Hybrid Power Module

Integrated Power Stage for 460 VAC Motor Drives

MHPM6B10N120
MHPM6B15N120
MHPM6B25N120
SERIES

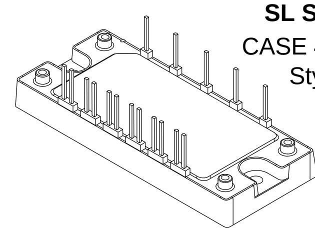
Motorola Preferred Devices

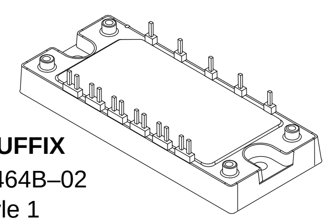
These modules integrate a 3–phase inverter in a single convenient package. They are designed for 2.0, 3.0, and 5.0 hp motor drive applications. The inverter incorporates advanced insulated gate bipolar transistors (IGBT) matched with fast soft free–wheeling diodes to give optimum performance. The top connector pins are designed for easy interfacing to the user's control board.

- Short Circuit Rated 10 µs @ 125°C, 720 V
- Pin-to-Baseplate Isolation Exceeds 2500 Vac (rms)
- Compact Package Outline
- Access to Positive and Negative DC Bus
- UL Recognized

10, 15, 25 A, 1200 V
HYBRID POWER MODULES

SL SUFFIX
CASE 464A–01
Style 1





SS SUFFIX
CASE 464B–02
Style 1

ORDERING INFORMATION

Device	Current Rating	Package
MHPM6B10N120SL MHPM6B15N120SL MHPM6B25N120SL	10 15 25	464A–01 Style 1
MHPM6B10N120SS MHPM6B15N120SS MHPM6B25N120SS	10 15 25	464B–02 Style 1

MAXIMUM DEVICE RATINGS (T_J = 25°C unless otherwise noted)

Rating		Symbol	Value	Unit
IGBT Reverse Voltage		V_{CES}	1200	V
Gate-Emitter Voltage		V_{GES}	± 20	V
Continuous IGBT Collector Current (T_C = 80°C)	10A120 15A120 25A120	I_{Cmax}	10 15 25	A
Repetitive Peak IGBT Collector Current (1)	10A120 15A120 25A120	$I_{C(pk)}$	20 30 50	A
Continuous Diode Current (T_C = 25°C)	10A120 15A120 25A120	I_{Fmax}	10 15 25	A
Continuous Diode Current (T_C = 80°C)	10A120 15A120 25A120	I_{F80}	8.3 11 14	A
Repetitive Peak Diode Current (1)	10A120 15A120 25A120	$I_{F(pk)}$	20 30 50	A
IGBT Power Dissipation per die (T_C = 95°C)	10A120 15A120 25A120	P_D	41 50 65	W
Diode Power Dissipation per die (T_C = 95°C)	10A120 15A120 25A120	P_D	16 22 27	W

(1) 1.0 ms = 1.0% duty cycle
Preferred devices are Motorola recommended choices for future use and best overall value.

MAXIMUM DEVICE RATINGS (T_J = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Junction Temperature Range	T_J	– 40 to +150	°C
Short Circuit Duration (V_{CE} = 720 V, T_J = 125°C)	t_{sc}	10	µs
Isolation Voltage, Pin to Baseplate	V_{ISO}	2500	Vac
Operating Case Temperature Range	T_C	– 40 to +95	°C
Storage Temperature Range	T_{stg}	– 40 to +150	°C
Mounting Torque — Heat Sink Mounting Holes	—	1.4	Nm

ELECTRICAL CHARACTERISTICS (T_J = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
DC AND SMALL SIGNAL CHARACTERISTICS						
Gate-Emitter Leakage Current (V_{CE} = 0 V, V_{GE} = ± 20 V)		I_{GES}	—	—	± 20	µA
Collector-Emitter Leakage Current (V_{CE} = 1200 V, V_{GE} = 0 V)		I_{CES}	—	5.0	100	µA
Gate-Emitter Threshold Voltage (V_{CE} = V_{GE}, I_C = 1.0 mA)		$V_{GE(th)}$	5.0	6.0	7.0	V
Collector-Emitter Breakdown Voltage (I_C = 10 mA, V_{GE} = 0 V)		$V_{(BR)CES}$	1200	—	—	V
Collector-Emitter Saturation Voltage (I_C = I_{Cmax}, V_{GE} = 15 V)		$V_{CE(SAT)}$	1.7	2.35	2.9	V
T_J = 125°C			—	2.69	—	
Forward Transconductance	10A120	g_{fe}	—	8.3	—	mho
	15A120		—	14	—	
	25A120		—	19	—	
Diode Forward Voltage (I_F = I_{Fmax}, V_{GE} = 0 V)		V_F	1.7	2.35	3.1	V
T_J = 125°C			—	1.9	—	
Input Capacitance (V_{CE} = 10 V, V_{GE} = 0 V, f = 1.0 MHz)	10A120	C_{ies}	—	1880	—	pF
	15A120		—	2620	—	
	25A120		—	4770	—	
Input Gate Charge (V_{CE} = 600 V, I_C = I_{Cmax}, V_{GE} = 15 V)	10A120	Q_T	—	65	—	nC
	15A120		—	87	—	
	25A120		—	150	—	
INDUCTIVE SWITCHING CHARACTERISTICS (T_J = 25°C)						
Recommended Gate Resistor ($R_{G(on)}$ = $R_{G(off)}$)		R_G				Ω
	10A120		—	82	—	
	15A120		—	82	—	
	25A120		—	68	—	
Turn-On Delay Time (V_{CE} = 600 V, I_C = I_{Cmax}, V_{GE} = 15 V)		$t_{d(on)}$				ns
	10A120		—	174	—	
	15A120		—	240	—	
	25A120		—	330	—	
Rise Time (V_{CE} = 600 V, I_C = I_{Cmax}, V_{GE} = 15 V)		t_r				ns
	10A120		—	84	—	
	15A120		—	105	—	
	25A120		—	150	—	
Turn–Off Delay Time (V_{CE} = 600 V, I_C = I_{Cmax}, V_{GE} = 15 V)		$t_{d(off)}$				ns
	10A120		—	640	—	
	15A120		—	780	—	
	25A120		—	1060	—	
Fall Time (V_{CE} = 600 V, I_C = I_{Cmax}, V_{GE} = 15 V)		t_f				ns
	10A120		—	39	47	
	15A120		—	48	58	
	25A120		—	70	84	
Turn-On Energy (V_{CE} = 600 V, I_C = I_{Cmax}, V_{GE} = 15 V)		E_{on}				mJ
	10A120		—	1.5	1.8	
	15A120		—	2.7	3.3	
	25A120		—	4.6	5.6	

INDUCTIVE SWITCHING CHARACTERISTICS (T_J = 25°C) – continued

Characteristic		Symbol	Min	Typ	Max	Unit
Turn-Off Energy (V_{CE} = 600 V, $I_C = I_{Cmax}$, V_{GE} = 15 V)	10A120 15A120 25A120	E_{off}	— — —	1.1 1.7 3.0	1.4 2.1 3.5	mJ
Diode Reverse Recovery Time ($I_F = I_{Fmax}$, V = 600 V)	10A120 15A120 25A120	t_{rr}	— — —	95 110 124	— — —	ns
Peak Reverse Recovery Current ($I_F = I_{Fmax}$, V = 600 V)	10A120 15A120 25A120	I_{rrm}	— — —	8.0 9.7 11.5	— — —	A
Diode Stored Charge ($I_F = I_{Fmax}$, V = 600 V)	10A120 15A120 25A120	Q_{rr}	— — —	550 600 740	— — —	nC

INDUCTIVE SWITCHING CHARACTERISTICS (T_J = 125°C)

Characteristic		Symbol	Min	Typ	Max	Unit
Turn–On Delay Time (V_{CE} = 600 V, $I_C = I_{Cmax}$, V_{GE} = 15 V)	10A120 15A120 25A120	$t_{d(on)}$	— — —	160 220 310	— — —	ns
Rise Time (V_{CE} = 600 V, $I_C = I_{Cmax}$, V_{GE} = 15 V)	10A120 15A120 25A120	t_r	— — —	93 110 160	— — —	ns
Turn–Off Delay Time (V_{CE} = 600 V, $I_C = I_{Cmax}$, V_{GE} = 15 V)	10A120 15A120 25A120	$t_{d(off)}$	— — —	680 850 1140	— — —	ns
Fall Time (V_{CE} = 600 V, $I_C = I_{Cmax}$, V_{GE} = 15 V)	10A120 15A120 25A120	t_f	— — —	51 60 76	— — —	ns
Turn–On Energy (V_{CE} = 600 V, $I_C = I_{Cmax}$, V_{GE} = 15 V)	10A120 15A120 25A120	E_{on}	— — —	2.0 3.6 6.1	— — —	mJ
Turn–Off Energy (V_{CE} = 600 V, $I_C = I_{Cmax}$, V_{GE} = 15 V)	10A120 15A120 25A120	E_{off}	— — —	1.5 2.4 4.2	— — —	mJ
Diode Reverse Recovery Time ($I_F = I_{Fmax}$, V = 600 V)	10A120 15A120 25A120	t_{rr}	— — —	160 210 250	— — —	ns
Peak Reverse Recovery Current ($I_F = I_{Fmax}$, V = 600 V)	10A120 15A120 25A120	I_{rrm}	— — —	11.0 14.1 17.4	— — —	A
Diode Stored Charge ($I_F = I_{Fmax}$, V = 600 V)	10A120 15A120 25A120	Q_{rr}	— — —	995 1770 2460	— — —	nC

THERMAL CHARACTERISTICS (Each Die)

Thermal Resistance — IGBT	10A120 15A120 25A120	$R_{\theta JC}$	— — —	1.1 0.89 0.68	1.3 1.1 0.85	°C/W
Thermal Resistance — Diode	10A120 15A120 25A120	$R_{\theta JC}$	— — —	2.8 2.0 1.6	3.5 2.5 2.0	°C/W

TYPICAL CHARACTERISTICS

(see also application information)

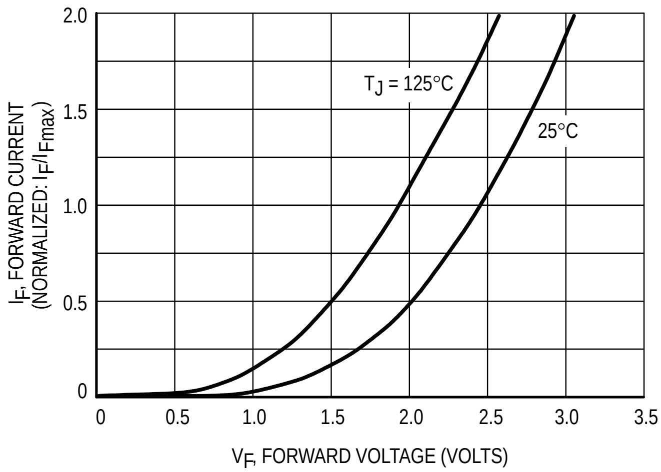


Figure 1. Forward Characteristics — Free–Wheeling Diode

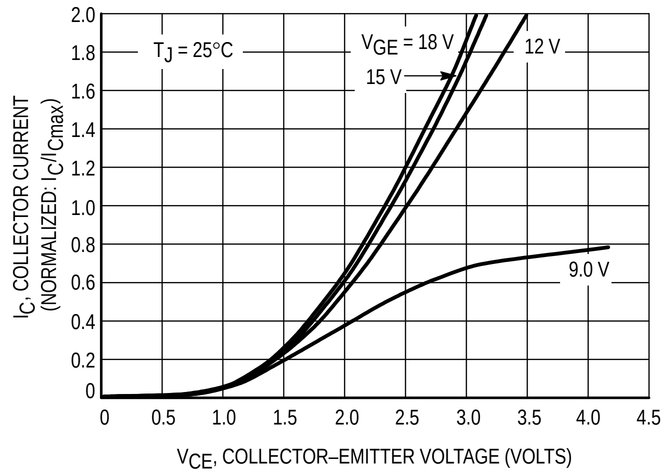


Figure 2. Forward Characteristics, T_J = 25°C

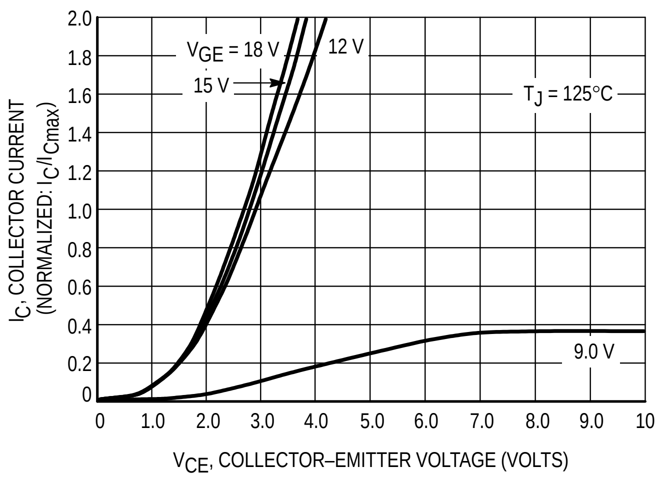


Figure 3. Forward Characteristics, T_J = 125°C

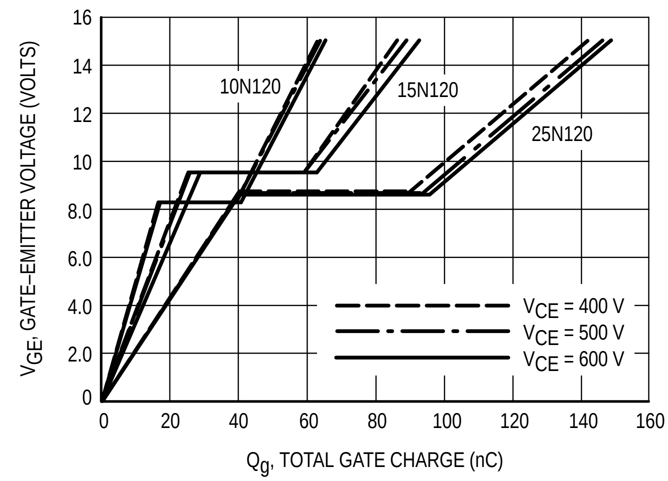


Figure 4. Gate–Emitter Voltage versus Total Gate Charge

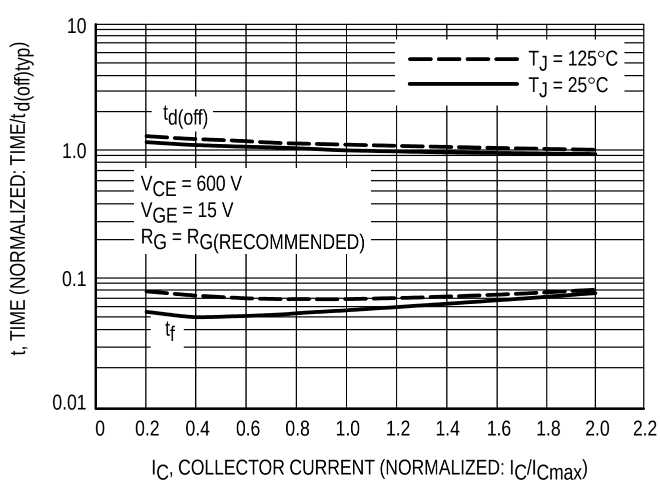


Figure 5. Inductive Switching Times versus Collector Current

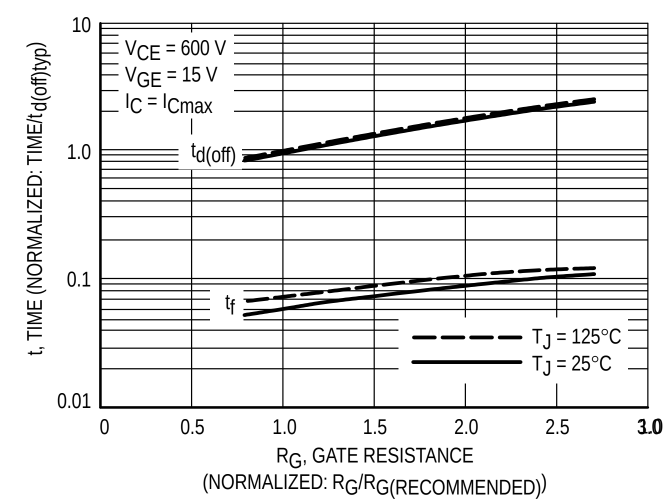


Figure 6. Inductive Switching Times versus Gate Resistance

TYPICAL CHARACTERISTICS

(see also application information)

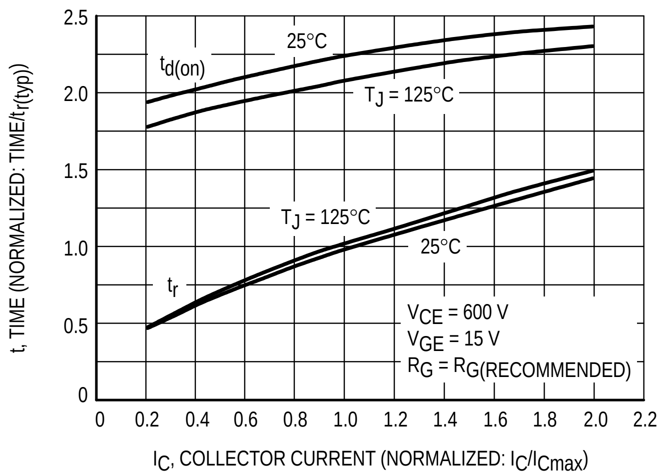


Figure 7. Inductive Switching Times versus Collector Current

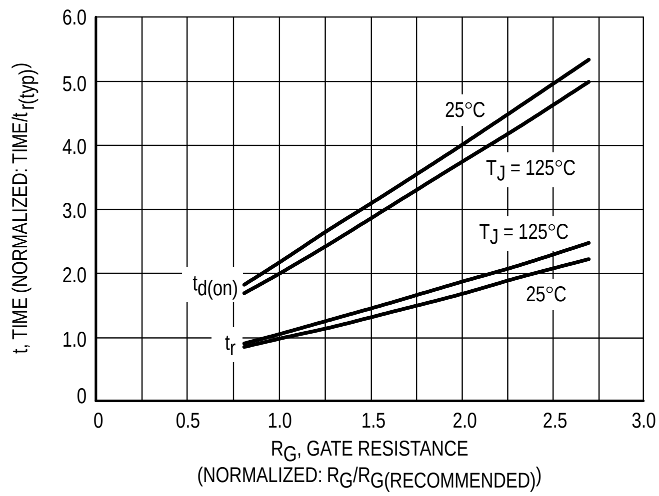


Figure 8. Inductive Switching Times versus Gate Resistance

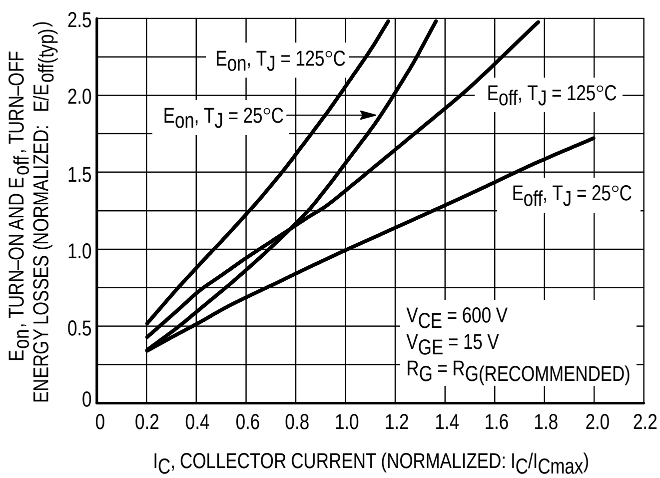


Figure 9. Turn–On and Turn–Off Energy Losses versus Collector Current

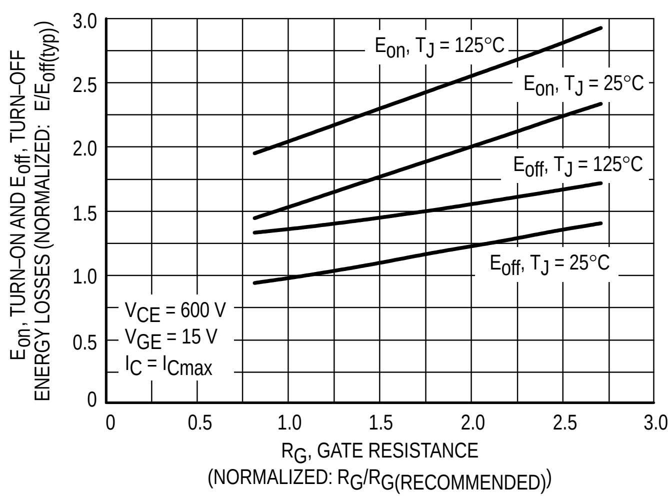


Figure 10. Turn–On and Turn–Off Energy Losses versus Gate Resistance

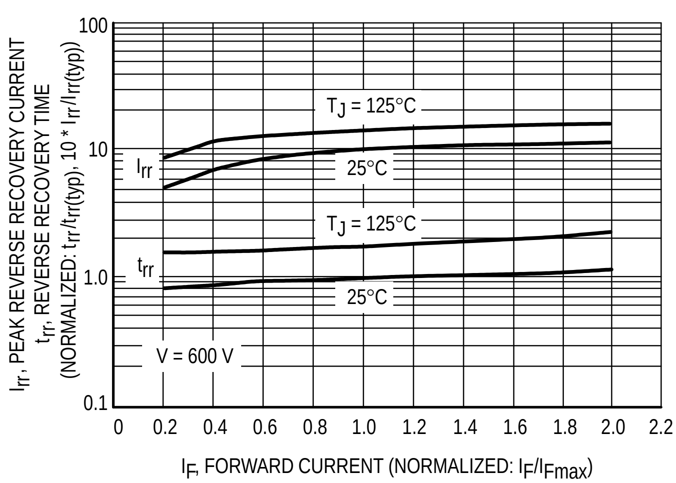


Figure 11. Reverse Recovery Characteristics — Free–Wheeling Diode

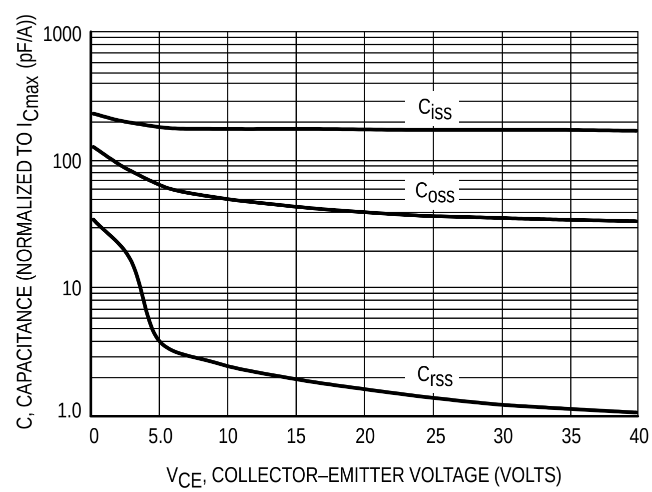


Figure 12. Capacitance Variation

TYPICAL CHARACTERISTICS

(see also application information)

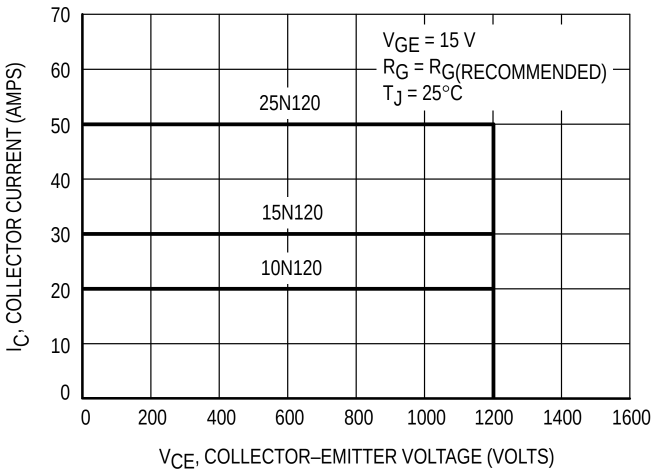


Figure 13. Reverse Biased Safe Operating Area (RBSOA)

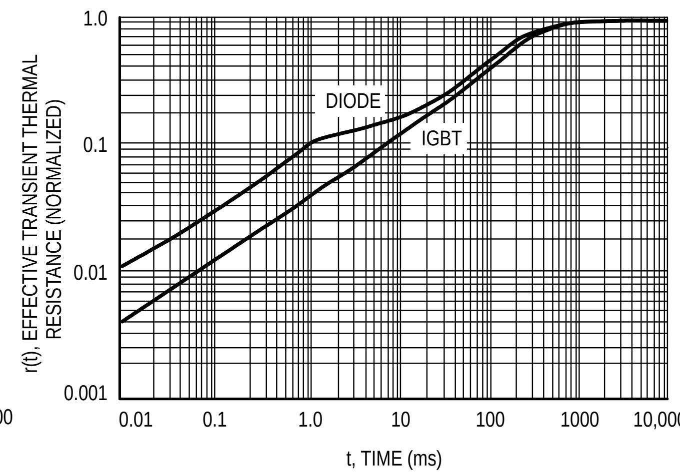


Figure 14. Thermal Response

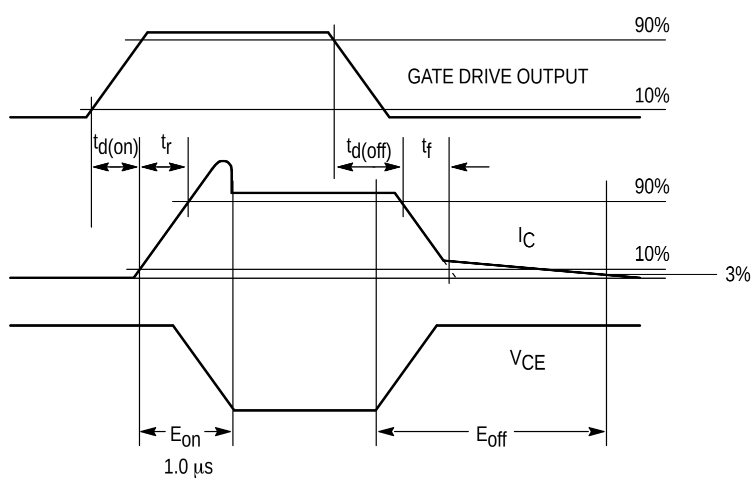


Figure 15. Timing Definitions

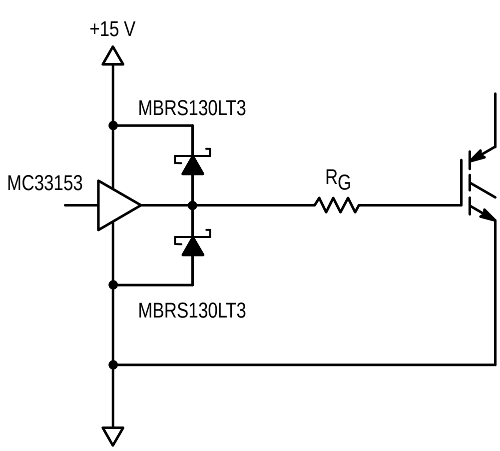


Figure 16. Common Gate Drive Circuit

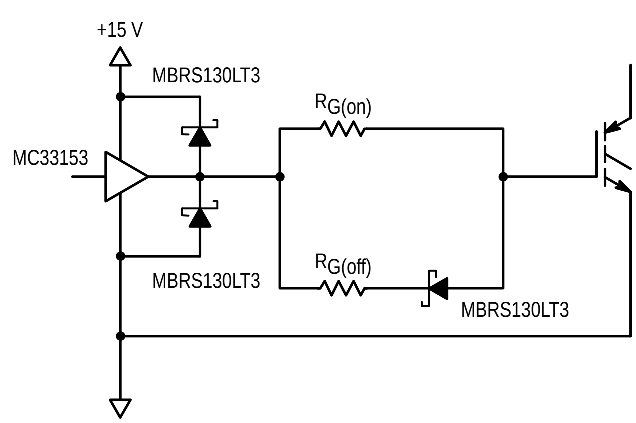


Figure 17. Recommended Gate Drive Circuit

APPLICATION INFORMATION

These modules are designed to be used as the power stage of a three–phase AC induction motor drive. They may be used for up to 460 VAC applications. Switching frequencies up to 15 kHz were considered in the design.

Gate resistance recommendations have been listed. These choices were based on the common gate drive circuit shown in Figure 16. However, significant improvements in E_{off} may be gained by either of two methods: use of a negative gate bias, or use of the gate drive shown in Figure 17. Separate turn–on and turn–off gate resistors give the best results; in this case, $R_{G(off)}$ should be chosen as small as possible while limiting current to prevent damage to the gate drive IC. Designers should also note that turn–on and turn–off delay times are measured from the rising and falling edges of the gate drive output, not the gate voltage waveform.

Since all three modules use similar technology, most of the graphs showing typical performance have been normalized. Actual values are listed for each size in the table, “Electrical Characteristics.” Data on the graphs reflect performance using the common gate drive circuit shown in Figure 16.

The first three curves, showing DC characteristics, are normalized for I_{Cmax}. The devices all perform similarly at rated current. The curves extend to $I_{C(pk)}$, the maximum allowable instantaneous current.

The next two graphs, turn–off and turn–on times versus I_C, are also normalized for I_{Cmax}. In addition, the time scales are normalized. Turn–off times are normalized to $t_{d(off)}$ at 25°C at rated current with recommended R_G, while turn–on times are normalized to t_r at 25°C at rated current with recommended R_G.

The graphs showing switching times as a function of R_G are similarly normalized. R_G has been normalized to the recommended value listed under “Electrical Characteristics.” The time axes are normalized exactly as for the corresponding graphs showing variation with I_C.

Similar transformations have been made for the next two figures, showing E_{on} and E_{off}. Energies have been normalized to E_{off} at 25°C at I_{Cmax} with the recommended R_G. I_C has been normalized to I_{Cmax}, and R_G has been normalized to the recommended value.

Reverse recovery characteristics are also normalized. I_C has again been normalized to I_{Cmax}. Reverse recovery time t_{rr} has been normalized to t_{rr} at 25°C at I_{Cmax}. Peak reverse recovery current I_{rrm} has been normalized to I_{rrm} at 25°C at I_{Cmax}, then multiplied by 10.

Capacitance has been normalized to device rated I_{Cmax}. Since all modules are rated for the same voltage, the voltage scale on Figure 11 does not need to be normalized.

Typical transient thermal impedance is shown for a diode and for an IGBT. All diodes behave quite similarly, as do all IGBTs.

The last two graphs, V_{GE} versus Q_G and RBSOA, are not normalized.

Many issues beyond the ratings must be considered in a system design. Dynamic characteristics can all be affected by external circuit parameters. For example, excessive bus inductance can dramatically increase voltage overshoot during switching, increasing the switching energy. The choice of gate drive IC can have quite a large effect on rise and fall times, corresponding to differences in switching energies. In many cases, this can be compensated by simply changing the gate resistor accordingly — a gate driver with a lower drive capability requires a smaller gate resistor. Ultimately, the module must be tested in the final system to characterize its performance.

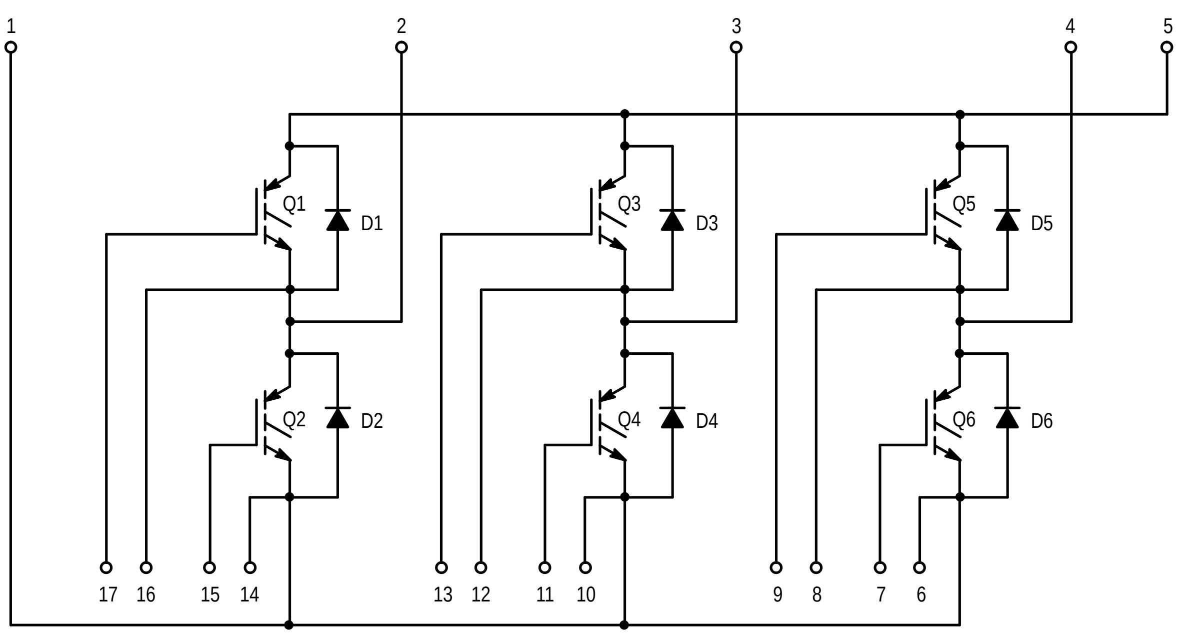


Figure 18. Schematic of Module, Showing Pin–Out

RECOMMENDED PCB LAYOUT
MODULE SIDE VIEW OF BOARD
(Typical Dimensions in mm)

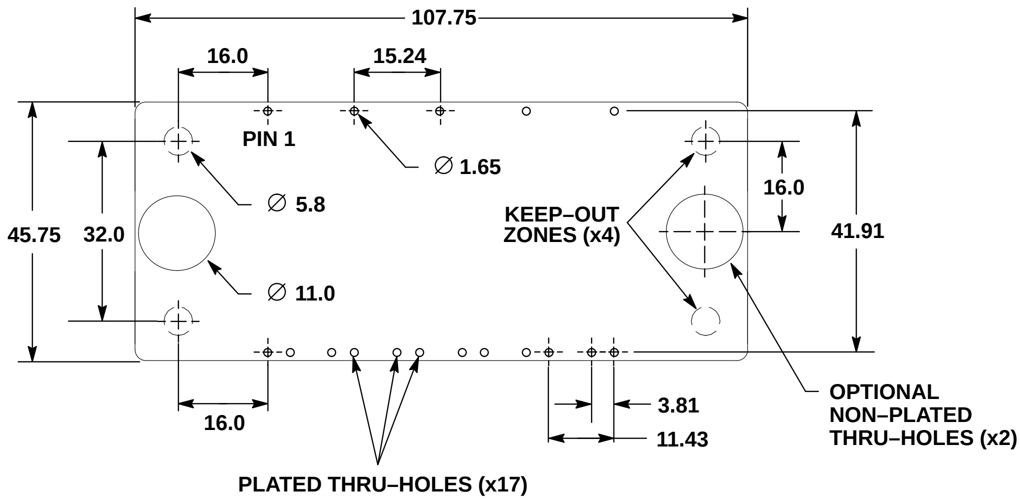
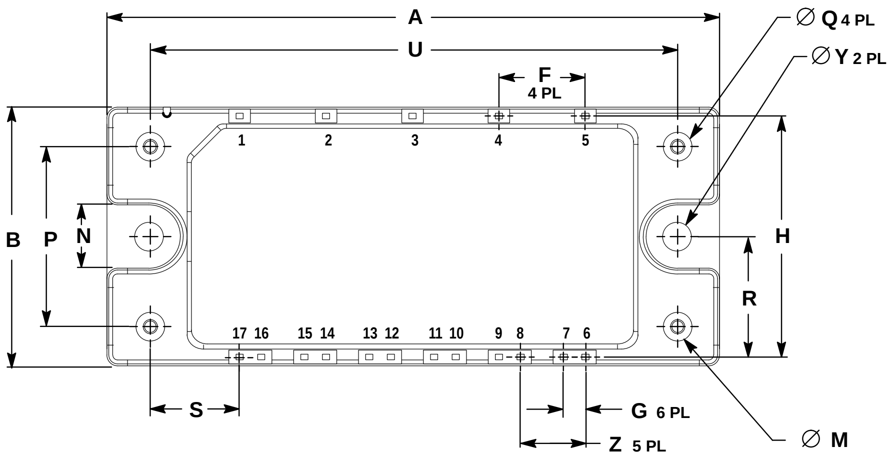


Figure 19. Package Footprint

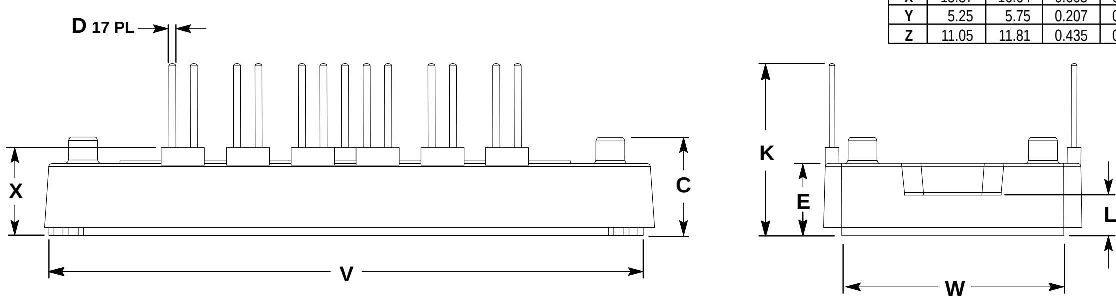
NOTES:
1. Package is symmetrical.
2. Dimension of plated thru–holes indicates finished hole size after plating.
3. Non–plated thru–holes shown for optional access to heat sink mounting screws.

PACKAGE DIMENSIONS



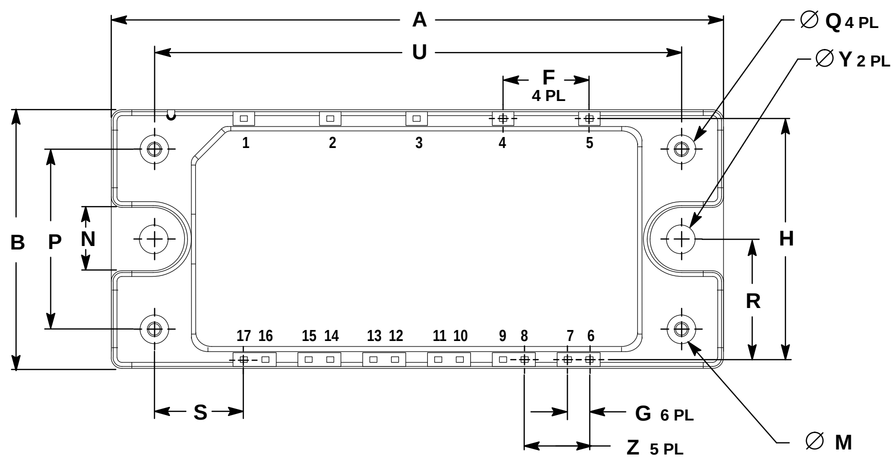
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. LEAD LOCATION DIMENSIONS (ie: G, S, R, H, F...) ARE TO THE CENTER OF THE LEAD.

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	---	107.75	---	4.242
B	---	45.75	---	1.801
C	16.37	17.64	0.644	0.694
D	0.77	1.53	0.030	0.060
E	12.49	13.51	0.492	0.532
F	14.86	15.62	0.585	0.615
G	3.43	4.19	0.135	0.165
H	41.53	42.29	1.635	1.665
K	29.99	31.01	1.181	1.221
L	6.29	7.31	0.248	0.288
M	1.59	2.61	0.063	0.103
N	10.49	11.51	0.413	0.453
P	31.49	32.51	1.240	1.280
Q	2.00	2.60	0.079	0.103
R	20.57	21.33	0.810	0.840
S	15.62	16.38	0.615	0.645
U	92.49	93.51	3.641	3.681
V	104.17	105.44	4.101	4.151
W	37.49	38.51	1.476	1.516
X	15.37	16.64	0.605	0.655
Y	5.25	5.75	0.207	0.227
Z	11.05	11.81	0.435	0.465



CASE 464A–01
ISSUE A

PACKAGE DIMENSIONS



NOTES:
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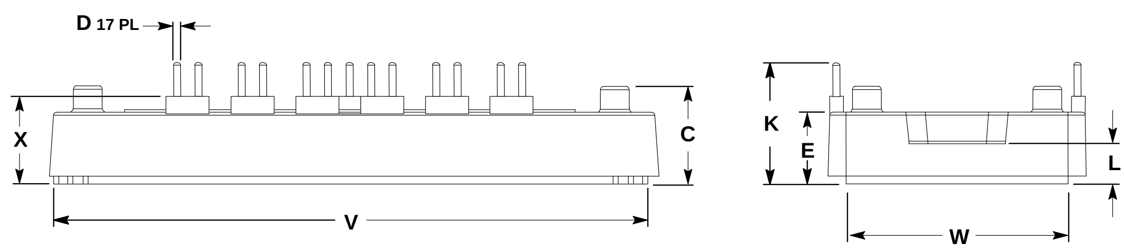
	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	—	107.75	—	4.242
B	—	45.75	—	1.801
C	16.37	17.64	0.644	0.694
D	0.77	1.53	0.030	0.060
E	12.49	13.51	0.492	0.532
F	14.86	15.62	0.585	0.615
G	3.43	4.19	0.135	0.165
H	41.53	42.29	1.635	1.665
K	19.81	20.60	0.780	0.881
L	6.29	7.31	0.248	0.288
M	1.59	2.61	0.063	0.103
N	10.49	11.51	0.413	0.453
P	31.49	32.51	1.240	1.280
Q	2.00	2.60	0.079	0.103
R	20.57	21.33	0.810	0.840
S	15.62	16.38	0.615	0.645
U	92.49	93.51	3.641	3.681
V	104.17	105.44	4.101	4.151
W	37.49	38.51	1.476	1.516
X	15.37	16.64	0.605	0.655
Y	5.25	5.75	0.207	0.227
Z	11.05	11.81	0.435	0.465



CASE 464B–02
ISSUE A

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