A

Seminar report

On

Polyfuse

Submitted in partial fulfillment of the requirement for the award of degree of Bachelor of Technology in ECE

SUBMITTED TO: SUBMITTED BY:

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Last but clearly not the least, I would thank The Almighty for giving me strength to complete my report on time.

Preface

I have made this report file on the topic **Polyfuse**; I have tried my best to elucidate all the relevant detail to the topic to be included in the report. While in the beginning I have tried to give a general view about this topic.

My efforts and wholehearted co-corporation of each and everyone has ended on a successful note. I express my sincere gratitude to …………..who assisting me throughout the preparation of this topic. I thank him for providing me the reinforcement, confidence and most importantly the track for the topic whenever I needed it.

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INTRODUCTION

Polyfuses is a new standard for circuit protection .It is re-settable by itself. Many manufactures also call it as Polyswitch or Multifuse. Polyfuses are not fuses but Polymeric Positive temperature Coefficient Thermistors (PPTC).

We can use several circuit protection schemes in power supplies to provide protection against fault condition and the resultant over current and over temperature damage. Current can be accomplished by using resistors, fuses, switches, circuit breakers or positive temperature coefficient devices.

Resistors are rarely an acceptable solution because the high power resistors required are expensive .One shot fuses can be used but they might fatigue and they must be replaced after a fault event. Another good solution available is the resettable Ceramic Positive Temperature Coefficient (CPTC) device. This technology is not widely used because of its high resistance and power dissipation characteristics. These devices are also relatively large and vulnerable to cracking as result of shock and vibration.

The preferred solution is the PPTC device, which has a very low resistance in normal operation and high resistance when exposed to fault. Electrical shorts and electrically overloaded circuits can cause over current and over temperature damage.

Like traditional fuses, PPTC devices limit the flow of dangerously high current during fault condition. Unlike traditional fuses, PPTC devices reset after the fault is cleared and the power to the circuit is removed. Because a PPTC device does not usually have to be replaced after it trips and because it is small enough to be mounted directly into a motor or on a circuit board, it can be located inside electronic modules, junction boxes and power distribution centers.

THE BASICS

Technically Polyfuses are not fuses but Polymeric Positive Temperature Coefficient Thermistors. For thermistors characterized as positive temperature coefficient, the device resistance increases with temperature. The PPTC circuit protection devices are formed from thin sheets of conductive semi-crystalline plastic polymers with electrodes attached to either side. The conductive plastic is basically a non-conductive crystalline polymer loaded with a highly conductive carbon to make it conductive. The electrodes ensure the distribution of power through the circuit.

Polyfuses are usually packaged in radial, axial, surface mount, chip or washer form. These are available in voltage ratings of 30 to 250 volts and current ratings of 20 mA to 100A.

PRINCIPLE OF OPERATION

PPTC circuit protection devices are formed from a composite of semi-crystalline polymer and conductive carbon particles. At normal temperature the carbon chains form low resistance conductive network through the polymer. In case an excessive current flows through the device, the temperature of the conductive plastic material rises. When the temperature exceeds the device's switching temperature, the crystallides in the polymer suddenly melts and become amorphous. The increase in volume during melting of the crystalline phase cause separation of the conductive particles and results in a large non-linear increase in the resistance of the device. The resistance typically increases by 3 or orders of magnitude.

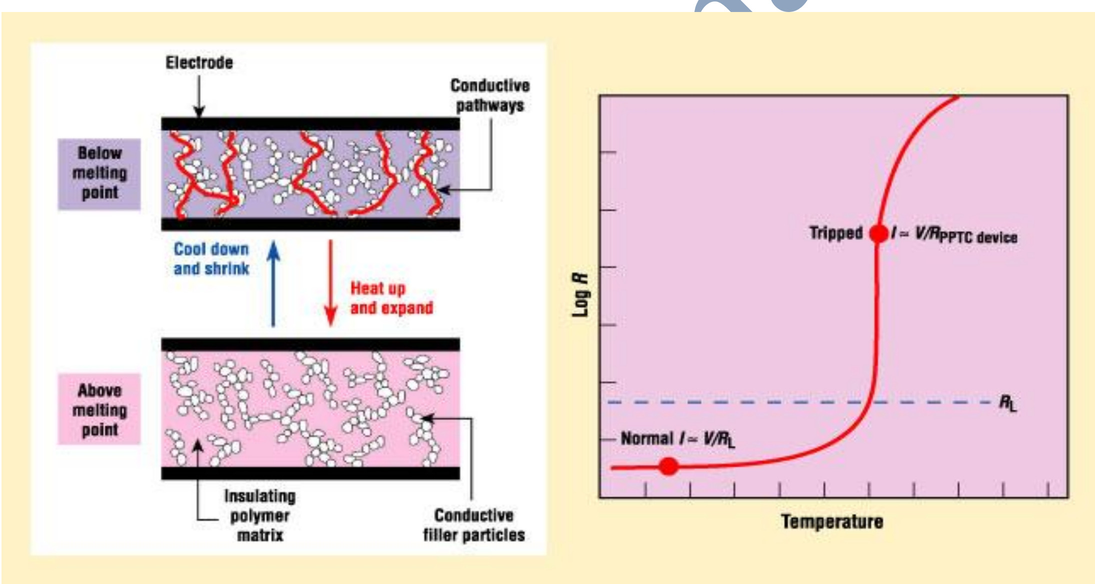


Figure 1

The principle of operation and increase in resistance in shown in the Fig.1. The increase in resistance protects the equipment in the circuit by reducing the amount of current that can flow under the fault condition to a low steady state level. The device will remain in its latched (high resistance state)until the fault is cleared, providing continuous protection to the circuit. At this time the conductive polymer particles cool and recrystallises restoring the PPTC to a low resistance state within few seconds. The circuit and the affected equipment return to the normal operating condition.

Thus a polyfuse acts like a self-resetting solid-state circuit breaker, which makes it suitable for providing low cost over current protection. The resistance of polyfuse at room temperature is in the order of few ohms and increases rapidly above 110° C.

OPERATING PARAMETERS FOR POLYFUSES

1. ***Initial Resistance*****:** The resistance of the device as received from the factory
2. ***Operating Voltage*****:** The maximum voltage a device can withstand without damage at rated current
3. ***Holding Current*****:** Safe current through the device.
4. ***Trip Current*****:** The current at which the interrupts the current
5. ***Time to Trip*****:** The time it takes for the device to trip at a given temperature and current
6. ***Tripped State*****:** Transition from low resistance state to high resistance state due to an overload
7. ***Leakage Current*****:** A small value of stray current flowing through the device after it has switched to high resistance mode.
8. ***Trip Cycle*****:** The number of trip cycles the device sustains without failure.
9. ***Trip Endurance*****:** The duration of time the device sustains its maximum rated voltage in the tripped state without failure.
10. ***Power Dissipation*****:** Power dissipated by the device in the tripped state.
11. ***Thermal Duration*****:** Influence of ambient temperature.
12. ***Hysteresis:*** The period between the actual beginning of the signaling of the device to trip and the actual tripping of the device.

DESIGN CONSIDERATIONS FOR PPTC DEVICES.

Some of the critical parameters to consider when designing PPTC devices into a circuit include device hold current and trip current, the effect of ambient conditions on device performance; device reset time, leakage current in the tripped state and the automatic or manual reset conditions.

1. **Hold and Trip Current:** The Fig.2 below illustrates the hold and trip current behavior of the PPTC devices as a function of temperature.

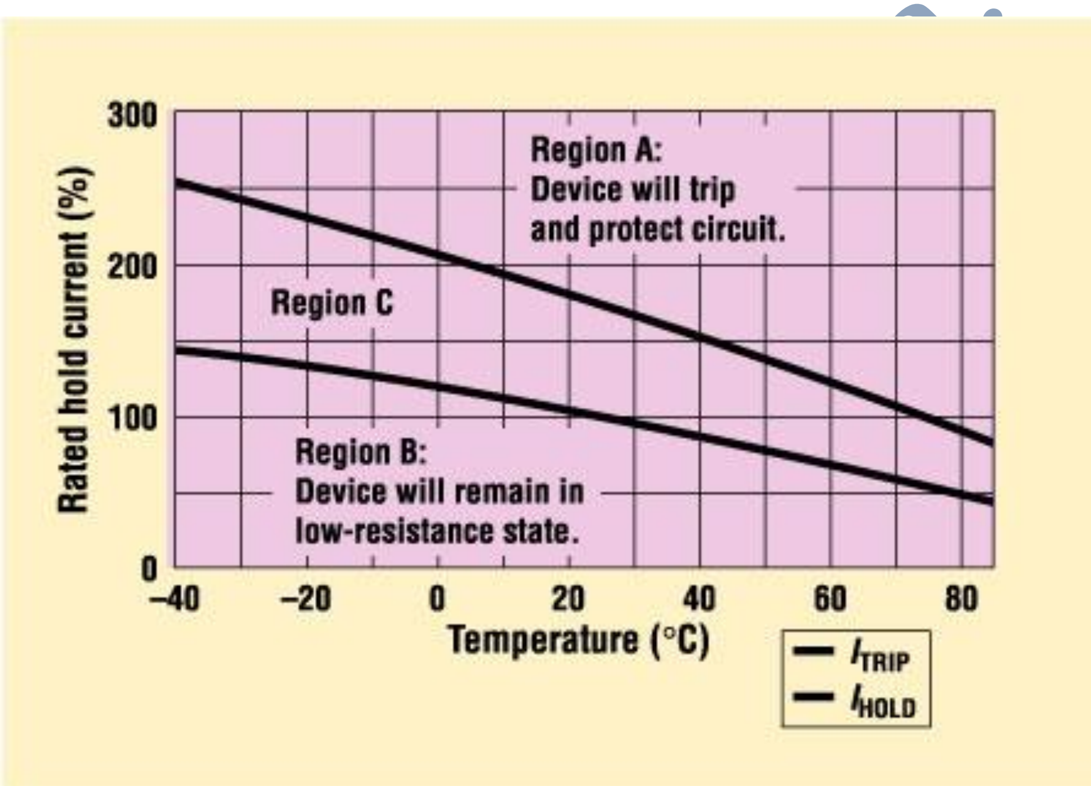


Figure 2

Region A shows the combination of current and temperature at which the PPTC device will trip and protect the circuit. Region B shows the combination of current and temperature at which the device will allow normal operation of the circuit. In Region C it is possible for the device to either trip or o remain in low resistance state depending on the individual device resistance and its environment.

Because PPTC devices can be thermally activated, any change in the temperature around the device could affect the performance of the device. As temperature around a PPTC device increases, less energy is required to trip the device and thus its hold current (I hold) decreases. The heat transfer environment can accurately define hold current. It can be affected by the design choices such as:

1. Placing the device in proximity to a heat generating source such as a power field effect transistor (FET), a resistor or a transformer resulting in reduced hold current, power dissipation and time to trip.
2. Increasing the size of the traces or leads that are in electrical contact with the device resulting in increased heat transfer and greater hold current, slower time to trip and greater power dissipation
3. Attaching the device to a long pair of wires before connecting to the circuit board, increasing the lead length of the device which results in reduced heat transfer and lowered hold current, power dissipation and time to trip.

2. Effect of Ambient Conditions on Device Performance:

The heat transfer environment of the device can significantly affect the device performance. In general, by increasing the heat transfer of the device, there is a corresponding increase in power dissipation, time to trip and hold current. The opposite occurs if the heat transfer from the device is decreased. Furthermore, changing the thermal mass around the device changes the time to trip of the device.

If the heat generated is greater than the heat lost to the environment, the device will increase in temperature resulting in a trip event. The rate of temperature rise and the total energy required to make a device trip depends on the fault current and heat transfer environment. Under normal operating conditions the heat generated by the device and the heat lost to the environment are in balance.

Increases in current or ambient temperature or increase in both, cause the device to reach a temperature at which the resistance rapidly increases. This large change in resistance causes a corresponding decrease in the current flowing through the circuit, protecting the circuit from damage.

3. Time to Trip

The time to trip of a PPTC device is defined as the time needed from the onset of a fault current to trip the device. Time to trip depends upon the size of the fault current and the ambient temperature.

DESIGN CRITERIA

To select the best device for a specific application, circuit designers should consider the following design criteria:

1. Choose the appropriate form factor. Select from radial- leaded, surface-mount, or chip parts. For mounting on circuit boards, a radial-leaded or surface- mount configuration is preferred. Radial-leaded parts are typically wave soldered to the board. Chip parts are designed to be held in clips, usually in an electric motor.
2. Choose a voltage rating. The voltage rating of a PPTC device should equal or exceed the source voltage in a particular circuit. Also the expected fault voltage should not be later than the PPTC voltage device. When a PPTC device trips, the majority of circuit voltage appears across the device because it is the highest resistance element present in the circuit.
3. Choose a hold current rating (At the proper ambient operating temperature). Hold current is defined as the greatest steady state current the PPTC device can carry without tripping into a high resistance state. Designers must choose a PPTC device with a hold current at maximum ambient temperature equal to or greater than the steady state operating current.
4. Check trip time. Designers should determine what fault currents may occur and how quickly the most sensitive system components could be damaged at these currents. A PPTC device should be selected that trips before these sensitive components would be damaged. Many applications experience a start-up surge current from a capacitance or motor. Normally, this in-rush current does not contain enough energy to trip the PPTC device, but the designers should confirm performance in their application over the range of expected ambient conditions.
5. Check maximum interrupt current. A PPTC device normally has a maximum interrupt current rating, i.e., the maximum fault current that the device consistently interrupts while remaining functional.

DIFFERENT TYPES OF POLYFUSES

Surface Mount Resettable Fuses

This surface mount polyfuse family of polymer of polymer based resettable fuses provides reliable over current protection for a wide range of products such as computer motherboards, USB hubs and ports, CD/DVD drives , digital cameras and battery packs. Each of these polyfuse series features low voltage drops and fast trip times while offering full resettability. This makes each an ideal choice for protection in datacom and battery powered applications where momentary surges may occur during interchange of batteries or plug and play operations.

The SMD0805 with the industry's smallest footprint, measuring only 2.2mm by 1.5mm, features four hold current ratings from 100mA to 500mA with a current interruption capability of 40A at rated voltage. Both the SMD1206 and SMD1210 series are optimized for protection of computer peripherals,PC cards and various port types.

Radial-Leaded Resettable Fuses

Due to the automatic resetting of the polyfuse, these components are ideal for applications, where temporary fault conditions (eg: during hot plugging) can occur. The radial-leaded RLD-USB-series 709 is specifically designed for universal serial bus (USB) applications with lower resistance, faster trip times and lower voltage drops.

Battery Strap Resettable Fuses

This type profile strap type polyfuse family of resettable fuses provides thermal and over charge protection for rechargeable battery packs commonly used in portable electronics such as mobile phones, notebook computers and camcorders.

Both Li-Ion and NiMH pack designs are enhanced with 0.8mm high form factor on the VTD-719 series. The LTD-717 series is optimized for prismatic packs and exhibits faster trip times- down to 2.9 sec at five times the fuse's hold current rating.

EDGES OVER CONVENTIONAL FUSES

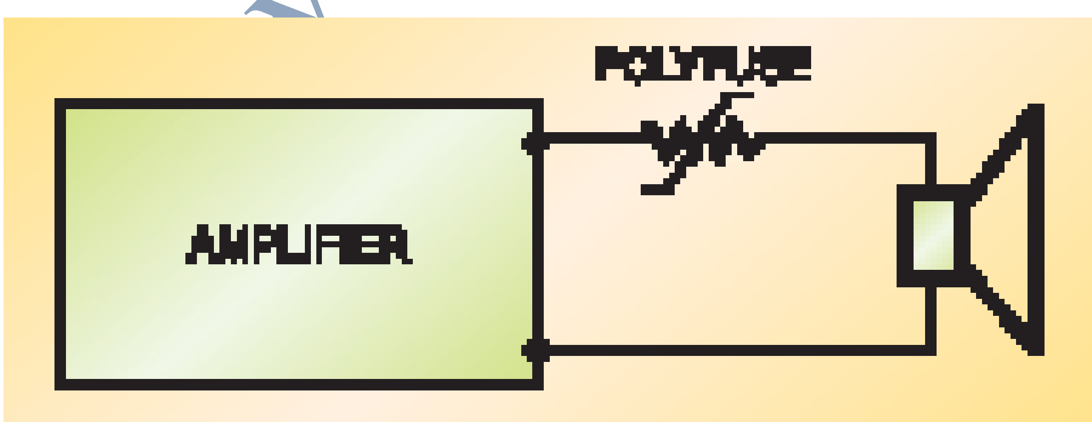
1. Over current protection
2. Low base resistance
3. Latching operation
4. Automatic resettability
5. Short time to trip
6. No arching during faulty situations
7. Small dimensions and compact designs
8. Internationally standardized and approved
9. No accidental hot plugging
10. Withstand mechanical shocks and vibrations
11. Life time- up to 10 times longer

APPLICATIONS

Polyfuses are used in automobiles, batteries, computers and peripherals, industrial controls, electronic modules, medical electronics, loud speakers, transformers etc.

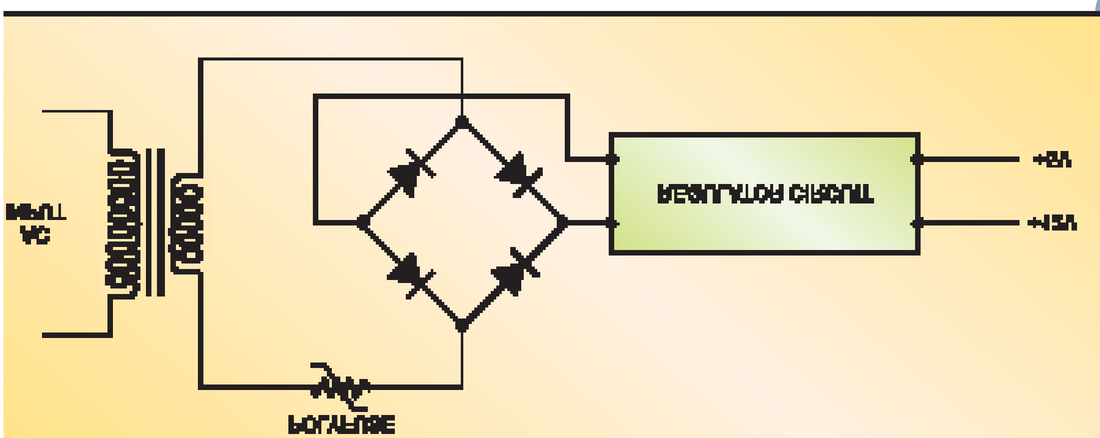
For protecting speakers:

Now a days, speakers are designed and sold independently of amplifiers. Therefore, there are possibilities of damage due to mismatches; for eg. High power amplifiers coupled with low power speakers or a speaker coil driven with a high volume. The protection choices for loud speakers are limited. Fuses protect the speaker but a blown fuse is always a source of frustration. Using a polyfuse in series with the speaker will protect it from over current and over heating damage. Choosing a correct trip current rated polyfuse is important to match the power level of the speaker.



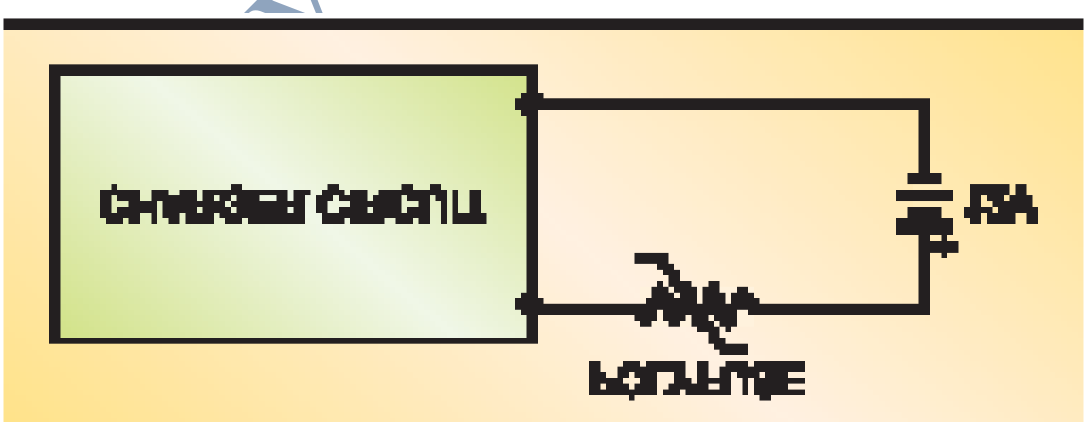
For Protecting Transformers:

The equipment powered by a transformer get over heated due to excessive current or short circuit. A polyfuse on the secondary side of the transformer will protect the equipment against overload.



For Protecting Batteries:

Batteries are constantly charged and discharged over their life cycle. Over charge results in an increase in the temperature of the electrolyte. This could cause either a fire or an explosion. Polyfuse can play a vital role in the charging and discharging cycles of batteries.



Applications for Resettable Circuit Protection in Automotive Electronics

The conventional solution groups similar circuits together and protects them all with a single fuse. The fuse must be sized to carry the sum of the currents drawn by each of the protected loads; and, to limit risk of damage and fire, the wires feeding from the fuse to each load must be chosen according to the fuse size selected. This design practice often results in oversized wires with high current-carrying capability feeding loads that require relatively low currents. Using heavy-gauge wire also requires use of larger terminals and connectors, which further increases cost, size, and weight. It also increases harness weight, and the weight of the automobile, which has an effect on fuel efficiency.

Because PPTC devices reset when a fault condition clears and power is removed from the circuit, they do not generally require routine replacement or service. Therefore, such devices can be placed inside doors, in switch assemblies, behind instrument panels, in electronic modules, and in other inaccessible areas within the vehicle. As shown in Figure 3, the option of locating circuit-protection devices strategically throughout the vehicle also allows power to be routed via the most direct and efficient route (rather than through a central fuse box), which reduces the number of wires in the harness and allows reduction in their length and weight.

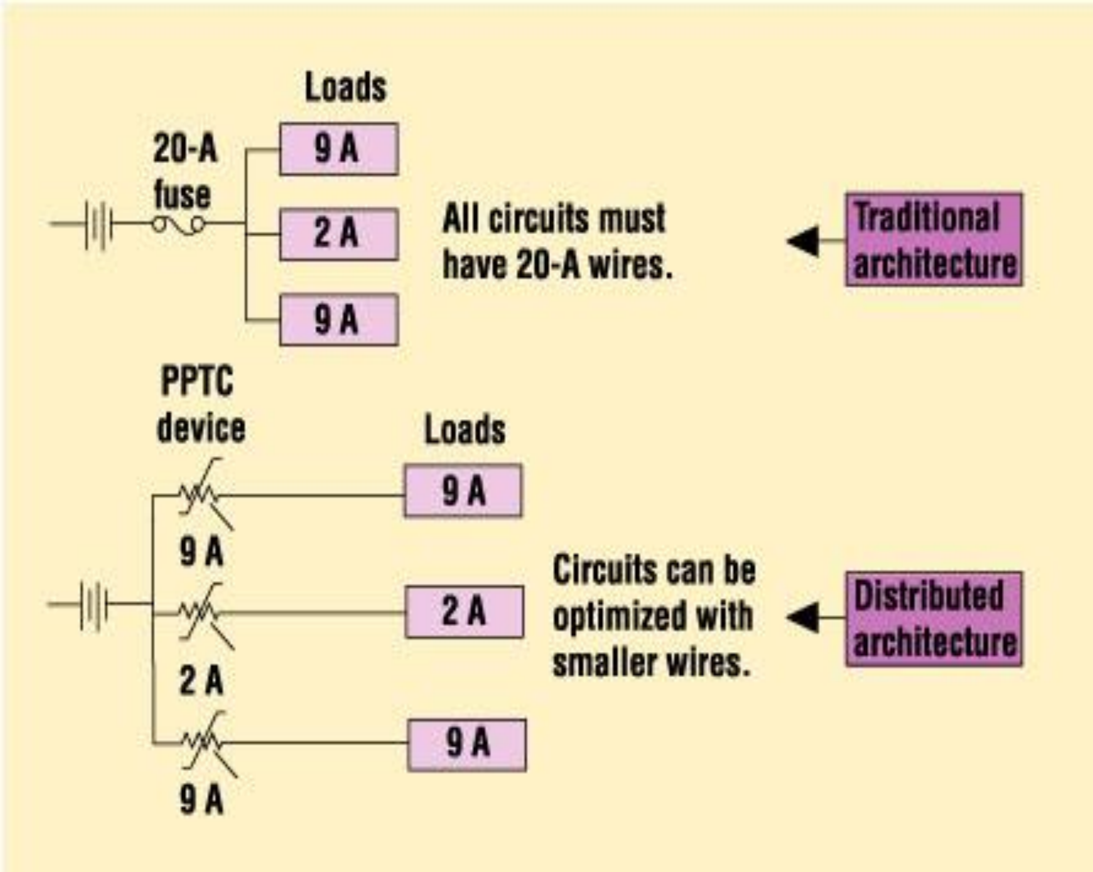


Figure 3. PPTC devices can be used in distributed electronic system architectures to help reduce wire size.

Electronic Control Module Protection. As more and more circuitry is packed into smaller and smaller packages, the width of the copper traces on printed circuit boards (PCBs) is reduced. Because motorized accessories are generally powered from high-amperage circuits, these narrow circuit board traces are susceptible to damage from excessive currents. Printed circuit traces function as wires carrying signals from one point to another. Depending on the cross-sectional area, the traces can carry only a certain amount of current before the heat generated by I^2R losses causes them to either melt or become hot enough to delaminate, resulting in damage to the PCB and mounted components.

Electronic module outputs typically require protection from over current situations caused by a short circuit or by the high stall current of motors. Module outputs can also be damaged by failure of some other portion of the system, such as a diode short or loss of a power ground. Because they are one-use devices and must be replaced in the event of a transient fault, fuses are not considered an acceptable solution to these potential problems. Multicomponent circuits used to sense and switch, called smart FETs, are frequently used to address these situations, but such devices require careful design and consume valuable board space. They can also be quite costly.

PPTC circuit-protection devices are gaining acceptance as a practical, cost-effective solution to over current and over temperature protection of electronic modules. Because they rapidly and effectively limit current to safe levels and are small enough to be mounted directly on the circuit board, each power circuit within the control module can be individually protected with a single device.

Small-Motor Protection. Most automotive actuators are used in applications that require them to move something until it reaches the end of its motion range—to move a seat or close a window, for example. However, because these activities can be manually controlled, the actuator may remain energized after the mechanism reaches its limit of travel. When this condition occurs, the actuator stalls, and it's back electromotive force (EMF) falls to zero. Without the back EMF opposing the supply voltage, the actuator's current may rise rapidly to levels typically between two and four times its normal operating value.

Because the actuator's winding is made with very-small-gauge wire, the high stall current causes a rapid rise in temperature. Often within seconds, the temperature may rise sufficiently to permanently damage the enamel varnish used to insulate the wire in the actuator's winding. With the loss of insulating properties, turn-to-turn short circuits may develop throughout the winding, rendering the actuator inoperable and creating a potential for a thermal event (see Figure 4).

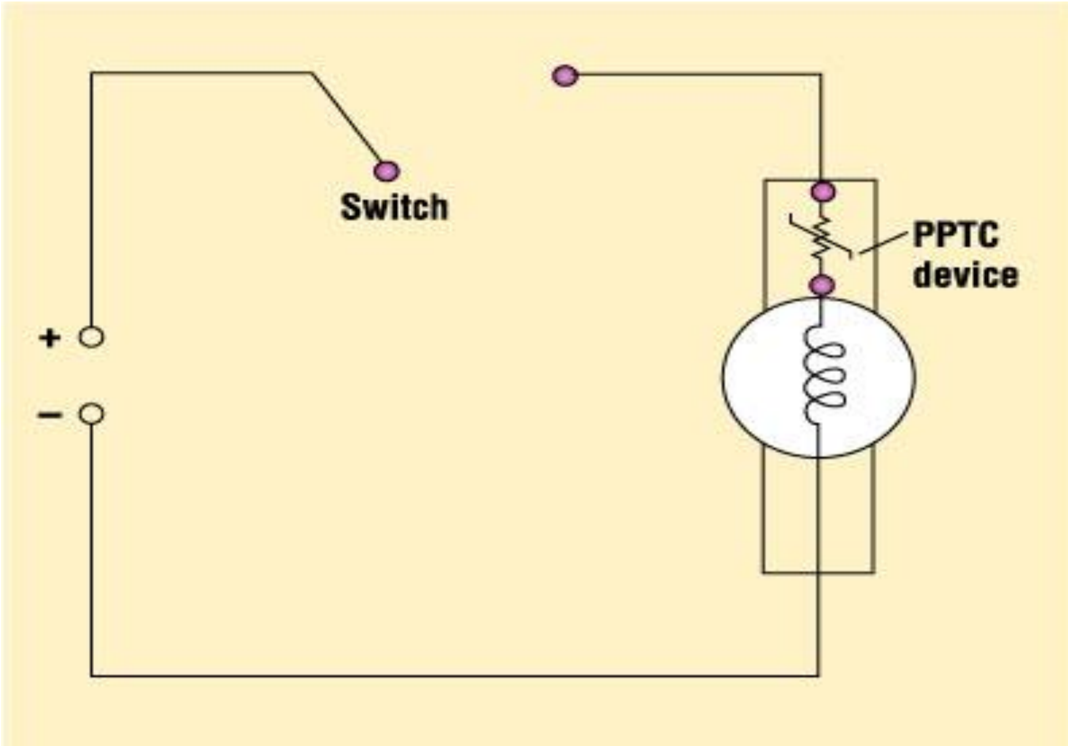


Figure 4: To interrupt excessive current, PPTC devices are wired in series with the actuator windings.

When the current or temperature of a winding rises above a certain value, the PPTC device latches into a high-resistance state, limiting current to a low level and preventing damage to the actuator. After the fault and power are removed and the PPTC device cools, the device resets for normal current flow.

CONCLUSION

Polymeric Positive Temperature Coefficient device provide net cost savings through reduced component count and reduction in wire size. They can help provide protection against short circuits in wire traces and electronic components. The low resistance, relatively fast time to trip and low profile of these devices improve reliability. In addition, these devices provide manufacturing compatibility with high volume electronic assembly techniques and later design flexibility through a wide range of product options.

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