

*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.

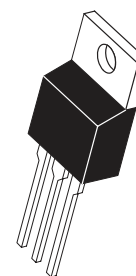
Typical Applications:

- 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  $\leq$  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)<br>( $I_C = 100\text{ mA}$ , $I_B = 0$ )  | $V_{CEO(sus)}$ | 450 | —   | —           | Vdc  |
| Collector Cutoff Current<br>( $V_{CEV} = 850\text{ Vdc}$ , $V_{BE(off)} = 1.5\text{ Vdc}$ )<br>( $V_{CEV} = 850\text{ Vdc}$ , $V_{BE(off)} = 1.5\text{ Vdc}$ , $T_C = 100^\circ\text{C}$ ) | $I_{CEV}$      | —   | —   | 0.25<br>1.5 | mAdc |
| Collector Cutoff Current<br>( $V_{CE} = 850\text{ Vdc}$ , $R_{BE} = 50\ \Omega$ , $T_C = 100^\circ\text{C}$ )  | $I_{CER}$      | —   | —   | 2.5         | mAdc |
| Emitter Cutoff Current<br>( $V_{EB} = 6.0\text{ Vdc}$ , $I_C = 0$ )  | $I_{EBO}$      | —   | —   | 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<br>( $I_C = 1.5\text{ Adc}$ , $I_B = 0.2\text{ Adc}$ )<br>( $I_C = 1.5\text{ Adc}$ , $I_B = 0.15\text{ Adc}$ )<br>( $I_C = 3.0\text{ Adc}$ , $I_B = 0.4\text{ Adc}$ )<br>( $I_C = 3.0\text{ Adc}$ , $I_B = 0.3\text{ Adc}$ )<br>( $I_C = 3.0\text{ Adc}$ , $I_B = 0.4\text{ Adc}$ , $T_C = 100^\circ\text{C}$ )<br>( $I_C = 3.0\text{ Adc}$ , $I_B = 0.3\text{ Adc}$ , $T_C = 100^\circ\text{C}$ ) | MJE16002<br>MJE16004<br>MJE16002<br>MJE16004<br>MJE16002<br>MJE16004 | $V_{CE(sat)}$ | —<br>—<br>—<br>—<br>—<br>— | —<br>—<br>—<br>—<br>—<br>— | 1.0<br>1.0<br>2.5<br>2.5<br>2.5<br>2.5 | Vdc |
| Base–Emitter Saturation Voltage<br>( $I_C = 3.0\text{ Adc}$ , $I_B = 0.4\text{ Adc}$ )<br>( $I_C = 3.0\text{ Adc}$ , $I_B = 0.3\text{ Adc}$ )<br>( $I_C = 3.0\text{ Adc}$ , $I_S = 0.4\text{ Adc}$ , $T_C = 100^\circ\text{C}$ )<br>( $I_C = 3.0\text{ Adc}$ , $I_B = 0.3\text{ Adc}$ , $T_C = 100^\circ\text{C}$ )   | MJE16002<br>MJE16004<br>MJE16002<br>MJE16004                         | $V_{BE(sat)}$ | —<br>—<br>—<br>—           | —<br>—<br>—<br>—           | 1.5<br>1.5<br>1.5<br>1.5               | Vdc |
| DC Current Gain<br>( $I_C = 5.0\text{ Adc}$ , $V_{CE} = 5.0\text{ Vdc}$ )   | MJE16002<br>MJE16004   | $h_{FE}$      | 5.0<br>7.0                 | —<br>—                     | —<br>—                                 | —   |

**DYNAMIC CHARACTERISTICS**

|  |          |   |   |     |    |
|--|----------|---|---|-----|----|
| Output Capacitance<br>( $V_{CB} = 10\text{ Vdc}$ , $I_E = 0$ , $f_{test} = 1.0\text{ kHz}$ ) | $C_{ob}$ | — | — | 200 | pF |
|--|----------|---|---|-----|----|

**SWITCHING CHARACTERISTICS**

| Resistive Load (Table 1) |   | MJE16002/MJH10002                                     |       |                                  |      |      |    |   |
|--------------------------|---|---|-------|----------------------------------|------|------|----|---|
| Delay Time               | $I_C = 3.0\text{ Adc}$ ,<br>$V_{CC} = 250\text{ Vdc}$ ,<br>$I_{B1} = 0.4\text{ Adc}$ ,<br>$PW = 30\ \mu\text{s}$ ,<br>Duty Cycle $\leq 2.0\%$ | $I_{B2} = 0.8\text{ Adc}$ ,<br>$R_{B2} = 8.0\ \Omega$ | $t_d$ | —                                | 30   | 100  | ns |   |
| Rise Time                |   |   |       | —                                | 100  | 300  |    |   |
| Storage Time             |   |   |       | —                                | 1000 | 3000 |    |   |
| Fall Time                |   |   |       | —                                | 60   | 300  |    |   |
| Storage Time             |   |   |       | $(V_{BE(off)} = 5.0\text{ Vdc})$ | —    | 400  |    | — |
| Fall Time                |   |   |       |                                  | —    | 130  |    | — |
| Resistive Load (Table 1) |   | MJE16004/MJH16004                                     |       |                                  |      |      |    |   |
| Delay Time               | $I_C = 3.0\text{ Adc}$ ,<br>$V_{CC} = 250\text{ Vdc}$ ,<br>$I_{B1} = 0.3\text{ Adc}$ ,<br>$PW = 30\ \mu\text{s}$ ,<br>Duty Cycle $\leq 2.0\%$ | $I_{B2} = 0.6\text{ Adc}$ ,<br>$R_{B2} = 8.0\ \Omega$ | $t_d$ | —                                | 30   | 100  | ns |   |
| Rise Time                |   |   |       | —                                | 130  | 300  |    |   |
| Storage Time             |   |   |       | —                                | 800  | 2700 |    |   |
| Fall Time                |   |   |       | —                                | 80   | 350  |    |   |
| Storage Time             |   |   |       | $(V_{BE(off)} = 5.0\text{ Vdc})$ | —    | 250  |    | — |
| Fall Time                |   |   |       |                                  | —    | 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                             | $I_C = 3.0 \text{ Adc},$<br>$I_{B1} = 0.4 \text{ Adc},$<br>$V_{BE(off)} = 5.0 \text{ Vdc},$<br>$V_{CE(pk)} = 400 \text{ Vdc}$ | $(T_J = 100^\circ\text{C})$ | $t_{sv}$ | —   | 500 | 1600 | ns |
| Fall Time                                |   |                             | $t_{fi}$ | —   | 100 | 200  |    |
| Crossover Time                           |   |                             | $t_c$    | —   | 120 | 250  |    |
| Storage Time                             |   | $(T_J = 150^\circ\text{C})$ | $t_{sv}$ | —   | 600 | —    |    |
| Fall Time                                |   |                             | $t_{fi}$ | —   | 120 | —    |    |
| Crossover Time                           |   |                             | $t_c$    | —   | 160 | —    |    |
| <b>Inductive Load (Table 2) MJE16004</b> |   |                             |          |     |     |      |    |
| Storage Time                             | $I_C = 3.0 \text{ Adc},$<br>$I_{B1} = 0.3 \text{ Adc},$<br>$V_{BE(off)} = 5.0 \text{ Vdc},$<br>$V_{CE(pk)} = 400 \text{ Vdc}$ | $(T_J = 100^\circ\text{C})$ | $t_{sv}$ | —   | 400 | 1300 | ns |
| Fall Time                                |   |                             | $t_{fi}$ | —   | 80  | 150  |    |
| Crossover Time                           |   |                             | $t_c$    | —   | 90  | 200  |    |
| Storage Time                             |   | $(T_J = 150^\circ\text{C})$ | $t_{sv}$ | —   | 450 | —    |    |
| Fall Time                                |   |                             | $t_{fi}$ | —   | 100 | —    |    |
| Crossover Time                           |   |                             | $t_c$    | —   | 110 | —    |    |

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

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

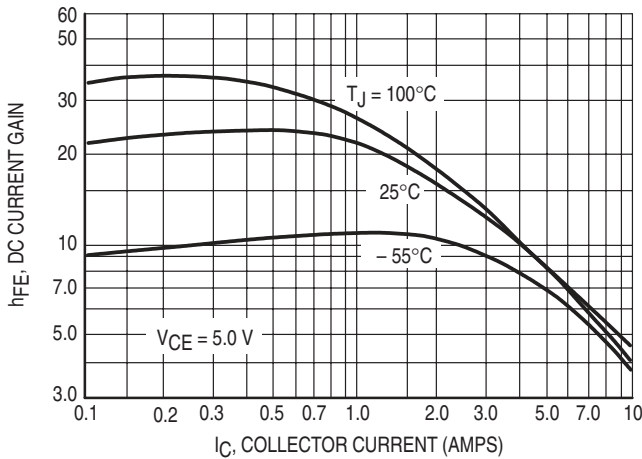


Figure 1. DC Current Gain

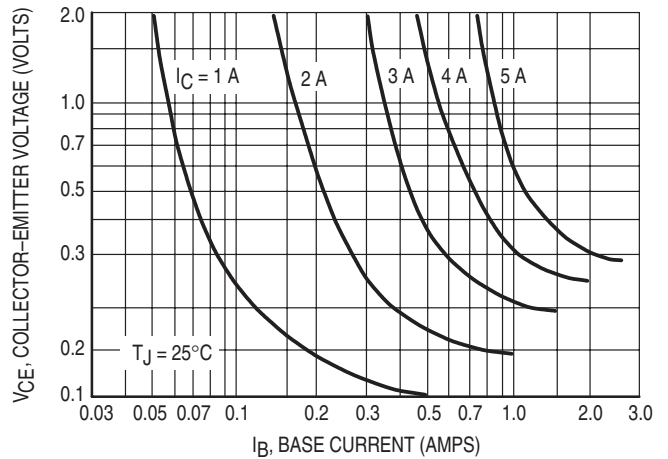


Figure 2. Collector Saturation Region

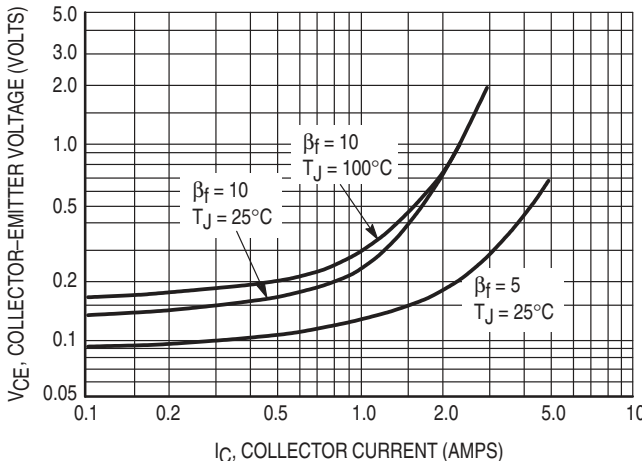


Figure 3. Collector-Emitter Saturation Region

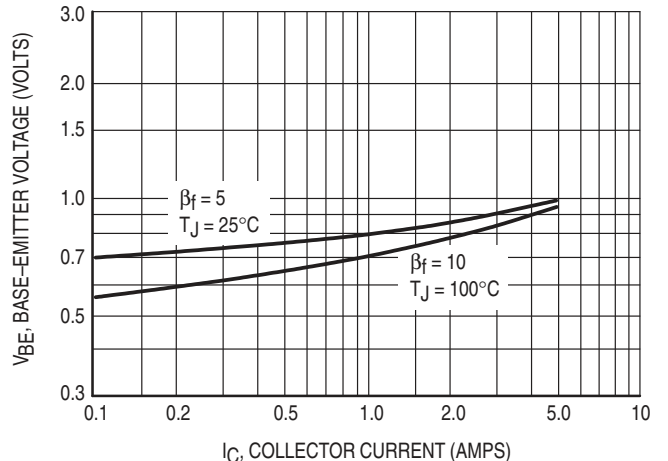


Figure 4. Base-Emitter Voltage

TYPICAL STATIC CHARACTERISTICS (continued)

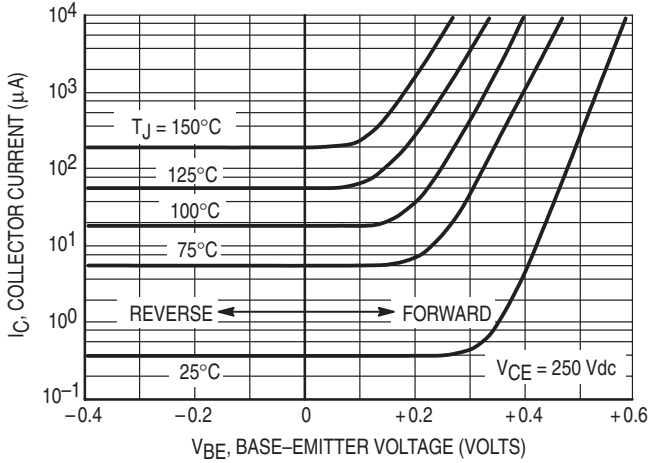


Figure 5. Collector Cutoff Region

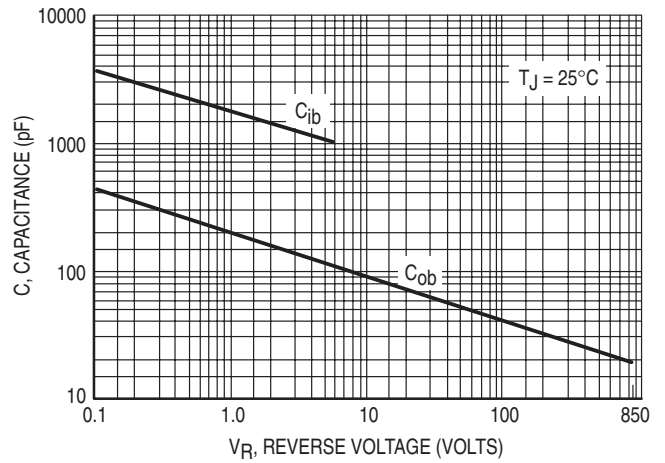


Figure 6. Capacitance

TYPICAL DYNAMIC CHARACTERISTICS

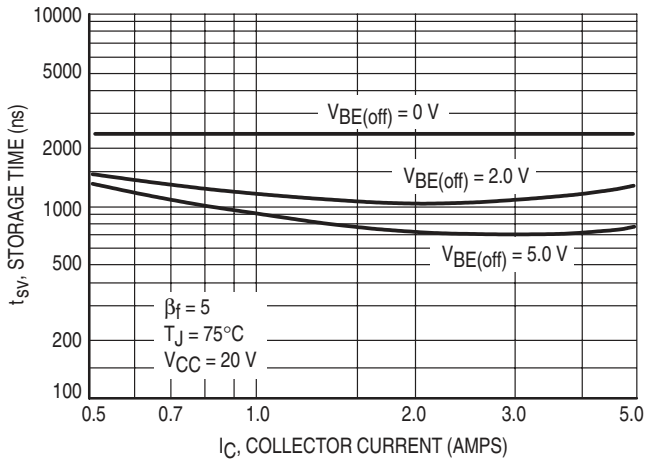


Figure 7. Storage Time

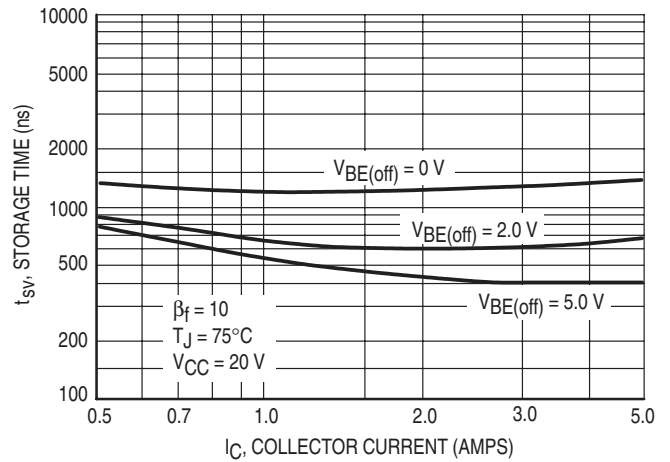


Figure 8. Storage Time

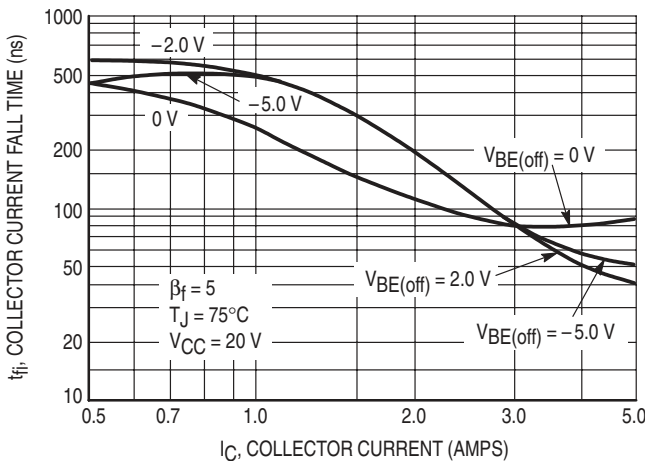


Figure 9. Collector Current Fall Time

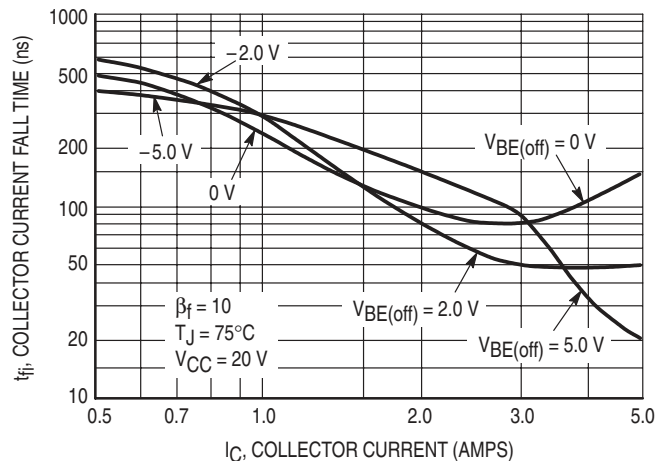


Figure 10. Collector Current Fall Time

TYPICAL DYNAMIC CHARACTERISTICS (continued)

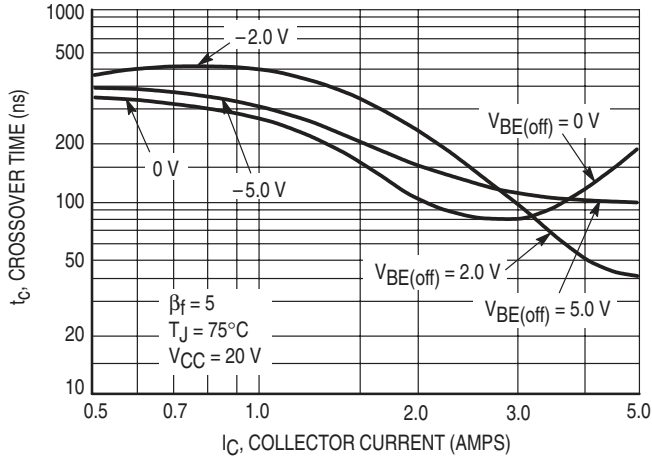


Figure 11. Crossover Time

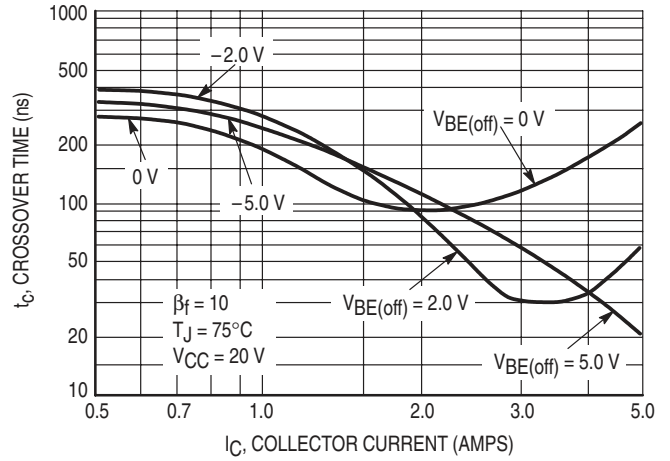


Figure 12. Crossover Time

TYPICAL ELECTRICAL CHARACTERISTICS

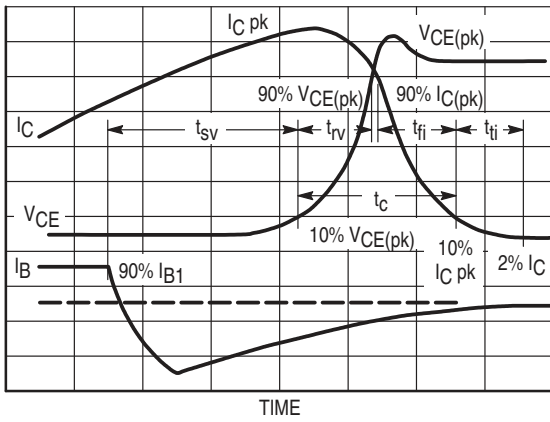


Figure 13. Inductive Switching Measurements

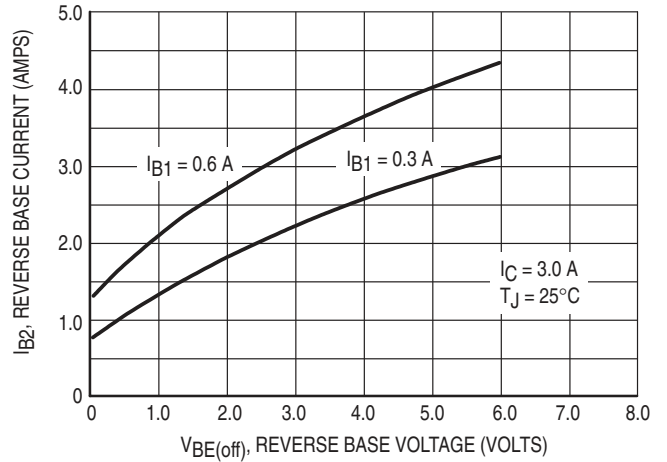


Figure 14. Peak Reverse Base Current

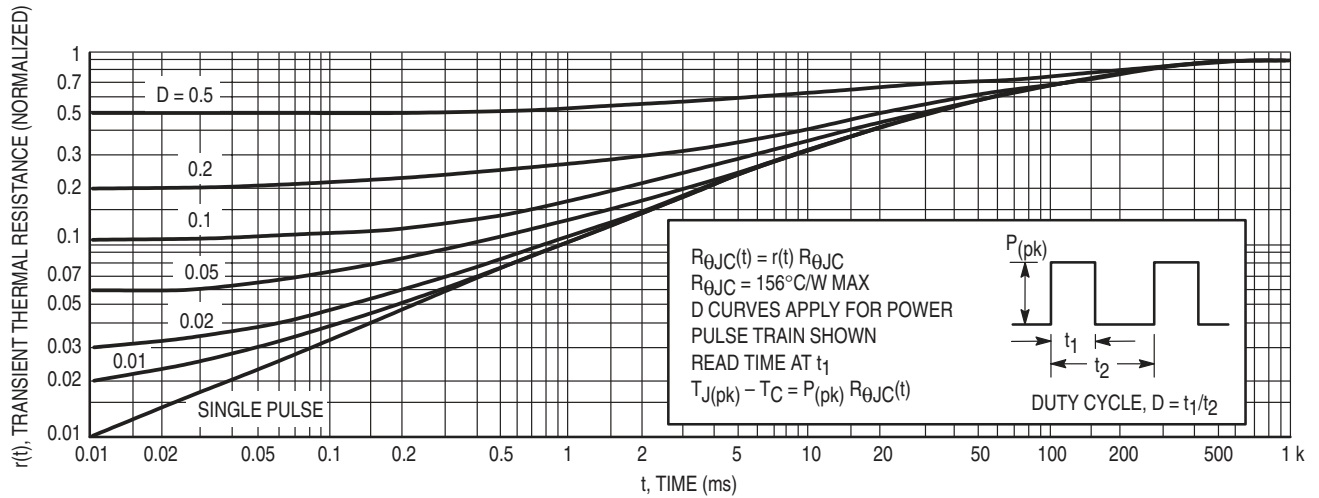


Figure 15. Thermal Response (MJE16002 and MJE16004)

SAFE OPERATING AREA INFORMATION

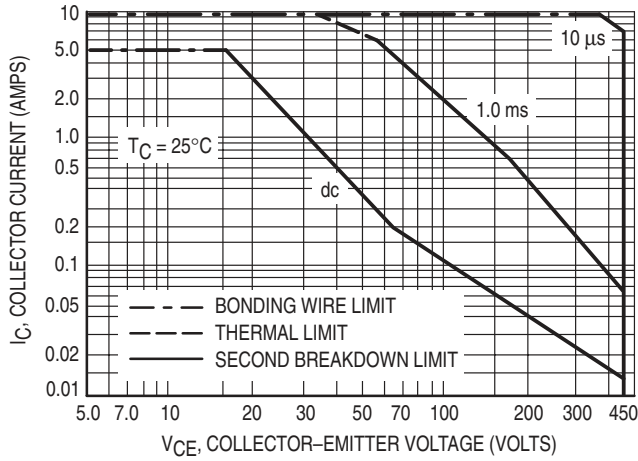


Figure 16. Maximum Rated Forward Bias Safe Operating Area (MJE16002 and MJE16004)

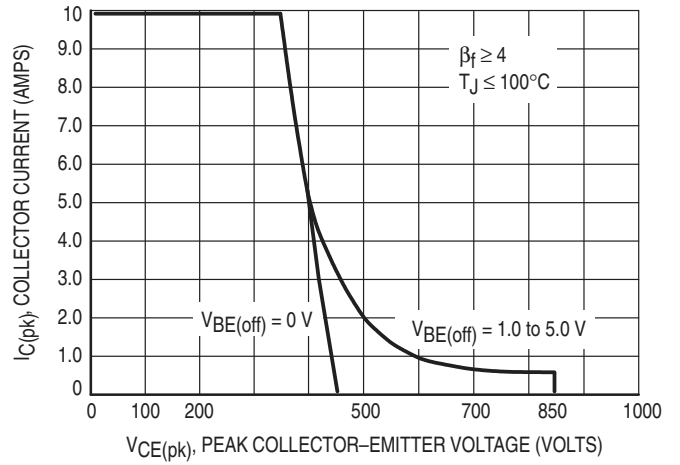


Figure 17. Maximum Rated Reverse Bias Safe Operating Area

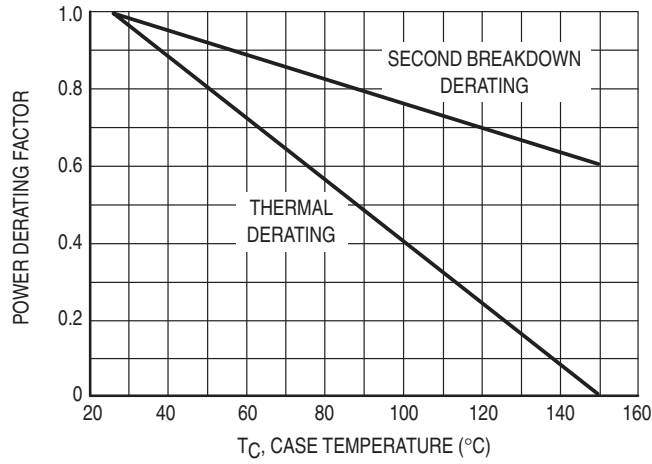


Figure 18. Power Derating

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.

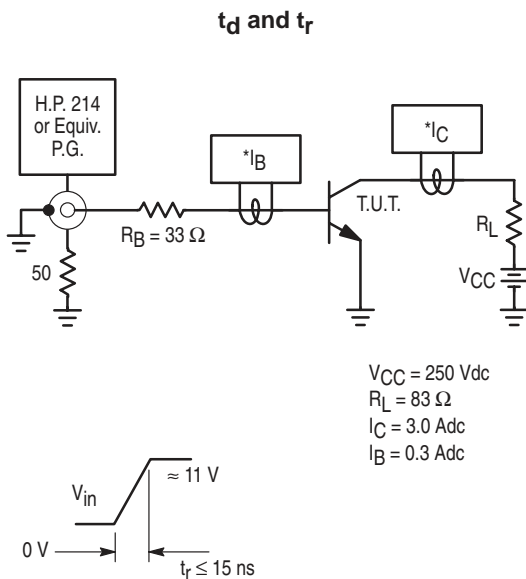
$T_{J(pk)}$  may be calculated from the data in Figure 15. At high case temperatures, thermal limitations will reduce the

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

REVERSE BIAS

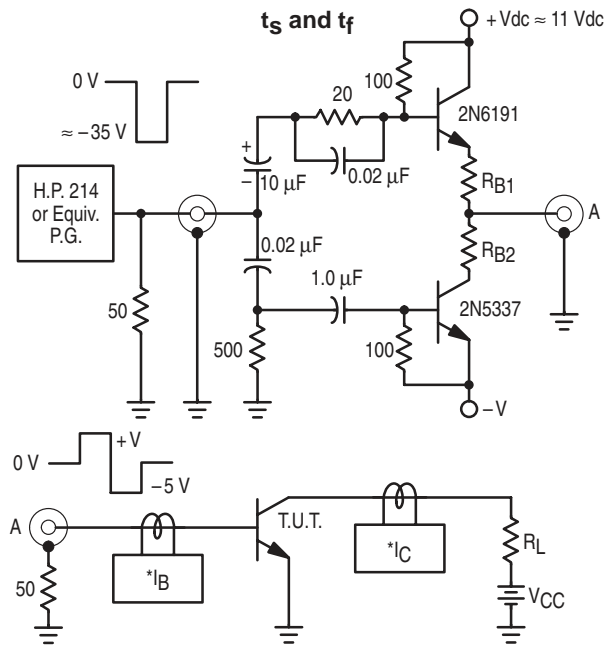
For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base-to-emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be 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



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

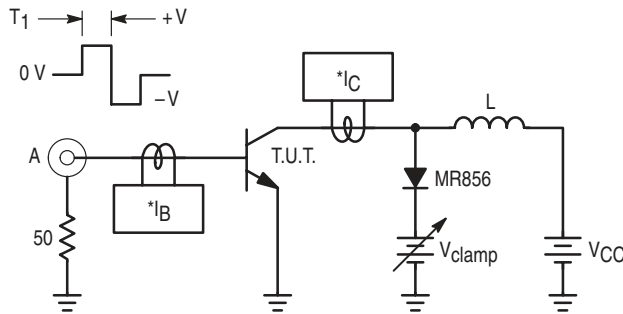
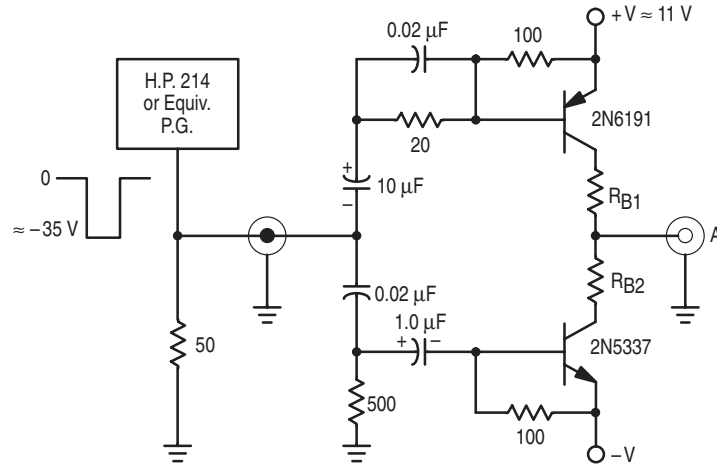
\*Tektronix  
 P-6042 or  
 Equivalent



$V_{CC} = 250$       $I_{B1} = 0.3\text{ Adc}$       $R_{B1} = 33\ \Omega$   
 $R_L = 83\ \Omega$       $I_{B2} = 0.6\text{ Adc}$       $R_{B2} = 8.0\ \Omega$   
 $I_C = 3.0\text{ Adc}$      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>

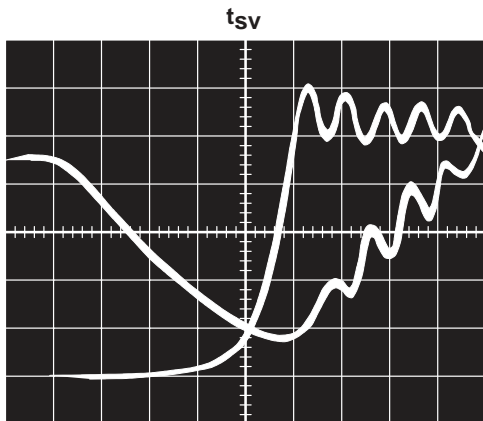
Scope — Tektronix  
7403 or  
Equivalent

**RBSOA**

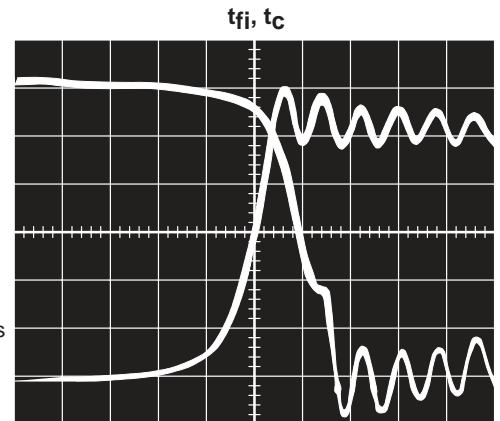
L = 200 μH  
R<sub>B2</sub> = 0  
V<sub>CC</sub> = 20 Volts  
R<sub>B1</sub> selected for desired I<sub>B1</sub>

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

**TYPICAL INDUCTIVE SWITCHING WAVEFORMS**



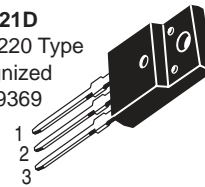
I<sub>C(pk)</sub> = 3.0 Amps  
I<sub>B1</sub> = 0.3 Amp  
V<sub>BE(off)</sub> = 5.0 Volts  
V<sub>CE(pk)</sub> = 300 Volts  
T<sub>C</sub> = 25°C  
Time Base =  
20 ns/cm



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

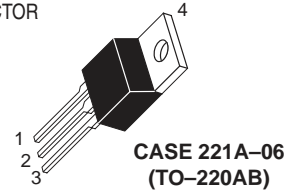


Table 2. Plastic TO-220AB

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

Devices listed in bold, italic are Motorola preferred devices.

Table 2. Plastic TO-220AB (continued)

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

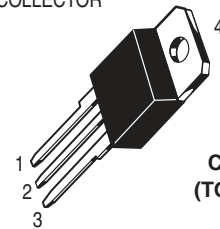
Devices listed in bold, italic are Motorola preferred devices.

Table 2. Plastic TO-220AB (continued)

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

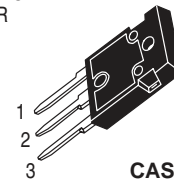
| I <sub>C</sub> Cont<br>Amps<br>Max | V <sub>CEO(sus)</sub><br>Volts<br>Min <sup>(8)</sup> | Device Type                   |                               | h <sub>FE</sub><br>Min/Max | @ I <sub>C</sub><br>Amp | Resistive Switching         |                             |                         | f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

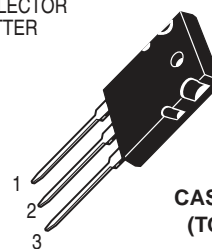
<sup>(3)</sup>Switching tests performed w/special application simulator circuit. See data sheet for details.

<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)

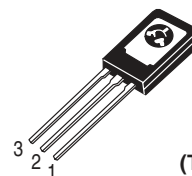
Table 5. Large Plastic TO-264

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

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

<sup>(2)</sup> Darlington

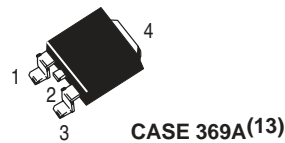
<sup>(11)</sup> Case 77, Style 3

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

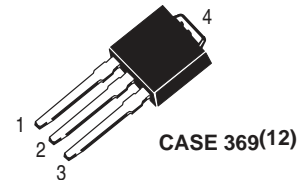


Table 7. DPAK – Surface Mount Power Packages

| I <sub>C</sub> Cont<br>Amps<br>Max | V <sub>CEO(sus)</sub><br>Volts<br>Min | Device Type     |                | h <sub>FE</sub><br>Min/Max | @ I <sub>C</sub><br>Amp | Resistive Switching         |                             |                         | f <sub>T</sub><br>MHz<br>Min | P <sub>D</sub><br>(Case)<br>Watts<br>@ 25°C |
|------------------------------------|---------------------------------------|-----------------|----------------|----------------------------|-------------------------|-----------------------------|-----------------------------|-------------------------|------------------------------|---|
|                                    |                                       | NPN             | PNP            |                            |                         | t <sub>s</sub><br>μs<br>Max | t <sub>f</sub><br>μs<br>Max | @ I <sub>C</sub><br>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)|h<sub>FE</sub>| @ 1 MHz

(2)Darlington

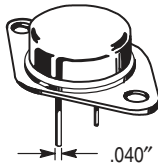
(12)Case 369–07 may be ordered by adding –1 suffix to part number.

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

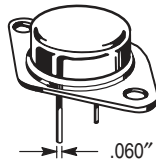
Devices listed in bold, italic are Motorola preferred devices.

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

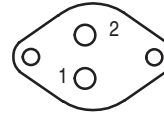
| I <sub>C</sub> Cont<br>Amps<br>Max | V <sub>CEO(sus)</sub><br>Volts<br>Min | Device Type        |                    | h <sub>FE</sub><br>Min/Max | @ I <sub>C</sub><br>Amp | Resistive Switching         |                             |                         | f <sub>T</sub><br>MHz<br>Min | P <sub>D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

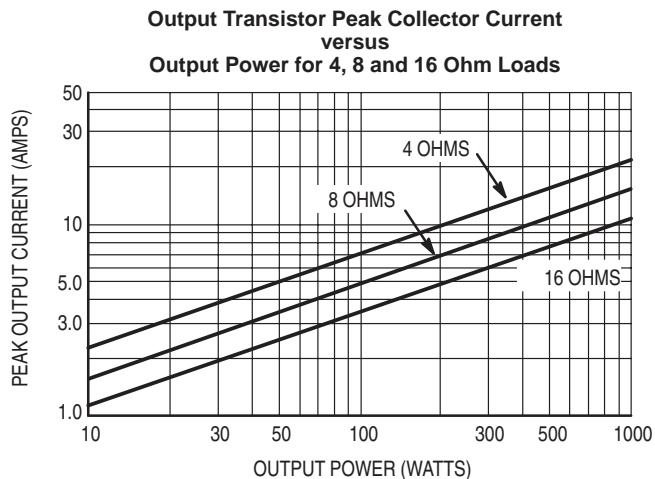
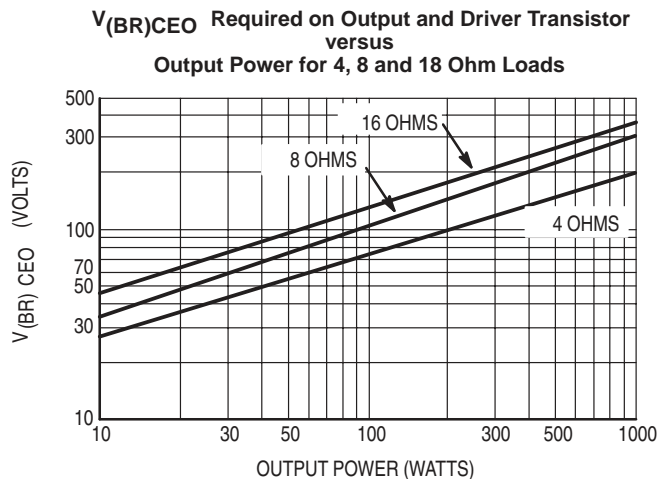
(8) When 2 voltages are given, the format is V<sub>CEO(sus)</sub>/V<sub>CES</sub>.

(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          |

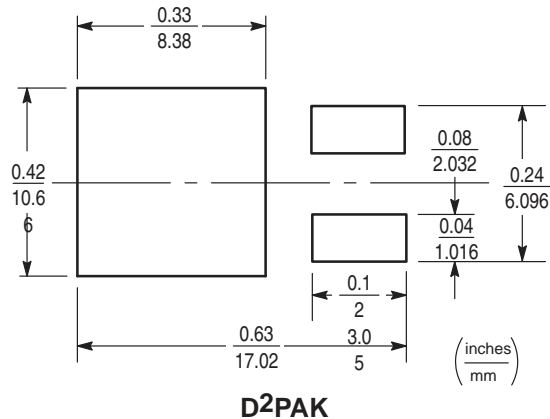
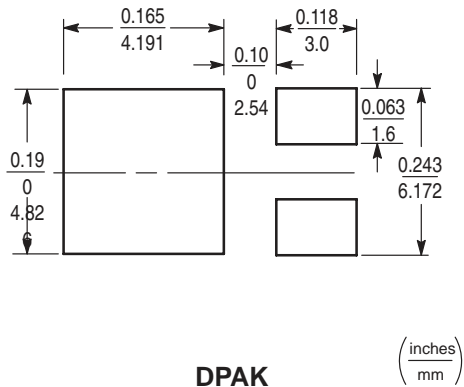
The Power Transistors shown are provided for reference only and show device capability. The final choice of the Power Transistors used is left to the circuit designer and depends upon the particular safe-operating area required and the mounting and heat sinking configuration used.

# 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.



## 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.

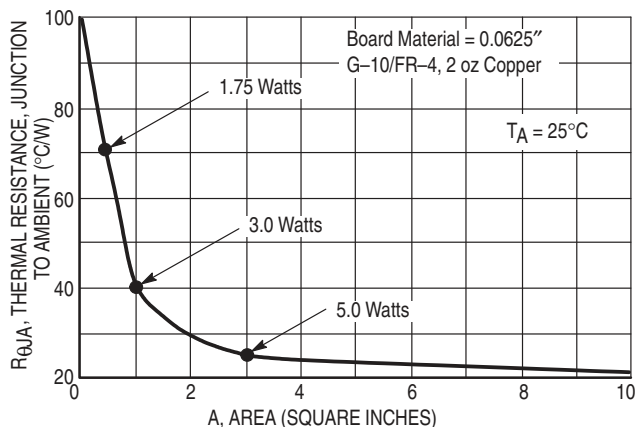


Figure 1. Thermal Resistance versus Drain Pad Area for the DPAK Package (Typical)

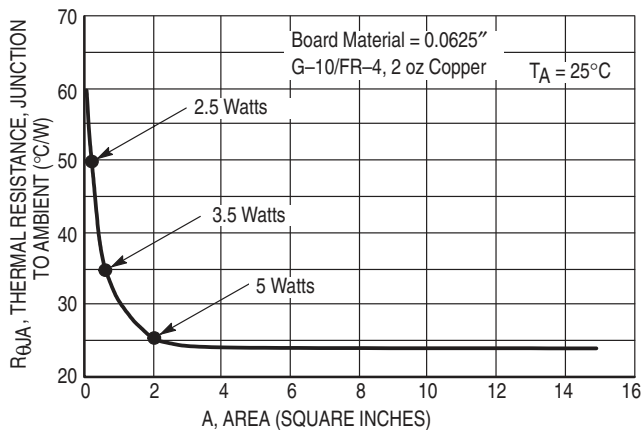
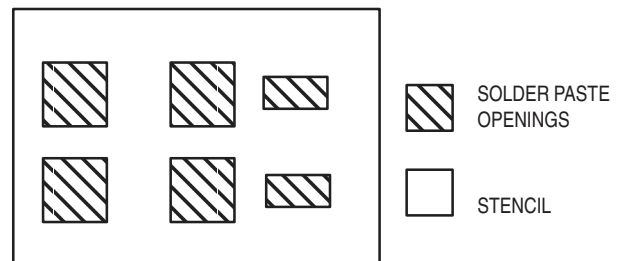


Figure 2. Thermal Resistance versus Drain Pad Area for the D2PAK Package (Typical)

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.

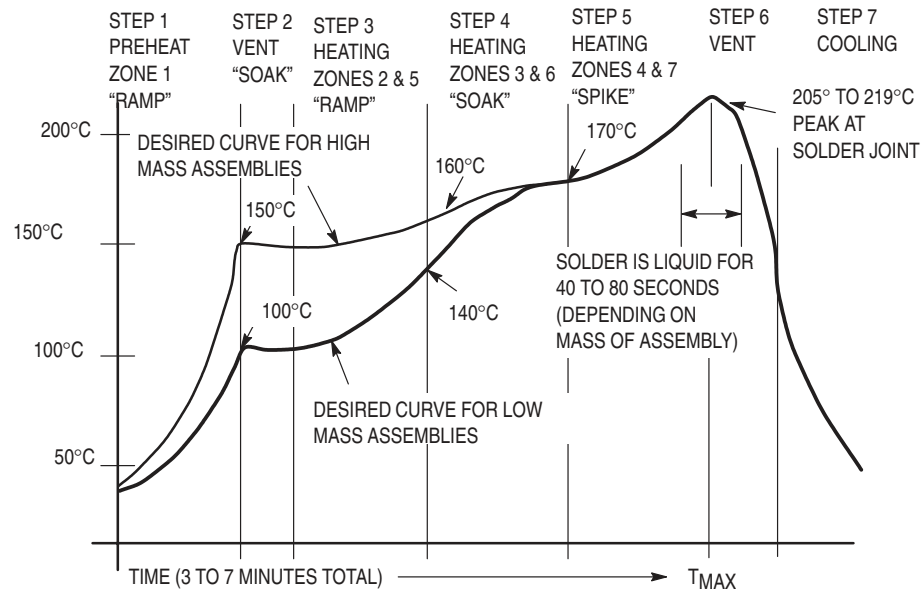


Figure 4. Typical Solder Heating Profile

# 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

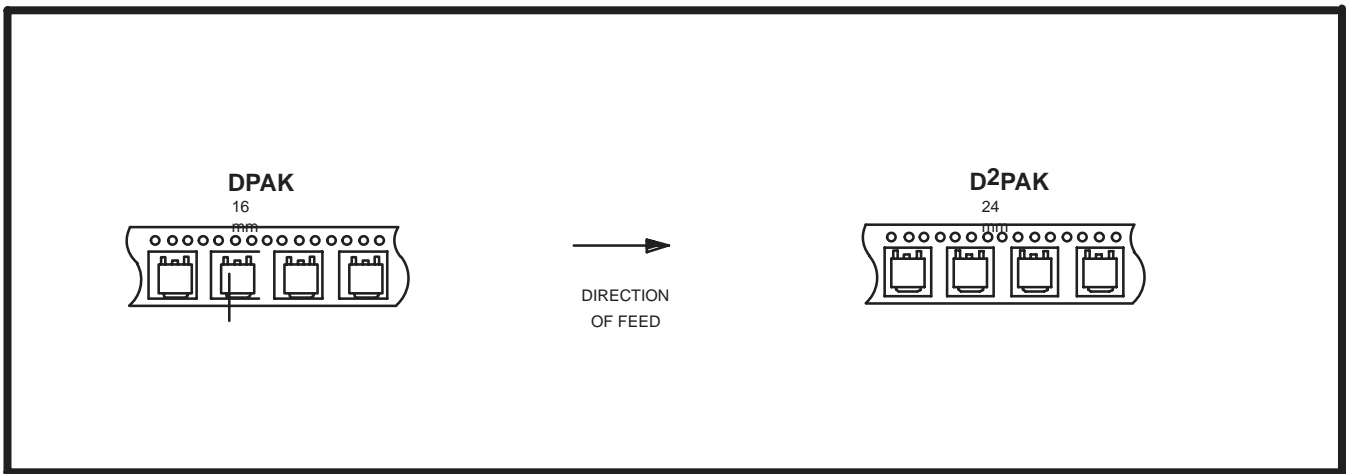
Wakefield Engineering, Inc., Wakefield, Massachusetts 01880 (617) 245-5900

# 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.

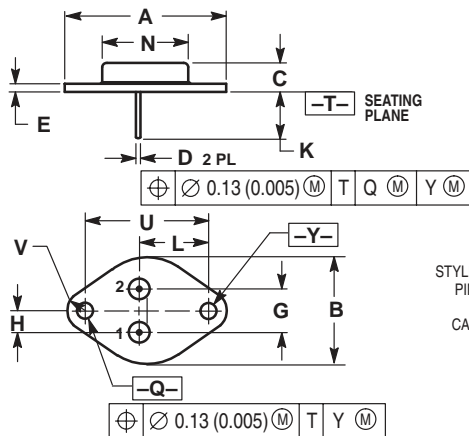
- Two Reel Sizes Available (7” and 13”)
- Used for Automatic Pick and Place Feed Systems
- Minimizes Product Handling
- EIA 481, -1, -2
- DPAK SO-14, in 16 mm Tape
- D<sup>2</sup>PAK in 24 mm Tape

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

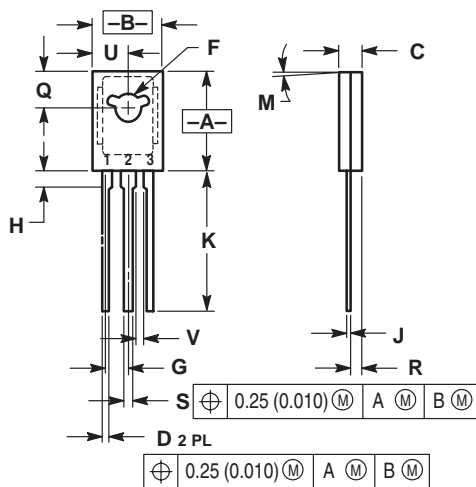


STYLE 1:  
PIN 1: BASE  
2: EMITTER  
CASE: COLLECTOR

- 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)**

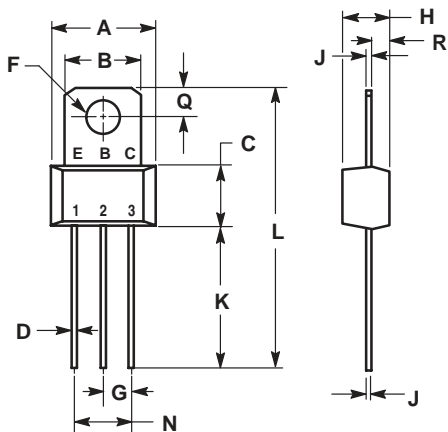


STYLE 1:  
PIN 1: EMITTER  
2: COLLECTOR  
3: BASE

- 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)**



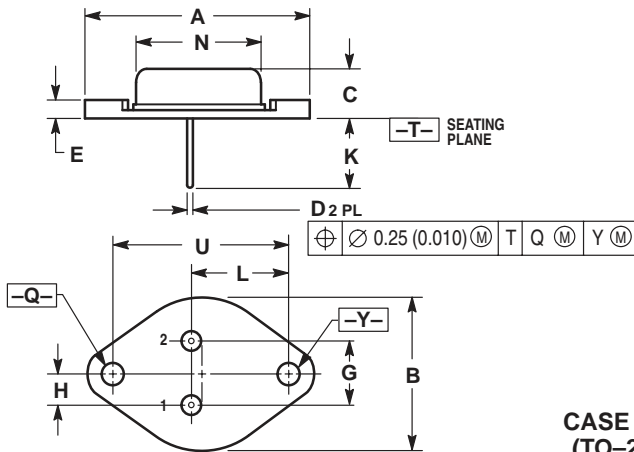
STYLE 1:  
PIN 1: EMITTER  
2: BASE  
3: COLLECTOR  
(COLLECTOR CONNECTED TO TAB)

- 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)

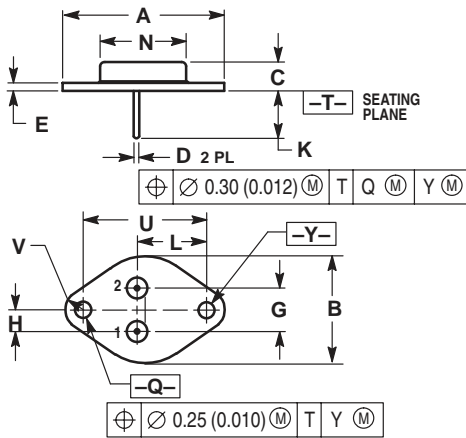


STYLE 1:  
PIN 1: BASE  
2: EMITTER  
CASE: COLLECTOR

**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 |

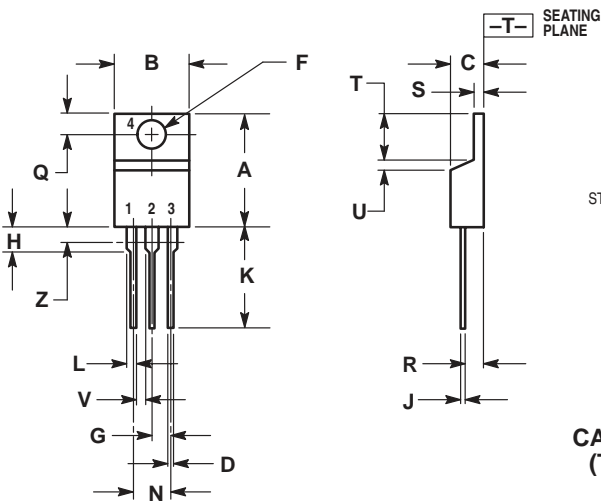


STYLE 1:  
PIN 1: BASE  
2: EMITTER  
CASE: COLLECTOR

**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

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-  
-Y-

**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-  
-Y-

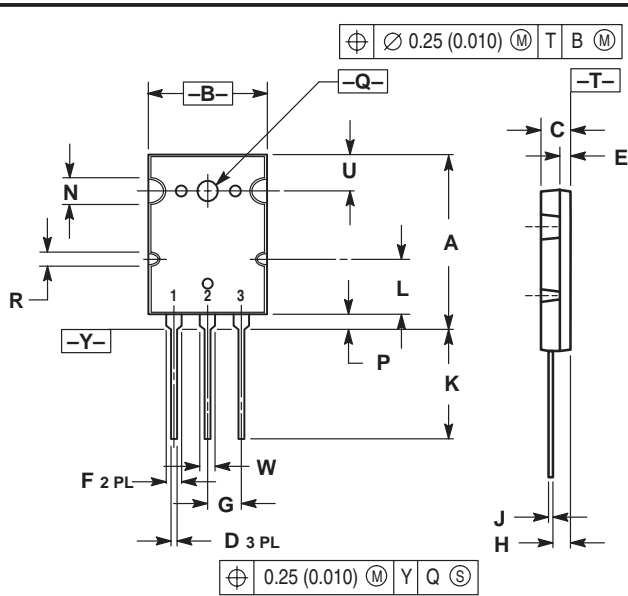
⊕ 0.25 (0.010) M T B M Y Q S

**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)

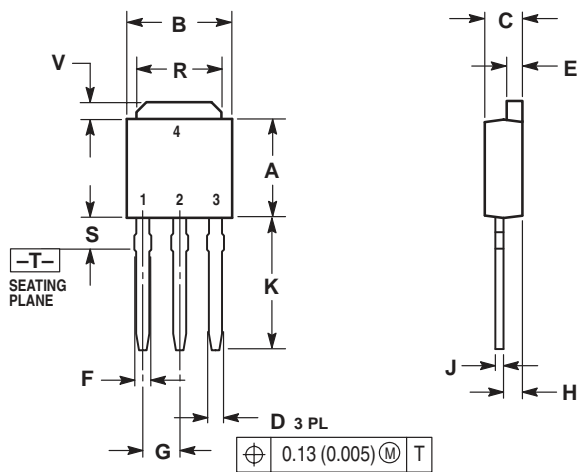


**CASE 340G-02  
(TO-3PBL)**

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 |

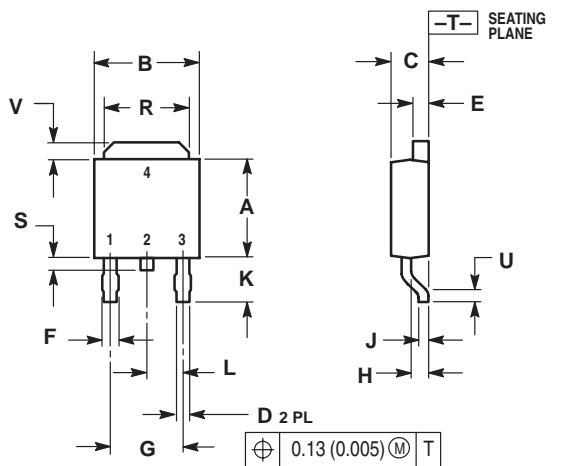


**CASE 369-07**

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**

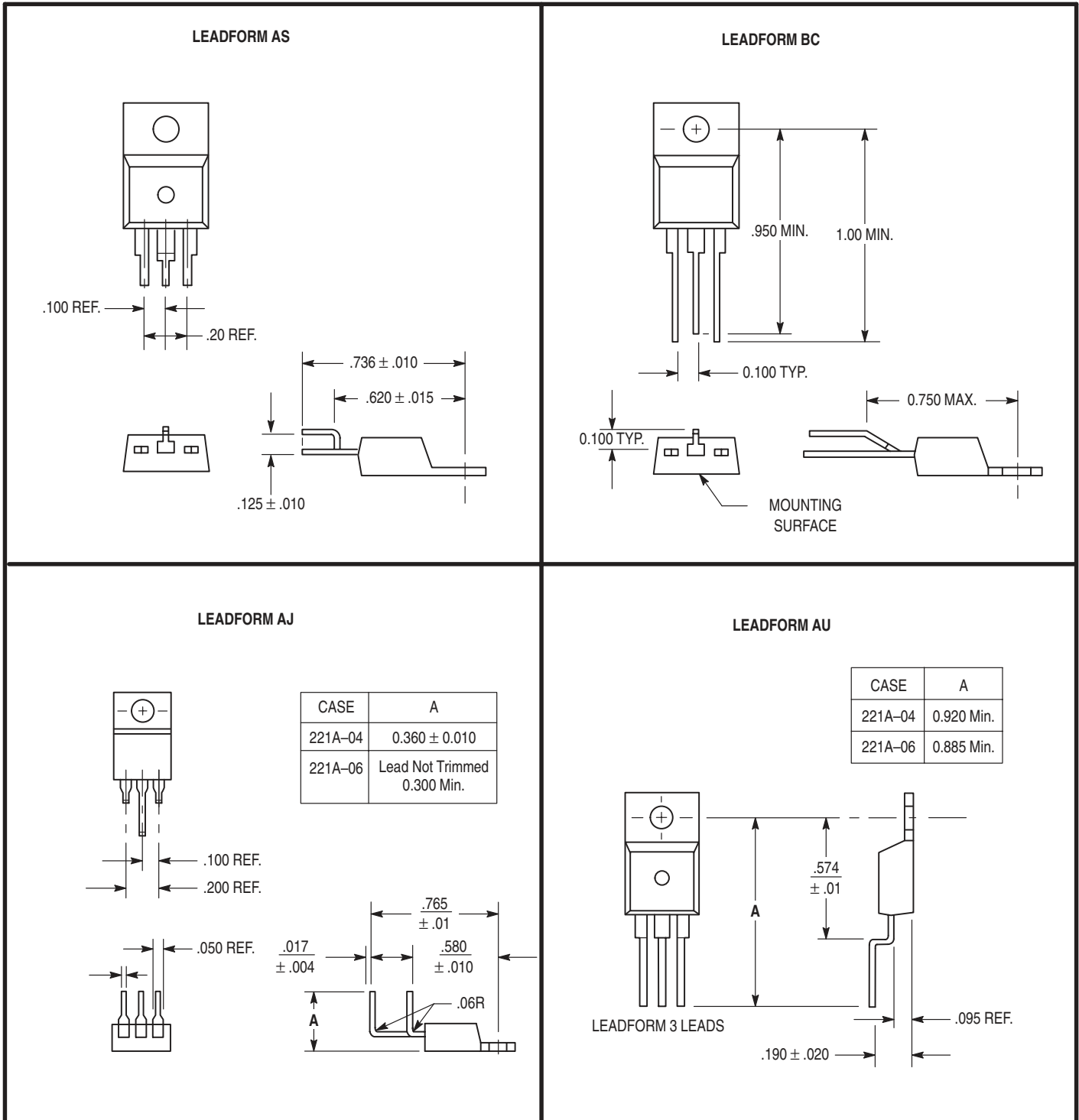
STYLE 1:  
PIN 1. BASE  
2. COLLECTOR  
3. EMITTER  
4. COLLECTOR

- 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)

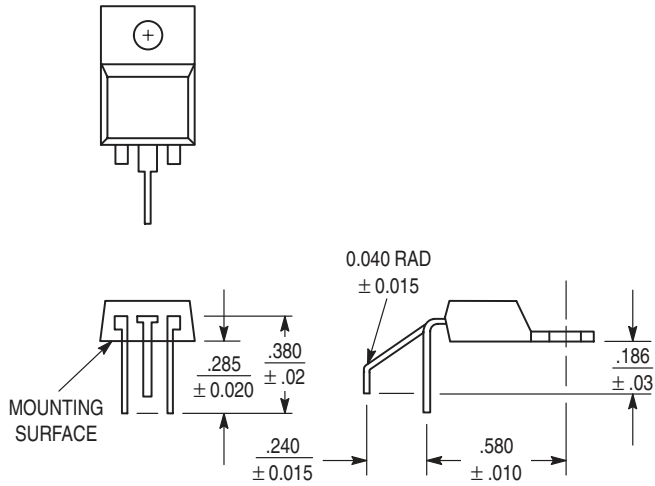
- Leadform options require assignment of a special part number before ordering.
- Contact your local Motorola representative for special part number and pricing.
- 10,000 piece minimum quantity orders are required.
- Leadform orders are non-cancellable after processing.
- Leadforms apply to both Motorola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



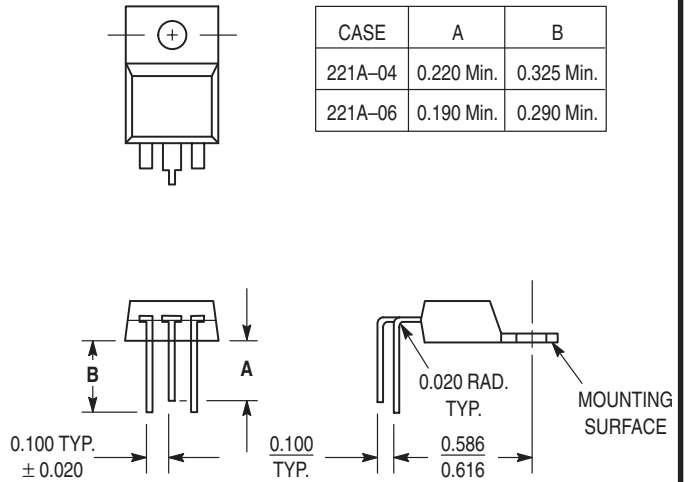


# TO-220 Leadform Options (continued)

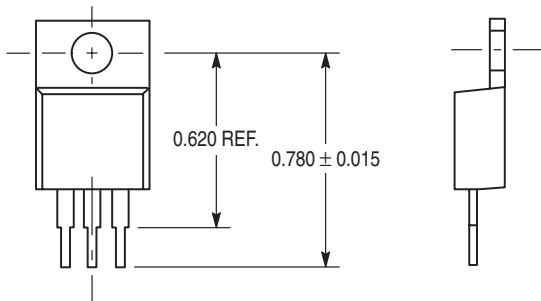
**LEADFORM AN**



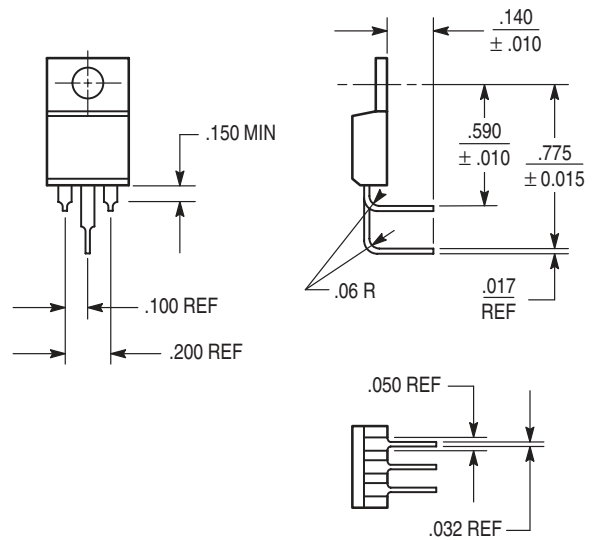
**LEADFORM BA**



**LEADFORM BG**

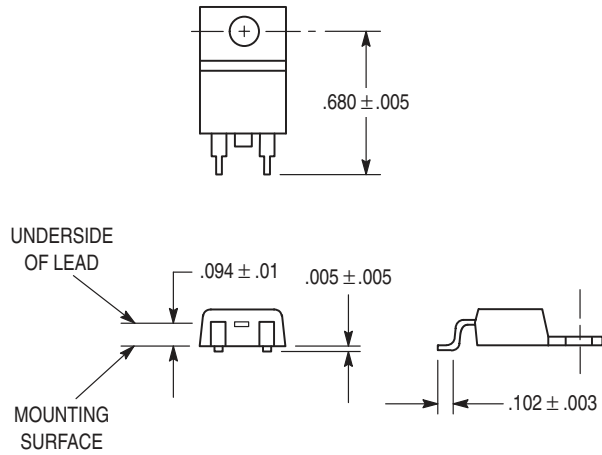


**LEADFORM AK**

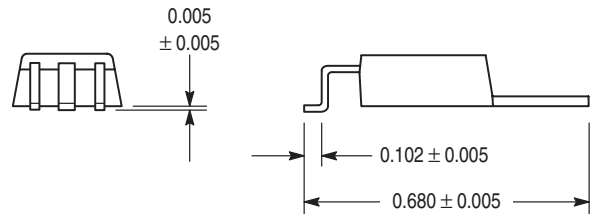


# TO-220 Leadform Options (continued)

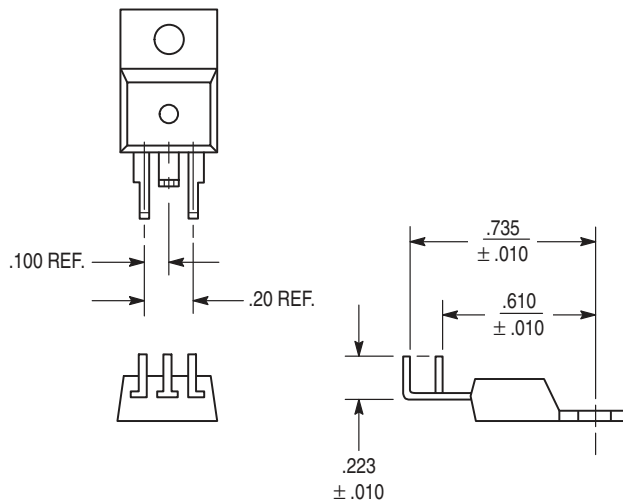
LEADFORM BU



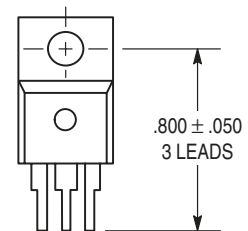
LEADFORM BV



LEADFORM BD

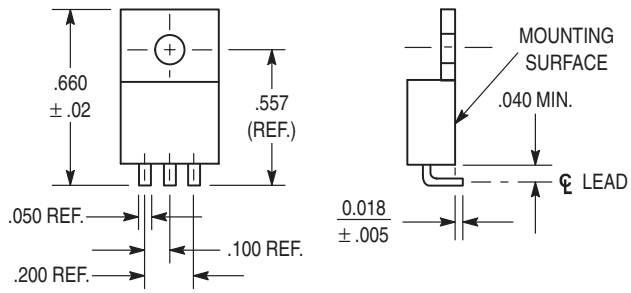


LEADFORM DW

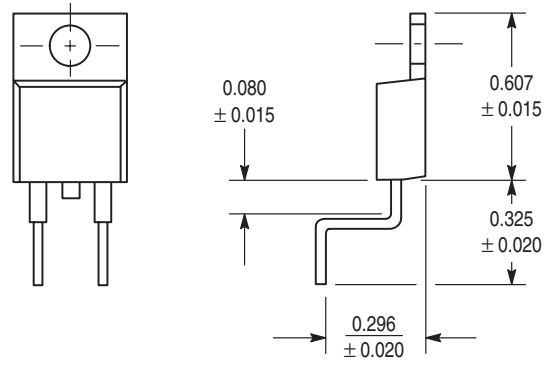


# TO-220 Leadform Options (continued)

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 |
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| 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       |
| 2N3055A              | 2N3055A                      |                              | 3-5         | 2N4111               |                              | 2N3716                       | 3-12        |

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| 2N4901               |                              | MJ15016                      | 3-5         |
| 2N4902               |                              | MJ15016                      | 3-5         |
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| 2N4906               |                              | MJ15016                      | 3-5         |
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| 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        |
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| 2N5190               | 2N5191                       |                              | 3-44        |
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| 2N5192               | 2N5192                       |                              | 3-44        |
| 2N5193               | 2N5194                       |                              | 3-49        |
| 2N5194               | 2N5194                       |                              | 3-49        |
| 2N5195               | 2N5195                       |                              | 3-49        |
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| 2N5241               |                              | BUX48A                       | 3-401       |
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| 2N5294               |                              | TIP31B                       | 3-873       |
| 2N5295               |                              | TIP31B                       | 3-873       |
| 2N5296               |                              | TIP31B                       | 3-873       |
| 2N5297               |                              | TIP31B                       | 3-873       |
| 2N5298               |                              | TIP31B                       | 3-873       |
| 2N5301               | 2N5302                       |                              | 3-54        |
| 2N5302               | 2N5302                       |                              | 3-54        |
| 2N5303               | 2N5303                       |                              | 3-54        |
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| 2N5490               |                              | MJE3055T                     | 3-628       |
| 2N5491               |                              | MJE3055T                     | 3-628       |
| 2N5492               |                              | 2N6292                       | 3-101       |
| 2N5493               |                              | 2N6292                       | 3-101       |
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| Industry Part Number | Motorola Nearest Replacement | Motorola Similar Replacement | Page Number |
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| 2N5630               | 2N5631                       |                              | 3-59        |
| 2N5631               | 2N5631                       |                              | 3-59        |
| 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        |
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| 2N5733               |                              | 2N6274                       | 3-108       |
| 2N5734               |                              | 2N6338                       | 3-117       |
| 2N5737               |                              | 2N5878                       | 3-74        |
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| 2N5742               |                              | 2N6031                       | 3-59        |
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