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IS-78: LONWORKS® goes into hazardous areas

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Hazardous Areas

Many industrial processes can give rise to a potentially explosive atmosphere. The areas at risk are known as hazardous areas. Any electrical equipment to be used in such areas must therefore be protected–by one of several techniques–to ensure that it cannot ignite the flammable atmosphere.

Present methods of extending bus communications networks into such areas often rely on expensive explosion-proof, flame-proof, pressurised or purged enclosures. The cost of these has meant that the extension of bus networks into hazardous areas has not occurred on a wide scale.

The most popular and cost-effective explosion protection technique for low-power applications is intrinsic safety (IS). It is based on the principle of restricting the energy available in hazardous-area circuits, so that any sparks or hot surfaces that may occur as a result of electrical faults are insufficient to cause ignition.

However, all previous attempts to apply this technique to bus communications networks have largely been proprietary, have been thwarted by the lack of a complete open network protocol or have had to be certified by using a complicated strategy. This has negated any cost-benefit. The ideal solution to extending bus networks into hazardous areas is therefore to develop an intrinsically-safe communication option for a standard open bus system. This should be available to designers and users in the form of pre-certified products and components, thus cutting certification costs and reducing development times.

This need was recognised by Measurement Technology Limited (MTL)–the world leader in intrinsic safety technology. The company also had expertise in network operating technology that had been gained in participating in the development of a physical layer for communication for IEC Fieldbus (IEC 1158-2). LONWORKS is a low-cost protocol which offers users a wide choice of interoperable products from different manufacturers. It needed only an open standard physical medium to allow its extension into hazardous areas to create a bus that could go anywhere.

LONWORKS network technology

LONWORKS networks are designed for control systems in which there are frequent communications of short messages between many nodes. Each node runs independently and has the capability of originating peer-to-peer communication as stimulated by events such as a change of state of inputs or a timeout. Nodes also have the capability of responding to requests for data or commands for action from other devices on the network.

The structure of a network is developed and installed using a network configuration tool. This is used to link the outputs of one node to the inputs of one or more other nodes. Once configured, information about communication links (the binding) is stored with EEPROM within each node.

A LONWORKS network, Fig 1, consists of a number of nodes connected by a suitable physical communications channel (a physical channel). There are a variety of different physical channels using different communications media including twisted pair, power line, radio frequency and optical fibre. There is also a variety of communication speeds.

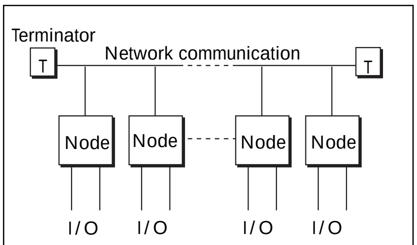

Fig 1 A LONWORKS network system

Each device connected to the network contains a NEURON® chip: an IC containing 3 microprocessors. Two of the processors are used for network communication but the third processor is used by instrument designers to program to run their application programmes.

On one side the NEURON chip has a transceiver that converts between physical signalling on the bus and logic levels at the NEURON chip. On the other side are 11 versatile I/O pins that can be configured for various functions.

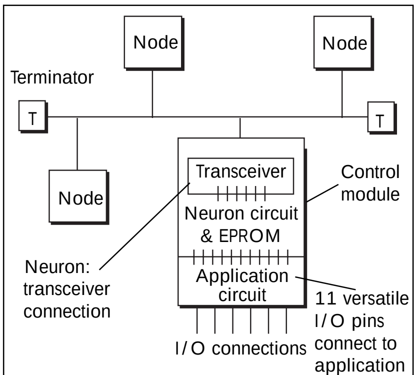

Fig 2 LONWORKS components

For each physical channel, transceivers and control modules (transceiver plus NEURON and associated circuitry, Fig 2) are available for designers to design into their products to accelerate product development.

Each physical channel has a limit for the maximum communication distance and the maximum number of nodes that can be connected to a single segment. If the number of nodes required in a network exceeds the maximum allowed, then two segments can be connected by using a 'router', Fig 3.

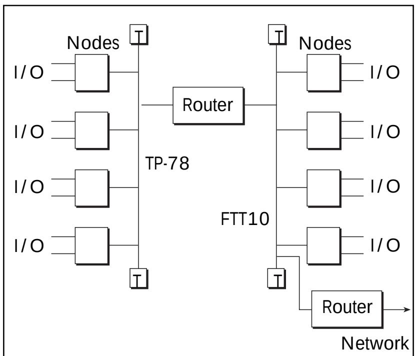

Fig 3 A LONWORKS network with a router

A 'router' normally consists of two NEURON chips connected back to back with one transceiver connected to each segment. Different physical channels can be interconnected by using routers with different transceivers to match the appropriate physical channels. Routers are used to build large networks and networks that need to use different physical channels.

To take LONWORKS networks into hazardous areas, MTL has developed IS-78, an intrinsically-safe physical channel that operates using twisted pair. As far as a network designer is concerned IS-78 is just like any other LONWORKS physical channel, with the exception that the requirements and regulations of intrinsic safety must also be followed.

Electrical circuits in hazardous areas

The laws of physics do not vary just because different circuits in hazardous areas are of different complexity or have different applications. Therefore, the overall restrictions imposed by intrinsic safety upon any circuit are similar. There are constraints on voltage, current, power, inductance and capacitance. All of these must be satisfied to eliminate the risk of ignition. Every circuit must be protected in such a way so that even in the presence of prescribed faults in either equipment or interconnecting cables the combination is incapable of causing ignition.

Research and experience of testing with spark-ignition test apparatus have produced sets of minimum ignition curves which are used by national and international standards for IS. These curves show the limiting combinations of voltage with current, capacitance with voltage and inductance with current for safety and define which combinations can be used.

Contact with a hot surface is an alternative cause of ignition. The relevant parameter influencing this for hazardous-area installations is the worst-case electrical power transfer (the matched power). The higher the matched power, the greater the surface temperature that can be caused under fault conditions. Smaller components can be used if the matched power connected to the device is limited. This is a significant advantage because there are internationally agreed relaxations of the testing of designs to achieve a T4 temperature classification provided the power supplied does not exceed 1.3W for a maximum ambient temperature of 40°C, (with corresponding figures of 1.2W at 60°C and 1.0W at 80°C). A T4 temperature classification covers the vast majority of industrial gasses. These testing relaxations apply to all components with a surface area between $20mm^2$ and $10cm^2$. While offering a significant advantage and simplification in the design and certification of equipment, the benefit is somewhat restricted when using surface mount technology because many common SMT packages have a surface area of less than $20mm^2$.

Inevitably, the different constraints pull against each other and choosing the appropriate values for any particular system is an exercise of optimising a compromise. As is shown in Figure 4, the practical operating region is voltage-limited by the reduction of allowed capacitance, and current-limited by the reduction in allowed inductance (remember the cable itself contributes capacitance and inductance).

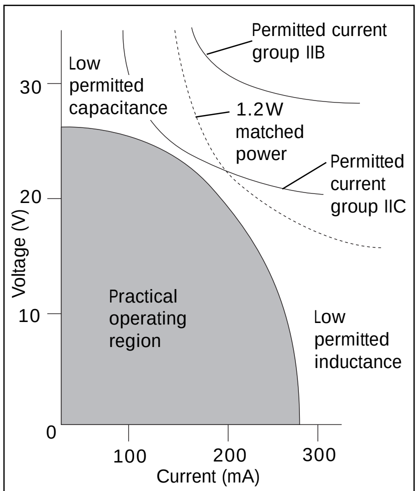

Fig 4 Intrinsic safety practical operating region

IS-78: standard physical channel for hazardous areas

From a network design point of view, IS-78 physical channel is just like any other LonWorks physical channel. Multiple devices can be connected and IS-78 can be linked to other physical channels by using routers. The difference with IS-78 is that it can be used in hazardous areas since it is certified intrinsically safe (if properly installed).

Any circuit or loop going into a hazardous area must have the voltage, current and matched power that can reach the hazardous area limited by using a certified shunt-diode safety barrier or galvanic isolator. For IS-78, this function is performed by an MTL3054 isolator. As well as its IS function, the MTL3054 acts as a physical repeater and converts standard TP/XF-78 communication into IS-78 as shown in Figure 5.

A typical IS node designed with 0.8u architecture (B series) Neuron running with a clock speed of 5MHz with all required power taken from the physical channel draws between 25 and 40mA. The limitations on the maximum current means that only 2 or 3 IS nodes can be powered by each MTL3054. The number of IS nodes can be increased if the nodes have additional IS sources of power.

Figure 7 illustrates a simple network diagram in which a segment of TP/XF-78 physical channel has a single spur of IS-78 going into a hazardous area.

Within this network the two hazardous area IS nodes could communicate to each other or to any of the safe area nodes directly as if the IS nodes were connected directly to the TP\XF-78 channel.

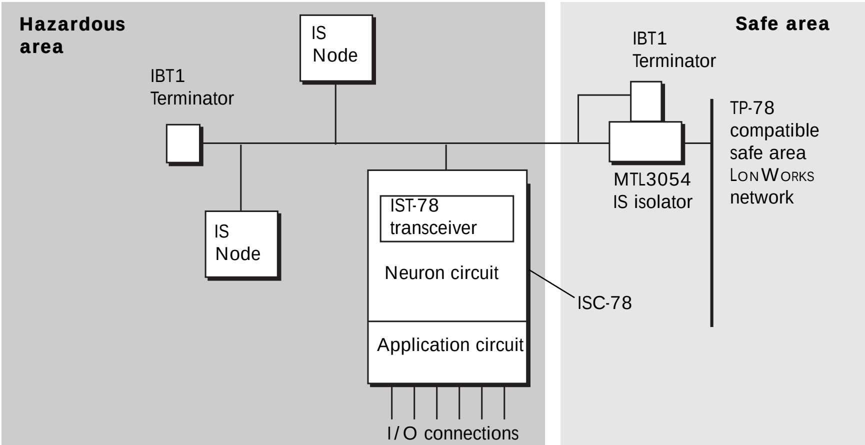

Fig 5 IS-78 components developed by MTL

IS-78 carries both power and communication signals on the same 2 wires. The total application current available is limited by the regulations of intrinsic safety. The usable application current is also a function of the cable length between the MTL3054 and the IS nodes. Figure 6 illustrates the relationship between cable length and the available application current. An IS barrier or isolator must have a series current limiting resistor in series with its output, and it is this resistor in combination with the resistance of the length of cable which causes the available voltage to fall as more application current is drawn (Ohms law $V=IR$!)

IS-78 offers two different topologies: bus topology and free topology. Bus topology requires all nodes to be connected to a single run of cable (the bus) and the bus should have a terminator at each end. With Bus topology, the maximum cable specification is 1000m with up to 8 nodes connected. Free topology has no restrictions on the arrangement of the cable, but there must be two terminators fitted to the network. With Free topology, the maximum total cable connected in any format is 300m with up to 8 nodes. (Note the maximum number of nodes in practice may be limited more by the power available.)

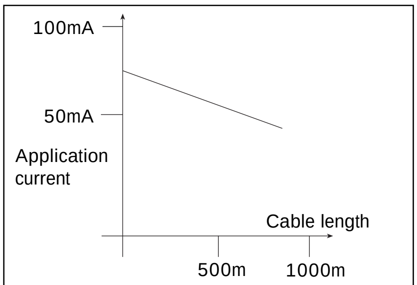

Fig 6 Current/cable length relationship for bus topologies

Figure 7 shows just a single spur going into the hazardous area from a network predominantly in the safe area but there is no reason that many spurs into the hazardous area should not be connected together in the safe area. Again all of the various nodes are effectively connected to the same segment even though they may have MTL3054 physical repeaters between them.

Unfortunately, in order to meet the requirements to be certified IS, the TP/XF-78 transceiver in the MTL3054 does not conform to the LonMark™ interoperability specification for TP/XF-78. The transceiver in MTL3054 loads the TP/XF-78 channel as if between 6 and 8 transceivers were connected. As a result, a modified specification has been produced

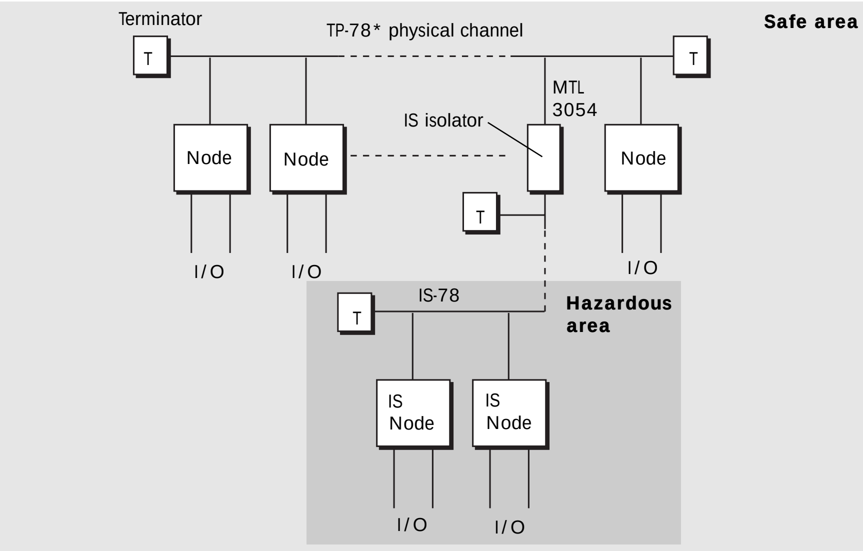

Fig 7 IS-78 takes LONWORKS into hazardous areas

called TP-78* which includes the changes to take account of this difference. Devices with normal TP/XF-78 transceivers operate with MTL3054s provided the modified specification is followed.

The modified TP-78* specification is not a major limitation to the design of networks.

What must be remembered is that once 8 (to be confirmed) MTL3054s have connected on a single segment then this is the limit and a router is required to connect more IS spurs into hazardous areas (see Fig 8).

The number of connections that can be made in the specification for TP-78* is analogous to the REN number system that is used for connecting telephone devices to a telephone line. For example two simple hand sets with a REN value of 1 each and a fax machine with a REN number of 2 can be connected to a household telephone line that can support a maximum of 4. Similarly, 6 MTL3054s with a loading of 8 and 16 standard TP/XF-78 nodes which each give a loading of 1 can be connected to a single TP-78* segment, which can support a maximum loading of 64 (6 x 8+16=64).

The limit of 8 MTL3054s does not impose such a restriction as it appears at first thought because more than one IS node can be connected to each MTL3054.

IS requirements prevent the TP/XF-78 transceiver in an MTL3054 from conforming to LONMARK interoperability guidelines. This does not prevent networks including hazardous areas from conforming to LONMARK guidelines. The solution is to use a router of which one side is connected to TP-78* and the other to TP/XF-78 (Figure 9).

IS-78 may also be used to communicate across hazardous areas, but two MTL3054s cannot just be connected together to give communication because the combination of the two power sources would exceed both the ignition curves and the matched power limits. The MTL3055 is a similar device, but with a reduced output and two MTL3055s can be connected together to offer communication across hazardous area with IIA or IIB gases. IS nodes can be connected to the physical channel in the hazardous area if required.

Communication to devices mounted in an explosion/flame proof enclosure can be treated as communication across a hazardous area and be achieved using MTL3055s as described above (Fig 10).

Connection of 2 MTL3055s by differently routed cables to the multiplexer (Fig 11) also enables IS-78 to offer dual redundant communications highways. The field device is not connected directly to the cables, but the connection is made though a “diode terminal”. This diode terminal performs 2 functions: it prevents the shorting of one highway cable from affecting the other highway, and it protects the field device from being connected to the voltage created by connecting the two MTL3055s accidentally in series. The disadvantages of this approach are that the maximum power available from one MTL3055 limits the number of multiplexers connected to one and this solution is restricted to gas groups IIA and IIB.

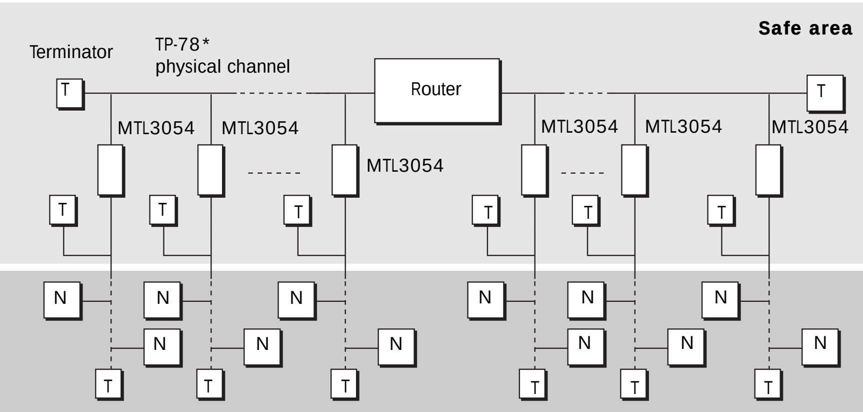

Fig 8 The hazardous-area network grows

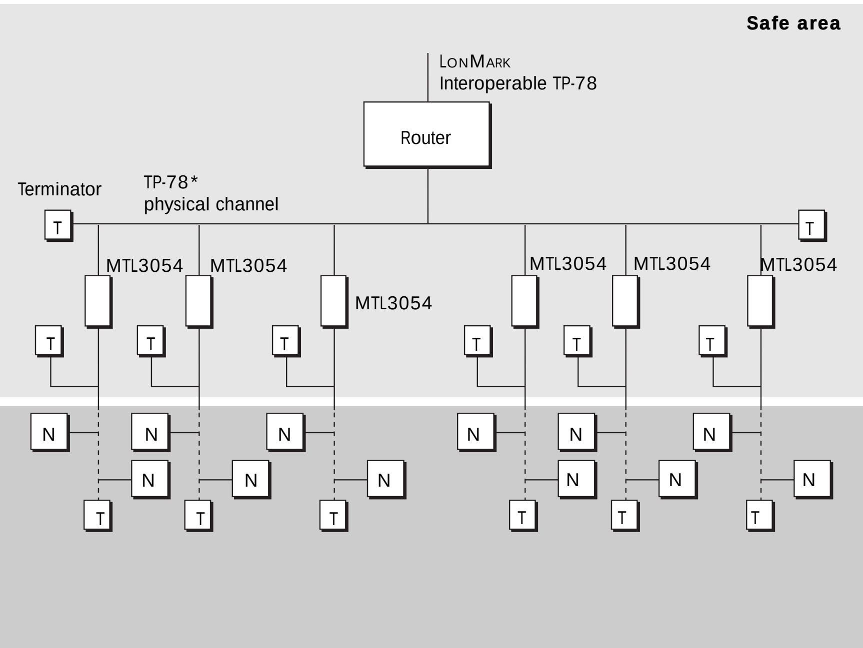

Fig 9 Making IS-78 LONMARK-compatible

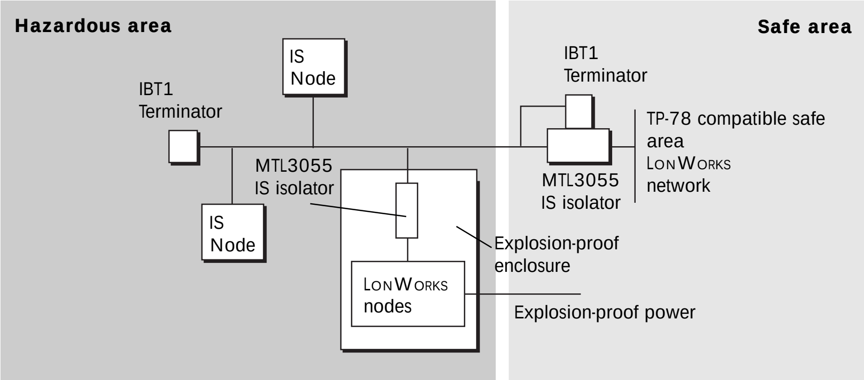

Fig 10 IS-78 connecting to a flame- or explosion-proof enclosure

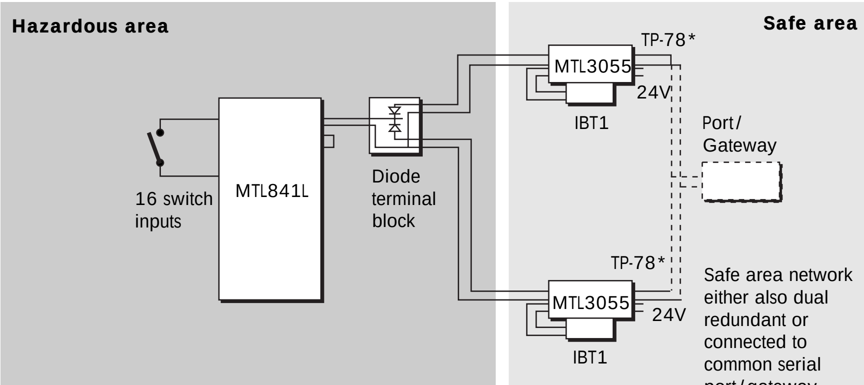

Fig 11 Dual redundancy

IS-78: specification

The specification for IS-78 is summarised below. The maximum cable length is specified using IEC1158-2 Type A cable, but tests using typical instrumentation cable have also given successful communication at lengths greater than 1000m using bus topology.

Communication speed

78.125 kbit/s

Maximum cable length

1000m with dual terminated bus topology
300m with free topology (including 2 terminators)

Application power

Either 2 wire power and signal or separate power. (see Figure 6 for application current/cable length relationship)

Signalling form

unipolar: IS node draws 20mA to transmit

Number of nodes per segment

a function of the power required for each node

Please contact MTL for more details

IS-78: components

The basic component developed for IS-78 physical channel is the IST-78 transceiver. Like any other LonWorks transceiver it consists of a small PCB which can be mounted onto sockets and pillars on another PCB which contains the appropriate Neuron and application circuitry.

Figure 12 shows a block diagram for the basic functions within the transceiver.

On the bus side there are two connections to the physical channel and these are polarity sensitive. The bus both provides power for the node and carries communication in both directions. On the Neuron side there are 5 connections: Receive, Transmit and Transmit Enable for communication and 0V/5V power (supplied by the transceiver to the node).

Within the transceiver there are 3 transformers which isolate the node circuitry from the physical channel, one for power and the other 2 for communication, one in each direction.

Other forms of transceiver that require separate IS power to be supplied to each IS node are feasible within the requirements of IS-78. Using separate IS power supplies would allow a greater number of IS nodes to be connected to the same segment.

ISC-78 is the corresponding control module for IS-78. Like IST-78 it has two connections to the physical channel. It also has the standard 18-way connection to application circuitry. The 50mA that the transceiver is capable of supplying must be shared between the Neuron chip and its associated circuitry and the application circuitry.

Products using IS-78 and applications

The first products designed using IS-78 are the MTL841L 16-channel switch or proximity detector input units and the MTL842L 16-channel digital output unit. Each unit consists of a transceiver, Neuron circuit and application circuit. The Neuron circuit drives the application circuitry directly (there is no separate application microprocessor).

Both units take their power from the physical channel. The MTL841L draws about 30mA and the MTL842L about 25mA so in most arrangements only 2 nodes can be connected

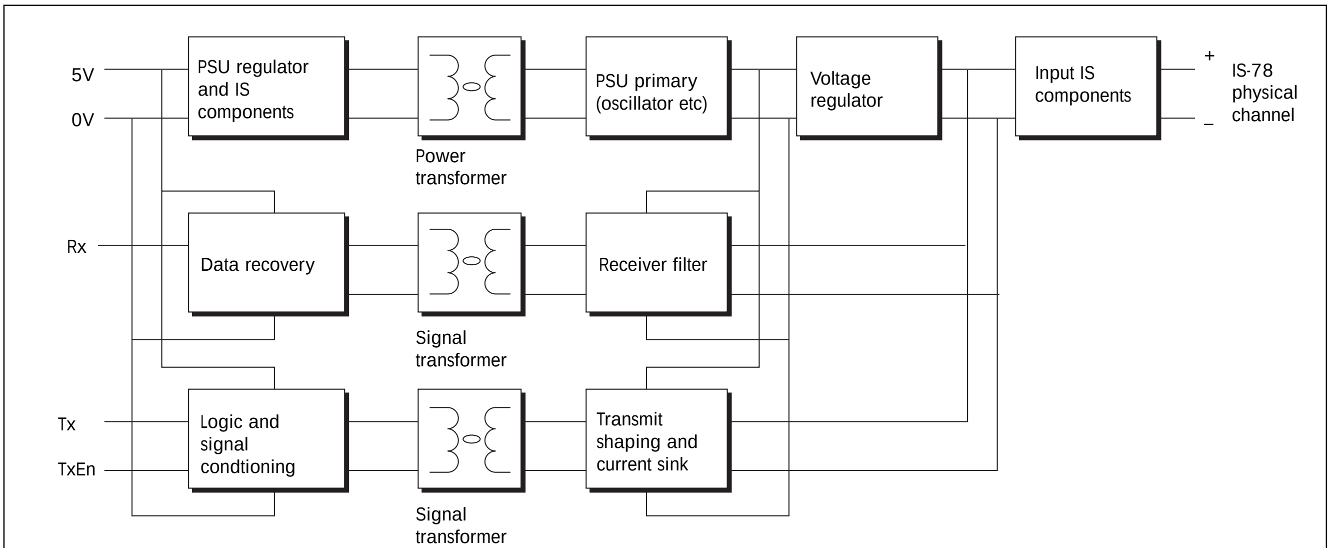

Fig 12 Block diagram: IS transceiver

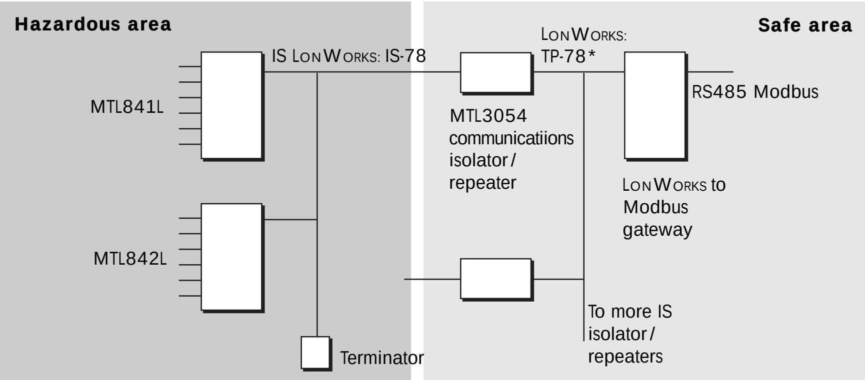

Fig 13 Simple MTL840L system

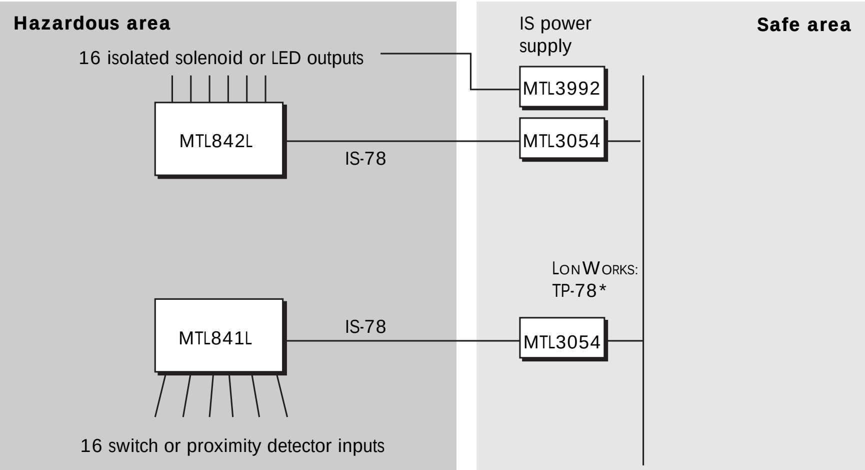

Fig 14 Valve status MTL840L application

to the same MTL3054. Figure 13 shows a typical installation with one input multiplexer and one output multiplexer connected to the same MTL3054. This Figure also shows a box marked as 'LonWorks to MODBUS gateway': a device which is available and is a way of using the functionality available from MTL840L series in installations which already have extensive DCS systems with the facility of adding a MODBUS port.

One simple application is local indication of valve status, Fig 14. In this, the 16 inputs of an MTL841L are connected to switches that sense whether a valve is open or closed. The MTL841L transfers the switch status to an MTL842L (and to a DCS in the safe area via a MODBUS gateway). The MTL842L then controls the output status of 16 LEDs or LED clusters to give local indication in the hazardous area. Even if the link between the MTL3054 and the DCS fails, local operation of valve status continues to operate.

This first example is most appropriate if indication is required physically close to the switch inputs. If indication is still required in the hazardous area but at a place remote from the switch inputs then the system is modified so that the MTL841L input device and the MTL842L output device are connected to different MTL3054s. In fact there is no reason why two units could not be connected to each MTL3054, either to increase the number of channels or to have bi-directional indication of switch status between two different locations in the hazardous area.

In all cases a suitable network management tool can be connected in the safe area network to read or write variables and to configure nodes.

Figure 14 also shows an MTL3992 as the source of power for the devices controlled by the MTL842L. is the basis of the demonstration used at various exhibitions with 'Thomas the Tank Engine'. If high brightness LEDs are used–with resistors fitted to each LED so that each LED draws 6mA when switched on–then all 16 LEDs can be powered by the same MT3992 and the brightness if the LEDs is not affected by the number of LEDs that are on.

The MTL842L controls outputs but it does not power them. There are alternative ways of getting power to the devices to be driven and the best alternative is a function of a number of variables: the distance from the safe area, the power required for the output devices and the zone classification for the outputs devices being the most important. A way of powering 16 LEDs from the safe area that requires only one IS isolator and two wires to take the power into the hazardous area is described above. This is one extreme of the level of power required. If on the other hand the output devices are solenoids, the option of having 16 solenoid drivers in the safe area being switched by the MTL842L mounted in the hazardous area is probably not the most sensible for most applications. Powering LED clusters falls somewhere in between single LEDs and solenoids.

One alternative for driving solenoids is to use hazardous-area mounted, Ex e powered power supplies, each having a number of IS isolated power outputs. This approach saves on cables (a single power cable can be taken to a group of power supplies) and saves on control room space but at the cost of a suitable mounting enclosure in the hazardous area and well thought out installation. A prototype of such a system is currently undergoing trials for use on bulk gas tankers

Conclusion

The development of IS-78 extends LonWorks into hazardous areas. The availability of off-the-shelf components and products for IS-78 provides 'building blocks' to give companies the flexibility to design their own hazardous-area devices with simpler certification.

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