

# FBA42060

## PFC SPM® 45 Series for Single-Phase Boost PFC

### Features

- UL Certified No. E209204 (UL1557)
- 600 V - 20 A Single-Phase Boost PFC with Integral Gate Driver and Protection
- Low Thermal Resistance Using Ceramic Substrate
- Full-Wave Bridge Rectifier and High-Performance Output Diode
- Optimized for 20kHz Switching Frequency
- Built-in NTC Thermistor for Temperature Monitoring
- Isolation Rating: 2000 Vrms/min.

### Applications

- Single-Phase Boost PFC Converter

### Related Source

- [AN-9091 - Boost PFC Inductor Design Guide](#)
- [AN-9072 - Motion SPM® 45 Series Mounting Guidance](#)

### General Description

The FBA42060 is an advanced PFC SPM® 45 module providing a fully-featured, high-performance Boost PFC (Power Factor Correction) input power stage for consumer, medical, and industrial applications. These modules integrate optimized gate drive of the built-in IGBT to minimize EMI and losses, while also providing multiple on-module protection features including under-voltage lockout, over-current shutdown, thermal monitoring, and fault reporting. These modules also feature a full-wave rectifier and high-performance output diode for additional space savings and mounting convenience.



Figure 1. Package Overview

### Package Marking & Ordering Information

Device	Device Marking	Package	Packing Type	Quantity
FBA42060	FBA42060	SPMAA-F26	Rail	12

## Integrated Drive, Protection and System Control Functions

- For IGBTs: gate drive circuit, Over-Current Protection (OCP), control supply circuit Under-Voltage Lock-Out (UVLO) Protection
- Fault signal: corresponding to OC and UV fault
- Built-in NTC thermistor: temperature monitoring
- Input interface: active-HIGH interface, works with 3.3 / 5 V logic, Schmitt trigger input

## Pin Configuration

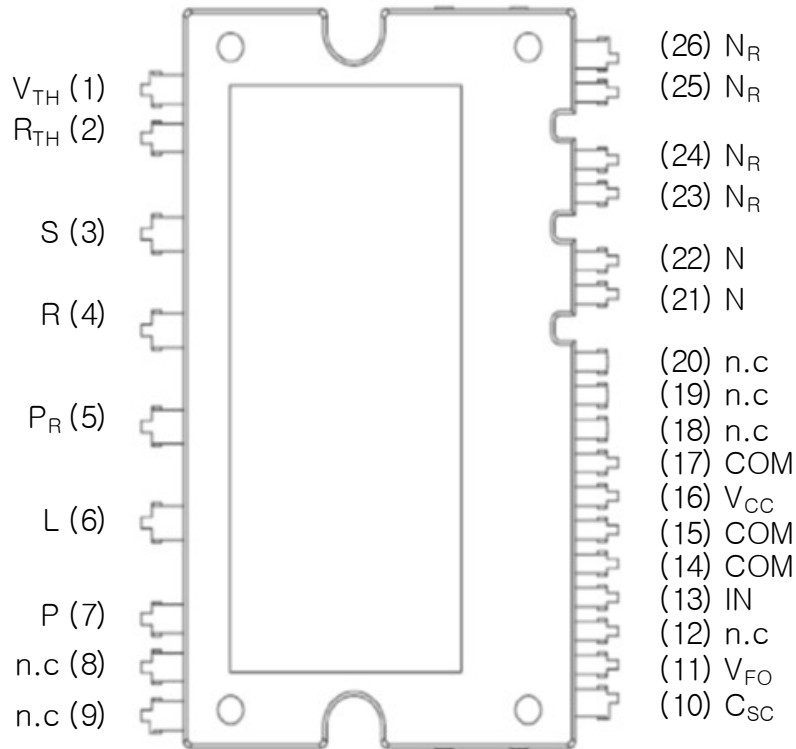


Figure 2. Top View

### Pin Descriptions

Pin Number	Pin Name	Pin Description
1	$V_{TH}$	Thermistor Bias Voltage
2	$R_{TH}$	Series Resistor for The Use of Thermistor
3	S	AC Input for S-Phase
4	R	AC Input for R-Phase
5	$P_R$	Positive DC-Link of Rectifier
6	L	Inductor Connection
7	P	Positive DC-Link Input
8, 9	N.C	-
10	$C_{OC}$	Signal Input for Over-Current Detection
11	$V_{FO}$	Fault Output
12	N.C	-
13	IN	PWM Input for IGBT Drive
14	COM	Common Supply Ground
15	COM	Common Supply Ground
16	$V_{CC}$	Common Supply Voltage of IC for IGBT Drive
17	COM	Common Supply Ground
18 ~ 20	N.C	-
21, 22	N	Negative DC-Link Input
23 ~ 26	$N_R$	Negative DC-Link of Rectifier Diode

### Internal Equivalent Circuit

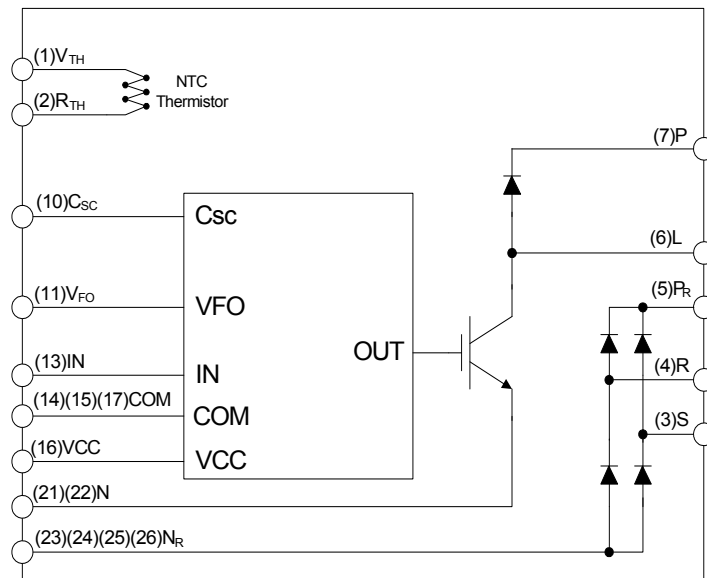


Figure 3. Internal Block Diagram

## Absolute Maximum Ratings

### Converter Part

Symbol	Parameter	Conditions	Rating	Unit
$V_i$	Input Supply Voltage	Applied between R - S	276	$V_{rms}$
$V_{i(Surge)}$	Input Supply Voltage (Surge)	Applied between R - S	500	V
$V_{PN}$	Output Voltage	Applied between $P_R - N_R$	450	V
$V_{PN(Surge)}$	Output Supply Voltage (Surge)	Applied between $P_R - N_R$	500	V
$V_{CES}$	Collector - Emitter Voltage		600	V
$V_{RRM}$	Repetitive Peak Reverse Voltage		600	V
$\pm I_C$	Each IGBT Collector Current	$T_C = 25^\circ\text{C}$ , $V_{CC} = 15\text{ V}$	20	A
$\pm I_{CP}$	Each IGBT Collector Current (Peak)	$T_C = 25^\circ\text{C}$ , Under 1 ms Pulse Width	30	A
$I_{FSM}$	Peak Forward Surge Current	Single Half Sine-Wave	200	A
$T_J$	Operating Junction Temperature		-40 ~ 150	$^\circ\text{C}$

### Control Part

Symbol	Parameter	Conditions	Rating	Unit
$V_{CC}$	Control Supply Voltage	Applied between $V_{CC} - \text{COM}$	20	V
$V_{IN}$	Input Signal Voltage	Applied between IN - COM	-0.3 ~ $V_{CC} + 0.3$	V
$V_{FO}$	Fault Output Supply Voltage	Applied between $V_{FO} - \text{COM}$	-0.3 ~ $V_{CC} + 0.3$	V
$I_{FO}$	Fault Output Current	Sink Current at $V_{FO}$ Pin	1	mA
$V_{SC}$	Current Sensing Input Voltage	Applied between $C_{SC} - \text{COM}$	-0.3 ~ $V_{CC} + 0.3$	V

### Total System

Symbol	Parameter	Conditions	Rating	Unit
$T_{STG}$	Storage Temperature		-40 ~ 125	$^\circ\text{C}$
$V_{ISO}$	Isolation Voltage	60 Hz, Sinusoidal, AC 1 Minute, Connect Pins to Heat Sink Plate	2000	$V_{rms}$

### Thermal Resistance

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
$R_{th(j-c)Q}$	Junction to Case Thermal Resistance at Chip Center	IGBT	-	-	2.5	$^\circ\text{C/W}$
$R_{th(j-c)D}$		FRD	-	-	2.5	$^\circ\text{C/W}$
$R_{th(j-c)R}$		Rectifier	-	-	2.5	$^\circ\text{C/W}$

## Electrical Characteristics ( $T_J = 25^\circ\text{C}$ , unless otherwise specified.)

### Converter Part

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
$V_{CE(SAT)}$	IGBT Collector - Emitter Saturation Voltage	$V_{CC} = 15\text{ V}$ , $V_{IN} = 5\text{ V}$ , $I_C = 20\text{ A}$	-	2.2	2.7	V
$V_{FF}$	FRD Forward Voltage	$I_F = 20\text{ A}$	-	2.1	2.6	V
$V_{FR}$	Rectifier Forward Voltage	$I_F = 20\text{ A}$	-	1.1	1.4	V
$t_{ON}$	Switching Characteristic	$V_{PN} = 300\text{ V}$ , $V_{CC} = 15\text{ V}$ , $I_C = 20\text{ A}$ , $V_{IN} = 0\text{ V} \leftrightarrow 5\text{ V}$ , Inductive Load (1st Note 1)	-	770	-	ns
$t_{OFF}$			-	640	-	ns
$t_{C(ON)}$			-	130	-	ns
$t_{C(OFF)}$			-	50	-	ns
$t_{rr}$			-	40	-	ns
$I_{rr}$			-	4.0	-	A
$I_{CES}$			Collector - Emitter Leakage Current	$V_{CE} = V_{CES}$	-	-

#### 1st Notes:

- $t_{ON}$  and  $t_{OFF}$  include the propagation delay 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.

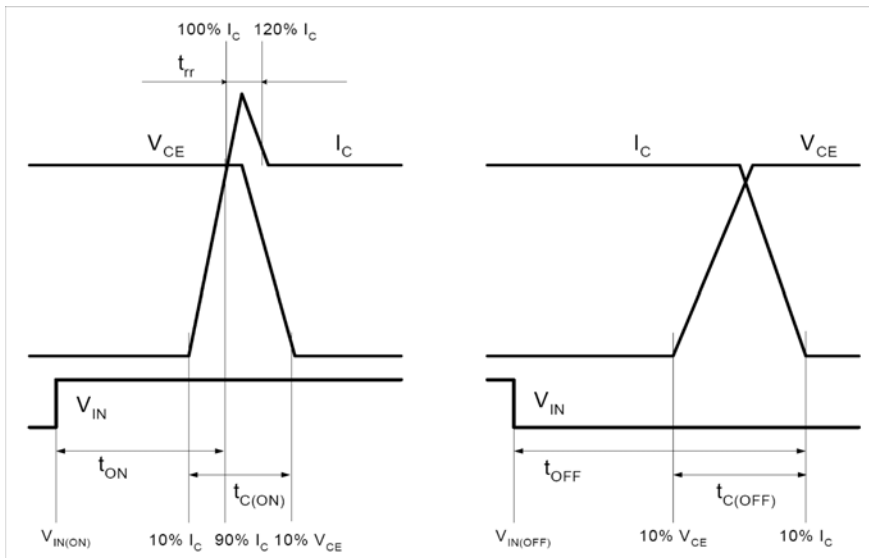


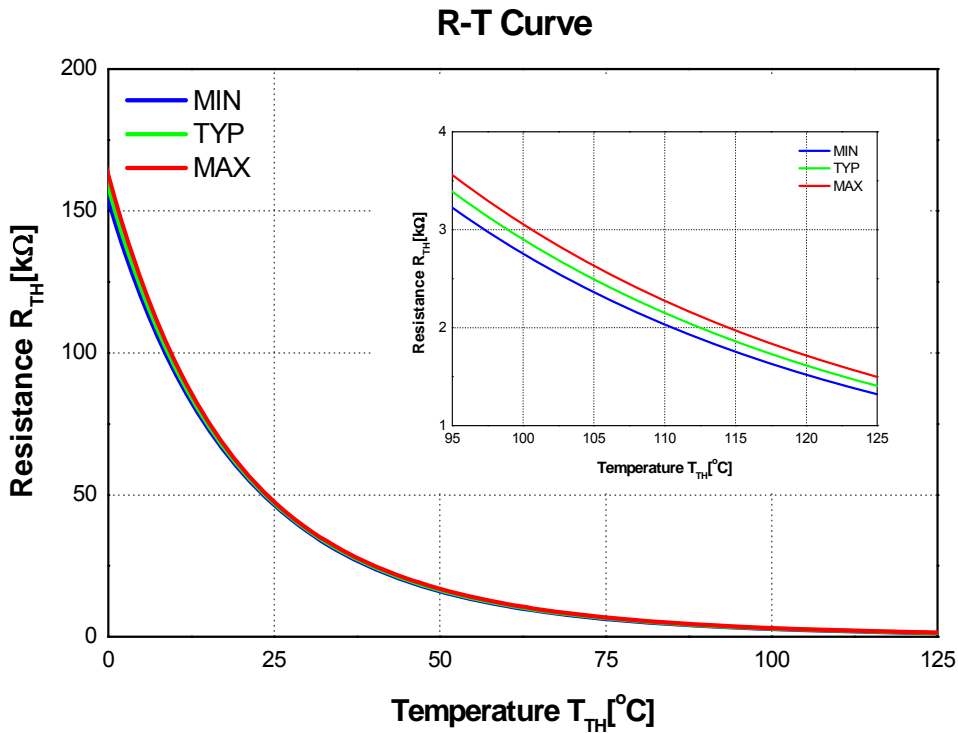
Figure 4. Switching Time Definitions

**Control Part**

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
$I_{OCC}$	Quiescent $V_{CC}$ Supply Current	$V_{CC} = 15\text{ V}$ , $V_{IN} = 0\text{ V}$ , $V_{CC} - \text{COM}$	-	-	2.65	mA
$V_{FOH}$	Fault Output Voltage	$V_{SC} = 0\text{ V}$ , $V_{FO}$ Circuit: 4.7 k $\Omega$ to 5 V Pull-up	4.5	-	-	V
$V_{FOL}$		$V_{SC} = 1\text{ V}$ , $V_{FO}$ Circuit: 4.7 k $\Omega$ to 5 V Pull-up	-	-	0.8	V
$V_{SC(\text{ref})}$	Over-Current Protection Trip Level Voltage of $C_{SC}$ pin	$V_{CC} = 15\text{ V}$ (1st Note 2)	0.45	0.50	0.55	V
$UV_{CCD}$	Supply Circuit Under-Voltage Protection	Detection Level	10.5	-	13.0	V
$UV_{CCR}$		Reset Level	11.0	-	13.5	V
$V_{IN(\text{ON})}$	ON Threshold Voltage	Applied between IN - COM	-	-	2.6	V
$V_{IN(\text{OFF})}$	OFF Threshold Voltage		0.8	-	-	V
$R_{TH}$	Resistance of Thermistor	$T_{TH} = 25^\circ\text{C}$ (1st Note 3)	-	47.0	-	k $\Omega$
		$T_{TH} = 100^\circ\text{C}$	-	2.9	-	k $\Omega$

**1st Notes:**

- Over-current protection is functioning on IGBT.
- $T_{TH}$  is the temperature of thermister itself. To know case temperature ( $T_C$ ), please make the experiment considering your application.



**Figure 5. R-T Curve of The Built-in Thermistor**

### Recommended Operating Conditions

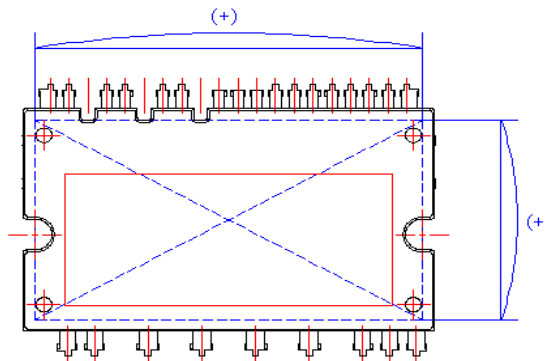
Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
$V_i$	Input Supply Voltage	Applied between R - S	198	220	242	$V_{rms}$
$V_{PN}$	Supply Voltage	Applied between P <sub>R</sub> - N	-	360	400	V
$I_i$	Input Current	$V_{DC} = 360\text{ V}$ , $F_{SW} = 20\text{ kHz}$ , $V_{CC} = 15\text{ V}$ , $T_C = 90^\circ\text{C}$ , $T_J \leq 150^\circ\text{C}$	-	20	-	$A_{peak}$
$V_{CC}$	Supply Voltage for inverter	Applied between V <sub>CC</sub> - COM	13.5	15.0	16.5	V
$P_{WIN(ON)}$	Minimum Input Pulse Width	(1st Note 4)	0.5	-	-	$\mu\text{s}$
$P_{WIN(OFF)}$			0.5	-	-	$\mu\text{s}$
$dV_{CC}/dt$	Supply Variation		-1	-	1	V/ $\mu\text{s}$
$f_{PWM}$	PWM Input Frequency	$T_J \leq 150^\circ\text{C}$	-	20	-	kHz
$V_{SEN}$	Voltage for Current Sensing	Applied between N - COM (Including surge voltage)	-4	-	4	V

**1st Notes:**

4. The PFC SPM® product might not make response if input pulse width is less than the recommended value.

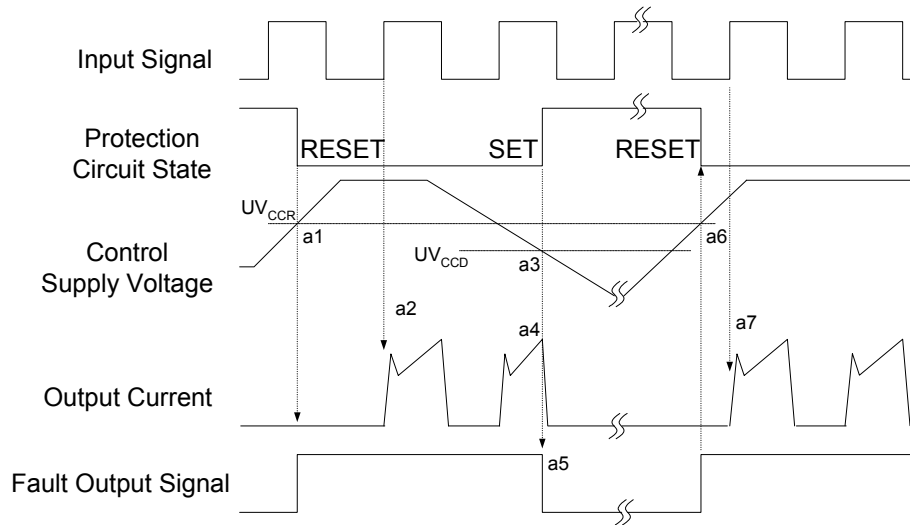
### Mechanical Characteristics and Ratings

Parameter	Conditions		Min.	Typ.	Max.	Unit
Mounting Torque	Mounting Screw: M3	Recommended 0.7 N•m	0.6	0.7	0.8	N•m
Device Flatness		See Figure 6	0	-	+120	$\mu\text{m}$
Weight			-	11	-	g



**Figure 6. Flatness Measurement Position**

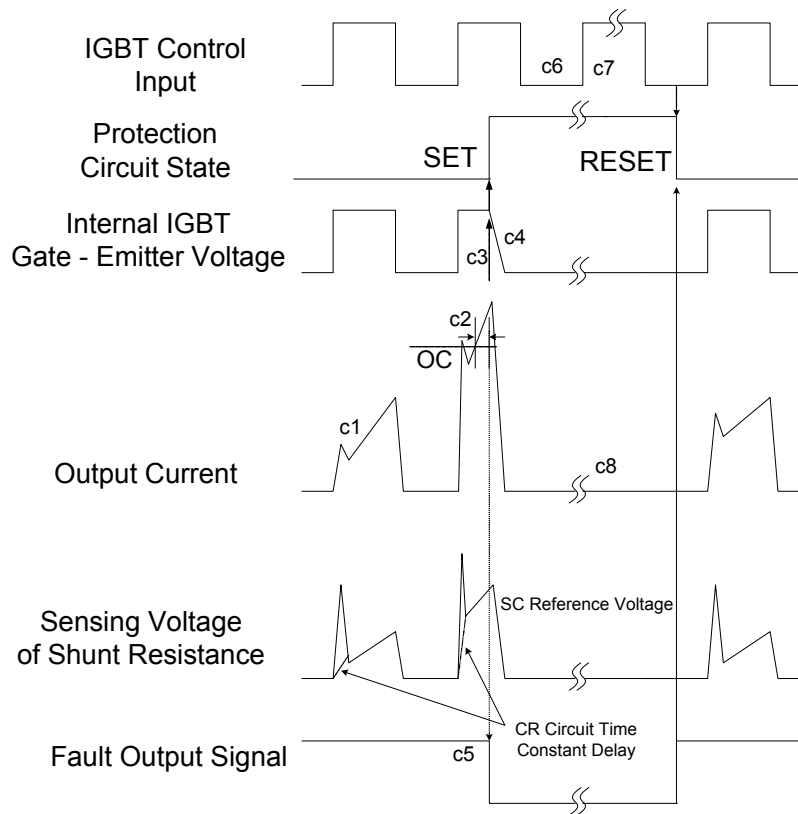
### Time Charts of Protective Function



- a1 : Control supply voltage rises: after the voltage rises  $UV_{CCR}$ , the circuits start to operate when the 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**



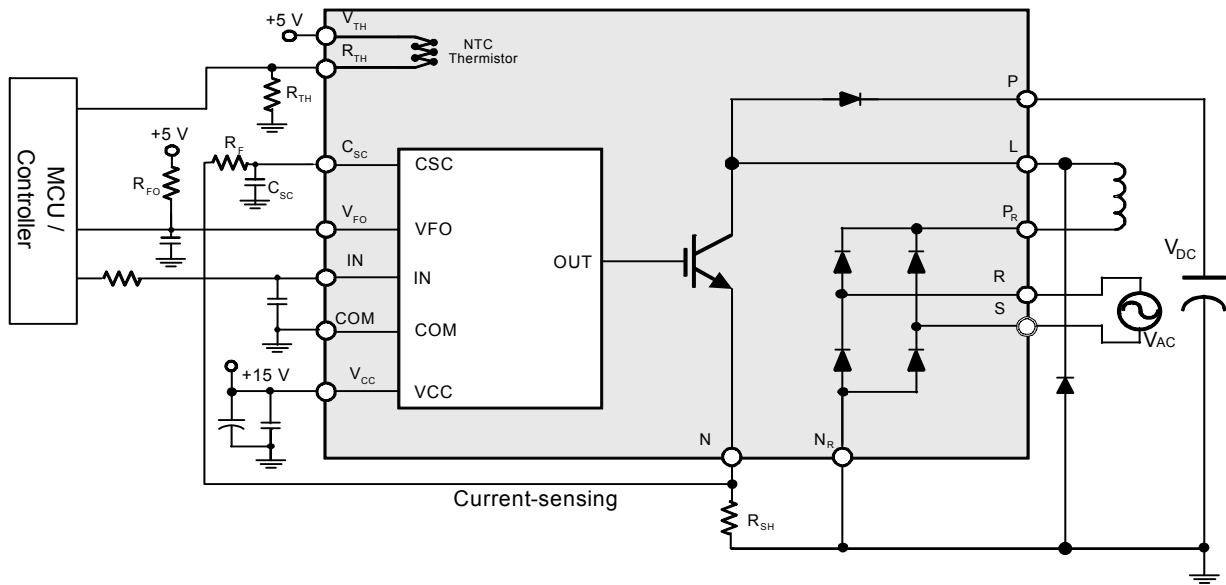


(with the external shunt resistance and CR connection)

- c1 : Normal operation: IGBT ON and carrying current.
- c2 : Over-current detection (OC trigger).
- c3 : Hard IGBT gate interrupt.
- c4 : IGBT turns OFF.
- c5 : Fault output timer operation starts.
- c6 : Input "LOW": IGBT OFF state.
- c7 : Input "HIGH": 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**

## Recommand circuit for Application

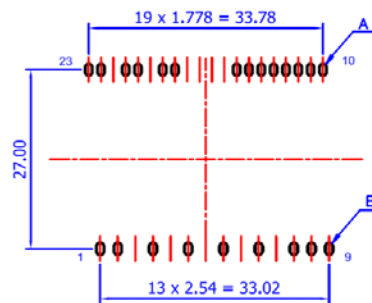
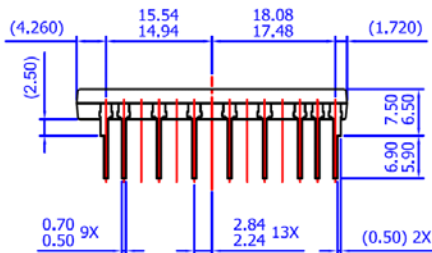
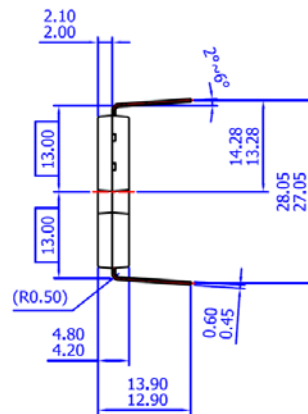
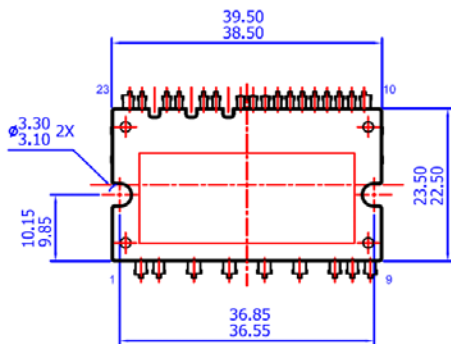
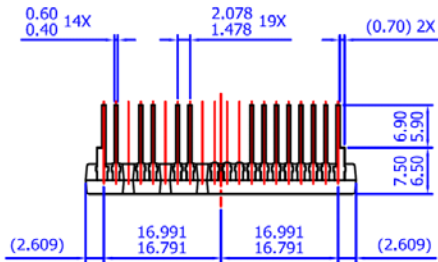


**Figure 9. Typical Application Circuit**

**2nd Notes:**

1. To avoid malfunction, the wiring of each input should be as short as possible (less than 2 - 3 cm).
2.  $V_{FO}$  output is open-drain type. This signal line should be pulled up to the positive side of the MCU or PFC controller power supply with a resistor that makes  $I_{FO}$  up to 1 mA.
3. Input signal is active-HIGH type. There is a 5 k $\Omega$  resistor inside the IC to pull-down each input signal line to GND. RC coupling circuits is recommended for the prevention of input signal oscillation.  $R_S C_{PS}$  time constant should be selected in the range 50 ~ 150 ns (recommended  $R_S = 100 \Omega$ ,  $C_{PS} = 1$  nF).
4. To prevent errors of the protection function, the wiring around  $R_F$  and  $C_{SC}$  should be as short as possible.
5. In the over-current protection circuit, please select the  $R_F$ ,  $C_{SC}$  time constant in the range 1~2  $\mu$ s.
6. Each capacitors should be mounted as close to the pins as possible.
7. Relays are used in almost every systems of electrical equipment in home appliances. In these cases, there should be sufficient distance between the MCU and the relays.
8. Internal NTC thermistor can be used for monitoring the case temperature and protecting the device from the over-heating operation. Please select an appropriate resistor  $R_{TH}$  according to the application. For example, use  $R_{TH} = 4.7$  k $\Omega$  that will make the voltage across  $R_{TH}$  to be 2.5 V at 85°C of the case temperature.
9. Please use an appropriate shunt resistor  $R_{SH}$  to protect the internal IGBT from the over-current operation.
10. It's recommended that anti-parallel diode should be connected with IGBT.

## Detailed Package Outline Drawings



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