

Motion-SPM[™]

October 2010



FNA41060/B2 Smart Power Module

Features

- 600V-10A 3-phase IGBT inverter bridge including control ICs for gate driving and protection
- Easy PCB layout due to built-in bootstrap diode and V_{S} output
- Divided negative dc-link terminals for inverter current sensing applications
- · Single-grounded power supply due to built-in HVIC
- · Built-in thermistor for over-temperature monitoring
- Isolation rating of 2000Vrms/min.

Applications

- AC 100V ~ 253V three-phase inverter drive for small power ac motor drives
- Home appliances applications like air conditioner and refrigerator

General Description

It is an advanced motion-smart power module (Motion-SPMTM) that Fairchild has newly developed and designed to provide very compact and high performance ac motor drives mainly targeting low-power inverter-driven application like air conditioner and refrigerator. It combines optimized circuit protection and drive matched to low-loss IGBTs. System reliability is further enhanced by the integrated under-voltage lock-out protection, short-circuit protection, and temperature monitoring. The high speed built-in HVIC provides opto-coupler-less single-supply IGBT gate driving capability that further reduce the overall size of the inverter system design. Each phase current of inverter can be monitored separately due to the divided negative dc terminals.

Additional Information

For further infomation, please see AN-9070 and FEB305-001 in http://www.fairchildsemi.com





Figure 1.

Integrated Power Functions

• 600V-10A IGBT inverter for three-phase DC/AC power conversion (Please refer to Figure 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
- For inverter low-side IGBTs: Gate drive circuit, Short circuit protection (SC) Control supply circuit under-voltage (UV) protection
- · Fault signaling: Corresponding to UV (Low-side supply) and SC faults
- Input interface: 3.3/5V CMOS compatible, Schmitt trigger input

Pin Configuration





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Pin Descriptions

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

Internal Equivalent Circuit and Input/Output Pins V_{TH} (1) -^/// Thermister R_{TH} (2) P (3) (26) V_{B(} UVB (25) V_{S(U)} UVS OUT(UH) (24) V_B VVB UVS U(4) (23) V_{S(1} VVS (22) V_{B(W} WVB (21) V_{S(V} wvs OUT(VH) ŧ (20) IN_{(UH} IN(UH) VVS V (5) (19) IN_{(VH} IN(VH) (18) IN(WH) IN(WH) (17) V_{CC(H)} VCC OUT(WH) сом WVS W(6) (16) V_{CC(L)} vcc OUT(UL) (15) COM сом N∪ (7) (14) IN_(UL) IN(UL) (13) IN_(VL) IN(VL) (12) IN_{(W} OUT(VL) IN(WL) (11) V_{FO} N_V (8) VFO (10) C_{SC} C(SC) OUT(WL) N_W (9)

Note:

1) Inverter high-side is composed of three IGBTs, freewheeling diodes and one control IC for each IGBT.

Inverter low-side is composed of three IGBTs, freewheeling diodes and one control IC for each IGBT. It has gate drive and protection functions.
 Inverter power side is composed of four inverter dc-link input terminals and three inverter output terminals.

Figure 3.

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

Inverter Part

Symbol	Parameter	Conditions	Rating	Units
V _{PN}	Supply Voltage	Applied between P- N_U , N_V , N_W	450	V
V _{PN(Surge)}	Supply Voltage (Surge)	Applied between P- N_U , N_V , N_W	500	V
V _{CES}	Collector-emitter Voltage		600	V
± I _C	Each IGBT Collector Current	T_{C} = 25°C, T_{J} < 150°C	10	А
± I _{CP}	Each IGBT Collector Current (Peak)	$\rm T_{C}$ = 25°C, $\rm T_{J} < 150^{\circ}C,~Under~1ms~Pulse$ Width	20	A
P _C	Collector Dissipation	T _C = 25°C per One Chip	34	W
TJ	Operating Junction Temperature	(Note 1)	-40 ~ 150	°C

Note:

1. The maximum junction temperature rating of the power chips integrated within the SPM is 150°C.

Control Part

Symbol	Parameter Conditions		Rating	Units
V _{CC}	Control Supply Voltage	Applied between V _{CC(H)} , V _{CC(L)} - COM	20	V
V _{BS}	High-side Control Bias Voltage	Applied between $V_{B(U)}$ - $V_{S(U)}$, $V_{B(V)}$ - $V_{S(V)}$, $V_{B(W)}$ - $V_{S(W)}$	20	V
V _{IN}	Input Signal Voltage	$\begin{array}{c} \mbox{Applied between } IN_{(UH)}, \ IN_{(VH)}, \ IN_{(WH)}, \\ IN_{(UL)}, \ IN_{(VL)}, \ IN_{(WL)} - \ COM \end{array}$	-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

Bootstrap Diode Part

Symbol	Parameter	Conditions	Rating	Units
V _{RRM}	Maximum Repetitive Reverse Voltage		600	V
١ _F	Forward Current	$T_{\rm C} = 25^{\circ}{\rm C}$	0.5	А
I _{FP}	Forward Current (Peak)	T_{C} = 25°C, Under 1ms Pulse Width	1	А
TJ	Operating Junction Temperature		-40 ~ 150	°C

Total System

Symbol	Parameter	Conditions	Rating	Units
V _{PN(PROT)}	Self Protection Supply Voltage Limit (Short Circuit Protection Capability)	$V_{CC} = V_{BS} = 13.5 \sim 16.5 V$ T _J = 150°C, Non-repetitive, less than 2µs	400	V
T _{STG}	Storage Temperature		-40 ~ 125	°C
V _{ISO}	Isolation Voltage	60Hz, Sinusoidal, AC 1 minute, Connection Pins to heat sink plate	2000	V _{rms}

Thermal Resistance

Symbol	Parameter	Conditions	Min.	Тур.	Max.	Units
R _{th(j-c)Q}	Junction to Case Thermal	Inverter IGBT part (per 1/6 module)	-	-	3.6	°C/W
R _{th(j-c)F}	Resistance	Inverter FWD part (per 1/6 module)	-	-	4.8	°C/W

Note:

2. For the measurement point of case temperature(T_C), please refer to Figure 2.

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

Inverter Part

S	ymbol	Parameter	Conditions		Min.	Тур.	Max.	Units
V	CE(SAT)	Collector-Emitter Saturation Voltage	$V_{CC} = V_{BS} = 15V$ $V_{IN} = 5V$	I _C = 10A, T _J = 25°C	-	1.7	2.2	V
	V _F	FWD Forward Voltage	V _{IN} = 0V	I _F = 10A, T _J = 25°C	-	1.8	2.3	V
HS	t _{ON}	Switching Times	$\begin{split} & V_{PN} = 300V, V_{CC} = V_{BS} = 15V, I_{C} = 10A \\ & T_{J} = 25^{\circ}C \\ & V_{IN} = 0V \leftrightarrow 5V, Inductive Load \\ & (Note 3) \end{split}$		0.40	0.70	1.20	μS
	t _{C(ON)}				-	0.20	0.45	μS
	t _{OFF}				-	0.75	1.25	μS
	t _{C(OFF)}				-	0.25	0.50	μs
	t _{rr}				-	0.15	-	μS
LS	t _{ON}		V_{PN} = 300V, V_{CC} = V_B	_S = 15V, I _C = 10A	0.40	0.70	1.20	μS
	t _{C(ON)}		$T_J = 25^{\circ}C$ $V_{IN} = 0V \leftrightarrow 5V$, Induct	ive Load	-	0.20	0.45	μS
	t _{OFF}		(Note 3)		-	0.75	1.25	μS
	t _{C(OFF)}				-	0.25	0.50	μS
	t _{rr}				-	0.15	-	μS
	I _{CES}	Collector-Emitter Leakage Current	V _{CE} = V _{CES}		-	-	1	mA

Note:

3. t_{ON} and t_{DFF} 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.



Figure 4. Switching Time Definition





Symbol	Parameter	Conditions		Min.	Тур.	Max.	Units
I _{QCCH}	Quiescent V _{CC} Supply	V _{CC(H)} = 15V, IN _(UH,VH,WH) = 0V	V _{CC(H)} - COM	-	-	0.10	mA
I _{QCCL}	Current	V _{CC(L)} = 15V, IN _(UL,VL,WL) = 0V	V _{CC(L)} - COM	-	-	2.65	mA
I _{PCCH}	Operating V _{CC} Supply Current	$V_{CC(H)}$ = 15V, f_{PWM} = 20kHz, duty=50%, applied to one PWM signal input for High-side	V _{CC(H)} - COM	-	-	0.15	mA
I _{PCCL}		$V_{CC(L)}$ = 15V, f_{PWM} = 20kHz, duty=50%, applied to one PWM signal input for Low-side	V _{CC(L)} - COM	-	-	3.65	mA
I _{QBS}	Quiescent V _{BS} Supply Current	V _{BS} = 15V, IN _(UH, VH, WH) = 0V	$V_{B(U)} - V_{S(U)}, V_{B(V)} - V_{S(V)}, V_{B(W)} - V_{S(W)}$	-	-	0.30	mA
I _{PBS}	Operating V _{BS} Supply Current		$V_{B(U)} - V_{S(U)}, V_{B(V)} - V_{S(V)}, V_{B(W)} - V_{S(W)}$	-	-	2.00	mA
V _{FOH}	Fault Output Voltage	$V_{\rm SC}$ = 0V, $V_{\rm FO}$ Circuit: 4.7k Ω to 5V Pull-up		4.5	-	-	V
V _{FOL}		V_{SC} = 1V, V_{FO} Circuit: 4.7k Ω to 5V P	Pull-up	-	-	0.5	V
V _{SC(ref)}	Short Circuit Trip Level	V _{CC} = 15V (Note 4)		0.45	0.5	0.55	V
UV _{CCD}		Detection Level		10.5	-	13.0	V
UV_CCR	Supply Circuit Under-Voltage	Reset Level		11.0	-	13.5	V
UV_BSD	Protection	Detection Level		10.0	-	12.5	V
UV_BSR		Reset Level		10.5	-	13.0	V
t _{FOD}	Fault-out Pulse Width			30	-	-	μS
V _{IN(ON)}	ON Threshold Voltage	Applied between IN _(UH) , IN _(VH) , IN	_(WH) , IN _(UL) , IN _(VL) ,	-	-	2.6	V
V _{IN(OFF)}	OFF Threshold Voltage	IN _(WL) - COM		0.8	-	-	V
R _{TH}	Resistance of	@T _{TH} =25°C, (Note 5)		-	47	-	kΩ
	Thermister	@T _{TH} =100°C		-	2.9	-	kΩ

4. Short-circuit current protection is functioning only at the low-sides.

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





Bootstrap Diode Part

Symbol	Parameter	Conditions	Min.	Тур.	Max.	Units
V _F	Forward Voltage	I _F = 0.1A, T _C = 25°C	-	2.5	-	V
t _{rr}	Reverse Recovery Time	I _F = 0.1A, T _C = 25°C	-	80	-	ns



Note:

6. Built in bootstrap diode includes around 15Ω resistance characteristic.



Symbol	Devenuetor	Conditions		Value		
	Parameter	Conditions	Min.	Тур.	Max.	Units
V _{PN}	Supply Voltage	Applied between P - N _U , N _V , N _W	-	300	400	V
V _{CC}	Control Supply Voltage	Applied between V _{CC(H)} , V _{CC(L)} -COM	13.5	15	16.5	V
V _{BS}	High-side Bias Voltage	Applied between $V_{B(U)}$ - $V_{S(U)}$, $V_{B(V)}$ - $V_{S(V)}$, $V_{B(W)}$ - $V_{S(W)}$	13.0	15	18.5	V
dV _{CC} /dt, dV _{BS} /dt	Control supply variation		-1	-	1	V/µs
t _{dead}	Blanking Time for Preventing Arm-short	For Each Input Signal	1.5	-	-	μS
f _{PWM}	PWM Input Signal	$-40^{\circ}C < T_{J} < 150^{\circ}C$	-	-	20	kHz
V_{SEN}	Voltage for Current Sensing	Applied between N _U , N _V , N _W - COM (Including surge voltage)	-4		4	V
P _{WIN(ON)}	Minimun Input Pulse	(Note 7)	0.5	-	-	μs
P _{WIN(OFF)}	Width		0.5	-	-	1

7. SPM might not make response if input pulse width is less than the recommanded value.



Allowable Maximum Output Current

Note:

8. The allowable output current value may be different from the actual application.



Package Marking and Ordering Information

Device Marking	Device	Package	Reel Size	Tape Width	Quantity
FNA41060	FNA41060	SPM26-AAA	-	-	12
FNA41060B2	FNA41060B2	SPM26-AAC	-	-	12

Parameter	C		Limits			
		Min.	Тур.	Max.	Units	
Device Flatness	Note Figure 9		0	-	+120	μm
Mounting Torque	Mounting Screw: - M3	Recommended 0.7N•m	0.6	0.7	0.8	N•m
	Note Figure 10	Recommended 7.1kg•cm	6.2	7.1	8.1	kg•cm
Weight		•	-	11	-	g



Figure 9. Flatness Measurement Position





9. Do not make over torque when mounting screws. Much mounting torque may cause ceramic cracks, as well as bolts and Al heat-sink destruction.

10. Avoid one side tightening stress. Fig.10 shows the recommended torque order for mounting screws. Uneven mounting can cause the SPM ceramic substrate to be damaged. The Pre-Screwing torque is set to 20~30% of maximum torque rating.





b4 : IGBT OFF in spite of control input condition, but there is no fault output signal.

b5 : Under voltage reset (UV_{BSR})

b6 : Normal operation: IGBT ON and carrying current

Figure 12. Under-Voltage Protection (High-side)



- c5 : Input "L" : IGBT OFF state.
- c6 : Input "H": IGBT ON state, but during the active period of fault output the IGBT doesn't turn ON.
- c7 : IGBT OFF state





Input/Output Interface Circuit

Note:

1) RC coupling at each input (parts shown dotted) might change depending on the PWM control scheme used in the application and the wiring impedance of the application's printed circuit board. The SPM input signal section integrates 5kΩ (typ.) pull-down resistor. Therefore, when using an external filtering resistor, please pay attention to the signal voltage drop at input terminal.

2) The logic input is compatible with standard CMOS outputs.

Figure 14. Recommended CPU I/O Interface Circuit



1) To avoid malfunction, the wiring of each input should be as short as possible. (less than 2-3cm)

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 possible.

3) 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. Please refer to Figure 14.

4) C_{SP15} of around 7 times larger than bootstrap capacitor C_{BS} is recommended.

5) Input signal is High-Active type. There is a $5k\Omega$ 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_SC_{PS} time constant should be selected in the range 50~150ns. (Recommended $R_S=100 \Omega$, $C_{PS}=1nF$)

6) To prevent errors of the protection function, the wiring around R_F and C_{SC} should be as short as possible.

7) In the short-circuit protection circuit, please select the $R_F C_{SC}$ time constant in the range 1.5~2µs.

8) Each capacitor should be mounted as close to the pins of the SPM as possible.

9) To prevent surge destruction, the wiring between the smoothing capacitor and the P&GND pins should be as short as possible. The use of a high frequency non-inductive capacitor of around 0.1~0.22 μF between the P&GND pins is recommended.

10) 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.

11) The zener diode should be adopted for the protection of ICs from the surge destruction between each pair of control supply terminals. (Recommanded zener diode=24V/1W)

12) Please choose the electrolytic capacitor with good temperature characteristic in C_{BS}. Also, choose 0.1~0.2µF R-category ceramic capacitors with good temperature and frequency characteristics in C_{BSC}.

13) For the detailed information, please refer to the AN-9070 and FEB305-001.

Figure 15. Typical Application Circuit







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