Segment design & and Bus Diagnostics

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On behalf of FF End user Council Taiwan
Part 1 - Segment design & Verification Tools

Part 2 – Validation and Diagnostic tools
Segment Design and Verification Tools

How to design Foundation Fieldbus segments?
Segment Design and Validation Tools

- Fieldbus allows to connect many devices on the same bus cable, but...

- How many devices can I really connect?

- What cable should I use, and what cable distances can I really achieve?

- What happens in case of a short circuit in the field?
Segment design

Engineers especially new to Fieldbus technology have some Common questions that has to be answered before proceeding to the real design.

• What are the common questions about Fieldbus design?

Fieldbus allows to connect many devices on the same bus cable, but…

• how many devices can I really connect?
• what cable should I use, and what cable distances can I really achieve?
• what happens in case of a short circuit in the field?
• what Power Supplies and wiring blocks can I connect in hazardous areas?
• how do I do the termination?
• and how do I document my calculations and designs?
• How do I do the proper segment design for various zones of applications
Segment Design and Validation Tools

- What Power Supplies and wiring blocks can I connect in hazardous areas?

- How do I do the termination?

- And how do I document my calculations and designs?

- What happen to my segment due to ambient temperature change? Will it work properly?
Segment Design and Validation Tools

- Most component manufacturers provide own versions of the segment design tools.

- Design tools are available in either Excel based versions or graphical based versions.

- Most segment design tools generate design report.

- The validation of a Fieldbus segment includes checks like application of bus terminators, cable distances, voltage and current values as well as short circuit simulation checks.
Segment Design and Validation Tools

Graphical segment design tool example

Pepperl+Fuchs Segment Checker design tool

www.segmentchecker.com
Segment Design and Validation Tools

• The Segment Checker is a software tools for design and validation of Fieldbus networks.

• The Segment Checker is a graphical design tool with report generator.

• The validation of a Fieldbus segment includes checks like application of bus terminators, cable distances, voltage and current values as well as short circuit simulation checks.
Segment Design and Validation Tools

• Before a segment can be validated, it needs to be designed.
The project report tab lists a result summary of the checks performed by the software.
Using Segment Checker - Report

Segment Checker

**Cable Parameters: T005-T00F**
- **Cable Type**: = A 0.8mm² (AWG 18)
- **Cross Wire Section**: = 0.8mm²
- **Wire Resistance**: = 44Ohm/km
- **Wire Length**: = 0.5m
- **Temp. Coefficient**: = 0.0039Ohm/min°C

**Cable Parameters: T005-T010**
- **Cable Type**: = A 0.8mm² (AWG 18)
- **Cross Wire Section**: = 0.8mm²
- **Wire Resistance**: = 44Ohm/km
- **Wire Length**: = 0.5m
- **Temp. Coefficient**: = 0.0039Ohm/min°C

**Cable Parameters: T005-T011**
- **Cable Type**: = A 0.8mm² (AWG 18)
- **Cross Wire Section**: = 0.8mm²
- **Wire Resistance**: = 44Ohm/km
- **Wire Length**: = 0.5m
- **Temp. Coefficient**: = 0.0039Ohm/min°C

**Cable Parameters: T005-T00E**
- **Cable Type**: = A 0.8mm² (AWG 18)
- **Cross Wire Section**: = 0.8mm²
- **Wire Resistance**: = 44Ohm/km
- **Wire Length**: = 0.5m
- **Temp. Coefficient**: = 0.0039Ohm/min°C

**Cable Parameters: T005-T012**
- **Cable Type**: = A 0.8mm² (AWG 18)
- **Cross Wire Section**: = 0.8mm²
- **Wire Resistance**: = 44Ohm/km
- **Wire Length**: = 0.5m
- **Temp. Coefficient**: = 0.0039Ohm/min°C

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**Checker Details**

<table>
<thead>
<tr>
<th>Tag</th>
<th>Current [mA]</th>
<th>Voltage [V]</th>
<th>Result</th>
</tr>
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<tbody>
<tr>
<td>HOST</td>
<td>19.0</td>
<td>10.0</td>
<td>9.000</td>
</tr>
<tr>
<td>FPC - Fieldbus Power</td>
<td>396.0</td>
<td>227.2</td>
<td>21.414</td>
</tr>
<tr>
<td>FPC - Fieldbus Power</td>
<td>396.0</td>
<td>217.2</td>
<td>21.414</td>
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<td>9.003</td>
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<td>FieldBarrier-1</td>
<td>396.0</td>
<td>217.2</td>
<td>16.000</td>
</tr>
<tr>
<td>FieldBarrier-1</td>
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<td>244.8</td>
<td>16.000</td>
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<td>35.0</td>
<td>9.000</td>
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<tr>
<td>FieldBarrier-1</td>
<td>35.0</td>
<td>35.0</td>
<td>9.000</td>
</tr>
</tbody>
</table>
Segment Design and Validation Tools

Excel spreadsheet based segment design tool example

Stahl Segment design tool
Segment Design and Validation Tools
Segment Design and Validation Tools

Excel spreadsheet based segment design tool example

MTL Segment design tool
Segment Design and Validation Tools
Segment Design and Validation Tools

• Other Vendors e.g. STAHL, may also provide segment design tools that consist of their own interface components.

• DCS Companies also provide segment design tools that consists of interface components from various vendors.
Part 2 - Validation and Diagnostic tools
Need for diagnostics

• Field study by installation and commissioning Engineers around the world shows that more than 80% of the plant disturbances come from the physical layer level be it conventional 4-20mA applications or Fieldbus applications.

• Unless the engineers sufficiently trained for Fieldbus applications the most common mistakes are made at the physical layer level such as wiring faults, wrong termination etc.
Typical problems

Electrical wiring of Fieldbus is same as conventional
→ same problems
  (loose wires, water ingress, faulty devices, EMC, etc)

Difference: bus topology
→ locating the problem is difficult and time consuming
  (many devices in one loop; Interoperability)

Available tools are optimized for conventional technology
→ tools are not able to solve majority of problems
Typical problems

- Improperly closed housing
- Loose wire
- Interoperability testing by end user
- Electro-magnetic interference
- Faulty field device
- Cable degradation
- Wrong termination
- Error log showing intermittent faults
Diagnostic Tools

Engineering tool
Digital Volt Meter
Portable oscilloscope
Fieldbus tester
Network sniffer
Advanced Online diagnostic tools
Portable diagnostic tools
Network Problems

Commissioning problems
- Insufficient power
- Poor wiring
- Interoperability

Problems introduced at changes and expansion
- Additional grounding points
- Version incompatibilities

Long term problems
- Water filling
- Deteriorating cable
Basic Troubleshooting

Communication errors are automatically detected and indicated in operator console and engineering tools.
As for all troubleshooting, removing parts one-by-one until it works finding the fault through elimination, is a useful way.

- This may detect communication problems as well as insufficient current being available from the power supply or galvanic isolator (barrier).

It is also a good idea to test a problem device on its own on the workbench.

If there is no communication at all, there is a problem with its configuration or installation.
Types of Communication Errors

Configuration download is not working
- “Error Log" window appears: block or parameter problem

Function block link from a block output in one device to a block input in another device does not appear to be working.
- Block input status is “Bad, no communication”

Supervisory data acquisition does not work
- Asterisk (*) or invalid character is appearing in operator console
Communication Errors

Communication errors are mainly caused by installation problems, not configuration or failure:

- Poor connections
- Wrong or no terminator placement
- Too low or unstable power supply
- Too long or over-populated spurs
- Wrong or no grounding
- Water filling due to poor plugs and cable-glands
H1 Bus Power

Simultaneous power supply and communication on a single pair of wires.

- DC power 9-32 VDC
- AC communication (@31.25 kHz)

Power consumption varies from one device to another. There are no upper or lower limits.

Power consumption is indicated on device ID plate.

The lower consumption the better, especially in intrinsic safety applications.

It is important that the wire resistance is not too high making the supply voltage at the device too low.

Good connections and junctions must be made.

It is possible to test the voltage (not signal) on the installed network using a hand-held Digital Volt Meter (DVM).
Check Points (1)

Are two (and only two) terminators connected per bus? Be especially careful where redundant power is used.

Is the display of the not communicating device working having any indication at all?

Is the power supply at the terminals of the not communicating DEVICE sufficient > 9 V? Is the polarity correct?

Verify continuity of wires, and that short circuits are not caused by junction box water filling.
Power Supply Example

Number of devices:
- Impedance output voltage is 19 V
- Cable loop resistance for 1.9 km is 84 ohm
- Device needs minimum 9 V
- Maximum voltage drop is therefore 10 V (19-9)
- Maximum total current draw thus is 120 mA (10/84)
- Each device needs 20 mA (many devices are as little as 12-15 mA)
- Maximum 6 devices, or shorter cable (120/20)

Cable length:
- Impedance output voltage is 19 V
- Device needs 20 mA and minimum 9 V
- Maximum voltage drop is therefore 10 V (19-9)
- Total current draw for 12 devices thus is 240 mA (12 x 20)
- Maximum cable loop resistance is therefore 42 ohm (10/0.24)
- Cable resistance is 22 ohm/km- in each direction
- Maximum 0.95 km, or less devices (42/(2 x 22))
Fieldbus Tester

Voltage (> 9 V)
LAS signal level (> 150 mV)
Number of devices
Lowest device signal level (> 150 mV)
Average noise (< 75 mV)
Peak noise (< 75 mV)
Signal level of new device (> 150 mV)
Inverted signal
Frame error

Draws 15 mA from the bus!
Fieldbus Wiring Validator

Used together with Fieldbus Tester (Relcom FBT-3)
Test the wiring, terminators, and junction bricks/couplers
- No Fieldbus devices, host, or power shall be connected

Simulates power and communication, in place of host
Permits tester to monitor:
- Voltage (drop)
- Signal level (attenuation)
- Noise level
Bus analyzer / Configurator

- Monitors device communication with monitor software
- Monitors communication faults with monitor software
- Configure devices with configurator software
Earthing (Grounding)

Don't ground shield in both ends
Make sure shield or ground wire does not get in touch with instrument housing
Other earth points along the wire
Open earth connection at host to measure

Earthing point for surge protector, not fieldbus shield
Advanced Troubleshooting

To find serious problems a bus analyser may be used to study the communication messages in order to find a protocol interoperability problem.

An oscilloscope (balanced/isolated - e.g. battery operated) may also be a useful tool in extreme cases of interoperability problems.
Oscilloscope

Well formed waveform:
- Sloped raising edge
- Flattish top
- Sloped falling edge
- Flattish bottom

Symmetrical

<table>
<thead>
<tr>
<th>Signal Level</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 350 mV</td>
<td>Excellent</td>
</tr>
<tr>
<td>200-350 mV</td>
<td>Good</td>
</tr>
<tr>
<td>150-200 mV</td>
<td>Fair</td>
</tr>
<tr>
<td>&lt; 150 mV</td>
<td>Poor</td>
</tr>
</tbody>
</table>
Terminator

If a terminator is missing the signal amplitude will be too high

If too many terminators are present the signal amplitude will be too low
Noise
Error Rate

CRC error exceeding 0.8% will not perform well
Fieldbus Sniffer (FBView)

Permits non-experts to capture communication and email to experts for analysis

Expert can filter, time, find, and decode frames
Locating physical layer faults

The problem can be anywhere...

Which tool?

Where to start?
<table>
<thead>
<tr>
<th>Measurements Tools of the Trade</th>
<th>Multi-meter</th>
<th>Handheld Tester</th>
<th>Handheld Communicator</th>
<th>Oscilloscope</th>
<th>Notebook Bus Analyzer</th>
<th>Advanced Diagnostic Module</th>
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</thead>
<tbody>
<tr>
<td>Segment voltage</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td></td>
<td></td>
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<td>Segment current</td>
<td></td>
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<td></td>
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<td>Segment noise (low freq.)</td>
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<td>Segment noise (high freq.)</td>
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<tr>
<td>Segment signal level</td>
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<td>●</td>
<td>●</td>
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<td>Segment signal jitter</td>
<td>●</td>
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<td>●</td>
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<td></td>
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<tr>
<td>Instrument signal jitter</td>
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<td>●</td>
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</tr>
<tr>
<td>Instrument noise (individual)</td>
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<td>●</td>
<td>●</td>
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<td>Fieldbus termination</td>
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<td>Segment earth fault (imbalance)</td>
<td>●</td>
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<td>●</td>
<td>●</td>
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<td></td>
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<tr>
<td>Device communication</td>
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<td>●</td>
<td>●</td>
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<td>Communication faults</td>
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<td>●</td>
<td>●</td>
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<tr>
<td>Cable degradation (trending)</td>
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<td>Device configuration</td>
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<td>Remote access</td>
<td></td>
<td>●</td>
<td>●</td>
<td>●</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

● Supported  = Result incomplete  ○ Requires shutdown  ✓ Fully

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Taiwan FF Seminar 27 & 29th July 2010
Portable Diagnostic tools

- Stand Alone diagnostic tools
- Some Diagnostic tools can also be used for data storage
Portable Diagnostic Module DM-AM

Features of the Diagnostic Module
- User-configurable warning and alarm levels for long-term diagnostic
- Alarming with time stamping (final version)
- History/trending for all measured values stored in the diagnostic module (final version)
- DCS system integration with OPC (final version)

Features of the PC Tool
- Commissioning tool for easy warning and alarm level definition
- Documentation tool, file or print out
- Expert system wizard to isolate cause of deviation or errors (final version)
- Build in Fieldbus oscilloscope
Physical Layer Measurement Report

Date: 04.08.2006 10:59:02
Description: Configuration with four fieldbarriers. Each is equipped with four field devices.

Fieldbus Type: FOUNDATION Fieldbus
Segment Tag:

Measurement Equipment
Type: DM-AM
Serial Number: 01036130658014
Software Revision: 1.1.0.0
DTM Revision: 1.19.3.2

Result: ☑ Passed, Excellent

Legend
☑ Excellent Passed, all values are within the specification limit with an adequate safety margin
☑ Good Passed, the value is within the specification limits but the safety margin is reduced
⚠ Out of Specification Failed, the value exceeds the allowed range

Limits used for this classification are listed on the last page of this report.

Global data and summary for 17 detected Field Devices

<table>
<thead>
<tr>
<th>Field Device</th>
<th>Min</th>
<th>Addr</th>
<th>Max</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Segment Voltage</td>
<td>28.7V</td>
<td>-</td>
<td>28.7V</td>
<td>Excellent</td>
</tr>
<tr>
<td>Unbalance</td>
<td>0%</td>
<td>-</td>
<td>0%</td>
<td>Excellent</td>
</tr>
<tr>
<td>Noise</td>
<td>20mV</td>
<td>17</td>
<td>34mV</td>
<td>Excellent</td>
</tr>
<tr>
<td>Jitter</td>
<td>0.8μs</td>
<td>19</td>
<td>1.5μs</td>
<td>Excellent</td>
</tr>
<tr>
<td>Signal Level</td>
<td>572mV</td>
<td>31</td>
<td>727mV</td>
<td>Excellent</td>
</tr>
</tbody>
</table>

And here you pause...
FBT6

- Fieldbus powered
- LC display
- Does the same function as FBT3 and additionally
  - Device add & drop indication
  - Shield short indication when + or – shorted to shield
  - The address and signal level of each device on the network is displayed in turn by pushing the “SELECT” button.
  - Checks for any device not responding to a LAS pass token and indicates the address of the last device that failed to respond to the LAS pass token
  - Upload measurement data to a PC via USB port

- Draws Power from Fieldbus
Field Communicator 375

Configures Fieldbus devices in the field
Measures and monitors
  • DC voltage
  • Average noise
  • Signal level per segment
Certified for Intrinsic safe applications
Online Diagnostic tools

- Usually integrated in the Power conditioner system
- Can also be used for data storage and trending
- Analyses complicated Fieldbus issues
- Some tools integrated with Fieldbus Oscilloscope
- Some tools generate automatic commissioning report
- Can transport the data on H1 bus or separate protocol like RS485 and Ethernet
The effect of Advanced Diagnostics

- Segment Checker: design of the physical layer
- Verify against original design
- Automated checkout procedures
- Longer plant uptime
- Know before you act
- Actionable information in clear text

Cash Flow

Plan and purchase
Install and commission
Operate and maintain

Commission
Monitor
Troubleshoot

Operate and maintain

Plan and purchase
Install and commission
Operate and maintain

Commission
Monitor
Troubleshoot

Cash Flow
Commissioning until now

- Always on the critical path
- Labor intensive
- Requires
  - Screwdriver
  - Check sheet
  - Pencil
  - Multimeter
  - Oscilloscope
- Connect one device at a time
- Disconnect after testing
Simple Commissioning Steps with ADM

- Verify address setting
- Wire up devices in the right location
- Check shielding
- Activate communication
- Use automated work procedures
  - Testing
  - Documentation
- All devices at once
- Wiring remains undisturbed
Commissioning Wizard

- Simple to use
- Eliminates manual test procedures
- Ensures compliance with AG181 and IEC 61158-2
- Creates baseline report:
  - Snapshot of all measurements
  - Complete documentation
- Recommends warning and alarm limits for the AD
- Stores limits in non-volatile memory
- Reduces pre-commissioning time by up to 80%
Control the physical layer

Supervision and diagnostics

• Measurements, trending, alarming

Part of the Power Hub

Online and in real-time with remote access

• from the control room and
• via Internet

Simple-to-use DTM s

• Signal measurements
• Color-coded status indicators
• Built-in oscilloscope for greatest detail

NOT a Fieldbus Device
Diagnostic Manager

Industrial Ethernet
DCS / Maintenance Station

Control Cabinet
Snapshot Functionality

Automatically generated documentation
Baseline report for online comparison and trending
Live supervision during operation
ADM delivers actionable information for fast fault finding

1. Active messages
2. Actionable information with solution guidance based on expert knowledge
3. History with timestamps
   - When the failure... occurred
   - ... disappeared
   - Export function for external analysis and storage
Oscilloscope function

Many trigger events selectable!

This telegram is lost...
In this example the frequency of noise was approx. 150Hz
ISbus Fieldbus Power Supply

Advance diagnostics

Same functionality as Basic FPS, plus:

Integrated physical layer diagnostics:

- trunk voltage, trunk current, communication level, noise level, asymmetry, jitter, waveform snapshot

adjustable warning levels for pro-active maintenance warning

warning with simple relay contact – Software independent in redundant operation, diagnostics is also redundant
Green LED: OK
- segment runs in specification with 100 % quality

Yellow LED: WARN
- segment runs in specification but with reduced quality (warning level can be adjusted 5…90 %)
- Soon maintenance required

Red LED: BAD
- segment out of specification (incl. cable break & short circuit)
- Maintenance required now!
Fieldbus Power Supply
Advanced diagnostics

Failure detection of physical layer problems: jitter, noise, asymmetries, voltage level, current level

Indication via LED

Signalling via relay contacts:
F809F diagnostic tool

Host control system

Instrument Management Software (including fieldbus diagnostics)

On-line Diagnostic Module

power supply system

Controller I/O

Alarm

Fieldbus
F809F Diagnostic tool

Fieldbus diagnostic module

- Fieldbus diagnostic module
- Resource block
- Diagnostic module transducer block
- Segments 1 to 8 transducer blocks
- Discrete input blocks for diagnostic module and segments 1 to 8 - any parameter in alarm
Conclusion

Follow the

- System design guidelines provided by AG guidelines at [www.Fieldbus.org](http://www.Fieldbus.org)
- Fieldbus Physical layer specification IEC 61158-2
- Good grounding and shielding concept as per the plant conditions
- Installation guidelines
- Approved and registered products
- Right diagnostic tools to reduce installation and commissioning time
QUESTIONS?