Foundation fieldbus solutions from ABB

Reap all the benefits of proven digital technology
IndustrialIT

The next way of thinking

IndustrialIT from ABB – dramatically improving enterprise connectivity and the quality of the information you acquire and use. Empowering you to access real-time information on a unified enterprise model – so you can make faster, more informed decisions and effectively and successfully implement them for profitable growth.

• Suite of compatible building blocks
• Superior levels of integration providing better quality information to all the users
• Domain expertise for industry specific processes and control techniques
• Standardised engineering interface for creation and re-use of proven solutions. Reducing engineering and operating life-cycle costs
• The common platform for all users and all fieldbus configurations

A powerful portfolio that makes automation easier

IndustrialIT integrates automation systems in real-time – right across the enterprise. It provides business information from initial order through the production facilities to delivery and to payment. ABB has aligned its products, services and people to create a powerful portfolio that provides real-time automation and information solutions – with one common architecture. This provides a consistent infrastructure for data, operations, configuration and maintenance right across your enterprise. The suite of integrated IndustrialIT solutions addresses the problems that you face in today’s e-business environment. Unified architecture and ABB’s expertise improve productivity, provides higher asset optimization and allows for more informed decision-making.
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1 INTRODUCTION

Fieldbus for process automation offers a digital only method of communication between the field and process control system. It has provided access to the vast amount of information resident in modern intelligent field devices, allowing a shift in the distribution of control functions from the system towards the field device.

The full access to device information provides the opportunity to take advantage of Asset Optimization functions at the highest system level. In this regard fieldbus technology is assuming a greater importance throughout industry.

This document provides an overview of the technology behind FOUNDATION fieldbus to help you draw your own conclusions as to its suitability for your applications.

1.1 Application areas and advantages of the fieldbus technology

As fieldbus technology matures, the focus has shifted from development to implementation issues in concrete process automation projects and to the supply of all the necessary devices and peripherals.

Although much progress is still required regarding true interoperability between devices and with foreign hosts and in streamlining the engineering effort, fieldbus technology has acquired a momentum of its own. Its acceptance in the market has much improved and its implementation scope has moved from pilot plants to large scale processes.

The expected benefits in installation costs, engineering and commissioning are now supplemented by those related to asset optimisation. Digital communication enables real time access and transfer of field resident information, previously unavailable to the control system. Advanced procedures for predictive maintenance are now possible.

Fieldbus is set to become the technology of choice for the future.

1.2 Automation fieldbuses and standards

PROFIBUS and FOUNDATION fieldbus dominate the Automation industry. Both buses can offer power over the bus for field devices and provide digital only communications from the field to control systems.

In terms of organisation they are similar with many user groups and support world-wide by the major manufacturers.

The PROFIBUS User Organisation has its headquarters in Karlsruhe, Germany and Fieldbus FOUNDATION has its headquarters in Austin, Texas.

The technologies of Proibus and Foundation fieldbus are different in several important areas although the installation guidelines of PROFIBUS PA and FOUNDATION H1 are similar as they share the same Physical layer (see section 2.1 ISO/OSI Model).

Foundation fieldbus has taken advantage of Ethernet technology as the basis for its high-speed bus. The FF HSE (High Speed Ethernet) standard was released in March 2000 and allows the connection of FF H1 segments, via a link device, to an Ethernet bus. Ethernet is a well-understood network technology with low cost peripheral equipment readily available, and this is one of the reasons FF selected it as the underlying technology for its high speed bus.

1.2.1 PROFIBUS

PROFIBUS has evolved from the high-speed buses required between PLC and I/O racks (PROFIBUS FMS and DP). This has resulted in a large well-developed range of DP devices. Support for automation was completed with the extension of DP to intelligent field devices via the PROFIBUS PA protocol. PA can supply power over the bus for devices such as pressure transmitters which can be extended into IS areas. The PROFIBUS segments connected to DP via a coupler.

PROFIBUS operates as a simple master slave (there can be more than one master) protocol with the DP device the master and the slaves being either DP I/O or PA devices. Once the system has been commissioned cyclic access can be optimized for the number of devices concerned. Acyclic commands (operator interaction) are allowed for as part of the network bandwidth.

Device Interoperability is via the use of Profiles.

1.2.2 FOUNDATION

FOUNDATION has evolved from the intelligent fieldbus level with devices becoming available from 1999. This is the FOUNDATION H1 level, that can supply power over the bus for devices such as pressure transmitters and can be extended into IS areas. The high-speed bus specification was release in March 2000 with product likely to be available by the end of 2000. A link device will be required to connect H1 devices to HSE level.

FOUNDATION devices benefit from time distribution and delegated token passing that allows for the following features:

1. Alarm stamping at source
2. Deterministic communications allowing distributed functions to field devices (PID etc)
3. Peer to peer communication

Field devices contain standard function blocks in the User Layer. These function blocks include PID but can also provide for manufacturer innovation.

Interoperability is via Profiles, Device Descriptions and Independent testing.

1.2.3 Standards

The vision of a single fieldbus has been diluted as a result of the IEC fieldbus standards committee decision to append other protocols to its IEC61158 standard. In all there are now 8 protocols to be appended to this standard. They are shown above.

If this latest revision is to pass the IEC ballot then the result will be to raise the importance of local standards. Confusion will be caused as the international standard will contain incompatible protocols.

1.3 User Requirements

As an encompassing communication technology for process automation, fieldbus must meet the stringent requirements of the process industry. These can be grouped in three categories.

On the concept and standardization side, the general requirements are:

- Standardization of the communication technology
- Comprehensive product availability in terms of both diversity of suppliers and required functionality
- Availability of engineering implementation tools and services, planning aids, technical training, maintenance services
- Standardized engineering interface for transportability of devices configuration and engineering effort to different systems environments
On the technical performance side, fieldbus products and solutions must match the performance achieved today by traditional analog and parallel methods for signal exchange between control system and field instruments:

- Reliability in the transfer of information and time behaviour guaranteed performance
- Complete data transfer redundancy
- Intrinsic safety and field devices power supply on the signal lines
- On line equipment substitution without interfering with plant operations
- Protection from electromagnetic interference from the environment
- Possibility to expand the control system and using distributed field units irrespective of the supplier
- True interoperability of field devices from different suppliers, between themselves and with foreign host control systems

On the future development side, the expectations are:

- Significant cost reductions at all stages of the life cycle; planning, procurement, engineering, installation, operation and maintenance
- Integration within the fieldbus based automation architecture of installed field inputs and outputs, whether conventional analogic or hybrid HART
- Integration of available field device based information for deployment of preventive maintenance strategies

### 1.4 User Benefits

The application of fieldbus technology provides benefits throughout total plant life time. Cost savings to commissioning stage vary between 25% and 43% depending on the layout and the technology used as a reference, with Operational and Asset Optimisation benefits following thereafter.

Be aware of claims for higher cost savings. These are typically a result of extremely long cable runs and are not representative. However they make good headlines!

![Fieldbus Technology Benefits](image)

**1.4.1 Pre-Commissioning**

Savings here are generally made in reduced planning and documentation costs.

**1.4.2 Installation & Commissioning**

In this case savings are possible due to:

- Reduced cable requirements
- Reduced peripheral equipment such as IS barriers – I/O cards – marshalling cabinet’s etc
- Reduced engineering time. (Ability to cut and paste applications and engineer from a central location)

### 1.4.3 Operation and Management

With a greater view of process conditions Asset Optimization will allow operation closer to plant design limits and a switch from ‘just in case maintenance to predictive maintenance’.

### 1.5 ABB Position

ABB supports both the major automation fieldbuses, namely PROFIBUS and FOUNDATION fieldbus and also LON for medium and low voltage systems.

We are an active driving force at all levels of FOUNDATION and PROFIBUS policy and technical development with significant real installations utilising both protocols.

### 1.6 IndustrialIT™ - The next way of thinking

The advent of eBusiness is rapidly changing business needs. Suppliers are now able to tailor messages and offerings on an individual customer basis rather than using the mass marketing techniques of the past. At the same time the customer demands are increasing. It is no longer adequate to simply use traditional business planning and production systems.

There is a growing need to deliver real time information across the whole enterprise – from plant floor to boardroom – in order to achieve greater flexibility, faster delivery times and higher customization.

ABB’s IndustrialIT™ approach is about replacing ‘islands’ of automation with an integrated system approach that spans marketing, design, supply chain, manufacturing, quality, distribution and other processes. It is a seamless integration of real time information (Process Control) and transactional information (Enterprise Resource Planning).

From the fieldbus perspective IndustrialIT deals with the integration of process information to and from the field device and particularly the enhanced information made available via fieldbus. Fieldbus devices provide additional information used by IndustrialIT application to assist with the shift from preventive maintenance to predictive maintenance and all the reduced life cycle cost advantages that result.

The diagram shows how field devices, both traditional and fieldbus, integrate within IndustrialIT™ as part of the FieldIT structure. It is clear that the IndustrialIT optimized applications suite OptimizeIT™ has access to all process information in support of its function of guiding management decisions based upon real-time data.

![IndustrialIT Structure Diagram](image)

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1. Namur AK 3.5 Dr Rathje, Bayer AG
2. EngineerIT™
3. OperateIT™
4. OptimizeIT™
5. ControlIT™
6. FieldIT™

**IndustrialIT™ (the control system level)**
2 BASIC PRINCIPLES - FOUNDATION FIELDBUS

2.1 General Definition: fieldbus in process automation

2.1.1 Fieldbus Types

A simplified description of a fieldbus is a method of digitally transporting data between devices. All fieldbuses provide this function. However, it is important to understand that different fieldbuses will dominate different levels in the plant network hierarchy – at least in the medium term. The important levels are (see diagram):

- **Sensor level** - communication between simple sensors or simple bulk I/O units
- **Intelligent device level** - communication between intelligent devices
- **Plant network level** - communication between systems, PLC’s and large controllers

Most confusion tends to occur between sensor buses and intelligent device buses as both are commonly called ‘fieldbus’. However, compared to the intelligent device level buses, which is the focus of this review:

- Sensor buses carry few bytes of information
- Sensor buses handle simple devices e.g. digital I/O, simple analog I/O
- Most information on sensor buses is one way

**Generally speaking, intelligent device level buses provide:**

- Power on the bus and intrinsic safety
- Interoperability between complex devices
- Communication between individual devices
- Cyclic, deterministic or predictable data transfers

In contrast to the sensor and intelligent device level buses, the **High Speed fieldbus level**:

- Handles larger size data transfers
- Does not supply power on the bus for devices
- Link together many device level buses
- Handles mainly acyclic data transfers

2.2 The FOUNDATION fieldbus protocols

FOUNDATION fieldbus provides an open standard for process automation applications and is supported by all the major control and automation product manufacturers. FF consists of a slow speed bus (FF H1) designed for the connection of 2-wire field devices and a high-speed bus (FF HSE) allowing optimization of network design and connection of complex devices such as analysers/PLC etc.

FF H1 is designed for the automation industry and specifically for field devices requiring power from the bus. This includes suitability for use in hazardous areas via IS protection. FF H1, although often described as the slow speed bus, is designed to incorporate deterministic communications allowing control functions to be distributed into the field and providing timely reporting of process conditions.

The requirement for a high speed bus is satisfied by FF HSE, being based upon Ethernet and using low cost readily available components already familiar to IT departments (routers, switches etc.). Part of its role is to provide connectivity for complex devices such as analysers, remote I/O (for conventional device integration) or other devices, which are independently powered.

2.3 Protocol architecture, functions, profiles and interoperability

2.3.1 Protocol Architecture (ISO/OSI)

In 1978 the International Standards Organisation (ISO) defined a general, non-industry specific, reference model to help the specification of open systems. This is called the Open System Interconnection (OSI) model often referred to as the “ISO/OSI model”.

The ISO/OSI model defines seven layers, each layer performing a specific function for data communication. A message is passed from the top layer (7) to the bottom layer (1) when sending, the reverse when receiving. The layers answer the following questions:

1. What should be the physical signalling method?
2. When can a device have access to the network to send data?
3. How should data be transmitted over separate networks?
4. How should large pieces of data be split up and put together again?
5. How should communication dialogues be synchronised between devices?
6. What should be the agreed format of the data?
7. What communication services should be supplied for particular applications?

It is not necessary to use all seven layers to build an effective open communications system, and additional layers can be added. The used set of layers is called a “stack”.

FOUNDATION fieldbus does not use layers 3 to 6 and the Fieldbus Access Sublayer (FAS) maps the Datalink Layer to the Fieldbus Message Specification (FMS). FOUNDATION fieldbus defines another layer, the User Layer, which provides standard function blocks (AI – AO – PID etc.) for use when process functions are distributed into the field.

The Physical layer used by FOUNDATION fieldbus is the IEC 1158-2 standard which is the same as that employed by PROFIBUS PA. The net result is that installation rules are the same for PA and FF H1 (IS guidelines are different). These rules govern topology design, cable types, devices per segment etc.

### ISO/OSI Model and FF layers used
2.3.2 Interoperability

One of the advantages of a traditional system using the 4-20mA standard is that you can be sure that a field device can be replaced with a similar unit from another manufacturer without loss of functionality. In other words, device interchangeability is provided.

To provide the same level of interchangeability fieldbus standards must provide interchangeability at the data communication level and at the device functionality and information level.

The ISO communication standard defines the standard for the data communication part. However, even using all 7 layers of the ISO standard does not ensure one device will work in place of, or with, another.

The main problem is the wide range of functionality and information that field devices can deliver, and the inevitable incompatibilities that result between devices from different vendors because of the different technologies employed in the devices. Some degree of differentiation between devices is also desirable as this enhances the users ability to select the best fit for specific applications.

The issue of interoperability then boils down to:

- Providing a useful level of interchangeability of devices – this is done by defining common behavior and parameters using function blocks, communication profiles and device profiles.
- Providing access to the proprietary features of a device from any system. FF utilise the device description language to provide this function.
- These interoperability methods are discussed next.

2.3.3 Profiles

A definition of a device profile would be “A definition of the minimum functionality required to provide a useful level of interchangeability for a device type”.

A profile consists of a subset of the services specified in a communication standard plus parameter definitions for applications using similar devices (e.g. a level or flow application). Because the communication standard consists of layers, the communications subset is defined as a sub-profile for each layer (see diagram).

A complete device profile defines the minimum requirements for a device to be interoperable with others.

The advantages of profiles are:
- Fewer implementation costs – because a subset of the standard can be used
- Enhanced interoperability – because of common device parameters
- Lower configuration cost – because default values for parameters are used

In FF the profile is incorporated into the device description

2.3.4 Device Description (DD) and Common File Format (CFF)

The DD and CFF files provide all the information required to configure and integrate a foundation device into a control system.

The DD is a binary file the main task of which is to provide information regarding how device data is displayed:
- The data variables and help text
- The menu based user interface to interact with the device
- The command/response sequences to do operations on the device
- Data relationships (e.g. ‘write these data as one’ block)
- Response codes from device

The device developer uses a device description language specified by FF to write the device description. The device description is then passed through a tokenizer to produce the final binary code.

The Common File Format (CFF) file consists of two subclasses, the value file and capabilities file. The CFF file is often referred to as the capabilities file, as this (capability) feature is so important. The CFF file looks similar to a Windows INI file so that it is more easily understood. The data contained includes:
- Device type and manufacturer
- Which function blocks are implemented, and how many
- Communications resources
- Profile class

Device testing for interoperability requires that the DD and CFF files are available.

2.3.5 User Layer

The use of an extra layer, the User Layer, to the ISO model provides another level of interoperability. This layer is unique to FOUNDATION fieldbus and is one reason why it is becoming a preferred protocol by many user and suppliers.

It is here in the user layer that Function Blocks (see diagram) are used in FOUNDATION fieldbus to allow control functions to be carried out in field devices. To ensure interoperability there are standard function blocks which must be present in devices of a similar nature. Vendors can also add advanced functions blocks.

FF function blocks and applications
2.3.6 Summary of Interoperability

The FF interoperability strategy and independent device conformance testing ensures that the system is truly open with end users able to choose the most suitable device for the application at hand, independent of manufacturer. (See also device selection section)

2.3.7 ABB AND INTEROPERABILITY

ABB has identified the ease of device selection and integration into a control system as a major concern for end users. In this respect ABB has several strategies within its IndustrialIT initiative to help build end user confidence in fieldbus technology.

- **Plug and Produce**
  The DD and CFF files provide all the information a system requires to display process data from a field device. ABB has gone one step further by allowing the system to automatically identify newly commissioned devices and attach display templates accordingly. These templates, or Aspects within the IndustrialIT world, would include Trending – Status – Documentation – Asset Optimization.

- **Device and IndustrialIT conformance testing**
  ABB has set up a conformance test centre to specifically test the integration of devices (fieldbus and traditional) into Industrial IT. This will provide the confidence that a device with the IndustrialIT Enabled tick mark is compatible with ABB systems.

2.4 Transmission Technology

2.4.1 FF H1 (31.25 kbit/s)

The H1 bus is compatible with typical 4-20mA wire (see Installation) and is used to connect field devices to the network. Devices are connected in a multi-drop fashion such that one fieldbus segment can accommodate up to 32 devices (non powered) or 240 if repeaters are used. If it is required to power devices from the fieldbus then the number of devices which can be connected is reduced (see section “Number of devices per segment”). As with the 4-20 mA standard, fieldbus allows devices to be located in hazardous areas with the application of intrinsic safety methodology.

The FF H1 protocol allows for deterministic inter-device communication, alarm time stamping at the device, full access to diagnostic information for asset optimization applications and interoperability assurance.

FF HSE supports the H1 function blocks and communications relationships allowing devices to communicate across segments. FF HSE also supports configuration management of H1 devices.

Installation guidelines for FF HSE are no different than for typical IT Ethernet. In this case with 10mbit/sec a category 5 copper wire can run for 100m and can be extended to 300m with the use of repeaters. It is also possible to use fiber optic with its advantages of greater data integrity and network distances. As you can see, the type of media used is defined by Ethernet standards and not FF.

The selection of Ethernet technology allows the use of readily available low cost networking peripherals with standard IT installation and support.

2.5 Bus accessing methods and network optimization

2.5.1 Bus Access

The foundation fieldbus protocol allows the following functions to be carried out over the bus:

- **Cyclical - Deterministic data communication**
  Data can be transmitted periodically to suit the execution of function blocks in other devices, e.g. transfer flow value from transmitter to PID function block in a positioner, then execute the PID function

- **Peer to peer communication of data between devices**

- **Acyclic data communications**
  Alarm reporting – Device configuration – Inter-device Messaging – Operator interaction. This represents data transfer which may be triggered via an event or operator interaction

2.4.2 FF HSE (10 – 1,000mbit/s)

If a fieldbus topology is designed with many segments connected via repeaters to a home run then the data refresh rate would be reduced due to the bottleneck effect at the home run. To overcome this problem and aid network optimization FF released its protocol using Ethernet technology.

FOUNDATION fieldbus uses a combination of a master and token passing as a method of bus access control to permit these functions. A device that has the scheduling function controls the FF segment. This function is referred to as the Link Active Scheduler (LAS) and can be considered an extension of the FF stack. In this case a segment will be comprised of standard devices (a bit like a slave) and at least one LAS device.

Macro Cycle Macro Cycle

Cyclic Bandwidth

Acyclic Comms Tasks

Cyclic Bandwidth

A-Cyclic Bandwidth

Master LAS

LAS and distributed PID

H1 segment to single host

It would be possible to design a fieldbus solution with H1 segments connected to a LAS card and then directly to the HSI. This may be how some users will set-up a device configuration facility to configure some device parameters off-line, in practice the use of a high-speed bus is required for any large installation.
The LAS controls the network bus by issuing tokens. The tokens and functions are:

- **Compel Data**
  This token is sent to particular devices when it is time for them to publish data on the segment.

- **Pass Token**
  For acyclic communication of data.

- **Probe Node**
  Search for new devices on the segment.

- **Time Distribution**
  Synchronizes device time.

### 2.6 Bus topologies, installation considerations and control in the field

#### 2.6.1 H1 Installation

**FOUNDATION fieldbus** exists at the H1 31.25KHz level at the moment. Devices for the High Speed Bus will start to become available in the year 2001.

The topologies allowed for FF are as a result of the Physical Layer IEC1158-2. This being the same standard as adopted by PROFIBUS PA, so the rules described here apply to PROFIBUS PA too.

FF H1 consists of twisted pair cable with terminators at the extreme ends and devices dropped off in parallel.

The cable types and maximum lengths are:

<table>
<thead>
<tr>
<th>Cable Type</th>
<th>Cable size (AWG)</th>
<th>Maximum Length (M)</th>
<th>Loop Impedance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type A–shielded twisted-pair with shield</td>
<td>18</td>
<td>1900</td>
<td>44Ω/km</td>
</tr>
<tr>
<td>Type B–multi twisted-pair with shield</td>
<td>22</td>
<td>1200</td>
<td>112Ω/km</td>
</tr>
<tr>
<td>Type C–single or multi twisted-pair w/o shield</td>
<td>26</td>
<td>400</td>
<td>264Ω/km</td>
</tr>
<tr>
<td>Type D–multi-core w/o shield</td>
<td>16</td>
<td>200</td>
<td>40Ω/km</td>
</tr>
</tbody>
</table>

**2.6.1.1 Bus with Spur Topology**

The segment has terminators located at the extreme points with devices dropped off in parallel. The total length of all spurs and the segment length must not exceed the maximum length defined by the cable used. (see previous table)

When combined the segment length and all spur lengths should not exceed 1.9km.

**Bus and spur topologies**

Max spur length \( L \) depends upon the number of devices on the segment and the number of devices on the spur.

<table>
<thead>
<tr>
<th>Number of communicating devices in the segment</th>
<th>Maximum spur length (L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25-31</td>
<td>0m</td>
</tr>
<tr>
<td>19-24</td>
<td>30m</td>
</tr>
<tr>
<td>15-18</td>
<td>60m</td>
</tr>
<tr>
<td>13-14</td>
<td>90m</td>
</tr>
<tr>
<td>1-12</td>
<td>120m</td>
</tr>
</tbody>
</table>

The maximum spur length is reduced by 30m for each additional device added to that spur.

**2.6.1.2 Daisy Chain**

In this case the fieldbus segment is connected to each field device and then looped out to the next device. Care must be taken that, if a device is removed from the segment, the terminator is not removed with it.

**Total segment length not to exceed 1.9km.**

**Daisy chain topology**
2.6.1.3 Tree Topology
Practical if devices are located close together.

Tree topology

Spur length from the hub in a tree configuration follows same rules as for a single spur.

2.6.1.4 Wiring Considerations
Generally, good installation routines must be followed using the correct tools and suitable cable.

Guidelines
- Make sure Terminators are installed at the extremes of the segment and that only 2 terminators are present in any one segment
- IS areas require IS terminators
- Do not ground the shield in more than one location
- Ensure the screen is passed through any junction box or T-Piece
- Ensure Shields of multiple segments are not connected together

2.6.2 Network Components (Connectors – Terminators etc.)
Each H1 segment requires two terminators and a fieldbus compatible power supply as minimum components for devices powered over the network. If you decide to use a traditional PSU then you will require a conditioner so that it does not affect the fieldbus signal.

For IS applications you would require an IS fieldbus rated power supply and barrier (often an integrated solution) together with an IS terminator.

As a result of the multi-drop bus then there is the opportunity to take advantage of new/different connector devices, some of which will have terminators built in.

2.6.2.1 Bus Topology with Spur Components
In this case use T-Pieces to provide the spur drops.

The advantages are
- Simple and quick-fit connections in the field
- Often the T-Piece will provide a jumper to add-in a terminator (Non-IS)

You will need
- Fieldbus rated power supply
- T-Pieces for each field device
- Connector for each field device
- IS Terminator if IS area

2.6.2.2 Tree Topology Components
In this case use Hubs to provide the spur drops. (Suppliers include TURK and RELCOM). Check if the HUB you have chosen requires mounting in an enclosure.

You will need
- Fieldbus rated power supply
- 4 or 8 port hub
- Connectors for each device
- Terminator (IS or Non-IS)

2.6.3 Number of devices per segment
Several parameters are going to effect the number of devices you can attach to a particular segment. These include:-
- Segment length
- Device current consumption
- Environment (IS)
- Data refresh rate requirement

Perhaps the best way to describe the guidelines is to run through a few examples.

Case 1
Type A cable at the maximum 1.9km length with devices that draw 11ma each. Non-IS:
Assuming that the PSU provides 24V and that the cable resistance is 44 Ohms/Km, and that no other load is present (surge protectors etc.)

Current available = Voltage/Resistance
= (24 – 9)/(44*1.9)
=179ma

Therefore 179ma/11ma = Number of devices = 16 devices
Reduce the segment length to 1km and the number of devices on the segment increases to 30.
You also need to consider the data refresh rate. FF H1 can provide roughly 30 messages/second. So for 30 devices the refresh rate will be 1 message/second. Don’t forget that the LAS could send the same message twice during this one second period to increase the refresh rate for individual parameters.

Case 2
Type A cable at the maximum 1.9km length with devices that draw 11ma each IS area:
Assuming that the PSU provides 22V and that the cable resistance is 44Ohms/Km, and that no other load is present apart from the barrier (surge protectors etc.)

Current available = Voltage/Resistance
= (22 – 9)/((44*1.9)+105)
=69ma

Therefore 69ma/11ma = Number of devices = 6 devices
Reduce the segment length to 1km and the number of devices on the segment increases to 8.

Note that in this case you must assume that one device (LAS) is likely to be in the safe area and you should also account for visiting devices, this reduces the 6 devices to 4 for a 1.9km run. (See “ABB foundation fieldbus example plant” Multibarrier MB204)

2.6.4 Intrinsic Safety
Fieldbus solutions will reduce the number of IS barriers required when compared to a traditional installation. This is a result of the multi-drop nature of FF and also PROFIBUS. As with the traditional IS solution the key is to reduce the power supplied to the field.

An IS barrier is required (it may also provide power for the bus) for each segment with an IS rated terminator at the end of the segment in the field. The number of devices depends upon the current consumption of the device (some devices may be externally powered) and cable length as previously shown.

An I.S. barrier must be within 100m of a terminator and the power available past an I.S. barrier is ~600 mw. Typically four field devices can be connected plus a hand terminal in the safe area.

Key points:
- Use an IS power supply for the IS segment or use a barrier with internal PSU
- Require IS rated terminator in the field (RC components are energy storing)
- Surge protector resistance must be taken into account
- PROFIBUS PA uses the FISCO guidelines to simplify IS installations. FF is currently looking at using these guidelines
2.6.6 Device Selection

An advantage of fieldbus solutions is that if a segment is working then system tools can often be used to trouble shoot. These device specific procedures are outside of the scope of this document.

The physical layer specification requires that devices should operate between 9 and 32 volts and so in many cases checking for this value is the first diagnostic to perform.

Suppliers such as RELCOM now offer FF test devices which will report if the LAS is active, how many devices are on the segment, noise and voltage levels etc. Tools such as this will simplify trouble shooting without being too sophisticated.

2.6.5 Control in the field

The ability to distribute functions into field devices and determine the sequence of communication and function block execution is a differentiating technology for foundation fieldbus. In this case the Link Active Scheduler (LAS) and standard function blocks resident in the user layer are the key enabling technologies.

The availability of standard function blocks in the user layer provides the interoperability between devices from different vendors, the Device Descriptor (DD) and capabilities file (CFF) provides the engineering tool with the information concerning which of these function blocks have been implemented in a device.

The advantages offered by distributing control between field devices revolve around loop integrity and efficiency of the use of communications capacity or bandwidth as it is often referred to. In the case of simple PID control distributed between a transmitter (e.g. pressure) and a positioner, then the most likely and communications efficient location for the PID algorithm would be in the positioning devices. More complex loops (cascade) may require PID in the transmitter as well. To maintain loop integrity there should be a back-up LAS (possibly in the positioner but not exclusively there) to maintain control functions in case of LAS failure. Other considerations should be that the transmitter and positioner should also be on the same H1 segment and not rely upon repeaters or high-speed Ethernet (FF HSE) link devices to relay control data.

The loop performance increase by distributing the function into the field is likely to be quite small and so complex loops, and loops including data across H1, segments are perhaps best performed at the DCS or supervisory system level. Control in the field device would provide a back-up function.

2.6.6 Device Selection

There are several new considerations to take account of when selecting new or replacement devices. For example, if your network strategy is to place as many devices on a segment as possible then a key parameter to check would be the device current consumption.

All devices displaying the FF tick mark will comply with the FF standard and this will guarantee that the communications stack is compliant with the FF standard. However, be aware that not all devices will implement the full complement of function blocks in the user layer. So if you decide to use PID functions in H1 devices make sure that this function block is implemented in the device you choose.

Check:
- Device has FF tick mark
- Device current consumption
- Function blocks implemented
- Level of local support

3 CONFIGURATION AND OBSERVATION OF FIELD UNITS

3.1 Integration of field devices, stand-alone tools and process control systems = the FDT concept

With the proliferation of intelligent field devices with digital interfaces such as HART, PROFIBUS and FOUNDATION fieldbus, there is a requirement for configuration tools using these protocols. It is desirable for this configuration tool to have a rich graphic user interface whilst providing access to devices from multiple manufacturers

A common proposal for a solution has been worked out in the PNK working group “Device Description” and in the working group formed by ZVEI, “Field Device Tool (FDT)”. The goal is not a new device description language, but rather a device-independent interface. This allows for the integration of a device-specific software component into each engineering tool.

Similar to the driver software for a printer, a DTM (Device Type Manager) belongs to a field device. The device manufacturer makes the DTM available, since only the manufacturer knows the full details of the device. A DTM might include, for example, user dialogs and plausibility checking for parameters.

The FDT software interface provides a uniform environment for design of device configuration components, increasing efficiency in working with the devices. The same DTM can be used as part of the stand-alone tool and also the system integrated tool. This provides a universal interface for the device type used independent of the platform used. It is only necessary to learn to use the device with a DTM once. This helps to reduce costs in administering and handling devices, tasks that often dramatically exceed the investment costs for the devices themselves.

3.2 Configuration – Device management tools

The boundaries between the system and instrument engineering environment are gradually being removed with the advent of fieldbus technology. For FF field devices the requirement to schedule communications necessitates the use of a system-wide tool for communications optimization. There is also the requirement for device management to provide support for calibration checking and general maintenance that may be best addressed via a stand-alone tool.

3.2.1 Stand-alone Configuration Tool SMART VISION

SMART VISION is an intelligent software package for stand-alone field device management. Whether the task is configuration, parameterization, calibration, commissioning, diagnostics or maintenance, this is a central tool for all devices – independent of the manufacturer. The modular structure corresponds to the FTD/DTM specification (Field Device Tool/Device Type Manager). This ensures continuous compatibility – today and in the future.
SMART VISION allows for communication between field devices through the following communication protocols:

- **HART communication**
  - Via FSK modems with point-to-point or multi-drop operation or FSK bus
- **PROFIBUS communication**
  - Via segment couplers to PROFIBUS-PA devices
- **FOUNDATION fieldbus**
  - Direct connect to H1 devices

SMART VISION is capable of running on modern standard PC’s or Notebooks with MS Windows™ with Version 3.1, MS Windows 95 or MS Windows NT 4.0.

SMART VISION offers management of all field devices independent of the protocol used. It provides the software environment for running the device DTM, and it is the DTM that creates the rich graphic user interface for device set-up and interrogation. The main areas of usage for SMART VISION are therefore found in:

- Diagnosis of field devices and calling up status reports
- Online display of device parameters (graphical/text) or printout
- Storage of device configuration, device measurement and status data
- Parameterization calibration of field devices
- Management of device data and planning and administration of device measurement stations
- Visual overview as a representation of devices connected on a segment

SMART VISION has allowed working with field devices to become less complicated, more effective and reliable as a result of removing the necessity of learning several device management applications provided by individual device manufacturers. With the plug-in concept of the DTM, SMART VISION supports all devices from manufacturers. SMART VISION uses standard Windows™ user interface techniques to reduce the learning curve for new users.

Along with reliable handling of field devices and the multiple protocol support, SMART VISION will save time, and thereby money.

SMART VISION supports the entire ABB portfolio of devices, including flow, temperature, pressure measurement devices, remote I/O’s, positioners and actuators. Devices from other manufacturers can be integrated too.

### 3.2.2 System Integrated Configuration Tool

For FF devices it is not always necessary to carry out any off-line configuration. For example, FF does not require network addresses to be set.

FF HSE provides for the configuration/management of H1 devices from the system level. This allows for the integration of devices in to the LAS schedule.

#### 3.2.2.1 Adding a New Device

As a new device is added to a FF H1 segment the LAS will identify it as a result of sending a probe node token. As a result, the device will automatically be given a unique system address.

The new device will be added to the system project tree where its tag and other parameters can be set (unless already set via stand-alone tool).

Replacing a device is similar to adding a new device. However instead of setting the device tag and parameters the option to replace a device is selected from the menu and correct configuration data is sent to the device.

![Adding a new device (DTM)](image)

#### 3.2.2.2 Device and Function Block Configuration

The interoperability strategy for FF requires devices to provide a device description file and compatibility file. These files are provided on disc and imported into the system tool providing information including function blocks supported. The ABB solution provides these files and also the DTM to provide a richer universal user interface. The difference between using DD/CFF files and FDT/DTM is summarized here:

<table>
<thead>
<tr>
<th>DD/CFF</th>
<th>FDT/DTM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solution for FF only</td>
<td>Solution for FF/PROFIBUS/HART</td>
</tr>
<tr>
<td>Each system tool will display the device information differently</td>
<td>Presentation of device information is independent of the system tool</td>
</tr>
<tr>
<td></td>
<td>Additional built-in applications for maintenance calibration etc</td>
</tr>
</tbody>
</table>

![Diagram showing the difference between DD/CFF and FDT/DTM](image)
3.2.2.3 Optimizing Bus Communications (LAS)

Once the function blocks have been configured and links between them made, the LAS schedule can be viewed and optimized for the application at hand. It is the LAS which supervises access to the H1 bus including distributing the time synchronization token enabling the correct scheduling of functions in the device. Care should be taken to ensure a suitable macro cycle is selected providing sufficient spare bandwidth for acyclic communications such as device configuration.

Device specific management such as calibration or setting device specific application parameters is best carried out via the DTM. In this respect these system user interfaces will be the same as those available from the stand-alone tool as it too supports the DTM methodology.

3.3 Fieldbus enables new control system structures

New technologies – such as fieldbus – open up new structures in control technology. Traditionally a system would comprise of field equipment with analog connection back to a marshalling cabinet in the central control room, and from there to supervisory/control equipment as part of a system or PID controller panel. Fieldbus allows a different approach where some functions can be distributed closer to the process and others such as Asset Optimization can make full use of two-way communication to field devices at the higher system level. A key feature of fieldbus technology is to allow the end user to take full advantage of the open standards incorporated. This allows for the selection of the most appropriate device for the application rather than locked into the manufacturer who provided the system.

The benefits of using a fieldbus solution has been described in section 1.4 with the emphasis on reducing costs over the entire life cycle of the plant. The magnitude of the benefit of using a fieldbus solution will differ from one installation to another with the obvious cost savings due to cable runs depending upon the geography of the plant installation. Long term operational/maintenance savings are more difficult to quantify but are made more effective as a result of the two-way data communications to field devices.

3.3.1 Future Control System Structures - IndustrialIT

The structures of modern day control systems from different manufacturers have evolved to a similar design that includes:

- Process area
- Bus network area
- Automation and supervisory area
Future control system structure

As you can see, the automation and process areas have become merged as the bus network extends out into the field. The extension of the bus and the two-way communications now available has allowed a shift in the system hierarchy. Some simple functions (totaliser – PID – alarms) can reside in field devices with sophisticated Asset Optimization applications running at the higher system level. The diagram also shows how ABB’s IndustrialIT provides real-time process information throughout the enterprise.

Operator Station:

The changes at the operator station as a direct result of foundation fieldbus applications include the following:

1. **Greater confidence in the process conditions reported at the workstation**
   This is a consequence of improvements in maintenance scheduling (switch to predictive maintenance) – data quality messages – no analog component to degrade data accuracy. As a result the operator has greater confidence in the process conditions reported from the field and can operate closer to plant capacity.

2. **Timely reporting of process information**
   Foundation fieldbus time stamps alarms at the field device with millisecond resolution and not when the system/master sees the alarm condition. Spare communications capacity is used to report alarms/events.

   Fieldbus has also been the catalyst to improve data presentation at the operator station, as there is simply more data available. ABB has taken the route of providing views of plant objects (plant equipment such as a compressor or single devices such as a transmitter) with different aspects (Object related data such as trends - alarms – data sheets – calibration).

   In the case of ABB’s Object/Aspect methodology the user will be presented with a data format personalized to their requirements as defined by the user log-in. The personalization will be via the creation/customization of user dashboards, a dashboard being the collection/presentation of information or aspects.

Engineer Station:

Traditionally the view of process control equipment from the engineer workstation would extend only to the I/O rack or marshalling cabinet. Fieldbus systems extend this view to the field device with reporting of diagnostic information. The engineering workflow now has to deal with multiple protocols and all the data available from automation equipment in such a way as to facilitate rapid drill down to locate faulty devices.

1. **Engineering tools:**
   Foundation uses the device descriptor (DD) to allow full access to device configuration parameters. The richer graphical displays made available from FDT/DTM would reduce learning curves and engineering time.

2. **Support information:**
   The same organisation of data as used for the operator (Objects and Aspects) allows the rapid call up of relevant maintenance/trouble shooting documentation for fault conditions.

**Optimization station: (Maintenance Triggers):**

Plant Optimization is already available in a limited form for traditional analog control systems. Fieldbus offers timely reporting of diagnostic information allowing a shift from preventative maintenance to predictive maintenance enabling higher availability of plant.

1. **Critical asset optimization**
   The analyses of information from sources such as specific device diagnostics – related device information – historian - providing maintenance triggers is the next step, although some maintenance alarms are already available (e.g. Positioner data such as valve stem travel), Maintenance triggers would allow the change from preventative to predictive maintenance.

2. **Process optimization**
   Timely maintenance of critical assets reduces plant upsets due to equipment failure allowing control strategies to run closer to the plant capacity.

   Process modelling and multivariable control would be able to adapt based on confidence levels in process data reported from the field.

**Bus Networks**

1. **High speed bus**
   For foundation fieldbus the high-speed bus is based on Ethernet and allows the passing of all data including configuration of fieldbus devices. Being based on ethernet the end user has access to all ethernet technology including switches – optical fiber media.....

2. **High-speed bus optimization**
   The ability to run the high-speed bus at faster speeds (1Gbit/sec) will offer a more predictable performance at the cost of segment length. The use of Ethernet switches will allow further optimisation as devices can share a smaller communications domain.

3. **H1 bus optimization**
   The scheduling of communications traffic allows for some flexibility in the H1 bus performance, however the more devices present on a segment the less the flexibility for optimization available (less spare bandwidth for acyclic data transfers).

4. **Field device bus**
   The H1 bus provides power for field devices that were traditionally of a 2-wire design. A link device is used to connect to the high-speed bus. The ABB device offers the connection of 4 off H1 segments to the high-speed bus.

5. **Gateways to other buses**
   As already mentioned there is not one all-embracing fieldbus technology, other buses would link to a control system via gateways at the high-speed bus level.

**Automation Area**

The automation area has traditionally included I/O cards and PLC-PID supervisory devices. I/O cards may still be required to support existing analogue devices however other functions may reside in field devices.

1. **Fieldbus controller**
   This is a device that will provide access to the high-speed bus. It may provide a gateway to other protocols and also PLC supervisory functions.
2 Distributed functions
This feature of Foundation fieldbus offers distribution of functions such as
- PID (Economic use of communications bandwidth)
- Alarms (time stamping at source)
- Totaliser

3 Multivariable device
Fieldbus enables the full economic use of multivariable devices as all
derived data (mass gas flow – totals etc) is available over the bus.

4 THE ABB FOUNDATION FIELDBUS EXAMPLE PLANT
The example pilot plant described here illustrates how an ABB fieldbus
system can be planned and set-up. It is not meant to be an exhaustive
analysis of a process but rather what components are required to get the
system working and what troubleshooting methods can be used. The
example plant includes the foundation high-speed bus with links to H1
segments in hazardous and non-hazardous areas.

4.1 Planning
For a traditional project based upon 4-20 mA devices a simple
Input/Output schedule is often the first request to estimate the project
budget. Fieldbus requires the extra dimension of process connection plant
geography to design fieldbus segment runs and the number of devices
available to each segment.

Device selection
Selecting a device requires choices to be made concerning distribution
of functions into the field. If control (PID) are to be distributed then check
that suitable devices have implemented this function.

Layout

Area 2
The two valve positioners will run PID functions with
process values from pressure transmitters on the same
segment.

Remembering that a fieldbus segment requires a terminator at the
two extreme points then a segment design which allows the simple
identification of these points, would be beneficial.

Ensure that segment guidelines have been applied and that interacting
devices are on the same segment.

4.2 Hazardous area considerations
As already described foundation, H1 segments can be used in hazardous
areas with the application of IS methods. A fieldbus IS rated power supply

Other components
Devices should be connected to the fieldbus segment via t-pieces
to allow rapid installation and facilitate device replacement in fault
conditions.

Terminators are required at the extreme points of the segment.
They would typically plug into the last t-piece.

The ABB system would comprise of the following components:

1 Operator & engineer stations linked via Ethernet
to fieldbus controllers
2 Fieldbus controllers supervising H1 segment
via link device
3 Link device powering H1 segments and
providing LAS functionality
4 MB204 multibarrier extends the number of
intrinsically safe devices into hazardous areas
5 T-Pieces and terminators for device
connection to H1
4.3 Summary of ABB Example Plant

At the higher system level an Ethernet bus connects three types of standard workstations. The operator workstation provides aspect views of the process plant enabling efficient operator interface to the process. The engineer workstation contains all the tools required to maintain the fieldbus system right down to calibration applications for field devices. The optimization application provides tools for plant and asset management. These three workstation types have the potential to view all the data available as a result of the fieldbus network.

At the Automation level the fieldbus controller provides supervisory applications (PLC type) and also acts as a gateway to other fieldbus protocols as required. There is an HSE link to the H1 Link Device. The link device may be located closer to the field devices saving H1 cable runs. The ABB Link Device has the ability to link and power 4 H1 segments to HSE.

At the H1 level 3 segments are used.

Segment 1 is used entirely for the 10 devices in the hazardous area. In this case a normal H1 segment is protected via increased safety methods into the hazardous area and connected to the MB204 multibarriers. This configuration allows more devices to be connected to the H1 segment and there is no requirement for t-pieces or additional terminator.

Segment 2 drives 6 devices in a safe area and a further 4 devices which are close by but in a hazardous area. This configuration will save the running of an extra segment into the hazardous area.

Segment 3 drives 4 devices, which have some distributed functions. In this case the positioner runs a PID algorithm with the process signal cyclically reported by pressure transmitters. The number of devices has been reduced to 4 in an attempt to allow maximum use of the H1 bandwidth for rapid inter-device communications.

The link device has remaining capacity for another H1 segment.

F I/O 100 and AC800F HSE

4.4 Trouble-shooting

Physical checking

Check the location of terminators and any grounding of screens. Ensure screens are carried through any junction boxes.

Device Addressing

There is no requirement to set device addresses with Foundation systems, however the system will reject duplicate tags.

Signal checking

There is still a role for the multimeter in trouble shooting a fieldbus H1 installation. In the simplest case, a check for voltage at the field device can often indicate a simple fault with root causes exactly the same as for an analogue installation. (broken cable-short circuit....) The specification for the physical layer (communications media) requires devices to operate between 9-32V DC.

There are test tools available (hand held) which connect to the H1 segment and report the number of communicating devices. A quick comparison with the physical count would indicate if a device is not active. These tools often report other noise errors and status of the LAS.

Device configuration

If data is not being refreshed then it may be due to the status of device function blocks. When commissioning a device, check the status of the function blocks used. An error made during configuration may result in a block remaining in manual mode (the configuration tool will indicate these kinds of errors when downloading or compiling the configuration database). When a block is initially configured it is often in an Out Of Service (OOS) mode and would require switching to Automatic.

Configuration tool set-up

If you do not have full access to device parameters then check the installation of the DD. To provide full access to the function blocks in a device ensure that the DD has been imported correctly into the system/tool. Each device has a unique DD file name that is imported into a unique directory (by manufacturer) on the system.

5 ASSET OPTIMIZATION - Reduces Life-cycle Costs

Fieldbus is one of the main driving technologies for the next generation of Asset Optimization applications within process automation. Traditional 4-20 mA or analog devices relay little or no maintenance information to maximize asset effectiveness. Fieldbus devices, on the other hand, provide timely reporting of diagnostic data with the facility to implement more sophisticated maintenance applications now and in the future.
The changing hierarchy of control and supervisory functions with the wealth of process data fieldbus makes available has impact upon support workflow. This is seen from maintenance planning to work order generation, from initial fault condition drill down to adapting control strategies. Asset Optimization applications are at the centre of this evolutionary change, providing the tools to guide management decisions and automate actions where appropriate. ABB has identified many of the requirements and opportunities made available by this modern technology and embraced it within their IndustrialIT program.

Intelligent field devices, such as transmitters and positioners, are able to provide critical status information to the higher system via fieldbus networks. In the simplest case, the process value is reported with a status condition that provides greater confidence in the accuracy of the value reported. Other condition events are used to provide maintenance triggers via logical comparison of data within the device or from other sources (e.g. historical conditions). In the case of maintenance triggers, fieldbus has been a prime motivator for the shift from preventative to predictive maintenance, maximising plant availability. The degree of assistance within the maintenance procedure could include work order generation – status tracking – component inventory checking and ordering.

The additional processing power fieldbus has made possible at the field device is also the driver for a level of self diagnosis and the storage of device specific data such as documentation and installation data (IS certification – materials used ...). This information will assist in installation by checking device certification and enabling ‘plug in’ procedures. ABB’s IndustrialIT program ensures that all ABB devices offer the advantages of fieldbus communications.

The wealth of data available from fieldbus devices requires a more intuitive interface with related data presented for a particular asset under investigation. An example would be linking for relevant audit trails for a particular asset, audit trails such as calibration, engineering and operator actions would be compiled and presented at the asset selection by the asset optimization workplace. Some of the data used to compile the audit trails would be stored in the field device and therefore be available to all subscribers to that data over the system. ABB’s IndustrialIT program extends this concept of linking data to assets by considering plant equipment to be an object and linking various aspects (views such as trending, alarms, live video etc.

Fieldbus is clearly the underlying driver for Asset Optimization opportunities as a result of access to device diagnostics and stored data. As technology advances further then the opportunity to distribute Asset Optimization functions and more advanced maintenance triggers in to the field device becomes possible. Again fieldbus will be the driver.

6 FUTURE PROSPECTS

Fieldbus technology has provided the full communications link from field devices to supervisory/management systems. The cost savings are evident in the installation/commissioning phases with further reduction in overall system components. In this regard user requirements have been largely satisfied. A warning against all-too-euphoric marketing pronouncements in the technical periodicals is appropriate in this context. Nothing but the shared experiences of suppliers and users will help to fully exploit the innovative potential of this technology.

The other side of the coin from the savings on input/output cards in the system is the added expenses for link devices (H1 to HSE), t-pieces and high-quality field devices. The reduction in the cost of components that goes hand-in-hand with the proliferation of fieldbus technology will bring with it the desired savings in hardware.

While it was previously believed that savings had to be achieved by reducing copper lines and hardware, overall costs are the centre of attention today. Fieldbus technology has provided process information with a greater level of confidence. However, further work is required in the presentation of this data at the higher system level. Rather than a host of diagnostic flags, knowledge based messages would be preferred, perhaps as a result of a maintenance trigger generated at the device level.

With the FDT interface (Field Device Tool) and DTM (Device Type Manager) acting as device drivers, a great stride has been made for the thorough engineering and operation of entire systems from the control room through to field devices. The rich graphical environment supports the use of multimedia for all field devices from the central engineering tool at the automation system. Maintenance information from individual field devices acting as device drivers, a great stride has been made for the thorough engineering and operation of entire systems from the control room through to field devices. The rich graphical environment supports the use of multimedia for all field devices from the central engineering tool at the automation system. Maintenance information from individual field devices acting as device drivers is also available via the DTM at the control room. Asset Optimization, with the goal of reducing life cycle costs of the entire system, thus reaches as far as the field device.

At the moment (April 2001) FF H1 installations for hazardous applications require involved calculations to discern the number of devices available on a segment if loop powered. The method adopted by PROFIBUS uses guidelines offered by FISCO (Fieldbus Intrinsically Safe COncept) and is much simpler to implement and also allows more devices when compared to the current FF method. A working party is already advanced in Considering FISCO for FF H1 that shares the same Physical Layer as PROFIBUS PA.

Applications of fieldbus technology in safety systems is another area where fieldbus can offer benefits however.
7 SUMMARY/CONCLUSION

The hard cost savings from fieldbus technology are estimated at about 24% for large installations (about 3000 I/O points). The first implementations are claiming even higher savings so the technology looks set to take off.

Rivalry between different fieldbus standards remains dynamic, but stable and certified products are emerging. For intelligent devices in the process control area choice has settled between PROFIBUS DP/PA and FF. Of these, PROFIBUS DP has a credible installed base while PROFIBUS PA and FF are starting, and vying for installations. FF will also have High Speed Ethernet, which will become the choice for high-speed plant and control networks.

Sensor buses will continue to survive for low level applications such as bulk I/O because of their simplicity and low cost. They will be linked to PROFIBUS and FF through gateways.

LON will find applications in electrical equipment such as switchgear and motor control centers. Therefore, a multi-fieldbus strategy will provide customers with the best choice of product.

In this situation, a prudent strategy for customers is:

- Choose a credible supplier with multivendor, multi fieldbus support and real experience
- To start with non-critical applications
- To evaluate devices from multiple vendors
- To begin with standard functionality of devices and then move to proprietary functions
- To use traditional systems as a back up when trying out fieldbus

8 ABBREVIATIONS USED

CAPEX  Capital Expenditure
FF    FOUNDATION™ fieldbus
      (the name of the fieldbus), or Fieldbus FOUNDATION (the name of the organisation)
H1    FF field device bus (similar to Profibus PA)
HSE   High Speed Ethernet
LAS   Link Active Scheduler
LD    Link Device (H1 to HSE)
DD    Device Description
DDL   Device Description Language
FIP   Factory Instrumentation Protocol
FISCO PROFIBUS ‘Fieldbus Intrinsically Safe Concept’. (Note that the I.S. guidelines for PROFIBUS & FOUNDATION are different.)
HART Highway Addressable Remote Transducer
IEC   International Electrotechnical Commission
ISO   International Standards Organisation
ISP   Interoperable Systems Project
LON   Local Operating Network
OPEX  Operational Expenditure
OSI   Open System Interconnection
OD    Object Dictionary
PROFIBUS DP PROFIBUS Distributed Peripheral
PROFIBUS PA PROFIBUS Process Automation
IndustrialIT ABB’s integrated system
      (Process information - enterprise planning applications.)
FieldIT ABB’s field device level definition
Aspects/Objects ABB’s method of linking information
Customer support and service

Our promise is to deliver intelligent, informed support throughout all stages of your process. Whatever your industry. Wherever you are in the world. And wherever you are you’ll find ABB. Delivering not only high quality solutions but also levels of customer care that continually enhance your business.

Power
Nobody knows the power generation industry better than ABB. And no other company can deliver as broad a range of intelligent, power-specific solutions.

Water/Waste Water
The acknowledged world leader in the water industry, ABB has unrivalled expertise across the entire water cycle – from extraction to wastewater disposal and sewage.

Pharmaceuticals
Specialist knowledge of a specialist application. Clean room technology. Micro-measurement and batch control. Across the process ABB is delivering.

Pulp and Paper
The process know-how to deliver complete solutions. ABB serves the entire process. From chips or pulp to the final product, ABB measures, controls, manages and optimizes.

Chemicals/Oil and Gas
Providing solutions for exploration, production and product transportation. ABB is optimizing process efficiency across all areas of the process.

Metals and Minerals
Robust performance for tough environments. Steel, glass, cement – in every process ABB is adding value. Providing solution that last longer and perform better.

Food and Beverages
Total solutions for process-critical performance in critical applications. ABB has over one hundred years of specialist knowledge, providing unique solutions dedicated to your needs.

Process Industry
Whatever the industry ABB has knowledge of it. Whatever the process - ABB can improve it. Making more from less. Making good business sense.

Environmental
ABB has the knowledge and in-depth process expertise to assist you to meet your statutory monitoring, measuring and recording obligations. Providing the data integrity to satisfy the most stringent requirements of internal and external auditors.

ABB Customer Care services include:

Equipment Health Care:
- Hardware Services
- Calibration Services
- Software Services
- Technical Support, including Solutions Bank

Training & Education:
- Automation University
- Off Campus
- Web-based
- Technical & Vocational

Parts & Logistics:
- Spares Support
- Logistics
- Parts Contracts
- Repairs

Asset Optimization:
- Process Analysis
- Project Implementation
- Results Assessment
- Financing
- Environmental, quality, health and safety consultancy services
- Energy monitoring
- Industry & product specific optimization services