

# Motion SPM<sup>®</sup> 2 Series, 600 V

## FNA25060

### General Description

The FNA25060 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.

### Features

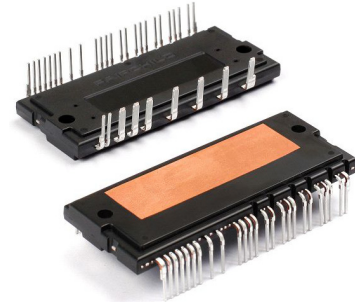
- UL Certified No. E209204 (UL1557)
- 600 V – 50 A 3-Phase IGBT Inverter, Including Control ICs for Gate Drive and Protections
- Low-Loss, Short-Circuit-Rated IGBTs
- Very Low Thermal Resistance Using Al<sub>2</sub>O<sub>3</sub> DBC Substrate
- Built-In Bootstrap Diodes and Dedicated Vs Pins Simplify 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.
- This Device is Pb-Free, Halogen Free/BFR Free and is RoHS Compliant

### Applications

- Motion Control – Industrial Motor (AC 200 V Class)

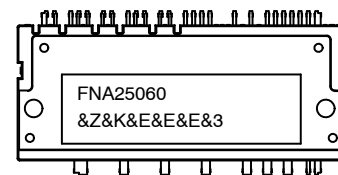
### Related Resources

- [AN-9121 – Users Guide for 600V SPM 2 Series](#)
- [AN-9076 – Mounting Guide for New SPM 2 Package](#)
- [AN-9079 – Thermal Performance of Motion SPM 2 Series by Mounting Torque](#)



SPMCA-A34  
CASE MODFQ

### MARKING DIAGRAM



|          |                        |
|----------|------------------------|
| FNA25060 | = Specific Device Code |
| &Z       | = Assembly Plant Code  |
| &K       | = Lot Code             |
| &E       | = Space Designator     |
| &3       | = 3-Digit Date Code    |

### ORDERING INFORMATION

See detailed ordering and shipping information on page 2 of this data sheet.

# FNA25060

## PACKAGE MARKING AND ORDERING INFORMATION

| Device   | Device Marking | Package   | Packing Type | Quantity |
|----------|----------------|-----------|--------------|----------|
| FNA25060 | FNA25060       | SPMCA-A34 | Rail         | 6        |

### Integrated Power Functions

- 600 V – 50 A IGBT inverter for three-phase DC / AC power conversion (refer to Figure 2)

### 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 Protection (UVLO),
  - Available bootstrap circuit example is given in Figures 4 and 14
- 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

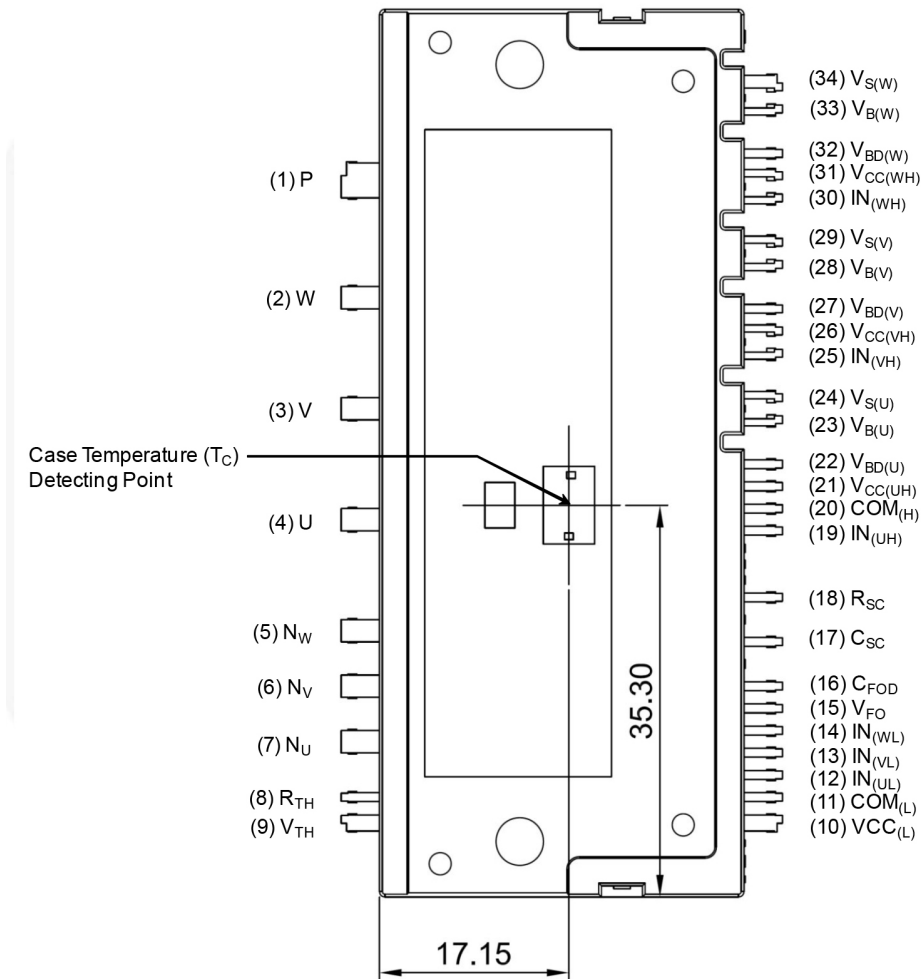
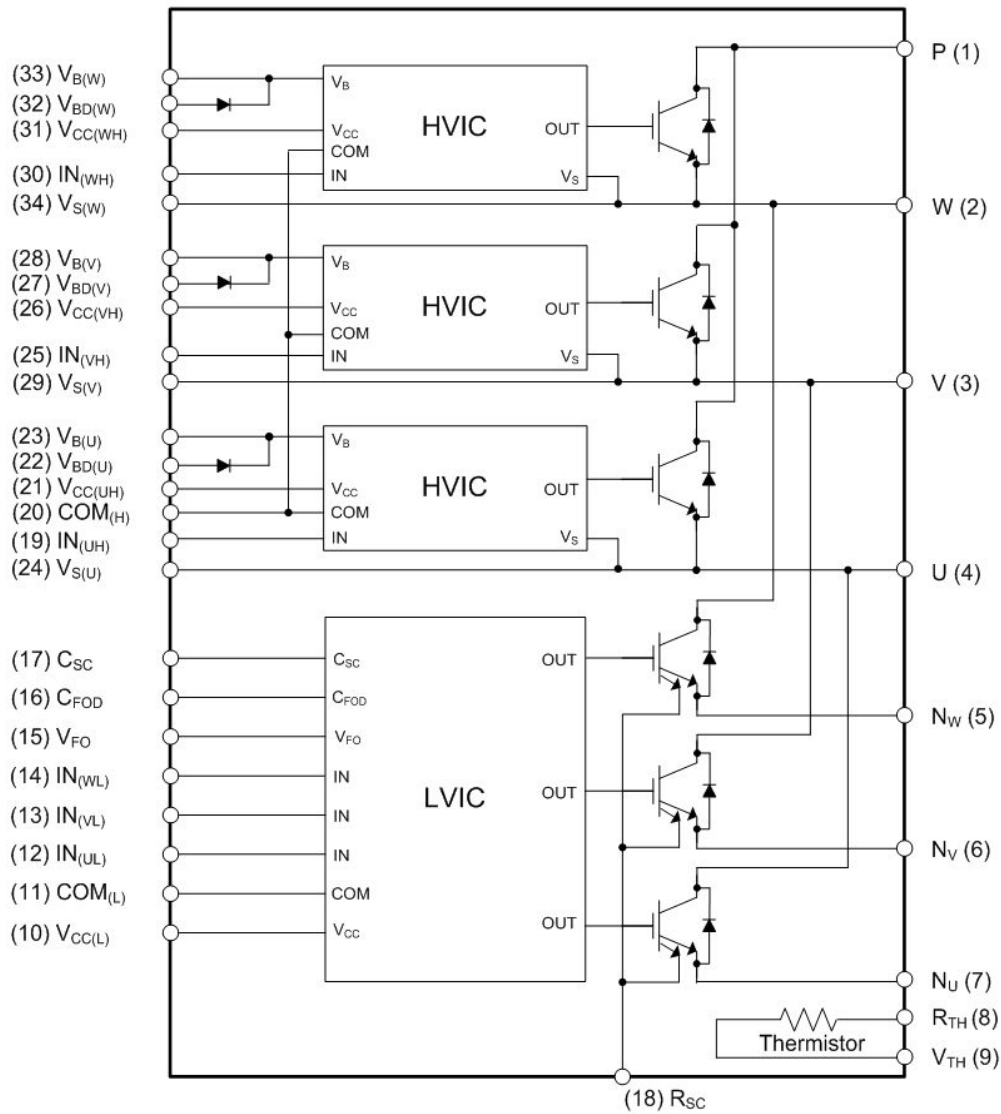


Figure 1. Top View

## PIN DESCRIPTIONS

| Pin No. | 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 <sub>W</sub>      | Negative DC-Link Input for W Phase                                    |
| 6       | N <sub>V</sub>      | Negative DC-Link Input for V Phase                                    |
| 7       | N <sub>U</sub>      | Negative DC-Link Input for U Phase                                    |
| 8       | R <sub>TH</sub>     | Series Resistor for Thermistor (Temperature Detection)                |
| 9       | V <sub>TH</sub>     | Thermistor Bias Voltage                                               |
| 10      | V <sub>CC(L)</sub>  | Low-Side Bias Voltage for IC and IGBTs Driving                        |
| 11      | COM <sub>(L)</sub>  | Low-Side Common Supply Ground                                         |
| 12      | IN <sub>(UL)</sub>  | Signal Input for Low-Side U Phase                                     |
| 13      | IN <sub>(VL)</sub>  | Signal Input for Low-Side V Phase                                     |
| 14      | IN <sub>(WL)</sub>  | Signal Input for Low-Side W Phase                                     |
| 15      | V <sub>FO</sub>     | Fault Output                                                          |
| 16      | C <sub>FOD</sub>    | Capacitor for Fault Output Duration Selection                         |
| 17      | C <sub>SC</sub>     | Capacitor (Low-Pass Filter) for Short-Circuit Current Detection Input |
| 18      | R <sub>SC</sub>     | Resistor for Short-Circuit Current Detection                          |
| 19      | IN <sub>(UH)</sub>  | Signal Input for High-Side U Phase                                    |
| 20      | COM <sub>(H)</sub>  | High-Side Common Supply Ground                                        |
| 21      | V <sub>CC(UH)</sub> | High-Side Bias Voltage for U Phase IC                                 |
| 22      | V <sub>BD(U)</sub>  | Anode of Bootstrap Diode for U Phase High-Side Bootstrap Circuit      |
| 23      | V <sub>B(U)</sub>   | High-Side Bias Voltage for U Phase IGBT Driving                       |
| 24      | V <sub>S(U)</sub>   | High-Side Bias Voltage Ground for U Phase IGBT Driving                |
| 25      | IN <sub>(VH)</sub>  | Signal Input for High-Side V Phase                                    |
| 26      | V <sub>CC(VH)</sub> | High-Side Bias Voltage for V Phase IC                                 |
| 27      | V <sub>BD(V)</sub>  | Anode of Bootstrap Diode for V Phase High-Side Bootstrap Circuit      |
| 28      | V <sub>B(V)</sub>   | High-Side Bias Voltage for V Phase IGBT Driving                       |
| 29      | V <sub>S(V)</sub>   | High-Side Bias Voltage Ground for V Phase IGBT Driving                |
| 30      | IN <sub>(WH)</sub>  | Signal Input for High-Side W Phase                                    |
| 31      | V <sub>CC(WH)</sub> | High-Side Bias Voltage for W Phase IC                                 |
| 32      | V <sub>BD(W)</sub>  | Anode of Bootstrap Diode for W Phase High-Side Bootstrap Circuit      |
| 33      | V <sub>B(W)</sub>   | High-Side Bias Voltage for W Phase IGBT Driving                       |
| 34      | V <sub>S(W)</sub>   | High-Side Bias Voltage Ground for W Phase IGBT Driving                |

Internal Equivalent Circuit and Input/Output Pins



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.

Figure 2. Internal Block Diagram

# FNA25060

## ABSOLUTE MAXIMUM RATINGS (T<sub>C</sub> = 25°C, Unless Otherwise Specified)

| Symbol | Parameter | Conditions | Rating | Unit |
|--------|-----------|------------|--------|------|
|--------|-----------|------------|--------|------|

### INVERTER PART

|                        |                                    |                                                                                |           |    |
|------------------------|------------------------------------|--------------------------------------------------------------------------------|-----------|----|
| V <sub>PN</sub>        | Supply Voltage                     | Applied between P – N <sub>U</sub> , N <sub>V</sub> , N <sub>W</sub>           | 450       | V  |
| V <sub>PN(Surge)</sub> | Supply Voltage (Surge)             | Applied between P – N <sub>U</sub> , N <sub>V</sub> , N <sub>W</sub>           | 500       | V  |
| V <sub>CES</sub>       | Collector – Emitter Voltage        |                                                                                | 600       | V  |
| ±I <sub>C</sub>        | Each IGBT Collector Current        | T <sub>C</sub> = 25°C, T <sub>J</sub> ≤ 150°C (Note 4)                         | 50        | A  |
| ±I <sub>CP</sub>       | Each IGBT Collector Current (Peak) | T <sub>C</sub> = 25°C, T <sub>J</sub> ≤ 150°C, Under 1 ms Pulse Width (Note 4) | 100       | A  |
| P <sub>C</sub>         | Collector Dissipation              | T <sub>C</sub> = 25°C per One Chip (Note 4)                                    | 192       | W  |
| T <sub>J</sub>         | Operating Junction Temperature     |                                                                                | –40 ~ 150 | °C |

### CONTROL PART

|                 |                                |                                                                                                                                                   |                             |    |
|-----------------|--------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|----|
| V <sub>CC</sub> | Control Supply Voltage         | Applied between V <sub>CC(H)</sub> , V <sub>CC(L)</sub> – COM                                                                                     | 20                          | V  |
| V <sub>BS</sub> | High–Side Control Bias Voltage | Applied between V <sub>B(U)</sub> – V <sub>S(U)</sub> , V <sub>B(V)</sub> – V <sub>S(V)</sub> , V <sub>B(W)</sub> – V <sub>S(W)</sub>             | 20                          | V  |
| V <sub>IN</sub> | Input Signal Voltage           | Applied between IN <sub>(UH)</sub> , IN <sub>(VH)</sub> , IN <sub>(WH)</sub> , IN <sub>(UL)</sub> , IN <sub>(VL)</sub> , IN <sub>(WL)</sub> – COM | –0.3 ~ V <sub>CC</sub> +0.3 | V  |
| V <sub>FO</sub> | Fault Output Supply Voltage    | Applied between V <sub>FO</sub> – COM                                                                                                             | –0.3 ~ V <sub>CC</sub> +0.3 | V  |
| I <sub>FO</sub> | Fault Output Current           | Sink Current at V <sub>FO</sub> pin                                                                                                               | 2                           | mA |
| V <sub>SC</sub> | Current Sensing Input Voltage  | Applied between C <sub>SC</sub> – COM                                                                                                             | –0.3 ~ V <sub>CC</sub> +0.3 | V  |

### BOOTSTRAP DIODE PART

|                  |                                    |                                                                                |           |    |
|------------------|------------------------------------|--------------------------------------------------------------------------------|-----------|----|
| V <sub>RRM</sub> | Maximum Repetitive Reverse Voltage |                                                                                | 600       | V  |
| I <sub>F</sub>   | Forward Current                    | T <sub>C</sub> = 25°C, T <sub>J</sub> ≤ 150°C (Note 4)                         | 1.0       | A  |
| I <sub>FP</sub>  | Forward Current (Peak)             | T <sub>C</sub> = 25°C, T <sub>J</sub> ≤ 150°C, Under 1 ms Pulse Width (Note 4) | 2.0       | A  |
| T <sub>J</sub>   | Operating Junction Temperature     |                                                                                | –40 ~ 150 | °C |

### TOTAL SYSTEM

|                       |                                                                            |                                                                                                                             |           |                  |
|-----------------------|----------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|-----------|------------------|
| V <sub>PN(PROT)</sub> | Self–Protection Supply Voltage Limit (Short–Circuit Protection Capability) | V <sub>CC</sub> = V <sub>BS</sub> = 13.5 ~ 16.5 V, T <sub>J</sub> = 150°C, V <sub>CES</sub> < 600 V, Non–Repetitive, < 2 μs | 400       | V                |
| T <sub>C</sub>        | Module Case Operation Temperature                                          | See Figure 2                                                                                                                | –40 ~ 125 | °C               |
| T <sub>STG</sub>      | Storage Temperature                                                        |                                                                                                                             | –40 ~ 125 | °C               |
| V <sub>ISO</sub>      | Isolation Voltage                                                          | 60 Hz, Sinusoidal, AC 1 Minute, Connection Pins to Heat Sink Plate                                                          | 2500      | V <sub>rms</sub> |

### THERMAL RESISTANCE

| Symbol                | Parameter                                    | Conditions                            | Min. | Typ. | Max. | Unit |
|-----------------------|----------------------------------------------|---------------------------------------|------|------|------|------|
| R <sub>th(j-c)Q</sub> | Junction to Case Thermal Resistance (Note 5) | Inverter IGBT Part (per 1 / 6 Module) | –    | –    | 0.65 | °C/W |
| R <sub>th(j-c)F</sub> |                                              | Inverter FWD Part (per 1 / 6 Module)  | –    | –    | 1.12 | °C/W |

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

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

5. For the measurement point of case temperature (T<sub>C</sub>), please refer to Figure 1.

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

| Symbol               | Parameter                              | Conditions                                                                                                                                                                                          | Min. | Typ. | Max. | Unit          |
|----------------------|----------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|---------------|
| <b>INVERTER PART</b> |                                        |                                                                                                                                                                                                     |      |      |      |               |
| $V_{CE(SAT)}$        | Collector – Emitter Saturation Voltage | $V_{CC} = V_{BS} = 15\text{ V}$<br>$V_{IN} = 5\text{ V}$                                                                                                                                            |      |      |      |               |
|                      |                                        | $I_C = 50\text{ A}$ ,<br>$T_J = 25^\circ\text{C}$                                                                                                                                                   | –    | 1.50 | 2.10 | V             |
| $V_F$                | FWDi Forward Voltage                   | $V_{IN} = 0\text{ V}$                                                                                                                                                                               |      |      |      |               |
|                      |                                        | $I_F = 50\text{ A}$ ,<br>$T_J = 25^\circ\text{C}$                                                                                                                                                   | –    | 1.80 | 2.40 | V             |
| HS                   | $t_{ON}$                               | $V_{PN} = 300\text{ V}$ , $V_{CC} = 15\text{ V}$ , $I_C = 50\text{ A}$<br>$T_J = 25^\circ\text{C}$<br>$V_{IN} = 0\text{ V} \leftrightarrow 5\text{ V}$ , Inductive Load<br>See Figure 4<br>(Note 6) | 0.80 | 1.30 | 1.90 | $\mu\text{s}$ |
|                      | $t_{C(ON)}$                            |                                                                                                                                                                                                     | –    | 0.30 | 0.70 | $\mu\text{s}$ |
|                      | $t_{OFF}$                              |                                                                                                                                                                                                     | –    | 1.20 | 1.80 | $\mu\text{s}$ |
|                      | $t_{C(OFF)}$                           |                                                                                                                                                                                                     | –    | 0.15 | 0.55 | $\mu\text{s}$ |
|                      | $t_{rr}$                               |                                                                                                                                                                                                     | –    | 0.25 | –    | $\mu\text{s}$ |
| LS                   | $t_{ON}$                               | $V_{PN} = 300\text{ V}$ , $V_{CC} = 15\text{ V}$ , $I_C = 50\text{ A}$<br>$T_J = 25^\circ\text{C}$<br>$V_{IN} = 0\text{ V} \leftrightarrow 5\text{ V}$ , Inductive Load<br>See Figure 4<br>(Note 6) | 0.50 | 1.00 | 1.60 | $\mu\text{s}$ |
|                      | $t_{C(ON)}$                            |                                                                                                                                                                                                     | –    | 0.30 | 0.70 | $\mu\text{s}$ |
|                      | $t_{OFF}$                              |                                                                                                                                                                                                     | –    | 1.20 | 1.80 | $\mu\text{s}$ |
|                      | $t_{C(OFF)}$                           |                                                                                                                                                                                                     | –    | 0.25 | 0.65 | $\mu\text{s}$ |
|                      | $t_{rr}$                               |                                                                                                                                                                                                     | –    | 0.20 | –    | $\mu\text{s}$ |
| $I_{CES}$            | Collector – Emitter Leakage Current    | $V_{CE} = V_{CES}$                                                                                                                                                                                  | –    | –    | 5    | mA            |

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

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 3.

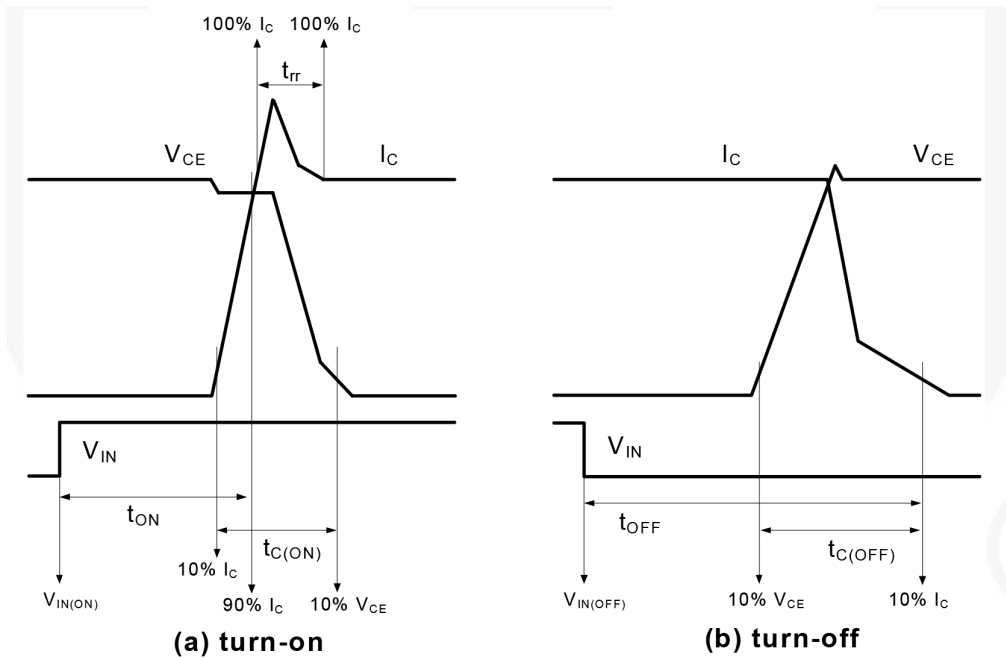


Figure 3. Switching Time Definition

# FNA25060

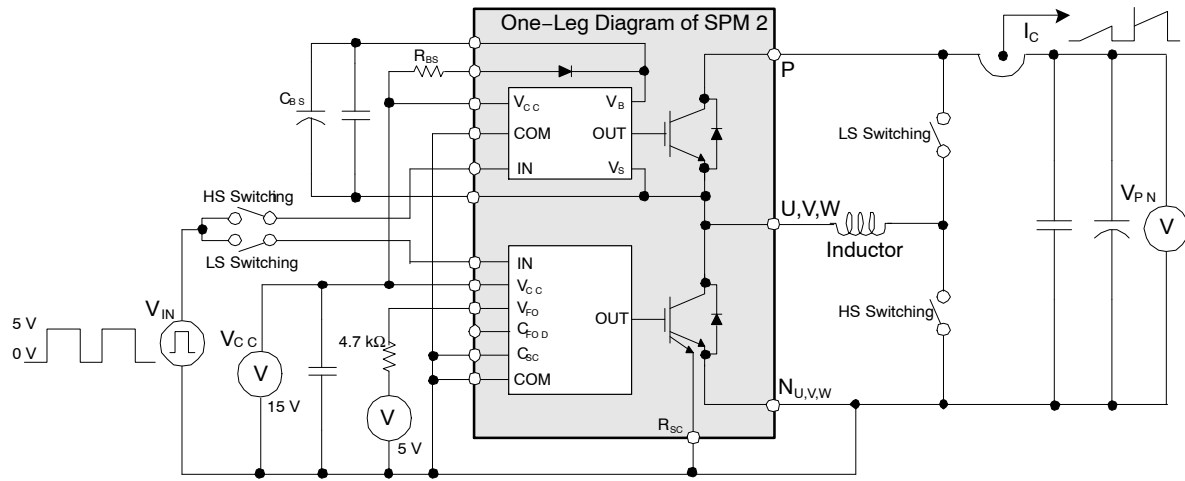


Figure 4. Example Circuit for Switching Test

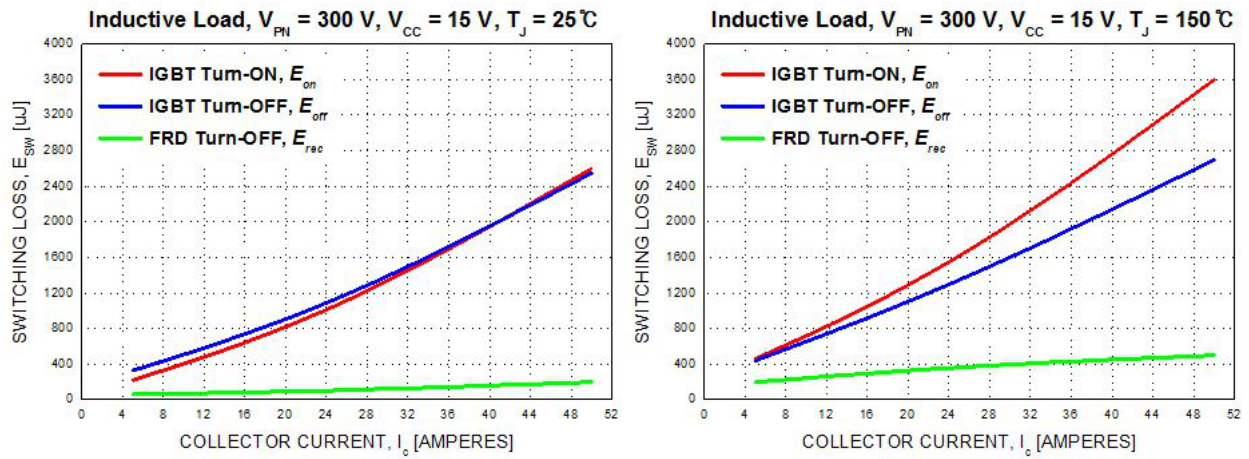


Figure 5. Switching Loss Characteristics (Typical)

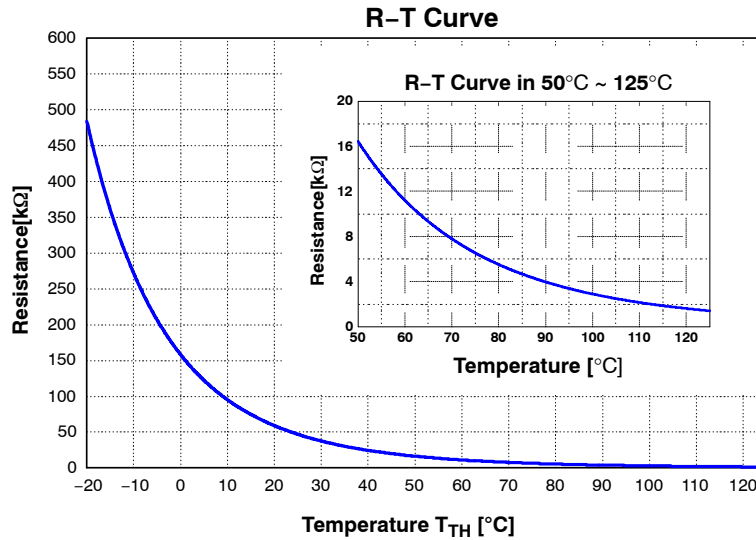


Figure 6. R-T Curve of Built-in Thermistor

## BOOTSTRAP DIODE PART

| Symbol | Parameter             | Conditions                                                                                     | Min. | Typ. | Max. | Unit |
|--------|-----------------------|------------------------------------------------------------------------------------------------|------|------|------|------|
| $V_F$  | Forward Voltage       | $I_F = 1.0 \text{ A}$ , $T_J = 25^\circ\text{C}$                                               | –    | 2.2  | –    | V    |
| trr    | Reverse-Recovery Time | $I_F = 1.0 \text{ A}$ , $dI_F / dt = 50 \text{ A} / \mu\text{s}$ ,<br>$T_J = 25^\circ\text{C}$ | –    | 80   | –    | ns   |

## CONTROL PART

| Symbol        | Parameter                               | Conditions                                                                                                                                  | Min.                                                                                 | Typ. | Max. | Unit             |
|---------------|-----------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|------|------|------------------|
| $I_{QCH}$     | Quiescent $V_{CC}$ Supply Current       | $V_{CC(UH, VH, WH)} = 15 \text{ V}$ ,<br>$I_{N(UH, VH, WH)} = 0 \text{ V}$                                                                  | $V_{CC(UH)} - COM_{(H)}$ ,<br>$V_{CC(VH)} - COM_{(H)}$ ,<br>$V_{CC(WH)} - COM_{(H)}$ |      |      | 0.15 mA          |
| $I_{QCL}$     |                                         | $V_{CC(L)} = 15 \text{ V}$ ,<br>$I_{N(UL, VL, WL)} = 0 \text{ V}$                                                                           | $V_{CC(L)} - COM_{(L)}$                                                              |      |      | 5.00 mA          |
| $I_{PCH}$     | Operating $V_{CC}$ Supply Current       | $V_{CC(UH, VH, WH)} = 15 \text{ V}$ ,<br>$f_{PWM} = 20 \text{ kHz}$ , Duty = 50%,<br>Applied to one PWM Signal<br>Input for High-Side       | $V_{CC(UH)} - COM_{(H)}$ ,<br>$V_{CC(VH)} - COM_{(H)}$ ,<br>$V_{CC(WH)} - COM_{(H)}$ |      |      | 0.30 mA          |
| $I_{PCL}$     |                                         | $V_{CC(L)} = 15 \text{ V}$ , $f_{PWM} = 20 \text{ kHz}$ ,<br>Duty = 50%, Applied to one<br>PWM Signal Input for Low-Side                    | $V_{CC(L)} - COM_{(L)}$                                                              |      |      | 9.00 mA          |
| $I_{QBS}$     | Quiescent $V_{BS}$ Supply Current       | $V_{BS} = 15 \text{ V}$ , $I_{N(UH, VH, WH)} = 0 \text{ V}$                                                                                 | $V_{B(U)} - V_{S(U)}$ ,<br>$V_{B(V)} - V_{S(V)}$ ,<br>$V_{B(W)} - V_{S(W)}$          |      |      | 0.30 mA          |
| $I_{PBS}$     | Operating $V_{BS}$ Supply Current       | $V_{CC} = V_{BS} = 15 \text{ V}$ ,<br>$f_{PWM} = 20 \text{ kHz}$ ,<br>Duty = 50%, Applied to one<br>PWM Signal Input for High-Side          | $V_{B(U)} - V_{S(U)}$ ,<br>$V_{B(V)} - V_{S(V)}$ ,<br>$V_{B(W)} - V_{S(W)}$          |      |      | 6.50 mA          |
| $V_{FOH}$     | Fault Output Voltage                    | $V_{CC} = 15 \text{ V}$ , $V_{SC} = 0 \text{ V}$ , $V_{FO}$ Circuit: 4.7 k $\Omega$ to 5 V Pull-up                                          | 4.5                                                                                  | –    | –    | V                |
| $V_{FOL}$     |                                         | $V_{CC} = 15 \text{ V}$ , $V_{SC} = 1 \text{ V}$ , $V_{FO}$ Circuit: 4.7 k $\Omega$ to 5 V Pull-up                                          | –                                                                                    | –    | 0.5  | V                |
| $I_{SEN}$     | Sensing Current of Each Sense IGBT      | $V_{CC} = 15 \text{ V}$ , $V_{IN} = 5 \text{ V}$ ,<br>$R_{SC} = 0 \Omega$ ,<br>No Connection of Shunt<br>Resistor at $N_{U, V, W}$ Terminal | $I_C = 50 \text{ A}$                                                                 |      |      | 20 mA            |
| $V_{SC(ref)}$ | Short Circuit Trip Level                | $V_{CC} = 15 \text{ V}$ (Note 7)                                                                                                            | $CSC - COM_{(L)}$                                                                    |      |      | 0.43 0.50 0.57 V |
| $I_{SC}$      | Short Circuit Current Level for Trip    | $R_{SC} = 18 \Omega (\pm 1\%)$ , No Connection of Shunt Resistor at $N_{U, V, W}$ Terminal (Note 7)                                         | –                                                                                    | 100  | –    | 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                   | $C_{FOD} = \text{Open}$                                                                                                                     | (Note 8)                                                                             |      |      | 50 $\mu\text{s}$ |
|               |                                         | $C_{FOD} = 2.2 \text{ nF}$                                                                                                                  |                                                                                      |      |      | 1.7 ms           |
| $V_{IN(ON)}$  | ON Threshold Voltage                    | Applied between $I_{N(UH, VH, WH)} - COM_{(H)}$ , $I_{N(UL, VL, WL)} - COM_{(L)}$                                                           | –                                                                                    | –    | 2.6  | V                |
| $V_{IN(OFF)}$ | OFF Threshold Voltage                   |                                                                                                                                             | 0.8                                                                                  | –    | –    | V                |
| $R_{TH}$      | Resistance of Thermistor                | at $T_{TH} = 25^\circ\text{C}$                                                                                                              | See Figure 6                                                                         |      |      | – k $\Omega$     |
|               |                                         | at $T_{TH} = 100^\circ\text{C}$                                                                                                             | (Note 9)                                                                             |      |      | – 2.9 k $\Omega$ |

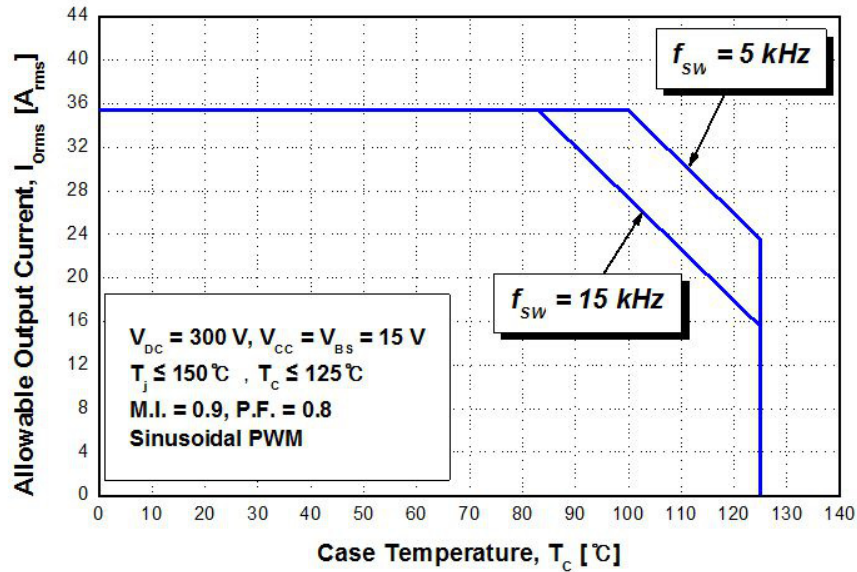
7. Short-circuit current protection functions only at the low-sides because the sense current is divided from main current at low-side IGBTs. Inserting the shunt resistor for monitoring the phase current at  $N_U$ ,  $N_V$ ,  $N_W$  terminal, the trip level of the short-circuit current is changed.
8. The fault-out pulse width  $t_{FOD}$  depends on the capacitance value of  $C_{FOD}$  according to the following approximate equation:  
 $t_{FOD} = 0.8 \times 10^6 \times C_{FOD} [\text{s}]$ .
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  | 400  | V                  |
| $V_{CC}$                       | Control Supply Voltage                   | Applied between $V_{CC(UH, VH, WH)} - COM_{(H)}$ , $V_{CC(L)} - COM_{(L)}$                                                                             | 14.5  | 15.0 | 16.5 | V                  |
| $V_{BS}$                       | High-Side Bias Voltage                   | Applied between $V_{B(U)} - V_{S(U)}$ , $V_{B(V)} - V_{S(V)}$ , $V_{B(W)} - V_{S(W)}$                                                                  | 13.5  | 15.0 | 18.5 | V                  |
| $dV_{CC}/dt$ ,<br>$dV_{BS}/dt$ | Control Supply Variation                 |                                                                                                                                                        | –1    | –    | 1    | V / $\mu$ s        |
| $t_{dead}$                     | Blanking Time for Preventing Arm – Short | For Each Input Signal                                                                                                                                  | 2.0   | –    | –    | $\mu$ s            |
| $f_{PWM}$                      | PWM Input Signal                         | $-40^{\circ}\text{C} \leq T_C \leq 125^{\circ}\text{C}$ ,<br>$-40^{\circ}\text{C} \leq T_J \leq 150^{\circ}\text{C}$                                   | –     | –    | 20   | kHz                |
| $V_{SEN}$                      | Voltage for Current Sensing              | Applied between $N_U$ , $N_V$ , $N_W - COM_{(H, L)}$<br>(Including Surge Voltage)                                                                      | –5    |      | 5    | V                  |
| $PW_{IN(ON)}$                  | Minimum Input Pulse Width                | $V_{CC} = V_{BS} = 15\text{ V}$ , $I_C \leq 100\text{ A}$ ,<br>Wiring Inductance between $N_U$ , $V$ , $W$<br>and DC Link $N < 10\text{ nH}$ (Note 10) | 2.5   | –    | –    | $\mu$ s            |
| $PW_{IN(OFF)}$                 |                                          |                                                                                                                                                        | 2.5   | –    | –    |                    |
| $T_J$                          | Junction Temperature                     |                                                                                                                                                        | –40   | –    | 150  | $^{\circ}\text{C}$ |

Functional operation above the stresses listed in the Recommended Operating Ranges is not implied. Extended exposure to stresses beyond the Recommended Operating Ranges limits may affect device reliability.

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



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.

Figure 7. Allowable Maximum Output Current

## MECHANICAL CHARACTERISTICS AND RATINGS

| Parameter                 | Conditions                          |                        | Min. | Typ. | Max. | Unit  |
|---------------------------|-------------------------------------|------------------------|------|------|------|-------|
| Device Flatness           | See Figure 9                        |                        | 0    | –    | +200 | μm    |
| Mounting Torque           | Mounting Screw: M4<br>See Figure 10 | Recommended 1.0 N/m    | 0.9  | 1.0  | 1.5  | N/m   |
|                           |                                     | 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     |

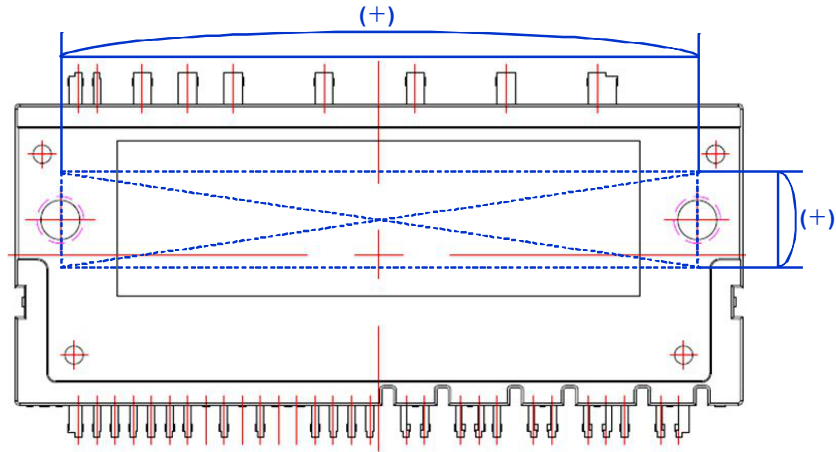


Figure 8. Flatness Measurement Position

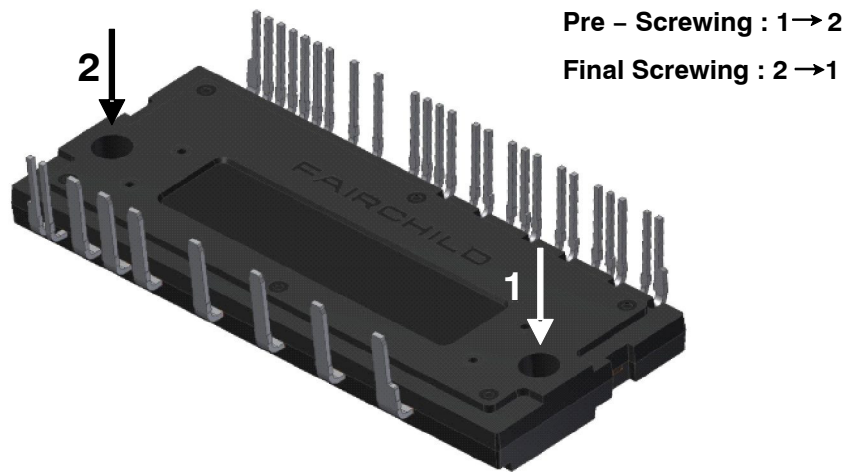
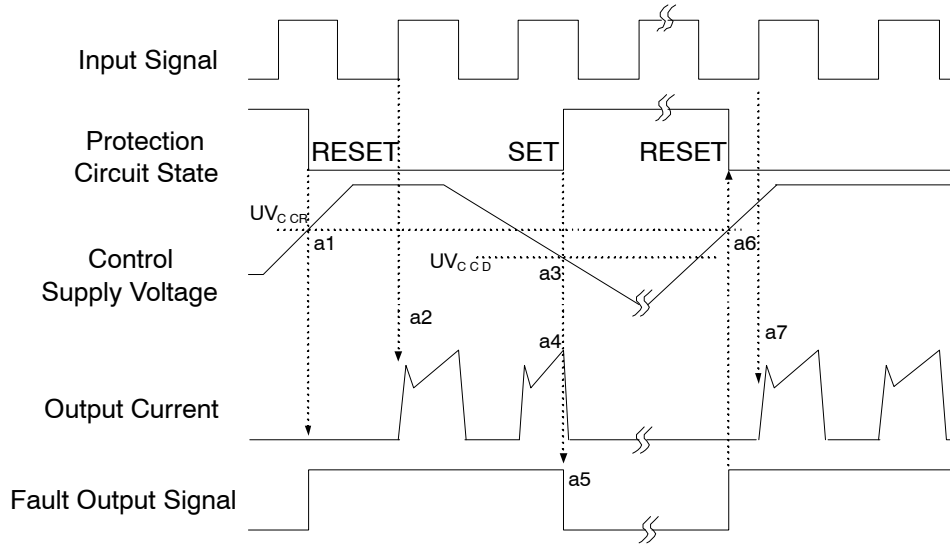


Figure 9. Mounting Screws Torque Order

## NOTES:

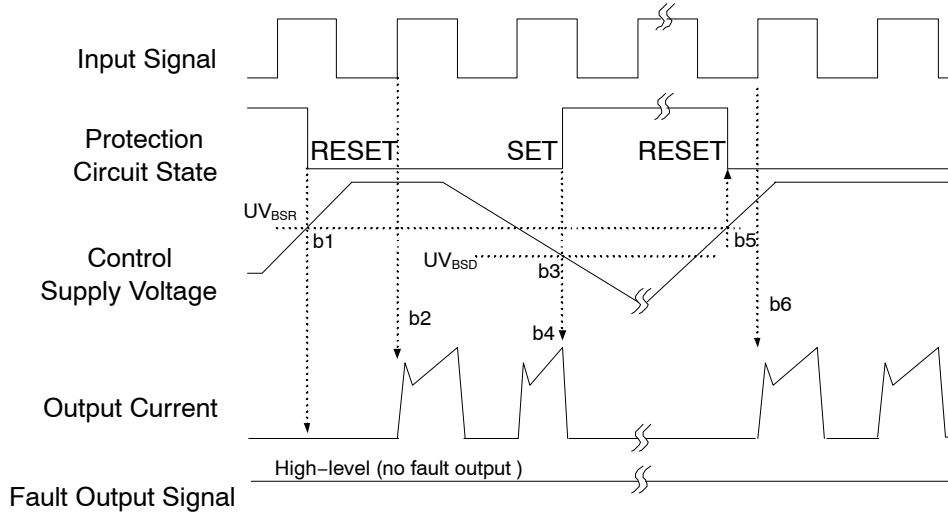
12. Do not over torque when mounting screws. Too much mounting torque may cause DBC cracks, as well as bolts and Al heat-sink destruction.
13. Avoid one-sided tightening stress. Figure 9 shows the recommended torque order for the mounting screws. Uneven mounting can cause the DBC substrate of package to be damaged. The pre-screwing torque is set to 20 ~ 30% of maximum torque rating.

Time Charts of SPMs Protective Function



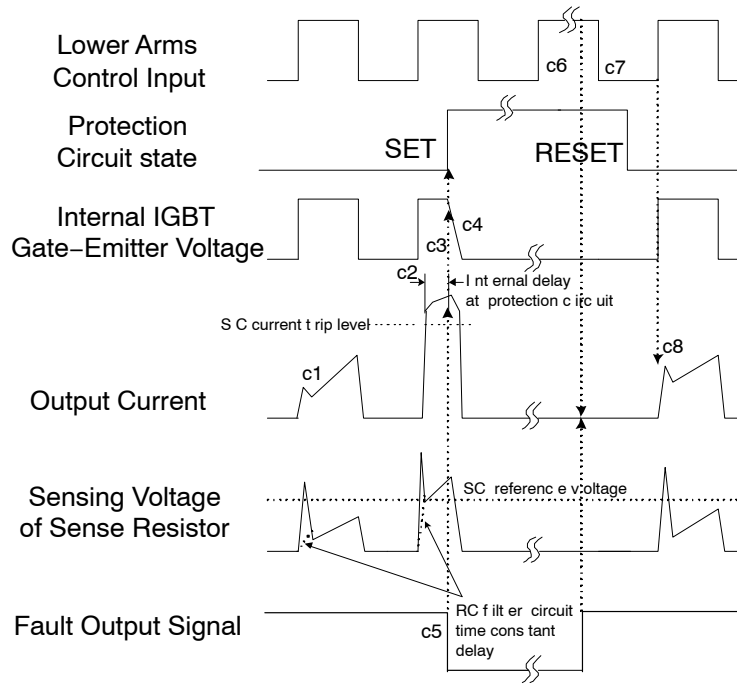
- a1 : Control supply voltage rises: after the voltage rises  $UV_{CCR}$ , the circuits start to operate when the next input is applied.  
a2 : Normal operation: IGBT ON and carrying current.  
a3 : Under-voltage detection ( $UV_{CD}$ ).  
a4 : IGBT OFF in spite of control input condition.  
a5 : Fault 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 10. Under-Voltage Protection (Low-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.

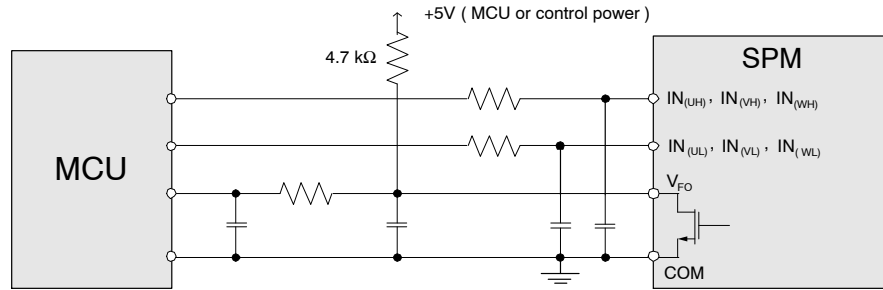
Figure 11. Under-Voltage Protection (High-Side)



- 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 CFOD.
- 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.

**Figure 12. Short-Circuit Current Protection (Low-Side Operation only)**

#### Input/Output Interface Circuit



14. RC coupling at each input 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 kW (typ.) pull-down resistor. Therefore, when using an external filtering resistor, please pay attention to the signal voltage drop at input terminal.

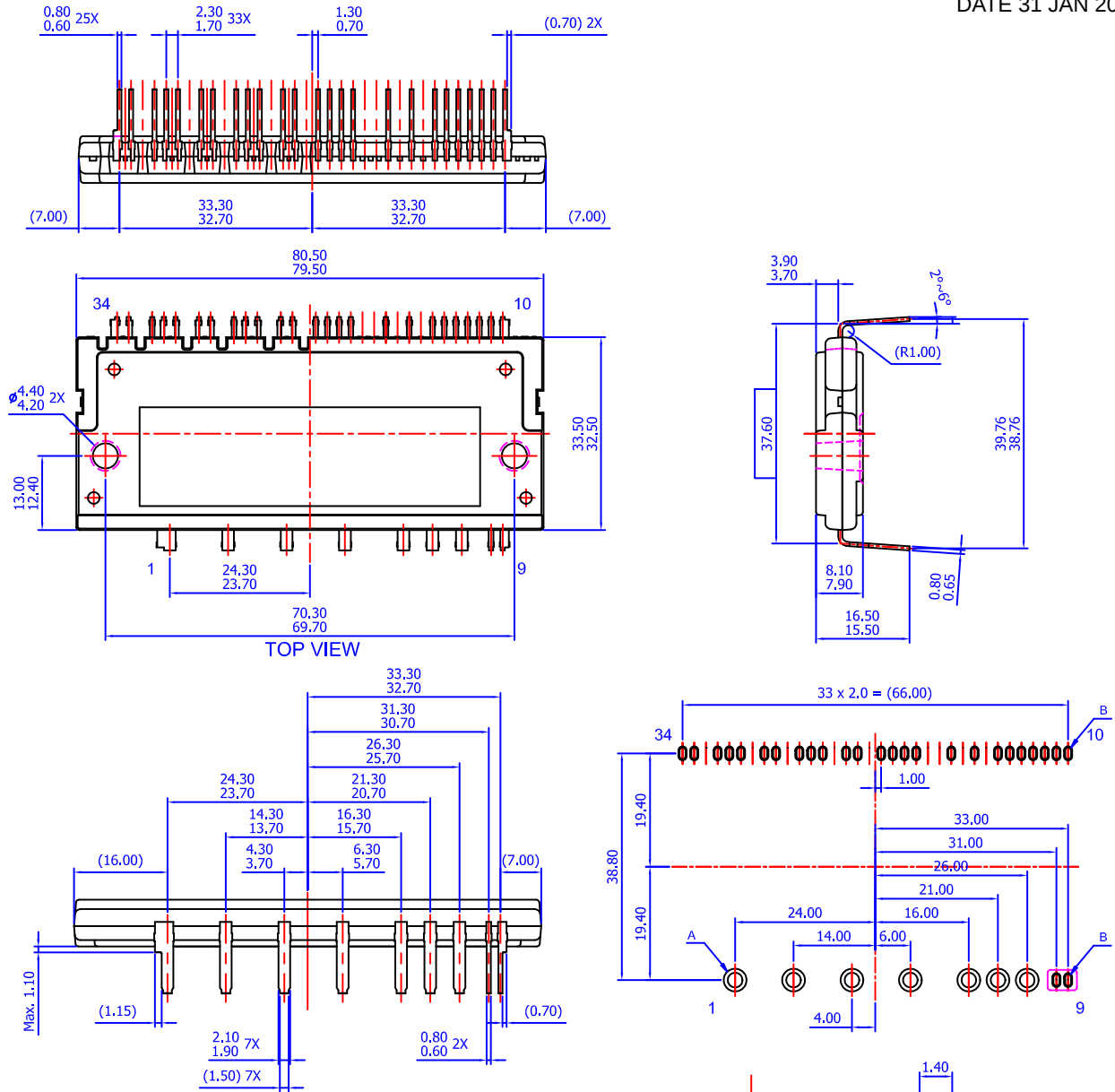
**Figure 13. Recommended MCU I/O Interface Circuit**



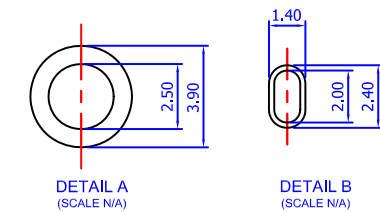
- SPM is a registered trademark of Semiconductor Components Industries, LLC dba "**onsemi**" or its affiliates and/or subsidiaries in the United States and/or other countries.

**SPMCA-A34 / 34LD, PDD STD, DBC DIP TYPE**  
**CASE MODFQ**  
**ISSUE O**

DATE 31 JAN 2017



- NOTES: UNLESS OTHERWISE SPECIFIED**
- A) THIS PACKAGE DOES NOT COMPLY TO ANY CURRENT PACKAGING STANDARD
  - B) ALL DIMENSIONS ARE IN MILLIMETERS
  - C) DIMENSIONS ARE EXCLUSIVE OF BURRS, MOLD FLASH, AND TIE BAR EXTRUSIONS
  - D) PACKAGE SURFACE VOID SHALL NOT EXCEED 2.3 x 2.3 x 1.0mm
  - E) ( ) IS REFERENCE



**LAND PATTERN RECOMMENDATIONS**

|                         |                                                |                                                                                                                                                                                     |
|-------------------------|------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>DOCUMENT NUMBER:</b> | <b>98AON13565G</b>                             | Electronic versions are uncontrolled except when accessed directly from the Document Repository.<br>Printed versions are uncontrolled except when stamped "CONTROLLED COPY" in red. |
| <b>DESCRIPTION:</b>     | <b>SPMCA-A34 / 34LD, PDD STD, DBC DIP TYPE</b> | <b>PAGE 1 OF 1</b>                                                                                                                                                                  |

onsemi and onsemi are trademarks of Semiconductor Components Industries, LLC dba onsemi or its subsidiaries in the United States and/or other countries. onsemi reserves the right to make changes without further notice to any products herein. onsemi makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does onsemi assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation special, consequential or incidental damages. onsemi does not convey any license under its patent rights nor the rights of others.

**onsemi**, **Onsemi**, and other names, marks, and brands are registered and/or common law trademarks of Semiconductor Components Industries, LLC dba "**onsemi**" or its affiliates and/or subsidiaries in the United States and/or other countries. **onsemi** owns the rights to a number of patents, trademarks, copyrights, trade secrets, and other intellectual property. A listing of **onsemi**'s product/patent coverage may be accessed at [www.onsemi.com/site/pdf/Patent-Marking.pdf](http://www.onsemi.com/site/pdf/Patent-Marking.pdf). **onsemi** reserves the right to make changes at any time to any products or information herein, without notice. The information herein is provided "as-is" and **onsemi** makes no warranty, representation or guarantee regarding the accuracy of the information, product features, availability, functionality, or suitability of its products for any particular purpose, nor does **onsemi** assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation special, consequential or incidental damages. Buyer is responsible for its products and applications using **onsemi** products, including compliance with all laws, regulations and safety requirements or standards, regardless of any support or applications information provided by **onsemi**. "Typical" parameters which may be provided in **onsemi** data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals" must be validated for each customer application by customer's technical experts. **onsemi** does not convey any license under any of its intellectual property rights nor the rights of others. **onsemi** products are not designed, intended, or authorized for use as a critical component in life support systems or any FDA Class 3 medical devices or medical devices with a same or similar classification in a foreign jurisdiction or any devices intended for implantation in the human body. Should Buyer purchase or use **onsemi** products for any such unintended or unauthorized application, Buyer shall indemnify and hold **onsemi** and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that **onsemi** was negligent regarding the design or manufacture of the part. **onsemi** is an Equal Opportunity/Affirmative Action Employer. This literature is subject to all applicable copyright laws and is not for resale in any manner.

## ADDITIONAL INFORMATION

### TECHNICAL PUBLICATIONS:

Technical Library: [www.onsemi.com/design/resources/technical-documentation](http://www.onsemi.com/design/resources/technical-documentation)  
onsemi Website: [www.onsemi.com](http://www.onsemi.com)

### ONLINE SUPPORT: [www.onsemi.com/support](http://www.onsemi.com/support)

For additional information, please contact your local Sales Representative at  
[www.onsemi.com/support/sales](http://www.onsemi.com/support/sales)