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TECHNICAL NOTES OF PPTC – POLIMERIC THERMISTOR – RESETABLE FUSE

How does the Polymer-Resettable-Fuse effect work?

A Polymer-Resettable-Fuse device comprises a polymer matrix that is loaded with carbon black particles to make it conductive. Since it is conductive it will pass a given amount of current. If too much current is passed through the device, the device will begin to heat by I2R effect. As the device heats it will expand. As it expands, the carbon particles will separate and the resistance of the device will increase. This will cause the device to heat faster and expand more, further raising the resistance. When the internal temperature of the device reaches 125°C, the change in resistance increases dramatically. This increase in resistance is sufficient to substantially reduce the current in the circuit. A small amount of current will still flow through the device sufficient to maintain the temperature of the device and keep the Polymer-Resettable-Fuse device at the high resistance level. When the power is cycled off and the fault removed, the Polymer-Resettable-Fuse device is allowed to cool. As the device cools, it contracts to its original shape and reconnects the carbon particles thus lowering the resistance of the device to a level where it can hold the current as specified for the device. This cycled can be repeated multiple times.

What is the difference between Rmin, Rmax, and R1max?

Rmin is the lowest specified resistance that any device supplied by Wayon have. Rmin will determine the specified minimum trip current of the device. Rmax is the highest specified resistance that any device supplied by Wayon will have. R1max is the highest resistance that a device should attain as a result of customer installation or normal use. This value determines the maximum hold current for a device. When a device is tripped by a customer, or installed using temperatures greater than the rated temperature of the device, the resistance of the device as supplied by Wayon (greater than or equal to Rmin and less than or equal to Rmax) may increase to a value less than or equal to R1max.

What voltage-drop values are expected?

This depends on the part in question. Typically the voltage drop of the device can be calculated if you know the resistance and the steady-state current flowing through the device. The value to use for the resistance of the Polymer-Resettable-Switch device is the R1max value to determine maximum voltage drop, or a typical voltage drop you can use either the Rmax value or, if that is not supplied, then a value that is the average of Rmin and R1max. If Iop is the normal operating

current and Rps is the resistance of the Polymer-Resettable-Fuse device (either R1max, (Rmax or Rmin + R1max)/2) then the voltage drop in the circuit can be calculated as: Vdrop = Iop x Rps.

Can Polymer-Resettable-Fuse devices be used in series?

This is not practical. Since one Polymer-Resettable-Fuse device will always trip first, the other device will provide no protection for the circuit.

What is the resistance of a Polymer-Resettable-Fuse device in the tripped state?

The resistance of the device in the tripped state depends on the following: the device used, the voltage across the device, the power dissipation of the device, the value of this resistance can be found using the following formula: Rt = V2/Pd.

How many times can you trip a Polymer-Resettable-Fuse device at the maximum voltage and interrupt currents?

Each Polymer-Resettable-Fuse device is rated to handle a specified operating voltage. Each device can withstand a specified interrupt current as a fault event. To obtain UL recognition, the device must be tripped at least 6,000 times and still exhibit PTC characteristics. For the telecom devices SN,SD,SF, they have a rating for maximum surge voltage for specific fault events that can occur in telecom applications. This may be as few as ten times or as many as several hundred times with the device still meeting the original specification values. Designers should keep in mind that the Polymer-Resettable-Fuse device is intended to protect against faults and failures and is not intended to be used in applications where it will be expected to be tripped as the normal mode of functioning.

How quickly do Polymer-Resettable-Fuse devices reset?

The time it takes a device to reset to the low resistance state depends on a variety of factors: Which device it is How it is mounted or fixtured The ambient temperature The nature and duration of the trip event In general, most devices under expected conditions will reset within a couple of minutes although many will reset within seconds.

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How long can a Polymer-Resettable-Fuse device stay in the tripped state without damage?

The UL rated devices must sustain a 1000 hour trip event at the maximum rated voltage without losing PTC characteristics. Longer trip events can be sustained with a fault event that is less than the maximum rated voltage and current for the device. The longer the device is held in a tripped state the more likely it is that the device will not recover all of its original resistance value when reset and therefore may not meet the original device specifications. The degree that each device will suffer this degradation is highly dependent on the fault event and the device in question

Can Polymer-Resettable-Fuse devices be resistance sorted?

Some of our devices are supplied in a resistance sorted variant of the standard product. This capability is primarily designed for the devices that are designed for use in telecommunications applications such as the SF250, SD250 and SF600 product families.

What are the effects of potting a Polymer-Resettable-Fuse device?

In general, potting is not a recommended practice. Although some customers have successfully potted our components, care must be exercised with the material selected for potting as well as with the means of curing the potting. If the potting material is too rigid it will not allow the PPTC device to expand as designed and therefore will prevent the device from operating as designed. Even if the material is a "soft" potting compound, the thermal transfer characteristics of the device will be affected and the device will perform differently than as specified.

What are the effects of pressure on a Polymer-Resettable-Fuse device?

Pressure on the device will affect the electrical performance of the device. If the pressure is sufficient to restrict the expansion of the device during a trip event the device will fail to function as specified.

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How can I identify which Polymer-Resettable-Fuse device I have from a sample or description?

Most Polymer-Resettable-Fuse devices are labeled with the Wayon symbol and an identifying mark or code. Standard product marking is outlined in each product section of the databook. However, Wayon manufactures many custom parts that can only be identified by a knowledgeable factory representative.

What is the maximum ambient temperature where Polymer-Resettable-Fuse devices can be used?

For the operational state this depends on the product family in question. For most of our products the usable range extends up to 85°C ambient. For some product families (certain SF, Chip and RHE devices) this can be as high as 125°C and for some others (LP-CW) this is as low as 70°C. For a non-operational state some of our devices will withstand solder reflow temperatures (LP-SM, LP-MSM, SD) for short duration.

Is the Polymer-Resettable-Fuse device self-resetting? How? How fast?

Yes, the device is self-resetting once the fault is cleared and the device has an opportunity to cool down. The cooling causes the device to contract and reconnects the carbon black molecules, thus lowering the resistance. The normal way to cool down the device is to power off the equipment that is being protected by the Polymer-Resettable-Fuse device, cutting the maintain or trickle current and allowing the device to cool. This should not be confused with a bi-metallic device which will also self-reset. A typical bi-metallic device will reset even if the fault is not removed, thus causing a cycling on and off between the fault event and a protected state which may damage the equipment. The Polymer-Resettable-Fuse device will latch at the high resistance state until the fault is removed. By combining the Polymer-Resettable-Fuse device in parallel with another PTC device such as a light bulb it is possible to design a circuit using a Polymer-Resettable-Fuse device that will reset without powering off the device. (See the speaker application note for an example.) The time it takes a device to reset to the low resistance state depends on a variety of factors: Which device it is How it is mounted or fixtured Ambient temperature Nature and duration of the trip event In general most devices under expected conditions will reset within a couple of minutes although many will reset within seconds.

Will the Polymer-Resettable-Fuse device cycle? How does it stay latched?

Polymer-Resettable-Fuse devices will not cycle between a normal and a tripped state when a fault condition is present. When the Polymer-Resettable-Fuse device trips it goes from a low resistance to a high resistance state. In the high resistance state a small amount of trickle current is still present. This small trickle current is sufficient to maintain the Polymer-Resettable-Fuse device in the high resistance state. The Polymer-Resettable-Fuse device generally requires the power to the circuit to be interrupted, allowing the Polymer-Resettable-Fuse device to cool before it will return to the normal low resistance state.

What is the relationship between IH and IT? Why the gap?

IH is defined as the maximum current at which a device will not trip at temperature (20°C to 25°C depending on product family) in still air. In other words, this is the expected maximum operational current at room temperature. IT is defined as the minimum current at which the device will always trip at temperature (20°C to 25°C) depending on product family) in still air. In other words, this is the expected minimum fault condition that is expected at room temperature. For most of our products there is a 2:1 relationship between IT and IH. For some products this can be as low as 1.7:1 and for others as great as 3:1. The material and manufacturing variance in resistance as well as the change of resistance after a trip event or high temperature installation will determine the closeness in value of IH to IT. For most of our products this makes the 2:1 ratio the most practical specification value.

When will a Polymer-Resettable-Fuse device reset?

The reset condition is a function of the current and voltage as well as the temperature. The device will usually begin to reset when its temperature decreases below 90°C (We can say that a device below 80°C has essentially reset).

What are the basic differences between a Polymer-Resettable-Fuse device, a fuse, or other circuit protection device? How does it work with overvoltage devices to provide protection?

The most obvious difference between a Polymer-Resettable-Fuse device and a fuse is the feature of resettability. While both products provide overcurrent protection, a single Polymer-Resettable-Fuse device can provide this protection multiple times, whereas after the fuse has provided its

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protection, it must be replaced for the circuit to function properly. The typical performance of a Polymer-Resettable-Fuse device is similar to that of a time delay fuse. Both devices need to have the thermal derating of the device taken into account, but the Polymer-Resettable-Fuse device does not need to have an I2t derating since it does not degrade like a fuse does under start-up conditions. When comparing a Polymer-Resettable-Fuse device to a bi-metallic circuit breaker the main difference is not resettability, but a rather latching. Both devices are resettable, but the bi-metallic circuit breaker can reset itself even when the fault is still present. This can lead to large EMFspikes on resetting and when tripping and potentially reconnecting a fault condition that could damage equipment and be unsafe. The Polymer-Resettable-Fuse device will latch in the high resistance state until the fault is cleared and the power is cycled off and on. Polymer-Resettable-Fuse devices differ from ceramic PTC devices in their initial resistance, the time to react to fault events, and size. Both products are resettable but the Polymer-Resettable-Fuse device, compared to a ceramic PTC device of the same hold current, will typically react (trip) much faster than the CPTC, because it is a smaller device. The most common application where Polymer-Resettable-Fuse devices are used in combination with overvoltage devices are in telecom applications. Here overvoltage devices such as thyristors, gas discharge tubes, MOVs, or diodes provide protection against lightning and power cross faults. The Polymer-Resettable-Fuse device protects the overvoltage protection device in some of these fault events and can also provide protection against other overcurrent events.

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