Basics of PROFIBUS
PROFIBUS in Practice

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Endress+Hauser
**Two Technologies, One Organization**

**PROFIBUS**
More than 40 million installed devices.
About 5.4 million in the process industry.

**PROFIBUS Nutzer Organisation (PNO)** is an
**Regional PI Association (RPA)**
and a permanent
**PI Support Center (PISC)**
(Karlsruhe, Germany):
administers global activities

**PROFINET**
4.3 million installed devices, end of 2012
49 PI Competence Centers (PICC) in 22 countries
27 Regional PI Associations (RPA) worldwide
11 PI Test laboratories (PITL) worldwide for certification
26 PI Training Center (PITC) worldwide
Technical Milestones

- **2010** First certified PA Profile 3.02 device
- **2008** Specification PROFIBUS PA Profile 3.02
- **2007** First PROFIBUS Coupler with embedded physical layer diagnostics
- **2005** I+M Function implemented for PROFIBUS PA
- **2004** PROFINET IO based on Real-Time & synchronized real-time
- **2002** PROFIBUS DP-V2 and PROFINET part of IEC 61158/IEC 61784; 10 profiles available
- **2001** Presentation of the Ethernet-based PROFINET (CBA)
- **2000** 100,000 PROFIBUS devices in process automation
- **1999** PROFIsafe – Profile for safety technology, PROFIdrive – Profile for variable-speed drives
- **1998** PROFIBUS PA – Profile for process automation
- **1996** PROFIBUS becomes European Standard EN 50170
- **1995** 1st application in process automation (PA)
- **1993** PROFIBUS DP becomes DIN 19245 (Part 3)
- **1991** PROFIBUS becomes DIN 19245 (Part 1 and 2)
PROFIBUS Product Spectrum

More than 5,000 products overall from more than 250 manufacturers
Development of Digital Communication

1965

Analog transmission of process value

4..20 mA

1987

Analog transmission of process value and parameters

4..20 mA with HART

HART-Modem

1991

Digital transmission of process value

PROFIBUS DPV0

A/D

D/A

D/A

DP

1965 4..20 mA 1987 4..20 mA with HART 1991 PROFIBUS DPV0
Development of Digital Communication

- **1997**: PROFIBUS DPV1 extension, PROFIBUS PA, Profile 2.0
  - Digital transmission of process value and parameters

- **2000**: Integration of fieldbus devices into Plant Asset Management
  - International Standardization, Profile 3.0X

- **2004...**: Integration of Industrial Ethernet into automation environment
  - PROFINET / PROFINET IO

Integration of fieldbus devices into Plant Asset Management.
What is a fieldbus?

The fundamental task of a fieldbus is to exchange information:
- In digital form
- With less wiring (unlike point-to-point connections)
- With a group of participants (hence “bus”)
- In a reliable way
- In real time
Communication layers (OSI model)

Layer 7
- PA Devices
- PROFIdrive
- Encoder
- etc.

Common application profiles
- PROFIsafe
- TimeStamp
- HART on PROFIBUS
- Redundancy

Layer 3-6
- Not in use

Layer 2
- PROFIBUS DP (DP -V0, -V1, -V2)

Layer 1
- Transmission technology
- (RS-485 / Fiber optics / MBP, MBP-IS)

Communication technology
- MBP = Manchester Bus Powered
Commissioning tool

Architecture PROFIBUS DP/PA

Process Automation System

Plant Asset Management System

Segment coupler

PROFIBUS PA

PROFIBUS DP
**Comparison PROFIBUS DP/PA**

<table>
<thead>
<tr>
<th>Application</th>
<th>PROFIBUS DP</th>
<th>PROFIBUS PA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protocol</td>
<td>Decentralized Peripheral</td>
<td>Process Automation</td>
</tr>
<tr>
<td>Common DP protocol:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• fast cyclic process data transmission</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• acyclic services to access device parameters</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• two defined master classes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physics</td>
<td>RS 485</td>
<td>MBP</td>
</tr>
<tr>
<td></td>
<td>9.6 ... 12000 kBit/s</td>
<td>31.25 kBit/s</td>
</tr>
</tbody>
</table>

MBP = Manchester encoding, Bus powered
PROFIBUS DP based on line topology
PROFIBUS DP based on line topology
PROFIBUS DP / Extension

Segment 1
31 Devices + 1 Rep

Segment 2
30 Devices + 2 Rep

Segment 3
30 Devices + 2 Rep
PROFIBUS DP

Process Automation System

Plant Asset Management System

PROFIBUS DP based on star topology
Facts: physical transmission via RS-485

- 2-wire cable, shielded
- 5V differential voltage signal
- Max. 1200 m line length per segment (depending on transmission rate)
- Max. 5 segments connected via repeater (depending on product type)
- Max. 126 addresses possible
- Max. 32 nodes per segment
- Alternatively fiber optic cable
- No reverse-connect protection
- A separate power supply is necessary for each device!
## PROFIBUS DP maximum line length

<table>
<thead>
<tr>
<th>Transmission Rate (kBit/s)</th>
<th>Max Segment Length (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.6</td>
<td>1200</td>
</tr>
<tr>
<td>19.2</td>
<td>1200</td>
</tr>
<tr>
<td>45.45</td>
<td>1200</td>
</tr>
<tr>
<td>93.75</td>
<td>1200</td>
</tr>
<tr>
<td>187.5</td>
<td>1000</td>
</tr>
<tr>
<td>500</td>
<td>400</td>
</tr>
<tr>
<td>1500</td>
<td>200</td>
</tr>
<tr>
<td>3000, 6000, 12000</td>
<td>100</td>
</tr>
</tbody>
</table>

The values refer to Cable Type A with the following properties:
- Impedance: 135...165 Ω
- Capacity: < 30 pf/m
- Loop resistance: 110 Ω/km
- Wire diameter: 0.64 mm
- Core cross-section: > 0.34 mm²
PROFIBUS PA

Process Automation System

Plant Asset Management System

PROFIBUS DP

Segment coupler
Facts: PROFIBUS PA

- Remote power supply and communication in 2-wire technology (optional intrinsically safe)
- Integrated reverse-connect protection possible (e.g. E+H)
- Fixed transmission rate of 31.25 kBit/s
- Up to 32 participants per segment (up to 10 for Ex-ia IIC applications)
- Line length up to 1900 m (Ex-ia IIC up to 1000 m)
Asynchronous format
- NRZ coding
- 1 Byte > 11 Bit
  (1 start + 8 Bit + 1 Stop + 1 Parity)
- Bitrate variable 9.6 Kbit/s to 12 Mbit/s

Synchronous format
- Manchester Coding
- 1 Byte = 8 Bit
- Fixed bitrate = 31.25 Kbit/s
SIEMENS DP/PA Link

IM 153-2
(IM 157 old version)

1..5 DP/PA Coupler(s)
Pepperl+Fuchs SK3 PROFIBUS Power Hub

- Coupling of PROFIBUS DP with PA

- PROFIBUS DP:
  - 45.45 kbps ... 12 Mbps
  - Automatic transmission rate detection
  - Cyclical data interchange over buffer
  - Transparent

- PROFIBUS PA:
  - Independent cycle
  - One bus master per segment, very fast
  - No configuration required
  - Advanced Diagnostics (More information in the chapter diagnostics)
Pepperl+Fuchs Compact PROFIBUS Power Hub

- Gateway for PROFIBUS DP/PA
  - 45.45 kbps ... 12 Mbps
- Transparent – Needs no configuration
- Two independent fieldbus segments
- Motherboard design
PROCENTEC Combricks

- 9.6 kbps .. 1.5 Mbps on PROFIBUS DP side
- Integrated PA termination in coupler mode
- 500 mA PA current
- Customizable PA voltage
- Max. 10 PA coupler modules
- Direct replacement for 3rd party couplers
**PROFIBUS PA – Profile 3.01**

### Market Requirements

- **Device Integration**
- **Fast Parameter Transmission**
- **Safety**
- **Device diagnostics**
- **Device identification**

### Solution

- **Version Handling**
- **Up/Download**

**PROFIsafe** for PA

- **Condensed Status**
- **I&M Functions**

**Separate document (Consistent with PROFIsafe)**

**Profile V3.01** (2004/5)

**Profile V3.02** (2008)

**Profile V3.0** (2000)

**Amendments**
Different Views of Diagnostics

Asset Management

Process Control

PLC Interface
- BAD
- UNCERTAIN
- GOOD

Status signals according to NE107

Failure
Maintenance request
Check
Out of Specification

Diagnostic Event
Condensed Status & Diagnostic Messages

Host Application,
 e.g. Process Control, Maintenance, Condition Monitoring

Maintenance Required  Failure  Functional Check  Out of Specification

PROFIBUS

Field Devices

Detailed Diagnostic Events
PROFIBUS PA – Profile 3.02

Market Requirements

- Device Integration
- Fast Parameter Transmission
- Safety
- Device diagnostics
- Device identification

Solution

- Version Handling
- Up/Download
- PROFIsafe for PA
- Condensed Status
- I&M Functions

Separate document (Consistent with PROFIsafe)

- Profile V3.02
  - 2008
- Profile V3.01
  - 2004/5
- Profile V3.0
  - 2000

Amendments

Standard field devices for process automation
Most important improvement by PA Profile 3.02

- Automatic Ident Number Adaptation (used by cyclic communication)
- Easy handling of device exchange during plant runtime
  - No GSD file exchange necessary
    - No plant shutdown because of required PLC download

Replacement device. New type, different Ident. number
PA Profile GSD vs. manufacturer-specific GSD

PA Profile 3.x devices are compatible with the:
Manufacturer-specific GSD and the PROFILE GSD!

- The device can either operate with the manufacturer specific GSD or with the PROFILE GSD.

- Using the PROFILE GSD, functionalities may remain unused!
No scaling necessary

**User benefits**

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**Conventional**

- 0bar
- 20mA

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**Fieldbus**

- 5bar
- 10011010110
- 0bar

Full resolution of process value over the entire physical measuring range e.g. Pressure membrane 0-5 bar
User benefits

- Higher precision of process value

**Conventional**

11.53mA (= 5.5 meter)

**Fieldbus**

5.532 meter
User benefits

- Multivariable devices

**Conventional**

One PV per outlet or cable e.g.
- Density

**Fieldbus**

Several PVs over the bus
- Density
- Temp.
- Flow
- Counter...
User benefits

- Parameterization of field devices via PROFIBUS from operator station

Conventional

Parameterization in the field on the device

Fieldbus

Parameterization from the control room
User benefits

- Diagnostic data
  - Bidirectional communication (device – PLC/DCS)
  - Predictive maintenance
  - Customized diagnostic
  - Devices offer substitute process value if device fails

- Failure
- Maintenance request
- Check
- Out of Specification

- Empty pipe detection
- Sensor drift
- Dirty pipe, please clean
- Maintenance needed
- ....
Cost savings: Maintenance Costs

- Plant and Life Cycle Management
Gen-X Project at DuPont, Dordrecht
Cost reductions and process optimization by digitalization
DuPont has committed to eliminate the use of a polymer processing aid in the Fluoropolymers production facilities before 2015. (Planned investment 9 million EURO)

To realize this, new facilities for chemical dosing, waste water - and air abatement should be installed. (3 separate projects fully operational before September 1, 2012)

Technology selection based on pilot tests. (Pilot project executed in 2009)

Automation technology selection to provide a fully automated plant with high availability.
Gen-X Project

- DuPont at Dordrecht, chemical industry.
- Full continuous operation 24/7/365.
- High availability technical installation.
- Siemens PCS7 process automation system.
- Endress+Hauser FieldCare Plant Asset Management system with Fieldgate SFG500 PROFIBUS intelligent access points.
  (>> PROFIBUS Device Health Status)
- PROCENTEC COMBricks modular repeaters.
  (>> PROFIBUS network diagnostics)
- Pepperl+Fuchs PROFIBUS DP/PA Gateway with advanced diagnostics.
  (>> PROFIBUS PA network diagnostics)
Gen-X Project

- PROFIBUS DP (80 slaves)
  - Siemens remote IO
  - Siemens variable speed drives
  - Festo valve islands
  - E+H plant access points (MC2)
  - PROCENTEC modular repeater

- PROFIBUS DP/PA
  - P+F DP/PA Gateway

- PROFIBUS PA (200 slaves)
  - E+H flow
  - E+H level
  - E+H pressure
  - E+H temperature
  - E+H analyse
  - Metso valve positioners
Plant Asset Management at Dordrecht
Applying Field Network Engineering and Plant asset management functions have made the project successful.

Marcel Middeldorp adds: “Far-reaching digitalization in particular has helped us reach the project targets. We have seen good results with the commissioning and start-up. The installation is robust and solid. **An unwanted malfunction can now be quickly and efficiently detected.** Much more information becomes available via the installed software than when using a conventional 4...20mA environment. Getting used to this new software takes some time and practice, but fortunately this was only minimal. In a relatively short time, we have fully commissioned our installation in Dordrecht and have started production.”

**Customer Benefits:**
- Remote maintenance
- Assurance of settings
- Easy troubleshooting
- Automatic Notification
- Online network monitoring
- Maintenance workflow optimization