

# 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.

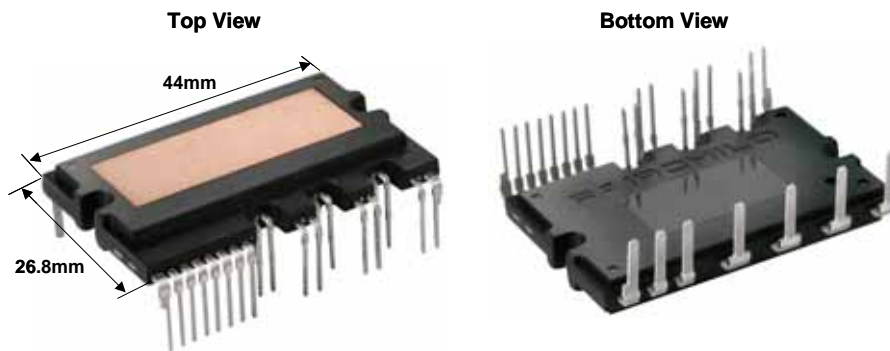


Figure 1.

### 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

#### Top View

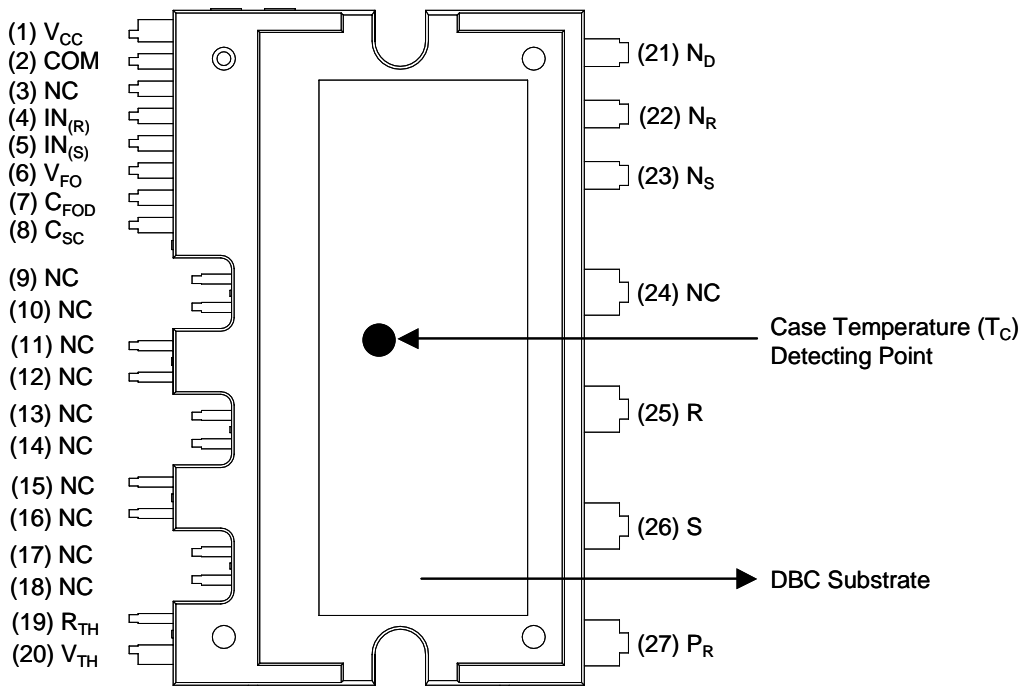
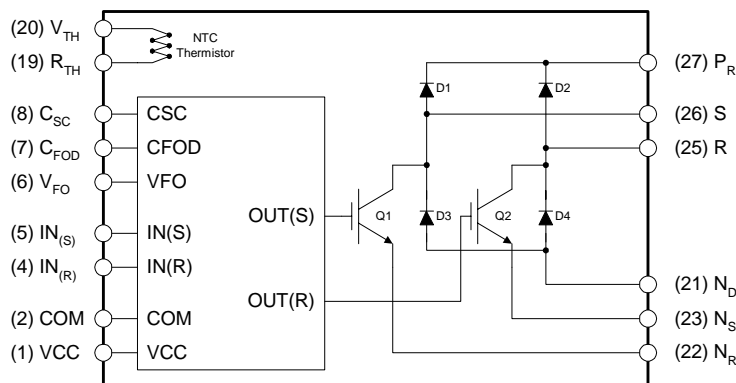


Figure 2.

### Pin Descriptions

| Pin Number | Pin Name          | Pin Description   |
|------------|-------------------|---|
| 1          | V <sub>CC</sub>   | Common Bias Voltage for IC  |
| 2          | COM               | Common Supply Ground  |
| 3          | NC                | Dummy Pin   |
| 4          | IN <sub>(R)</sub> | Signal Input for R-phase IGBT                                     |
| 5          | IN <sub>(S)</sub> | Signal Input for 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 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 <sub>(TH)</sub> | Series Resistor for the Use of Thermistor (Temperature Detection) |
| 20         | V <sub>(TH)</sub> | Thermistor Bias Voltage   |
| 21         | N <sub>D</sub>    | Negative DC-Link of Rectifier Diode                               |
| 22         | N <sub>R</sub>    | Negative DC-Link of R-phase IGBT                                  |
| 23         | N <sub>S</sub>    | 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 <sub>R</sub>    | 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 ( $T_J = 25^\circ\text{C}$ , Unless Otherwise Specified)

#### Converter Part

| Symbol                 | Parameter                       | Conditions  | Rating    | Units            |
|------------------------|---------------------------------|---|-----------|------------------|
| $V_i$                  | Input Supply Voltage            | Applied between R-S   | 276       | V                |
| $V_{i(\text{Surge})}$  | Input Supply Voltage (Surge)    | Applied between R-S   | 500       | V                |
| $V_{PN}$               | Output Voltage                  | Applied between P-N   | 400       | V                |
| $V_{PN(\text{surge})}$ | 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)       | $T_C \leq 90^\circ\text{C}$ , $V_O = 280\text{V}$ , $f_{PWM} = 60\text{Hz}$ | 11        | $A_{RMS}$        |
| $I_i$                  | Input Current (130% Load)       | $T_C \leq 90^\circ\text{C}$ , $V_O = 280\text{V}$ , $f_{PWM} = 60\text{Hz}$ | 14        | $A_{RMS}$        |
| $T_J$                  | Operating Junction Temperature  | (Note 1)  | -20 ~ 125 | $^\circ\text{C}$ |

**Note:**

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

#### 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 | $-0.3 \sim V_{CC} + 0.3$ | V     |
| $V_{FO}$ | Fault Output Supply Voltage   | Applied between $V_{FO}$ - COM                | $-0.3 \sim V_{CC} + 0.3$ | 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                | $-0.3 \sim V_{CC} + 0.3$ | V     |

#### Total System

| Symbol    | Parameter                         | Conditions  | Rating    | Units            |
|-----------|-----------------------------------|---|-----------|------------------|
| $T_C$     | Module Case Operation Temperature | $-20^\circ\text{C} < T_J < 125^\circ\text{C}$ , See Fig.2 | -20 ~ 100 | $^\circ\text{C}$ |
| $T_{STG}$ | Storage Temperature               |   | -40 ~ 125 | $^\circ\text{C}$ |
| $V_{ISO}$ | 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  | $^{\circ}C/W$ |
| $R_{th(j-c)D}$ |                                     | Each Diode under Operating Condition | -    | -    | 2.6  | $^{\circ}C/W$ |

**Note:**

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

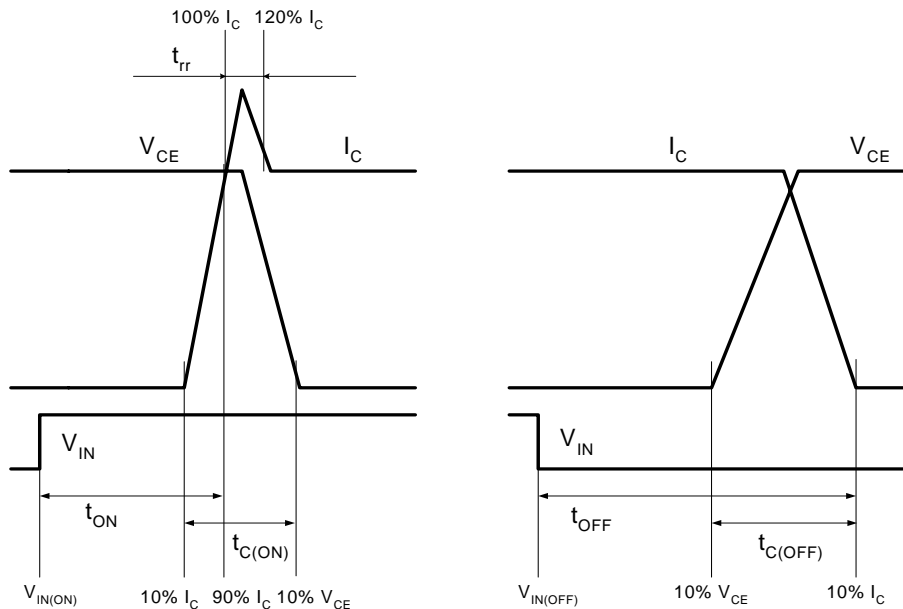
### Electrical Characteristics ( $T_J = 25^{\circ}C$ , Unless Otherwise Specified)

#### Main Circuit Part

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

**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 Figure 4.



**Figure 4. Switching Time Definition**

## Electrical Characteristics (T<sub>J</sub> = 25°C, Unless Otherwise Specified)

### Control Part

| Symbol               | Parameter                                | Conditions   | Min. | Typ. | Max. | Units |
|----------------------|--|--|------|------|------|-------|
| I <sub>QCCL</sub>    | Quiescent V <sub>CC</sub> Supply Current | V <sub>CC</sub> = 15V<br>I <sub>N(L)</sub> = 0V                    | -    | -    | 23   | mA    |
| V <sub>FOH</sub>     | Fault Output Voltage                     | V <sub>SC</sub> = 0V, V <sub>FO</sub> Circuit: 4.7kΩ to 5V Pull-up | 4.5  | -    | -    | V     |
| V <sub>FOL</sub>     |  | V <sub>SC</sub> = 1V, V <sub>FO</sub> Circuit: 4.7kΩ to 5V Pull-up | -    | -    | 0.8  | V     |
| V <sub>SC(ref)</sub> | Short Circuit Trip Level                 | V <sub>CC</sub> = 15V (Note 4)                                     | 0.45 | 0.5  | 0.55 | V     |
| UV <sub>CCD</sub>    | Supply Circuit Under-Voltage Protection  | Detection Level  | 10.7 | 11.9 | 13.0 | V     |
| UV <sub>CCR</sub>    |  | Reset Level  | 11.2 | 12.4 | 13.2 | V     |
| t <sub>FOD</sub>     | Fault-out Pulse Width                    | C <sub>FOD</sub> = 33nF (Note 5)                                   | 1.0  | 1.8  | -    | ms    |
| V <sub>IN(ON)</sub>  | ON Threshold Voltage                     | Applied between I <sub>N(R)</sub> , I <sub>N(S)</sub> - COM        | 3.0  | -    | -    | V     |
| V <sub>IN(OFF)</sub> | OFF Threshold Voltage                    |  | -    | -    | 0.8  | V     |
| R <sub>TH</sub>      | Resistance of Thermistor                 | @ T <sub>C</sub> = 25°C (Note Fig. 10)                             | -    | 50   | -    | kΩ    |
|                      |  | @ T <sub>C</sub> = 80°C (Note Fig. 10)                             | -    | 5.76 | -    | kΩ    |

**Note:**

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

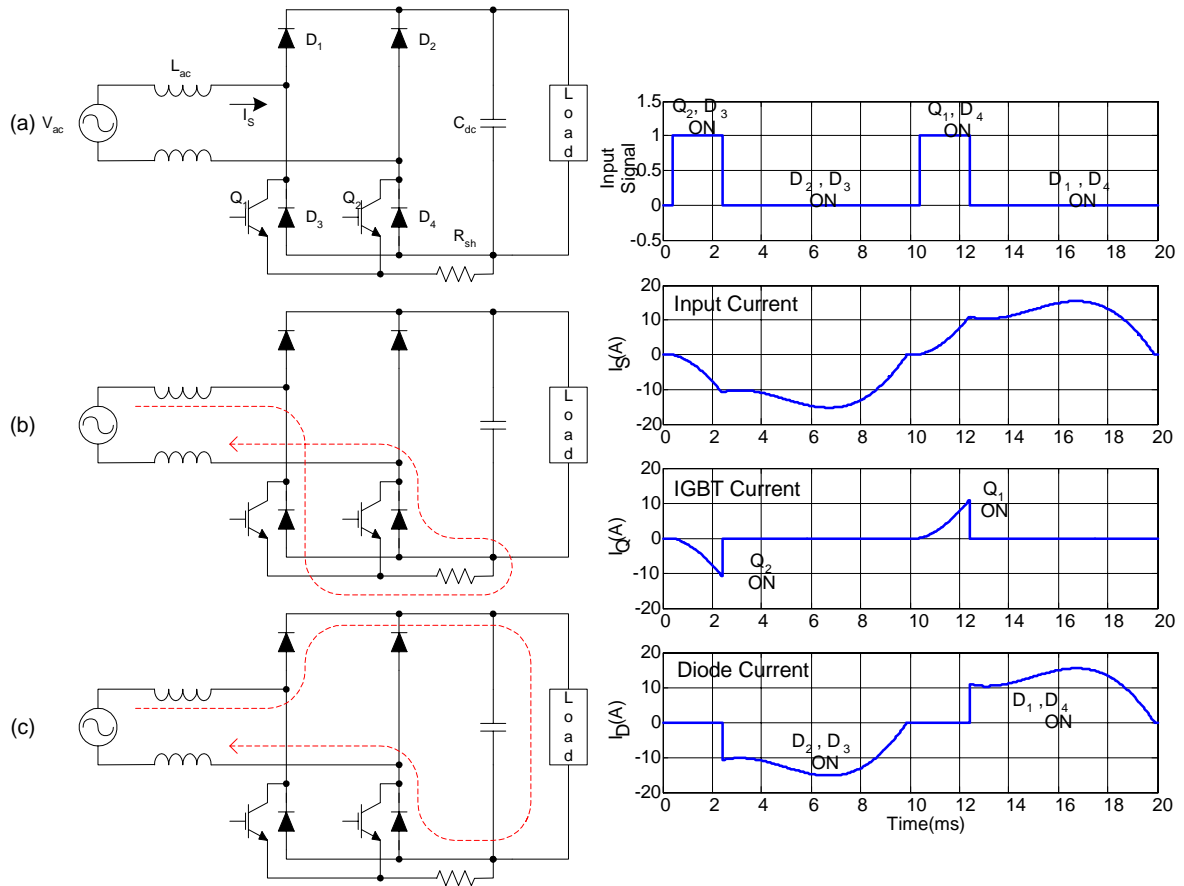
5. The fault-out pulse width t<sub>FOD</sub> depends on the capacitance value of C<sub>FOD</sub> according to the following approximate equation : C<sub>FOD</sub> = 18.3 × 10<sup>-6</sup> × t<sub>FOD</sub>[F]

### Recommended Operating Conditions

| Symbol           | Parameter              | Condition   | Value |      |      | Units            |
|------------------|------------------------|---|-------|------|------|------------------|
|                  |                        |   | Min.  | Typ. | Max. |                  |
| V <sub>i</sub>   | Input Supply Voltage   | Applied between R - S   | 187   | -    | 276  | V <sub>rms</sub> |
| V <sub>PN</sub>  | Output Voltage         | Applied between P - N   | -     | 280  | 400  | V                |
| V <sub>CC</sub>  | Control Supply Voltage | Applied between V <sub>CC</sub> - COM                             | 13.5  | 15   | 16.5 | V                |
| f <sub>PWM</sub> | PWM Input Signal       | T <sub>C</sub> ≤ 100°C, T <sub>J</sub> ≤ 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.



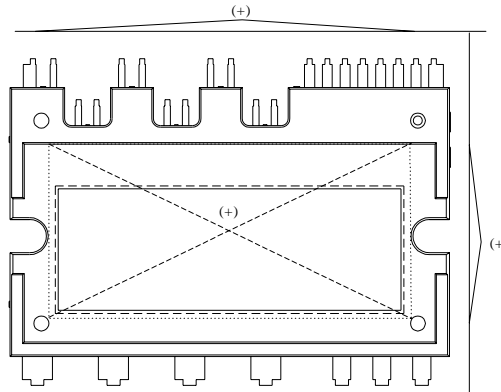
**Note:**

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

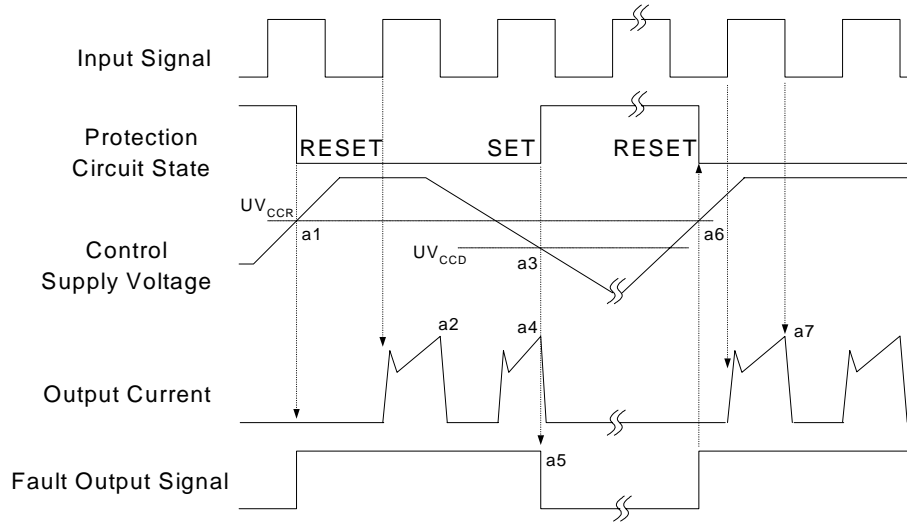
| Parameter         | Conditions         |                    | Limits |       |      | Units |
|-------------------|--------------------|--------------------|--------|-------|------|-------|
|                   |                    |                    | Min.   | Typ.  | Max. |       |
| Mounting Torque   | 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**

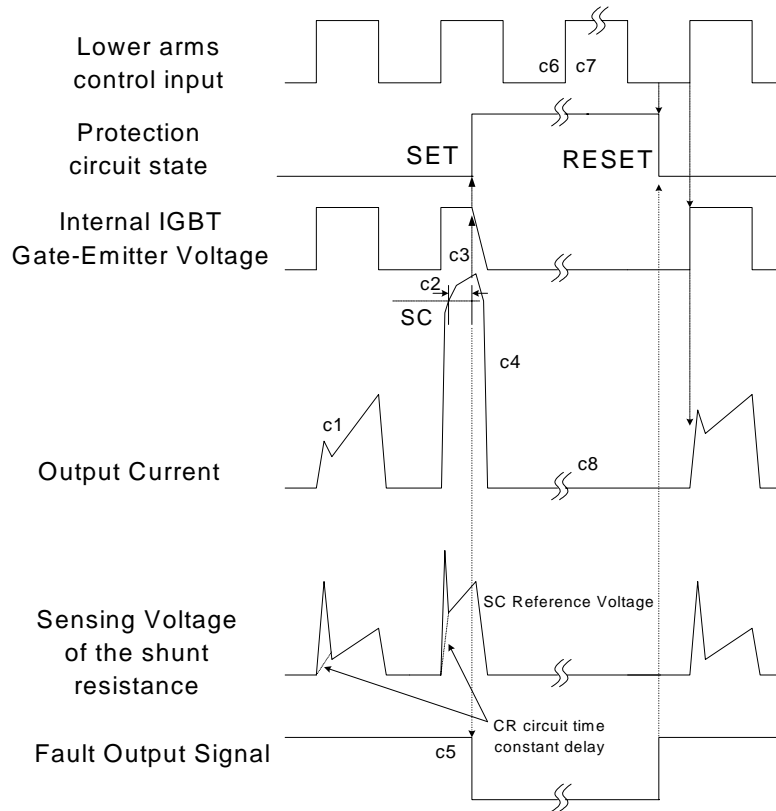


### Time Charts of SPMs Protective Function



- 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.

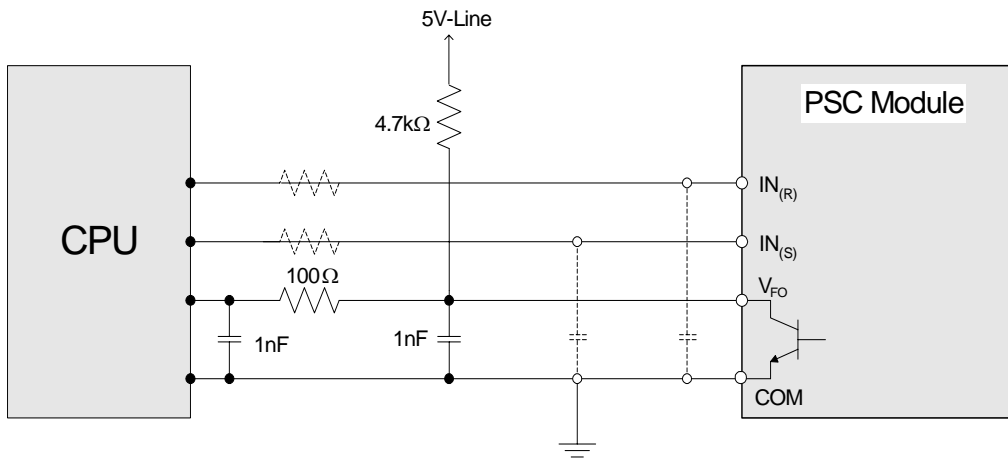
**Figure 7. Under-Voltage Protection**



(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**

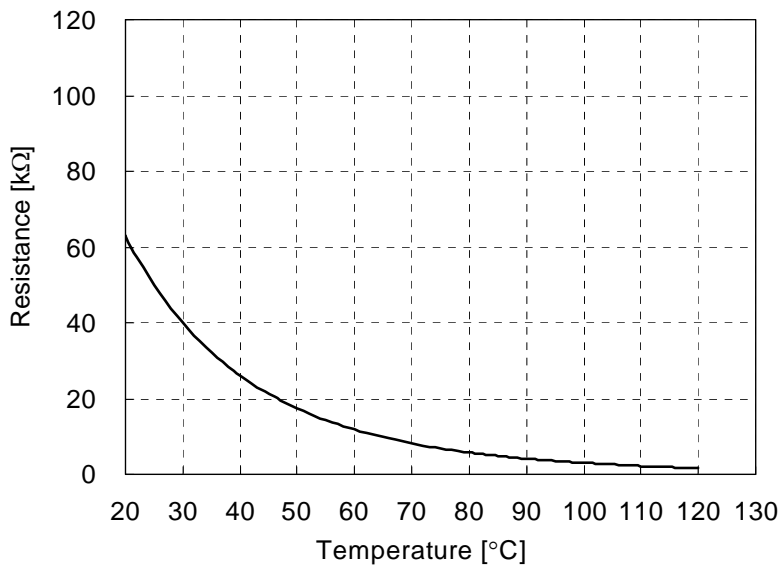


**Note:**

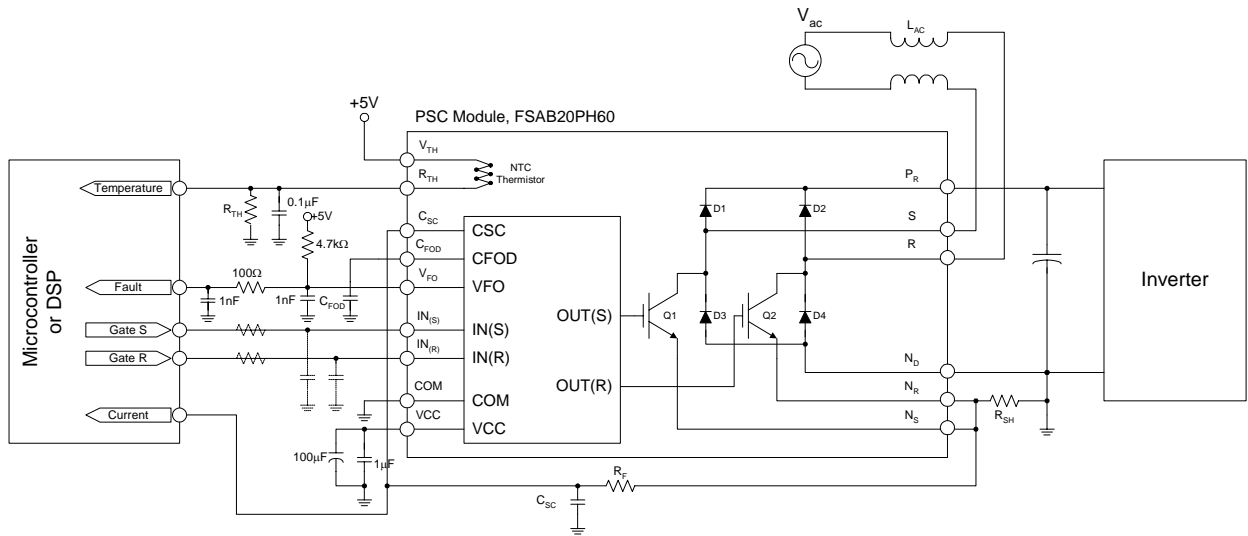
1. RC coupling at each input (parts shown dotted) might change depending on the PWM control scheme used in the application and the wiring impedance of the application's printed circuit board. The SPM input signal section integrates 3.3kΩ (typ.) pull-down resistor. Therefore, when using an external filtering 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**

**R-T Graph**



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

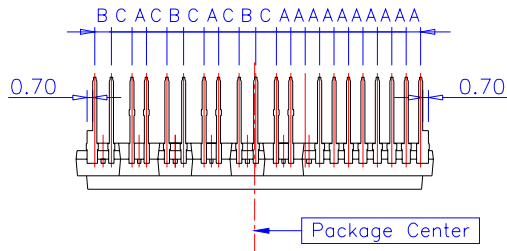


**Note:**

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 4.7k $\Omega$  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  $t_{FO} = 1.8$ ms (typ.)) Please refer to the note 6 for calculation method.
4. Input signal is High-Active type. There is a 3.3k $\Omega$  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  $R_F C_{SC}$  time constant in the range 3-4  $\mu$ s.
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  $R_{TH}=4.7k\Omega$  that will make the voltage across  $R_{TH}$  to be 2.5V at 85 $^{\circ}$ 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 internal IGBT from the overcurrent operation. For example, if the IGBT current has to be protected below 25A, then use 20m $\Omega$  resistor of  $R_{SH}$ . When selecting protecting current level, please consider the variation and tolerance of external components. Moreover, the shunt resistor path from  $N_P$  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

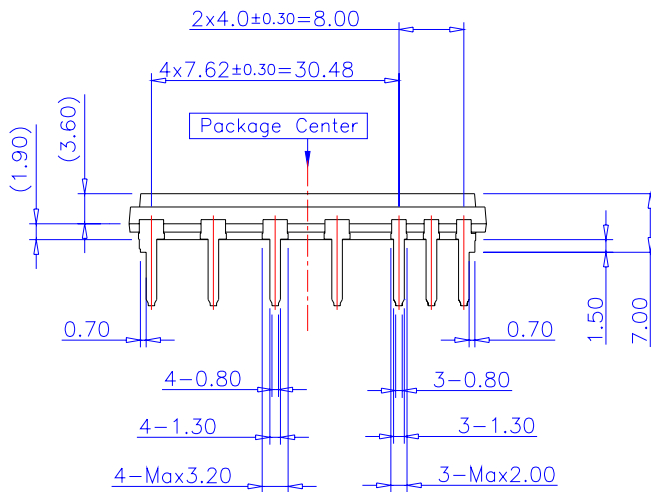
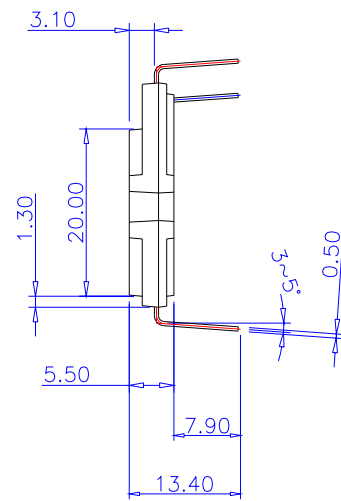
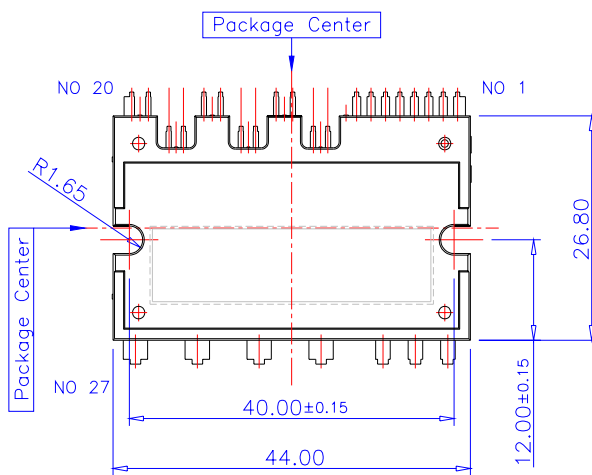


Lead Pitch :  $\pm 0.30$

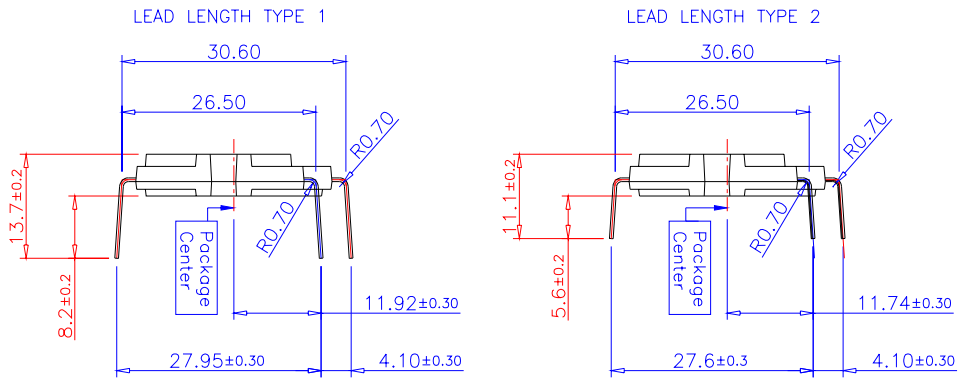
A : 1.778

B : 2.050

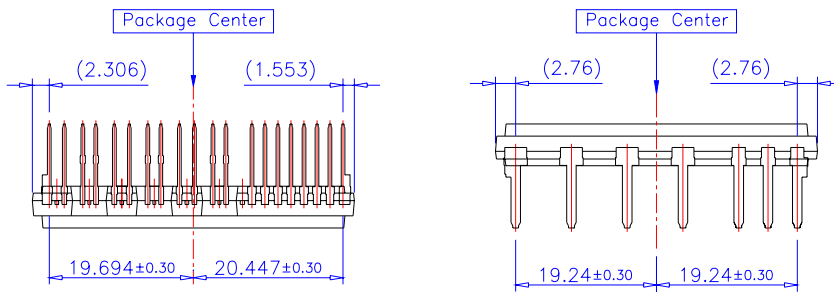
C : 2.531



Detailed Package Outline Drawings (Continued)

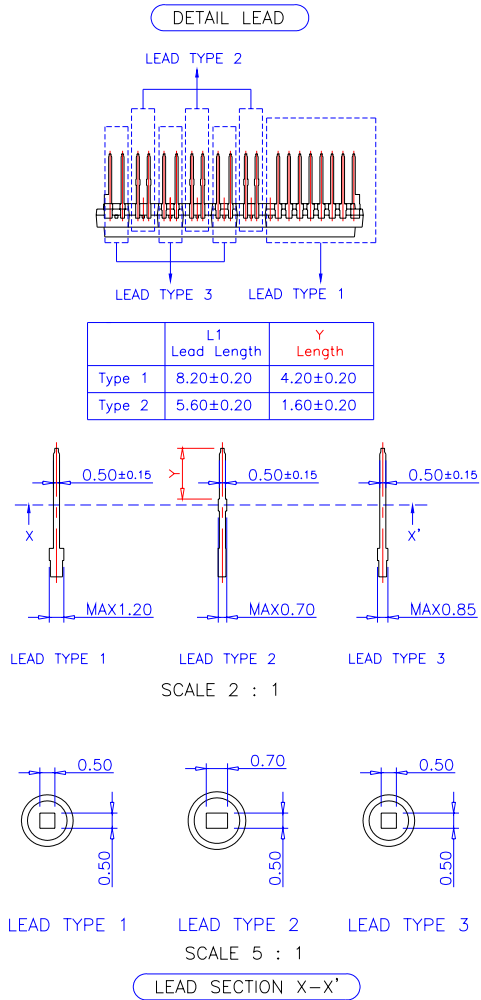


Lead Forming Dimension



PKG Center to Lead Distance

Detailed Package Outline Drawings (Continued)



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| Bottomless™                          | FPS™                | LittleFET™    | PowerEdge™          | SuperFET™       |
| CoolFET™                             | FRFET™              | MICROCOUPLER™ | PowerSaver™         | SuperSOT™-3     |
| CROSSVOLT™                           | GlobalOptoisolator™ | MicroFET™     | PowerTrench®        | SuperSOT™-6     |
| DOMET™                               | GTO™                | MicroPak™     | QFET®               | SuperSOT™-8     |
| EcoSPARK™                            | HiSeC™              | MICROWIRE™    | QS™                 | SyncFET™        |
| E <sup>2</sup> C MOS™                | I <sup>2</sup> C™   | MSX™          | QT Optoelectronics™ | TinyLogic®      |
| EnSigna™                             | i-Lo™               | MSXPro™       | Quiet Series™       | TINYOPTO™       |
| FACT™                                | ImpliedDisconnect™  | OCX™          | RapidConfigure™     | TruTranslation™ |
| FACT Quiet Series™                   |                     | OCXPro™       | RapidConnect™       | UHC™            |
| Across the board. Around the world.™ |                     | OPTOLOGIC®    | μSerDes™            | UltraFET®       |
| The Power Franchise®                 |                     | OPTOPLANAR™   | SILENT SWITCHER®    | UniFET™         |
| Programmable Active Droop™           |                     | PACMAN™       | SMART START™        | VCX™            |

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|--------------------------|------------------------|---|
| Advance Information      | Formative or In Design | This datasheet contains the design specifications for product development. Specifications may change in any manner without notice.  |
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