Welcome to PHOENIX CONTACT

The highly available Solution for reliable Process Control:

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Vice President
Seminar Content – Section 1

Section 1: Introduction / Differences between fieldbus & Analogue

Section 2: Physical Layer

Section 3: Innovations in Network Design
4-20 mA Systems

Advantages:
- OPEN, interoperable, interchangeable
- Broad range of equipment
- Multiple suppliers
- Standard control system interfaces
- Standard support equipment

Shortcomings:
- Limited information
  - one variable, one direction
- Point-to-point wiring
Smart Instruments

- **Advantages:**
  - More information
  - Two-way communication of multiple variables
  - Better accuracy, reliability
  - Faster system commissioning
  - Easier configuration, calibration maintenance, and support

- **Tradeoffs:**
  - Limited interoperability
  - Lack practical multidrop capability
  - Lack control loop performance
  - Special control system interfaces
  - Special support devices
HART Communication Protocol

- Majority of HART devices in service at HART 5
- Foundation Fieldbus advantages
  - 31.25 kbps vs 1.2 kbps
    - 30 x faster
  - Multi-drop capability
  - FULL bi-directional communications
  - Deterministic communications
    - Enables Control in Field

<table>
<thead>
<tr>
<th>Feature</th>
<th>Protocol Revision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analog Loop Check</td>
<td>🟦</td>
</tr>
<tr>
<td>Broadcast messaging</td>
<td>🟦</td>
</tr>
<tr>
<td>Device Calibration</td>
<td>🟦</td>
</tr>
<tr>
<td>Device Configuration</td>
<td>🟦</td>
</tr>
<tr>
<td>Device Status</td>
<td>🟦</td>
</tr>
<tr>
<td>Multi-Variable Reads</td>
<td>🟦</td>
</tr>
<tr>
<td>PV with status</td>
<td>🟦</td>
</tr>
<tr>
<td>32 Character Tag</td>
<td>🟦</td>
</tr>
<tr>
<td>All variables with status</td>
<td>🟦</td>
</tr>
<tr>
<td>Digital Loop Check</td>
<td>🟦</td>
</tr>
<tr>
<td>Enhanced Multi-variable support</td>
<td>🟦</td>
</tr>
<tr>
<td>Local Interface Lock</td>
<td>🟦</td>
</tr>
<tr>
<td>Manual ID of device by host</td>
<td>🟦</td>
</tr>
<tr>
<td>Peer to peer messages</td>
<td>🟦</td>
</tr>
<tr>
<td>Visual ID of Device</td>
<td>🟦</td>
</tr>
<tr>
<td>Time or Condition based Alerts</td>
<td>🟦</td>
</tr>
<tr>
<td>Report by Exception</td>
<td>🟦</td>
</tr>
<tr>
<td>Synchronized Sampling</td>
<td>🟦</td>
</tr>
<tr>
<td>Time stamp</td>
<td>🟦</td>
</tr>
<tr>
<td>Trends</td>
<td>🟦</td>
</tr>
<tr>
<td>Wireless Co-existence</td>
<td>🟦</td>
</tr>
<tr>
<td>Wireless diagnostics</td>
<td>🟦</td>
</tr>
<tr>
<td>Wireless mesh &amp; star topologies</td>
<td>🟦</td>
</tr>
<tr>
<td>Wireless message routing</td>
<td>🟦</td>
</tr>
<tr>
<td>Wireless Security</td>
<td>🟦</td>
</tr>
</tbody>
</table>
How Fieldbus is Different from 4-20

- Fieldbus devices are connected in parallel on the bus, which carries digital data from/to all the devices on the bus.
- Fieldbus devices provide almost unlimited information to all other devices on the network.
- Data have cyclical redundancy checking (CRC) to ensure receiving devices use only good data.
- A multi-drop fieldbus does not have the shortcoming of point-to-point wiring.

\[ \text{P.S.} \quad \text{4-20mA} \]  

\[ \text{P.S.} \quad \text{fieldbus} \]
Fieldbus and 4 – 20 mA

**Similarities**
- Conforms to existing standard
  - Twisted pair wiring
  - Terminal blocks
- Similar wiring practices
- Provision for intrinsic safety
- Support for redundant power supply

**Differences**
- Foundation Fieldbus is different from the traditional system as it
  - Supports up to 32 parallel field devices
  - Requires special power supply
  - Requires power conditioners
  - Requires network terminators
Section 2

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Process-Connect Technologies

FOUNDATION HSE

ProfiNet

Industrial Ethernet

Fieldbus

Wireless

Point to point

Inline IO

fieldbus Power Supply (optional redundancy)

Junction box / scalable barriers

Wireless HART

Point to point

HART Multiplexer

Signal Isolators

Inline IO
Physical Layer – Basics – Foundation Fieldbus H1

**Physical Layer** — The Physical Layer receives messages from the Communications Stack and converts the messages into physical signals on the fieldbus transmission medium, and vice-versa.

- Transmission speed: 31.25 kBit/s
- Manchester code Bus Powered (MBP)
- Via twisted-pair cable
- Power and Communication in one cable
Physical Layer – Basics – Profibus PA

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Transmission Speed: 31.25 kBit/s
Manchester Code: Bus Powered (MBP)
Transmission via twisted-pair cable
Power and Communication in one cable

Power Supply

DP/PA Coupler or Link

DCS oder PLC, DP basierend

Process-data
Parameter-data
Diagnostics-data

9…32 VDC
0,75…1,2 Vpp
## Difference between FF and PA in ISO-OSI Model

<table>
<thead>
<tr>
<th>Layer</th>
<th>Fieldbus</th>
<th>FF</th>
<th>PA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fieldbus Access Sublayer (FAS)</td>
<td>FF Access Sublayer (FAS)</td>
<td>Profibus Access Sublayer (FAS)</td>
</tr>
<tr>
<td>Presentation Layer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Data Link Layer</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Physical Layer</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Difference in Protocol
- **Publisher - Subscriber**
- **Master - Slave**

- **Foundation H1**
- **Profibus DP V1**

- Manchester Bus
- Manchester Bus
Data Encoding

- Bit Level Encoding
  - Inserts a time reference on a signal to determine bit boundaries
  - Applies Manchester bit encoding method

![Diagram showing Data Encoding process]

- Data: 1 0 1 1 0 0 1 1
- Clock
- Encoded Data: Aligns with the clock pulses
## Permitted Fieldbus Cable Types

<table>
<thead>
<tr>
<th>Foundation Fieldbus</th>
<th>Max Segment Length</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cable Type and Description</strong></td>
<td></td>
</tr>
<tr>
<td>Type A: Multi or single-twisted-pair, individually shielded</td>
<td>1,900 m (6,232 ft)</td>
</tr>
<tr>
<td>Type B: Multi-twisted-pair, with an overall shield</td>
<td>1,200 m (3,936 ft)</td>
</tr>
<tr>
<td>Type C: Multi-twisted-pair, without a shield</td>
<td>400 m (1,312 ft)</td>
</tr>
<tr>
<td>Type D: Multi-core, without twisted pairs, without a shield</td>
<td>200 m (656 ft)</td>
</tr>
</tbody>
</table>
Fieldbus Terminators

- Terminators are required (one at each end)
  - Match line impedance to minimise reflections and distortions
- Maximum of two terminators
Terminator

- A terminator is placed at the beginning or end of a segment to avoid reflection.
- The terminator impedance value is equivalent to an impedance of 100 Ohm and 1uF.
Power Conditioner

- Passes DC (power)
- Rejects AC (signal)

This image represents the basic required circuit though all manufacturers incorporate additional features.
Fieldbus Power Supply Specification

- FF-831
- Issued March 2004
- Manufacturer ‘Self-Certifies” and submits test results to Fieldbus Foundation
Typical Field Device Couplers

- FF-846 Specification
  - Passive Device Couplers
    - Typically referred to as “Blocks”
  - Active Device Couplers
    - Fieldbus Barriers
Surge Protection for Fieldbus

- Fieldbus installations are more vulnerable to surge damage than conventional ‘point-to-point’ wiring
- Surge Protectors are available for:
  - FISCO (Fieldbus Intrinsically Safe Concept)
  - Fieldbus Barriers
  - Trunk (optionally at one or both ends of trunk-depending on integrity of protection required)
  - Spurs
  - Field Devices
Grounding or Earthing

- Grounding rules used in the installation of the fieldbus should follow current standard practices based on company/plant standards and applicable international standards.
- Fieldbus devices should not connect either conductor of the twisted pair to the ground at any point in the network.
- Shields shall NOT be used as a power conductor.
- There may be additional specific requirements for I.S. installation.
Foundation Fieldbus / Profibus PA

- Digital, parallel, plug n play Communication Network
- For up to 32 intelligent Field Devices
- Current Consumption between 10 and 50 mA each
- Max 1900 Meters
- Bus-Termination at Beginning and End
H1 Topology Single Combined Segment

Control Highway

Host

Input/Output Boards

JB T
Most Common Installation-Error: Termination

- correctly terminated Signal

- Signal with one missing Terminator

- Preventable using mechanical Terminator in Output-Terminal
Setup of a Fieldbus Segment

Control Room

Power Supply

DCS-System

FF Power Supply

Trunk

Spurs

Intrinsically safe Spurs

Foundation Fieldbus

Field

Device Couplers for Short Circuit Protection

Fieldbus-Barrier for Ex-Isolation

Zone 2

Zone 1 or 0

Intrinsically safe Spurs
Segment-Length – The real Limits

Length: theoretically 1900 Meters – depending on cable type

<table>
<thead>
<tr>
<th>Cable type</th>
<th>Pair config.</th>
<th>Twisted pair</th>
<th>Shield config.</th>
<th>Wire size</th>
<th>Segment length</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Single</td>
<td>Yes</td>
<td>By pair</td>
<td>0.8 mm²</td>
<td>1900 m</td>
</tr>
<tr>
<td>A</td>
<td>Multiple</td>
<td>Yes</td>
<td>By pair</td>
<td>0.8 mm²</td>
<td>1900 m</td>
</tr>
<tr>
<td>B</td>
<td>Multiple</td>
<td>Yes</td>
<td>Overall</td>
<td>0.32 mm²</td>
<td>1200 m</td>
</tr>
<tr>
<td>C</td>
<td>Either</td>
<td>Yes</td>
<td>None</td>
<td>0.13 mm²</td>
<td>400 m</td>
</tr>
<tr>
<td>D</td>
<td>Multiple</td>
<td>No</td>
<td>Overall</td>
<td>0.8 mm²</td>
<td>200 m</td>
</tr>
</tbody>
</table>

Max 32 devices, but: Max Spur-Length depending on number of devices connected → realistic: 12 to 24

<table>
<thead>
<tr>
<th>Total devices</th>
<th>Spur length</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 to 32</td>
<td>1 m</td>
</tr>
<tr>
<td>19 to 24</td>
<td>30 m</td>
</tr>
<tr>
<td>15 to 18</td>
<td>60 m</td>
</tr>
<tr>
<td>13 to 14</td>
<td>90 m</td>
</tr>
<tr>
<td>1 to 12</td>
<td>120 m</td>
</tr>
</tbody>
</table>
Section 3

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Example of 4…20mA Control Loop

- Continuous regulation of Temperature
- Save and reliable process through redundancy and diversity
- Valid from the 1960’s to now
- Single failures will be
  - Recognized,
  - Removed,
  - And won’t influence production
→ Single Loop Integrity
The first try

- Daisy Chain-topology / Foundation Fieldbus or Profibus PA
- Bridging a 2-wire-cable with power and communication
The first try – installation example

- Continuous regulation of Temperature
- Less IO cards!
- Less cables!
- Less Cabinets!
- Easy planning / installation and startup!
- Fully digital communication enabled!
- Still highly reliable

Mission accomplished?

1992
The first try – negative experiences

- What happens at frequent field device exchanges and expansions?
- Short circuits cause segment breakdown
- Include short circuit protection in each channel / spur
Impact of Improvement

- Again Signal conditioning
  - Again Junction Boxes
- But good segment protection during device exchange and expansion
Next Improvement - Fieldbarrier

- Moving intrinsically safe isolation in the field:
  - High Power Trunk Concept
  - With FISCO Spurs at „Multibarrier / Fieldbarrier“
Impact of Improvement

- Energy Limitation moves from Trunk to Field (FISCO spurs)
- Realistically up to 16 intrinsically safe devices connected to each segment

- Saving more cables
- Saving more IO cards
- Enlarging No. of devices in each Segment
Weakness of Brick-barriers

- Current limitation and Intrinsically safe isolation creates heat
- Heat ages electrical components, reduces MTBF-times
Weakness of Brick-barriers

- Current limitation and Intrinsically safe isolation creates heat
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- No single spurs fail
  - But complete bricks
  - Exchanging a brick means shutting down the complete segment
Weakness of Brick-barriers

- Current limitation and Intrinsically safe isolation creates heat
- Heat ages electrical components, reduces MTBF-times

- No single spurs fail
  - But complete bricks
  - Exchanging a brick means shutting down the complete segment

Far away from "single loop integrity"
Final Improvement – Scalable Barriers

- Isolating each spur separately
- Cutting Bricks into pieces
- Daisy Chaining fieldbus signal in a modular backplane
Final Improvement – Scalable Barriers

- How we made it happen:
Final Improvement – Scalable Barriers

- How we made it happen:
- Single failures will be
  - Recognized,
  - Removed,
  - And won’t influence production
→ Single Loop Integrity
The modern solution – Scalable Barriers

- Overview
  - Exchange without segment interruption
  - Single Loop Integrity
  - Get rid of unused spare
  - Always ready for expansions
  - Channel 2 channel isolation
    - Ready for the future
      - Mixing Ex ic and Ex ia next to each other

2012
Modular Segment Couplers and Terminator

Can hot-swap modules with the bus in operation
Tailored installation

- Not more than really needed
  - break away from „spare“
- No unused electronics in the field!
- Easy installation-mixing
  - FISCO and FISCO ic
    Zone 0 / 1 Zone 2
Expandable during operation

- Uninterruptably
- Fast and easy, thanks T-Bus

- Termination errors impossible

- Easy installation-mixing, also later on
  - FISCO and FISCO ic
  - Zone 0 / 1  Zone 2
Exchangable fail-safe

- Without loosing contact to Process
- Single-Point-Integrity
- Ideal for use in highly available applications
Continuously scalable

- Also the Fieldbus Power Supplies

redundant

simplex
Each Segment highly available on its own

- Segment for Segment expandable
- Exchangable - Also each base
- 50:50 load-balancing thanks ACB (Auto current balancing)
- Basic-Diagnostics via Relay and LED
The Junction Box for scalable Use

- Pre-wired
- Space saving
- Easy connecting

Step 1: Choose pre wired Junction Box

Step 2: Order the desired device couplers / isolators

Step 3: Mount cable glands depending on cable type

Step 4: Snap on the Tbus connector and couplers, when the instruments are in place
www.phoenixcontact.com/processfieldbus