2 Reference Designs

This section is intended to offer specific examples of how the SIDACtor can be used by manufacturers to ensure their equipment provides long term operability and uninterrupted service during transient electrical activity. For additional line interface protection circuits, refer to Regulatory Compliant Solutions beginning on page 3-37.

NOTES:

The circuits referenced in this section represent typical interfaces used in telecommunications equipment. The SIDACtor is not the sole component that is required to pass applicable regulatory requirements such as UL 1950, UL 1459, Bellcore GR-1089 or FCC Part 68 requirements nor are these requirements specifically directed at the SIDACtor.

The SIDACtor as a component is recognized under UL497B

Customer Premise Equipment (CPE)

Overview

CPE is defined as any telephone terminal equipment which resides at the customers site and is connected to the public switched telephone network (PSTN). Telephones, modems, caller ID adjunct boxes, PBX's and answering machines are all considered CPE.

Protection Requirements

CPE should be protected against over-voltages that can exceed 800V and surge currents up to 100A. In Figures 2-1 through 2-5, the SIDACtor was chosen because the associated peak pulse current (I_{PP}) is great enough to withstand the lightning immunity test of FCC Part 68 without the additional use of series line impedance. Likewise, the fuse in Figures 2-1 through 2-5 was chosen because the amps^{2}time (I^2t) rating is large enough to withstand the lightning immunity tests of FCC Part 68, but small enough to pass UL power cross conditions.

Applicable Regulatory Requirements

- FCC Part 68
- UL 1459
- UL 1950

All CPE that is intended for connection to the PSTN must be registered in compliance with FCC Part 68. Also, because the National Electric Code mandates that "equipment intended for connection to the telephone network be listed for that purpose", consideration should be given to certifying equipment with an approved safety lab such as Underwriters Laboratories.

CPE Reference Circuits

Figures 2-1 through 2-5 are examples of interface circuits which meet all applicable regulatory requirements for CPE. The P3100SB and P3100EB are used in these circuits because the peak off-state voltage (V_{DRM}) is greater than the potential of a Type B ringer superimposed on a POTS (plain old telephone service) battery.

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

It should be noted that the circuits shown in Figures 2-1 through 2-5 provide an operational solution for FCC Part 68, however FCC Part 68 allows CPE designs to pass non-operationally as well.

For a non-operational solution, the I_{PP} rating of the SIDACtor and the I^2t rating of the fuse should be coordinated such that both will withstand the Type B surge, but during the Type A surge, the fuse will open (Table 4-1, Fuse Selection Criteria).

Note: For alternative line interface protection circuits, please refer to Regulatory Requirements and Regulatory Compliant Solutions.

Figure 2-1 Basic CPE Interface

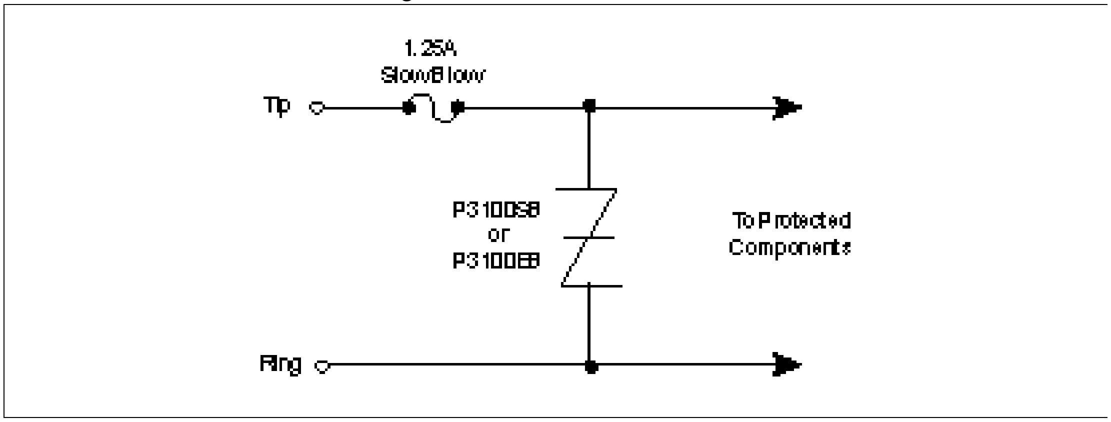


Figure 2-2 Transformer Coupled Tip and Ring Interface

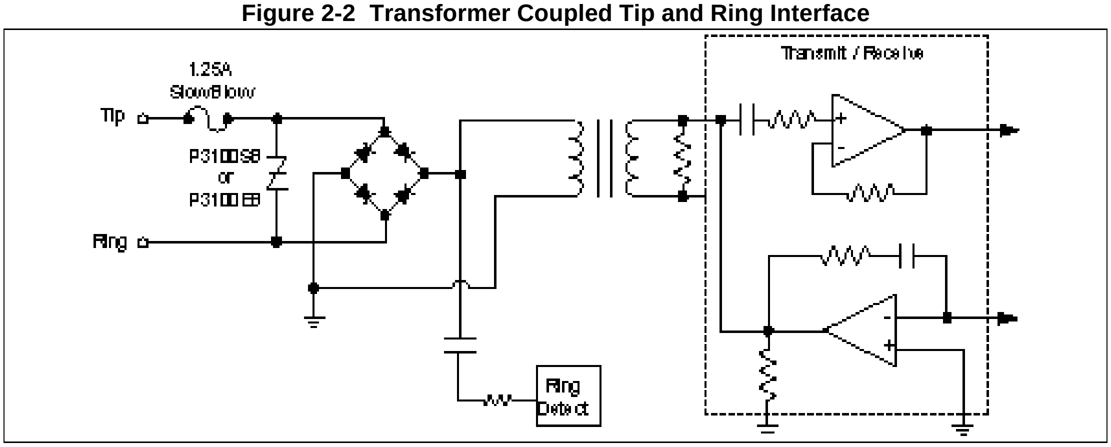


Figure 2-3 Modem Interface

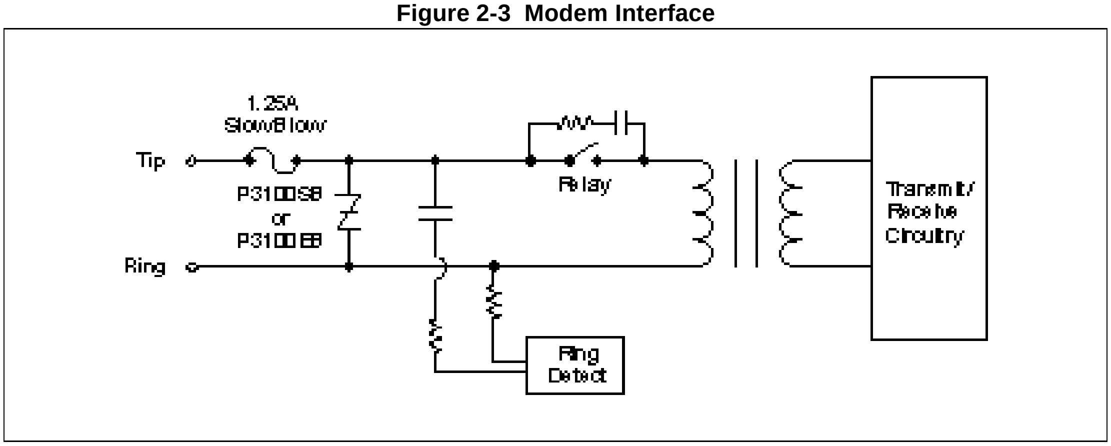


Figure 2-4 CPE Transistor Network Interface

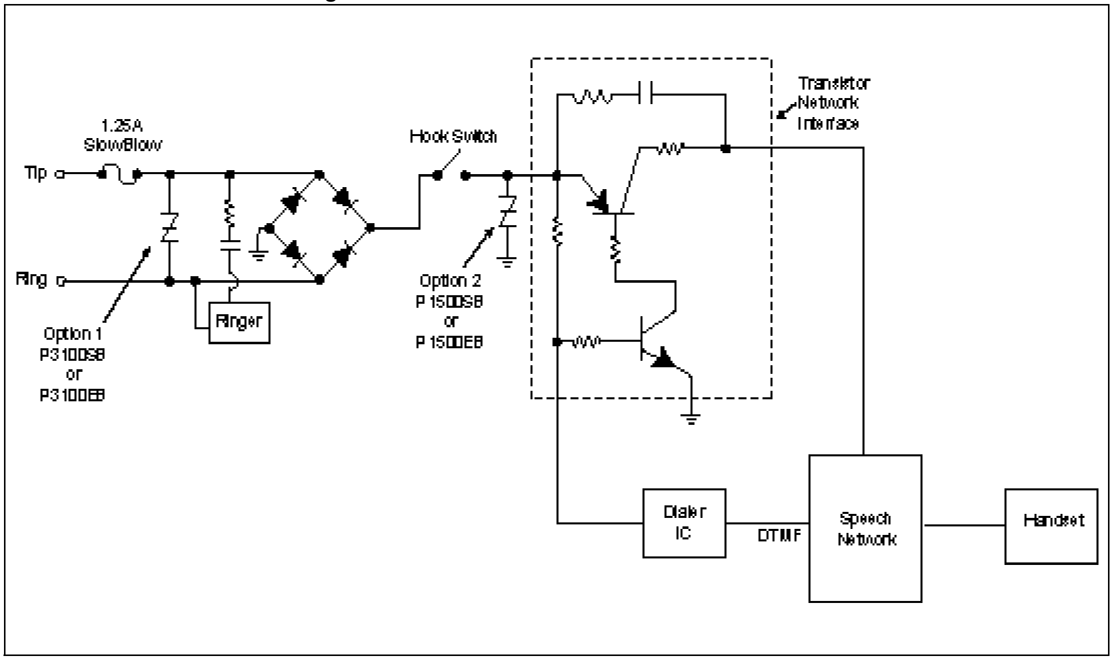
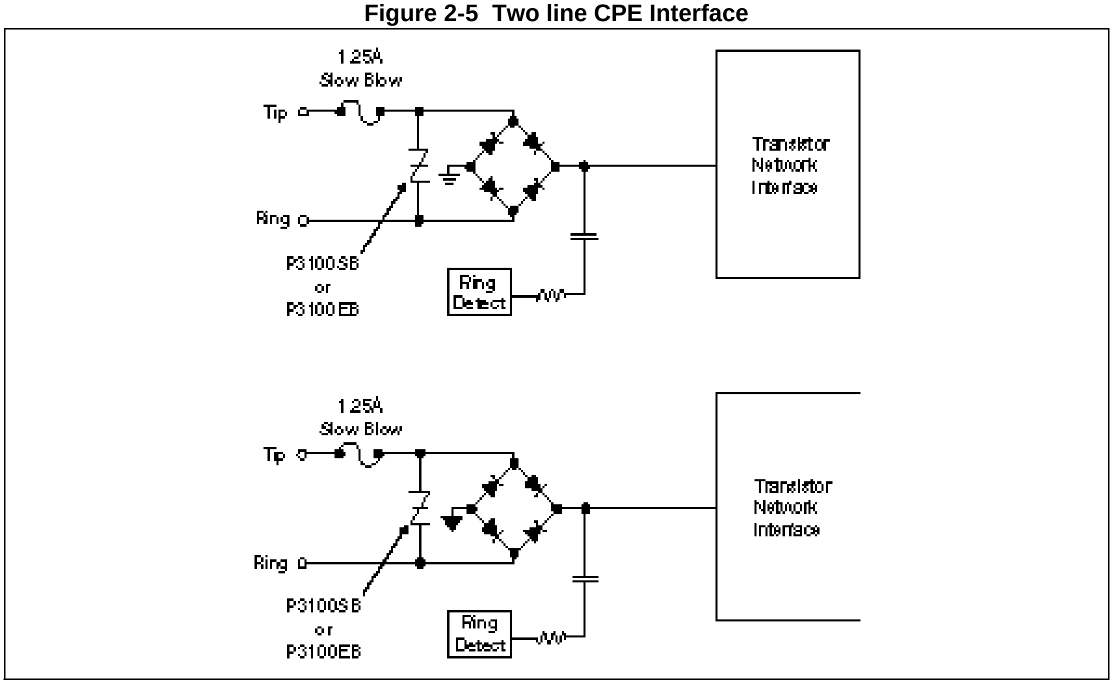


Figure 2-5 Two line CPE Interface



Reference Designs

Digital Transmission Equipment

Overview

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

Protection Requirements

Digital transmission equipment should be protected against over-voltages that can exceed 2500V and surge currents up to 500A. In Figures 2-7 through 2-11, the SIDACtor was chosen because the associated peak pulse current (I_{PP}) is great enough to withstand the lightning immunity tests of Bellcore 1089 without the additional use of series line impedance. Likewise, the fuse in Figures 2-7 through 2-11 was chosen because the amps^{2}time (I^2t) rating is large enough to withstand the lightning immunity tests of Bellcore 1089, but small enough to pass Bellcore's current limiting protector test and power cross conditions.

Applicable Regulatory Requirements

- FCC Part 68
- Bellcore GR-1089-CORE
- ITU-T K.20
- UL 1459
- UL 1950

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

xDSL Reference Circuit

Figure 2-7 is an example of an interface circuit which meets all applicable regulatory requirements for equipment which is located at the central office terminal (COT) and the remote terminal (RT). Unlike a typical POTS (plain old telephone service) application that requires a higher V_{DRM} rating at the RT, a lower V_{DRM} rating can be used in xDSL applications because a POTS splitter (Figure 2-6) separates the analog signal from the discrete multitone (DMT) signal.

Figure 2-6 xDSL Architecture

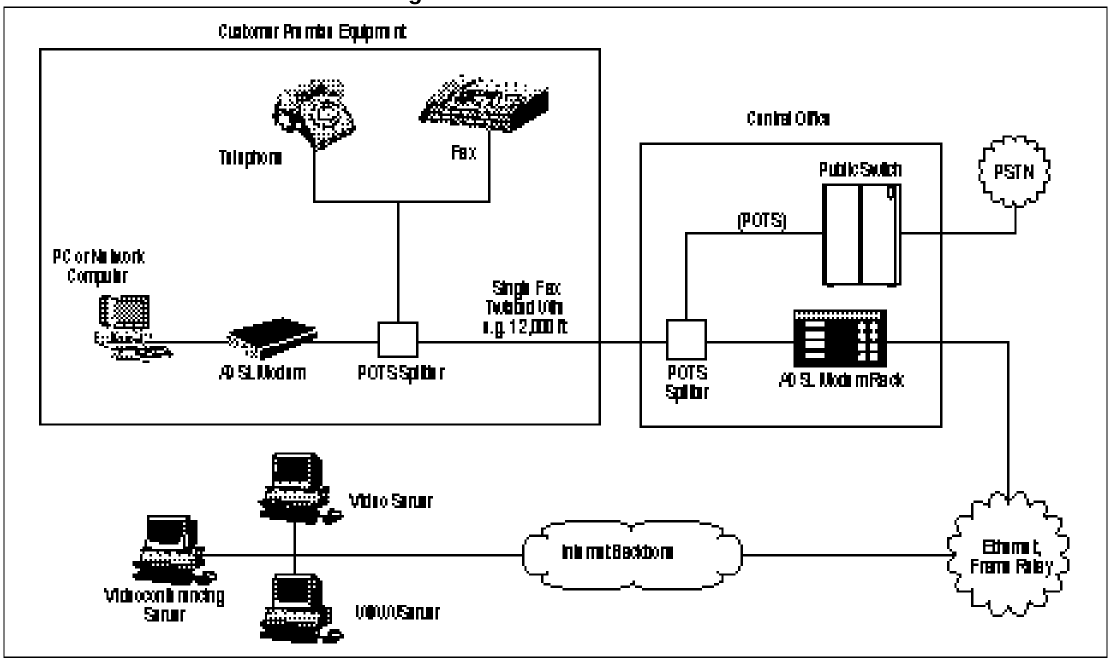
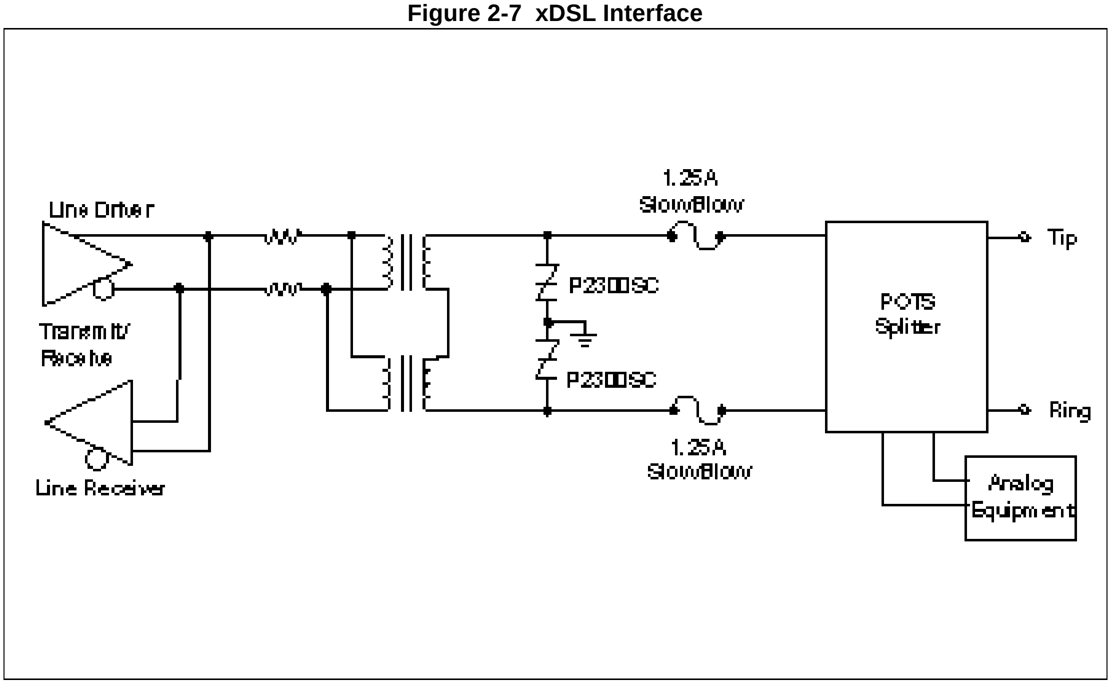


Figure 2-7 xDSL Interface



ISDN Reference Circuit

Because ISDN line termination cards and network termination equipment (NT1) interface to the telephone network (Figure 2-8), over-voltage protection is required to ensure reliable operation and regulatory compliance.

Figure 2-8 ISDN Architecture

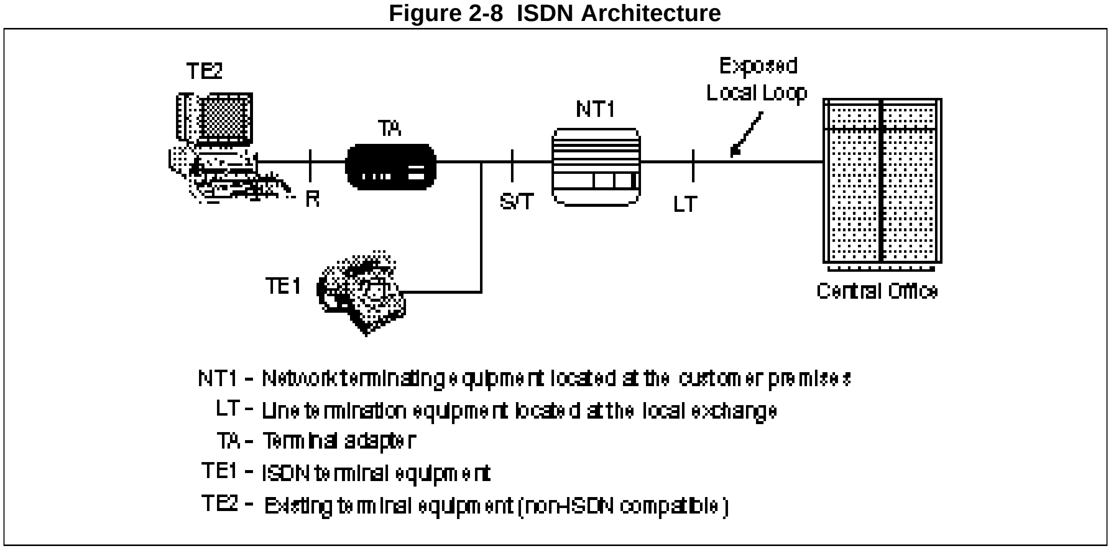
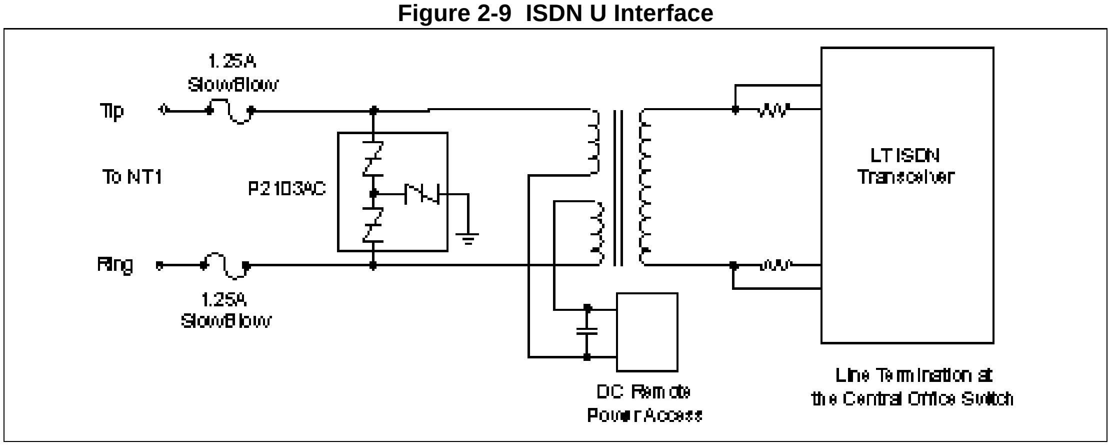


Figure 2-9 is an example of an interface design which meets all applicable regulatory requirements for ISDN equipment located at the central office terminal (COT) and the remote terminal (RT). Because techniques vary in how power is supplied, the V_{DRM} of the SIDACtor should be selected above the sum of the voltage supplied by the DC power feed and the transmission signal, and the holding current (I_H) of the SIDACtor should be greater than the current supplied by the DC power feed.

Figure 2-9 ISDN U Interface



T1/E1 Reference Circuit

T1/E1 equipment such as channel service units (CSUs), wide area network (WAN) interfaces, and network channel termination equipment require protection to ensure reliable operation and regulatory compliance. The interface circuits in Figure 2-10 & 2-11 provide an enhanced level of surge and power cross protection and meets all applicable regulatory requirements.

Figure 2-10 T1/E1 Protection Interface

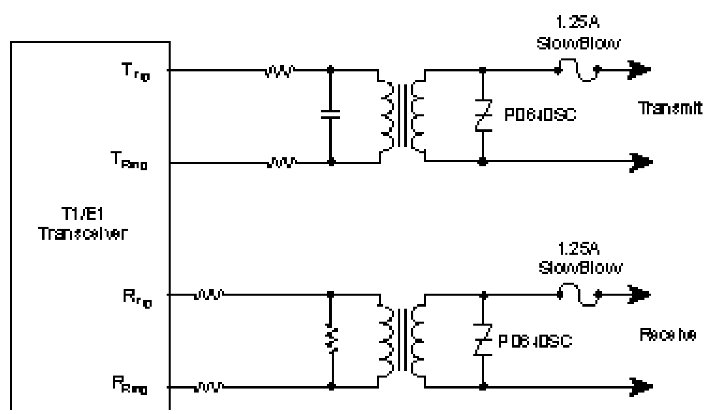
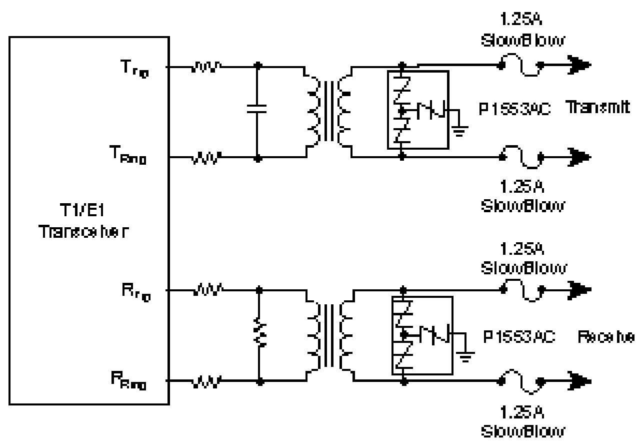


Figure 2-11 T1/E1 Protection Interface Design referenced to earth ground.



Subscriber Line Interface Circuit (SLIC)

Because SLIC IC's are highly susceptible to transient voltages, network hazards such as lightning and power cross conditions pose a serious threat to line cards deployed at the central office and in remote switching locations. To minimize this threat, manufacturers must design adequate levels of protection to ensure reliable operation and regulatory compliance.

Protection Requirements

SLIC line cards should be protected against over-voltages that can exceed 2500V and surge currents up to 500A. In Figure 2-12, the SIDACtors were chosen because their peak pulse current (I_{PP}) is great enough to withstand the lightning immunity tests of Bellcore 1089 without the additional use of series line impedance. Likewise, the fuse in Figure 2-12 was chosen because the amps^{2}time (I^2t) rating is large enough to withstand the lightning immunity tests of Bellcore 1089, but small enough to pass Bellcore's current limiting protector test and power cross conditions.

In Figure 2-13, the SIDACtor was chosen because the line feed resistors limit the surge currents administered during Bellcore 1089 to within the I_{PP} rating of the SIDACtor.

Applicable Regulatory Requirements

- Bellcore GR-1089-CORE
- ITU-T K.20
- FCC Part 68
- UL 1459
- UL 1950

Line Card Reference Circuit

In order to adequately protect SLIC line cards, both on-hook and off-hook protection is required (Figures 2-12 & 2-13).

Figure 2-12

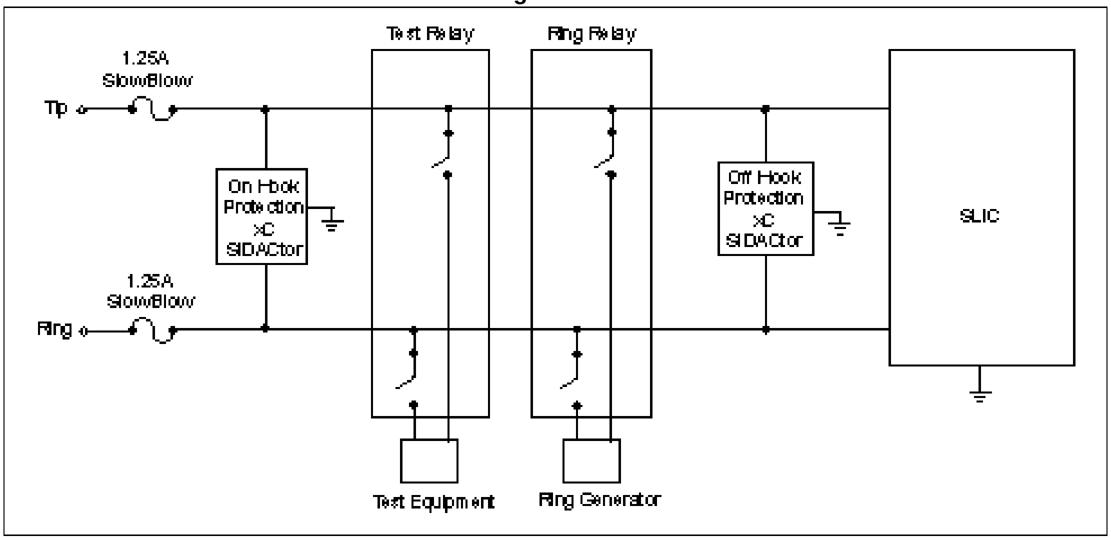
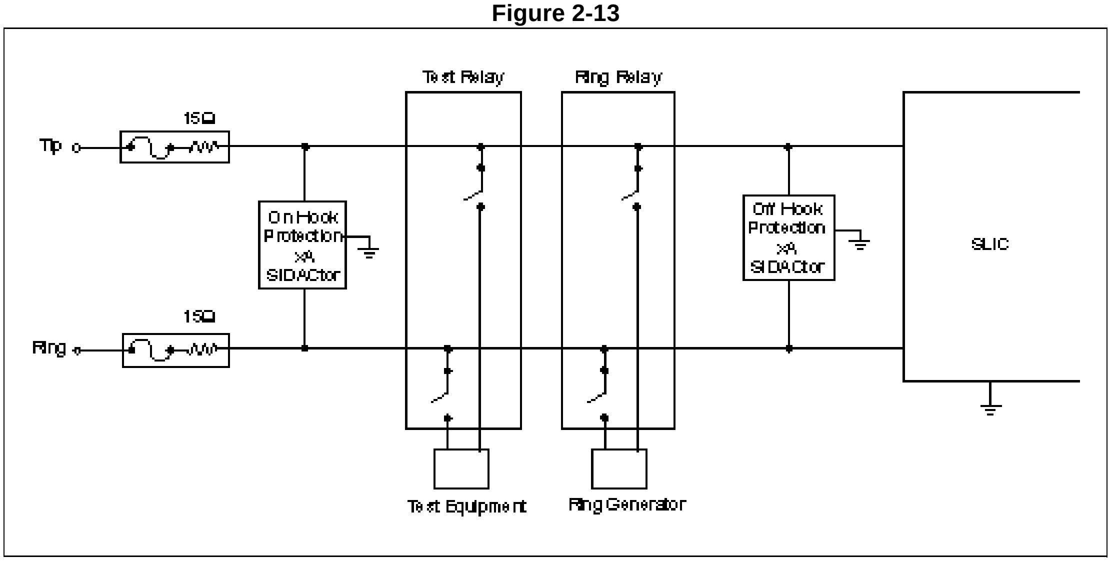


Figure 2-13



On-Hook (Relay) Protection

On-hook protection is accomplished by choosing a SIDACtor that meets the following criteria to ensure proper coordination between the ring voltage and the voltage rating of the relay:

$$V_{DRM} > V_{BATT} + V_{RING}$$

$$V_S \leq V_{Relay\ Breakdown}$$

To ensure the proper surge current rating is selected, the I_{PP} of the SIDACtor should be greater than or equal to the resultant surge currents of the applicable regulatory requirements (Figure 2-14 & 2-15).

Figure 2-14

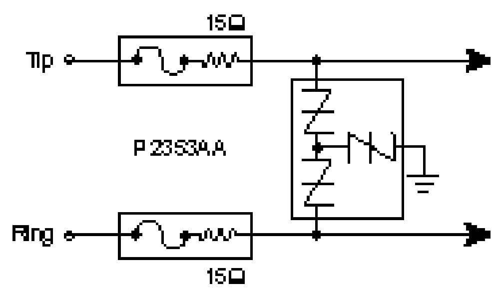
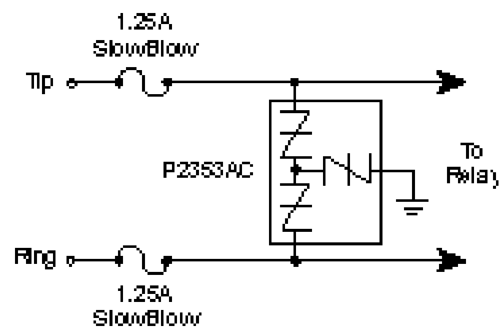


Figure 2-15

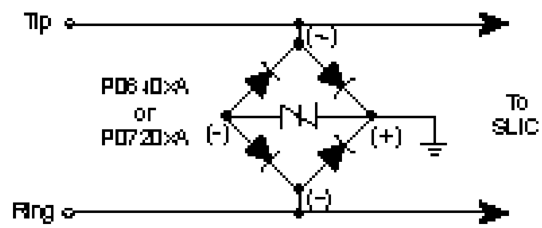


Note:
Line feed resistors are optional with the SIDACtor. If line feed resistors are not used, then the C series SIDACtor is required. If line feed resistors equal to or greater than 15Ω on Tip and 15Ω on Ring are used, then the A Series SIDACtor is recommended.

Off-Hook (SLIC) Protection

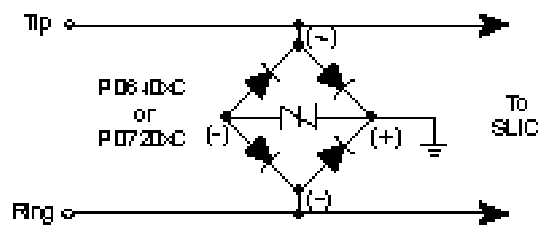
For off-hook protection, Teccor offers four different solutions. The first is to use either a P0640xA or P0720xA and a 1A, 100V diode bridge. Used per the configuration shown in Figure 2-16, the SIDACtor will limit any negative transients to within the devices break-over voltage rating and the diode bridge will limit any positive transients to less than 5V.

Figure 2-16



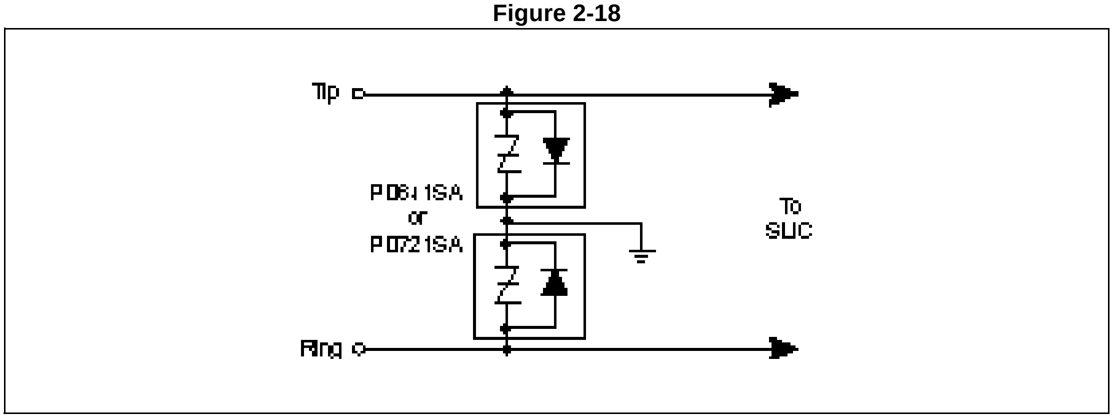
A similar solution (Figure 2-17) uses Teccor's "C" series. The advantage of using the "C" series over the "A" series is that the "C" series does not require any additional impedance to withstand the surges applied during Bellcore 1089 testing. The obvious benefit is the elimination of bulky, expensive line feed resistors.

Figure 2-17



Another alternative for SLIC Protection is to use either two P0641SA's or two P0721SA's. These devices are constructed with a bi-directional SIDACtor and integrated diode, and are connected from Tip to ground and Ring to ground as shown in Figure 2-18. Using this configuration, all positive over-voltages are shunted to ground through the diode and all negative over-voltages are shunted to ground through the SIDACtor.

Figure 2-18



Teccor's fourth solution for protecting SLIC's is similar to Figure 2-18 but uses the Battrax versus a SIDACtor. The Battrax is an SCR and a diode packaged in a three leaded DO-214 and is designed to shunt all negative voltages that are more negative than the referenced supply voltage {|-V_{BATT}|+|-1.2V|} to ground. Used in conjunction with a 1A, 100V diode (used to shunt all positive voltages to ground) and a .1µF capacitor (used to help fire the gate of the SCR), the Battrax will protect all SLIC's including those that can generate their own ringing signal such as AMD's AM79R79. Rated at 500A, the Battrax will pass Bellcore 1089 lightning immunity tests without the use of bulky and expensive line feed resistors.

Figure 2-19

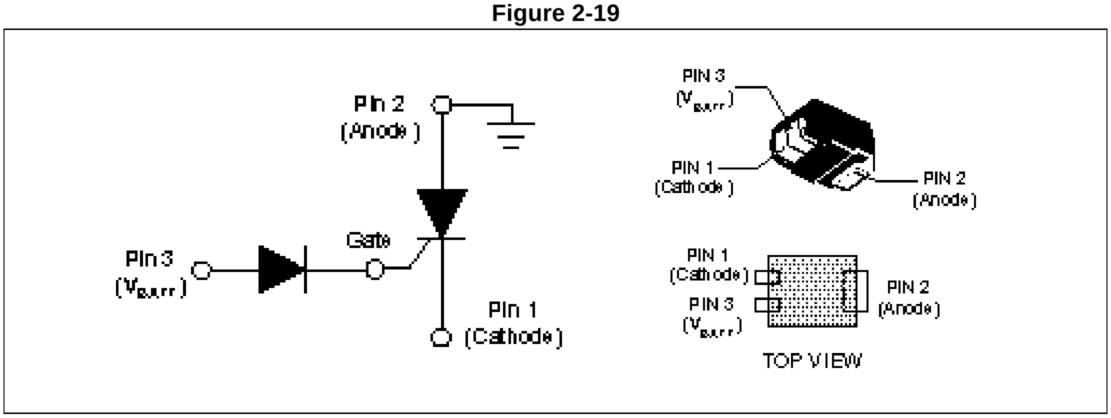
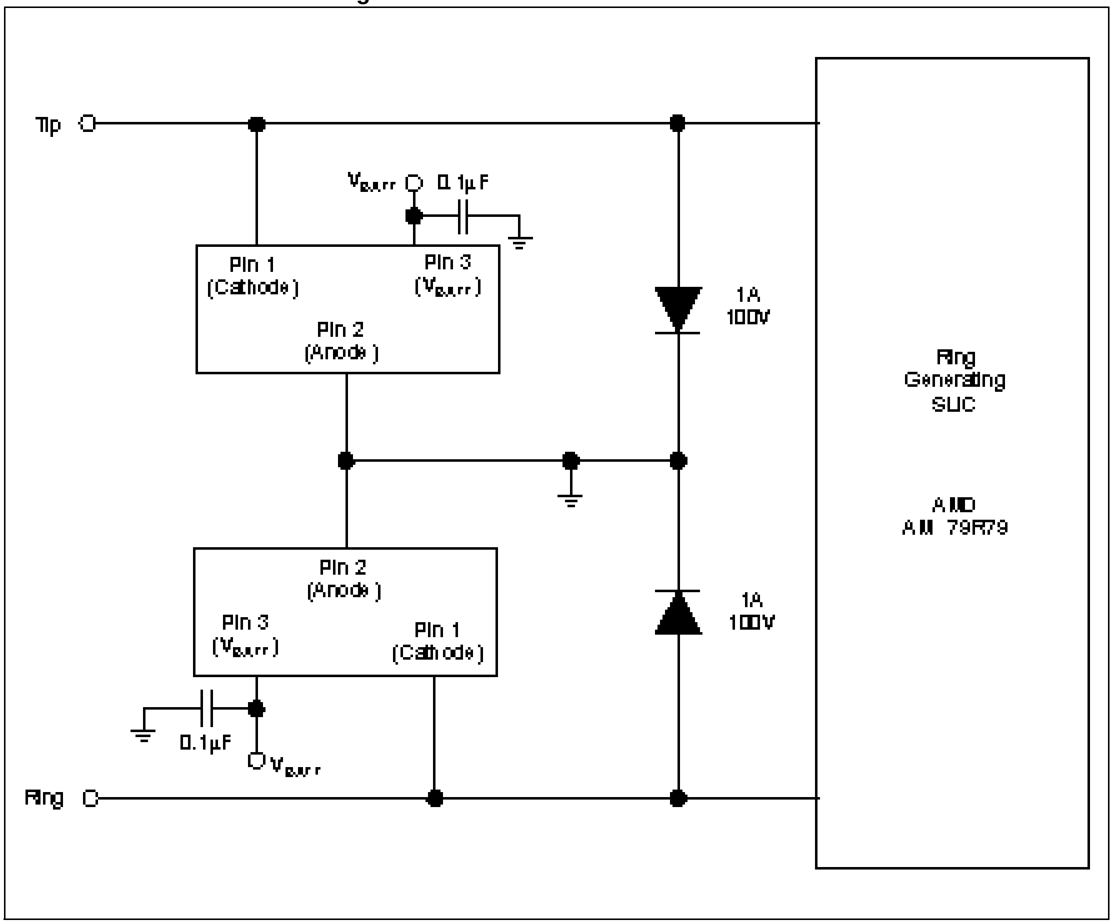


Figure 2-20 Battrax Referenced Circuit



PBX Systems

Branch Exchange Switches

PBX's, KSU's, and PABX's contain line cards that support various transmission protocols such as ISDN, T1/E1, HDSL, and ADSL (Figure 2-21). PBXs also have features such as a POTS (plain old telephone service) pull through which allows stations to have outside line access in the event of power failure. All incoming lines to the PBX are subject to environmental hazards such as lightning and power cross.

Protection Requirements

Branch exchange switches should be protected against over-voltages that can exceed 800V and surge currents of up to 100A.

Applicable Regulatory Requirements

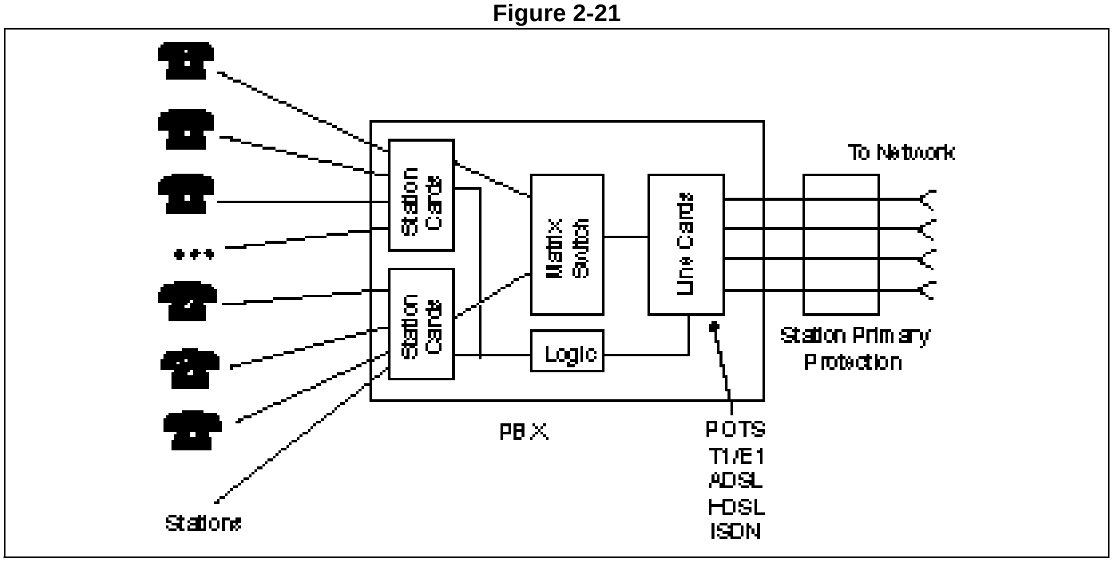
- FCC Part 68
- UL 1459
- UL 1950

Branch Exchange Reference Circuit

The following sections contain interface circuits used for protection of PBX line cards.

- For POTS protection see pages 2-3 through 2-5.
- For ADSL/HDSL protection see pages 2-6 and 2-7.
- For ISDN protection see page 2-8.
- For T1/E1 protection see page 2-9.
- For Station Protection see pages 2-20 through 2-23.

Figure 2-21



CATV Equipment

As cable providers enter the local exchange market, protection of CATV equipment becomes even more critical in order to ensure reliable operation of equipment and uninterrupted service.

Protection Requirements

CATV line equipment should be able to withstand over-voltages that exceed 6000V and surge currents of up to 3000A. CATV station protectors should be able to withstand over-voltages that exceed 5000V and surge currents of up to 1000A. The SIDACtors chosen in Figures 2-22 through 2-25 meet these requirements.

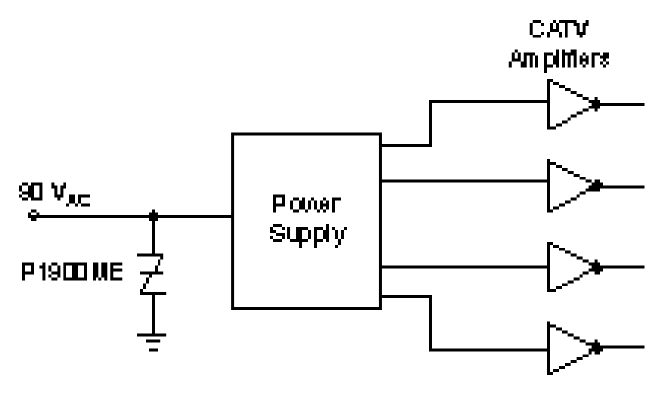
Applicable Regulatory Requirements

- UL 497C
- SCTE IPS-SP-204
- SCTE Practices
- NEC Article 830

Power Inserter and Line Amplifier Reference Circuit

Figures 2-22 & 2-23 show how the P1900ME SIDACtor is used to protect line amplifiers and power supplies versus using Teccor's patented circuit that requires two SCRs and one SIDACtor (Figure 2-24). The P1900ME is used because the peak off-state voltage (V_{DRM}) is well above the peak voltage of the CATV power supply ($90V_{RMS}\sqrt{2}$) and the peak pulse current rating (I_{PP}) is 3000A.

Figure 2-22



Reference Designs

Figure 2-23 CATV Amplifier protection incorporated into a power inserter module

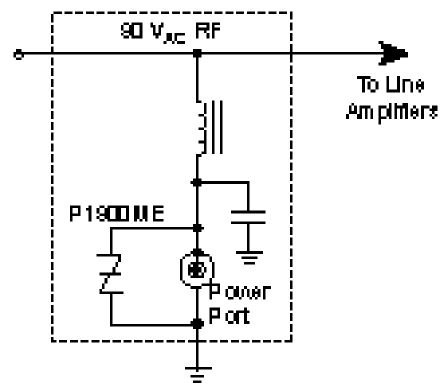
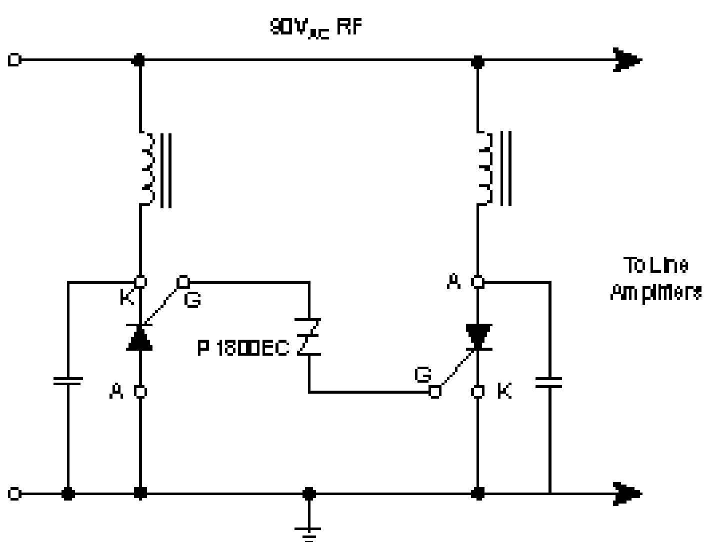


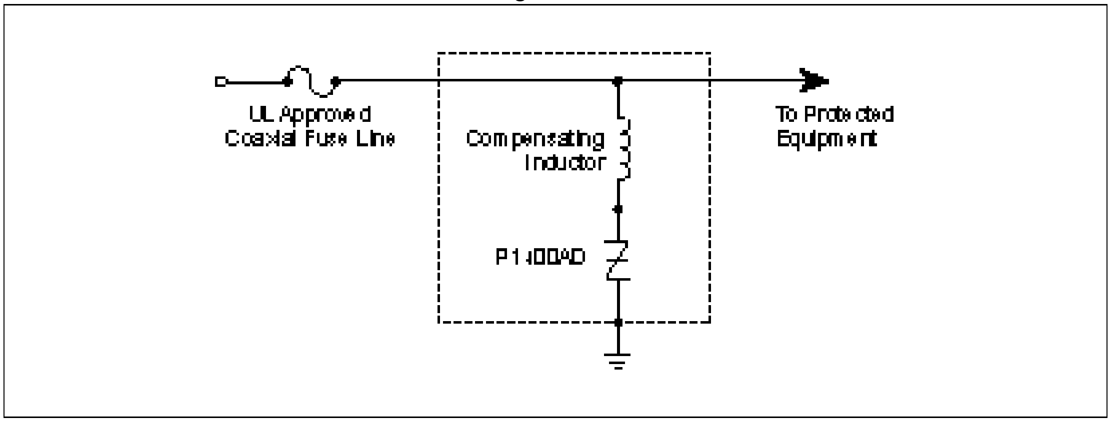
Figure 2-24



Station Protection Reference Circuit

Figure 2-25 shows a P1400MD SIDACtor used in a CATV station protection application. Note that a compensation inductor may be required to meet insertion and reflection loss requirements for CATV networks. If so, the inductor should be designed to saturate quickly and withstand surges of up to 200V and 1000A. An inductor with a core permeability of approximately 900 and wound with 24 gauge wire to an inductance of 20 to 30 µH is an example of a suitable starting point, but the actual value is design dependent and must be verified through laboratory testing.

Figure 2-25



Primary Protection

Overview

Primary telecommunications protectors are required to 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) and is done so to protect end users from the hazards associated with lightning and power cross conditions.

Provided by the local exchange carrier, primary protection can be segregated into three distinct categories:

1. Station protection - typically associated with a single twisted pair.
2. Building entrance protection - typically associated with multiple (25 or more) twisted pair.
3. 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 companies lines from the customer's.

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

Central and remote office protection is accomplished using a 5-pin protection module which is plugged into a main distribution frame (MDF). Like station and building entrance protection, the MDF is located where exposed cables enter the switching office.

Protection Requirements

Station protectors should be able to withstand over-voltages that exceed 5000V and surge currents up to 250A. Building entrance and 5-pin module protectors should be able to withstand over-voltages that exceed 2500V and surge currents of up to 100A. The SIDACtors shown in Figures 2-26 & 2-27 meet these requirements.

Applicable Regulatory requirements

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

Primary Protection Reference Circuit

Figures 2-26 & 2-27 show different configurations used in primary protection. It should be noted that the peak off-state voltage (V_{DRM}) of any device intended to be used in primary protection applications should be greater than the potential of a Type B ringer superimposed on a POTS (plain old telephone service) battery.

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

Figure 2-26 Asymmetrical Primary Protection

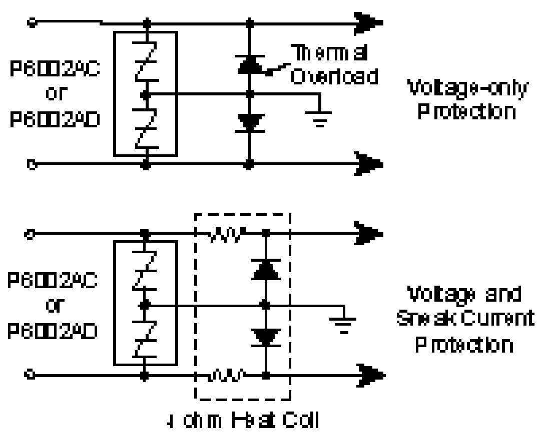
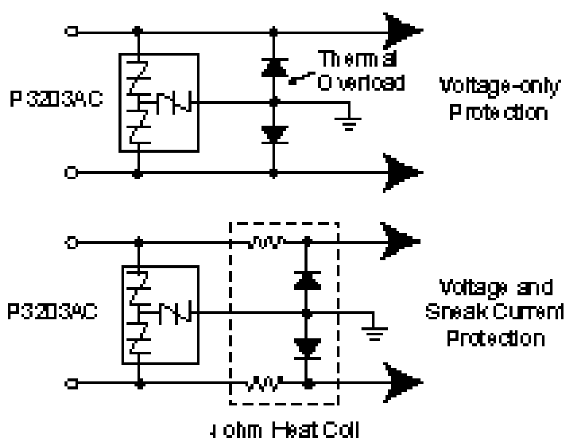


Figure 2-27 Symmetric Primary Protection



Secondary Protection

Secondary Protectors

Secondary protectors are adjunct devices (they can be either stand alone units or integrated into strip protectors and UPS') used to enhance the protection level of customer premise equipment (CPE). Due to the inadequate level of protection being designed into CPE, secondary protectors are often required to help prevent premature failure of equipment that is exposed to environmental hazards (Figure 2-28).

Protection Requirements

Secondary protectors should be able to withstand over-voltages that can exceed 800V and surge currents of up to 100A. In Figure 2-29, the SIDACtor was chosen because the associated peak pulse current (I_{PP}) is great enough to withstand the lightning immunity tests of FCC Part 68 without the additional use of series line impedance. Likewise, the fuse in Figure 2-29 was chosen because the amps^{2}time (I^2t) rating is large enough to withstand the lightning immunity tests of FCC Part 68, but small enough to pass UL power cross conditions.

Applicable Regulatory Requirements

- UL 497A

Secondary Protection Reference Circuit

Figure 2-29 is an example of an interface design for a secondary protector. The P3203AB SIDACtor 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.

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

Coordination between the station protector and the secondary protector occurs due to the line impedance between the two devices (Figure 2-28). 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.

Figure 2-28

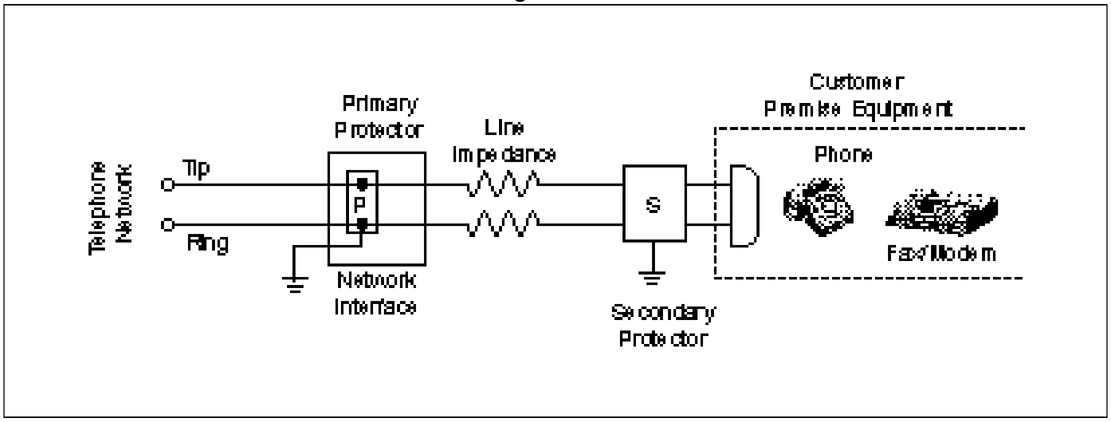
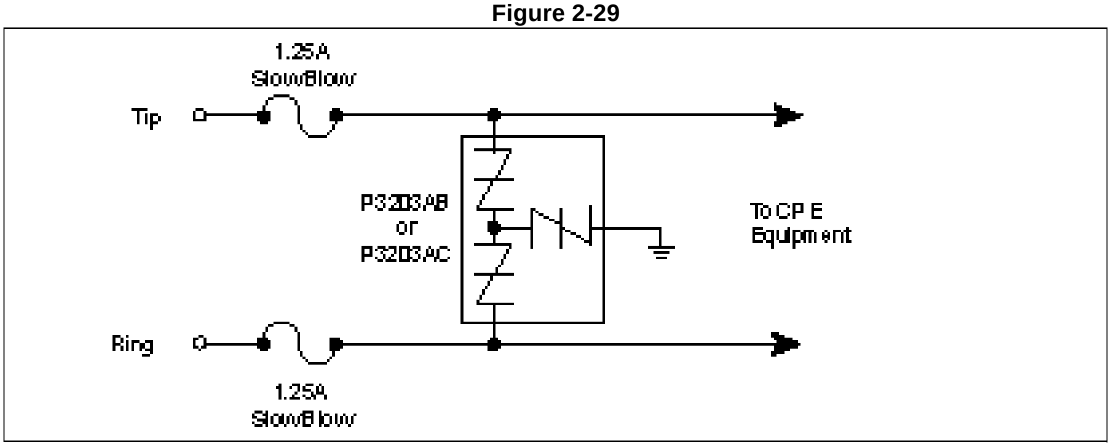


Figure 2-29



Triac Protection

Thyristors

Damage can occur to a thyristor if the thyristor's repetitive peak off-state voltage is exceeded. A thyristor's repetitive peak off-state voltage may be exceeded due to dirty AC power mains, inductive spikes, motor latch up, etc.

Thyristor Reference Circuit

Figures 2-30 & 2-31 show two different methods of protecting a triac. In Figure 2-30, a SIDACtor is connected from MT2 to the gate of the triac. When the voltage applied to the triac exceeds the SIDACtor's V_{DRM}, the SIDACtor turns on, producing a gate current which turns the triac on.

The circuit in Figure 2-31 places a SIDACtor across MT2 and MT1 of the triac. In this instance the SIDACtor protects the triac by turning on and shunting the transient before it exceeds the V_{DRM} rating of the triac.

Regardless of the method chosen, when using a SIDACtor to protect a thyristor, the following design considerations must be followed:

- V_{DRM} of the SIDACtor < V_{DRM} of Triac
- SIDACtor V_{DRM} > 120% $V_{PK(power\ supply)}$
- SIDACtor must be placed behind the load

Figure 2-30

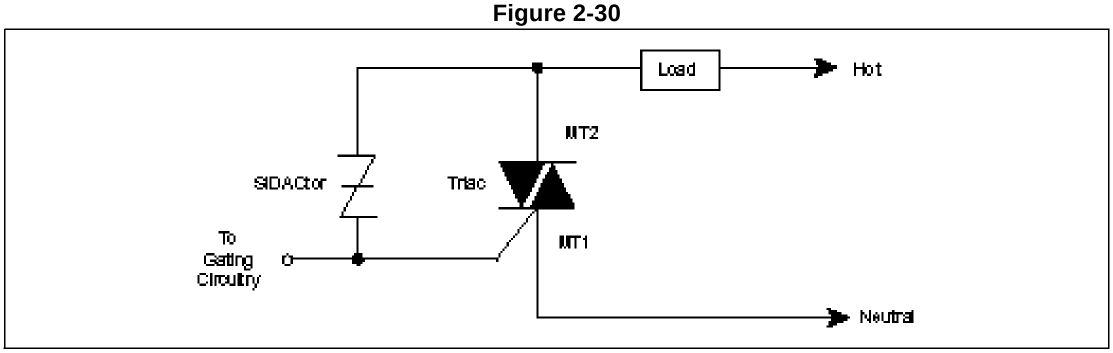
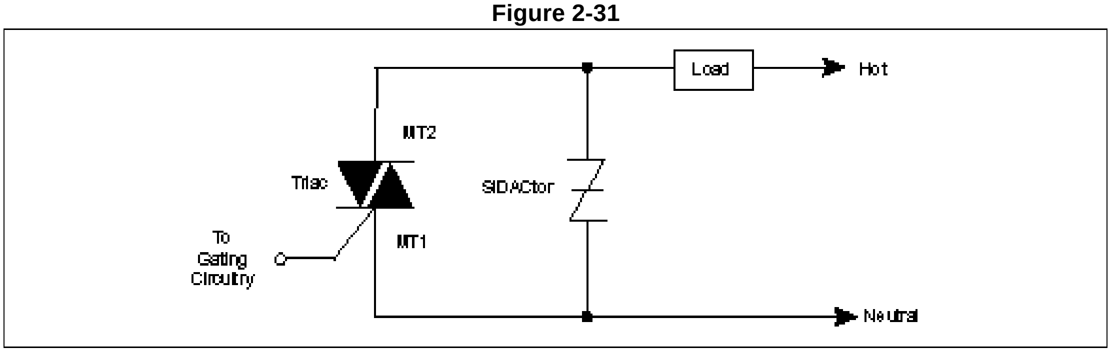


Figure 2-31



Data Line Protectors

Data Line Protection

In many office and industrial locations, data lines (such as RS-232) 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.

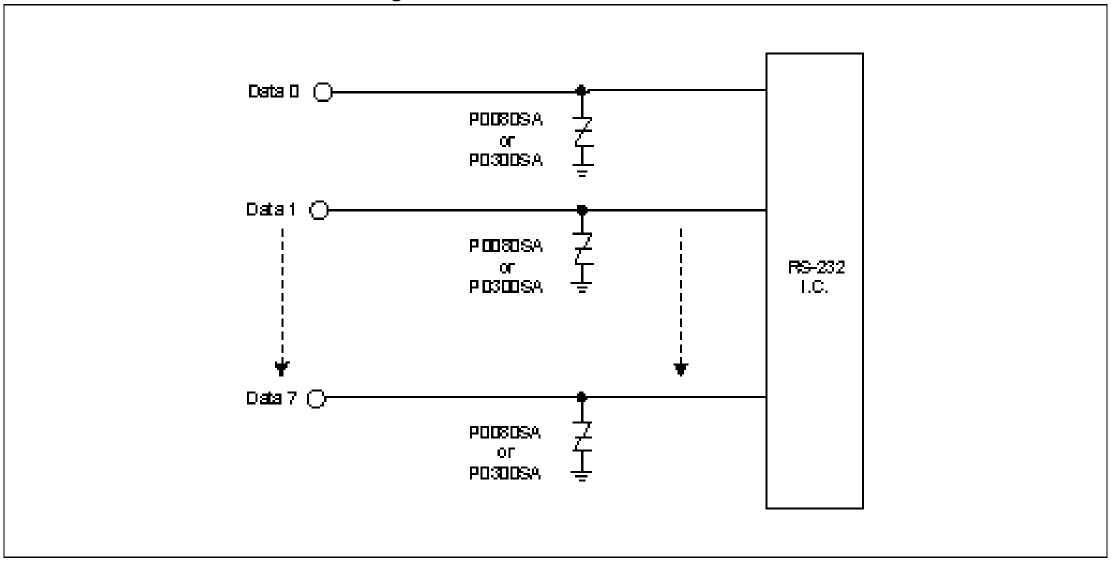
Protection Requirements

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

Data Line Reference Circuit

Figure 2-32 shows how a SIDACtor is used to protect low voltage data line circuits.

Figure 2-32 Data Line Protection



Reference Designs