P-N-P DIFFUSED-BASE MESA GERMANIUM TRANSISTOR

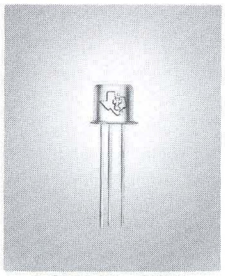
TYPE 2N710
BULLETIN No. DL-S 1128 OCTOBER, 1959
REPLACES BULLETIN No. DL-S 1081 JUNE, 1959

A HIGH-SPEED SWITCHING TRANSISTOR

Made by the Diffusion Process

for High-Speed Logic

Applications



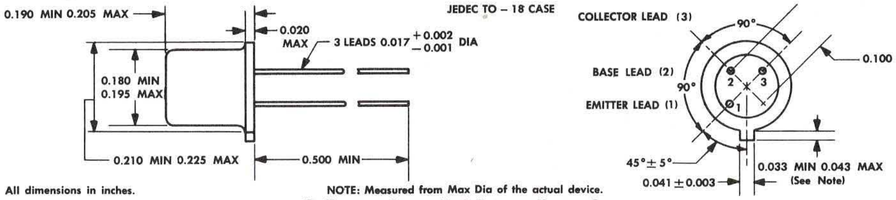
ACTUAL SIZE

qualification testing

To assure maximum reliability, stability, and long life all units are heat cycled from −55°C and room humidity to +95°C and +95% relative humidity for four complete cycles over an eight-hour period. All units are given stabilization bake at 100°C for 250 hours and then thoroughly tested for rigid adherence to specified design characteristics.

mechanical data

Welded case with glass-to-metal hermetic seal between case and leads. Approximate unit weight is 0.35 gram.



All dimensions in inches.

NOTE: Measured from Max Dia of the actual device.

Collector Grounded Internally to Case

absolute maximum ratings at 25°C case temperature (unless otherwise specified)

Collector-Base Voltage	−15 v
Emitter-Base Voltage	−2 v
Emitter Current	−50 ma
Collector Current	−50 ma
Total Device Dissipation	300 mw*
Collector Junction Temperature	+100°C
Storage Temperature Range	−65 to +100°C

typical design characteristics at 25°C

symbol	parameter	conditions	min	typ	max	unit
I_{CBO}	Collector Reverse Current	$V_{CB} = -5$ v, $I_E = 0$	—	−0.3	−3	μa
BV_{CBO}	Collector-Base Breakdown Voltage	$I_E = 0$, $I_C = -0.1$ ma	−15	—	—	v
BV_{CES}	Collector-Emitter Breakdown Voltage	$V_{EB} = 0$, $I_C = -0.1$ ma	−15	—	—	v
BV_{EBO}	Emitter-Base Breakdown Voltage	$I_E = -0.1$ ma, $I_C = 0$	−2	—	—	v
h_{FE}	DC Forward-Current Transfer Ratio	$V_{CE} = -0.5$ v, $I_C = -10$ ma	25	40	—	—
V_{BE}	Base-Emitter Voltage	$I_B = -0.4$ ma, $I_C = -10$ ma	−0.34	—	−0.50	v
$V_{CE\,(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -0.4$ ma, $I_C = -10$ ma	—	−0.23	−0.50	v
C_{Te}	Emitter Transition Capacitance	$V_{EB} = -2$ v, $I_C = 0$, f = 1 mc	—	3.5	—	μμf
C_{Tc}	Collector Transition Capacitance	$V_{CB} = -10$ v, $I_E = 0$, f = 1 mc	—	5	—	μμf
h_{fe}	AC Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$ v, $I_C = -10$ ma, f = 100 mc	—	6	—	db
$f_{\alpha b}$	Common-Base Alpha Cutoff Frequency	$V_{CB} = -5$ v, $I_C = -10$ ma	—	300	—	mc

*Derate at 4 mw/°C; this is equivalent to a maximum power rating of 300 mw at a case temperature of 25°C. The power rating in free air at 25°C is 150 mw.

LICENSED UNDER BELL SYSTEM PATENTS

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typical current switching design characteristics at 25 °C

symbol	parameter	conditions*	min	typ	max	unit
$t_d + t_r$	Turn-on Time	$V_{BE(0)} = 0.5$ v, $I_{B(1)} = -1$ ma $V_{CC} = -3.5$ v, $R_C = 300$ ohms	—	60	75	mμsec
t_s	Storage Time	$I_{B(1)} = -1$ ma, $I_{B(2)} = 0.25$ ma $V_{CC} = -3.5$ v, $R_C = 300$ ohms	—	75	100	mμsec
t_f	Fall Time	$I_{B(1)} = -1$ ma, $I_{B(2)} = 0.25$ ma $V_{CC} = -3.5$ v, $R_C = 300$ ohms	—	80	100	mμsec

*$V_{BE(0)}$ = prior base-emitter voltage, OFF state $I_{B(1)}$ = ON state base current $I_{B(2)}$ = post base current, OFF state

switching speed measurements

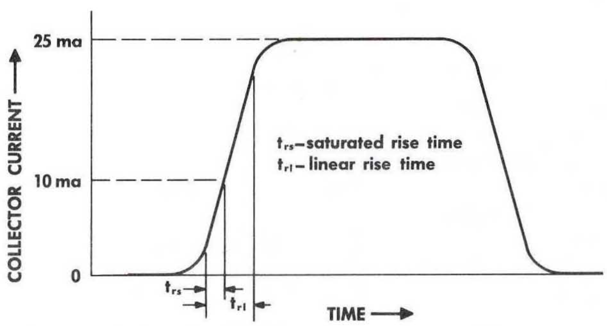
The specified switching times are given for a *current* "Turn-on" and "Turn-off" condition. These conditions are given for a particular value of *overdrive.*

In order to clarify switching time specifications, it is necessary to clearly define the nomenclature used. The term *current* "Turn-on" or "Turn-off" is used when the base drive consists of a constant-amplitude current pulse; in other words, the transistor is being driven from a generator having a theoretically infinite source impedance. In comparison, *voltage* "Turn-on" or "Turn-off" indicates that a constant-amplitude voltage pulse is applied to the base, or the transistor is driven by a generator with zero source impedance. By using a *voltage* "Turn-on" circuit, faster times are achieved because the voltage generator is theoretically able to supply an infinite current to the base of the transistor. In practice, of course, operating conditions are somewhere in between these two extremes.

When measuring the switching speeds using the *current* "Turn-on" or "Turn-off" techniques, the *overdrive* factor must be taken into account.

The overdrive factor is defined as: $\frac{I_B h_{FE}}{I_{CS}}$

where I_B, is the constant base drive, h_{FE} is the forward-current transfer ratio (in the linear portion of the transistor's characteristics) and I_{CS} is the collector current when the transistor is in saturation. For example, if the base drive is 1 ma and h_{FE} is 25, one would expect a collector current of 25 ma if the transistor was not driven into saturation. Suppose, however, that the collector voltage supply and the load resistor limited the eollector current to 10 ma. Hence, the collector current pulse of 25 ma is clipped or clamped at 10 ma. The rise-time of the 25-ma pulse will be determined solely by the high-frequency response of the transistor acting as a linear device. The high-frequency response is dependent on the alpha-cutoff frequency and the time constant of the load resistance and the collector transition capacitance. This is illustrated in the following figure.

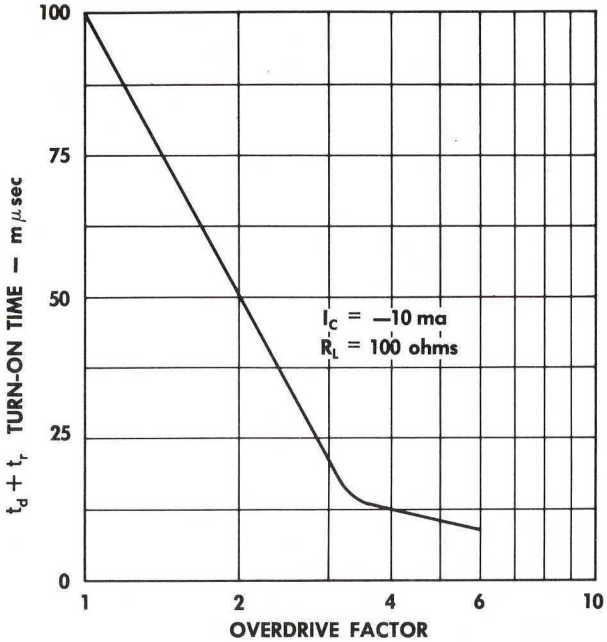


The rise time of the clipped pulse is obviously improved by about 2½ times (notice that 2½ is also the *overdrive* factor).

The switching times shown above are given for an overdrive factor of about 2½ and load resistance of 300 ohms. An illustration of how switching times vary with the overdrive factor is shown on the following page (notice that the load resistance in this case is 100 ohms; this explains the faster switching times than those given when the load resistance is 300 ohms).

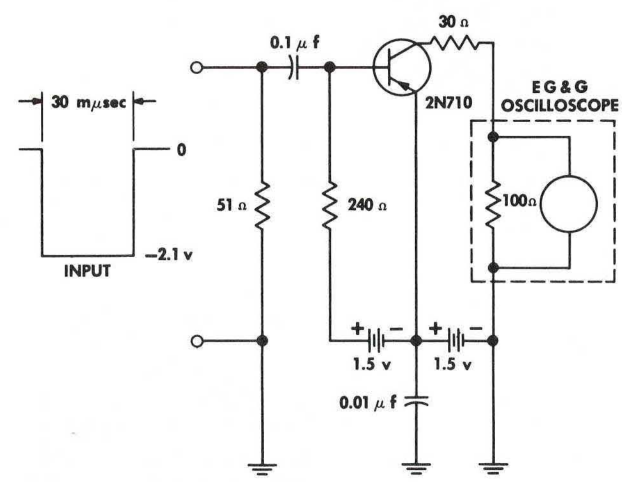
TYPICAL APPLICATION DATA

TURN-ON TIME vs OVERDRIVE FACTOR

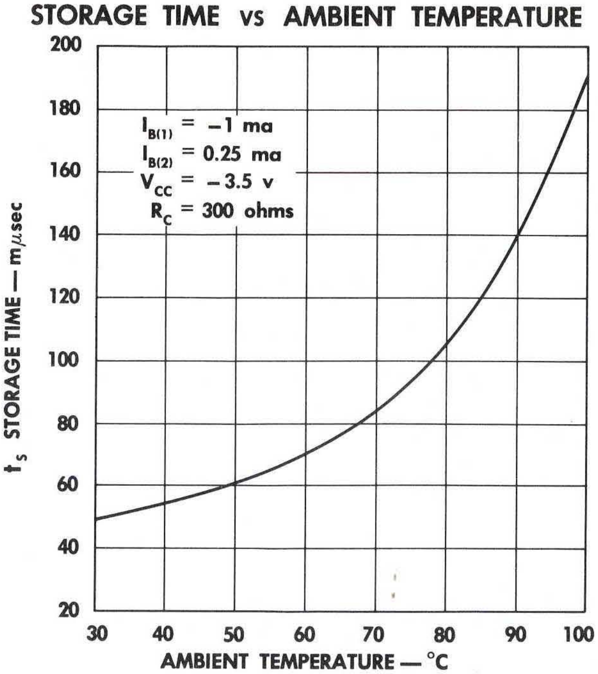


VOLTAGE SWITCHING CIRCUIT

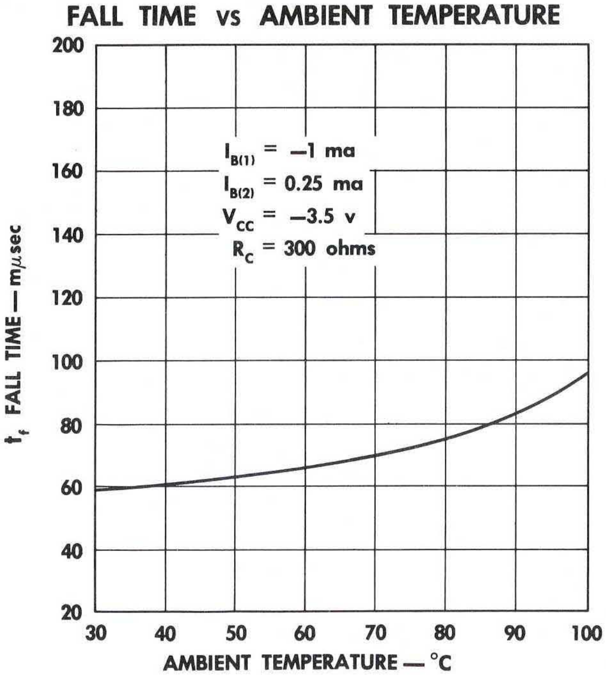
t_d	t_r	t_s	t_f	$V_{BE(0)}$	$V_{BE(1)}$	$V_{BE(2)}$
5 mμsec	7 mμsec	7 mμsec	7.5 mμsec	1.5 v	—0.6 v	1.5 v



STORAGE TIME vs AMBIENT TEMPERATURE

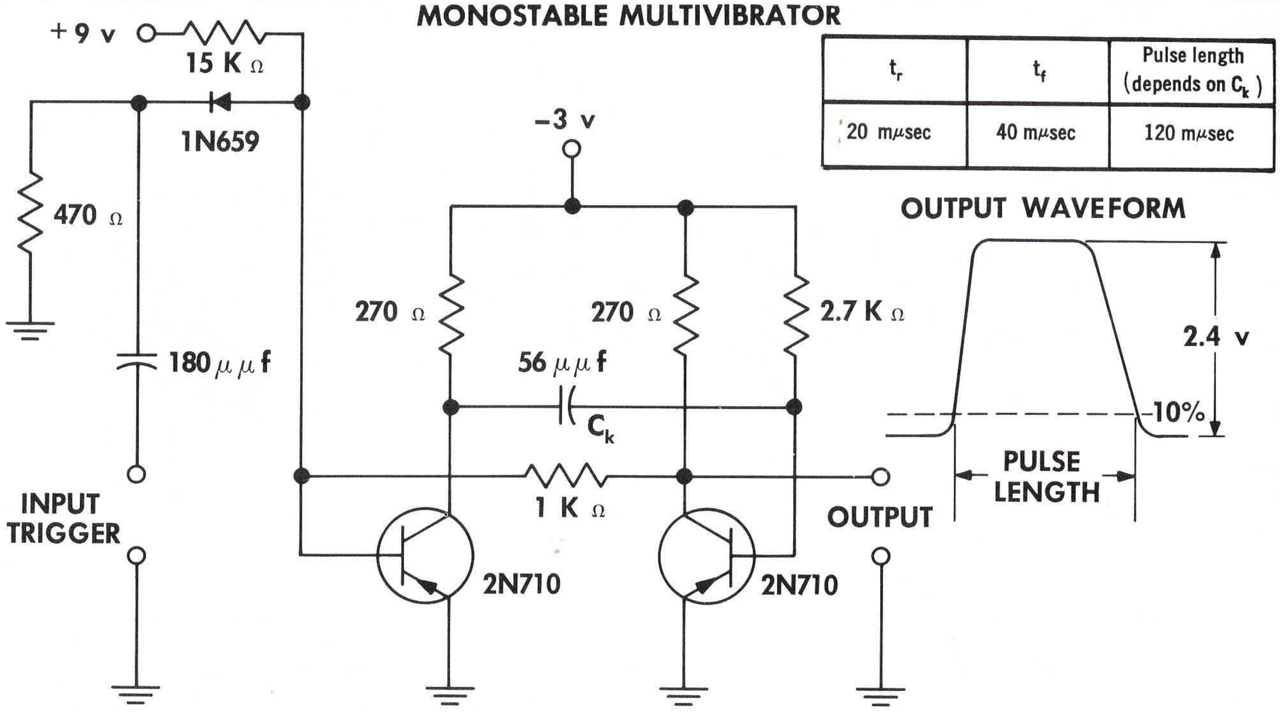


FALL TIME vs AMBIENT TEMPERATURE



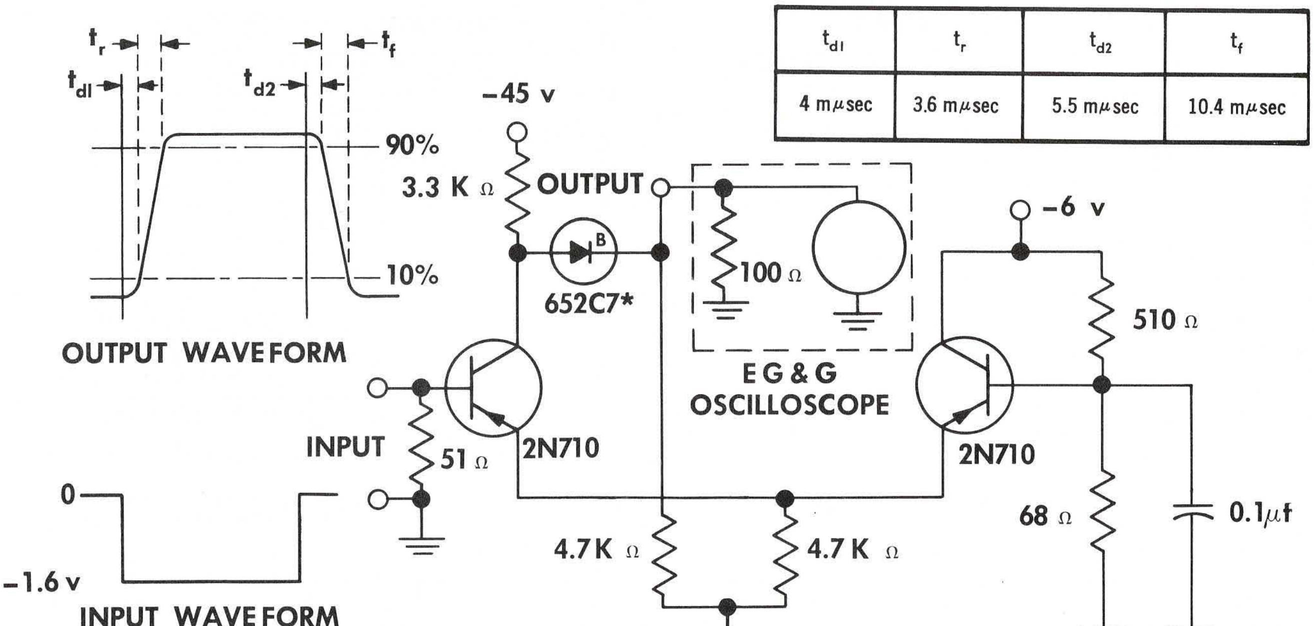
MONOSTABLE MULTIVIBRATOR

t_r	t_f	Pulse length (depends on C_k)
20 mμsec	40 mμsec	120 mμsec



NON-SATURATING CURRENT MODE SWITCH

t_{d1}	t_r	t_{d2}	t_f
4 mμsec	3.6 mμsec	5.5 mμsec	10.4 mμsec



*6 v breakdown diode

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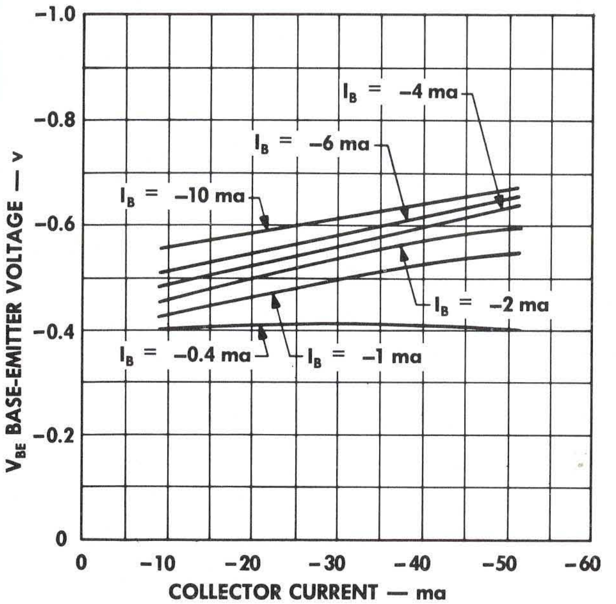
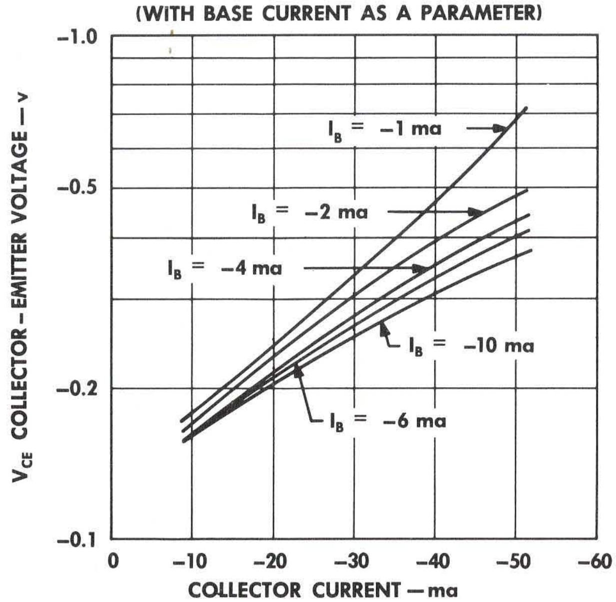
TYPICAL CHARACTERISTICS

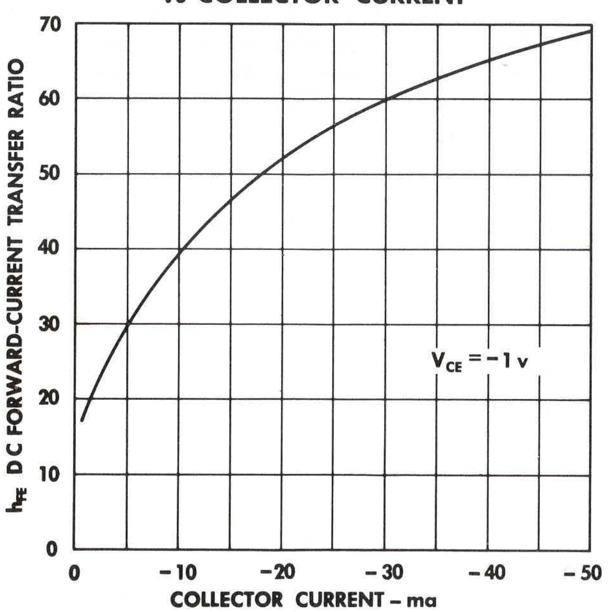
BASE-EMITTER VOLTAGE vs COLLECTOR CURRENT
(WITH BASE CURRENT AS A PARAMETER)



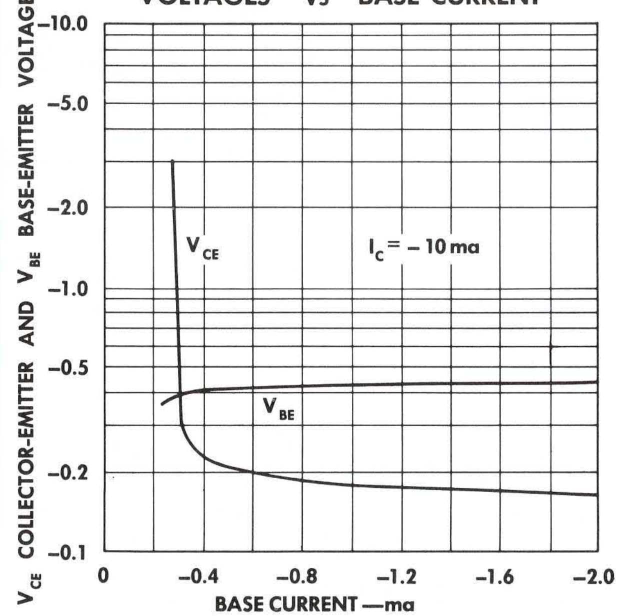
COLLECTOR-EMITTER VOLTAGE vs COLLECTOR CURRENT
(WITH BASE CURRENT AS A PARAMETER)



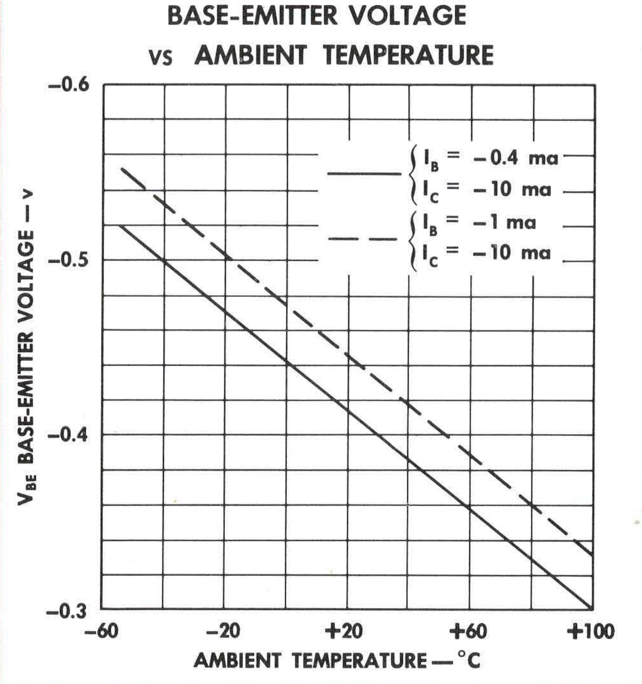
DC FORWARD-CURRENT TRANSFER RATIO vs COLLECTOR CURRENT

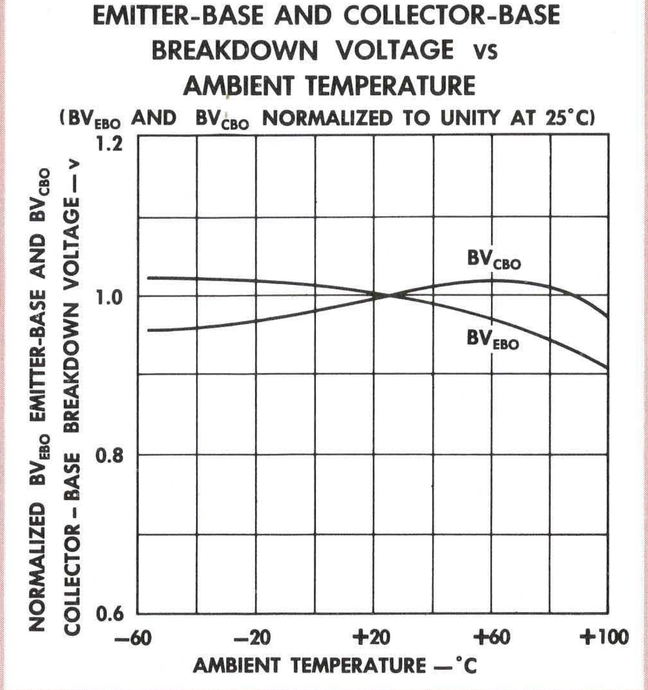


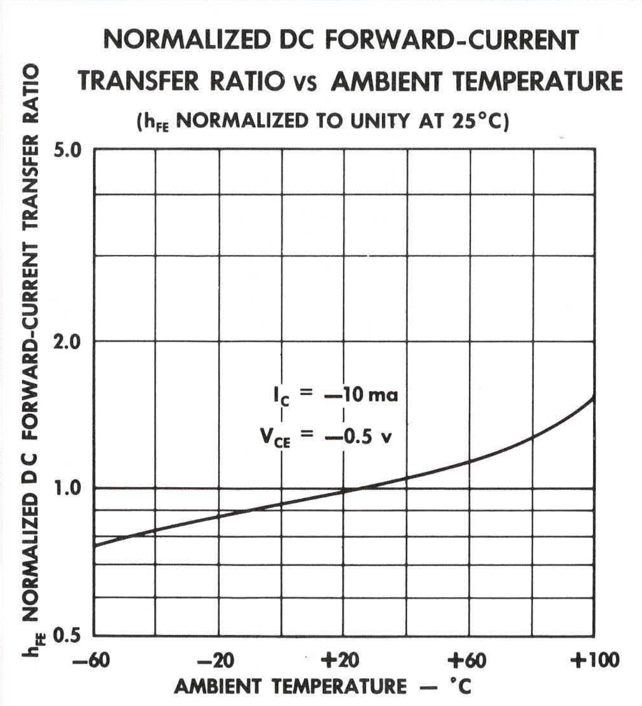
COLLECTOR-EMITTER AND BASE-EMITTER VOLTAGES vs BASE CURRENT

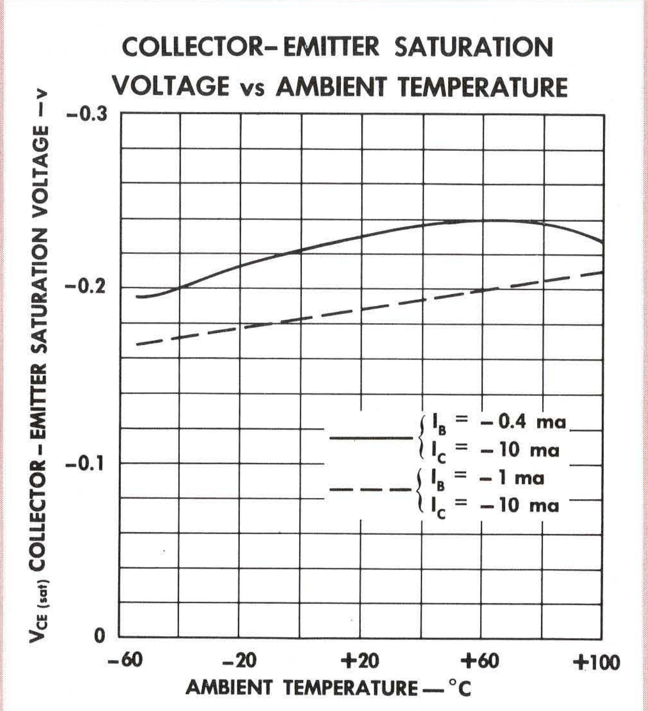


TYPICAL CHARACTERISTICS









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