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FNE41060 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 washing machine

General Description

It is an advanced motion-smart power module (Motion-SPM™) 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 washing machine. 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 information, please see AN-9070 and FEB306-001 in <http://www.fairchildsemi.com>

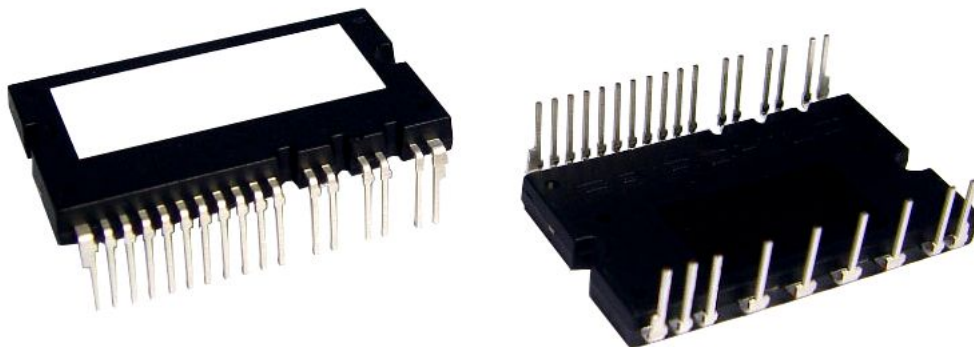


Figure 1.

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

Top View

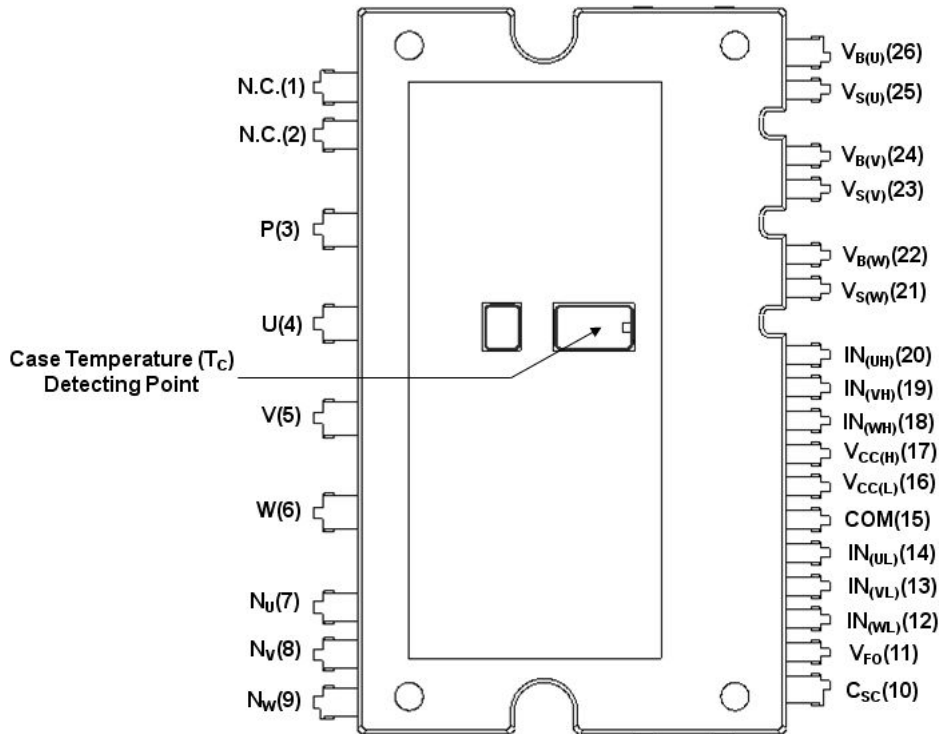
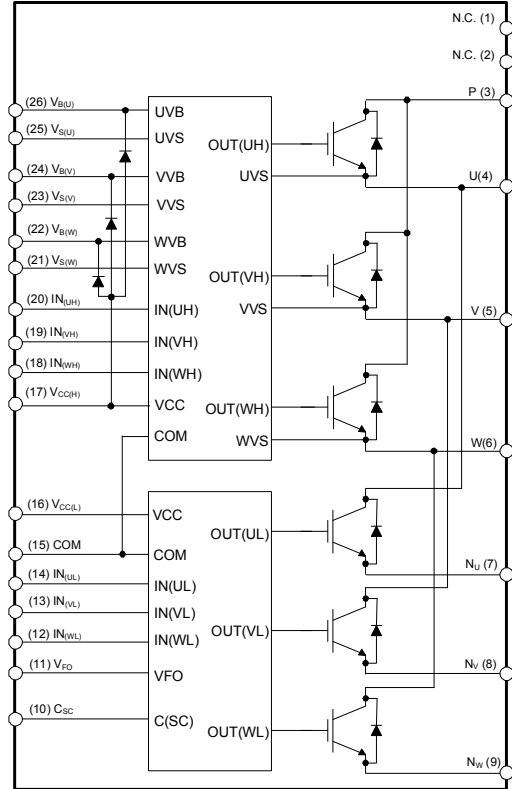


Figure 2.

Pin Descriptions

Pin Number	Pin Name	Pin Description
1	N.C.	No Connection
2	N.C.	No Connection
3	P	Positive DC-Link Input
4	U	Output for U Phase
5	V	Output for V Phase
6	W	Output for W Phase
7	N _U	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	COM	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



Note:

- 1) Inverter high-side is composed of three IGBTs, freewheeling diodes and one control IC for each IGBT.
- 2) Inverter low-side is composed of three IGBTs, freewheeling diodes and one control IC for each IGBT. It has gate drive and protection functions.
- 3) 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 _{O,25}	Output Phase Current	T _C = 25°C, T _J < 150°C (Note 1)	10	A
I _{O,100}	Output Phase Current	T _C = 100°C, T _J < 150°C (Note 1)	5	A
I _{pk}	Output Peak Phase Current	T _C = 25°C, T _J < 150°C, Under 1ms Pulse Width	15	A
P _C	Collector Dissipation	T _C = 25°C per One Chip	32	W
T _J	Operating Junction Temperature	(Note 2)	-40 ~ 150	°C

Note:

- Sinusoidal PWM at V_{PN}=300V, V_{CC}=V_{BS}=15V, T_J < 150°C, F_{SW}=20kHz, MI=0.9, PF=0.8
- 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	Applied between IN _(UH) , IN _(VH) , IN _(WH) , IN _(UL) , IN _(VL) , IN _(WL) - 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

Bootstrap Diode Part

Symbol	Parameter	Conditions	Rating	Units
V _{RRM}	Maximum Repetitive Reverse Voltage		600	V
I _F	Forward Current	T _C = 25°C	0.5	A
I _{FP}	Forward Current (Peak)	T _C = 25°C, Under 1ms Pulse Width	1	A
T _J	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 ~ 16.5V 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.	Typ.	Max.	Units
R _{th(j-c)Q}	Junction to Case Thermal Resistance	Inverter IGBT part (per 1/6 module)	-	-	3.8	°C/W
R _{th(j-c)F}		Inverter FWD part (per 1/6 module)	-	-	4.8	°C/W

Note:

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

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

Inverter Part

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Units	
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage	$V_{CC} = V_{BS} = 15\text{V}$ $V_{IN} = 5\text{V}$ $I_C = 5\text{A}, T_J = 25^\circ\text{C}$	-	1.5	2.0	V	
V_F	FWD Forward Voltage	$V_{IN} = 0\text{V}$ $I_F = 5\text{A}, T_J = 25^\circ\text{C}$	-	1.5	2.0	V	
HS	Switching Times	$V_{PN} = 300\text{V}, V_{CC} = V_{BS} = 15\text{V}, I_C = 5\text{A}$ $T_J = 25^\circ\text{C}$ $V_{IN} = 0\text{V} \leftrightarrow 5\text{V}$, Inductive Load (Note 4)	t_{ON}	0.45	0.75	1.25	μs
			$t_{C(ON)}$	-	0.20	0.45	μs
			t_{OFF}	-	0.70	1.20	μs
			$t_{C(OFF)}$	-	0.15	0.40	μs
			t_{rr}	-	0.15	-	μs
LS	Switching Times	$V_{PN} = 300\text{V}, V_{CC} = V_{BS} = 15\text{V}, I_C = 5\text{A}$ $T_J = 25^\circ\text{C}$ $V_{IN} = 0\text{V} \leftrightarrow 5\text{V}$, Inductive Load (Note 4)	t_{ON}	0.35	0.65	1.15	μs
			$t_{C(ON)}$	-	0.15	0.40	μs
			t_{OFF}	-	0.65	1.15	μs
			$t_{C(OFF)}$	-	0.15	0.40	μs
			t_{rr}	-	0.15	-	μs
I_{CES}	Collector-Emitter Leakage Current	$V_{CE} = V_{CES}$	-	-	1	mA	

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 Figure 4.

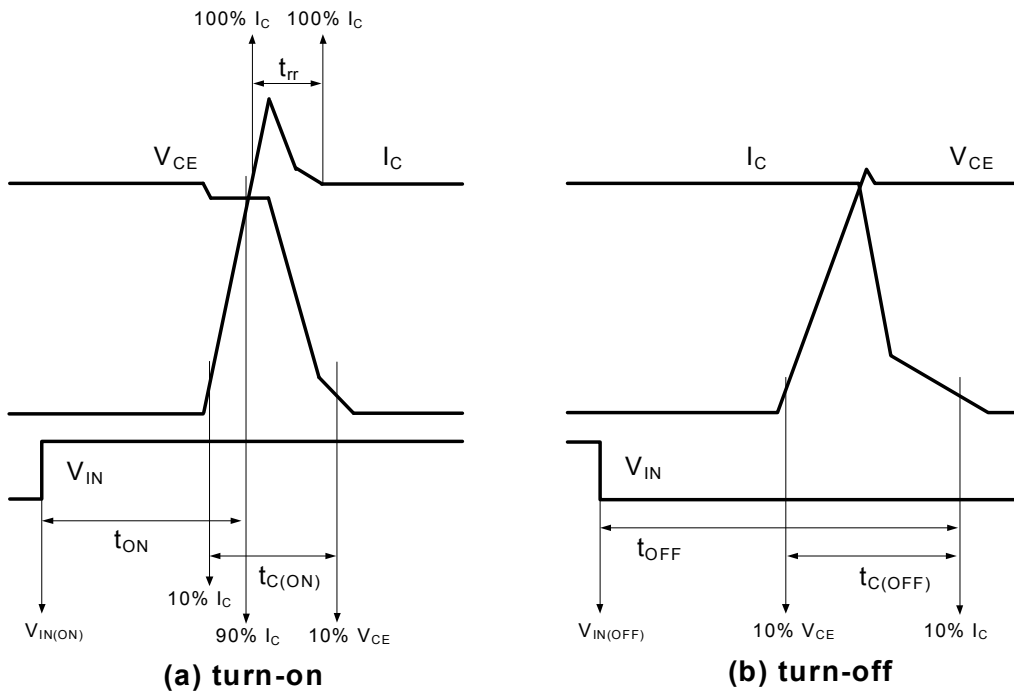


Figure 4. Switching Time Definition

Switching Loss (Typical)

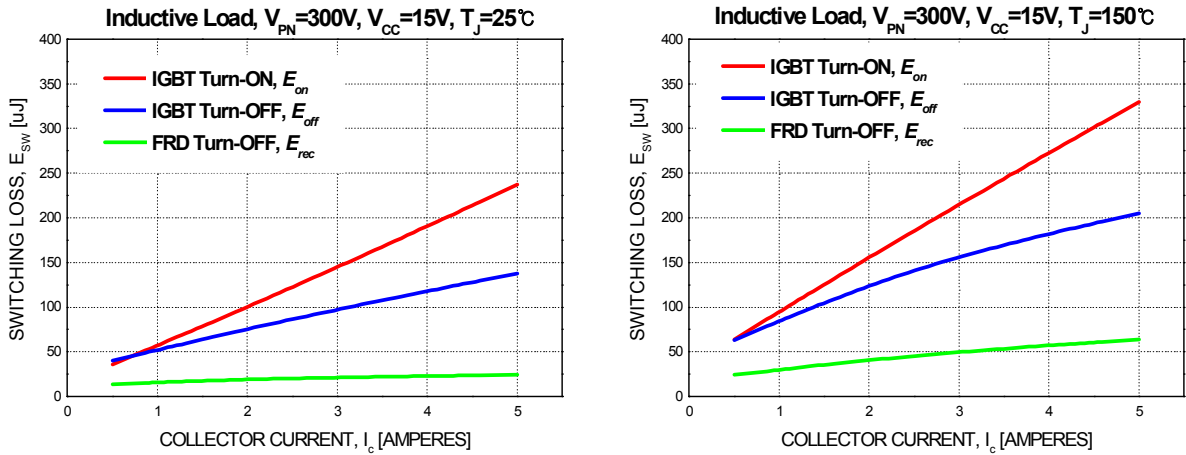


Figure 5. Switching Loss Characteristics

Control Part

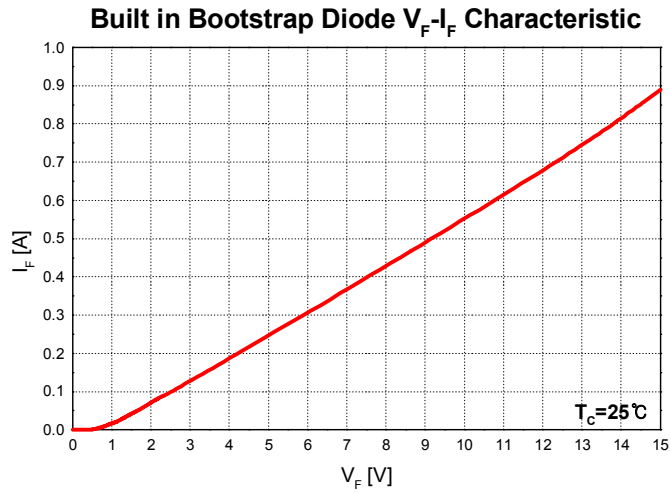
Symbol	Parameter	Conditions	Min.	Typ.	Max.	Units	
I_{QCCH}	Quiescent V_{CC} Supply Current	$V_{CC(H)} = 15V, I_{N(UH, VH, WH)} = 0V$	$V_{CC(H)} - COM$	-	-	0.10	mA
I_{QCCL}		$V_{CC(L)} = 15V, I_{N(UL, VL, WL)} = 0V$	$V_{CC(L)} - COM$	-	-	2.65	mA
I_{PCCH}	Operating V_{CC} Supply Current	$V_{CC(H)} = 15V, f_{PWM} = 20kHz, \text{duty}=50\%$, applied to one PWM signal input for High-side	$V_{CC(H)} - COM$	-	-	0.15	mA
I_{PCCL}		$V_{CC(L)} = 15V, f_{PWM} = 20kHz, \text{duty}=50\%$, applied to one PWM signal input for Low-side	$V_{CC(L)} - COM$	-	-	3.65	mA
I_{QBS}	Quiescent V_{BS} Supply Current	$V_{BS} = 15V, I_{N(UH, VH, WH)} = 0V$	$V_{B(U)} - V_{S(U)}, V_{B(V)} - V_{S(V)}, V_{B(W)} - V_{S(W)}$	-	-	0.30	mA
I_{PBS}	Operating V_{BS} Supply Current	$V_{CC} = V_{BS} = 15V, f_{PWM} = 20kHz, \text{duty}=50\%$, applied to one PWM signal input for High-side	$V_{B(U)} - V_{S(U)}, V_{B(V)} - V_{S(V)}, V_{B(W)} - V_{S(W)}$	-	-	2.00	mA
V_{FOH}	Fault Output Voltage	$V_{SC} = 0V, V_{FO}$ Circuit: 4.7k Ω to 5V Pull-up	4.5	-	-	V	
V_{FOL}		$V_{SC} = 1V, V_{FO}$ Circuit: 4.7k Ω to 5V Pull-up	-	-	0.5	V	
$V_{SC(ref)}$	Short Circuit Trip Level	$V_{CC} = 15V$ (Note 5)	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	
UV_{BSD}		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 $I_{N(UH)}, I_{N(VH)}, I_{N(WH)}, I_{N(UL)}, I_{N(VL)}, I_{N(WL)} - COM$	-	-	2.6	V	
$V_{IN(OFF)}$	OFF Threshold Voltage		0.8	-	-	V	

Note:

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

Bootstrap Diode Part

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Units
V_F	Forward Voltage	$I_F = 0.1A, T_C = 25^\circ C$	-	2.5	-	V
t_{rr}	Reverse Recovery Time	$I_F = 0.1A, T_C = 25^\circ C$	-	80	-	ns



Note:

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

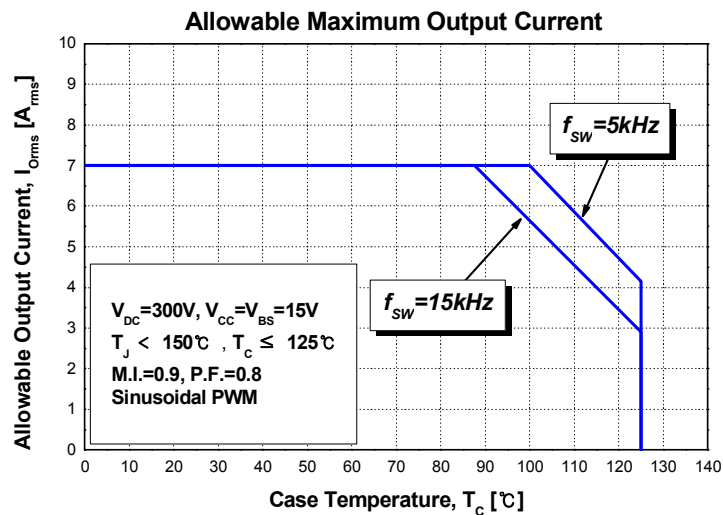
Figure 6. Built in Bootstrap Diode Characteristic

Recommended Operating Conditions

Symbol	Parameter	Conditions	Value			Units
			Min.	Typ.	Max.	
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°C < T _J < 150°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)}	Minimum Input Pulse Width	(Note 7)	0.5	-	-	μs
P _{WIN(OFF)}			0.5	-	-	

Note:

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



Note:

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

Figure 7. Allowable Maximum Output Current

Package Marking and Ordering Information

Device Marking	Device	Package	Reel Size	Tape Width	Quantity
FNE41060	FNE41060	SPM26-AAA	-	-	12

Mechanical Characteristics and Ratings

Parameter	Conditions		Limits			Units
			Min.	Typ.	Max.	
Device Flatness	Note Figure 8		0	-	+120	μm
Mounting Torque	Mounting Screw: - M3	Recommended 0.7N•m	0.6	0.7	0.8	N•m
	Note Figure 9	Recommended 7.1kg•cm	6.2	7.1	8.1	kg•cm
Weight			-	11	-	g

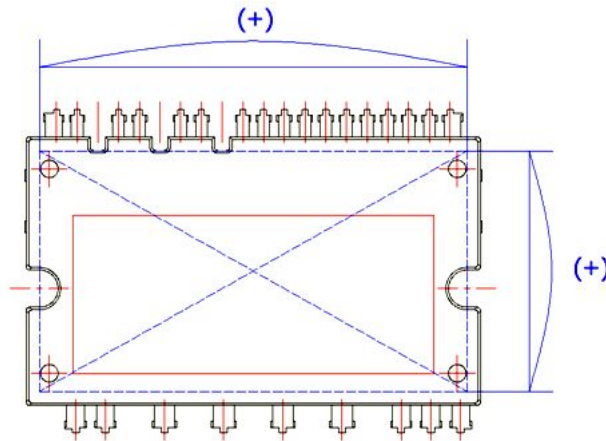
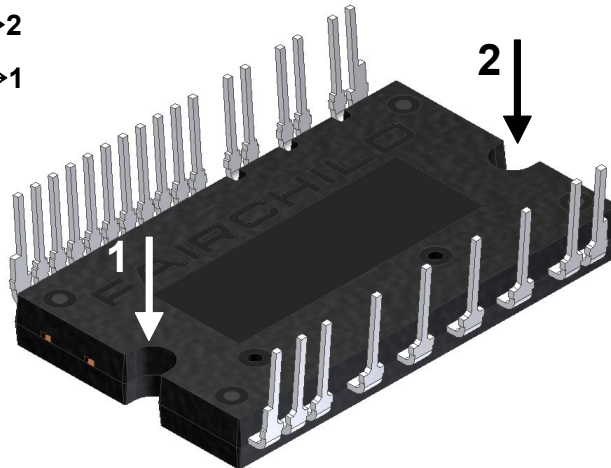


Figure 8. Flatness Measurement Position

Pre - Screwing : 1→2

Final Screwing : 2→1

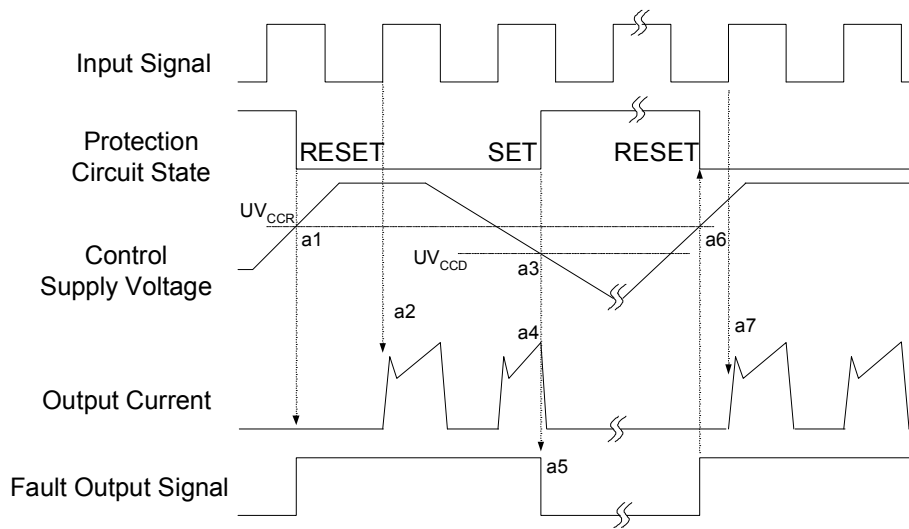


Note:

- 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.9 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.

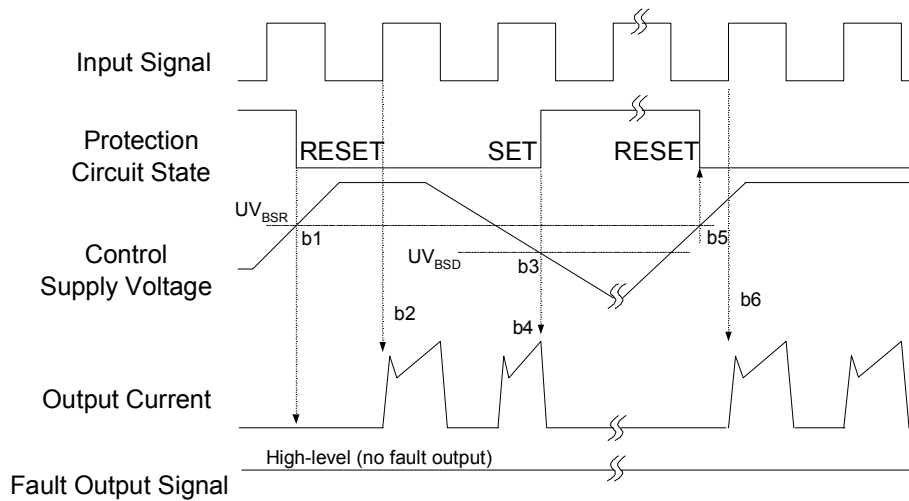
Figure 9. Mounting Screws Torque Order

Time Charts of SPMs Protective Function



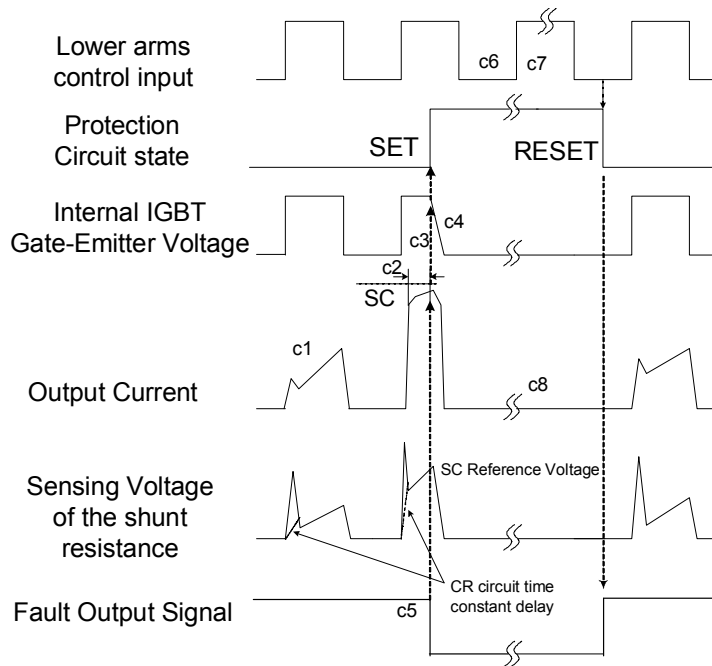
- a1 : Control supply voltage rises: After the voltage rises UV_{CCR} , the circuits start to operate when next input is applied.
- a2 : Normal operation: IGBT ON and carrying current.
- a3 : Under voltage detection (UV_{CCD}).
- a4 : IGBT OFF in spite of control input condition.
- a5 : Fault output operation starts.
- a6 : Under voltage reset (UV_{CCR}).
- a7 : Normal operation: IGBT ON and carrying current.

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



- b1 : Control supply voltage rises: After the voltage reaches UV_{BSR} , the circuits start to operate when next input is applied.
- b2 : Normal operation: IGBT ON and carrying current.
- b3 : Under voltage detection (UV_{BSD}).
- 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 11. Under-Voltage Protection (High-side)

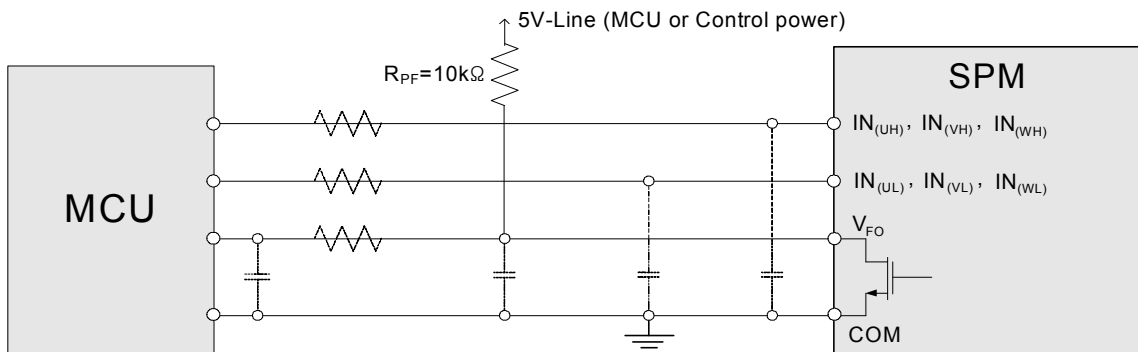


(with the external shunt resistance and CR connection)

- c1 : Normal operation: IGBT ON and carrying current.
- c2 : Short circuit current detection (SC trigger).
- c3 : Hard IGBT gate interrupt.
- c4 : IGBT turns OFF.
- 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

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

Input/Output Interface Circuit

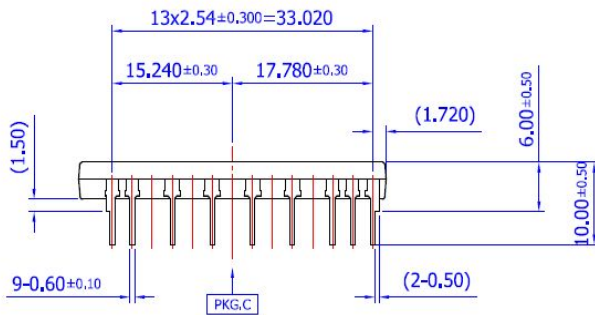
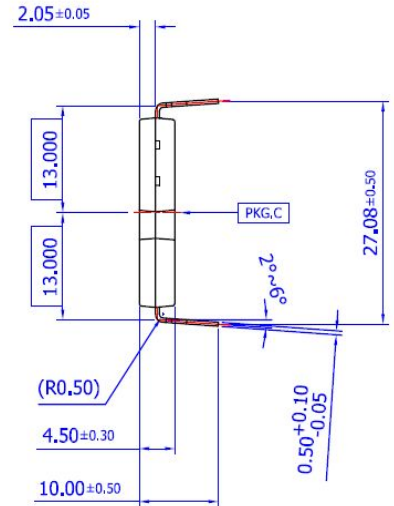
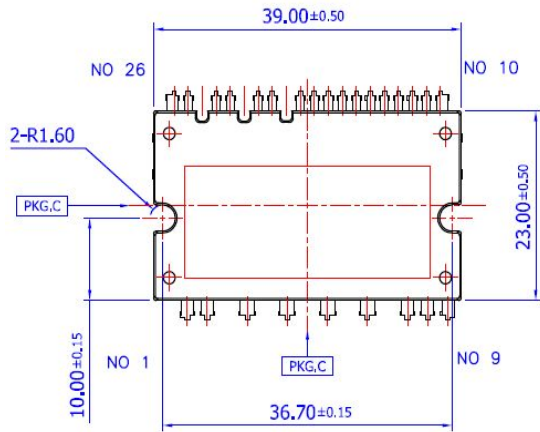
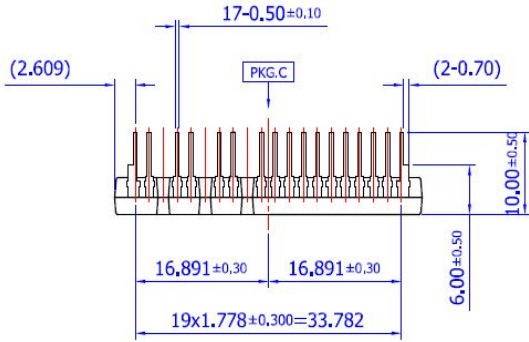


Note:

- 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 13. Recommended CPU I/O Interface Circuit

Detailed Package Outline Drawings





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Definition of Terms

Datasheet Identification	Product Status	Definition
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Preliminary	First Production	Datasheet contains preliminary data; supplementary data will be published at a later date. Fairchild Semiconductor reserves the right to make changes at any time without notice to improve design.
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