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September 2016

FNB81060T3

Motion SPM® 8 Series

Features

- UL Certified No. E209204 (UL1557)
- 600 V - 10 A 3-Phase IGBT Inverter Including Control IC for Gate Drive and Protections
- Low-Loss, Short-Circuit Rated IGBTs
- 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, Over Current and Short-Circuit Current Protection
- Fault Output for Under-Voltage, Over Current and Short-Circuit Current Protection
- Inter-Lock Function to Prevent Short-Circuit
- Shut-Down Input
- HVIC Temperature-Sensing Built-In for Temperature Monitoring
- Isolation Rating: 1500 V_{rms} / min.

Applications

- Motion Control - Home Appliance / Industrial Motor / HVAC.

Related Resources

- *AN-9112 - Smart Power Module, Motion SPM® 8 Series User's Guide.*

General Description

FNB81060T3 is a Motion SPM 8 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.

SPMFA-A25

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

Package Marking and Ordering Information

Device	Device Marking	Package	Packing Type	Quantity
FNB81060T3	NB81060T3	SPMFA-A25	RAIL	15

Integrated Power Functions

- 600 V - 10 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
  Note: Available bootstrap circuit example is given in Figures 5 and 17
- control circuit Under-Voltage Lock-Out (UVLO) protection
- For inverter low-side IGBTs: gate drive circuit, Over Curent Pretection(OCP), 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

Pin Configuration

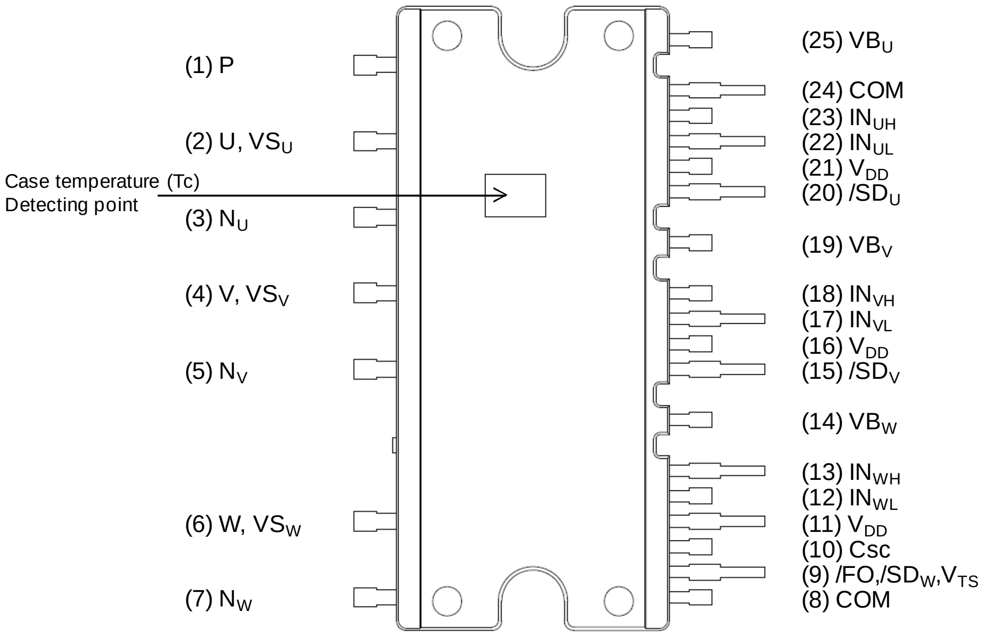


Figure 2. Top View

Pin Descriptions

Pin Number	Pin Name	Pin Description
1	P	Positive DC-Link Input
2	U, VS_U	Output for U Phase
3	N_U	Negative DC-Link Input for U Phase
4	V, VS_V	Output for V Phase
5	N_V	Negative DC-Link Input for V Phase
6	W, VS_W	Output for W Phase
7	N_W	Negative DC-Link Input for W Phase
8	COM	Common Supply Ground
9	/FO, $/SD_W$, V_{TS}	Fault Output, Shut-Down Input for W Phase, Temperature Output of Drive IC
10	C_{SC}	Shut Down Input for Over Current and Short Circuit Protection
11	V_{DD}	Common Bias Voltage for IC and IGBTs Driving
12	IN_{WL}	Signal Input for Low-Side W Phase
13	IN_{WH}	Signal Input for High-Side W Phase
14	VB_W	High-Side Bias Voltage for W-Phase IGBT Driving
15	$/SD_V$	Shut-Down Input for V Phase
16	V_{DD}	Common Bias Voltage for IC and IGBTs Driving
17	IN_{VL}	Signal Input for Low-Side V Phase
18	IN_{VH}	Signal Input for High-Side V Phase
19	VB_V	High-Side Bias Voltage for V-Phase IGBT Driving
20	$/SD_U$	Shut-Down Input for U Phase
21	V_{DD}	Common Bias Voltage for IC and IGBTs Driving
22	IN_{UL}	Signal Input for Low-Side U Phase
23	IN_{UH}	Signal Input for High-Side U Phase
24	COM	Common Supply Ground
25	VB_U	High-Side Bias Voltage for U-Phase IGBT Driving

Internal Equivalent Circuit and Input/Output Pins

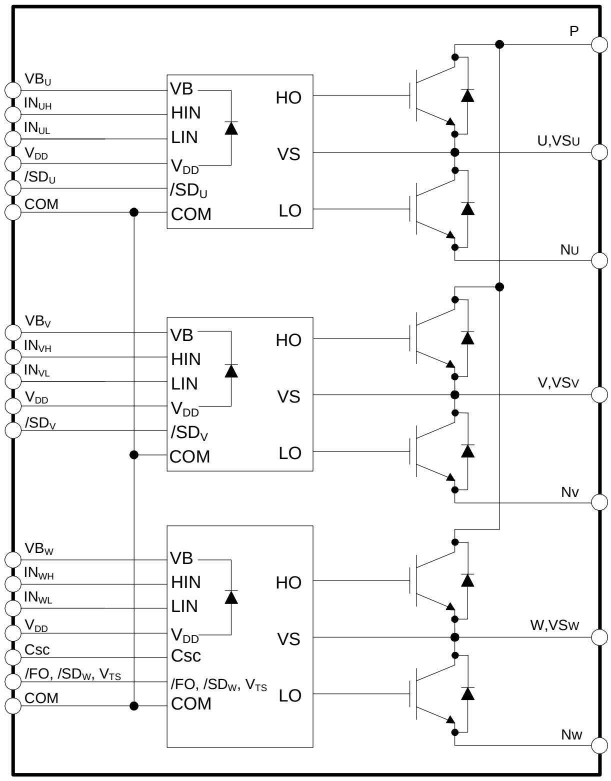


Figure 3. Internal Block Diagram

Note:

1. Inverter high-side is composed of three IGBTs, freewheeling diodes.
2. Inverter low-side is composed of three IGBTs, freewheeling diodes.
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	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, $T_J \leq$150°C (Note 4)	10	A
$\pm I_{CP}$	Each IGBT Collector Current (Peak)	T_C = 25°C, $T_J \leq$150°C, Under 1 ms Pulse Width (Note 4)	20	A
T_J	Operating Junction Temperature		-40 ~ 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 VB_U - VS_U, VB_V - VS_V, VB_W - VS_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_{FS}	Function Supply Voltage	Applied between /FO, $/SD_W$,V_{TS} - COM	-0.3 ~ V_{DD} +0.3	V
I_{FO}	Fault Current	Sink Current at /FO, $/SD_W$,V_{TS} pin	2	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_C	Module Case Operation Temperature	*See Figure 2*	-40 ~ 125	°C
T_{STG}	Storage Temperature		-40 ~ 125	°C
V_{ISO}	Isolation Voltage Connect Pins to Heat Sink Plate	AC 60 Hz, Sinusoidal, 1 Minute, Connection Pins to Heat Sink Plate	1500	V_{rms}

Thermal Resistance

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
$R_{th(j-c)Q}$	Junction to Case Thermal Resistance (Note 4)	Inverter IGBT part, (Per Module)	-	-	3.40	°C / W
$R_{th(j-c)F}$		Inverter FWDi part (Per Module)	-	-	3.86	°C / W

Note:

4. These values had been made an acquisition by the calculation considered to design factor.

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 = 8 A	T_J = 25°C	-	1.50	2.10	V
				T_J = 150°C	-	1.80	-	V
V_F		FWDi Forward Voltage	V_{IN} = 0 V I_F = 8 A	T_J = 25°C	-	1.90	2.50	V
				T_J = 150°C	-	1.80	-	V
HS	t_{ON}	Switching Times	V_{PN} = 400 V, V_{DD} = V_{BS} = 15 V, I_C = 10A T_J = 25°C V_{IN} = 0 V ↔ 5 V, Inductive load (Note 5)		0.25	0.75	1.25	us
	$t_{C(ON)}$				-	0.15	0.45	us
	t_{OFF}				-	0.50	1.00	us
	$t_{C(OFF)}$				-	0.10	0.40	us
	t_{rr}				-	0.10	-	us
LS	t_{ON}		V_{PN} = 400 V, V_{DD} = V_{BS} = 15 V, I_C = 10A T_J = 25°C V_{IN} = 0 V ↔ 5 V, Inductive load (Note 5)		0.25	0.75	1.25	us
	$t_{C(ON)}$				-	0.15	0.45	us
	t_{OFF}				-	0.50	1.00	us
	$t_{C(OFF)}$				-	0.10	0.40	us
	t_{rr}				-	0.10	-	us
I_{CES}		Collector - Emitter Leakage Current	V_{CE} = V_{CES}		-	-	1.00	mA

Note:

5. 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.*

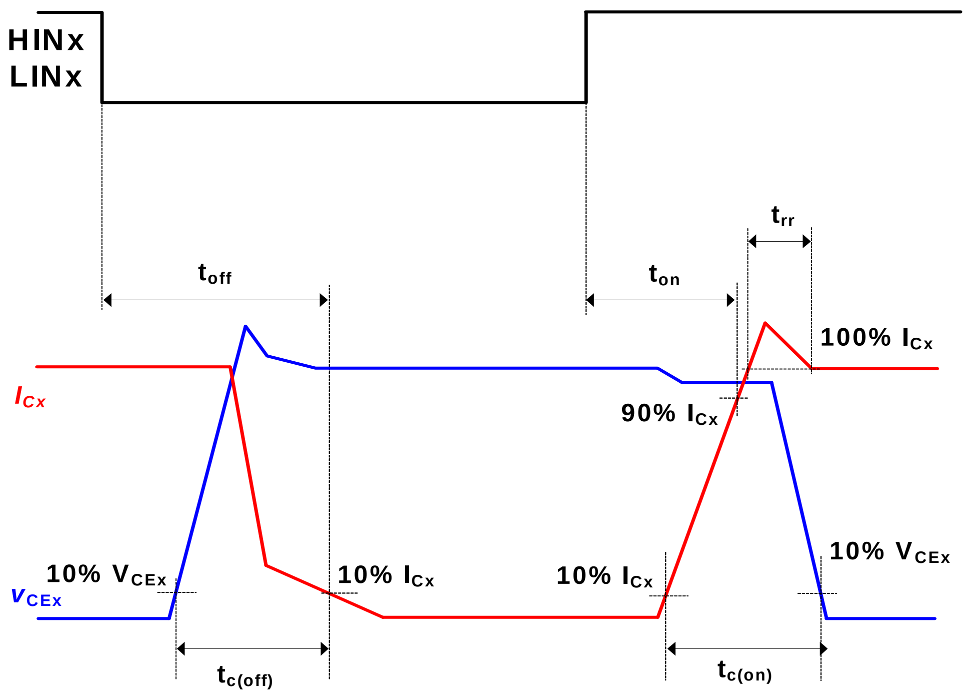


Figure 4. Switching Time Definition

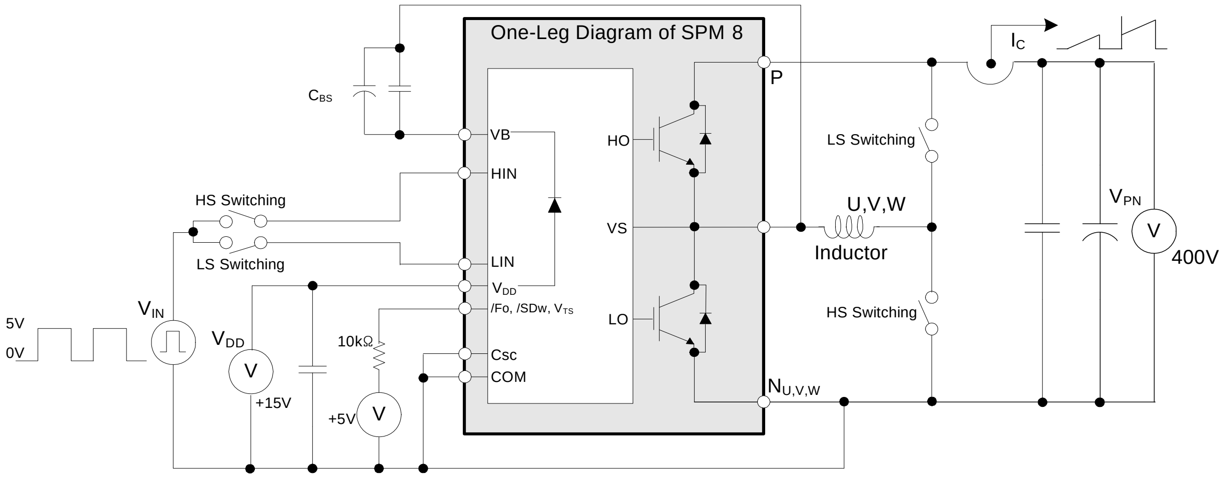


Figure 5. Example Circuit for Switching Test

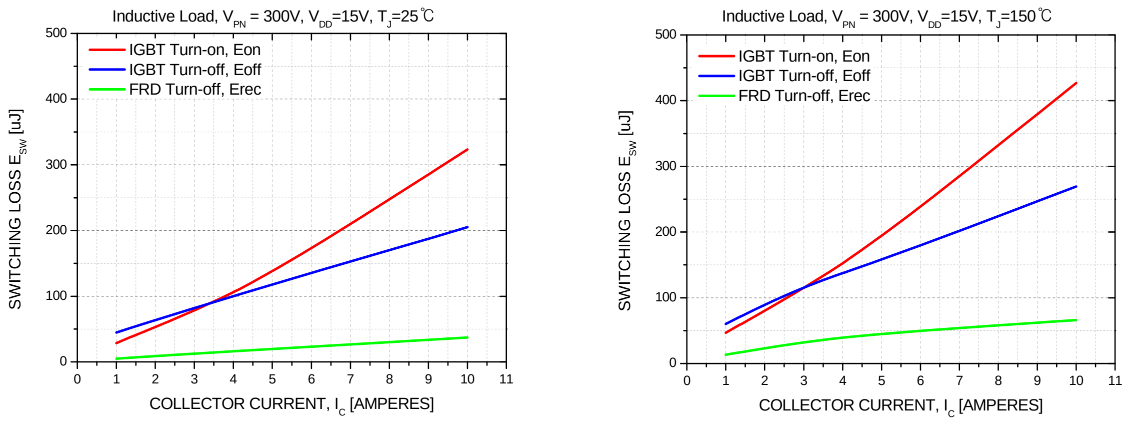


Figure 6. Switching Loss Characteristics

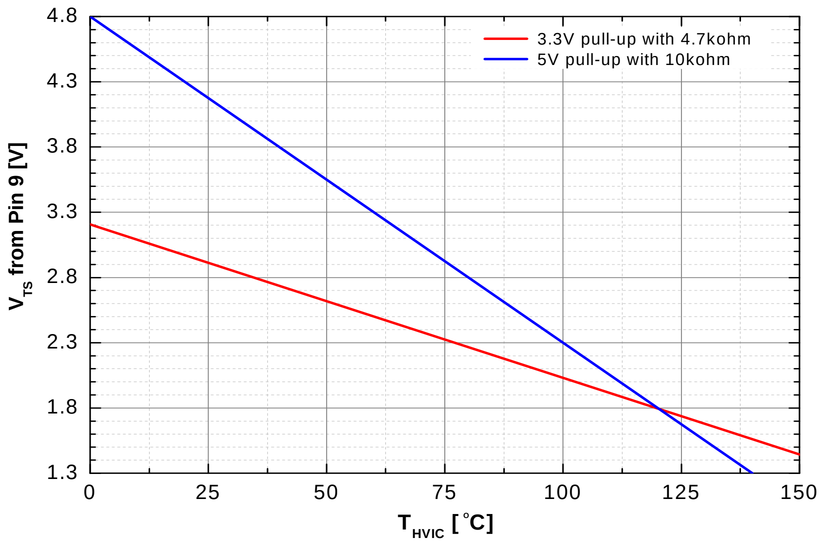


Figure 7. V-T Curve of Temperature Output of IC

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	-	-	1.7	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	-	-	2.2	mA
I_{QBS}	Quiescent V_{BS} Supply Current	V_{BS} = 15 V, $IN_{(UH, VH, WH)}$ = 0 V	VB_U - VS_U, VB_V - VS_V, VB_W - VS_W	-	-	100	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	VB_U - VS_U, VB_V - VS_V, VB_W - VS_W	-	-	600	μA
V_{FOH}	Fault Output Voltage	V_{SC} = 0 V, /FO Circuit: 10 kΩ to 5 V Pull-up		3.81	-	-	V
V_{FOL}		V_{SC} = 1 V, /FO Circuit: 10 kΩ to 5 V Pull-up		-	-	0.5	V
$V_{SC(ref)}$	Short-Circuit Trip Level	V_{DD} = 15 V (Note 6)		0.46	0.49	0.52	V
UV_{DDD}	Supply Circuit Under-Voltage Protection	Detection level		10.0	11.5	13.0	V
UV_{DDR}		Reset level		10.5	12.0	13.5	V
UV_{BSD}		Detection level		9.5	11.0	12.5	V
UV_{BSR}		Reset level		10.0	11.5	13.0	V
I_{FO_T}	HVIC Temperature Sensing Current	V_{DD} = V_{BS} = 15 V, T_{HVIC} = 25°C		-	82.5	-	μA
		V_{DD} = V_{BS} = 15 V, T_{HVIC} = 75°C		-	207.5	-	μA
V_{FO_T}	HVIC Temperature Sensing Voltage *See Figure 7*	V_{DD} = V_{BS} = 15 V, T_{HVIC} = 25°C, 10 kΩ to 5 V Pull-up		-	4.18	-	V
		V_{DD} = V_{BS} = 15 V, T_{HVIC} = 75°C, 10 kΩ to 5 V Pull-up		-	2.93	-	V
t_{FOD}	Fault-Out Pulse Width			40	-	-	μs
V_{FSDR}	Shut-down Reset level	Applied between /FO - COM		-	-	2.4	V
V_{FSDD}	Shut-down Detection 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:

6. Short-circuit current protection function is for all six IGBTs if the /FO, $/SD_W$, V_{TS} pin is connected to $/SD_x$ pins.

Bootstrap Diode Part

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

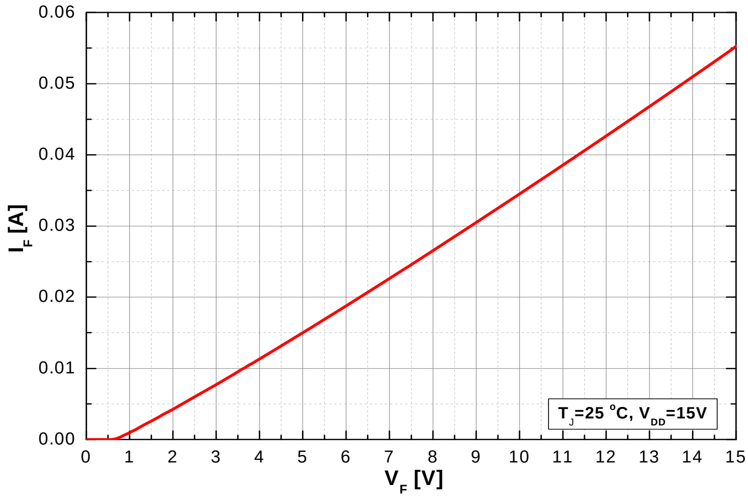


Figure 8. Built-In Bootstrap Diode Charaterstics

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 VB_U - VS_U, VB_V -VS_V, VB_W - VS_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
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	V_{DD} = V_{BS} = 15 V, I_C ≤ 20 A, Wiring Inductance between $N_{U, V, W}$ and DC Link N < 10nH (Note 7)	0.7	-	-	μs
$P_{WIN(OFF)}$			0.7	-	-	

Note:

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

Mechanical Characteristics and Ratings

Parameter	Conditions		Min.	Typ.	Max.	Unit
Device Flatness	*See Figure 9*		-50	-	100	μm
Mounting Torque	Mounting Screw: - M3	Recommended 0.7 N • m	0.6	0.7	0.8	N • m
	See Figure 10	Recommended 7.1 kg • cm	5.9	6.9	7.9	kg • cm
Weight			-	5.0	-	g

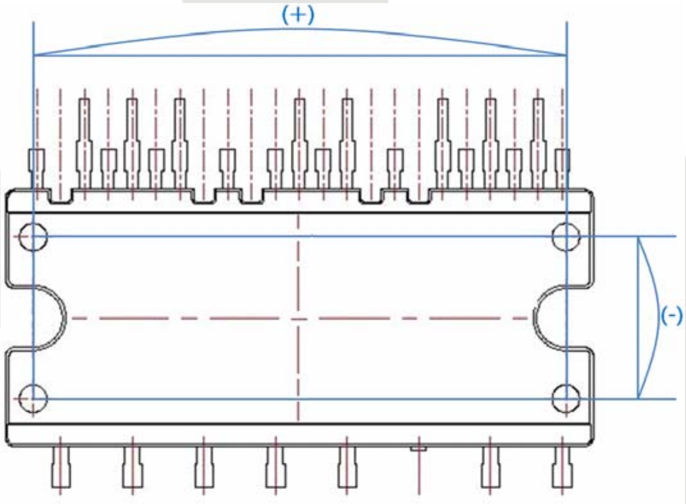


Figure 9. Flatness Measurement Position

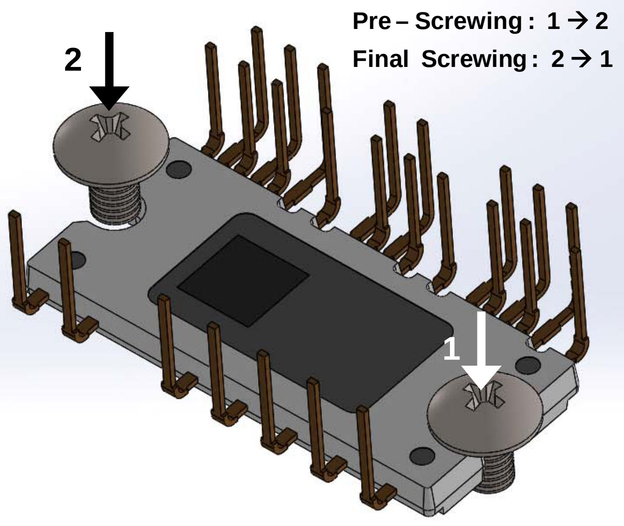


Figure 10. Mounting Screws Torque Order

Note:

8. Do not make over torque when mounting screws. Much mounting torque may cause package cracks, as well as bolts and Al heat-sink destruction.
9. Avoid one side tightening stress. *Figure 10* shows the recommended torque order for mounting screws. Uneven mounting can cause of package to be damaged. The pre-screwing torque is set to 20 ~ 30 % of maximum torque rating.

Time Charts of Protective Function

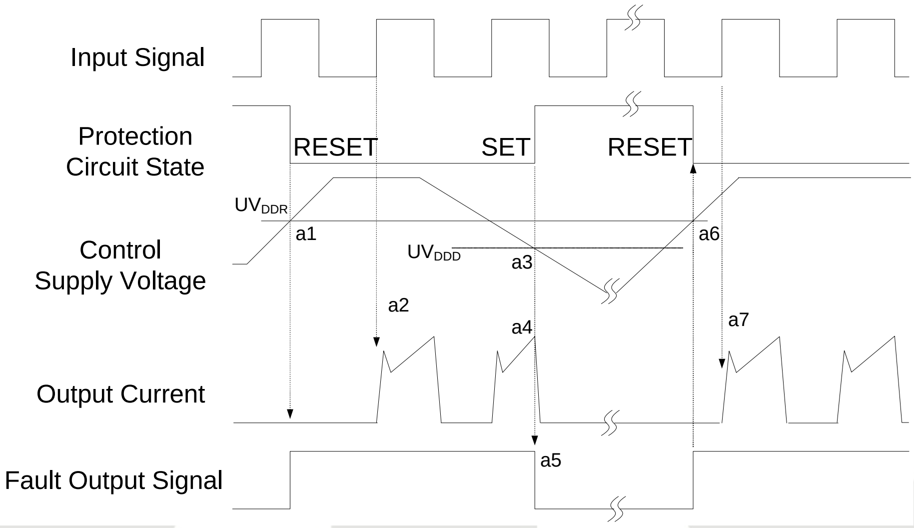


Figure 11. Under-Voltage Protection (Low-Side)

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.

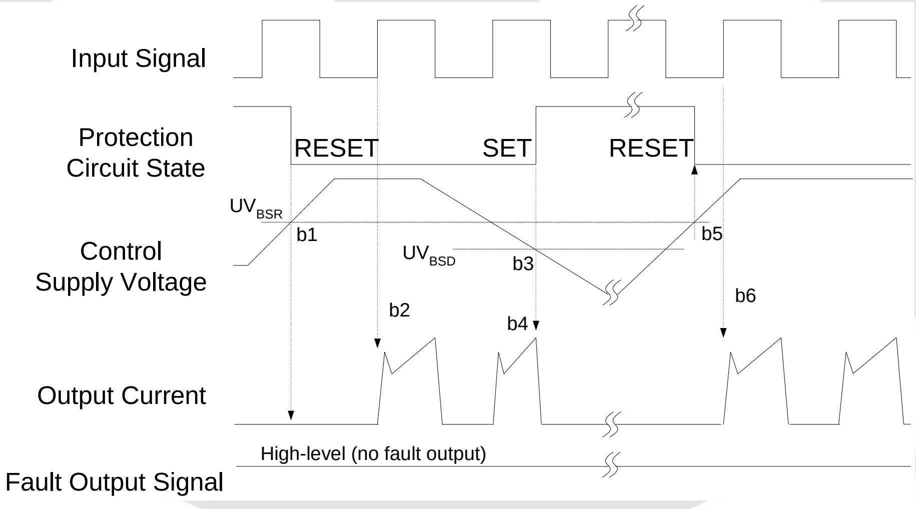


Figure 12. Under-Voltage Protection (High-Side)

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

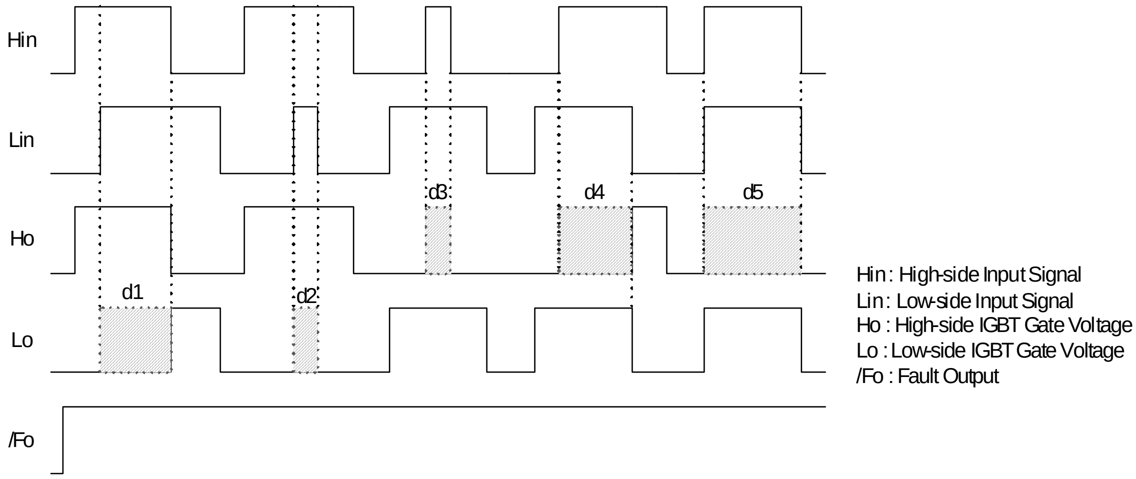


Figure 13. Inter-Lock Function

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

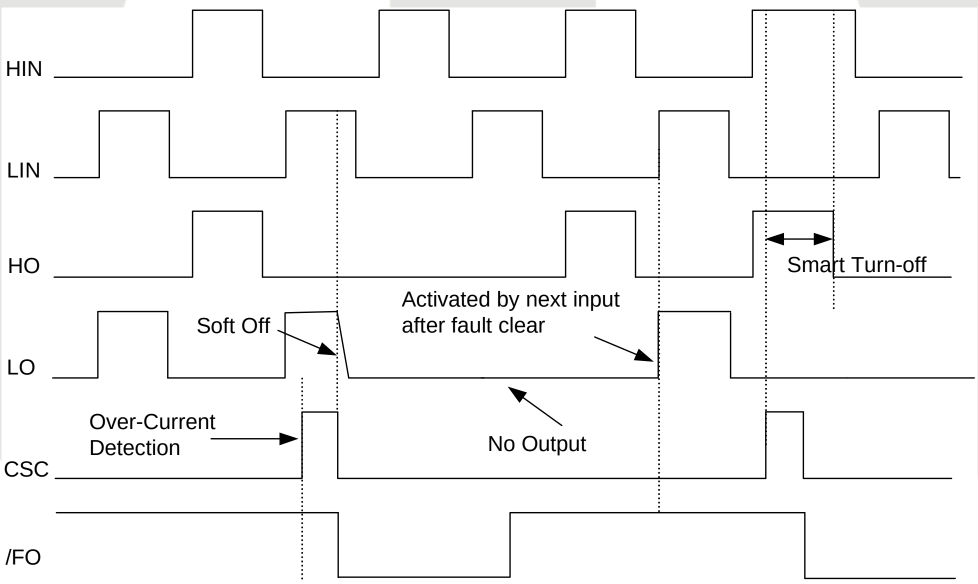


Figure 14. Fault-Out Function By Over Current Protection

HIN : High-side Input Signal

LIN : Low-side Input Signal

HO : High-Side Output Signal

LO : Low-Side Output Signal

C_{SC} : Over Current Detection Input

/FO : Fault Out Function

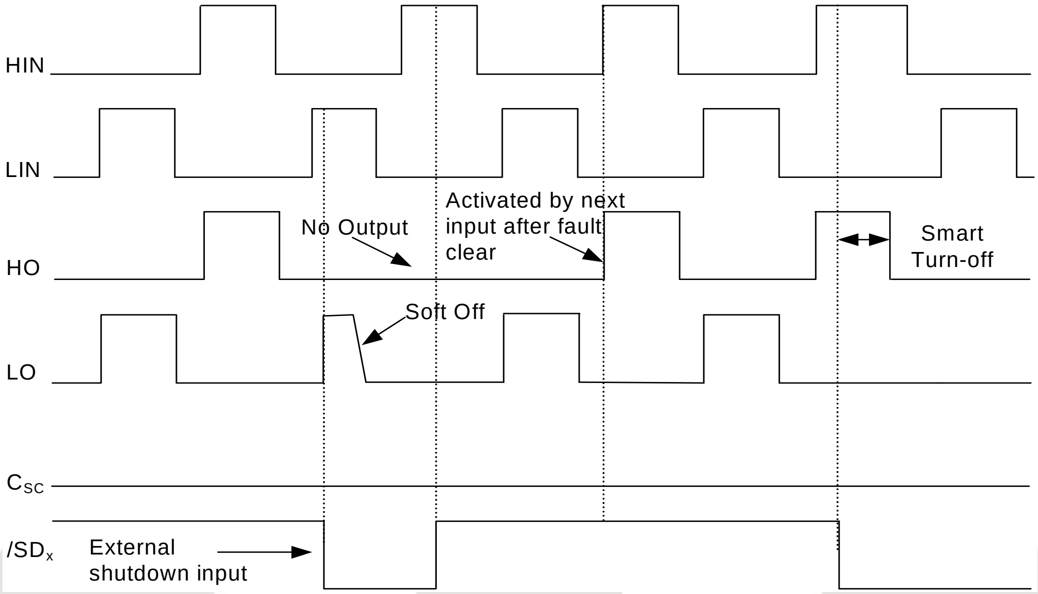


Figure 15. Shutdown Input Function By External Command

HIN : High-side Input Signal
LIN : Low-side Input Signal
HO : High-Side Output Signal
LO : Low-Side Output Signal
C_{SC} : Over Current Detection Input
/SD_x : Shutdown Input Function

Input/Output Interface Circuit

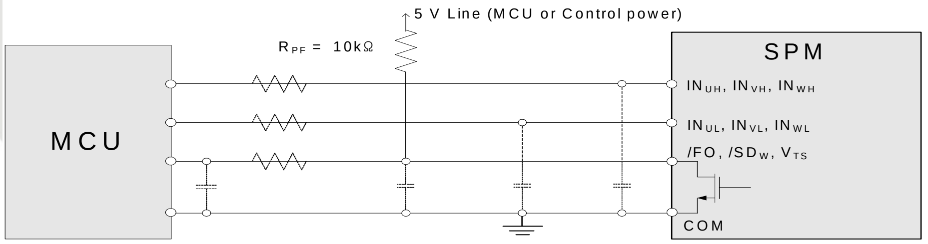


Figure 16. Recommended MCU I/O Interface Circuit

Note:

10. 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 8 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.

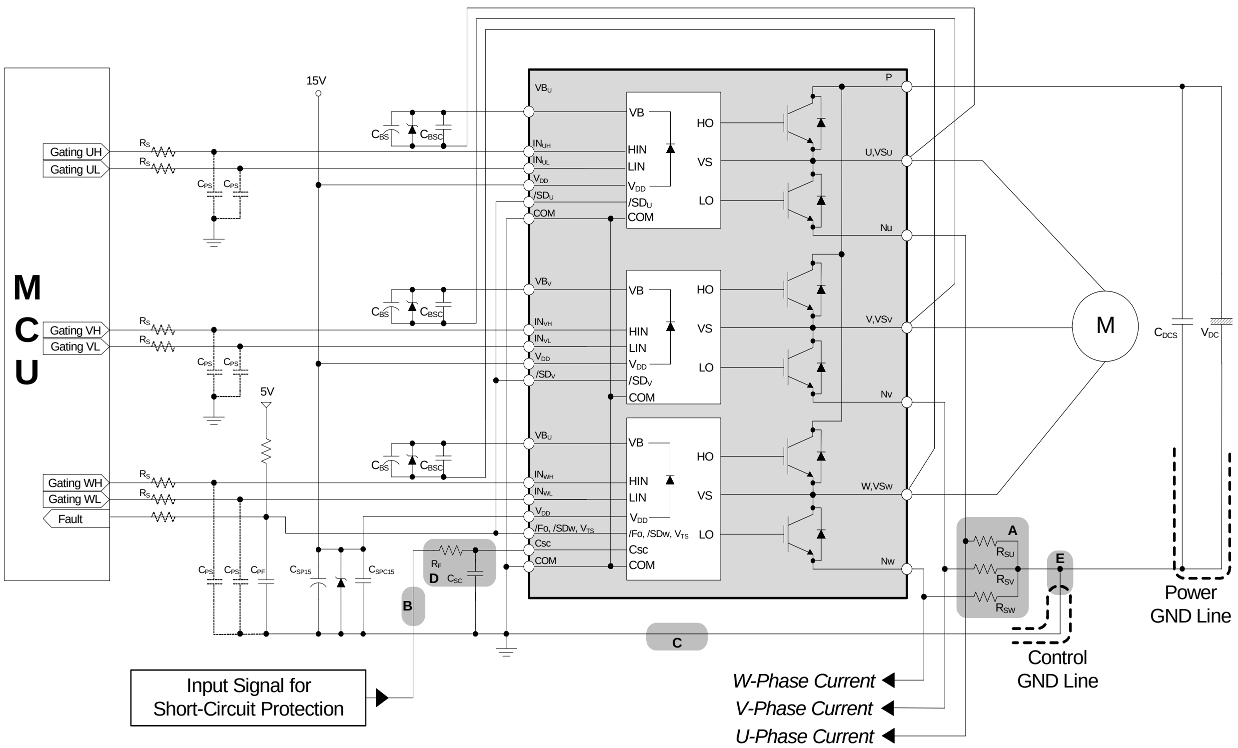
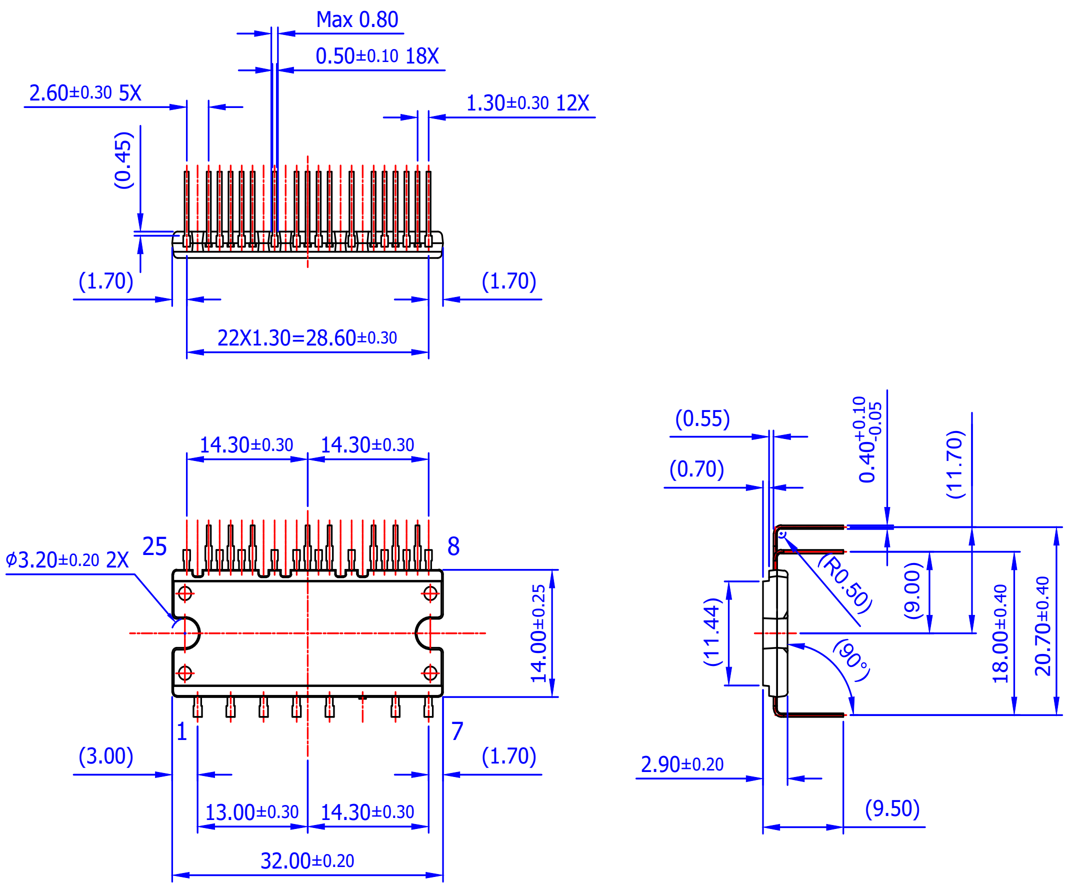


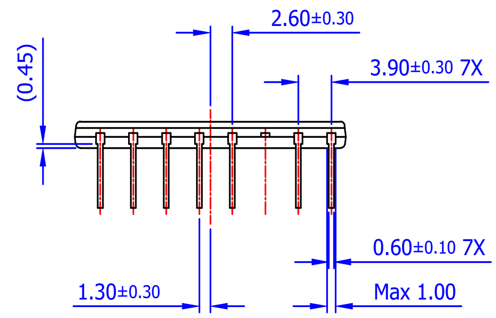
Figure 17. Typical Application Circuit

Note:

11. To avoid malfunction, the wiring of each input should be as short as possible. (less than 2 ~ 3 cm)
12. /FO 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 1 mA. *Please refer to Figure 16.*
13. C_{SP15} of around seven times larger than bootstrap capacitor C_{BS} is recommended.
14. 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 is recommanded for the prevention of input signal oscillation. $R_S C_{PS}$ time constant should be selected in the range 50 ~ 150 ns. (Recommended R_S = 100 Ω, C_{PS} = 1 nF)
15. Each wiring pattern inductance of A point should be minimized (Recommend less than 10nH). Use the shunt resistor $R_{S(U/V/W)}$ 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 $R_{S(U/V/W)}$ as close as possible.
16. To prevent errors of the protection function, the wiring of B, C, and D point should be as short as possible.
17. In the short-circuit protection circuit, please select the $R_F C_{SC}$ time constant in the range 1.5 ~ 2 μs. Do enough evaluation on the real system because short-circuit protection time may very wiring pattem layout and value of the R_F and C_{SC} time constant.
18. 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.
19. Each capacitor should be mounted as close to the pins of the Motion SPM 8 product as possible.
20. 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.
21. 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.
22. 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)
23. 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}.
24. For the detailed information, please refer to the application notes.
25. /FO and /SD must be connected as short as possible.

Detailed Package Outline Drawings (FNB81060T3, Long Lead)





NOTES: UNLESS OTHERWISE SPECIFIED
A) NO PACKAGING STANDARD APPLIES
B) ALL DIMENSIONS ARE IN MILLIMETERS
C) DIMENSIONS ARE EXCLUSIVE OF BURRS, MOLD FLASH, AND TIE BAR EXTRUSIONS
D) ( ) IS REFERENCE
E) DRAWING FILENAME: MOD25DAREV2

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Always visit Fairchild Semiconductor's online packaging area for the most recent package drawings:

http://www.fairchildsemi.com/dwg/MO/MOD25DA.pdf

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