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*Consult Motorola if a direct replacement is necessary.

TABLE 4 — PLASTIC TO-218 (continued)

I_CCont Amps Max	$V_{CEO(sus)}$ Volts Min	Device Type NPN	Device Type PNP	h_{FE} Min/Max	@ I_C Amp	Resistive Switching t_s μs Max	Resistive Switching t_f μs Max	Resistive Switching @ I_C Amp	f_T MHz Min	P_D (Case) Watts @ 25°C
15	400	BUV48†		8 min	10	2	0.4	10		150
		MJH13090		8 min	10	2.5	0.5	10		125
		MJH16110		6/20	10	0.8 typ	0.1 typ	10		135
	450	BUV48A†		8 min	8	2	0.4	10		150
		MJH16010		5 min	15	1.2	0.2	10		150
		MJH16012		7 min	15	0.9	0.15	10		150
	500	BUT51P##†		40 min	5	1.1	0.16	10		125
		MJH16010A		5 min	15	3	0.4	10		150
16	100	MJE4340	MJE4350	15 min	8	1.2 typ	1.2 typ	8	1	125
	120	MJE4341	MJE4351	15 min	8	1.2 typ	1.2 typ	8	1	125
	140	MJE4342	MJE4352	15 min	8	1.2 typ	1.2 typ	8	1	125
	160	MJE4343	MJE4353	15 min	8	1.2 typ	1.2 typ	8	1	125
20	60	MJH6282##	MJH6285##	750/18k	10				4#	125
	80	MJH6283##	MJH6286##	750/18k	10				4#	125
	100	MJH6284##	MJH6287##	750/18k	10				4#	125
25	40	TIP35	TIP36	10/75	15	0.6 typ	0.3 typ	10	3	125
	45	BD249†	BD250†	10 min	15				3	125
	60	BD249A†	BD250A†	10 min	15				3	125
		TIP35A	TIP36A	10/75	15	0.6 typ	0.3 typ	10	3	125
	80	BD249B†	BD250B†	10 min	15				3	125
		TIP35B	TIP36B	10/75	15	0.6 typ	0.3 typ	10	3	125
	100	BD249C†	BD250C†	10 min	15				3	125
		TIP35C	TIP36C	10/75	15	0.6 typ	0.3 typ	10	3	125

$|h_{fe}|$ @ 1 MHz, ## Darlington
† These devices supplied in Case 340D-01. Consult Motorola for details.

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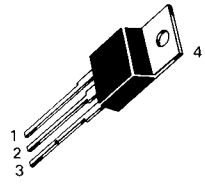
TABLE 5 — PLASTIC TO-220

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



CASE 221A-04 (TO-220AB)

I_CCont Amps Max	$V_{CEO(sus)}$ Volts Min	Device Type NPN	Device Type PNP	h_{FE} Min/Max	@ I_C Amp	Resistive Switching t_s μs Max	Resistive Switching t_f μs Max	Resistive Switching @ I_C Amp	f_T MHz Min	P_D (Case) Watts @ 25°C
0.5	350	MJE2360T		15 min	0.1				10 typ	30
		MJE2361T		40 min	0.1				10 typ	30
1	40	TIP29	TIP30	15/75	1	0.6 typ	0.3 typ	1	3	30
	60	TIP29A	TIP30A	15/75	1	0.6 typ	0.3 typ	1	3	30
	80	TIP29B	TIP30B	15/75	1	0.6 typ	0.3 typ	1	3	30
	100	TIP29C	TIP30C	15/75	1	0.6 typ	0.3 typ	1	3	30
	250	TIP47		30/150	0.3	2 typ	0.18 typ	0.3	10	40
	300	TIP48		30/150	0.3	2 typ	0.18 typ	0.3	10	40
	350	TIP49		30/150	0.3	2 typ	0.18 typ	0.3	10	40
	400	TIP50		30/150	0.3	2 typ	0.18 typ	0.3	10	40

(continued)

MOTOROLA
SEMICONDUCTOR
TECHNICAL DATA

TIP47 TIP48 TIP49 TIP50

HIGH VOLTAGE NPN SILICON POWER TRANSISTORS

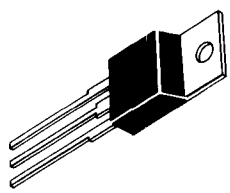
. . . designed for line operated audio output amplifier, Switchmode power supply drivers and other switching applications.

- 250 V to 400 V (Min) – $V_{CEO(sus)}$
- 1 A Rated Collector Current
- Popular TO-220 Plastic Package
- TO-66 Leadform Available

1.0 AMPERE

POWER TRANSISTORS NPN SILICON

250-300-350-400 VOLTS
40 WATTS



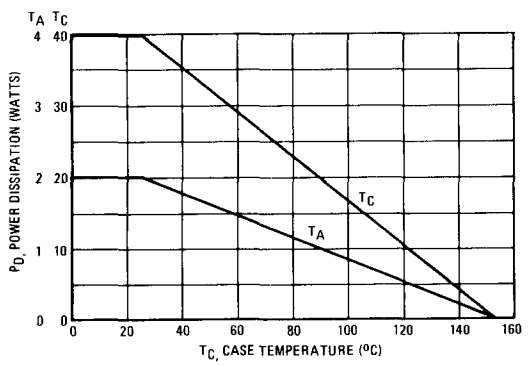
MAXIMUM RATINGS

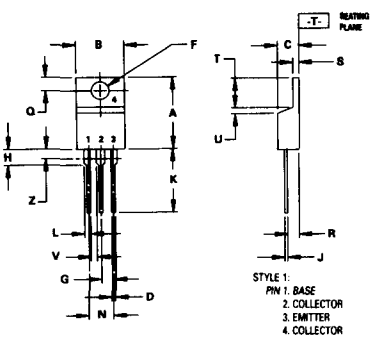
Rating	Symbol	TIP47	TIP48	TIP49	TIP50	Unit
Collector-Emitter Voltage	V_{CEO}	250	300	350	400	Vdc
Collector-Base Voltage	V_{CB}	350	400	450	500	Vdc
Emitter-Base Voltage	V_{EB}	5.0				Vdc
Collector Current—Continuous Peak	I_C	1.0 2.0				Adc
Base Current	I_B	0.6				Adc
Total Power Dissipation @ T_C = 25° C Derate above 25° C	P_D	40 0.32				Watts W/°C
Total Power Dissipation @ T_A = 25° C Derate above 25° C	P_D	2.0 0.016				Watts W/°C
Unclamped Inducting Load Energy (See Figure 8)	*E*	20				mJ
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +150				°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	3.125	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	62.5	°C/W

FIGURE 1 – POWER DERATING





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

NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIM Z DEFINES A ZONE WHERE ALL BODY AND LEAD IRREGULARITIES ARE ALLOWED.

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	14.48	15.75	0.570	0.620
B	9.66	10.28	0.380	0.405
C	4.07	4.82	0.160	0.190
D	0.64	0.88	0.025	0.035
F	3.61	3.73	0.142	0.147
G	2.42	2.66	0.095	0.105
H	2.80	3.93	0.110	0.155
J	0.46	0.71	0.018	0.028
K	12.70	14.27	0.500	0.562
L	1.15	1.39	0.045	0.055
N	4.83	5.33	0.190	0.210
Q	2.54	3.04	0.100	0.120
R	2.04	2.79	0.080	0.110
S	1.15	1.39	0.045	0.055
T	5.97	6.47	0.235	0.255
U	0.00	1.27	0.000	0.050
V	1.15	—	0.045	—
Z	—	2.04	—	0.080

CASE 221A-04
TO-220AB

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

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) (I_C = 30 mAdc, I_B = 0)	TIP47	$V_{CEO(sus)}$	250	–	Vdc
	TIP48		300	–	
	TIP49		350	–	
	TIP50		400	–	
Collector Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 150 Vdc, I_B = 0)	TIP47		–	1.0	
(V_{CE} = 200 Vdc, I_B = 0)	TIP48		–	1.0	
(V_{CE} = 250 Vdc, I_B = 0)	TIP49		–	1.0	
(V_{CE} = 300 Vdc, I_B = 0)	TIP50		–	1.0	
Collector Cutoff Current		I_{CES}			mAdc
(V_{CE} = 350 Vdc, V_{BE} = 0)	TIP47		–	1.0	
(V_{CE} = 400 Vdc, V_{BE} = 0)	TIP48		–	1.0	
(V_{CE} = 450 Vdc, V_{BE} = 0)	TIP49		–	1.0	
(V_{CE} = 500 Vdc, V_{BE} = 0)	TIP50		–	1.0	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	1.0	mAdc
ON CHARACTERISTICS (1)					
DC Current Gain		h_{FE}			–
(I_C = 0.3 Adc, V_{CE} = 10 Vdc)			30	150	
(I_C = 1.0 Adc, V_{CE} = 10 Vdc)			10	–	
Collector-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 0.2 Adc)		$V_{CE(sat)}$	–	1.0	Vdc
Base-Emitter On Voltage (I_C = 1.0 Adc, V_{CE} = 10 Vdc)		$V_{BE(on)}$	–	1.5	Vdc
DYNAMIC CHARACTERISTICS					
Current Gain – Bandwidth Product (I_C = 0.2 Adc, V_{CE} = 10 Vdc, f = 2.0 MHz)		f_T	10	–	MHz
Small-Signal Current Gain (I_C = 0.2 Adc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{fe}	25	–	–

(1) Pulse Test: Pulsewidth ≤ 300 μs, Duty Cycle ≤ 2.0%.

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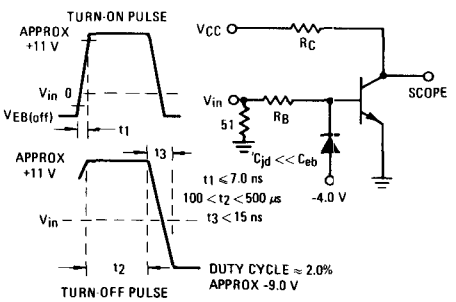
FIGURE 2 – SWITCHING TIME EQUIVALENT CIRCUIT



RB and RC VARIED TO OBTAIN DESIRED CURRENT LEVELS.

FIGURE 3 – TURN-ON TIME

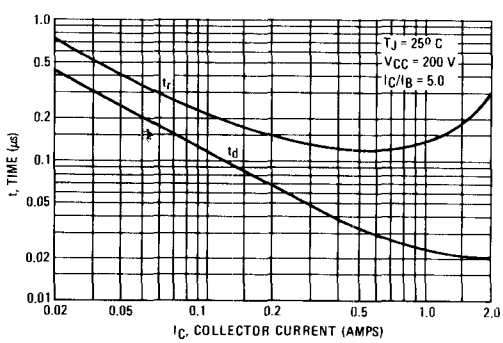


FIGURE 4 – THERMAL RESPONSE

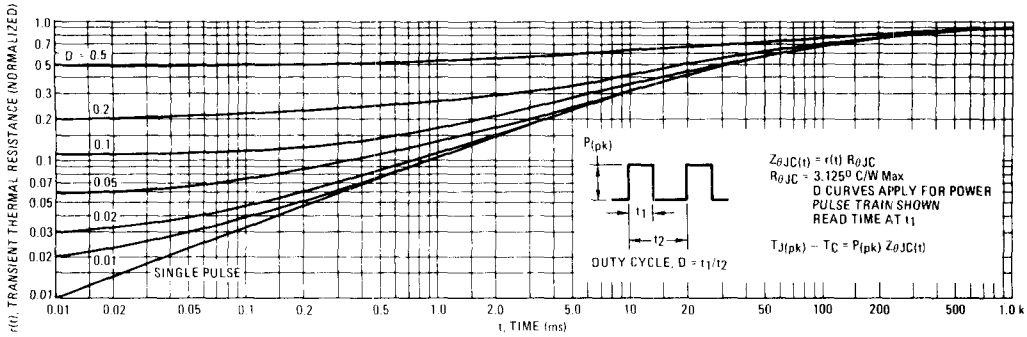
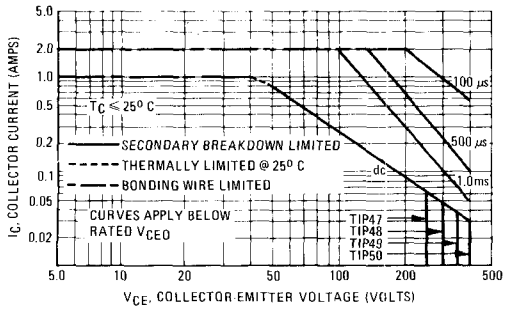


FIGURE 5 – ACTIVE REGION SAFE OPERATING AREA



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°C; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 150°C$. $T_{J(pk)}$ 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

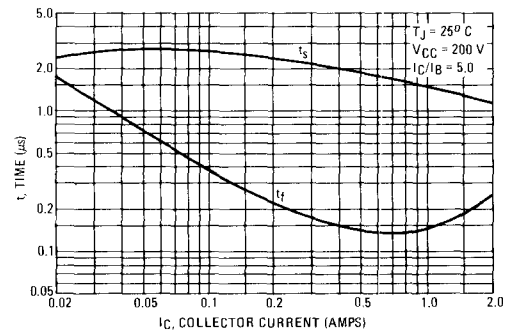


FIGURE 7 – TEMPERATURE COEFFICIENTS

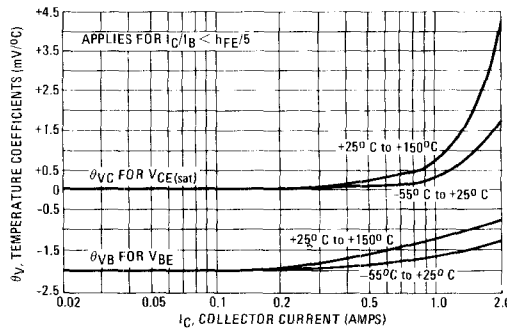


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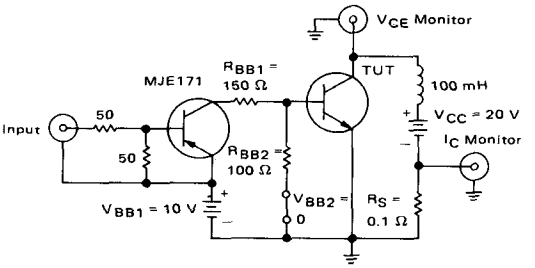
FIGURE 8 – INDUCTIVE LOAD SWITCHING

Test Circuit



Note A: Input pulse width is increased until I_{CM} = 0.63 A.

Voltage and Current Waveforms

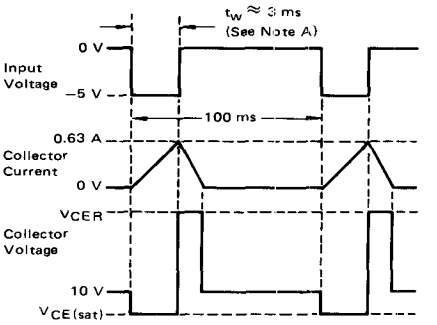


FIGURE 9 – DC CURRENT GAIN

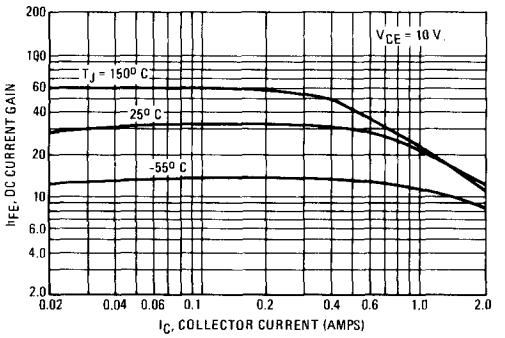
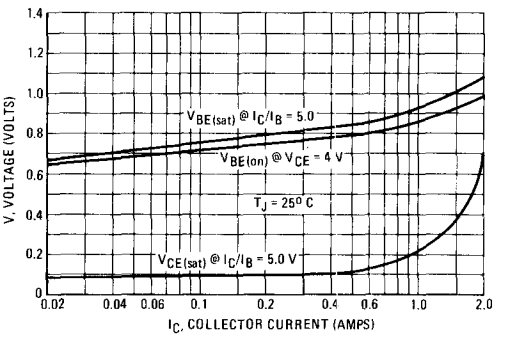


FIGURE 10 – "ON" VOLTAGES



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