NOVARIS

Application Note
(0015-D17V9)

SURGE PROTECTION FOR PROCESS CONTROL

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CONTENTS

1 INTRODUCTION

Modern process control equipment is based on large scale integrated electronics, sophisticated sensors and control units connected by copper cabling often covering large sites that are wholly or partly outdoors.

These complex systems are key to controlling most industrial processes such as chemical, oil and gas, manufacturing, water treatment, electrixcity generation and pharmaceuticals. As such they are often mission critical and safety related. Keeping these systems operating in the harsh environments often encountered is important for the business to operate effectively and protecting these systems from electrical surge damage is one of the most important aspects.

2 BACKGROUND AND RISKS

Most process control systems use Computers, Programmable Logic Controllers (PLCs), Remote Terminal Units (RTUs) and associated sensing and metering equipment in the field that contain sensitive electronics. These electronics are susceptible to electrical disturbances. Despite this, manufacturers only build in the most basic levels of protection internally in order to contain costs. This equipment is therefore at a high risk of damage in the event of electrical surges, and particularly from lightning due to its high intensity. Furthermore, the equipment itself and the downtime necessary to repair and replace damaged equipment and restart the plant can become extremely costly. When designing a surge protection system, the process control and other sensor (transmitter) equipment must be given special consideration to minimize the risk of damage and system downtime.

3 MODES OF DAMAGE

Process control systems are susceptible to all three methods of induction of surges, earth potential rise (EPR), magnetic field and electric field.

EPR is probably the most damaging effect for systems with many outdoor sensors mounted in and around the plant at different locations whereas electric and magnetic fields can act on the cabling systems even when they are inside a structure. All three effects can generate large voltage differences sufficient to damage the sensors, controls and the controlling equipment.

Protection against damage from these effects takes the form of correctly specified Surge Protection Devices (SPD) that can keep the system voltages well below the levels where equipment is damaged whilst bypassing the high surge current waveforms at the same time.

All electrical services require SPDs to be fitted if good protection is to be assured, signal/data cables, power cables and the main power supply.

Novaris has engineered a range of products intended to minimize the risk to process control equipment in the event of electrical surges, whilst not affecting the operation of the equipment. The level of protection provided, and the correct operation of equipment depends upon selecting the correct surge protective device (SPD) for the application.

This application note is intended to aid the designer in selecting the correct SPD for a variety of different applications commonly found in process control, and to provide the designer with information as to where SPDs should be installed. For detailed advice please contact your local Novaris distributor or visit the Novaris website **www.novaris.com.au.**

4 DESIGN CONSIDERATIONS

The following sections detail general advice for the design engineer when designing or selecting surge protection devices for any process control application.

4.1 Common and Transverse Mode

These are the two possible modes whereby a transient voltage and hence current can present to a piece of equipment.

4.1.1 Common Mode

A common mode transient presents to the equipment between the signal lines and ground or the equipment chassis. For example, if a pressure transmitter is connected to a controller with a 4 core cable, a common mode transient is present on all four of the cable cores relative to the local equipment ground or chassis. When this transient voltage exceeds the breakdown voltage of the equipment then a current will flow damaging the equipment.

In systems where cable runs are long and equipment is earthed at different physical locations common mode is the dominant damage mechanism.

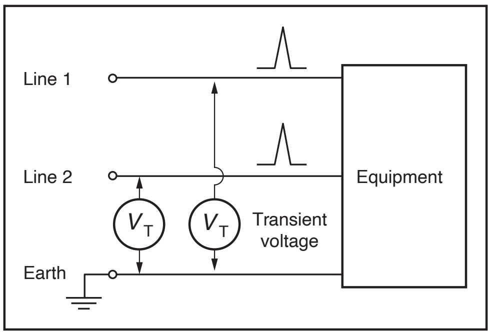

Figure 1a. Common Mode Transient

4.1.2 Transverse Mode

A transverse mode transient presents to the equipment between individual conductors within a cable or between conductors in more than one cable connected to the same piece of equipment.

Usually process control equipment has some internal transverse mode protection on inputs and outputs, but this is not capable of protecting the equipment from damage from higher magnitude transients such as those produced by lightning.

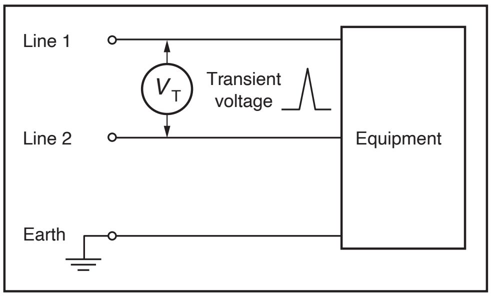

Figure 1b. Transverse / Differential Mode Transient

4.2 Surge Rating

Ratings of primary and secondary surge protection devices can be obtained by identifying their position in relation to the lightning protection zone barriers shown in Figure 2. Figure 3 shows recommended surge ratings for signal / data line SPDs.

These tables are based upon AS1768 and IEC61643 standards.

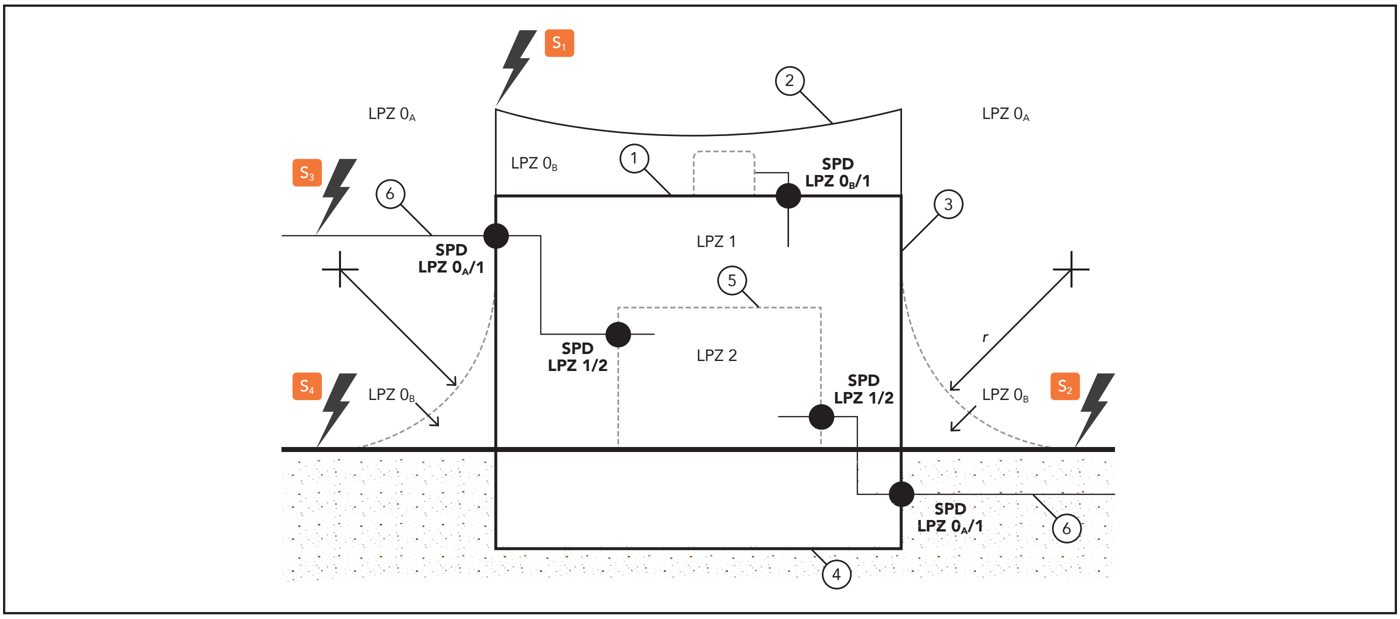

Figure 2. Lightning Protection Zones

Novaris offers two basic ratings for signal line type protection. The 7mm wide SL and SSP6A units are suitable for most process control applications with an I_{max} of 10kA @ 8/20µs, but if the site is highly exposed then the SL2/SL4 and SSP10A units at 12mm wide offers an I_{max} of 20kA @ 8/20µs.

SURGE RATINGS FOR SIGNAL / DATA LINE SPDs

Zone Boundary	SPD Location	I_{max} Rating 8/20µs	I_{imp} Rating 10/350µs
LPZ2/.. 2	Internal marshalling cubicle or equipment cabinet	5kA	-
$LPZ0_B$/..1	External signal cables shielded from direct lightning strike	10kA	2.5kA
$LPZ0_A$/..1	Point of entry, long overhead or underground signal cables	20kA	5kA
$LPZ0_A$/..1	Point of entry signal cables, building in a high lightning area (N_g greater than 2.5), or fitted with an LPS	20kA	5kA

Figure 3. Recommended Surge Ratings - Signal / Data

4.3 Selection of Surge Protection Devices

When selecting SPDs for process control, it is important to ensure that the signal is not attenuated or lost through the SPD.
Novaris manufactures process control SPDs for most applications and custom solutions can be designed.

1. **Determine the signalling protocol and peak line voltage**
The table in section 7 provides common signalling protocols and the appropriate Novaris SPD for each application. If the protocol is unknown, the peak signal voltage must be determined.

2. **Select the clamping voltage**
The clamping voltage of the SPD must be greater than the peak signalling voltage.
The following is a guide:

Nominal Peak Signal Voltage (V)	Power System (V)	Clamping Voltage (V)
0 - 6	5	7v5
6 - 15	12	18
15 - 30	24	36
30 - 60	48	68

3. **Determine the signal current**
   - SL models are rated at I_L = 250 mA
   - SL2/4 models are rated at I_L = 500 mA
   - SLH2 models are rated at I_L = 2.5 A
   - SSP6A models are rated at I_L = 6 A
   - SSP10A models are rated at I_L = 10 A

   For higher current applications, consider using SFD2 surge filters.

4. **Select signal frequency / data rate**
Standard SL/SL2 series will pass signals up to 60MHz. For higher frequency / faster data rates consider using the SL485.

4.4 System Grounding

Many process control systems cover a significant area that will include different physical earth connections. For example, the control equipment may be housed inside the main building and earthed to this building's buried earth system but connected sensors may be 100's or even 1000's of meters away and earthed to remote pipework or a separate earth system completely. This scenario can have consequences for the SPD's and for system performance due to earth/ground loops causing unwanted electrical noise on the sensor circuits.

In any equipment cabinet there must be only one common earthing point. Power and signal must connect to this common point. This may be a direct connection or via an earth clamp, normally a gas discharge tube either stand alone or included in the SPD. This is illustrated in figure 4.

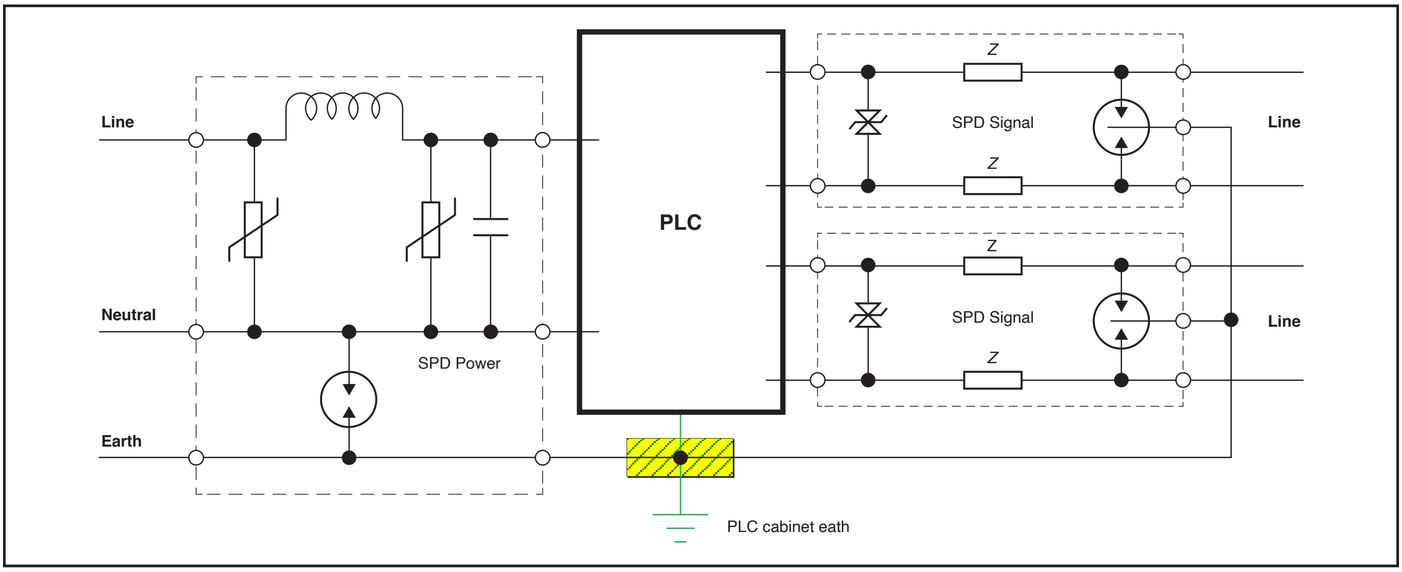

Figure 4. Common Earthing

Novaris produces two types of SLxx SPD. One type has a direct ground connection, known as a "-G" type and the other has an isolated ground known as an "-EC90" type. The indirect type has a 90 volt DC gas discharge tube in the earth connection so that under normal conditions it is isolated from earth, there is no earth leakage current and there is no path for earth/ground loops to be formed. However, when a common mode surge presents itself the gas discharge tube will fire momentarily to shunt the surge energy to the local ground and then recover again to an open circuit.

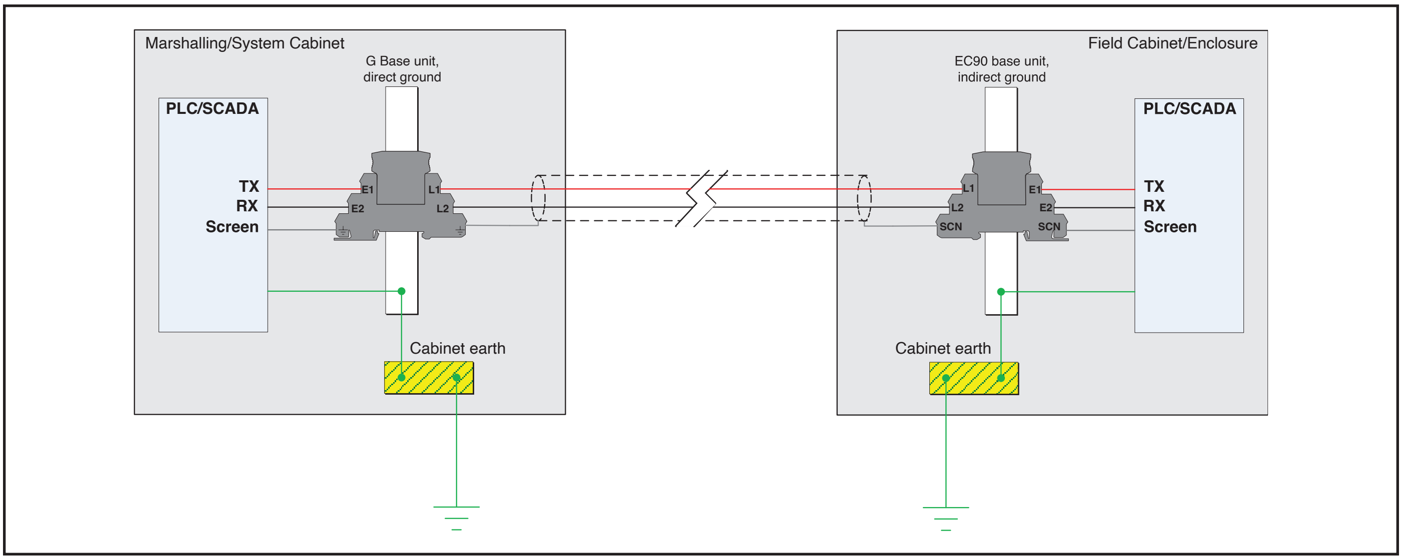

Figure 5. Example Showing Correct Orientation of SPD Connections with Single Screen Ground via SL36-G

The SL4 does not have the -EC90 option. Instead, a secondary SPD containing a single GDT can be used. This is SL1-G90 and its use is illustrated in figure 6.

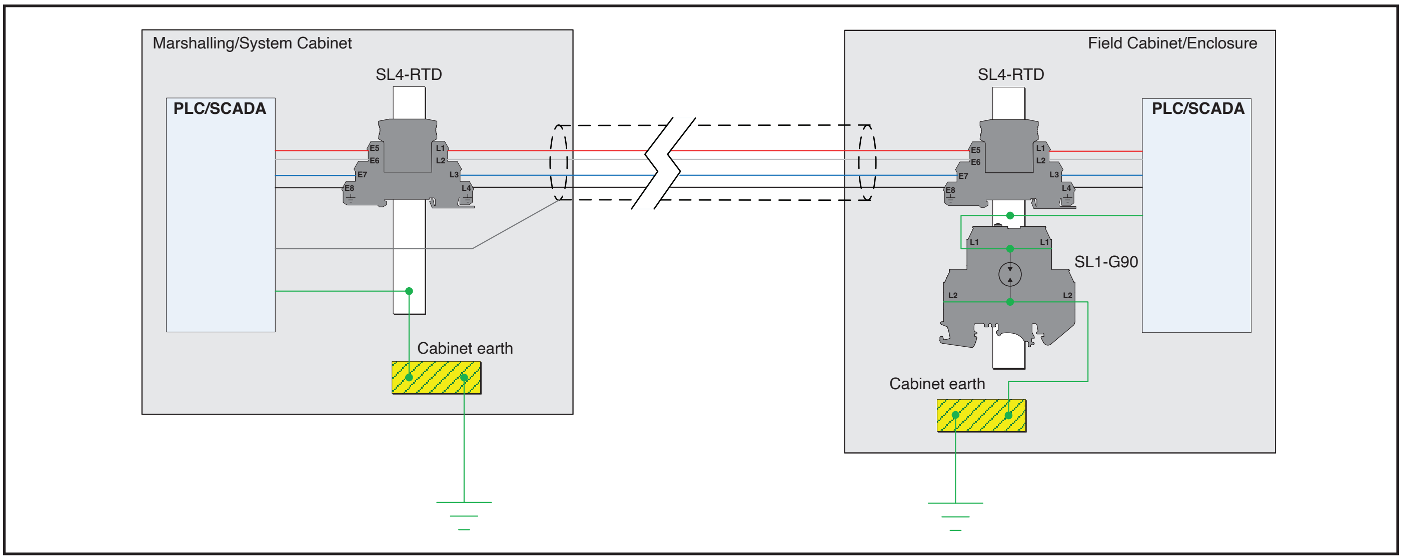

Figure 6. Use of SL1-G90 with an SL4 (Ensure Field Side DIN rail is Not Earthed Other than via the SL1-G90)

4.5 Cable Screens at Instrument

Many of the cables used to connect process control equipment are screened to protect the low level and or analogue signals from interference. How the cable screens are connected to the SPDs and where they are grounded can have a big influence on the levels of interference induced into the cable cores as well as the degree of protection provided by the SPD to the cable itself.

As a rule, the drain wire of a metallic cable screen should only be grounded at one end of the cable. The normal standard is at the controlling equipment end or the end where the power is provided as in figures 5 and 6. This eliminates circulating unwanted earth/ground currents in the cable screen which can cause interference to the cable cores or even damage the cable screen itself in the case of potential differences between the two ends.

The Novaris range of threaded signal line protectors have a separate connection for the cable screen. This uses a gas discharge tube, isolating the screen from earth until a surge is applied. This is illustrated in figure 7 and ensures earth/ground loops are eliminated whilst still protecting the screen from damage at the field side.

If the field side SPD is also a DIN mounted type, SL or SL2 then choose the EC90 or SL1-GDT option for these to avoid the earth loops mentioned above.

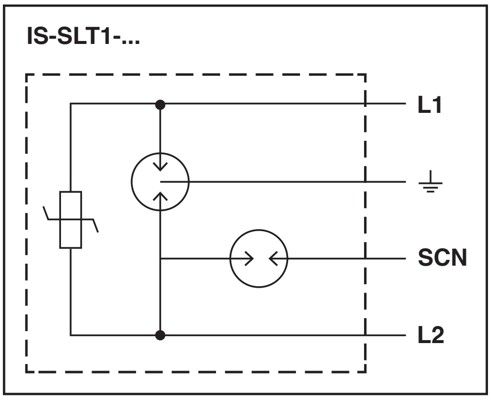

Figure 7. Example of Isolated Screen Connection for Field SPD

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4.6 Cable Lengths

The length of connection cables and how the equipment at either end is earthed are very important in getting the best protection. The following basic points should be followed:

a) If the controlling and field equipment are earthed to different physical points, then SPDs should be installed at both ends of the cable. The earth of each SPD should be directly connected to the earth connection or chassis of the equipment at each end. If the SPD is DIN rail mounted then ensure the DIN rail is connected (bonded) to the main earth bar, 6mm² wire is suitable for this and it should be installed as short and straight as possible; loops or coils should not be present.
b) If the controlling and field equipment are earthed to the same physical earth system but the connecting cables are more than 10 meters in length, then SPDs should be installed at both ends of the cable. The earth of each SPD should be directly connected to the earth connection or chassis of the equipment at each end.
c) If the controlling and field equipment are earthed to the same physical earth system and the connecting cables are less than 10 meters in length then SPDs are only required at the controlling equipment end of the cable. The earth of the SPD should be directly connected to the earth connection or chassis of the equipment being protected.

4.7 Hazardous Areas

This application note does not cover the special requirements for hazardous areas. These requirements can be different depending on the jurisdiction, so in the first instance refer to IEC 60079-0 and IEC 60079-11 for guidance on this subject. Novaris has a fully certified range of signal line protectors that comply with both IEC and ATEX standards for intrinsically safe protectors for explosive atmospheres. These are the IS-SL range of DIN mounted units and the IS-SLT range of threaded instrument protectors.

5 APPLICATIONS

The following sections provide guidance on the application of SPDs to the most common types of signalling and control circuits used in process control systems.

Refer to the section on surge rating (Page 2) to determine if an SL or SL2/4 type protector is best for your application.

5.1 Analogue and Digital Inputs / Outputs – 2 Wire

Surge protection requirements for analogue and digital inputs / outputs are almost identical. Figure 8 below shows how to protect 24V digital inputs and outputs with a current less than 250mA.

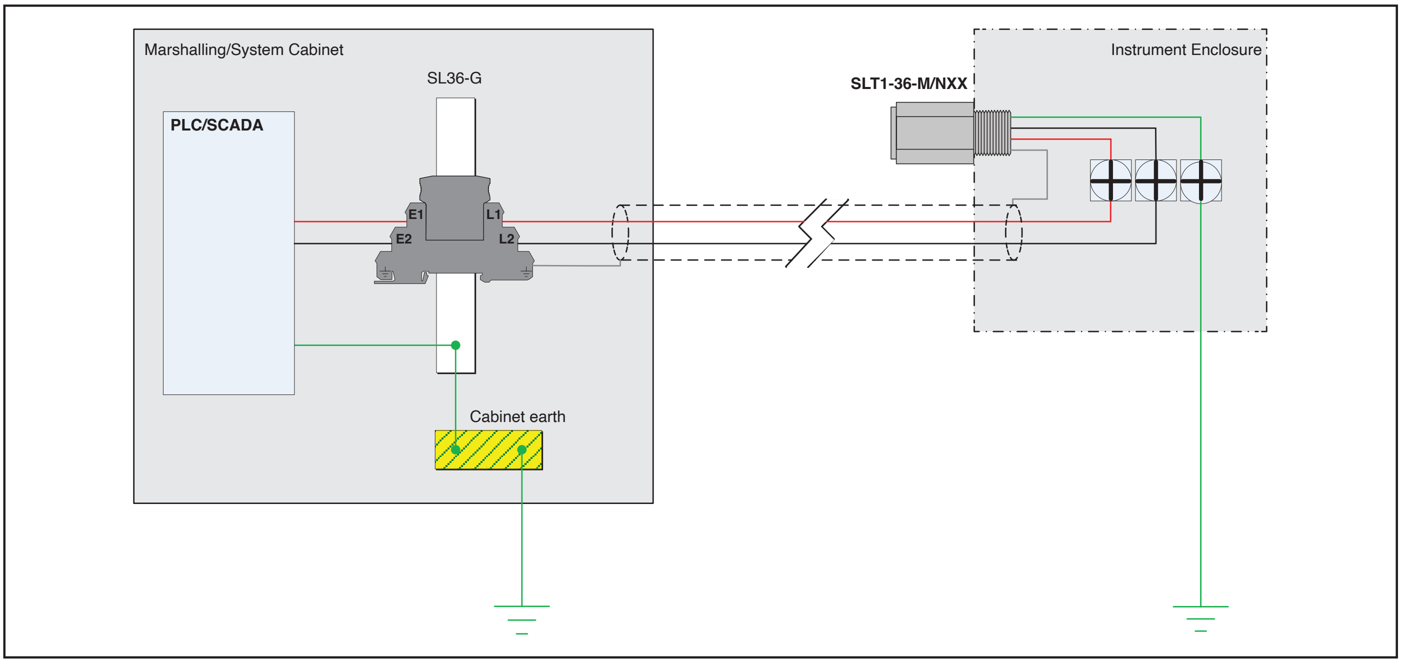

Figure 8. Surge Protection for Analogue and Digital I/O 2-Wire

The location and installation of process control SPDs is the same for all voltage ranges from 5V to 110V, however different models of SPD are required.

If the load current is >250mA and <500mA use the equivalent SL2 type SPD in place of the SL type. Refer to the Novaris product handbook for details of the SL2 and SL4 range.

Refer to Table 2 in section 7 for the applicable surge protection devices.

5.2 Analogue and Digital Inputs / Outputs – 3 Wire

Surge protection requirements for analogue and digital inputs / outputs are almost identical. Figure 9 shows how to protect 3 wire 24V digital inputs and outputs with a current less than 500mA.

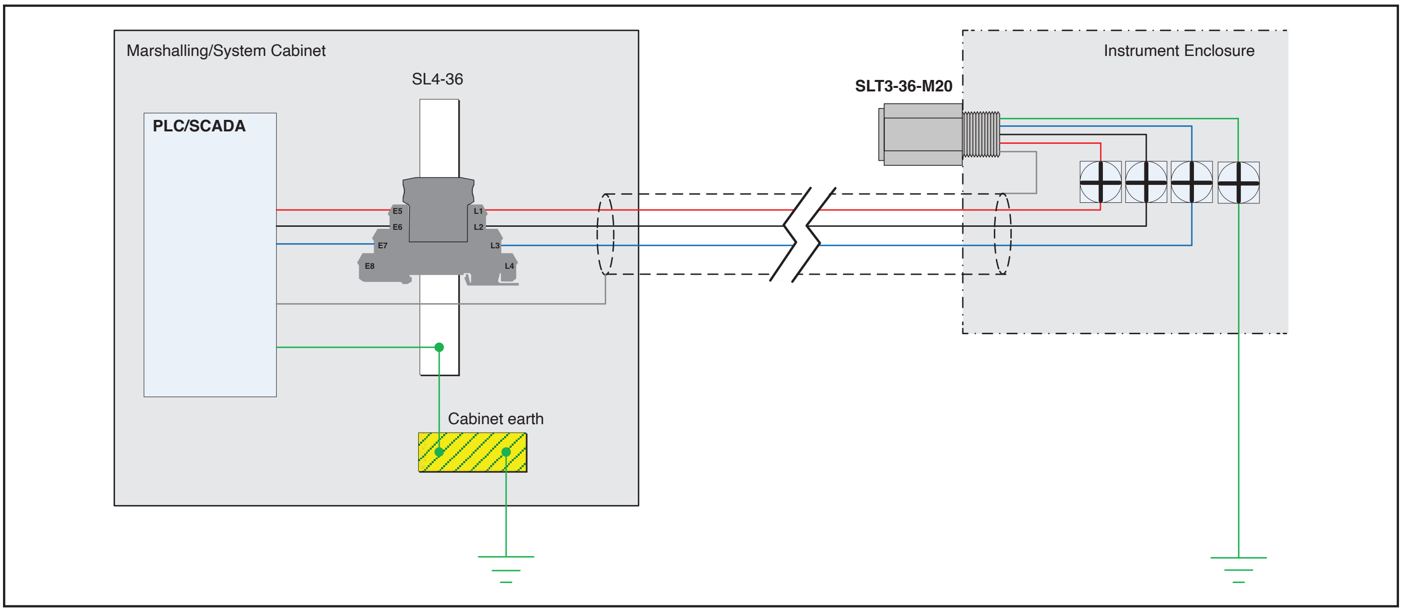

Figure 9. Surge Protection for Analogue and Digital I/O 3-Wire

5.2.1 Signals to 2.5A

If an I/O draws current in excess of 250mA for an SL, 500mA for an SL2, the SLH2 is suitable for current up to 2.5A. Above this the SSP6A may be used up to 6A and the SSP10A up to 10A.

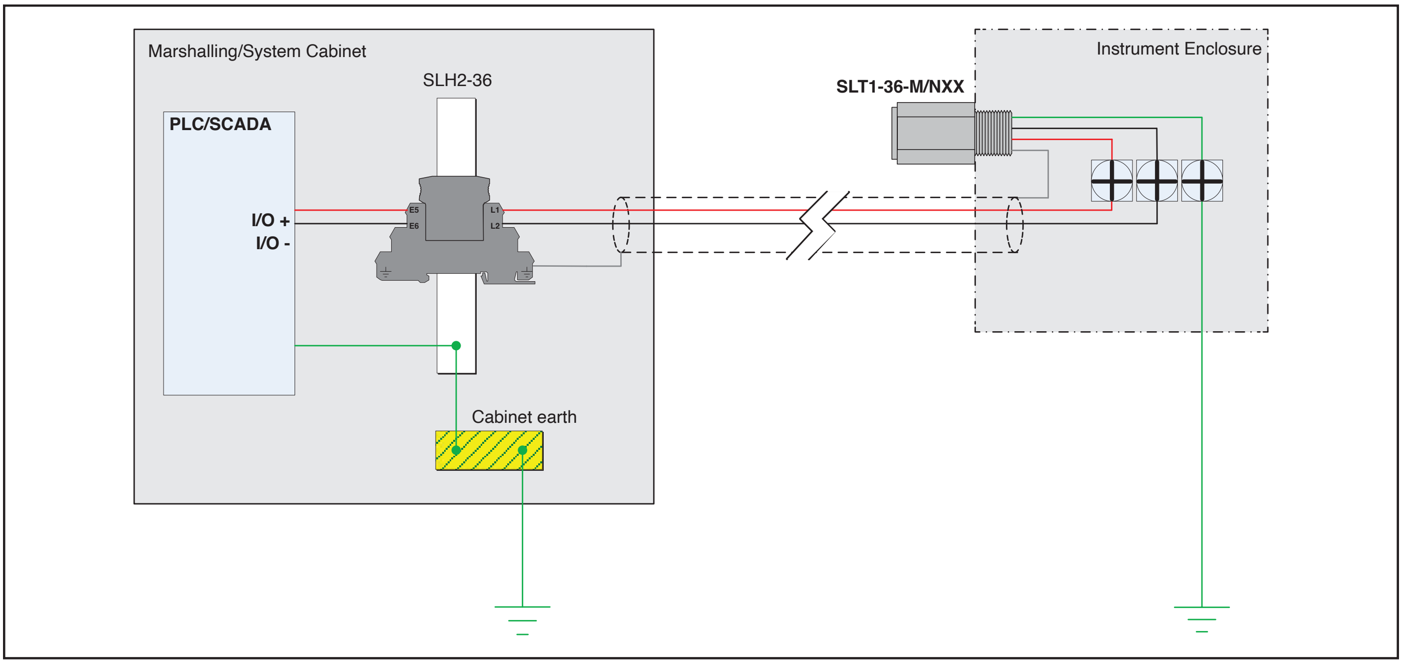

Figure 10. Surge Protection for I/O up to 2.5A

5.3 Interposing Relays

Due to the isolation provided by an interposing relay, both the digital output from the PLC and the power source can be protected using a single SPD. The example in Figure 11 shows an SSP protecting the power supply, the digital output on the PLC and the interposing relay.

The SSP6A-38 is suitable for current up to 6A. For current up to 10A use the SSP10A-38. If the supply is a well regulated 24V, SSP6A-26 or SSP10A-26 may be used. Where the supply is derived from a battery and charger the -38 versions are recommended.

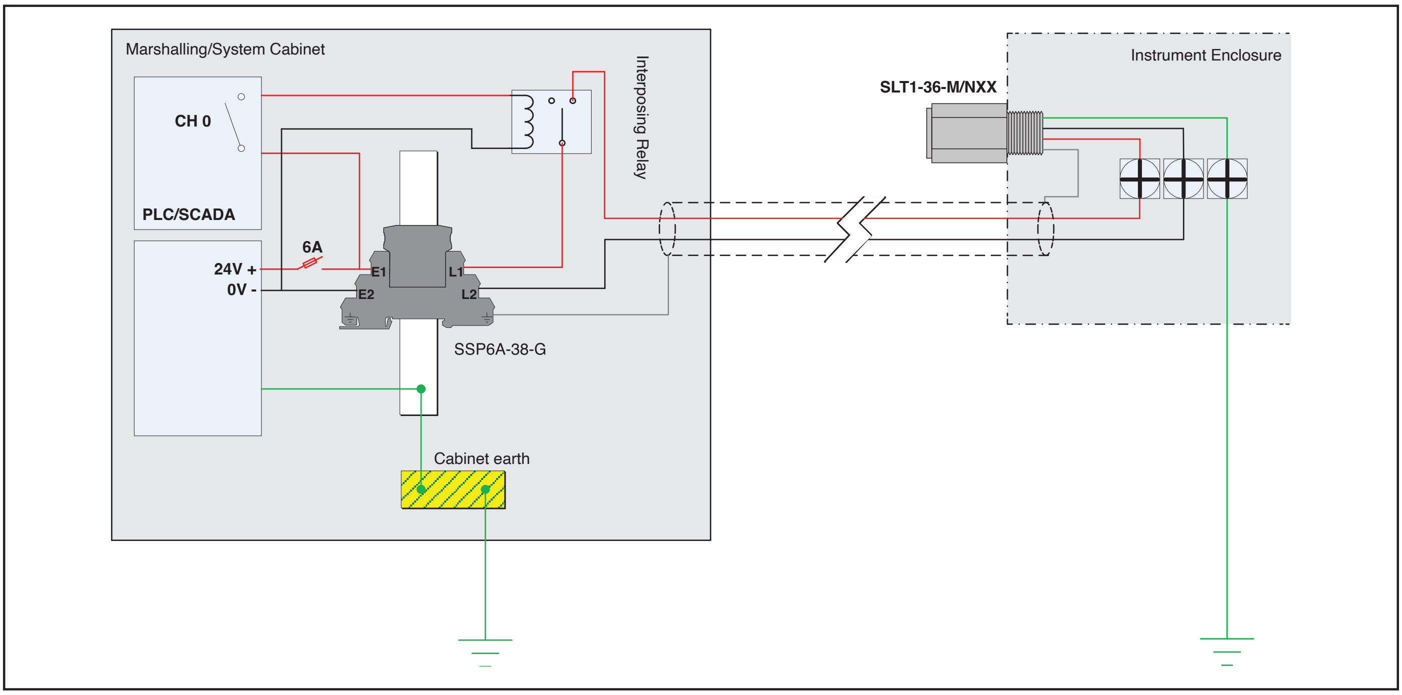

Figure 11. Surge Protection for I/O with Interposing Relay

5.4 4-20mA Instrument Loops

The recommended SPD for 4/20mA instrument loops is the SL36-G in combination with the SLT1-36-M/NXX. The SL36 drops 0.3V at 20mA. The Novaris SL420 incorporates an LED display. This is powered by and provides a visual display of loop current. Note that the voltage drop created by the display circuitry is 3.8V at 20mA. This may limit the available voltage to the field instrument.

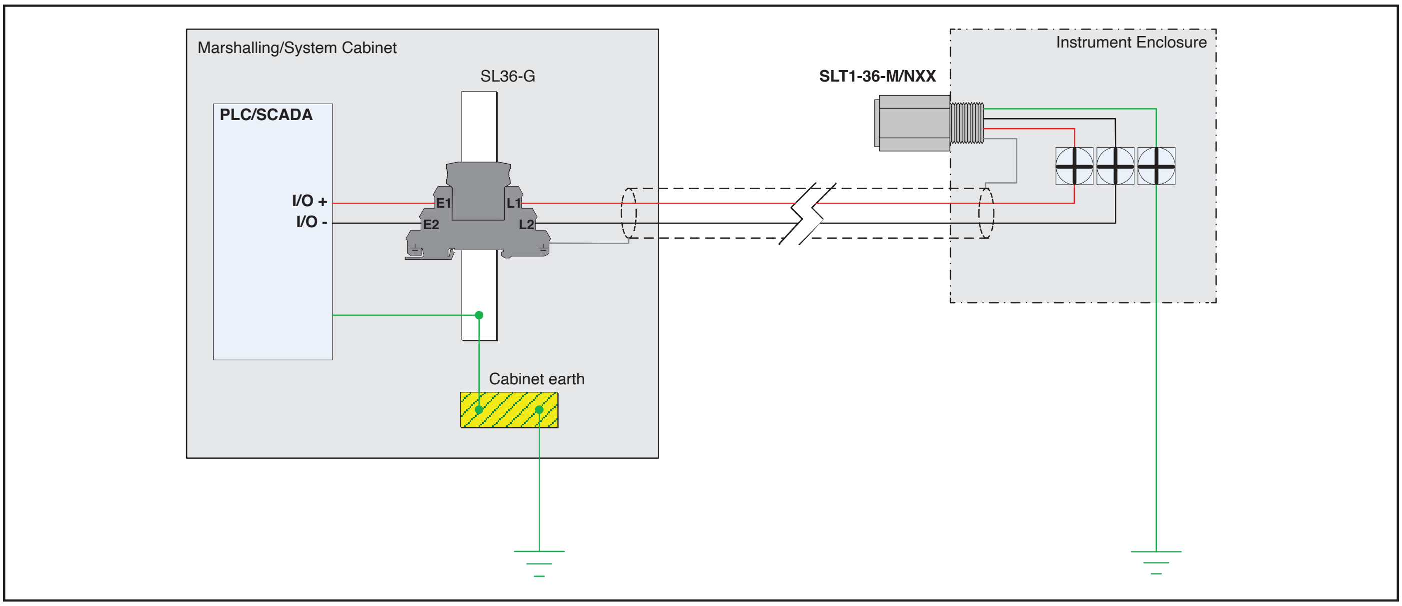

Figure 12. Surge Protection for a 4-20mA Instrument Loop

5.5 HART Over 4-20mA Loops

The addition of HART protocol on 4-20mA loops significantly increases the maximum frequency of the signal, and therefore the SPDs need to be capable of passing the signal. The SL36 has a frequency response up to 60MHz. Figure 13 shows how to effectively protect combined 4-20mA loops and HART.

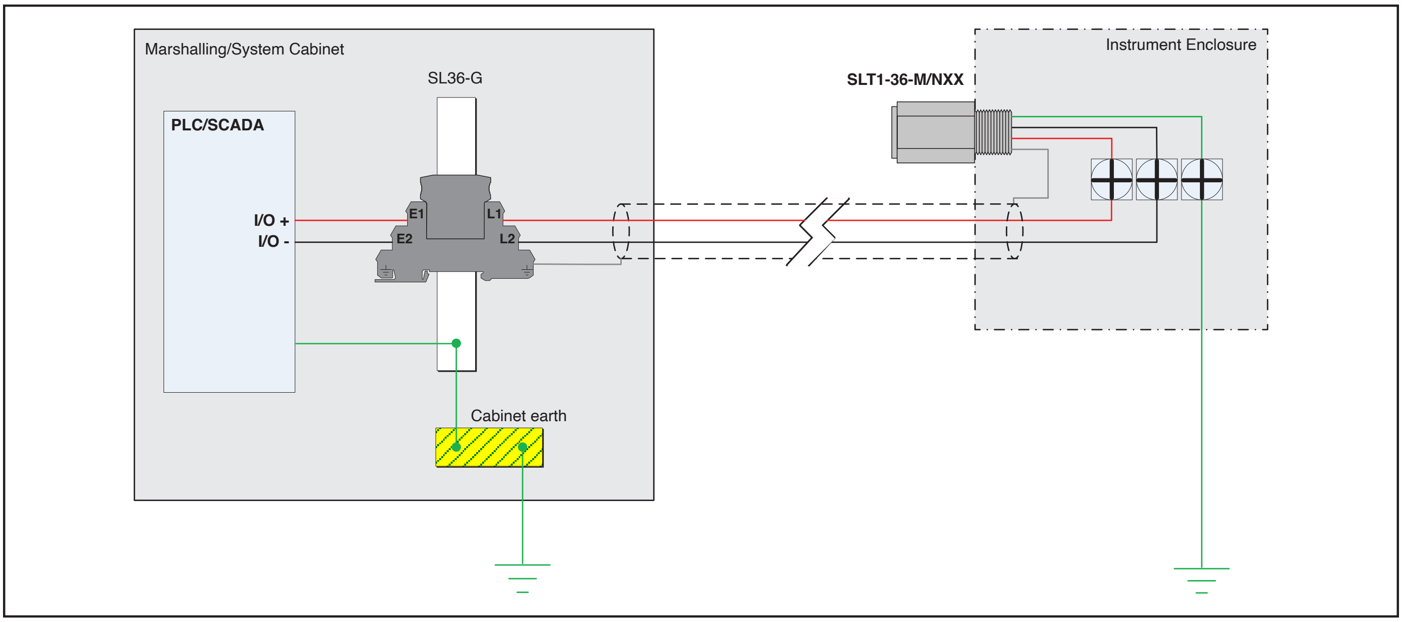

Figure 13. Surge protection for combined 4-20mA & HART

Multidrop HART may be protected in the same manner, with a Novaris SL36 or Novaris SLT1-36 at the end of every significant cable run (depending on which model of SPD is easier to install). The termination for multidrop HART will be very similar to HART over 4-20mA loops.

5.6 Resistance Temperature Detectors

The operation of resistance temperature detectors is somewhat different to other analogue instruments, in that they work on a change in resistance, and use lower signal levels. There are three common configurations of RTDs, each outlined below with a recommended method of protection. The combination of an SL4-RTD and an IS-SLT-RTD-M20 is a standard solution for protecting all configurations of RTD with just the two devices.

5.6.1 2 Wire RTD

Figure 14 shows a 2 wire RTD. An SL-RTD is used on the input to the control or PLC, and an IS-SLT-RTD is installed into the instrument enclosure. The SL-RTD provides the most convenient protection for 2 wire RTDs. For high exposure applications an SL4-RTD may be used. Novaris does not manufacture an SL2-RTD.

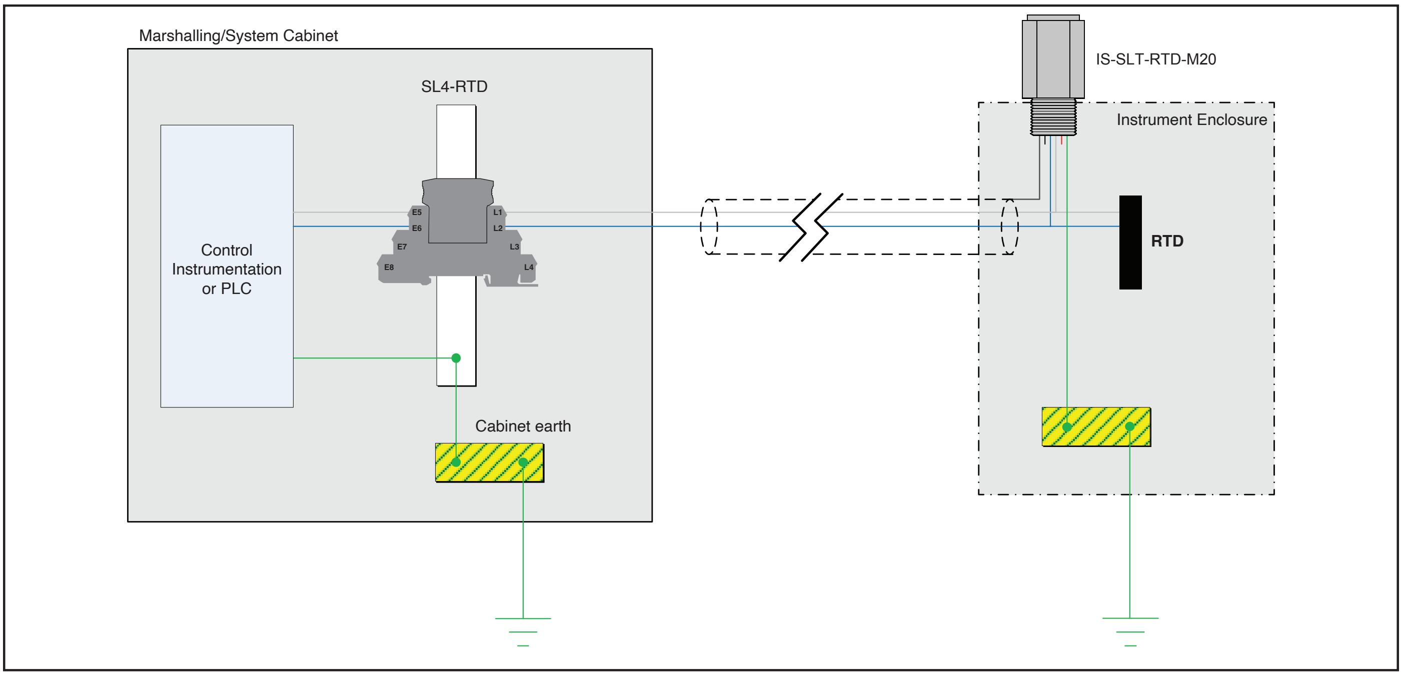

Figure 14. Surge Protection Wiring for a 2 Wire RTD

5.6.2 3 Wire RTD

Figure 15 shows a 3 wire RTD. An SL4-RTD is used on the input to the control or PLC, and an IS-SLT-RTD is installed into the instrument enclosure. The SL4-RTD provides the most convenient protection for 3 wire RTDs. For low exposure sites two SL-RTD units can be used.

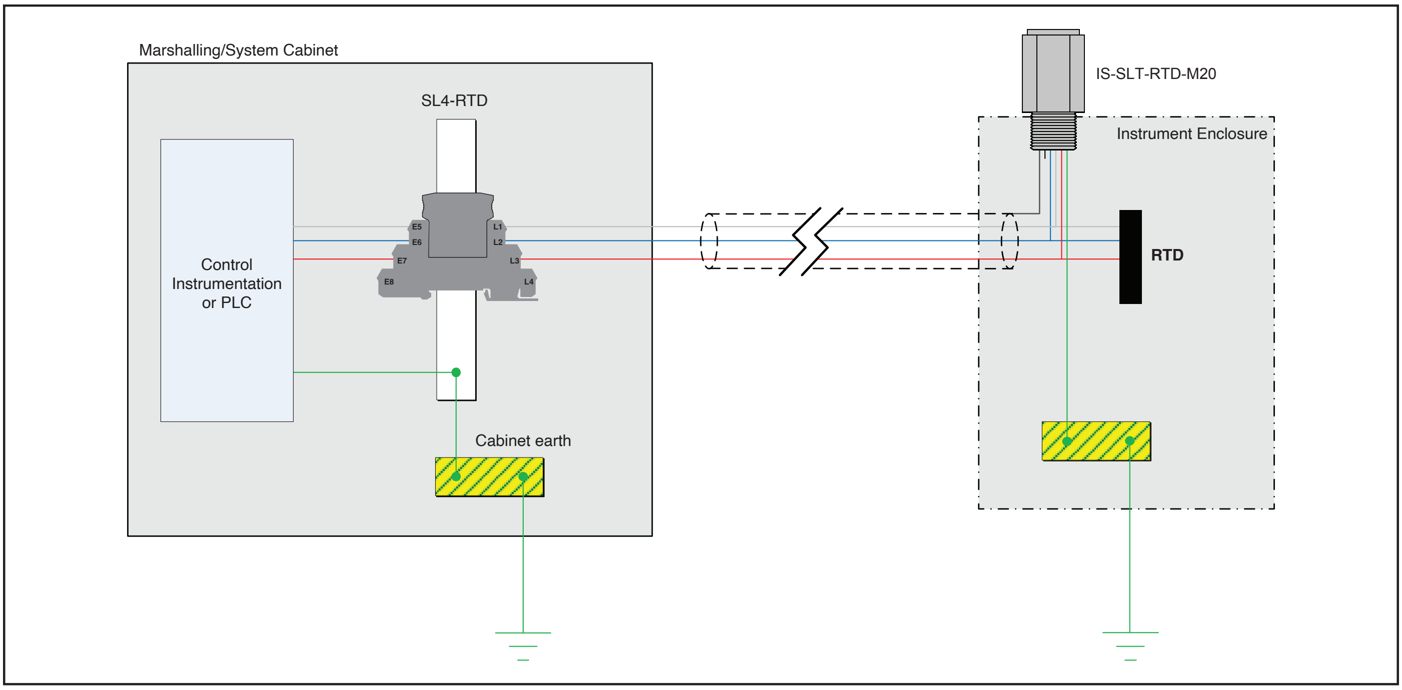

Figure 15. Surge Protection Wiring for a 3 Wire RTD

5.6.3 4 Wire RTD

Figure 16 shows a 4 wire RTD. An SL4-RTD is used on the input to the control or PLC, and an IS-SLT-RTD is installed into the instrument enclosure. Please refer to the product datasheets and installation manuals for further detail. The SL4-RTD provides the most convenient protection for 4 wire RTDs. For low exposure sites two SL-RTD can be used.

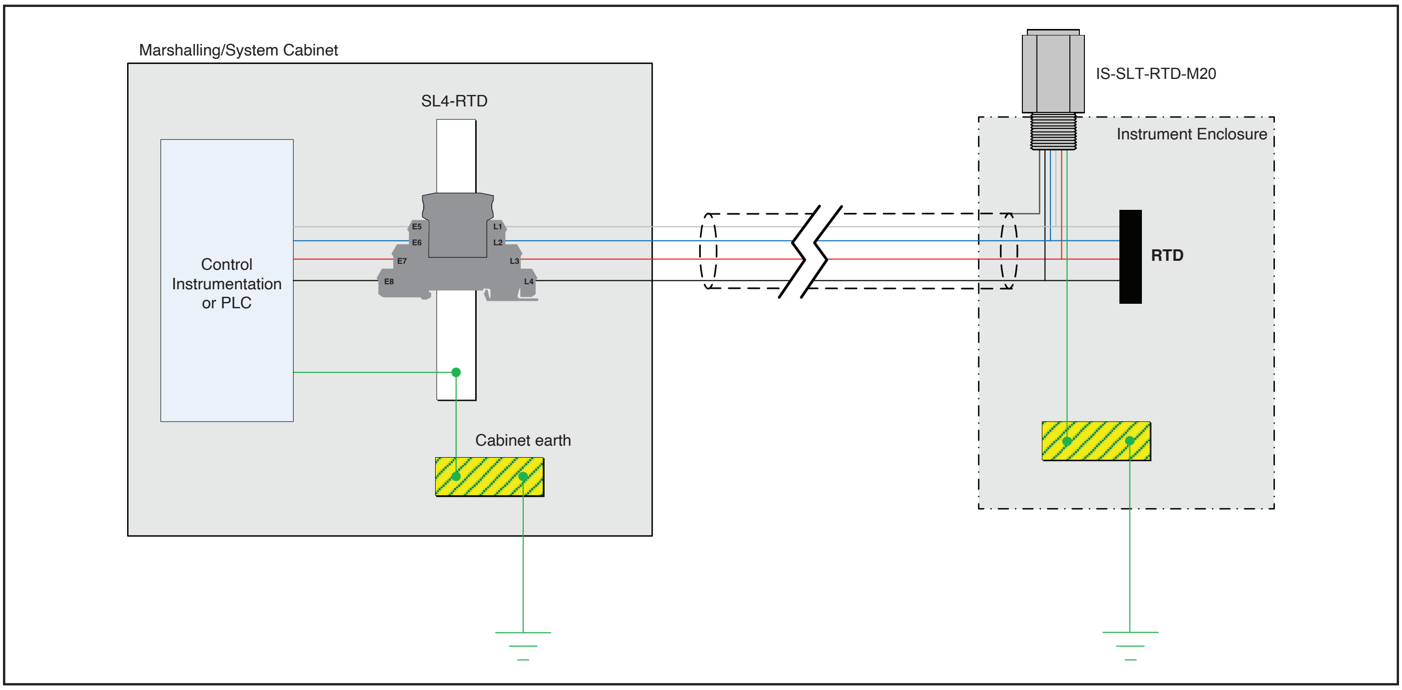

Figure 16. Surge Protection Wiring for a 4 Wire RTD

5.7 RS232, RS422 & RS485 Signals

RS232 and RS422/485 signals are significantly faster in nature than other digital I/O signals, and therefore raise the maximum operating frequency. The SPDs used must be capable of passing the higher frequency signal. Surge protection for Profibus or Modbus, should be done in the same manner as its physical layer protocol.

5.7.1 RS232

Figure 17 shows protection of a simple paired wire signal such as RS232 using Novaris SL36 SPDs.

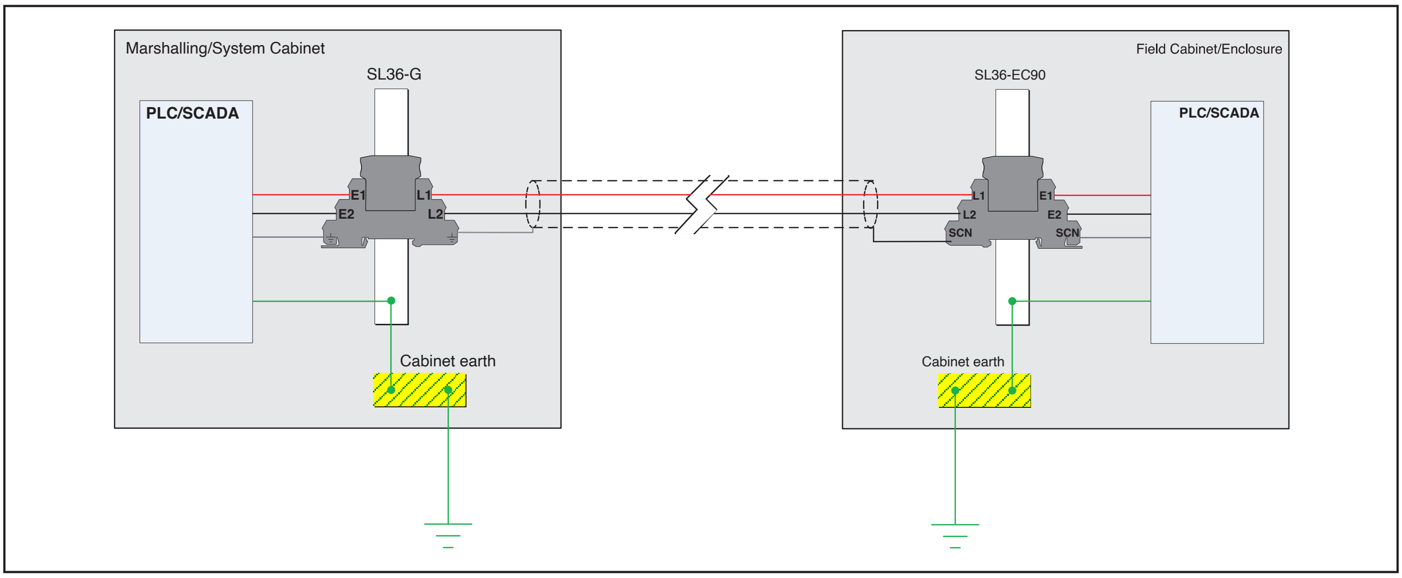

Figure 17. Surge Protection for RS232

The number of SL36 units at each end of the cable is dependent on the number of pairs implemented in the RS-232 communication system. Table 1 provides a list of grouped pairs commonly implemented in RS-232 communication systems.

For each pair one SL36 unit is required with the ground of each connected together to the ground or shield of their respective bases.

Multidrop RS232 may be protected in the same manner, with a Novaris SL36 at the end of every significant cable run. The termination for each wire will be very similar to point-to-point RS232.

Pin No	Names	Description
2, 3	RXD, TXD	Receive/Transmit Data
7, 8	RTS, CTS	Request/Clear to send
4, 6	DTR, DSR	Data Terminal/Set ready
1, 9	DCD, RI	Carrier Data / Ring Indictor

Table 1. DB9 Connections for RS232

5.7.2 RS485

Figure 18 shows a point-to-point RS485 signal using Novaris SL485-EC90 surge protectors. Note that only one end of the cable screen should be terminated to the equipment to avoid earth loops.

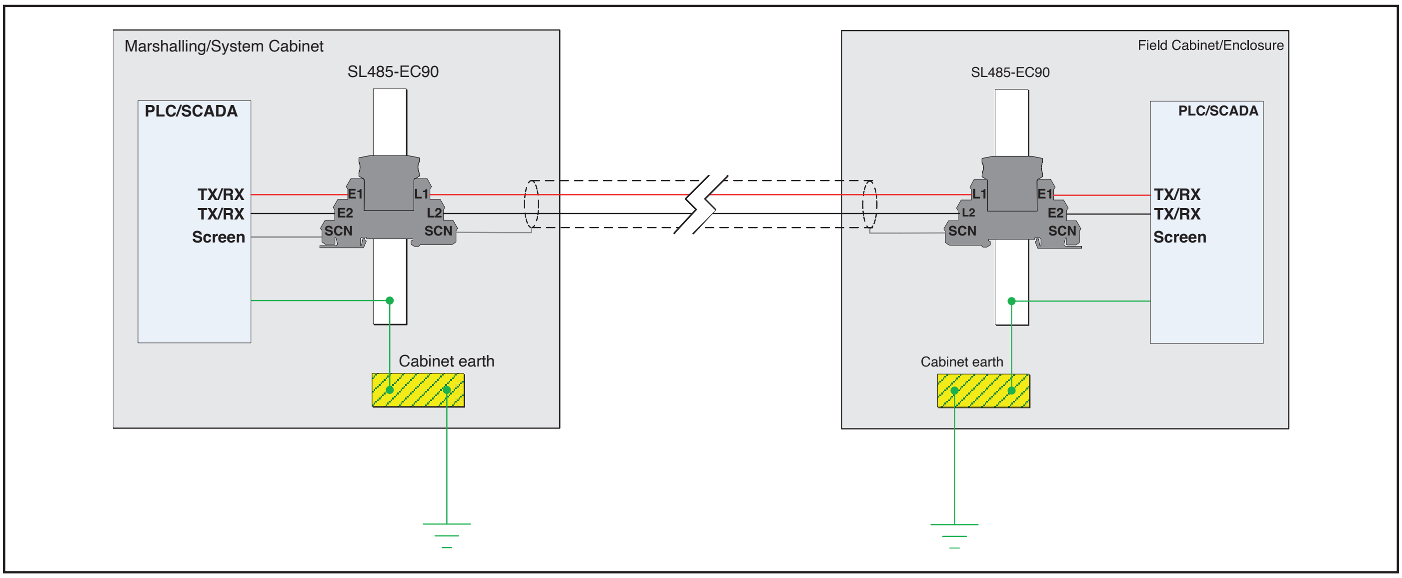

Figure 18. Surge Protection for RS485

5.7.3 Multidrop RS485

Multidrop RS485 may be protected in the same manner, with a Novaris SL485-EC90 at the end of every significant cable run. The termination for each wire will be very similar to point to point RS485. Figure 19 shows an example of a multidrop RS485 network. Note that only one end of the cable screen should be terminated to the equipment to avoid earth loops.

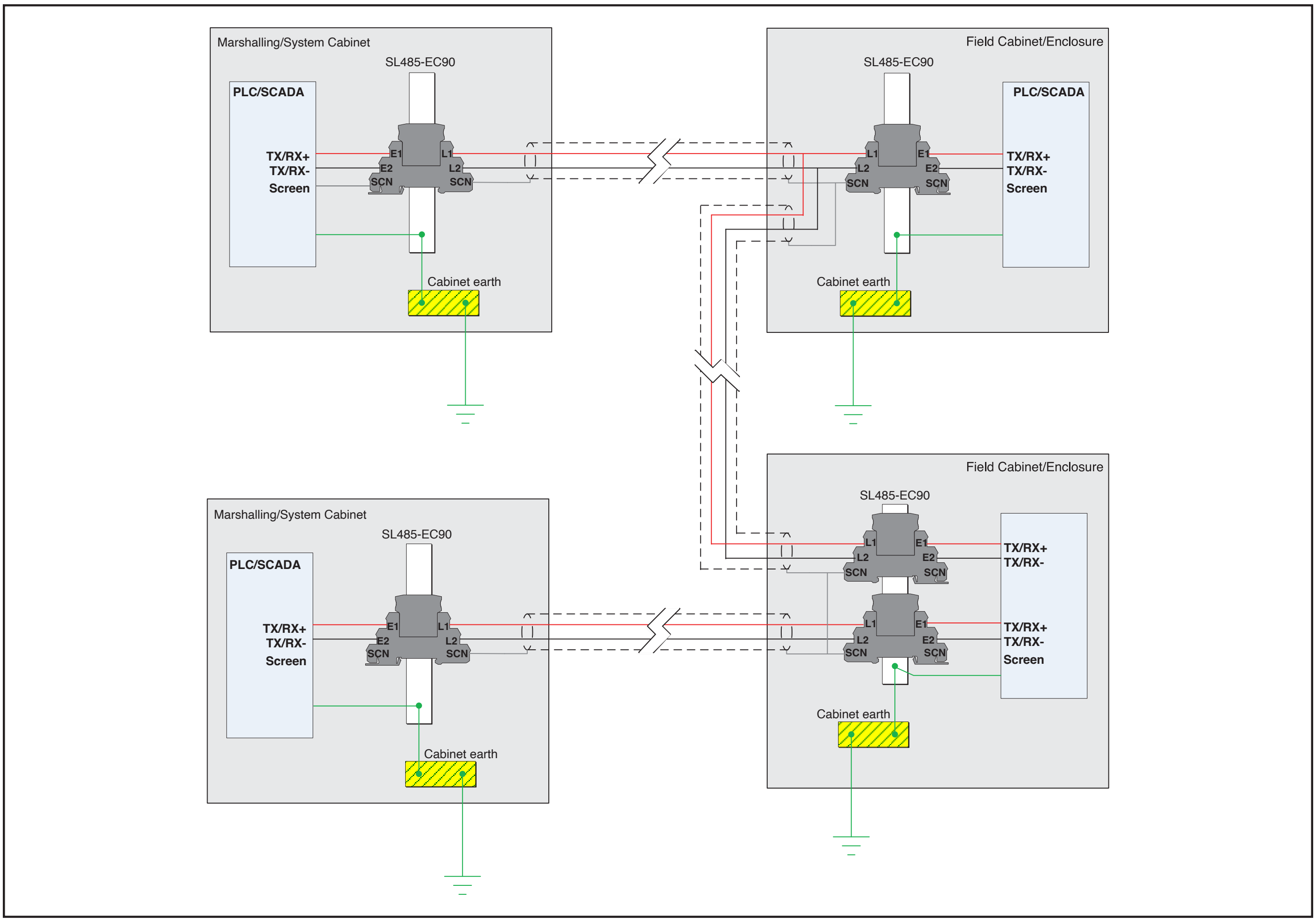

Figure 19. Surge Protection for Multidrop RS485

5.7.4 RS422

Figure 20 shows a point to point RS422 signal using Novaris SL485-EC90 surge protectors. This is a duplication of the RS485 protection. Note that only one side of the screen should be terminated to the equipment to avoid earth loops.

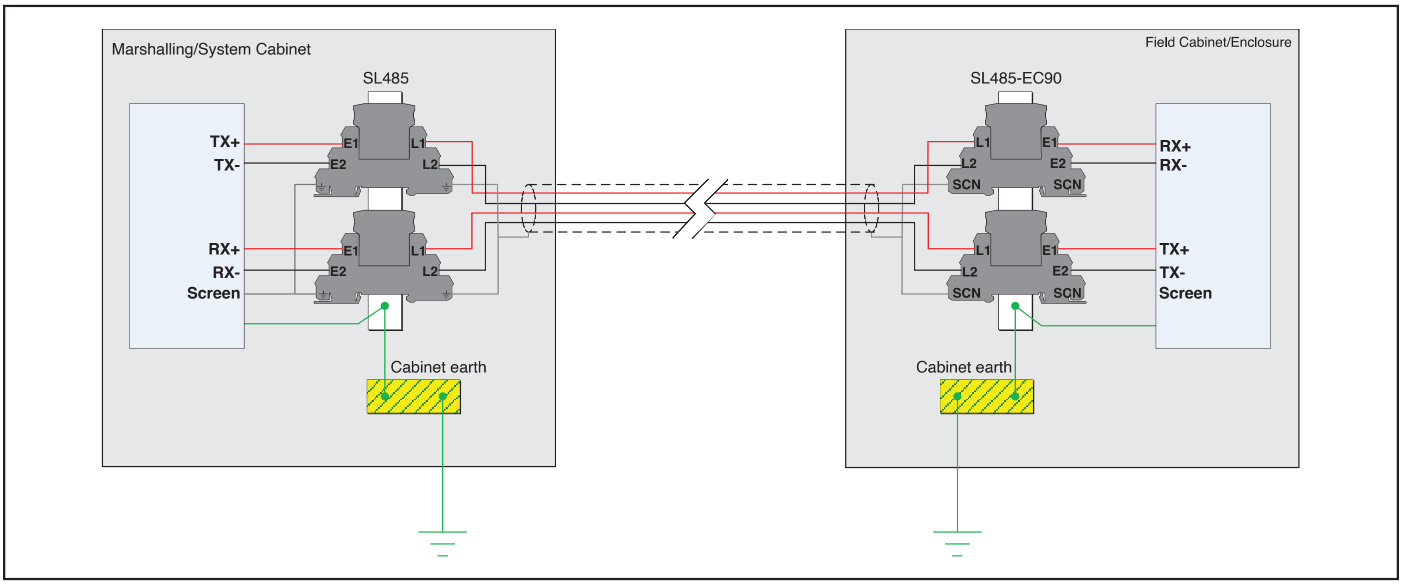

Figure 20. Surge Protection for RS422

Multidrop RS422 may be protected in the same manner, with a Novaris SL485-EC90 (Figure 19) at the end of every significant cable run. The termination for each wire will be very similar to point to point RS422.

The SL4-485 may be used in place of the two SL-485-EC90. However, an SL1-GDT must be used in conjunction with the SL4s.

This configuration is shown in figure 6.

5.8 Ethernet & Industrial Ethernet, PoE

Industrial Ethernet is becoming increasing popular as the data link layer protocol in process control and SCADA systems, often forming the link between PLCs and RTUs, and the supervisory system and HMI. Surge protection should be considered for all significant (greater than 20M) cable runs in a network.

Figure 21 shows a cabled network with 4 remote nodes and surge protection. A Novaris RJ45-24CAT 6 is used to protect the network switch, and Novaris RJ45-1CAT6 SPDs are used at each remote node. This protection is suitable for any network using a CAT5, CAT5e, CAT6 or PoE physical layer, including Modbus-TCP, PROFINET IO as well as standard local area computer networks.

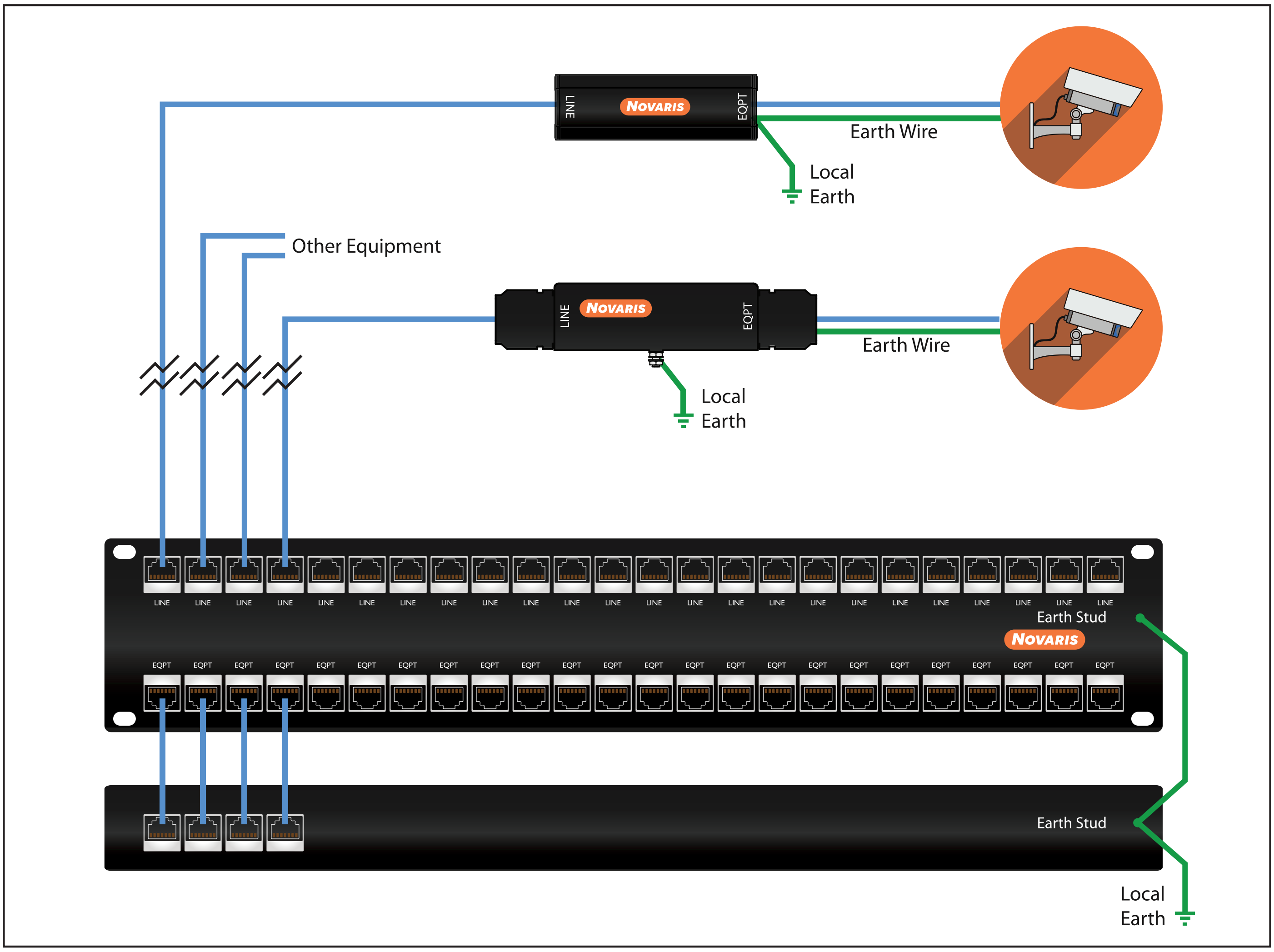

Figure 21. Surge Protection for Ethernet

Note: If field cabling is Unshielded Twisted Pair (UTP) then use RJ45-1CAT6.
If field cabling is Screened Twisted Pair (STP) then use RJ45-1CAT6-EC90 to avoid earth loops.

In the cases where no suitable enclosures are available at the equipment side to house indoor TCP/IP based protectors then a Novaris ORJ45-2CAT6 can be used. This is a weatherproof unit that can be used in sheltered outdoor locations. If the field location is totally exposed to the weather, such as on a pole, then the Novaris RJ45-1CAT6-IP67 can be used.

6 SPECIAL CASES

The following sections provide guidance for some specific applications. For any other products or systems not covered in this document please contact Novaris directly at **sales@novaris.com.au** or via the website **www.novaris.com.au**.

6.1 ABB WaterMaster Flow Meter

This unit is an electromagnetic flow meter comprising a sensor that is mounted inside the pipe where the flow is to be measured and a separate transmitter unit connected by a proprietary 10 core cable as shown in figure 22.

The distance between the sensor and transmitter can be up to 100 meters.

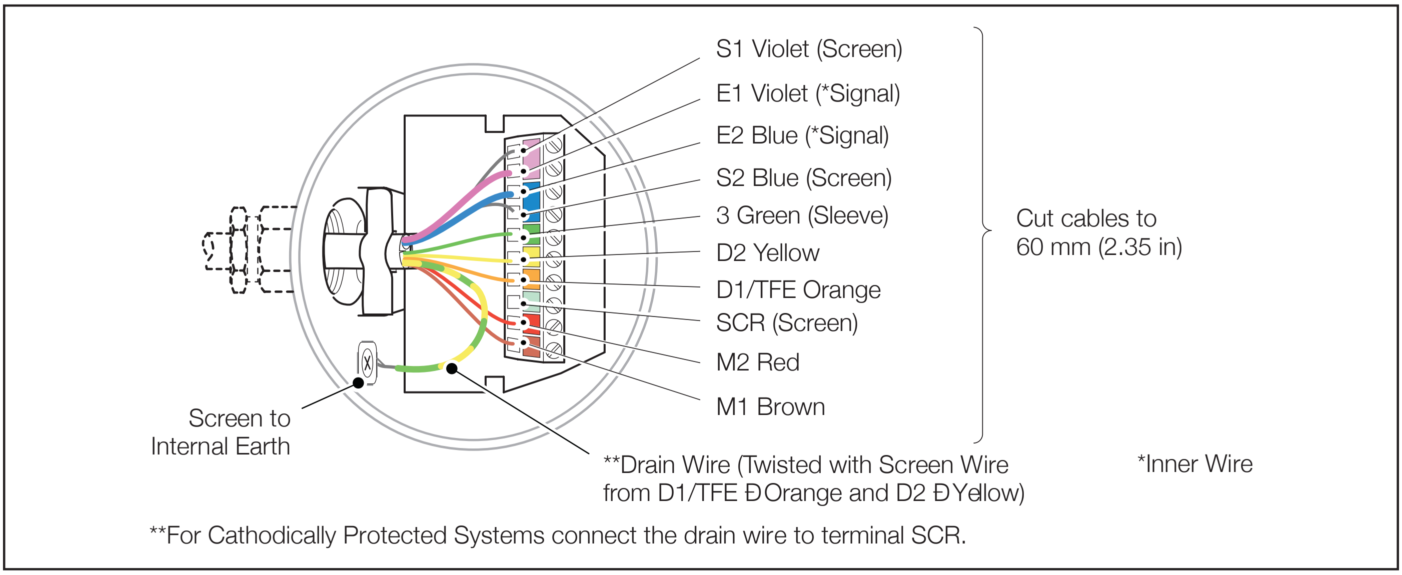

Figure 22. ABB WaterMaster sensor connection schematic, courtesy of ABB

The signals contained within this cable are low level and proprietary and as such a specially designed SPD is required to deal with the combinations of signals, common and transverse mode effects, and the high frequency of some of the signals.

This special SPD is the Novaris WMP-8.2 shown in figure 23.

Figure 23. Novaris water meter protector WMP-8.2

5.8 Ethernet & Industrial Ethernet, PoE

Load cells are common in the process control industry for weighing incoming/outgoing commodities and for monitoring the stock levels in silos and hoppers.

Load cells are extremely sensitive to surge damage and installing an inappropriate SPD can affect the calibration of the cells and lead to erroneous measurements.

Novaris has overcome these issues by designing a specific SPD to protect load cells of both 4 and 6-wire configuration, this is shown in figure 24.

The Novaris LCP is certified by the Australian National Standards Commission (No. S366). This certification confirms that when installed the LCP will not affect calibration of the weighing system.

Figure 24. Load Cell Protector

The LCP should be installed as close to each load cell as possible, one LCP for each loadcell, and the earth stud connected to the mounting point of the support frame of the load cell itself. If the measuring equipment is more than 10 meters from the closest loadcell then another LCP should be installed at the connection of the measuring equipment. The earth stud of this LCP should be connected to the earth point or chassis of the measuring equipment.

Junction boxes between load cells do not require LCP's to be installed.
Figure 25 below details the connection of an LCP in 6-wire configuration as required at each load cell.

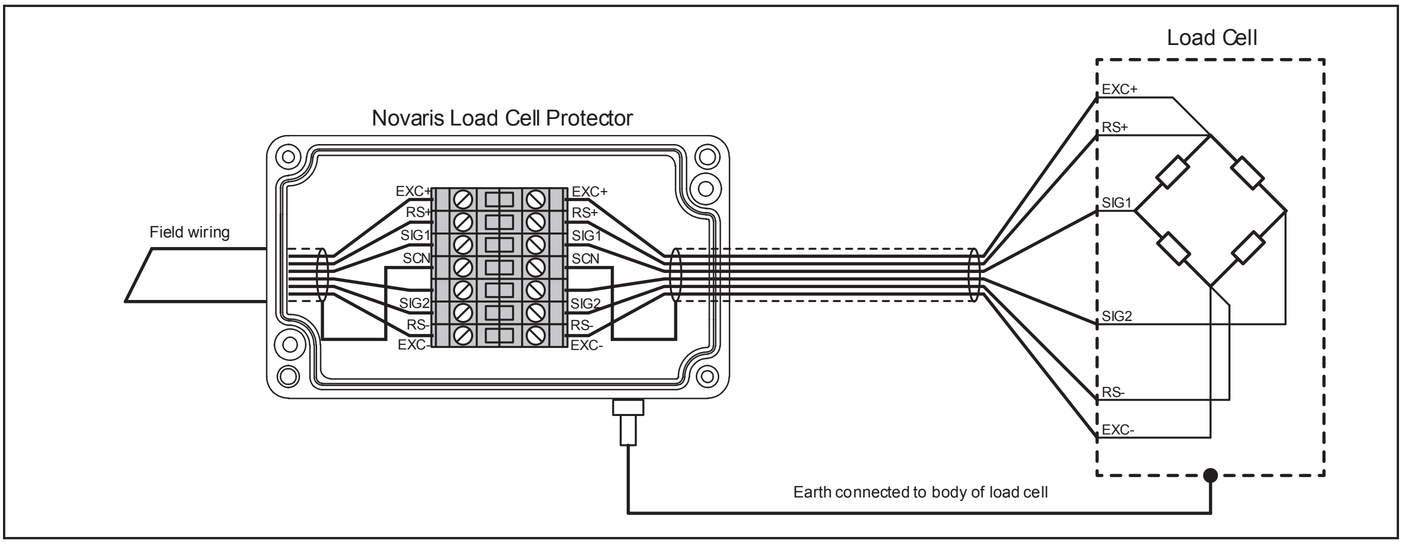

Figure 25. LCP Wiring Schematic

7 SIGNALLING PROTOCOLS

This table outlines some of the most common signalling protocols and the product best suited to these applications. For other signalling protocols, please contact Novaris to discuss the requirements.

		Novaris Product		
Protocol	**Signal Type**	**High Exposure**	**Low Exposure**	**Field Instrument**
I/O (Analog / Digital) <500mA)	± 7VDC, <60MHz	SL2-7v5	SL7v5-G	SLT1-7v5
I/O (Analog / Digital) <500mA)	± 16VDC, <60MHz	SL2-18	SL18-G	SLT1-18
I/O (Analog / Digital) <500mA)	± 34VDC, <60MHz	SL2-36	SL36-G	SLT1-36
I/O (Analog / Digital) <500mA)	± 65VDC, <60MHz	SL2-68	SL68-G	SLT1-68
I/O	0-20mA / 4-20mA	SL2-36	SL36-G	SLT1-36
I/O	RS232	SL4-36	SL36-EC90	SLT3-36
I/O	RS422	SL4-485 + SL1-G90	SL485-EC90 (x2)	SLT4-7v5
I/O	RS485	SL2-485-EC90	SL485-EC90	SLT1-7v5
I/O	1-Wire	SL2-485-EC90	SL485-EC90	SLT1-7v5
I/O (Digital <10A)	2-Wire 24VDC	SSP10A-38	SSP6A-38 (6A)	SLT1-36
I/O (Digital <6A)	4-Wire 24VDC Dual Channel	SSP4-6A-38	SSP4-6A-38	SLT4-36
I/O (Analog / Digital <10A)	3-Wire (Signal, 24VDC Power)	SLC-36	SLC-36	SLT3-36
I/O (Analog / Digital <10A)	4-Wire (Signal, 24VDC power)	SLC-36	SLC-36	SLT4-36
I/O (RTD)	2-Wire RTD	SL2-RTD	SL-RTD	SLT1-RTD
I/O (RTD)	3-Wire / 4-Wire RTD	SL4-RTD	SL4-RTD	SLT4-RTD
10 / 100 / 1000T	Ethernet	DRJ45-1CAT6	DRJ45-1CAT6	RJ45-1CAT6-IP67
AS-i	32VDC 1-Pair	SL2-36	SL36-G	SLT1-36
BACnet	ARCNET / Ethernet / BACnet/IP	DRJ45-1CAT6	DRJ45-1CAT6	RJ45-1CAT6-IP67
BACnet	RS-232	SL4-36	SL36-EC90	SLT3-36
BACnet	RS-485	SL2-485-EC90	SL485-EC90	SLT1-7v5
BitBus	RS-485	SL2-485-EC90	SL485-EC90	SLT1-7v5
CAN Bus (Signal)	5VDC 1-Pair	SL2-36	SL36-G	
C-Bus	36VDC 1-Pair	SL2-68	SL68-G	SLT1-68
CC-Link / LT / Safety	RS-485	SL2-485-EC90	SL485-EC90	SLT1-7v5

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Protocol	**Signal Type**	**High Exposure**	**Low Exposure**	
CC-Link IE Field	Ethernet	DRJ45-1CAT6	DRJ45-1CAT6	RJ45-1CAT6-IP67
CCTV	Power over Ethernet	DRJ45-1CAT6	DRJ45-1CAT6	RJ45-1CAT6-IP67
DALI / DALI 2	Digital Serial Interface	SL2-36	SL36-G	SLT1-36
Data Highway / Plus	RS-485	SL2-485-EC90	SL2-485-EC90	SLT1-7v5
DeviceNet (Signal)	5VDC 1-Pair	SL2-7v5	SL7v5-G	SLT1-7v5
DF1	RS-232	SL4-36	SL36-EC90	SLT3-36
DirectNET	RS-232	SL4-36	SL36-EC90	SLT3-36
DirectNET	RS-485	SL2-485-EC90	SL485-EC90	SLT1-7v5
Dupline (Signal)	5VDC 1-Pair	SL2-7v5	SL7v5-G	SLT1-7v5
Dynalite	DyNet	DRJ45-1CAT6	DRJ45-1CAT6	RJ45-1CAT6-IP67
EtherCAT	Ethernet	DRJ45-1CAT6	DRJ45-1CAT6	RJ45-1CAT6-IP67
Ethernet Global Data	Ethernet	DRJ45-1CAT6	DRJ45-1CAT6	RJ45-1CAT6-IP67
Ethernet Single Pair (SPE)	Single Pair Ethernet	SPE-1	SPE-1	SPE-1
Ethernet Powerlink	Ethernet	DRJ45-1CAT6	DRJ45-1CAT6	RJ45-1CAT6-IP67
FIP Bus	RS-485	SL2-485-EC90	SL485-EC90	SLT1-7v5
FINS	Ethernet	DRJ45-1CAT6	DRJ45-1CAT6	RJ45-1CAT6-IP67
FINS	RS-232	SL4-36	SL36-EC90	SLT3-36
FINS	RS-485	SL2-485-EC90	SL485-EC90	SLT1-7v5
FINS	DeviceNet (Signal)	SL2-36	SL36-G	SLT1-36
Fire and Security	12V	SSP10A-14	SSP6A-14-G	
Fire and Security	24V	SSP10A-38	SSP6A-38-G	
FOUNDATION Fieldbus H1	32VDC 1-Pair	SSP10A-38	SSP6A-38-G	SLT1-36
FOUNDATION Fieldbus HSE	Ethernet	DRJ45-1CAT6	DRJ45-1CAT6	RJ45-1CAT6-IP67
GE-SRTP	Ethernet	DRJ45-1CAT6	DRJ45-1CAT6	RJ45-1CAT6-IP67
HART	4-20mA + HF Data	SL2-36	SL36	SLT1-36
HostLink	RS-232	SL4-36	SL36-EC90	SLT3-36
HostLink	RS-422	SL4-485 + SL1-G90	SL485-EC90 (x2)	SLT4-7v5
Interbus	RS-485	SL2-485-EC90	SL485-EC90	SLT1-7v5
KNX	30V, 1.2A DC max, 9.6kb	SSP10A-38	SSP6A-38	SSP6A-38 / SSP10A-38
Load Cell 12V	Wheatstone Bridge	LCP-18	LCP-18	LCP-18
Load Cell 24V	Wheatstone Bridge	LCP-36	LCP-36	LCP-36
MODBUS	RS-485	SL2-485-EC90	SL485-EC90	SLT1-7v5

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Protocol	**Signal Type**	**High Exposure**	**Low Exposure**	
MODBUS	Ethernet TCP / IP	DRJ45-1CAT6	DRJ45-1CAT6	RJ45-1CAT6-IP67
OPC UA	Ethernet TCP / IP	DRJ45-1CAT6	DRJ45-1CAT6	RJ45-1CAT6-IP67
P-Net	RS-485	SL2-485-EC90	SL485-EC90	SLT1-7v5
PieP	Ethernet	DRJ45-1CAT6	DRJ45-1CAT6	RJ45-1CAT6-IP67
PoE, UPoE, UPoE+	Power over Ethernet	DRJ45-1CAT6	DRJ45-1CAT6	RJ45-1CAT6-IP67
Process Bus (P-Bus)	RS-485	SL2-485-EC90	SL485-EC90	SLT1-7v5
Profibus DP/FMS	RS-485	SL2-485-EC90	SL485-EC90	SLT1-7v5
Profibus PA	32VDC 1-Pair	SL2-36	SL36-G	SLT1-36
Profinet IO	Ethernet	DRJ45-1CAT6	DRJ45-1CAT6	RJ45-1CAT6-IP67
PSTN	POTS	SL-PSTN	KP1/10	MPP-RJxx
S-Bus	32VDC 1-Pair	SL2-36	SL36-G	SLT1-36
SDS	4-Wire (Signal, 24VDC power)	SLC-36	SLC-36	SLT4-36
Sercos III	Ethernet	DRJ45-1CAT6	DRJ45-1CAT6	RJ45-1CAT6-IP67
Sinec H1	Ethernet	DRJ45-1CAT6	DRJ45-1CAT6	RJ45-1CAT6-IP67
SynqNet	Ethernet	DRJ45-1CAT6	DRJ45-1CAT6	RJ45-1CAT6-IP67
VDSL	VDSL	MPP-VDSL	MPP-VDSL	MPP-VDSL-IP67

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