Bellcore TR-NWT-001089

The circuit designed in **Figure Y** uses SIDACtors and fuses in order to meet the surge and AC power cross requirements of Bellcore 1089. The circuit in **Figure Y**. also takes advantage of the T1 line transformers isolation to prevent damage from longitudinal surges. NOTE: careful analysis of the transformer is required to prevent damage or safety hazards resulting from transformer ratings being exceeded during First and Second level lightning immunity tests. (Ref. AN1012)

UL 1459 & UL 1950

All T1 interface circuits must have shock and fire hazard protection in order to pass UL 1459 and UL 1950. In **Figure Y**, two fuses are used on the transmit and receive lines to protect the equipment from the 600 VAC power cross tests that all equipment is subjected to as part of UL 1459/1950 evaluations. The SIDACtor will provide the added benefit of limiting the power cross to its Maximum V_{BO} during the power cross tests. (Ref. AN1020, AN1024).

AN1024 — Bi-National Safety Standard UL 1950

The requirements and tests listed in UL 1950 under “Protection against overvoltage” are essentially the same requirements and tests as listed in UL 1459 under “Overvoltage testing”. The major difference in UL 1950 and UL 1459 overvoltage testing is in the allowed design exceptions that were adopted into the new Bi-national standard. The design exceptions of UL 1950 allow the designer greater flexibility in the designing overvoltage protection into telecommunications or business equipment.

Applications notes AN1010, AN1011, AN1018, AN1019 that reference UL1459 are still valid applications with respect to UL 1950. By meeting the surge requirements of UL1459, the equipment has essentially met the worst case overvoltage testing scenario of UL 1950.

Implementation of the new Bi-National Standard is shown below.

July 28, 1996 - April 1, 2000	**The new bi-national standard will be used to evaluate new products unless the use of another specification is requested in writing. (UL 1459)**
From April 1, 2000	**Products previously approved in accordance with UL 1459 or other national standards will be considered approved until April 5, 2005**
As of April 5, 2005	**All products whether new or previously approved, will be evaluated against the new bi-national standard**

AN1025 — ISDN Applications

Figure Z shows where SIDACtors can be used to protect ISDN network U & T interface circuits. ISDN circuits operate in 320kHz to 10 MHz range. The SIDACtors low capacitance allows it top operate in the 10 MHz range with less than 3dB of insertion loss. The SIDACtor’s low level of insertion loss, fast clamping and low over shoot make it an ideal overvoltage protection solution for Basic and Primary rate ISDN interface circuit applications and equipment.

FCC registration of Network Termination equipment (NT1) is required for ISDN terminal equipment indebted for direct connection to the Public Switched Digital Network (PSDN). ISDN interface circuitry will be required to undergo FCC environmental testing (See applications notes: AN1010, AN1011, AN1017, AN1019 & AN1022). Suggested SIDACtors for ISDN applications include the P1500SC, and the P1500EC70 (**Figure AA**).

Figure Z - ISDN Network Architecture

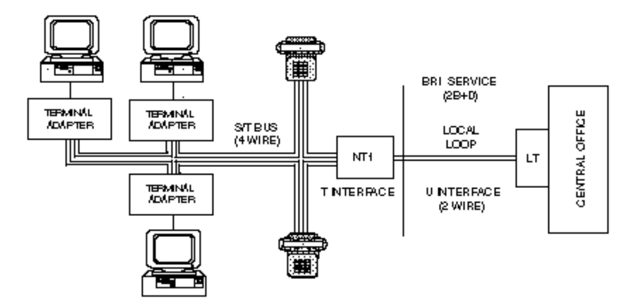


Figure AA - ISDN Interface Circuitry

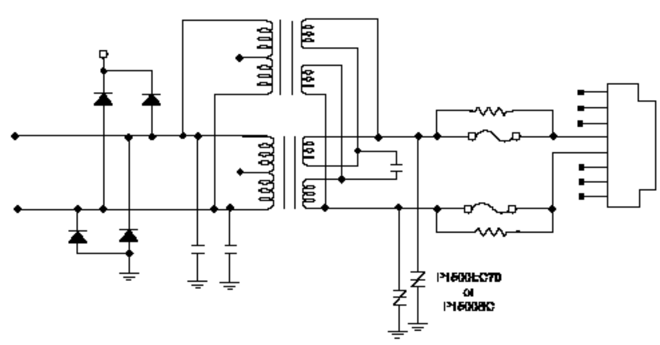
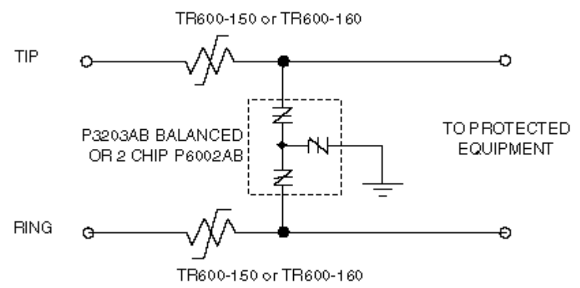


Figure W - FCC Part 68 and UL1459 Longitudinal



AN1021 — SIDACtors Used In AC Circuits

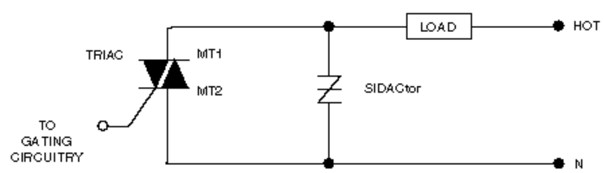
SIDACtors can be used in any number of AC applications where the normal operating current of the line being protected is limited to less than the holding current (I_H) and the AC surge capability rating (I_{TSM}) of the SIDACtor.

Figure X shows a typical AC circuit application where a SIDACtor is used to protect a triac from an overvoltage surge. The requirements for using a SIDACtor in this application are:

- SIDACtor must be placed behind the Load
- SIDACtor V_{BO} < Triac V_{DRM}
- SIDACtor V_{BO} > supply voltage (peak)

Examples of AC applications where SIDACtors can be used include security system sensors, zoning lines, sprinkler systems, and the input side of a solid state relays.

Figure X - Typical AC Applications Using SIDACtors as Transient Overvoltage Protectors



AN1022 — Proposed changes to FCC Part 68

Several proposed changes to FCC Part 68 testing are currently before the Federal Communications Commission. If adopted, these changes would become effective in late 1996 or early 1997. One significant change to FCC Part 68 testing is in the area of *Environmental Simulation*.

The environmental simulation section of FCC Part 68 includes surge testing requirements for Terminal Equipment. The following table summarizes the existing and proposed FCC Part 68 surge testing:

Current Part 68 Surges

Surge Type	Peak Volt. (V)	Rise/ Decay µs	Current (A)	Rise/ Decay µs	App. in each polarity
A-Metallic	800	10 x 560	100	10 x 560	1
A-Longitudinal	1500	10 x 160	200	10 x 160	1
Proposed Surges					
B-Metallic	1000	9 x 720	25	5 x 320	1
B-Longitudinal	1500	9 x 720	37.5	5 x 320	1

The allowed failure mode for a Type A surge is either open-circuit (permanent on-hook condition) or a short circuit to ground. Any equipment that fails short to ground after a surge must be designed in such a way as to cause the equipment to either be disconnected or repaired rapidly after such a state is reached should it occur in service.

Equipment subject to Type B. surges (currently proposed before the FCC) must withstand the lower levels of surge energy without causing permanent opening or shorting of the interface circuitry.

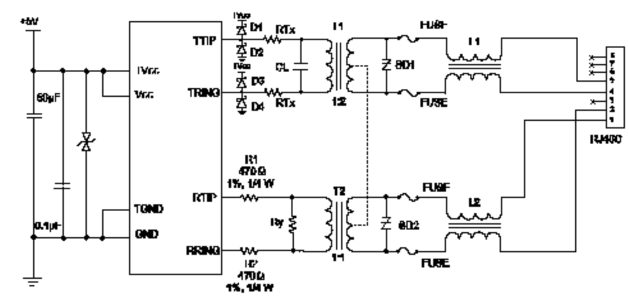
FCC Part 68 testing is referenced in applications notes AN1010, AN1011, AN1017 and AN1019. The referenced applications notes provide effective solutions for passing the Type A. FCC surging and also the proposed Type B. surge testing requirements.

AN1023 — Protection to T1 Digital Line Cards

The broader deployment of T1 Line Cards into applications outside the central office requires enhanced secondary protection of T1 circuitry. T1 lines running between customer premises equipment and the central office are subject to overvoltage and over current stresses from lightning strikes and power crosses. SIDACtors can be used to protect critical T1 transceiver chips from excessive levels of transient energy.

Figure Y shows a protection scheme that uses two Teccor SIDACtors on the line side of the T1 coupling transformer (T1 & T2). Typical SIDACtor devices used in this application would be P0720EA70 or a P0300SA (SD1 & SD2).

Figure Y - Protection Scheme Using Two SIDACtors on Line Side of T1 Coupling Transformer



The Teccor SIDACtors provide the first layer of protection for the circuit shown in **Figure Y**. The SIDACtor will effectively provide protection from lightning surges and AC power cross. T1 & T2 coupling transformers provide a second layer of high isolation protection (typically 1500 - 3000 V) against longitudinal surges. D1 - D4 and R1 - R2 provided a final layer of protection by providing voltage and current protection for any residual energy that may have coupled through the T1 line transformers. (T1 & T2).

T1 Digital line Card Regulatory Requirements

T1 equipment must meet the regulatory requirements of FCC Part 68. UL - 1459/1950 and Bellcore TR-NWT-001089.

FCC Part 68

FCC registration is required for all customers premises telecommunications equipment intended for connection to the public network. AN1022 summarizes the Part 68 lightning surge immunity requirements applicable to T1 equipment. In **Figure Y**, the SIDACtor provides protection against the metallic surges of FCC part 68 quickly clamping and shunting the surge energy away from the T1 transceiver.

Application Notes

EXAMPLE 1: FCC Part 68 Metallic Surge (Line to Line), 800 volt, 100 amp 10x560µSec.

$$\text{Metallic } R_S = \frac{800Volts}{100Amps} = 8.0\Omega$$

$$\text{Metallic } \Sigma\ R_{(metal)} = \frac{800Volts}{I_{Peak}(Fuse\ \ 10x560)}$$

$$\text{Metallic } R_{Tip} = \frac{[\Sigma\ R_{(metal)} - R_S]}{2}$$

Note: $R_{TIP} = R_{RING}$

Metallic

Selected BEL FUSE Type MJS Value mA	Fuse 10v560 µSec. Withstanding Rating (1) Amps	Calculated $\Sigma R_{(metal)}$ Ohms	Calculated (2) R_{Tip} & R_{Ring} Ohms	SIDACtor (4) Required I_{pp} 10x1000µS Amps
		MIN	MIN	
250	15	53.3	22.7	50
350	25	32.0	12.0	50
400	28	28.6	10.3	50
500	35	23.0	7.5	50
600	43	18.6	5.3	50
700	50	16.0	4.0	50
800	62	12.9	2.5	100 (3)
1.00A	78	10.3	1.2	100 (3)
1.25A	100	8.0	0.0	100 (3)

Notes:

(1) The Fuse Type and Waveform withstanding rating are BEL FUSE INC. type MJS.

(2) R_{Tip} & R_{Ring} values are minimum and should be chosen from the next higher standard ohm value.

(3) If a 50 amp 10x1000µSec. rated SIDACtor is preferred, use a 4.0Ω or greater resistor for R_{Tip} & R_{Ring} .

(4) The SIDACtor should be selected with an Ipp 10x1000µSec. equal to or greater than the applied 10x560µSec. surge current.

EXAMPLE 2: FCC Part 68 Longitudinal Surge (Line to Ground), 1500 volt, 200 amp 10x160µSec.

$$\text{Longitudinal } R_S = \frac{1500V}{200Amps} = 7.5\Omega$$

$$\text{Longitudinal } \Sigma\ R\ \ (long) = \frac{1500V}{I_{Peak}\ \ (Fuse 10x160)}$$

Longitudinal $R_{Tip} = [\Sigma\ R_{(long)} - R_S]$ Note: $R_{Tip} = R_{Rin}$

Longitudinal

Selected BEL FUSE Type MJS Value mA	Fuse 10v160µS Withstanding Rating (1) Amps	Calculated $\Sigma R_{(long)}$ Ohms	Calculated (2) R_{Tip} & R_{Ring} Ohms	SIDACtor (4) Required I_{pp} 10x160µS Amps
		MIN	MIN	
250	32	46.9	39.4	100
350	45	33.3	25.3	100
400	52	28.9	20.9	100
500	65	23.1	15.1	100
600	78	19.3	11.3	100
700	91	16.5	8.5	100
800	104	14.3	7.0	100
1000	130	11.6	4.1	150
1250	162	9.3	2.5 (3)	150

Notes:

(1) The Fuse Type and Waveform withstanding rating are BEL FUSE INC. type MJS.

(2) R_{Tip} & R_{Ring} values are minimum and should be chosen from the next higher standard ohm value.

(3) A 2.5Ω resistor was chosen (as opposed to the actual 1.8Ω) to limit the peak current to within the rated value of the SIDACtor 10x160µSec. and not the fuse.

(4) The SIDACtor should be selected with an Ipp 10x160µSec. equal to or greater than the applied 10x160µSec. surge current.

AN1020 — Using PTCs

Figures V and **W** are suggested methods of passing FCC Part 68 metallic and longitudinal surges operationally, as well as complying with UL1459 using PTC's. The Raychem Polyswitch PTC resettable fuse circuit protector is a UL recognized Positive Temperature Coefficient (PTC) resistor. When an overcurrent condition occurs, the PTC dramatically increases in resistance from its base resistance. The surge current is reduced typically to a few milliamps, that is, no significant current flow. After the over current condition subsides, the PTC resets to its base resistance allowing normal circuit operation to continue. For further information, call Raychem Polyswitch Division (1-800-227-4856).

Figure V - FCC Part 68 and UL1459 Metallic

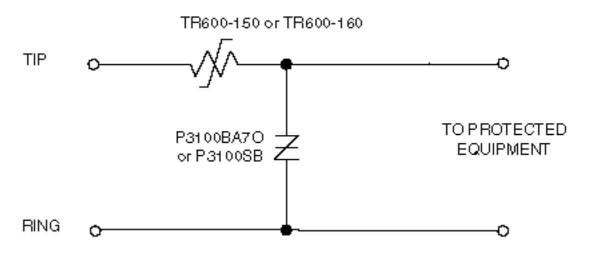


Figure S - UL1459 Longitudinal

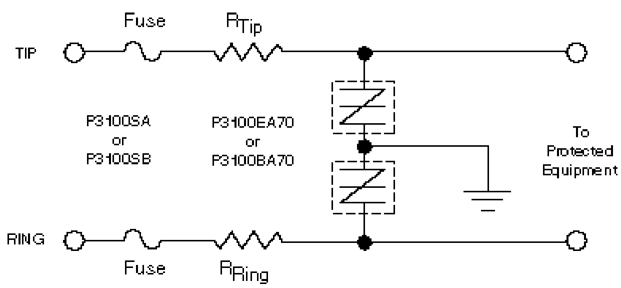


Figure T shows a "Delta" configuration protection solution. It is the same as **Figures R** and **S** except it has a third SIDACtor added between Tip and Ring that will limit the Metallic voltage Surge to its V_{B0} (breakover voltage) level.

Figure T - UL1459 Longitudinal

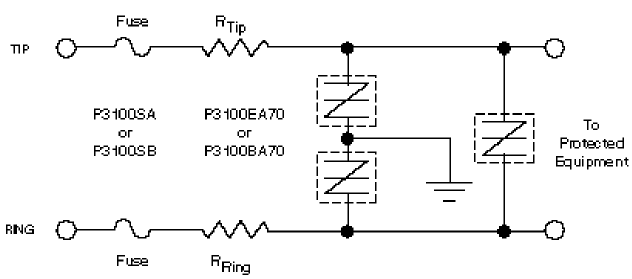
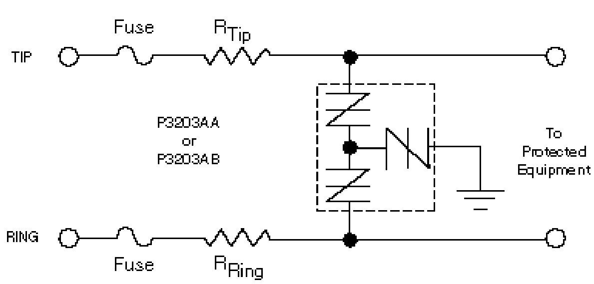


Figure U shows a Balanced "Y" configuration protection solution using a Teccor patented 3 chip "Y" configuration P3203AB or P3403AB (with 150 amp 10x160µS surge capability) or the P3203AA or P3403AA (100 amp 10x160µS surge capability).

Figure U - UL1459 Longitudinal



AN1019 — Circuit Calculations for FCC Part 68 and UL 1459

Selecting the proper SIDACtor V_{B0} (Breakover voltage): take the circuit maximum operating Ring RMS voltage, convert this to a peak voltage and add the maximum operating dc bias.

V_{B0} (minimum) = √2[RMS ring voltage maximum] + [DC bias maximum]

EXAMPLE:

V_{B0} (minimum) = √2[150 V_{RMS} maximum] + [56.6VDC maximum]

V_{B0} (minimum) = [212V_{Peak}] + [56.6V dc] = 268.6V_{Peak}

The SIDACtor V_{B0} (minimum) should be greater than your maximum circuit operating voltages and the V_{B0} (maximum) should be the protected components maximum voltage withstanding rating. A device with a V_{B0} (minimum) = 275 volts will work for this example.

The following equations are necessary for calculating the surge path impedances. Impedances can then be added to the circuit's series surge path to reduce the applied peak surge current to a value within the current carrying capabilities of the components used (SIDACtor and the fuse).

(R_S) Surge Generator Internal Source Impedance: Open Circuit voltage divided by the Short Circuit Current.

$$\text{Source Impedance } R_S = \frac{V_{Peak}}{I_{Peak}}$$

($\Sigma R_{(long)}$) Longitudinal Total Loop Impedance: Sum of all Loop Impedances in *either* Tip *or* Ring line to ground (but not both) including the Source Impedance.

Longitudinal $\Sigma R_{Tip\ (long)} = R_S + R_{Tip}$

Note: $R_{Tip} = R_{Ring}$

— Or —

Longitudinal $\Sigma R_{Ring\ (long)} = R_S + R_{Ring}$

Note: $R_{Tip(long)} = R_{Ring(long)}$

(($I_{Peak\ (long)}$) Longitudinal Peak Surge Current: Open Circuit voltage divided by the Sum of all Longitudinal Loop impedances.

$$\text{Longitudinal Tip } I_{Peak(long)} = \frac{V_{Peak}}{\Sigma R_{Tip(long)}}$$

— Or —

$$\text{Longitudinal Ring } I_{Peak(long)} = \frac{V_{Peak}}{\Sigma R_{Ring(long)}}$$

($\Sigma R_{(metal)}$) Metallic Total Loop Impedance: Sum of all Loop Impedances in Tip and Ring including the Source Impedance.

Metallic $\Sigma R_{(metal)} = R_S + R_{Tip} + R_{Ring}$ If $R_{Tip} = R_{Ring}$ then Metallic $\Sigma R_{(metal)} = R_S + [2R_{Tip}]$

($I_{Peak\ (metal)}$) Metallic Peak Surge Current: Open Circuit voltage divided by the Sum of all Metallic Loop Impedances.

$$\text{Metallic } I_{Peak(metal)} = \frac{V_{Peak}}{\Sigma R_{metal}}$$

The following examples show how to calculate the values of R_{Tip} and R_{Ring} to reduce the applied surge current to within the surge ratings of the components used and to remain operational after the surges.

Fuse Selection: Calculate the value of R_{Tip} & R_{Ring} by first selecting a fuse using its applicable waveform surge withstanding rating, calculate $\Sigma R_{(metal)}$ or $\Sigma R_{(long)}$ then R_{Tip} & R_{Ring}. Then select a SIDACtor with an Ipp 10x1000µSec. or 10x160µSec. greater than or equal to the fuse I_{Peak} 10x560µSec. or 10x160µSec.

AN1018 — UL 1459 (Standard for Telephone Equipment) and CSA-C22.2 No. 225 (Telecommunications Equipment), Detailed

The UL 1459 and CSA-C22.2 No. 225 Metallic (M), differential mode (Line to Line) and Longitudinal (L), common mode (Line to Ground), AC open circuit voltage and short circuit current test levels at 50 or 60 Hz are as follows:

Test M-1 or L-1: 600 V_{RMS}, 40 A_{RMS}, applied for 1.5 seconds.

Test M-2 or L-2: 600 V_{RMS}, 7A_{RMS}, applied for 5.0 seconds.

Test M-3 or L-3:

A. 600 V_{RMS}, 2.2 A_{RMS} and
B. This test is conducted at less than 2.2 A_{RMS}, 600 V_{RMS}, with the short circuit current set just below the current interrupting device's (fuse or PTC) activation level.

Test M-4 or L-4: 200 V_{RMS}, 2.2A_{RMS};This test is conducted with the voltage set just below the breakdown voltage (V_{B0}) of the overvoltage protection device (SIDACtor) and short circuit current just below the current interrupting device's (fuse or PTC) activation level.

Test L-5: 120 V_{RMS}, 25A_{RMS}

Test M-3, L-3, M-4, L-4 and L-5: are conducted for 30 minutes or until an open circuit condition occurs.

Note: Longitudinal surges are conducted simultaneously (Tip to Ground and Ring to Ground).

Compliance with the testing is determined by the following:

Telecom equipment shall not present a risk of fire (no ignition or charring of the cheese cloth indicator), no electrical shock and it shall not interrupt the current during the test (open the UL circuit wiring simulator, a fuse, Bussman Mfg. Co. type MDQ 1.6 amp).

Using SIDACtors (overvoltage surge protectors) in circuits to comply with UL 1459 and CSA-C22.2 No. 225 requirements:

Note: U.L. requires components used to be U.L. recognized. CSA-C22.2 No. 225 does not require the components used to be CSA certified. Only the final product meets the CSA requirements.

SIDACtors are recognized under UL 497B (Standard for Secondary protectors for data communications and fire alarm circuits).

SIDACtor epoxy used is UL recognized and the encapsulated body passes UL 94V0 requirements for flammability.

SIDACtors have 1600VAC_{RMS} electrical isolation between the leads and the case.

SIDACtors are offered with V_{B0}'s (breakover voltages) greater than the normal operating voltages.

SIDACtors will withstand the UL surges for the duration required for the UL circuit 1.6A fuse to clear (open). If the SIDACtors surge current rating is exceeded, the SIDACtor will fail shorted and not open.

UL 1459 Solution: Use a SIDACtor (overvoltage surge protector) and add a fuse or a resettable device, PTC (Positive Temperature Coefficient). The minimum value of the fuse required is determined by the maximum normal operating circuit currents (to allow normal circuit operation). The maximum fuse value is the UL circuit wiring simulator, the Bussman Mfg. type MDQ 1.6 amp fuse. Typical fuse values are between 250 mA and 1.0 amp. See Telecom Application Notes on circuit impedance calculations. Telecom equipment that must comply with UL 1459 must also comply with FCC Rules Part 68 Subpart D. To comply with UL 1459 and CSA-C22.2 No. 225 surge testing (by interrupting overcurrent, open) and remain operational after FCC Rules Part 68 Subpart D on-hook Metallic and Longitudinal voltage Surges, see the following examples:

Figure P shows a single SIDACtor and a fuse to protect against the on-hook UL Metallic surges. Note that FCC Part 68 does not require the circuit to be operational after the FCC surges.

Figure Q shows a single SIDACtor, resistor, and a fuse to protect against the on-hook UL Metallic surges. The resistor values are selected in conjunction with the fuse to pass FCC Metallic voltage Surge. A substitute for the fuse would be a PTC (Positive Temperature Coefficient) resettable current limiting device, such as is manufactured by Raychem.

See Application Note AN1020.

Figure P - UL1459 Metallic

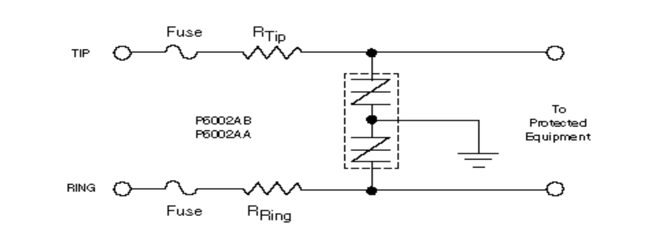
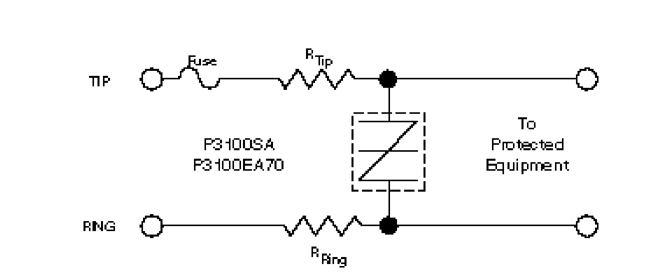


Figure Q - UL1459 Metallic



Figures R and **S** show a common scheme to protect against the on-hook UL surges using SIDACtor(s) and fuses. A design consideration should be to know that during a Metallic voltage Surge, the protected circuit will see a voltage equal to two times the V_{B0} (breakover voltage) of the selected overvoltage protection device.

Figure R - UL1459 Longitudinal

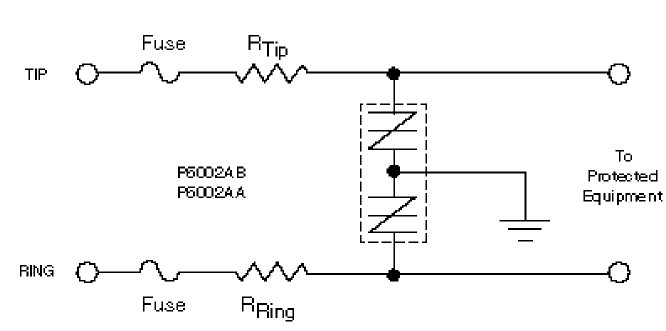


Figure J - FCC Part 68 Metallic

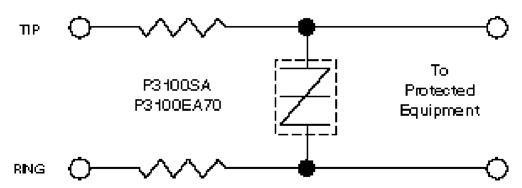
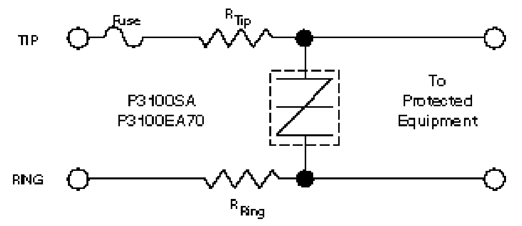


Figure K is the same as **Figure J** except it utilizes one fuse. The National Electric Code (NEC) article 800 states that telecommunication lines with no connections or paths to ground are only required to incorporate one overcurrent protection device (fuse) in series with either Tip or Ring.

Figure K - FCC Part 68 Metallic



Longitudinal Voltage Surge

The FCC Part 68 telecom Longitudinal Voltage Surge is a 1500 volt, 200 amp 10x160µs surge applied longitudinally (Line to Ground), between tip to ground, ring to ground and tip tied to ring to ground. This surge has the highest peak current of the two FCC Part 68 telecom voltage surges. A circuit designed to withstand the Longitudinal voltage Surge should also survive the Metallic voltage Surge. The tip and ring impedances should be selected to reduce the applied surge current to within the selected SIDACtor's surge rating. To calculate the Tip and Ring impedance, see Telecom Application Notes section on circuit calculations. To survive operational against an on-hook longitudinal voltage surge, see **Figures L**, **M**, **N**, and **O**.

Figures L and **M** show how to protect against a longitudinal surge with a single SIDACtor or two individual devices. A design consideration should be to know that during a Metallic voltage Surge, the protected circuit will see a voltage equal to two times the V_{BO} (breakover voltage) of the selected device.

Figure L - FCC Part 68 Longitudinal

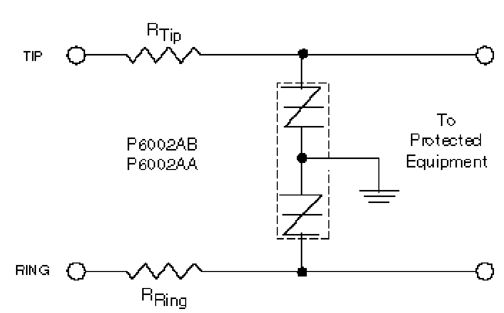


Figure M - FCC Part 68 Longitudinal

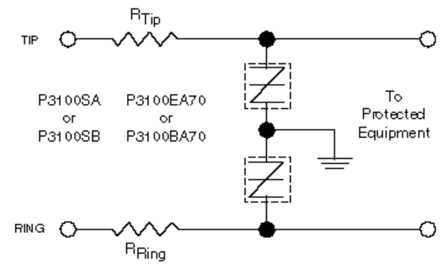


Figure N shows a "Delta" configuration protection solution. It is the same as **Figure L** and **M**, except it has a third SIDACtor added between Tip and Ring that will limit the Metallic voltage Surge to its breakover voltage (V_{BO}) level.

Figure N - FCC Part 68 Longitudinal

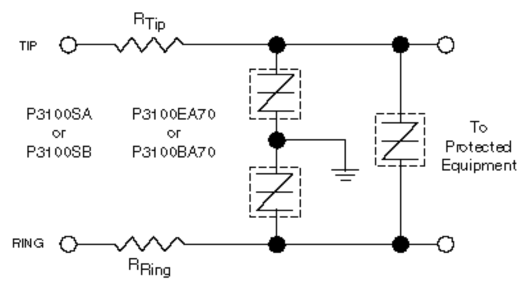
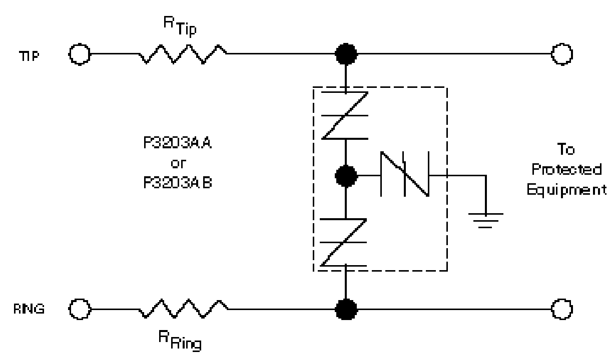


Figure O shows a Balanced "Y" configuration protection solution. This unique Teccor patented 3 chip "Y" configuration (using 2 SIDACtor chips in series between any two terminals) offers additional protection in its operation. See Telecom Applications Note explaining the patented 3 chip "Y" configuration operation.

Figure O - FCC Part 68 Longitudinal



Application Notes

AN1014 — Low Voltage Data Line Protection

AC and data lines are often run in close proximity of each other which can result in overvoltages being induced on to data lines. Teccor SIDACtors can be used to protect data lines from AC induced overvoltage conditions.

Figures F and **G** show how P0300SA, P0300EA70, and P0602AA SIDACtors can be used to protect low voltage data lines. The recommended devices have a Peak One Cycle Surge Current rating of 30 Amps and a continuous current rating of 1 Amp RMS.

Figure F — Data Line Protection

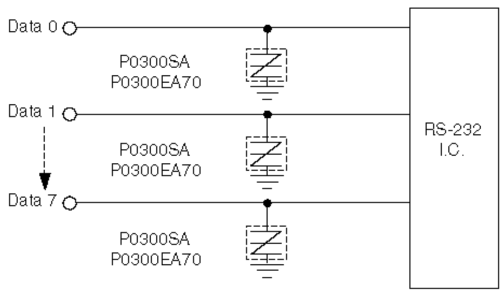
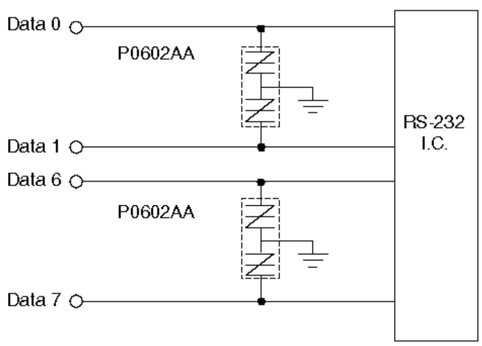


Figure G — Data Line Protection



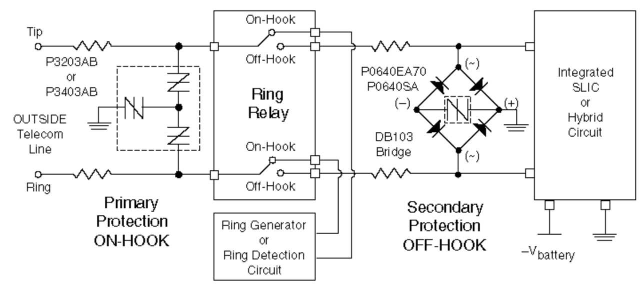
AN1015 — Teccor Patented 3-Chip "Y" Configuration

The patented TECCOR 3-chip "Y" configuration (using two SIDACtor chips in series between any terminal pair) offers additional protection in its operation. Example: When an overvoltage surge occurs on a typical telecommunication twisted pair line, a simultaneous longitudinal surge occurs (between Tip to ground and Ring to ground). The Tip or Ring terminal SIDACtor chip with the lowest V_{B0} and the center (or Ground) SIDACtor chip will turn-on first (to the device's V_{TM}). This leaves the opposite side of the 3-chip SIDACtor protector at the V_{B0} of only one SIDACtor chip to ground, or approximately 1/2 V_{B0} rating of the device. The simultaneous voltage surge on the opposite side will also be at least at a voltage equal to V_{B0} so the opposite side SIDACtor chip (at 1/2 V_{B0}) will turn-on also. The low I_H of the center (or ground) SIDACtor chip allows it to be the first SIDACtor chip to turn-on and the last to turn-off, to force and maintain the connection or path to ground. This patented 3-chip SIDACtor offers differential voltages between Tip and Ring terminals limited to approximately 1/2 V_{B0} maximum rating of the device occurring typically within a few hundred nanoseconds during a simultaneous longitudinal voltage surge.

AN1016 — On-Hook & Off-Hook Protection Requirements

FCC, UL, Bellcore, etc. require telecommunications equipment to be surged in all its operating states. This refers to the two commonly referred to states as "On-Hook" state (ring generator or ring detection monitoring) and the "Off-Hook" state (operational state). The On-Hook state must allow operation of the normal battery voltage (DC bias) plus ring voltage without interference. The Off-Hook state should only allow operation of the battery voltage (DC bias) plus operation signals and has a typical maximum of 70 to 80 volts (FCC Part 68 has a 70 volt maximum). Telecommunications equipment needs **primary** protection for the On-Hook surge and **secondary** protection for the Off-Hook surge (see AN1013, SLIC protection schemes). The two applications have different voltage protection requirements and therefore two overvoltage protectors are required. See **Figure H** below for circuit protection scheme.

Figure H - Complete PC Board Operation Protection



AN1017 — FCC Rules Part 68, Subpart D Metallic Voltage Surge, Detailed

The FCC Part 68 telecom Metallic Voltage Surge is an 800 volt, 100 amp 10x560µs surge applied metallically (Line to Line) between tip and ring of a 2-wire connection. To select the proper SIDACtor V_{BO} and calculate the Tip and Ring impedances required to limit the surge current within the surge current ratings of the SIDACtor, see Telecom Application Notes section on circuit calculations. To survive operational and against a metallic voltage surge, see **Figures I**, **J**, and **K**.

Figure I shows how to protect against an on-hook metallic surge without utilizing any circuit impedance using a P3100SB or P3100BA70. This is because the surge current rating of the overvoltage protection device (100 amp 10x1000µs) is greater than the surge requirement.

Figure I - FCC Part 68 Metallic

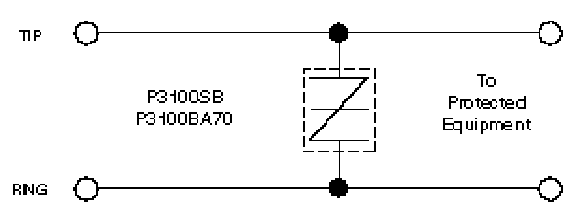


Figure J shows how to protect against an on-hook metallic surge utilizing circuit impedances to reduce the 100 amp metallic surge to less than the 50 amp 10x1000µs surge capability of the P3100SA or P3100EA70.

Bellcore TR-NWT-001089, Table 4-2 First Level Lightning Surge Test (Telecommunications Port).					
Surge Test Number	Peak voltage Volts	Peak Current Amps	Waveform time µSec	P1500EC70 P1500SC P3002AC P3202AC	Required R_{Tip} & R_{Ring} Ω
1	±600	100	10 x 1000	Withstand	None
2	±1000	100	10 x 360	Withstand	None
3	±1000	100	10 x 1000	Withstand	None
4	±2500	500	2 x 10	Withstand	None (1)
5	±1000	25	10 x 360	Withstand	None

AN1012 — Bellcore TR-NWT-001089

"Electromagnetic Compatibility and Electrical Safety Generic Criteria for Network Telecommunications Equipment". Table 4-2, First Level Lightning Surge tests (Telecommunications Port). There are designs and designers that prefer or require overvoltage protection devices that can withstand all 5 surges of Table 4-2 without the use of any series resistance (0Ω). Meeting the challenge, Teccor has developed devices specifically to pass operationally all 5 surges of Table 4-2. Teccor recommends the following Devices: P1500EC70, P1500SC, P3002AC, or P3202AC. These devices are rated with an I_{PP} surge of 100 amp 10x1000µs and 500 amp 2x10µs (Surge #4).

Note:

(1)A standard SIDACtor with a 100 amp 10x1000µs surge rating may be used, but an R_{Tip} = 12Ω and R_{Ring} = 12Ω minimum is required to pass Surge #4 operationally. The 12Ω limits Surge #4 rise time to within the devices di/dt rating.

AN1013 — SLIC (Subscriber Line Interface Circuit)

SLICs (Subscriber Line Interface Circuits) are normally operated from a nominal -50VDC supply (with respect to ground), located behind the ring generator or ring detection circuit and are not exposed to ring voltages. Protection of the SLIC is accomplished by using a diode for positive overvoltage protection and a SIDACtor for all negative overvoltages exceeding the -50VDC supply voltage (typically -56.6VDC). The SIDACtor minimum V_{BO} should be greater than the typical supply voltage to insure non-operation of the SIDACtor during normal operation.

Figure C shows how to protect a SLIC with a single SIDACtor and a diode bridge. The P0640EA70 or P0640SA SIDACtors offer V_{BO} 58 volts minimum & 70 volts maximum with the ability to hold fast rising transients up to 1kV/µsec to 70 volts maximum, thus protecting sensitive SLICs. The bridge may be a 4 pin DIP (surface mount package if preferred) or discrete components. The cost of this protection scheme is approximately one half that of single SLIC protection components other manufacturers offer.

Figures D and **E** show how to protect a SLIC with either a single P1602AA and two diodes or two discrete P0641SA (DO-214AA, surface mount packages). The P0641SA contains one $58V_{MIN}$ – $70V_{MAX}$ SIDACtor chip and a diode.

Figure C — SLIC Protection Using a SIDACtor and a Diode Bridge

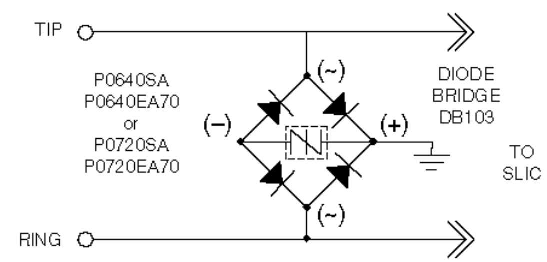


Figure D — SLIC Protection Using a SIDACtor and Two Diodes

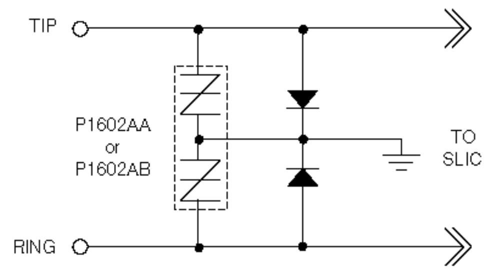
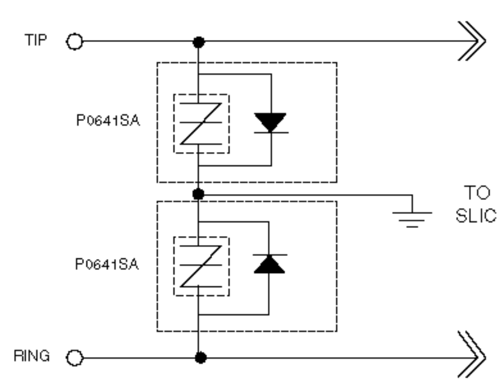


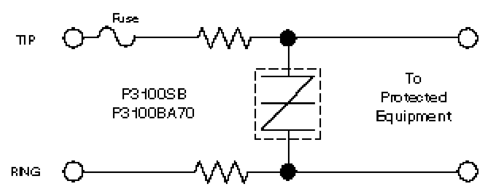
Figure E — SLIC Protection Using Two P0641SA SIDACtor packages



Application Notes

AN1010 — FCC Part 68 and UL 1459 Metallic Protection

Figure A — UL 1450 Metallic



Consideration for Metallic Surge 800V, 100A, 10x560µs				
Selected Fuse Bel Fuse type MJS or Littlefuse Series 230 mA	Fuse 10x560µs Rating Amps	R_{TOT} MIN Ω	R_T & R_R MIN Ω	Required 10x560µs I_{PP} of SIDACtor Amps
350	25	32.0	12	50
400	28	28.6	10	50
500	35	23.0	7	50
600	43	18.6	5	50
700	50	16.0	4	50
1000	78	10.3	1.15	100

$R_{TOT}=R_S+R_T+R_R$
(R_S = Source Impedance of Surge Generator)

$$R_{TOT}=\frac{V_{PK}(Surge)}{I_{PP}(Fuse)}$$

1. To meet UL1459, a current-limiting device (e.g. PTC, fuse) must be used. If using a fuse, Teccor recommends that the fuse rating be no greater than 1.0A. The 10x560µs I_{PP} rating listed above is the maximum I_{PP} surge limitation of the selected Bel fuse (type MJS) without R_T and R_R.

2. R_T and R_R are optional with the SIDACtor. They are used to limit the 100A, 10x560µs surge within the rating of the selected fuse. I.E., for a 500mA fuse an additional 15Ω (R_T=7.5Ω, R_R=7.5Ω) is necessary to prevent the fuse from opening during FCC Part 68 surge. Hence, R_T and R_R allow the circuit to pass Part 68 operationally.

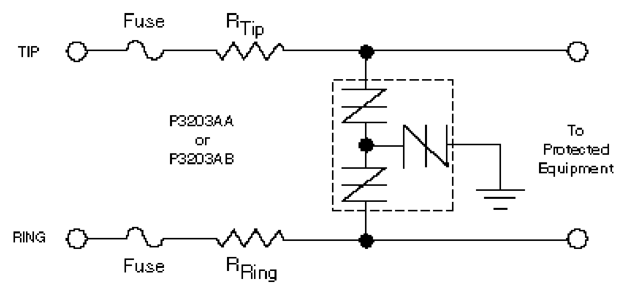
3. If desired, R_T and R_R may be eliminated. This will allow the circuit still to pass Part 68 and UL1459; however, it will pass FCC Part 68 non-operationally since the fuse will open.

4. The robustness of a circuit designed to pass FCC Part 68 non-operationally is dependent on the size of fuse used. The SIDACtor allows the engineer to use up to a full 1A fuse without any series resistance. See required 10x560µs I_{PP} of SIDACtor to determine the proper value of the SIDACtor for the selected fuse.

5. See application notes AN1017, AN1018, and AN1019 for detailed description of FCC Part 68, UL1459, and circuit component value calculations.

AN1011 — FCC Part 68 and UL 1459 Longitudinal Protection

Figure B — Data Line Protection



Consideration for Longitudinal Surge 1500V, 200A, 10x160µs				
Selected Fuse Bel Fuse type MJS or Littlefuse Series 230 mA	Fuse 10x160µs Rating Amps	R_{TOT} MIN Ω	R_T & R_R MIN Ω	Required 10x160µs I_{PP} of SIDACtor Amps
350	45	33.3	25.3	100
400	52	28.9	20.9	100
500	65	23.1	15.1	100
600	78	19.3	11.3	100
700	91	16.5	8.5	100
1000	130	11.6	4.1	150

$R_{TOT}=R_S+R_T+R_R$ (or) R_S+R_R

$$R_{TOT}=\frac{V_{PK}(Surge)}{I_{PP}(Fuse)}$$

1. To meet UL1459, a current-limiting device (e.g. PTC, fuse) must be used. If using a fuse, Teccor recommends that the fuse rating be no greater than 1.0A. The 10x160µs I_{PP} rating listed above is the maximum I_{PP} surge limitation of the selected Bel fuse (type MJS) without R_T and R_R.

2. R_T and R_R are optional with the SIDACtor. They are used to limit the 200A, 10x160µs surge within the rating of the selected fuse. I.E., for a 500mA fuse an additional 15.1Ω on R_T and R_R is necessary to prevent the fuse from opening during FCC Part 68 surge. Hence, R_T and R_R allow the circuit to pass Part 68 operationally.

3. If desired, R_T and R_R may be eliminated. This will allow the circuit still to pass Part 68 and UL1459; however, it will pass FCC Part 68 non-operationally since the fuse will open.

4. The robustness of a circuit designed to pass FCC Part 68 non-operationally is dependent on the size of fuse used. The SIDACtor allows the engineer to use up to a full 1A fuse without any series resistance. See required 10x160µs I_{PP} of SIDACtor to determine the proper value of the SIDACtor for the selected fuse.

5. See application notes AN1017, AN1018, and AN1019 for detailed description of FCC Part 68, UL1459, and circuit component value calculations.