Transformers
Application Overview

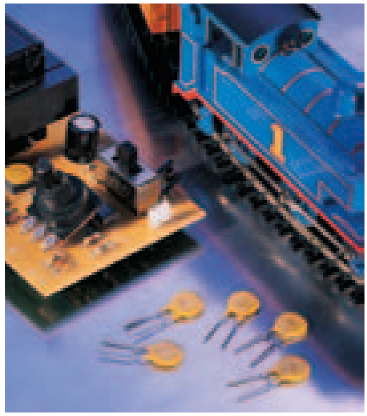
The Problem
Equipment that uses a transformer is subject to failures from two main causes: overcurrent and overvoltage. Overcurrent is typically the result of a short circuit within the equipment, a substantial increase in load or miswiring of the equipment during installation. Overcurrent can cause overheating in the transformer itself and can lead to smoke, fire and damaged wires and connectors.

Overvoltage is typically the result of power line surges caused by lightning or load switching at local power stations. These voltage surges travel through the power lines and are imposed upon the AC power input of the equipment. They can be devastating to semiconductor devices and damage the equipment if not properly suppressed.

The Solution
Using an LVR PolySwitch device in combination with a Raychem Metal Oxide Varistor (ROV) device on the primary side of the AC Mains input can help protect electronic equipment from damage due to overcurrent and overvoltage faults (See Figure 1).

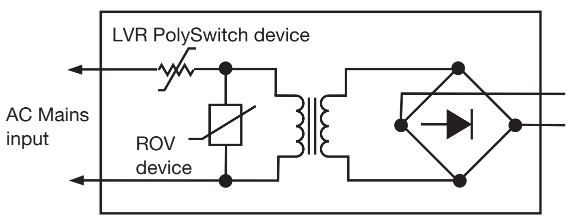
The LVR device helps provide overcurrent protection for the equipment against shorts, increased loads or miswiring of the equipment's outputs. The protection mechanism that the LVR device uses is the same as other PolySwitch devices. Using the LVR device in the AC Mains primary can provide additional protection when $120V_{AC}$ equipment is inappropriately connected to $240V_{AC}$ power. The LVR device will limit current and drop additional voltage when this problem occurs. This can help protect both the power transformer and the electronics.

The ROV device clamps voltage surges that may not trip the LVR device but might still damage the transformer or the equipment's electronic components. An example would be fast transients due to lightning strikes.



This protection strategy can be applied to a variety of applications including lighting ballasts, toys, portable electronics and battery chargers.

Figure 1. Transformer Circuit



Adding Thermal Protection
Clever use of the LVR device can help provide a level of thermal protection for transformers as well. Because the LVR device is a positive temperature coefficient device, thermally linking it to the transformer can help provide protection under conditions in which the LVR device might not trip due to current alone. Such conditions might exist when the AC Mains voltage droops and equipment becomes less efficient creating increased power dissipation in the electronics. Combining the temperature increase from an overheating transformer with current induced heating in an LVR device can cause it to trip faster and protect the transformer under such "soft fault" conditions. Thermally

coupling the LVR device to the transformer can be accomplished either by making physical contact with the transformer or specifying that the transformer supplier design the LVR device into the transformer itself.

Care should be taken to account for both normal current and temperature effects when choosing an LVR device for this application.

Device Selection

Table 1 provides a guideline for selecting an LVR device based on the power drawn by the primary. This guideline assumes 40°C ambient temperature and does not take into account thermal coupling to the transformer or any other device.

Table 2 provides a guideline for selecting an ROV device based on the AC Mains voltage and the power quality.

Technology Comparison

Bimetal thermostatic switches, fuses, and ceramic positive temperature coefficient (CPTC) devices have been used to protect transformers. The limitations of bimetal switches include cycling and the potential for contacts to weld shut. CPTC devices have a relatively high resistance and are relatively large; their temperature rises significantly, making them vulnerable to cracking as a result of shock or vibration. CPTCs also have a relatively slower time-to-trip compared to Polymeric PTC devices, resulting in a smaller protection envelope. Fuses can fatigue as well, but most significantly they are one-use devices that must be replaced after a fault has occurred. PolySwitch resettable devices latch into a high-resistance state when a fault occurs. Once the fault and power to the circuit are removed, the device automatically resets and is ready for normal operation.

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Table 1. LVR Device Selection Guideline at 40°C*

Power Rating	AC Mains Voltage	Recommended LVR Device
5W	$120V_{AC}$	LVR008
5W	$240V_{AC}$	LVR005
10W	$120V_{AC}$	LVR012
10W	$240V_{AC}$	LVR008
20W	$120V_{AC}$	LVR025
20W	$240V_{AC}$	LVR012
30W	$120V_{AC}$	LVR040
30W	$240V_{AC}$	LVR016
40W	$120V_{AC}$	LVR040
40W	$240V_{AC}$	LVR025

*Table 1 is a guideline. Check the specific requirements defined by your application or any regulatory standards that your equipment must meet for any special conditions when using these protection devices. Additionally, any part should be thoroughly tested in the application to ensure proper operation.

Table 2. ROV Device Selection Guideline†

Rated AC Mains Voltage	Recommended ROV Device‡	Power Quality
$120V_{AC}$	ROVxx-201K	Stable, minimal voltage variation, regular sinusoidal shape
$120V_{AC}$	ROVxx-241K	Unstable, large unpredictable voltage variations
$240V_{AC}$	ROVxx-391K	Stable, minimal voltage variation, regular sinusoidal shape
$240V_{AC}$	ROVxx-471K	Unstable, large unpredictable voltage variations

‡ "xx" indicates device diameter. Proper diameter depends on the surge current, wattage and energy ratings defined by the application or standards requirements.

† Table 2 is a guideline. Check the specific requirements defined by your application or any regulatory standards that your equipment must meet for any special conditions when using these protection devices. Additionally, any part should be thoroughly tested in the application to ensure proper operation.