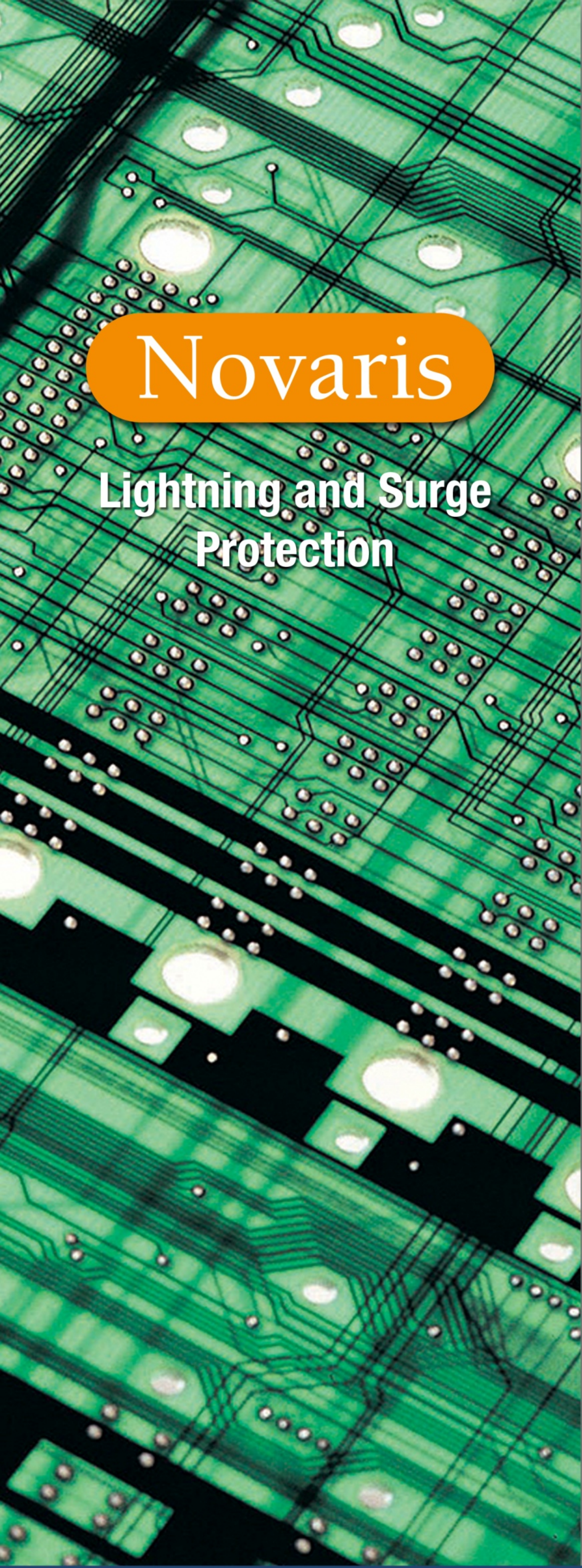

Novaris

Lightning and Surge Protection

iSwitch Technology for Instrument Surge Protection

Application Note

Phillip Tompson

This paper discusses the merits and applications of iSwitch technology in the surge protection of data and signalling lines. In particular a design solution is presented for the surge protection of 4-20mA instrument loops that overcomes a fundamental shortcoming in existing traditional designs.

This application note should be read in conjunction with Novaris Application Note 0015-D30V1 that discusses iSwitch technology in more detail.

1. Background

Of all process control I/O, analogue instrument circuits are the most vulnerable to overvoltage disturbances caused by lightning and other voltage transients. The most common analogue input is the 4-20mA loop. Surge protection for these instrument loops generally comprises two port SPDs containing a primary gas discharge tube (GDT) and secondary ZnO varistors or avalanche diodes (transzorbs). They generally provide effective protection.

Unfortunately the very configuration of the loop circuit can be problematic to the SPD. The GDT once fired can place a short circuit upon the power supply. This can cause the SPD to fail, overheat or, if fitted, for internal fuses to fail.

A design utilising the advantages of the iSwitch overcomes these difficulties and provides a far more effective and reliable device.

A similar design philosophy can be adopted for surge protection for RS485 signalling and provides significant improvements in reliability over more traditional methods.

2. The 4-20mA instrument loop

The 4-20 mA current loop is one of the most common sensor signalling standards for analogue instruments. Current loops are ideal for data transmission because of their inherent insensitivity to electrical noise. In a 4-20 mA current loop, all the signalling current flows through all components; the same current flows even if the wire terminations are less than perfect. All the components in the loop drop voltage due to the signalling current flowing through them. The signalling current is not affected by these voltage drops so long as the power supply voltage is greater than the sum of the voltage drops around the loop at the maximum signalling current of 20 mA.

Figure 1 shows a schematic of the simplest 4-20 mA current loop. There are four components:

1. A DC power supply, generally 24V;
2. A 2-wire transmitter;
3. A receiver resistor that converts the current signal to a voltage;
4. The wire that interconnects it all.

The two R_{wire} symbols represent the resistance of the wires running out to the sensors and back to the power supply and controller.

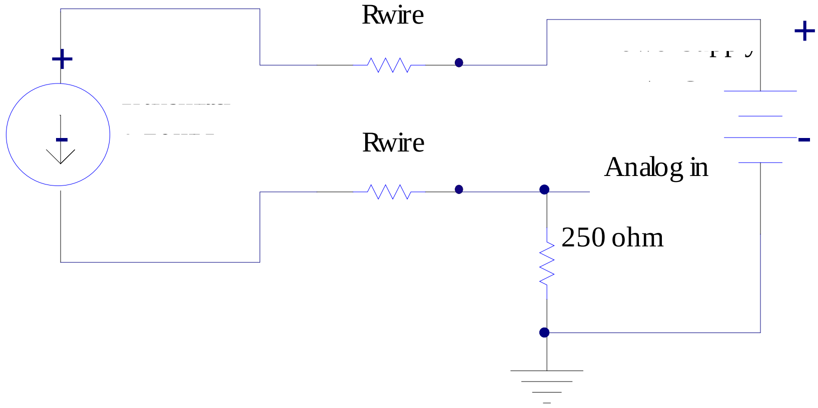

Figure 1. Basic Current Loop Schematic

3. Surge protection for current loops

Most manufacturers of surge protection devices provide products for the protection of 4-20mA instrument loops. These are most often two port designs using a three terminal GDT as the primary protection, followed by a series impedance then secondary voltage clamping components using ZnO varistors or avalanche (transzorb) diodes or both. The series impedance may be resistors or inductors or a combination of these. Figure 2 shows a typical SPD configuration applied to the schematic of figure 1. Note that line fuses are included in this schematic. The addition of these is often optional but when used are generally rated at around 100mA.

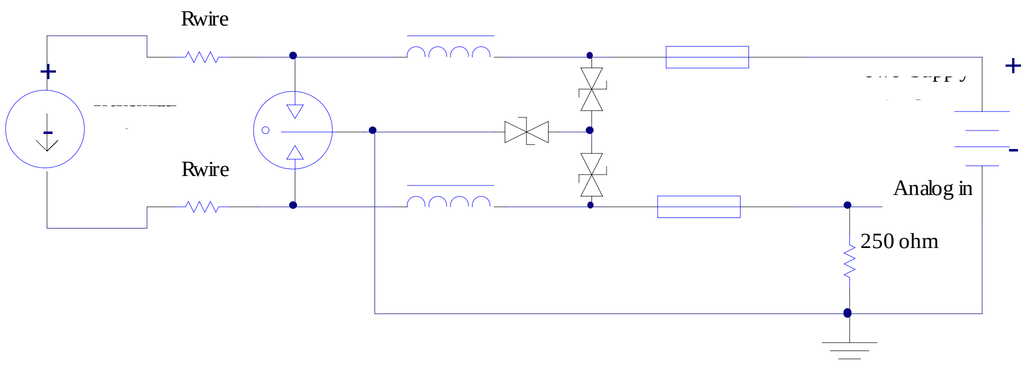

Figure 2. SPD protection applied to the current loop

This configuration has two potential shortcomings. Firstly if an overvoltage does not trigger the GDT the transzorbs will be called to dissipate all the energy and may be damaged. This is a real possibility if AC induction is the source of disturbance because the coordination inductor then has no effect. Secondly if the GDT fires, then the power supply is effectively short circuited through the common earth connection. One positive leg fuse will immediately rupture and the loop broken. If there are no fuses then the positive leg coordinating impedance will overheat and eventually be

destroyed. This problem is not uncommon because most small GDTs will not extinguish under the application of 24VDC.

4. iSwitch solution

If the coordinating impedances are replaced with iSwitch components both problems described above are overcome. The iSwitch has a maximum operating current of 180mA and a trip current of 290mA. The advantages are:

1. The transzorbs can never pass more than 290mA and then only for less than a microsecond. So they will not be damaged.
2. Once the iSwitch opens the GDT must fire as it is no longer held to the transzorb voltage, (particularly the case with AC induction).
3. Once the iSwitch opens the 24V supply is disconnected from the SPD, the GDT will immediately extinguish, the iSwitch reset and the circuit will be back to normal without any disruption.

Figure 3 shows this arrangement. Note that some components are omitted from the SPD for clarity.

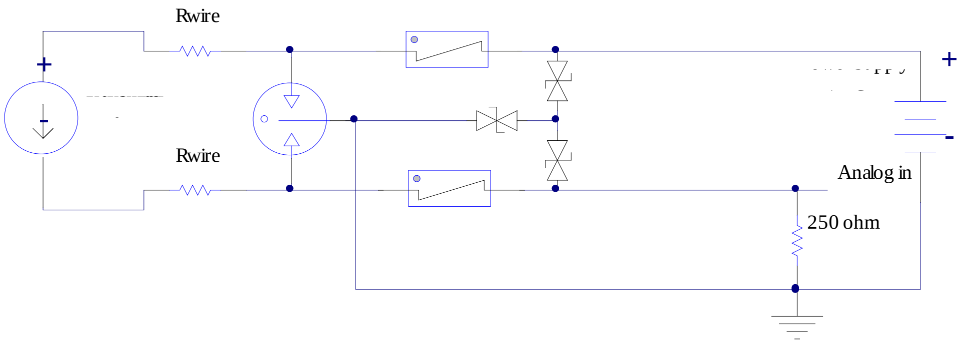

Figure 3. iSwitch solution for analog input

It is now possible to provide a complete protection solution using the iSwitch SPD (Novaris model SL420i) in conjunction with the Novaris field instrument protector (model SLT1-36-M20). The SLT is connected as shown in figure 4. The GDT provides common mode protection from each line to earth and a further GDT provides protection from the screen to earth (the instrument frame). This configuration means the screen is still open circuit under normal operation but all conductors are clamped to earth during an overvoltage disturbance. The transzorb diode provides transverse mode protection.

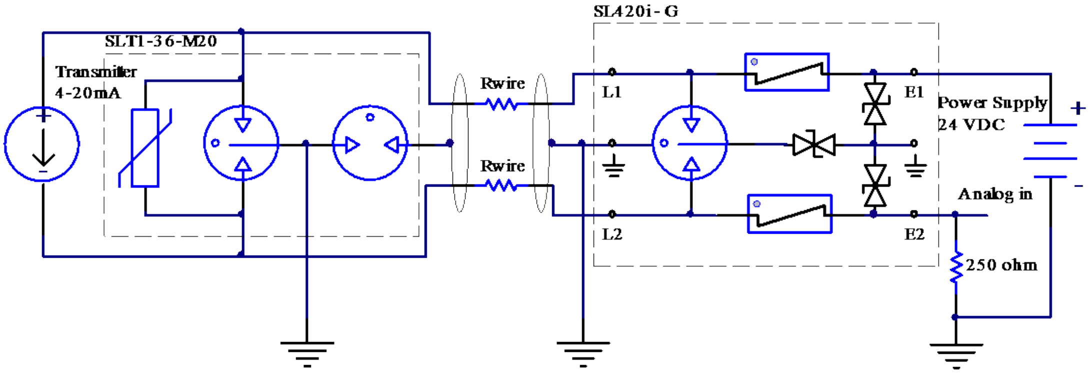

Figure 4. Complete instrument loop protection using SL420i-G and SLT1-36-M20

The Novaris SLT1-36-M20 is housed in an ExD rated threaded enclosure. It has four coloured leads identified as in figure 5.

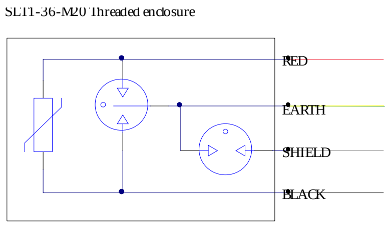

Figure 5. SLT1-36-M20 Configuration

5. Protection for RS485 signalling

As a standard for industrial communications, RS-485 features fast data rates that achieve 35 Mbps for short distances (12m) and 100 kbps over longer distances (1200m).

RS-485 systems are inherently more robust than many other networks because the signal is delivered differentially between two wires, relative to a third reference voltage. The reference voltage is often, but not always, the local earth potential. This provides substantial immunity to common mode noise such as ground noise and induced noise from nearby motors, solenoids and transformers. The interface uses voltages that are high by communication system standards, also making it more robust than networks using other protocols.

Transients and surges can be generated by induced energy on the data lines due to environmental conditions or switching of heavy inductive loads. Any of these issues can degrade the serial port’s data transfer performance.

RS-485 commonly is deployed in building automation, security system controls, and other industrial process control applications.

RS485 is a half-duplex differential signalling scheme. Figure 6 shows the configuration of the Novaris SL485i. For clarity not all circuit components are shown. For RS422 and other four wire duplex signalling schemes use two SL 485i devices.

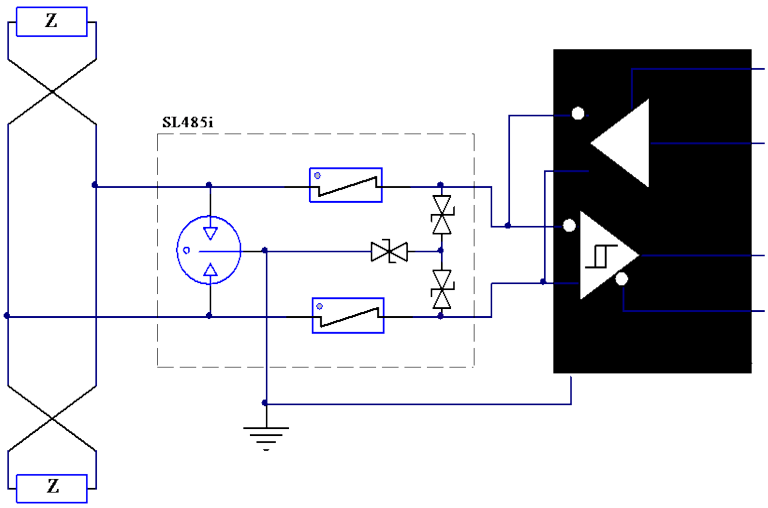

Fig 6. Protection for RS485 using SL485i

6. Novaris SLDIN–G and SLDIN-EC90 SPD bases

Most process control and field instrument cables are screened. The usual practice is to earth one end of the screened cable only in order to avoid interference and noise caused by earth loops that could occur by earthing both ends of the screen at points of different potential. In a typical process control application the I/O end of the screen would be earthed to the instrument earth bar in the marshalling cubicle. For effective protection this must be bonded to the electrical earth in the cabinet. If this cannot be directly bonded it should be bonded via an EC20-90 earth clamp.

At the remote end, the field instrument, the screen would be left unterminated.

This principle conflicts with the requirement for effective protection from overvoltage disturbances where each end of the cable must be referenced to a common point. To overcome this difficulty Novaris manufactures two versions of its SL base. The SLDIN-G base connects the common terminal to earth via the DIN rail clip. The SLDIN-EC90 base connects the common terminal to earth through the DIN rail clip via a small gas discharge tube contained within the base.

At a location where the cable screen is earthed the SLDIN-G base is used and at a location where the cable screen is not earthed the SLDIN-EC90 base is used.

All Novaris SL, SLi and SSP protection modules may be used with either base depending upon the circumstances. Figure 7 shows a typical application.

Novaris Pty Ltd
33 061 301 88
novaris.com.au
sales@novaris.com.au
72 Browns Rd, Kingston
TAS, AUSTRALIA 7050
Tel +613 6229 7233
Fax +613 6229 9245
Document No: 0015-D31V1

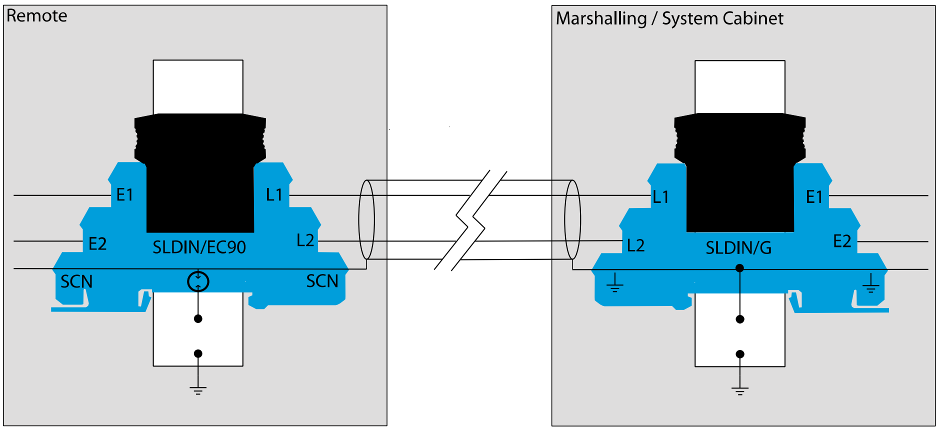

Fig 7. Application of SLDIN-G and SLDIN-EC90 bases

Novaris Pty Ltd
33 061 301 88
novaris.com.au
sales@novaris.com.au
Document No: 0015-D31V1
72 Browns Rd, Kingston
TAS, AUSTRALIA 7050
Tel +613 6229 7233
Fax +613 6229 9245