Foundation™ Fieldbus Technology

Bindert Douma
Certified FF trainer

FF Seminar
May 2011
Contents

Introduction

- STC and FF
- Project Experiences

Foundation Fieldbus (FF)
(a selection of items)
- Physical layer
- Communication layer
- User layer

Summary
Mission

• Centre of excellence
• Education, training, consultancy, simulation and research
• Total logistic chain and maritime industry
• Operating globally
Vision

• ‘One-stop-shopping’
• Shipping, ship building, ports, logistics and petro-chemical process industry’s
• Innovative and high-quality education, training, consultancy, simulation and research
• The Netherlands and Europe
Position within STC-Group
The Netherlands
− Rotterdam
  − Lloydstraat (HQ)
  − Wilhelminakade
  − Waalhaven
  − Soerweg
− Brielle (centre for FF)
− Stellendam
− Katwijk

− Philippines
  − Palompon
− South Korea
  − Gwangyang
− South Africa
  − Johannesburg (centre for FF)
− Sultanate of Oman
  − Muscat
  − Sohar
− Vietnam
Brielle: Training units for (petro)chemical process industry
Control Room
Instrumentation including FF
Maintenance
FF Training packages

• FF Technology; 2 days awareness training
• FF Engineering and Design; 2 days focus on project approach
• FF Certified Technical Specialist; 5 days with hands-on
# FF Project Experiences

>15 y FF experience at Shell in:

- Testing
- Training
- Project Support

<table>
<thead>
<tr>
<th>Project</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>AOSP (Althabasca Oil Sand Project)</td>
<td>2006 – 2009</td>
</tr>
<tr>
<td>Bintulu</td>
<td>2005 – 2008</td>
</tr>
<tr>
<td>Brent Alpha</td>
<td>2001 – 2002</td>
</tr>
<tr>
<td>Brunei Champion West</td>
<td>2002 – 2005</td>
</tr>
<tr>
<td>Bukom HCU Re-instrumentation</td>
<td>2003</td>
</tr>
<tr>
<td>Bukom HCU Asset Management</td>
<td>2008 – 2010</td>
</tr>
<tr>
<td>Corrib</td>
<td>2004 – 2010</td>
</tr>
<tr>
<td>Deer Park HCU</td>
<td>2001</td>
</tr>
<tr>
<td>DSM Melamine</td>
<td>2003</td>
</tr>
<tr>
<td>HDS6 Pernis</td>
<td>2008 – 2009</td>
</tr>
<tr>
<td>Houdini</td>
<td>2005 – 2010</td>
</tr>
<tr>
<td>KNPC (Kuwait)</td>
<td>2006</td>
</tr>
<tr>
<td>Marathon Pernis</td>
<td>2005</td>
</tr>
<tr>
<td>MOL (Hungary)</td>
<td>2003</td>
</tr>
<tr>
<td>Nanhai</td>
<td>2001 – 2006</td>
</tr>
<tr>
<td>NAM (GLT and Schoonebeek)</td>
<td>2002 – 2009</td>
</tr>
<tr>
<td>NORCO - Chemical</td>
<td>2003 – 2009</td>
</tr>
<tr>
<td>Ormen Lange</td>
<td>2003 – 2009</td>
</tr>
<tr>
<td>PDO (Harweel; Yibal; Mussalim; Qaharir)</td>
<td>2000 – 2007</td>
</tr>
<tr>
<td>Pearl</td>
<td>2003 – 2010</td>
</tr>
<tr>
<td>Sabic NAK 5</td>
<td>2004</td>
</tr>
<tr>
<td>Sakhalin II (Top sides; OPF; LNG)</td>
<td>2002 – 2008</td>
</tr>
<tr>
<td>Steiger (Pernis)</td>
<td>2007</td>
</tr>
</tbody>
</table>
Process control:

500 - 2000 measurement and control points per process unit

Up to 15000 - 25000 per plant

Signal Cables 4-20 mA

Control - DCS

Smart Computer talks to dumb devices
A digital, two-way multi-drop communication link among intelligent measurement and control devices, and automation and display systems.

Ah, FF is a communication protocol! No technology?
H1 is the main application of FF.
HSE is hardly used.
The Physical Layer receives messages from the communication layer, converts them into physical signals and transmits them on the wire. Conversely, the Physical Layer detects electrical signals on the wire and converts them into messages. Conversion tasks include adding and removing preambles, start, and end delimiters.
H1 Physical Layer

- Device
  - Voltage: 0.75 to 1.0V p-p
  - Power: 9 to 32 Volts
- Time
- Devices
- Power Supply & Conditioner
- 100 Ohm
- 1 μf
- Termination
- ONE Segment: AC superimposing on DC power

Receiving Transmitting

15 to 20 mA p-p
FF Segment Components

Power supply

Power conditioner

Barrier

System I/O

T

Cable

JB

T: Termination
JB: Junction Box

Terminal strips

Devices

DEVICE COUPLER

Short-circuit protection
Current limit
Barrier

Entity
FISCO
FNICO
Project philosophy determines component selection (early decision)
- IS Concept has a large impact on component selection
- Apply redundancy on I/O and power supply
- Apply segment protection by appropriate device couplers
- Limited # of devices per segment (communication is the main limit)
  - FF Specification: max 32 devices
  - Testing shows max 16 devices at 1 sec macrocycle
    (less with faster loops and subcycles)
  - Most projects use max 12 devices per segment (incl. margin)
    - Cost effective at average 6 devices per segment
FF power supplies

(Bulk) Power Supply 24Vdc

- Galvanic Isolation
- Short Circuit protection and Current limitation
- Power Conditioner

Segment 19-30 Vdc

100 Ohm
1 μf

Most bulk power supplies have neg. to ground

Select output & current Floating!

Redundant?

Integrated? Switchable? Reliability
H1 Physical Layer

Robust protocol (Manchester L), but noise, grounding, cable quality, etc. have an impact.
## FF Cable Specification

<table>
<thead>
<tr>
<th>Cable type and Description</th>
<th>Size</th>
<th>Max Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type A: Shielded, twisted-pair</td>
<td>0.8 mm² (#18 AWG)</td>
<td>1900 m (6232 ft.)</td>
</tr>
<tr>
<td>Type B: Multi-twisted-pair, with shield</td>
<td>0.3 mm² (#22 AWG)</td>
<td>1200 m (3936 ft.)</td>
</tr>
<tr>
<td>Type C: Multi-twisted-pair, without shield</td>
<td>0.15 mm² (#26 AWG)</td>
<td>400 m (1312 ft.)</td>
</tr>
<tr>
<td>Type D: Multi-core, without twisted pairs and having an overall shield</td>
<td>1.25 mm² (#16 AWG)</td>
<td>200 m (656 ft.)</td>
</tr>
</tbody>
</table>
# Required Cable Specification

<table>
<thead>
<tr>
<th>Essential Cable Parameters</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size of conductor</td>
<td>min 0.8 mm² (#18 AWG)</td>
</tr>
<tr>
<td>Shield coverage</td>
<td>min 90 %</td>
</tr>
<tr>
<td>Conductor resistance</td>
<td>max 25 Ω/km</td>
</tr>
<tr>
<td>Loop resistance (2x Cond. Res.)</td>
<td>max 50 Ω/km</td>
</tr>
<tr>
<td>Capacitance unbalance to shield</td>
<td>max 2 nF/km</td>
</tr>
<tr>
<td>Attenuation at 39 kHz</td>
<td>max 3.0 dB/km</td>
</tr>
<tr>
<td>Impedance at 31.25 kHz</td>
<td>100 Ω (max ± 20 Ω)</td>
</tr>
</tbody>
</table>

- Projects use same cable for FF and 4-20 mA HART (cost!)
- Existing cable can be used, but quality testing recommended
Point to point works but is not cost effective and should not be considered.
Bus with spurs is used in small installations where distance between devices and I/O is less than 120 m
Daisy-chain should never be used. Device couplers are designed for only one device (including some handheld tools!). Loss of first device is a risk.
Tree is preferred
Use device couplers with full protection

Topology

Control Network

I/O

Junction Box

Tree

Point-to-Point

Bus with Spurs

Daisy-Chain
Toplogy

Multicore is used for locations with high density # of devices Segregation!
More JB’s per segment to increase segment loading (cost effective).
Terminators!
Nice on the drawing board, but a disaster in actual implementation!
Multiple earthing only if equipotential grounding is guaranteed.
Communication Layer

Peer to peer communication based on token passing

Supports Client/Server Model (Unscheduled Request/Response)

Supports Publisher/Subscriber Model (Scheduled Data Acquisition)

Supports Event Notification (Unscheduled Multicast)
Link Active Scheduler controls the segment communication by token passing.

Do not use LAS in devices with redundant I/O!

- LAS (Link Active Scheduler)
- Link Master Device (Primary)
- Basic Device
- Link Master Device (Redundant Primary)
- Basic Device
- Link Master Device (Backup)
- Basic Device
Communication Layer

Publish/Subscribe

Source/Sink

Client/Server

Temp = 100°F

PV: 100

HI TEMP Alarm

Compel Data

Pass Token

Request

Response

Data

Pass Token

Pass Token
Publish/Subscribe has the highest priority, is fully deterministic, is firstly executed in the macrocycle.

Publish/Subscribe should only be used for loop control and not for PV updating!
Client/Server is not deterministic, but frequent and scheduled by the DCS (a device receives 3x per sec a token)

Client/Server should be used for graphics, setpoints, device interrogation, ….
Source/Sink is not deterministic, but can be frequent (a device receives 3x per sec a token)

Process alarms should be routed to operator
Diagnostic alarms should be routed to maintenance
User Layer

Standard Function Blocks
Consistent definition of data for integrated and seamless distribution of functions in field devices from different suppliers.

System Management
Deterministic scheduling of Function Blocks.

Device Descriptions
Allows the host system to operate the device without custom programming.
“Key to Interoperability”

Common File Format
Allows the host system to configure the system off line.

Diagnostic drivers
Allows the host system to interoperate with device diagnostic information
Values are read from the device over the fieldbus.

Number of digits of precision
Engineering Unit
Label of the value

Descriptions for values are read by the host from the Device Description.

25.50%
Measured_Value
DD + CFF files allow the host system to configure the fieldbus system off line.

No Devices Needed

Configuration Files
<table>
<thead>
<tr>
<th>Device Description</th>
<th>Capability File</th>
</tr>
</thead>
<tbody>
<tr>
<td>Describes function blocks</td>
<td>Profile information</td>
</tr>
<tr>
<td>Menu’s and methods Procedures for configuring the device.</td>
<td>Actual number of Function Blocks inside device</td>
</tr>
<tr>
<td>Multi-lingual label and help information</td>
<td>Instantiable Function Blocks</td>
</tr>
<tr>
<td>Parameter relationships</td>
<td>Function Block Timing</td>
</tr>
<tr>
<td></td>
<td>Provides example communication and Function Block data</td>
</tr>
<tr>
<td></td>
<td>Device current consumption</td>
</tr>
<tr>
<td></td>
<td>Details for the host to offline configure the device</td>
</tr>
</tbody>
</table>
User Layer; DD & CFF Download

DD + CFF files (3 files) come as one zip file and can be obtained from:
- The FF website
- Device vendor
- DCS vendor

Correct DD & CFF’s are critical for device version control and device replacement

DCS capability is critical for the DD&CFF’s and therefore the best download is in general from the DCS vendor.
Include EDDL or DTM files!

It is recommended to fully load all available DD&CFF’s
Advanced Transmitters: An Example

Diagnostics & Advanced diagnostics

Arithmetic: scaling square root low cut filter

Simulate

Channel

Sub tagging !!

Calc

mass flow: PV & detailed status
Summary

Foundation Fieldbus is an attractive and robust communication protocol for plant automation

Successful Foundation Fieldbus implementation requires appropriate technology

- Healthy physical layer
- Balanced and no overloaded communication layer
- Exploitation of the User layer for diagnostics

Training is essential for successful implementation