Fieldbus Foundation
Fieldbus Foundation – India Marketing Committee

The Foundation Fieldbus Physical Layer … … and how to diagnose it

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Introduction

The Fieldbus ‘Physical Layer’ and its elements

Why are Physical Layer diagnostics needed?

Typical problems
- during start-up and commissioning
- during operation

Which parameters should be measured?

Ad-hoc and on-line maintenance tools
- Turn data into information
- Use Information for Predictive and Preventative Maintenance
What is the Fieldbus Physical Layer?

Physical layer represents the actual data transmission
This concept is typically applied to:
- Any kind of instrument in the safe (non-hazardous) area
- Ex nA instruments in Zone 2
- Ex d instruments in Zone 1
Physical layer elements – High Energy

This concept is typically applied to:
- Ex nL instruments in Zone 2
- Ex i instruments in Zone 1 or 0
Physical layer elements – FISCO/FNICO

This concept is typically applied to:
- Ex nL/FNICO instruments in Zone 2
- Ex i/FISCO instruments in Zone 1 or 0
Physical layer diagnostics

- Which parameters? … voltage, …?
- What about efficient commissioning?
- How can I troubleshoot properly?
- Can I do a health check-up
  - from time to time
  - or constantly on-line?
Why physical layer diagnostics?

- A failure could result in loss of revenue, production and/or damage to plant

- Need to maximize plant availability
  - Identify problems before the process is affected
  - Reduce troubleshooting time

- Not covered by instrument diagnostics
  - Instrument diagnosis permits early diagnosis of sensor and actuator faults
  - Physical layer diagnosis covers the health of the interconnecting network

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Physical layer experience

“Fieldbus physical layer has proved very reliable with no problems since installation. We used good quality cabling and a quality contractor for the installation.”

Plant Engineer, European Chemical Plant

“The power supplies and wiring components have not made any problems since they were installed and put into operation. The high reliability provides solid foundation for the successful applications of the Fieldbus.”

Head of Automation, Chinese Integrated Polymer Plant
Physical layer experience

“Most common problem on fieldbus segments is wrong grounding of cable screen.”

*Fieldbus Support Specialist,
Major Automation Contractor*

“Problems observed included electrical noise from welding on site, capacitance imbalance of field device and wiring component deforming signal when noise on bus.”

*Instrument Engineer
European Chemical Plant*
Physical layer experience

“Visited site with problems of lots of noise on fieldbus and were using 3 terminators as way of reducing noise. Checked screen grounding which was connected to control system ground bar, but ground bar had not been connected to earth. This was connected to earth, noise eliminated and segments now operate with 2 terminators”

Fieldbus Support Specialist, Physical Layer Supplier

“Communication errors were experienced on site. Visited site and identified problems of loose connections. Correctly tightening screw terminals with a torque screwdriver resolved the communication issues.”

Fieldbus Support Specialist, Physical Layer Supplier
Theoretical approach

- Fieldbus specification defines all FF parameters with limits.
- If the network operates within the specified limits, it should work properly.
Theoretical approach

Problem with that:

- Impossible to measure all parameters in a system environment
- Individual components can meet individual criteria, but problems can arise due to interaction
- If you know a parameter is off-limit, what to do next?
- *Never fix a running system*
Practical approach

- Proper commissioning
  - Fix all problems as far as possible
  - Establish a baseline (take a snapshot)
- Which are the **relevant** parameters that can eventually lead to a failure?
  - Measure them
  - Monitor them
  - If they worsen, fix it before it fails
## Faults at start-up/commissioning

### Wiring errors
- Wrong connections
- Open/short circuits
- Intermittent connections
- Reversed polarity

### Too many or too few terminators

### Faulty components
- Power supply or fieldbus barrier
- Fieldbus instrument

### Inadequate grounding
- Multiple grounds in field
- No clear grounding strategy

<table>
<thead>
<tr>
<th>Fault Type</th>
<th>Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wrong connections</td>
<td>Device does not appear on DCS</td>
</tr>
<tr>
<td>Open/short circuits</td>
<td>Diagnostic tool will tell you</td>
</tr>
<tr>
<td>Intermittent connections</td>
<td>Device log on DCS, tool info</td>
</tr>
<tr>
<td>Reversed polarity</td>
<td>Diagnostic tool will tell you</td>
</tr>
<tr>
<td>Signal amplitude</td>
<td></td>
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<tr>
<td>Too many or too few terminators</td>
<td></td>
</tr>
<tr>
<td>Faulty components</td>
<td>Communication retransmissions</td>
</tr>
<tr>
<td>Power supply or fieldbus barrier</td>
<td>Insufficient voltage / LF noise</td>
</tr>
<tr>
<td>Fieldbus instrument</td>
<td>Retransmissions / FF noise</td>
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<tr>
<td>Inadequate grounding</td>
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</table>
Faults in operation

Environmental damage
- Water ingress
- Corrosion
- Vibration
- Temperature Variations

Manually inflicted damage
- Insufficient Maintenance

Surge damage
- Lightning
- On-site welding

Electrical noise
- Faulty or improperly grounded electrical apparatus

Component failure
- Physical layer component or fieldbus device

Compare measurements to baseline. Observe differences. Are differences related to a particular device only, or to the whole segment? Combine the various measurements from diagnostic tool to draw conclusion.
Prevention

Installation Tools
- Torque screwdriver
- Ferrules
- Wire strippers
- Digital Multimeter
Prevention

Monitoring

- Establish baseline during commissioning
- On-line

Tools:

- Portable fieldbus diagnostic test equipment
- Plug-on fieldbus diagnostic monitoring
Portable diagnostic tools

Connect at respective location to obtain accurate measurement.
Portable diagnostic tools

To measure at fieldbus barrier, PDI needs to be Ex i approved. Important since the galvanic isolation of fieldbus barrier impacts on measurement.
Portable diagnostic tools

Fieldbus power supply system

Use plug on Power supplies and wiring components

Junction box

Use clips on instruments and open cable ends

Hand-held Diagnostic Module

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Typical measured parameters

Shield short
- Easy to measure and understand
- Further measurements can identify location

Signal level
- Minimum level is specified by Fieldbus specification
- Low or high levels on all devices suggests incorrect bus termination
- If only one device, suggests problem on single spur

DC voltage
- Indicates correct function of power supply/conditioner
- Instrument supposed to operate from 9V onwards

Noise
- Maximum level is specified by Fieldbus specification
- Tri-band measurement helps identify source

Retransmissions
- Good measurement of physical layer health
- Re-tries can obscure faulty device or network
Portable diagnostic tools

Establish baseline during commissioning

1. Connect fieldbus tester to network (between rack room and field devices)
2. Store measurements
3. Upload to PC
4. Record data as Excel spreadsheet
Portable diagnostic tools – turn data into information

Repeat this process from time to time

1. Use Excel to create trend charts
2. Identify long-term degradation
Good diagnostic information

Easy to measure
- Doesn’t require extreme skill or long time

Easy to understand
- Useless if operators don’t know what it means

Gives definite indication of a problem
- Use thresholds and limits to indicate problems

Eliminates possible causes
- Provide short list, or ideally exact source

Actionable
- Leads to next step in troubleshooting process
Good diagnostic information (?)

OK?
NOT OK?

OK?
NOT OK?

Tools need to be suitable for the people who use it!
On-line monitoring

Permanently installed at the fieldbus power supply in the control room.
On-line diagnostic monitoring

Host control system

Instrument Management Software (including fieldbus diagnostics)

Fieldbus power supply system

Controller I/O

Fieldbus

On-line Diagnostic Module

wiring components
On-line diagnostic module

- Continuously monitors segment and individual instrument parameters
- Monitors up to 8 fieldbus segments
- Diagnostic software
  - Integrated in control systems’ instrument management software via “DD”
  - No special software required
Fieldbus diagnostic module

- Fieldbus diagnostic module
- Resource block
- Diagnostic module transducer block
- Segments 1 to 8 transducer blocks
- DI alarm function blocks with individual and common alarms
Example of trending on a DCS – turn data into information

Trending of fieldbus segment noise
Conclusions

- Physical layer health is critical
  - Avoid problems from the start
- Select approved and proven devices
- Use quality cable, wiring components and power conditioners
- Follow good installation practice
- Periodic and on-line maintenance tools aid diagnosis during start-up and operation
- Open-architecture diagnostic monitor is independent of control platform
Thank You

Questions?