September 2006

FSAB20PH60

Smart Power Module for Partial Switching Converter

Features

- Very low thermal resistance due to using DBC
- 600V-20A single-phase rectifier bridge diode including two IGBTs for partial switching converter
- Integrated IC for gate driving and protection
- Divided negative dc-link terminals for current sensing
- Isolation rating of 2500Vrms/min.

Applications

- AC 187V ~ 276V single-phase partial-switching converter of air-conditioner

General Description

FSAB20PH60 is an advanced smart power module of PSC(Partial Switching Converter) that Fairchild has newly developed and designed mainly targeting low-power application especially for an air conditioners. It combines optimized circuit protection and drive IC matched to IGBTs. System reliability is further enhanced by the integrated under-voltage lock-out and short-circuit protection function.

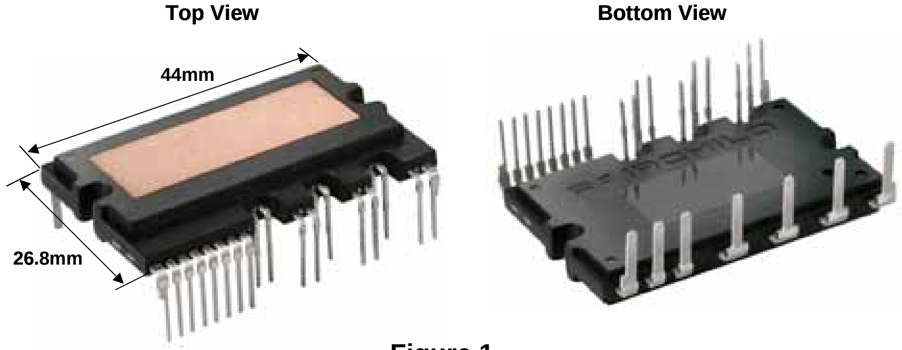


Figure 1.

Integrated Power Functions

- 600V-20A rectifiers for single-phase ac input with IGBT switches for operation of partial switching converter

Integrated Drive, Protection and System Control Functions

- For IGBTs: Gate drive circuit, Short circuit protection (SC)
  Control supply circuit under-voltage (UV) protection
- Fault signaling: Corresponding to a UV fault (Low-side supply)
- Input interface: 5V CMOS/LSTTL compatible, Schmitt trigger input
- Built-in thermistor: Over-temperature monitoring

Pin Configuration

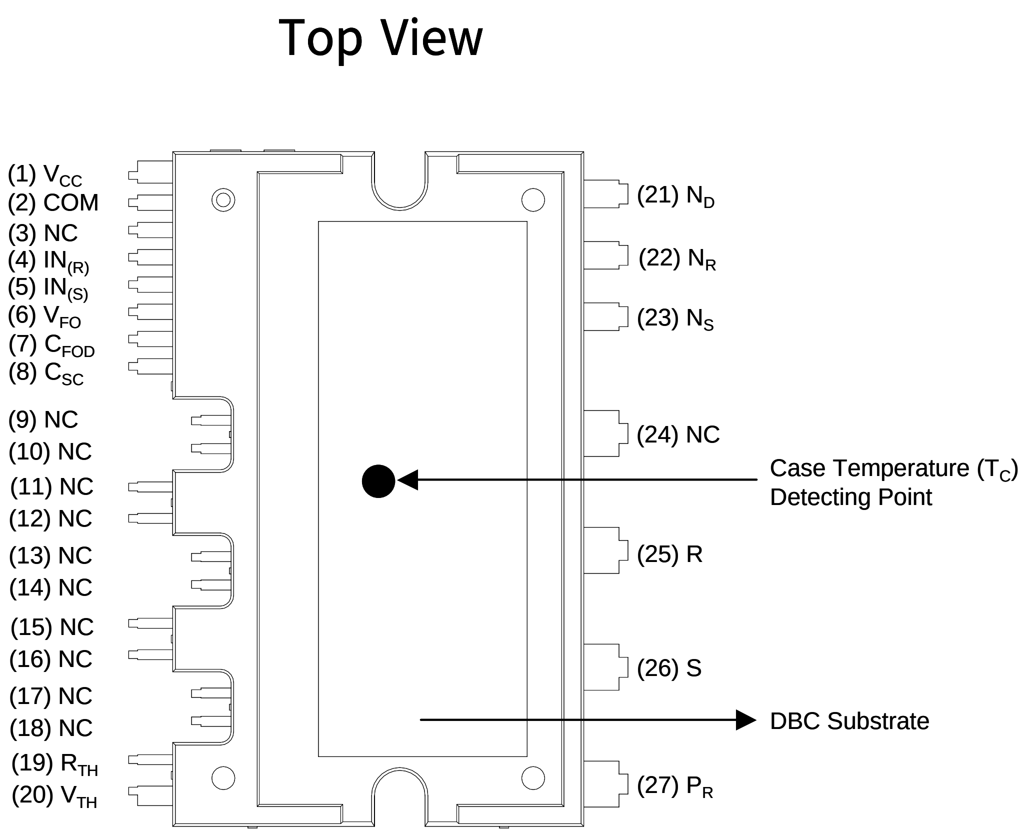
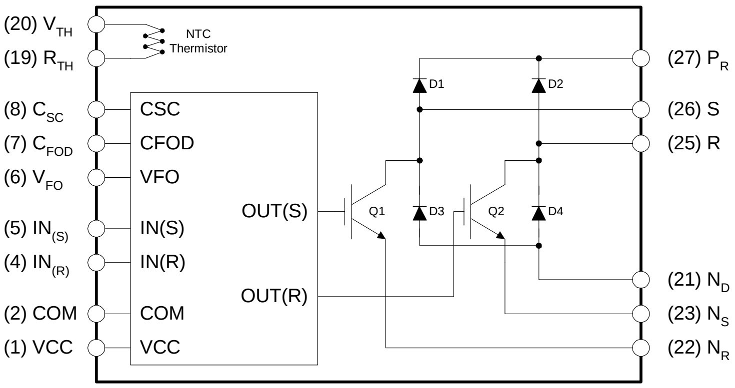


Figure 2.

Pin Descriptions

Pin Number	Pin Name	Pin Description
1	V_{CC}	Common Bias Voltage for IC
2	COM	Common Supply Ground
3	NC	Dummy Pin
4	$IN_{(R)}$	Signal Input for R-phase IGBT
5	$IN_{(S)}$	Signal Input for 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 Short-Current Detection
9	NC	Dummy Pin
10	NC	Dummy Pin
11	NC	Dummy Pin
12	NC	Dummy Pin
13	NC	Dummy Pin
14	NC	Dummy Pin
15	NC	Dummy Pin
16	NC	Dummy Pin
17	NC	Dummy Pin
18	NC	Dummy Pin
19	$R_{(TH)}$	Series Resistor for the Use of Thermistor (Temperature Detection)
20	$V_{(TH)}$	Thermistor Bias Voltage
21	N_D	Negative DC–Link of Rectifier Diode
22	N_R	Negative DC–Link of R-phase IGBT
23	N_S	Negative DC–Link of S-phase IGBT
24	NC	Dummy Pin
25	R	AC Input for R Phase
26	S	AC Input for S Phase
27	P_R	Positive DC–Link Output

Internal Equivalent Circuit and Input/Output Pins



Note:

The low-side is composed of two IGBTs including rectifying diodes for each IGBT and one control IC which has gate driving, current sensing and protection functions. The high-side is composed of two rectifying diodes without gate driving IC.

Figure 3.

Absolute Maximum Ratings (T_J = 25°C, Unless Otherwise Specified)

Converter Part

Symbol	Parameter	Conditions	Rating	Units
V_i	Input Supply Voltage	Applied between R-S	276	V
$V_{i(Surge)}$	Input Supply Voltage (Surge)	Applied between R-S	500	V
V_{PN}	Output Voltage	Applied between P-N	400	V
$V_{PN(surge)}$	Output Voltage (Surge)	Applied between P-N	500	V
V_{CES}	Collector-emitter Voltage	IGBT	600	V
V_{RRM}	Repetitive Peak Reverse Voltage	Diode	600	V
I_i	Input Current (100% Load)	$T_C \le 90$°C, V_O = 280V, f_{PWM} = 60Hz	11	A_{RMS}
I_i	Input Current (130% Load)	$T_C \le 90$°C, V_O = 280V, f_{PWM} = 60Hz	14	A_{RMS}
T_J	Operating Junction Temperature	(Note 1)	-20 ~ 125	°C

Note:

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

Control Part

Symbol	Parameter	Conditions	Rating	Units
V_{CC}	Control Supply Voltage	Applied between V_{CC} - COM	20	V
V_{IN}	Input Signal Voltage	Applied between $IN_{(R)}$, $IN_{(S)}$ - 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	Parameter	Conditions	Rating	Units
T_C	Module Case Operation Temperature	-20°C < T_J < 125°C, See Fig.2	-20 ~ 100	°C
T_{STG}	Storage Temperature		-40 ~ 125	°C
V_{ISO}	Isolation Voltage	60Hz, Sinusoidal, AC 1 minute, Connection Pins to DBC	2500	V_{rms}

Absolute Maximum Ratings

Thermal Resistance

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Units
$R_{th(j-c)Q}$	Junction to Case Thermal Resistance	Each IGBT under Operating Condition	-	-	2.8	°C/W
$R_{th(j-c)D}$		Each Diode under Operating Condition	-	-	2.6	°C/W

Note:

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

Electrical Characteristics (T_J = 25°C, Unless Otherwise Specified)

Main Circuit Part

Symbol	Item	Conditions		Min.	Typ.	Max.	Units
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage	V_{CC} = V_{BS} =15V V_{IN} = 5V	I_C = 6.5A, T_J = 25°C	-	2.1	2.6	V
V_{FM}	Diode Forward Voltage	V_{IN} = 0V	I_C = 20A, T_J = 25°C	-	1.1	1.5	V
t_{ON}	Switching Times	V_{PN} = 300V, V_{CC} = V_{BS} = 15V I_C = 6.5A V_{IN} = 0V ↔ 5V, Inductive Load (Note 3)		-	0.48	-	μs
$t_{C(ON)}$				-	0.85	-	μs
t_{OFF}				-	0.56	-	μs
$t_{C(OFF)}$				-	0.10	-	μs
t_{rr}				-	1.35	-	μs
I_{CES}	Collector - Emitter Leakage Current	V_{CE} = V_{CES}		-	-	250	μA
I_R	Diode Leakage Current	V_R = V_{RRM}		-	-	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 Figure 4.

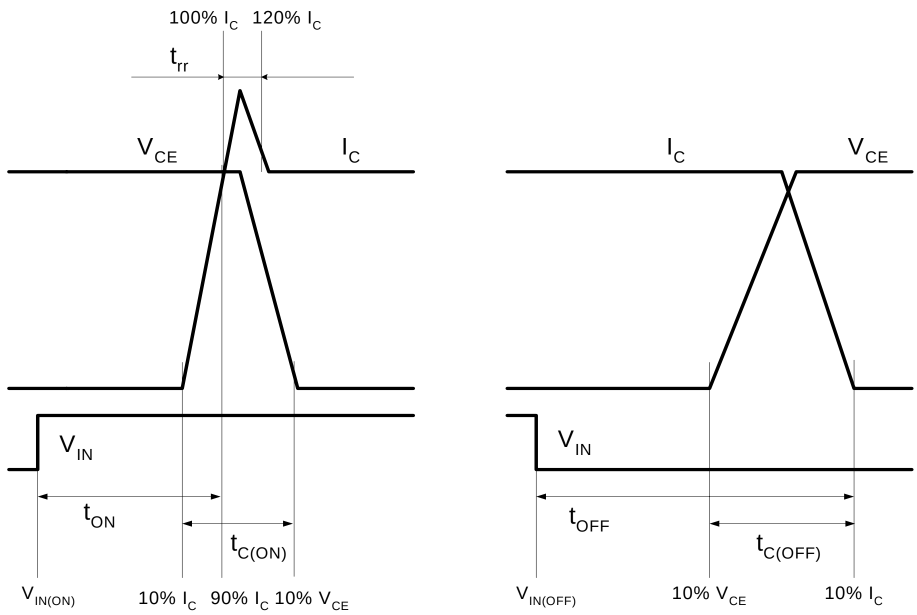


Figure 4. Switching Time Definition

Electrical Characteristics (T_J = 25°C, Unless Otherwise Specified)

Control Part

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Units
I_{QCCL}	Quiescent V_{CC} Supply Current	V_{CC} = 15V $IN_{(L)}$ = 0V	$V_{CC(L)}$ - COM	-	-	23	mA
V_{FOH}	Fault Output Voltage	V_{SC} = 0V, V_{FO} Circuit: 4.7kΩ to 5V Pull-up		4.5	-	-	V
V_{FOL}		V_{SC} = 1V, V_{FO} Circuit: 4.7kΩ to 5V Pull-up		-	-	0.8	V
$V_{SC(ref)}$	Short Circuit Trip Level	V_{CC} = 15V (Note 4)		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} = 33nF (Note 5)		1.0	1.8	-	ms
$V_{IN(ON)}$	ON Threshold Voltage	Applied between $IN_{(R)}$, $IN_{(S)}$ - COM		3.0	-	-	V
$V_{IN(OFF)}$	OFF Threshold Voltage			-	-	0.8	V
R_{TH}	Resistance of Thermistor	@ T_C = 25°C (Note Fig. 10)		-	50	-	kΩ
		@ T_C = 80°C (Note Fig. 10)		-	5.76	-	kΩ

Note:

4. Over current protection is functioning only for the low-side IGBT.

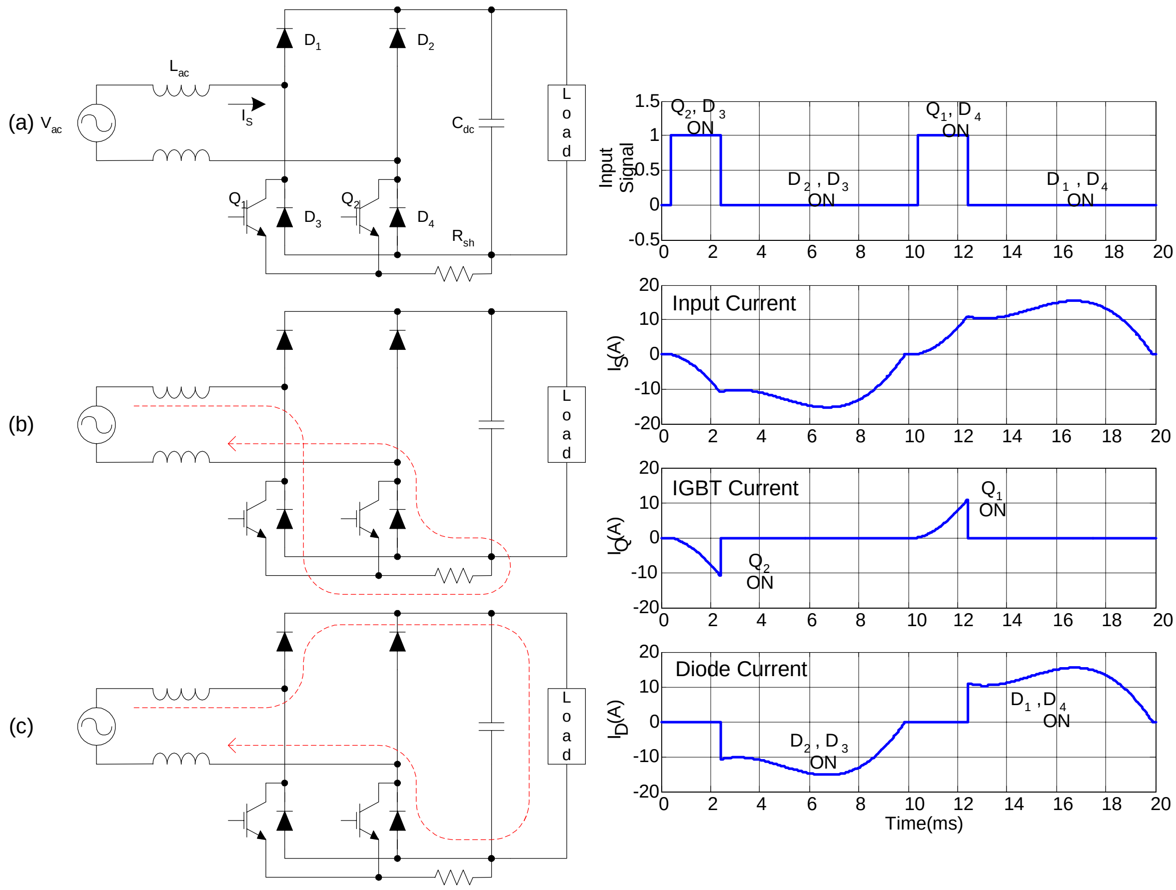
5. The fault-out pulse width t_{FOD} depends on the capacitance value of C_{FOD} according to the following approximate equation : $C_{FOD} = 18.3 \times 10^{-6} \times t_{FOD}$[F]

Recommended Operating Conditions

Symbol	Parameter	Condition	Value			Units
			Min.	Typ.	Max.	
V_i	Input Supply Voltage	Applied between R - S	187	-	276	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
f_{PWM}	PWM Input Signal	$T_C \leq 100°C$, $T_J \leq 125°C$, Per IGBT (Note 6)	-	60	-	Hz

Note:

6. Regarding the switching method of FSAB20PH60, it follows the control method of the typical partial-switching power factor correction circuit as shown in Figure 5.



Note:

Depending on the polarity of input voltage V_{ac}, Q_1 or Q_2 is turned on at the zero crossing point of input voltage, and turned off considering the output power and distortion of input current. Each IGBT turns on with zero current with the utility frequency, 50 or 60Hz.

Figure 5. PWM Example of FSAB20PH60

Mechanical Characteristics and Ratings

Parameter	Conditions		Limits			Units
			Min.	Typ.	Max.	
Mounting Torque	Mounting Screw: M3	Recommended 0.62Nm	0.51	0.62	0.72	N•m
Heatsink Flatness		Note Fig. 6	0	-	120	um
Weight			-	15.00	-	g

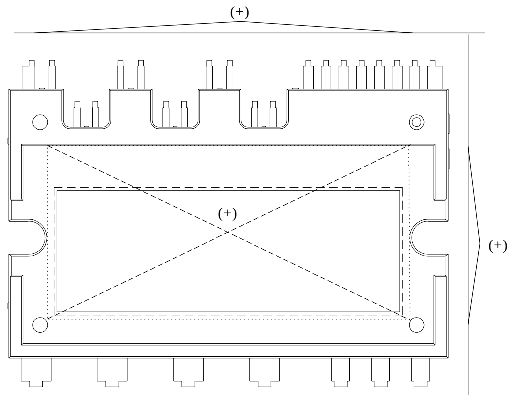
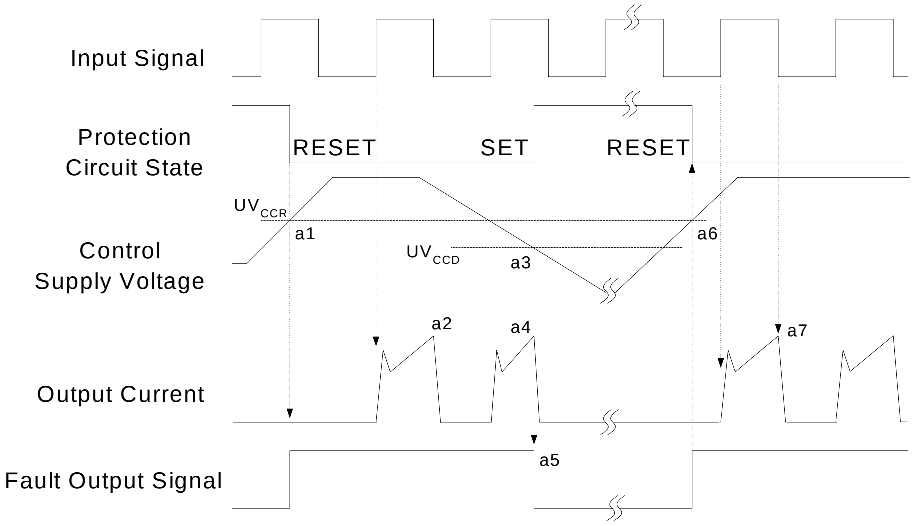


Figure 6. Flatness Measurement Position

Time Charts of SPMs Protective Function



a1 : Control supply voltage rises: After the voltage rises UV_{CCR}, the circuits start to operate when next input is applied.

a2 : Normal operation: IGBT ON and carrying current.

a3 : Under voltage detection (UV_{CCD}).

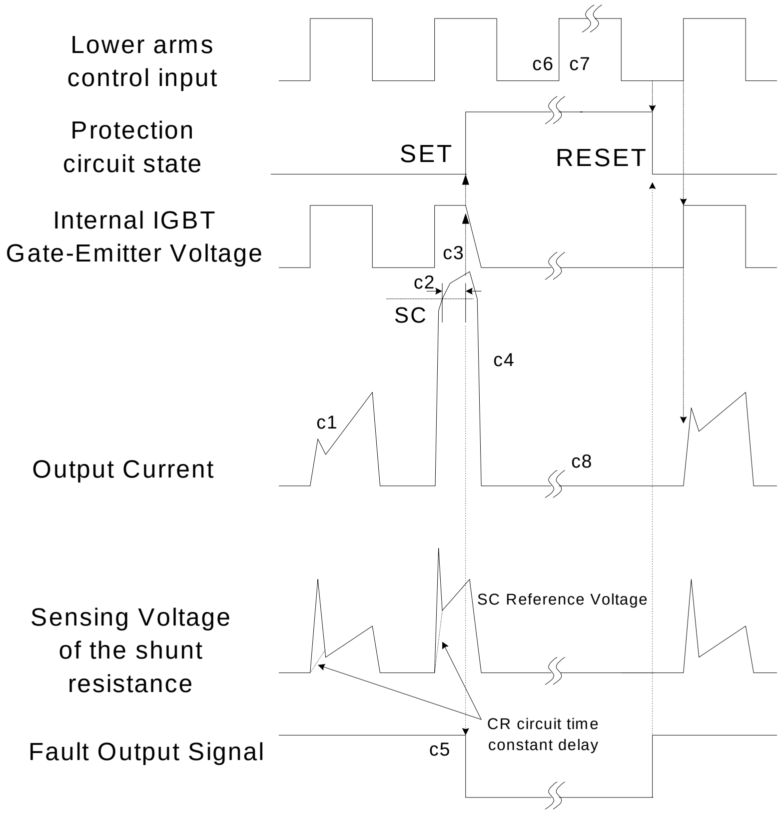
a4 : IGBT OFF in spite of control input condition.

a5 : Fault output operation starts.

a6 : Under voltage reset (UV_{CCR}).

a7 : Normal operation: IGBT ON and carrying current.

Figure 7. Under-Voltage Protection



(with the external shunt resistance and CR connection)

c1 : Normal operation: IGBT ON and carrying current.

c2 : Short circuit current detection (SC trigger).

c3 : Hard IGBT gate interrupt.

c4 : IGBT turns OFF.

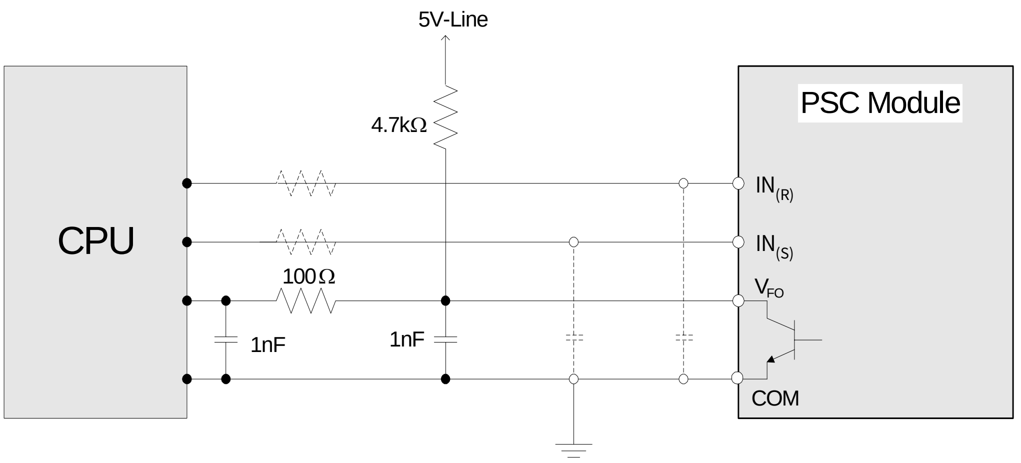
c5 : Fault output timer operation starts: The pulse width of the fault output signal is set by the external capacitor C_{FO}.

c6 : Input “L” : IGBT OFF state.

c7 : Input “H”: IGBT ON state, but during the active period of fault output the IGBT doesn’t turn ON.

c8 : IGBT OFF state

Figure 8. Over Current Protection



Note:

1. RC coupling at each input (parts shown dotted) might change depending on the PWM control scheme used in the application and the wiring impedance of the application's printed circuit board. The SPM input signal section integrates 3.3kΩ (typ.) pull-down resistor. Therefore, when using an external filtering resistor, please pay attention to the signal voltage drop at input terminal.
2. The logic input is compatible with standard CMOS or LSTTL outputs.

Figure 9. Recommended CPU I/O Interface Circuit

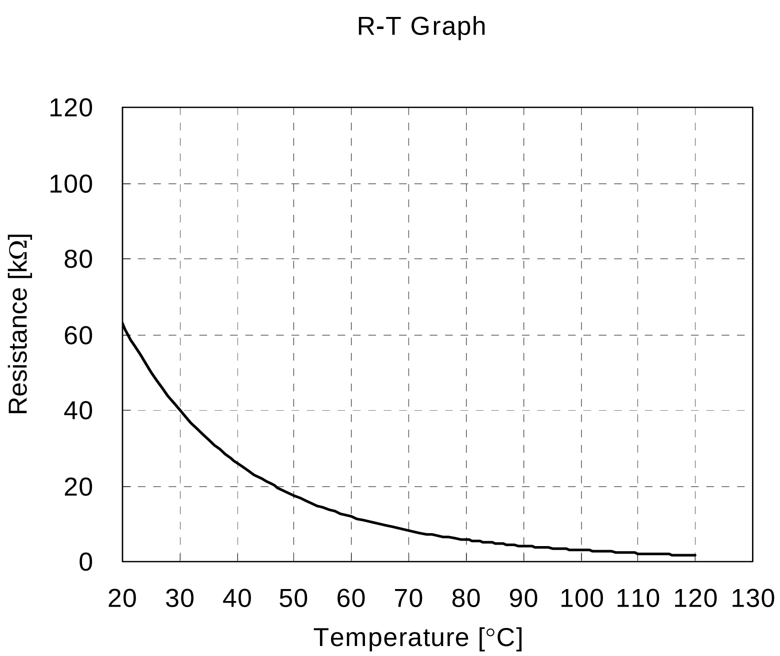
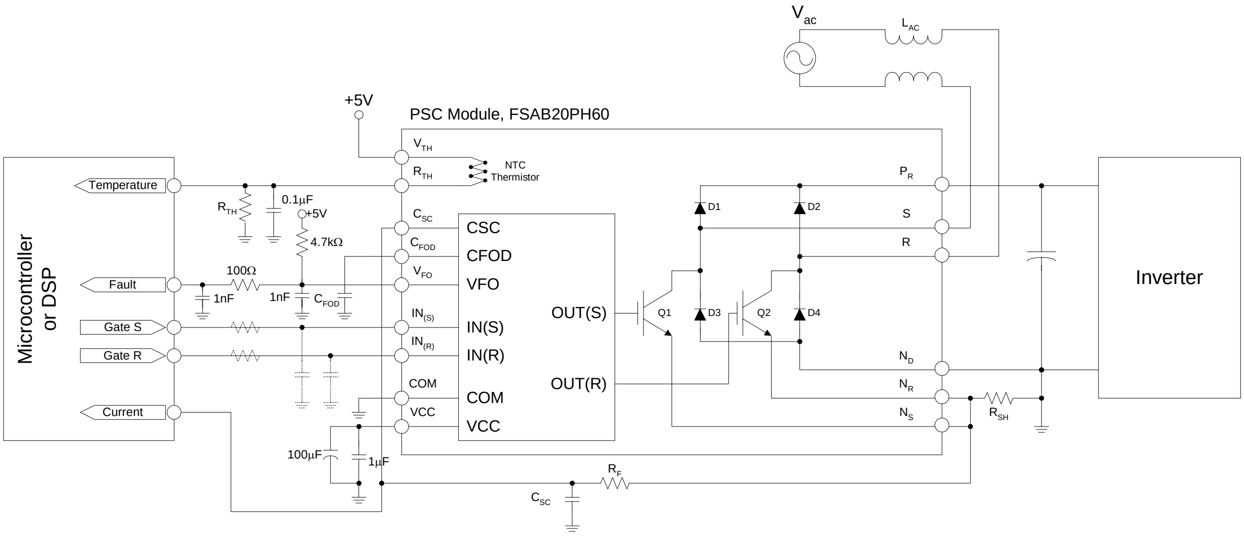


Figure 10. R-T Curve of the Built-in Thermistor

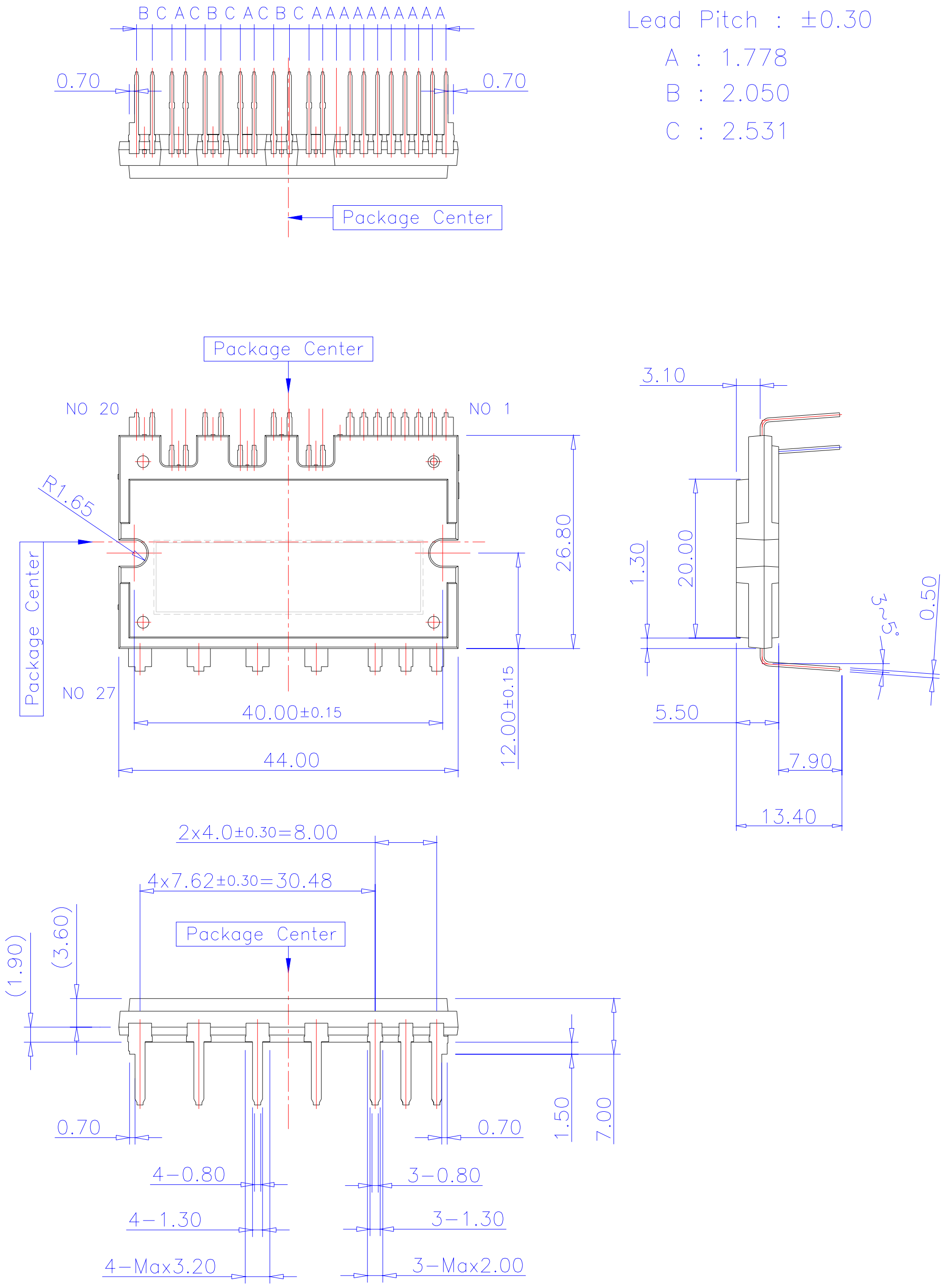


Note:

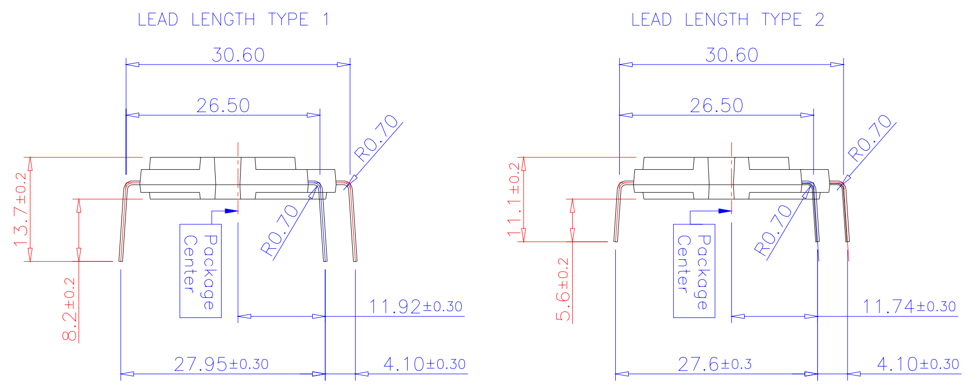
1. To avoid malfunction, the wiring of each input should be as short as possible. (less than 2-3cm)
2. V_{FO} output is open collector type. This signal line should be pulled up to the positive side of the 5V power supply with approximately 4.7kΩ resistance. Please refer to Figure 9.
3. V_{FO} output pulse width should be determined by connecting an external capacitor(C_{FOD}) between C_{FOD}(pin7) and COM(pin2). (Example : if C_{FOD} = 33 nF, then t_{FO} = 1.8ms (typ.)) Please refer to the note 6 for calculation method.
4. Input signal is High-Active type. There is a 3.3kΩ resistor inside the IC to pull down each input signal line to GND. When employing RC coupling circuits, set up such RC couple that input signal agree with turn-off/turn-on threshold voltage.
5. To prevent errors of the protection function, the wiring around R_{SC}, R_F and C_{SC} should be as short as possible.
6. In the over current protection circuit, please select the R_FC_{SC} time constant in the range 3~4 µs.
7. Each capacitors should be mounted as close to the pins as possible.
8. Relays are used at almost every systems of electrical equipments of home appliances. In these cases, there should be sufficient distance between the CPU and the relays.
9. Internal NTC thermistor can be used for monitoring the case temperature and protecting the device from the overheating operation. Please select an appropriate resistor R_{TH} according to the application. For example, use R_{TH}=4.7kΩ that will make the voltage across RTH to be 2.5V at 85°C of the case temperature.
10. This PSC module is not designed for the internal IGBT to be turned on when the current is flowing through the input reactor L_{AC}. Otherwise, there will be large reverse recovery current that makes considerably large turn-on switching loss of IGBT, which may destroy the internal IGBTs.
11. Please use an appropriate shunt resistor R_{SH} to protect the intenal IGBT from the overcurrent operation. For example, if the IGBT current has to be protected below 25A, then use 20mΩ resistor of R_{SH}. When selecting protecting current level, please consider the variation and tolerance of external components. Moreover, the shunt resistor path from N_R and N_S to N_D and ground that is connected to COM of the internal drive IC, should be thick and short in order to minimize the stray inductance that may generate improper switching of the module.

Figure 11. Application Circuit

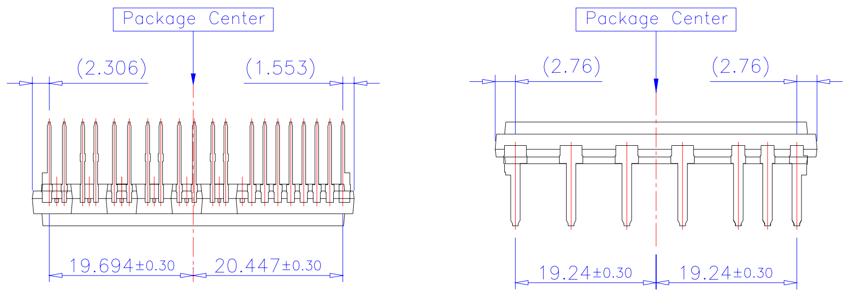
Detailed Package Outline Drawings



Detailed Package Outline Drawings (Continued)

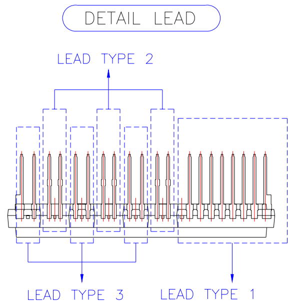


Lead Forming Dimension

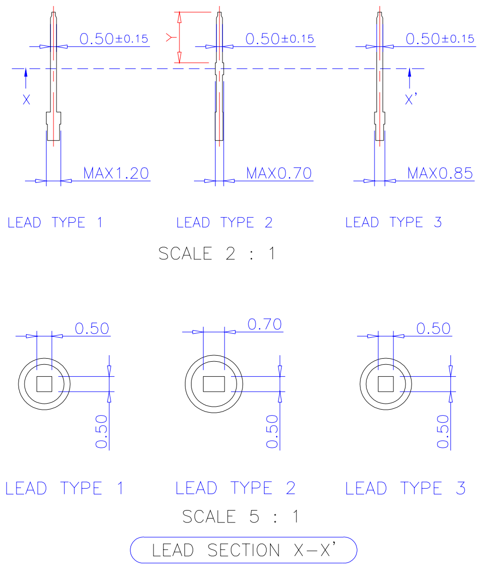


PKG Center to Lead Distance

Detailed Package Outline Drawings (Continued)



	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



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