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February 2016

FSBB20CH60C

Motion SPM[®] 3 Series

Features

- UL Certified No. E209204 (UL1557)
- 600 V - 20 A 3-Phase IGBT Inverter with Integral Gate Drivers and Protection
- Low-Loss, Short-Circuit Rated IGBTs
- Very Low Thermal Resistance Using Al₂O₃ DBC Substrate
- Built-in Bootstrap Diodes and Dedicated Vs Pins Simplify PCB Layout
- Separate Open-Emitter Pins from Low-Side IGBTs for Three-Phase Current Sensing
- Single-Grounded Power Supply
- Isolation Rating: 2500 V_{rms} / min.

Applications

- Motion Control - Home Appliance / Industrial Motor

Related Resources

- [AN-9044 - Motion SPM[®] 3 Series Users Guide](#)

General Description

FSBB20CH60C is an advanced Motion SPM[®] 3 module providing a fully-featured, high-performance inverter output 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, over-current shutdown, 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.

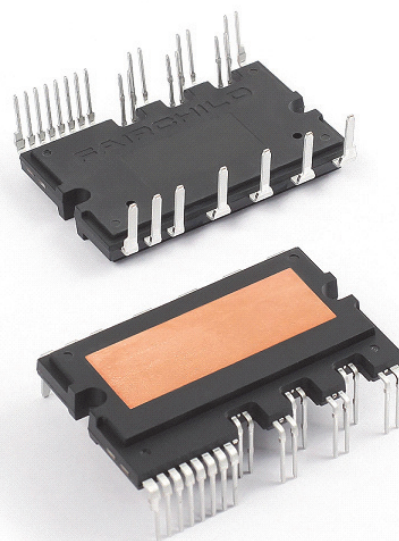


Figure 1. Package Overview

Package Marking and Ordering Information

Device	Device Marking	Package	Packing Type	Quantity
FSBB20CH60C	FSBB20CH60C	SPMCC-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 Lock-Out Protection (UVLO)
Note: Available bootstrap circuit example is given in Figures 12 and 13.
- For inverter low-side IGBTs: gate drive circuit, Short-Circuit Protection (SCP)
control supply circuit Under-Voltage Lock-Out Protection (UVLO)
- Fault signaling: corresponding to UVLO (low-side supply) and SC faults
- Input interface: active-HIGH interface, works with 3.3 / 5 V logic, Schmitt-trigger input

Pin Configuration

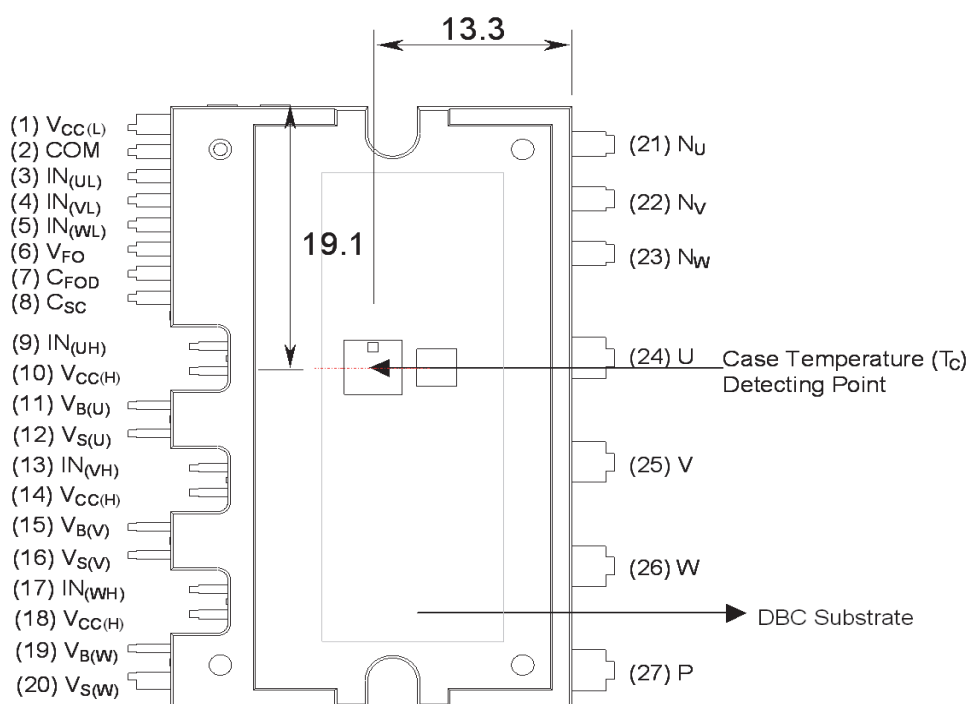


Figure 2. Top View

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 Selection
8	C_{SC}	Capacitor (Low-Pass Filter) for Short-Circuit Current Detection Input
9	$IN_{(UH)}$	Signal Input for High-Side U-Phase
10	$V_{CC(H)}$	High-Side Common Bias Voltage for IC and IGBTs Driving
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	$V_{CC(H)}$	High-Side Common Bias Voltage for IC and IGBTs Driving
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	$V_{CC(H)}$	High-Side Common Bias Voltage for IC and IGBTs Driving
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

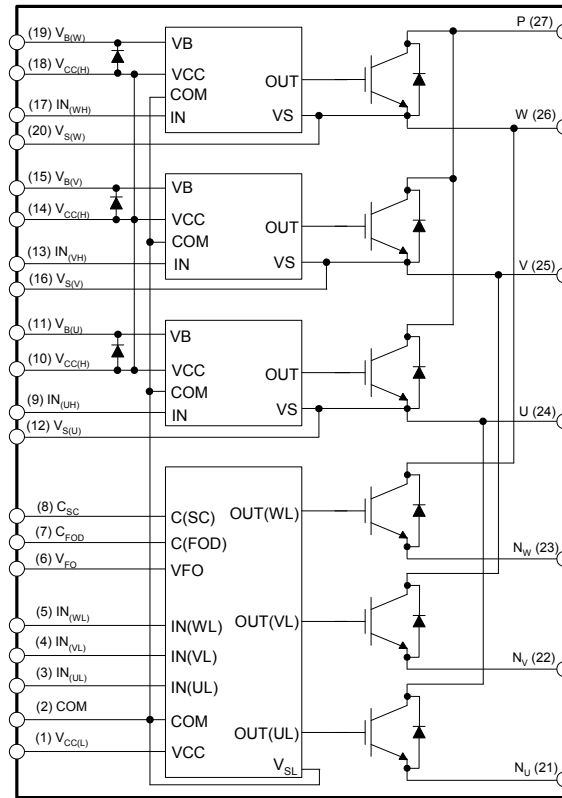


Figure 3. Internal Block Diagram

1st Notes:

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.

Absolute Maximum Ratings ($T_J = 25^\circ\text{C}$, 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
$V_{PN(\text{Surge})}$	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	$T_C = 25^\circ\text{C}$, $T_J \leq 150^\circ\text{C}$	20	A
$\pm I_{CP}$	Each IGBT Collector Current (Peak)	$T_C = 25^\circ\text{C}$, $T_J \leq 150^\circ\text{C}$, Under 1 ms Pulse Width	40	A
P_C	Collector Dissipation	$T_C = 25^\circ\text{C}$ per Chip	62	W
T_J	Operating Junction Temperature	(2nd Note 1)	- 40 ~ 150	$^\circ\text{C}$

2nd Notes:

1. The maximum junction temperature rating of the power chips integrated within the Motion SPM® 3 product is 150°C (at $T_C \leq 125^\circ\text{C}$).

Control Part

Symbol	Parameter	Conditions	Rating	Unit
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	5	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	Unit
V_{RRM}	Maximum Repetitive Reverse Voltage		600	V
I_F	Forward Current	$T_C = 25^\circ\text{C}$, $T_J \leq 150^\circ\text{C}$	0.5	A
I_{FP}	Forward Current (Peak)	$T_C = 25^\circ\text{C}$, $T_J \leq 150^\circ\text{C}$ Under 1 ms Pulse Width	2.0	A
T_J	Operating Junction Temperature		-40 ~ 150	$^\circ\text{C}$

Total System

Symbol	Parameter	Conditions	Rating	Unit
$V_{PN(\text{PROT})}$	Self-Protection Supply Voltage Limit (Short-Circuit Protection Capability)	$V_{CC} = V_{BS} = 13.5 \sim 16.5 \text{ V}$ $T_J = 150^\circ\text{C}$, Non-Repetitive, < 2 μs	400	V
T_C	Module Case Operation Temperature	$-40^\circ\text{C} \leq T_J \leq 150^\circ\text{C}$, See Figure 2	-40 ~ 125	$^\circ\text{C}$
T_{STG}	Storage Temperature		-40 ~ 125	$^\circ\text{C}$
V_{ISO}	Isolation Voltage	60 Hz, Sinusoidal, AC 1 Minute, Connect Pins to Heat Sink Plate	2500	V_{rms}

Thermal Resistance

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
$R_{th(j-c)Q}$	Junction to Case Thermal Resistance	Inverter IGBT part (per 1 / 6 module)	-	-	2.0	$^\circ\text{C} / \text{W}$
$R_{th(j-c)F}$		Inverter FWDi part (per 1 / 6 module)	-	-	3.0	$^\circ\text{C} / \text{W}$

2nd Notes:

2. 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.	Unit
$V_{CE(SAT)}$	Collector - Emitter Saturation Voltage	$V_{CC} = V_{BS} = 15\text{ V}$ $V_{IN} = 5\text{ V}$ $I_C = 20\text{ A}$, $T_J = 25^\circ\text{C}$	-	-	2.0	V
V_F	FWDi Forward Voltage	$V_{IN} = 0\text{ V}$ $I_F = 20\text{ A}$, $T_J = 25^\circ\text{C}$	-	-	2.2	V
HS	t_{ON}	$V_{PN} = 300\text{ V}$, $V_{CC} = V_{BS} = 15\text{ V}$ $I_C = 20\text{ A}$ $V_{IN} = 0\text{ V} \leftrightarrow 5\text{ V}$, Inductive Load (2nd Note 3)	-	0.75	-	μs
	$t_{C(ON)}$		-	0.2	-	μs
	t_{OFF}		-	0.45	-	μs
	$t_{C(OFF)}$		-	0.15	-	μs
	t_{rr}		-	0.1	-	μs
LS	t_{ON}	$V_{PN} = 300\text{ V}$, $V_{CC} = V_{BS} = 15\text{ V}$ $I_C = 20\text{ A}$ $V_{IN} = 0\text{ V} \leftrightarrow 5\text{ V}$, Inductive Load (2nd Note 3)	-	0.5	-	μs
	$t_{C(ON)}$		-	0.3	-	μs
	t_{OFF}		-	0.45	-	μs
	$t_{C(OFF)}$		-	0.15	-	μs
	t_{rr}		-	0.1	-	μs
I_{CES}	Collector - Emitter Leakage Current	$V_{CE} = V_{CES}$	-	-	1	mA

2nd Notes:

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.

Control Part

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
I_{QCCL}	Quiescent V_{CC} Supply Current	$V_{CC} = 15\text{ V}$ $I_{N(UL, VL, WL)} = 0\text{ V}$ $V_{CC(L)} - \text{COM}$	-	-	23	mA
I_{QCCH}		$V_{CC} = 15\text{ V}$ $I_{N(UH, VH, WH)} = 0\text{ V}$ $V_{CC(H)} - \text{COM}$	-	-	600	μA
I_{QBS}	Quiescent V_{BS} Supply Current	$V_{BS} = 15\text{ V}$ $I_{N(UH, VH, WH)} = 0\text{ V}$ $V_{B(U)} - V_{S(U)}$, $V_{B(V)} - V_{S(V)}$, $V_{B(W)} - V_{S(W)}$	-	-	500	μA
V_{FOH}	Fault Output Voltage	$V_{SC} = 0\text{ V}$, V_{FO} Circuit: 4.7 k Ω to 5 V Pull-up	4.5	-	-	V
V_{FOL}		$V_{SC} = 1\text{ V}$, V_{FO} Circuit: 4.7 k Ω to 5 V Pull-up	-	-	0.8	V
$V_{SC(ref)}$	Short-Circuit Current Trip Level	$V_{CC} = 15\text{ V}$ (2nd Note 4)	0.45	0.50	0.55	V
TSD	Over-Temperature Protection	Temperature at LVIC	-	160	-	$^\circ\text{C}$
ΔTSD	Over-Temperature Protection Hysteresis	Temperature at LVIC	-	5	-	$^\circ\text{C}$
UV_{CCD}	Supply Circuit Under-Voltage Protection	Detection Level	10.7	11.9	13.0	V
UV_{CCR}		Reset Level	11.2	12.4	13.4	V
UV_{BSD}		Detection Level	10	11	12	V
UV_{BSR}		Reset Level	10.5	11.5	12.5	V
t_{FOD}	Fault-Out Pulse Width	$C_{FOD} = 33\text{ nF}$ (2nd Note 5)	1.0	1.8	-	ms
$V_{IN(ON)}$	ON Threshold Voltage	Applied between $I_{N(UH)}$, $I_{N(VH)}$, $I_{N(WH)}$, $I_{N(UL)}$, $I_{N(VL)}$, $I_{N(WL)} - \text{COM}$	2.8	-	-	V
$V_{IN(OFF)}$	OFF Threshold Voltage		-	-	0.8	V

2nd Notes:

4. Short-circuit 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: $C_{FOD} = 18.3 \times 10^{-6} \times t_{FOD} [\text{F}]$

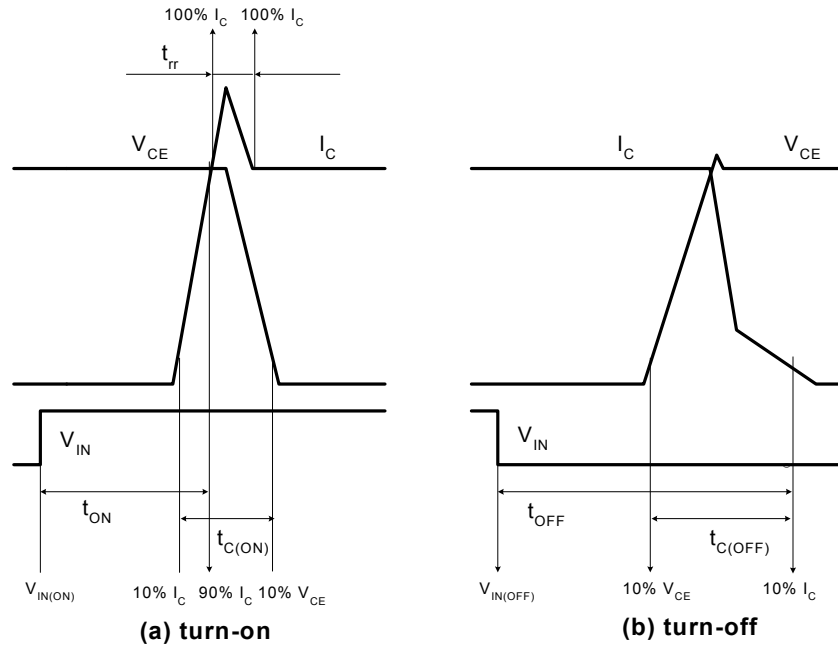


Figure 4. Switching Time Definition

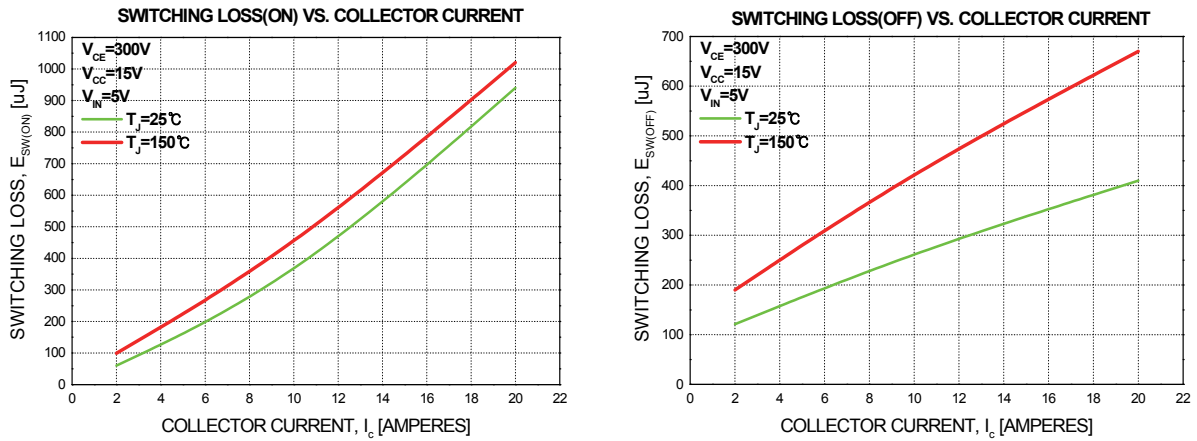
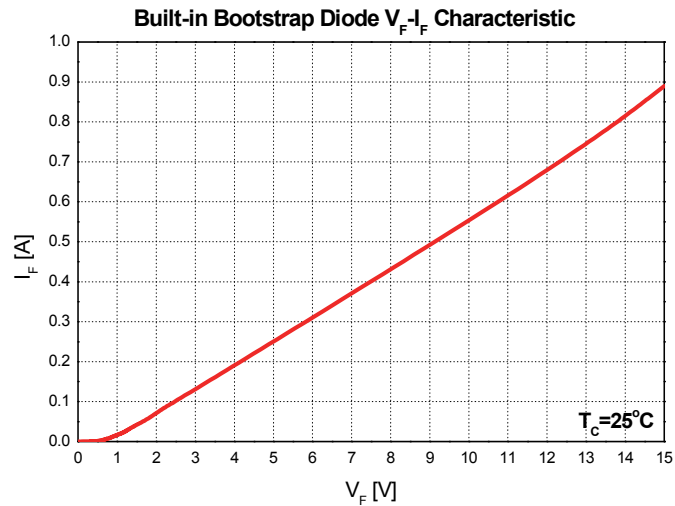


Figure 5. Switching Loss Characteristics (Typical)

Bootstrap Diode Part

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

**Figure 6. Built-in Bootstrap Diode Characteristics****2nd Notes:**

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

Recommended Operating Conditions

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
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	15.0	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	15.0	18.5	V
dV_{CC}/dt , dV_{BS}/dt	Control Supply Variation		-1	-	1	V / μs
t_{dead}	Blanking Time for Preventing Arm-Short	Each Input Signal	2	-	-	μs
f_{PWM}	PWM Input Signal	$-40^\circ\text{C} \leq T_C \leq 125^\circ\text{C}$, $-40^\circ\text{C} \leq T_J \leq 150^\circ\text{C}$	-	-	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		Min.	Typ.	Max.	Unit
Mounting Torque	Mounting Screw: M3	Recommended 0.62 N•m	0.51	0.62	0.80	N•m
Device Flatness		See Figure 7	0	-	+120	μm
Weight			-	15.00	-	g

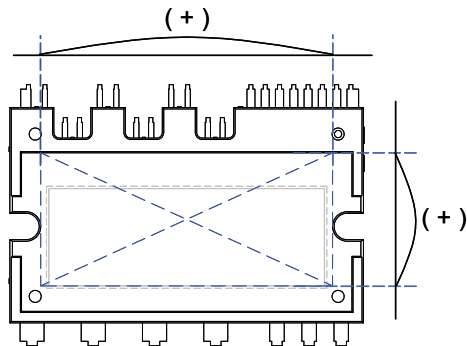
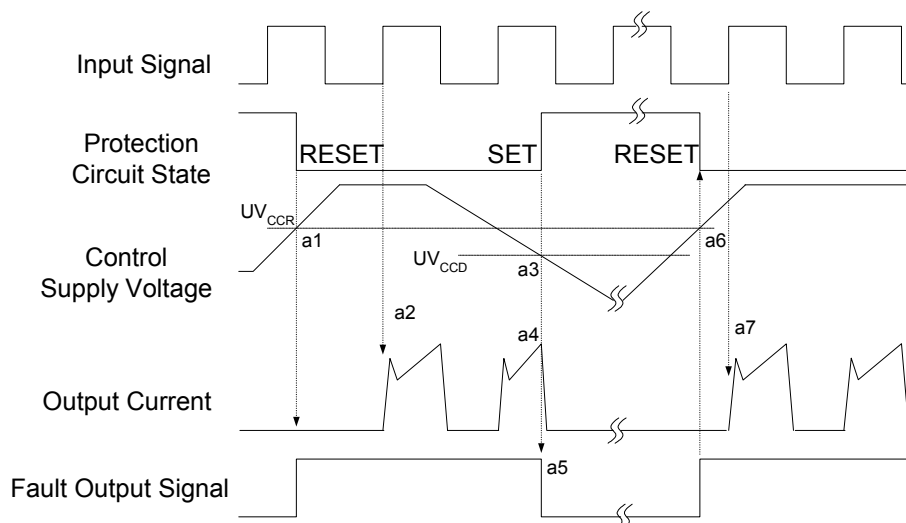


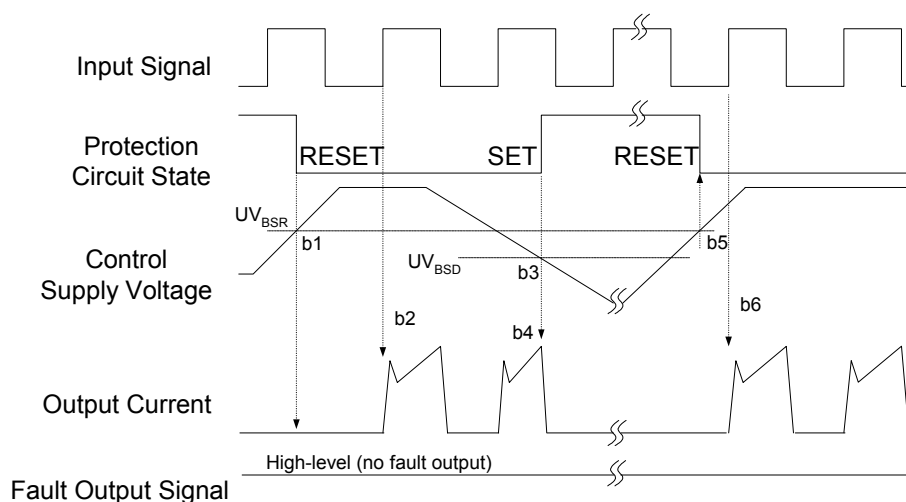
Figure 7. Flatness Measurement Position

Time Charts of Protective Function



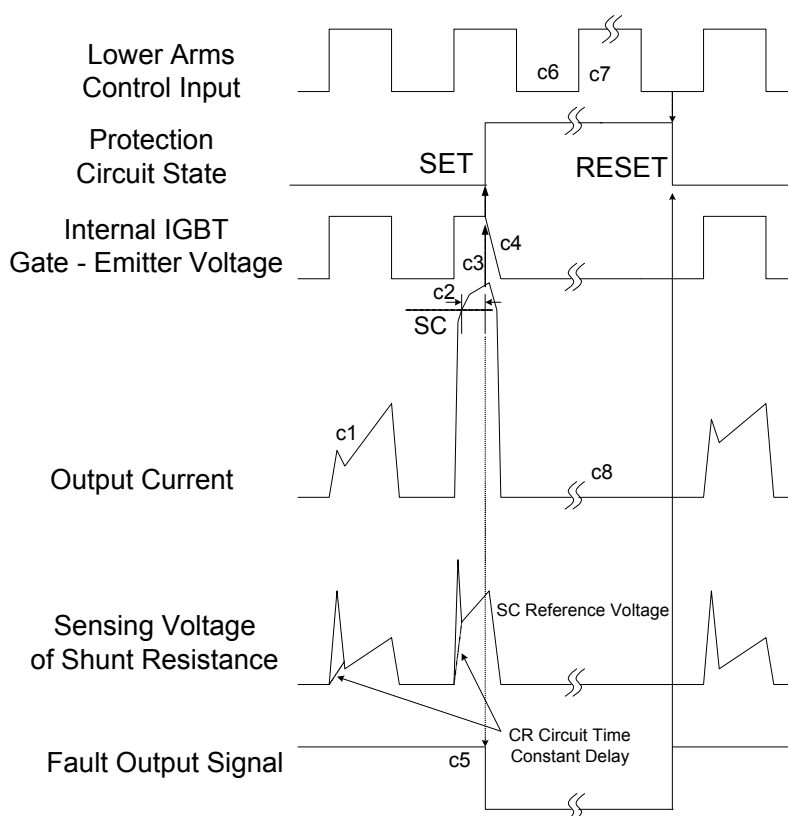
- a1 : Control supply voltage rises: after the voltage rises UV_{CCR} , the circuits start to operate when next input is applied.
 a2 : Normal operation: IGBT ON and carrying current.
 a3 : Under-voltage detection (UV_{CCD}).
 a4 : IGBT OFF in spite of control input condition.
 a5 : Fault output operation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

Figure 8. 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 9. 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 "LOW": IGBT OFF state.

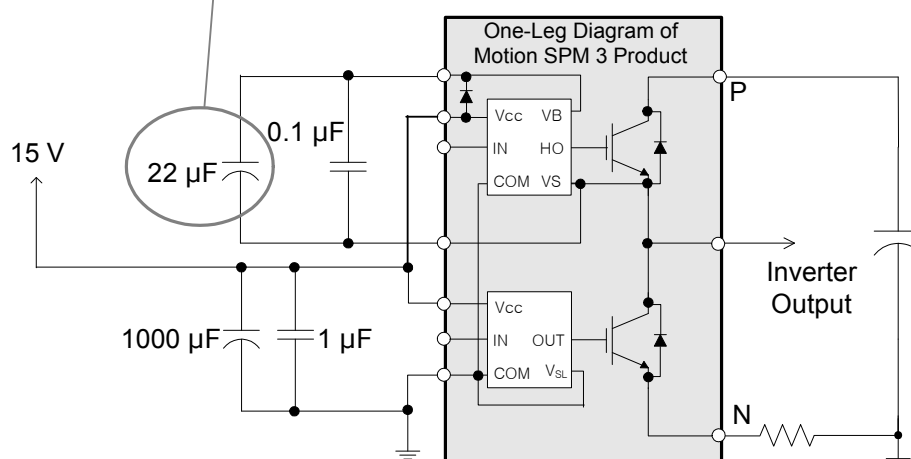
c7 : Input "HIGH": IGBT ON state, but during the active period of fault output, the IGBT doesn't turn ON.

c8 : IGBT OFF state.

Figure 10. Short-Circuit Protection (Low-Side Operation Only)

3rd Notes:

- These values depend on PWM control algorithm.*



3rd Notes:

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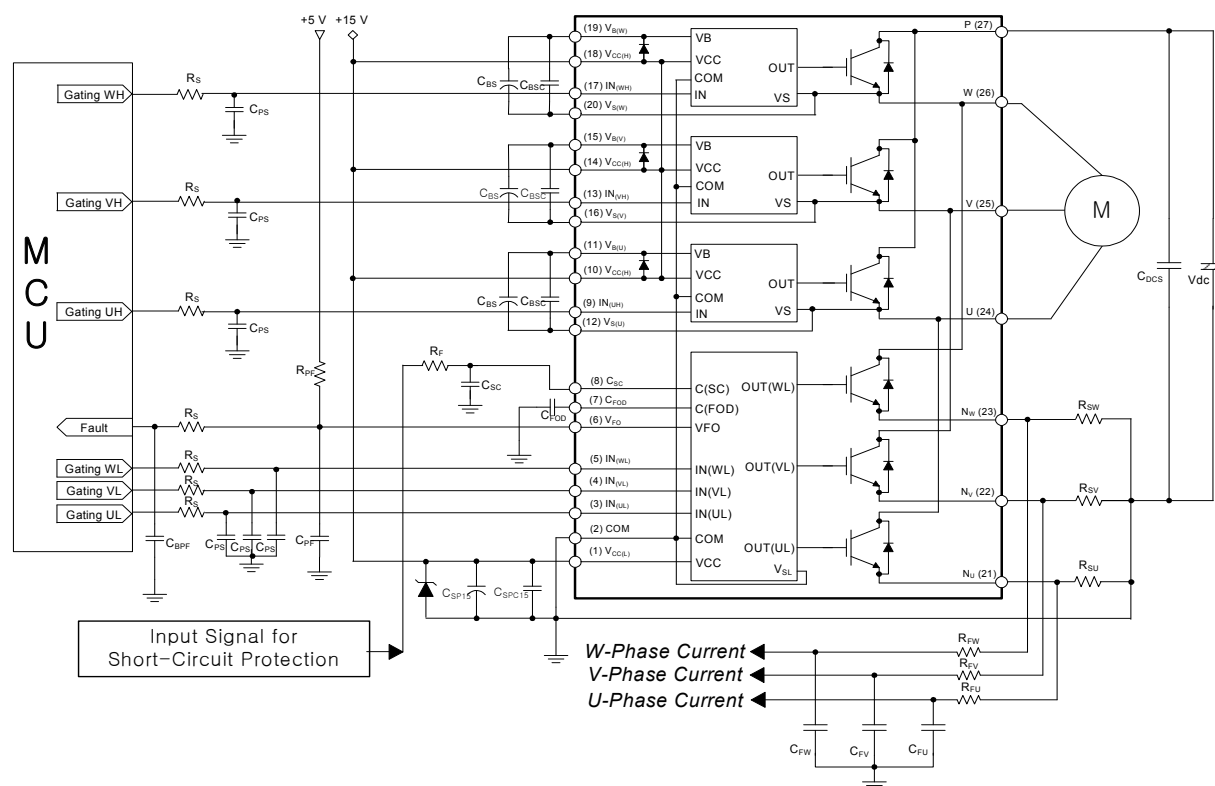
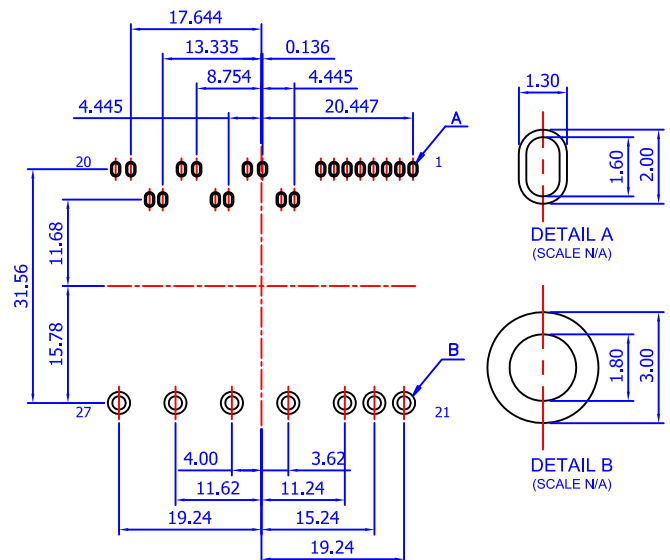
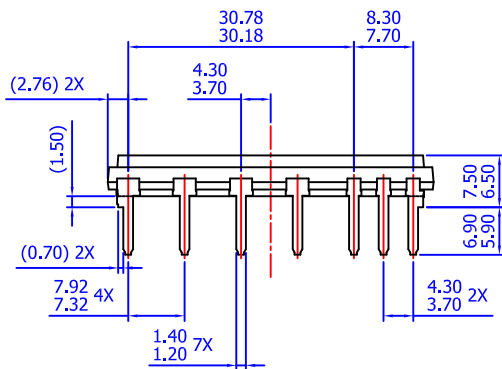
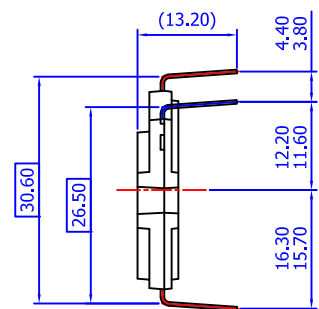
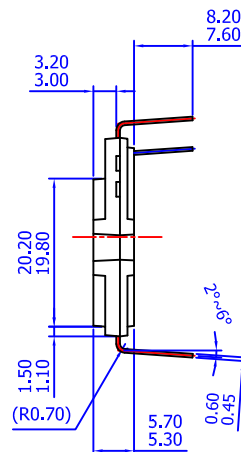
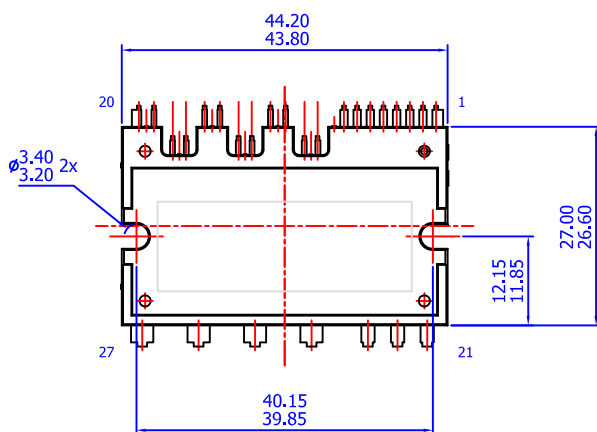
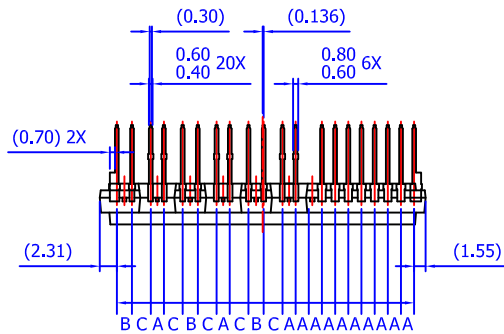


Figure 13. Typical Application Circuit

4th Notes:

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 of HVIC inside the Motion SPM® 3 product, direct coupling to MCU terminals without any optocoupler 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 k Ω resistance (please refer to Figure 11).
4. C_{SP15} 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 7) and COM (pin 2). (Example: if $C_{FOD} = 33$ nF, then $t_{FO} = 1.8$ ms (typ.)) Please refer to the 2nd note 5 for calculation method.
6. Input signal is active-HIGH type. There is a 5 k Ω resistor inside the IC to pull down each input signal line to GND. RC coupling circuits should be used to prevent input signal oscillation. $R_S C_{PS}$ time constant should be selected in the range 50 ~ 150 ns. C_{PS} should not be less than 1 nF (recommended $R_S = 100 \Omega$, $C_{PS} = 1$ nF).
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 ~ 2.0 μ s.
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 μ F between the P & GND pins is recommended.
11. Relays are used in almost every systems of electrical equipment in home appliances. In these cases, there should be sufficient distance between the MCU and the relays.
12. C_{SP15} should be over 1 μ F and mounted as close to the pins of the Motion SPM 3 product as possible.



- NOTES: UNLESS OTHERWISE SPECIFIED
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