



# THE DATASHEET OF FPDB20PH60



## FPDB20PH60

### Smart Power Module for Front-End Rectifier

#### General Description

FPDB20PH60 is an advanced smart power module of PFC(Power Factor Correction) that Fairchild has newly developed and designed mainly targeting mid-power application especially for an air conditioners. It combines optimized circuit protection and drive IC matched to high frequency switching IGBTs. System reliability is further enhanced by the integrated under-voltage lock-out and over-current protection function.

#### Features

- Low thermal resistance due to  $Al_2O_3$ -DBC substrate
- 600V-20A 2-phase IGBT PWM semi-converter including a drive IC for gate driving and protection
- Typical switching frequency of 20kHz
- Isolation rating of 2500Vrms/min.

#### Applications

- AC 180V ~ 264V single-phase front-end rectifier

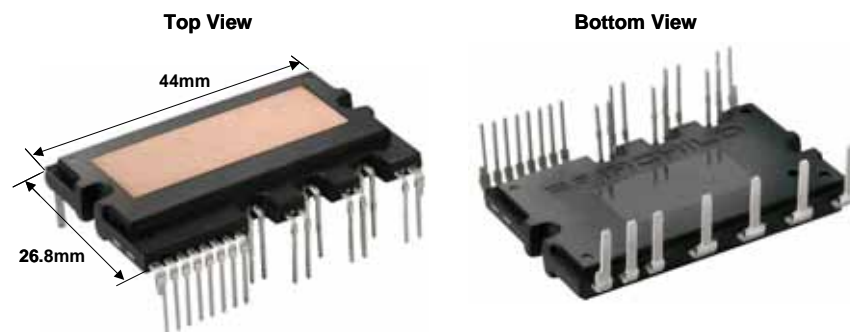


Fig. 1.

### Integrated Power Functions

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

### Integrated Drive, Protection and System Control Functions

- For IGBTs: Gate drive circuit, Overcurrent circuit protection (OC), Control supply circuit under-voltage (UV) protection
- Fault signaling: Corresponding to a UV fault
- Input interface: 5V CMOS/LSTTL compatible, Schmitt trigger input

### Pin Configuration

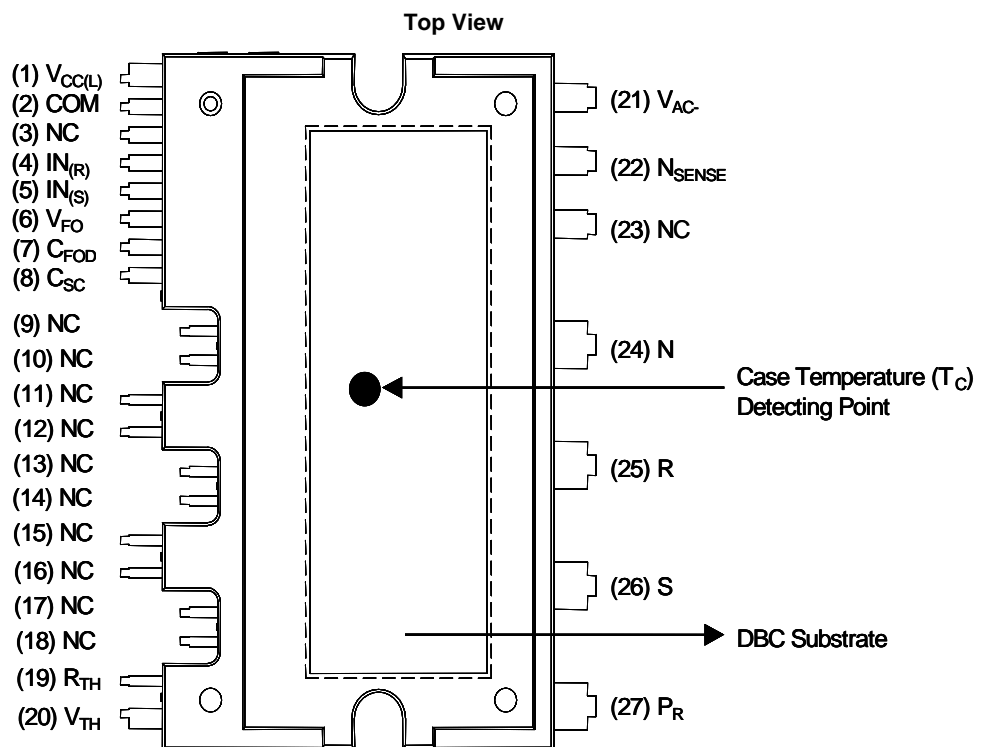
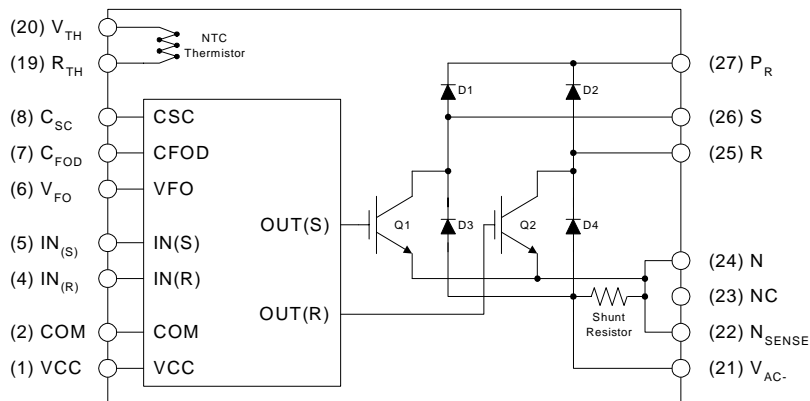


Fig. 2.

## 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 Time Selection     |
| 8           | C <sub>SC</sub>    | Capacitor (Low-pass Filter) for Over Current Detection |
| 19          | R <sub>(TH)</sub>  | NTC Thermistor terminal                                |
| 20          | V <sub>(TH)</sub>  | NTC Thermistor terminal                                |
| 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 and Input/Output Pins



### Note :

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

Fig. 3.

**Absolute Maximum Ratings** ( $T_J = 25^\circ\text{C}$ , Unless Otherwise Specified)**Converter Part**

| Item                           | Symbol          | Condition  | Rating    | Unit             |
|--------------------------------|-----------------|--|-----------|------------------|
| Supply Voltage                 | $V_i$           | Applied between R-S  | 264       | $V_{RMS}$        |
| Supply Voltage (Surge)         | $V_{i(Surge)}$  | Applied between R-S  | 500       | V                |
| Output Voltage                 | $V_{PN}$        | Applied between P- N   | 450       | V                |
| Output Voltage (Surge)         | $V_{PN(Surge)}$ | Applied between P- N   | 500       | V                |
| Collector-emitter Voltage      | $V_{CES}$       |  | 600       | V                |
| Input Current (100% Load)      | $I_i$           | $T_C < 95^\circ\text{C}$ , $V_i=220\text{V}$ , $V_{PN}= 390\text{V}$ ,<br>$V_{PWM}=20\text{kHz}$                       | 12        | A                |
| Input Current (125% Load)      | $I_{i(125\%)}$  | $T_C < 95^\circ\text{C}$ , $V_i=220\text{V}$ , $V_{PN}= 390\text{V}$ ,<br>$V_{PWM}=20\text{kHz}$ , 1min Non-repetitive | 15        | A                |
| Collector Dissipation          | $P_C$           | $T_C = 25^\circ\text{C}$ per One IGBT  | 62.5      | W                |
| Power Rating of Shunt Resistor | $P_{RSH}$       | $T_C < 125^\circ\text{C}$  | 1.5       | W                |
| Operating Junction Temperature | $T_J$           | (Note 1)   | -20 ~ 125 | $^\circ\text{C}$ |

**Note**

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

**Control Part**

| Item                          | Symbol   | Condition                      | Rating             | Unit |
|-------------------------------|----------|--------------------------------|--------------------|------|
| Control Supply Voltage        | $V_{CC}$ | Applied between $V_{CC}$ - COM | 20                 | V    |
| Input Signal Voltage          | $V_{IN}$ | Applied between IN - COM       | -0.3~5.5           | V    |
| Fault Output Supply Voltage   | $V_{FO}$ | Applied between $V_{FO}$ - COM | -0.3- $V_{CC}+0.3$ | V    |
| Fault Output Current          | $I_{FO}$ | Sink Current at $V_{FO}$ Pin   | 5                  | mA   |
| Current Sensing Input Voltage | $V_{SC}$ | Applied between $C_{SC}$ - COM | -0.3- $V_{CC}+0.3$ | V    |

**Total System**

| Item                              | Symbol    | Condition  | Rating    | Unit             |
|-----------------------------------|-----------|--|-----------|------------------|
| Module Case Operation Temperature | $T_C$     |  | -20 ~ 100 | $^\circ\text{C}$ |
| Storage Temperature               | $T_{STG}$ |  | -40 ~ 125 | $^\circ\text{C}$ |
| Isolation Voltage                 | $V_{ISO}$ | 60Hz, Sinusoidal, AC 1 minute, Connection<br>Pins to DBC | 2500      | $V_{rms}$        |

**Thermal Resistance**

| Item  | Symbol              | Condition       | Min. | Typ. | Max. | Unit               |
|---|---------------------|-----------------|------|------|------|--------------------|
| Junction to Case Thermal<br>Resistance<br>(Referenced to chip center) | $R_{\theta(j-c)Q}$  | IGBT            | -    | -    | 1.6  | $^\circ\text{C/W}$ |
|   | $R_{\theta(j-c)HD}$ | High-side diode | -    | -    | 2.4  | $^\circ\text{C/W}$ |
|   | $R_{\theta(j-c)LD}$ | Low-side diode  | -    | -    | 1.9  | $^\circ\text{C/W}$ |

**Note :**

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

**Electrical Characteristics** ( $T_J = 25^\circ\text{C}$ , Unless Otherwise Specified)**Converter Part**

| Item                                | Symbol        | Condition  | Min. | Typ. | Max. | Unit             |
|-------------------------------------|---------------|--|------|------|------|------------------|
| IGBT saturation voltage             | $V_{CE(sat)}$ | $V_{CC} = 15\text{V}$ , $V_{IN} = 5\text{V}$ ; $I_C = 20\text{A}$  | -    | 2.4  | 3.0  | V                |
| High-side diode voltage             | $V_{FH}$      | $I_F = 20\text{A}$   | -    | 1.9  | 2.7  | V                |
| Low-side diode voltage              | $V_{FL}$      | $I_F = 20\text{A}$   | -    | 1.1  | 1.5  | V                |
| Switching Times                     | $t_{ON}$      | $V_{PN} = 400\text{V}$ , $V_{CC} = 15\text{V}$ , $I_C = 20\text{A}$<br>$V_{IN} = 0\text{V} \leftrightarrow 5\text{V}$ , Inductive Load<br>(Note 3) | -    | 690  | -    | ns               |
|                                     | $t_{C(ON)}$   |  | -    | 510  | -    | ns               |
|                                     | $t_{OFF}$     |  | -    | 450  | -    | ns               |
|                                     | $t_{C(OFF)}$  |  | -    | 120  | -    | ns               |
|                                     | $t_{rr}$      |  | -    | 50   | -    | ns               |
|                                     | $I_{rr}$      |  | -    | 2    | -    | A                |
| Current sensing resistor            | $R_{SENSE}$   |  | 3.6  | 4.0  | 4.4  | $\text{m}\Omega$ |
| Collector - emitter Leakage Current | $I_{CES}$     | $V_{CE} = V_{CES}$   | -    | -    | 250  | $\mu\text{A}$    |

**Note**

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

**Control Part**

| Item                                    | Symbol        | Condition  | Min. | Typ. | Max. | Unit       |
|---|---------------|--|------|------|------|------------|
| Quiescent $V_{CC}$ Supply Current       | $I_{QCCL}$    | $V_{CC} = 15\text{V}$ , $I_N = 0\text{V}$   $V_{CC} - \text{COM}$    | -    | -    | 26   | mA         |
| Fault Output Voltage                    | $V_{FOH}$     | $V_{SC} = 0\text{V}$ , $V_{FO}$ Circuit: 4.7k $\Omega$ to 5V Pull-up | 4.5  | -    | -    | V          |
|   | $V_{FOL}$     | $V_{SC} = 1\text{V}$ , $V_{FO}$ Circuit: 4.7k $\Omega$ to 5V Pull-up | -    | -    | 0.8  | V          |
| Over Current Trip Level                 | $V_{SC(ref)}$ | $V_{CC} = 15\text{V}$  | 0.45 | 0.5  | 0.55 | V          |
| Supply Circuit Under-Voltage Protection | $UV_{CCD}$    | Detection Level  | 10.7 | 11.9 | 13.0 | V          |
|   | $UV_{CCR}$    | Reset Level  | 11.2 | 12.4 | 13.2 | V          |
| Fault-out Pulse Width                   | $t_{FOD}$     | $C_{FOD} = 33\text{nF}$ (Note 4)                                     | 1.4  | 1.8  | 2.0  | ms         |
| ON Threshold Voltage                    | $V_{IN(ON)}$  | Applied between IN - COM   | 3.0  | -    | -    | V          |
| OFF Threshold Voltage                   | $V_{IN(OFF)}$ |  | -    | -    | 0.8  | V          |
| Resistance of Thermistor                | $R_{TH}$      | @ $T_C = 25^\circ\text{C}$ (Note Fig. 9)                             | -    | 50   | -    | k $\Omega$ |
|   |               | @ $T_C = 80^\circ\text{C}$ (Note Fig. 9)                             | -    | 5.76 | -    | k $\Omega$ |

**Note**

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

### Electrical Characteristics

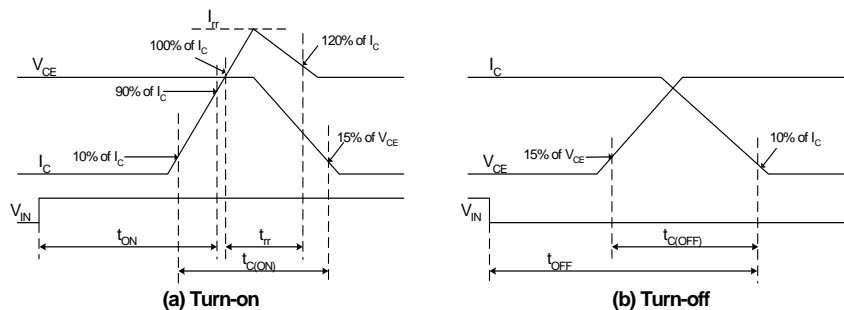


Fig. 4. Switching Time Definition

### Mechanical Characteristics and Ratings

| Item            | Condition                                  | Limits |       |      | Units         |
|-----------------|--|--------|-------|------|---------------|
|                 |  | Min.   | Typ.  | Max. |               |
| Mounting Torque | Mounting Screw: - M3   Recommended 0.62N•m | 0.51   | 0.62  | 0.72 | N•m           |
| Device Flatness | Note Fig. 5                                | 0      | -     | +120 | $\mu\text{m}$ |
| Weight          |  | -      | 15.00 | -    | g             |

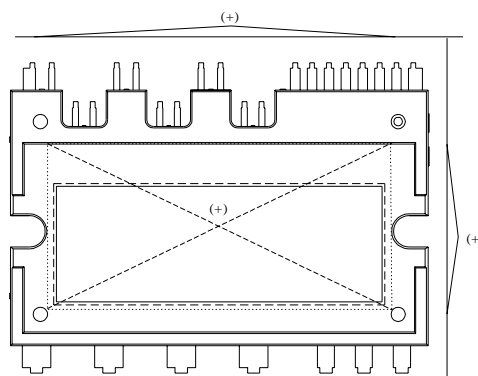
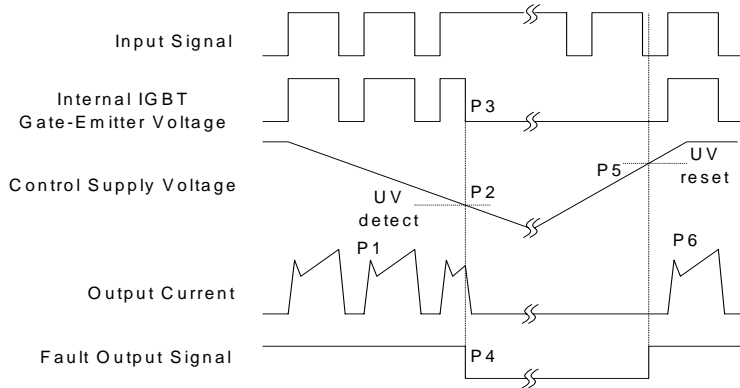


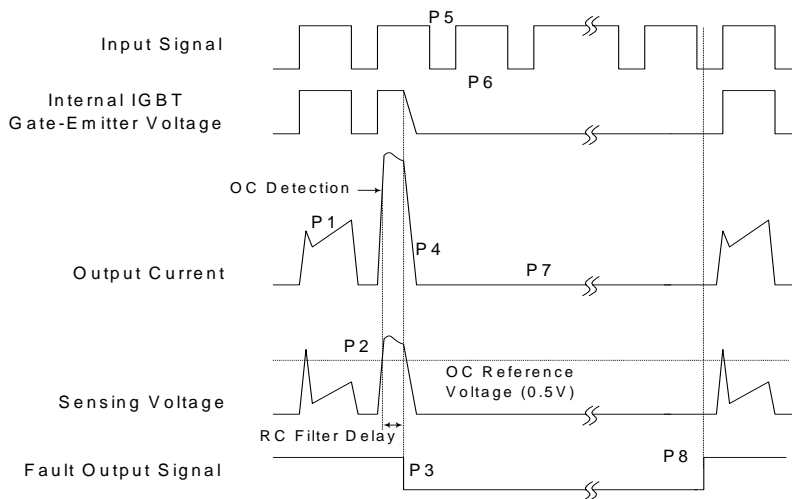
Fig. 5. Flatness Measurement Position

**Time Charts of SPMs 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

**Fig. 6. 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

**Fig. 7. Over Current Protection**

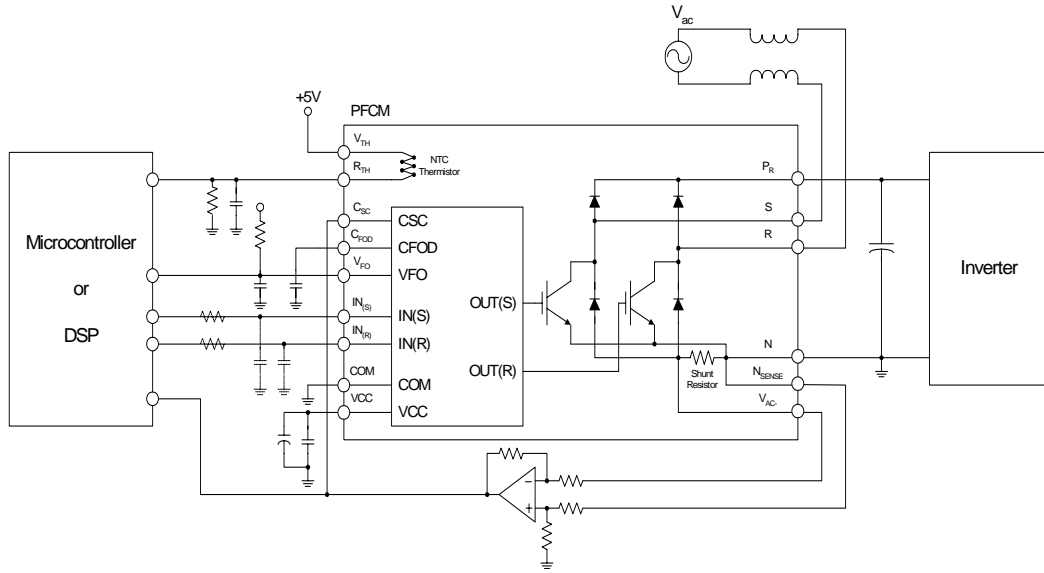


Fig. 8. Application Example

R-T Graph

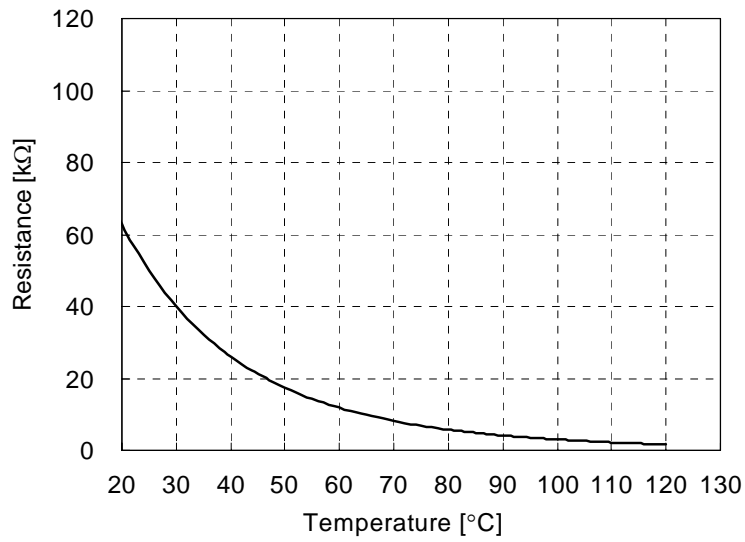
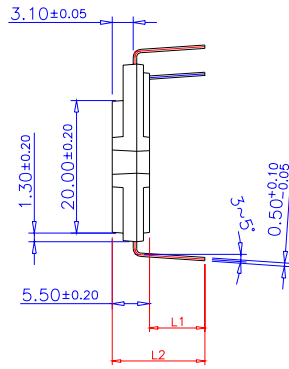
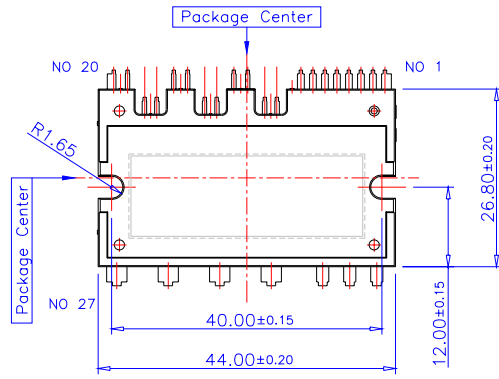
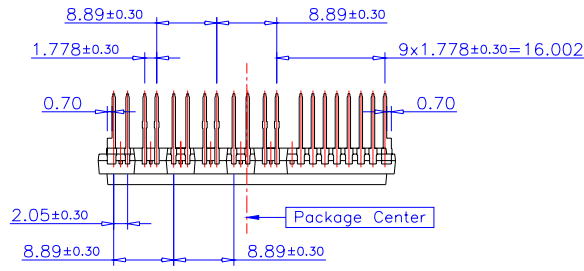


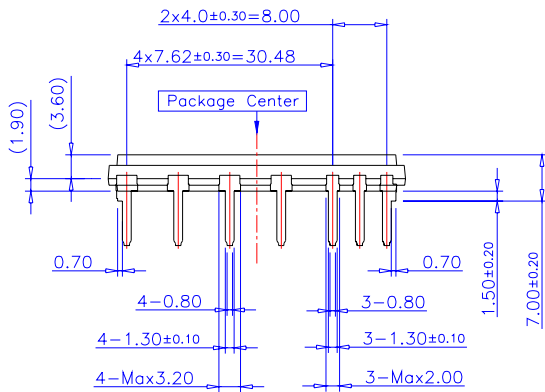
Fig. 9. R-T Curve of the Built-in Thermistor

Detailed Package Outline Drawings

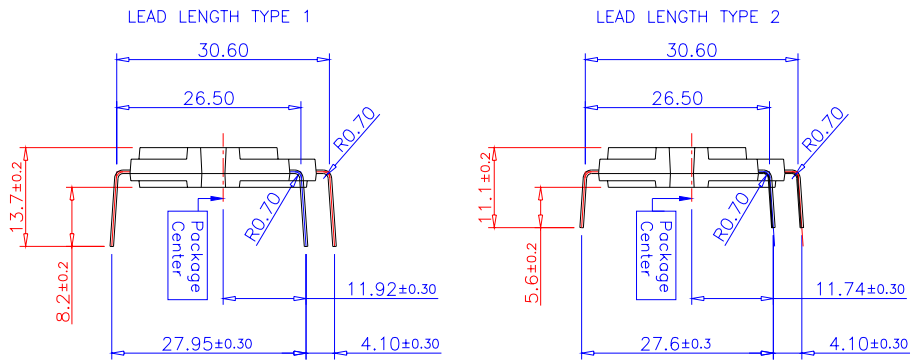


Lead Length Option

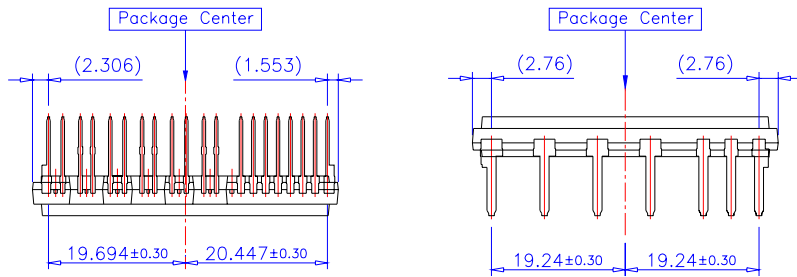
|        | L1              | L2              |
|--------|-----------------|-----------------|
|        | Lead Length     | PKG Height      |
| Type 1 | $8.20 \pm 0.20$ | $13.7 \pm 0.20$ |
| Type 2 | $5.60 \pm 0.20$ | $11.1 \pm 0.20$ |



Detailed Package Outline Drawings

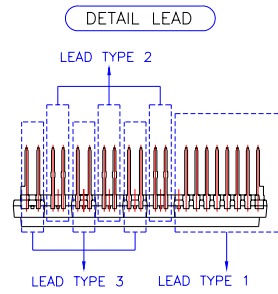


Lead Forming Dimension

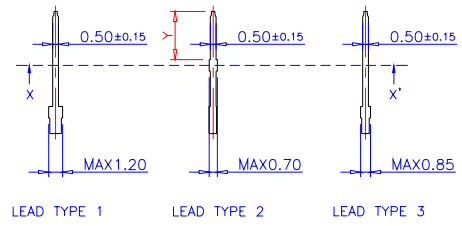


PKG Center to Lead Distance

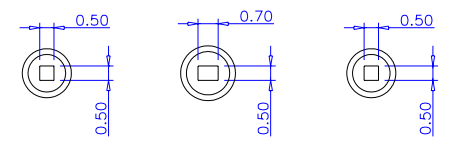
Detailed Package Outline Drawings



|        | L1<br>Lead Length | Y<br>Length |
|--------|-------------------|-------------|
| Type 1 | 8.20±0.20         | 4.20±0.20   |
| Type 2 | 5.60±0.20         | 1.60±0.20   |



SCALE 2 : 1



SCALE 5 : 1

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