Foundation Fieldbus Technology Overview

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Disclaimer and Acknowledgement

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Individuals using this document are encouraged to seek out equivalent functioning equipment from other registered vendors of which the authors may be unaware.

FFMEMC is thankful to the following organizations, who have jointly supported this workshop by providing all technical contents and have authorized use of their logos, product and system images, arranged speakers, managed logistics and of course, commercially sponsored the workshop.
Where are we today, @Fieldbus?

Markets Served

>1,000,000 devices

> 12,000 Systems
Contents

Introduction
- History of process signals
- What is a Fieldbus
- What is Foundation Fieldbus

Physics of Fieldbus
- Power Supplies, Cable, Segment Sizing

Fieldbus Software
- Blocks, Configuration
- Scheduling / LAS

Explanation on “Freedom to choose, Power to integrate

Questions and answers
History of Process Automation Signals

- **Pneumatic**: Air Operated, 3 - 15 psi
- **Analog**: Electrical, 4-20 mA / 10-50mA
- **Digital**: Electronic, Pulses, Multi-dropped
History of Interfacing – A Microscopic Overview!!

- Pneumatic
- Zener Barriers
- DIN Rail Mounted barriers
- Power Rail
  - Power Redun.
  - Flexi terminals
  - Programmable
  - Universal
  - Slim Design
- TIB Mounted Surge Protectors
- Digital World - Fieldbus
- Developing...
  - Wireless
  - Higher Speed
  - Longer distance
  - More Power
  - DART, Power-i.....
- Remote I/Os
- 19” Rack Mounted TIB
- Mother board solutions
- 1950’s---2010
Field Communication Illustrated

The Dark Ages

Must be right
Tx says so

Analogue Signal

16mA
The Middle Ages

What are you ????

Communication request Using Hart

What would you like to know ???
Your pump appears to need some attention soon
What is a fieldbus?

An all-digital, bi-directional, multi-drop method of communicating process information between automation equipment.
What is FOUNDATION fieldbus?

The name of the fieldbus developed and owned by the Fieldbus FOUNDATION.

Just to highlight / clarify.....

Fieldbus Foundation is the organization
FOUNDATION™ Fieldbus is the bus
What is FOUNDATION fieldbus?

Is that all there is to it?..........................

Well not quite!
Bus Positioning

Common Attributes of Digital Busses

Reduced installation cost

- Reduced wiring
- Reduced control room real estate
- Remote diagnostics and commissioning

Reduced engineering cost

- Cross-termination and junction boxes
- Fewer engineering drawings
The protocols required are NOT equal!

Typical Network Positioning

- **FOUNDATION™ Fieldbus**
- Fieldbus
- Devicebus
- Sensorbus

**Process Control & Diagnostics**
- Process Variables
- Logic Control

**Simple Devices**
**Complex Devices**
Typical Name Positioning

- Foundation™ Fieldbus
- ControlNet
- Profibus PA
- Profibus DP & FMS
- CAN
- DeviceNet
- SDS
- LonWorks
- Interbus S
- P-Net
- WorldFIP

- Simple Devices
- Complex Devices
General Characteristics

FOUNDATION™ Fieldbus

- **Interoperability**
  - Between devices and device to host

- **Substitution**
  - Swap one vendor/technology for another

- **Innovation**
  - Accommodates future functionality

- **Location Independent Control**
  - Support control in the field, the host or both
Physical FOUNDATION Fieldbus
What Does FOUNDATION Fieldbus Do

- Sensor
  - User Layer
  - Communication Stack
  - Physical Layer
  - Fieldbus Device

- Communication Stacks ensure secure communications

- Moves data from here to there

- You connect wires here

- Sensor, Final Control Element, or Host
  - User Layer
  - Communication Stack
  - Physical Layer
  - Fieldbus Device

- You do control, trends, alarms with data here

- Wire Medium
Typical FF Segment Components

Host system H1

interface
Fieldbus needs terminators

Terminators are required, one at each end

- matched line impedance to minimise reflections & distortions

No more than 2 terminators may be used
Daisy Chain

Very simple
Low Cost but ...........

NOT Recommended!

As removing an instrument breaks the network!
Tee

Very simple
Low cost
May be custom built T unit or configured with standard terminals
Allows disconnection of devices without interruption to segment
Crows Foot / Spur / Chicken Foot

Most widely used and preferred topology
Allows easy removal / addition of devices
Can provide short circuit protection
Typical wiring hubs

- Connects spurs to trunk cable
- 2/4/8/10 and 12 devices supported per hub
- Short-circuit protected with visual fault indication.
- Optional, built-in/switchable terminator
- Removable Spur wiring connections
- Global hazardous area approvals
- Encapsulated for environmental protection
DC power source with superimposed digital communication
up to 1 900 m
- Fieldbus causes a voltage change on the segment.

- Traditional Power Supply will work to regulate the power to a constant 24 volts.

- Power Conditioner ‘isolates’ the power supply from the network.
High Speed Ethernet
FF Bridges Between FF Networks

Linking Device

FIELDBUS H1

DEVICES ON DIFFERENT NETWORKS
Digital Plant Control

ETHERNET/TCP/IP
INTERNET/INTRANET

MANAGEMENT

PC/VME

OPERATIONS

MAINTENANCE

HOST/LAS LINKING DEVICE

FACTORY LEVEL
Bus Cycle Time < 1000 ms

CELL LEVEL
Bus Cycle Time < 100 ms

FIELD LEVEL
Bus Cycle Time < 10 ms

HIGH-SPEED ETHERNET (HSE)
Typical FOUNDATION® Fieldbus Layout

Physical Layer Components:

- Power Supplies/Power Conditioners
- Cable
- Terminator
- Distribution Boxes
  - Passive Junction Boxes
  - Segment Protectors / wiring blocks
  - FieldBarrier / Device Coupler
- Surge protectors
Network Diagnostic Tools

Device Name: HD2-DM-A
Device Tag: DMA_ADR_2
Fieldbus Type: FOUNDATION Fieldbus

Segment Focus: 1 2 3 4
System Status: ✓
Segment 1 Status: ✓
Segment 3 Status: ■
Segment 4 Status: ■

Save As

Start Recording
Cancel

Recording Length: 32,768 ms
Amplitude: +/− 0.625 V

Trigger Events:
- Pass Token to Address
- Probe Node to Address
- Token usage from Address
- Missing Token usage from Address
- Probe Response from Address
- Missing Probe Response from Address
- Claim LAS from Address
- Transfer LAS to Address
- CRC Error
- Framing Error

Trigger Address: All
Pretrigger Time: Automatic ms
Trigger Level: Ignore V
Trigger Timeout: 240 s

Framing Error

Courtesy of P+F
FOUNDATION Fieldbus Software

Resource Blocks
Transducer Blocks
Function Blocks
Block Scheduling & LAS
**User Layer**

- Provides the interface with the process and for user interaction with the control system.
- Uses block structure for interaction:
  - Resource blocks
  - Transducer blocks
  - Function blocks
- Enables trending and alarms
- Key differentiating technology in Foundation Fieldbus
Block Diagram of User Layer

1. Resource Block - describes characteristics of device
2. Transducer Block(s) - represent local connections for physical I/O
3. Function Block(s) - provide the control and I/O behavior of the device
Resource Blocks

- Contain manufacturer information
- Provide information about the device, such as manufacturer’s name, device name, and serial number
- no links
- no data processing
- each device must have a resource block
- ON / OFF switch for device

All configurations
- MODE_BLK: Auto
Transducer Blocks

Are associated with field measurements and actuators
Manufacturer-specific
Each device has a different XD
Sensor information
Calibration
Status
All configurations
- MODE_BLK: Auto
Device-specific
- TERMINAL_NUMBER (IF and FI devices)
- SENSOR_TRANSUDUCER_NUMBER (dual temp. dev.)

Perform such functions as analog to digital conversion and linearization
Transmit information to/from function blocks
Function Blocks

- Concept modeled after blocks used in many DCS and PLC systems
  - can be located in field devices or host devices
  - can be turned on and off
  - have operational states
  - execute periodically (cyclically)
  - can be interconnected to form deterministic control schemes
  - can be linked to blocks in DCS or PLC

- 29 standard function blocks defined which encapsulate basic automation functions
<table>
<thead>
<tr>
<th>Function Block</th>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analog Input</td>
<td>AI</td>
<td>Reads analog input</td>
</tr>
<tr>
<td>Analog Output</td>
<td>AO</td>
<td>Sends analog output</td>
</tr>
<tr>
<td>Bias Gain</td>
<td>BG</td>
<td>Scaling</td>
</tr>
<tr>
<td>Control Selector</td>
<td>CS</td>
<td>Override control</td>
</tr>
<tr>
<td>Discrete Input</td>
<td>DI</td>
<td>Reads discrete input</td>
</tr>
<tr>
<td>Discrete Output</td>
<td>DO</td>
<td>Sends discrete output</td>
</tr>
<tr>
<td>Manual Loader</td>
<td>ML</td>
<td>Manual control</td>
</tr>
<tr>
<td>PID Control</td>
<td>PID</td>
<td>PID control</td>
</tr>
<tr>
<td>PD Control</td>
<td>PD</td>
<td>PD only control</td>
</tr>
<tr>
<td>Ratio Control</td>
<td>RA</td>
<td>Ratio control</td>
</tr>
</tbody>
</table>
Target Applications

Input

Manual Control

Feedback Control

Output

Track, Feedforward Capability in Control

Override Control

Ratio Control

Cascade Control

Split Range Control
New Block Subclass - Flexible

- Flexible (MIO) - Part 4
  - Multiple Analog Input - 8 Channels
  - Multiple Analog Output - 8 Channels
  - Multiple Discrete Input - 8 Channels
  - Multiple Discrete Output - 8 Channels

- Flexible (IEC 61131-3) - Part 5
  - Application-specific Blocks
Flexible Function Blocks

Any Application in a fieldbus “Wrapper”

Application Algorithm
written in
Ladder Logic, C++, Basic, FB’s, etc.

Contained Parameters
Function Block Scheduling

Scheduled Function Block Execution (SM)

Scheduled Cyclic Communication (DLL)

Unscheduled Communication

Cyclic

Function Block Execution
Cyclic Communication - Publish
Acyclic Communication

Loop 110 period of execution

Acyclic

Alarms/Events
Maintenance/Diagnostic Information
Program Invocation
Permissives/Interlocks
Display Information
Trend Information
Configuration
Deteministic Scheduling

- Execution of function blocks and communication is scheduled
- Execution is deterministic
- Control is really distributed “on the wire”
- KEY feature of FOUNDATION fieldbus - it is a system, not just a bus
- FF also includes provisions for a back-up schedule
Macrocycle

Cyclic Time
- Publish/Subscribe
- Deterministic
- Communicates control data
  - PV
  - Status
  - Time Stamp

Acyclic Time
- Communicate information NOT used for control including:
  - Alerts
  - Trends
  - Queries
  - Upload
  - Download
- Uses Token Passing
Interoperability Testing

- Interoperability testing of a device ensures devices from different manufacturers can communicate without loss of functionality.
- Performed by Fieldbus Foundation in Austin, Texas.
- Tests device operation for compliance with the Foundation Fieldbus specification.
Interoperability of FOUNDATION fieldbus devices is assured by the Fieldbus Foundation’s program for conformance and interoperability testing and device registration.
H1 Device Registration

The H1 stack must pass the FOUNDATION stack conformance test at Fraunhofer in Karlsruhe Germany.

The function blocks must conform to Foundation standards.

The Device and Device Description must pass interoperability test in the Foundation’s test lab.
H1 Device & DD Registration

H1 Stack

H1 Device & DD Registration

Function Blocks

H1 Testers

Registered H1 Device

Registered DD

DD
Specifications Drive Device Interoperability

Device Name (TAG Name)
FIT-625

Device ID
0003020001xxx83847

Device Address
23

Manufacturer code
Device code
Card serial #
Specifications Drive The Drivers

Device Descriptions (DD)

Values are read from the device.

Digits of precision

Engineering Unit

Label of the value

Descriptions for variables are obtained from the DD.

5.50 m³/h

Wastewater Flow
Specifications Drive The Bus

Device development and testing
HSE development and testing
Host development and testing
Freedom To Choose. Power To Integrate.

Two of the benchmarks that drive FOUNDATION fieldbus applications

- Freedom to Choose
- Power to Integrate

A quick study of these benchmarks and how they apply to your work and the bottom line.
Benchmarks, yes. BUT-

Choice and power are not left totally open to anyone’s interpretation.

To bring a common frame of reference to the technology, choices are guided by specifications and registration.

Registration, then, helps you know the specifications are met.
Freedom to Choose
Freedom To Choose

A hallmark of FOUNDATION fieldbus applications

A look at just a few of the choices FOUNDATION fieldbus adds to your Menu
Physical Layouts? – You Choose

- You Choose

HSE

- Input/Output Boards

- Bus with Spurs (or drops)

- Tree

- Daisy Chain
  (maybe not really a great choice to make)
Grounding - You Choose

Multi-Point Grounding

Alternative Grounding

Single Point Grounding

Fieldbus device

Spur

Wiring block

Trunk

Host

Enclosure ground (Note 2)

Equipotential bond

Fieldbus device

Spur

Wiring block

Trunk

Host

Enclosure ground (Note 2)
Surge Protection is often taken for granted and not specified!

Surge Protection reports additional Operating Expenses (OPEX) benefits through:

- Higher System Integrity
- Increased Reliability
- Reduced Downtime
- Reduced Spares Inventory
Fieldbus In Hazardous Areas - You Choose

Safe Area / Non-Hazardous Location

Fieldbus Power Supply

Control System

Zone 2 / Div 2

Zone 1/ Div 1

Zone 0
Hazardous Area Protection - You Choose

End users invested in hazardous area protection methods

Two groups:

- Use intrinsic safety or non-incendive field wiring
  - allows live working without gas clearance certificate
  - eg. Aramco, BP, Bayer, Chevron, Mol, ONGC

- Use Ex d/explosionproof or non-arcing
  - gas clearance certificate required for live working
  - eg. Shell, Exxon Mobil

Fieldbus offers all hazardous area options
Energy Limited Trunk Solutions For Hazardous Areas

Control Room

HOST

FNICO

FISCO

Entity

Class I, Div.2 Zone 2

Class I, Div.1 Zone 1
High Power Trunk Concepts
High Power Trunk Applications

Zone 1

Zone 2/Div.2

General Purpose

Zone 2/Div.2

Zone 1/Div.1

Zone 1
Multivariable Measurements = Less Hardware – Your Choice

Conventional:
• 1 measurement / device
• Penetration / signal

Fieldbus:
• Multiple measurements
  • Pressure
  • Temperature
  • Mass Flow
  • Volumetric Flow
Choices - Not Limited To The Physical Layer. HIST Applies To The Host Of Choice As Well
Power to Integrate
Fieldbus Specifications

The Glue that Binds the Technology and Makes Choices Possible

Example:
FF-831
Issued March 2004
Manufacturer ‘Self-Certifies’ and submits test results to Fieldbus Foundation
Physical Layer Specification: Example

- Power Supply/Conditioner
- Spur Block
- Wiring
- Terminator

Transmitter

- 9-32 V dc
- 10 - ~20 mA

Reversed leads cannot affect segment
(but device may not work)

min signal = 150 mV
noise pk = <75 mV
Standard FAQ:

1. **How can I get the copy of presentations for this event?**
   We will upload all the presentations on www.fieldbus.org ----Global ----EMEA----Middle East. Please check after 2/3 weeks.

2. **How can I download official FF documents like Engineering Guide, wiring and installation guide and other?**
   www.fieldbus.org ---- Enduser resources --- Technical References

3. **How can I ask my technical queries related to FF to other end users and experts?**
   www.fieldbus.org ---- End user resources --- Fieldbus forums
   (Please register yourself (its free!) and post your questions. I assure you that you will get answers and advices from all around the world. In fact, this forum is holding all past Q&A so you can also refer the same before posting your questions. May be answer is readily available for you!
FOUNDATION™ fieldbus
Technical Overview

Questions ?
What is the engineering rationale behind maintaining 31.25 kbps speed of H1 segment in FF? Why not higher speed in FF?

This is highest frequency we could achieve for a noise free communications with highest cable length (1900 m total and 120m for spurs)

The low frequency and trapezoidal curve helps achieving this.

Increasing the frequency means reducing the cable length. Also higher power and hence, compromise on intrinsic safety. H2 (1Mbps, 400m) was planned but never implemented.

Increasing frequency means more powerful processor...which means higher cost!

More importantly, 31.25 Kbps is sufficiently fast for process control applications. It is much faster than 4-20mA. We can easily achieve 250-300 ms control response time. Just to remind ourselves...response time of HART, Brain, FoxCom or DE was to the tune of 0.2-1.2 kbps i.e. FF H1 is at least 25 times faster!!

Lower frequency means low power requirements

Hence, considering all above, it’s a perfect winning solution!
Standard FAQ:

**Why 31.25 KBPS, why such an odd figure?**

Actually it is not an odd number, it is 31250 bits/sec. All microprocessors have 4/8/16MHz speed. So when it comes to achieving 31.25 KBPS frequency, it is achieved through multiplications / divisions of 2 with the processor speed.

**Can FF power supply be redundant? Yes**

**In case of emergency and lack of spares at site, can I connect regular 24Vdc as FFPS? No.**

**Do you know this?**
As per IEC 61158-2, the physical layer for Fieldbus H1 and Profibus PA is same. Therefore, all wiring blocks, segment protectors and fieldbarriers are generally suitable for both Profibus Pa and Fieldbus H1.
Standard FAQ:

How many max. devices can be connected? What restricts more devices on FF segment?

Majority users have used 8-10 devices per segment around the world.

There are 3 reasons for not interfacing too many devices on a segment...

- **Bandwidth** (more devices means more time devices have to wait for communicate i.e. longer macro cycle time and hence, control time). So it’s a balanced decision depending on the timings requirement
- **Power consumption**..in FF H1 the power to the devices is fed by the FFPS / H1 bus itself. So number of devices are restricted by the amount of power available from H1. However, these days, we have more power available through High Power Trunk technology so point no. 1 above is relevant
- **Plant uptime:** time required for configuration of devices on a same segment
- **How much risk you want to take by keeping max. no. of devices on a same 2 wire segment??

What is superior HART of FF?

The answer is FF.....reasons?

FF are pure digital devices…no A/D or D/A conversions…Speed is faster
More comprehensive diagnostic facility
Multivariable transmitter is a huge benefit in FF to reduce wires and
Control in field is another huge benefit for faster control