



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.

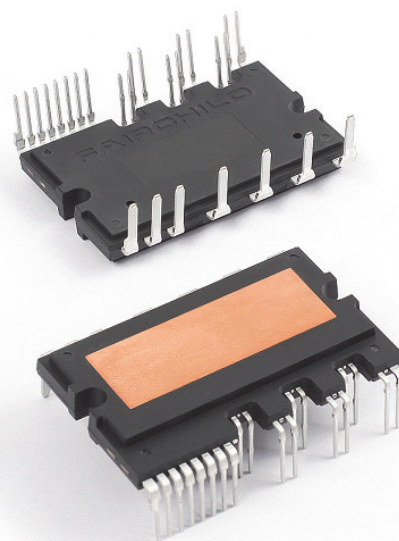


Figure 1. Package Overview

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

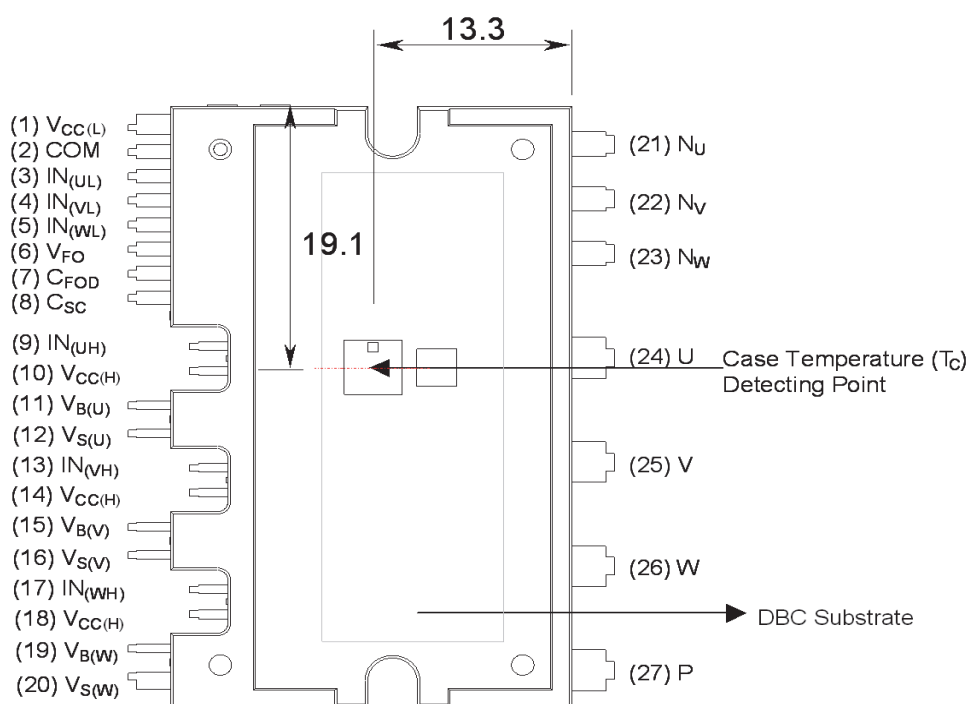


Figure 2. Top View

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

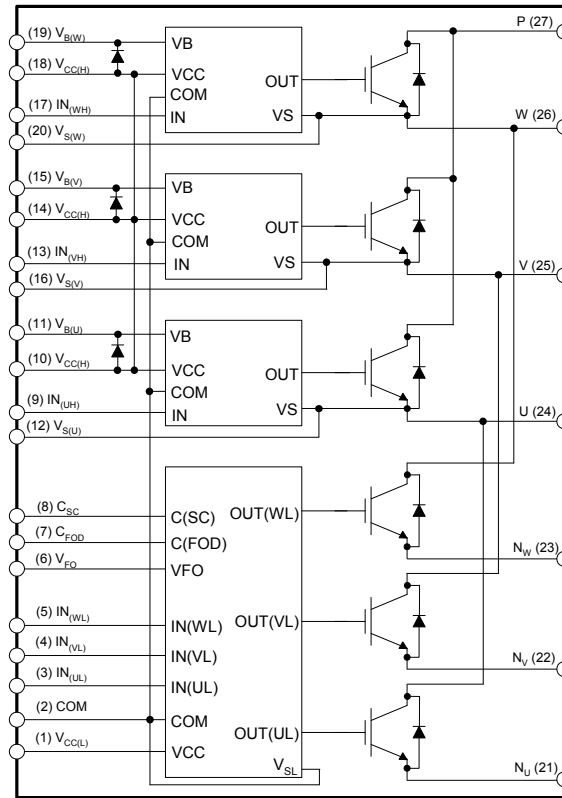


Figure 3. Internal Block Diagram

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

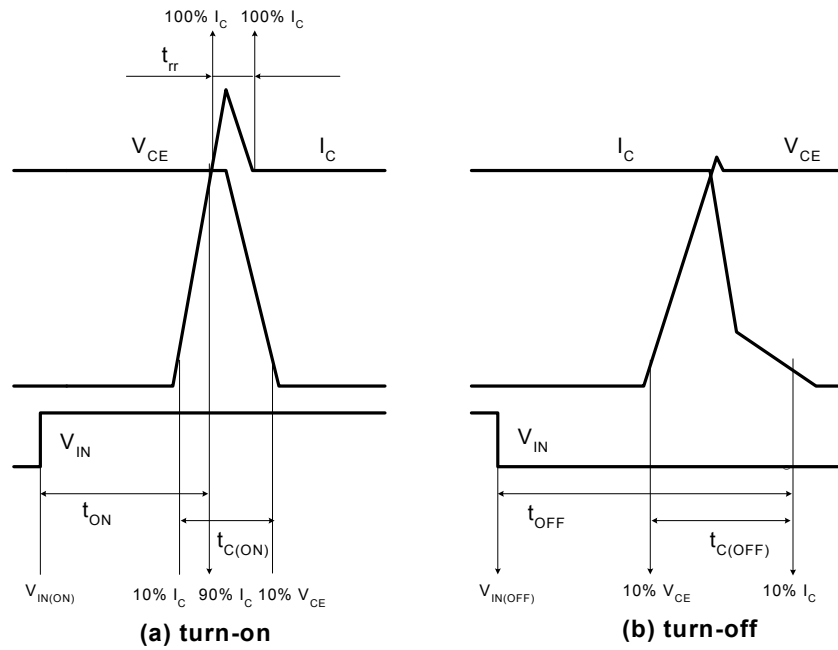


Figure 4. Switching Time Definition

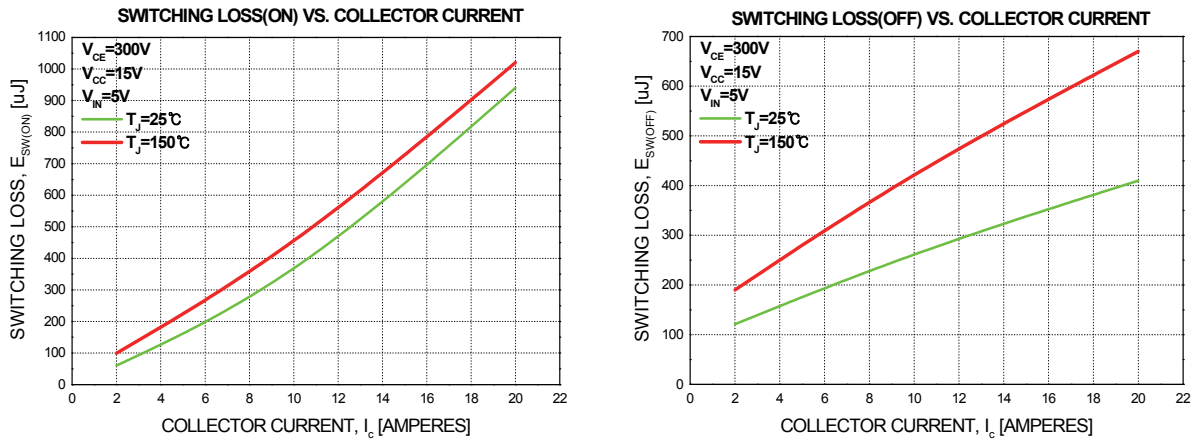
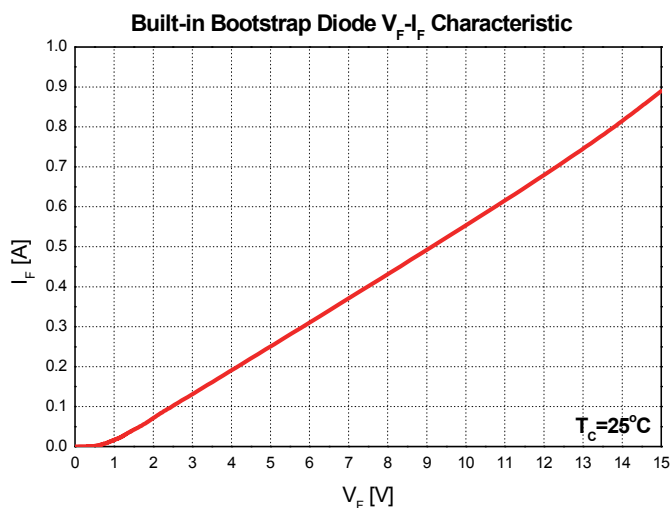


Figure 5. Switching Loss Characteristics (Typical)

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

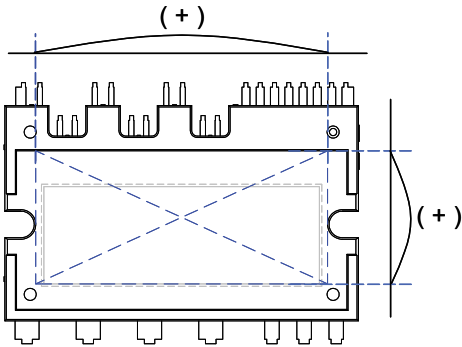
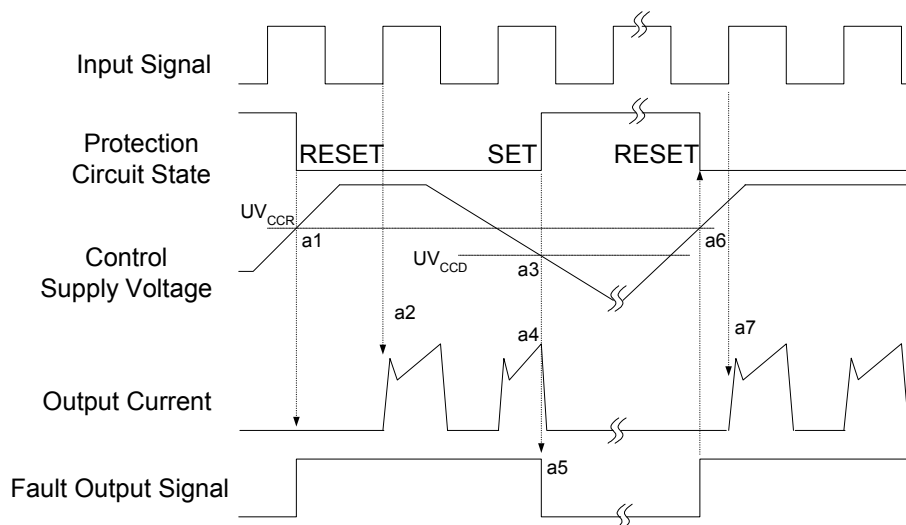


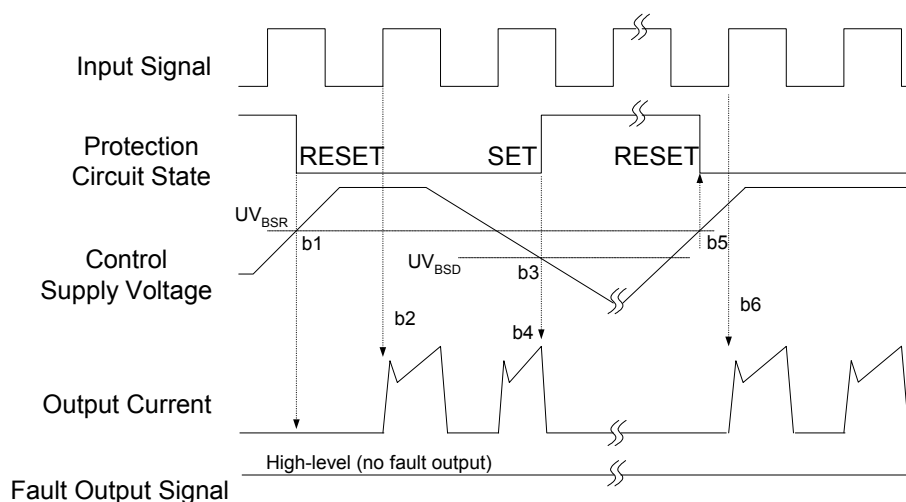
Figure 7. Flatness Measurement Position

Time Charts of Protective Function



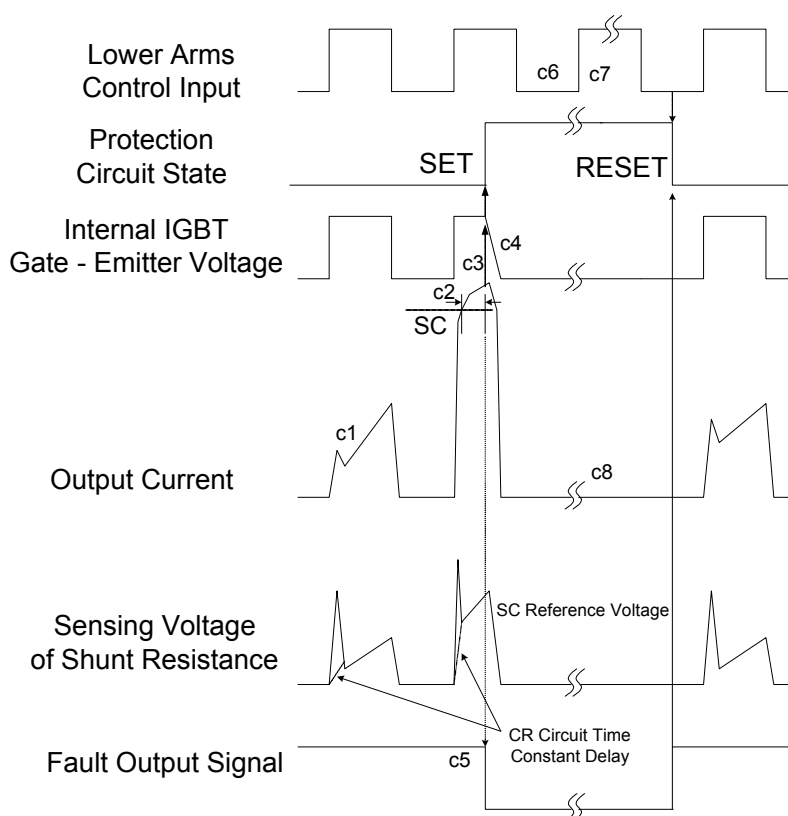
- a1 : Control supply voltage rises: after the voltage rises UV_{CCR} , the circuits start to operate when next input is applied.
 a2 : Normal operation: IGBT ON and carrying current.
 a3 : Under-voltage detection (UV_{CCD}).
 a4 : IGBT OFF in spite of control input condition.
 a5 : Fault output operation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

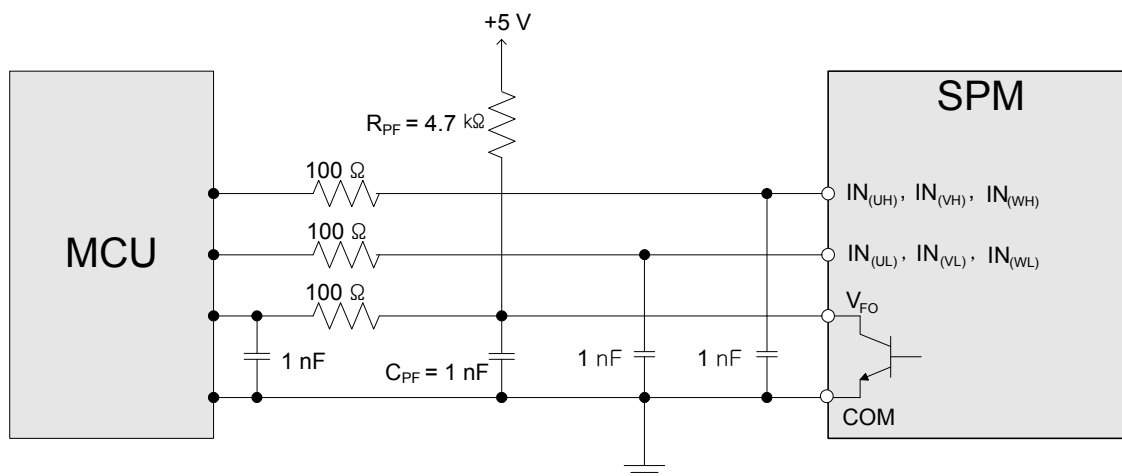


Figure 11. Recommended MCU I/O Interface Circuit

3rd Notes:

1. RC coupling at each input might change depending on the PWM control scheme in the application and the wiring impedance of the application's printed circuit board. The input signal section of the Motion SPM® 3 product integrates a 5 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 works with standard CMOS or LSTTL outputs.

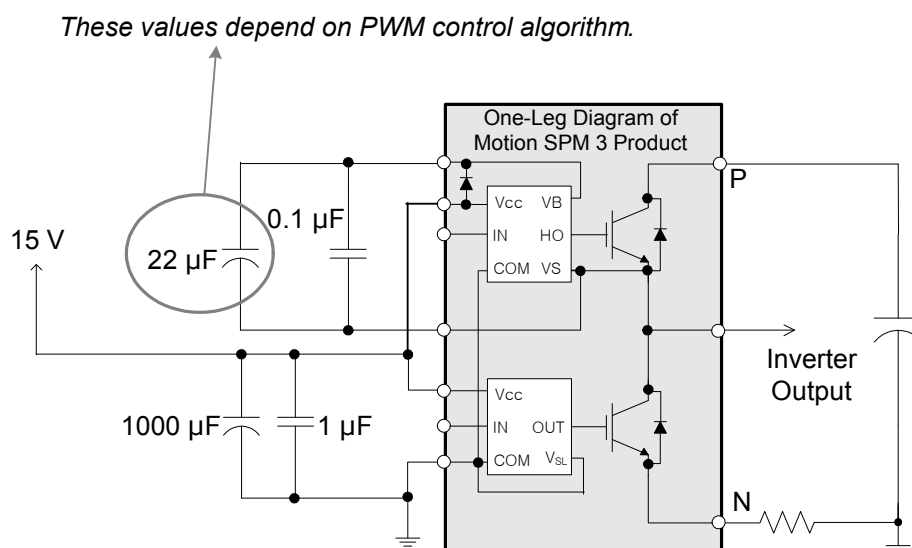
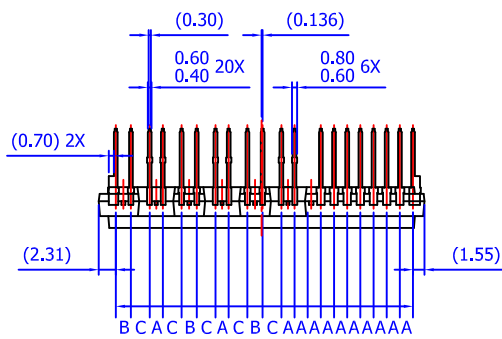


Figure 12. Recommended Bootstrap Operation Circuit and Parameters

3rd Notes:

3. The ceramic capacitor placed between V_{CC} - COM should be over 1 μ F and mounted as close to the pins of the Motion SPM 3 product as possible.

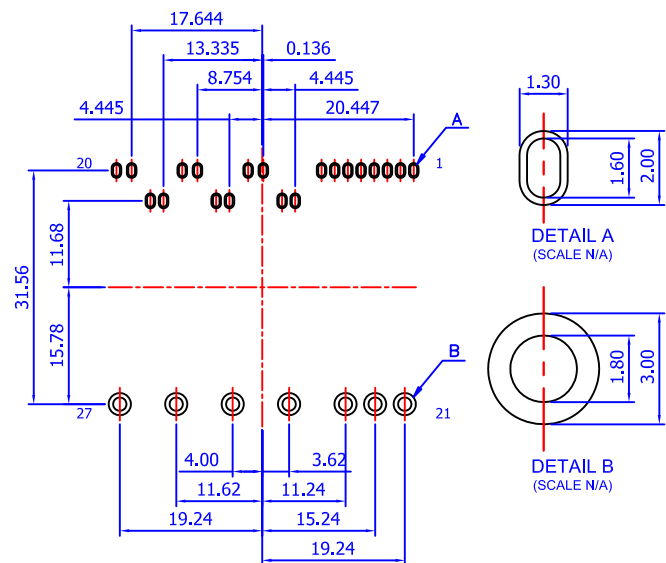
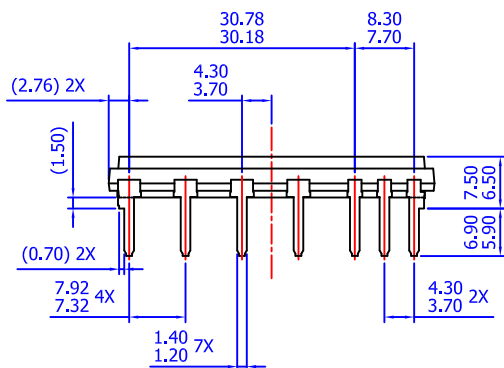
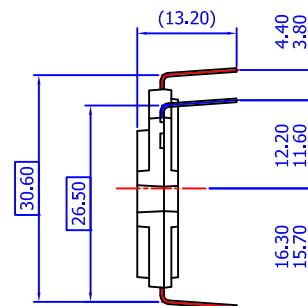
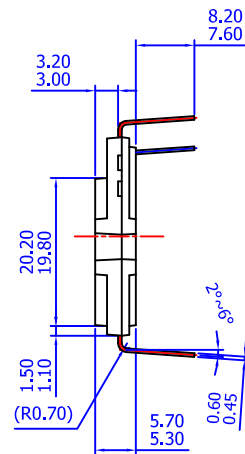
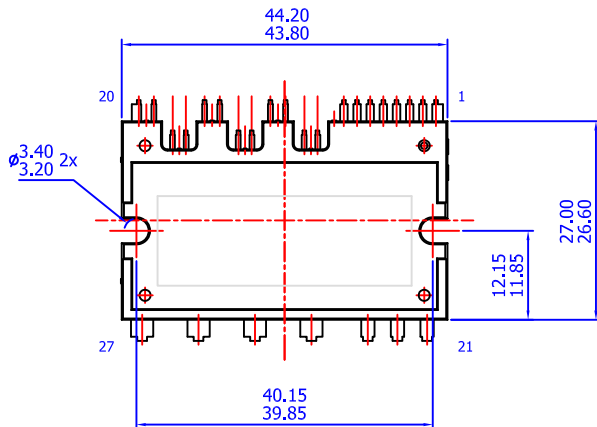


LEAD PITCH (TOLERANCE : ± 0.30)

A : 1.778

B : 2.050

C : 2.531



- NOTES: UNLESS OTHERWISE SPECIFIED
- A) THIS PACKAGE DOES NOT COMPLY TO ANY CURRENT PACKAGING STANDARD
 - B) ALL DIMENSIONS ARE IN MILLIMETERS
 - C) DIMENSIONS ARE EXCLUSIVE OF BURRS, MOLD FLASH, AND TIE BAR EXTRUSIONS
 - D) () IS REFERENCE
 - E) [] IS ASS'Y QUALITY
 - F) DRAWING FILENAME: MOD27BAREV3
 - G) FAIRCHILD SEMICONDUCTOR

LAND PATTERN RECOMMENDATIONS



ON Semiconductor and  are trademarks of Semiconductor Components Industries, LLC dba ON Semiconductor or its subsidiaries in the United States and/or other countries. ON Semiconductor owns the rights to a number of patents, trademarks, copyrights, trade secrets, and other intellectual property. A listing of ON Semiconductor's product/patent coverage may be accessed at www.onsemi.com/site/pdf/Patent-Marking.pdf. ON Semiconductor reserves the right to make changes without further notice to any products herein. ON Semiconductor makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does ON Semiconductor assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation special, consequential or incidental damages. Buyer is responsible for its products and applications using ON Semiconductor products, including compliance with all laws, regulations and safety requirements or standards, regardless of any support or applications information provided by ON Semiconductor. "Typical" parameters which may be provided in ON Semiconductor data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals" must be validated for each customer application by customer's technical experts. ON Semiconductor does not convey any license under its patent rights nor the rights of others. ON Semiconductor products are not designed, intended, or authorized for use as a critical component in life support systems or any FDA Class 3 medical devices or medical devices with a same or similar classification in a foreign jurisdiction or any devices intended for implantation in the human body. Should Buyer purchase or use ON Semiconductor products for any such unintended or unauthorized application, Buyer shall indemnify and hold ON Semiconductor and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that ON Semiconductor was negligent regarding the design or manufacture of the part. ON Semiconductor is an Equal Opportunity/Affirmative Action Employer. This literature is subject to all applicable copyright laws and is not for resale in any manner.

PUBLICATION ORDERING INFORMATION

LITERATURE FULFILLMENT:

Literature Distribution Center for ON Semiconductor
19521 E. 32nd Pkwy, Aurora, Colorado 80011 USA
Phone: 303-675-2175 or 800-344-3860 Toll Free USA/Canada
Fax: 303-675-2176 or 800-344-3867 Toll Free USA/Canada
Email: orderlit@onsemi.com

N. American Technical Support: 800-282-9855 Toll Free
USA/Canada

Europe, Middle East and Africa Technical Support:
Phone: 421 33 790 2910

Japan Customer Focus Center
Phone: 81-3-5817-1050

ON Semiconductor Website: www.onsemi.com

Order Literature: <http://www.onsemi.com/orderlit>

For additional information, please contact your local
Sales Representative