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FAIRCHILD SEMICONDUCTOR®

December 2013

# FPDB30PH60

# PFC SPM® 3 Series for 2-Phase Bridgeless PFC

## Features

- UL Certified No. E209204 (UL1557)
- 600 V - 30 A 2-Phase Bridgeless PFC with Integral Gate Driver and Protection
- Very Low Thermal Resistance Using $Al_2O_3$ 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 FPDB30PH60 is a 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, 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.

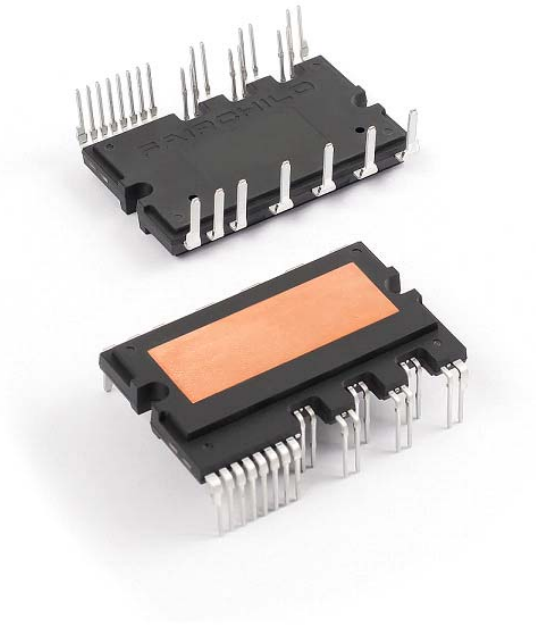

**Figure 1. Package Overview**

## Package Marking & Ordering Information

| Device | Device Marking | Package | Packing Type | Quantity |
|---|---|---|---|---|
| FPDB30PH60 | FPDB30PH60 | SPMGA-027 | Rail | 10 |

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## Integrated Power Functions

- PFC converter for single-phase AC / DC power conversion.(please refer to Figure 3)

## 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

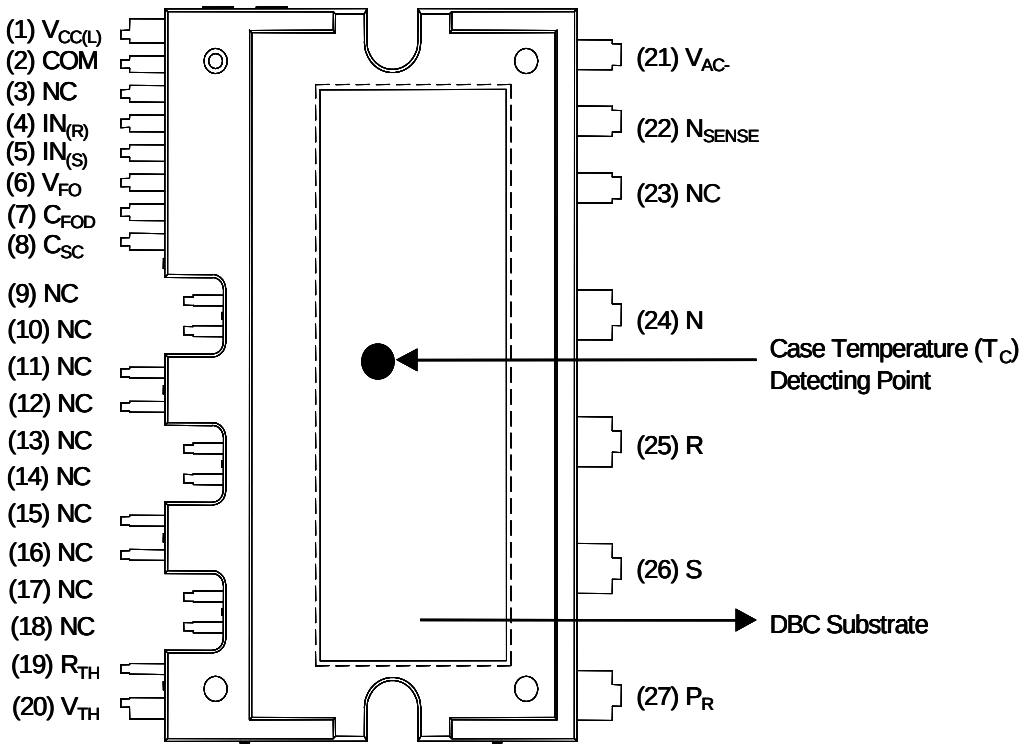


**Figure 2. Top View**

## Pin Descriptions

| Pin Number | Pin Name | Pin Description |
|---|---|---|
| 1 | $V_{CC}$ | Common Bias Voltage for IC and IGBTs Driving |
| 2 | COM | 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 | $V_{FO}$ | Fault Output |
| 7 | $C_{FOD}$ | Capacitor for Fault Output Duration Selection |
| 8 | $C_{SC}$ | Capacitor(Low-Pass Filter) for Over-Current Detection |
| 19 | $R_{(TH)}$ | Series Resistor for The Use of Thermistor |
| 20 | $V_{(TH)}$ | Thermistor Bias Voltage |
| 21 | $V_{AC-}$ | Current Sensing Terminal |
| 22 | $N_{SENSE}$ | Current Sensing Reference Terminal |
| 24 | N | Negative Rail of DC-Link |
| 25 | R | Output for R-Phase |
| 26 | S | Output for S-Phase |
| 27 | $P_R$ | Positive Rail of DC-Link |
| 3, 9~18, 23 | NC | No Connection |

## Internal Equivalent Circuit

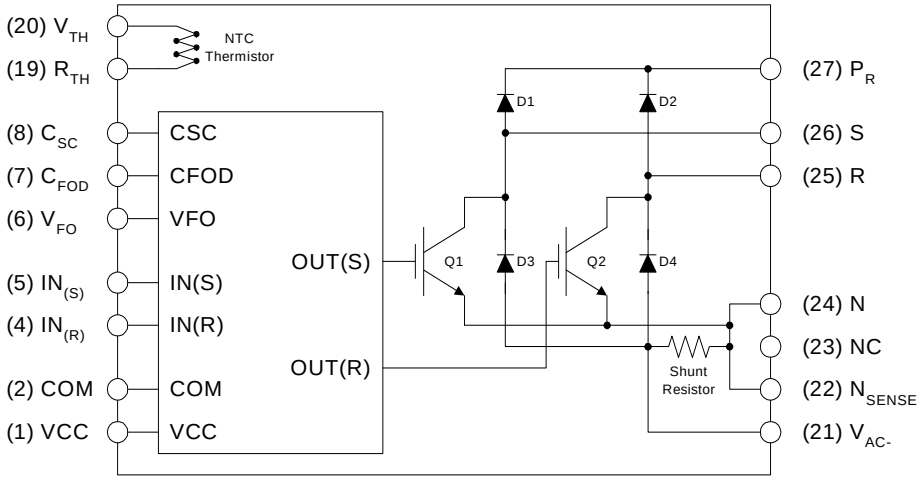


**Figure 3. Internal Block Diagram**

**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°C, unless otherwise specified.)

### Converter Part

| Symbol | Item | Condition | Rating | Unit |
|---|---|---|---|---|
| $V_i$ | Supply Voltage | Applied between R - S | 264 | $V_{rms}$ |
| $V_{i(Surge)}$ | Supply Voltage (Surge) | Applied between R - S | 500 | V |
| $V_{PN}$ | Output Voltage | Applied between P - N | 450 | V |
| $V_{PN(Surge)}$ | Output Voltage (Surge) | Applied between P - N | 500 | V |
| $V_{CES}$ | Collector - Emitter Voltage | | 600 | V |
| $I_i$ | Input Current (100% Load) | $T_C$ < 95°C, $V_i$ = 220 V, $V_{PN}$ = 390 V, $V_{PWM}$ = 20 kHz | 20 | A |
| $I_{i(125\%)}$ | Input Current (125% Load) | $T_C$ < 95°C, $V_i$ = 220V , $V_{PN}$ = 390 V, $V_{PWM}$ = 20 kHz, 1 min Non-Repetitive | 25 | A |
| $P_C$ | Collector Dissipation | $T_C$ = 25°C per IGBT | 83 | W |
| $P_{RSH}$ | Power Rating of Shunt Resistor | $T_C$ < 125°C | 2 | W |
| $T_J$ | Operating Junction Temperature | (Note 2) | -20 ~ 125 | °C |

**Notes:**

2. The maximum junction temperature rating of the power chips integrated within the PFC SPM® product is 150 °C(@$T_C \le$ 100°C). However, to insure safe operation of the PFC SPM product, the average junction temperature should be limited to $T_{J(ave)} \le$ 125°C (@$T_C \le$ 100°C)

### Control Part

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

### Total System

| Symbol | Item | Condition | Rating | Unit |
|---|---|---|---|---|
| $T_C$ | Module Case Operation Temperature | | -20 ~ 100 | °C |
| $T_{STG}$ | Storage Temperature | | -40 ~ 125 | °C |
| $V_{ISO}$ | Isolation Voltage | 60 Hz, Sinusoidal, AC 1 Minute, Connect Pins to Heat-Sink Plate | 2500 | $V_{rms}$ |

### Thermal Resistance

| Symbol | Item | Condition | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $R_{\theta(j-c)Q}$ | Junction to Case Thermal Resistance (Referenced to PKG Center) | IGBT | - | - | 1.2 | °C/W |
| $R_{\theta(j-c)HD}$ | | High-Side Diode | - | - | 2.0 | °C/W |
| $R_{\theta(j-c)LD}$ | | Low-Side Diode | - | - | 1.4 | °C/W |

**Notes :**

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

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## Electrical Characteristics ($T_J$ = 25°C, unless otherwise specified.)

### Converter Part

| Symbol | Item | Condition | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_{CE(SAT)}$ | IGBT Saturation Voltage | $V_{CC}$ = 15 V, $V_{IN}$ = 5 V, $I_C$ =30 A | - | 2.4 | 3.1 | V |
| $V_{FH}$ | High-Side Diode Voltage | $I_F$ = 30 A | - | 1.9 | 2.5 | V |
| $V_{FL}$ | Low-Side Diode Voltage | $I_F$ = 30 A | - | 1.2 | 1.6 | V |
| $t_{ON}$ | Switching Times | $V_{PN}$ = 400 V, $V_{CC}$ = 15 V, $I_C$ =30 A<br>$V_{IN}$ = 0 V ↔ 5 V, Inductive Load<br>(Note 4) | - | 550 | - | ns |
| $t_{C(ON)}$ | | | - | 200 | - | ns |
| $t_{OFF}$ | | | - | 430 | - | ns |
| $t_{C(OFF)}$ | | | - | 180 | - | ns |
| $t_{rr}$ | | | - | 60 | - | ns |
| $I_{rr}$ | | | - | 6 | - | A |
| $R_{SENSE}$ | Current-Sensing Resistor | | 1.8 | 2.0 | 2.2 | mΩ |
| $I_{CES}$ | Collector - Emitter Leakage Current | $V_{CE}$ = $V_{CES}$ | - | - | 250 | μA |

**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.

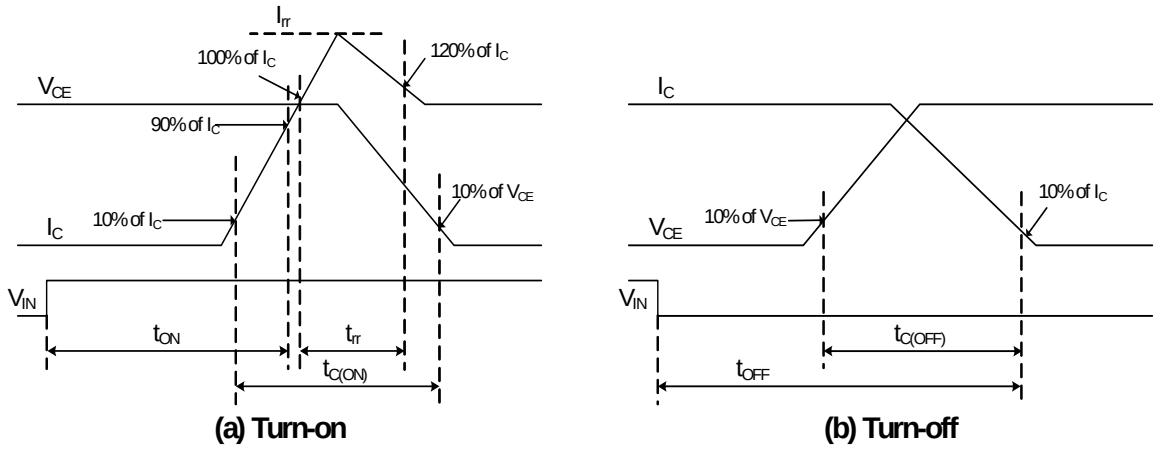



**Figure 4. Switching Time Definition**

### Control Part

| Symbol | Item | Condition | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $I_{QCCL}$ | Quiescent $V_{CC}$ Supply Current | $V_{CC}$ = 15 V, IN = 0 V \| $V_{CC}$ - COM | - | - | 26 | mA |
| $V_{FOH}$ | Fault Output Voltage | $V_{SC}$ = 0 V, $V_{FO}$ Circuit: 4.7 kΩ to 5 V Pull-up | 4.5 | - | - | V |
| $V_{FOL}$ | | $V_{SC}$ = 1 V, $V_{FO}$ Circuit: 4.7 kΩ to 5 V Pull-up | - | - | 0.8 | V |
| $V_{SC(ref)}$ | Over-Current Trip Level | $V_{CC}$ = 15 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 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°C (See Figure 5) | - | 50 | - | kΩ |
| | | at $T_C$ = 80°C (See Figure 5) | - | 5.76 | - | kΩ |

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

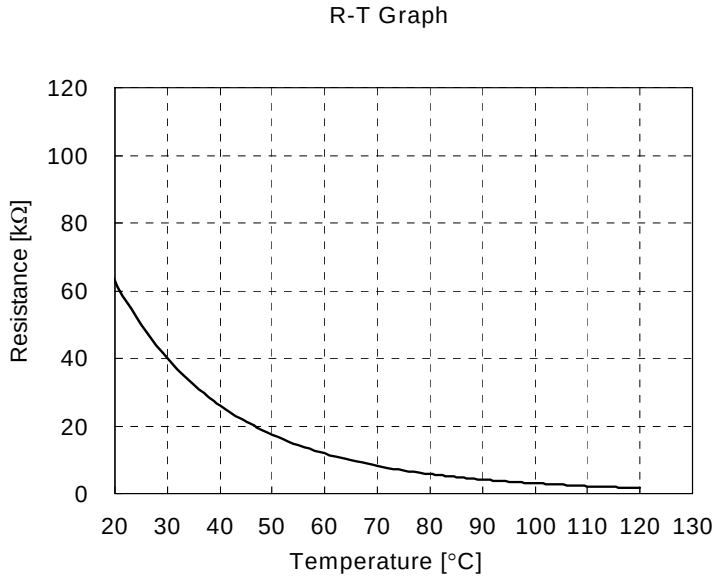



**Figure 5. R-T Curve of the Built-in Thermistor**

## 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 | 15.0 | 16.5 | V |
| $dV_{CC}/dt$ | Control Supply Variation | Applied between IN - COM | -1 | - | 1 | V/μs |
| $f_{PWM}$ | PWM Input Signal | $T_C \le 100°C$, $T_J \le 125°C$, 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 |

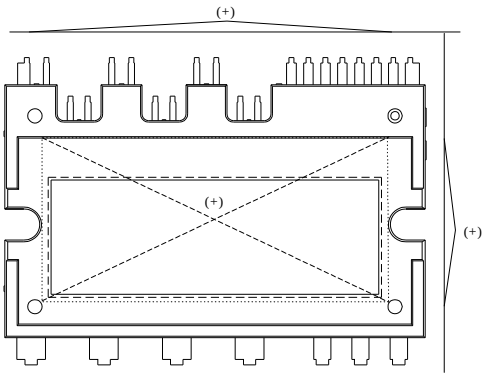
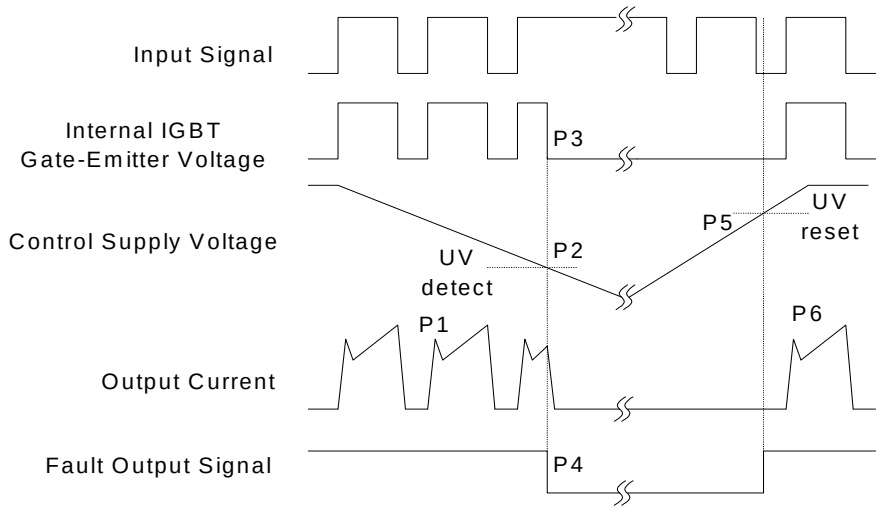


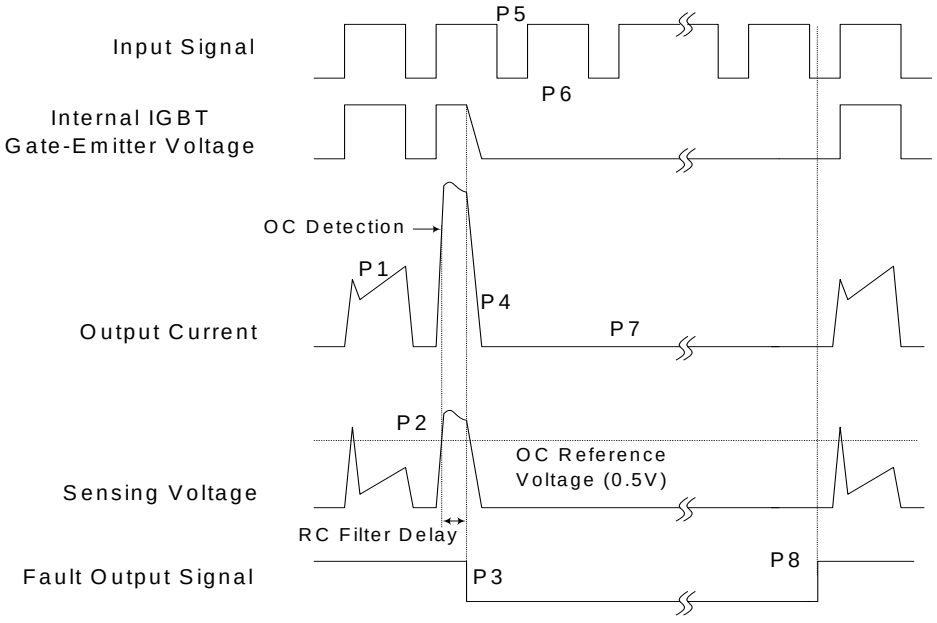

**Figure 6. Flatness Measurement Position**

## 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**

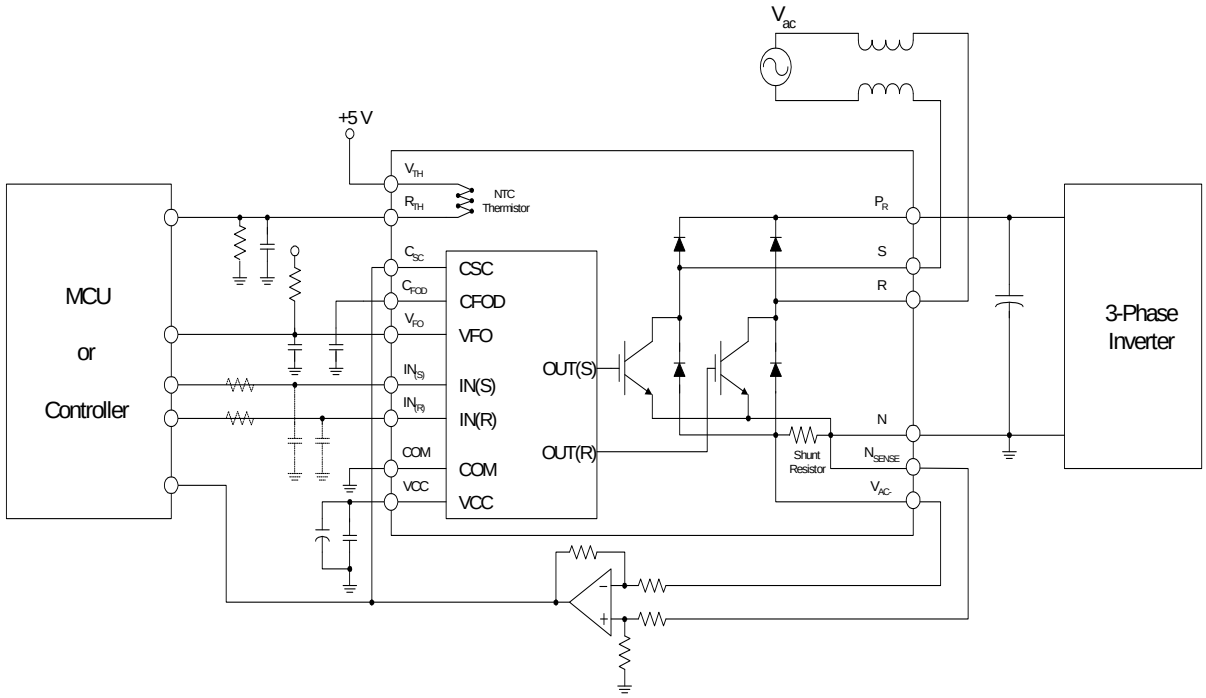
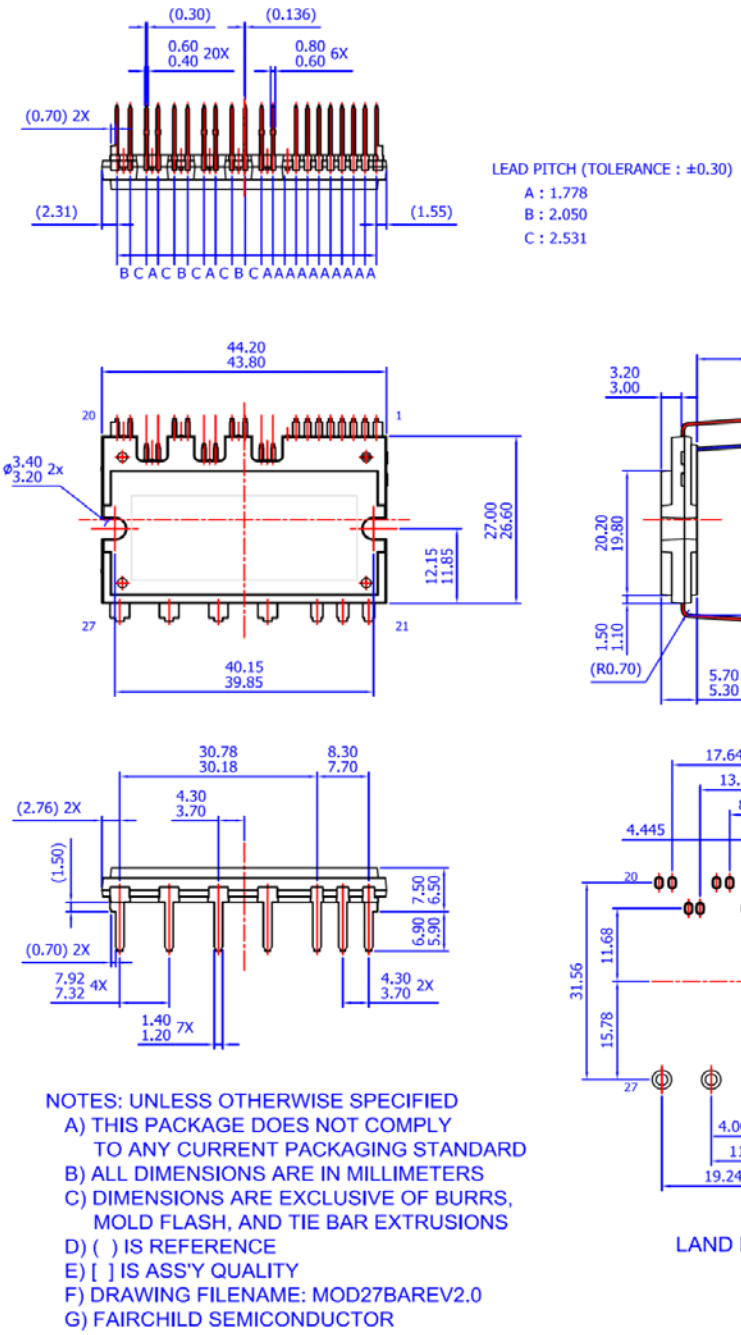



**Figure 9. Application Example**

**Notes:**
6. For the over-current protection, please set time constant in the range 3 ~ 4 μs.

## Detailed Package Outline Drawings

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