Protecting PoE Systems from Lightning and Other Electrical Hazards

Power over Ethernet (PoE) is becoming increasingly popular because it eliminates the need for power supplies and power cables for connected equipment and for locating equipment near an AC outlet. Recent developments allow PoE to deliver up to 30W (namely PoE+), and this, in turn, has increased the number of potential applications. Ethernet now delivers sufficient power for VoIP (Voice-over-Internet Protocol) telephony devices, extended-range wireless-access points, and surveillance cameras.

While higher power levels have proven to be a boon for many designers, they have also allowed users to move these devices outdoors or into other environments that expose them to lightning strikes, ESD discharges, and accidental power faults. It’s very important, therefore, to provide the proper circuit protection.

TVS Diodes Provide Lightning Protection

The choice of lightning protection for a particular device depends on how exposed it will be. For an indoor, less-severe application, you can use transient voltage suppressor (TVS) diode arrays between the RJ-45 and the Ethernet PHY (physical) layer in both the secondary position and the tertiary position. (See Figure 1.)
A lightning-induced surge event activates the TVS-diode array, TVS1, within nanoseconds, providing a clamping function that routes the offending surge away from the sensitive Ethernet-line-driver circuit. TVS2 clamps any residual surge that couples across the transformer. For a more robust approach, you can use a TVS-diode array for each wire pair; otherwise, one TVS array can protect two wire pairs, as TVS2 does. Power-fault events, which involve long-term 50- and 60-Hz waveshapes, activate 1.25A fuses F1 through F4 after a TVS device provides a current path.

**Powered-Device Protection**

At the powered-device (PD) end, you must provide protection against 57 - 90 V surges, with everything hardened to more than 100V. The surge-protection device should have a trigger voltage greater than any steady-state voltage likely to appear on the cable. PoE voltages can reach 57 V, so the device must not trigger at or below this voltage.

This approach also prevents the surge protector from turning on during power-classification testing or during the resistive power discovery test. Further, some power systems supply 48 V, whereas others supply −48 V, so the protection device must not be polarity-sensitive. Designers typically use bidirectional thyristor surge-protection devices in this case. (See Figure 2.) The solid-state crowbar devices reset only when the available current falls below the specified holding current. This setup is not a problem because it draws excess current from the equipment supplying the power (PSE), which temporarily shuts down during an overcurrent condition, allowing the thyristor surge protector to reset.
Figure 2: GR-1089 compliant solution for overvoltage and overcurrent events for 100/1000baseT applications in an outside environment subject to both lightning surge and power fault events.

The fuses in both data-pair leads provide the necessary overcurrent protection that is insensitive to lightning-induced overvoltage surges for first-level GR-1089 events. The bidirectional thyristor surge-protection devices, IC1 through IC4, or SIDACtor devices, (See Figure 3.) provide an overvoltage-crowbar-protection approach that complies with both first- and second-level lightning surges, according to Issue 6 of GR-1089.

The two bias leads for IC1 through IC4 connect to any available voltage rails that are less than the turn-on threshold voltage of the protective devices, which stabilizes their off-state capacitance and helps preserve signal integrity. The bidirectional thyristor surge-protection devices IC1 through IC4 can have a 58 V minimum threshold for a 48 V PoE. Noncompliant IEEE 802.3 systems that have a PoE voltage higher than 57 V would require a protection device with a higher minimum threshold.

The tertiary, or chip-side, approach is a TVS-diode rail-clamp array, TVS3, which provides additional protection after the coupling transformer. Bob Smith termination is a method of reducing the longitudinal or common-mode current on multipair conductor systems in which the pairs interrelate in a uniform manner. If you use Bob Smith terminations, you should capacitively isolate the terminations so that they do not load the PoE power supply. This combined metallic/differential and longitudinal/common-mode-protection approach requires a fuse on both leads of the transmitting and receiving pair.
Figure 3: These SIDACtor Ethernet/PoE Protector devices have a surge rating compatible with GR1089 Inter-building and ITU K.20/21 Enhanced protection requirements.

An approach without the longitudinal mode may require only one fuse per pair for lower-data-rate Ethernet, such as 10BaseT. For 100 and 1000BaseT systems, it is prudent to place the identical fuse element in both legs of a pair to maintain loop balance.

The single-fuse approach is permissible if pins 3 and 6 of the protective thyristor device do not connect to ground but instead remain open for a 10BaseT Ethernet system. Because IEEE 802.3 does not strictly allow for common-mode protection on the primary side of the coupling transformer for cable-discharge-event-protection reasons, the thyristor surge-protection devices usually do not connect to ground. Therefore, most Ethernet approaches depend on the isolation rating of the coupling transformer for longitudinal/common-mode protection on the line side, whereas the tertiary position on the secondary side of the coupling transformer may connect to the Ethernet line driver’s ground reference.

TVS3, a 2.5V TVS-diode array, provides tertiary protection on the chip side of the coupling transformer. This approach complies with the surge and power-fault requirements of GR 1089Core, Issue 6, for intrabuilding and interbuilding PoE. You can substitute a 0.3 A PTC device for the fuses for compliance with ITU K.20/21, both enhanced and basic, which contain coordination clauses for 10BaseT Ethernet.

However, for 100 and 1000BaseT, you would use a pair of appropriately sized, precision, 1 percent resistors to force coordination between the secondary and the primary protectors.

Figure 4: TVS protection solution for the PD end power supply portion of a PoE system compliant with both Mode A and Mode B PoE power. Typical TVS devices for this type of circuit are available.
in 400W, 600W, 1500W and 3000W ratings. The fuses provide overcurrent protection compliant with GR-1089 Issue 6 and UL 60950-1.

Figure 4 shows a simple 400W TVS approach that complies with both Mode A and Mode B PoE power for the PD end of the system. More robust, 1500 and 3000W, approaches are also available for harsher surge environments, such as those that regulatory standards ITU K.20 Enhanced or GR-1089 Port Type 5 describe.

As the power PoE systems deliver has increased, developers are installing Ethernet equipment in areas that expose it to increased hazards from lightning-induced overvoltages and 50- to 60-Hz power-line faults. Judicious use of bi-directional surge-protection devices, TVS diodes, fuses, and PTC devices can help ensure reliable operation despite these hazards.

Learn more, at www.littelfuse.com, or by contacting Phillip Havens, phavens@littelfuse.com, or Chad Marak, cmarak@littelfuse.com. You may also download our Ethernet Protection Design Guide.

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