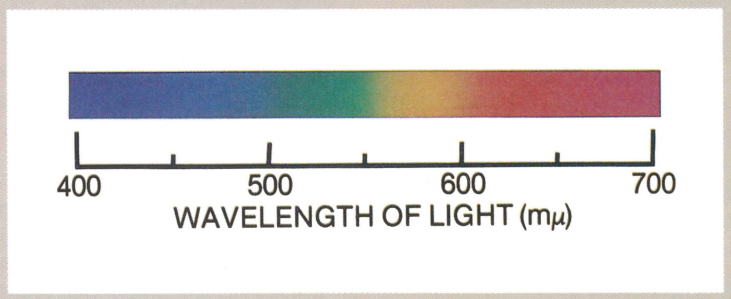
THE IDD
APPLICATIONS NEWSLETTER

VOL. 7 NO. 4
WINTER 1983

Tekniques

Color: The First of Three Articles on Combining Color for Effective Displays



SNOTEL: Forecasting the Runoff

PLOT 10 Computer-Aided Drafting under Local Programmability

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Tekniques

In This Issue

TEKniques, the IDD Applications Newsletter, is published in the Information Display Division of Tektronix, Inc., Mail Stop 63-635, P.O. Box 1000, Wilsonville, Oregon 97070. It is distributed to TEKTRONIX computer and terminal users.

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To submit articles to *TEKniques* or for information on reprinting articles, write to the above address. Changes of address should be sent to the IDD Program Exchange serving your area (see Program Exchange addresses).

*Editor's Note

Readers Ask for Indexes

In the Spring issue (Vol. 8, No. 1) of *TEKniques,* we'll summarize the subscription forms returned telling what readers like or dislike about *TEKniques* and their suggestions.

One request from many readers was for an index to past issues. Although indexes were published for Volumes 1 through 4, no indexes exist for subsequent volumes. We are, therefore, compiling one index for Volumes 5, 6 and 7 identifying articles by application area and equipment and programming tips by procedure and equipment. It will be printed in the Spring issue.

Keep User Library Catalog

The catalog of program abstracts for the user's library (now the IDD Program Exchange, formerly the Applications Library and 4050 Series Applications Library) should be retained. As descriptions of programs contributed to the library are printed in the *New Abstracts* section of *TEKniques,* clip these pages and add them to your catalog binder. You'll have an up-to-date reference of user programs available.

Although the abstracts are added to the catalog at each reprinting, there is no set reprint schedule, and the new catalog copies are only sent to new subscribers or current users who haven't received one. If you don't have a copy of the catalog, contact your local Tektronix office.

IDD Program Exchange

For each program accepted into the Program Exchange, you receive one of the packages in exchange. Remember that each package is comprised of from six to over 20 programs.

Readers who wish to contribute to the IDD Program Exchange for Tektronix Graphics Systems may acquire documentation instructions and forms by writing to:

Tektronix, Inc.
IDD Program Exchange
Mail Stop 63-575
P.O. Box 1000
Wilsonville, OR 97070

Back Issues

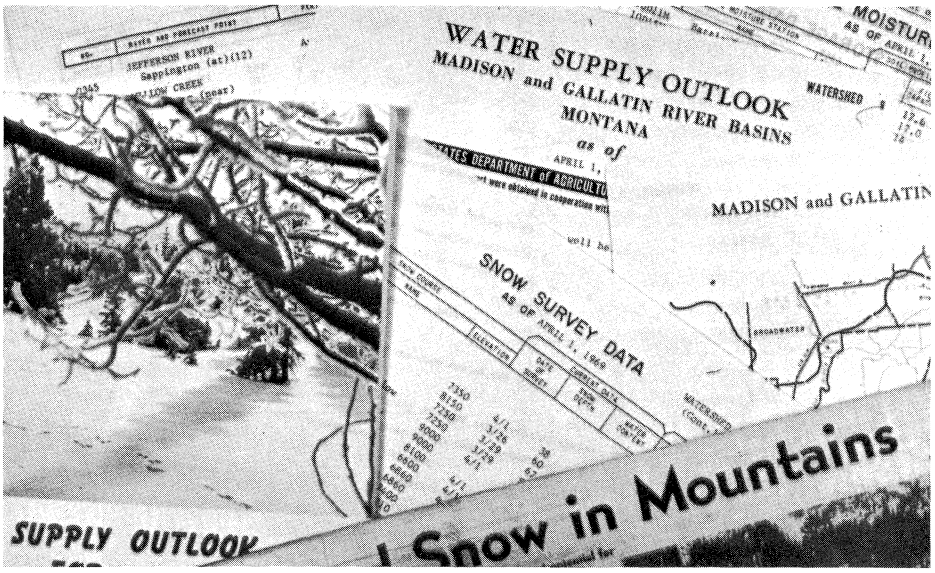
Back issues of *TEKniques* Vol. 4 through the current issue are available by writing to the address noted under IDD Program Exchange or contacting your local Tektronix office. Although issues from Vol. 1 through 4 are out of print, the Programming Tips for the 4050 Desktop Computer in those issues are compiled in a booklet which is included in the IDD Program Exchange package "Programming Aids T2," part number 062-5972-01.

Beginning with *TEKniques* Vol. 6, No. 3 (Fall, 1982) coverage was expanded to include all of Tektronix IDD graphics displays, not just the 4050 Series.

On the cover:

Soil Conservation Service snow samplers are weighing the snow on a simple spring balanced scale. The snow core was retrieved with a 15-foot long aluminum tube with a cutter.

The Tektronix 4115B teams with PLOT 10 Computer Aided Drafting Software to create color drawings with superior line quality.



The Soil Conservation Service of the U.S.D.A. has funded snow surveys and water supply forecasting since 1935. Recently the Tektronix 4050 Graphics Systems have been employed to interpret and graph the data.

Snow Pack and Water Outlook Analyzed With Aid of Tektronix 4052

by Patricia Kelley
Tekniques Staff

Meandering through downtown Reno, Nevada, the Truckee River is normally a complacent stream, a cool respite for residents and visitors to this desert town. But in the spring, when the snow melts in the surrounding mountains, the Truckee can quickly swell and threaten to escape its banks. Vigilant river management keeps the Truckee and many other Western rivers contained. Successful management results from accurate data, data describing snow pack, snow melt and stream flows.

Collected by the U.S.D.A. Soil Conservation Service (SCS), with the exception of California, who has maintained the snow measurement work as a state operation with over 350 sites, the data is gathered from some 1800 sites throughout the mountainous areas of the west. The SCS has automated many of the collection sites through a system known as SNOTEL – for snow telemetry. Important links in SNOTEL are the Tektronix 4050 Graphics Systems which sort out and interpret the massive amounts of data.

In Portland, Oregon, Manes Barton, head of the West National Technical Center of the SCS, reviewed the predecessors of SNOTEL. About 1904 Dr. James Church, a professor at the University of Nevada, began taking measurements on Mt. Rose (above Reno) to determine how much water was in the snow. Although his initial interest lay in the trees of the forest and how they trapped water, concerned individuals pursuaded him to apply the data to the seasonal rise of Lake Tahoe. In conjunction with Dr. Horace P. Boardman, an engineering professor at the University, Dr. Church developed a simple equation and determined from previously gathered data that the snow water at the maximum, usually April 1, could be used to predict the rise of the Lake. The two professors expanded their predictions to the Truckee River flow which comes from Lake Tahoe, and to the Carson drainages.

Realizing the importance of Dr. Church and Dr. Boardman's work, several states and federal agencies began measuring snow at various locations in the West. Forecasting the amount of spring runoff would aid individuals who rely on water in planning their cropping, reservoir management, flood control and so forth. The proven value of the forecasts resulted in the extensive program carried out today.

Measuring the Snow Water

Helicopters, snow machines, snowshoes and skiis still transport snow surveyors and their gear to the more accessible measurement points (called snow courses) which represent about two-thirds of all measurement sites. At each snow course typically ten measurements are taken, each about 15 feet apart, which are averaged for depth and snow water equivalent. The task is not easy. Using an aluminum tube with a cutter on the end, the snow surveyors push the device down into the packed ice and snow until it reaches soil (figure 1). Once depth is determined, the extracted snow is weighed for water content with an ounce of snow equivalent to an inch of water (shown on the cover). Because of the difficulty in reaching these sites, however, measurements are taken only monthly or in a few cases semi-monthly.

In contrast, the automated SNOTEL sites permit measurements to be taken as frequently as every half-hour and at substantially less cost than the manual readings. At each of the 526 SNOTEL sites (figure 2) Butyl rubber or stainless steel "pillows" filled with antifreeze are bedded on the ground. As the snow falls and rests on the pillows, the weight of the snow pressurizes the antifreeze which is connected through a tube into the shelter house (shown in figure 3). A transducer changes the water volume measurement into an electrical signal which is stored in the SNOTEL transceiver. Supplementing the snow readings are rainfall and temperature data gathered by the SNOTEL system from gauges and thermometers at the site.

Two master stations (figures 4 and 5), one at Boise, Idaho, and one at Ogden, Utah, control the automated sites and report to the Portland, Oregon, headquarters. When the master stations receive a command from central (Portland), they poll the collector sites. The SNOTEL transceivers respond with their stored data.

Deciphering the Measurements

At the Portland office a Hewlett-Packard 1000 minicomputer collects the data from the master stations. To alleviate the very laborious process of manually graphing the data, Tektronix 4050 Graphics Systems were acquired for the Portland office and most of the state field offices.

In Portland Lloyd Vancil, Electronics Technician, and Laurel Grimsted, Computer Programmer, wrote a series of programs which download the data to the 4050 System, manipulate it, graph it, then upload it to the HP1000. Once the SNOTEL "picture" is captured, the field offices, in Boise, Idaho, Bozeman, Montana, Denver, Colorado, Salt Lake City, Utah, Spokane, Washington, Casper, Wyoming, Reno, Nevada, and Portland, Oregon, can access the data with their Tektronix Systems.

According to Jim Marron, hydrologist in the Portland office, of tremendous value to the field sites is a graphing program modified from the PLOT 50 system software. Within five minutes, a field office can access the HP1000, download the data to the 4050 System and display a graph. This enables the SCS to determine what's taking place in the very short term and notify the individuals who have an immediate need for the data and predictions of the SCS. In Nevada, for example, the entire Truckee River Basin must be closely managed to avoid localized, if not severe, flooding. Therefore, operators of reservoirs and diversion ditches along the Truckee River from Lake Tahoe to Pyramid Lake require daily information.

Line graphs plotted by the 4050 System depicting pillow data are valuable indicators of conditions to come. Figure 6 identifies when snow is accumulating, then melting, then accumulating once more. Tracking these occurrences enables the SCS to inform their water users whether the river will be rising, stabilizing or actually dropping.

Many water users don't have a pressing demand for immediate information but do require it on a weekly basis. Again, the 4050 System is employed to present this information. Marron, formerly Snow Survey Supervisor in Nevada, related that preparing the weekly Nevada report manually required about two days, time which they just didn't have in the rush of their daily work. By automating the report, they reduced the time to about two hours. Now they enter the current water content and precipitation, and the 4050 program takes over, comparing the data with previously stored data and interpreting the results. A narrative from the SCS staff is inserted. Once the report is transmitted to a 132-column letter quality printer, it is reduced and printed, resulting in a sharp, legible report (figure 7).

Reports are also issued monthly from each state field office in conjunction with state water administrators, agricultural experiment stations and other agencies or organizations. Included in these several-page bulletins are comprehensive data on the accumulated snow, reservoir storage, water outlook, streamflow predictions, and other types of data a user would need. A program on the 4050 System averages the past 20 years of data on a daily basis, averages current data on a daily basis and plots it out for a meaningful comparison. The graphic interpretation is valuable for the reservoir manager and ditch company operator, and, Marron said, the histograms have proven to be the best graphic tool for managing the water on a month-to-month basis. They clearly show where this year's accumulation is in relation to the past 20 years (figures 8, 9, and 10).

Although in May of 1983 the snow pack was 250% (compared to the highest on record of 150% in 1952), and the potential from snow melt for having one of the worst flood situations in recorded history was looming, the Truckee River system managers were able to combat the threat based on the data provided by the SCS. The river actually did leave the banks at one time, but was confined to an area of mostly pasture and hayland which had minimal impact.

Figure 1. A snow tube has been inserted to determine depth of the snow and extract a core.

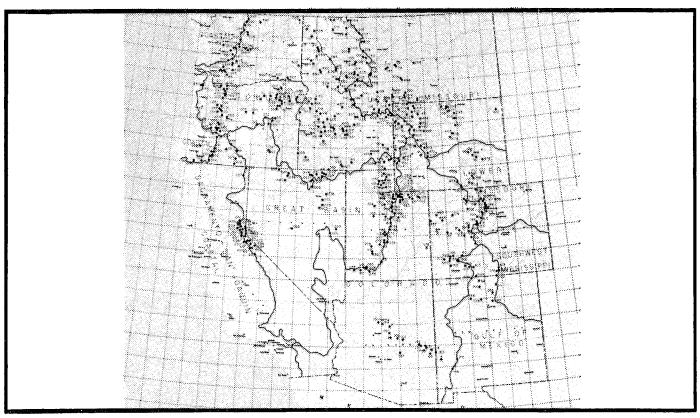


Figure 2. SNOTEL sites in the Western United States.

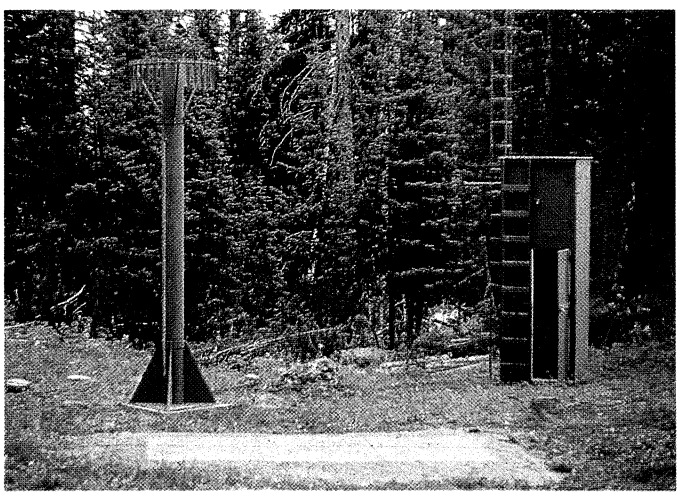


Figure 3. Bare snow pillows lie waiting to register winter snowfall at a SNOTEL site. A transceiver in the shelter house stores the data from the pillows, precipitation gauge (left) and thermometers for transmittal to the SCS central computer. A Tektronix 4052 or 4054 system graphs the data for river managers' and others' use.

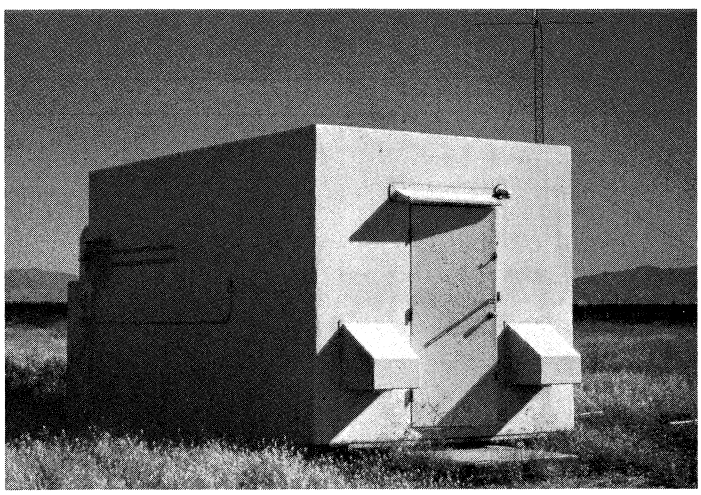


Figure 4. Master stations at Boise, Idaho, and Ogden, Utah, poll SNOTEL sites and transmit the data to the Portland office of the SCS.

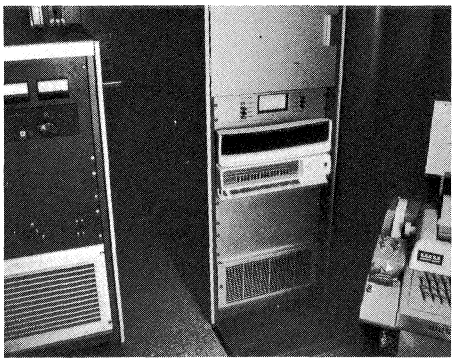


Figure 5. Four antenna surround each master station. Within the master station a rack contains a computer, four channels of receivers and an exciter. A final amplifier and duplexers along with a teletype complete the system.

Along with the SNOTEL and precipitation data, the SCS offices also track streamflows and reservoir storage based on data from the U.S. Geological Survey. Using the 4050 System they enter data and store it on the 4907 disk. A series of routines interpret the data and graph it. The task is not trivial, for to understand the true amount of water being produced in a drainage basin, a streamflow must be corrected to show what would naturally occur if an upstream reservoir were not there. The 4050 program takes streamflow data and adjusts it with reservoir data, producing "natural" streamflow data. Soon the 4050 Systems will access the USGS data base directly eliminating the manual entry.

In some cases people aren't interested in the state reports, but rather in a Western report. Figure 11 illustrates the use of another of the SCS programs. A map of the Western United States is drawn on a Tektronix 4662 Plotter, then the program reads through the collected data for specific site information. For each desired site, it positions and plots the information on the map. This permits a fast analysis of the Western situation, encompassing the Sierras, the Rockies, Idaho, Utah and other states. Beyond the quick look, the Portland SCS office and the National Weather Service jointly publish a comprehensive westwide water supply outlook which covers the Western United States.

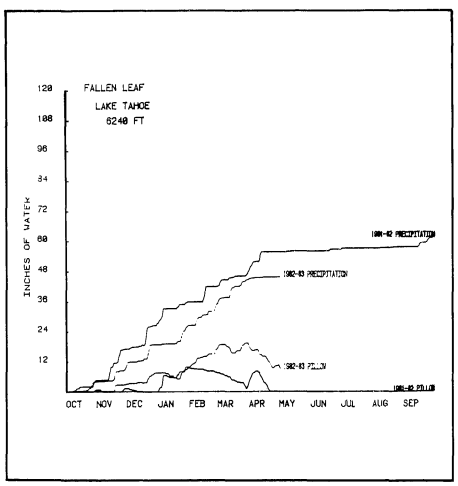


Figure 6. Periods of snow accumulation and melting in 1983 compared to 1982 are readily grasped from the snow pillow lines graphed by the Tektronix 4952. The precipitation data encompass both snow and rainfall.

In Alaska a sizeable SNOTEL program exists which the SCS along with several other agencies operate. The SNOTEL data comes into the Bureau of Reclamation's master station located near Anchorage. From there a Tektronix 4054 System collects the data similar to the Portland office's HP1000. With this exception the system is basically the same as that in the lower Western states.

Streamlining the Future

Marron stated that the basic frameworks in the PLOT 50 packages had enabled them to

NARRATIVE: DATE: 6/ 9/83

* The past week in the Nevada/California portion of the Great Basin has been typified by warm temperatures with thunder-showers in the afternoon. The warm temperatures are melting the record snow pack and keeping the streamflow high. In the Sierra Nevada Mountains, for the sites still having snow, 46% of the maxium snow water remains, while in the interior of the Great Basin, 26% of the snow pack is left.
* On June 13,1983, Jim Marron, the snow survey supervisor for Nevada will report for duty at the Data Analysis Unit of the Water Supply Forecasting Staff at Portland, Oregon. Good luck Jim!!! JL

DRAINAGE BASIN AND SITE LOCATION	ELEVATION	SNOW WATER CONTENT (inches of water) CURRENT	LAST YR.	APRIL 1 AVERAGE	% OF AVG.	PRECIPITATION (inches) October 1 to date CURRENT	LAST YR.	% OF AVG.
TAHOE-TRUCKEE BASIN								
Big Meadows	8,300	23.4	0.0	25.7	---	50.1	49.1	---
Cen. Sierra Snow Lab (CA)	6,900	44.1	0.0	---	---	94.5	---	---
Echo Peak (CA)	7,800	44.5	0.9	39.5	---	80.8	81.5	144
Fallen Leaf (CA)	6,240	0.0	0.0	7.0	---	45.8	56.1	396
Hagan's Meadow (CA)	8,000	10.4	0.0	16.5	---	40.6	48.6	154
Heavenly Valley (CA)	8,800	23.0	0.0	28.1	---	50.9	46.9	125
Independence Camp (CA)	6,500	11.9	0.0	21.8	---	52.2	65.7	142
Independence Creek (CA)	6,500	0.0	0.0	12.7	---	52.4	61.6	240
Independence Lake (CA)	8,450	61.9	56.4	41.4	---	70.1	75.6	130
Marlette Lake	8,000	24.2	0.0	21.1	---	53.9	51.3	189
Mt. Rose	9,000	36.2	36.7	35.9	---	50.2	50.8	147
Mt. Rose Ski Area	8,850	63.7	43.4	38.5	---	88.0	88.7	192
Rubicon #2 (CA)	7,500	18.8	0.8	29.1	---	62.9	72.4	158
Squaw Valley G.C. (CA)	8,200	80.7	50.6	46.5	---	85.7	122.4	131
Tahoe City Cross (CA)	6,750	0.0	0.0	16.0	---	51.6	66.8	220
Truckee #2 (CA)	6,400	1.0	0.0	14.3	---	49.8	60.0	256
Ward Creek #3 (CA)	6,750	30.4	0.0	39.4	---	97.2	121.5	153
AVERAGES:		27.9	11.1	27.1	---	63.3	69.9	168
CARSON-WALKER BASIN								
Blue Lakes (CA)	8,000	48.8	25.5	34.6	---	74.6	70.1	178
Ebbetts Pass #2 (CA)	8,700	48.0	21.3	36.9	---	84.6	80.0	161
Leavitt Meadows (CA)	7,200	0.0	0.0	6.7	---	43.1	48.7	136
Lobdell Lake (CA)	9,200	11.7	0.0	16.3	---	38.3	31.3	171
Poison Flat (CA)	7,900	0.0	0.0	16.2	---	48.3	50.3	212
Sonora Pass Bridge (CA)	8,800	23.9	2.2	26.0	---	57.2	57.9	166
Spratt Creek (CA)	6,080	0.0	0.0	4.5	---	46.8	51.5	159
Virginia Lakes Ridge (CA)	9,200	19.3	1.7	16.9	---	43.5	36.7	184
Wet Meadows #2 (CA)	8,050	58.1	17.3	33.5	---	80.3	70.9	203
AVERAGES:		23.3	7.6	21.3	---	57.4	55.3	173
HUMBOLDT BASIN								
Big Creek Summit	8,700	7.6	0.0	12.0	---	33.8	20.1	171
Buckskin, Lower	6,700	0.0	0.0	7.0	---	31.7	28.7	183
Corral Canyon	8,500	5.7	0.0	17.5	---	31.4	28.3	124
Dorsey Basin	8,100	0.3	0.0	12.3	---	34.6	32.3	152
Granite Peak	7,800	21.0	11.6	21.9	---	45.1	33.7	206
Green Mountain	8,000	0.0	0.0	11.6	---	34.0	30.1	165
Lamance Creek	6,000	0.0	0.0	7.7	---	33.9	32.0	202
Lamoille #3	7,700	0.0	0.0	12.2	---	30.7	30.7	117
AVERAGES:		4.3	1.5	12.8	---	34.4	29.5	161
SNAKE-OWYHEE BASIN								
Bear Creek	7,800	12.0	6.7	21.3	---	34.5	37.6	131
Big Bend	6,600	0.0	0.0	10.6	---	16.8	20.7	92
Fawn Creek	7,000	0.0	0.0	11.4	---	36.3	37.5	107
Goat Creek	8,800	9.9	9.2	18.4	---	37.5	36.9	145
Jack Creek #2, Upper	7,250	1.4	0.0	14.0	---	30.7	35.5	132
Jacks Peak	8,420	---	---	24.4	---	44.9	44.4	---
Laurel Draw	6,700	0.0	0.0	6.8	---	26.6	29.9	121
Pole Creek R.S.	8,330	6.0	7.9	21.7	---	20.8	22.6	109
Seventysix Creek	7,100	0.0	0.0	11.4	---	20.7	23.6	107
Taylor Canyon	6,300	0.0	0.0	2.7	---	7.9	13.9	74
AVERAGES:		3.3	2.6	14.3	---	27.7	30.3	125
EASTERN NEVADA								
Berry Creek	9,100	---	1.2	14.2	---	---	27.0	---
Hole-in-Mountain	7,900	---	0.0	21.1	---	---	43.6	---
Ward Mountain	8,900	5.8	0.0	7.7	---	28.6	27.6	138
AVERAGES:		5.8	0.4	14.3	---	28.6	32.7	138
NORTHERN GREAT BASIN								
Cedar Pass (CA)	7,100	0.0	---	16.3	---	43.7	39.8	135
Disaster Peak	6,500	0.0	0.0	10.9	---	29.3	25.1	156
Dismal Swamp #2 (CA)	7,050	18.0	1.5	25.0	---	60.3	61.7	103
AVERAGES:		6.0	0.8	17.4	---	44.4	42.2	122

SNOTEL Provisional data, subject to revision
Figures for % of average are for date of report, based on interpolation between first of month averages. All averages are estimated from adjacent snow courses, and are developed from a 1963-77 data base.

Figure 7. A weekly report prepared on the Tektronix 4052 Graphics Systems informs water users of the current outlook.

Streamlining the Future

Marron stated that the basic frameworks in the PLOT 50 packages had enabled them to

achieve their current position, but they were looking forward to a more automated system. A major reorganization of the SCS is consolidating certain activities to free time for tackling other tasks such as modeling.

Most readers are familiar with the hydrologic picture model which depicts rain coming from the sky, dropping into the lakes and stream and on the ground, draining into the ocean and evaporating, with the cycle repeating. By creating a computer version of the model and fitting it to previous records, the amount of water coming down a stream can be predicted. Plugging in anticipated or known amounts using the SNOTEL data enables the modeling to be done in a relatively short time span, for instance, two weeks.

Such modeling could influence and perhaps alleviate water rights squabbles. Many water decrees in the West are based on the premise that first in time have first rights with junior rights dropping out when the streamflows drop below a certain point. Using the computer hydrologic model, the individuals concerned will know what to expect and be able to plan accordingly.

Although the modeling will be done on a "supermini" because of the number of data points to be analyzed, the Tektronix systems in the field offices will receive the forecasts and narratives from Portland. They will also be used to produce the graphs for the state publications, as they are now.

The SCS staff is working to streamline the various field office programs. For instance, the weekly report program of the Wyoming office which downloads the current data from the HP1000 directly to the 4050 could be merged with the Nevada report program which does more analysis but requires manual entry. Consolidating the programs will result in a more sophisticated system with the capacity for more analysis and better service.

Note: All photographs, drawings and graphs are courtesy of the Soil Conservation Service, U.S.D.A.

TEKniques thanks Manes Barton and his staff at the SCS for taking time to describe their applications. Lloyd Vancil, Laurel Grimsted, Jim Marron, Ken Jones and Art Crook use the 4050 systems extensively and felt their work might aid others. No endorsement by the U.S. Soil Conservation Service is implied or intended.

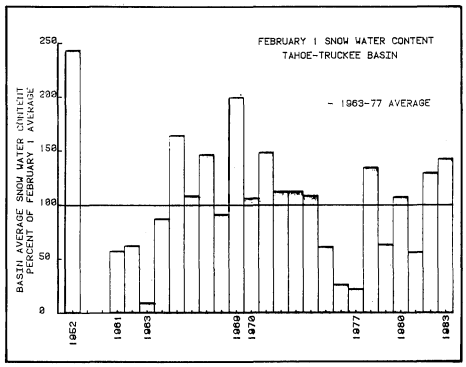


Figure 8. In February of 1983 the Tahoe-Truckee Basin reservoirs were managed much the same as they were in 1978 or 1971 because the snow pack and water outlook were similar.

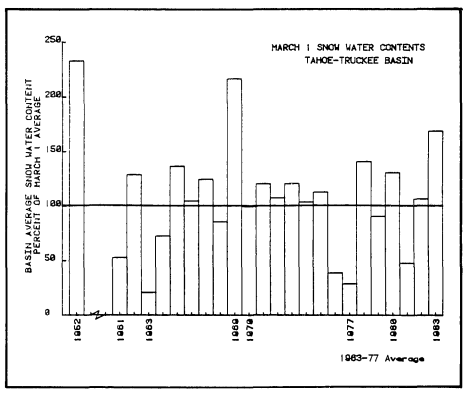


Figure 9. In March the 1983 data showed the snow pack had risen to the third highest, so the reservoir operators started dropping their stored water.

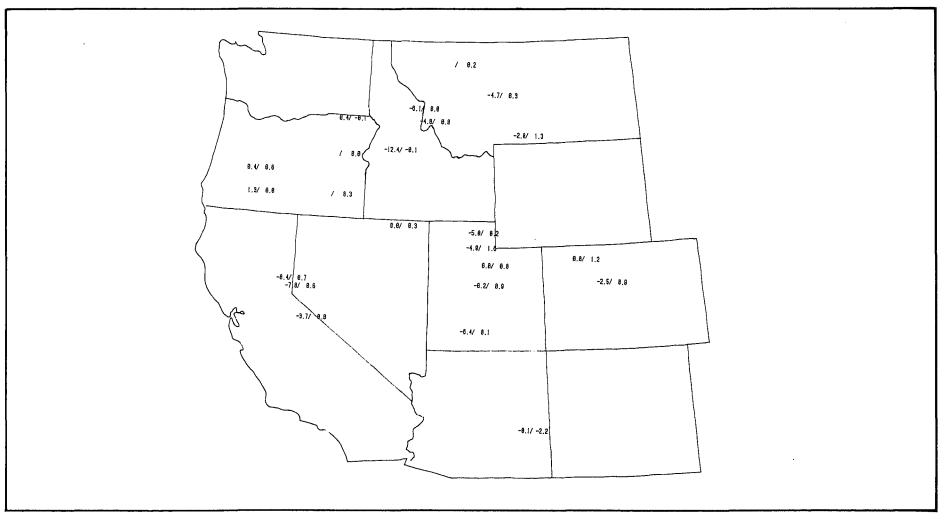


Figure 11. Staff members at SCS can quickly review the Western snow situation from a plot generated on the 4050 which correlates snow data with geographical locations on this plot.

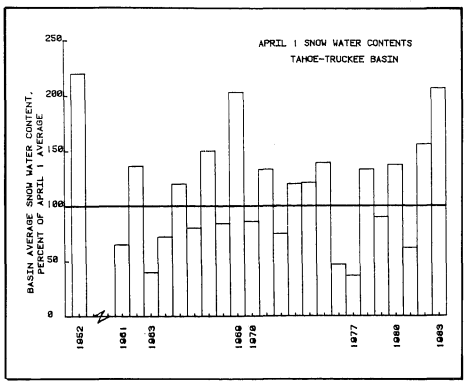


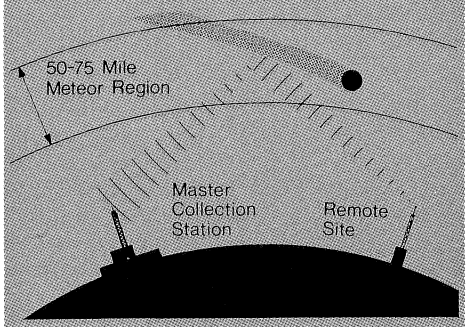
Figure 10. By April the situation had worsened considerably and the snow water was the second highest in record, clearly in evidence in the graph.

Transmittal of data to and from U.S. Soil Conservation Service SNOTEL sites and the master stations relies on the meteor burst propagation technique. This technique bounces radio signals off ionized meteor trails.

Billions of sand-sized meteorites enter the earth's atmosphere every day, heating and burning in a zone 50 to 75 miles above the earth's surface. Their disintegration creates a cigar-shaped trail of ionized gasses, which have a life of several milliseconds to a few seconds. This provides enough time to reflect VHF radio signals off these trails.

The meteor burst phenomenon was discovered accidentally by radio operators who found their signals reaching long distances when inadvertently bounced off meteor trails. The principle gained attention when radio contact with astronauts temporarily was lost during re-entry. The cause of the blackouts: a sheath of ionized gasses surrounding the space capsule repelled radio signals.

Ref: Soil Conservation, March 1977.



SNOTEL links ground stations up to 1200 miles apart by bouncing signals off short-lived meteorite trails high above the earth.

MicroPERT® 2: Low Cost Project Management Tool for 4050 Series

by Michael B. Kitz-Miller and Leland C. Sheppard

"Today's business environment demands more efficient engineering and construction, along with more accurate cost and time control throughout all project activities, if a company is to survive and grow."

That quote by Mr. J.H. Bottom of American Enka Company in an article on project management in *TEKniques* Vol. 4 No. 2 (March 1980) is just as accurate and timely today.

In the article "Portable Project Management" published in *Portable Computer,* January, 1984, Dr. Scott L. Norman says, "Project managers can use project management software to analyze the impact on cost and completion schedule of assigning more or fewer workers to a given task. Or, they can postulate a wide range of "what-if" scenarios similar to those that made the electronic spreadsheet so valuable in financial analysis."

The evolution from the hand-drawn milestone charts of Henry Gantt in 1914 to PERT developed in 1958 (to manage the Navy's Polaris Fleet Ballistic Missile project), to today's vast array of project management software supports the importance of project management tools.

Among these tools is MicroPERT® 2 which employs a combination of PERT (Program Evaluation and Review Technique) and CPM (Critical Path Method) methodologies to aid 4050 Series users in planning their projects of up to 220 activities per project unit.

This graphics-oriented software package is highly interactive. It leads the user through the steps required to enter, edit and manipulate the project data with a series of menus and question-and-answer prompts.

Extensively documented, MicroPERT® 2 is accompanied by a 300 page user's manual which is written with some deliberate redundancy to minimize the amount of page flipping. The manual serves as a tutorial and as a reference. An extensive index and glossary of terms are included.

Among the unique features of MicroPERT® 2 are its time-scaled Network Diagram (PERT chart) and large number of chart and report options. The software allows as much or as little data for the activities of the project as desired. For example, if the primary interest is in scheduling activities across time, labor, resource and cost data may be omitted. If dates aren't supplied for each event, MicroPERT® 2 calculates them. MicroPERT® 2 contains several tools to aid you in rearranging activities within the project.

MicroPERT® 2 accepts up to four labor entries per activity, two additional resource entries, and five cost types, each of which can be broken down into estimated and actual costs. Estimated costs can be subdivided into Total, To-Date and To-Completion. Actual costs can be separated into Paid and Committed.

Any or all of these features is optional: MicroPERT® 2 will accept as few as five items of information per activity or as many as sixty-four; it's entirely up to the user.

MicroPERT® 2 is available from Sheppard Software Company in three versions: Dual-Disk, Single-Disk and Tape. The following table shows some of the hardware requirements and options for using MicroPERT® 2:

VERSION:	Dual-Disk*	Single-Disk	Tape
4051	No	Yes	Yes
4052/4054	Yes	Yes	Yes
Memory	64K	32K	32K
4907	2 drives	1 drive	No
4924	No	No	Yes

*available in a Transera hard-disk version

Chart output from MicroPERT® 2 can be directed to the display screen, a 4611 or 4631 Hardcopy or a 4662 or 4663 Plotter. Report output can be directed to the display screen, a 4611 or 4631 Hardcopy or to a 4641 or 4643 Printer.

Source code for the programs and extensive internals documentation are available from Sheppard Software Company at extra cost, for those who wish to modify the programs.

The authors can be reached at Sheppard Software Company, 4750 Clough Creek Road, Redding, California 96002, telephone: (916) 222-1553.

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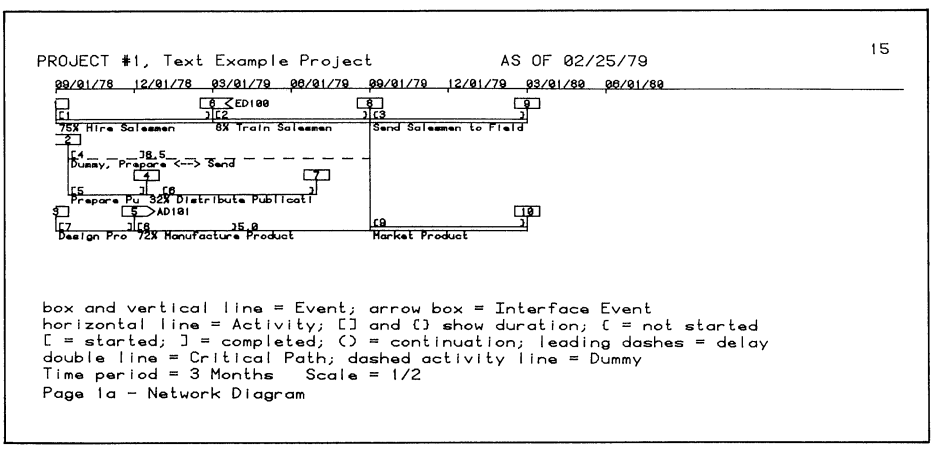
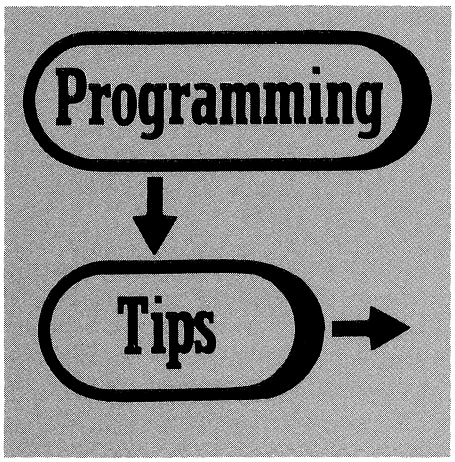
```
PROJECT # 1, Text Example Project    AS OF 02/25/79

                Labor Conflict Report

Labor ID      Time Period       Limit  Requirement

    M3        09/01/79 - 12/01/79   4        8.00
Activities associated:
003, 009

    M3        12/01/79 - 03/01/80   4        8.00
Activities associated:
003, 009

    M2        09/01/79 - 12/01/79   2        4.00
Activities associated:
009, 003

    M2        12/01/79 - 03/01/80   2        4.00
Activities associated:
009, 003
```

Extensive report options include the Labor Conflict Report.



Among the many chart options in MicroPERT® 2 is the Network Diagram which provides a quick overview of interconnectivity of events and the critical path.



Undocumented Functions Facilitate Graphics in 4052A/4054A Systems

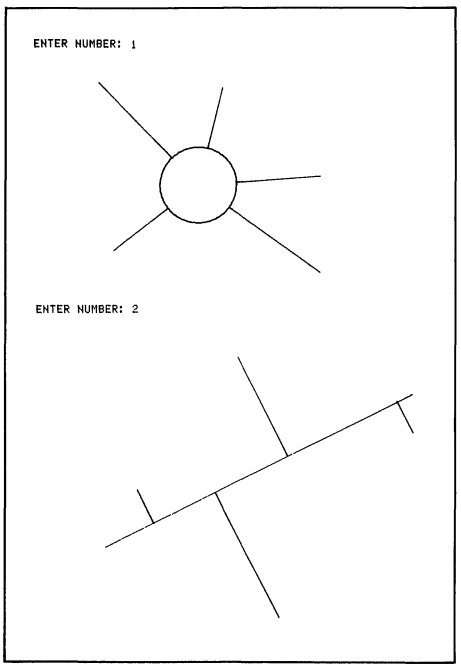
by Jim Gish
and Ed Post
Tektronix, Inc.
Wilsonville, OR

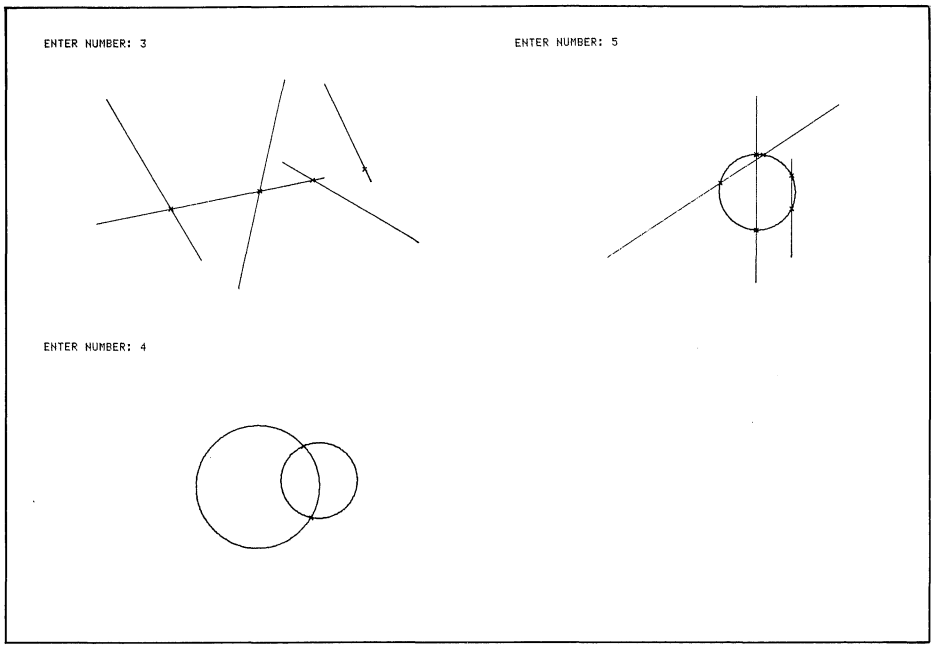
Five system calls in the 4052A/4054A Desktop Computers can aid graphics manipulation. They are:

"NTA" - Line normal to an arc
"NTL" - Line normal to a second line
"LXL" - Intersection of two lines
"AXL" - Intersection of an arc and a line
"AXA" - Intersection of two arcs

The following program illustrates their use.

Note that because their names begin with control characters, these calls will not appear in the "CLIST" command






```
100 INIT
110 SET DEGREES
120 PAGE
130 PRINT "ENTER NUMBER: ";
140 INPUT N
150 IF N=0 THEN 180
160 GOSUB N OF 200,380,520,710,910
170 GO TO 120
180 END
190 REM
200 REM     NORMAL TO ARC
210 RESTORE 240
220 DELETE A1
230 DIM A1(5)
240 DATA 65,50,10,0,360
250 READ A1
260 X5=A1(1)
270 Y5=A1(2)
280 V6=A1(3)
290 CALL Circle(A1)
300 REM
310 POINTER X3,Y3,A$
320 IF A$="" THEN 370
330 CALL "NTA",X3,Y3,X5,Y5,V6,X,Y,X6,Y6,W1
340 MOVE X3,Y3
350 DRAW X,Y
360 GO TO 310
370 RETURN
380 REM     NORMAL TO LINE
390 RESTORE 400
400 DATA 20,20,100,60
410 READ X1,Y1,X2,Y2
420 MOVE X1,Y1
430 DRAW X2,Y2
440 REM
450 POINTER X3,Y3,A$
460 IF A$="" THEN 510
470 CALL "NTL",X3,Y3,X1,Y1,X2,Y2,X,Y,X6,Y6
480 MOVE X3,Y3
490 DRAW X,Y
500 GO TO 450
510 RETURN
520 REM     LINE INTERSECT LINE
530 RESTORE 560
540 DELETE A1,A2
550 DIM A1(4),A2(4)
560 DATA 30,45,90,55
570 DATA 3,100,130,10
580 READ A1,A2
590 MOVE A1(1),A1(2)
600 DRAW A1(3),A1(4)
610 POINTER A2(1),A2(2),A$
620 IF A$="" THEN 700
630 POINTER A2(3),A2(4),A$
640 MOVE A2(1),A2(2)
650 DRAW A2(3),A2(4)
660 CALL "LXL",A1,A2,X,Y,C0,C1,C2
670 IF C0=0 THEN 610
680 CALL Symbol(X,Y)
690 GO TO 610
700 RETURN
710 REM     ARC INTERSECT ARC
720 RESTORE 750
730 DELETE A1,A2
740 DIM A1(5),A2(5)
750 DATA 65,50,10,0,360
760 DATA 60,50,10,0,360
770 READ A1,A2
780 CALL Circle(A1)
790 POINTER A2(1),A2(2),A$
800 IF A$="" THEN 900
810 POINTER S1,S2,A$
820 A2(3)=SQR((S1-A2(1))^2+(S2-A2(2))^2)
830 CALL Circle(A2)
840 CALL "AXA",A1,A2,X,Y,X1,Y1,C0
850 IF C0=0 THEN 790
860 CALL Symbol(X,Y)
870 IF C0=1 THEN 790
880 CALL Symbol(X1,Y1)
890 GO TO 790
900 RETURN
910 REM     LINE INTERSECT ARC
920 RESTORE 950
930 DELETE A1,A2
940 DIM A1(4),A2(5)
950 DATA 0,0,130,100
960 DATA 65,50,10,0,360
970 READ A1,A2
980 CALL Circle(A2)
990 POINTER A1(1),A1(2),A$
1000 IF A$="" THEN 1100
1010 POINTER A1(3),A1(4),A$
1020 MOVE A1(1),A1(2)
1030 DRAW A1(3),A1(4)
1040 CALL "LXA",A1,A2,X,Y,X1,Y1,C0
1050 IF C0=0 THEN 990
1060 CALL Symbol(X,Y)
1070 IF C0=1 THEN 990
1080 CALL Symbol(X1,Y1)
1090 GO TO 990
1100 RETURN
1110 REM SUBROUTIME TO DRAW X
1120 SUB Symbol(X,Y)
1130     MOVE X,Y
1140     D=0.5
1150     RMOVE D,D
1160     RDRAW -2*D,-2*D
1170     RMOVE 0,2*D
1180     RDRAW 2*D,-2*D
1190     RMOVE -D,D
1200 END SUB
1210 SUB Circle(A)
1220     DIM A(5)
1230     MOVE A(1)+A(3),A(2)
1240     FOR I=A(4) TO A(5) STEP 2
1250         DRAW A(1)+COS(I)*A(3),A(2)+SIN(I)*A(3)
1260     NEXT I
1270     MOVE A(1),A(2)
1280 END SUB
```

Calls Check Extended Memory in 4050 Series

by Mark Mehall
Tektronix, Inc.
Wilsonville, OR

Two system calls allow you to examine the contents of Extended Memory and one allows you to write to any location in Extended Memory. Three additional calls provide HEX utility functions.

Although these are documented in the Extended Memory Service manual, not everyone has this manual and the calls could be useful in program development.

CALL "MDUMP". Addr$ [,Count]

MDUMP dumps selected contents of the External Memory to the screen.

Addr$ - a string expression with 1 to 6 ASCII-hex characters (e.g., "340"). (Can be null, which means continue from "previous" address.)

If LEN (Addr$) ⩽ 4 then it is a block address, else it is a "byte" address. (Example: "4" means "000400.")

Count - a numeric expression, for the number of bytes desired (defaults to 256). Must be less than $2^{16} - 1$.

CALL "MREAD", Addr$, Count, Out$

MREAD allows you to read any location in External Memory into a string variable.

Out$ - a string variable. Each byte from RAM is put as 1 byte in Out$.

CALL "MWRITE", Addr$, In$

MWRITE allows you to write to any location in the External memory from a string variable.

CAUTION

This utility may, if misused, destroy any or all files in the External Memory.

In$ - a string expression. Each byte from it goes into 1 byte in RAM.

The following three utilities are aids to help you convert expressions to HEX since MREAD, and MWRITE require character data instead of HEX.

CALL "HEXBYT", InHex$, Out$

InHex$ - a string expression. It must contain only ASCII-hex character "0..9 A..F a..f". If its LEN is odd, then a leading "0" is assumed.

Out$ - each pair of characters in InHex$ form 1 byte in Out$; e.g., "12A"→ Out$ with ASC(Out$,1) = 1, ASC(Out$,2) = 42. Out$ cannot be same variable as InHex$.

CALL "BYTHEX", Inbyt$, Outhex$

Reverse of "HEXBYT" (Note: OutHex$ will always be even in LEN).

CALL "NUMHEX", InAddr, OutAddr$

InAddr - numeric expression with value $0..2^{24} - 1$.

OutAddr$ - a 6 character string with the ASCII-hex equivalent of InAddr. (Note: leading zeroes will be generated, so that it is always 6 long.) This can then be passed to "MDUMP" etc., as an address.

Predicting the Ordering of Files in Directories of the 4907

by Steve Duncan
Tektronix, Inc.
Beaverton, OR

When sequentially opening "groups" of files in the 4907 File Manager disk unit, you may wish to predict the order in which those files will be opened. Anyone who has examined a 4907 directory knows that it is not strictly alphabetical. The ordering is dependent on three factors:

1) the filename.
2) the order in which they are created.
3) the number of "chains" specified when the disk was formatted at the library or file level that is being "hashed."

The outcome of the order can be predicted if the three factors mentioned above are known; here is how . . .

Letters A–Z in the filename are mapped into the integers 1–26

Numbers 0–9 in the filename are mapped into the integers 27–36

The formula is (SUM of INTEGERS + NUMBER of INTEGERS) MOD (C), where "C" is the number of chains specified in the formatting of the disk. In this example, the # of chains at level 2 is 5.

CREATE "@NAMES/JOHN"
or ((10 + 15 + 8 + 14) + 4) MOD 5 = 1

CREATE "@NAMES/BOB"
or ((2 + 15 + 2) + 3) MOD 5 = 2

CREATE "@NAMES/STAN"
or ((19 + 20 + 1 + 14) + 4) MOD 5 = 3

CREATE "@NAMES/DEAN2"
or (4 + 5 + 1 + 14 + 29) + 5) MOD 5 = 3

The largest result becomes the first file, the next largest next, and so on. When two or more of the results are the same, the one created first is selected first. The order for our example files would then be:

NAMES/STAN NAMES/DEAN2
NAMES/BOB NAMES/JOHN

The easiest way to predict ordering is to format your disk with "1" as the number of chains for the level(s) you want to order, and create the files in the sequence you wish. Example:

CALL "FORMAT",0,"CONTENT",1,1,
"USER","PASS",7,7,1,3,3
(NOTE: 3rd level) ↑

CREATE "A/B/F1";1,0
CREATE "A/B/F2";1,0
CREATE "A/B/F3";1,0

(These files will be opened in the order F1, F2, and F3 for "group" access.)

However, if library names are dissimilar, a "1" must also be specified at those levels as well to keep files ordered as they were created.

When using the conventions remember - the ordering of files can be changed by the 4907 if those files are manipulated by file management operations such as KILL, RENAME, COPY or COMPRESS after creation.

Editor's Note: See related articles in *TEKniques,* Vol. 7 No. 1 p.29 and Vol. 3 No. 4 p.20, (the latter also in Programming Tips handbook, p.84).

Call LINK and Named Subprograms

by Jim Gish
Tektronix, Inc.
Wilsonville, OR

The LINK routine transfers a stored binary program to memory from the specified tape drive without disturbing variables and associated values stored in memory. It is commonly used to "chain" together program modules that would be too large to fit into the 4050 memory as a whole.

Some problems can occur when the LINK routine is combined with the named subprograms capability added to the 4052A and 4054A.

The 4050 system can become confused if the program in memory and the program being LINKED into memory have a subprogram with the same name. A system error will occur under these circumstances.

The routine APPEND/BAPPEND and DELETE are functionally very similar to the LINK routine and can be used with subprograms of the same name.

4054A With Option 10 and NEC 7710 Printer

by Jim Gish
Tektronix, Inc.
Wilsonville, OR

Captain Dennis Nuttbrock at Edwards Air Force Base has successfully integrated a NEC 7710 printer into his 4054A system. Initially there were problems. When the printer was connected to the Option 10 interface, it would list programs correctly but when driven from a BASIC program, the printer would detect an error, and characters at the end of each line, most notably carriage returns, were ignored. These results occurred at BAUD rates as low as 150. The solution was to use an appropriate null modem. It eliminated the problem above and provided Data Terminal Ready (DTR) flagging as well.

The NEC printer expects pin 8 of the RS-232 connector to be constantly high during the operation of the printer. The LIST keyword does hold this pin high for the entire listing. The PRINT keyword, however, doesn't necessarily hold the pin high throughout the transmission. The fluctuating state of pin 8 does not conform to what the NEC 7710 printer expects so a null modem was constructed (see figure 1) to satisfy the printer's expectations. Pin 6, which the Option 10 keeps high whenever the unit has power, was diverted to pin 8. This solved the major problem.

Data Terminal Ready (DTR) flagging is not mentioned in the NEC documentation, but pin 19 is dropped when the buffer is near capacity, or operator intervention is required. The NEC manual calls pin 19 a "reverse channel." Pin 19 has all the characteristics to satisfy a DTR flagging protocol so pin 20 (DTR) of the Option 10 was routed to pin 19 on NEC side of the null modem.

If the NEC printer is used with this null modem it performs quite well. PRINT statements are printed correctly and the printer can be run at 1200 BAUD.

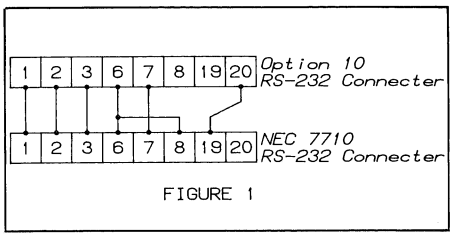


FIGURE 1

Using the 4050 Series Copy Command

by J.E. Jobaris
U.S. Postal Service
San Bruno, CA

In *TEKniques,* Vol. 6, No. 4, Winter 1982, page 23, there is a Programming Tip entitled "Initializing Random Data Files on the 4907." Essentially this tip recommends the use of the COPY command to save time initializing a data file. We have been using this technique on a 4051. We also use the COPY command to backup selected files onto a disk in another drive.

We discovered that the COPY command does not always work and that there is no system message when it doesn't. The result of the COPY command not working, and without a message to that effect warning the user, could cause the programmer many lost hours looking for a program (logic) bug which does not exist.

No one seems to know why the COPY command does not work all of the time. It might have something to do with a very small window of the seconds portion of the 4907 clock. It has to be a very small window because the COPY command works at least 99% of the time.

We have incorporated our own error message and a program STOP to eliminate the unhappy surprise of trying to access a nonexistent file during an application program. The listing illustrates our error trap. Depending on our application, we may not use the printer for the error message.

When using the COPY command to backup existing files, there must be a time delay between the KILL and COPY commands, see lines 911 through 915 on the listing.

```
895 REM S$=NAME OF SOURCE FILE
897 REM S=SOURCE DRIVE NUMBER (0,1, OR 2)
899 REM T$=NAME OF TARGET FILE
901 REM T=TARGET DRIVE NUMBER (0,1, OR 2)
903 REM IF COPYING TO AN EXISTING FILE REMOVE THE REMS IN
905 REM LINES 907, 909, 911, 915, & 917
907 REM UNIT T
909 REM KILL T$
911 REM FOR I=1 TO 100
913 REM WASTING TIME
915 REM NEXT I
917 REM UNIT S
919 COPY F$,S TO T$,T
921 CALL "FILE",T,T$,E$
923 IF LEN(E$)>0 THEN 947
925 FOR D=32 TO 51 STEP 19
927 PRINT @D:"GLJJJ                THE COPY COMMAND DID NOT WORK !!GJ"
929 PRINT @D:"FILE ";S$;" IN DRIVE ";S;" WAS NOT COPIED TO FILE ";T$;
931 PRINT @D:" IN DRIVE ";T
933 PRINT @D:"JGET THE PROGRAMMER IMMEDIATELY AND SHOW HIM THE ";
935 PRINT @D:"HARDCOPY MESSAGE"
937 IF D=32 THEN 941
939 PRINT @D:"L"
941 NEXT D
943 COPY
945 STOP
947 REM RETURN GOES HERE IF SUBROUTINE, OR CONTINUE WITH PROGRAM
```

Quick Initialize for 4907 Random Files

by Lloyd Vancil
Soil Conservation Service
Portland, OR

Program listing #1 is the recommended way to create and initialize random access files on the TEK 4052. Lines 100–160 create a working string with a length one less than the length of the file record. Lines 180–190 create and open the file for full access. Lines 210–230 initialize the file by printing the work string of blanks in the file. This program will run in 3.94 minutes, including the time for building W$.

```
          PGM #1
100 INIT
110 DIM W$(100)
120 W$=""
140 FOR I=1 TO 99
150 W$=W$&" "
160 NEXT I
170 REM          WORK STRING BUILT
180 CREATE "@SYSLIB/TEST","A";1000,100
190 OPEN "@SYSLIB/TEST";1,"F",Z$
200 REM          CREATED AND OPEN
210 FOR I=1 TO 1000
220 PRINT #1,I;W$
230 NEXT I
```

The default record separator character is a carriage return, ASCII 13. Note line #140 in program 1. The work string is one character short of the value defined for record length in line #180. The last character is filled by the record separator.

In program #2 W$ becomes a super string – a long string made up of several smaller strings concatenated with carriage returns between each sub-string. The calculation for the dimension of W$ is:

Length W$ = Lt × Nr

Where Lt = the total length of a record (record length + length of record separator).

Nr = the number of records

In program #2 lines 110–200 dimension and build W$. Lines 220–230 create and open the file for full access. Lines 250–270 print W$ to the file to fill it with blanks.

This program runs in 1.35 minutes, including the time required to build W$. If there is space in memory to hold W$, it can be built at any time within the program. The file initialization then drops to 1.17 minutes.

```
100 INIT
110 DIM W$(10000)
120 W$=""
130 E$=CHR(13)
150 FOR I1=1 TO 100
160 FOR I=1 TO 99
170 W$=W$&" "
180 NEXT I
190 W$=W$&E$
200 NEXT I1
210 REM          WORK STRING BUILT
220 CREATE "@SYSLIB/TEST","A";1000,100
230 OPEN "@SYSLIB/TEST";1,"F",Z$
240 REM          CREATED AND OPEN
250 FOR I=1 TO 1000 STEP 100
260 PRINT #1,I;W$
270 NEXT I
```

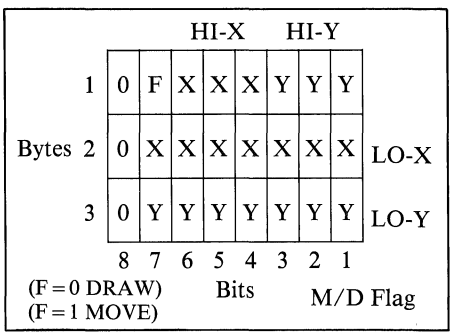
4050A Series Graphics Enhancement ROM Pack: Color Information and Plotting

by Mark Mehall
Tektronix, Inc.
Wilsonville, OR

The 4051R12 and 4052R12 add new graphics capabilities to the 4050 Series Desktop Computer. (See *TEKniques* Vol. 7, No. 3 for a complete description.) These new ROM packs use a condensed data storage format for graphics information. The coordinates are converted into 10 bit values and then packed in three character bytes. (See Diagram.)

An additional advantage of this packing technique is that the high order bit (bit 8) is ignored by the ROM pack. This means that the 3 bits are available for color code information. This allows for 8 colors (2 ↑ 3 is 8). The following routine shows one way to color code the graphics information contained in the image string G$ generated by the ROM pack:

The second routine is a sample driver for the 4662 Digital Plotter with the 8 pen option:




```
100 REM INITIALIZE COLORS
110 REM B IS THE MATRIX OF COLOR CODES
120 DIM B(7,3)
130 REM BLACK
140 DATA 0,0,0
150 REM MAGENTA
160 DATA 1,0,0
170 REM RED
180 DATA 1,1,0
190 REM YELLOW
200 DATA 0,1,0
210 REM GREEN
220 DATA 0,1,1
230 REM CYAN
240 DATA 0,0,1
250 REM VIOLET
260 DATA 1,0,1
270 READ B
280 REM NUM IS THE POINT TO BE COLOR CODED
290 REM GET POINT
300 F$=SEG$(G$,Num*3-2,3)
310 REM SET COLOR BITS
320 REM COLOR IS THE COLOR FOR THE POINT (FROM 1 TO 7)
330 FOR I=1 TO 3
340    CALL "BITSET",F$,8*I,B(Color,I)
350 NEXT I
360 REM CHECK FOR AN ASCII 255 (EOF ON TAPE) REPLACE WITH 254
370 FOR I=1 TO 3
380    IF ASC(F$,I)=255 THEN
390       CALL "BITSET",F$,(3-I)*8+1,0
400    END IF
410 NEXT I
420 G$=REP$(F$,Num*3-2,3)
430 REM WHEN COMPLETE THE STRING G$ CAN BE WRITTEN TO TAPE
440 REM  BY USING A WRITE STATEMENT
```

```
LIST
100 REM PLOT 4050R12 IMAGE ON THE 4662 OPTION 31 (8 PENS)
110 REM 4052A/4054A VERSION
120 REM THE COLOR ORDER IS:
130 REM   BLACK, MAGENTA, YELLOW, RED,
    BLUE (CYAN), PURPLE, GREEN
140 REM    (POSITION 8 IS NOT USED)
150 A=1
160 FIND 11
170 DIM T$(8200)
180 REM NOTE THAT A READ IS USED
    - INPUT STRIPS THE COLOR CODE (BIT 8)
190 READ @33:T$
200 REM DEFAULT COLOR IS BLACK
210 PRINT @1,8:1
220 _old_color=1
230 FOR I=1 TO LEN(T$)/3
240    REM GET THE COLOR
250    F$=SEG$(T$,I*3-2,3)
260    Color=(ASC(F$,1)>127)*4+
       (ASC(F$,2)>127)*2+(ASC(F$,3)>127)+1
270    IF Color<>_old_color THEN
280       REM CHANGE PENS
290       PRINT @1,8:Color
300       _old_color=Color
310    END IF
320    N=I
330    REM GET THE X,Y VALUES FOR THIS IMAGE POINT
340    CALL "POINTS",T$,N,X,Y
350    REM PLOT IT
360    PRINT @A,21-(N>0):X,Y
370 NEXT I
```

4051E01 ROM Expander Available

A small number of specially priced 4051E01 ROM Expanders are available for the 4051. The ROM Expander plugs into one of the 4051 backpack slots and provides additional slots for up to eight ROM Packs and Interfaces. Two 4051E01's may be connected to a single 4051 to allow up to sixteen ROM Packs to be used at the same time. Each ROM Expander slot has its own unique address so that multiple Printer Interfaces (4051 Opt. 10 or 4051F10) can be used to drive different printers.

The 4050E01 ROM Expander is also available for use with the 4051, 4052/4052A or 4054/4054A. (The 4050E01 was described in *TEKniques* Vol. 6 No. 1.)

4050 Series Reconditioned and Demonstrator Equipment at Low Cost

by Mark Mehall
Tektronix, Inc.
Wilsonville, OR

Some reconditioned and demonstrator models of the Tektronix 4050 Series are still available at very special savings. Each meets original specifications and includes all standard accessories.

Some examples are:

Reconditioned 4052 with 4052F39	$ 6,600
Reconditioned 4054 with 4054F39	9,900
Reconditioned 4909 File Manager	12,500
Reconditioned 4956 Tablet	1,995

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The Effective Use of Color: Physiological Principles

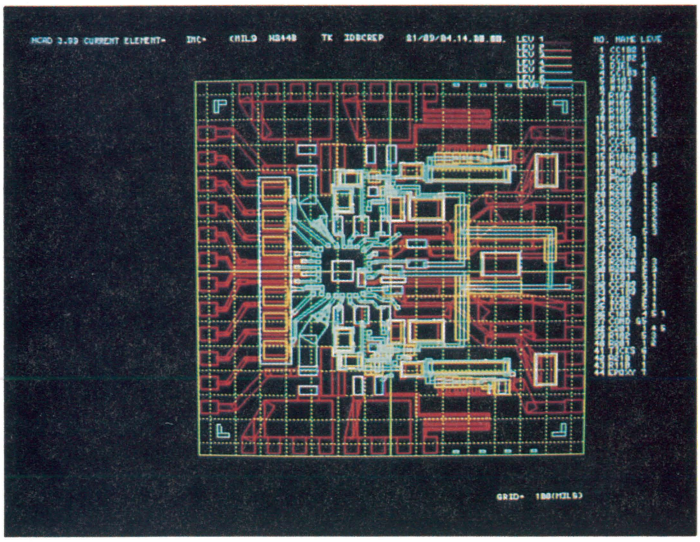

Figure 1. The qualitative use of color: a circuit layout in which layers are color coded.

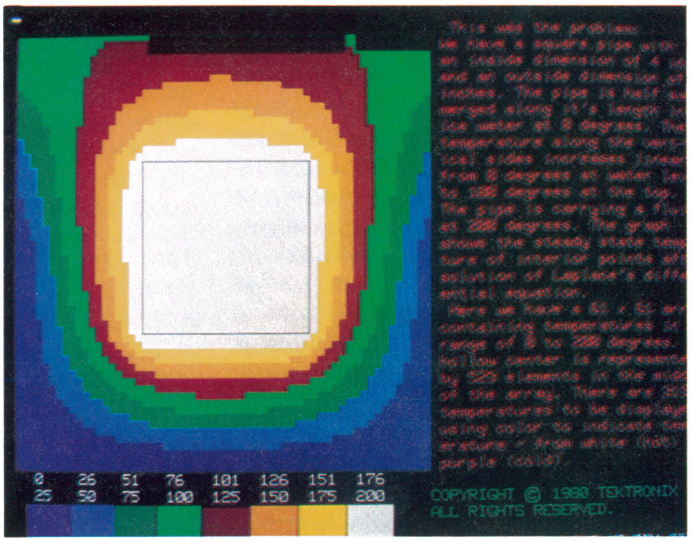

Figure 2. The quantitative use of color: color is used to denote the temperature at different points along a pipe.

by Gerald Murch
Tektronix, Inc.
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Without a doubt color has come to dominate the information display world. In fact about 85% of display systems currently sold are color. This domination has occurred over such a short period of time that the basic knowledge of how to use color effectively is at best sparse and at worst missing altogether. Color can be a powerful tool to improve the usefulness of an information display in a wide variety of areas if color is itself used properly. Conversely, the inappropriate use of color can seriously reduce the functionality of a display system.

Up to now, color has been used almost exclusively in a qualitative rather than a quantitative fashion, i.e., showing that one item is "different from" another rather than displaying relationships of degree. A typical example would be the color-coding of each layer of a multi-layer circuit board (figure 1). Color serves to differentiate the layers but says nothing about their relationships. A simple quantitative extension of the multi-layer circuit board might involve ordering the layers in spectral order, with the first layer red, the second orange, and so on, following the popular mnemonic ROY G. BIV (red, orange, yellow, green, blue, indigo, violet).

The demands for proper color use increase as color is used quantitatively to show progressing change. The example in figure 2 shows a color temperature map of a square pipe carrying a fluid at 200 degrees. The pipe is half submerged along its length in chilled water at 0 degrees. The temperature along the vertical sides increases linearly from 0 degrees at water level to 100 degrees at the top. The graph shows the steady-state temperature of interior points after solving Laplace's differential equation.

The result is a 61×61 array containing temperatures in the range of 0 to 200 degrees. The hollow center is surrounded by 3,192 temperatures, displayed in colors approximating the temperatures: from white (hot) to purple (cold).

Although it is not possible to develop a complete set of guidelines for the effective use of color which would be appropriate for all applications, some principles follow from an understanding of the mechanisms of human color perception. This note, then, will describe the basic functions of human color vision from a physiological perspective and derive some general principles for the effective use of color.

Physiology of Color

Perhaps the most critical aspect of understanding how we see color is the knowledge that the sensation of color occurs as the result of the properties of the nervous system.

In figure 3 the range of wavelengths to which the eye is sensitive is shown along with a representation of the accompanying color sensation. Although we often refer to light of a particular wavelength as having a color, in fact, wavelengths are not colored. Color results from the interaction of light with an appropriately designed nervous system. The range of species possessing such a nervous system extends from primates through many species of fish to bumble bees, while exclud-

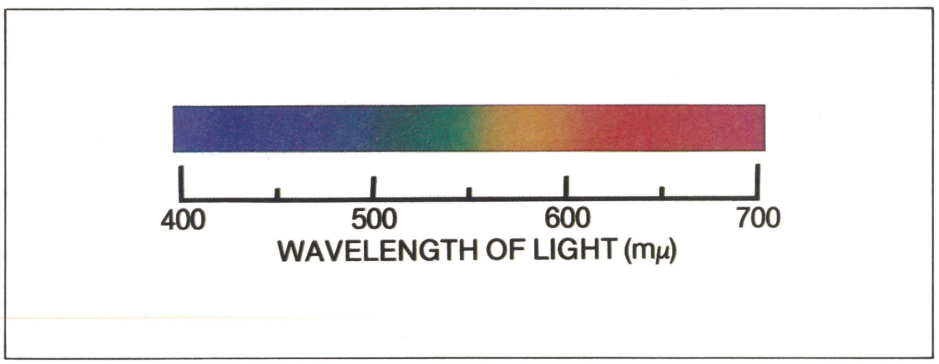

Figure 3. The color spectrum of human vision.

ing many others such as dogs. Interestingly, not all of these color sensing systems function alike. As an example the bee is insensitive to the long wavelengths of light which evoke the sensation of red in humans while perceiving ultra-violet light which is invisible to the human eye. Also there is considerable variation between individuals within a species in their color discrimination capability.

The Lens: Let's start with the eye itself. Images are formed on the light sensitive surface of the eye, the *retina,* through the combined action of several sets of muscles which coordinate the aiming of the two eyes and the shape of the lens. From the perspective of color, these two processes, called convergence and accommodation respectively, introduce a first form of color dependence. The lens of the human eye, like any lens, is not color corrected. This means that the wavelength producing specific color sensations will be focused at different distances behind the lens. Figure 4 diagrams the eye in cross section and shows the relative focal points of six colors. The top drawing shows the eye focused such that the middle wavelengths – those producing the sensation of green – fall on the retinal surface. Longer and shorter wavelengths are out of focus imaging either behind or in front of the retina. This means that the eye will have to refocus to see each color sharply in focus. In the lower drawing the lens is accommodated to red. Note the greater curvature of the lens. The end result is the need for constant refocusing as different colors are viewed.

A perceptual effect results from the lack of color correction, known as chromostereopsis, in which pure colors located at the same distances from the eye, appear to be at different distances. For most people reds appear closer and blues more distant. Fortunately the range of colors which can be seen in focus simultaneously depends upon the purity of the colors. Very pure colors require more refocusing than less pure. The wavelength dependency of the lens creates an additional problem: short wavelengths – pure blue – always focus in front of the retina and thus appear defocused. This effect can be readily seen at night in which deep blue signs look fuzzy and out of focus while other colors appear sharp.

Before moving to the retina, an additional property of the eye needs to be considered. The lens itself does not transmit all wavelengths equally. It absorbs almost twice as much in the blue region of the color spectrum as in the yellow and red. Additionally, a pigmentation in the central part of the retina transmits yellow while absorbing blue. The net result is a relative insensitivity for shorter wavelengths (cyan to deep blue sensations) and enhanced sensitivity for longer wavelengths (yellows and oranges). The yellowing of the lens, which causes it to filter out short wavelengths, also increases with age. Thus, as we get older we are increasingly insensitive to blue. A similar reduction in transmittance occurs for the fluids which support the eye so that as we grow older colors become less vivid and of lower perceived brightness. Actually a great deal of individual variation occurs with some persons' eyes very transparent and others' naturally yellowed. This variation contributes to differences in color sensitivities between individuals.

The Retina: The human retina consists of a densely packed population of light sensitive receptors which translate the incoming light into nervous impulses. These can be divided into two types which, due to their physical appearances, are called rods and cones. Rods are primarily night vision receptors while cones function at higher levels of light intensity. It is the cones which provide the initial element in the sensation of color. The visual system accomplishes this translation of wavelength to color as a result of light sensitive chemicals (photopigments) in the cones. One of three types of photopigments are found in each of the cones of the human eye. The three types differ in their relative sensitivity to wavelength as is shown in figure 5. One type of photopigment is maximally sensitive to short wavelengths with a peak response at about 445 nanometers. Notice that this photopigment is insensitive to wavelength longer than about 520 nm. Colloquially this photopigment is often called the "blue" photopigment. The other two types of photopigments are maximally sensitive to 535 and 575 nm respectively. Note that both of these actually respond to all wavelengths over the visual range. Traditionally these two have been referred to as "green" and "red" photopigments. Obviously, the photopigments are not colored, but are named on the basis of the color sensation associated with each maximal sensitivity. Even so "red" is a misnomer as the wavelength of peak sensitivity of 575 nm evokes the sensation yellow.

A color is signified as the ratio of the neural activities of the three photopigments. A monochromatic single wavelength light at 450 nm would produce a strong response from the "blue," a weaker response from the "green" and weaker still from the "red." The ratio changes as the wavelength composition of the light changes.

Each cone in the retina contains one of the three types of photopigments, however, the three are not distributed evenly. That is 64% of the cones contain the "red" pigment while 32% contain "green." "Blue" photopigment is found in about 2% of the cones.

Beyond the disproportionate frequency of each photopigment, the relative distribution of rods and cones changes over the surface of the retina. The center of the retina with which we do our detailed seeing is densely packed with cones. This central area contains no rods. Towards the periphery of the retina, and hence the field of vision, the proportion of rods to cones rapidly changes in favor of rods. In fact in the extreme periphery of vision we can only detect unclear and colorless shapes.

For the eye to detect a form of a specific color, an edge is created by focusing the image on the mosaic of receptors. Through the constant motion of the eye, the edge moves across the receptors in a consistent manner. An edge is the basic element in the perception of form. It can be created by adjacent areas which differ in brightness, color, or both. Edges are used to guide the accommodation mechanism which brings images into focus on the retina. Recent research has shown, however, that edges formed by color differences alone with no brightness difference, such as a red circle centered on a large green square of equal brightness, are poor guides to accurate focusing. Such contours remain fuzzy and unsharp. For sharp focused images it is necessary to combine color and brightness differences.

Another important attribute of visual photoreceptors is that they adjust their level of sensitivity to the overall light level. We observe this phenomenon when entering a bright or dark room from an area of intermediate illumination. Some time must pass for the visual system to adjust. Consequently, the perceived brightness of objects will depend opon the adaptive state of the eye. General increases in adaptation level improve color discriminability.

For the photopigments to respond to incoming light a minimum intensity level of light is required. Additionally, the response level is dependent upon wavelength. This dependency can be anticipated from the curves of figure 5. The overall level of sensitivity is governed by the sum of the output of the "red" and "green" channels. Their response dictates the perceived brightness of a color. Consequently, the visual system is most sensitive to the center of the spectrum with decreasing sensitivity towards the spectral extremes. This means that a blue or red must be of much greater intensity than a green or yellow to be perceived. Similarly, equal energy reds may not appear equally intense.

The changes in visual sensitivity as a function of wavelength make it difficult to equate colors in terms of brightness. Typically one expresses brightness in terms of *luminance:* a

scale in which the energy of the light is corrected for the eyes' wavelength sensitivity. Unfortunately the luminance value provides only a rough approximation of the actual perceived brightness.

We have already mentioned the loss of color sensitivity in the periphery of the retina. Interestingly our visual systems are able to detect yellows and blues further into the periphery than reds and greens. Also, the very center of the retina, while capable of high acuity, is practically devoid of cones with blue photopigment. The result is a "blue-blindness" for the central fovea which manifests itself with the disappearance of small blue objects when they are fixated upon. Figure 6 maps the color zones of a typical retina.

After the Retina: The bundle of nerves collectively called the optic nerve is made up of fibers which connect to the photoreceptors. The first way station along the optic nerve path is the *lateral geniculate body*. Here a re-evaluation of the output from the photoreceptors takes place, that is, the information from cones containing the three photopigments is recombined. Figure 7 provides a schematic outline of the way in which the recombination takes place. Notice that the original three channels from the retina, called red, green and blue for simplicity's sake, form three new "opponent channels." One channel signals the red to green ratio while the second signals yellow to blue. These two channels provide the color signal with the final channel indicating brightness. Again we find a bias against the blue photopigments in that the perception of brightness and, hence, edges and shapes is signaled by the red and green photopigment.

The lack of participation of the blue photopigment in brightness perception means that colors differing only in terms of the amount of blue will not produce sharp edges. Thus adjacent mixtures with a given percentage of red and green which differ only by the amount of blue will produce a fuzzy border.

The neural organization into opponent channels manifests itself in a number of ways. The retinal color zones are one example in which the opponent colors of red and green and yellow and blue are linked together. Although we will consider perceptual aspects of color in a later article, one obvious outgrowth of the opponent process organization of human vision is the impossibility of the visual combination of opposing colors. Thus we cannot experience redish green or yellowish blue.

Obviously the signals from opponent process cells continue on to the cortex of the brain. It is this aspect of the process of color vision which we understand the least. Specialized cells encode the information in order to allow the vast expanding of color experience.

Color Blindness: It is unfortunate that we use the term color blindness to summarize the variety of color deficiencies which beset about 9% of the population, as only a tiny proportion of the color deficiencies produce a true blindness for color. Such persons are called *monochromats* and usually experience several visual problems such as foveal blindness.

Although all of the causes of color deficient vision are not known, some stem directly from the cones and their photopigments. Perhaps the best known is the so-called red-green deficiency of *dichromatism*. In reality this form of color deficiency is produced by the lack of either the red or the green photopigment. Obviously such persons would experience difficulty in discriminating any color which depended upon a ratio of red to green photopigment (see figure 5). Thus two distinct forms of color deficiency produce similar color discrimination problems. They do differ, however, in the perception of brightness as long wavelength stimuli appear much darker to the individual lacking the red photopigment. A relatively rare form of color deficiency exists in which the blue photopigment is missing.

More common among the color deficiencies are those individuals whose photopigment response functions (figure 5) deviate significantly from normal. In one form the red photopigment's peak lies very close to that of the green while in another the green is shifted towards the red. The net result is a reduction in the individual's capability to distinguish small color differences, particularly those of low brightness. Such variations may be extreme cases of the normal variability between persons with regard to the photopigment responses. These variations account for the differences between individuals in the sensitivity to certain colors. In fact one can explain a common phenomenon in which persons differ on whether a given color is blue or green. Notice on figure 5 that the blue photopigment drops sharply in its sensitivity at 500 nm. Whether or not a color is signaled as blue or green will depend upon the point at which the blue and green curves cross. A small shift in the blue on the green photopigment curve would change the cross-over and hence the point at which the ratio of blue to green favors one or another.

Using Color Effectively

An understanding of some of the fundamental principles of human color vision allows us to derive some guidelines for the proper use of color on a visual display.

Avoid the simultaneous display of highly saturated spectrally extreme colors

Our research* has shown that colors on a typical display such as the 4105, 4113, or 4115B induce the expected wavelength-dependent changes in accommodation. The changes, however, are of lower magnitude than for spectral lights. For example reds, oranges, yellows, and greens can be viewed without refocusing, but cyan and blues cannot be viewed at the same time as red. In order to avoid frequent refocusing, which may cause visual fatigue, extreme color pairs such as red and blue or yellow and purple should be avoided. The amount of refocusing also depends upon the purity of the colors: desaturating the spectrally extreme colors such as red, blue, and purple, reduces the need for refocusing.

Pure blue should be avoided for text, thin lines and small shapes

The visual system is just not set up to handle detailed, sharp short wavelength stimuli. A number of reasons exist such as the inability of the eye to focus on blue, the blue blindness of the fovea and the absorption of short wavelength light in the eye itself. By the same token blue, for all the same reasons, makes an excellent choice for a background color. Additionally the sensitivity of the retina shows that blue is perceived clearly out into the periphery of the visual field making it a good background for large fields.

Avoid adjacent colors which differ only in the amount of blue

Because the short wavelength photopigment does not contribute to the perception of brightness, edges which differ only in the amount of blue will appear indistinct.

Older operators will need higher brightness levels to distinguish colors

The overall sensitivity of the eye is reduced with age. Coupled with a loss in the transparency of the media in the eye, it is wise to avoid low luminance colors depicting subtle differences.

Colors will change in appearance as the ambient light level changes

Naturally a display will change in color if viewed under differing kinds of light - fluorescent, incandescent or daylight. It will also change in appearance as the light level is increased or decreased. On one hand, a change due to an increase or decrease in contrast occurs, and on the other, due to the shift in the sensitivity of the eye.

*G. Murch, "Visual accommodation and convergence to multichromatic display terminals," *Proceedings of the Society For Information Display,* 24 (1983): pp. 67–72.

The magnitude of a detectable change in color varies across the spectrum

Based on the sensitivities of the photopigments it is not surprising that small changes in extreme reds and purples are more difficult to detect than changes in other colors such as yellow and blue-green. The visual system also does not readily perceive changes in green. The photopigment sensitivities (figure 5) are such that fairly large changes in wavelength produce relatively small changes in the ratios of the photopigments. Hence the discriminability of colors in the middle of the spectrum is reduced as well.

Difficulty in focusing results from edges created by color alone

The accommodating mechanism depends upon a brightness difference at an edge to effect clear focusing. Multi-colored images, then, should be differentiated on the basis of brightness as well as color. This need creates a problem in that the assessment of brightness is difficult. The specification of different luminance levels for adjacent colored segments does not solve the problem as luminance is a poor prediction of the perceived brightness of the colors on a visual display. In one of our studies we found, for example, that the luminance of a white square had to be even 300% higher than an adjacent blue square in order for them to be equally bright.

Avoid red and green in the periphery of large scale displays

Due to the insensitivity of the retinal periphery to red and green these colors, in saturated form, should be avoided, particularly for small symbols and shapes. Yellow is a good peripheral color as is blue. Although the latter, as previously mentioned, should not be used for text and thin lines. Again blue makes a good background color.

Opponent colors go well together

The opponent colors of red and green on one hand and yellow and blue on the other make good combinations for simple color displays. The opposite combinations produce poorer images.

For color deficient observers avoid single color distinctions

The most extreme forms of color deficiency involve the loss of either the red or green photopigment. A display utilizing a color mixture series in which one color, say red, is varied while the other two are held constant will produce problems for the color deficient observer. Mixture colors, then, should differ by a change in at least two of the three colors. As individuals differ markedly in their color sensitivity, very small subtle differences in color should be used with caution. Ironically a monochromatic display which uses gray level to distinguish elements may prove more difficult for the color difficient observer than a color display. This is due to the reduced brightness sensitivity that typically accompanies color deficient vision.

We have reviewed some basic principles of human color vision and have derived some functional relationships that should improve the visual effectiveness of the display. The usefulness of a complex instrument such as a color display depends, in part, on the degree to which it is engineered to meet the needs of the sensory system of the user. Color is a powerful tool, which can be used effectively.

A second paper will appear in the spring issue of *TEKniques* in which we consider the process of human perception – the experience of color – and develop additional principles for the effective use of color.

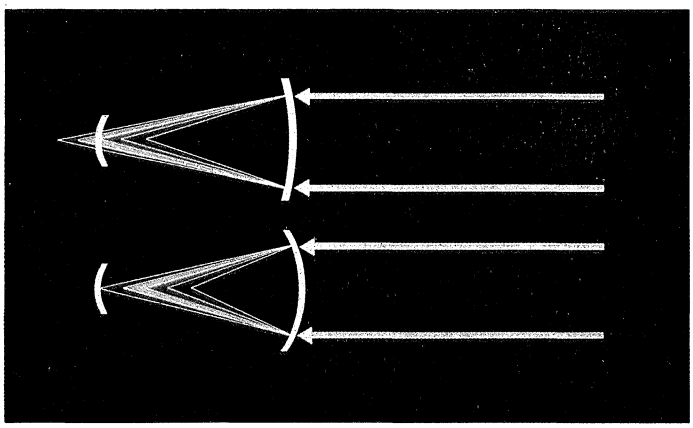

Figure 4. The lens of the human eye accommodated to the middle (green) of the spectrum (top) and to the long wavelength of the spectrum (bottom).

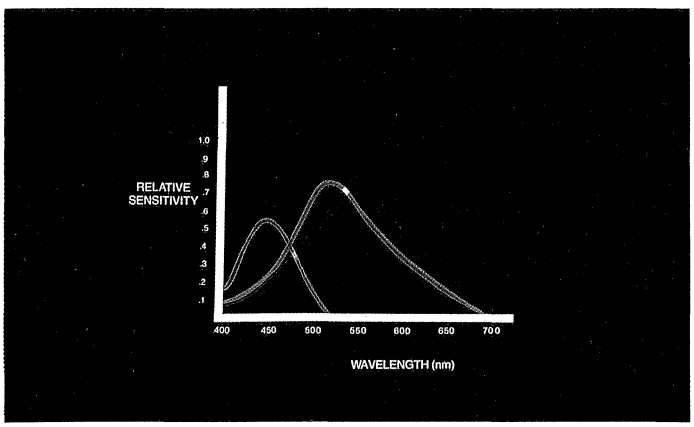

Figure 5. The relative response sensitivities of the three classes of photopigments in the normal human eye.

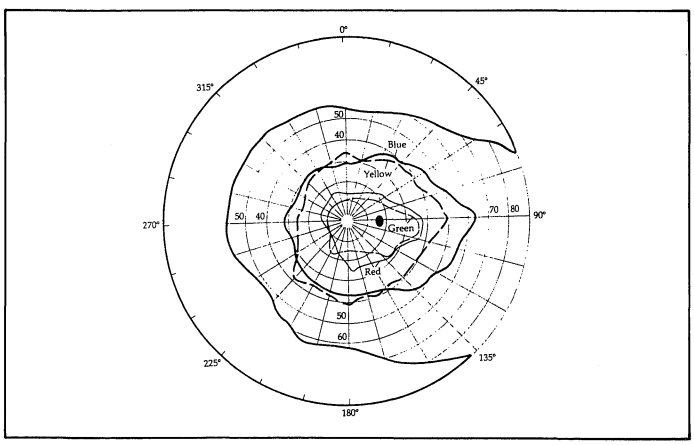

Figure 6. The zones of color sensitivity for the normal human eye.

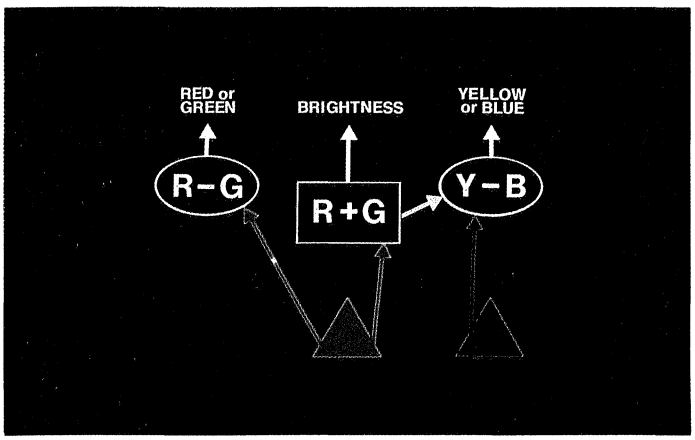

Figure 7. The processing of color input into opponent process channels.

Which 4100 Series Terminal for You?

by Joel Spinhirne
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Which Tektronix 4100 Series terminal – 4105, 4107, or 4109 – is best for your application?

First, let's take a look at features common to all members of the 4100 Series. Each terminal acts like two terminals in one package – a graphics terminal responding to Tektronix PLOT 10 commands and an alphanumeric terminal responding to the full ANSI X3.64 full-screen editing command set. In addition, Tektronix added the full set of VT100* extensions to the ANSI commands. Text and graphics each use their own display controller within the terminal. A push of the Dialog Key lets you switch between the two or, of course, both can be displayed simultaneously.

All members of the 4100 Series use high-contrast color displays that eliminate flicker by completely refreshing the screen sixty times a second. Many terminals use a 30 Hz interlaced display that refreshes the screen at half the rate of the 4100 Series. The resulting flicker soon becomes tiring and causes eye strain.

All 4100 Series terminals use the same keyboard. Features include a joydisk for controlling cursor movement, a ten-key numeric pad, and a VT100 type layout. Every key, with the exception of Ctrl, Shift, and Caps Lock, can be redefined by either the operator or host system.

Comparing the ANSI features of the 4100 Series is easy. The 4105, 4107, and 4109 are essentially identical in this respect. The only difference is that the 4107 and 4109 can display thirty-two lines of text versus the 4105's thirty lines.

Choosing from 4100 Series graphics features is a little more difficult. All three terminals require that the host system specify graphics locations in a 4096 × 4096 coordinate space. The terminals then display the graphics with their own pixel resolution. Table 1 outlines the differences in displays.

The 4107 and 4109 have exactly the same PLOT-10 graphics command set (and, of course, the same ANSI command set). When you specify a color to the 4107, it selects the closest match from its palette of 64 colors. The 4109 selects a match from its palette of 4096.

The 4105 can mimic many of the more sophisticated features of the 4107 and 4109, but it needs some help from your host system. The 4107 and 4109 have full segment capability. This means that graphics can be manipulated locally at the terminal without help from the host. Your display, or a named portion of it, can be rotated, scaled, and made visible or invisible.

Segments permit local zoom and pan operations on the 4107 and 4109. Remember that the host specifies locations to 4100 Series terminals in a 4096 × 4096 space. The user can view this high resolution at any time by zooming in on a portion of the display and by moving (panning) the enlarged view to different areas of the display. Segments and internal 4107/4109 software let the user do this without help from the host.

The 4105 also has the ability to display the details of the 4096 × 4096 graphics space. Either the host or operator can select the area (window) of the graphics space to enlarge. The host then retransmits the display and the 4105 tends to enlarging the selected area.

Other features provided locally by segments can also be provided by the host. Tektronix PLOT-10 Interactive Graphics Library provides routines for the segment features.

The 4107 and 4109 also give some help with text in graphics displays. They provide user-definable fonts and stroke precision text that the 4107 or 4109 can display at various slants. The 4107 and 4109 retain the scalable, rotatable block-style graphtext that is so popular in the 4105.

All 4100 Series terminals offer RS-232-C communications to the host and a parallel port for connecting the 4695 Color Graphics Copier. In addition, the 4107 and 4109 offer two extra RS-232-C ports for connecting auxiliary devices such as tablets and plotters. The 4109 has 60 Hz non-interlaced video out.

When choosing a 4100 Series terminal, look at your application and determine how much graphics manipulation is required. Assess the value of having a terminal such as the 4107 or 4109 that can handle these tasks on its own.

Remember the Tektronix commitment to compatibility. A 4105 application will run without any programming changes on a 4107 or 4109. The 4105's subset of 4107/4109 commands lets you transfer many 4107/4109 applications to the 4105.

This compatibility carries beyond the 4100 Series. Applications can transfer upwards to terminals such as the 4115. Perhaps more exciting, with few additions, older 4010-type applications can be moved to the 4105, 4107, or 4109. Low-cost Tektronix color graphics is ready and waiting for your application.

Table 1
4100 Series Display Comparison

	4105	4107	4109
Screen Size (diagonal)	13 in	13 in	19 in
Resolution	360 × 480	480 × 640	480 × 640
Color Palette	64	64	4096
Simultaneously Displayable Colors	8	16	16

*VT100 is a registered trademark of Digital Equipment Corporation.

4105 Plays Major Role in Colorful User Interface

Advanced use of color and graphics enrich a user interface for the Tektronix 8560 Series Multi-User Software Development Systems, VAX minicomputers and the Tektronix 8540 Integration Unit. Using the Tektronix 4105 Color Terminal, the Tektronix ColorKey+ interface skillfully links an engineer to the tools provided by the systems. Special features of the 4105 Color Terminal combined with intensive ergonomic research conducted at Tektronix[1] and other research sites contribute to the success of this friendly communication link.

Communicating through Color

Judicious color coding helps the user identify functional areas of the 4105 Terminal's screen while minimizing eye fatigue (figure 1). Blue defines the user's work area, a natural choice for a background because the eye doesn't focus on this hue. Blue is also visible under high ambient light conditions, but without a tendency to glare. White print against the blue background is easy to see, reducing eye strain.

Across the bottom of the 4105 screen, the user is presented a set of "current key labels" that are associated with eight soft (programmable) keys on the 4105 keyboard. Easily visible in peripheral vision, yellow is used to shade the simulated keys. Yellow also contrasts pleasantly with the blue in the user's work area.

Prompts, commands and parameters are visible on a background of rust, compatible with the blue user area and the yellow keys.

Red, the universal warning color, directs the user's attention to error messages or to critical elements of a task.

ColorKey+ takes advantage of the two display planes of the 4105 Color Terminal. Because the graphics plane and dialog plane operate independently, the user can be provided with an on-line reference card for the current task. When one of the software tools is called, its particular reference card is loaded into the graphics plane. A quick press of one key switches the user between the work area (dialog plane) of his current task and the reference card (graphics plane) explaining the aids for the task.

At the invocation of ColorKey+, for example, the reference card contains a "road map" of the interface, identifying the major software development tools and the pathways to their various components (figure 2). When using the line directed editor tool, color quickly guides the user through the reference card.

When using the line directed editor tool, color quickly guides the user through the reference card.

Key words commonly used by software de-

Figure 1. Functional areas of the 4105 display are readily discernible by their colors.

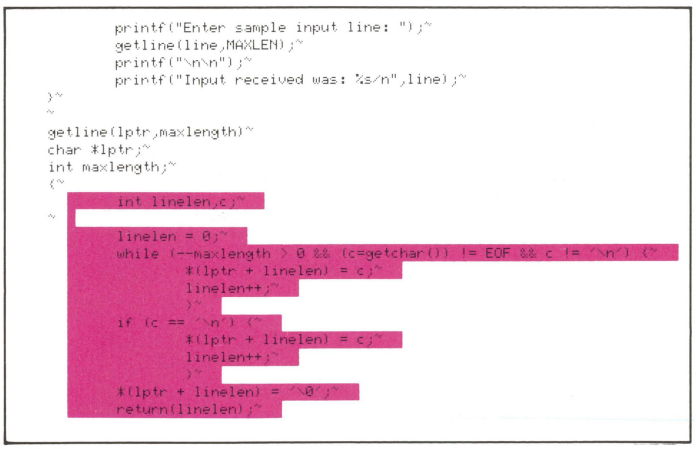


Figure 3. Red highlights the portion of text being deleted during an edit function.

Figure 2. The reference card for ColorKey+ depicts the pathways to the 8560/8561 software development tools.

Figure 4. The key labels on the 4105 display identify the top layer of the interface hierarchy: the major tools within the system. Pressing the corresponding key on the 4105 keyboard will select that tool.

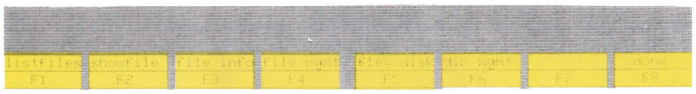


Figure 5. The key labels on the 4105 screen change to show the next path available, i.e., the major functions of the FILES tool.

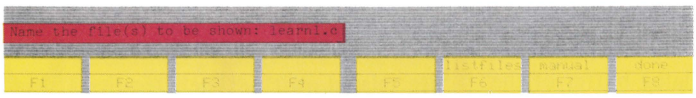


*Figure 6. The soft keys are reprogrammed for operations within a selected function as reflected on the 4105 key display after **SHOWFILE** key pressed.*

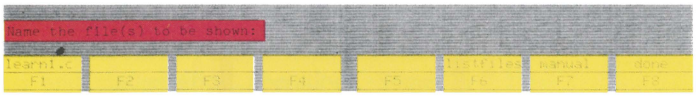


*Figure 7. If the user presses **SHOWFILE** again he may press soft key F1 to retain the current file name for the parameter or type in a new file name.*

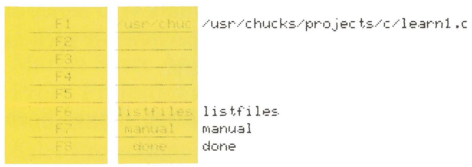


Figure 8. The file name is too long for the F1 key label space, so only a portion is shown. An expand key function displays the keys and their complete labels to the side.

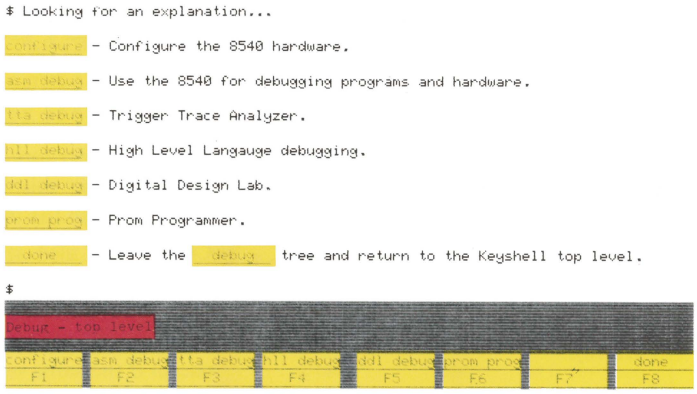


Figure 9. A key may be pressed to explain the key labels.

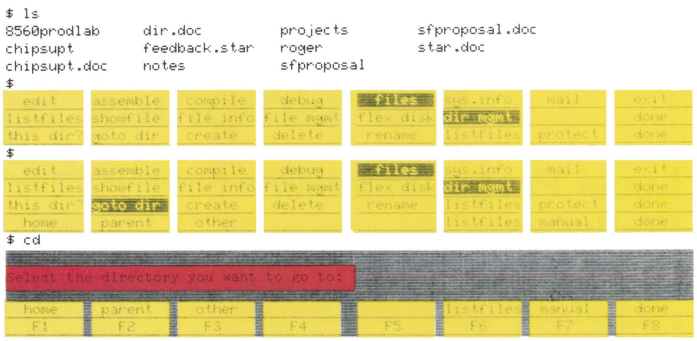


Figure 10. Step 1: The list command was entered manually (1s) and the listing obtained.

*Step 2: The user pressed the **where am I** key which displays the interface block showing the pathway in gray. The **files** key and **dir mgmt** keys have been pressed. It also displays the functions available at the current level, i.e., **this dir?, go to dir** and so forth.*

*Step 3: The user then pressed the **go to dir** key followed by the **where am I** key. The next block reflects this path.*

*Step 4: The user is prompted for the directory and the key labels identify their new functions at this level of the interface. Notice ColorKey+ displays the command which could have been entered manually (cd) instead of pressing the **go to dir** function key.*

---

signers for a particular operation are displayed in yellow. The color attracts the user's attention. Once focused on the keyword, the user's eyes are drawn by the hue of orange to the command syntax for that operation. Clarifying information is displayed in green. Blue points out the user's options.

During execution of a task, for example, a cut and paste operation in the editor, red identifies the test being manipulated (figure 3).

Although the colors in ColorKey+ have been selected for their ergonomic values, users may choose their own colors with the 4105 Terminal's Interactive Color Interface.[2] By redefining the color map in the 4105, users can tune the colors to their own preferences, or change colors periodically - weekly, daily, or even hourly - to stimulate interest or reduce fatigue.

Accessing the Tools

ColorKey+ provides two routes to the 8560/8561 software development and 8540 debugging tools. Pressing the soft keys on the 4105 keyboard gives the user a simple and systematic method through the structured interface. As each level of the interface hierarchy is reached, ColorKey+ updates the labels on the 4105 screen, thus, informing the user of the current functions available on the keyboard (figures 4, 5 and 6).

The 4105 display, thus, guides the user on a self-explanatory path through the entire system of software and hardware tools.

A bonus is the extra level of intelligence ColorKey+ adds to make the interaction even faster. Whenever a command parameter is typed (for instance the file name in figure 6), ColorKey+ retains the parameter, assigning it to one of the unused soft keys. The next time the user selects that function, the last entered parameter for that function will be displayed as one of the soft key labels. The user then has the option of pressing the soft key to retain the current parameter of typing in a new parameter (figure 7).

ColorKey+ provides an "EXPAND" key which may be pressed at any time to display the full label of a key (figure 8). The user need never guess at a key label.

Pushing the *EXPLAIN* key on the 4105

displays the key labels and their meanings on the screen (figure 9).

While the structured interface of ColorKey+ permits the user to easily reach the tools by using the 4105 soft keys, it also permits a more direct route: commands can be entered manually.

To help the user learn these commands, ColorKey+ displays the actual command that corresponds to the soft key selection (figure 10).

ColorKey+ allows the user to freely mix interface commands (soft keys) with manually entered commands. A user, therefore, can bypass ColorKey+ at any time to interact directly with the system, and then use ColorKey+ when needed.

A good memory jogger, especially after an extended interruption, is the *WHERE AM I* key. Pressing this key displays the user's route through the interface (figure 10).

ColorKey+ also stores the command sequence history in the dialog buffer of the 4105, which can be scrolled backward or forward (up to 49 lines). This is particularly useful if the same sequence of commands is to be used again, but with different parameters. The user simply scrolls through the command history, edits the parameters, and the executes the command sequence with the new parameters.

Color - Key - Plus = Friendly Interface

Optimized for the Tektronix 4105 Color Terminal, ColorKey+ integrates color, graphics and soft keys to put a friendly user interface at the user's fingertips.

[1]See related article "The Effective Use of Color" in this issue.

[2]The 4105 Interactive Color Interface was described in *TEKniques* Vol. 7, No. 2.

IDD Graphics Systems Workshops

Local Programmability Workshops

Spending one week in a Tektronix workshop getting to know Local Programmability is the equivalent of three to six months of on-the-job education. The Tektronix Local Programmability Workshop is a hands-on course which teaches the FORTRAN programmer the basics of Local Programmability, its capabilities, and support libraries. The student will understand the operation of Tektronix graphics terminals. Tablet, plotter, copier and disk interaction with Local Programmability and the terminal is thoroughly reviewed. Basic and advanced data communications concepts are taught. The small class size of 12 students allows for individual attention. The schedule for the first part of the year is:

Gaithersburg, MD	Santa Clara,CA
April 16-20	Feb. 6-10
	Mar. 19-23
Boston, MA	May 7-11
Feb. 27-Mar. 2	
May 21-25	

Computer-Aided Drafting Workshops

A comprehensive workshop gives PLOT 10 Computer-Aided Drafting and PLOT 50 2-D Drafting users a jump on productivity. Taught by Tektronix professionals, the one week workshop equips the students with knowledge and skills usually gained only through months of experience. Instruction in optimum use of the Drafting system combined with "hands-on" training tailored to the user's environment accelerates the individual's effectiveness.

Course Objectives/Content:

The workshop consists of lectures and laboratories emphasizing efficient working habits and a working knowledge of all system functions and capabilities. Specific topics which will be covered in the workshop are:

- Reviewing and using all functions
- Generation of quality ink drawings
- Digitizing drawings
- Geometric operations (lines, arcs, line smoothing)
- Note generation and editing
- Workset usage
- Blanking
- Drawing modifications
- Drawing organization
- Uses and creation of symbols
- Configuring equipment

The workshop is not intended to *introduce* the student to drafting.

Enrollment in a workshop is limited to ensure each participant receives the maximum benefit. The following workshops will be taking place in the next few months. Classes may also be scheduled at a customer site.

Gaithersburg, MD	Santa Clara, CA
Mar. 5-9	May 21-25

IGL Workshops

An intensive workshop will give programmers or project managers a familiarity with IGL which will speed them on their way in program development. Instruction in the proper use of IGL routines eliminates the need for experimenting, permitting faster, more effective graphics applications design. Effective training results from keeping class size small and focusing on tasks typical of a user's work. The workshop features hands-on use of the entire Tektronix 4110 Series of graphics terminals, and peripherals such as tablets, plotter and copiers.

Several spring workshops have been scheduled.

Gaithersburg, MD	Santa Clara, CA
Apr. 2-5	Jan. 30-Feb. 3
	Apr. 30-May 4

4050 Series Workshops

Tektronix desktop computers are ideal tools for improving operating effectiveness. Although satisfied with the job the Tektronix graphics system is doing now, the user probably isn't aware of all its capabilities and how they can be used to increase efficiency.

To help the user get the most out of the 4050 Desktop Computer, Tektronix provides workshops combining classroom lecture with extensive supervised laboratory sessions. Each day the students will exercise the problem-solving concepts presented using a complete desktop computing system.

The 1983 Schedule follows:

Gaithersburg, MD	Santa Clara, CA
Jan. 30-Feb. 3	Feb. 20-24
Mar. 19-23	Apr. 23-27
May 7-11	

For additional information regarding these workshops, or to register, please contact:

Tektronix, Inc.
ATTN: Customer Training Registrar
Mail Station 63-574
P.O. Box 1000
Wilsonville, OR 97070

(503) 685-3808

SuperCalc^2 ™ : Spreadsheet Program for Local Programmability

One of the most advanced electronic spreadsheet packages available may be installed on the Tektronix 4110B Raster Terminals with Local Programmability or on the Tektronix 4170 Processing Unit which supports Local Programmability for the Tektronix 4105, 4107 or 4109 Terminals.

Developed by Sorcim®, SuperCalc^2 is a powerful but friendly aid for financial, business and mathematical operations. Some common uses are:

- Balance Sheets
- Cash Flow Analysis/Forecasting
- General Ledger
- Inventory Control
- Job Cost Estimates
- Market Share Analysis
- Profit Projections
- Budgeting and Control
- Sales Projections and Records

Editing, formatting, storage, recalculations and printing are just a few of the functions of SuperCalc^2. It can consolidate two spreadsheets into one, sort rows or columns in alphabetic or numeric order, interchange data with other packages and perform a host of other functions. Dual windows simultaneously display results and formulas.

	A	B	C	D	E	F
1	Date	4/15/1983				
2						
3		March	June	Sept	Dec	Year
4						
5	Sales	$3,000	$5,000	$4,500	$6,000	$18,500
6						
7	Cost of Sales	1,800	3,000	2,700	3,600	11,100
8						
9						
10	Gross Profit	1,200	2,000	1,800	2,400	7,400
11						
12						
13	Selling Expense	450	750	675	900	2,775
14	Gen & Admin Exp	360	600	540	720	2,220
15						
16	Net Before Tax	390	650	585	780	2,405
17	Income Tax	179	299	269	359	1,106
18						
19	Net Income	$211	$351	$316	$421	$1,299
20						

SuperCalc^2 ™ spreadsheet software is available for Tektronix 4110B Series raster terminals and all 410X Series terminals with Local Programmability.

Its ease of use belies the capabilities of SuperCalc^2. A first time user can create a spreadsheet in 10 minutes or less. The new user is able to enjoy the full benefits of SuperCalc^2 because it displays the options while it prompts for each step. A helpful feature called AnswerScreens explains the options available at any step in response to a question mark entered by the user. A user may also invoke a tutorial.

To gain the best color presentations on the Tektronix terminals, Tektronix has done significant work on the device drivers for SuperCalc^2 resulting in full color spreadsheets.

Data interchange is also a feature of the low cost business package. CP/M-86® programs as well as other business packages running under Tektronix Local Programmability may exchange data with SuperCalc^2.

For more details on this powerful spreadsheet program, ask your local Tektronix sales engineer for information on: 4100P22 SuperCalc^2.

Local Programmability Gains Word Processing Power with WordStar®

WordStar® brings the power of a dedicated word processing system to Tektronix raster terminals equipped with Local Programmability. The defacto industry standard for microprocessor word processing systems, WordStar aids professional writers, programmers, text editors, office administrators and clerical staff to produce error-free, professional looking documents.

WordStar is a screen editor. It shows exactly what will be printed: margin widths, line justification, line and word spacing, indentations and so forth. Selective margination permits cutting around pictures.

Developed by MicroPro, WordStar is designed for non-technical users and is equipped with a full range of editing commands, print options and help menus. Powerful editing commands allow the user wide flexibility in moving, deleting, copying, replacing or inserting characters, words, lines or blocks of text. Print commands automatically center, indent, underline, boldface text. Sub- and super-scripting, and variable line height and character pitch extend WordStar's versatility.

On-line help menus reduce the need for referring to a manual.

File management is simple for non-technical users, and documents can be written on one terminal and transferred to another without program modification.

4100P27 WordStar is the second member of a family of compatible products for Tektronix raster terminals. Like SuperCalc^2, WordStar supports a common data format enabling data to be interchanged from one package to another, and between user-written CP/M-86 programs.

With WordStar Tektronix 4112B, 4113B, 4115B, 4105, 4107, and 4109 Terminals with Local Programmability have all the functions of a word processing system, plus graphics, for a lot less than a word processing system alone.

PLOT 10 Computer Aided Drafting: Standalone 2-D Drafting for Tektronix Terminals

A TekniCAD configuration could include a Tektronix color raster 4107 or a 4109 Computer Display Terminal paired with the Tektronix 4170 Local Graphics Processing Unit and an optional 4957 Graphics Tablet.

To help engineers, scientists, drafters and technical illustrators in their drawing tasks, Tektronix has developed a versatile two-dimensional drafting package for the Tektronix 4110 and 4100 Series Terminals. Known as PLOT 10 Tektronix Computer Aided Drafting (TekniCAD), it runs under Local Programmability* to provide standalone drafting at a very low cost.

The family-wide compatibility of TekniCAD and the Tektronix 410X and 411X computer graphics terminals lets you match the hardware/software to the drafting application.

The 4107 Terminal features a 15-inch screen and a 640×480-pixel displayable matrix. Up to 16 colors can be selected from a 64-color palette. With a 19-inch display, the 4109 Display Terminal would be a practical choice when your drawings include small or tightly spaced objects.

When the application involves high-density images, your TekniCAD configuration could include a high performance terminal, such as the 4115B. Capable of producing 256 displayable colors from a palette of 16 million, the 4115B is well suited for the creation of multi-level electronic circuit drawings. Superior line quality is assured with display resolution of 1280 by 1024 pixels.

TekniCAD software can also be teamed with either the 19-inch 4114B or 25-inch 4116B DVST display terminal for applications that demand unmatched resolution.

Written in FORTRAN-77, TekniCAD may be installed on the 4170 Local Graphics Processing Unit which provides Local Programmability to the 4107 and 4109 Terminals, or the 411X Local Programmability system. Both employ the industry-standard CP/M-86® ** operating system.

Terminal Features Integrated

TekniCAD keeps pace with your drafting needs by accessing the features of Tektronix display terminals. Using the terminal's refresh graphics, TekniCAD lets you move objects (symbols and text) freely around the screen until you're satisfied with their location. Tektronix color displays can highlight drawing items in color allowing quick identification of the item being drawn or edited.

Accessing the terminal's zoom/pan function, TekniCAD can fill the entire screen with any portion of the drawing you specify. Because the system's zoom/pan facilities recompute the coordinate information of the area to be enlarged, you see a more detailed image. The segment feature which allows each drawing item to be stored as a local segment, permits extremely fast local display redraws. On the 4115B, this enables TekniCAD to provide you with the capability to zoom and pan dynamically using the thumbwheels.

The Interactive Color Interface allows you to define the color of 15 pens, and of everything

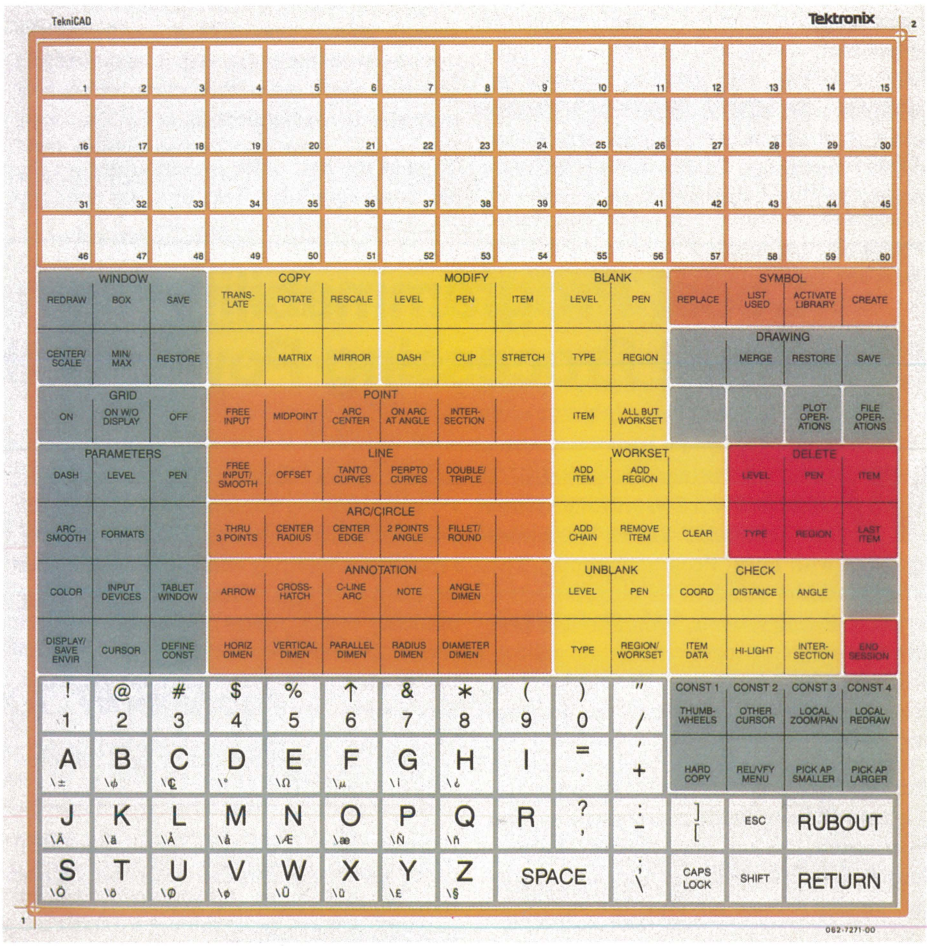


Figure 1. A separate 11-by-11 inch tablet menu with cursor device is available for making drawing selections. You can step through the same selection process by responding to on-screen prompts.

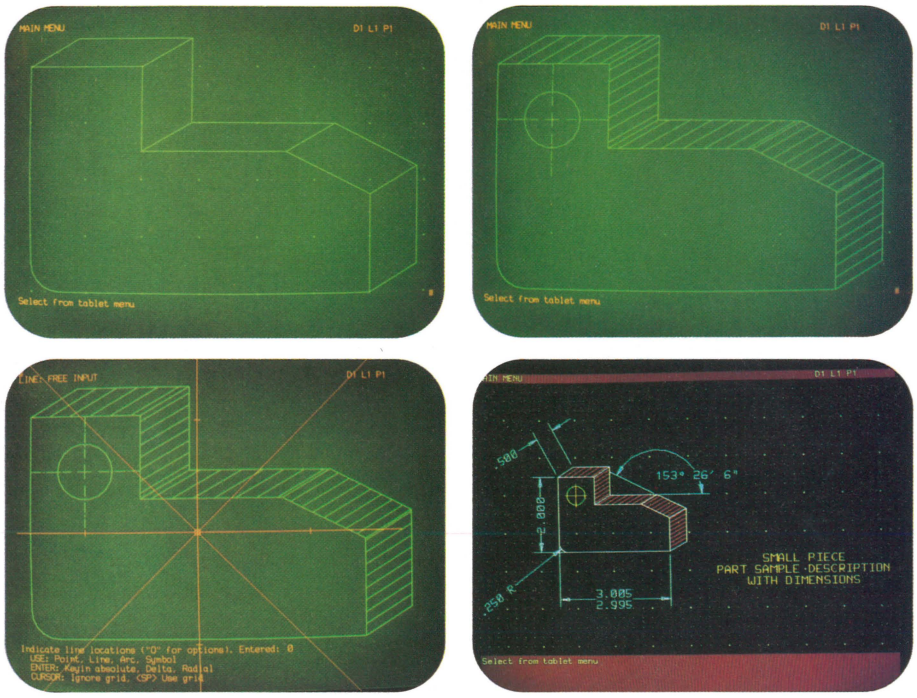


Figure 2. A) An object is drawn using a combination of the basic item types. The user-defined background grid is displayed to help position and size the figure. B) Crosshatching and symbols further define the object. C) The entire figure is defined as a workset. Then it is rescaled using one of the system's copy functions. D) The image appears on a color graphics terminal with annotation and dimensions highlighted in separate colors.

else you see on the screen such as the prompts, cursors and background. Hue, lightness and saturation (which map to gray levels on the 4112B Terminal) can be easily changed and specified dynamically with thumbwheels or joydisk.

Easily Mastered

TekniCAD is a responsive and comfortable tool. Interaction is through a tablet menu (figure 1) or on-screen menu which outlines the steps to follow when creating or editing a drawing. Concise, easily understood English prompts appear on the screen to inform you of the options available within a function. Selection steps that aren't desired can be skipped using the many programmed defaults.

You can define system parameters setting drawing sheet size, basic drawing unit (inches, feet, miles, etc.) scale and other parameters. Up to 15 pens can be assigned to different drawing items. The dash type may be solid, short dash, long dash, centerline or phantom. Either English or Metric units and sizes may be used.

Streamlined Procedures

TekniCAD helps you create and edit drawings with a minimum amount of error and duplicated effort (figure 2). Any image can be created by combining TekniCAD's eight basic item types (which are lines, points, arcs, notes, dimensions, arrows, symbols and crosshatch). The terminal's display quality assures smooth curves and well defined lines.

The TekniCAD concept of Free Input means you can enter drawing information anywhere on the screen. A background grid is always available to easily position and size drawing items.

Symbols, objects or subassemblies may be created once, then repeatedly copied in the drawing. TekniCAD's Copy and Modify functions allow you to move, mirror, matrix, rotate or rescale any individual item, a selected portion of any drawing, or an entire drawing. You can add dimensions, notes and crosshatching to define drawing features. Libraries of up to 60 symbols each store commonly used symbols for use in drawings. The number of symbol libraries allowed is unlimited.

TekniCAD permits drawings to be manipulated in ways that would be difficult or time consuming with manual drafting methods. Complex drawings may be separated into as many as 250 levels (layers) expediting drawing creation and revision. Common drawing elements such as geometry or dimensions can be assigned to different levels. For example, components of electrical work on one level, mechanical work on another, and so forth. Revisions affecting only one level can be done without impacting the others. The drawing may be manipulated by level, turning on or off levels in any combination. Only those levels containing the information of interest need be displayed avoiding unnecessary detail.

Blanking reduces the complexity of a drawing. You may display only a selected group of items speeding redraw and item selection.

Worksets aid in changing parameters on groups of items. For example, the level and line styles of several automobile components can be changed by assigning the components to a workset and changing the group, instead of each one individually. Worksets can be moved, rotated, scaled, etc., as a single unit. Up to eight worksets can be defined and the number of items in a workset is unlimited. For example, the entire drawing can be placed in a workset and moved around the screen (or "sheet").

Once a drawing is completed, it needn't be redrafted if used as part of another drawing. TekniCAD can integrate (i.e., merge) a stored drawing into a current drawing at any location, scale and rotation.

Flexible File Handling

TekniCAD's plot utilities support a wide range of plotters. The plot operations will send an entire display or selected drawing portions to a plotter.

File utilities organize and archive drawings for easy recall. Drawing file compatibility permits TekniCAD users to exchange drawings and display them on any of the compatible Tektronix terminals without revision. A program is included to transfer drawing and symbol files from previous Tektronix drafting software packages to maintain file compatibility with drawings created by PLOT 50 2-D Drafting users.

A General Purpose Tool

Compliance with International (ISO) and U.S. (ANSI Y14) standards frees you from having to relearn drawing conventions. The software is also flexible enough to be tailored to unique company standards.

Tektronix PLOT 10 Computer Aided Drafting software is a tool with multiple applications and multiple configurations. For hardcopy output, Tektronix high quality color copiers can be easily added as well as a variety of plotters.

Whether drawing worm gears, circuit diagrams, bridges, illustration documentation, or making presentation slides, TekniCAD enhances your drawing speed and accuracy.

*Local Programmability functions and components are described in *TEKniques* Vol. 7 No. 1.

**CP/M-86 is a registered trademark of Digital Research, Inc.

Low-Cost Graphics Input for Today and Tomorrow: Tektronix 4957 Tablet

by Mark Barnett
Tektronix, Inc.
Wilsonville, OR

For economical digitizing, connect the new Tektronix 4957 Tablet to your Tektronix 4107 or 4109 Color Graphics Terminal or to your 4050 Series Desktop Computer. Use it to transfer drawings or other graphics images from paper to computerized data bases, or to share menu display and selection tasks with your terminal's screen and keyboard; or use its cursor-puck to steer the cursor on your screen. Portable and smart, the 4957 Tablet fits readily into many graphics environments. Its low cost makes the tablet a logical tool for graphics input.

Convenient

Weighing just four pounds (1.8 kg) and packaged in a compact 16½ by 15½ inch case, the 4957 Tablet is truly transportable. The electronic hardware that controls the tablet fits right around the 4957's 11.7″ × 11.7″ active (i.e., sensing) area. This eliminates the need for separating the tablet control unit from the active area. An injection molded cover provides a tough, durable tablet surface which resists chipping and staining.

You can adjust the tablet's horizontal orientation from 0° to 20°. The four-button cursor-puck comes standard with each unit. A simple to use telephone-style jack attaches the cursor-puck (or optional stylus) to the tablet.

Maintenance is an occasional wash with a gentle detergent. Biasing, a familiar task for users of other tablets, is not required with the 4957 Tablet. The need for a grid of wires and the periodic chore of realigning them is eliminated because the active area of the 4957 is etched right into a printed circuit board.

Compatible

Special firmware drivers on the 4107 or 4109 terminals permit concise 4107 or 4109 Terminal commands to invoke complex 4957 Tablet functions. For example, using these terminal-based commands, you are relieved of many set-up details.

Because the terminal-based commands are compatible with most Tektronix 4110 Terminal-tablet commands, you can include the 4107/4109-4957 team in your current digitizing application without major software revision from the programs that ran your 411X terminal with its Opt. 13 tablet.

Capable

The 4957 Tablet, however, is not restricted to use with the 4107 or 4109 Terminals. Tablet-based commands provide a 4050 Series Computer or other host a pathway to the tablet's power. Because the tablet is programmable, the tablet's communications speed, digitizing mode, and resolution may be quickly changed to suit the graphics input task.

Although normally transmitting at 9600 baud, a special "autobaud" feature permits the tablet to run at any of the following speeds: 19200, 9600, 4800, 2400, 1200, 600, 300, 150, or 75 baud. It receives commands in ASCII 7-bit data format and sends data in binary 7-bit format, or, optionally, ASCII 7-bit format (the 8th bit is an odd parity bit). The 4957's use of DC1/DC3 flagging helps ensure that the host's buffer doesn't overflow.

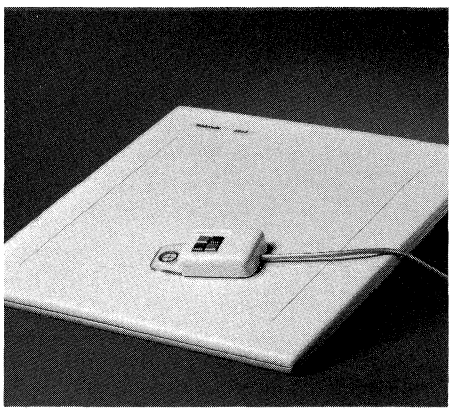
From one point at a time up to a continuing stream, coordinates can be collected from the tablet. Time and distance filters may be activated to reduce the amount of input: 2 to 90 coordinates per second; 1 to 1016 points per inch.

Testable

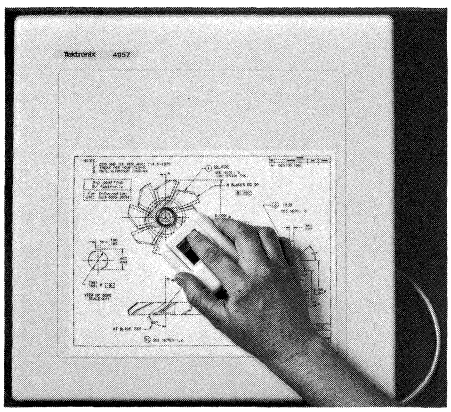
Each 4957 should operate for years without problems. However, to be safe, a built-in self test routine exists on the tablet to check its operation and report the results of that test to a host. The routine checks digital and analog circuitry and verifies cursor connection.

A Versatile Digitizer

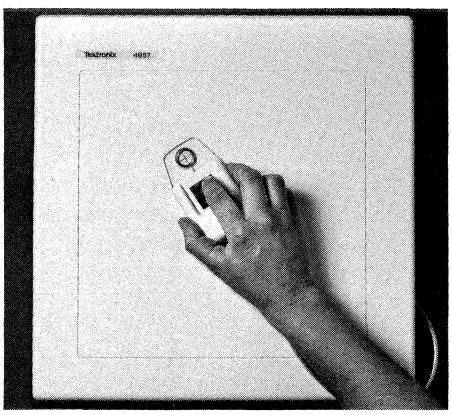
The new Tektronix 4957 Graphics Tablet provides you with a tool for low cost, good performance graphics input to Tektronix 4107, 4109 Terminals and other hosts with RS-232 ports.



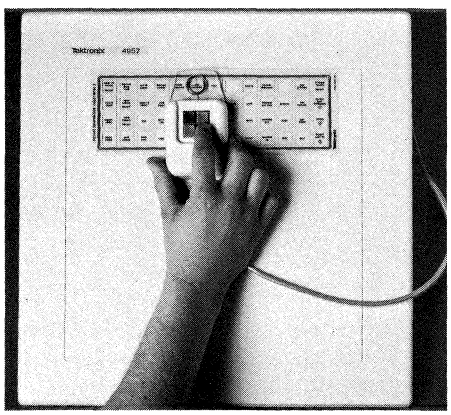
Tektronix 4957 Graphics Tablet



The 4957's high resolution surface and easy-to-view cursor crosshairs make it an effective tool in digitizing drawings of up to 11 in. × 11 in.



The mouse emulation mode provides a powerful solution to cursor-steering problems.



The flat-top surface and four-button cursor make the 4957 an ideal menu-selection device.

Option 3A for the Tektronix 4115B Terminal permits direct memory transfer between the 4115B and a DEC PDP-11 or the VAX* family of computers equipped with the DEC Unibus.**

**Registered trademarks of Digital Equipment Corporation*

Fast Image Display on 4115B Through DMA Option

While the RS-232-C interface between the Tektronix 4115B Color Graphics Terminal and its host computer transmits data at rates up to 19,200 baud, twice the speed of many terminals, an even faster data link is available. For users who have a DEC host with the DEC Unibus, Option 3A for the 4115B Terminal permits direct memory transfer between the 4115B and a DEC PDP-11 or the VAX family of computers.

Using the DMA link, Landsat and other inherently complex images can be displayed at realistic speeds.* Intermixing image displays with vector displays is practical, for example, overlaying the image of a mechanical part with its tolerence envelope, or a Landsat image with political boundaries.

DMA Transmits Five Data Types

Display generation speed depends on the type of data transferred on the DMA link. Five different types of data can be sent along the DMA with different levels of apparent performance and different levels of host software involvement.

For an understanding of where these data types fit, let's take a simplified look at how the 4115B builds a graphics image.

Graphics commands coming into the 4115B as *escape sequence* data along with their parameters are converted by the 8086 microprocessor to *display list* format and stored in 8086 memory. Control is passed to the Picture Processor which interprets the display list to create *pixel* data which is stored in the frame buffer (figure 1).

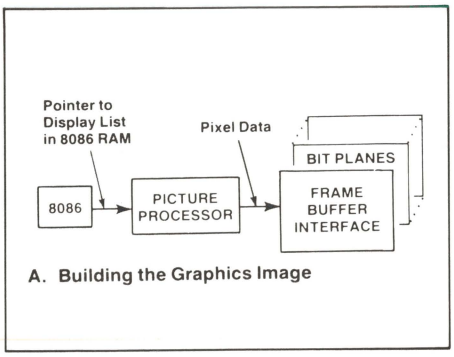


Figure 1. Building a graphics image in the 4115B entails a sequence of data conversion.

Escape sequence data and parameters defining surface color maps are converted by the 8086 microprocessor to *color map* data and stored in the Timing Controller's memory (figure 2).

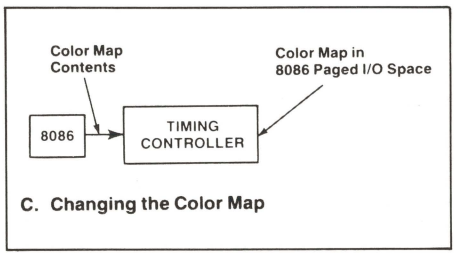


Figure 2. A separate memory holds the color information for the graphics image.

Escape Sequence Data is the kind of data normally output by Tektronix PLOT 10 software; it is often referred to as "Tektronix-compatible graphics data." Escape sequence data can be both transmitted and received through the DMA. To a user, its display rate will seem comparable to a data rate of 19 to 32 Kbps, because the 4115B's processor still has to convert this data into internal Display List format before it goes to the screen.

Pixel Data is transferred directly to the frame buffer. Because it requires the least intermediate processing by the 4115, pixel data is the fastest apparent transfer. How fast a pixel image is displayed is dependent upon its size and number of repeated pixels as in a solid panel fill. A 1.3 million pixel image that fills the screen of the 4115B can be transferred in three to six seconds, depending on other host and terminal tasks that take place concurrently. Pixel data can be both transmitted and received through the DMA.

Segments in Display List format can bypass the critical step of conversion from Escape Sequence data to Display List format in the 4115B. By doing so they can be transferred at an apparent rate that is about 20% less than that of internal display repainting (a 50,000 vector segment residing internally can be redisplayed in one second). This type of data can be both transmitted and received through the DMA.

Unretained Segments in Display List format is a long name for the Display List data that is rapidly displayed on the screen, but cannot be manipulated by the user or software. The apparent transfer rate is somewhat faster than Segments in Display List format because of reduced 4115B processing, and is approximately that of internal display repainting. This data can travel in only one direction: from host to terminal.

*For example, a $1280 \times 1024 \times 8$ bit full screen image can be transmitted to the 4115B in less than six seconds.

Color Map Data is generally not more than 1K in size and appears to be moved through the DMA in an instant. This data set can be transmitted bidirectionally.

The 4115B Option 3A DMA Interface supplements the standard RS-232-C interface; it does not replace it. Normal keyboard input and normal output directed towards the 4115B still flow through the RS-232-C lines, permitting handling of interactive traffic by the host's teleprocessing software and operating system. When the transfer of a large amount of data is desired, the user activates the DMA and accomplishes the transfer faster and with less host overhead than if moved through the RS-232-C connection. During most types of DMA transfers, normal terminal operations and communication through the terminal's host port are not interrupted.

How it Works

A DMA transfer is started by one of the 4110 Series device transfer commands:

<save>, <spool>, <copy>, or <load> (<spool> is more restricted in operation).

"DM:" as the source or destination device denotes a DMA transfer, and would be used to send Escape Sequence Data as well as other 4115 formats. The 4115B's node in this transfer is the *Processor Board* just as it is in RS-232-C communications.

Pseudo devices allow DMA transfer of raw picture data to or from four internal memory areas in the 4115B that demand specific data structures, bypassing normal terminal operations. A pseudo device, however, cannot participate in <load> or <save>.

"PX:" specifies the current pixel viewport as an input or output device, allowing Pixel Data to be read from or written to the frame buffer.

"SG:" specifies part or all of the retained segment list as an input or output device and transmits data in Display List format directly from or to the Picture Processor.

"DS:" specifies a non-retained segment (the vector display list) and may be used as an output device (host to 4115B) only. It is received by the 4115B's Picture Processor.

"CM:" specifies the color map as an input or output device. A color map RAM on the Timing Controller Board contains this data.

Where It Works

In a CAD environment where complex drawings are being constructed, modified and redisplayed continuously, sending the vectors in Display List format via the DMA will provide the rapid response that designers demand.

Graphics symbols created in the 4115B and saved in the host data base in Display List format can be quickly recalled and displayed in the 4115B through the DMA interface.

In any application using pixel data, the DMA exponentially speeds the display. And for applications which overlay the pixel image with vector data, the user has the option of transmitting the vector data through the RS-232 or the DMA depending on the application and vector quantity.

The DMA can also be used in animation applications, especially if the animated objects are in display list format. Double buffered frame-by-frame management works well in this task.

Although the conversion to the various data types is not a trivial task, it is well worth the effort for applications requiring maximum display speeds.

Drivers for DMA

Drivers that manage DMA handshaking and data transfer have been developed for two VAX operating systems. Both are available through the IDD Program Exchange at a nominal cost and are described in the "New Abstracts" section of this issue of *TEKniques.*

The VAX/VMS Driver is written for VMS version 3.3 but can serve as a reference for writing 4115 DMA drivers for other VMS versions. The VAX/UNIX (Berkeley) driver is written for UNIX version 4.1 bsd. It, too, can serve as a reference for writing 4115 DMA drivers for other UNIX versions.

These drivers support the transfer of data, but do not perform any graphic data conversion, such as Escape Sequence to Display List, and so forth.

Specifications for data in Display List and Pixel formats are described in the 4115B Option 3A User's manual accompanying the interface.

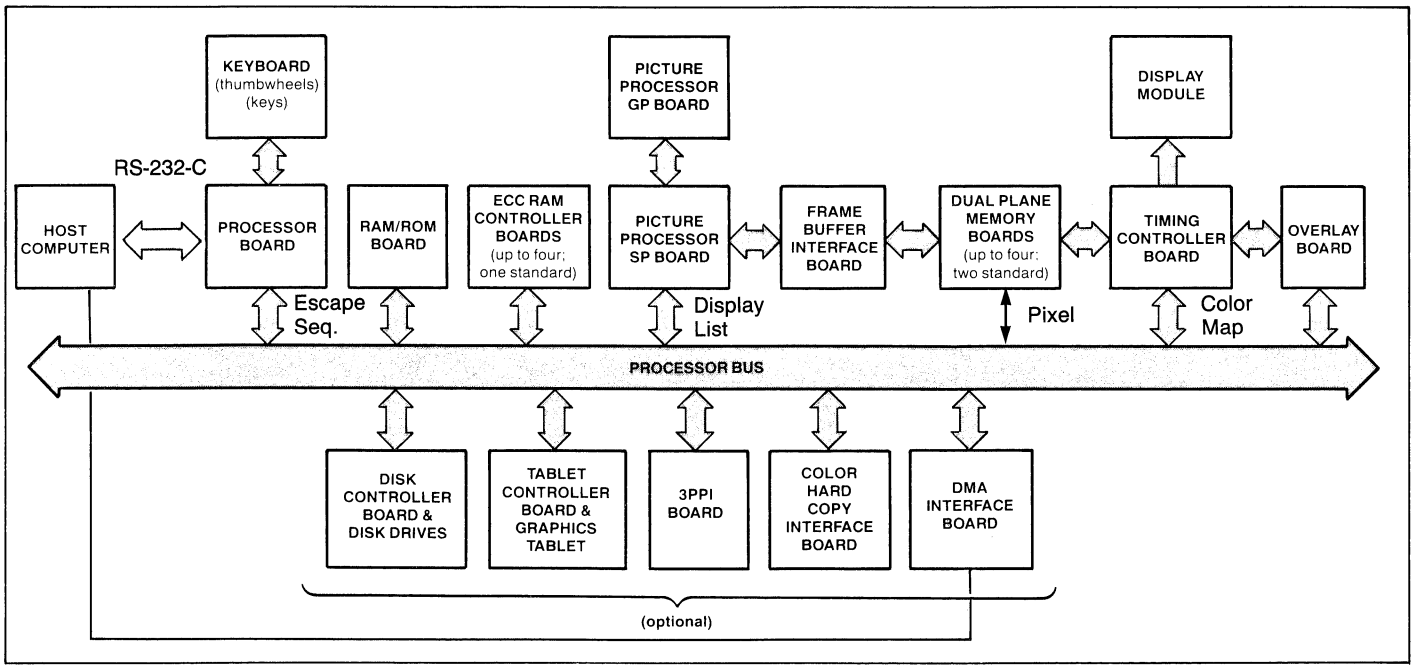
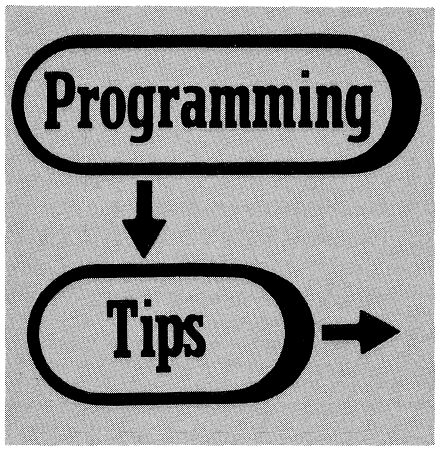


Figure 3. Using the DMA interface, raw picture data can be transferred to four internal memory areas of the 4115B that demand specific data structures.



— !Correction! 4110 Terminal Parameter Settings for 4010 GIN

In *TEKniques* Vol. 7 No. 3 we described how to set four parameters on a 4110 Terminal. Unfortunately, part of the instructions for the BYPASSCANCEL parameter were omitted. Please refer to page 32 and insert the following under BYPASSCANCEL:

A (CR) is entered by BYPASS~RETURN RETURN

(We omitted the "tilde" and second return in the example.)

Converting Existing Applications to GKS

by Dave Straayer
Tektronix, Inc.
Wilsonville, OR

GKS is a standard for a programming interface to graphics, a standard graphics subroutine package. The implications of such a standard, however, extend beyond graphics subroutine packages, because the existence of a standard for graphics functions suggests that this functionality will also migrate into devices. Already GKS workstations are appearing.

The availability of such products has profound implications for the future of existing applications software. To extend and protect the value of existing applications it is likely that many applications programmers must determine whether conversion is appropriate. It is useful to examine some of the reasons to convert software to GKS, to survey a number of graphics packages on which computer graphics applications are based, and to discuss several strategies for conversion.

Probably the most important single reason to convert an existing computer graphics application to GKS would be to allow the software to draw its pictures on a new terminal, plotter, or other graphics device. Computer graphics devices are being introduced almost daily, with exciting performance, features, and prices, but it takes software to use these new graphics devices so the current software must be replaced or modified to take advantage of these new devices. This software is far from free.

Existing software could be rewritten to use a new piece of computer graphics equipment. But this only solves the immediate problem, and does nothing for tomorrow's problem, the next generation of graphics device. If the application was based on "Device-Independent" software, it would be much easier to adapt it to a new device. With device-independent software, writing or buying a "device driver" (a sort of software adapter) often completes the conversion, and the application will work nicely. If the graphics software is not based on a device-independent package, then converting to GKS will provide these advantages, since GKS is designed to be device-independent.

Is there any reason to consider converting an application which is already based on a device-independent package? GKS is the first officially adopted standard for device-independent computer graphics software packages. This is already generating a lot of excitement in the computer graphics vendor community, and more GKS-compatible products are expected in the near future. Support of GKS implies the availability of a significant base of compatible graphics software. As more devices are introduced with GKS-standard software support, it will become easier to reap the benefits of improved computer graphics technology. Thus, the real reason to convert application software to GKS would be to make it compatible with the new applications which are likely to be written. Another advantage is simplification of software maintenance and conversion when all graphics software is based on the same package.

Does it make sense to base new software on GKS? Absolutely! GKS has some real advantages as a graphics interface. For example, GKS has a published "Binding" to Fortran, which specifies the actual names and argument sequences for graphics functions. Thus, if an application is written for one vendor's GKS package, and later another vendor's version is substituted (perhaps to run on a different host computer, or to use a new device not supported by the first vendor's GKS), the original code has an excellent chance of being able to use the other GKS software package without modification. (See related articles in this issue of *TEKniques*.)

Current Graphics Utility Packages

Here are brief descriptions of three widely used and representative graphics utility packges. These packages form the basis of thousands of graphics applications which may need to be converted to GKS.

CalComp

This is one of the oldest software interfaces to graphics. It was originally written to support pen plotters produced by the CalComp company. Many other plotter manufacturers have supplied software for their plotters which is "CalComp compatible," and a lot of application programs have been based on this interface. Because these programs are not highly interactive nor do they use the newer graphics features like filled areas or dynamics, conversion is simplified despite the device-dependent nature of the package.

PLOT 10 TCS

PLOT 10 TCS, or Terminal Control System, is a software product introduced by Tektronix to support the 4010 terminal, one of the earliest affordable computer graphics terminals in wide use.

Because of the pioneering aspect of the 4010 terminal and a large number of "PLOT 10 compatible" terminals, a significant number of applications are based on TCS.

TCS has a rich repertoire of coordinate systems, including a device-independent "virtual coordinate" system. Although TCS was originally device-dependent, additions of the

4014 terminal and 4662 plotter caused Tektronix to put some device-independence into TCS.

TCS has significantly more routines than the CalComp package. Like the CalComp package, TCS is mostly non-modal. This means that there are commands to draw different styles of lines, rather than commands which establish the "mode" of line drawing. There are different routines to draw solid and dashed lines, for example, rather than a mode setting routine which specifies whether subsequent lines are to be dashed or solid. With more routines and input, converting TCS-based applications will be more difficult than converting CalComp-based applications.

DI-3000

DI-3000 is used here as an example of SIGGRAPH Core software.

Tektronix' PLOT 10 Interactive Graphics Library and Megatek's TEMPLATE are other software packages which are described as Core software. However, since no "binding" of Core functionality was ever published to Fortran, all three Fortran packages use their own subroutine names and calling sequences.

DI-3000, as well as other core implementations, is 3-D as well as 2-D. Since GKS is (today) only a 2-D standard, obviously any applications which require 3-D functions cannot be converted to standard GKS.

Core systems also have a feature called segmentation, which is not available in either CalComp or TCS systems. Segmentation refers to the ability of a graphics system to store and manipulate parts of pictures. DI-3000 supports a large variety of different graphics devices, as do other Core packages. Also, there is a good selection of software built on top of such Core systems available.

Although GKS is 2-D and Core is 3-D, in most other respects GKS is a superset of Core functionality, and this implies most Core-based applications will be relatively easy to convert to GKS. However, applications which make use of esoteric Core functions may pose special problems.

Conversion Strategies

Three different strategies for converting software to the GKS standard will be examined. The first is to make GKS look like the existing package. The second would be to convert the application completely to make it use GKS. Finally, a hybrid strategy, a combination of the above two, might prove the solution of choice in certain conditions.

Make GKS Look Like the Existing Interface

This strategy consists of putting a software layer on top of GKS with subroutines which match in names and calling sequences those of the package on which an application was originally based.

This approach would be justified if there is a lot of application software, and particularly attractive if source code is not present for all of the software, in which case this may be the only solution. This approach makes the smallest possible impact on the original source code (none).

Since GKS is powerful, device-independent, and rich in functions, it will usually be larger than the original package, and adding a software layer will only make it bigger. However, since today's computers are larger, faster, and less expensive than those for which many existing applications, this is less likely to be a serious problem than it would at first seem.

It will be easier to build interfaces which look like simpler systems like CalComp than richer systems like Core. Probably the biggest problem will be coping with the heavy device-dependence of packages like TCS. Building such a layer will require a substantial knowledge of the original graphics interface package, as well as GKS.

Convert the Existing Application to GKS

This approach is likely to result in the most efficient result. It also makes the biggest impact on the source code of the original application. To convert an application will require intimate knowledge of the original graphics package, the application program itself, and GKS. This is an appropriate strategy when there are not a large number of applications programs, or if they could benefit from overhaul (to use new features, for example). One benefit of this approach is that you may find yourself "ripping out" a lot of application code that is really doing graphics; because early graphics packages did so little, a lot of the graphics work ended up being done in application code.

Several tools are helpful when converting software in this manner. Listings of the source code with cross-references can be a real aid in locating and modifying calls. Another method to accomplish the same goals is the use of a good interactive text editor. A user manual for the current graphics package is required to identify what the calls do, and user manuals for the devices supported by the current package will be needed, plus a good working knowledge of GKS.

The general approach is as follows: First, identify which parts of the application call on graphics. Then, classify these calls to major types, control functions, actual drawing functions (primitives), calls which modify appearance (attributes), transforms, viewing, etc. Make a trial recoding, and use the system to help you debug. In graphics, often it is the final display, rather than error messages, which is the arbiter of correctness.

Hybrid Strategies

While it is easy to make adapters for very simple packages like CalComp, the complexity of Core will often make it easier to modify the applications, or to use the hybrid approach that follows.

This approach is a blend. The intent is to modify the original source code as little as possible without accepting responsibility for constructing an adapter which will cover all situations. If an adapter is not available, and the amount of application code to convert is not too large, this will be the easiest method and most likely the quickest.

The general approach is to make adapters for the most commonly used routines, in particular the graphics primitives. Adapters for initialization and termination routines will help details such as buffer management.

When these adapters are complete, then convert less frequently called routines on a case-by-case basis. The major technical problem will be the current position. Since GKS does not have a "current position", which is analogous to the location of a pen on a plotter, and previous graphics packages usually do, this will be a major source of difference. The current position problem is easily solved by creating a current position via a Fortran named common. Routines like text display and line-drawing routines which need to know the current position can access this common, and update it if need be.

One decision which must be made is whether to buffer or not to buffer line segments. Not buffering will result in many calls to GKS, buffering will result in fewer calls. Many applications, where efficiency is not critical, will be able to tolerate the unbuffered approach.

Conversion to GKS will not be appropriate for all graphics application programs. Programs which represent substantial investment and potential for future adaptation to new graphics devices will benefit most from conversion to GKS. The ultimate goal of GKS is portability and device-independence of application programs.

The next issue of *TEKniques* will illustrate unbuffered and buffered approaches.

Required Settings for 4643 Printer Connected to 4050 Using Option 10 & 4110 Series Terminals

by Sharon Allison
and John Fehr
Tektronix, Inc.
Dallas, TX

We find these settings on the 4643 Printer to work consistently for the 4050 Series using Option 10 and the 4110 Series in host mode as well as stand along.

4643 Printer

SWITCH	1	2	3	4	5	6	7	8
S1*	ON	ON	OFF	ON				
S1*	ON	ON	ON	ON				
S3*	OFF	OFF	OFF	OFF	(9600 Baud)			
S14	OFF	OFF	OFF	ON	OFF	OFF	OFF	OFF
S15	ON	OFF	ON	OFF	ON	ON	ON	OFF

These switch settings will work for any 405X using Option 10 or any 411X using the following parameter settings.

PASSIGN PO: 4643
PBAUD PO: 9600
PBITS PO: 1 8
PPARITY PO: NONE
PFLAG PO: DTR
PEOF PO: ' '
PEOL PO: ' '

*Positions 1–4 are only available on this switch.

Some 4110 Commands Require Pause to Ensure Execution

by Dave Scott
Tektronix, Inc.
Wilsonville, OR

Commands that affect how characters are handled as they are input at the terminal's communications port should be followed by about a one-half second delay to be sure that the command has taken effect. This is recommended for:

<Arm-for-Block-Mode>
<Prompt-Mode>
<Set-Baud-Rates>*
<Set-Bypass-Cancel-Character>
<Set-EOF-String>
<Set-Flagging-Mode>
<Set-Parity>*
<Set-Prompt-String>
<Set-Stop-Bits>*
<Set-Transmit-Delay>

Either force your host to wait by some internal means or transmit one-half second's worth of no-op characters (SYNCs are recommended). If several of the above commands are sent one after another, the pause is only required after the last command.

Because these commands alter the terminal's communications, you should not send a report command at the same time.

*It is recommended that these commands NOT be sent from a host; enter them at the terminal in SETUP or from a disk.

Specifying More Than 64 Classes for 4110 Segments

by Carl Goodwin
Tektronix, Inc.
Wilsonville, OR

When a segment is created, 64 bits are allocated for segment class information. Generally, we speak of each of the 64 bits as representing a segment class. For example, consider a circuit design in which each resistor must be in a separate class based on its value. That is, all 5K ohm resistors are to be in class 49. The conventional method for putting a segment (say segment 5) in class 49 is

(ESC)SA 5 <– 1> <49>

(Note that, for clarity, the command is as it would be typed in setup mode.) First, segment 5 is removed from all classes, and then it is put in class 49. This amounts to setting the 49th bit in the 64-bit field.

To set the current matching class so that segment 5 is included in class operations, the following command would be issued.

(ESC)SL <49> < >

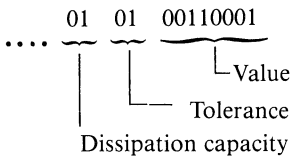
This technique works fine as long as there are not more than 64 values for resistors for a given circuit. However, 64 bits are capable of representing 2**64 (or over 1.8 × 10**19) distinct numbers. If the application requires that segments be grouped into more than 64 classes, then groups of bits can be turned on in combination to provide a virtually unlimited number of classes. In this example, instead of turning on the 49th bit, a set of bits can be turned on to be a binary representation of 49 (110001). The following command

(ESC)SA 5 <– 1> <1 5 6>

turns on the first, fifth, and sixth bits in the 64-bit field. Note that 64 classes can be represented using only 6 bits. If, in the example, 256 different resistor values are possible, then 8 bits are needed. This leaves 56 bits which can be used for other information about a particular resistor (segment). The resistor's tolerance might be 1%, 5%, or 10%. This information can be coded into two additional bits (00 for 1%, 01 for 5%, and 10 for 10%). The power dissipation capacity of each resistor could use another two bits (00 for 1/8 watt, 01 for 1/4 watt, 10 for 1/2 watt, and 11 for 1 watt resistors). The command to designate the proper classes (set the proper bits) for a 1/4 watt, 5%, 5K ohm resistor would be

(ESC)SA 5 <– 1> <1 5 6 9 11>

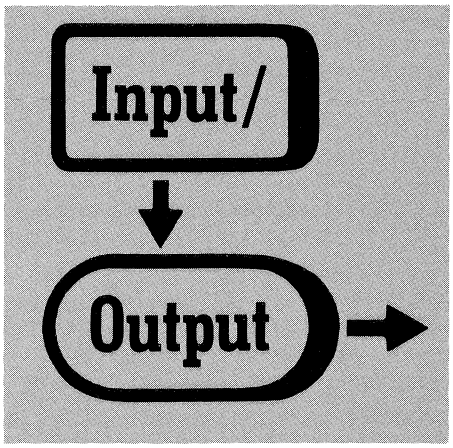
and the last 12 bits of the 64-bit pattern would be



The same technique can be used for segment class operations. To set the current matching class so that segment 5 will be included in class operations, the command

(ESC)SL <1 5 6 9 11> <2 3 4 7 8 10 12>

is issued. (The other 52 bits do not matter.)



Any Suggestions for a Function to Ascertain Cyclical Overlap?

by David Walcutt
Radio Free Europe/Radio Liberty
New York, NY

We schedule broadcasts with a starting time and an ending time, e.g. 0300–0900. So we have pairs of numbers stored in an array representing the beginning and the end of each transmission. These times can be any number from 0 to 2400. Ideally perhaps each starting time would be represented by a smaller number than the ending time, but in reality, since some transmissions begin before midnight and end in the wee hours of the morning, this is not always the case.

The broadcasts crossing midnight are the real crux of the problem of comparing two transmissions to see if they overlap. If the start time was always less than the end time, expressed as a number from 0 to 2400, then only two lines of program would be required.

But because we are dealing with a cyclical situation expressed in linear terms, it appears that it would be effective to find a trigonometric way of evaluating the same thing. Clock time is based on the convention of a circle and the numbers repeat over and over, from 0 to 2400. Thus there is no 3600 but only 1200 or 12 noon. So I am sure there is a simpler way of comparing two broadcasts to see if they overlap than by looking at each in purely linear terms.

In the attached illustration, I show how I solved the problem in linear terms. For the first transmission, P1 is the start time and P2 is the stop time. For the second transmission, P7 is the start time and P8 is the end time. The question is, does P1–P2 overlap P7–P8?

Attached is some illustrative material, which should, incidentally, give you a picture of how your equipment serves one user.

Does anyone know of something faster?

Dan Taylor, Tektronix Design Engineer, suggests two methods to use. It is a modulus situation of A MOD B where B = 24. If a user has a 4052A or 4054A, the MODULUS function is resident. Otherwise, a function may be defined.

A MOD B = A – B*INT(A/B)

therefore

```
DEF FNM(X) =
X – 24*INT(1E – 10 + X/24)
```

then

```
FNM(0)  = 0
.
.
.
FNM(23) = 23
FNM(24) = 0
FNM(36) = 12
```

This provides the kind of cycle that may be useful. How to implement it would be up to the individual.

Another method may be through arrays.

DIM T1(24), T2(24), T3(24)

T1 and T2 are 0 when not broadcasting and 1 when broadcasting

therefore

```
T3 = T1 and T2

IF SUM (T3) THEN
! overlap, since SUM > 0
.
.
ELSE
! no overlap, since SUM = 0
.
.
END IF
```

Whether either of these two methods would be faster would have to be determined.

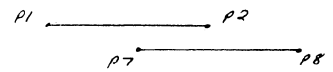
If anyone else has an idea, please submit it to *TEKniques* and it will be printed in the I/O column.

RADIO FREE EUROPE * RADIO LIBERTY

Frequency Schedule No.94 EFFECTIVE 6 NOVEMBER 1983 0100 hrs GMT (14.9.83)

Frequency	Day of Week (Start time = P1 or P7)	Time	Transmitter (End time = P2 or P8)	Power	Language	Antenna	Row
720	1234567	0000 - 0042	MWT	150	CS	HMW - 46	129
720	123456	0400 - 0600	MWT	150	PO	HMW - 46	102
720	1234567	0600 - 2400	MWT	150	PO	HMW - 46	103
3960	1234567	1800 - 0700	L11	20	RU	LEG - 56	1
3970	123456	0400 - 0600	B1	100	CS	BC4 - 90	130
3970	1234567	2000 - 0042	B1	100	CS	BC4 - 90	131
3985	1234567	0200 - 0230	B7	100	ES	BP4 - 63	185
3985	1234567	0230 - 0300	B7	100	LA	BP4 - 63	186
3985	1234567	0300 - 0330	B7	100	BR	BP4 - 63	187
3985	1234567	0330 - 0400	B7	100	LI	BP4 - 63	188
3990	123456	0400 - 0600	B7	100	PO	BP4 - 63	104
3990	1234567	1700 - 2400	B7	100	PO	BP4 - 63	105

P1, P7 = start times
P2, P8 = end times




```
1060 IF (M(Y,2)=T)+(M(Y,6)=F)+(A2<>B2)+(Q1=0)=0 THEN 1380
1070 IF P2<P1 AND P8<P7 THEN 1160     Both lines cross midnight so they MUST overlap.
1080 IF P2>P1 THEN 1110               P1 - P2 does not cross midnight.
1090 IF P7=>P2 AND P8<=P1 THEN 1380   P1-P2 crosses midnight, P7-P8 does not; no overlap
1100 GO TO 1160
1110 IF P8>P7 THEN 1140               P7 - P8 does not cross midnight.
1120 IF P1=>P8 AND P2<=P7 THEN 1380   P7-P8 crosses midnight, P1-P2 does not; no overlap
1130 GO TO 1160
1140 IF P7<P1 AND P8<=P1 THEN 1380    Neither P1 - P2 nor P7 - P8 cross midnight, and
1150 IF P7=>P2 AND P8>P2 THEN 1380    neither overlap.
1160 IF M(X,3)+M(Y,3)=123463 OR M(X,3)+M(Y,3)=12412 THEN 1380
1170 GOSUB 3040
1180 L1=M(Y,7)
1190 T1=M(Y,2)
1200 A8=B
1210 S1=INT(B2/1000)
1220 A9=B2-S1*1000                    NB: Lines 1140-1150 cover the "normal" situation
1230 W$=STR(M(Y,5))                   where neither broadcast crosses midnight.
1240 V$=STR(M(Y,4))
1250 GOSUB 3360
1260 PRINT @51: USING 3030;M(Y,1),Z$,M(Y,6),V$,W$,T$,A$,S$,A9,M(Y,3)%P
1270 PRINT @51:
1280 IF M(Y,2)<>T THEN 1300
1290 PRI @51:"TRANSMITTER ASSIGNED TWICE ON ";M(X,6);" AND ";M(Y,6);"."
1300 IF M(Y,6)<>F THEN 1320
1310 PRINT @51:"FREQUENCY OVERLAP ON ";M(X,6);"."
1320 IF A<>B OR A1<>B1 THEN 1340
1330 PRINT @51:"ANTENNA OPERATING SIMULTANEOUSLY IN SAME BAND."
1340 IF A<>B OR A2=B2 THEN 1360
1350 PRINT @51:"ANTENNA SCHEDULED WITH CONLICTING SLEW/BEARING."
1360 IF Q1>0 THEN 1380
1370 PRINT @51:"ANTENNA INCORRECTLY DIPLEXED."
1380 NEXT Y
1390 NEXT X
```

IDD Program Exchange

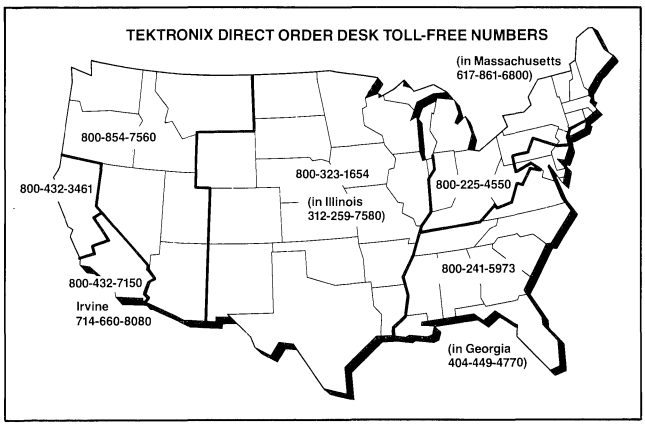
The IDD Program Exchange is a central location of user software for Tektronix Graphics Display Products. As programs are received, they are collected into packages according to the product they support. The packages are available to all uses through exchanges for program contributions or for a nominal charge.

Program Contributions

Contribute one program to the Applications Library and receive the package of your choice in exchange. To receive documentation instructions and forms, contact the Program Exchange serving your area. In the U.S., you may TWX: 910-467-8708 or TLX: 15-1754.

U.S. Orders

Order IDD Program Exchange packages through the toll-free number of Tektronix Central Parts Ordering. The following map delineates the geographical regions and the toll-free number serving each region.



Call the number serving your area and give the customer service representative the nine-digit part number and name of the Program Exchange package you wish. If you have any questions, call your local Tektronix Field Office. The field office has the current prices. (Note: The minimum acceptable Tektronix order is $25.00.)

Orders Outside U.S.

To order a copy of the catalog, or to order a package, contact the local Tektronix sales office or the Program Exchange serving your area. See Program Exchange Addresses section of *TEKniques*.

4000 Series Graphics Terminals

The 4010, 4020 and 4100 Series programs are packaged and nomenclated with the appropriate prefix and disk number.

Each package includes media with the source code together with the supporting documentation; listings are not included. Documentation may be purchased separately.

A 4000 Series catalog will be published when a sufficient number of packages are collected.

Package Title	Documentation Part #	Package Part #
4110 LP Program Exchange Disk 1	062-6955-00	062-6955-01

4115

Package Title	Documentation Part #	Package Part #
VAX/VMS Driver for 4115 DMA (Option 3A)	062-7305-00	062-7305-01
VAX/UNIX (Berkeley) Driver for 4115 DMA (Option 3A)	067-7327-00	062-7327-01

4050 Series Desktop Computers

The 4050 Series programs included in the IDD Program Exchange prior to September 1981 are packaged and nomenclated by function. Those programs accepted after September 1981 are packaged and nomenclated with the Volume and Number of the corresponding issue of *TEKniques* in which the package was announced.

Each package includes the source code on tape or disk (T = tape; D = disk) together with the supporting documentation; listings are not included. Documentation may be purchased separately.

The 4050 Series IDD Program Exchange catalog contains the abstracts describing the programs in each package along with representative output in most cases. The catalog part number is *062-6343-00.*

Package Title	Documentation Part #	Package Part #
Business Aids T1	062-5987-00	062-5987-01
Business Aids T2	062-5988-00	062-5988-01
CAD T1	062-5976-00	069-5976-01
CAD D1	062-5977-00	062-5977-01
Character Generator T1	062-5951-00	062-5951-01
Education/Research T1	062-5982-00	062-5982-01
Education/Research T2	062-5983-00	062-5983-01
Electrical Enginenering T1	062-5978-00	062-5978-01
Graphing T1	062-5964-00	062-5964-01
Graphing T2	062-5965-00	062-5965-01
Graphing T3	062-5966-00	062-5966-01
Graphing D1	062-5967-00	062-5967-01
Graphing D2	062-5968-00	062-5968-01
Interfacing T1	062-5984-00	062-5984-01
Mapping T1	062-5980-00	062-5980-01
Mechanical Engineering T1	062-5979-00	062-5979-01
Programming Aids T1	062-5971-00	062-5971-01
Programming Aids T2	062-5972-00	062-5972-01
Project Aids T1	062-5985-00	062-5985-01
Project Aids D1	062-5986-00	062-5986-01
Recreational Plots T1	062-5989-00	062-5989-01
Slidemaker T1	062-5962-00	062-5962-01
Slidemaker D1	062-5963-00	062-5963-01
Text Processing T1	062-5969-00	062-5969-01
Text Processing D1	062-5970-00	062-5970-01
Utilities T1	062-5974-00	062-5974-01
Utilities D1	062-5975-00	062-5975-01
Tekniques Vol. 5 No. 4 T1	062-5981-00	062-5981-01
Tekniques Vol. 6 No. 1 T1	062-6443-00	062-6443-01
Tekniques Vol. 6 No. 1 D1	062-6442-00	062-6442-01
Tekniques Vol. 6 No. 2 D1	062-6515-00	062-6515-01
Tekniques Vol. 6 No. 3 D1	062-6516-00	062-6516-01
Tekniques Vol. 6 No. 3 T1	062-6514-00	062-6514-01
Tekniques Vol. 6 No. 4 T1	062-6704-00	062-6704-01
Tekniques Vol. 7 No. 1 D1	062-6715-00	062-6715-01
Tekniques Vol. 7 No. 3 DI	062-7276-00	062-7276-01
Tekniques Vol. 7 No. 3 TI	062-6775-00	062-6775-01
Tekniques Vol. 7 No. 4 T1	062-7455-00	062-7455-01
Tekniques Vol. 7 No. 4 T2	062-7456-00	062-7456-01

Software Support Category C

The program material contained herein is supplied without warranty of any kind, and without any representation regarding quality, performance or suitability. TEKTRONIX specifically disclaims any implied warranties of merchantability of fitness for a particular purpose. Software support is TEKTRONIX Category C: Software is provided on an "as is" basis.

4050 Series

TEKniques Vol. 7 No. 4 T1 Part #062-7455-01

TEKniques Vol. 7 No. 4 T1 consists of 11 programs: three CAD, one Education/Research, one Graphing, two Interfacing, one Mapping, one Programming Aids, and two Utility. Two of the programs require a 4052 or 4054 due to memory requirements, four require the A-Series of 4052 or 4054, and five require the 4054 for its dynamic graphics, character size or hardware line style capabilities. The latter could be modified to run on the 4052. Of course, the A-Series programs take advantage of the new functions, commands, variables, etc., within these machines.

Three of the programs must be transferred to separate tapes. The individual abstracts describe the programs.

Program 1

Title: UDF Key Overlay Generator
Author: V.V. Baicher
Lockheed Missiles & Space Co.
Sunnyvale, CA
Memory Requirement: 4054, 32K
Peripherals: Optional-4662/3 Plotter
Files: 1 Program
Statements: 347

This user-friendly program generates UDF Key overlay board images to accompany your personally developed software. You are prompted to enter the overlay board title, then up to three lines of description for each UDF Key used. You may print two full size, or up to eight reduced size, overlay board images per page with the 4054. The full-sized images may be cut out and glued to plastic overlay boards. The reduced images may be used for documentation. The program uses the reduced character sizes of the 4054. No data storage is provided.

Program 2

Title: 4050A Extended Memory Backup/Restore
Author: John G.D. Eichsteadt
Tektronix, Inc.
Wilsonville, OR
Memory Requirement: 4050A
Peripherals: 4050A Extended Memory
Files: 1 ASCII Program
Statements: 133

Using the new functions of the 4050A Series Computer, this program performs rapid backup of Extended Memory to tape and restore from tape to Extended Memory.

Program 3

Title: 64K Data Graphing
Author: Lynn Cueto
Tektronix, Inc.
Memory Requirement: 64K
Peripherals: Optional - 4662/3 Plotter
Files: 1 Binary Program
Statements: 1228

This revised version of Data Graphing developed by Chuck Eng stores data on tape or 4907 disk. It will also accept negative or positive data for one to 10 curves for 1 to 40 points on the X-axis.

Data may be created from keyboard input, sum of all previous curves, average of all previous curves, cumulative sum of the previous curve, least squares fit of the previous curves or data from a tape or disk file.

Program 4

Title: Tek Digitizer
Author: John Cannon, Jr.
Hartwick College
Oneonta, NY
Memory Requirement: 4052/54 32-64K
Peripherals: 4662/3 Plotter
Files: 1 ASCII Program
Requires pre-marked data files
Statements: 745

This digitizer package accepts points from the Plotter and stores them in a pre-marked data file. It is a menu driven program with many main options and a complete editor submenu. The data files are simplistically designed so that specific application programs can use the gathered data. With the editor the operator can manipulate the coordinates in memory, changing the figure that was previously digitized. A maximum of 1350 points may be entered in a 64K machine.

Data entry may be a set of points at a time using the CALL button on the plotter or in stream mode with optional filtering. The entered points may be drawn on the screen or plotter. They can be saved on a pre-marked specified data file.

Data editing includes listing all or some of the points, deleting, inserting, changing points and smoothing curves.

Program 5

Title: Four View Draw
Author: Philip R. Klitzke
U. of Wisconsin-Stout
Menomonie, WI
Memory Requirement: 4054 32K
Files: 1 ASCII Program
Statements: 293

This program will display a box in three dimensions which may be rotated. Upon request the front, side and top views will be displayed while the rotated view remains in the upper right corner of the screen. A border with title block is drawn around the four views.

User input is from the keyboard. Functions are called from the User-Definable Keys.

Program 6

Title: 3D Shade
Author: Philip R. Klitzke
U. of Wisconsin-Stout
Menomonie, WI
Memory Requirement: 4054 32K
Files: 1 ASCII Program
Statements: 351

This program will display a box in three dimensions, rotate and translate it upon user command. It shades the visible sides. The user inputs the dimensions of the box and signifies its center by the thumbwheels.

Program 7

Title: Aeronautical Miles
Author: Scott Marvin
U. of Wisconsin-Stout
Menomonie, WI
Memory Requirement: 4054 32K
Files: 1 ASCII Program
1 Binary Data
Statements: 122

The program draws a map of Wisconsin on the 4054 Screen. Any two localities on the map may be chosen through the thumbwheels and the program will calculate the distance in aeronautical miles from the first point to the second.

Since most of the major cities are noted by an asterisk, any other locality may be found in relation to them.

The program would be useful to pilots who wish to know distances between two localities in the Wisconsin area, and to individuals who want to know general distances in the state.

Program 8

Title: Polyfit
Author: S(a) Section
PERME
Westcott, Aylesbury, Bucks, U.K.
Memory Requirement: 4050A
Peripherals: Character Enhancement ROM
464X Printer
Files: 1 ASCII Program
Statements: 416

Polyfit provides the coefficients to solve a polynomial equation of the form:

$$y = a_0 + a_1x + a_2x^2 + a_3x^3 \ldots$$

It uses the "Weighted Least Squares Polynomial Approximation."

The program is menu driven and allows data to be input, edited, increased, graphed, and listed on screen or printer.

Program 9

Title: Header
Author: Larry Parkhurst and
Mike Anderson
Dieterich Standard Corporation
Boulder, CO
Memory Requirement: 4054 w/Opt. 30
Peripherals: Optional - 4662 Plotter
Files: 2 Binary Programs (1 example)
1 Binary Data
Requires dedicated tape
Statements: 245

This program maintains a user defined menu of the contents of the tape on which it is contained. The menu describes the tape location, program description, program author, amount of memory used to store the program, the file type (ASCII or binary), and the amount of tape left for further storage. The tape will load and start a selected program. The menu can be output to the 4662 plotter for permanent file or may be used on the screen only.

Program 10

Title: 7D20/4050A Utility
Author: Craig Bulmer
Tektronix, Inc.
Chicago, IL
Memory Requirement: 4050A w/64K
Extended Memory or 4907 File Manager
7D20 Programmable Digitizer for 7K mainframes
4052R07 SPS ROM #1
4052R08 SPS ROM #2
4052R14A1 GPIB Enhancement ROM for 4050A
Files: 1 ASCII Program
16 Binary Programs
(Transfer all files to separate tape)
Statements: 2278

This software acquires waveforms from the Tektronix 7D20, based on 7D20 acquisition mode, and applies user selected signal processing routines to the acquired waveforms. The software can also save to or retrieve from the extended memory (or file manager) waveforms and instrument settings. A general purpose talk/listen routine and a menu-driven 7D20 front panel set-up routine are also included.

Program 11

Title: 7912AD/4050A Utility/Demo
Author: John McHugh
Tektronix, Inc.
St. Paul, MN
Memory Requirement: 4050A w/64K
Peripherals: 7912AD Programmable Digitizer with
7A16P Programmable Vertical Plug-in
and 7B90 Programmable Horizontal Plug-In
4050A Extended Memory or 4907 File Manager
4052R07 SPS ROM #1
4052R08 SPS ROM #2
Optional - 4052R14A1 GPIB Enhancement ROM
Files: 1 ASCII Program
18 Binary Programs
5 Binary Data (Examples)
(Transfer all files to separate tape)
Statements: 1561

This software acquires waveforms from the Tektronix 7912AD (either referenced to ground, not referenced to ground, or averaged) and applies a variety of user-selectable signal processing routines to the acquired waveform. Waveforms may be stored and recalled from Extended Memory/4907 file or tape. A talk/listen function permits the operator to communicate with any instrument on the bus. The operator may define a sequence of User-Defined Key (UDK) keystrokes and let the 7912AD/4052A run unattended. Functions include:

Acquire Waveform/Graph it on 4052A (the entire 7912AD may be set to a previously defined setup), Min-Max Pulse Parameter measurements, Analysis of waveform when pulse analysis is not applicable, Differentiation (2-point or 3-point), FFT (may be cosine tapered), Average, Correlation, Convolution, Integrate. The software is well documented for those wishing to use only portions of it or to change it.

TEKniques Vol. 7 No. 4 T2 Part #062-7456-01

TEKniques Vol. 7 No. 4 T2 consists of 11 programs: one Education/Research, three Graphing, three Interfacing, two Mapping, and two Programming Aids. These programs will run on any of the 4050 Series systems.

One of the programs must be transferred to a 4907 File Manager, and four of the programs must be transferred to their own dedicated tapes. The individual abstracts describe the programs.

Program 1

Title: Multivariate Bargraph with Enhancements
Author: Lysander Ng
NMFS-Charleston
Charleston, SC
Memory Requirement: 16K
Peripherals: Optional - 4662/3 Plotter
Files: 1 ASCII Program
Statements: 290

Multivariate data consisting of one continuous variable in addition to up to four discrete variables may be represented in one output using this program. The discrete variables are denoted as treatment, group, block, and story.

If data only consist of one continuous variable and three discrete variables, then output may be produced with one level of story. Or you may use just one block level, and so forth. You have complete latitude in assigning discrete variables according to the adopted terminology, depending on desired output format, arrangement of meaningful data patterns, and priority of comparisons among various levels of discrete variables.

Each variable and the graph may be labeled. On plotter output, character sizes for the labels may be specified, and the Y-axis label (the continuous variable) may be rotated 90 degrees. Seven shade enhancements distinguish bars of each treatment level.

Optionally, standard deviation of each bar may be represented.

Output is to the screen or plotter. No provision for data storage.

Program 2

Title: Log Axis
Author: Dr. Jay R. Herman
Goddard Space Flight Center
Greenbelt, MD
Memory Requirement: 8K
Files: 1 ASCII Program
Statements: 88

Two short subprograms and two sample drivers produce logarithmic tic marks on the vertical or horizontal axis of a plot using externally defined WINDOW and VIEWPORT statement, and axis statements. The size of the tic marks are adjustable. A reverse logarithmic grid can be produced. The two subprograms are intended to be appended to the user's driver program.

Program 3

Title: INTERP
Author: Dr. Jay R. Herman
Goddard Space Flight Center
Greenbelt, MD
Memory Requirement: 8K
Files: 1 ASCII Program
Statements: 64

INTERP performs linear interpolation on data stored in vector form. Given a numerically defined function y(x) where the data is stored in the vectors Y and X, and a list of new independent variable values are stored in the vector D, the linear interpolation

$$C(I) = (Y(J+1) - Y(J))/(X(J+1) - X(J))*(B(I) - X(J)) + Y(J)$$

is solved for all C(I) corresponding to the B(I). The program insures that B(I) falls in the interval between some pair [X(J),X(J+1)], if not, then a default value is inserted into C(I). The vectors X and B must be monotonic.

Program 4

Title: LORAN-C Distance and Time Difference Readings
Author: Mike Lombardi
National Bureau of Standards
Boulder, CO
Memory Requirement: 16K
Files: 1 ASCII Program
Statements: 409

This program computes distances and time difference readings from any given receiver site to any of the fourteen LORAN-C navigation chains in operation worldwide. The user is only required to select a LORAN-C chain, and to enter the coordinates of the receiving site (these coordinates may be permanently entered into the program and used as a default value).

The program is useful in determining which LORAN-C chain is best for navigation purposes from your location, which stations your receiver has acquired, and whether or not your receiver is tracking these stations on the right cycle. The program can be used by those who use LORAN-C to navigate as well as by those who use LORAN navigation receivers for purposes of frequency calibration.

Program 5

Title: GPIB General Device Exerciser
Author: John Burgess
Tektronix, Inc.
Beaverton, OR
Memory Requirement: 32K
Peripherals: IEEE-488 Device Under Test
Files: 1 ASCII Program
Statements: 721

This program provides the facilities to send commands to a device under test (DUT) connected to the IEEE-488 port, and to receive responses from it. Some features are: 1) The Carriage Return character (0D hex) may be sent within the command string by including the characters "<CR>"; 2) If a "?" is found in the command string, the program will automatically try to get a response from the DUT; 3) Several options are available concerning communication protocol - use "ITRM" or UDK #18; 4) All program control commands are three characters or less, preceded by "CTRL-I" - the TAB character.

The specific commands for these and the other features are provided by a "directions" section within the program. All program control commands prompt the user for input, tell what the default is, and the allowable range of responses, where appropriate.

There are three commands to control the display mode when receiving information from the DUT: 1) Print the ASCII representation of the character with control characters sent unmodified - for example, CTRL-L would page the 405X screen; 2) Same as #1, except the mnemonics of control characters are printed in < > - for example, CTRL-L would be printed as <FF>; 3) The decimal value of each character will be printed. In any display mode, if a character whose ASCII value is greater than 127 (DI08 asserted) is received, its decimal value will be printed. If EOI is asserted with a byte, the characters < >&EOI will surround the character. For example, <FF&EOI>.

The program can handle up to 9 instruments on the bus at once.

Program 6

Title: 4050/1980 Interface
Author: William C. Bean, PAE
Tektronix, Inc.
Beaverton, OR
Memory Requirement: 8K
Peripherals: Opt. 1 Data Comm. I/F
Tektronix 1980 Automatic
Video Measurement Set
Files: 1 ASCII Program
(Requires pre-marked data files)
Statements: 56

The Tektronix 1980 Automatic Video Measurement Set provides the television facility widely variable measurement capabilities under software control. Nonvolatile storage of program data, however, is limited to the space provided in the 1980's internal nonvolatile memory (8K words) and limits the possibility of transporting data external to the 1980.

This program uses the tape cartridge in the 4050 to store and transport data. You can save your own programs, transport 1980 program patches from one site to another and archive routines. In addition the 4050 is used as the controlling terminal for normal 1980 operations.

The files must be pre-marked. Because 1980 code is written in "ANSWER BASIC," the data will not be readily processable by the 4050.

Areas of application are T.V. studios, production facilities and manufacturing lines.

Program 7

Title: BASIC Linker
Author: James B. Bains, Jr.
AMF Tuboscope, Inc.
Houston, TX
Memory Requirement: 4050
Peripherals: 4907 File Manager
Files: 5 ASCII Program
(Must be transferred to disk)
Statements: 350

The Linker is a set of BASIC programs assigned to link together any number of files to form one BASIC program. A syntax (using REMARK statements) has been defined to allow symbolic labels for BASIC line numbers to be defined and referenced. The Linker is invoked, the operator responds to prompts to direct the Linker. The user's files are concatonated and the symbolic references are resolved. The sections of the Linker program are automatically paged in and out to allow the maximum size of user program to be concatonated. The label definitions and references may be left in the linked program or not, as desired. Error messages are given for a variety of error conditions.

Program 8

Title: Modified Data Graphing, Pie Chart and Slidemaker
Author: Lynn Cueto
Tektronix, Inc.
Memory Requirement: 16K
Peripherals: Optional - 4662 Plotter
Files: 7 ASCII Program
(Transfer to separate tape)
Data files must be pre-marked
Statements: 1279

The popular Data Graphing program authored by Chuck Eng has been separated into several overlays so it may run in a 4051 with 16K memory. Computer expertise is not required since you are prompted for the minimal inputs.

Program 9

Title: Stereonet Plot (Equal Area)
Author: Steve Wilson
University of California
Dept. of Earth Sciences
Riverside, CA
Memory Requirement: 32K
Peripherals: Optional - 4662 Plotter
464X Printer
Files: 4 ASCII Program
(Transfer to dedicated tape)
Statements: 764

Stereonet Plot is a general graphics program for plotting and manipulating geologic data or any other 3-D orientation data expressed as direction and amount of dip, for example, fault planes, joints pebble orientation, paleocurrents, petrofabrics, paleomagnetic poles, on an Equal Area Projection.

Features include:
1) data storage/recall
2) data rotation
3) vector mean calculation
4) least squares best fit great circle
5) data editing (add, delete, change, list)
6) plotting on a 10cm radius net with:
   - 3 symbols for pole to plane data
   - 2 symbols for lineation data
   - 1 symbol for vector mean
   - 1 symbol for best fit pole including cylographic trace

Program 10

Title: TM5000 Instrument Checkout
Author: Jim Ormond and
Bill Vesser
Tektronix, Inc.
Beaverton, OR
Memory Requirement: 32K
Peripherals: Optional - 464X Printer
TM5000 Series Instrument
Files: 16 ASCII Program
(Transfer to dedicated tape)
Statements: 4071

A collection of BASIC programs checks out the TM5000 Series of programmable instruments for all GPIB functions. It checks for compliance to the reference library of commands and Tek Codes and Formats for GPIB instruments.

This verification software provides a go/no-go testing of the firmware command set used during normal operation of the TM5000 instruments. It also verifies that the proper error codes are returned for specific conditions created by the software.

Operator interaction is minimal. Once a test or test sequence has been selected, no additional settings or display screen pagings are required. The exception is testing the error code generation. In this mode, the operator is required to interact periodically by pressing the front panel ID button on an instrument, connecting a signal to the instrument, etc.

Program 11

Title: 4051 Assembler
Author: Carl Hovey and
Steve Tuttle
Tektronix, Inc.
Wilsonville, OR
Memory Requirement: 4051 16K
Files: 1 ASCII Program
1 ASCII Data
3 ASCII Text
(Transfer to a separate tape)
Statements: N/A (In Call Execute Format)

This program is an interactive assembly and debugging tool for the 4051. It provides the 4051 programmer with a versatile system for creating and debugging programs in 6800 machine code. The one pass assembler allows the user to examine memory locations and registers.

To create source files the Editor ROM or any other text processing program for the 4051 can be used. Also source can be entered directly into the program.

VAX/UNIX (Berkeley) Driver For 4115 DMA (Option 3A)

Part #062-7327-01

Author: Pat Franz
Tektronix, Inc.
Wilsonville, OR
Equipment: 4115B w/Opt. 3A
VAX, UNIX (Berkeley)
Media: 9-track tape

This driver supports the 4115* color display terminal with Option 3A DMA Interface in a VAX/UNIX environment. Written for UNIX version 4.lbsd, this driver can serve as a reference for writing 4115 DMA drivers for other UNIX versions.

All included files are recorded in "TAR" format on the tape.

Documentation files and examples of application programs written in C are also included on tape.

Contents of tape are:

hsg.c	Driver
hsg.h	Defines for use with driver
hsgmanual.p	Driver manual text
pixeldma.c	Program that DMA's pixel image to 4115
term.c	Subroutine that converts two integers to 4115 escape code format
termint.c	Subroutine that converts an integer to 4115 escape code format
testdma.c	Tests the DMA link to the 4115

*Driver developed specifically for 4115B.

VAX/ VMS Driver For 4115* DMA (Option 3A)

Part #062-7305-01

Author: Kevin Nolan
QTC
Equipment: 4115B w/Opt. 3A
VAX, VMS
Media: 9-track tape

This driver supports the 4115* color display terminal with Option 3A DMA Interface in a VAX/VMS environment. Written for VMS version 3.3, the driver can serve as a reference for writing 4115 DMA drivers for other VMS versions.

All included files are recorded in "Files 11" format on the tape.

Documentation files and examples of application programs written in RATFOR (and their FORTRAN outputs) that call drivers are also included on tape.

*Driver developed specifically for 4115B.

IDD Graphics Displays and Computing System Publications Update

A regular feature of *TEKniques* will be a list of part numbers for manuals for new products, manuals for updated products as well as updated manuals. *TEKniques* Vol. 6 No. 4 contains a summary of all IDD manuals current at that time.

Customers in the U.S. may order manuals through the Tektronix Central Parts Ordering office serving their area. International customers should contact their local Tektronix distributor.

Key to Titles

Operator's	=	operator instructions for hardware product
Service	=	maintenance information
Instruction	=	operation and maintenance combined
User's	=	operation instructions for software product
Reference	=	programmable features
Guide/Card	=	pocket-size summary

4100 Series Computer Display Terminals

Standard

4105 Reference Guide	070-4528-01
4105 Programmer's	070-4526-01
4107/4109 Programmer's	070-4893-00
4107/4109 Reference Guide	070-4892-00

Options

4105F30 (Pixel Operations)	070-4991-00
AD501 Adjustable Display Stand Instruction	070-4680-00

Service

4107	070-4889-00
4107 Display	070-4891-00

4170 Graphics Processing Unit

Standard

Installation Instructions	070-4683-00
Instruction	061-2880-00

Service

4170F45 Mass Storage Interface Board	061-2899-00

Options

067-1176-99 Power Supply Calib. Fixture Instructions	061-2819-00
4170F45 Mass Storage Interface Instruction	070-4773-00

PLOT 10 Software

4010A01-4010A10 Terminal Control System

User's	070-2241-01

4010B06 Easy Graphing II

Opt. 13 Installation Guide Univac 1100	070-4575-00
User's	070-4587-00

4010C01 Interactive Graphics Library

User's	070-4482-01
I/O Routines Installation Guides	
Opt. 0D Prime 350-850 w/PRIMOS	070-4750-01
Opt. 0H Honeywell 6000 Series w/GCOS	070-4786-00
Opt. 0M Data General w/AOS/VS FORTRAN 77	070-4785-00

Note: Users who belong to the Software Subscription Service automatically receive updates to their PLOT 10 manuals along with the new code.

4110 Series Computer Graphics Terminals

Standard

4110 Command Reference	070-3892-00
4110 Reference Guide	070-4715-00
4115 Host Programmers	070-4664-00
4115B Intro Brochure	070-4663-00
4115B Operator's	070-4665-00
M4115B	061-2919-00

Service

4112B Vol. 1	070-4708-00
4112B Vol. 2	070-4710-00
4113B Vol. 1	070-4711-00
4113B Vol. 2	070-4712-00
4114B/4116B Vol. 1	070-4713-00
4114B/4116B Vol. 2	070-4714-00
Opt. 45 Mass Storage I/F Board	061-2899-00

Options

4112/13/14/16 A Models-Upgrade to B Instr.	070-4897-00
4112/13/14 Initial Models-Upgrade to B Instr.	070-4684-00
4110F42/43/44 Flexible Disks Install.	070-4898-00
4110F42/43/44 Flexible Disks Instruction	070-5005-00
Opt. 45 Mass Storage I/F Instruction	070-4773-00
4115F22/23 Add'l Display Memory Instr.	070-4774-00
067-1146-99 4115B Power Supply Calib. Fixture Instruction	061-2861-00
067-1154-99 4115B Power Supply Calib. Fixture Instruction	061-2860-00
4112F42 Instruction	070-5006-00
4115B Option 3A Instruction	070-4761-01

Local Programmability

CP/M-86® System Overview and DTI User's	070-4738-00
4110 Series DTI Programmers Reference	070-4534-01
FORTRAN-86 User's	061-2916-00
4100P11/12 Instruction Sheet	070-4809-00

Applications

4100P22 Supercalc^{2} tm Instruction Sheet	070-4747-00
4100P27 Wordstar Instruction Sheet	070-5001-00

4050 Series Graphics Computing Systems

Options

Extended Memory Instruction	070-4775-00

4600 Series Hard Copy Units

Standard

4695 Operator's	070-4646-00

Service

4695	070-4645-00

Options

4633 FCM Dual Process Kit Instruction	061-2764-00
4635 Opt. 5 Imaging Recorder Instruction	061-2831-00
4635 Opt. 01, 02 Imaging Recorder Instr.	061-2830-00
4691 Transparency Upgrade Kit Instr.	070-4871-00

4900 Series File Manager Systems

Standard

4926/F25 Installation Guide	070-4687-00
4925/26 Instruction	070-4688-01

Service

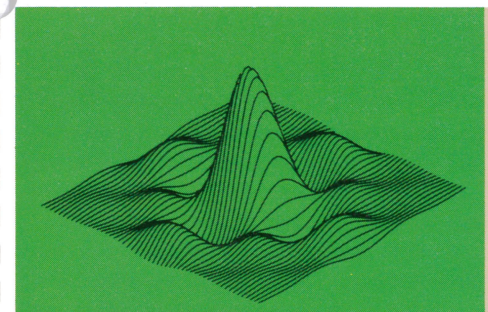
4909 Multi-User	070-3998-00
4926 10 mB Hard Disk	070-4731-00

4900 Series Graphics Tablets

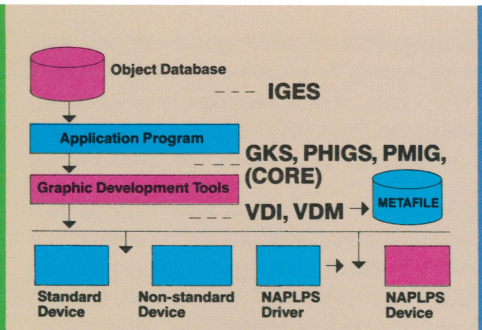
Standard

4957 User's	070-4784-00

Tekniques



4050 Series



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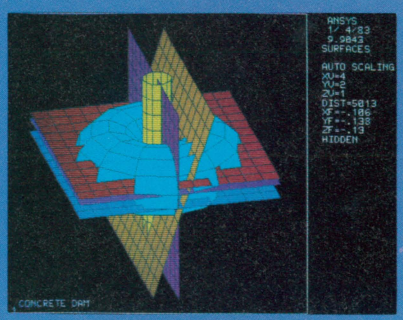
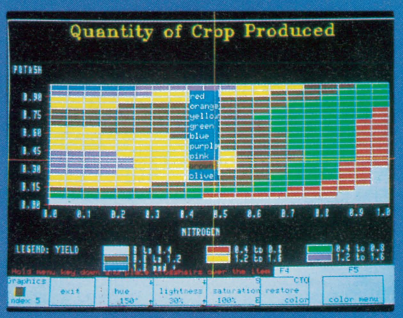
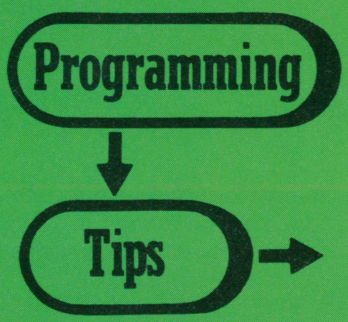


4110 Series



4100 Series



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Low Cost Film for Top Quality Transparencies on the 4691 Color Copier

Bright colors that retain their vibrancy, black that isn't muddy, and area fills without distinguishable patterning or individual dot patterns attest to the quality of the new transparent film made especially for the Tektronix 4691 Color Graphics Copier. In less than three minutes, overhead slides are ready for viewing. The film is dry to the touch as soon as the copy is finished, and notations can be made right on the film.

Transparency output from the 4691 provides a quick, convenient source of presentation materials at a reasonable cost. Both "A" (8½ ″ × 11 ″) and "A4" (210 × 297 mm) sizes are available, but are not interchangeable.

Copiers must have the transparency adapter kit installed for the transparency size desired. The kit provides a specially designed transparency feeder tray, firmware change and feeder roller. Information on these kits may be secured from your local Tektronix field office.

Part numbers for transparency film are:

"A" size
100 sheets/package 016-0765-00

"A4" size
100 sheets/package 016-0766-00

In the United States the film may be ordered from the Tektronix Central Parts Ordering office.

4695 Color Copier Produces Transparencies on New Film

A specially coated transparency film for the 4695 Color Copier produces overhead slides at a fraction of the cost of traditional photographic or manual methods. Colors are clear and true (not mottled or muddy) and dry quickly.

Slides can be quickly made for informal meetings or presentations. Roll a transparency into the 4695's carrier, push the feed button, adjust the film edge, press the copy button and watch it happen.

The film is a full 10 inches wide eliminating the chance of printing on the platen. It also fits easily into a cardboard frame.

The part number for 100 sheets of 4695 transparency films is: 016-0480-00. In the United States, the film may be ordered from the Tektronix Central Parts Ordering office nearest you.

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