

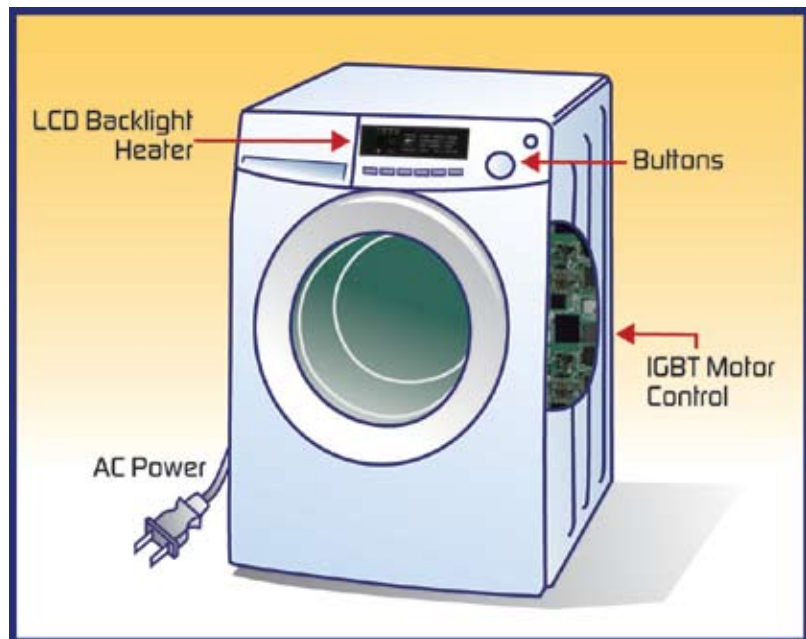
Coordinated Circuit Protection for Electric Motors, Transformers and Control Units in Home and Professional Appliances

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The electric motors, transformers and controllers used in home and professional grade appliances are often subjected to mechanical overloads, overheating, stalls, lost neutral, severe overvoltages, humidity and other damaging factors. New polymeric positive temperature coefficient (PPTC) devices are designed for operation at line voltages of 120 VAC and 240 VAC, and can help appliance designers prevent safety and fire hazards, as well as reduce warranty return and replacement costs resulting from motor failure.

Protecting increasingly sophisticated and complex control boards from misconnection, power surges or short circuit damage is of particular concern to the equipment manufacturer. Although appliance transformers, their enclosures and connections are capable of withstanding higher voltage transients, the use of sensitive solid-state devices on the board necessitates improved overcurrent, overtemperature and overvoltage control.

Coordinating overcurrent and overvoltage protection can also help designers comply with safety agency requirements, minimize component count and improve equipment reliability. A metal oxide varistor (MOV) overvoltage protection device, used in a coordinated circuit protection strategy with a line-voltage rated PPTC overcurrent device helps manufacturers meet IEC 6100-4-5,



Resettable circuit protection devices can be used to help provide overtemperature, overcurrent and overvoltage protection for the electric motors and fans, controllers, touchpads, displays and interface circuitry required by sophisticated appliances.



Figure 1. Effect of a secondary short on a 240 VAC transformer utilizing a thermal fuse as the primary protection element.

the global standard for voltage and current test conditions for equipment connected to AC Mains.

Overcurrent Circuit Protection Technology Comparison

When a fault occurs in a transformer or power supply, some of the components may begin to overheat. There are several circuit protection schemes that can be used to help guard against damage caused by these fault conditions and the resultant overtemperature damage, including thermal fuses, current fuses, and circuit breakers. A common solution is to use a thermal fuse on the primary side and an overcurrent fuse on the secondary side.

However, in many appliance applications resettable devices such as PPTC devices are the preferred solution. These devices do not generally require replacement after a fault event, and allow the circuit to return to the normal operating condition after the power has been cycled and/or the overcurrent condition is eliminated.

Tyco Electronics recently conducted comparison tests of their Raychem Circuit Protection PolySwitch™ LVR devices as primary protection elements on a variety of transformers. The performance characteristics of the PolySwitch LVR PPTC devices were compared to those of thermal fuses.

Some power supply designs utilize a single-use thermal fuse as a primary protection solution. Figure 1 illustrates the effect of overheating on such a transformer. In this test, a short on the secondary side resulted in coil temperatures exceeding 200°C. The thermal fuse – rated at 115°C and mounted near the center of the core – failed to open, and the insulation on the windings melted, destroying the transformer.

Figure 2 shows the results of a test in which a similar transformer was tested with a PPTC device installed as a primary protection element. A primary input voltage of 253VAC was applied and a secondary short was simulated. Surface temperatures of the primary (T_{prim}) and secondary (T_{sec}) windings as well as that of the PPTC device (T-PPTC) were measured. The PPTC device

started to trip when its external temperature reached approximately 95°C, at which time the primary coil temperature was about 95°C. Once it had tripped and limited the current, the coils began to cool.

The performance characteristics of the PPTC devices versus thermal fuses studied in similar tests on a 120VAC transformer with a short on the secondary side are shown in the following table (Figure 3). These data demonstrate the advantages of the PPTC device's faster time-to-trip and its ability to limit the maximum coil temperature, thereby helping protect the transformer windings, as well as the secondary circuitry.

Coordinating Protection for AC Mains Applications

From small countertop appliances to professional grade ovens, increasing complexity and functionality are driving the industry toward circuit integration and board size reduction. Protecting sensitive electronic components from voltage transients, short circuits and customer misuse is of primary concern to manufacturers. Electrical equipment can be exposed to potential damage from large

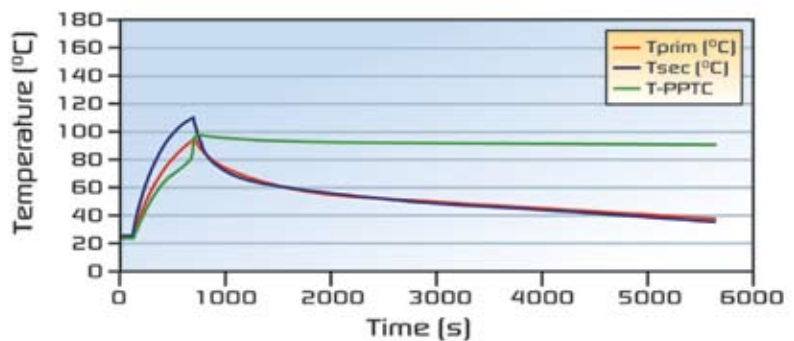


Figure 2. Effect of a secondary short on a 240VAC transformer utilizing a PPTC device as the primary protection element.

voltage or power transients on the AC Mains inputs caused by lightning strikes or power station load-switching transients.

Coordinating overcurrent and overvoltage protection at the AC Mains input can help designers comply with safety agency requirements and minimize component count and cost.

Figure 4 shows how an MOV is used in combination with a PPTC device to help improve equipment reliability in the harsh AC environment, and helps fulfill the IEC-61000 test requirements.

The MOV device's high current-handling and energy absorption capability, fast response and low cost make it suitable for overvoltage protection in power supplies, control board transformers and electric motors. The PPTC overcurrent protection device is also rated at 240 VAC, permitting maximum intermittent voltages of up to 265 VAC and can be installed with the MOV device in the AC Mains input lines.

Unlike a single-use current fuse, the resettable PPTC device helps protect against damage from conditions where faults may cause a rise in temperature with only a slight increase in current draw. When installed on the primary side of the circuit, in proximity to potential heat-generating components such as

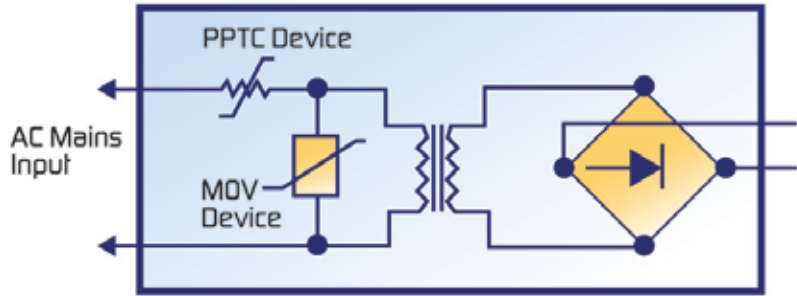


Figure 4. Coordinated overvoltage and overcurrent protection on AC Mains circuit.

magnetics, field-effect transistors (FET), or power resistors, the PPTC device helps provide both overcurrent and overtemperature protection with a single installed component.

Certain Mains overload conditions may cause the MOV device to remain in a clamped state where it will continue to conduct current. This may eventually result in an overtemperature failure of the device. While not directly applicable to passing IEC 61000-4-5 tests, placing the PPTC device in close thermal proximity to the MOV device can help protect the MOV device in extended overload conditions – by transferring heat to the PPTC device. This causes the PPTC device to trip faster, limiting the current through the MOV device.

This application of the PPTC device allows designers to leverage the component's temperature response and replace other thermal protection devices in the circuit. Not only

does the PPTC device perform dual functions in this case, it also provides a fully resettable solution. Because the device resets after the fault is cleared and power to the circuit is cycled, maintenance or replacement are not normally required.

The PPTC and MOV devices chosen for a particular application depend on the IEC 61000-4-5 class rating for the equipment as well as the operating conditions of the equipment itself. When selecting a PPTC device, the primary consideration is to match the hold current rating of the device to the primary current drawn by the electrical equipment under normal operating conditions.

Summary

Coordinating overcurrent, overtemperature and overvoltage protection can help designers minimize component count and reduce warranty returns resulting from failed motors and control board transformers. The low resistance, fast time-to-trip, low profile, and resettable functionality of the PPTC device helps circuit designers provide a safe and dependable product and comply with regulatory agency requirements.

Device	Time- to-Trip/Open	Max Coil Temp (°C)	Max Current (mA)
Thermal Fuse	>100 min	147	90
Thermal Fuse	51 min	157	89
Thermal Fuse	66 min	147	90
PPTC Device	11 min	107	87
PPTC Device	13 min	112	86
PPTC Device	11 min	103	88

Figure 3. Comparison of performance characteristics of thermal fuses and PPTC devices used as primary protection elements on 120VAC transformer with a short on the secondary.

Coordinated Circuit Protection for Consumer and Industrial Appliances



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Reliable Circuit Protection Components from One Reliable Source

Coordinated overcurrent and overvoltage circuit protection can help manufacturers meet critical safety agency requirements, enhance equipment reliability and reduce component count.

White goods producers as well as manufacturers of the motors, controllers and other components used in today's sophisticated appliances turn to Tyco Electronics for a broad range of Raychem Circuit Protection resettable overcurrent and surge protection devices.

Key Applications Include:

- Electric Motors and Actuators
- Fans and Chillers
- Control Modules
- AC Mains Interfaces
- Transformers
- Touchpads
- Displays

Go to www.circuitprotection.com/industries.asp to learn more

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