Based on an article entitled ‘Isolators or Barriers for Intrinsic Safety’,
published in Control and Instrumentation, November 1986

Fire detection in hazardous areas

Isolators can ease the application of fire and smoke detectors in hazardous areas. This article examines the possibilities.

The use of traditional shunt-diode safety barriers with certified detectors in an intrinsically safe (IS) fire and smoke protection system requires that the system be designed with certain limitations regarding voltage and earthing. A range of certified galvanic isolators removes these restrictions and allows conventional fire zone panels to be specified.

In the field of fire protection practically all buildings contain sufficient combustible material for fire prevention and detection procedures to be considered. Many industrial processes and plant handle or produce gases or vapours which, if released and mixed with air, can form a potentially explosive atmosphere. Installation of electrical equipment in such plants should follow the recommendations given in EN60079-14, *Electrical Apparatus for Explosive Gas Atmospheres - Part 14 Electrical Installations in Hazardous Areas (other than mines).* Fire and smoke detectors for use in such designated areas must themselves be prevented from causing ignition of the gas or vapour likely to be present.

The most suitable form of protection for low-power sensors and instrumentation is called intrinsic safety. The technique is based on limiting the amount of energy available in the hazardous area to below that required for ignition. Intrinsic safety is the only technique which considers faults in equipment and field wiring, and which is permitted for use in the most hazardous area, Zone 0. Live maintenance in the hazardous area is another feature available only with intrinsic safety. Energy-storing apparatus in the hazardous area must be certified as suitable for the intended Zone of use and the gas or vapour expected. A certified interface device must also be used to prevent fault energy passing into the hazardous area from safe-area equipment faults. such a device can be either a shunt-diode safety barrier or a galvanic isolator. Each, correctly applied, gives the same degree of electrical protection. Barriers have been successfully used for many years in an enormous number of applications. Isolators tend to be more expensive and are normally designed with a specific application in mind.

The traditional shunt-diode safety barrier uses reverse-biased Zener diodes, to clamp the safe area output voltage, and series resistors to limit the current. This results in the fire zone control panel output voltage being squeezed between the barrier maximum operating level and the detector minimum voltage requirement. Furthermore, correct operation of a shunt-diode safety barrier depends upon the provision of a high integrity, low-impedance earth path for the return of fault currents. These features can readily be accommodated in the design of a complete installation, but if only a small proportion of the building or plant is classified as a hazardous area then having to re-specify the control panel operation and make an IS earth available may be both expensive and inconvenient.

In use, fire and smoke detectors are widely distributed throughout the plant. Areas monitored by detectors are called fire protection zones and each zone has one or more detectors in parallel. Two wires connect each zone to a zone control card and the current flowing through each loop is monitored. Detectors typically take 4mA in standby mode and up to 40mA in alarm mode. End-of-line resistors are used so that short circuit and open circuit line faults can be distinguished from normal and alarm conditions.

The use of certified galvanic isolators does away with many of the restrictions imposed by shunt-diode safety barriers. Galvanic isolation means that there is no direct electrical connection between two circuits. Information and power transfer across the isolating boundary can be magnetic, mechanical or optically-coupled, for example transformers, relays and opto-isolators. The basic attraction of such an isolator as an IS interface is that when correctly designed, no high-integrity earth connection is required.

The safe-area side of the isolator can be used to condition or transform the signal in some suitable fashion. This circuit can also allow a large supply voltage range. The result is that interfacing to the IS fire detection zones becomes very much easier. Any fire zone loop powered by an isolator, is fully floating and therefore a single earth fault in the wiring does not cause an immediate fire alarm signal. The earth-free normal operation can further be improved if an earth leakage detector such as the MTL 4220 is used. Any single earth fault is detected and a warning (contact closure) given without affecting normal operation or giving a spurious fire alarm. A single MTL 4220 can be used in up to eight zone circuits, or more if a convenient means of loop disconnection is incorporated.

The current levels in the zone wiring have to be calculated and the zone panel set to discriminate those levels. The procedure for such a calculation is different for barriers and isolators and actual values are also affected by detector characteristics and end-of-line resistors. The examples below consider an Apollo ionisation smoke detector certified for a 28V 300Ω interface device, such as an MTL7728+ shunt-diode safety barrier or an MTL5061 galvanic isolator. The detector minimum standby voltage is 17V dc. Most control units provide 24V dc through a 100Ω monitoring resistor; however, in some circumstances the voltage level can fall. The following calculations are based on 24V dc.

Figure 1 - An MTL 7728+ shunt-diode safety barrier

A detector consists of a switch, a 400Ω (typical) resistor and a diode chain (~2V) all in series. In alarm, the switch closes and the resistor/diode chain appears in parallel with the end-of-line resistor. See Figure 2.

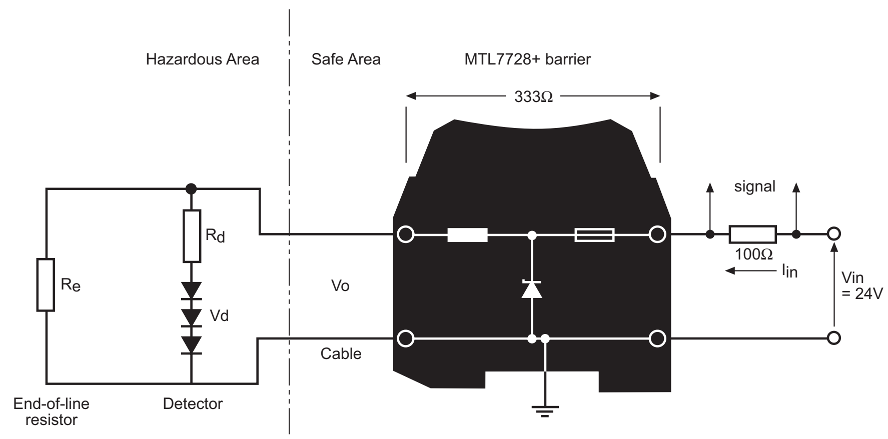

Figure 2 - Fire detector loop using a barrier

Example 1: IS fire detector loop using a shunt-diode safety **barrier**

The barrier safety description specified by the detector certificate is 28V 300Ω. An MTL7728+ barrier has a maximum operating voltage of 25.9V at 10µA leakage and a maximum end-to-end resistance of 333Ω. The circuit shown in Figure 2 includes actual values, not the barrier safety description, and assumes 100Ω resistance in the fire panel. The end-of-line resistor defines the monitoring current in normal mode so, ignoring barrier and detector leakage, and taking R1 as 3900Ω:

Monitoring current =

$$\frac{24}{100 + 333 + 3900} = 5.54\text{mA}$$

Detector standby voltage =

$$24 \times \frac{3900}{100 + 333 + 3900} = 21.6\text{V}$$

In alarm mode, the detector can be considered (for simplicity*) as just a 400Ω resistor in parallel with the end-of-line resistor (3900Ω). These are typical values but others can be substituted for further calculations.

Consequently, the total circuit resistance (ignoring any detector voltage drop)

$$= 100 + 333 + \frac{(3900 \times 400)}{(3900 + 400)}$$

$$= 433 + 362.8 = 795.8\Omega$$

and so with Vs = 24V dc the current drawn is

$$= 24 \div 795.8 = 30.2\text{mA}$$

Example 2: IS fire detector loop using a galvanic isolator

The safety description of the MTL4061 or MTL5061 isolators is 28V 300Ω which allows their use with most certified detectors. Figure 4 shows an MTL5061 connected into a typical loop. Both of these isolators include a voltage regulator and the supply voltage can be 20–35V dc. The output voltage (Vo) is related to the supply voltage (Vs) and the current drawn (I) in milliamps such that

Vo = Vs – (0.38 x current in mA) – 2V

or

Vo = 21 – (0.35 x current in mA)

if Vs = 24V or greater.

** if greater accuracy is required, see MTL web site link*
http://www.mtl-inst.com/tp1077.htm

Figure 3 - An MTL5061 isolator

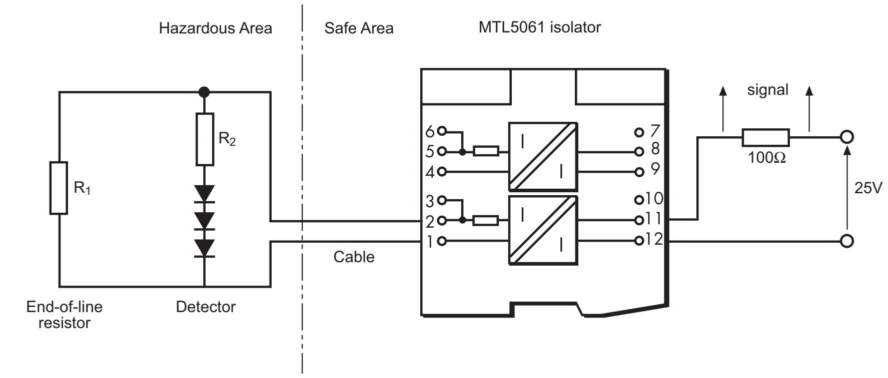

Figure 4 - Fire detector loop using a galvanic isolator

Determination of operating voltage and current for any particular load resistance is made much easier by using graphical techniques.

In Figure 5 the isolator output voltage/current relationship is shown as the heavy line for supply voltages greater than 24V. If the end-of-line resistor is again 3900Ω then a load line (1) of this slope intercepts the output line at 19.27V, 4.95mA. This is therefore the standby circuit condition.

The detector is considered as 400Ω + 2V (see load line 2) for minimum trigger current . In both cases the control unit settings should be:

<5mA open-circuit line fault
5–20mA normal mode
20–35mA alarm mode
>35mA short–circuit line fault

Whether a fire detection system uses barriers or isolators is a decision based on economic or applicational grounds, since both barriers and isolators give the same degree of protection when properly applied. Isolators tend to be more expensive than shunt-diode barriers because of their greater component count and complexity. However their wide power supply voltage tolerance can make them easier to use; particularly in plant extensions. Exposure of a barrier to a voltage at or above its maximum rating, even fleetingly, invariably blows the barrier fuse and the whole device needs to be replaced. The MTL4061and MTL5061 isolators however, can withstand transients up to 60V DC for 1ms without blowing the internal fuse.

A major advantage of an isolator is the removal of the requirement to provide a high–integrity IS earth which leads to a significant saving in installation cost. The isolator output is fully floating and not affected by a single earth fault. In the final analysis, it is important to remember that if you are going to fill your plant with foam, it had better be because of a fire not an earth fault.

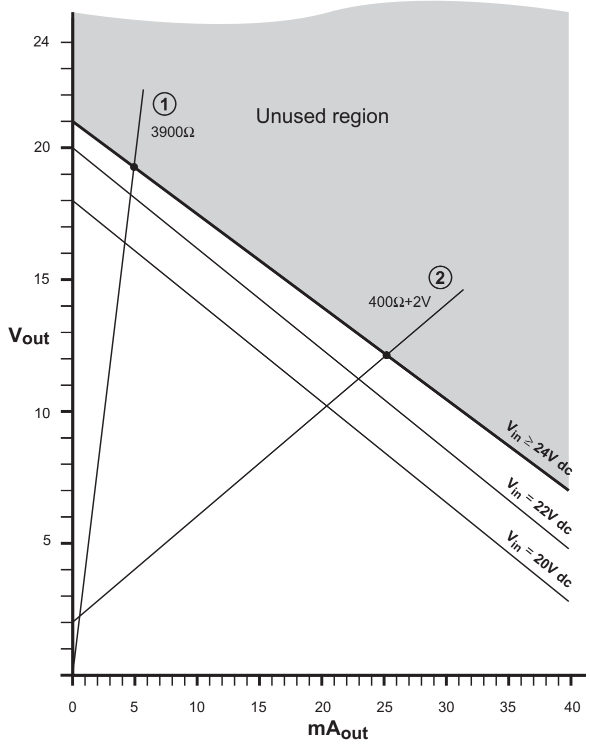

Figure 5 - MTL4061/MTL5061 load line graph

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