

# Motion SPM<sup>®</sup> 45 Series

## NFA41560R42

### General Description

NFA41560R42 is a Motion SPM 45 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 RC-IGBTs to minimize EMI and losses, while also providing multiple on-module protection features including under-voltage lockouts, 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 internal IGBTs. Separate negative IGBT terminals are available for each phase to support the widest variety of control algorithms.

### Features

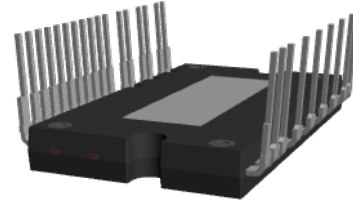
- UL Certified No. E209204 (UL1557)
- 600 V – 15 A 3-Phase RC-IGBT Inverter with Integral Gate Drivers and Protection
- Low Thermal Resistance Using Ceramic Substrate
- Low-Loss, Short-Circuit Rated FS4 RC-IGBTs
- Built-In Bootstrap Diodes and Dedicated Vs Pins Simplify PCB Layout
- Built-In NTC Thermistor for Temperature Monitoring
- Separate Open-Emitter Pins from Low-Side RC-IGBTs for Three-Phase Current Sensing
- Single-Grounded Power Supply
- Isolation Rating: 2000 V<sub>rms</sub> / Min.
- Remove Dummy Pin
- This is a Pb-Free Device

### Applications

- Motion Control – Home Appliance / Industrial Motor

### Related Resources

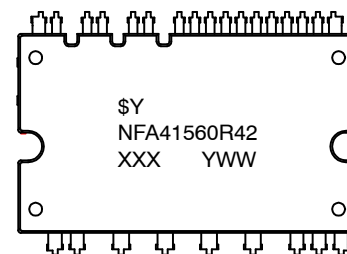
- [AN-9084](#) – Smart Power Module, Motion SPM<sup>®</sup> 45 H V3 Series User's Guide
- [AN-9072](#) – Smart Power Module Motion SPM<sup>®</sup> in SPM45H Thermal Performance Information
- [AN-9071](#) – Smart Power Module Motion SPM<sup>®</sup> in SPM45H Mounting Guidance
- [AN-9760](#) – PCB Design Guidance for SPM<sup>®</sup>



3D Package Drawing (Click to Activate 3D Content)

**SPMAA-C26 / 26LD, PDD STD CERAMIC TYPE,  
LONG LEAD DUAL FORM TYPE  
CASE MODFC**

### MARKING DIAGRAM



\$Y = onsemi Logo  
NFA41560R42 = Specific Device Code  
XXX = Trace Code  
Y = Year  
WW = Work Week

### ORDERING INFORMATION

See detailed ordering and shipping information on page 14 of this data sheet.

## Integrated Power Functions

- 600 V – 15 A IGBT inverter for three-phase DC / AC power conversion (please 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) NOTE: Available bootstrap circuit example is given in Figure 13.
- For inverter low-side IGBTs: gate drive circuit, Short-Circuit Protection (SCP) control supply circuit Under-Voltage Lock-Out Protection (UVLO)
- Fault signaling: corresponding to UVLO (low-side supply) and SC faults
- Input interface: active-HIGH interface, works with 3.3 / 5 V logic, Schmitt-trigger input

## PIN CONFIGURATION

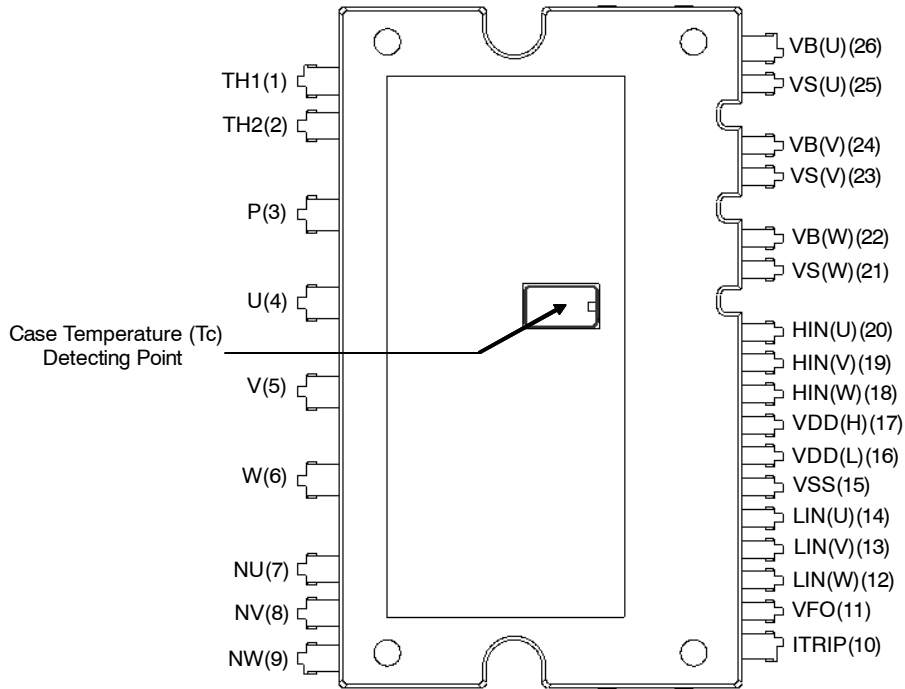


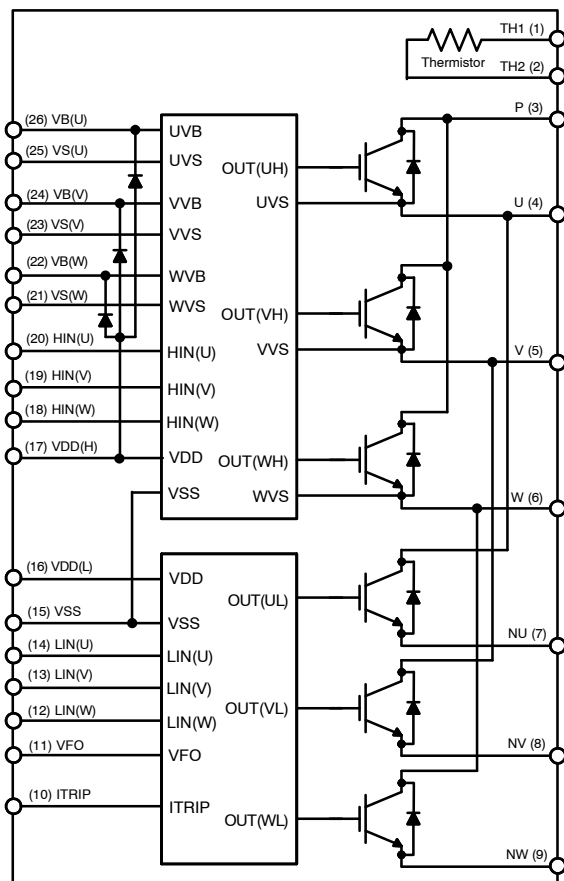
Figure 1. Top View

**PIN DESCRIPTION**

| Pin No. | Pin Name | Description   |
|---------|----------|---|
| 1       | TH1      | Thermistor Bias Voltage   |
| 2       | TH2      | Series Resistor for the Use of Thermistor (Temperature Detection) |
| 3       | P        | Positive DC-Link Input  |
| 4       | U        | Output for U-Phase  |
| 5       | V        | Output for V-Phase  |
| 6       | W        | Output for W-Phase  |
| 7       | NU       | Negative DC-Link Input for U-Phase                                |
| 8       | NV       | Negative DC-Link Input for V-Phase                                |
| 9       | NW       | Negative DC-Link Input for W-Phase                                |
| 10      | ITRIP    | Input for Current Protection                                      |
| 11      | VFO      | Fault Output  |
| 12      | LIN(W)   | Signal Input for Low-Side W-Phase                                 |
| 13      | LIN(V)   | Signal Input for Low-Side V-Phase                                 |
| 14      | LIN(U)   | Signal Input for Low-Side U-Phase                                 |
| 15      | VSS      | Common Supply Ground  |
| 16      | VDD(L)   | Low-Side Common Bias Voltage for IC and IGBTs Driving             |
| 17      | VDD(H)   | High-Side Common Bias Voltage for IC and IGBTs Driving            |
| 18      | HIN(W)   | Signal Input for High-Side W-Phase                                |
| 19      | HIN(V)   | Signal Input for High-Side V-Phase                                |
| 20      | HIN(U)   | Signal Input for High-Side U-Phase                                |
| 21      | VS(W)    | High-Side Bias Voltage Ground for W-Phase IGBT Driving            |
| 22      | VB(W)    | High-Side Bias Voltage for W-Phase IGBT Driving                   |
| 23      | VS(V)    | High-Side Bias Voltage Ground for V-Phase IGBT Driving            |
| 24      | VB(V)    | High-Side Bias Voltage for V-Phase IGBT Driving                   |
| 25      | VS(U)    | High-Side Bias Voltage Ground for U-Phase IGBT Driving            |
| 26      | VB(U)    | High-Side Bias Voltage for U-Phase IGBT Driving                   |

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## Internal Equivalent Circuit and Input/Output Pins



### NOTE:

1. Inverter high-side is composed of three RC-IGBTs and one control IC for each IGBT.
2. Inverter low-side is composed of three RC-IGBTs 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**

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## ABSOLUTE MAXIMUM RATINGS (T<sub>j</sub> = 25°C, unless otherwise noted)

| Symbol               | Parameter                          | Conditions                                    | Rating   | Unit |
|----------------------|------------------------------------|---|----------|------|
| <b>INVERTER PART</b> |                                    |   |          |      |
| VPN                  | Supply Voltage                     | P – NU, NV, NW                                | 450      | V    |
| VPN(surge)           | Supply Voltage (Surge)             | P – NU, NV, NW                                | 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                         | 15       | A    |
| ±I <sub>cp</sub>     | Each IGBT Collector Current (Peak) | T <sub>c</sub> = 25°C, Under 1 ms Pulse Width | 30       | A    |
| P <sub>c</sub>       | Collector Dissipation              | T <sub>c</sub> = 25°C Per One Chip (Note 4)   | 45       | W    |
| T <sub>j</sub>       | Operating Junction Temperature     |   | – 40~150 | °C   |

## CONTROL PART

|        |                                |   |                |    |
|--------|--------------------------------|---|----------------|----|
| VDD    | Control Supply Voltage         | VDD(H), VDD(L) – VSS                                    | 20             | V  |
| VBS    | High-Side Control Bias Voltage | VB(U) – VS(U), VB(V) – VS(V),<br>VB(W) – VS(W)          | 20             | V  |
| VIN    | Input Signal Voltage           | HIN(U), HIN(V), HIN(W),<br>LIN(U), LIN(V), LIN(W) – VSS | –0.3~VDD + 0.3 | V  |
| VFO    | Fault Output Supply Voltage    | VFO – VSS   | –0.3~VDD + 0.3 | V  |
| IFO    | Fault Output Current           | Sink Current at VFO pin                                 | 1              | mA |
| VITRIP | Current-Sensing Input Voltage  | ITRIP – VSS   | –0.3~VDD + 0.3 | V  |

## BOOTSTRAP DIODE PART

|                 |                                    |   |         |    |
|-----------------|------------------------------------|---|---------|----|
| VRRM            | Maximum Repetitive Reverse Voltage |   | 600     | V  |
| I <sub>f</sub>  | Forward Current                    | T <sub>c</sub> = 25°C                                     | 0.5     | A  |
| I <sub>fp</sub> | Forward Current (Peak)             | T <sub>c</sub> = 25°C, Under 1 ms Pulse Width<br>(Note 4) | 2.0     | A  |
| T <sub>j</sub>  | Operating Junction Temperature     |   | –40~150 | °C |

## TOTAL SYSTEM

|                  |  |   |         |                  |
|------------------|--|---|---------|------------------|
| VPN(PROT)        | Self-Protection Supply Voltage Limit (Short-Circuit Protection Capability) | VDD = VBS = 13.5~16.5 V<br>T <sub>j</sub> = 150°C, V <sub>ces</sub> < 600 V<br>Non-Repetitive, < 2 μs | 400     | V                |
| T <sub>c</sub>   | Module Case Operation Temperature  | See Figure 1  | –40~125 | °C               |
| T <sub>stg</sub> | Storage Temperature  |   | –40~125 | °C               |
| V <sub>iso</sub> | Isolation Voltage  | 60 Hz, Sinusoidal, AC 1 minute,<br>Connection Pins to Heat Sink Plate                                 | 2000    | V <sub>rms</sub> |

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.

## ABSOLUTE MAXIMUM RATINGS (T<sub>j</sub> = 25°C, unless otherwise noted)

| Symbol                    | Parameter                                       | Conditions                          | Min | Typ | Max  | Unit |
|---------------------------|---|-------------------------------------|-----|-----|------|------|
| <b>THERMAL RESISTANCE</b> |   |                                     |     |     |      |      |
| R <sub>th(j-c)Q</sub>     | Junction to Case Thermal Resistance<br>(Note 5) | Inverter IGBT Part (per 1/6 module) | –   | –   | 2.75 | °C/W |
| R <sub>th(j-c)F</sub>     |   | Inverter FWDi Part (per 1/6 module) | –   | –   | 4.2  | °C/W |

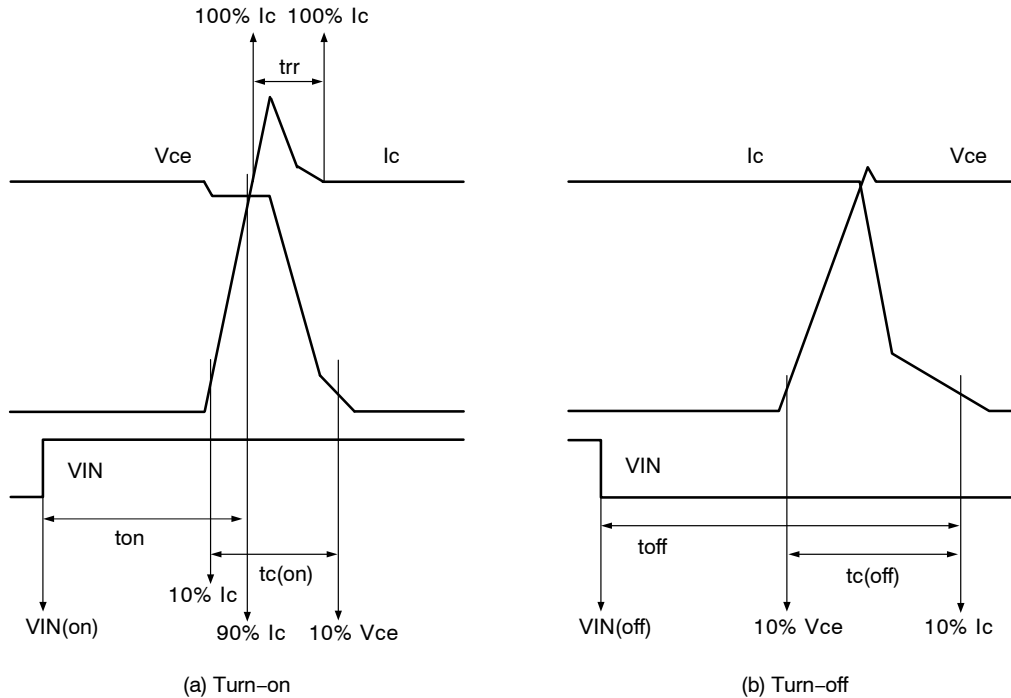
5. For the measurement point of case temperature T<sub>c</sub>, please refer to Figure 1.

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

| Symbol               | Parameter                            | Conditions   | Min | Typ  | Max  | Unit |
|----------------------|--------------------------------------|--|-----|------|------|------|
| <b>INVERTER PART</b> |                                      |  |     |      |      |      |
| VCE(sat)             | Collector-Emitter Saturation Voltage | VDD = VBS = 15 V, IN = 5 V, Ic = 15 A, Tj = 25°C   | –   | 1.5  | 2.1  | V    |
| VF                   | FWDi Forward Voltage                 | IN = 0 V, Ic = –15 A, Tj = 25°C  | –   | 1.75 | 2.35 | V    |
| HS                   | ton                                  | VPN = 300 V, VDD(H) = VDD(L) = 15 V, Ic = 15 A, Tj = 25°C, IN = 0 ↔ 5 V, Inductive Load (Note 6) | –   | 0.75 | –    | μs   |
|                      | tc(on)                               |  | –   | 0.12 | –    | μs   |
|                      | toff                                 |  | –   | 0.85 | –    | μs   |
|                      | tc(off)                              |  | –   | 0.14 | –    | μs   |
|                      | trr                                  |  | –   | 0.13 | –    | μs   |
| LS                   | ton                                  | VPN = 300 V, VDD(H) = VDD(L) = 15 V, Ic = 15 A, Tj = 25°C, IN = 0 ↔ 5 V, Inductive Load (Note 6) | –   | 0.80 | –    | μs   |
|                      | tc(on)                               |  | –   | 0.15 | –    | μs   |
|                      | toff                                 |  | –   | 0.90 | –    | μs   |
|                      | tc(off)                              |  | –   | 0.14 | –    | μs   |
|                      | trr                                  |  | –   | 0.18 | –    | μs   |
| Ices                 | Collector-Emitter Leakage Current    | Vce = Vces   | –   | –    | 1    | 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. ton and toff include the propagation delay time of the internal drive IC. tc(on) and tc(off) are the switching time of IGBT itself under the given gate driving condition internally. For the detailed information, please see Figure 3.



**Figure 3. Switching Time Definitions**

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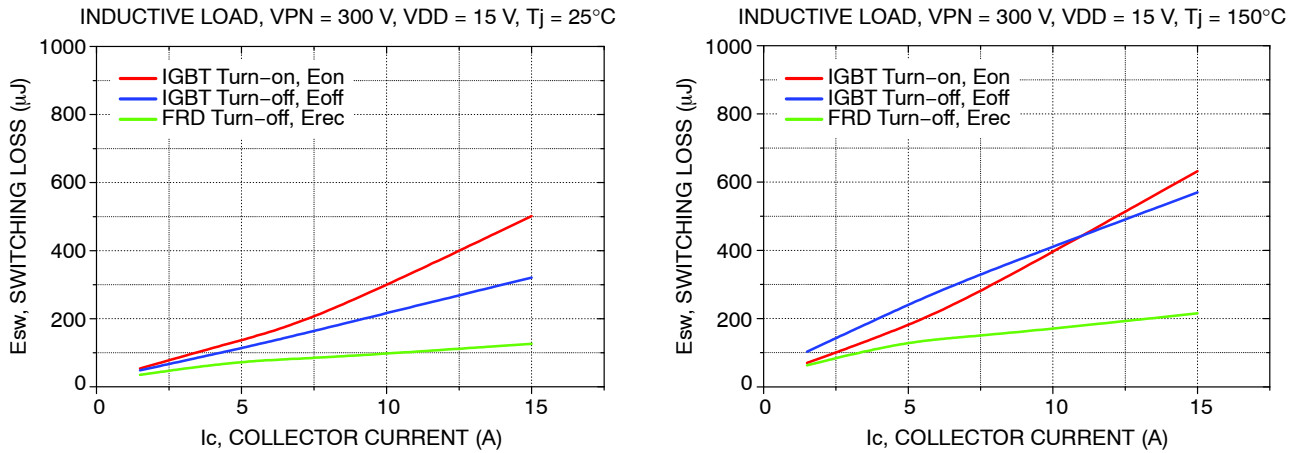


Figure 4. Switching Loss Characteristics (Typical)

## ELECTRICAL CHARACTERISTICS ( $T_j = 25^\circ\text{C}$ , unless otherwise noted)

| Symbol              | Parameter                               | Conditions  | Min  | Typ  | Max  | Unit          |
|---------------------|---|---|------|------|------|---------------|
| <b>CONTROL PART</b> |   |   |      |      |      |               |
| IQDDH               | Quiescent VDD Supply Current            | $V_{DD}(H) = 15\text{ V}$ , $HIN = 0\text{ V}$ , $V_{DD}(H) - V_{SS}$   | –    | –    | 0.10 | mA            |
| IQDDL               |   | $V_{DD}(L) = 15\text{ V}$ , $LIN = 0\text{ V}$ , $V_{DD}(L) - V_{SS}$   | –    | –    | 2.65 | mA            |
| IPDDH               | Operating VDD Supply Current            | $V_{DD}(H) = 15\text{ V}$ , $f_{PWM} = 20\text{ kHz}$ , Duty = 50%, Applied to One PWM Signal Input for High-Side | –    | –    | 0.15 | mA            |
| IPDDL               |   | $V_{DD}(L) = 15\text{ V}$ , $f_{PWM} = 20\text{ kHz}$ , Duty = 50%, Applied to One PWM Signal Input for Low-Side  | –    | –    | 4.00 | mA            |
| IQBS                | Quiescent VBS Supply Current            | $V_{DD}(H) = 15\text{ V}$ , $HIN = 0\text{ V}$ , $VB(U) - VS(U)$ , $VB(V) - VS(V)$ , $VB(W) - VS(W)$              | –    | –    | 0.30 | mA            |
| IPBS                | Operating VBS Supply Current            | $V_{DD}(H) = 15\text{ V}$ , $f_{PWM} = 20\text{ kHz}$ , Duty = 50%, Applied to One PWM Signal Input for High-Side | –    | –    | 2.00 | mA            |
| VFOH                | Fault Output Voltage                    | $V_{DD} = 0\text{ V}$ , $ITRIP = 0\text{ V}$ , VFO Circuit: 10 k $\Omega$ to 5 V Pull-up                          | 4.5  | –    | –    | V             |
| VFOL                |   | $V_{DD} = 0\text{ V}$ , $ITRIP = 1\text{ V}$ , VFO Circuit: 10 k $\Omega$ to 5 V Pull-up                          | –    | –    | 0.5  | V             |
| VSC(ref)            | Short Circuit Trip Level                | $V_{DD} = 15\text{ V}$ , $ITRIP - V_{SS}$   | 0.45 | 0.50 | 0.55 | V             |
| UVDDD               | Supply Circuit Under-Voltage Protection | Detection Level   | 10.5 | –    | 13.0 | V             |
| UVDDR               |   | Reset Level   | 11.0 | –    | 13.5 | V             |
| UVBSD               | Supply Circuit Under-Voltage Protection | Detection Level   | 10.0 | –    | 12.5 | V             |
| UVBSR               |   | Reset Level   | 10.5 | –    | 13.0 | V             |
| tFOD                | Fault-Output Pulse Width                |   | 30   | –    | –    | $\mu\text{s}$ |
| VIN(ON)             | ON Threshold Voltage                    | $HIN - V_{SS}$ , $LIN - V_{SS}$   | –    | –    | 2.6  | V             |
| VIN(OFF)            | OFF Threshold Voltage                   |   | 0.8  | –    | –    | V             |
| RTH                 | Resistance of Thermistor                | @ $T_{TH} = 25^\circ\text{C}$   | –    | 47   | –    | k $\Omega$    |
|                     |   | @ $T_{TH} = 100^\circ\text{C}$  | –    | 2.9  | –    | k $\Omega$    |

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.

7. Short-circuit current protection is functioning only at the low-sides.

8.  $T_{TH}$  is the temperature of thermistor itself. To know case temperature ( $T_c$ ), please make the experiment considering your application.

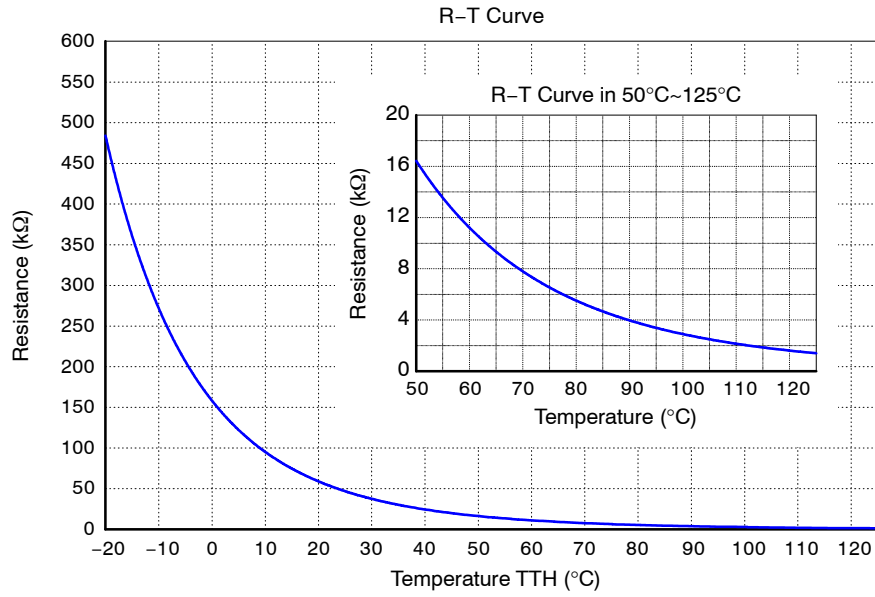
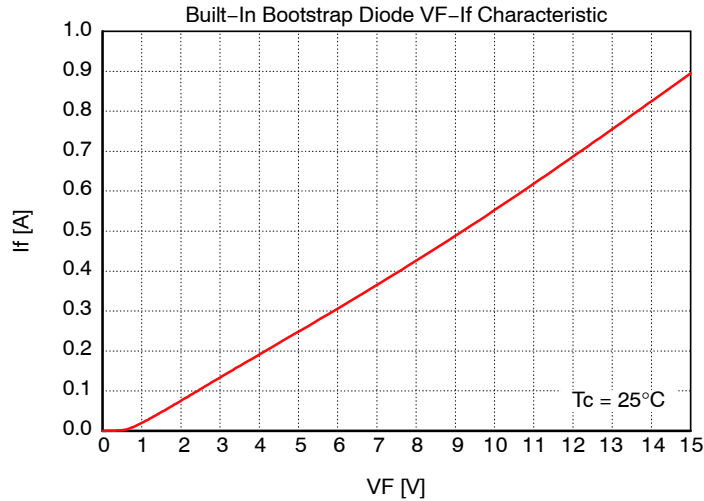


Figure 5. R-T Curve of The Built-In Thermistor

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

| Symbol                      | Parameter             | Conditions   | Min | Typ | Max | Unit |
|-----------------------------|-----------------------|--|-----|-----|-----|------|
| <b>BOOTSTRAP DIODE PART</b> |                       |  |     |     |     |      |
| VF                          | Forward Voltage       | If = 0.1 A, $T_c = 25^\circ\text{C}$                                       | –   | 2.5 | –   | V    |
| trr                         | Reverse-Recovery Time | If = 0.1 A, $dlf/dt = 50 \text{ A}/\mu\text{s}$ , $T_c = 25^\circ\text{C}$ | –   | 80  | –   | ns   |

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.



NOTE:

9. Built-in bootstrap diode includes around  $15 \Omega$  resistance characteristic.

Figure 6. Built-In Bootstrap Diode Characteristics (Typ.)



RECOMMENDED OPERATING CONDITIONS

| Symbol              | Parameter                              | Conditions  | Min  | Typ  | Max  | Unit |
|---------------------|--|---|------|------|------|------|
| VPN                 | Supply Voltage                         | P – NU, NV, NW  | –    | 300  | 400  | V    |
| VDD                 | Control Supply Voltage                 | VDD(H), VDD(L) – VSS  | 13.5 | 15.0 | 16.5 | V    |
| VBS                 | High-Side Bias Voltage                 | VB(U) – VS(U), VB(V) – VS(V), VB(W) – VS(W)   | 13.0 | 15.0 | 18.5 | V    |
| dVDD/dt,<br>dVBS/dt | Control Supply Variation               |   | –1   | –    | 1    | V/μs |
| tdead               | Blanking Time for Preventing Arm-Short | For each input signal   | 1    | –    | –    | μs   |
| fPWM                | PWM Input Signal                       | –40°C ≤ Tc ≤ 125°C, –40°C ≤ Tj ≤ 150°C  | –    | –    | 20   | kHz  |
| VSEN                | Voltage for Current Sensing            | Applied between NU, NV, NW – VSS (Including Surge-Voltage)  | –4   | –    | 4    | V    |
| PWIN(ON)            | Minimum Input Pulse Width              | VDD = VBS = 15 V, Ic ≤ 30 A, Wiring Inductance between NU, NV, NW and DC Link N < 10 nH (Note 10) | 1.2  | –    | –    | μs   |
| PWIN(OFF)           |  |   | 1.2  | –    | –    |      |
| Tj                  | Junction Temperature                   |   | –40  | –    | 150  | °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 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 7                       |                         | 0   | –     | +120 | μm      |
| Mounting Torque | Mounting Screw: M3<br>See Figure 8 | Recommended 0.7 N · m   | 0.6 | 0.7   | 0.8  | N · m   |
|                 |                                    | Recommended 7.1 kg · cm | 6.2 | 7.1   | 8.1  | kg · cm |
| Weight          |                                    |                         | –   | 11.00 | –    | g       |

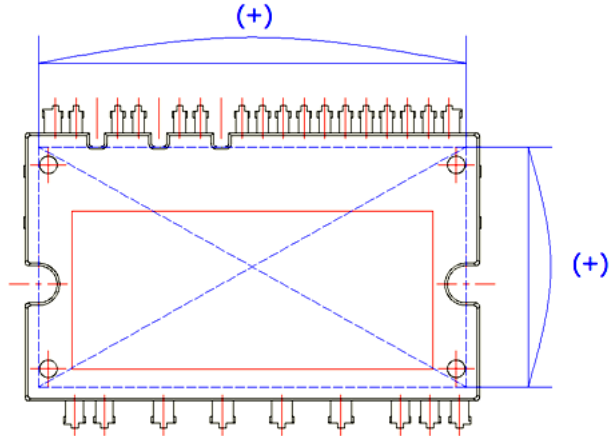
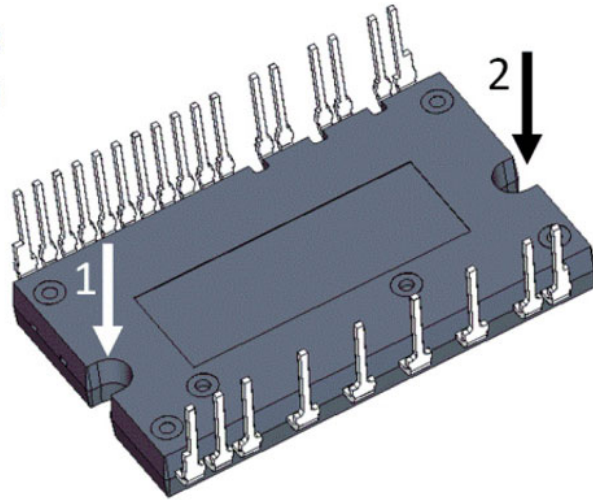


Figure 7. Flatness Measurement Position

Pre - Screwing : 1→2

Final Screwing : 2→1

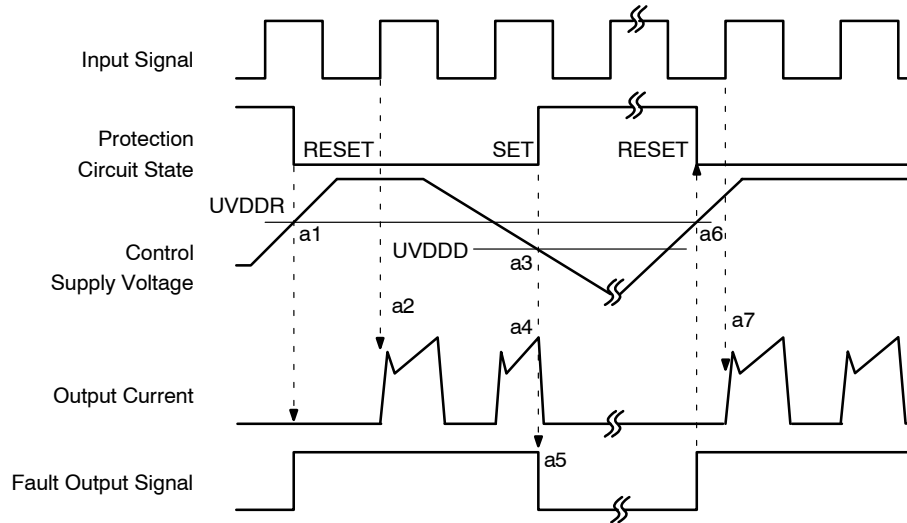


NOTE:

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

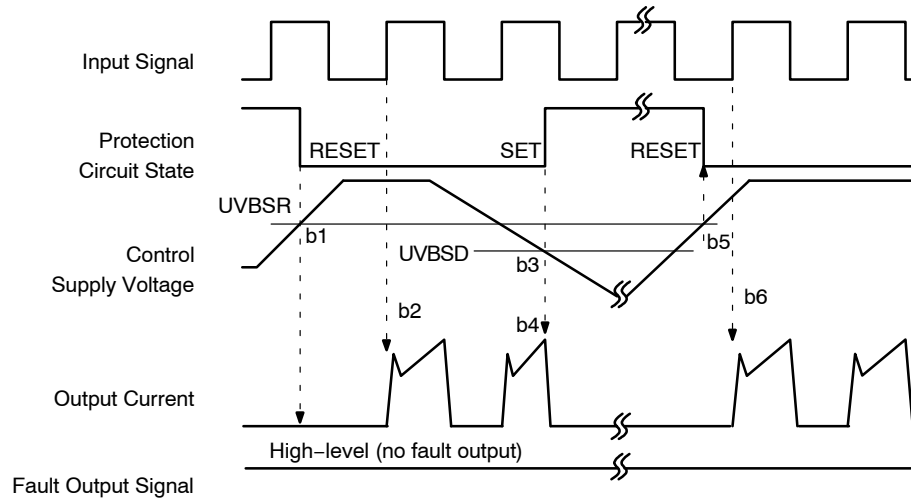
Figure 8. Mounting Screws Torque Order

## Time Charts of Protective Function



- a1: Control supply voltage rises: After the voltage rises UVDDR, the circuits start to operate when next input is applied.  
a2: Normal operation: IGBT ON and carrying current.  
a3: Under voltage detection (UVDDD).  
a4: IGBT OFF in spite of control input condition.  
a5: Fault output operation starts with a fixed pulse width.  
a6: Under voltage reset (UVDDR).  
a7: Normal operation: IGBT ON and carrying current by triggering next signal from LOW to HIGH.

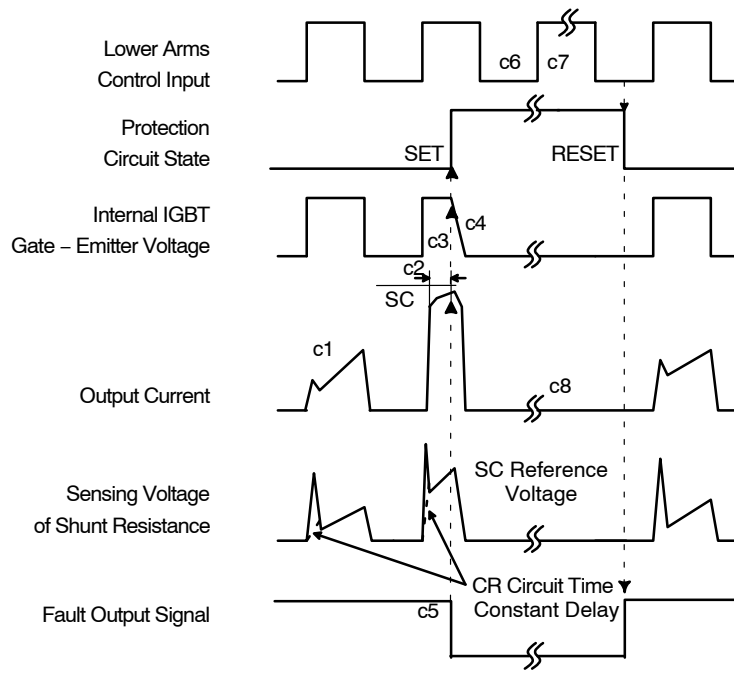
**Figure 9. Under-Voltage Protection (Low-Side)**



- b1: Control supply voltage rises: After the voltage reaches UVBSR, the circuits start to operate when next input is applied.  
b2: Normal operation: IGBT ON and carrying current.  
b3: Under voltage detection (UVBSD).  
b4: IGBT OFF in spite of control input condition, but there is no fault output signal.  
b5: Under voltage reset (UVBSR).  
b6: Normal operation: IGBT ON and carrying current by triggering next signal from LOW to HIGH.

**Figure 10. Under-Voltage Protection (High-side)**

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(with the external sense resistance and RC filter connection)

c1: Normal operation: IGBT ON and carrying current.

c2: Short circuit current detection (SC trigger).

c3: All low-side IGBT's gate are hard interrupted.

c4: All low-side IGBT's turn OFF.

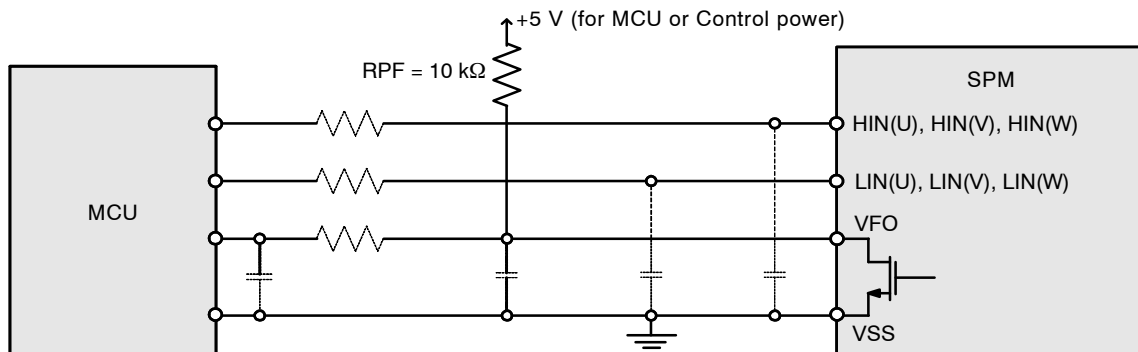
c5: Fault output operation starts with a fixed pulse width.

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 next signal from LOW to HIGH.

c8: Normal operation: IGBT ON and carrying current.

**Figure 11. Short-Circuit Protection (Low-Side Operation Only)**

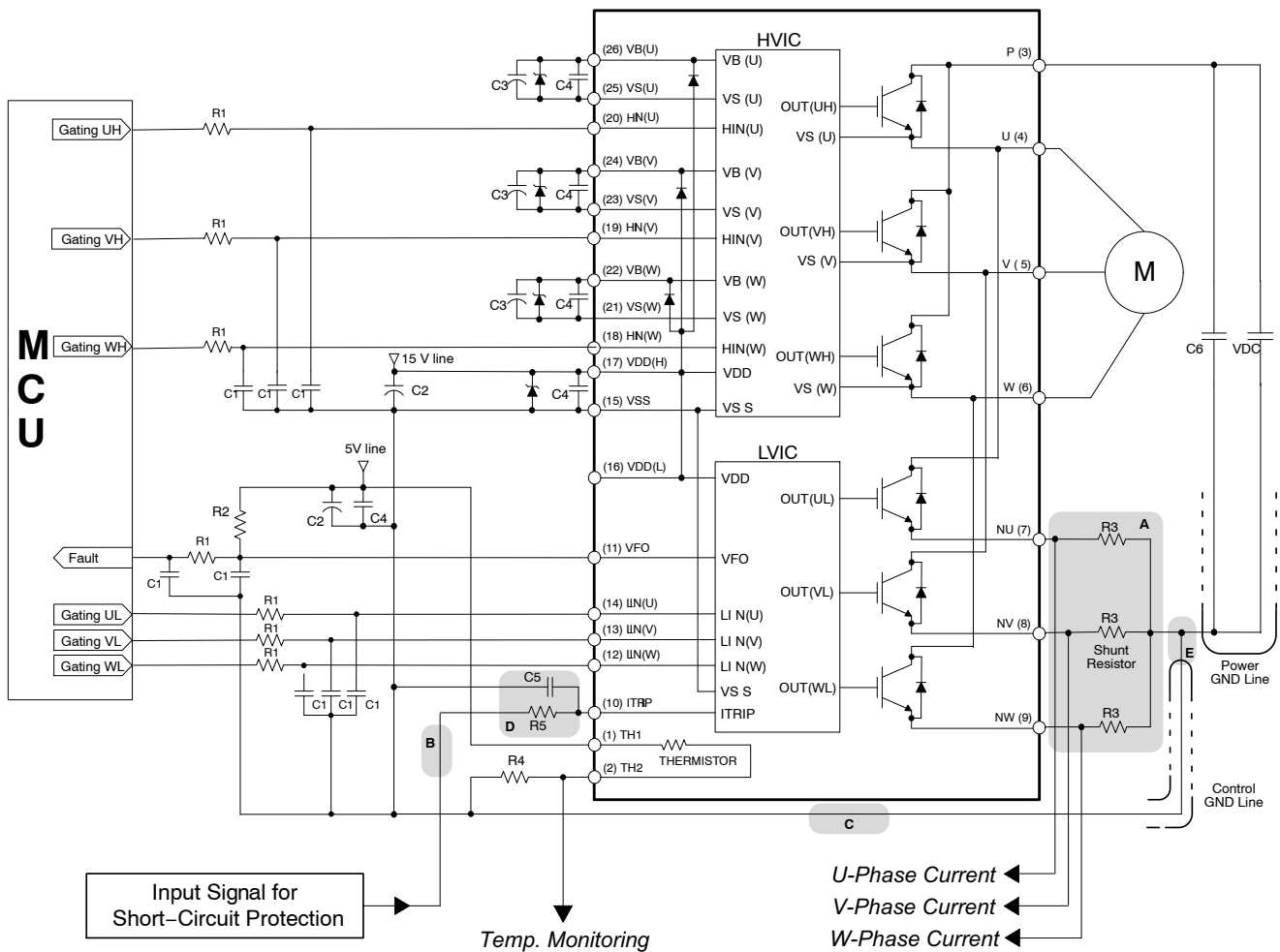


NOTE:

13. 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 45 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 12. Recommended MCU I/O Interface Circuit**

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## NOTE:

14. To avoid malfunction, the wiring of each input should be as short as possible (less than 2 ~ 3 cm).
15. VFO output 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 IFO up to 1 mA.
16. Input signal is active-HIGH type. There is a 5kΩ resistor inside the IC to pull down each input signal line to GND. RC coupling circuits is recommended for the prevention of input signal oscillation. R1C1 time constant should be selected in the range 50~150 ns (recommended R1 = 100 Ω, C1 = 1 nF).
17. Each wiring pattern inductance of point A should be minimized (recommend less than 10 nH). Use the shunt resistor R3 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 R3 as close as possible.
18. To insert the shunt resistor to measure each phase current at NU, NV, NW terminal, it makes to change the trip level ISC about the short-circuit current.
19. To prevent errors of the protection function, the wiring of point B, C, and D should be as short as possible.
20. In the short-circuit protection circuit, please select the R5C5 time constant in the range 1.5~2 μs. Do enough evaluation on the real system because short-circuit protection time may vary wiring pattern layout and value of the R5C5 time constant.
21. Each capacitor should be mounted as close to the pins of the Motion SPM 45 product as possible.
22. To prevent surge destruction, the wiring between the smoothing capacitor C6 and the P & 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.
23. Relays are used in almost every systems of electrical equipment in home appliances. In these cases, there should be sufficient distance between the MCU and the relays.
24. 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 (recommended zener diode is 22 V / 1 W, which has the lower zener impedance characteristic than about 15 Ω).
25. C2 of around seven times larger than bootstrap capacitor C3 is recommended.
26. Please choose the electrolytic capacitor with good temperature characteristic in C3. Also, choose 0.1~0.2 μF R-category ceramic capacitors with good temperature and frequency characteristics in C4.

**Figure 13. Typical Application Circuit**

## NFA41560R42

### ORDERING INFORMATION

| Device      | Device Marking | Package  | Shipping        |
|-------------|----------------|--|-----------------|
| NFA41560R42 | NFA41560R42    | SPMAA-C26 / 26LD, PDD STD CERAMIC TYPE,<br>LONG LEAD DUAL FORM TYPE<br>(Pb-Free) | 12 Units / Rail |

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# MECHANICAL CASE OUTLINE

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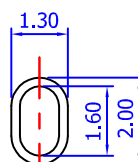
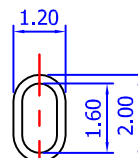
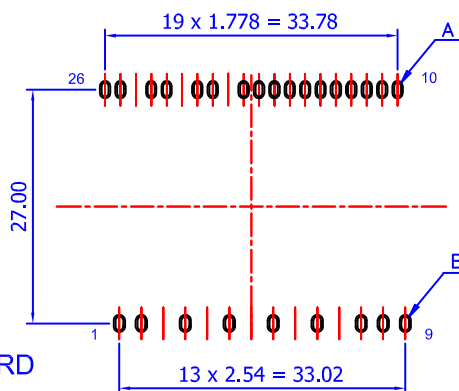
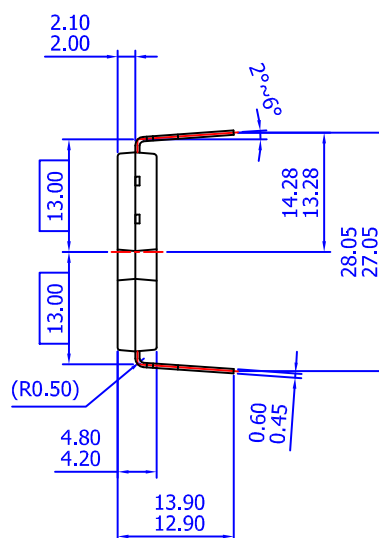
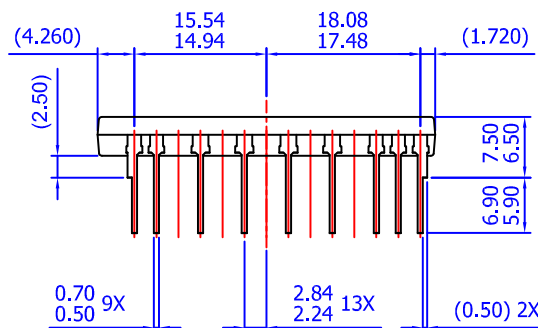
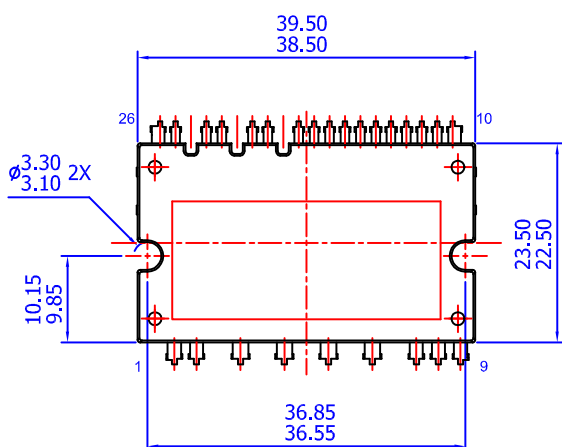
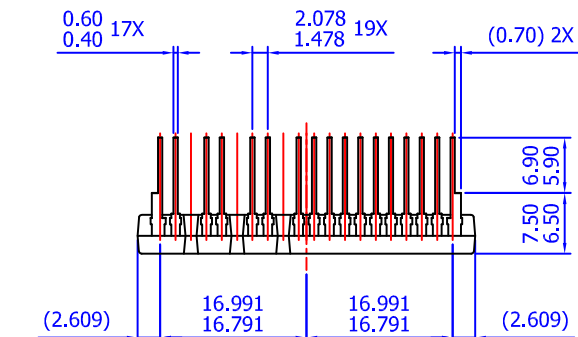


### SPMAA-C26 / 26LD, PDD STD CERAMIC TYPE, LONG LEAD DUAL FORM TYPE

#### CASE MODFC

#### ISSUE O

DATE 31 JAN 2017



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- B) ALL DIMENSIONS ARE IN MILLIMETERS
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|                  |  |  |
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