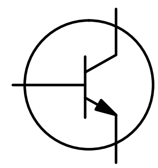
# MJE18206
# MJF18206

*Designer's™ Data Sheet*

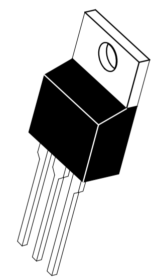
# SWITCHMODE™ NPN Bipolar Power Transistor for Electronic Light Ballast and Switching Power Supply Applications

**POWER TRANSISTORS**
**8 AMPERES**
**1200 VOLTS**
**40 and 100 WATTS**

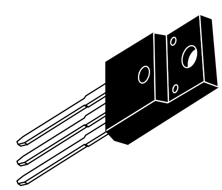


The MJE/MJF18206 have an application specific state–of–the–art die dedicated to the electronic ballast ("light ballast") and power supply applications.

- Improved Global Efficiency Due to Low Base Drive Requirements:
  - — High and Flat DC Current Gain $h_{FE}$
  - — Fast Switching
  - — No Coil Required in Base Circuit for fast Turn–Off (No Current Tail)
- Full Characterization at 125°C
- Motorola "6 SIGMA" Philosophy Provides Tight and Reproducible Parametric Distributions
- Two Package Choices: Standard TO–220 or Isolated TO–220



**CASE 221A–06**
**TO–220AB**



**CASE 221D–02**
**TO–220 FULLPACK**

**MAXIMUM RATINGS**

| Rating | Symbol | MJE18206 | MJF18206 | Unit |
|---|---|---|---|---|
| Collector–Emitter Voltage | $V_{CEO}$ | 600 | | Vdc |
| Collector–Base Voltage | $V_{CBO}$ | 1200 | | Vdc |
| Collector–Emitter Voltage | $V_{CES}$ | 1200 | | Vdc |
| Emitter–Base Voltage | $V_{EBO}$ | 10 | | Vdc |
| Collector Current — Continuous<br>— Peak (1) | $I_C$<br>$I_{CM}$ | 8<br>16 | | Adc |
| Base Current — Continuous<br>— Peak (1) | $I_B$<br>$I_{BM}$ | 5<br>9 | | Adc |
| RMS Isolation Voltage (2) Per Figure 22<br>(for 1 sec, R.H. ≤ 30%) Per Figure 23<br>$T_C$ = 25°C Per Figure 24 | $V_{ISOL1}$<br>$V_{ISOL2}$<br>$V_{ISOL3}$ | | 4500<br>3500<br>1500 | Volts |
| *Total Device Dissipation @ $T_C$ = 25°C<br>*Derate above 25°C | $P_D$ | 100<br>0.8 | 40<br>0.32 | Watt<br>W/°C |
| Operating and Storage Temperature | $T_J$, $T_{stg}$ | –65 to 150 | | °C |

**THERMAL CHARACTERISTICS**

| Rating | Symbol | MJE18206 | MJF18206 | Unit |
|---|---|---|---|---|
| Thermal Resistance — Junction to Case<br>— Junction to Ambient | $R_{\theta JC}$<br>$R_{\theta JA}$ | 1.25<br>62.5 | 3.125<br>62.5 | °C/W |
| Maximum Lead Temperature for Soldering Purposes: 1/8″ from Case for 5 Seconds | $T_L$ | 260 | | °C |

(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle ≤ 10%.
(2) Proper strike and creepage distance must be provided.

**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.

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MOTOROLA

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

| Characteristic | | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| **OFF CHARACTERISTICS** | | | | | | |
| Collector–Emitter Sustaining Voltage ($I_C$ = 100 mA, L = 25 mH) | | $V_{CEO(sus)}$ | 550 | 630 | | Vdc |
| ($I_C$ = 200 mA, L = 25 mH, R = 200 Ω) | | $V_{CER(sus)}$ | 600 | 700 | | |
| Collector–Base Breakdown Voltage ($I_{CBO}$ = 1 mA, $I_E$ = 0) | | $V_{CBO}$ | 1200 | 1320 | | Vdc |
| Emitter–Base Breakdown Voltage ($I_{EBO}$ = 1 mA, $I_C$ = 0) | | $V_{EBO}$ | 10 | 12.9 | | Vdc |
| Collector Cutoff Current ($V_{CE}$ = 550 V, $I_B$ = 0) | @ $T_C$ = 25°C | $I_{CEO}$ | | | 200 | µAdc |
| ($V_{CE}$ = 550 V, $I_B$ = 0) | @ $T_C$ = 125°C | | | | 2000 | |
| Collector Cutoff Current ($V_{CE}$ = Rated $V_{CES}$, $V_{BE}$ = 0) | @ $T_C$ = 25°C | $I_{CES}$ | | | 100 | µAdc |
| | @ $T_C$ = 125°C | | | | 1000 | |
| ($V_{CE}$ = 1000 V, $V_{BE}$ = 0) | @ $T_C$ = 125°C | | | | 100 | |
| Collector Cutoff Current ($V_{CB}$ = 1200 V, $I_E$ = 0) | | $I_{CBO}$ | | | 100 | µAdc |
| Emitter–Cutoff Current ($V_{EB}$ = 9 Vdc, $I_C$ = 0) | | $I_{EBO}$ | | | 100 | µAdc |
| **ON CHARACTERISTICS** | | | | | | |
| Base–Emitter Saturation Voltage ($I_C$ = 1.3 Adc, $I_B$ = 0.13 Adc) | @ $T_C$ = 25°C | $V_{BE(sat)}$ | | 0.77 | 1 | Vdc |
| | @ $T_C$ = 125°C | | | 0.67 | 0.9 | |
| ($I_C$ = 2 Adc, $I_B$ = 0.4 Adc) | @ $T_C$ = 25°C | | | 0.85 | 1.1 | |
| | @ $T_C$ = 125°C | | | 0.75 | 1 | |
| ($I_C$ = 3 Adc, $I_B$ = 0.6 Adc) | @ $T_C$ = 25°C | | | 0.91 | 1.1 | |
| | @ $T_C$ = 125°C | | | 0.8 | 1 | |
| Collector–Emitter Saturation Voltage ($I_C$ = 1.3 Adc, $I_B$ = 0.13 Adc) | @ $T_C$ = 25°C | $V_{CE(sat)}$ | | 0.3 | 0.75 | Vdc |
| | @ $T_C$ = 125°C | | | 0.4 | 1 | |
| ($I_C$ = 3 Adc, $I_B$ = 0.6 Adc) | @ $T_C$ = 25°C | | | 0.4 | 0.75 | |
| | @ $T_C$ = 125°C | | | 0.8 | 1.25 | |
| DC Current Gain ($I_C$ = 0.5 Adc, $V_{CE}$ = 5 Vdc) | @ $T_C$ = 25°C | $h_{FE}$ | 18 | 25 | | — |
| | @ $T_C$ = 125°C | | | 25 | | |
| ($I_C$ = 1 Adc, $V_{CE}$ = 5 Vdc) | @ $T_C$ = 25°C | | 18 | | 45 | |
| | @ $T_C$ = 125°C | | | 20 | | |
| ($I_C$ = 3 Adc, $V_{CE}$ = 1 Vdc) | @ $T_C$ = 25°C | | 5 | 8 | | — |
| | @ $T_C$ = 125°C | | 4 | 6 | | |
| ($I_C$ = 10 mAdc, $V_{CE}$ = 5 Vdc) | @ $T_C$ = 25°C | | 11 | | 50 | — |
| | @ $T_C$ = 125°C | | | 33 | | |
| **DYNAMIC CHARACTERISTICS** | | | | | | |
| Current Gain Bandwidth ($I_C$ = 0.5 Adc, $V_{CE}$ = 10 Vdc, f = 1 MHz) | | $f_T$ | | 13 | | MHz |
| Output Capacitance ($V_{CB}$ = 10 Vdc, $I_E$ = 0, f = 1 MHz) | | $C_{ob}$ | | | 200 | pF |
| Input Capacitance ($V_{EB}$ = 8 Vdc) | | $C_{ib}$ | | | 2000 | pF |
| **DYNAMIC SATURATION VOLTAGE** | | | | | | |
| Dynamic Saturation Voltage: Determined 1 µs and 3 µs respectively after rising $I_{B1}$ reaches 90% of final $I_{B1}$ — $I_C$ = 1.3 Adc, $I_{B1}$ = 130 mAdc, $V_{CC}$ = 300 V | @ 1 µs, @ $T_C$ = 25°C | $V_{CE(dsat)}$ | | 7.5 | | V |
| | @ 3 µs, @ $T_C$ = 25°C | | | 4.5 | | |
| $I_C$ = 3 Adc, $I_{B1}$ = 0.6 Adc, $V_{CC}$ = 300 V | @ 1 µs, @ $T_C$ = 25°C | | | 14.5 | | |
| | @ 3 µs, @ $T_C$ = 25°C | | | 6 | | |

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

| Characteristic | | | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| **SWITCHING CHARACTERISTICS: Resistive Load** (D.C. ≤ 10%, Pulse Width = 40 μs) | | | | | | | |
| Turn–on Time | $I_C$ = 3 Adc, $I_{B1}$ = 0.6 Adc, $I_{B2}$ = 1.5 Adc, $V_{CC}$ = 300 Vdc | @ $T_C$ = 25°C | $t_{on}$ | | 200 | 350 | ns |
| Turn–off Time | | @ $T_C$ = 25°C<br>@ $T_C$ = 125°C | $t_{off}$ | | 2<br>2.5 | 2.5 | μs |
| Turn–on Time | $I_C$ = 3 Adc, $I_{B1}$ = 0.6 Adc, $I_{B2}$ = 0.6 Adc, $V_{CC}$ = 300 Vdc | @ $T_C$ = 25°C | $t_{on}$ | | 190 | 250 | ns |
| Turn–off Time | | @ $T_C$ = 25°C<br>@ $T_C$ = 125°C | $t_{off}$ | | 3.7<br>4.5 | 4.5 | μs |
| Turn–on Time | $I_C$ = 1 Adc, $I_{B1}$ = 70 mAdc, $I_{B2}$ = 1 Adc, $V_{CC}$ = 125 Vdc, PW = 70 μs | @ $T_C$ = 25°C | $t_d$ | | 125 | 300 | ns |
| | | | $t_r$ | | 400 | 750 | ns |
| Turn–off Time | | @ $T_C$ = 25°C | $t_s$ | | 600 | 1.2 | μs |
| | | | $t_f$ | | 450 | 700 | ns |
| Turn–on Time | $I_C$ = 1 Adc, $I_{B1}$ = 100 mAdc, $I_{B2}$ = 500 mAdc, $V_{CC}$ = 300 Vdc | @ $T_C$ = 25°C<br>@ $T_C$ = 125°C | $t_{on}$ | | 250<br>225 | 350 | ns |
| Turn–off Time | | @ $T_C$ = 25°C<br>@ $T_C$ = 125°C | $t_{off}$ | | 2<br>2.5 | 2.75 | μs |
| **SWITCHING CHARACTERISTICS: Inductive Load** ($V_{clamp}$ = 300 V, $V_{CC}$ = 15 V, L = 200 μH) | | | | | | | |
| Fall Time | $I_C$ = 1.3 Adc, $I_{B1}$ = 0.13 Adc, $I_{B2}$ = 0.65 Adc | @ $T_C$ = 25°C<br>@ $T_C$ = 125°C | $t_f$ | | 150<br>225 | 200 | ns |
| Storage Time | | @ $T_C$ = 25°C<br>@ $T_C$ = 125°C | $t_s$ | | 1.6<br>1.9 | 2 | μs |
| Crossover Time | | @ $T_C$ = 25°C<br>@ $T_C$ = 125°C | $t_c$ | | 260<br>300 | 350 | ns |
| Fall Time | $I_C$ = 3 Adc, $I_{B1}$ = 0.6 Adc, $I_{B2}$ = 1.5 Adc | @ $T_C$ = 25°C<br>@ $T_C$ = 125°C | $t_f$ | | 300<br>400 | 450 | ns |
| Storage Time | | @ $T_C$ = 25°C<br>@ $T_C$ = 125°C | $t_s$ | | 2.25<br>2.5 | 2.75 | μs |
| Crossover Time | | @ $T_C$ = 25°C<br>@ $T_C$ = 125°C | $t_c$ | | 500<br>700 | 800 | ns |
| Fall Time | $I_C$ = 3 Adc, $I_{B1}$ = 0.6 Adc, $I_{B2}$ = 0.6 Adc | @ $T_C$ = 25°C<br>@ $T_C$ = 125°C | $t_f$ | | 350<br>500 | 500 | ns |
| Storage Time | | @ $T_C$ = 25°C<br>@ $T_C$ = 125°C | $t_s$ | | 4.25<br>5.1 | 5 | μs |
| Crossover Time | | @ $T_C$ = 25°C<br>@ $T_C$ = 125°C | $t_c$ | | 600<br>1100 | 800 | ns |

## TYPICAL STATIC CHARACTERISTICS

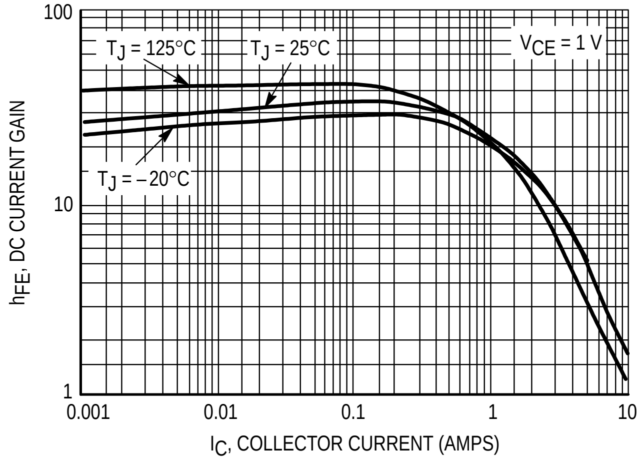



**Figure 1. DC Current Gain @ 1 Volt**

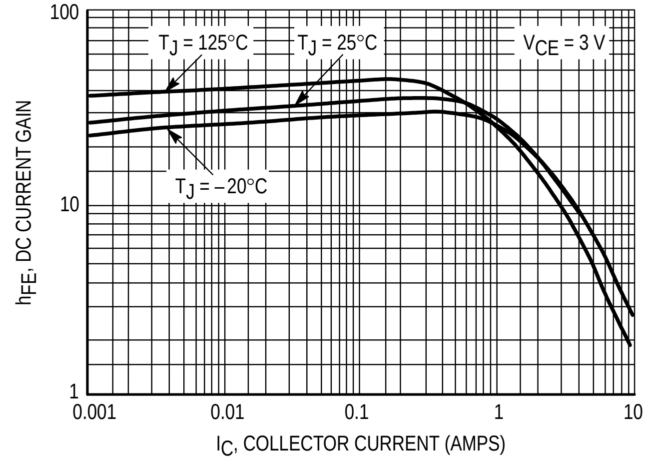



**Figure 2. DC Current Gain @ 3 Volts**

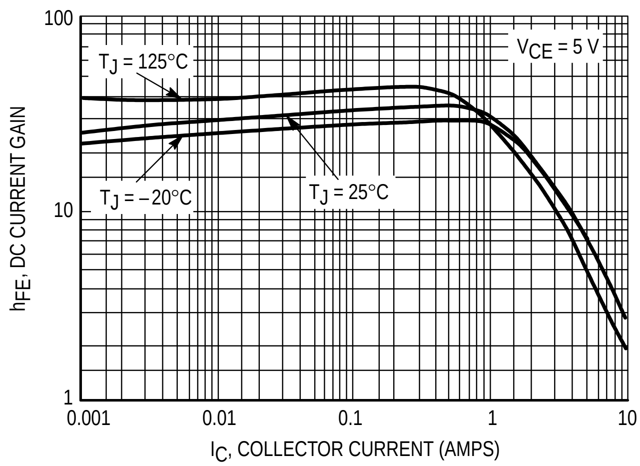



**Figure 3. DC Current Gain @ 5 Volts**

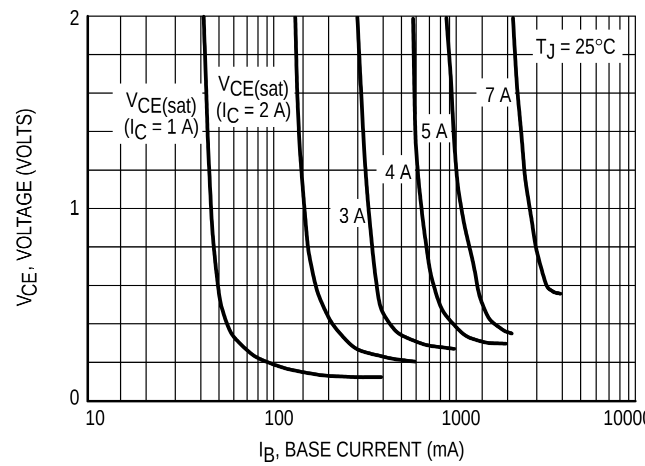



**Figure 4. Collector Saturation Region**

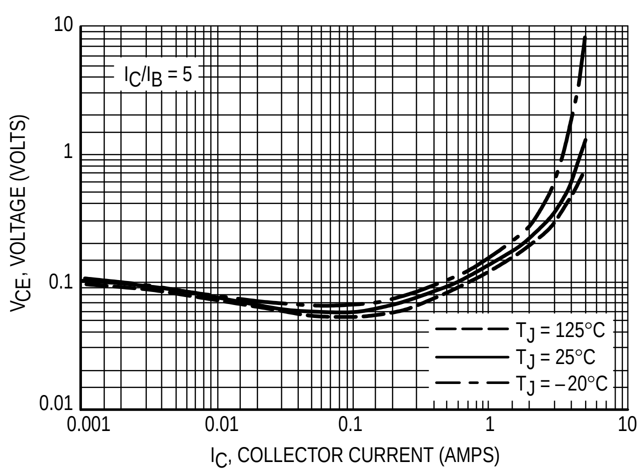



**Figure 5A. Collector–Emitter Saturation Voltage**

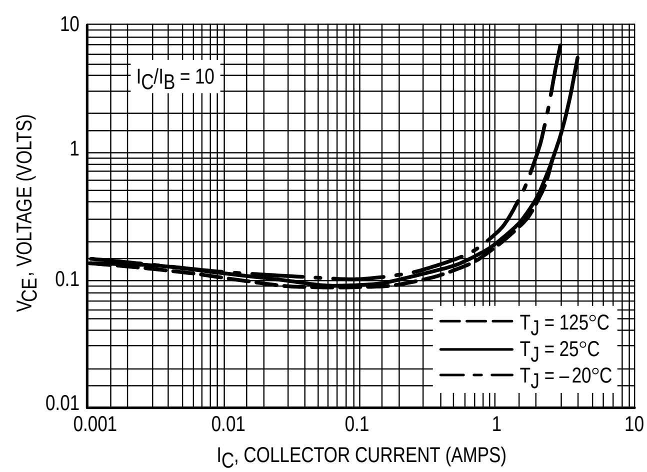



**Figure 5B. Collector–Emitter Saturation Voltage**

## TYPICAL STATIC CHARACTERISTICS

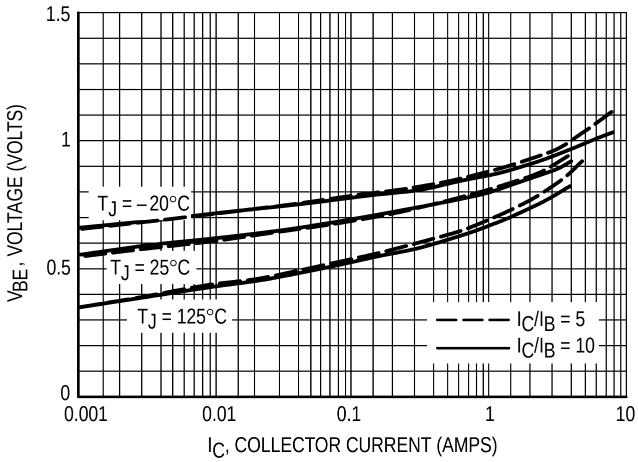



**Figure 6. Base–Emitter Saturation Region**

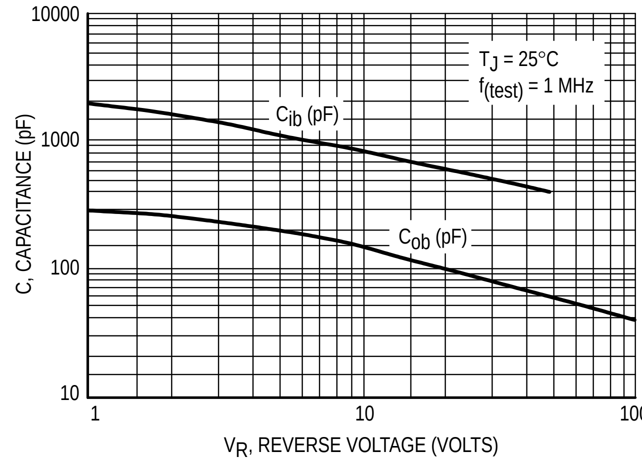



**Figure 7. Capacitance**

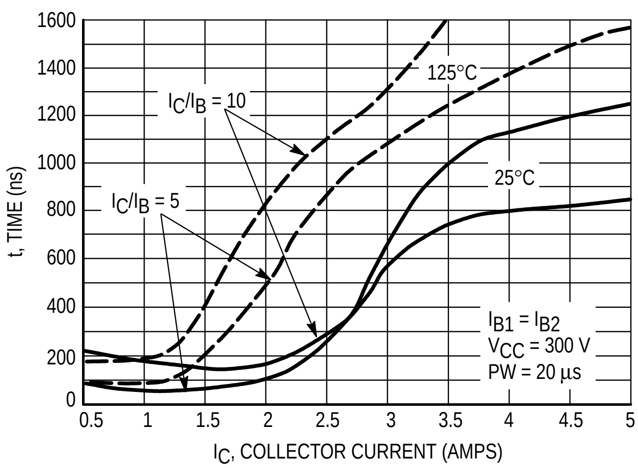



**Figure 8. Resistive Switching, $t_{on}$**

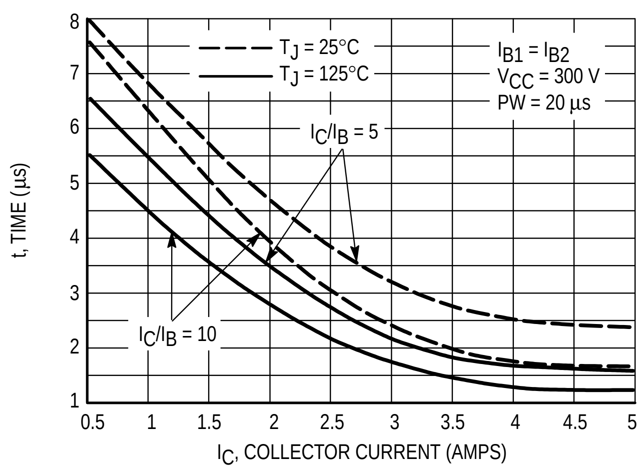



**Figure 9. Resistive Switching, $t_{off}$**

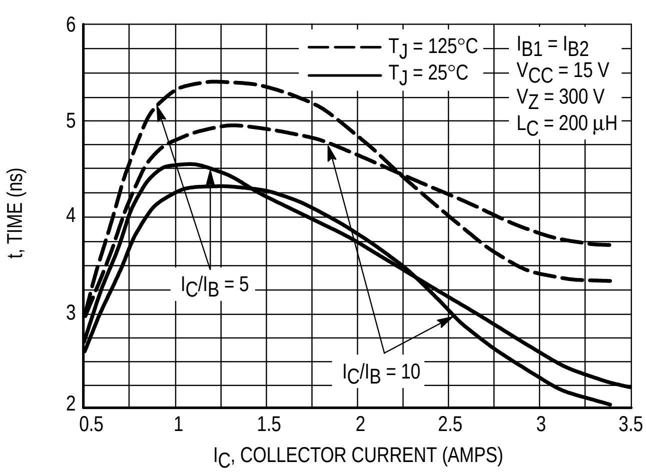



**Figure 10. Inductive Storage Time, $t_{si}$**

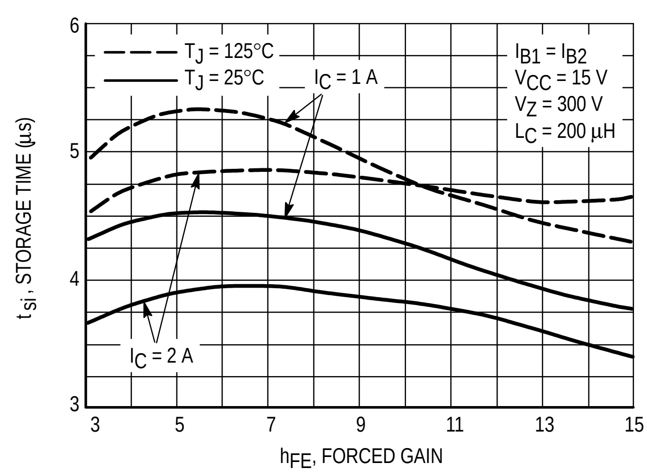



**Figure 11. Inductive Storage Time**

## TYPICAL STATIC CHARACTERISTICS

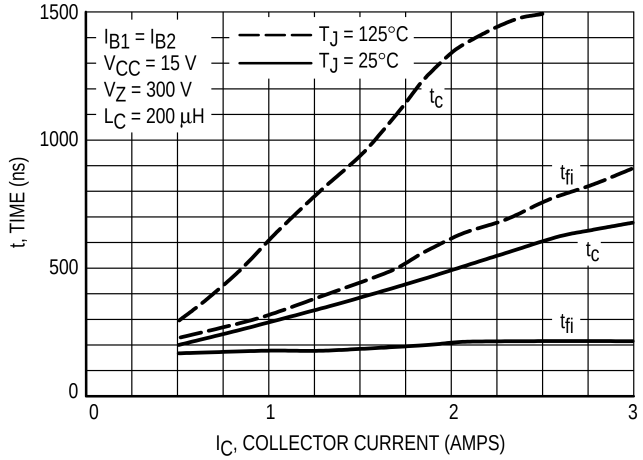



**Figure 12. Inductive Switching, $t_c$ & $t_{fi}$ @ $I_C/I_B$ = 5**

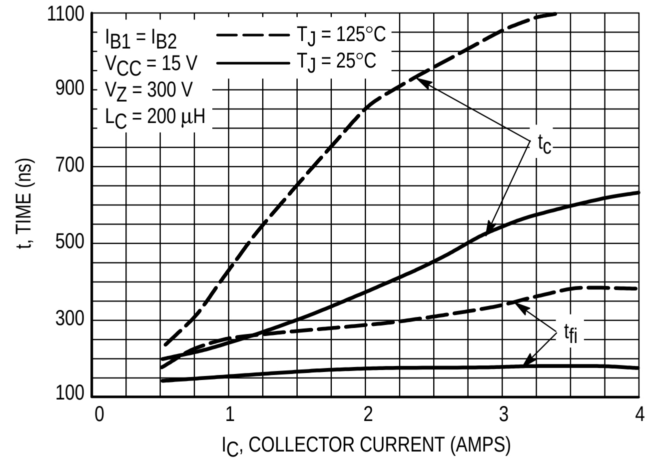



**Figure 13. Inductive Switching, $t_c$ & $t_{fi}$ @ $I_C/I_B$ = 10**

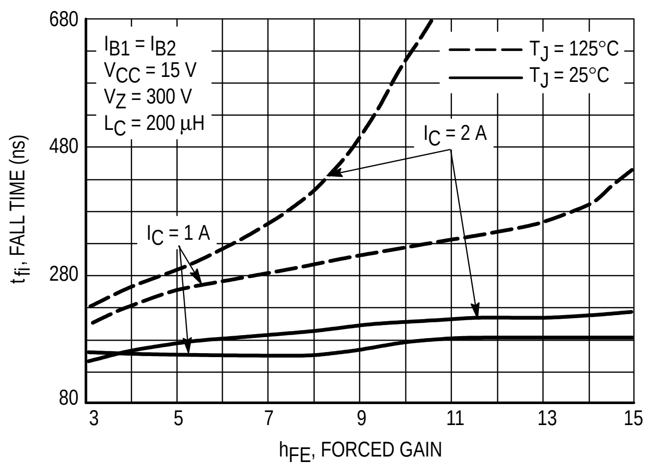



**Figure 14. Inductive Fall Time**

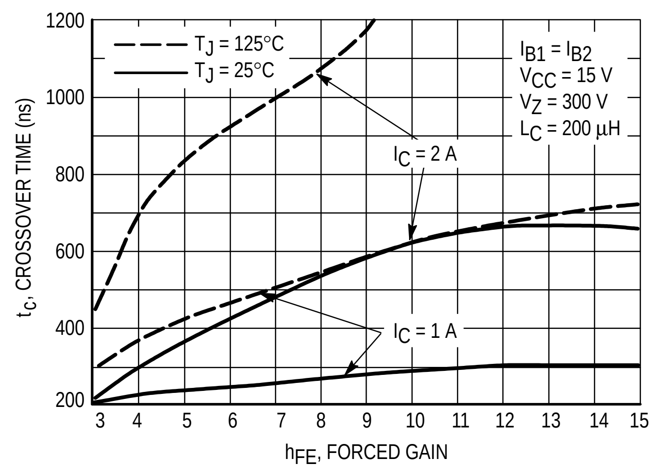



**Figure 15. Inductive Crossover Time**

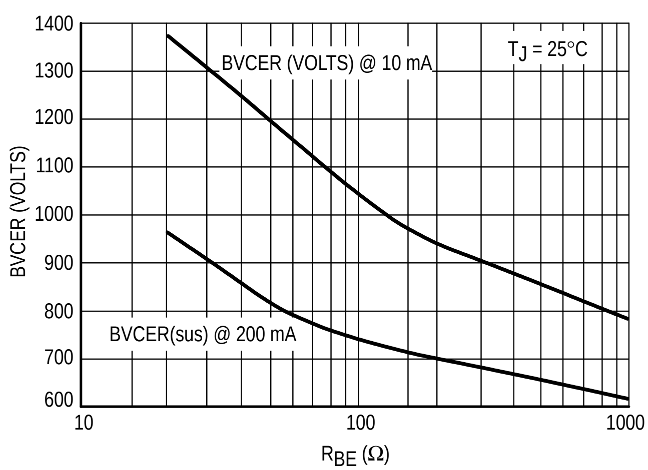



**Figure 16. BVCER = f ($R_{BE}$)**

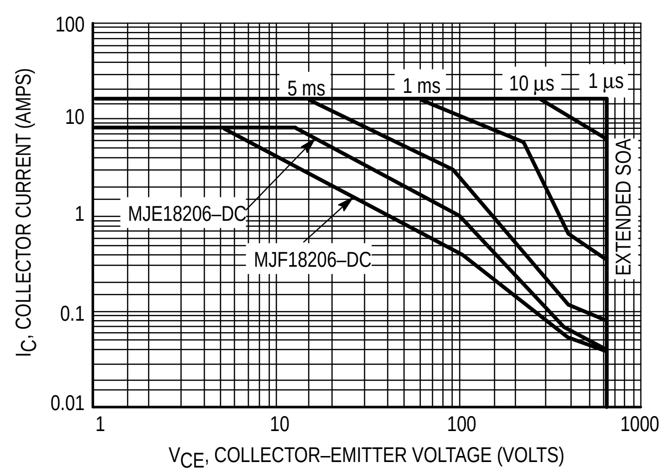



**Figure 17. Forward Bias Safe Operating Area**

## TYPICAL STATIC CHARACTERISTICS

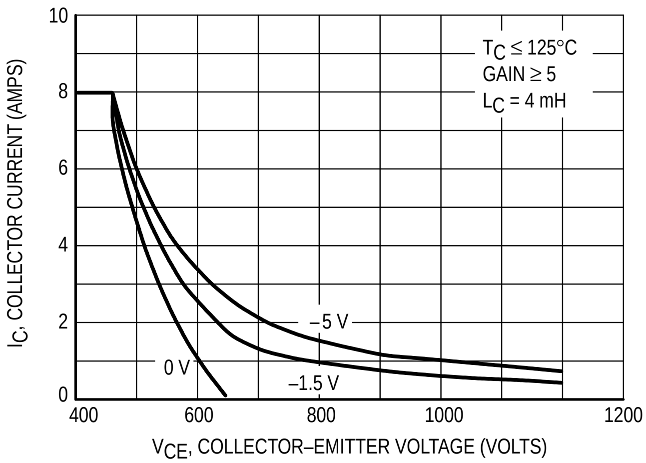



**Figure 18. Reverse Bias Switching Safe Operating Area**

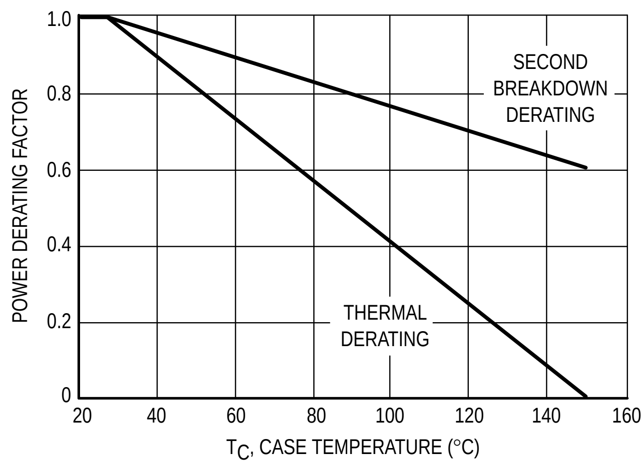



**Figure 19. Forward Bias Power Derating**

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate $I_C$–$V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate. The data of Figure 17 is based on $T_C$ = 25°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 $T_C$ > 25°C. Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 17 may be found at any case temperature by using the appropriate curve on Figure 19.

$T_J$(pk) may be calculated from the data in Figures 22 and 23. At any case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. For inductive loads, high voltage and current must be sustained simultaneously during turn–off with the base–to–emitter junction reverse biased. The safe level is specified as a reverse–biased safe operating area (Figure 18). This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode.

## TYPICAL SWITCHING CHARACTERISTICS ($I_{B1}$ = $I_{B2}$ FOR ALL CURVES)

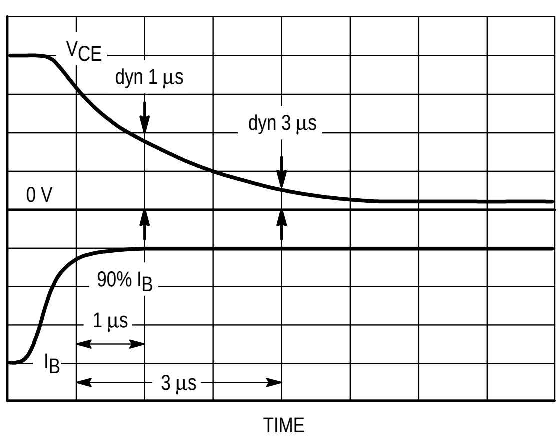



**Figure 20. Dynamic Saturation Voltage Measurements**

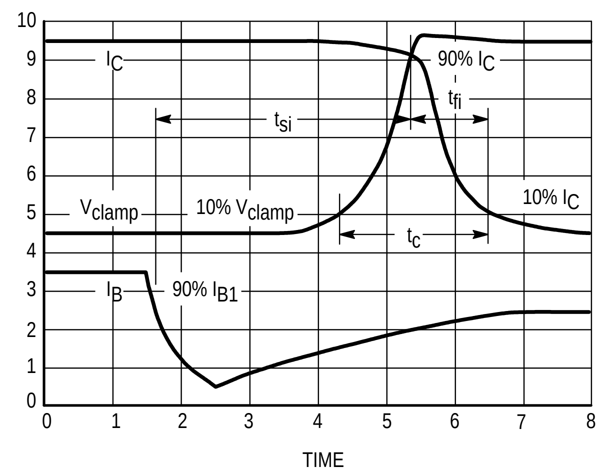
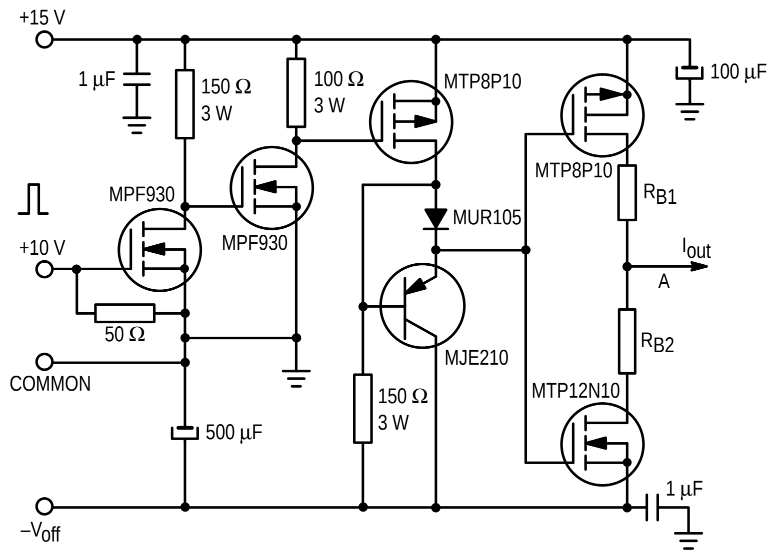
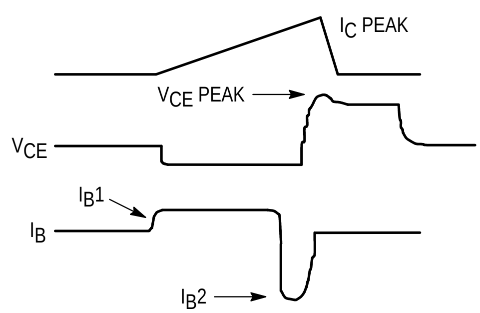



**Figure 21. Inductive Switching Measurements**

## TYPICAL SWITCHING CHARACTERISTICS
## ($I_{B1} = I_{B2}$ FOR ALL CURVES)

**Table 1. Inductive Load Switching Drive Circuit**




| $V_{(BR)CEO(sus)}$ | Inductive Switching | RBSOA |
|---|---|---|
| L = 10 mH | L = 200 μH | L = 500 μH |
| $R_{B2} = \infty$ | $R_{B2} = 0$ | $R_{B2} = 0$ |
| $V_{CC}$ = 20 Volts | $V_{CC}$ = 15 Volts | $V_{CC}$ = 15 Volts |
| $I_{C(pk)}$ = 100 mA | $R_{B1}$ selected for desired $I_{B1}$ | $R_{B1}$ selected for desired $I_{B1}$ |

## TYPICAL THERMAL RESPONSE
## ($I_{B1} = I_{B2}$ FOR ALL CURVES)

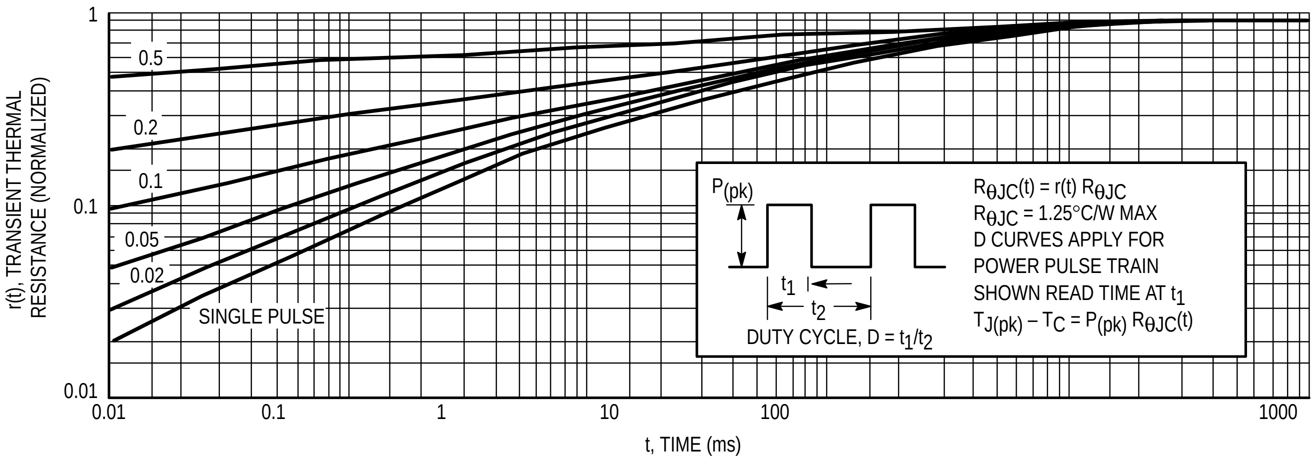



**Figure 22. Typical Thermal Response ($Z_{\theta JC(t)}$) for MJE18206**

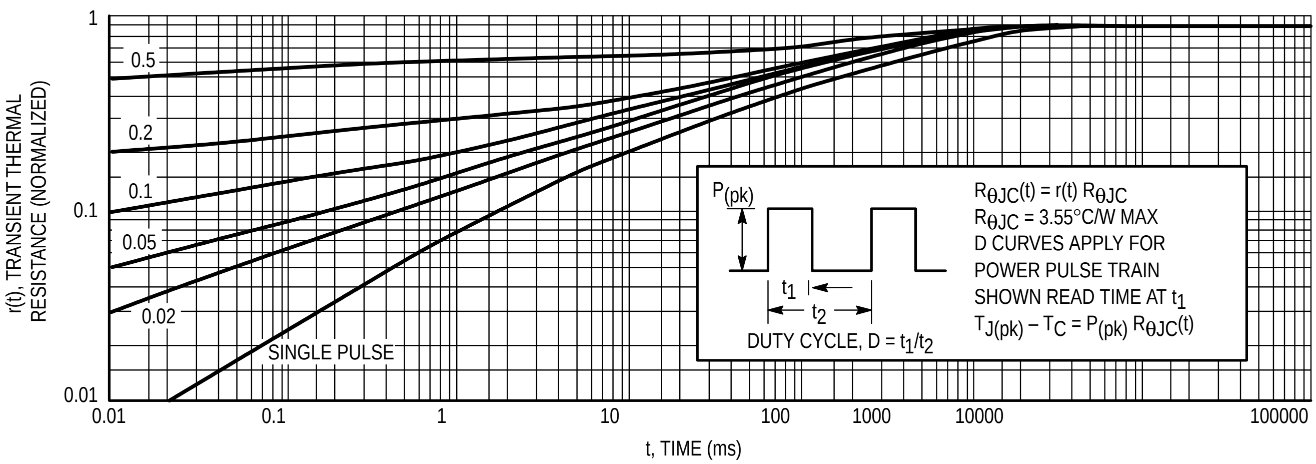



**Figure 23. Typical Thermal Response ($Z_{\theta JC(t)}$) for MJF18206**

## TEST CONDITIONS FOR ISOLATION TESTS*

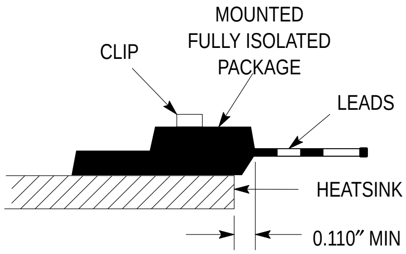



**Figure 24. Clip Mounting Position for Isolation Test Number 1**

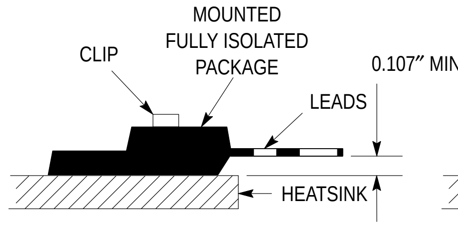



**Figure 25. Clip Mounting Position for Isolation Test Number 2**

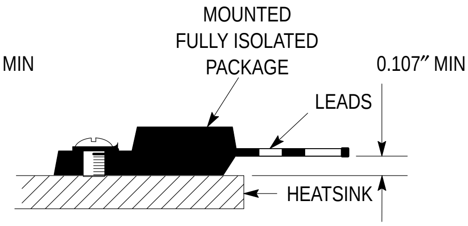



**Figure 26. Screw Mounting Position for Isolation Test Number 3**

* Measurement made between leads and heatsink with all leads shorted together

## MOUNTING INFORMATION**

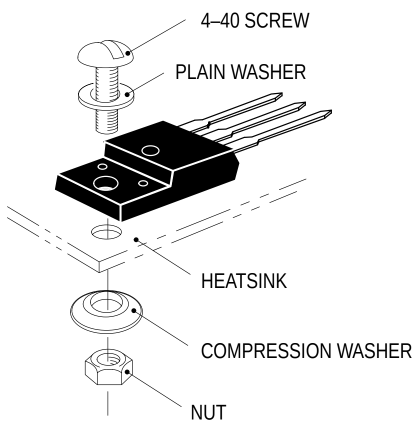



**Figure 27a. Screw–Mounted**

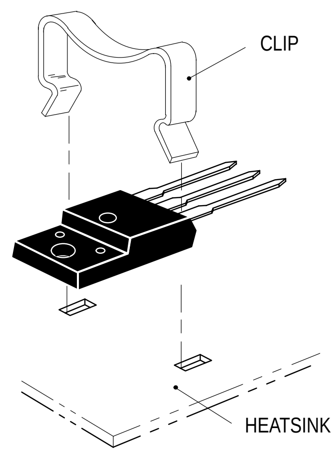



**Figure 27b. Clip–Mounted**

**Figure 27. Typical Mounting Techniques for Isolated Package**

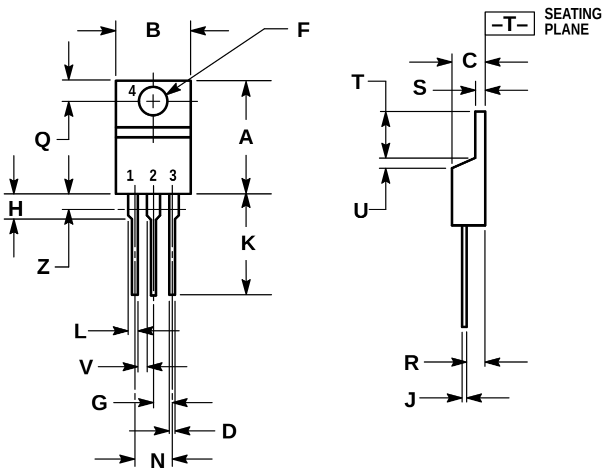
Laboratory tests on a limited number of samples indicate, when using the screw and compression washer mounting technique, a screw torque of 6 to 8 in · lbs is sufficient to provide maximum power dissipation capability. The compression washer helps to maintain a constant pressure on the package over time and during large temperature excursions.

Destructive laboratory tests show that using a hex head 4–40 screw, without washers, and applying a torque in excess of 20 in · lbs will cause the plastic to crack around the mounting hole, resulting in a loss of isolation capability.

Additional tests on slotted 4–40 screws indicate that the screw slot fails between 15 to 20 in · lbs without adversely affecting the package. However, in order to positively ensure the package integrity of the fully isolated device, Motorola does not recommend exceeding 10 in · lbs of mounting torque under any mounting conditions.

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

## PACKAGE DIMENSIONS

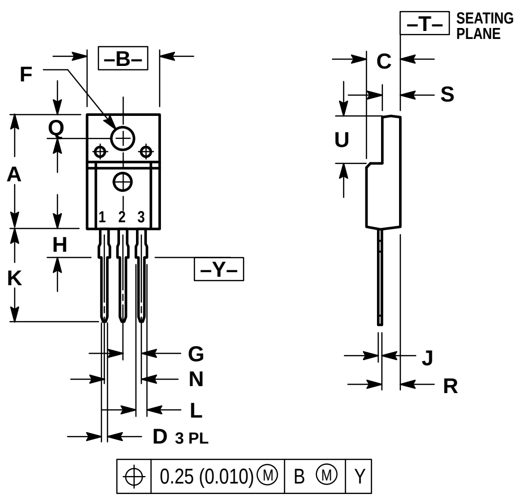



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION Z DEFINES A ZONE WHERE ALL BODY AND LEAD IRREGULARITIES ARE ALLOWED.

| | INCHES | | MILLIMETERS | |
|---|---|---|---|---|
| DIM | 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 |

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

**CASE 221A–06**
**TO–220AB**
**ISSUE Y**




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

| | INCHES | | MILLIMETERS | |
|---|---|---|---|---|
| DIM | 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. GATE
2. DRAIN
3. SOURCE

**CASE 221D–02**
**(ISOLATED TO–220 TYPE)**
**UL RECOGNIZED: FILE #E69369**
**ISSUE D**

**How to reach us:**
**USA / EUROPE**: Motorola Literature Distribution;
P.O. Box 20912; Phoenix, Arizona 85036. 1–800–441–2447

**MFAX**: RMFAX0@email.sps.mot.com – TOUCHTONE (602) 244–6609
**INTERNET**: http://Design–NET.com

**JAPAN**: Nippon Motorola Ltd.; Tatsumi–SPD–JLDC, Toshikatsu Otsuki,
6F Seibu–Butsuryu–Center, 3–14–2 Tatsumi Koto–Ku, Tokyo 135, Japan. 03–3521–8315

**HONG KONG**: Motorola Semiconductors H.K. Ltd.; 8B Tai Ping Industrial Park,
51 Ting Kok Road, Tai Po, N.T., Hong Kong. 852–26629298