Analog Line Cards

Given that line cards are highly susceptible to transient voltages, network hazards such as lightning and power cross conditions pose a serious threat to equipment deployed at the central office and in remote switching locations. To minimize this threat, adequate levels of protection must be incorporated to ensure reliable operation and regulatory compliance.

Protection Requirements

When designing overvoltage protection for analog line cards, it is often necessary to provide both on-hook (relay) and off-hook (SLIC) protection. This can be accomplished in two stages, as shown in Figure 3.21.

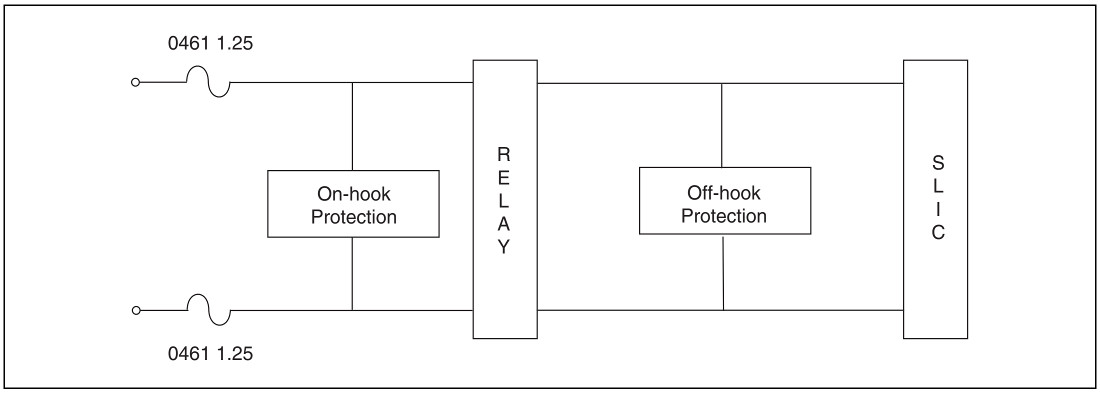


Figure 3.21 SLIC Overview

The following regulatory requirements may apply:

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

On-Hook (Relay) Protection

On-hook protection is accomplished by choosing a *SIDACtor* device that meets the following criteria to ensure proper coordination between the ring voltage and the maximum voltage rating of the relay to be protected.

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

$V_S \leq V_{Relay\ Breakdown}$

This criterion is typically accomplished using two P2600S_ *SIDACtor* devices (where _ denotes the surge current rating) connected from Tip to Ground and Ring to Ground. However, for applications using relays such as an LCAS (Line Card Access Switch), consider the P1200S_ from Tip to Ground and the P2000S_ from Ring to Ground.

Off-Hook (SLIC) Protection

Off-hook protection is accomplished by choosing a *SIDACtor* device that meets the following criteria to ensure proper coordination between the supply voltage (V_{REF}) and the maximum voltage rating of the SLIC to be protected.

$V_{DRM} > V_{REF}$

$V_S \leq V_{SLIC\ Breakdown}$

This criterion can be accomplished in a variety of different ways. For applications using an external ring generator and a fixed battery voltage, two P0641S_ *SIDACtor* devices (P0721S_, P0901S_, or P1101S_ depending on the value of V_{REF}) are used — one Tip to Ground, one Ring to Ground. For applications using a ring-generating SLIC such as AMD's Am79R79, the B1XX0C_ or B1XX1U_ can be used.

I_{PP} Selection

The I_{PP} of the *SIDACtor* device must be greater than or equal to the maximum available surge current ($I_{PK(available)}$) of the applicable regulatory requirements. Calculate the maximum available surge current by dividing the peak surge voltage supplied by the voltage generator (V_{PK}) by the total circuit resistance (R_{TOTAL}). The total circuit resistance is determined by adding the source resistance (R_S) of the surge generator to the series resistance in front of the *SIDACtor* device on Tip and Ring (R_{TIP} and R_{RING}).

$I_{PP} \geq I_{PK(available)}$

$I_{PK(available)} = V_{PK} / R_{TOTAL}$

For metallic surges:

$R_{TOTAL} = R_S + R_{TIP} + R_{RING}$

For longitudinal surges:

$R_{TOTAL} = R_S + R_{TIP}$

$R_{TOTAL} = R_S + R_{RING}$

Reference Diagrams

Figure 3.22 shows the use of Littelfuse's "SC" rated *SIDACtor* devices and the **0461** 1.25 *TeleLink* fuse to meet the surge immunity requirements of GR 1089. Littelfuse's P1200SC and P2000SC, specifically designed to protect Agere Systems (formerly Lucent Microelectronics) Line Card Access Switch (LCAS), provide on-hook protection. Two P0641SCs provide off-hook protection. Any additional series resistance is absent because the "C" series *SIDACtor* device and **0461** 1.25 *TeleLink* fuse are designed to withstand GR 1089 surges without the aid of additional components such as line feed resistors and PTCs.

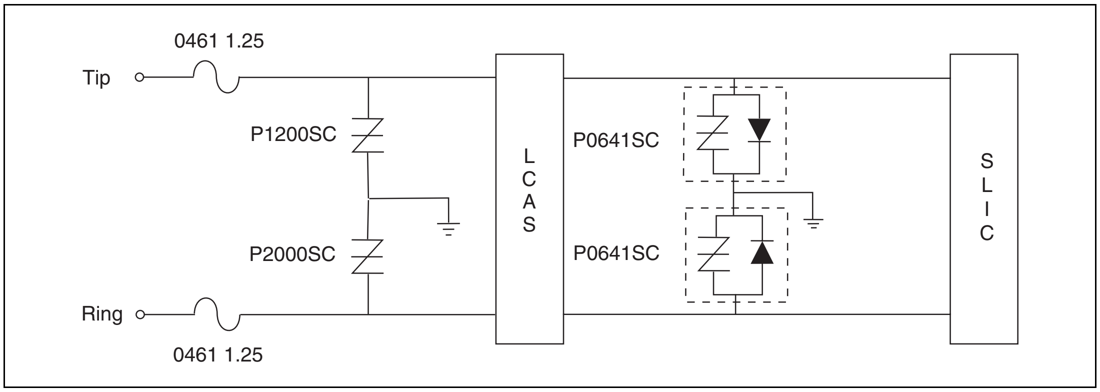
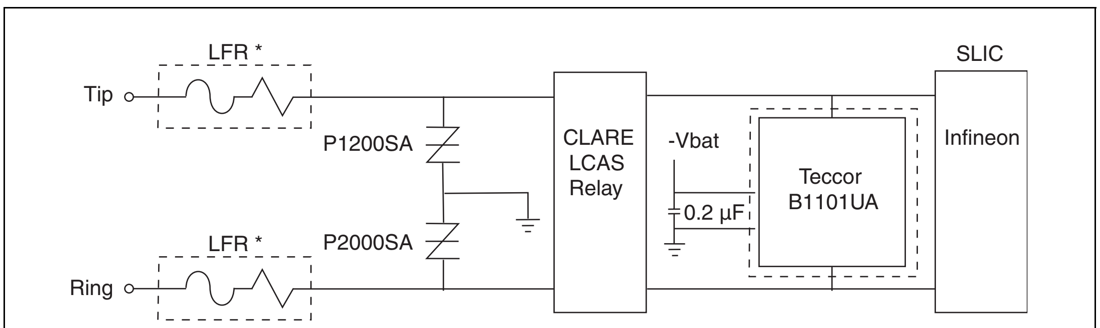


Figure 3.22   SLIC Protection for LCAS



* Assumed minimum resistance of 20 Ω. If the LFR does not have a fusible link, then the 0461 1.25 is recommended for overcurrent protection.

Figure 3.23   SLIC Protection with Limiting Resistance

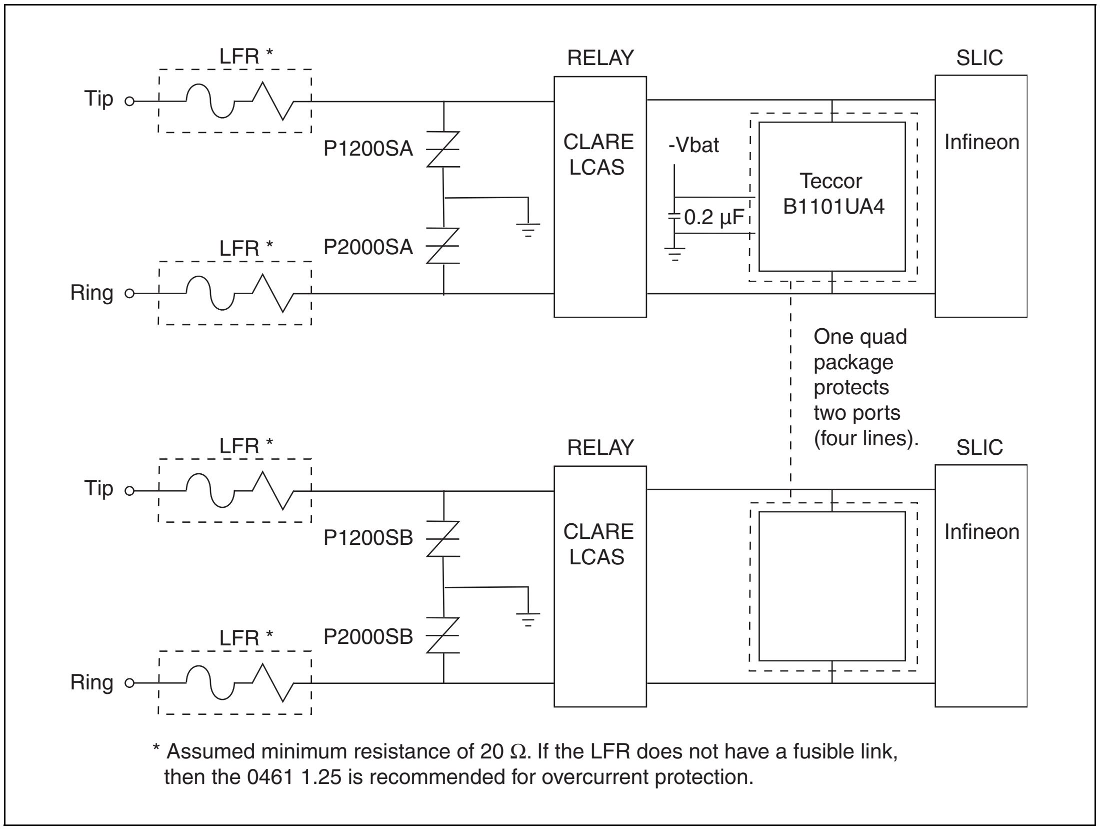


Figure 3.24 SLIC Protection with Quad *Battrax*

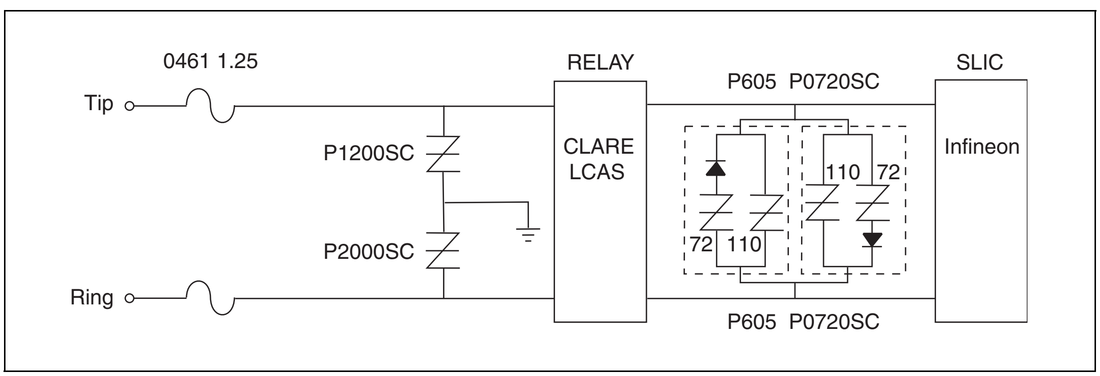


Figure 3.25 SLIC Protection with Asymmetrical Devices

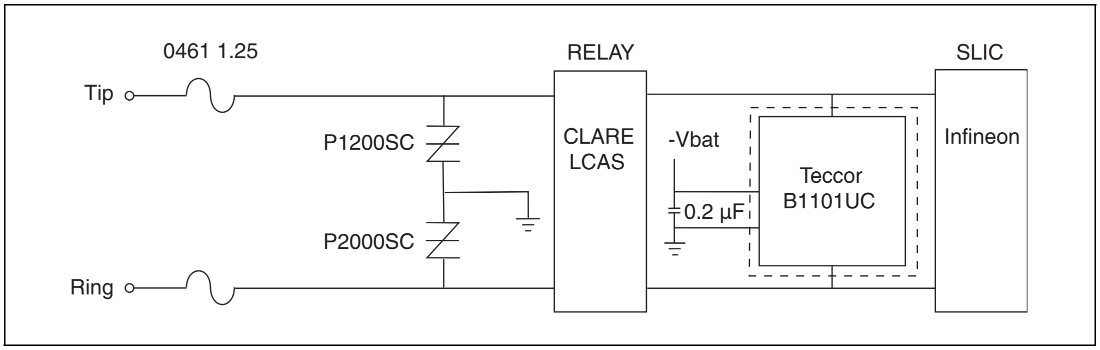


Figure 3.26 SLIC Protection with *Battrax*

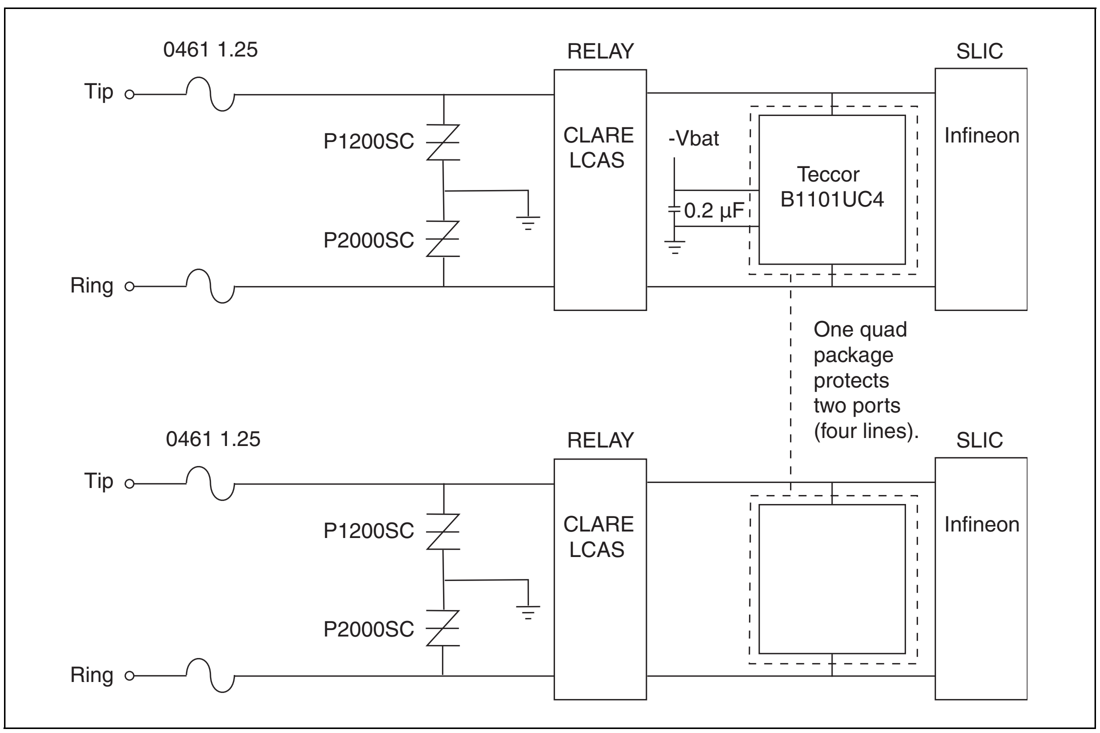


Figure 3.27 SLIC Protection with Quad *Battrax*

Figure 3.28 illustrates uses of asymmetrical *SIDACtor* protection for overvoltage conditions and the **0461** 1.25 for overcurrent conditions.

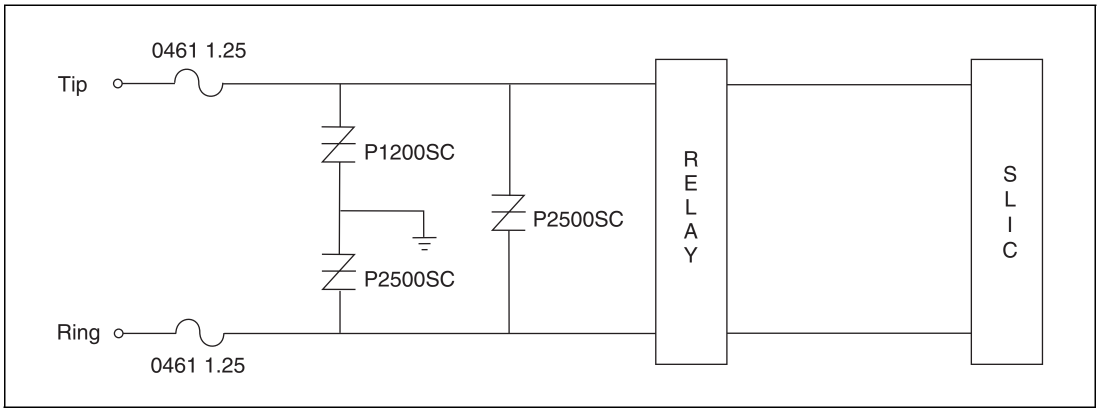


Figure 3.28 SLIC Asymmetrical Protection

Figure 3.29 illustrates the use of the P2600SA and P0721CA2 for overvoltage protection and the **0461** .500 for overcurrent protection in addition to 20 Ω of series resistance on both Tip and Ring. The series resistance is required to limit the transient surge currents to within the surge current rating of the "A" series *SIDACtor* devices and the **0461** .500 *TeleLink* fuse.

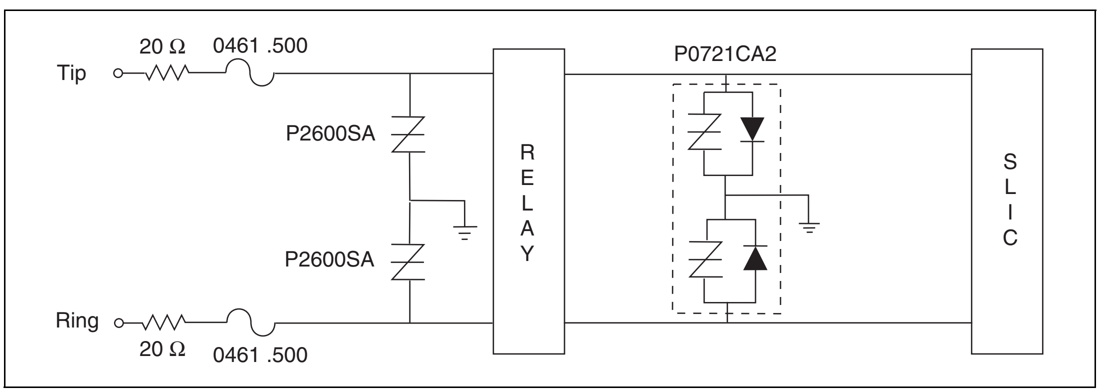


Figure 3.29 SLIC Protection with Fixed Voltage *SIDACtor* Devices

Figure 3.30, Figure 3.31, and Figure 3.32 illustrate the use of different circuits to coordinate overvoltage and overcurrent protection when protecting the LCAS family of solid state switches. Figure 3.30 illustrates the use of the *TeleLink* and the *SIDACtor*. The *TeleLink* is a surface mount, surge resistant fuse that saves cost and PCB real estate over more traditional solutions.

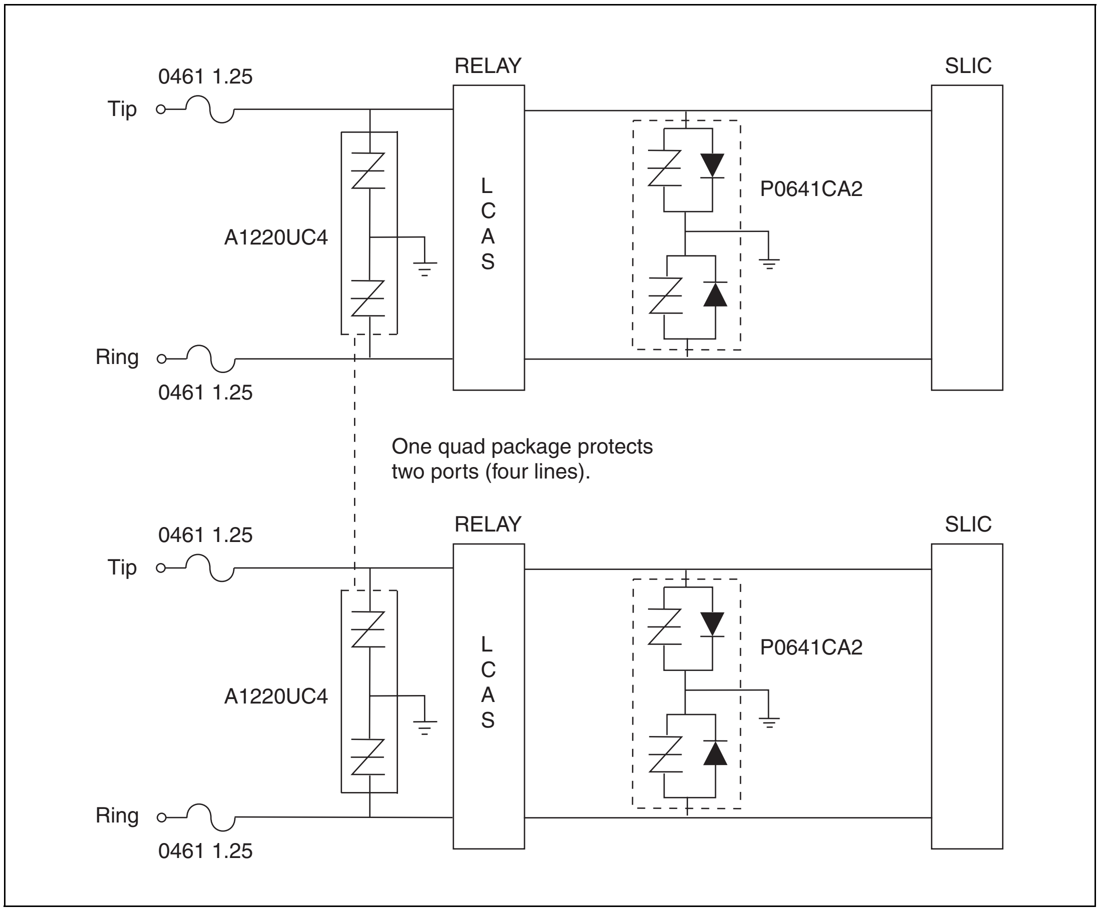
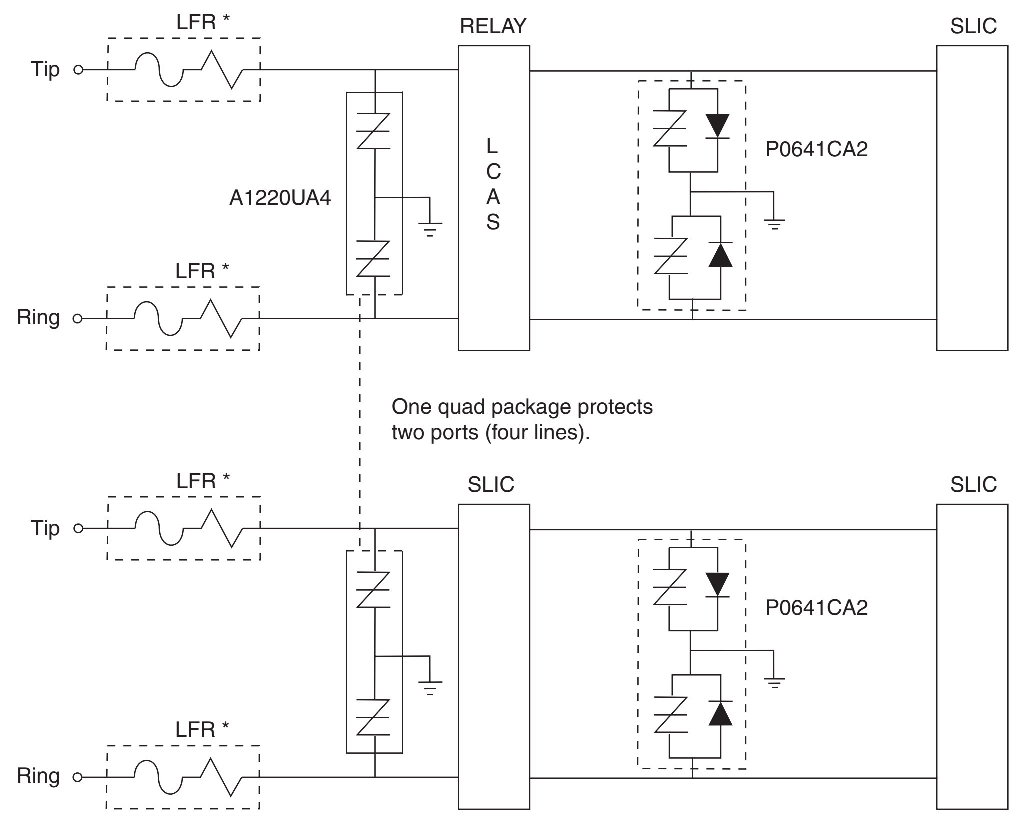


Figure 3.30 SLIC Protection with *TeleLink* Multiport

Figure 3.31 illustrates the use of a line feed resistor with a thermal link and the *SIDACtor*. The advantage of using an LFR is that it attenuates surge currents, allowing use of a *SIDACtor* with a lower surge current rating.



* Assumed minimum resistance of 20 Ω. If the LFR does not have a fusible link, then the 0461 1.25 is recommended for overcurrent protection.

Figure 3.31 SLIC Protection with LFR Multiport

Figure 3.32 illustrates a single port version with the *TeleLink* and discrete *SIDACtors*.

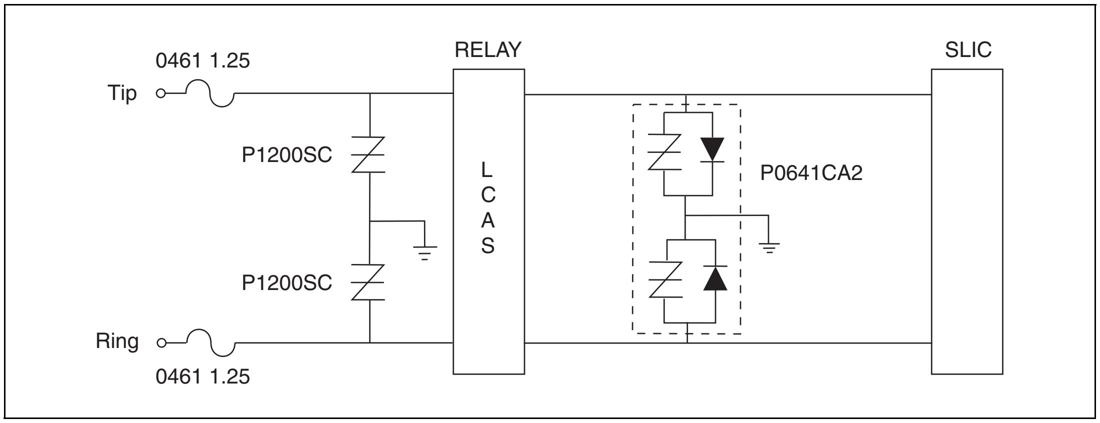


Figure 3.32 SLIC Protection with Single Port Discrete

The illustration of SLIC protection in Figure 3.33 shows Littelfuse's *Battrax* device protecting Legerity's (formerly AMD's) Am79R79 from overvoltages and uses a **0461** 1.25 to protect against sustained power cross conditions. The *Battrax* product was designed specifically to protect SLICs that cannot withstand potential differences greater than V_{REF} ± 10 V.

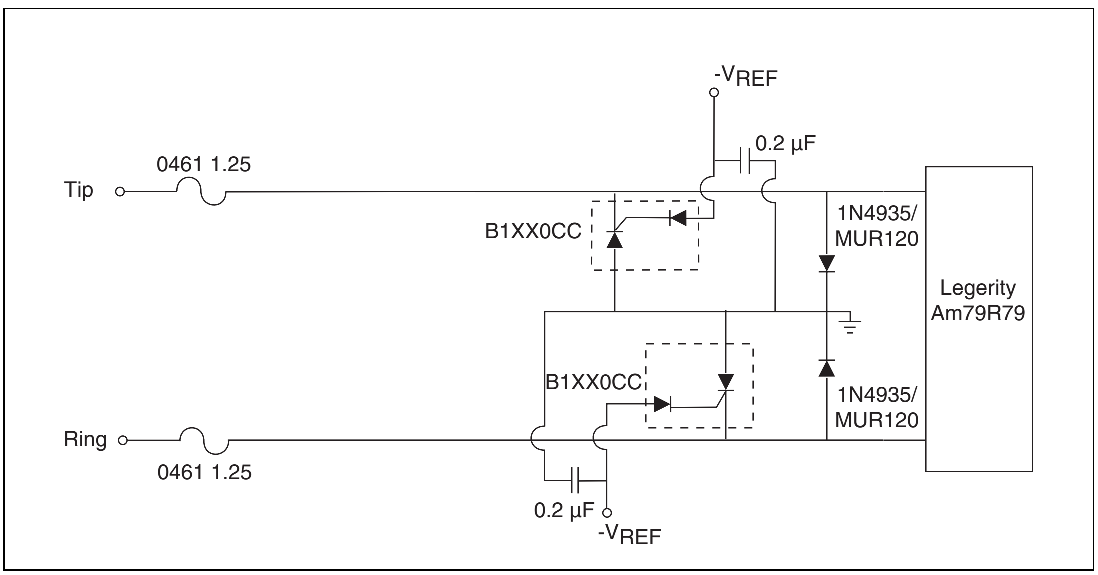


Figure 3.33 SLIC Protection with Programmable Voltage *SIDACtor* Devices

Figure 3.34 shows protection of a SLIC using 20 Ω series resistors on both Tip and Ring in addition to Littelfuse's *Battrax* (B1100CC) and a diode bridge (General Semiconductor part number EDF1BS). However, the overshoot caused by the diode bridge must be considered. The series resistance (a minimum of 20 Ω on Tip and 20 Ω on Ring) limits the simultaneous surge currents of 100 A from Tip to Ground and 100 A from Ring to Ground (200 A total) to within the surge current rating of the SA-rated *SIDACtor* device and *Battrax*. The diode bridge shunts all positive voltages to Ground, and the B1100CC shunts all negative voltages greater than $|-V_{REF}$ -1.2 V$|$ to Ground.

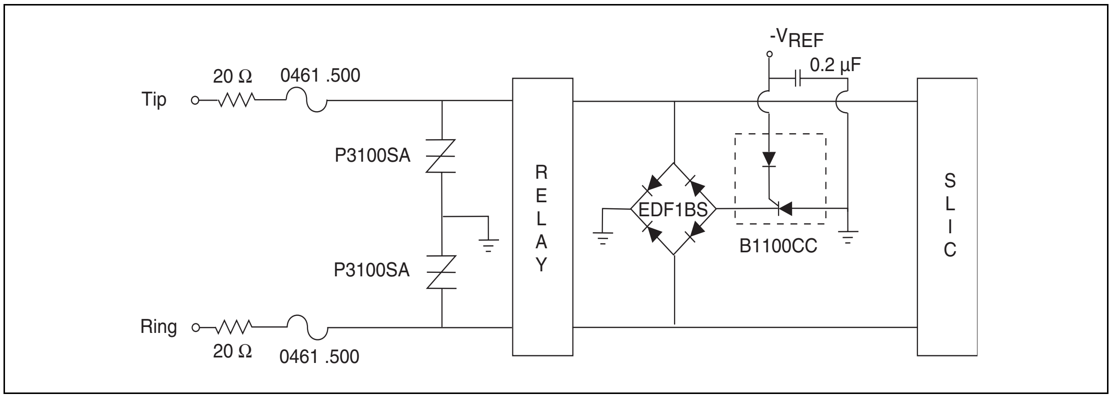


Figure 3.34 SLIC Protection with a Single *Battrax* Device

In Figure 3.35 an application that requires 50 Ω Line Feed Resistors (LFR) uses one B1160CC and two EDF1BS diode bridges in place of multiple SLIC protectors. The overshoot caused by the diode bridge must be considered; however, with this approach it is imperative that the sum of the loop currents does not exceed the *Battrax*'s holding current. In the application shown in Figure 3.35, each loop current would have to be limited to 80 mA. For applications requiring the protection of four twisted pair with one *Battrax*, use the B1200CC and limit each individual loop current to 50 mA.

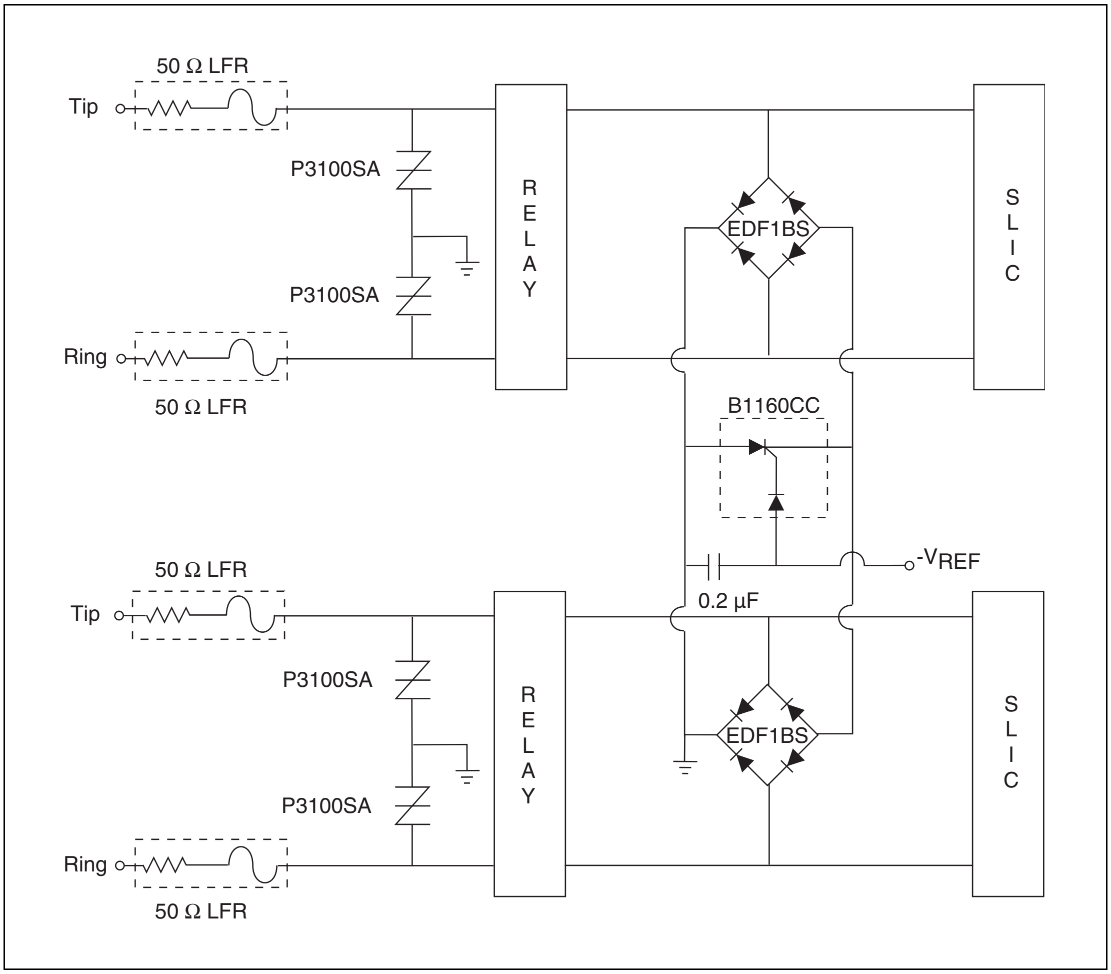


Figure 3.35 SLIC Protection with a Single *Battrax* Device

Figure 3.36 and Figure 3.37 show circuits that use negative *Battrax* devices containing an internal diode for positive surge protection. This obviates using the discrete diodes shown in Figure 3.33.

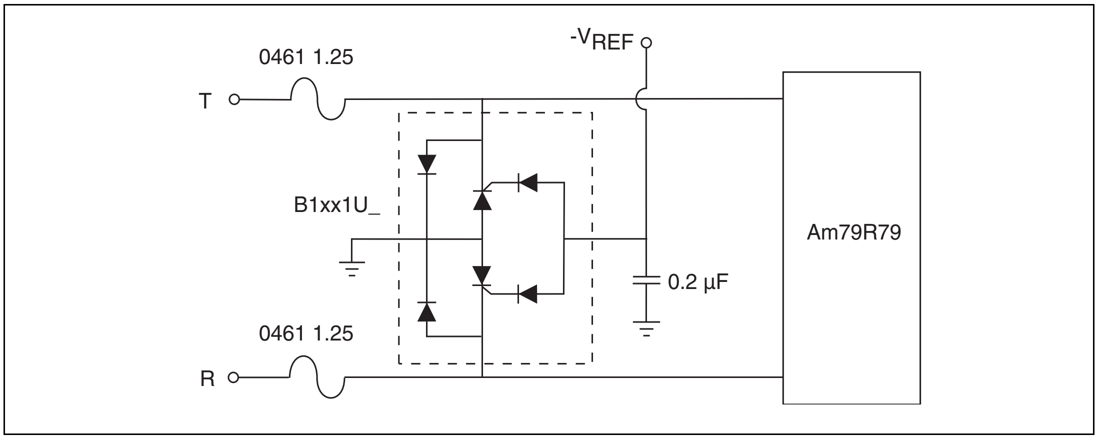


Figure 3.36 SLIC Protection with a Dual *Battrax* Device

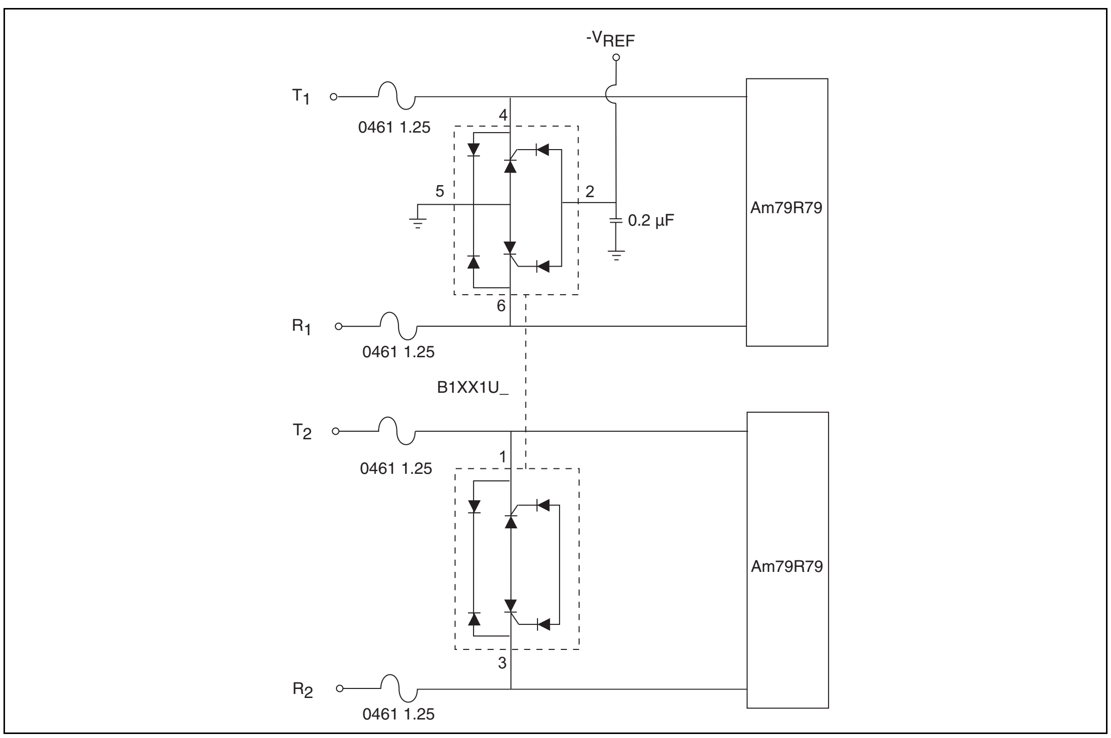


Figure 3.37 SLIC Protection with a Single *Battrax* Quad Negative Device

Figure 3.38 shows two negative *Battrax* discrete parts and two positive *Battrax* discrete parts. This arrangement is required for SLIC applications using both the positive and negative ringing signals. Figure 3.39 shows a similar application but with the two negative *Battrax* discrete parts and two positive *Battrax* discrete parts integrated into a single surface mount package.

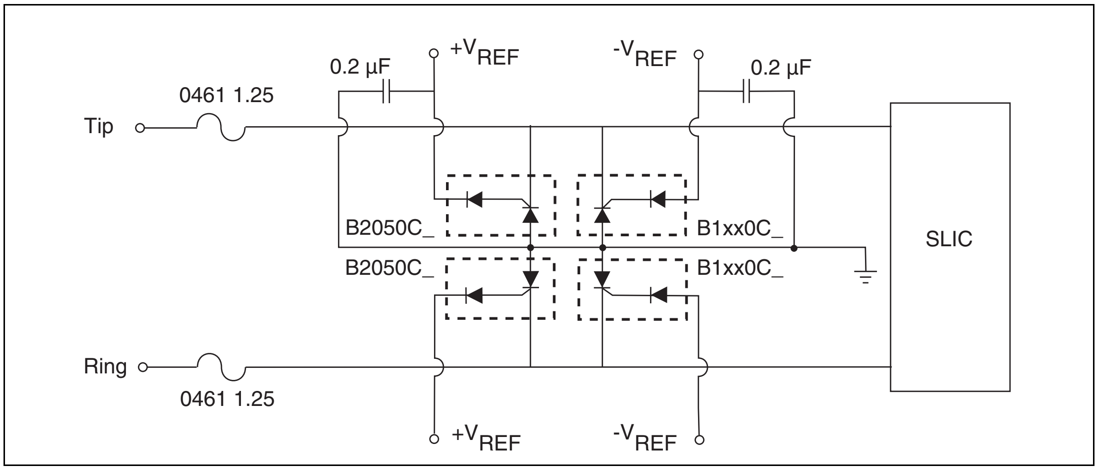


Figure 3.38   SLIC Protection with discrete positive and negative *Battrax* Devices

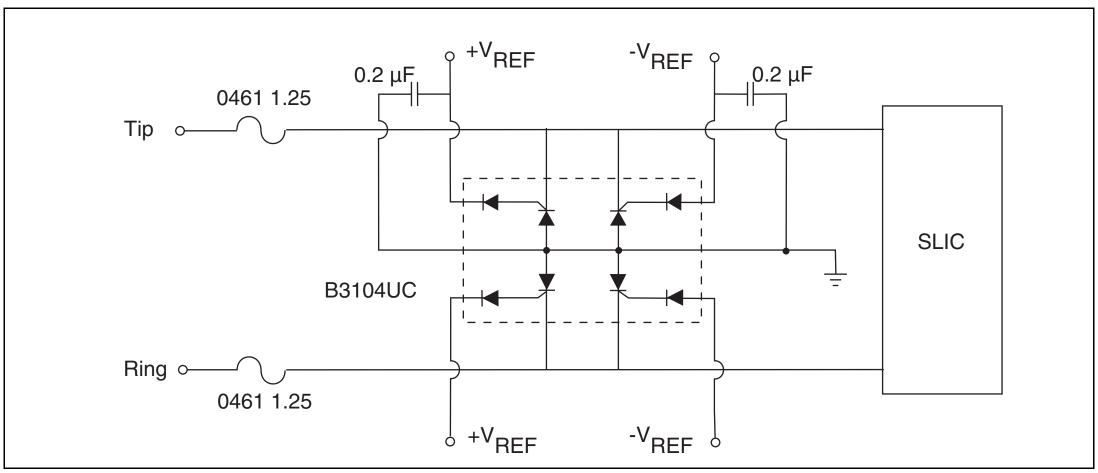


Figure 3.39   SLIC Protection with a *Battrax* Dual Positive/Negative Device

Infineon SLIC Protection Options

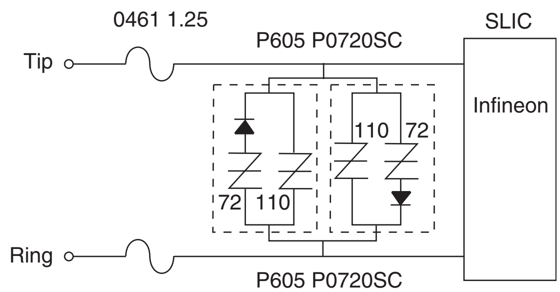


Figure 3.40 SLIC Protection with Asymmetrical Device

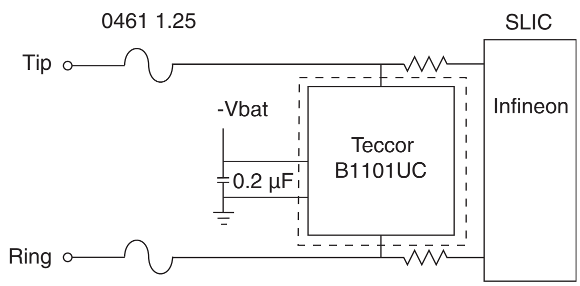


Figure 3.41 SLIC Protection with *Battrax*

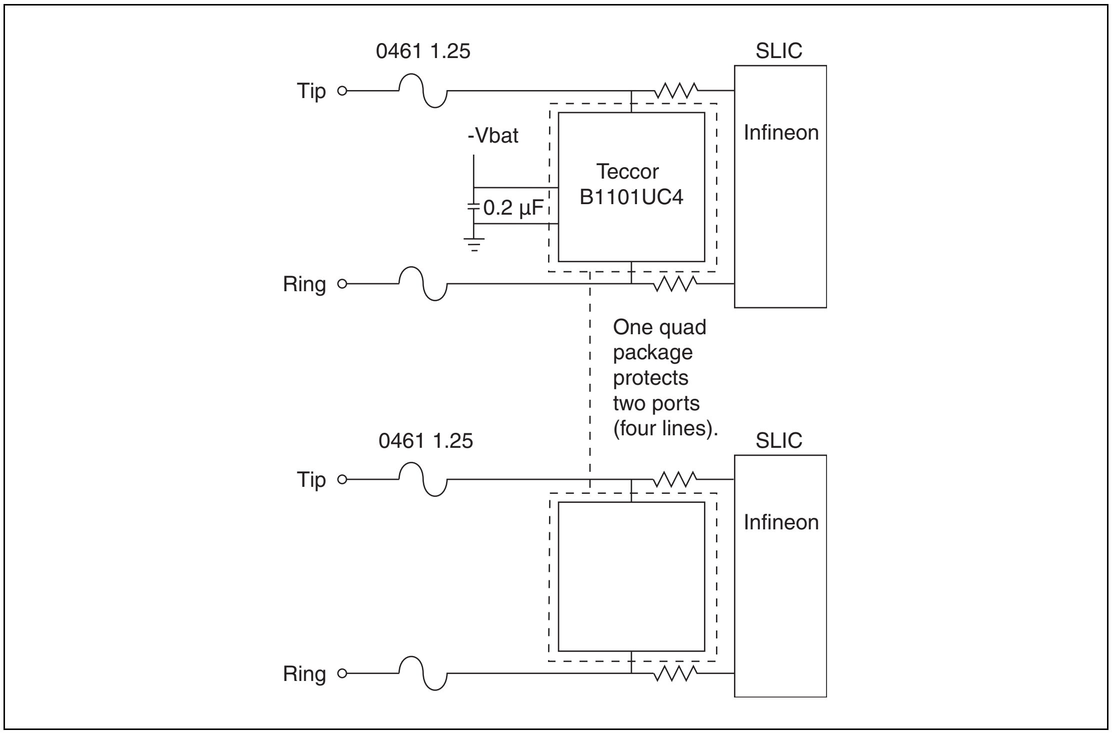


Figure 3.42 SLIC Protection with Quad *Battrax*

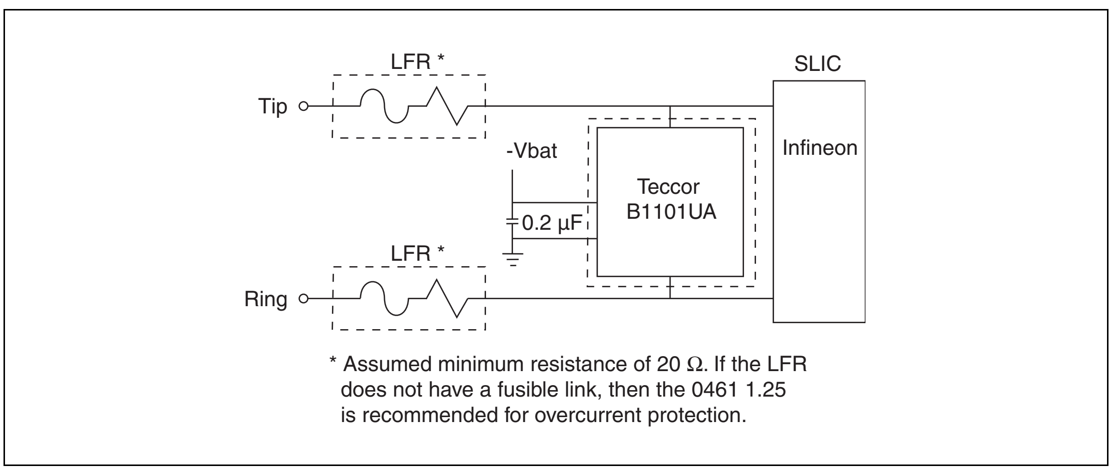
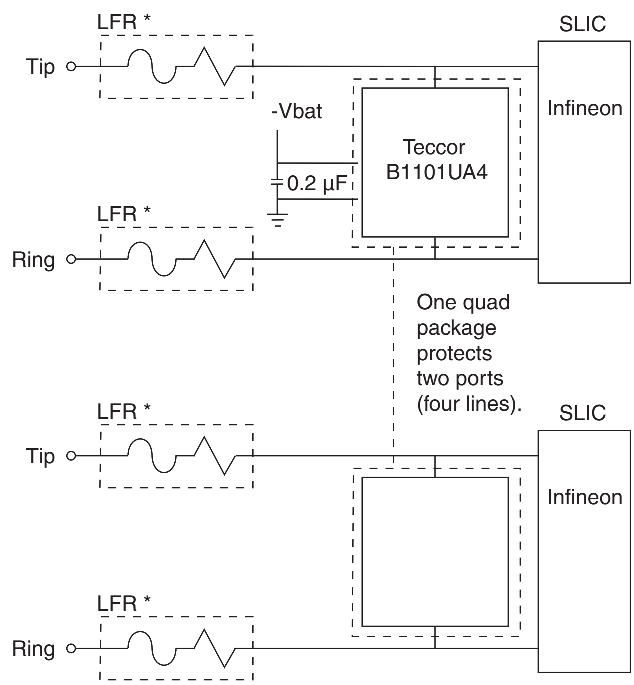


Figure 3.43 SLIC Protection with Series R and *Battrax*



* Assumed minimum resistance of 20 Ω. If the LFR does not have a fusible link, then the 0461 1.25 is recommended for overcurrent protection.

Figure 3.44 SLIC Protection with Series R and Quad *Battrax*

Reference Designs

Battrax **Protection Gate Buffer Circuit**

Many SLIC card designs do not require the *Battrax* protection gate buffer circuit shown in Figure 3.45. This circuit is useful to improve the voltage overshoot performance during AC power cross events. There is no impact on lightning surge performance as the gate capacitor is the only current source required during high dv/dt events.

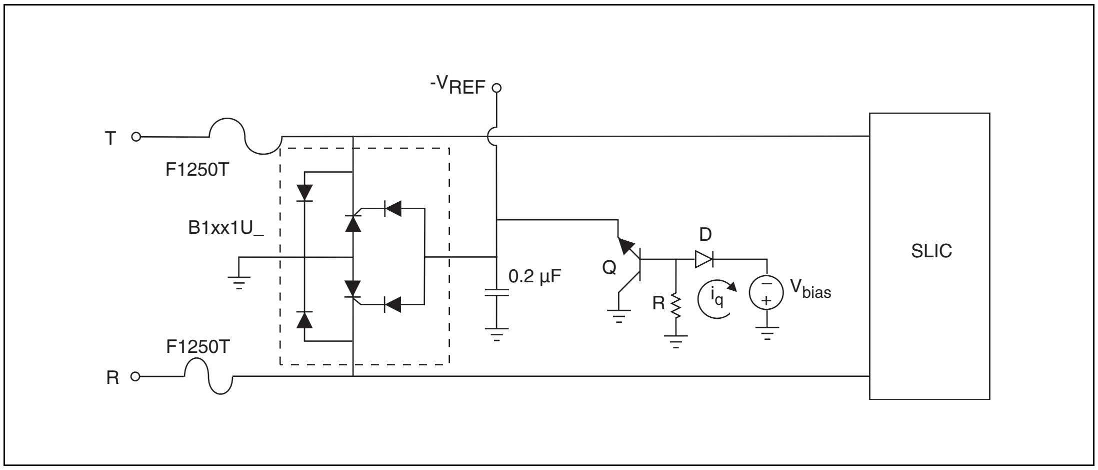


Figure 3.45 *Battrax* Protection Gate Buffer Circuit

During slower events (such as power cross), the current from the capacitor (C x dv/dt) may not source the needed current (100 mA max) to gate the SCR on. Under these conditions, this buffer circuit will source the needed current. The SLIC card bias supply is a negative (sinking) supply and cannot source any current.

In many designs, the bias supply is also the main supply powering the SLIC card. As such, the supply has a significant load at all times. This is the source of the gate current. When sourcing the gate current, the bias supply is actually being relieved of the load. As long as the load on the bias supply is 100 mA for each line protected, this buffer circuit is not needed. For lightly loaded bias supplies, this circuit may be useful.

Protection Circuitry

The buffer circuit consists of a diode, a resistor, and a transistor connected as shown. A small current i_q circulates constantly from the supply through the resistor and diode. When required to source current (during a fault condition where the emitter is being pulled more negative than the V_{bias} supply), the transistor Q will turn on because i_q is available as base current and Q will provide the needed current from its collector, out the emitter and into the gate of the *Battrax* device. One buffer circuit may provide current to several *Battrax* devices if properly designed.

Component Selection

Transistor Q should be selected to have a collector breakdown voltage well in excess of the bias supply voltage. The current available from Q will be H_{fe} x V_{bias} / R where H_{fe} is the gain of the transistor. The current available should be at least 100 mA per line protected. Selection of a Darlington pair transistor with a large gain can greatly increase the allowed value of R, reducing the quiescent dissipation.

The diode D need only be a small signal diode and may not be needed if the supply has its own source current protection built in.

The resistor R should be selected by the equation above to yield the needed source current. Keep in mind that it will dissipate V_{bias}^2 / R and should be sized appropriately. If there is ANY constant load on the V_{bias} supply due to the SLIC card design, the equivalent resistance of that load may be lumped into the R calculation and, in many cases, make R unnecessary.