NFP36060L42T

SPM® 3 27 Series Intelligent Power Module (IPM) Bridgeless PFC, 600 V, 60 A

The NFP36060L42T is an advanced PFC SPM 3 module providing a fully−featured, high−performance Bridgeless PFC (Power Factor Correction) input power stage for consumer, medical, and industrial applications. These modules integrate optimized gate drive of the built−in IGBTs to minimize EMI and losses, while also providing multiple on−module protection features including under−voltage lockout, short−circuit current protection, thermal monitoring, and fault reporting. These modules also feature high−performance output diodes and shunt resistor for additional space savings and mounting convenience.

Features

- UL Certified No. E209024 (UL1557)
- 600 V – 60 A 2−Phase Bridgeless PFC with Integral Gate Drivers and Protection
- Very Low Thermal Resistance using AlN DBC Substrate
- Low−Loss Field Stop 4th Generation IGBT
- Optimized for 20 kHz Switching Frequency
- Built−in NTC Thermistor for Temperature Monitoring
- Built−in Shunt Resistor for Current Sensing
- Isolation Rating of 2500 Vrms / 1 min
- These Devices are RoHS Compliant

Typical Applications

- 2−Phase Bridgeless PFC Converter (AC 200V Class)
  - HVAC (Commercial Air−conditioner)

Integrated Power Functions

- 600 V – 60 A 2−Phase Bridgeless PFC for Single−phase AC / DC Power Conversion (refer to Figure 2)

Integrated Drive, Protection, and System Control Functions

- For IGBTs: Gate−drive Circuit, Short−Circuit Protection (SCP) Control Circuit, Under−Voltage Lock−Out Protection (UVLO)
- Fault Signaling: Corresponding to UV and SC faults
- Built−in Thermistor: Temperature Monitoring
- Input Interface: Active−HIGH Interface, works with 3.3 V / 5 V Logic, Schmitt−Trigger Input

Related Resources

- AN−9041 – Bridgeless PFC SPM 3 Series Design Guide
- AN−9086 – SPM 3 Package Mounting Guidance

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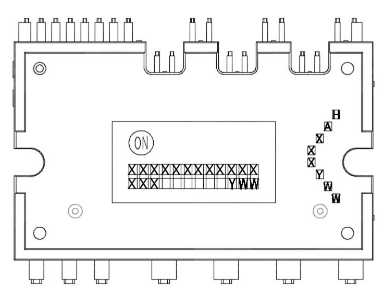
3D Package Drawing
(Click to Activate 3D Content)

SPMHC−027
CASE MODFJ

MARKING DIAGRAM



ON	= ON Semiconductor Logo
NFP36060L42T	= Specific Device Code
XXX	= Lot Number
Y	= Year
WW	= Work Week

ORDERING INFORMATION

See detailed ordering and shipping information on page 7 of this data sheet.

PIN CONFIGURATION

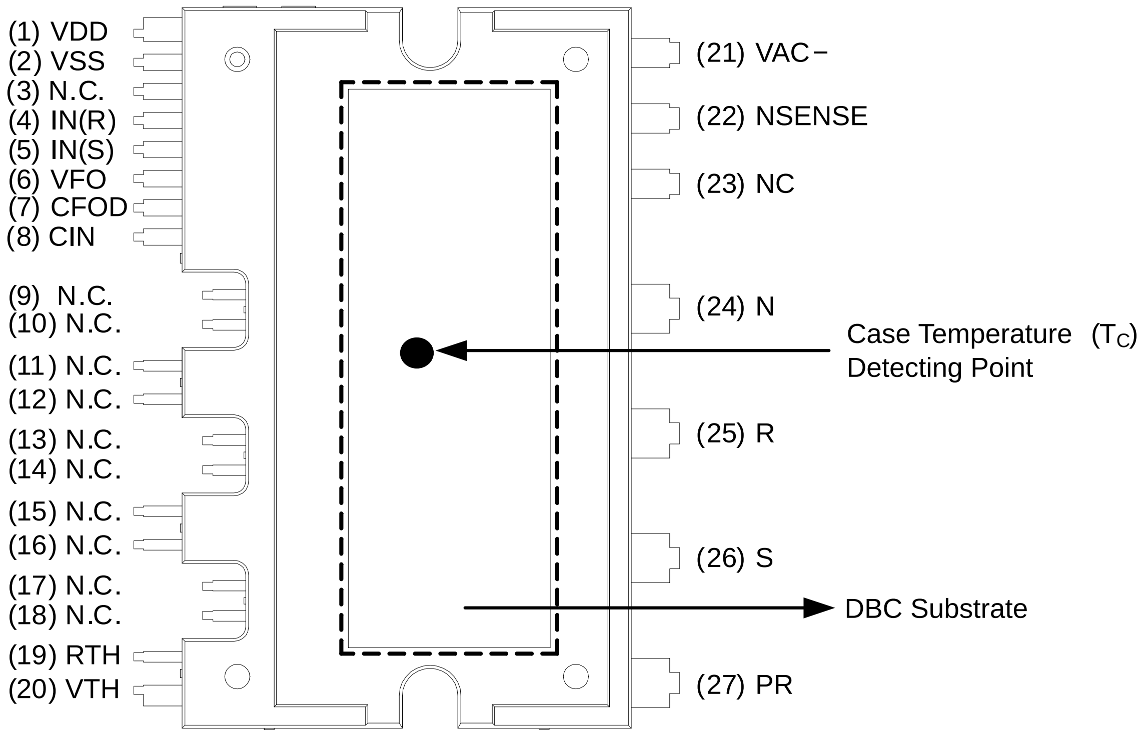


Figure 1. Pin Configuration − Top View

INTERNAL EQUIVALENT CIRCUIT AND INPUT/OUTPUT PINS

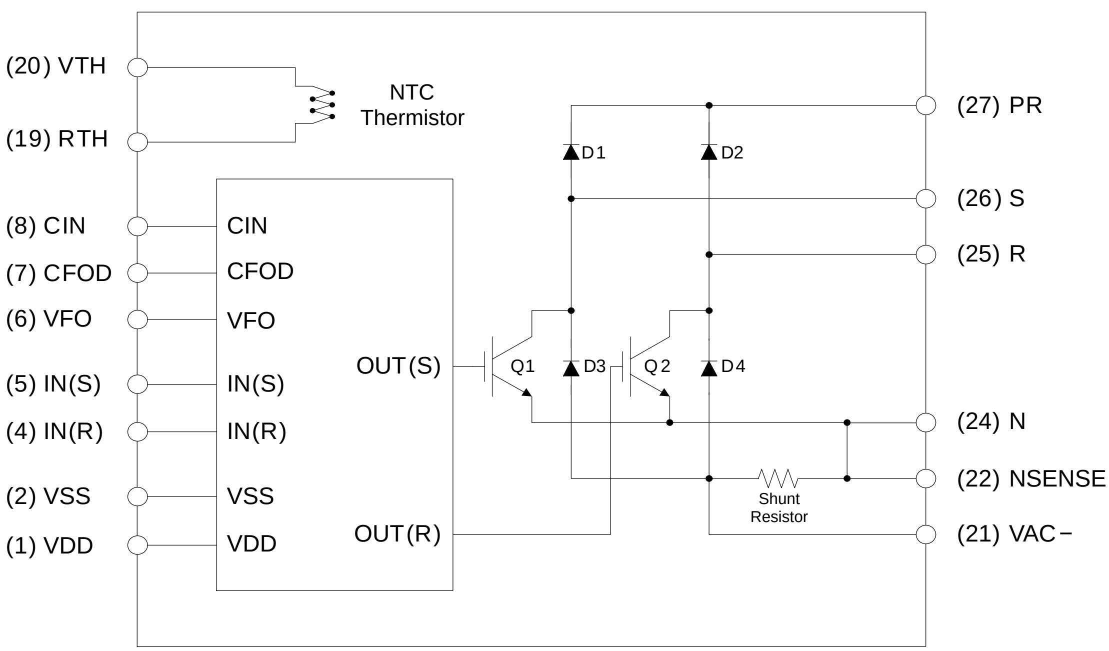


Figure 2. Internal Block Diagram

Table 1. PIN DESCRIPTION

Pin Number	Pin Name	Pin Description
1	VDD	Common Supply Voltage of IC for IGBTs Driving
2	VSS	Common Supply Ground
4	IN(R)	Signal Input for Low−Side R−Phase IGBT
5	IN(S)	Signal Input for Low−Side S−Phase IGBT
6	VFO	Fault Output
7	CFOD	Capacitor for Fault Output Duration Selection
8	CIN	Capacitor (Low−Pass Filter) for Short−Circuit Current Detection
19	RTH	Series Resistor for The Use of Thermistor
20	VTH	Thermistor Bias Voltage
21	VAC−	Current Sensing Terminal
22	NSENSE	Current Sensing Reference Terminal
24	N	Negative Rail of DC−Link
25	R	Output for R−Phase
26	S	Output for S−Phase
27	PR	Positive Rail of DC−Link
3, 9~18, 23	N.C.	No Connection

Table 2. ABSOLUTE MAXIMUM RATINGS (T_J = 25°C unless otherwise noted)

Symbol	Parameter	Conditions	Rating	Unit
CONVERTER PART				
Vi	Input Supply Voltage	Applied between R − S	264	Vrms
$Vi_{(Surge)}$	Input Supply Voltage (Surge)	Applied between R − S	500	V
VPN	Output Voltage	Applied between P − N	450	V
$VPN_{(Surge)}$	Output Supply Voltage (Surge)	Applied between P − N	500	V
VCES	Collector - Emitter Voltage	Breakdown Voltage	600	V
VRRM	Repetitive Peak Reverse Voltage	Breakdown Voltage	600	V
IF	Diode Forward Current	Tc = 25°C, Tj ≤ 150°C (Note 1)	60	A
IFSM	Peak Forward Surge Current	Non−Repetitive, 60 Hz Single Half−Sine Wave (Note 1)	350	A
± Ic	Each IGBT Collector Current	VDD = 15 V, Tc = 25°C, Tj ≤ 150°C (Note 1)	60	A
± Icp	Each IGBT Collector Current (Peak)	Tc = 25°C, Tj ≤ 150°C, Under 1 ms Pulse Width (Note 1)	90	A
Pc	Collector Dissipation	Tc = 25°C per IGBT (Note 1)	160	W
PRSH	Power Rating of Shunt Resistor	Tc < 125°C	2	W
Tj	Operating Junction Temperature		−40 ~ 150	°C
CONTROL PART				
VDD	Control Supply Voltage	Applied between VDD − VSS	20	V
VIN	Input Signal Voltage	Applied between IN(X), IN(Y) − VSS	~0.3 ~ VDD + 0.3	V
VFO	Fault Output Supply Voltage	Applied between VFO − VSS	~0.3 ~ VDD + 0.3	V
IFO	Fault Output Current	Sink Current at VFO pin	2	mA
VCIN	Current Sensing Input Voltage	Applied between CIN − VSS	~0.3 ~ VDD + 0.3	V
Tj	Operating Junction Temperature		−40 ~ 150	°C
TOTAL SYSTEM				
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	2500	Vrms

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.

1. These values had been made an acquisition by the calculation considered to design factor.

Table 3. THERMAL RESISTANCE

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$R_{th(j-c)Q}$	Junction−to−Case Thermal Resistance (Note 2)	Each IGBT under Operating Condition	−	−	0.78	°C/W
$R_{th(j-c)D}$		Each Boost Diode under Operating Condition	−	−	1.50	°C/W
$R_{th(j-c)R}$		Each Rectifier under Operating Condition	−	−	0.85	°C/W

2. For the measurement point of case temperature (Tc), please refer to Figure 1. DBC discoloration and Picker Circle Printing allowed, please refer to application note AN−9190 (Impact of DBC Oxidation on SPM® Module Performance).

Table 4. ELECTRICAL CHARACTERISTICS (T_J = 25°C unless otherwise specified.)

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
CONVERTER PART							
VCE(sat)	Collector − Emitter Saturation Voltage	VDD = 15 V, VIN = 5 V, Ic = 50 A, Tj = 25°C		−	1.55	2.05	V
VFH	High−Side Diode Forward Voltage	IFH = 50 A, Tj = 25°C		−	2.40	2.90	V
VFL	Low−Side Diode Forward Voltage	IFL = 50 A, Tj = 25°C		−	1.20	1.60	V
ton	Switching Characteristics	VPN = 400 V, VDD = 15 V, Ic = 60 A Tj = 25°C VIN = 0 V ↔ 5 V, Inductive Load See Figure 3 (Note 3)		−	990	−	ns
tc(on)				−	120	−	ns
toff				−	930	−	ns
tc(off)				−	190	−	ns
trr				−	65	−	ns
Irr				−	5	−	A
ICES	Collector − Emitter Leakage Current	VCE = VCES		−	−	1	mA
IR	Boost Diode Revers Leakage Current	VR = VRRM		−	−	1	mA
RSENSE	Collector Sensing Resistor			1.83	2.00	2.17	mΩ
CONTROL PART							
IQDD	Quiescent VDD Supply Current	VDD = 15 V, IN(X), IN(Y) − VSS = 0 V, Supply Current between VDD and VSS		−	−	5.00	mA
IPDD	Operating VDD Supply Current	VDD = 15 V, FPWM = 20 kHz, Duty = 50%, Applied to one PWM Signal Input per IGBT, Supply Current between VDD and VSS		−	−	10.00	mA
VFOH	Fault Output Voltage	VDD = 15 V, VFO Circuit: 10 kΩ to 5 V Pull−up	VCIN = 0 V	4.50	−	−	V
VFOL		VDD = 15 V, IFO = 1 mA	VCIN = 1 V	−	−	0.50	V
VCIN(ref)	Short Circuit Trip Level	VDD = 15 V	CIN − VSS	0.45	0.50	0.55	V
UVDDD	Supply Circuit Under−Voltage Protection	Detection Level		9.8	−	13.3	V
UVDDR		Reset Level		10.3	−	13.8	V
VIN(ON)	ON Threshold Voltage	Applied between IN(X), IN(Y) − VSS		−	−	2.6	V
VIN(OFF)	OFF Threshold Voltage			0.8	−	−	V
tFOD	Fault−Out Pulse Width	CFOD = 33 nF (Note 4)		25	−	−	ms
RTH	Resistance of Thermistor	at TTH = 25°C	See Figure 4 (Note 5)	−	50	−	kΩ
		at TTH = 85°C		−	5.76	−	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.

3. ton and toff include the propagation delay of the internal drive IC. tc(on) and tc(off) are the switching times of IGBT under the given gate−driving condition internally. For the detailed information, please see Figure 3.
4. The fault−out pulse width tFOD depends on the capacitance value of CFOD according to the following approximate equation: CFOD = 0.89 x 10−6 x tFOD [F]
5. TTH is the temperature of thermistor itself. To know case temperature (Tc), conduct experiments considering the application.

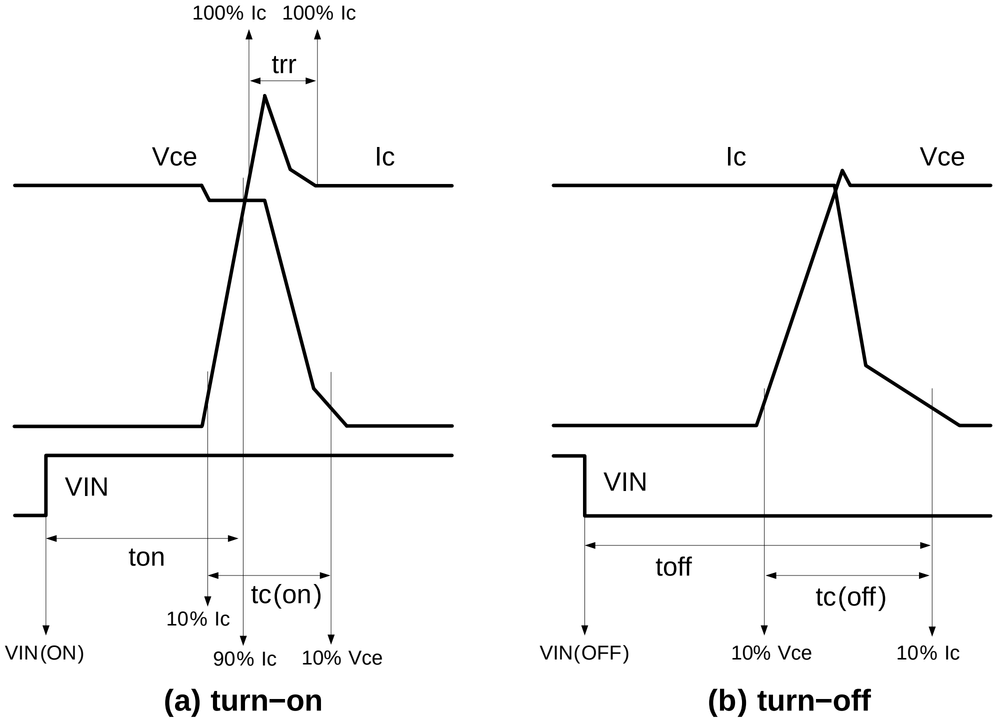


Figure 3. Switching Time Definition

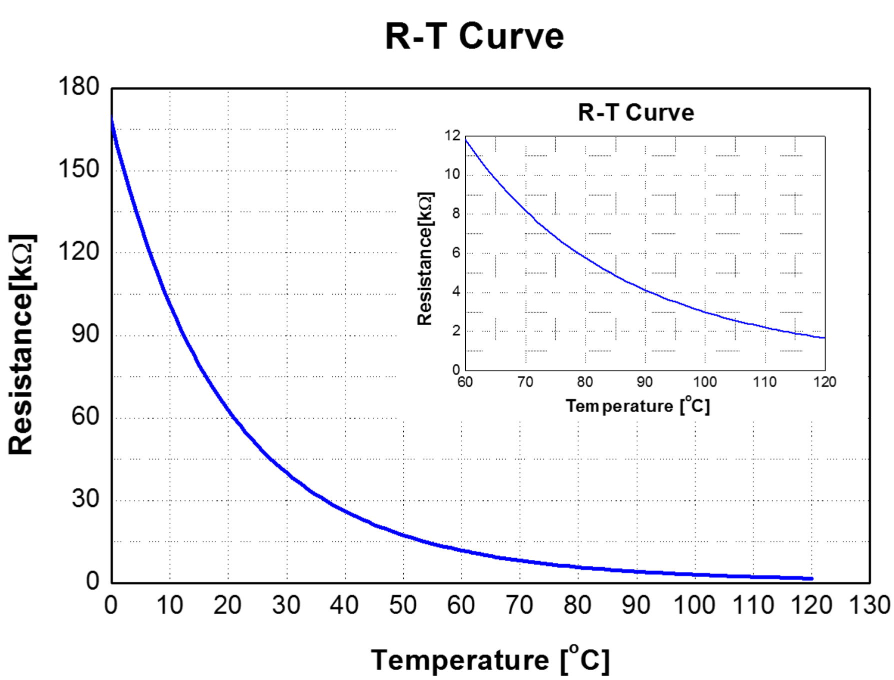


Figure 4. R−T Curve of Built−in Thermistor

Table 5. RECOMMENDED OPERATIONG CONDITIONS

Symbol	Parameter	Conditions	Value			Unit
			Min	Typ	Max	
Vi	Input Supply Voltage	Applied between R − S	160	−	264	Vrms
VPN	Supply Voltage	Applied between P − N	−	280	400	V
VDD	Control Supply Voltage	Applied between VDD − VSS	13.5	15.0	16.5	V
dVDD / dt	Control Supply Variation		−1	−	+1	V / μs
FPWM	PWM Input Signal	−40°C ≤ Tc ≤ 125°C, −40°C ≤ Tj ≤ 150°C	−	20	−	kHz
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.

PACKAGE MARKING AND ODERING INFORMATION

Device	Device Marking	Package	Shipping
NFP36060L42T	NFP36060L42T	SPMHC-027	10 Units / Tube

MECHANICAL CHARACTERISTICS AND RATINGS

Parameter	Conditions		Value			Unit
			Min	Typ	Max	
Device Flatness	See Figure 5		0	−	+120	μm
Mounting Torque	Mounting Screw: M3 See Figure 6 (Note 6, 7)	Recommended 0.62 N • m	0.51	0.62	0.72	N • m
Weight			−	15.00	−	g

6. Do not over torque when mounting screws. Too much mounting torque may cause DBC cracks, as well as bolts and Al heat−sink destruction.
7. Avoid one−sided tightening stress. Uneven mounting can cause the DBC substrate of package to be damaged. The pre−screwing torque is set to 20 ~ 30% of maximum torque rating.

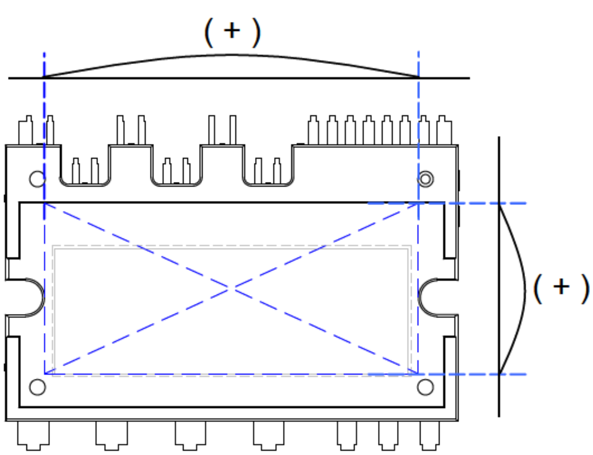


Figure 5. Flatness Measurement Position

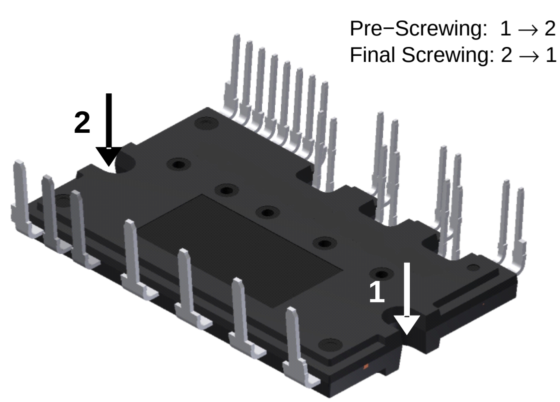
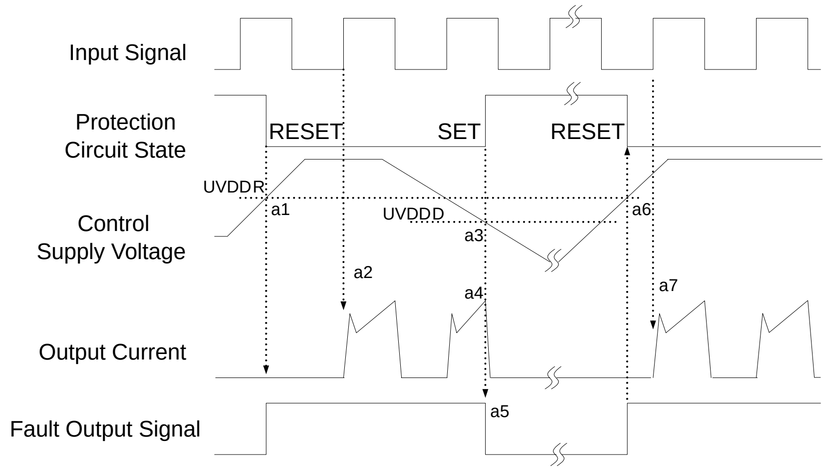


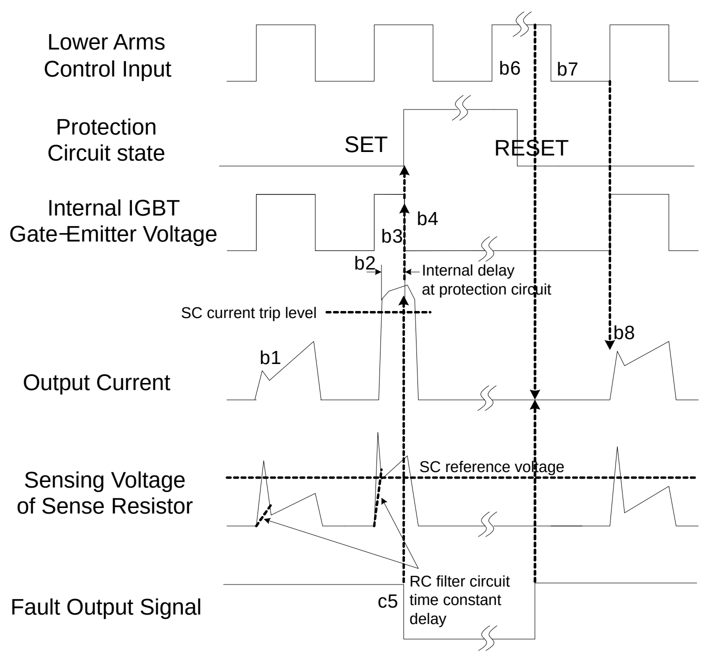
Figure 6. Mounting Screws Torque Order

TIME CHARTS OF SPMs PROTECTIVE FUNCTION



a1: Control supply voltage rises: after the voltage rises UVDDR, the circuits start to operate when the 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.
a6: Under−voltage reset (UVDDR).
a7: Normal operation: IGBT ON and carrying current by triggering next signal from LOW to HIGH.

Figure 7. Under−Voltage Protection



(With the external over current detection circuit)
b1: Normal operation: IGBT ON and carrying current.
b2: Short−Circuit current detection (SC trigger).
b3: All IGBTs gate are hard interrupted.
b4: All IGBTs turn OFF.
b5: Fault output operation starts with a fixed pulse width.
b6: Input HIGH − IGBT ON state, but during the active period of fault output, the IGBT doesn't turn ON.
b7: Fault output operation finishes, but IGBT doesn't turn ON until triggering next signal from LOW to HIGH.
b8: Normal operation: IGBT ON and carrying current.

Figure 8. Short−Circuit Current Protection

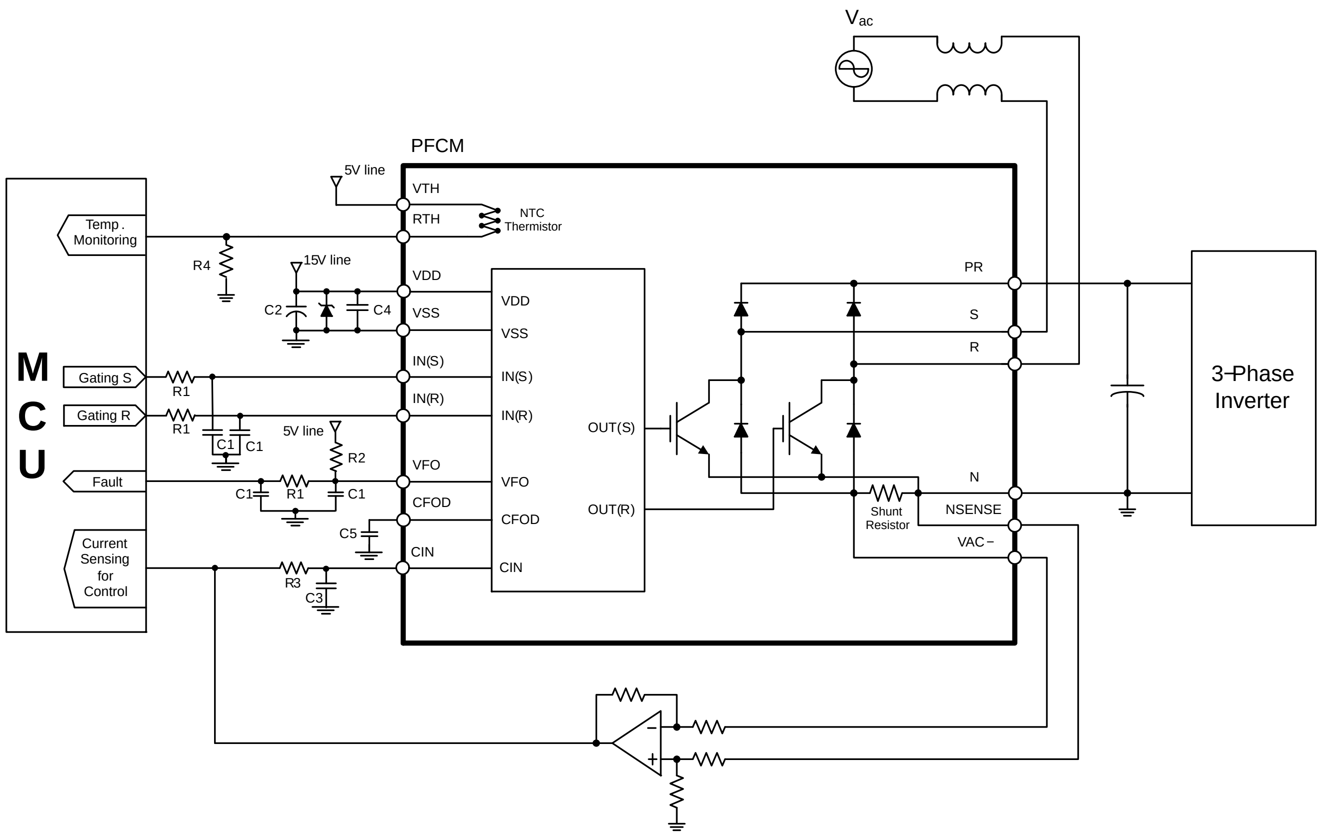


Figure 9. Typical Application Circuit

8. To avoid malfunction, the wiring of each input should be as short as possible (Less than 2 − 3 cm).
9. VFO output is an 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 2 mA.
10. Input signal is active−HIGH type. There is a 5 kΩ resistor inside the IC to pull−down each input signal line to GND. RC coupling circuits should be adopted for the prevention of input signal oscillation. 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. R1C1 time constant should be selected in the range 50 ~ 150 ns (Recommended R1 = 100 Ω, C1 = 1 nF).
11. To prevent error of the protection function, the wiring related with R3 and C3 should be as short as possible.
12. In the short−circuit current protection circuit, select the R3C3 time constant in the range 3.0 ~ 4.0 μs. Do enough evaluation on the real system because over−current protection time may vary wiring pattern layout and value of the R3C3 time constant.
13. Each capacitor should be mounted as close to the pins of the Motion SPM 3 product as possible.
14. Relays are used in most systems of electrical equipment in industrial application. In these cases, there should be sufficient distance between the MCU and the relays.
15. The zener diode or transient voltage suppressor should be adapted 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).
16. Please choose the electrolytic capacitor with good temperature characteristic in C2. Choose 0.1 ~ 0.2 μF R−category ceramic capacitors with good temperature and frequency characteristics in C4.

SPMCA−027 / PDD STD, SPM27−CA, DBC TYPE
CASE MODFJ
ISSUE O

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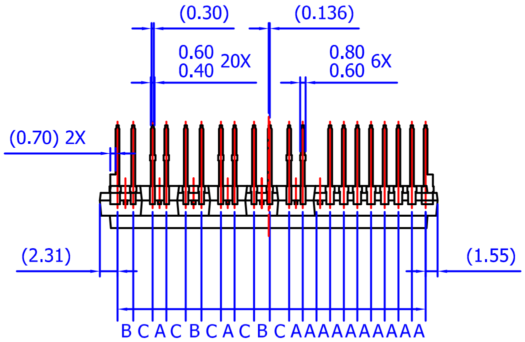
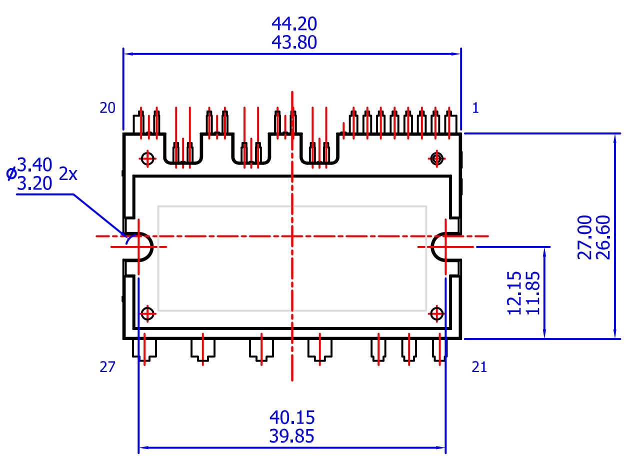
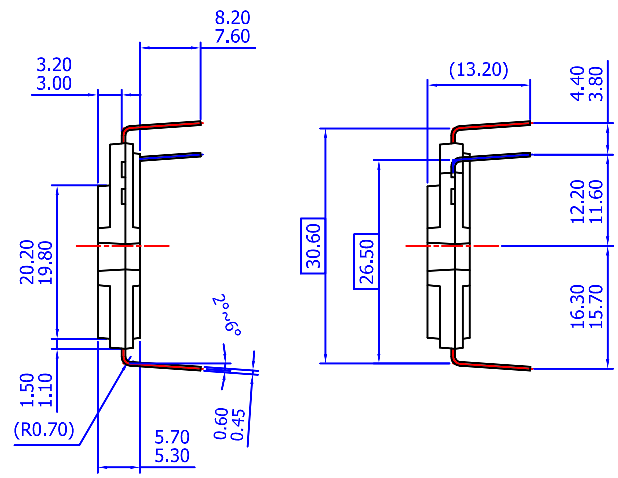
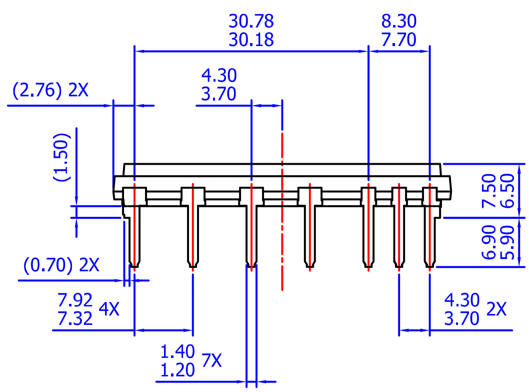
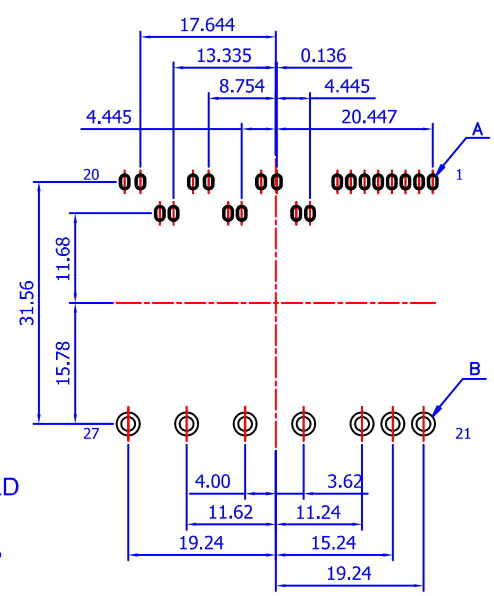


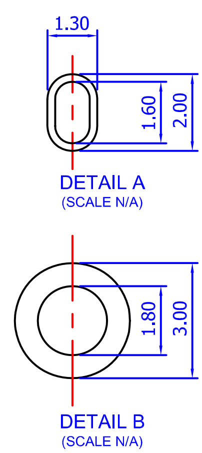
LEAD PITCH (TOLERANCE : ±0.30)
A : 1.778
B : 2.050
C : 2.531











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