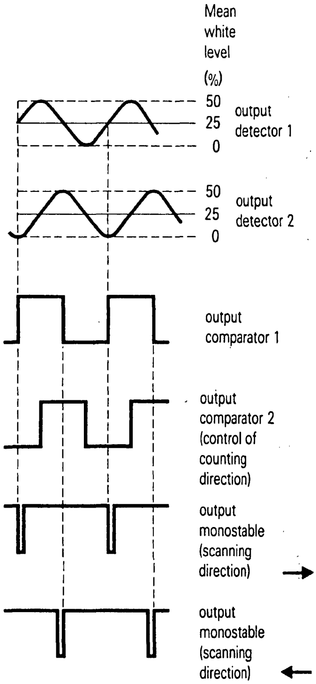
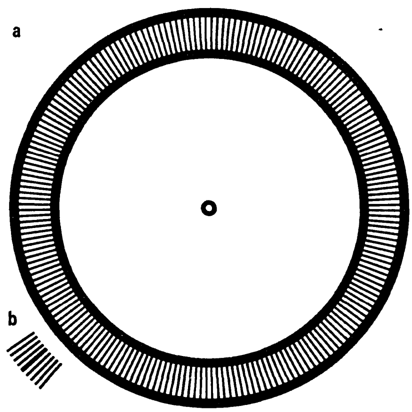
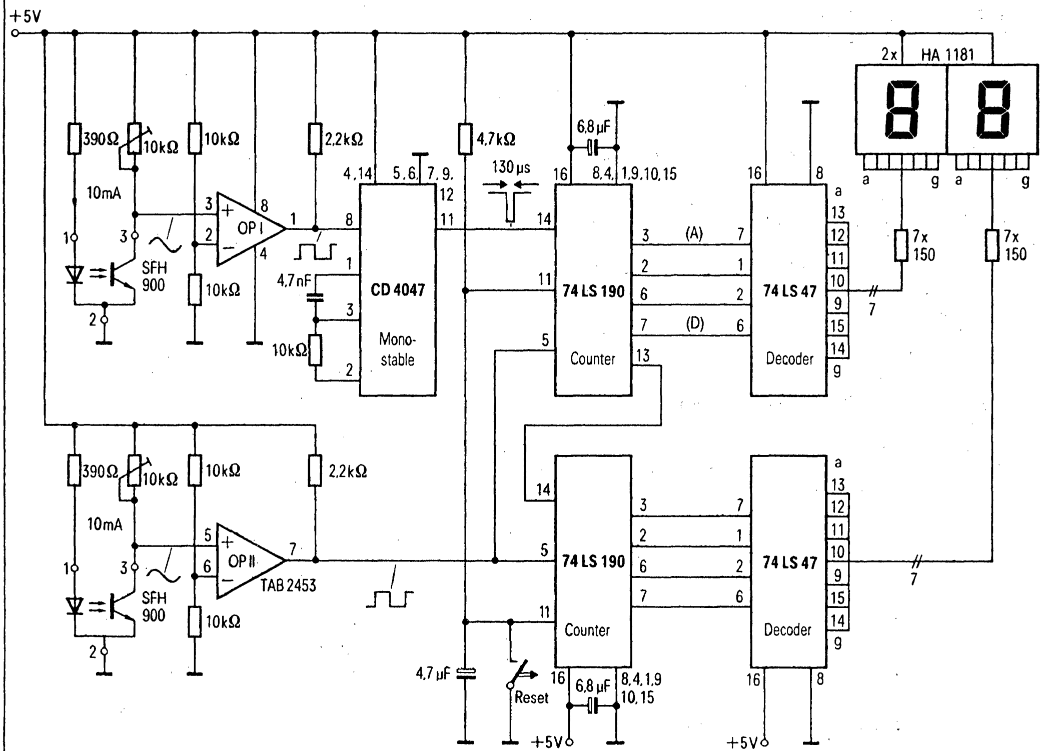


Fig. 12 Example of a patterned disc (a) and its counting grid (b)



Application Notes

Fig. 14 SFH 900: circuit for shaft encoder with direction sensing



SIEMENS

The DLO 4135/DLG 4137 5 x 7 Dot Matrix Intelligent Display® Appnote 28

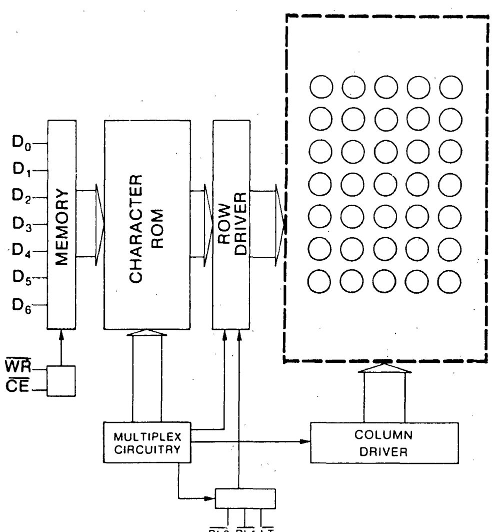
by Dave Takagishi

This application note is intended to serve as a design and application guide for users of the DLO 4135 and DLG 4137 Siemens Opto Intelligent Displays. The information presented covers device electrical description, operation, general circuit design considerations, and interfacing to microprocessors.

Electrical Description

The DLO 4135/DLG 4137 Intelligent Alphanumeric 5 x 7 Dot Matrix Display contains memory, character generator, multiplexing circuits, and drivers built into a single package.

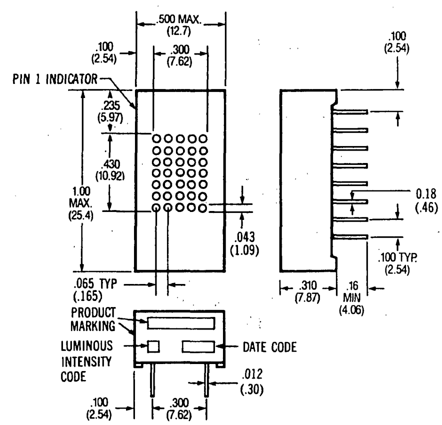
Figure 1 is a block diagram of DLO 4135/DLG 4137. The unit consists of 35 LED die arranged in a 5x7 pattern and a single CMOS integrated circuit chip. The IC chip contains the column drivers, row drivers, 96 character generator ROM, memory, multiplex and blanking circuitry.



DLO 4135/DLG-4137 BLOCK DIAGRAM
FIGURE 1

Package

The 35 dots form a 0.30 x 0.43 inch overall character size in a .500 x 1.00 inch dual-in-line package. The ±50 degree wide viewing angle complements the display and is the ideal display for industrial control applications. Display construction is a filled reflector type with the integrated circuit in the back and then filled with IC-grade epoxy. This results in a very rugged part which is quite impervious to moisture, shock, and vibration.



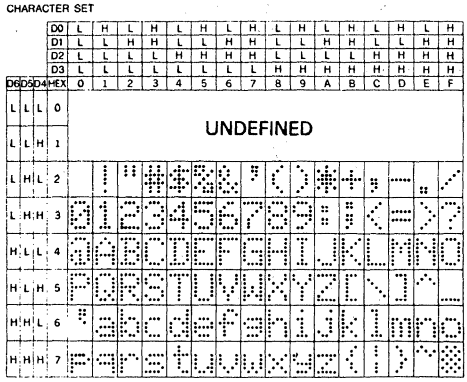
Physical Dimensions in Inches (mm)
FIGURE 2

DLO 4135/DLG 4137 PIN FUNCTIONS			
PIN	FUNCTION	PIN	FUNCTION
1	$\overline{LT}$ LAMP TEST	9	D0 DATA LSB
2	$\overline{WR}$ WRITE	10	D1 DATA
3	$\overline{BL1}$ BRIGHTNESS	11	D2 DATA
4	$\overline{BL0}$ BRIGHTNESS	12	D3 DATA
5	NO PIN	13	D4 DATA
6	NO PIN	14	D5 DATA
7	$\overline{CE}$ CHIP ENABLE	15	D6 DATA MSB
8	GND	16	+ VCC

Pin Description

Vcc	Positive Supply +5 volts
GND	Ground
D0-D6	Data Lines see figure 3 for character set
$\overline{CE}$	Chip Enable (active low) This determines which device in an array will accept data
$\overline{WR}$	Write (active low) Data and chip enable must be present and stable before and after the write pulse (see data sheet for timing)
$\overline{BL0}$,$\overline{BL1}$	Blanking Control Input (active low) Used to control the level of display brightness
$\overline{LT}$	Lamp Test (active low) Causes all dots to light at ½ brightness

CHARACTER SET



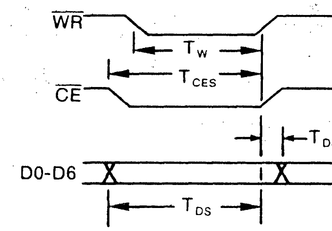
Character Set
FIGURE 3

Operation

In a dot matrix display system, it is advantageous to use a multiplexed approach with 12 drivers (5 digit + 7 segments) rather than 35 segment drivers. This obviously reduces the number of drivers and interconnections required. A multiplexed system must be a synchronous system, or the digits or elements may have different on (lit) times and therefore varying brightness.

The DLO 4135/DLG 4137 is an internally multiplexed display, but the data entry is asynchronous. Loading data is similar to writing into a RAM. Present the data, select the chip, and give a write signal. For a multi-digit system, each digit has its own unique address location and will display its contents until replaced by another code.

The waveforms of Figure 4 shows the relationship of the signals required to generate a write cycle. Check the data sheet for minimum values required for each signal.



Timing Characteristics
FIGURE 4

Display Blanking and Dimming

The DLO 4135/DLG 4137 Intelligent Display has the capability of three levels of brightness plus blank. Figure 5 shows the combination of $\overline{BLØ}$ and $\overline{BL1}$ for the different levels of brightness. The $\overline{BLØ}$ and $\overline{BL1}$ inputs are independent of write and chip enable and does not affect the contents of the internal memory. A flashing display can be achieved by pulsing the blanking pins at a 1-2 hertz rate. Either $\overline{BLØ}$ or $\overline{BL1}$ should be held high to light up the display.

Brightness Level	$\overline{BL1}$	$\overline{BL0}$
Blank	0	0
¼ brightness	0	1
½ brightness	1	0
full brightness	1	1

Dimming and Blanking Control
FIGURE 5

Lamp Test

The lamp test when activated causes all dots on the display to be illuminated at half brightness. It does not destroy any previously stored characters. The lamp test function is independent of chip enable, write, and the settings of the blanking inputs.

This convenient test gives a visual indication that all dots are functioning properly. The lamp test can be used as a cursor or pointer in a line of displays because it does not affect the display memory.

General Design Considerations

When using the DLO 4135/DLG 4137 on a separate display board having more than 6 inches of cable length, it may be necessary to buffer all of the input lines. A non-inverting 74365 hex buffer can be used. The object is to prevent current transient into the DLO 4135/DLG 4137 protection diodes. The buffers should be located on the display board and as close to the displays as possible.

Because of high switching currents caused by the multiplexing, local power supply by-pass capacitors are also needed in many cases. These should be 10 volt, tantalum type having 5 - 10 uf capacitance. The capacitors may only be required every 6-7 displays depending on the line regulation and other noise generators.

If small wire cables are used, it is good engineering practice to calculate the wire resistance of the ground and the +5 volt wires. More than 0.2 volt drop (at 100ma per digit) should be avoided, since this loss is in addition to any inaccuracies or load regulation of the power supply.

The 5 volt power supply for the DLO 4135/DLG 4137 should be the same one supplying the Vcc to all logic devices. If a separate power supply must be used, then local buffers should be used on all the inputs. These buffers should be powered from the display power supply. This precaution is to avoid line transients or any logic signals to be higher than Vcc during power up.

Interfacing

For an eight digit display using the DLO 4135/DLG 4137 interfacing to a single chip microprocessor, such as the 8748, is easy and straight forward. One approach may be to dedicate one port for the seven data signals and another 8-bit port for the write signals. The schematic is shown in Figure 6.

Subroutine to Load an 8-Digit Display using the DLO 4135/DLG 4137

```
                          ; DATA IN RAM 10H-17H (MSD-LSD)
INIT:   ORL   P1,#0FFH    ; PORT 1 ALL HIGH (WRITE)
        ORL   P2,#00H     ; PORT 2 ALL LOW (DATA)
        MOV   R1,#OFH     ; RAM ADDRESS — 1
        MOV   R2,#0FEH    ; WRITE PULSE
        MOV   R3,#08H     ; COUNTER
START:  INC   R1          ; INCREMENT RAM POINTER
DATA:   MOV   A,@R1       ; FETCH DATA FROM RAM
        OUTL  P2,A        ; LOAD PORT 2
        MOV   A,R2        ; RECALL WRITE
        RR    A           ; SHIFT A TO NEXT WRITE
        MOV   R2,A        ; SAVE WRITE
WRITE:  OUTL  P1,A        ; SEND WRITE PULSE
        MOV   A,#OFFH     ; WAIT
        OUTL  P1,A        ; RESET WRITE PULSE
        DJNZ  R3, START   ; LOAD COMPLETE?
        RET               ; RETURN TO MAIN PROGRAM
```

I/O or Memory Mapped System

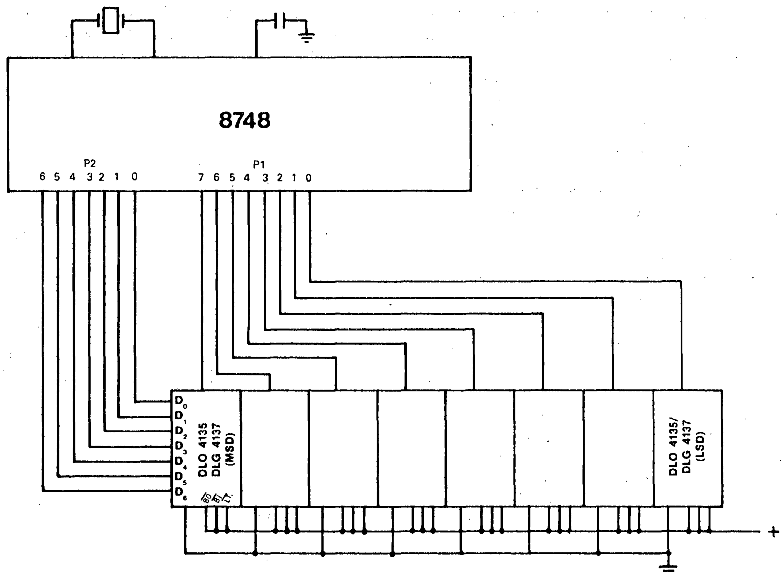
For a memory mapped system using a processor such as the 8080 or 8085, the interfacing is also straight-forward. Each display is treated as a memory location with its own address, like another I/O or RAM location. See figure 7.

Routine for an 8-Digit Display using the DLO 4135/DLG 4137 and 8085 or 8080 Microprocessor

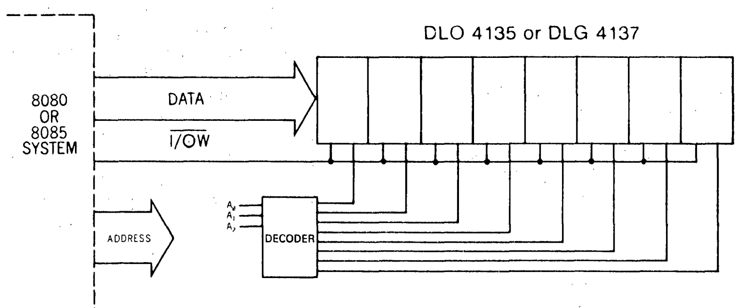
```
                          ; DATA TO BE DISPLAYED IS IN
                          ; A0(LSD) THRU A7 (MSD).
                          ;
                          ; DISPLAY ADDRESS C00X
                          ; LSD IS RIGHT MOST DIGIT
                          ;
                          ; DOES NOT SAVE REG A,B,H,L,D,E
DADD    EQU   0A000H      ; DATA ADDRESS LOCATION
DPAD    EQU   0C000H      ; DISPLAY ADDRESS LOCATION
LEN     EQU   08H         ; DISPLAY LENGTH
                          ;
ORG     100H
                          ;
DISP:   LXI   H,DADD      ; LOAD DATA ADDRESS
        LXI   D,DPAD      ; LOAD DISPLAY ADDRESS
        MVI   B,LEN       ; LOAD DISPLAY LENGTH
DISP1:  MOV   A,M         ; GET DATA
        XCHG              ; XCHG H/L & D/E
        MOV   M,A         ; LOAD DISPLAY FROM REG A
        XCHG              ; RESTORE H/L & D/E
        INX   D           ; INCREMENT DISPLAY ADDRESS
        INX   H           ; INCREMENT DATA ADDRESS
        DCR   B           ; DECREMENT LENGTH COUNTER
        JNZ   DISP1       ; END OF DISPLAY?
        RET               ; RETURN TO MAIN PROGRAM
```

Conclusion

Note that although other manufacturer's products are used in the examples, this application note does not imply specific endorsement, or warranty of other manufacturer's products by Siemens. The interface schemes shown demonstrate the simplicity of using the DLO 4135/DLG 4137 Dot Matrix Intelligent Display. Slight timing differences may be encountered for various microprocessors, but can be resolved using similar methods as those used when using interfacing microprocessors with various RAMs. The techniques used in the examples were shown for their generality. The user will undoubtedly invent other schemes to optimize his particular system to its requirements.



DLO 4135/DLG 4137 with 8748
FIGURE 6



Block Diagram for 8-Digit
DLO 4135/DLG 4137 Dot Matrix Display
FIGURE 7

SIEMENS

Serial Intelligent Display Appnote 29

by Dave Takagishi

This application note describes a method of obtaining a serial input display with a selected number of digits using an 8051/8031 microprocessor and DL 2416 Intelligent Displays. The very popular DL 2416 has been selected as the example for this Application Note; however, the information contained herein can also be applied to other Intelligent Displays. (Refer to Intelligent Display Product Guide)

Introduction

A parallel bus configuration is frequently used to transfer data to a microprocessor when it is used on a single card system. However, if the system is not physically small in number of chips or has multiple cards, data handling becomes cumbersome and costly. For long distances, serial communications over a two (2) or four (4) wire link is desirable and is economically attractive. However, the trade-off between cost and speed has to be considered by the designer.

Description

The DL 2416 'Intelligent Display' is a .160" four (4) character, 17 segment, LED display module with "On-Board" memory, character generator, multiplexer and display drivers integrated into a custom integrated circuit. This eliminates the necessity to design external circuitry normally required to drive a multiplexed display. Using these important attributes of the Intelligent Display, the designer now only has to provide for interfacing, which is a seven-bit ASCII parallel code, a two-bit address, and a write signal. The procedure for writing these commands is similar to those used for an external Random Access Memory.

The serial/parallel and parallel/serial conversion is normally accomplished by using a UART (Universal Asynchronous Receiver/Transmitter) or a USART (Universal Synchronous/Asynchronous Receiver/Transmitter). The 8031 is a very attractive mircrocontroller to use in this application because it has an integral UART. This integral UART provides the designer with the means for controlling the conversion of serial into parallel information or vice-versa. The 8031 has more RAM than the popular 8048, but the operation and instruction sets are very similar. Refer to the 8031 data sheet for a complete description of the product.

Circuit Description

The block diagrams of the 8031 (Fig. 1) and the DL 2416 (Fig. 2) show the internal structure of these devices. By combining the DL 2416, an easy to use peripheral device in a parallel system, and the 8031 results in a low cost, simple serial display system. A 32-digit system can be built using an 8031 microprocessor, an 8212 or equivalent latch, a 2716 EPROM, and a 75189 IC for interfacing to 20mA or RS232 input lines. Buffers were added to minimize the long cable noise spikes and interface loading on the bus. See Figure 3 for system schematic.

Software Considerations

This system, as described, is set up to receive data only at 100 baud rate. Additional software is required for transmit routine. For a given data rate and (data format is start bit, 9-data bits and a stop bit) three (3) sections of software and possibly a special crystal oscillator frequency may be required for a given transmit rate. On power-up or reset, the serial port and timer control words must be initialized.

Special control functions have been included in this program as follows:

- Power Up
- Return
- Backspace
- Line Feed

See Figure 5 for the actual program listing.

Conclusion

This Application Note has introduced the reader to the ease of interfacing the DL 2416 to any microprocessor. By combining the DL 2416 and the 8031, difficulties usually associated with serial conversion using software and its attendant timing problems can be easily overcome.

SIEMENS OPTOELECTRONIC DIVISION does not endorse or guarantee other manufacturer's products used in this Application Note.

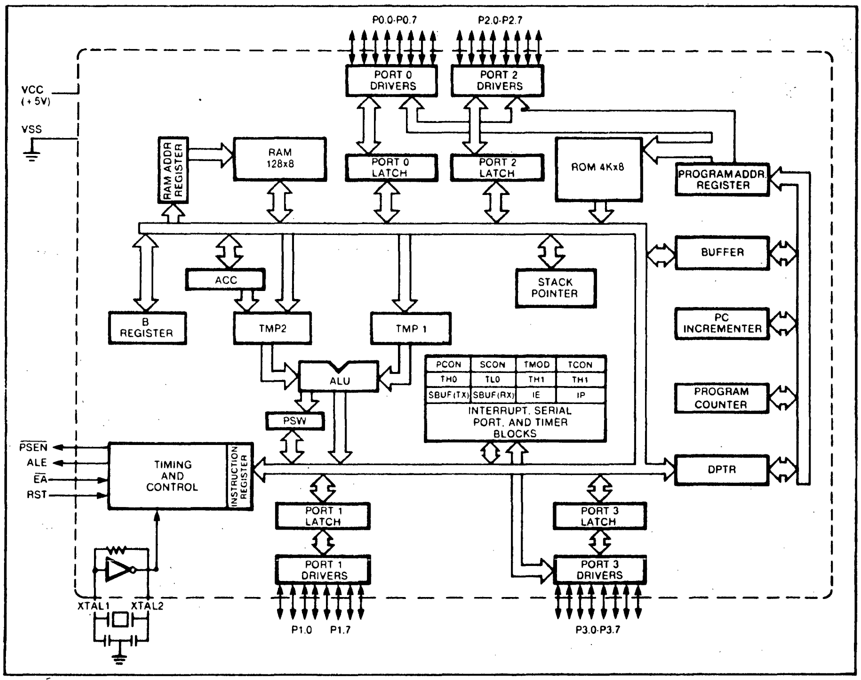


FIGURE 1 — 8031 BLOCK DIAGRAM

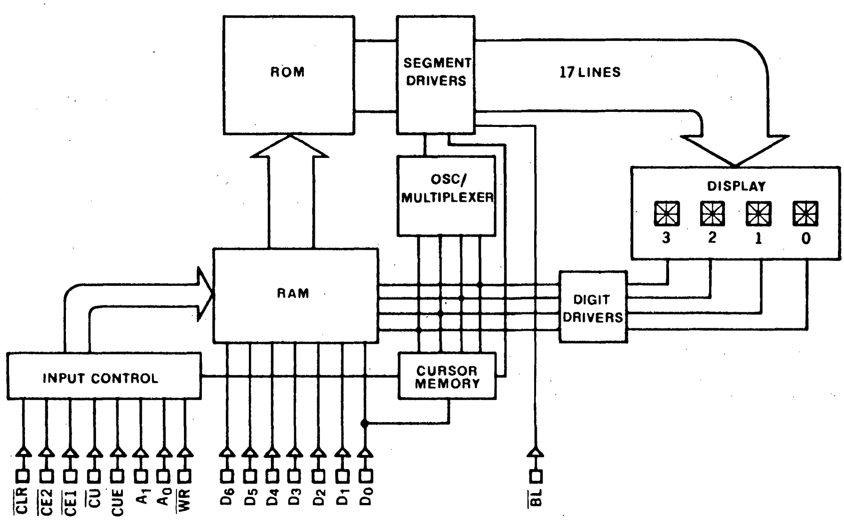


FIGURE 2 — DL 2416 INTERNAL BLOCK DIAGRAM

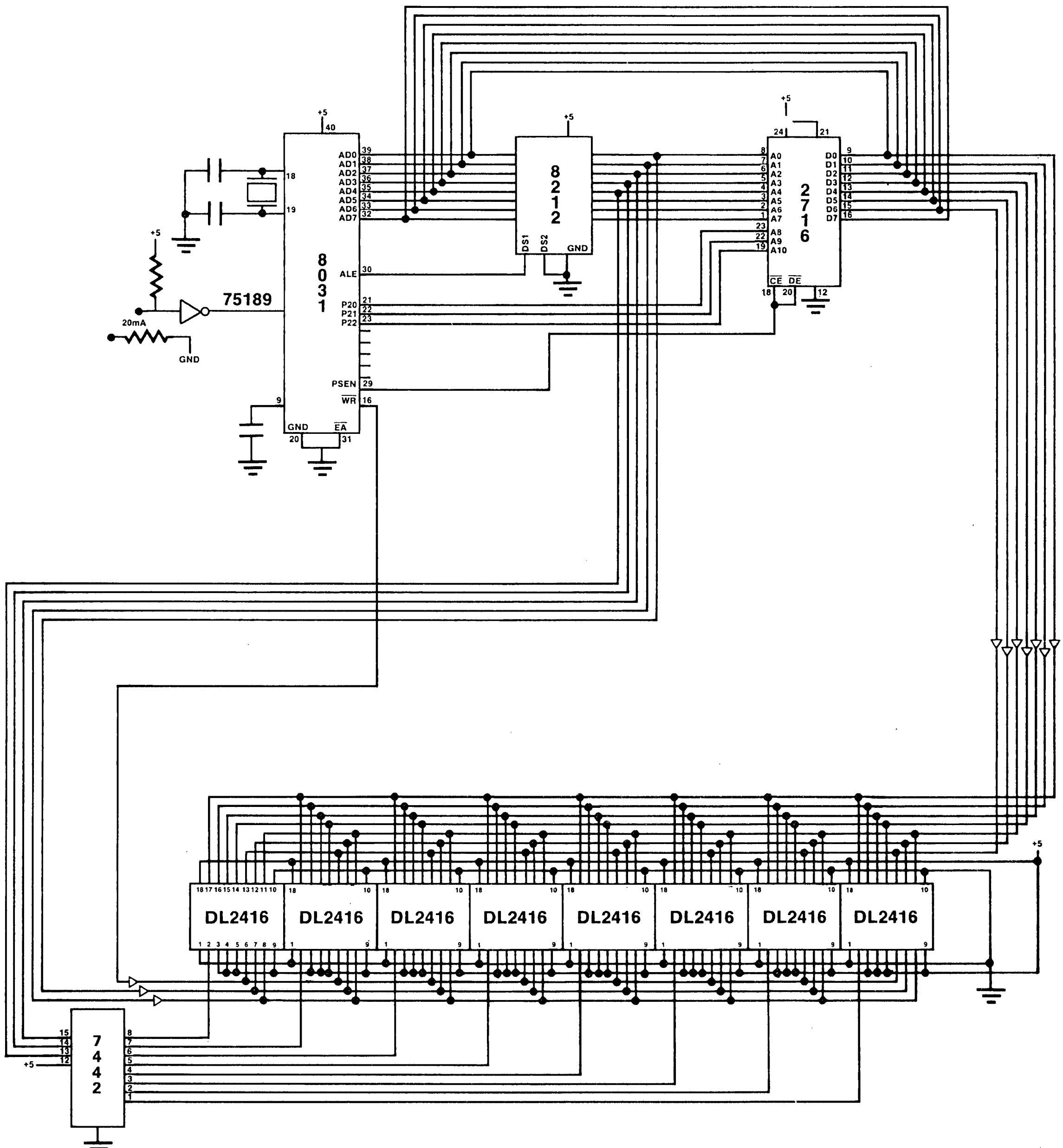


FIGURE 3 — SYSTEM SCHEMATIC

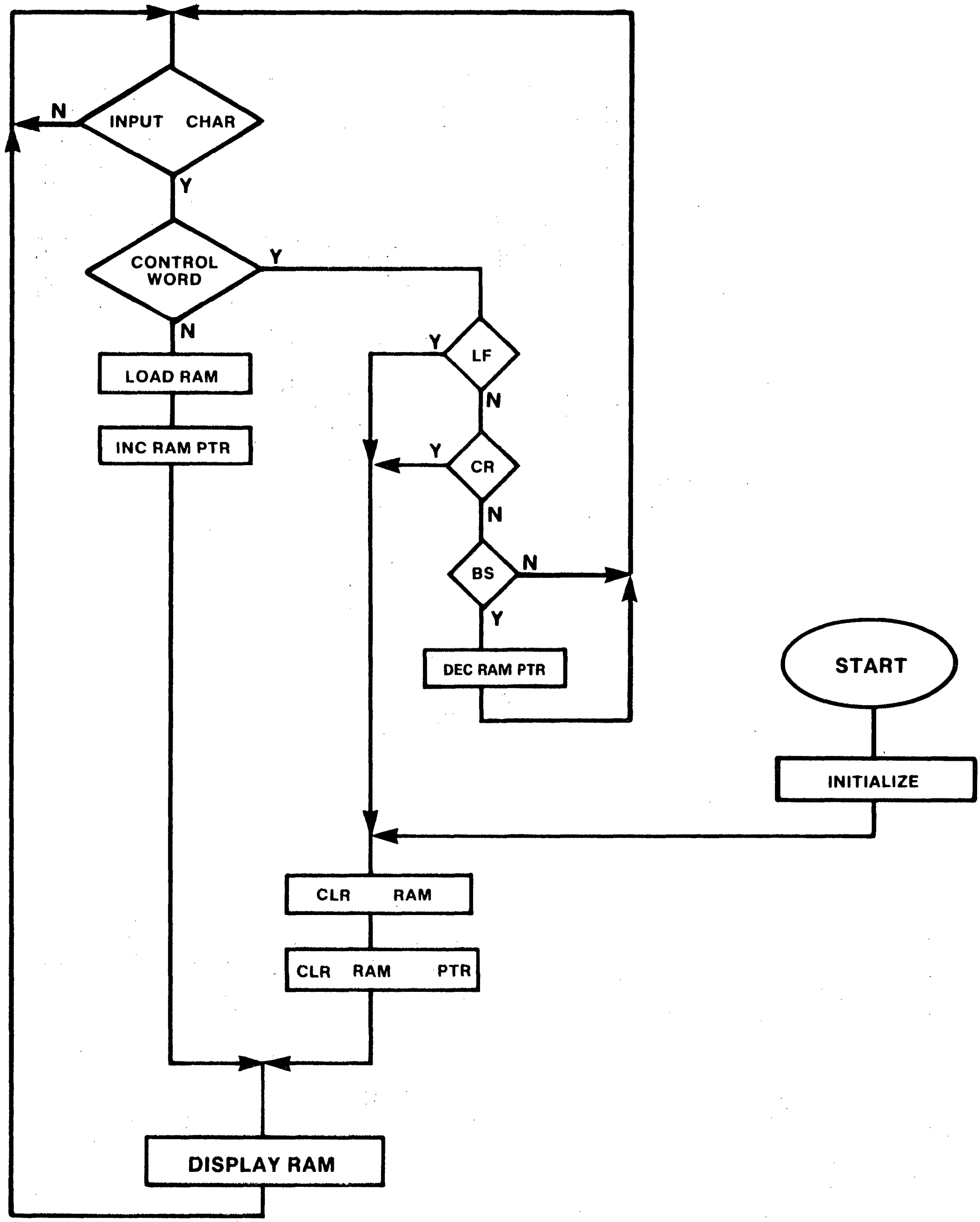


FIGURE 4 — SERIAL IDA FLOW CHART

FIGURE 5 — PROGRAM LISTING

```
                                                 ;SERIAL IDA USING 8031 UP
                                                 ;AND IDA2416-32
                          ORG     0000H
0000  020040              LJMP    INIT
                          ORG     0003H          ;EXTERNAL INTERRUPT 0            ]
0003  32                  RTI                                                     ]
                          ORG     000BH          ;TIMER 0 OVERFLOW                ]
000B  32                  RTI                                                     ]
                          ORG     0013H          ;EXTERNAL INTERRUPT 1            ] INTERRUPTS
0013  32                  RTI                                                     ] NOT USED
                          ORG     001BH          ;TIMER 1 OVERFLOW                ]
001B  32                  RTI                                                     ]
                          ORG     0023H          ;SERIAL I/O INTERRUPT            ]
0023  32                  RTI
                                                 ;SETUP SERIAL PORT
                                                 ;9 BIT UART MODE 3
                                                 ;SET TIMER
                          ORG     0040H
0040  75A800     INIT:    MOV     IE,#00H        ;ENABLE INTERRUPTS               ]
0043  758922              MOV     TMOD,#22H      ;TIMER 0 & 1 AUTO RELOAD         ]
0046  758D72              MOV     TH1,#72H       ;RELOAD FOR 110                  ] INITIALIZE
0049  759870              MOV     SCON,#70H      ;MODE 3 RCV                      ] 803 1μP
004C  D28E                SETB    #8EH           ;TIMER 1 ON                      ]

004E  7920       CLRAM:   MOV     R1,#RAM        ;RAM INITIAL ADDRESS             ]
0050  E4                  CLR     A                                               ]
0051  7B20                MOV     R3,#CNTR       ;LOAD # OF DIGITS                ] CLR RAM
0053  F7         CLR1:    MOV     @R1,A          ;LOAD RAM                        ]
0054  09                  INC     R1
0055  DBFC                DJNZ    R3,CLR1
0057  7820                MOV     R0,#RAM        ;SET RAM INPUT PNTR TO INITIAL   ] CLR RAM PTR

0059  7B20       DISPRM:  MOV     R3,#CNTR       ;R3=COUNTER                      ]
005B  900000              MOV     DPTR,#DSPTR    ;DPTR=DISPLAY POINTER            ]
005E  793F                MOV     R1,#RAM        ;R1=RAM DISPLAY POINTER+LENGTH   ] DISPLAY
0060  E7         DISP1:   MOV     A,@R1          ;FETCH DATA FROM RAM             ] RAM
0061  F0                  MOVX    @DPTR,A        ;LOAD DISPLAY                    ]
0062  19                  DEC     R1
0063  A3                  INC     DPTR
0064  DBFA                DJNZ    R3,DISP1

0066  3098FD     SERIN:   JNB     RI,SERIN       ;WAIT UNTIL AN INPUT             ]
0069  C298                CLR     RI                                              ] INPUT CHAR
006B  E599                MOV     A,SBUF                                          ]

                                                 ;CHECK FOR CONTROL WORDS
006D  FC         CNTLWD:  MOV     R4,A           ;SAVE A
006E  2460                ADD     A,#060H
0070  4013                JC      LDATA          ;JUMP IF DATA
0072  EC                  MOV     A,R4
0073  2473                ADD     A,#073H
0075  40D7                JC      CLRAM          ;CR                              ]
0077  EC                  MOV     A,R4                                            ] DATA = CR
0078  2476                ADD     A,#076H                                         ]
007A  40D2                JC      CLRAM          ;LF                              ]
007C  EC                  MOV     A,R4                                            ] DATA = LF
007D  2478                ADD     A,#078H                                         ]
007F  50E5                JNC     SERIN          ;OTHER CONTROL                   ]
0081  18                  DEC     R0             ;BS                              ] DATA = BS
0082  020066              AJMP    SERIN

0085  EC         LDATA:   MOV     A,R4                                            ]
0086  F6                  MOV     @R0,A          ;LOAD RAM                        ] LOAD
0087  08                  INC     R0                                              ]
0088  E8                  MOV     A,R0                                            ] DATA
0089  24C0                ADD     A,#0C0H                                         ]
008B  5002                JNC     LDAT1                                           ] INTO
008D  7820                MOV     R0,#RAM                                         ]
008F  020059     LDAT1:   AJMP    DISPRM                                          ] RAM

END
```


Application Notes

SIEMENS

Blue-Light Emitting Silicon-Carbide Diodes — Materials, Technology, Characteristics Appnote 31

by Dr. Claus Weyrich
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Introduction

Light-emitting diodes (LEDs) are widely used in the field of electronics as indicator lamps and seven-segment displays because of their excellent characteristics such as high mechanical stability, low operating voltage, compatibility with semiconductor drive circuits, low operating temperature and long service life. LEDs are now mass-produced in the colors red, super-red, yellow and green. The semiconductor materials that are used are III-V compounds such as gallium arsenide phosphide ($GaAs_{1-x}P_x$), gallium phosphide (GaP) and, recently, also gallium aluminum arsenide ($Ga_{1-x}A1_xAs$). An extension of the color of LEDs into the blue region of the spectrum has been wished by many users. The materials that are suitable for blue-light diodes are discussed here, followed by a survey of the technology and characteristics of blue-light diodes based on silicon carbide (SiC), the material that is preferred for this application by the Siemens company.

Semiconductor materials for blue-light emitting diodes

For emission in the blue region of the spectrum $GaAs_{1-x}P_x$ or GaP is out of the question because the band gap is too small, limiting the wavelength of the emitted radiation towards the lower end. But there are other semiconducting compounds such as gallium nitride (GaN), zinc sulfide (ZnS), zinc selenide (ZnSe) and silicon carbide (SiC). GaN was investigated quite intensively for the purpose of creating blue-light LEDs at the beginning of the 70s. With but one exception however, industrial research into this semiconductor material was then discontinued. The major drawback is the fact that GaN cannot be p-doped with sufficiently low resistance. Thus the light in this semiconductor is not produced by the radiative recombination of injected charge carriers at the pn junction as with the other III-V materials, but by highly accelerated electrons that are generated in the very high-resistance i layer of a metal-i-GaN-n-GaN layer by collision-ionization processes and thus lead to the emission of light. The efficiency of this mechanism, which results in higher operating voltages of the device, decreases with increasing current density (and thus luminous intensity of the diode). The situation is similar in the case of blue-light diodes using ZnS and ZnSe materials, in which likewise no low-resistance pn junction can be produced. The result of this is that with all the materials mentioned, despite the direct band-gap structure that is favorable for the generation of light and which leads to very efficient photoluminescence or cathodoluminescence for instance, the efficiency of the internal conversion of electrical energy into light is lower in comparison.

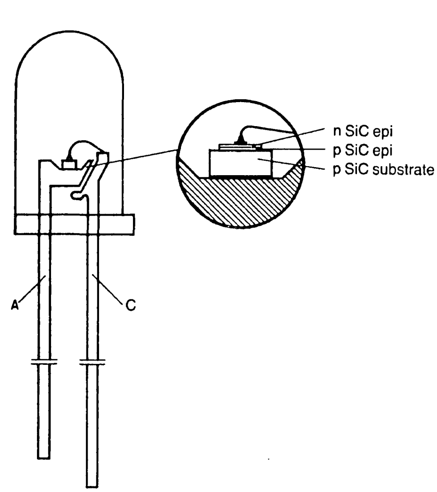
SiC is the only material that allows reproducible p and n doping and possesses a suitable band gap for the emission of light in the blue region of the spectrum. The advantage of a device that can easily be controlled in all its physical characteristics more than makes up for the fact that SiC has an indirect band-gap structure, which is less favorable for generating light.

Groundwork on SiC blue-emitting LEDs has been performed in Great Britain, the USSR, Japan and in the Federal Republic of Germany at Hannover Technical University. Proceeding from the work done in Hannover, the development of SiC blue-emitting LEDs was pursued in the Siemens research laboratories and diodes were created with the highest efficiencies known to date. Siemens is one of the first semiconductor manufacturers to have successfully produced such diodes in the laboratory.

Technology and design of SiC LEDs

An essential feature of SiC is its appearance in several modifications with different band gaps. For the production of blue-light LEDs the hexagonal modification 6H (αSiC) is the most favorable. As with all known LEDs, with SiC LEDs too the active light zone consists of epitaxial, monocrystalline material deposited on a p-type substrate crystal. The layer is grown from an Si melt saturated with carbon (liquid-phase epitaxy) at temperatures between 1600 and 1700 °C, the p-type layer being doped with aluminum and the n-type layer additionally with nitrogen. The contacting and the diode structure are produced using the technologies already familiar with LEDs. The structure of an SiC lamp is shown in fig. 1.

Figure 1
Schematic of an SiC LED (dia. 5 mm)
Section: SiC chip with epitaxial layers (epi)

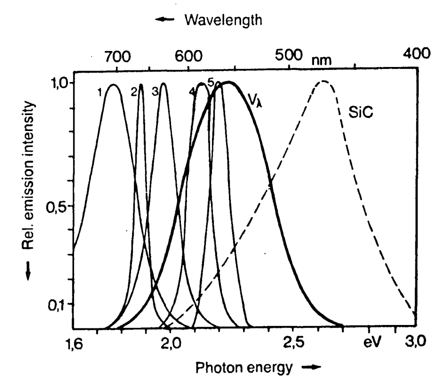


In additon to the, compared to other semiconductor materials, high process temperatures, the major problem in SiC LED technology is the lack of large-area substrate crystals – an absolute necessity where low manufacturing costs are concerned. Up to now it has been necessary to make do by preparing small crystal wafers of the appropriate modification from the kind of crystal clusters that appear as a by-product in the large-scale industrial synthesis of SiC for producing grinding powder, but their diameter is no more than 10 to 14 mm. The big disadvantage of this is that the yield of suitable substrate crystals is only very small. At Siemens a substantial step towards a solution has now been taken. By means of a newly devised process, involving sublimation followed by condensation, monocrystals with a diameter of 15 mm and a length of 25 mm – that makes about 30 substrate wafers – were produced on a nucleus. This technology is, admittedly, considerably more elaborate than the technology of III-V semiconductors, so one cannot expect the price of blue-emitting diodes from SiC to fall to the level of more common LEDs; on the other hand though, an appreciable step towards mass production has thus been taken.

Characteristics of SiC LEDs

The emission spectrum of SiC LEDs and the dependence of the light current on diode current are illustrated in figs 2 and 3 in comparison with other LEDs. Fig. 4 shows the color locations of different LEDs on a standard color diagram. Whereas the red-, yellow- and green-emitting diodes lie practically on the spectrum locus, the blue-emitting SiC diodes exhibit two peculiarities. Their color location is not on the spectrum locus, and the dominant wavelength experienced by the observer shifts slightly with increasing diode current towards shorter wavelengths. Associated with this is a decrease in the rise and decay

Figure 2
Photopic luminosity (normal vision) V_λ and the emission spectra of different light-emitting diodes based on $GaAs_{1-x}P_x$, GaP, $Ga_{1-x}Al_xAs$ and SiC in the visible spectral range



1 GaP:Zn,O
2 $GaAs_{0,6}P_{0,4}$ and $Ga_{0,65}Al_{0,35}As$
3 $GaAs_{0,35}P_{0,65}$:N
4 $GaAs_{0,15}P_{0,85}$:N
5 GaP:N

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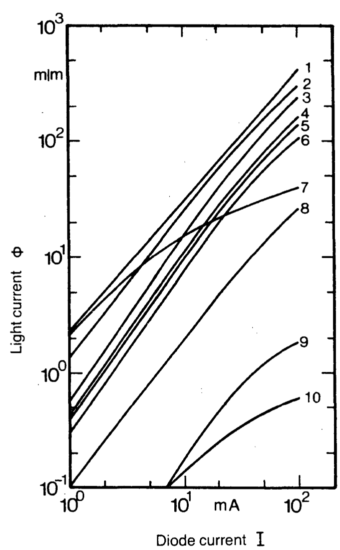
time of the luminescence from typically 0.9 μs (90−10%) at 5 mA to typically 0.5 μs at 50 mA. For a diode current of 20 mA the diodes have a luminous intensity of typically 4 mcd, the luminous efficiency being approx. 10^{-2} lm/W. A typical current/voltage characteristic is shown in fig. 5.

Applications and prospects

The possible applications for SiC LEDs are all those in which small light emitters are required that are capable of emitting in the blue spectral range and are suitable for fast modulation (up to 500 kHz), in the scientific and technical field as a calibration light source for photomultipliers for example, in TV-camera engineering and photography, and as a radiation source in spectroscopy, biophysics and medicine.

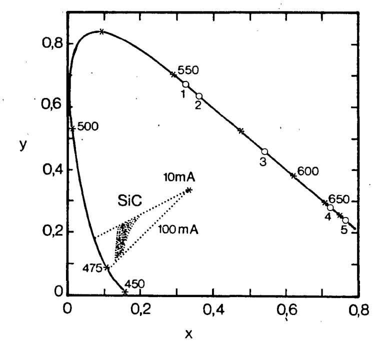
It will no doubt be possible to make this technology cheaper through continuing development of the individual process steps that are involved. It should be emphasized once more, however, that the fundamental problems of SiC technology are such that the prices of conventional LEDs are not likely to be approached. This does not only apply to SiC, incidentally, but also to the other materials being considered for blue-light emitting diodes.

Figure 3
Light current/diode current characteristics Φ (I) of different LEDs
(VPE = vapor-phase epitaxy, LPE = liquid-phase epitaxy)



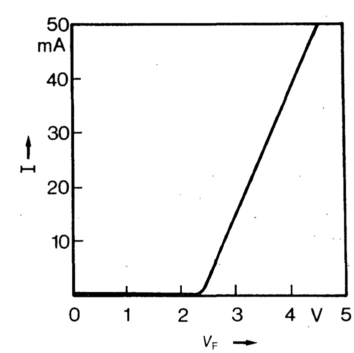
1 $Ga_{0,65}Al_{0,35}As$-LPE
2 GaP:N-LPE
3 $GaAs_{0,35}P_{0,65}$:N-VPE
4 GaP:X-LPE
5 $GaAs_{0,15}P_{0,85}$:N-VPE
6 GaP:N-VPE
7 GaP:NZn,O-LPE
8 $GaAs_{0,6}P_{0,4}$-VPE
9 SiC:Al,N-LPE
10 GaN-MiS-VPE

Figure 4
Color location of SiC LEDs (dotted) compared to other LEDs



1 GaP:X
2 GaP:N
3 $GaAs_{0,15}P_{0,85}$:N
4 GaP:Zn,O and $GaAs_{0,35}P_{0,65}$:N
5 $GaAs_{0,6}P_{0,4}$ and $Ga_{0,65}Al_{0,35}As$

Figure 5
Current/voltage characteristic $I(V_F)$ of a typical SiC LED



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Light Activated Switches
Appnote 33

1. Miniature Light Barrier for a Shaft Position Encoder or a Revolution Counter

Miniature light barriers are required for shaft position encoders, since light transmitter and receiver are closely facing each other by a distance of a few millimeters. For this application a practical combination is achieved by using the light emitting diode LD261 and the phototransistor BPX81. Both components have the same epoxy case with an edge length of 2.2 mm. The LED operates in the infrared range at about 950 nm, since the efficiency is essentially higher than that of the visible radiation. The circuit described in the following converts interruptions of a light beam into electrical pulses for counting.

The construction of a shaft position encoder is shown in Fig. 1.1. The distance between the transmitting and the receiving components is about 3 to 5 mm. Both are inserted in a hole with a diameter of 3 mm, whereby the opening is diminished to 1.4 mm at its front ends. A plastic disc carrying a line pattern at its circumference as shown in Fig. 1.2 is rotating between transmitter and receiver. A pervious section follows a non-pervious one and the angle position of the disc is determined by counting the quantity of sections having passed.

Fig. 1.1

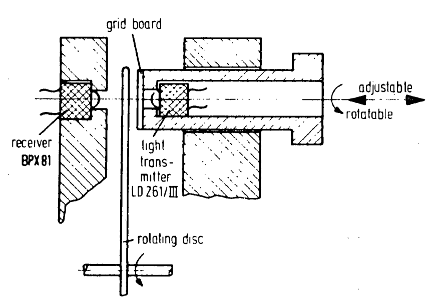
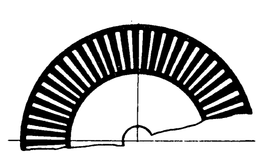


Fig. 1.2

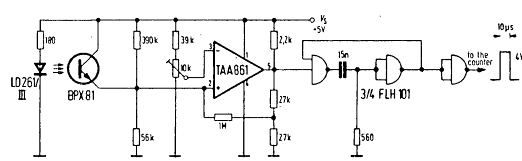


Assuming that the rotating disc with a diameter of about 50 mm has a pattern of 600 lines, the distance between two lines is about 0.25 mm. To increase the light-to-dark ratio at the receivers side a plate with the same grid structure is mounted in front of the transmitter-hole as shown in Fig. 1.3. If the position of the grid on the rotating disc coincides with the one of the plate, the phototransistor receives a maximum of light. If both grid patterns are displaced with half the distance of two lines, the received light becomes a minimum. As the transmitter is rotatable and adjustable in its position an efficiency maximum can be achieved.

Fig. 1.3

The circuit is shown in Fig. 1.4. The emitting diode LD261 is operated at a current of about 20 mA.

Fig. 1.4



Technical Data

Supply voltage V_s	5 V
Supply current (total) I_s	35 mA
Wave-length of the transmitted light	950 nm
Maximum counting frequency	40 kHz
Duration of the output pulses	10 µs
Amplitude of the output pulses	4 V

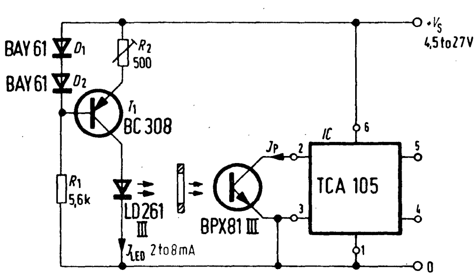
The collector current of the potentiometer varies between about 3µA (minimum) and about 12µA (maximum) when the disc is rotating. Since the minimum value is to be kept constant, strong ambient light influences have to be eliminated.

The current variation is sufficient to safely trigger the op amp TAA 861, which serves as a Schmitt-trigger. The following NAND-gates (FLH101) operating as monostable multivibrator produce a definite square pulse with a duration of about 10 μs, for each line passing the light barrier. The circuit operates up to a frequency of 40 kHz, which corresponds to about 4000 r.p.m. of the disc.

2. Light Barrier using TCA105

The light barrier shown in Fig. 2.1 consists of the GaAs light-emitting diode LD261, the phototransistor BPX81 and the integrated threshold switch TCA105. The LED is operated at a constant current to meet the total range of the power supply voltage being between 4.5 V and 27 V. The IC itself is specified for a wider range. The constant current source is realized by the transistor T_1, the diodes D_1 and D_2 as well as the two resistors R_1 and R_2. By the two diodes an independent, nearly constant voltage is achieved at the base of T_1. The constant current of the transistor can be adjusted by the potentiometer R_2.

Fig. 2.1

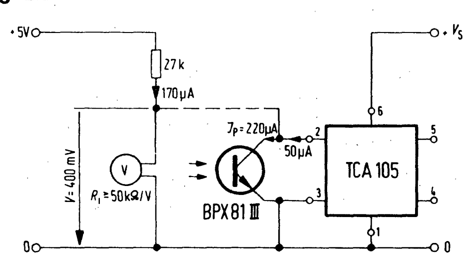


Parameter changes of the components created by temperature and aging effects are compensated for if the photocurrent of the phototransistor is chosen four times higher than the required input threshold current of the TCA105, i.e. about 200 μA. The output signal is available at the two antivalent outputs of the IC (pins 4 and 5).

Adjustment

The light barrier is adjusted by setting the LED-current. If the IC is operated in the test circuit as shown in Fig. 2.2, the current of the LED has to be set in such a way that a voltage of 400 mV is available between pins 1 and 2 of the TCA105.

Fig. 2.2



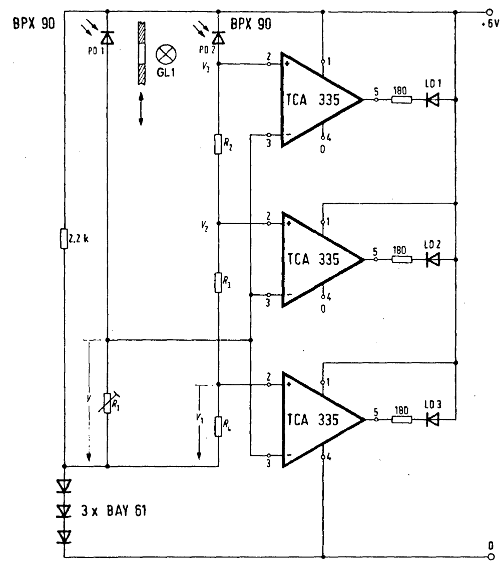
Technical Data

Supply voltage	4.5 to 27 V
Supply current	3.5 to 11.3 mA
LED current	2 to 8 mA
Supply current of the IC	3.3 mA
Ambient temperature range	−25 to +70 °C.

3. Optical Weight-Quantizer for Large Scales

The optoelectronic circuit described in Fig. 3.1 facilitates the weight quantization of large scales, whereby a 3-stage LED-display indicates the difference of the adjustment.

Fig. 3.1



The incandescent lamp Gl_1 illuminates the two photodiodes PD_1 and PD_2. The first is covered by a slot diaphragm, which is moved up and down by the balance arm of the scale with a stroke of 4.5 mm, corresponding to the balance difference. A voltage, being proportional to the balance difference, drops across the resistor R_1 and is supplied to the three op amps TCA335 operating as threshold switches. The reference voltages V_1, V_2 and V_3 are produced by the photocurrent of the photodiode PD_2 and drop across the resistors R_2, R_3 and R_4. They are supplied to the non-inverted inputs of the TCA335. If the voltage across the resistor R_1 exceeds the reference value then the corresponding LED's LD_1, LD_2 and LD_3 are switched on. An inverse function can be achieved by interchanging inputs 2 and 3 of the op amps. Since both photodiodes are illuminated by the same incandescent lamp, brightness changes created by aging or supply voltage variations are ineffective.

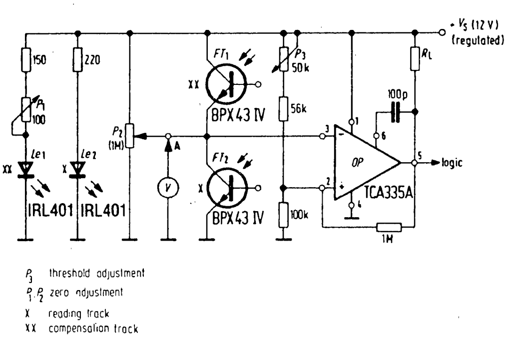
The common mode voltage, necessary for operating the op amps drops across the diodes $D1$, D_2 and D_3.

4. Optically Code Reading Regardless of whether Different Kinds of Papers have Different Reflexion Coefficients

When identifying stroke markings placed on different kinds of papers, the uncertainty exists that the code is erroneously read due to different reflexion coefficients.

The circuit described in the following and shown in Fig. 4.1 avoids this difficulty by means of an additional compensation track. The two phototransistors FT_1 and FT_2 being connected in series serve as a voltage divider, the center tap of which is joint to the inverted input of the amplifier OP. To each phototransistor belongs an LED.

Fig. 4.1



Both are connected in parallel, whereby the pair consisting of Le_1 and FT_1 serves for the compensation track and the one incorporating Le_2 and FT_2 functions for the reading track.

Therefore, the influence of a reflexion coefficient of the paper is eliminated and the reading result is determined only by the different reflexion of the strokes.

Adjustment Procedure

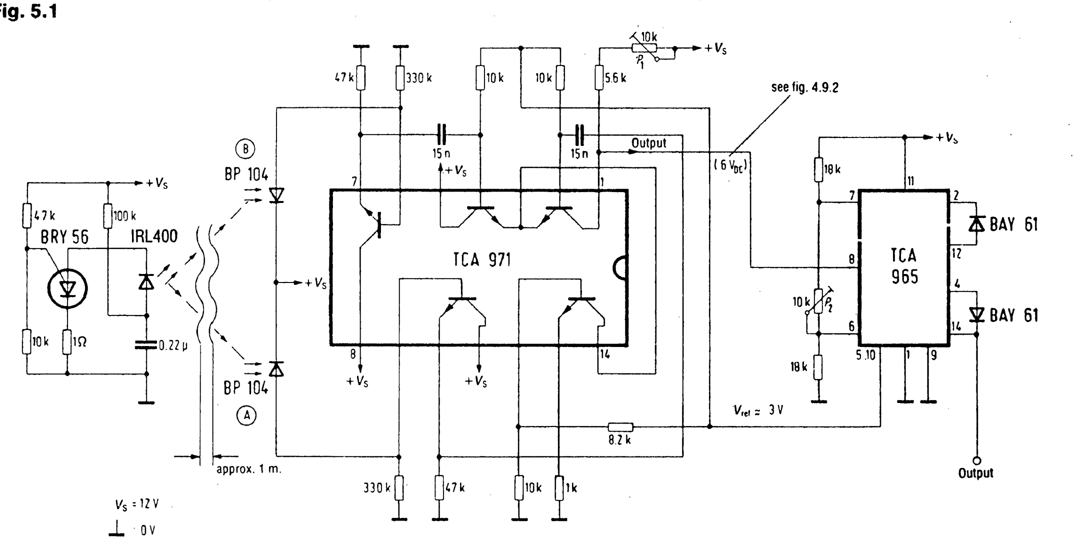
Firstly, the potentiometer P_2 is adjusted so that a level of 0.5 $\times$ V_S is measured at point A. During this procedure the phototransistors have to be completely covered. Then a paper of any kind without stroke markings is inserted into the readchannel and P_1 is adjusted in such a way that point A has a level of 0.5 $\times$ V_S. The threshold for the stroke markings is determined by the potentiometer P_3.

5. Light Barrier Indicating the Direction of Interruption

It is generally important to know not only that a light barrier has been passed but also from which direction the passing occurred. These requirements can be met by using the window discriminator TCA965 with RS memory function. Two receiver diodes are necessary to indicate the passing direction (see Fig. 5.1).

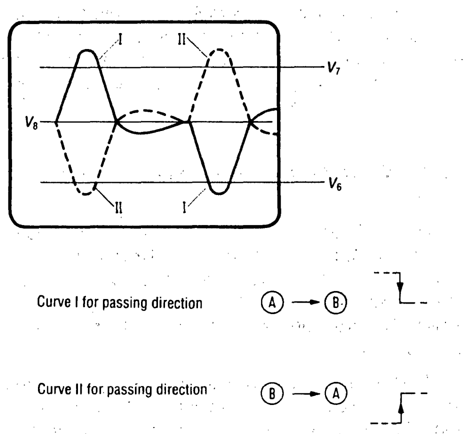
The LED IRL400 operates as a transmitter diode. It is supplied with short current pulses of approx. 1A peak value and a repetition period of 30 ms. These pulses are generated by the programmable unijunction transistor BRY56. The emitted light pulses are received by the diodes BP104. They are connected to two transistors operating as emitter followers. The transistors are connected to a differential amplifier via a 15 nF-capacitor each. The output signal of the TCA971 is supplied to pin 8 of the window discriminator.

Fig. 5.1



No signal is available from the differential amplifier if both receiver diodes are covered and when both receive light. If the diode A is not met by the light beam, the voltage V_8 at pin 8 is greater than that at pin 7. If the diode B is not met by the light beam, V_8 is lower than V_6 (see Fig. 5.2).

Fig. 5.2



If the light barrier is passed from A to B, an L-level is available at pin 14 (curve I). But if it is passed from B to A, pin 14 shows an H-level (curve II).

The sensitivity of the curcuit is adjustable by potentiometer P_2. Potentiometer P_1 sets the dc level of the output symmetrically to V_6 and V_7. The five transistors are combined in the transistor-array TCA971.

Thus, a very good temperature behaviour of the differential amplifier is obtained. The reference voltage V_{10} at pin 10 of the TCA965 is also utilized by the constant-current source of the TCA971.

6. Infrared Reflex-Light Barrier with IRL400 and TDA4050

The transmitter of this circuit is an IR-LED, type IRL400, emitting a strongly focused light beam. TDA4050B is used as receiving preamplifier. When using a triplet mirror with an area of about 20 cm² as reflector, the maximum distance is at least 10 m. The allowed interfering light in lens axis is up to 200 lux (incandescent lamp light). This corresponds to a white surface illuminated at 50 klx over the whole irradiation of the receiver. Emitter and receiver can be placed in the same housing. The circuit is particularly suited for decoding fast changing codes (e.g. running bar patterns) and as a light barrier.

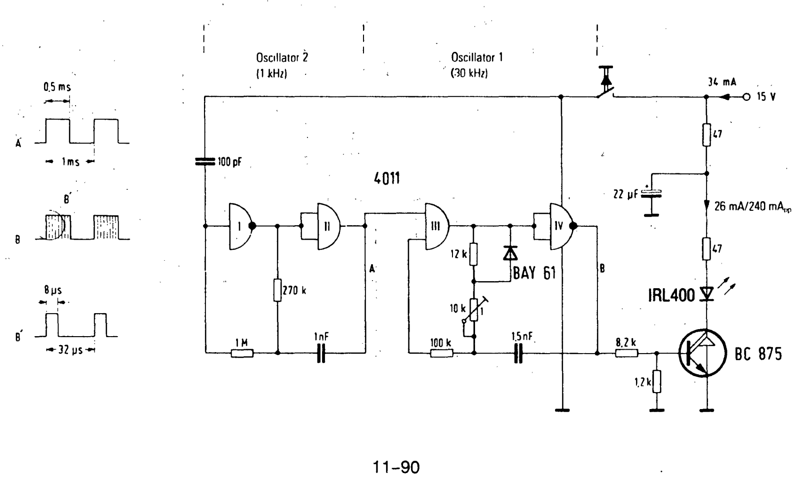
Contrary to IR remote controls, IR reflex-light barriers require only very narrow emitting and receiving characteristics. Because of the short reaction time required, a continuous emitter signal is also needed. Therefore, the pulse currents cannot be as high as with remote controls as this operation would exceed the admissible power dissipation.

Transmitter

A circuit consisting of 2 CMOS-NAND-gates (Fig. 6.1) generates a square-wave oscillation with a frequency of approx. 30 kHz. The pulse duty factor is fixed at 4:1. According to experience, a good efficiency is achieved herewith. To obtain the desired ratio between pulse duration and pulse space, the discharging resistor is partially by-passed by a diode. The 30 kHz-carrier is 1 kHz-modulated by a second pair of gates. When decoding running bar patterns, this modulation is not necessary as the object itself will be the source for the modulation.

A Darlington stage with BC875 drives the transmitter diode with peak currents of 200 to 250 mA, resulting in a mean diode current of around 25 mA. Without modulation, the mean diode current would reach twice this value.

Fig. 6.1



Receiver

The IR signal received by the photodiode BP104 (Fig. 6.2) is amplified through a transistor stage by 20 dB. The gain is determined by the collector resistance of 4.7 kΩ as well as by the 1.8 kΩ-input impedance of TDA4050B. The coupling capacitance of 22 nF and the RC circuit of the emitter reduce drastically low frequency-signals, especially the 50 and 100 Hz-components mainly present in artificial light.

The integrated circuit TDA4050B has a gain of about 60 dB between input and output. In order to limit the bandwidth, an active filter consisting of a double-T-section is connected between pin 4 and 5. Thus, the bandwidth is limited to approx. 10 kHz.

The gain of the TDA4050B depends on the potential at the control input (pin 2). Normally only a capacitor, being charged to a level of 1 V without signal, is connected to this terminal. In the circuit, according to Fig. 6.2, a bias of 1.85 V is set via a voltage divider and the gain is reduced by approx. 20 dB therewith. This is necessary as otherwise, with the increased gain at the output, short-time peaks could result from the control action and would disturb the function. Notwithstanding the adjustment of the basic gain at pin 2, the automatic control is preserved, avoiding an overdrive of the receiver. Due to different charging and discharging resistors of the TDA4050B, downward control is very fast but upward control is relatively slow. The controlling time-constant is determined by the capacitor connected to pin 2.

When the input signal at the photodiode exceeds a signal current of 5 nA_{pp}, the output at pin 3 becomes negative.

Acoustic Indication and Evaluation

Should the incoming signal be acoustically indicated, pin 3 has to be connected to an evaluation circuit. It consists, for example, of a loudspeaker with a transistor BC309. Besides that, with this circuit the limit range can be easily defined as the tone becomes undefined when the maximum range is exceeded.

Optics

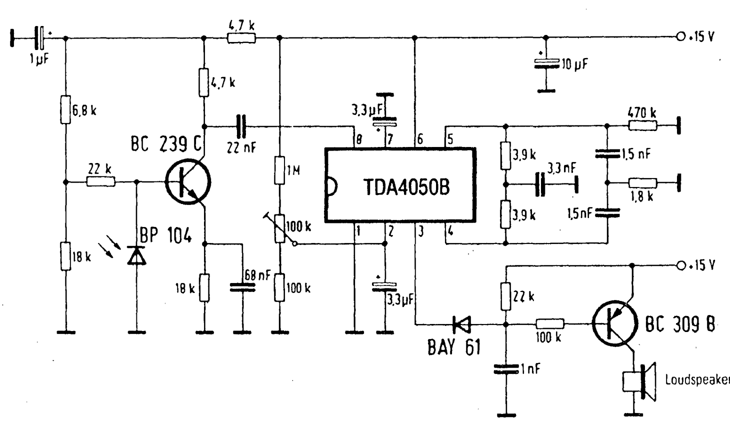
For the receiver, a collecting lens with a diameter of 15 mm and a focal length of 30 mm is used. Thus an effective receiver area 30 times larger than with photodiode BP104 is achieved. At the same time the angle of irradiation is restricted to $\pm 3°$. With an increase of the lens diameter the range increases proportionally. But an increase of the focal length at the same time will limit the angle of irradiation.

For the transmitter, no additional optic is used, but the parasitic radiation remainder outside the cone becomes inoperative by means of a blackened tubus.

Electrical Features

The transmitter must be well shielded against the receiver so that the highly-sensitive receiver input cannot be disturbed. The electrical separation of the lines signals is sufficiently obtained by the filter circuits mentioned.

Fig. 6.2



Technical Data

a) Transmitter

Supply current at $V_S = 15$ V	
unmodulated	60 mA
with 1 kHz-modulation, duty cycle 0.5	34 mA
Carrier frequency (square wave oscillation)	30 kHz
Duty cycle of carrier	0.25
Carrier-pulse-peak radiant intensity	100 mW/sr
Opt. wavelength	950 nm
Cone of radiation (half-angle)	6°

b) Receiver

Supply current at $V_S = 15$ V	
without load (loudspeaker)	10 mA
load (loudspeaker) only	18 mA
Angle of irradiation with lens	±3°
Intermediate frequency	30 kHz
Bandwidth (3 dB)	10 kHz
Min. pulse-peak-radiant-power to diode BP 104	10 nW
Max. modulation frequency	
at standard sensitivity	5 kHz
at reduced sensitivity	10 kHz
Dynamic range	60 dB
Max. interfering light (incandescent lamp light in lens axis)	200 lux

c) Total circuit

Supply current at $V_S = 15$ V	max. 70 mA[1])
Range with simple triplet mirrors as reflector	
Seize of reflector 20 cm²	approx. 12 m
Seize of reflector 1000 cm²	approx. 80 m
Range with top-quality pentaprism as reflector	
seize of reflector 25 cm²	approx. 20 m

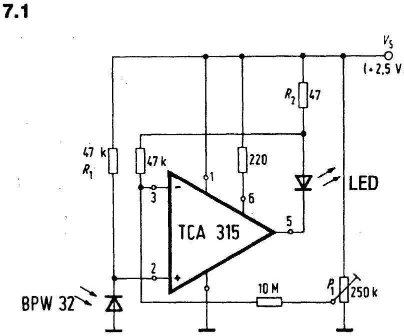
[1]) Without modulation and load (loudspeaker)

7. Current Control of LEDs as a Function of Ambient Light

A brightness control of LEDs is required especially when the ambient light intensity varies within a wide range. Fig. 7.1 shows a circuit for this application. It operates sufficiently even at a supply voltage of only 2.5 V. In complete darkness the LED is driven with a current of 100 µA. If the intensity of the ambient light rises, the current, i.e., the brightness of the LED, increases accordingly. At daylight the LED is operated by an impressed current of 5 mA/100 lux.

The ambient light intensity is sensored by the Silicon photodiode BPW32. The signal is amplified through the Darlington operational amplifier TCA315. The sensitivity of the circuit is determined by the resistances of R_1 and R_2. The LED current exceeds the one of the photodiode by a factor of 1000 with the exception of in darkness, where the LED-current is 100 µA, as described above.

Fig. 7.1

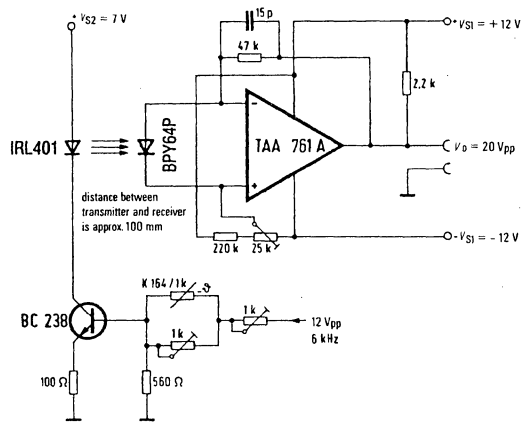


The current referring to a complete darkness is adjusted by the potentiometer P_1. The total supply current is 220 µA plus the LED-current (at V_S = 2.5 V).

8. Temperature-Response Compensation of the LED IRL401

Fig. 8.1 shows a circuit which is especially favored for compensating temperature effects of the LED IRL401. It is used in a light barrier operating with modulated light. The max. diode current is rated to 50 mA_{pp} and the temperature range is +10° to +55°C.

Fig. 8.1



The NTC-resistor K 164 has been connected to the base of the transistor BC238 and not directly to the LED as usually practiced. This measure reduces the self-heating of the thermistor. The control characteristic is adjustable by the two 1-kΩ-potentiometers. To obtain a temperature drift of only 2.5% for the complete circuit in the mentioned temperature range, the resistance of the potentiometers should be set to a value of approx. 500 Ω each.

It should be mentioned for comparison purposes that the output voltage shifts about 20% when the circuit has no compensation.

The photovoltaic cell BPY64P operates as a detector in conjunction with an amplifier circuit. For processing a square-wave voltage with a frequency of 6 kHz, it is recommended to drive the photovoltaic cell BPY64P in a short-circuit operation. This will advantageously be realized by using the operational amplifier TAA761A operating with an impressed input current.

9. Reflection Light Barrier

This circuit is applicable for realizing a reflection light barrier. If, however, there are no requirements for improved sensitivity and reduced immunity against undesired influence of ambient light, this circuit can be simplified.

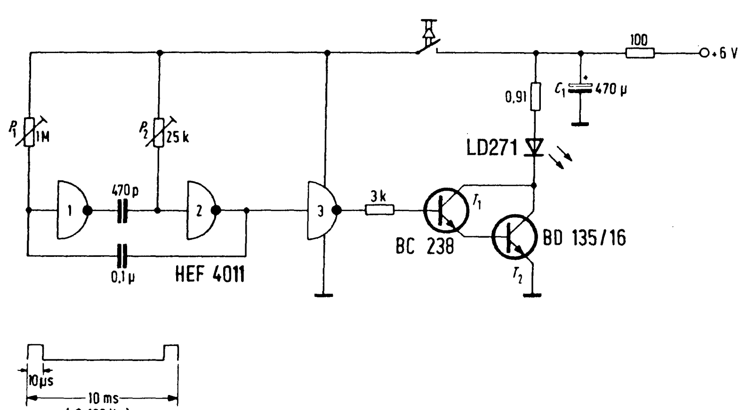
The circuit described in the following reacts within a range of 1 m, regardless as to whether the light is reflected from the human skin or from textiles.

Transmitter

The pulse generator of the transmitter circuit shown in Fig. 9.1 operates with a CMOS-gate, type HEF4011[1], and produces pulses with a duration of 10 μs and a repetition frequency of 100 Hz. The peak current of 1.5 A required by the LED, type LD27, is supplied by the Darlington stage consisting of T_1 and T_2. The electrolytic capacitor C_1 operates as a buffer. The pulse duration is adjustable by potentiometer P_2 and the repetition frequency is set by potentiometer P_1. Under the assumption of a duty cycle 1000:1, an average current of 1.7 mA is required for the complete transmitter circuit.

[1] HEF4011 refers to RCACD4011

Fig. 9.1



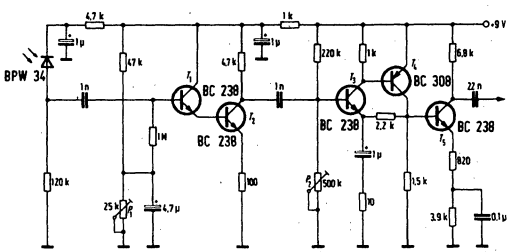
Characteristics

Supply voltage	6 V
Supply current	1.7 mA at V_s = 6 V
Pulse interval	10 ms
Pulse duration	10 μs
Half angle of the radiation cone	35°

Receiver

The broadband receiver circuit shown in Fig. 9.2 is applicable if the ambient light is less than 500 lx. For realizing the infrared filter in front of the photodiode BPW34 a non-exposed but developed color film, type CT18 (Agfa) is used. The signal supplied from the BPW34 is amplified by the transistors T_1 to T_5 and is available at the output with an amplitude of 6 V_{pp}. The gain is about 20,000. The operating point of T_5 is adjusted by the potentiometer P_2, setting a dc-level of 3 V to the base of T_5. The output signal is symmetrized by potentiometer P_1 which determines the operating point of the transistor T_2.

Fig. 9.2



Characteristics

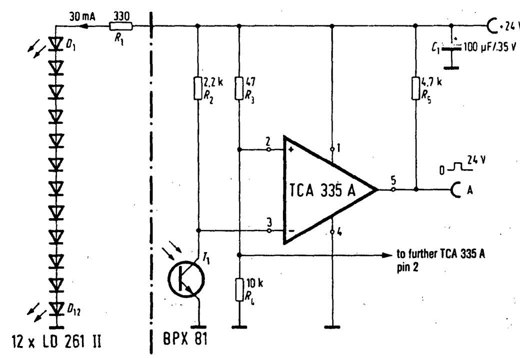
Supply voltage	9 V
Supply current	5 mA at Vs = 9 V
Gain	20,000
Output voltage	6 V_{pp}
Noise (without ambient light)	approx. 0.5 V
Operating range in conjunction with the above described transmitter, reflection from skin or textiles	max. 1 m

10. Optoelectronic Steel Tape Reader

Under more adverse conditions steel tape is often used instead of normal punched tape for reading control data into numerically controlled machine tools. The circuit proposed here is based on a configuration with 12 bit parallel read-in. The LEDs associated with the 12 bit are connected in series and supplied through the resistor R_1 from the 24 V supply. Each bit is allocated a phototransistor BPX81 and operational amplifier TCA335A. The phototransistor is connected to the inverting input of its associated operational amplifier, so with incident light (hole in the tape) the voltage at pin 3 of the TCA335A drops. A positive pulse then appears at the output.

Up to an ambient temperature of 40°C the LEDs require no additional cooling. Compared with tape readers employing light bulbs, the LED configuration is more robust, requires less maintenance and its power consumption is a factor of 10 lower. Reader errors cannot occur in practice because if a LED goes open circuit all 12 are without current and the fault is immediately apparent.

Fig. 10.1



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Remote Control Appnote 34

1. Simple Infrared Remote Control with Low Current Consumption

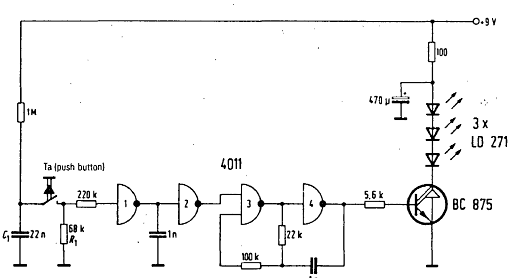
For remote-controlled switch operation only a very simple circuit is needed. The infrared signal consists of a 20 kHz burst with a duration of approx. 1 ms. To reduce the interference by ambient light and flashes, an integrating circuit is connected to the receiver, which will only supply a trigger pulse after having been applied by a series of pulses.

Transmitter

A 20 kHz-oscillator consisting of two CMOS-NAND gates (Fig. 1.1) is used. As long as gate 2 has L-level, the oscillation is interrupted. After pressing key T, H-potential is applied to the input of gate 1 as well as to the output of gate 2 and the oscillator starts operating. After a certain time, determined by the time constant of the C_1R_1-circuit, the voltage at the input of gate 1 drops below the minimum H-level threshold and thus the oscillation is interrupted. The time constant of R_1C_1-circuit is dimensioned for a burst-length of 1 ms. The 1 nF-capacitor, connected to output of gate 1, suppresses pulse spikes during turn-on.

Due to the oscillation at the output of G_4, the Darlington transistor BC875 is periodically conductive. The transmitter diodes, type LD271 are operated at peak currents of up to 1 A. The energy is supplied during 1 ms by the 470 µF-capacitor. Its voltage drops by a value of 1 V during the burst.

Fig. 1.1

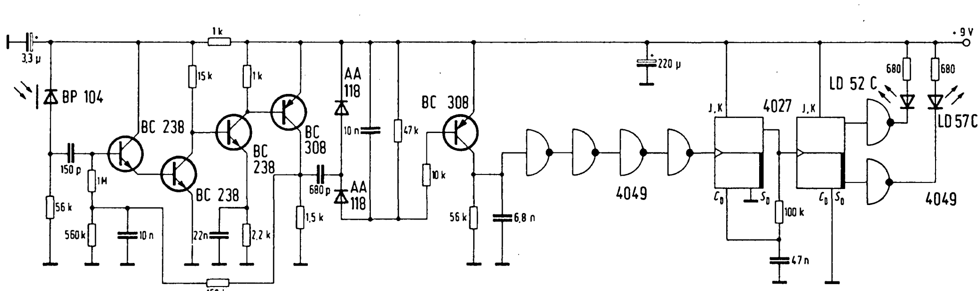


Receiver

The photodiode BP104 with integrated IR filter is used as a load with a resistance of 56 kΩ (Fig. 1.2). At normal ambient light this resistance is low enough to generate no voltage drop. The next stage is an emitter follower with an input impedance of approx. 1 MΩ. In conjunction with the second stage a gain of 100 is achieved. The dc operating point is controlled by means of an inverse feedback. By the next two stages, being also part of the inverse feedback circuit, the signal is further amplified by a factor of approx. 100.

The input signal, amplified totally by a factor of 10,000 is supplied to an integrated rectifier circuit. At each pulse the 10 nF-capacitor is charged by a certain voltage depending on the ratio of the capacitors (680 pF and 10 nF). As soon as the threshold of the transistor, being connected to the rectifying circuit is reached, a pulse with a positive switching edge is generated. It is steepened by means of four inverters. This edge triggers the following JK-flip-flop 4027 operating as a monoflop. At its output a defined pulse is available for triggering the following flip-flop 4027. In this case antivalent outputs are used to drive a red or a green LED.

Fig. 1.2



Application Notes

Technical Data

Transmitter

Supply voltage	9 V
Pulse width (single pulse)	approx. 1 ms
Carrier frequency	approx. 20 kHz
Peak current	approx. 1 A

Receiver

Supply voltage	9 V
Supply current (without LED)	2 mA
Intermediate frequency	approx. 20 kHz
Gain	approx. 80 dB
Range	≧15 m

2. Power-Saving Infrared Transmission for One Channel

With the transmitter-receiver combination described in the following it is possible to transmit simple instructions, e.g. on-off, over a distance of about 20 m by using the light emitting diode LD271 and the receiving photodiode BPW34. Therefore this device is favored for remote control operations of electrical equipment, e.g. dimmers, motors, switches, model railways or even installations carrying high tensions. Besides that, it can be advantageously used to realize light barriers, since the high carrier frequency guarantees a high interference immunity against continuous and low-frequency modulated light. If an optical system is used for the transmitter as well as for the receiver, much greater distances than the above mentioned can be covered.

An extension to more than one channel is possible, but the current consumption will increase by the number of channels. Thus this operating principle is also applicable for remote controlling of TV-receivers and of other devices demanding higher requirements. If the number of channels is n, 2^n–1 different instructions can be transmitted.

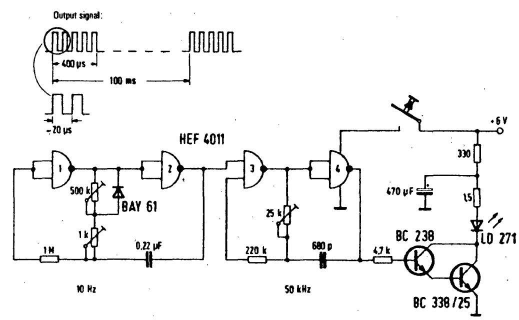
Since the information is only transmitted for a short period, the average power dissipation is reduced by a factor of 500 in comparison to the peak power. In the described application the repetition frequency is 10 Hz, i.e. the interval between two instructions is 100 ms.

By the ambient light a noise voltage is generated in the photodiode BPW34. Therefore, the input circuit of the receiver operates with a narrow-band-filter, keeping the noise influence low. Each instruction consists of a pulse train with constant pulse interval (e.g. 50 kHz). The number of pulses per train required for processing a statement depends on the amplifier. Therefore, it has to be considered that a narrow-band amplifier has a transient response which is not to be negligible. For instance, a resonant circuit with a determined quality factor Q needs pulses in a quantity of (Q/3) in order to reach 50% of the maximum resonant amplitude. Assuming a carrier frequency of 50 kHz, a quality factor of 16 and a bandwidth of 3 kHz, 5 pulses are required to obtain a value, which is 50% of the maximum resonant-circuit voltage. In the described circuit the interval for the total pulse train was chosen with 400µs which refers to 20 pulses.

Transmitter

Only one CMOS-IC, type HEF4011[1] has been utilized to realize the two oscillating circuits of the transmitter, operating at 10 Hz resp. 50 kHz (see Fig. 2.1). The 10 Hz-oscillator has a duty cycle of 250:1.

Fig. 2.1



These different intervals are obtained through by-passing the charging capacitor by means of the diode BAY61. The 50 kHz-oscillator is modulated by 10 Hz, i.e. it operates only during a time of 400µs. The LD27, emitting infrared light, is square-wave modulated by a Darlington stage with reference to the rhythm of the output signal. If the peak current is a 1 A, the average value is only 2 mA. As this peak current is not available from the battery, it is supplied from a 470µF-capacitor, the voltage of which decreases by a value of 0.5 V for the duration of the pulse train. The diode current being higher at the start positively effects the resonant circuit of the receiver.

Characteristics

Supply voltage	6 V
Supply current	2 mA at 6 V
Subcarrier frequency	50 kHz
Duration of pulse train to train repetition period	400 µs : 100 ms
Emitted peak power	80 mW/sr
Half-angle of the radiation cone	35°

Receiver

The receiver shown in Fig. 2.2 operates with the photodiode BPW34, which is matched to an input impedance of approx. 80 kΩ at 50 kHz. The dc diode-current should not exceed a value of 20 μA. For the infrared filter placed in front of the photodiode, a non-exposed but developed color film, type CT18 (Agfa) has been used. In the following circuit the pulses are amplified, clipped, rectified and applied to a monostable multivibrator, which covers the space between two pulse trains. Therefore a dc voltage is available at the output of the receiver as long as the push button of the transmitter is operated. Thus the required function can be realized.

The amplifier consisting of transistors T_1 to T_5 offers a gain of 20,000. T_1 operates as an impedance former. The bandwidth is adjusted to a value of 3 kHz by a selective feedback between T_3 and T_4. T_6 operates as the threshold switch and limiter. The signal is integrated by the capacitor C_S and delayed, so that after the start of the pulse train three to four 50 kHz-oscillations pass before the following monostable multivibrator is triggered. Thus it is guaranteed that short pulse-interferences do not trigger the monovibrator, consisting of two NAND-gates, type HEF4011[1]. The duration of the monovibrator pulse is 100 ms. Thus it is assured that the steady state is obtained after a period of 100 ms, if the following pulse train is not emitted from the LED.

[1]HEF4011 refers to RCA CD4011

Characteristics

Supply voltage	9 V
Required current (without output circuit)	10 mA at V_s = 9 V
Receiving bandwidth	3 kHz
Centre frequency	50 kHz
Admissible ambient light	
day light	max. 4,000 lux
incandescent light	max. 500 lux
fluorescent lamp light	max. 10,000 lux
IR-filter, cut-off wavelength	870 nm

Fig. 2.2

3. IR Preamplifier with the IC TCA440 for Infrared Remote Control Systems

Preamplifiers for IR remote control systems with pulse code modulation must meet additional overdrive requirements compared with frequency coded systems.

Receiver overdrive in conjuction with tuned circuits results in falsification of the envelope pulse duration. However, the receiver can only process such pulse "distortion" to a certain degree. As the input signals can differ by a factor of more than 10^5, a control loop must be introduced to prevent overdrive. The control circuit must act fast enough to assure correct transmission of the first bit. This is especially important for the transmission of single instructions. The requirements are less critical for repetition instructions; here it suffices when the correct control state condition is achieved by the time transmission of the second instruction commences.

With single instructions, the signal AGC circuit must act within a fraction of the bit duration. This necessitates a response time of less than 100μs. The dwell time in the control state must, however, be much longer, ideally more than 100 ms so that for repetition instructions a more-or-less steady control state condition already exists for the second instruction.

In addition to this control loop driven by the useful signal for single instructions, a control circuit dependent on light level is also advisable. This assures maximum sensitivity under low ambient light conditions and reduces the amplification with increasing light level to maintain the light noise just below its disturbing level.

In practice, the operator can bring the transmitter very close to the receiver. When this form of overdrive occurs it must be assured that correct recognition of the signal is not prevented. For guidance purposes, a minimum separation of 5 cm can be assumed. The resultant level differences of more than 100 dB generally can not be fully handled by the internal control circuit of the IC; additional measures such as peak level limiting are therefore required to hold pulse distortion within the admissible limits.

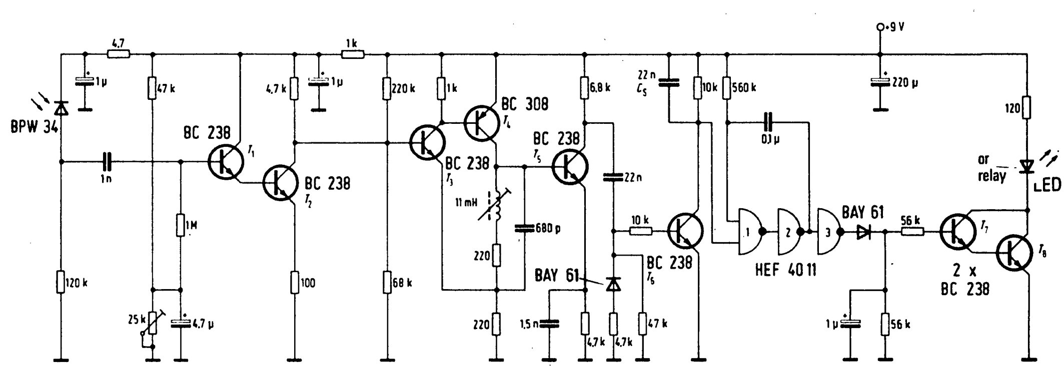
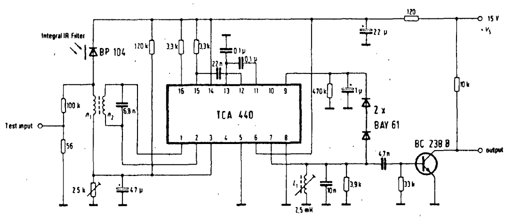


Fig. 3.1 shows a circuit incorporating the IC TCA440 which essentially meets all the above requirements.

Fig. 3.1



It is assumed that the transmitter radiates an IR signal with a carrier of approximately 30 kHz modulated with information as 7 bit instructions in biphase code. The bit length should be about 1 ms, the repetition frequency, if present, about 10 Hz.

In series with the IR diode BP104, which is similar to the photodiode BPW34 but with integral IR filter, is a resonant circuit tuned to 31.25 kHz and having a resonant impedance of 50 kΩ. Damping is provided by the 100 kΩ resistor and transformed input impedance of the TCA440. With a transformation ratio of 5:1, the TCA input impedance of about 4 kΩ appears as 100 kΩ on the primary side. The bandwidth of 10 to 12 kHz is relatively large, but this makes the input circuit design uncritical and assures short rise and fall times. The capacitive loading is mainly on the secondary side, only the BP104 junction capacitance loads the primary side. The bandwidth can be halved if required by removing the 100 kΩ resistor.

In the TCA440 the preamplifier stage with inputs 1, 2 and output 15 and the controlled IF amplifier with input 12 and output 7 are utilized. The latter requires a resonant circuit at the output, otherwise the output voltage is too low. The AGC starts to operate through pin 9 when the output circuit voltage exceeds 2.5 V_{pp}.

Under high ambient light conditions the input amplifier gain can also be controlled. The DC output current of the BP104 causes a small voltage drop at the bottom end of the primary winding which is utilized for gain control. Input 3 is current biassed such that the AGC already acts at relatively low photocurrent levels.

The output circuit bandwidth is about 4 kHz and contributes decisively to the receiver sensitivity. The output voltage is limited by the TCA440 to about 4 to 5 V_{pp}. When designing this circuit, care should be taken to prevent inductive feedback from the circuit inductance L_1 to the input transformer.

Technical Data

Input IR irradiance ($\lambda = 950 \pm 30$ nm)	
Minimum	1 nW/mm²
Maximum	$5 \cdot 10^5$ nW/mm²
Range	
a) without wall influence (free room)	
Angle 0°	>12 m
Angle 30°	> 8 m
b) with wall influence (corridor) Corridor 2 m wide × 2.5 m high	
Angle 0°	>20 m

under the following conditions:

- Transmitter peak power 160 mW (i.e. 2 lower limit LD 271 with 1 A peak current)
- Low outside light (Max. illumination 500 Lux, caused by daylight or fluorescent lamp)

Outside light influence	
With incandescent light E = 1000 Lux Range reduction	<50%
Admissible variation in pulse group length (rated value 500 or 1000 µs)	±10%
AGC time constants	
Gain reduction	<100 µs
Gain increase	>100 ms
Center frequency	31.25 kHz
Bandwidth	
for small signals (AGC not operating) referred to output 7	approx. 3 kHz
Output signal	15 V_{pp} modulated
Supply voltage	15 V + 3 V, − 5 V
admissible ripple	<2%

Input transformer: B65531-L0250-A028
Pot core 11 × 7, $A_L = 250$ nH
$n_1 = 565$ turns, 0.07 dia.
$n_2 = 111$ turns, 0.07 dia.

Primary inductance approx. 85 mH

L_1: B65517-A0250-A028
Pot core 9 × 5, $A_L = 250$ nH
$n = 100$ turns, 0.1 dia.

4. Single Channel IR Receiver with High Interference Resistance

Fig. 4.1 shows an IR receiver circuit which is especially suitable for light barriers or simple IR transmission systems. It features increased resistance to extraneous light interference, for example the switch-on pulses of fluorescent lamps.

The pulse groups emitted by the transmitter (f_0 = 40 kHz, t = 1 ms, T = 100 ms) are received and amplified by approximately 60 dB on OP 1. P_3 sets the switching threshold for the following threshold switch OP 2, at the output of which the pulses are again available at TTL level. The first pulse received by the diode triggers MF1 which produces a pulse of duration t_1 (see Fig. 4.2). This in turn releases after approximately 90 ms a pulse of duration t_2 (G_1 and G_2). The second transmitted pulse can only pass G_4 during the period t_2. The output signal A (continuous signal) is delivered by MF3, a post-triggered monoflop with $t_3 > T$.

The circuit is therefore insensitive to incoming interference pulses for a time $T - t_2$ and only responds when at least two pulse groups are received with a spacing T.

It is possible to replace the TTL IC's MF1 to MF3 by C-MOS monoflops (4047). This reduces the power requirements and permits the use of a higher supply voltage, for example from a 9 V battery. The Zener voltage of diode D_1 must in this case be about half the supply voltage.

Technical Data (TTL Version)

Supply voltage	5 V
Supply current	55 mA
Carrier center frequency f_0	40 kHz
Input circuit bandwidth	4 kHz
Pulse group duration t	1 ms
Pulse group repetition frequency $1/T$	10 Hz
Response threshold (max sensitivity) referenced to the photodiode useful current	approx. 3 nA
Range measured with a transmitter fitted with 3 × LD271, I_F = 1 A	>12 m

Fig. 4.2

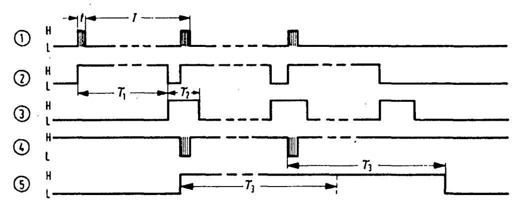
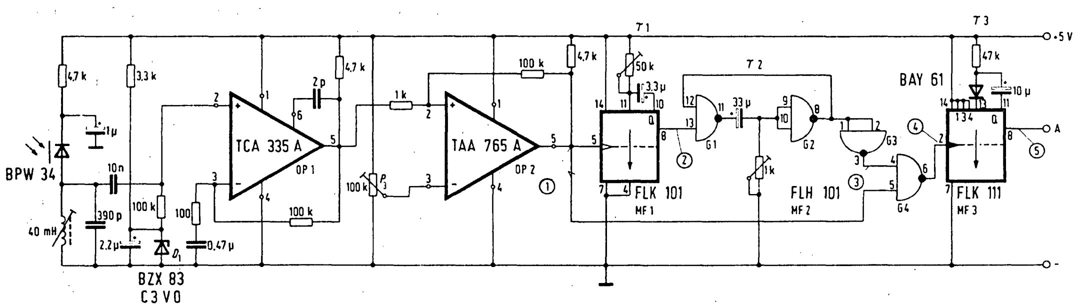


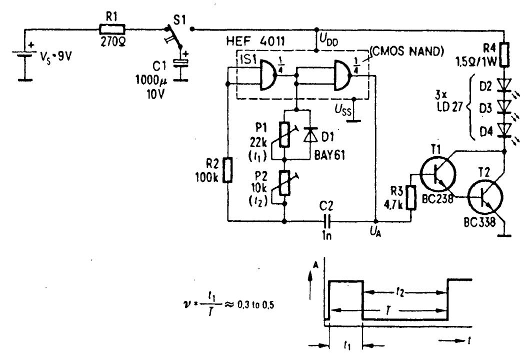
Fig. 4.1



5. Simple Battery-Operated IR Remote Control Transmitter for Single Instructions

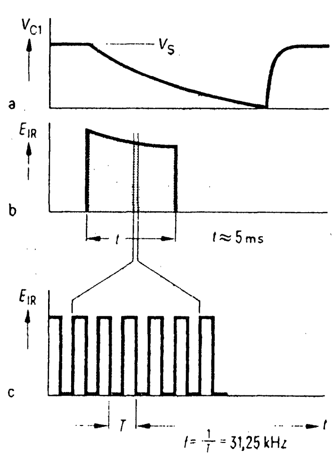
The IR transmitter circuit is shown in Fig. 5.1. The capacity of a normal 9 V battery (240 mAh) suffices for about 30,000 switching operations; thus it is not the switching rate which normally determines the battery life but its storage capacity.

Fig. 5.1



When the switch S_1 is operated, the transmitter radiates a single IR pulse of about 5 ms duration modulated with 31.25 kHz (see Fig. 5.2). After demodulation of the signal, 5 ms square wave pulses corresponding to the envelope of the modulated pulses emitted by the transmitter appear at

Fig. 5.2



the receiver output. These can be used for various purposes, for example to change over a flip-flop state for switching equipment off or on, to drive counter circuits that actuate different switching processes, etc. The modulating frequency of 31.25 kHz is generated by a stable multivibrator incorporating CMOS NAND gates to minimize the power consumption. The multivibrator supplies the driver stage T_1, T_2 for the GaAs LEDs (IR radiators) D_2, D_3 and D_4. With S_1 in its rest position C_1 charges up through R_1. When S_1 is pushed, C_1 is connected as a voltage source to the transmitter circuit which then starts to oscillate. The current consumption of the circuit and the value of C_1 determine the duration of transmission.

The center frequency of 31.25 kHz is determined by P_1 and P_2: P_1 affects the pulse duration t_1 and P_2 the interval t_2.

The duty cycle $v = t_1/T$ should be between 0.3 and 0.5. This gives the longest range for minimum power consumption. Because of resistance tolerances within the CMOS circuit, the frequency can only be calculated roughly:

$$f = \frac{1}{T} \approx \frac{1}{1.1\,(P_1 + 2P_2)\,C_2}$$

Technical Data

DC supply voltage	9 V
Center frequency (adjustable)	31.25 kHz
Duration of transmission per single pulse ($C_1 = 1000$ µF)	5 ms
Energy consumption per switching operation	25 mWs

6. Preamplifier for IR Remote Control Systems

Infrared remote control receivers with MOS-ICs usually require a digital input signal with TTL-levels. Therefore a preamplifier has to be connected between the photodiode and the MOS-circuit. Such a preamplifier has already been described (see ¶3). In the following, a circuit, using the IC DA4050 is commented. The TDA4050 was especially developed for applications of IR remote control systems. It comprises a controlled prestage, an amplifier and a threshold amplifier. This IC offers excellent large-signal characteristics, an output with short-circuit protection and a simple driver circuit for active band-pass filters. Although solutions without coils are cheaper, an LC-network is connected to the input of the circuit shown in Fig. 6.1 to obtain a higher selectivity. The photodiode SFH205 is connected directly to the resonant circuit. It is reversely operated and biased with 11 to 14 Volt. The signal from the resonant circuit is supplied to the input of the IC via transistor BC414C. Thus, the signal-to-noise ratio is improved. An active filter is connected to pins 4 and 5. It is part of the reverse feedback circuit of the operational amplifier. The output signal is available at pin 3, offering a protection against short-circuits to ground (R_i = *10 kΩ*). At L-level, the output has a low impedance.

Fig. 6.1

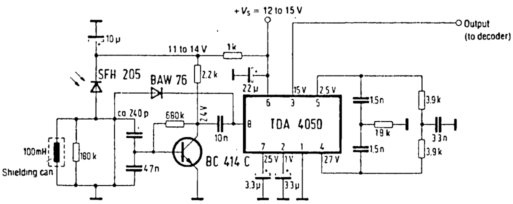
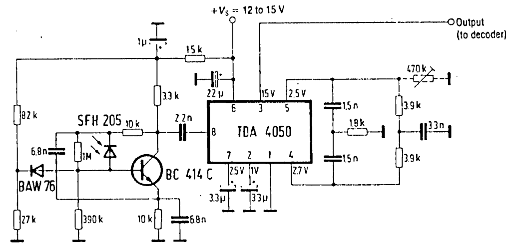


Fig. 6.2 shows a circuit without coils. The large-signal characteristics and noise immunity are improved by a network consisting of resistors and diodes.

Both circuits should advantageously be mounted in a double-screened case.

Fig. 6.2



Without any influence of extraneous light, a distance of 25 to 30 m between transmitter and receiver can be easily realized, whereas the distance is much higher if the circuit with LC-network is used.

The described preamplifier circuit is also applicable for IR remote control systems used in TV sets. In this case, only a range of 15 to 18 m is covered because of the wire-netting protection and the stray influences of the TV defection coils.

SIEMENS

Photographic Aperture, Exposure Controls, and Electronic Flash Appnote 35

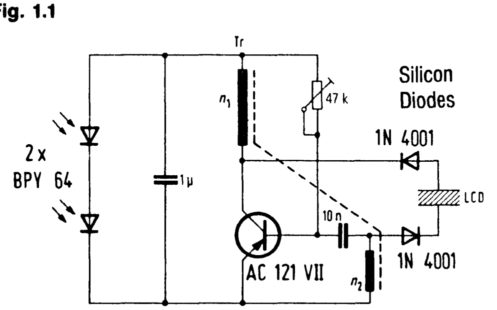
1. Solar Cell Generator for Exposure Control in Cameras without Moving Parts

Exposure meters normally work with a moving coil instrument. With a field effect liquid crystal display and a solar generator with two photovoltaic cells, type BPY64 a fully electronic light control without mechanical moving parts can be realized. The reversal point of the indicator is reached at an illumination of 100 lux (color temperature of 2850 K). Thus exposure-time display for low-priced cameras is possible.

Circuit Description

A basic requirement is an oscillator which starts oscillating at a voltage below 100 mV. Two photovoltaic cells, type BPY64, feed a blocking oscillator with transistor AC121 VII as shown in Fig. 1.1. Because of the low photo-electric voltage available at low illuminations a germanium transistor with a low threshold voltage has to be used. In operation, the transistor is at first conductive so that a magnetic field can be built up in the primary winding of the transformer Tr. Through the secondary winding, a reverse voltage is induced to the base circuit which turns off the transistor. At this moment the magnetic field of the coil collapses. The potential difference between collector and base is momentarily approx. 5 V at the break-down point of the liquid crystal display. To avoid a too strong damping of the base circuit by the capacitor of the display, two diodes are connected in series to the LCD. The pulse duration of the blocking oscillator signal is mainly defined by the self-inductance and self-capacitance of the coil, while the repeating frequency depends on the time constant of the base circuit. The optimum output voltage is achieved at a repeating frequency of approx. 3 kHz. The oscillations start at a collector voltage V_{CE} of –60 mV and a mean current I_C of 30 μA.

Fig. 1.1



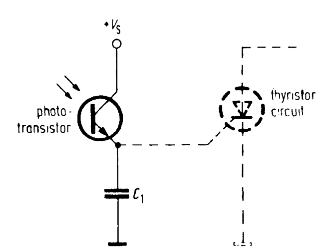
Coil Pot Core 14 × 8
Material N30
n_1 = 666 turns
n_2 = 333 turns
0.07 ECu
L = 1.84

2. Phototransistor Used In a Computerized Photoflash Unit

A new circuit has been designed for the receiving part of the computerized photoflash unit. It offers the advantage in that it essentially compensates all the undesired influences produced by exposure time errors, ambient light, temperature, and tolerances of the photosensitivity. A phototransistor in conjunction with an integrating capacitor connected to the emitter serves as a photodetector.

A computerized photoflash unit differs from a standard one in that the duration of the photoflash is determined by a photodetector. Therefore, the exposure time for a camera film is constant and does not depend on the intensity of the reflected light, i.e. the flash is interrupted sooner or later in dependence on the quantity of reflected light. Fig. 2.1 shows on principle the control circuit of a computerized photoflash unit. The photocurrent of the phototransistor charges the capacitor C_1 and thus the turn-off thyristor shown in the figure with broken lines is triggered.

Fig. 2.1



A trial was conducted to find out how far exposure time errors of photoflash devices using the circuit of Fig. 2.1 depend on the sensitivity of the phototransistor. It has been experienced that the sensitivity changes by about 25% in a distance between 0.9 m to 4.0 m. This variation is generated through the change of the current gain depending on the collector current.

The compensation of the linearity error of a phototransistor is only partially possible because of its unavoidable characteristic tolerance. Therefore it is more convenient to use a circuit in which the value of the current gain does not essentially influence the exposure time of a computerized photoflash unit.

The base collector current dependence on the luminous intensity is completely linear whereas this is contrary to the one of the emitter collector current. This is founded in the fact that the base-collector-junction serves as a photodiode. Therefore, a special circuit has been designed. The current generated through the light is integrated by a capacitance not being connected to the emitter of the phototransistor but to its base as shown in Fig. 1.1. At the beginning of the exposure the capacitor is not charged, i.e. the base-emitter-junction is not conductive. If the phototransistor is illuminated charge carriers are generated. A hole moves to the base terminal and positively charges the capacitor C_1 with reference to ground potential. When the capacitor is charged so that the base-collector-junction becomes conductive, the phototransistor starts to amplify, i.e. the emitter current increases. The amplified photocurrent produces a voltage drop across the load resistor R_2 and thus the following turn-off thyristor is triggered.

The disadvantage of the circuit shown in Fig. 2.1 is that the signal slewing rate is not fast enough, because the capacitance of the integrating capacitor C_1 is increased by the gain of the phototransistor at that instant when the base-emitter-junction becomes conductive, i.e. when there is an amplification effect. In order to improve the signal slewing rate the circuit shown in Fig. 2.2 is recommended. Here the capacitor C_1 is connected to the base and emitter. If the voltage across the load resistor R_4 increases, the level at the capacitors low end also rises with nearly the same amount as at the high end of C_1 connected to the base. Therefore, the capacitor C_1 usually requires no charge. The circuit according to Fig. 2.3 assures that at the beginning of each photoflash the capacitor C_1 always has the same charge impedance of the illumination which previously occurred. The resistors R_2 and R_3 serve as voltage divider, at which a positive voltage of 1 V referred to the level of the phototransistor emitter is disposable before the photoflash is started. The diode D_1 is turned off. Its voltage difference effects that a current flows via the resistor R_1 into the base of the phototransistor. At its base-emitter-junctions a voltage drop, not being essentially increased by the external illumination is produced. At the beginning of the photoflash, a negative pulse is applied via terminal B to the resistor R_2. By the current flowing through R_2 the diode D_1 becomes conductive and its level changes from +1 V to -0.7 V. This potential difference is fully transmitted via the integrating capacitor C_1 to the base of the phototransistor, which is therefore reversely biased by this voltage. Thereafter, this bias is compensated by the photocurrent. The negative voltage pulse required at the beginning of the photoflash can be derived from the same voltage source, which generates the collector-emitter-voltage at the beginning of the photoflashing. The voltage at terminal A is taken from a divider being in parallel to the photoflash capacitor, i.e. it is also available before the photoflashing occurs.

Fig. 2.2

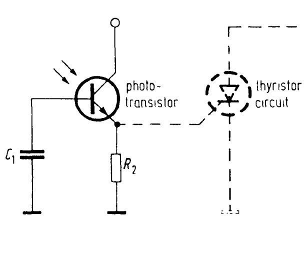
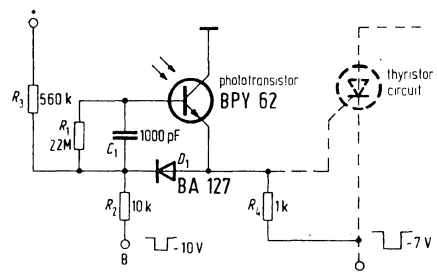


Fig. 2.3



The advantageous features of the circuit according to Fig. 2.3 compared to the one of a conventionally computerized photoflash unit are as follows:

a. Exposure time failures are nearly not detectable – presuming an objective lux meter (<5%).
b. The phototransistors must not be selected according to their photosensitivity since their base-collector-junction is utilized and there is no difference in sensitivity amongst the phototransistors.
c. No neutral absorber is required, since the internal base-collector-diode of the phototransistor operates linearly. Therefore, the photodetector is able to receive more light, i.e. signals with a higher amplitude are produced and the operation is trouble-free. The gate current of the thyristor does not influence the exposure time control. The total temperature coefficient is low (about 0.3% K^{-1}). If necessary the TC can be additionally decreased by applying at terminal B a pulse with a higher amplitude.
The charging of the integrating capacitor is extremely low when the supply voltage is suddenly applied to the phototransistor.

SIEMENS

General Photoelectric Application Circuits Appnote 36

1. Suppression of DC Component in Photocurrent of Phototransistors

In many applications, phototransistors are intended to transmit only intensity-modulated light signals. Non-modulated light intensity interferes; the dc component caused by it must be suppressed.

Two circuits are described here in which the dc component remains ineffective. In the first circuit the direct current is kept constant through an automatic control system, in the second an active, frequency-dependent external resistance is used which is much smaller at low frequencies than at high ones.

Phototransistors are particularly suitable as light detectors for many applications since they are economical and, due to their amplification, offer a larger output signal than photodiodes. Thus they are less sensitive to external interferences.

In optoelectronics, a number of applications are used in which an intensity-modulated signal is superimposed upon a non-modulated one, e.g. in optical flame control, in light barriers involving moving objects, and in computerized flashlight equipment as well as slave flashlight equipment in which the primary illumination can cause interference. In many instances the suppression of the dc component is required because of the danger of overdriving through unmodulated light intensity.

Using phototransistors, the dc component of the photocurrent cannot be suppressed by a coupling capacitor.

Circuit for Phototransistors with Base Terminal

In Fig. 1.1 phototransistor T_1 and transistor T_2 form an automatic control system which regulates the voltage drop at resistor R_1, maintaining it at a constant value, independent of the unmodulated light intensity at phototransistor T_1. When the light intensity rises, a larger photocurrent I_p flows through T_1, and the voltage drop at resistor R_1 becomes greater. As a result, a larger current flows to the base of T_2. The rising collector current T_2 keeps reducing the primary photocurrent of T_2 until the voltage drop at resistor R_1 reaches its original value.

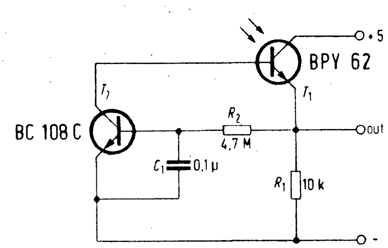
Due to the by-passing of the base-emitter junction of T_2 by capacitor C_1, this control mechanism is ineffective during rapid changes. The cut-off frequency above, which the control becomes ineffective, is determined by capacitor C_1 and resistor R_2.

Resistor R_1 determines the quiescent current. R_2 should be as large as possible to permit small values for C_1. However, when resistance of R_2 becomes too large, the drive of T_2 is too weak. As a result the maximum light intensity at which the control still works is reduced. The maximum light intensity is also limited by the power supply voltage, because the voltage drop at R_1 must not exceed a fixed maximum value.

For the dimensioning given in Fig. 1.1, the maximum light intensity can be 25,000 lx; the voltage drop at R_1 must not exceed the value V_{R1} = 4 V. The photosensitivity of phototransistor BPY62 is 2 mA/1000 lx. The dark current of the circuit is smaller than the dark current I_{CEO} of the simple phototransistor, because part of the dark current is split as residual current from T_2. The lower cut-off frequency of the circuit in the above dimensioning is f_{gu} = 16 Hz, the upper frequency f_{go} =2.5 kHz. If an increase in the upper cut-off frequency f_{go} is required, resistance of R_1 must become smaller.

To exclude interference signals, the connection between the collector of T_2 and the base of phototransistor T_1 must be held as short as possible.

Fig. 1.1



Circuit for Phototransistors Without Base Connection

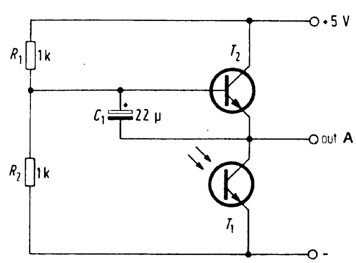
The circuit shown in Fig. 1.2 is intended for phototransistors without base connection. At low frequencies the base voltage of transistor T_2 remains constant, and is determined by the voltage divider of resistors R_1 and R_2. The collector resistance of phototransistor T_1 is determined by the relatively low diffusion resistance of the base-emitter junction of transistor T_2. A large collector current can flow without resulting in a substantial decrease of the collector voltage of phototransistor T_1. For the diffusion resistance it applies that

$$R_D = \frac{k \times T}{e \times I},$$

k standing for Boltzmann constant (1.38×10^{-23} WsK^{-1});
T for absolute temperature of phototransistor T_1, in Kelvin;
e for elementary charge (1.6×10^{-19} As); and I for emitter current of transistor T_2 in Ampere.

At high frequencies the base-emitter junction is short-circuited by capacitor C_1. As a result the considerably larger differential resistance of the emitter-collector junction of transistors T_2 functions as external resistance. Parallel to it there is the series circuit consisting of capacitor C_1 and the resistors R_1 and R_2, parallel-connected through the power supply. In the circuit presented in Fig. 1.2, the maximum light intensity for the given dimensions can amount to 20,000 lx.

Fig. 1.2



The sensitivity of phototransistor BPX81, used in the experimental circuit, is 2.5 mA/1000 lx. The lower cut-off frequency is f_{gu} = 80 Hz, the upper frequency is f_{go} = 40 kHz. The ac voltage at point A can be raised by increasing the resistance of R_1 and R_2. For a maximum light intensity of 20,000 lx, resistances of up to 10 kΩ are permissible.

List of Capacitors Used in the Circuit 1.1

1 pc	Ceramic Capacitor	0.1 µF/63 V

List of Capacitors Used in the Circuit 1.2

1 pc	Electrolytic Capacitor	22 µF/40 V

2. Power Supply Using the Photovoltaic Cell BPY64P for Low-Consumption-Devices

In the following, a circuit using the photovoltaic cell BPY64P and a blocking oscillator is described. It is utilized for supplying energy to small electronic devices of low power consumption, e.g., transmitter of infrared remote control systems. Generally a buffer accumulator is connected in parallel to this circuit and thus an operation without any batteries or other power supplies is realized.

On sunny days, transmitted energy of approx. 1 mWh can be generated by a Silicon-diode area of 2 cm^2 (corresp. to 6 × BPY64P) even in standard-size living rooms. But on cloudy or winter days, a maximum value of only 0.2 mWh can be expected.

Assuming a current of 10 mA for the short operation period of an IR remote control transmitter, a power of 60 mW at a battery voltage of 6 V is necessary. As the sum of all operations for remote control of a TV set does not exceed one minute per day, an electric energy of 1 mWh per day is required.

Under ideal conditions (i.e. power matching $R_i = R_o$, meeting exactly the color temperature for the sensitivity maximum) the photovoltaic cell BPY64P supplies approx. 60 µW at 1000 lx and at a color temperature of 2856 K. In practice, however, an average power generation between 15 and 16 µW can be obtained at diffused daylight and cloudy sky (E = 1000 lx).

Six photovoltaic cells, type BPY64P, connected in series as shown in Fig. 2.1 guarantee a safe starting of the blocking oscillator even at a low illuminance of 100 lx (daylight). The oscillator operates at 10 kHz. Its frequency strongly depends on the illuminance and the load. The basic current is adjusted by resistor R_1. A value of 82 kΩ can be considered as a good compromise especially at a low illuminance. The resistance of R_1 should be lower for higher illuminance values.

The circuit offers an efficiency of approx. 60 to 65%.

Five NiCd-cells (20 DK, Varta, ordering number 3910020001) can be suitably utilized as buffer accumulators. They supply an open-circuit voltage of approx. 6.2 V at a 100% charge. The capacity is 20 mAh.

Fig. 2.1

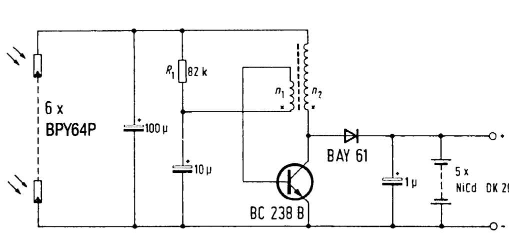


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Fig. 2.2 shows the accumulator current as a function of illuminance at an open-circuit voltage of 5.8 V and at a charge without load. The two curves show the dependence on incandescent lighting (60 W-bulb, matt, with white reflector) and on daylight (diffuse, near the window).

Fig. 2.2

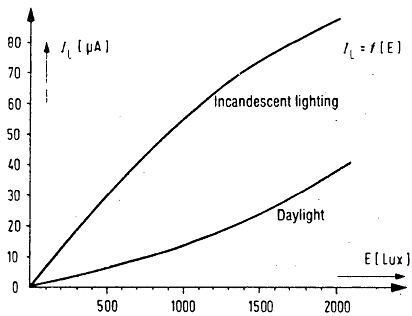
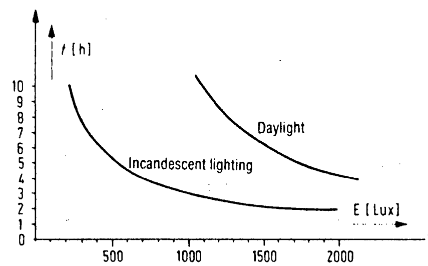


Fig. 2.3 shows the time necessary per day as a function of the illuminance. As reference an energy of 1000 µWh is assumed. This is required by the accumulator if the remote control transmitter is operated 60 times per day for a period of 1 s.

Fig. 2.3



Coil Data

n_1: 15 turns 0.07 enamelled copper wire
n_2: 340 turns 0.07 enamelled copper wire

SIEMENS

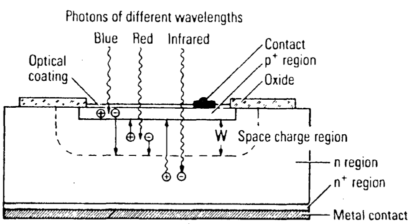
General IR and Photodetector Information Appnote 37

1. Detectors (Radiation-sensitive components)

Charge Carrier Generation in a Photodiode

Fig. 1.1 shows the basic design of a planar silicon photodiode with an abrupt pn transition. Due to the differing carrier concentrations, a field region free of mobile carriers,

Fig. 1.1
Planar silicon photodiode (schematic)



the space charge region, builds up between the p+ and n region, which only reaches into the n region if there is an abrupt p+ n transition. The following applies to the width of the space charge region:

(1) $$w \sim \sqrt{\frac{V_D + V}{n_D}}.$$

In this case, V_D is the diffusion voltage, V is the external voltage and n_D is the donor concentration on the n side. For the junction capacitance $C_j \sim \frac{1}{w}$ with w from equation (1) the g is obtained:

(2) $$C_j \sim \sqrt{\frac{n_D}{V_D + V}}.$$

If photons with an energy $h\nu \geq E_g$ penetrate into the diode, electron hole pairs are generated on both sides of the pn junction. The energy difference ($h\nu - E_g$) is dissipated to the grid on the form of heat. The electrical field in the space charge region repels the majority carriers and attracts the minority carriers on the other respective side (thus, holes from the n side to the p side and, vice versa, electrons from the p side to the n side). In this way, the charge carrier pairs are separated and a photocurrent flows through an external circuit, also without an additional voltage (photovoltaic effect). Carriers occurring in the space charge region are immediately sucked off due to the field prevailing in this layer. The carriers from the other regions must first of all diffuse into the space charge region in order to be separated. If they recombine beforehand, they are lost with respect to the photocurrent. Thus, the photocurrent I_p consists of a drift current I_{drift} of the space charge region and of a diffusion current I_D from the remaining regions.

Should the p+ region be far thinner than the penetration depth $\frac{1}{\alpha_\lambda}$ (α_λ = absorption coefficient) of the radiation, the photocurrent from the p+ region can be neglected and the following relationship can be derived for the photocurrent I_p.

(3) $$I_p = q\,\Phi_0 \left[1 - \frac{e^{-\alpha_\lambda w}}{1 + \alpha_\lambda L_p}\right].$$

L_O is the diffusion length of the holes in the n region, q is the elementary charge and Φ_O the radiant flux. The absorption coefficient α_λ is the only variable in the equation which depends on the wavelength. It predominantly determines the spectral characteristic of the diode's photosensitivity. In accordance with equation (1), the space charge region width w depends on the voltage and the doping which, in addition to the crystal quality, also influences L_D. High sensitivity is achieved with high values for w and/or L_D.

With respect to the electrical mode of operation, we differentiate between diode mode (with bias voltage) and cell mode (without bias voltage). In cell mode, the diode acts as a current generator which converts the radiant energy into electrical energy. If the photodiode is considered as a current source with the photocurrent I_p and a diode of equal polarity is connected in parallel to the load resistance R_{LE} (idealized equivalent circuit diagram), the relationship between the current and voltage can be expressed as follows:

(4) $$I = I_S\left[e^{\frac{V}{n \cdot V_T}} - 1\right] - I_p.$$

In this case, I_p is the photocurrent, I_{sat} the saturation current, V the voltage between the p and n contact, V_T the voltage equivalent of the temperature and n is the diode factor.
In the case of I_p = 0, equation (4) is reduced to a normal diode equation and describes the dark characteristic (E_v = 0). When subjected to light, the characteristic is shifted downwards corresponding to the illuminance. The open-circuit voltage

(5) $$V_L = n V_T \ln\left[1 + \frac{I_p}{I_S}\right]$$

belongs to I = 0 ($R_{LE} = \infty$) and the short-circuit current $I_s = -I_p$ belongs to V = 0 (R_{LE} = 0).

There is a linear relationship, depending on the diode type, between the illuminance E_v and the photocurrent I_p, which covers several powers of ten (eight and more). However, due

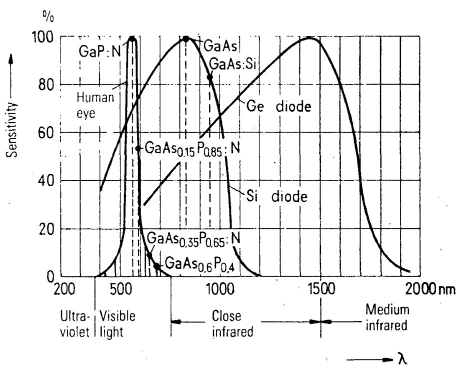
Application Notes

to $I_p \sim E_V$ and $I_p > I_s$, a logarithmic relationship prevails between the open-circuit voltage V_L and the illuminance E_V. The forward current I_F belonging to the open-circuit voltage V_L is equal to the impressed photocurrent. In diode mode, the photocurrent of one or the other diode type may slightly change together with the applied voltage. This is due to the voltage dependence of the space charge region. In the case of silicon photodiodes, the dark current [first term in equation (4)] once again only plays a role with extremely low illuminances (in the millilux range).

Spectral Sensitivity

Fig. 1.2 shows the graph of the spectral sensitivity of a silicon and a germanium photodiode. The positions of the emission maxima of the most important light emitting diodes and the sensitivity of the human eye are also shown.

Fig. 1.2
Relative sensitivity of a silicon and a germanium diode



The two photodiodes cover the wavelength band from approximately 300 to 1800 mm. In this case, the silicon diode is of greater significance; it covers the visible range and, with its maximum sensitivity in the near infrared area, is well matched to the GaAs infrared emitting diode, whose best-known field of application covers IR remote controls and light barriers.

The sensitivity limit of semiconductor detectors in the long wave spectral wave band λ_g is determined by the energy gap E_g.

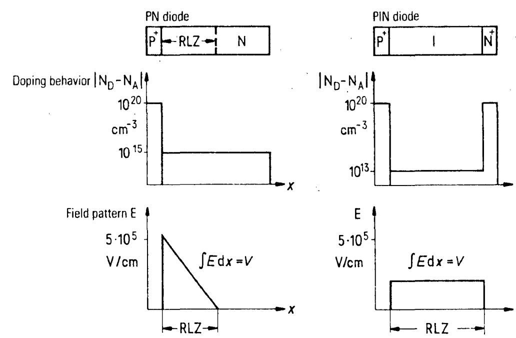
$$\lambda_g\,[\mathrm{nm}] = \frac{h \cdot c}{E_g} = \frac{1{,}24}{E_g\,[\mathrm{eV}]}$$

The run of the spectral sensitivity curve in the remaining wave band is determined by the absorption coefficient α_λ and the recombination relationships in the interior and on the surface of the semiconductor (carrier loss). The drop in the curve towards shorter wavelengths is due to the higher absorption for shortwave radiation; for this reason, carrier pairs are only generated in the regions near the surface but, due to the high prevalent recombination rate, are mostly lost with respect to the photocurrent.

Photodiodes (PN and PIN diodes)

Photodiodes can optimally be matched to the desired application by choosing the correct mode of operation and by means of a suitable internal structure. In addition to the schematic structure of each individual diode type, figure 1.3 shows the doping behavior and the field pattern as well as the region in which the avalanche effect takes place at a sufficiently high voltage (ionization region).

Fig. 1.3
Doping behavior and field pattern of photodiodes



In the case of the *PN photodiode*, the radiation which, as a rule, enters the p+ region vertically, is absorbed in the mainly quasi-neutral p and n regions due to the narrow space charge region; thus, the photocurrent predominantly consists of the diffusion current. As the characters are diffused relatively slowly, PN diodes are frequently used in applications in which the stress is placed rather more on low dark currents than on high speed. (For complete diffusion of a 5 μm thick p layer, an electron needs 3 ns, and a hole needs 15 ns for the same distance in the n region). Therefore, silicon PN diodes can be found in exposure meters which still operate perfectly under starlight; this presupposes dark currents of less than approximately 10^{-11} A/mm^2. Solar cells also belong to the group of PN photodiodes.

Contrary to the PN diode, in the case of *PIN photodiodes* most of the light is absorbed in the space charge region. These photodiodes are mostly used in applications requiring high speeds. In order to achieve a large space charge region, if possible, in accordance with equation (2), the semiconductor material must be intrinsic (intrinsic I) (mostly weak n or weak p doped) into which a p+ region is diffused on the one side and an n+ region is diffused on the other side. A P+ IN+ structure ("sandwich" structure) is obtained. In accordance with equation (3), the junction capacitance C_j is low due to the large space charge region of the PIN diode. C_j values are used between a few picofarad and a few tenths of a picofarad. The product from C_j and R_L (load resistance) is the time constant of the measurement circuit.

In order to achieve PIN diodes which are as "fast" as possible, the voltage is increased to such an extent that the carriers drift through the space charge region at saturation speed V_{sat}. In silicon and germanium, a saturation speed V_{sat} from 5 × 10^6 to 1 × 10^7 cm/sec is achieved with fields of approximately 2 × 10^4 V/cm. Accordingly, a carrier requires approximately 50 ps to completely drift through a 5 μm thick region.

Photovoltaic Cells

Voltaic cells are active dipole components which convert optical energy into electrical energy without requiring an external voltage source.

The properties of a voltaic cell are essentially characterized by the open-circuit voltage and the short-circuit current. In the case of a short circuit (V = 0), the current I_S is a linear function of the illuminance and thus also proportional to the area subjected to radiation. The open-circuit voltage V_O initially increases logarithmically with the luminous intensity.

This is independent of the size of the cell and amounts to approximately 0.5 V at 1000 lx. In order to extract the maximum amount of energy from a voltaic cell, the load resistance R_L must lie in the order of magnitude of $R_i = \sqrt{V_O/I_S}$. The internal resistance R_i of a voltaic cell should be as low as possible in order to prevent unnecessary loss.

In order to measure the luminous intensity, the proportional relationship between the optical and electrical signals is important, and in practice, this applies up to a load resistance of $R_i \approx V_O/2\ I_S$.

In principle, voltaic cells can also be operated in diode mode by applying a voltage in reverse direction. Obviously, this voltage must not exceed the maximum reverse voltage.

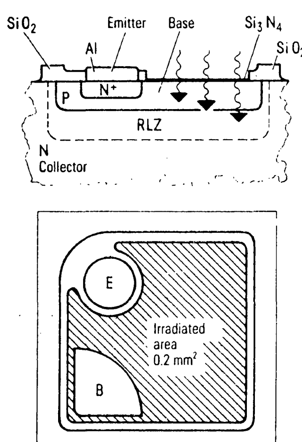
Phototransistors

In principle, a phototransistor corresponds to a photodiode (collector-base diode) with a series-connected transistor as amplifier. The phototransistor is the simplest integrated photoelectric component. Figure 1.4 shows one of the practical designs of a bipolar phototransistor (cross-section and view) with emitter (n+), base (p) and collector (n); the latter is mostly subdivided into a weakly doped n and a highly doped n+ region. As the diffusion length L_D of the holes in the n+ region is low due to the high amount of doping, only the p and n regions provide the maximum amount to the primary photocurrent I_{CB} of the collector-base diode. This is due to the low photosensitivity (also in comparison with photodiodes) of epitaxial transistors in the long wave band. A large part of the long-wave radiation is absorbed in the n+ region as the n region is mostly extreme thin (10 to 20 μm) as a result of the requirement for extremely low conductor resistances. The view of the transistor shows a base with a large area in which the emitter and also the base connection are attached to the side; in this way, as uniform as possible a surface sensitivity is achieved. The gain of phototransistors normally lies between 100 and 1000. Gain deviations from the linearity and thus from the linear relationship between the illuminance and the photocurrent amount to (over approximately four powers of ten of the photocurrent I_p, from some 100 nA to some mA) less than 20% and mostly less than 10%. With regard to dynamic behavior, phototransistors are less favorable than photodiodes as, in addition to the collecting and charging processes in photodiodes, there is also a delay due to the amplification mechanism (Miller effect). In addition to the rise and fall times t_r and t_f, the transistor also has the delay time t_d. This is the time required until the photocurrent has reached 10% of its final value after activation of an optical square-wave pulse. For the rise and fall times of a phototransistor, the following relationship applies:

$$t_{r,f} = \sqrt{\left(\frac{1}{2_{f_T}}\right)^2 + a\,(R \cdot C_{CB} \cdot V)^2}$$

In this case, f_T is the transition frequency, R is the load resistance, C_{CB} is the collector-base capacitance, G is the gain, a is a constant whose value lies between four and five. The rise and fall times of usual phototransistors range from 1 to approximately 30 μs with 1 kOhm load resistance. Therefore, they are particularly suitable for utilization within a frequency range up to some 100 kHz, which suffices for important applications such as light barriers, punch tapes, and punch card readers.

Fig. 1.4
Bipolar phototransistor

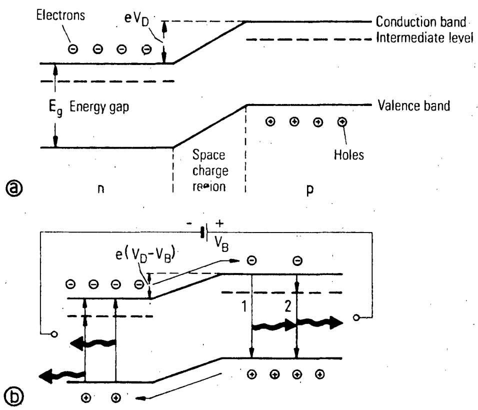


2. Emitters (Radiation emitting components)

Principle of Operation and Materials

Light emitting diodes operate in accordance with the principle of injection luminescence. Through a pn junction operated in forward direction, n-type charge carriers are injected into the neutral n and p region where they partially recombine for emission, sending out a photon with the energy $hv = hc/\lambda \leq E_g$ (h = Planck's constant, v = frequency, c = speed of light, λ= wavelength, E_g = energy gap). This is shown in figure 2.1 in the energy diagram for a pn junction.

Fig. 2.1
The pn junction of a light emitting diode



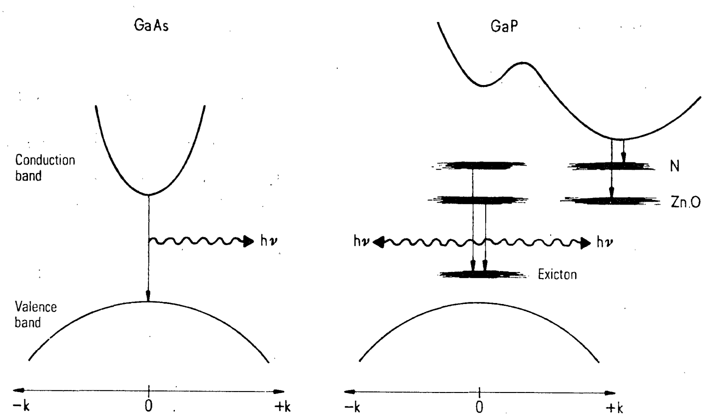
ⓐ without external voltage
ⓑ with externally applied voltage. Diode operated in forward direction (1 ≙ direct recombination. 2 ≙ indirect recombination)

The probability of radiant recombination essentially depends on the band structure type of the corresponding semiconductor material. In the case of direct semiconductors with GaAs as the most important representative, an electron can directly fall from the conduction band into a free state in the valence band (hole), in which case the released energy is given off as a photon (cp figure 2.2, left). In the case of the so-called indirect semiconductors with Si, Ge, and GaP as the most important representatives, however, this transition is linked with a pulse change of the electron. Recombination is then only possible with the participation of third partners, for example, phonons or impurities. These must ensure pulse compensation. The energy released during the transition is mainly dissipated as heat to the grid. In indirect semiconductors, this leads to the probability of radiant recombination being less by orders of magnitude than in direct semiconductors. Nevertheless, effective radiant recombination can be generated in some indirect semiconductors. This is achieved by doping with isoelectronic impurities. The two most efficient isoelectronic impurities in GaP are the nitrogen atom and the zinc-oxygen pair. Radiant recombination is then achieved by way of the decay of an electron hole pair (exciton) bonded to the isoelectronic impurity (cp figure 2.2, right).

A high degree of crystal perfection is a precondition for the creation of effectively radiant recombination as crystal defects act as centers for non-radiating recombination. For this reason, the active layers of light emitting diodes are produced epitaxially at temperatures far below the melting point of the semiconductor material.

III-V compound semiconductors and mixtures of these can be used as materials for light emitting diodes as their energy gaps cover wide spectrum and the band structure, contrary to the classical semiconductors Si and Ge, enable the creation of effective radiant recombination. Above all, the semiconductors GaAs, GaP, and the terniary mixtures Ga (As, P) and (Ga, Al) As have practical significance.

Fig. 2.2
Dependence of energy states on the wave number vector k in the case of direct (GaAs) and indirect (GaP) semiconductors.



Infrared Emitters (IR LEDs)

IR emitters are based on GaAs which has an energy gap of approximately 1.43 eV, corresponding to emission of approximately 900 nm. Higher external quantum efficiencies can be achieved with these diodes than with light emitting diodes for the visible wave band. The left-hand side of figure 2.3 shows the schematic of the diode body of a silicon-doped GaAs IRED. By means of liquid phase epitaxy (LPE), the active layer with a high crystal perfection can be grown onto a GaAs substrate. Due to the amphoteric characteristic of the silicon impurity, the pn junction forms automatically during the process of epitaxy. Due to the silicon doping, the emission lies at 950 nm and is thus so far underneath the band edge that the radiation created in the diode body is only absorbed to a slight extent. Part of the radiation leaves the diode body on a direct path through the near surface. However, radiation emitted in the direction of the substrate is also useful. For this purpose, the rear of the diode body is mirrored and serves as a reflection surface.

GaAs-IREDs are fitted in plastic packages or in hermetically sealed glass-metal housings.

An essential piece of information for the user is the radiation characteristic. If the light emitting diodes are used in an arrangement without optical lenses, for example, in a punch tape reading head, the radiation should have a small half angle. This is the case with LD260 to 269 and CQY77.

In conjunction with optical lens systems, designs are preferred in which the radiation leaves the component through a flat window (CQY78, SFH402).

Array designs are suitable for a wide range of applications as they can be rowed up in any configuration.

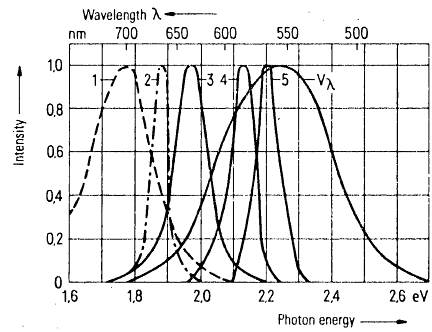
Further developments in the field of silicon-doped liquid phase epitaxial IREDs is aimed at expanding the wave band. The amphoteric character of the silicon doping is retained in the terniary mixed crystal (GaAl) As in that the energy gap can be varied by means of the amount of Al. In this way, it is possible to produce emission wave bands between 850 and 900 nm and to tune the emitter diodes to the maximum detector sensitivity. With selectively sensitive detectors, it would be possible to create transmission systems with two (or more) optically separate channels.

Electrical and Optical Characteristics of IR LEDs

Figure 2.4 shows the emission spectrum of the most important LEDs and the relative spectral contact sensitivity $V\lambda$. With respect to the emission spectrum of the IRED relative to the sensitivity curve of the silicon photodiode, see figure 1.2.

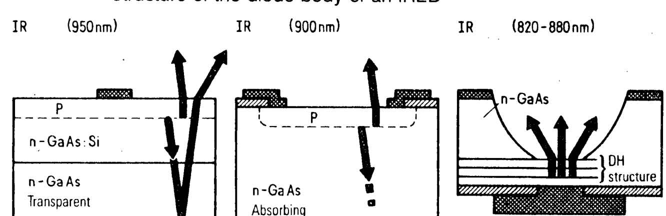
The emission spectrum of the GaP diode ranges from the yellow to the green wave band. By dying the plastic seal, the emission band can be limited in such a way that the emitted light appears yellow (λ_p = 575 nm) or green (λ_p = 560 nm) to the viewer.

Fig. 2.4
Emission spectra of the most important LEDs



1: GaP: Zn,0 — Red
2: $GaAs_{0.6}P_{0.4}$ — Red
3: $GaAs_{0.35}P_{0.65}$: N — TSN-Red
4: $GaAs_{0.15}P_{0.85}$: N — TSN-Yellow
5: GaP: N — GaP-Green/yellow
V_λ: Spectral contact sensitivity curve

Fig. 2.3
Structure of the diode body of an IRED



Epitaxy	LPE	—	LPE (Hetero)
pn junction	LFE	Diffusion	LPE (Hetero)
Technology	GaAs-IRED	Diffused GaAs IRED	Burrus type
Switching time (typical)	1000 ns	50ns	15 ns

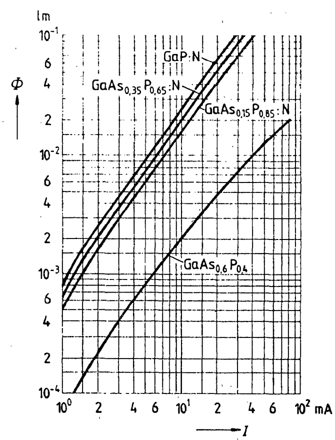
Semiconductor — Contact — Oxide

LPE = liquid phase epitaxy

Application Notes

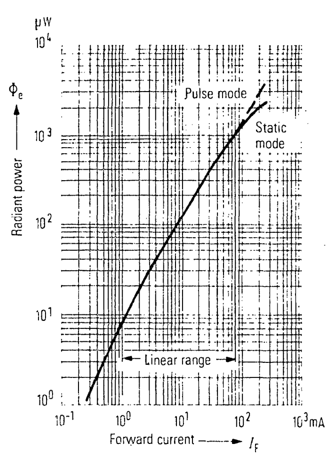
In the case of GaAs diodes and the red $GaAs_{0.6}P_{0.4}$ diode, the emitted radiation (or luminous intensity, respectively) of IREDs and LEDs changes in the normal operating range in a linear relationship with the forward current while, in the case of TSN diodes and GaP diodes, it rises slightly over-proportionally (figure 2.5).

Fig. 2.5
Light current – diode current characteristic



If the forward current is very high, the curve asymptotically approaches a threshold value. This is caused by a strong heating of the semiconductor system. The linearity range can be widened by switching from static to pulse operation. Non-linearity also turns up at small forward currents. It is caused by excess current not contributing to the radiation and cannot be influenced by the customer. Figure 2.6 shows the radiant power versus the forward current.

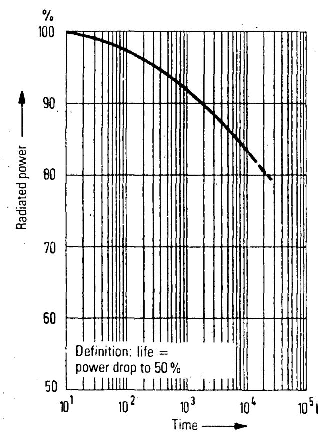
Fig. 2.6
Radiant power versus forward current



At constant current, the radiant intensity or luminous intensity, respectively, decreases with rising temperature. The temperature coefficient is –0.7% per degree for GaAs, –0.8% per degree for GaAsP, and –0.3% per degree for GaP. This is negligible for many applications. If the temperature dependence proves disturbing, it can widely be eliminated by compensation circuits.

The radiant power emitted by LEDs declines with increasing length of operation ("aging"). A "life" of components was introduced to describe the degree of degradation. It is defined as the time after which the radiant power has fallen to half the value. In the case of IREDs, for example, the average life dependent on the operating current and ambient temperature is approximately 10^5 h (extrapolated from continuous tests). Refer to figure 2.7.

Fig. 2.7
Radiated power versus operating life



3. Measuring Technique

Detectors (Radiation sensitive components)

Radiation-sensitive semiconductor devices serve to convert radiation energy into an electrical one. Radiation energy can be offered to the component in manifold forms, depending on the source of radiation. For measuring purposes only such radiation sources can be taken into consideration which, in their spectral energy distribution, can easily be covered and are reproducible, i.e. thermic radiation sources like the tungsten filament lamp, which at least in the wavelength range here of interest comes very close to the black body and monochromatic light sources that means those emitting radiation of only one wavelength or at least of a very narrow wavelength range, above all light emitting diodes and a combination of whatever emitters with narrow band filters. Especially for applications with infrared emitting diodes (IREDs), this measurement of the spectral photo-sensitivity is increasingly gaining significance and is taking the place of integral measurement with standard light A.

Because of its high energy, the tungsten filament lamp is mainly used for measuring the radiation sensitivity when set to a "color temperature" of 2856 K, corresponding to standard light A as per IEC306-1 part 1 and DIN5033 while light emitting diodes are primarily employed for cut-off frequency and switching time measurements as they can be modulated or pulsed up to high frequencies. At this instance, we want to draw your attention to the following. The definition "color temperature" is limited in its use for the optoelectronic measuring technique, quasi only as auxiliary. But unfortunately the term has come to stay. In practice the lamps are not calibrated to color temperature but to "relative temperature in the visible range", mostly to a green-red relation. An extension to a red-green-infrared relation and thus an approach to the, for our measuring technique solely correct, "distribution temperature" in the wavelength range 350 to 1200 nm, or even better 300 to 1800 nm, is worth aspiring after. This still meets with objections on the part of lamp manufacturers to extend their calibration equipment and the relatively small quantity of lamps required.

The tungsten filament lamps used for measuring purposes have to be set to a relative spectral energy distribution that corresponds to that of the black body at a temperature of normally 2856 K at least in the wavelength range 350 to 1200 nm, and have to be operated under very stable conditions. It is necessary to have the lamp operated with constant current, the deviation from the rated value must be kept less than ±0.1%. This requirement seems to be very high, but one has to consider that a deviation of the lamp current by 0.1% brings about a change of the radiant intensity by 0.7% and, of the color temperature, by 2 K. Naturally, the lamp can also be operated with constant voltage but this is hard to realize in practice because of the inevitable and varying contact resistances in the lamp socket, therefore an operation with constant current is to be preferred.

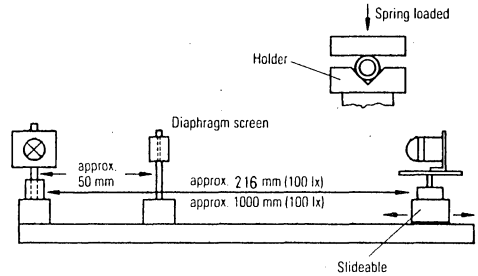
A lamp voltage check at the same time permits a control of the lamp with regard to a change in its characteristics, for example, by evaporating of coiled filament material which would point to the fact that the lamp is no longer suitable for measuring purposes and has either to be replaced or calibrated anew. This check is mainly recommended for the "standard lamps" which are standard for color temperature, radiant and/or luminous intensity.

For general measuring purposes, serial measurements in particular, the standard lamps gauged by the PTB or the manufacturer are usually not used because of the calibration costs. Therefore, the service lamps are set to the given ratings by a comparison with these standard lamps.

Photosensitivity

For photosensitivity measurements (photocurrent or photovoltage) the components to be measured are placed at the position predetermined for the specific irradiance and there they are held in such a way that the radiant sensitive surface of the semiconductor chip is vertical to the direction of light. Cylindric components such as in TO18, TO5 or similar plastic packages are put up so that the package axis coincide with the direction of radiation. This is of prime importance for components with a highly focusing lens. A holder with a sliding socket for the terminal wires proved useful (see figure 3.1).

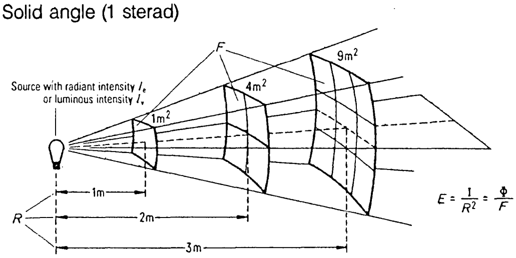
Fig. 3.1
I_p test set-up for photoelectric devices



Solid Angle

The solid angle is a part of space. It is limited by all the beams which radiate conically from one point (radiation source) and which end on a closed curve in the space. If this closed curve lies on the unitary sphere (radius R = 1 m) and envelopes an area of 1 m^2, and if all rays originate from the center point of the unitary sphere, the solid angle has one sterad (sr).

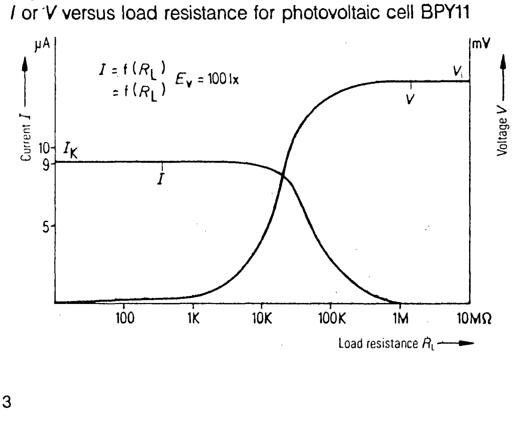
Fig. 3.2
Solid angle (1 sterad)



Short-circuit Current

When measuring the short-circuit current I_S of photovoltaic cells care has to be taken that the internal resistance of the measuring instrument used is small enough compared to the internal resistance of the photovoltaic cell. The same applies to measuring the open circuit, the internal resistance of the measuring instrument is large compared to the internal resistance of the photovoltaic cell.

Fig. 3.3
I or V versus load resistance for photovoltaic cell BPY11



Switching Times

The switching times are measured oscillographically by a set-up as shown in the circuit diagram below (figure 3.4) by means of a pulsed infrared emitting GaAs diode as a measuring source and a double-beam oscillograph. The switching times of the GaAs must, of course, be small compared to the switching times of the component to be measured.

Fig. 3.4
"Measuring the switching times of detectors"

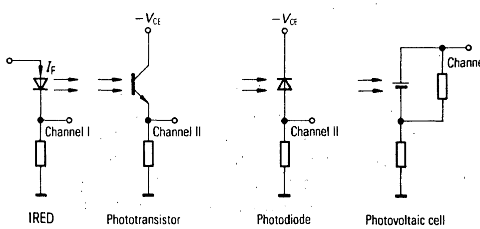
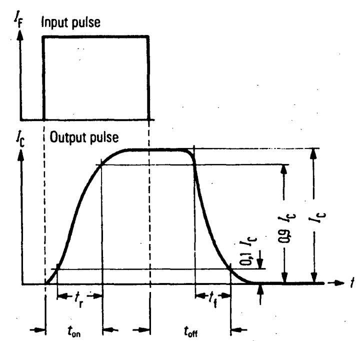


Fig. 3.5
Switching time definitions



Turn-on time t_{on}:
The time in which the collector current I_C rises to 90% of its maximum value after activation of the drive current I_F.

Rise time t_r:
The time in which the collector current I_C rises from 10% to 90% of its final value.

Turn-off time t_{off}:
The time in which the collector current I_C drops to 10% of its maximum value after deactivation of the drive current I_F.

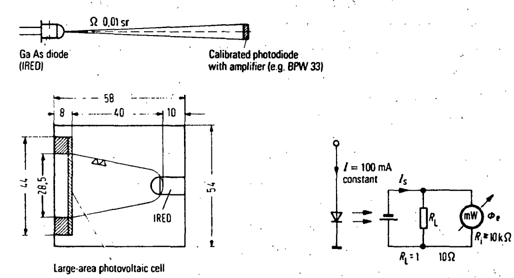
Fall time t_f:
The time in which the collector current I_C drops from 90% to 10% of its maximum value.

Radiation in the Infrared Range

The radiant intensity I_e in the direction of the case axis should be measured by a wavelength independent detector (thermocouple element) but low sensitivity, inertia, and temperature sensitivity cause difficulties. For this reason, one usually measures with a correspondingly calibrated photovoltaic cell. In such case, the spectral sensitivity curve of the photovoltaic cell has to be considered and the measuring result corrected with regard to the deviations in the emitted wavelength of the radiator to be measured (for example IRED with different production technology). If the total radiation of the component shall be measured, the IRED has to be fitted in a parabolic like reflector to ensure that all radiation emitted by the component reaches the photovoltaic cell that forms the end of the parabola.

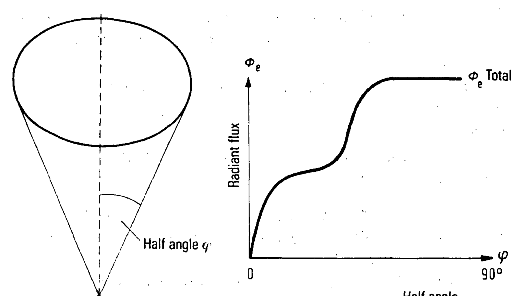
Figure 3.6 shows the outline of such a measuring parabola. As for the rest, the same requirements apply as for radiant intensity measurements.

Fig. 3.6
Calibrated photodiode with amplifier (for example BPW33)



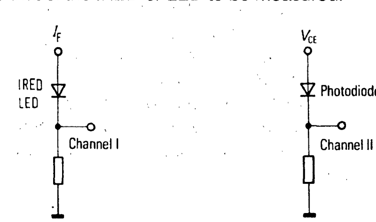
In cases where IRED emitting diodes are used in connection with mirrors or lenses, for example in light barriers, it can prove useful to state the radiant power (radiation capacity) Φ_e defined in a cone with the half angle φ, or the curve $\Phi_e = f(\varphi)$, respectively (see figure 3.7).

Fig. 3.7
Radiation cone and radiant flux Φ_e versus the half angle φ



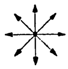
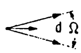
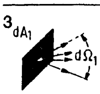
Switching Times

For measuring the switching times the same applies as to the radiant sensitive components except that now a photodiode serves as detector and its switching time must be small compared to that of the IRED or LED to be measured.



4. Terms and Definitions

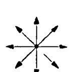
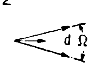
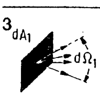
Radiation and Light Measurements

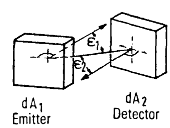
No.	Radiometric terms				
	Term	Symbol	Unit	Relation	Simplified definition
1 	Radiant power	Φ_e, P	W		Radiant power is the total power given in the form of radiation
	Emitter				
2 	Radiant intensity	I_e	$\frac{W}{sr}$	$I_e = \frac{d\Phi_e}{d\Omega_1}$	Radiant intensity is radiant power per solid angle
3 	Radiance	L_e	$\frac{W}{m^2\,sr}$	$L_e = \frac{d^2\Phi_e}{dA_1 \cdot d\Omega_1}$	Radiance is radiant power per area and solid angle
	Sensor				
4 	Irradiance	E_e	$\frac{W}{m^2}$	$E_e = \frac{d\Phi_e}{dA_2}$	Irradiance is incident radiant power per (sensor) surface

Indices "e" (= energetic) and "v" (= visual) may be omitted unless danger of confusion

DIN 1301, DIN 1304, DIN 5031, DIN 5496

International Dictionary of Light Engineering, 3rd Ed. publ. by CIE and IEC

No.	Spectral radiometric terms			Photometric terms		
	Term	Symbol	Unit	Term	Symbol	Unit
1 	Spectral radiant power distribution	$\Phi_{e\lambda}$	$\frac{W}{nm}$	Luminous flux	Φ_v	lm Lumen
	Emitter					
2 	Spectral radiant intensity distribution	$I_{e\lambda}$	$\frac{W}{sr\,nm}$	Luminous intensity	I_v	$\frac{lm}{sr} = cd$ Candela
3 	Spectral radiance distribution	$L_{e\lambda}$	$\frac{W}{cm^2\,sr\,nm}$	Luminance	L_v	$\frac{cd}{cm^2} = sb$ Stilb
	Sensor					
4 	Spectral irradiance distribution	$E_{e\lambda}$	$\frac{W}{m^2\,nm}$	Illuminance	E_v	$\frac{lm}{m^2} = lx$ Lux



dA_1 = element of area of emitter
dA_2 = element of area of detector
ε_1 = angle of radiation

Photometric Basic Law

$$d^2\Phi = L\,\frac{dA_1 \cdot \cos\varepsilon_1 \cdot dA_2 \cdot \cos\varepsilon_2}{R^2}\,\Omega_0$$

Inverse Square Law

$$E = \frac{I}{R^2}\cos\varepsilon_2\Omega_0$$

(r should be 10 times the max. spacing of emitter-detector to keep error below 1%).

ε_2 = angle of irradiation
R = spacing emitter-detector
Ω_0 = sr

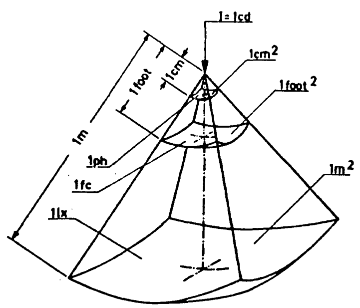
Application Notes

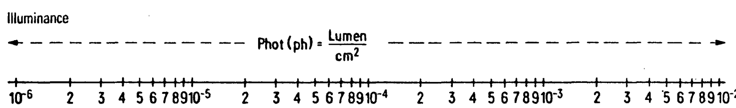
Radiation Characteristics

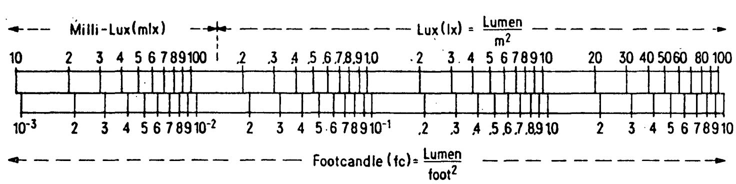
Designation	Symbol	Meas. quant.	Abbr.	Definition
Quantity of radiation	Q	Joule Wattsecond	J Ws	Quantity of radiation through a surface
Radiant power	Φ	Watt	W	Quantity of radiation Q per second through a surface
Point source of radiation	–	–	–	...is a source viewed from such a great distance R that all rays seem to emanate from one point. The max. linear expansion of the source must be substantially smaller than the distance R (example: sun for observer on earth).
Solid angle	Ω	Sterad	sr	$\Omega = \frac{A_1}{R_1^2} = \frac{A_2}{R_2^2} = \frac{A_3}{R_3^2} = \frac{A}{R^2}$; the radiant power Φ[W] of a point source is constant in solid angle. (Prerequisite: homogenous, undamping medium.) $\Omega = 1$ is $A = R^2$ so that $\Omega_{hemisphere} = \Omega_{\bigcap} = 2\pi$ sr; $\Omega_{full\ sphere} = \Omega_{\ominus} = 4\pi$ sr
Radiant intensity	I	$\frac{\text{Watt}}{\text{sterad}}$	$\frac{W}{sr}$	...is the solid angle density of the radiant power $\left(\frac{d\Phi}{d\Omega}\right)$ I of one source generally varies depending upon viewing direction. I only defined when $R \rightarrow \infty$
Total radiant power of a source	Φ_{tot}	Watt	W	$\Phi_{tot} = \int_0^{4.7} I \, d\Omega$
Irradiance	E	$\frac{\text{Watt}}{\text{meter}^2}$	$\frac{W}{m^2}$	...is the surface density of the radiant power (spherical surface) for a point source. $E = \frac{d\Phi}{dA}$; $dA = R^2 \, d\Omega$ $E = \frac{d\Phi}{d\Omega \, R^2} = \frac{I}{R^2}$; $I = ER^2$
Radiance	L	$\frac{\text{Watt}}{\text{m}^2\ \text{sterad}}$	$\frac{W}{m^2\ sr}$	...is the radiant intensity referred to the radiant surface viewed by the observer. (Surface projection $A_p = A \cos \varepsilon$, when ε is the angle by which the radiant surface is rotated against the connecting line to viewer. $L = \frac{I}{A_p} = \frac{I}{A \cos \varepsilon}$). Important optical quantity. 1) In an undamped beam path L is maintained and cannot be increased by any optical measure. 2) The human eye sees differences in radiance as differences in brightness.
Sensitivity of detector	$S = \frac{I}{E}$	$\frac{\text{Ampere}}{\text{irradiance}}$	$\frac{A \cdot m^2}{W}$	Electrical quantity (current, voltage or resistance) in relation to irradiance

Illuminance (units and conversion factors)

		lx	mlx	ph	fc
1 Lux = lx	=	1	10^{-3}	10^{-4}	9.29×10^{-2}
1 Millilux = mlx	=	10^{-3}	1	10^{-7}	9.29×10^{-5}
1 Phot = ph	=	10^{4}	10^{7}	1	929
1 Footcandle = fc[1])	=	10.76	10760	1.076×10^{-3}	1







1) equivalent footcandle / apparent footcandle } footlambert (Luminous density) ≙ footcandle (Illuminance).

Application Notes

Figure 5.1
Conversion of illuminance E_v into irradiance E_e
(Planck's black body)

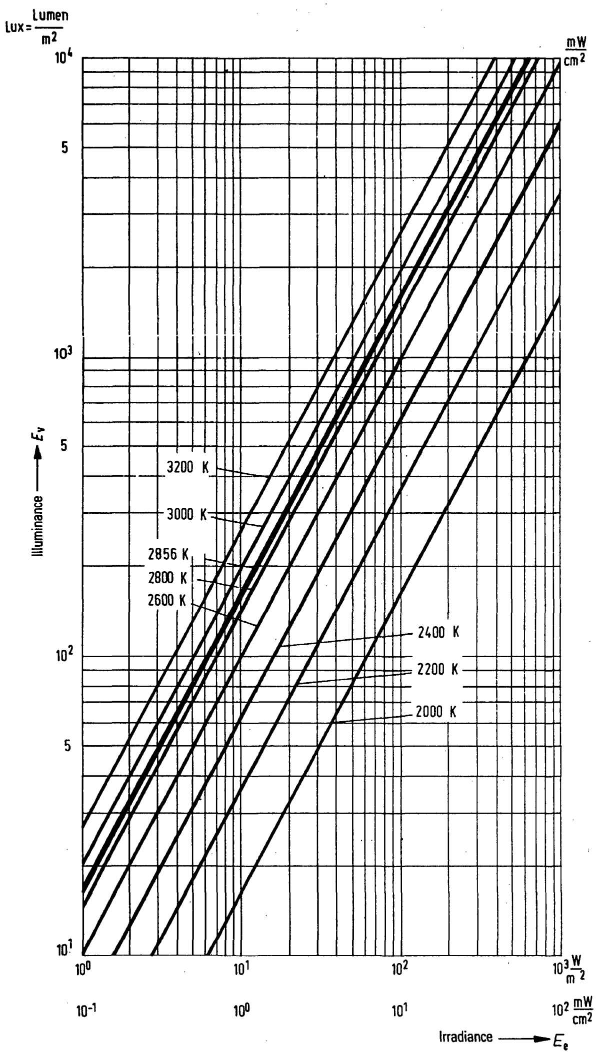
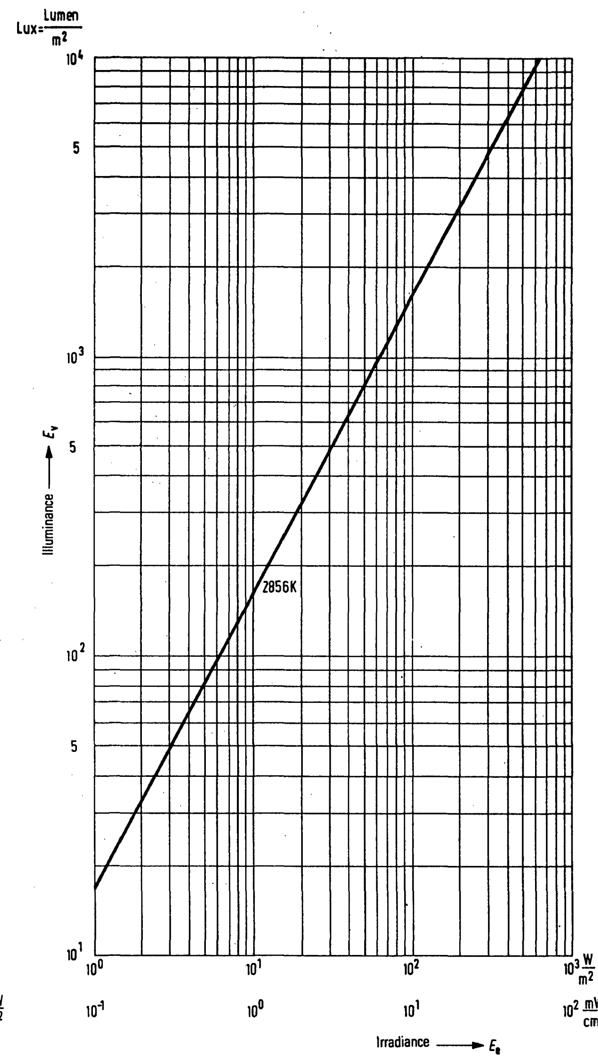
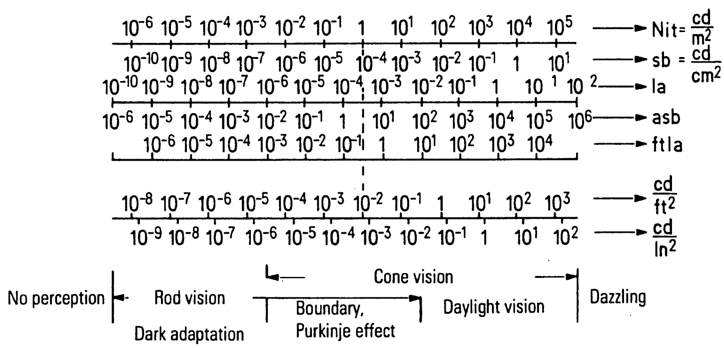


Figure 5.2
Conversion of illuminance E_v into irradiance E_e at 2856 K
(Planck's black body)



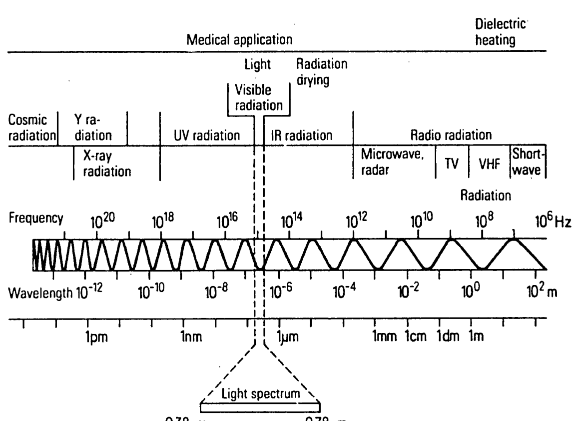
Luminous density (units and conversion factors)

Units		sb	cd/m²	cd/ft²	cd/in²	asb	L	Lm	ftL
1 Stilb = cd/cm² = sb	=	1	10^4	929	6.45	31400	3.14	3140	2920
1 cd/m² = Nit = nt	=	10^{-4}	1	9.29×10^{-2}	6.45×10^{-4}	3.14	3.14×10^{-4}	0.314	0.292
1 cd/ft²	=	1.076×10^{-3}	10.76	1	6.94×10^{-3}	33.8	3.38×10^{-3}	3.38	3.14
1 cd/in²	=	0.155	1550	144	1	4870	0.487	487	452
1 Apostilb = asb	=	3.18×10^{-5}	0.318	2.96×10^{-2}	2.05×10^{-4}	1	10^{-4}	0.1	9.29×10^{-2}
1 Lambert = L or la	=	0.318	3183	296	2.05	10^4	1	10^3	929
1 mL or mla	=	3.18×10^{-4}	3.18	0.296	2.05×10^{-3}	10	10^{-3}	1	0.929
1 footlambert	=								
1 equivalent footcandle	=								
1 apparent footcandle ftL or ftla	=	3.43×10^{-4}	3.43	0.318	2.21×10^{-3}	10.76	1.076×10^{-3}	1.076	1



Electromagnetic radiation

Figure 5.3
Frequency and wave bands



Application Notes

Figure 5.4
Relative sensitivity of different light-sensitive detectors

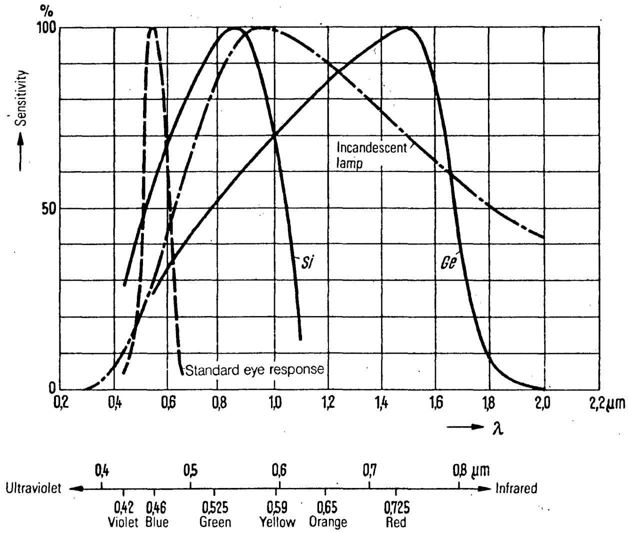


Figure 5.5
Nomogram for electromagnetic radiation

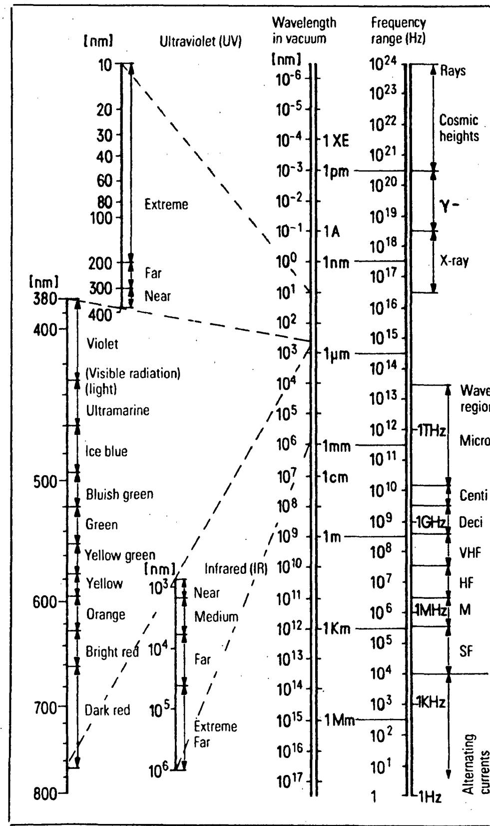
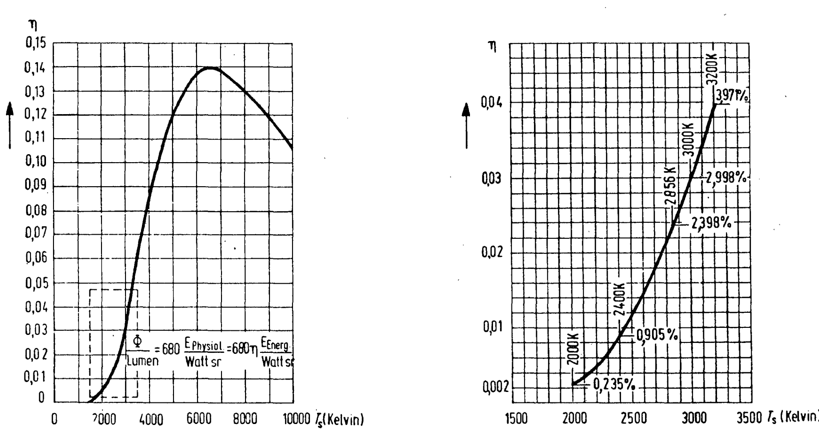


Figure 5.6
Visual efficiency η of the total radiation of a black body versus temperature



SIEMENS

Surface Mounting Appnote 38

1. What is Surface Mounting?

In conventional board assembly technology the component leads are inserted into holes through the PC board and connected to the solder pads by wave soldering on the reverse side (through-hole assembly).
In hybrid circuits (thick and thin film circuits) "chips", i.e. leadless components, are reflow soldered (see chapter 7.2) onto the ceramic or glass substrate in addition to the components already integrated on the substrate. Surface mounting evolved from these two techniques (fig. 1).

In through-hole technology the components are placed on one PCB side (component side) and soldered on the other (solder side) (fig. 1, top), whereas in surface mount technology the components can be assembled on both sides of the board (fig. 1, bottom). The components are attached to the PCB by solder paste or non-conductive glue and then soldered.

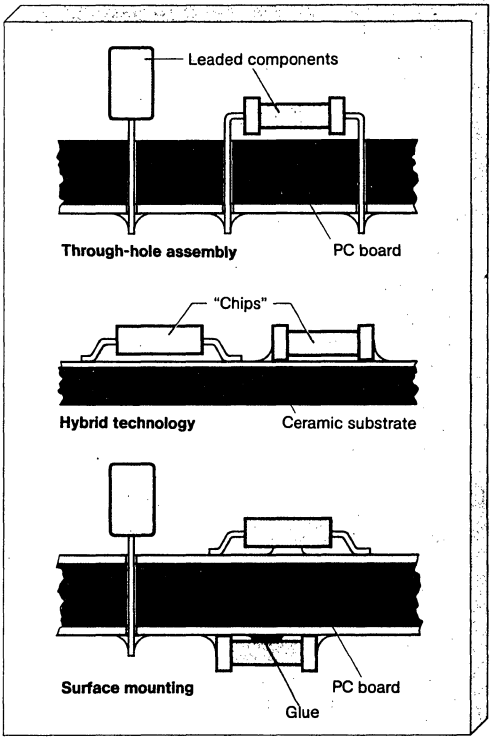
In the near future mixed assemblies, i.e. a combination of leaded and surface mounted components, will prevail, since not yet all component types are available as surface mount version.

Automatic assembly machines are a must for an expedient production; there are systems for simultaneous and for sequential assembly (see chapter 12).

The following explanations point out what actually new in surface mounting is:

- Up to now the connection of materials with large differences in the thermal coefficient of expansion, such as plastic boards and ceramic components, by rigid soldering has been regarded as a serious problem. Practice has shown, however, that this is feasible owing to the elasticity of board and solder; of course, component size and thermal stress are subject to certain restrictions (see chapter 4).
- Components for surface mounting have to withstand high thermal stress during the soldering procedure. Not all component types meet these requirements; therefore new components suitable for surface mounting are constantly developed (see chapter 4).
- In some cases the components are non-conductively glued to the PCB before soldering.
- As compared to through-hole technology there is a closer interrelation between the individual steps in design and production.
- Automatic assembly gains prior importance.

Figure 1 Through-hole assembly - Hybrid technology - Surface mounting



Application Notes

2. What are SMDs?

The abbreviation SMD* for **S**urface **M**ounted **D**evice is the most common designation for this new component. SMDs are designed with soldering pads or short leads and are much smaller than comparable leaded components. In contrast to conventional components, the leads of which must be inserted into holes, SMDs are directly attached to the surface of the PCB and then soldered. In figure 2 and the section below the various SMD types are summarized. Surface mountable components include "chips"** with cubic dimensions, cylindrical SMDs, plastic packages with solder pins (SOT, SO, VSO package), chip carrier packages, miniature IC packages (Quad Flat Pack, Flat Pack), TAB components and special SMDs such as inductors, trimmers, quartz crystals, switches, plugs, relays etc.

* Besides, the terms SMC (**S**urface **M**ounted **C**omponent), SMT (**S**urface **M**ount **T**echnology), SMA (**S**urface **M**ount **A**ssembly) are used.

** The designation "chip" should only be used when confusion with semiconductor chip as used in semiconductor technology can be excluded.

SMD types:
(see also chapter 13 "Siemens SMD Product Spectrum")

Cubic components ("chips")
Preference types 0805, 1206, 1210, 1812, 2220,...

Cylindrical components
MELF[1], MINIMELF, MIKROMELF
TUBULAR (e.g. tubular capacitors)
SOD 80 (MELF-similar diodes)

SOT 23, 143, 89, 192

SO[2] 4...28 pins (SOIC)

VSO[3] 40 pins

CHIP CARRIER
Plastic case (PLCC[4])
Ceramic case (LCCC[5])

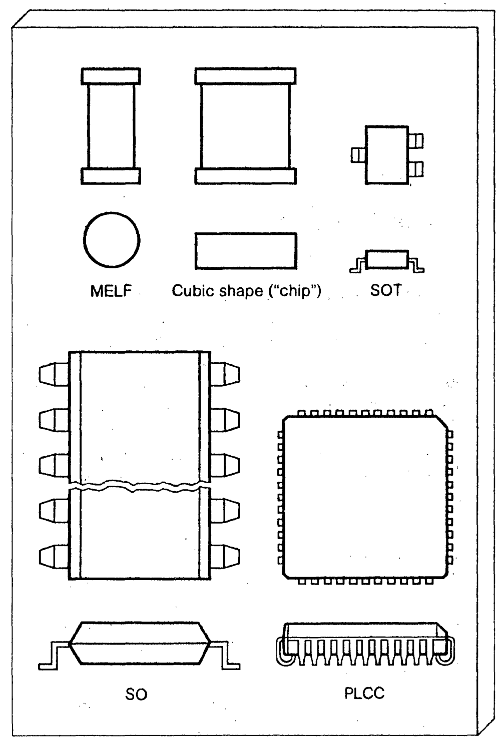
ICs with gull-wing leads
Flat Pack
Quad Flat Pack

MIKROPACK TAB[6]

Special packages for:
Inductors, SAWs[7], trimmers,
quartz crystals, switches, plugs, relays etc.

1) **M**etal **E**lectrode **F**ace Bonding
2) **S**mall **O**utline
3) **V**ery **S**mall **O**utline
4) **P**lastic **L**eaded **C**hip **C**arrier
5) **L**eadless **C**eramic **C**hip **C**arrier
6) **T**ape **A**utomated **B**onding
7) **S**urface **A**coustic **W**ave Filter

Figure 2 SMD types



Most of these components are suitable for dip soldering; chip carriers, TAB (MIKROPACK) and some special versions require other soldering methods.

Resistors, ceramic capacitors and discrete semiconductors represent at 80% the largest part of the SMD spectrum. In the range of SMDs the cubic shape prevails over cylindrical versions, as the latter can only have two pins thus being exclusively suitable for resistors, capacitors and diodes.

If development of a special SMD package is not advisable for electric or economic reasons, the DIP package can be converted into a surface mountable version by bending the leads (see chapter 13.2, optocouplers in DIP 6 SMD package).

SMD dimensions

Package	Dimensions (mm)	Standard
0805	2.0 x 1.25	IEC
1206	3.2 x 1.6	IEC
1210	3.2 x 2.5	IEC
1812	4.5 x 3.2	IEC
2220	5.7 x 5.0	IEC
MELF	5.9 x 2.2 ∅	
MINIMELF	3.6 x 1.4 ∅	
MIKROMELF	2.0 x 1.27 ∅	
SOD 80	3.5 x 1.6 ∅	
SOT 23	3.0 x 1.3	DIN 23 A 3 JEDEC TO-236
SOT 143	3.0 x 1.3	DIN 23 A 3
SOT 89	4.5 x 1.5	JEDEC TO-243
SOT 192	4.5 x 4.0	
SO 4...28[1]	spacing 1.27	JEDEC MO-046...
VSO (SOT 158)[2]	spacing 0.76	
PLCC	spacing 1.27	JEDEC MO-04...
LCCC	spacing 1.27	JEDEC MO-04...

[1] SO 6 3.9 x 4.0 or 3.9 x 6.2 (incl pins)
SO 8 5.2 x 4.0 or 5.2 x 6.2 (incl. pins)
SO 14 8.8 x 4.0 or 8.8 x 6.2 (incl. pins)
SO 20 L 12.8 x 7.6 or 12.8 x 10.7 (incl. pins)
[2] VSO 15.5 x 7.6 or 15.5 x 12.8 (incl. pins)

An important factor for automatic assembly is the components' adequate and uniform geometry. Some packages are already standardized (IEC) or are proposed for standardization (JEDEC Recommendation).

For more than ten years Siemens has offered its customers SMDs and thus has gained considerable experience in the field of SMD production through continual modernization and development. The spectrum of active and passive components available covers ICs, transistors, diodes, ceramic multilayer capacitors, NTC thermistors, as well as SIFERRIT miniature ferrites, and the product menu is growing larger almost daily.

3. Advantages of Surface Mounting

The three major benefits of surface mounting

- rationalization
- miniaturization
- reliability

are discussed in the following.

A consistent concept as regards components, board layout, assembly machines, processing and testing is essential for an efficient application of surface mount technology; in other words, the aim should be an optimized overall concept. The component price, for example, should not be seen isolated, but with regard to the total cost including placement, soldering and testing which may already be considerably lower than with conventional board assembly technology.

In the following the advantages of surface mounting are analyzed as to component, PC board, automatic assembly, reliability and rework.

3.1 Components

- SMDs are much smaller than leaded components, thus enabling smaller board size, higher packing density, reduced storage space and finally smaller equipment to be obtained.
- Light weight makes them ideal for mobile appliances.
- No leads means high resistance to shock and vibration.
- Cutting and bending of leads are eliminated.
- Parasitic inductance and capacitance due to leads are substantially lowered making SMDs particularly suitable for RF applications.
- Automatic assembly machines ensure accurate placement.
- MIKROPACKs, PLCCs and similar packages permit a considerably higher number of pins.
- Closer capacitance tolerances can easily be obtained for capacitors with low capacitance values.
- The growing demand for SMDs results in lower production costs, so that further cost reductions can be anticipated. The surface mount version of ceramic multilayer capacitors, for example, is even today cheaper than the leaded version.

3.2 Printed Circuit Board

- Surface mount technology makes PC boards smaller. When using SMDs on both sides of the board, size can be recuced by more than 50 per cent. On the other hand, maintaining the PCB size implies reduced packing density and thus higher yields and higer reliablity.
- In many cases the printed circuits can be shortened and reduced in number. Owing to the compact "leadless" construction the electrical characteristics can easily be reproduced, thus cutting the cost for adjusting RF circuits.
- Surface mount technology does not require a special PCB material; standard materials such as phenolic resin laminated paper and glass-fiber laminated epoxy material are quite suitable, but of course, special materials, e.g. for RF circuits, can be used, too. For normal packing density the printed circuit precision should meet current requirements.
- The elimination of through-holes entails a further cost reduction. This is quite an important factor, as the cost for the drilling of holes can amount up to 10% of the total PCB cost.
- Mixed assembly with leaded components is possible. The reason for using this assembly variation was explained in the beginning.

3.3 Assembly

The average cost per component for automatic assembly can be considerably cut by surface mounting, because the smaller number of assembly machines[1] entails less capital investment, maintenance, servicing and factory space.

- A major advantage of surface mounting are the high component placement rates attained by automatic placers. Fast machines can place several hundred thousand components on the PCBs per hour.
- Automatic placement systems for SMDs feature high placement reliability. Failure rates of less than or equal to 20 ppm (parts per million) can be obtained by machines capable of identity checking and defective recognition. This means that out of a million placed components only max. 20 are not at all or incorrectly assembled.
- In mixed assembly any ratio of SMDs and leaded components is possible, thus facilitating transition to the new technology.
- Some automatic placement systems can handle a wide range of different components. For details see chapter 12.3.

3.4 Reliability

The demands on quality and reliability of PCB assemblies increase steadily. It is a matter of fact, that in this respect SMDs have at least to meet the standard set by conventional through-hole technology.

As surface mount technology is a relatively new development, sufficient proven information on quality and reliability is not yet available. However, the following general statements can be made:

- The failure rate of SMDs does not exceed that of leaded components. Omission of leads means one point of contact less. Owing to their small size and light weight SMD assemblies feature a higher resistance to mechanical stress (vibration, shock) than the corresponding assemblies with leaded components.
- A quality approval for SMDs used in hybrid circuits can be usually applied to surface mounting, as well.
- High requirements are placed on the solderability of SMDs. The specifications for wetting, leaching and storage have to be observed (see chapter 7).
- In many cases the soldering methods are the same as with other mounting methods. The known advantages and disadvantages apply to surface mount technology as well. One should bear in mind, however, that the criteria for judging solder joints are different for wave soldering and reflow soldering (see chapter 7.2). For example, the filling of through-holes with solder is only possible with the wave soldering method, with reflow soldering the amount of solder is too small.
- If components have to be replaced because of incorrect assembly, reliablity of the board – although correctly assembled then – is diminished. Hence, automatic placement systems with their high degree of placement reliability enhance board reliability.

3.5 Rework

Elimination of component preparation, high placement reliability provided by automated systems, and careful planning of each step of the design and production process considerably reduce expensive rework of PCB assemblies with SMDs.

[1] At present three assembly machines are usually required for leaded components:
insertion machine for radial-leaded components,
insertion machine for axial-leaded components,
insertion machine for DIPs.

4. Restrictions and Special Features of Surface Mounting

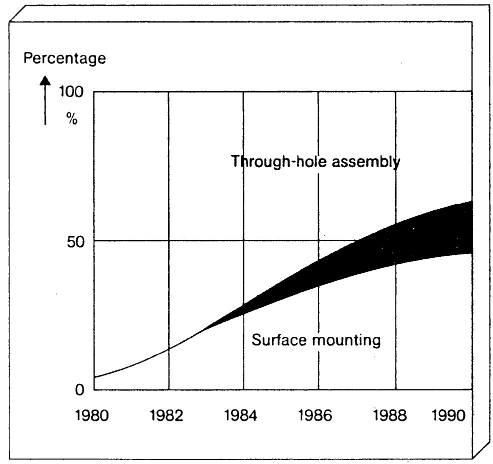
Maximum packing density – one of the primary goals in surface mount technology – requires the use of miniature components, i.e. certain IC packages (e.g. VSO or MIKROPACK). This involves problems, not necessarily resulting from surface mount technology as such, but from miniaturization in general.

- The use of high-pin-count ICs may require new PCB design (fine etching and super-fine etching) and an increased number of layers (multilayer) because the space between the IC pins is too narrow for printed circuits.
- Due regard must be paid to heat dissipation. The high packing density may cause thermal problems. Special PCBs with good thermal conductivity can aid heat removal, if necessary.
- The use of ceramic components is restricted. Due to the different thermal expansion coefficient of ceramic and PCB material, ceramic SMDs with edges longer than 6 mm should not be used on phenolic resin laminated paper and epoxy glass fiber boards.
- Not all SMDs are suitable for dip or wave soldering. This has to be considered when designing the PC board.
- Some components are not yet available as SMD version. Not all SMDs available are standardized.
- High voltages naturally require certain minimum spacings.
- Visual inspection of solder joints becomes difficult if the leads are partially beneath the component body. Therefore, soldering methods should be optimized so that visual inspection will become unnecessary.
- Test methods have to be adjusted to SMD assemblies. Development of new adapters may be required.
- Repair of SMD assemblies may be more costly as compared with conventional PCB assemblies.

5. Market Forecast for SMD Applications

Figure 3 shows the increasing share of surface mount technology in the market. Internationally, the replacement of leaded components on PCB assemblies by SMDs is expected to reach 50% by 1990.

Figure 3 Trends in mounting techniques



6. Fixing SMDs by Glue

New in surface mounting is the gluing procedure required for fixing the components when the PC board is to be turned upside down for soldering. The glue has to meet numerous requirements. It must provide reliable fixing of the components (also of heavy ones) on all kinds of PC boards. Furthermore, it should feature uniform viscosity to ensure easy handling; a pot life of at least several days is advisable. The glue should feature short curing time at low temperature. After curing the glue must not show chemical reactions in order not to impair board or components. On the one hand the adhesive is required to withstand high thermal stress, and on the other hand it must permit removal of SMDs from the assembled board in case of repair. For repairs the component body is heated, so that the adhesive becomes soft and allows the component to be removed without damaging the printed circuit below it. The glue has to be non-toxic, as odorless as possible, and free of solvents. Besides, it should feature good heat conductivity. Development of new adhesives is under way.

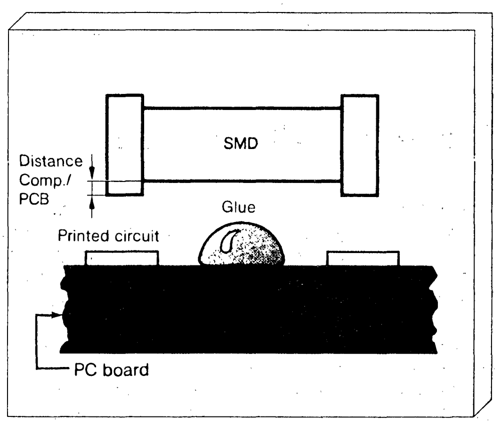
The component outline should be such that the adhesive can easily be applied, i.e. the distance between component body and board must be closely tolerated (fig. 4).

There are three methods of dispensing the glue
- by applicator
- by pin transfer
- by screen printing.

Not all adhesives are equally suitable for all methods.

The Siemens pick-and-place machine (see chapter 12.3) dispenses the glue by an applicator simultaneously with the placement process.

Figure 4 Form of the glue dot and component outline
Component and glue dot have to be shaped such that the component is reliably wetted while the contact area remains free of glue.



7. Soldering Techniques

An appropriate soldering method is particularly important for obtaining good electrical contact and inhibiting short circuits. The choice of the soldering procedure depends on the PCB design (single or double-clad, multilayer etc.), the components supplied, and the production facilities. While many SMDs are suitable for all soldering methods, the soldering technique for ICs, for example, has to be chosen very carefully. Besides manual soldering, which should only be used for repair purposes, there are several automated soldering methods such as bath soldering (wave and dip soldering) and reflow soldering.

With bath soldering the solder is applied during the soldering process itself, whereas with reflow soldering the solder is applied before. For this reason the preconditions for bath soldering, e.g. component orientation and configuration are quite different from those for reflow soldering. The reflow method is particularly advisible for soldering certain ICs (see chapter 9).

7.1 Wave soldering

Wave soldering is the most popular automated soldering process in the production of PCB assemblies. The solder bath temperature lies between 240 and 260 °C and the dwell time is 1 to 3 seconds. Before soldering the flux is applied.

High packing density on the PCB side to be wave soldered involves the problem of solder bridges and shadows (not completely wetted leads and pads). Therefore, PCB layout, i.e. component configuration, should match the soldering method used.

Dual-wave soldering best meets requirements of surface mounting. The first turbulent wave sends up a jet of solder to ensure good wetting of all metalization areas, while the second more laminar wave removes the excess solder (solder accumulations and bridges).

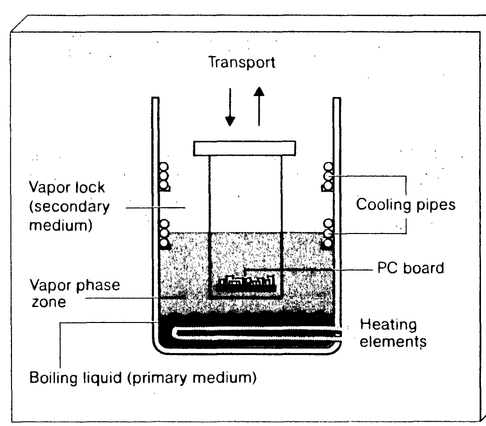
7.2 Reflow soldering

In reflow soldering a specific amount of solder, e.g. in form of solder paste, is applied to the PC board. After attaching the SMDs the reflow process is performed by one of the following methods:

- vapor phase soldering
- hot gas soldering
- heat collet soldering
- infrared soldering.

The latest reflow technique is vapor phase soldering, where the entire PC board is uniformly heated until a defined temperature is reached; there is no possibility of overheating. The defined temperature (e.g. 215°C) in a saturated vapor zone is obtained by heating an inert (neutral) fluid to the boiling point. A vapor lock above this primary vapor zone prevents the expensive primary medium from escaping (fig. 5).

Figure 5 Principle of vapor phase soldering



When the assembled PC board is immersed in the vapor zone the vapor condenses at the cold parts and transfers its heat to the workpiece. Adequate heating control ensures continuous vapor supply. Summing up, it can be said that vapor phase soldering is a very gentle method that excludes overheating. At present it is the best reflow soldering method, if components with different thermal capacity are densely positioned or if adequate heating cannot be provided otherwise.

Other methods are hot gas and infrared soldering in continuous-type furnace. As compared to vapor phase soldering these methods have the disadvantage of poor heat transfer and nonuniform heating effect on components with different thermal capacity.

For heat collet or pulse soldering a collet or a soldering iron is used to transfer the heat to the component leads. It is important to force the leads into reliable contact with the solder pads before and during the soldering process. This method is preferably used for MIKRO-PACK and Flat Pack packages.

7.3 Iron soldering

Manual soldering with temperature-controlled miniature iron should only be used in exceptional cases (repair, etc.), because this method is not only uneconomic, but can also damage components or PC board.

7.4 Fluxes, cleaning agents

Wave soldering requires no other fluxes than those used for conventional techniques (e.g. collophony F-SW32 in accordance with DIN 8511).

Most of the solder pastes required for reflow soldering, however, contain aggressive fluxes the residues of which must be removed by a cleaning process.

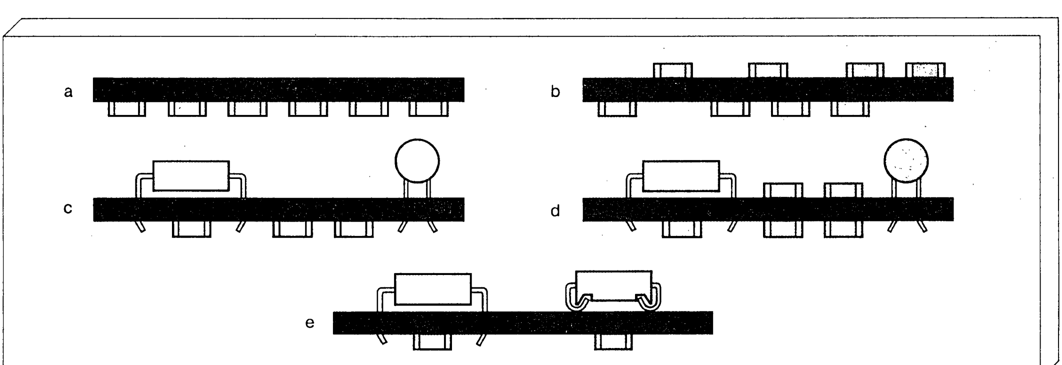
7.5 Conductive adhesion

Conductive adhesion is not a soldering process, but shall be described here for the sake of completeness. It is not very often used since most conventional PC boards with a surface of tin or solder tin are not suitable for gluing. If components or PC board permit gluing, silver-filled mixed epoxy resin adhesives can be recommended. These can be spread by an applicator, screen printing, or by pin transfer. The times required for curing are between 1 min and 12 h depending on the temperature. The thermal stress imposed on the components is less than with soldering, but the adhesion process must be performed separately after soldering the other components.

8. Assembly Variations

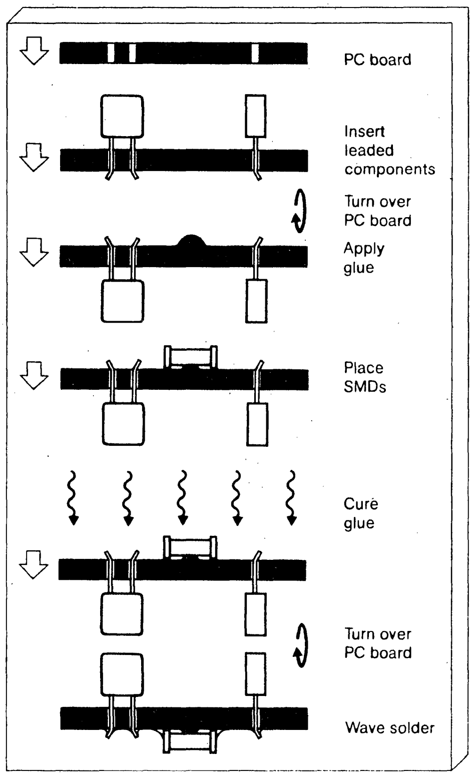
Figure 6 shows the PCB assembly variations possible with SMDs: Assemblies exclusively with SMDs in the top row (fig. 6a and 6b), mixed assemblies, i.e. SMDs combined with leaded components in the middle (fig. 6c and 6d), and mixed assembly consisting of dip solderable components (on solder side) and non-dip-solderable components (on component side) in the last row (fig. 6e). The versions illustrated in figures 6b, d, e require double-clad PC boards.

Figure 6 Variations of PCB assemblies



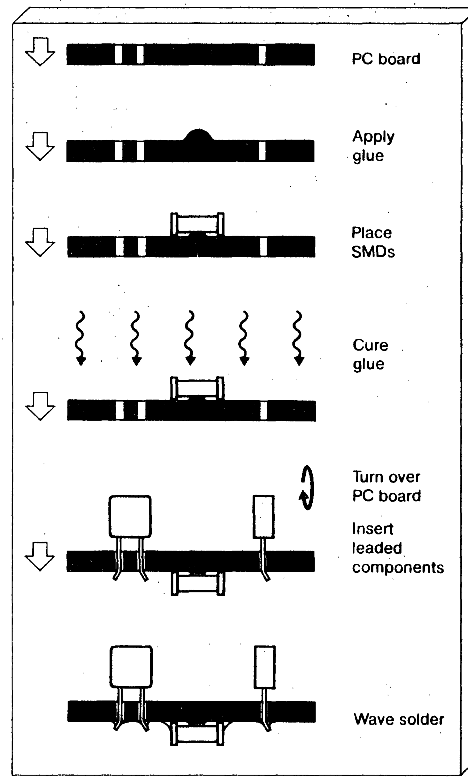
In mixed assemblies with SMDs and leaded components (fig. 6c and 7) the leaded components are usually placed first, then the board is turned over and the glue applied. Subsequently the SMDs are placed, the glue is cured and after a renewed turn over the board is wave soldered.

Figure 7 Mixed assembly of SMDs and leaded components (variant 1)



The second variant shown in figure 8 differs from the first in so far as the glue is applied by screen printing at first; the following production steps are executed as illustrated in figure 8. This procedure has the advantage that the glue can be applied by screen printing, however, it has to be taken into account that because of the already mounted SMDs vacant board space is required for the mounting tools of the insertion machines, which are needed for cutting and bending the leads of conventional components.

Figure 8 Mixed assembly of SMDs and leaded components (variant 2)



The procedure for double-sided SMD mounting is as follows:

- Screen printing of solder paste
- SMD placement
- Reflow soldering
- Insertion of leaded components
- PCB turn over
- Application of glue
- Placement of SMDs on the reverse side
- Curing of the glue
- PCB turn over
- Mounting of components requiring special handling
- Fluxing, wave soldering

Here both reflow and wave soldering are used. Assemblies including leaded components always require wave soldering.

The aim is a uniform mounting procedure with the exclusive use of SMDs. Figure 9 shows examples for totally surface mounted assemblies with reflow soldering (top) and wave soldering (bottom).

Figure 10 is a flow chart for the various assembly and soldering variants.

Figure 9 PC board exclusively with SMDs, reflow soldered or wave soldered

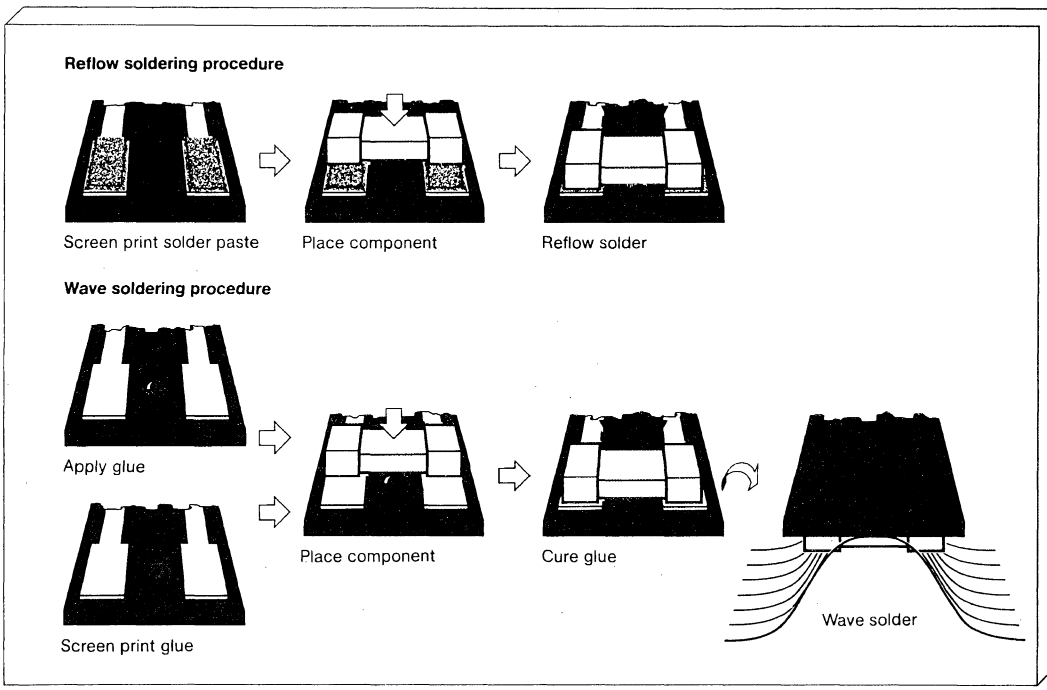
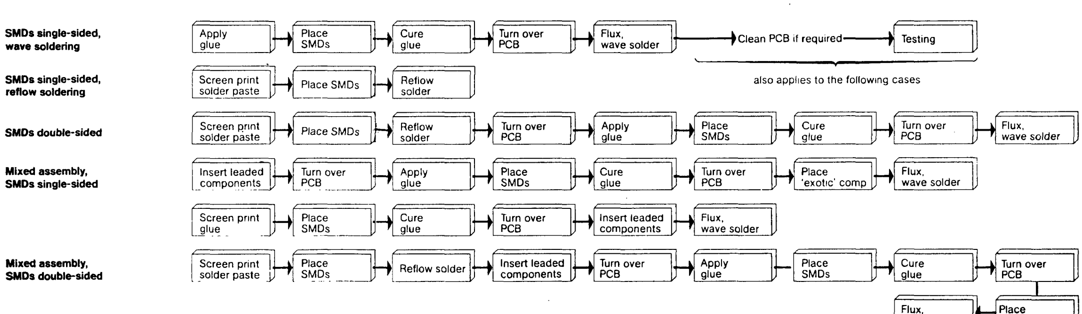


Figure 10 Possible assembly procedures for SMDs and leaded components



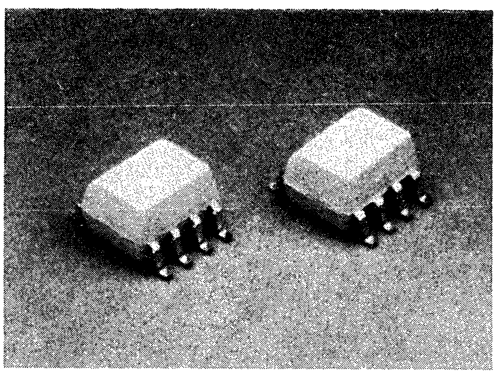
SIEMENS

Solderability of the Small Outline Coupler Appnote 39

by Karsten Uhde
Jim Hopper

OBJECTIVE

Investigate the effect of various surface mount component assembly operations on the electrical and mechanical performance of the small outline coupler (SOC).



SUMMARY

The small outline coupler is an SOIC-8 package, modified in height to achieve adequate isolation between input and output. Because of the reduced package dimensions of the device and the rigorous soldering techniques that surface mount technology requires, the coupler was submitted for testing under wave solder, vapor phase, and IR reflow processes.

The SOC performed well in all the assembly and soldering tests. All three soldering processes can be safely used with no trade-off in electrical performance (data sheet compliance) or package integrity (hermeticity). For wave soldering, correct orientation of the devices is recommended to minimize solder bridging.

DESCRIPTION

A test lot of 240 SOC's were processed through a state-of-the-art surface mount assembly line (*see Table 3, Equipment*). The couplers were mounted in lots of ten on 5″ by 5″ test boards using the Dyna Pert MPS-118 pick and place machine. The assembled boards were prepared for soldering by curing and preheating. The soldering processes chosen were the three most common techniques; wave soldering, vapor phase, and IR reflow. The tests varied the durations, temperature profiles, and repetitions. After the first and last soldering steps, the boards passed through a cleaning operation (*See 4, Cleaning Conditions*).

All 240 couplers were tested for compliance to the IL212 specification after each soldering step. For each soldering technique, read and record data was taken on twenty devices (*see Table 2, Worst Case Examples*). To study the effect of solder heat on package integrity and long term reliability, two lots of unmounted SOC's were submerged in 260°C solder and then subjected to pressure pot and 85°C/85% RH tests.

1. DUAL WAVE SOLDERING

A. Process Description

The Dyna Pert MPS-118 was used for the automatic epoxy dispensing and the pick-and-placement of the SOC. After curing the epoxy for 3 min. at 110-120°C the boards passed through the Electrovert Century 3000 dual wave solder machine (*Figure 1, Wave Soldering Procedure*).

This equipment has 2 waves, 2″ and 4″ wide respectively and 4″ apart. The first wave is turbulent to avoid shadowing on high density boards and to reach all exposed contacts with liquid solder. The second wave is homogeneous and removes excess solder, i.e., solder bridges.

After the first and the last pass through the solder equipment, the boards were cleaned to remove flux and other residue.

B. Process Conditions

NORMAL PROCESS
4 boards, 40 units
Preheating Temp/Time: 25°C - 120°C, linear/12 min.
Solder Temp/Time: 256°C/4 seconds (submerged)
Cleaning
Number of passes: 2

Result: 0/40 failures to IL212 spec. (*See Table 2, Group 1 for read/record data*)

NORMAL PROCESS, Repetitive
2 boards, 20 units
Same as normal process except:
Number of passes: 5

Result: 0/20 failures to IL212 spec.

2. VAPOR PHASE SOLDERING

A. Process Description

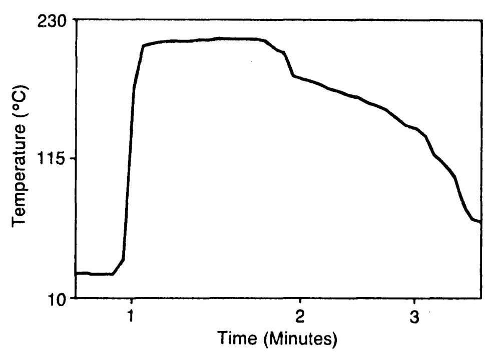
After the solder paste screening of the boards, the couplers were placed on the PC boards. To harden the solder paste, the boards were heated to 110°C to 120°C for three minutes. This curing secures component positioning during handling. Curing is followed by preheating, vapor phase soldering (HTC IL-18), and cleaning after the first and last pass. (*Figure 2*).

B. Process Conditions

NORMAL PROCESS
8 boards, 80 units
Preheating Temp/Time: 25°C - 120°C, linear/12 min.
Primary Zone Temp/Time: 215°C/18 seconds (*See Figure 3, Temperature Profile*)
Cleaning
Number of passes: 2

Result: 0/80 failures to the IL-212 spec. (*See Table 2, Group 2 for read/record data*)

Figure 3. Typical Vapor Phase Profile



LONG FLOW PROCESS
2 boards, 20 units
Same as normal process except:
Primary Zone Temp/Time: 215°C/46 seconds
Number of passes: 2

Result: 0/20 failures to the IL-212 spec.

LONG FLOW PROCESS, Repetitive
2 boards, 20 units
Same as Long Flow process except:
Number of passes: 5

Result: 0/20 failures to the IL-212 spec.

Figure 1. Wave Soldering Procedure

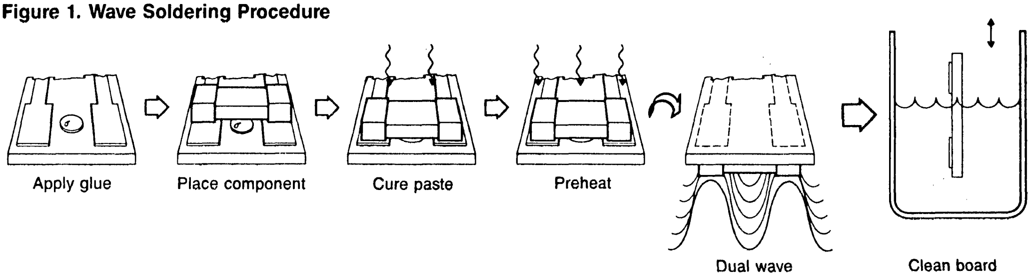
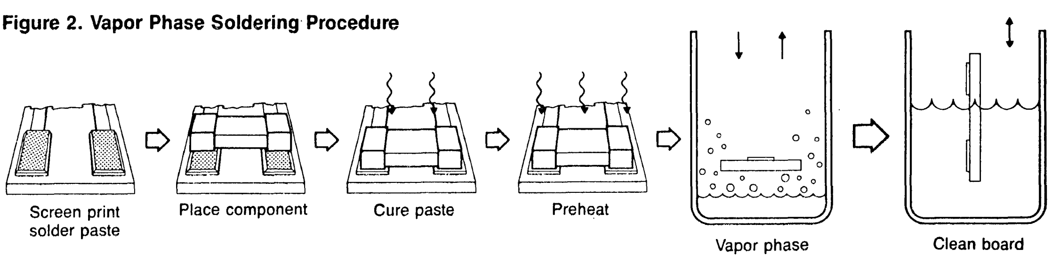


Figure 2. Vapor Phase Soldering Procedure



3. IR REFLOW SOLDERING

A. Process Description

Preparation and assembly were similar to the vapor phase process. The boards were passed through the SPT 770 for the reflow process and then cleaned (*Figure 4, IR Reflow Soldering Procedure*) using the Cougar 1000, and Dyna Pert pick and place machine except for the omission of the epoxy attachment operation.

B. Process Conditions

NORMAL PROCESS
2 boards, 20 units
Preheating Temp/Time: 100°C/30 seconds
Reflow Temp/Time:
Zone 1 150°C/1 minute
Zone 2 180°C/1.5 minutes
Zone 3 235°C/1.5 minutes (includes cool down)
(*see Figure 5, Temperature Profile*)
Cleaning
Number of passes: 2

Result: 0/20 failures to the IL212 spec. (*See Table 2, Group 3 for read/record data*)

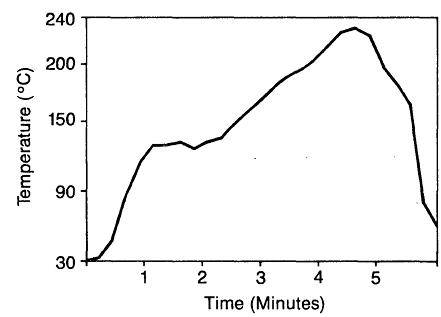
LONG FLOW PROCESS
2 boards, 20 units
Preheating Temp/Time: 100°C/1 minute
Reflow Temp/Time:
Zone 1 150°C/2 minutes
Zone 2 180°C/3 minutes
Zone 3 235°C/3 minutes (includes cool down)
Number of passes: 2

Result: 0/20 failures to the IL212 spec.

LONG FLOW PROCESS, Repetitive
2 boards, 20 units
Same as Long Flow process, except:
Number of passes: 5

Result: 0/20 failures to IL212 spec.

Figure 5. Typical IR Reflow Profile



4. CLEANING CONDITIONS

Solvent: Freon TMS
Solvent Temp: 40°C

Cleaning Zones:
1. Spray: 23 PSI top of PWB
   16 PSI bottom of PWB
2. Emersion: 16 PSI top spray to create turbulence
3. Spray: 10 PSI top of PWB
   8 PSI bottom of PWB

Dwell time: Approx. 1 minute in each Zone

Figure 4. IR Reflow Soldering Procedure

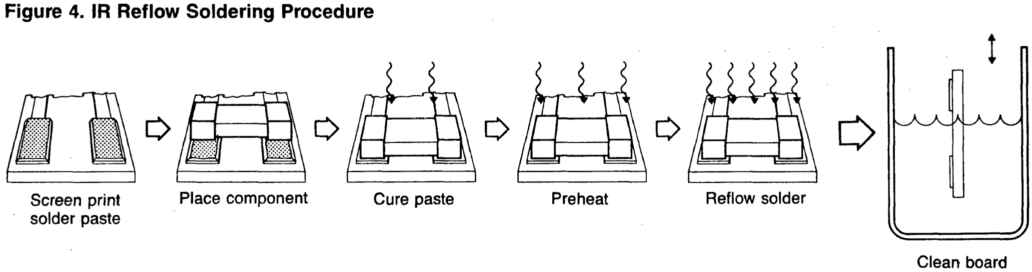


Table 1. Reliability Test (after Solder Heat)

1A. Pressure Pot Test (121°C, 15 psig steam)

Sample Size	260°C 3 × 10 sec.	48h	96h	144h	192h	240h	288h	BViso	Overall
38	0/38	0/38	0/38	1/38*	0/37	0/37	0/37	0/37	1/38

*failed I_R (25 μa at V_R = 10 V)

1B. Temperature/Humidity (85°C/85% RH)

Sample Size	260°C 3 × 10 sec.	168h	504h	1Kh	BViso	Overall
38	0/38	0/38	0/38	0/38	0/38	0/38

Note: Datasheet parameters were checked at each time point. BViso was only tested at the end of the test sequence.

5. PACKAGE INTEGRITY TEST

To simulate a worst case condition of heat exposure, the couplers were submerged in solder for 10 seconds, three times consecutively. Immediately thereafter, the parts were submitted to pressure pot test and high temperature/humidity to verify the package integrity as well as isolation breakdown voltage (*see Table 1, Reliability Tests after Solder Heat*). These tests could not be done mounted on a board. FR4 PC board material is not completely moisture resistant, therefore providing a leakage path.

No discoloring of the white outermold was observed. After 5 cycles of wave soldering the pc board started to discolor and flex.

The effect on CTR change was minimal.

The average change at 1 mA I_F was:

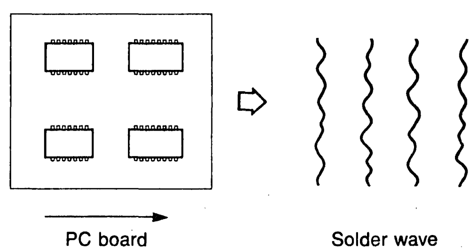
Dual Wave Soldering	+1.5%
Vapor Phase Soldering	+ .8%
IR Reflow Soldering	+1.8%

The visual inspection showed no cracks or damages and the reliability test results were excellent. After a pre-conditioning of 3 times 10 seconds in 260°C solder, only 1 out of 38 units failed 288h pressure pot (after 144h one I_R failure) and 0 failures out of 38 after 1000h 85°C/85% RH.

6. CONCLUSIONS

The small outline coupler, a modified SOIC-8 package, was easy to handle during assembly and processing. No electrical failures occurred as a result of the soldering processes. Visual inspection of the solder joints showed consistent results. Solder bridges tended to form in the wave soldering process due to the narrow lead spacing. This is a recognized phenomena for this process, although the increased component height may be another factor contributing a shadowing effect. This possible effect can be minimized by orienting the SOC with its length perpendicular to the solder wave (*see Figure 6*).

Figure 6. Orientation of Components on PC Board Before Wave Soldering



Application Notes

Table 2. Worst Case Examples of Read/Record Data

Group 1: Dual wave soldering

CTR (%) at VCE = 5 V									H_{FE} at V_{CE} = 5V		
I_F = 1 mA			I_F = 5 mA			I_F = 10 mA			I_B = 1 μA		
PRE	POST	CHG	PRE	POST	CHG	PRE	POST	CHG	PRE	POST	CHG
90	85	–6%	170	168	–1%	200	200	0	600	620	+3%
80	80	0	160	180	+12%	195	200	+3%	590	600	+2%
80	85	+6%	150	150	0	175	180	+3%	580	600	+3%
Average of 20 samples: PRE = 64, POST = 65, CHG = +1.5%											

Group 2: Vapor phase soldering

CTR (%) at VCE = 5 V									H_{FE} at V_{CE} = 5V		
I_F = 1 mA			I_F = 5 mA			I_F = 10 mA			I_B = 1 μA		
PRE	POST	CHG	PRE	POST	CHG	PRE	POST	CHG	PRE	POST	CHG
70	80	+14%	150	160	+7%	170	180	+6%	580	590	+2%
60	62	+3%	136	124	–8%	150	155	+3%	600	620	+3%
77	80	+4%	150	160	+6%	170	180	+6%	640	650	+2%
Average of 20 samples: PRE = 63, POST = 64, CHG = +1%											

Group 3: IR reflow soldering

CTR (%) at VCE = 5 V									H_{FE} at V_{CE} = 5V		
I_F = 1 mA			I_F = 5 mA			I_F = 10 mA			I_B = 1 μA		
PRE	POST	CHG	PRE	POST	CHG	PRE	POST	CHG	PRE	POST	CHG
62	65	+5%	140	130	–7%	155	160	+3%	560	570	+2%
53	57	+8%	120	116	–3%	140	145	+3%	530	550	+4%
74	84	+14%	150	160	+7%	170	180	+6%	550	560	+2%
Average of 20 samples: PRE = 60, POST = 61, CHG = +2%											

Table 3: List of Equipment

Procedure	Equipment Used
Solder Paste Screen	Cougar, 1000
Pick-and-Place	Dyna Pert, MPS-118
IR Reflow	SPT, 770
Vapor Phase	HTC, IL-18
Dual Wave	Electrovert, Century 3000
Solvent Clean	Detrex, PCBD – 18ER – A

Table 4: List of Materials

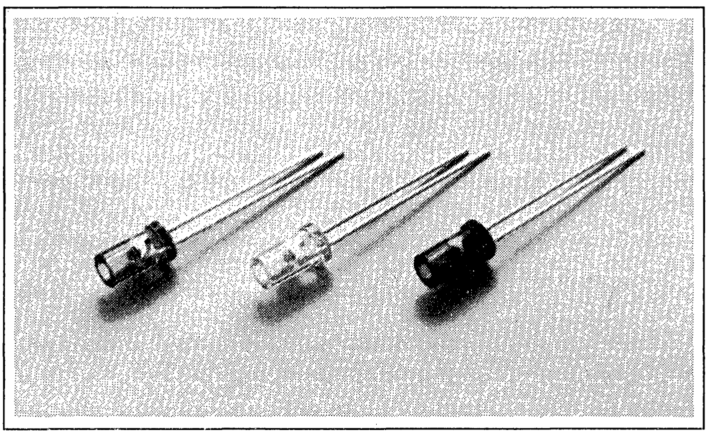
Procedure	Material
Mount Components	FR4 PC board, single side
Attach Wave Soldered Components to PWB	Locktite #360 epoxy
Wave Solder	Alpha Flux RMA SM34-18
Wave Solder	Federated Fry Metals bar solder (63Sn/37Pb)
Vapor Phase & IR Reflow	Alpha Solder Paste RMA 390 DH3 (62Sn/36PB)
Vapor Phase	Fluoroinert 5312 (mfg. by 3M)
Cleaning	Freon TMS

SIEMENS

Low Cost, Plastic Fiber Optic Systems Using Siemens Light-Link Emitters and Detectors Appnote 40

Part 1 – Light-Link Emitters & Detectors Features & Description

by Heinz Haas, Wilhelm Karsten, Franz Schellhorn



Signal transmission through optical fibers is a fully developed technology. Some million kilometers of transmission systems have already been installed. Making full use of the benefits of this technique in all conceivable applications is so far held back by extremely high cost of opto-electronic components and connectors. The new light-link components described here are ideal for applications with less stringent requirements, for example, where only low bit rates have to be transmitted or fairly short distances need to be covered. The devices are very inexpensive because they are derived from proven emitter diodes and detector components. Typical applications, apart from signal transmission are in optical sensors, optocouplers, display elements and optical-fiber sensors. Siemens has introduced three emitter diodes, for radiation wavelengths of 560 nm (SFH 751), 660 nm (SFH 750, SFH 750V), and 950 nm (SFH450, SFH450V) and these can easily be connected via optical fibers. A high-sensitivity phototransistor (SFH 350, SFH 350V) and a PIN photodiode (SFH 250, SFH 250V) for high frequencies and pulse rates up to several Mbit/s are available as detectors.

Special emphasis on the device shape

The particular shape of the new light-link devices, which are similar to 5-mm

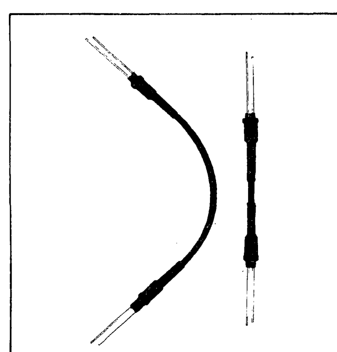


Fig. 1 Optocouplers built from light-link components optical fiber and connected with a shrink sleeve.

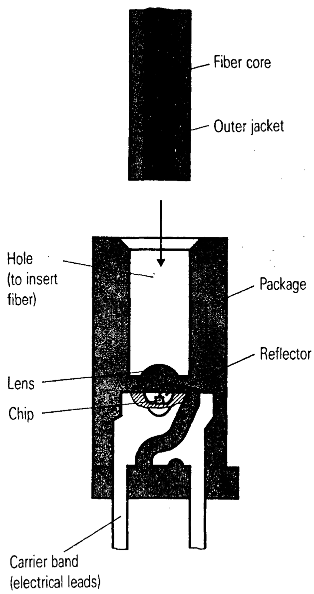


Fig. 2 Cross section of light-link emitter diode

diodes, is crucial to making transmission links simple to construct. A cylindrical opening is provided in the top of the component for inserting the plastic fiber **(Fig. 2).**

Minimum hole diameter is 2.2 mm to suit commercially available plastic fibers. The light-link core, 1 mm in diameter, has an opaque outer jacket which need not be stripped off before insertion. The optical fiber is automatically located on the chip. Firm connection between the component and the optical fiber is made by a shrink sleeve which also provides protection against extraneous light **(Fig. 1). Except the SFH 751 all parts are also available in our plastic connector version (SFH 250V, SFH 350V, SFH 450V, SFH 451V, SFH 750 V).**

Lens prevents misalignment

The bottom of the insertion hole is lens-shaped so that most of the radiation emitted from the semiconductor chip is coupled into the optical fiber and then guided to the detector chip at the receiving end. This increases the coupled-in power by around 20%.

Another important function of this computer-designed lens is in compensating for production tolerances and assembly errors to concentrate maximum radiation at the fiber ends. Possible inaccuracies are: position of the semiconductor on the carrier, dimensional tolerances of the fiber and incorrect lens-fiber distance.

The effect of these tolerances when deviations are kept fairly small can be seen from **Figs. 3** and **4.**

So even with a lens-fiber distance of 1 mm as much as 60% of the maximum obtainable radiation is coupled in **(Fig. 3).**

Fig. 4 shows that the lateral misalignment is negligible with a 0.05-mm typical center inaccuracy of the plastic fiber. The lens incorporated in the package allows simple mechanical construction of a transmission system at low cost using light-link components.

Effects of the fiber on the transmitted power

Fiber ends

What proportion of radiant power is coupled into the fiber is not only determined by the emitter diode characteristics but depends a great deal on the finish of the optical fiber ends. Cutting the fiber to the desired length with a blade introduces attentuation up to a factor of 3. For short-distance applications (below 3 m) this loss may be acceptable because no special fiber treatment is required. With long transmission distances, however, it is a good idea to polish the fiber ends with a suitable finishing compound. All data sheet values refer to polished fiber ends.

Fiber bending

The total reflection at the boundary between the fiber core and the outer jacket, that is, at the transition from a high refractive index to a low one, is crucial to the light guidance in the fiber. Radiation striking the boundary at a glancing angle is reflected and remains in

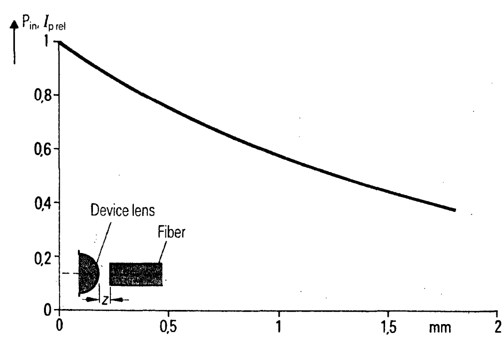


Fig. 3 Relative change of coupled-in power P_{in} and photocurrent I_P measured at the receiver with distance z between device lens and fiber

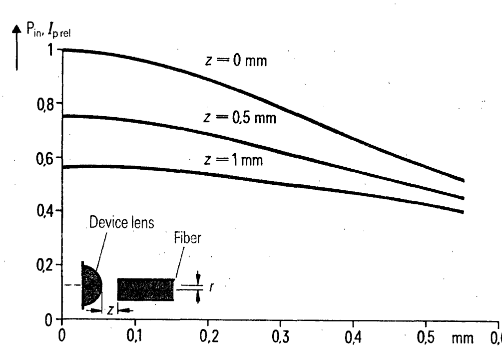


Fig. 4 Relative change of coupled-in power P_{in} and photocurrent I_p measured at the receiver with lateral misalignment r of fiber to device lens

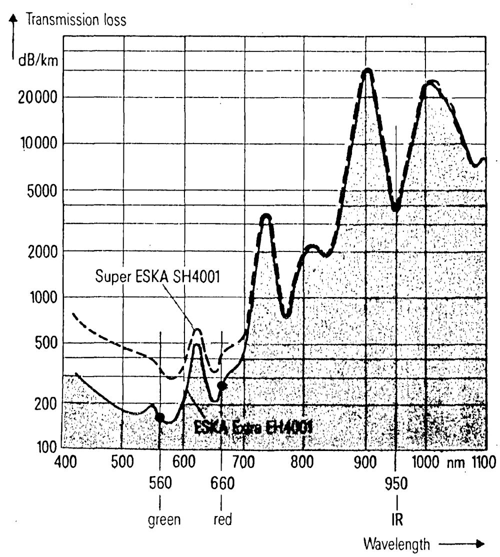


Fig. 5 Transmission losses of two Mitsubishi fibers with radiation wavelength

the fiber core. Bending the fiber, however, changes the angle of incidence at the bending point and allows a certain proportion of the radiation to disappear through the outer jacket.
To give an example: bending a plastic fiber to about 180° with a radius of 1 cm produces losses of 10 to 20%. Particularly with large cables and fixed connections it is important to maintain or, better, to choose as large a radius as possible.

Absorption losses in the fiber

Radiation losses discussed so far appear to be negligible as they are easily reduced by appropriate methods. Losses produced by absorption of radiation in the fiber material, however, cannot be influenced at all. **Fig. 5** shows transmission losses of two Mitsubishi plastic fibers.
These plastic fibers do not stand up to some of the optical fiber cables widely discussed in the media.
Their advantages are low price and easy use in linking short distances. The red **emitting diode SFH 750, SFH 750V in pulsed mode and the ESKA EXTRA EH 4001 fiber are capable of reliably covering transmission distances up to 100 m.**

Quality safeguards long service life

Experience gained from producing millions of optical transmitters and detectors is now going into the manufacture of light-link components.
The SFH 450, SFH 450V infrared diode have an average service life of 10^6 component hours at 10 mA forward current and 60 °C ambient temperature. SFH 750, SFH 750V and SFH 751 achieve more than 10^5 component hours (at 20 mA and 40 °C). Ageing effects are not to be expected with optical detectors.
The ruggedness of light-link components makes them ideal for applications where they are exposed to severe mechanical stresses. Stress tests on vibration (to DIN IEC, part 2 to 6, test Fc) and shock (to IEC 68-2-27, test Ea) were successfully passed.

Optocouplers with almost unlimited dielectric strength

Optocouplers are used to transmit signals between areas making no electrical connection or between areas at different potentials. In conventional optocouplers the transmitter and receiver are a very short distance apart. Even the outer creepage distance along the plastic package is only a few millimeters. Thus the maximum voltage that can be handled by the devices, is relatively low. For higher dielectric strength requirements, couplers constructed from light-link components are to be preferred.
Using a 5-cm long fiber to connect emitter diode and detector allows an insulation voltage of 40 kV. Even when the dielectric strength is not the important point, the set up has a capacitance of only 0.01 pF between emitter and detector. A low coupling capacitance is necessary in transmitting high-frequency signals.
One application of such an optocoupler is described on the following pages.

Part 2 – Plastic Fiber; Light-Link Optocouplers are Faster

Application Example

by Günther Hirschmann

Derived from opto-electronic mass-produced components, light-link devices are special types which permit the simple construction of signal transmission paths using plastic fibers.
Optical signal transmission has the following advantages relative to conventional wire links:

- Handling of high frequencies because of short switching times and negligible capacitive coupling,
- maximum transmission distance is several **yards**.
- the low power transmitter allows operation in areas subject to explosion hazards because there is no risk of ignition,
- interference-free transmission even in the presence of strong, varying electromagnetic fields,
- no crosstalk because of negligible capacitive coupling between emitter and detector,
- unlimited isolation voltage ratings.

Every device has particular features

The three optical emitter diodes available are distinguished by emission colors and radiation wavelengths:
SFH 450 - infrared, 950 nm,
SFH 750 - red, 660 nm and
SFH 751 - green, 560 nm.
In addition, they have features which either recommend or exclude their use in particular applications. The SFH 450 IR-diode provides the highest efficiency in converting electrical power into radiation. It allows the strongest signals to be obtained in the detector circuit.
Attenuation in the plastic fiber at 950 mm is so high **(Fig. 5),** however, that this combination is only suitable for short-distance transmission.
Moreover, the switching times of about 1 µs do not satisfy the more stringent frequency response requirements. With ten times shorter switching times [2] but reduced radiation power, the SFH 750 red diode is better suited to handling high-frequency pulse trains. The SFH 751 green diode is not suitable for signal transmission tasks. Its radiation power is far below that of the red diode and its switching time is much longer. Attenuation in the plastic fiber is fairly small with the green diode. The human eye, however, is particularly sensitive at a wavelength of 560 mm. For these reasons, the SFH 751 diode is mainly employed as a single spot or to set up displays.
Detector devices can be distinguished in a similar way. The SFH 350 device benefits from on-chip power gain and so has a high sensitivity. With a given fiber output power, its signal is 250 times greater than that of the SFH 250 diode. Transistor switching times in the order of 15 µs permit applications of only 10 kHz when the switching edges of pulse trains have to be detected with almost no delay. If there is no such requirement the phototransistor is capable of handling frequencies of 50 to 100 kHz.
The SFH 250 silicon PIN-diode is ideal when switching speed and frequency response requirements are more stringent. Its signal rise and fall times are around 10 ns. When the PIN-diode is used in conjunction with the SFH 750 diode, however, the latter is the frequency-determining component with rise times of about 120 ns and fall times of 50 ns.

Coupler circuits using light-link components

The mechanical construction of transmission paths is simple:
The plastic fiber is inserted in the cylindrical holes on top of the components and is firmly connected by a shrink sleeve. With long transmission distances, it is a good idea to polish the fiber ends to avoid attenuation losses. **Fig. 1** gives examples of such optocoupler set-ups.
In the circuits described here the SFH 750 red emitting diode is used as the transmitter and the SFH 250 PIN-diode as the detector. The basic circuit is shown in **Fig. 6.** The resistor connected in series with the transmitter diode serves for current limiting.
When the diode is measured its forward current may reach values (independent of switch-on time and duty factor) as listed in **Fig. 7.** In the following examples the diode's rms current is limited to about 27 mA.
The receiver diode is operated in the reverse condition. Its load resistor R_L across which the output signal is developed, not only influences the output amplitude $\hat{u}_{out}$ but also the rate of change of the output pulses. High resistances result in higher signal voltages and longer rise and fall times. Characteristics

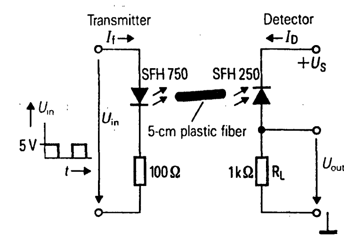


Fig. 6 Basic circuit to operate light-link optocouplers

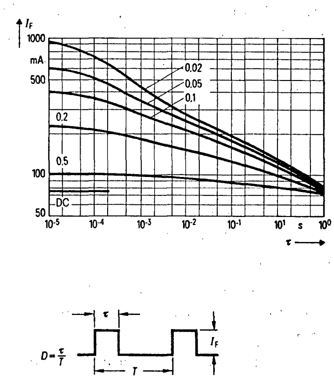


Fig. 7 Pulse handling capability of the SFH750 emitter diode

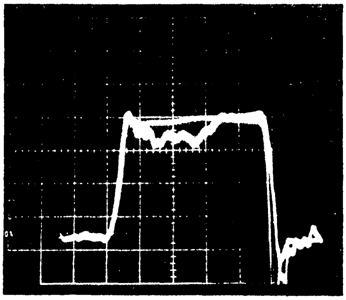


Fig. 8 Drive signal (5 V) and output voltage (70 mV) with 1-MHz frequency in the Fig. 6 circuit

of the input signal U_{in} and the output signal U_{out} for the **Fig. 6** circuit with a 1-MHz switching frequency are shown in **Fig. 8.**
The current transfer ratio is a crucial factor with opto-electronic coupling distances.
This is the ratio of current through the detector to current through the emitting diode. In the described set-up of SFH 750, 5-cm long plastic fiber and SFH 250, the current transfer ratio is 0.13%. Under these conditions the detector signal has to be further amplified. **Fig. 9** is a simple amplifier circuit suitable for frequencies up to 50 kHz.
The detected signal is amplified by a common-emitter stage. The unit is characterized by high current gain and low upper limit frequency. To phase match the input and output signals, a phase reversal stage is provided by transistor T2.
The anti-saturation diode D1 improves the switching characteristic. Rise and fall times of the output signals are about 200 ns. The output signal delay relative to the input signal is 0.7 µs.
Fig. 10 is a circuit suitable for transmitting analog signals up to 200 kHz:
The TAE 1453 A op-amp has a pnp input differential stage and an open-collector output. The incoming signal is applied to the non-inverting op-amp input and is amplified by the ratio of R_1/R_2. A high-speed CMOS logic driver converts the output signal to TTL level. Delay times with this circuit are only about 250 ns, while rise and fall times can be neglected. To handle higher frequencies (up to 1 MHz) the **Fig. 11** circuit is the most

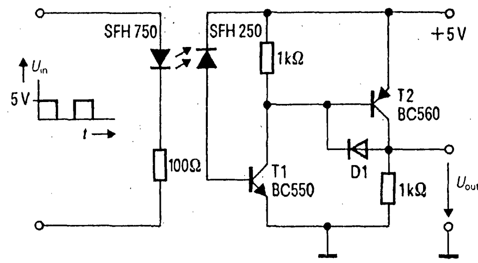


Fig. 9 Amplifier with common-emitter circuit suitable for analog signals up to 50 kHz

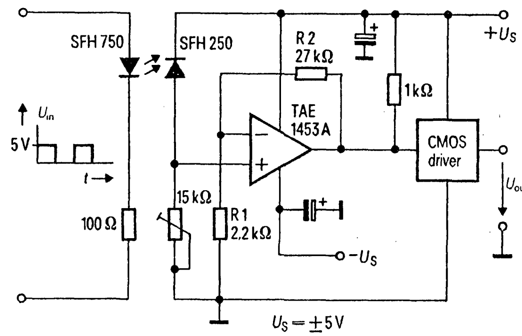


Fig. 10 Optocoupler circuit to transmit analog signals up to 200 kHz

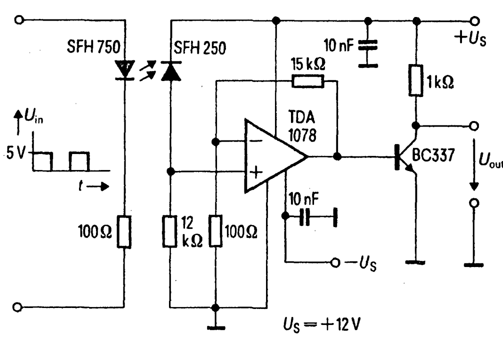
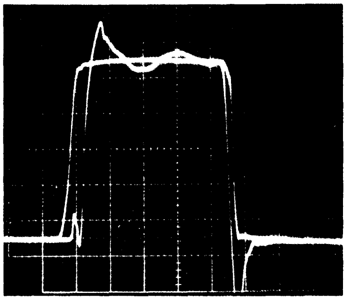


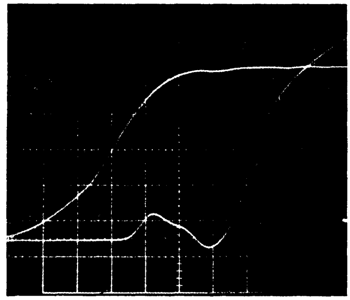
Fig. 11 Optocoupler circuit to transmit analog signals up to 1 MHz

Application Notes



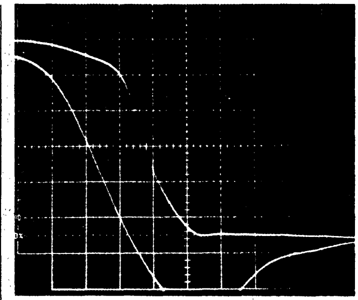
U = 1 V/Div
t = 100 ns/Div
f = 1 MHz

Fig. 12 Switching performance of the Fig. 11 circuit, input pulse (left) and output pulse (right)



t = 10 ns/Div
f = 1 MHz
35 ns delay time of the output signal
25 ns rise time of the output signal

Fig. 13 Rising edges of input and output pulses in Fig. 11



t = 10 ns/Div
f = 1 MHz
16 ns delay time of the output signal
18 ns fall time of the output signal

Fig. 14 Falling edges of input and output pulses in Fig. 11

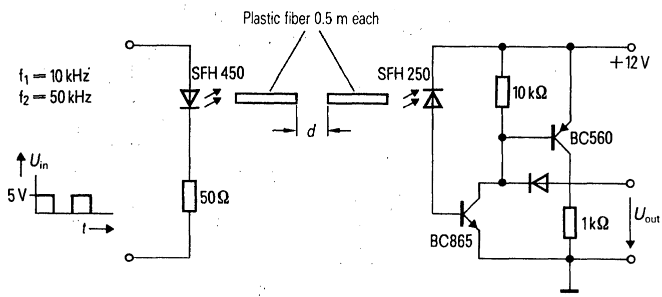


Fig. 15 Photo interrupter arrangement using light-link components

suitable. It uses the fast TDA 1078 op-amp. The device is operated as a non-inverting amplifier with a gain of about 150.

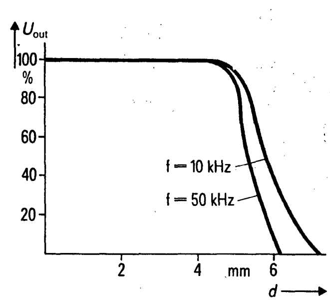


Fig. 16 Output signal of the photo interrupter circuit dependent on the distance of the end of the plastic fiber

Transistor T1 brings the output voltage U_{out} to 5 V. **Fig. 12** shows the appropriate switching characteristic. **Fig. 13** and **14** illustrate in more detail the rising and falling edges of the input pulses on the left, and the waveforms of the output pulses on the right. It is obvious that the amplifier circuit introduces short delays of 35 and 10 ns but does not further extend the remaining switching times.

Photo interrupter circuit

In **Fig. 15** a photo interrupter arrangement is shown. The ends of the optical fiber are polished. As shown in **Fig. 16** the distance from the optical fiber end must not exceed 5 mm to avoid an excessive voltage drop in signal voltage level. Thanks to the optical fiber the optical detection area can be remote from the electronic circuit. The optical detector is ideal for use in atmospheres subject to explosion hazards.

SIEMENS

Light-Link Components Control High-Frequency Switched-Mode Power Supplies Appnote 41

by Reinhard Blöckl

Operating frequencies of 100 kHz are common practice in modern switched-mode power supplies. And the trend continues towards even higher frequencies. The reason for this is that they allow the development of power supplies of smaller size and improved dynamic control characteristics. The necessary feedback is done by Siemens light-link components which permit reliable control of SMPS with working frequencies in the MHz range.

Feedback of control information in switched-mode power supplies is mainly handled by integrated analog optocouplers (e.g. CNY 17 and SFH 600). The limited bandwidth of these couplers allows SMPS to be controlled at working frequencies below 100 kHz.
Use of the new light-link components, SFH 450 and SFH 750 (emitters) and SFH 250 (detector), greatly extends the range of optical signal transmission.
The circuits described here for analog signal transmission are characterized by

- suitability for SMPS with high and very high working frequencies,
- minimizing parasitic coupling capacitance between emitter and detector,
- no electromagnetic interference in the transmission line (plastic fiber).

Using the new light-link components in SMPS results in a higher efficiency and a reduction of screening. The savings achieved largely compensate for the extra costs of light-link components and mounting them relative to integrated optocouplers.

Low-cost opto-electronic coupling elements can be used in SMPS with higher working frequencies (above 100 kHz). This has so far been the domain of sophisticated transformer techniques.

Electrical isolation of the SMPS is provided by a power transformer with primary and secondary windings isolated from each other. **Fig. 1** is a block diagram of such an arrangement.

With the control and monitoring circuit on the primary side of the SMPS, as shown in **Fig. 1,** the closed-loop voltage control therefore bridges the isolation between the primary and secondary sides.

To maintain electrical isolation, the control feedback path must include an isolated linear transmission device.

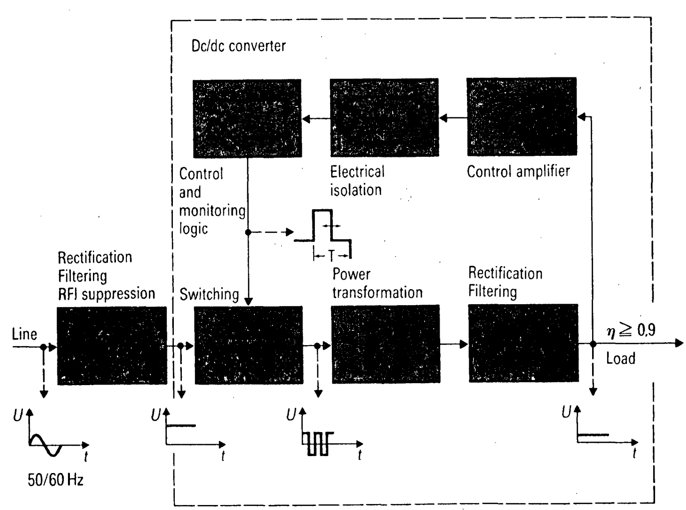


Fig. 1 Block diagram of a pulsewidth-modulation controlled switched-mode power supply

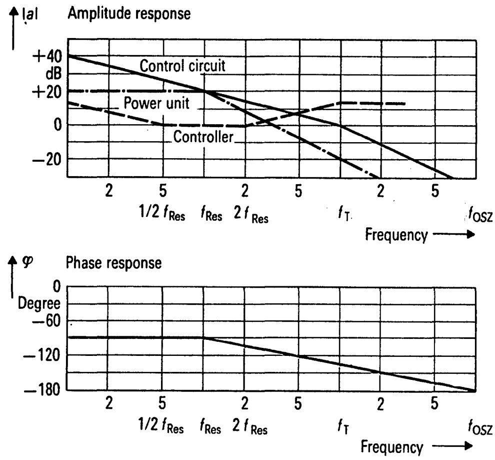


Fig. 2 Typical frequency characteristics in the control of switched-mode power supplies

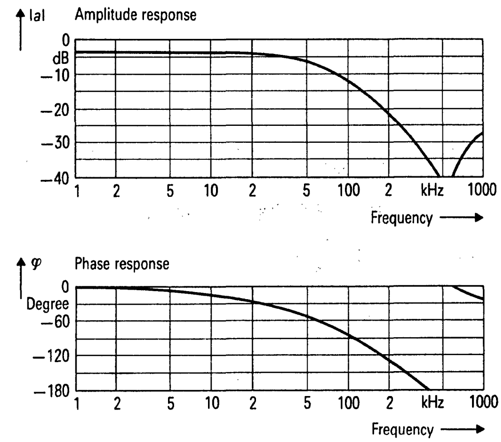


Fig. 3 Frequency characteristics of CNY 17-1 coupler

This device is governed by the same VDE regulations as the power transformer in terms of isolation voltage, air and creepage paths.
Two methods are currently employed in isolated signal transmission:

- transformer signal transmission,
- optical signal transmission.

Relative to the technically valuable but expensive transformer solution, optocouplers are less costly. But this method does have some engineering restrictions.

Design of SMPS control circuits

Forward-converter SMPS operating in the »voltage mode«, normally use a controller with PIDT1-characteristic (proportional – integral – derivative 1st order action) whereas SMPS in the »current mode« use controllers with a PIT1 characteristic. Frequency response is compensated to maintain the widest possible bandwidth with sufficient stability.
The SFH 600, CNY 17 available optocouplers have a limited achievable bandwidth.
The new broadband light-link components are linear transmission elements which allow for a control bandwidth depending only on the chosen working frequency of the SMPS. Hence an improved SMPS dynamic control characteristic (the most important reason for increasing the working frequency) can be implemented in practice. **Fig. 2** shows the Bode diagram of a »voltage mode« forward converter power unit (chain line).

The LC output filter has a transfer function with two poles at the resonance point. This implies a −180° phase shift at higher frequencies. The circuitry for frequency response compensation is designed so that the control amplifier has the desired PIDT1 type frequency response, as shown in **Fig. 2** (broken lines). From this the frequency response (solid line) of the complete control circuit is obtained.

Time constant *T*1 has been chosen so that the associated corner frequency corresponds to the transition frequency f_T of the system

$$f_T = 1/(2 \cdot \pi \cdot T1)$$

This serves for the bandwidth limiting necessary to suppress the switching frequency.

Sufficient attenuation is guaranteed by making the transition frequency one decade below the switching frequency.

A parameter of control stability is the phase shift of the separated control circuit at the transition frequency (gain at transit frequency is 0 dB). A maximum phase angle of −150° – this means a −30° phase margin – is still considered sufficiently stable.

So far we have neglected the optocoupler's frequency response. We started from the assumption that the control op-amp would not cause any significant phase shift of the given transition frequency.

A phase shift of −135° results from **Fig. 2** for the transition frequency.

Consequently, the additional phase shift of the optocoupler at transition frequency may be a maximum of −15° to maintain a minimum phase margin of 30°.

As a rule of thumb, the working frequency of a switched-mode power supply should exceed the frequency at which the optocoupler produces a −15° phase shift by a factor of ten.

Although a higher switching frequency is possible, it will not improve the dynamic control characteristics as the transition frequency cannot be raised appropriately for reasons of stability.

Properties of integrated optocouplers in linear operation

Obvious benefits of optocouplers are their compact size and low price.
Against these, however, are some drawbacks:
- low cut-off frequency,
- coupling capacitance between emitter and detector,
- air and creepage paths between external connections are likely to fall short of requirements after pc board mounting.

Frequency response of integrated optocouplers

When a high cut-off frequency is required, the optocoupler should be used in a low-impedance circuit. For example, the data sheet specifications for the limit frequency for the SFH 600 optocoupler is 250 kHz with a load resistance of $R_L = 75\ \Omega$.
The permissible component current limits the reduction of resistance values. To assess the possibilities of using optocouplers as part of a control circuit, the frequency response characteristic method (Bode diagram) is very useful.
Fig. 3 shows the measured frequency response characteristics of the CNY 17 standard optocoupler for a load resistance $R_L = 1\ \text{k}\Omega$.
The amplitude characteristic |a| here has a logarithmic current transfer ratio.

$$|a| = 20 \cdot \log (I_C/I_F)$$

The phase response shows the phase angle between the light emitting diode current I_F and the detector transistor current I_C.
From the frequency response characteristic it can be seen that
- the phase angle of −15° lies at about 10 kHz,
- a zero occurs at about 550 kHz in the amplitude response.

From the first, it can be concluded that the integrated optocoupler is suitable for working at frequencies up to 100 kHz. The second observation points to the effect of the parasitic coupling capacitance. By superimposing both signal transfer paths, optoelectrical and capacitive, which produce phase displacements with opposite signs, the output signal may be partially erased. This gives the observed non-uniformity of the frequency response.

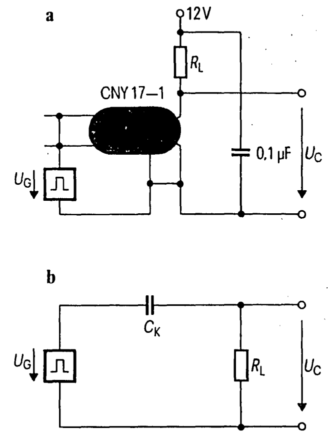


Fig. 4 Common-mode transmission through coupling capacitance C_K
a measuring circuit to determine the coupling capacitance
b equivalent circuit of common-mode transmission

Common-mode suppression with integrated optocoupler

The undesired transmission of common-mode signals through optocouplers is caused by the parasitic coupling capacitance C_K between the input and the output of the optocoupler.
Fig. 4 shows a measurement circuit to find the coupling capacitance and obtain the high-frequency equivalent circuit. As can be seen from the equivalent circuit the transmission of common-mode signals corresponds to an *RC* first-order high pass filter consisting of parasitic coupling capacitance C_K and the external load resistance R_L.
The common-mode signal transmission produces spiked interference waveforms in the output voltage U_C from the square-wave input voltage U_G.
The appropriate signal characteristics are shown in **Fig. 5.** The measured load resistance R_L was 10 kΩ.

With the switched-mode power supply described common-mode transfer action is most disturbing as capacitively coupled in (e.g. transformer winding capacitance) common-mode signals of high amplitude are likely to occur at regular intervals because of the clock-pulse mode of operation.

Insufficient common-mode suppression may cause these interference waveforms to be transmitted through the optocoupler to the pulsewidth-modulation control circuit.

This often leads to incorrect operation of the PWM. Here an additional interference suppression in the form of a screen inside the power transformer is required.

Useful features of light-link components

Unlike integrated optocouplers, light-link components consist of separate emitter and detector units optically coupled through an optical fiber (for example plastic fiber) over any desired distance.

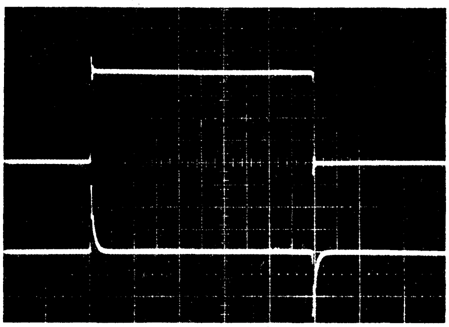
This technology brings some major benefits with it:

- The coupling capacitance is negligible because of the spacing between emitter and detector,
- the required air and creepage paths and isolation voltages are easily provided because of the spacing between emitter and detector,
- optical fiber links can neither emit nor receive electromagnetic interference in the radio frequency band,
- using a PIN photodiode as the detector provides very broad bandwidths.

A technical description of available emitter and detector devices and amplifier circuits is given in [1].

This article deals with applications in linear transmission, especially in the control feedback paths of SMPS. Suitable circuits are discussed.

To determine the limit values of the individual circuits, their frequency response characteristics were measured and plotted as Bode diagrams.



U_G = 5 V/Div
U_C = 200 mV/Div
t = 2µs/Div

Fig. 5 Common-mode interference at the output of the Fig. 4 circuit with R_L = 10 kΩ

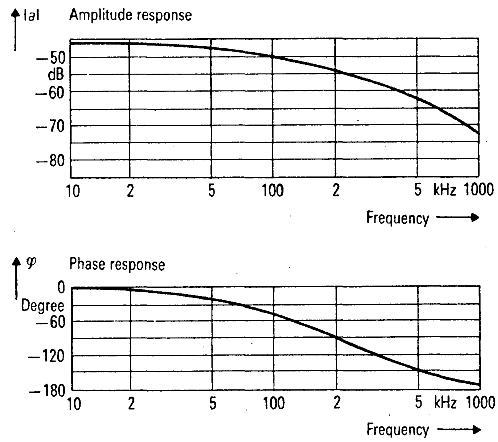


Fig. 7 Frequency characteristics of the Fig. 6 circuit

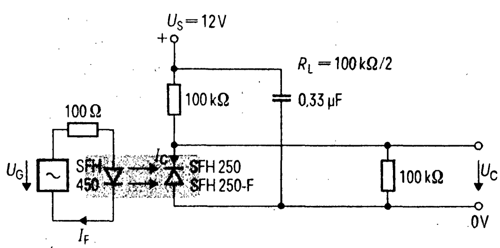


Fig. 6 Optical signal transmission circuit without amplifier

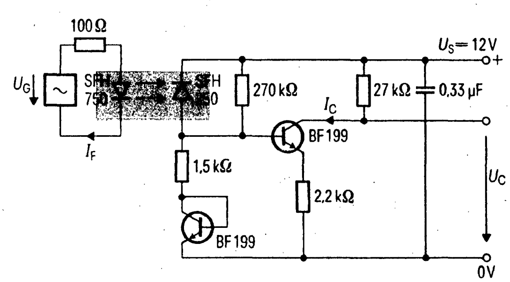


Fig. 8 Optical signal transmission circuit with single-stage amplifier

Circuits for linear optical signal transmission

Interface requirements

The design of optical signal transmission circuits is based on the following assumptions:

- for driving the photodiode (emitter) a current I_F between 0 and 50 mA is available,
- a voltage U_C of about 5 V is provided at the detector circuit output,
- with LED control current I_F = 0 A, the output voltage is $U_C \geq 5$ V,
- the complete circuit is inverted – in other words – the output voltage U_C drops with rising control current I_F.

These interface conditions are so chosen that the optoelectronic circuits can be driven by standard amplifiers and there is compatibility with the TDA 47xx and TDA 49xx SMPS control IC series. The optical signal transmission circuit can be incorporated into the SMPS concept of Fig. 1.

Three optical transmission circuits are described which meet the increasing demands for transmissible frequencies.

Optical signal transmission circuits without amplifiers for frequencies up to 450 kHz

The circuit shown in **Fig. 6** is built from just a few components. As the current transfer ratio I_C/I_F of the combination SFH 450 (IR emitter diode) and SFH 250 (photodiode) is sufficient, the output signal can be obtained at the load resistor R_L without any additional amplification after the photodiode.

As the 1-µs switching time of the SFH 450 is rather long, a wide bandwidth cannot be achieved with this simple circuit.

The SFH 250-F infra-red light-transmitting filter detector diode can be used with the same results as protection against daylight in the **Fig. 6** circuit. The associated Bode diagram is given in **Fig. 7.**

From this it can be seen that at about 45 kHz a phase shift of −15° occurs. With these parameters the circuit is suitable for switched-mode power supplies operating at frequencies up to 450 kHz. Technical data are summarized in the **Table.**

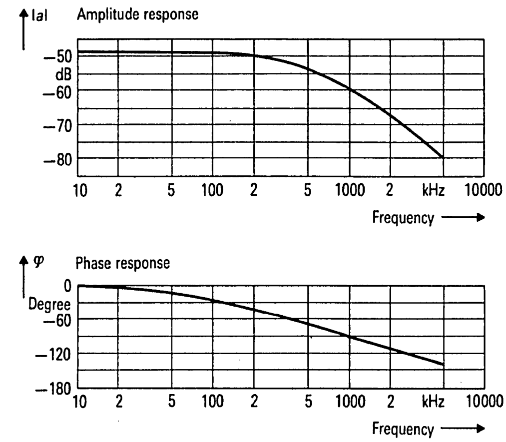


Fig. 9 Frequency characteristics of Fig. 8 circuit

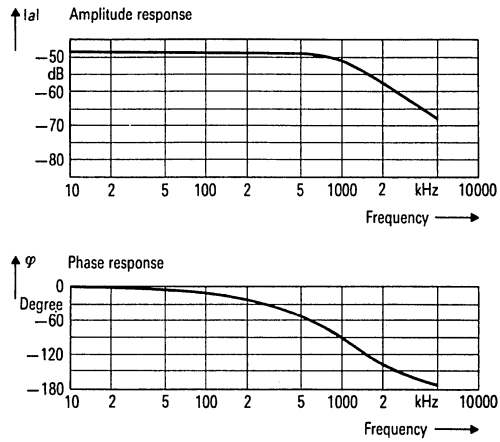


Fig. 11 Frequency characteristics of Fig. 10 circuit

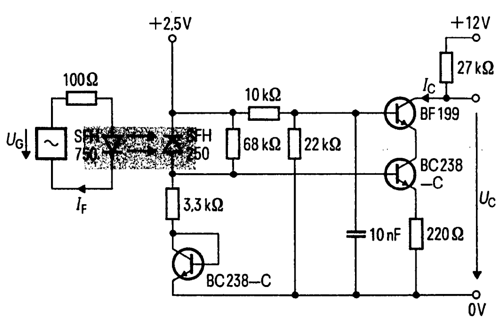
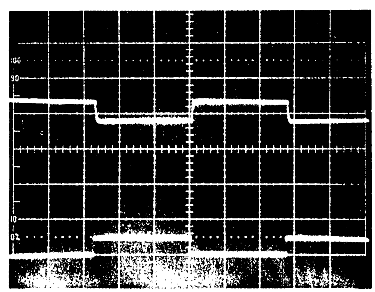


Fig. 10 Optical signal transmission circuit with amplifier in cascode arrangement



U_C = 1 V/Div
I_F = 10 mA/Div
t = 10 μs/Div

Fig. 12 Output voltage U_C waveform with square-wave current I_F

Circuits with single-stage amplifier for frequencies up to 650 kHz

The limit frequency can be increased when the SFH 450 IR LED is replaced by the SFH 750 emitter diode operating in the red spectral range. Switching times are reduced by a factor of 10. The radiant power coupled into the optical fiber from this LED is, however, much smaller. An amplifier stage is required to produce the necessary output voltage. **Fig. 8** is the block diagram.

The BF 199 transistor is used as common-emitter amplifier. The base-emitter diode of another transistor provides temperature compensation.

To allow for the manufacturing tolerances of the transistor, it may become necessary to trim the 270-kΩ resistor. The Bode diagram of this arrangement is shown in **Fig. 9.**

The frequency at which the phase is shifted by −15° lies at 65 kHz. The transmission circuit is suitable for SMPS with working frequencies up to 10 times higher than this. The **Table** gives the technical data on this circuit.

Circuits using cascode amplifier for frequencies up to 1600 kHz

The cascode circuit is characterized by an excellent high-frequency performance. The **Fig. 10** arrangement requires a stabilized 2.5-V source and 12-V supply voltage, which are already provided when TDA 47xx or TDA 49xx SMPS control ICs are used.

The cascode circuit uses one BC238-C and one BF 199 transistor.

The operating point of the BF 199 transistor is set by a voltage divider supplied from the 2.5-V source. The base-emitter

Description	Symbol	Circuit to Fig. 6 typical values	Fig. 8	Fig. 10	Unit
Operating point ($U_S = 12$ V)	I_F	10	10	12	mA
	U_C	4.2	5.5	5	V
DC transmission performance	$\frac{\Delta U_C}{\Delta I_F}$	0.24	0.1	0.1	$\frac{V}{mA}$
3-dB limit frequency	f_{3dB}	100	250	700	kHz
Dependency of output voltage on U_S	$\frac{\Delta U_C}{\Delta U_S}$	0.5	−0.53	–	–
Dependency of output voltage on 2.5-V supply voltage	$\frac{\Delta U_C}{\Delta 2.5\ V}$	–	–	9.5	–
Temperature coefficient of output voltage (in the range 0 °C ≤ ϑ ≤ 60 °C) $I_F = 15$ mA	$\frac{\Delta U_C}{\Delta \vartheta}$	9	2	~0	$\frac{mV}{K}$

Table Technical data on three transmission circuits using light-link components to control switched-mode power supplies with different working frequencies

diode of the third transistor provides temperature compensation. To allow for the transistor manufacturing tolerances, it may be necessary to trim the 68-kΩ resistor. The Bode diagram of this arrangement is shown in **Fig. 11.** The frequency at which the phase is shifted by −15° lies at 160 kHz. Consequently, the highest possible working frequency for a SMPS using this circuit is about 1.6 MHz.

Fig. 12 shows the behaviour of the circuit with time. The emitter diode is driven with a square-wave current I_F of 5-mA amplitude. The amplitude of the output signal U_C is 0.6 V. Technical data are given in the **Table.**

Conclusion

Switched-mode power supplies using light-link components in the control feedback path provide broadband control characteristics which depend on the chosen switching frequency. Stability and excellent dynamic control characteristics are obtained.

The small coupling capacitance between emitter and detector in the optical transmission path (large spacing) eliminates the need for a screen in the power transformer.

The possibility of obtaining higher working frequencies with simpler and thus lower-cost configurations of SMPS will be an impetus towards further increases of frequency in power supply design.

Motor Control with Electrical Isolation of Operator Module and Power Unit Using Light-Link Components Appnote 42

by Manfred Stürzer

There are already numerous applications of motor speed control in household and leisure appliances using the TLE 3102 phase control IC. New areas for use are opened up by the method described in this article.
Benefits of this phase control circuit are standby operation, soft start and overheat protection.

A stepless speed control using the TLE 3102 IC was developed for 220-V universal motors. The operator unit which is supplied from low voltage is electrically isolated from the motor control circuitry to cater for situations where the operator unit must not be powered from line potential.
Control signals are transmitted optically by an optocoupler or a combination of light-link transmitter diode, phototransistor and plastic fiber of any desired length.
The potentiometer for speed adjustment and an LED used for status indication can be combined in a single unit which is connected to the control electronics by two leads.

Operation

The circuit **(Figure)** consists of the operator module, which works at low voltage, and the control unit. The latter utilizes the TLE 3102 phase control IC to trigger the triac (e.g. TXD 10K60). Design of external circuitry for the power supply, sawtooth voltage, trigger pulse width, triac trigger current and synchronization, is identical to that of established systems.

A PTC thermistor is used for temperature monitoring as protection against overheating. The temperature-dependent divider voltage from R_K and R1 is inverted by the op-amp of the TLE 3102 IC and amplified to become effective at the control input U_ψ from a defined temperature.

Hence the conduction angle and motor speed are reduced. The temperature protection circuit – at first glance a rather expensive one – allows the triac and PTC thermistor to be mounted onto the motor and connected straightforwardly to the drive circuit by only 4 wires. In normal operation, the maximum permissible conduction angle is defined by a voltage of 0.6 to 2 V at U_ψ to eliminate the risk of half-wave operation caused by phase shift between current and voltage. The maximum rating must be adapted to the motor type. For this purpose the full-scale control setting of the trimmer R2 is made so that full-wave operation is guaranteed. The operator module and power unit are electrically isolated. The control information is transmitted in the form of a pulse-width modulated rectangular signal via an optocoupler to generate the control voltage U_{st}. Any effects of non-linearity, tolerances and ageing of the optocouplers are reliably excluded.

Light-link components are ideal for replacing optocoupler elements. The use of the SFH 450 light-link transmitter diode, the SFH 350 phototransistor and a plastic fiber permits not only electrical isolation but also separate low-voltage module and power unit and enables them to be interconnected via a plastic fiber. The permissible distance is determined by the coupled-in power of the transmitter diode and the plastic fiber attenuation. Capacitor C1 serves mainly for filtering the rectangular signal to dc voltage.
In addition, it supports soft motor start from the standby mode. Here »standby« means zero rpm.

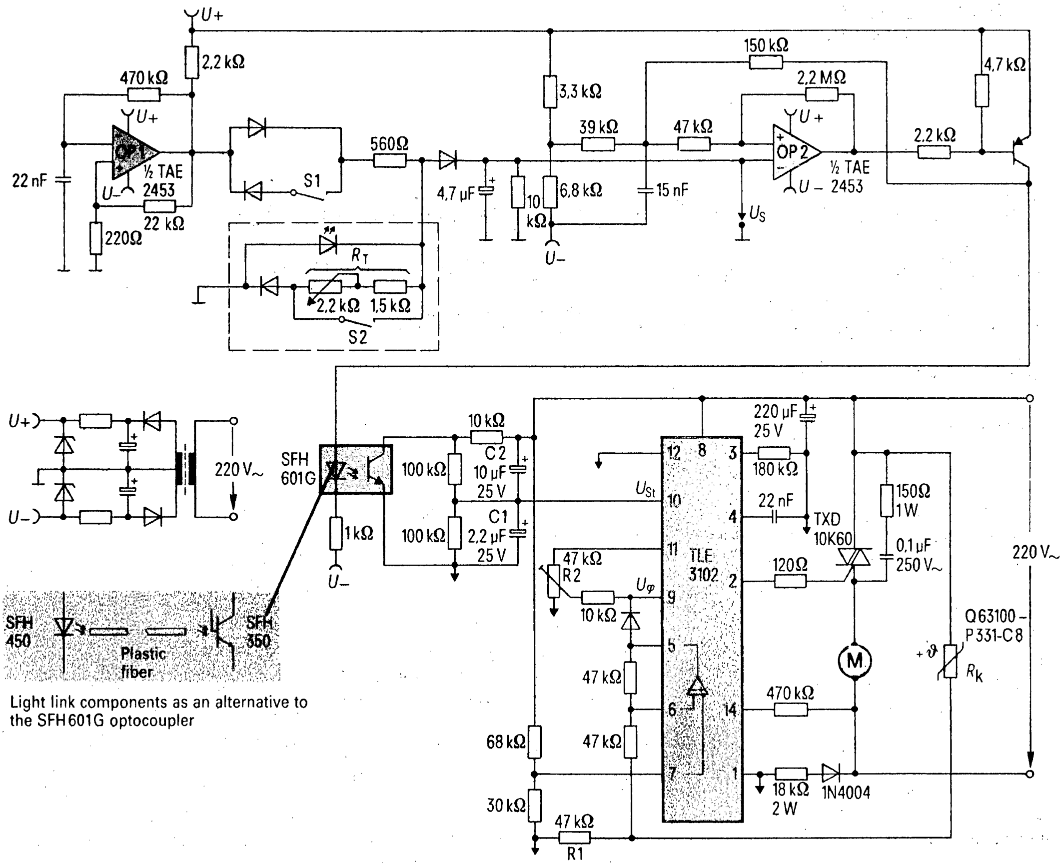
In the range 1.2 to 4 V an increase of control voltage U_{st} causes a drop in motor speed.

When line voltage is supplied, the operating voltage is built up gradually and is still below its maximum at the time of the trigger pulse.

Therefore the motor starts abruptly and is then slowed down to the desired speed. This is avoided and a soft start is permitted by inserting capacitor C2.

As long as the operating voltage is changing appreciably the capacitor's impedance is negligible and provides higher voltage at the control input U_{st}.

In the steady state, however, it no longer affects the control voltage, which then reaches the desired value.



Circuit diagram of motor control with electrical isolation of operator module and power unit

A rectangular signal generator and a pulse width modulator are the main components of the low-voltage module. OP1 op-amp works as a multivibrator and supplies a bipolar square-wave voltage at a frequency of about 2.5 kHz.

The positive half-wave should be considered first. The variable voltage, falling at R_T is smoothed before further processing.

From a defined range of the signal voltage the subsequent pulse duty converter [2] generates a rectangular signal in which the duty cycle is proportional to the voltage and drives the transmitter diode of the optocoupler via the pnp transistor. When the voltage drops below the lower threshold, for example, by closing standby switch S2, the duty cycle is zero and the phototransistor is no longer conducting.

Voltage U_{st} at the control input of the phase control IC is above 4 V. The triac is not triggered and the motor is stationary.

For voltages exceeding the upper threshold the transmitter diode is permanently conducting. Hence U_{st} is at a minimum and the motor runs at a maximum speed determined by U_{ψ}.

An additional indication not requiring extra wiring is provided by the negative half-wave of the square-wave generator. Whenever switch S1 is closed, an LED is activated and indicates the current status without affecting the signal voltage U_s.

Applications

One application of this motor control is in canister-type vacuum cleaners. Potentiometer, standby switch S2 and LED are easily housed in the cleaner handle.

Thanks to the electrical isolation of the low-voltage module and power unit, only two, fairly thin wires run through the hose to the canister without restricting the suction hose flexibility.

Adjustable speed, in other words, suction performance, soft start and standby operation are ideal for vacuum cleaner operation. The additional LED can be used to indicated dust bag fill level. The control method ensures proper cleaner operation even with a broken wire in the hose which would only reduce the convenience to the user. Finally, the temperature circuit gives protection against overheating of the motor and its housing.

SIEMENS

FREDFET Power Half-Bridge: Short-Circuit Proof through Light-Link Components Appnote 43

by Walter Schumbrutzki

With higher clock frequencies in power switches inverse-capable MOS power transistors (FREDFET) are going to replace bipolar devices. In the low power range (≤ 2 kW) MOS half-bridges are already being designed which are far superior to those using bipolar transistors.

The most important requirements to be met by bridge circuits are:
minimum forward and switching losses,
duty factor of 0 to 100%,
current limiting (if necessary, short-circuit and leakage protection),
low control power,
separate drive of individual transistors,
electrical isolation of control and output circuits.
Driving of »high side« transistors is made somewhat difficult because of the switched source potential (floating).
Apart from providing a solution to this problem, the circuit described in this article fulfils all the above requirements.

Transformer-coupled SIPMOS half-bridge (Fig. 1)

Pulse transmission of input signal using a ring core

Though transformer coupling permits fast switching times, the effects of magnetic saturation generally confine the duty factor to about 50%. Magnetic saturation also limits the time a transformer can hold a MOSFET in the on-state. To overcome this problem the transformer in the circuit described is fed with a high-frequency pulse train (burst of 1 MHz) for the duration of the input pulse.
The FET is operated as long as the *burst* is present. Thus turn-on times are freely selectable. An auxiliary power supply on the secondary side is not necessary. Driving the half-bridge entails two opposed square-wave signals with some delay of the positive edge (around 500 ns) and a 2-MHz clock signal. These signals can be derived from a pulse-width modulation circuit. The 2-MHz clock can be obtained from the drive circuit via the ALE line of a microcomputer. The drive signal (active high) goes to a turn-off logic circuit which blocks the input signal when the current threshold is reached. Then, with active low on pins R and S of the data flipflop 4013, complementary 1-MHz bursts are delivered to the push-pull stage and the ring core transformer (R 10/N 30) is energized. Both windings are put on face to face to minimize their capacitance. The primary has 10 turns, the secondary 12.

As the carrier current flowing through the capacitance between primary and secondary circuits is rectified and may cause spurious turn-on of the FREDFET, special attention has to be given to the design of the transformer.
Common-mode rejection of more than 100 V/µs is achieved by simply using a thin coaxial cable for the secondary winding. One end of the outer shield (not both) has to be connected to the appropriate FREDFET source.
On the secondary side the burst is rectified via a diode bridge and a positive gate signal is produced which simultaneously switches on the load and the current measuring MOSFETs.
Fig. 2 shows the transmission of an input pulse of 1.5 µs duration. When switched on the MOSFET gates are discharged via the BC 327/25 pnp transistor. Discharge time is determined by the time constant of the base resistance (1 kΩ) and smoothing capacitance (220 pF). The FREDFET is operated as long as the 1-MHz carrier is available, that is, when the control input (R, S) is low.

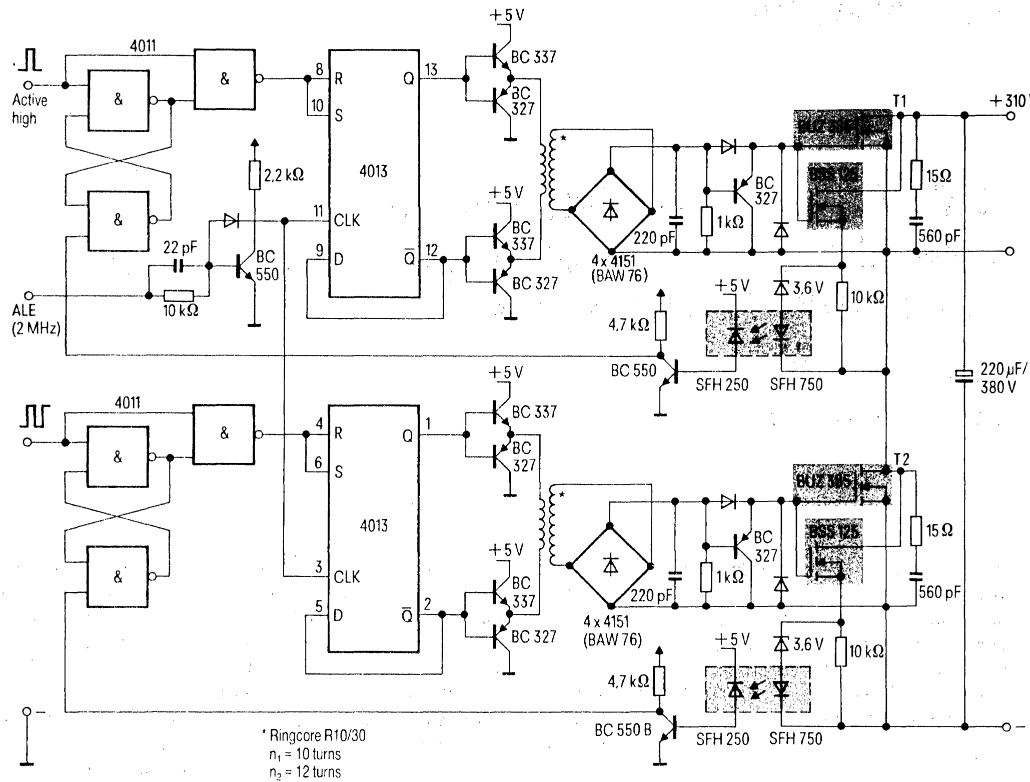


Fig. 1 Circuit diagram of SIPMOS half-bridge

Low-loss use of the signal for current measurement (Fig. 3)

Current measurement resistance in the load circuit means high additional losses. For current measurement the drain-source voltage of the load transistor in the on-state is taken out via a small-signal transistor (BSS 125). In the on-state it can be measured by the BSS 125 source resistance as the gates and drains of the two transistors are connected. This drain voltage is a direct measure for the flowing current ($U_{DS} = I_{DS} \cdot R_{DS\,(on)}$) and can be used to turn off the transistor via a threshold switch.

Transmission of current measurement signals via light-link components

The main problem in transmitting the turn-off pulse is the $\frac{du}{dt}$ sensitivity of commercially available fast optocouplers. Their high coupling capacitance prevents the transmission of steep signal edges. For this reason, a diode coupler is used here as a transfer device. It is made up from one special light-link transmitting diode and one receiving diode and a plastic fiber about 4-cm long. A shrink sleeve supports the junction between the diodes and the fiber and protects the

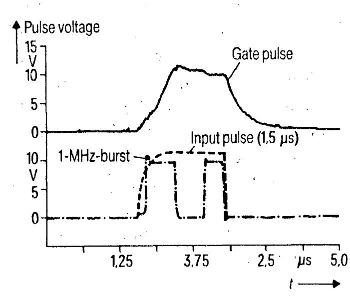


Fig. 2 Waveform in the driver stage

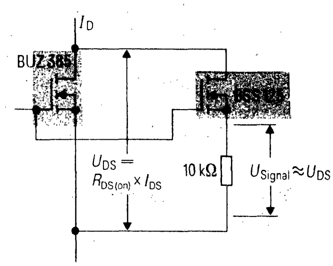


Fig. 3 Circuit (extract) for low-loss capture of the signal for current measurement

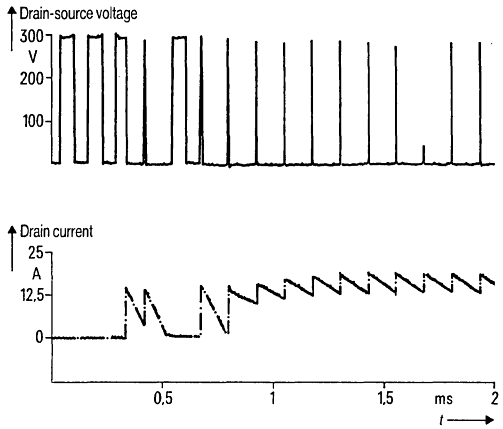


Fig. 4 Overcurrent behaviour of the Fig. 1 circuit with a load switched in abruptly via T2 (77 μH, 186 mΩ)

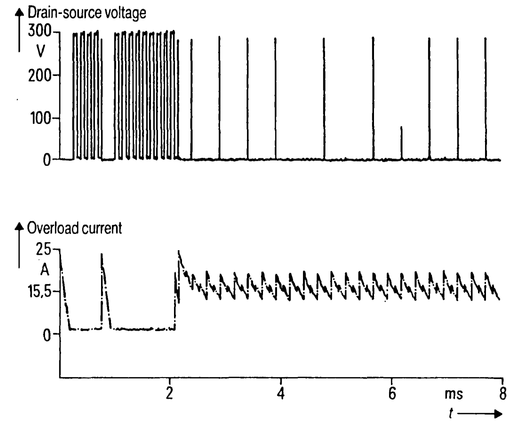


Fig. 6 Current and voltage waveforms in the FREDFET with overload

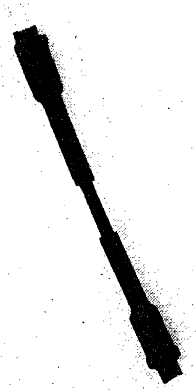


Fig. 5 Diode coupler built from light-link diodes and plastic fiber

assembly against extraneous light **(Fig. 5).**

Coupling capacitance can be neglected in this case, which, in turn leads to excellent $\frac{du}{dt}$ immunity. Here the signal voltage is taken from the source circuit of the small signal transistor. The transmitting diode of the light-link device is connected in series with the Z-diode.

With a certain signal voltage (limit current drop) sufficient current flows through the transmitting diode to cause information to be sent through the plastic fiber to the detecting diode in the drive circuit. An amplifier transistor then actuates the flipflop which turns off the output stage.

The turn-off circuit is incorporated on the low-voltage side because any short-circuit would seriously load the transformer and the risk of coupling in capacitive interference currents in the turn-of circuit would occur.

The current transfer ratio of the diode coupler is very low with this system configuration.

Unambiguous pulse transmission requires a diode current of 50 to 60 mA. The on-resistance of the BSS 125 transistor is a crucial factor in this current, so that the Z-diode voltage should be fairly small for a trigger current of 10 A. The actual turn-off current (after 2 μs) is about 18 A with a test overload of 77 μH and 186 mΩ, see **Fig. 4.**

The circuit is so designed as to reset the flipflop immediately after the overload current has been turned off. If the overload is not eliminated, the remaining input control pulses will initiate another turn-off operation. This constant repetition results in load current limiting, as can be seen in **Fig. 6.**

Refer to Appnote 40 "Low Cost, Fiber Optic Systems Using Siemens Light-Link Emitters and Detectors."

SIEMENS

Designing with the Small AlphaNumeric Display Appnote 44

By Bob Krause and Dave Takagishi

Introduction

The Siemens Small AlphaNumeric (SAN) Display family is one of the most versatile and flexible LED readout systems available today. Its four 5x7 characters are dot addressable permitting alphanumeric, graphics, and special symbols to be easily programmed in four colors (red, high efficiency red, yellow, green). SANs are available in 0.15" or 0.20" character heights, which are efficiently assembled in row and column stackable plastic or ceramic DIP packages. These packages allow environmental operation from commercial to the most demanding industrial and military requirements. Table 1 lists the SAN model numbers and their principle characteristics.

The internal CMOS row drivers and memory reduce power consumption and support electronics. Blanking Control makes night vision to sunlight ambient intensity control easy.

This appnote covers the SAN family capabilities which include: display operation, intensity control, thermal and optical management, and an 8051 MPU interface.

Display Operation

As compared to Siemens Intelligent and Programmable Displays, SANs require dot decoded serial data rather than parallel ASCII to operate. Figure 1 block diagram shows that the display with its four 5x7 LED characters and two CMOS 14 bit serial-in, parallel-out (SIPO) shift registers. Each LED matrix is a 5x7 diode array organized with the anode of each column tied in common and the cathodes of each character tied in common. The seven row cathode commons of each character are connected to the constant current sinking outputs of the seven successive stages of the shift register. The like columns of the four characters are tied together and brought to a single column pin (i.e., column one of all four digits is connected to pin one, etc.). So that any diode of any character may be addressed by shifting data to the appropriate shift register location and supplying current to the appropriate column.

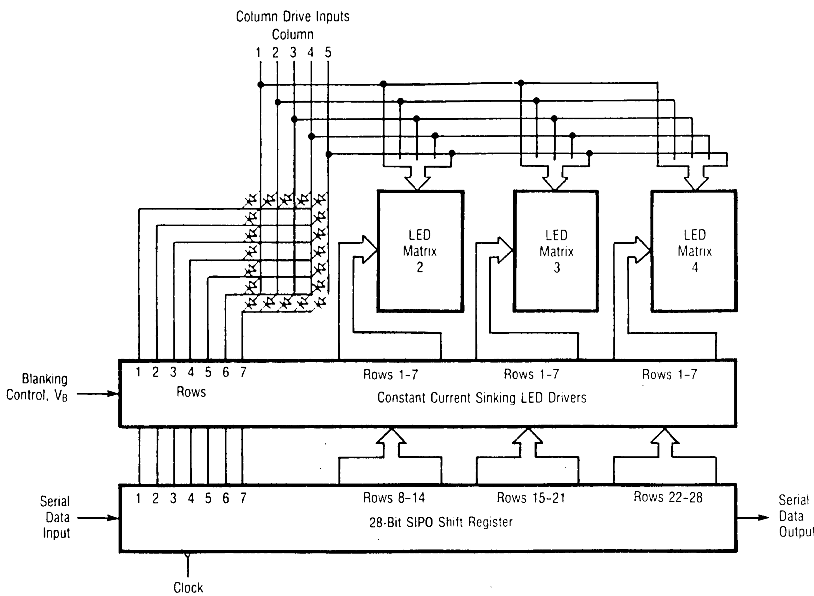
The SIPO shift register has constant current sinking outputs associated with each shift register stage. A FET current mirror supplies a reference signal to all of the 28 constant

Table 1. SAN Display Principal Characteristics

Part No.	Color	Character Height	Power Dissipation*	Temperature Range	Package Type
HDSP2000LP HDSP2001LP HDSP2002LP HDSP2003LP	Red Yellow HER Green	0.15 in.	0.40 W	-40°C to +85°C	Plastic
ISD/MSD2010 ISD/MSD2011 ISD/MSD2012 ISD/MSD2013	Red Yellow HER Green	0.15 in.	0.40 W	-55°C to +100°C	Ceramic
ISD/MSD2310 ISD/MSD2311 ISD/MSD2312 ISD/MSD2313	Red Yellow HER Green	0.20 in.	0.52 W	-55°C to +100°C	Ceramic
ISD/MSD2351 ISD/MSD2352 ISD/MSD2353	Yellow HER Green	0.20 in.	0.74 W	-55°C to +100°C	Ceramic

* 15 LEDs ON per character/4 characters per package.

Figure1. Block Diagram



current shift register out (logic 1) and is ANDed with this reference source to turn on the output drivers. Data is loaded serially into the shift register when the clock goes from HIGH to LOW and the data is stable for a minimum hold time and will be latched on the LOW to HIGH signal of the clock.

The Data Output (pin 7) is a TTL buffer interface from the 28th bit of the shift register (i.e., the 7th row of character four in each package). The Data Output directly interconnects to the Data Input (pin 12) on a succeeding SAN display. The data, clock and Vb inputs are all buffered to allow direct interface to any TTL logic family.

Theory of Operation

Dot matrix alphanumeric display systems generally are organized logically so that any character can be generated either as a combination of five subsets of seven bits each or seven subsets of five bits each. This technique reduces from 35 to five or seven the number of outputs required from the character generator. To display a complete character, these subsets of data appear sequentially in the appropriate locations of the display matrix. Repeating this process a minimum of 100 times per second insures that each of the appropriate matrix locations is re-energized, the eye will perceive a continuous image of the entire character. The apparent intensity of each of the display elements will be equal to the intensity of that element during the "ON" period multiplied by the ratio of the "ON" time to refresh period. This ratio is referred to as the display duty factor and the technique, "strobing."

Each character of SANs is made up of five subsets of seven bits. For a four character display, 28 bits representing the first subset of each of the four characters are loaded serially into the on-board SIPO shift register. The first column is energized for a period of time, T. This process is repeated for columns two through five. If the time required to load the 28 bits into the SIPO shift register is t, the duty factor is: $DF = t/5(t+T)$, and the term $5(t+T)$, the refresh period. For a satisfactory display, the refresh frequency should be ≥100Hz, which means:

$$5(t+T) = 10ms$$

$$(t+T) = 2ms$$

Therefore, two milliseconds is the maximum time period which should be allowed for loading and displaying of each column.

Interfacing

A display system using the SAN display requires interfacing with a character generator and refresh memory electronics. The system in Figure 2 is a single four digit display, therefore the 1/N counter becomes a 1/4 counter where N equals the number of characters in the string. The refresh memory stores the information to be displayed. Information can be coded in any one of several different standard data codes, such as ASCII or EBDIC; or a customized code and display font using a custom coded ROM. The only requirement being that the output data be generated as five subsets of seven bits each.

The character generator receives data from the refresh memory and outputs seven displaying data bits that correspond to the character and the column select data input. This data is converted to serial format in the parallel to serial shift register. In a typical system the right most character to be displayed is selected first, and the data corresponding to the ON and OFF display elements in the first column is clocked into the first seven shift register locations of the SAN.

In a similar manner, column one data for characters three, two and one is selected by the 1/N counter, decoded and shifted into the display shift register. After 28 clock counts, data for each character is located in the SAN shift register locations which are associated with the seven rows of the appropriate LED matrix. The 1/N counter overflows, triggering the display time counter enabling the output of the 1/5 column select decoder, and disabling the clock input to the display. The information now in the shift registers will be displayed for a period, T. The divide by five counter which provides column select data for both the SAN and the character generator is incremented one count and column data is loaded and displayed in the same manner as column one.

This process is repeated for each of the five columns which comprise the five subsets of data necessary to display the desired characters. After the fifth count, the 1/5 decoder automatically resets to one and the sequence is repeated. The only changes required to extend this interface to character strings of more than four digits are to increase the size of the refresh memory and to change the divide one by four counter to a module equal to the number of digits in the desired string.

Since data is loaded for all of the like columns in the display string and these columns are enabled simultaneously, only five columns are enabled simultaneously. Only five column transistors are required regardless of the number of characters in the string. The column switch transistors should be selected to handle approximately 110 mA per character in the display string. The collector voltage saturation voltage characteristics and column voltage supply should be chosen to provide a 2.6V ≤Vcol >Vcc. To save power supply costs and improve efficiency, this supply may be a full rectified unregulated DC voltage as long as the PEAK value doesn't exceed the Vcc and the minimum value doesn't drop below 2.6 volts. Since large current transients can occur if a column line is enabled during data shifting operations, the most satisfactory operations will be achieved if the columns current is switched off before clocking begins.

Interface Design

A logical "1" in the display shift register turns a corresponding LED "ON." Clocking occurs on the high to low transition of the clock input. A character generator which produces seven bit "column" data can be used. The internal shift register is 28 bits in length. The right hand digit is loaded first. Each column should be refreshed at a minimum rate of 100 Hz.

The following program uses a single chip microprocessor to control a SAN display (i.e., the 8051 microprocessor and a Sprague UCN5890A driver). See Figure 3.

The processing speed of a microprocessor is so high that the refresh rate of 1/5 can't be comprehended, therefore this program repeats itself 255 times before continuing to another line of data (similar to the scanning technique of a television screen).

Figure 2. Block Diagram

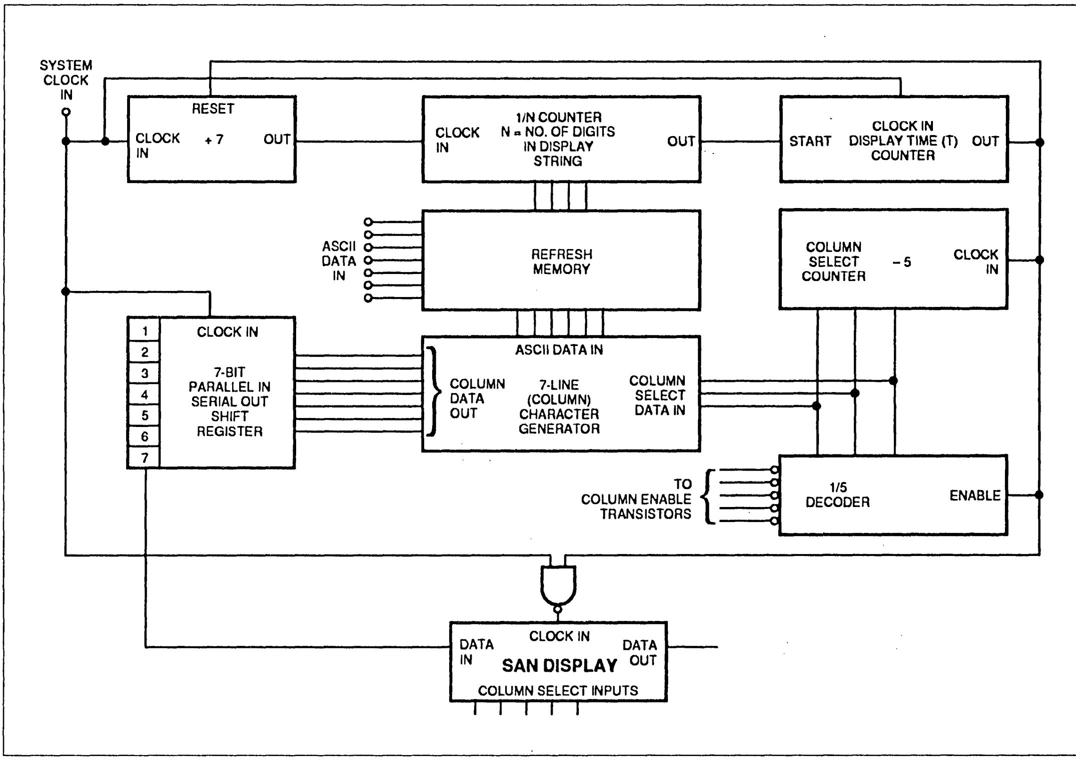
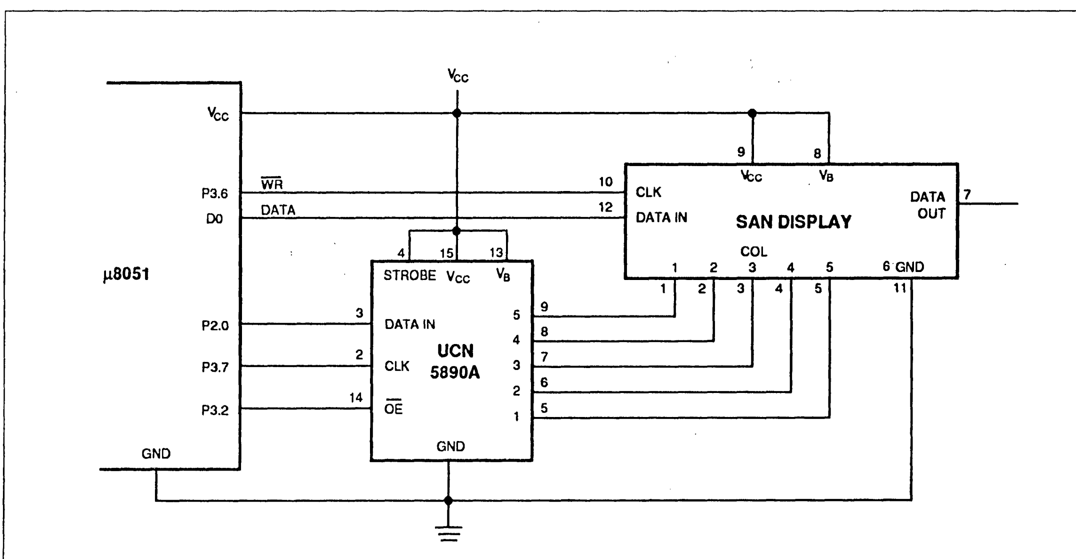


Figure 3. Schematic for SAN Display & UCN5890A



Program to Drive One SAN Display with the 8051 and the UCN5890A as the Column Driver

This program assumes that the data memory address is loaded into DPTR prior to entering this subroutine:

```
                                ;R0 = # REPEATS
                                ;R1 = DISPLAY ADDRESS
                                ;R2 = WAIT
                                ;R3 = # COL
                                ;R4 = ROW COUNTER
                                ;R5 = BIT/COL
                                ;R6 = DIGIT COUNTER
                                ;R7 = UNUSED

REG  30H   EQU DPTRL                    ;DPTR MEM LOW REGISTER
REG  31H   EQU DPTRH                    ;DPTR MEM HIGH REGISTER

HDSP:      MOV   R0, #0FFH              ;# OF REPEAT CYCLES
BEGIN:     MOV   DPTRL, DPL             ;SAVE DPTR LOW
           MOV   DPTRH, DPH             ;SAVE DPTR HIGH
           SETB  P3.2                   ;TURN OFF COLUMN
           SETB  P2.0                   ;DATA 1st COLUMN
           MOV   R3, #5H                ;# OF COL
START:     CLR   P3.7                   ;COL CLK
           SETB  P3.7                   ;COL CLK
           MOV   R4, #7H                ;# ROWS
NXCOL:     MOV   R6, #4H                ;4 DIGITS
NWBYT:     MOV   R5, #7H                ;7 BIT/COL
           CLR   A
           MOVC  A, @A+DPTR             ;GET DATA
           INC   DPTR                   ;INC DATA ADDRESS
NXBT:      MOVX  @R1, A                 ;OUTPUT D0 & CLK
           RR    A                      ;SHIFT TO NEXT BIT
           DJNZ  R5, NXBT               ;DO 7 TIMES
           DJNZ  R6, NWBYT              ;DO 4 CHARS
           CLR   P3.2                   ;TURN ON COL
           MOV   R2, #77H               ;WAIT TIME
           DJNZ  R2, $                  ;WAIT
           MOV   R2, #77H
           DJNZ  R2, $                  ;WAIT
           SETB  P3.2                   ;TURN OFF COL
           MOV   P2, #00H               ;SET COL DRVR DATA
           DJNZ  R3, START              ;NEXT COL
           MOV   DPH, DPTRH             ;RESTORE DPTR HIGH
           MOV   DPL, DPTRL             ;RESTORE DPTR LOW
           DJNZ  R0, BEGIN              ;REPEATS?
           RET                          ;RETURN FOR ANOTHER LINE
```

Table 2. SAN Display Optical Characterics

Part No.	LED PK I_V	Average LED I_V	Character* I_V	Peak I_F	Average I_F	η_V	Average Sterance L_V LED	
	μcd	μcd	mcd	mA	mA	μcd/mA	cd/m²	ft candle
HDSP2000LP	200	40	0.60	12.0	2.4	17	717	67
HDSP2001LP	750	150	2.25	12.0	2.4	63	1923	179
HDSP2002LP	1430	286	4.30	12.0	2.4	119	3667	340
HDSP2003LP	1550	310	4.65	12.0	2.4	129	3974	369
ISD/MSD2010	200	40	0.60	12.0	2.4	17	717	67
ISD/MSD2011	750	150	2.25	12.0	2.4	63	1923	179
ISD/MSD2012	1430	286	4.30	12.0	2.4	119	3667	341
ISD/MSD2013	1550	310	4.65	12.0	2.4	129	3974	369
ISD/MSD2310	300	60	0.90	13.6	2.7	22	1075	100
ISD/MSD2311	1140	228	3.42	13.6	2.7	84	2923	271
ISD/MSD2312	1632	326	4.89	13.6	2.7	120	4179	388
ISD/MSD2313	2410	482	7.23	13.6	2.7	177	6179	573
ISD/MSD2351	3400	680	10.20	16.0	3.2	212	8718	810
ISD/MSD2352	2850	570	8.55	16.0	3.2	178	7308	679
ISD/MSD2353	3000	600	9.00	16.0	3.2	187	7692	714

* 15 LEDs ON per character, DF=20%.

Optical Considerations

Luminous Intensity Control

The luminous intensity of the Small Alphanumeric display can be easily adjusted from sunlight viewability through night vision requirements (ISD/MSD 235X only).

The light output of the SAN display depends on a number of variables. These include the absolute efficiency of the LED material, the average current through the LED, and the LED's junction temperature. The readability of the display's light output depends upon the luminous and chrominous contrast of the LED diode to the package and ambient lighting environment.

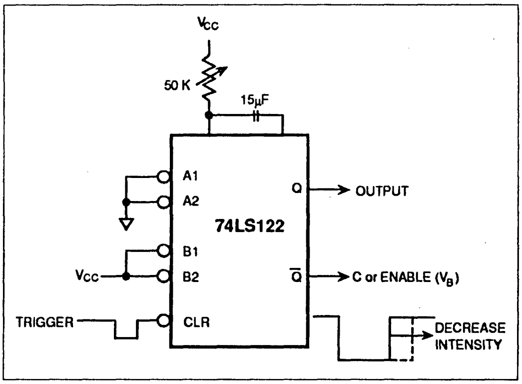
Table 2 lists the luminous intensity per LED for the SAN family. The average character brightness is based on 15 LEDs per character with a 20% duty factor. The time averaged LED current for the SAN is in the range of 2.4 – 3.2 mA/LED (DF = 20%). The Blanking Control (VB) can be used to change the duty factor ON time, resulting in a lower LED intensity. Figure 4 shows a 74LS122 timer whose pulse width can be manually adjusted for a 1000:1 intensity control.

Optical Filtering

Having a bright display does not guarantee readability in a given lighting ambient. The readability of the SAN depends on the contrast of the LED to the ambient light. The human eye measures contrast in both brightness (luminance) and color (chrominance) perception.

There are three contrast ratios that describe the optimum readability for the display. The first is ratio between the ON LED to an OFF LED and should be much greater than one. The second ratio deals with the ON LED to the color and brightness of the surrounding package and also is much greater than one. The third ratio is equal to OFF LED to the brightness and color of the surrounding package. This ratio should be equal to one, meaning no color or brightness difference between the OFF LED and the package.

Figure 4. Brightness Control Using a One Shot Multivibrator



Using proper package design and optical filter selection insures high constrast ratios. In dim ambients high optical transmission long wave and bandpass filters are the best choice. However, in high light ambients low transmission neutral density (grey) filters give the best contrast ratios of the OFF LED and ON LED to the package background, improving the true readability of the display. For sunlight readability, the SAN's glass window permits the use of glass or plastic circularly polarized filters. These filters greatly minimize the incident light that falls on the surface of the OFF LEDs and the package background. Table 3 is a guide for filter selection.

Table 3. Contrast Enhancement Filters

Display Color[2] Part No.	Ambient Light		
	Dim	**Moderate**	**Bright**
Red HDSP2000LP	Panelgraphic Dark Red 63 Panelgraphic Ruby Red 60 Chequers Red 118 Plexiglass 2423	Polaroid HNCP37 3M Light Control Film Panelgraphic Gray 10 Chequers Gray 105	
Yellow HDSP2001LP	Panelgraphic Yellow 27		Polaroid HNCP10-Glass Marks Polarized MPC 30-25C
HER HDSP2002LP	Panelgraphic Ruby Red 60 Chequers Red 112		Note 1 Polaroid HNCP10-Glass Marks Polarized MPC 20-15C
Bright Green HDSP2003LP	Panelgraphic Green 48 Chequers Green 107		Polaroid HNCP10-Glass Marks Polarized MPC 50-12C

Display Color Part No.	Filter Color	Marks Polarized Corp. Filter Series	Optical Characteristics of Filter	
Red, HER MSD 2010, 2012, 2310, 2312, 2352	Red	MPC 20-15C	25% @ 635 nm	Circular Polarizer
Yellow MSD 2011, 2311, 2351	Amber	MPC 30-25C	25% @ 583 nm	
Green MSD 2013, 2313, 2353	Yellow/Green	MPC 50-22C	22% @ 568 nm	
Multiple Colors High Ambient Light	Neutral Gray	MPC 80-10C	10% Neutral	
Multiple Colors	Neutral Gray	MPC 80-37C	37% Neutral	

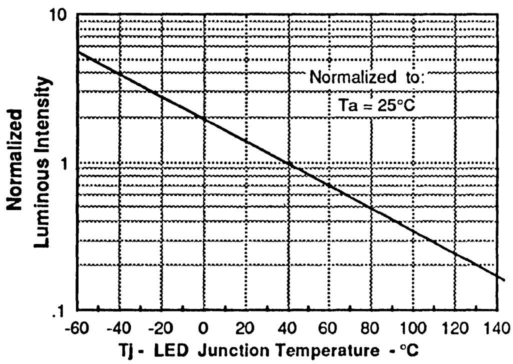
Note:
1. Optically coated circular polarized filters, such as Polaroid HNCP10.
2. For multiple colors use Marks Polarized Corporation filters, MPC 80-10C or MPC 80-37C.

Polaroid Corporation
1 Upland Road, Bldg. #2
Norwood, MA 02062
☎ (800) 225-2770

Marks Polarized Corporation
25-B Jefryn Blvd. W.
Deer Park, NY 11729
☎ (516) 242-1300
FAX (516) 242-1347

Marks Polarized Corp. manufactures to MIL-I-45208 inspection system.

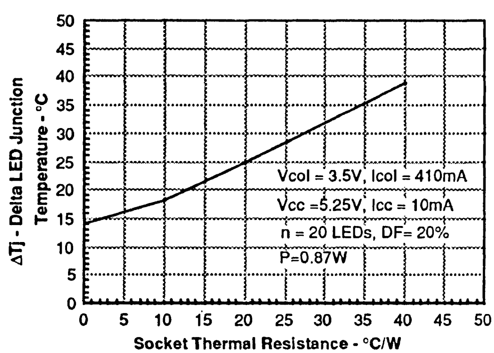
Figure 5. Normalized Luminous Intensity vs. Junction Temperature



The light output of the LEDs is inversely related to the LED diodes junction temperature as shown in Figure 5. For optimum light output, keep thermal resistance of the socket of PC board as low as possible.

For example, when the HDSP200XLP is mounted in a 10°C/W socket and operated at Absolute Maximum Electrical conditions, the LED junction will rise 17°C above ambient. If T_A = 40°C, then the LED's T_J will be 57°C. Under these conditions Figure 5 shows that the I_V will be 75% of its 25°C value.

Figure 6. Maximum LED Junction Temperature vs. Socket Thermal Resistance



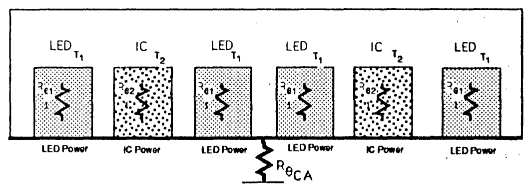
Thermal Consideration

Optimum reliability and optical performance will result when the junction temperature of the LEDs and CMOS ICs are kept as low as possible. The plastic HDSP200XLP should operate to a maximum ambient temperature of 85°C, while maintaining a maximum junction temperature of ≤100°C. The ceramic and glass SANs (ISD/MSD2XXX) may operate up to 100°C as long as the junction temperature of the IC is maintained at less then 125°C.

Table 4.

Model Number	V_F		
	Min.	**Typ.**	**Max.**
HDSP2000LP	1.6	1.7	2.0
HDSP2001/2/3LP	1.9	2.2	3.0

Figure 7. Thermal Model



Thermal Modeling

For a thermal model of the display, see Figure 7 which shows junction self heating + the case temperature rise + ambient temperature = junction temperature of the semiconductor. Equation 1 shows this relationship.

Application Notes

Equation 1.

$$T_{J(LED)} = P_{LED} Z_{\theta JC} + P_{CASE} (R_{\theta JC} + R_{\theta CA}) + T_A$$

$$T_{J(LED)} = [(I_{COL}/28)\, V_{F(LED)}\, Z_{\theta JC}] + [(n/35)\, I_{COL}\, DF\, (5\, V_{COL}) + V_{CC}\, I_{CC}] \bullet [R_{\theta JC} + R_{\theta CA}] + T_A$$

The junction rise within the LED equals the thermal impedance of an individual LED (37°C/W, DF = 20%, F = 200 Hz) times the forward voltage, $V_{F(LED)}$, and forward current, $I_{F(LED)}$, of 13–14.5 mA. This rise averages $T_{J(LED)} = 1°C$. Table 4 shows the $V_{F(LED)}$ for respective displays.

The junction rise within the LED driver IC is the combination of the power dissipated by the IC quiescent current and the 28 row driver current sinks. The IC junction rise is given in Equation 2. A thermal resistance of 28°C/W results in a typical junction rise of 6°C.

Equation 2.

$$T_{J(IC)} = P_{COL} (R_{\theta JC} + R_{\theta CA}) + T_A$$

$$T_{J(IC)} = [5\, (V_{COL} - V_{F(LED)}) \bullet (I_{COL}/2) \bullet (n/35)\, DF + V_{CC} \bullet I_{CC}] \bullet [R_{\theta JC} + R_{\theta CA}] + T_A$$

For easier calculations, the maximum allowable electrical operating condition is dependant on the the aggregate thermal resistance of the LED matrixes and the two driver ICs. The parallel combination of these two networks is 15°C/W. All of the thermal management calculations are based on this number. The maximum allowable power dissipation is given in Equation 3.

Equation 3.

$$P_{DISPLAY} = \frac{T_{J(MAX)} - T_A}{R_{\theta JC} + R_{\theta CA}}$$

$$P_{DISPLAY} = 5\, V_{COL}\, I_{COL}\, (n/35)\, DF + V_{CC}\, I_{CC}$$

KEY TO EQUATION SYMBOLS

DF	Duty factor
I_{CC}	Quiescent IC current
I_{COL}	Column current
n	Number of LEDs on in a 5 x 7 array
P_{CASE}	Package power dissipation excluding LED under consideration
P_{COL}	Power dissipation of a column
$P_{DISPLAY}$	Power dissipation of the display
P_{LED}	Power dissipation of a LED
$R_{\theta CA}$	Thermal resistance case to ambient
$R_{\theta JC}$	Thermal resistance junction to case
T_A	Ambient temperature
$T_{J(IC)}$	Junction temperature of an IC
$T_{J(LED)}$	Junction temperature of a LED
$T_{J(MAX)}$	Maximum junction temperature
V_{CC}	IC voltage
V_{COL}	Column voltage
$V_{F(LED)}$	Forward voltage of LED
$Z_{\theta JC}$	Thermal impedance junction to case

SIEMENS

How to Use Optocoupler Normalized Curves Appnote 45

by Bob Krause

An optocoupler provides insulation safety, electrical noise isolation, and signal transfer between its input and output. The insulation and noise rejection characteristics of the optocoupler are provided by the mechanical package design and insulating materials.

A phototransistor optocoupler provides signal transfer between an isolated input and output via an infrared LED and a silicon NPN phototransistor.

When current is forced through the LED diode, infrared light is generated that irradiates the photosensistive base-collector junction of the phototransistor. The base-collector junction converts the optical energy into a photocurrent which is amplified by the current gain (HFE) of the transistor.

The gain of the optocoupler is expressed as a Current Transfer Ratio (CTR), which is the ratio of the photoransistor collector current to the LED forward current. The current gain (HFE) of the transistor is dependent upon the voltage between its collector and emitter. Two separate CTRs are often needed to complete the interface design. The first CTR, the non-saturated or linear operation of the transistor, is the most common specification of a phototransistor optocoupler and has a Vce of 10 volts. The second is the saturated or switching CTR of the coupler with a Vce of 0.4 volts. Figure 1 and 2 illustrate the Normalized CTR_{CE} for the linear and switching operation of the phototransistor. Figure 1 shows the Normalized Non-Saturated CTR_{CE} operation of the coupler as a function of LED current and ambient temperature when the transistor is operated in the linear mode. Normalized $CTR_{CE(SAT)}$ is illustrated in Figure 2. The saturated gain is lower with LED drive greater than 10 mA.

Figure 1. Normalized CTR versus I_F and T_{amb}

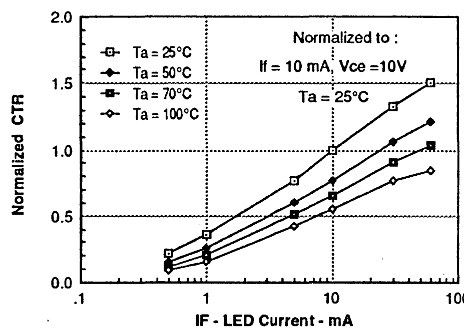
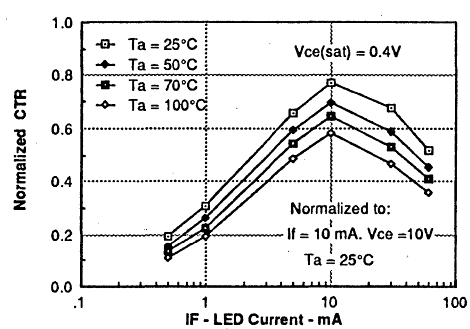


Figure 2. Normalized Saturated CTR



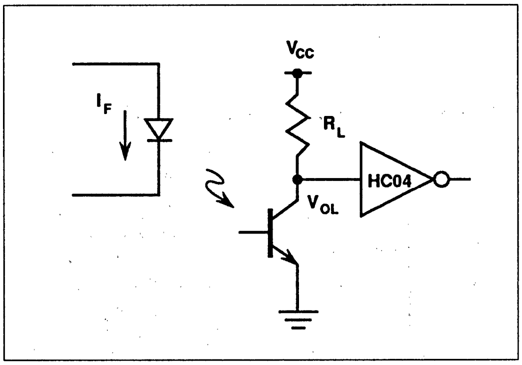
Application Notes

The following design example illustrates how normalized curves can be used to calculate the appropriate load resistors.

Problem 1.

Using an IL1 optocoupler in a common emitter amplifier (Figure 3) determine the worst case load resistor under the following operation conditions:

Figure 3. IL1 to 74HC04 Interface



T_{amb}=70°C, I_F =2 mA, V_{OL}=0.4 V, Logic load=74HC04

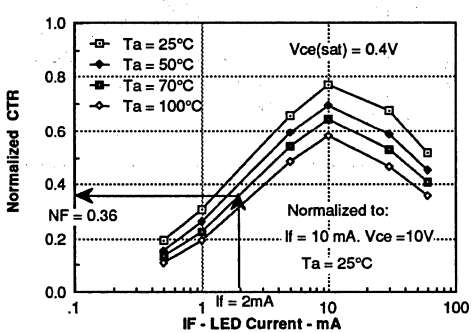
IL1 Characteristics:

$CTR_{CE(NON\ SAT)}$=20% Min. @ (T_{amb}=25°C, I_F=10 mA, V_{CE}=10 V)

Solution

Step 1. Determine $CTR_{CE(SAT)}$ using the normalization factor ($NF_{CE(SAT)}$) found in Figure 2.

Figure 4. Normalized Saturated CTR



(1) $CTR_{CE(SAT)}=CTR_{CE(NON\ SAT)}\ NF_{CE(SAT)}$

$CTR_{CE(SAT)}=20\% * 0.36$

$CTR_{CE(SAT)}=7.2\%$

Step 2. Select the minimum load resistor using the following equation

(2) $$R_{L(MIN)} = \frac{V_{CC} - V_{OL}}{\frac{CTR_{CE(SAT)}\ I_F}{100\%} - I_{IL}}$$

$$R_{L(MIN)} = \frac{5V - 0.4V}{\frac{7.2\%\ 2mA}{100\%} - 50\mu A}$$

$R_{L(MIN)}$=48.94 KΩ, select 51 KΩ ±5%

The switching speed of the optocoupler can be greatly improved through the use of a resistor between the base and emitter of the output transistor. This is shown in Figure 5. This resistor assists in discharging the charge stored in the base to emitter and collector to base junction capacitances. When such a speed-up technique is used the selection of the collector load resistor and the base-emitter resistor requires the determination of the photo-current and the HFE of the optocoupler.

The photocurrent generated by the LED is decribed by the CTR_{CB} of the coupler. This relationship is shown in equations 3 and 4. Equation 5 shows that CTR_{CE} is the product of the CTR_{CB} and the HFE. The HFE of the transistor is easily determined by evaluating equation 4, once the $CTR_{CE(SAT)}$ and CTR_{CB} are known. The Normalized CTR_{CB} is shown in Figure 6. Equations 5, 6, and 7 describe the solution for determing the R_{BE} that will permit reliable operation.

Figure 5. Optocoupler/Logic Interface with R_{BE} Resistor

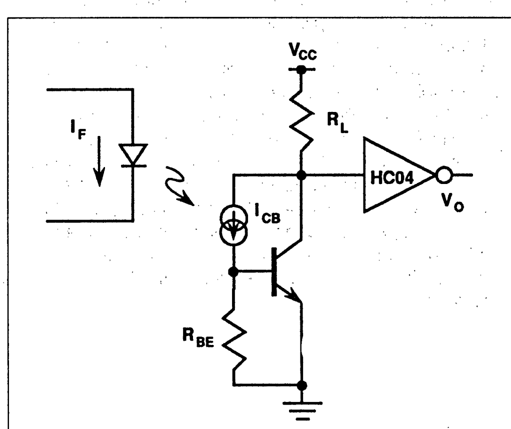
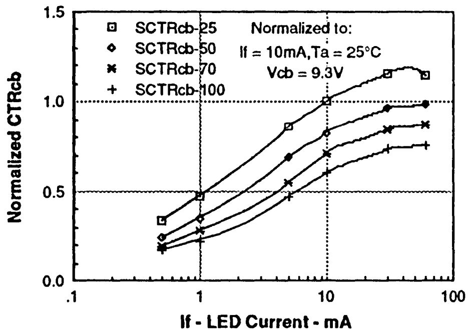


Figure 6. Normalized CTR_{CB} versus LED Current



(3) $$CTR_{CB} = \frac{I_{CB}}{I_F} \times 100\%$$

(4) $$I_{CB} = I_F \frac{CTR_{CB}}{100\%}$$

(5) $$CTR_{CE(SAT)} = CTR_{CB}\, HFE_{(SAT)}$$

(6) $$HFE_{(SAT)} = \frac{CTR_{CE(SAT)}}{CTR_{CB}}$$

(7) $$R_{BE} = \frac{V_{be}}{I_{CB} - I_{BE}}$$

(8) $$R_{BE} = \frac{V_{BE}\, HFE_{(SAT)}\, R_L}{I_{CB}\, HFE_{(SAT)}\, R_L - [V_{CC} - V_{CE(SAT)}]}$$

(9) $$R_{BE} = \frac{V_{BE} \frac{CTR_{CE}\, NF_{CE(SAT)}}{CTR_{CB}\, NF_{CB}} R_L}{\frac{I_F\, CTR_{CE}\, NF_{CE(SAT)}\, R_L}{100\%} - [V_{CC} - V_{CE(SAT)}]}$$

Problem 2

Using an IL2 optocoupler in the circuit shown in Figure 6, determine the value of the collector load and base-emitter resistor, given the following operational conditions:

T_{amb}=70°C, I_F=5 mA, V_{OL}=0.4 V, Logic load =74HC04

IL2 Characteristics:

CTR_{CE}=100% @ T_{amb}=25°C, V_{CE}=10 V, I_F=10 mA

CTR_{CB}= 0.24% @ T_{amb}=25°C, V_{CB}=9.3 V, I_F=10 mA

Solution

Step 1. Determine $CTR_{CE(SAT)}$, and CTR_{CB}.

From Figure 2 the $CTR_{CE(SAT)}$=55%, [$NF_{CE(SAT)}$=0.55]

From Figure 6 the CTR_{CB}=0.132%, [NF_{CB}=0.55]

Step 2. Determine R_L

From Equation 2 R_L=1.7 KΩ

Select R_L= 3.3 KΩ

Step 3. Determine R_{BE}, using Equation 9

(10) $$R_{BE} = \frac{0.65V \frac{100\%\ 0.55}{0.24\%\ 0.55} 3.3K\Omega}{\frac{5mA\ 100\%\ 0.55\ 3.3K\Omega}{100\%} - [5V - 0.4V]}$$

R_{BE}= 199KΩ , select 220KΩ

Using a 3.3 kΩ collector and a 220 KΩ base-emitter resistor greatly minimize the turn-off propagation delay time and pulse distortion. The following table illustrates the effect the R_{BE} has on the circuit performance.

	I_F = 5 mA, V_{CC}= 5 V	
	R_L=3.3 KΩ R_{BE}=∞ Ω	R_L=3.3 KΩ R_{BE}=220 kΩ
t_{delay}	1 µs	2 µs
t_{rise}	4 µs	5 µs
$t_{storage}$	17 µs	10 µs
t_{fall}	5 µs	12 µs
t_{PHL}	3.5 µs	7 µs
t_{PLH}	22 µs	12 µs
Pulse Distortion 50 µs pulse	37%	10%

Not only does this circuit offer less pulse distortion, but it also improves high temperature switching and lower static DC power dissipation and improved common mode transient rejection.

NOTES

NOTES

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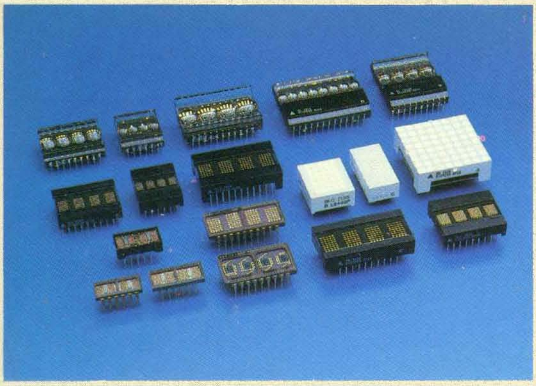

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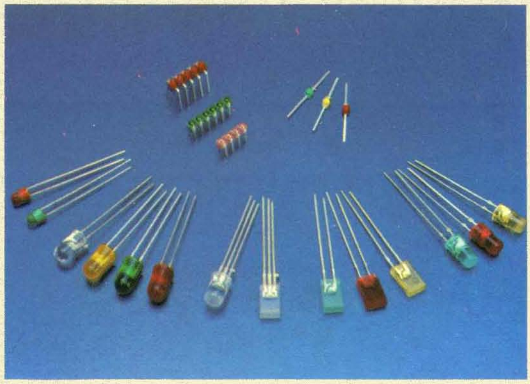
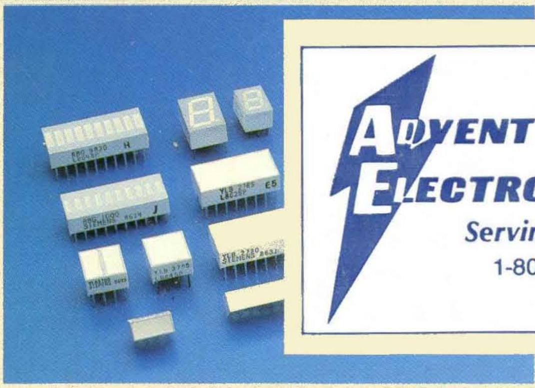
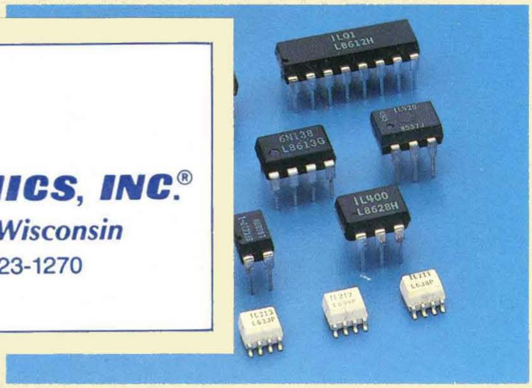


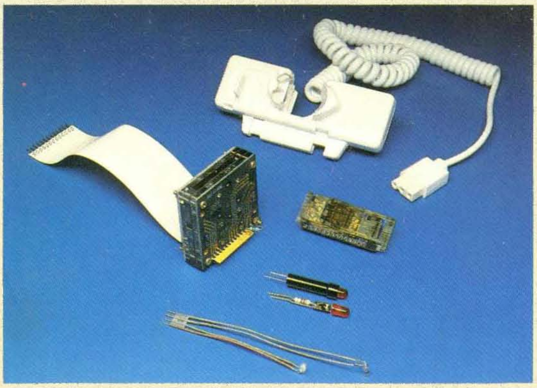
LED Lamps



Bar Graphs, Light Bars, Numeric and Alphanumeric Displays



Optocouplers



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