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## FAIRCHILD

SEMICONDUCTOR

## FSAM50SM60A Motion SPM<sup>®</sup> 2 Series

## Features

- UL Certified No. E209204 (UL1557)
- 600 V 50 A 3-Phase IGBT Inverter with Integral Gate Drivers and Protection
- Low-Loss, Short-Circuit Rated IGBTs
- Very Low Thermal Resistance Using Al<sub>2</sub>O<sub>3</sub> DBC Substrate
- Separate Open-Emitter Pins from Low Side IGBTs for Three-Phase Current Sensing
- Single-Grounded Power Supply
- Optimized for 5 kHz Switching Frequency
- Built-in NTC Thermistor for Temperature Monitoring
- Inverter Power Rating of 4.0 kW / 100~253 VAC
- Adjustable Current Protection Level via Selection of Sense-IGBT Emitter's External Rs
- Isolation Rating: 2500 V<sub>rms</sub> / min.

## Applications

Motion Control - Home Appliance / Industrial Motor

### Resource

• AN-9043 - Motion SPM® 2 Series User's Guide

January 2014

FSAM50SM60A Motion SPM® 2 Series

## **General Description**

FSAM50SM60A is a Motion SPM® 2 module providing a fully-featured, high-performance inverter stage for AC Induction, BLDC, and PMSM motors. 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 lockouts, overcurrent shutdown, thermal monitoring, and fault reporting. The built-in, high-speed HVIC requires only a single supply voltage and translates the incoming logic-level gate inputs to the high-voltage, high-current drive signals required to properly drive the module's internal IGBTs. Separate negative IGBT terminals are available for each phase to support the widest variety of control algorithms.





### Package Marking and Ordering Information

Device	Device Marking	Package	Packing Type	Quantity
FSAM50SM60A	FSAM50SM60A	S32CA-032	Rail	8

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Pin Number	Pin Name	Pin Description
1	V <sub>CC(L)</sub>	Low-Side Common Bias Voltage for IC and IGBTs Driving
2	COM <sub>(L)</sub>	Low-Side Common Supply Ground
3	IN <sub>(UL)</sub>	Signal Input Terminal for Low-Side U-Phase
4	IN <sub>(VL)</sub>	Signal Input Terminal for Low-Side V-Phase
5	IN <sub>(WL)</sub>	Signal Input Terminal for Low-Side W-Phase
6	COM <sub>(L)</sub>	Low-Side Common Supply Ground
7	V <sub>FO</sub>	Fault Output
8	C <sub>FOD</sub>	Capacitor for Fault Output Duration Selection
9	C <sub>SC</sub>	Capacitor (Low-Pass Filter) for Short-Circuit Current Detection Input
10	R <sub>SC</sub>	Resistor for Short-Circuit Current Detection
11	IN <sub>(UH)</sub>	Signal Input for High-Side U-Phase
12	V <sub>CC(UH)</sub>	High-Side Bias Voltage for U-Phase IC
13	V <sub>B(U)</sub>	High-Side Bias Voltage for U-Phase IGBT Driving
14	V <sub>S(U)</sub>	High-SideBias Voltage Ground for U-Phase IGBT Driving
15	IN <sub>(VH)</sub>	Signal Input for High-Side V-Phase
16	COM <sub>(H)</sub>	High-Side Common Supply Ground
17	V <sub>CC(VH)</sub>	High-Side Bias Voltage for V-Phase IC
18	V <sub>B(V)</sub>	High-Side Bias Voltage for V-Phase IGBT Driving
19	V <sub>S(V)</sub>	High-Side Bias Voltage Ground for V-Phase IGBT Driving
20	IN <sub>(WH)</sub>	Signal Input for High-side W-Phase
21	V <sub>CC(WH)</sub>	High-Side Bias Voltage for W-Phase IC
22	V <sub>B(W)</sub>	High-Side Bias Voltage for W-Phase IGBT Driving
23	V <sub>S(W)</sub>	High-Side Bias Voltage Ground for W-Phase IGBT Driving
24	V <sub>TH</sub>	Thermistor Bias Voltage
25	R <sub>TH</sub>	Series Resistor for the Use of Thermistor (Temperature Detection)
26	NU	Negative DC-Link Input Terminal for U-Phase
27	N <sub>V</sub>	Negative DC-Link Input Terminal for V-Phase
28	N <sub>W</sub>	Negative DC-Link Input Terminal 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



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

Item	Symbol	Condition	Rating	Unit
Supply Voltage	V <sub>DC</sub>	Applied to DC-Link	450	V
Supply Voltage (Surge)	V <sub>PN(Surge)</sub>	Applied between P and N	500	V
Collector - Emitter Voltage	V <sub>CES</sub>		600	V
Each IGBT Collector Current	± I <sub>C</sub>	$T_{\rm C} = 25^{\circ}{\rm C}$	50	А
Each IGBT Collector Current	± I <sub>C</sub>	$T_{\rm C} = 100^{\circ}{\rm C}$	25	А
Each IGBT Collector Current (Peak)	± I <sub>CP</sub>	$T_{C} = 25^{\circ}C$ , Under 1ms Pulse Width	100	Α
Collector Dissipation	P <sub>C</sub>	T <sub>C</sub> = 25°C per Chip	100	W
Operating Junction Temperature	T,	(2nd Note 1)	-20 ~ 125	°C

2nd Notes: 1. It would be recommended that the average junction temperature should be limited to  $T_J \le 125^{\circ}C$  (at  $T_C \le 100^{\circ}C$ ) in order to guarantee safe operation.

#### **Control Part**

ltem	Symbol	Condition	Rating	Unit
Control Supply Voltage	V <sub>CC</sub>	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 <sub>BS</sub>	Applied between V <sub>B(U)</sub> - V <sub>S(U)</sub> , V <sub>B(V)</sub> - V <sub>S(V)</sub> , V <sub>B(W)</sub> - V <sub>S(W)</sub>	20	V
Input Signal Voltage	V <sub>IN</sub>	$ \begin{array}{l} \mbox{Applied between IN}_{(UH)}, \mbox{IN}_{(VH)}, \mbox{IN}_{(WH)} \mbox{-} \mbox{COM}_{(H)} \\ \mbox{IN}_{(UL)}, \mbox{IN}_{(VL)}, \mbox{IN}_{(WL)} \mbox{-} \mbox{COM}_{(L)} \end{array} $	-0.3 ~ V <sub>CC</sub> +0.3	V
Fault Output Supply Voltage	V <sub>FO</sub>	Applied between V <sub>FO</sub> - COM <sub>(L)</sub>	-0.3 ~ V <sub>CC</sub> +0.3	V
Fault Output Current	I <sub>FO</sub>	Sink Current at V <sub>FO</sub> Pin	5	mA
Current-Sensing Input Voltage	V <sub>SC</sub>	Applied between C <sub>SC</sub> - COM <sub>(L)</sub>	-0.3 ~ V <sub>CC</sub> +0.3	V

### **Total System**

Item	Symbol	Condition	Rating	Unit
Self-Protection Supply Voltage Limit	V <sub>PN(PROT)</sub>	Applied to DC-Link,	400	V
(Short-Circuit Protection Capability)	. ,	V <sub>CC</sub> = V <sub>BS</sub> = 13.5 ~ 16.5 V		
		$T_J = 125^{\circ}C$ , Non-Repetitive, < 5 µs		
Module Case Operation Temperature	т <sub>с</sub>	See Figure 2	-20 ~ 100	°C
Storage Temperature	T <sub>STG</sub>		-20 ~ 125	°C
Isolation Voltage	V <sub>ISO</sub>	60Hz, Sinusoidal, AC 1 Minute, Connect Pins to Heat Sink Plate	2500	V <sub>rms</sub>

#### **Thermal Resistance**

Item	Symbol	Condition	Min.	Тур.	Max.	Unit
Junction to Case Thermal	R <sub>th(j-c)Q</sub>	Inverter IGBT Part (per 1/6 module)	-	-	1.00	°C/W
Resistance	R <sub>th(j-c)F</sub>	Inverter FWDi Part (per 1/6 module)	-	-	1.50	°C/W
Contact Thermal	R <sub>th(c-f)</sub>	DBC Substrate (per 1 Module)	-	-	0.06	°C/W
Resistance	~ /	Thermal Grease Applied (2nd Note 3)				

#### 2nd Notes:

2. For the measurement point of case temperature(T<sub>c</sub>), please refer to Figure 2. 3. The thickness of thermal grease should not be more than 100  $\mu$ m.

## **Electrical Characteristics**

Inverter Part (T<sub>J</sub> = 25°C, unless otherwise specified.)

ltem	Symbol	Conditio	on	Min.	Тур.	Max.	Unit
Collector - emitter	V <sub>CE(SAT)</sub>	$V_{CC} = V_{BS} = 15 V$	$I_{C} = 50 \text{ A}, \text{ T}_{J} = 25^{\circ}\text{C}$	-	-	2.4	V
FWDi Forward Voltage	Vem	$V_{\rm IN} = 5 V$	l <sub>c</sub> = 50 A. T <sub>1</sub> = 25°C	-	-	2.1	V
Switching Times	t <sub>ON</sub>	$V_{PN} = 300 \text{ V}, \text{ V}_{CC} = \text{V}_{BS} = 1300 \text{ V}$	5 V	-	0.69	-	μS
	t <sub>C(ON)</sub>	$I_{\rm C} = 50 \text{ A}, T_{\rm J} = 25^{\circ}{\rm C}$		-	0.32	-	μS
	t <sub>OFF</sub>	$V_{IN} = 5 V \leftrightarrow 0 V$ , Inductive L	$V_{IN} = 5 V \leftrightarrow 0 V$ , Inductive Load		1.32	-	μS
	t <sub>C(OFF)</sub>	(Tigh-And Low-Side)		-	0.46	-	μS
	t <sub>rr</sub>	(2nd Note 4)		-	0.10	-	μS
Collector-Emitter Leakage Current	I <sub>CES</sub>	$V_{CE} = V_{CES}, T_J = 25^{\circ}C$		-	-	250	μA

2nd Notes:
 4. t<sub>ON</sub> and t<sub>OFF</sub> include the propagation delay time of the internal drive IC. t<sub>C(ON)</sub> and t<sub>C(OFF)</sub> are the switching time of IGBT itself under the given gate driving condition internally. For the detailed information, please see Figure 4.







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6

Control Part							
ltem	Symbol	C	Condition	Min.	Тур.	Max.	Unit
Quiescent V <sub>CC</sub> Supply Current	I <sub>QCCL</sub>	V <sub>CC</sub> = 15 V IN <sub>(UL, VL, WL)</sub> = 5V	V <sub>CC(L)</sub> - COM <sub>(L)</sub>	-	-	26	mA
	I <sub>QCCH</sub>	V <sub>CC</sub> = 15 V IN <sub>(UH, VH, WH)</sub> = 5V	$V_{CC(UH)}, V_{CC(VH)}, V_{CC(WH)} - COM_{(H)}$	-	-	130	μΑ
Quiescent V <sub>BS</sub> Supply Current	I <sub>QBS</sub>	V <sub>BS</sub> = 15 V IN <sub>(UH, VH, WH)</sub> = 5V	$ \begin{array}{l} V_{B(U)} \text{ - } V_{S(U)},  V_{B(V)} \text{ - } V_{S(V)}, \\ V_{B(W)} \text{ - } V_{S(W)} \end{array} $	-	-	420	μΑ
Fault Output Voltage	V <sub>FOH</sub>	$V_{SC} = 0 V, V_{FO} Circuit:$	: 4.7 k $\Omega$ to 5 V Pull-up	4.5	-	-	V
	V <sub>FOL</sub>	V <sub>SC</sub> = 1 V, V <sub>FO</sub> Circuit:	: 4.7 k $\Omega$ to 5 V Pull-up	-	-	1.1	V
Short-Circuit Trip Level	V <sub>SC(ref)</sub>	$V_{CC}$ = 15 V (2nd Note	5)	0.45	0.51	0.56	V
Sensing Voltage of IGBT Current	V <sub>SEN</sub>	$R_{SC} = 40 \Omega$ , $R_{SU} = R_S$ (See a Figure 6)	$_{\rm SV}$ = R $_{\rm SW}$ = 0 $\Omega$ and I $_{\rm C}$ = 75 A	0.45	0.51	0.56	V
Supply Circuit Under-	UV <sub>CCD</sub>	Detection Level		11.5	12.0	12.5	V
Voltage Protection	UV <sub>CCR</sub>	Reset Level		12.0	12.5	13.0	V
	UV <sub>BSD</sub>	Detection Level		7.3	9.0	10.8	V
	UV <sub>BSR</sub>	Reset Level		8.6	10.3	12.0	V
Fault Output Pulse Width	t <sub>FOD</sub>	C <sub>FOD</sub> = 33 nF (2nd No	te 6)	1.4	1.8	2.0	ms
ON Threshold Voltage	V <sub>IN(ON)</sub>	High-Side	Applied between IN(UH),	-	-	0.8	V
OFF Threshold Voltage	V <sub>IN(OFF)</sub>		$IN_{(VH)}$ , $IN_{(WH)}$ - $COM_{(H)}$	3.0	-	-	V
ON Threshold Voltage	V <sub>IN(ON)</sub>	Low-Side	Applied between IN <sub>(UL)</sub> ,	-	-	0.8	V
OFF Threshold Voltage	V <sub>IN(OFF)</sub>		IN <sub>(VL)</sub> , IN <sub>(WL)</sub> - COM <sub>(L)</sub>	3.0	-	-	V
Resistance of Thermistor	R <sub>TH</sub>	@ T <sub>TH</sub> = 25°C (2nd No	ote 7, Figure 5)	-	50	-	kΩ
		@ T <sub>TH</sub> = 100°C (2nd N	lote 7, Figure 5)	-	3.0	-	kΩ

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

2nd Notes:
5. Short-circuit protection is functioning only at the low-sides. It would be recommended that the value of the external sensing resistor (R<sub>SC</sub>) should be selected around 40 Ω in order to make the SC trip-level of about 75A at the shunt resistors (R<sub>SU</sub>, R<sub>SV</sub>, R<sub>SW</sub>) of 0 Ω. For the detailed information about the relationship between the external sensing resistor (R<sub>SC</sub>) and the shunt resistors (R<sub>SU</sub>, R<sub>SV</sub>, R<sub>SW</sub>), please see Figure 6.
6. The fault-out pulse width t<sub>FOD</sub> depends on the capacitance value of C<sub>FOD</sub> according to the following approximate equation: C<sub>FOD</sub> = 18.3 x 10<sup>-6</sup> x t<sub>FOD</sub> [F]
7. T<sub>TH</sub> is the temperature of thermistor itself. To know case temperature (T<sub>C</sub>), please make the experiment considering your application.



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

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Figure 6. R<sub>SC</sub> Variation by Change of Shunt Resistors ( R<sub>SU</sub>, R<sub>SV</sub>, R<sub>SW</sub>) for Short-Circuit Protection (1) @ Current Trip Level ≒ 50 A (2) @ Current Trip Level ≒ 75 A

ltem	Symbol	Condition	Min.	Тур.	Max.	Unit
Supply Voltage	V <sub>PN</sub>	Applied between P - N <sub>U</sub> , N <sub>V</sub> , N <sub>W</sub>	-	300	400	V
Control Supply Voltage	V <sub>CC</sub>	Applied between $V_{CC(UH)}$ , $V_{CC(VH)}$ , $V_{CC(WH)}$ - COM <sub>(H)</sub> , $V_{CC(L)}$ - COM <sub>(L)</sub>	13.5	15.0	16.5	V
High-side Bias Voltage	V <sub>BS</sub>	Applied between $V_{B(U)}$ - $V_{S(U)}$ , $V_{B(V)}$ - $V_{S(V)}$ , $V_{B(W)}$ - $V_{S(W)}$	13.0	15.0	18.5	V
Blanking Time for Preventing Arm-short	t <sub>dead</sub>	For Each Input Signal	3.5	-	-	μs
PWM Input Signal	f <sub>PWM</sub>	$T_C \le 100^{\circ}C, T_J \le 125^{\circ}C$	-	5	-	kHz
Minimum Input Pulse Width	PW <sub>IN(OFF)</sub>	$\begin{array}{l} 200 \leq V_{PN} \leq 400  \text{V},  13.5 \leq V_{CC} \leq 16.5  \text{V}, \\ 13.0 \leq V_{BS} \leq 18.5  \text{V},  0 \leq I_C \leq 100  \text{A}, \\ -20 \leq T_J \leq 125^\circ \text{C} \\ V_{IN} = 5  \text{V} \leftrightarrow 0  \text{V},  \text{Inductive Load}  (\text{2nd Note 8}) \end{array}$	3	-	-	μS
Input ON Threshold Voltage	V <sub>IN(ON)</sub>	$\begin{array}{l} \text{Applied between IN}_{(\text{UH})}, \text{IN}_{(\text{VH})}, \text{IN}_{(\text{WH})} \text{ - } \\ \text{COM}_{(\text{H})}, \text{IN}_{(\text{UL})}, \text{IN}_{(\text{VL})}, \text{IN}_{(\text{WL})} \text{ - } \text{COM}_{(\text{L})} \end{array}$		0 ~ 0.65	5	V
Input OFF Threshold Voltage	V <sub>IN(OFF)</sub>	Applied between $IN_{(UH)}$ , $IN_{(VH)}$ , $IN_{(WH)}$ - COM <sub>(H)</sub> , $IN_{(UL)}$ , $IN_{(VL)}$ , $IN_{(WL)}$ - COM <sub>(L)</sub>		4 ~ 5.5		V

**2nd Notes:** 8. Motion SPM<sup>®</sup> 2 product might not make response if the PW<sub>IN(OFF)</sub> is less than the recommended minimum value.

		Condition	ndition Min. Typ. Max.		Units	
wounting forque	Mounting Screw: M4	Recommended 10 kg•cm	8	10	12	kg•cm
	(2nd Note 9 and 10)	Recommended 0.98 N•m	0.78	0.98	1.17	N∙m
DBC Flatness		See Figure 7	0	-	+120	μm
Weight			-	32	-	g
			(+)			
nd Notes: . Do not make over torque 0.Avoid one side tightenin DBC substrate to be da	Figure 7. Flatness N e or mounting screws. Much mounti g stress. Figure 8 shows the recom maged.	leasurement Position of The ng torque may cause DBC substrate cracks a mended torque order for mounting screws. Un	DBC Subs	strate heat-sink de can cause th	struction. e Motion SP	M <sup>®</sup> 2 pack
		1	2 ↓			
	Figure 8. Mo	unting Screws Torque Order	F (1 → 2)			





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#### Figure 13. Recommended Bootstrap Operation Circuit and Parameters

#### 3rd Notes:

- 4. It would be recommended that the bootstrap diode,  $D_{BS}$ , has soft and fast recovery characteristics.
- 5. The bootstrap resistor(R<sub>BS</sub>) should be three times greater than R<sub>E(H)</sub>. The recommended value of R<sub>E(H)</sub> is 5.6Ω, but it can be increased up to 20 Ω for a slower dv/ dt of high-side.
- 6. The ceramic capacitor placed between  $V_{CC}$  COM should be over 1  $\mu$ F and mounted as close to the pins of the Motion SPM<sup>®</sup> 2 product as possible.



#### **Figure 14. Application Circuit**

#### 4th Notes:

- 1. R<sub>PL</sub>C<sub>PL</sub>/R<sub>PH</sub>C<sub>PH</sub> /R<sub>PF</sub>C<sub>PF</sub> coupling at each Motion SPM<sup>®</sup> 2 product input is recommended in order to prevent input signals' oscillation and it should be as close as possible to each Motion SPM 2 product input pin.
- 2. By virtue of integrating an application specific type HVIC inside the Motion SPM 2 product, direct coupling to MCU terminals without any optocoupler or transformer isolation is possible.
- 3. V<sub>FO</sub> output is open-collector type. This signal line should be pulled up to the positive side of the 5 V power supply with approximately 4.7 kΩ resistance. Please refer to Figure 12.
- 4. Sprig of around seven 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  $C_{FOD}$ (pin 8) and  $COM_{(L)}$ (pin 2). (Example : if  $C_{FOD}$  = 33 nF, then
- 5. V<sub>FO</sub> output pulse width should be determined by connecting an external capacitor(C<sub>FOD</sub>) between C<sub>FOD</sub>(pin e) and COM(L)(pin 2). (Example : II C<sub>FOD</sub> = 35 nr, then t<sub>FO</sub> = 1.8 ms (typ.)) Please refer to the 2nd note 6 for calculation method.
  6. Each input signal line should be pulled up to the 5 V power supply with approximately 4.7 kΩ (at high side input) or 2 kΩ (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 ~ 2 nF by-pass capacitor should be used across each power supply connection terminals.

- Approximately a 0.22 ~ 2 in by pass capacitor should be used across each power supply connection terminals. 7. To prevent errors of the protection function, the wiring around  $R_{SC}$ ,  $R_F$  and  $C_{SC}$  should be as short as possible. 8. In the short-circuit protection circuit, please select the  $R_F C_{SC}$  time constant in the range 3 ~ 4 µs. 9. Each capacitor should be mounted as close to the pins of the Motion SPM 2 product as possible. 10. 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 non-independent sectors are as a possible. inductive capacitor of around 0.1 – 0.22 µF between the P&N pins is recommended. 11. Relays are used at almost every systems of electrical equipments of home appliances. In these cases, there is hould be sufficient distance between the MCU and
- the relays. It is recommended that the distance be 5 cm at least.







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Благодаря сотрудничеству с мировыми поставщиками мы осуществляем комплексные и плановые поставки широчайшего спектра электронных компонентов.

Собственная эффективная логистика и склад в обеспечивает надежную поставку продукции в точно указанные сроки по всей России.

Мы осуществляем техническую поддержку нашим клиентам и предпродажную проверку качества продукции. На все поставляемые продукты мы предоставляем гарантию.

Осуществляем поставки продукции под контролем ВП МО РФ на предприятия военно-промышленного комплекса России, а также работаем в рамках 275 ФЗ с открытием отдельных счетов в уполномоченном банке. Система менеджмента качества компании соответствует требованиям ГОСТ ISO 9001.

Минимальные сроки поставки, гибкие цены, неограниченный ассортимент и индивидуальный подход к клиентам являются основой для выстраивания долгосрочного и эффективного сотрудничества с предприятиями радиоэлектронной промышленности, предприятиями ВПК и научноисследовательскими институтами России.

С нами вы становитесь еще успешнее!

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