

COMMUNICATION NETWORKS FOR ZONE APPLICATIONS (PROFIBUS PA)

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INTRODUCTION:

In recent years it has become increasingly popular to connect to field devices and instrumentation using digital bus systems as opposed to 4-20mA analogue systems. Digital communications systems offer sizable advantages over analogue systems, including: reduced cabling, shorter commissioning times, greater accuracy, fewer instruments as well as the implementation of smarter instruments that support intelligent device asset management reducing the maintenance effort and increasing reliability.

The intention of this paper is to discuss the application of the fieldbus systems within the Hazardous Locations that often exist in processes that deal with potentially explosive gases, liquids or dusts. To this end the fundamentals and application of the Fieldbus Intrinsic Safe Concept (FISCO) and Fieldbus Non-Incendive Concept (FNICO) and their application with PROFIBUS PA will be discussed. Also the more recent development of High Powered Trunk technology for improved power delivery to field devices will be examined.

FISCO & FNICO:

It is well known that any electronic or electrically powered device that operates in a potentially explosive atmosphere must meet certain regulations to ensure its safe operation. Painful historical examples are a testimony to the damage and loss to property and human life that can result when systems are not correctly implemented or insufficient precautions taken. When Fieldbus applications in the process industry started to gain popularity it was soon realised that a solution for hazardous areas was required.

Preliminary attempts utilised the “Entity Concept” derived from conventionally wired systems. This employed the use of cabinet mounted barriers but this was soon found to be too complex and restrictive. Research for an alternative ensued and eventually FISCO standard was born. Developed in Germany, FISCO and was incorporated as part 27¹ of the IEC 60079² in 2002. It is important to note that FISCO

¹ Published as IEC 60079-27 “Fieldbus Intrinsically Safe Concept (FISCO) and Fieldbus Non-Incendive Concept (FNICO)”, it is also adopted (with modifications) by ANSI/ISA as ISA-60079-27.

was developed based on the intrinsically-safe protection class (IEC 60079-11). As a result it is not a complete solution on its own and should be used in conjunction with the rest of IEC 60079, especially IEC 60079-0, IEC 60079-11 and IEC 60079-15.

The FISCO and FNICO standards were developed to limit the amount of energy available within the bus system to within safe limits. Definitions for Intrinsically Safe and Non-Incendive are given as:

Intrinsically safe circuit: *“A circuit in which any spark or any thermal effect produced in the conditions specified in IEC 60079-11, which include normal operation and specified fault conditions, is not capable of causing ignition of a given explosive gas atmosphere.”* (ANSI/ISA-60079-11, 2002)

Non-incendive circuit: *“A concept in which any arc or thermal effect produced under intended operating conditions of the equipment is not capable, under specified test conditions, of igniting the flammable gas-air mixture.”* (ANSI/ISA-60079-27, 2006)

The major difference between the two is the consideration of the safety of the circuitry under fault conditions. While intrinsically safe equipment is expected to remain safe even in the event of a fault, non-incendive devices can only be regarded as safe under normal operating conditions. As a result FNICO installation rules are only applicable in Zone 2 applications with FISCO installations can be applied to Zone 2, 1 and even Zone 0 applications.

Currently no FNICO equipment is available from suppliers so its definition is purely academic. It is possible that with the advent of the high power trunk concept no installations of FNICO may ever be realised.

FISCO AND MBP-IS (PROFIBUS PA):

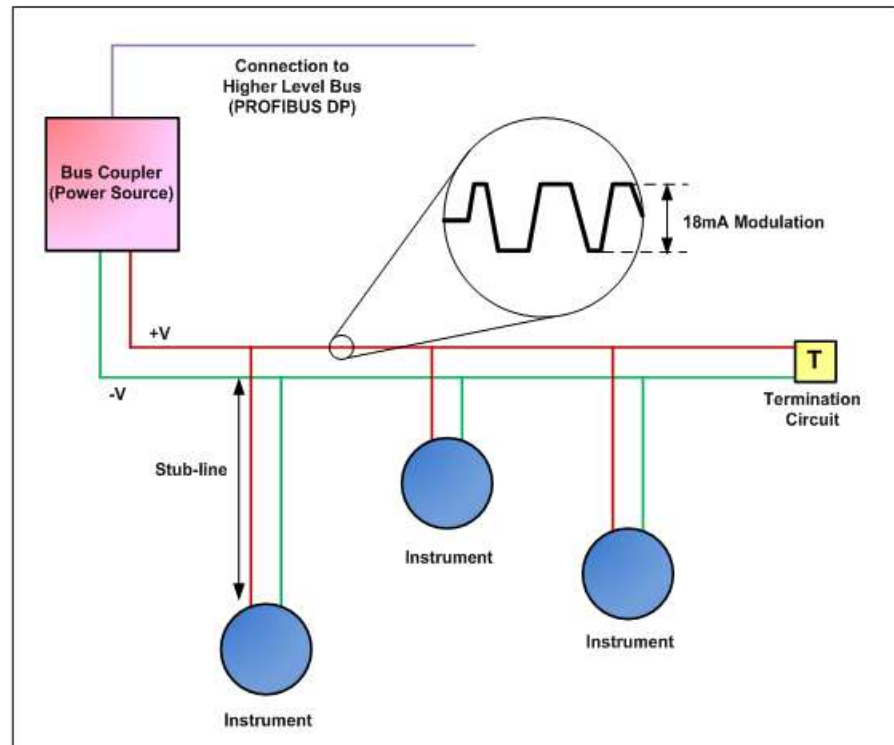
FISCO was developed primarily with consideration for implementation with a Manchester Bus Powered (MBP) network. MBP is the physical transmission layer utilized by both Profibus PA and Foundation Fieldbus and is specified in IEC 61158-2. When operated in conjunction with FISCO rules the physical standard is known as MBP-IS (Manchester Bus Powered – Intrinsically Safe)

Non-intrinsically safe MBP operates over a two wire bus cable system. Devices, connected in parallel across the two bus lines, draw their power directly from the cable. The actual current required for operation varies from device to device but most devices fall in a 10mA to 30mA range. A minimum of voltage 9v must exist at all points on the bus so voltage drops due to the current consumption and line resistance must be evaluated to validate a chosen network topology. Superimposed over the DC power supplied by the bus is a high-frequency current modulation which carries digital messages between devices.

MBP network topology is fairly flexible but usually consists of a main “trunk-line” from which multiple spur-lines are made to connect to instruments. These stub-

² IEC 60079 standardises the requirements for electrical devices in hazardous locations. It is also adopted (with modifications) by ANSI/ISA as ISA-60079.

lines can vary in length as long as none exceeds 120m and the voltage at any point does not drop below the minimum 9v. Each end of the trunk-line is terminated using an impedance matching resistor and a capacitor – these terminations suppress high frequency reflections which can interfere with clear signal modulation.



The solution for Fieldbus intrinsic safety is to consider the bus as one large intrinsic safe circuit that must satisfy all the requirements of IEC 60079-11 the specification for Electrical Apparatus for Use in Class I, Zones 0, 1, & 2 Hazardous (Classified) Locations - Intrinsic Safety "i".

For the purposes of intrinsic safety the actual encoding of data on the bus is not significant. The components of the system that have to be considered with regard to intrinsic safety are the power supply(s), field devices, the termination circuits, cabling and system topology.

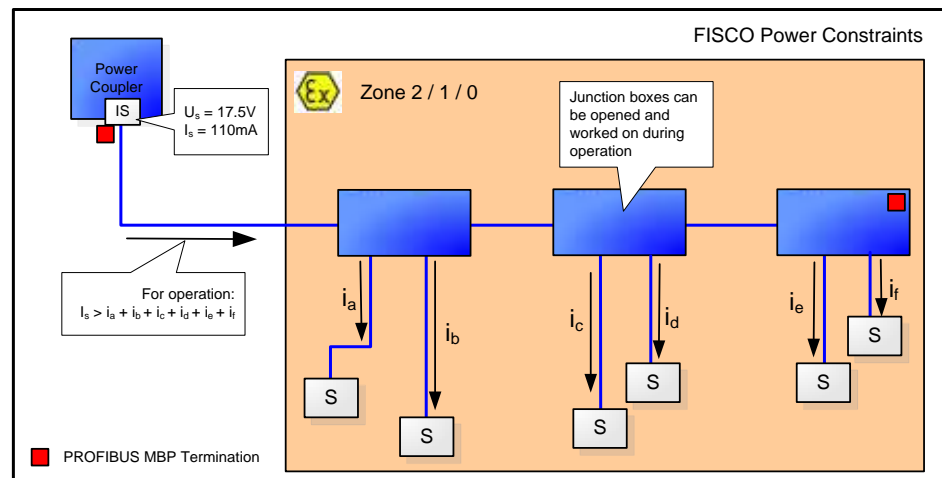
POWER SUPPLIES:

The power supply is usually installed outside the hazardous zone. However, as it is the source of all energy available in the circuit it must meet certain requirements. In this way FISCO/FNICO is very similar to traditional 4-20mA IS protection the power supply output must be voltage and current limited with a built-in IS-barrier.

FISCO power supplies must:

- Output between 14V and 17.5V
- Output less than 380mA (calculated in accordance with ignition curves)
- Output less than 5.32W
- Have limited internal inductance and capacitance

- Carry the markings “Ex ia” or “Ex ib”

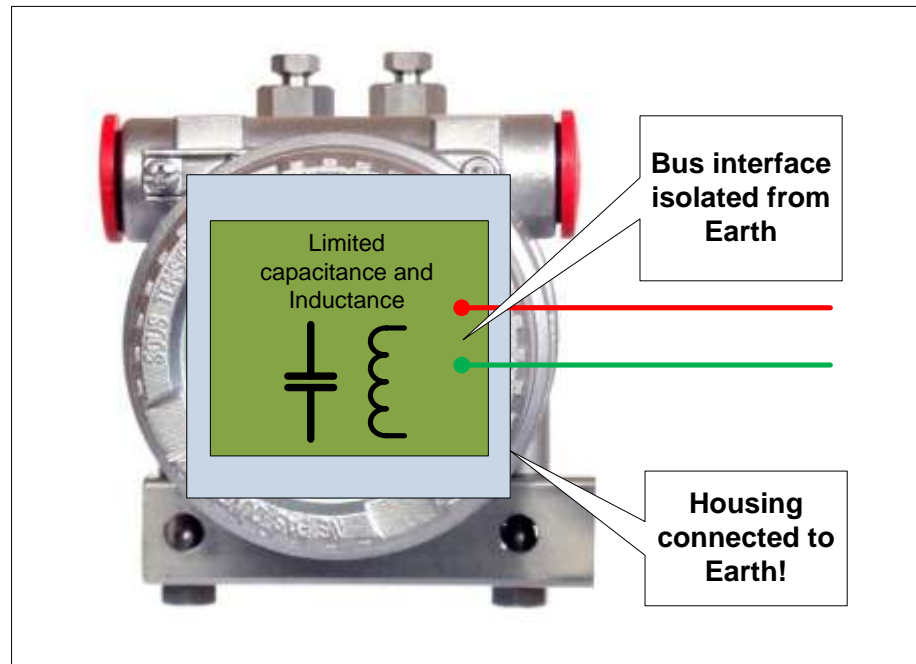


Naturally for IS compliance, it is essential that only 1 power source is installed per segment! It is also interesting to note that the power supply should be installed within 30 meters of one end of the cable.

FIELD DEVICES:

FISCO compliant field devices must be passive current sinks – this means that under no circumstances are they allowed to inject power back into the system. Effectively they must:

- Be intrinsically safe with an input Voltage of 17.5 V.
- Be intrinsically safe with an input current of 380 mA
- Be intrinsically safe with an input power of 5.32 W
- Have limited internal inductance and capacitance
- The bus terminals MUST be isolated from ground
- Carry the markings “Ex ia” or “Ex ib”



TERMINATION CIRCUIT:

Is simply made up of a resistor ($90\ \Omega$ - $102\ \Omega$) and a capacitor ($0.2\ \mu\text{F}$ – $1.2\ \mu\text{F}$) but must also:

- Be intrinsically safe with an input Voltage of 17.5 V.
- Be intrinsically safe with an input current of 380 mA
- Be intrinsically safe with an input power of 5.32 W
- MUST be isolated from ground.
- Carry the markings “Ex ia” or “Ex ib”

CABLE AND TOPOLOGY

The topology of the system cannot utilise more than 1000 meters of cable and stub-line lengths must be less than 60m.

Please note that this is based on the use of cable that has the following properties:

- loop resistance R_c 15 Ω /km to 150 Ω /km
- loop inductance L_c 0,4 mH/km to 1 mH/ km
- capacitance C_c 45 nF/km to 200 nF/km

If all the requirements listed above are met by the system, no further certification is required. This was a significant milestone in the development of Fieldbus systems for Hazardous Locations as it significantly reduced the design and certification effort involved. Correspondingly FISCO systems save end-users time and money in system design and commissioning. Classification of the system as “Ex ia” requires that all components are “Ex ia”.

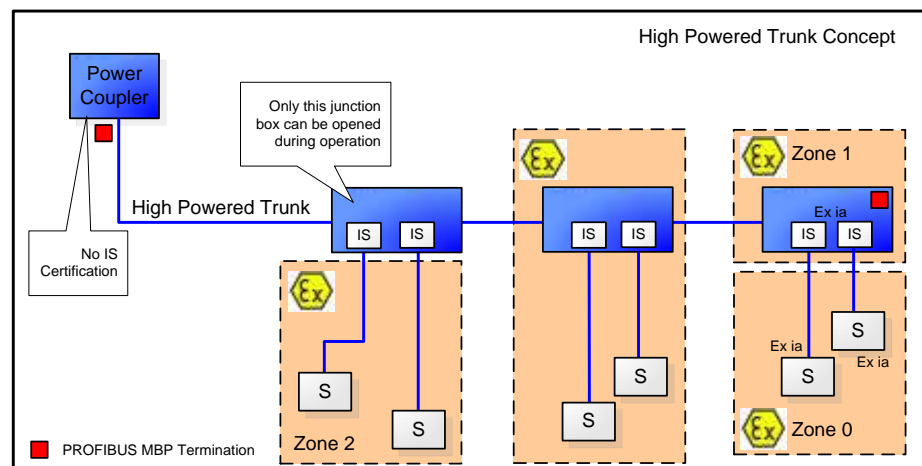
Another advantage of FISCO was that it increased the current available in the fieldbus segment over traditional entity based calculations. It is now possible to use

115mA³ per bus as opposed to the 80mA limitation which could occur in entity based calculations (O'Neill, 2007). Considering that most PA devices use between 10mA and 20mA this permits the attachment of 6-8 devices to each bus rather than the meagre 4-5 possible utilizing conventional barriers and isolators.

HIGH POWER TRUNK:

The largest challenge in using fieldbus systems in hazardous areas remains that of supplying sufficient power to multiple field devices through the same cable. Non-IS fieldbus segments, which have no power restrictions, can connect to far more devices - up to 31 devices to a single segment. Limiting the number of devices per segment due to IS power constraints means IS installations of the same number of devices require more segments, cable, couplers, terminators, drop boxes and installation time. This drives up the comparative costs significantly.

Recently there has been growing support for a new architecture for fieldbus installation in hazardous areas termed the “High Power Trunk” concept. The high power trunk concept overcomes FISCO restrictions and short-comings by moving IS barriers found in FISCO segment couplers from the coupler to the field drop boxes. This succeeds in reducing the power bottle neck on the main trunk line while still allowing spur lines to devices to operate at the highest of IS levels where required. Utilising such an architecture can allow for segments to be designed that incorporate similar numbers of devices and segment topologies to non hazardous systems. The full complement of 1900 meters of cable is possible and even the spur-line length limitation of 60 meters is removed as each spur becomes its own FISCO domain isolated from the trunk line by the barrier.



In most hazardous areas applications the number of Zone 0 devices is usually quite small, while much larger numbers of devices will exist in Zone 1 (Div. 1) and even larger Zone 2 (Div.2) atmospheres. The high power trunk concept allows the different classes of instruments to be connected to the same high powered trunk. One spur line may be placed behind a Ex ia field barrier for an instrument in Zone 0

³ Calculations based on Gas group II C

while another might just employ non-incendive protection for a device in a Zone 2 area.

The only limitation imposed by the high power trunk concept is that whereas the cables in a FISCO system could be disconnected and even shorted while exposed to explosive hazards, the high powered trunk line cannot be disconnected during operation. Whether this is a real limitation is questioned (O'Neill, 2007) (Schuessler) as being able to work on the trunk line during operation is an unnecessary luxury as in most cases disconnection of the trunk line would require the system to be brought down anyway.

The high power trunk concept is also challenging the perception that devices in Zone 1 require "Ex i" certification. The costs for intrinsic safety evaluation and testing are high and device manufacturers are forced to pass this on to consumers. The mean time to failure of these devices is also higher. (O'Neill, 2007). When utilising FISCO all devices had to be Ex ia or Ex ib certified even though in many cases Ex d or Ex m would be sufficient. Users of the high powered trunk concept may be able to circumvent some of the costs by avoiding Ex i devices.

When it comes to connecting and disconnecting devices and spurs from the trunk line intelligent placement on drop boxes (Zone 2 over Zone 1) and the application of intelligent connection / disconnection mechanisms makes this possible.

All-in-all, the high power trunk concept provides a powerful new mechanism of bringing the advantages of fieldbusses such as PROFIBUS PA to applications involving hazardous areas.

BIBLIOGRAPHY:

ANSI/ISA-60079-0. (2006). *Electrical Apparatus for Use in Class I, Zones 0, 1 & 2 Hazardous (Classified) Locations: General Requirements*. North Carolina: ANSI/ISA.

ANSI/ISA-60079-11. (2002). *Electrical Apparatus for Use in Class I, Zones 0, 1, & 2 Hazardous (Classified) Locations - Intrinsic Safety "i"*. ANSI/ISA.

ANSI/ISA-60079-27. (2006). *Fieldbus Intrinsically Safe Concept (FISCO) and Fieldbus Non-Incendive Concept (FNICO)*. North Carolina: ANSI/ISA.

Booma, D. v. (2006). Presentation 13 - Explosion Safety. *PICC Meeting 9*. Winterthur: PI.

O'Neill, M. (2007, Jan-Feb). Advances in Fieldbus. *Process Industry Informer* , pp. 36-37.

Schuessler, B. (n.d.). *High_Power_Trunk.pdf*. Retrieved September 09, 2008, from www.pfsolutions.info/FieldConnex:
http://www.pfsolutions.info/FieldConnex/pdf/High_Power_Trunk_2.pdf