

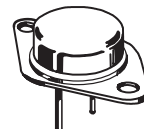
BUV23

SWITCHMODE Series NPN Silicon Power Transistor

... designed for high current, high speed, high power applications.

- High DC current gain: HFE min. = 15 at $I_C = 8$ A
- Low $V_{CE(sat)}$, $V_{CE(sat)}$ max. = 0.8 V at $I_C = 8$ A
- Very fast switching times:
 $T_F = 0.4 \mu s$ at $I_C = 16$ A

**30 AMPERES
NPN SILICON
POWER
METAL TRANSISTOR
325 VOLTS
250 WATTS**



**CASE 197A-05
TO-204AE
(TO-3)**

MAXIMUM RATINGS

| Rating | Symbol | Value | Unit |
|---|----------------|------------|------------|
| Collector-Emitter Voltage | $V_{CEO(sus)}$ | 325 | Vdc |
| Collector-Base Voltage | V_{CBO} | 400 | Vdc |
| Emitter-Base Voltage | V_{EBO} | 7 | Vdc |
| Collector-Emitter Voltage ($V_{BE} = -1.5$ V) | V_{CEX} | 400 | Vdc |
| Collector-Emitter Voltage ($R_{BE} = 100 \Omega$) | V_{CER} | 390 | Vdc |
| Collector-Current— Continuous | I_C | 30 | Adc |
| — Peak ($p_w \leq 10$ ms) | I_{CM} | 40 | Apk |
| Base-Current continuous | I_B | 6 | Adc |
| Total Power Dissipation @ $T_C = 25^\circ C$ | P_D | 250 | Watts |
| Operating and Storage Junction Temperature Range | T_J, T_{stg} | -65 to 200 | $^\circ C$ |

THERMAL CHARACTERISTICS

| Characteristic | Symbol | Max | Unit |
|--------------------------------------|---------------|-----|--------------|
| Thermal Resistance, Junction to Case | θ_{JC} | 0.7 | $^\circ C/W$ |

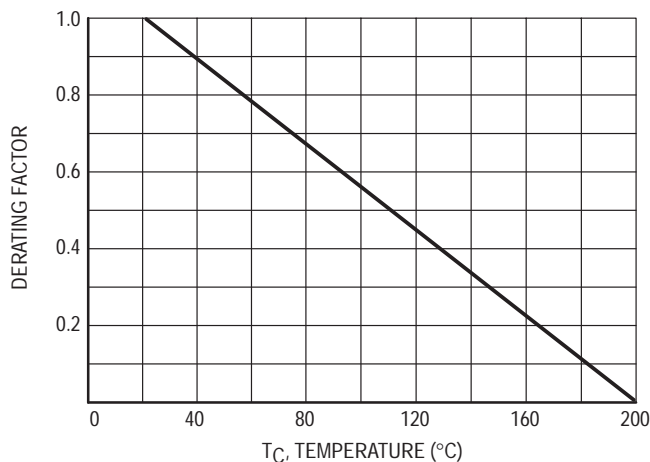


Figure 1. Power Derating

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

| Characteristic | Symbol | Min | Max | Unit |
|--|---------------|-----|-----------|------|
| OFF CHARACTERISTICS¹ | | | | |
| Collector–Emitter Sustaining Voltage ($I_C = 200\text{ mA}$, $I_B = 0$, $L = 25\text{ mH}$) | $V_{CE(sus)}$ | 325 | | Vdc |
| Collector Cutoff Current at Reverse Bias ($V_{CE} = 400\text{ V}$, $V_{BE} = -1.5\text{ V}$) ($V_{CE} = 400\text{ V}$, $V_{BE} = -1.5\text{ V}$, $T_C = 125^\circ\text{C}$) | I_{CEX} | | 3.0 12 | mAdc |
| Collector–Emitter Cutoff Current ($V_{CE} = 260\text{ V}$) | I_{CEO} | | 3.0 | mAdc |
| Emitter–Base Reverse Voltage ($I_E = 50\text{ mA}$) | V_{EBO} | 7 | | V |
| Emitter–Cutoff Current ($V_{EB} = 5\text{ V}$) | I_{EBO} | | 1.0 | mAdc |

SECOND BREAKDOWN

| | | | | |
|--|-----------|------------|--|-----|
| Second Breakdown Collector Current with base forward biased ($V_{CE} = 20\text{ V}$, $t = 1\text{ s}$) ($V_{CE} = 140\text{ V}$, $t = 1\text{ s}$) | $I_{S/b}$ | 12 0.15 | | Adc |
|--|-----------|------------|--|-----|

ON CHARACTERISTICS¹

| | | | | |
|---|---------------|---------|------------|-----|
| DC Current Gain ($I_C = 8\text{ A}$, $V_{CE} = 4\text{ V}$) ($I_C = 16\text{ A}$, $V_{CE} = 4\text{ V}$) | h_{FE} | 15 8 | 60 | |
| Collector–Emitter Saturation Voltage ($I_C = 8\text{ A}$, $I_B = 1.6\text{ A}$) ($I_C = 16\text{ A}$, $I_B = 3.2\text{ A}$) | $V_{CE(sat)}$ | | 0.8 1.0 | Vdc |
| Base–Emitter Saturation Voltage ($I_C = 16\text{ A}$, $I_B = 3.2\text{ A}$) | $V_{BE(sat)}$ | | 1.5 | Vdc |

DYNAMIC CHARACTERISTICS

| | | | | |
|--|-------|-----|--|-----|
| Current Gain — Bandwidth Product ($V_{CE} = 15\text{ V}$, $I_C = 2\text{ A}$, $f = 4\text{ MHz}$) | f_T | 8.0 | | MHz |
|--|-------|-----|--|-----|

SWITCHING CHARACTERISTICS (Resistive Load)

| | | | | |
|--------------|--|----------|-----|---------------|
| Turn–on Time | ($I_C = 16\text{ A}$, $I_{B1} = I_{B2} = 3.2\text{ A}$, $V_{CC} = 100\text{ V}$, $R_C = 6.25\ \Omega$) | t_{on} | 0.8 | μs |
| Storage Time | | t_s | 2.5 | |
| Fall Time | | t_f | 0.4 | |

¹Pulse Test: Pulse Width $\leq 300\ \mu\text{s}$, Duty Cycle $\leq 2\%$.

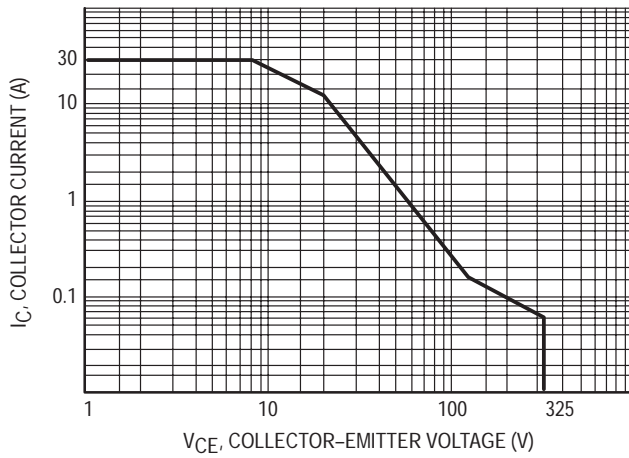


Figure 2. Active Region Safe Operating Area

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 2 is based on $T_C = 25^\circ\text{C}$; $T_{J(pk)}$ is variable depending on power level. Second breakdown limitations do not derate the same as thermal limitations.

At high case temperatures, thermal limitations will reduce the power that can handled to values less than the limitations imposed by second breakdown.

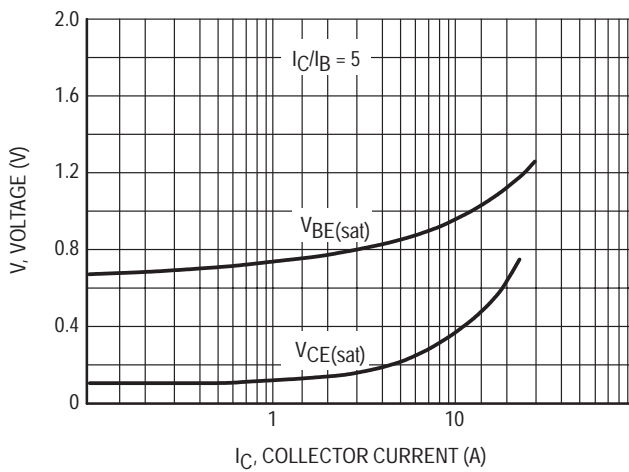


Figure 3. "On" Voltages

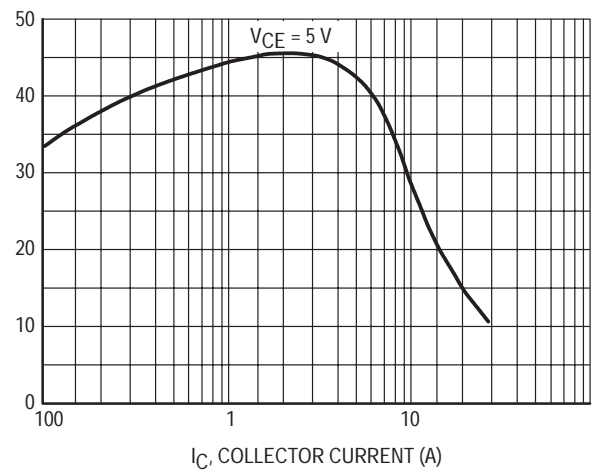


Figure 4. DC Current Gain

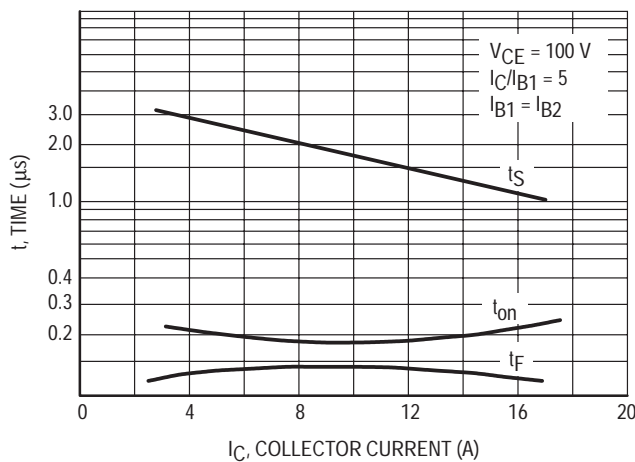
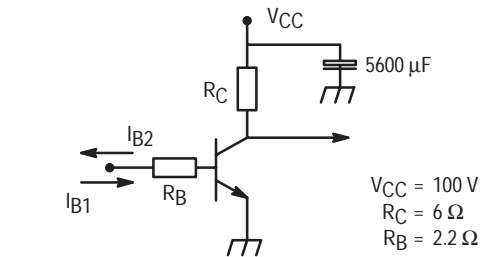


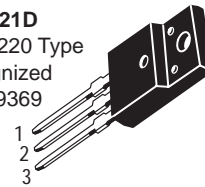
Figure 5. Resistive Switching Performance



$R_C - R_B$: Non inductive resistances

Figure 6. Switching Times Test Circuit

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

(1)|h_{FE}| @ 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

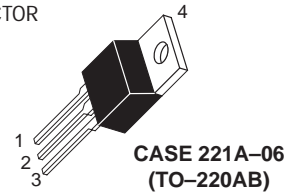


Table 2. Plastic TO-220AB

| I _C Cont Amps Max | V _{CEO(sus)} Volts Min ⁽⁸⁾ | Device Type | | h _{FE} Min/Max | @ I _C Amp | Resistive Switching | | | f _T MHz Min | P _D (Case) Watts @ 25°C |
|------------------------------------|--|-----------------------------|-------------------------------|----------------------------|-------------------------|-----------------------------|-----------------------------|-------------------------|------------------------------|---|
| | | NPN | PNP | | | t _s μs Max | t _f μs Max | @ I _C Amp | | |
| 0.5 | 350 | MJE2360T | | 15 min | 0.1 | | | | 10 typ | 30 |
| | | MJE2361T | | 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 | TIP49 | MJE5731 | 30/150 | 0.3 | 2 typ | 0.18 typ | 0.3 | 10 | 40 |
| | 400 | TIP50 | MJE5731A⁽⁷⁾ | 30/150 | 0.3 | 2 typ | 0.18 typ | 0.3 | 10 | 40 |
| 2 | 100 | TIP112⁽²⁾ | TIP117⁽²⁾ | 500 min | 2 | 1.7 typ | 1.3 typ | 2 | 25 ⁽¹⁾ | 50 |
| | 400/700 | BUL44 | | 14/36 | 0.4 | 2.75 ⁽³⁾ | 0.175 ⁽³⁾ | 1 | 13 typ | 50 |
| | 450/1000 | BUX85 | | 30 | 0.1 | 3.5 | 1.4 | 1 | 4 | 50 |
| | 450/1000 | MJE18002 | | 14/34 | 0.2 | 3 ⁽³⁾ | 0.17 ⁽³⁾ | 1 | 12 typ | 40 |
| | 900/1800 | MJE1320 | | 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 |
| | | TIP31C | TIP32C | 25 min | 1 | 0.6 typ | 0.3 typ | 1 | 3 | 40 |
| | 150 | | MJE9780 | 50/200 | 0.5 | | | | 5 typ | 40 |

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

Devices listed in bold, italic are Motorola preferred devices.

Table 2. Plastic TO-220AB (continued)

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

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

Devices listed in bold, italic are Motorola preferred devices.

Table 2. Plastic TO-220AB (continued)

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

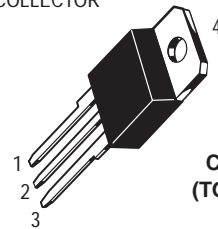
(1) |h_{FE}| @ 1 MHz
 (2) Darlington
 (3) Switching tests performed w/special application simulator circuit. See data sheet for details.
 (7) V_{CEO} = 375 V
 (8) When 2 voltages are given, the format is V_{CEO(sus)}/V_{CES}.
 (9) Self protected Darlington

Devices listed in bold, italic are Motorola preferred devices.

Table 2. Plastic TO-220AB (continued)

| I _C Cont Amps Max | V _{CEO(sus)} Volts Min(8) | Device Type | | h _{FE} Min/Max | @ I _C Amp | Resistive Switching | | | f _T MHz Min | P _D (Case) Watts @ 25°C |
|------------------------------------|--|-------------------|-------------------|----------------------------|-------------------------|-----------------------------|-----------------------------|-------------------------|------------------------------|---|
| | | NPN | PNP | | | t _s μs Max | t _f μs Max | @ I _C 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 _C Cont Amps Max | V _{CEO(sus)} Volts Min(8) | Device Type | | h _{FE} Min/Max | @ I _C Amp | Resistive Switching | | | f _T MHz Min | P _D (Case) Watts @ 25°C |
|------------------------------------|--|--------------------|-------------------|----------------------------|-------------------------|-----------------------------|-----------------------------|-------------------------|------------------------------|---|
| | | NPN | PNP | | | t _s μs Max | t _f μs Max | @ I _C 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_{FE}| @ 1 MHz

(2)Darlington

(8)When 2 voltages are given, the format is V_{CEO(sus)}/V_{CES}.

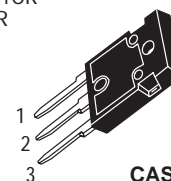
Table 3. Plastic TO-218 Type (continued)

| I _C Cont Amps Max | V _{CEO(sus)} Volts Min ⁽⁸⁾ | Device Type | | h _{FE} Min/Max | @ I _C Amp | Resistive Switching | | | f _T MHz Min | P _D (Case) Watts @ 25°C |
|------------------------------------|--|-------------------------------|-------------------------------|----------------------------|-------------------------|-----------------------------|-----------------------------|-------------------------|------------------------------|---|
| | | NPN | PNP | | | t _s μs Max | t _f μs Max | @ I _C Amp | | |
| 15 | 60 | TIP3055 | TIP2955 | 5 min | 10 | | | | 2.5 | 80 |
| | 150 | MJH11018 ⁽²⁾ | MJH11017 ⁽²⁾ | 400/15k | 10 | | | | 3 | 150 |
| | 200 | MJH11020 ⁽²⁾ | MJH11019 ⁽²⁾ | 400/15k | 10 | | | | 3 | 150 |
| | 250 | MJH11022⁽²⁾ | MJH11021⁽²⁾ | 400/15k | 10 | | | | 3 | 150 |
| | 400 | BUV48 | | 8 min | 10 | 2 | 0.4 | 10 | | 150 |
| | 450 | BUV48A | | 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 | MJE4343 | MJE4353 | 15 min | 8 | 1.2 typ | 1.2 typ | 8 | 1 | 125 |
| 20 | 60 | MJH6282 ⁽²⁾ | MJH6285 ⁽²⁾ | 750/18k | 10 | | | | 4 | 125 |
| | 100 | MJH6284⁽²⁾ | MJH6287⁽²⁾ | 750/18k | 10 | | | | 4 | 125 |
| 25 | 80 | TIP35A | TIP36A | 15/75 | 15 | 0.6 typ | 0.3 typ | 10 | 3 | 125 |
| | 100 | BD249C | BD250C | 10 min | 15 | | | | 3 | 125 |
| | | TIP35C | TIP36C | 15/75 | 15 | 0.6 typ | 0.3 typ | 10 | 3 | 125 |

⁽²⁾Darlington

⁽⁸⁾When 2 voltages are given, the format is V_{CEO(sus)}/V_{CES}.

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



CASE 340F
(TO-247 Type)

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

| I _C Cont Amps Max | V _{CEO(sus)} Volts Min | V _{CES} Volts Min | Device Type | | h _{FE} Min/Max | @ I _C Amp | Resistive Switching | | | f _T MHz Min | P _D (Case) Watts @ 25°C |
|------------------------------------|---------------------------------------|----------------------------------|------------------|-----|----------------------------|-------------------------|-----------------------------|-----------------------------|-------------------------|------------------------------|---|
| | | | NPN | PNP | | | t _s μs Max | t _f μs Max | @ I _C Amp | | |
| 10 | 650 | 1500 | MJW16212 | | 4/10 | 10 | 4 ⁽³⁾ | 0.5 ⁽³⁾ | 5.5 | | 150 |
| | 800 | 1500 | MJW16018 | | 4 min | 5 | 4.5 typ | 0.2 typ | 5 | 3 typ | 150 |
| 12 | 500 | 1200 | MJW16206 | | 5/13 | 10 | 2.25 | 0.25 | 6.5 | 3 typ | 150 |
| 15 | 450 | 850 | MJW16010 | | 5 min | 15 | 1.2 typ | 0.2 typ | 10 | | 150 |
| | | 850 | MJW16012 | | 7 min | 15 | 0.9 typ | 0.15 typ | 10 | | 150 |
| | 500 | 1000 | MJW16010A | | 5 min | 15 | 3 | 0.4 | 10 | | 150 |

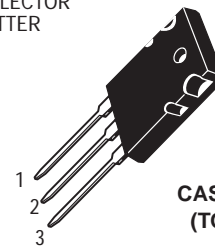
⁽³⁾Switching tests performed w/special application simulator circuit. See data sheet for details.

⁽¹⁰⁾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)

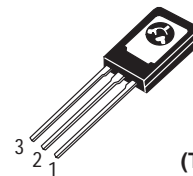
Table 5. Large Plastic TO-264

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

(1) |h_{FE}| @ 1 MHz

(2) Darlington

(11) Case 77, Style 3

Devices listed in bold, italic are Motorola preferred devices.

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

| I _C Cont Amps Max | V _{CEO(sus)} Volts Min | Device Type | | h _{FE} Min/Max | @ I _C Amp | Resistive Switching | | | f _T MHz Min | P _D (Case) Watts @ 25°C |
|------------------------------------|---------------------------------------|-------------------|-------------------|----------------------------|-------------------------|-----------------------------|-----------------------------|-------------------------|------------------------------|---|
| | | NPN | PNP | | | t _s μs Max | t _f μs Max | @ I _C 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

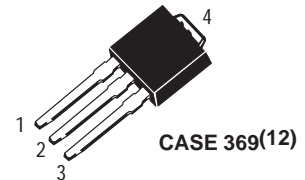


Table 7. DPAK – Surface Mount Power Packages

| I _C Cont Amps Max | V _{CEO(sus)} Volts Min | Device Type | | h _{FE} Min/Max | @ I _C Amp | Resistive Switching | | | f _T MHz Min | P _D (Case) Watts @ 25°C |
|------------------------------------|---------------------------------------|-----------------|----------------|----------------------------|-------------------------|-----------------------------|-----------------------------|-------------------------|------------------------------|---|
| | | NPN | PNP | | | t _s μs Max | t _f μs Max | @ I _C 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_{FE}| @ 1 MHz

(2)Darlington

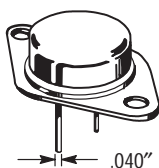
(12)Case 369–07 may be ordered by adding –1 suffix to part number.

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

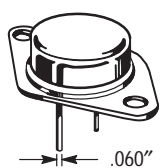
Devices listed in bold, italic are Motorola preferred devices.

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

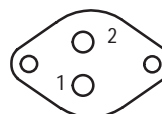
| I _C Cont Amps Max | V _{CEO(sus)} Volts Min | Device Type | | h _{FE} Min/Max | @ I _C Amp | Resistive Switching | | | f _T MHz Min | P _D (Case) Watts @ 25°C |
|------------------------------------|---------------------------------------|--------------------|--------------------|----------------------------|-------------------------|-----------------------------|-----------------------------|-------------------------|------------------------------|---|
| | | NPN | PNP | | | t _s μs Max | t _f μs Max | @ I _C 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 _C Cont Amps Max | V _{CEO(sus)} Volts Min(8) | Device Type | | h _{FE} Min/Max | @ I _C Amp | Resistive Switching | | | f _T MHz Min | P _D (Case) Watts @ 25°C |
|------------------------------------|--|-------------------|----------------|----------------------------|-------------------------|-----------------------------|-----------------------------|-------------------------|------------------------------|---|
| | | NPN | PNP | | | t _s μs Max | t _f μs Max | @ I _C 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_{FE}| @ 1 MHz

(2)Darlington

(8)When 2 voltages are given, the format is V_{CEO(sus)}/V_{CES}

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

(1)|h_{FE}| @ 1 MHz

(2)Darlington

(8)When 2 voltages are given, the format is V_{CEO(sus)}/V_{CES}.

Devices listed in bold, italic are Motorola preferred devices.

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

| I _C Cont Amps Max | V _{CEO(sus)} Volts Min ⁽⁸⁾ | Device Type | | h _{FE} Min/Max | @ I _C Amp | Resistive Switching | | | f _T MHz Min | P _D (Case) Watts @ 25°C |
|------------------------------------|--|-------------------------------|-------------------------------|----------------------------|-------------------------|-----------------------------|-----------------------------|-------------------------|------------------------------|---|
| | | NPN | PNP | | | t _s μs Max | t _f μs Max | @ I _C Amp | | |
| 15 | 450/850 | MJ16010 | | 5 min | 15 | 1.2 typ | 0.2 typ | 10 | | 175 |
| | | MJ16012 | | 7 min | 15 | 0.9 typ | 0.15 typ | 10 | | 175 |
| 16 | 140 | 2N3773 | 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 | MJ15024 | MJ15025 | 15/60 | 8 | | | | 5 | 250 |
| | | MJ21194 | MJ21193 | 25/75 | 8 | | | | 4 | 250 |
| | 20 | 60 | 2N3772 | | 15/60 | 10 | | | | 2 |
| 2N6282 ⁽²⁾ | | | 2N6285 ⁽²⁾ | 750/18k | 10 | 2.5 typ | 2.5 typ | 10 | 4 ⁽¹⁾ | 160 |
| 75 | | 2N5039 | | 20/100 | 10 | 1.5 | 0.5 | 10 | 60 | 140 |
| 80 | | 2N6283 ⁽²⁾ | 2N6286 ⁽²⁾ | 750/18k | 10 | 2.5 typ | 2.5 typ | 10 | 4 ⁽¹⁾ | 160 |
| 90 | | 2N5038 | | 20/100 | 12 | 1.5 | 0.5 | 12 | 60 | 140 |
| 100 | | 2N6284 ⁽²⁾ | 2N6287 ⁽²⁾ | 750/18k | 10 | 2.5 typ | 2.5 typ | 10 | 4 ⁽¹⁾ | 160 |
| 140 | | MJ15003 | MJ15004 | 25/150 | 5 | | | | 2 | 250 |
| 200 | | BUV11 | | 10 min | 12 | 1.8 | 0.4 | 12 | 8 | 150 |
| 350 | | MJ10000 ⁽²⁾ | | 40/400 | 10 | 3 | 1.8 | 10 | 10 ⁽¹⁾ | 175 |
| 400 | | MJ10005 ⁽²⁾ | | 40/400 | 10 | 1.5 | 0.5 | 10 | 10 ⁽¹⁾ | 175 |
| | | MJ13333 | | 10/60 | 5 | 4 | 0.7 | 10 | | 175 |
| 500 | | MJ10009 ⁽²⁾ | | 30/300 | 10 | 2 | 0.6 | 10 | 8 ⁽¹⁾ | 175 |
| 25 | | 60 | 2N5885 | 2N5883 | 20/100 | 10 | 1 | 0.8 | 10 | 4 |
| | 80 | 2N5886 | 2N5884 | 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 | 2N6438 | 30/120 | 10 | 1 | 0.25 | 10 | 40 | 200 |
| | 140 | 2N6340 | | 30/120 | 10 | 1 | 0.25 | 10 | 40 | 200 |
| 150 | 2N6341 | | 30/120 | 10 | 1 | 0.25 | 10 | 40 | 200 | |
| 30 | 40 | 2N3771 | | 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 ⁽²⁾ | MJ11011 ⁽²⁾ | 1k min | 20 | | | | 4 ⁽¹⁾ | 200 |
| | 90 | MJ11014 ⁽²⁾ | MJ11013 ⁽²⁾ | 1k min | 20 | | | | 4 ⁽¹⁾ | 200 |
| | 100 | 2N6328 | | 6/30 | 30 | | | | 3 | 200 |
| | | MJ802 | MJ4502 | 25/100 | 7.5 | | | | 2 | 200 |
| | 120 | MJ11016 ⁽²⁾ | MJ11015 ⁽²⁾ | 1k min | 20 | | | | 4 ⁽¹⁾ | 200 |

(1) |h_{FE}| @ 1 MHz

(2) Darlington

(8) When 2 voltages are given, the format is V_{CEO(sus)}/V_{CES}.

Devices listed in bold, italic are Motorola preferred devices.

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

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

(1) |h_{FE}| @ 1 MHz

(2) Darlington

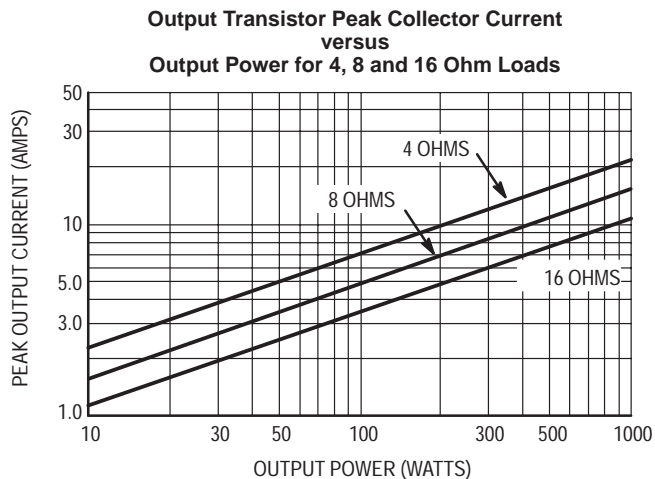
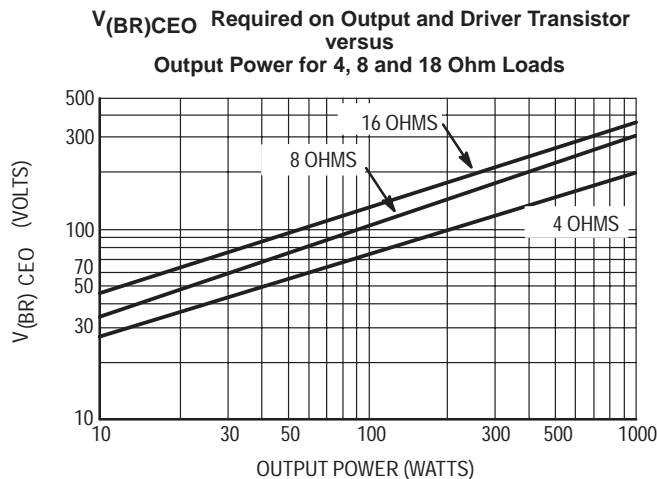
(8) When 2 voltages are given, the format is V_{CEO(sus)}/V_{CES}.

(16) Case 197A–03 (TO–204AE)

Devices listed in bold, italic are Motorola preferred devices.

Audio

GENERAL DESIGN CURVES FOR POWER AUDIO OUTPUT STAGES



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

Table 9. Recommended Power Transistors for Audio/Servo Loads

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

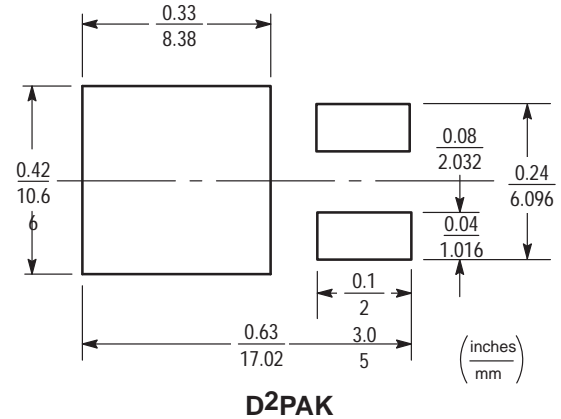
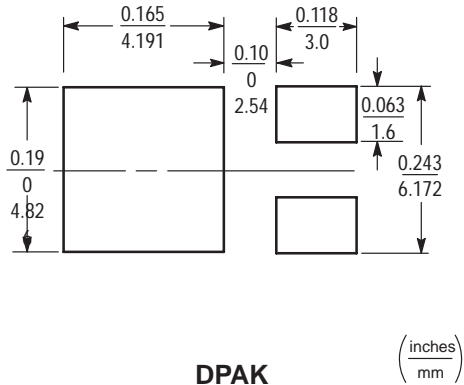
The Power Transistors shown are provided for reference only and show device capability. The final choice of the Power Transistors used is left to the circuit designer and depends upon the particular safe-operating area required and the mounting and heat sinking configuration used.

INFORMATION FOR USING SURFACE MOUNT PACKAGES

RECOMMENDED FOOTPRINTS FOR SURFACE MOUNTED APPLICATIONS

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

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



POWER DISSIPATION FOR A SURFACE MOUNT DEVICE

The values for the equation are found in the maximum ratings table on the data sheet. Substituting these values into the equation for an ambient temperature T_A of 25°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.

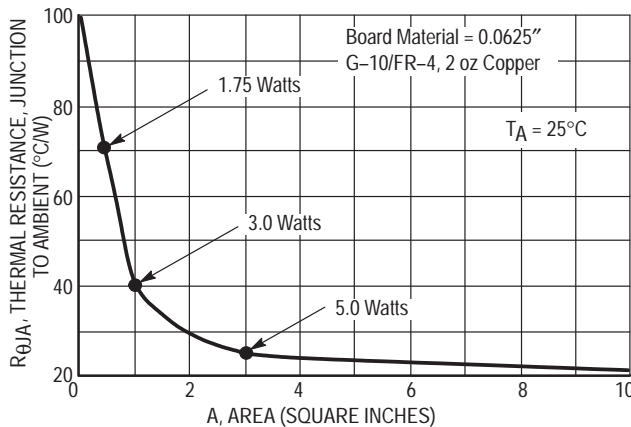


Figure 1. Thermal Resistance versus Drain Pad Area for the DPAK Package (Typical)

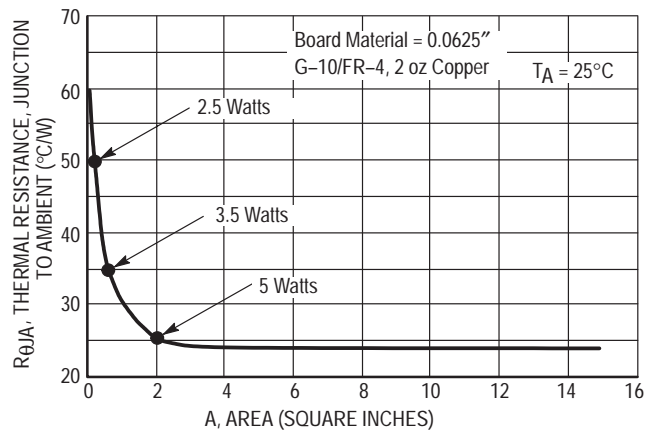


Figure 2. Thermal Resistance versus Drain Pad Area for the D2PAK Package (Typical)

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 D²PAK 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 D²PAK 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.

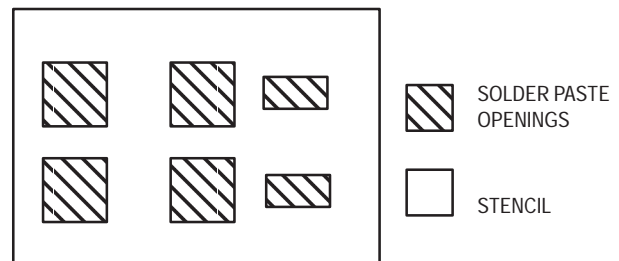


Figure 3. Typical Stencil for DPAK and D²PAK Packages

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 D²PAK 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.

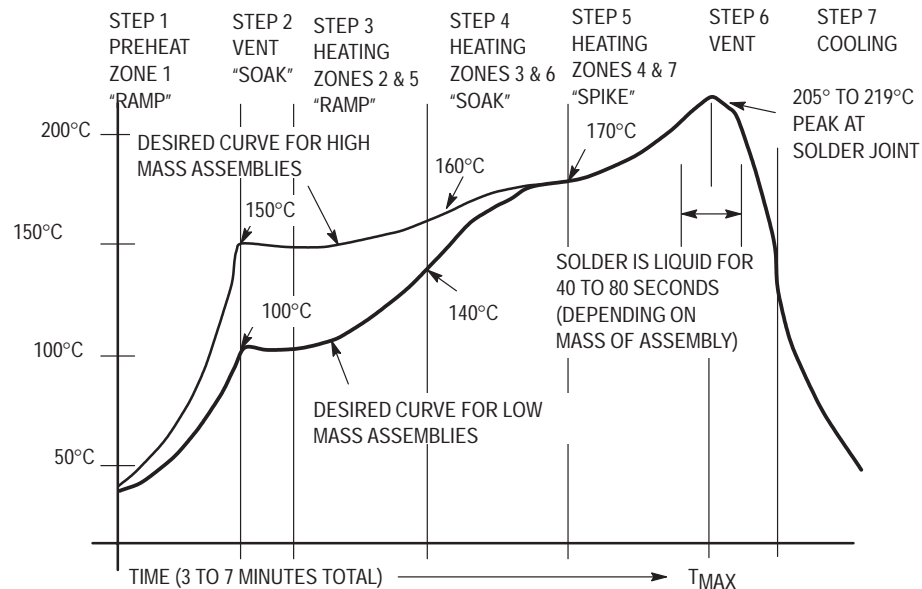


Figure 4. Typical Solder Heating Profile

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 ₂ | 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

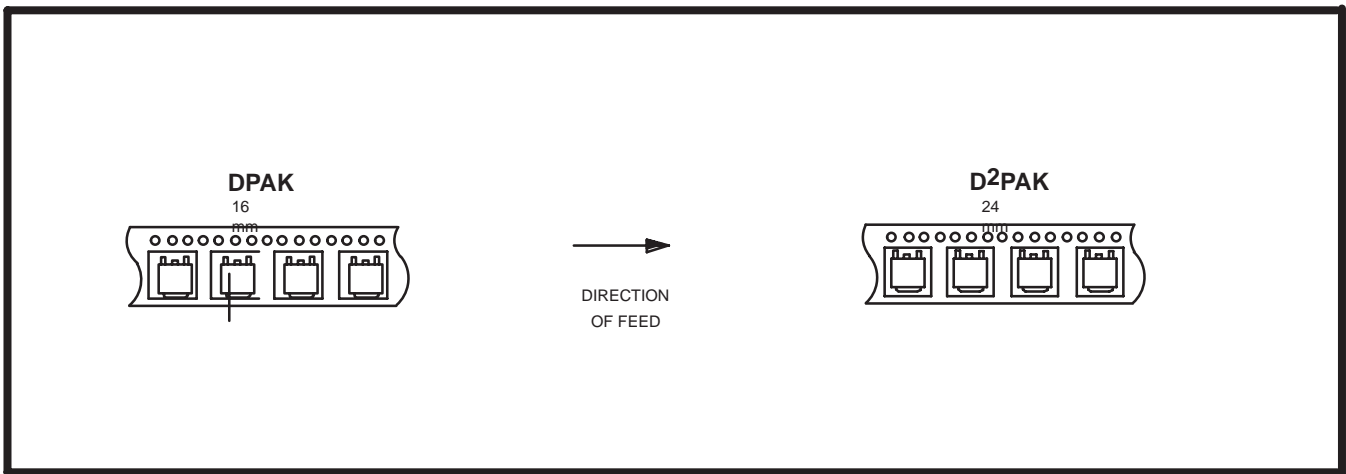
Wakefield Engineering, Inc., Wakefield, Massachusetts 01880 (617) 245-5900

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.

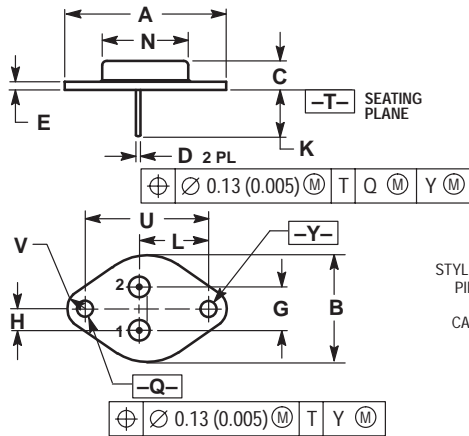
- Two Reel Sizes Available (7” and 13”)
- Used for Automatic Pick and Place Feed Systems
- Minimizes Product Handling
- EIA 481, -1, -2
- DPAK SO-14, in 16 mm Tape
- D²PAK in 24 mm Tape

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 ² PAK | 24 | 16.0 ± 0.1 (.630 ± .004) | 330 | (13) | 800 | T4 |

Outline Dimensions

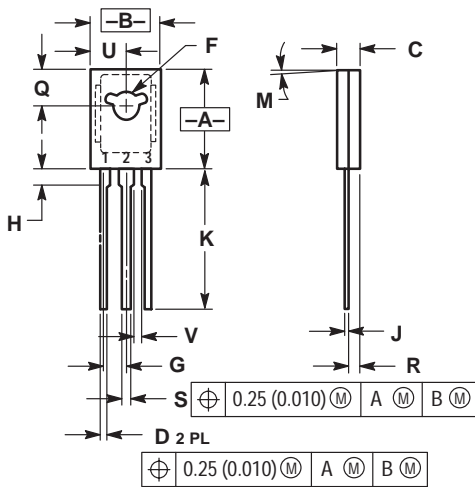


STYLE 1:
PIN 1: BASE
2: EMITTER
CASE: COLLECTOR

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

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

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

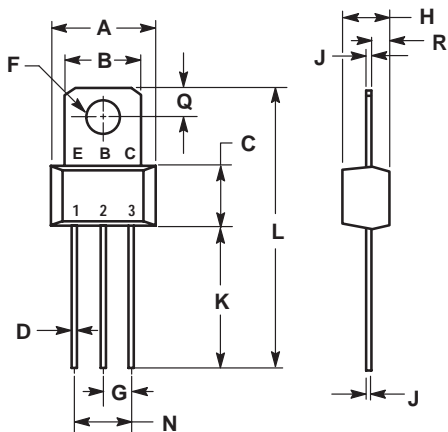


STYLE 1:
PIN 1: EMITTER
2: COLLECTOR
3: BASE

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

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

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



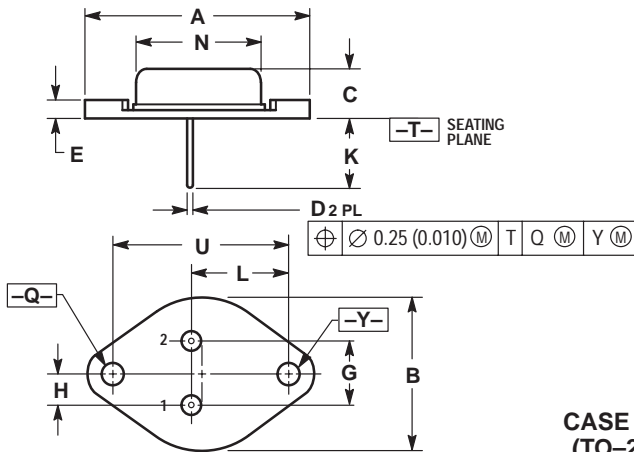
STYLE 1:
PIN 1: EMITTER
2: BASE
3: COLLECTOR
(COLLECTOR CONNECTED TO TAB)

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

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

CASE 152-02

Outline Dimensions (continued)

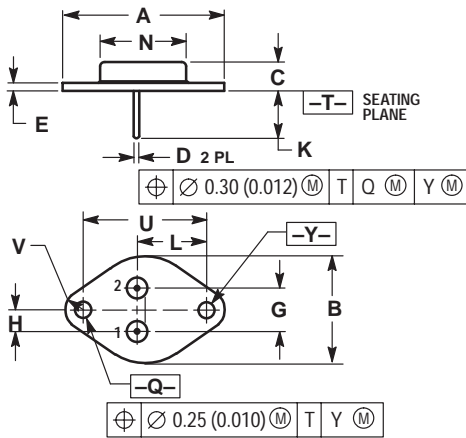


STYLE 1:
PIN 1: BASE
2: EMITTER
CASE: COLLECTOR

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

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

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

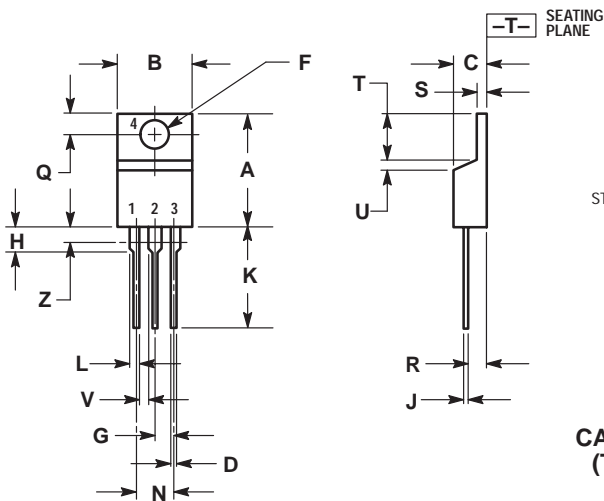


STYLE 1:
PIN 1: BASE
2: EMITTER
CASE: COLLECTOR

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

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

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



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

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

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

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

Outline Dimensions (continued)

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

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

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

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

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

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

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

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

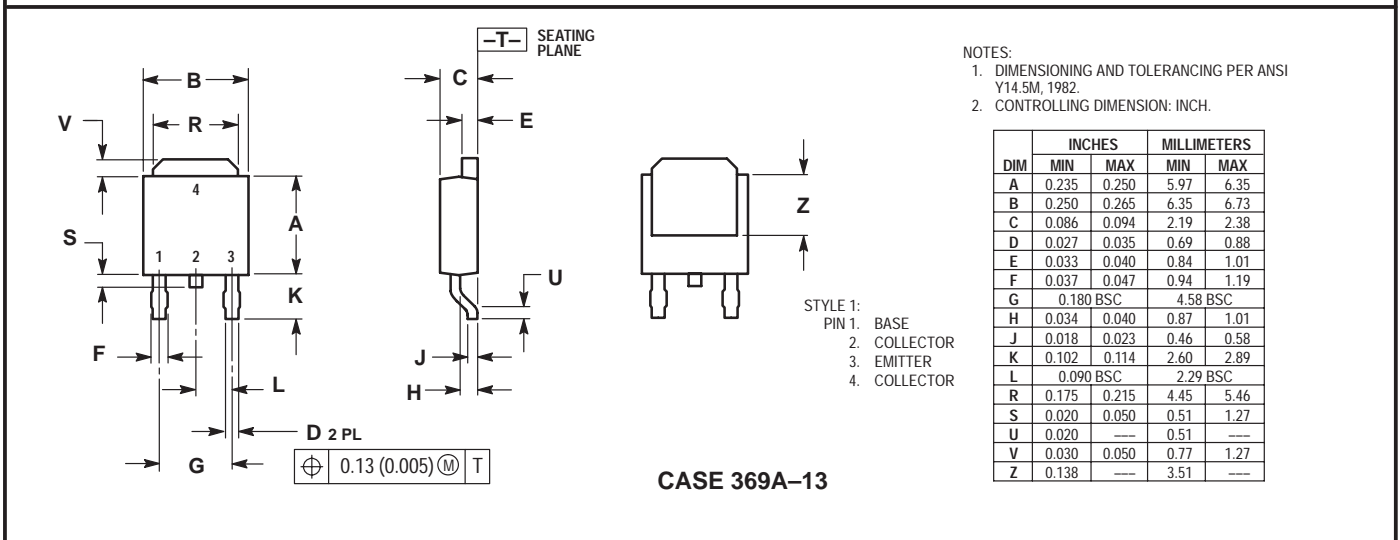
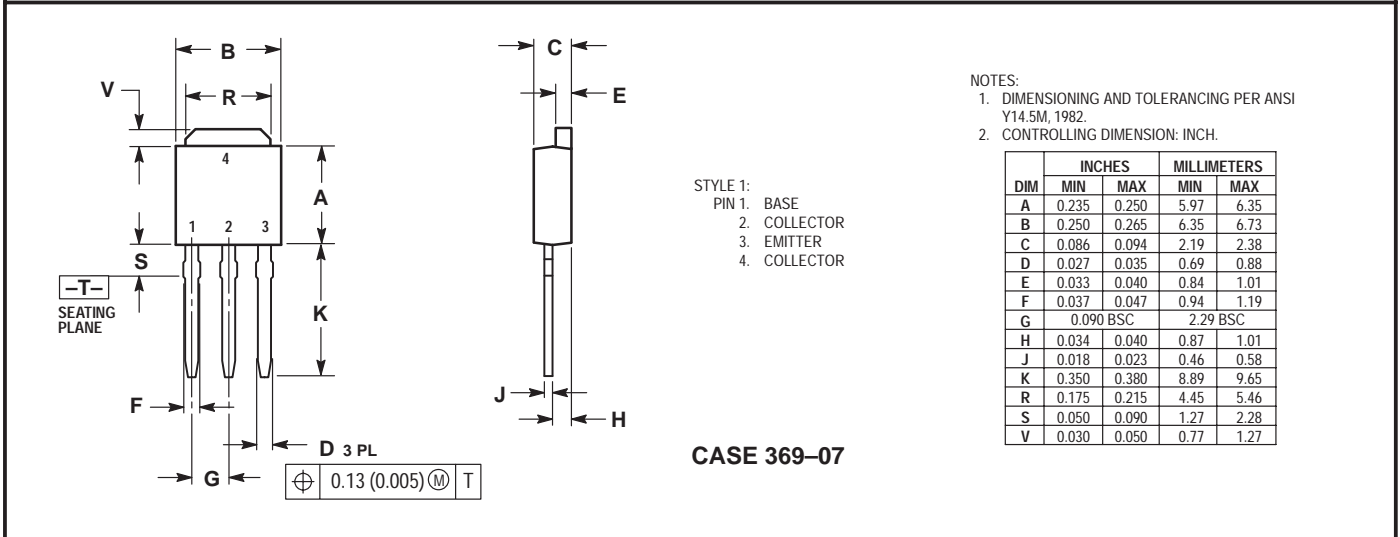
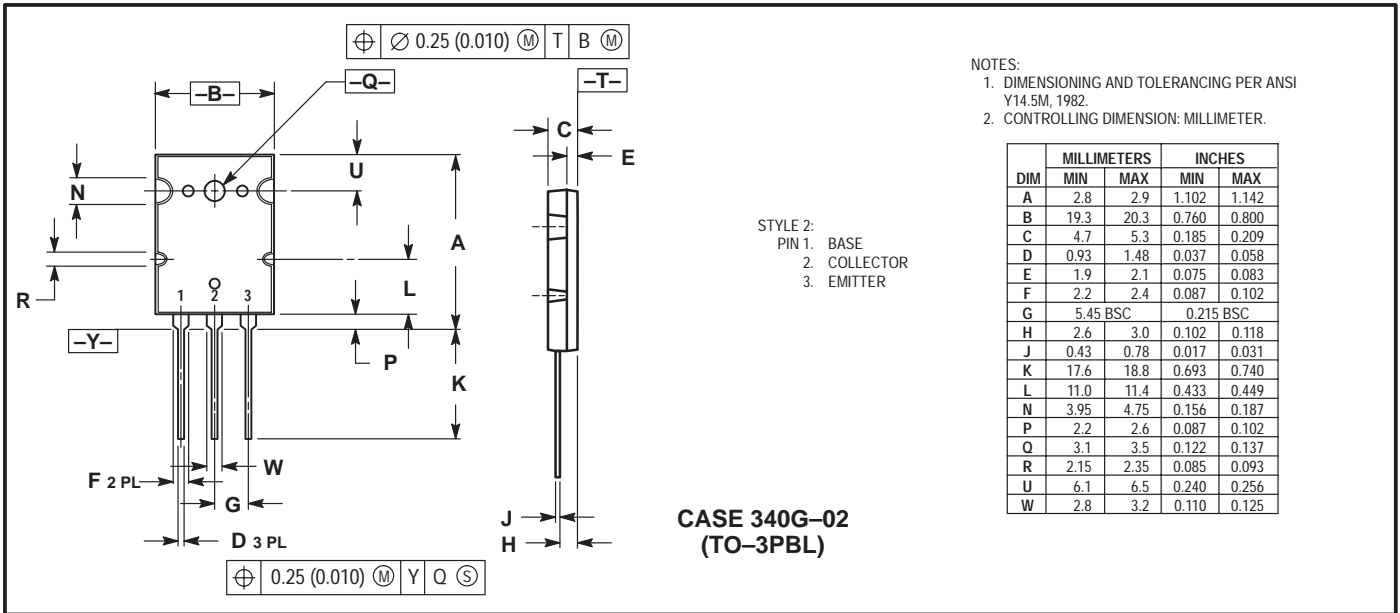
STYLE 3:
PIN 1. BASE
2. COLLECTOR
3. EMITTER
4. COLLECTOR

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

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

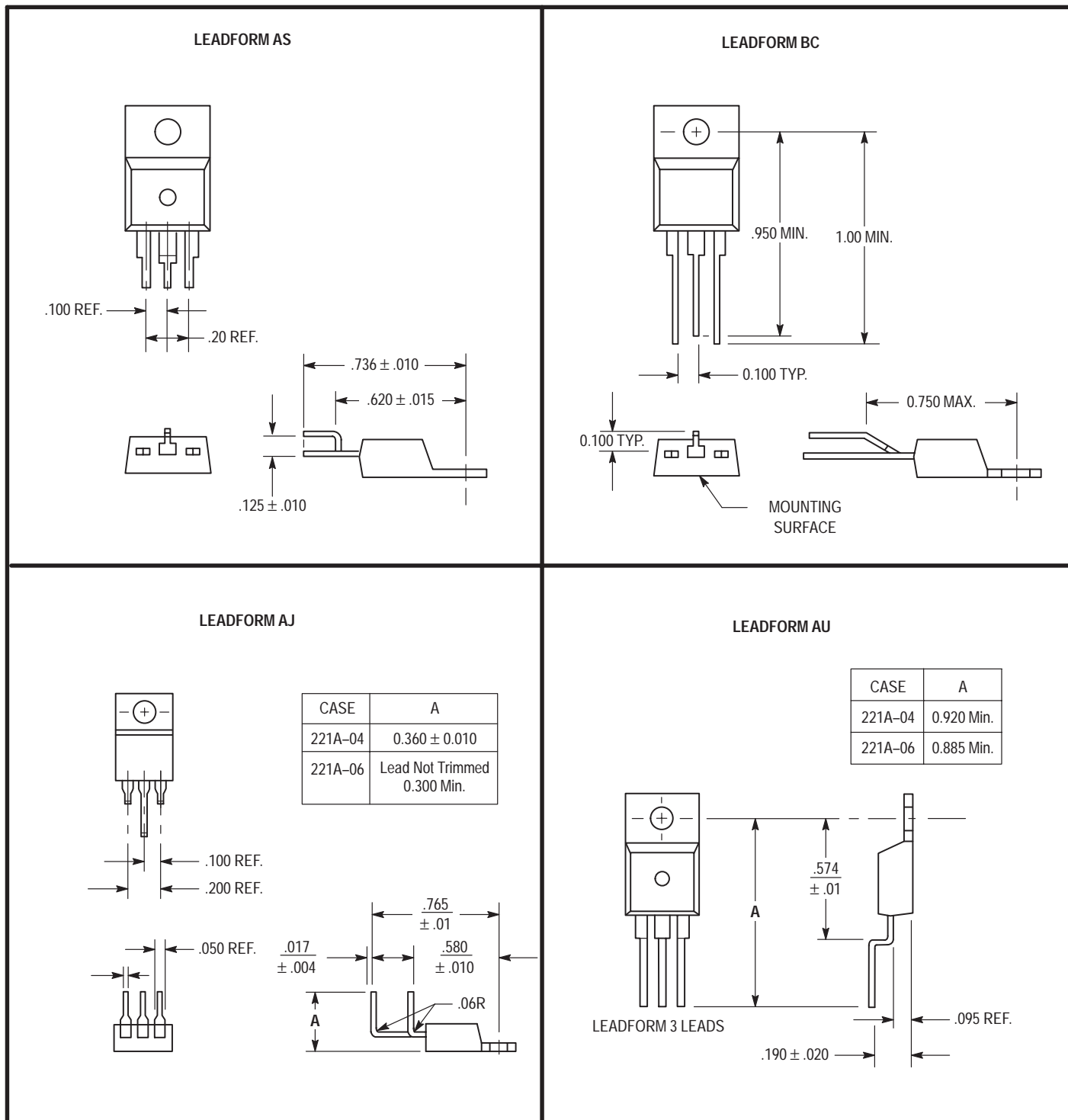
| DIM | MILLIMETERS | | INCHES | |
|-----|-------------|-------|-----------|-------|
| | MIN | MAX | MIN | MAX |
| A | 20.40 | 20.90 | 0.803 | 0.823 |
| B | 15.44 | 15.95 | 0.608 | 0.628 |
| C | 4.70 | 5.21 | 0.185 | 0.205 |
| D | 1.09 | 1.30 | 0.043 | 0.051 |
| E | 1.50 | 1.63 | 0.059 | 0.064 |
| F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

Outline Dimensions (continued)



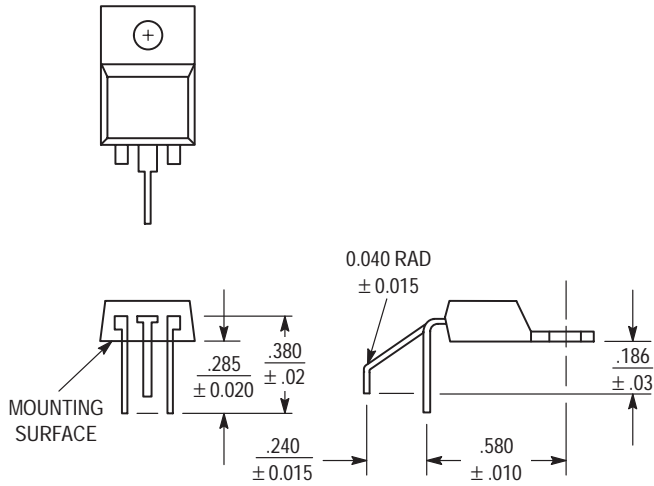
Leadform Options — TO-220 (Case 221A)

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

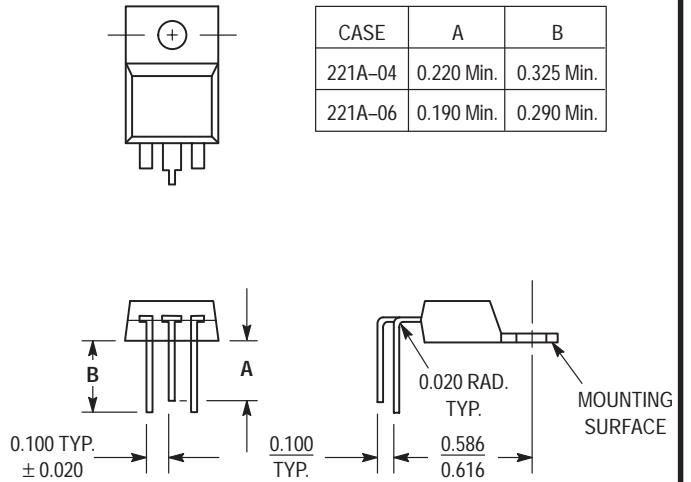


TO-220 Leadform Options (continued)

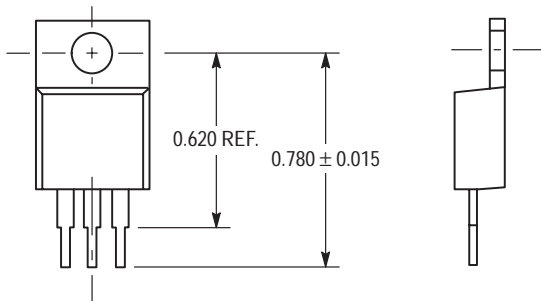
LEADFORM AN



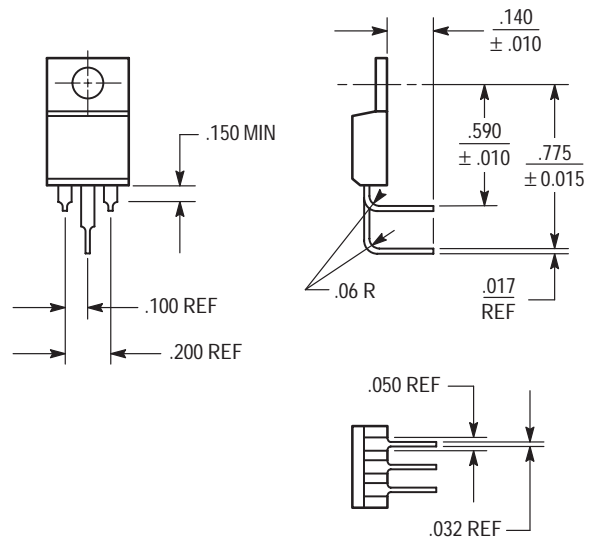
LEADFORM BA



LEADFORM BG

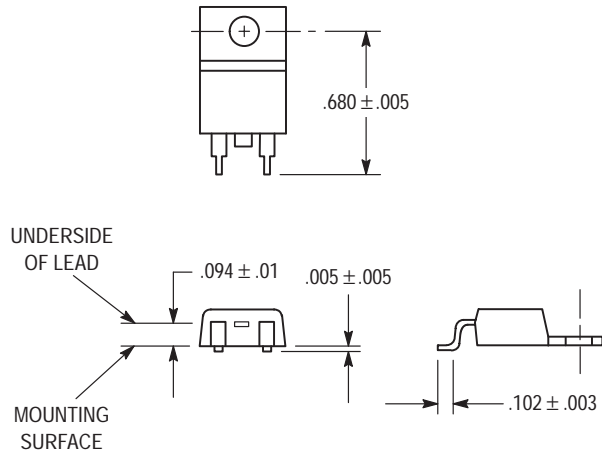


LEADFORM AK

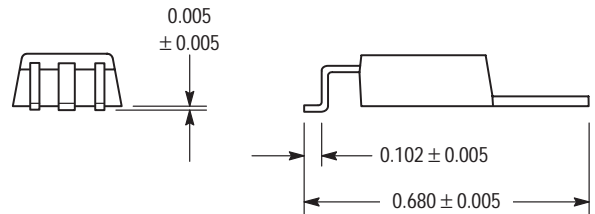


TO-220 Leadform Options (continued)

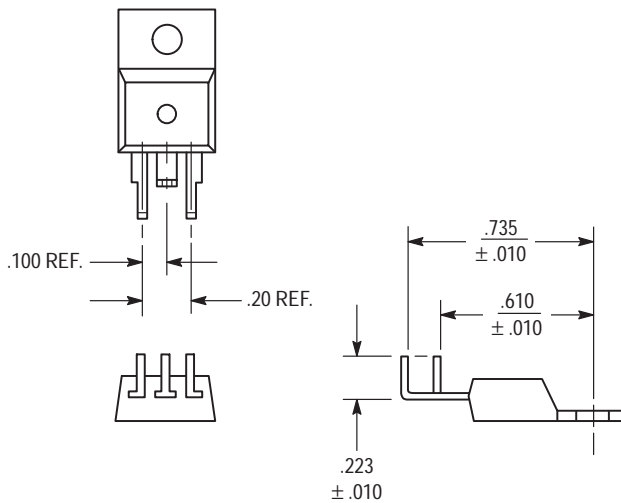
LEADFORM BU



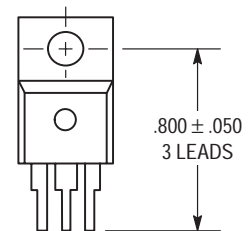
LEADFORM BV



LEADFORM BD

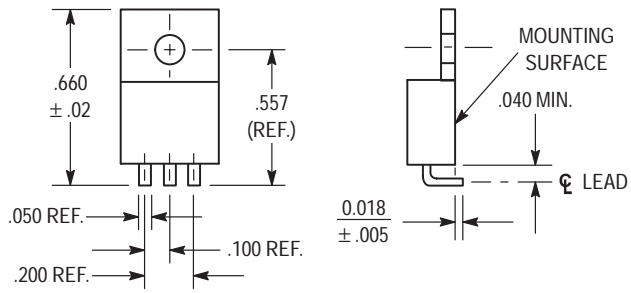


LEADFORM DW

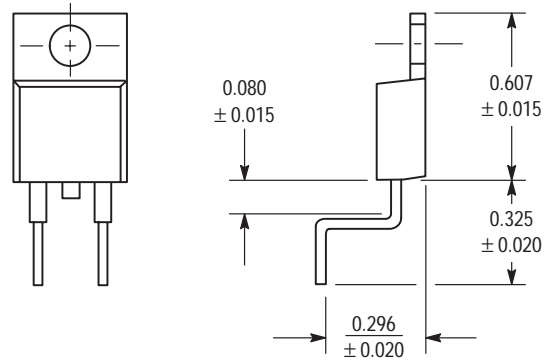


TO-220 Leadform Options (continued)

LEADFORM AF



LEADFORM BS



INDEX AND CROSS REFERENCE

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

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