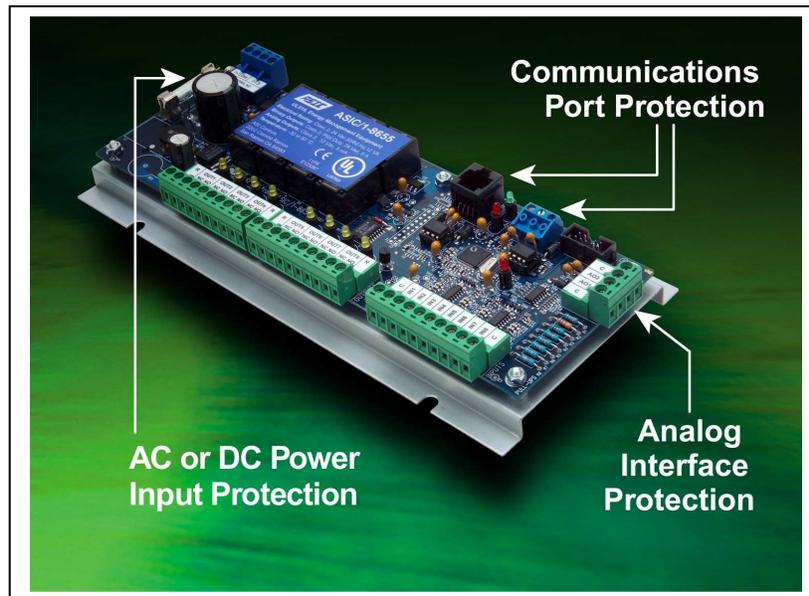


TYCO ELECTRONICS eDIGEST

A series of technology briefs spanning Tyco Electronics' product portfolio

Technology Focus: Circuit Protection Devices

Coordinated Circuit Protection Schemes Help Prevent Overvoltage and Overcurrent Damage



Through advances in materials science and broad applications expertise, the Raychem Circuit Protection business unit of Tyco Electronics has pioneered the development of polymeric positive temperature coefficient (PPTC) circuit protection devices for more than 25 years. In recent years, however, its research and development has focused on technologies that expand circuit protection capabilities and encompass a wider range of application solutions.

One of the design challenges being closely followed is the need for coordinated circuit protection. Because overcurrent and overvoltage protection are often viewed as two unrelated elements of the circuit protection design process, protection strategies can result

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in costly multi-component solutions, and synergies between protective devices can be overlooked.

This article presents two examples of how coordinated protection helps designers enhance equipment reliability, reduce component count and meet critical safety agency requirements.

Telecom Equipment Protection Developments

The PolySwitch™ PPTC devices and SiBar™ thyristors that provide overvoltage and overcurrent protection for telecommunication and networking applications were initially introduced more than ten years ago to meet the growing demand for resettable overcurrent protection. Along with new metal oxide varistors (MOVs) and gas discharge tubes (GTDs), these components help designers meet the protection requirements of ITU, Telcordia, and UL.

Telecommunications network equipment, including analog and digital linecards, DSL and ISDN modems, T1 equipment and Voice over IP (VoIP) equipment, must comply with regional safety agency standards. These standards mandate the use of overcurrent and overvoltage protection to help achieve safe and reliable equipment performance.

Telecom network equipment is exposed to two types of electrical hazards. The first results from lightning strikes that may hit a network directly, or induce high-voltage spikes in a pair of telephone wires. These spikes can damage sensitive electronic equipment at either end of the network. Therefore, they must be shunted to ground with an overvoltage device.

The other hazard results from induced AC power currents or direct AC power contact. If the voltage of an overcurrent event is below the breakover voltage of the overvoltage protection device, continuous current will flow to the equipment. On the other hand, when the voltage of the overcurrent fault is higher than the breakover voltage of the overvoltage protection device, the overvoltage device must be protected from prolonged exposure to high current.

When this type of fault occurs, the resistance of an installed PPTC overcurrent protection device increases from its base resistance to a much higher resistance, typically by three or more orders of magnitude, effectively isolating the fault. The device then remains in its latched position until the fault is cleared and power to the circuit is removed – at which time the PPTC device resets to a low impedance state so that normal telephone operation can resume.

There are two categories of overvoltage circuit protection devices – clamping and foldback, or “crowbar”, devices. Clamping devices, such as MOVs and diodes, allow voltages up to a designed clamping level to pass through to the load during operation. Foldback devices, such as gas discharge tubes and thyristor surge suppressors, operate as shunt devices in response to a surge that exceeds the breakover voltage.

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When the voltage exceeds the breakover voltage the thyristor surge protection device “folds back”, creating a low-impedance path, effectively shorting out the overvoltage condition. The device will remain in this low-impedance state until the current through the device is decreased below its hold rating. After an overvoltage event has passed, the thyristor resets to its high-impedance state and allows for normal system operation.

In addition to resettable functionality, thyristor foldback devices offer some advantages over clamping devices. For a given fault current, the power dissipated in a thyristor is smaller than a clamp device. This permits the use of a smaller-sized overvoltage device, and results in lower capacitance, a highly desirable attribute for high-speed communication equipment.

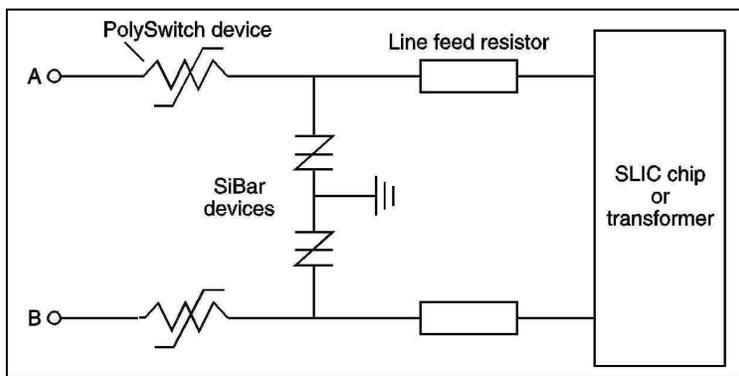


Figure 1. Typical overcurrent/overvoltage circuit protection system for network equipment.

Figure 1 shows a typical protection system employed by network equipment manufacturers to help comply with ITU-T K.20 requirements. The SiBar thyristors help protect the sensitive electronics from fast overvoltage events, including lightning transients. The line feed resistor serves the purpose of regulating the steady-state current to the telephone line.

The PolySwitch devices provide current limiting that may be required during power contact events that have a voltage lower than the foldback voltage of the SiBar devices. Additionally, the base resistance of the PPTC device limits the current during events that exceed the foldback voltage of the SiBar device.

When a PPTC device is installed in the circuit it provides two important benefits. First, it protects the line feed resistors from overheating, and second it helps limit sneak current. During AC sneak current events – in the 200 mA to 1A range – if there is no overcurrent protection these resistors do not fuse open, and typically they will overheat and damage the circuit board.

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Due to their fast and accurate breakover voltage, new GDT devices are also used on main distribution frame (MDF) modules, high data-rate telecom applications (e.g. ADSL, VDSL), and surge protection on power lines. GDTs are placed in front of, and in parallel with, the sensitive equipment and act as a high impedance component. These devices do not influence the signal in normal operation. However, in the event of an overvoltage surge, such as a lightning strike, the GDT switches to a low impedance state and diverts the energy away from the sensitive equipment.

Coordinating Protection for AC Mains Applications

Electrical equipment can be exposed to risk from large voltage or power transients on the AC Mains inputs caused by lightning strikes or power station load-switching transients. IEC 61000-4-5 is the global standard for voltage and current test conditions for equipment connected to AC Mains.

Equipment for AC Mains applications is tested for surge immunity using a combination wave having a voltage waveform with 1.2 μ s rise and 50 μ s fall times and a current waveform having 8 μ s rise and 20 μ s fall times for all installation classes. Different rise and fall times exist for some telecom and datacom applications, but all AC Mains applications are tested to this combination wave.

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 2 illustrates how Raychem Circuit Protection's ROV series metal oxide varistor is used in combination with the LVR series of PolySwitch devices to improve equipment reliability in the harsh AC environment, and help fulfill the IEC-61000 test requirements.

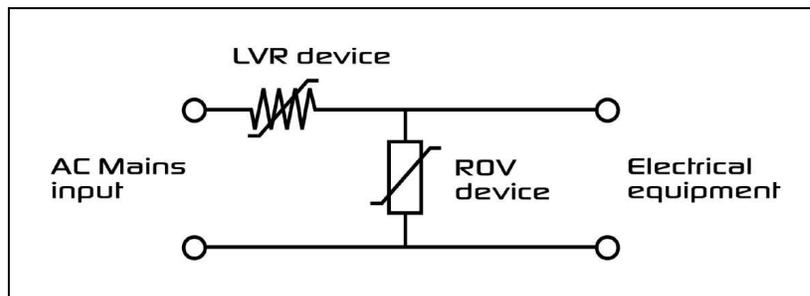


Figure 2. Coordinated overvoltage and overcurrent protection on AC Mains circuit.

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

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Unlike a single-shot current fuse, the resettable LVR device helps protect against 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 magnetics, FETs, or power resistors, the LVR device helps provide both overcurrent and overtemperature protection with a single installed component.

Conditions that might cause the ROV device to remain clamped and conducting current can eventually result in overtemperature failure of the ROV. If the board geometry allows, placing the LVR device adjacent to the ROV device can also help protect the ROV device in extended overload conditions – by transferring heat to the LVR device and causing it to trip more quickly. While not directly applicable to passing IEC 61000-4-5 tests, placing the LVR device in close thermal proximity to the ROV device can cause the LVR device to trip faster, limit the current through the ROV and help protect it in continuous overload conditions.

Any remote sensor, indicator, or actuator that requires an AC power, analog interface, or communications bus interface can also benefit from the use of coordinated circuit protection. These system components are subject to damage caused by miswiring, power cross or loose neutral connections on AC Mains inputs.

An example of how coordinated overvoltage/overcurrent protection can be used with individual power, signal or communications interfaces is presented in Figure 3. Each PPTC device is combined with an overvoltage protection device, such as an ROV device, to help protect against overvoltage transients in addition to overcurrent faults. This circuit topology can be used to help equipment meet the UL requirements for Class 2 products, as well as IEC61000-4-5 surge immunity requirements.

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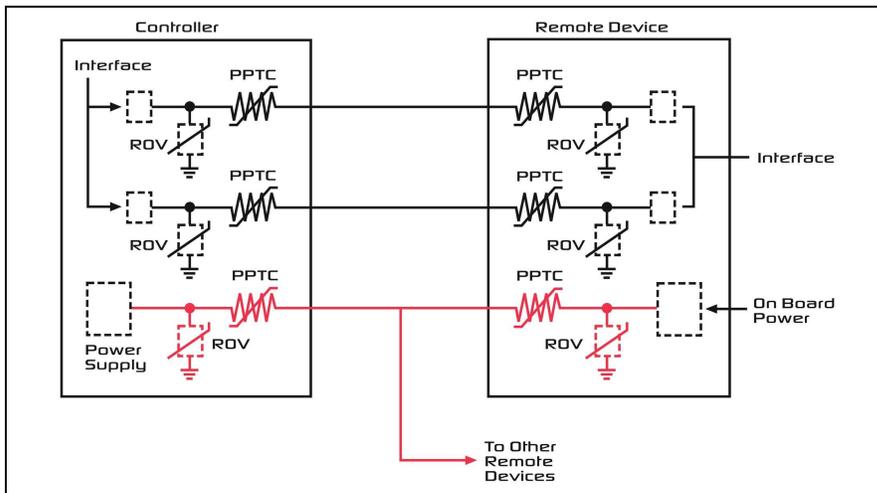


Figure 3. Coordinated overvoltage/overcurrent design helps protect the interfaces between controllers and remote devices as well as power inputs.

Summary

PPTC devices provide resettable functionality, small size and low resistance, and are used worldwide as overcurrent protection elements in a wide range of telecom and AC Mains equipment applications.

Thyristors, GDTs and MOVs are designed to help manufacturers meet ITU and Telcordia lightning surge and overvoltage protection requirements. Their key advantages are small form factor, low on-state power dissipation, and accurate voltage clamping or shunting. Their low capacitance also allows them to be used on high data rate circuits.

Coordinated overvoltage/overcurrent circuit protection can help designers reduce component count, provide a safe and reliable product, comply with regulatory agency requirements and reduce warranty and repair costs.

For additional technical information, contact your local Tyco Electronics Sales Engineer, or visit <http://www.circuitprotection.com> .