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## FPDB50PH60

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

### Features

- UL Certified No. E209204 (UL1557)
- 600 V - 50 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 FPDB50PH60 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.

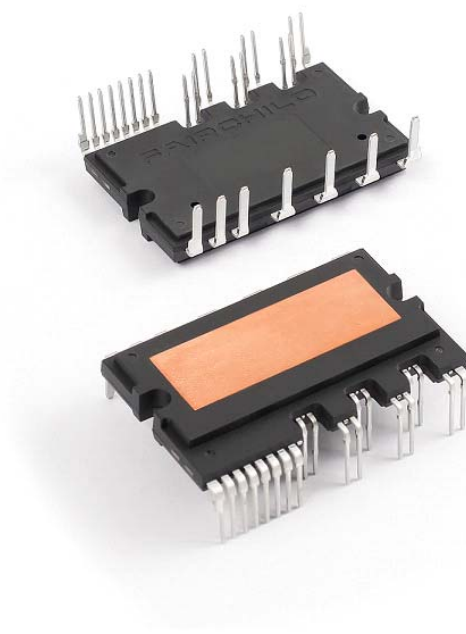


Figure 1. Package Overview

### Package Marking & Ordering Information

| Device     | Device Marking | Package   | Packing Type | Quantity |
|------------|----------------|-----------|--------------|----------|
| FPDB50PH60 | FPDB50PH60     | SPMHA-027 | Rail         | 10       |

## 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

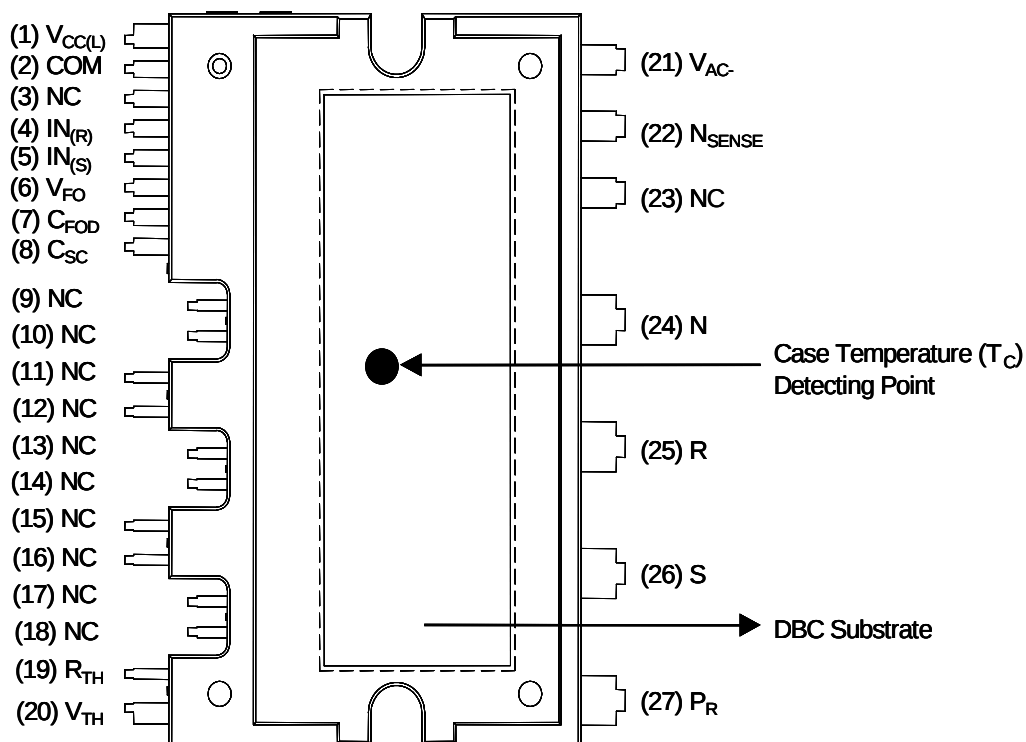
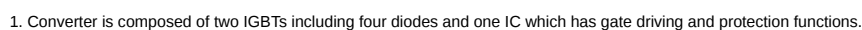


Figure 2. Top View

## 3

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**Notes:**



### Figure 3. Internal Block Diagram

**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                |
| $I_i$                         | Input Current (100% Load)      | $T_C < 95^\circ\text{C}$ , $V_i = 220\text{ V}$ , $V_{\text{PN}} = 390\text{ V}$ ,<br>$V_{\text{PWM}} = 20\text{ kHz}$                        | 30        | A                |
| $I_{i(125\%)}$                | Input Current (125% Load)      | $T_C < 95^\circ\text{C}$ , $V_i = 220\text{ V}$ , $V_{\text{PN}} = 390\text{ V}$ ,<br>$V_{\text{PWM}} = 20\text{ kHz}$ , 1 min Non-Repetitive | 37.5      | A                |
| $P_C$                         | Collector Dissipation          | $T_C = 25^\circ\text{C}$ per IGBT                                                                                                             | 143       | W                |
| $P_{\text{RSH}}$              | Power Rating of Shunt Resistor | $T_C < 125^\circ\text{C}$                                                                                                                     | 2         | W                |
| $T_J$                         | Operating Junction Temperature | (Note 2)                                                                                                                                      | -20 ~ 125 | $^\circ\text{C}$ |

**Notes:**

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

**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 ~ 125 | $^\circ\text{C}$ |
| $V_{\text{ISO}}$ | 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<br>(Referenced to PKG Center) | IGBT            | -    | -    | 0.7  | $^\circ\text{C/W}$ |
| $R_{\theta(j-c)HD}$ |                                                                   | High-Side Diode | -    | -    | 1.5  | $^\circ\text{C/W}$ |
| $R_{\theta(j-c)LD}$ |                                                                   | Low-Side Diode  | -    | -    | 0.85 | $^\circ\text{C/W}$ |

**Notes :**

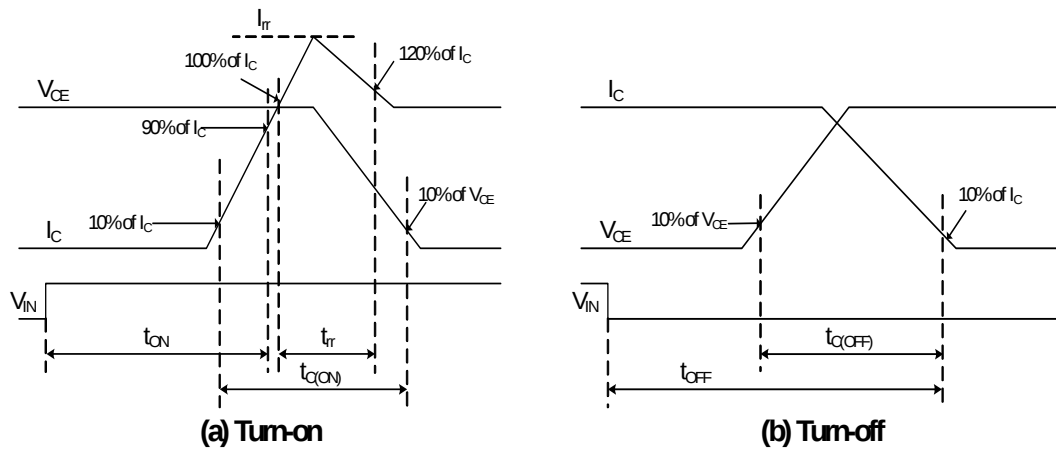
3. For the measurement point of case temperature( $T_C$ ), please refer to Figure 2.

**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             | $V_{CC} = 15\text{ V}$ , $V_{IN} = 5\text{ V}$ , $I_C = 50\text{ A}$                                                                                    | -    | 2.8  | 3.2  | V                |
| $V_{FH}$      | High-Side Diode Voltage             | $I_F = 50\text{ A}$                                                                                                                                     | -    | 2.1  | 2.7  | V                |
| $V_{FL}$      | Low-Side Diode Voltage              | $I_F = 50\text{ A}$                                                                                                                                     | -    | 1.3  | 1.7  | V                |
| $t_{ON}$      | Switching Times                     | $V_{PN} = 400\text{ V}$ , $V_{CC} = 15\text{ V}$ , $I_C = 50\text{ A}$<br>$V_{IN} = 0\text{ V} \leftrightarrow 5\text{ V}$ , 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  | $\text{m}\Omega$ |
| $I_{CES}$     | 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 :  $C_{FOD} = 18.3 \times 10^{-6} \times t_{FOD}[\text{F}]$

R-T Graph

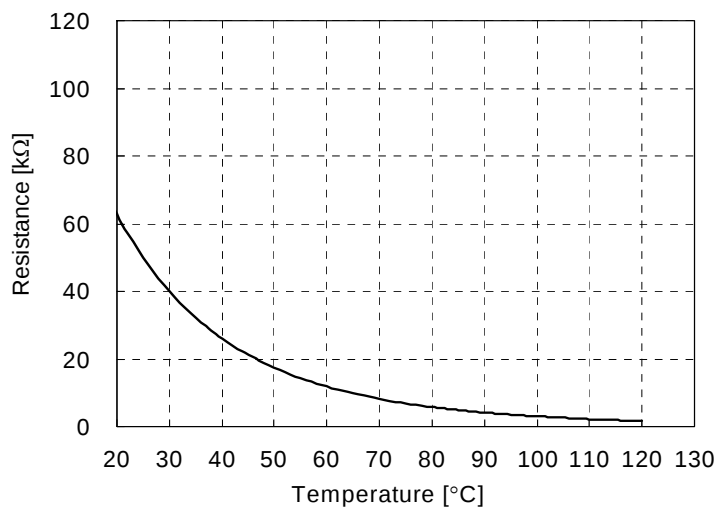


Figure 5. R-T Curve of the Built-in Thermistor

## 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 | 15.0 | 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     |

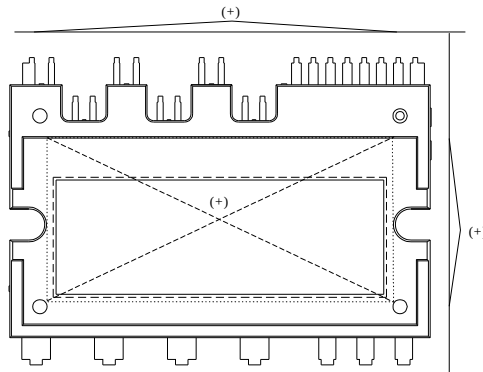
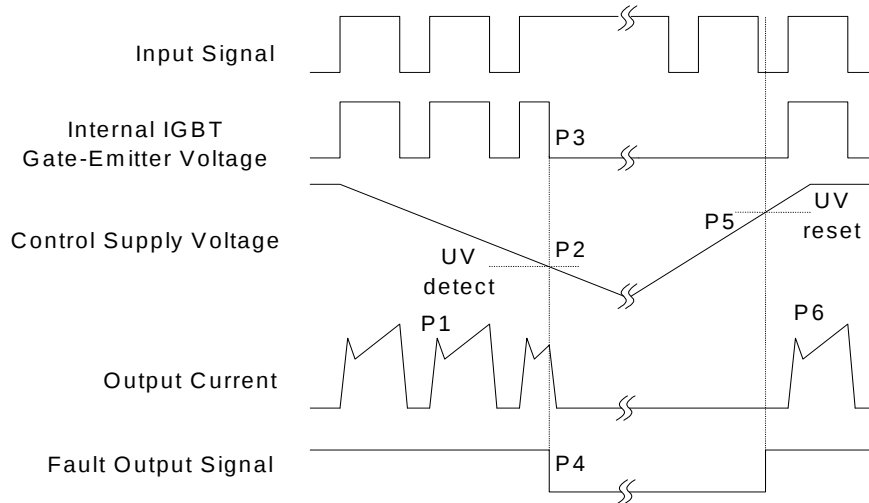


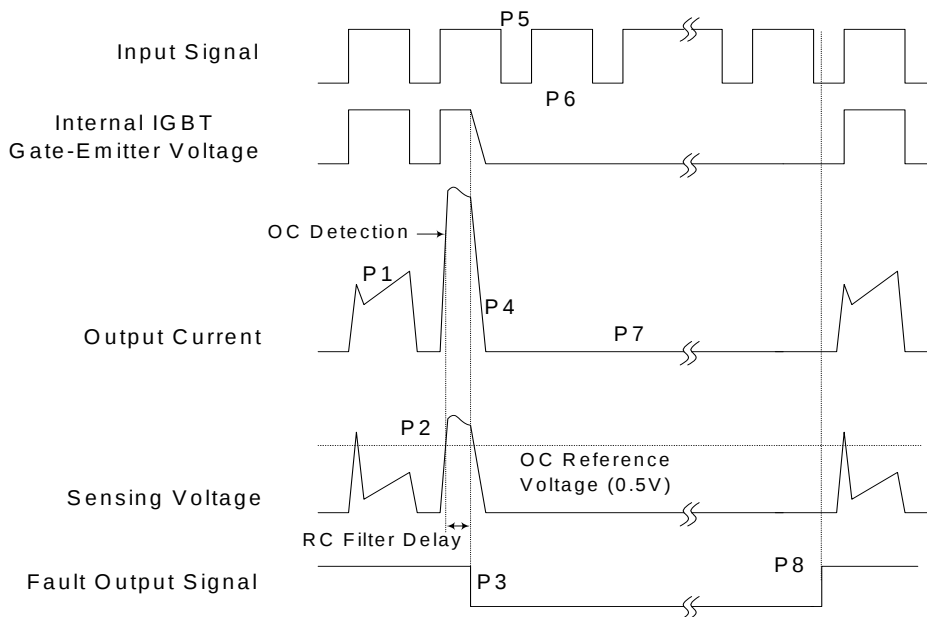
Figure 6. Flatness Measurement Position

## 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**

**Notes:**

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





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