

FNA51560T1/T3

Motion SPM® 55 Series

Features

- UL Certified No. E209204 (UL1557)
- 600 V - 15 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
- Inter-Lock Function
- HVIC for Gate Driving and Under-Voltage Protection
- HVIC Temperature-Sensing Built-In for Temperature Monitoring
- Optimized for 5 kHz Switching Frequency
- Isolation Rating: 1500 V_{rms} / min.

Applications

- Motion Control - Home Appliance / Industrial Motor

Related Resources

General Description

FNA51560T1/T3 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.

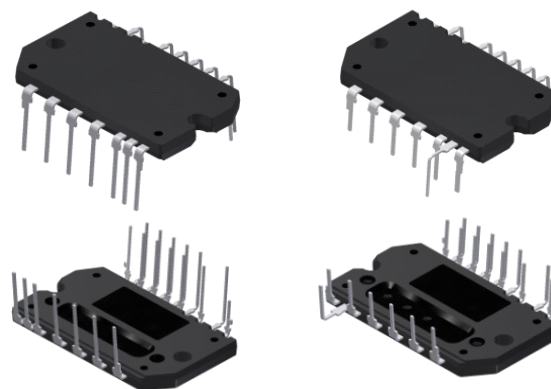


Figure 1. Package Overview

Package Marking and Ordering Information

Device	Device Marking	Package	Packing Type	Quantity
FNA51560T1	FNA51560T1	SPMFA-B20	RAIL	13
FNA51560T3	FNA51560T3	SPMFA-A20	RAIL	13

Integrated Power Functions

- 600 V - 15 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

Pin Configuration

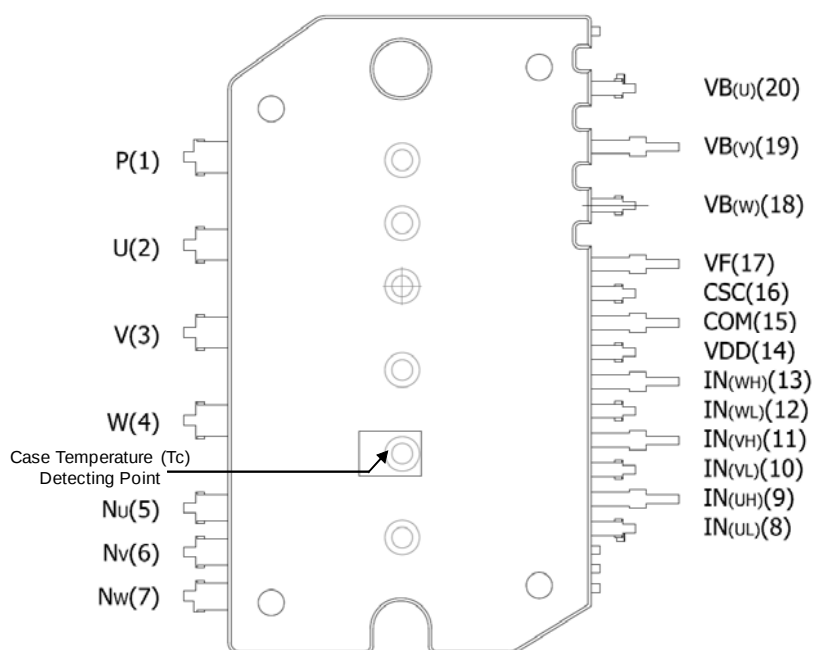


Figure 2. Top View

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-Side 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

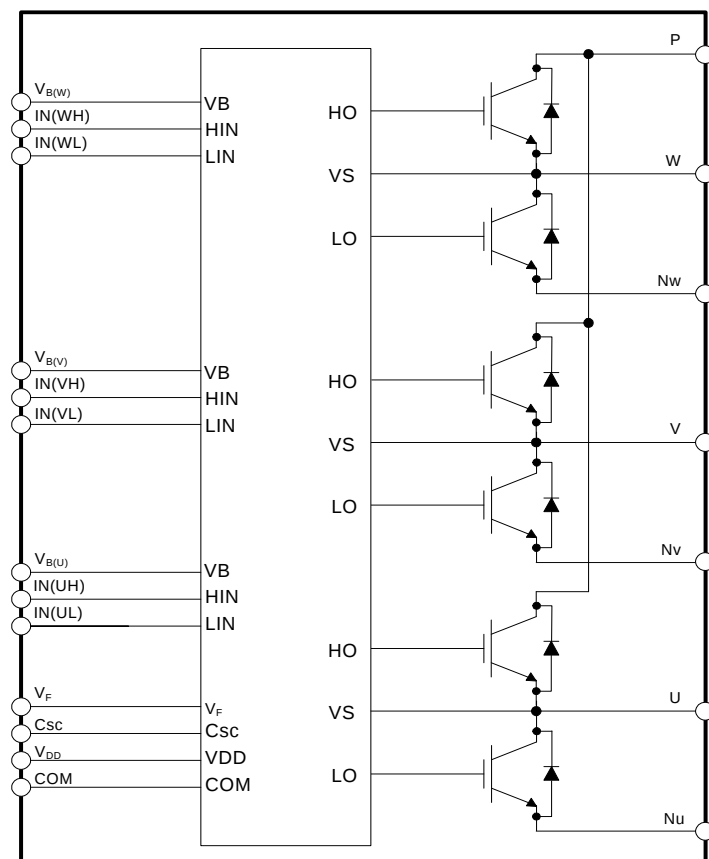


Figure 3. Internal Block Diagram

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 ($T_J = 25^\circ\text{C}$, 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	$T_C = 25^\circ\text{C}$, $T_J < 150^\circ\text{C}$	15	A
$\pm I_{CP}$	Each IGBT Collector Current (Peak)	$T_C = 25^\circ\text{C}$, $T_J < 150^\circ\text{C}$, Under 1 ms Pulse Width	30	A
P_C	Collector Dissipation	$T_C = 25^\circ\text{C}$ per Chip	27	W
T_J	Operating Junction Temperature	(Note 5)	-40 ~ 150	$^\circ\text{C}$

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
$V_{PN(\text{PROT})}$	Self Protection Supply Voltage Limit (Short Circuit Protection Capability)	$V_{DD} = V_{BS} = 13.5 \sim 16.5 \text{ V}$ $T_J = 150^\circ\text{C}$, Non-Repetitive, $< 2 \mu\text{s}$	400	V
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	1500	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)	-	-	4.55	$^\circ\text{C} / \text{W}$
$R_{th(j-c)F}$		Inverter FWD part (per 1 / 6 module)	-	-	5.4	$^\circ\text{C} / \text{W}$

Note:

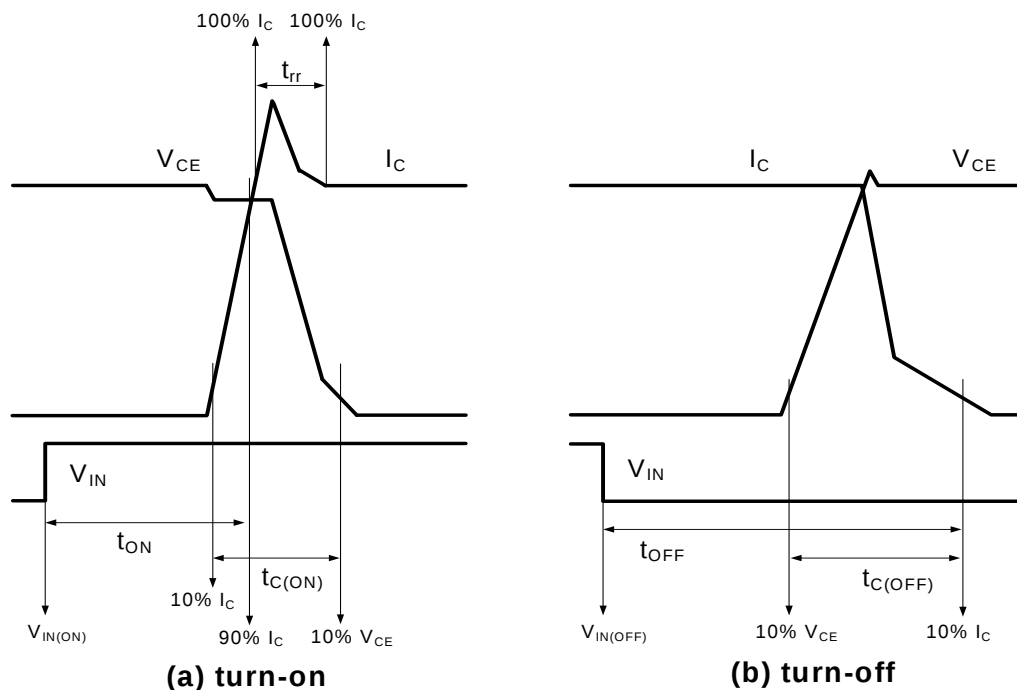
6. For the measurement point of case temperature (T_C), please refer to Figure 2.

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	$V_{DD} = V_{BS} = 15\text{ V}$ $V_{IN} = 5\text{ V}$ $I_C = 15\text{ A}$ $T_J = 25^\circ\text{C}$	-	1.45	1.85	V
		$T_J = 150^\circ\text{C}$		1.65		V
V_F	FWDi Forward Voltage	$V_{IN} = 0\text{ V}$ $I_F = 15\text{ A}$ $T_J = 25^\circ\text{C}$	-	1.7	2.1	V
		$T_J = 150^\circ\text{C}$		1.7		V
HS	t_{ON}	$V_{PN} = 400\text{ V}$, $V_{DD} = V_{BS} = 15\text{ V}$, $I_C = 15\text{ A}$ $T_J = 25^\circ\text{C}$ $V_{IN} = 0\text{ V} \leftrightarrow 5\text{ V}$, Inductive load (Note 7)	-	700	-	ns
	$t_{C(ON)}$		-	140	-	ns
	t_{OFF}		-	850	-	ns
	$t_{C(OFF)}$		-	140	-	ns
	t_{rr}		-	85	-	ns
LS	t_{ON}	$V_{PN} = 400\text{ V}$, $V_{DD} = V_{BS} = 15\text{ V}$, $I_C = 15\text{ A}$ $T_J = 25^\circ\text{C}$ $V_{IN} = 0\text{ V} \leftrightarrow 5\text{ V}$, Inductive load (Note 7)	-	800	-	ns
	$t_{C(ON)}$		-	250	-	ns
	t_{OFF}		-	850	-	ns
	$t_{C(OFF)}$		-	150	-	ns
	t_{rr}		-	90	-	ns
I_{CES}	Collector - Emitter Leakage Current	$V_{CE} = V_{CES}$	-	-	1	mA

Note:

7. 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**

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	-	2.0	2.6	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	-	2.5	3.5	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)}	-	70	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	V _{B(U)} - V _{S(U)} , V _{B(V)} - V _{S(V)} , V _{B(W)} - V _{S(W)}	-	600	800	μA
V _{FH}	Fault Output Voltage	V _{SC} = 0 V, V _F Circuit: 4.7 kΩ to 5 V Pull-up		4.5	-	-	V
V _{FL}		V _{SC} = 1 V, V _F Circuit: 4.7 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		10.0	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
V _{FT}	HVIC Temperature Sensing Voltage	V _{DD} = V _{BS} = 15 V, T _{HVIC} = 25°C, 4.7 kΩ to 5 V Pull-up (Figure. 5)		4.43	4.58	4.71	V
t _{FOD}	Fault-Out Pulse Width			40	100	-	μs
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:

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

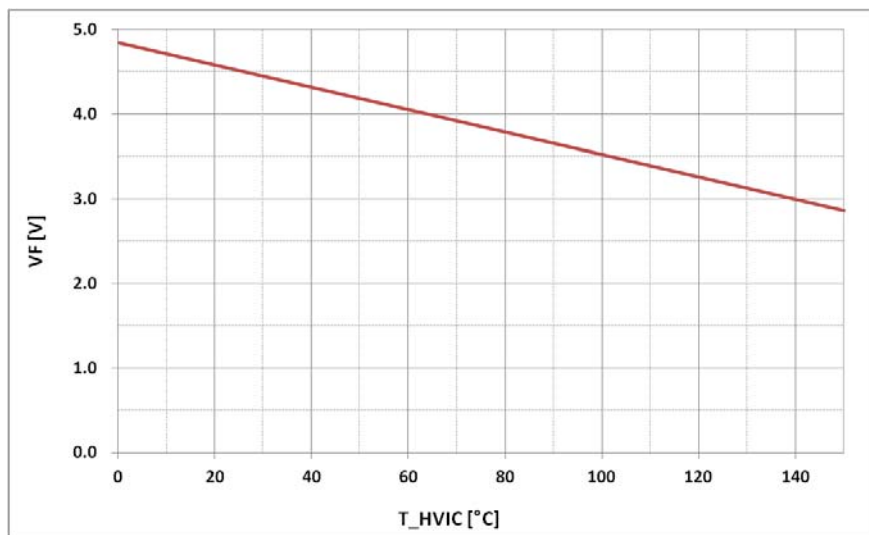


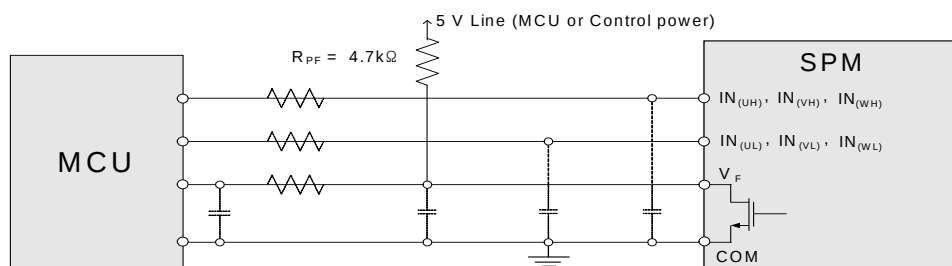
Figure. 5. V-T Curve of Temperature Output of IC (5V pull-up with 4.7kohm)

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	13.5	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 / μ s
t_{dead}	Blanking Time for Preventing Arm - Short	For each input signal	1.0	-	-	μ s
f_{PWM}	PWM Input Signal	$-40^{\circ}\text{C} < T_J < 150^{\circ}\text{C}$	-	-	20	kHz
V_{SEN}	Voltage for Current Sensing	Applied between N_U , N_V , N_W - COM (Including surge voltage)	-4		4	V
$P_{WIN(ON)}$	Minimum Input Pulse Width	(Note 9)	1.0	-	-	μ s
$P_{WIN(OFF)}$			1.0	-	-	

Note:

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



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 55 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 6. Recommended MCU I/O Interface Circuit

Mechanical Characteristics and Ratings

Parameter	Conditions		Min.	Typ.	Max.	Unit
Device Flatness	See Figure 7		-50	-	100	μm
Mounting Torque	Mounting Screw: - M3 Note Figure 8	Recommended 0.7 N • m	0.6	0.7	0.8	N • m
		Recommended 7.1 kg • cm	5.9	6.9	7.9	kg • cm
Weight			-	6.0	-	g

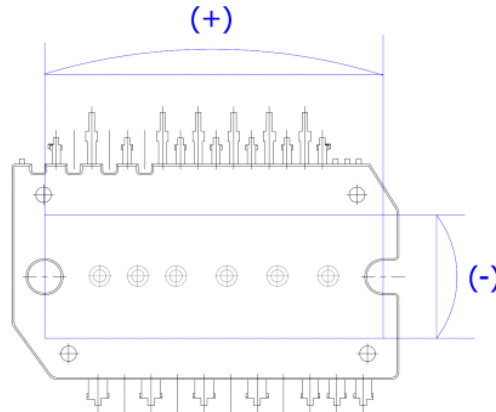


Figure 7. Flatness Measurement Position

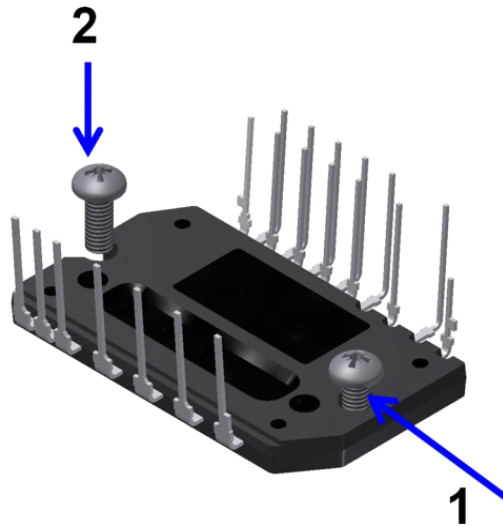
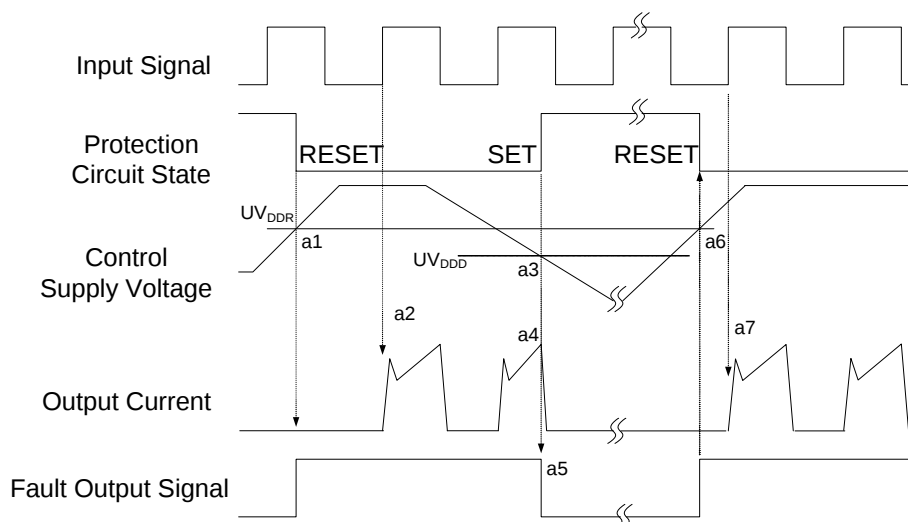


Figure 8. Mounting Screws Torque Order

Note:

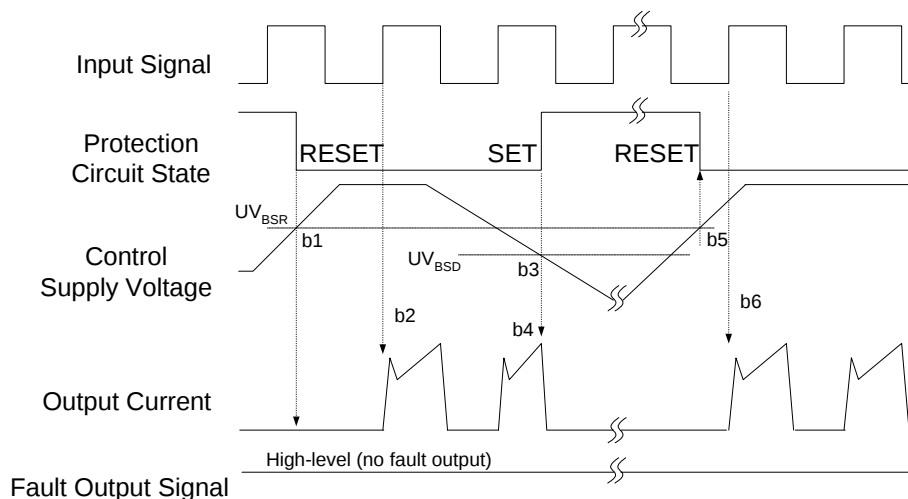
11. Do not make over torque when mounting screws. Much mounting torque may cause package cracks, as well as bolts and Al heat-sink destruction.
12. Avoid one side tightening stress. Figure 10 shows the recommended torque order for mounting screws. Uneven mounting can cause the ceramic substrate of the 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



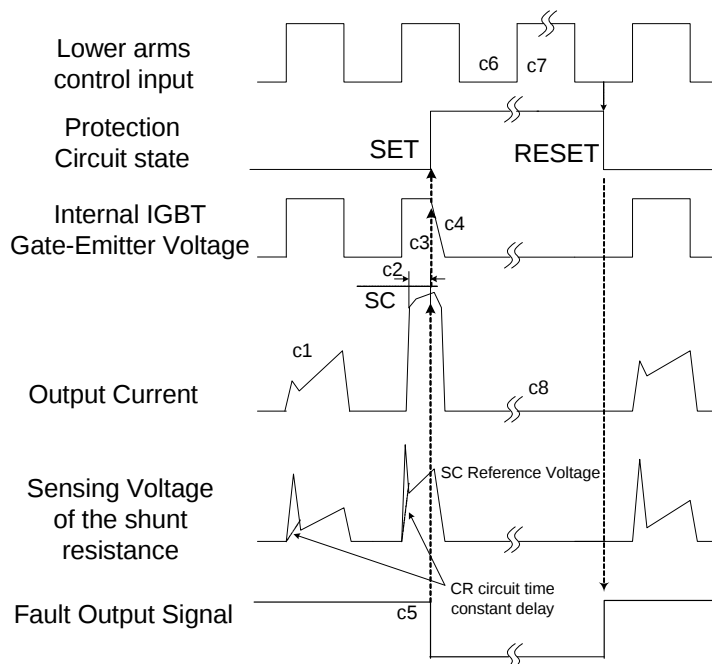
- a1 : Control supply voltage rises: After the voltage rises UV_{DDR} , the circuits start to operate when next input is applied.
- a2 : Normal operation: IGBT ON and carrying current.
- a3 : Under voltage detection (UV_{DDD}).
- a4 : IGBT OFF in spite of control input condition.
- a5 : Fault output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

Figure 9. 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 10. 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.

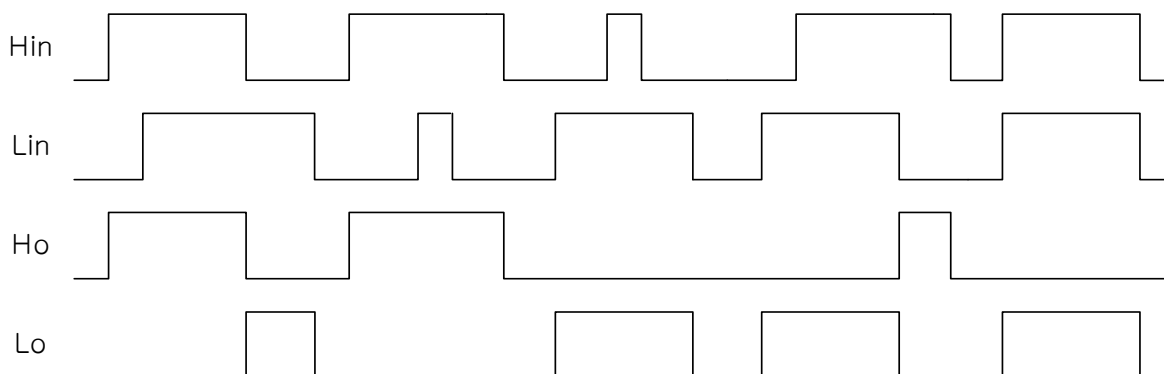
c4 : IGBT turns OFF.

c5 : Input "L" : IGBT OFF state.

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

c7 : IGBT OFF state

Figure 11. Short-Circuit Protection



Hin : High-side Input Signal

Lin : Low-side Input Signal

Ho : Internal IGBT Gate - Emitter Voltage of High-side

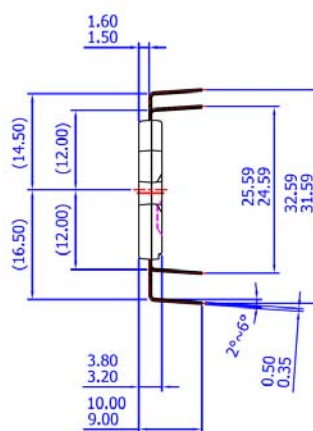
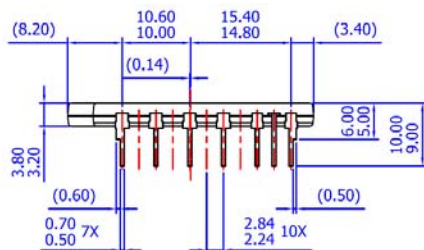
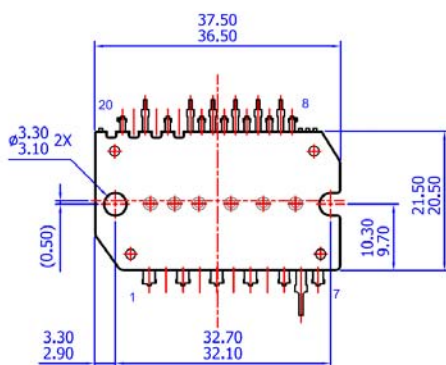
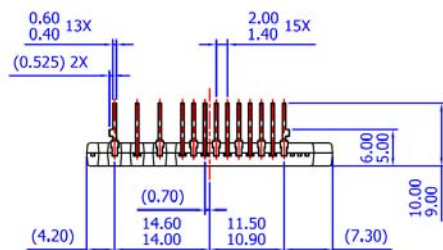
Lo : Internal IGBT Gate - Emitter Voltage of Low-side

Figure 12. Inter-Lock Function



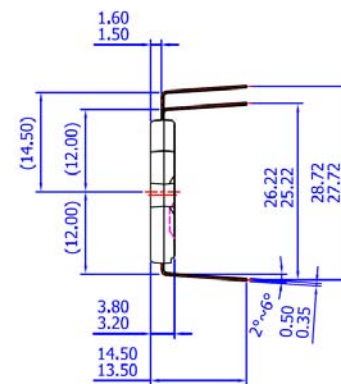
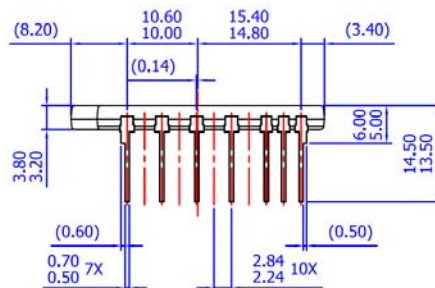
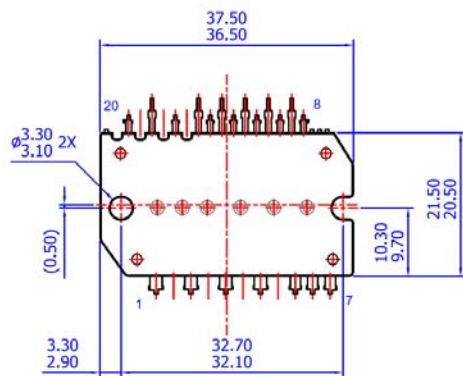
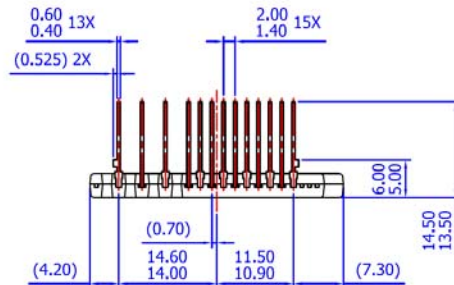
- ### Figure 13. Typical Application Circuit

Detailed Package Outline Drawings (FNA51560T1, Short Lead)



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Detailed Package Outline Drawings (FNA51560T3, Long Lead)



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Datasheet Identification	Product Status	Definition
Advance Information	Formative / In Design	Datasheet contains the design specifications for product development. Specifications may change in any manner without notice.
Preliminary	First Production	Datasheet contains preliminary data; supplementary data will be published at a later date. Fairchild Semiconductor reserves the right to make changes at any time without notice to improve design.
No Identification Needed	Full Production	Datasheet contains final specifications. Fairchild Semiconductor reserves the right to make changes at any time without notice to improve the design.
Obsolete	Not In Production	Datasheet contains specifications on a product that is discontinued by Fairchild Semiconductor. The datasheet is for reference information only.

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