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Part numbers in this brochure are RoHS Compliant*, unless marked otherwise.
*as defined www.te.com/leadfree

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RCP0095E 03/2013



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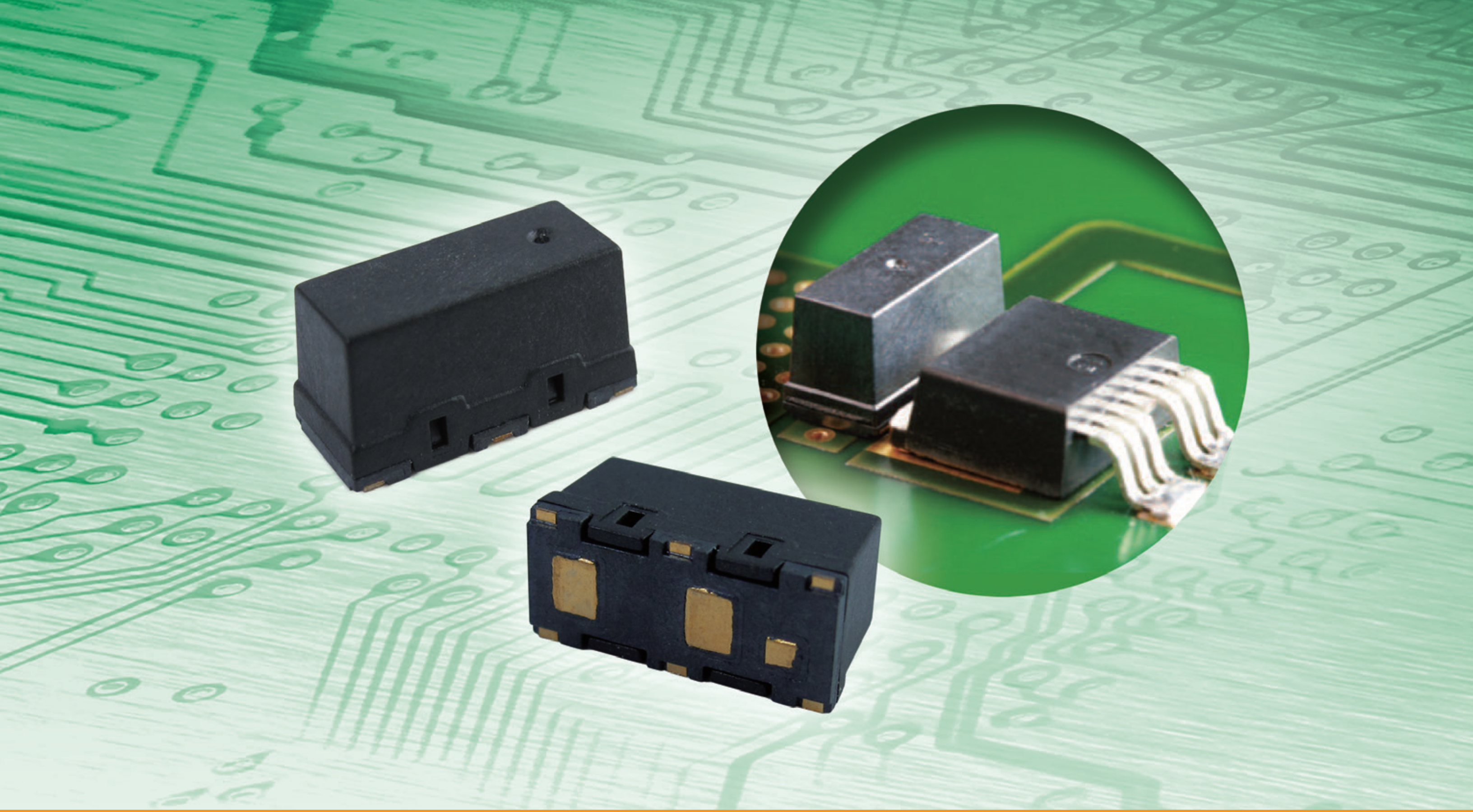

# Product Overview

## Reflowable Thermal Protection Solutions for Power Electronics Designs in Rugged Environments

TE Reflowable Thermal Protection (RTP) device is a low resistance, robust surface mountable thermal protector. It has a set open temperature and can be installed using reliable, lead-free, Surface Mount Device (SMD) assembly and reflow processes.

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The RTP device described in this overview can withstand the demanding environmental, life, and reliability requirements of automotive and industrial applications, including shock, vibration, temperature cycling, and humidity exposures. In the field, the RTP device opens if its internal junction exceeds the device's specified open temperature. Temperature increases can have multiple sources, one of which is component failure (i.e. when using power components such as a power FET, capacitor, resistor, triac, etc.). The RTP device open temperature is selected so that the device does not open within normal component operating windows, but it does open in a thermal runaway event and before the melt temperature of typical lead free solders.

To simplify installation, improve reliability, and optimize thermal coupling with the PCB, the RTP device is surface mountable. No special SMD installation is required. Instead, after installation, the RTP device utilizes a one time electronic arming process to become thermally sensitive. Before the arming procedure, the device can go through installation temperatures up to 260°C without going open. After arming, the device will open when the critical junction exceeds the open temperature. Arming can occur during test, or in the field.

## KEY FEATURES

- Opens at temperature below critical thermal threshold
- Compatible with up to 3 Pb-free solder reflow processes with peak temperatures up to 260°C
- Low series resistance
- DC interrupt voltage capable
- Robust design for harsh environment tested per stringent qualification specification
- RoHS compliant, lead and halogen free

## APPLICATIONS

- Helps provide protection against thermal runaway for power FETs and other components if failure occurs in applications such as automotive HVAC, ABS, power steering, DC/DC converters, PTC heaters, etc. or IT servers, telecom power, converters, etc.
- Other DC thermal protection

## BENEFITS

- Helps prevent failed components from smoking, and or de-soldering in case of a thermal event
- Allows use of standard surface-mount production methods with no special assembly costs
- Low power dissipation and voltage drop
- Supports DC electronic circuits
- Suitable for rugged environment applications (automotive and industrial)
- Green design



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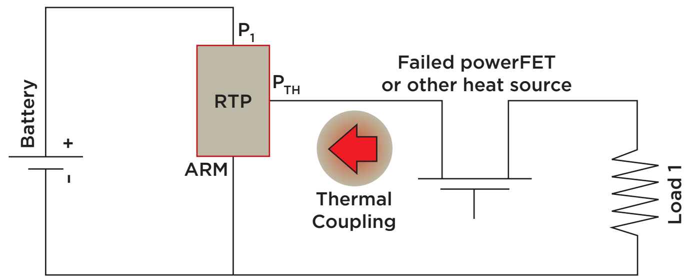
## TYPICAL APPLICATION BLOCK DIAGRAM

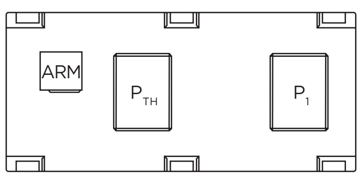



## PIN CONFIGURATION & DESCRIPTION PAD LAYOUT RECOMMENDATIONS

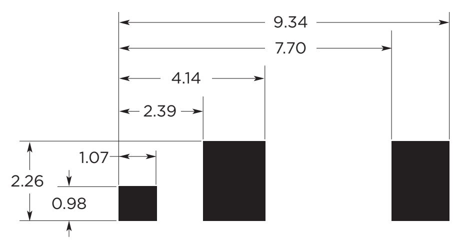
**Pin Description**

| Pin Number | Pin Name | Pin Function |
|---|---|---|
| 1 | $P_1$ | Power I/O pin (Main power current path) |
| 2 | $P_{TH}$ | Thermally sensitive power I/O pin - Intended to share protected component heat sink |
| 3 | ARM | Electronic arming pin |

**Pin Configuration (Bottom View of Device)**

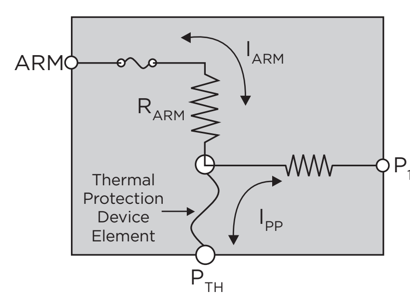



**Pad Dimensions in mm (Top View – Through Component)**




## DEFINITION OF TERMS / DEVICE BLOCK DIAGRAM

| | |
|---|---|
| Junction | The internal interface which must achieve the “Open Temperature” for the RTP device to open thermally after arming. This interface (thermal element) is located directly above the $P_{TH}$ pad. |
| Open Temp | The device will open when the junction temperature achieves this value. |
| $I_{ARM}$ and $R_{ARM}$ | Current and resistance levels measured between the ARM pin and either the $P_1$ or $P_{TH}$ pin. These values are relevant only pre device arming. |
| $R_{PP}$ and $I_{PP}$ | Current and resistance levels measured between the $P_1$ and $P_{TH}$ pins. |



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## METHOD OF OPERATION – ELECTRONIC ARMING

The RTP device is a unique thermal protector. It can be reflowed at temperatures up to 260°C without opening, yet in operation it will open at temperatures well below 260°C. To achieve this functionality, the RTP device uses an electronic arming mechanism.

Electronic arming must be done after reflow, and can be done during final test.

The device is armed by sending a specified arming current through the ARM pin of the device. Arming is a time- & current-dependent event. Arming times vs. current are provided in the “Arming Characteristics” section of this overview. Current can flow in either direction through the ARM pin.

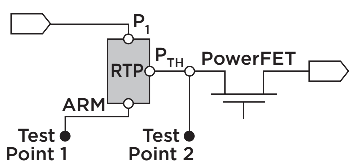
Prior to arming, $R_{ARM}$ should have typical resistance as specified in the “Arming Characteristics” section. Once armed, the ARM pin will be electrically open relative to the $P_1$ or $P_{TH}$ pins.

Arming has been successful once $R_{ARM}$ exceeds the post-arming minimum resistance specified in the “Arming Characteristics” section. RTP devices must be armed individually and cannot be armed simultaneously in series.

Once “armed”, the RTP device will permanently open when the device junction achieves its specified opening temperature.

Although multiple options exist, below is one simple arming option.

**Sample Arming Options**

| During Test | Current Flow | Description |
|---|---|---|
|   | $P_{TH} \leftrightarrow$ ARM = Arming | **ARM pin connected between two test points**<br>In this case, pin $P_1$ is left “floating”, and arming can occur during test, at a user defined time, by connecting to the Test Points and applying sufficient current ($I_{ARM}$) between Test Point 1 and Test Point 2 until the device is armed. |

## ABSOLUTE MAX RATINGS

| Absolute Max Ratings | | RTP200R060SA | RTP140R060SD | Units |
|---|---|---|---|---|
| | | Max | Max | |
| Max DC Open Voltage [1] | | 32 | 32 | $V_{DC}$ |
| Max DC Interrupt Current [1] | @ 16 $V_{DC}$ | 200 | 200 | A |
| | @ 24 $V_{DC}$ | 130 | 130 | |
| | @ 32 $V_{DC}$ | 100 | 100 | |
| ESD rating (Human Body Model) | | 25 | 25 | KV |
| Max Reflow Temperature (pre-arming) | | 260 | 260 | °C |
| Operating temperature limits, post-arming, non-opening | | -55<br>+175 | -40<br>+105 | °C |

[1] Performance capability at these conditions can be influenced by board design. Performance should be verified in the user’s system.



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## PERFORMANCE CHARACTERISTICS

| Resistance and Open Characteristics $P_1$ to $P_{TH}$ | | RTP200R060SA | | | RTP140R060SD | | | Units |
|---|---|---|---|---|---|---|---|---|
| | | Min | Typ | Max | Min | Typ | Max | |
| $R_{PP}$ (Resistance from $P_1$ to $P_{TH}$) | @ 23+/-3°C | – | 0.6 | 0.8 | – | 0.7 | 1.1 | mΩ |
| | @ 105+/-3°C | – | – | – | – | 0.9 | 1.2 | |
| | @ 175+/-3°C | – | 0.8 | 1.2 | – | – | – | |
| Operating Voltage | - | - | 32 | - | - | 32 | - | $V_{DC}$ |
| Open Temperature, post-arming | $I_{PP}$ = 0 | 196 | 205 | 213 | 135 | 140 | 145 | °C |
| Thermal Resistance: Junction to Case | Case = $P_{TH}$ pad | – | 0.5 | – | – | 0.5 | – | °C/W |
| Installation dependent Operating Current, post-arming (2)(3) | @ 23+/-3°C | 32 | – | – | 25 | – | – | A |
| | @ 100+/-3°C | 27 | – | – | – | – | – | |
| | @ 105+/-3°C | – | – | – | 12 | – | – | |
| | @ 175+/-3°C | 9 | – | – | – | – | – | |
| Moisture Sensitivity Level Rating (4) | – | – | 1 | – | – | 1 | – | – |

## ARMING CHARACTERISTICS

| Arming Characteristics ARM | | RTP200R060SA | | | RTP140R060SD | | | Units |
|---|---|---|---|---|---|---|---|---|
| | | Min | Typ | Max | Min | Typ | Max | |
| Arming Type | | Electronically Armed | | | Electronically Armed | | | – |
| $R_{ARM}$ (Resistance from ARM to $P_1$ or $P_{TH}$) | Pre-Arming | – | 300 | – | – | 300 | – | mΩ |
| | Post-Arming | 10 | – | – | 10 | – | – | KΩ |
| Arming Current ($I_{ARM}$) (2) | @ 23 +/-3°C | 2 | – | 5 | 2 | – | 5 | A |
| Arming Time (@23 +/-3°C) (2) | @ 2A | – | 0.10 | – | – | 0.10 | – | Sec |
| | @ 5A | – | 0.01 | – | – | 0.01 | – | |

(2) Results were obtained on 44.5 x 57.2 x 1.6 (mm) single layer FR4 boards with 70µm (2oz) Cu traces, and a 645mm², 70µm (2oz) Cu heat spreader connected to the $P_{TH}$ pad of the RTP device. (See RTP device test board drawing) Results will vary based on user's configuration and should be validated by the user in the end system.

(3) Operating current is measured on the RTP test boards at the specified temperature. It is a highly installation dependent value.

(4) As per JEDEC J-STD-020C.



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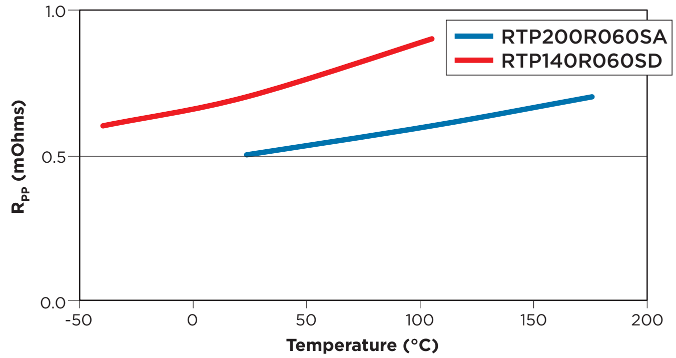
## TYPICAL ELECTRICAL PERFORMANCE CHARACTERISTICS

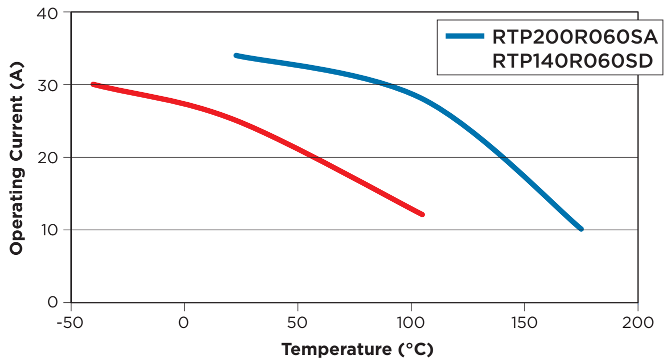
**Typical Resistance ($R_{PP}$) Vs Temperature**
**(Passive Testing)**



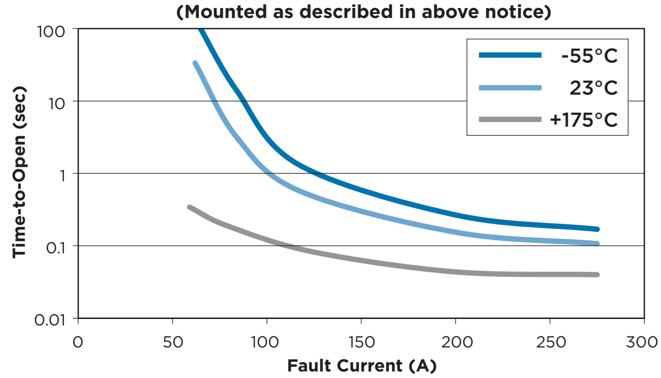

## INSTALLATION DEPENDENT PERFORMANCE CHARACTERISTICS

**Note:** Results were obtained on 44.5 x 57.2 x 1.6 (mm) single layer FR4 boards with 70µm (2oz) Cu traces, and a 645mm², 70µm (2oz) Cu heat spreader connected to the $P_{TH}$ pad of the RTP device. (See RTP device test board drawing)
Results will vary based on user's configuration and should be validated by the user in the end system.

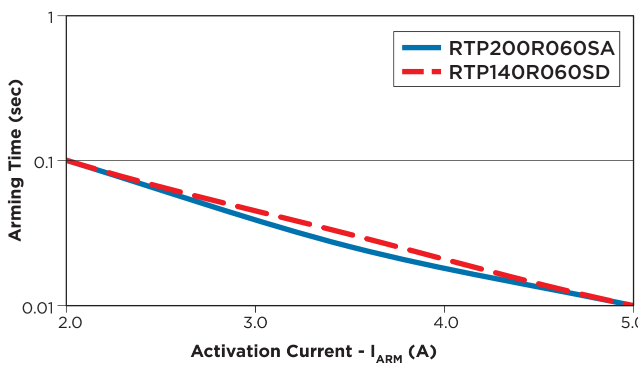
**Operating Current Vs Temperature**
**(Mounted as described in above notice)**



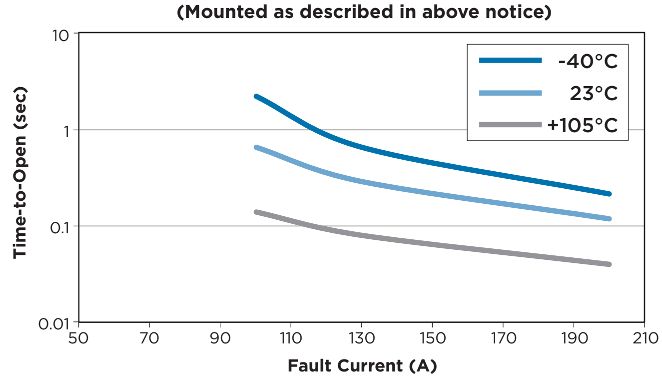

**Typical Time-to-Open Vs Fault Current ($I_{PP}$ Open)**
**for RTP200R060SA Device**
**(Mounted as described in above notice)**




**Typical Arming Time @ 23 +/-3°C**
**(Mounted as described in above notice)**




**Typical Time-to-Open Vs Fault Current ($I_{PP}$ Open)**
**for RTP140R060SD Device**
**(Mounted as described in above notice)**



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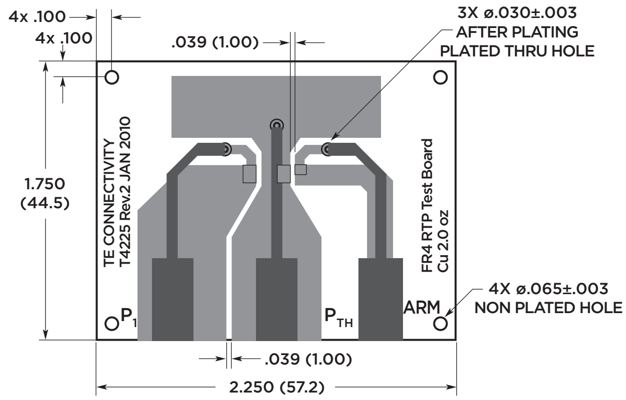
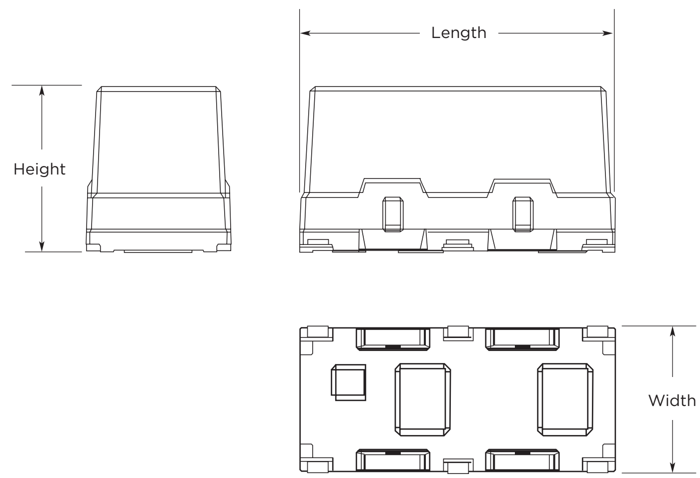
**Test Board: 44.5 x 57.2 x 1.6 mm, 70µm (2oz) Cu**




$P_{TH}$ pad area = 661mm², $P_1$ pad area = 393mm², ARM pad area = 169mm²

## MECHANICAL DIMENSIONS

| | RTP200R060SA | | Units |
|---|---|---|---|
| | Min | Max | |
| Height | 6.00 | 6.35 | mm |
| Length | 11.60 | 12.00 | mm |
| Width | 5.25 | 5.50 | mm |




## MATERIAL CONSTRUCTION

**RoHS Compliant**

**Directive 2002/95/EC Compliant**

**ELV Compliant**

**Directive 2000/53/EC Compliant**

**Pb-Free**

**Halogen Free***

HF

* Halogen Free refers to: Br≤900ppm, Cl≤900ppm, Br+Cl≤1500ppm.



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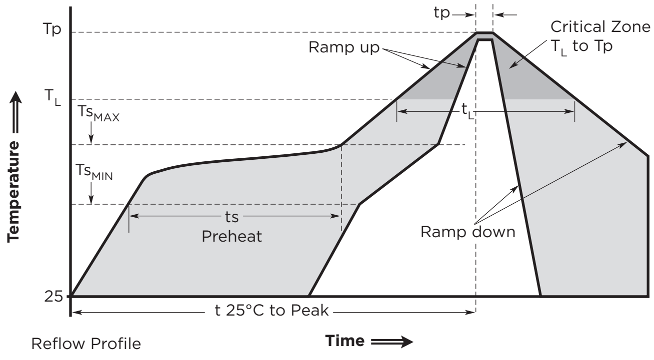
## RECOMMENDED REFLOW PROFILE

### Classification Reflow Profiles

| Profile Feature | Pb-Free Assembly |
|---|---|
| **Average Ramp-Up Rate ($Ts_{MAX}$ to Tp)** | 3°C/second max. |
| **Preheat** | |
| • Temperature Min ($Ts_{MIN}$) | 150°C |
| • Temperature Max ($Ts_{MAX}$) | 200°C |
| • Time ($ts_{MIN}$ to $ts_{MAX}$) | 60-180 seconds |
| **Time maintained above:** | |
| • Temperature ($T_L$) | 217°C |
| • Time ($t_L$) | 60-150 seconds |
| **Peak/Classification Temperature (Tp)** | 260°C |
| **Time within 5°C of actual Peak Temperature** | |
| Time (tp) | 20-40 seconds |
| **Ramp-Down Rate** | 6°C/second max. |
| **Time 25°C to Peak Temperature** | 8 minutes max. |

### Reflow Profile



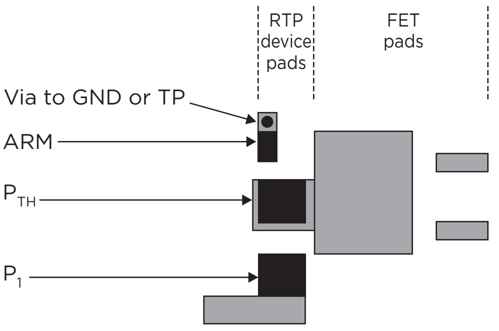
Reflow Profile

## LAYOUT RECOMMENDATIONS

Intimate thermal contact with the potential heat source is critical to achieve the desired protection performance. The RTP device should be used so that the $P_{TH}$ pin shares a copper mounting pad with the primary thermal pin or heat sink of the FET or protected component. Board layout recommendations for appropriate thermal coupling are provided below.

1. The RTP device $P_{TH}$ pad must be placed as close to the FET heat sink as practical.
2. Connect the $P_{TH}$ pad to the FET heat sink with as thick and wide a copper trace as practical.
3. Additional copper layers should NOT be placed directly underneath the $P_{TH}$ pad, and if possible, pull additional copper layers away from the RTP device $P_{TH}$ pad. These additional copper layers work to pull heat away from the RTP device and decrease its thermal sensitivity.
4. Pull top layer "cooling" traces as far away from RTP device $P_{TH}$ pad as practical.

**Example layout of an RTP device mounted near to a typical powerFET package on an FR4 type PCB**




**Note:** Thermal conductivity between the RTP device and the heat source is highly dependent on board layout, heat sink structures, and relative placement and design of co-located components. It is the responsibility of the user to verify that the RTP device provides sufficient protection in the user's specific final device implementation.



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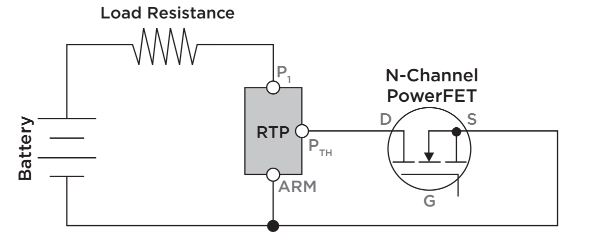
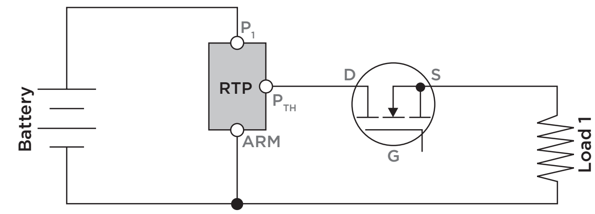
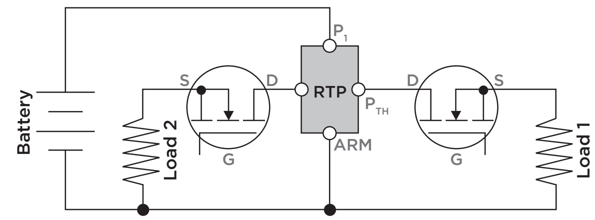
## ALTERNATE & MULTI-FET SCHEMATIC IMPLEMENTATIONS

| | | Schematic | Solution Considerations |
|---|---|---|---|
| Low Side, N-Channel Single FET Protection | |  | • Low side N-Channel FET architectures allow only one FET to be installed per RTP device.<br>• Note: Load may limit "arming" current. |
| High Side, N-Channel FET Protection | Single FET |  | • High Side FET designs allow multiple FETs to be installed with 1 RTP device while all sharing the same copper mounting pad (heat sink).<br>• In the Multi-FET configuration, care must be taken to assure proper thermal response can be achieved with each FET. |
| | Multi FET |  | |

**Note:** The degree of thermal connectivity between the heat source and the RTP device is highly dependent on board layouts, PCB material, heat sink structures, and relative placement and design of co-located components. It is the responsibility of the user to verify that the RTP device provides sufficient protection in the user's specific final device implementation.

## QUALIFICATION TESTING

The Qualification testing plan for this series of RTP devices is built upon AEC automotive grade testing for ICs (AEC-Q100), discrete semiconductors (AEC-Q101), and passive components (AEC-Q200), with the intent to demonstrate survivability to the most stringent of the relevant requirements.

Contact TE Circuit Protection for updated qualification status and detailed procedures.

*A specific list of tests and conditions is available upon request.

## ENVIRONMENTAL SPECIFICATIONS

| RTP200R060SA | | RTP140R060SD | |
|---|---|---|---|
| **Test** | **Conditions** | **Test** | **Conditions** |
| Passive thermal aging | 175°C, 1000 hours | Passive aging | 105°C, 1000 hours |
| Active thermal aging | 175°C, 3A bias, 1000hr | Humidity aging | 85°C, 85% RH, 1000 hours |
| Passive humidity aging | 85°C, 85% RH, 1000 hours | Storage humidity | Per IPC/JEDEC J-STD020A level 1 (MSL1) |
| Active humidity aging | 85°C, 85% RH, 5A bias, 1000hr | Thermal shock | 105°C, -40°C (300 times) |
| Storage humidity | Per IPC/JEDEC J-STD020A level 1 (MSL1) | | |
| Thermal shock | 125°C, -55°C (300 times) | | |



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