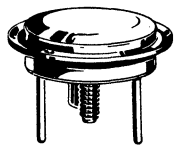
2N4048 thru 2N4053 (GERMANIUM)

CASE 7



Collector connected to case

PNP germanium power transistors designed for high-current applications requiring high gain and extremely low saturation voltage.

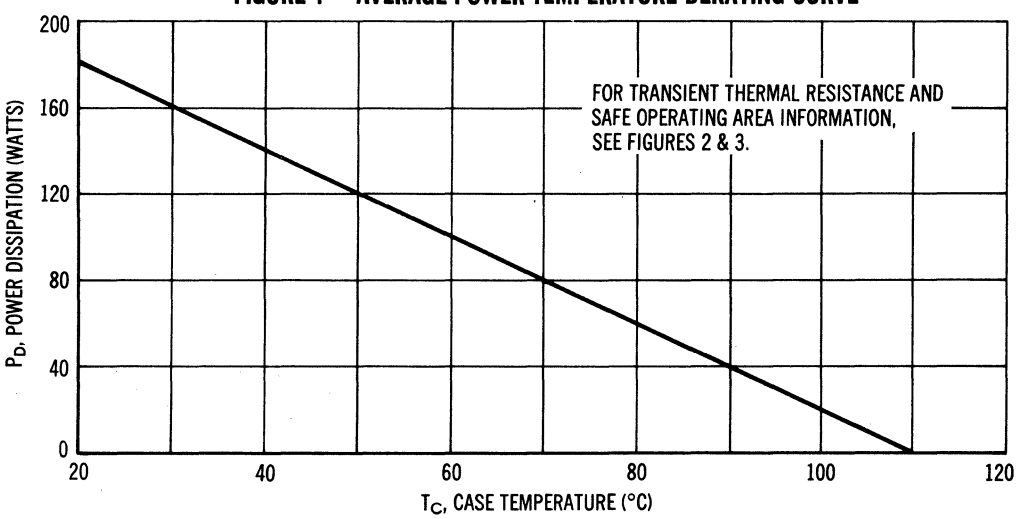
MAXIMUM RATINGS

Rating	Symbol	2N4048 2N4051	2N4049 2N4052	2N4050 2N4053	Unit
Collector-Emitter Voltage	V_{CEO}	30	45	60	Vdc
Collector-Emitter Voltage	V_{CES}	45	60	75	Vdc
Collector-Base Voltage	V_{CB}	45	60	75	Vdc
Emitter-Base Voltage	V_{EB}	25	30	40	Vdc
Collector Current — Continuous	I_C*	← 60 →			Adc
Total Device Dissipation @ T_C = 25°C	P_D	← 170 →			Watts
Derate above 25°C		← 2.0 →			W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +110 →			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	← 0.5 →	°C/W

FIGURE 1 — AVERAGE POWER-TEMPERATURE DERATING CURVE



* JEDEC Registered Values, For True Capability See Figure 3

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage† (I_C = 1.0 Adc, I_B = 0)	2N4048, 2N4051	BV_{CEO}†	30	-	Vdc
	2N4049, 2N4052		45	-	
	2N4050, 2N4053		60	-	
Collector-Emitter Breakdown Voltage (I_C = 300 mAdc, V_{BE} = 0)	2N4048, 2N4051	BV_{CES}	45	-	Vdc
	2N4049, 2N4052		60	-	
	2N4050, 2N4053		75	-	
Floating Potential (V_{CB} = 45 Vdc, I_E = 0)	2N4048, 2N4051	V_{EBF}	-	0.5	Vdc
(V_{CB} = 60 Vdc, I_E = 0)	2N4049, 2N4052		-	0.5	
(V_{CB} = 75 Vdc, I_E = 0)	2N4050, 2N4053		-	0.5	
Collector Cutoff Current (V_{CE} = 30 Vdc, $V_{BE(off)}$ = 2.0 Vdc, T_C = +71°C)	2N4048, 2N4051	I_{CEX}	-	15	mAdc
(V_{CE} = 45 Vdc, $V_{BE(off)}$ = 2.0 Vdc, T_C = +71°C)	2N4049, 2N4052		-	15	
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 2.0 Vdc, T_C = +71°C)	2N4050, 2N4053		-	15	
Collector Cutoff Current (V_{CB} = 2.0 Vdc, I_E = 0)		I_{CBO}	-	0.2	mAdc
(V_{CB} = 45 Vdc, I_E = 0)	2N4048, 2N4051		-	4.0	
(V_{CB} = 60 Vdc, I_E = 0)	2N4049, 2N4052		-	4.0	
(V_{CB} = 75 Vdc, I_E = 0)	2N4050, 2N4053		-	4.0	
Emitter Cutoff Current (V_{BE} = 25 Vdc, I_C = 0)	2N4048, 2N4051	I_{EBO}	-	4.0	mAdc
(V_{BE} = 25 Vdc, I_C = 0, T_C = +71°C)			-	15	
(V_{BE} = 30 Vdc, I_C = 0)	2N4049, 2N4052		-	4.0	
(V_{BE} = 30 Vdc, I_C = 0, T_C = +71°C)			-	15	
(V_{BE} = 40 Vdc, I_C = 0)	2N4050, 2N4053		-	4.0	
(V_{BE} = 40 Vdc, I_C = 0, T_C = +71°C)			-	15	
ON CHARACTERISTICS					
DC Current Gain† (I_C = 15 Adc, V_{CE} = 2.0 Vdc)	2N4048, 2N4049, 2N4050	h_{FE}†	60	180	-
	2N4051, 2N4052, 2N4053		120	240	
(I_C = 60 Adc, V_{CE} = 2.0 Vdc)			15	-	
Collector-Emitter Saturation Voltage† (I_C = 15 Adc, I_B = 1.0 Adc)		$V_{CE(sat)}$†	-	0.15	Vdc
(I_C = 60 Adc, I_B = 6.0 Adc)			-	0.3	
Base-Emitter Saturation Voltage† (I_C = 15 Adc, I_B = 1.0 Adc)		$V_{BE(sat)}$†	-	0.6	Vdc
(I_C = 60 Adc, I_B = 6.0 Adc)			-	1.0	
SMALL SIGNAL CHARACTERISTICS					
Common-Emitter Cutoff Frequency (I_C = 15 Adc, V_{CE} = 2.0 Vdc)		$f_{\alpha e}$	2.0	-	kHz

† To avoid excessive heating of the collector junction, perform test with pulse method.

The switching performance of this transistor is determined primarily by the gain-bandwidth product, f_T*, and the behavior of the base-spreading resistance, r_B'.

In the case of rise time, the base-spreading resistance plays a small part, and the test circuit delivers a constant current step of turn-on current to the transistor (I_{B1}). Therefore, the curve of t, on Figure 6 follows theory closely, i.e.:

$$t_r = 0.8 \frac{I_C}{I_{B1}} \cdot \frac{1}{2\pi f_T}$$

From the curve, it can be seen that f_T is roughly constant with current; using the equation, its large signal value can be calculated to be approximately 120 kHz at the 20-Amp level. A lower supply voltage will increase rise time slightly.

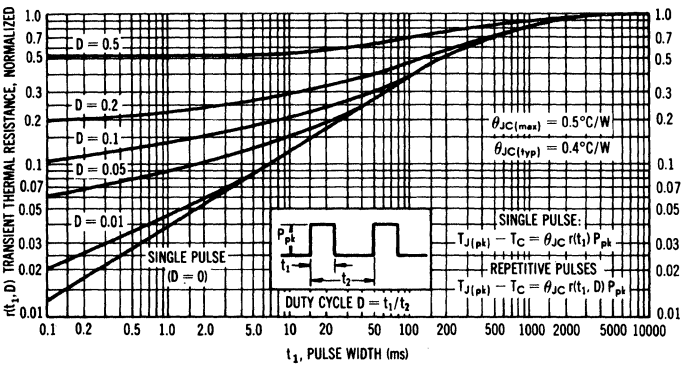
Turn-off time is slow because of conductivity modulation which occurs in the base region. When the transistor is held "on" in saturation, the base region becomes filled with excess charge; i.e., charge in excess of that necessary to sustain the circuit limited value of I_C. As a result, the base resistivity and consequently r_B' become very low. During turn off, as the excess charge is reduced, the accompanying increase in resistivity causes a marked reduction in the turn-off current, i_{B2}, as can be seen from the waveforms of Figure 5. During fall time, the i_{B2} current is very low causing an extended fall time.

Only a slight improvement in turn-off performance is achieved with a "speed-up" capacitor placed across R_B. This unusual behavior occurs because r_B' limits the amount of reverse current which can be achieved. Also, it seems evident that r_B' increases with applied reverse current, so that efforts to speed up the turn-off behavior are somewhat futile.

In most applications, switching time will be close to the values shown on Figure 6. Delay time is not shown as it is negligible in comparison to the other times.

* $f_T \approx f_{\alpha e} \times h_{fe}$

FIGURE 2 — TRANSIENT THERMAL RESISTANCE



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e. the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 3 is based on $T_{J(pk)}$ = 110°C; T_C is variable depending upon conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} < 110°C$. $T_{J(pk)}$ may be calculated from the data in Figure 2. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 3 — ACTIVE REGION SAFE-OPERATING AREA

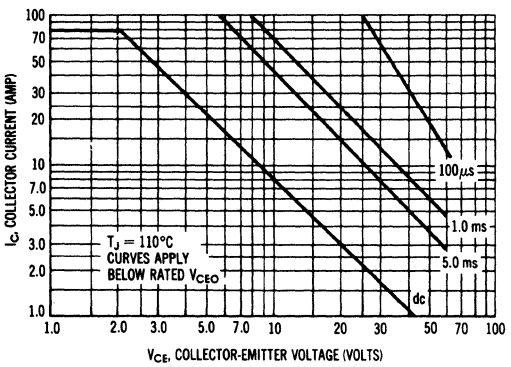
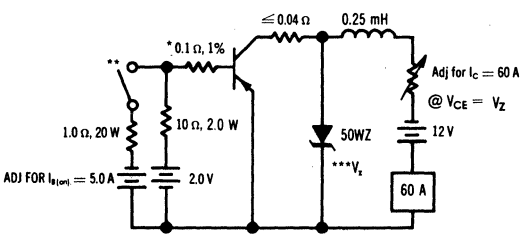


FIGURE 4 — SAFE OPERATING AREA TEST CIRCUIT



*NOT REQUIRED IF CURRENT PROBE USED TO READ $I_{B(on)}$

**PRF ≈ 60 Hz

SERIES IMPEDANCE & INDUCTANCE MUST BE KEPT TO A MINIMUM.

***ZENER SELECTED TO ESTABLISH SAFE OPERATING AREA VOLTAGE.

@ I_C = 60 Adc:
2N4048, 2N4051 = 35 Vdc
2N4049, 2N4052 = 40 Vdc
2N4050, 2N4053 = 45 Vdc

FIGURE 5 — SWITCHING TEST CIRCUIT

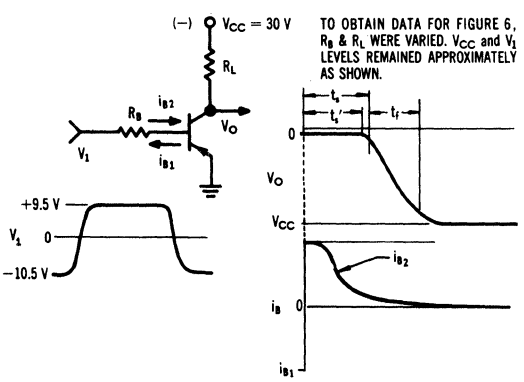
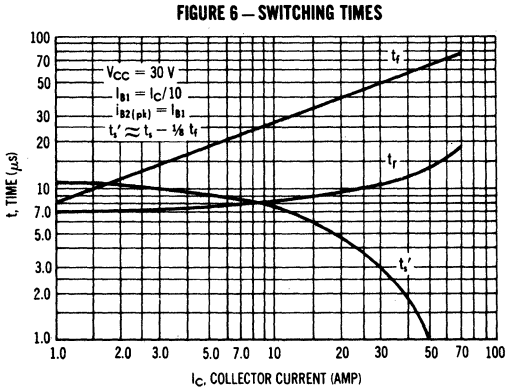


FIGURE 6 — SWITCHING TIMES



TYPICAL DC CHARACTERISTICS

FIGURE 7 — DC CURRENT GAIN

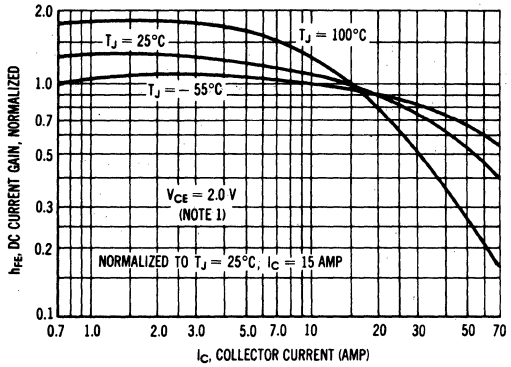


FIGURE 8 — COLLECTOR SATURATION REGION

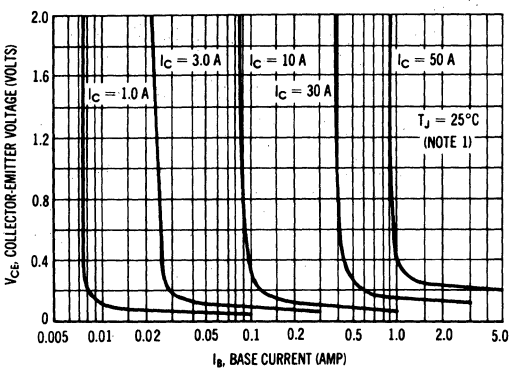


FIGURE 9 — EFFECTS OF BASE-EMITTER RESISTANCE

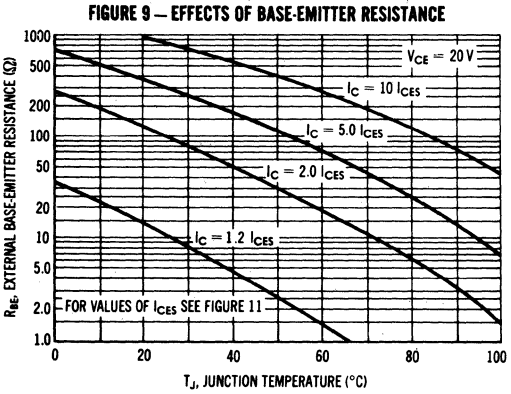


FIGURE 10 — "ON" VOLTAGES

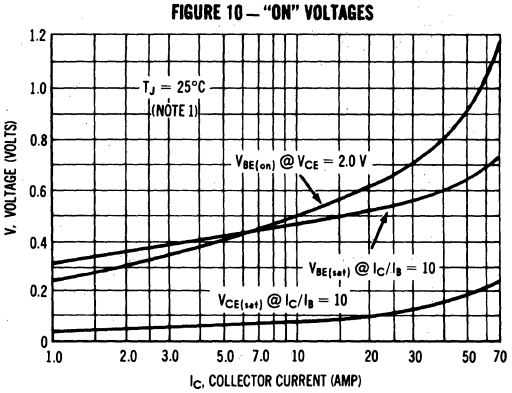


FIGURE 11 — COLLECTOR CUTOFF REGION

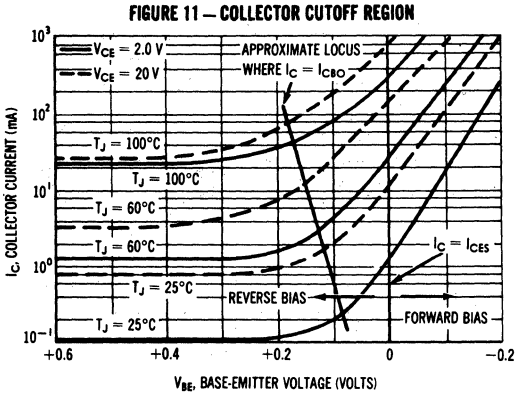
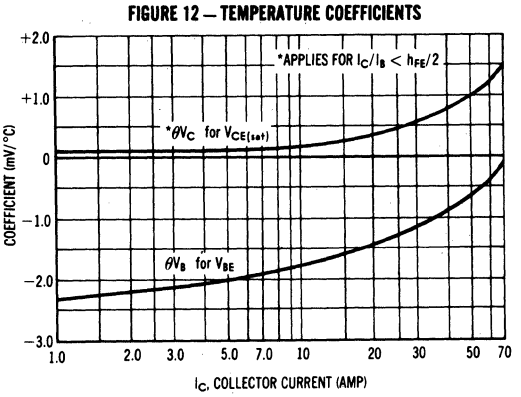


FIGURE 12 — TEMPERATURE COEFFICIENTS



NOTE 1: Data is obtained from pulse tests and adjusted to nullify the effect of I_{CBO}.