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PROFIBUS PA Device Calibration and Maintenance

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What is PROFIBUS PA?

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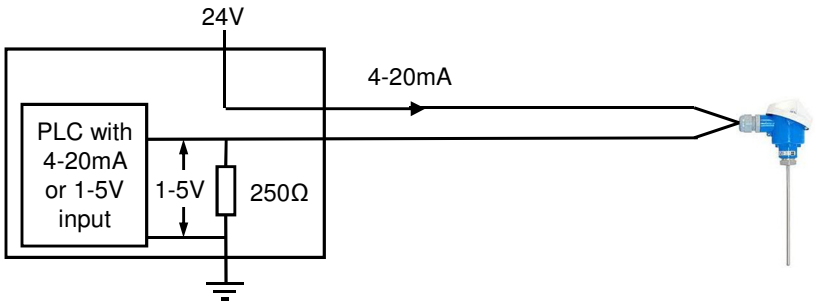
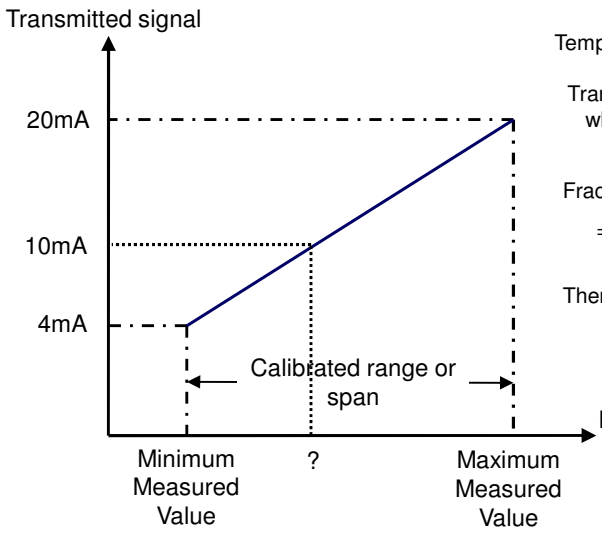
- Most people understand that:
  - The PROFIBUS PA protocol is exactly the same as PROFIBUS DP. I.e. the structure and content of the telegrams are the same.
  - But the PA physical layer uses Manchester Bus Powered (MBP) wiring instead of the RS485 wiring used in DP.
- However, this is not totally correct!
  - 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.

4-20mA transmission

- ⇨ 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).



4-20mA calibration



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

Fraction of range

$$= \frac{(10-4)}{(20-4)} = \frac{6}{16} = 0.375$$

Therefore temperature

$$= 0℃ + 0.375 \times 250℃$$
$$= 93.75℃$$

PROFIBUS PA

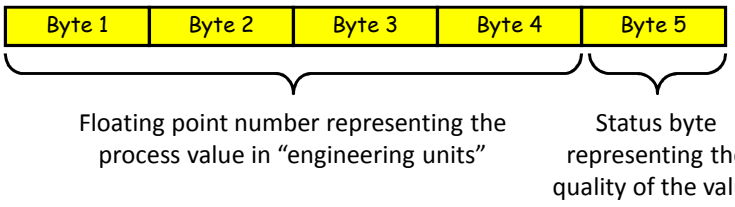
- 4-20mA devices always connect to a 4-20mA input on a remote IO unit or controller IO card.
  - Communication is analogue.
  - Scaling is done in the controller (PLC).
  - The controller only sees the value as a 12 or 16 bit integer value (range 0 to 4095, or 0 to 65535).
- PROFIBUS PA is quite different.
  - 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, m^3 etc.)

The PA Profile

- 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.

Data representation

- 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:



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	X	X	X	X	X	X	X

= Bad ($<80_{hex}$, 128_{10})

1	X	X	X	X	X	X	X

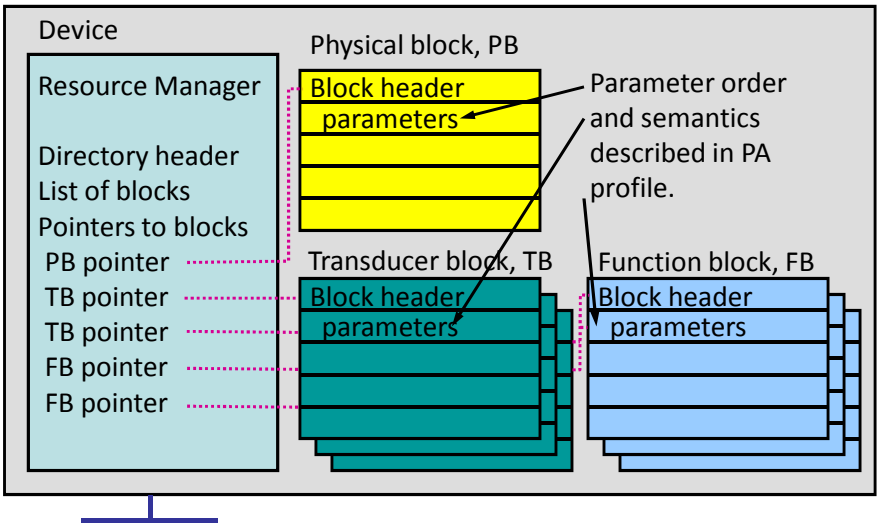
= Good ($\geq 80_{hex}$, 128_{10})

- The remaining bits in the status byte give further information on the device status.

PA device model

- 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.

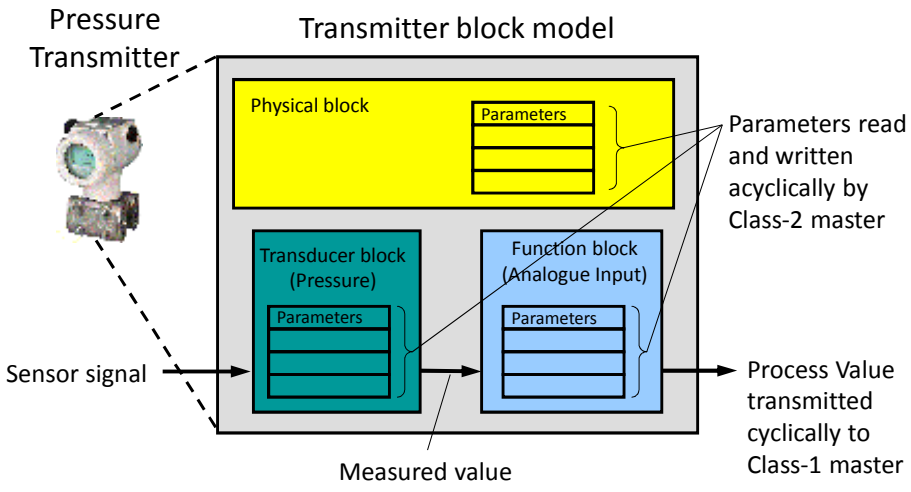
PA device model



Data access

- 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.

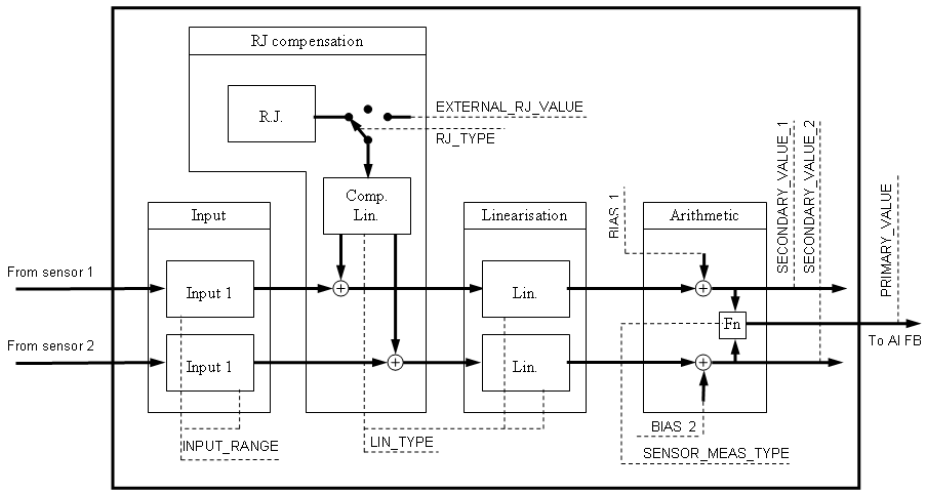
PA device model



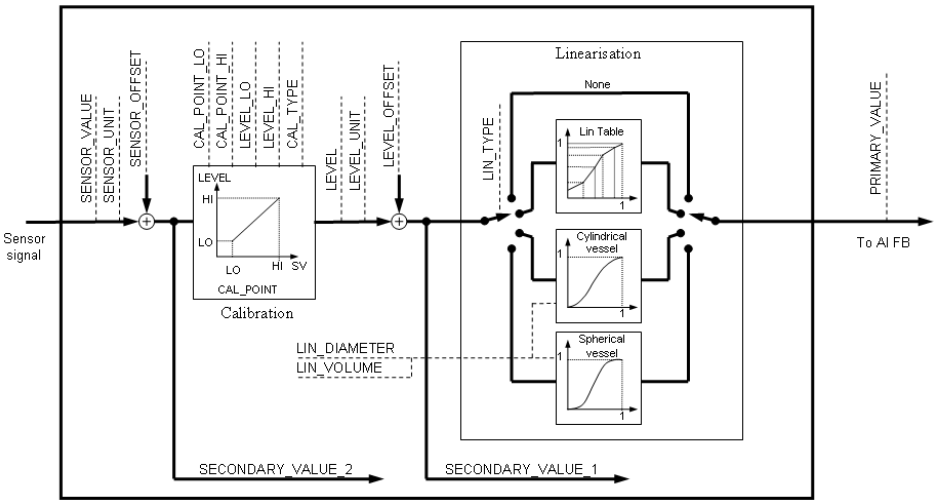
Transducer blocks

- 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.

Temperature transducer block



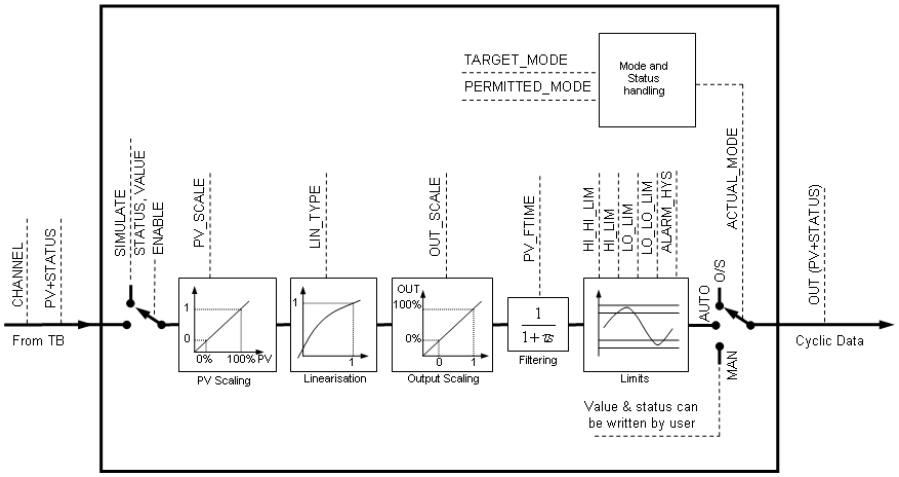
Level transducer block



Function blocks

- 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.

Analogue input function block



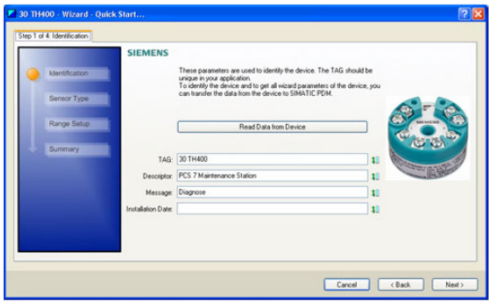
PA engineering tools

- 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

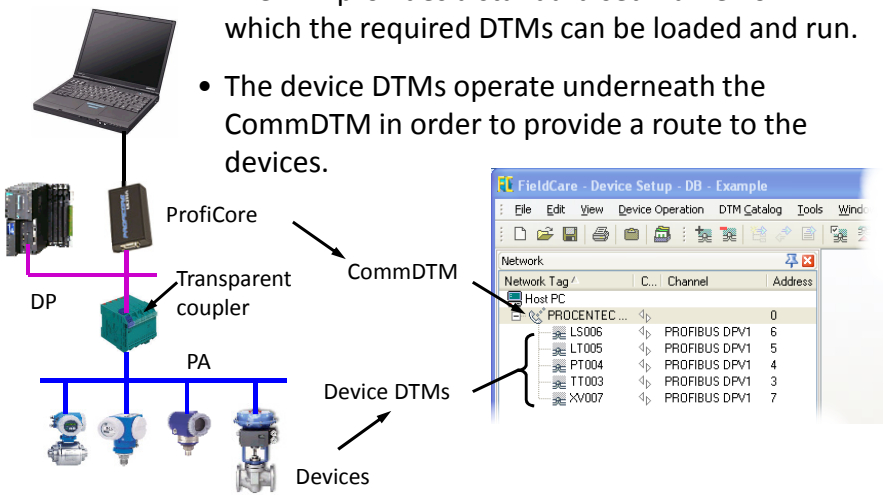
- Specialist calibration tools are available from several manufacturers.
- Beamex, for example, offer specialist calibration tools with capabilities for pressure, temperature and various electrical signals.
- The Beamex MC6 incorporates a communicator for PROFIBUS PA instruments (Based on EDD technology)

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.

FDT/DTM

- 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.



FDT/DTM tools

- 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.