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## **FIELDBUS- THE ROUTE TO THE FUTURE, GOING WHERE NO INSTRUMENT ENGINEER HAS GONE BEFORE**

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**Abstract:** There are some who would “knock” fieldbus technology, owing to perhaps a fear of change, a shortfall in competencies or just a misconception that there are too many risks associated with implementing it. This paper covers the primary advantages/disadvantages of fieldbus systems with particular emphasis on Foundation fieldbus™. It highlights why making a decision to embrace fieldbus is so important along with the advantages and disadvantages of each of the IEC 61158 standardised fieldbuses. Ideas of how to take a grip on the risks and manage them through to successful project implementation are covered. Also the future directions for digital control are discussed with the theme “if you are not implementing digital technology you are on the route to opportunity lost- those with vision will prosper”.

# FIELDBUS- THE ROUTE TO THE FUTURE, GOING WHERE NO INSTRUMENT ENGINEER HAS GONE BEFORE

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As an Instrument Engineer today in a design environment, just what decision to make in terms of an operating platform boils down to either Analogue or Digital control. Analogue means that one stays in the comfort zone with minimal risk, whereas digital can be described as a decision that certainly will mean some “heartache” for those implementing this brave new world. Those who take the easy Analogue path will not be doing your company or client any favours as the advantages made available by Digital control both today and in the future will not be available. Sure there is HART which in its day was excellent, however whilst affording some maintenance benefits, the concept does not give the flexibility and functionality which is and will be made available by Digital Control.

It should be highlighted that DIGITAL CONTROL= FIELDBUS

## FIELDBUS PROTOCOLS

There are a huge variety of fieldbus protocols, some of which are covered by International Standards and others which are Manufacturer proprietary types. There are eight fieldbus protocols covered by IEC61158 (Fieldbus Standard for use in Industrial Control Systems)

Type 1 - Foundation fieldbus
Type 2 - ControlNet
Type 3 - Profibus
Type 4 - P-net
Type 5 - Foundation fieldbus High Speed Ethernet
Type 6 - Swiftnet
Type 7 - WorldFip
Type 8 - Interbus-S

Other fieldbus standards are:
AS-Interface ASI
Bitbus
CanOpen
DeviceNet
FL-Net
Industrial Ethernet
JPCN-1
LonWorks
Modbus
Profinet
Sercos

## ADVANTAGES OF FIELDBUS

Fieldbus provides many advantages over those afforded by Analogue systems. These include generic ones that apply to all fieldbus techniques as follows;

- Installation, termination and wiring savings due to “multidropping” techniques.
- Hardware Savings as a result of fewer devices, elimination of I/O cards with minimal field interface cards.
- Documentation savings, segment drawings mean that the old days of single loop diagrams are limited. In addition the concept simplifies the instrument layout and drawings.

- Reduced Engineering and Capital costs.
- Footprint savings.
- Multifunctional Field devices hence less process connections.
- Interoperability and freedom of choice (\* some concepts only).
- Reduced Commissioning and startup costs (including faster configuration, testing and commissioning of instrument systems).
- Reduced downtime due to smart diagnostics and trouble shooting, leading to a reduction in unplanned trips, shutdowns and maintenance costs.
- Improved Integrity.
- Distributed Control System future capacity savings.
- International Acceptance.
- Asset Management.

**Foundation fieldbus** provides additional enhancements on these generic advantages;

- Control in the field with improved process control flexibility and availability of field based control algorithms.
- Device “Plug and Play”.
- On line configuration of instruments.
- Time Stamping and synchronisation.
- Obsolescence Robustness.
- Status Information.
- Tag search capability.
- Interface to High Speed Ethernet.
- Trend Storage in the field device.
- Automated data collection for asset management.
- THE BIG ONE- Predictive maintenance, rather than using corrective and preventative maintenance utilising true predictive and condition based maintenance strategies.

A useful fieldbus comparison chart can be found in **Appendix 1**

### **WHICH FIELDBUS TO SELECT?**

There is no particular “right fieldbus” as it is up to the individual engineer to determine a design that meets the required technical profile, budget, and net profit value (ensuring that long term cost of ownership has been considered).

The selection depends on business requirements. For example if one was building a bottling plant instrumentation system the most cost effective engineering solution may be an AS-interface as the majority of the plant instrumentation is likely to be discrete. The same may be the case for building automation systems.

However if the system was Discrete and Continuous, for instance a motor vehicle manufacturing plant or Electrical Motor Control Centre Interface, Profibus DP is common.

On a major chemical plant or offshore facility there is likely to be a “hybrid” approach, with several fieldbuses being utilised. For instance the MCC may be Profibus DP, the interface to PLC’s utilising Modbus and the continuous process plant using Foundation fieldbus or Profibus PA. It is highlighted that Foundation fieldbus has advanced features that are not available on the Profibus platform. These were detailed previously.

### **RISKS/ CHALLENGES AND HOW TO MANAGE THEM**

Have you been thinking seriously about being a fieldbus technology champion in your company? This aspiration is not one to be taken lightly as it will mean quite a good deal of “hard yakka”. You will be taking on Management, Engineering luddites<sup>\*1</sup> and the vast majority of the technical population who are in their comfort zone and see change as another impost to their general workload. We must admit that in these days of “downsizing” there are so many demands on time, however fieldbus is a technology that must be embraced. International competitors are realising the fieldbus commercial gains and if we remain with older technology will gain a huge competitive advantage. The result of this is likely to be that Australia as a whole will suffer, with exports declining and new projects going offshore.

\*1 Luddite- One who is opposed to especially technological change

How does one start with fieldbus? The first step is to get a good understanding of the technology. This is not a simple task that can be achieved by little work, perhaps this is why there is a reluctance to accept that this brave new digital control world is about to hit us at warp speed. The best route is to look at one’s plant and decide which fieldbus is applicable, determining whether is it purely discrete, manufacturing, batch or a continuous process plant. If discrete and non hazardous look at AS-I, Manufacturing eg., making cars typically Profibus DP and Continuous Process Foundation fieldbus, Profibus PA with a Hybrid of others. Where does one source this information? For a start each fieldbus has its own website, these are detailed in **Appendix 2**. The quality of information on these sites is generally very good. There are also other sites that provide great data.

In addition there are training courses that are available, however if possible avoid the trap of depending on suppliers for training as logically these will focus on their own product and not make the most of the technology. This is particularly the approach that should be taken with Foundation fieldbus as the interoperability feature should be utilised fully. Also a supplier’s fieldbus competency must be verified, as to not do so may be the difference between a successful fieldbus implementation and an unmitigated disaster. Lack of fieldbus competency is common...the old adage “those who think they know and do not know are bad news” is really true.

For Foundation fieldbus there are few accredited courses, with the Southern Alberta Institute of Technology (Canada) Essentials and Discovery range being the only ones being given the “tick” from the Fieldbus Foundation. These courses are run regularly under licence by the Foundation fieldbus End Users Council Australia (Inc).

The next part of the process is to convince managers of the benefits of the technology. At the end of the day they are looking for return on investment and that is what must be concentrated on. It will be necessary for the technology champion to “sell” the concept along these lines rather than harping on about the wonderful engineering concepts. So where are the best savings?

## THE BUSINESS CASE

**(This is based on Foundation fieldbus but may be applicable to other protocols)**

The best way to capture the imagination of Managers and Bean Counters is to put together a business case that details all the fieldbus features that were detailed earlier. Against each a weighting should be identified which is backed up by facts. A starting point is detailed below:

- **Installation, Termination and Wiring Savings**

*“Multidropping” techniques mean that less wiring and terminations are required.*

*Usually identified as a 20% saving, in the overall project sense not a huge amount as Instrumentation and Control usually amounts to around 5-7% of a project budget.*

- **Hardware Savings**

*There are fewer devices required, with I/O cards being minimised with just a “home run”.*

*Savings in the order of 20%, however there is a cost adder associated with the fieldbus device which is usually about 10%. Therefore the net savings are approximately 10%.*

- **Reduced Engineering and Capital costs**

*The Foundation fieldbus concept incorporates the use of advanced electronic tools which affords slick configuration, the device descriptions and other macro tools mean that design time is reduced dramatically. Realistic Design Savings of conservatively 20% could be expected after full design competencies are achieved.*

- **Documentation savings**

*Segment drawings mean that the old days of single loop diagrams are limited, additionally layout and drawings are simplified.*

*In a major project savings could amount to around 25% in terms of Instrument design, however it should be noted that on the first project most of the savings are likely to be taken up by additional training.*

- **Footprint savings**

*Generally space is very expensive, MCC rooms are not cheap and rack after rack of I/O cards and associated ancillaries add to the demands on real estate.*

*For an onshore installation it is not unrealistic to look at \$10000 per square metre and for an Offshore facility \$100000 per square metre.*

- **Multifunctional Field devices**

*Of course there are some savings associated with hardware and rationalisation of vessel nozzles however there is a prize which is far larger.*

*What price “Integrity”? Any concept which minimizes process intrusions must improve the risk equation. One event could cost anything from a minor trip costing \$100,000 to a major disaster amounting to \$ Millions. In addition there are the savings associated with reduction in the number of instruments and associated hardware.*

- **Interoperability and freedom of choice (\* some concepts only)**

*The great plus with interoperability is that Instrumentation that really meets plant requirements can be selected. This may be on the basis of cost or special features.*

*Foundation fieldbus has both Field device and Host Interoperability testing “ticks”. What is this worth? Well it depends on the application and should be determined on that basis.*

*However at a minimum a 10% saving should be realised.*

- **Reduced Commissioning and startup costs**

*Foundation fieldbus achieves faster configuration, testing and commissioning of instrument systems. This is potentially a huge saving. Generally if competent (again that word-highlighting the importance of training) personnel are used Foundation fieldbus loops can be commissioned in 15 to 30 minutes. Analogue Commissioning is generally based on 6 to 8 hours, thus the savings here are easy to quantify as the number of loops multiplied by 5.75 hours at the tradesman's hourly rate.*

*Also there is the fact that the Instrument Control discipline is always 'Tail End Charlie' at the project commissioning stage and thus any concept which can reduce the commissioning time is a real cost advantage. Take for instance a refinery which has a profit of \$500,000 per day, say that the concept gives a start up two weeks in advance of that originally planned...an Increased profit of \$7M.*

- **Reduced downtime**

*Smart diagnostics and trouble shooting will lead to reduction in unplanned trips, shutdowns and maintenance costs.*

*This is another large business case driver, Analogue just gives "dumb" instruments with little to offer in the way of self diagnostics. The smart concepts afforded by Digital Control provide instant viability to problem areas, either avoiding trips altogether, along with assisting troubleshooting and enabling a faster startup. Thus quantify this on a minimum saving of one unplanned trip per year and two improved startup times. How much does one less trip per Annum save in your plant?. On an offshore facility this can be quantified in the \$Millions. Thus take the savings and multiply by the projected life of the plant, this will give a figure that Managers will "boggle at".*

- **Integrity improved**

*Improved diagnostics = Improved Integrity. This is a winner for your Management. The Condition Based Maintenance systems available can give reports that prove the condition of the plant. Also future concepts which will no doubt be put in place ie., Self Validating Safety Relief Valves and Shutdown/Blowdown valves will also result in substantial savings. A starting figure for this is suggested to be a saving of 20% in the production of Integrity reports. Also the improved diagnostics have implications for Advanced Process Control (APC) since it is pretty pointless having a sophisticated system which is connected to dumb instruments that have minimal self-validation. The true savings of APC can be realised by integrating the concept into Foundation fieldbus. If APC is required add 0.1% of production to the overall figure. This may not look much but on a major LNG plant it is worth \$Millions over the life of the project.*

- **Distributed Control System future capacity savings**

*Today when one installs a new DCS it is usual to install about 25% additional I/O and 50% software capacity for future expansion. With Foundation fieldbus this can be reduced significantly, allowing for 25% segment expansion and 10% software capacity for those Advanced Process Control features. Quantification of the savings depends on your system size.*

- **Control in the field**

*This provides improved process control flexibility with availability of field based control algorithms. Control in the field has considerable advantages, should you lose the operator interface the plant will continue to run. There is no cost for this feature as it is incorporated in the device and can also be part of complex Cascade or Ratio control strategies. For smaller*

plants there are savings associated with the deletion of stand alone controllers. Also the control is faster as the controller can be installed in the final device. In critical applications fallback controllers can also be configured. This allows for savings of 100% on stand-alone controllers and \$200 for each DCS controller. For faster control 0.01% of production is a realistic gain.

- **Device “Plug and Play”**

This a great feature of Foundation fieldbus where the device identifies itself along with all it's features immediately it is connected. This must result in savings when any instrument is added to the network. Quantify this on the basis of hours, conservatively 1 hour at the technician rate multiplied by the number of instruments.

- **On line configuration**

It is not necessary to take the segment off line to configure. Quantify the cost saving on the basis of hours, conservatively 1 hour at the technician rate times the number of instruments.

- **Time Stamping and synchronisation**

How often have you cursed the DCS scan time when troubleshooting trips? This is a thing of the past when Foundation fieldbus is utilised as time stamping is accomplished in the instrument rather than the host. Thus the need for sophisticated sequence of event (SOE) reporting is eliminated. Times are synchronised from a master time clock and thus all segments are running on the same clock. If one has Turbines, Compressors or any other plant that requires SOE, quantify the potential savings as troubleshooting efficiencies enabling 2 hours earlier startup twice per annum.

- **Obsolescence Robustness**

As soon as an Instrument or Control System is purchased it has a very limited time before it becomes obsolescent. In the case of Foundation fieldbus one is constantly updating the plant instrumentation, because every time a new instrument is purchased it will have the latest features available if one desires them. Also the new features may be able to be uploaded into existing infrastructure. Savings are hard to quantify however a suitable method may be to add 5 years to the Control System life. So say a replacement system was going to cost \$10M, at 5% interest per annum =  $\$500K \times 5 \text{ years} = \$2.5M$

- **Interface to High Speed Ethernet**

High Speed Ethernet in Foundation fieldbus is rather different from standard Ethernet since it has been designed to be more robust as is required in a continuous process control environment. It provides an interface to fast acting devices such as Surge Control and Analysers. This is difficult to quantify however a good starting point is to allow a figure of 0.1% of production.

- **Universal Programming Language**

The Universal programming language applies to different Manufacturers and is shared by HI and HSE networks. This leads to a reduction in engineering time, both at original configuration and also when adding to or modifying the system. For the first projects there may be little reward as one is gaining competencies. However after the skills improve allow an initial 10% reduction in configuration engineering time which progresses to a 25% figure when full competency is gained .

- **Interface to Trend Storage in the field device and Status Information Tag search capability**

*A small cost saver that is difficult to quantify.*

- **THE BIG ONE- Predictive Maintenance and Automated Data Collection**

*Rather than using corrective and preventative maintenance fieldbus realises true predictive and condition based maintenance strategies.*

*When Operation, Production and Maintenance (OPEX) savings are considered over the lifespan of the project the really large benefits of fieldbus can be achieved. The quantification of this is dependent on your plant, however a good starting point would be a minimum 30% annual reduction in Instrument and Control maintenance costs. There will be no need to undertake the normal annual, three yearly or other planned maintenance because the diagnostics affords the concept of Predictive Maintenance in a “hands off” sense. In effect this really intelligent technology means that the instrument will predict and flag that the instrument performance is falling.*

### **MANAGING THE TECHNOLOGY RISKS**

There are indeed risks with taking on board any emerging technology. Now is the time to take up the challenge, determine the risks, review them and if acceptable manage them. Some of the known challenges are as follows:

#### ➤ **Interoperability not functioning**

There will be heart stoppers if one connects the instruments and nothing works. When the competency associated with Foundation fieldbus technology is in place this may not be so much of a risk, however this is not the case at the moment. Therefore it is best to stage one instrument of each type with the host, as this will verify that there will be no unexpected failures. Taking this approach will highlight any Device description firmware errors or Interoperability Test Kit revision problems and increase user confidence.

#### ➤ **Training**

Allow a large budget for training Engineers, Technicians and Operators, this investment will reap benefits. At a minimum the Foundation fieldbus Essentials/ Operators/ Managers and Discovery Course should be funded.

#### ➤ **Code of Practice**

A comprehensive Code of Practice is essential, suggested contents of this are detailed in **Appendix 3**.

#### ➤ **Pilot Project**

It may be worthwhile considering implementing a Pilot project with for example 3 segments and 15 instruments, this will enable competencies to be developed.

#### ➤ **Selecting Vendors**

This is a very important consideration, as many Vendors and their agents are not yet competent in this technology. Ensure that the Vendor you select is technically ready otherwise instrument/host problems will result in considerable “heartache”. Also ensure that

your primary vendor focal point has been on the training courses detailed previously in addition to “in house” training.

➤ **Ancillary Hardware**

It is recommended to utilize ancillary hardware that has been specifically designed for fieldbus systems ie., connection blocks and earth fault protection.

➤ **Instrument Engineering Tools**

Use an Instrument Database system that has a proven Foundation fieldbus interface, Intools is one of these. Also make sure that you make your consultant responsible for ensuring operation of the configuration tools. Use the Relcom test tools to ensure wiring is satisfactory and communications are error free.

➤ **Call in the Experts!**

It is worthwhile considering expert consultants to review your design and be available at the commissioning stage. At the end of the day this is a good investment as problems will be addressed quickly and also your own personnel can improve their competencies.

### **FUTURE DIRECTIONS FOR DIGITAL CONTROL**

If you are upgrading an old plant’s instrumentation or building a new plant then fieldbus should be seriously considered. To proceed with the risk free Analogue route is short sighted and certainly is not doing your company or client any favours. With a fieldbus technology platform you have all the advantages along with the terrific business drivers previously described instantly available. This is only the beginning because as an emerging technology Foundation fieldbus is developing further and will be impacting other traditional methods in the Instrumentation world. Some of these future directions are described below.

#### **Safety Systems**

**Do NOT consider Foundation fieldbus or any other fieldbus for any Process Shutdown System.** Why is this? Actually the technology is really better in terms of integrity than what we have today (those old “dumb” transmitters and final elements). The advanced diagnostics mean this is so. However one should not “run before we can walk” and get the necessary competencies in place prior to going down this route. Implementing Fieldbus in a Process Control System is far more forgiving than having trips or even worse failure to trip occurrences. The unfortunate consequence will be that the technology rather than the skill level will get the blame for these events.

Transmitters are also likely to require Safety Integrity Level configuration ratings. Work is ongoing at the moment to develop codes of practice in this area and within five years implementation of Foundation fieldbus in the safety system environment should be the norm. Also the Foundation fieldbus High Speed Ethernet affords opportunities for companies to develop mini-instrumented protective systems which can interface to the Host.

#### **Fire and Gas Systems**

Building Fire and Gas systems have utilised addressable techniques for years so in a heavy industrial environment development of a Foundation fieldbus interface will not be too far away. These devices lend themselves to the technology and the diagnostics that will be

available through the digital platform will provide a predictive maintenance interface that will save a considerable amount of maintenance.

### **Multi-Variables**

Instrumentation that is measuring multi-variables is already available in the market place because of fieldbus. The future is likely to head towards non-invasive technologies or minimisation of instrument connections into vessels. The digital fieldbus techniques mean that one could have level, pressure, temperature and even SG all from the one instrument. There are multi-variable devices already on the market, again providing cost and efficiency benefits.

### **Self Validation and Diagnostics**

Digital Control means that instrument diagnostics can self validate instruments, this will lead to maintenance savings in the future. Instruments are likely to have dual processors and sensing elements as the costs and power consumption is likely to drop as technology improves. The situations where operations call the instrument technician to look at instruments when actually the instrument is fine are likely to be minimised because the Instrument can be interrogated as to its health.

In the future we are likely to see self validation of really costly maintenance items such as safety relief and shutdown/blowdown valves, fieldbus will deliver these benefits.

These future directions are just a few of many that are likely to develop.

## **CONCLUSION**

As one can see the benefits of implementing fieldbus technology/ digital control are all encompassing both for today and the future. Taking the “comfort zone” approach is the easy way out. However one should note.... **“If you are not implementing digital technology you are on the route to opportunity lost”**.

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**APPENDIX 1- FIELDBUS COMPARISON SPREADSHEET-** Note: whilst every effort is made to ensure the accuracy of this spreadsheet, please report any errors or blanks to the author

FIELDBUS	Standard	Continuous Or Digital	Topology	max Segment Length	max Speed	Wire Type	max devices	max data/ PDU	Inter-operability	Device Plug and Play	Loop Powered	Control in field	On-Line Config	Time Stamp and synch	Obsolescence robustness	Predictive Maint
ASI	EN50295	Continuous and Digital	bus/tree	100m 300m total	167kb/s	2	32	4 bits	✓	✗	Optional	✗	✓	✗	✗	✓
CAN	ISO11898 ISO11519	DIGITAL	bus	500m/125kb/s 40m/1Mb/s	1Mb/s	2	64	8 bytes	✓	✗	✓	✗		✗	✗	✗
ControlNet	EN50170 IEC61158	DIGITAL	bus/star/ tree	5km 250m/48 nodes	5Mb/s	coax	99	510 bytes	✗	✗	✗	✗	✓	✗	✗	✗
DeviceNet (ODVA)	EN50325	DIGITAL	bus	500m/125kb/s 100m/500kb/s	500kb/s	4	64	8 bytes	✗	✗	✓	✗	✓	✗	✗	✗
Foundation Fieldbus	IEC61158 EN50170	Continuous and Digital	bus	2000m 9.5km total	31.25kb/s -H1 100Mb/s -HSE	2	240	246 bytes	✓	✓	✓	✓ patented	✓	✓	✓	✓
FIP	EN50170 EN50254 IEC61158	Continuous and Digital	bus	1000m	2.5Mb/s	2	256	256 bytes	✓	✗	Optional	✗	✓	✓	✓	✓
INTERBUS-S	EN50254 IEC61158	Continuous and Digital	ring	12.8km	500kb/s	2/8	255	64 bytes	✓	✗	✗	✗	✓			
LON	ANSI 709-1-A-1999	DIGITAL	bus/tree	6.1km/5kb/s	1.2Mb/s	2	2	228 bytes	✗	✗	✓	✗	✓	✓	✓	
Modbus plus	Proprietary	Continuous and Digital	bus	1.8km	1Mb/s	2	32	32 bytes	✓	✗	✗	✗	✗	✗	✗	✗
P-Net	EN50170 IEC61158	Continuous and Digital	bus/tree	1200m 9.3 km total	76.8kb/s	2	32 masters 125 slav	56 bytes	✓	✗	✗	✗	✓	✓	✓	✗
PROFIBUS FMS	EN50170	DIGITAL	bus	19.2km/9.6kb/s 200m/500kb/s	500kb/s	2	127	246 bytes	✓	✗	✗	✗		✓	✓	✓
PROFIBUS DP	IEC61158	DIGITAL	bus	1km/12Mb/s (4 repeater)	12Mb/s	2	127	246 bytes	✓	✗	✗	✗	✓	✓	✓	✓
PROFIBUS PA	IEC61158		bus	1.9km	93.75kb/s	2	32	246 bytes	✓	✗	✓	✗	✓	✓	✓	✓
SERCOS	IEC61491	DIGITAL	ring	250m	16Mb/s	2/fiber	245	16 bytes	✓	✗	✓	✗	✓	✓	✓	✗
Seriplex	Proprietary	DIGITAL	bus	1000 feet	~250kb/s	4	510	32 bytes	✓	✗	✓	✗	✗	✗	✗	✗

SwiftNet	Proprietary IEC61158	DIGITAL	bus	360m	5Mb/s	2	>1024	896 bytes	*	*		*	*	✓	*	*
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## APPENDIX 2- FIELDBUS WEBSITES

### FIELDBUSES

#### ASI

<http://www.as-interface.com>

#### BITBUS

<http://www.bitbus.org>

#### CAN

<http://www.can-cia.de>

#### ControlNet

<http://www.controlnet.org>

#### DeviceNet

<http://www.odva.org>

#### FL-Net

[http://www.fanuc.co.jp/en/product/new\\_product/h1304/flnet.htm](http://www.fanuc.co.jp/en/product/new_product/h1304/flnet.htm)

#### Foundation Fieldbus

<http://www.fieldbus.org>

#### FIP

<http://www.worldfip.org>

#### INDUSTRIAL ETHERNET

<http://ethernet.industrial-networking.com/index.html>

#### INTERBUS

<http://www.interbusclub.com>

#### LON

<http://www.echelon.com>

#### MODBUS

<http://www.modicon.com>

#### P-Net

<http://www.p-net.dk>

#### PROFIBUS

<http://www.profibus.com>

#### PROFINET

[http://www.ad.siemens.de/cba/microsite/html\\_76/subcba4.html](http://www.ad.siemens.de/cba/microsite/html_76/subcba4.html)

#### SERCOS

<http://www.sercos.org>

#### SERIPLEX

<http://www.seriplex.org>

#### SWIFNET

<http://www.shipstar.com>

### OTHER INTERNET SITES

<http://www.iceweb.com.au/Instrument/fieldbus.htm>

This site by Jim Russell and Ian Verhappen has great information/comparisons of buses, fieldbus acronyms and loads of links

<http://www.relcominc.com/fieldbus/index.htm>

<http://www.fieldbusinc.com/>

<http://www.ni.com/fieldbus/>

<http://www.ta-eng.com/industry/mforum/fbtut/default.htm>

<http://www.iac.honeywell.com/openfield/>

<http://www.yca.com/company/fieldbus.htm>

<http://ireland.iol.ie/~readout/fieldbus>

<http://www.smar.com>

<http://ourworld-top.cs.com/rahulsebos/index.htm>

[http://www.emersonprocess.com/plantweb/fieldbus/f\\_index.htm](http://www.emersonprocess.com/plantweb/fieldbus/f_index.htm)

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## Appendix 3

### TYPICAL CODE OF PRACTICE CONTENTS

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