



February, 2009



FPDB40PH60B

## FPDB40PH60B

### Smart Power Module for Front-End Rectifier

#### General Description

FPDB40PH60B 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-40A 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

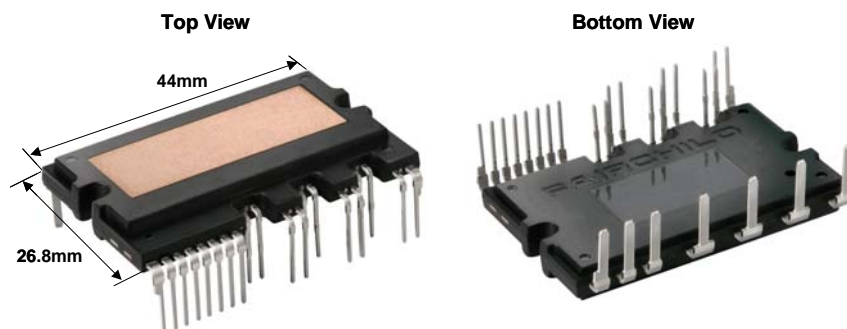


Fig. 1.

### 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

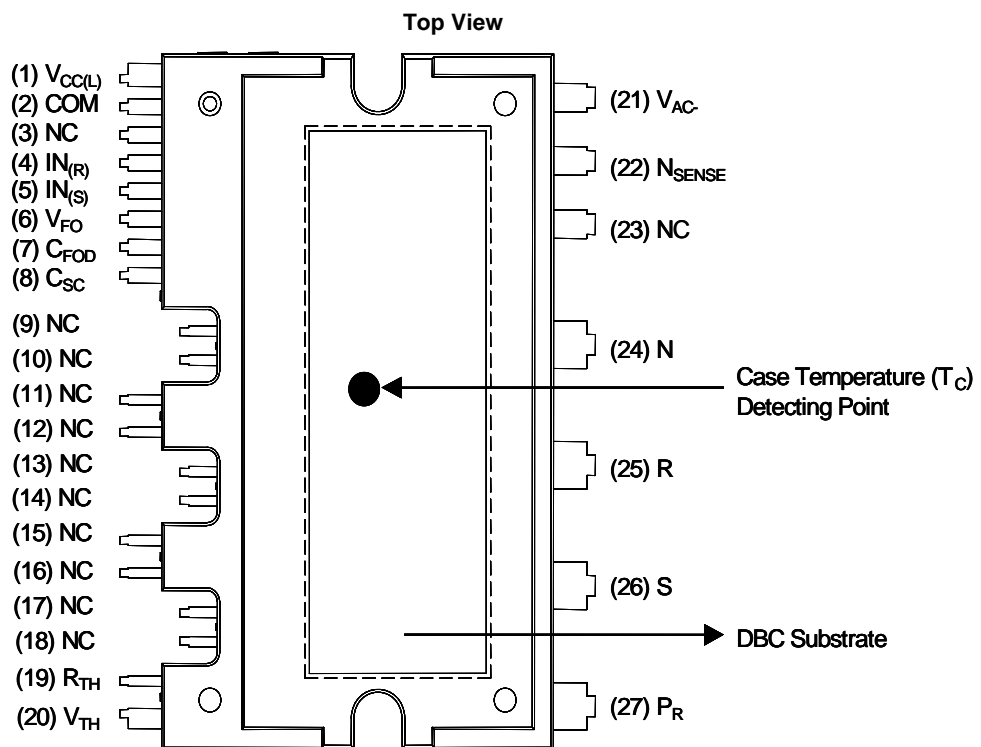
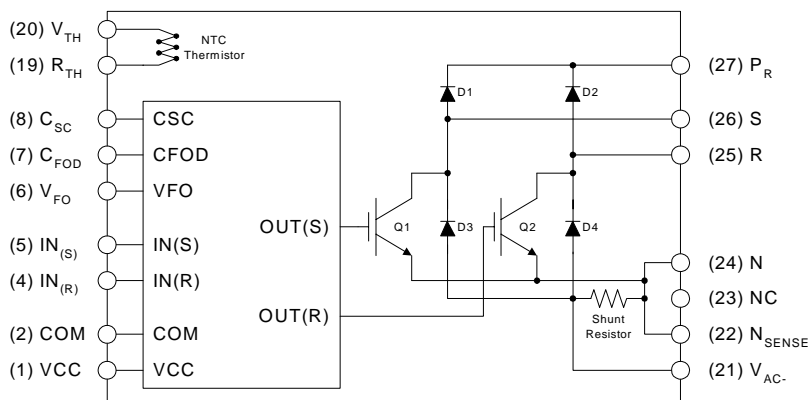


Fig. 2.

### 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
Each IGBT collector current	$\pm I_C$	$T_C = 25^\circ\text{C}$	40	A
Each IGBT collector current (Peak)	$\pm I_{CP}$	$T_C = 25^\circ\text{C}$ , Under 1ms pulse width	70	A
Collector Dissipation	$P_C$	$T_C = 25^\circ\text{C}$ per One IGBT	113	W
Repetitive Peak Reverse Voltage	$V_{RRM}$		600	V
Peak Forward Surge Current	$I_{FSM}$	Single half sine-wave	350	A
Power Rating of Shunt Resistor	$P_{RSH}$	$T_C < 125^\circ\text{C}$	2	W
Operating Junction Temperature	$T_J$	(Note 1)	-40 ~ 150	$^\circ\text{C}$

**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	-0.3~17	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 ~ 150	$^\circ\text{C}$
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 PKG center)	$R_{\theta(j-c)Q}$	IGBT	-	-	1.1	$^\circ\text{C/W}$
	$R_{\theta(j-c)HD}$	High-side diode	-	-	1.9	$^\circ\text{C/W}$
	$R_{\theta(j-c)LD}$	Low-side diode	-	-	1.4	$^\circ\text{C/W}$

**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	$V_{CE(sat)}$	$V_{CC} = 15\text{V}$ , $V_{IN} = 5\text{V}$ ; $I_C = 40\text{A}$	-	1.8	2.3	V
High-side diode voltage	$V_{FH}$	$I_F = 40\text{A}$	-	2.2	2.7	V
Low-side diode voltage	$V_{FL}$	$I_F = 40\text{A}$	-	1.15	1.55	V
Switching Times	$t_{ON}$	$V_{PN} = 400\text{V}$ , $V_{CC} = 15\text{V}$ , $I_C = 40\text{A}$ $V_{IN} = 0\text{V} \leftrightarrow 5\text{V}$ , Inductive Load (Note 3)	-	500	-	ns
	$t_{C(ON)}$		-	180	-	ns
	$t_{OFF}$		-	500	-	ns
	$t_{C(OFF)}$		-	90	-	ns
	$t_{rr}$		-	43	-	ns
	$I_{rr}$		-	6	-	A
Current sensing resistor	$R_{SENSE}$		1.8	2.0	2.2	$\text{m}\Omega$
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 :  $C_{FOD} = 18.3 \times 10^{-6} \times t_{FOD}[\text{F}]$

**Recommended Operating conditions**

Item	Symbol	Condition	Min.	Typ.	Max.	Unit
Input Supply Voltage	$V_I$	Applied between R - S	180	-	264	$V_{rms}$
Output Voltage	$V_{PN}$	Applied between P - N	-	280	400	V
Control Supply Voltage	$V_{CC}$	Applied between $V_{CC} - \text{COM}$	13.5	15	16.5	V
Control Supply Variation	$dV_{CC}/dt$	Applied between IN - COM	-1	-	1	V/ $\mu\text{s}$
PWM Input Signal	$f_{PWM}$	$T_C \leq 100^\circ\text{C}$ , $T_J \leq 125^\circ\text{C}$ , Per IGBT	-	20	-	kHz

### Electrical Characteristics

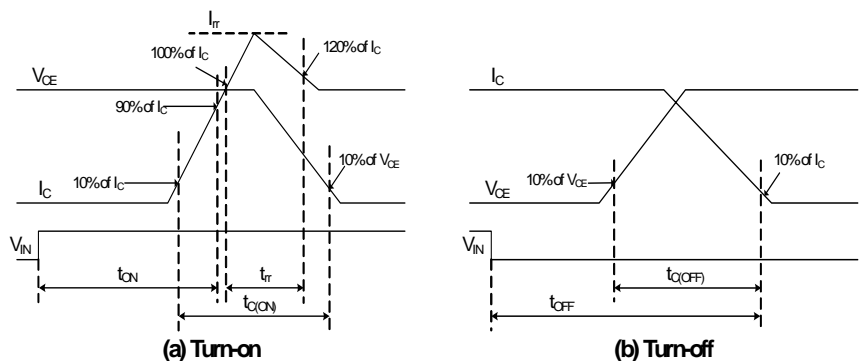


Fig. 4. Switching Time Definition

### 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

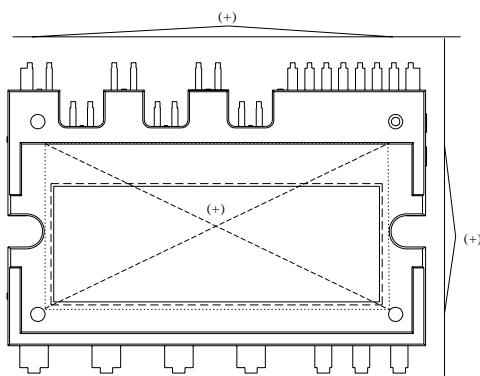
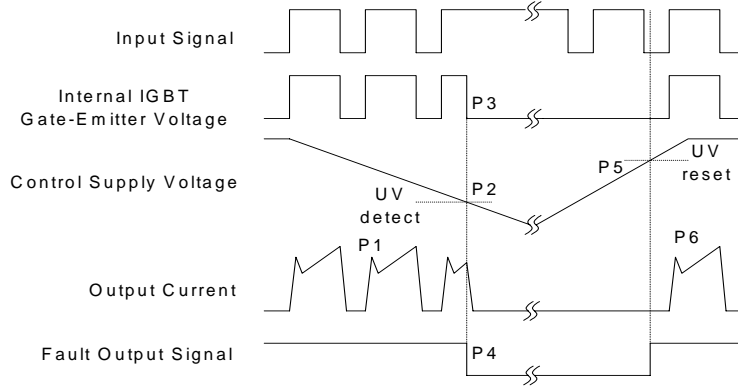


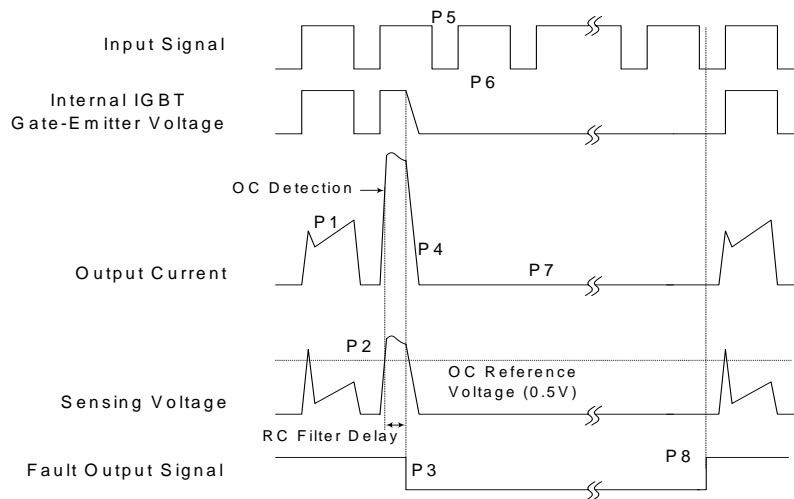
Fig. 5. Flatness Measurement Position

### Time Charts of SPMs Protective Function



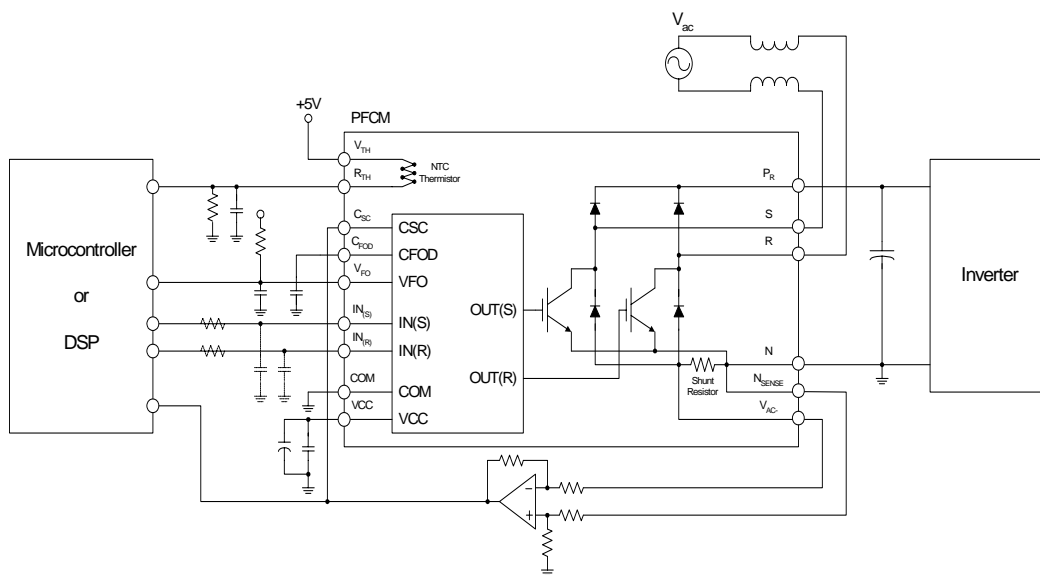
- P1 : Normal operation - IGBT ON and conducting current
- P2 : Under voltage detection
- P3 : IGBT gate interrupt
- P4 : Fault signal generation
- P5 : Under voltage reset
- P6 : Normal operation - IGBT ON and conducting current

**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**



Note :

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

Fig. 8. Application Example

R-T Graph

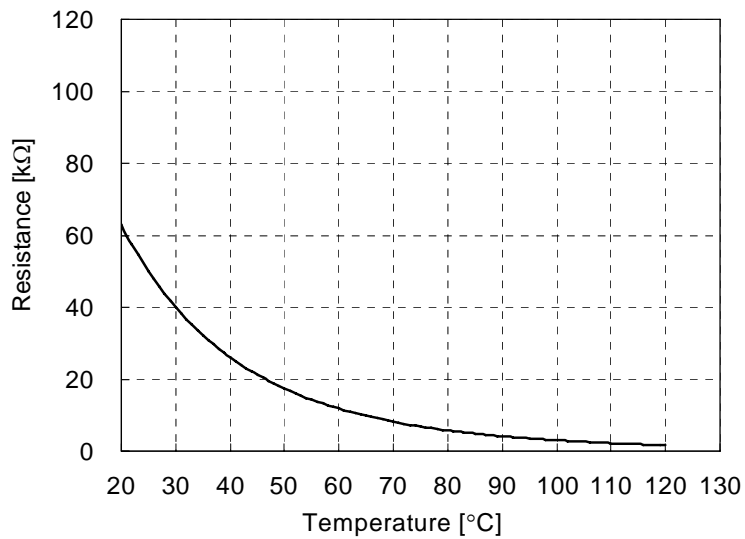
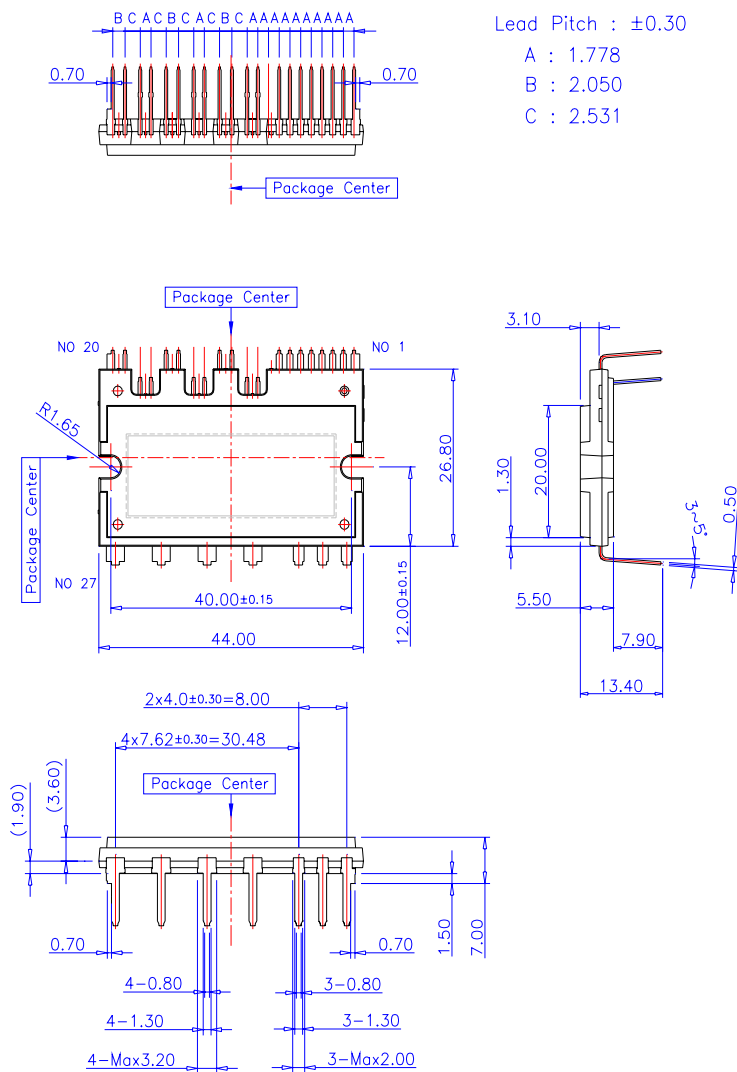


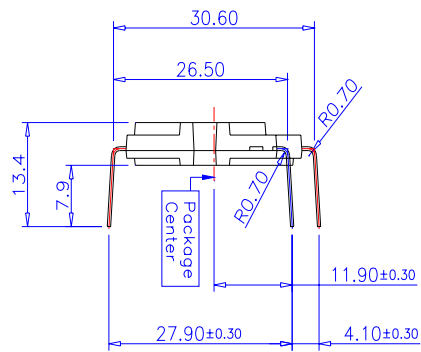
Fig. 9. R-T Curve of the Built-in Thermistor



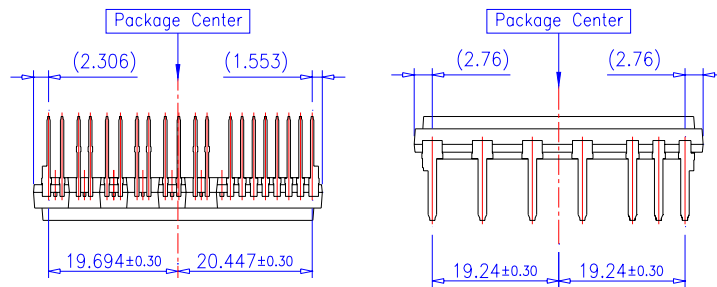
Detailed Package Outline Drawings



### Detailed Package Outline Drawings

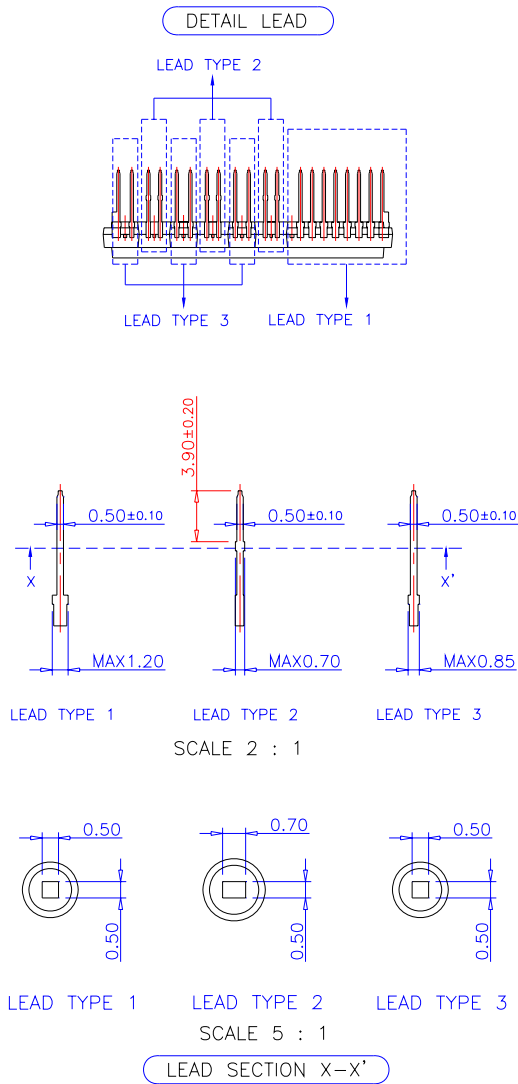


Lead Forming Dimension



PKG Center to Lead Distance

### Detailed Package Outline Drawings



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