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June 2015

FPAM50LH60

PFC SPM® 2 Series for 2-Phase Interleaved PFC

Features

- UL Certified No.E209024 (UL1557)
- 600 V - 50 A 2-Phase Interleaved PFC with Integral Gate Driver and Protection
- Very Low Thermal Resistance Using Al_2O_3 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_{rms}/min

Applications

- 2-Phase Interleaved PFC Converter

General Description

The FPAM50LH60 is a PFC SPM® 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.

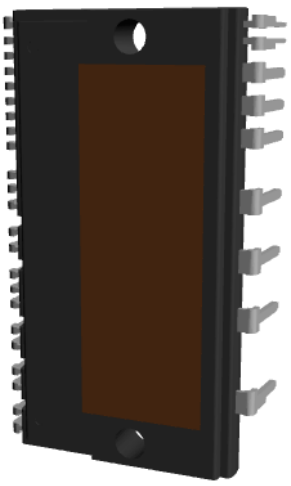


Fig. 1. 3D Package Drawing

(Click to Activate 3D Content)

Package Marking and Ordering Information

Device	Device Marking	Package	Packing Type	Quantity
FPAM50LH60	FPAM50LH60	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

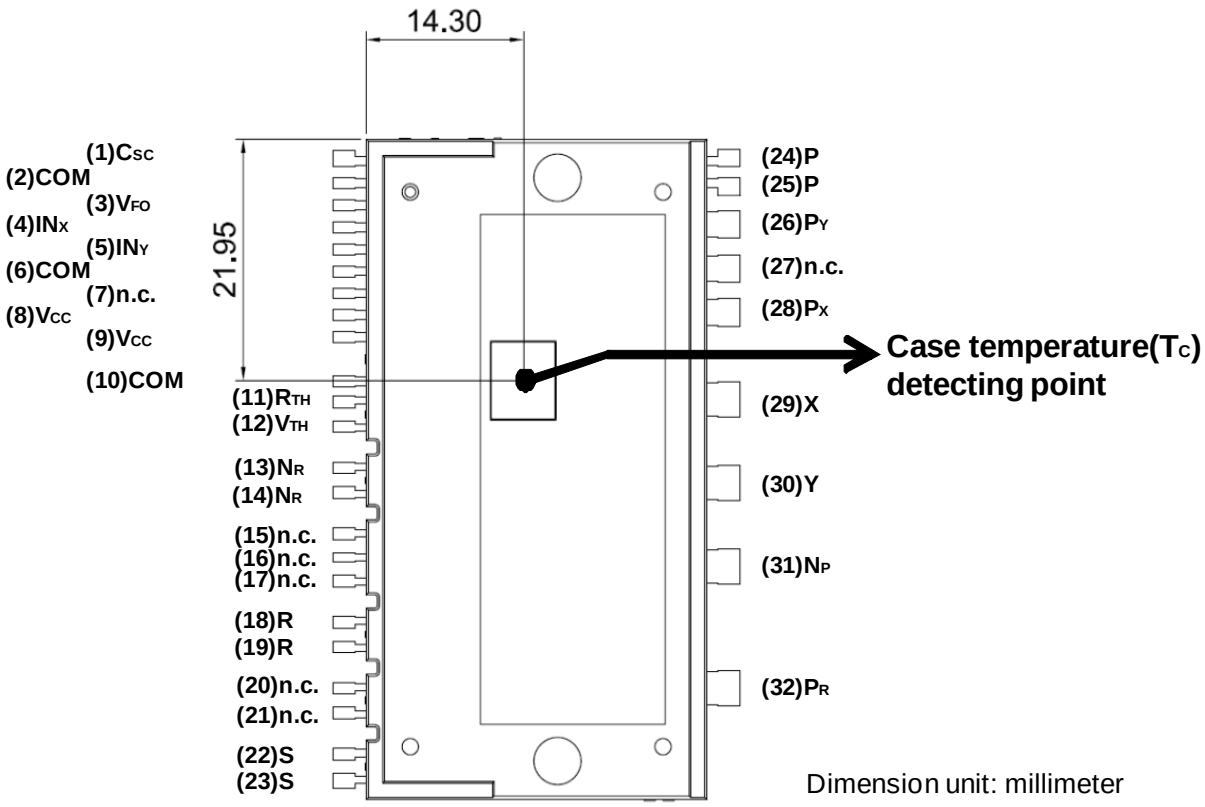


Figure 2. Top View

Pin Descriptions

Pin Number	Pin Name	Pin Description
1	C_{SC}	Signal Input for Over-Current Detection
2,6,10	COM	Common Supply Ground
3	V_{FO}	Fault Output
4	IN_X	PWM Input for X IGBT Drive
5	IN_Y	PWM Input for Y IGBT Drive
7	N.C	No Connection
8,9	V_{CC}	Common Supply Voltage of IC for IGBT Drive
11	R_{TH}	Series Resistor for The Use of Thermistor
12	V_{TH}	Thermistor Bias Voltage
13,14	N_R	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_Y	Input of Diode
27	N.C	No Connection
28	P_X	Input of Diode
29	X	Output of X Phase IGBT
30	Y	Output of Y Phase IGBT
31	N_P	Negative DC-Link of IGBT
32	P_R	Positive DC-Link of Rectifier Diode

Internal Equivalent Circuit

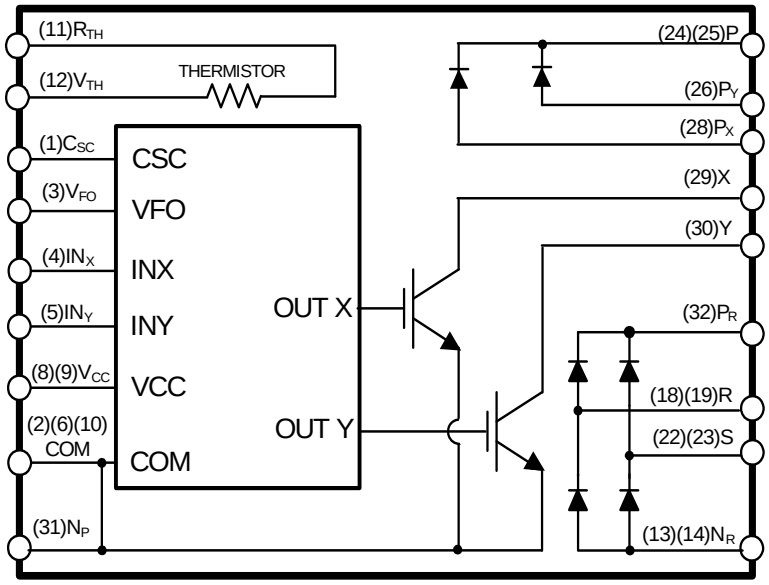


Figure 3. Internal Block Diagram

Absolute Maximum Ratings (T_J = 25°C, unless otherwise specified.)

Converter Part

Symbol	Parameter	Conditions	Rating	Unit
V_i	Input Supply Voltage	Applied between R - S	264	V_{rms}
V_{PN}	Output Voltage	Applied between X - N_P, Y - N_P, P - P_X, P - P_Y	450	V
$V_{PN(Surge)}$	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°C, T_J < 125°C	50	A
$*I_{FSM}$	Peak Surge Current of FRD	Non-Repetitive, 60 Hz Single Half-Sine Wave	500	A
$*I_{FR}$	Rectified Forward Current	T_C = 25°C, T_J < 125°C	50	A
$*I_{FSMR}$	Peak Surge Current of Rectifier	Non-Repetitive, 60 Hz Single Half-Sine Wave	500	A
± $*I_C$	Each IGBT Collector Current	T_C = 25°C, T_J < 125°C	50	A
± $*I_{CP}$	Each IGBT Collector Current(Peak)	T_C = 25°C, T_J < 125°C, Under 1 ms Pulse Width	100	A
$*P_C$	Collector Dissipation	T_C = 25°C per IGBT	135	W
T_J	Operating Junction Temperature	(1st Note 1)	-40 ~ 125	°C

1st Notes:

1. The maximum junction temperature rating of the power chips integrated within the PFC SPM® product is 125°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	°C
V_{ISO}	Isolation Voltage	60 Hz, Sinusoidal, AC 1 Minute, Connect Pins to Heat-Sink Plate	2500	V_{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	-	-	0.74	°C/W
$R_{th(j-c)D}$		Each Diode under Operating Condition	-	-	1.13	°C/W
$R_{th(j-c)R}$		Each Rectifier under Operating Condition	-	-	0.74	°C/W

Electrical Characteristics (T_J = 25°C, unless otherwise specified.)

Converter Part

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
$V_{CE(SAT)}$	IGBT Saturation Voltage	V_{CC} = 15 V, V_{IN} = 5 V, I_C = 50 A	-	1.7	2.2	V
V_{FF}	FRD Forward Voltage	I_F = 50 A	-	1.9	2.4	V
V_{FR}	Rectifier Forward Voltage	I_{FR} = 50 A	-	1.13	1.35	V
I_{RR}	Switching Characteristic	V_{PN} = 400 V, V_{CC} = 15 V, I_C = 25 A, V_{IN} = 0 V ↔ 5 V, Inductive Load (1st Note 3), per IGBT	-	27	-	A
t_{RR}			-	55	-	ns
t_{ON}			-	772	-	ns
t_{OFF}			-	1117	-	ns
$t_{C(ON)}$			-	110	-	ns
$t_{C(OFF)}$			-	125	-	ns
I_{CES}	Collector - Emitter Leakage Current	V_{CES} = 600 V	-	-	250	μA

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.

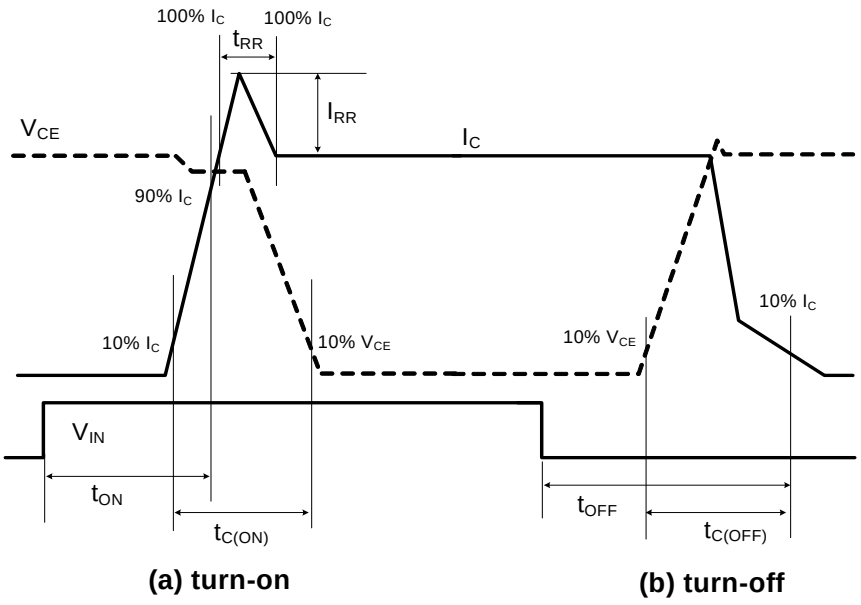


Figure 4. Switching Time Definition

Control Part

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
I_{QCC}	Quiescent V_{CC} Supply Current	V_{CC} = 15 V, IN_X, IN_Y - COM = 0 V, Supply current between V_{CC} and COM	-	-	2.65	mA
I_{PCC}	Operating V_{CC} Supply Current	V_{CC} = 15 V, f_{PWM} = 20 kHz, Duty = 50% Applied to One PWM Signal Input per IGBT Supply Current between V_{CC} and COM	-	-	7.0	mA
V_{FOH}	Fault Output Voltage	V_{SC} = 0 V, V_{FO} Circuit: 10 kΩ to 5 V Pull-up	4.5	-	-	V
V_{FOL}		V_{SC} = 1 V, V_{FO} Circuit: 10 kΩ to 5 V Pull-up	-	-	0.5	V
$V_{SC(Ref)}$	Over-Current Protection Trip Level Voltage of CSC Pin	V_{CC} = 15 V	0.45	0.5	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	-	-	µs
$V_{IN(ON)}$	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°C (1st Note 4, Figure 5)	-	47	-	kΩ
		at T_{TH} = 100°C (1st Note 4, Figure 5)	-	2.9	-	kΩ

1st Notes:

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

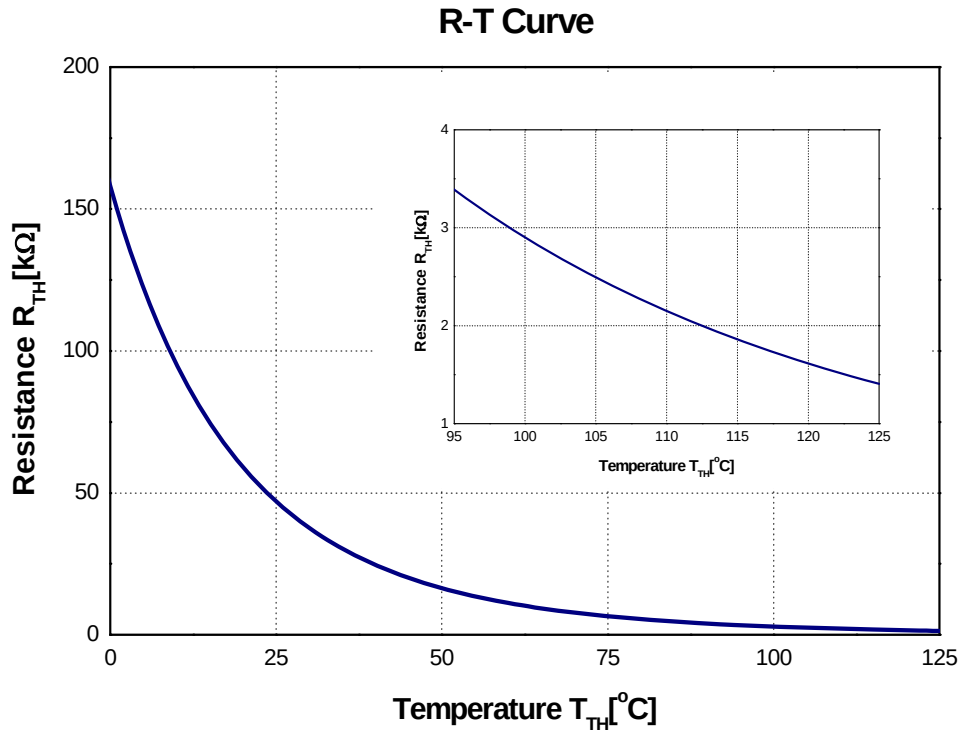


Figure 5. R-T Curve of The Built-in Thermistor

Recommended Operating Conditions (T_J = 25°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°C, V_i = 220 V, V_O = 360 V, f_{PWM} = 20 kHz per IGBT	-	-	35	A_{rms}
V_{PN}	Supply Voltage	Applied between X - N_P, Y - N_P, P - P_X, P - P_Y	-	-	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/μs
I_{FO}	Fault Output Current	Sink Current at V_{FO} Pin	-	-	1	mA
f_{PWM}	PWM Input Frequency	-40°C < T_J < 125°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	μm
Weight			-	32	-	g

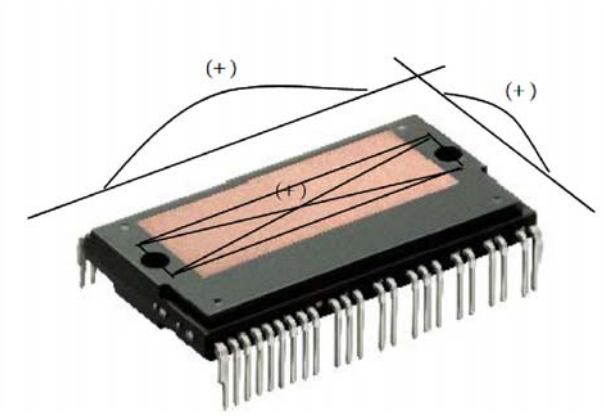
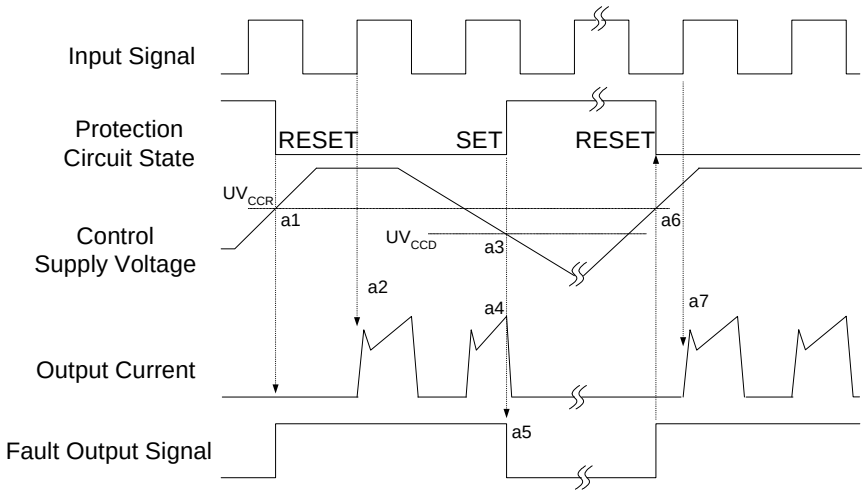


Figure 6. Flatness Measurement Position

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}).

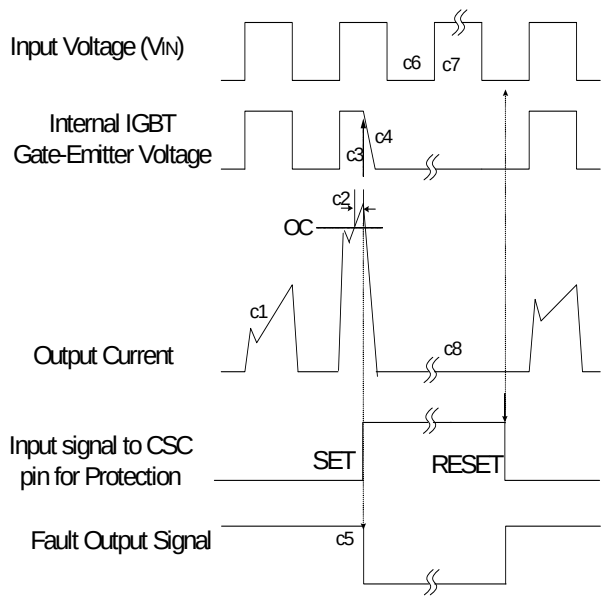
a4 : IGBT OFF in spite of control input condition.

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

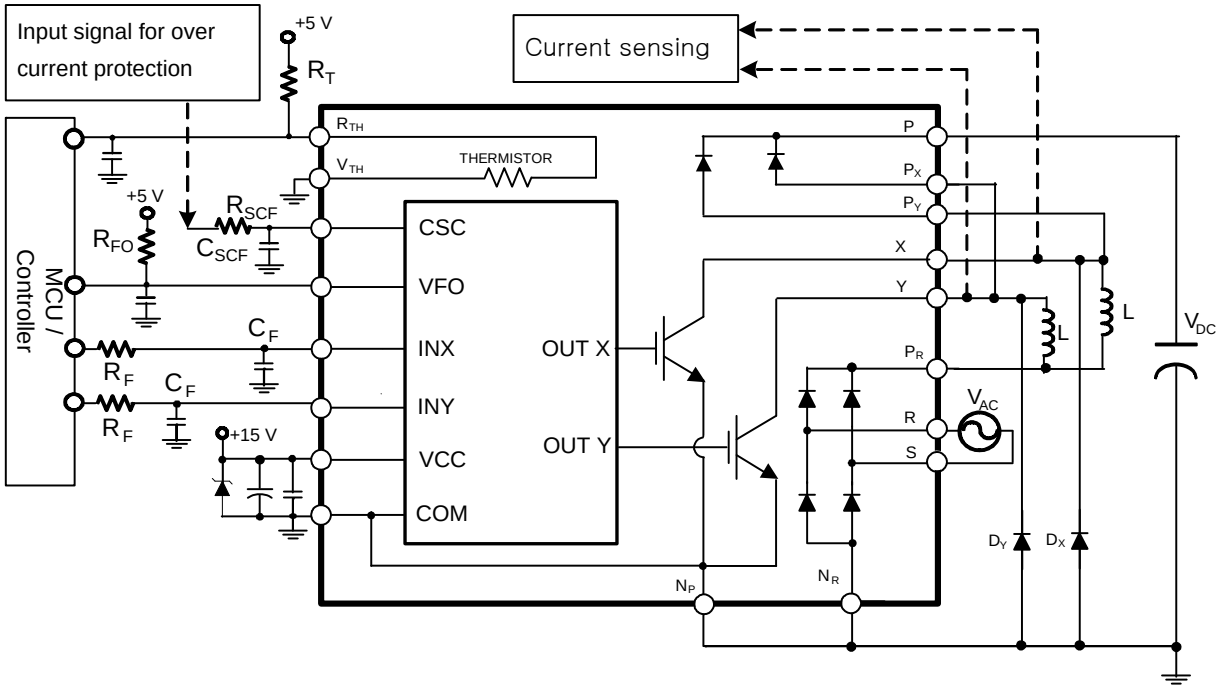
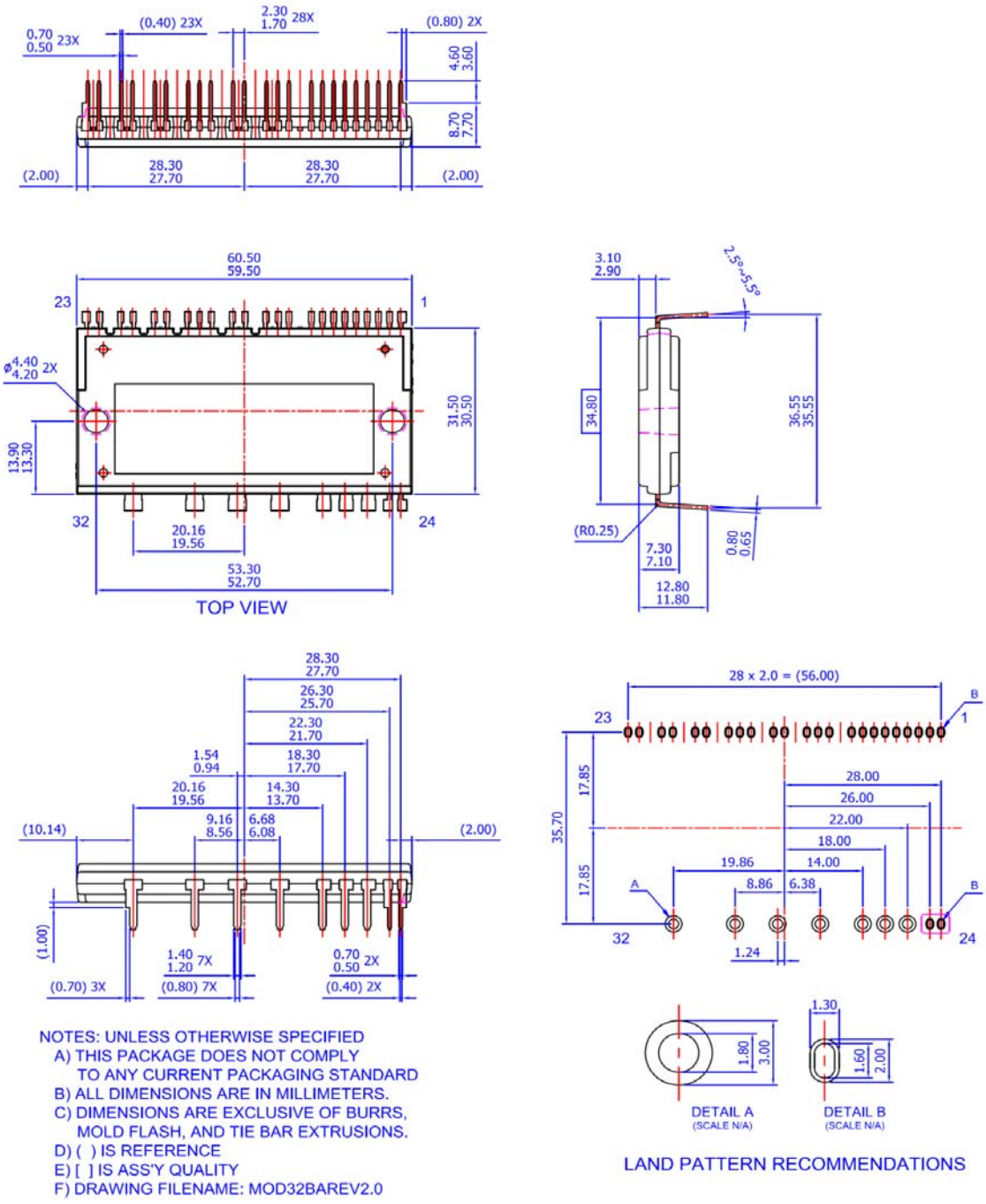


Figure 9. Typical Application Circuit

2nd Notes:

1. To avoid malfunction, the wiring of each input should be as short as possible(less than 2 ~ 3 cm).
2. V_{FO} 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_{FO} 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 recommanded for the prevention of input signal oscillation. R_FC_F constant should be selected in the range 50~150ns (recommended R_F = 100 Ω , C_F = 1 nF).
4. To prevent error of the protection function, the wiring related with R_{SCF} and C_{SCF} should be as short as possible.
5. In the over current protection circuit, please select the R_{SCF} , C_{SCF} 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_T according to the application.
9. It is recommended that anti-parallel diode (D_X ,D_Y) be connected with each IGBT.

Detailed Package Outline Drawings



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