2N2218,A, 2N2219,A 2N2221,A(SILICON)
2N2222,A, 2N5581, 2N5582

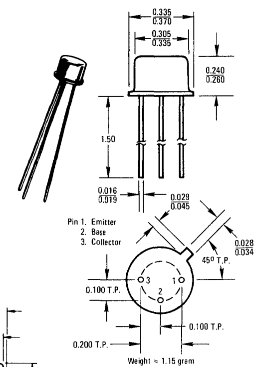
NPN SILICON ANNULAR HERMETIC TRANSISTORS

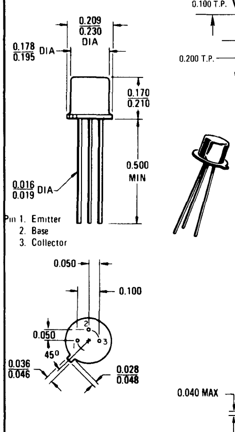
. . . widely used "Industry Standard" transistors for applications as medium-speed switches and as amplifiers from audio to VHF frequencies.

- DC Current Gain Specified — 1.0 to 500 mAdc
- Low Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ @ I_C = 500 mAdc
  = 1.6 Vdc (Max) — Non-A Suffix
  = 1.0 Vdc (Max) — A-Suffix
- High Current-Gain—Bandwidth Product —
  f_T = 250 MHz (Min) @ I_C = 20 mAdc — All Types Except
  = 300 MHz (Min) @ I_C = 20 mAdc — 2N2219A, 2N2222A, 2N5582
- Complements to PNP 2N2904,A thru 2N2907,A
- JAN/JANTX Available for all devices

NPN SILICON SWITCHING AND AMPLIFIER TRANSISTORS

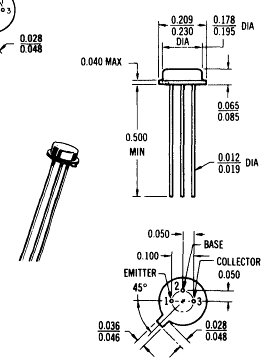
CASE 31 (1)
TO-5
2N2218,A
2N2219,A





CASE 22 (1)
TO-18
2N2221,A
2N2222,A

CASE 26
TO-46
2N5581
2N5582



The respective JEDEC registered dimensions and notes apply

SELECTION GUIDE

Device Type	Characteristic: BV_{CEO} I_C = 10 mAdc Volts	h_{FE} I_C = 150 mAdc Min/Max	h_{FE} I_C = 500 mAdc Min	Package
2N2218 2N2219	30	40/120 100/300	20 30	TO-5
2N2221 2N2222	30	40/120 100/300	20 30	TO-18
2N5581 2N5582	40	40/120 100/300	25 40	TO-46
2N2218A 2N2219A	40	40/120 100/300	25 40	TO-5
2N2221A 2N2222A	40	40/120 100/300	25 40	TO-18

***MAXIMUM RATINGS**

Rating	Symbol	2N2218 2N2219 2N2221 2N2222	2N2218A 2N2219A 2N2221A 2N2222A	2N5581 2N5582	Unit
Collector-Emitter Voltage	V_{CEO}	30	40	40	Vdc
Collector-Base Voltage	V_{CB}	60	75	75	Vdc
Emitter-Base Voltage	V_{EB}	5.0	6.0	6.0	Vdc
Collector Current — Continuous	I_C	800	800	800**	mAdc
		2N2218,A 2N2219,A	2N2221,A 2N2222,A	2N5581 2N5582	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.8 5.33	0.5 3.33	0.5 3.33	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.0 20	1.8 12	2.0 11.43	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200			°C

*Indicates JEDEC Registered Data.
**Motorola Guarantees this Data in Addition to JEDEC Registered Data.

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage		BV_{CEO}			Vdc
(I_C = 10 mAdc, I_B = 0)	Non-A Suffix		30	–	
	A-Suffix, 2N5581,2N5582		40	–	
Collector-Base Breakdown Voltage		BV_{CBO}			Vdc
(I_C = 10 μAdc, I_E = 0)	Non-A Suffix		60	–	
	A-Suffix, 2N5581,2N5582		75	–	
Emitter-Base Breakdown Voltage		BV_{EBO}			Vdc
(I_E = 10 μAdc, I_C = 0)	Non-A Suffix		5.0	–	
	A-Suffix, 2N5581,2N5582		6.0	–	
Collector Cutoff Current		I_{CEX}			nAdc
(V_{CE} = 60 Vdc, $V_{EB(off)}$ = 3.0 Vdc)	A-Suffix, 2N5581,2N5582		–	10	
Collector Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 50 Vdc, I_E = 0)	Non-A Suffix		–	0.01	
(V_{CB} = 60 Vdc, I_E = 0)	A-Suffix, 2N5581,2N5582		–	0.01	
(V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)	Non-A Suffix		–	10	
(V_{CB} = 60 Vdc, I_E = 0, T_A = 150°C)	A-Suffix, 2N5581,2N5582		–	10	
Emitter Cutoff Current		I_{EBO}			nAdc
(V_{EB} = 3.0 Vdc, I_C = 0)	A-Suffix, 2N5581,2N5582		–	10	
Base Cutoff Current		I_{BL}			nAdc
(V_{CE} = 60 Vdc, $V_{EB(off)}$ = 3.0 Vdc)	A-Suffix		–	20	
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			–
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	2N2218,A,2N2221,A,2N5581(1)		20	–	
	2N2219,A,2N2222,A,2N5582(1)		35	–	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	2N2218,A,2N2221,A,2N5581		25	–	
	2N2219,A,2N2222,A,2N5582		50	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	2N2218,A,2N2221,A,2N5581(1)		35	–	
	2N2219,A,2N2222,A,2N5582(1)		75	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = -55°C)	2N2218A,2N2221A,2N5581		15	–	
	2N2219A,2N2222A,2N5582		35	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)(1)	2N2218,A,2N2221,A,2N5581		40	120	
	2N2219,A,2N2222,A,2N5582		100	300	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)(1)	2N2218A,2N2221A,2N5581		20	–	
	2N2219A,2N2222A,2N5582		50	–	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)(1)	2N2218,2N2221		20	–	
	2N2219,2N2222		30	–	
	2N2218A,2N2221A,2N5581		25	–	
	2N2219A,2N2222A,2N5582		40	–	
Collector-Emitter Saturation Voltage(1)		$V_{CE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)	Non-A Suffix		–	0.4	
	A-Suffix, 2N5581,2N5582		–	0.3	
(I_C = 500 mAdc, I_B = 50 mAdc)	Non-A Suffix		–	1.6	
	A-Suffix, 2N5581,2N5582		–	1.0	
Base-Emitter Saturation Voltage(1)		$V_{BE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)	Non-A Suffix		0.6	2.0	
	A-Suffix, 2N5581,2N5582		0.6	1.2	
(I_C = 500 mAdc, I_B = 50 mAdc)	Non-A Suffix		–	2.6	
	A-Suffix, 2N5581,2N5582		–	2.0	

*ELECTRICAL CHARACTERISTICS (Continued)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product(2) (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	All Types, Except 2N2219A,2N2222A,2N5582	f_T	250 300	— —	MHz
Output Capacitance(3) (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	—	8.0	pF
Input Capacitance(3) (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)	Non-A Suffix A-Suffix, 2N5581,2N5582	C_{ib}	— —	30 25	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A,2N2221A,2N5581 2N2219A,2N2222A,2N5582	h_{ie}	1.0 2.0	3.5 8.0	k ohms
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A,2N2221A,2N5581 2N2219A,2N2222A,2N5582		0.2 0.25	1.0 1.25	
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A,2N2221A,2N5581 2N2219A,2N2222A,2N5582	h_{re}	— —	5.0 8.0	X 10^{-4}
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A,2N2221A,2N5581 2N2219A,2N2222A,2N5582		— —	2.5 4.0	
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A,2N2221A,2N5581 2N2219A,2N2222A,2N5582	h_{fe}	30 50	150 300	—
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A,2N2221A,2N5581 2N2219A,2N2222A,2N5582		50 75	300 375	
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A,2N2221A,2N5581 2N2219A,2N2222A,2N5582	h_{oe}	3.0 5.0	15 35	μmhos
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A,2N2221A,2N5581 2N2219A,2N2222A,2N5582		10 25	100 200	
Collector-Base Time Constant (I_E = 20 mAdc, V_{CB} = 20 Vdc, f = 31.8 MHz)	A-Suffix, 2N5581,2N5582	$r_b'C_c$	—	150	ps
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 1.0 k ohm, f = 1.0 kHz)	2N2219A,2N2222A	NF	—	4.0	dB
SWITCHING CHARACTERISTICS (A-Suffix, 2N5581 and 2N5582)					
Delay Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = 0.5 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc) (Figure 14)	t_d	—	10	ns
Rise Time		t_r	—	25	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc) (Figure 15)	t_s	—	225	ns
Fall Time		t_f	—	60	ns
Active Region Time Constant** (I_C = 150 mAdc, V_{CE} = 30 Vdc)		T_A	—	2.5	ns

*Indicates JEDEC Registered Data.
**Motorola Guarantees this Data in Addition to JEDEC Registered Data.
(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2)f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.
(3)2N5581 and 2N5582 are Listed C_{cb} and C_{eb} for these conditions and values.

FIGURE 1 – NORMALIZED DC CURRENT GAIN

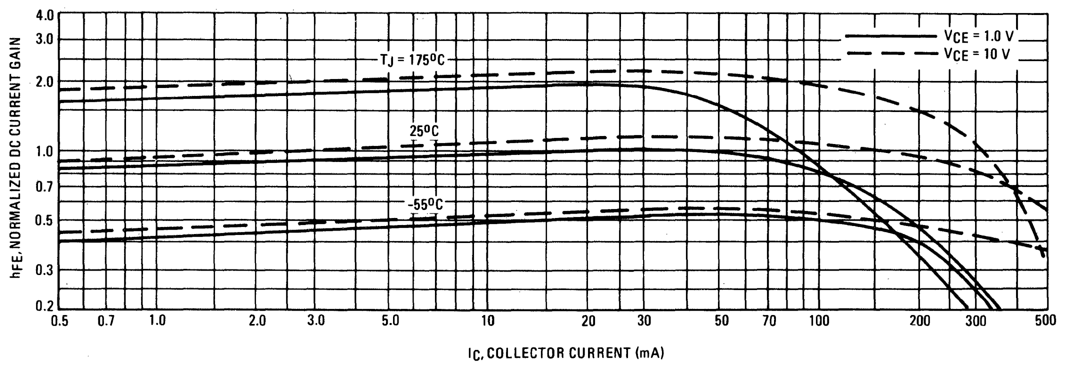
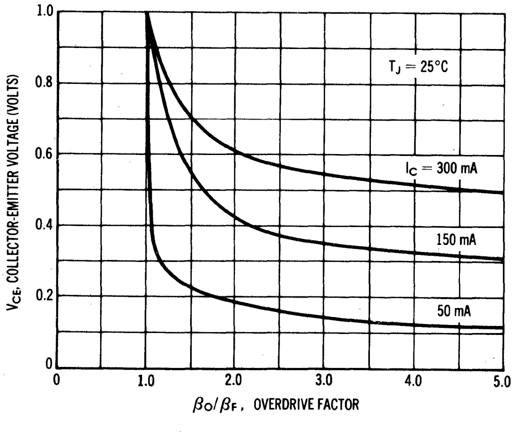


FIGURE 2 – COLLECTOR CHARACTERISTICS IN SATURATION REGION



This graph shows the effect of base current on collector current. β_o (current gain at the edge of saturation) is the current gain of the transistor at 1 volt, and β_F (forced gain) is the ratio of I_C/I_{BF} in a circuit.

EXAMPLE: For type 2N2219, estimate a base current (I_{BF}) to insure saturation at a temperature of 25°C and a collector current of 150 mA.

Observe that at I_C = 150 mA an overdrive factor of at least 2.5 is required to drive the transistor well into the saturation region. From Figure 1, it is seen that h_{FE} @ 1 volt is approximately 0.62 of h_{FE} @ 10 volts. Using the guaranteed minimum gain of 100 @ 150 mA and 10 V, β_o = 62 and substituting values in the overdrive equation, we find:

$$\frac{\beta_o}{\beta_F} = \frac{h_{FE} @ 1.0\,V}{I_C/I_{BF}} \qquad 2.5 = \frac{62}{150/I_{BF}} \qquad I_{BF} \approx 6.0 \text{ mA}$$

FIGURE 3 – "ON" VOLTAGES

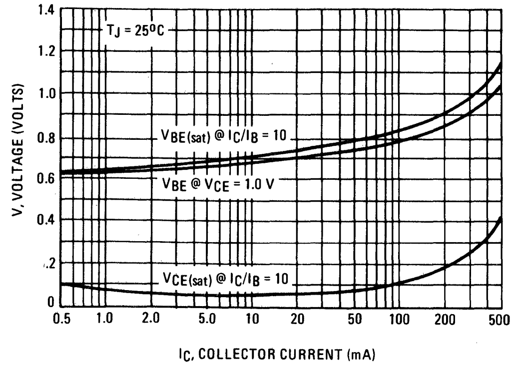
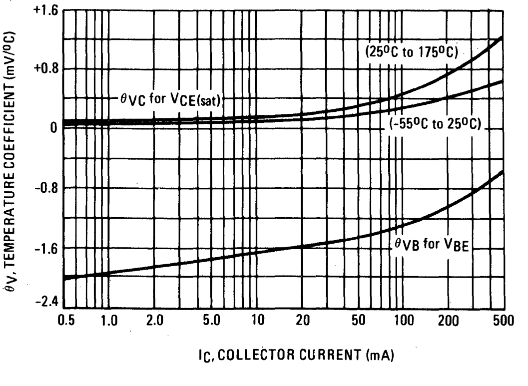


FIGURE 4 – TEMPERATURE COEFFICIENTS



NOISE FIGURE

V_{CE} = 10 V, T_A = 25°C

FIGURE 5 — FREQUENCY EFFECTS

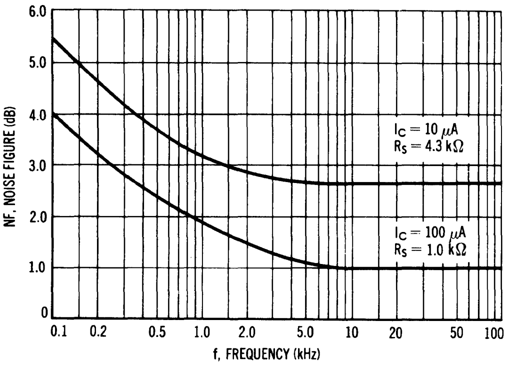
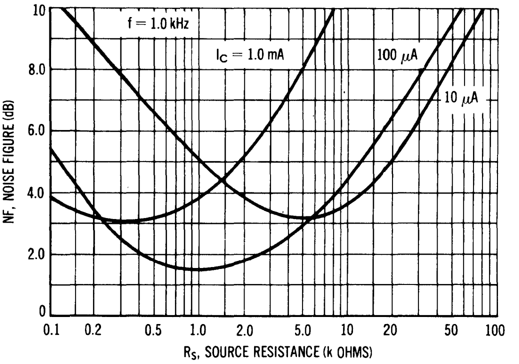


FIGURE 6 — SOURCE RESISTANCE EFFECTS



h PARAMETERS

V_{CE} = 10 Vdc, f = 1.0 kHz, T_A = 25°C

This group of graphs illustrates the relationship between h_{fe} and other "h" parameters for this series of transistors. To obtain these curves, a high-gain and a low-gain unit were selected and the same units were used to develop the correspondingly numbered curves on each graph.

FIGURE 7 — INPUT IMPEDANCE

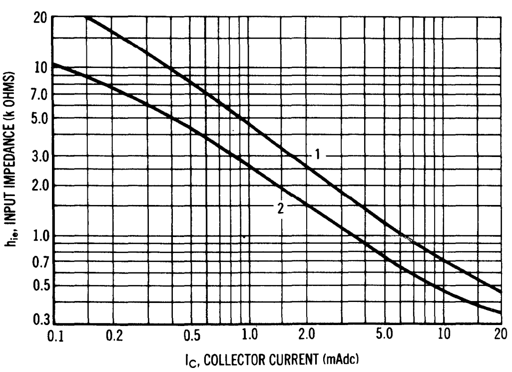


FIGURE 8 — VOLTAGE FEEDBACK RATIO

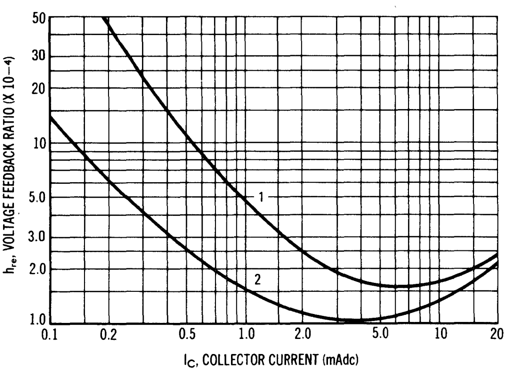


FIGURE 9 — CURRENT GAIN

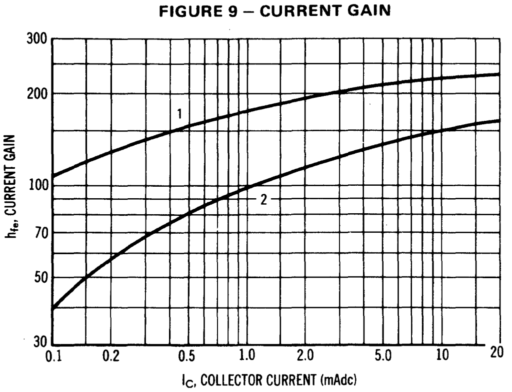
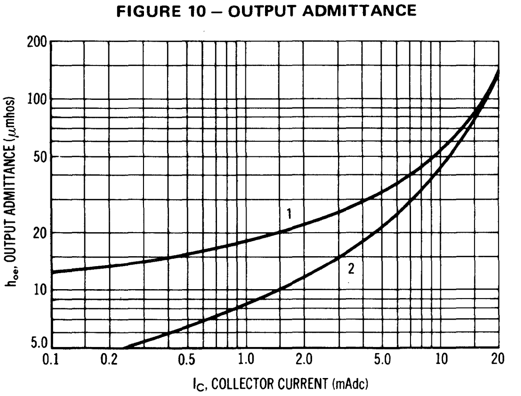


FIGURE 10 — OUTPUT ADMITTANCE



SWITCHING TIME CHARACTERISTICS

FIGURE 11 – TURN-ON TIME

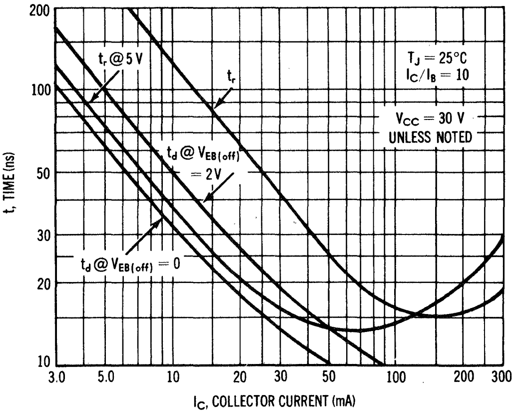


FIGURE 12 – CHARGE DATA

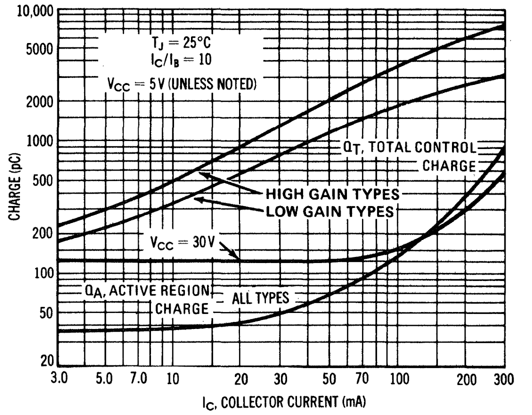


FIGURE 13 – TURN OFF BEHAVIOR

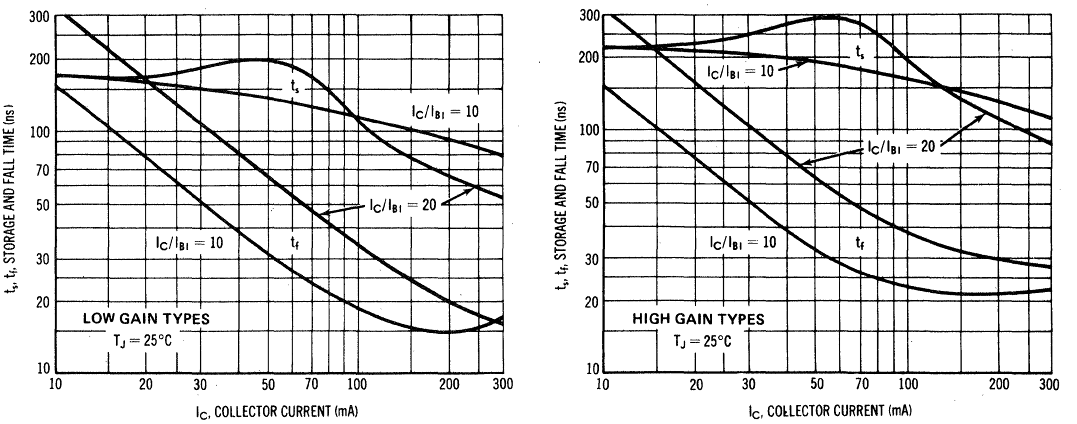


FIGURE 14 – DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

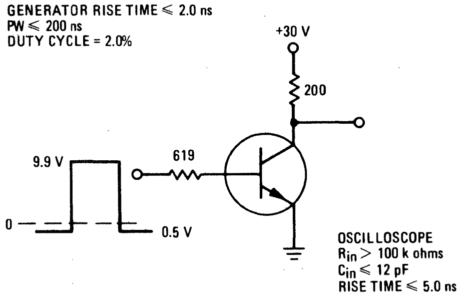


FIGURE 15 – STORAGE TIME AND FALL TIME EQUIVALENT TEST CIRCUIT

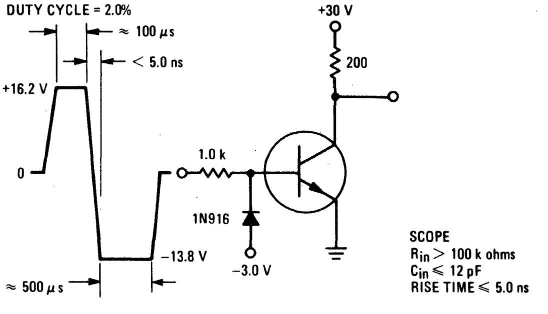


FIGURE 16 – CURRENT-GAIN–BANDWIDTH PRODUCT AND COLLECTOR-BASE TIME CONSTANT DATA

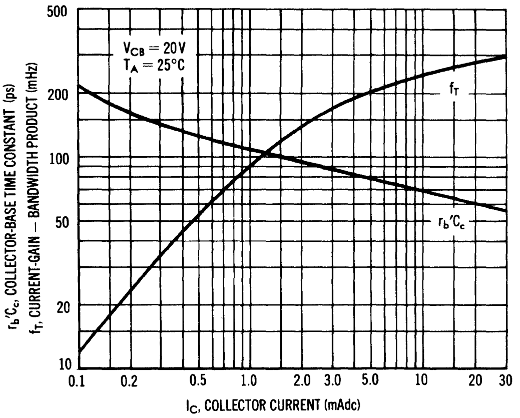


FIGURE 17 – CAPACITANCES

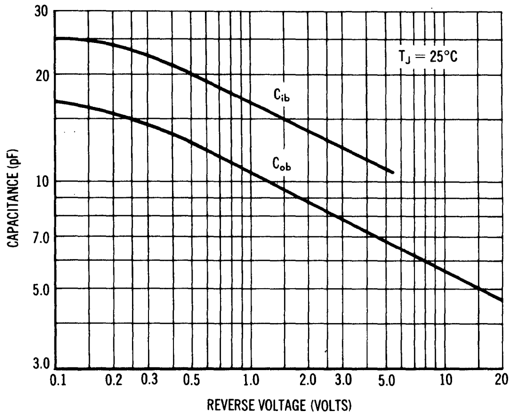
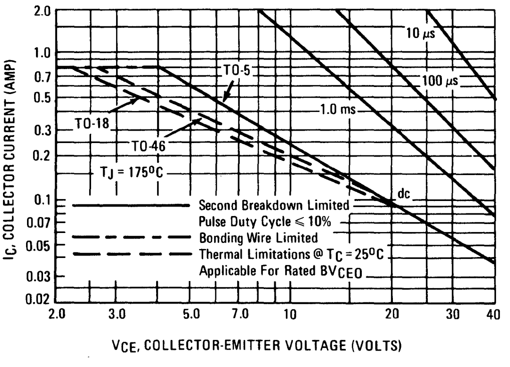


FIGURE 18 – ACTIVE-REGION SAFE OPERATING AREAS

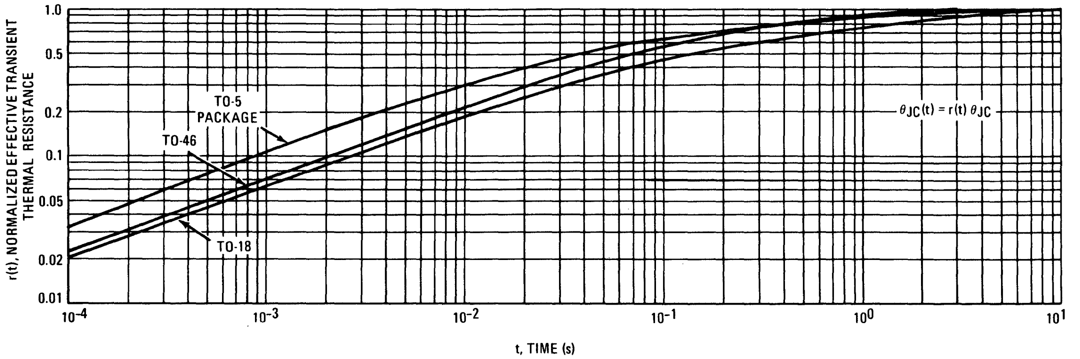


This graph shows the maximum I_C-V_{CE} limits of the device both from the standpoint of thermal dissipation (at 25°C case temperature), and secondary breakdown. For case temperatures other than 25°C, the thermal dissipation curve must be modified in accordance with the derating factor in the Maximum Ratings table.

To avoid possible device failure, the collector load line must fall below the limits indicated by the applicable curve. Thus, for certain operating conditions the device is thermally limited, and for others it is limited by secondary breakdown.

For pulse applications, the maximum I_C-V_{CE} product indicated by the dc thermal limits can be exceeded. Pulse thermal limits may be calculated by using the transient thermal resistance curve of Figure 19.

FIGURE 19 – THERMAL RESPONSE



2N2223, A

For Specifications, See 2N2060 Data.