

Data Line Protectors

In many office and industrial locations, data lines (such as RS-232 and ethernet) and AC power lines run in close proximity to each other, which often results in voltage spikes being induced onto the data line, causing damage to sensitive equipment.

Protection Requirements

Data lines should be protected against overvoltages that can exceed 1500 V and surge currents up to 50 A.

Data Line Reference Circuit

Figure 3.57 shows how a *SIDACtor* device is used to protect low voltage data line circuits.

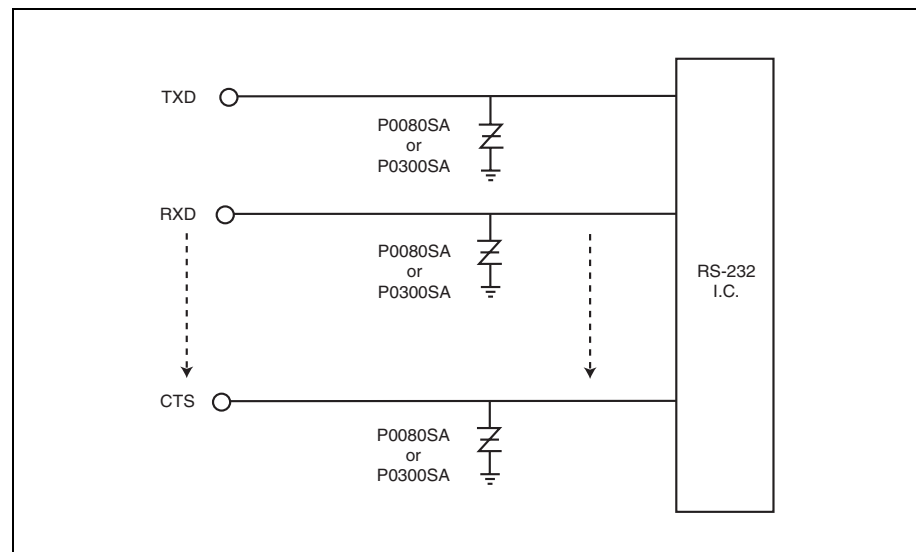


Figure 3.57 Data Line Protection

High Speed Transmission Equipment

High speed transmission equipment encompasses a broad range of transmission protocols such as T1/E1, xDSL, and ISDN. Transmission equipment is located at the central office, customer premises, and remote locations.

Protection Requirements

Transmission equipment should be protected against overvoltages that can exceed 2500 V and surge currents up to 500 A. In Figure 3.7 through Figure 3.17, *SIDACtor* devices were chosen because their associated peak pulse current (I_{PP}) rating is sufficient to withstand the lightning immunity tests of GR 1089 without the additional use of series line impedance. Likewise, the fuse shown in Figure 3.7 through Figure 3.17 was chosen because the amps^2time (I^2t) rating is sufficient to withstand the lightning immunity tests of GR 1089, but low enough to pass GR 1089 current limiting protector test and power cross conditions (both first and second levels).

The following regulatory requirements apply:

- TIA-968-A (formerly known as FCC Part 68)
- GR 1089-CORE
- ITU-T K.20/K.21
- UL 60950

Most transmission equipment sold in the US must adhere to GR 1089. For Europe and other regions, ITU-T K.20/K.21 is typically the recognized standard.

ADSL Circuit Protection

Asymmetric Digital Subscriber Lines (ADSLs) employ transmission rates up to 6.144 Mbps from the Central Office Terminal (COT) to the Remote Terminal (RT) and up to 640 kbps from the RT to the COT at distances up to 12,000 feet. (Figure 3.7)

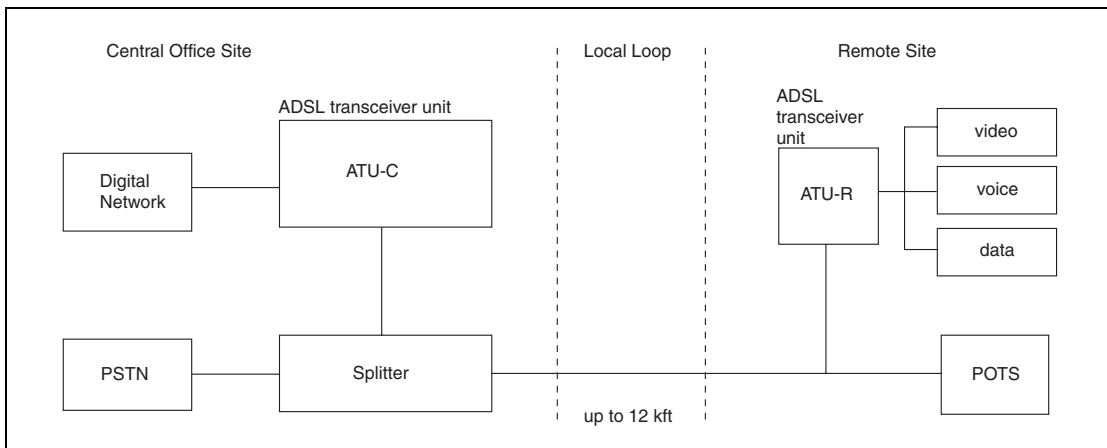


Figure 3.7 ADSL Overview

Protection Circuitry

Longitudinal protection was not used at either the ADSL Transceiver Unit – Central Office (ATU-C) interface or the ADSL Transceiver Unit – Remote (ATU-R) interface due to the absence of earth ground connections. (Figure 3.8) In both instances, the P3500SC MC *SIDACtor* device and the **0461 1.25** *TeleLink* fuse provide metallic protection. For ATUs not isolated from earth ground, reference the HDSL protection topology.

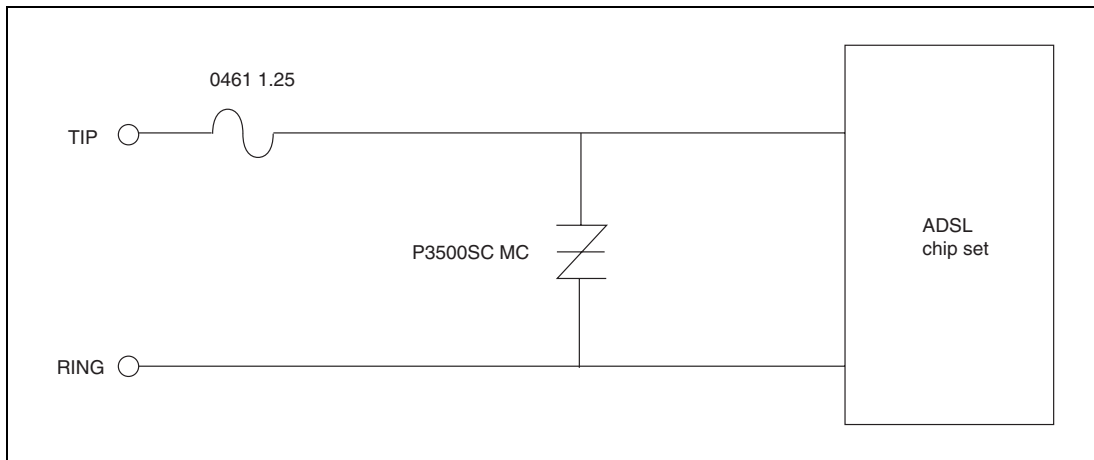


Figure 3.8 ADSL Protection

Component Selection

The P3500SC MC *SIDACtor* device and **0461 1.25** *TeleLink* fuse were chosen to protect the ATUs because both components meet GR 1089 surge immunity requirements without the use of additional series resistance. Although the P3100 series *SIDACtor* device may be used to meet current ANSI specifications, Littelfuse recommends the P3500 series to avoid interference with the $20 V_{P-P} \times DSL$ signal on a 150 V rms ringing signal superimposed on a 56.5 V battery.

HDSL Circuit Protection

HDSL (High-bit Digital Subscriber Line) is a digital line technology that uses a 1.544 Mbps (T1 equivalent) transmission rate for distances up to 12,000 feet, eliminating the need for repeaters. The signaling levels are a maximum of ± 2.5 V while loop powering is typically under 190 V. (Figure 3.9)

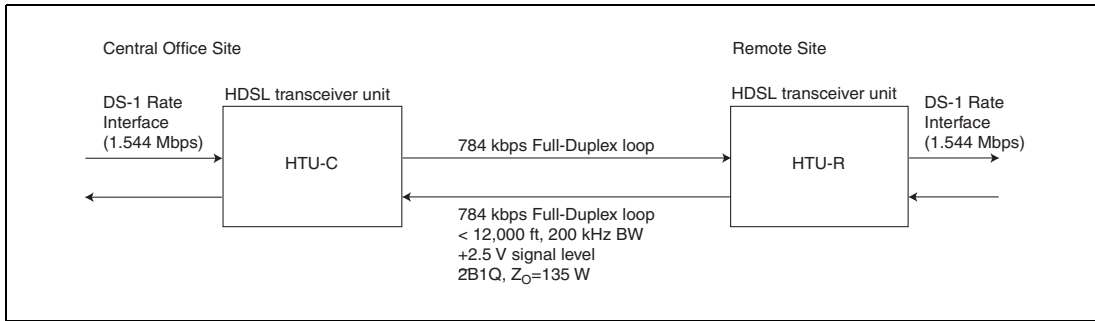


Figure 3.9 HDSL Overview

Protection Circuitry

Longitudinal protection is required at both the HDSL Transceiver Unit – Central Office (HTU-C) and HDSL Transceiver Unit – Remote (HTU-R) interfaces because of the ground connection used with loop powering. Two P2300SC MC SIDACtor devices provide overvoltage protection and two 0461 1.25 TeleLink fuses (one on Tip, one on Ring) provide overcurrent protection. (Figure 3.10) For the transceiver side of the coupling transformer, additional overvoltage protection is provided by the P0080SA SIDACtor device. The longitudinal protection on the primary coil of the transformer is an additional design consideration for prevention of EMI coupling and ground loop issues.

Reference Designs

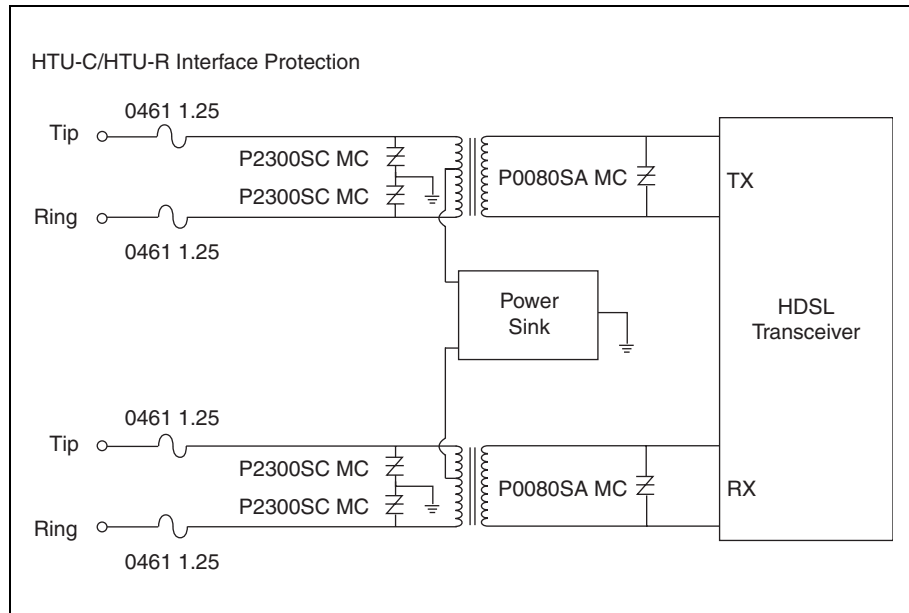


Figure 3.10 HDSL Protection

Component Selection

The P2300SC MC *SIDACtor* device and the **0461** 1.25 *TeleLink* fuse were chosen because both components meet GR 1089 surge immunity requirements without the use of additional series resistance. The P2300SC MC voltage rating was selected to ensure loop powering up to 190 V. For loop powering greater than 190 V, consider the P2600SC MC. The P0080SA MC *SIDACtor* device was chosen to eliminate any sneak voltages that may appear below the voltage rating of the P2300SC MC.

ISDN Circuit Protection

Integrated Services Digital Network (ISDN) circuits require protection at the Network Termination Layer 1 (NT1) U-interface and at the Terminating Equipment (TE) or Terminating Adapter (TA) S/T interface. Signal levels at the U-interface are typically ± 2.5 V; however, with sealing currents and maintenance loop test (MLT) procedures, voltages approaching 150 V rms can occur. (Figure 3.11)

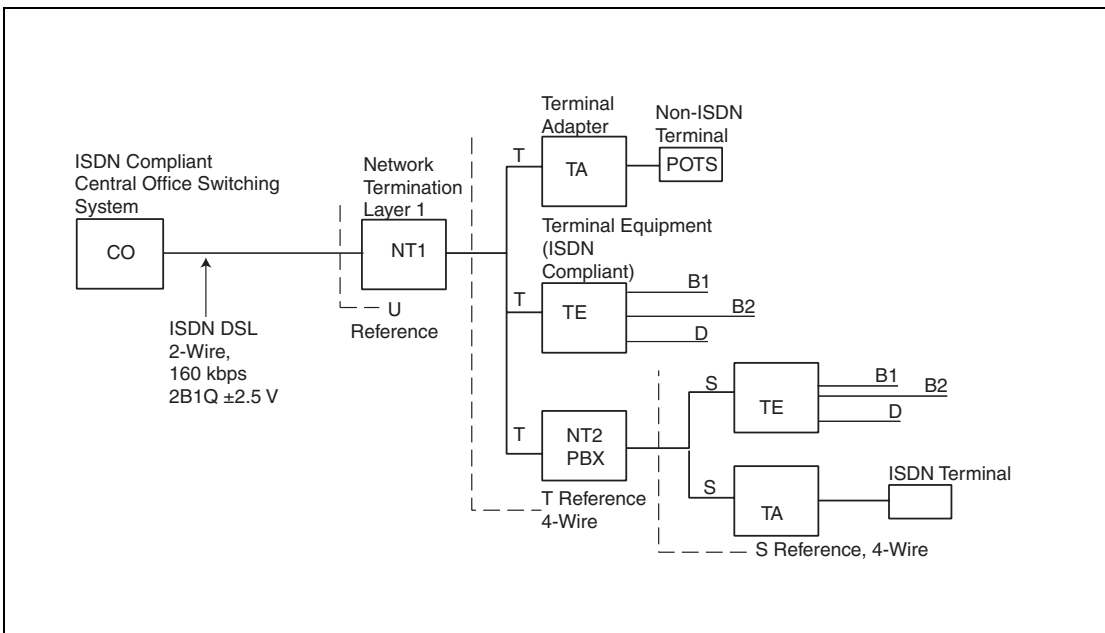


Figure 3.11 ISDN Overview

Protection Circuitry

Longitudinal protection was not used at either the U- or the TA/TE-interface due to the absence of an earth-to-ground connection. (Figure 3.12) At the U-interface, the P2600SC MC *SIDACtor* device and **0461** 1.25 *TeleLink* fuse provide metallic protection, while the TA/TE-interface uses the P0640SC MC *SIDACtor* device and **0461** 1.25 *TeleLink* fuse. Figure 3.12 also shows interfaces not isolated from earth ground.

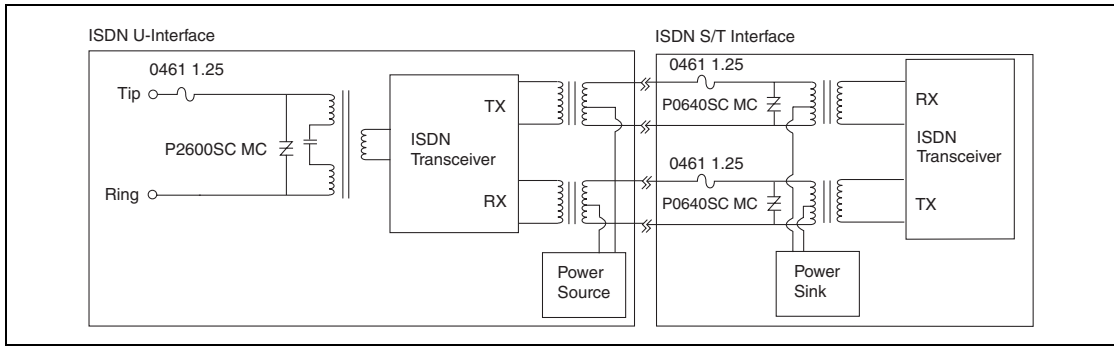


Figure 3.12 ISDN Protection

Component Selection

The “SC MC” *SIDAct*or devices and **0461 1.25 TeleLink** fuse were chosen because these components meet GR 1089 surge immunity requirements without the use of additional series resistance. An MC is chosen to reduce degradation of data rates. The P2600SC MC voltage rating was selected to ensure coordination with MLT voltages that can approach 150 V rms. The voltage rating of the P0640SC MC was selected to ensure coordination with varying signal voltages.

Pair Gain Circuit Protection

A digital pair gain system differs from an ISDN circuit in that ring detection, ring trip, ring forward, and off-hook detection are carried within the 64 kbps bit stream for each channel rather than using a separate D channel. The pair gain system also uses loop powering from 10 V up to 145 V with a typical maximum current of 75 mA. (Figure 3.13)

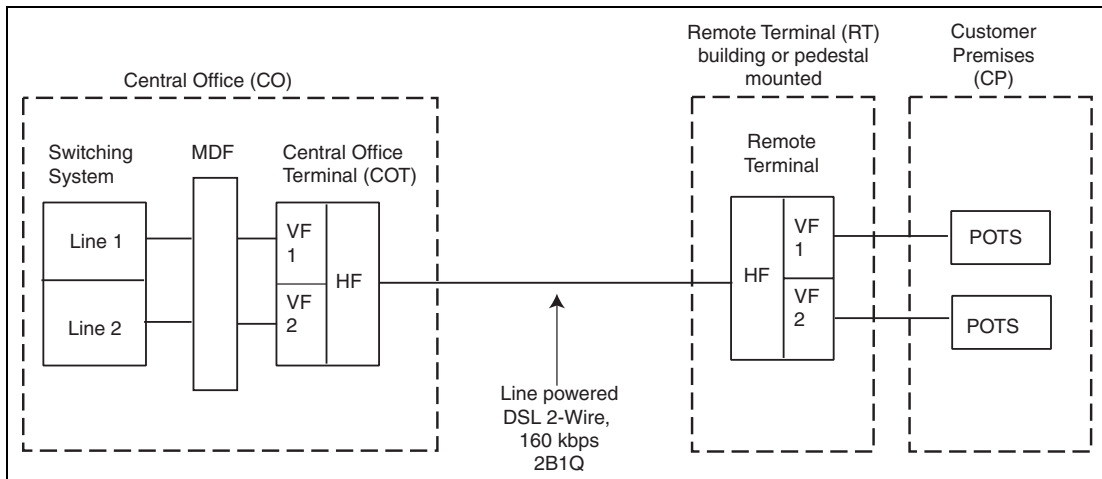


Figure 3.13 Pair Gain Overview

Protection Circuitry

Longitudinal protection is required at the Central Office Terminal (COT) interface because of the ground connection used with loop powering. (Figure 3.14) Two P1800SC MC *SIDACtor* devices provide overvoltage protection and two **0461** 1.25 *TeleLink* fuses (one on Tip, one on Ring) provide overcurrent protection. For the U-interface side of the coupling transformer, the illustration shows the P0080SA MC *SIDACtor* device used for additional overvoltage protection.

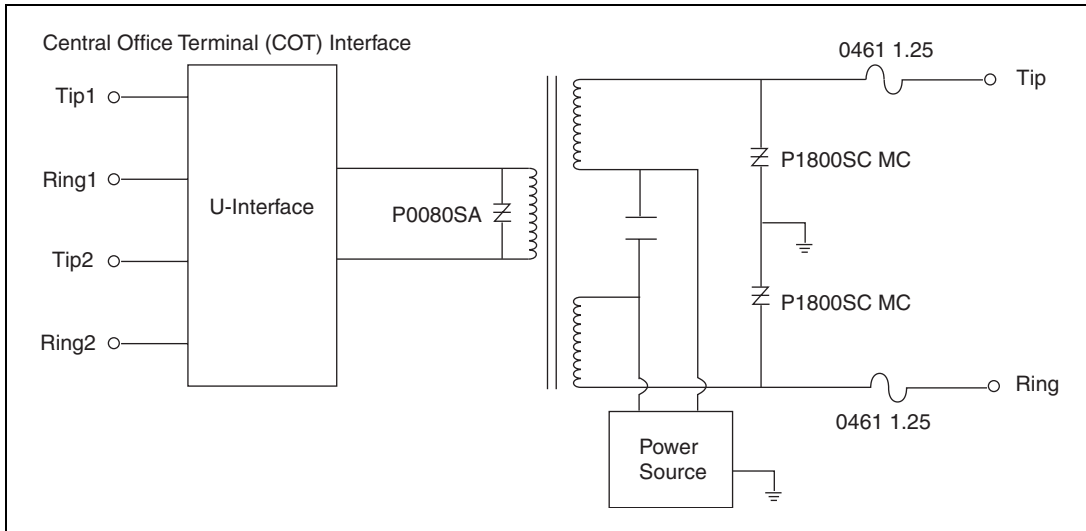


Figure 3.14 Pair Gain COT Protection

For Customer Premises (CP) and Remote Terminal (RT) interfaces where an earth ground connection is not used, only metallic protection is required. Figure 3.15 shows metallic protection satisfied using a single P3100SC MC across Tip and Ring and a single **0461** 1.25 on either Tip or Ring to satisfy metallic protection.

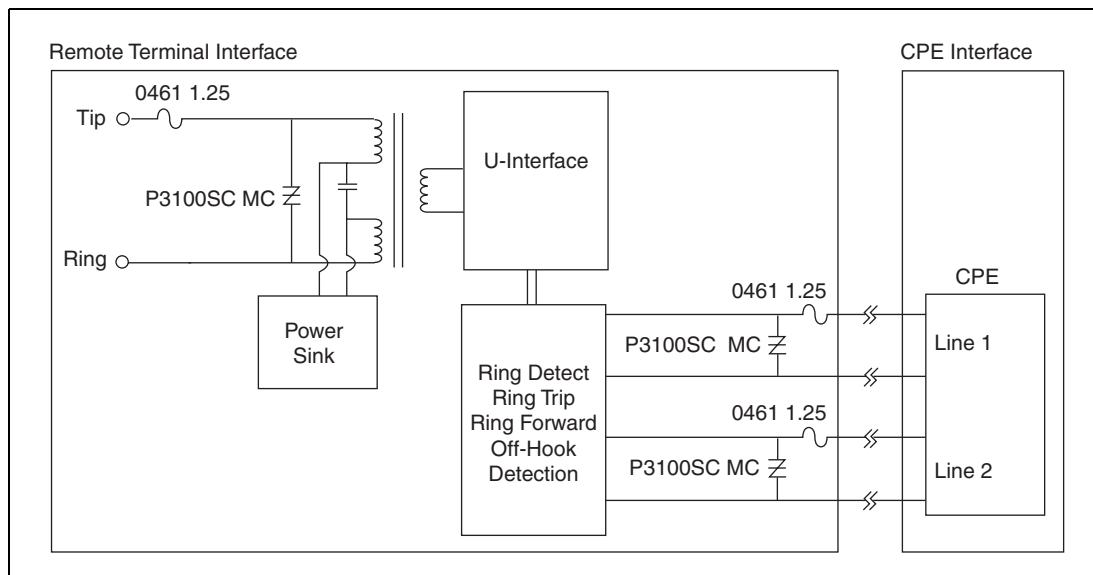


Figure 3.15 Pair Gain RT Protection

Component Selection

The "SC MC" SIDACtor device and 0461 1.25 TeleLink fuse were chosen because both components meet GR 1089 surge immunity requirements without the use of additional series resistance. An MC is chosen to reduce degradation of data rates. The voltage rating of the P1800SC MC was selected to ensure coordination with loop powering up to 150 V. The voltage rating of the P3100SC MC was selected to ensure coordination with POTS ringing and battery voltages.

T1/E1/J1 Circuit Protection

T1/E1 networks offer data rates up to 1.544 Mbps (2.058 for E1) on four-wire systems. Signal levels on the transmit (TX) pair are typically between 2.4 V and 3.6 V while the receive (RX) pair could go as high as 12 V. Loop powering is typically ± 130 V at 60 mA, although some systems can go as high as 150 V. (Figure 3.16)

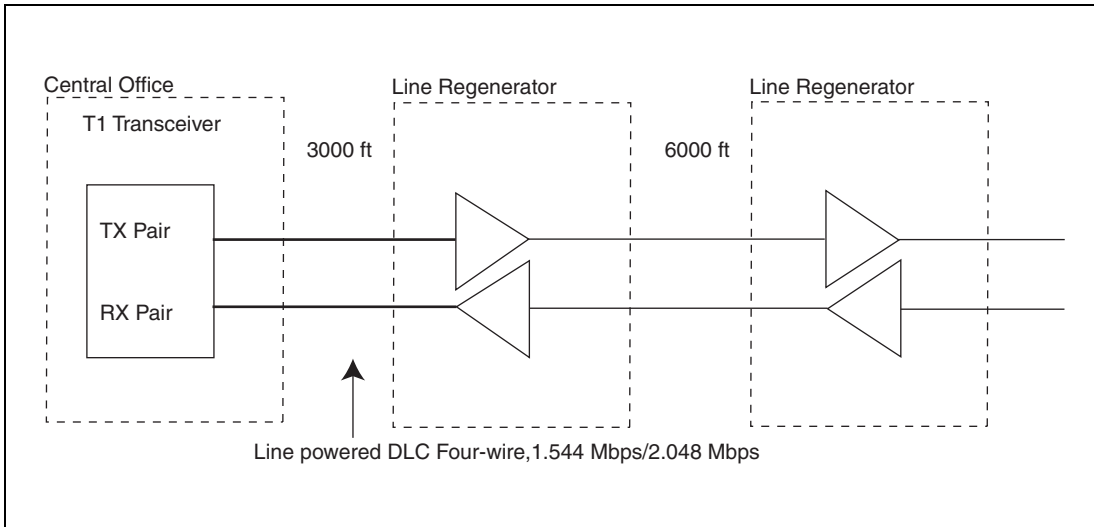


Figure 3.16 T1/E1 Overview

Protection Circuitry

Longitudinal protection is required at the Central Office Terminal (COT) interface because of the ground connection used with loop powering. (Figure 3.17) Two P1800SC MC *SIDACtor* devices provide overvoltage protection and two **0461** 1.25 *TeleLink* fuses (one on Tip, one on Ring) provide overcurrent protection. The P1800SC MC device is chosen because its V_{DRM} is compliant with TIA-968-A regulations, Section 4.4.5.2, "Connections with protection paths to ground." These regulations state:

Approved terminal equipment and protective circuitry having an intentional dc conducting path to earth ground for protection purposes at the leakage current test voltage that was removed during the leakage current test of section 4.3 shall, upon its replacement, have a 50 Hz or 60 Hz voltage source applied between the following points:

- a. Simplex telephone connections, including Tip and Ring, Tip-1 and Ring-1, E&M leads and auxiliary leads
- b. Earth grounding connections

The voltage shall be gradually increased from zero to 120 V rms for approved terminal equipment, or 300 V rms for protective circuitry, then maintained for one minute. The current between (a) and (b) shall not

exceed 10 mA_{PK} at any time. As an alternative to carrying out this test on the complete equipment or device, the test may be carried out separately on components, subassemblies, and simulated circuits, outside the unit, provided that the test results would be representative of the results of testing the complete unit.

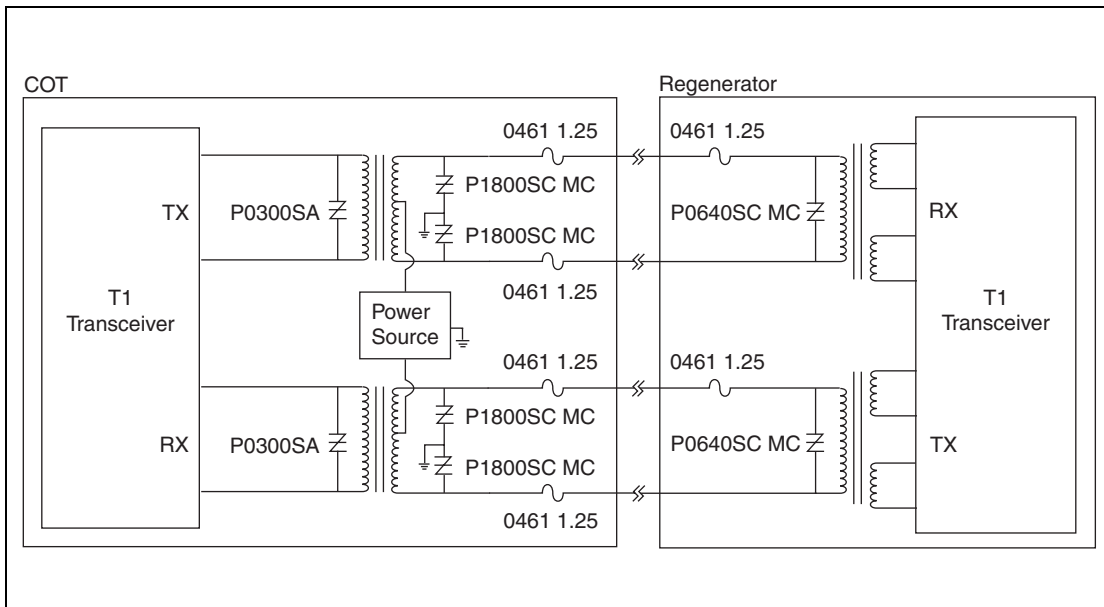


Figure 3.17 T1/E1 Protection

The peak voltage for 120 V rms is 169.7 V. The minimum stand-off voltage for the P1800 is 170 V, therefore, the P1800SC MC will pass the test in Section 4.4.5.2 by not allowing 10 mA of current to flow during the application of this test voltage.

For the transceiver side of the coupling transformer, additional overvoltage protection is shown in Figure 3.17 using the P0300SA SIDACtor device. When an earth ground connection is not used, only metallic protection is required. Metallic protection is satisfied using a single P0640SC MC SIDACtor device across Tip and Ring and a single 0461 1.25 TeleLink fuse on either Tip or Ring.

Component Selection

The "SC MC" SIDACtor device and 0461 1.25 TeleLink fuse were chosen because these components meet GR 1089 surge immunity requirements without the use of additional series resistance. An MC is chosen to reduce degradation of data rates. The voltage rating of the P1800SC MC was selected to ensure loop powering up to 150 V. The voltage rating of the P0640SC MC was selected to ensure coordination with varying voltage signals.

Reference Designs

T1/E1/J1 Asymmetrical Circuit Protection

The A2106UC6 Surface Mount *SIDACtor* device provides asymmetrical protection for T1/E1/J1 transceivers. Metallic events are limited to less than 80 V on the line side of the transformer. The minimum turn on voltage for the A2106 is 170 V from tip to ground and ring to ground. This is compliant with TIA-968-A (formerly known as FCC Part 68). The secondary side of the transformer has the P0080SA MC *SIDACtor* device that limits differential voltages to less than 25 V.

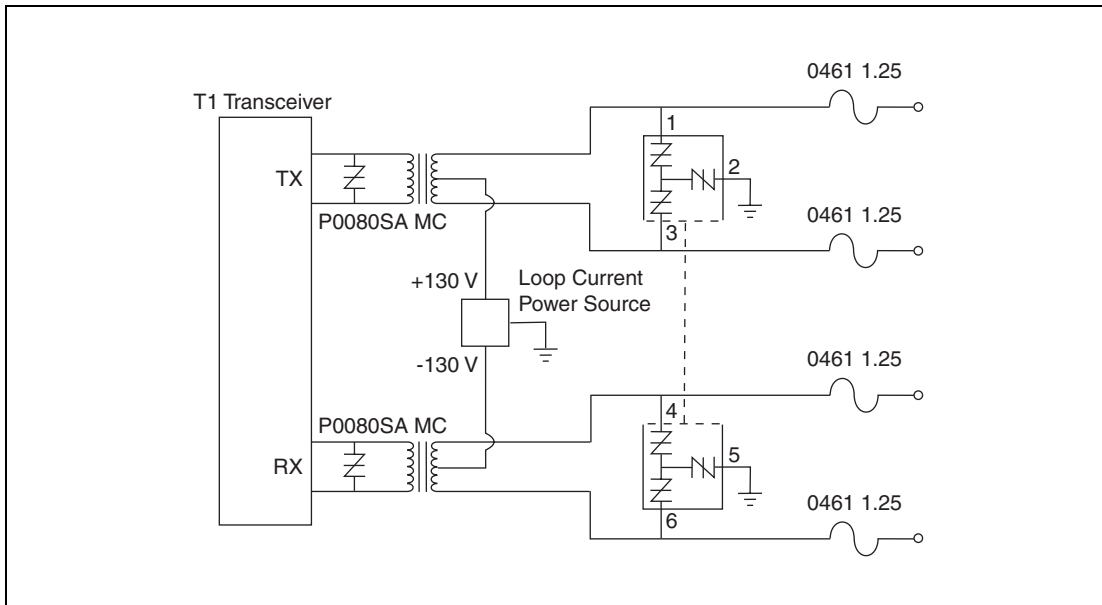


Figure 3.18 T1/E1/J1 Protection

Protection Circuitry

The T1/E1 transceiver circuit is protected from AC power cross events (also known as over current events) by the **0461 1.25 TeleLink** fuses. The *TeleLink* fuses in combination with the *SIDACtor* devices are compliant with the requirements of GR 1089, TIA-968-A, and UL 60950.

Additional T1 Design Considerations

A T1 application can be TIA-968-A approved as two different possible device types. An XD device means an external CSU is used and the unit does not have to meet the TIA-968-A environmental test conditions, but it must connect only behind a separately registered DE device. This XD equipment does not have to meet the T1 pulse template requirements. If not classified as an XD device, then typically the application must adhere to TIA-968-A environmental test conditions.

T3 Protection

The capacitance across the pair of wires = (D1 || D2) + P0640EC/SC. The diode capacitance is approximately (10 pF || 10 pF) 20 pF. Then adding the capacitive effect of the P0640EC/SCMC, which is typically 60 pF, the total capacitance across the pair of wires is approximately 15 pF. The MUR 1100E diodes are fast-switching diodes that will exhibit this level of capacitance. MURS160T3 is a surface mount equivalent. (Figure 3.19)

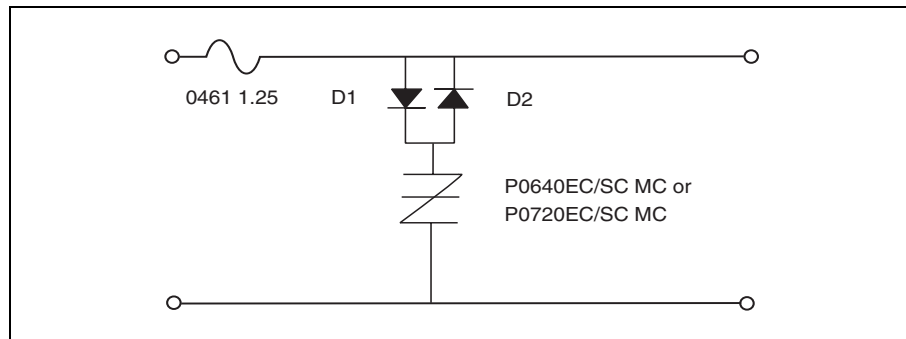


Figure 3.19 T3 Protection

Alternately, the advanced P0642SA exhibits very low capacitance and can be used as a stand-alone device.

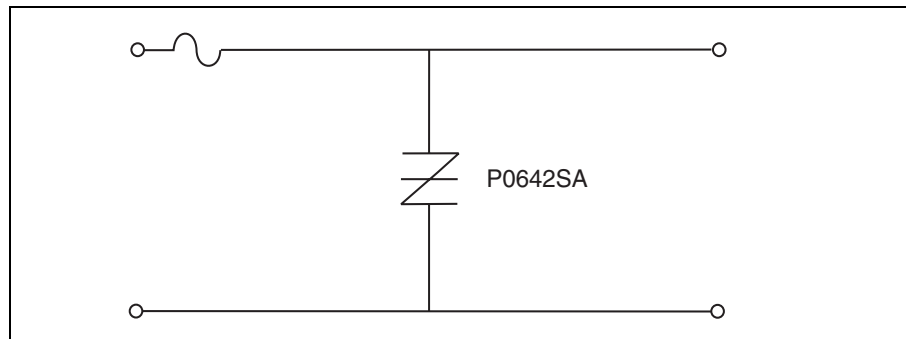


Figure 3.20 Alternate T3 Protection

Reference Designs

LAN / WAN Protectors

10Base-T Protection

Capacitance across the pair of wires = (D1 || D2) + P0640EA/SA

The MUR 1100E diodes capacitance is approximately (10 pF || 10 pF) 20 pF. Then, adding the capacitive effect of the *SIDACtor* (typically 50 pF), the total capacitance across the pair of wires is approximately 14 pF. This provides a GR 1089 intra-building compliant design. (Figure 3.58)

Note: MURS160T3 is an SMT equivalent of the MUR 1100E.

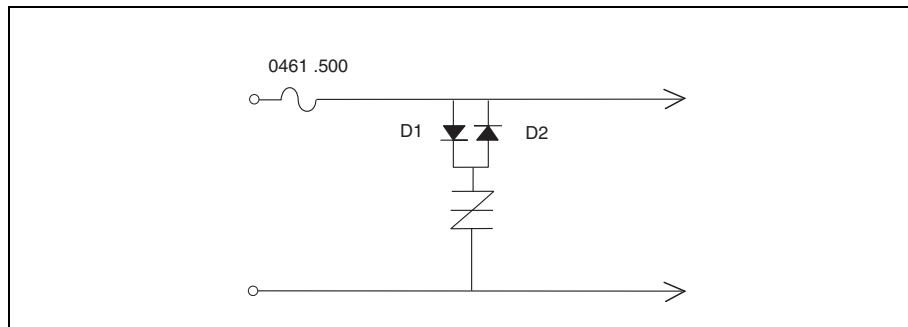


Figure 3.58 10Base-T Metallic-only Protection

Figure 3.59 shows an application requiring longitudinal protection.

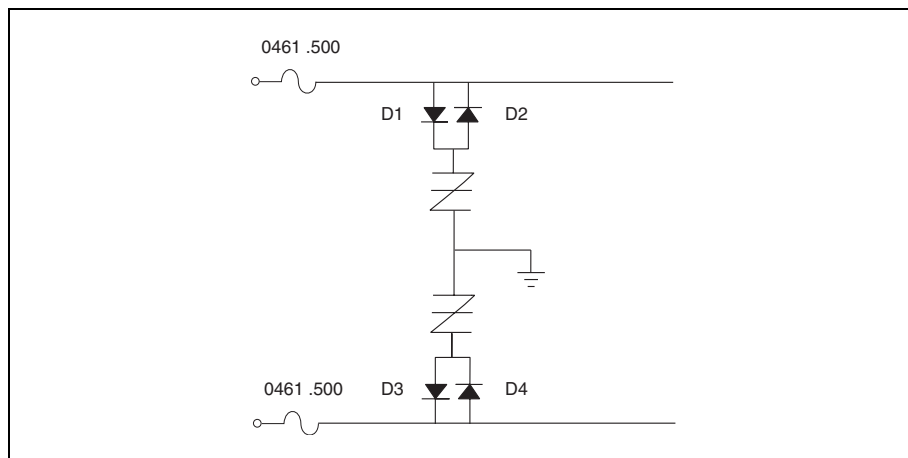


Figure 3.59 10Base-T Metallic and Longitudinal Protection

100Base-T Protection

Capacitance across the pair of wires = $(D1 \parallel D2) + P0640EA/SA + (D3 \parallel D4)$

The MUR 1100E pair of diodes capacitance is approximately $(10 \text{ pF} \parallel 10 \text{ pF})$ 20 pF. Then, adding the capacitive effect of the P0640EA/SA (typically 50pF), the total capacitance across the pair of wires is approximately 8 pF. This will provide a GR 1089 intra-building compliant design. (Figure 3.60)

Note: MURS160T3 is a SMT equivalent of the MUR 1100E.

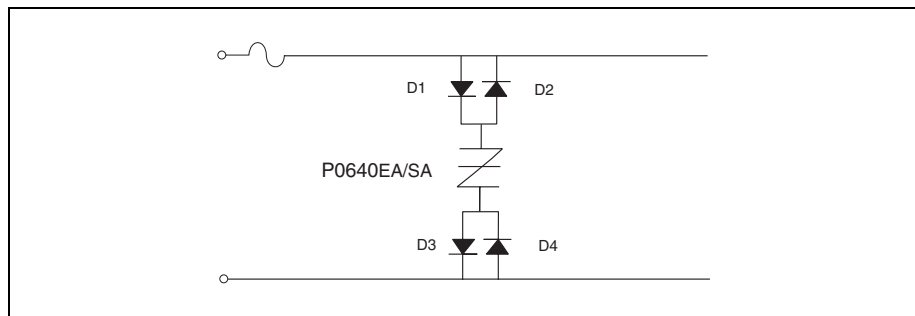


Figure 3.60 100 Base-T Protection

The P0642SA is a very low capacitance device that requires no compensating diodes. (Figure 3.61)

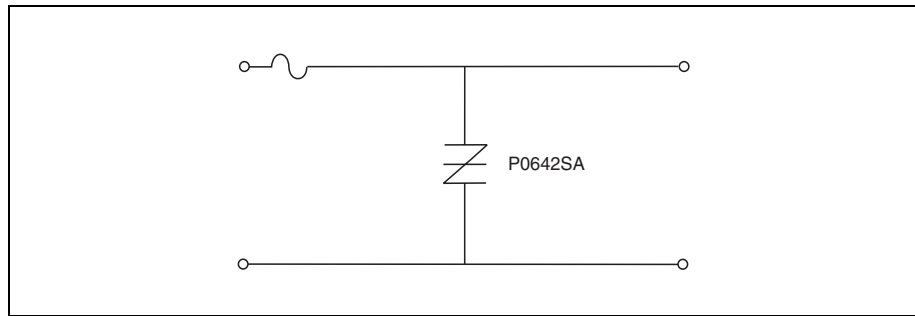


Figure 3.61 100 Base-T Protection Without External Compensation

Primary Protection

Primary telecommunications protectors must be deployed at points where exposed twisted pairs enter an office building or residence. This requirement is mandated in North America by the National Electric Code (NEC) to protect end users from the hazards associated with lightning and power cross conditions.

Primary protection is provided by the local exchange carrier and can be segregated into three distinct categories:

- Station protection — typically associated with a single twisted pair
- Building entrance protection — typically associated with multiple (25 or more) twisted pair
- Central office protection — typically associated with numerous twisted pair feeding into a switch

Station protectors provide primary protection for a single-dwelling residence or office. The station protector is located at the Network Interface Unit (NIU), which acts as the point of demarcation, separating the operating company's lines from the customer's.

Building entrance protection is accomplished by installing a multi-line distribution panel with integrated overvoltage protection. These panels are normally located where multiple twisted pairs enter a building.

A five-pin protection module plugged into a Main Distribution Frame (MDF) provides Central and Remote Office protection. Like station and building entrance protection, the MDF is located where exposed cables enter the switching office.

Littelfuse also offers a full line of five-pin protectors. For further details, contact factory at protectionsystems@teccor.com or +1 972-580-7777.

Protection Requirements

Station protectors must be able to withstand 300 A 10x1000 surge events. The building entrance protectors and CO protectors must be able to withstand 100 A 10x1000 surge events. Figure 3.51 shows building entrance protector and CO protector asymmetrical solutions. Figure 3.52 shows building entrance protector and CO protector balanced solutions.

The following regulatory requirements apply:

- UL 497
- GR 974-CORE
- ITU K.28

Primary Protection Reference Circuit

Figure 3.51 and Figure 3.52 show different configurations used in primary protection. Note that the peak off-state voltage (V_{DRM}) of any device intended for use in primary protection applications should be greater than the potential of a Type B ringer superimposed on a POTS (plain old telephone service) battery.

$$150 V_{RMS} \sqrt{2} + 56.6 V_{PK} = 268.8 V_{PK}$$

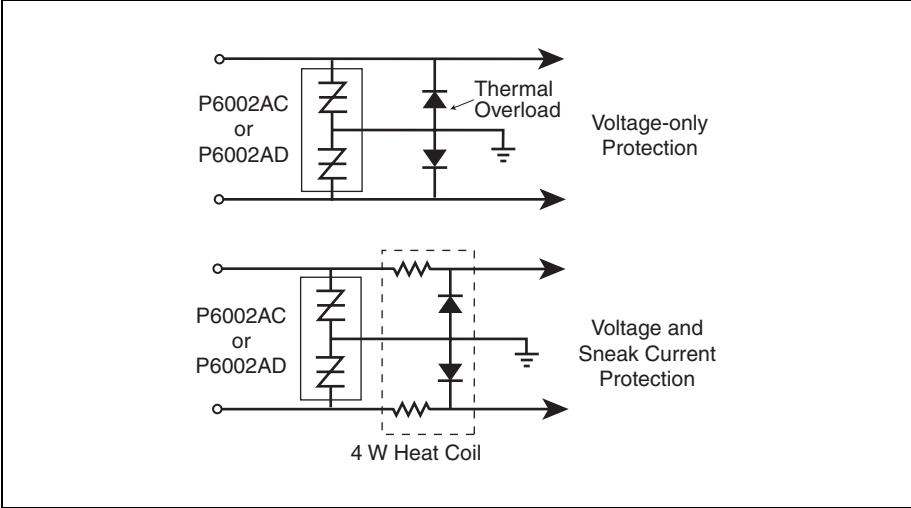


Figure 3.51 Primary Protection

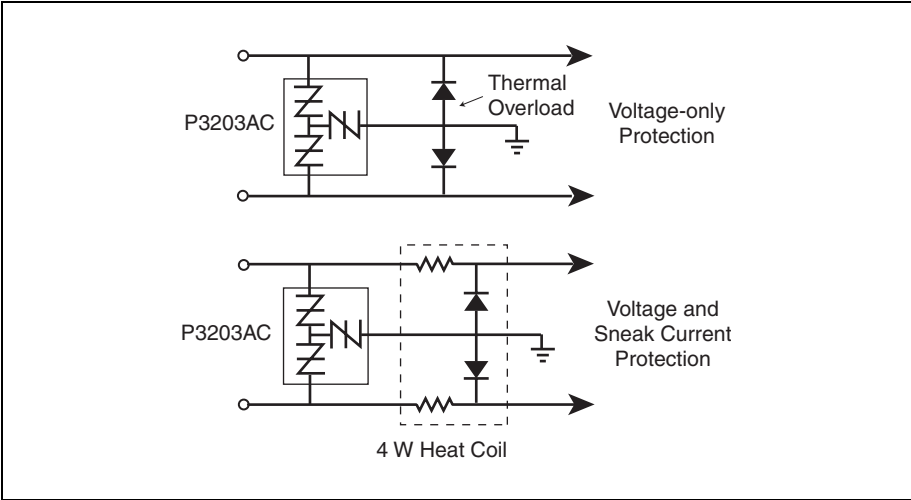


Figure 3.52 Balanced Primary Protection

Reference Designs

Secondary Protection

Secondary protectors (stand alone units or integrated into strip protectors and UPSs) are adjunct devices used to enhance the protection level of customer premise equipment (CPE). Due to the inadequate level of protection designed into CPE, secondary protectors often are required to prevent premature failure of equipment exposed to environmental hazards (Figure 3.53).

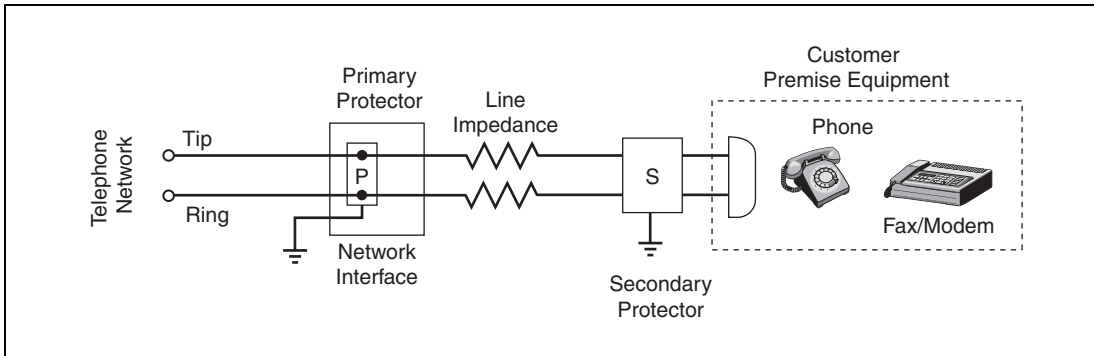


Figure 3.53 CPE Secondary Protection

Protection Requirements

Secondary protectors should be able to withstand overvoltages that can exceed 800 V and surge currents up to 100 A. Figure 3.54 illustrates a *SIDACtor* device selected because the associated peak pulse current (I_{PP}) is sufficient to withstand the lightning immunity tests of TIA-968-A (formerly known as FCC Part 68) without the additional use of series line impedance. Likewise, Figure 3.54 illustrates a fuse selected because the amps²time (I^2t) rating is sufficient to withstand the lightning immunity tests of TIA-968-A, but low enough to pass UL power cross conditions.

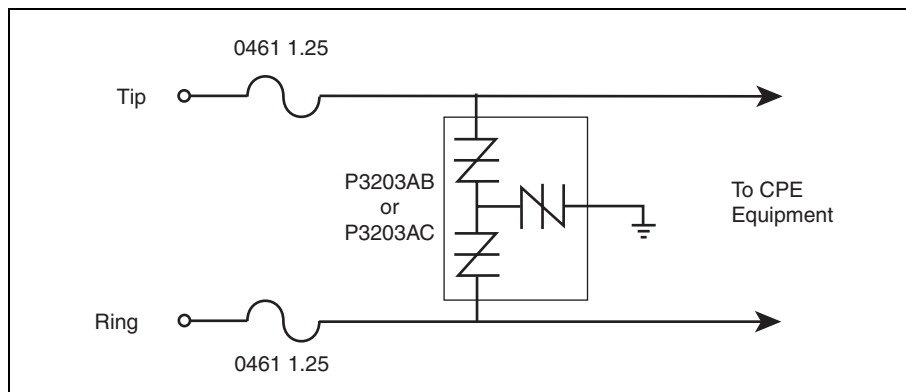


Figure 3.54 CPE Protection

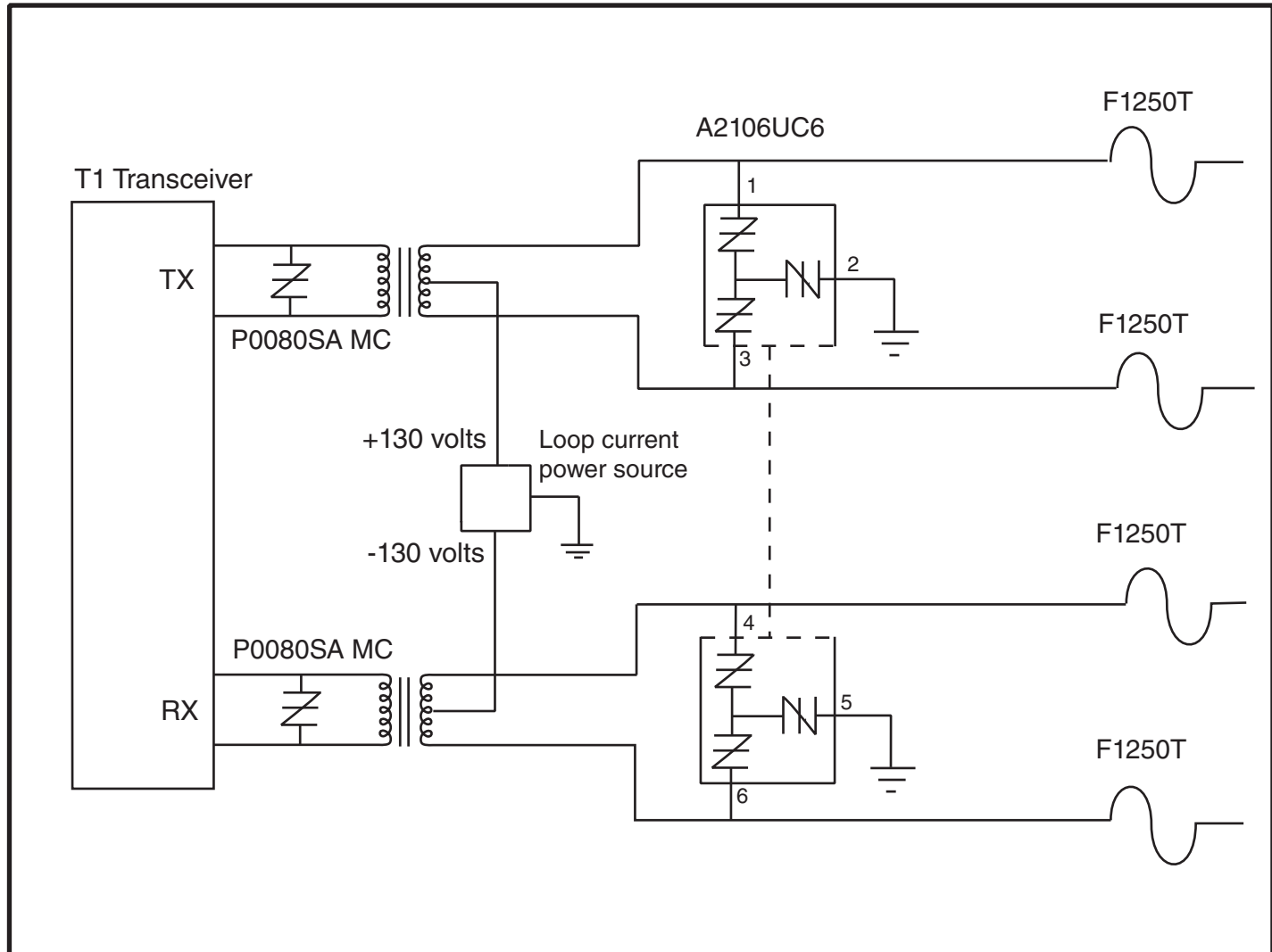
Secondary Protection Reference Circuit

Figure 3.53 also shows an example of an interface design for a secondary protector. The P3203AB *SIDACtor* device is used because the peak off-state voltage (V_{DRM}) is greater than the potential of a Type B ringer signal superimposed on the POTS (plain old telephone service) battery.

$$150 V_{\text{RMS}} \sqrt{2} + 56.6 V_{\text{PK}} = 268.8 V_{\text{PK}}$$

Coordination between the station protector and the secondary protector occurs due to the line impedance between the two devices. The line impedance helps ensure that the primary protector will begin to conduct while the secondary protector limits any of the let-through voltage to within the V_{S} rating of the *SIDACtor* device.

T1/E1/J1 Asymmetrical Protection



The A2106UC6 surface mount **SIDACTor®** device provides asymmetrical protection for T1/E1 transceivers. Longitudinal events will be limited to voltage levels less than 250 volts and metallic events will be limited to less than 80 volts on the line side of the transformer. The minimum turn on voltage for the A2106 is 170 volts from tip to ground and ring to ground. This is compliant with TIA-968 (formerly known as FCC Part 68) section 4.4.5.2 titled "Intentional paths to ground". The secondary side of the transformer has the P0080SA MC **SIDACTor®** device that will limit differential voltages to less than 25 volts.

The T1/E1 transceiver circuit is protected from AC power cross events (also known as over current events) by the F1250T **TeleLink®** fuses. The **TeleLink®** fuses in combination with the **SIDACTor®** devices provide a robust solution for compliance with the requirements of GR 1089, TIA-968, and UL 60950.

Littelfuse
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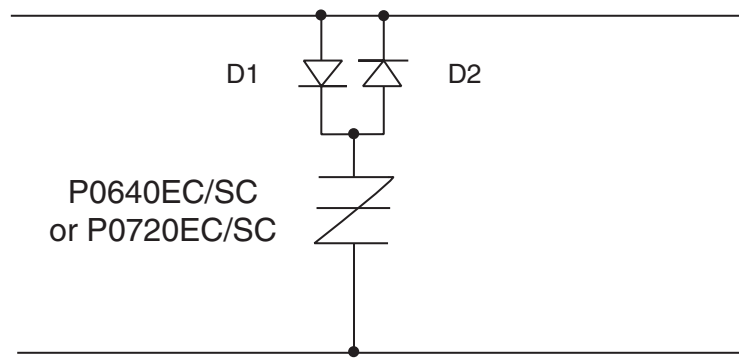
Web site: <http://www.littelfuse.com>

Ref. data sheet: T1E1J1 Asymm Prot - 030529

Please call the factory for further information.

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T3 PROTECTION



The capacitance across the pair of wires = (D1 || D2) + P0640EC/SC. The diode capacitance is approximately (10 pF || 10 pF) 20 pF. Then adding the capacitive effect of the P0640EC/SC, which is typically 120 pF, the total capacitance across the pair of wires is approximately 17 pF. The MUR 1100E diodes (the MURS160T3 is a surface mount equivalent) are fast switching diodes that will exhibit this level of capacitance.