Motion SPM® 45 Series NFA42060R42

General Description

NFA42060R42 is a Motion SPM 45 module providing a fully−featured, high−performance inverter output stage for AC Induction, BLDC, and PMSM motors. These modules integrate optimized gate drive of the built−in RC−IGBTs to minimize EMI and losses, while also providing multiple on−module protection features including under−voltage lockouts, over−current shutdown, thermal monitoring of drive IC, and fault reporting. The built−in, high−speed HVIC requires only a single supply voltage and translates the incoming logic−level gate inputs to the high−voltage, high−current drive signals required to properly drive the module's internal IGBTs. Separate negative IGBT terminals are available for each phase to support the widest variety of control algorithms.

Features

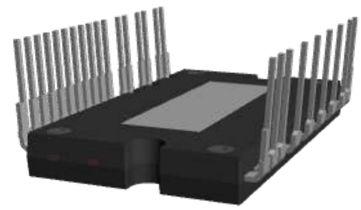
- 600 V – 20 A 3−Phase RC−IGBT Inverter with Integral Gate Drivers and Protection
- Low Thermal Resistance Using Ceramic Substrate
- Low−Loss, Short−Circuit Rated FS4 RC−IGBTs
- Built−In Bootstrap Diodes and Dedicated Vs Pins Simplify PCB Layout
- Built−In NTC Thermistor for Temperature Monitoring
- Separate Open−Emitter Pins from Low−Side RC−IGBTs for Three−Phase Current Sensing
- Single−Grounded Power Supply
- Isolation Rating: 2000 V_{rms} / Min.
- Remove Dummy Pin
- This is a Pb−Free Device

Applications

- Motion Control – Home Appliance / Industrial Motor

Related Resources

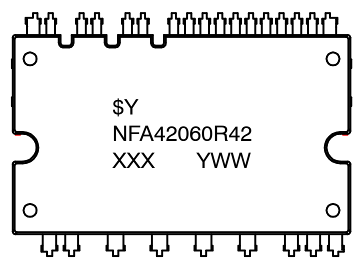
- AN−9084 – *Smart Power Module, Motion SPM® 45 H V3 Series User's Guide*
- AN−9072 – *Smart Power Module Motion SPM® in SPM45H Thermal Performance Information*
- AN−9071 – *Smart Power Module Motion SPM® in SPM45H Mounting Guidance*
- AN−9760 – *PCB Design Guidance for SPM®*



3D Package Drawing (Click to Activate 3D Content)

SPMAA−C26 / 26LD, PDD STD CERAMIC TYPE, LONG LEAD DUAL FORM TYPE CASE MODFC

MARKING DIAGRAM



$Y = **onsemi** Logo
NFA42060R42 = Specific Device Code
XXX = Trace Code
Y = Year
WW = Work Week

ORDERING INFORMATION

See detailed ordering and shipping information on page 14 of this data sheet.

Integrated Power Functions

- 600 V – 20 A IGBT inverter for three−phase DC / AC power conversion (please refer to Figure 2)

Integrated Drive, Protection, and System Control Functions

- For inverter high−side IGBTs: gate drive circuit, high−voltage isolated high−speed level shifting control circuit Under−Voltage Lock−Out Protection (UVLO) NOTE: Available bootstrap circuit example is given in Figures 13.
- For inverter low−side IGBTs: gate drive circuit, Short−Circuit Protection (SCP) control supply circuit Under−Voltage Lock−Out Protection (UVLO)
- Fault signaling: corresponding to UVLO (low−side supply) and SC faults
- Input interface: active−HIGH interface, works with 3.3 / 5 V logic, Schmitt−trigger input

Pin Configuration

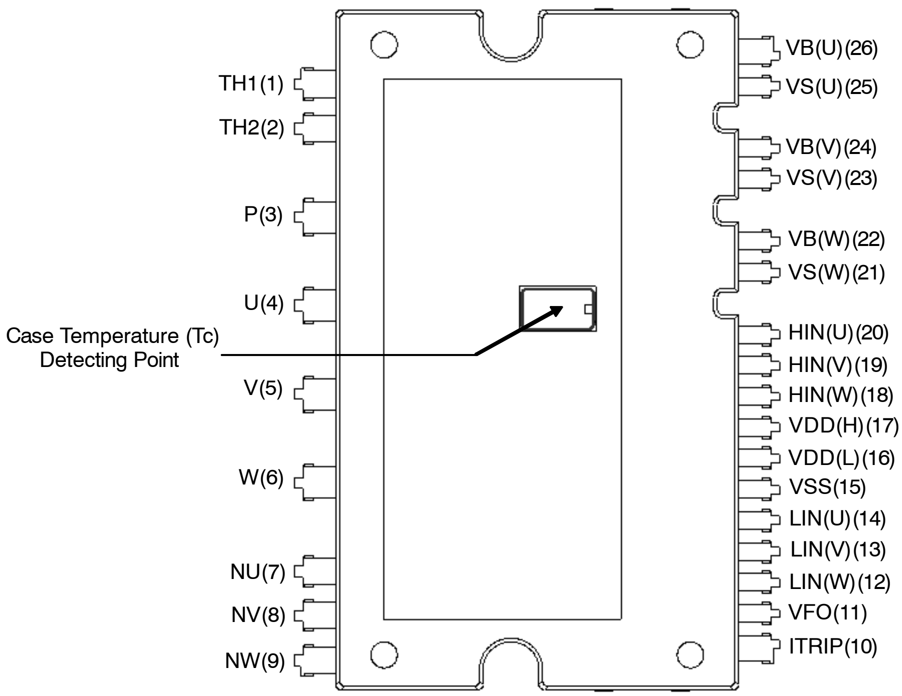
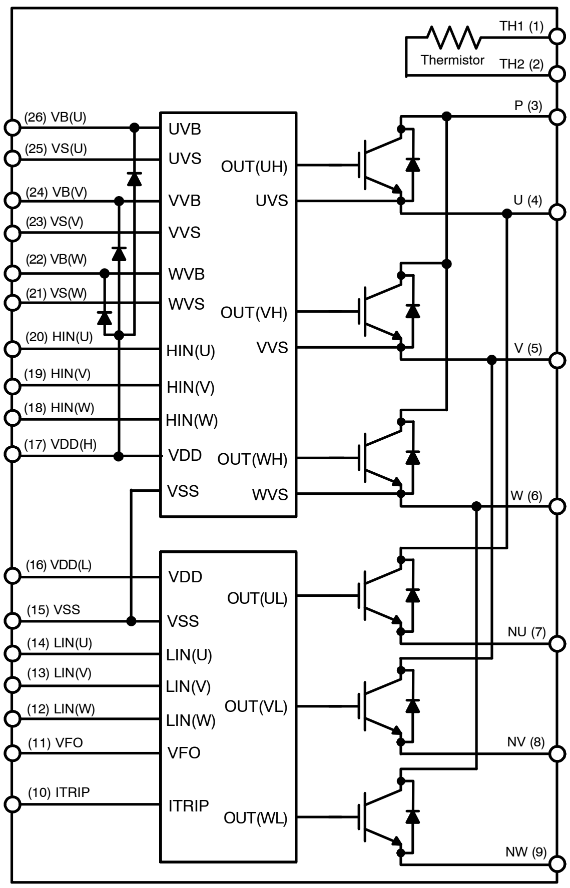


Figure 1. Top View

PIN DESCRIPTION

Pin No.	Pin Name	Description
1	TH1	Thermistor Bias Voltage
2	TH2	Series Resistor for the Use of Thermistor (Temperature Detection)
3	P	Positive DC−Link Input
4	U	Output for U−Phase
5	V	Output for V−Phase
6	W	Output for W−Phase
7	NU	Negative DC−Link Input for U−Phase
8	NV	Negative DC−Link Input for V−Phase
9	NW	Negative DC−Link Input for W−Phase
10	ITRIP	Input for Current Protection
11	VFO	Fault Output
12	LIN(W)	Signal Input for Low−Side W−Phase
13	LIN(V)	Signal Input for Low−Side V−Phase
14	LIN(U)	Signal Input for Low−Side U−Phase
15	VSS	Common Supply Ground
16	VDD(L)	Low−Side Common Bias Voltage for IC and IGBTs Driving
17	VDD(H)	High−Side Common Bias Voltage for IC and IGBTs Driving
18	HIN(W)	Signal Input for High−Side W−Phase
19	HIN(V)	Signal Input for High−Side V−Phase
20	HIN(U)	Signal Input for High−Side U−Phase
21	VS(W)	High−Side Bias Voltage Ground for W−Phase IGBT Driving
22	VB(W)	High−Side Bias Voltage for W−Phase IGBT Driving
23	VS(V)	High−Side Bias Voltage Ground for V−Phase IGBT Driving
24	VB(V)	High−Side Bias Voltage for V−Phase IGBT Driving
25	VS(U)	High−Side Bias Voltage Ground for U−Phase IGBT Driving
26	VB(U)	High−Side Bias Voltage for U−Phase IGBT Driving

Internal Equivalent Circuit and Input/Output Pins



NOTE:

1. Inverter high−side is composed of three RC−IGBTs and one control IC for each IGBT.
2. Inverter low−side is composed of three RC−IGBTs and one control IC for each IGBT. It has gate drive and protection functions.
3. Inverter power side is composed of four inverter DC−link input terminals and three inverter output terminals.

Figure 2. Internal Block Diagram

ABSOLUTE MAXIMUM RATINGS (Tj = 25°C, unless otherwise noted)

Symbol	Parameter	Conditions	Rating	Unit
INVERTER PART				
VPN	Supply Voltage	P − NU, NV, NW	450	V
VPN(surge)	Supply Voltage (Surge)	P − NU, NV, NW	500	V
Vces	Collector − Emitter Voltage		600	V
±Ic	Each IGBT Collector Current	Tc = 25°C	20	A
±Icp	Each IGBT Collector Current (Peak)	Tc = 25°C, Under 1 ms Pulse Width	40	A
Pc	Collector Dissipation	Tc = 25°C Per One Chip (Note 4)	58	W
Tj	Operating Junction Temperature		− 40~150	°C
CONTROL PART				
VDD	Control Supply Voltage	VDD(H), VDD(L) − VSS	20	V
VBS	High−Side Control Bias Voltage	VB(U) − VS(U), VB(V) − VS(V), VB(W) − VS(W)	20	V
VIN	Input Signal Voltage	HIN(U), HIN(V), HIN(W), LIN(U), LIN(V), LIN(W) − VSS	−0.3~VDD + 0.3	V
VFO	Fault Output Supply Voltage	VFO − VSS	−0.3~VDD + 0.3	V
IFO	Fault Output Current	Sink Current at VFO pin	1	mA
VITRIP	Current−Sensing Input Voltage	ITRIP − VSS	−0.3~VDD + 0.3	V
BOOTSTRAP DIODE PART				
VRRM	Maximum Repetitive Reverse Voltage		600	V
If	Forward Current	Tc = 25°C	0.5	A
Ifp	Forward Current (Peak)	Tc = 25°C, Under 1 ms Pulse Width (Note 4)	2.0	A
Tj	Operating Junction Temperature		−40~150	°C
TOTAL SYSTEM				
VPN(PROT)	Self−Protection Supply Voltage Limit (Short−Circuit Protection Capability)	VDD = VBS = 13.5~16.5 V Tj = 150°C, Vces < 600 V Non−Repetitive, < 2 μs	400	V
Tc	Module Case Operation Temperature	*See Figure 1*	−40~125	°C
Tstg	Storage Temperature		−40~125	°C
Viso	Isolation Voltage	60 Hz, Sinusoidal, AC 1 minute, Connection Pins to Heat Sink Plate	2000	V_{rms}

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.
4. These values had been made an acquisition by the calculation considered to design factor.

ABSOLUTE MAXIMUM RATINGS (Tj = 25°C, unless otherwise noted)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
THERMAL RESISTANCE						
Rth(j−c)Q	Junction to Case Thermal Resistance (Note 5)	Inverter IGBT Part (per 1/6 module)	−	−	2.13	°C/W
Rth(j−c)F		Inverter FWDi Part (per 1/6 module)	−	−	3.2	°C/W

5. For the measurement point of case temperature T_C, please refer to Figure 1.
Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.
6. t_{ON} and t_{OFF} include the propagation delay time of the internal drive IC. $t_{C(ON)}$ and $t_{C(OFF)}$ are the switching time of IGBT itself under the given gate driving condition internally. For the detailed information, *please see Figure 3*.

ELECTRICAL CHARACTERISTICS (Tj = 25°C, unless otherwise noted)

Symbol		Parameter	Conditions	Min	Typ	Max	Unit
INVERTER PART							
VCE(sat)		Collector−Emitter Saturation Voltage	VDD = VBS = 15 V, IN = 5 V, Ic = 20 A, Tj = 25°C	–	1.5	2.1	V
VF		FWDi Forward Voltage	IN = 0 V, Ic = −20 A, Tj = 25°C	–	1.80	2.40	V
HS	ton	Switching Times	VPN = 300 V, VDD(H) = VDD(L) = 15 V, Ic = 20 A, Tj = 25°C, IN = 0 ↔ 5 V, Inductive Load (Note 6)	–	0.85	–	μs
	tc(on)			–	0.15	–	μs
	toff			–	1.00	–	μs
	tc(off)			–	0.15	–	μs
	trr			–	0.20	–	μs
LS	ton		VPN = 300 V, VDD(H) = VDD(L) = 15 V, Ic = 20 A, Tj = 25°C, IN = 0 ↔ 5 V, Inductive Load (Note 6)	–	0.90	–	μs
	tc(on)			–	0.20	–	μs
	toff			–	1.05	–	μs
	tc(off)			–	0.15	–	μs
	trr			–	0.25	–	μs
Ices		Collector−Emitter Leakage Current	Vce = Vces	–	–	1	mA

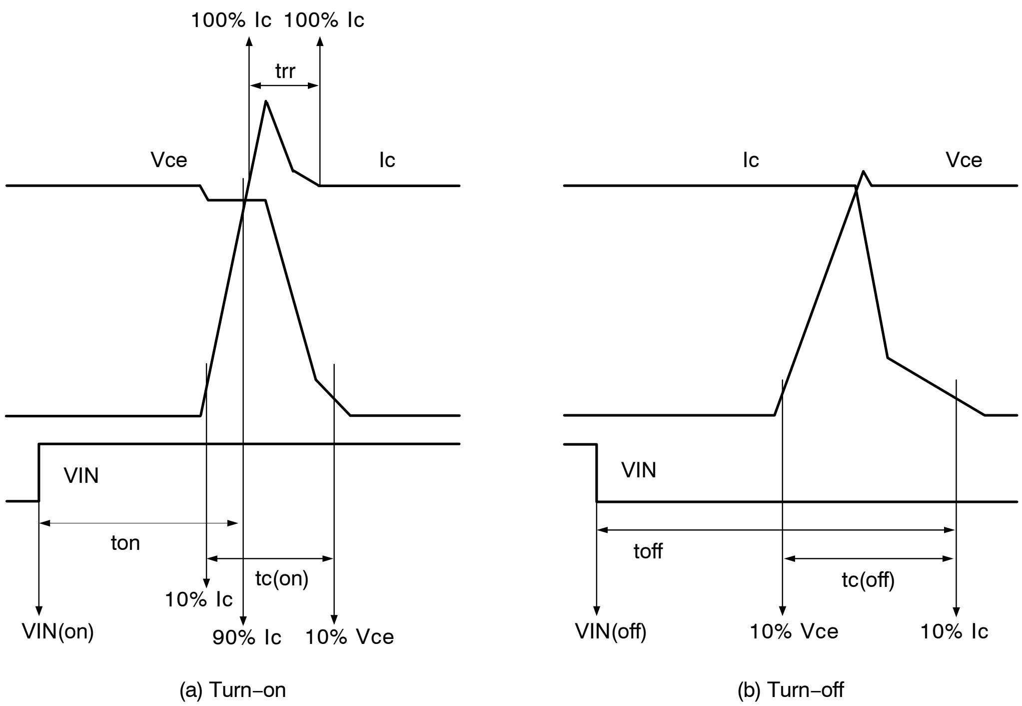


Figure 3. Switching Time Definitions

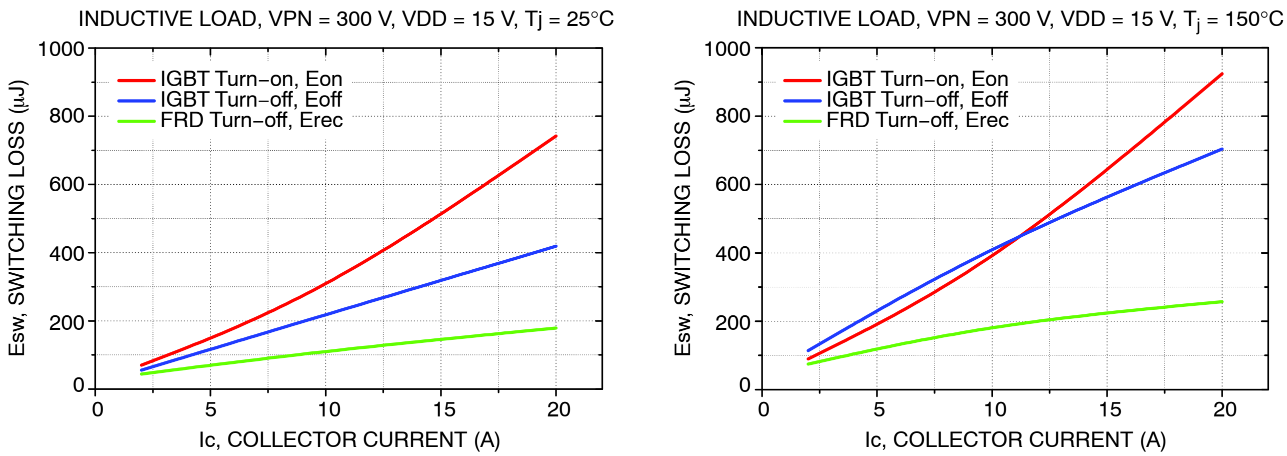


Figure 4. Switching Loss Characteristics (Typical)

ELECTRICAL CHARACTERISTICS (Tj = 25°C, unless otherwise noted)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
CONTROL PART						
IQDDH	Quiescent VDD Supply Current	VDD(H) = 15 V, HIN = 0 V, VDD(H) − VSS	–	–	0.10	mA
IQDDL		VDD(L) = 15 V, LIN = 0 V, VDD(L) − VSS	–	–	2.65	mA
IPDDH	Operating VDD Supply Current	VDD(H) = 15 V, fPWM = 20 kHz, Duty = 50%, Applied to One PWM Signal Input for High−Side	–	–	0.15	mA
IPDDL		VDD(L) = 15 V, fPWM = 20 kHz, Duty = 50%, Applied to One PWM Signal Input for Low−Side	–	–	4.00	mA
IQBS	Quiescent VBS Supply Current	VDD(H) = 15 V, HIN = 0 V, VB(U) − VS(U), VB(V) − VS(V), VB(W) − VS(W)	–	–	0.30	mA
IPBS	Operating VBS Supply Current	VDD(H) = 15 V, fPWM = 20 kHz, Duty = 50%, Applied to One PWM Signal Input for High−Side	–	–	2.00	mA
VFOH	Fault Output Voltage	VDD = 0 V, ITRIP = 0 V, VFO Circuit: 10 kΩ to 5 V Pull−up	4.5	–	–	V
VFOL		VDD = 0 V, ITRIP = 1 V, VFO Circuit: 10 kΩ to 5 V Pull−up	–	–	0.5	V
VSC(ref)	Short Circuit Trip Level	VDD = 15 V, ITRIP − VSS	0.45	0.50	0.55	V
UVDDD	Supply Circuit Under−Voltage Protection	Detection Level	10.5	–	13.0	V
UVDDR		Reset Level	11.0	–	13.5	V
UVBSD	Supply Circuit Under−Voltage Protection	Detection Level	10.0	–	12.5	V
UVBSR		Reset Level	10.5	–	13.0	V
tFOD	Fault−Output Pulse Width		30	–	–	μs
VIN(ON)	ON Threshold Voltage	HIN − VSS, LIN − VSS	–	–	2.6	V
VIN(OFF)	OFF Threshold Voltage		0.8	–	–	V
RTH	Resistance of Thermistor	@ TTH = 25°C	–	47	–	kΩ
		@ TTH = 100°C	–	2.9	–	kΩ

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

7. Short−circuit current protection is functioning only at the low−sides.
8. TTH is the temperature of thermistor itself. To know case temperature (Tc), please make the experiment considering your application.

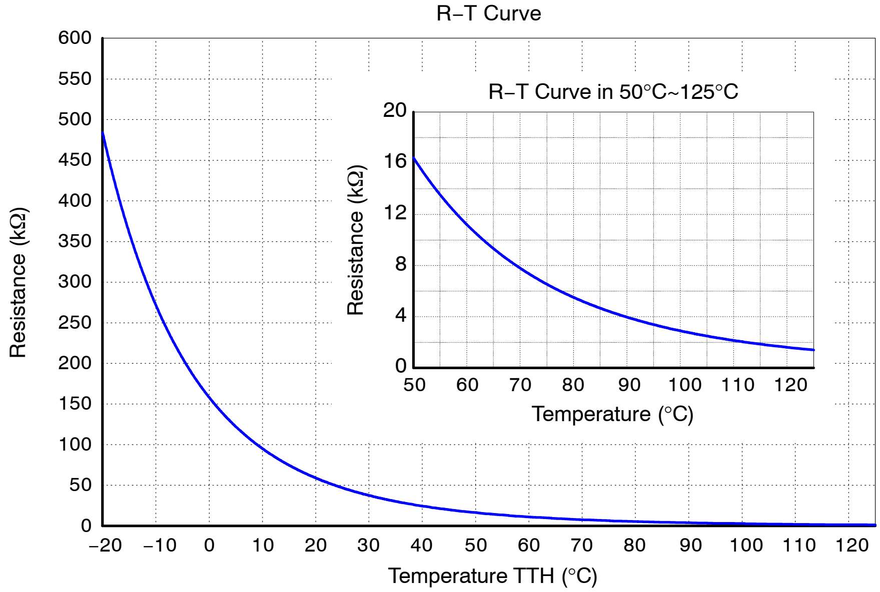
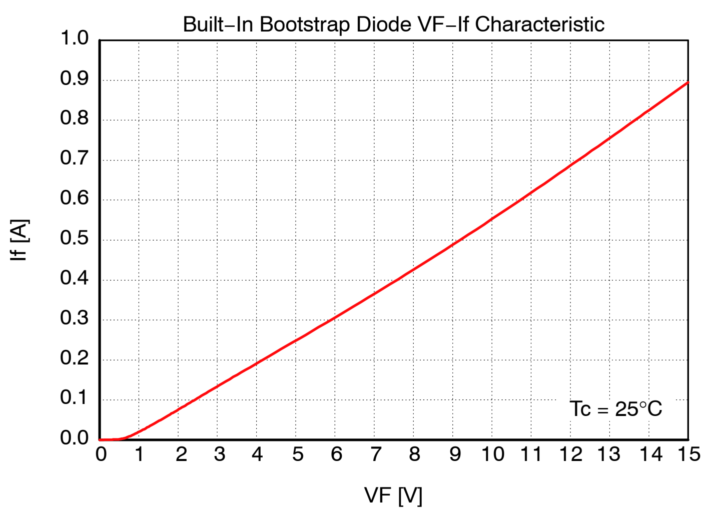


Figure 5. R−T Curve of The Built−In Thermistor

ELECTRICAL CHARACTERISTICS (Tj = 25°C, unless otherwise noted)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
BOOTSTRAP DIODE PART						
VF	Forward Voltage	If = 0.1 A, Tc = 25°C	−	2.5	−	V
trr	Reverse−Recovery Time	If = 0.1 A, dIf/dt = 50 A/μs, Tc = 25°C	−	80	−	ns

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.



NOTE:
9. Built−in bootstrap diode includes around 15 Ω resistance characteristic.

Figure 6. Built−In Bootstrap Diode Characteristics (Typ.)

RECOMMENDED OPERATING CONDITIONS

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
VPN	Supply Voltage	P – NU, NV, NW	–	300	400	V
VDD	Control Supply Voltage	VDD(H), VDD(L) – VSS	13.5	15.0	16.5	V
VBS	High−Side Bias Voltage	VB(U) – VS(U), VB(V) – VS(V), VB(W) – VS(W)	13.0	15.0	18.5	V
dVDD/dt, dVBS/dt	Control Supply Variation		−1	–	1	V/μs
tdead	Blanking Time for Preventing Arm−Short	For each input signal	1	–	–	μs
fPWM	PWM Input Signal	−40°C ≤ Tc ≤ 125°C, −40°C ≤ Tj ≤ 150°C	–	–	20	kHz
VSEN	Voltage for Current Sensing	Applied between NU, NV, NW – VSS (Including Surge−Voltage)	−4	–	4	V
PWIN(ON)	Minimum Input Pulse Width	VDD = VBS = 15 V, Ic ≤ 40 A, Wiring Inductance between NU, NV, NW and DC Link N < 10 nH (Note 10)	1.2	–	–	μs
PWIN(OFF)			1.2	–	–	
Tj	Junction Temperature		−40	–	150	°C

Functional operation above the stresses listed in the Recommended Operating Ranges is not implied. Extended exposure to stresses beyond the Recommended Operating Ranges limits may affect device reliability.
10. This product might not make response if input pulse width is less than the recommended value.

MECHANICAL CHARACTERISTICS AND RATINGS

Parameter	Conditions		Min	Typ	Max	Unit
Device Flatness	*See Figure 7*		0	–	+120	μm
Mounting Torque	Mounting Screw: M3 *See Figure 8*	Recommended 0.7 N · m	0.6	0.7	0.8	N · m
		Recommended 7.1 kg · cm	6.2	7.1	8.1	kg · cm
Weight			–	11.00	–	g

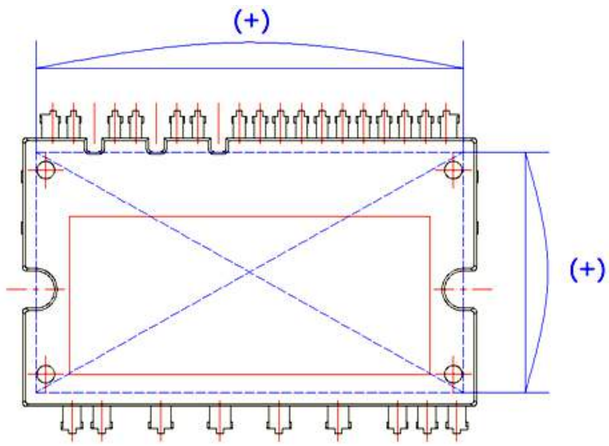
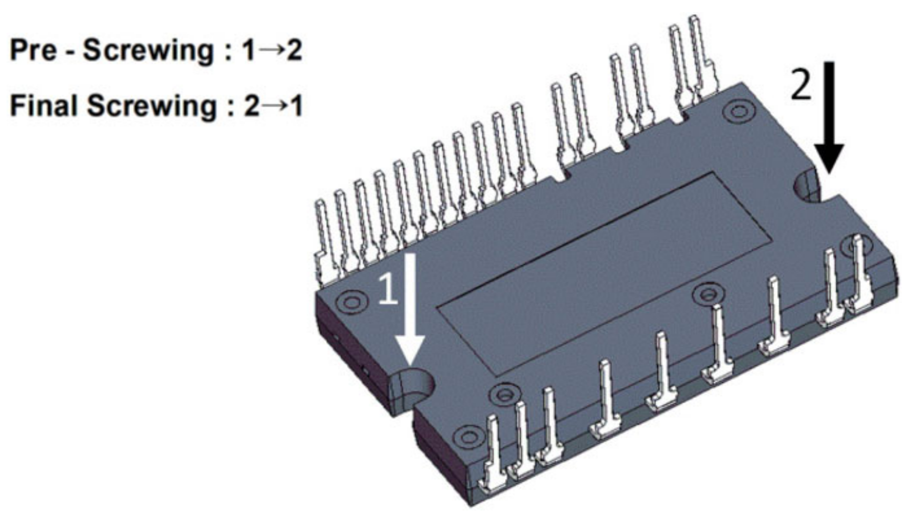


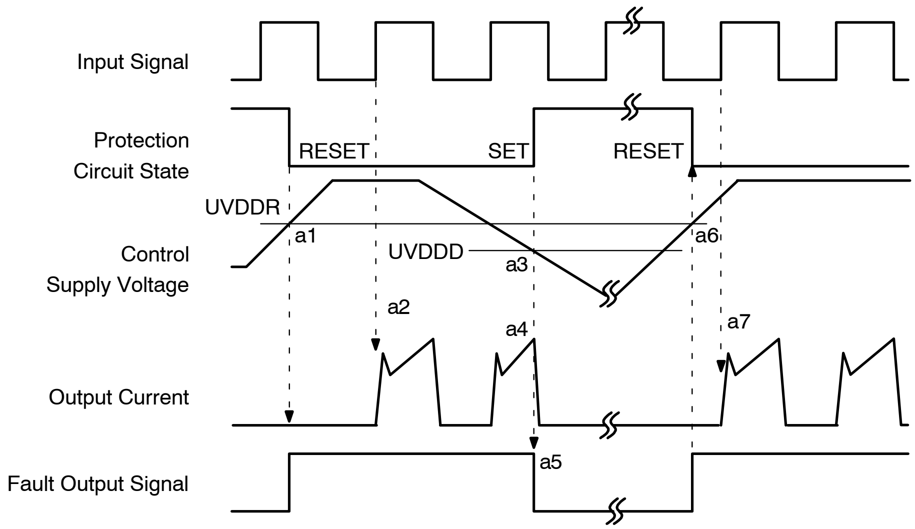
Figure 7. Flatness Measurement Position



NOTE:
11. Do not make over torque when mounting screws. Much mounting torque may cause ceramic cracks, as well as bolts and Al heat−sink destruction.
12. Avoid one−sided tightening stress. Figure 8 shows the recommended torque order for mounting screws. Uneven mounting can cause the ceramic substrate of package to be damaged. The pre−screwing torque is set to 20~30% of maximum torque rating.

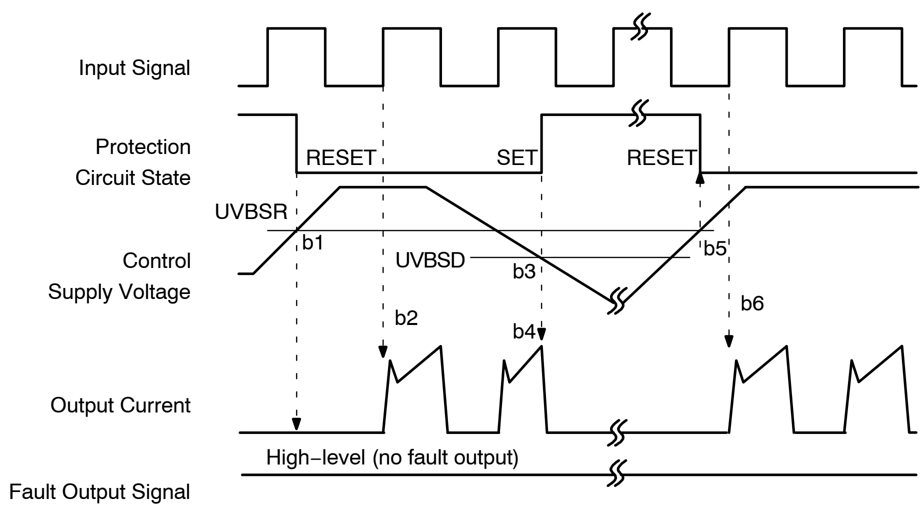
Figure 8. Mounting Screws Torque Order

Time Charts of Protective Function



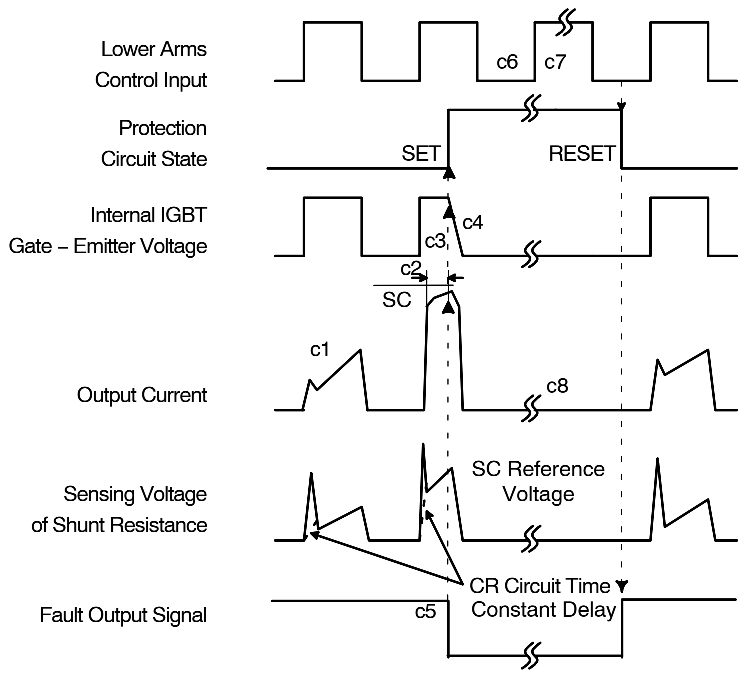
a1: Control supply voltage rises: After the voltage rises UVDDR, the circuits start to operate when next input is applied.
a2: Normal operation: IGBT ON and carrying current.
a3: Under voltage detection (UVDDD).
a4: IGBT OFF in spite of control input condition.
a5: Fault output operation starts with a fixed pulse width.
a6: Under voltage reset (UVDDR).
a7: Normal operation: IGBT ON and carrying current by triggering next signal from LOW to HIGH.

Figure 9. Under−Voltage Protection (Low−Side)



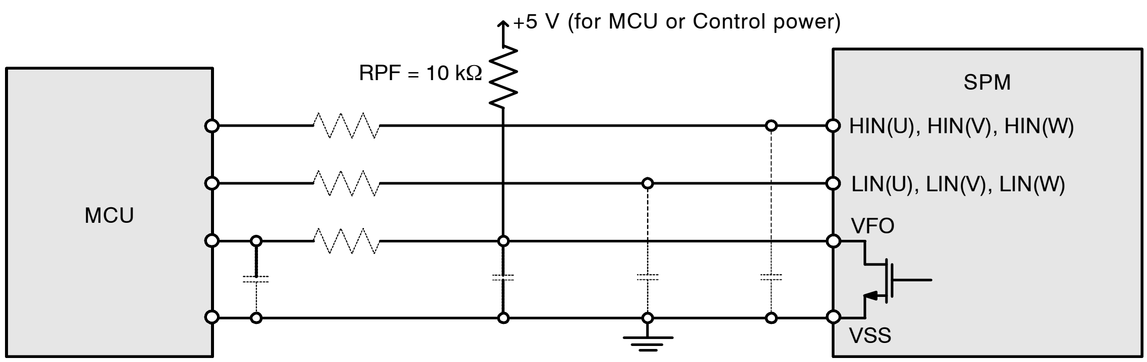
b1: Control supply voltage rises: After the voltage reaches UV_{BSR}, the circuits start to operate when next input is applied.
b2: Normal operation: IGBT ON and carrying current.
b3: Under voltage detection (UVBSD).
b4: IGBT OFF in spite of control input condition, but there is no fault output signal.
b5: Under voltage reset (UVBSR).
b6: Normal operation: IGBT ON and carrying current by triggering next signal from LOW to HIGH.

Figure 10. Under−Voltage Protection (High−side)



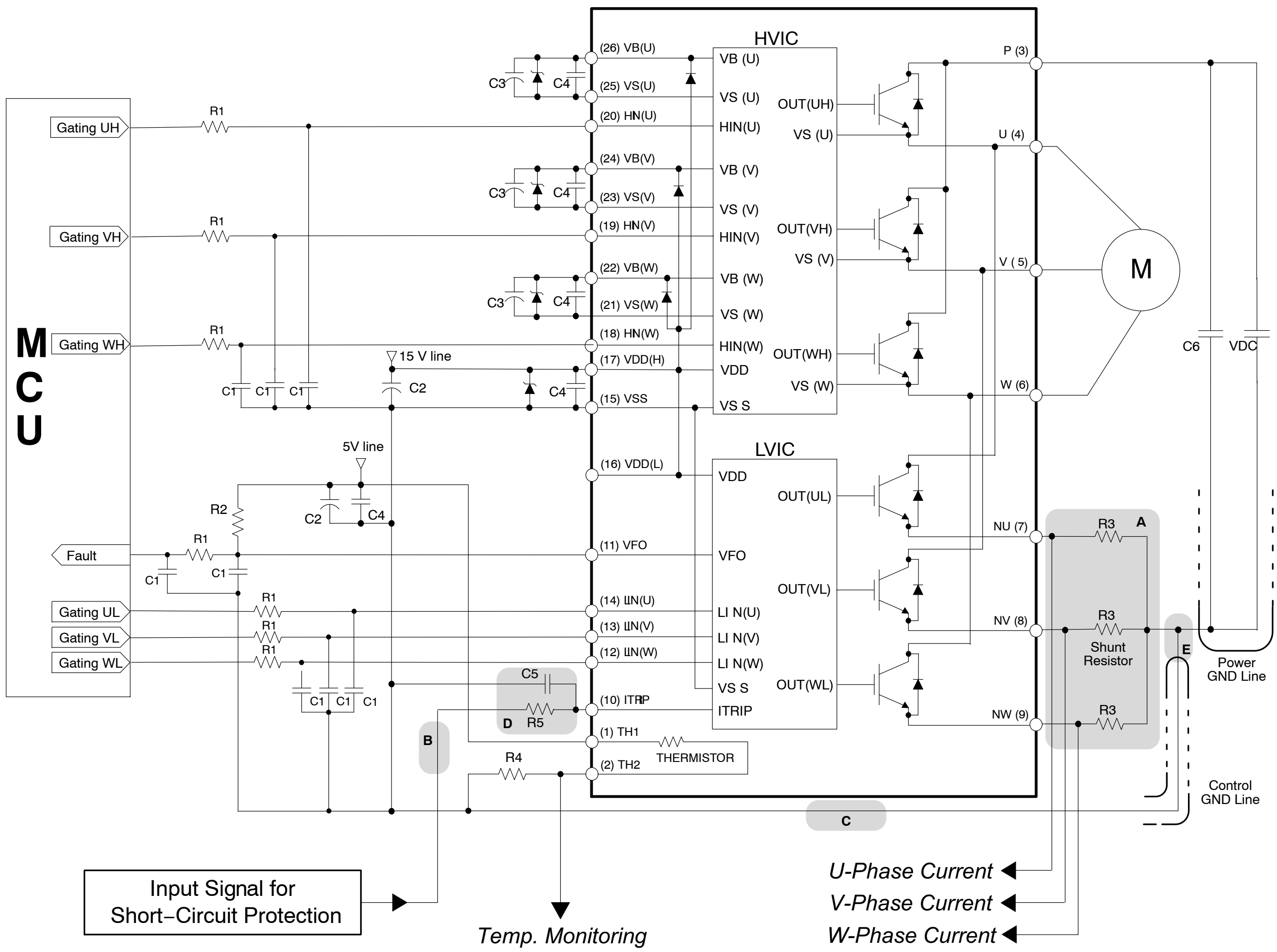
(with the external sense resistance and RC filter connection)
c1: Normal operation: IGBT ON and carrying current.
c2: Short circuit current detection (SC trigger).
c3: All low−side IGBT's gate are hard interrupted.
c4: All low−side IGBT's turn OFF.
c5: Fault output operation starts with a fixed pulse width.
c6: Input HIGH: IGBT ON state, but during the active period of fault output the IGBT doesn't turn ON.
c7: Fault output operation finishes, but IGBT doesn't turn on until triggering next signal from LOW to HIGH.
c8: Normal operation: IGBT ON and carrying current.

Figure 11. Short−Circuit Protection (Low−Side Operation Only)



NOTE:
13. RC coupling at each input might change depending on the PWM control scheme used in the application and the wiring impedance of the application's printed circuit board. The input signal section of the Motion SPM 45 product integrates 5 kΩ (typ.) pull−down resistor. Therefore, when using an external filtering resistor, please pay attention to the signal voltage drop at input terminal.

Figure 12. Recommended MCU I/O Interface Circuit



NOTE:

14. To avoid malfunction, the wiring of each input should be as short as possible (less than 2 − 3 cm).
15. VFO output is open−drain type. This signal line should be pulled up to the positive side of the MCU or control power supply with a resistor that makes IFO up to 1 mA.
16. Input signal is active−HIGH type. There is a 5kΩ resistor inside the IC to pull down each input signal line to GND. RC coupling circuits is recommended for the prevention of input signal oscillation. R1C1 time constant should be selected in the range 50~150 ns (recommended R1 = 100 Ω, C1 = 1 nF).
17. Each wiring pattern inductance of point A should be minimized (recommend less than 10 nH). Use the shunt resistor R3 of surface mounted (SMD) type to reduce wiring inductance. To prevent malfunction, wiring of point E should be connected to the terminal of the shunt resistor R3 as close as possible.
18. To insert the shunt resistor to measure each phase current at NU, NV, NW terminal, it makes to change the trip level ISC about the short−circuit current.
19. To prevent errors of the protection function, the wiring of point B, C, and D should be as short as possible.
20. In the short−circuit protection circuit, please select the R5C5 time constant in the range 1.5~2 μs. Do enough evaluation on the real system because short−circuit protection time may vary wiring pattern layout and value of the R5C5 time constant.
21. Each capacitor should be mounted as close to the pins of the Motion SPM 45 product as possible.
22. To prevent surge destruction, the wiring between the smoothing capacitor C6 and the P & GND pins should be as short as possible. The use of a high−frequency non−inductive capacitor of around 0.1~0.22 μF between the P and GND pins is recommended.
23. Relays are used in almost every systems of electrical equipment in home appliances. In these cases, there should be sufficient distance between the MCU and the relays.
24. The zener diode or transient voltage suppressor should be adopted for the protection of ICs from the surge destruction between each pair of control supply terminals (recommended zener diode is 22 V / 1 W, which has the lower zener impedance characteristic than about 15 Ω).
25. C2 of around seven times larger than bootstrap capacitor C3 is recommended.
26. Please choose the electrolytic capacitor with good temperature characteristic in C3. Also, choose 0.1~0.2 μF R−category ceramic capacitors with good temperature and frequency characteristics in C4.

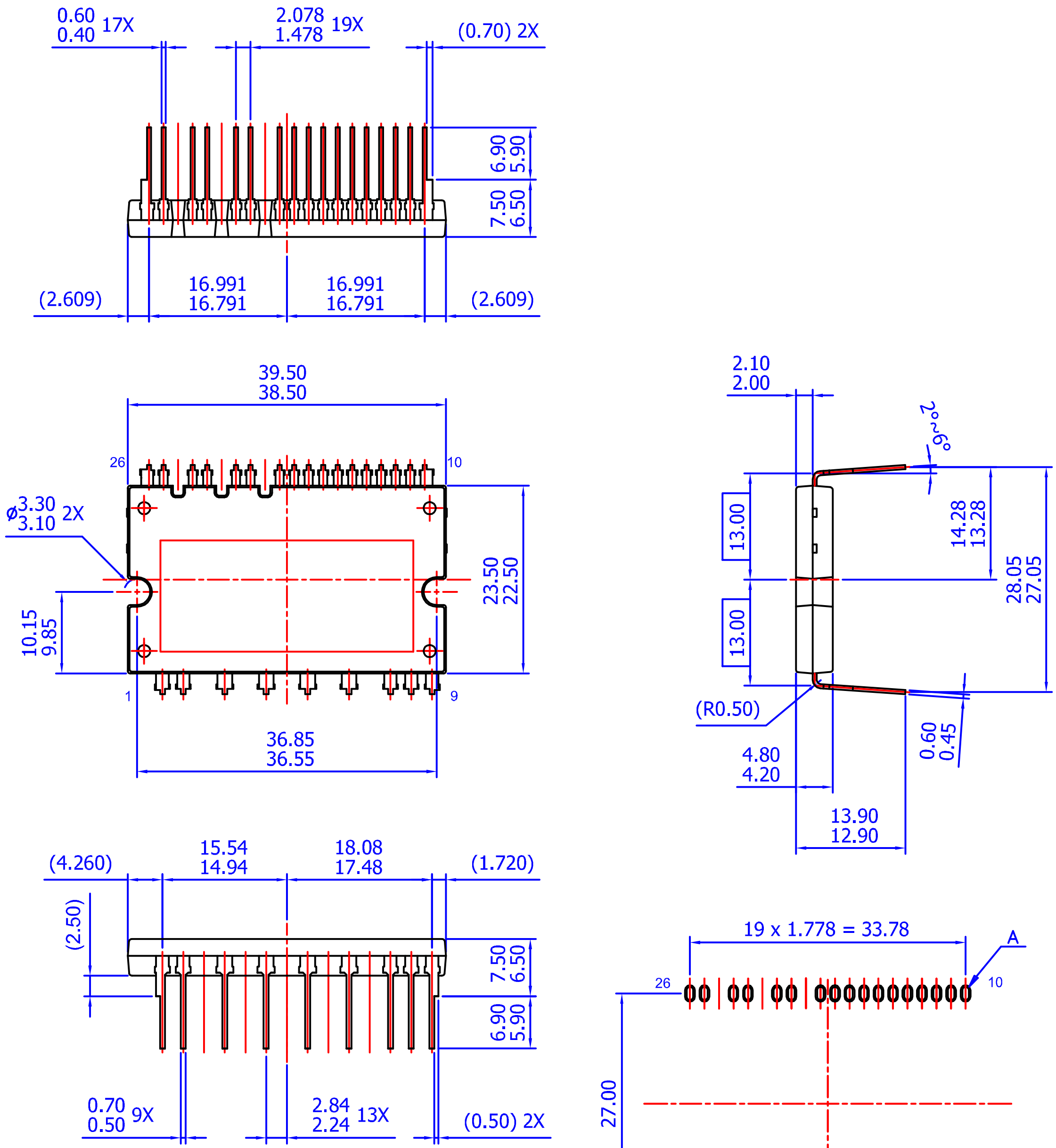
Figure 13. Typical Application Circuit

ORDERING INFORMATION

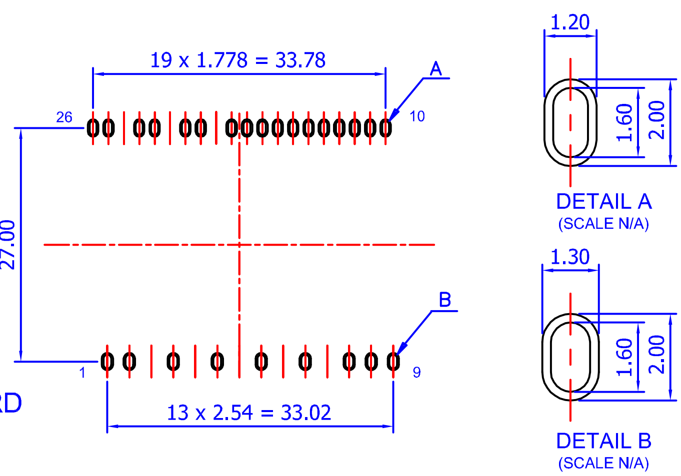
Device	Device Marking	Package	Shipping
NFA42060R42	NFA42060R42	SPMAA−C26 / 26LD, PDD STD CERAMIC TYPE, LONG LEAD DUAL FORM TYPE (Pb−Free)	12 Units / Rail

PACKAGE DIMENSIONS

SPMAA−C26 / 26LD, PDD STD CERAMIC TYPE, LONG LEAD DUAL FORM TYPE
CASE MODFC
ISSUE O



NOTES: UNLESS OTHERWISE SPECIFIED
A) THIS PACKAGE DOES NOT COMPLY TO ANY CURRENT PACKAGING STANDARD
B) ALL DIMENSIONS ARE IN MILLIMETERS
C) DIMENSIONS ARE EXCLUSIVE OF BURRS, MOLD FLASH, AND TIE BAR EXTRUSIONS
D) ( ) IS REFERENCE



LAND PATTERN RECOMMENDATIONS

PUBLICATION ORDERING INFORMATION

LITERATURE FULFILLMENT:
Email Requests to: orderlit@onsemi.com

onsemi Website: www.onsemi.com

TECHNICAL SUPPORT
North American Technical Support:
Voice Mail: 1 800−282−9855 Toll Free USA/Canada
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For additional information, please contact your local Sales Representative