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THE FUNDAMENTAL OF PPTC RESETTABLE FUSES

1. Principle and characteristic of PPTC Resettable fuses

1. 1. What is PTC material?

PTC material is a functional compound which resistivity increase as the temperature rise with a positive temperature coefficient. That is PTC thermal sensitive material. These materials are classified as linear or non-linear changing, or/and ceramic PTC (CPTC) or polymeric PTC (PPTC) materials. The resettable fuse is made of PPTC.

PPTC is made from a composite of semi-crystalline polymer and conductive particles (fig.1). At the normal temperature, there are a lot of crystals in the composite, and the conductive particles contact each other and form low-resistance networks. If the temperature rises above the melting point of the crystal, crystal will melt and expand sharply, and make the conductive particles breakaway, and the resistance of the composite will increase sharply (fig.2).

1. 2. The structure and the principle of PPTC resettable fuses

The resettable fuses are made of PTC polymer. At room temperature because the resistance is very low, the heat generated by the resettable fuse is very little, and the heat lost to the environment are in balance, and the crystalline structure of the polymer will not be changed. The rated current can flow over the resettable fuse. But at an overcurrent condition, the heat generated by I^2R heating will increase more than heat dissipation, the temperature of resettable fuse will increase, and therefore the temperature rise and expansion of PTC polymer increase, so that the separation of conductive particles and the resistance increased; as the resistance increase, more heat, further more rapid expansion, the resistance will be increased more rapidly. When the internal temperature of the component rise to 125°C , the resistance increases more sharply. The increasing resistance of the circuit makes a sharp drop in the current, only a very small amount of current flows through the fuse. The small current is enough to maintain the high temperature and a high resistance state of the fuse. When the power switch off and the failure has been eliminated, the resettable fuse will be cool and recovered to its initial state, and so that the conductive particles will be re-contacted with each other. Their resistance drop down so small to let the rated current flow over fuse and non-trip. This cycle can be repeated many times.

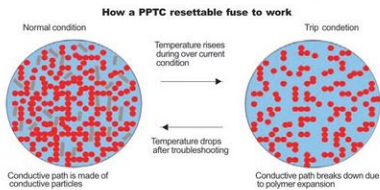


Fig. 1

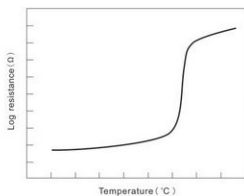


Fig. 2

1. 3. 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.



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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.

1. 4. The function of temperature for the behavior of PPTC resettable fuses

Figure 3 illustrates the hold- and trip-current behavior of resettable fuses as a function of temperature. Since resettable fuses are thermally activated, any change in the temperature around the devices will impact the performance of the device. As the temperature around the device increases, less energy is required to trip the device and thus the hold current decreases. This is why the I_{TRIP} curve and I_{HOLD} curve have negative slopes in Figure 3. At 25°C, 100% I_{HOLD} can flow over the fuse without tripping, but at higher or lower temperature around the fuse, the holding and the tripping current will decrease or increase by the derating curves in the fig.3.

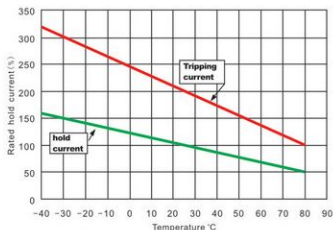


Fig.3 the hold- and trip-current function of the temperature

2. The difference between the PPTC device and other protective devices

Usually there may be many kind of overcurrent or/and over thermal protective devices in electrical or electronic systems: e.g. traditional glass fuses, double-metal thermal protective devices, and CPTC devices. Fuses would be used only one time, and we have to instead a new one after the trip. PPTC resettable fuses can be used many times without any instance, and it is so small to be easy to install. Double-metal thermal protective devices can recover, but even at the fault state, it would conduct the circuit at the fault state and would damage the circuit. Other way, PPTC device have to recover after power-off and the fault to be repaired.

PPTC device' initial resistance is lower, the tripping time is shorter and the size is smaller than CPTC device

3. The steps for selection of the fuses (For reference only)

3.1. To understand the operation characteristics of circuit devices.

E.g.:

- 1) maximum ambient temperature
- 2) rated non-trip current at 25°C (I_n)
- 3) maximum operation voltage (V_{rms})
- 4) minimum trip current at 25°C (I_T)



3.2. select the fuses family by the way to install and V_{rms} , and select the part number by I_n .

3.3. If ambient temperature is not 25°C , we select the part number on I_n which should be calculated by the following equation:

$$I_n = \text{rated non-trip current} \times \text{Thermal Derating at the ambient temperature}$$

3.4. choice the part number it's I_n should be larger than the data calculated by step 3rd.

3.5. confirm the minimum trip current I_T and time to trip t_T (sec/A) at a rated over-current by the table for "electrical characteristics".

4. Application guide

The guide below lists resettable fuse devices that are typically used in these applications. Specifications for the suggested device part numbers can be found in this section.

Once a part number has been selected, the user should evaluate and test each product for its intended application.

4.1. table for the fuses family

Part family	$V_{rms}(v)$	$I_n(A)$	installation	applications
PSL	6-16	0.030-16.00	Radial-leaded Devices	Electro magnetic loads, Halogen lighting, Lighting ballast, Loudspeakers, Medical equipment, MOSFET devices, Motors, fans and blowers, POS equipment, Process and industrial controls, Satellite video receivers.
PSM	30	0.05-9.00	Radial-leaded Devices	Security and fire alarm systems, USB, Test and measurement equipment, Transformers, DDC computer and consumer electronics, IEEE-1394 computer and consumer electronics.
PSN	60,130,180	0.03-6.00	Radial-leaded Devices	Mouse and keyboard, SCSI, Traces and printed circuit board protection, battery packs, power, phones, and so on
PSO	120	0.05-2.10	Radial-leaded Devices	
PSP	250	0.09-3.80	Radial-leaded Devices	
PSC	250	0.09-0.15	Radial-leaded /chip Devices	telecommunication
PSD	600	0.13-0.15	Radial-leaded /chip Devices	
PSB	12/16/20/24	0.70-7.30	chip Devices	battery (packs)
PSBD	16	2-2.5	chip Devices	lithium battery

Note: This list is not exhaustive. HOLLYLAND Electronics welcomes customer's input for additional application ideas for PPTC resettable devices.

4. 2. operation conditions

Operation /storage ambient temperature	-40~85 °C
Maximum surface temperature	≤125 °C
Typical time to recover	(25 °C) ≤20Sec. after power-off
Operation condition	relative humidity: ≤95% (25 °C); air pressure: 86~106KPa
Resistance at tripping state*	V^2/P_d

*: The fuse will recover if $V^2/4R_L < P_d$ (P_L = load resistance, V = operation voltage, P_d = dissipation power)

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4. 3. Physical Characteristics

Lead material	Tin-plated copper or Tin-plated copper clad-steel,
Soldering characteristics	Solderability per ANSI/J-STD-002 Category 3
Insulating material	Cured, flame-retardant epoxy polymer; meets UL 94V-0

4. 4. Environmental Specifications

Test	Conditions	Resistance Change
Passive aging	70°C, 1000 hours ±5% 85°C, 1000 hours	± 5%
Humidity aging	85°C, 85%RH, 1000 hours	± 5%
Thermal Shock	85°C, -40°C (10 times)	± 5%
Solvent resistance	MIL-STD-202, Method 215F	No change

4. 5. Notes:

I_H : Hold current: maximum current device will pass without interruption in 25°C still air.

I_T : Trip current: minimum current that will switch the device from low resistance to high resistance in 25°C still air.

V_{Max} : Maximum continuous voltage device can withstand without damage at rated current.

I_{Max} : Maximum fault current device can withstand without damage at rated voltage.

P_D : Power dissipated from device when in the tripped state in 25°C still air.

R_{Min} : Minimum resistance of device as supplied at 25°C unless otherwise specified.

R_{Max} : Maximum resistance of device as supplied at 25°C unless otherwise specified.

R_{1Max} : Maximum resistance of device when measured one hour post reflow (surface-mount device) or one hour post trip (radial-leaded device) at 25°C unless otherwise specified.

* Electrical characteristics determined at 25°C

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 overcurrent or overtemperature 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.