

Motion SPM[®] 5 Series

NFA50460R4B, NFA50460R47

General Description

The NFA50460R4B/7 is an advanced Motion SPM5 module providing a fully featured, high performance inverter output stage for AC induction, BLDC and PMSM motors such as refrigerators, fans and pumps. These modules integrate optimized gate drive of the built-in IGBTs (FS4 RC IGBT technology) to minimize EMI and losses, while also providing multiple on-module protection features including under-voltage lockouts and thermal monitoring. The built-in high speed Driver IC 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 open emitter IGBT terminals are available for each phase to support the widest variety of control algorithms.

Features

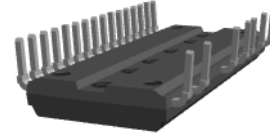
- UL Certified No. E209204 (UL1557)
- 600 V FS4 RC IGBT 3-Phase Inverter with Gate Drivers and Protection
- Built-In Bootstrap Diodes Simplify PCB Layout
- Separate Open-Emitter Pins from Low-Side IGBTs for Three-Phase Current-Sensing
- Active-High Interface, Works with 3.3 / 5 V Logic, Schmitt-Trigger Input
- Optimized for Low Electromagnetic Interference
- Driver IC Temperature Sensing Built-In for Temperature Monitoring
- Driver IC for Gate Driving and Under-Voltage Protection
- Isolation Rating: 1500 V_{rms}/min.
- Moisture Sensitive Level (MSL) 3 for SMD PKG
- RoHS Compliant

Applications

- 3-Phase Inverter Driver for Small Power AC Motor Drives

Related Source

- [AN-9080 – Motion SPM[®] 5 Series Version 2 User's Guide](#)
- [AN-9082 – Motion SPM[®] 5 Series Thermal Performance by Contact Pressure](#)

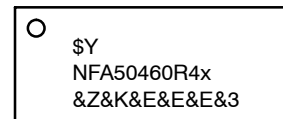


SPM5P-023 / 23LD, PDD STD,
FULL PACK, DIP TYPE
CASE MODEJ



SPM5Q-023 / 23LD, PDD STD,
SPM23-BD (Ver1.5) SMD TYPE
CASE MODEM

MARKING DIAGRAM



- \$Y = onsemi Logo
- NFA50460R4x = Specific Device Code
→ x = B or 7
- &Z = Assembly Plant Code
- &K = Lot Traceability Code
- &3 = Date Code (Year & Week)

ORDERING INFORMATION

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

NFA50460R4B, NFA50460R47

ORDERING INFORMATION

| Device | Device Marking | Package | Packing Type [†] | Reel Size | Quantity |
|-------------|----------------|-----------|---------------------------|-----------|----------|
| NFA50460R4B | NFA50460R4B | SPM5P-023 | Rail | NA | 15 |
| NFA50460R47 | NFA50460R47 | SPM5Q-023 | Tape & Reel | 330 mm | 450 |

[†]For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

ABSOLUTE MAXIMUM RATINGS ($V_{DD} = V_{BS} = 15\text{ V}$, $T_C = 25^\circ\text{C}$, unless otherwise noted)

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

INVERTER PART (Each IGBT Unless Otherwise Specified)

| | | | | |
|------------------------|-----------------------------------|---|---------|------------------|
| 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 | $T_C = 25^\circ\text{C}$, $V_{DD} = 15\text{ V}$, $T_J < 150^\circ\text{C}$ | 4 | A |
| $\pm I_{CP}$ | Each IGBT Collector Current, Peak | $T_C = 25^\circ\text{C}$, $V_{DD} = 15\text{ V}$, $T_J < 150^\circ\text{C}$, Under 1 ms Pulse Width (Note 2) | 8 | A |
| P_C | Collector Dissipation | $T_C = 25^\circ\text{C}$ per One Chip (Note 2) | 10.3 | W |
| T_J | Operating Junction Temperature | | -40~150 | $^\circ\text{C}$ |

CONTROL PART (Each IC Unless Otherwise Specified)

| | | | | |
|----------|--------------------------------|--|----------------------|---|
| V_{DD} | Control Supply Voltage | Applied between V_{DD} and V_{SS} | 20 | V |
| V_{BS} | High-Side Control Bias Voltage | Applied between V_B and V_S | 20 | V |
| V_{IN} | Input Signal Voltage | Applied between H _{IN} , L _{IN} and V_{SS} | -0.3~ $V_{DD} + 0.3$ | V |

BOOTSTRAP DIODE PART (Each Bootstrap Diode Unless Otherwise Specified)

| | | | | |
|-----------|------------------------------------|--|-----|---|
| V_{RRM} | Maximum Repetitive Reverse Voltage | | 600 | V |
| I_F | Forward Current | $T_C = 25^\circ\text{C}$, $T_J < 150^\circ\text{C}$ (Note 2) | 0.5 | A |
| I_{FP} | Forward Current (Peak) | $T_C = 25^\circ\text{C}$, $T_J < 150^\circ\text{C}$, Under 1 ms Pulse Width (Note 2) | 1.5 | A |

THERMAL RESISTANCE

| | | | | |
|----------------|-------------------------------------|--|------|--------------------|
| $R_{th(j-c)Q}$ | Junction to Case Thermal Resistance | Inverter IGBT Part (per 1/6 Module) (Note 1) | 12.2 | $^\circ\text{C/W}$ |
|----------------|-------------------------------------|--|------|--------------------|

TOTAL SYSTEM

| | | | | |
|-----------|--------------------------------|--|---------|------------------|
| t_{SC} | Short Circuit Withstand Time | $V_{DD} = V_{BS} \leq 16.5\text{ V}$, $V_{PN} \leq 400\text{ V}$, $T_J = 150^\circ\text{C}$, Non-repetitive | 3 | μs |
| T_J | Operating Junction Temperature | | -40~150 | $^\circ\text{C}$ |
| T_{STG} | Storage Temperature | | -40~125 | $^\circ\text{C}$ |
| V_{ISO} | Isolation Voltage | 60 Hz, Sinusoidal, AC 1 minute, Connect Pins to Heat Sink Plate | 1500 | V_{rms} |

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.

- For the measurement point of case temperature T_C , Please refer to Figure 4.
- These values had been made an acquisition by the calculation considered to design factor.
- Using continuously under heavy loads or excessive assembly conditions (e.g. the application of high temperature/ current/ voltage and the significant change in temperature, etc.) may cause this product to decrease in the reliability significantly even if the operating conditions (i.e. operating temperature/ current/ voltage, etc.) are within the absolute maximum ratings and the operating ranges.

NFA50460R4B, NFA50460R47

PIN DESCRIPTION

| Pin No. | Pin Name | Description |
|---------|----------------------|--|
| 1 | V _{SS} | IC Common Supply Ground |
| 2 | V _{B(U)} | High-Side Bias Voltage for U phase IGBT Driving |
| 3 | V _{DD(U)} | Low-Side Bias Voltage for U phase IC and IGBT Driving |
| 4 | HIN _(U) | Signal Input for High-Side U Phase |
| 5 | LIN _(U) | Signal Input for Low-Side U Phase |
| 6 | N.C | N.C |
| 7 | V _{B(V)} | High-Side Bias Voltage for V phase IGBT Driving |
| 8 | V _{DD(V)} | Low-Side Bias Voltage for V phase IC and IGBT Driving |
| 9 | HIN _(V) | Signal Input for High-Side V Phase |
| 10 | LIN _(V) | Signal Input for Low-Side V Phase |
| 11 | VTS | Voltage Output for IC Temperature Sensing Unit |
| 12 | V _{B(W)} | High-Side Bias Voltage for W phase IGBT Driving |
| 13 | V _{DD(W)} | Low-Side Bias Voltage for W phase IC and IGBT Driving |
| 14 | HIN _(W) | Signal Input for High-Side W Phase |
| 15 | LIN _(W) | Signal Input for Low-Side W Phase |
| 16 | N.C | N.C |
| 17 | P | Positive DC-Link Input |
| 18 | U, V _{S(U)} | Output for U Phase & High-Side Bias Voltage GND for U phase IGBT Driving |
| 19 | N _U | Negative DC-Link Input for U Phase |
| 20 | N _V | Negative DC-Link Input for V Phase |
| 21 | V, V _{S(V)} | Output for V Phase & High-Side Bias Voltage GND for V phase IGBT Driving |
| 22 | N _W | Negative DC-Link Input for W Phase |
| 23 | W, V _{S(W)} | Output for W Phase & High-Side Bias Voltage GND for W phase IGBT Driving |

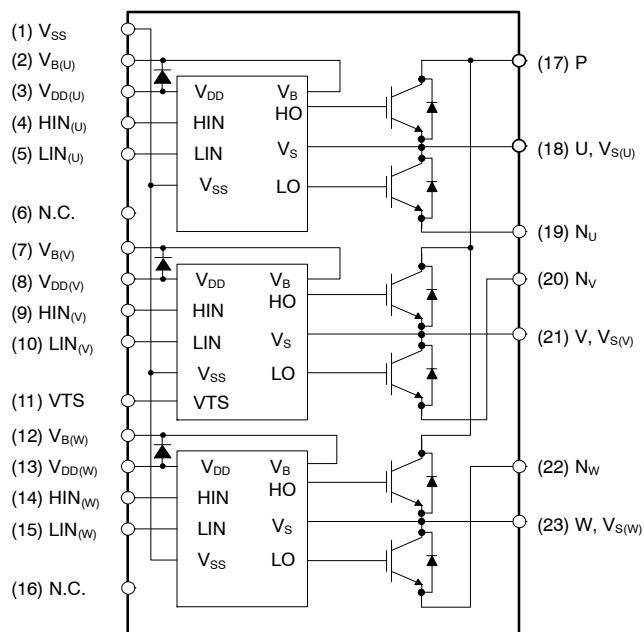


Figure 1. Pin Configuration and Internal Block Diagram (Bottom View)

NOTE:

4. Emitter terminal of each low-side IGBT is not connected to supply ground or bias voltage ground inside Motion SPM 5 product. External connections should be made as indicated in Figure 3.

NFA50460R4B, NFA50460R47

ELECTRICAL CHARACTERISTICS ($T_J = 25^\circ\text{C}$, $V_{DD} = V_{BS} = 15\text{ V}$ unless otherwise noted)

| Symbol | Parameter | Test Conditions | Min. | Typ. | Max. | Unit |
|--------|-----------|-----------------|------|------|------|------|
|--------|-----------|-----------------|------|------|------|------|

INVERTER PART (Each IGBT unless otherwise specified)

| | | | | | | |
|---------------|--------------------------------------|--|-------------|------|-----|---------------|
| BV_{CES} | Collector–Emitter Breakdown Voltage | $V_{IN} = 0\text{ V}$, $I_D = 1\text{ mA}$ (Note 5) | 600 | – | – | V |
| I_{CES} | Collector–Emitter Leakage Current | $V_{IN} = 0\text{ V}$, $V_{CE} = 600\text{ V}$ | – | – | 1 | mA |
| $V_{CE(SAT)}$ | Collector–Emitter Saturation Voltage | $V_{DD} = V_{BS} = 15\text{ V}$, $V_{IN} = 5\text{ V}$, $I_C = 4\text{ A}$, $T_J = 25^\circ\text{C}$ | – | 1.75 | 2.2 | V |
| | | $V_{DD} = V_{BS} = 15\text{ V}$, $V_{IN} = 5\text{ V}$, $I_C = 4\text{ A}$, $T_J = 150^\circ\text{C}$ | – | 2.0 | – | |
| V_F | Emitter–Collector Forward Voltage | $V_{IN} = 0\text{ V}$, $I_F = 4\text{ A}$, $T_J = 25^\circ\text{C}$ | – | 1.87 | 2.3 | V |
| | | $V_{IN} = 0\text{ V}$, $I_F = 4\text{ A}$, $T_J = 150^\circ\text{C}$ | – | 2.0 | – | |
| t_{ON} | Switching Times | $V_{PN} = 300\text{ V}$, $V_{DD} = V_{BS} = 15\text{ V}$, $I_C = 4\text{ A}$ $V_{IN} = 0\text{ V} \leftrightarrow 5\text{ V}$, Inductive Load, High– and Low–Side IGBT Switching (Note 6) | – | 370 | – | ns |
| t_{OFF} | | | – | 358 | – | ns |
| t_{rr} | | | – | 151 | – | ns |
| E_{ON} | | | – | 150 | – | μJ |
| E_{OFF} | | | – | 35 | – | μJ |
| RBSOA | Reverse–Bias Safe Operating Area | $V_{PN} = 400\text{ V}$, $V_{DD} = V_{BS} = 15\text{ V}$, $I_C = I_{CP}$, $V_{CE} = BV_{CES}$, $T_J = 150^\circ\text{C}$ High– and Low–Side IGBT Switching (Note 7) | Full Square | | | |

CONTROL PART (Each HVIC Unless Otherwise Specified)

| | | | | | | | |
|------------|--|---|---|-----|-----|-----|---------------|
| I_{QDD} | Quiescent V_{DD} Current | $V_{DD} = 15\text{ V}$, $V_{IN} = 0\text{ V}$ | Applied between V_{DD} and V_{SS} | – | – | 200 | μA |
| I_{QBS} | Quiescent V_{BS} Current | $V_{BS} = 15\text{ V}$, $V_{IN} = 0\text{ V}$ | Applied between $V_{B(U)} - U$, $V_{B(V)} - V$, $V_{B(W)} - W$ | – | – | 100 | μA |
| I_{PDD} | Operating V_{DD} Supply Current | $V_{DD} - V_{SS}$ | $V_{DD} = 15\text{ V}$, $f_{PWM} = 20\text{ kHz}$, duty = 50%, Applied to One PWM Signal Input for Low–Side | – | – | 900 | μA |
| I_{PBS} | Operating V_{BS} Supply Current | $V_{B(U)} - V_{S(U)}$, $V_{B(V)} - V_{S(V)}$, $V_{B(W)} - V_{S(W)}$ | $V_{DD} = V_{BS} = 15\text{ V}$, $f_{PWM} = 20\text{ kHz}$, Duty = 50%, Applied to One PWM Signal Input for High–Side | – | – | 800 | μA |
| UV_{DDE} | Low–Side Under–voltage Protection (Figure 8) | V_{DD} Under–voltage Protection Detection Level | | 7.4 | 8.0 | 9.4 | V |
| UV_{DDR} | | V_{DD} Under–voltage Protection Reset Level | | 8.0 | 8.9 | 9.8 | V |
| UV_{BSE} | High–Side Under–voltage Protection (Figure 8) | V_{BS} Under–voltage Protection Detection Level | | 7.4 | 8.0 | 9.4 | V |
| UV_{BSR} | | V_{BS} Under–voltage Protection Reset Level | | 8.0 | 8.9 | 9.8 | V |
| V_{TS} | IC Temperature Sensing Voltage Output | $V_{DD} = 15\text{ V}$, $T_{driver} = 25^\circ\text{C}$ (Note 8) | | 600 | 790 | 980 | mV |
| V_{IH} | ON Threshold Voltage | Logic HIGH Level | Applied between H_{IN} , L_{IN} and V_{SS} | – | – | 2.9 | V |
| V_{IL} | OFF Threshold Voltage | Logic LOW Level | | 0.8 | – | – | V |

BOOTSTRAP DIODE PART (Each bootstrap diode unless otherwise specified)

| | | | | | | |
|----------|-----------------------|--|---|-----|---|----|
| V_{FB} | Forward Voltage | $I_F = 0.1\text{ A}$, $T_C = 25^\circ\text{C}$ (Note 9) | – | 2.5 | – | V |
| t_{rB} | Reverse Recovery Time | $I_F = 0.1\text{ A}$, $T_C = 25^\circ\text{C}$ | – | 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.

NFA50460R4B, NFA50460R47

RECOMMENDED OPERATING CONDITION

| Symbol | Parameter | Conditions | Min. | Typ. | Max. | Unit |
|---------------|--|---|------------|------|----------|---------------|
| V_{PN} | Supply Voltage | Applied between P and N | $> V_{DD}$ | 300 | 450 | V |
| V_{DD} | Control Supply Voltage | Applied between V_{DD} and V_{SS} | 14.0 | 15.0 | 16.5 | V |
| V_{BS} | High-Side Bias Voltage | Applied between V_B and V_S | 13.0 | 15.0 | 18.5 | V |
| $V_{IN(ON)}$ | Input ON Threshold Voltage | Applied between H_{IN} , L_{IN} and V_{SS} | 3.0 | – | V_{DD} | V |
| $V_{IN(OFF)}$ | Input OFF Threshold Voltage | | 0 | – | 0.6 | V |
| t_{dead} | Blanking Time for Preventing Arm-Short | $V_{DD} = V_{BS} = 13.5\sim 16.5\text{ V}$, $T_J \leq 150^\circ\text{C}$ | 1.0 | – | – | μs |
| f_{PWM} | PWM Switching Frequency | $T_J \leq 150^\circ\text{C}$ | – | – | 20 | kHz |

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.

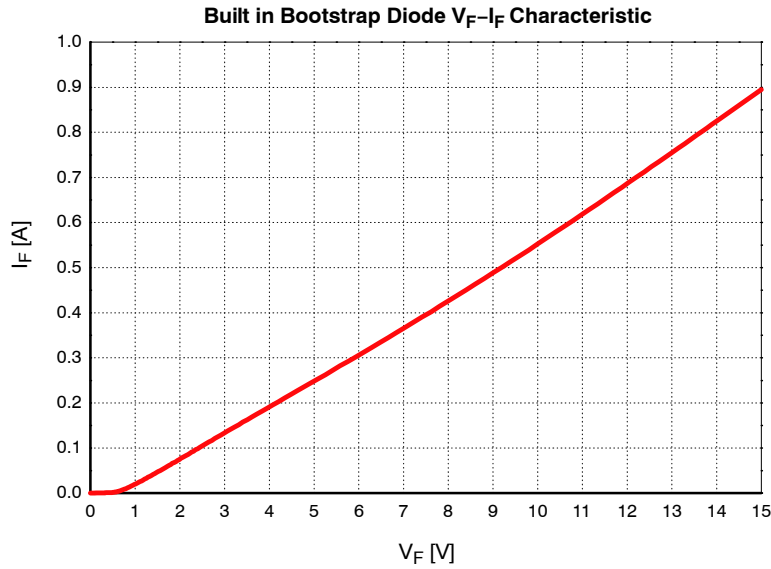


Figure 2. Built-in Bootstrap Diode Characteristics (Typical)

NOTES:

5. BV_{CES} is the absolute maximum voltage rating between collector and emitter terminal of each IGBT inside Motion SPM 5 product. V_{PN} should be sufficiently less than this value considering the effect of the stray inductance so that V_{CE} should not exceed BV_{CES} in any case.
6. t_{ON} and t_{OFF} include the propagation delay time of the internal driver IC. Listed values are measured at the laboratory test condition, and they can be different according to the field applications due to the effect of different printed circuit boards and wirings. Please see Figure 6 for the switching time definition with the switching test circuit of Figure 7.
7. The peak current and voltage of each IGBT during the switching operation should be included in the Safe Operating Area (SOA). Please see Figure 7 for the RBSOA test circuit that is same as the switching test circuit.
8. VTS is only for sensing temperature of module and cannot shutdown IGBTs automatically.
9. Built in bootstrap diode includes around $15\ \Omega$ resistance characteristic. Please refer to Figure 2.

NFA50460R4B, NFA50460R47

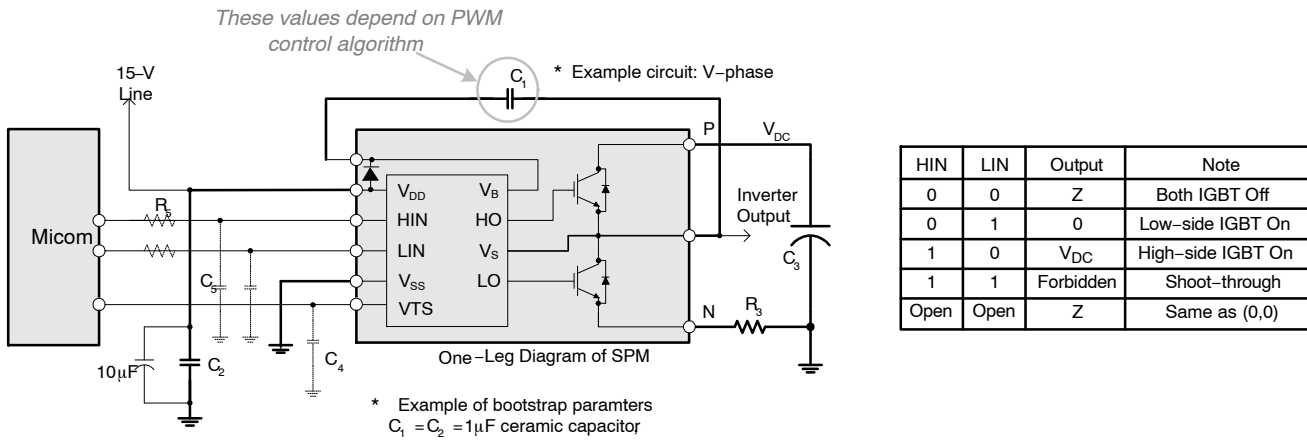


Figure 3. Recommended CPU Interface and Bootstrap Circuit with Parameters

NOTES:

- 10. Parameters for bootstrap circuit elements are dependent on PWM algorithm. Typical example of parameters is shown above.
- 11. RC coupling (R₅ and C₅) and C₄ at each input of SPM and Microm (Indicated as dotted lines) may be used to prevent improper signal due to surge noise.
- 12. Bold lines should be short and thick in PCB pattern to have small stray inductance of circuit, which results in the reduction of surge voltage. Bypass capacitors such as C₁, C₂ and C₃ should have good high-frequency characteristics to absorb high-frequency ripple current.

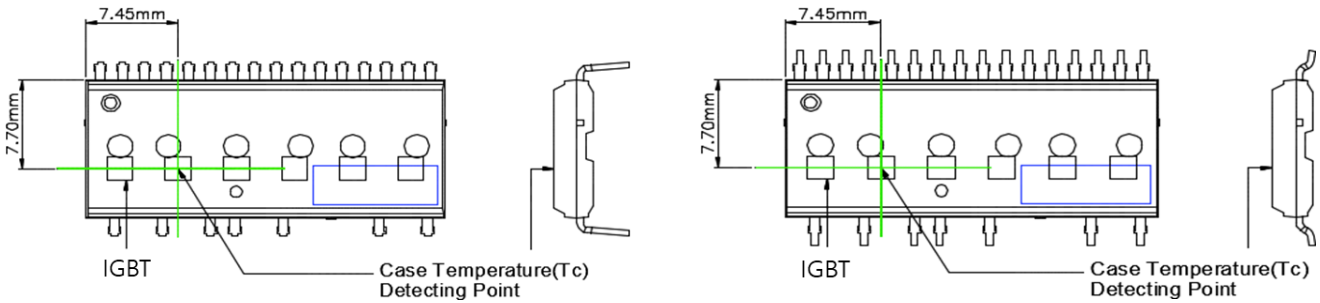


Figure 4. Case Temperature Measurement

NOTE:

- 13. Attach the thermocouple on top of the heatsink-side of SPM (between SPM and heatsink if applied) to get the correct temperature measurement.

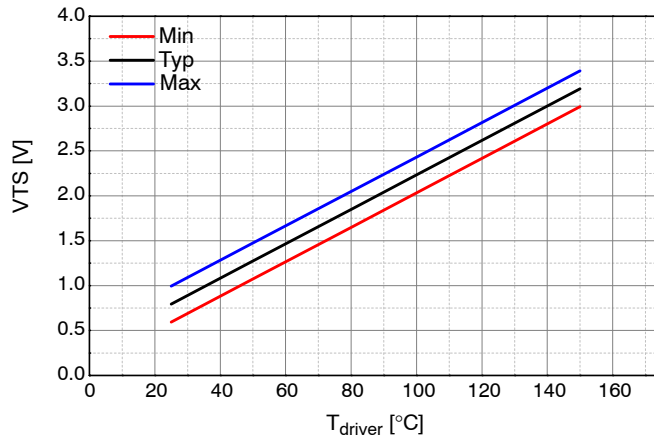


Figure 5. Temperature Profile of VTS

NFA50460R4B, NFA50460R47

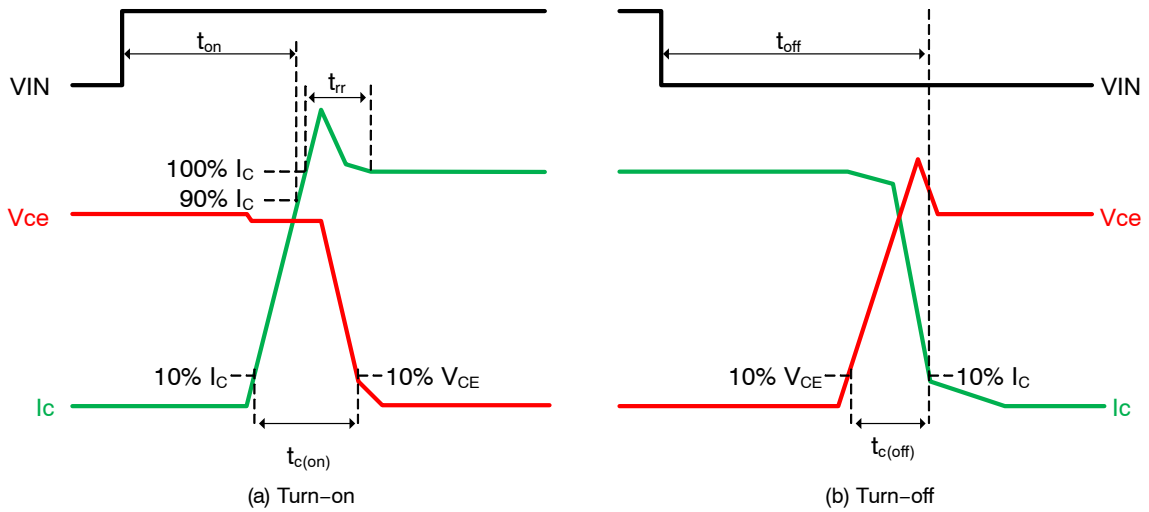


Figure 6. Switching Time Definitions

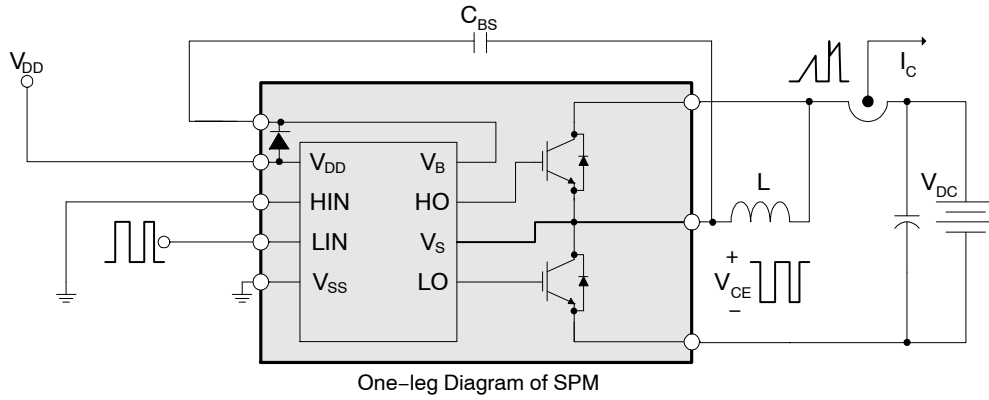


Figure 7. Switching and RBSOA (Single-pulse) Test Circuit (Low-side)

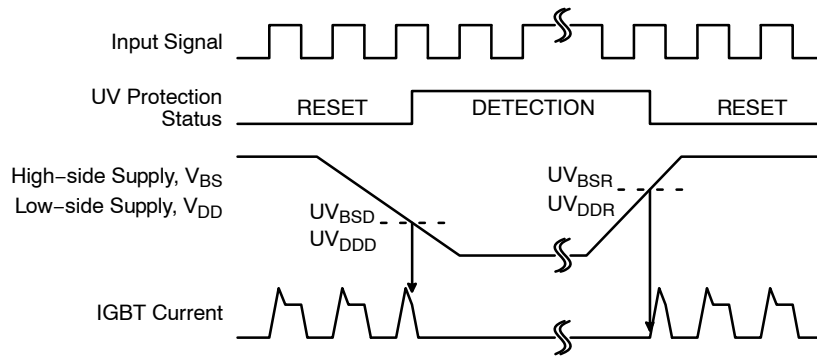


Figure 8. Under-Voltage Protection (High-side and Low-side)

NFA50460R4B, NFA50460R47

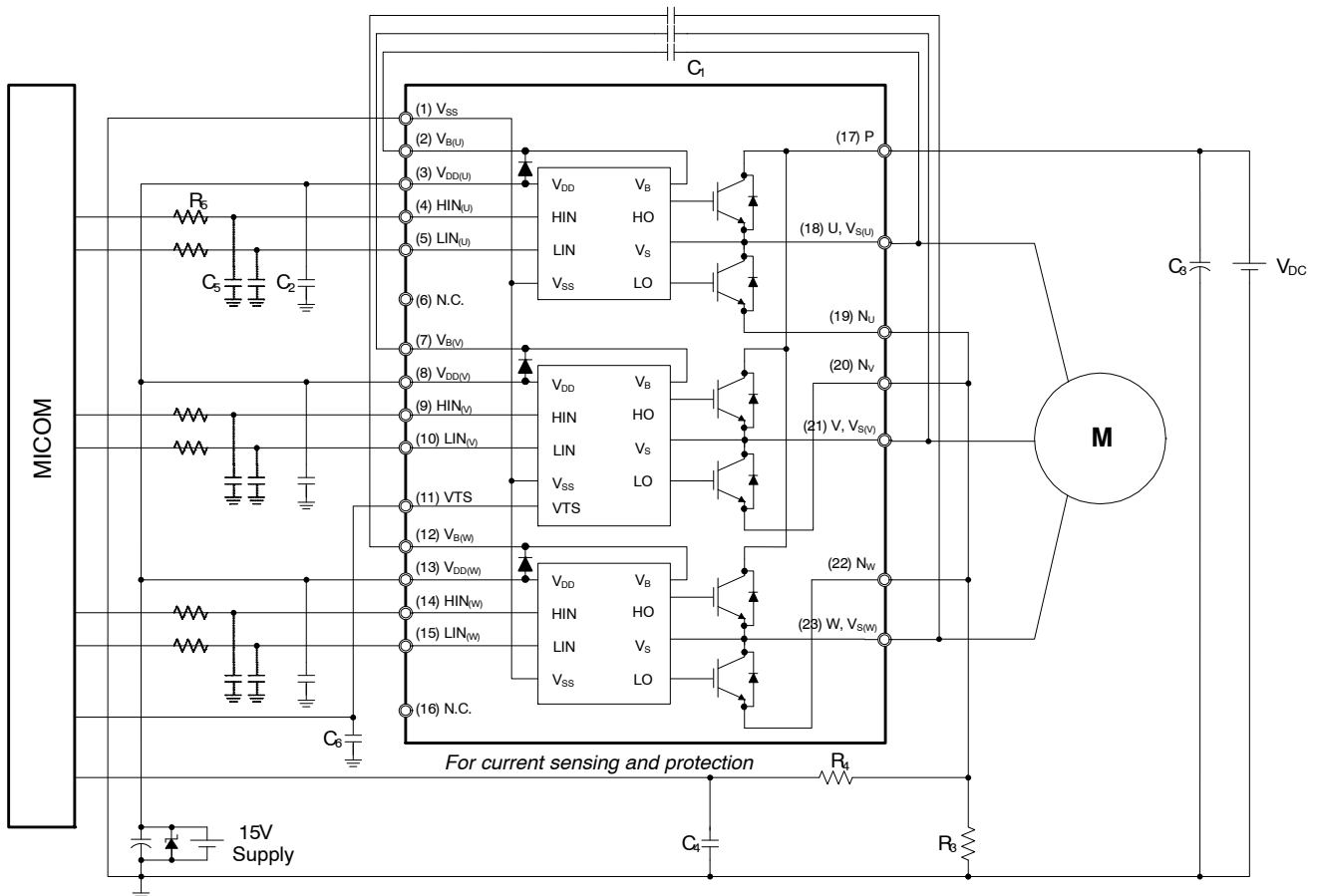


Figure 9. Example of Application Circuit

NOTES:

14. About pin position, refer to Figure 1.
15. RC coupling (R_5 and C_5 , R_4 and C_4) and C_6 at each input of Motion SPM 5 product and Micom are useful to prevent improper input signal caused by surge noise.
16. The voltage drop across R_3 affects the low side switching performance and the bootstrap characteristics since it is placed between V_{SS} and the emitter terminal of the low side IGBT. For this reason, the voltage drop across R_3 should be less than 1 V in the steady-state.
17. Ground wires and output terminals, should be thick and short in order to avoid surge voltage and malfunction of IC.
18. All the filter capacitors should be connected close to Motion SPM 5 product, and they should have good characteristics for rejecting high-frequency ripple current.

TYPICAL PERFORMANCE CHARACTERISTICS

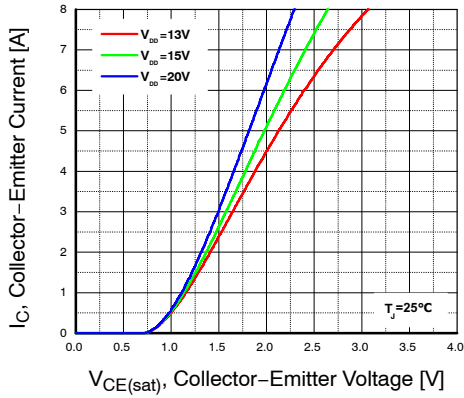


Figure 10. Typ. Collector-Emitter Saturation Voltage

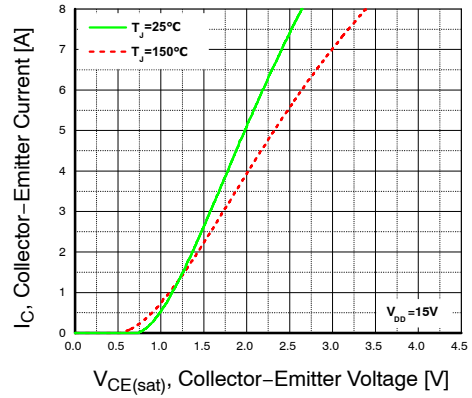


Figure 11. Typ. Collector-Emitter Saturation Voltage

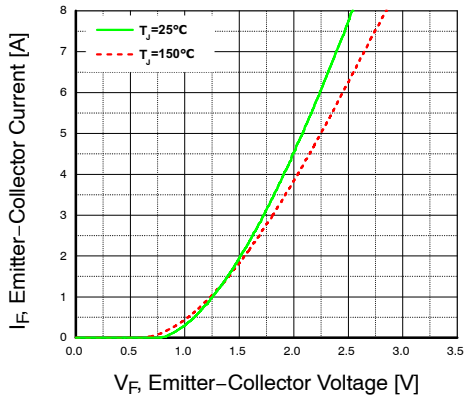


Figure 12. Typ. Emitter-Collector Forward Voltage

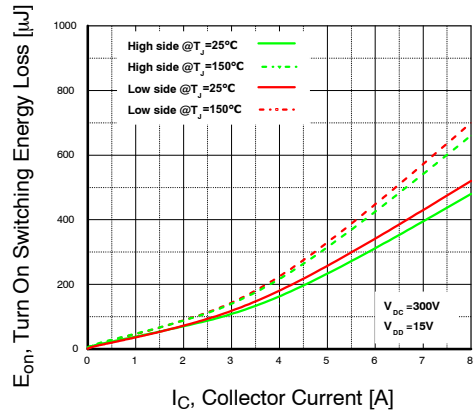


Figure 13. Typ. Turn On Switching Energy Loss

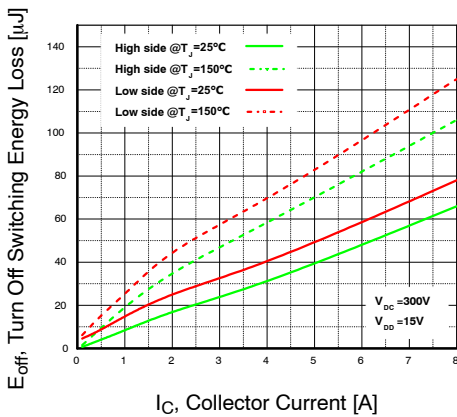


Figure 14. Typ. Turn Off Switching Energy Loss

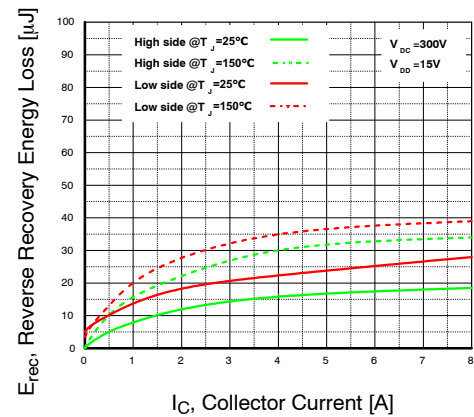


Figure 15. Typ. Reverse Recovery Energy Loss

TYPICAL PERFORMANCE CHARACTERISTICS

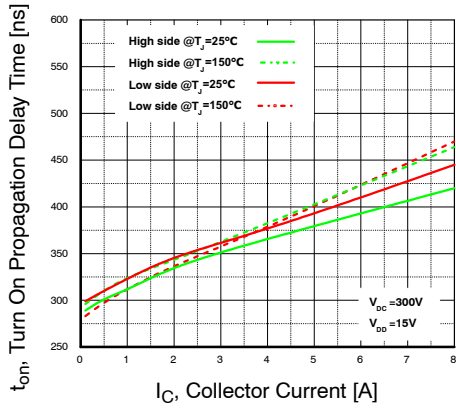


Figure 16. Typ. Turn On Propagation Delay Time

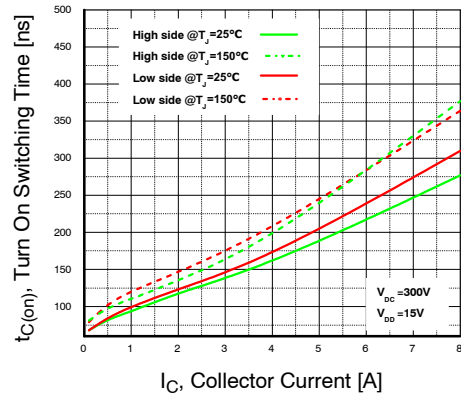


Figure 17. Typ. Turn On Switching Time

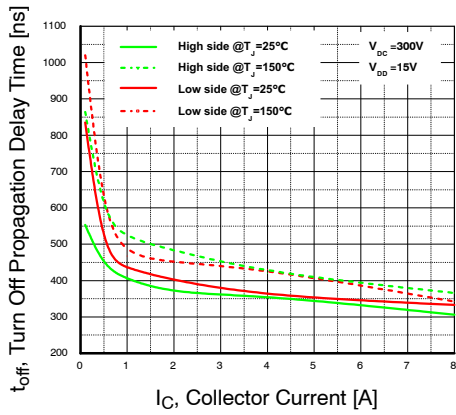


Figure 18. Typ. Turn Off Propagation Delay Time

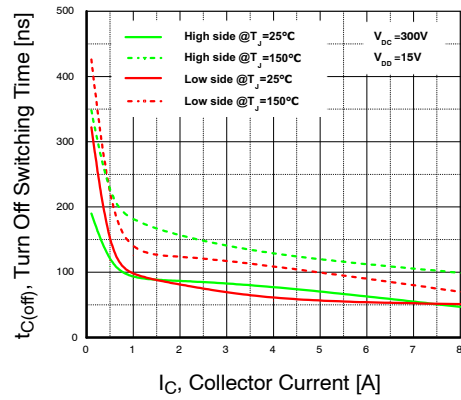


Figure 19. Typ. Turn Off Switching Time

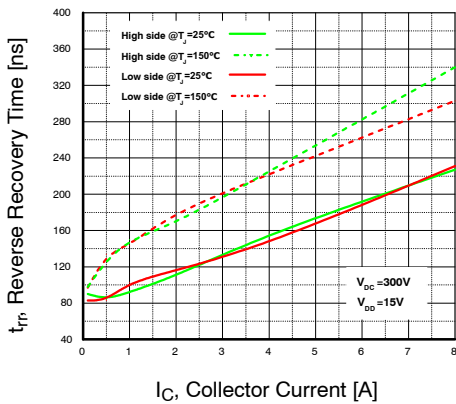


Figure 20. Typ. Reverse Recovery Time

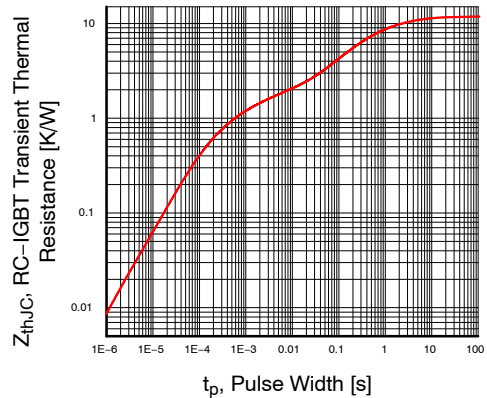
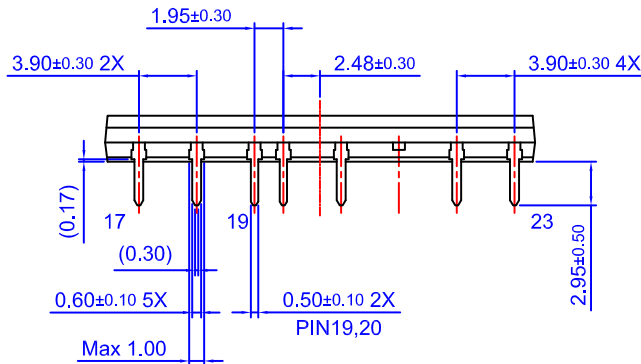
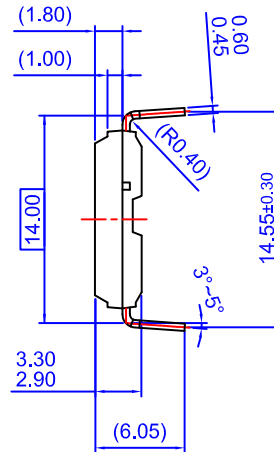
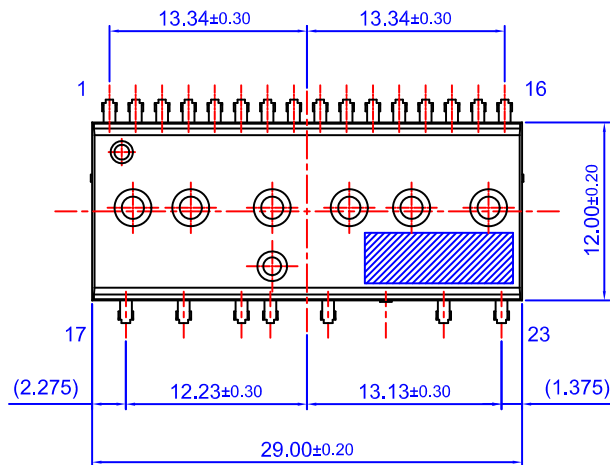
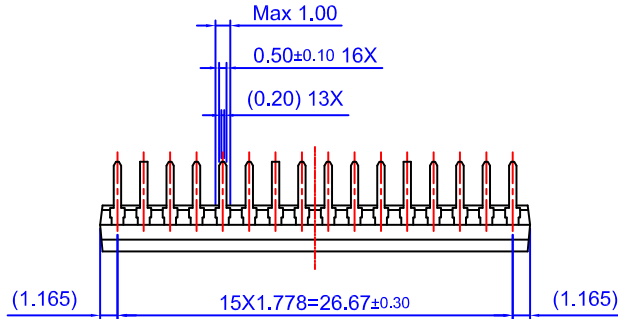


Figure 21. RC-IGBT Transient Thermal Resistance

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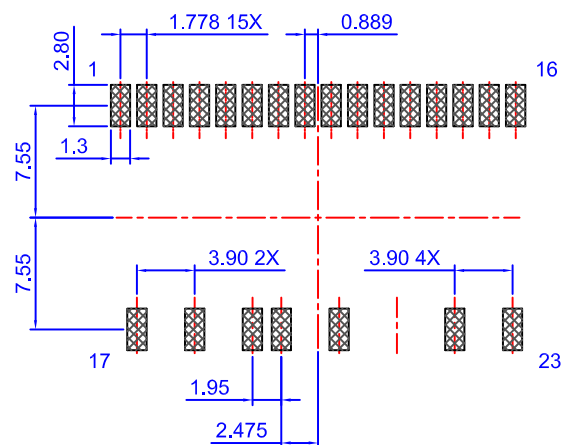
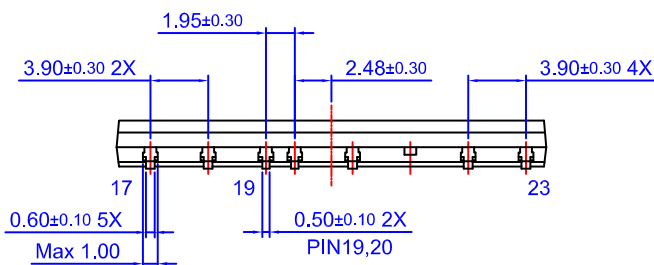
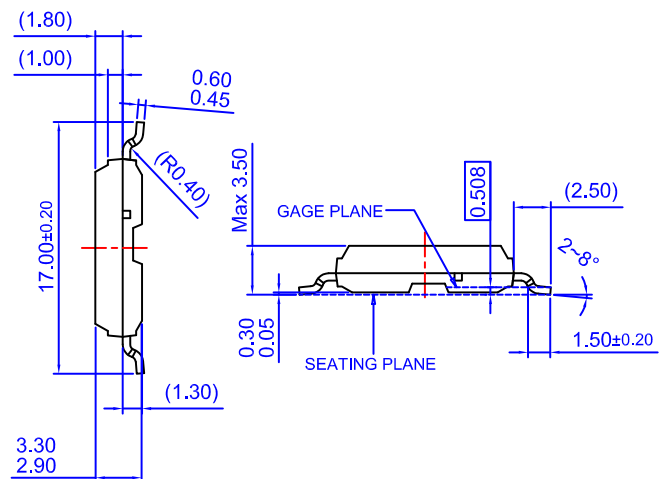
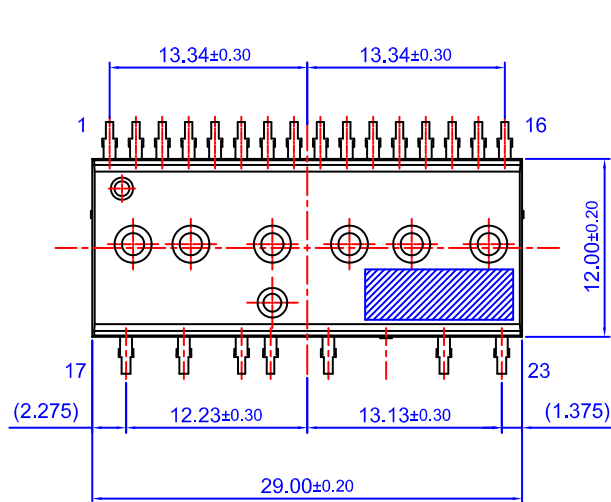
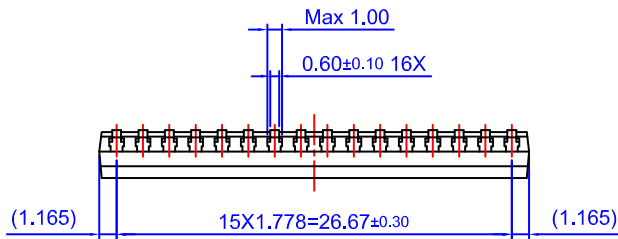
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