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PRACTICAL ASPECTS OF FIELDBUS INSTALLATION

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Abstract: Fieldbus technology has many benefits and Foundation Fieldbus is certainly easy to use. However, there are practical issues touted as being easy to use, wire up and commission; really a version of 'plug'n'play' for process control. In reality, there are just as many things to trip up the unwary as in any other new technology implementation. This paper describes some of the more practical (mundane?) aspects of fieldbus installation, which are still required to get the system off the ground.

conditioning, intrinsic safety, FISCO, protection, wiring

1. Introduction.

There are many users and systems integrators who believe that fieldbus is a simple technology, easy to design and easy to specify. Some of this is true; the whole thing is quite straightforward as long as you are at the stage of project design where everything can be drawn with single-line connections and anything as yet unclear or incomplete can be left as an unfilled box with a TBA annotation. Once things move into the real world and that project approval comes through from head office, the detailed design is quickly required which, as ever, exposes things which were 'estimated' or simply left out. Filling in these gaps and making a system really work is not too difficult, but at this stage of market acceptance of the technology, many engineers are coming face to face with real fieldbus applications for the first time.

2. Power Supplies

Most project engineers request bulk DC power packs as and when required within project designs without extensive thought as to the type & performance; power supplies are now a 'commodity' item. The Procurement Dept. has absorbed the responsibility of looking for the best (cheapest?) power pack capable of the required output, reliability and form factor. However, fieldbus power supplies are NOT the same as COTS (Commercial Off The Shelf) power supplies and this is likely to become evident only during loop testing and pre-commissioning checks.

Fieldbus wiring must be capable and required to carry both DC power and ac communications. The DC power requirement is defined as normal for a power supply package, but the ac communications component will 'see' the DC regulator section of the power supply as low impedance and effectively completes its circuit without 'troubling the scorers'. No communications is the result, even though to all intents and purposes, both the power supply and the fieldbus devices are working fine.

Fieldbus power supplies require 'conditioning' whereby the ac component is isolated from the DC regulator by series inductors or their electronic equivalent. Either type needs to be designed to block 31.25 kHz fieldbus communications and harmonics thereof, and the performance of these networks is comprehensively and exhaustively defined within IEC61158-2 Clause 22. Note that the conditioning network is a series component and it needs to be designed to suit operational current conditions. This tends to ensure that fieldbus power supplies are relatively low capacity, typically 200 to 500mA. Compact fieldbus power supplies tend to be switch-mode units incorporating quite complex electronic filter designs, which has the drawback that the higher number of components needed then reduces reliability (since MTBF is a direct function of the number of series components). A coil providing 5mH and capable of 500mA is quite large but quite inexpensive compared to the electronic equivalent, and the component has such a high MTBF that you won't believe the calculation.

3. Terminators

The presence of the ac communications on the fieldbus cable pair (segment, trunk or home-run, depending on personal preference) means that a simple open-circuit at the end of the line will cause reflections. These returning ac waves will then interfere with the signals being transmitted and lead to serious errors or missed messages. Luckily, the elimination of reflections in ac communications cable is a well understood process since everyone installs Ethernet in their offices & homes... all it takes is a 'terminator' at each end of the line. It is an enlightening experience to open up a commercially-produced terminator – 75 USD can buy a sophisticated plastic enclosure with an internal printed circuit board struggling manfully to hold a small resistor and a tiny capacitor! The resistor provides the nominal load for the communications signal, and for fieldbus systems at 31.25kHz, 100 Ohms) works just fine. The capacitor stops the DC supply draining through the resistor, and 1 microfarad is specified for fieldbus. Two terminators at 100R gives a nominal 50R load for the communications current (20mA p-p) and a signal voltage for receiving devices of 1V p-p.

The absence of terminators leads to reflections and aborted messages, plus some devices are sensitive to voltages being too high. However, there can also be a problem with over-termination; extra terminators can easily be installed if each field junction box and the power supply all have terminators fitted and active. 3 terminators on a short network with few series connections (each of which introduce attenuation in their own right) are usually OK, since the signal levels fall to around 660mV and still above the 150mV minimum. However, as segment length increases and/or more devices are connected, the total attenuation will cause some devices to 'drop off' the network and an increase in systems diagnostic messages.

The simplest and most efficient method is to have terminators which are automatically provided at the end of the segment with no additional cost or specification workload, but field-selectable to suit all possible permutations.

4. Protection in hazardous areas

There is little different about fieldbus in hazardous areas as far as conventional explosionproof devices are concerned. Clearly, the devices must be certified or approved for the Zone (Division) of use by a suitable and competent authority, and the wiring selected must be similarly protected by an appropriate technique.

However, the most popular technique for the protection of instrumentation systems is Intrinsic Safety (IS) and there are some real difficulties with IS fieldbus. In principle, IS designs ensure safety by limiting the energy available in the hazardous location to levels below which an explosion can be initiated, by spark or by hot surface, under both normal and fault conditions. The technique has been used successfully all over the world for decades, and most world-wide standards agree very closely on safe limits and all incorporate 'ignition curves' based on Gas Groups (Sub-Divisions) for open-circuit voltage and short-circuit current. Specialist companies have promoted IS as the best technology for instrumentation systems and have been very keen to provide detailed engineering solutions (barriers & isolators) for individual IS devices. The concept and economics of Fieldbus requires many devices per segment, and this naturally leads to the demand for as much power down the segment as the supply capability and Ohms Law allows. There is a fundamental mismatch between conventional IS provision and fieldbus demand.

Within the confines of IS design, the simplest approach is to consider an IS interface in the non-hazardous area feeding field devices in the hazardous area. The best choices of voltage and current for this configuration tend towards safety parameters of 22V and 200mA, and a resulting operational capability of 15V and 80mA. If every fieldbus device requires 20mA quiescent current, this means that 4 devices is the maximum number per wired pair for a short segment and any significant cable resistance will reduce that number still further.

FISCO (Fieldbus Intrinsically-Safe Concept) is an attempt to 'stretch' the capability of IS design by invoking the tenets of empirical testing in order to allow more current than permitted by the conventional ignition curves. The current-limiting sections within FISCO designs are series electronic circuits which are required to be triplicated for the highest level of safety and therefore add to the complexity of the design. In operation, the fold-back nature of these circuits can result in accidental shut-down since the response to any perceived increase in current (intermittent field

short-circuit?) has to be rapidly controlled. FISCO is comprehensively designed and certainly safe, but that safety has to be demonstrated by practical explosion testing rather than paper-based design and there are attendant restrictions: segment length is limited to 1000m, spur length is limited to 30m, and all components of the system (power supply, interface, cable, terminator & devices) must match FISCO specifications. The final result is that FISCO systems are available which can provide 110mA for IIC applications, and perhaps as much as 240mA for IIB.

An alternative approach uses conventional IS design techniques but for the first time, splits the IS current-limiting components into more than one part and indifferent locations. In this system, the power supply provides a much higher source current into the fieldbus segment, which is then restricted locally to levels compatible with individual devices. This approach can drive 350mA into the hazardous area, with field-mounting device couplers controlling each spur connection to levels appropriate to individual devices. The result is a segment which can easily have 16 devices even in IIC (hydrogen-risk areas) without any of the operational limitations brought about by adoption of the FISCO model.

There are still further permutations, which usually involve provision of Exd or Exe protected power to field-mounting electronic packages which may or may not conform to the FISCO model at the point of device connection. One area of contention is the number of devices per spur, where some manufacturers need to offset the overhead cost of their field power supplies across as many devices as possible. One of the problems in this regard is the requirement within IEC61158-2 to limit the voltage impressed onto receiving devices; if one device transmits through a properly-loaded segment AND through a series resistance in its spur (as required to make that spur intrinsically-safe), the voltage received by another device on that spur will almost certainly exceed the allowable limits and damage to devices has been reported. For this reason, more than one device per IS spur is not recommended.

5. Cable & Field Wiring

One of the central themes of fieldbus for process control is that it should be as practical as possible. Power and signal shall be available on the same cable, and that cable should not be fundamentally different to conventional instrument cable already in common use. There are standards for instrumentation & control cables (BS5308 is one) and fieldbus cable follows similar principles; screened twisted pair is best, multi-core cables with overall screens are allowable, as are much less attractive cables; unpaired cables and unscreened cables. Some manufacturers take advantage of the uninitiated by offering 'fieldbus' cable in the same way as they make 'intrinsically-safe cable' (same as ordinary instrumentation cable but in blue). In general, if a cable is already in use for instrumentation & control, it is probably fine for fieldbus.

Field wiring techniques are however more problematic. Fieldbus systems are simple to design because all the device wire-pairs are connected in parallel, but in practice, any attempt to fill a box full of terminals and just 'jump' between all positives and all negatives results in a 'rats nest' of cables within the enclosure. This may be acceptable in some plants, but all installers of this level will have trouble if there are any field wiring faults. If all the wires are in parallel, how do you find a spur short-circuit? The simplest approach is to remove all the wires and start again.

A better idea is to use the device coupler or fieldbus junction box now offered by some manufacturers. These units automatically provide the necessary system interconnections without confusion and generally speed up the process of device installation. Some units also incorporate the required terminator with some form of on/off switching, and also some form of spur short-circuit protection. The protection concept offered may be electronic current-limiting which is effective and resettable once the fault is cleared, but each trip draws a constant current (typically 40 or 60mA) which may draw down the segment power supply and cause all devices to drop out anyway. Another approach is to use individual fuses per spur which will permanently disconnect a failed spur without loading the segment and causing no interference to operation of other devices. Both approaches require the fault to be cleared before the spur can be returned to normal operation.

It has become fashionable to use plug & socket connectors on field devices, which augments the concept of digital systems and the current plug'n'play environment. This certainly has merit where field devices are regularly changed or need to be quickly replaced for other reasons, and any pluggable device allows less skilled staff to be used. However, these connections are expensive and can be quite vulnerable at a junction box. In reality, there are few systems where the junction boxes are required to be replaced or moved at regular intervals.

7. Conclusion

Fieldbus is an exciting technology and there are many benefits which will accrue to end users and early adopters. Implementation of real fieldbus systems is still a new experience for many engineering companies, and many sub-contractors are coming to wire up devices without any real understanding of the different requirements and problems presented by fieldbus systems.

References:

- IEC61158-2: Fieldbus standard for use in industrial control systems
Part 2: Physical layer specification and service definition
(IEC, Switzerland; CENELEC, Brussels; or National Standards bodies.)
- EN 50020, "Electrical apparatus for potentially explosive atmospheres – Intrinsic safety 'i'"
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- FOUNDATION Fieldbus Application Guide AG163 "31.25 kbit/s Intrinsically-Safe Systems"
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