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# FPDB60PH60B

## PFC SPM<sup>®</sup> 3 Series for 2-Phase Bridgeless PFC

### Features

- UL Certified No. E209204 (UL1557)
- 600 V - 60 A 2-Phase Bridgeless PFC with Integral Gate Driver and Protection
- Very Low Thermal Resistance Using AlN DBC Substrate
- Built-in NTC Thermistor for Temperature Monitoring
- Built-in Shunt Resistor for Current Sensing
- Optimized for 20kHz Switching Frequency
- Isolation Rating: 2500 Vrms/min.

### Applications

- 2-Phase Bridgeless PFC Converter

### Related Source

- [AN-9041 - Bridgeless PFC SPM 3 Series Design Guide](#)

### General Description

The FPDB60PH60B is an advanced PFC SPM<sup>®</sup> 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, over-current shutdown, thermal monitoring, and fault reporting. These modules also feature high-performance output diodes and shunt resistor for additional space savings and mounting convenience.

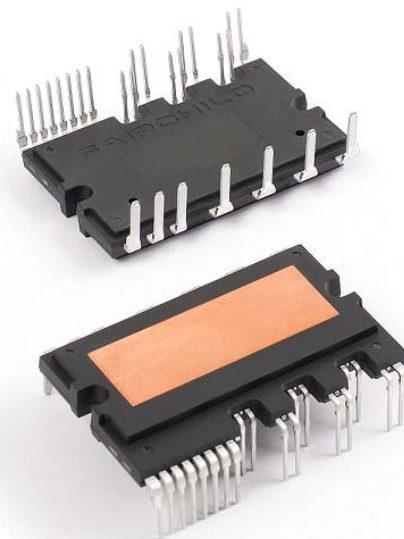


Figure 1. Package Overview

### Package Marking & Ordering Information

Device	Device Marking	Package	Packing Type	Quantity
FPDB60PH60B	FPDB60PH60B	SPMHC-027	Rail	10

## Integrated Drive, Protection and System Control Functions

- For IGBTs: gate drive circuit, Over-Current Protection (OCP), control supply circuit Under-Voltage Lock-Out (UVLO) Protection
- Fault signal: corresponding to OC and UV fault
- Built-in thermistor: temperature monitoring
- Input interface: active-HIGH interface, works with 3.3 / 5 V logic, Schmitt-trigger input

## Pin Configuration

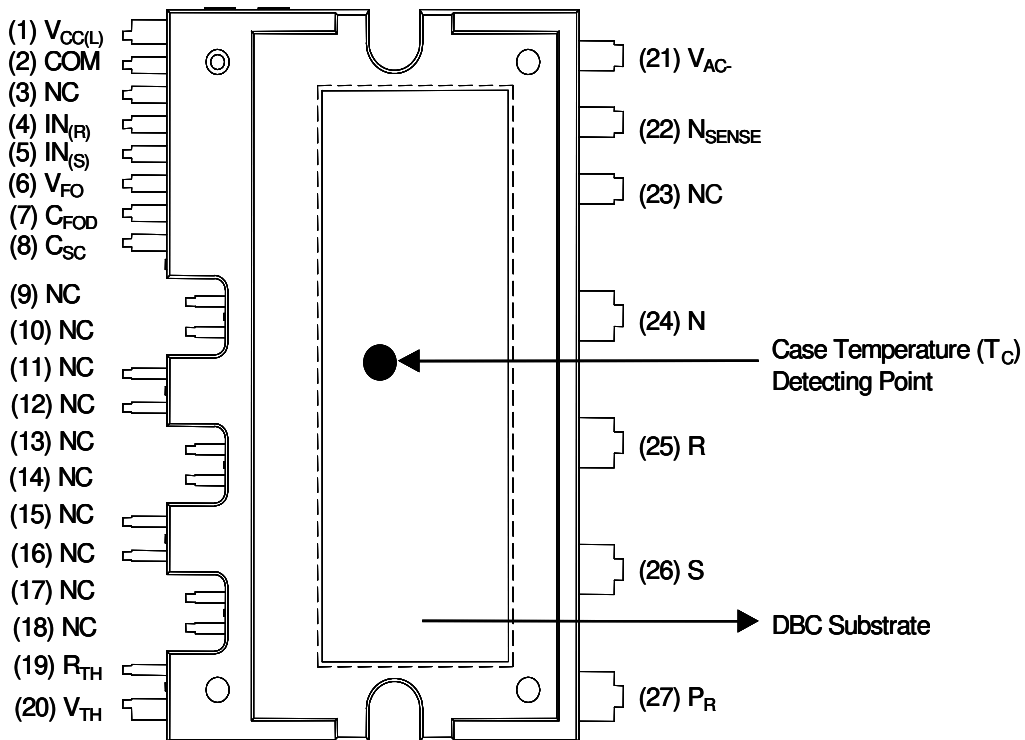
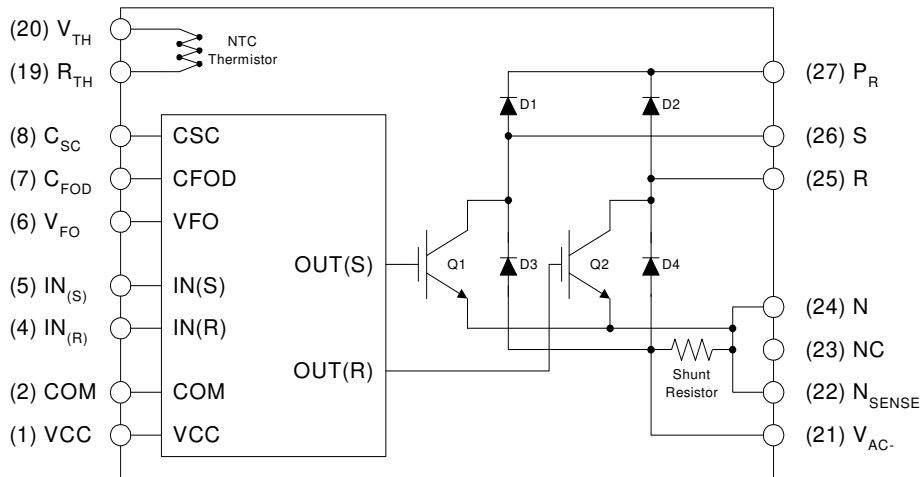


Figure 2. Top View

## Pin Descriptions

Pin Number	Pin Name	Pin Description
1	V <sub>CC</sub>	Common Bias Voltage for IC and IGBTs Driving
2	COM	Common Supply Ground
4	IN <sub>(R)</sub>	Signal Input for Low-Side R-Phase IGBT
5	IN <sub>(S)</sub>	Signal Input for Low-Side S-Phase IGBT
6	V <sub>FO</sub>	Fault Output
7	C <sub>FOD</sub>	Capacitor for Fault Output Duration Selection
8	C <sub>SC</sub>	Capacitor(Low-Pass Filter) for Over-Current Detection
19	R <sub>(TH)</sub>	Series Resistor for The Use of Thermistor
20	V <sub>(TH)</sub>	Thermistor Bias Voltage
21	V <sub>AC-</sub>	Current Sensing Terminal
22	N <sub>SENSE</sub>	Current Sensing Reference Terminal
24	N	Negative Rail of DC-Link
25	R	Output for R-Phase
26	S	Output for S-Phase
27	P <sub>R</sub>	Positive Rail of DC-Link
3, 9~18, 23	NC	No Connection

## Internal Equivalent Circuit



**Figure 3. Internal Block Diagram**

**Notes:**

1. Converter is composed of two IGBTs including four diodes and one IC which has gate driving and protection functions.

**Absolute Maximum Ratings** ( $T_J = 25^\circ\text{C}$ , unless otherwise specified.)**Converter Part**

Symbol	Item	Condition	Rating	Unit
$V_i$	Supply Voltage	Applied between R - S	264	$V_{\text{rms}}$
$V_{i(\text{Surge})}$	Supply Voltage (Surge)	Applied between R - S	500	V
$V_{\text{PN}}$	Output Voltage	Applied between P - N	450	V
$V_{\text{PN}(\text{Surge})}$	Output Voltage (Surge)	Applied between P - N	500	V
$V_{\text{CES}}$	Collector - Emitter Voltage		600	V
$\pm I_C$	Each IGBT Collector Current	$T_C = 25^\circ\text{C}$	60	A
$\pm I_{\text{CP}}$	Each IGBT Collector Current (Peak)	$T_C = 25^\circ\text{C}$ , Under 1 ms Pulse Width	90	A
$P_C$	Collector Dissipation	$T_C = 25^\circ\text{C}$ per IGBT	178	W
$V_{\text{RRM}}$	Repetitive Peak Reverse Voltage		600	V
$I_{\text{FSM}}$	Peak Forward Surge Current	Single Half Sine-Wave	350	A
$P_{\text{RSH}}$	Power Rating of Shunt Resistor	$T_C < 125^\circ\text{C}$	2	W
$T_J$	Operating Junction Temperature	(Note 2)	-40 ~ 150	$^\circ\text{C}$

**Notes:**

2. The maximum junction temperature rating of the power chips integrated within the PFC SPM® product is  $150^\circ\text{C} (@T_C \leq 100^\circ\text{C})$ .

**Control Part**

Symbol	Item	Condition	Rating	Unit
$V_{\text{CC}}$	Control Supply Voltage	Applied between $V_{\text{CC}}$ - COM	20	V
$V_{\text{IN}}$	Input Signal Voltage	Applied between IN - COM	-0.3 ~ 17.0	V
$V_{\text{FO}}$	Fault Output Supply Voltage	Applied between $V_{\text{FO}}$ - COM	-0.3 ~ $V_{\text{CC}}+0.3$	V
$I_{\text{FO}}$	Fault Output Current	Sink Current at $V_{\text{FO}}$ Pin	5	mA
$V_{\text{SC}}$	Current Sensing Input Voltage	Applied between $C_{\text{SC}}$ - COM	-0.3~ $V_{\text{CC}}+0.3$	V

**Total System**

Symbol	Item	Condition	Rating	Unit
$T_C$	Module Case Operation Temperature		-20 ~ 100	$^\circ\text{C}$
$T_{\text{STG}}$	Storage Temperature		-40 ~ 150	$^\circ\text{C}$
$V_{\text{ISO}}$	Isolation Voltage	60 Hz, Sinusoidal, AC 1 Minute, Connect Pins to Heat-Sink Plate	2500	$V_{\text{rms}}$

**Thermal Resistance**

Symbol	Item	Condition	Min.	Typ.	Max.	Unit
$R_{\theta(j-c)Q}$	Junction to Case Thermal Resistance (Referenced to PKG Center)	IGBT	-	-	0.7	$^\circ\text{C}/\text{W}$
$R_{\theta(j-c)HD}$		High-Side Diode	-	-	1.5	$^\circ\text{C}/\text{W}$
$R_{\theta(j-c)LD}$		Low-Side Diode	-	-	0.85	$^\circ\text{C}/\text{W}$

**Notes:**

3. For the measurement point of case temperature( $T_C$ ), please refer to Figure 2.

**Electrical Characteristics** ( $T_J = 25^\circ\text{C}$ , unless otherwise specified.)

**Converter Part**

Symbol	Item	Condition	Min.	Typ.	Max.	Unit
$V_{CE(SAT)}$	IGBT Saturation Voltage	$V_{CC} = 15\text{ V}$ , $V_{IN} = 5\text{ V}$ , $I_C = 50\text{ A}$	-	2.0	2.5	V
$V_{FH}$	High-Side Diode Voltage	$I_F = 50\text{ A}$	-	2.4	2.9	V
$V_{FL}$	Low-Side Diode Voltage	$I_F = 50\text{ A}$	-	1.2	1.6	V
$t_{ON}$	Switching Times	$V_{PN} = 400\text{ V}$ , $V_{CC} = 15\text{ V}$ , $I_C = 60\text{ A}$ $V_{IN} = 0\text{ V} \leftrightarrow 5\text{ V}$ , Inductive Load (Note 4)	-	560	-	ns
$t_{C(ON)}$			-	270	-	ns
$t_{OFF}$			-	520	-	ns
$t_{C(OFF)}$			-	110	-	ns
$t_{rr}$			-	44	-	ns
$I_{rr}$			-	6.5	-	A
$R_{SENSE}$	Current-Sensing Resistor		1.8	2.0	2.2	$\text{m}\Omega$
$I_{CES}$	Collector - Emitter Leakage Current	$V_{CE} = V_{CES}$	-	-	250	$\mu\text{A}$

**Notes:**

4.  $t_{ON}$  and  $t_{OFF}$  include the propagation delay 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 4.

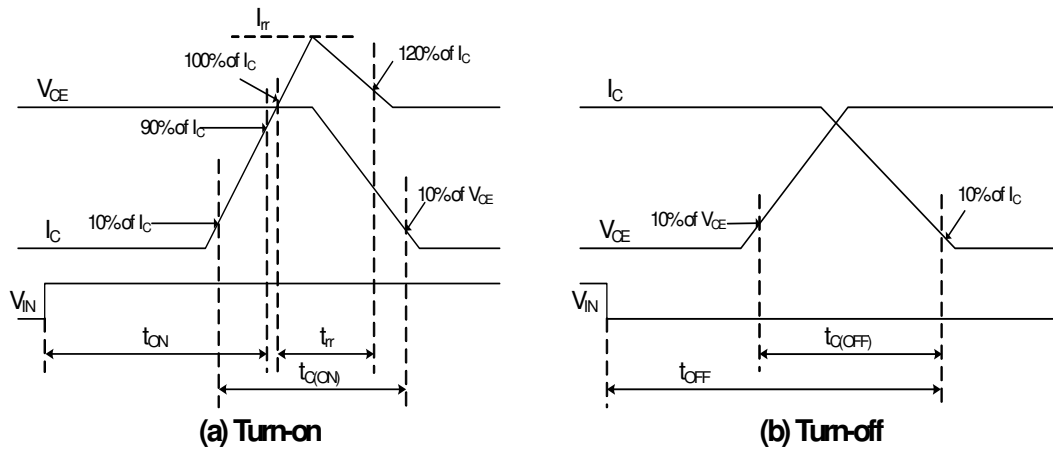


Figure 4. Switching Time Definition

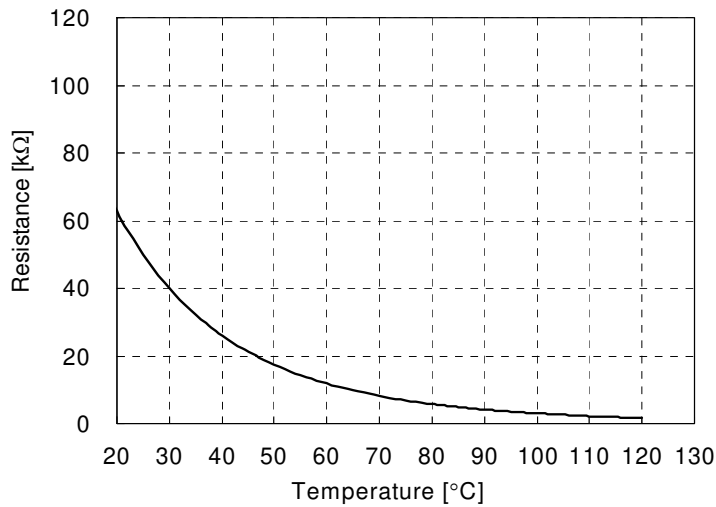
**Control Part**

Symbol	Item	Condition	Min.	Typ.	Max.	Unit
$I_{QCCL}$	Quiescent $V_{CC}$ Supply Current	$V_{CC} = 15\text{ V}$ , $IN = 0\text{ V}$   $V_{CC} - COM$	-	-	26	mA
$V_{FOH}$	Fault Output Voltage	$V_{SC} = 0\text{ V}$ , $V_{FO}$ Circuit: 4.7 k $\Omega$ to 5 V Pull-up	4.5	-	-	V
$V_{FOL}$		$V_{SC} = 1\text{ V}$ , $V_{FO}$ Circuit: 4.7 k $\Omega$ to 5 V Pull-up	-	-	0.8	V
$V_{SC(ref)}$	Over-Current Trip Level	$V_{CC} = 15\text{ V}$	0.45	0.50	0.55	V
$UV_{CCD}$	Supply Circuit Under-Voltage Protection	Detection Level	10.7	11.9	13.0	V
$UV_{CCR}$		Reset Level	11.2	12.4	13.2	V
$t_{FOD}$	Fault-Out Pulse Width	$C_{FOD} = 33\text{ nF}$ (Note 5)	1.4	1.8	2.0	ms
$V_{IN(ON)}$	ON Threshold Voltage	Applied between IN - COM	3.0	-	-	V
$V_{IN(OFF)}$	OFF Threshold Voltage		-	-	0.8	V
$R_{TH}$	Resistance of Thermistor	at $T_C = 25^\circ\text{C}$ (See Figure 5)	-	50	-	k $\Omega$
		at $T_C = 80^\circ\text{C}$ (See Figure 5)	-	5.76	-	k $\Omega$

**Notes:**

5. The fault-out pulse width  $t_{FOD}$  depends on the capacitance value of  $C_{FOD}$  according to the following approximate equation:  $C_{FOD} = 18.3 \times 10^{-6} \times t_{FOD}[F]$

R-T Graph



**Figure 5. R-T Curve of the Built-in Thermistor**

**Recommended Operating conditions**

Symbol	Item	Condition	Min.	Typ.	Max.	Unit
$V_I$	Input Supply Voltage	Applied between R - S	180	-	264	$V_{rms}$
$V_{PN}$	Output Voltage	Applied between P - N	-	280	400	V
$V_{CC}$	Control Supply Voltage	Applied between $V_{CC} - COM$	13.5	15	16.5	V
$dV_{CC}/dt$	Control Supply Variation	Applied between IN - COM	-1	-	1	V/ $\mu\text{s}$
$f_{PWM}$	PWM Input Signal	$T_C \leq 100^\circ\text{C}$ , $T_J \leq 125^\circ\text{C}$ , per IGBT	-	20	-	kHz



### Mechanical Characteristics and Ratings

Item	Condition		Min.	Typ.	Max.	Units
Mounting Torque	Mounting Screw: M3	Recommended 0.62 N•m	0.51	0.62	0.72	N•m
Device Flatness	See Figure 6		0	-	+120	μm
Weight			-	15.00	-	g

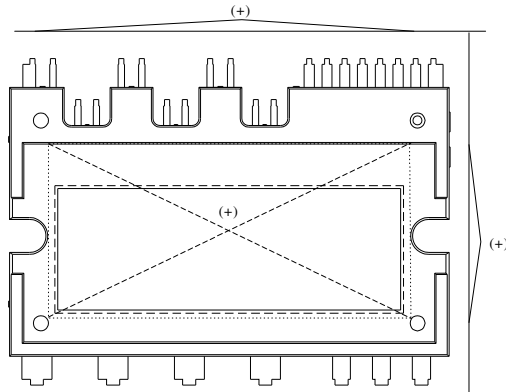
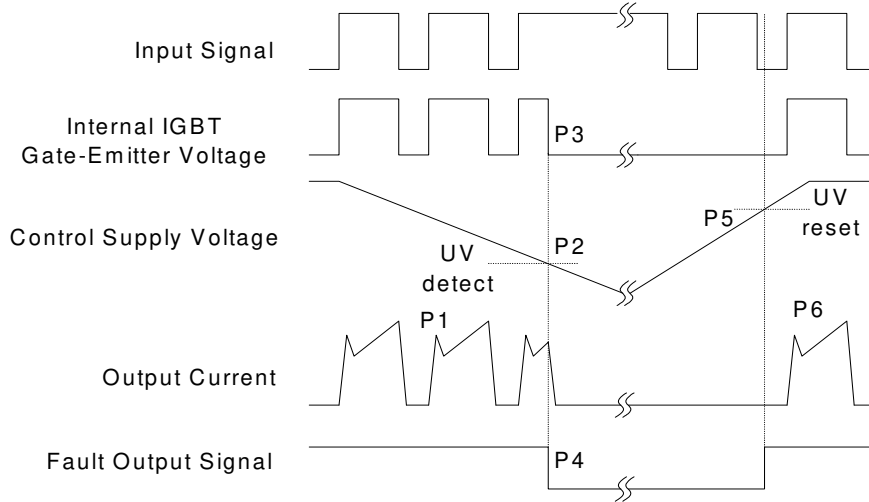


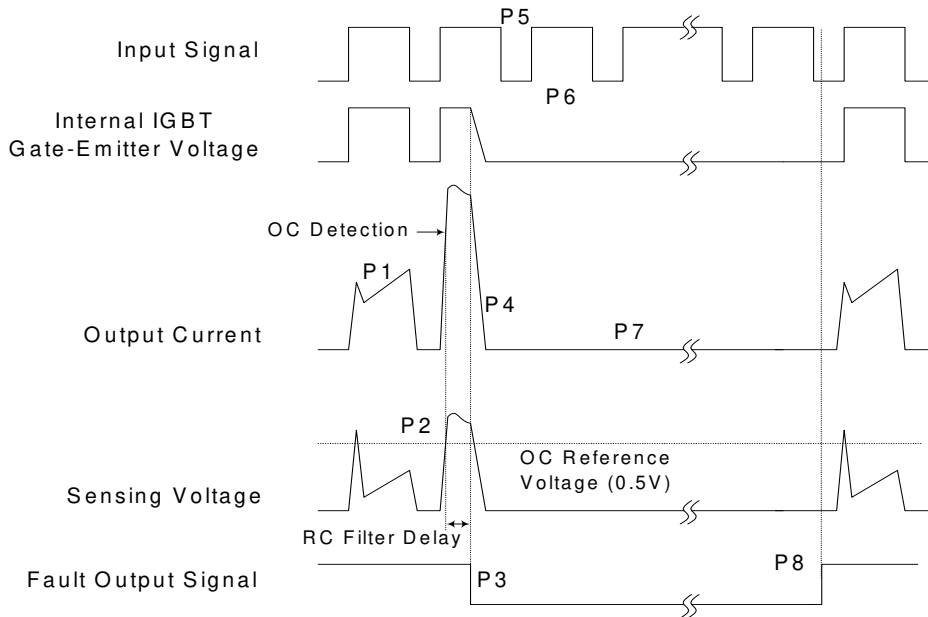
Figure 6. Flatness Measurement Position

### Time Charts of Protective Function



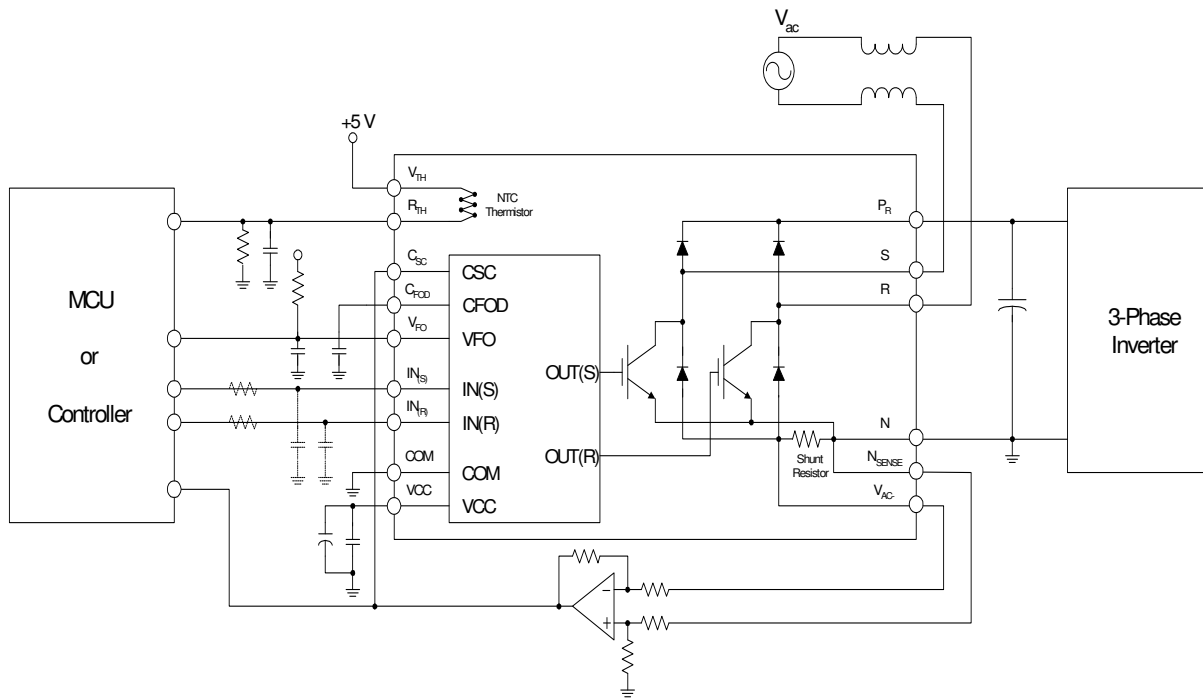
- P1 : Normal operation: IGBT ON and conducting current.
- P2 : Under-voltage detection.
- P3 : IGBT gate interrupt.
- P4 : Fault signal generation.
- P5 : Under-voltage reset.
- P6 : Normal operation: IGBT ON and conducting current.

**Figure 7. Under-Voltage Protection**



- P1 : Normal operation: IGBT ON and conducting current.
- P2 : Over current detection.
- P3 : IGBT gate interrupt / fault signal generation.
- P4 : IGBT is slowly turned off.
- P5 : IGBT OFF signal.
- P6 : IGBT ON signal: but IGBT cannot be turned on during the fault output activation.
- P7 : IGBT OFF state.
- P8 : Fault output reset and normal operation start.

**Figure 8. Over-Current Protection**

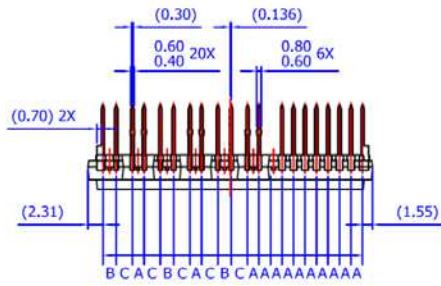


**Figure 9. Application Example**

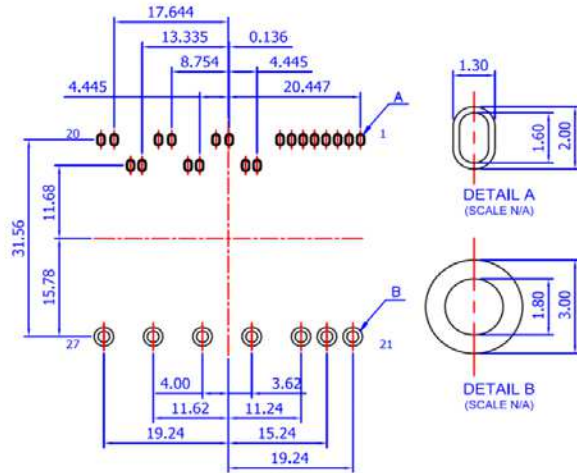
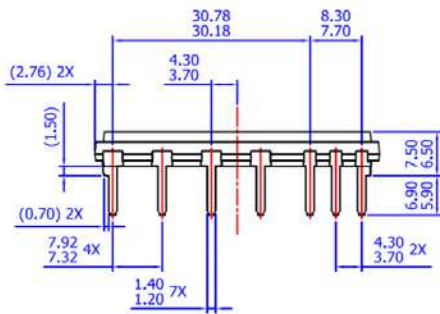
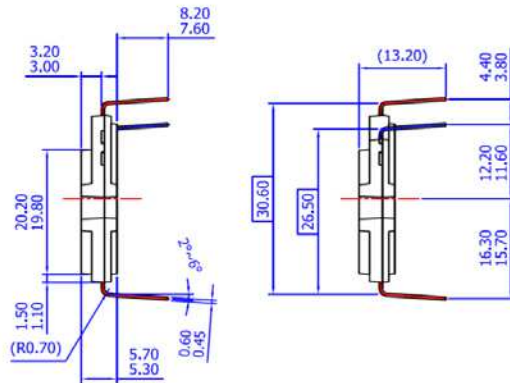
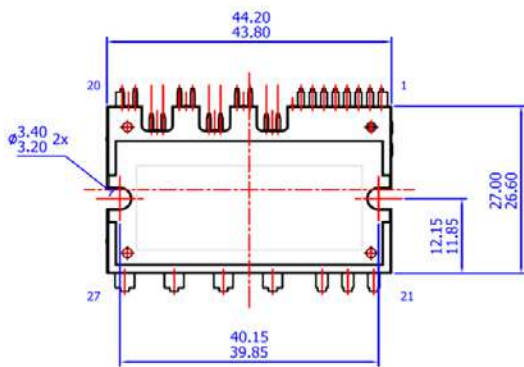
**Notes:**

- 6. For the over-current protection, please set time constant in the range 3 ~ 4  $\mu$ s.

### Detailed Package Outline Drawings



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



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| FACT Quiet Series™  | MotionMax™                                     | SuperSOT™-3   | UniFET™   |
| FACT®   | mWSaver®                                       | SuperSOT™-6   | VCX™  |
| FAST®   | OptoHiT™                                       | SuperSOT™-8   | VisualMax™  |
| FastvCore™  | OPTOLOGIC®                                     | SupreMOS®   | VoltagePlus™  |
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