Surge Protection for Instrumentation

Voltage/Current Loop Protection

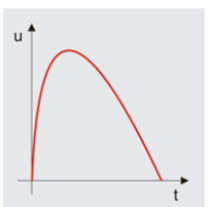
The omnipresent 4-20mA current loop and its voltage derivatives are commonly found in industrial installations wherever analogue processes are controlled and monitored. Most commonly twisted pair cables are used to interconnect field mounted sensors and devices back to supervisory and control equipment located in control rooms. Whenever signals that are sent over copper cables, leave or enter a building, the risk of transient voltage damage is dramatically increased. Some form of surge protection is desirable in this case.

To understand surge protection techniques, we should take a look at the components used in surge protection devices.

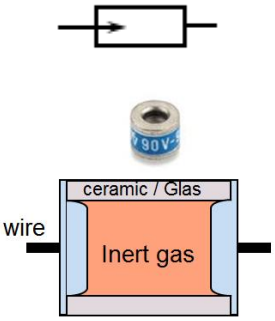
Components used in Surge Protection Devices

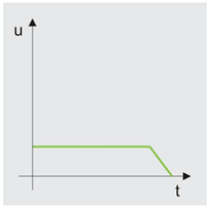
Gas Discharge Tubes

Gas Discharge Tubes (GDT'S) are enclosed spark gaps. They typically consist of a sealed ceramic tube containing an inert gas. One electrode is found at each end and sometimes a third electrode is placed in the centre. When a voltage is present, that is higher than the spark over voltage the gas ionises producing an arc. The arc provides a low impedance path for the transient to be discharged to earth clamping the output to a safer level.



Transient Waveform



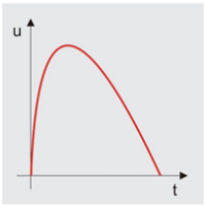


Clamped Output

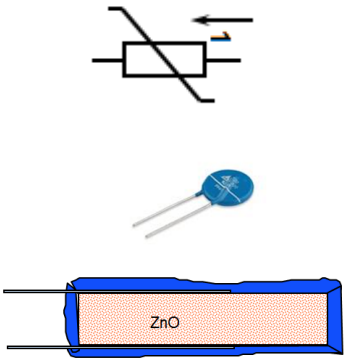
Metal Oxide Varistors

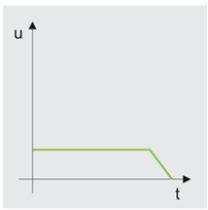
Metal Oxide Varistors (MOV's) are nonlinear resistors. They exhibit a very high resistance under normal operating conditions but become an effective short circuit once the clamping voltage is exceeded. MOV's are typically made from two conductive plate electrodes separated by a zinc oxide compound. When a voltage above the rating of the MOV is applied, randomly placed PN junctions are formed. These diode junctions effectively form a non-polarised connection between the two electrodes providing an effective short circuit.

The advantage of MOV's over GDT's is that they operate over 1000 times faster. This fact makes them very effective in providing surge protection from very fast transients. The disadvantage is that they have a finite life and degrade over time when conducting transients. Surge protection devices incorporating MOV's should have some alarm to inform that they have failed.



Transient Waveform

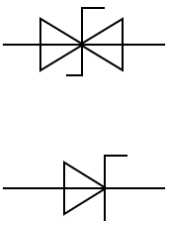


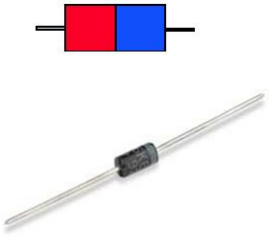


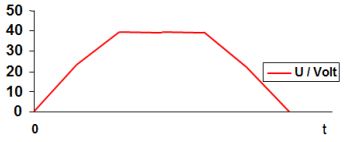
Clamped Output

Transient Suppression Diodes

Transient-voltage-suppression diode operate in a similar manner to Zener diodes but can handle high currents for very short periods. They are commonly used in multistage surge protection devices to clamp the residual voltage to a more acceptable level. They have a particularly fast response and can switch 1000 times faster than a MOV.







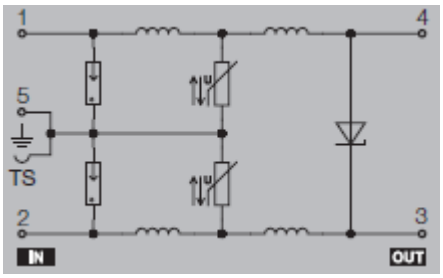
Clamped Output

Multistage Surge Protection Devices

Single stage devices only give a basic level of protection. For process instrumentation applications something more sophisticated is desirable. A combination of two or three different types of devices together in one module to obtain a much greater level of protection is recommended. An example is shown below.

Unprotected field side

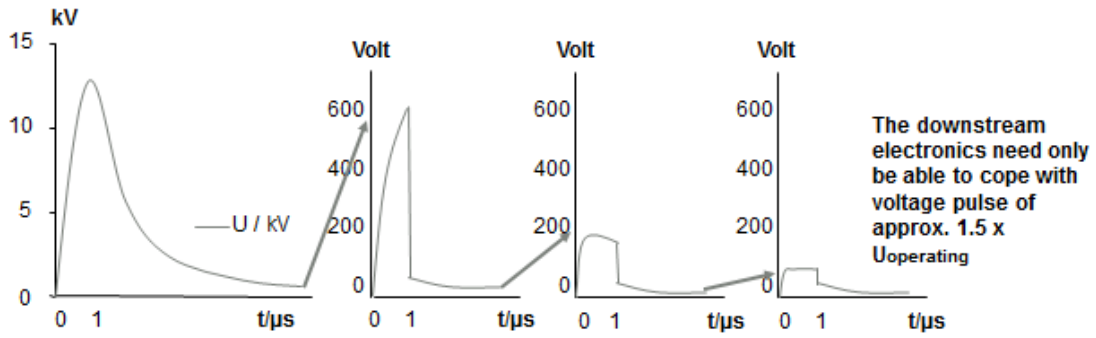
To sensor



Protected side

To PLC

In the diagram above you will see GDT's, MOV's and a Tranzorb connected in a three-stage arrangement. Note series inductors must be included to prevent the second and third stages from conducting before the GDT, and MOV has time to respond. The graphs below show the relative attenuation for each different device. With an input transient of around 15kV, we can achieve a protection level of around 1.5 x the supply voltage. In this case, about 36 to 40VDC for a 24VDC supply.



Transient GDT MOV Tranzorb

Each stage provides additional attenuation of the transient voltage to a safe level.

Failure Modes

This method of surge protection for instrumentation loops has been in use for many years. However, it is not without its problems. The weak link in the chain is the MOV. As the device ages and conducts multiple transients its effectiveness diminishes to a point where it can fail as a short circuit. This has been known to lead to fires if some way of disconnecting the MOV is not utilised. It is very difficult to provide status feedback on the failure of the MOV plus the added cost of monitoring could be prohibitive.

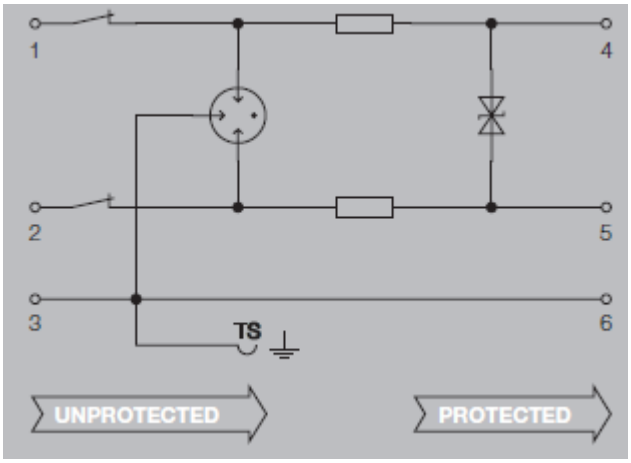
A safer more reliable solution is now available.

Increased Reliability and Safety with 2 Stages

Some manufacturers can now offer a more reliable solution. This solution removes the MOV's completely. By stringent selection of the latest GDT's and Tranzorbs, we can achieve overlapping voltage protection characteristics. This **two stage** surge protection device provides the equivalent level of protection as the old three stage version but is far more reliable.

Unprotected side

To sensor



Protected side

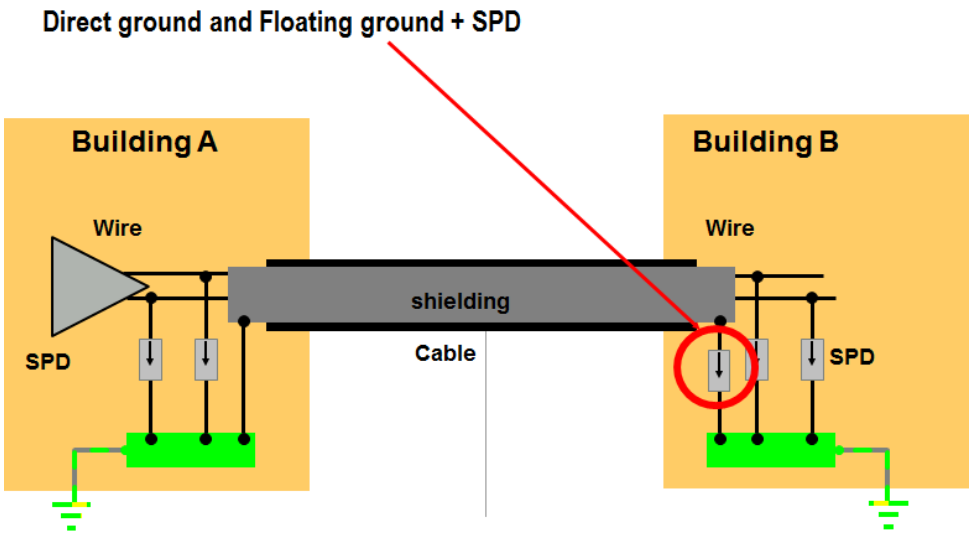
To PLC

Added Protection Circuitry

To meet the IEC 61643-21: 2008 standard for overstress mode, products are now available with a thermal switch attached to the body of the GDT. This provides a sacrificial short circuit to earth if the device is overloaded by a transient above its ratings. This greatly reduces the possibility of overheating of the device leading to fire. As a result, of the permanent short to earth, it will be evident that the instrumentation loop has shorted to earth, and a replacement can be quickly installed.

Direct and Floating Ground

When connecting instrumentation loops, it is standard procedure to earth the screen of the twisted pair cable at one end, typically the end of the control room. If we install surge protection at each end of the cable, we need to earth the shield at both ends to ensure efficient surge protection. If we connect the shield to earth at both ends, we can end up with the possibility of circulating currents from different earth potentials. This can cause errors in the signal levels or complete loss of transmission. To overcome this, a floating ground is provided in the surge protection device at the field end. This is achieved by including a GDT in series with the earth connection. For this reason, suppliers provide both direct and floating ground versions where the direct connection to the ground under normal operating conditions is not possible.



Surge protection for instrumentation circuits has often been ignored!

Today's surge protection devices are designed to give the maximum levels of protection within the smallest footprint. With critical processes relying on clean and accurate signals, more consideration should be given to the selection of appropriate surge protection devices. Once installed correctly they can greatly enhance overall system reliability.

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