

*Designer's™ Data Sheet*  
**SWITCHMODE™**  
**NPN Bipolar Power Transistor**  
**For Switching Power Supply Applications**

The MJE/MJF18002 have an applications specific state-of-the-art die designed for use in 220 V line operated Switchmode Power supplies and electronic light ballasts. These high voltage/high speed transistors offer the following:

- Improved Efficiency Due to Low Base Drive Requirements:
  - High and Flat DC Current Gain  $h_{FE}$
  - Fast Switching
  - No Coil Required in Base Circuit for Turn-Off (No Current Tail)
- Tight Parametric Distributions are Consistent Lot-to-Lot
- Two Package Choices: Standard TO-220 or Isolated TO-220
- MJF18002, Case 221D, is UL Recognized at 3500  $V_{RMS}$ : File #E69369

**MAXIMUM RATINGS**

Rating	Symbol	MJE18002	MJF18002	Unit
Collector-Emitter Sustaining Voltage	$V_{CEO}$	450		Vdc
Collector-Emitter Breakdown Voltage	$V_{CES}$	1000		Vdc
Emitter-Base Voltage	$V_{EBO}$	9.0		Vdc
Collector Current — Continuous	$I_C$	2.0		Adc
— Peak(1)	$I_{CM}$	5.0		
Base Current — Continuous	$I_B$	1.0		Adc
— Peak(1)	$I_{BM}$	2.0		
RMS Isolated Voltage(2) (for 1 sec, R.H. < 30%, $T_C = 25^\circ C$ )	$V_{ISOL}$	—	4500 3500 1500	V
Total Device Dissipation Derate above 25°C	$P_D$	50 0.4	25 0.2	Watts W/°C
Operating and Storage Temperature	$T_J, T_{stg}$	-65 to 150		°C

**THERMAL CHARACTERISTICS**

Rating	Symbol	MJE18002	MJF18002	Unit
Thermal Resistance — Junction to Case	$R_{\theta JC}$	2.5	5.0	°C/W
— Junction to Ambient	$R_{\theta JA}$	62.5	62.5	
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	$T_L$	260		°C

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

Characteristic	Symbol	Min	Typ	Max	Unit
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**OFF CHARACTERISTICS**

Collector-Emitter Sustaining Voltage ( $I_C = 100$ mA, $L = 25$ mH)	$V_{CEO(sus)}$	450	—	—	Vdc
Collector Cutoff Current ( $V_{CE} = \text{Rated } V_{CEO}, I_B = 0$ )	$I_{CEO}$	—	—	100	$\mu\text{Adc}$
Collector Cutoff Current ( $V_{CE} = \text{Rated } V_{CES}, V_{EB} = 0$ )	$I_{CES}$	$T_C = 125^\circ C$	—	100	$\mu\text{Adc}$
( $V_{CE} = 800$ V, $V_{EB} = 0$ )		$T_C = 125^\circ C$	—	500 100	
Emitter Cutoff Current ( $V_{EB} = 9.0$ Vdc, $I_C = 0$ )	$I_{EBO}$	—	—	100	$\mu\text{Adc}$

(1) Pulse Test: Pulse Width = 5.0 ms, Duty Cycle  $\leq 10\%$ .

(2) Proper strike and creepage distance must be provided.

(continued)

**Designer's Data for "Worst Case" Conditions** — The Designer's Data Sheet permits the design of most circuits entirely from the information presented. SOA Limit curves — representing boundaries on device characteristics — are given to facilitate "worst case" design.

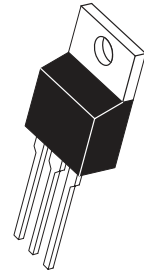
**Preferred** devices are Motorola recommended choices for future use and best overall value.

REV 1

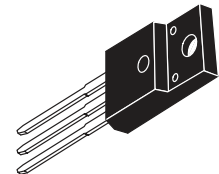
**MJE18002\***  
**MJF18002\***

\*Motorola Preferred Device

**POWER TRANSISTOR**  
**2.0 AMPERES**  
**1000 VOLTS**  
**25 and 50 WATTS**



**CASE 221A-06**  
**TO-220AB**  
**MJE18002**



**CASE 221D-02**  
**ISOLATED TO-220 TYPE**  
**UL RECOGNIZED**  
**MJF18002**

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

Characteristic	Symbol	Min	Typ	Max	Unit
Base–Emitter Saturation Voltage ( $I_C = 0.4 \text{ Adc}, I_B = 40 \text{ mAdc}$ ) ( $I_C = 1.0 \text{ Adc}, I_B = 0.2 \text{ Adc}$ )	$V_{BE(sat)}$	— —	0.825 0.92	1.1 1.25	Vdc
Collector–Emitter Saturation Voltage ( $I_C = 0.4 \text{ Adc}, I_B = 40 \text{ mAdc}$ )  ( $I_C = 1.0 \text{ Adc}, I_B = 0.2 \text{ Adc}$ )	$V_{CE(sat)}$	— — —	0.2 0.2 0.25 0.3	0.5 0.5 0.5 0.6	Vdc
DC Current Gain ( $I_C = 0.2 \text{ Adc}, V_{CE} = 5.0 \text{ Vdc}$ )  ( $I_C = 0.4 \text{ Adc}, V_{CE} = 1.0 \text{ Vdc}$ )  ( $I_C = 1.0 \text{ Adc}, V_{CE} = 1.0 \text{ Vdc}$ )  ( $I_C = 10 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}$ )	$h_{FE}$	14 — 11 11 6.0 5.0 10	— 27 17 20 8.0 8.0 20	34 — — — — — —	—

**DYNAMIC CHARACTERISTICS**

Current Gain Bandwidth ( $I_C = 0.2 \text{ Adc}, V_{CE} = 10 \text{ Vdc}, f = 1.0 \text{ MHz}$ )	$f_T$	—	13	—	MHz	
Output Capacitance ( $V_{CB} = 10 \text{ Vdc}, I_E = 0, f = 1.0 \text{ MHz}$ )	$C_{ob}$	—	35	60	pF	
Input Capacitance ( $V_{EB} = 8.0 \text{ V}$ )	$C_{ib}$	—	400	600	pF	
Dynamic Saturation:  determined 1.0 $\mu\text{s}$ and 3.0 $\mu\text{s}$ after rising $I_{B1}$ reach 0.9 final $I_{B1}$ (see Figure 18)	$V_{CE(dsat)}$	$I_C = 0.4 \text{ A}$ $I_{B1} = 40 \text{ mA}$ $V_{CC} = 300 \text{ V}$	1.0 $\mu\text{s}$ 3.0 $\mu\text{s}$	@ $T_C = 125^\circ\text{C}$ @ $T_C = 125^\circ\text{C}$	— — — — — — — —	Vdc
		$I_C = 1.0 \text{ A}$ $I_{B1} = 0.2 \text{ A}$ $V_{CC} = 300 \text{ V}$	1.0 $\mu\text{s}$ 3.0 $\mu\text{s}$	@ $T_C = 125^\circ\text{C}$ @ $T_C = 125^\circ\text{C}$	— — — — — — — —	

**SWITCHING CHARACTERISTICS: Resistive Load** (D.C.  $\leq 10\%$ , Pulse Width = 20  $\mu\text{s}$ )

Turn–On Time	$I_C = 0.4 \text{ Adc}$ $I_{B1} = 40 \text{ mAdc}$ $I_{B2} = 0.2 \text{ Adc}$ $V_{CC} = 300 \text{ V}$	@ $T_C = 125^\circ\text{C}$	$t_{on}$	— —	200 130	300 —	ns
Turn–Off Time		@ $T_C = 125^\circ\text{C}$	$t_{off}$	— —	1.2 1.5	2.5 —	$\mu\text{s}$
Turn–On Time	$I_C = 1.0 \text{ Adc}$ $I_{B1} = 0.2 \text{ Adc}$ $I_{B2} = 0.5 \text{ Adc}$ $V_{CC} = 300 \text{ V}$	@ $T_C = 125^\circ\text{C}$	$t_{on}$	— —	85 95	150 —	ns
Turn–Off Time		@ $T_C = 125^\circ\text{C}$	$t_{off}$	— —	1.7 2.1	2.5 —	$\mu\text{s}$

**SWITCHING CHARACTERISTICS: Inductive Load** ( $V_{clamp} = 300 \text{ V}, V_{CC} = 15 \text{ V}, L = 200 \mu\text{H}$ )

Fall Time	$I_C = 0.4 \text{ Adc}, I_{B1} = 40 \text{ mAdc}, I_{B2} = 0.2 \text{ Adc}$	@ $T_C = 125^\circ\text{C}$	$t_{fi}$	— —	125 120	200 —	ns
Storage Time		@ $T_C = 125^\circ\text{C}$	$t_{sj}$	— —	0.7 0.8	1.25 —	$\mu\text{s}$
Crossover Time		@ $T_C = 125^\circ\text{C}$	$t_c$	— —	110 110	200 —	ns
Fall Time	$I_C = 1.0 \text{ Adc}, I_{B1} = 0.2 \text{ Adc}, I_{B2} = 0.5 \text{ Adc}$	@ $T_C = 125^\circ\text{C}$	$t_{fi}$	— —	110 120	175 —	ns
Storage Time		@ $T_C = 125^\circ\text{C}$	$t_{sj}$	— —	1.7 2.25	2.75 —	$\mu\text{s}$
Crossover Time		@ $T_C = 125^\circ\text{C}$	$t_c$	— —	200 250	300 —	ns
Fall Time	$I_C = 0.4 \text{ Adc}, I_{B1} = 50 \text{ mAdc}, I_{B2} = 50 \text{ mAdc}$	@ $T_C = 125^\circ\text{C}$	$t_{fi}$	— —	140 185	200 —	ns
Storage Time		@ $T_C = 125^\circ\text{C}$	$t_{sj}$	— —	2.2 2.5	3.0 —	$\mu\text{s}$
Crossover Time		@ $T_C = 125^\circ\text{C}$	$t_c$	— —	140 220	250 —	ns

TYPICAL STATIC CHARACTERISTICS

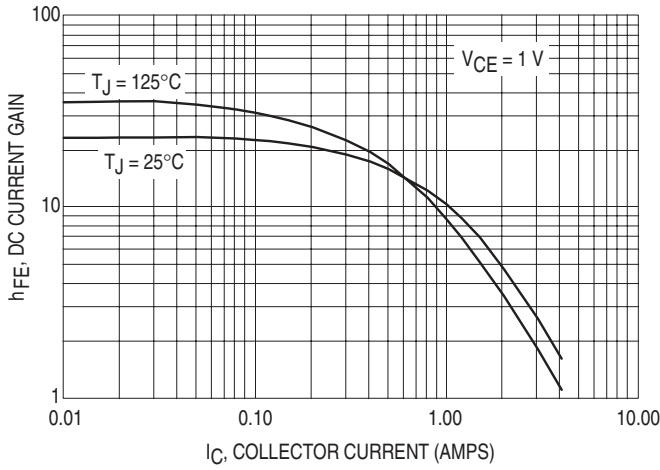


Figure 1. DC Current Gain @ 1 Volt

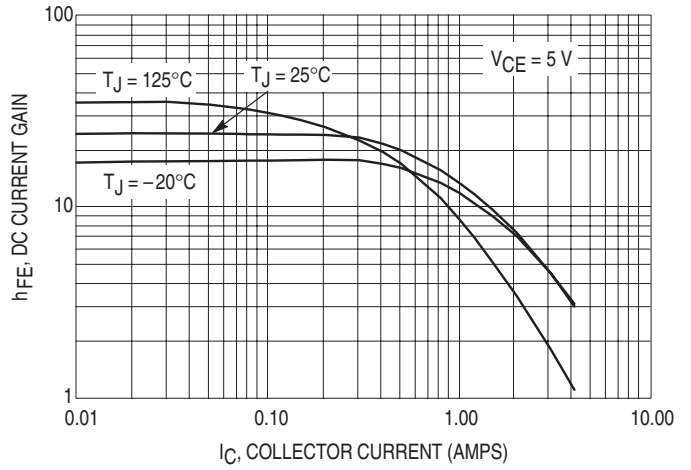


Figure 2. DC Current Gain @ 5 Volts

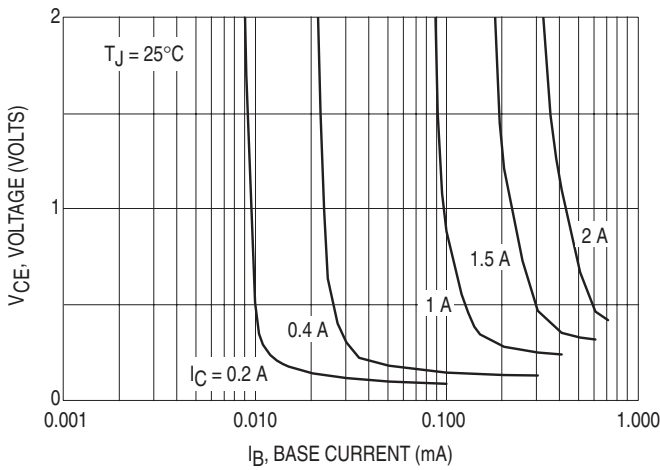


Figure 3. Collector Saturation Region

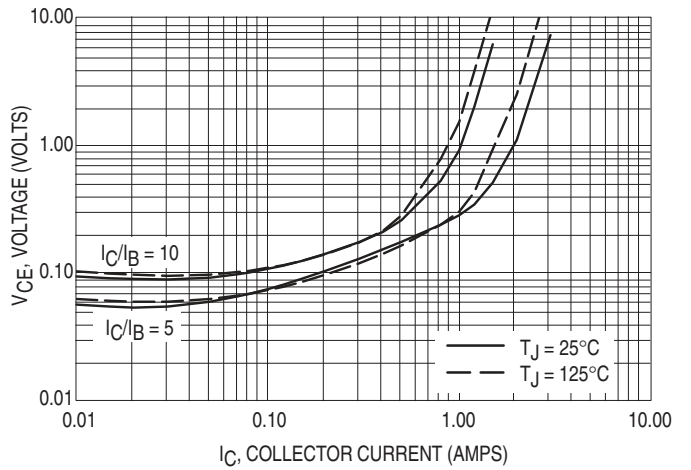


Figure 4. Collector-Emitter Saturation Voltage

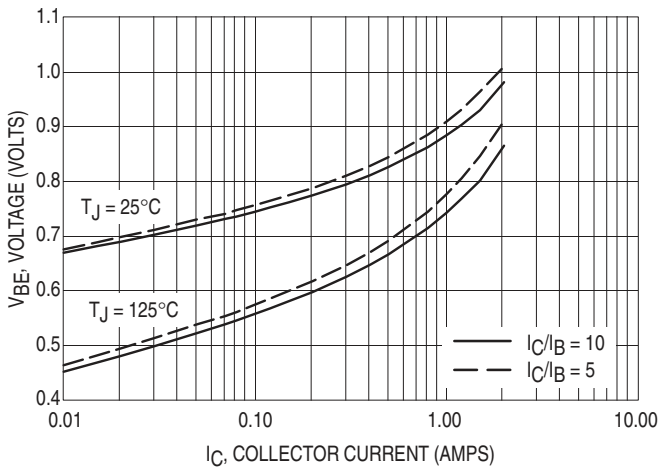


Figure 5. Base-Emitter Saturation Region

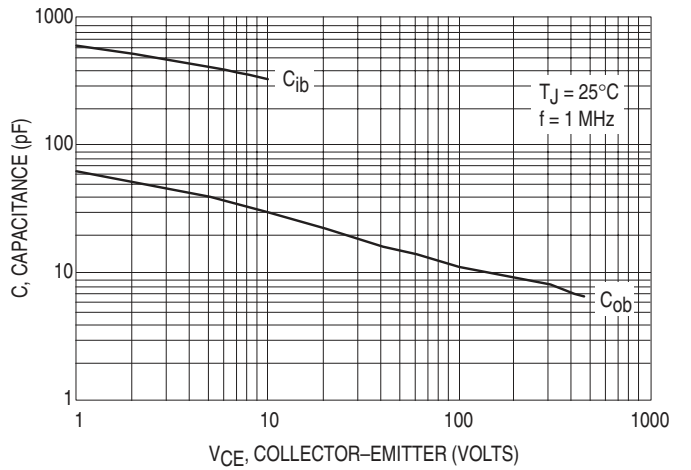
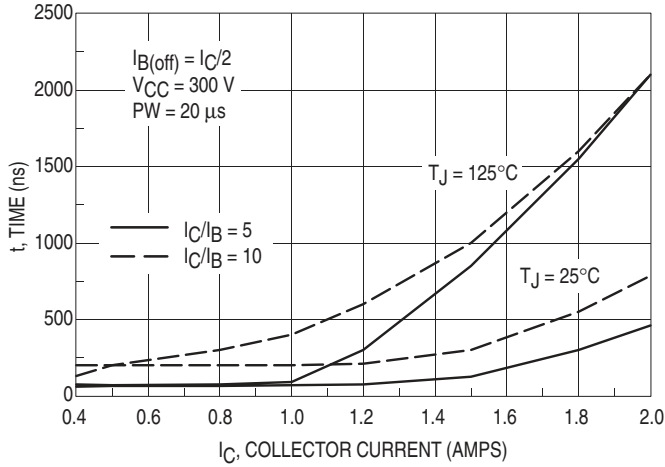
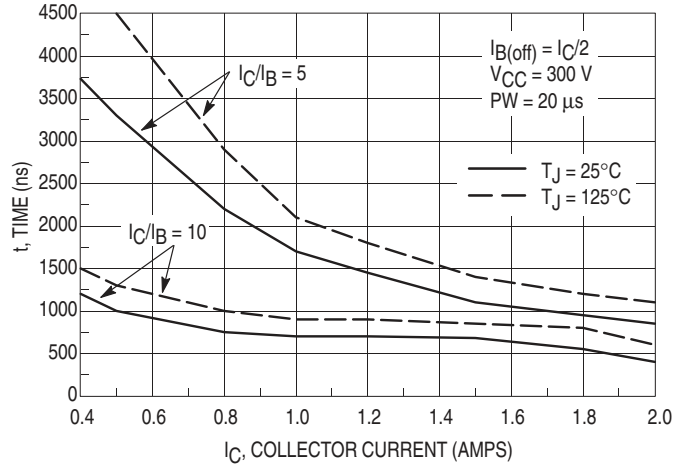


Figure 6. Capacitance

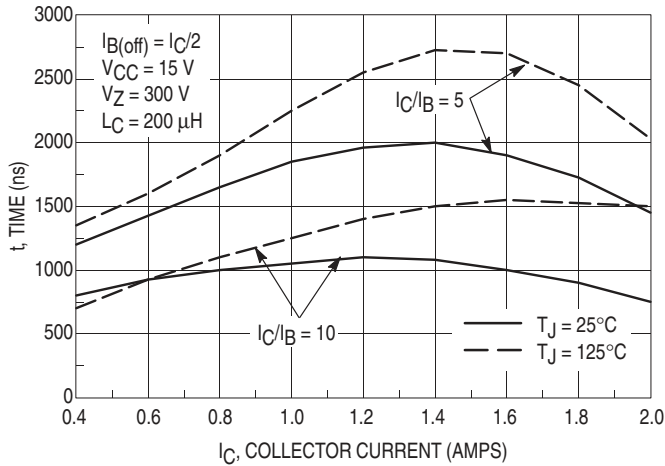
**TYPICAL SWITCHING CHARACTERISTICS**  
**( $I_{B2} = I_C/2$  for all switching)**



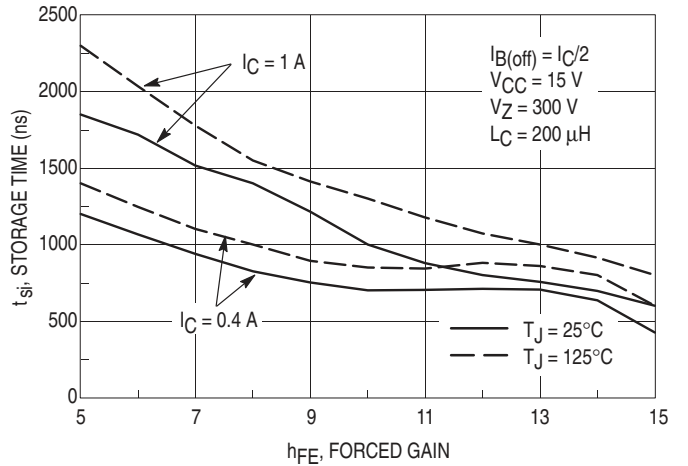
**Figure 7. Resistive Switching,  $t_{on}$**



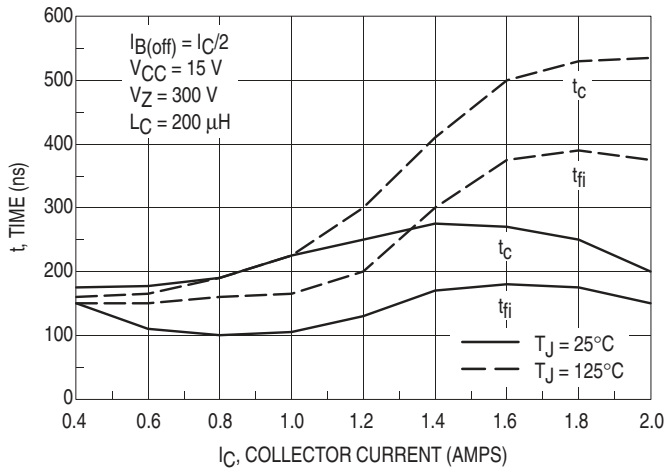
**Figure 8. Resistive Switching,  $t_{off}$**



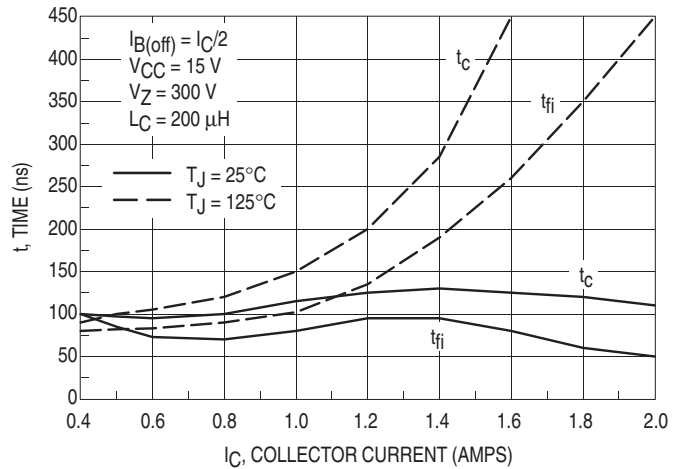
**Figure 9. Inductive Storage Time,  $t_{si}$**



**Figure 10. Inductive Storage Time**



**Figure 11. Inductive Switching,  $t_c$  &  $t_{fi}$ ,  $I_C/I_B = 5$**



**Figure 12. Inductive Switching,  $t_c$  &  $t_{fi}$ ,  $I_C/I_B = 10$**

**TYPICAL SWITCHING CHARACTERISTICS**  
( $I_{B2} = I_C/2$  for all switching)

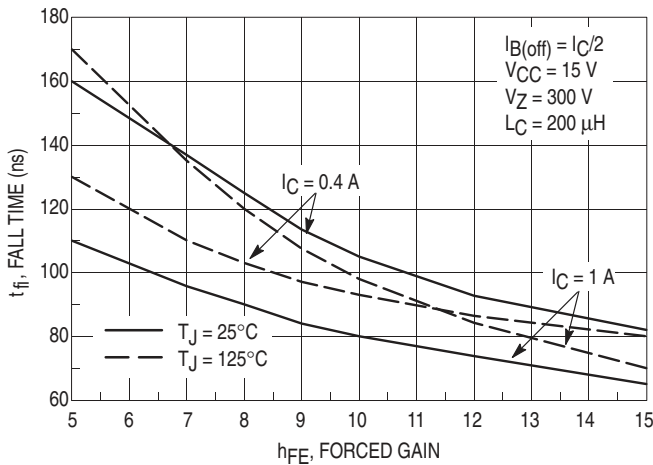


Figure 13. Inductive Fall Time

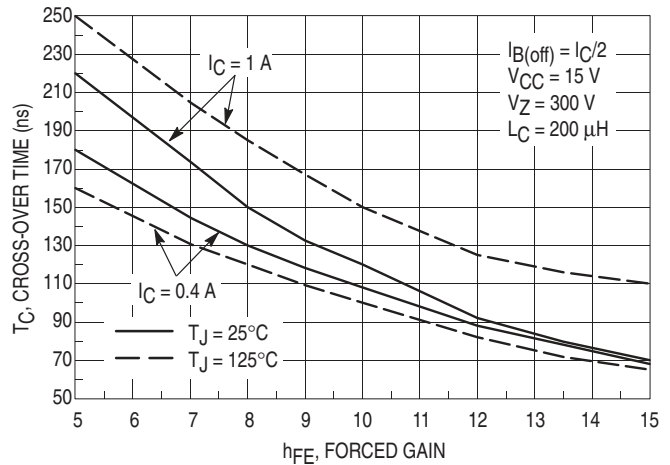


Figure 14. Inductive Crossover Time

**GUARANTEED SAFE OPERATING AREA INFORMATION**

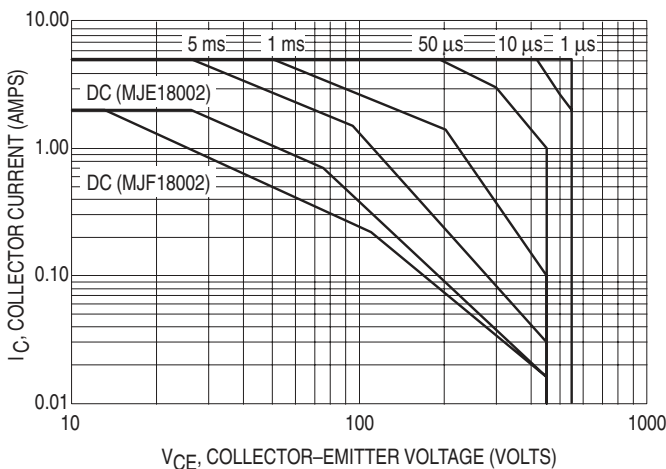


Figure 15. Forward Bias Safe Operating Area

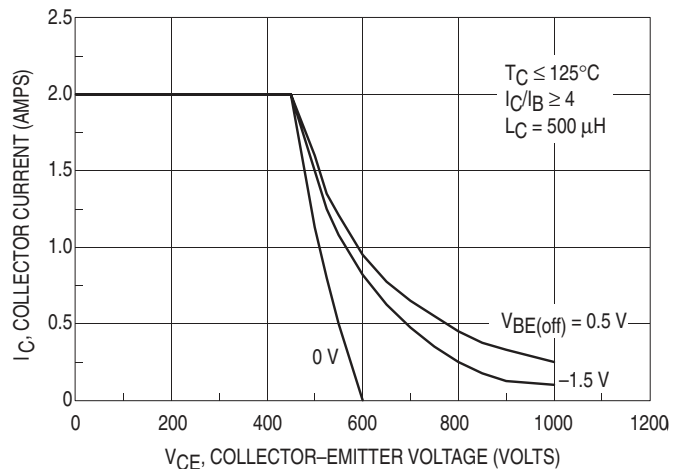


Figure 16. Reverse Bias Switching Safe Operating Area

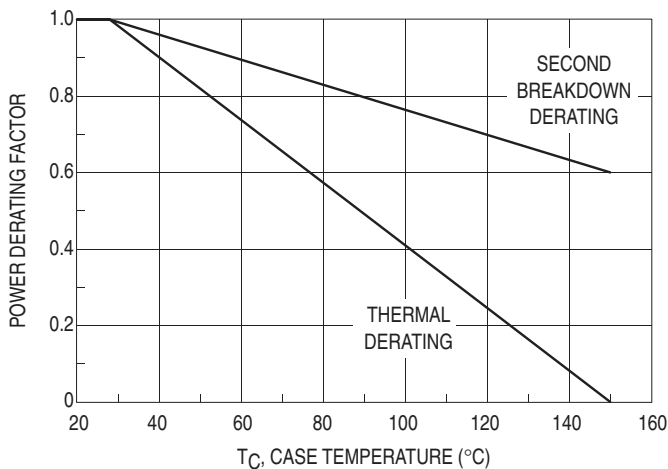


Figure 17. Forward Bias Power Derating

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 15 is based on  $T_C = 25^\circ\text{C}$ ;  $T_J(\text{pk})$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C > 25^\circ\text{C}$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 15 may be found at any case temperature by using the appropriate curve on Figure 17.  $T_J(\text{pk})$  may be calculated from the data in Figures 20 and 21. At any case temperatures, thermal limitations will reduce the power that can be handled to values less the limitations imposed by second breakdown. For inductive loads, high voltage and current must be sustained simultaneously during turn-off with the base to emitter junction reverse biased. The safe level is specified as a reverse biased safe operating area (Figure 16). This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode.

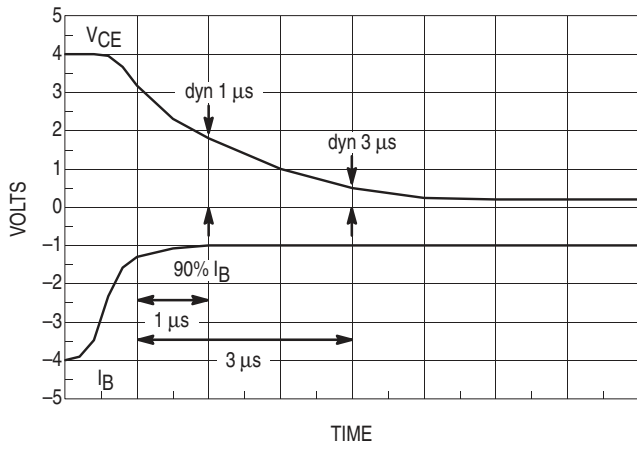


Figure 18. Dynamic Saturation Voltage Measurements

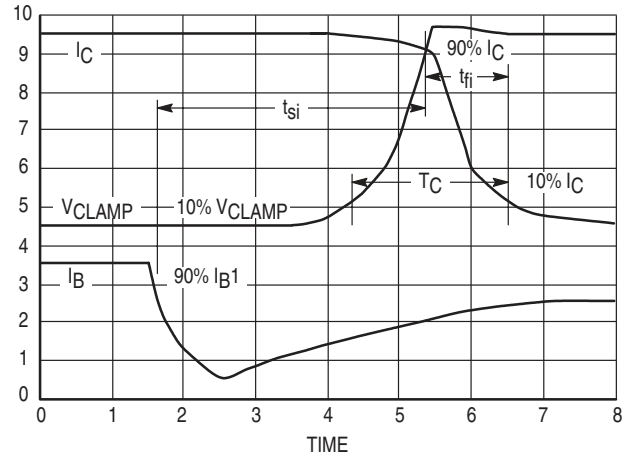
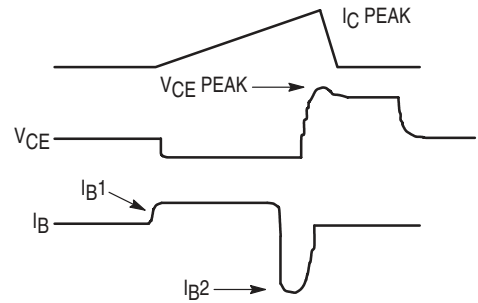
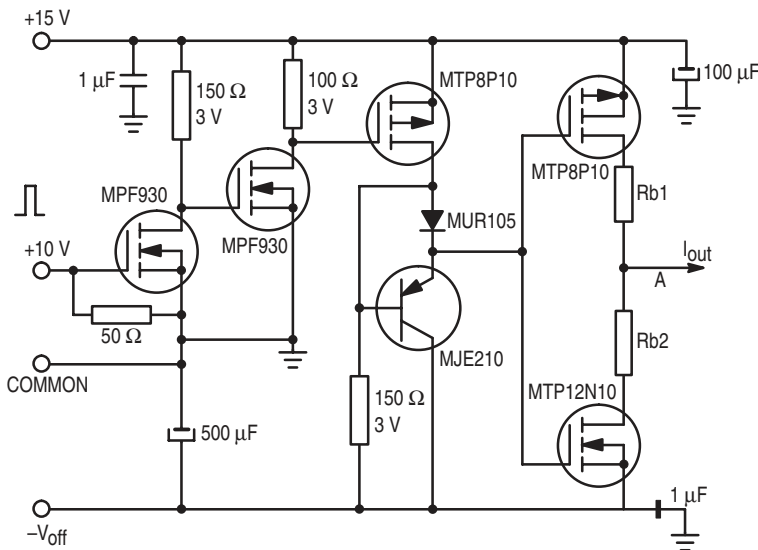


Figure 19. Inductive Switching Measurements



V(BR)CEO(sus)	INDUCTIVE SWITCHING	RBSOA
L = 10 μH	L = 200 μH	L = 500 μH
RB2 = ∞	RB2 = 0	RB2 = 0
VCC = 20 VOLTS	VCC = 15 VOLTS	VCC = 15 VOLTS
IC(pk) = 100 mA	RB1 SELECTED FOR DESIRED IB1	RB1 SELECTED FOR DESIRED IB1

Table 1. Inductive Load Switching Drive Circuit

TYPICAL THERMAL RESPONSE

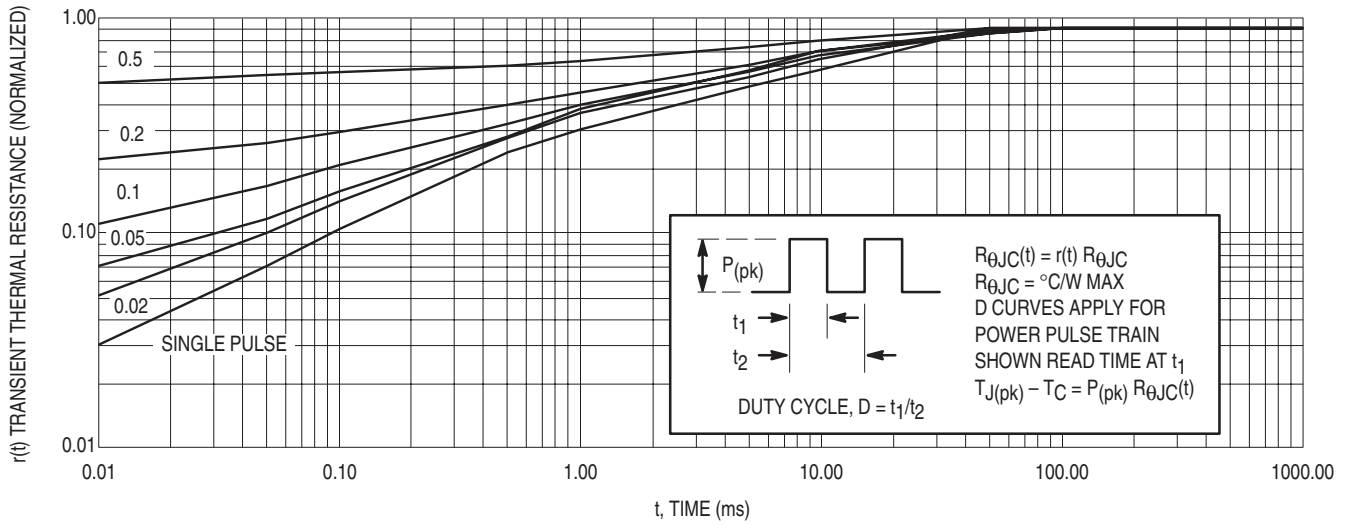


Figure 20. Typical Thermal Response ( $Z_{\theta JC}(t)$ ) for MJE18002

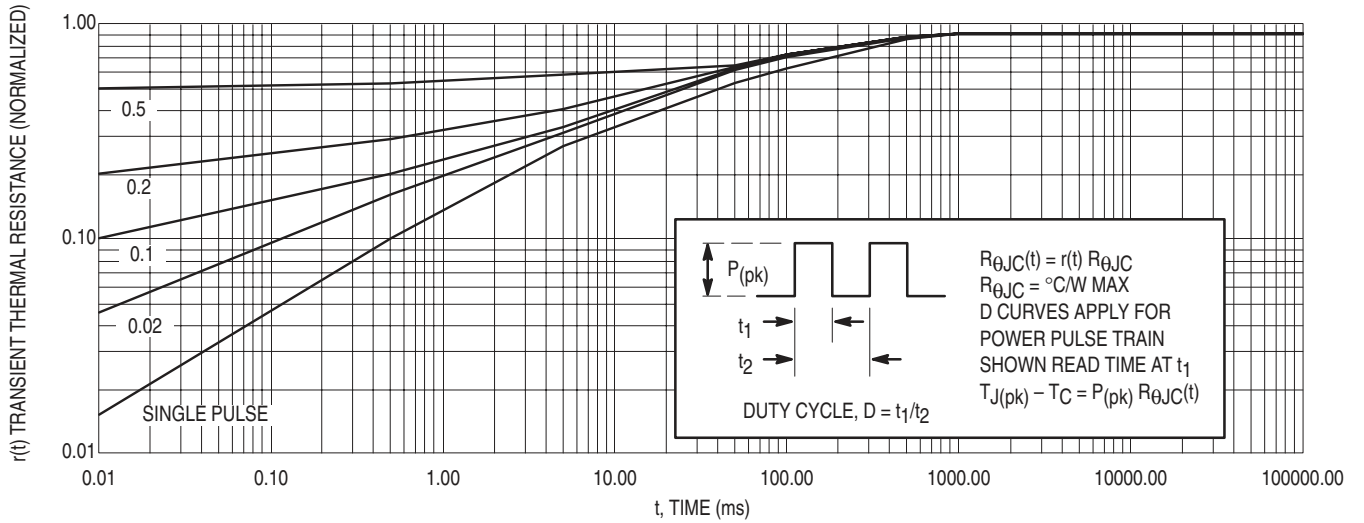
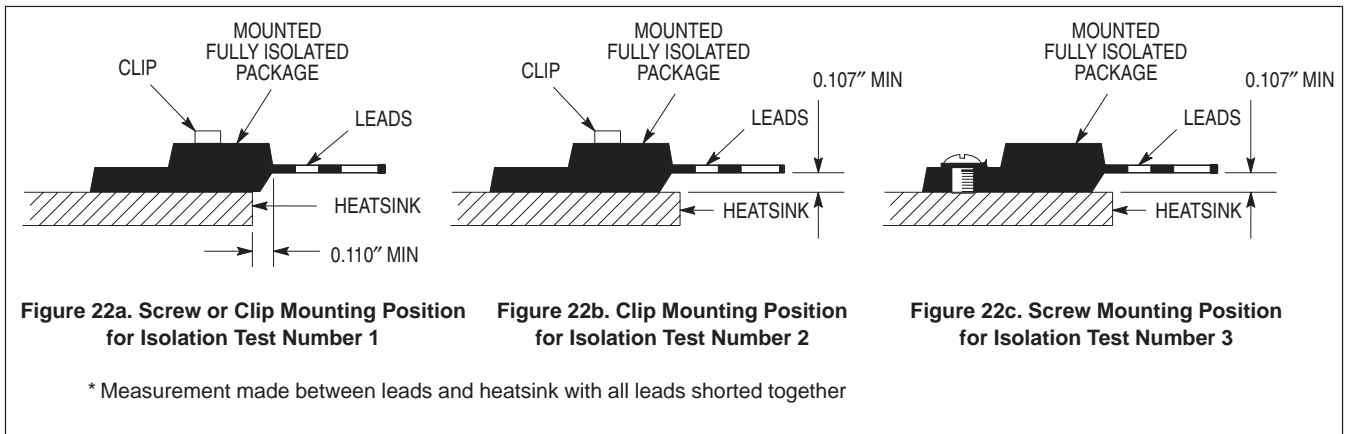
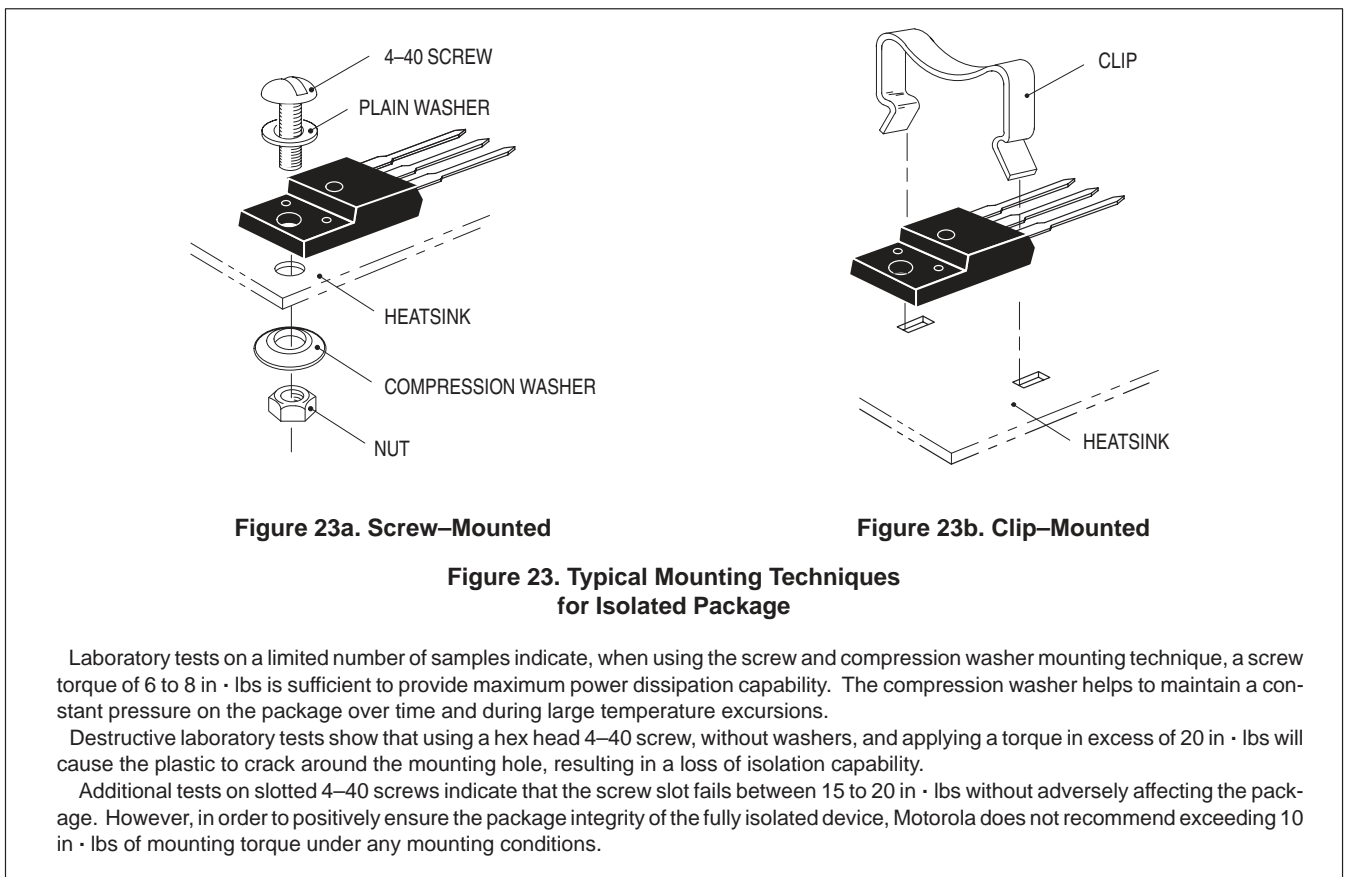


Figure 21. Typical Thermal Response ( $Z_{\theta JC}(t)$ ) for MJF18002

TEST CONDITIONS FOR ISOLATION TESTS\*



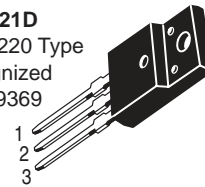
MOUNTING INFORMATION\*\*



\*\* For more information about mounting power semiconductors see Application Note AN1040.



CASE 221D  
Isolated TO-220 Type  
UL Recognized  
File #E69369



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

Table 1. Plastic (Isolated TO-220 Type)

I <sub>C</sub> Cont Amps Max	V <sub>CEO(sus)</sub> Volts Min	V <sub>CES</sub> Volts Min	Device Type		h <sub>FE</sub> Min/Max	@ I <sub>C</sub> Amp	Resistive Switching			f <sub>T</sub> MHz Min	P <sub>D</sub> (Case) Watts @ 25°C
			NPN	PNP			t <sub>s</sub> μs Max	t <sub>f</sub> μs Max	@ I <sub>C</sub> Amp		
1	250		<b>MJF47</b>		30/150	0.3	2 typ	0.17 typ	0.3	10	28
2	400	700	<b>BUL44F</b>		14/34	0.2	2.75 <sup>(3)</sup>	0.2 <sup>(3)</sup>	1	13 typ	25
		1000	<b>MJF18002</b>		14/34	0.2	2.75 <sup>(3)</sup>	0.175 <sup>(3)</sup>	1	13 typ	25
3	100		<b>MJF31C</b>	<b>MJF32C</b>	10 min	1	0.6	0.3	1	3	28
5	100		<b>MJF122</b> <sup>(2)</sup>	<b>MJF127</b> <sup>(2)</sup>	2000 min	3	1.5 typ	1.5 typ	3	4 <sup>(1)</sup>	28
	400	700	<b>BUL45F</b>		14/34	0.3	1.7 <sup>(3)</sup>	0.15 <sup>(3)</sup>	1	12 typ	35
	450	1000	<b>BUT11AF</b>		10 min	.005	4	0.8	2.5		40
		1000	<b>MJF18004</b>		14/34	0.3	1.7 <sup>(3)</sup>	0.15 <sup>(3)</sup>	1	13 typ	35
550	1200	<b>MJF18204</b>		18/35	0.5	2.75 <sup>(3)</sup>	0.2 <sup>(3)</sup>	2	12	35	
6	400	700	<b>BUL146F</b>		14/34	0.5	2.5 <sup>(3)</sup>	0.15 <sup>(3)</sup>	3	14 typ	40
	450	1000	<b>MJF18006</b>		14/34	0.5	3.2 <sup>(3)</sup>	0.15 <sup>(3)</sup>	3	14 typ	40
8	80			<b>MJF6107</b>	30/90	2	0.5 typ	0.13 typ	2	4	35
	150		<b>MJF15030</b>	<b>MJF15031</b>	40 min	3	1 typ	0.15 typ	3	30	35
	400	700	<b>MJF13007</b>		5/30	5	3	0.7	5	4	40
				<b>BUL147F</b>		14/34	1	2.5 <sup>(3)</sup>	0.18 <sup>(3)</sup>	2	14 typ
450	1000	<b>MJF18008</b>		16/34	1	2.75 <sup>(3)</sup>	0.18 <sup>(3)</sup>	2	13 typ	45	
10	60		<b>MJF3055</b>	<b>MJF2955</b>	20/100	4	—	—	—	2	40
	80		<b>MJF44H11</b>	<b>MJF45H11</b>	40/100	4	0.5 typ	0.14 typ	5	40	35
	100		<b>MJF6388</b> <sup>(2)</sup>	<b>MJF6668</b> <sup>(2)</sup>	3k/20k	3	1.5 typ	1.5 typ		20 <sup>(1)</sup>	40
	450	1000	<b>MJF18009</b>		14/34	1.5	2.75 <sup>(3)</sup>	0.2 <sup>(3)</sup>	3	12	50
12	400	700	<b>MJF13009</b>		6/30	8	3	0.7	8	8	40

(1)|h<sub>FE</sub>| @ 1 MHz

(2)Darlington

(3)Switching tests performed w/special application simulator circuit. See data sheet for details.

Devices listed in bold, italic are Motorola preferred devices.

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

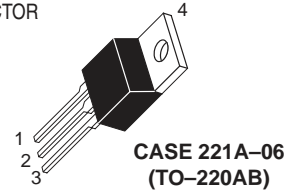


Table 2. Plastic TO-220AB

I <sub>C</sub> Cont Amps Max	V <sub>CEO(sus)</sub> Volts Min <sup>(8)</sup>	Device Type		h <sub>FE</sub> Min/Max	@ I <sub>C</sub> Amp	Resistive Switching			f <sub>T</sub> MHz Min	P <sub>D</sub> (Case) Watts @ 25°C
		NPN	PNP			t <sub>s</sub> μs Max	t <sub>f</sub> μs Max	@ I <sub>C</sub> Amp		
0.5	350	MJE2360T		15 min	0.1				10 typ	30
		<b>MJE2361T</b>		40 min	0.1				10 typ	30
1	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	MJE5730	30/150	0.3	2 typ	0.18 typ	0.3	10	40
	350	<b>TIP49</b>	<b>MJE5731</b>	30/150	0.3	2 typ	0.18 typ	0.3	10	40
	400	<b>TIP50</b>	<b>MJE5731A<sup>(7)</sup></b>	30/150	0.3	2 typ	0.18 typ	0.3	10	40
2	100	<b>TIP112<sup>(2)</sup></b>	<b>TIP117<sup>(2)</sup></b>	500 min	2	1.7 typ	1.3 typ	2	25 <sup>(1)</sup>	50
	400/700	<b>BUL44</b>		14/36	0.4	2.75 <sup>(3)</sup>	0.175 <sup>(3)</sup>	1	13 typ	50
	450/1000	<b>BUX85</b>		30	0.1	3.5	1.4	1	4	50
	450/1000	<b>MJE18002</b>		14/34	0.2	3 <sup>(3)</sup>	0.17 <sup>(3)</sup>	1	12 typ	40
	900/1800	<b>MJE1320</b>		3 min	1	4 typ	0.8 typ	1		80
3	80	BD241B	BD242B	25 min	1				3	40
	100	BD241C	BD242C	25 min	1				3	40
		<b>TIP31C</b>	<b>TIP32C</b>	25 min	1	0.6 typ	0.3 typ	1	3	40
	150		<b>MJE9780</b>	50/200	0.5				5 typ	40

(1)|h<sub>FE</sub>| @ 1 MHz  
 (2)Darlington  
 (3)Switching tests performed w/special application simulator circuit. See data sheet for details.  
 (7)V<sub>CEO</sub> = 375 V  
 (8)When 2 voltages are given, the format is V<sub>CEO(sus)</sub>/V<sub>CES</sub>.

Devices listed in bold, italic are Motorola preferred devices.

Table 2. Plastic TO-220AB (continued)

I <sub>C</sub> Cont Amps Max	V <sub>CEO(sus)</sub> Volts Min <sup>(8)</sup>	Device Type		h <sub>FE</sub> Min/Max	@ I <sub>C</sub> Amp	Resistive Switching			f <sub>T</sub> MHz Min	P <sub>D</sub> (Case) Watts @ 25°C
		NPN	PNP			t <sub>s</sub> μs Max	t <sub>f</sub> μs Max	@ I <sub>C</sub> Amp		
4	40		<b>MJE1123</b>	45/100	4				5	75
	60	<b>MJE800</b> <sup>(2)</sup>	<b>MJE700</b> <sup>(2)</sup>	750 min	1.5				1 <sup>(1)</sup>	40
	80	<b>D44C12</b>	<b>D45C12</b>	40/120	0.2			1	40 typ	30
	400/700	<b>MJE13005</b>		6/30	3	3	0.7	3	4	60
5	100	<b>TIP122</b> <sup>(2)</sup>	<b>TIP127</b> <sup>(2)</sup>	1k min	3	1.5 typ	1.5 typ	4	4 <sup>(1)</sup>	75
	250	2N6497		10/75	2.5	1.8	0.8	2.5	5	80
	300	<b>2N6498</b>		10/75	2.5	1.8	0.8	2.5	5	80
	400/700	<b>BUL45</b>		14/34	0.3	1.7 <sup>(3)</sup>	0.15 <sup>(3)</sup>	1	12 typ	75
	450/1000	MJE16002		5 min	5	3	0.3	3		80
	450/850	<b>MJE16004</b>		7 min	5	2.7	0.35	3		80
	450/1000	<b>MJE18004</b>		14/34	0.3	1.7	0.15	1.0	13	75
	550/1200	<b>MJE18204</b>		18/35	0.5	2.75 <sup>(3)</sup>	0.2 <sup>(3)</sup>	2	12	75
6	80	<b>BD243B</b>	<b>BD244B</b>	15 min	3	0.4 typ	0.15 typ	3	3	65
	100	<b>BD243C</b>	<b>BD244C</b>	15 min	3	0.4 typ	0.15 typ	3	3	65
		<b>TIP41C</b>	<b>TIP42C</b>	15/75	3	0.4 typ	0.15 typ	3	3	65
	250/550	<b>MJE16204</b>		5 min	6	1.5 <sup>(2)</sup>	0.15 <sup>(2)</sup>	1	10	80
	400/700	<b>BUL146</b>		14/34	0.5	1.75 <sup>(3)</sup>	0.15 <sup>(3)</sup>	3	14 typ	100
	450/1000	<b>MJE18006</b>		14/34	0.5	3.2 <sup>(3)</sup>	0.13 <sup>(3)</sup>	3	14 typ	100
7	30	2N6288	2N6111	30/150	3	0.4 typ	0.15 typ	3	4	40
	50		2N6109	30/150	2.5	0.4 typ	0.15 typ	3	4	40
	70	<b>2N6292</b>	<b>2N6107</b>	30/150	2	0.4 typ	0.15 typ	3	4	40
	100	<b>BD801</b>	<b>BD802</b>	15 min	3				3	65
	150	BU407		30 min	1.5		0.75	5	10	60
	200	<b>BU406</b>		30 min	1.5		0.75	5	10	60
	450	<b>BU522B</b> <sup>(2)</sup>		250 min	2.5				7.5	75

(1)|h<sub>FE</sub>| @ 1 MHz

(2)Darlington

(3)Switching tests performed w/special application simulator circuit. See data sheet for details.

(7)V<sub>CEO</sub> = 375 V

(8)When 2 voltages are given, the format is V<sub>CEO(sus)</sub>/V<sub>CES</sub>.

Table 2. Plastic TO-220AB (continued)

I <sub>C</sub> Cont Amps Max	V <sub>CEO(sus)</sub> Volts Min <sup>(8)</sup>	Device Type		h <sub>FE</sub> Min/Max	@ I <sub>C</sub> Amp	Resistive Switching			f <sub>T</sub> MHz Min	P <sub>D</sub> (Case) Watts @ 25°C
		NPN	PNP			t <sub>s</sub> μs Max	t <sub>f</sub> μs Max	@ I <sub>C</sub> Amp		
8	60	2N6043 <sup>(2)</sup>	2N6040 <sup>(2)</sup>	1k/10k	4	1.5 typ	1.5 typ	3	4 <sup>(1)</sup>	75
	80	<b>2N6044</b> <sup>(2)</sup>	<b>2N6041</b> <sup>(2)</sup>	1k/10k	4	1.5 typ	1.5 typ	3	4 <sup>(1)</sup>	75
		<b>BDX53B</b> <sup>(2)</sup>	<b>BDX54B</b> <sup>(2)</sup>	750 min	3				4 <sup>(1)</sup>	60
	100	<b>2N6045</b> <sup>(2)</sup>	<b>2N6042</b> <sup>(2)</sup>	1k/10k	3	1.5 typ	1.5 typ	3	4 <sup>(1)</sup>	75
		<b>BDX53C</b> <sup>(2)</sup>	<b>BDX54C</b> <sup>(2)</sup>	750 min	3					
		<b>TIP102</b> <sup>(2)</sup>	<b>TIP107</b> <sup>(2)</sup>	1k/20k	3	1.5 typ	1.5 typ	3	4 <sup>(1)</sup>	80
	120	MJE15028	MJE15029	20 min	4				30	50
	150	<b>MJE15030</b>	<b>MJE15031</b>	20 min	4				30	50
	200	<b>BU806</b> <sup>(2)</sup>		100 min	5	0.55 typ	0.2 typ	5		60
	300/600	MJE5740 <sup>(2)</sup>		200 min	4	8 typ	2 typ	6	4	80
			MJE5850	15 min	2	2	0.5	4		80
	350	<b>MJE5741</b> <sup>(2)</sup>		200 min	4	8 typ	2 typ	6		80
			<b>MJE5851</b>	15 min	2	2	0.5	4		80
		<b>MJE5742</b> <sup>(2)</sup>		200 min	4	8 typ	2 typ	6		80
		<b>MJE13007</b>		5/30	5	3	0.7	5		80
				<b>MJE5852</b>	15 min	2	2	0.5	4	
400/650	<b>MJE16106</b>		6/22	8	2 typ	0.1 typ	5		100	
400/700	<b>BUL147</b>		14/34	1	2.5 <sup>(3)</sup>	0.18 <sup>(3)</sup>	2	14 typ	125	
450/1000	<b>MJE18008</b>		16/34	1	2.75 <sup>(3)</sup>	0.18 <sup>(3)</sup>	2	13 typ	125	
10	20		<b>BD808</b>	15 min	4				1.5	90
	60	D44H8	D45H8	40 min	4					50
		<b>MJE3055T</b>	<b>MJE2955T</b>	20/70	4					75
		<b>2N6387</b> <sup>(2)</sup>	<b>2N6667</b> <sup>(2)</sup>	1k/20k	5				20 <sup>(1)</sup>	65
	80	<b>BDX33B</b> <sup>(2)</sup>	<b>BDX34B</b> <sup>(2)</sup>	750 min	3				3	70
		<b>BD809</b>	<b>BD810</b>	15 min	4				1.5	90
		<b>2N6388</b> <sup>(2)</sup>	<b>2N6668</b> <sup>(2)</sup>	1k/20k	5				20 <sup>(1)</sup>	65
		D44H10	D45H10	20 min	4	0.5 typ	0.14 typ	5	50 typ	50
<b>D44H11</b>		<b>D45H11</b>	40 min	4	0.5 typ	0.14 typ	5	50 typ	50	

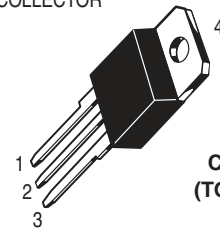
(1) |h<sub>FE</sub>| @ 1 MHz  
 (2) Darlington  
 (3) Switching tests performed w/special application simulator circuit. See data sheet for details.  
 (7) V<sub>CEO</sub> = 375 V  
 (8) When 2 voltages are given, the format is V<sub>CEO(sus)</sub>/V<sub>CES</sub>.  
 (9) Self protected Darlington

Devices listed in bold, italic are Motorola preferred devices.

Table 2. Plastic TO-220AB (continued)

I <sub>C</sub> Cont Amps Max	V <sub>CEO(sus)</sub> Volts Min(8)	Device Type		h <sub>FE</sub> Min/Max	@ I <sub>C</sub> Amp	Resistive Switching			f <sub>T</sub> MHz Min	P <sub>D</sub> (Case) Watts @ 25°C
		NPN	PNP			t <sub>s</sub> μs Max	t <sub>f</sub> μs Max	@ I <sub>C</sub> Amp		
10	100	<i>BDX33C</i> (2)	<i>BDX34C</i> (2)	750 min	3				3	70
	450/1000	<i>MJE18009</i>		14/34	1.5	2.75(3)	0.2(3)	3	12	150
12	400/700	<i>MJE13009</i>		6/30	8	3	0.7	8	4	100
15	80	<i>2N6488</i>	<i>2N6491</i>	20/150	5	0.6 typ	0.3 typ	5	5	75
		<i>D44VH10</i>	<i>D45VH10</i>	20 min	4	0.5	0.09	8	50 typ	83
	100	<i>BDW42</i> (2)	<i>BDW47</i> (2)	1k min	5	1 typ	1.5 typ	5	4	85

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



CASE 340D  
(TO-218 Type,  
SOT-93)

Table 3. Plastic TO-218 Type

I <sub>C</sub> Cont Amps Max	V <sub>CEO(sus)</sub> Volts Min(8)	Device Type		h <sub>FE</sub> Min/Max	@ I <sub>C</sub> Amp	Resistive Switching			f <sub>T</sub> MHz Min	P <sub>D</sub> (Case) Watts @ 25°C
		NPN	PNP			t <sub>s</sub> μs Max	t <sub>f</sub> μs Max	@ I <sub>C</sub> Amp		
8	500/1000	<i>MJH16006A</i>		5 min	8	2.5	0.25	5		125
10	60	TIP140(2)	TIP145(2)	500 min	10	2.5 typ	2.5 typ	5	4(1)	125
		TIP141(2)	TIP146(2)	500 min	10	2.5 typ	2.5 typ	5	4(1)	125
	100	<i>BDV65B</i> (2)	<i>BDV64B</i> (2)	1k min	5					125
		TIP33C	TIP34C	20/100	3				3	80
		<i>TIP142</i> (2)	<i>TIP147</i> (2)	500 min	10	2.5 typ	2.5 typ	5	4(1)	125
	400	<i>BU323AP</i> (2)		150/100	6	15	15	6		125
<i>MJH10012</i> (2)			100/2k	6	15	15	6		118	

(1)|h<sub>FE</sub>| @ 1 MHz

(2)Darlington

(8)When 2 voltages are given, the format is V<sub>CEO(sus)</sub>/V<sub>CES</sub>.

Devices listed in bold, italic are Motorola preferred devices.

Table 3. Plastic TO-218 Type (continued)

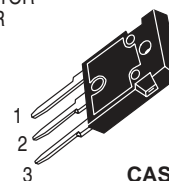
I <sub>C</sub> Cont Amps Max	V <sub>CEO(sus)</sub> Volts Min <sup>(8)</sup>	Device Type		h <sub>FE</sub> Min/Max	@ I <sub>C</sub> Amp	Resistive Switching			f <sub>T</sub> MHz Min	P <sub>D</sub> (Case) Watts @ 25°C
		NPN	PNP			t <sub>s</sub> μs Max	t <sub>f</sub> μs Max	@ I <sub>C</sub> Amp		
15	60	<b>TIP3055</b>	<b>TIP2955</b>	5 min	10				2.5	80
	150	MJH11018 <sup>(2)</sup>	MJH11017 <sup>(2)</sup>	400/15k	10				3	150
	200	MJH11020 <sup>(2)</sup>	MJH11019 <sup>(2)</sup>	400/15k	10				3	150
	250	<b>MJH11022<sup>(2)</sup></b>	<b>MJH11021<sup>(2)</sup></b>	400/15k	10				3	150
	400	BUV48		8 min	10	2	0.4	10		150
	450	<b>BUV48A</b>		8 min	8	2	0.4	10		150
16	140	MJE4342	MJE4352	15 min	8	1.2 typ	1.2 typ	8	1	125
	160	<b>MJE4343</b>	<b>MJE4353</b>	15 min	8	1.2 typ	1.2 typ	8	1	125
20	60	MJH6282 <sup>(2)</sup>	MJH6285 <sup>(2)</sup>	750/18k	10				4	125
	100	<b>MJH6284<sup>(2)</sup></b>	<b>MJH6287<sup>(2)</sup></b>	750/18k	10				4	125
25	80	TIP35A	TIP36A	15/75	15	0.6 typ	0.3 typ	10	3	125
	100	<b>BD249C</b>	<b>BD250C</b>	10 min	15				3	125
		<b>TIP35C</b>	<b>TIP36C</b>	15/75	15	0.6 typ	0.3 typ	10	3	125

<sup>(2)</sup>Darlington

<sup>(8)</sup>When 2 voltages are given, the format is V<sub>CEO(sus)</sub>/V<sub>CES</sub>.

STYLE 2:

- PIN 1. BASE
- 2. COLLECTOR
- 3. EMITTER



CASE 340F  
(TO-247 Type)

Table 4. Isolated Mounting Hole — Plastic TO-247 Type

I <sub>C</sub> Cont Amps Max	V <sub>CEO(sus)</sub> Volts Min	V <sub>CES</sub> Volts Min	Device Type		h <sub>FE</sub> Min/Max	@ I <sub>C</sub> Amp	Resistive Switching			f <sub>T</sub> MHz Min	P <sub>D</sub> (Case) Watts @ 25°C
			NPN	PNP			t <sub>s</sub> μs Max	t <sub>f</sub> μs Max	@ I <sub>C</sub> Amp		
10	650	1500	<b>MJW16212</b>		4/10	10	4 <sup>(3)</sup>	0.5 <sup>(3)</sup>	5.5		150
	800	1500	<b>MJW16018</b>		4 min	5	4.5 typ	0.2 typ	5	3 typ	150
12	500	1200	<b>MJW16206</b>		5/13	10	2.25	0.25	6.5	3 typ	150
15	450	850	<b>MJW16010</b>		5 min	15	1.2 typ	0.2 typ	10		150
		850	<b>MJW16012</b>		7 min	15	0.9 typ	0.15 typ	10		150
	500	1000	<b>MJW16010A</b>		5 min	15	3	0.4	10		150

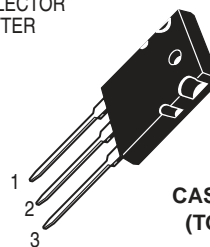
<sup>(3)</sup>Switching tests performed w/special application simulator circuit. See data sheet for details.

<sup>(10)</sup>Tested in Applications simulator: see Data Sheet.

Devices listed in bold, italic are Motorola preferred devices.

# New Product New Product New Product New Product

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



CASE 340G  
(TO-264)

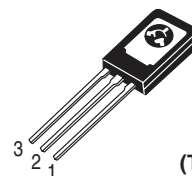
Table 5. Large Plastic TO-264

I <sub>C</sub> Cont Amps Max	V <sub>CEO(sus)</sub> Volts Min	Device Type		hFE Min/Max	@ I <sub>C</sub> Amp	Resistive Switching			f <sub>T</sub> MHz Min	P <sub>D</sub> (Case) Watts @ 25°C
		NPN	PNP			t <sub>s</sub> μs Max	t <sub>f</sub> μs Max	@ I <sub>C</sub> Amp		
15	200	<i>MJL3281A</i>	<i>MJL1302A</i>	60/175	0.1				30 typ	200
	650/1500	<i>MJL16218</i>		4/11	12				2.5 typ	170
16	250	<i>MJL21194</i>	<i>MJL21193</i>	25/75	8				4	200

# New Product New Product New Product New Product

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

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



CASE 77  
(TO-225AA)

Table 6. Plastic TO-225AA Type (Formerly TO-126 Type)

I <sub>C</sub> Cont Amps Max	V <sub>CEO(sus)</sub> Volts Min	Device Type		hFE Min/Max	@ I <sub>C</sub> Amp	Resistive Switching			f <sub>T</sub> MHz Min	P <sub>D</sub> (Case) Watts @ 25°C
		NPN	PNP			t <sub>s</sub> μs Max	t <sub>f</sub> μs Max	@ I <sub>C</sub> Amp		
0.3	350	<i>MJE3439</i>		40/160	0.02				15	15
0.5	150	MJE341		25/200	0.05				15	20.8
	200	<i>MJE344</i>		30/300	0.05				15	20.8
	250	2N5655		30/250	0.1	3.5 typ	0.24 typ	0.1	10	20
		BD157		30/240	0.05					20
	300	<i>BD158</i>		30/240	0.05					20
		<i>MJE340</i>	<i>MJE350</i>	30/240	0.05					20.8
	2N5656		30/250	0.1	3.5 typ	0.24 typ	0.1	10	20	

Devices listed in bold, italic are Motorola preferred devices.

Table 6. Plastic TO–225AA Type (Formerly TO–126 Type) (continued)

I <sub>C</sub> Cont Amps Max	V <sub>CEO(sus)</sub> Volts Min	Device Type		h <sub>FE</sub> Min/Max	@ I <sub>C</sub> Amp	Resistive Switching			f <sub>T</sub> MHz Min	P <sub>D</sub> (Case) Watts @ 25°C
		NPN	PNP			t <sub>s</sub> μs Max	t <sub>f</sub> μs Max	@ I <sub>C</sub> Amp		
0.5	350	<b>2N5657</b>		30/250	0.1	3.5 typ	0.24 typ	0.1	10	20
		<b>BD159</b>		30/240	0.05					20
1	40	2N4921	2N4918	20/100	0.5	0.6 typ	0.3 typ	0.5	3	30
	60	2N4922	2N4919	20/100	0.5	0.6 typ	0.3 typ	0.5	3	30
	80	<b>2N4923</b>	<b>2N4920</b>	20/100	0.5	0.6 typ	0.3 typ	0.5	3	30
1.5	45	<b>BD165</b>	<b>BD166</b>	15 min	0.5				6	20
		BD135	BD136	40/250	0.15					12.5
	60	BD137	BD138	40/250	0.15					12.5
	80	<b>BD169</b>		15 min	0.5				6	20
		<b>BD139</b>	<b>BD140</b>	40/250	0.15					12.5
			<b>BD140–10</b>	63/160	0.15					12.5
	300	MJE13002 <sup>(11)</sup>		5/25	1	4	0.7	1	5	40
	400	<b>MJE13003</b> <sup>(11)</sup>		5/25	1	4	0.7	1	5	40
2	80	<b>BD237</b>	<b>BD238</b>	25 min	1				3	25
	100	<b>MJE270</b> <sup>(2)(11)</sup>	<b>MJE271</b> <sup>(2)(11)</sup>	1.5k min	0.12				6	15
3	60	MJE181	MJE171	50/250	0.1	0.6 typ	0.12 typ	0.1	50	12.5
	80	<b>BD179</b>	<b>BD180</b>	40/250	0.15				3	30
		<b>MJE182</b>	<b>MJE172</b>	50/250	0.1	0.6 typ	0.12 typ	0.1	50	12.5
200	<b>BUY49P</b>		30 min	0.5				25	20	
4	40	<b>MJE521</b>	<b>MJE371</b>	40 min	1					40
	45	<b>BD437</b>	<b>BD438</b>	40 min	2				3	36
			<b>BD776</b> <sup>(2)</sup>	750 min	2				20	15
	60		<b>BD440</b>	25 min	2				3	36
		<b>BD677</b> <sup>(2)</sup>	<b>BD678</b> <sup>(2)</sup>	750 min	1.5					40
		<b>BD677A</b> <sup>(2)</sup>	<b>BD678A</b> <sup>(2)</sup>	750 min	2					40
		<b>BD787</b>	<b>BD788</b>	20 min	2				50	15
		<b>BD777</b> <sup>(2)</sup>	<b>BD778</b> <sup>(2)</sup>	750 min	2				20	15
		<b>2N5191</b>	<b>2N5194</b>	25/100	1.5	0.4 typ	0.4 typ	1.5	2	40
		<b>MJE800</b> <sup>(2)</sup>	<b>MJE700</b> <sup>(2)</sup>	750 min	1.5				1 <sup>(1)</sup>	40
		<b>2N6038</b> <sup>(2)</sup>	<b>2N6035</b> <sup>(2)</sup>	750/18k	2	1.7 typ	1.2 typ	2	25	40
	80	<b>2N5192</b>	<b>2N5195</b>	25/100	1.5	0.4 typ	0.4 typ	1.5	2	40
		<b>BD441</b>	<b>BD442</b>	15 min	2				3	36
		<b>BD679</b> <sup>(2)</sup>	<b>BD680</b> <sup>(2)</sup>	750 min	1.5					40
<b>BD679A</b> <sup>(2)</sup>		<b>BD680A</b> <sup>(2)</sup>	750 min	2					40	
<b>BD789</b>		<b>BD790</b>	10 min	2				40	15	

(1) |h<sub>FE</sub>| @ 1 MHz

(2) Darlington

(11) Case 77, Style 3

Devices listed in bold, italic are Motorola preferred devices.



Table 6. Plastic TO–225AA Type (Formerly TO–126 Type) (continued)

I <sub>C</sub> Cont Amps Max	V <sub>CEO(sus)</sub> Volts Min	Device Type		hFE Min/Max	@ I <sub>C</sub> Amp	Resistive Switching			f <sub>T</sub> MHz Min	P <sub>D</sub> (Case) Watts @ 25°C
		NPN	PNP			t <sub>s</sub> μs Max	t <sub>f</sub> μs Max	@ I <sub>C</sub> Amp		
4	80	<i>BD779</i> (2)	<i>BD780</i> (2)	750 min	2				20	15
		MJE802(2)	MJE702(2)	750 min	1.5				1(1)	40
		<i>MJE803</i> (2)	<i>MJE703</i> (2)	750 min	2				1(1)	40
		<i>2N6039</i> (2)	<i>2N6036</i> (2)	750/18k	2	1.7 typ	1.2 typ	2	25	40
	100	<i>BD681</i> (2)	<i>BD682</i> (2)	750 min	1.5					40
		<i>BD791</i>	<i>BD792</i>	10 min	2				40	15
<i>MJE243</i>		<i>MJE253</i>	40/120	0.2	0.15 typ	0.07 typ	2	40	15	
5	25	<i>MJE200</i>	<i>MJE210</i>	45/180	2	0.13 typ	0.035 typ	2	65	15



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

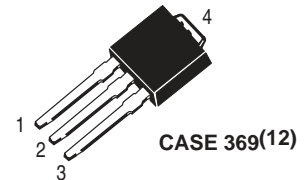


Table 7. DPAK – Surface Mount Power Packages

I <sub>C</sub> Cont Amps Max	V <sub>CEO(sus)</sub> Volts Min	Device Type		hFE Min/Max	@ I <sub>C</sub> Amp	Resistive Switching			f <sub>T</sub> MHz Min	P <sub>D</sub> (Case) Watts @ 25°C
		NPN	PNP			t <sub>s</sub> μs Max	t <sub>f</sub> μs Max	@ I <sub>C</sub> Amp		
0.5	300	<i>MJD340</i>	<i>MJD350</i>	30/240	0.05					15
1	250	MJD47		30/150	0.3	2	0.2	0.3	10	15
	375		<i>MJD5731</i>	TBD	TBD	TBD	TBD	TBD	TBD	TBD
	400	<i>MJD50</i>		30/150	0.3	2	0.2	0.3	10	15
1.5	400	<i>MJD13003</i>		5/25	1	4	0.7	1	4	15

(1)|hFE| @ 1 MHz

(2)Darlington

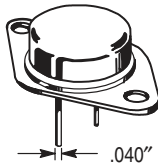
(12)Case 369–07 may be ordered by adding –1 suffix to part number.

(13)Case 369A–13 may be ordered as tape and reel by adding a “T4” suffix; 2500 units/reel.

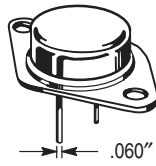
Devices listed in bold, italic are Motorola preferred devices.

Table 7. DPAK – Surface Mount Power Packages (continued)

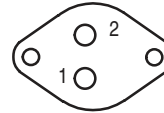
I <sub>C</sub> Cont Amps Max	V <sub>CEO(sus)</sub> Volts Min	Device Type		h <sub>FE</sub> Min/Max	@ I <sub>C</sub> Amp	Resistive Switching			f <sub>T</sub> MHz Min	P <sub>D</sub> (Case) Watts @ 25°C
		NPN	PNP			t <sub>s</sub> μs Max	t <sub>f</sub> μs Max	@ I <sub>C</sub> Amp		
2	100	<i>MJD112</i> (2)	<i>MJD117</i> (2)	1000 min	2	1.7	1.3	2	25(1)	20
3	40	MJD31	MJD32	10 min	1	0.6	0.3	1	3	15
	100	<i>MJD31C</i>	<i>MJD32C</i>	10 min	1	0.6	0.3	1	3	15
4	80	<i>MJD6039</i> (2)	<i>MJD6036</i> (2)	1k/12k	2	1.7	1.2	2	25	20
	100	<i>MJD243</i>	<i>MJD253</i>	40/180	0.2	0.16	0.04	1	40	12.5
5	25	<i>MJD200</i>	<i>MJD210</i>	45/180	2	0.15	0.04	2	65	12.5
6	100	<i>MJD41C</i>	<i>MJD42C</i>	15/75	3	0.4	0.15	3	3	20
8	80	<i>MJD44H11</i>	<i>MJD45H11</i>	40 min	4	0.5	0.14	5	50 typ	20
	100	<i>MJD122</i> (2)	<i>MJD127</i> (2)	1k/12k	4	1.5	2	4	4(1)	20
10	60	<i>MJD3055</i>	<i>MJD2955</i>	20/100	4	1.5	1.5	3	2	20
	80	<i>MJD44E3</i> (2)		1k min	5	2	0.5	10		20



CASE 1-07  
TO-204AA



CASE 197A TO-204AE  
(Used for high current types at end of  
table. See types w/footnote(16).)



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

Table 8. Metal TO-204AA (Formerly TO-3), TO-204AE

I <sub>C</sub> Cont Amps Max	V <sub>CEO(sus)</sub> Volts Min(8)	Device Type		h <sub>FE</sub> Min/Max	@ I <sub>C</sub> Amp	Resistive Switching			f <sub>T</sub> MHz Min	P <sub>D</sub> (Case) Watts @ 25°C
		NPN	PNP			t <sub>s</sub> μs Max	t <sub>f</sub> μs Max	@ I <sub>C</sub> Amp		
4	200	MJ15018		30 min	1				20	150
	250	<i>MJ15020</i>	<i>MJ15021</i>	30 min	1				20	150
5	700/1500	<i>BU208A</i>		2.5 min	4.5	8 typ	0.4 typ	4.5	4 typ	90
8	60	MJ1000(2)		1k min	3					90
		2N6055(2)		750/18k	4	1.5 typ	1.5 typ	4	4(1)	100
	80	<i>MJ1001</i> (2)		1k min	3					90
		<i>2N6056</i> (2)		750/18k	4	1.5 typ	1.5 typ	4	4(1)	100

(1)|h<sub>FE</sub>| @ 1 MHz

(2)Darlington

(8)When 2 voltages are given, the format is V<sub>CEO(sus)</sub>/V<sub>CES</sub>.

(12)Case 369 may be ordered by adding -1 suffix to part number.

(13)Case 369A may be ordered as tape and reel by adding a "T4" suffix; 2500 units/reel.

Devices listed in bold, italic are Motorola preferred devices.

Table 8. Metal TO–204AA (Formerly TO–3), TO–204AE (continued)

I <sub>C</sub> Cont Amps Max	V <sub>CEO(sus)</sub> Volts Min <sup>(8)</sup>	Device Type		h <sub>FE</sub> Min/Max	@ I <sub>C</sub> Amp	Resistive Switching			f <sub>T</sub> MHz Min	P <sub>D</sub> (Case) Watts @ 25°C
		NPN	PNP			t <sub>s</sub> μs Max	t <sub>f</sub> μs Max	@ I <sub>C</sub> Amp		
10	60	2N3715	2N3791	30 min	3	0.3 typ	0.4 typ	5	4	150
		MJ3000 <sup>(2)</sup>	MJ2500 <sup>(2)</sup>	1k min	5					150
	80	2N3716	2N3792	30 min	3	0.3 typ	0.4 typ	5	4	150
		2N5878		20/100	4	1	0.8	4	4	150
		MJ3001 <sup>(2)</sup>	<b>MJ2501<sup>(2)</sup></b>	1k min	5					150
	140	2N3442		20/70	4					117
	250	<b>MJ15011</b>	<b>MJ15012</b>	20/100	2					200
	325	<b>MJ413</b>		20/80	0.5				2.5	125
		MJ423		30/90	1				2.5	125
	400	<b>BU323A<sup>(2)</sup></b>		150 min	6	7.5 typ	5.2 typ	6		175
<b>MJ10007<sup>(2)</sup></b>			30/300	5	1.5	0.5	5	10 <sup>(1)</sup>	150	
<b>MJ10012<sup>(2)</sup></b>			100/2k	6	15	15	6		175	
12	60	2N6057 <sup>(2)</sup>	2N6050 <sup>(2)</sup>	750/18k	6	1.6 typ	1.5 typ	6	4 <sup>(1)</sup>	150
	80	2N6058 <sup>(2)</sup>	2N6051 <sup>(2)</sup>	750/18k	6	1.6 typ	1.5 typ	6	4 <sup>(1)</sup>	150
	100	<b>2N6059<sup>(2)</sup></b>	<b>2N6052<sup>(2)</sup></b>	750/18k	6	1.6 typ	1.5 typ	6	4 <sup>(1)</sup>	150
15	60	<b>2N3055</b>	<b>MJ2955</b>	20/70	4	0.7 typ	0.3 typ	4	2.5	115
		<b>2N3055A</b>	<b>MJ2955A</b>	20/70	4				0.8	115
		2N6576 <sup>(2)</sup>		2k/20k	4	2	7	10	10–200 <sup>(1)</sup>	120
		2N5881	2N5879	20/100	6	1	0.8	6	4	160
	80	<b>2N5882</b>	<b>2N5880</b>	20/100	6	1	0.8	6	4	160
	90	2N6577 <sup>(2)</sup>		2k/20k	4	2	7	10	10–200 <sup>(1)</sup>	120
	120	<b>MJ15015</b>	<b>MJ15016</b>	20/70	4	0.7 typ	0.3 typ	4	1	180
		<b>2N6578<sup>(2)</sup></b>		2k/20k	4	2	7	10	10–200 <sup>(1)</sup>	120
	140	MJ15001	MJ15002	25/150	4				2	200
	150	MJ11018 <sup>(2)</sup>	MJ11017 <sup>(2)</sup>	100 min	15				3 <sup>(1)</sup>	175
	200	MJ11020 <sup>(2)</sup>		100 min	15				3 <sup>(1)</sup>	175
		<b>MJ3281A</b>	<b>MJ1302A</b>	60/175	0.1				30 typ	250
	250	<b>MJ11022<sup>(2)</sup></b>	MJ11019 <sup>(2)</sup>	100 min	15				3 <sup>(1)</sup>	175
			<b>MJ11021<sup>(2)</sup></b>	6/30	10	4	0.7	10	6 to 24	175
	400/850	<b>BUX48</b>		8 min	10	2	0.4	10		175
		2N6547		6/30	10	4	0.7	10	6 to 24	175
	400/650	<b>MJ16110</b>		6/20	15	0.8 typ	0.1 typ	10		175
450/1000	<b>BUX48A</b>		8 min	8	2	0.4	10		175	

(1)|h<sub>FE</sub>| @ 1 MHz

(2)Darlington

(8)When 2 voltages are given, the format is V<sub>CEO(sus)</sub>/V<sub>CES</sub>.

Devices listed in bold, italic are Motorola preferred devices.

Table 8. Metal TO–204AA (Formerly TO–3), TO–204AE (continued)

I <sub>C</sub> Cont Amps Max	V <sub>CEO(sus)</sub> Volts Min <sup>(8)</sup>	Device Type		h <sub>FE</sub> Min/Max	@ I <sub>C</sub> Amp	Resistive Switching			f <sub>T</sub> MHz Min	P <sub>D</sub> (Case) Watts @ 25°C
		NPN	PNP			t <sub>s</sub> μs Max	t <sub>f</sub> μs Max	@ I <sub>C</sub> Amp		
15	450/850	MJ16010		5 min	15	1.2 typ	0.2 typ	10		175
		<b>MJ16012</b>		7 min	15	0.9 typ	0.15 typ	10		175
16	140	<b>2N3773</b>	2N6609	15/60	8	1.1 typ	1.5 typ	8	4	150
		2N5631	2N6031	15/60	8	1.2 typ	1.2 typ	8	1	200
	200	MJ15022	MJ15023	15/60	8				5	250
	250	<b>MJ15024</b>	<b>MJ15025</b>	15/60	8				5	250
		<b>MJ21194</b>	<b>MJ21193</b>	25/75	8				4	250
	20	60	<b>2N3772</b>		15/60	10				2
2N6282 <sup>(2)</sup>			2N6285 <sup>(2)</sup>	750/18k	10	2.5 typ	2.5 typ	10	4 <sup>(1)</sup>	160
75		2N5039		20/100	10	1.5	0.5	10	60	140
80		<b>2N6283</b> <sup>(2)</sup>	2N6286 <sup>(2)</sup>	750/18k	10	2.5 typ	2.5 typ	10	4 <sup>(1)</sup>	160
90		2N5038		20/100	12	1.5	0.5	12	60	140
100		<b>2N6284</b> <sup>(2)</sup>	<b>2N6287</b> <sup>(2)</sup>	750/18k	10	2.5 typ	2.5 typ	10	4 <sup>(1)</sup>	160
140		<b>MJ15003</b>	<b>MJ15004</b>	25/150	5				2	250
200		<b>BUV11</b>		10 min	12	1.8	0.4	12	8	150
350		<b>MJ10000</b> <sup>(2)</sup>		40/400	10	3	1.8	10	10 <sup>(1)</sup>	175
400		<b>MJ10005</b> <sup>(2)</sup>		40/400	10	1.5	0.5	10	10 <sup>(1)</sup>	175
		<b>MJ13333</b>		10/60	5	4	0.7	10		175
500		<b>MJ10009</b> <sup>(2)</sup>		30/300	10	2	0.6	10	8 <sup>(1)</sup>	175
25		60	2N5885	2N5883	20/100	10	1	0.8	10	4
	80	<b>2N5886</b>	<b>2N5884</b>	20/100	10	1	0.8	10	4	200
			2N6436	30/120	10	1	0.25	10	40	200
	100	2N6338	2N6437	30/120	10	1	0.25	10	40	200
	120	2N6339	<b>2N6438</b>	30/120	10	1	0.25	10	40	200
	140	2N6340		30/120	10	1	0.25	10	40	200
150	<b>2N6341</b>		30/120	10	1	0.25	10	40	200	
30	40	<b>2N3771</b>		15/60	15				2	150
		2N5301	2N4398	15/60	15	2	1	10	2	200
	60	2N5302	2N4399	15/60	15	2	1	10	2	200
		MJ11012 <sup>(2)</sup>	MJ11011 <sup>(2)</sup>	1k min	20				4 <sup>(1)</sup>	200
	90	<b>MJ11014</b> <sup>(2)</sup>	<b>MJ11013</b> <sup>(2)</sup>	1k min	20				4 <sup>(1)</sup>	200
	100	2N6328		6/30	30				3	200
		<b>MJ802</b>	<b>MJ4502</b>	25/100	7.5				2	200
	120	<b>MJ11016</b> <sup>(2)</sup>	<b>MJ11015</b> <sup>(2)</sup>	1k min	20				4 <sup>(1)</sup>	200

(1) |h<sub>FE</sub>| @ 1 MHz

(2) Darlington

(8) When 2 voltages are given, the format is V<sub>CEO(sus)</sub>/V<sub>CES</sub>.

Devices listed in bold, italic are Motorola preferred devices.

**Table 8. Metal TO–204AA (Formerly TO–3), TO–204AE (continued)**

I <sub>C</sub> Cont Amps Max	V <sub>CEO(sus)</sub> Volts Min <sup>(8)</sup>	Device Type		h <sub>FE</sub> Min/Max	@ I <sub>C</sub> Amp	Resistive Switching			f <sub>T</sub> MHz Min	P <sub>D</sub> (Case) Watts @ 25°C
		NPN	PNP			t <sub>s</sub> μs Max	t <sub>f</sub> μs Max	@ I <sub>C</sub> Amp		
30	325	<b>BUV23</b>		8 min	16	1.8	0.4	16	8	250
	400/1000	<b>BUS98</b>		8 min	20	2.3	0.4	20		250
		<b>BUX98</b>		8 min	20	3	0.8	20		250
	450/850	MJ16020 <sup>(16)</sup>		5 min	30	1.8	0.2	20		250
		<b>MJ16022</b> <sup>(16)</sup>		7 min	30	1.5	0.15	20		250
	450/1000	<b>BUS98A</b>		8 min	16	2.3	0.4	16		250
		<b>BUX98A</b>		8 min	16	3	0.8	16		250
40	200	BUV21 <sup>(16)</sup>		10 min	25	1.8	0.4	25	8	150
	250	<b>BUV22</b> <sup>(16)</sup>		10 min	20	1.1	0.35	20	8	250
	350	MJ10022 <sup>(2)</sup> <sup>(16)</sup>		50/600	10	2.5	0.9	20		250
	400	<b>MJ10023</b> <sup>(2)</sup> <sup>(16)</sup>		50/600	10	2.5	0.9	20		250
50	60	2N5685 <sup>(16)</sup>		15/60	25	0.5 typ	0.3 typ	25	2	300
	80	<b>2N5686</b> <sup>(16)</sup>	<b>2N5684</b> <sup>(16)</sup>	15/60	25	0.5 typ	0.3 typ	25	2	300
	90	<b>MJ11030</b> <sup>(2)</sup> <sup>(16)</sup>	<b>MJ11031</b> <sup>(2)</sup> <sup>(16)</sup>	400 min	50					300
	100	2N6274 <sup>(16)</sup>		30/120	20	0.8	0.25	20	30	250
	120	2N6275 <sup>(16)</sup>	<b>2N6379</b> <sup>(16)</sup>	30/120	20	0.8	0.25	20	30	250
		<b>MJ11032</b> <sup>(2)</sup> <sup>(16)</sup>	<b>MJ11033</b> <sup>(2)</sup> <sup>(16)</sup>	400 min	50					300
	125	<b>BUV20</b> <sup>(16)</sup>		10 min	50	1.2	0.25	50	8	250
		<b>BUV60</b> <sup>(16)</sup>		10 min	80	1.1	0.25	80		250
	150	<b>2N6277</b> <sup>(16)</sup>		30/120	20	0.8	0.25	20	30	250
	400	<b>MJ10015</b> <sup>(2)</sup> <sup>(16)</sup>		10 min	40	2.5	1	20		250
	500	<b>BUT34</b> <sup>(2)</sup> <sup>(16)</sup>		15 min	32	3	1.5	32		250
<b>MJ10016</b> <sup>(2)</sup> <sup>(16)</sup>			10 min	40	2.5	1	20		250	
56	400	<b>BUT33</b> <sup>(2)</sup> <sup>(16)</sup>		20 min	36	3.3	1.6	36		250
60	60		MJ14001 <sup>(16)</sup>	15/100	50					300
	80	<b>MJ14002</b> <sup>(16)</sup>	<b>MJ14003</b> <sup>(16)</sup>	15/100	50					300
	200	MJ10020 <sup>(2)</sup> <sup>(16)</sup>		75 min	15	3.5	0.5	30		250
	250	<b>MJ10021</b> <sup>(2)</sup> <sup>(16)</sup>		75 min	15	3.5	0.5	30		250
70	125	<b>BUS50</b> <sup>(16)</sup>		15 min	50	1.5	0.3	70		350
80	100	<b>BUV18A</b> <sup>(16)</sup>		10 min	80	1.1	0.25	80		250

(1) |h<sub>FE</sub>| @ 1 MHz

(2) Darlington

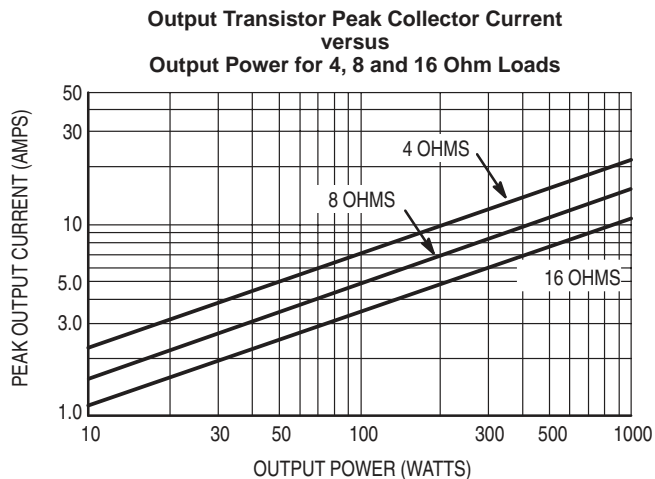
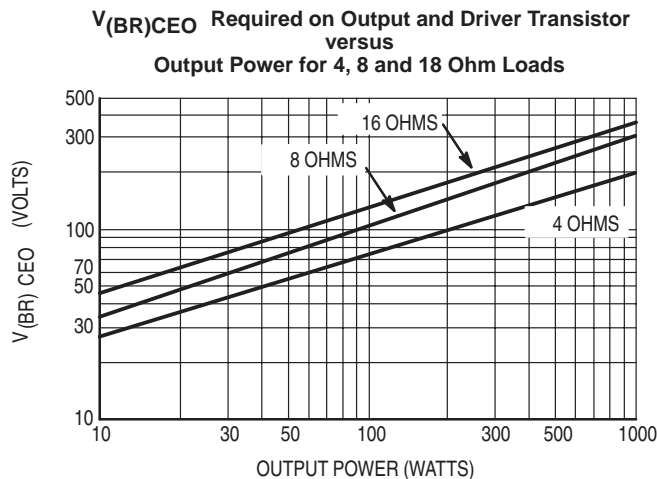
(8) When 2 voltages are given, the format is V<sub>CEO(sus)</sub>/V<sub>CES</sub>.

(16) Case 197A–03 (TO–204AE)

Devices listed in bold, italic are Motorola preferred devices.

# Audio

## GENERAL DESIGN CURVES FOR POWER AUDIO OUTPUT STAGES



Another important parameter that must be considered before selecting the output transistors is the safe-operating area these devices must withstand. For a complete discussion see Application Note AN485.

**Table 9. Recommended Power Transistors for Audio/Servo Loads**

RMS Power Output	NPN	PNP	Case	$P_D$ Watts @ 25°C	$V_{CEO}$	$h_{FE}$ @ Min/Max	$I_C$ Amps	$f_T$ MHz Typ	ISB Volts/Amps
To 25W	MJE15030	MJE15031	TO-220	50	150	20 min	4	30	14/3.6
	MJE15032	MJE15033	TO-220	50	250	50 min	1	40	50/1
25 to 50W	2N3055A	MJ2955A	TO-204	120	120	20/70	4	3	60/2
	MJ15001	MJ15002	TO-204	200	140	25/150	4	3	40/5
50 to 100W	MJ15015	MJ15016	TO-204	180	120	20/70	4	3	60/3
	MJ15003	MJ15004	TO-204	250	140	25/150	5	3	100/1
	MJ15020	MJ15021	TO-204	150	250	30 min	1	20	50/3
Over 100W	MJ15024	MJ15025	TO-204	250	250	15/60	8	8	80/2.2
	MJ3281A	MJ1302A	TO-204	250	200	60/175	7	30	50/4
	MJL3281A	MJL1302A	340G-01	150	200	60/175	7	30	40/4
	MJ21194	MJ21193	TO-204	250	250	25/75	8	7	100/2
	MJL21194	MJL21193	340G-01	200	200	25/75	8	7	100/2

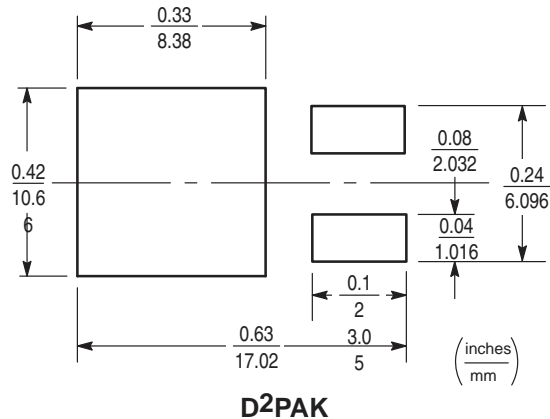
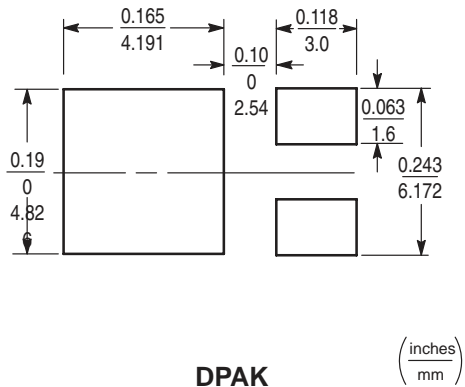
The Power Transistors shown are provided for reference only and show device capability. The final choice of the Power Transistors used is left to the circuit designer and depends upon the particular safe-operating area required and the mounting and heat sinking configuration used.

# INFORMATION FOR USING SURFACE MOUNT PACKAGES

## RECOMMENDED FOOTPRINTS FOR SURFACE MOUNTED APPLICATIONS

Surface mount board layout is a critical portion of the total design. The footprint for the semiconductor packages must be the correct size to ensure proper solder connection interface between the board and the package. With the correct

pad geometry, the packages will self align when subjected to a solder reflow process.



## POWER DISSIPATION FOR A SURFACE MOUNT DEVICE

The values for the equation are found in the maximum ratings table on the data sheet. Substituting these values into the equation for an ambient temperature  $T_A$  of  $25^\circ\text{C}$ , one can calculate the power dissipation of the device. For example, for a D2PAK,  $P_D$  is calculated as follows.

$$P_D = \frac{150^\circ\text{C} - 25^\circ\text{C}}{50^\circ\text{C/W}} = 2.5 \text{ watts}$$

The  $50^\circ\text{C/W}$  for the D2PAK package assumes the use of the recommended footprint on a glass epoxy printed circuit board to achieve a power dissipation of 2.5 watts. There are other alternatives to achieving higher power dissipation from the surface mount packages. One is to increase the area of the drain/collector pad. By increasing the area of the drain/collector pad, the power dissipation can be increased.

Although the power dissipation can almost be doubled with this method, area is taken up on the printed circuit board which can defeat the purpose of using surface mount technology. For example, a graph of  $R_{\theta JA}$  versus drain pad area is shown in Figures 1 and 2.

Another alternative would be to use a ceramic substrate or an aluminum core board such as Thermal Clad™. Using a board material such as Thermal Clad, an aluminum core board, the power dissipation can be doubled using the same footprint.

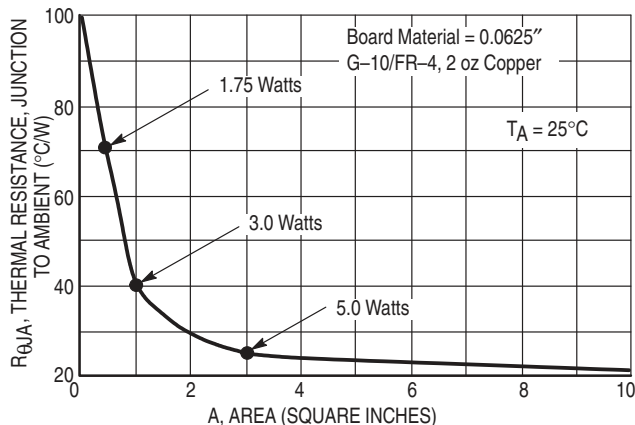


Figure 1. Thermal Resistance versus Drain Pad Area for the DPAK Package (Typical)

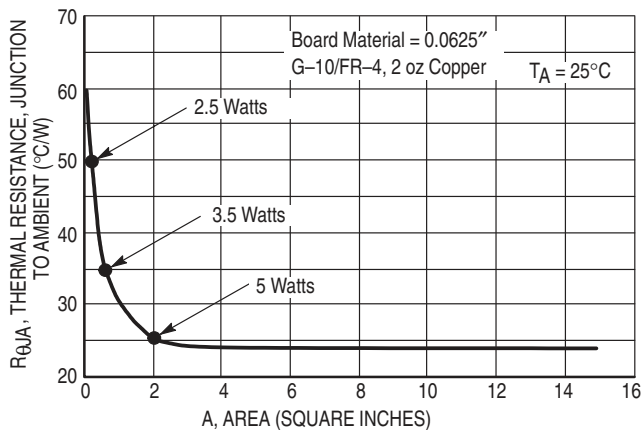
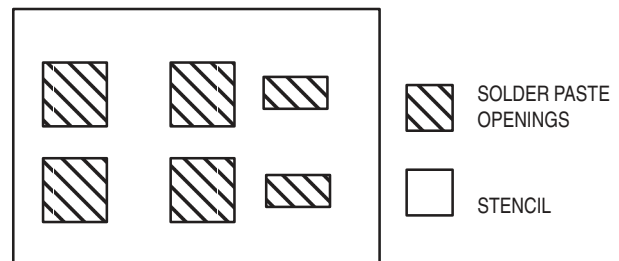


Figure 2. Thermal Resistance versus Drain Pad Area for the D2PAK Package (Typical)

Prior to placing surface mount components onto a printed circuit board, solder paste must be applied to the pads. Solder stencils are used to screen the optimum amount. These stencils are typically 0.008 inches thick and may be made of brass or stainless steel. This is not the case with the DPAK and D<sup>2</sup>PAK packages. If a 1:1 opening is used to screen solder onto the drain pad, misalignment and/or “tombstoning” may occur due to an excess of solder. For these two packages, the opening in the stencil for the paste should be approximately 50% of the tab area. The opening for the leads is still a 1:1 registration. Figure 3 shows a typical stencil for the DPAK and D<sup>2</sup>PAK packages. The pattern of the opening in the stencil for the drain pad is not critical as long as it allows approximately 50% of the pad to be covered with paste.



**Figure 3. Typical Stencil for DPAK and D<sup>2</sup>PAK Packages**

### SOLDERING PRECAUTIONS

The melting temperature of solder is higher than the rated temperature of the device. When the entire device is heated to a high temperature, failure to complete soldering within a short time could result in device failure. Therefore, the following items should always be observed in order to minimize the thermal stress to which the devices are subjected.

- Always preheat the device.
  - The delta temperature between the preheat and soldering should be 100°C or less.\*
  - When preheating and soldering, the temperature of the leads and the case must not exceed the maximum temperature ratings as shown on the data sheet. When using infrared heating with the reflow soldering method, the difference should be a maximum of 10°C.
  - The soldering temperature and time should not exceed 260°C for more than 10 seconds.
  - When shifting from preheating to soldering, the maximum temperature gradient shall be 5°C or less.
- After soldering has been completed, the device should be allowed to cool naturally for at least three minutes. Gradual cooling should be used since the use of forced cooling will increase the temperature gradient and will result in latent failure due to mechanical stress.
  - Mechanical stress or shock should not be applied during cooling.

\* Soldering a device without preheating can cause excessive thermal shock and stress which can result in damage to the device.

\* Due to shadowing and the inability to set the wave height to incorporate other surface mount components, the D<sup>2</sup>PAK is not recommended for wave soldering.



## TYPICAL SOLDER HEATING PROFILE

For any given circuit board, there will be a group of control settings that will give the desired heat pattern. The operator must set temperatures for several heating zones and a figure for belt speed. Taken together, these control settings make up a heating "profile" for that particular circuit board. On machines controlled by a computer, the computer remembers these profiles from one operating session to the next. Figure 5 shows a typical heating profile for use when soldering a surface mount device to a printed circuit board. This profile will vary among soldering systems, but it is a good starting point. Factors that can affect the profile include the type of soldering system in use, density and types of components on the board, type of solder used, and the type of board or substrate material being used. This profile shows temperature versus time. The line on the graph shows the

actual temperature that might be experienced on the surface of a test board at or near a central solder joint. The two profiles are based on a high density and a low density board. The Vitronics SMD310 convection/infrared reflow soldering system was used to generate this profile. The type of solder used was 62/36/2 Tin Lead Silver with a melting point between 177–189°C. When this type of furnace is used for solder reflow work, the circuit boards and solder joints tend to heat first. The components on the board are then heated by conduction. The circuit board, because it has a large surface area, absorbs the thermal energy more efficiently, then distributes this energy to the components. Because of this effect, the main body of a component may be up to 30 degrees cooler than the adjacent solder joints.

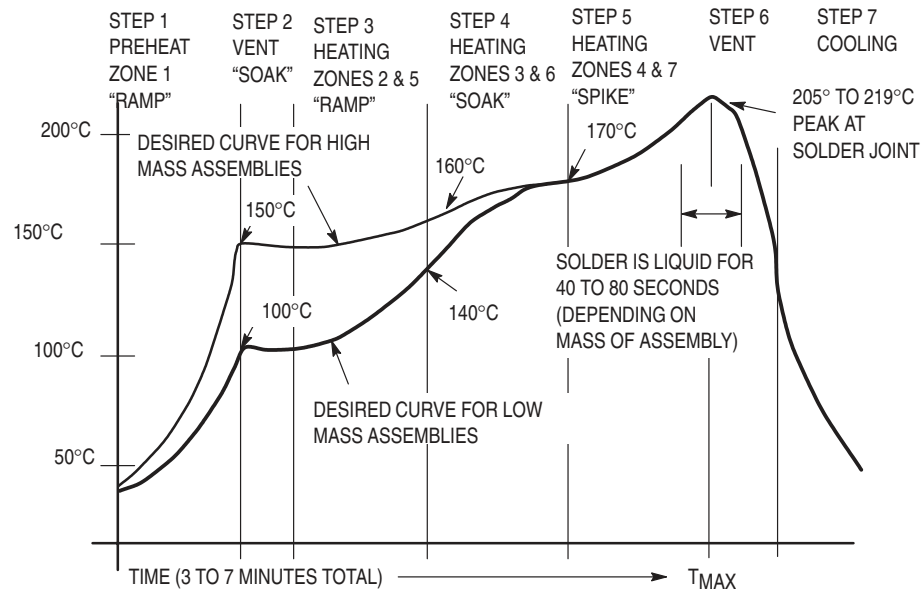


Figure 4. Typical Solder Heating Profile

# Mounting Hardware and Techniques

There are many methods available and options possible for installing power semiconductors. A complete discussion of mounting is contained in Motorola Application Note AN1040, "Mounting Considerations for Power Semiconductors," reprinted in Section 6 of this data book. Various suppliers of mounting hardware, listed below, may be contacted for their catalogs which contain considerable technical information.

## Sources for Mounting Hardware

Manufacturer	Joint Compound	Adhesives	Insulators						Heatsinks	Clips	
			BeO	AlO <sub>2</sub>	Anodize	Mica	Plastic Film	Silicone Rubber			
Aavid Eng.	—	—	—	—	—	—	—	X	X	X	X
AHAM-TOR	—	—	—	—	—	—	—	—	—	X	—
Asheville-Schoonmaker	—	—	—	—	—	—	X	—	—	—	—
Astroynamics	X	—	—	—	—	—	—	—	—	X	—
Delbert Blinn	—	—	X	—	X	X	X	X	X	X	—
IERC	X	—	—	—	—	—	—	—	—	X	—
Staver	—	—	—	—	—	—	—	—	—	X	—
Thermalloy	X	X	X	X	X	X	X	X	X	X	X
Tran-tec	X	—	X	X	X	X	X	—	X	X	—
Wakefield Eng.	X	X	X	—	X	—	—	—	X	X	X

Other sources for silicone rubber pads: Chomerics, Berquist

### Suppliers Addresses

Aavid Engineering, Inc., P.O. Box 400, Laconia, New Hampshire 03247 (603) 528-1478

AHAM-TOR Heatsinks, 27901 Front Street, Rancho, California 92390 (714) 676-4151

Asheville-Schoonmaker, 900 Jefferson Ave., Newport News, VA 23607 (804) 244-7311

Astro Dynamics, Inc., 2 Gill St., Woburn, Massachusetts 01801 (617) 935-4944

Berquist, 5300 Edina Industrial Blvd., Minneapolis, Minnesota 55435 (612) 835-2322

Chomerics, Inc., 16 Flagstone Drive, Hudson, New Hampshire 03051 1-800-633-8800

Delbert Blinn Company, P.O. Box 2007, Pomona, California 91769 (714) 623-1257

International Electronic Research Corporation, 135 West Magnolia Boulevard, Burbank, California 91502 (213) 849-2481

The Staver Company, Inc., 41-51 Saxon Avenue, Bay Shore, Long Island, New York 11706 (516) 666-8000

Thermalloy, Inc., P.O. Box 34829, 2021 West Valley View Lane, Dallas, Texas 75234 (214) 243-4321

Tran-tec Corporation, P.O. Box 1044, Columbus, Nebraska 68601 (402) 564-2748

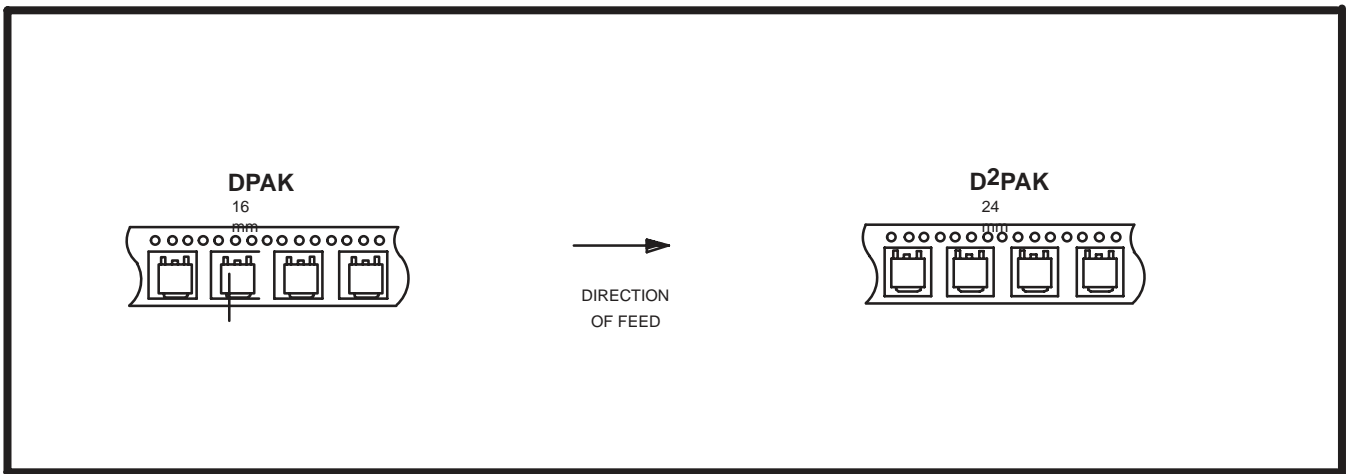
Wakefield Engineering, Inc., Wakefield, Massachusetts 01880 (617) 245-5900

# Tape and Reel Specifications and Packaging Specifications

Embossed Tape and Reel is used to facilitate automatic pick and place equipment feed requirements. The tape is used as the shipping container for various products and requires a minimum of handling. The antistatic/conductive tape provides a secure cavity for the product when sealed with the “peel-back” cover tape.

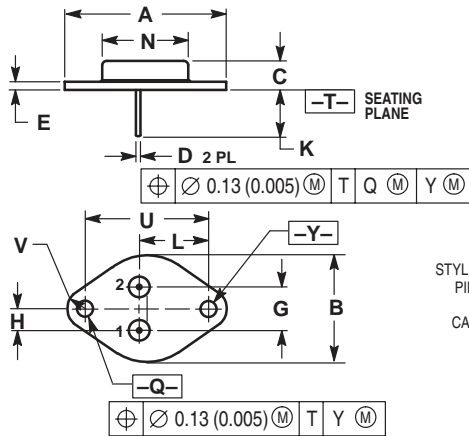
- Two Reel Sizes Available (7” and 13”)
- Used for Automatic Pick and Place Feed Systems
- Minimizes Product Handling
- EIA 481, -1, -2
- DPAK SO-14, in 16 mm Tape
- D<sup>2</sup>PAK in 24 mm Tape

Use the standard device title and add the required suffix as listed in the option table on the following page. Note that the individual reels have a finite number of devices depending on the type of product contained in the tape. Also note the minimum lot size is one full reel for each line item, and orders are required to be in increments of the single reel quantity.



Package	Tape Width (mm)	Reel Size (inch)				
DPAK	16	8.0 ± 0.1 (.315 ± .004)	330	(13)	2,500	T4
D <sup>2</sup> PAK	24	16.0 ± 0.1 (.630 ± .004)	330	(13)	800	T4

# Outline Dimensions

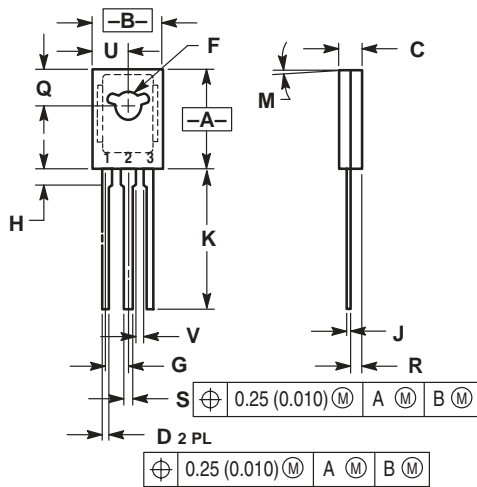


STYLE 1:  
PIN 1: BASE  
2: EMITTER  
CASE: COLLECTOR

- NOTES:  
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.  
2. CONTROLLING DIMENSION: INCH.  
3. ALL RULES AND NOTES ASSOCIATED WITH REFERENCED TO-204AA OUTLINE SHALL APPLY.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	1.550 REF	—	39.37 REF	—
B	—	1.050	—	26.67
C	0.250	0.335	6.35	8.51
D	0.038	0.043	0.97	1.09
E	0.055	0.070	1.40	1.77
G	0.430 BSC	—	10.92 BSC	—
H	0.215 BSC	—	5.46 BSC	—
K	0.440	0.480	11.18	12.19
L	0.665 BSC	—	16.89 BSC	—
N	—	0.830	—	21.08
Q	0.151	0.165	3.84	4.19
U	1.187 BSC	—	30.15 BSC	—
V	0.131	0.188	3.33	4.77

**CASE 1-07  
(TO-204AA)**

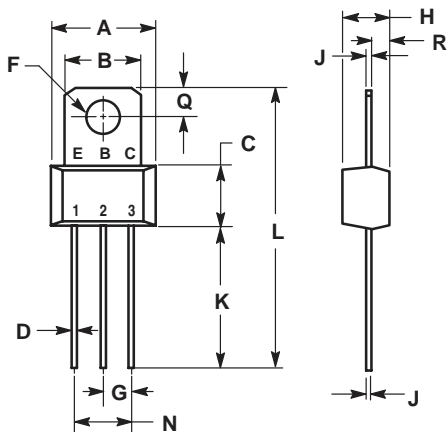


STYLE 1:  
PIN 1: EMITTER  
2: COLLECTOR  
3: BASE

- NOTES:  
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.  
2. CONTROLLING DIMENSION: INCH.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.425	0.435	10.80	11.04
B	0.295	0.305	7.50	7.74
C	0.095	0.105	2.42	2.66
D	0.020	0.026	0.51	0.66
F	0.115	0.130	2.93	3.30
G	0.094 BSC	—	2.39 BSC	—
H	0.050	0.095	1.27	2.41
J	0.015	0.025	0.39	0.63
K	0.575	0.655	14.61	16.63
M	5° TYP	—	5° TYP	—
Q	0.148	0.158	3.76	4.01
R	0.045	0.055	1.15	1.39
S	0.025	0.035	0.64	0.88
U	0.145	0.155	3.69	3.93
V	0.040	—	1.02	—

**CASE 77-08  
(TO-225AA)**



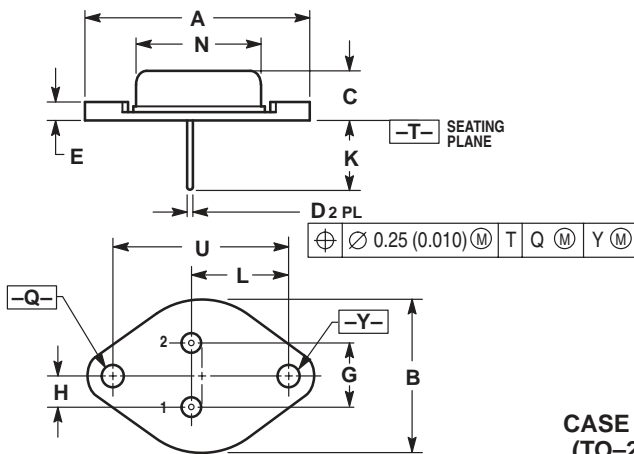
STYLE 1:  
PIN 1: EMITTER  
2: BASE  
3: COLLECTOR  
(COLLECTOR CONNECTED TO TAB)

- NOTES:  
1. LEADS WITHIN 0.15 (0.006) TOTAL OF TRUE POSITION AT CASE, AT MAXIMUM MATERIAL CONDITION.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	9.14	9.53	0.360	0.375
B	6.60	7.24	0.260	0.285
C	5.41	5.66	0.213	0.223
D	0.38	0.53	0.015	0.021
F	3.18	3.33	0.125	0.131
G	2.54 BSC	—	0.100 BSC	—
H	3.94	4.19	0.155	0.165
J	0.36	0.41	0.014	0.016
K	11.63	12.70	0.458	0.500
L	24.58	25.53	0.968	1.005
N	5.08 BSC	—	0.200 BSC	—
Q	2.39	2.69	0.094	0.106
R	1.14	1.40	0.045	0.055

**CASE 152-02**

# Outline Dimensions (continued)

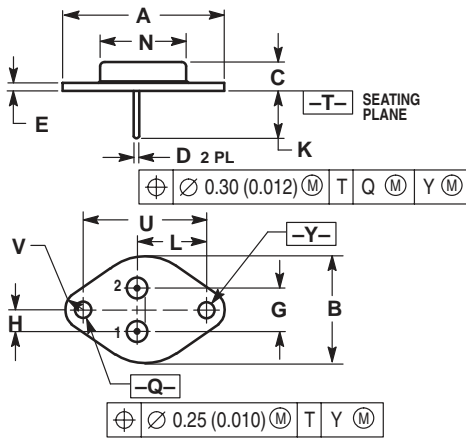


STYLE 1:  
PIN 1: BASE  
2: EMITTER  
CASE: COLLECTOR

**CASE 197-05  
(TO-204AE)**

- NOTES:  
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.  
2. CONTROLLING DIMENSION: INCH.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	1.510	1.550	38.35	39.37
B	0.980	1.050	24.89	26.67
C	0.250	0.335	6.35	8.51
D	0.057	0.063	1.45	1.60
E	0.060	0.135	1.52	3.43
G	0.420	0.440	10.67	11.18
H	0.205	0.225	5.21	5.72
K	0.440	0.480	11.18	12.19
L	0.655	0.675	16.64	17.15
N	0.760	0.830	19.30	21.08
Q	0.151	0.175	3.84	4.19
U	1.177	1.197	29.90	30.40

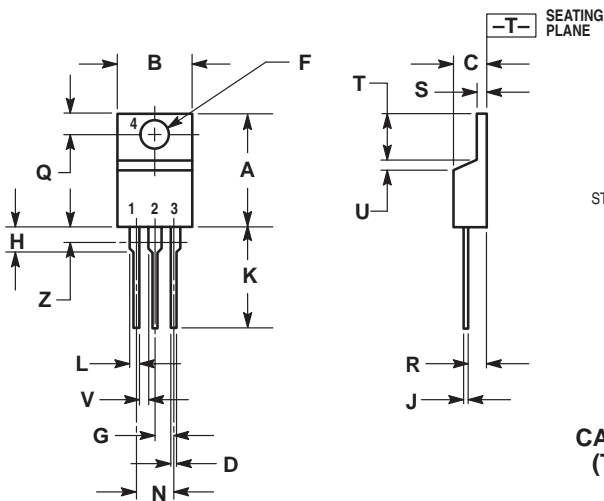


STYLE 1:  
PIN 1: BASE  
2: EMITTER  
CASE: COLLECTOR

**CASE 197A-05  
(TO-204AA)**

- NOTES:  
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.  
2. CONTROLLING DIMENSION: INCH.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	1.530 REF		38.86 REF	
B	0.990	1.050	25.15	26.67
C	0.250	0.335	6.35	8.51
D	0.057	0.063	1.45	1.60
E	0.060	0.070	1.53	1.77
G	0.430 BSC		10.92 BSC	
H	0.215 BSC		5.46 BSC	
K	0.440	0.480	11.18	12.19
L	0.665 BSC		16.89 BSC	
N	0.760	0.830	19.31	21.08
Q	0.151	0.165	3.84	4.19
U	1.187 BSC		30.15 BSC	
V	0.131	0.188	3.33	4.77



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

**CASE 221A-06  
(TO220-AB)**

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

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.570	0.620	14.48	15.75
B	0.380	0.405	9.66	10.28
C	0.160	0.190	4.07	4.82
D	0.025	0.035	0.64	0.88
F	0.142	0.147	3.61	3.73
G	0.095	0.105	2.42	2.66
H	0.110	0.155	2.80	3.93
J	0.018	0.025	0.46	0.64
K	0.500	0.562	12.70	14.27
L	0.045	0.060	1.15	1.52
N	0.190	0.210	4.83	5.33
Q	0.100	0.120	2.54	3.04
R	0.080	0.110	2.04	2.79
S	0.045	0.055	1.15	1.39
T	0.235	0.255	5.97	6.47
U	0.000	0.050	0.00	1.27
V	0.045	—	1.15	—
Z	—	0.080	—	2.04

# Outline Dimensions (continued)

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

SEATING PLANE  
-T-  
-Y-

⊕ 0.25 (0.010) M B M Y

**CASE 221D-02  
(TO-220)**

NOTES:  
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.  
2. CONTROLLING DIMENSION: INCH.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.621	0.629	15.78	15.97
B	0.394	0.402	10.01	10.21
C	0.181	0.189	4.60	4.80
D	0.026	0.034	0.67	0.86
F	0.121	0.129	3.08	3.27
G	0.100 BSC		2.54 BSC	
H	0.123	0.129	3.13	3.27
J	0.018	0.025	0.46	0.64
K	0.500	0.562	12.70	14.27
L	0.045	0.060	1.14	1.52
N	0.200 BSC		5.08 BSC	
Q	0.126	0.134	3.21	3.40
R	0.107	0.111	2.72	2.81
S	0.096	0.104	2.44	2.64
U	0.259	0.267	6.58	6.78

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

-Q-

**CASE 340D-01  
(TO-218)**

NOTES:  
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.  
2. CONTROLLING DIMENSION: MILLIMETER.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	19.00	19.60	0.749	0.771
B	14.00	14.50	0.551	0.570
C	4.20	4.70	0.165	0.185
D	1.00	1.30	0.040	0.051
E	1.45	1.65	0.058	0.064
G	5.21	5.72	0.206	0.225
H	2.60	3.00	0.103	0.118
J	0.40	0.60	0.016	0.023
K	28.50	32.00	1.123	1.259
L	14.70	15.30	0.579	0.602
Q	4.00	4.25	0.158	0.167
S	17.50	18.10	0.689	0.712
U	3.40	3.80	0.134	0.149
V	1.50	2.00	0.060	0.078

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

-Q-  
-B-  
-T-

⊕ 0.25 (0.010) M T B M

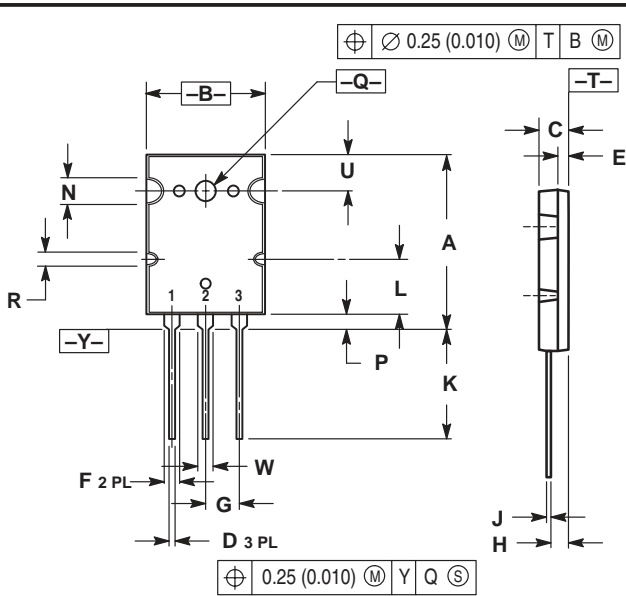
⊕ 0.25 (0.010) M Y Q S

**CASE 340F-03  
(TO-247AE)**

NOTES:  
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.  
2. CONTROLLING DIMENSION: MILLIMETER.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	20.40	20.90	0.803	0.823
B	15.44	15.95	0.608	0.628
C	4.70	5.21	0.185	0.205
D	1.09	1.30	0.043	0.051
E	1.50	1.63	0.059	0.064
F	1.80	2.18	0.071	0.086
G	5.45 BSC		0.215 BSC	
H	2.56	2.87	0.101	0.113
J	0.48	0.68	0.019	0.027
K	15.57	16.08	0.613	0.633
L	7.26	7.50	0.286	0.295
P	3.10	3.38	0.122	0.133
Q	3.50	3.70	0.138	0.145
R	3.30	3.80	0.130	0.150
U	5.30 BSC		0.209 BSC	
V	3.05	3.40	0.120	0.134

# Outline Dimensions (continued)

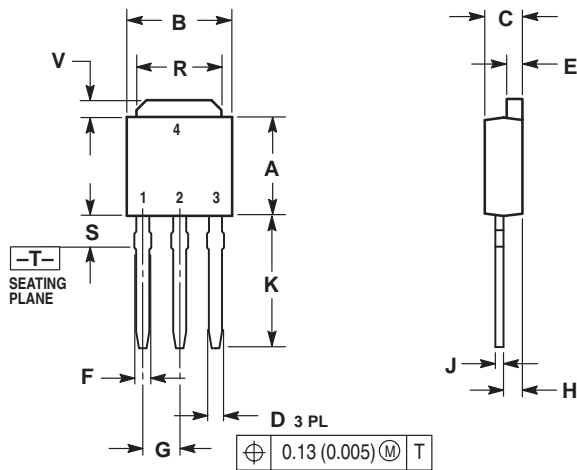


**CASE 340G-02  
(TO-3PBL)**

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

- NOTES:  
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.  
2. CONTROLLING DIMENSION: MILLIMETER.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	2.8	2.9	1.102	1.142
B	19.3	20.3	0.760	0.800
C	4.7	5.3	0.185	0.209
D	0.93	1.48	0.037	0.058
E	1.9	2.1	0.075	0.083
F	2.2	2.4	0.087	0.102
G	5.45 BSC		0.215 BSC	
H	2.6	3.0	0.102	0.118
J	0.43	0.78	0.017	0.031
K	17.6	18.8	0.693	0.740
L	11.0	11.4	0.433	0.449
N	3.95	4.75	0.156	0.187
P	2.2	2.6	0.087	0.102
Q	3.1	3.5	0.122	0.137
R	2.15	2.35	0.085	0.093
U	6.1	6.5	0.240	0.256
W	2.8	3.2	0.110	0.125

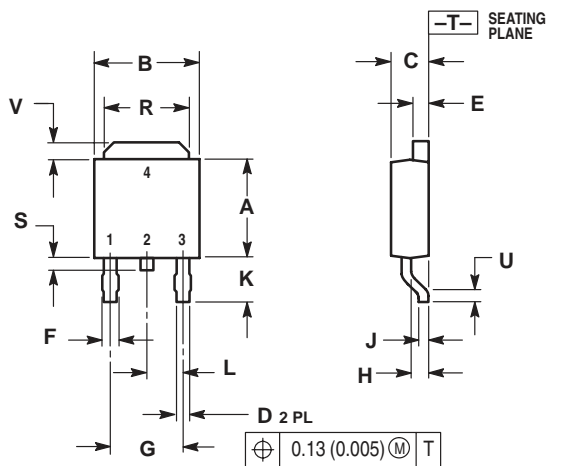


**CASE 369-07**

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.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.235	0.250	5.97	6.35
B	0.250	0.265	6.35	6.73
C	0.086	0.094	2.19	2.38
D	0.027	0.035	0.69	0.88
E	0.033	0.040	0.84	1.01
F	0.037	0.047	0.94	1.19
G	0.090 BSC		2.29 BSC	
H	0.034	0.040	0.87	1.01
J	0.018	0.023	0.46	0.58
K	0.350	0.380	8.89	9.65
R	0.175	0.215	4.45	5.46
S	0.050	0.090	1.27	2.28
V	0.030	0.050	0.77	1.27



**CASE 369A-13**

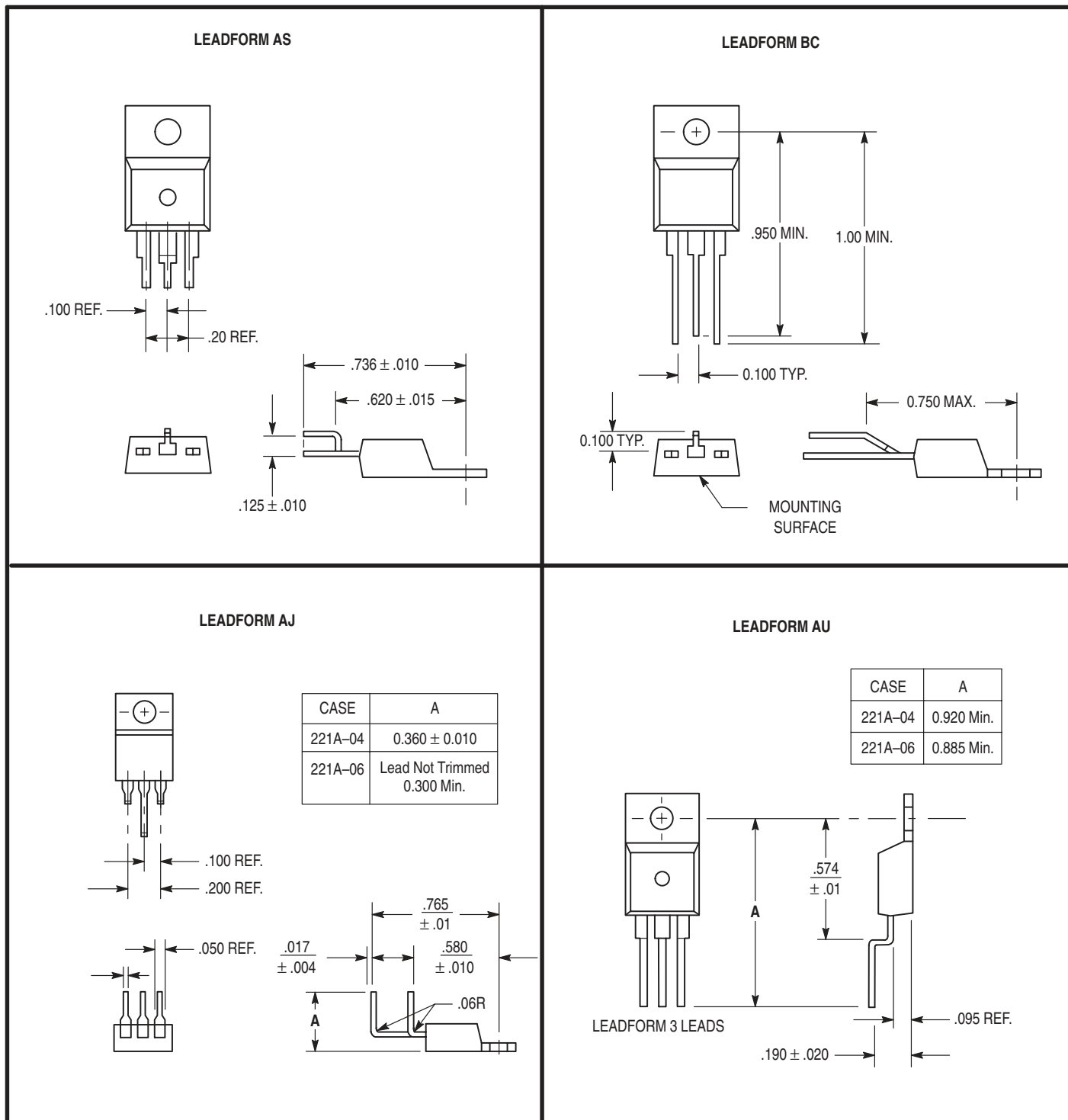
STYLE 1:  
PIN 1. BASE  
2. COLLECTOR  
3. EMITTER  
4. COLLECTOR

- NOTES:  
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.  
2. CONTROLLING DIMENSION: INCH.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.235	0.250	5.97	6.35
B	0.250	0.265	6.35	6.73
C	0.086	0.094	2.19	2.38
D	0.027	0.035	0.69	0.88
E	0.033	0.040	0.84	1.01
F	0.037	0.047	0.94	1.19
G	0.180 BSC		4.58 BSC	
H	0.034	0.040	0.87	1.01
J	0.018	0.023	0.46	0.58
K	0.102	0.114	2.60	2.89
L	0.090 BSC		2.29 BSC	
R	0.175	0.215	4.45	5.46
S	0.020	0.050	0.51	1.27
U	0.020	—	0.51	—
V	0.030	0.050	0.77	1.27
Z	0.138	—	3.51	—

# Leadform Options — TO-220 (Case 221A)

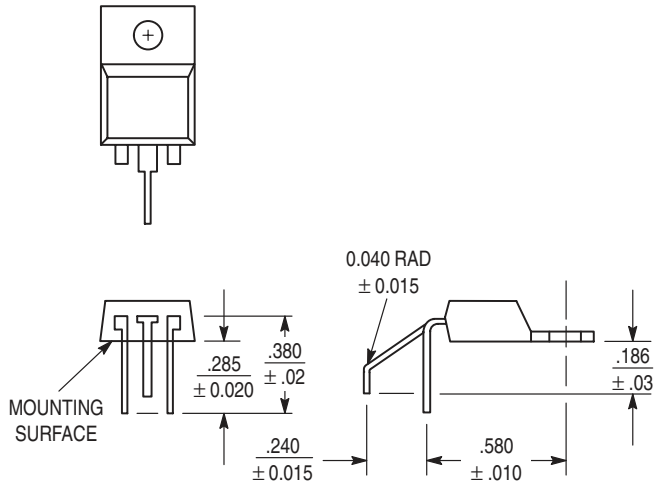
- Leadform options require assignment of a special part number before ordering.
- Contact your local Motorola representative for special part number and pricing.
- 10,000 piece minimum quantity orders are required.
- Leadform orders are non-cancellable after processing.
- Leadforms apply to both Motorola Case 221A-04 and 221A-06 except as noted.



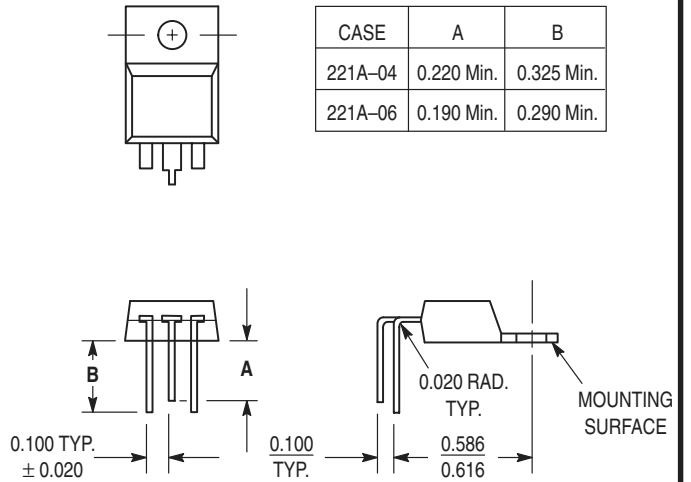


# TO-220 Leadform Options (continued)

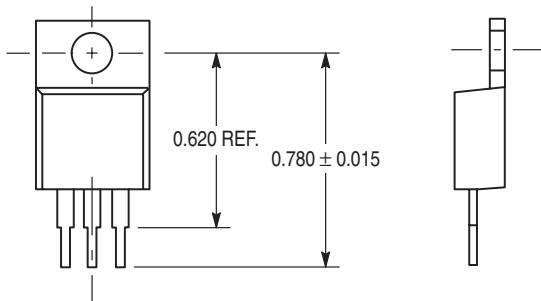
**LEADFORM AN**



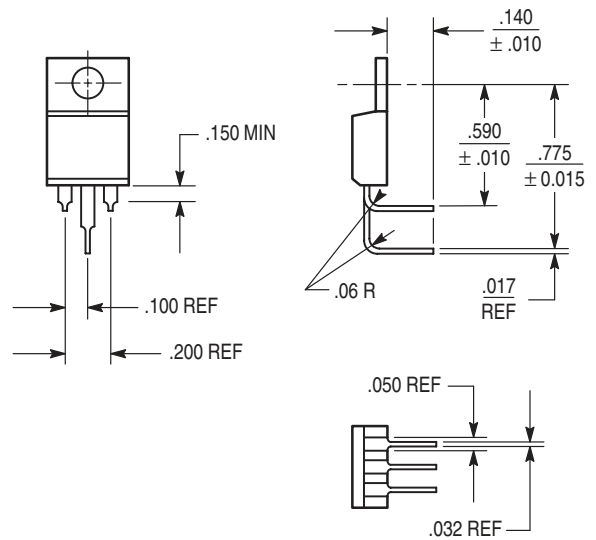
**LEADFORM BA**



**LEADFORM BG**

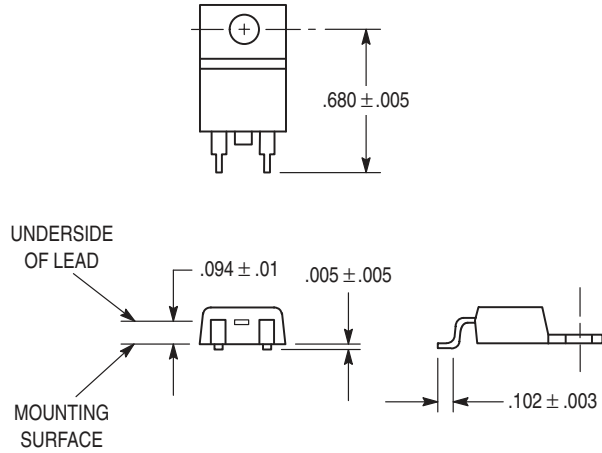


**LEADFORM AK**

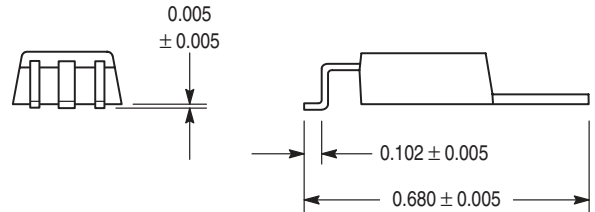


# TO-220 Leadform Options (continued)

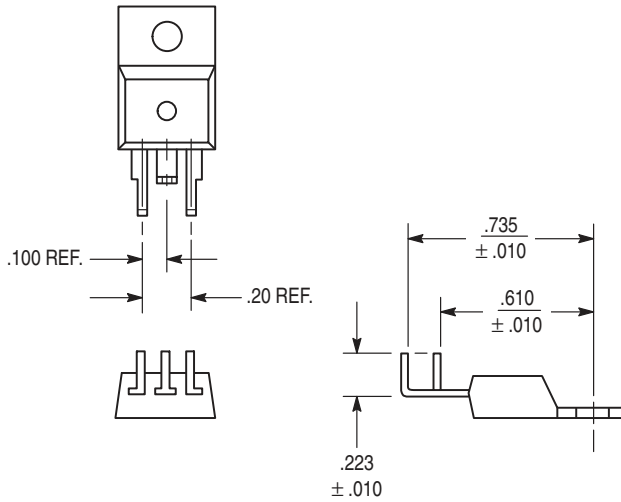
LEADFORM BU



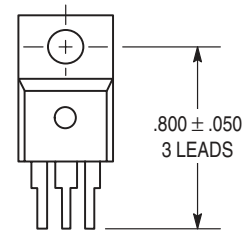
LEADFORM BV



LEADFORM BD

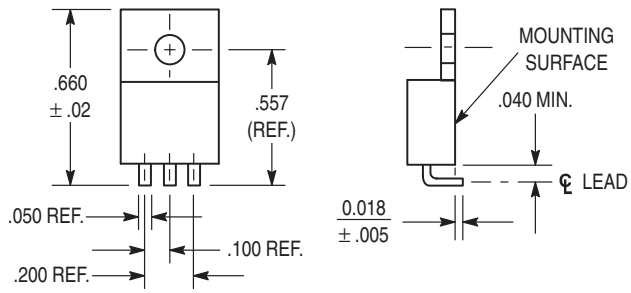


LEADFORM DW

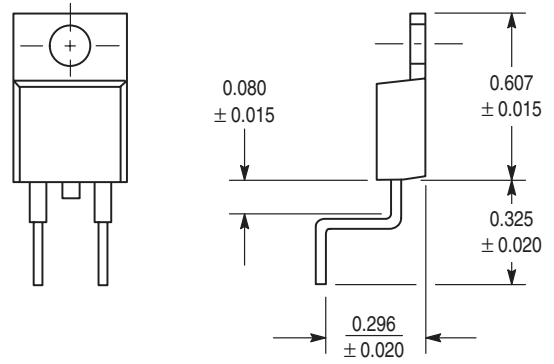


# TO-220 Leadform Options (continued)

LEADFORM AF



LEADFORM BS



# INDEX AND CROSS REFERENCE

The following table represents an index and cross-reference guide for all low-frequency power transistors which are either manufactured directly by Motorola or for which Motorola manufactures a suitable equivalent. Where the Motorola part number differs from the industry part number, the Motorola device is a "form, fit and function" replacement for the industry type number — however, subtle differences in characteristics and/or specifications may exist. Where multiple replacement parts appear for a given industry part number, the page number represents the first replacement device listed.

Industry Part Number	Motorola Nearest Replacement	Motorola Similar Replacement	Page Number	Industry Part Number	Motorola Nearest Replacement	Motorola Similar Replacement	Page Number
40251		2N3055	3-2	2N3055H		2N3055A	3-5
40325		2N3055	3-2	2N3055SD		2N3055A	3-5
40363		2N5878	3-74	2N3055UB		2N3055A	3-5
40369		2N5878	3-74	2N3076		BUV23	3-388
40411		MJ802	3-421	2N3171		2N3792	3-25
40513		MJE3055T	3-628	2N3172		2N3792	3-25
40514		MJE3055T	3-628	2N3173		2N3792	3-25
40542		MJE3055T	3-628	2N3174		MJ15016	3-5
40543		MJE3055T	3-628	2N3183		2N3792	3-25
40613		TIP31B	3-873	2N3184		2N3792	3-25
40618		TIP31B	3-873	2N3185		2N3792	3-25
40621		TIP31B	3-873	2N3186		MJ15016	3-5
40622		TIP31B	3-873	2N3195		2N3792	3-25
40624		TIP41B	3-883	2N3196		2N3792	3-25
40627		TIP41B	3-883	2N3198		MJ15016	3-5
40629		TIP31B	3-873	2N3232		2N5878	3-74
40630		TIP31B	3-873	2N3233		2N5882	3-77
40631		TIP31B	3-873	2N3234		2N3442	3-9
40632		TIP41B	3-883	2N3235		2N3055	3-2
40636		2N5878	3-74	2N3236		2N5882	3-77
40853		2N6547	3-140	2N3237		2N5302	3-54
40854		2N6547	3-140	2N3238		2N5882	3-77
40871		TIP41C	3-883	2N3239		2N5882	3-77
40872		TIP42C	3-883	2N3240		2N5882	3-77
40873		TIP41B	3-883	2N3441	2N3442		3-9
40874		TIP41B	3-883	2N3442	2N3442		3-9
40875		TIP41C	3-883	2N3445		2N3716	3-12
40876		TIP41B	3-883	2N3446		2N3716	3-12
40887		MJE340	3-602	2N3447		2N3716	3-12
41012		2N5038	3-42	2N3448		2N3716	3-12
41013		2N6339	3-117	2N3667		2N5882	3-77
41500		TIP31B	3-873	2N3713		2N5882	3-77
41501		TIP32B	3-873	2N3714	2N3716		3-12
41504		TIP31B	3-873	2N3715	2N3716		3-12
43104		2N5631	3-59	2N3716	2N3716		3-12
1S110A-100		MJ16018	3-520	2N3771	2N3771		3-17
2N1487		2N5878	3-74	2N3772	2N3772		3-17
2N1488		2N5878	3-74	2N3773	2N3773		3-21
2N1489		2N5878	3-74	2N3789	2N3792		3-25
2N1490		2N5878	3-74	2N3790	2N3792		3-25
2N1702		2N5878	3-74	2N3791	2N3792		3-25
2N3021		2N3792	3-25	2N3792	2N3792		3-25
2N3022		2N3792	3-25	2N3863		2N3716	3-12
2N3023		2N3792	3-25	2N3864		2N5882	3-77
2N3024		2N3792	3-25	2N3865		MJ15001	3-497
2N3025		2N3792	3-25	2N3902		BUX48A	3-401
2N3026		2N3792	3-25	2N4002		2N6274	3-108
2N3055	2N3055		3-2	2N4032		2N6274	3-108
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2N4347		2N3055A	3-5
2N4348		2N5631	3-59
2N4398	2N4399		3-29
2N4399	2N4399		3-29
2N4901		MJ15016	3-5
2N4902		MJ15016	3-5
2N4903		MJ15016	3-5
2N4904		MJ15016	3-5
2N4905		MJ15016	3-5
2N4906		MJ15016	3-5
2N4907		2N3792	3-25
2N4908		2N3792	3-25
2N4909		2N3792	3-25
2N4918	2N4918		3-34
2N4919	2N4919		3-34
2N4920	2N4920		3-34
2N4921	2N4921		3-38
2N4922	2N4922		3-38
2N4923	2N4923		3-38
2N5034		2N3055	3-2
2N5035		2N3055	3-2
2N5036		2N3055	3-2
2N5037		2N3055	3-2
2N5038	2N5038		3-42
2N5039	2N5038		3-42
2N5157		BUX48A	3-401
2N5190	2N5191		3-44
2N5191	2N5191		3-44
2N5192	2N5192		3-44
2N5193	2N5194		3-49
2N5194	2N5194		3-49
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2N5241		BUX48A	3-401
2N5264		BUV23	3-388
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2N5295		TIP31B	3-873
2N5296		TIP31B	3-873
2N5297		TIP31B	3-873
2N5298		TIP31B	3-873
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2N5302	2N5302		3-54
2N5303	2N5303		3-54
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2N5387		2N6547	3-140
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2N5466		BUX48A	3-401
2N5467		BUX48A	3-401
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2N5491		MJE3055T	3-628
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2N5493		2N6292	3-101
2N5494		MJE3055T	3-628
2N5495		MJE3055T	3-628
2N5496		2N6292	3-101
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2N5575		2N5685	3-66
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Industry Part Number	Motorola Nearest Replacement	Motorola Similar Replacement	Page Number
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2N5630	2N5631		3-59
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2N5632		2N5882	3-77
2N5633		MJ15001	3-497
2N5634		MJ15001	3-497
2N5655	2N5657		3-63
2N5656	2N5657		3-63
2N5657	2N5657		3-63
2N5659		2N5631	3-59
2N5683	2N5684		3-66
2N5684	2N5684		3-66
2N5685	2N5685		3-66
2N5686	2N5686		3-66
2N5733		2N6274	3-108
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2N5737		2N5878	3-74
2N5738		2N5880	3-77
2N5739		2N5878	3-74
2N5740		2N5880	3-77
2N5741		2N5884	3-81
2N5742		2N6031	3-59
2N5743		2N5884	3-81
2N5744		MJ4502	3-431
2N5745	2N5745		3-29
2N5758	2N5758		3-70
2N5759		2N3055A	3-5
2N5760		2N3442	3-9
2N5867		2N3792	3-25
2N5868		2N3792	3-25
2N5869		2N3716	3-12
2N5870		2N3716	3-12
2N5871		2N3792	3-25
2N5872		2N3792	3-25
2N5873		2N3716	3-12
2N5874		2N3716	3-12
2N5877	2N5878		3-74
2N5878	2N5878		3-74
2N5879	2N5880		3-77
2N5880	2N5880		3-77
2N5881	2N5882		3-77
2N5882	2N5882		3-77
2N5883	2N5884		3-81
2N5884	2N5884		3-81
2N5885	2N5886		3-81
2N5886	2N5886		3-81
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2N5987		2N6490	3-132
2N5988		2N6490	3-132
2N5989		2N6486	—
2N5990		2N6488	3-132
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2N6021		TIP32C	3-873
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2N6031	2N6031		3-59
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2N6033		2N6277	3-108
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2N6035	2N6035		3-85
2N6036	2N6036		3-85
2N6037	2N6038		3-85
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2N6039	2N6039		3-85
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2N6043	2N6044		3-89
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2N6050	2N6052		3-93
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2N6052	2N6052		3-93
2N6055	2N6056		3-97
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2N6057	2N6059		3-93
2N6058	2N6059		3-93
2N6059	2N6059		3-93
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2N6100		2N6487	3-132
2N6101		2N6488	3-132
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2N6274	2N6274		3-108
2N6275	2N6275		3-108
2N6276		2N6275	3-108
2N6277	2N6277		3-108
2N6278		2N6274	3-108
2N6279		2N6275	3-108
2N6280		2N6275	3-108
2N6281		2N6277	3-108
2N6282	2N6283		3-112
2N6283	2N6283		3-112
2N6284	2N6284		3-112
2N6285	2N6286		3-112
2N6286	2N6286		3-112
2N6287	2N6287		3-112
2N6288	2N6292		3-101
2N6289		2N6292	3-101
2N6290	2N6292		3-101
2N6291	2N6292		3-101
2N6292	2N6292		3-101
2N6293		2N6292	3-101
2N6302		2N5631	3-59
2N6322		MJ10015	3-461
2N6323		MJ10015	3-461
2N6324		MJ10015	3-461
2N6325		MJ10015	3-461
2N6326	2N6328		—
2N6327	2N6328		—
2N6328	2N6328		—
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2N6356		2N6059	3-93
2N6357		2N6059	3-93
2N6358		2N6059	3-93
2N6359		2N5886	3-81
2N6371		2N3055	3-2
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2N6373		2N6315	—
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