ProfiBus overview

1. Introduction

ProfiBus (PROcess FIeld BUS) is a widely accepted international networking standard, commonly found in process control and in large assembly and material handling machines. It supports single-cable wiring of multi-input sensor blocks, pneumatic valves, complex intelligent devices, smaller sub-networks (such as AS-i), and operator interfaces. It is an open, vendor independent standard. It adheres to the OSI model and ensures that devices from a variety of different vendors can communicate together easily and effectively. It has been standardized as DIN 19 245 Parts 1 and 2 and, in addition, has also been ratified under the European National standard EN 50170 Volume 2.

The bus interfacing hardware is implemented on ASIC (application specific integrated circuit) chips produced by multiple vendors, and is based on the RS 485 standard as well as the European EN50170 electrical specification. The standard is supported by the ProfiBus Trade Organization.

2. Devices

ProfiBus supports two main types of devices, namely, masters and slaves.

- Master devices control the bus and when they have the right to access the bus, they may transfer messages without any remote request. These are referred to as active stations.
- Slave devices are typically peripheral devices i.e. transmitters/sensors and actuators. They may only acknowledge received messages or, at the request of a master, transmit messages to that master. These are also referred to as passive stations.

3. Profibus standards and communication levels

There are several versions of the standard (fig.1), namely, ProfiBus DP (master /slave), ProfiBus FMS (multi-master/peer-to-peer), and ProfiBus PA (intrinsically safe).

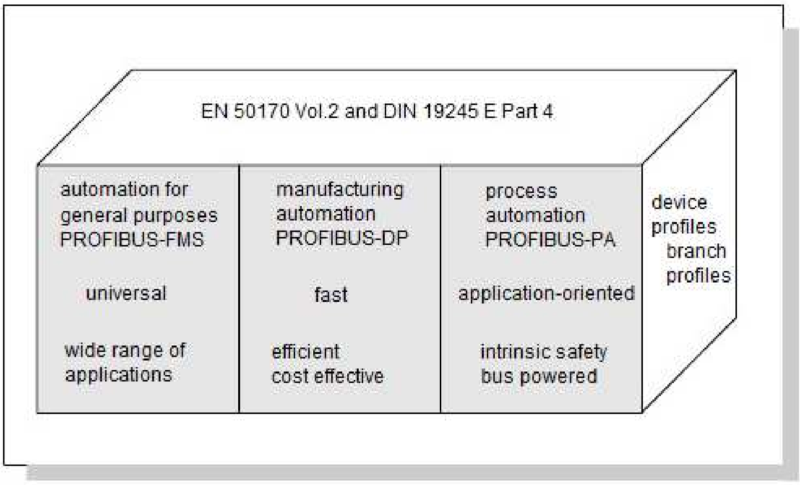
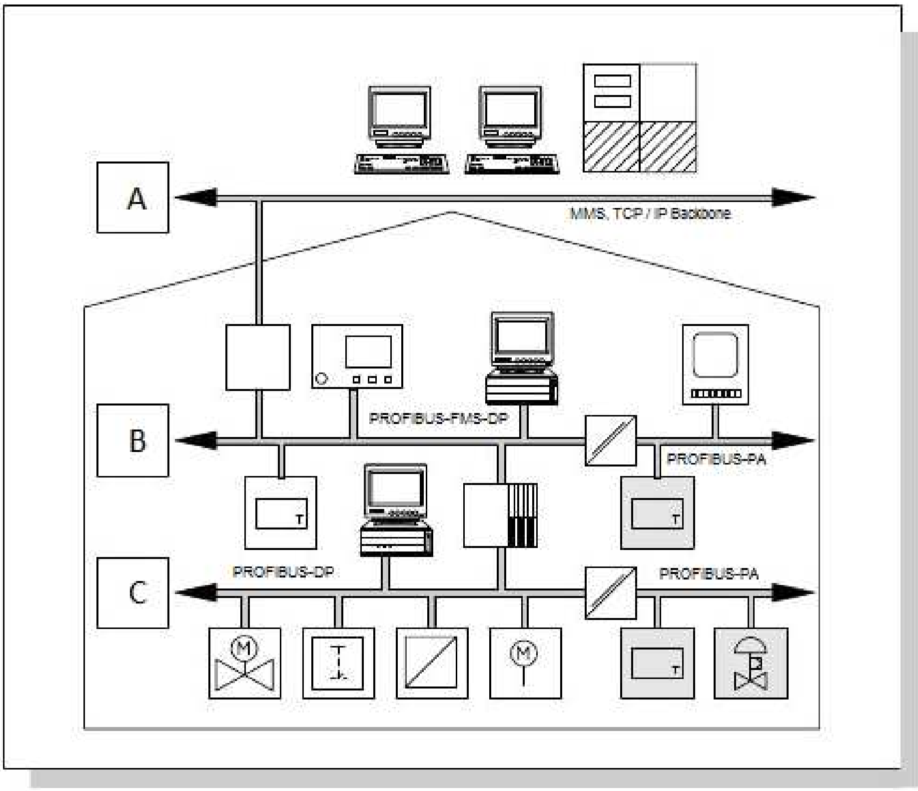


Fig.1 Overview of PROFIBUS versions

The levels of communication in automation technology are shown in fig. 2. High-performance process control level PC, using standard software and network can realize the process of diagnosis, process monitoring, control and whole plant information management.

Display and operation with a standard window can display the picture of the production chain and charts. Calling all operating parameters and equipment parameters to modify and adjust, archive copies of all data at any time, the system is completely open. Automation level are used with a single processor or multiple processor CPU, automation level and the process control level of communication. At field level distributed devices such as I/O modules, transducers, drive units, analysis devices, valves or operator terminals, communicate with automation systems over a powerful, real-time communication system.



A: Control level
B: Automation level
C: Field level

Fig. 2. Communication in automation technology

4. Profibus layers

PROFIBUS protocol architecture follows the ISO / OSI (open system interconnection) reference model, in line with international standard ISO 7498.

In this model each layer takes on precisely defined tasks. Layer 1 (physical layer) defines the physical transmission technology. Layer 2 (data link layer) defines the bus access procedure. Layer 7 (application layer) defines the user level.

4.1 PROFIBUS layer 1 (physical layer)

A fieldbus system's field of use is essentially determined by the choice of transmission medium and the physical bus interface. Apart from the requirements of transmission security, expenditure on purchasing and installing the bus cable is crucially important. The PROFIBUS standard therefore provides for various forms of transmission technology, while retaining a uniform bus protocol.

Cable-bound transmission: this version complies with US standard RS-485 and was defined as the basic version for applications in the field of production engineering, building control technology and drive technology. It uses screened, twisted copper cable with a pair of conductors.

Fibre-optic cable: for applications in very interference-prone environments, and to extend working range at high transmission speeds, the PNO has worked out a specification for fibre-optic based transmission technology.

Intrinsically safe transmission: PROFIBUS-PA enables the intrinsically safe transmission and supply of stations across the bus. The transmission technology is described in international standard IEC 1158-2.

4.2 PROFIBUS layer 2 (data link layer)

The PROFIBUS bus access method therefore includes a **token-passing procedure** for communication between complex stations (masters) and an underlying **master-slave procedure** for the communication of complex stations with low-expense peripheral devices (slaves). This combined procedure is called a **hybrid bus access procedure.**

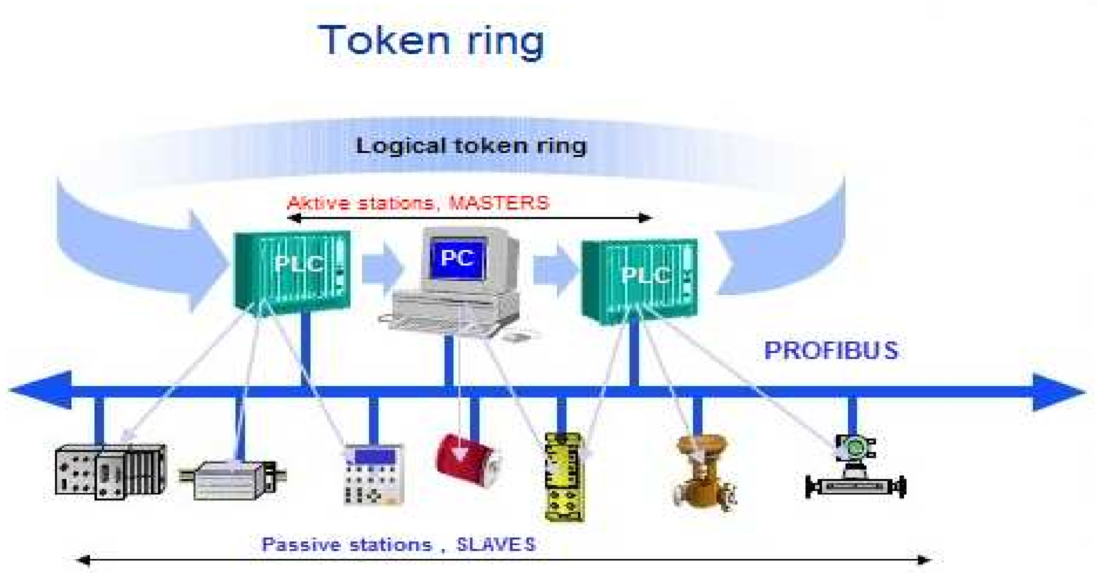


Fig. 3. Hybrid bus access method

PROFIBUS gives a deterministic network. This means that each station is guaranteed the access to the bus within a fixed time. This determinisme is taken care of by a token ring system – administrated from the data link level (fig.3). The token passes between the masters . The station that holds the token can control the bus. The master communicates with all its slaves during the period it has the token. The master either sends data to the slave or asks the slave for data. A slave can never send any data other than when it gets a request from its master.

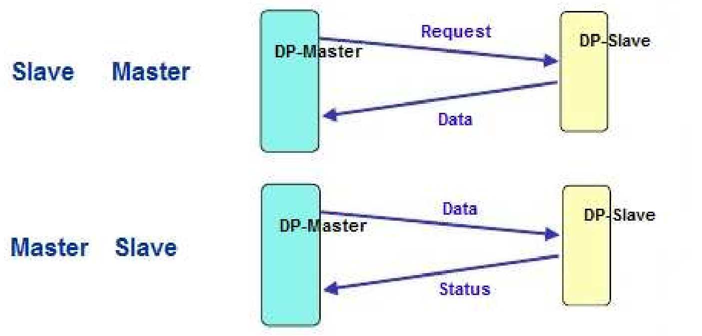


Fig. 4. Exchange of data

Fig. 4 shows the principle of data exchange between master and slave. The master gets the data telegram from a slave after having sent a request telegram. When the master sends a data telegram to the slave, the slave must respond with a status telegram.

4.3 PROFIBUS layer 7 (application layer)

Layer 7 of the OSI model provides the application services to the user. These services make an efficient and open data transfer possible between the application programs and layer 2. The PROFIBUS application layer is specified in DIN 19 245 part 2 and consists of:

- The Fieldbus message specification (FMS)
- The lower layer interface (LLI)
- The Fieldbus management services – layer 7 (FMA 7)

5. PROFIBUS Wiring

PROFIBUS DP/FMS wiring can be done with:

- twisted shielded pair copper cable;
- fiber optic components;
- infrared components.

5.1 PROFIBUS-cable

The PROFIBUS-cable must have special characteristics conserning surge impedance, cable capacitance, core cross section, loop resistance and signal attenuation.

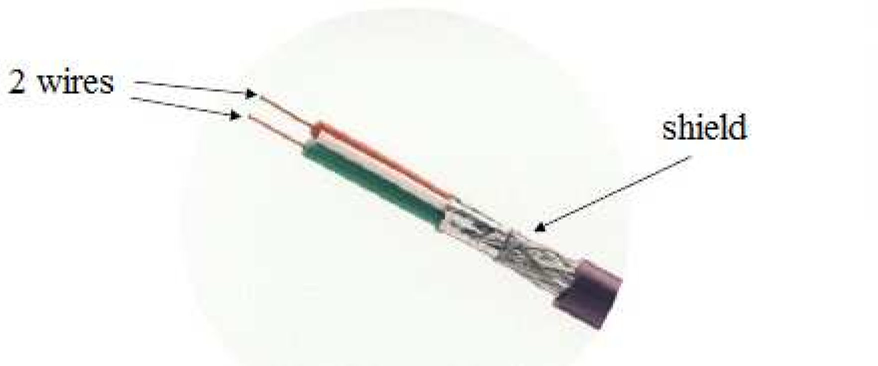


Fig. 5. Bus cable

It must be a twisted pair type cable (fig.5) with shield (braided and/or foil). A standard PROFIBUS cable has one green and one red wire. Red shall be connected to + or A and green to – or B at the PROFIBUS stations .

One preferred connector type -9 pin Sub-D:

- connectors with integrated termination available;
- for use of higherbaudrates,inductivitybuilt in;
- easy plug and unplug without interrupting the;
- communication to other devices;
- other connector types are possible; mandatory signals (A,B, GND, 5V) must be provided as well as a possibility for termination.

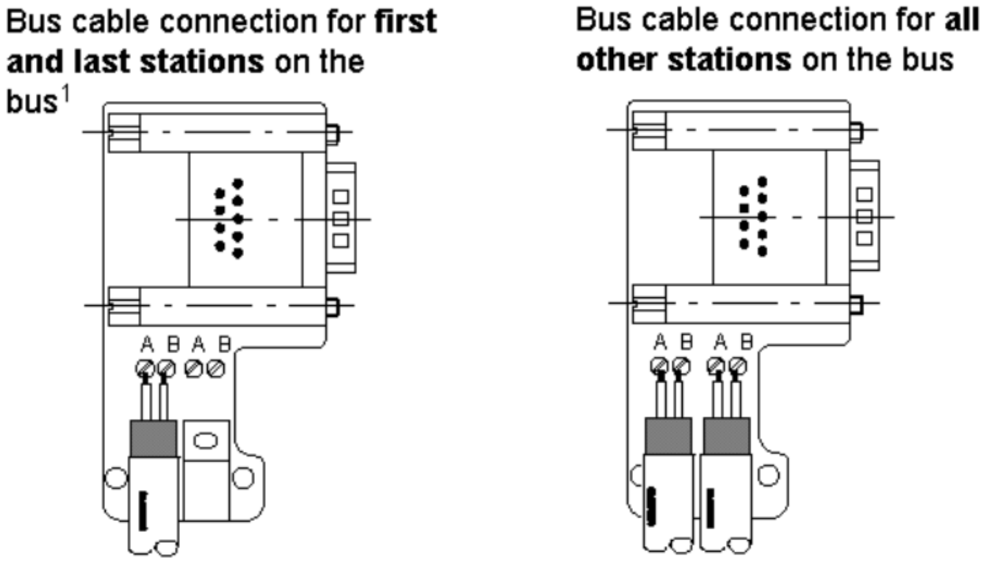


Fig. 6. 9 pin sub D

Termination (RS485 feature):

- each segment needs to be terminated at both ends;
- termination needs to be powered at all time;
- if possible use one termination at the master;
- power for termination or the termination itself needs to be provided by the device.

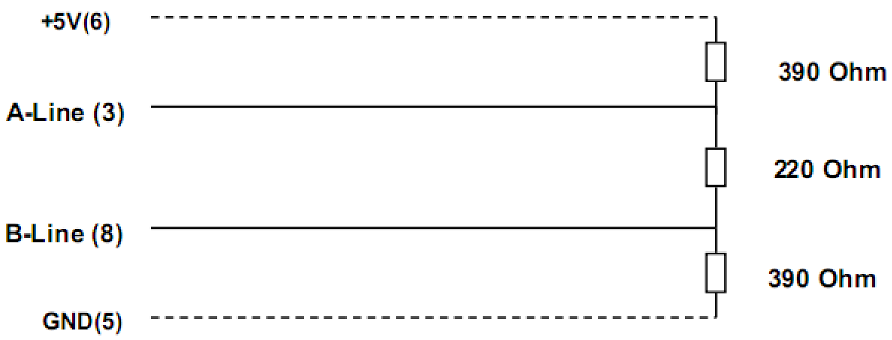


Fig. 7. Bus termination

Segment structure with termination is shown in fig. 8.

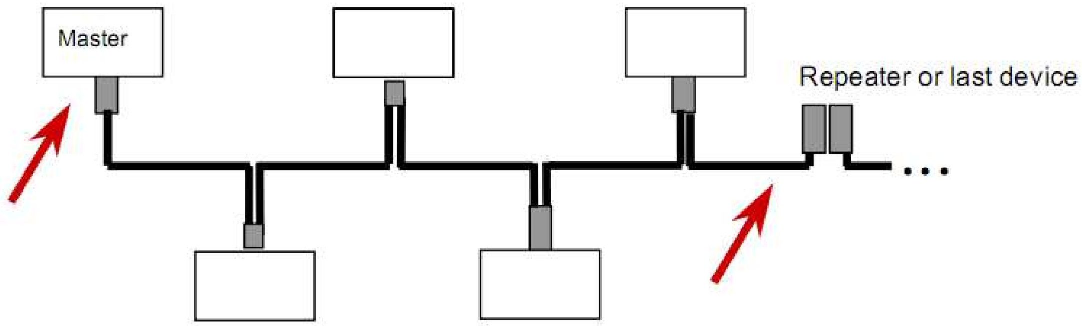


Fig. 8. Structure with termination

Termination "on" (usually whenever only one cable is connected to a device the termination needs to be "on").

Segments are needed for exceeding the length and exceeding 32 devices (incl. Repeater/OLM). They can be used for building branch segments and connecting up to 126 stations (noaddr. for Repeater/ OLM).

The rules are:

- segment has a max. of 32 devices (incl. Repeater/OLM);
- the first and the last segment can have 31 stations;
- segments between have 30 stations as a maximum.

Each PROFIBUS station is given a unique address which should be a number between 0 and 126. This means that it can never be more than 127 stations in a network. If the cables are long or the number of stations exceeds 32, it is a need for repeaters. Each segment has to be terminated in each end – see fig. 9.

In RS 485, the network needs a repair for every 32 stations. A repeater is also needed if the cable distance is long (100m at 12 Mbit/s, 1200 at 9.6 kBit.s). The total length of the network can not exceed 10 km.

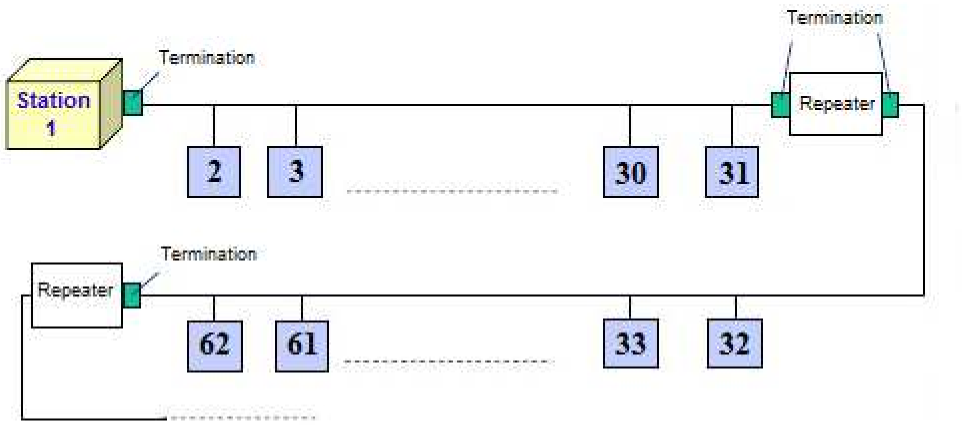


Fig. 9. Stations and repeaters

5.2 Fiber optic components

Plastic and glass fiber optic and optical plugs and modules are available.

The features of fiber optic are:

- noise immune;

- potential difference independent;
- longer distances (up to 20 miles);
- redundant operating is possible;
- line, ring and star configuration.

5.3 Infrared components

Wireless linking of devices in close-up ranges, realized communication with moving and changing devices. It is noise immune and ground independent.

6. PROFIBUS communication protocols

The PROFIBUS Protocol is in Accordance with the ISO/OSI Reference Model for Open Systems. The principles for the FMS, DP and PA protocols are shown in fig. 10. FMS and DP use the same transmission technology. The physical layer for these two protocols follow the standard EN 50 170. The PA standard for this layer is IEC 61158-2. The next layer, the link layer, is equally described in all three protocols. At user level, DP and PA are equal and FMS is different.

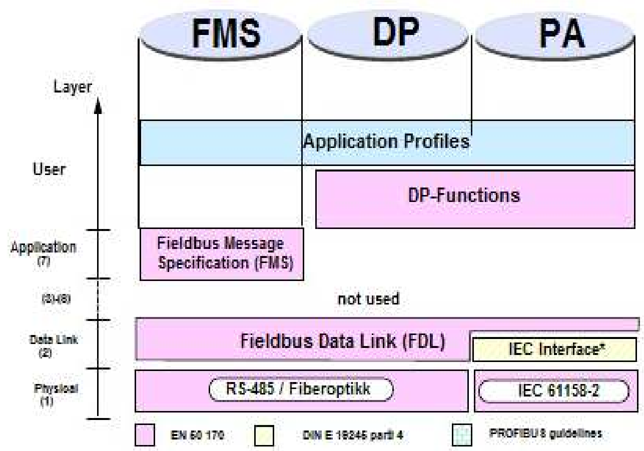


Fig. 10. The PROFIBUS protocols

PROFIBUS DP uses high and low voltage to represent each bit . When nothing is transmitted, the voltage is high. The 8 bits of data are packed in packages of 11 bits (fig. 11).

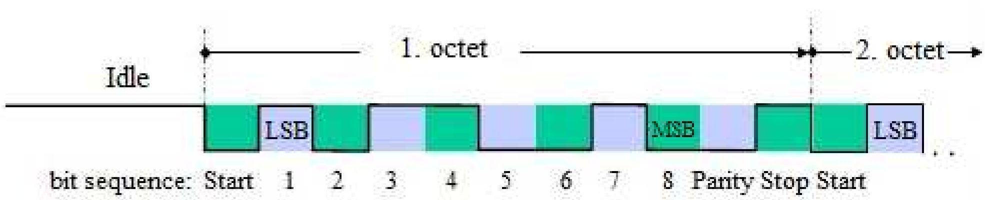


Fig. 11. Data packages

The first bit is a low start bit, then comes the 8 data bits. The last bit is a high stop bit. After the data bits and before the stop bit, the package has a **parity** bit. This bit is set to 1 (high) or 0 (low) depending on the number of ones in the data word – and so that there always are an odd number of ones among the 11 bits of the package. The station that receives the package can then check for the number of ones and in that way check if errors have occured during transmission. So – already in the physical layer – there is an overhead of 3 bits for every 8 databits. The 11 bits that carries one byte (8 bits) are called an OCTET

The physical code used in DP and FMS, is called NRZ : Non Return to Zero

Fig. 12 shows how the data is modulated on top of the 10 mA current – giving a signal that changes between about 19 mA and 1 mA. Notice the bit representation which is called **Manchester Code.** In this code it is always a shift for each data bit (this differs from the NRZ code used in DP).

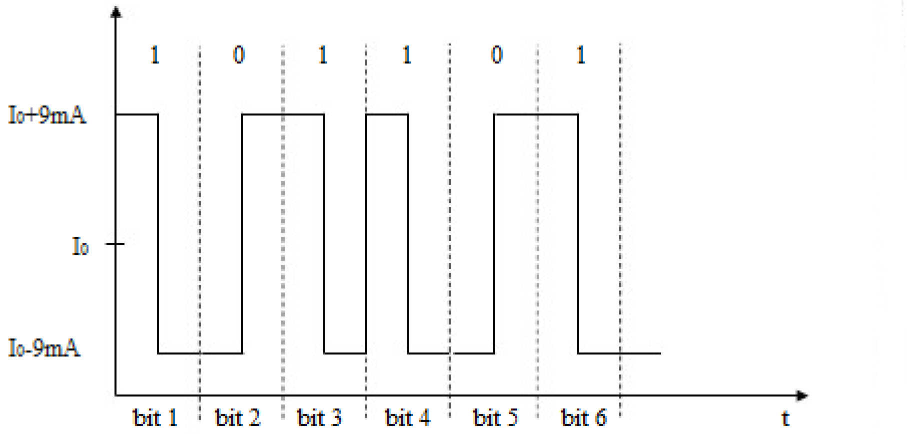


Fig. 12. Data representation IEC – 6 1158 – 2

A shift from high to low means 1 and a shift from low to high means 0. In the fig. 13 each little box is one OCTET – except for the DU, the Data Unit, which can be one or more octets depending on the length of data.

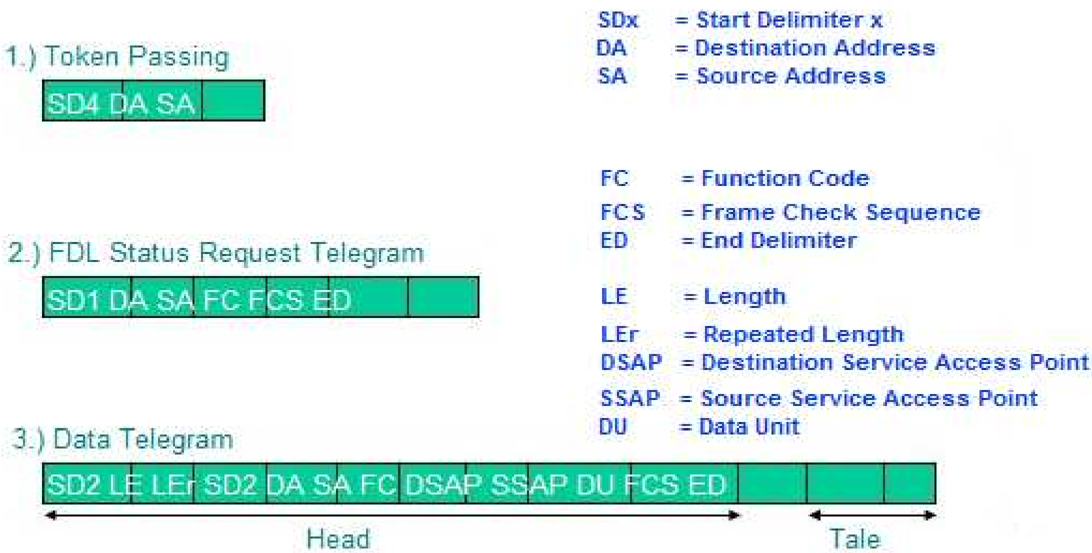


Fig. 13. The 3 most common PROFIBUS

The Token Passing telegram is three octets = 33 bits.
The FDL Status Request telegram is 6 octets = 66 bits.
The Data Telegram has a head of 9 octets = 99 bits and a tale of 2 octets = 22 bits.

6.1 ProfiBus DP

ProfiBus DP (distributed peripheral) allows the use of multiple master devices, in which case each slave device is assigned to one master. This means that multiple masters can read inputs from the device but only one master can write outputs to that device. The objective of PROFIBUS DP is fast and effective communication on the field level. It uses RS 486 (voltage levels 0 and 5 V) or Fiber Optics. The baudrate can be chosen from 9.6 kBit/s to 12 Mbit/s.

The communication is built on the master/slave principle, with tipically a PLC or a PC as a master and several stations as slaves: Digital I/O, Analogue I/O, AC or DC drives, Magnetic or pneumatic valves, panels, etc. (fig. 14). The data exchange for ProfiBus DP is generally cyclic in nature. The central controller, which acts as the master, reads the input data from the slave and sends the output data back to the slave. The cycle time will also depend on the amount of data to be transmitted. The bus cycle time is much shorter than the program cycle time of the controller (less than 10 mS).

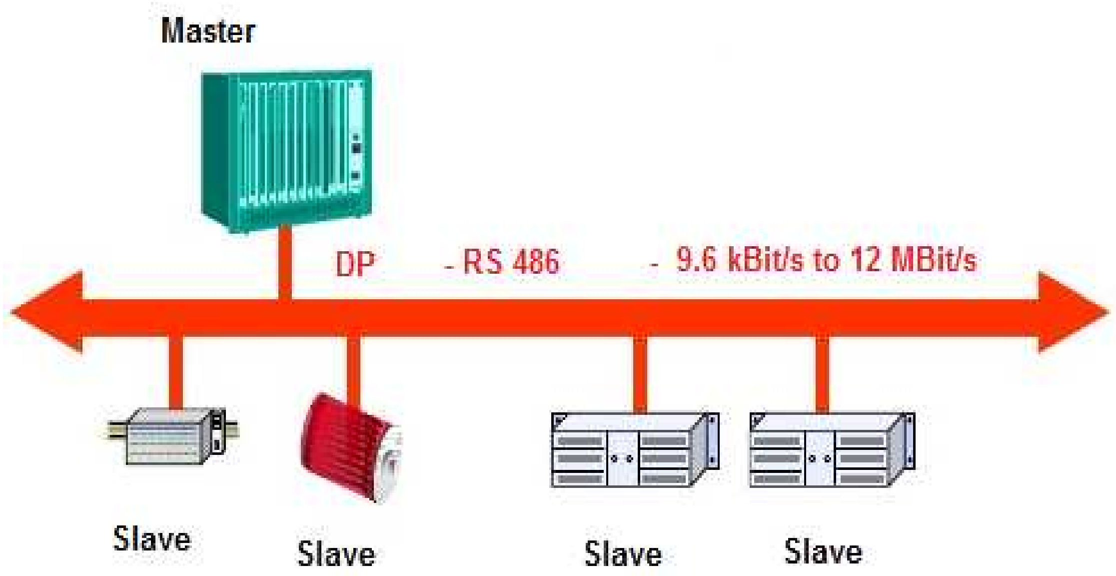


Fig. 14. Profibus DP

In some installations it is important to decide an exact cycle time. The cycle time depends on the baudrate and the number of slaves, see fig.15.

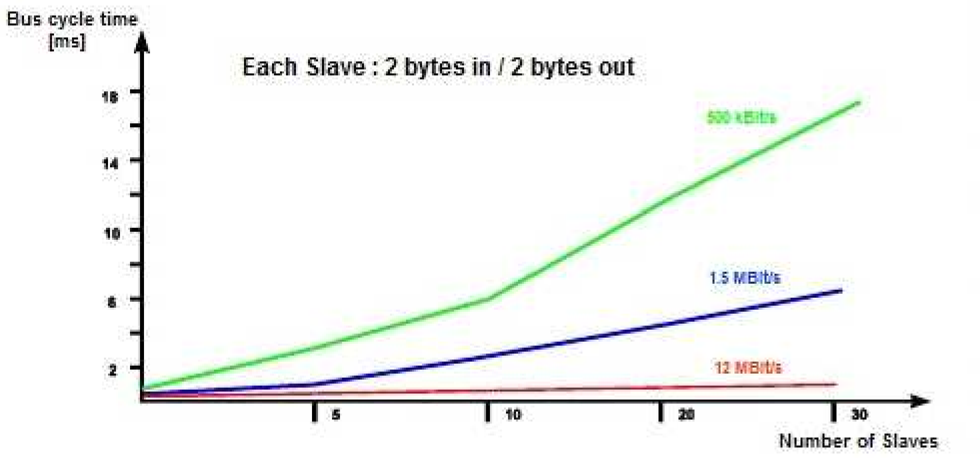


Fig.15. Cycle time, DP mono-master

The DP stations must be assigned a unique address, a number (0 to 126). One master can handle at most 126 slaves. Each station can send or receive a maximum of 244 bytes.

6.2 Profibus PA

Profibus PA (process automation) meets the special requirements of process automation. The PA communication is based on the services provided by DPV1, and is implemented as a partial system embedded in a higher-level DP communication system (fig. 2). Unlike the automated applications in manufacturing engineering which require short cycle times of few milliseconds, other factors are of importance in process automation, such as following:

- Intrinsically safe transmission techniques;
- Field devices are powered over the bus cable;
- Reliable data transmission;
- Interoperability (standardization of device functions).

PA uses the DP protocol, and it can not exist without a DP master. The PA network will be a part of a DP network.

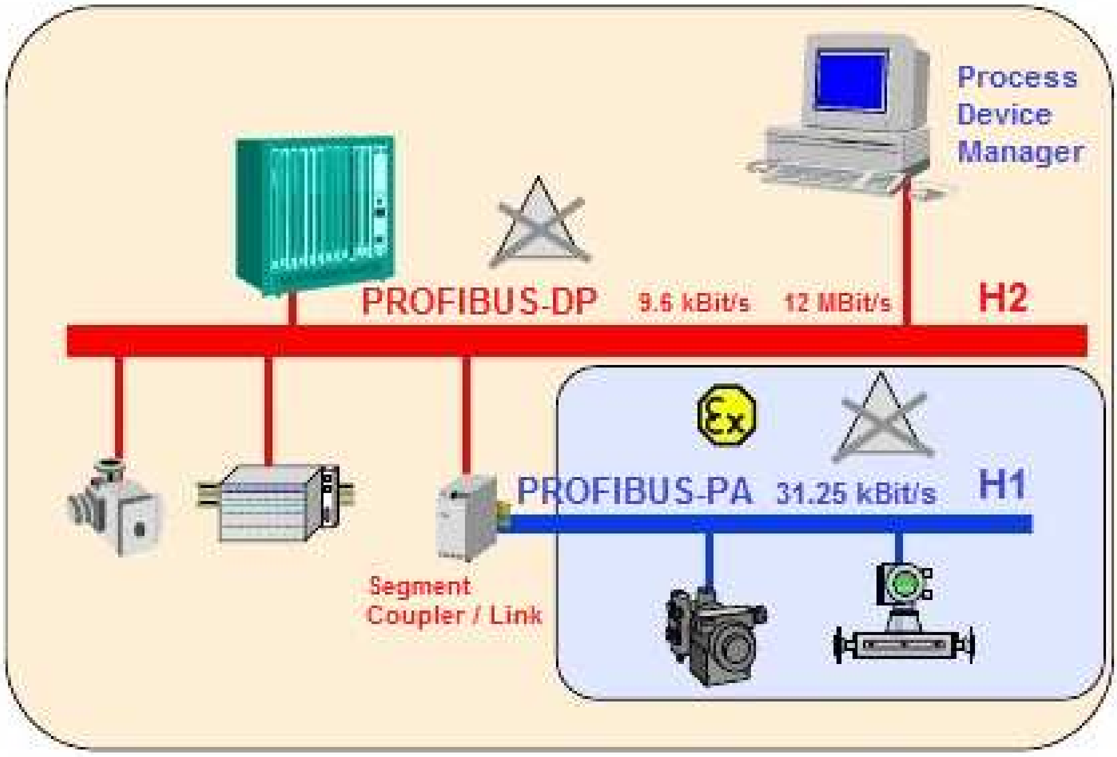


Fig. 16. Profibus PA

The transmission technology used by PA is IEC 1158-2. The baudrate is fixed: 31.25 kBit/s, and the signal levels are 0 and 20 mA. Therefore it is a need for a signal translator between the PA and the DP part of the network. There are two kinds of such a translator: Coupler and Link.

A **Coupler** does signal transmission only – Seen from the DP side, all the PA instruments act like DP stations. The coupler is totally transparent. If a coupler is used, the baudrate on the DP side will be fixed.

A **Link** is equipped with intelligence so that the DP network can run with any of the H2 baudrates (9.6kBit/s to 12 Mbit/s). The link has its own DP address – and the PA stations are addresses under this.

7. Configuration

The configuration of the PROFIBUS network is done in the software for the master (fig.18). So – it looks a bit different for the Moeller PLC than for the Siemens or other PLC. But the principle is the same. Each PROFIBUS station must be accompanied by a GSD or GSE file which is an electronic data sheet. (GSD is German and stands for Geräte Stamme Datei). GSD-files can be downloaded from the PROFIBUS web site (www.profibus.com).

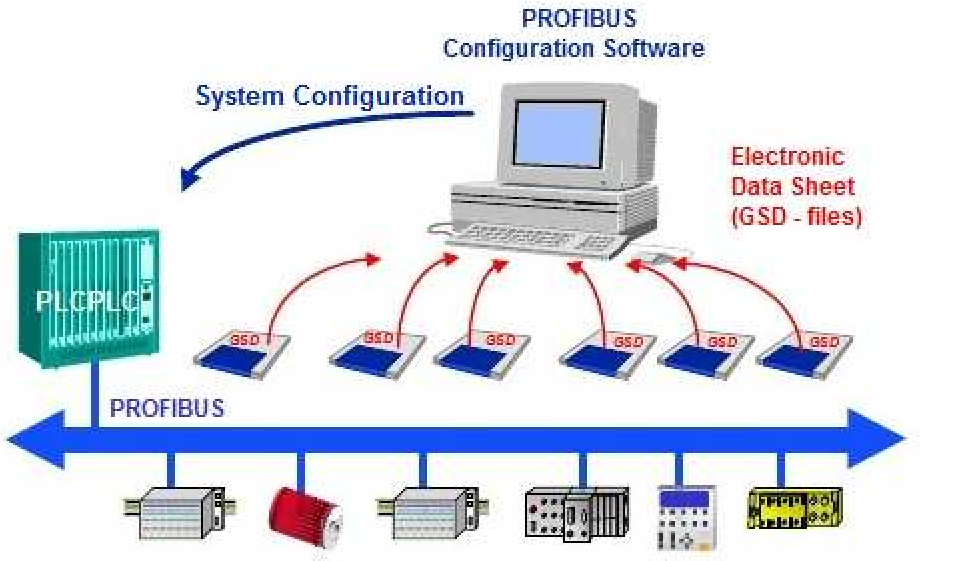


Fig.18 . PROFIBUS configuration

The GSD-files must be installed in the hardware catalogue or data base of the configuration software. The network is configured by connecting to the PROFIBUS network the actual stations which must be present in the catalogue.