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January, 2006

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

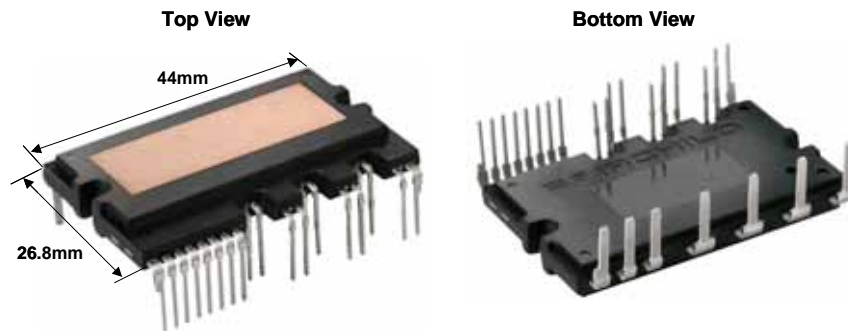


Fig. 1.

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

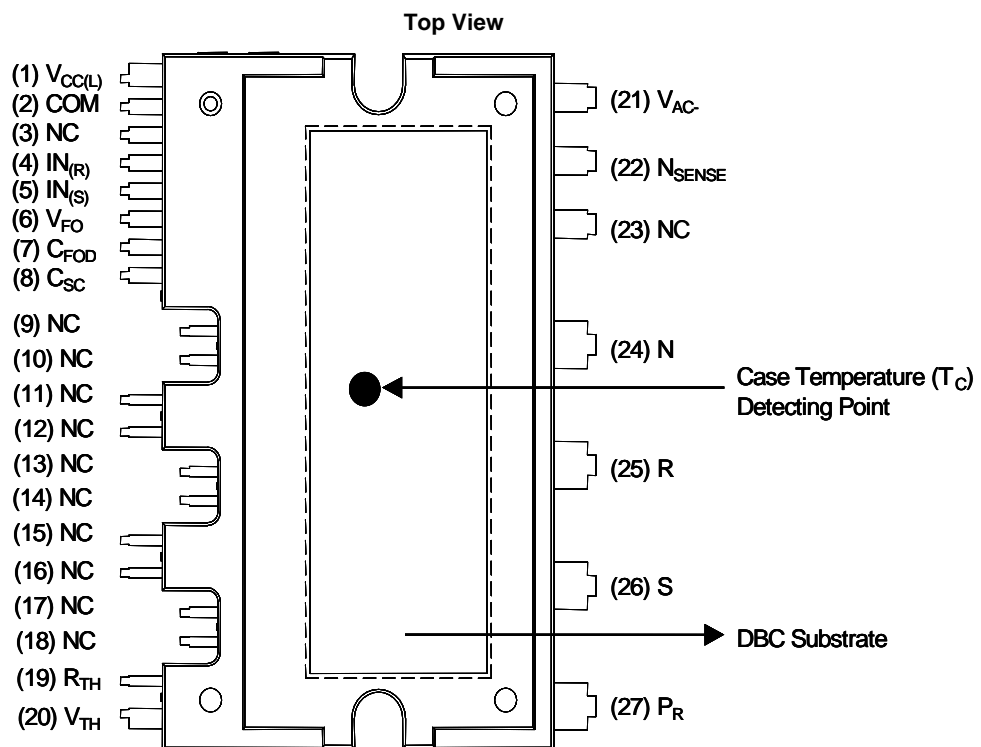
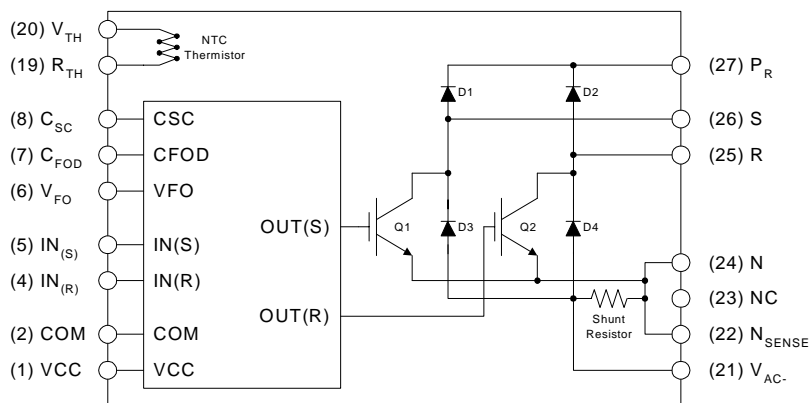


Fig. 2.

Pin Descriptions

| Pin Number | Pin Name | Pin Description |
|-------------|--------------------|--|
| 1 | V _{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 Time Selection |
| 8 | C _{SC} | Capacitor (Low-pass Filter) for Over Current Detection |
| 19 | R _(TH) | NTC Thermistor terminal |
| 20 | V _(TH) | NTC Thermistor terminal |
| 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 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 | $T_C < 95^\circ\text{C}$, $V_i=220\text{V}$, $V_{PN}= 390\text{V}$, $V_{PWM}=20\text{kHz}$ | 12 | A |
| Input Current (125% Load) | $I_{i(125\%)}$ | $T_C < 95^\circ\text{C}$, $V_i=220\text{V}$, $V_{PN}= 390\text{V}$, $V_{PWM}=20\text{kHz}$, 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°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 Pins to DBC | 2500 | V_{rms} |

Thermal Resistance

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

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} | $V_{PN} = 400\text{V}$, $V_{CC} = 15\text{V}$, $I_C = 20\text{A}$ $V_{IN} = 0\text{V} \leftrightarrow 5\text{V}$, Inductive Load (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 | μA |

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 Ω to 5V Pull-up | 4.5 | - | - | V |
| | V_{FOL} | $V_{SC} = 1\text{V}$, V_{FO} Circuit: 4.7k Ω 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 Ω |
| | | @ $T_C = 80^\circ\text{C}$ (Note Fig. 9) | - | 5.76 | - | k Ω |

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

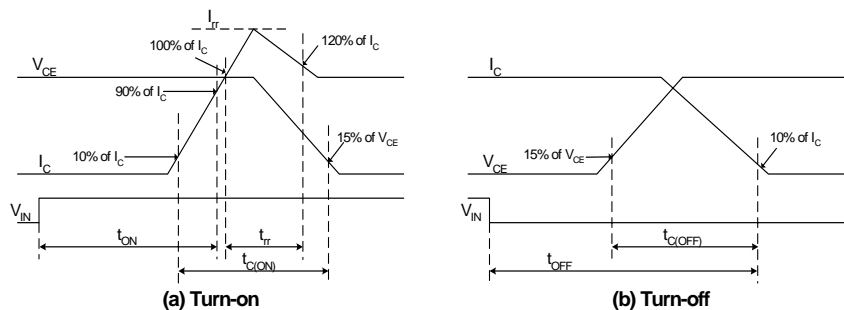


Fig. 4. Switching Time Definition

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 | μm |
| Weight | | - | 15.00 | - | g |

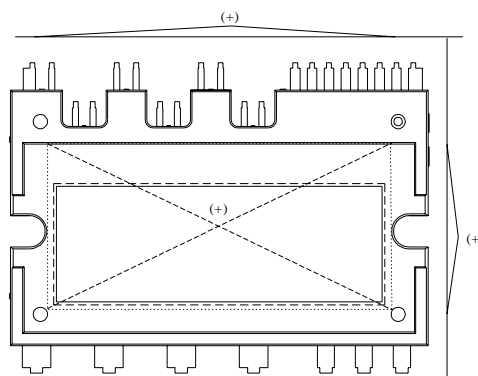
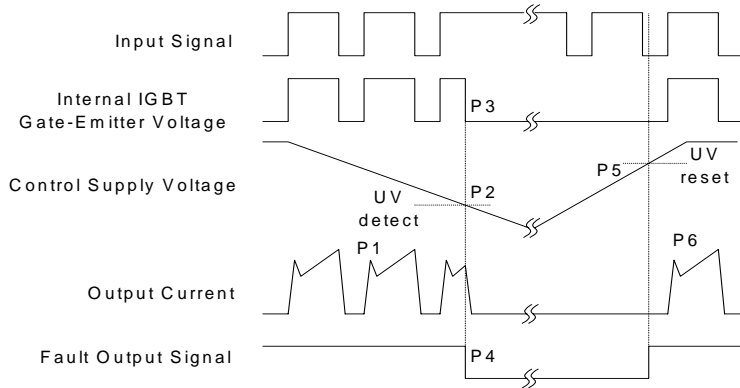


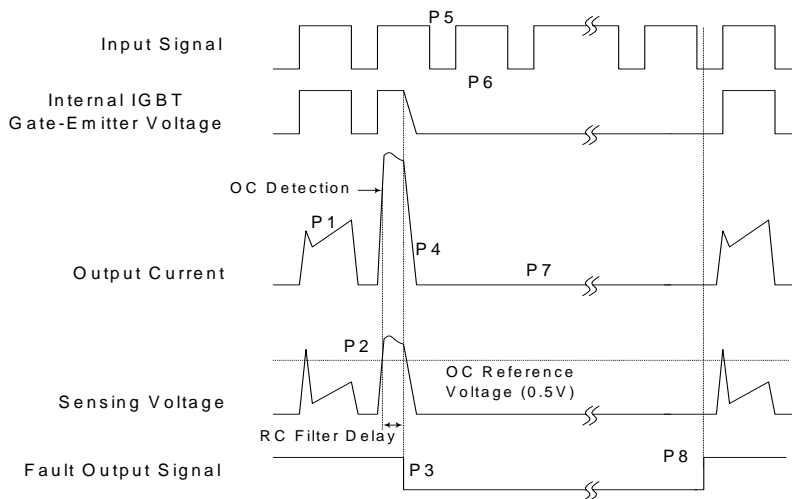
Fig. 5. Flatness Measurement Position

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

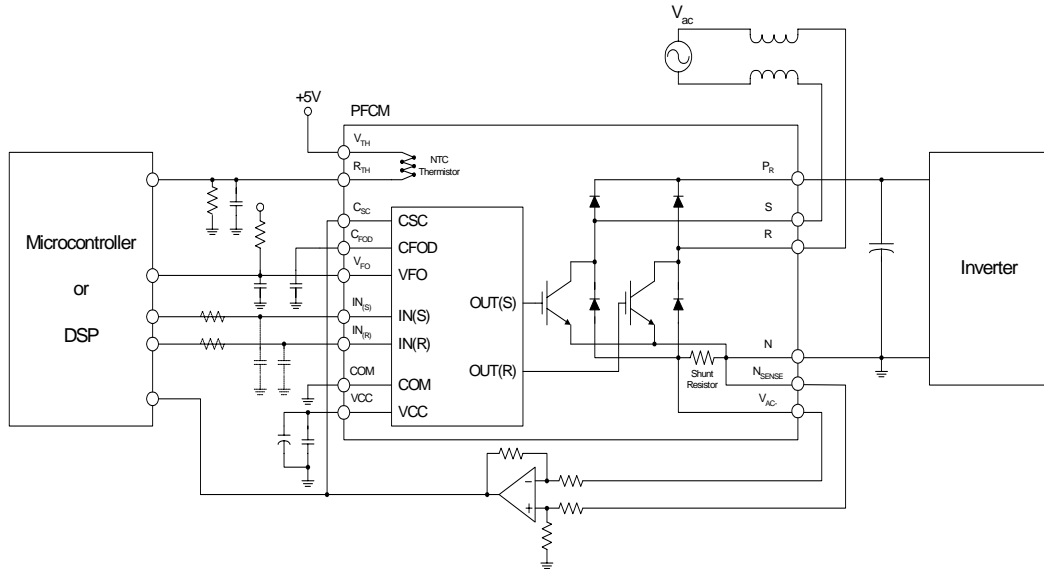


Fig. 8. Application Example

R-T Graph

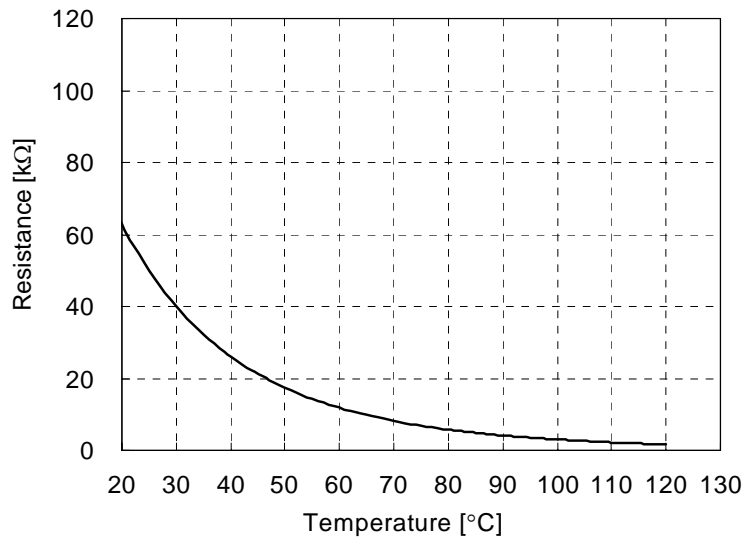
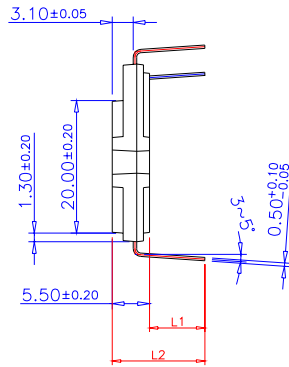
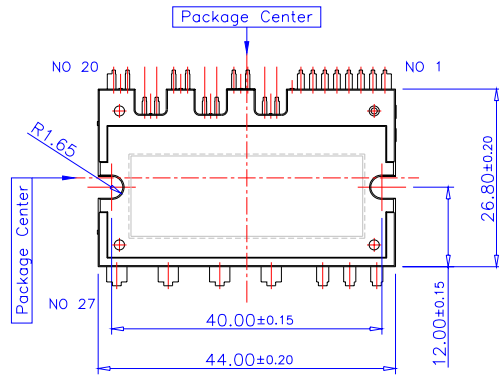
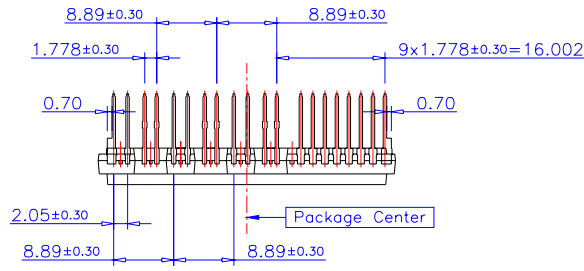


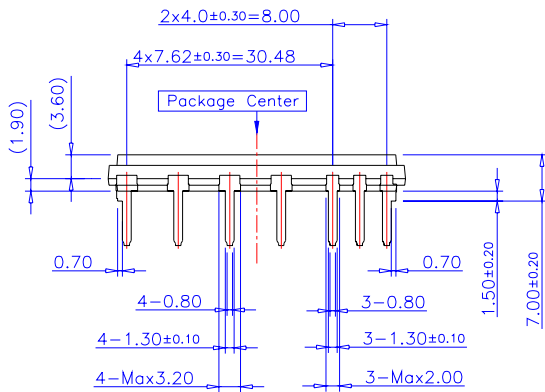
Fig. 9. R-T Curve of the Built-in Thermistor

Detailed Package Outline Drawings

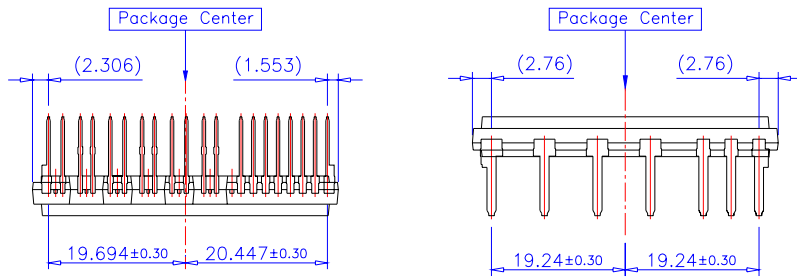
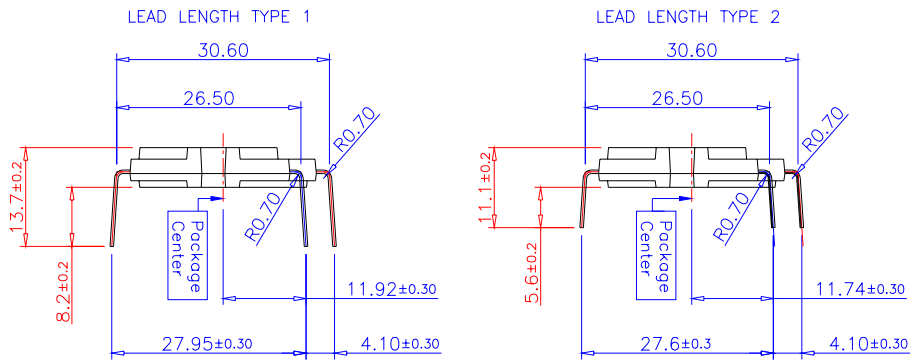


Lead Length Option

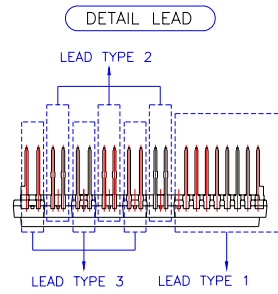
| | L1 | L2 |
|--------|-------------|-------------|
| | Lead Length | PKG Height |
| Type 1 | 8.20 ± 0.20 | 13.7 ± 0.20 |
| Type 2 | 5.60 ± 0.20 | 11.1 ± 0.20 |



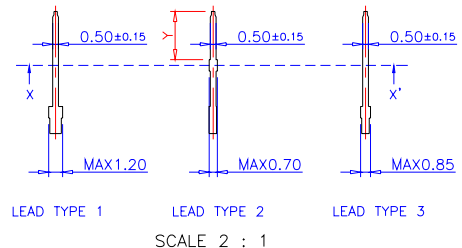
Detailed Package Outline Drawings



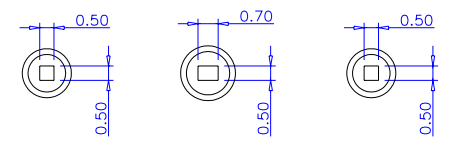
Detailed Package Outline Drawings



| | L1 Lead Length | Y 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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