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ON Semiconductor®

July 2017

FNB81560T3

Motion SPM® 8 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
- 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
- Isolation Rating: 1500 V_{rms} / min.

Applications

- Motion Control - Home Appliance / Industrial Motor

Related Resources

- [AN-9112 - Smart Power Module, Motion SPM® 8 Series User's Guide.](#)
- [AN-9548 - SPM® 8 Package Assembly Guidance for 25L double DIP.](#)

General Description

FNB81560T3 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 |
|------------|----------------|-----------|--------------|----------|
| FNB81560T3 | NB81560T3 | SPMFA-A25 | RAIL | 15 |

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
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 Current Protection (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

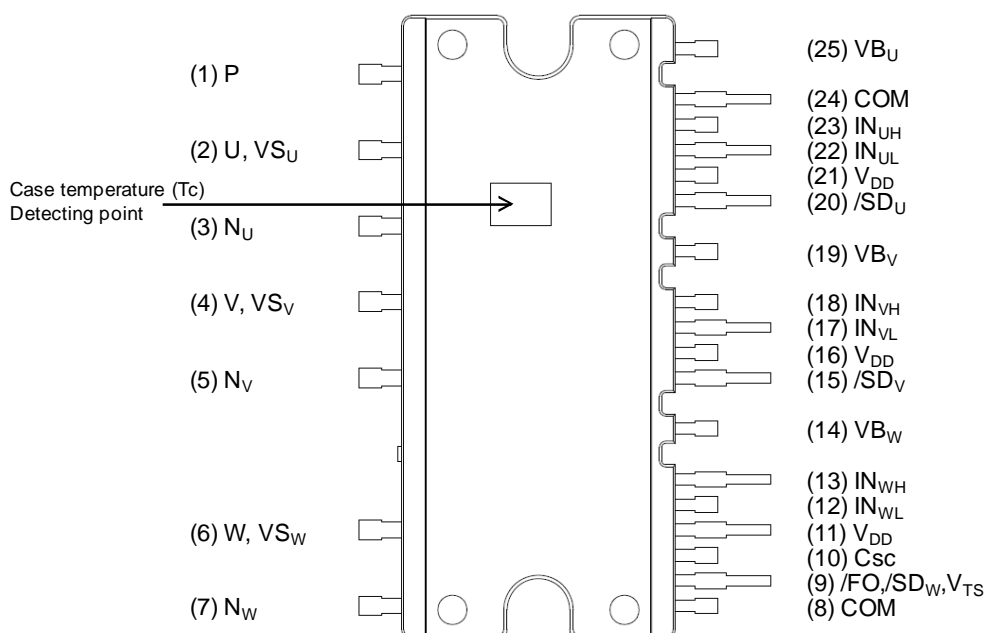


Figure 2. Top View

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

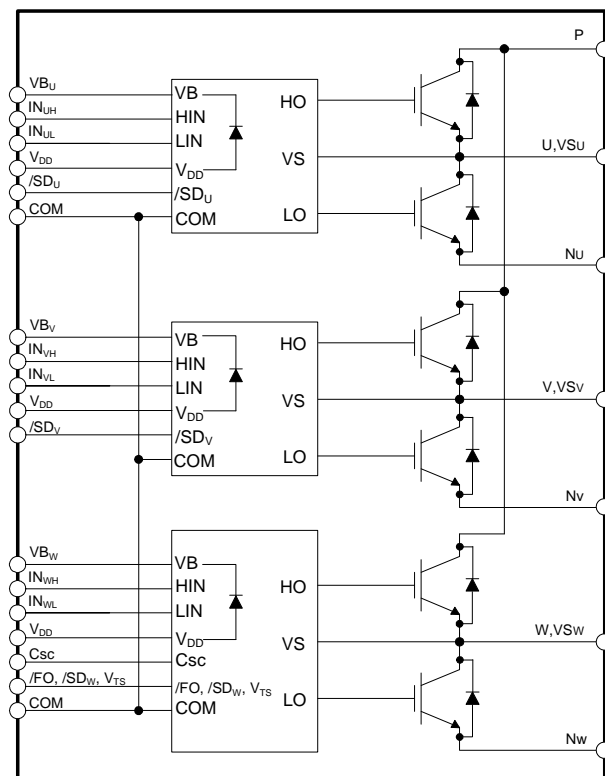


Figure 3. Internal Block Diagram

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 ($T_J = 25^\circ\text{C}$, 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 | $T_C = 25^\circ\text{C}$, $T_J \leq 150^\circ\text{C}$ (Note 4) | 15 | 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 (Note 4) | 30 | A |
| T_J | Operating Junction Temperature | | -40 ~ 150 | $^\circ\text{C}$ |

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 |
|-----------------------|--|--|-----------|------------------|
| $V_{PN(\text{PROT})}$ | 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 μs | 400 | V |
| T_{STG} | Storage Temperature | | -40 ~ 125 | $^\circ\text{C}$ |
| 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 5) | Inverter IGBT part, (Per Module) | - | - | 3.40 | $^\circ\text{C} / \text{W}$ |
| $R_{th(j-c)F}$ | | Inverter FWDi part, (Per Module) | - | - | 3.86 | $^\circ\text{C} / \text{W}$ |

Note:

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 ($T_J = 25^\circ\text{C}$, unless otherwise specified.)

Inverter Part

| Symbol | Parameter | Conditions | Min. | Typ. | Max. | Unit |
|---------------|--|--|------|------|------|------|
| $V_{CE(SAT)}$ | Collector - Emitter Saturation Voltage | $V_{DD} = V_{BS} = 15\text{ V}$ $V_{IN} = 5\text{ V}$ $I_C = 12\text{ A}$ $T_J = 25^\circ\text{C}$ | - | 1.60 | 2.10 | V |
| | | $T_J = 150^\circ\text{C}$ | - | 1.80 | - | V |
| V_F | FWDi Forward Voltage | $V_{IN} = 0\text{ V}$ $I_F = 12\text{ A}$ $T_J = 25^\circ\text{C}$ | - | 2.00 | 2.50 | V |
| | | $T_J = 150^\circ\text{C}$ | - | 1.90 | - | 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 6) | 0.25 | 0.75 | 1.25 | us |
| | $t_{C(ON)}$ | | - | 0.20 | 0.50 | us |
| | t_{OFF} | | - | 0.55 | 1.05 | us |
| | $t_{C(OFF)}$ | | - | 0.10 | 0.40 | us |
| | t_{rr} | | - | 0.10 | - | us |
| 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 6) | 0.25 | 0.75 | 1.25 | us |
| | $t_{C(ON)}$ | | - | 0.20 | 0.50 | us |
| | t_{OFF} | | - | 0.55 | 1.05 | 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:

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 time of IGBT itself under the given gate driving condition internally. For the detailed information, please see Figure 4.

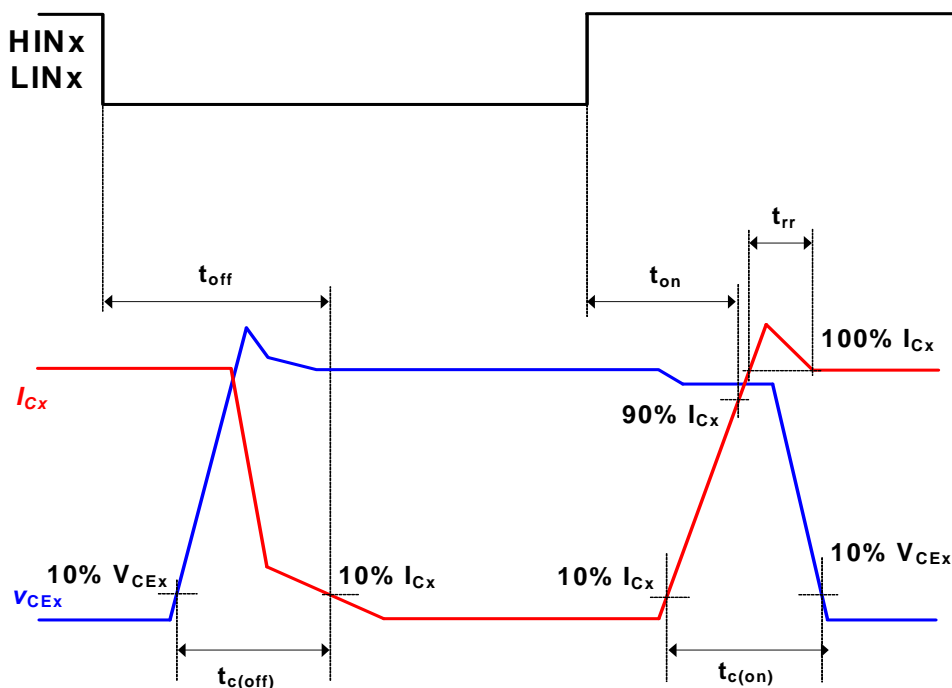


Figure 4. Switching Time

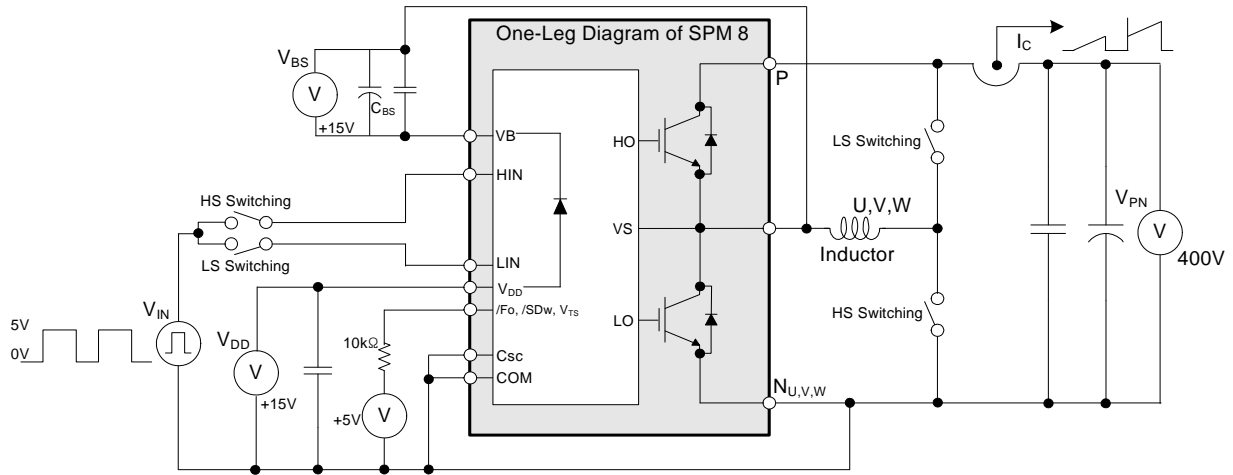


Figure 5. Example Circuit for Switching Test

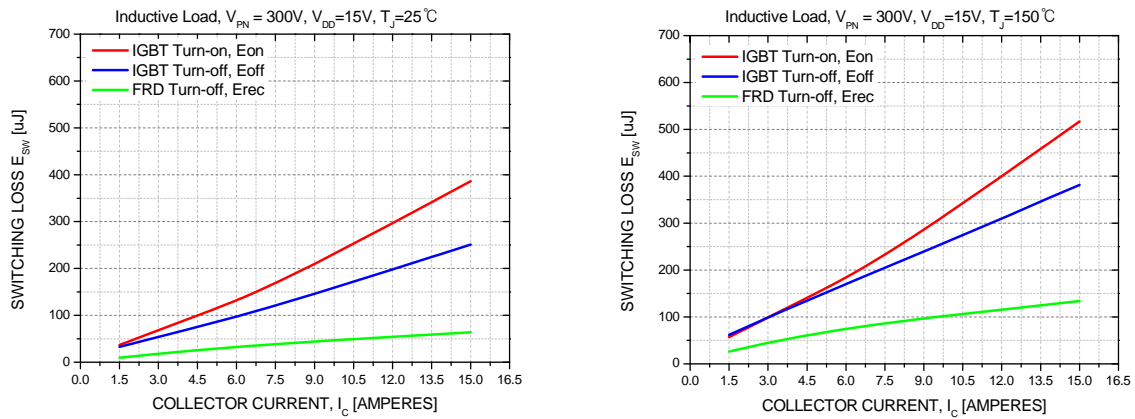


Figure 6. Switching Loss Characteristics

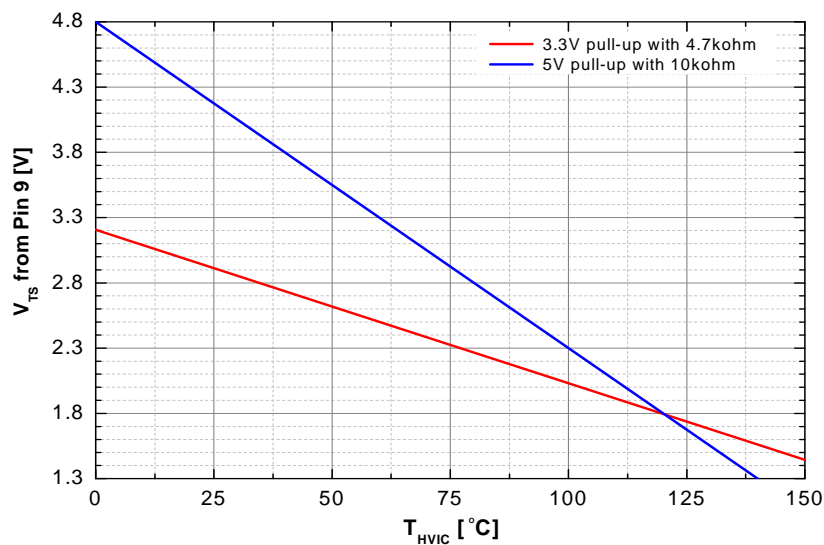


Figure 7. V-T Curve of Temperature Output of IC

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 | V _{B(U)} - V _{S(U)} , V _{B(V)} - V _{S(V)} , V _{B(W)} - V _{S(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 | V _{B(U)} - V _{S(U)} , V _{B(V)} - V _{S(V)} , V _{B(W)} - V _{S(W)} | - | - | 700 | μA |
| V _{FOH} | Fault Output Voltage | V _{SC} = 0 V, V _F Circuit: 10 kΩ to 5 V Pull-up | | 3.81 | - | - | V |
| V _{FOL} | | 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 7) | | 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 <i>See Figure 7</i> | 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:

7. 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 | $V_{DD} = 15V, T_J = 25^{\circ}C$ | - | 280 | - | Ω |

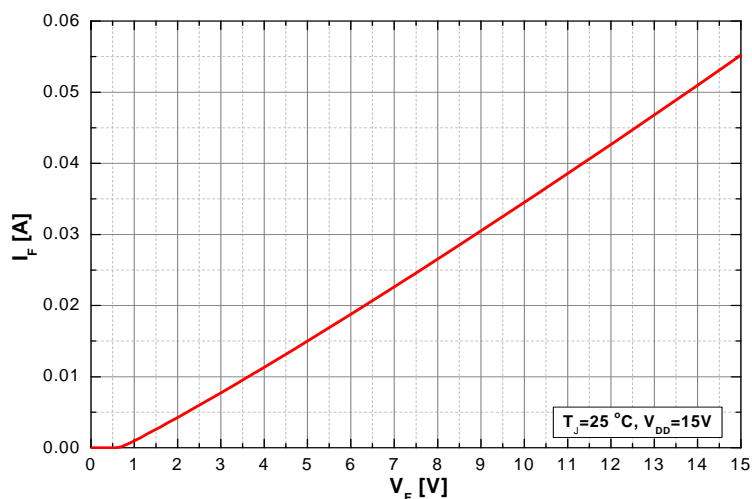


Figure 8. Built-In Bootstrap Diode Charateristics

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 $V_{BU} - VS_U, V_{BV} - VS_V, V_{BW} - VS_W$ | 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 | $V_{DD} = V_{BS} = 15 V, I_C \leq 30 A$, Wiring Inductance between N_U, V, W and DC Link N < 10nH (Note 8) | 0.7 | - | - | μs |
| $P_{WIN(OFF)}$ | | | 0.7 | - | - | |

Note:

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

Mechanical Characteristics and Ratings

| Parameter | Conditions | | Min. | Typ. | Max. | Unit |
|-----------------|---------------------------------------|-------------------------|------|------|------|---------|
| Device Flatness | See Figure 9 | | -50 | - | 100 | μm |
| Mounting Torque | Mounting Screw: - M3 See Figure 10 | 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 | | | - | 5.0 | - | g |

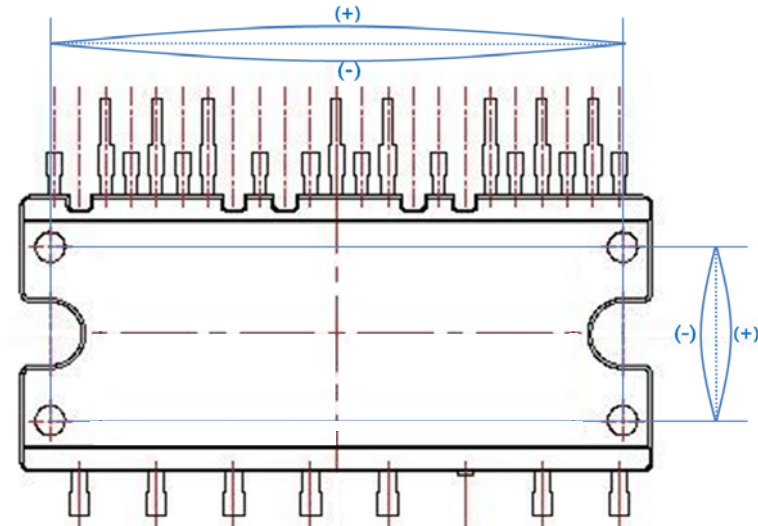


Figure 9. Flatness Measurement Position

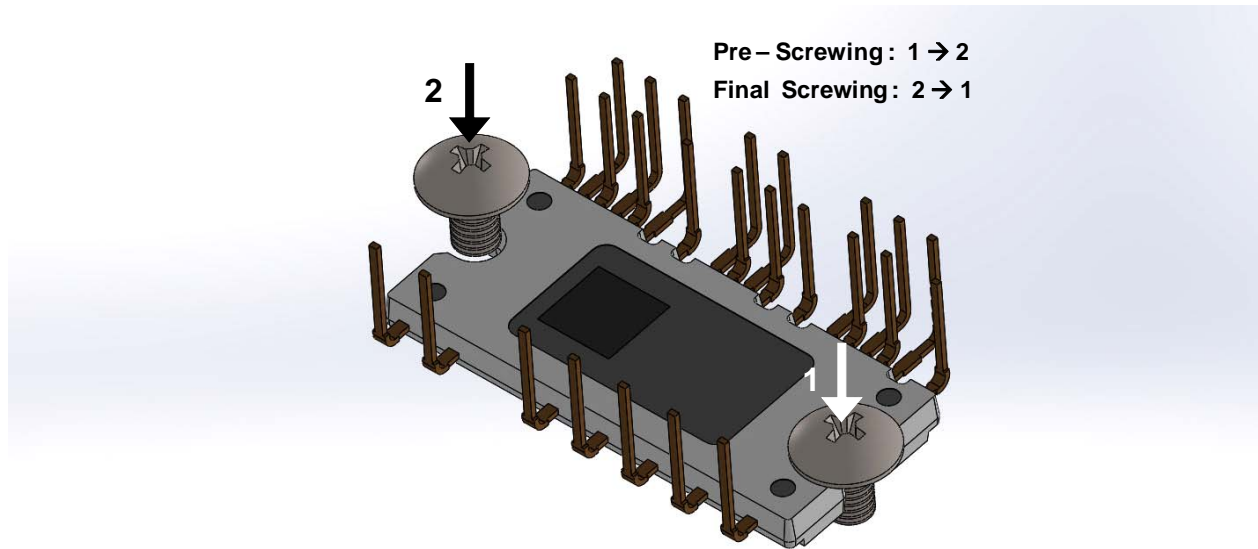


Figure 10. Mounting Screws Torque Order

Note:

9. Do not make over torque when mounting screws. Much mounting torque may cause package cracks, as well as bolts and Al heat-sink destruction.
10. 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

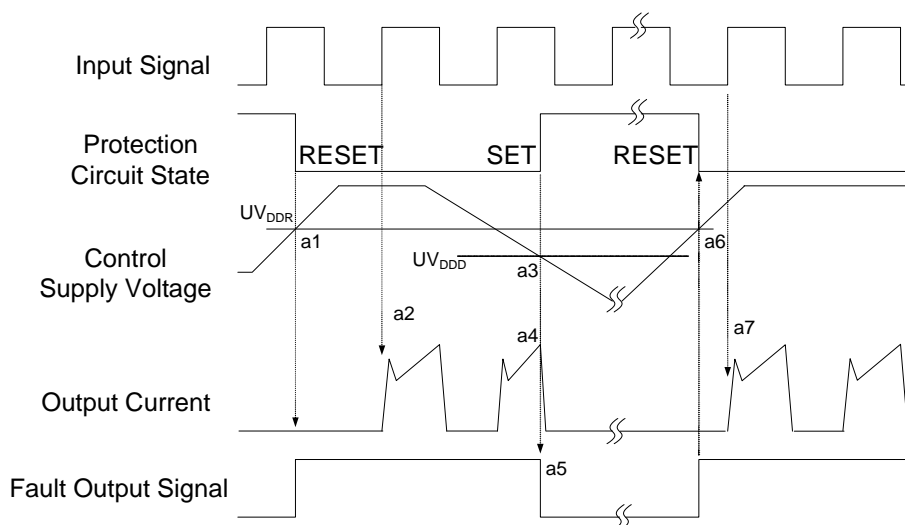


Figure 11. Under-Voltage Protection (Low-Side)

- 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_{DDR}).
- 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.

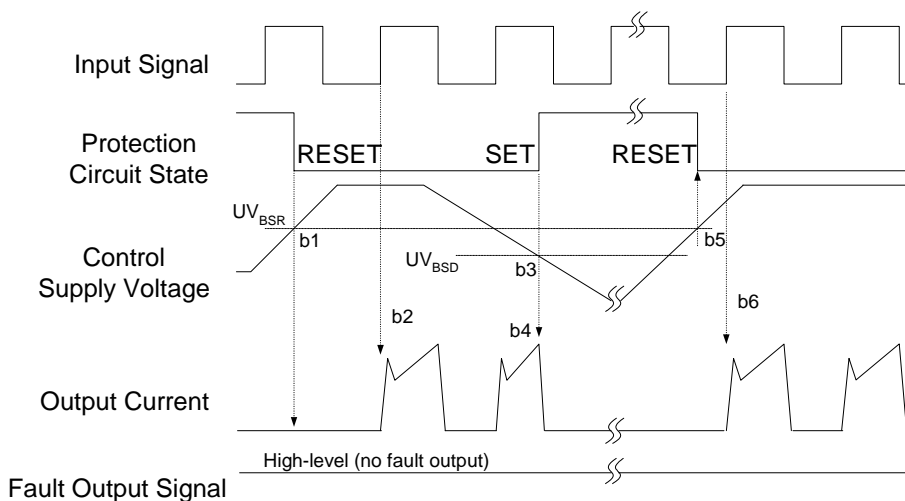


Figure 12. Under-Voltage Protection (High-Side)

- 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

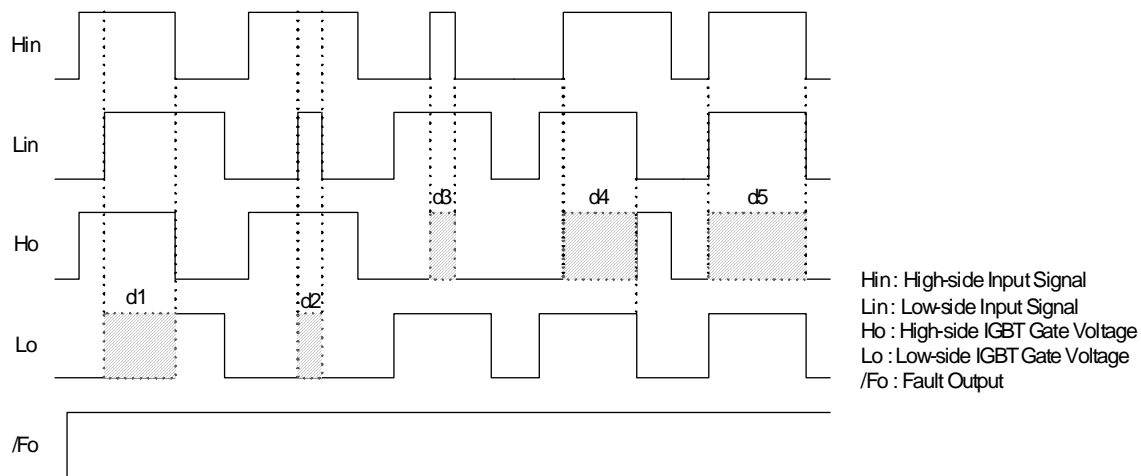


Figure 13. Inter-Lock Function

- 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

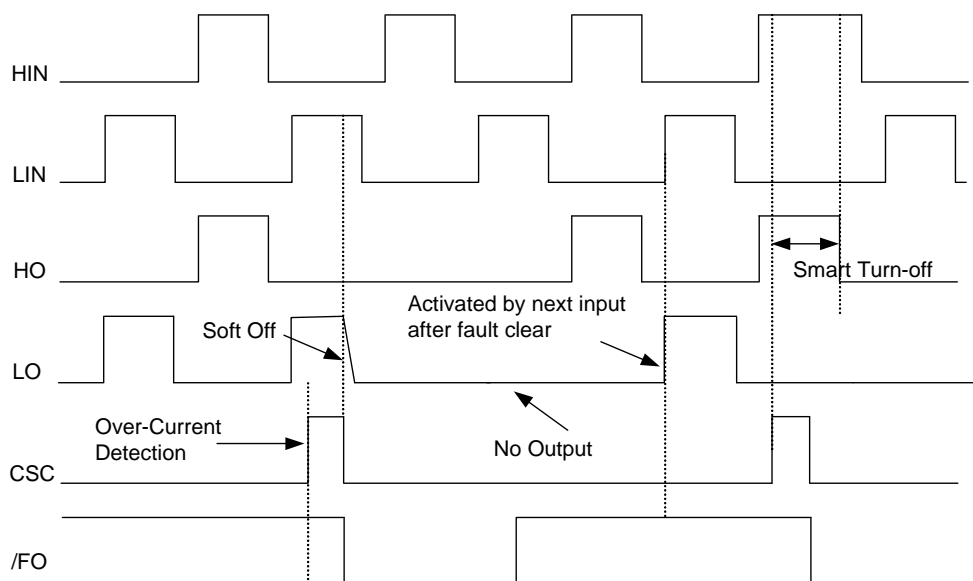


Figure 14. Fault-Out Function By Over Current Protection

- HIN : High-side Input Signal
- LIN : Low-side Input Signal
- HO : High-Side Output Signal
- LO : Low-Side Output Signal
- CSC : Over Current Detection Input
- /FO : Fault Out Function

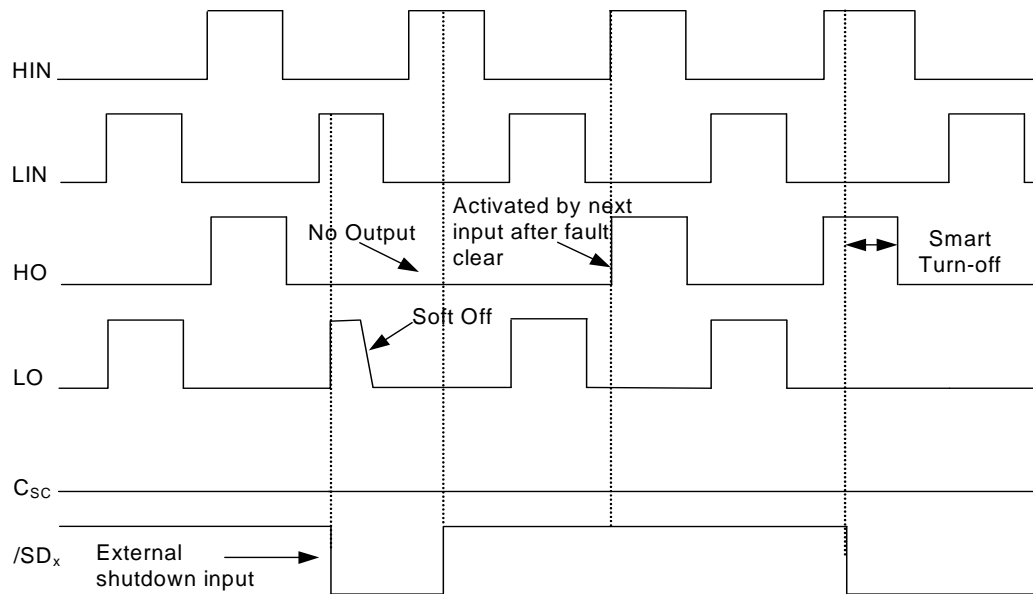


Figure 15. Shutdown Input Function By External Command

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

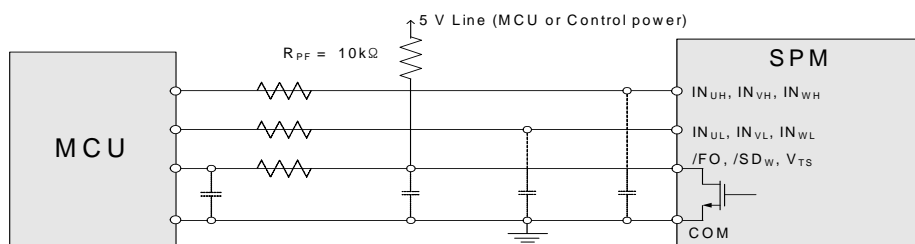


Figure 16. Recommended MCU I/O Interface Circuit

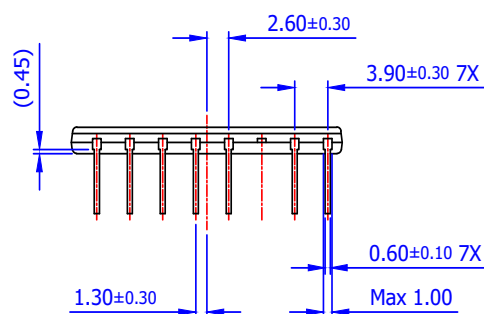
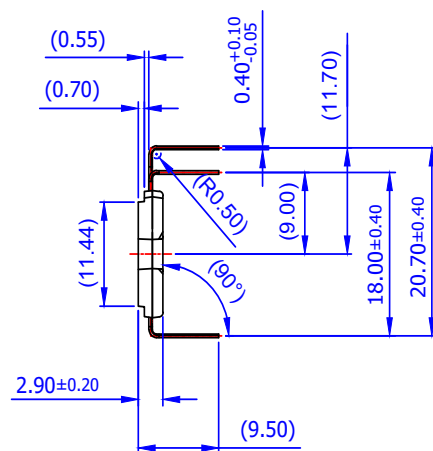
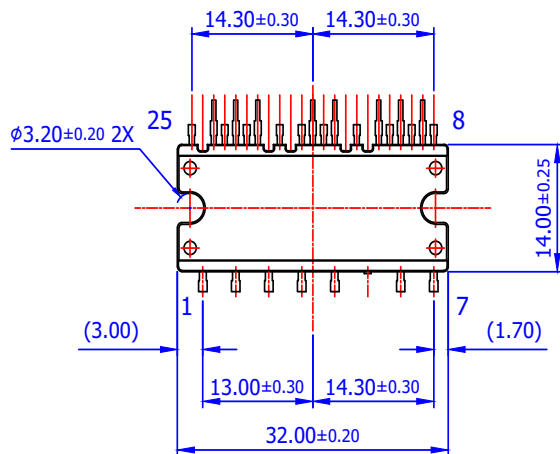
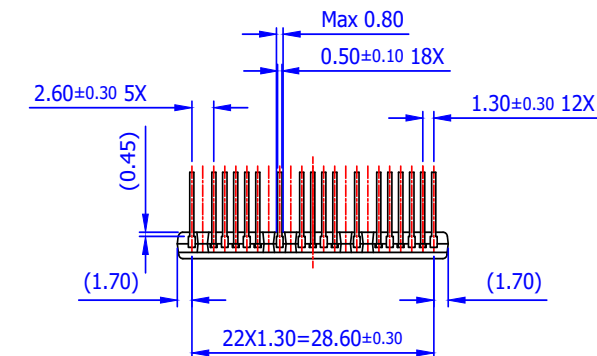
Note:

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 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.

Note:

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Detailed Package Outline Drawings (FNB81560T3, 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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