

6367254 MOTOROLA SC (XSTRS/R F)

**MOTOROLA**  
**SEMICONDUCTOR**  
**TECHNICAL DATA**

96D 80416

2N6049 T-33-21

**MEDIUM-POWER PNP SILICON TRANSISTOR**

... designed for general-purpose switching and amplifier applications

- Excellent Safe Operating Area
- DC Current Gain Specified to 4.0 Amperes
- Complement to NPN Type 2N3054A

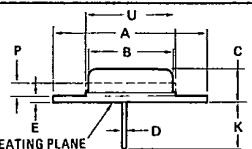
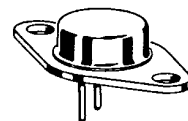
**4 AMPERE**  
**POWER TRANSISTOR**  
**PNP SILICON**  
**55 VOLTS**  
**75 WATTS**
**\*MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	$V_{CEO}$	55	Vdc
Collector-Emitter Voltage ( $R_{BE} = 100 \Omega$ )	$V_{CER}$	60	Vdc
Collector-Base Voltage	$V_{CB}$	90	Vdc
Emitter-Base Voltage	$V_{EB}$	7.0	Vdc
Collector Current — Continuous	$I_C$	4.0	Adc
Peak		10	
Base Current	$I_B$	2.0	Adc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$	$P_D$	75	Watts
Derate above $25^\circ\text{C}$		0.43	W/ $^\circ\text{C}$
Operating and Storage Junction, Temperature Range	$T_J, T_{stg}$	-65 to +200	$^\circ\text{C}$

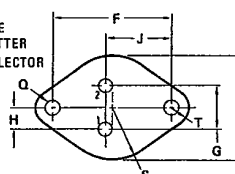
\*Indicates JEDEC Registered Data

**THERMAL CHARACTERISTICS**

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$\theta_{JC}$	2.33	$^\circ\text{C/W}$

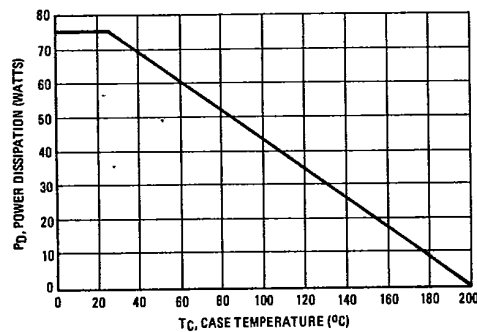


STYLE 1:  
 PIN 1: BASE  
 2: EMITTER  
 CASE: COLLECTOR



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
B	11.94	12.70	0.470	0.500
C	6.35	8.54	0.250	0.340
D	0.71	0.86	0.028	0.034
E	1.27	1.91	0.050	0.075
F	24.33	24.43	0.958	0.962
G	4.83	5.33	0.190	0.210
H	2.41	2.67	0.095	0.105
J	14.48	14.99	0.570	0.590
K	9.14	—	0.360	—
P	—	1.27	—	0.050
Q	3.61	3.86	0.142	0.152
S	—	8.89	—	0.350
T	—	3.68	—	0.145
U	—	15.75	—	0.620

All JEDEC Dimensions and Notes Apply.

**CASE 80-02**  
**TO-213AA**
**FIGURE 1 — POWER-TEMPERATURE DERATING**

6367254 MOTOROLA SC (XSTRS/R F)

96D 80417 D

2N6049

T-33-21

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

Characteristic	Symbol	Min	Max	Unit
<b>OFF CHARACTERISTICS</b>				
Collector-Emitter Sustaining Voltage (1) ( $I_C = 100 \text{ mA}$ , $I_B = 0$ )	$V_{CE(sus)}$	55	—	Vdc
Collector-Emitter Sustaining Voltage (1) ( $I_C = 100 \text{ mA}$ , $R_{BE} = 100 \Omega$ )	$V_{CER(sus)}$	60	—	Vdc
Collector Cutoff Current ( $V_{CE} = 30 \text{ Vdc}$ , $I_B = 0$ )	$I_{CEO}$	—	500	$\mu\text{A}$
Collector Cutoff Current ( $V_{CE} = 90 \text{ Vdc}$ , $V_{BE(off)} = 1.5 \text{ Vdc}$ ) ( $V_{CE} = 90 \text{ Vdc}$ , $V_{BE(off)} = 1.5 \text{ Vdc}$ , $T_C = 150^\circ\text{C}$ )	$I_{CEX}$	—	1.0 6.0	$\text{mA}$
Emitter Cutoff Current ( $V_{BE} = 7.0 \text{ Vdc}$ , $I_C = 0$ )	$I_{EBO}$	—	1.0	$\text{mA}$

**ON CHARACTERISTICS (1)**

DC Current Gain ( $I_C = 500 \text{ mA}$ , $V_{CE} = 4.0 \text{ Vdc}$ ) ( $I_C = 3.0 \text{ A}$ , $V_{CE} = 4.0 \text{ Vdc}$ )	$h_{FE}$	25 6.0	100	—
Collector-Emitter Saturation Voltage ( $I_C = 500 \text{ mA}$ , $I_B = 50 \text{ mA}$ ) ( $I_C = 4.0 \text{ A}$ , $I_B = 800 \text{ mA}$ )	$V_{CE(sat)}$	—	0.5 2.0	Vdc
Base-Emitter On Voltage ( $I_C = 500 \text{ mA}$ , $V_{CE} = 4.0 \text{ Vdc}$ )	$V_{BE(on)}$	—	1.0	Vdc

**DYNAMIC CHARACTERISTICS**

Current Gain — Bandwidth Product ( $I_C = 200 \text{ mA}$ , $V_{CE} = 10 \text{ Vdc}$ )	$f_T$	3.0	—	MHz
Output Capacitance ( $V_{CB} = 10 \text{ Vdc}$ , $I_E = 0$ , $f = 0.1 \text{ MHz}$ )	$C_{ob}$	—	200	pF
Small-Signal Current Gain ( $I_C = 100 \text{ mA}$ , $V_{CE} = 4.0 \text{ Vdc}$ , $f = 1.0 \text{ kHz}$ )	$h_{fe}$	25	180	

\*Indicates JEDEC Registered Data

(1) Pulse test: Pulse Width  $\leq 300 \mu\text{s}$ , Duty Cycle  $\leq 2.0\%$ 

FIGURE 2 — SWITCHING TIME EQUIVALENT TEST CIRCUIT

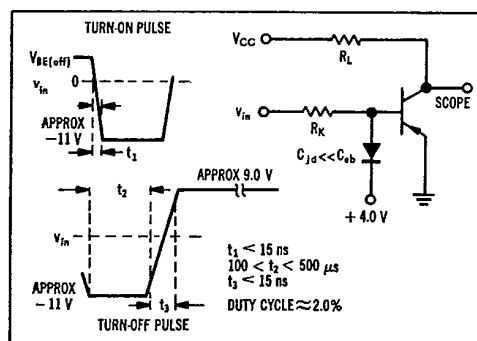
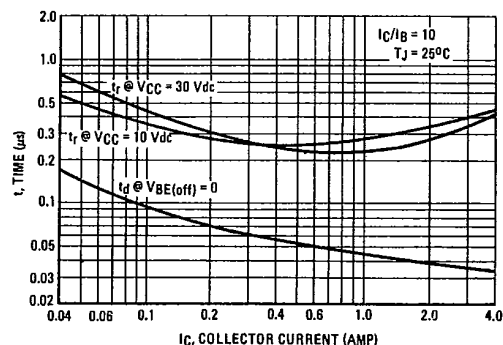


FIGURE 3 — TURN-ON TIME



6367254 MOTOROLA SC (XSTRS/R F)

96D 80418

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2N6049

T-33-21

FIGURE 4 - THERMAL RESPONSE

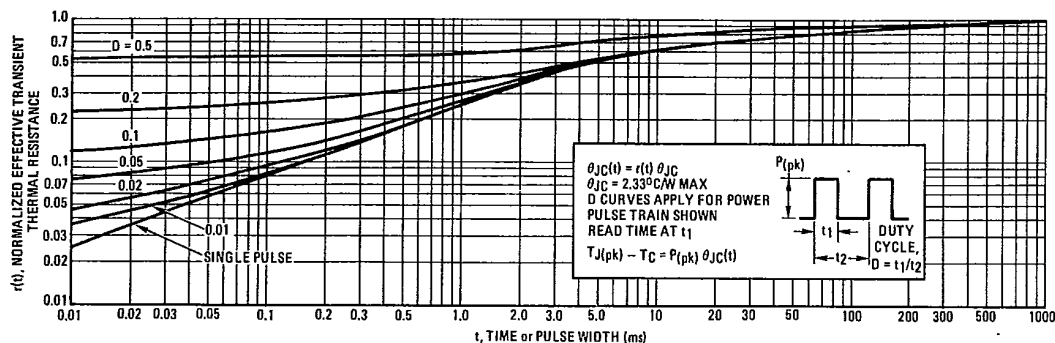
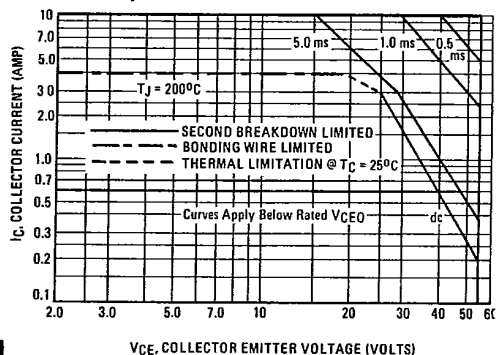


FIGURE 5 - ACTIVE-REGION SAFE OPERATING AREA



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  $T_{J(pk)} = 200^{\circ}\text{C}$ ;  $T_C$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} < 200^{\circ}\text{C}$ .  $T_{J(pk)}$  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

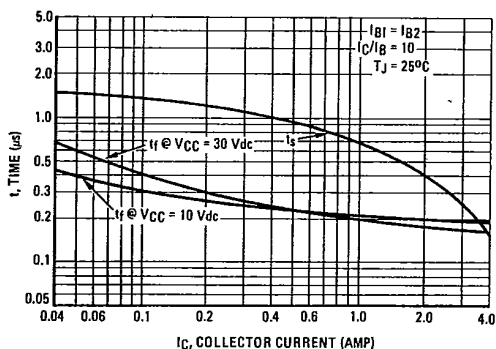
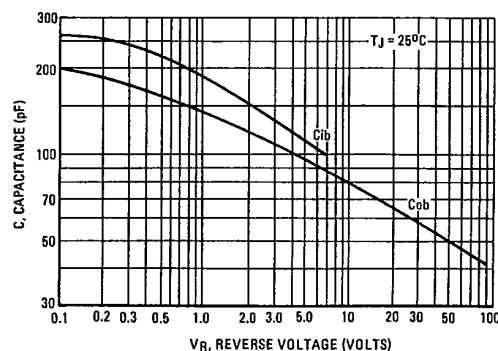


FIGURE 7 - CAPACITANCE



6367254 MOTOROLA SC (XSTRS/R F)

96D 80440

D

T-33-11

# **MOTOROLA** **SEMICONDUCTOR** **TECHNICAL DATA**

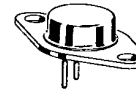
**2N6233**  
**2N6235**

## **HIGH VOLTAGE NPN SILICON TRANSISTORS**

... useful for high-voltage medium power applications such as switching regulators.

- High Collector-Emitter Sustaining Voltage —  
 $V_{CE(sus)} = 225 \text{ Vdc} - 2N6233$   
 $325 \text{ Vdc} - 2N6235$
- DC Current Gain —  $h_{FE} = 25 \text{ to } 125 - I_C = 1.0 \text{ Adc}$
- Low Collector-Emitter Saturation Voltage  
 $V_{CE(sat)} = 0.5 \text{ Vdc (Max)} @ I_C = 1.0 \text{ Adc}$
- High Frequency Response —  $f_T = 20 \text{ MHz (Min)}$
- Fast Switching Times @  $1.0 \text{ Adc}$  —  
 $t_r = 0.5 \mu\text{s (Max)}$   
 $t_s = 3.5 \mu\text{s (Max)}$   
 $t_f = 0.5 \mu\text{s (Max)}$

5 AMPERE

**POWER TRANSISTORS**  
**NPN SILICON**
**225,275,325 VOLTS**  
**50 WATTS**


### \*MAXIMUM RATINGS

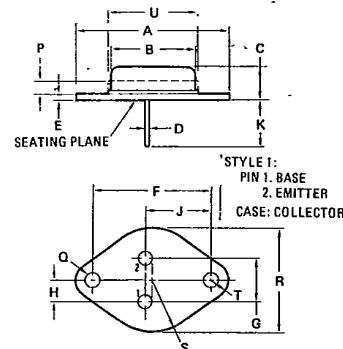
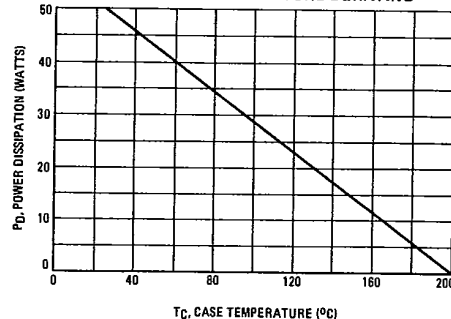
Rating	Symbol	2N6233	2N6235	Unit
Collector-Emitter Voltage	$V_{CEO}$	225	325	Vdc
Collector-Base Voltage	$V_{CB}$	250	350	Vdc
Emitter-Base Voltage	$V_{EB}$	6.0		Vdc
Collector Current — Continuous Peak	$I_C$	5.0	10	Adc
Base Current	$I_B$	2.0		Adc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above $25^\circ\text{C}$	$P_D$	50	0.286	Watts W/C
Operating and Storage Junction Temperature Range	$T_J, T_{stg}$	-65 to +200		$^\circ\text{C}$

### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$\theta_{JC}$	3.5	$^\circ\text{C/W}$

\*Indicates JEDEC Registered Data.

FIGURE 1 — POWER TEMPERATURE DERATING



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
B	11.94	12.70	0.470	0.500
C	6.35	8.64	0.250	0.340
D	0.71	0.86	0.028	0.034
E	1.27	1.91	0.050	0.075
F	24.33	24.43	0.958	0.962
G	4.83	5.33	0.180	0.210
H	2.41	2.67	0.095	0.105
J	14.48	14.99	0.570	0.590
K	9.14	—	0.360	—
P	—	1.27	—	0.050
Q	3.61	3.86	0.142	0.152
S	—	8.89	—	0.350
T	—	3.68	—	0.145
U	—	15.75	—	0.620

All JEDEC Dimensions and Notes Apply.

**CASE 80-02**  
**TO-213AA**

6367254 MOTOROLA SC (XSTRS/R F)

96D 80441

D

2N6233, 2N6235

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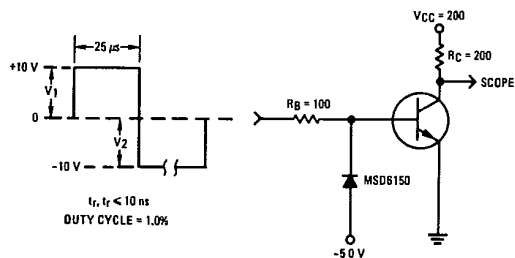
\*ELECTRICAL CHARACTERISTICS ( $T_C = 25^\circ\text{C}$  unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
<b>OFF CHARACTERISTICS</b>				
Collector-Emitter Sustaining Voltage (1) ( $I_C = 20\text{ mA}$ , $I_B = 0$ )	$V_{CE(sus)}$	225 325	—	Vdc
Collector Cutoff Current ( $V_{CE} = 225\text{ Vdc}$ , $I_B = 0$ ) ( $V_{CE} = 325\text{ Vdc}$ , $I_B = 0$ )	$I_{CEO}$	— —	1.0 1.0	mA
Collector Cutoff Current ( $V_{CE} = 250\text{ Vdc}$ , $V_{EB(off)} = 1.5\text{ Vdc}$ , $T_C = 150^\circ\text{C}$ ) ( $V_{CE} = 350\text{ Vdc}$ , $V_{EB(off)} = 1.5\text{ Vdc}$ , $T_C = 150^\circ\text{C}$ )	$I_{CEX}$	— —	1.0 1.0	mA
Collector Cutoff Current ( $V_{CB} = 250\text{ Vdc}$ , $I_E = 0$ ) ( $V_{CB} = 350\text{ Vdc}$ , $I_E = 0$ )	$I_{CBO}$	— —	0.1 0.1	mA
Emitter Cutoff Current ( $V_{BE} = 6.0\text{ Vdc}$ , $I_C = 0$ )	$I_{EBO}$	—	0.1	mA
<b>ON CHARACTERISTICS (1)</b>				
DC Current Gain ( $I_C = 0.1\text{ A}$ , $V_{CE} = 5.0\text{ Vdc}$ ) ( $I_C = 1.0\text{ A}$ , $V_{CE} = 5.0\text{ Vdc}$ ) ( $I_C = 3.0\text{ A}$ , $V_{CE} = 5.0\text{ Vdc}$ )	$h_{FE}$	25 25 10	— 125 —	—
Collector-Emitter Saturation Voltage ( $I_C = 1.0\text{ A}$ , $I_B = 0.1\text{ A}$ ) ( $I_C = 5.0\text{ A}$ , $I_B = 1.0\text{ A}$ )	$V_{CE(sat)}$	— —	0.5 2.5	Vdc
Base-Emitter Saturation Voltage ( $I_C = 1.0\text{ A}$ , $I_B = 0.1\text{ A}$ ) ( $I_C = 5.0\text{ A}$ , $I_B = 1.0\text{ A}$ )	$V_{BE(sat)}$	— —	1.0 2.0	Vdc
Base-Emitter On Voltage ( $I_C = 1.0\text{ A}$ , $V_{CE} = 5.0\text{ Vdc}$ )	$V_{BE(on)}$	—	1.0	Vdc
<b>DYNAMIC CHARACTERISTICS</b>				
Current-Gain Bandwidth Product (2) ( $I_C = 0.25\text{ A}$ , $V_{CE} = 10\text{ Vdc}$ , $f_{test} = 10\text{ MHz}$ )	$f_T$	20	—	MHz
Output Capacitance ( $V_{CB} = 10\text{ Vdc}$ , $I_E = 0$ , $f = 0.1\text{ MHz}$ )	$C_{ob}$	—	250	pF
<b>SWITCHING CHARACTERISTICS</b>				
Rise Time ( $V_{CC} = 200\text{ Vdc}$ , $I_C = 1.0\text{ A}$ , $I_B = 0.1\text{ A}$ )	$t_r$	—	0.5	$\mu\text{s}$
Storage Time ( $V_{CC} = 200\text{ Vdc}$ , $I_C = 1.0\text{ A}$ , $I_{B1} = I_{B2} = 0.1\text{ A}$ )	$t_s$	—	3.5	$\mu\text{s}$
Fall Time ( $V_{CC} = 200\text{ Vdc}$ , $I_C = 1.0\text{ A}$ , $I_{B1} = I_{B2} = 0.1\text{ A}$ )	$t_f$	—	0.5	$\mu\text{s}$

\*Indicates JEDEC Registered Data.

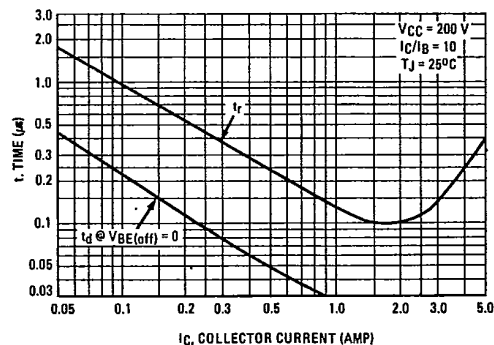
(1) Pulse Test: Pulse Width  $\leq 300\text{ }\mu\text{s}$ , Duty Cycle  $\leq 2\%$ .(2)  $f_T = |h_{fe}| \cdot f_{test}$ 

FIGURE 2 — SWITCHING TIME TEST CIRCUIT



FOR INFORMATION ON FIGURES 3 AND 6  
 $R_B$  AND  $R_C$  ARE VARIED TO OBTAIN  
 DESIRED CURRENT LEVELS.  $D_1$  DIS-  
 CONNECTED AND  $V_2$  REDUCED TO 5  
 VOLTS FOR  $t_d$  MEASUREMENT.

FIGURE 3 — TURN-ON TIME



6367254 MOTOROLA SC (XSTRS/R F)  
2N6233, 2N6235

96D 80442 D

T-33-11

FIGURE 4 - THERMAL RESPONSE

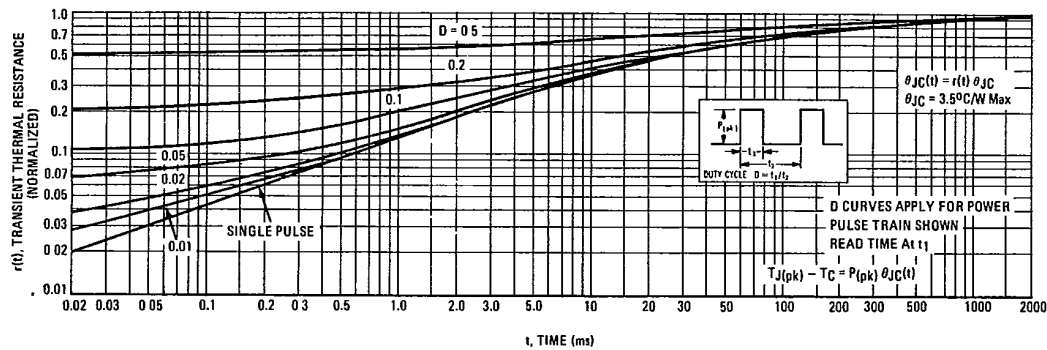
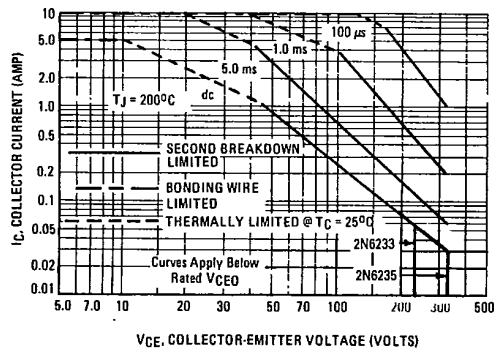


FIGURE 5 - ACTIVE-REGION SAFE OPERATING AREA



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  $T_{J(pk)} = 200^\circ\text{C}$ ;  $T_C$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} \leq 200^\circ\text{C}$ .  $T_{J(pk)}$  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

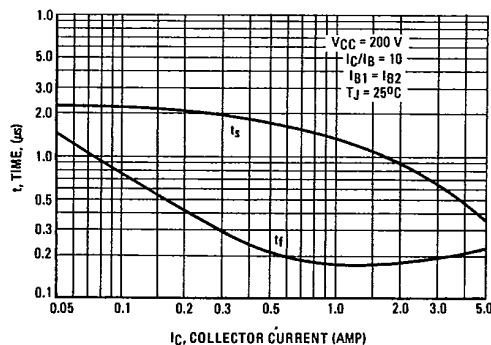


FIGURE 7 - CAPACITANCES

