Introduction to PROFIBUS and PROFINET

Andy Verwer
Technical Officer for PROFIBUS UK
Verwer Training & Consultancy Ltd

PROFIBUS Characteristics

⇒ PROFIBUS is a bi-directional digital communication network for field devices.
  ✓ Multi-drop network, many devices on one cable
  ✓ Communicates not only process values but also diagnostics, device parameters, calibration and performance data etc.

⇒ The data can represent analogue values and/or discrete (on/off) values.
  ✓ But all data is digitally encoded and transmitted.

⇒ PROFIBUS is extensively specified.
  ✓ All PROFIBUS devices are interoperable.
    • Multi vendor systems are easily constructed.
    • Best of breed devices can be selected.
    • Common set of tools for maintenance and engineering.
PROFIBUS

PROFIBUS is the world's leading fieldbus system:

- Over 40 million devices installed worldwide.
- Approximately 3,000 products from over 300 different suppliers.

PROFIBUS has been around for almost 25 years.

- Over that period the specification has been extended and refined (in a backwardly compatible way) so that new application areas have been opened up.
  - High speed synchronised servo applications (Robotics and NC machines).
  - Functional safety systems (process safety, interlocking).
  - Operation in hazardous environments (intrinsic safety).
  - High availability systems (reliability and redundancy).
  - Etc.

The PROFIBUS Family

PROFIBUS DP - Decentralised Periphery

- Low cost, simple, high speed field-level communications.
- Generally designed for internal use (cabinet mounting).
The PROFIBUS Family

PROFIBUS PA - Process Automation
- Developed specifically for the process industry to replace 4-20mA transmission.
- Two-wire connection carrying both power and data.
- Generally designed for external use (field mounting).

PROFINET
- Standardised Industrial Ethernet
- High speed highly deterministic and capable networking.
- Generally designed for internal use (just like DP)
Connection Technologies

- PROFIBUS DP uses 2-core RS485 screened twisted pair wiring.
  - 9-pin sub-D or M12 connectors extensively used.
- DP can also use plastic or glass fibre optic cabling.
  - BFOC (ST) connectors widely used
- PROFIBUS PA uses "Manchester Bus Powered" (MBP) cabling over 2 cores.
  - Glanded screw or M12 connection normally used
- PROFINET uses 4-core Ethernet screened twisted pair cabling.
  - RJ45 or M12 connectors universally used

Application areas

- Manufacturing Automation
  - Car manufacturing
  - Bottling systems
  - Storage systems
  - Robotics
- Building Automation
  - Traffic automation
  - Heating, air-conditioning
- Process Automation
  - Water and sewage treatment
  - Chemical and petrochemical plant
  - Paper and textile industries
- Power industry
  - Power plants
  - Switchgear
- Functional safety systems
- High reliability systems
- Redundancy
The PROFIBUS family

Factory/plant level
Demanding tasks, extensive data
Cell/control level
High speed, modest data
Field level

TCP/IP

Master
Slave

PROFIBUS DP
PROFIBUS PA
RS485

Remote I/O
Control valves
Transmitters
DP cells

Sensors
Actuators
Drives

TCP/IP

Other fieldbus networks

Exi

Ethernet
Levels of Access

Control
- Requires regular cyclic update of process values.
- Deterministic timing (not necessarily fast).
- The most important – cannot be interrupted!

Monitoring
- Not necessarily regularly updated (cyclic or acyclic).
- Interruptions can be tolerated.

Engineering
- Active only when required (acyclic).
- Non-deterministic communication OK.
- But must not interrupt the above!
**Class-1 Masters**

- The Class-1 master is responsible for cyclic or regular data exchange. This provides all process values for control and monitoring.
- The Class-1 master must be configured to communicate with the slaves.
- Configuration is normally carried out using a proprietary software tool supplied for the PROFIBUS master station.
- All PROFIBUS equipment suppliers provide standard General Station Description or *GSD files*.
- GSD files can be read by the configuration tool to provide detailed information on the devices being used on the bus.
- GSD files make integration of devices from different vendors in a bus system simple.

**Network Configuration**

Every PROFIBUS device is given a unique *identification number* which identifies the type of device. The GSD file is specific to the ID number.
Class-2 Masters

- Class-2 masters can be used to access management and engineering information from devices (acyclic data).
- This is particularly important in PA systems where extensive device information can be accessed in a standardised way.
- Class-2 masters do not need configuration, however, they do need information on the devices that are to be accessed.
- This information can be provided in two different ways:
  - Electronic Device Description (EDD) files.
  - Device Type Manager (DTM) software.

The PA Profile

- The PROFIBUS PA Profile provides a mandatory specification for all PA devices.
- It specifies the organisation of the cyclic data so that the process value for every device is standardised.
- The Process Value is always communicated in a standardised format:
  - Standard floating point format for analogue values.
  - Standard digital format for discrete values.
  - Plus a standardised status value which encodes the quality of the measurement (good, bad, usable etc.)
- The profile also specifies the organisation of the acyclic data so that standard tools can be used to access this data.
What is PROFINET?

PROFINET is an open Industrial Ethernet standard developed by the PROFIBUS Organisation.

- PROFIBUS
  - is completely standard Ethernet (IEEE802.3).
  - operates at 100Mbit/s over twisted-pair copper or fibre-optic cables,
  - makes use of TCP/IP and other IT standards for non-real-time communications (i.e. configuration and parameters).
  - Provides a "real-time" channel for time-critical communications (i.e. process data)

PROFINET is NOT PROFIBUS over Ethernet!

However, PROFINET is well thought out to incorporate the requirements of modern systems based on the lessons learned from PROFIBUS.

PROFINET IO

- PROFINET IO provides remote IO using Ethernet connection and the PROFINET communication protocol.
- PROFINET IO uses Real-Time and Non Real-Time communications.
- PROFINET makes use of relevant TCP/IP protocols for setup, configuration and maintenance functions:
  - DHCP – Dynamic Host Configuration Protocol,
  - DNS – Domain Name Service,
  - SNMP – Simple Network Management Protocol,
  - ARP – Address Resolution Protocol,
  - HTTP – Web page access, and lots more!
PROFINET stack (OSI model):

- 7 - Application Layer
- 6 - Presentation Layer
- 5 - Session Layer
- 4 - Transport Layer
- 3 - Network Layer
- 2 - Data Link Layer
- 1 - Physical layer

<table>
<thead>
<tr>
<th>Layer Type</th>
<th>OSI Layer</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non time-critical communication</td>
<td>7</td>
<td>Application Layer</td>
</tr>
<tr>
<td>Real-time communication</td>
<td>3</td>
<td>Network Layer</td>
</tr>
<tr>
<td>TCP/UDP</td>
<td>4</td>
<td>Transport Layer</td>
</tr>
<tr>
<td>IP</td>
<td>3</td>
<td>Network Layer</td>
</tr>
<tr>
<td>Standard Fast Ethernet, IEEE802.3</td>
<td>2</td>
<td>Data Link Layer</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Physical layer</td>
</tr>
</tbody>
</table>

**PROFINET IO**

- The TCP/IP channel is used for non-time critical tasks:
  - Downloading of configuration, parameters,
  - Diagnostics,
  - Device management information, etc.
- The Real-Time channel is used for time-critical data:
  - Cyclic process data,
  - Alarms and critical messages,
  - Communication monitoring.
PROFINET IO

⇒ Many features that have been developed for PROFIBUS devices have been directly incorporated into PROFINET:
  ⇒ Standardised module and channel-related diagnostics,
  ⇒ Alarm and status information,
  ⇒ Identification and Maintenance (I&M) functions,
  ⇒ Time stamping,
  ⇒ Highly deterministic process cycle timing (Isochronous),
  ⇒ Device description file (GSD) with configuration data for the device and available modules – PROFINET uses XML.

Integration with Fieldbus

⇒ PROFIBUS devices are widely used in many different application areas.
⇒ This investment is protected with PROFINET for both manufacturers and end-users.
⇒ PROFINET provides a transparent interface with PROFIBUS via a standardised gateway or “Proxy”.
⇒ The Proxy is a PROFINET IO device on one side and a PROFIBUS master on the other.
⇒ PROFIBUS Configuration is integrated into the PROFINET configurator and is downloaded via Ethernet.
**Some Myths about PROFINET**

- PROFIBUS runs at up to 12 Mbit/s, whereas PROFINET runs at 100 Mbit/s. Therefore PROFINET is about 8 times faster than PROFIBUS.

  **NOT TRUE!**

  ✴️ PROFINET gives similar performance to PROFIBUS.

- PROFINET will replace PROFIBUS in the next five years.

  **NOT TRUE!**

  ✴️ PROFINET will replace some PROFIBUS DP devices, but PROFIBUS PA will continue.

  ✴️ Both DP and PA will be supported for many years to come.
**Some Myths about PROFINET**

- **PROFINET is not standard Ethernet**  
  **NOT TRUE!**  
  ✓ PROFINET always uses completely standard Ethernet. It just doesn’t always use TCP/IP protocols – only used for non time critical communications.

- **PROFINET systems can be maintained by our IT people.**  
  **TRUE, BUT NOT A GOOD IDEA!**  
  ✓ PROFINET is much more than just an IT network. Real time determinism, reliability, device diagnostics and security are all much more important than on IT systems.

---

**Functional Safety with PROFIBUS & PROFINET**

- **PROFIBUS and PROFINET also offer safety oriented communication that allows for integrating safety oriented components.**

- **A second 'safety fieldbus' is not necessary.**

- **ProfiSafe V2 can be used in systems that are certified according to IEC61158 to Safety Integrity Level 3 (SIL3).**

- **ProfiSafe is used in a wide range of applications:**  
  ✓ Factory Automation, Robotics, Materials storage.  
  ✓ Process Automation, Gas & Oil
**Functional Safety with PROFINET**

- PROFIsafe V2 provides functional safety for both PROFIBUS and PROFINET systems.
- Suitable for use in SIL3 applications.

**Benefits of PROFIBUS/PROFINET**

- Totally standardised and interoperable.
  - Choose best of breed devices.
  - Ensures compatibility.
  - Protects your investment.

- Flexible connection technologies.
  - Systems for internal or external use
  - Saves wiring – but things often go wrong!
  - Training in design and installation is essential.

- Levels of access.
  - Control & monitoring.
  - Engineering and management information.
Training

- A wide range of PROFIBUS and PROFINET training is available including:
  - Certified Installer Courses
    - basic courses for anyone involved in PROFIBUS or PROFINET technology
  - Commissioning & Maintenance training
    - Practical troubleshooting for PROFIBUS & PROFINET.
  - Certified PROFIBUS or PROFINET Engineer
    - In depth training for experts.
  - Certified System Design Course
    - Covers essential and optimal design of all networked control and automation systems

Certified PROFIBUS and PROFINET training is available from the UK’s accredited training centres:

- PROFIBUS International Competence Centre
- Manchester Metropolitan University.
  - in Manchester, or a location of your choice.
  - (www.sci-eng.mmu.ac.uk/ascent/).

- PROFIBUS International Training Centre
- Verwer Training & Consultancy Ltd
  - On-site training.
  - (www.VerwerTraining.com)