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FAIRCHILD SEMICONDUCTOR®

February 2014

FNA21012A

1200 V Motion SPM® 2 Series

Features

- UL Certified No. E209204 (UL1557)
- 1200 V - 10 A 3-Phase IGBT Inverter, Including Control ICs for Gate Drive and Protections
- Low-Loss, Short-Circuit-Rated IGBTs
- Very Low Thermal Resistance Using Al_2O_3 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 Supported
- Built-In NTC Thermistor for Temperature Monitoring and Management
- Adjustable Over-Current Protection via Integrated Sense-IGBTs
- Isolation Rating of 2500 Vrms / 1 min.

Applications

- Motion Control - Industrial Motor (AC 400 V Class)

Related Resources

- *AN-9075 - Users Guide for 1200V SPM® 2 Series*
- *AN-9076 - Mounting Guide for New SPM® 2 Package*
- *AN-9079 - Thermal Performance of 1200V Motion SPM® 2 Series by Mounting Torque*

General Description

The FNA21012A is a Motion SPM® 2 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: under-voltage lockouts, over-current shutdown, temperature sensing, and fault reporting. The built-in, high-speed HVIC requires only a single supply voltage and translates the incoming logic-level gate inputs to high-voltage, high-current drive signals 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.

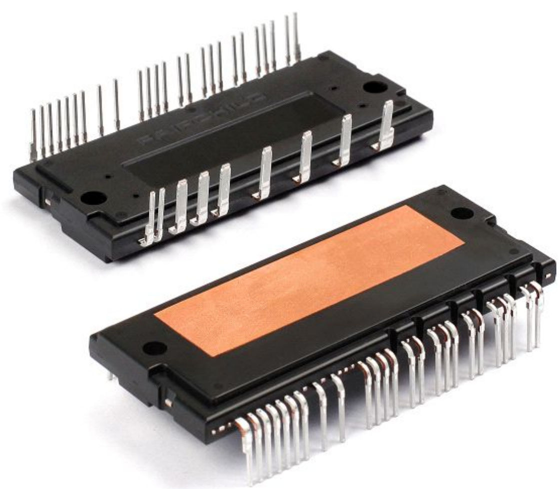


Figure 1. Package Overview

Package Marking and Ordering Information

Device	Device Marking	Package	Packing Type	Quantity
FNA21012A	FNA21012A	SPMCA-A34	Rail	6

Intergrated Power Functions

- 1200 V - 10 A IGBT inverter for three-phase DC / AC power conversion (*refer to Figure 3*)

Intergrated 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),
  Available bootstrap circuit example is given in Figures 5 and 15.
- For inverter low-side IGBTs: gate-drive circuit, Short-Circuit Protection (SCP) control circuit,
  Under-Voltage Lock-Out Protection (UVLO)
- Fault signaling: corresponding to UV (low-side supply) and SC faults
- Input interface: active-HIGH interface, works with 3.3 / 5 V logic, Schmitt-trigger input

Pin Configuration

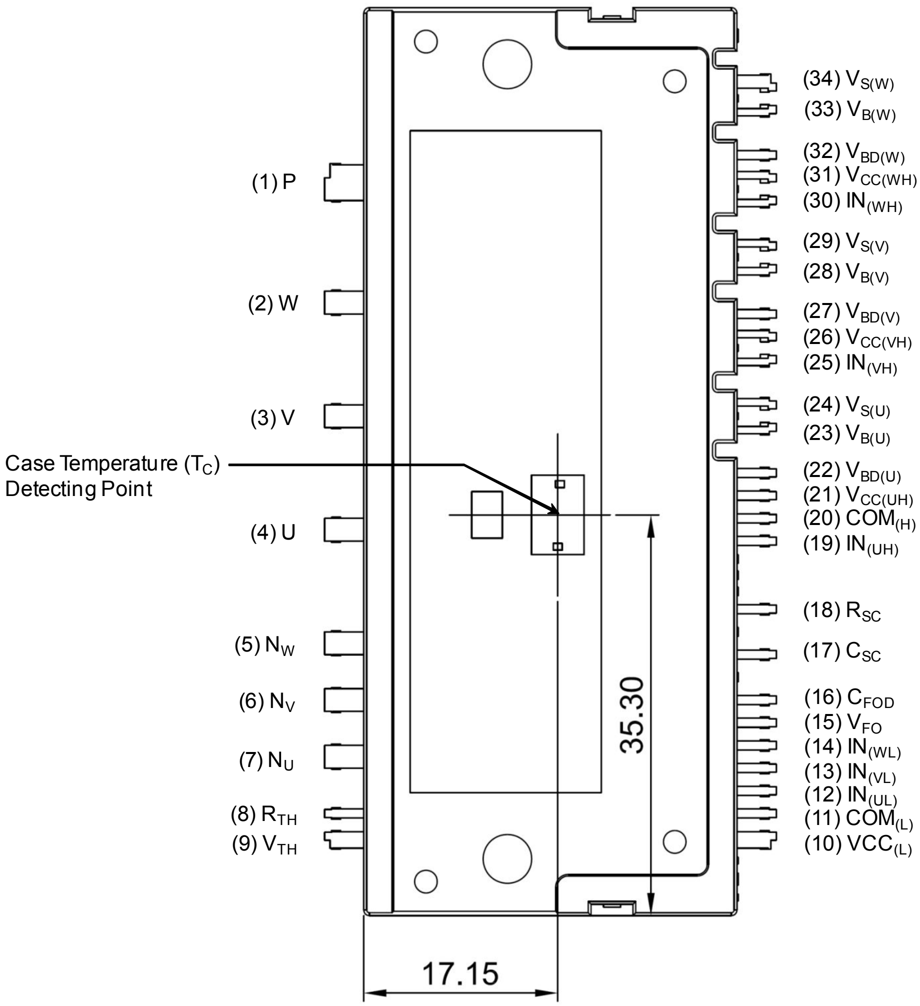


Figure 2. Top View

Pin Descriptions

Pin Number	Pin Name	Pin Description
1	P	Positive DC-Link Input
2	W	Output for W Phase
3	V	Output for V Phase
4	U	Output for U Phase
5	N_W	Negative DC-Link Input for W Phase
6	N_V	Negative DC-Link Input for V Phase
7	N_U	Negative DC-Link Input for U Phase
8	R_{TH}	Series Resistor for Thermistor (Temperature Detection)
9	V_{TH}	Thermistor Bias Voltage
10	$V_{CC(L)}$	Low-Side Bias Voltage for IC and IGBTs Driving
11	$COM_{(L)}$	Low-Side Common Supply Ground
12	$IN_{(UL)}$	Signal Input for Low-Side U Phase
13	$IN_{(VL)}$	Signal Input for Low-Side V Phase
14	$IN_{(WL)}$	Signal Input for Low-Side W Phase
15	V_{FO}	Fault Output
16	C_{FOD}	Capacitor for Fault Output Duration Selection
17	C_{SC}	Capacitor (Low-Pass Filter) for Short-Circuit Current Detection Input
18	R_{SC}	Resistor for Short-Circuit Current Detection
19	$IN_{(UH)}$	Signal Input for High-Side U Phase
20	$COM_{(H)}$	High-Side Common Supply Ground
21	$V_{CC(UH)}$	High-Side Bias Voltage for U Phase IC
22	$V_{BD(U)}$	Anode of Bootstrap Diode for U Phase High-Side Bootstrap Circuit
23	$V_{B(U)}$	High-Side Bias Voltage for U Phase IGBT Driving
24	$V_{S(U)}$	High-Side Bias Voltage Ground for U Phase IGBT Driving
25	$IN_{(VH)}$	Signal Input for High-Side V Phase
26	$V_{CC(VH)}$	High-Side Bias Voltage for V Phase IC
27	$V_{BD(V)}$	Anode of Bootstrap Diode for V Phase High-Side Bootstrap Circuit
28	$V_{B(V)}$	High-Side Bias Voltage for V Phase IGBT Driving
29	$V_{S(V)}$	High-Side Bias Voltage Ground for V Phase IGBT Driving
30	$IN_{(WH)}$	Signal Input for High-Side W Phase
31	$V_{CC(WH)}$	High-Side Bias Voltage for W Phase IC
32	$V_{BD(W)}$	Anode of Bootstrap Diode for W Phase High-Side Bootstrap Circuit
33	$V_{B(W)}$	High-Side Bias Voltage for W Phase IGBT Driving
34	$V_{S(W)}$	High-Side Bias Voltage Ground for W Phase IGBT Driving

Internal Equivalent Circuit and Input/Output Pins

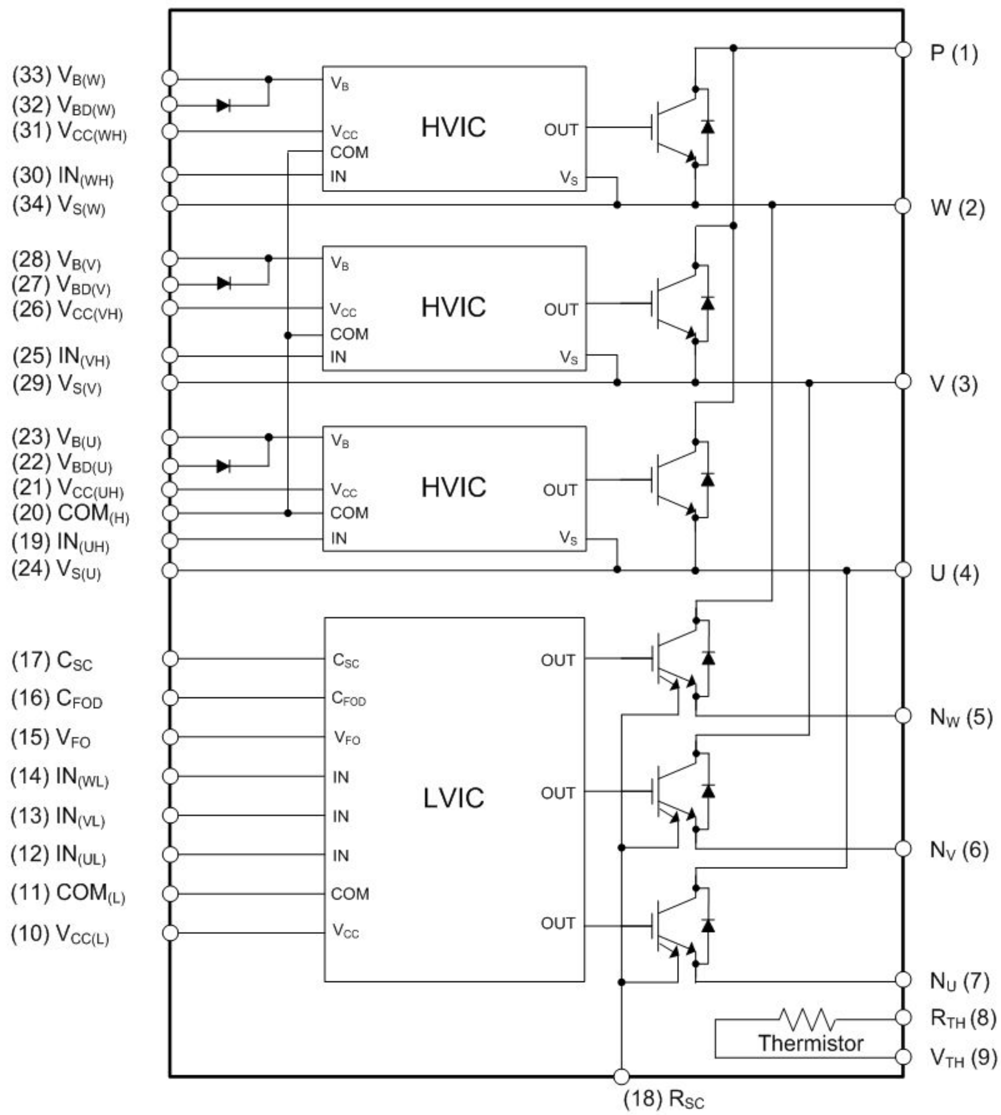


Figure 3. Internal Block Diagram

Notes:

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

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	900	V
$V_{PN(Surge)}$	Supply Voltage (Surge)	Applied between P - N_U, N_V, N_W	1000	V
V_{CES}	Collector - Emitter Voltage		1200	V
± I_C	Each IGBT Collector Current	T_C = 25°C, $T_J \leq$ 150°C (Note 4)	10	A
± I_{CP}	Each IGBT Collector Current (Peak)	T_C = 25°C, $T_J \leq$ 150°C, Under 1 ms Pulse Width (Note 4)	20	A
P_C	Collector Dissipation	T_C = 25°C per One Chip (Note 4)	93	W
T_J	Operating Junction Temperature		-40 ~ 150	°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	2	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		1200	V
I_F	Forward Current	T_C = 25°C, $T_J \leq$ 150°C (Note 4)	1.0	A
I_{FP}	Forward Current (Peak)	T_C = 25°C, $T_J \leq$ 150°C, Under 1 ms Pulse Width (Note 4)	2.0	A
T_J	Operating Junction Temperature		-40 ~ 150	°C

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 = 150°C, Non-Repetitive, < 2 μs	800	V
T_C	Module Case Operation Temperature	*See Figure 2*	-40 ~ 125	°C
T_{STG}	Storage Temperature		-40 ~ 125	°C
V_{ISO}	Isolation Voltage	60 Hz, Sinusoidal, AC 1 Minute, Connection 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 (Note 5)	Inverter IGBT Part (per 1 / 6 Module)	-	-	1.33	°C / W
$R_{th(j-c)F}$		Inverter FWD Part (per 1 / 6 Module)	-	-	2.30	°C / W

Notes:

4. These values had been made an acquisition by the calculation considered to design factor.
5. For the measurement point of case temperature (T_C), *please refer to Figure 2*.

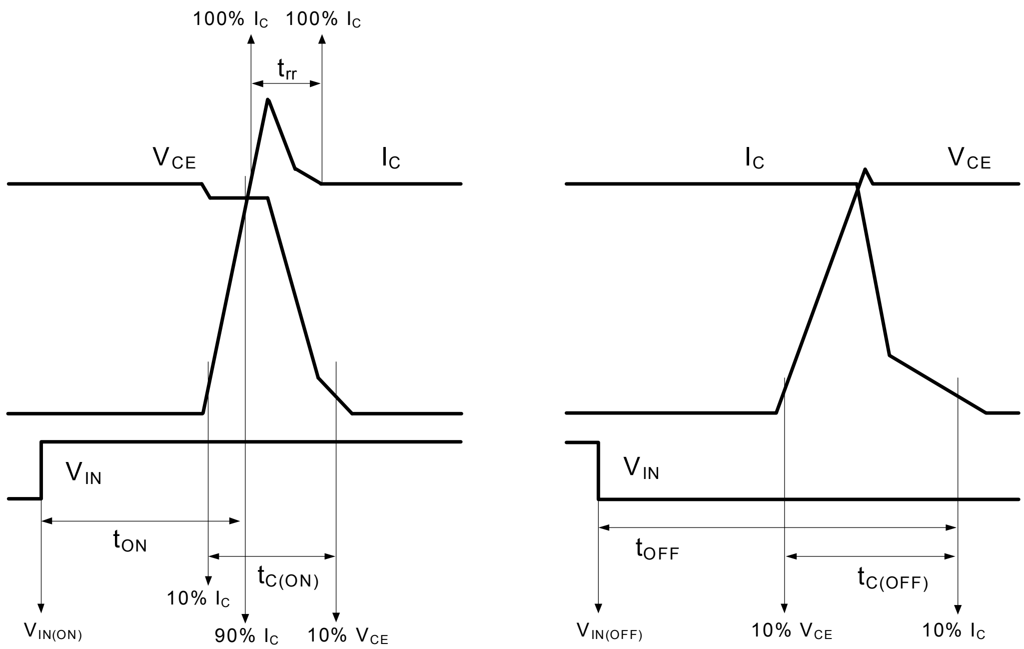
Electrical Characteristics (T_J = 25°C, unless otherwise specified.)

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 = 10 A, T_J = 25°C	-	2.20	2.80	V
V_F		FWDi Forward Voltage	V_{IN} = 0 V	I_F = 10 A, T_J = 25°C	-	2.20	2.80	V
HS	t_{ON}	Switching Times	V_{PN} = 600 V, V_{CC} = 15 V, I_C = 10 A T_J = 25°C V_{IN} = 0 V ↔ 5 V, Inductive Load *See Figure 5* (Note 6)		0.45	0.85	1.35	μs
	$t_{C(ON)}$				-	0.25	0.55	μs
	t_{OFF}				-	0.95	1.45	μs
	$t_{C(OFF)}$				-	0.10	0.40	μs
	t_{rr}				-	0.25	-	μs
LS	t_{ON}		V_{PN} = 600 V, V_{CC} = 15 V, I_C = 10 A T_J = 25°C V_{IN} = 0 V ↔ 5 V, Inductive Load *See Figure 5* (Note 6)		0.35	0.75	1.25	μs
	$t_{C(ON)}$				-	0.20	0.50	μs
	t_{OFF}				-	0.95	1.45	μs
	$t_{C(OFF)}$				-	0.10	0.40	μs
	t_{rr}				-	0.20	-	μs
I_{CES}		Collector - Emitter Leakage Current	V_{CE} = V_{CES}		-	-	5	mA

Note:

6. t_{ON} and t_{OFF} include the propagation delay of the internal drive IC. $t_{C(ON)}$ and $t_{C(OFF)}$ are the switching times of IGBT 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

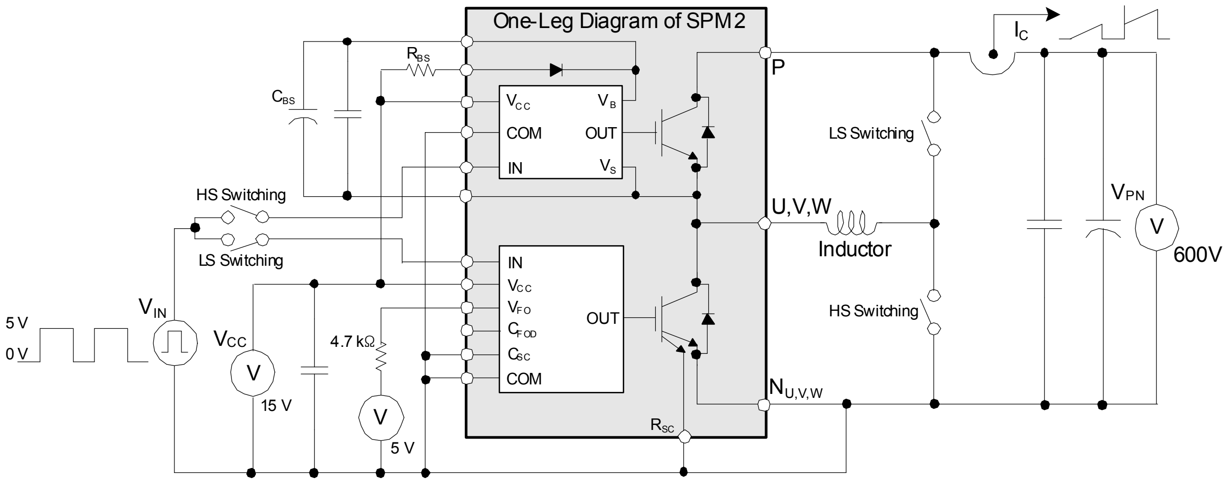


Figure 5. Example Circuit for Switching Test

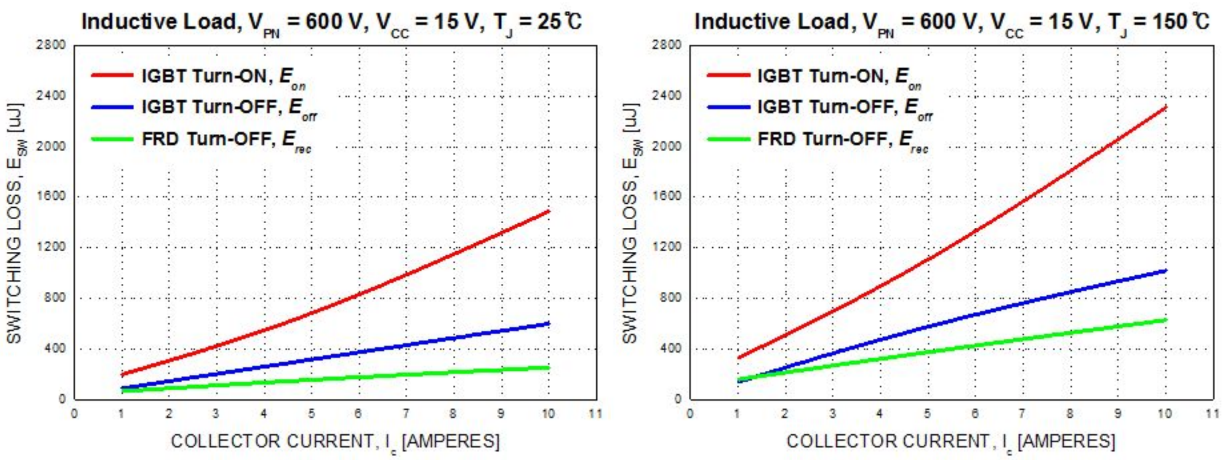


Figure 6. Switching Loss Characteristics (Typical)

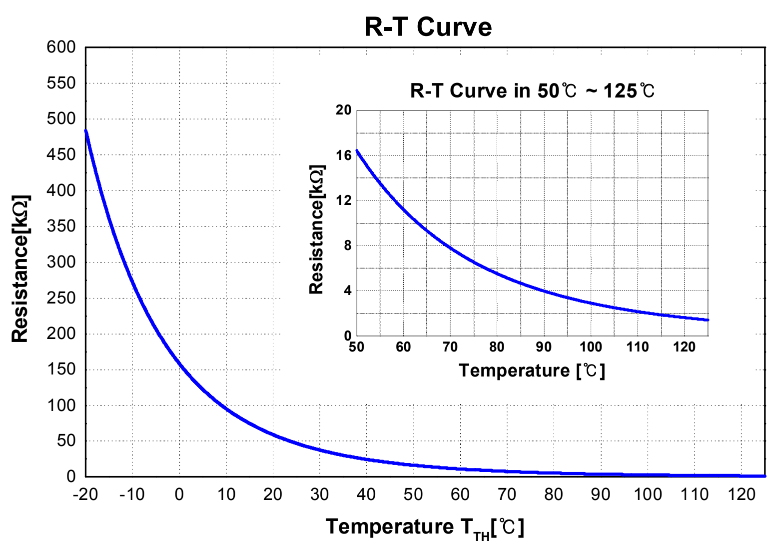


Figure 7. R-T Curve of Built-in Thermistor

Bootstrap Diode Part

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
V_F	Forward Voltage	I_F = 1.0 A, T_J = 25°C	-	2.2	-	V
t_{rr}	Reverse-Recovery Time	I_F = 1.0 A, dI_F / dt = 50 A / µs, T_J = 25°C	-	80	-	ns

Control Part

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Unit
I_{QCCH}	Quiescent V_{CC} Supply Current	$V_{CC(UH,VH,WH)}$ = 15 V, $IN_{(UH,VH,WH)}$ = 0 V	$V_{CC(UH)}$ - $COM_{(H)}$, $V_{CC(VH)}$ - $COM_{(H)}$, $V_{CC(WH)}$ - $COM_{(H)}$	-	-	0.15	mA
I_{QCCL}		$V_{CC(L)}$ = 15 V, $IN_{(UL,VL,WL)}$ = 0 V	$V_{CC(L)}$ - $COM_{(L)}$	-	-	5.00	mA
I_{PCCH}	Operating V_{CC} Supply Current	$V_{CC(UH,VH,WH)}$ = 15 V, f_{PWM} = 20 kHz, Duty = 50%, Applied to one PWM Signal Input for High-Side	$V_{CC(UH)}$ - $COM_{(H)}$, $V_{CC(VH)}$ - $COM_{(H)}$, $V_{CC(WH)}$ - $COM_{(H)}$	-	-	0.30	mA
I_{PCCL}		$V_{CC(L)}$ = 15V, f_{PWM} = 20 kHz, Duty = 50%, Applied to one PWM Signal Input for Low-Side	$V_{CC(L)}$ - $COM_{(L)}$	-	-	8.50	mA
I_{QBS}	Quiescent V_{BS} Supply Current	V_{BS} = 15 V, $IN_{(UH,VH,WH)}$ = 0 V	$V_{B(U)}$ - $V_{S(U)}$, $V_{B(V)}$ - $V_{S(V)}$, $V_{B(W)}$ - $V_{S(W)}$	-	-	0.30	mA
I_{PBS}	Operating V_{BS} Supply Current	V_{CC} = V_{BS} = 15 V, f_{PWM} = 20 kHz, Duty = 50%, Applied to one PWM Signal Input for High-Side	$V_{B(U)}$ - $V_{S(U)}$, $V_{B(V)}$ - $V_{S(V)}$, $V_{B(W)}$ - $V_{S(W)}$	-	-	4.50	mA
V_{FOH}	Fault Output Voltage	V_{CC} = 15 V, V_{SC} = 0 V, V_{FO} Circuit: 4.7 kΩ to 5 V Pull-up		4.5	-	-	V
V_{FOL}		V_{CC} = 15 V, V_{SC} = 1 V, V_{FO} Circuit: 4.7 kΩ to 5 V Pull-up		-	-	0.5	V
I_{SEN}	Sensing Current of Each Sense IGBT	V_{CC} = 15 V, V_{IN} = 5 V, R_{SC} = 0 Ω, No Connection of Shunt Resistor at $N_{U,V,W}$ Terminal	I_C = 10 A	-	7	-	mA
$V_{SC(ref)}$	Short Circuit Trip Level	V_{CC} = 15 V (Note 7)	C_{SC} - $COM_{(L)}$	0.43	0.50	0.57	V
I_{SC}	Short Circuit Current Level for Trip	R_{SC} = 68 Ω (± 1%), No Connection of Shunt Resistor at $N_{U,V,W}$ Terminal (Note 7)		-	20	-	A
UV_{CCD}	Supply Circuit Under-Voltage Protection	Detection Level		10.3	-	12.8	V
UV_{CCR}		Reset Level		10.8	-	13.3	V
UV_{BSD}		Detection Level		9.5	-	12.0	V
UV_{BSR}		Reset Level		10.0	-	12.5	V
t_{FOD}	Fault-Out Pulse Width	C_{FOD} = Open	(Note 8)	50	-	-	µs
		C_{FOD} = 2.2 nF		1.7	-	-	ms
$V_{IN(ON)}$	ON Threshold Voltage	Applied between $IN_{(UH,VH,WH)}$ - $COM_{(H)}$, $IN_{(UL,VL,WL)}$ - $COM_{(L)}$		-	-	2.6	V
$V_{IN(OFF)}$	OFF Threshold Voltage			0.8	-	-	V
R_{TH}	Resistance of Thermistor	at T_{TH} = 25°C	*See Figure 7* (Note 9)	-	47	-	kΩ
		at T_{TH} = 100°C		-	2.9	-	kΩ

Notes:

7. Short-circuit current protection functions only at the low-sides because the sense current is divided from main current at low-side IGBTs. Inserting the shunt resistor for monitoring the phase current at N_U, N_V, N_W terminal, the trip level of the short-circuit current is changed.

8. The fault-out pulse width t_{FOD} depends on the capacitance value of C_{FOD} according to the following approximate equation : $t_{FOD} = 0.8 \times 10^6 \times C_{FOD}$ [s].

9. T_{TH} is the temperature of thermistor itself. To know case temperature (T_C), conduct experiments considering the application.

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	600	800	V
V_{CC}	Control Supply Voltage	Applied between $V_{CC(UH, VH, WH)}$ - $COM_{(H)}$, $V_{CC(L)}$ - $COM_{(L)}$	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	For Each Input Signal	2.0	-	-	µs
f_{PWM}	PWM Input Signal	-40°C ≤ T_C ≤ 125°C, -40°C ≤ T_J ≤ 150°C	-	-	20	kHz
V_{SEN}	Voltage for Current Sensing	Applied between N_U, N_V, N_W - $COM_{(H, L)}$ (Including Surge Voltage)	-5		5	V
$PW_{IN(ON)}$	Minimun Input Pulse Width	I_C ≤ 20 A, Wiring Inductance between $N_{U, V, W}$ and DC Link N < 10nH (Note 10)	1.5	-	-	µs
$PW_{IN(OFF)}$			1.5	-	-	
T_J	Junction Temperature		-40	-	150	°C

Note:

10. This product might not make output response if input pulse width is less than the recommanded value.

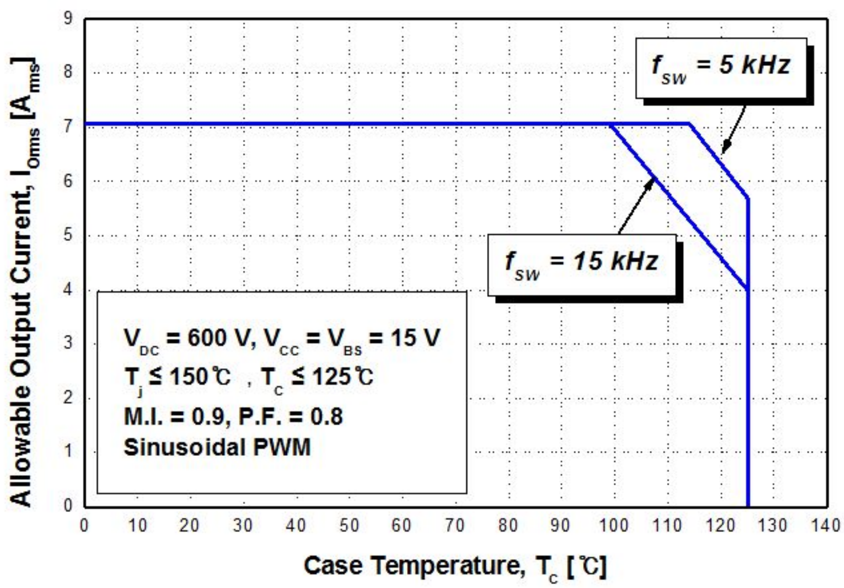


Figure 8. Allowable Maximum Output Current

Note:

11. This allowable output current value is the reference data for the safe operation of this product. This may be different from the actual application and operating condition.

Mechanical Characteristics and Ratings

Parameter	Conditions		Min.	Typ.	Max.	Unit
Device Flatness	*See Figure 9*		0	-	+200	μm
Mounting Torque	Mounting Screw: M4	Recommended 1.0 N • m	0.9	1.0	1.5	N • m
	See Figure 10	Recommended 10.1 kg • cm	9.1	10.1	15.1	kg • cm
Terminal Pulling Strength	Load 19.6 N		10	-	-	s
Terminal Bending Strength	Load 9.8 N, 90 degrees Bend		2	-	-	times
Weight			-	50	-	g

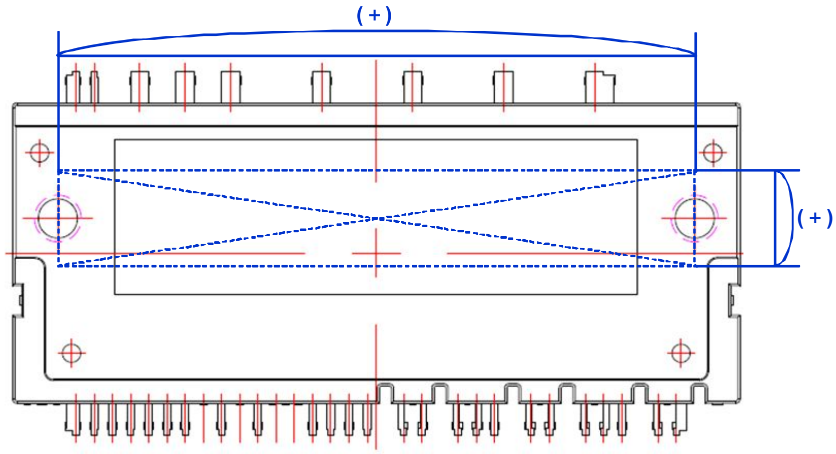


Figure 9. Flatness Measurement Position

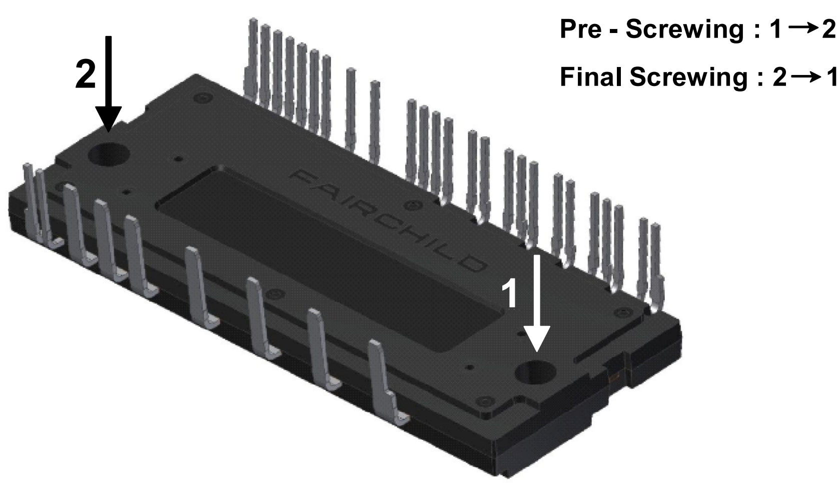


Figure 10. Mounting Screws Torque Order

Notes:

12. Do not over torque when mounting screws. Too much mounting torque may cause DBC cracks, as well as bolts and Al heat-sink destruction.

13. Avoid one-sided tightening stress. Figure 10 shows the recommended torque order for the mounting screws. Uneven mounting can cause the DBC substrate of package to be damaged. The pre-screwing torque is set to 20 ~ 30% of maximum torque rating.

Time Charts of SPMs Protective Function

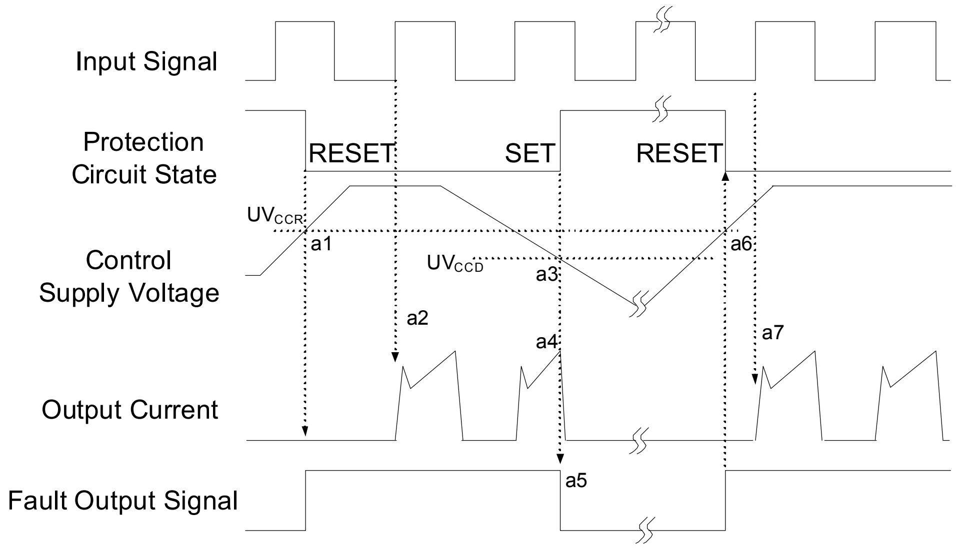


Figure 11. Under-Voltage Protection (Low-Side)

a1 : Control supply voltage rises: after the voltage rises UV_{CCR}, the circuits start to operate when the 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 with a fixed pulse width according to the condition of the external capacitor C_{FOD}.

a6 : Under-voltage reset (UV_{CCR}).

a7 : Normal operation: IGBT ON and carrying current by triggering next signal from LOW to HIGH.

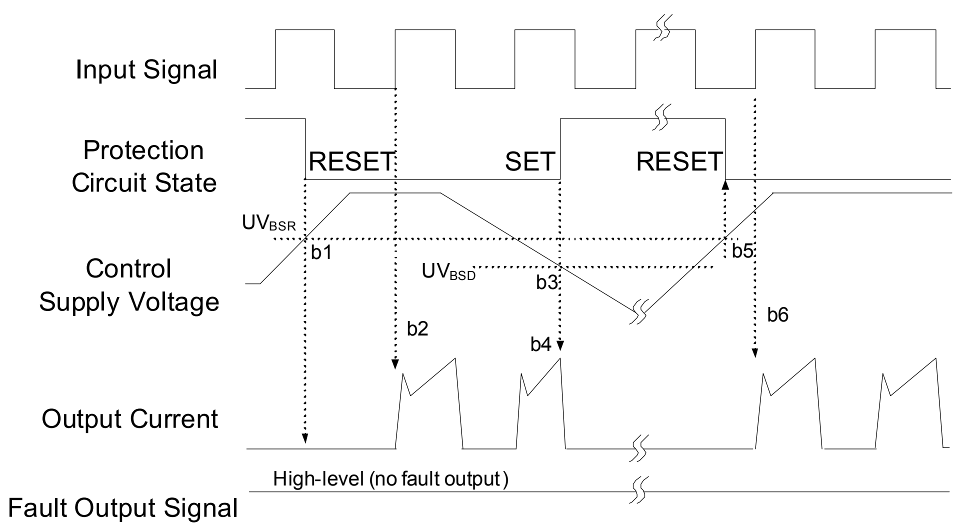


Figure 12. Under-Voltage Protection (High-Side)

b1 : Control supply voltage rises: after the voltage reaches UV_{BSR}, the circuits start to operate when the 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 by triggering next signal from LOW to HIGH.

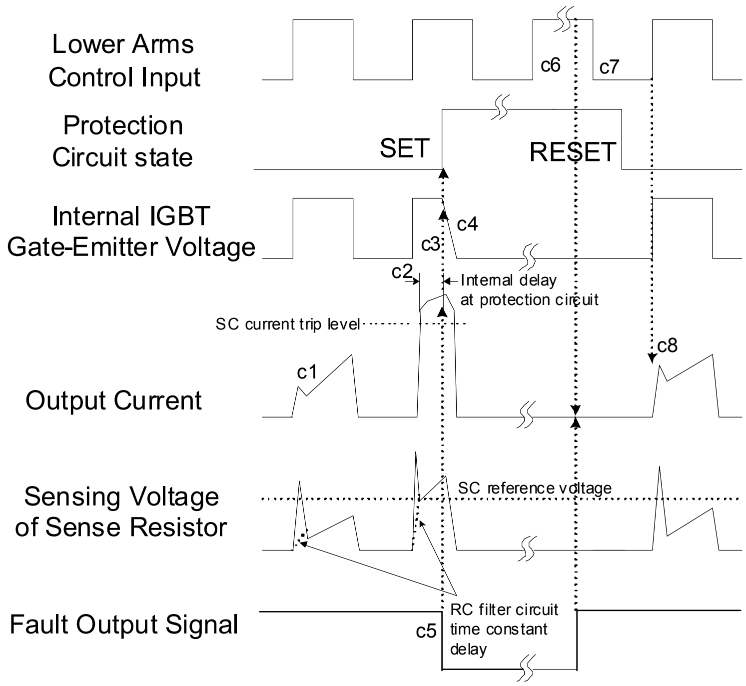


Figure 13. Short-Circuit Current Protection (Low-Side Operation only)

(with the external sense resistance and RC filter connection)

c1 : Normal operation: IGBT ON and carrying current.

c2 : Short-circuit current detection (SC trigger).

c3 : All low-side IGBTs gate are hard interrupted.

c4 : All low-side IGBTs turn OFF.

c5 : Fault output operation starts with a fixed pulse width according to the condition of the external capacitor C_{FOD}.

c6 : Input HIGH: IGBT ON state, but during the active period of fault output, the IGBT doesn't turn ON.

c7 : Fault output operation finishes, but IGBT doesn't turn on until triggering the next signal from LOW to HIGH.

c8 : Normal operation: IGBT ON and carrying current.

Input/Output Interface Circuit

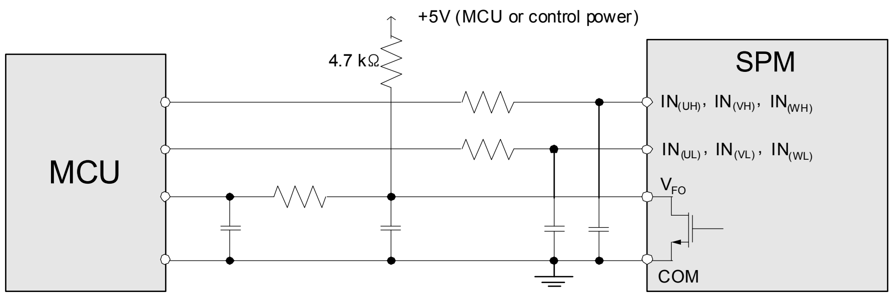


Figure 14. Recommended MCU I/O Interface Circuit

Note:

14. 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 input signal section of the Motion SPM 2 product integrates 5 kΩ (typ.) pull-down resistor. Therefore, when using an external filtering resistor, please pay attention to the signal voltage drop at input terminal.

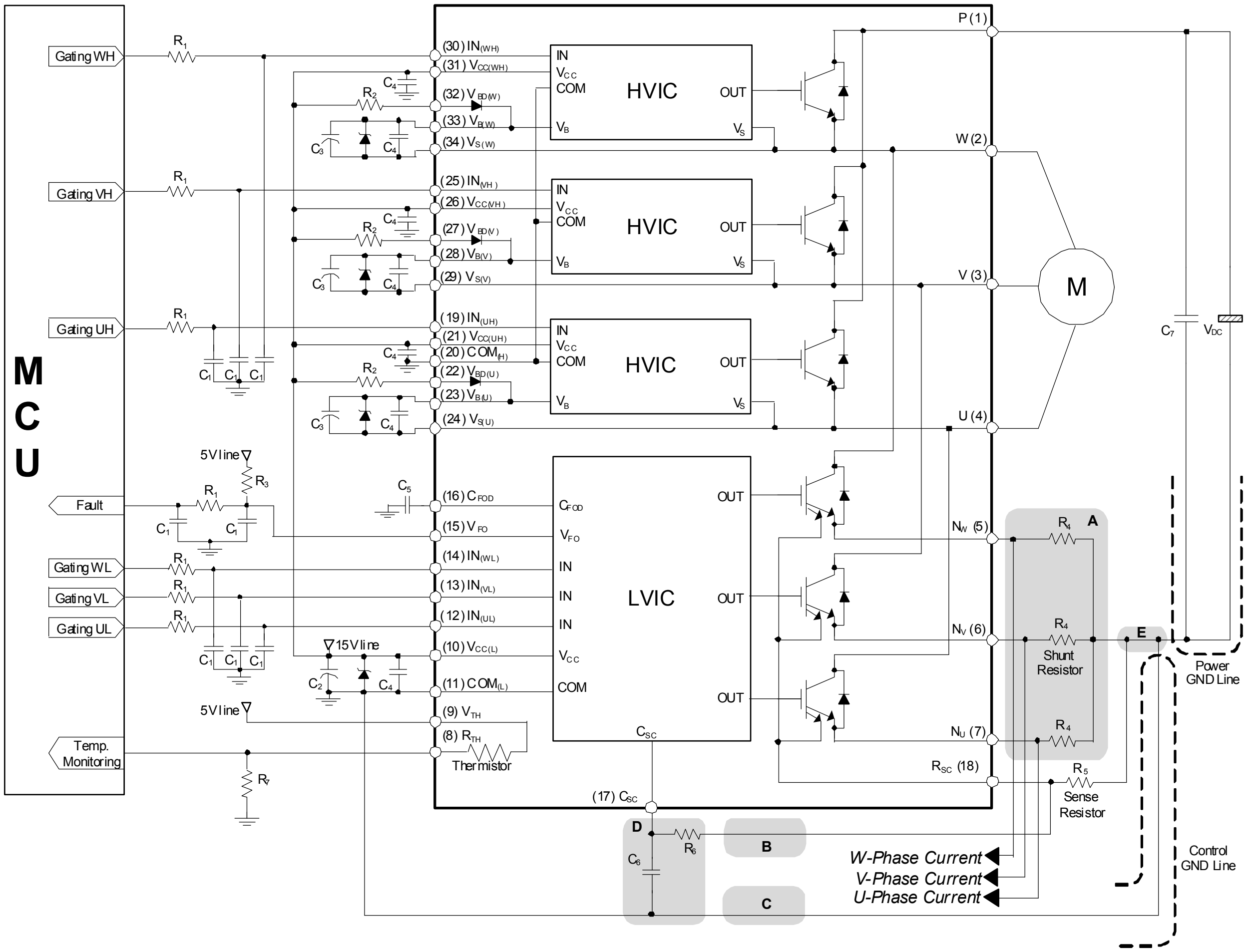


Figure 15. Typical Application Circuit

Notes:

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

16. V_{FO} output is an 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 2 mA. *Please refer to Figure 14.*

17. Fault out pulse width can be adjust by capacitor C_5 connected to the C_{FOD} terminal.

18. Input signal is active-HIGH type. There is a 5 kΩ resistor inside the IC to pull-down each input signal line to GND. RC coupling circuits should be adopted for the prevention of input signal oscillation. R_1C_1 time constant should be selected in the range 50 ~ 150 ns (recommended R_1 = 100 Ω, C_1 = 1 nF).

19. Each wiring pattern inductance of point A should be minimized (recommend less than 10 nH). Use the shunt resistor R_4 of surface mounted (SMD) type to reduce wiring inductance. To prevent malfunction, wiring of point E should be connected to the terminal of the shunt resistor R_4 as close as possible.

20. To insert the shunt resistor to measure each phase current at N_U, N_V, N_W terminal, it makes to change the trip level I_{SC} about the short-ciruit current.

21. To prevent errors of the protection function, the wiring of points B, C, and D should be as short as possible. The wiring of B between C_{SC} filter and R_{SC} terminal should be divided at the point that is close to the terminal of sense resistor R_5.

22. For stable protection function, use the sense resistor R_5 with resistance variation within 1% and low inductance value.

23. In the short-circuit protection circuit, select the R_6C_6 time constant in the range 1.0 ~ 1.5 μs. R_6 should be selected with a minimum of 10 times larger resistance than sense resistor R_5. Do enough evaluaiton on the real system because short-circuit protection time may vary wiring pattern layout and value of the R_6C_6 time constant.

24. Each capacitor should be mounted as close to the pins of the Motion SPM® 2 product as possible.

25. To prevent surge destruction, the wiring between the smoothing capacitor C_7 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.

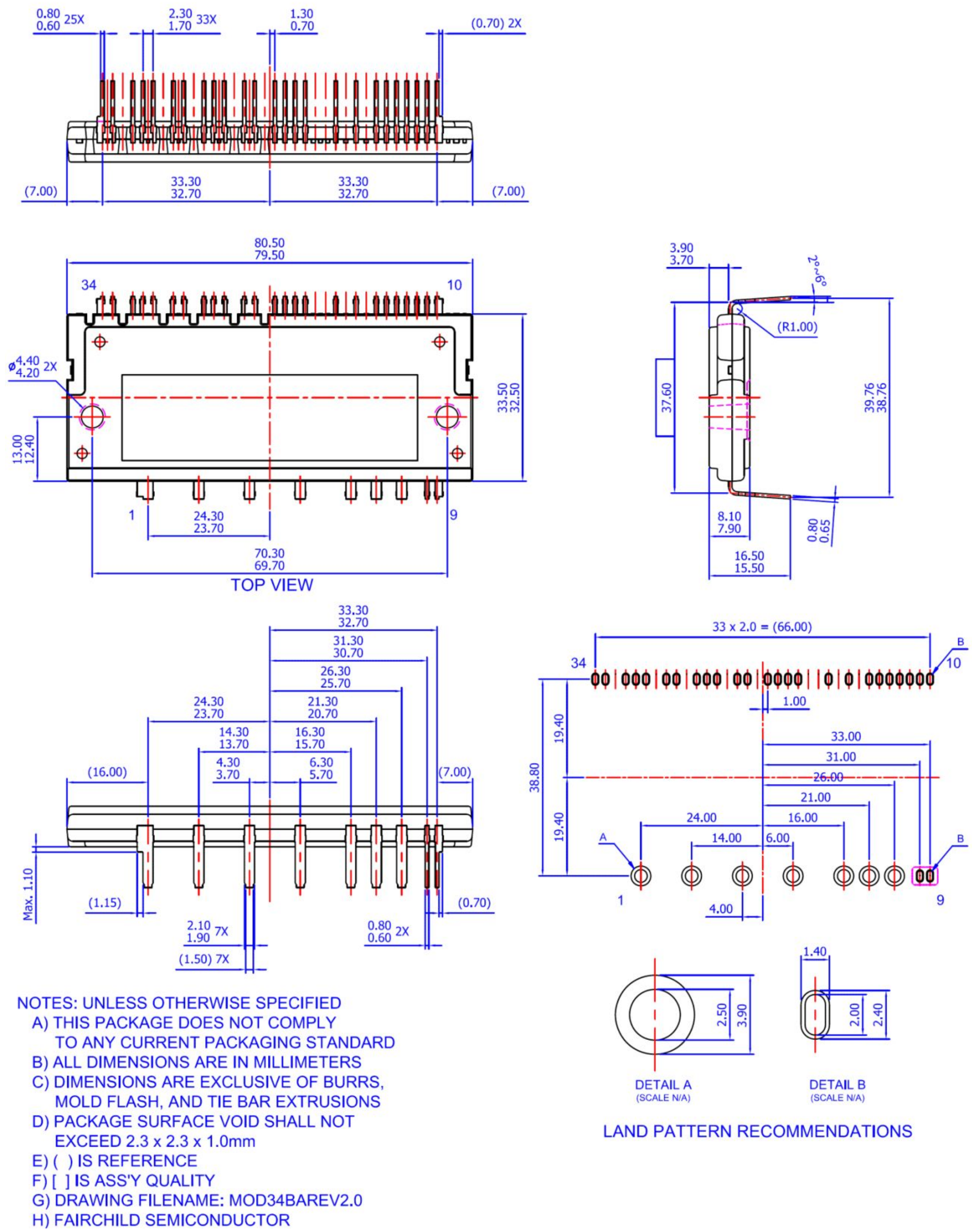
26. Relays are used in most systems of electrical equipments in industrial application. In these cases, there should be sufficient distance between the CPU and the relays.

27. The Zener diode or transient voltage suppressor should be adapted for the protection of ICs from the surge destruction between each pair of control supply terminals (recommanded Zener diode is 22 V / 1 W, which has the lower Zener impedance characteristic than about 15 Ω).

28. C_2 of around seven times larger than bootstrap capacitor C_3 is recommended.

29. Please choose the electrolytic capacitor with good temperature characteristic in C_3. Choose 0.1 ~ 0.2 μF R-category ceramic capacitors with good temperature and frequency characteristics in C_4.

Detailed Package Outline Drawings (FNA21012A)



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