

# Hybrid Power Module

## Integrated Power Stage for 1.0 hp Motor Drives

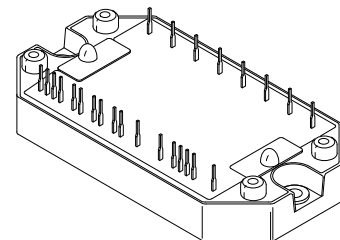
The MHPM7A15A60A module integrates a 3-phase input rectifier bridge, 3-phase output inverter, brake transistor/diode, current sense resistor and temperature sensor in a single convenient package. The output inverter utilizes advanced insulated gate bipolar transistors (IGBT) matched with free-wheeling diodes to give optimal dynamic performance. It has been configured for use as a three-phase motor drive module or for many other power switching applications. The top connector pins have been designed for easy interfacing to the user's control board.

- DC Bus Current Sense Resistor Included
- Short Circuit Rated 10  $\mu$ s @ 25°C
- Temperature Sensor Included
- Pin-to-Baseplate Isolation exceeds 2500 Vac (rms)
- Convenient Package Outline
- UL  Recognized and Designed to Meet VDE 
- Access to Positive and Negative DC Bus

**MHPM7A15A60A**

Motorola Preferred Device

**15 AMP, 600 VOLT  
HYBRID POWER MODULE**



PLASTIC PACKAGE  
CASE 440-01, Style 1

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

| Rating                                               | Symbol      | Value        | Unit             |
|------------------------------------------------------|-------------|--------------|------------------|
| <b>INPUT RECTIFIER BRIDGE</b>                        |             |              |                  |
| Repetitive Peak Reverse Voltage                      | $V_{RRM}$   | 600          | V                |
| Average Output Rectified Current                     | $I_O$       | 15           | A                |
| Peak Non-repetitive Surge Current — (1/2 Cycle) (1)  | $I_{FSM}$   | 200          | A                |
| <b>OUTPUT INVERTER</b>                               |             |              |                  |
| IGBT Reverse Voltage                                 | $V_{CES}$   | 600          | V                |
| Gate-Emitter Voltage                                 | $V_{GES}$   | $\pm 20$     | V                |
| Continuous IGBT Collector Current                    | $I_C$       | 15           | A                |
| Peak IGBT Collector Current — (PW = 1.0 ms) (2)      | $I_{C(pk)}$ | 30           | A                |
| Continuous Free-Wheeling Diode Current               | $I_F$       | 15           | A                |
| Peak Free-Wheeling Diode Current — (PW = 1.0 ms) (2) | $I_{F(pk)}$ | 30           | A                |
| IGBT Power Dissipation                               | $P_D$       | 55           | W                |
| Free-Wheeling Diode Power Dissipation                | $P_D$       | 30           | W                |
| IGBT Junction Temperature Range                      | $T_J$       | - 40 to +125 | $^\circ\text{C}$ |
| Free-Wheeling Diode Junction Temperature Range       | $T_J$       | - 40 to +125 | $^\circ\text{C}$ |

(1) 1 cycle = 50 or 60 Hz

(2) 1.0 ms = 1.0% duty cycle

**Preferred** devices are Motorola recommended choices for future use and best overall value.

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

| Rating                                              | Symbol      | Value           | Unit             |
|-----------------------------------------------------|-------------|-----------------|------------------|
| <b>BRAKE CIRCUIT</b>                                |             |                 |                  |
| IGBT Reverse Voltage                                | $V_{CES}$   | 600             | V                |
| Gate-Emitter Voltage                                | $V_{GES}$   | $\pm 20$        | V                |
| Continuous IGBT Collector Current                   | $I_C$       | 15              | A                |
| Peak IGBT Collector Current (PW = 1.0 ms) (2)       | $I_{C(pk)}$ | 30              | A                |
| IGBT Power Dissipation                              | PD          | 55              | W                |
| Diode Reverse Voltage                               | $V_{RRM}$   | 600             | V                |
| Continuous Output Diode Current                     | $I_F$       | 15              | A                |
| Peak Output Diode Current (PW = 1.0 ms) (2)         | $I_{F(pk)}$ | 30              | A                |
| <b>TOTAL MODULE</b>                                 |             |                 |                  |
| Isolation Voltage — (47–63 Hz, 1.0 Minute Duration) | $V_{ISO}$   | 2500            | VAC              |
| Ambient Operating Temperature Range                 | $T_A$       | $-40$ to $+85$  | $^\circ\text{C}$ |
| Operating Case Temperature Range                    | $T_C$       | $-40$ to $+90$  | $^\circ\text{C}$ |
| Storage Temperature Range                           | $T_{stg}$   | $-40$ to $+150$ | $^\circ\text{C}$ |
| Mounting Torque                                     | —           | 6.0             | lb-in            |

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

| Characteristic                                                                                                                 | Symbol          | Min    | Typ    | Max        | Unit                |
|--------------------------------------------------------------------------------------------------------------------------------|-----------------|--------|--------|------------|---------------------|
| <b>INPUT RECTIFIER BRIDGE</b>                                                                                                  |                 |        |        |            |                     |
| Reverse Leakage Current ( $V_{RRM} = 600$ V)                                                                                   | $I_R$           | —      | 10     | 50         | $\mu\text{A}$       |
| Forward Voltage ( $I_F = 15$ A)                                                                                                | $V_F$           | —      | 1.05   | 1.5        | V                   |
| Thermal Resistance (Each Die)                                                                                                  | $R_{\theta JC}$ | —      | —      | 2.9        | $^\circ\text{C/W}$  |
| <b>OUTPUT INVERTER</b>                                                                                                         |                 |        |        |            |                     |
| Gate-Emitter Leakage Current ( $V_{CE} = 0$ V, $V_{GE} = \pm 20$ V)                                                            | $I_{GES}$       | —      | —      | $\pm 20$   | $\mu\text{A}$       |
| Collector-Emitter Leakage Current ( $V_{CE} = 600$ V, $V_{GE} = 0$ V)<br>$T_J = 25^\circ\text{C}$<br>$T_J = 125^\circ\text{C}$ | $I_{CES}$       | —<br>— | —<br>— | 200<br>2.0 | $\mu\text{A}$<br>mA |
| Gate-Emitter Threshold Voltage ( $V_{CE} = V_{GE}$ , $I_C = 1.0$ mA)                                                           | $V_{GE(th)}$    | 4.0    | 6.0    | 8.0        | V                   |
| Collector-Emitter Breakdown Voltage ( $I_C = 10$ mA, $V_{GE} = 0$ )                                                            | $V_{(BR)CES}$   | 600    | 700    | —          | V                   |
| Collector-Emitter Saturation Voltage ( $V_{GE} = 15$ V, $I_C = 15$ A)                                                          | $V_{CE(SAT)}$   | —      | 2.7    | 3.5        | V                   |
| Input Capacitance ( $V_{GE} = 0$ V, $V_{CE} = 10$ V, $f = 1.0$ MHz)                                                            | $C_{ies}$       | —      | 950    | —          | pF                  |
| Input Gate Charge ( $V_{CE} = 300$ V, $I_C = 15$ A, $V_{GE} = 15$ V)                                                           | $Q_T$           | —      | 75     | —          | nC                  |
| Fall Time — Inductive Load<br>( $V_{CE} = 300$ V, $I_C = 15$ A, $V_{GE} = 15$ V, $R_G = 150$ $\Omega$ )                        | $t_{fi}$        | —      | 200    | 350        | ns                  |
| Turn-On Energy<br>( $V_{CE} = 300$ V, $I_C = 15$ A, $V_{GE} = 15$ V, $R_G = 150$ $\Omega$ )                                    | $E_{(on)}$      | —      | —      | 1.0        | mJ                  |
| Turn-Off Energy<br>( $V_{CE} = 300$ V, $I_C = 15$ A, $V_{GE} = 15$ V, $R_G = 150$ $\Omega$ )                                   | $E_{(off)}$     | —      | —      | 1.0        | mJ                  |
| Diode Forward Voltage ( $I_F = 15$ A, $V_{GE} = 0$ V)                                                                          | $V_F$           | —      | 1.5    | 2.0        | V                   |
| Diode Reverse Recovery Time<br>( $I_F = 15$ A, $V = 400$ V, $di/dt = 50$ A/ $\mu\text{s}$ )                                    | $t_{rr}$        | —      | 140    | 200        | ns                  |
| Diode Stored Charge ( $I_F = 15$ A, $V = 400$ V, $di/dt = 50$ A/ $\mu\text{s}$ )                                               | $Q_{rr}$        | —      | —      | 900        | nC                  |
| Thermal Resistance — IGBT (Each Die)                                                                                           | $R_{\theta JC}$ | —      | —      | 1.9        | $^\circ\text{C/W}$  |
| Thermal Resistance — Free-Wheeling Diode (Each Die)                                                                            | $R_{\theta JC}$ | —      | —      | 3.7        | $^\circ\text{C/W}$  |

(2) 1.0 ms = 1.0% duty cycle

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

| Characteristic                                                                                                                                     | Symbol          | Min    | Typ    | Max        | Unit                         |
|----------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|--------|--------|------------|------------------------------|
| <b>BRAKE CIRCUIT</b>                                                                                                                               |                 |        |        |            |                              |
| Gate-Emitter Leakage Current ( $V_{CE} = 0\text{ V}$ , $V_{GE} = \pm 20\text{ V}$ )                                                                | $I_{GES}$       | —      | —      | $\pm 20$   | $\mu\text{A}$                |
| Collector-Emitter Leakage Current ( $V_{CE} = 600\text{ V}$ , $V_{GE} = 0\text{ V}$ ) (1)<br>$T_J = 25^\circ\text{C}$<br>$T_J = 125^\circ\text{C}$ | $I_{CES}$       | —<br>— | —<br>— | 200<br>2.0 | $\mu\text{A}$<br>$\text{mA}$ |
| Gate-Emitter Threshold Voltage ( $V_{CE} = V_{GE}$ , $I_C = 1.0\text{ mA}$ )                                                                       | $V_{GE(th)}$    | 4.0    | 6.0    | 8.0        | V                            |
| Collector-Emitter Breakdown Voltage ( $I_C = 10\text{ mA}$ , $V_{GE} = 0$ )                                                                        | $V_{(BR)CES}$   | 600    | 700    | —          | V                            |
| Collector-Emitter Saturation Voltage ( $V_{GE} = 15\text{ V}$ , $I_C = 15\text{ A}$ ) (1)                                                          | $V_{CE(SAT)}$   | —      | 2.7    | 3.5        | V                            |
| Input Capacitance ( $V_{GE} = 0\text{ V}$ , $V_{CE} = 10\text{ V}$ , $f = 1.0\text{ MHz}$ )                                                        | $C_{ies}$       | —      | 950    | —          | pF                           |
| Input Gate Charge ( $V_{CE} = 300\text{ V}$ , $I_C = 15\text{ A}$ , $V_{GE} = 15\text{ V}$ )                                                       | $Q_T$           | —      | 75     | —          | nC                           |
| Fall Time — Inductive Load<br>( $V_{CE} = 300\text{ V}$ , $I_C = 15\text{ A}$ , $V_{GE} = 15\text{ V}$ , $R_G = 150\ \Omega$ )                     | $t_{fi}$        | —      | 200    | 350        | ns                           |
| Turn-On Energy<br>( $V_{CE} = 300\text{ V}$ , $I_C = 15\text{ A}$ , $V_{GE} = 15\text{ V}$ , $R_G = 150\ \Omega$ )                                 | $E_{(on)}$      | —      | —      | 1.0        | mJ                           |
| Turn-Off Energy<br>( $V_{CE} = 300\text{ V}$ , $I_C = 15\text{ A}$ , $V_{GE} = 15\text{ V}$ , $R_G = 150\ \Omega$ )                                | $E_{(off)}$     | —      | —      | 1.0        | mJ                           |
| Diode Forward Voltage ( $I_F = 15\text{ A}$ )                                                                                                      | $V_F$           | —      | 1.5    | 2.0        | V                            |
| Diode Reverse Leakage Current                                                                                                                      | $I_R$           | —      | —      | 50         | $\mu\text{A}$                |
| Thermal Resistance — IGBT                                                                                                                          | $R_{\theta JC}$ | —      | —      | 1.9        | $^\circ\text{C/W}$           |
| Thermal Resistance — Diode                                                                                                                         | $R_{\theta JC}$ | —      | —      | 3.7        | $^\circ\text{C/W}$           |
| <b>SENSE RESISTOR</b>                                                                                                                              |                 |        |        |            |                              |
| Resistance                                                                                                                                         | $R_{sense}$     | —      | 10     | —          | $\text{m}\Omega$             |
| Resistance Tolerance                                                                                                                               | $R_{tol}$       | −1.0   | —      | +1.0       | %                            |
| <b>TEMPERATURE SENSE DIODE</b>                                                                                                                     |                 |        |        |            |                              |
| Forward Voltage (@ $I_F = 1.0\text{ mA}$ )                                                                                                         | $V_F$           | —      | 0.660  | —          | V                            |
| Forward Voltage Temperature Coefficient (@ $I_F = 1.0\text{ mA}$ )                                                                                 | $TC_{VF}$       | —      | −1.95  | —          | $\text{mV}/^\circ\text{C}$   |

(1) 1 cycle = 50 or 60 Hz.

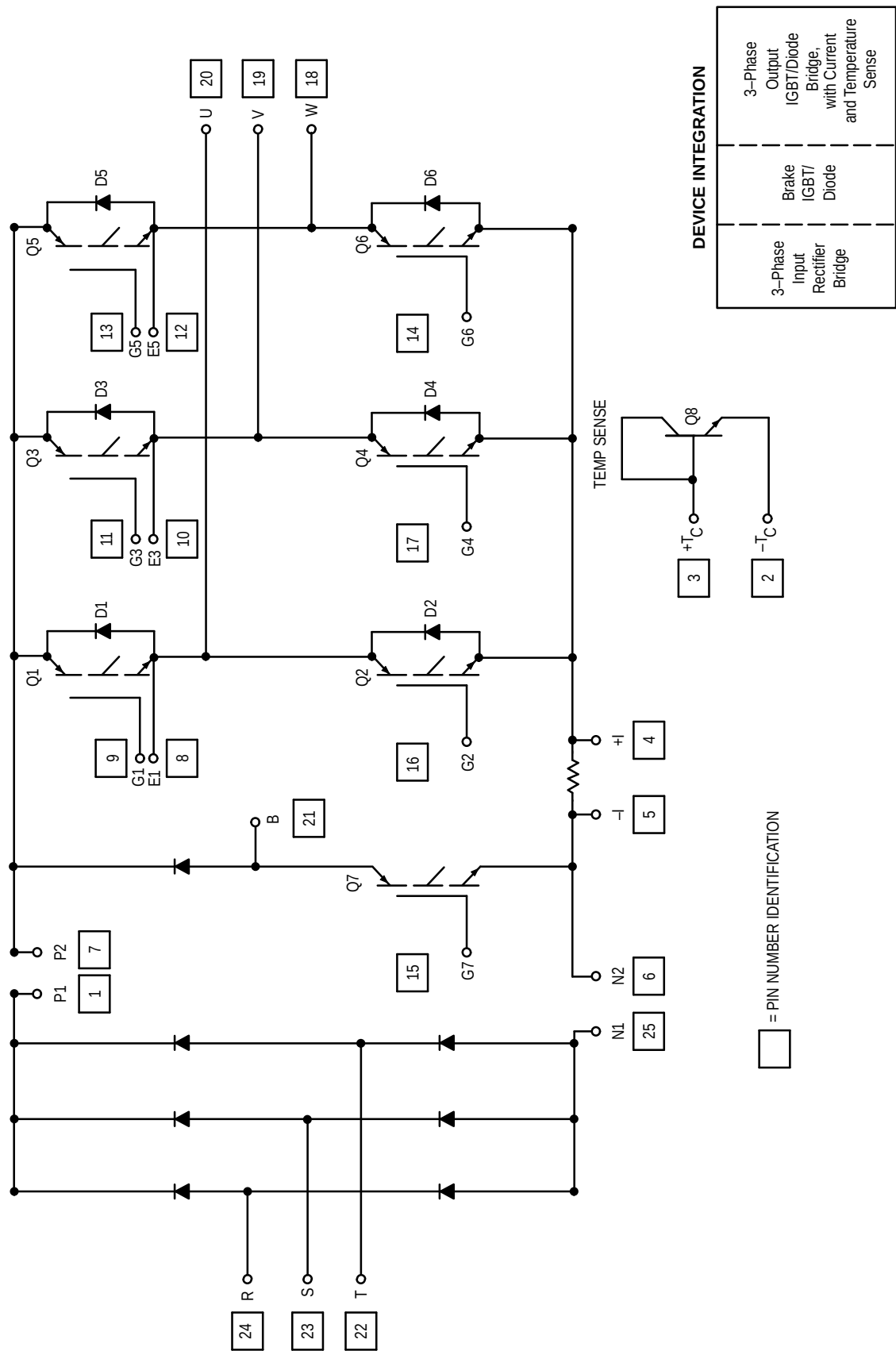


Figure 1. Integrated Power Stage Schematic

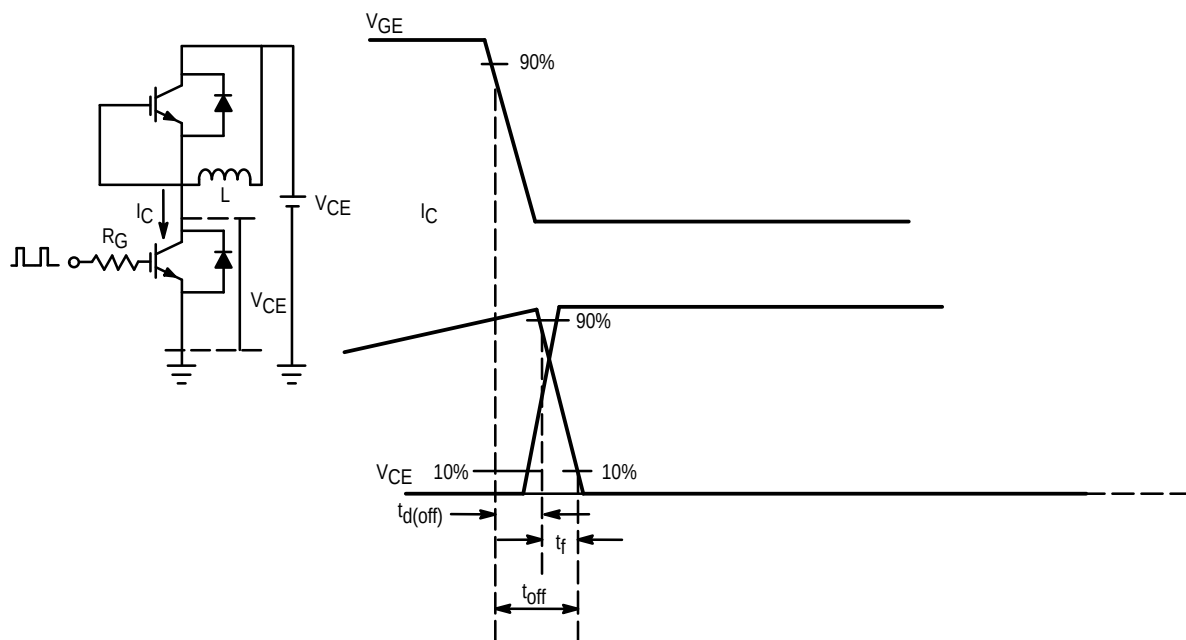


Figure 2. Inductive Switching Time Test Circuit and Timing Chart

### Typical Characteristics

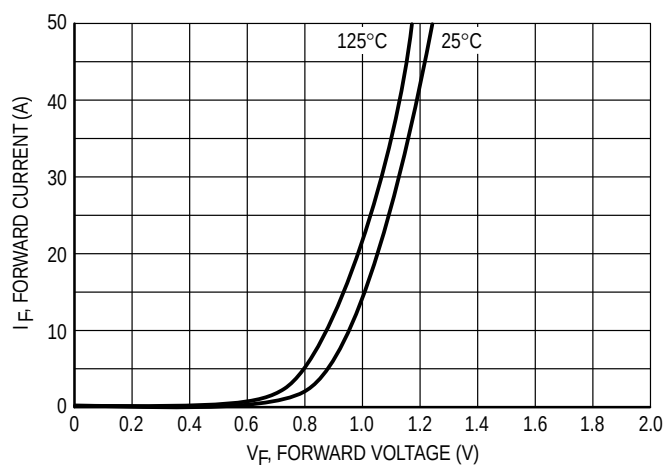


Figure 3. Input Bridge Forward Current versus Forward Voltage

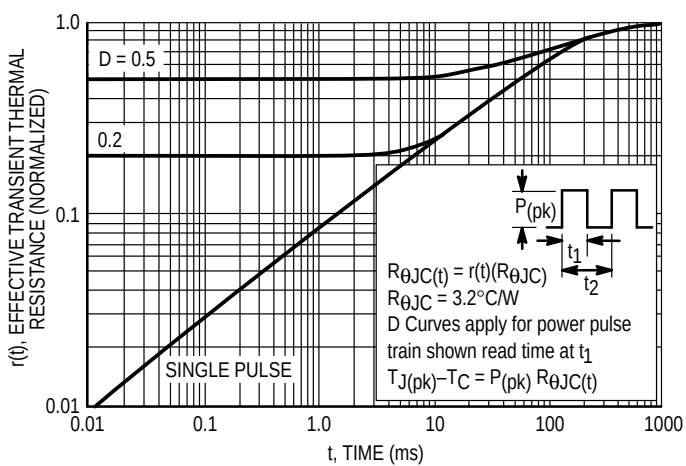


Figure 4. Input Rectifier Bridge Thermal Response

## Typical Characteristics

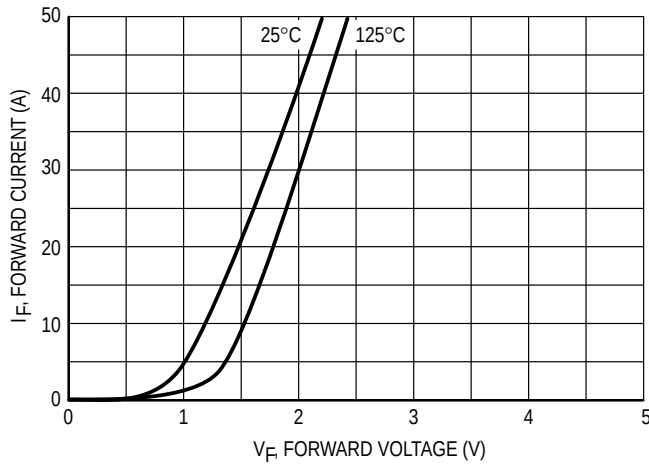


Figure 5. Output Inverter Diode Forward Current versus Forward Voltage

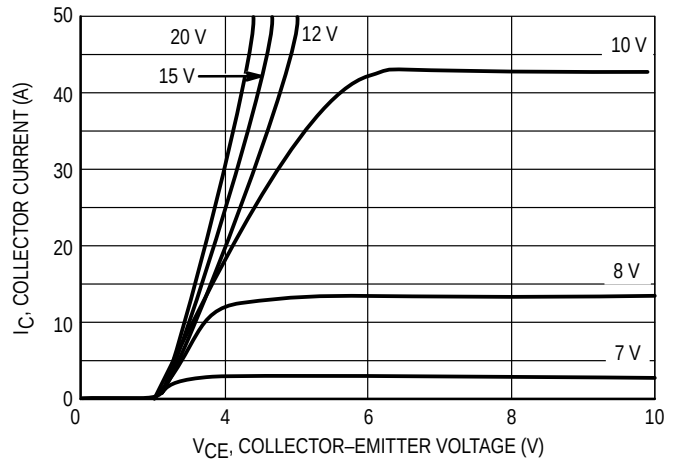


Figure 6. Output Inverter Collector-Current versus Collector-Emitter Voltage

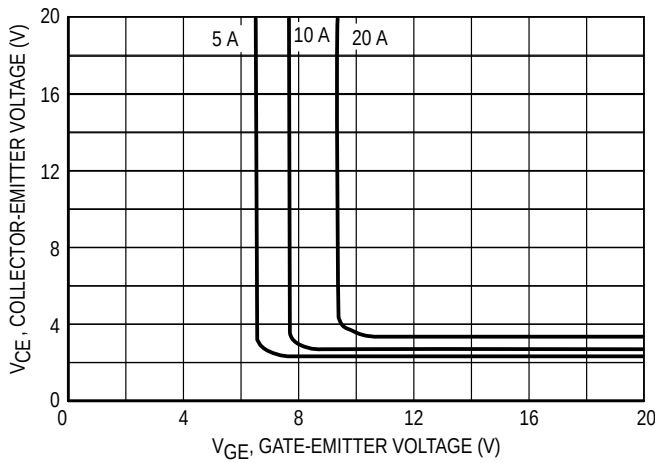


Figure 7. Output Inverter Collector-Emitter Voltage versus Gate-Emitter Voltage

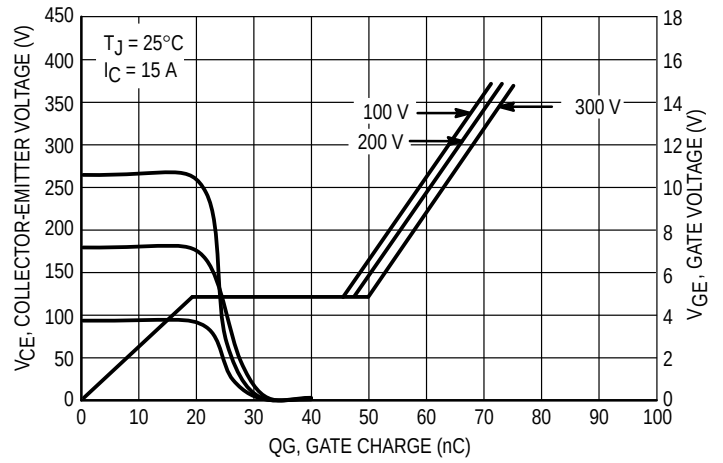


Figure 8. Gate-to-Emitter Voltage versus Gate Charge

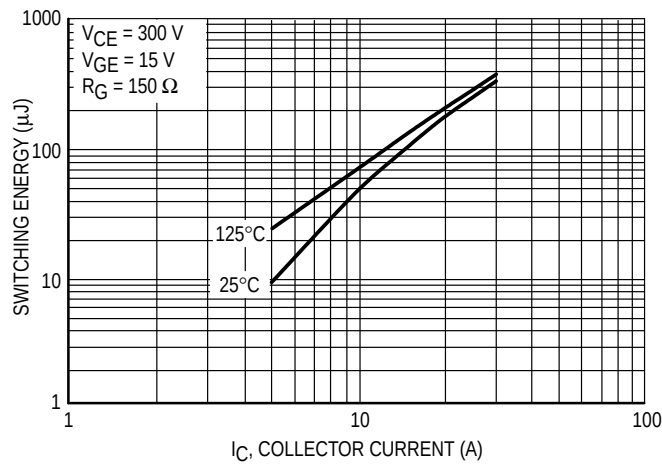


Figure 9. Inverter Switching Energy  $E_{(off)}$  versus Collector Current  $I_C$

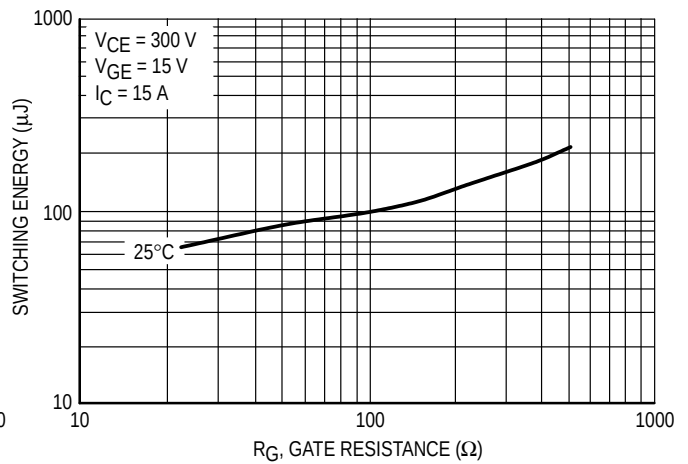


Figure 10. Inverter Switching Energy  $E_{(off)}$  versus Gate Resistance  $R_G$

## Typical Characteristics

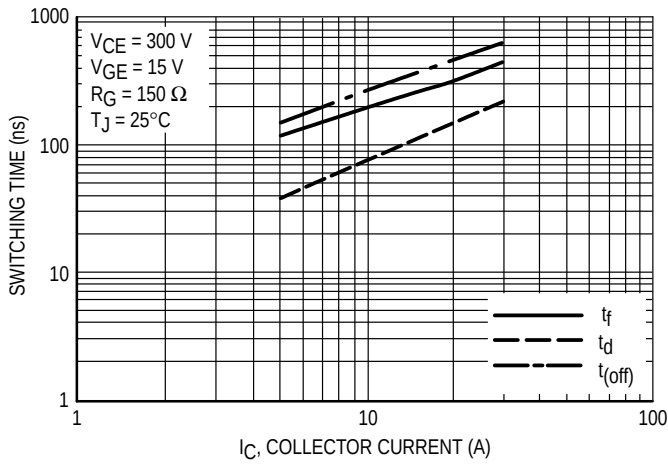


Figure 11. Inverter Switching Time  $t_f$ ,  $t_d$ ,  $t_{(off)}$  versus Collector Current  $I_C$

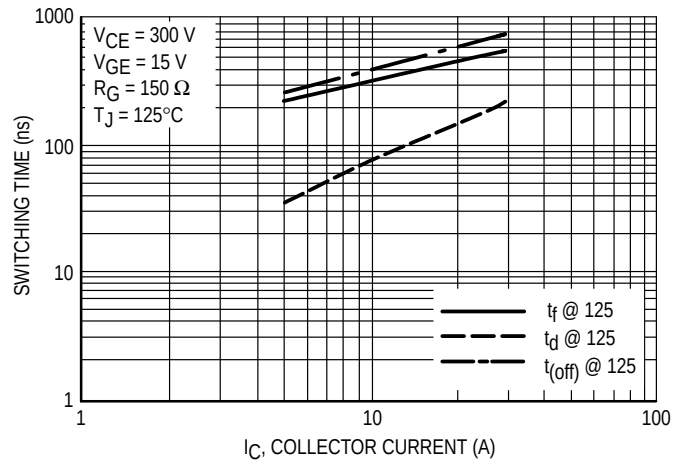


Figure 12. Inverter Switching Time  $t_f$ ,  $t_d$ ,  $t_{(off)}$  versus Collector Current  $I_C$

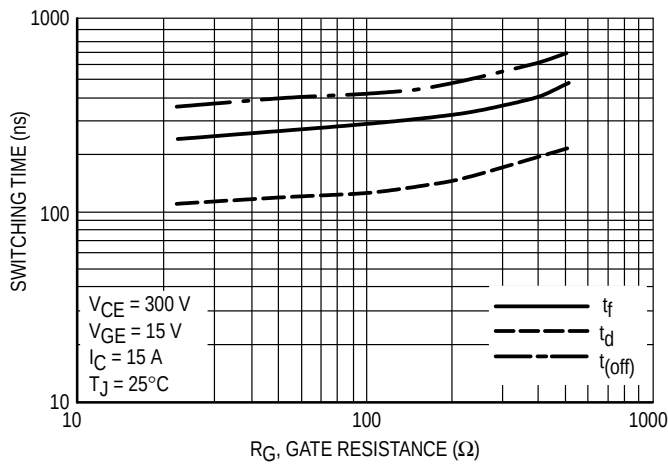


Figure 13. Inverter Switching Time  $t_f$ ,  $t_d$ ,  $t_{(off)}$  versus Gate Resistance  $R_G$

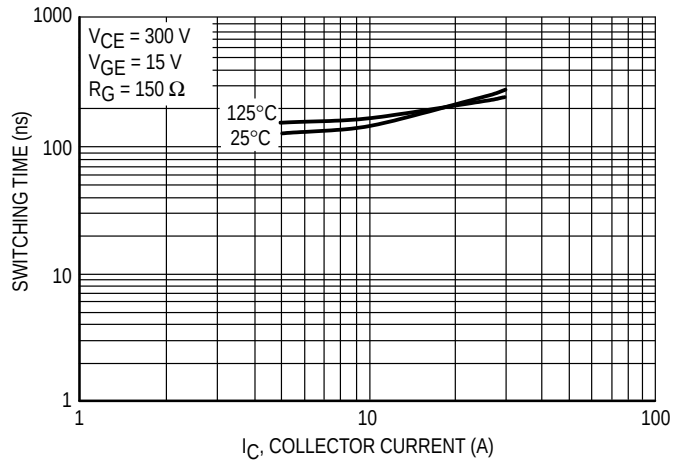


Figure 14. Inverter Switching Time  $t_f$  versus Collector Current  $I_C$

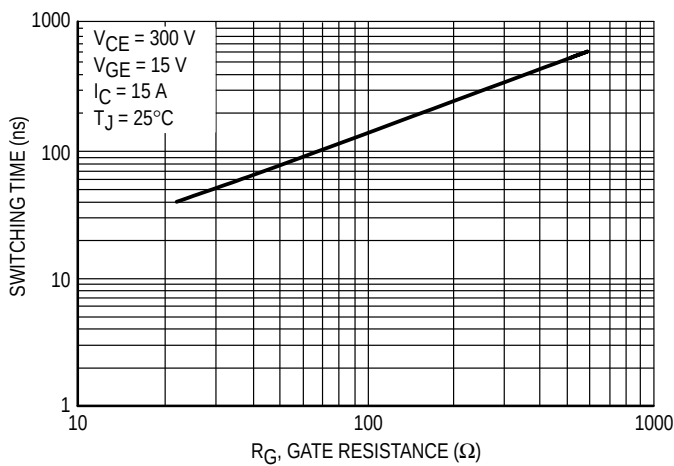


Figure 15. Inverter Switching Time  $t_f$  versus Gate Resistance  $R_G$

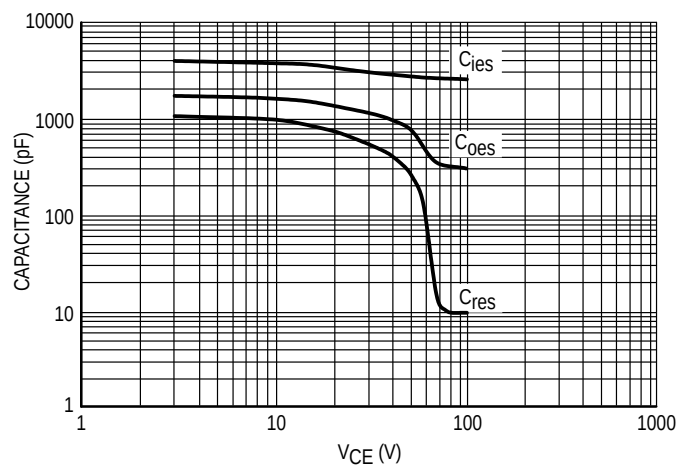


Figure 16. Inverter Capacitance versus  $V_{CE}$

## Typical Characteristics

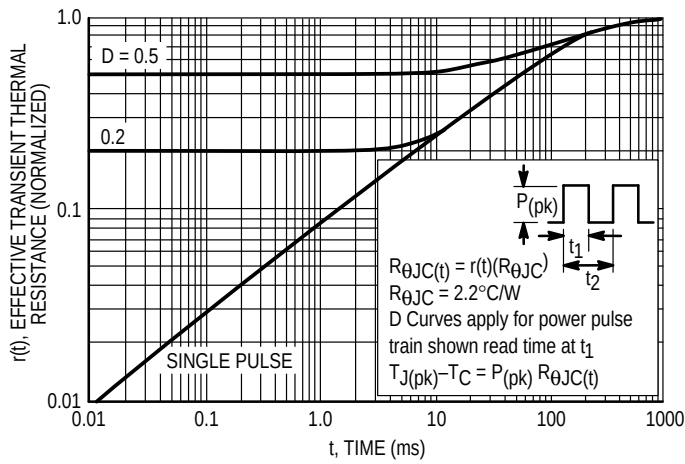


Figure 17. Output Inverter IGBT Thermal Response

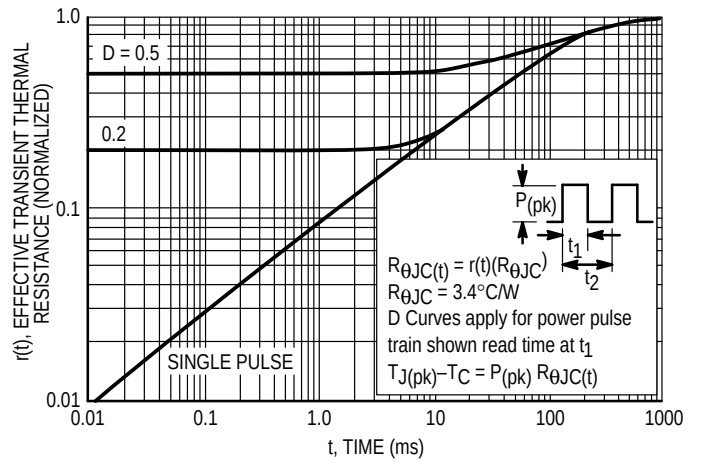


Figure 18. Output Diode Thermal Response

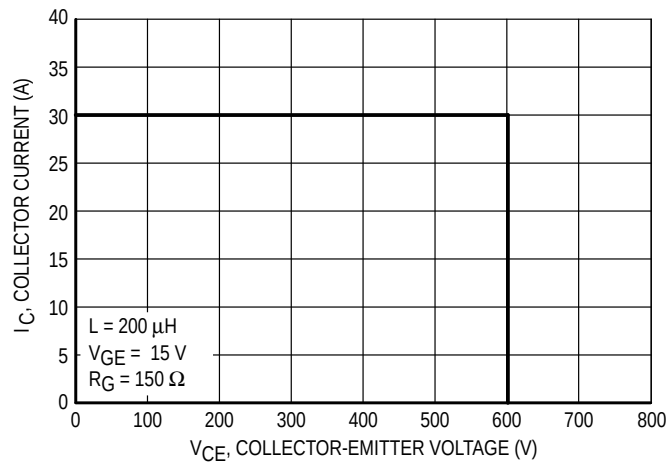
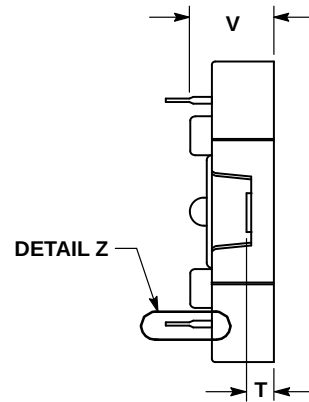
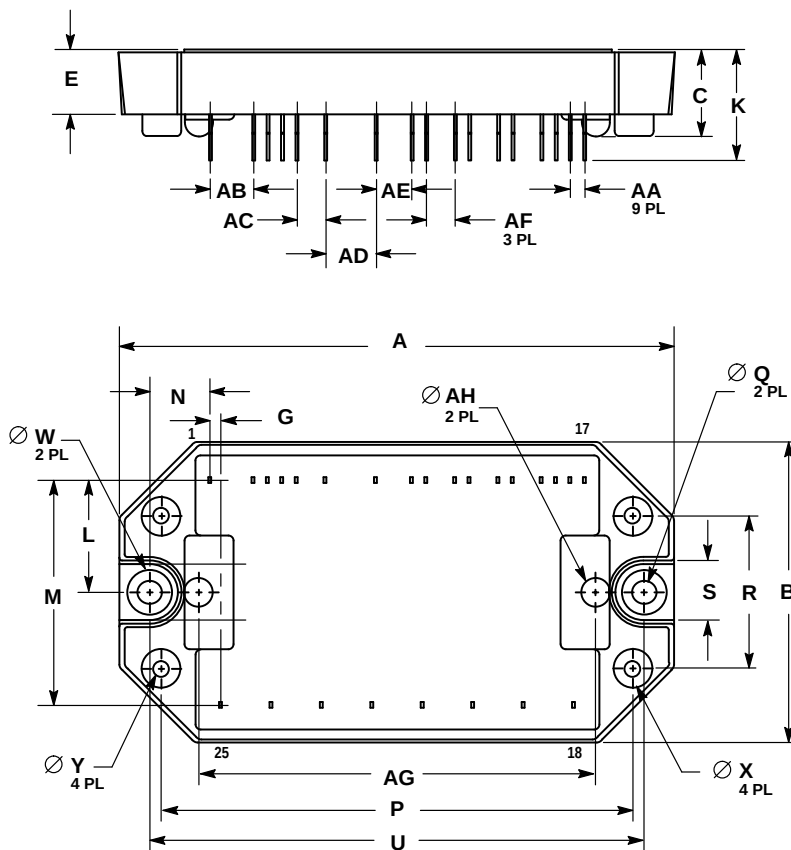


Figure 19. Output Inverter Reverse Bias Safe Operating Area (RBSOA)



# PACKAGE DIMENSIONS



- NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
  2. CONTROLLING DIMENSION: MILLIMETER.
  3. LEAD LOCATION DIMENSIONS (ie: M, B, AA...) ARE TO THE CENTER OF THE LEAD.

| DIM | MILLIMETERS |       | INCHES |       |
|-----|-------------|-------|--------|-------|
|     | MIN         | MAX   | MIN    | MAX   |
| A   | 97.54       | 98.55 | 3.840  | 3.880 |
| B   | 52.45       | 53.47 | 2.065  | 2.105 |
| C   | 14.60       | 15.88 | 0.575  | 0.625 |
| D   | 0.43        | 0.84  | 0.017  | 0.033 |
| E   | 10.80       | 12.06 | 0.425  | 0.475 |
| F   | 0.94        | 1.35  | 0.037  | 0.053 |
| G   | 1.60        | 2.21  | 0.063  | 0.087 |
| H   | 8.58        | 9.19  | 0.338  | 0.362 |
| J   | 0.30        | 0.71  | 0.012  | 0.028 |
| K   | 18.80       | 20.57 | 0.74   | 0.81  |
| L   | 19.30       | 20.32 | 0.760  | 0.800 |
| M   | 38.99       | 40.26 | 1.535  | 1.585 |
| N   | 9.78        | 11.05 | 0.385  | 0.435 |
| P   | 82.55       | 83.57 | 3.250  | 3.290 |
| Q   | 4.01        | 4.62  | 0.158  | 0.182 |
| R   | 26.42       | 27.43 | 1.040  | 1.080 |
| S   | 12.06       | 12.95 | 0.475  | 0.515 |
| T   | 4.32        | 5.33  | 0.170  | 0.210 |
| U   | 86.36       | 87.38 | 3.400  | 3.440 |
| V   | 14.22       | 15.24 | 0.560  | 0.600 |
| W   | 7.62        | 8.13  | 0.300  | 0.320 |
| X   | 6.55        | 7.16  | 0.258  | 0.282 |
| Y   | 2.49        | 3.10  | 0.098  | 0.122 |
| AA  | 2.24        | 2.84  | 0.088  | 0.112 |
| AB  | 7.32        | 7.92  | 0.288  | 0.312 |
| AC  | 4.78        | 5.38  | 0.188  | 0.212 |
| AD  | 8.58        | 9.19  | 0.338  | 0.362 |
| AE  | 6.05        | 6.65  | 0.238  | 0.262 |
| AF  | 4.78        | 5.38  | 0.188  | 0.212 |
| AG  | 69.34       | 70.36 | 2.730  | 2.770 |
| AH  | —           | 5.08  | —      | 0.200 |

STYLE 1:

|           |           |            |            |           |
|-----------|-----------|------------|------------|-----------|
| PIN 1. P1 | PIN 6. N2 | PIN 11. G3 | PIN 16. G2 | PIN 21. B |
| 2. T-     | 7. P2     | 12. K5     | 17. G4     | 22. T     |
| 3. T+     | 8. K1     | 13. G5     | 18. W      | 23. S     |
| 4. I+     | 9. G1     | 14. G6     | 19. V      | 24. R     |
| 5. I-     | 10. K3    | 15. G7     | 20. U      | 25. N1    |

CASE 440-01  
ISSUE O

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**MOTOROLA**

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**MHPM7A15A60A/D**

