Most people understand that:

- The PROFIBUS PA protocol is exactly the same as PROFIBUS DP. I.e. the structure and content of the telegrams are the same.
- But the PA physical layer uses Manchester Bus Powered (MBP) wiring instead of the RS485 wiring used in DP.
- However, this is not totally correct!
  - PA devices can have an RS485 interface.
  - The real difference between DP and PA is that PA devices must adhere to the “PROFIBUS PA profile”.
- The PA profile defines how the device data is organised and accessed and defines which functions and parameters must be provided on PA devices.
PROFIBUS PA Device Calibration and Maintenance, Andy Verwer, page 3
MTC, Coventry, 25 February 2016

- PA was designed to replace 4-20mA technology.
- With 4-20mA each device needs a separate cable and input/output on the controller.
- The IO card on the controller contains an Analogue to Digital Converter (ADC).

![Diagram of 4-20mA transmission](image)

PROFIBUS PA Device Calibration and Maintenance, Andy Verwer, page 4
MTC, Coventry, 25 February 2016

**4-20mA calibration**

Example:
- Temperature transmitter span = 0 to 250°C
- Transmitted current = 10mA, what is the temperature?

\[
\text{Fraction of range} = \frac{10 - 4}{20 - 4} = \frac{6}{16} = 0.375
\]

Therefore temperature:
\[
= 0°C + 0.375 \times 250°C = 93.75°C
\]
4-20mA devices always connect to a 4-20mA input on a remote IO unit or controller IO card.

- Communication is analogue.
- Scaling is done in the controller (PLC).
- The controller only sees the value as a 12 or 16 bit integer value (range 0 to 4095, or 0 to 65535).

PROFIBUS PA is quite different.

- The Devices all communicate digitally.
- The scaling is done in the device (i.e. the instrument).
- Transmitted process values are sent as floating point numbers, scaled and calibrated in engineering units (e.g. °C, mBar, litres/minute, m³ etc.)

The PROFIBUS PA Profile provides a mandatory specification for all PA devices.

- Defines the device functions, data organisation and formatting.
- 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 mandatory device parameters so that standardised tools can be used to access this data with any manufacturer’s devices.
The process values of PA devices are transmitted as:
- 32-bit floating-point values (analogue devices), or
- discrete bits or bytes (switching devices).
Together with a “status byte” containing information about the “quality” of the process value.

Typical analogue instrument or actuator value:

<table>
<thead>
<tr>
<th>Byte 1</th>
<th>Byte 2</th>
<th>Byte 3</th>
<th>Byte 4</th>
<th>Byte 5</th>
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</table>

Floating point number representing the process value in “engineering units”

Status byte representing the quality of the value

Status byte interpretation

- The status byte consists of eight bits representing signal quality.
- The most significant bit is used to indicate the overall quality of the associated value:

0 xen| XX XX XX XX = Bad (|80x128)|

1 xen| XX XX XX XX = Good (|80x128)|

- The remaining bits in the status byte give further information on the device status.
The PA profile structures a device into “Blocks”:

- A Physical Block, PB
  - Contains the parameters and functions of the device hardware and installation etc.
- One or more Transducer Blocks, TB
  - Describes the interface to the process, i.e. the sensor or actuator characteristics.
- One or more Function Blocks, FB
  - Contains common signal manipulation and automation functions.
- Each device also incorporates a Resource or Device Manager.
  - Describes which blocks are available in the device and a look-up table for the device parameters.
The blocks can execute functions that manipulate the process value or device state.

Each TB/FB pair is responsible for a process value, which can be a measurement from an instrument or an actuator value to a valve or positioner.

Each process value is exchanged with the controlling Class-1 master using normal cyclic data exchange.

The parameters of the blocks can be read from or written to the device using acyclic functions.

These are normally accessed by a Class-2 master (Engineering Tool), or alternatively by the controlling Class-1 master.

PA device model

- Pressure Transmitter
- Sensor signal
- Measured value
- Transmitter block model
  - Physical block
  - Parameters
  - Transducer block (Pressure)
    - Parameters
  - Function block (Analogue Input)
    - Parameters
- Process Value transmitted cyclically to Class-1 master
- Parameters read and written acyclically by Class-2 master
Transducer blocks reflect the measurement or actuation that is taking place.

Transducer blocks are available for a wide range of instruments and actuators:
- Temperature – RTD, thermocouple etc.
- Pressure/differential pressure etc.
- Level – hydrostatic, displacement, microwave, capacitance etc.
- Flow – head meters, electromagnetic, Coriolis etc.
Function blocks contain common signal conditioning and automation functions.

There are currently three function blocks for inputs and two for outputs defined in the PA profile:

- Analogue input, Analogue output,
- Discrete input, Discrete output,
- Totaliser (for use with flow measurement),

The analogue input block is the most common block, being used for all analogue instruments. It provides for each measurement:

- Linearisation, filtering, alarms, fail-safe action, simulation facilities and auto/manual mode control.
The functions and addressing to access parameters is defined in the PA profile.

Specialist PA engineering tools are available that can interact with devices without requiring explicit addresses.

PA engineering tools come in two types:

- EDD tools (such as Siemens PDM)
- FDT tools (such as E+H FieldCare, P+F PactWare etc.)

(EDD = Electronic Device Description, FDT = Field Device Tool)
PA engineering tools

- Siemens supply an extensive package for Process Automation.
- Process Device Manager, PDM, provides a universal, manufacturer-independent tool for configuration, parameter assignment, commissioning, diagnostics and maintenance of intelligent field devices and components.
- PDM is based on EDD technology.

Specialist Calibration tools

- Specialist calibration tools are available from several manufacturers.
- Beamex, for example, offer specialist calibration tools with capabilities for pressure, temperature and various electrical signals.
- The Beamex MC6 incorporates a communicator for PROFIBUS PA instruments (Based on EDD technology)
FDT/DTM tools

- FDT is an open technology that is defined by international standards and supported by several manufacturers (E+H FieldCare, P+F PactWare etc.)
- The FTD tools use Device Type Managers (DTMs) to establish the required communications and to access parameters in the different devices.
- Two different types of DTM are available:
  - Communications DTMs (CommDTMs) – establish a communication route to the devices.
  - Device DTMs – to access data within a particular type of device.

- The FDT provides a standardised framework in which the required DTMs can be loaded and run.
- The device DTMs operate underneath the CommDTM in order to provide a route to the devices.
ProfiTrace is a widely-used fault-finding and commissioning tool for PROFIBUS DP and PA.

COMbricks is a widely-used modular PROFIBUS network monitoring solution, which incorporates a built-in ProfiTrace analyser available over Ethernet.

These products both support a CommDTM that allows them to be used in any FDT environment.