



# Hybrid Power Module

## Integrated Power Stage for 1.0 hp Motor Drives

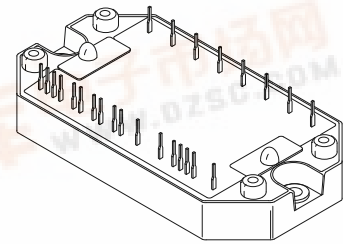
The MHPM7A15A60A module integrates a 3-phase input rectifier bridge, 3-phase output inverter, brake transistor/diode, current sense resistor and temperature sensor in a single convenient package. The output inverter utilizes advanced insulated gate bipolar transistors (IGBT) matched with free-wheeling 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
-  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<sub>J</sub> = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
<b>INPUT RECTIFIER BRIDGE</b>			
Repetitive Peak Reverse Voltage	V <sub>R</sub> RM	600	V
Average Output Rectified Current	I <sub>O</sub>	15	A
Peak Non-repetitive Surge Current — (1/2 Cycle) (1)	I <sub>F</sub> SM	200	A
<b>OUTPUT INVERTER</b>			
IGBT Reverse Voltage	V <sub>C</sub> ES	600	V
Gate-Emitter Voltage	V <sub>G</sub> ES	± 20	V
Continuous IGBT Collector Current	I <sub>C</sub>	15	A
Peak IGBT Collector Current — (PW = 1.0 ms) (2)	I <sub>C</sub> (pk)	30	A
Continuous Free-Wheeling Diode Current	I <sub>F</sub>	15	A
Peak Free-Wheeling Diode Current — (PW = 1.0 ms) (2)	I <sub>F</sub> (pk)	30	A
IGBT Power Dissipation	P <sub>D</sub>	55	W
Free-Wheeling Diode Power Dissipation	P <sub>D</sub>	30	W
IGBT Junction Temperature Range	T <sub>J</sub>	- 40 to +125	°C
Free-Wheeling Diode Junction Temperature Range	T <sub>J</sub>	- 40 to +125	°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

**TOTAL MODULE**

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
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**INPUT RECTIFIER BRIDGE**

Reverse Leakage Current ( $V_{RRM} = 600\text{ V}$ )	$I_R$	—	10	50	$\mu\text{A}$
Forward Voltage ( $I_F = 15\text{ A}$ )	$V_F$	—	1.05	1.5	V
Thermal Resistance (Each Die)	$R_{\theta JC}$	—	—	2.9	$^\circ\text{C/W}$

**OUTPUT INVERTER**

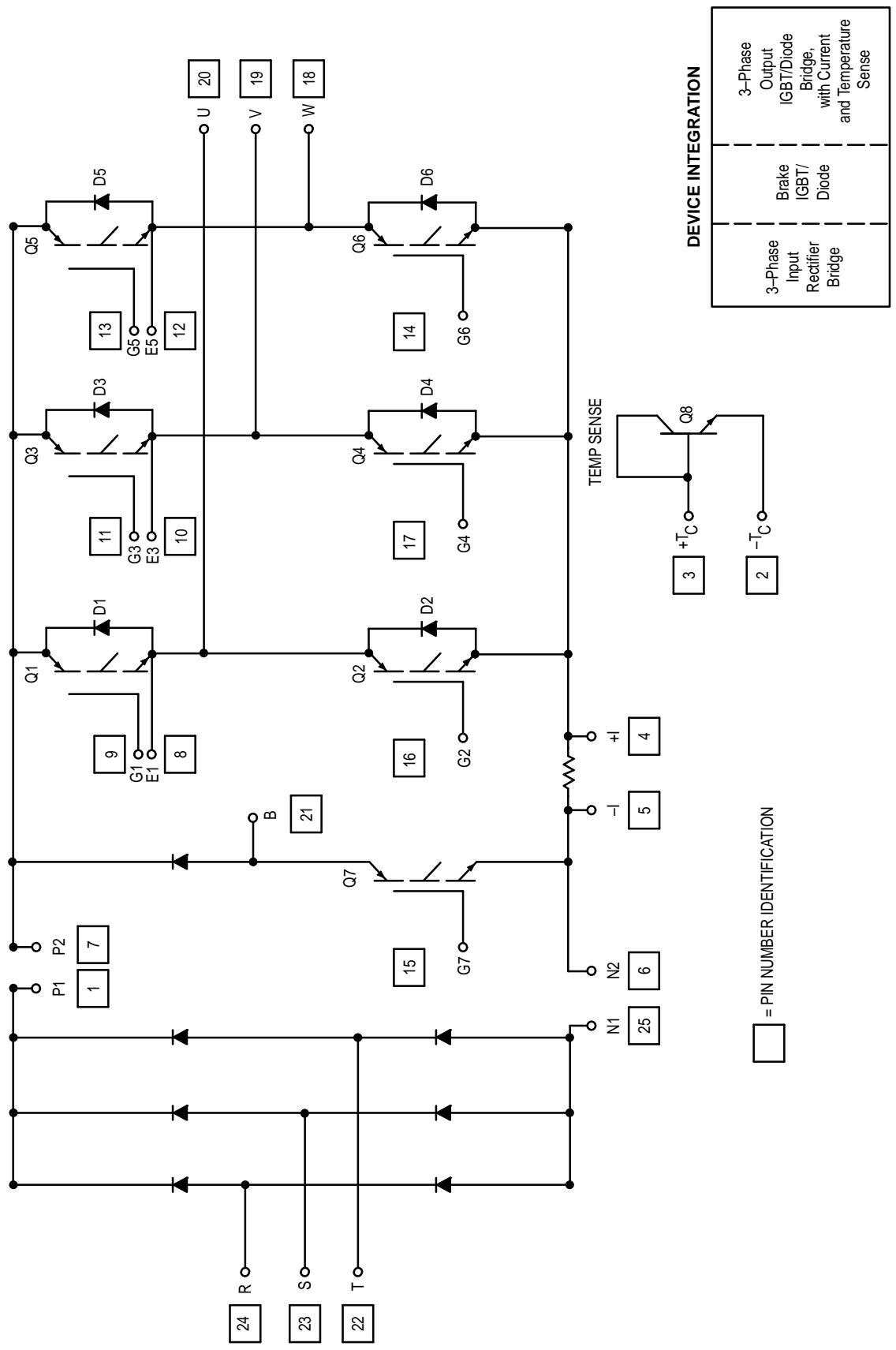
Gate-Emitter Leakage Current ( $V_{CE} = 0\text{ V}$ , $V_{GE} = \pm 20\text{ V}$ )	$I_{GES}$	—	—	$\pm 20$	$\mu\text{A}$
Collector-Emitter Leakage Current ( $V_{CE} = 600\text{ V}$ , $V_{GE} = 0\text{ V}$ ) $T_J = 25^\circ\text{C}$ $T_J = 125^\circ\text{C}$	$I_{CES}$	— —	— —	200 2.0	$\mu\text{A}$ mA
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 ( $V_{GE} = 15\text{ V}$ , $I_C = 15\text{ A}$ )	$V_{CE(SAT)}$	—	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 ( $V_{CE} = 300\text{ V}$ , $I_C = 15\text{ A}$ , $V_{GE} = 15\text{ V}$ , $R_G = 150\ \Omega$ )	$t_{fi}$	—	200	350	ns
Turn-On Energy ( $V_{CE} = 300\text{ V}$ , $I_C = 15\text{ A}$ , $V_{GE} = 15\text{ V}$ , $R_G = 150\ \Omega$ )	$E_{(on)}$	—	—	1.0	mJ
Turn-Off Energy ( $V_{CE} = 300\text{ V}$ , $I_C = 15\text{ A}$ , $V_{GE} = 15\text{ V}$ , $R_G = 150\ \Omega$ )	$E_{(off)}$	—	—	1.0	mJ
Diode Forward Voltage ( $I_F = 15\text{ A}$ , $V_{GE} = 0\text{ V}$ )	$V_F$	—	1.5	2.0	V
Diode Reverse Recovery Time ( $I_F = 15\text{ A}$ , $V = 400\text{ V}$ , $di/dt = 50\text{ A}/\mu\text{s}$ )	$t_{rr}$	—	140	200	ns
Diode Stored Charge ( $I_F = 15\text{ A}$ , $V = 400\text{ V}$ , $di/dt = 50\text{ A}/\mu\text{s}$ )	$Q_{rr}$	—	—	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) $T_J = 25^\circ\text{C}$ $T_J = 125^\circ\text{C}$	$I_{CES}$	— —	— —	200 2.0	$\mu\text{A}$ $\text{mA}$
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 ( $V_{CE} = 300\text{ V}$ , $I_C = 15\text{ A}$ , $V_{GE} = 15\text{ V}$ , $R_G = 150\ \Omega$ )	$t_{fi}$	—	200	350	ns
Turn-On Energy ( $V_{CE} = 300\text{ V}$ , $I_C = 15\text{ A}$ , $V_{GE} = 15\text{ V}$ , $R_G = 150\ \Omega$ )	$E_{(on)}$	—	—	1.0	mJ
Turn-Off Energy ( $V_{CE} = 300\text{ V}$ , $I_C = 15\text{ A}$ , $V_{GE} = 15\text{ V}$ , $R_G = 150\ \Omega$ )	$E_{(off)}$	—	—	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	—	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	—	mV/ $^\circ\text{C}$

(1) 1 cycle = 50 or 60 Hz.



**DEVICE INTEGRATION**

3-Phase Input Rectifier Bridge	Brake IGBT/Diode	3-Phase Output IGBT/Diode Bridge, with Current and Temperature Sense
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□ = PIN NUMBER IDENTIFICATION

Figure 1. Integrated Power Stage Schematic

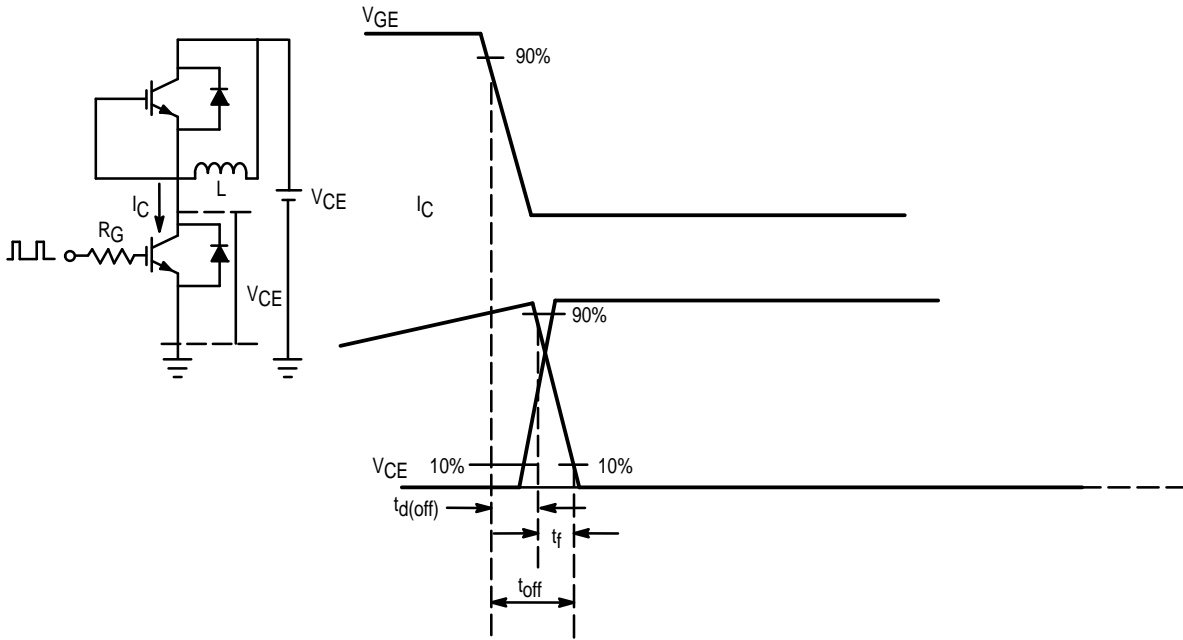


Figure 2. Inductive Switching Time Test Circuit and Timing Chart

### Typical Characteristics

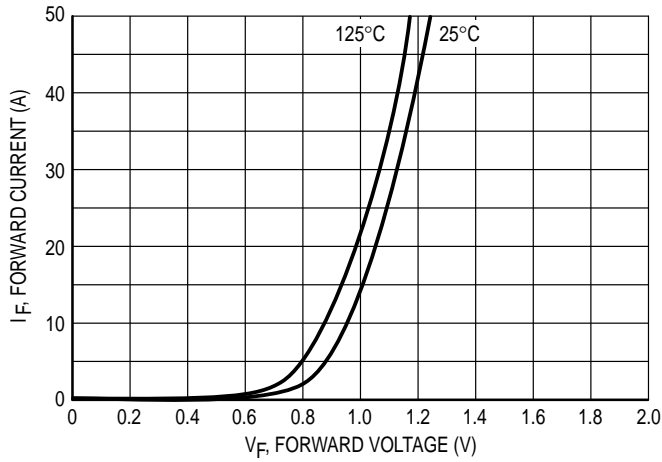


Figure 3. Input Bridge Forward Current versus Forward Voltage

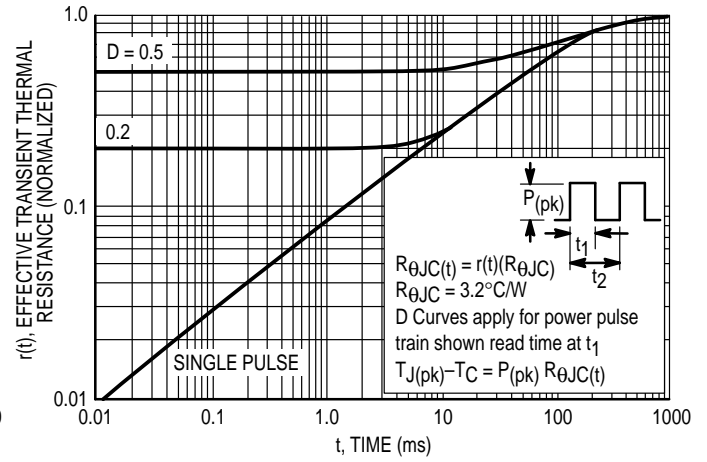
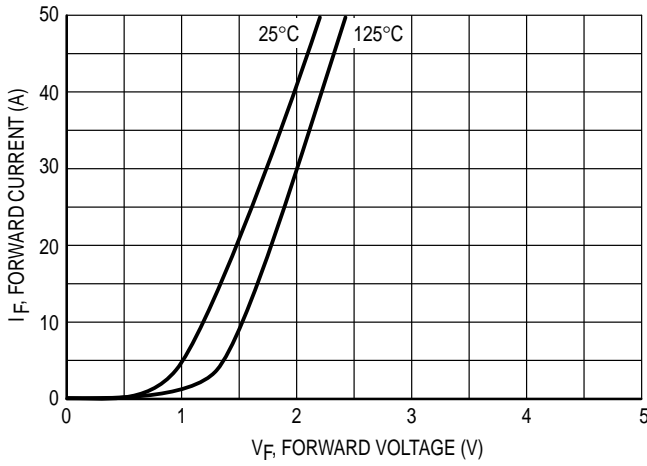
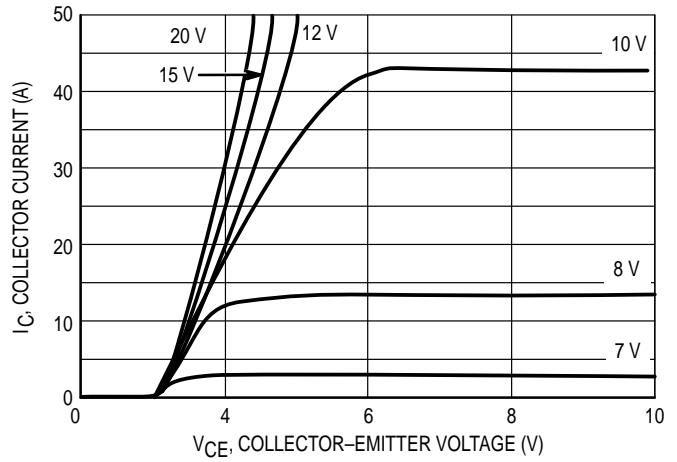


Figure 4. Input Rectifier Bridge Thermal Response

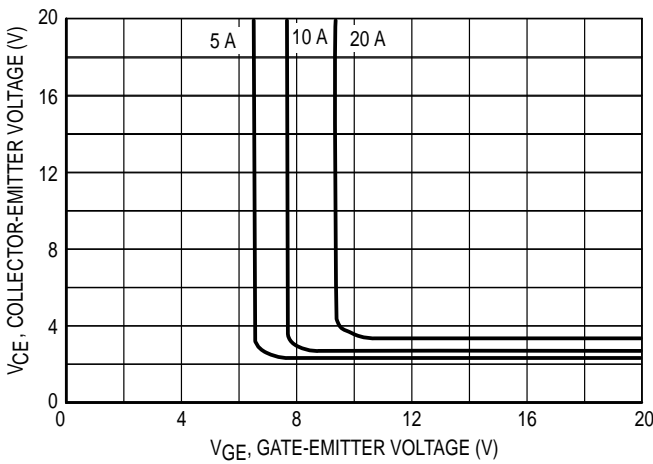
## Typical Characteristics



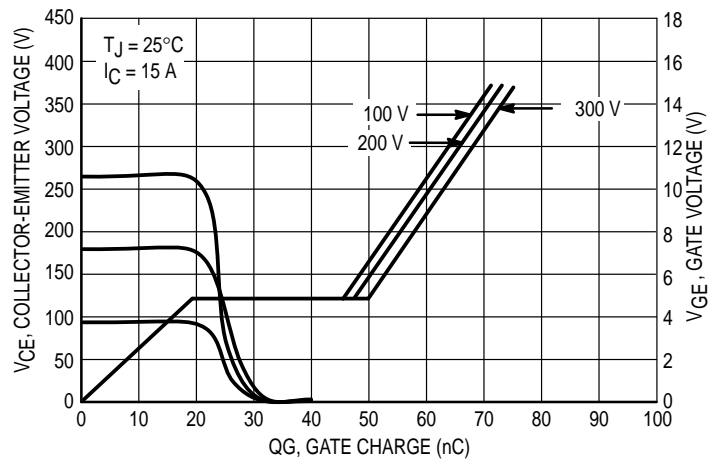
**Figure 5. Output Inverter Diode Forward Current versus Forward Voltage**



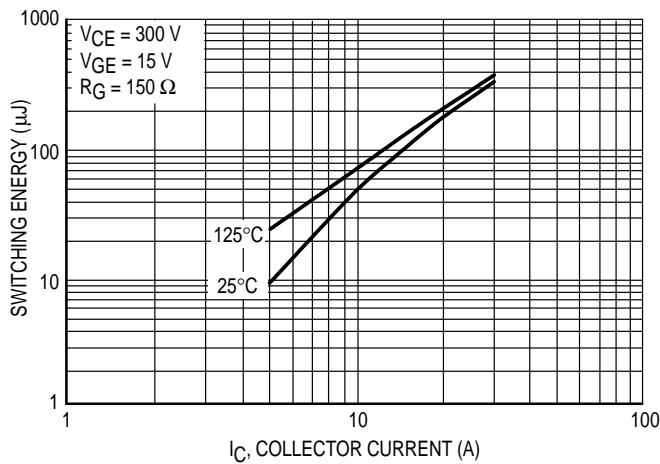
**Figure 6. Output Inverter Collector-Current versus Collector-Emitter Voltage**



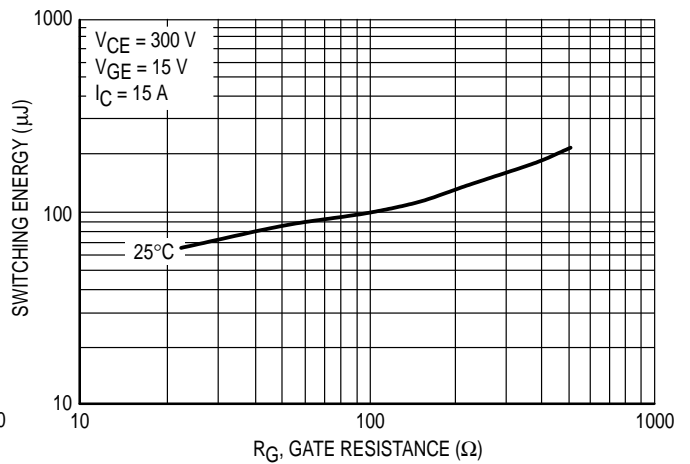
**Figure 7. Output Inverter Collector-Emitter Voltage versus Gate-Emitter Voltage**



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

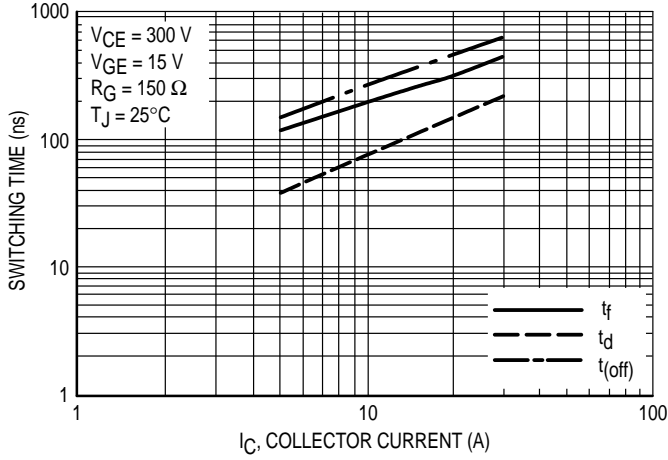


**Figure 9. Inverter Switching Energy  $E_{(off)}$  versus Collector Current  $I_C$**

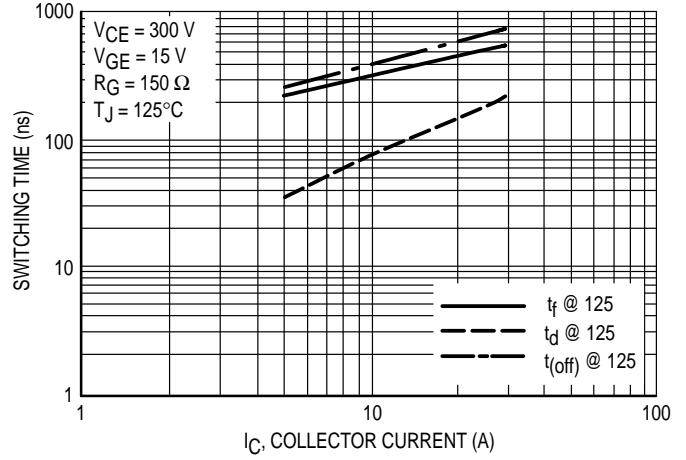


**Figure 10. Inverter Switching Energy  $E_{(off)}$  versus Gate Resistance  $R_G$**

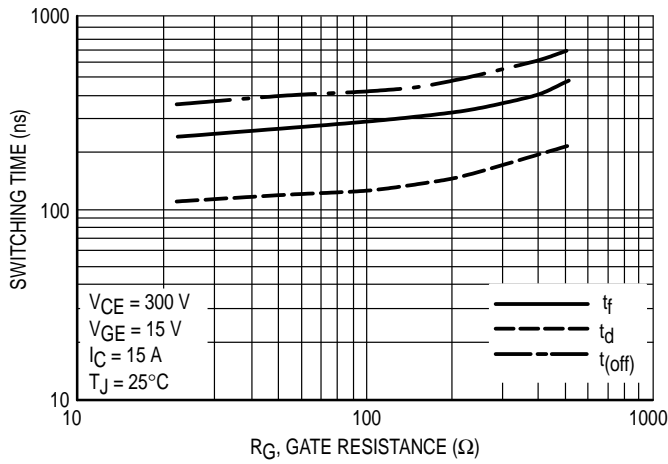
## Typical Characteristics



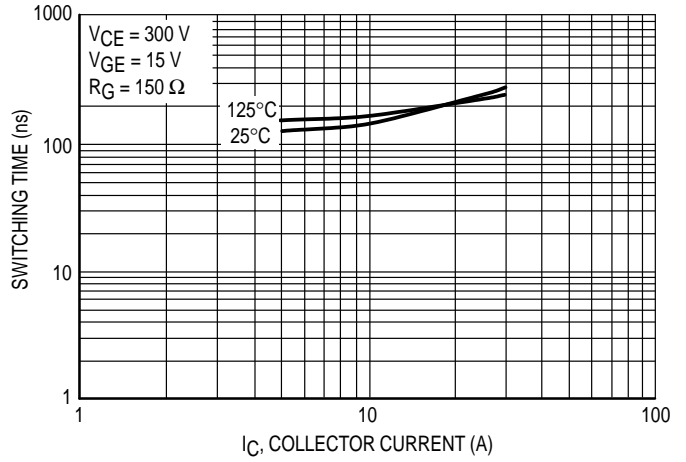
**Figure 11. Inverter Switching Time  $t_f$ ,  $t_d$ ,  $t_{(off)}$  versus Collector Current  $I_C$**



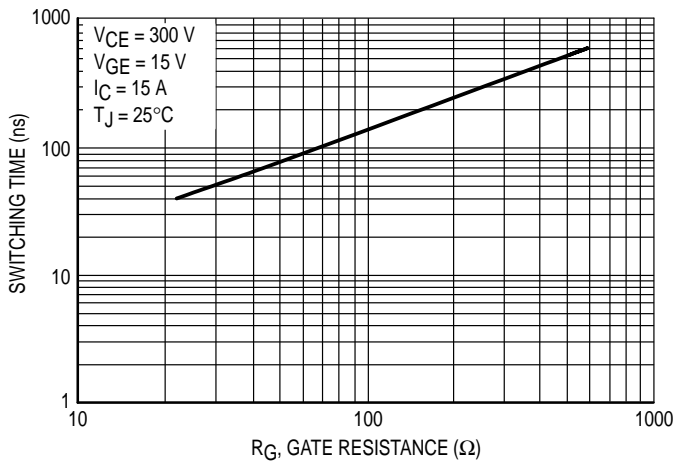
**Figure 12. Inverter Switching Time  $t_f$ ,  $t_d$ ,  $t_{(off)}$  versus Collector Current  $I_C$**



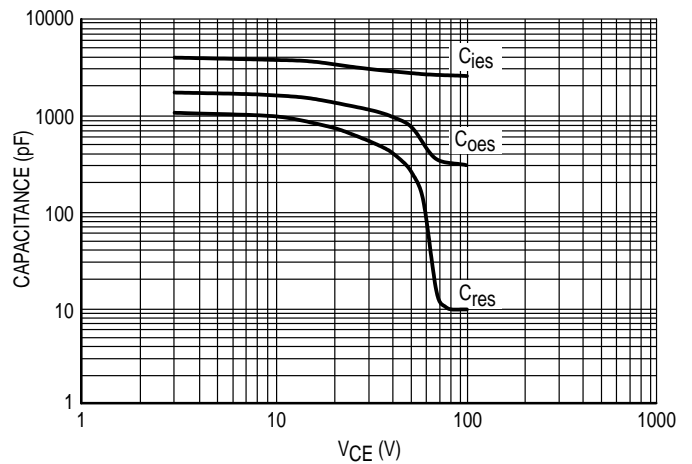
**Figure 13. Inverter Switching Time  $t_f$ ,  $t_d$ ,  $t_{(off)}$  versus Gate Resistance  $R_G$**



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

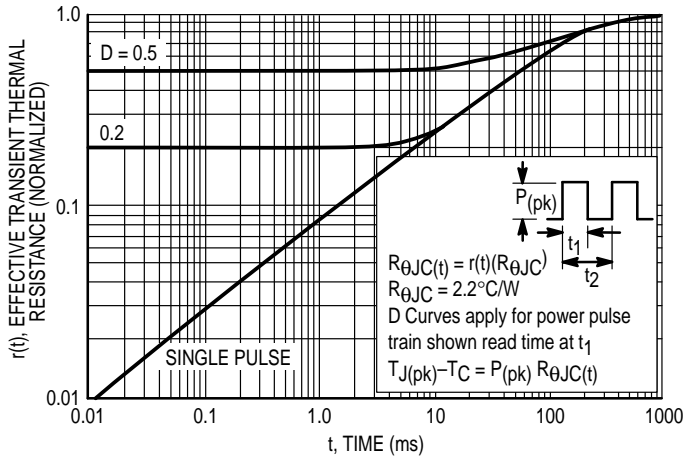


**Figure 15. Inverter Switching Time  $t_f$  versus Gate Resistance  $R_G$**

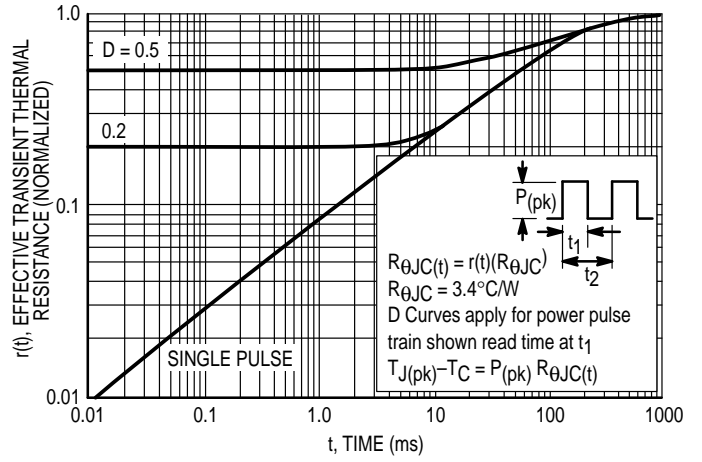


**Figure 16. Inverter Capacitance versus  $V_{CE}$**

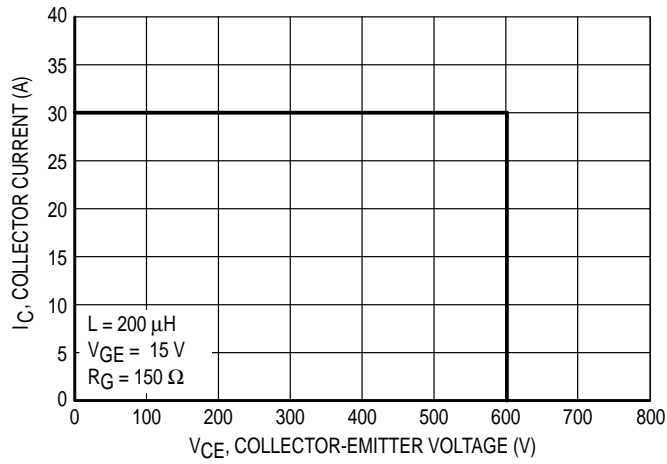
### Typical Characteristics



**Figure 17. Output Inverter IGBT Thermal Response**



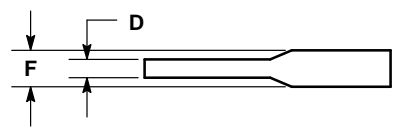
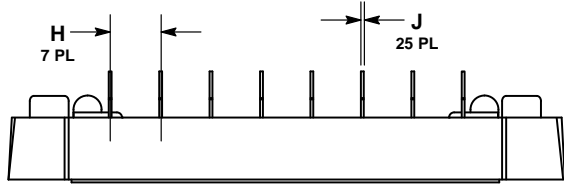
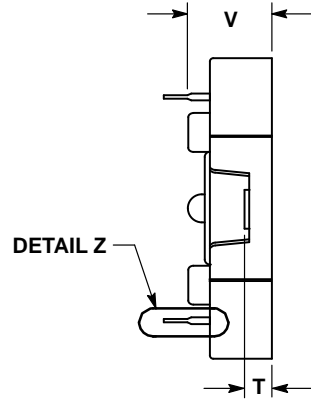
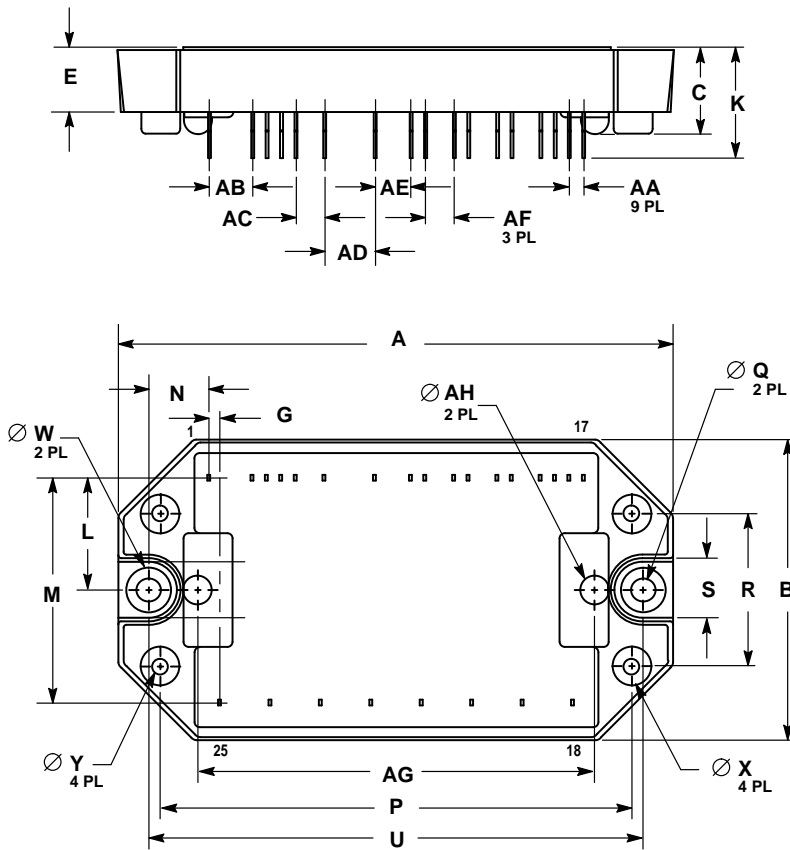
**Figure 18. Output Diode Thermal Response**



**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 0**

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