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October 2015

FNF50560TD1

Motion SPM® 55 Series

Features

- UL Certified No. E209204 (UL1557)
- 600 V - 5 A 3-Phase IGBT Inverter Including Control IC for Gate Drive and Protections
- Low-Loss, Short-Circuit Rated IGBTs
- Built-In Bootstrap Diodes in HVIC
- Separate Open-Emitter Pins from Low-Side IGBTs for Three-Phase Current Sensing
- Active-HIGH interface, works with 3.3 / 5 V Logic, Schmitt-trigger Input
- HVIC for Gate Driving, Under-Voltage and Short-Circuit Current Protection
- Fault Output for Under-Voltage and Short-Circuit Current Protection
- Inter-Lock Function to Prevent Short-Circuit
- Shut-Down Input
- HVIC Temperature-Sensing Built-In for Temperature Monitoring
- Optimized for 15 - 20 kHz Switching Frequency
- Isolation Rating: 1500 V_{rms} / min.

Applications

- Motion Control - Home Appliance / Industrial Motor

Related Resources

- AN-9096 - Smart Power Module, Motion SPM® 55 Series User's Guide
- AN-9097 - SPM® 55 Packing Mounting Guidance

General Description

FNF50560TD1 is a Motion SPM 55 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, inter-lock function, over-current shutdown, thermal monitoring of drive IC, 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 robust short-circuit-rated IGBTs. Separate negative IGBT terminals are available for each phase to support the widest variety of control algorithms.

Figure 1. 3D Package Drawing (Click to Activate 3D Content)

Package Marking and Ordering Information

Device	Device Marking	Package	Packing Type	Quantity
FNF50560TD1	FNF50560TD1	SPMFA-A20	RAIL	13

Integrated Power Functions

- 600 V - 5 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 (UVLO) protection
- For inverter low-side IGBTs: gate drive circuit, Short-Circuit Protection (SCP) control supply circuit Under-Voltage Lock-Out (UVLO) protection
- Fault signaling: corresponding to UVLO (low-side supply) and SC faults
- Input interface: High-active interface, works with 3.3 / 5 V logic, Schmitt trigger input
- Built in Bootstrap circuitry in HVIC

Pin Configuration

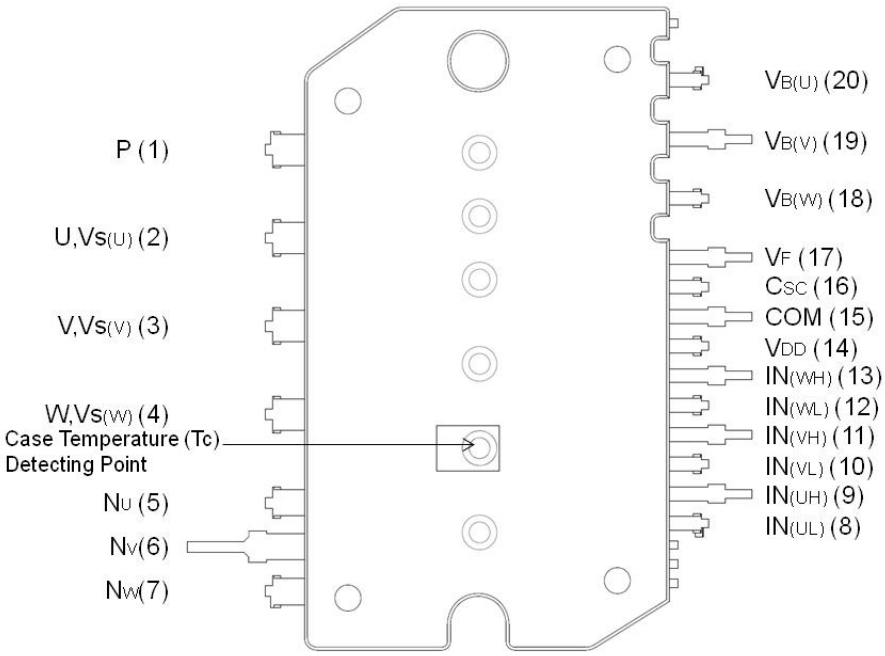


Figure 2. Top View

Pin Descriptions

Pin Number	Pin Name	Pin Description
1	P	Positive DC-Link Input
2	U, V_S(U)	Output for U Phase
3	V, V_S(V)	Output for V Phase
4	W, V_S(W)	Output for W Phase
5	N_U	Negative DC-Link Input for U Phase
6	N_V	Negative DC-Link Input for V Phase
7	N_W	Negative DC-Link Input for W Phase
8	$IN_{(UL)}$	Signal Input for Low-Side U Phase
9	$IN_{(UH)}$	Signal Input for High- ide U Phase
10	$IN_{(VL)}$	Signal Input for Low-Side V Phase
11	$IN_{(VH)}$	Signal Input for High-Side V Phase
12	$IN_{(WL)}$	Signal Input for Low-Side W Phase
13	$IN_{(WH)}$	Signal Input for High-Side W Phase
14	V_{DD}	Common Bias Voltage for IC and IGBTs Driving
15	COM	Common Supply Ground
16	C_{SC}	Capacitor (Low-Pass Filter) for Short-circuit Current Detection Input
17	V_F	Fault Output, Shut-Down Input, Temperature Output of Drive IC
18	$V_{B(W)}$	High-Side Bias Voltage for W-Phase IGBT Driving
19	$V_{B(V)}$	High-Side Bias Voltage for V-Phase IGBT Driving
20	$V_{B(U)}$	High-Side Bias Voltage for U-Phase IGBT Driving

Internal Equivalent Circuit and Input/Output Pins

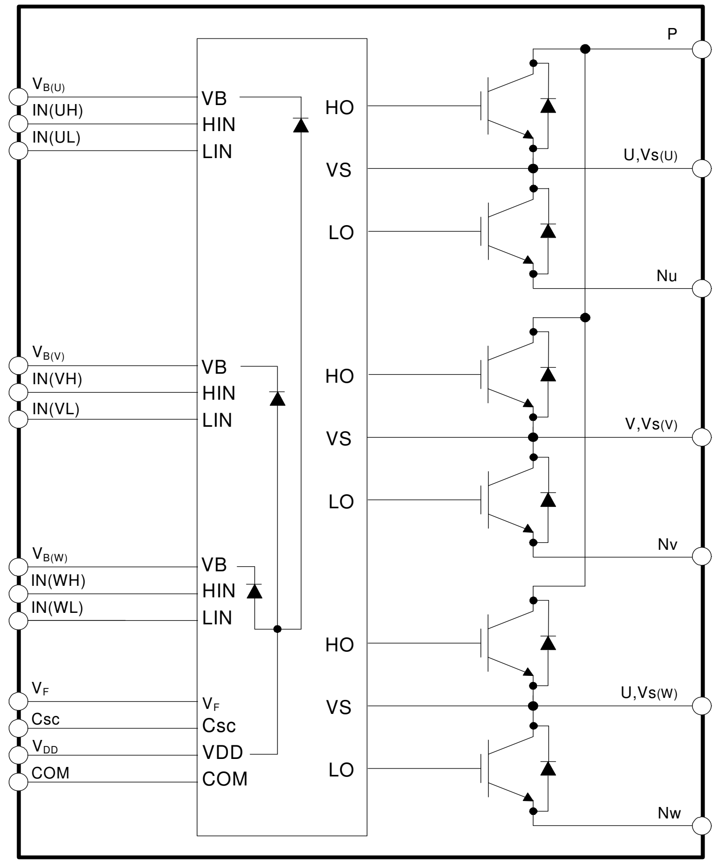


Figure 3. Internal Block Diagram

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. Single drive IC has gate driver for six IGBTs and protection functions.
4. 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	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_C	Each IGBT Collector Current	T_C = 25°C, T_J < 150°C	5	A
* ± I_{CP}	Each IGBT Collector Current (Peak)	T_C = 25°C, T_J < 150°C, Under 1 ms Pulse Width	10	A
* P_C	Collector Dissipation	T_C = 25°C per Chip	19	W
T_J	Operating Junction Temperature	(Note 5)	-40 ~ 150	°C

Note:

5. The maximum junction temperature rating of the power chips integrated within the Motion SPM® 55 product is 150°C.

Control Part

Symbol	Parameter	Conditions	Rating	Unit
V_{DD}	Control Supply Voltage	Applied between V_{DD} - 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_{DD} +0.3	V
V_F	Fault Supply Voltage	Applied between V_F - COM	-0.3 ~ V_{DD} +0.3	V
* I_F	Fault Current	Sink Current at V_F pin	5	mA
V_{SC}	Current Sensing Input Voltage	Applied between C_{SC} - COM	-0.3 ~ V_{DD} +0.3	V

Total System

Symbol	Parameter	Conditions	Rating	Unit
$V_{PN(PROT)}$	Self Protection Supply Voltage Limit (Short Circuit Protection Capability)	V_{DD} = V_{BS} = 13.5 ~ 16.5 V T_J = 150°C, Non-Repetitive, < 2 μs	400	V
T_{STG}	Storage Temperature		-40 ~ 125	°C
V_{ISO}	Isolation Voltage Connect Pins to Heat Sink Plate	AC 60 Hz, Sinusoidal, 1 Minute	1500	V_{rms}

Thermal Resistance

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
$R_{th(j-c)Q}$	Junction to Case Thermal Resistance (Note 7)	Inverter IGBT part (per 1 / 6 module)	-	-	6.5	°C / W
$R_{th(j-c)F}$		Inverter FWD part (per 1 / 6 module)	-	-	8.9	°C / W

Note:

6. For Marking " * ", These Value had been made an acquisition by the calculation considered to design factor.
7. For the measurement point of case temperature (T_C), please refer to Figure 2.

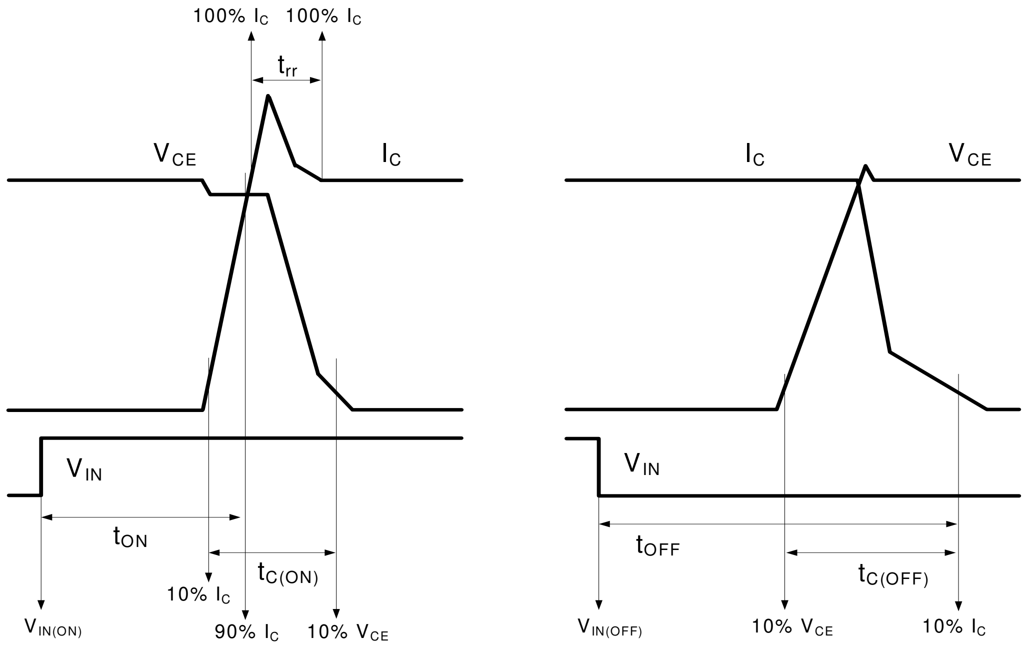
Electrical Characteristics (T_J = 25°C, unless otherwise specified.)

Inverter Part

Symbol		Parameter	Conditions		Min.	Typ.	Max.	Unit
$V_{CE(SAT)}$		Collector - Emitter Saturation Voltage	V_{DD} = V_{BS} = 15 V, V_{IN} = 5 V, I_C = 4 A	T_J = 25°C	-	1.9	2.25	V
				T_J = 150°C	-	2.4	-	V
V_F		FWDi Forward Voltage	V_{IN} = 0 V, I_F = 4 A	T_J = 25°C	-	2.2	2.55	V
				T_J = 150°C	-	2.0	-	V
HS	t_{ON}	Switching Times	V_{PN} = 400 V, V_{DD} = V_{BS} = 15 V, I_C = 5A, T_J = 25°C, V_{IN} = 0 V ↔ 5 V, Inductive load (Note 8)		0.30	0.60	0.90	us
	$t_{C(ON)}$				-	0.15	0.35	us
	t_{OFF}				-	0.30	0.50	us
	$t_{C(OFF)}$				-	0.07	0.20	us
	t_{rr}				-	0.07	-	us
LS	t_{ON}		V_{PN} = 400 V, V_{DD} = V_{BS} = 15 V, I_C = 5A, T_J = 25°C, V_{IN} = 0 V ↔ 5 V, Inductive load (Note 8)		0.30	0.60	0.90	us
	$t_{C(ON)}$				-	0.15	0.35	us
	t_{OFF}				-	0.30	0.50	us
	$t_{C(OFF)}$				-	0.07	0.20	us
	t_{rr}				-	0.07	-	us
I_{CES}		Collector - Emitter Leakage Current	V_{CE} = V_{CES}		-	-	1	mA

Note:

8. t_{ON} and t_{OFF} include the propagation delay 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

Control Part

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Unit
I_{QDD}	Quiescent V_{DD} Supply Current	V_{DD} = 15 V, $IN_{(UH,VH,WH,UL,VL,WL)}$ = 0 V	V_{DD} - COM	-	1.5	2.0	mA
I_{PDD}	Operating V_{DD} Supply Current	V_{DD} = 15 V, f_{PWM} = 20 kHz, duty = 50%, applied to one PWM signal input	V_{DD} - COM	-	2.0	2.5	mA
I_{QBS}	Quiescent V_{BS} Supply Current	V_{BS} = 15 V, $IN_{(UH, VH, WH)}$ = 0 V	$V_{B(U)}$ - $V_{S(U)}$, $V_{B(V)}$ - $V_{S(V)}$, $V_{B(W)}$ - $V_{S(W)}$	-	30	60	μA
I_{PBS}	Operating V_{BS} Supply Current	V_{DD} = V_{BS} = 15 V, f_{PWM} = 20 kHz, duty = 50%, applied to one PWM signal input for high - side	$V_{B(U)}$ - $V_{S(U)}$, $V_{B(V)}$ - $V_{S(V)}$, $V_{B(W)}$ - $V_{S(W)}$	-	500	650	μA
V_{FH}	Fault Output Voltage	V_{SC} = 0 V, V_F Circuit: 10 kΩ to 5 V Pull-up		4.5	-	-	V
V_{FL}		V_{SC} = 1 V, V_F Circuit: 10 kΩ to 5 V Pull-up		-	-	0.5	V
$V_{SC(ref)}$	Short-Circuit Trip Level	V_{DD} = 15 V (Note 4)		0.45	0.5	0.55	V
UV_{DDD}	Supply Circuit Under-Voltage Protection	Detection level		10.7	11.4	12.1	V
UV_{DDR}		Reset level		11.2	12.3	13.0	V
UV_{BSD}		Detection level		10.1	10.8	11.5	V
UV_{BSR}		Reset level		10.7	11.4	12.1	V
I_{FT}	HVIC Temperature Sensing Current	V_{DD} = V_{BS} = 15 V, T_{HVIC} = 25°C		68	81	95	μA
V_{FT}	HVIC Temperature Sensing Voltage	V_{DD} = V_{BS} = 15 V, T_{HVIC} = 25°C, 10 kΩ to 5 V Pull-up (Figure. 5)		4.05	4.19	4.32	V
t_{FOD}	Fault-Out Pulse Width			40	120	-	μs
V_{FSDR}	Shut-down Reset level	Applied between V_F - COM		-	-	2.4	V
V_{FSDS}	Shut-down Set level			0.8	-	-	V
$V_{IN(ON)}$	ON Threshold Voltage	Applied between $IN_{(UH)}$, $IN_{(VH)}$, $IN_{(WH)}$, $IN_{(UL)}$, $IN_{(VL)}$, $IN_{(WL)}$ - COM		-	-	2.4	V
$V_{IN(OFF)}$	OFF Threshold Voltage			0.8	-	-	V

Note:

9. Short-circuit protection is functioning for all six IGBTs.

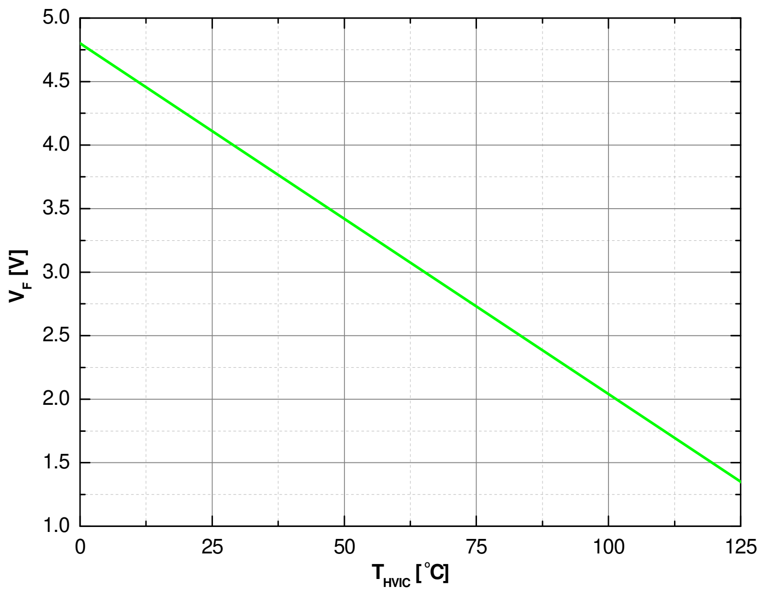


Figure. 5. V-T Curve of Temperature Output of IC (5V pull-up with 10kohm)

Bootstrap Diode Part

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
R_{BS}	Bootstrap Diode Resitance	V_{DD} = 15V, T_C = 25°C	-	280	-	Ω

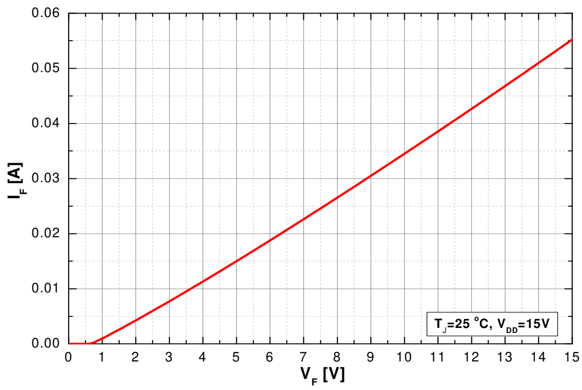


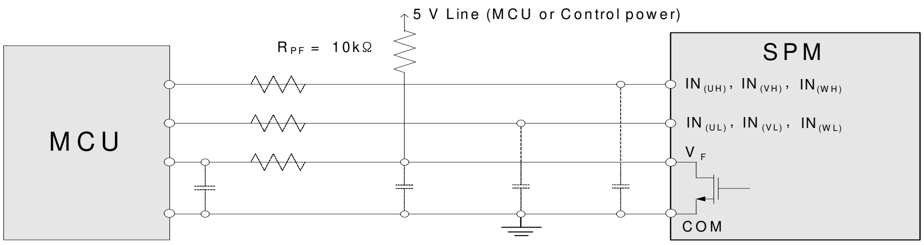
Figure 6. Built-In Bootstrap Diode Charatersts

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_{DD}	Control Supply Voltage	Applied between V_{DD} - COM	14.0	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_{DD} / dt, dV_{BS} / dt	Control Supply Variation		-1	-	1	V / µs
t_{dead}	Blanking Time for Preventing Arm - Short	For each input signal	0.5	-	-	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
$P_{WIN(ON)}$	Minimun Input Pulse Width	(Note 10)	0.7	-	-	µs
$P_{WIN(OFF)}$			0.7	-	-	

Note:

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



Note:

11. 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 SPM 55 product integrates 10 kΩ (typ.) pull-down resistor. Therefore, when using an external filtering resistor, please pay attention to the signal voltage drop at input terminal.

Figure 7. Recommended MCU I/O Interface Circuit

Mechanical Characteristics and Ratings

Parameter	Conditions		Min.	Typ.	Max.	Unit
Device Flatness	See Figure 8		-50	-	100	µm
Mounting Torque	Mounting Screw: - M3	Recommended 0.7 N • m	0.6	0.7	0.8	N • m
	Note Figure 9	Recommended 7.1 kg • cm	5.9	6.9	7.9	kg • cm
Weight			-	6.0	-	g

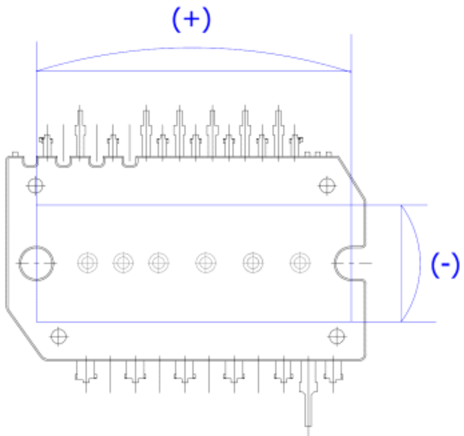


Figure 8. Flatness Measurement Position

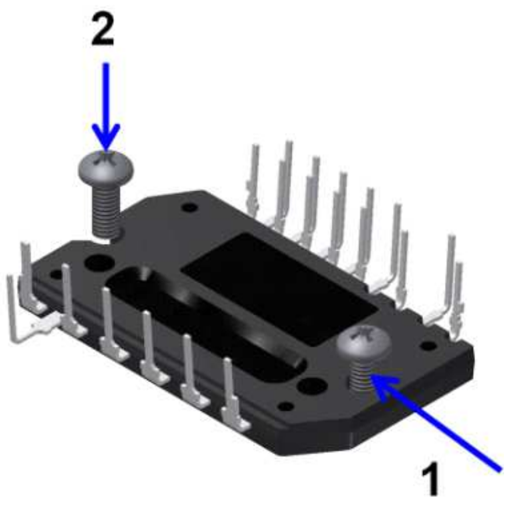


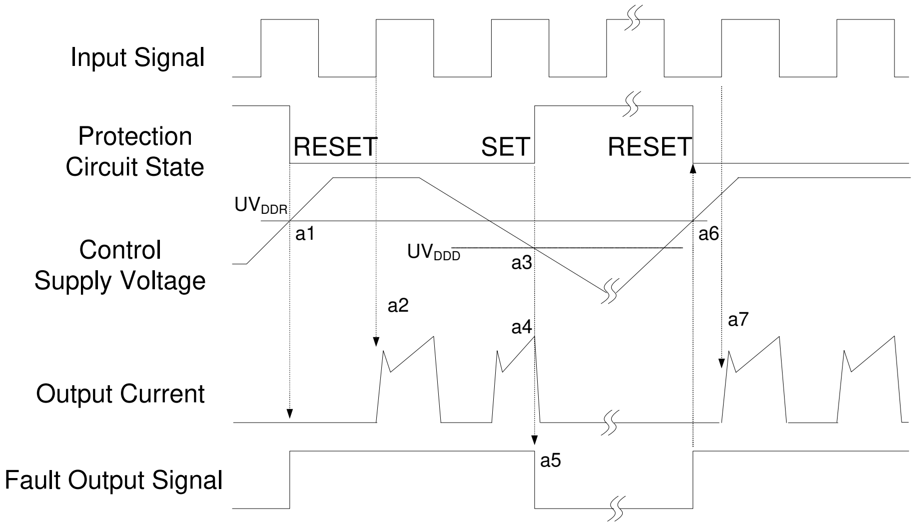
Figure 9. Mounting Screws Torque Order

Note:

12. Do not make over torque when mounting screws. Much mounting torque may cause package cracks, as well as bolts and Al heat-sink destruction.

13. Avoid one side tightening stress. Figure 10 shows the recommended torque order for mounting screws. Uneven mounting can cause the ceramic substrate of the Motion SPM 55 product to be damaged. The Pre-screwing torque is set to 20 ~ 30 % of maximum torque rating.

Time Charts of Protective Function



a1 : Control supply voltage rises: After the voltage rises UV_{DDR}, the circuits start to operate when next input is applied.

a2 : Normal operation: IGBT ON and carrying current.

a3 : Under voltage detection (UV_{DDD}).

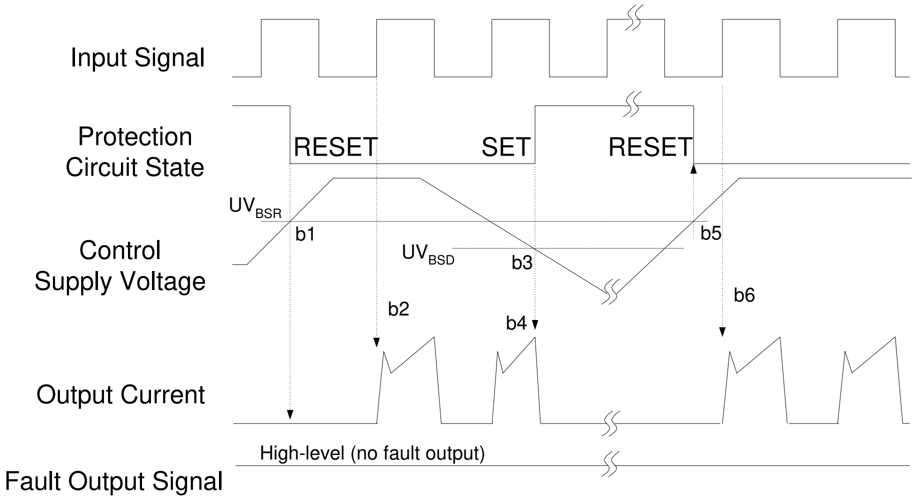
a4 : IGBT OFF in spite of control input condition.

a5 : Fault output operation starts.

a6 : Under voltage reset (UV_{DDR}).

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}).

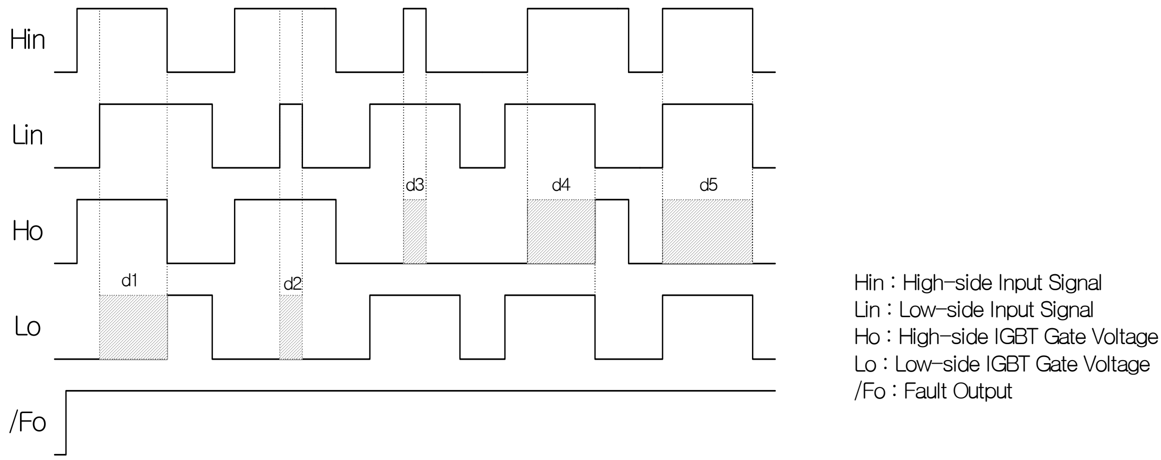
b4 : IGBT OFF in spite of control input condition, but there is no fault output signal.

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)



d1 : High Side First - Input - First - Output Mode

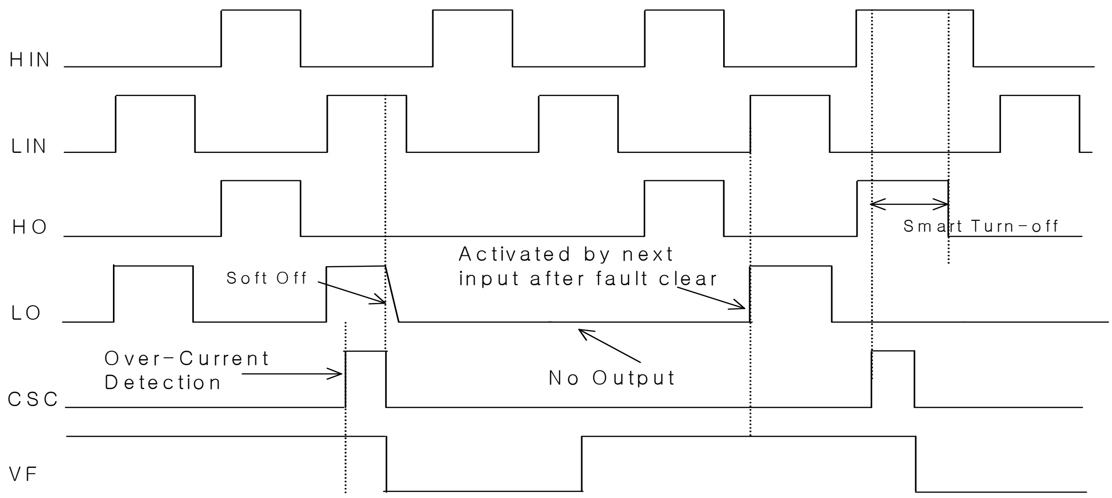
d2 : Low Side Noise Mode : No Lo

d3 : High Side Noise Mode : No Ho

d4 : Low Side First - Input - First - Output Mode

d5 : In - Phase Mode : No Ho

Figure 12. Inter-Lock Function



HIN : High-side Input Signal

LIN : Low-side Input Signal

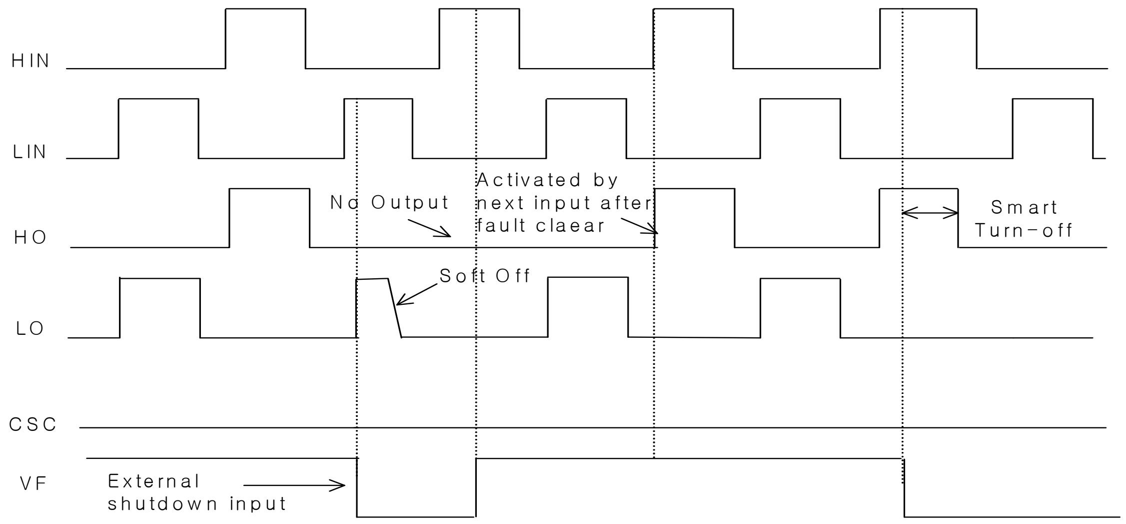
HO : High-Side Output Signal

LO : Low-Side Output Signal

CSC : Short-circuit Current Detection Input

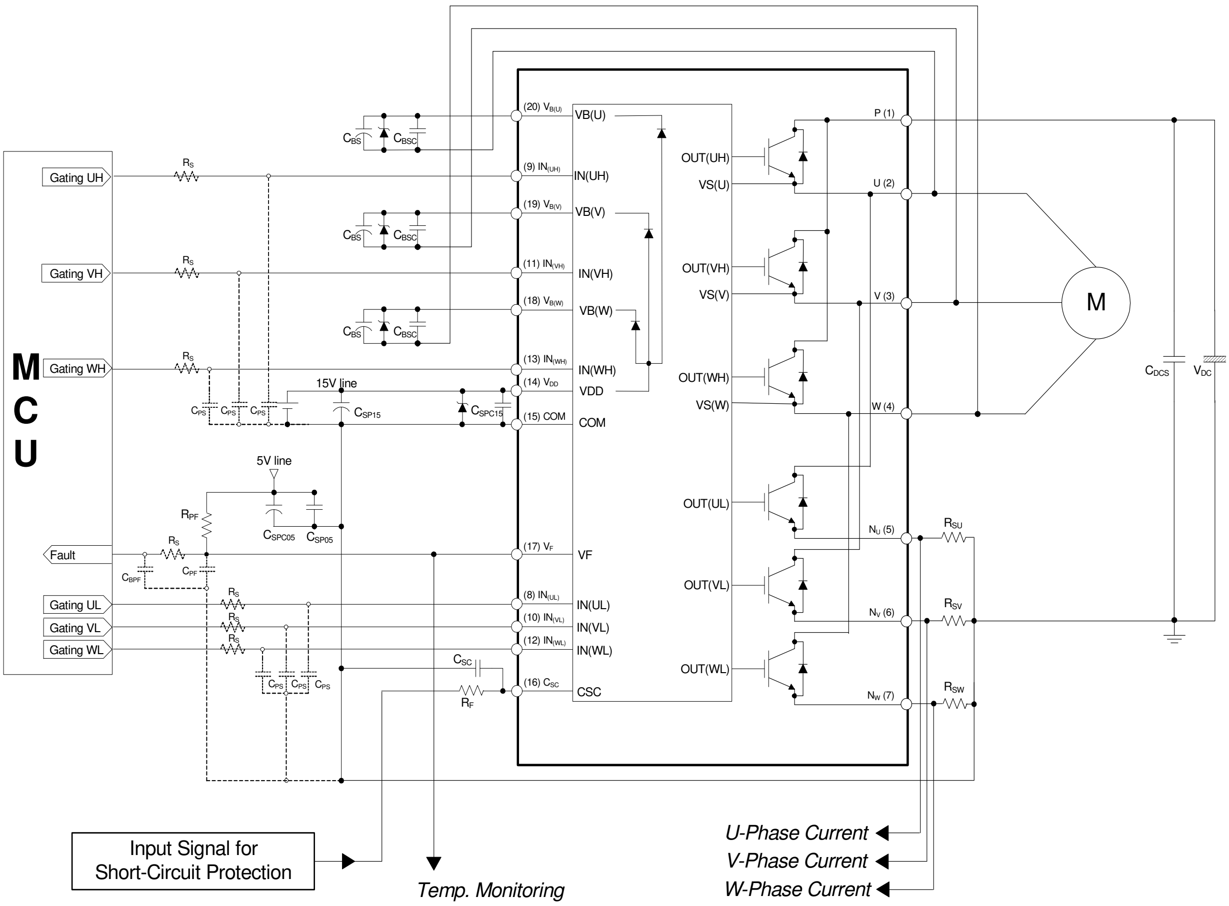
VF : Fault Out Function

Figure 13. Fault-Out Function By Over Current Protection



HIN : High-side Input Signal
LIN : Low-side Input Signal
HO : High-Side Output Signal
LO : Low-Side Output Signal
CSC : Over Current Detection Input
VF : Shutdown Input Function

Figure 14. Shutdown Input Function By External Command



Note:

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

2) By virtue of integrating an application specific type of HVIC inside the SPM® 55 product, direct coupling to MCU terminals without any opto-coupler or transformer isolation is possible.

3) V_F is 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 5 mA. Please refer to Figure 15.

4) C_{SP15} of around seven times larger than bootstrap capacitor C_{BS} is recommended.

5) Input signal is active-HIGH type. There is a 10 kΩ resistor inside the IC to pull down each input signal line to GND. RC coupling circuits is recommanded for the prevention of input signal oscillation. R_SC_{PS} time constant should be selected in the range 50 ~ 150 ns. (Recommended R_S = 100 Ω, C_{PS} = 1 nF)

6) To prevent errors of the protection function, the wiring around R_F and C_{SC} should be as short as possible.

7) In the short-circuit protection circuit, please select the R_FC_{SC} time constant in the range 1.5 ~ 2 μs.

8) The connection between control GND line and power GND line which includes the N_U, N_V, N_W must be connected to only one point. Please do not connect the control GND to the power GND by the broad pattern. Also, the wiring distance between control GND and power GND should be as short as possible.

9) Each capacitor should be mounted as close to the pins of the Motion SPM 55 product as possible.

10) To prevent surge destruction, the wiring between the smoothing capacitor and the P and 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 and 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.

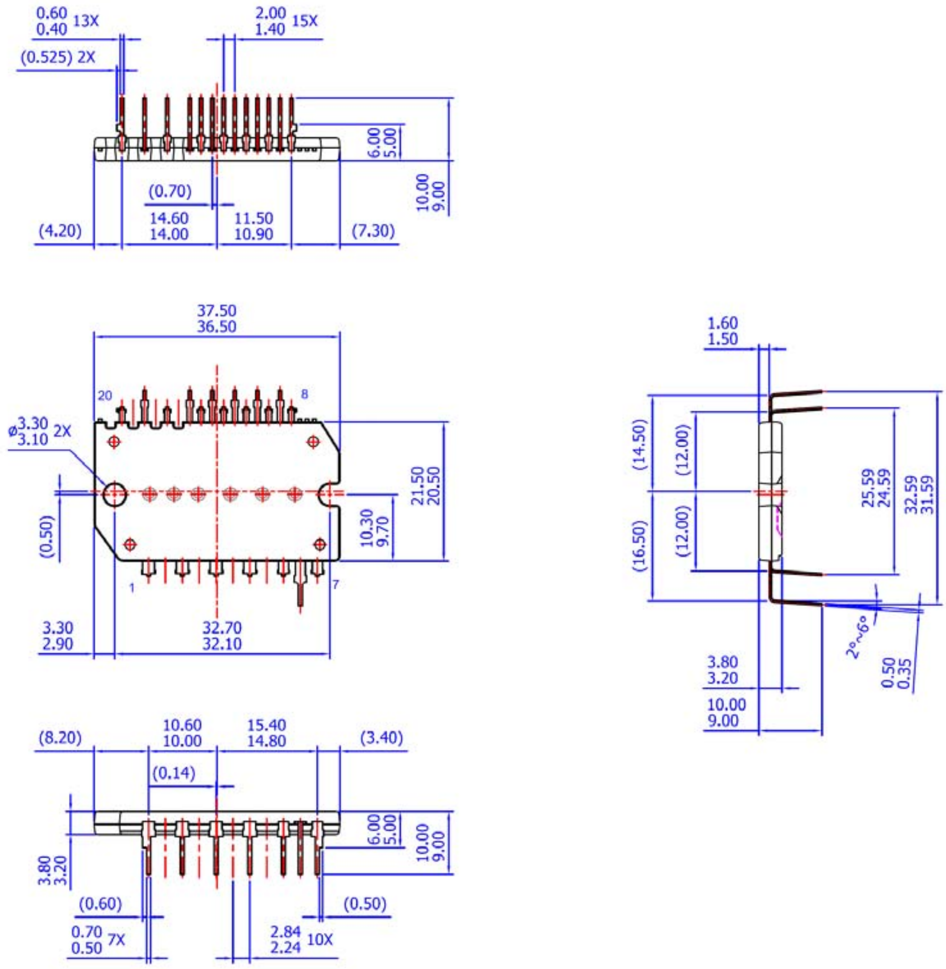
12) The zener diode or transient voltage suppressor should be adopted for the protection of ICs from the surge destruction between each pair of control supply terminals. (Recommanded zener diode is 22 V / 1 W, which has the lower zener impedance characteristic than about 15 Ω)

13) Please choose the electrolytic capacitor with good temperature characteristic in C_{BS}. Also, choose 0.1 ~ 0.2 μF R-category ceramic capacitors with good temperature and frequency characteristics in C_{BSC}.

14) For the detailed information, please refer to the application notes.

Figur15. Typical Application Circuit

Detailed Package Outline Drawings (FNF50560TD1, Short Lead)



NOTES: UNLESS OTHERWISE SPECIFIED
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- 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: MOD20DBREV2

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FACT Quiet Series™
FACT®
FastvCore™
FETBench™
FPS™
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