FAIRCHILD SEMICONDUCTOR®

September 2013

FSBB20CH60
Motion SPM® 3 Series

Features

- UL Certified No.E209204 (SPMCA-027 Package)
- Very Low Thermal Resistance by Using DBC
- 600 V - 20 A 3 - phase IGBT Inverter Bridge Including Control ICs for Gate Driving and Protection
- Three Separate Open - Emitter Pins from Low Side IGBTs for Three Leg Current Sensing
- Single-Grounded Power Supply for Built-in HVICs
- Isolation Rating of 2500 Vrms/min.

General Description

FSBB20CH60 Is A Motion SPM® 3 Series that Fairchild Has Developed to Provide A Very Compact and High Performance Inverter Solution for AC Motor Drives in Low-Power Applications Such as Air Conditioners. It Combines Optimized Circuit Protections and Drives Matched to Low-Loss IGBTs. The System Reliability Is Further Enhanced by The Integrated Under-Voltage Lock-Out and Over-Current Protection. The High Speed Built-In HVIC Provides Optocoupler-Less Single-Supply IGBT Gate Driving Capability that Further Reduces The Overall Size of The Inverter System. Each Phase Leg Current of The Inverter Can Be Monitored Thanks to Three Separate Negative DC Terminals.

Applications

- Motion Control - Home Appliance / Industrial Motor

Related Source

- AN-9035 : Motion SPM 3 Series Ver.2 User’s Guide

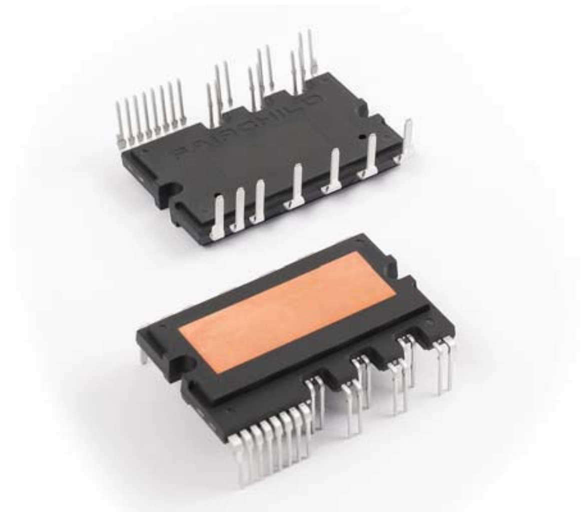


Figure 1.

Package Marking and Ordering Information

Device Marking	Device	Package	Real Size	Packing Type	Quantity
FSBB20CH60	FSBB20CH60	SPMCA-027	-	RAIL	10

Integrated Power Functions

- 600 V - 20 A 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
  Note) Available bootstrap circuit example is given in Figures 10 and 11.
- For inverter low-side IGBTs: Gate drive circuit, Short circuit protection (SC)
  Control supply circuit under-voltage (UV) protection
- Fault signaling: Corresponding to a UV fault (Low-side supply)
- Input interface: Active-high interface, can work with 3.3 / 5 V Logic

Pin Configuration

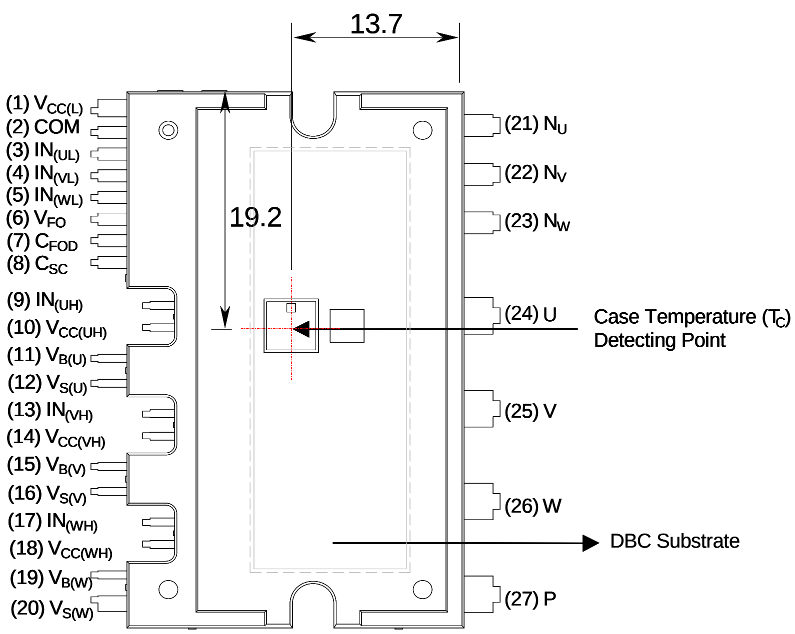
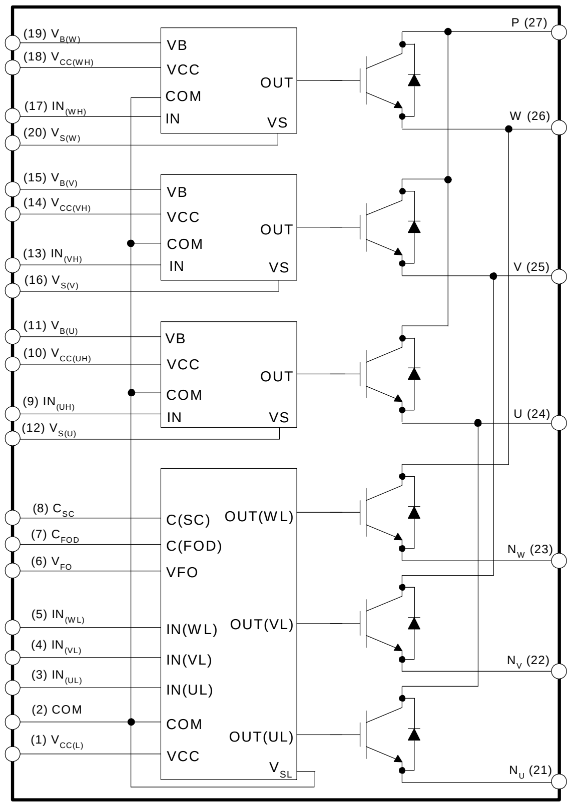


Figure 2.

Pin Descriptions

Pin Number	Pin Name	Pin Description
1	$V_{CC(L)}$	Low-side Common Bias Voltage for IC and IGBTs Driving
2	COM	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	V_{FO}	Fault Output
7	C_{FOD}	Capacitor for Fault Output Duration Time Selection
8	C_{SC}	Capacitor (Low-pass Filter) for Short-Current Detection Input
9	$IN_{(UH)}$	Signal Input for High-side U Phase
10	$V_{CC(UH)}$	High-side Bias Voltage for U Phase IC
11	$V_{B(U)}$	High-side Bias Voltage for U Phase IGBT Driving
12	$V_{S(U)}$	High-side Bias Voltage Ground for U Phase IGBT Driving
13	$IN_{(VH)}$	Signal Input for High-side V Phase
14	$V_{CC(VH)}$	High-side Bias Voltage for V Phase IC
15	$V_{B(V)}$	High-side Bias Voltage for V Phase IGBT Driving
16	$V_{S(V)}$	High-side Bias Voltage Ground for V Phase IGBT Driving
17	$IN_{(WH)}$	Signal Input for High-side W Phase
18	$V_{CC(WH)}$	High-side Bias Voltage for W Phase IC
19	$V_{B(W)}$	High-side Bias Voltage for W Phase IGBT Driving
20	$V_{S(W)}$	High-side Bias Voltage Ground for W Phase IGBT Driving
21	N_U	Negative DC–Link Input for U Phase
22	N_V	Negative DC–Link Input for V Phase
23	N_W	Negative DC–Link Input for W Phase
24	U	Output for U Phase
25	V	Output for V Phase
26	W	Output for W Phase
27	P	Positive DC–Link Input

Internal Equivalent Circuit and Input/Output Pins



Note:

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

Figure 3.

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

Inverter Part

Symbol	Parameter	Conditions	Rating	Unit
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
$\pm I_C$	Each IGBT Collector Current	T_C = 25°C	20	A
$\pm I_{CP}$	Each IGBT Collector Current (Peak)	T_C = 25°C, Under 1ms Pulse Width	40	A
P_C	Collector Dissipation	T_C = 25°C per One Chip	61	W
T_J	Operating Junction Temperature	(Note 1)	-20 ~ 125	°C

Note:

1. The maximum junction temperature rating of the power chips integrated within the Motion SPM® 3 Product is 150 °C(@$T_C \leq$ 100°C). However, to insure safe operation of the Motion SPM 3 Product, the average junction temperature should be limited to $T_{J(ave)} \leq$ 125°C (@$T_C \leq$ 100°C)

Control Part

Symbol	Parameter	Conditions	Rating	Unit
V_{CC}	Control Supply Voltage	Applied between $V_{CC(UH)}$, $V_{CC(VH)}$, $V_{CC(WH)}$, $V_{CC(L)}$ - 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	-0.3~17	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	5	mA
V_{SC}	Current Sensing Input Voltage	Applied between C_{SC} - COM	-0.3~V_{CC}+0.3	V

Total System

Symbol	Parameter	Conditions	Rating	Unit
$V_{PN(PROT)}$	Self Protection Supply Voltage Limit (Short Circuit Protection Capability)	$V_{CC} = V_{BS}$ = 13.5 ~ 16.5 V T_J = 125°C, Non-repetitive, less than 2μs	400	V
T_C	Module Case Operation Temperature	-20°C≤ T_J ≤ 125°C, See Figure 2	-20 ~ 100	°C
T_{STG}	Storage Temperature		-40 ~ 125	°C
V_{ISO}	Isolation Voltage	60 Hz, Sinusoidal, AC 1 minute, Connection Pins to DBC substrate	2500	V_{rms}

Thermal Resistance

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
$R_{th(j-c)Q}$	Junction to Case Thermal Resistance	Inverter IGBT part (per 1 / 6 module)	-	-	1.63	°C/W
$R_{th(j-c)F}$		Inverter FWD part (per 1 / 6 module)	-	-	2.55	°C/W

Note:

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

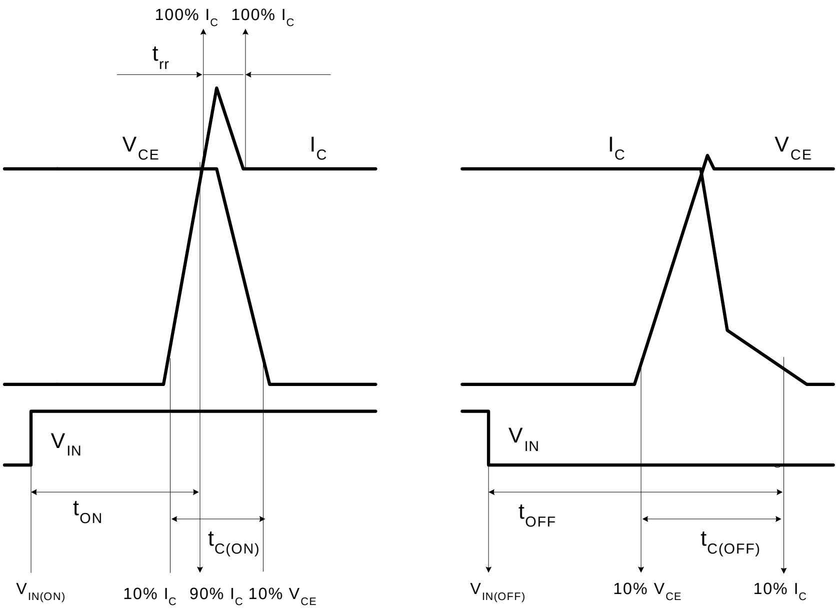
Electrical Characteristics (T_J = 25°C, Unless Otherwise Specified)

Inverter Part

Symbol		Parameter	Conditions		Min.	Typ.	Max.	Unit
$V_{CE(SAT)}$		Collector-Emitter Saturation Voltage	V_{CC} = V_{BS} = 15 V V_{IN} = 5 V	I_C =20 A, T_J = 25°C	-	-	2.3	V
V_F		FWD Forward Voltage	V_{IN} = 0V	I_C = 20 A, T_J = 25°C	-	-	2.1	V
HS	t_{ON}	Switching Times	V_{PN} = 300 V, V_{CC} = V_{BS} = 15 V I_C = 20 A V_{IN} = 0 V ↔ 5 V, Inductive Load (Note 3)		-	0.48	-	μs
	$t_{C(ON)}$				-	0.30	-	μs
	t_{OFF}				-	0.93	-	μs
	$t_{C(OFF)}$				-	0.52	-	μs
	t_{rr}				-	0.10	-	μs
LS	t_{ON}		V_{PN} = 300 V, V_{CC} = V_{BS} = 15 V I_C = 20 A V_{IN} = 0 V ↔ 5 V, Inductive Load (Note 3)		-	0.63	-	μs
	$t_{C(ON)}$				-	0.30	-	μs
	t_{OFF}				-	1.01	-	μs
	$t_{C(OFF)}$				-	0.51	-	μs
	t_{rr}				-	0.10	-	μs
	I_{CES}	Collector-Emitter Leakage Current	V_{CE} = V_{CES}		-	-	250	μA

Note:

3. 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.



(a) turn-on (b) turn-off

Figure 4. Switching Time Definition

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

Control Part

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Unit
I_{QCCL}	Quiescent V_{CC} Supply Current	V_{CC} = 15 V $IN_{(UL, VL, WL)}$ = 0 V	$V_{CC(L)}$ - COM	-	-	23	mA
I_{QCCH}		V_{CC} = 15 V $IN_{(UH, VH, WH)}$ = 0 V	$V_{CC(UH)}$, $V_{CC(VH)}$, $V_{CC(WH)}$ - COM	-	-	100	μA
I_{QBS}	Quiescent V_{BS} Supply Current	V_{BS} = 15 V $IN_{(UH, VH, WH)}$ = 0 V	$V_{B(U)}$ - $V_{S(U)}$, $V_{B(V)}$ -$V_{S(V)}$, $V_{B(W)}$ - $V_{S(W)}$	-	-	500	μA
V_{FOH}	Fault Output Voltage	V_{SC} = 0 V, V_{FO} Circuit: 4.7 kΩ to 5 V Pull-up		4.5	-	-	V
V_{FOL}		V_{SC} = 1 V, V_{FO} Circuit: 4.7 kΩ to 5 V Pull-up		-	-	0.8	V
$V_{SC(ref)}$	Short Circuit Trip Level	V_{CC} = 15 V (Note 4)		0.45	0.5	0.55	V
UV_{CCD}	Supply Circuit Under-Voltage Protection	Detection Level		10.7	11.9	13.0	V
UV_{CCR}		Reset Level		11.2	12.4	13.2	V
UV_{BSD}		Detection Level		10.1	11.3	12.5	V
UV_{BSR}		Reset Level		10.5	11.7	12.9	V
t_{FOD}	Fault-out Pulse Width	C_{FOD} = 33 nF (Note 5)		1.0	1.8	-	ms
$V_{IN(ON)}$	ON Threshold Voltage	Applied between $IN_{(UH)}$, $IN_{(VH)}$, $IN_{(WH)}$, $IN_{(UL)}$, $IN_{(VL)}$, $IN_{(WL)}$ - COM		3.0	-	-	V
$V_{IN(OFF)}$	OFF Threshold Voltage			-	-	0.8	V

Note:

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

5. 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]

Recommended Operating Conditions

Symbol	Parameter	Conditions	Value			Unit
			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 $V_{CC(UH)}$, $V_{CC(VH)}$, $V_{CC(WH)}$, $V_{CC(L)}$ - 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	2.5	-	-	μs
f_{PWM}	PWM Input Signal	-20°C ≤ T_C ≤ 100°C, -20°C ≤ T_J ≤ 125°C	-	-	20	kHz
V_{SEN}	Voltage for Current Sensing	Applied between N_U, N_V, N_W - COM (Including surge voltage)	-4		4	V

Mechanical Characteristics and Ratings

Parameter	Conditions		Limits			Unit
			Min.	Typ.	Max.	
Mounting Torque	Mounting Screw: - M3	Recommended 0.62 N•m	0.51	0.62	0.72	N•m
Device Flatness		Note Figure 5	0	-	+120	μm
Weight			-	15.00	-	g

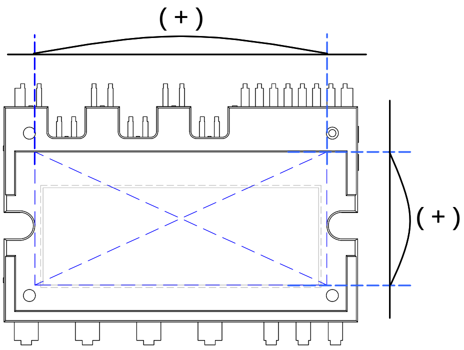
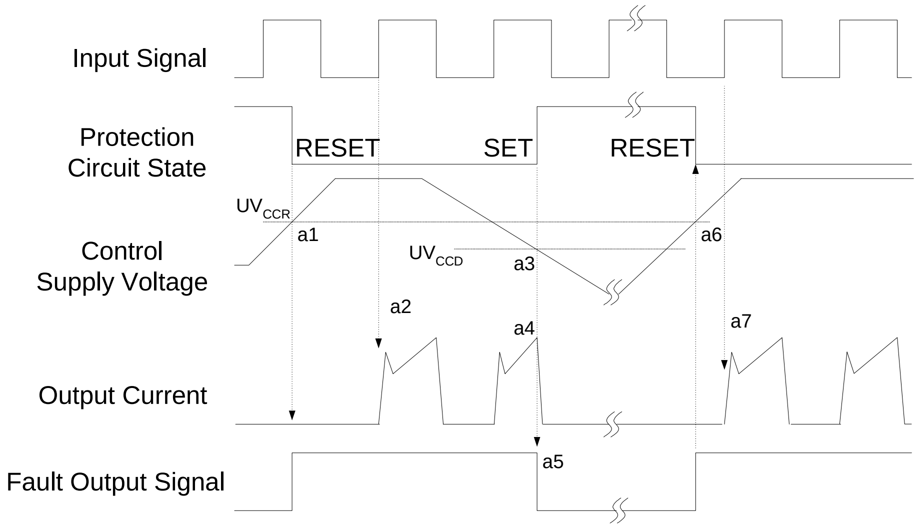


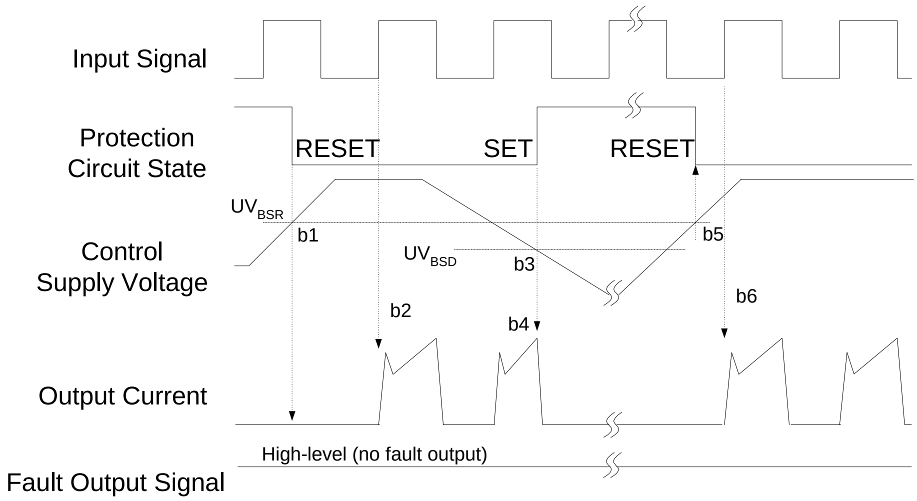
Figure 5. Flatness Measurement Position

Time Charts of Protective Function



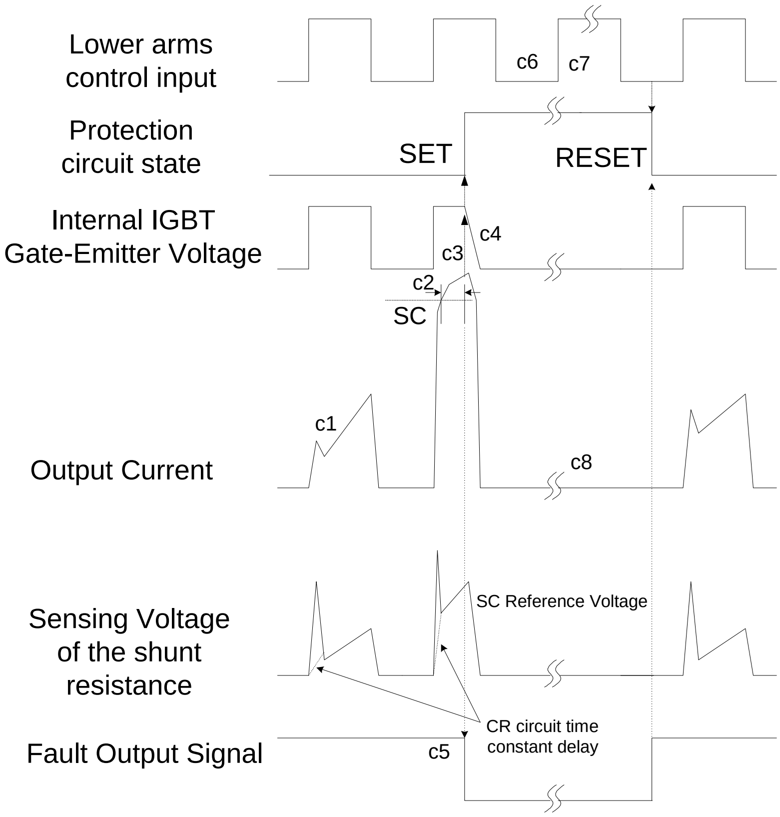
a1 : Control supply voltage rises: After the voltage rises UV_{CCR}, the circuits start to operate when next input is applied.
a2 : Normal operation: IGBT ON and carrying current.
a3 : Under voltage detection (UV_{CCD}).
a4 : IGBT OFF in spite of control input condition.
a5 : Fault output operation starts.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

Figure 6. 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 7. 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.

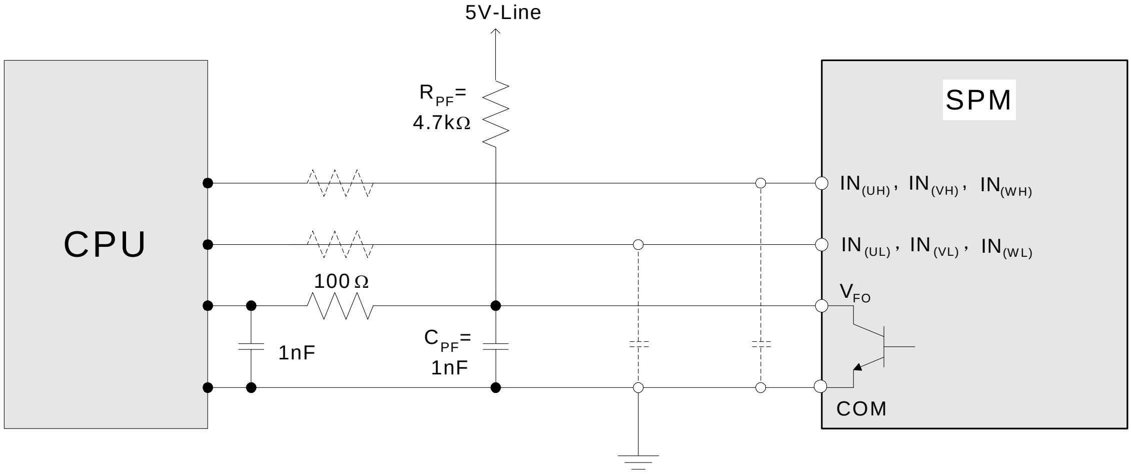
c5 : Fault output timer operation starts: The pulse width of the fault output signal is set by the external capacitor C_{FO}.

c6 : Input “L” : IGBT OFF state.

c7 : Input “H”: IGBT ON state, but during the active period of fault output the IGBT doesn’t turn ON.

c8 : IGBT OFF state

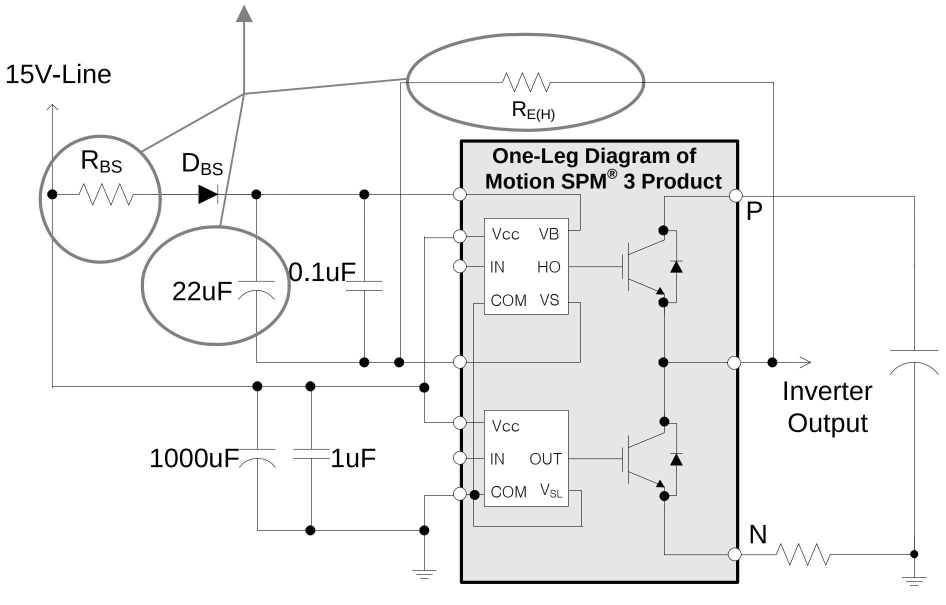
Figure 8. Short-Circuit Current Protection (Low-side Operation only)



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 Motion SPM® 3 Product input signal section integrates 3.3 KΩ(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 or LSTTL outputs.

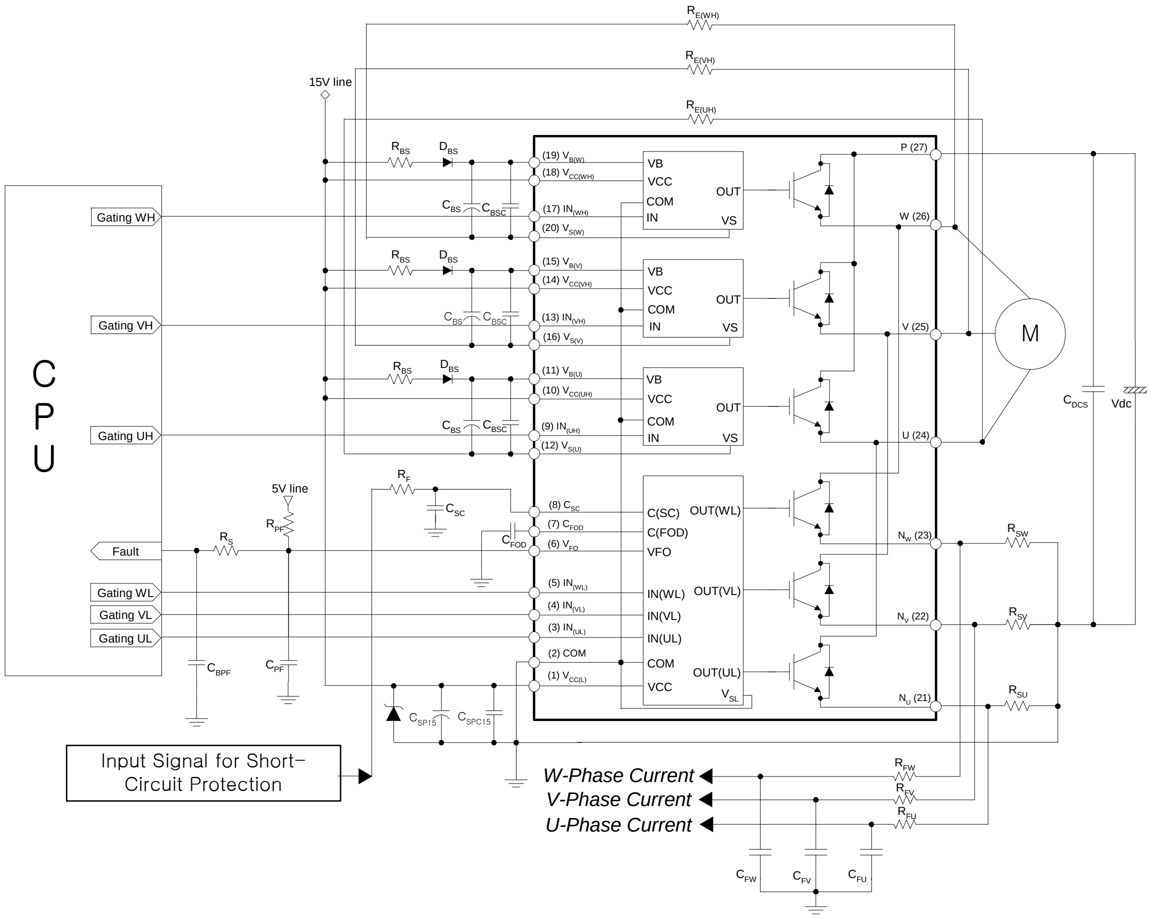
Figure 9. Recommended CPU I/O Interface Circuit



Note:

1. It would be recommended that the bootstrap diode, D_{BS}, has soft and fast recovery characteristics.
2. The bootstrap resistor (R_{BS}) should be 3 times greater than $R_{E(H)}$. The recommended value of $R_{E(H)}$ is 5.6 Ω, but it can be increased up to 20 Ω (maximum) for a slower dv/dt of high-side.
3. The ceramic capacitor placed between V_{CC}-COM should be over 1 μF and mounted as close to the pins of the Motion SPM 3 Product as possible.

Figure 10. Recommended Bootstrap Operation Circuit and Parameters

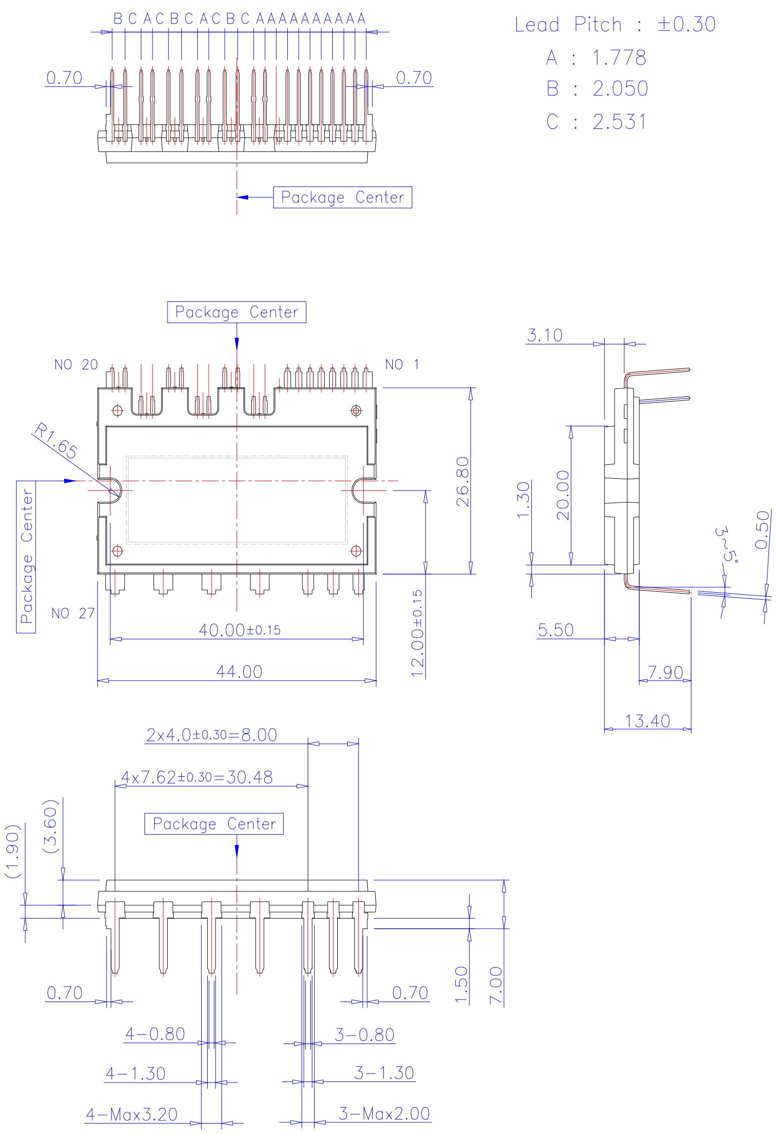


Note:

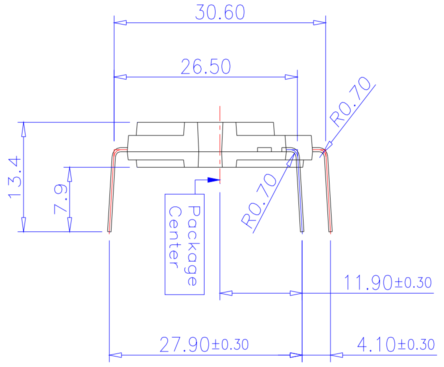
1. To avoid malfunction, the wiring of each input should be as short as possible. (less than 2-3cm)
2. By virtue of integrating an application specific type HVIC inside the Motion SPM® 3 Product, direct coupling to CPU terminals without any opto-coupler or transformer isolation is possible.
3. V_{FO} 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 9.
4. 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}(pin7) and COM(pin2). (Example : if C_{FOD} = 33 nF, then t_{FO} = 1.8 ms (typ.)) Please refer to the note 5 for calculation method.
6. Input signal is High-Active type. There is a 3.3 kΩ resistor inside the IC to pull down each input signal line to GND. When employing RC coupling circuits, set up such RC couple that input signal agree with turn-off/turn-on threshold voltage.
7. To prevent errors of the protection function, the wiring around 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 1.5~2 μs.
9. Each capacitor should be mounted as close to the pins of the Motion SPM 3 Product as possible.
10. 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.
11. 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.
12. C_{SPC15} should be over 1uF and mounted as close to the pins of the Motion SPM 3 Product as possible.

Figure 11. Typical Application Circuit

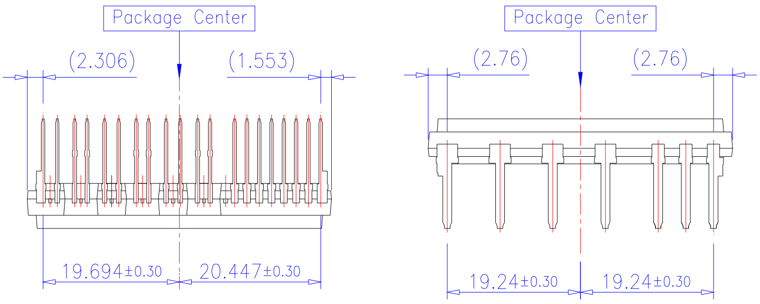
Detailed Package Outline Drawings



Detailed Package Outline Drawings (Continued)

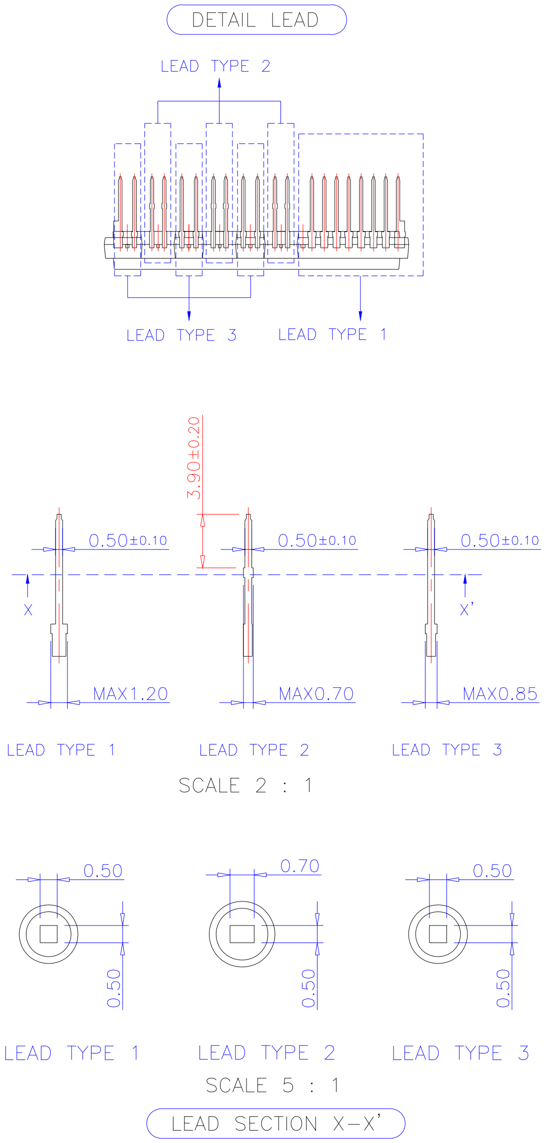


Lead Forming Dimension



PKG Center to Lead Distance

Detailed Package Outline Drawings (Continued)



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2. A critical component in any component of a life support, device, or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

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PRODUCT STATUS DEFINITIONS

Definition of Terms

Datasheet Identification	Product Status	Definition
Advance Information	Formative / In Design	Datasheet contains the design specifications for product development. Specifications may change in any manner without notice.
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.
No Identification Needed	Full Production	Datasheet contains final specifications. Fairchild Semiconductor reserves the right to make changes at any time without notice to improve the design.
Obsolete	Not In Production	Datasheet contains specifications on a product that is discontinued by Fairchild Semiconductor. The datasheet is for reference information only.

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