Fieldbus is Easy!

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Fieldbus is Easy!

- Technology
- Foundation guidelines
- Component choice
- Segment design
- Verification
How is fieldbus different from 4-20mA?

4-20mA

- In 4-20mA circuits, the power supply, field device and input card are connected in series.

Fieldbus

- In a Fieldbus system, the power supply, field devices and input card are connected in parallel.

Expanded System View

DCS: Limited system view. Does not include diagnostics and other information from field devices.

FCS: Expanded view. Field devices are part of the system.

TAG = LIC-012
VALUE = 70.34
UNITS = m³
STATUS = GOOD
ALARM = Y/N
Diagnostics

- Diagnostic information available in device
- Allows faster commissioning and troubleshooting

<table>
<thead>
<tr>
<th></th>
<th>Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4-20mA Fieldbus w/o diagnosis</td>
</tr>
<tr>
<td>Constructional checks (connections, polarity,..)</td>
<td>12.5 days</td>
</tr>
<tr>
<td>Time to repair</td>
<td>6 days</td>
</tr>
<tr>
<td>Preliminary commissioning instrument checks</td>
<td>25 days</td>
</tr>
<tr>
<td>Time to repair</td>
<td>3 days</td>
</tr>
<tr>
<td>Sum</td>
<td>46.5 days</td>
</tr>
</tbody>
</table>

ISO/OSI 7-layer International Reference Model

- **APPLICATION LAYER**
  - Provides a standard interface to the manufacturer's application.
- **PRESENTATION LAYER**
  - Data transformation, e.g., data compression
- **SESSION LAYER**
  - Controls connections between applications
- **TRANSPORT LAYER**
  - Transfer data across system bridges
- **NETWORK LAYER**
  - Establishes connection routing
- **DATALINK LAYER**
  - Arranges data transfer between adjacent and remote devices
- **PHYSICAL LAYER**
  - Converts data to a form suitable for transmission
  - Transmits/receives data from the medium.
Determinism

- 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
LAS

Link Active Scheduler
- Controls communications on segment
  - Who publishes data when via
    - Compel Data (CD)
    - Pass Token (PT)
- Maintains Live List
  - Listing of all devices on segment

Compel Data (Publish)

Real Time component of Fieldbus
- Controlled by LAS (and Back-up LAS)
- Controls when each device/function block on the network is to publish its information for all the other devices/function blocks to subscribe to or read.
## Macrocycle

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

### Acyclic Time
- Communicate NON control data:
  - Alerts
  - Trends
  - Queries
  - Upload
  - Download
- Uses Token Passing

## Foundation Design Guidelines
- FF-569, Host Interoperability Support Test
- FF-831, Fieldbus Specification for Power Supplies and Conditioners
- FF-844, Fieldbus Specification for Cable
- FF-846-1.1, Fieldbus Device Couplers
- AG-181, System Engineering Guidelines (Rev 3.1)
- Foundation Website lists all approved products
Physical Layer - specifications

- Power and Data on same cable
- Uses:
  - IEC 61158-2 Physical Layer standard
  - IEC 60079 Hazardous Area standard

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. number of devices (Link Master and Basic Devices)</td>
<td>32</td>
</tr>
<tr>
<td>Transmission Rate</td>
<td>31.25 kBit/s</td>
</tr>
<tr>
<td>Min. current consumption per node</td>
<td>10 mA</td>
</tr>
<tr>
<td>Data transmission via current change</td>
<td>+/- 9 mA</td>
</tr>
<tr>
<td>Min. supply voltage</td>
<td>9 V</td>
</tr>
<tr>
<td>Trunk cable length max</td>
<td>1800 m</td>
</tr>
<tr>
<td>Spur cable length max</td>
<td>120 m</td>
</tr>
<tr>
<td>Communication</td>
<td>Publisher/Subscriber</td>
</tr>
</tbody>
</table>

Definitions

Host H1 card

Control room

Field

Trunk ("home run")

Fieldbus devices

Wiring hub

Power supply/conditioner

Segment

Spur
Wiring Topologies

Point-to-Point

Bus with Spurs

Daisy-Chain

"Chicken Foot" or Tree

Preferred

Permitted Fieldbus Cable Types

<table>
<thead>
<tr>
<th>Fieldbus Foundation Cable Type and Description</th>
<th>Max Segment Length</th>
</tr>
</thead>
<tbody>
<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 with an overall shield</td>
<td>200 m (656 ft)</td>
</tr>
</tbody>
</table>
Segment Design

Macro cycle time
- Bus bandwidth - approx. 50 messages/sec
- Typical cycle time of 500ms from input to output

Physical layer may limit number of devices per segment and/or cable length in some applications:
- Field devices require 9V minimum
- Ohm’s Law - Voltage drop along cable may limit the maximum cable length
- Output current of power supply determines number of devices supported

Consequence of failure
- May need to limit the number of Fieldbus devices (control loops) in critical applications

Voltage drop example (simplified)

For 10 fieldbus devices @ 20mA/device*
\[ \Sigma = (10 \times 20) = 200mA \]

Field devices require 9.0V min.
- Defined by Fieldbus Foundation

Voltage @ end of trunk cable = 11V
- 9.0V + 2.0V margin

Max. voltage drop in cable
\[ = 21 - 11 = 10V \]

\[ R_{\text{cable max}} = \frac{10}{0.2} = 50\text{ohms} \]

Assume 0.8mm² cable
- 44ohms/km loop

Max cable length
\[ = \frac{50 \times 1000}{44} = 1136m \]

* NOTE: Bus-powered FOUNDATION™ Fieldbus devices require 10 to 30 mA between 9 and 32 volts. Most devices have a current consumption at 15 to 17 mA.

Taken from Page 21, Shell DEP 32.30.20.13-Gen., August 2008
Cable lengths with typical power supply

![Graph showing cable lengths with typical power supply](image)

* 19V, 350mA output

Maximum spur length

<table>
<thead>
<tr>
<th>No. of communication elements</th>
<th>Max. spur output cable length</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – 12</td>
<td>120m</td>
</tr>
<tr>
<td>13 – 14</td>
<td>90m</td>
</tr>
<tr>
<td>15 – 18</td>
<td>60m</td>
</tr>
<tr>
<td>19 – 24</td>
<td>30m</td>
</tr>
<tr>
<td>25 – 32</td>
<td>1m</td>
</tr>
</tbody>
</table>
Risk management

Level 1
- Failure of segment or valve results in an immediate plant shutdown
  - Limit to one Level 1 valve and associated transmitter

Level 2
- Failure of the segment or valve will not result in a short term risk of a plant shutdown
  - Two Level 2 valves can reside on the same segment along with Level 3 devices

Level 3
- Monitoring only devices
  - Up to 12 on one segment

Verification

Segment Verification consists of:

- Electrical Limits for Bus Powered Devices
- Device Voltage
- Device Current
- Signal Attenuation
- Function Block execution times
- Macrocycle “Free Time”
- VCRs (in older Host systems)
- Risk management guidelines
Thank you