FOUNDATION™ Fieldbus
Fieldbus Basics

Presented by
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On behalf of the
Fieldbus Foundation Marketing Society
Topics

- FOUNDATION fieldbus Architecture
- H1 fieldbus Overview
- H1 Technology
- High Speed Ethernet (HSE) Overview
FOUNDATION fieldbus Architecture
What is Fieldbus?

- A fieldbus is an all-digital, serial two-way, multi-drop communication System.
- H1 network interface to field equipment: Sensors, Actuators & I/O. (31.25kbps)
- HSE provides integration of high speed controllers, subsystems (via Linking Device) and data servers and workstation. (High Speed Ethernet, 100mbps)
Integrated Architecture

- Management Information Systems (MIS), Enterprise Resource Planning (ERP), and Human Machine Interface (HMI) access the H1 Fieldbus information via the Data Servers.
- Fieldbus expands the operators view of the entire process.
H1 Overview

The Future is Digital
Multiple Variables

- Fieldbus supports “multiple variables” from each device to be brought into the control system for archiving, trend analysis, process optimization, reporting, predictive maintenance and for asset management.
- MVT Devices: pH Transmitter, Coriolis flowmeter; Valve Positioner; DP Transmitter; Magnetic Flowmeter; Vortex flowmeter;
Diagnostics

- Self Diagnostics and communication capabilities of Fieldbus devices increase asset utilization that helps reduce downtime.
- Both Plant operation and Maintenance personnel are informed allowing corrective actions to be promptly taken.
- Process Management is no longer just process control. It’s now also asset management using a wealth of information from your assets.
Control Strategy

- Standard Function Blocks is used to implement the Control Strategy.
- Many control system functions such as AI, PID and AO can be performed by the field device through the use of these Standard Function Blocks.
- Distribution of control into field devices can reduce the amount of hardware and cabinet footprint needed.
H1 Technology

- Physical Layer
- Communication Stack
- User Layer Application
H1 Technology

- Physical Layer
- Communication Stack
- User Layer Application

- Open Systems Interconnect (OSI) layered communication model is used to model these components
Physical Layer

Fieldbus Physical Layer: Mechanism to Transmit and receive signals across the network

- Cables
- Terminators
- Power Conditioners
- Device Couplers
- Short Circuit Protection
- Redundancy Considerations
- Hazardous Area Considerations
- Up to max 32 devices per segment - depends on several factors
  - Limited to 16 by host
  - Limited to less by distance
  - Limited to less by process cycle time
Device Communications

Device Current

Steady-state

Receiving

Transmitting

±10mA

i

t

Fieldbus signal

0.75 to 1.0 V pk-pk

DC Power
9.0 to 32V

Device Connections

Power Supply/Conditioner

100Ω
Terminator

1μF
This concept is typically applied to:
- Any kind of instrument in the safe (non hazardous) area
- Ex nA instruments in Zone 2
- Ex d instruments in Zone 1
Fieldbus Cable

- Recommended: Shielded, twisted-pair cable, designed to a specific impedance to reduce signal reflections and maximize network length.
- The Fieldbus Foundation has a Cable Specification (FF-844) so look for cable with a “check mark.”

### IEC 61158-2

<table>
<thead>
<tr>
<th>Description</th>
<th>Type A</th>
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<tr>
<td>Cable Design</td>
<td>Shielded, twisted pair</td>
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<tr>
<td>Conductor Cross Section *</td>
<td>0.8 mm² 18AWG</td>
</tr>
<tr>
<td>Loop Resistance * (DC current)</td>
<td>44Ω/km</td>
</tr>
<tr>
<td>Impedance @31.25kHz</td>
<td>100Ω 20%</td>
</tr>
<tr>
<td>Segment Length (including Spur Length)</td>
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</tbody>
</table>

* Typical values
### Power Conditioning

- Instrument bulk power supply must be “Conditioned” for robust Fieldbus Communications
- Placing inductance between the power supply and the Fieldbus wiring is a way to isolate the Fieldbus signal from the low impedance of the bulk supply.
- Provides isolation of the Fieldbus circuits from ground, current limiting to the segment if the cable is shorted.
- Typically installed in load sharing redundant configurations.

**Diagram:**

- **Power supply conditioning**
  - Passes DC (power), Blocks AC (signal)

- **Host System**

- **Segment Trunk Cable**

- **Field Devices**

**Diagram Components:**

- **18 to 32V**
- **Signal Isolation Inductors**

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The Future is Digital
Device Coupler (Field Junction Box)

- Terminate the trunk cable
- Distribute power to field devices
- Short circuit protection
- Test points for maintenance
- Local LED diagnostics

- Each device is connected in parallel
- Without protection, a short circuit could shut the segment down
Segment Terminators

- Terminators are required one at each end
- The wiring between the two terminators is defined as the trunk.

- No more than two terminators may be used
- Matches the impedance of the cable
- Ensures a balanced transmission line
Segment Terminators

- Terminator errors generally occur in the field Junction Box; either not installed (or switched-on) or too many installed.
- No terminators are to be installed in the Field Device.
- Terminator at Power Conditioner is built-in
- Installed by the electrical contractor, not normally aware of the importance of the Terminator.
- Use Automatic Terminators where possible to eliminate installation errors.

(Waveform with 300 metres of Cable)
Segment Loading – Considerations

- Ohm’s Law is best guide
  - Determine total device draw per segment = $\sum I_d$
    - Include 20% spares allowance
    - Spur Short Circuit current
    - Hand Held Diagnostic Tools
  - Determine cable resistance & length = $R_c$, $X_m$
  - Define source voltage = $V_p$

- Assume ALL devices are at end of segment
  - Need to ensure that $V_d \geq 9V$
  - Voltage at device $V_d = V_p - [\sum I_d + I(HH) + 1SC] \times R_c \times X_m$
Fault Tolerant Hardware

Segment Loading Considerations
- Balance between Availability and Reliability
- Redundant Controller
- Redundant H1 Interface
- Redundant Bulk DC Power with Battery Back-up
- Redundant Fieldbus Power Supply
- Redundant Field Devices
- Redundant Trunk Cable
- Restrict no. of Valves & Devices per segment

Fieldbus System Engineering Guidelines (AG-181) Rev 3.1
H1 Technology

- Physical Layer
- Communication Stack
- User Layer Application

- Open Systems Interconnect (OSI) layered communication model is used to model these components
H1 “Scheduled Communications”

- Link Active Scheduler (LAS) controls the transmission of messages
- Recognises and add new devices to the segment
- Removes non-responsive devices from the segment
- Polls devices for process loop data at scheduled times; (CD token)

- LAS Redundancy; If the current LAS fails, one of the Link Masters will take over the LAS functions and the operation of the fieldbus will continue.
H1 “Unscheduled Communications”

- The LAS grants permission to a device to use the fieldbus by issuing a Pass Token (PT) message to the device.
- Devices that respond properly to the Pass Token (PT) command will remain in the Live List.
- Whenever a device is added or removed from the Live List, the LAS broadcasts changes to the Live List to all devices. This allows each device to maintain a current copy of the Live List.

![Diagram showing the flow of data between LAS, Live List, PT (x), Trunk, Data, and Alarms, &/or Setpoint Changes.](Image)
H1 Technology

- Physical Layer
- Communication Stack
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Resource Block

- The Resource Block describes characteristics of the fieldbus device such as device name, manufacturer and serial number, etc.
- There is only one Resource Block in a device.

Control Builder Project tab
Transducer Block

- Transducer Blocks are used to configure devices.
- Transducer Blocks are required to Read sensors value and command output value.

Control Builder Project tab
Function Blocks

- The Control System Strategy is built using Function Blocks.
- Each Function Block has an Input, performs a set of operations and produces an output, they can be linked in the device or over the fieldbus.
- The execution of each Function Blocks is precisely scheduled and there can be many function blocks in a single user application.
Example of a Control Loop

- Control Strategy can be built using Function Blocks built into field devices.
- A flow transmitter may contain an AI function block. A Control Valve might contain a PID function block as well as the expected AO Block.
- Thus, a complete control loop can be built using a simple transmitter and a control valve.

Example of a complete control loop using Function Blocks located in fieldbus Devices.

Example of a complete control module strategy Control on the Wire.
H1 Link Active Scheduler

- PID Loop scheduled and unscheduled communication.

Function blocks:
- AI 110
- PID 110
- AO 110

Scheduled Communication

Unscheduled Communication

Scheduled Communication

Unscheduled Communication

Scheduled

Closed loop control

Unscheduled

Alarms/Events
Maintenance/Diagnostic Information
Program Invocation
Permissives/Interlocks
Display Information
Trend Information
Configuration
High Speed Ethernet (HSE) Overview
FF Integrated Architecture
HSE – Subsystem Integration

- High Speed Ethernet Compliments H1
- Linking Devices (LD) Integrate H1 segments
- HSE High Speed Control Backbone
- Provides the Open Interface for Data Servers
- Standard Function Blocks PLUS
- Flexible Function Blocks for Discrete/Batch/PLC
- Redundant HSE Interfaces and Devices
- Commercial “off the shelf” Ethernet Hardware (COTS)
High Speed Ethernet Devices

- HSE Client
- Gateway
- 100 Mbit/s Switch
- I/O Network
- Linking Device
- HSE Field Device
- Plant

The Future is Digital
HSE - LAN Redundancy
HSE - Device Redundancy

HSE Client

HSE Field Device

Gateway

Linking Device

I/O Network

Plant

Plant

Plant
Summary

Proven:

- FF provides closed loop digital control: sensor to actuator

- FOUNDATION H1 has made it possible to "mine" important information from the plant floor.

- This information empowers operators and technicians to make plant operation and maintenance easier

- The technology enables improved asset management using device management software, as many failures can be predicted and faults can be diagnosed in detail

- FOUNDATION fieldbus is tried and tested since 15 years