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FAIRCHILD SEMICONDUCTOR®

December 2013

# FPAB20BH60B

# PFC SPM® 3 Series for Single-Phase Boost PFC

## Features

- UL Certified No. E209204 (UL1557)
- 600 V - 20 A Single-Phase Boost PFC with Integral Gate Driver and Protection
- Very Low Thermal Resistance Using $Al_2O_3$ DBC Substrate
- Full-Wave Bridge Rectifier and High-Performance Output Diode
- Built-in NTC Thermistor for Temperature Monitoring
- Optimized for 20kHz Switching Frequency
- Isolation Rating: 2500 Vrms/min.

## Applications

- Single-Phase Boost PFC Converter

## Related Source

- *AN-9090 - PFC SPM 3 Series User's Guide*
- *AN-9091 - Boost PFC Inductor Design Guide*

## General Description

The FPAB20BH60B is an advanced PFC SPM® 3 module providing a fully-featured, high-performance Boost PFC (Power Factor Correction) input power stage for consumer, medical, and industrial applications. These modules integrate optimized gate drive of the built-in IGBT 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 a full-wave rectifier, and high-performance output diode for additional space savings and mounting convenience.

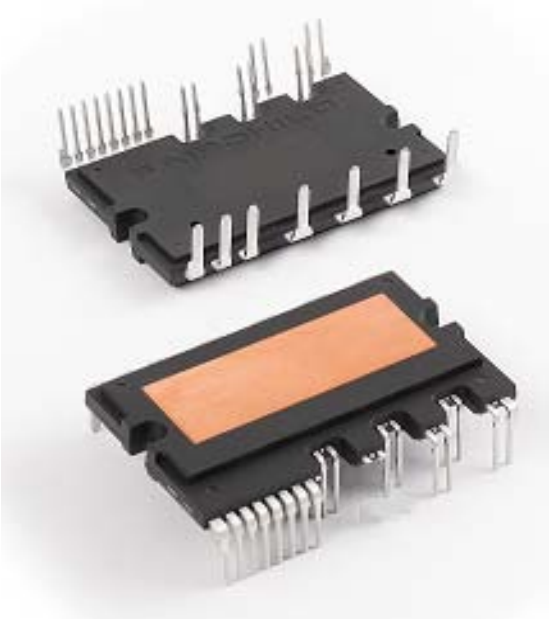


**Figure 1. Package Overview**

## Package Marking & Ordering Information

| Device | Device Marking | Package | Packing Type | Quantity |
|---|---|---|---|---|
| FPAB20BH60B | FPAB20BH60B | SPMIC-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

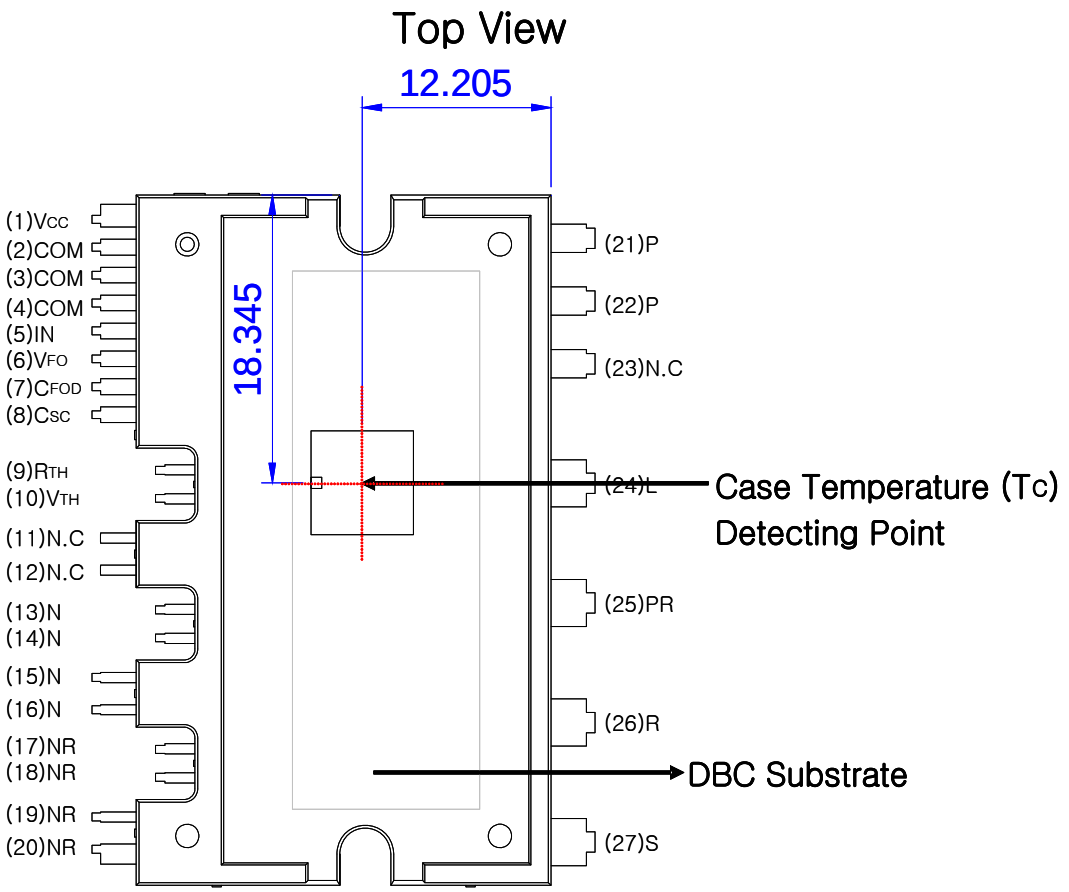



**Figure 2. Top View**

**Notes :**
**1. For the measurement point of case temperature($T_C$), please refer to Figure 2.**

## Pin Descriptions

| Pin Number | Pin Name | Pin Description |
|---|---|---|
| 1 | $V_{CC}$ | Common Bias Voltage for IC and IGBT Driving |
| 2,3,4 | COM | Common Supply Ground |
| 5 | IN | Signal Input for 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 |
| 9 | $R_{(TH)}$ | Series Resistor for The Use of Thermistor |
| 10 | $V_{(TH)}$ | Thermistor Bias Voltage |
| 11,12 | N.C | No Connection* |
| 13~16 | N | IGBT Emitter |
| 17~20 | $N_R$ | Negative DC-Link of Rectifier |
| 21,22 | P | Positive Rail of DC-Link |
| 23 | N.C | No Connection |
| 24 | L | Reactor Connection Pin |
| 25 | $P_R$ | Positive DC-Link of Rectifier |
| 26 | R | AC Input for R-Phase |
| 27 | S | AC Input for S-Phase |

* 11th and 12th pins are cut. Please refer to package outline drawings for more detail.

## Internal Equivalent Circuit and Input/Output Pins

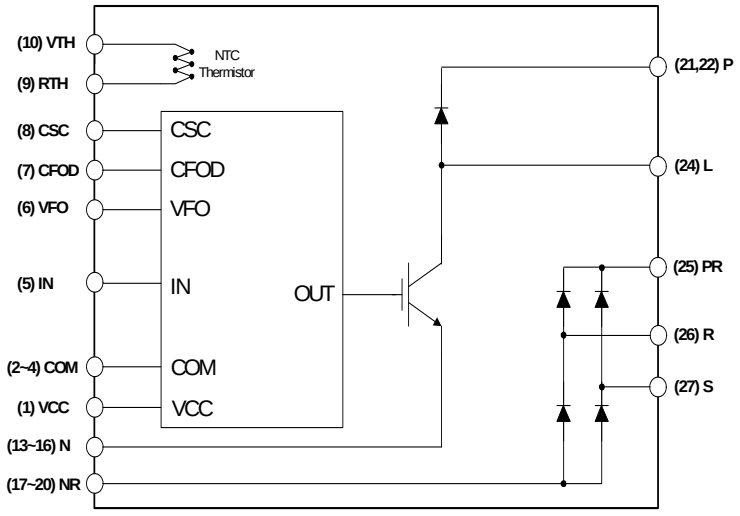



**Figure 3. Internal Block Diagram**

## 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 |
| $I_C$ | Each IGBT Collector Current | $T_C$ = 25°C, $T_J$ < 150°C | 20 | A |
| $I_{CP}$ | Each IGBT Collector Current (Peak) | $T_C$ = 25°C, $T_J$ < 150°C, Under 1ms Pulse Width | 40 | A |
| $P_C$ | Collector Dissipation | $T_C$ = 25°C | 89 | W |
| $V_{RRM}$ | Repititive Peak Reverse Voltage | | 600 | V |
| $I_{FSM}$ | Peak Forward Surge Current | Single Half Sine-Wave | 250 | A |
| $T_J$ | Operating Junction Temperature | | -40 ~ 150 | °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 ~ $V_{CC}$+0.3 | 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 |
|---|---|---|---|---|
| $T_{STG}$ | 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 | IGBT | - | - | 1.4 | °C/W |
| $R_{\theta(j-c)F}$ | | FRD | - | - | 1.4 | °C/W |
| $R_{\theta(j-c)R}$ | | Rectifier (per 1 / 4 module) | - | - | 2.1 | °C/W |

## 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, $I_C$ = 20 A | - | 2.3 | 3.0 | V |
| $V_{FF}$ | FRD Forward Voltage | $I_F$ = 20 A | - | 1.8 | 2.5 | V |
| $V_{FR}$ | Rectifier Forward Voltage | $I_F$ = 20 A | - | 1.2 | 1.5 | V |
| $t_{ON}$ | Switching Times | $V_{PN}$ = 400 V, $V_{CC}$ = 15V, $I_C$ = 20 A<br>$V_{IN}$ = 0 V ↔ 5 V, Inductive Load<br>(Note 2) | - | 450 | - | ns |
| $t_{C(ON)}$ | | | - | 200 | - | ns |
| $t_{OFF}$ | | | - | 350 | - | ns |
| $t_{C(OFF)}$ | | | - | 80 | - | ns |
| $t_{rr}$ | | | - | 70 | - | ns |
| $I_{rr}$ | | | - | 6 | - | A |
| $I_{CES}$ | Collector - Emitter Leakage Current | $V_{CE}$ = $V_{CES}$ | - | - | 250 | μA |

**Notes:**

2. $t_{ON}$ 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.

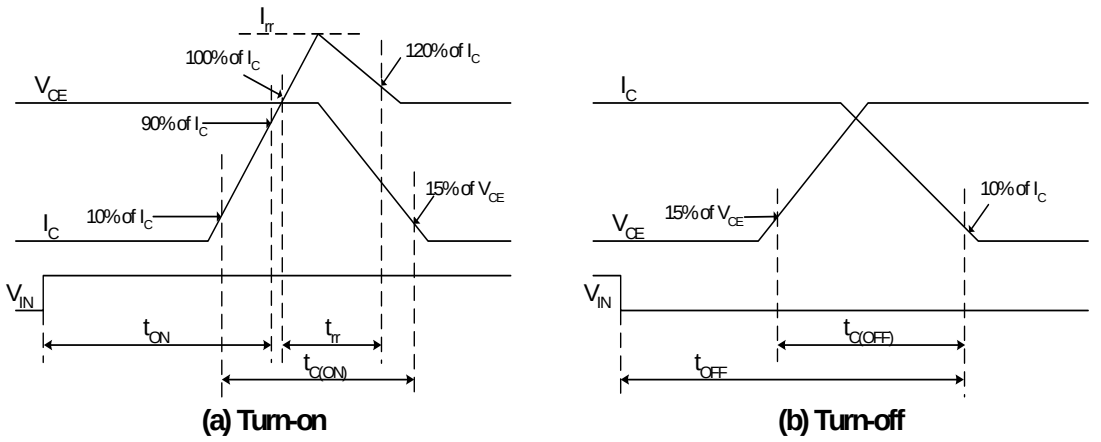



**Figure 4. Switching Time Definition**

## 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 | 0.5 | 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 3) | 1.4 | 1.8 | 2.0 | ms |
| $V_{IN(ON)}$ | ON Threshold Voltage | Applied between IN - COM | 2.8 | - | - | V |
| $V_{IN(OFF)}$ | OFF Threshold Voltage | | - | - | 0.8 | V |
| $R_{TH}$ | Resistance of Thermistor | @ $T_{TH}$ = 25°C (Note 4, Figure 5) | - | 47.0 | - | kΩ |
| | | @ $T_{TH}$ = 100°C (Note 4, Figure 5) | - | 2.9 | - | kΩ |

**Notes:**
3. 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 x $10^{-6}$ x $t_{FOD}$ [F].
4. $T_{TH}$ is the temperature of know case temperature($T_C$), please make the experiment considering your application.

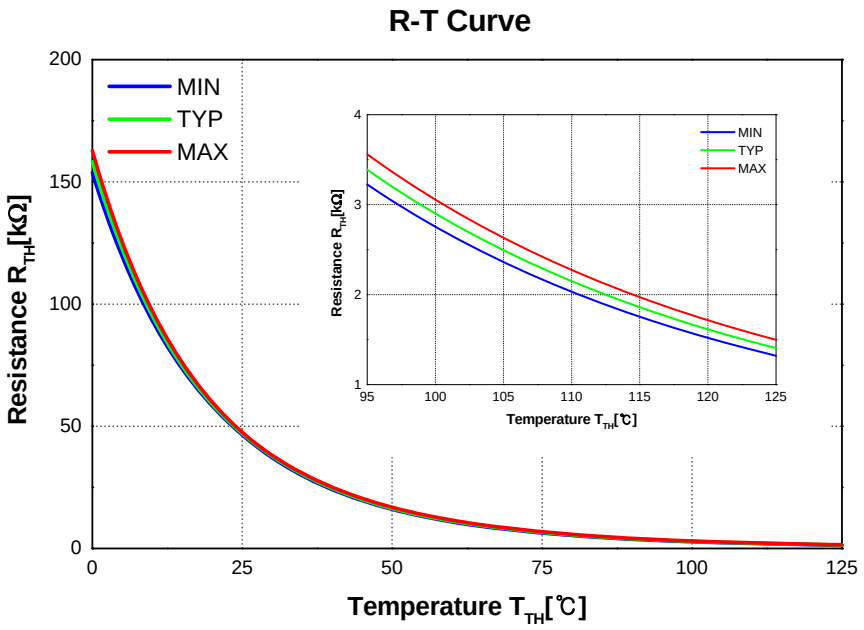



**Figure 5. R-T Curve of the Built-In Thermistor**

## Recommended Operating Condition

| Symbol | Item | Condition | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_i$ | Input Supply Voltage | Applied between R - S | 187 | 220 | 253 | $V_{rms}$ |
| $V_{PN}$ | Output Voltage | Applied between P - N | - | 380 | 400 | V |
| $V_{CC}$ | Control Supply Voltage | Applied between $V_{CC(L)}$ - COM | 13.5 | 15.0 | 16.5 | V |
| $dV_{CC}/dt$ | Control Supply Variation | | -1 | - | 1 | V/μs |
| $f_{PWM}$ | PWM Input Frequency | $T_J \leq 150°C$ | - | 20 | - | kHz |
| $I_i$ | Allowable Input Current | $T_C < 90°C$, $V_i = 220$ V, $V_{PN} = 380$ V<br>$V_{PWM} = 20$ kHz | - | - | 20 | $A_{peak}$ |

## Mechanical Characteristics and Ratings

| Item | Condition | | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| 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 |

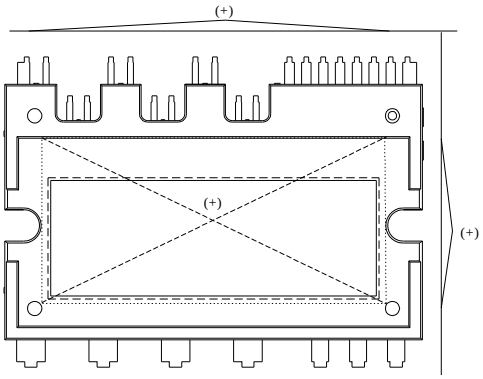
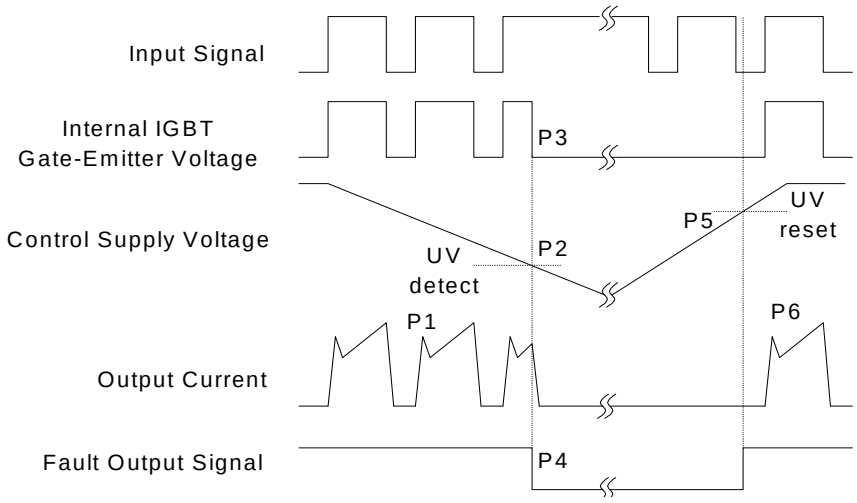


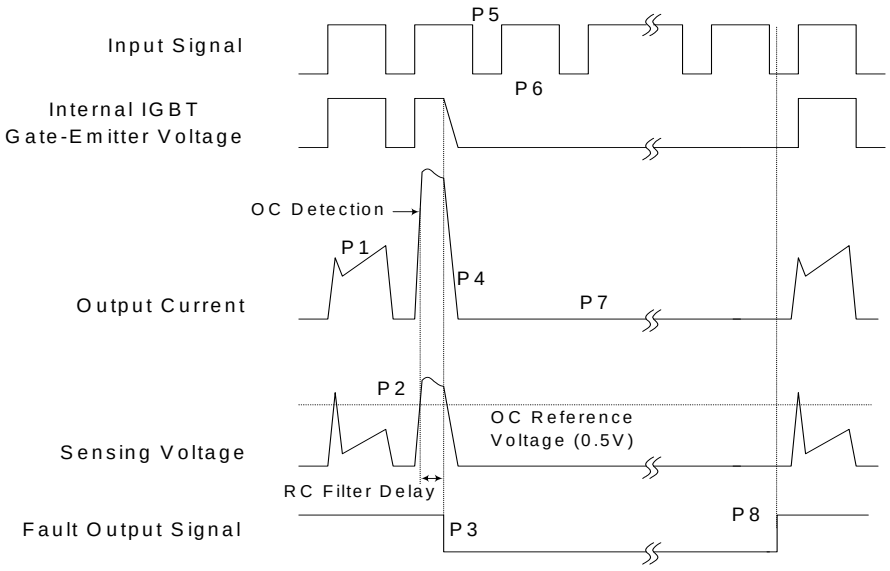

**Figure 6. Flatness Measurement Position**

## 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 signa:  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**

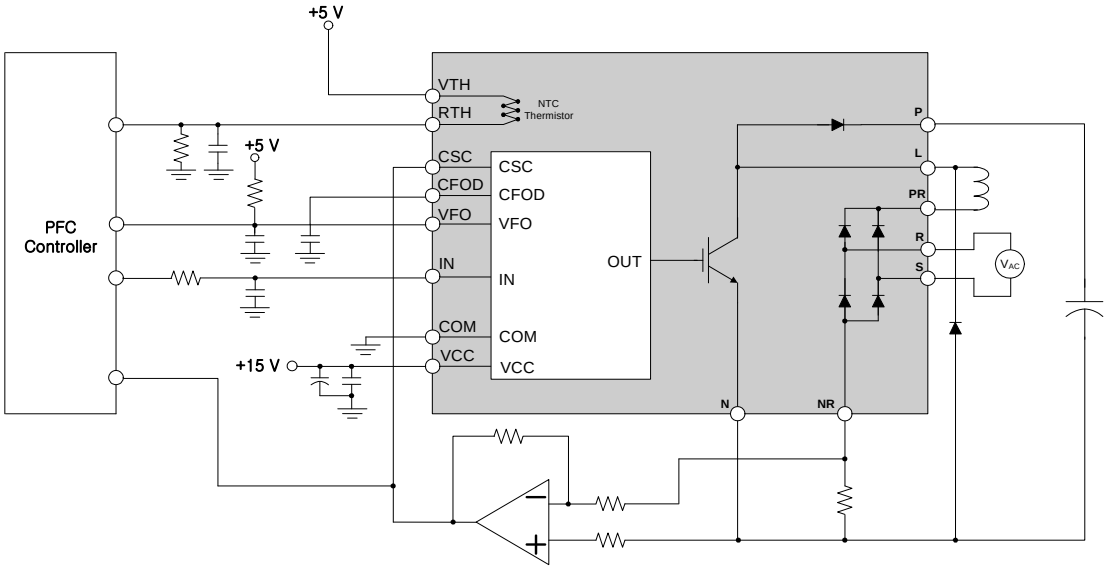
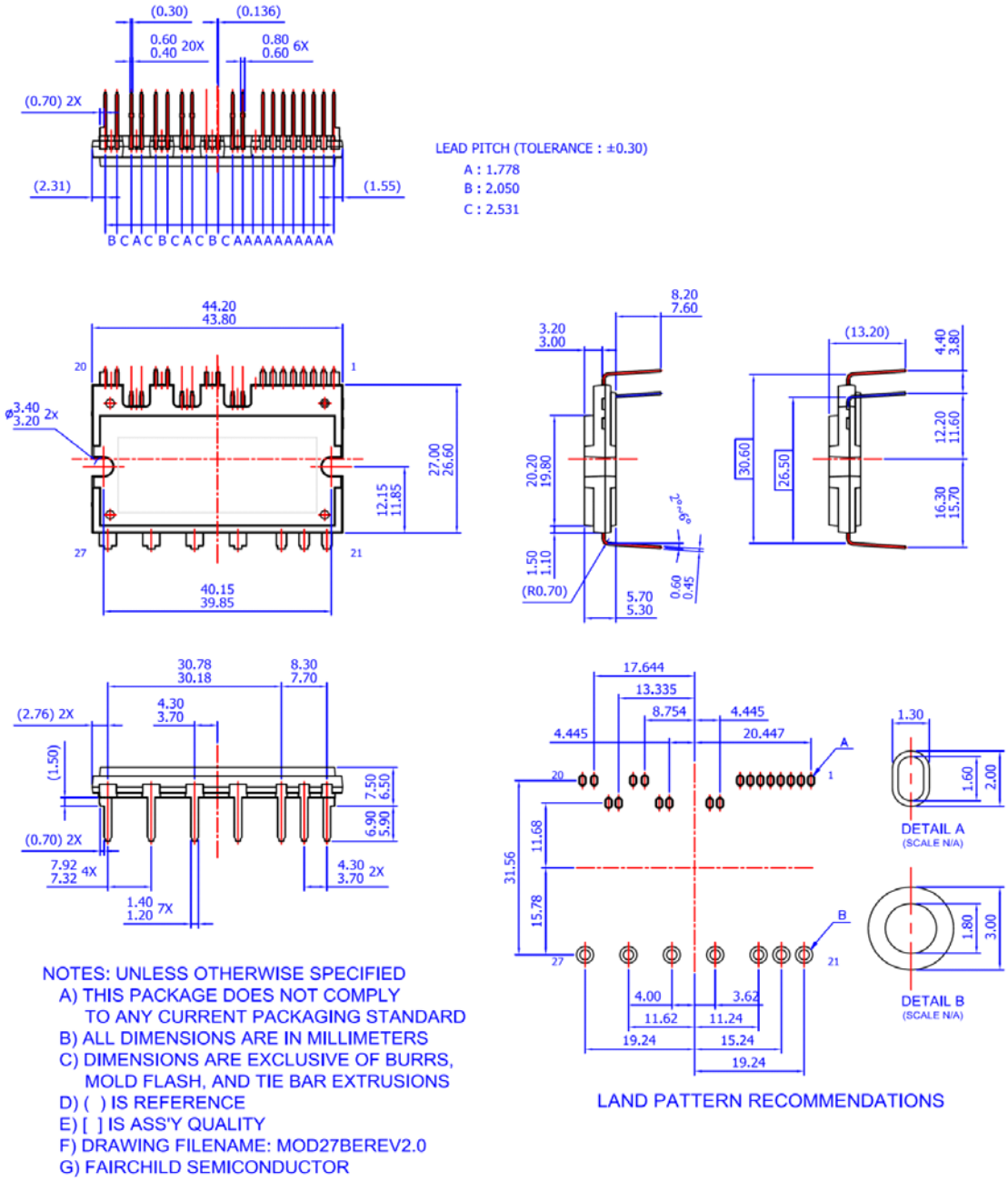



**Fig. 9. Application Example**

**Notes:**

5. Each capacitors should be located as close to PFC SPM® product pins as possible.
6. It's recommended that anti-parallel diode should be connected with IGBT.

## Detailed Package Outline Drawings

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