Fieldbus
Technical Overview
What is FOUNDATION™ Fieldbus?

... AN ENABLER

An open, digital, multi-drop communication technology for intelligent field devices and automation systems.

- enables digital replacement of 4-20 mA
- enables unification of field with business / control
- enables some basic process control in the field
All Buses Are Not “Fieldbus”

• Many buses used in plants are being called “fieldbus”, creating confusion.

• There are several types of buses, designed for different devices and uses- “sensor buses”, “device buses”, “local area networks”, etc.

• The term “fieldbus” properly applies only to buses with technical correspondence to the IEC/ISA SP50 fieldbus standard, such as FOUNDATION fieldbus.

• FOUNDATION fieldbus now an approved member of the physical layer standard IEC 61158-2, which includes other protocols.
Plants Have Different Networks for Different Devices

One bus type cannot serve all applications and all device types efficiently.

Data Networks
- Workstations, robots, PCs
  - $$$ (higher cost connection)
  - Not bus powered
  - Long messages (e-mail, files)
  - Not intrinsically safe
  - Coax cable, fiber
  - Max distance miles

Sensor Bus
- Simple sensors, actuators
  - $ (low cost connection)
  - Non bus powered
  - Short messages (bits)
  - Fixed configuration
  - Not intrinsically safe
  - Twisted pair
  - Max distance 1600’

HSE - High Speed Ethernet
- PLC, DCS, remote I/O, motors
  - $$ (medium cost connection)
  - Non bus powered
  - Messages: values, status
  - Not intrinsically safe

H1 - Low Speed Fieldbus
- Process instruments, valves
  - $$ (medium cost connection)
  - Bus-powered (2 wire)
  - Messages: values, status
  - Intrinsically safe
  - Twisted pair (reuse 4-20)
  - Max distance 5200’
FOUNDATION Fieldbus Differentiators

- **Supports Intrinsic Safety and Existing Wiring**
  - Uses IEC/ISA fieldbus standard.

- **Secure Process Data Messages**
  - Separates time-critical process data from background MMI messages, downloads, etc.
  - Uses IEC/ISA fieldbus standard.

- **Function Blocks**
  - Standard Set (AI, AO, DI, DO, PID, ML, SS, ...)
  - Modeled after DCS points.
  - Supports distribution of control to field devices.

- **Device Description Language (DDL)**
  - Defines which Function Blocks are in a device.
  - Provides interoperability between devices.

- **Supported by all major global controls suppliers**
Fieldbus devices and host systems must use a common language or no meaningful communications occurs.

**User Layer**

**Application Layer**

**Data Link Layer**

**Physical Layer**

Network Management

Postmaster: Coordination

Mail message:
- Common language
- Read & understood

FB: Function Blocks

Paper contains:
- TO/FROM
- Mail message

FB: Data values

Envelope contains:
- Address TO/FROM
- Stamp
- Mail message inside
- Data location is critical

FB: which message is sent when by which device

Mailbox:
- Holds envelope
- Address & flag

Truck transports envelope, independent of message

FB: electrical signals on wire

= IEC/ISA Fieldbus Standard

TAG TIC 101
Reactor Temperature
PV = 242 degrees C

Honeywell

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Basic Capabilities of FOUNDATION Fieldbus

**HSE: High Speed Ethernet**
- Integrates up to 32 H1 fieldbuses
- 750/500 m, comm. grade twisted pair req’d
- Supports PLC’s and manufacturing devices
- Can integrate other buses (e.g. SDS)

**H1: Lower Speed Fieldbus (31.25 kbps)**
- Power & Communications on same wires
- Intrinsically Safe for hazardous areas
- 1900 m, comm. grade twisted pair
- Can use existing 4-20mA wires
- Primary bus for process devices
- First fieldbus products will be H1
How Does H1 Fieldbus Compare to 4-20 mA?

D = Device  
T = Terminator  
R = Repeater  
PS = Power  
IS = Barrier/Galv. Isolator

**Similarities**
- Twisted pair carries power and signal.
- Existing 4-20 mA wire can be used, though communication wire is preferred.
- Familiar process devices (transmitters, valves, etc.) can be connected.
- Intended for use by instrument technicians, not communications experts.

**Differences**
- Multiple transmitters and valves can be connected to one wire pair.
- Devices are connected in parallel, not serial.
- Electronics in all devices are different.
- Terminators (R-C circuit) are required to “nail down” each bus segment.
- A fieldbus can have multiple segments, interconnected by repeaters.
How Many Devices Can Be on an H1 Fieldbus?

(1) General Purpose or Non-Incendive System

D = Device
T = Terminator
R = Repeater
PS = Power
IS = Barrier/Galv. Isolator

It depends---

A) Bandwidth  A fieldbus can carry ~50 messages/sec. So there could be 5 devices @ 10 messages/sec each or 200 devices @ 1 message/4 seconds each.

B) Segments  A fieldbus can be 1 or more segments of up to 1900m each; up to 32 devices per segment; up to 240 devices maximum with repeaters.

C) Power   Power supply on each segment must have sufficient capacity. Devices draw different amounts of power; some draw none (separately powered).

D) Wire Size  Existing wire with high resistance may reduce the segment length.
How Many Devices Can Be on an H1 Fieldbus?

(2) Intrinsically Safe System

D = Device
T = Terminator
R = Repeater
PS = Power
IS = Barrier/ Galv. Isolator

It depends---

A) Bandwidth [same] A fieldbus can carry ~50 messages/sec.

B) Segments [same] 32 devices/segment; up to 240 devices total with repeaters.

C) Power I.S. barrier must be within 100m of a terminator. Power available past I.S. barrier is ~800 mw. Devices draw different amounts of power; add them up to find how many will fit, like adding up ohms in a 4-20mA loop. E.g.: 8 100mw devices; 4 200mw devices. Rule of thumb: 2-6 devices past I.S. barrier.

D) Wire Size [same] Existing wire with high resistance may reduce segment length.
How Many Devices Can Be on H1: Technical Limits

- **A segment may have 32 device loads.**  
  Example above: Segment 1 has 8 loads (DCS + 7xR). Segments 2-7 have 2 loads each (R + D).

- **There can be no more than 4 Repeaters in series between any 2 Devices.**  
  Example: 1 Repeater between DCS and any Device; 2 Repeaters between any 2 Devices.

- **A fieldbus may have up to 240 Devices.**  
  Many more than 240 devices could be properly connected, but only 240 can be addressed.
1. Fault Tolerance for Control
   - Many applications can’t tolerate loss of more than one loop due to a single failure.
   - So a fieldbus would have devices for just one loop: 1 valve and 1-2 transmitters.
   - Some monitoring devices could be added.

2. Wiring Topology
   - Plant wiring typically runs from a device to a junction box to the control room.
   - When devices are close together, wiring them to a single bus is convenient.
   - When devices are far apart, a single bus may require additional wire runs.

**Fault Tolerance, Topology, Power, and Barriers/Isolators may limit the number of devices to 3-8 (more if only monitoring devices).**
Key Field Device Characteristics for Fieldbus

• Number and types of Function Blocks

• Link Master (LAS) capability
  — keeps the bus running if the host LAS becomes inactive

• How are software revisions installed
  — board change
  — PROM change / local rewrite
  — download over fieldbus

• How much bus power is consumed

• Bus polarity tolerance
  — none
  — protected
  — insensitive
### Function Blocks

<table>
<thead>
<tr>
<th>Code</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>DI</td>
<td>Discrete Input</td>
</tr>
<tr>
<td>DO</td>
<td>Discrete Output</td>
</tr>
<tr>
<td>AI</td>
<td>Analog Input (pressure, flow, temperature, level)</td>
</tr>
<tr>
<td>AO</td>
<td>Analog Output (transducer, valve positioner)</td>
</tr>
<tr>
<td>PID</td>
<td>PID, PI, I Controller</td>
</tr>
<tr>
<td>PD</td>
<td>P, PD Controller</td>
</tr>
<tr>
<td>SS</td>
<td>Signal Selector</td>
</tr>
<tr>
<td>ML</td>
<td>Manual Loader</td>
</tr>
<tr>
<td>BG</td>
<td>Bias/Gain Station</td>
</tr>
<tr>
<td>RA</td>
<td>Ratio Station</td>
</tr>
</tbody>
</table>

A simple control loop with FB’s in a transmitter and a valve positioner.
Data Link Layer Provides Precise Timing for Control

How a simple PID loop is executed

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

Loop 110 period of execution

Cyclic/scheduled:
- Closed loop control

Acyclic/unscheduled:
- Alarms/Events
- Maintenance/Diagnostic Information
- Program Invocation
- Permissives/Interlocks
- Display Information
- Trend Information
- Configuration

[ADAPTED FROM FIELDBUS FOUNDATION MATERIAL]
FOUNDATION fieldbus enables interoperability of all devices.

Process Monitoring and Operation

Configuration and Maintenance of Fieldbus and Field Devices

Operational Control Strategy over Fieldbus

Fieldbus Device Configuration
MODEL: YOKOGAWA DP HARP EJ110
TAG No: FD03
INSTRUMENT ID: YL24012900384
PS ID: N82 A60A UM01
DD ID: FD03
LOC: BOILER 02
DESC: INLET COOLANT FLOW 1
CONFIG PAR ID: BOUL1, COOL1, FLOW
CONFIGURATION RECORD
LAST CONFIGURED: 93/02/21 SCHEDULED
LAST CALIBRATED: 93/08/02
NEXT SCHEDULED: 95/08/02

Configuration and maintenance console
Manufacturer B

Operator's console
Manufacturer A

D/P Transmitter
Manufacturer C

Control Valve
Manufacturer D

[ADAPTED FROM FIELDbus FOUNDATION MATERIAL]
Field devices will consist of:

- **Actual physical field device**
- **DDL device description (DD)**

DDs will be provided by device supplier or host supplier.

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**FIELD bus Technology**

**FOUNDATION Device Description Language (DDL)**

- Key to *interoperability*
- Defines what function blocks and special parameters a device contains.
- Eliminates need to revise host system software to add a new device to the system.
- Eliminates need to develop & support custom interfaces and custom drivers.
- Fosters product innovation and development of new field devices.
Levels of Interoperability

- **FF Comm Protocol Specified by FF Specification**
- **FF Function Blocks Specified by FF Specification**
  - **Manufacturer Specific Function Blocks**
  - **Parameters (DD Delivered)**
  - **Mfr. Specific Device Parameters (DD Not Delivered)**
- **Physical Interface**
  - (Interoperable)

- **Manufacturer Specific Function Blocks**
- **Parameters (DD Delivered)**
- **Physical Interface**
  - (Interoperable)

- **Manufacturer Specific Function Block**
- **Parameters (DD Not Delivered)**
- **Physical Interface**
  - (Not Interoperable)
FF Verification and DD Registration

FF Device Registration:
1. Contains registered Stack
   • Passed Conformance Test
2. Interoperability Test
   • Automated dynamic test
3. Physical Layer Test
   • Manual test per FF procedure
4. DD Verification
   • Manual test per FF procedure

FF Conformance Test
(Stack)
(3rd Party Verification)

FF Interoperability Test
(Device)
(3rd Party or self-test)

DD registration

FF Comm Protocol
(Stack)
Specified by
FF Specification

FF Function Blocks
(Device)
Specified by
FF Specification

Manufacturer Specific
Function Blocks

Parameters
(DD Delivered)

Mfr. Specific Device Parameters
(DD Not Delivered)

Physical Interface

[ADAPTED FROM FIELDBUS FOUNDATION MATERIAL]
Fieldbus Foundation Documents

- **FD-043** Technical Overview FOUNDATION Fieldbus
- **AG-140** Wiring and Installation 31.25 kbit/s, Voltage Mode, Wire Medium
- **AG-163** 31.25 kbit/s Intrinsically Safe systems

$9.95 each + S&H  (MasterCard and Visa accepted)

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