SLIC Devices
Applications of the Zarlink SLIC Devices
Generic SLIC Device Surge Protection
Application Note

Application Note

This application note presents a method for protecting the Zarlink family of Subscriber Line Interface Circuits against lightning and power cross conditions such as referenced in the Bellcore document GR-1089 of November, 1994. This document covers the electrical safety characteristics necessary for equipment "to perform reliably and safely in a Bellcore client company network environment."

GENERIC SLIC DEVICE PROTECTION FROM LIGHTNING SURGES AND AC MAINS POWER CROSS

Introduction

While emphasis is placed on the Bellcore requirement for North America, information is also presented for applications that must follow ITU-T Recommendation K.20, Volume IX, defining the resistibility of telecommunications equipment to over voltages and currents.

No SLIC device can withstand the large amounts of voltage and current that result from power cross or lightning. Therefore, a protection circuit must be inserted between the SLIC device and the line. The network consists of series fuse resistors and thyristor or zener devices specially designed for surge protection applications.

It is important to mention that this application note deals only with secondary levels of protection that would be incorporated on the linecard. The voltage and power handling requirements, such as specified by Bellcore or CCITT, deal with power cross or surge energy that could actually appear at the linecard itself, and has already been limited by primary protection. Unless the test specification states otherwise for a specific condition, primary protection, such as carbon blocks or gas tubes, is always assumed to be present.

This application note will address only the thyristor type protector. The advantages of a thyristor protector circuit over zener type protector circuits include low power dissipation, small size, and low cost. The thyristor's power dissipation is much less because of the much lower voltage drop that occurs across the device while reacting to a power surge. In order to limit a lightning surge to a voltage level that will not damage the SLIC device, large and expensive zener devices, with low internal impedance and long thermal reaction time, are required.

Most Zarlink SLIC devices require protection on the A lead (TIP) and the B lead (RING). The protection must limit the voltage applied to the SLIC device pins to within the specific device's absolute maximum ratings. While each SLIC device may be somewhat different, each lead has an absolute maximum positive and absolute maximum negative voltage rating. This rating is also time-dependant. The SLIC device can withstand slightly higher voltages for shorter periods of time. Zarlink SLIC devices have ratings for continuous, 10 ms, 1 μs, and 250 ns. If the applied voltage remains less than these ratings, the SLIC device should survive.

CIRCUIT DESCRIPTION

A protection device, shown in Figure 1, uses an external gate input, typically tied to the battery voltage, which establishes a breakover threshold that tracks the external voltage instead of a fixed internal threshold. This type of device requires a diode for positive clamping and does not rely upon an external diode bridge. The battery tracking thyristor protector can provide better protection when using higher battery supply voltages. This device is recommended for use with SLIC devices using multiple battery supplies or internally generating ringing.

NOTE: On August 3, 2007, Zarlink Semiconductor acquired the products and technology of Legerity Holdings.

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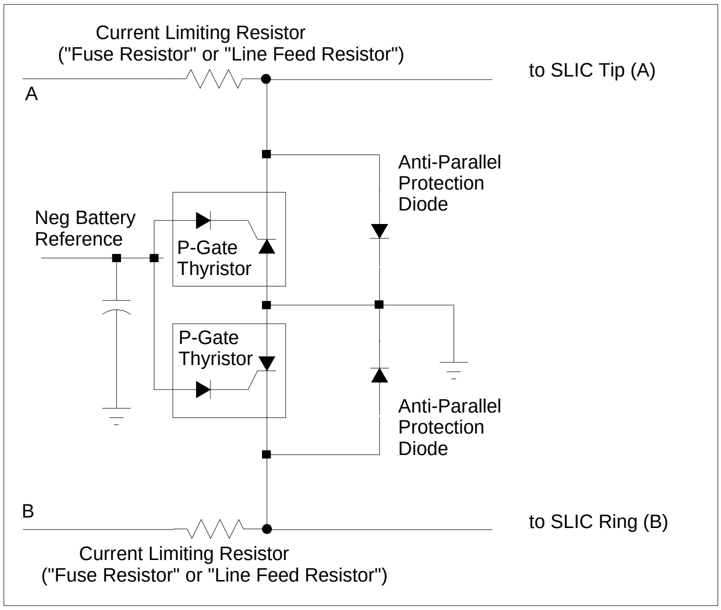

Figure 1. Voltage-Tracking Thyristor Surge Protector

Figure 2 shows a thyristor circuit that protects the SLIC device by firing when the applied voltage reaches the breakover voltage of the device. The device (SIDACtor) is connected across the terminals of a diode bridge network. The diode bridge adds the benefit of providing a direct clamping action to positive voltages in addition to allowing the thyristor to clamp at its threshold voltage for negative voltages. The actual protection voltage (protector voltage plus diode voltage) must be less than the maximum voltage rating of the SLIC device. The thyristor remains on until the fault is removed and the thyristor current drops below the minimum holding current specified for the device. The breakover voltage is set by the thyristor manufacturer and should be specified for a value less than the maximum voltage rating of the SLIC device.

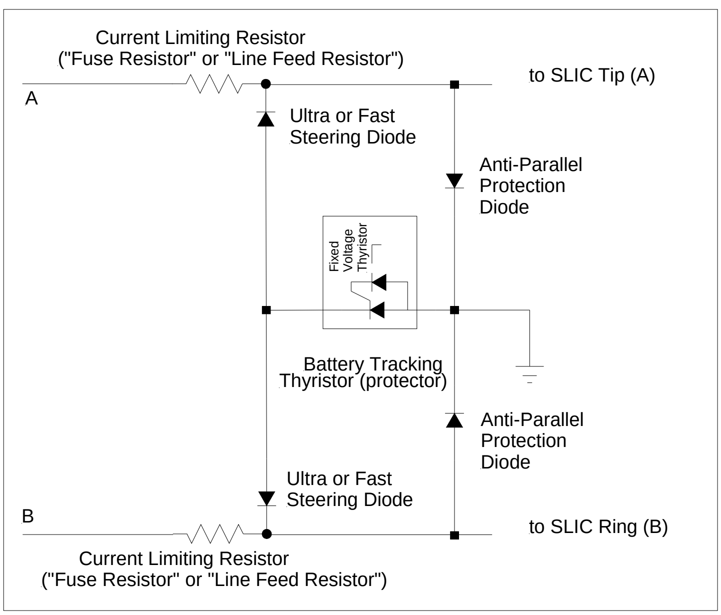

Figure 2. Single Thyristor Surge Protector

This circuit topology has a hidden complication. One normally assumes that the peak clamping voltage seen by the SLIC device is the thyristor firing voltage plus one diode drop. Diodes actually have a turn-on time called the forward recovery time. This turn-on time for slower or “standard” speed diodes cause the applied voltage to SLIC device to overshoot the predicted clamping point. A later section in this application note addresses the selection of diodes for use in protection circuits.

THYRISTOR SELECTION

Protection devices are available with various ratings. The following sections consider the following important parameters: Peak Surge Current, Breakover Voltage, and Holding Current.

Peak Surge Current

The peak surge current rating is determined by the resistance supplied in the A or B leads. Zarlink refers to these resistors as a “fuse resistor”. The fuse resistor has the entire applied surge voltage across it after the thyristor protector is triggered into conduction. The surge voltages applied in North America (GR-1089) are 1000 V with a 10 μs rise and 1000 μs fall and a 2500 V with a 2 μs rise and 10 μs fall. These surges create currents in a typical 50 Ω resistor of 20 A (for a 10x1000 μs surge) and 50 A (for 2x10 μs surge). Choosing a smaller fuse resistor raises the peak surge current rating for the thyristor. Zarlink recommends resistor values between 20 and 50 Ω for typical applications. The resistor value and peak current rating of the thyristor must be coordinated.

Breakover Voltage

The absolute maximum battery voltage of the SLIC devices varies for different SLIC families. (Refer to the specific SLIC device’s data sheet maximum limit specifications for exact values.) The maximum thyristor breakover voltage must be specified not to exceed –70 V or the specified data sheet value. The minimum thyristor breakover voltage must not be less than the maximum A to B line voltage to ensure current is not sourced from the SLIC device under normal line conditions.

For battery tracking protection, thyristor ICs, which can be externally programmed for a desired voltage, the minimum breakover is guaranteed to be greater than V_{BAT} (the battery voltage), so problems during normal line conditions will not occur. The actual breakover will happen at a voltage somewhat greater than the battery, which can be up to 15 V under pulse conditions or only 2.5 V steady state. This overshoot of the clamping or breakover voltage can be even greater if slow external diodes are used in the main current path.

The battery tracking voltage range readily supports using this type of device in systems using a nominal –48 V battery (–42 to –56 V). If operation with battery supplies near the maximum rating of a SLIC device is required, attention should be given to how fast the device turns on. This is because under pulse conditions, the line voltage under surge conditions may overshoot the absolute maximum rating for the SLIC device. Provided that the line voltage stays less than the absolute maximum ratings for the time interval given (250 ns, 1 μs, or 10 ms), the Zarlink SLIC device will not be damaged. Most of the tracking protectors can be sped up by connecting a capacitor to the gate input or increasing the capacitor’s value (up to 0.1 μfd).

Some examples of these components are the Teccor BC1100CC and BC2100CC, the Power Innovations TISP61089 and TISPA79R79, ST (SGS-Thompson) LCP-1511 and LCP-1505, and the Lucent ME L7591. Fixed voltage thyristors are also available from Teccor and Power Innovations. See Appendix II for contact details.

Thyristor protectors with a fixed breakover voltage ranging from 58 V to 95 V are available. To protect Zarlink SLIC devices, the most suitable rating is 58 V to 70 V (nominal 64 V), giving a relatively consistent breakover voltage during a surge. It must also be ensured that the peak transient voltage applied to the SLIC device is within the transient voltage limits (see the data sheet for the limits for a specific device).

The nominal fixed voltage rating of 64 V is suitable for typical 48 V battery applications. If a higher battery is used, (i.e. 63 V) then the breakover voltage of the protector may need to be increased, particularly if the TIP OPEN state is being used (i.e. Ground Start lines). In the TIP OPEN state, the BX pin will be within a few volts of battery with no load applied. While there is insufficient current drive to cause protection clamping (B leg is current limited to 30 mA), enough current may flow into the protection device to cause a false off-hook detect. In these cases, a higher clamping voltage should be specified or an externally programmable protection part used.

An example of a device with the 58 V breakover voltage is the Teccor P0640EA SIDACtor. This device, when used with “fast” or “ultrafast” diodes, has been shown to exhibit a very low overshoot when subjected to fast rise time surge voltages. The *Current Limiting Resistors* section has additional information of diode selection.

Holding Current

The holding current (I_h) is the current below which the thyristor releases (stops conducting) and is ready for the next surge or normal operation. I_h for most protection devices is specified as 150 mA minimum at 25^{o}C. As junction temperature rises, the thyristor holding current falls with a temperature coefficient up to 1 mA/^{o}C to as low as 100 mA at T_j = 75^{o}C.

In order to achieve its excellent longitudinal induction and balance characteristics, the SLIC device is designed to deliver a relatively large longitudinal current when the longitudinal impedance is low. The longitudinal current capability causes B lead current to be larger than the programmed loop current during a B lead-to-ground fault. At high ambient temperatures, the SLIC device's fault current can become greater than the thyristor holding current causing the protector to remain in conduction after the surge goes away. The protector can always be released under these conditions by placing the SLIC device temporarily into the disconnect or disable mode, which reduces the SLIC device current to a value below I_h. SLIC devices that provide the ground key detect feature can be used to detect this type of situation, by treating a persistent ground key indication in firmware as a reason to attempt protector release by using the above method. If this is not successful, then a permanent short-to-ground probably exists on the line.

If reliable automatic thyristor release is required, I_{LLIM}, the maximum SLIC device fault current from any output when shorted to a ground line must be less than the holding current over the ambient temperature range. The maximum longitudinal fault current depends upon the type of SLIC device and the DC feed characteristics for which the SLIC device is programmed.

Because available longitudinal current must always be greater than the peak value of the 25 mArms induced AC current per leg, for which all SLIC devices have been specified, the SLIC device is designed to provide nominally a longitudinal DC current per leg, I_{LONG}, of 40 mA. I_{LLIM}, the total current from the B (most negative leg in normal polarity, active mode) can be obtained by adding I_{LIMIT}, the short circuit metallic current and I_{LONG}.

$$I_{LLIM} = I_{LONG} + I_{LIMIT}$$

For constant current versions of the SLIC device in the Zarlink SLIC family, I_{LIMIT} becomes the line current programmed by RDC_1 and RDC_2. Because line current is usually programmed for 40 mA or less, the resulting I_{LLIM}(Max) is less than 100 mA.

However, for resistive feed devices, $I_{LLIM(max)}$ can be larger. As an example, for a resistive feed device with internal current gain of 200, I_{LIMIT} can be calculated assuming RDC_1 and RDC_2 values of 2 kΩ:

$$I_{LIMIT} = \frac{230}{RDC_1 + RDC_2} = \frac{230}{2K + 2K} = 57.5\ mA$$

Included in the final calculation are process variations that cause a ±30% variation in longitudinal DC current and a ±20% variation in I_{LIMIT} using factors of 1.3 and 1.2, respectively.

$$I_{FAULT}(Max) = I_{LONG}(Max) + I_{LIMIT}(Max)$$

$$I_{FAULT}(Max) = 40\ mA \bullet 1.3 + I_{LIMIT}\ 1.2 = 40\ mA \bullet 1.3 + 57.5\ mA \bullet 1.2 = 121\ mA$$

This value of I_{FAULT} is above the minimum elevated temperature holding current specified for most thyristor devices. As stated previously, the thyristor can always be released by placing the SLIC device momentarily into the disable/ disconnect state. The ground condition caused by thyristor latch up can be detected using the ground key detector function (E_1 = Logic 1) of most SLIC devices. For guaranteed automatic release after a fault condition, thyristor devices for the above application should be specified that have holding currents greater than 121 mA at the highest ambient temperature.

LIGHTNING SURGE

The Bellcore Gr-1089 specification calls for the linecard to withstand a maximum 2500 V lightning surge with rise/decay times of 2/10 µs and a 1000 V 10/1000 µs pulse without line circuit failure. For both of the above conditions, the thyristor breaks over in less than 1 µs after the start of the surge pulse. With 50 Ω fuse resistors, the peak current in the thyristor after breakover rises to 50 A for 2500 V pulse and to 20 A for the 1000 V pulse. These are both well within the maximum current ratings of the protection devices. Other choices of resistor value should be coordinated with the protector chosen.

The ITU-T lightning surge recommendations, K.20 and K.21, define a test circuit that generates a high voltage transient similar to the 1000 V, 10/1000 µs pulse called for by Bellcore. The surge test circuit has 40 Ω of resistance in series with the test circuit's output. The GR-1089 test circuit has only 5 Ω of resistance by comparison. Lower value fuse resistors could be used if designing for the ITU-T K.20 market.

POWER CROSS

Typical current and voltage waveforms during an AC mains power cross are shown in Figure 3. When the thyristor voltage reaches V_Z, a trigger circuit internal to the device starts conducting. When the thyristor voltage reaches V_{BO}, the thyristor finally triggers and remains on until the thyristor current falls below it's holding current, I_h.

When voltages and currents involved in the 60 Hz power cross are large, the thyristor remains in the low voltage conduction state for most of the cycle. The power dissipation of the thyristor remains low during these conditions. Lower voltage mains power faults may not be enough to trigger the thyristor into the full conduction state. During these conditions, the thyristor may act as a voltage limiting zener diode and hence may dissipate more power than if it had been triggered into conduction as an SCR thyristor device.

Some thyristor devices are designed so that as the thyristor heats during partial conduction modes, the zener mode voltage increases until it is sufficiently close to the breakover voltage to cause triggering into the SCR mode of conduction. The thyristor now fires into the SCR low voltage conduction mode for a portion of every cycle. This reduces its power dissipation and the thyristor device cools until a stable operating point is reached.

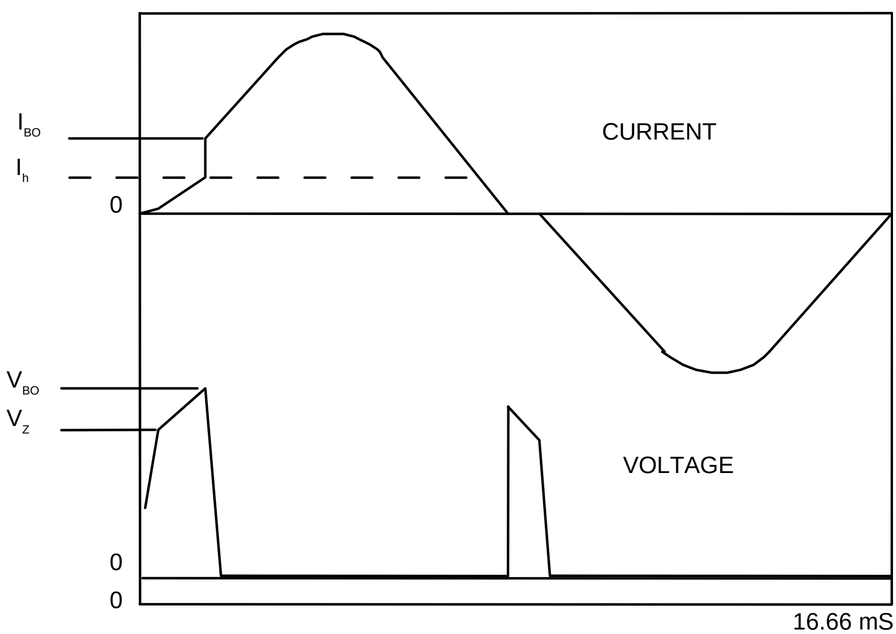

Figure 3. Typical Thyristor Performance under Power Cross Conditions

Component Power Dissipation

The component power dissipations during a power cross can be calculated by integrating the product of voltage across the device times the current through the device over one cycle:

$$P = \frac{w}{2\pi}\int_{0}^{\frac{2\pi}{w}} v \bullet i \bullet dt$$

Table 1 summarizes the power dissipations computed for the various power cross conditions for North American Central Office applications as described in Table 4-7 of Bellcore GR-1089. There are additional tests that are much less severe, which are not included in the table.

Table 1. Bellcore GR-1089 Power Cross Conditions

Test #	Vrms	Current per Conductor	Duration	P_{fuse} (Ω)	$P_{thyristor}$ (Ω)
1	50	0.333A	15 minutes	1.5	0.14
2	100	0.167A	15 minutes	1.1	0.3
3	200	0.333A	60x1 sec ** applications	4.6	0.32
	400	0.666A	60x1 sec ** applications	19	0.6
	600	1.0A	60x1 sec ** applications	42.8 (1 sec)	1.05
4	1000	1.0A	60x1 sec ** applications	45.7 (1 sec)	1.02
5	See Figure 4-3 GR-1089		60x5 sec	0.006	0.18

Table 2 is the same for ITU-T recommendation K.20, Volume IX and assumes 20 Ω fuse resistors. Individual countries generally impose additional country-specific requirements not given in ITU-T K.20.

Table 2. CCITT Recommendation K.20, Volume IX

Test #	Vrms	Current per Conductor	Duration	P_{fuse} (Ω)	$P_{thyristor}$ (Ω)*
n/a	300	0.5A	5 0.2 sec ** applications	10.7	0.5

Notes:

* *Power per line is shown. Multiply by 2 for total dual thyristor power.*

** *Sufficient time between applications is permitted to allow recovery of protection components to non-fault conditions.*

CURRENT LIMITING RESISTORS

The current limiting resistors can be placed on a thick film hybrid, combined with fuses, and trimmed into balance. Discrete resistors designed for linecard applications can also be used. These are available from a number of resistor manufacturers. The GR-1089 requirements may require a fuse to be placed in series with the resistor to afford maximum circuit protection for test three. In all cases, the resistors must be flame proof. This means that a cheesecloth wrapping around the linecard under test shall show no evidence of charring. See Appendix II for contact details.

Following is a preliminary electrical specification for a fuse resistor suitable for this application.

Typical Fuse Resistor Specification

Resistance: 50 Ω ± 0.1 Ω

Note: ± 0.1 Ω accuracy is required to meet North American longitudinal balance requirements. Less precise and lower value resistors may be suitable for applications in other markets.

Power Dissipation:

For 60 1-second applications --- 50 W*
(Allow to recover to zero power conditions between each application.)

For 15 minutes -- 1.9 W*

Continuous dissipation due to maximum SLIC device current flowing through fuse resistor when AX and BX are shorted to ground --- 0.9 W

Maximum Power Applied pulse:

1000 V, T_{rise} = 10 μs, T_{fall} = 1000 μs*
2500 V, T_{rise} = 2 μs, T_{fall} = 10 μs*
*Resistor should remain within tolerance after application.

Blow current: 2–5 A (not critical)
Blow time: < 1 second

Resistor devices meeting all of these requirements are available from Microelectronic Modules Corp. Other traditional resistor vendors such as IRC or Ohmite have products that may be suitable.

PROTECTION DIODE SELECTION

Several diode parameters are critical in selection of a protection diode. They are: non-repetitive surge current rating; current rating; peak reverse or peak inverse voltage rating; and diode speed.

Non-Repetitive Surge Current Rating

The non-repetitive surge current rating generally indicates the current level the diode can sustain for one half cycle of a sinusoid waveform with a period of 8.3 ms. This is typically longer than the surge tests applied, thus it is a conservative selection criterion. The diode must conduct a peak current as high or slightly higher than the thyristor protector. For applications with 50 Ω fuse resistors, diodes with surge ratings greater than 20 A should be chosen. 30 A or 50 A rating is preferred for GR-1089 tests. ITU-T K.20 requirements with 20 Ω resistors also require greater than 20 A.

Current Rating

The current rating of the diode is a straightforward selection. Refer to the AC mains power cross tests requirements for the application to see the continuous current requirements. The GR-1089 has a maximum level one requirement of 1 A for 1 second. This is the continuous current requirement for the diode. Other tests either permit diode failure or are transient conditions that require a different parameter rating.

PRV/PIV Rating

Reverse voltage or Peak Inverse voltage ratings are easy to understand. The requirement is that the diode have a peak reverse voltage rating larger than the highest voltage allowed by the clamping device. This voltage rating can often be 100 V. Zarlink recommends usage of 200 V diodes as a general rule as there is often little difference in cost.

Diode Speed

Diodes have a turn-off or reverse recovery time and a related and more important turn-on or forward recovery time. The turn-on time is an interval during which the diode voltage is greater than the normal forward voltage. Depending on diode construction, this peak voltage can be 2–5 times the forward voltage. The time interval for “standard” speed diodes varies from 1–5 μs. Because the fast rise time surge tests are similar to this time period, these diodes should not be considered for use in protection circuits. Strict purchasing to specification and testing to verify might allow these types of parts to be used.

“Fast” speed diodes with forward and reverse recovery times in the 100 to 300 ns range conduct fast enough to limit overshoot to 2–5 V. This class of diode should be usable with the other diode parameters mentioned in the *Protection Diode Selection* section. The 1N4935 diode is typical of a suitable diode. “Ultra-fast” speed diodes with forward and reverse recovery times in the 25–75 ns range conduct fast enough to cause a lower overshoot of 2–3 V. This gives this diode type only a small advantage over the “fast” diodes. These diodes are more widely available than “fast” diodes being widely used in switching power supplies. The Motorola MUR120 is a typical diode of the “ultra-fast” type.

“Standard” speed diodes can only be considered acceptable after test evaluation. Many “standard” speed diodes do not have any guaranteed data sheet parameters for forward or reverse recovery time. Zarlink does not recommend any standard speed diodes for general protection usage. Packaged diode bridges generally should be avoided. Certain specific bridge parts from specific vendors might be usable after evaluation. It is recommended that standard packaged bridges be avoided and use of “fast” or “ultra-fast” diodes is encouraged.

Summary

This application note has described a method for using various diode, thyristor, and fuse resistor combinations to protect Zarlink SLIC devices from lightning and power cross surges. Some design considerations discussed were:

— Thyristor breakover voltage

— Minimum thyristor holding current and release requirements

— Current and voltage waveforms during power cross conditions

— Fuse resistor power rating requirements

— Thyristor power dissipation

— Diode parameters

For most of the Zarlink SLIC device family, linecard protection can be met using standard thyristor type surge protection devices that are available from several suppliers.

Under some conditions, when substantially higher feed power is required and during high ambient temperature operation, the SLIC device fault current may exceed the minimum holding current guaranteed by the protection device manufacturer. In this case, a device selected for a greater holding current should be used.

The information supplied in this application note should allow the linecard designer to specify the most reliable and cost-effective protection components.

APPENDIX I

Surge Waveforms

This appendix includes typical surge waveforms captured with a Tektronix TDS460 oscilloscope. The waveform is graphed using Microsoft® Excel. The surges are created with a Haefley Trench PS6 surge generator with a 1.2x50 μs surge waveform. The surge peak was 2150 V with a peak current of approximately 29 A. Figure A1 shows the voltage applied to a SLIC device after passing through a limiting resistor and shunt clamping provided by a Teccor P0640EA Sidactor protection device. The surge applied was a positive-going surge voltage. The peak voltage applied to the SLIC device was just under 70 V. While the data was collected with a positive-going waveform, the typical protector would be arranged to limit the maximum negative-going excursion rather than the positive as shown in Figure A1. This waveform should be compared with Figure A2.

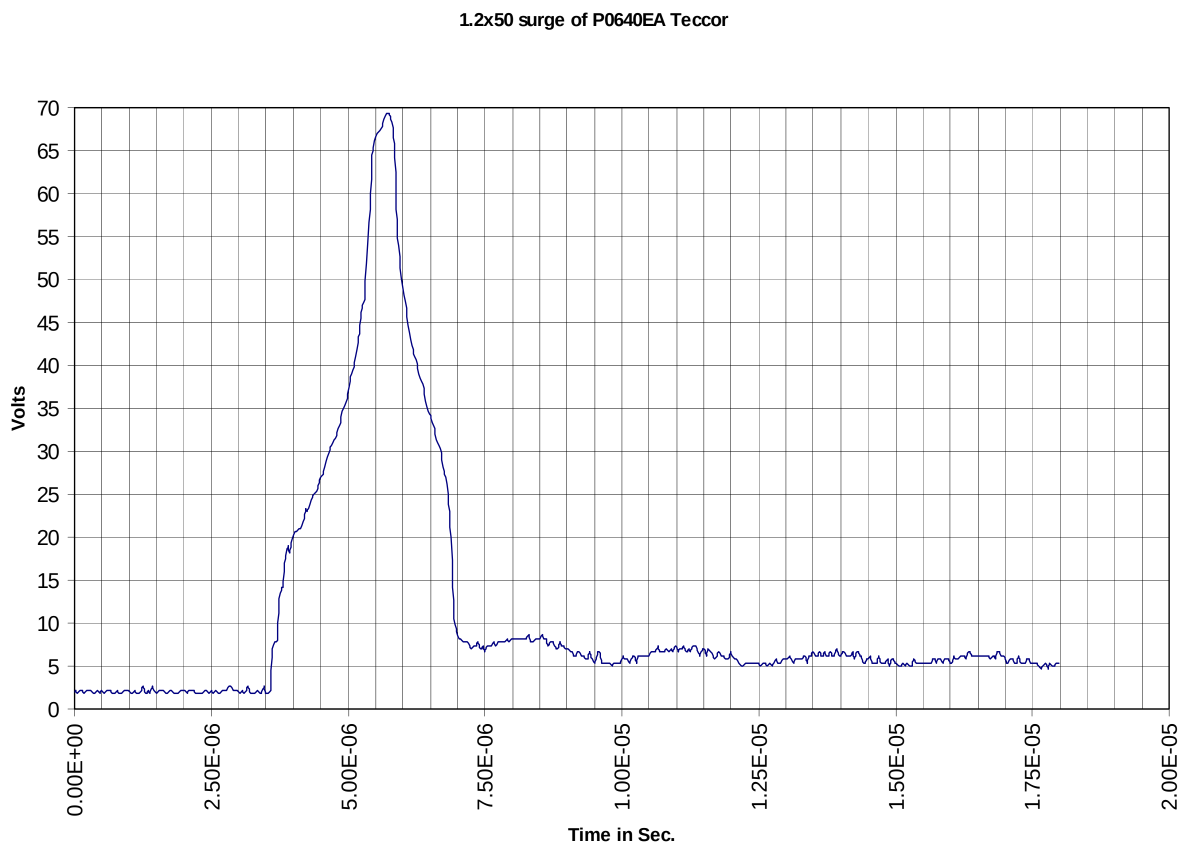

Figure A1. Surge of Teccor P0640EA Peak Current 28 A

Figure A2 shows two traces recorded in a similar fashion. The traces represent the voltage applied to a SLIC device protected with a series current limiting resistance, and a shunt protection network consisting of an "ultra-fast" diode (MUR120) and the same Teccor P0640EA Sidactor. This network represents the diode used in a bridge network to share one Sidactor device for both Tip (A lead) and Ring (B lead). Note that the device fires during the rise of the surge and is fully conducting during the peak and tail of the surge. The Sidactor has low dissipation during this interval because its voltage is below 6 V, except during the turn-on period when the surge is increasing. Notice that the applied voltage to the SLIC device is only several volts higher than when using the Sidactor by itself. This additional voltage results from a good predictable diode such as the 1N4935 or the MUR120.

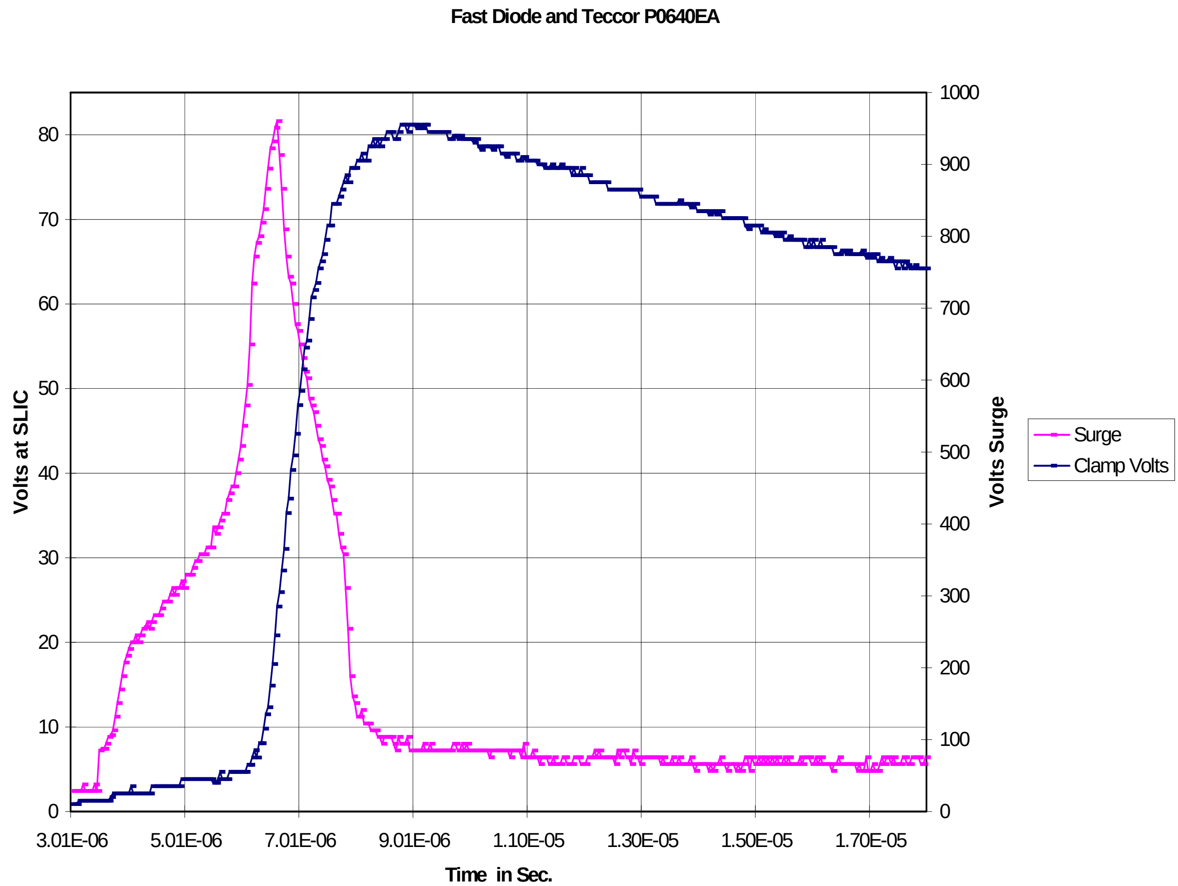

Figure A2. Applied Surge and SLIC Voltage With Diode and Sidactor

Figure A3 shows the applied voltage waveform with the Teccor P0640EA sidactor device connected in series with a slow packaged diode bridge. This bridge rectifier device meets all other requirements, except for the diode speed. The same resistor as in the previous two graphs limits the surge current. The surge applied is the same 2.15 KV open circuit voltage with 1.2x50 second waveshape. The additional nearly 35 V applied to the SLIC device is sufficient to cause some SLIC devices to fail. This overvoltage condition lasts for nearly 460 ns and exceeds many of the Zarlink SLIC device absolute maximum ratings. Use of packaged diode bridge requires a significant testing effort and research to find a vendor whose diode devices consistently limit the applied surge voltage to the SLIC device to within the SLIC's absolute maximum ratings.

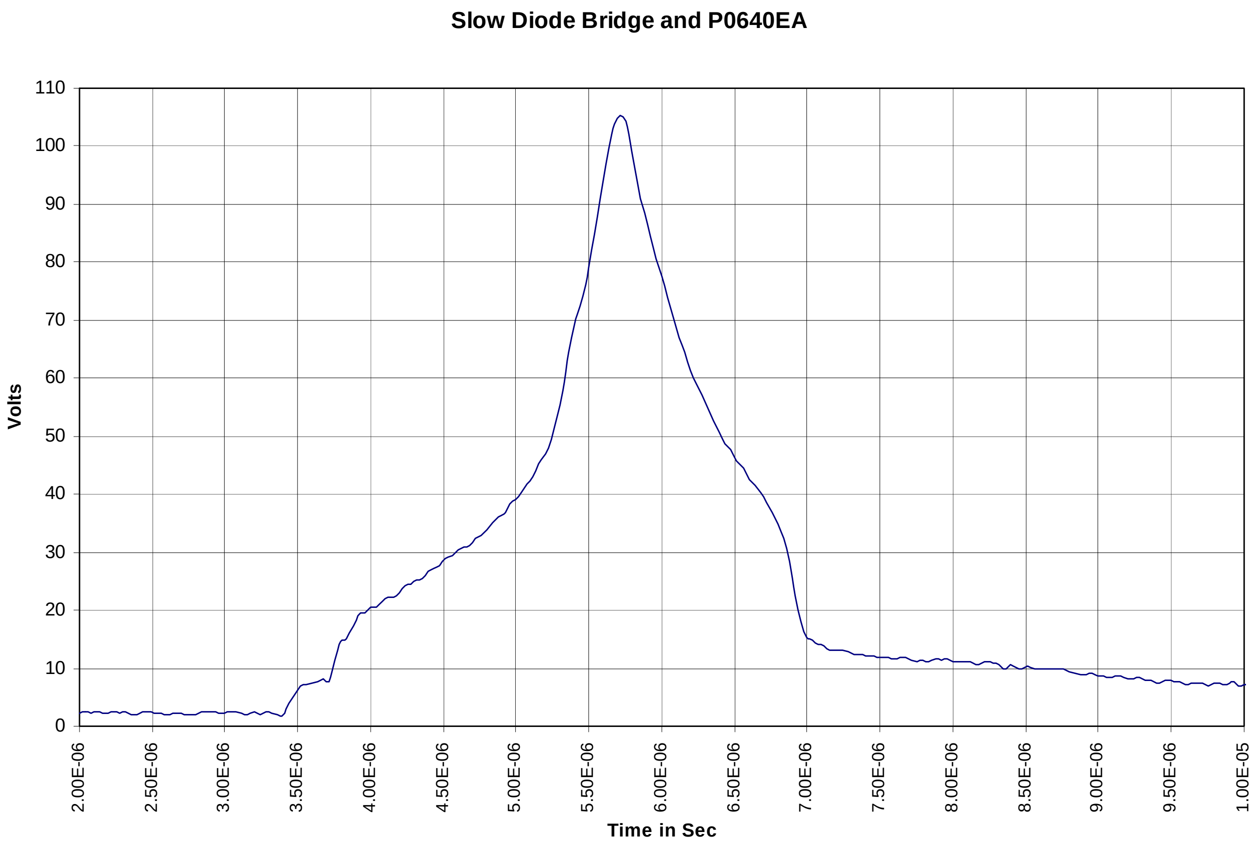

Figure A3. Voltage with Slow Diode Bridge and Teccor P0640EA

APPENDIX II

Thyristor Protector Contact Information

Teccor Electronics Inc.
1801 Hurd Dr.
Irving, TX 75038
Phone: (972) 580-7777
Website: www.teccor.com
Email: sidactor@teccor.com
Great databook with terrific application information available.

Power Innovations Ltd.
Manton Lane
Bedford MK41 7BJ, UK
Phone: +44 (0) 1234-223001
Website: www.powinv.com
Email: info@powinv.com

Many models and some Zarlink-specific models.

In North America, Power Innovation is represented by Texas Instruments Material & Controls Division NOT TI Semiconductor!
Phone: (508) 236-1744
Website: www.ti.com/mc/docs/telecom/docs/index.htm
Email: bkinkade@ti.com

Resistor Contact Information

Microelectronic Modules Corp.
2601 S. Moorland Rd.
New Berlin, WI 53151
Phone: (414) 785-6505
Website: www.mmccorp.com
Email: sales@mmccorp.com

Many standard models, including some Zarlink-specific module with added features, for use with Zarlink SLIC devices.

International Resistive Company Inc.
736 Greenway Road
PO Box 1860
Boone, NC 28607
Phone: (704) 264-8861
Website: www.irctt.com

Model ALFR2

Ohmite Mfg. Co.
3601 Howard St.
Skokie, IL 60076
Phone: (847) 675-2600
Website: www.ohmite.com
Email: ohmite@wwa.com

Many models: TUM, TUW, TVM, TVW, TW, TWM, and TWW

Diode Information

Many diodes are available from different vendors that can give acceptable performance when correctly specified. Generally, diodes must have a non-repetitive surge rating of greater than 30 A. Diodes with PIV/PRV ratings of at least 200 V should be used. The diode must be of at least the "fast" speed rating, with "ultra-fast" preferred. An average forward current rating of at least 1 A is required. The following diodes should be acceptable, but others with similar ratings should also be acceptable:

Vendor	P/N	Pkg	Avg I	Surge I	PIV	Speed
MOT	MUR120	Axial	1	35	200	Ultra
MOT	MUR420	Axial	4	125	200	Ultra
MOT	MR852	Axial	3	100	200	Fast
JEDEC	1N4935	Axial	1	30	200	Fast
MOT	MURS120T3	SMB	1	40	200	Ultra
ST	SMBYW02-200	SMB	2	50	200	Ultra

APPENDIX III

Design Concerns When Using No Current Limiting Resistance Protection

A segment of the Telecom market has expressed a design interest in eliminating any current limiting resistance used in the linecard or SLIC device surge protection. Zarlink SLIC device solutions normally incorporate a resistance into the SLIC design, which is used for the purpose of limiting surge current in linecard secondary protection. The current limiting resistance is incorporated into the transmission design for Zarlink SLIC devices. This means that no performance penalty is related to this element.

It is possible for a design with no current limiting resistance to comply with any market segment's surge requirements. Two significant design issues are created when this direction is taken in a linecard design. The first design issue is that the entire system must handle the higher surge current, which can be up to 10 times that in circuits using current limiting resistors. This effect on system design increases for multi-line products. The second design issue is Electro-Magnetic Compatibility (EMC) interference and susceptibility. Removal of a series impedance (the current limiting resistor) reduces the control a designer has for EMC.

Magnitude of Current and Voltage

When a designer chooses to use the topology with no current limiting resistance, the surge current is essentially unlimited. The linecard designer counts on the surge test generator modeling the real world. The system designer must accommodate the large surge currents traversing the interconnects, system power distribution, and grounding sub-systems. These currents are 500 amps per conductor (not per pair). Consider the rise of potential cause by just the interconnection inductance. Typical current limiting resistance reduces this by a factor of 10.

Fast surges have rise time of approximately 2 μs. Printed Circuit Wiring creates 15–20 nH per inch of wiring. Each line surge creates a voltage (L*di/ dt) of 4–5 V per inch of wiring. Several line surges, simultaneously with a few inches of wiring, can create large voltage differences in grounds, which could potentially damage system components (such as the SLAC™ device). Careful physical design can create a usable PCB layout for a topology with no current limiting resistance for systems with a small number of lines.

The EMC Issue

The second drawback in using a protection topology with no current limiting resistance is that the low or no series impedance makes EMC filtering potentially more expensive or difficult. Zarlink suggests the use of an RC filter to reduce the susceptibility to EMC. This RC filter is composed of a low cost (surge protected) capacitor and the current limiting resistor as the series impedance. Removal of this RC filter may require the linecard design to incorporate a common-mode choke or series inductors. These added EMC parts carry the telephone DC feed current and are exposed to surges so they must carry high surge currents.

These components are not normally necessary using recommended Zarlink circuit topology. These components, if needed, are large, bulky, and expensive. So the system design has difficult choices to make trading the cost of the current limiting resistors against the more expensive EMC components.

Summary

The removal of the current limiting resistors may or may not reduce the linecard cost when all system issues are considered. Zarlink SLIC devices successfully work in designs with current limiting resistors in the protection scheme and in designs with low or no resistance in the protection sub-system. The Zarlink Intelligent Access™ Voice family of ISLIC devices and the Zarlink ASLIC-ASLAC device family require the presence of a resistor that can be used to limit surge current. Use of this resistor for these device families enables advanced line test capabilities for these advanced chip sets. Be sure that a proposed design has evaluated these tradeoffs if the design contemplates removing the current limiting resistance from the protection for the SLIC device.