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# FPAM30LH60

## PFC SPM<sup>®</sup> 2 Series for 2-Phase Interleaved PFC

### Features

- UL Certified No.E209204 (UL1557)
- 600 V - 30 A 2-Phase Interleaved PFC with Integral Gate Driver and Protection
- Very Low Thermal Resistance Using Al<sub>2</sub>O<sub>3</sub> DBC Substrate
- Full-Wave Bridge Rectifier and High-Performance Output Diode
- Optimized for 20kHz Switching Frequency
- Built-in NTC Thermistor for Temperature Monitoring
- Isolation Rating: 2500 V<sub>rms</sub>/min

### Applications

- 2-Phase Interleaved PFC Converter

### General Description

The FPAM30LH60 is a PFC SPM<sup>®</sup> 2 module providing a fully-featured, high-performance Interleaved PFC (Power Factor Correction) input power stage for consumer, medical, and industrial applications. These modules integrate optimized gate drive of the built-in IGBTs 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 diodes for additional space savings and mounting convenience.

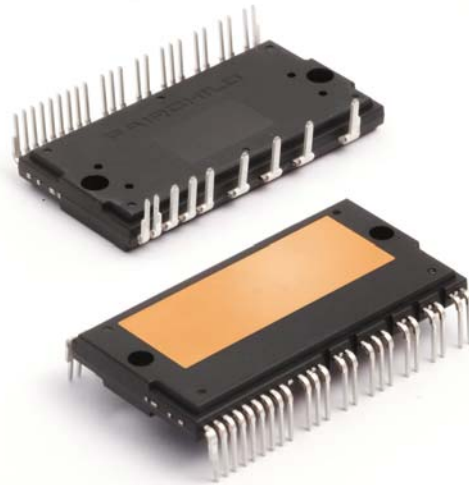


Fig. 1. Package Overview

### Package Marking and Ordering Information

Device	Device Marking	Package	Packing Type	Quantity
FPAM30LH60	FPAM30LH60	S32EA-032	Rail	8

### 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 thermistor: temperature monitoring
- Input interface : active-HIGH interface, works with 3.3 / 5 V logic, Schmitt trigger input

### Pin Configuration

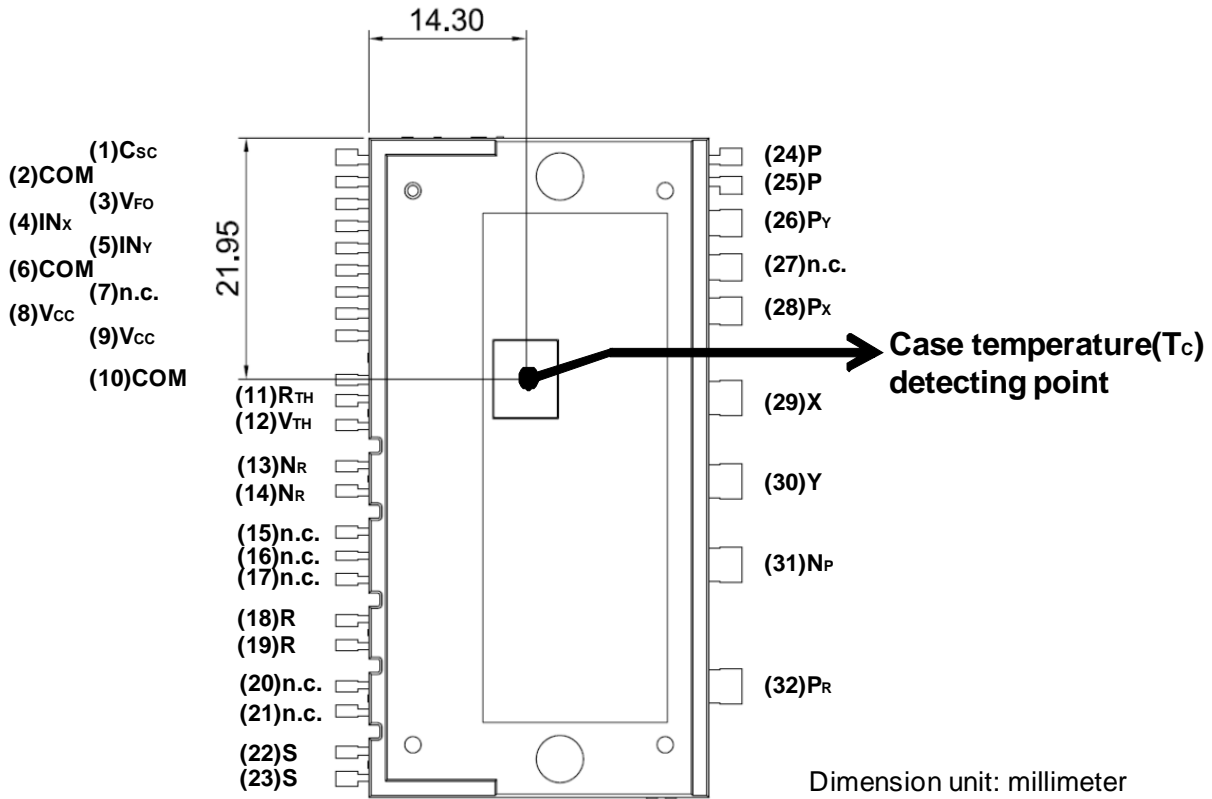


Figure 2. Top View

## Pin Descriptions

Pin Number	Pin Name	Pin Description
1	C <sub>SC</sub>	Signal Input for Over-Current Detection
2,6,10	COM	Common Supply Ground
3	V <sub>FO</sub>	Fault Output
4	IN <sub>X</sub>	PWM Input for X IGBT Drive
5	IN <sub>Y</sub>	PWM Input for Y IGBT Drive
7	N.C	No Connection
8,9	V <sub>CC</sub>	Common Supply Voltage of IC for IGBT Drive
11	R <sub>TH</sub>	Series Resistor for The Use of Thermistor
12	V <sub>TH</sub>	Thermistor Bias Voltage
13,14	N <sub>R</sub>	Negative DC-Link of Rectifier Diode
15,16,17	N.C	No Connection
18,19	R	AC Input for R-Phase
20,21	N.C	No Connection
22,23	S	AC Input for S-Phase
24,25	P	Output of Diode
26	P <sub>Y</sub>	Input of Diode
27	N.C	No Connection
28	P <sub>X</sub>	Input of Diode
29	X	Output of X Phase IGBT
30	Y	Output of Y Phase IGBT
31	N <sub>P</sub>	Negative DC-Link of IGBT
32	P <sub>R</sub>	Positive DC-Link of Rectifier Diode

## Internal Equivalent Circuit

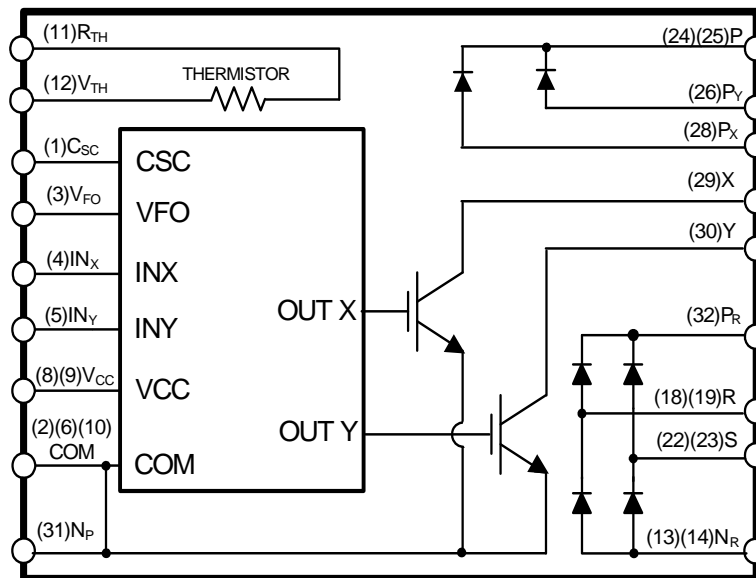


Figure 3. Internal Block Diagram

## Absolute Maximum Ratings ( $T_J = 25^\circ\text{C}$ , unless otherwise specified.)

### Converter Part

Symbol	Parameter	Conditions	Rating	Unit
$V_i$	Input Supply Voltage	Applied between R - S	264	$V_{\text{rms}}$
$V_{PN}$	Output Voltage	Applied between X - $N_P$ , Y - $N_P$ , P - $P_X$ , P - $P_Y$	450	V
$V_{PN(\text{Surge})}$	Output Supply Voltage (Surge)	Applied between X - $N_P$ , Y - $N_P$ , P - $P_X$ , P - $P_Y$	500	V
$V_{CES}$	Collector-emitter Voltage	Breakdown Voltage between X - $N_P$ , Y - $N_P$	600	V
$V_{RRM}$	Repetitive Peak Reverse Voltage of FRD	Breakdown Voltage between P - $P_X$ , P - $P_Y$	600	V
$V_{RRMR}$	Repetitive Peak Reverse Voltage of Rectifier	Breakdown Voltage between $P_R$ - R, $P_R$ - S, R - $N_R$ , S - $N_R$	900	V
$*I_F$	FRD Forward Current	$T_C = 25^\circ\text{C}$ , $T_J < 125^\circ\text{C}$	30	A
$*I_{FSM}$	Peak Surge Current of FRD	Non-Repetitive, 60 Hz Single Half-Sine Wave	300	A
$*I_{FR}$	Rectified Forward Current	$T_C = 25^\circ\text{C}$ , $T_J < 125^\circ\text{C}$	30	A
$*I_{FSMR}$	Peak Surge Current of Rectifier	Non-Repetitive, 60 Hz Single Half-Sine Wave	300	A
$\pm *I_C$	Each IGBT Collector Current	$T_C = 25^\circ\text{C}$ , $T_J < 125^\circ\text{C}$	30	A
$\pm *I_{CP}$	Each IGBT Collector Current(Peak)	$T_C = 25^\circ\text{C}$ , $T_J < 125^\circ\text{C}$ , Under 1 ms Pulse Width	60	A
$*P_C$	Collector Dissipation	$T_C = 25^\circ\text{C}$ per IGBT	107	W
$T_J$	Operating Junction Temperature	(1st Note 1)	-40 ~ 125	$^\circ\text{C}$

#### 1st Notes:

1. The maximum junction temperature rating of the power chips integrated within the PFC SPM® product is  $125^\circ\text{C}$ .
2. Marking " \* " is calculation value or design factor.

### Control Part

Symbol	Parameter	Conditions	Rating	Unit
$V_{CC}$	Control Supply Voltage	Applied between $V_{CC}$ - COM	20	V
$V_{IN}$	Input Signal Voltage	Applied between $IN_X$ , $IN_Y$ - 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	1	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	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	2500	$V_{\text{rms}}$

### Thermal Resistance

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
$R_{th(j-c)Q}$	Junction to Case Thermal Resistance	Each IGBT under Operating Condition	-	-	0.93	$^\circ\text{C/W}$
$R_{th(j-c)D}$		Each Diode under Operating Condition	-	-	1.42	$^\circ\text{C/W}$
$R_{th(j-c)R}$		Each Rectifier under Operating Condition	-	-	0.74	$^\circ\text{C/W}$

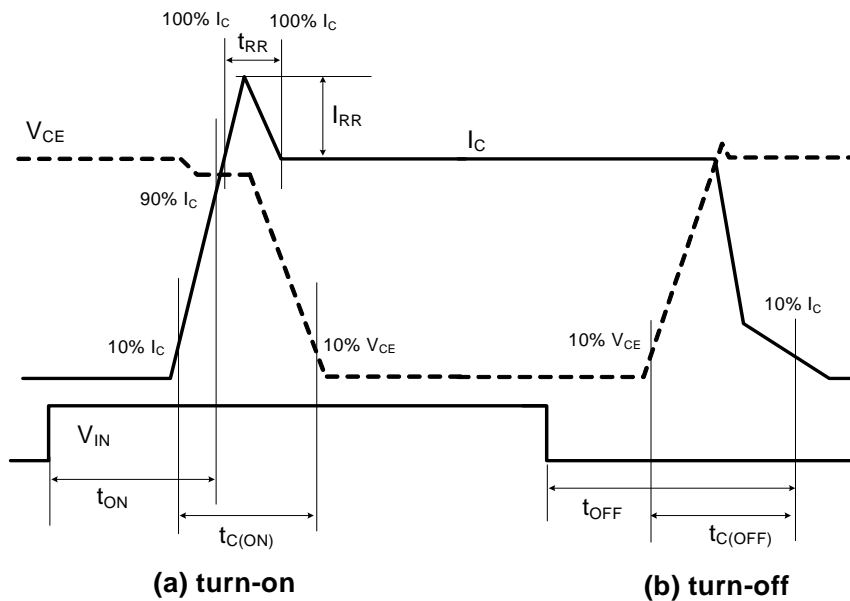
## Electrical Characteristics ( $T_J = 25^\circ\text{C}$ , unless otherwise specified.)

### Converter Part

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
$V_{CE(SAT)}$	IGBT Saturation Voltage	$V_{CC} = 15\text{ V}$ , $V_{IN} = 5\text{ V}$ , $I_C = 30\text{ A}$	-	1.7	2.2	V
$V_{FF}$	FRD Forward Voltage	$I_F = 30\text{ A}$	-	1.9	2.4	V
$V_{FR}$	Rectifier Forward Voltage	$I_{FR} = 30\text{ A}$	-	1.10	1.25	V
$I_{RR}$	Switching Characteristic	$V_{PN} = 400\text{ V}$ , $V_{CC} = 15\text{ V}$ , $I_C = 15\text{ A}$ , $V_{IN} = 0\text{ V} \leftrightarrow 5\text{ V}$ , Inductive Load (1st Note 3), per IGBT	-	11	-	A
$t_{RR}$			-	41	-	ns
$t_{ON}$			-	700	-	ns
$t_{OFF}$			-	852	-	ns
$t_{C(ON)}$			-	104	-	ns
$t_{C(OFF)}$			-	102	-	ns
$I_{CES}$			Collector - Emitter Leakage Current	$V_{CES} = 600\text{ V}$	-	-

**1st Notes:**

3.  $t_{ON}$  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.



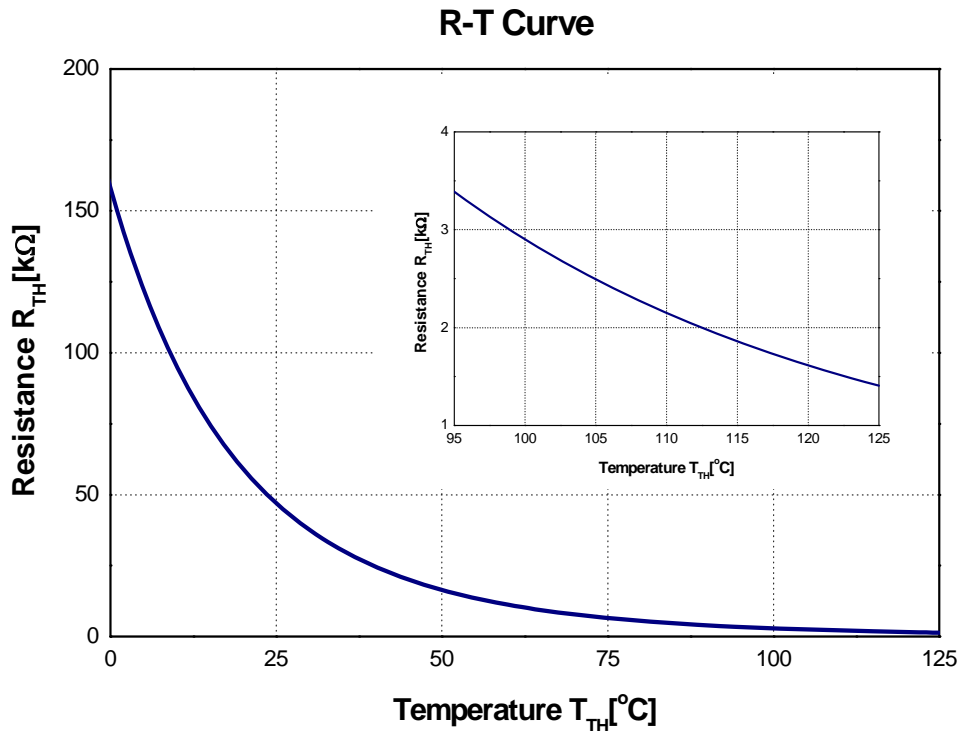
**Figure 4. Switching Time Definition**

**Control Part**

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
$I_{QCC}$	Quiescent $V_{CC}$ Supply Current	$V_{CC} = 15\text{ V}$ , $IN_X$ , $IN_Y - COM = 0\text{ V}$ , Supply current between $V_{CC}$ and COM	-	-	2.65	mA
$I_{PCC}$	Operating $V_{CC}$ Supply Current	$V_{CC} = 15\text{ V}$ , $f_{PWM} = 20\text{ kHz}$ , Duty = 50% Applied to One PWM Signal Input per IGBT Supply Current between $V_{CC}$ and COM	-	-	6.0	mA
$V_{FOH}$	Fault Output Voltage	$V_{SC} = 0\text{ V}$ , $V_{FO}$ Circuit: 10 k $\Omega$ to 5 V Pull-up	4.5	-	-	V
$V_{FOL}$		$V_{SC} = 1\text{ V}$ , $V_{FO}$ Circuit: 10 k $\Omega$ to 5 V Pull-up	-	-	0.5	V
$V_{SC(Ref)}$	Over-Current Protection Trip Level Voltage of CSC Pin	$V_{CC} = 15\text{ V}$	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
$t_{FOD}$	Fault-Out Pulse Width		30	-	-	$\mu\text{s}$
$V_{IN(ON)}$	ON Threshold Voltage	Applied between $IN_X$ , $IN_Y - COM$	2.6	-	-	V
$V_{IN(OFF)}$	OFF Threshold Voltage	Applied between $IN_X$ , $IN_Y - COM$	-	-	0.8	V
$R_{TH}$	Resistance of Thermistor	at $T_{TH} = 25^\circ\text{C}$ (1st Note 4, Figure 5)	-	47	-	k $\Omega$
		at $T_{TH} = 100^\circ\text{C}$ (1st Note 4, Figure 5)	-	2.9	-	k $\Omega$

**1st Notes:**

4.  $T_{TH}$  is the temperature of thermister itself. To know case temperature ( $T_C$ ), please make the experiment considering your application.



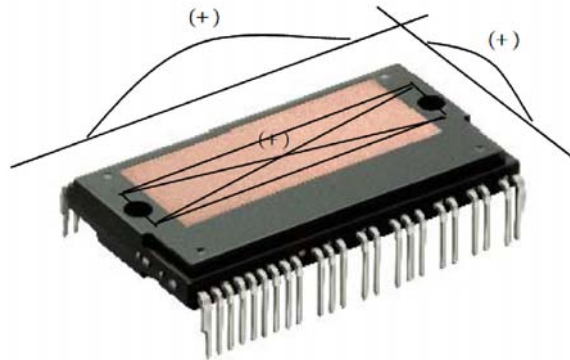
**Figure 5. R-T Curve of The Built-in Thermistor**

**Recommended Operating Conditions** ( $T_J = 25^\circ\text{C}$ , unless otherwise specified.)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
$V_i$	Input Supply Voltage	Applied between R - S	187	-	253	$V_{rms}$
$I_i$	Input Current	$T_C < 100^\circ\text{C}$ , $V_i = 220\text{ V}$ , $V_O = 360\text{ V}$ , $f_{PWM} = 20\text{ kHz}$ per IGBT	-	-	21	$A_{rms}$
$V_{PN}$	Supply Voltage	Applied between X - N <sub>P</sub> , Y - N <sub>P</sub> , P - P <sub>X</sub> , P - P <sub>Y</sub>	-	-	400	V
$V_{CC}$	Control Supply Voltage	Applied between $V_{CC}$ - COM	13.5	15.0	16.5	V
$dV_{CC}/dt$	Supply Variation		-1	-	1	$V / \mu\text{s}$
$I_{FO}$	Fault Output Current	Sink Current at $V_{FO}$ Pin	-	-	1	mA
$f_{PWM}$	PWM Input Frequency	$-40^\circ\text{C} < T_J < 125^\circ\text{C}$ per IGBT	-	20	-	kHz

**Mechanical Characteristics and Ratings**

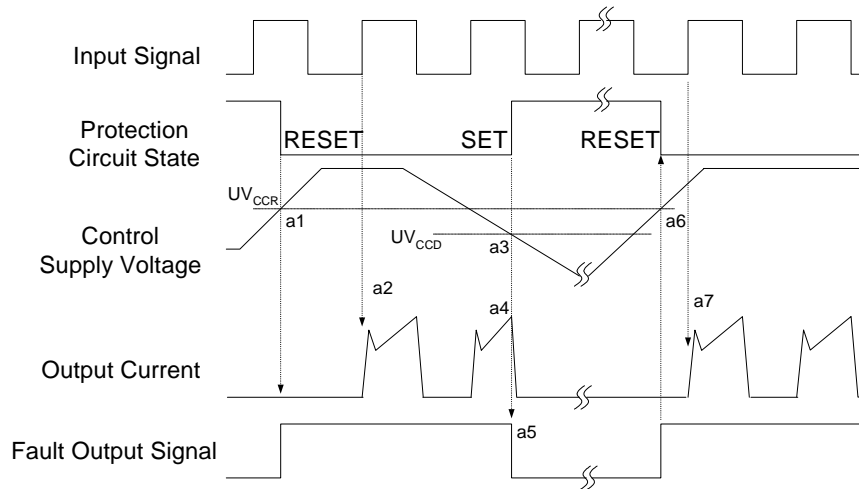
Parameter	Conditions		Min.	Typ.	Max.	Unit
Mounting Torque	Mounting Screw: M4	Recommended 0.98 N•m	0.78	0.98	1.17	N•m
		Recommended 10 kg•cm	8	10	12	kg•cm
Device Flatness	See Figure 6		0	-	+150	$\mu\text{m}$
Weight			-	32	-	g



**Figure 6. Flatness Measurement Position**

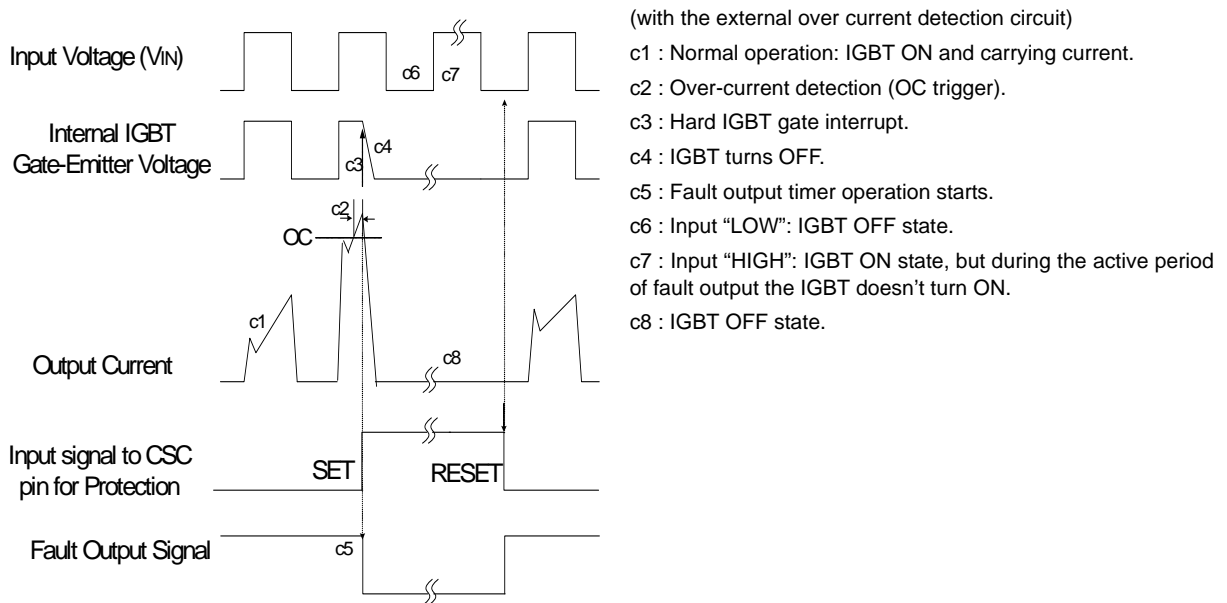


### Time Charts of Protective Function



- 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 over current detection circuit)
- 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**

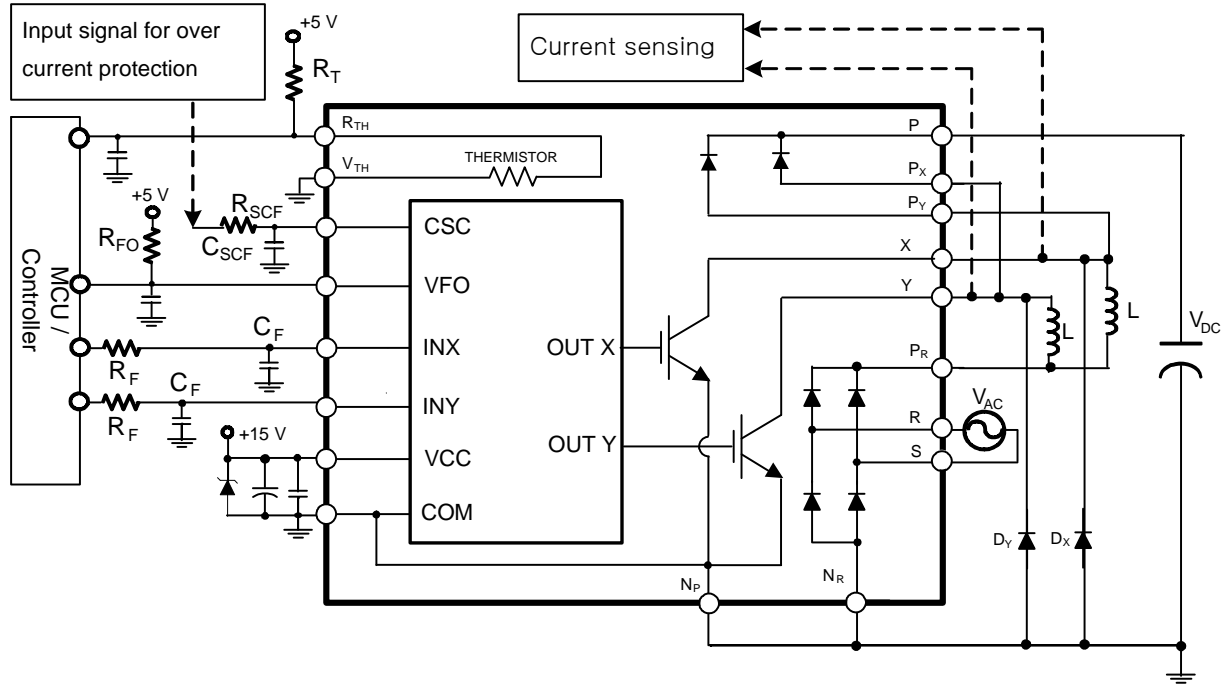
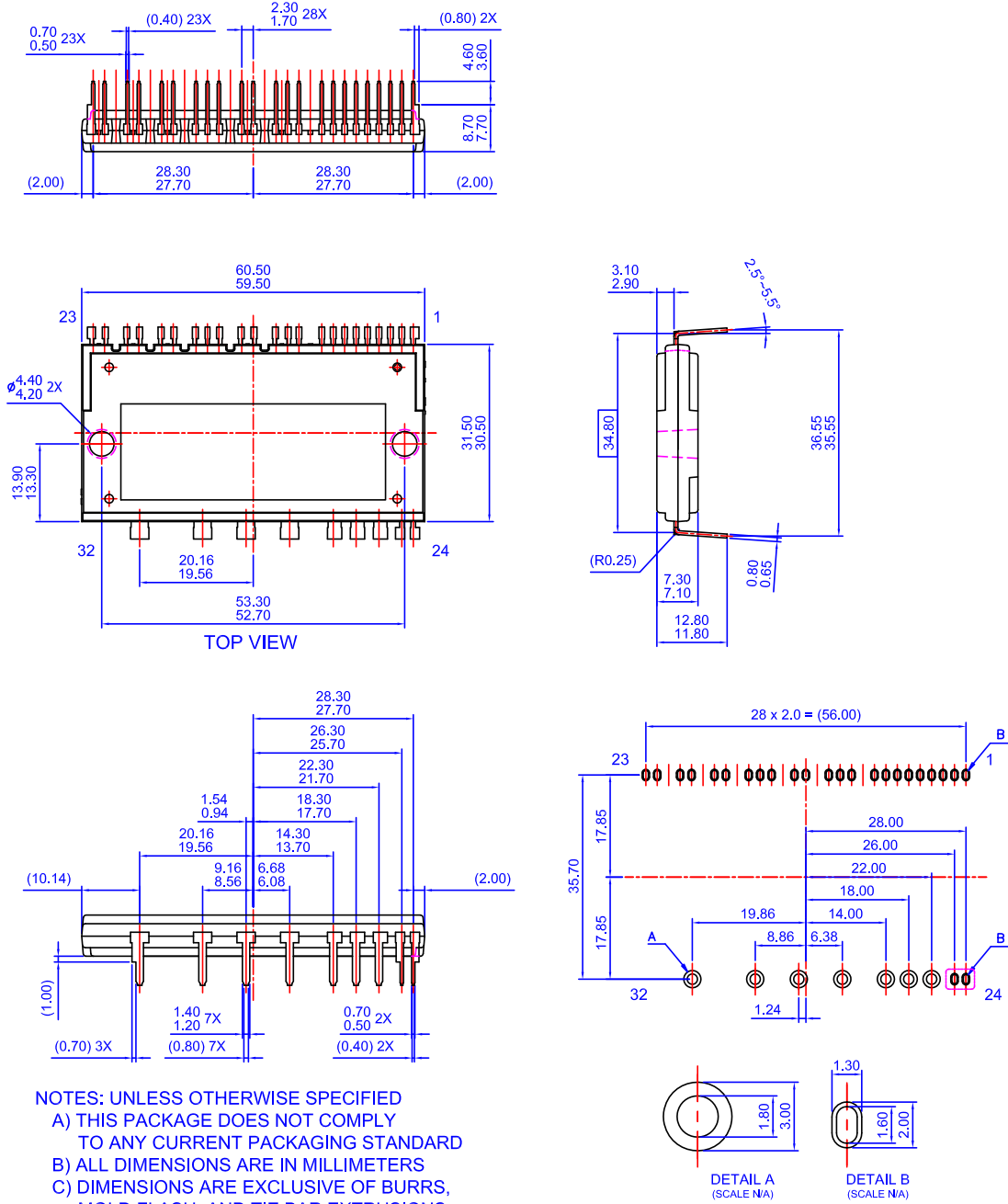


Figure 9. Typical Application Circuit

**2nd Notes:**

1. To avoid malfunction, the wiring of each input should be as short as possible (less than 2 ~ 3 cm).
2. V<sub>FO</sub> output is open-drain type. This signal line should be pulled up to the positive-side of the MCU or control power supply with a resistor that makes I<sub>FO</sub> up to 1 mA.
3. Input signal is active-HIGH type. There is a 5 kΩ 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<sub>F</sub>C<sub>F</sub> constant should be selected in the range 50~150ns (recommended R<sub>F</sub> = 100 Ω , C<sub>F</sub> = 1 nF).
4. To prevent error of the protection function, the wiring related with R<sub>SCF</sub> and C<sub>SCF</sub> should be as short as possible.
5. In the over current protection circuit, please select the R<sub>SCF</sub> , C<sub>SCF</sub> time constant in the range 1.5 ~ 2 μs.
6. Each capacitors should be mounted as close to the PFC SPM® product pins as possible.
7. Relays are used at almost every systems of electrical equipments of home appliances. In these cases, there should be sufficient distance between the MCU / controller and the relays.
8. Internal NTC thermistor can be used for monitoring of the case temperature and protecting the device from the overheating operation. Select an appropriate resistor R<sub>T</sub> according to the application.
9. It is recommended that anti-parallel diode (D<sub>X</sub> , D<sub>Y</sub>) be connected with each IGBT.

### Detailed Package Outline Drawings



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| EcoSPARK®                | MicroFET™                                      |             | SerDes™          |
| EfficientMax™            | MicroPak™                                      |             | UHC®             |
| ESBC™                    | MicroPak2™                                     |             | Ultra FRFET™     |
| <b>F</b> ®               | MillerDrive™                                   |             | UniFET™          |
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