

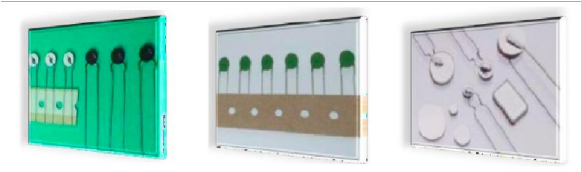
Resettable PPTC Fuse Fundamentals and it's working

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Polymeric Positive Temperature Coefficient (PPTC) devices are used to help protect against harmful overcurrent surges and overtemperature faults, thereby reducing warranty, service and repair costs. Ideal for situations where frequent

overcurrent conditions occur or constant uptime is required, resettable PTCs (PPTCs) are typically used in consumer electronics, power line, telecom, I/O port, process control and medical equipment protection and railways outdoor signaling applications. PPTC devices can be used as heaters and fuses. This article is about use of PPTC as a fuse only.



PPTCs increase resistance as temperature increases due to increased flow. Designed to limit unsafe currents while allowing constant safe current levels, resistance will "reset" automatically when the fault is removed and temperature returns to a safe levels. Like traditional fuses, these devices limit the flow of dangerously high current during fault conditions.

Recommended makes for railways applications are RACHEM, BOURNS, LITTLE FUSE, FUSETECH & TYCO.

The characteristics of PPTC resettable fuses

Protect the devices against overcurrent and over-temperature the resistance of resettable fuses will change to very high state to cut off the current flow over the circuit as an overcurrent flow through the circuit, so to protect the device against the failures.

Resettable after power off and the failure has been eliminated, resettable fuses will recover to the initial state without any manual operation. The PPTC, however, resets after the fault is cleared and power to the circuit is removed, thereby re-

ducing warranty, service and repair costs.

Non-cycle running There are a little current flow over the fuse to keep high resistance of the fuse at tripping state until the failure is eliminated and the device is powered off.

Large interrupting capacity Resettable fuses can cut off larger interrupting current, even more than 100A.

Tolerance to lightning strike the resettable fuses can be used in the systems where may be some strong lightning surge flow over without any damage.

Rapidly tripping PPTC resettable fuses trip more rapidly than other similar devices.

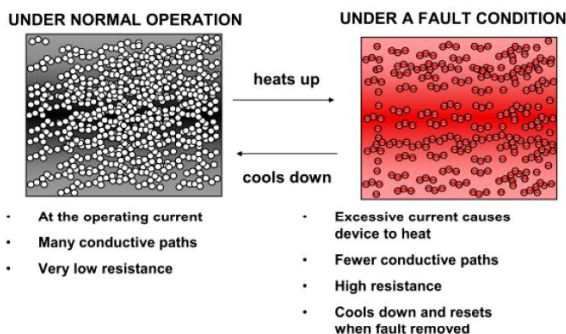
How PPTC device works?

PPTC fuses reach a high resistance with a low holding current under fault conditions and cycle back to a conductive state after the current is removed, acting more like circuit breakers, allowing the circuit to function again without opening the chassis or replacing anything. A PPTC device has a current rating. When the current flowing through the device (which has a small resistance in the on state) exceeds the current limit, the PPTC device warms up above a threshold temperature and the electrical resistance of the PPTC device suddenly increases several orders of magnitude to a "tripped" state where the resistance will typically be hundreds or thousands of ohms. The current subsequently reduces due to the finite voltage of the power source. The rated trip current can be anywhere from 20 mA to 100 A.

A polymeric PTC device comprises a non-conductive crystalline organic polymer matrix that is loaded with carbon black particles to make it conductive. While cool, the polymer is in a crystalline state, with the carbon forced into the regions between crystals, forming many conductive chains. Since it is conductive (the "initial resistance"), it will pass a given current, called the "hold current". If too much current is passed through the device, the "trip current", the device will begin to heat. As the device heats, the

polymer will expand, changing from a crystalline into an amorphous state. The expansion separates the carbon particles and breaks the conductive pathways, causing the resistance of the device to increase. This will cause the device to heat faster and expand more, further raising the resistance. This increase in resistance substantially reduces the current in the circuit. A small current still flows through the device and is sufficient to maintain the temperature at a level which will keep it in the high resistance state. The device can be said to have latching functionality.

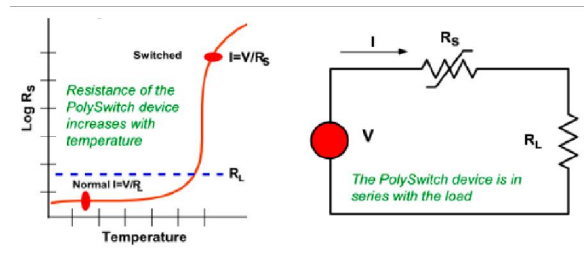
When power is removed, the heating due to the holding current will stop and the PPTC device will cool. As the device cools, it regains its original crystalline structure and returns to a low resistance state where it can hold the current as specified for the device. This cooling usually takes a few seconds, though a tripped device will retain a slightly higher resistance for hours, slowly approaching the initial resistance value. The resetting will often not take place even if the fault alone has been removed with the power still flowing as the operating current may be above the holding current of the PPTC. The device may not return to its original resistance value; it will most likely stabilize at a significantly higher resistance (up to 4 times initial value). It could take hours, days, weeks or even years for the device to return to a resistance value similar to its original value, if at all. Since a PPTC device has an inherently higher resistance than a metallic fuse or circuit breaker at ambient temperature, it may be difficult or impossible to use in circuits that cannot tolerate significant reductions in operating voltage, forcing the engineer to choose the latter in a design.



Why is PPTC useful?

- Employed as series elements in circuit
- Under normal operating conditions, the PPTC remains low in resistance

- When a fault occurs, the PPTC heats up and increases in resistance thereby protecting the equipment from fault.
- PPTC resets when power is removed, and fault is cleared, returning to low resistance state



Benefits

- Reduced warranty and service costs
- Increased product reliability
- Superior shock and vibration withstand
- Wide variety of applications

Features

- Remotely resettable
- Testable
- Solid-state
- Wide variety of stock and custom form factors
- Low resistance devices available

Traditional Fuses vs. PPTCs

Fuses and PPTCs are both overcurrent protection devices, though each offer their own unique operating characteristics and benefits. Understanding the differences between the two technologies should make the choice in selection easier, depending on the application.

The most obvious difference is that PPTCs are automatically resettable whereas traditional Fuses need to be replaced after they are tripped. Whereas a fuse will completely stop the flow of current (which may be desired in critical applications) after most similar overcurrent event, PPTCs continue to enable the equipment to function, except in extreme cases.

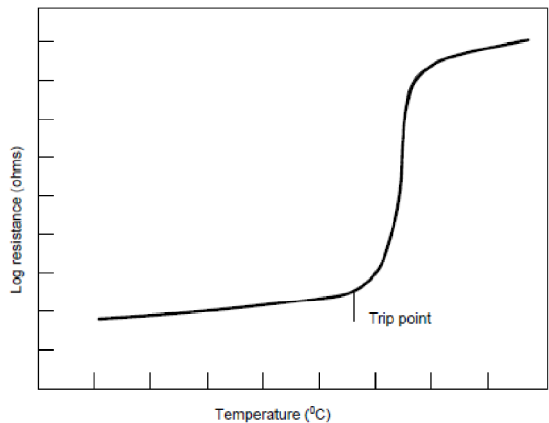
Because they reset automatically, many circuit designers choose PPTCs in instances where overcurrent events are expected to occur often, and where maintaining low warranty and service costs, constant system uptime, and/or user transparency are at a premium. They are also often chosen in circuits that are difficult to access or in remote locations, where fuse replacement would be difficult.

There are several other operating characteristics to be considered that distinguish PPTCs and fuses, and it is also best to test and verify device performance before use within the end application.

PPTC Characteristics

Both Polymeric (Positive Temperature Coefficient) PPTC and traditional Fuse devices

react to heat generated by the excessive current flow in a circuit. A fuse melts open, interrupting the current flow whereas a PPTC limits current flow as it rises in temperature, changing from low to high resistance state. In both cases this condition is called "tripping." The graph at right shows the typical response of a PPTC to temperature.



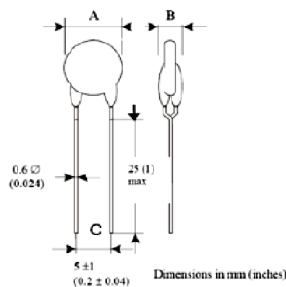
PTC = Positive Temperature Coefficient thermistors. That is, the resistance increases as the temperature increases.

Physical Dimensions :

A = Diameter
B = Thickness
C = Lead Spacing

PTCs typically are used as disc or uncoated wired parts for heaters

PTCs typically are coated with a silicone resin for fuse applications

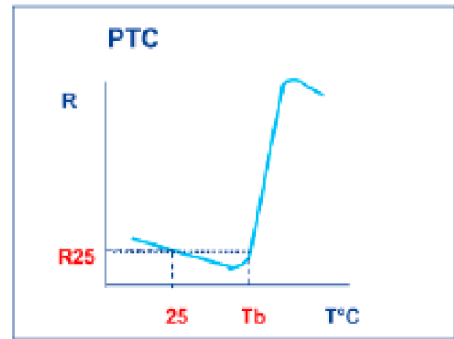


PPTC Fuse – Typical Values

- Resistance Range = 0.8 to 5,000 ohms
- Voltage Range = 5V – 1000V
- The diameter Range from 2.5 – 18 mm
- The thickness Range from 1.0 – 4 mm
- Normally supplied as leaded disc but can also be supplied as a non-leaded part.
- Steady state current range is between 0.014 Amps-1.0 Amps. At current levels above this, the size of the PPTC needed to work in this application would make it cost prohibitive so another fuse technology needs to be considered.
- Because PPTC fuses are used for safety, and most circuits never see a fault condition, the vast majority of PPTC fuses are never used. That is, they never operate above their transition temp.



The resistance versus temperature graph shows how a PPTC reacts to temperature changes.



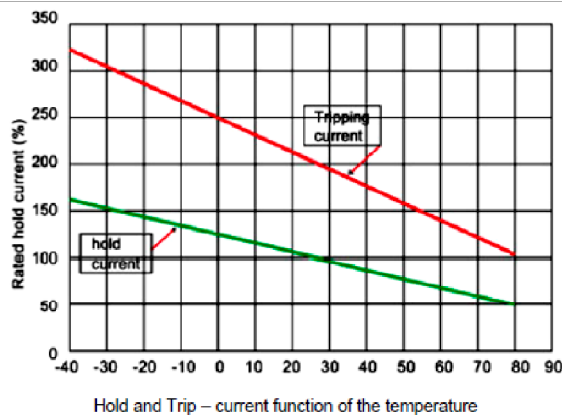
Tb = transition temperature. The temperature where the ceramic microstructure changes. The resistance above this point is much higher than the resistance below this point.

Operating parameters

- **Initial resistance:** The resistance of the device as received from factory of manufacturing.
- **Operating voltage:** The maximum voltage a device can withstand without damage at the rated current.
- **Steady State Current or non trip current:** The highest current that the PPTC can take over the entire application temperature range without heating the PPTC above its transition temperature (high resistance state). The electricity will flow through the circuit. Analogy: The water faucet remains open and the water flows freely.
- **Holding current:** Safe current through the device.
- **Trip current:** Where the device interrupts the current. Trip Current is the current level that sufficiently heats up the PPTC so that it switches into its high resistance mode. The electricity will cease to flow through the circuit. Analogy: The faucet closes and the flow of water stops.
- **Time to trip:** The time it takes for the device to trip at a given temperature.
- **Tripped state:** Transition from the low resistance state to the high resistance state due to an overload.
- **Leakage current:** A small value of stray current.

rent flowing through the device after it has switched to high resistance mode.

- **Trip cycle:** The number of trip cycles (at rated voltage and current) the device sustains without failure.
- **Trip endurance:** The duration of time the device sustains its maximum rated voltage in the tripped state without failure.
- **Power dissipation:** Power dissipated by the device in its tripped state.
- **Thermal duration:** Influence of ambient temperature.
- **Hysteresis:** The range between where the device trips and where the device returns to a conductive state.



Since PPTC's fuses are designed to remain in their low resistance state at the circuits normal current levels, something wrong happens to the circuit to cause the current to increase high enough to send the PPTC above its transition temperature. The PPTC will automatically reset itself when the current returns to normal levels, hence the name self resettable fuses.

Equations for trip and steady state current are given below :

Steady State Current Equations :

PPTC Fuse Equations for Time to Trip :

$$I_{min} = \sqrt{\frac{\delta(T_{tr} - T_{min})}{R@25^{\circ}C}}$$

$$I_{max} = \sqrt{\frac{\delta(T_{tr} - T_{max})}{R@25^{\circ}C}}$$

$$t \cong \left(\frac{H}{\delta}\right) \ln \left[\frac{P_o}{P_o - \delta(T_{tr} - T_{amb})} \right]$$

$$t \cong \frac{H}{P_o} (T_{tr} - T_{amb})$$

Where:

I = Current

T_{tr} = Switch temperature

T_{min} = Min temperature

$R@25$ = Resistance @ 25

T_{max} = Max temperature

Where:

δ = Dissipation constant

H = Heat capacity

T_{tr} = Transition temperature

T_a = Ambient temperature

P_o = Initial power input

Warning:

- Operation beyond the maximum ratings or improper use may result in device damage and possible electrical arcing and flame.
- The devices are intended for protection against occasional over current or over temperature fault conditions and should not be used when repeated fault conditions or prolonged trip events are anticipated.
- Contamination of the PPTC material with certain silicon based oils or some aggressive solvents can adversely impact the performance of the devices.
- Device performance can be impacted negatively if devices are handled in a manner inconsistent with recommended electronic, thermal, and mechanical procedures for electronic components.
- Operation in circuit with a large inductance can generate a circuit voltage ($L di/dt$) above the rated voltage of the PPTC resettable device.

Provision of PPTC fuses for outdoor circuits

Sr. No.	Location	Outer Circuits	Capacity of fuse	PPTC fuse
1	Apparatus case	i) Feed end of Track circuit	2 amp	Required
2		ii) TPR fuse	2 amp	Required
3		iii) ED fuse (if provided) (ED of mechanical signal)	2 amp	Required
4		iv) NWKPR/RWKPR fuse (ED of mechanical signal)	2 amp	Required
7		v) Track feed charger 110V AC input fuse	2 amp	Required
8		vi) EJB fuse for analog axle counter	2 amp	Required
9		vii) NKPR/KPR fuse	2 amp	Required
10		viii) Boom motor operation fuse (24V/110V)	8 amp	Required
11		ix) XCKPR fuse	2 amp	Required
12		x) Location lamp fuse	2 amp	Required
13			Signal motor operation fuse (For mechanical signaling)	4 amp
14	Relay room (CT rack)	i) 110V AC N/S supply for track feed charger	8 amp	Required
15		ii) 24V DC N/S supply for TPR	4 amp	Required
16		iii) 110V AC for LC gate located within 2 Km	8 amp	Required
19	Power equipment (Main fuse board)	i) 24V for CEL BPAC	2 amp	Required
20		ii) 24V for Eldyne BPAC	2 amp	Required
21		iii) 24V DC External N/S for TPR	4 amp	Required
22		iv) 110V AC N/S for track feed charger	8 amp	Required
25		v) 24V External N/S for EJB of analog AXT	4 amp	Required
26		vi) 60V/24V External for KLCR	2 amp	Required
27		vii) Panel indication fuse	4 amp	Required
Note - Fuse capacity may depend on load current and it must be at least 2 times of load current				

Fixing arrangement of PPTC fuses

PPTC fuses are to be connected with crimped ring type lugs. With these lugs, PPTC fuses fit nicely on ARA (American Rail Associates) terminals. This will provide a high reliability grip to the fuses in addition to the crimping. The crimped area is also to be filled with solder for enhancing reliability.

