FAIRCHILD

SEMICONDUCTOR®

FSAM10SH60A

SPM™ (Smart Power Module)

General Description

FSAM10SH60A 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 high speed low-power inverter-driven application like washing machines. 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 under-voltage 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 FSAM10SH60A to be driven by only one drive supply voltage without negative bias. Inverter current sensing application can be achieved due to the divided nagative dc terminals.

Features

- UL Certified No. E209204
- 600V-10A 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 15kHz
- Built-in thermistor for over-temperature monitoring
- Inverter power rating of 0.5kW / 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 (0.5kW) ac motor drives
- Home appliances applications requiring high switching frequency operation like washing machines drive system
- Application ratings:
  - Power : 0.5 kW / 100~253 Vac
  - Switching frequency : Typical 15kHz (PWM Control)
  - 100% load current : 3.3A (Irms)
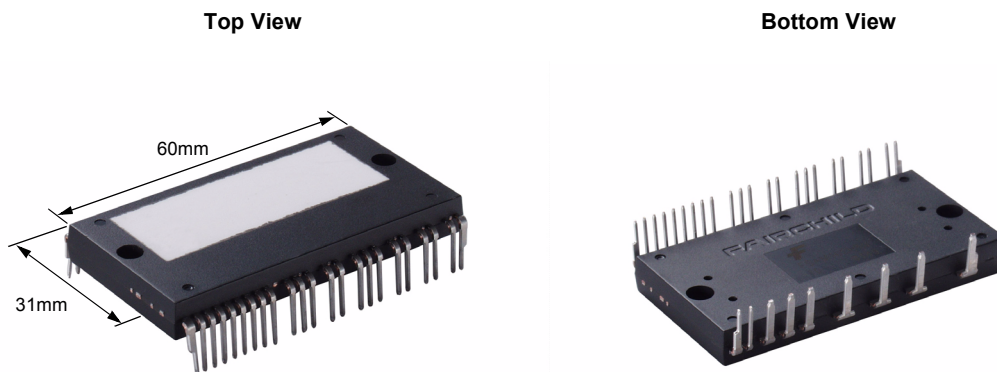 - 150% load current : 5.0A (Irms) for 1 minute

External View

Top View

Bottom View

60mm

31mm

Fig. 1.

Integrated Power Functions

• 600V-10A 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

(1) $V_{CC(L)}$
(2) $com_{(L)}$
(3) $IN_{(UL)}$
(4) $IN_{(VL)}$
(5) $IN_{(WL)}$
(6) $com_{(L)}$
(7) FO
(8) C_{FOD}
(9) C_{SC}

(10) R_{SC}
(11) $IN_{(UH)}$
(12) $V_{CC(UH)}$

(13) $V_{B(U)}$
(14) $V_{S(U)}$

(15) $IN_{(VH)}$
(16) $com_{(H)}$
(17) $V_{CC(VH)}$

(18) $V_{B(V)}$
(19) $V_{S(V)}$

(20) $IN_{(WH)}$
(21) $V_{CC(WH)}$

(22) $V_{B(W)}$
(23) $V_{S(W)}$

(24) V_{TH}
(25) R_{TH}

(26) N_U

(27) N_V

(28) N_W

(29) U

(30) V

(31) W

(32) P

Case Temperature (T_C)
Detecting Point

Ceramic Substrate
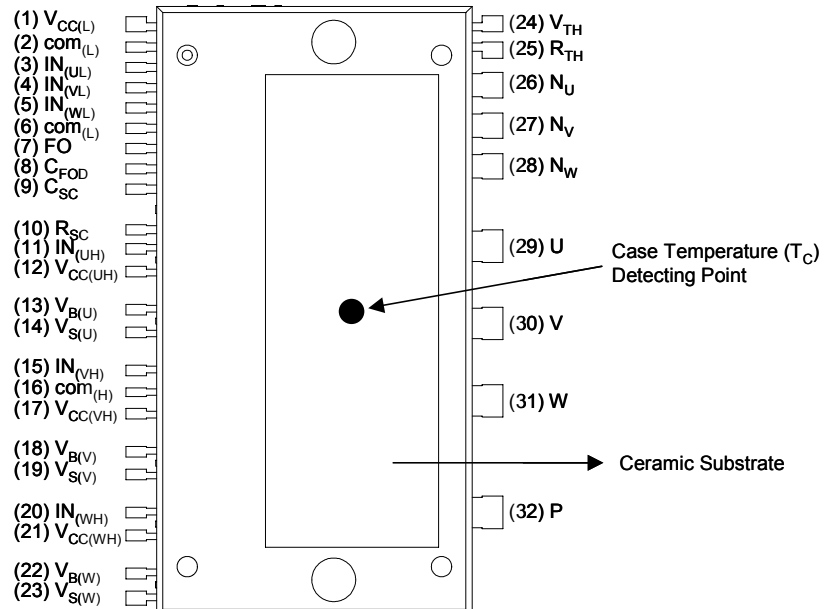
Fig. 2.

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	P	Positive DC–Link Input

Internal Equivalent Circuit and Input/Output Pins

Bottom View

Pin	Label
(22)	$V_{B(W)}$
(21)	$V_{CC(WH)}$
(20)	$IN_{(WH)}$
(23)	$V_{S(W)}$
(18)	$V_{B(V)}$
(17)	$V_{CC(VH)}$
(16)	$COM_{(H)}$
(15)	$IN_{(VH)}$
(19)	$V_{S(V)}$
(13)	$V_{B(U)}$
(12)	$V_{CC(UH)}$
(11)	$IN_{(UH)}$
(14)	$V_{S(U)}$
(10)	R_{SC}
(9)	C_{SC}
(8)	C_{FOD}
(7)	V_{FO}
(6)	$COM_{(L)}$
(5)	$IN_{(WL)}$
(4)	$IN_{(VL)}$
(3)	$IN_{(UL)}$
(2)	$COM_{(L)}$
(1)	$V_{CC(L)}$
(32)	P
(31)	W
(30)	V
(29)	U
(28)	N_W
(27)	N_V
(26)	N_U
(25)	R_{TH}
(24)	V_{TH}

VB, VCC, COM, IN, OUT, VS

C(SC), C(FOD), VFO, IN(WL), IN(VL), IN(UL), COM(L), VCC

OUT(WL), OUT(VL), OUT(UL)

THERMISTOR

Note:
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°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	$\pm I_C$	T_C = 25°C	10	A
Each IGBT Collector Current	$\pm I_C$	T_C = 100°C	9	A
Each IGBT Collector Current (Peak)	$\pm I_{CP}$	T_C = 25°C, Instantaneous Value (Pulse)	20	A
Collector Dissipation	P_C	T_C = 25°C per One Chip	43	W
Operating Junction Temperature	T_J	(Note 1)	-20 ~ 125	°C

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

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 ~ 16.5V 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}

FSAM10SH60A

Absolute Maximum Ratings

Thermal Resistance

Item	Symbol	Condition	Min.	Typ.	Max.	Unit
Junction to Case Thermal Resistance	$R_{th(j-c)Q}$	Each IGBT under Inverter Operating Condition	-	-	2.9	°C/W
	$R_{th(j-c)F}$	Each FWDi under Inverter Operating Condition	-	-	3.6	°C/W
Contact Thermal Resistance	$R_{th(c-h)}$	Ceramic Substrate (per 1 Module) Thermal Grease Applied (Note 3)	-	-	0.06	°C/W

Note:
2. 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 100um.

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

Inverter Part

Item	Symbol	Condition		Min.	Typ.	Max.	Unit
Collector - Emitter Saturation Voltage	$V_{CE(SAT)}$	$V_{CC} = V_{BS} = 15V, V_{IN} = 0V$	$I_C = 10A, T_J = 25°C$	-	-	2.5	V
FWDi Forward Voltage	V_{FM}	$V_{IN} = 5V$	$I_C = 10A, T_J = 25°C$	-	-	2.3	V
Switching Times	t_{ON}	$V_{PN} = 300V, V_{CC} = V_{BS} = 15V$ $I_C = 10A, T_J = 25°C$ $V_{IN} = 5V \leftrightarrow 0V$, Inductive Load (High, Low-side) (Note 4)		-	0.27	-	us
	$t_{C(ON)}$			-	0.12	-	us
	t_{OFF}			-	0.6	-	us
	$t_{C(OFF)}$			-	0.23	-	us
	t_{rr}			-	0.13	-	us
Collector - Emitter Leakage Current	I_{CES}	$V_{CE} = V_{CES}, T_J = 25°C$		-	-	250	µA

Note:
4. 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 Fig. 4.

Electrical Characteristics $(T_J = 25°C$, Unless Otherwise Specified)

Control Part

Item	Symbol	Condition		Min.	Typ.	Max.	Unit
Quiescent V_{CC} Supply Current	I_{QCCL}	V_{CC} = 15V $IN_{(UL, VL, WL)}$ = 5V	$V_{CC(L)} - COM_{(L)}$	-	-	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	$V_{B(U)} - V_{S(U)}, V_{B(V)} - V_{S(V)}, V_{B(W)} - V_{S(W)}$	-	-	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)		0.45	0.51	0.56	V
Sensing Voltage of IGBT Current	V_{SEN}	R_{SC} = 50 Ω, $R_{SU} = R_{SV} = R_{SW}$ = 0 Ω and I_C = 15A (Note Fig. 7)		0.45	0.51	0.56	V
Supply Circuit Under-Voltage Protection	UV_{CCD}	Detection Level		11.5	12	12.5	V
	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 $IN_{(UH)}, IN_{(VH)}, IN_{(WH)} - COM_{(H)}$	-	-	0.8	V
OFF Threshold Voltage	$V_{IN(OFF)}$			3.0	-	-	V
ON Threshold Voltage	$V_{IN(ON)}$	Low-Side	Applied between $IN_{(UL)}, IN_{(VL)}, IN_{(WL)} - COM_{(L)}$	-	-	0.8	V
OFF Threshold Voltage	$V_{IN(OFF)}$			3.0	-	-	V
Resistance of Thermistor	R_{TH}	@ T_{TH} = 25°C (Note Fig. 6) (Note 7)		-	50	-	kΩ
		@ T_{TH} = 100°C (Note 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 50 Ω in order to make the SC trip-level of about 15A at the shunt resistors (R_{SU}, R_{SV}, R_{SW}) of 0Ω. For the detailed information about the relationship between the external sensing resistor (R_{SC}) 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

Item	Symbol	Condition	Values			Unit
			Min.	Typ.	Max.	
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}	$T_C \leq 100°C, T_J \leq 125°C$	-	15	-	kHz
Input ON Threshold Voltage	$V_{IN(ON)}$	Applied between $IN_{(UH)}, IN_{(VH)}, IN_{(WH)} - COM_{(H)}, IN_{(UL)}, IN_{(VL)}, IN_{(WL)} - COM_{(L)}$	0 ~ 0.65			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

Mechanical Characteristics and Ratings

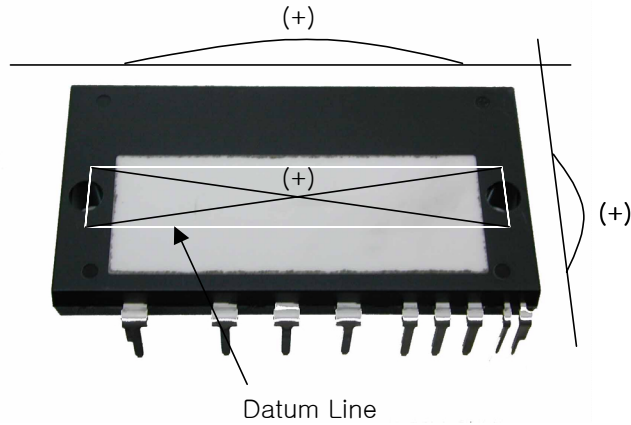| Item	Condition		Min.	Typ.	Max.	Unit
			Limits			**Unit**
Mounting Torque	Mounting Screw: M4 (Note 8 and 9)	Recommended 10Kg•cm	8	10	12	Kg•cm
		Recommended 0.98N•m	0.78	0.98	1.17	N•m
Ceramic Flatness		Note Fig.8	0	-	+120	um
Weight			-	35	-	g

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.
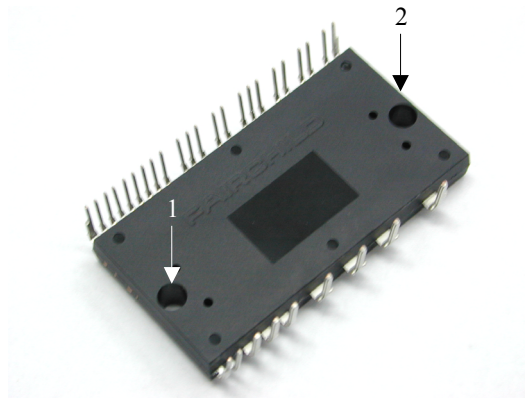9. Avoid one side tightening stress. Fig.9 shows the recommended torque order for mounting screws. Uneven mounting can cause the SPM ceramic substrate to be damaged.

Fig. 9. Mounting Screws Torque Order

Detailed Package Outline Drawings

SPM32-AA

28x2.00 ±0.30=(56.0)

(2.00)

2.00 ±0.30

MAX1.05

0.60 ±0.10

0.40

MAX1.00

0.60 ±0.10

0.40

28.0 ±0.30

#23

#1

(17.00)

31.0 ±0.50

13.6 ±0.30

(3.30)

#32

19.86±0.30

#24

(46.60)

53.0 ±0.30

60.0 ±0.50

(34.80)

Ø4.30

36.05 ±0.50

(3°~5°)

0.70 +0.10 -0.05

7.20 ±0.5

12.30 ±0.5

3x7.62 ±0.30=(22.86)

11.0 ±0.30

3x4.0 ±0.30=(12.0)

(10.14)

2.00 ±0.30

(3.50)

(3.70)

MAX8.20

MAX1.00

0.80

1.30±0.10

MAX3.20

0.80

1.30±0.10

MAX2.50

0.40

0.60±0.10

MAX1.60

Dimensions in Millimeters