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FPDB40PH60B

PFC SPM® 3 Series for 2-Phase Bridgeless PFC

Features

- UL Certified No. E209204 (UL1557)
- 600 V - 40 A 2-Phase Bridgeless PFC with Integral Gate Driver and Protection
- Very Low Thermal Resistance Using Al₂O₃ 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 FPDB40PH60B 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, 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.

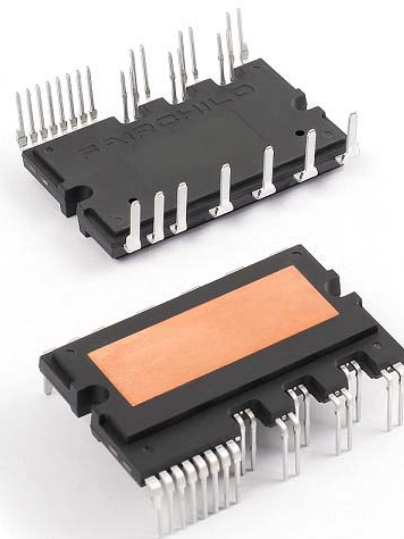


Figure 1. Package Overview

Package Marking & Ordering Information

| Device | Device Marking | Package | Packing Type | Quantity |
|-------------|----------------|-----------|--------------|----------|
| FPDB40PH60B | FPDB40PH60B | SPMGC-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

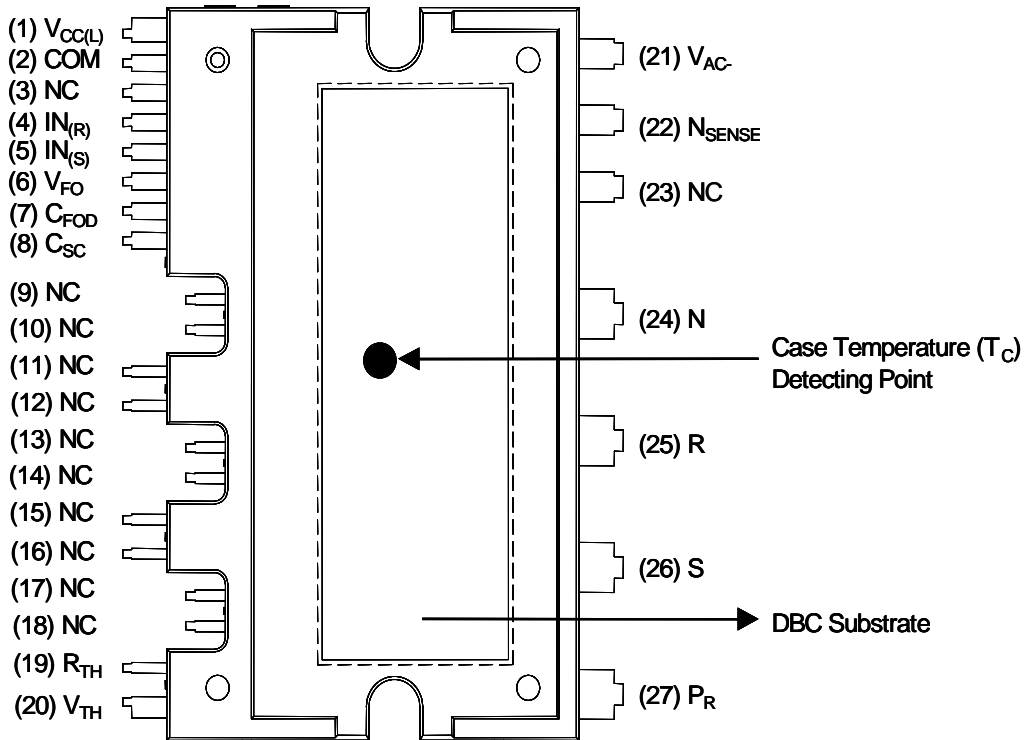


Figure 2. Top View

Pin Descriptions

| Pin Number | Pin Name | Pin Description |
|-------------|--------------------|---|
| 1 | V _{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

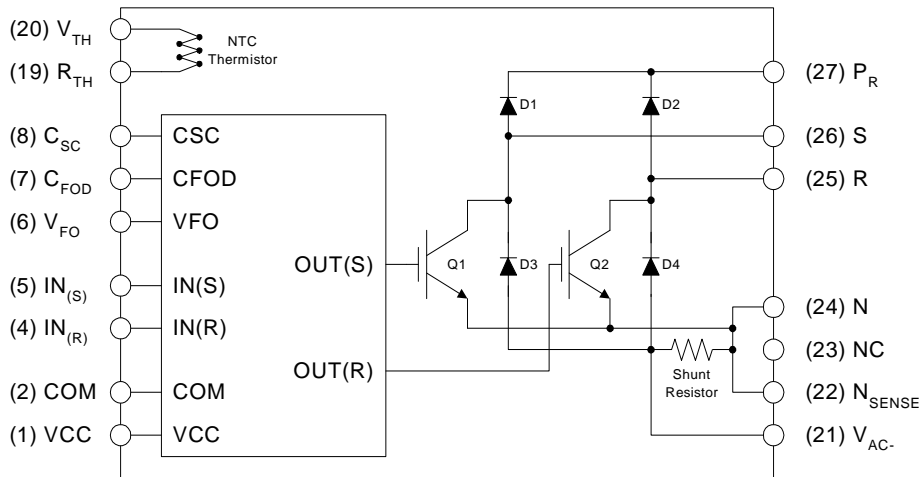


Figure 3. Internal Block Diagram

Notes:

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

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

Converter Part

| Symbol | Item | Condition | Rating | Unit |
|-------------------------------|------------------------------------|---|-----------|------------------|
| V_i | Supply Voltage | Applied between R - S | 264 | V_{rms} |
| $V_{i(\text{Surge})}$ | Supply Voltage (Surge) | Applied between R - S | 500 | V |
| V_{PN} | Output Voltage | Applied between P - N | 450 | V |
| $V_{\text{PN}(\text{Surge})}$ | Output Voltage (Surge) | Applied between P - N | 500 | V |
| V_{CES} | Collector - Emitter Voltage | | 600 | V |
| $\pm I_C$ | Each IGBT Collector Current | $T_C = 25^\circ\text{C}$ | 40 | A |
| $\pm I_{\text{CP}}$ | Each IGBT Collector Current (Peak) | $T_C = 25^\circ\text{C}$, Under 1 ms Pulse Width | 70 | A |
| P_C | Collector Dissipation | $T_C = 25^\circ\text{C}$ per IGBT | 113 | W |
| V_{RRM} | Repetitive Peak Reverse Voltage | | 600 | V |
| I_{FSM} | Peak Forward Surge Current | Single Half Sine-Wave | 350 | A |
| P_{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°C ($@T_C \leq 100^\circ\text{C}$).

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 ~ $V_{\text{CC}}+0.3$ | 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~ $V_{\text{CC}}+0.3$ | V |

Total System

| Symbol | Item | Condition | Rating | Unit |
|------------------|-----------------------------------|---|-----------|------------------|
| T_C | Module Case Operation Temperature | | -20 ~ 100 | $^\circ\text{C}$ |
| T_{STG} | Storage Temperature | | -40 ~ 150 | $^\circ\text{C}$ |
| 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 | - | - | 1.1 | $^\circ\text{C}/\text{W}$ |
| $R_{\theta(j-c)HD}$ | | High-Side Diode | - | - | 1.9 | $^\circ\text{C}/\text{W}$ |
| $R_{\theta(j-c)LD}$ | | Low-Side Diode | - | - | 1.4 | $^\circ\text{C}/\text{W}$ |

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 | $V_{CC} = 15\text{ V}$, $V_{IN} = 5\text{ V}$, $I_C = 40\text{ A}$ | - | 1.8 | 2.3 | V |
| V_{FH} | High-Side Diode Voltage | $I_F = 40\text{ A}$ | - | 2.2 | 2.7 | V |
| V_{FL} | Low-Side Diode Voltage | $I_F = 40\text{ A}$ | - | 1.15 | 1.55 | V |
| t_{ON} | Switching Times | $V_{PN} = 400\text{ V}$, $V_{CC} = 15\text{ V}$, $I_C = 40\text{ A}$ $V_{IN} = 0\text{ V} \leftrightarrow 5\text{ V}$, Inductive Load (Note 4) | - | 500 | - | ns |
| $t_{C(ON)}$ | | | - | 180 | - | ns |
| t_{OFF} | | | - | 500 | - | ns |
| $t_{C(OFF)}$ | | | - | 90 | - | ns |
| t_{rr} | | | - | 43 | - | 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 | 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.

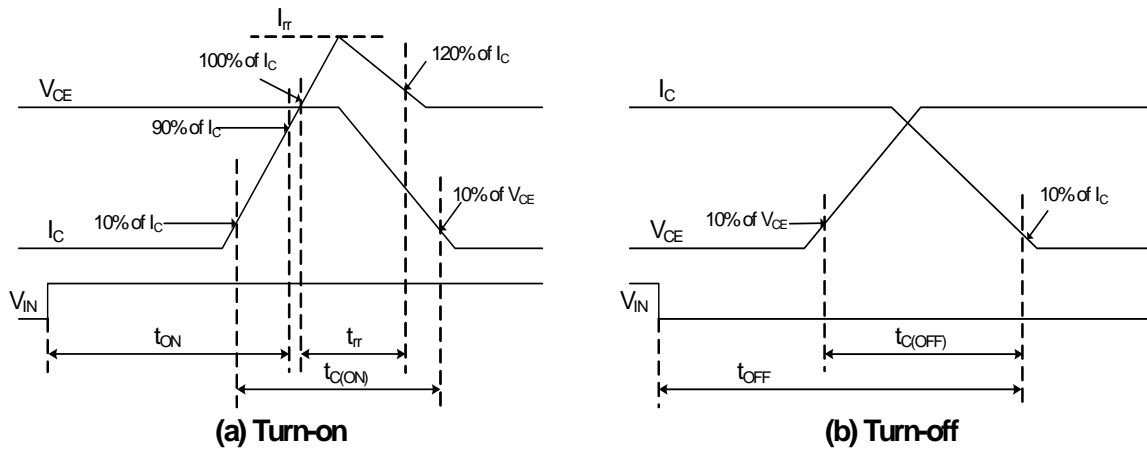


Figure 4. Switching Time Definition

Control Part

| Symbol | Item | Condition | Min. | Typ. | Max. | Unit |
|----------------------|--|---|------|------|------|------|
| I _{QCCL} | Quiescent V _{CC} Supply Current | V _{CC} = 15 V, I _N = 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 x 10⁻⁶ x t_{FOD}[F]

R-T Graph

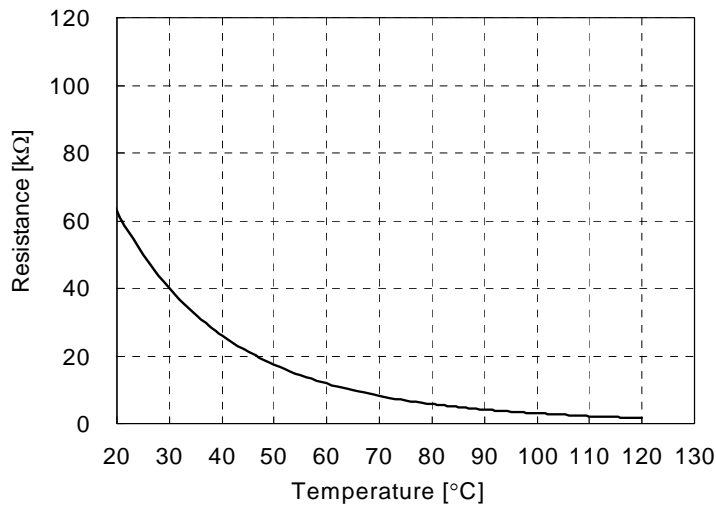


Figure 5. R-T Curve of the Built-in Thermistor

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/μs |
| f _{PWM} | PWM Input Signal | T _C ≤ 100°C, T _J ≤ 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 |

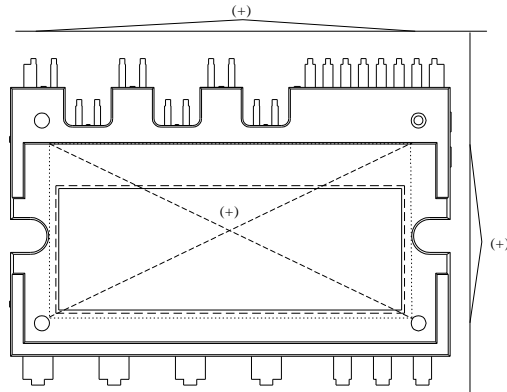


Figure 6. Flatness Measurement Position

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

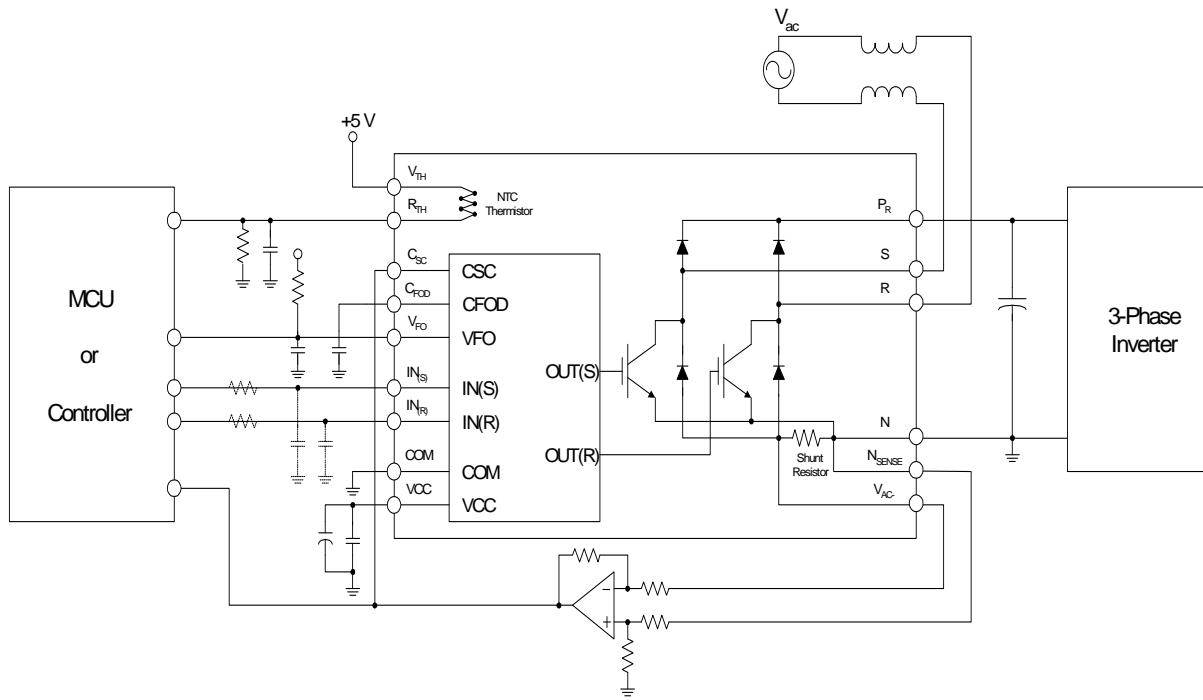
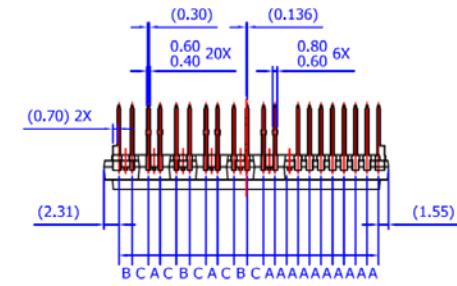


Figure 9. Application Example

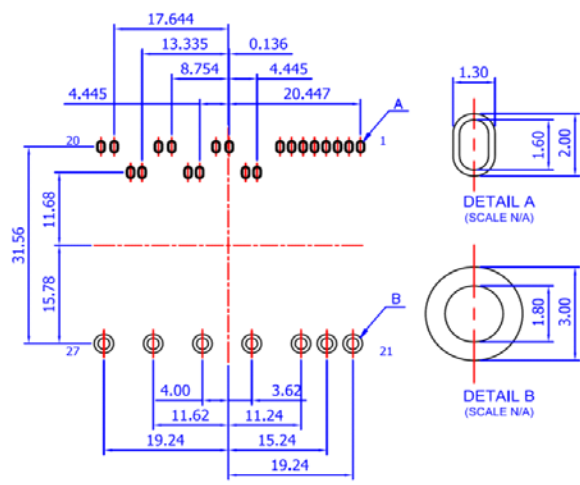
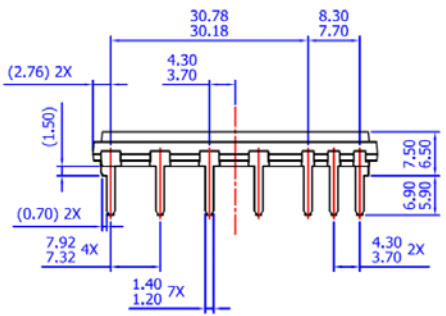
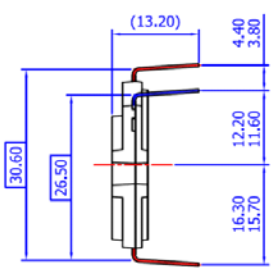
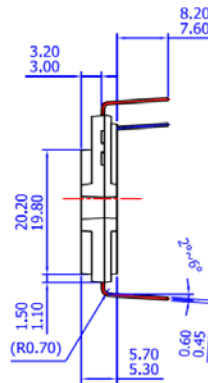
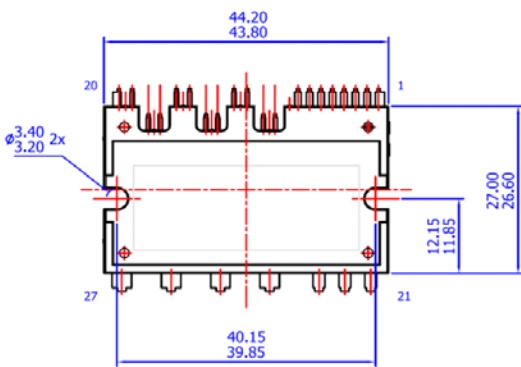
Notes:

- For the over-current protection, please set time constant in the range 3 ~ 4 μ s.

Detailed Package Outline Drawings



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



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