FAIRCHILD SEMICONDUCTOR®

January 2012

Motion-SPM™

FPAM30LH60

Smart Power Module for 2-phase Interleaved PFC

Features

- Single phase rectifier for AC input
- 2-phase interleaved PFC
- Control IC for gate driving and protection
- Built-in NTC thermistor for monitoring over-temperature
- Low thermal resistance due to DBC substrate
- Isolation lating of 2500V_{rms}/min
- UL Certified No.E209024

Applications

System air conditioner

General Description

FPAM30LH60 is an advanced smart power module of 2-phase interleaved PFC(Power Factor Correction). It combines optimized drive circuit with low-loss IGBTs and using DBC which has low thermal resistance. System reliability is further enhanced by the integrated under-voltage lock-out, over-current protection, and built-in NTC thermistor for monitoring over-temperature.

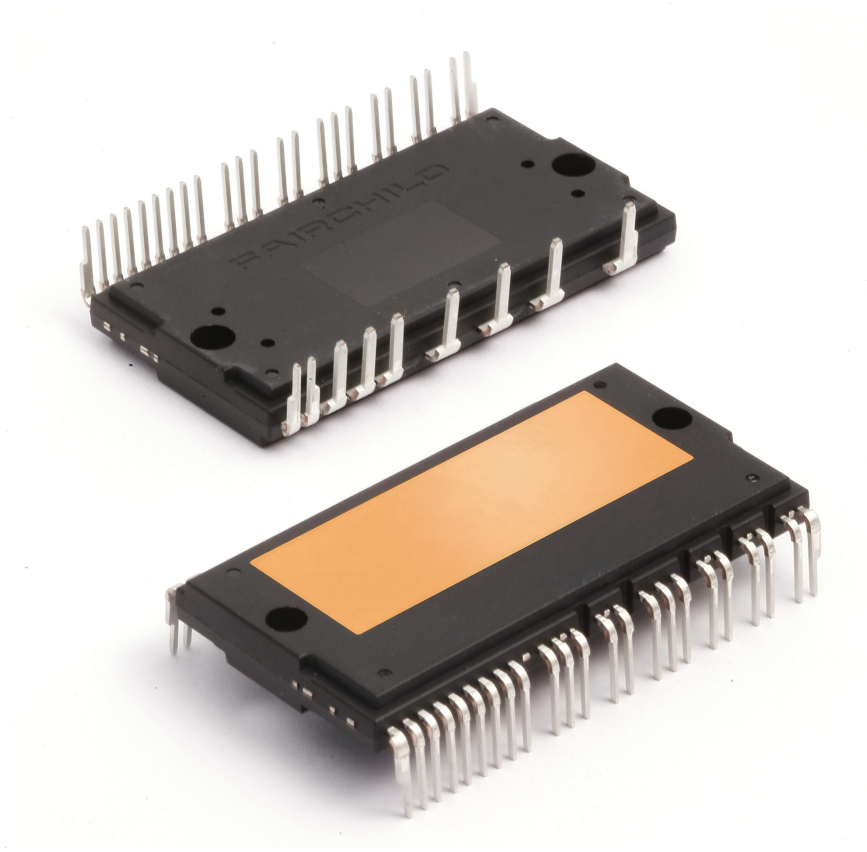


Figure 1.

Integrated Drive, Protection and System Control Functions

- For IGBTs : Gate drive circuit, Over Current protection(SC), Control supply circuit under-voltage(UV) protection
- Fault signal : Corresponding to SC and UV fault
- Built-in thermistor: Over-temperature monitoring
- Input interface : 3.3/5V CMOS/LSTTL compatible

Pin Configuration

Top View

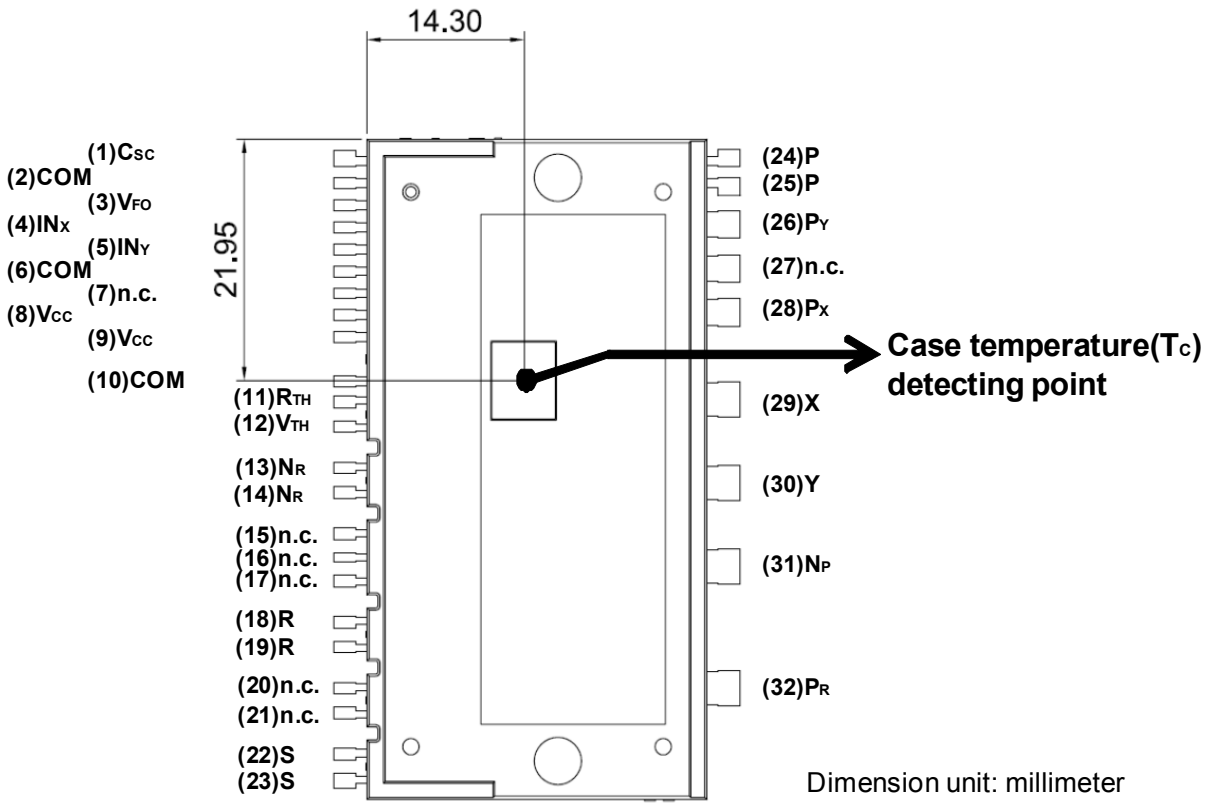


Figure 2.

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 out
4	IN_X	PWM input for X IGBT drive
5	IN_Y	PWM input for Y IGBT drive
7	n.c.	
8,9	V_{CC}	Common supply voltage of IC for IGBT drive
11	R_{TH}	Thermister
12	V_{TH}	Thermister
13,14	N_R	Negative DC-link of Rectifier Diode
15,16,17	n.c.	
18,19	R	AC input for R phase
20,21	n.c.	
22,23	S	AC input for S phase
24,25	P	Output of Diode
26	P_Y	Input of Diode
27	n.c.	
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

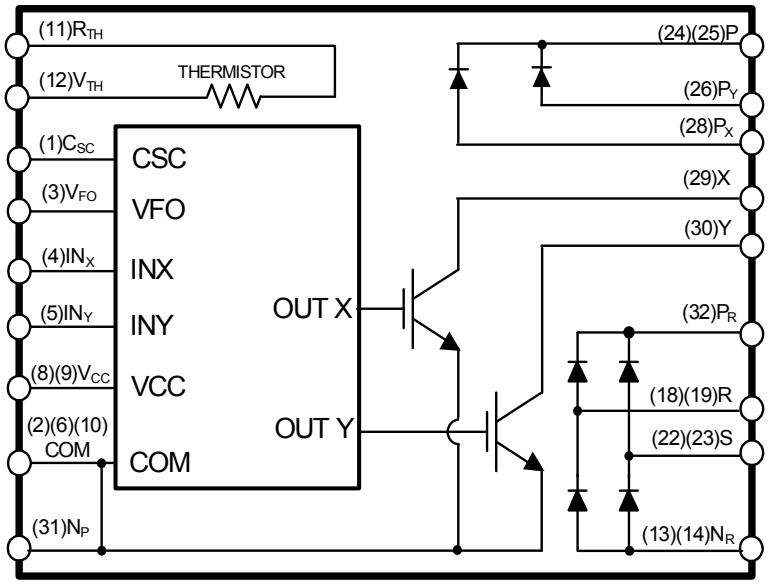


Figure 3. Internal Block Diagram

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

Converter Part

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

Note:

1. The maximum junction temperature rating of the power chips integrated within the SPM is 125°C.
2. Marking " * " is calculation value or design factor.

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_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	Units
T_{STG}	Storage Temperature		-40 ~ 125	°C
V_{ISO}	Isolation Voltage	60Hz, Sinusoidal, AC 1 minute, Connection Pins to heat sink plate	2500	V_{rms}

Thermal Resistance

Symbol	Parameter	Condition	Min.	Typ.	Max.	Units
$R_{th(j\text{-}c)Q}$	Junction to Case Thermal Resistance	Each IGBT under Operating Condition	-	-	0.93	°C/W
$R_{th(j\text{-}c)D}$		Each Diode under Operating Condition	-	-	1.42	°C/W
$R_{th(j\text{-}c)R}$		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.	Units
$V_{CE(SAT)}$	IGBT Saturation Voltage	V_{CC} = 15V, V_{IN} = 5V, I_C = 30A	-	1.7	2.2	V
V_{FF}	FRD Forward Voltage	I_F = 30A	-	1.9	2.4	V
V_{FR}	Rectifier Forward Voltage	I_{FR} = 30A	-	1.10	1.25	V
I_{RR}	Switching Characteristic	V_{PN} = 400V, V_{CC} = 15V, I_C = 15A, V_{IN} = 0V ↔ 5V, Inductive Load (Note 3), per single 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} =600V	-	-	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.

Control Part

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Units
I_{QCC}	Quiescent V_{CC} Supply Current	V_{CC} = 15V, IN_X, IN_Y - COM = 0V, Supply current between V_{CC} and COM	-	-	2.65	mA
I_{PCC}	Operating V_{CC} Supply Current	V_{CC} = 15V, f_{PWM} = 20kHz, duty=50%, applied to one PWM signal input per single IGBT, Supply current between V_{CC} and COM	-	-	6.0	mA
V_{FOH}	Fault Output Voltage	V_{SC} = 0V, V_{FO} Circuit: 10kΩ to 5V Pull-up	4.5	-	-	V
V_{FOL}		V_{SC} = 1V, V_{FO} Circuit: 10kΩ to 5V Pull-up	-	-	0.5	V
$V_{SC(Ref)}$	Over-Current Protection Trip Level Voltage of CSC pin	V_{CC} = 15V	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	@ T_{TH} = 25°C (Figure 5)(Note 4)	-	47	-	kΩ
		@ T_{TH} = 100°C (Figure 5)(Note 4)	-	2.9	-	kΩ

Note:

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

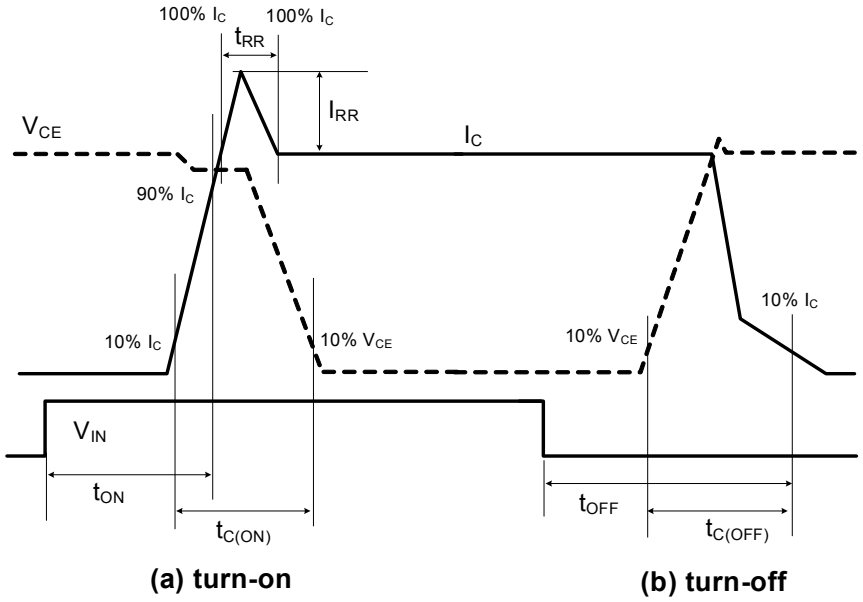


Figure 4. Switching Time Definition

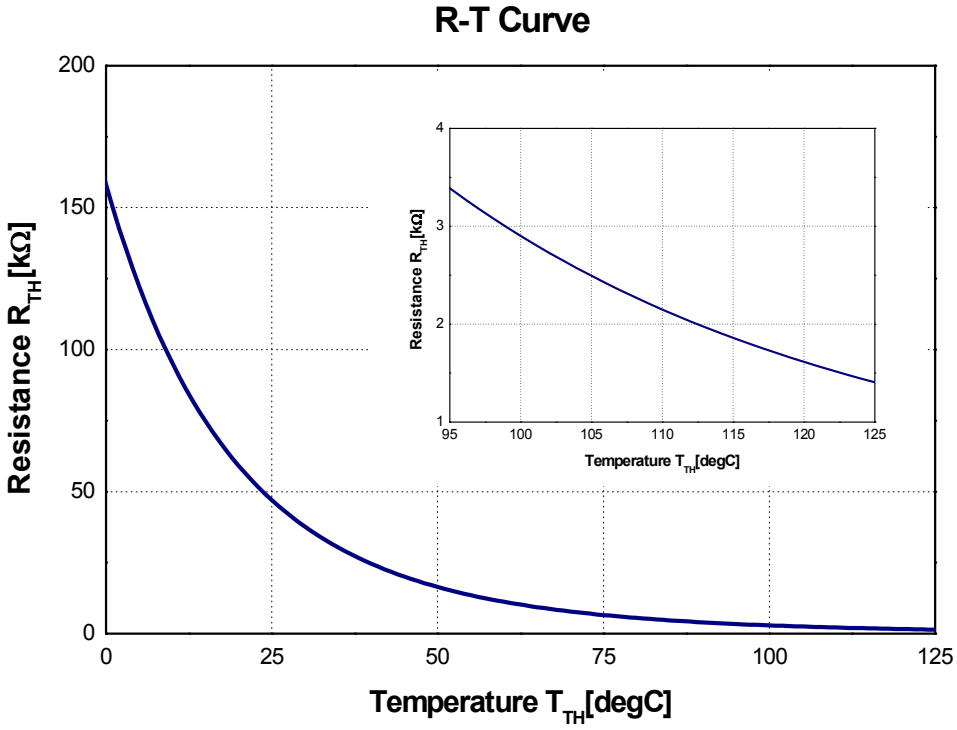


Figure 5. R-T Curve of The Built-in Thermistor

Recommended Operating Conditions (T_J = 25°C, Unless Otherwise Specified)

Symbol	Parameter	Conditions	Value			Units
			Min.	Typ.	Max.	
V_i	Input Supply Voltage	Applied between R - S	187	-	253	V_{rms}
I_i	Input Current	T_C<100°C, V_i=220V, V_O=360V, f_{PWM}=20kHz per each IGBT	-	-	21	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	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 single IGBT	-	20	-	kHz

Mechanical Characteristics and Ratings

Parameter	Conditions		Limits			Units
			Min.	Typ.	Max.	
Mounting Torque	Mounting Screw: M4	Recommended 0.98N•m	0.78	0.98	1.17	N•m
		Recommended 10kg•cm	8	10	12	kg•cm
Device Flatness	Refer to Figure 6		0	-	+150	μm
Weight			-	32	-	g

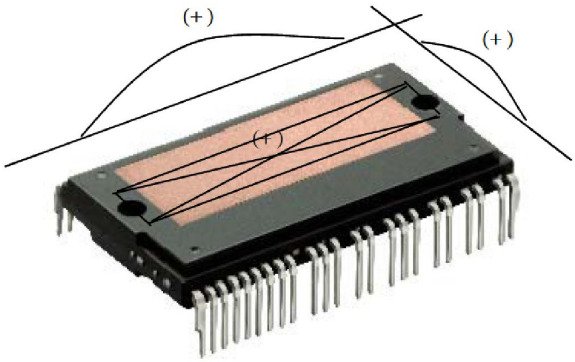
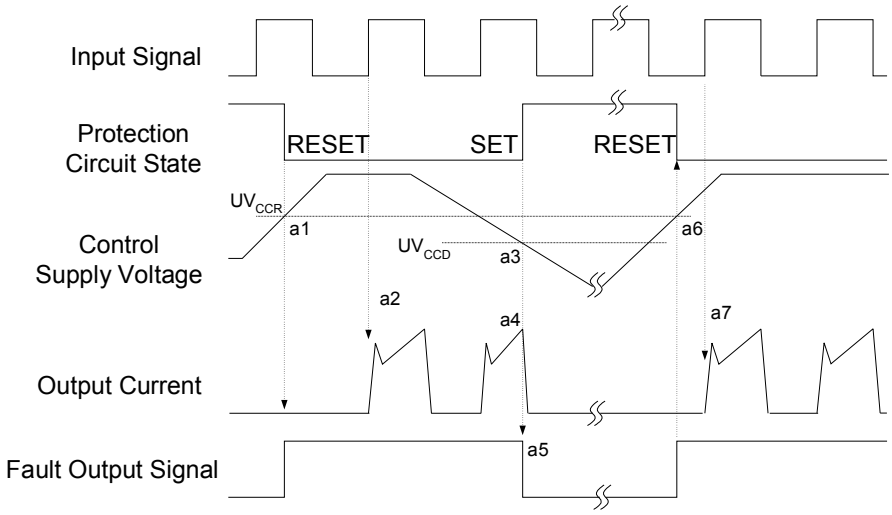


Figure 6. Flatness Measurement Position

Package Marking and Ordering Information

Device Marking	Device	Package	Reel Size	Tape Width	Quantity
FPAM30LH60	FPAM30LH60	SPM32-EA	-	-	8

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}).

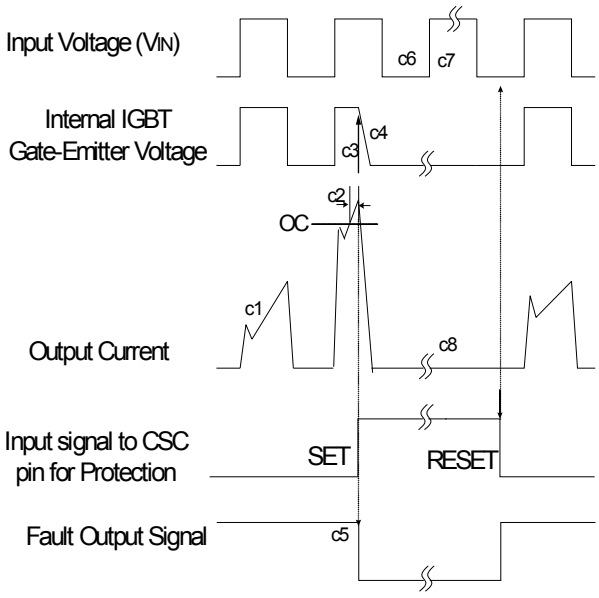
a4 : IGBT OFF in spite of control input condition.

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.

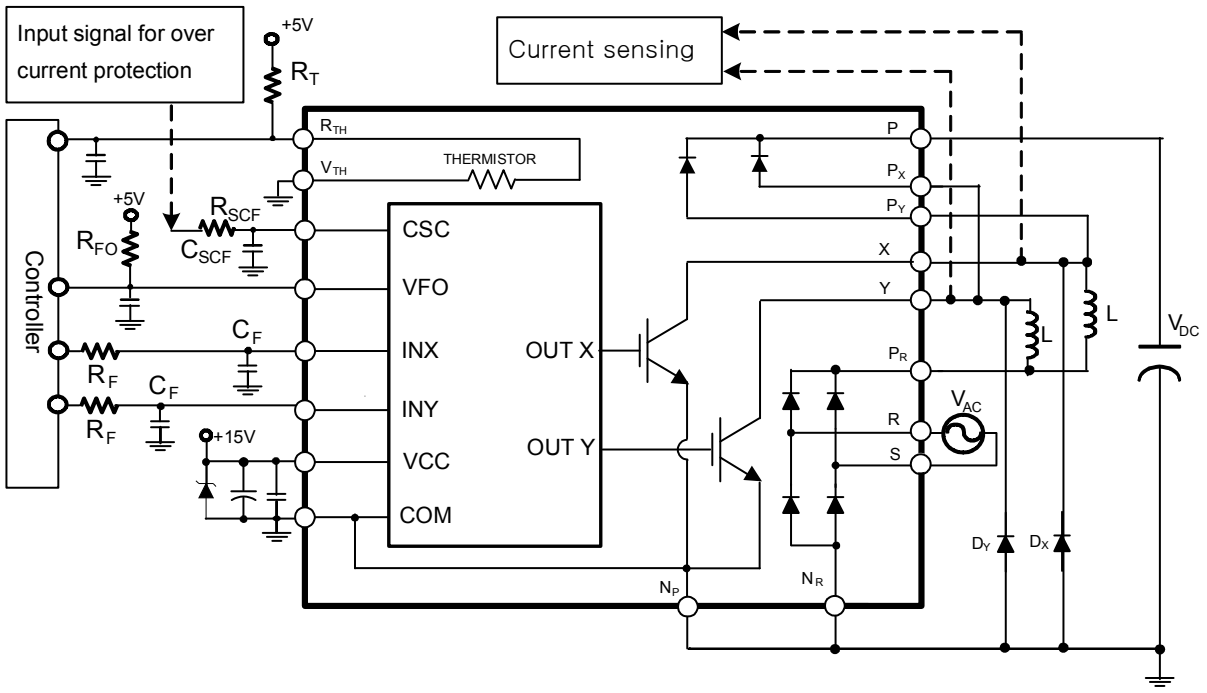
c5 : Fault output timer operation starts.

c6 : Input “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

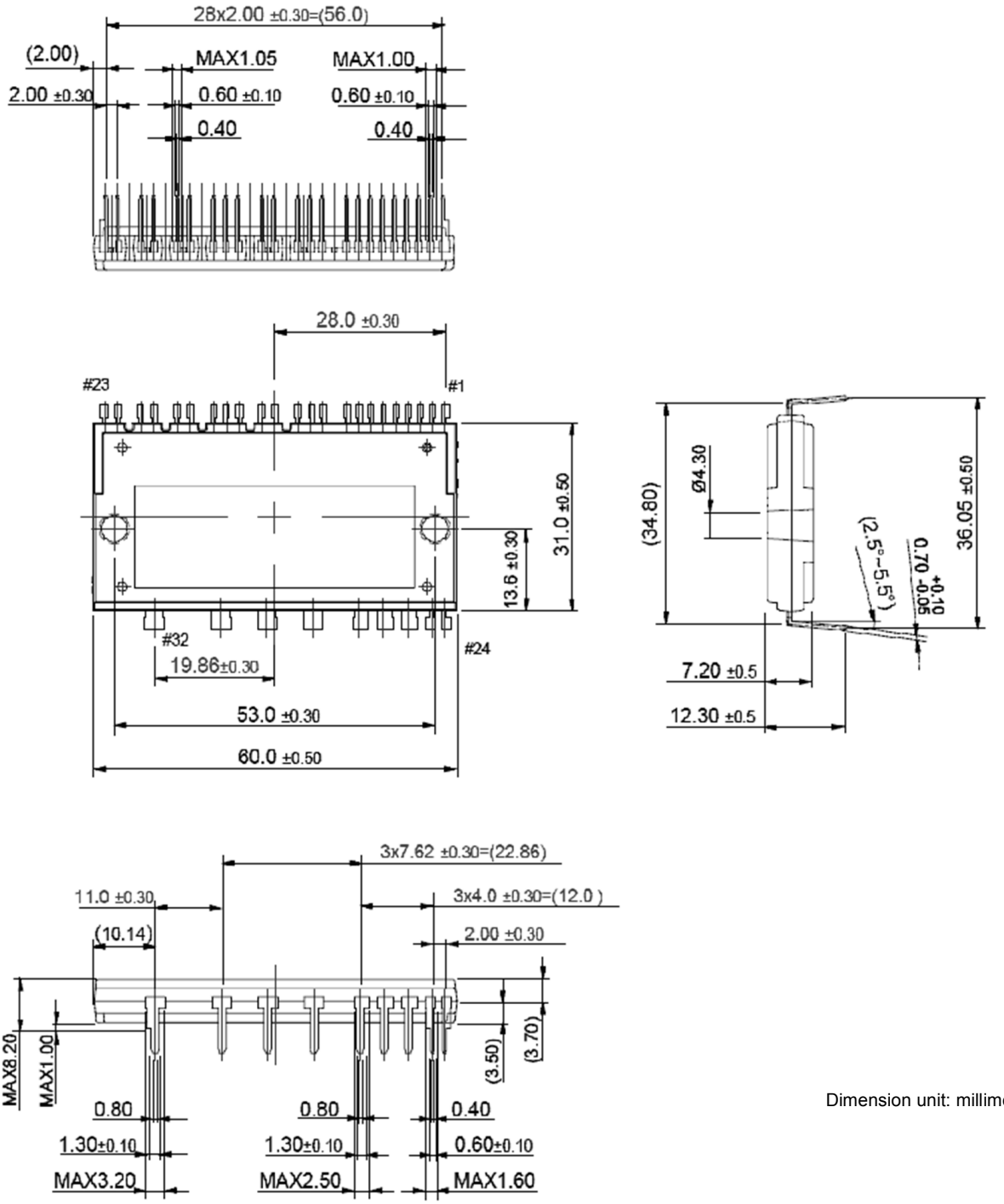


Note:

1. To avoid malfunction, the wiring of each input should be as short as possible. (less than 2~3cm)
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 1mA.
3. Input signal is High-Active type. There is a 5kΩ 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=1nF)
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 SPM 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 CPU 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.

Figure 9. Typical Application Circuit

Detailed Package Outline Drawings



Dimension unit: millimeter

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