

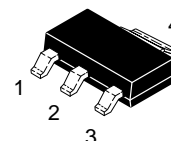
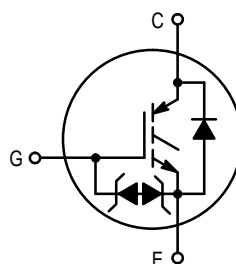
*Designer's™ Data Sheet*  
**Insulated Gate Bipolar Transistor**  
**N-Channel Enhancement-Mode Silicon Gate**

**MMG05N60D**

**IGBT**  
**0.5 A @ 25°C**  
**600 V**

This IGBT contains a built-in free wheeling diode and a gate protection zener diodes. Fast switching characteristics result in efficient operation at higher frequencies. This device is ideally suited for high frequency electronic ballasts.

- Built-In Free Wheeling Diode
- Built-In Gate Protection Zener Diodes
- Industry Standard Package (SOT223)
- High Speed  $E_{off}$ : Typical  $6.5 \mu\text{J}$  @  $I_C = 0.3 \text{ A}$ ;  $T_C = 125^\circ\text{C}$  and  $dV/dt = 1000 \text{ V}/\mu\text{s}$
- Robust High Voltage Termination
- Robust Turn-Off SOA



1 = G  
2 = 4 = C  
3 = E

**CASE 318E-04**  
**STYLE 13**  
**TO-261A**

**MAXIMUM RATINGS** ( $T_J = 25^\circ\text{C}$  unless otherwise noted)

| Parameters  | Symbol                             | Value             | Unit                      |
|---|------------------------------------|-------------------|---------------------------|
| Collector-Emitter Voltage   | $V_{CES}$                          | 600               | Vdc                       |
| Collector-Gate Voltage ( $R_{GE} = 1.0 \text{ M}\Omega$ )   | $V_{CGR}$                          | 600               | Vdc                       |
| Gate-Emitter Voltage — Continuous   | $V_{CGR}$                          | $\pm 15$          | Vdc                       |
| Collector Current — Continuous @ $T_C = 25^\circ\text{C}$<br>— Continuous @ $T_C = 90^\circ\text{C}$<br>— Repetitive Pulsed Current (1) | $I_{C25}$<br>$I_{C90}$<br>$I_{CM}$ | 0.5<br>0.3<br>2.0 | Adc                       |
| Total Device Dissipation @ $T_C = 25^\circ\text{C}$   | $P_D$                              | 1.0               | Watt                      |
| Operating and Storage Junction Temperature Range  | $T_J, T_{stg}$                     | -55 to 150        | $^\circ\text{C}$          |
| Thermal Resistance — Junction to Case – IGBT<br>— Junction to Ambient   | $R_{\theta JC}$<br>$R_{\theta JA}$ | 30<br>150         | $^\circ\text{C}/\text{W}$ |
| Maximum Lead Temperature for Soldering Purposes, 1/8" from case for 5 seconds   | $T_L$                              | 260               | $^\circ\text{C}$          |

**UNCLAMPED DRAIN-TO-SOURCE AVALANCHE CHARACTERISTICS** ( $T_C \leq 150^\circ\text{C}$ )

|  |          |           |    |
|--|----------|-----------|----|
| Single Pulse Drain-to-Source Avalanche Energy – Starting @ $T_C = 25^\circ\text{C}$<br>@ $T_C = 125^\circ\text{C}$<br>$V_{CE} = 100 \text{ V}$ , $V_{GE} = 15 \text{ V}$ , Peak $I_L = 2.0 \text{ A}$ , $L = 3.0 \text{ mH}$ , $R_G = 25 \Omega$ | $E_{AS}$ | 125<br>40 | mJ |
|--|----------|-----------|----|

(1) Pulse width is limited by maximum junction temperature repetitive rating.

**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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# MMG05N60D

## ELECTRICAL CHARACTERISTICS (T<sub>J</sub> = 25°C unless otherwise noted)

| Characteristic   | Symbol                               | Min      | Typ        | Max       | Unit        |
|--|--------------------------------------|----------|------------|-----------|-------------|
| <b>OFF CHARACTERISTICS</b>   |                                      |          |            |           |             |
| Collector-to-Emitter Breakdown Voltage<br>(V <sub>GE</sub> = 0 Vdc, I <sub>C</sub> = 250 μAdc)<br>Temperature Coefficient (Positive)   | V <sub>(BR)CES</sub>                 | 600<br>— | 680<br>0.7 | —<br>—    | Vdc<br>V/°C |
| Zero Gate Voltage Collector Current<br>(V <sub>CE</sub> = 600 Vdc, V <sub>GE</sub> = 0 Vdc, T <sub>C</sub> = 25°C)<br>(V <sub>CE</sub> = 600 Vdc, V <sub>GE</sub> = 0 Vdc, T <sub>C</sub> = 125°C) | I <sub>CES</sub><br>I <sub>CES</sub> | —<br>—   | 0.1<br>5.0 | 5.0<br>50 | μAdc        |
| Gate-Body Leakage Current (V <sub>GE</sub> = ±15 Vdc, V <sub>CE</sub> = 0 Vdc)   | I <sub>GES</sub>                     | —        | 10         | 100       | μAdc        |

## ON CHARACTERISTICS

|  |                     |          |            |          |              |
|--|---------------------|----------|------------|----------|--------------|
| Collector-to-Emitter On-State Voltage<br>(V <sub>GE</sub> = 15 Vdc, I <sub>C</sub> = 0.3 Adc, T <sub>C</sub> = 25°C)<br>(V <sub>GE</sub> = 15 Vdc, I <sub>C</sub> = 0.3 Adc, T <sub>C</sub> = 125°C) | V <sub>CE(on)</sub> | —<br>—   | 1.6<br>1.5 | 2.0<br>— | Vdc          |
| Gate Threshold Voltage<br>(V <sub>CE</sub> = V <sub>GE</sub> , I <sub>C</sub> = 250 μAdc)<br>Threshold Temperature Coefficient (Negative)  | V <sub>GE(th)</sub> | 3.5<br>— | —<br>6.0   | 6.0<br>— | Vdc<br>mV/°C |
| Forward Transconductance (V <sub>CE</sub> = 10 Vdc, I <sub>C</sub> = 0.5 Adc)  | g <sub>fe</sub>     | 0.3      | 0.42       | —        | Mhos         |

## DYNAMIC CHARACTERISTICS

|                      |   |                  |   |     |     |    |
|----------------------|---|------------------|---|-----|-----|----|
| Input Capacitance    | (V <sub>CE</sub> = 20 Vdc, V <sub>GE</sub> = 0 Vdc,<br>f = 1.0 MHz) | C <sub>ies</sub> | — | 75  | 100 | pF |
| Output Capacitance   |   | C <sub>oes</sub> | — | 11  | 20  |    |
| Transfer Capacitance |   | C <sub>res</sub> | — | 1.6 | 5.0 |    |

## DIODE CHARACTERISTICS

|  |                  |                  |                          |                      |     |
|--|------------------|------------------|--------------------------|----------------------|-----|
| Diode Forward Voltage Drop<br>(I <sub>EC</sub> = 0.3 Adc, T <sub>C</sub> = 25°C)<br>(I <sub>EC</sub> = 0.3 Adc, T <sub>C</sub> = 125°C)<br>(I <sub>EC</sub> = 0.1 Adc, T <sub>C</sub> = 25°C)<br>(I <sub>EC</sub> = 0.1 Adc, T <sub>C</sub> = 125°C) | V <sub>FEC</sub> | —<br>—<br>—<br>— | 5.0<br>5.2<br>2.3<br>2.3 | 6.0<br>—<br>3.0<br>— | Vdc |
| Reverse Recovery Time @ T <sub>C</sub> = 25°C<br>I <sub>F</sub> = 0.4 Adc, V <sub>R</sub> = 300 Vdc, dI <sub>F</sub> /dt = 10 A/μs   | t <sub>rr</sub>  | —                | 150                      | —                    | ns  |
| Reverse Recovery Stored Charge<br>I <sub>F</sub> = 0.4 Adc, V <sub>R</sub> = 300 Vdc, dI <sub>F</sub> /dt = 10 A/μs  | Q <sub>RR</sub>  | —                | 35                       | —                    | μC  |

## SWITCHING CHARACTERISTICS (1)

|                         |   |                     |   |      |      |    |
|-------------------------|---|---------------------|---|------|------|----|
| Turn-Off Delay Time     | (V <sub>CC</sub> = 300 Vdc, I <sub>C</sub> = 0.4 Adc,<br>V <sub>GE</sub> = 15 Vdc, L = 3.0 mH, R <sub>G</sub> = 25 Ω,<br>T <sub>C</sub> = 25°C, dV/dt = 1000 V/μs)<br>Energy losses include "tail"  | t <sub>d(off)</sub> | — | 28   | —    | ns |
| Fall Time               |   | t <sub>f</sub>      | — | 150  | —    |    |
| Turn-Off Switching Loss |   | E <sub>off</sub>    | — | 3.25 | 4.25 |    |
| Turn-Off Delay Time     | (V <sub>CC</sub> = 300 Vdc, I <sub>C</sub> = 0.4 Adc,<br>V <sub>GE</sub> = 15 Vdc, L = 3.0 mH, R <sub>G</sub> = 25 Ω,<br>T <sub>C</sub> = 125°C, dV/dt = 1000 V/μs)<br>Energy losses include "tail" | t <sub>d(off)</sub> | — | 21   | —    | ns |
| Fall Time               |   | t <sub>f</sub>      | — | 280  | —    |    |
| Turn-Off Switching Loss |   | E <sub>off</sub>    | — | 8.0  | 10   |    |
| Gate Charge             | (V <sub>CC</sub> = 300 Vdc, I <sub>C</sub> = 0.3 Adc,<br>V <sub>GE</sub> = 15 Vdc)  | Q <sub>T</sub>      | — | 6.4  | —    | nC |

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

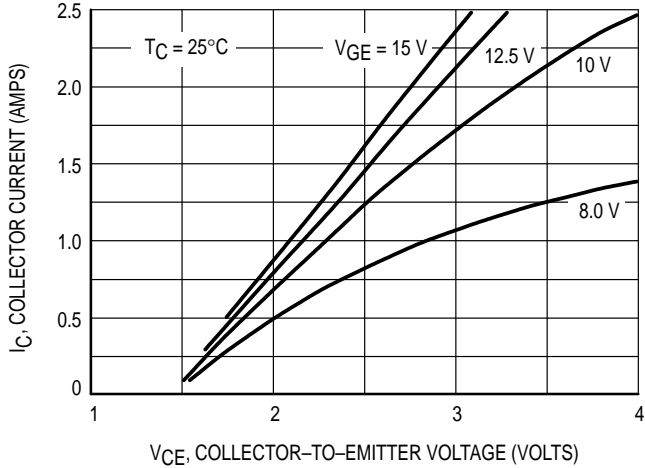


Figure 1. Saturation Characteristics

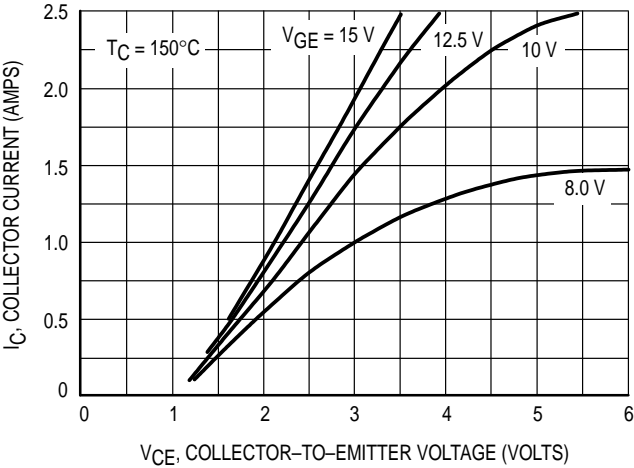


Figure 2. Saturation Characteristics

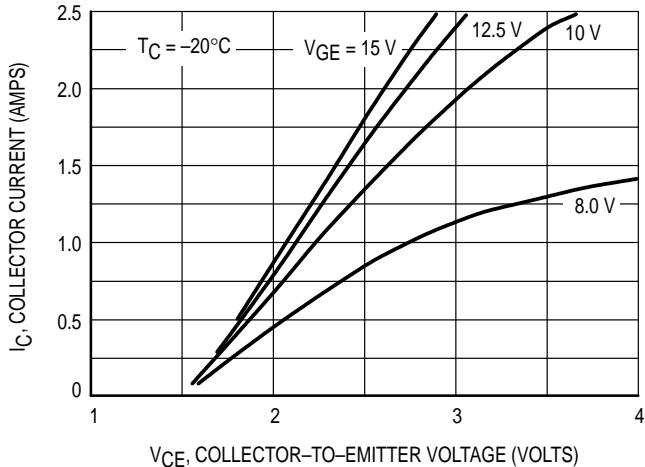


Figure 3. Saturation Characteristics

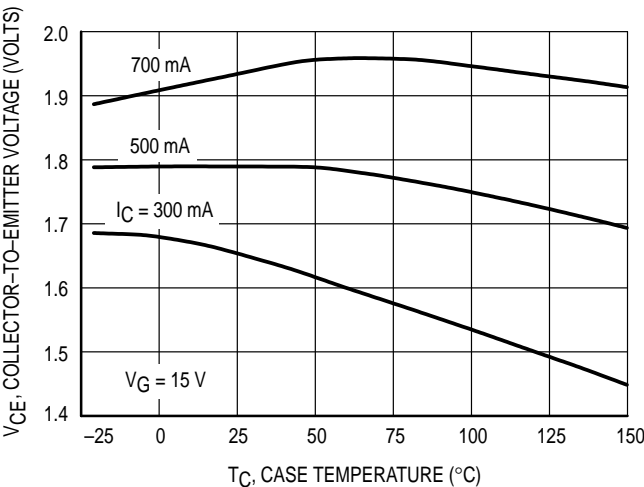


Figure 4. Collector-To-Emitter Saturation Voltage versus Case Temperature

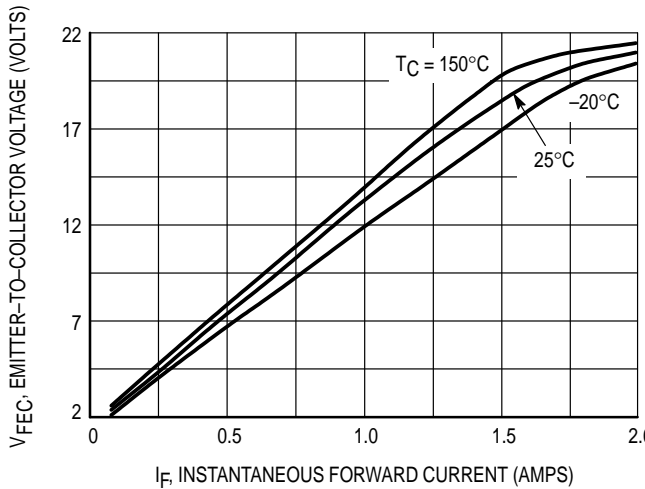


Figure 5. Diode Forward Voltage

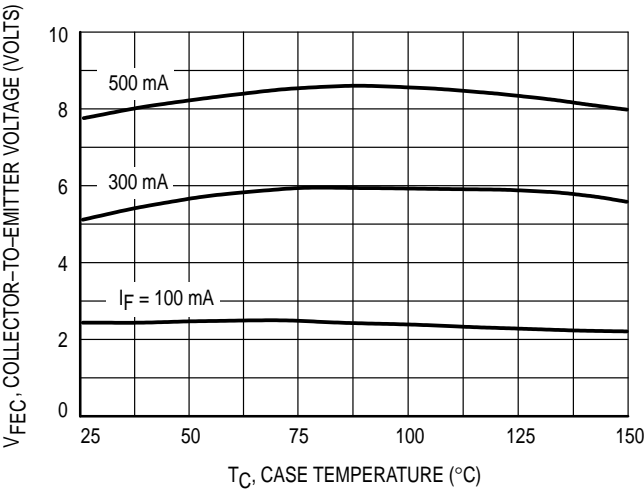


Figure 6. Diode Forward Voltage versus Case Temperature

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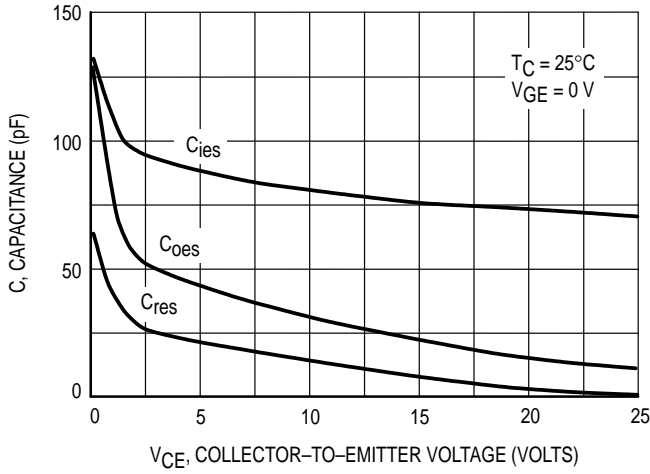


Figure 7. Capacitance Variation

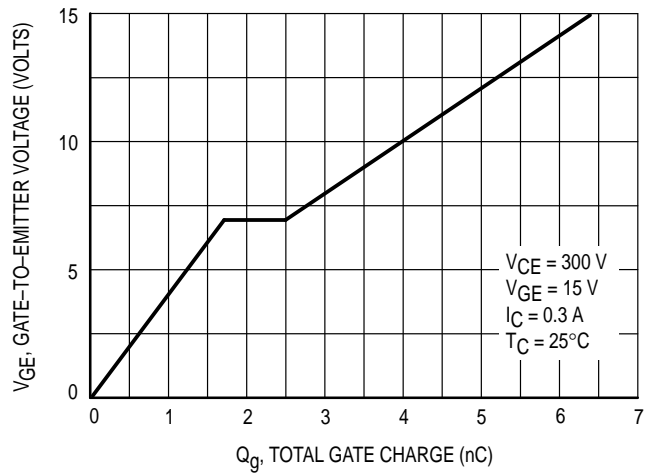


Figure 8. Gate-To-Emitter Voltage versus Total Charge

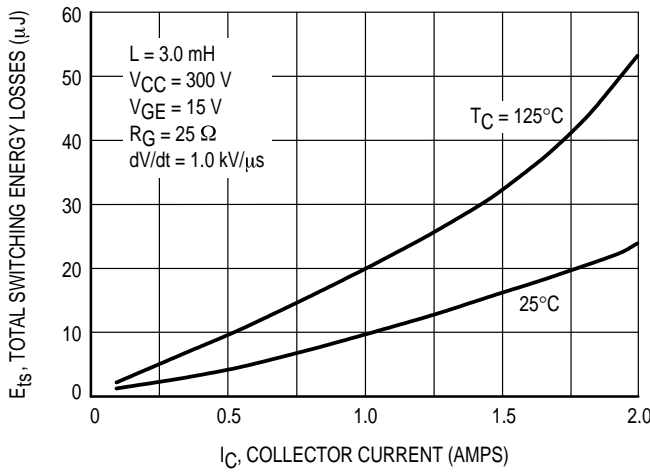


Figure 9. Total Switching Losses versus Collector Current

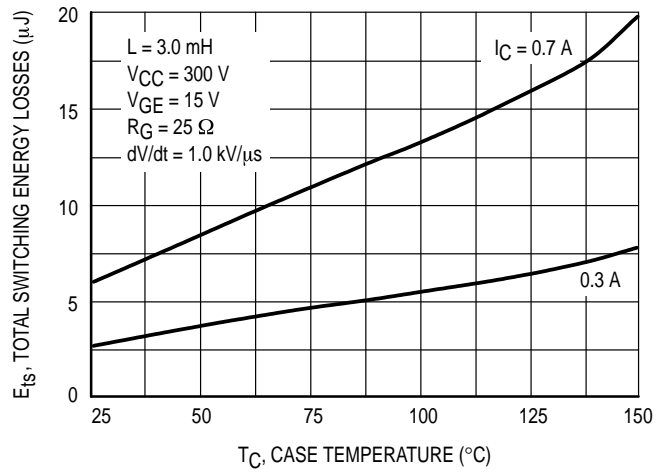


Figure 10. Total Switching Losses versus Case Temperature

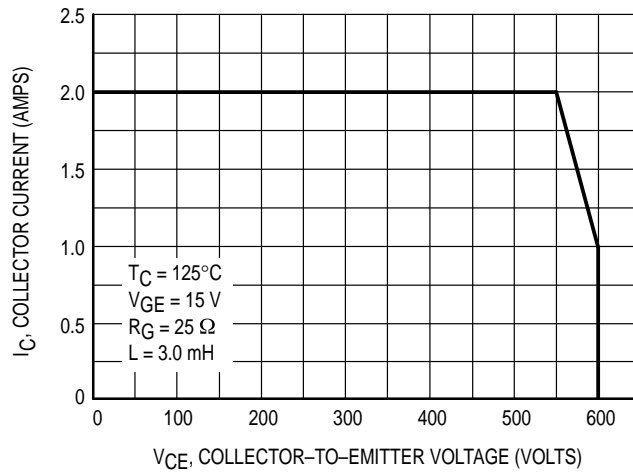


Figure 11. Minimum Turn-Off Safe Operating Area

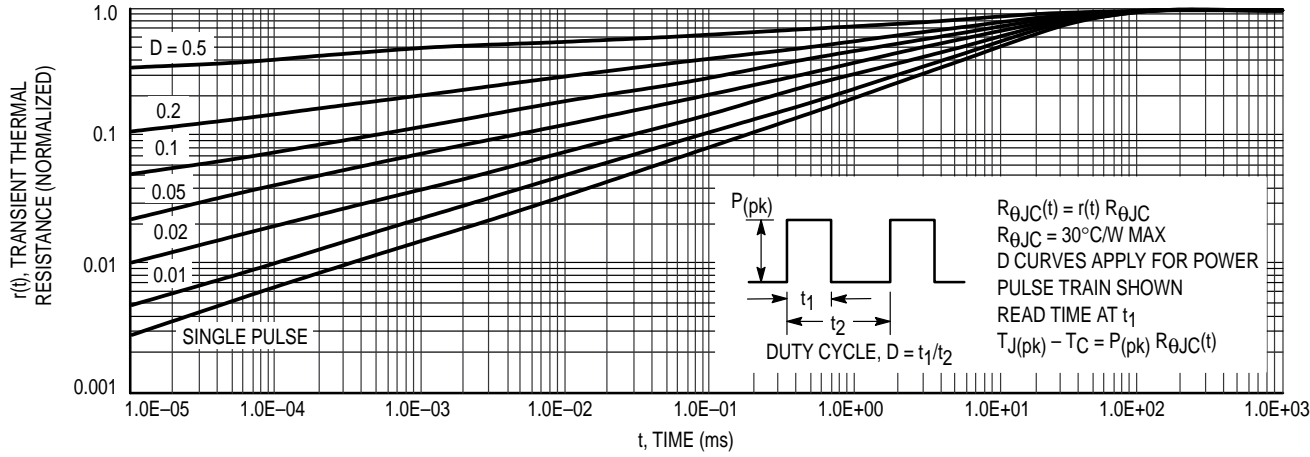
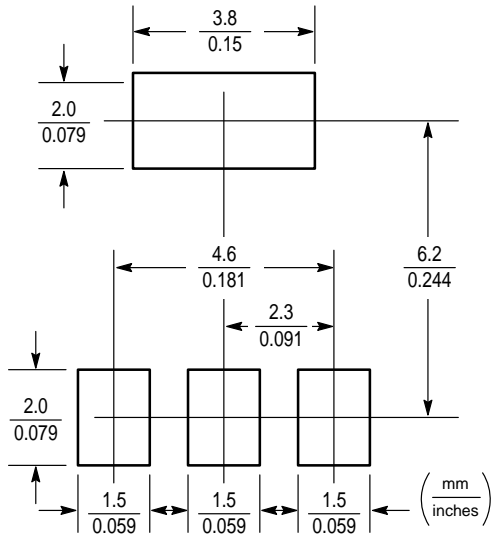
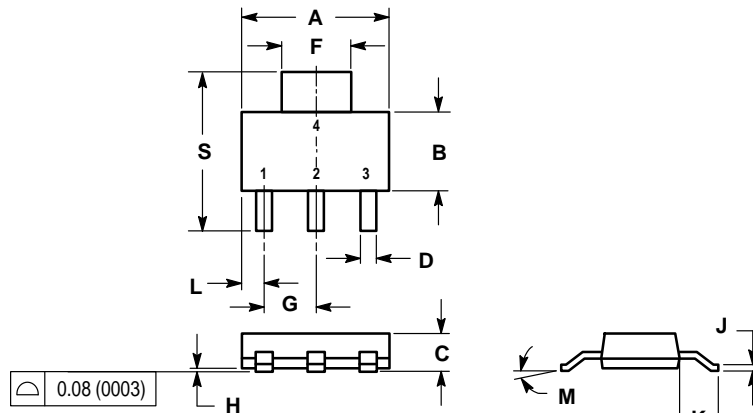


Figure 12. Typical Thermal Response



PACKAGE DIMENSIONS



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

| DIM | INCHES |        | MILLIMETERS |       |
|-----|--------|--------|-------------|-------|
|     | MIN    | MAX    | MIN         | MAX   |
| A   | 0.249  | 0.263  | 6.30        | 6.70  |
| B   | 0.130  | 0.145  | 3.30        | 3.70  |
| C   | 0.060  | 0.068  | 1.50        | 1.75  |
| D   | 0.024  | 0.035  | 0.60        | 0.89  |
| F   | 0.115  | 0.126  | 2.90        | 3.20  |
| G   | 0.087  | 0.094  | 2.20        | 2.40  |
| H   | 0.0008 | 0.0040 | 0.020       | 0.100 |
| J   | 0.009  | 0.014  | 0.24        | 0.35  |
| K   | 0.060  | 0.078  | 1.50        | 2.00  |
| L   | 0.033  | 0.041  | 0.85        | 1.05  |
| M   | 0°     | 10°    | 0°          | 10°   |
| S   | 0.264  | 0.287  | 6.70        | 7.30  |

- STYLE 13:  
 PIN 1. GATE  
 2. COLLECTOR  
 3. EMITTER  
 4. COLLECTOR

CASE 318E-04  
 TO-261A  
 ISSUE H

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