

# MOTOROLA SEMICONDUCTOR TECHNICAL DATA

## HIGH POWER PLASTIC COMPLEMENTARY SILICON POWER TRANSISTORS

... designed for use in general-purpose amplifier and switching circuits.

- Collector-Base Voltage –  $V_{CB0} = 60 \text{ Vdc} - 2\text{N}5986, 2\text{N}5989$   
 $= 80 \text{ Vdc} - 2\text{N}5987$   
 $= 100 \text{ Vdc} - 2\text{N}5988, 2\text{N}5991$
- Collector-Emitter Voltage –  $V_{CEO} = 40 \text{ Vdc} - 2\text{N}5986, 2\text{N}5989$   
 $= 60 \text{ Vdc} - 2\text{N}5987$   
 $= 80 \text{ Vdc} - 2\text{N}5988, 2\text{N}5991$
- DC Current Gain –  
 $h_{FE} = 20-120 @ I_C = 6.0 \text{ Adc}$   
 $= 7.0 (\text{Min}) @ I_C = 12 \text{ Adc}$
- Collector-Emitter Saturation Voltage –  
 $V_{CE(\text{sat})} = 0.7 \text{ Vdc (Max)} @ I_C = 6.0 \text{ Adc}$

### \*MAXIMUM RATINGS

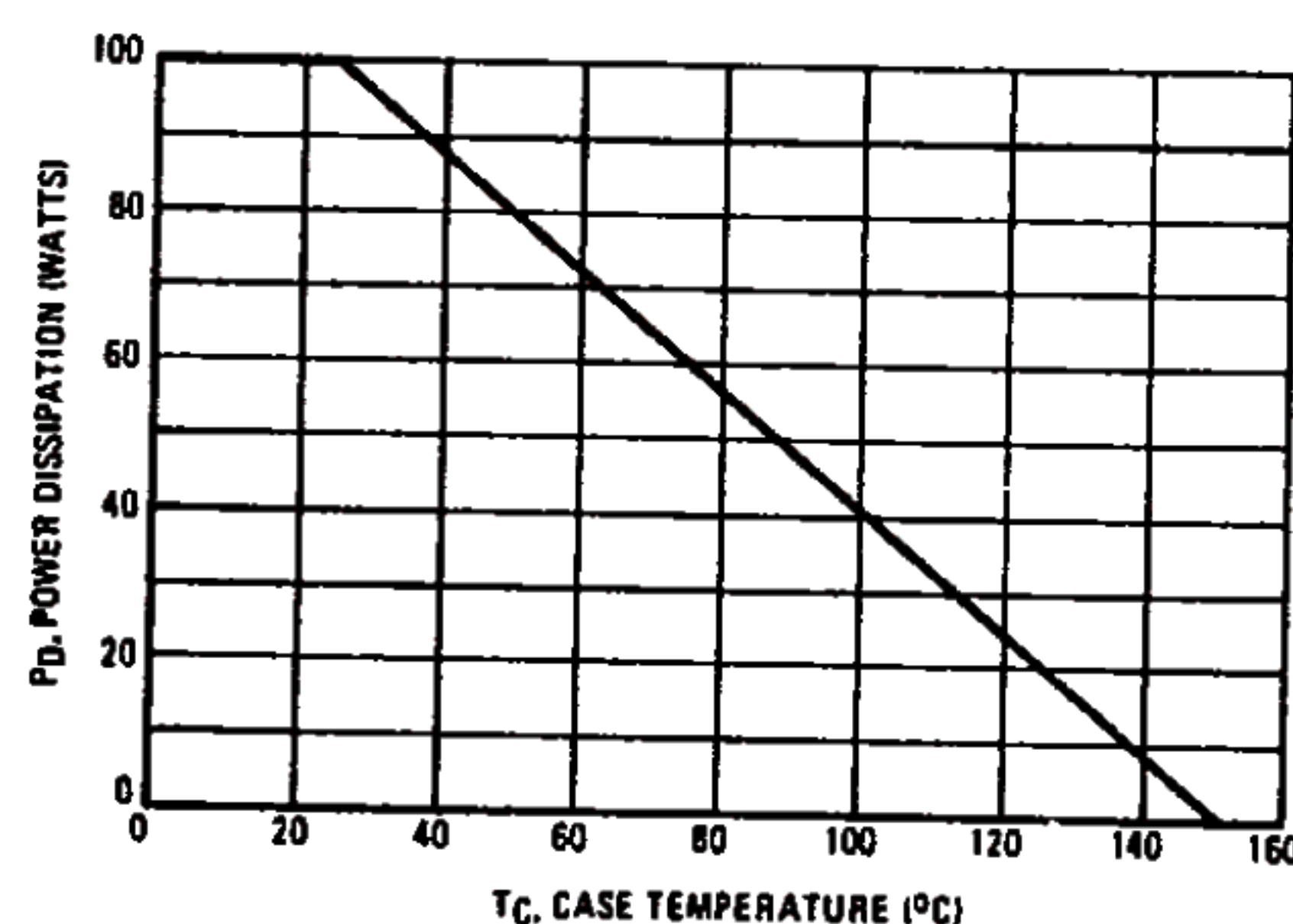
Rating	Symbol	2N5986 2N5989	2N5987	2N5988 2N5991	Unit
Collector-Base Voltage	$V_{CB}$	60	80	100	Vdc
Collector-Emitter Voltage	$V_{CEO}$	40	60	80	Vdc
Emitter-Base Voltage	$V_{EB}$	5.0			Vdc
Collector Current – Continuous Peak	$I_C$	12 20			Adc
Base Current	$I_B$	4.0			Adc
Total Power Dissipation @ $T_C = 25^\circ\text{C}$ Derate above $25^\circ\text{C}$	$P_D$	100 0.8			Watts W/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	$T_J, T_{stg}$	-65 to +150			$^\circ\text{C}$

### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$\theta_{JC}$	1.25	$^\circ\text{C/W}$

\* Indicates JEDEC Registered Data

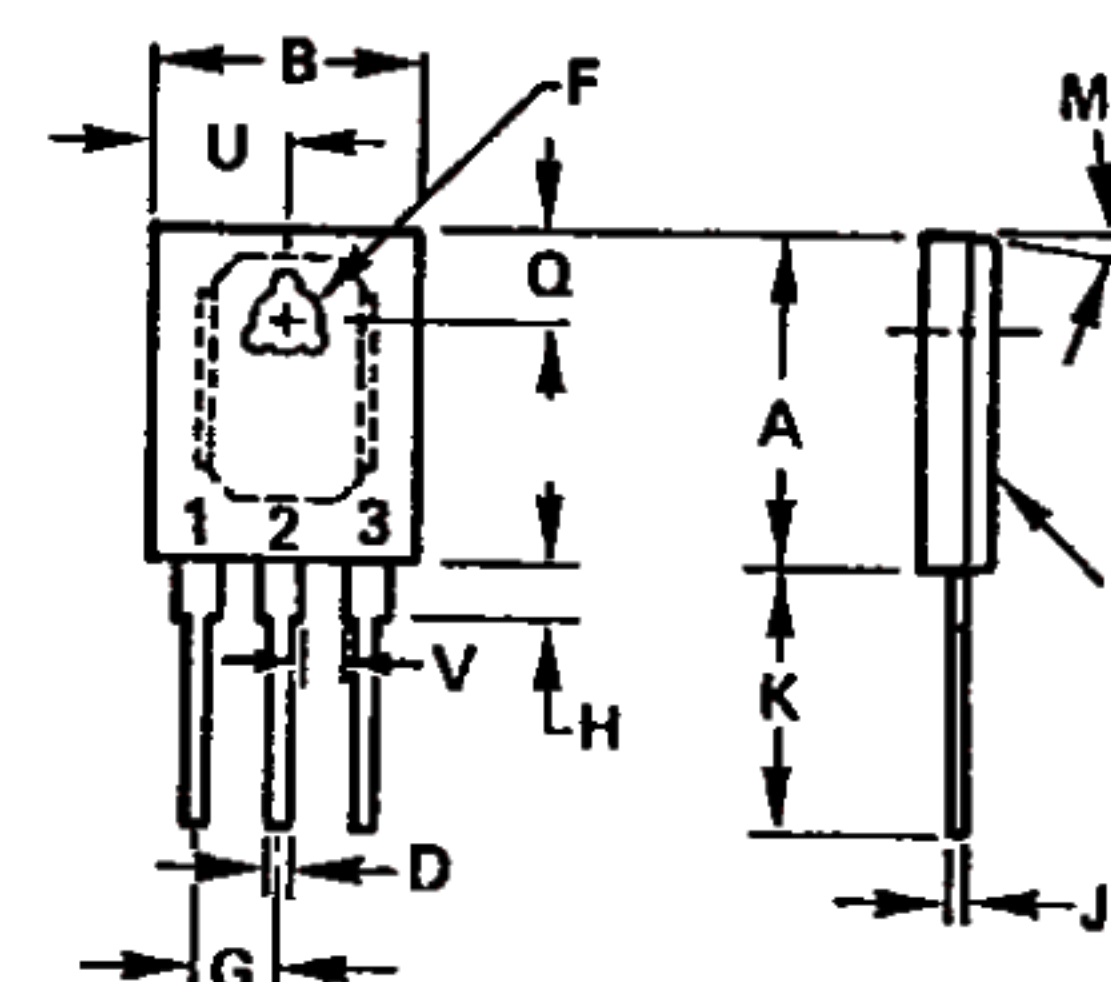
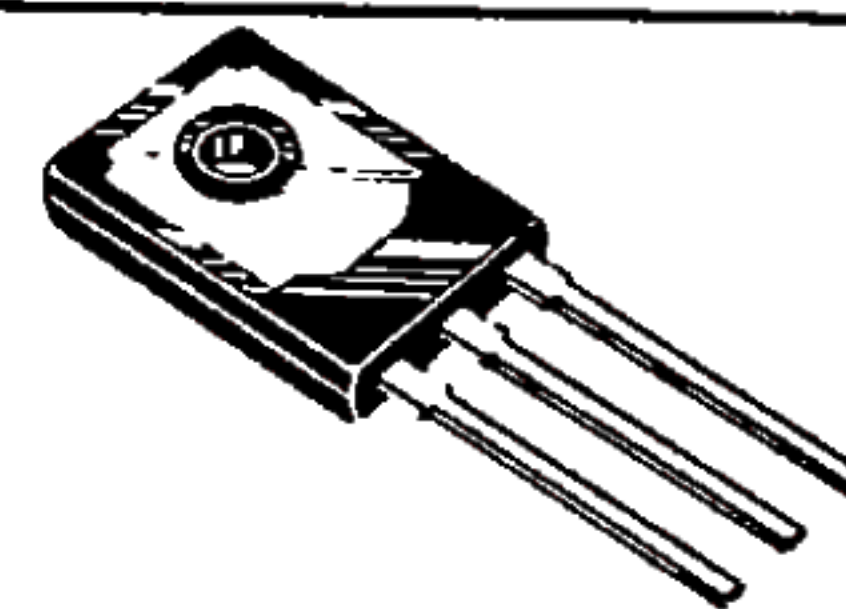
FIGURE 1 – POWER DERATING



PNP  
2N5986, 2N5987  
2N5988  
NPN  
2N5989, 2N5991

## 12 AMPERE POWER TRANSISTORS COMPLEMENTARY SILICON

40, 60, 80 VOLTS  
100 WATTS



STYLE 2:  
PIN 1. EMITTER  
2. COLLECTOR  
3. BASE

#### NOTES:

- DIM "D" UNCONTROLLED IN ZONE "H"
- DIM "F" DIA THRU
- HEAT SINK CONTACT AREA (BOTTOM)
- LEADS WITHIN 0.005" RAD OF TRUE POSITION (TP) AT MAXIMUM MATERIAL CONDITION.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	16.13	16.38	0.635	0.645
B	12.57	12.83	0.495	0.505
C	3.18	3.43	0.125	0.135
D	1.09	1.24	0.043	0.049
F	3.51	3.76	0.138	0.148
G	4.22 BSC		0.166 BSC	
H	2.67	2.92	0.105	0.115
J	0.813	0.864	0.032	0.034
K	15.11	16.38	0.595	0.645
M	90 TYP		90 TYP	
Q	4.70	4.95	0.185	0.195
R	1.91	2.16	0.075	0.085
U	6.22	6.48	0.245	0.255
V	2.03	—	0.080	—

CASE 90-05  
TO-225AB



6367254 MOTOROLA SC (XSTRS/R F)  
2N5986, 2N5987, 2N5988 PNP / 2N5989, 2N5991 NPN

\*ELECTRICAL CHARACTERISTICS ( $T_C = 25^\circ\text{C}$  unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
<b>OFF CHARACTERISTICS</b>				
Collector-Emitter Sustaining Voltage ( $I_C = 0.2 \text{ A dc}, I_B = 0$ )	$V_{CEO(sus)}$	40 60 80	— — —	Vdc
Collector Cutoff Current ( $V_{CE} = 20 \text{ Vdc}, I_B = 0$ ) ( $V_{CE} = 30 \text{ Vdc}, I_B = 0$ ) ( $V_{CE} = 40 \text{ Vdc}, I_B = 0$ )	$I_{CEO}$	— — —	2.0 2.0 2.0	mA dc
Collector Cutoff Current ( $V_{CE} = 60 \text{ Vdc}, V_{BE(off)} = 1.5 \text{ Vdc}$ ) ( $V_{CE} = 80 \text{ Vdc}, V_{BE(off)} = 1.5 \text{ Vdc}$ ) ( $V_{CE} = 100 \text{ Vdc}, V_{BE(off)} = 1.5 \text{ Vdc}$ ) ( $V_{CE} = 40 \text{ Vdc}, V_{BE(off)} = 1.5 \text{ Vdc}, T_C = 125^\circ\text{C}$ ) ( $V_{CE} = 60 \text{ Vdc}, V_{BE(off)} = 1.5 \text{ Vdc}, T_C = 125^\circ\text{C}$ ) ( $V_{CE} = 80 \text{ Vdc}, V_{BE(off)} = 1.5 \text{ Vdc}, T_C = 125^\circ\text{C}$ )	$I_{CEX}$	— — — — — —	200 200 200 2.0 2.0 2.0	$\mu\text{A dc}$   mA dc
Emitter Cutoff Current ( $V_{BE} = 5.0 \text{ Vdc}, I_C = 0$ )	$I_{EBO}$	—	1.0	mA dc
<b>ON CHARACTERISTICS</b>				
DC Current Gain ( $I_C = 1.5 \text{ A dc}, V_{CE} = 2.0 \text{ Vdc}$ ) ( $I_C = 6.0 \text{ A dc}, V_{CE} = 2.0 \text{ Vdc}$ ) ( $I_C = 12 \text{ A dc}, V_{CE} = 2.0 \text{ Vdc}$ )	$h_{FE}$	40 20 7.0	— 120 —	—
Collector-Emitter Saturation Voltage ( $I_C = 6.0 \text{ A dc}, I_B = 0.6 \text{ A dc}$ ) ( $I_C = 12 \text{ A dc}, I_B = 1.8 \text{ A dc}$ )	$V_{CE(sat)}$	— —	0.6 1.7	Vdc
Base-Emitter Saturation Voltage ( $I_C = 12 \text{ A dc}, I_B = 1.8 \text{ A dc}$ )	$V_{BE(sat)}$	—	2.5	Vdc
Base-Emitter On Voltage ( $I_C = 6.0 \text{ A dc}, V_{CE} = 2.0 \text{ Vdc}$ )	$V_{BE(on)}$	—	1.4	Vdc
<b>DYNAMIC CHARACTERISTICS</b>				
Current-Gain — Bandwidth Product ( $I_C = 0.5 \text{ A dc}, V_{CE} = 10 \text{ Vdc}, f_{test} = 1.0 \text{ MHz}$ )	$f_T$	2.0	—	MHz
Output Capacitance ( $V_{CB} = 10 \text{ Vdc}, I_E = 0, f = 1.0 \text{ MHz}$ )	$C_{ob}$	— —	500 300	pF
Small-Signal Current Gain ( $I_C = 2.0 \text{ A dc}, V_{CE} = 4.0 \text{ Vdc}, f = 1.0 \text{ kHz}$ )	$h_{fe}$	20	—	—

\*Indicates JEDEC Registered Data.

(1)  $f_T = |h_{fe}| \cdot f_{test}$

FIGURE 2 — SWITCHING TIMES TEST CIRCUIT

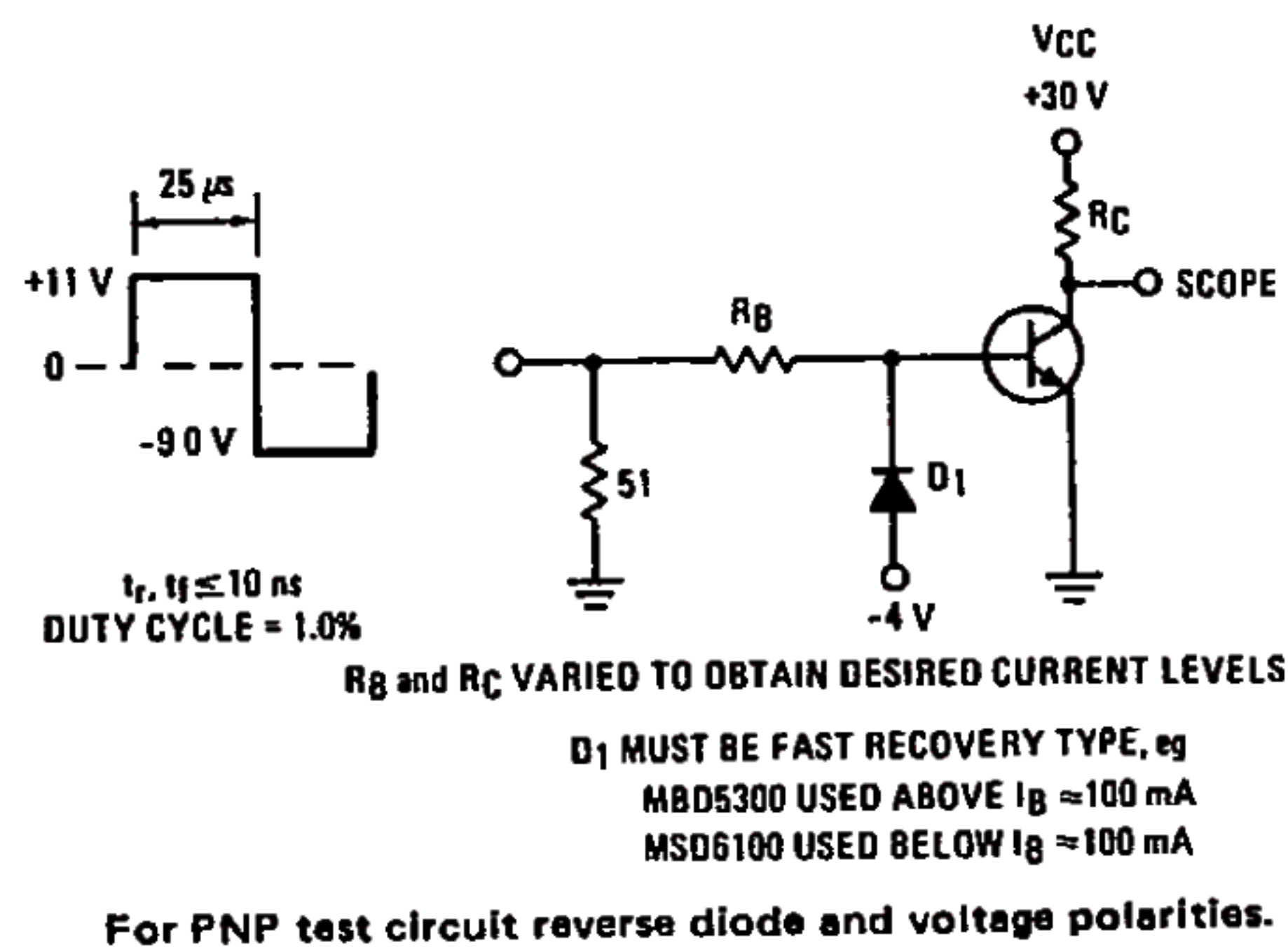
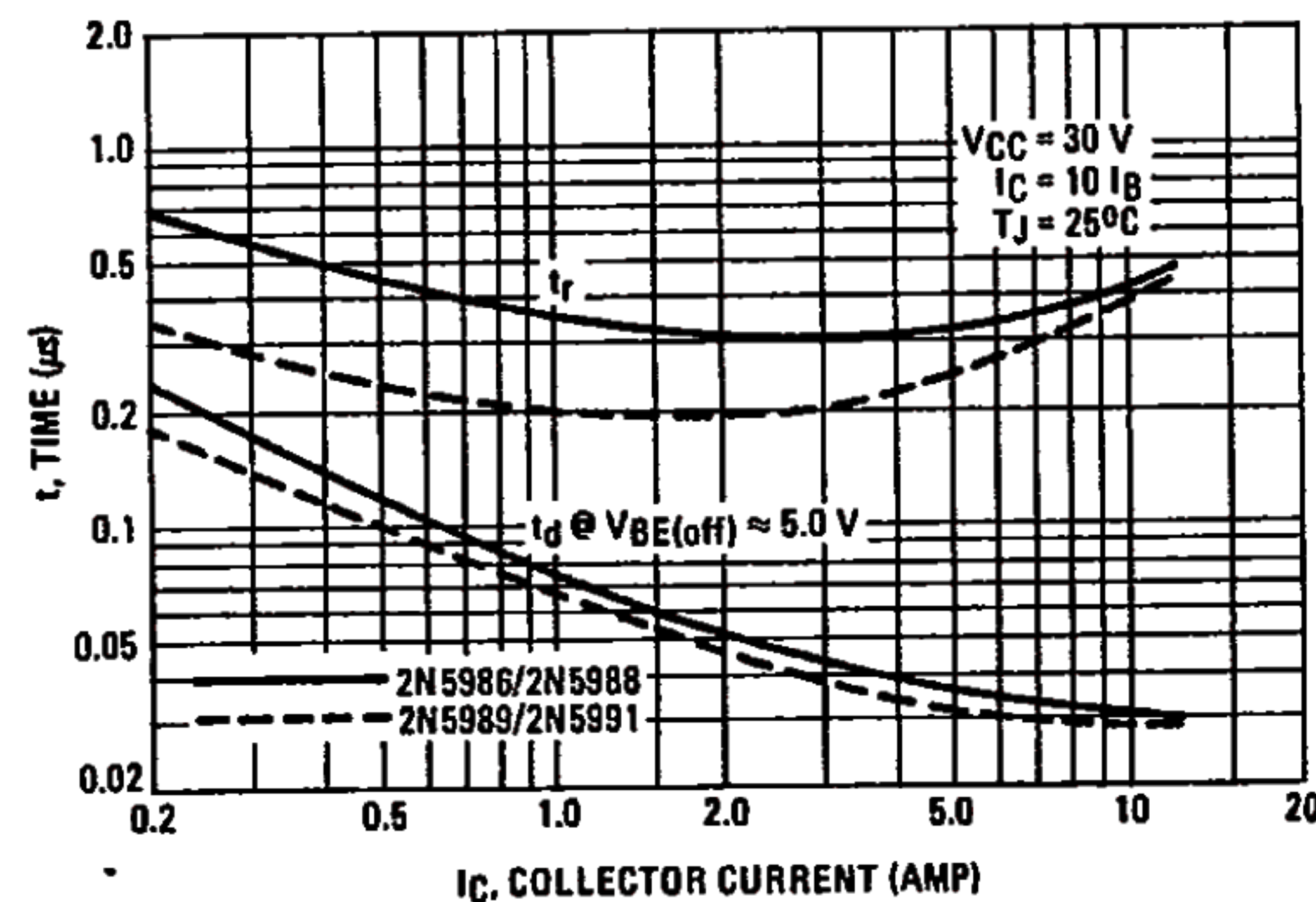


FIGURE 3 — TURN-ON TIME





6367254 MOTOROLA SC (XSTRS/R F)  
 2N5986, 2N5987, 2N5988 PNP / 2N5989, 2N5991 NPN

FIGURE 4 - THERMAL RESPONSE

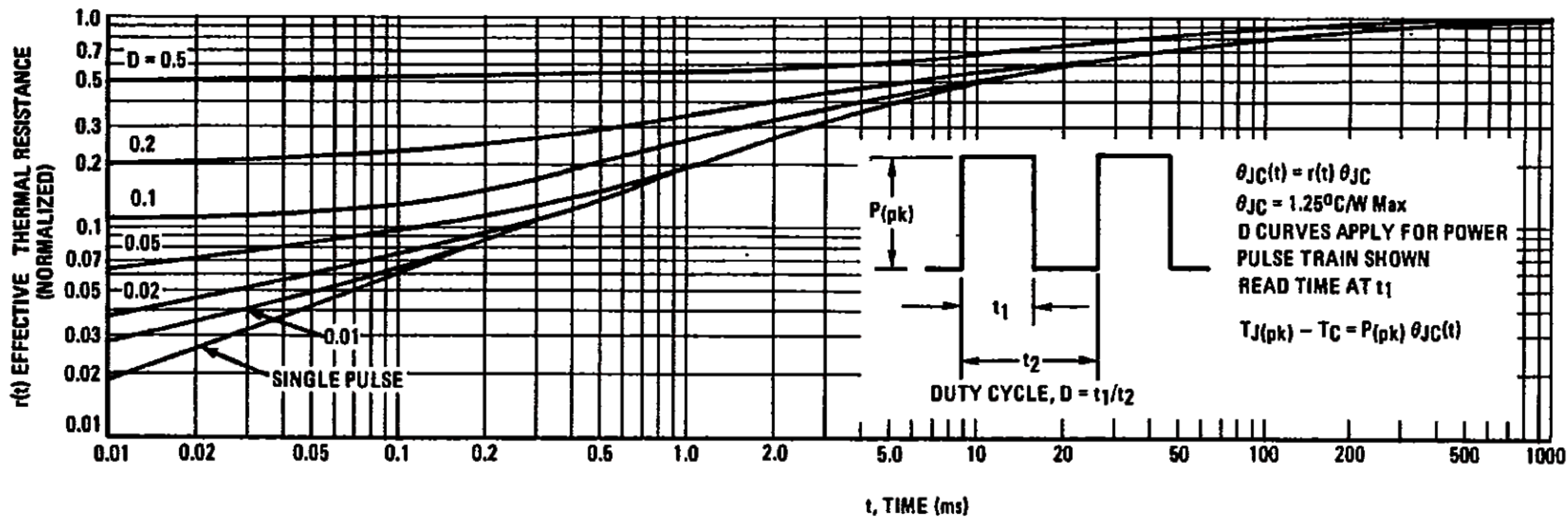
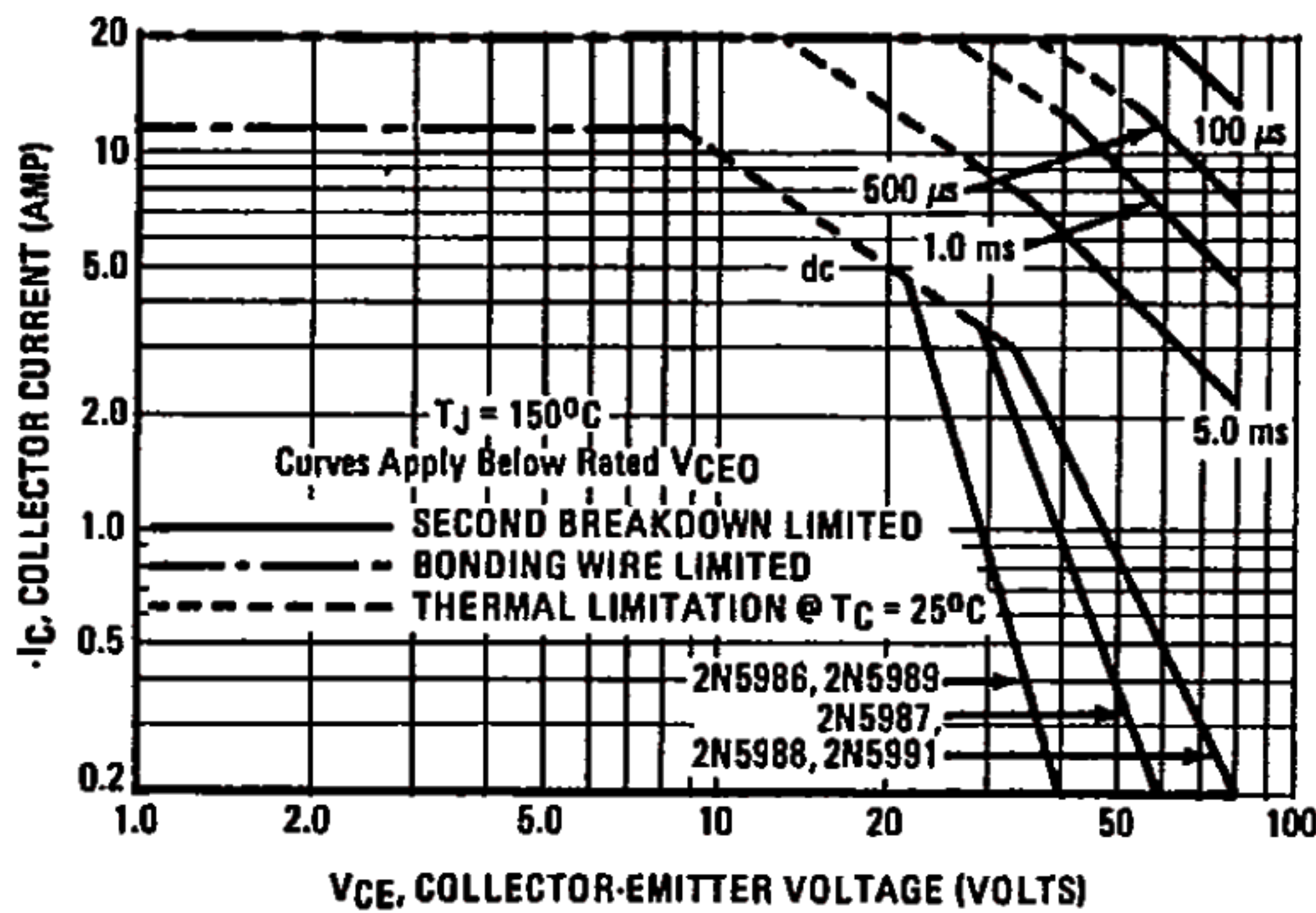


FIGURE 5 - ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second 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 5 is based on  $T_J(pk) = 150^\circ\text{C}$ ;  $T_C$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_J(pk) \leq 150^\circ\text{C}$ .  $T_J(pk)$  may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

FIGURE 6 - TURN-OFF TIME

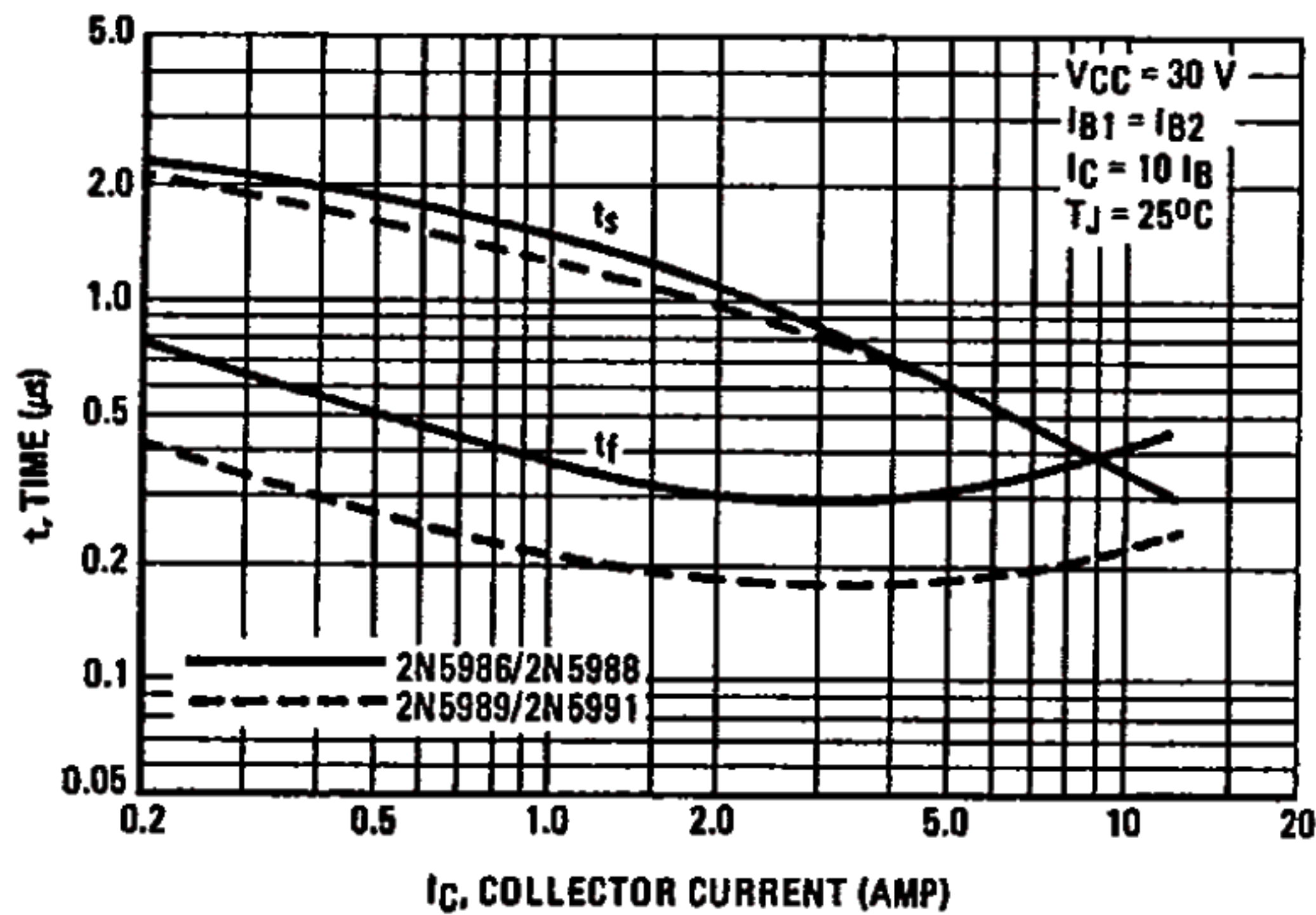
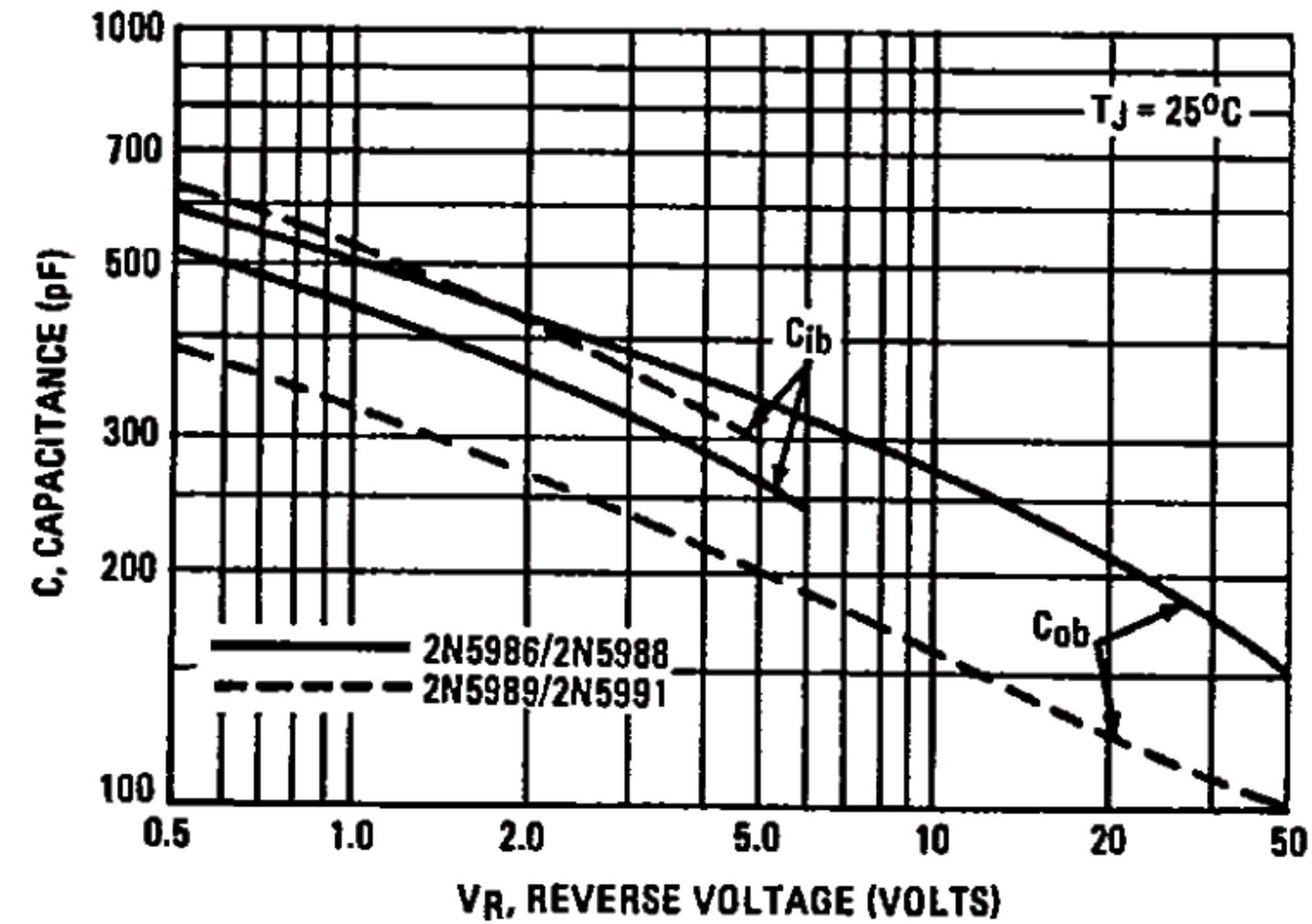


FIGURE 7 - CAPACITANCE





6367254 MOTOROLA SC (XSTRS/R F)  
 2N5986, 2N5987, 2N5988 PNP / 2N5989, 2N5991 NPN

PNP  
 2N5986 thru 2N5988

NPN  
 2N5989, 2N5991

FIGURE 8 - DC CURRENT GAIN

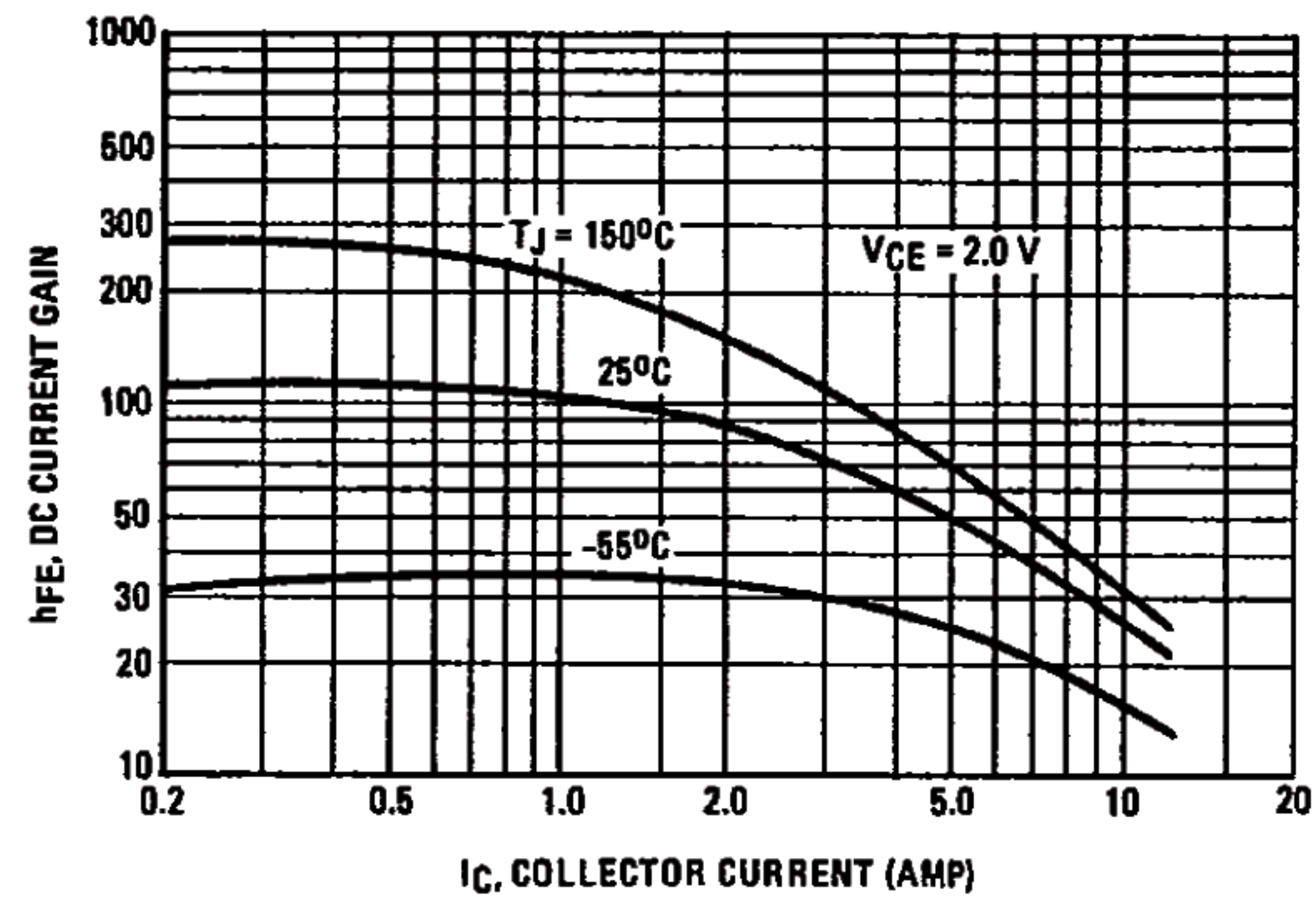
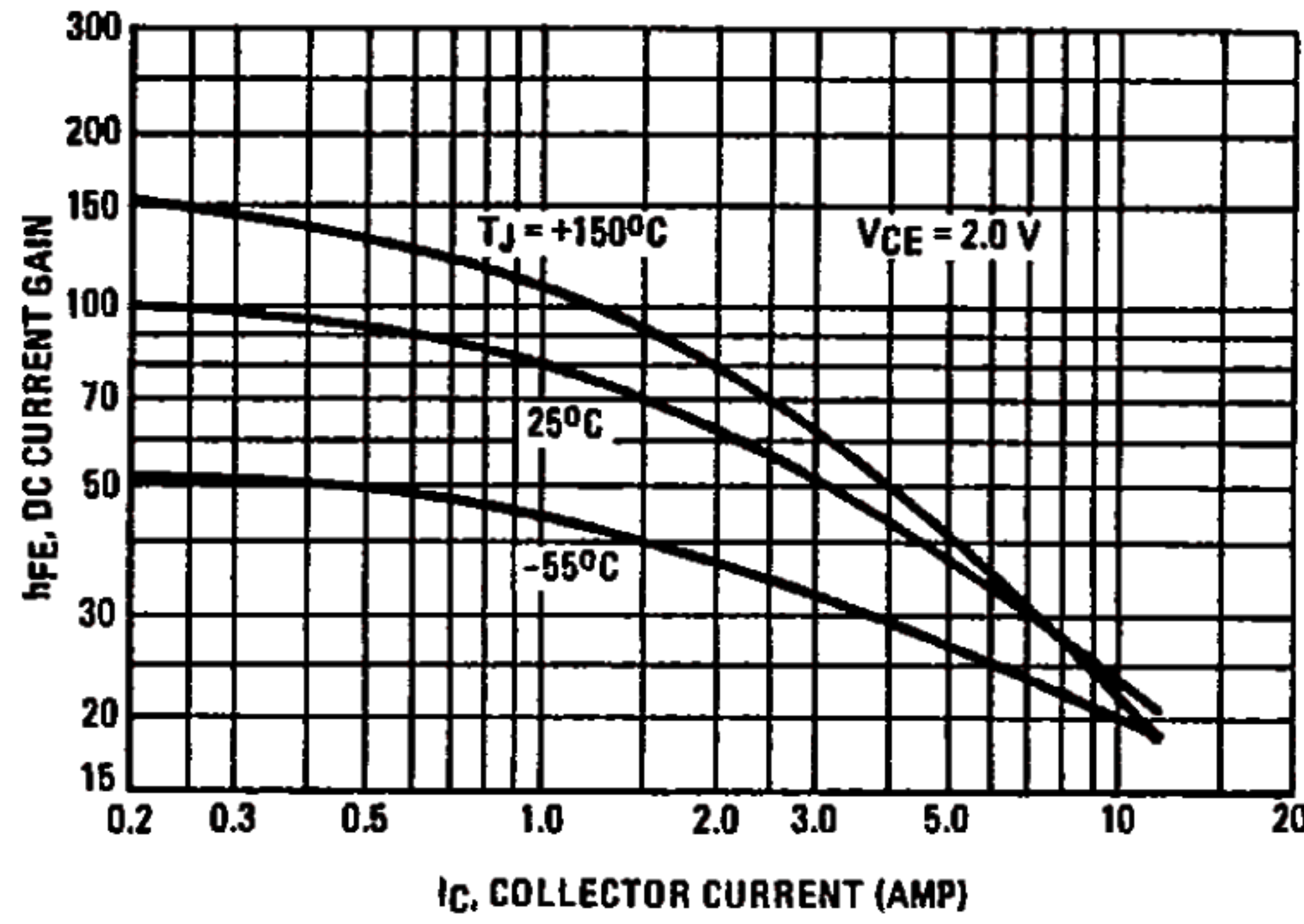


FIGURE 9 - COLLECTOR SATURATION REGION

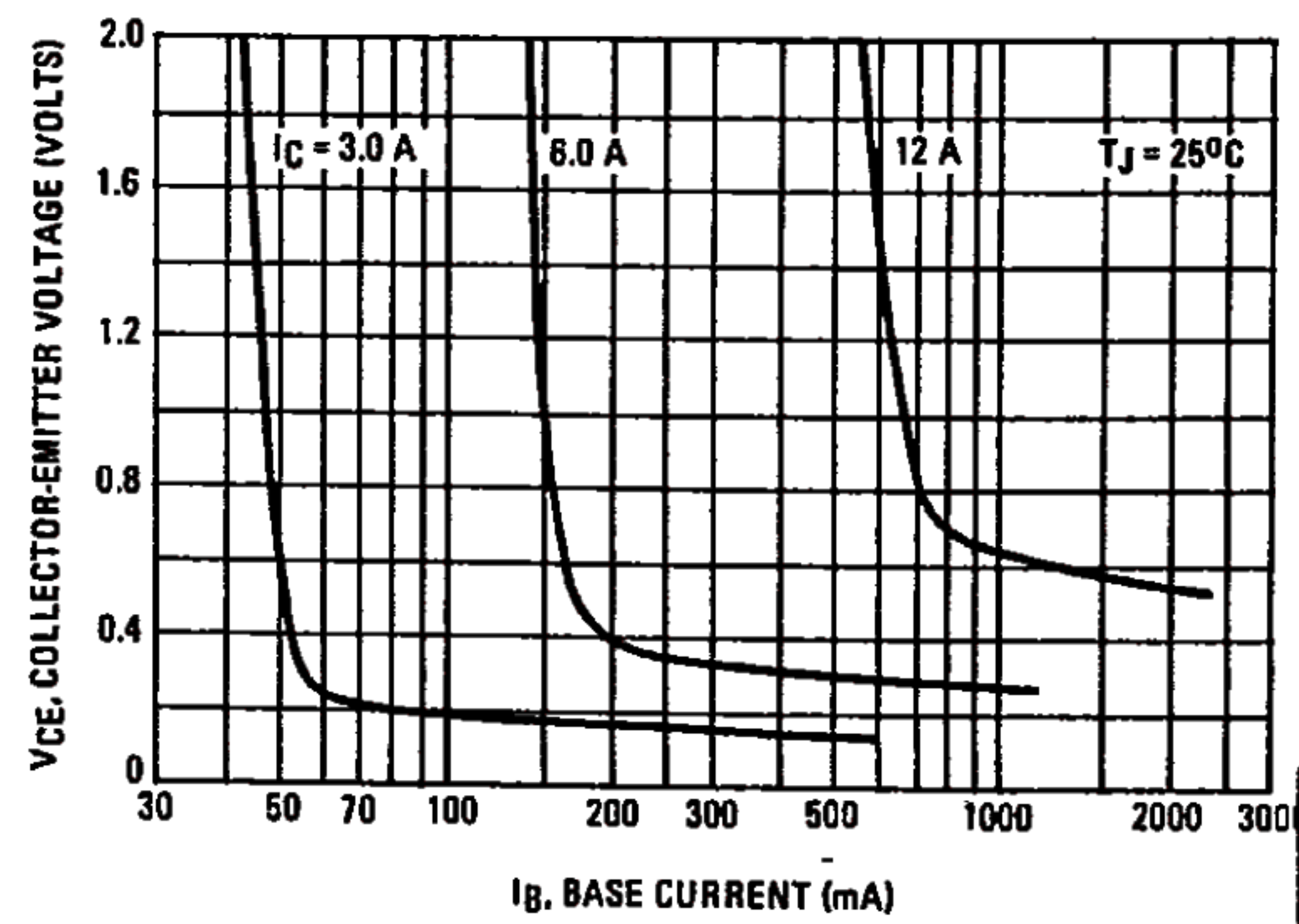
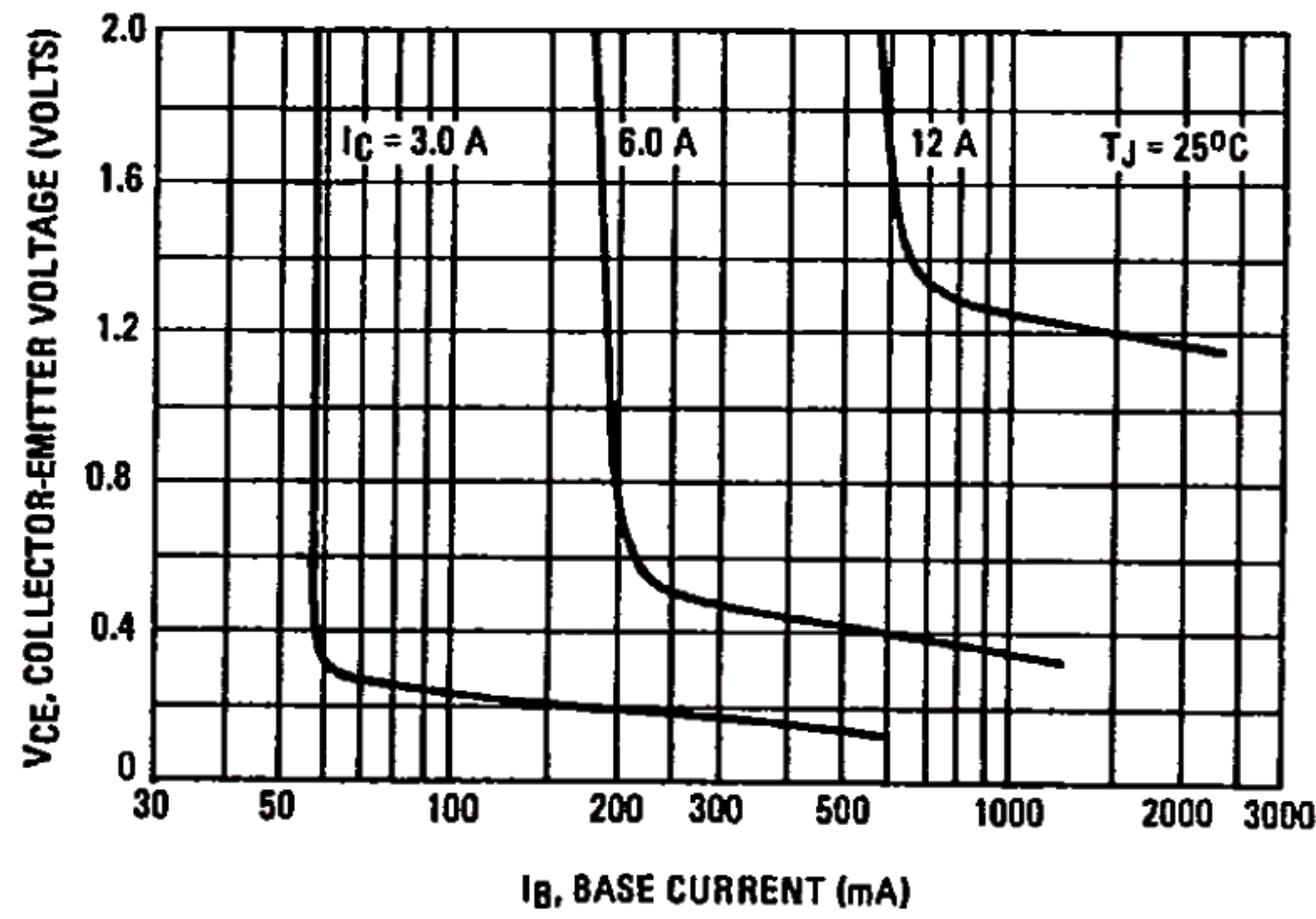


FIGURE 10 - "ON" VOLTAGES

