

FSAM30SM60A

SPM™ (Smart Power Module)

General Description

FSAM30SM60A is an advanced smart power module (SPM) that Fairchild has newly developed and designed to provide very compact and high performance ac motor drives mainly targeting medium speed low-power inverterdriven application like air conditioners. It combines optimized circuit protection and drive matched to low-loss IGBTs. Highly effective short-circuit current detection/ protection is realized through the use of advanced current sensing IGBT chips that allow continuous monitoring of the IGBTs current. System reliability is further enhanced by the built-in over-temperature monitoring and integrated undervoltage lock-out protection. The high speed built-in HVIC provides opto-coupler-less IGBT gate driving capability that further reduce the overall size of the inverter system design. In addition the incorporated HVIC facilitates the use of single-supply drive topology enabling the FSAM30SM60A to be driven by only one drive supply voltage without negative bias. Inverter current sensing application can be achieved due to the divided negative dc terminals.

Features

- UL Certified No. E209204
- 600V-30A 3-phase IGBT inverter bridge including control ICs for gate driving and protection
- Divided negative dc-link terminals for inverter current sensing applications
- · Single-grounded power supply due to built-in HVIC
- · Typical switching frequency of 5kHz
- Built-in thermistor for over-temperature monitoring
- Inverter power rating of 2.4kW / 100~253 Vac
- · Isolation rating of 2500Vrms/min.
- Very low leakage current due to using ceramic substrate
- Adjustable current protection level by varying series resistor value with sense-IGBTs

Applications

- AC 100V ~ 253V 3-phase inverter drive for small power (2.4kW) ac motor drives
- Home appliances applications requiring medium switching frequency operation like air conditioners drive system
- Application ratings:
 - Power : 2.4kW / 100~253 Vac
 - Switching frequency: Typical 5kHz (PWM Control)
 - 100% load current : 11A (Irms)
 - 150% load current: 16.5A (Irms) for 1 minute

External View

Top View



Bottom View



Fig. 1.

Integrated Power Functions

• 600V-30A IGBT inverter for 3-phase DC/AC power conversion (Please refer to Fig. 3)

Integrated Drive, Protection and System Control Functions

- For inverter high-side IGBTs: Gate drive circuit, High voltage isolated high-speed level shifting Control circuit under-voltage (UV) protection
 - Note) Available bootstrap circuit example is given in Figs. 14 and 15.
- For inverter low-side IGBTs: Gate drive circuit, Short-Circuit (SC) protection
 Control supply circuit under-voltage (UV) protection
- Temperature Monitoring: System over-temperature monitoring using built-in thermistor Note) Available temperature monitoring circuit is given in Fig. 15.
- Fault signaling: Corresponding to a SC fault (Low-side IGBTs) or a UV fault (Low-side control supply circuit)
- Input interface: 5V CMOS/LSTTL compatible, Schmitt trigger input

Pin Configuration

Top View

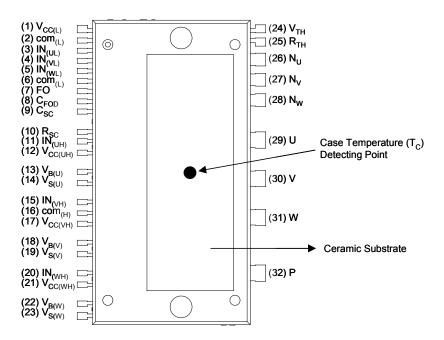


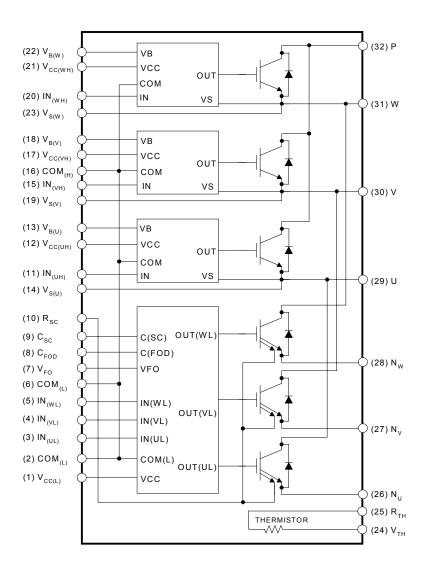
Fig. 2.

Pin Descriptions

Pin Number	Pin Name	Pin Description
1	$V_{CC(L)}$	Low-side Common Bias Voltage for IC and IGBTs Driving
2	COM _(L)	Low-side Common Supply Ground
3	IN _(UL)	Signal Input for Low-side U Phase
4	IN _(VL)	Signal Input for Low-side V Phase
5	IN _(WL)	Signal Input for Low-side W Phase
6	COM _(L)	Low-side Common Supply Ground
7	V_{FO}	Fault Output
8	C _{FOD}	Capacitor for Fault Output Duration Time Selection
9	C _{SC}	Capacitor (Low-pass Filter) for Short-Circuit Current Detection Input
10	R _{SC}	Resistor for Short-Circuit Current Detection
11	IN _(UH)	Signal Input for High-side U Phase
12	V _{CC(UH)}	High-side Bias Voltage for U Phase IC
13	V _{B(U)}	High-side Bias Voltage for U Phase IGBT Driving
14	V _{S(U)}	High-side Bias Voltage Ground for U Phase IGBT Driving
15	IN _(VH)	Signal Input for High-side V Phase
16	COM _(H)	High-side Common Supply Ground
17	V _{CC(VH)}	High-side Bias Voltage for V Phase IC
18	V _{B(V)}	High-side Bias Voltage for V Phase IGBT Driving
19	V _{S(V)}	High-side Bias Voltage Ground for V Phase IGBT Driving
20	IN _(WH)	Signal Input for High-side W Phase
21	V _{CC(WH)}	High-side Bias Voltage for W Phase IC
22	V _{B(W)}	High-side Bias Voltage for W Phase IGBT Driving
23	V _{S(W)}	High-side Bias Voltage Ground for W Phase IGBT Driving
24	V_{TH}	Thermistor Bias Voltage
25	R _{TH}	Series Resistor for the Use of Thermistor (Temperature Detection)
26	N _U	Negative DC-Link Input for U Phase
27	N _V	Negative DC–Link Input for V Phase
28	N _W	Negative DC–Link Input for W Phase
29	U	Output for U Phase
30	V	Output for V Phase
31	W	Output for W Phase
32	Р	Positive DC–Link Input

Internal Equivalent Circuit and Input/Output Pins

Bottom View



- 1) Inverter low-side is composed of three sense-IGBTs including freewheeling diodes for each IGBT and one control IC which has gate driving, current sensing and protection functions.

 2) Inverter power side is composed of four inverter dc-link input pins and three inverter output pins.

 3) Inverter high-side is composed of three normal-IGBTs including freewheeling diodes and three drive ICs for each IGBT.

Fig. 3.

Absolute Maximum Ratings $(T_J = 25^{\circ}C, Unless Otherwise Specified)$

Inverter Part

Item	Symbol	Condition	Rating	Unit
Supply Voltage	V_{PN}	Applied between P- N_U , N_V , N_W	450	V
Supply Voltage (Surge)	V _{PN(Surge)}	Applied between P- N _U , N _V , N _W	500	V
Collector-Emitter Voltage	V _{CES}		600	V
Each IGBT Collector Current	± I _C	T _C = 25°C	30	Α
Each IGBT Collector Current	± I _C	T _C = 100°C	16	Α
Each IGBT Collector Current (Peak)	± I _{CP}	T _C = 25°, Instantaneous Value (Pulse)	60	Α
Collector Dissipation	P _C	T _C = 25°C per One Chip	62	W
Operating Junction Temperature	T _J	(Note 1)	-20 ~ 125	°C

Control Part

Item	Symbol	Condition	Rating	Unit
Control Supply Voltage	V _{CC}	Applied between $V_{CC(UH)}$, $V_{CC(VH)}$, $V_{CC(WH)}$ - $COM_{(H)}$, $V_{CC(L)}$ - $COM_{(L)}$	20	V
High-side Control Bias Voltage	V _{BS}	Applied between $V_{B(U)}$ - $V_{S(U)}$, $V_{B(V)}$ - $V_{S(V)}$, $V_{B(W)}$ - $V_{S(W)}$	20	V
Input Signal Voltage	V _{IN}	Applied between $IN_{(UH)}$, $IN_{(VH)}$, $IN_{(WH)}$ - $COM_{(H)}$ $IN_{(UL)}$, $IN_{(VL)}$, $IN_{(WL)}$ - $COM_{(L)}$	-0.3 ~ V _{CC} +0.3	V
Fault Output Supply Voltage	V_{FO}	Applied between V _{FO} - COM _(L)	-0.3 ~ V _{CC} +0.3	V
Fault Output Current	I _{FO}	Sink Current at V _{FO} Pin	5	mA
Current Sensing Input Voltage	V _{SC}	Applied between C _{SC} - COM _(L)	-0.3 ~ V _{CC} +0.3	V

Total System

Item	Symbol	Condition	Rating	Unit
Self Protection Supply Voltage Limit (Short-Circuit Protection Capability)	V _{PN(PROT)}	$V_{CC} = V_{BS} = 13.5 \sim 16.5 V$ T _J = 25°C, Non-repetitive, less than 6μs	400	V
Module Case Operation Temperature	T _C	Note Fig.2	-20 ~ 100	°C
Storage Temperature	T _{STG}		-20 ~ 125	°C
Isolation Voltage	V _{ISO}	60Hz, Sinusoidal, AC 1 minute, Connection Pins to Heat-sink Plate	2500	V _{rms}

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Note:
1. It would be recommended that the average junction temperature should be limited to $T_J \le 125^{\circ}C$ (@ $T_C \le 100^{\circ}C$) in order to guarantee safe operation.

Absolute Maximum Ratings

Thermal Resistance

ltem	Symbol	Condition	Min.	Тур.	Max.	Unit
Junction to Case Thermal Resistance	R _{th(j-c)Q}	Each IGBT under Inverter Operating Condition	-	-	2.0	°C/W
	R _{th(j-c)F}	Each FWDi under Inverter Operating Condition	-	-	3.2	°C/W
Contact Thermal Resistance	R _{th(c-f)}	Ceramic Substrate (per 1 Module) Thermal Grease Applied (Note 3)	-	1	0.06	°C/W

- $\label{eq:Note:2} \textbf{Note:} \\ 2. \ \ \text{For the measurement point of case temperature}(T_C), \ please \ refer to \ Fig. \ 2. \\ 3. \ \ The \ thickness \ of \ thermal \ grease \ should \ not \ be \ more \ than \ 100 um. \\ \end{cases}$

$\textbf{Electrical Characteristics} \quad (T_j = 25^{\circ}\text{C, Unless Otherwise Specified})$

Inverter Part

Item	Symbol	Condition	Condition		Тур.	Max.	Unit
Collector - Emitter Saturation Voltage	V _{CE(SAT)}	$V_{CC} = V_{BS} = 15V$ $V_{IN} = 0V$	$I_C = 30A, T_J = 25^{\circ}C$	-	-	2.3	V
FWDi Forward Voltage	V_{FM}	V _{IN} = 5V	$I_C = 30A, T_J = 25^{\circ}C$	-	-	2.6	V
Switching Times	t _{ON}	V_{PN} = 300V, V_{CC} = V_{BS} = 15V I_{C} = 30A, T_{J} = 25°C V_{IN} = 5V \leftrightarrow 0V, Inductive Load		-	0.39	-	us
	t _{C(ON)}			-	0.2	-	us
	t _{OFF}			-	0.95	-	us
	t _{C(OFF)}	(Figit, Low-side)	(High, Low-side)		0.39	-	us
	t _{rr}	(Note 4)		-	0.13	-	us
Collector - Emitter Leakage Current	I _{CES}	$V_{CE} = V_{CES}$, $T_{J} = 25$ °C		-	-	250	μА

^{4.} to_N and to_FF 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 Fig. 4.

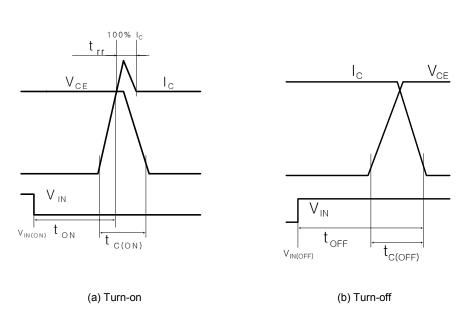


Fig. 4. Switching Time Definition

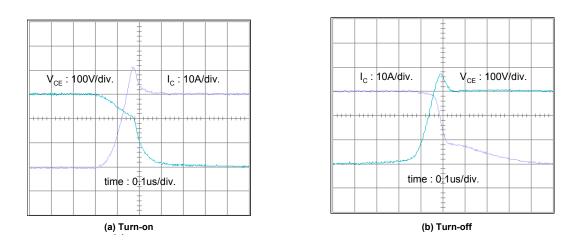


Fig. 5. Experimental Results of Switching Waveforms Test Condition: Vdc=300V, Vcc=15V, L=500uH (Inductive Load), T_J =25°C

Electrical Characteristics (T_J = 25°C, Unless Otherwise Specified) **Control Part**

Item	Symbol		Condition	Min.	Тур.	Max.	Unit
Quiescent V _{CC} Supply Current	I _{QCCL}	V _{CC} = 15V IN _(UL, VL, WL) = 5V	$V_{CC(L)}$ - $COM_{(L)}$	-	1	26	mA
	I _{QCCH}	V _{CC} = 15V IN _(UH, VH, WH) = 5V	$V_{CC(UH)}$, $V_{CC(VH)}$, $V_{CC(WH)}$ - $COM_{(H)}$	-	-	130	uA
Quiescent V _{BS} Supply Current	I_{QBS}	V _{BS} = 15V IN _(UH, VH, WH) = 5V	$egin{array}{c} V_{B(U)} - V_{S(U)}, \ V_{B(V)} - V_{S(V)}, \ V_{B(W)} - V_{S(W)} \end{array}$	-	1	420	uA
Fault Output Voltage	V_{FOH}	V_{SC} = 0V, V_{FO} Circuit	: 4.7kΩ to 5V Pull-up	4.5	-	-	V
	V_{FOL}	V_{SC} = 1V, V_{FO} Circuit	: 4.7kΩ to 5V Pull-up	-	-	1.1	V
Short-Circuit Trip Level	V _{SC(ref)}	V _{CC} = 15V (Note 5)			0.51	0.56	V
Sensing Voltage of IGBT Current	V _{SEN}	R_{SC} = 56 Ω , R_{SU} = R_{SV} = R_{SW} = 0 Ω and I_C = 45A (Note Fig. 7)			0.51	0.56	V
Supply Circuit Under-	UV _{CCD}	Detection Level		11.5	12	12.5	V
Voltage Protection	UV _{CCR}	Reset Level		12	12.5	13	V
	UV _{BSD}	Detection Level		7.3	9.0	10.8	V
	UV _{BSR}	Reset Level		8.6	10.3	12	V
Fault Output Pulse Width	t _{FOD}	C _{FOD} = 33nF (Note 6)	1.4	1.8	2.0	ms
ON Threshold Voltage	V _{IN(ON)}	High-Side	Applied between IN _(UH) , IN _(VH) ,	-	-	0.8	V
OFF Threshold Voltage	V _{IN(OFF)}]	IN _(WH) - COM _(H)	3.0	-	-	V
ON Threshold Voltage	V _{IN(ON)}	Low-Side	Applied between IN _(UL) , IN _(VL) ,	-	-	8.0	V
OFF Threshold Voltage	V _{IN(OFF)}		IN _(WL) - COM _(L)	3.0	-	-	V
Resistance of Thermistor	R _{TH}	@ T _{TH} = 25°C (Note Fig. 6) (Note 7)		-	50	-	kΩ
		@ T _{TH} = 100°C (Note	e Fig. 6) (Note 7)	-	3.4	-	kΩ

- Note: 5. Short-circuit current protection is functioning only at the low-sides. It would be recommended that the value of the external sensing resistor (R_{SC}) should be selected around 56 Ω in order to make the SC trip-level of about 45A at the shunt resistors (R_{SU},R_{SV},R_{SW}) of $\Omega\Omega$. For the detailed information about the relationship between the external sensing resistor (R_{SQ}) and the shunt resistors (R_{SU},R_{SV},R_{SW}), please see Fig. 7.

 6. The fault-out pulse width t_{FOD} depends on the capacitance value of C_{FOD} according to the following approximate equation: $C_{FOD} = 18.3 \times 10^{-6} \times t_{FOD}[F]$ 7. T_{TH} is the temperature of thermistor itself. To know case temperature (T_{C}), please make the experiment considering your application.

Recommended Operating Conditions

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Item	Symbol	Condition		Тур.	Max.	Unit
Supply Voltage	V_{PN}	Applied between P - N _U , N _V , N _W	-	300	400	V
Control Supply Voltage	V _{CC}	Applied between $V_{CC(UH)}$, $V_{CC(VH)}$, $V_{CC(WH)}$ - $COM_{(H)}$, $V_{CC(L)}$ - $COM_{(L)}$	13.5	15	16.5	V
High-side Bias Voltage	V _{BS}	Applied between $V_{B(U)}$ - $V_{S(U)}$, $V_{B(V)}$ - $V_{S(V)}$, $V_{B(W)}$ - $V_{S(W)}$	13.5	15	16.5	V
Blanking Time for Preventing Arm-short	t _{dead}	For Each Input Signal	3	-	-	us
PWM Input Signal	f _{PWM}	T _C ≤ 100°C, T _J ≤ 125°C	-	5	-	kHz
Input ON Threshold Voltage	V _{IN(ON)}	$ \begin{array}{c} \text{Applied between IN}_{(\text{UH})}, \text{IN}_{(\text{VH})}, \text{IN}_{(\text{WH})} - \\ \text{COM}_{(\text{H})}, \text{IN}_{(\text{UL})}, \text{IN}_{(\text{VL})}, \text{IN}_{(\text{WL})} - \text{COM}_{(\text{L})} \end{array} $		0 ~ 0.65	5	V
Input OFF Threshold Voltage	V _{IN(OFF)}	Applied between $IN_{(UH)}$, $IN_{(VH)}$, $IN_{(WH)}$ - $COM_{(H)}$, $IN_{(UL)}$, $IN_{(VL)}$, $IN_{(WL)}$ - $COM_{(L)}$		4 ~ 5.5		V

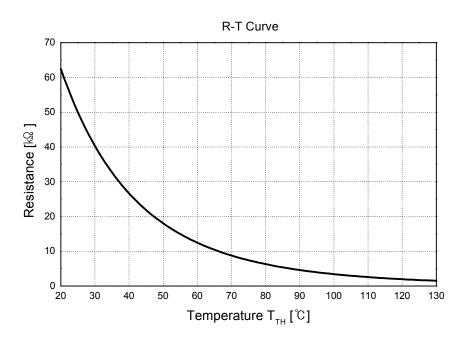


Fig. 6. R-T Curve of The Built-in Thermistor

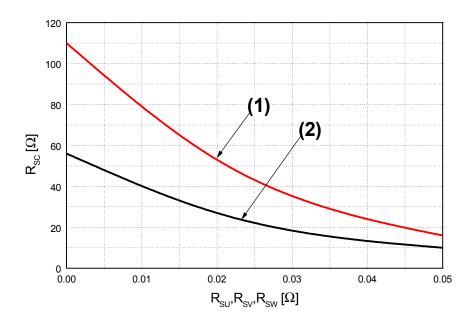


Fig. 7. R_{SC} Variation by change of Shunt Resistors (R_{SU}, R_{SV}, R_{SW}) for Short-Circuit Protection (1) @ around 100% Rated Current Trip (I_C = . 30A) (2) @ around 150% Rated Current Trip (I_C = . 45A)

Mechanical Characteristics and Ratings

lto	Condition			Limits			
Item		Condition	Min.	Тур.	Max.	Unit	
Mounting Torque	Mounting Screw: M4	Recommended 10Kg•cm	8	10	12	Kg•cm	
	(Note 8 and 9)	Recommended 0.98N•m	0.78	0.98	1.17	N•m	
Ceramic Flatness		Note Fig.8	0	-	+120	um	
Weight			-	35	-	g	

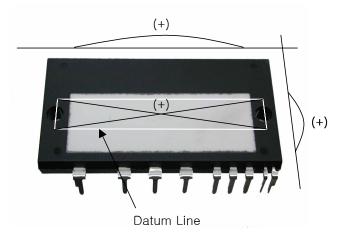


Fig. 8. Flatness Measurement Position of The Ceramic Substrate

- Note:
 8. Do not make over torque or mounting screws. Much mounting torque may cause ceramic cracks and bolts and Al heat-fin destruction.
 9. Avoid one side tightening stress. Fig.9 shows the recommended torque order for mounting screws. Uneven mounting can cause the SPM ceramic substrate to be damaged.

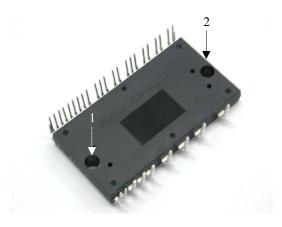
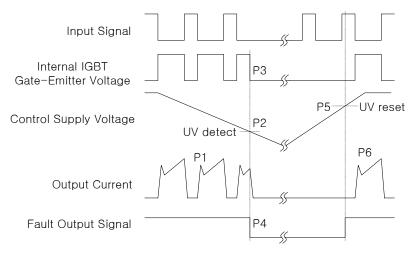


Fig. 9. Mounting Screws Torque Order

Time Charts of SPMs Protective Function

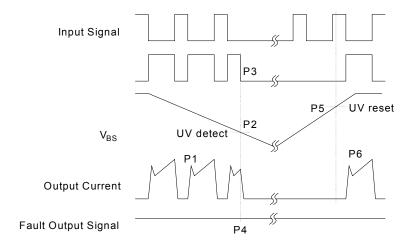


P1: Normal operation - IGBT ON and conducting current

P2 : Under-Voltage detection P3 : IGBT gate interrupt P4 : Fault signal generation P5 : Under-Voltage reset

P6: Normal operation - IGBT ON and conducting current

Fig. 10. Under-Voltage Protection (Low-side)



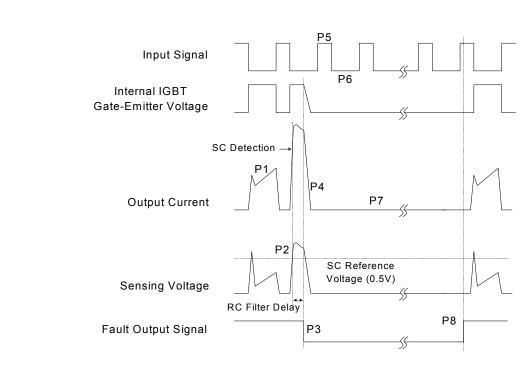
P1 : Normal operation - IGBT ON and conducting current

P2 : Under-Voltage detection P3 : IGBT gate interrupt

P4 : No fault signal P5 : Under-Voltage reset

P6: Normal operation - IGBT ON and conducting current

Fig. 11. Under-Voltage Protection (High-side)



P1: Normal operation - IGBT ON and conducting current

P2 : Short-Circuit current detection

P3: IGBT gate interrupt / Fault signal generation

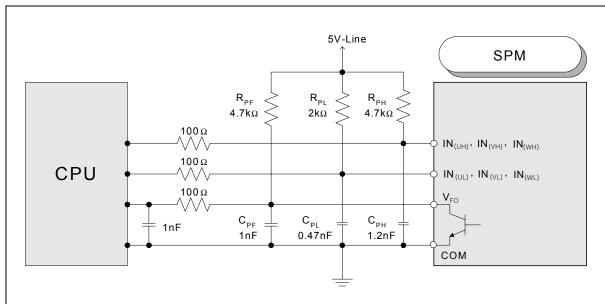
P4: IGBT is slowly turned off

P5 : IGBT OFF signal
P6 : IGBT ON signal - but IGBT cannot be turned on during the fault Output activation

P7 : IGBT OFF state

P8: Fault Output reset and normal operation start

Fig. 12. Short-Circuit Current Protection (Low-side Operation only)



Note:

- 1) It would be recommended that by-pass capacitors for the gating input signals, IN_(UL), IN_(VL), IN_(UL), IN_(UH), IN_(UH), IN_(UH), and IN_(WH) should be placed on the SPM pins and on the both sides of CPU and SPM for the fault output signal, V_{FO}, as close as possible.

 2) The logic input is compatible with standard CMOS or LSTTL outputs.
- 2) The logic imput is companied with standard civids in LSTTE outputs.
 3) R_{PL}C_{PL}/R_{PH}C_{PH}/R_{PF}C_{PF} coupling at each SPM input is recommended in order to prevent input/output signals' oscillation and it should be as close as possible to each of SPM pins.

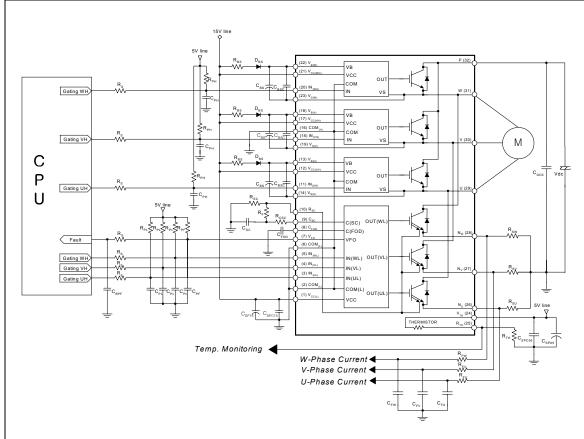
Fig. 13. Recommended CPU I/O Interface Circuit

One-Leg Diagram of SPM 15V-Line D_{BS} **20**Ω Vcc VΒ IN НО 56uF 0.1uE COM VS Inverter Output Vcc 470uF > 0.1uF IN OUT COM

These Values depend on PWM Control Algorithm

It would be recommended that the bootstrap diode, D_{BS}, has soft and fast recovery characteristics.

Fig. 14. Recommended Bootstrap Operation Circuit and Parameters



Note:

- 1) R_{PL}C_{PL}/R_{PH}C_{PH} /R_{PF}C_{PF} coupling at each SPM input is recommended in order to prevent input signals' oscillation and it should be as close as possible to each SPM input pin.
- 2) By virtue of integrating an application specific type HVIC inside the SPM, direct coupling to CPU terminals without any opto-coupler or transformer isolation is
- 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 Fig. 15
- C_{SP15} of around 7 times larger than bootstrap capacitor C_{BS} is recommended.
- 5) V_{FO} output pulse width should be determined by connecting an external capacitor(C_{FOD}) between C_{FOD} (pin8) and $COM_{(L)}$ (pin2). (Example : if C_{FOD} = 33 nF, then t_{FO} = 1.8 ms (typ.)) Please refer to the note 6 for calculation method.
- 6) Each input signal line should be pulled up to the 5V power supply with approximately 4.7kΩ (at high side input) or 2kΩ (at low side input) resistance (other RC coupling circuits at each input may be needed depending on the PWM control scheme used and on the wiring impedance of the system's printed circuit board). Approximately a 0.22~2nF by-pass capacitor should be used across each power supply connection terminals.

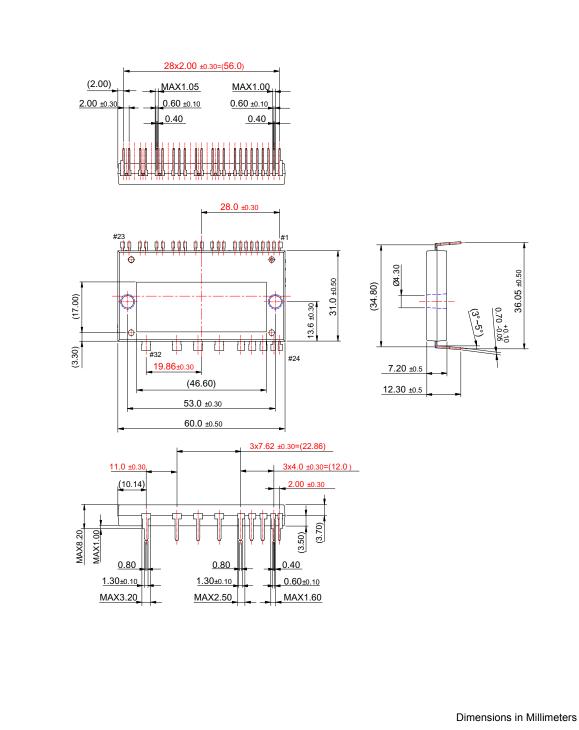
- To prevent errors of the protection function, the wiring around R_{SC}, R_F and C_{SC} should be as short as possible.
 In the short-circuit protection circuit, please select the R_FC_{SC} time constant in the range 3~4 μs.
 To enhance the noise immunity, C_{SC} pin should be connected to the external circuit through a series resistor, R_{CSC}, which is approximately 390Ω. R_{SCS} should be connected to $C_{\mbox{\footnotesize SC}}$ pin as close as possible.
- 10)Each capacitor should be mounted as close to the pins of the SPM as possible.
- 11)To prevent surge destruction, the wiring between the smoothing capacitor and the P&N pins should be as short as possible. The use of a high frequency noninductive capacitor of around 0.1~0.22 uF between the P&N pins is recommended.
- 12)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. It is recommended that the distance be 5cm at least.

Fig. 15. Typical Application Circuit

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Detailed Package Outline Drawings

SPM32-AA



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PRODUCT STATUS DEFINITIONS

Definition of Terms

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