

*Designer's™ Data Sheet*  
**SWITCHMODE Series**  
**NPN Silicon Power Transistors**

These transistors are designed for high-voltage, high-speed switching of inductive circuits where fall time and RBSOA are critical. They are particularly well-suited for line-operated switchmode applications.

The MJE16004 is a high-gain version of the MJE16002 and MJH16002 for applications where drive current is limited.

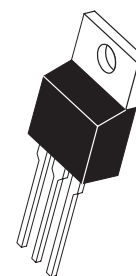
Typical Applications:

- Switching Regulators
- High Resolution Deflection Circuits
- Inverters
- Motor Drives
- Fast Switching Speeds
  - 50 ns Inductive Fall Time @ 75°C (Typ)
  - 70 ns Crossover Time @ 75°C (Typ)
- 100°C Performance Specified for:
  - Reverse-Biased SOA
  - Inductive Switching Times
  - Saturation Voltages
  - Leakage Currents

**MJE16002\***  
**MJE16004\***

\*Motorola Preferred Device

**5.0 AMPERE**  
**NPN SILICON**  
**POWER TRANSISTORS**  
**450 VOLTS**  
**80 WATTS**



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

**MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	$V_{CEO(sus)}$	450	Vdc
Collector-Emitter Voltage	$V_{CEV}$	850	Vdc
Emitter-Base Voltage	$V_{EB}$	6.0	Vdc
Collector Current — Continuous	$I_C$	5.0	Adc
— Peak (1)	$I_{CM}$	10	
Base Current — Continuous	$I_B$	4.0	Adc
— Peak (1)	$I_{BM}$	8.0	
Total Power Dissipation @ $T_C = 25^\circ\text{C}$	$P_D$	80	Watts
@ $T_C = 100^\circ\text{C}$		32	
Derate above $T_C = 25^\circ\text{C}$		0.64	W/°C
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	$R_{\theta JC}$	1.56	°C/W
Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	$T_L$	275	°C

(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle ≤ 10%.

**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.

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

Characteristic	Symbol	Min	Typ	Max	Unit
<b>OFF CHARACTERISTICS (1)</b>					
Collector–Emitter Sustaining Voltage (Table 2) ( $I_C = 100\text{ mA}$ , $I_B = 0$ )	$V_{CEO(sus)}$	450	—	—	Vdc
Collector Cutoff Current ( $V_{CEV} = 850\text{ Vdc}$ , $V_{BE(off)} = 1.5\text{ Vdc}$ ) ( $V_{CEV} = 850\text{ Vdc}$ , $V_{BE(off)} = 1.5\text{ Vdc}$ , $T_C = 100^\circ\text{C}$ )	$I_{CEV}$	—	—	0.25 1.5	mAdc
Collector Cutoff Current ( $V_{CE} = 850\text{ Vdc}$ , $R_{BE} = 50\ \Omega$ , $T_C = 100^\circ\text{C}$ )	$I_{CER}$	—	—	2.5	mAdc
Emitter Cutoff Current ( $V_{EB} = 6.0\text{ Vdc}$ , $I_C = 0$ )	$I_{EBO}$	—	—	1.0	mAdc

**SECOND BREAKDOWN**

Second Breakdown Collector Current with Base Forward Biased	$I_{S/b}$	See Figure 17 or 18			
Clamped Inductive SOA with Base Reverse Biased	RBSOA	See Figure 19			

**ON CHARACTERISTICS (1)**

Collector–Emitter Saturation Voltage ( $I_C = 1.5\text{ Adc}$ , $I_B = 0.2\text{ Adc}$ ) ( $I_C = 1.5\text{ Adc}$ , $I_B = 0.15\text{ Adc}$ ) ( $I_C = 3.0\text{ Adc}$ , $I_B = 0.4\text{ Adc}$ ) ( $I_C = 3.0\text{ Adc}$ , $I_B = 0.3\text{ Adc}$ ) ( $I_C = 3.0\text{ Adc}$ , $I_B = 0.4\text{ Adc}$ , $T_C = 100^\circ\text{C}$ ) ( $I_C = 3.0\text{ Adc}$ , $I_B = 0.3\text{ Adc}$ , $T_C = 100^\circ\text{C}$ )	MJE16002 MJE16004 MJE16002 MJE16004 MJE16002 MJE16004	$V_{CE(sat)}$	— — — — — —	— — — — — —	1.0 1.0 2.5 2.5 2.5 2.5	Vdc
Base–Emitter Saturation Voltage ( $I_C = 3.0\text{ Adc}$ , $I_B = 0.4\text{ Adc}$ ) ( $I_C = 3.0\text{ Adc}$ , $I_B = 0.3\text{ Adc}$ ) ( $I_C = 3.0\text{ Adc}$ , $I_S = 0.4\text{ Adc}$ , $T_C = 100^\circ\text{C}$ ) ( $I_C = 3.0\text{ Adc}$ , $I_B = 0.3\text{ Adc}$ , $T_C = 100^\circ\text{C}$ )	MJE16002 MJE16004 MJE16002 MJE16004	$V_{BE(sat)}$	— — — —	— — — —	1.5 1.5 1.5 1.5	Vdc
DC Current Gain ( $I_C = 5.0\text{ Adc}$ , $V_{CE} = 5.0\text{ Vdc}$ )	MJE16002 MJE16004	$h_{FE}$	5.0 7.0	— —	— —	—

**DYNAMIC CHARACTERISTICS**

Output Capacitance ( $V_{CB} = 10\text{ Vdc}$ , $I_E = 0$ , $f_{test} = 1.0\text{ kHz}$ )	$C_{ob}$	—	—	200	pF
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**SWITCHING CHARACTERISTICS**

Resistive Load (Table 1) MJE16002/MJH10002								
Delay Time	$I_C = 3.0\text{ Adc}$ , $V_{CC} = 250\text{ Vdc}$ , $I_{B1} = 0.4\text{ Adc}$ , $PW = 30\ \mu\text{s}$ , Duty Cycle $\leq 2.0\%$	$I_{B2} = 0.8\text{ Adc}$ , $R_{B2} = 8.0\ \Omega$	$t_d$	—	30	100	ns	
Rise Time			$t_r$	—	100	300		
Storage Time			$t_s$	—	1000	3000		
Fall Time			$t_f$	—	60	300		
Storage Time			$(V_{BE(off)} = 5.0\text{ Vdc})$	$t_s$	—	400		—
Fall Time				$t_f$	—	130		—
Resistive Load (Table 1) MJE16004/MJH16004								
Delay Time	$I_C = 3.0\text{ Adc}$ , $V_{CC} = 250\text{ Vdc}$ , $I_{B1} = 0.3\text{ Adc}$ , $PW = 30\ \mu\text{s}$ , Duty Cycle $\leq 2.0\%$	$I_{B2} = 0.6\text{ Adc}$ , $R_{B2} = 8.0\ \Omega$	$t_d$	—	30	100	ns	
Rise Time			$t_r$	—	130	300		
Storage Time			$t_s$	—	800	2700		
Fall Time			$t_f$	—	80	350		
Storage Time			$(V_{BE(off)} = 5.0\text{ Vdc})$	$t_s$	—	250		—
Fall Time				$t_f$	—	60		—

(1) Pulse Test:  $PW = 300\ \mu\text{s}$ , Duty Cycle  $\leq 2\%$ .

$$* \beta_f = \frac{I_C}{I_{B1}}$$

SWITCHING CHARACTERISTICS (continued)

Characteristics		Symbol	Min	Typ	Max	Unit	
<b>Inductive Load (Table 2) MJE16002</b>							
Storage Time	(I <sub>C</sub> = 3.0 Adc, I <sub>B1</sub> = 0.4 Adc, V <sub>BE(off)</sub> = 5.0 Vdc, V <sub>CE(pk)</sub> = 400 Vdc)	(T <sub>J</sub> = 100°C)	t <sub>sv</sub>	—	500	1600	ns
Fall Time			t <sub>fi</sub>	—	100	200	
Crossover Time			t <sub>c</sub>	—	120	250	
Storage Time		(T <sub>J</sub> = 150°C)	t <sub>sv</sub>	—	600	—	
Fall Time			t <sub>fi</sub>	—	120	—	
Crossover Time			t <sub>c</sub>	—	160	—	
<b>Inductive Load (Table 2) MJE16004</b>							
Storage Time	(I <sub>C</sub> = 3.0 Adc, I <sub>B1</sub> = 0.3 Adc, V <sub>BE(off)</sub> = 5.0 Vdc, V <sub>CE(pk)</sub> = 400 Vdc)	(T <sub>J</sub> = 100°C)	t <sub>sv</sub>	—	400	1300	ns
Fall Time			t <sub>fi</sub>	—	80	150	
Crossover Time			t <sub>c</sub>	—	90	200	
Storage Time		(T <sub>J</sub> = 150°C)	t <sub>sv</sub>	—	450	—	
Fall Time			t <sub>fi</sub>	—	100	—	
Crossover Time			t <sub>c</sub>	—	110	—	

(1) Pulse Test: PW = 300 μs, Duty Cycle ≤ 2%.

$$*\beta_f = \frac{I_C}{I_{B1}}$$

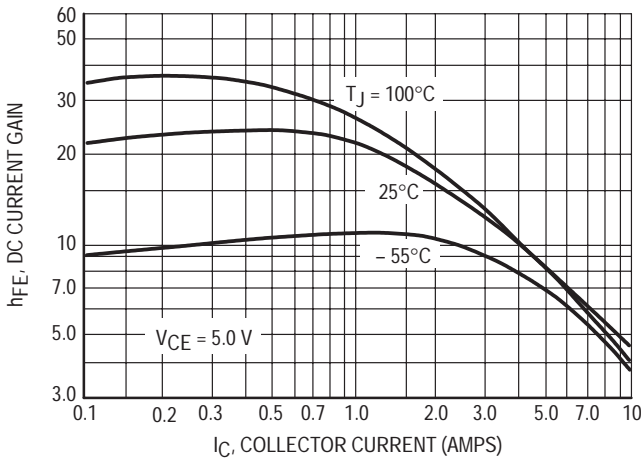


Figure 1. DC Current Gain

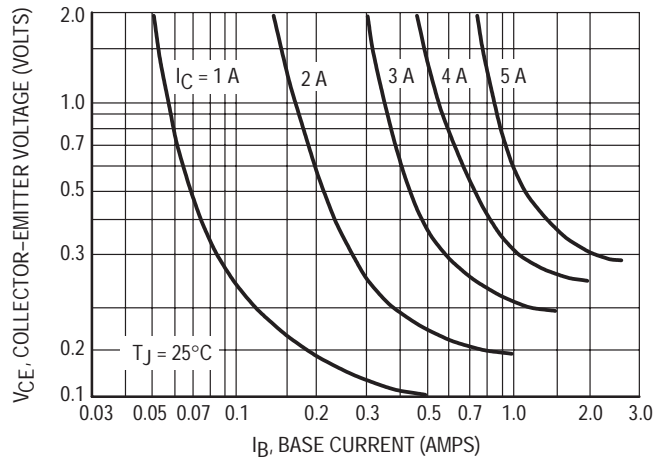


Figure 2. Collector Saturation Region

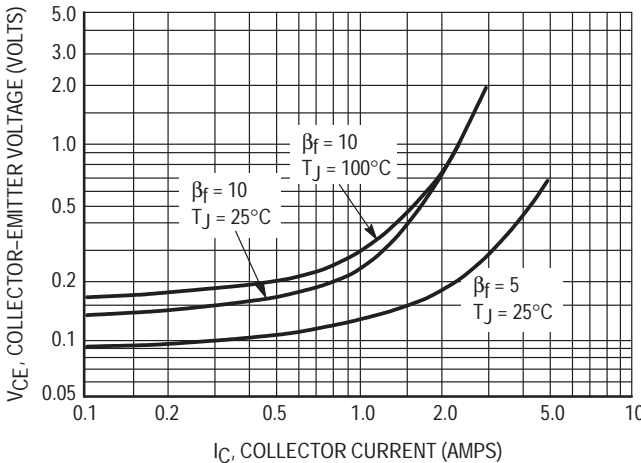


Figure 3. Collector-Emitter Saturation Region

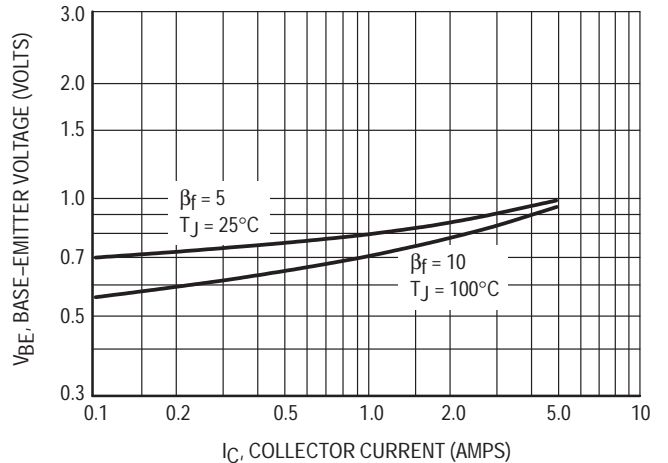


Figure 4. Base-Emitter Voltage

TYPICAL STATIC CHARACTERISTICS (continued)

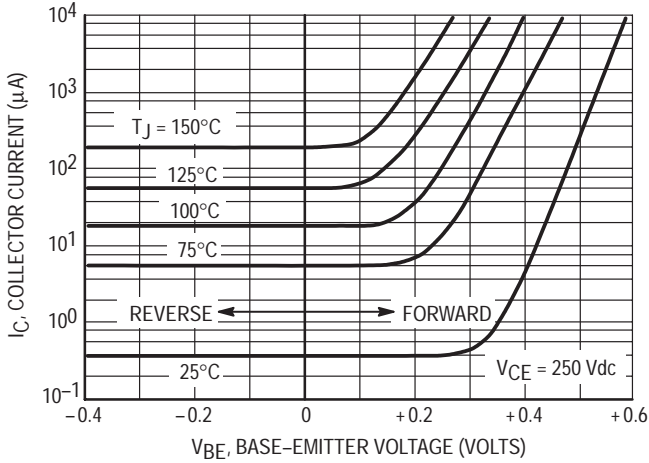


Figure 5. Collector Cutoff Region

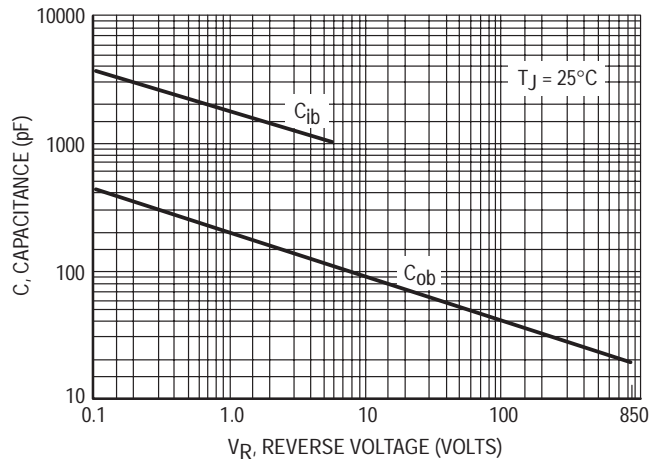


Figure 6. Capacitance

TYPICAL DYNAMIC CHARACTERISTICS

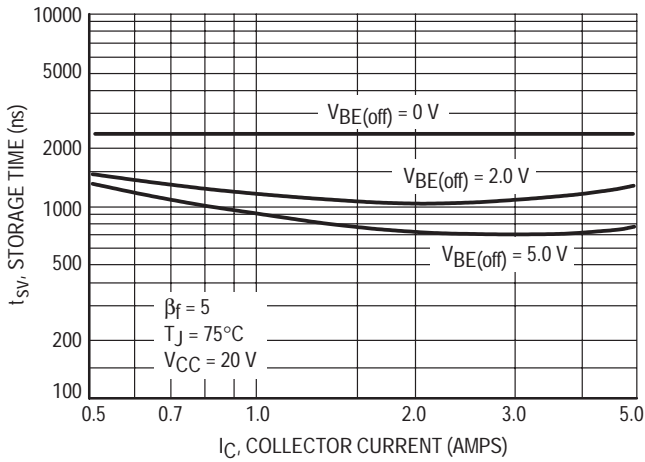


Figure 7. Storage Time

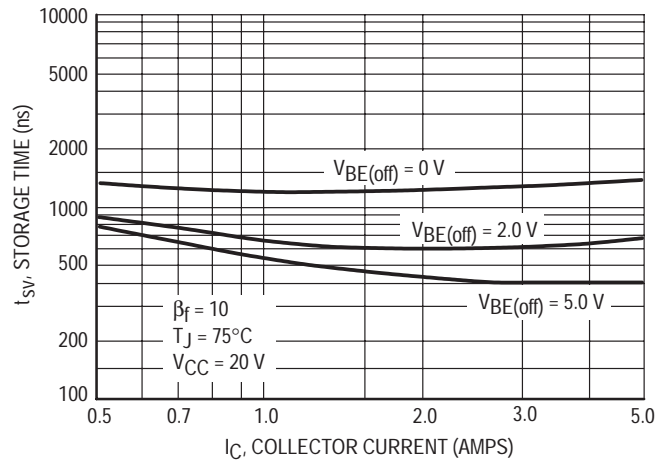


Figure 8. Storage Time

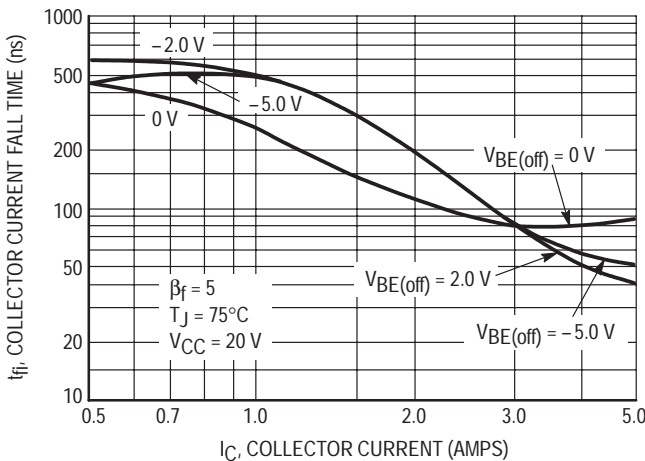


Figure 9. Collector Current Fall Time

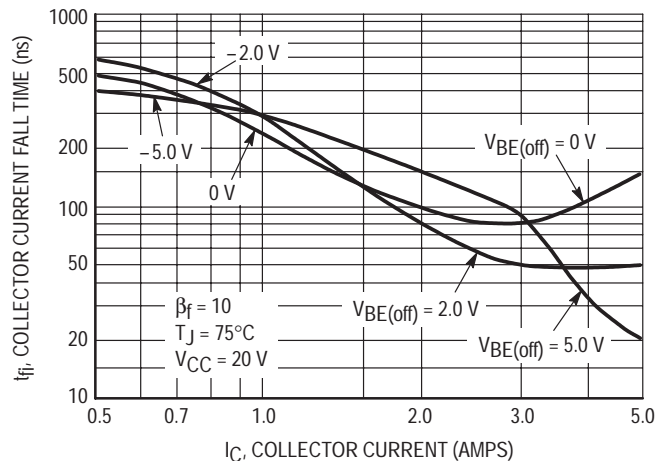


Figure 10. Collector Current Fall Time

TYPICAL DYNAMIC CHARACTERISTICS (continued)

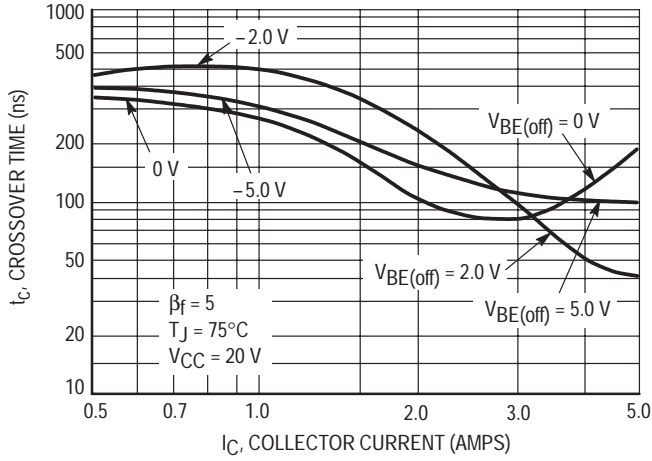


Figure 11. Crossover Time

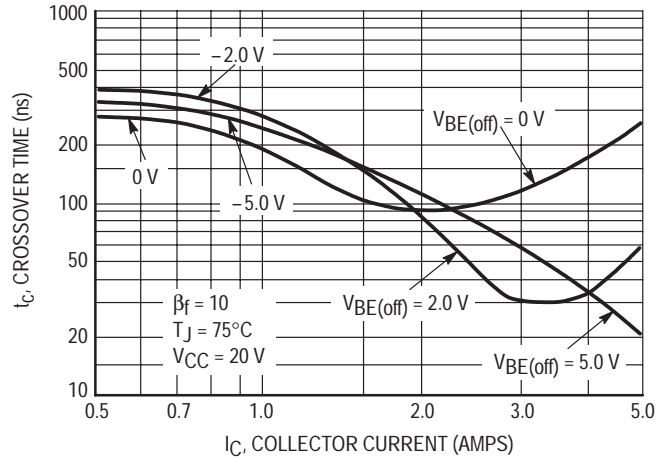


Figure 12. Crossover Time

TYPICAL ELECTRICAL CHARACTERISTICS

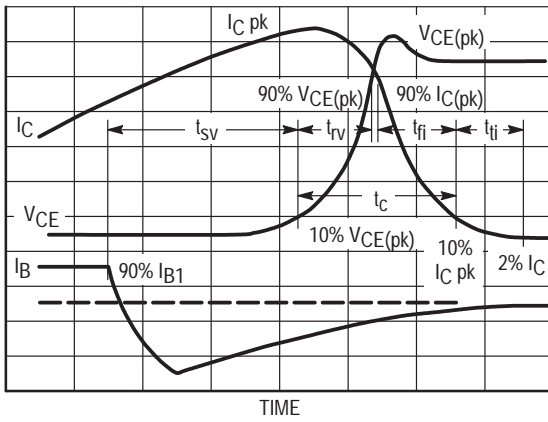


Figure 13. Inductive Switching Measurements

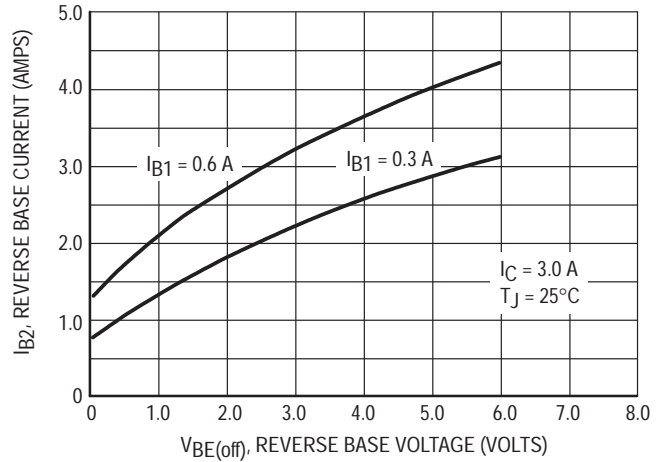


Figure 14. Peak Reverse Base Current

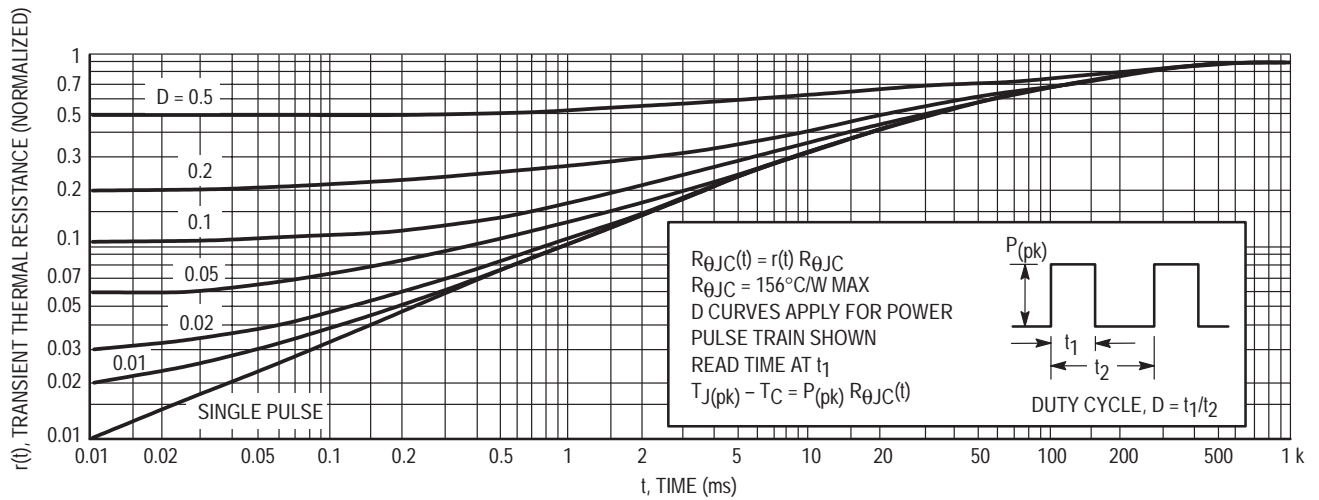


Figure 15. Thermal Response (MJE16002 and MJE16004)

SAFE OPERATING AREA INFORMATION

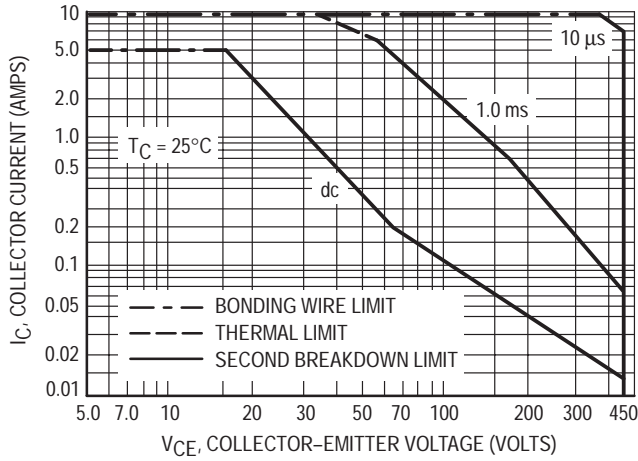


Figure 16. Maximum Rated Forward Bias Safe Operating Area (MJE16002 and MJE16004)

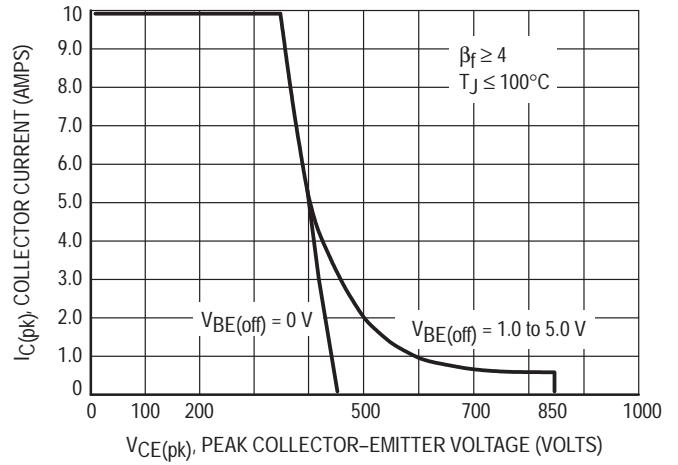


Figure 17. Maximum Rated Reverse Bias Safe Operating Area

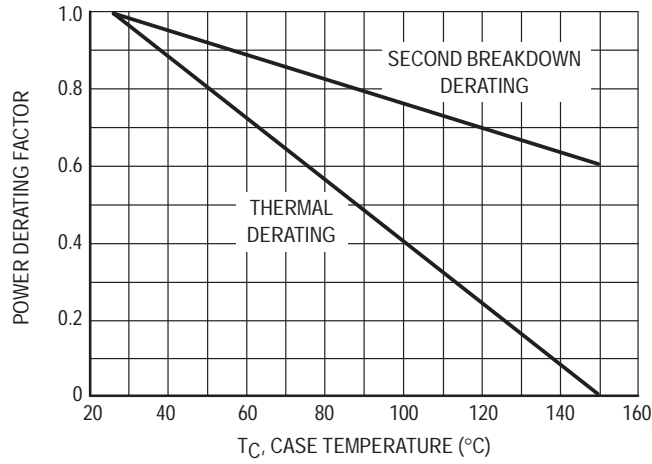


Figure 18. Power Derating

SAFE OPERATING AREA INFORMATION

FORWARD BIAS

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 16 is based on  $T_C = 25^\circ\text{C}$ ;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \geq 25^\circ\text{C}$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figures 17 and 18 may be found at any case temperature by using the appropriate curve on Figure 20.

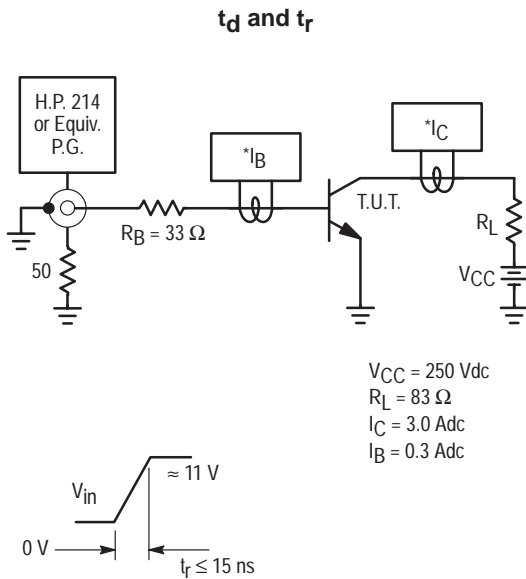
$T_{J(pk)}$  may be calculated from the data in Figure 15. At high case temperatures, thermal limitations will reduce the

power that can be handled to values less than the limitations imposed by second breakdown.

REVERSE BIAS

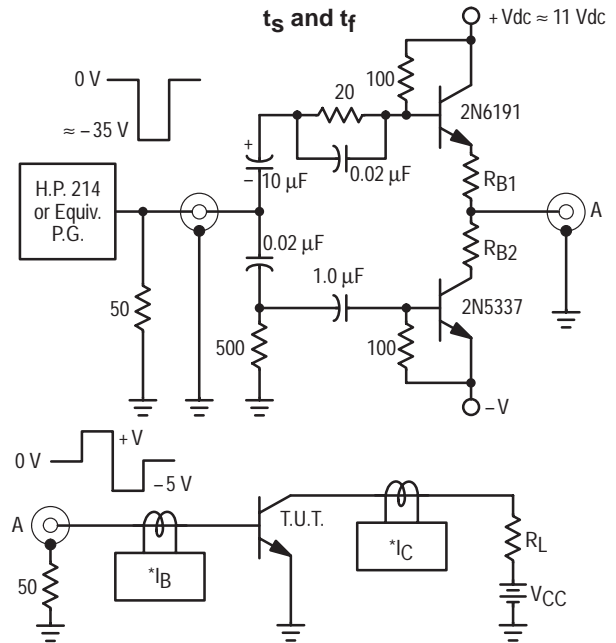
For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base-to-emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current condition allowable pulling reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 17 gives the RBSOA characteristics.

Table 1. Resistive Load Switching



$V_{CC} = 250\text{ Vdc}$   
 $R_L = 83\ \Omega$   
 $I_C = 3.0\text{ Adc}$   
 $I_B = 0.3\text{ Adc}$

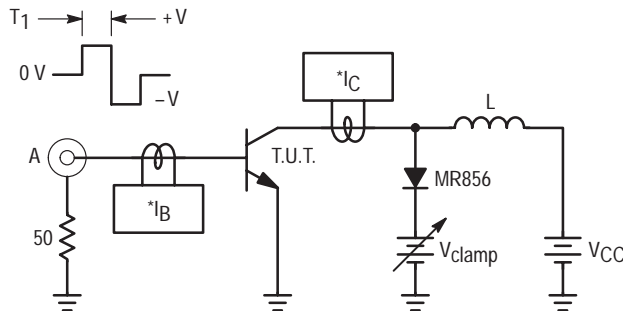
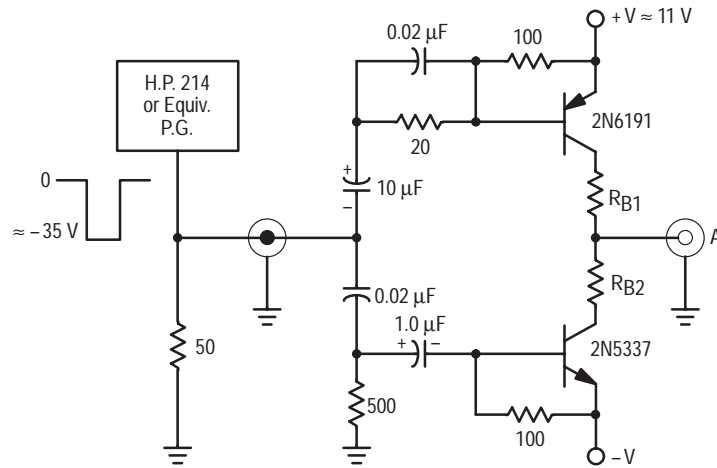
\*Tektronix  
 P-6042 or  
 Equivalent



$V_{CC} = 250$      $I_{B1} = 0.3\text{ Adc}$      $R_{B1} = 33\ \Omega$   
 $R_L = 83\ \Omega$      $I_{B2} = 0.6\text{ Adc}$      $R_{B2} = 8.0\ \Omega$   
 $I_C = 3.0\text{ Adc}$     For  $V_{BE(off)} = 5.0\text{ V}$      $R_{B2} = 0\ \Omega$

Note: Adjust -V to obtain desired  $V_{BE(off)}$  at Point A.

Table 2. Inductive Load Switching



$$T_1 \approx \frac{L_{coil} (I_{Cpk})}{V_{CC}}$$

T<sub>1</sub> adjusted to obtain I<sub>C(pk)</sub>

**V<sub>CEO(sus)</sub>**

L = 10 mH  
R<sub>B2</sub> = ∞  
V<sub>CC</sub> = 20 Volts

\*Tektronix  
P-6042 or  
Equivalent

**Inductive Switching**

L = 200 μH  
R<sub>B2</sub> = 0  
V<sub>CC</sub> = 20 Volts  
R<sub>B1</sub> selected for desired I<sub>B1</sub>

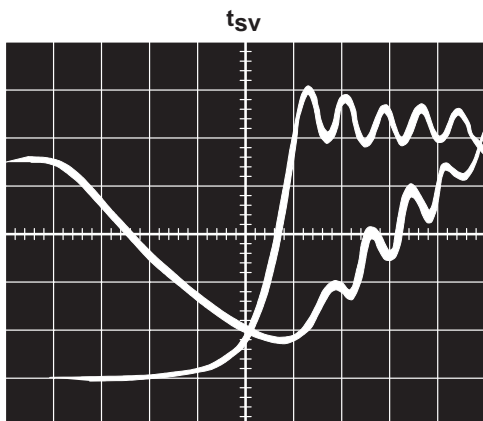
Scope — Tektronix  
7403 or  
Equivalent

**RBSOA**

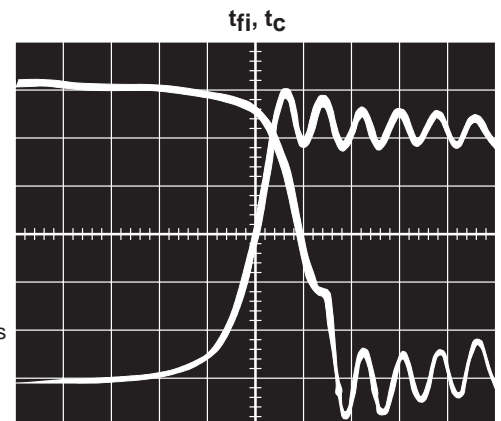
L = 200 μH  
R<sub>B2</sub> = 0  
V<sub>CC</sub> = 20 Volts  
R<sub>B1</sub> selected for desired I<sub>B1</sub>

Note: Adjust -V to obtain desired V<sub>BE(off)</sub> at Point A.

**TYPICAL INDUCTIVE SWITCHING WAVEFORMS**



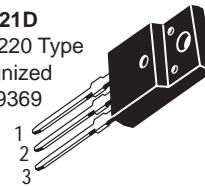
I<sub>C(pk)</sub> = 3.0 Amps  
I<sub>B1</sub> = 0.3 Amp  
V<sub>BE(off)</sub> = 5.0 Volts  
V<sub>CE(pk)</sub> = 300 Volts  
T<sub>C</sub> = 25°C  
Time Base =  
20 ns/cm



I<sub>C(pk)</sub> = 3.0 Amps  
I<sub>B1</sub> = 0.3 Amp  
V<sub>BE(off)</sub> = 5.0 Volts  
V<sub>CE(pk)</sub> = 300 Volts  
T<sub>C</sub> = 25°C  
Time Base =  
20 ns/cm



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

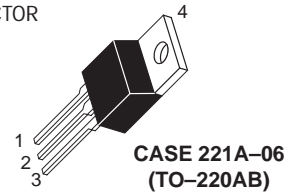


Table 2. Plastic TO-220AB

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		80
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	

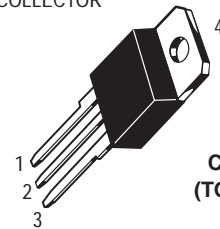
(1)h<sub>FE</sub> @ 1 MHz  
 (2)Darlington  
 (3)Switching tests performed w/special application simulator circuit. See data sheet for details.  
 (7)V<sub>CEO</sub> = 375 V  
 (8)When 2 voltages are given, the format is V<sub>CEO(sus)</sub>/V<sub>CES</sub>.  
 (9)Self protected Darlington

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)

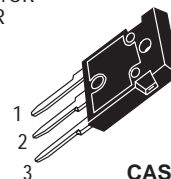
I <sub>C</sub> Cont Amps Max	V <sub>CEO(sus)</sub> Volts Min <sup>(8)</sup>	Device Type		h <sub>FE</sub> Min/Max	@ I <sub>C</sub> Amp	Resistive Switching			f <sub>T</sub> MHz Min	P <sub>D</sub> (Case) Watts @ 25°C
		NPN	PNP			t <sub>s</sub> μs Max	t <sub>f</sub> μs Max	@ I <sub>C</sub> Amp		
15	60	<b>TIP3055</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

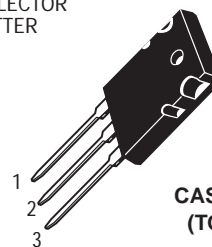
<sup>(3)</sup>Switching tests performed w/special application simulator circuit. See data sheet for details.

<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)

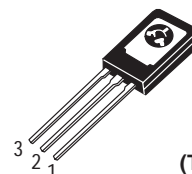
Table 5. Large Plastic TO-264

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

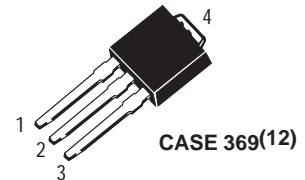


Table 7. DPAK – Surface Mount Power Packages

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

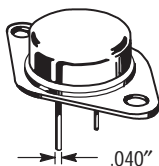
(12)Case 369–07 may be ordered by adding –1 suffix to part number.

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

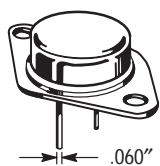
Devices listed in bold, italic are Motorola preferred devices.

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

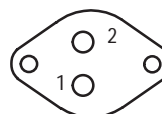
I <sub>C</sub> Cont Amps Max	V <sub>CEO(sus)</sub> Volts Min	Device Type		h <sub>FE</sub> Min/Max	@ I <sub>C</sub> Amp	Resistive Switching			f <sub>T</sub> MHz Min	P <sub>D</sub> (Case) Watts @ 25°C
		NPN	PNP			t <sub>s</sub> μs Max	t <sub>f</sub> μs Max	@ I <sub>C</sub> Amp		
2	100	<i>MJD112</i> (2)	<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

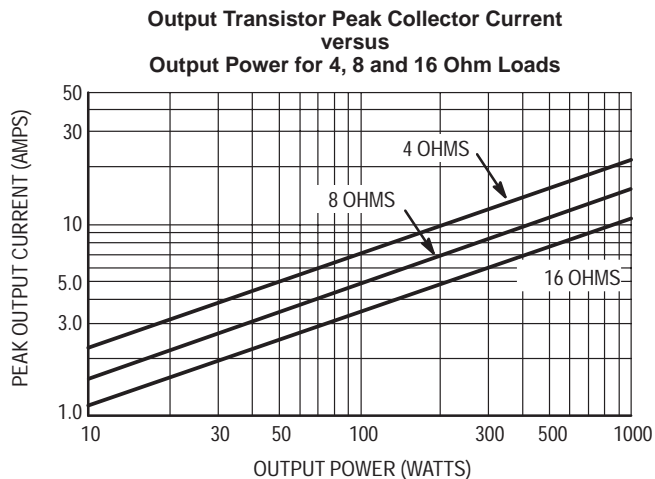
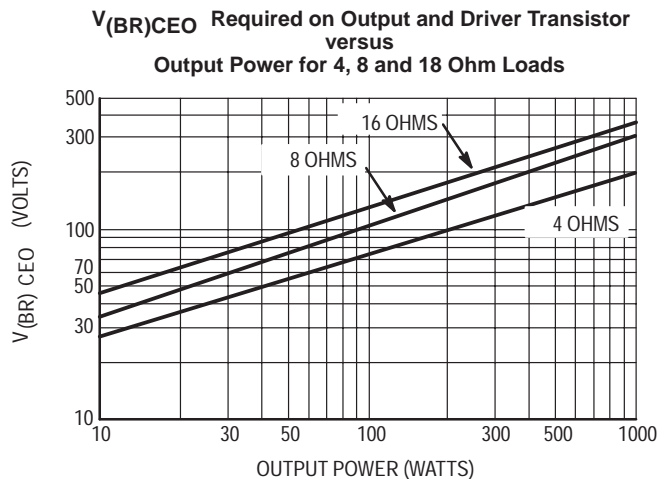
(8) When 2 voltages are given, the format is V<sub>CEO(sus)</sub>/V<sub>CES</sub>.

(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 <sub>D</sub> Watts @ 25°C	V <sub>CEO</sub>	h <sub>FE</sub> @ Min/Max	I <sub>C</sub> Amps	f <sub>T</sub> 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

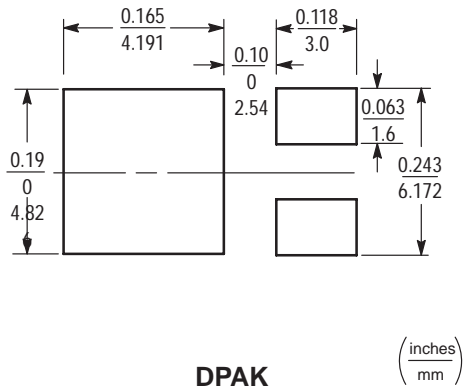
The Power Transistors shown are provided for reference only and show device capability. The final choice of the Power Transistors used is left to the circuit designer and depends upon the particular safe-operating area required and the mounting and heat sinking configuration used.

# INFORMATION FOR USING SURFACE MOUNT PACKAGES

## RECOMMENDED FOOTPRINTS FOR SURFACE MOUNTED APPLICATIONS

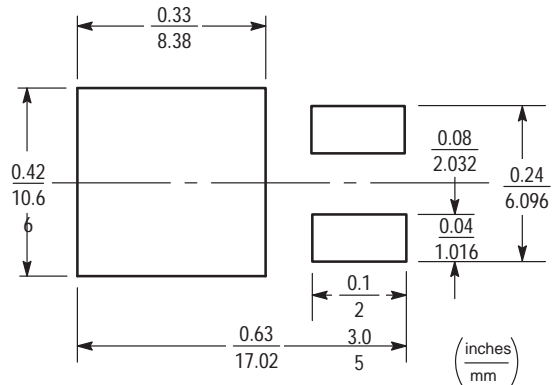
Surface mount board layout is a critical portion of the total design. The footprint for the semiconductor packages must be the correct size to ensure proper solder connection interface between the board and the package. With the correct

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



DPAK

(inches/mm)



D2PAK

(inches/mm)

## 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°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 °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.

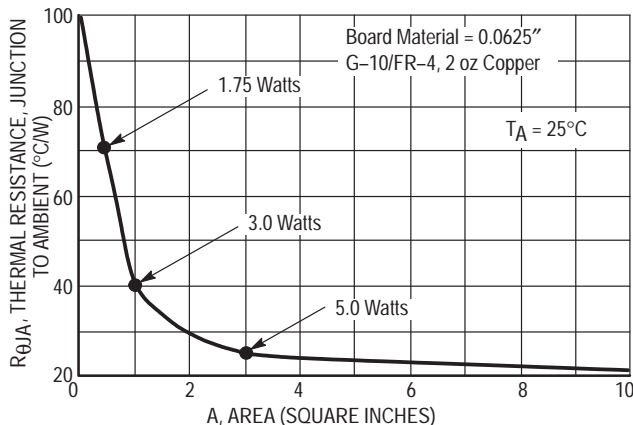


Figure 1. Thermal Resistance versus Drain Pad Area for the DPAK Package (Typical)

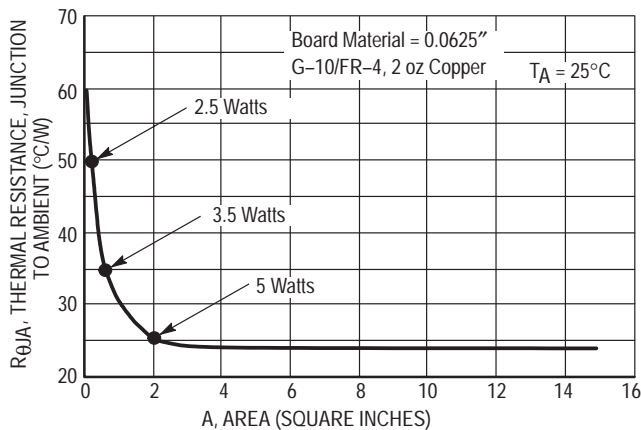
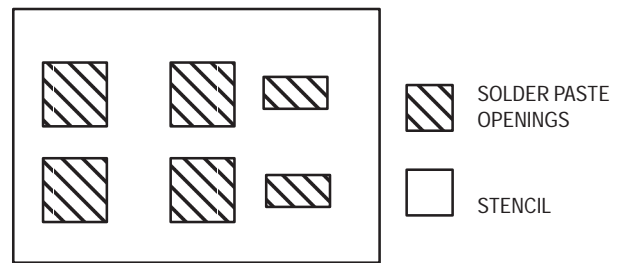


Figure 2. Thermal Resistance versus Drain Pad Area for the D2PAK Package (Typical)

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.

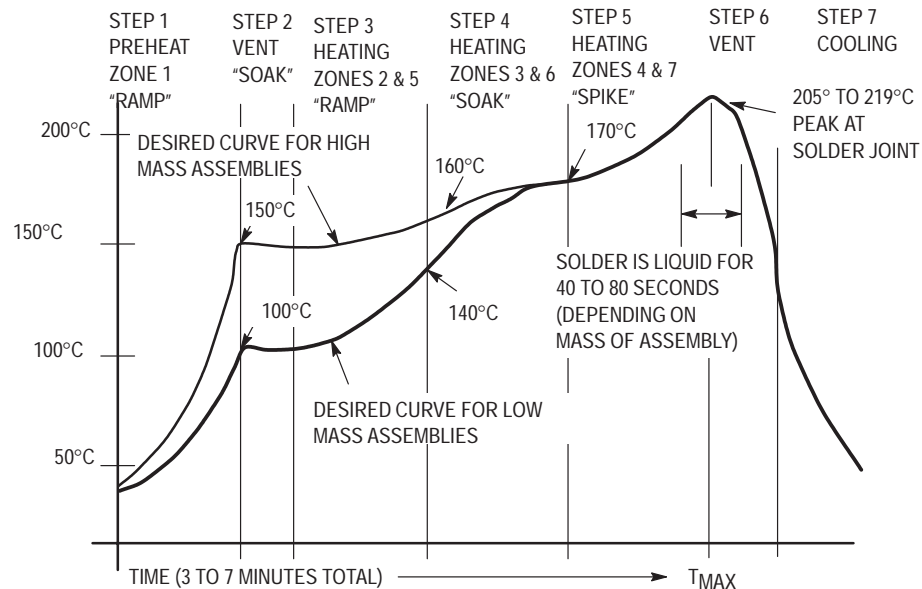


Figure 4. Typical Solder Heating Profile

# 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

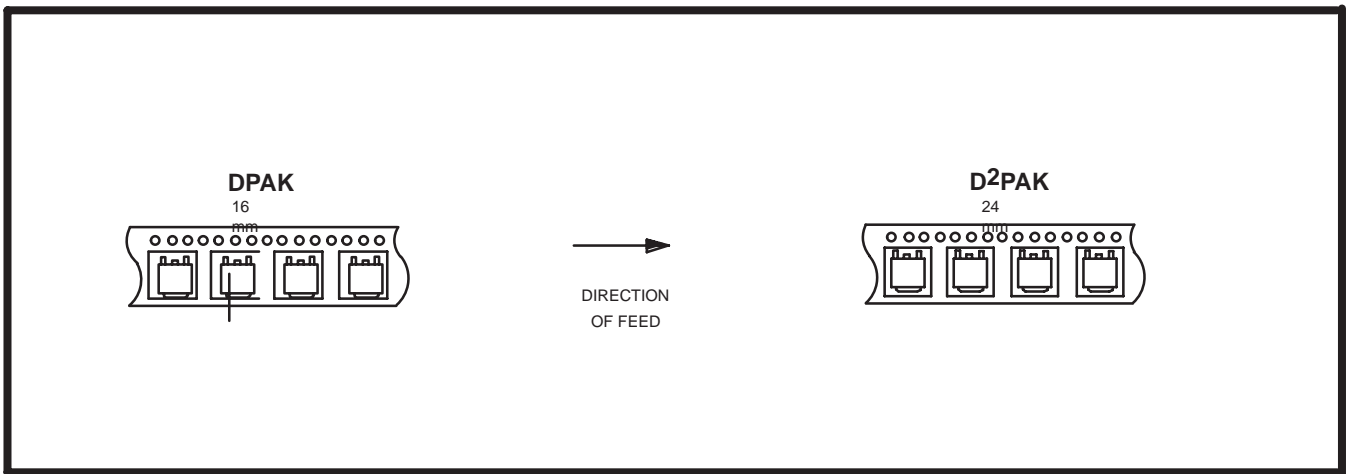
Wakefield Engineering, Inc., Wakefield, Massachusetts 01880 (617) 245-5900

# 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.

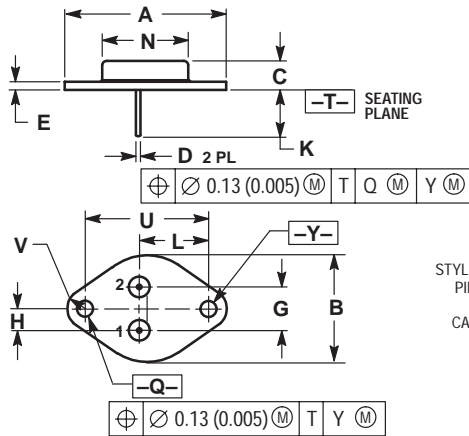
- Two Reel Sizes Available (7” and 13”)
- Used for Automatic Pick and Place Feed Systems
- Minimizes Product Handling
- EIA 481, -1, -2
- DPAK SO-14, in 16 mm Tape
- D<sup>2</sup>PAK in 24 mm Tape

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

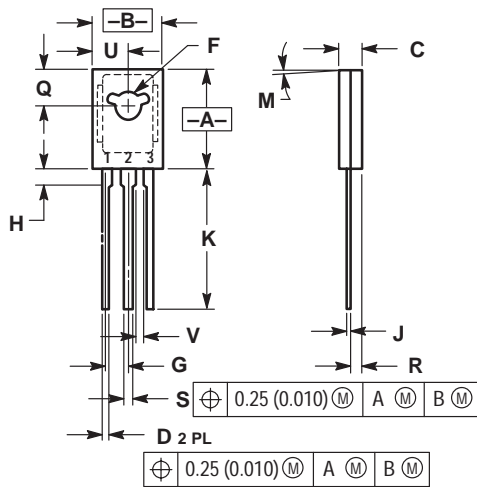


STYLE 1:  
PIN 1: BASE  
2: EMITTER  
CASE: COLLECTOR

- 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)**

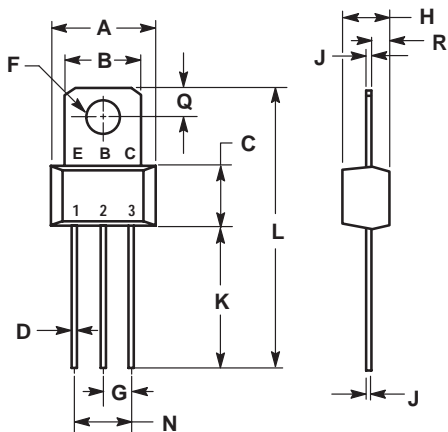


STYLE 1:  
PIN 1: EMITTER  
2: COLLECTOR  
3: BASE

- 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)**



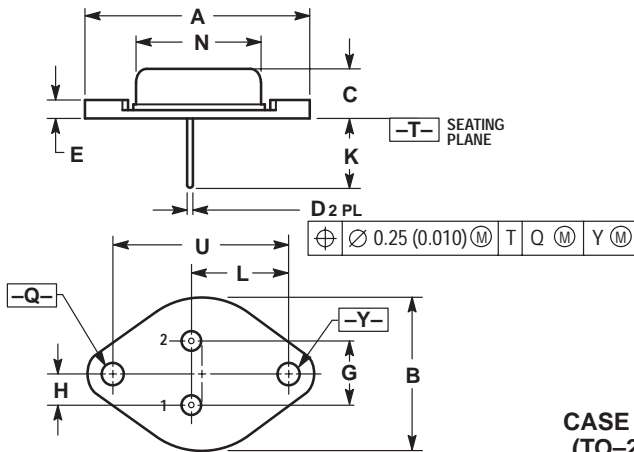
STYLE 1:  
PIN 1: EMITTER  
2: BASE  
3: COLLECTOR  
(COLLECTOR CONNECTED TO TAB)

- 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)

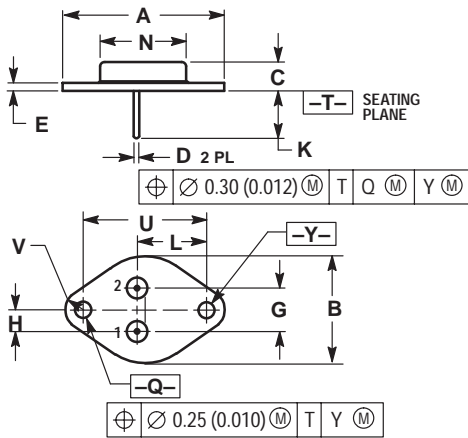


STYLE 1:  
PIN 1: BASE  
2: EMITTER  
CASE: COLLECTOR

**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

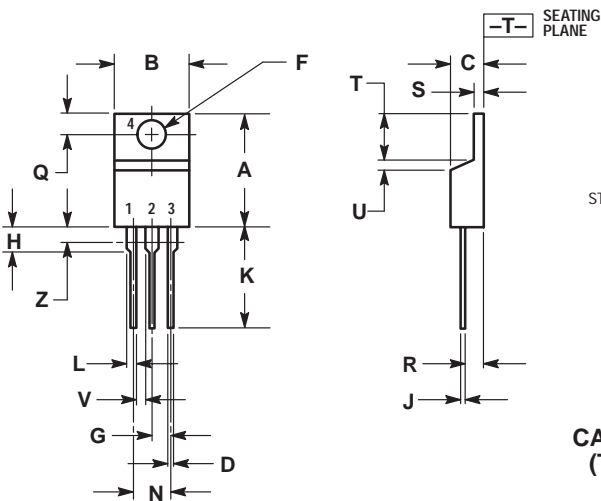


STYLE 1:  
PIN 1: BASE  
2: EMITTER  
CASE: COLLECTOR

**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

**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

**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

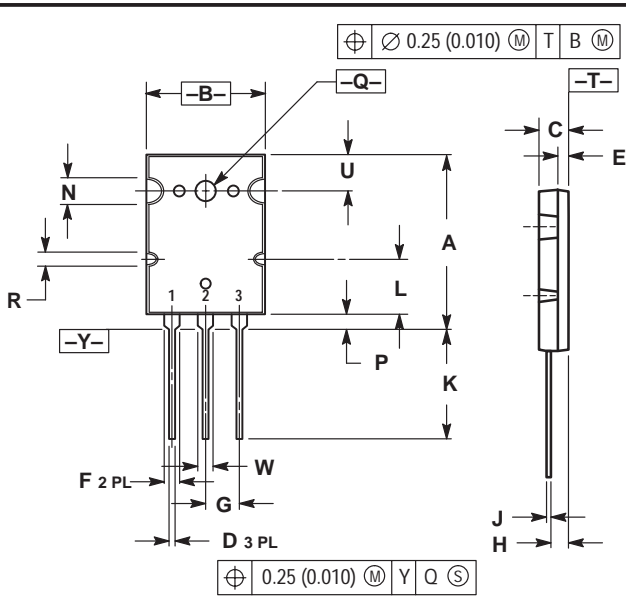
STYLE 3:  
PIN 1. BASE  
2. COLLECTOR  
3. EMITTER  
4. COLLECTOR

**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)

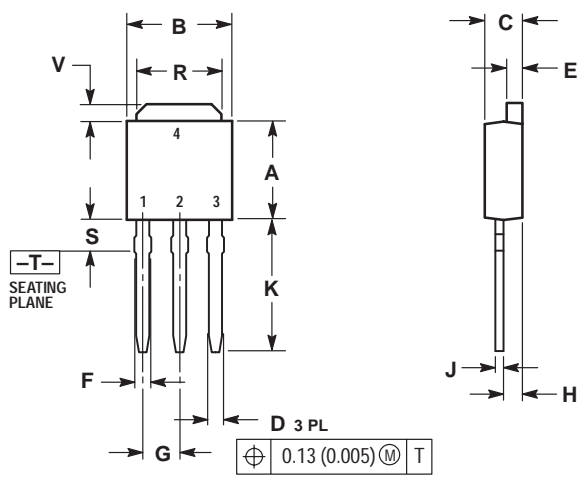


STYLE 2:  
PIN 1. BASE  
2. COLLECTOR  
3. EMITTER

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

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

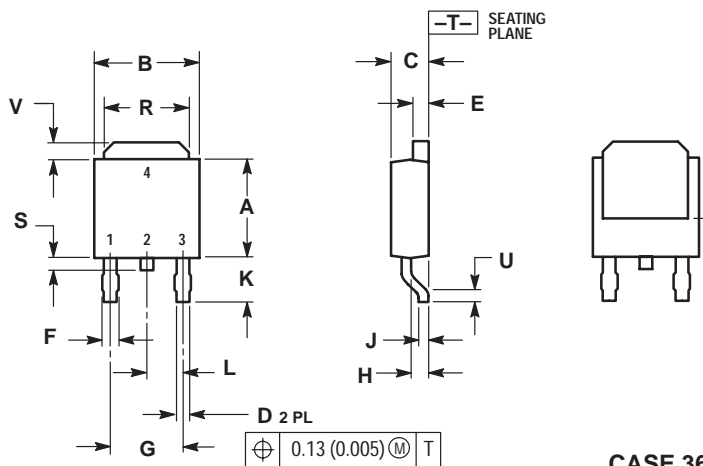


STYLE 1:  
PIN 1. BASE  
2. COLLECTOR  
3. EMITTER  
4. COLLECTOR

**CASE 369-07**

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



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

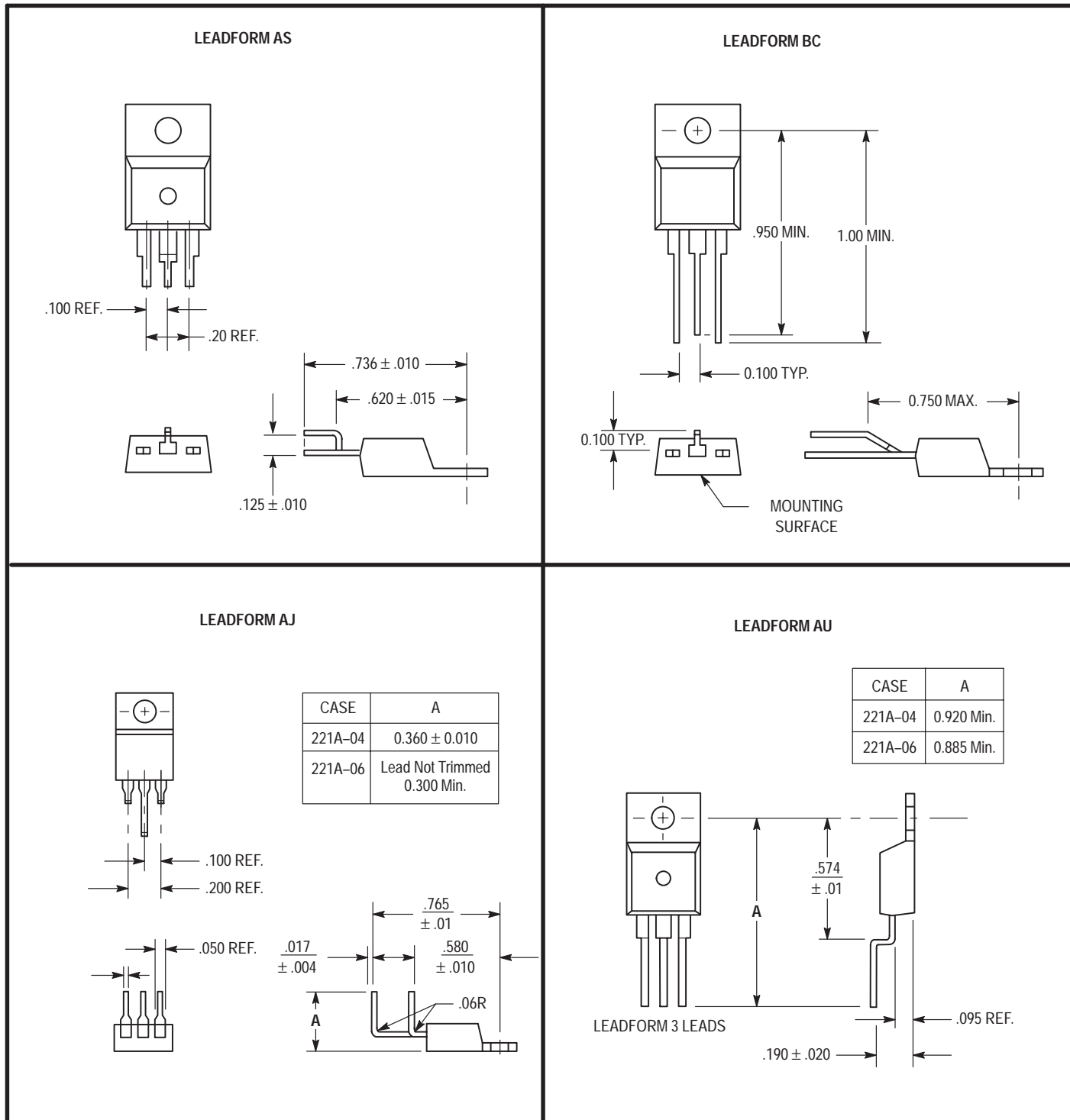
**CASE 369A-13**

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)

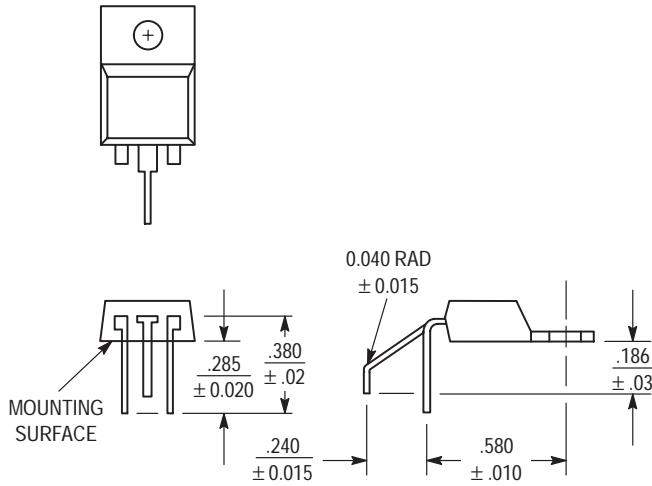
- Leadform options require assignment of a special part number before ordering.
- Contact your local Motorola representative for special part number and pricing.
- 10,000 piece minimum quantity orders are required.
- Leadform orders are non-cancellable after processing.
- Leadforms apply to both Motorola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



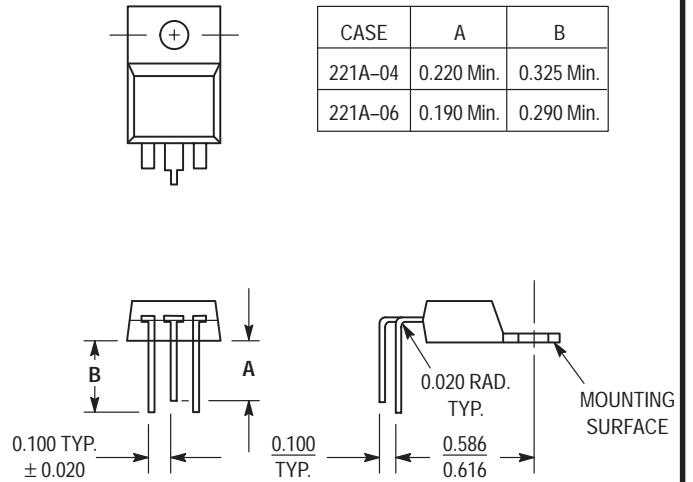


# TO-220 Leadform Options (continued)

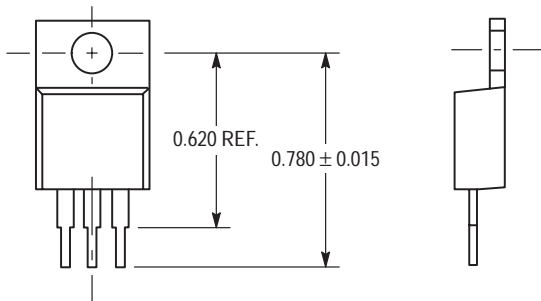
LEADFORM AN



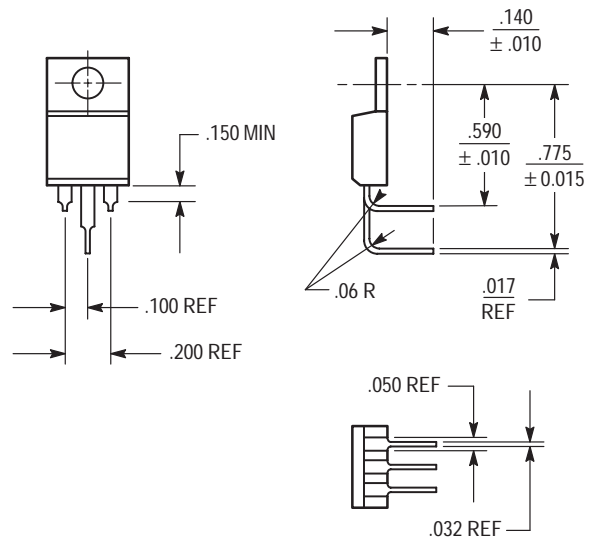
LEADFORM BA



LEADFORM BG

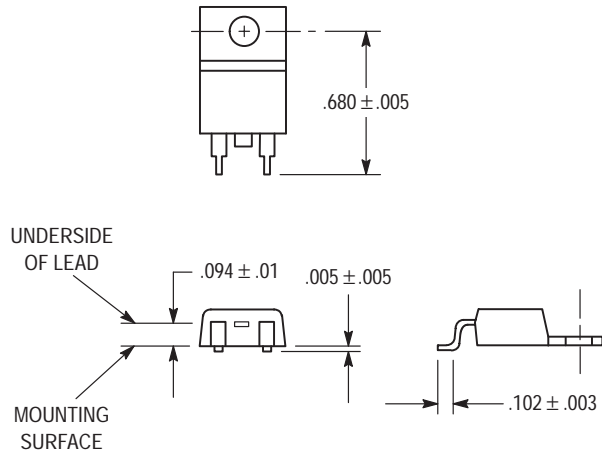


LEADFORM AK

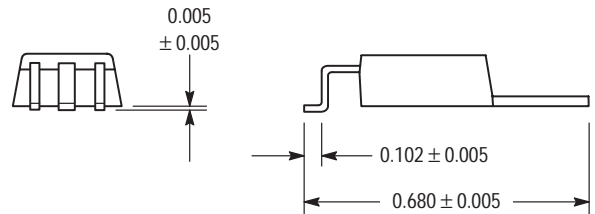


# TO-220 Leadform Options (continued)

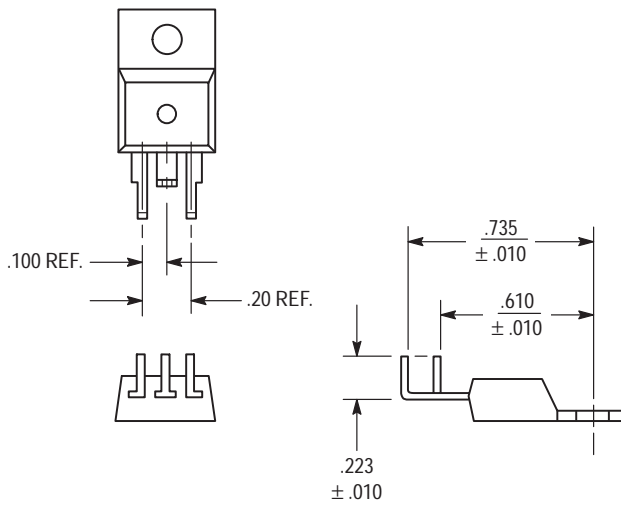
LEADFORM BU



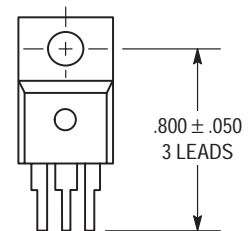
LEADFORM BV



LEADFORM BD

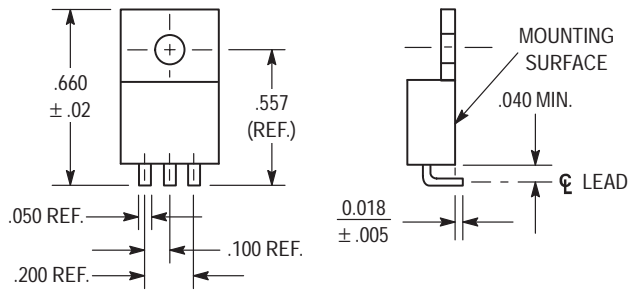


LEADFORM DW

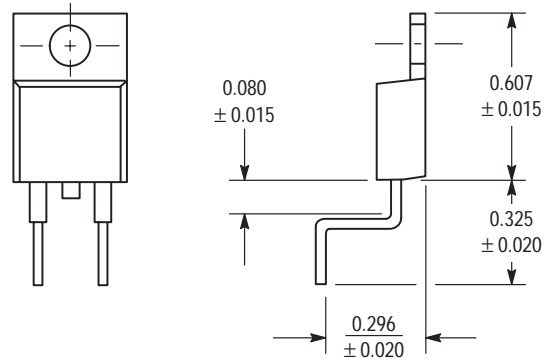


# TO-220 Leadform Options (continued)

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.

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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
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2N1489		2N5878	3-74	2N3789	2N3792		3-25
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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
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2N4906		MJ15016	3-5
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2N4920	2N4920		3-34
2N4921	2N4921		3-38
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2N4923	2N4923		3-38
2N5034		2N3055	3-2
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2N5037		2N3055	3-2
2N5038	2N5038		3-42
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2N5191	2N5191		3-44
2N5192	2N5192		3-44
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2N5194	2N5194		3-49
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2N5879	2N5880		3-77
2N5880	2N5880		3-77
2N5881	2N5882		3-77
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2N6286	2N6286		3-112
2N6287	2N6287		3-112
2N6288	2N6292		3-101
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2N6290	2N6292		3-101
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2N6292	2N6292		3-101
2N6293		2N6292	3-101
2N6302		2N5631	3-59
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2N6323		MJ10015	3-461
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