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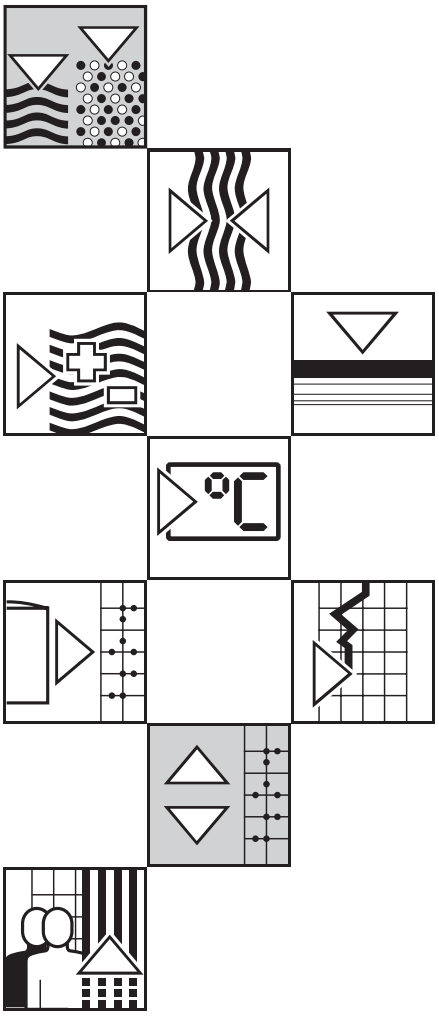
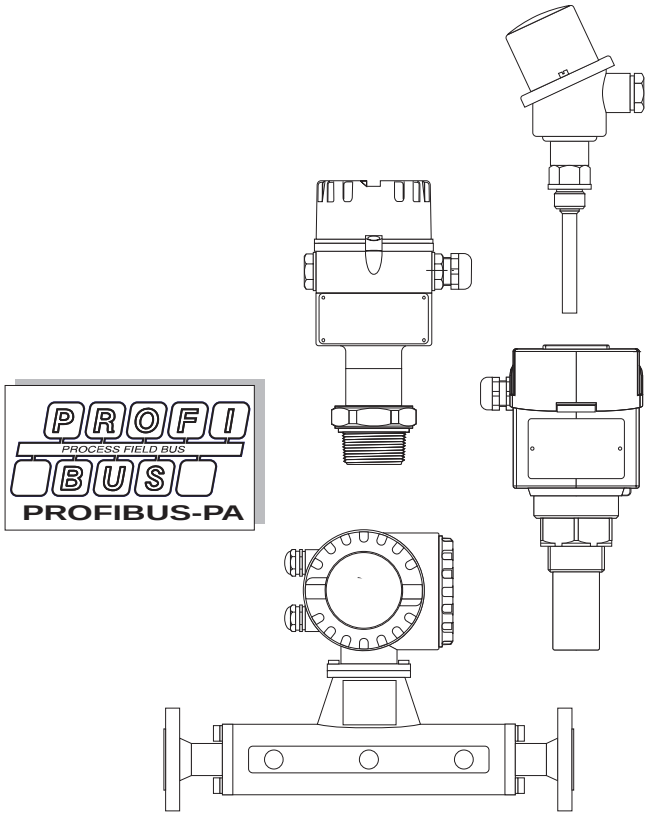
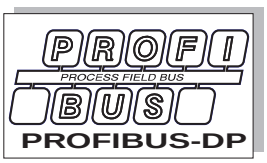
# *Field Communication*
# PROFIBUS-DP/PA: Guidelines for planning and commissioning






Endress + Hauser

The Power of Know How

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# Notes on Safety

**Approved usage**

These operating instructions are intended as a planning aid for the use of Endress+Hauser devices in PROFIBUS-PA systems. The approved usage of the individual devices can be taken from the corresponding device operating instructions.

**Installation, commissioning, operation**

The field devices, segment coupler, cables and other components must be designed to operate safely in accordance with current technical safety and EU standards. If installed incorrectly or used for applications for which they are not intended, it is possible that dangers may arise. For this reason, the system must be installed, connected, operated and maintained according to the instructions in this manual: personnel must be authorised and suitably qualified.

**Explosion hazardous area**

If the system is to be installed in an explosion hazardous area, then the specifications in the certificate as well as all national and local regulations must be observed.

- Ensure that all personnel are suitably qualified
- Observe the specifications in the certificate as well as national and local regulations.

For PROFIBUS-PA all components should be designed in accordance with the FISCO model. This greatly simplifies the acceptance testing of the PROFIBUS-PA segment.

# Safety conventions and symbols

In order to highlight safety-relevant or alternative operating procedures in the manual, the following conventions have been used, each indicated by a corresponding icon in the margin.

## Safety conventions

| Symbol | Meaning |
|---|---|
|  Note! | **Note!** A note highlights actions or procedures which, if not performed correctly, may indirectly affect operation or may lead to an instrument response which is not planned |
|  Caution! | **Caution!** Caution highlights actions or procedures which, if not performed correctly, may lead to personal injury or incorrect functioning of the instrument |
|  Warning! | **Warning!** A warning highlights actions or procedures which, if not performed correctly, will lead to personal injury, a safety hazard or destruction of the instrument |

## Explosion protection

| | |
|---|---|
|  | **Device certified for use in explosion hazardous area** If the device has this symbol embossed on its name plate it can be installed in an explosion hazardous area |
|  | **Explosion hazardous area** Symbol used in drawings to indicate explosion hazardous areas. Devices located in and wiring entering areas with the designation “explosion hazardous areas” must conform with the stated type of protection |
|  | **Safe area (non-explosion hazardous area)** Symbol used in drawings to indicate, if necessary, non-explosion hazardous areas. Devices located in safe areas stiill require a certificate if their outputs run into explosion hazardous areas. |

## Electrical symbols

| | |
|---|---|
|  | **Direct voltage** A terminal to which or from which a direct current or voltage may be applied or supplied |
|  | **Alternating voltage** A terminal to which or from which an alternating (sine-wave) current or voltage may be applied or supplied |
|  | **Grounded terminal** A grounded terminal, which as far as the operator is concerned, is already grounded by means of an earth grounding system |
|  | **Protective grounding (earth) terminal** A terminal which must be connected to earth ground prior to making any other connection to the equipment |
|  | **Equipotential connection (earth bonding)** A connection made to the plant grounding system which may be of type e.g. neutral star or equipotential line according to national or company practice |

# 1 Introduction

**Application**

These guidelines have been written with the view of giving the potential PROFIBUS user an introduction to the planning and commissioning of a PROFIBUS-PA network. They are based on the experience of Endress+Hauser employees who have been actively involved in PROFIBUS projects and who, in the meantime, have successfully commissioned a number of plants. The guidelines are structured as follows:

| Chapter | Titel | Inhalt |
|---|---|---|
| Chapter 1 | Introduction | Advantages of a bus as well as general information about the PROFIBUS standard |
| Chapter 2 | PROFIBUS-DP basics | Information about PROFIBUS-DP |
| Chapter 3 | Grundlagen PROFIBUS-PA | Information about PROFIBUS-PA, couplers, links and use in explosion hazardous areas (FISCO-Model) |
| Chapter 4 | Planning | What must be observed when planning PROFIBUS-DP/PA systems, with examples |
| Chapter 5 | Installation | Notes on the installation of devices in a PROFIBUS-DP/PA system |
| Chapter 6 | System integration | Notes on mapping PROFIBUS-PA devices in a PLC |
| Chapter 7 | Device configuration | General information on setting the parameters in Endress+Hauser devices PROFIBUS applications |
| Chapter 8 | Trouble-shooting | Causes and remedies for general faults that may occur during the commissioning of a system |
| Chapter 9 | Technical data | Principle technical data of PROFIBUS-PA and PROFIBUS-DP |
| Chapter 10 | PROFIBUS-PA components | Profiles of the Endress+Hauser PROFIBUS-DP and PROFIBUS-PA devices |
| Chapter 11 | Terms and definitions | Explanation of the terminology used to describe bus systems |
| Chapter 12 | Appendix | Calculation sheets for your applications |

Should you have any questions regarding PROFIBUS which go beyond the subjects discussed in this manual, do not hesitate to get in touch with us.

## 1.1 Advantages of a bus system

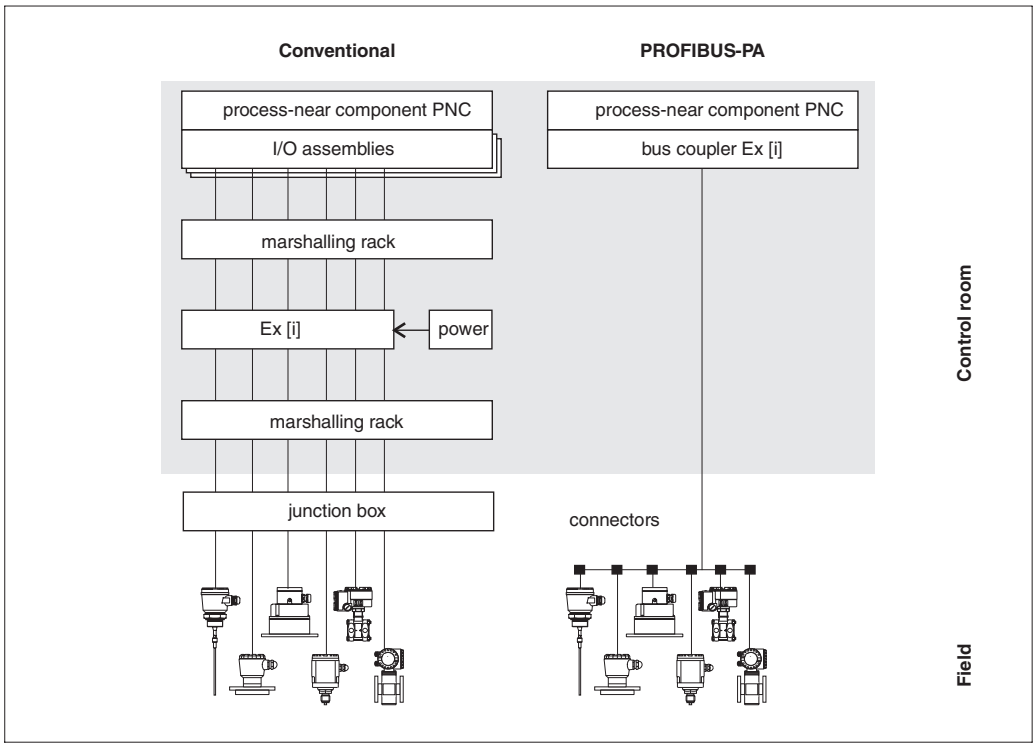


*Fig. 1.1*
*Signal transfer: conventional and with PROFIBUS-PA*

**Wiring**

Figure 1.1 illustrates the difference between the wiring of a conventional 4..20 mA control system and a fieldbus system.

- For a compact plant, the wiring from the field to the junction box is roughly the same: if the measuring points are widely distributed, however, the fieldbus requires decidedly less cable.
- For conventional wiring, every signal line must be continued from the junction box to the process-near component, e.g. a programmable logic controller, where it terminates in a I/O module. For every device a separate power supply is required, where necessary, suitable for use with devices in hazardous areas.
- In contrast, the fieldbus requires a single cable only to carry all information. The bus terminates in a bus coupler that communicates directly with the process near components. Not only cable, but also I/O modules are saved. Since the bus is powered from a single intrinsically safe power unit, there is no need for individual isolators and barriers.

**Commissioning**

Digital communication allows comfortable commissioning of field devices from the control room. Individual devices can not only be configured from a personal computer but the settings can also be archived centrally. If there are several identical measuring points in an application, the stored parameters can be downloaded to the devices. An individual configuration of each device is no longer necessary.

**Operation**

In addition to the process variables that are processed in the programmable logic controller (PLC) or process control system (PCS), the operator has access to a number of other parameters at every measuring point. These can be displayed in the Commuwin II operating and display program or a SCADA application. The programs offer a clear overview of the application.

**Maintenance**

Devices with diagnosis functions or self-monitoring signal faults to the bus master. The status of each device can be checked from the control room, so that the maintenance team can quickly localise and eliminate the fault.

## 1.2 PROFIBUS standard

PROFIBUS is an open fieldbus standard to EN 50 170. It was developed by a German consortium that quickly and pragmatically produced the German Standard DIN 19 245 after attempts to produce an international fieldbus failed in 1992. The European Standard followed roughly a year later. PROFIBUS is supported by an international network of PROFIBUS User Organisations.

**PROFIBUS-DP**

PROFIBUS-DP (decentralised periphery) is an extension of the original PROFIBUS standard, see Fig. 1.2. An extension contains a subset of the functionality of the original standard and is targeted at a specific area of application. PROFIBUS-DP was primarily developed for the fast processes involved in factory automation. In the original version, PROFIBUS-DP allowed only one master that communicated via the master-slave method. The extended version DPV1 allows up to 127 participants including up to 32 masters. A slave, however, may be allocated to only one "Class 1" master, see Chapter 2. Slaves are configured by a Class 2 master using acyclic services.

**PROFIBUS-PA**

PROFIBUS-PA (process automation) is an extension of PROFIBUS-DP for process automation. It has two specialities: firstly, participants can draw intrinsically safe power from the bus, secondly, the data transfer is handled according to the international standard IEC 61158-2. A maximum of 32 participants can be connected to a PROFIBUS-PA segment. Bus access is governed by the master/slave method, see Chapter 3.

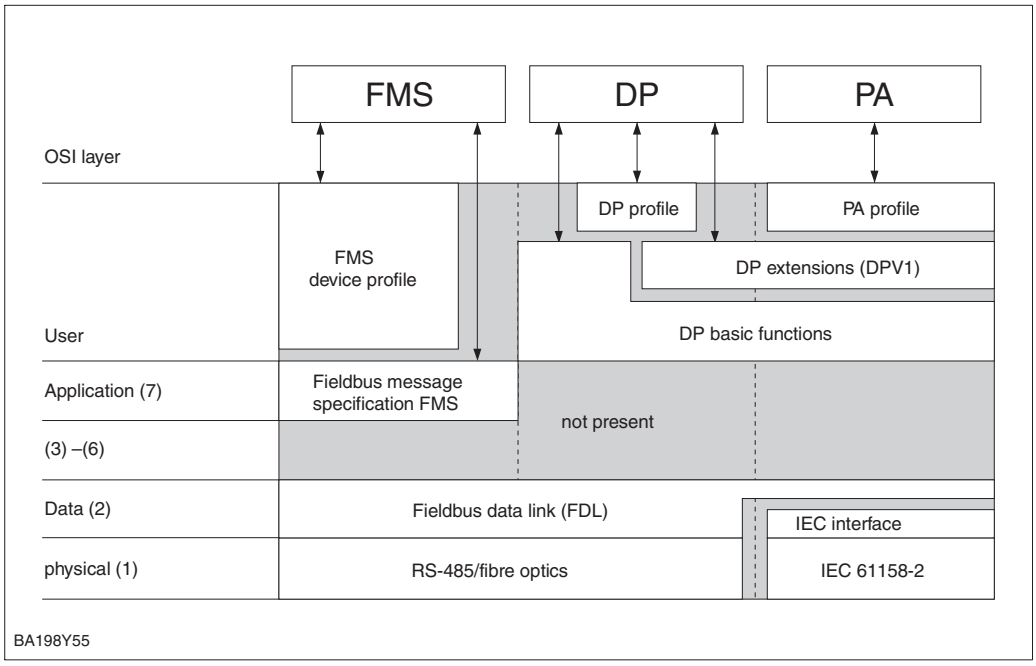


*Fig. 1.2*
*PROFIBUS versions and functions*

## 1.3 PROFIBUS in process engineering

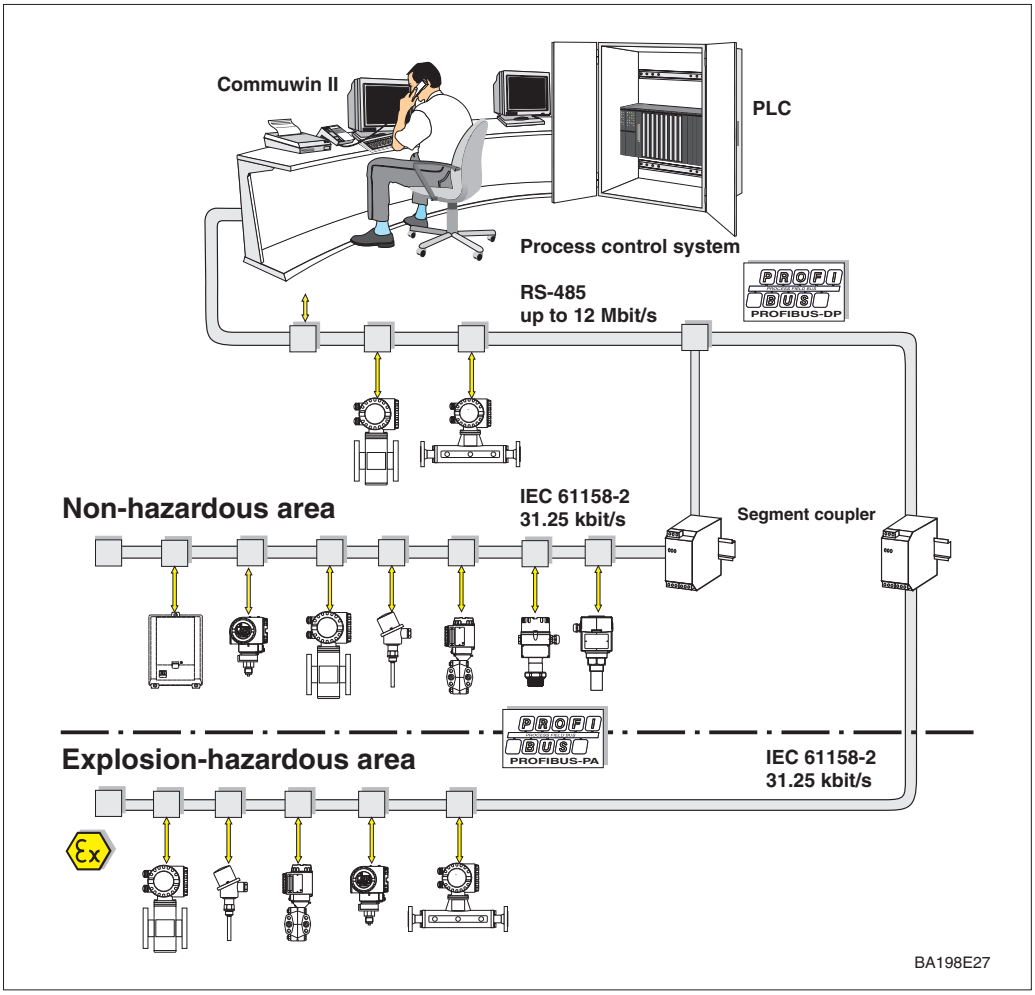


*Fig. 1.3*
*Process automation with PROFIBUS-DP and PROFIBUS-PA*

Every manufacturing facility has tasks which are associated with process and factory automation:

- Process automation: measurement, actuation, control...
- Factory automation: filling, storage, conveyance, drives...

For this reason it is possible that the Endress+Hauser devices installed in a factory are integrated in PROFIBUS-DP, PROFIBUS-DP or mixed systems. Fig. 1.3 shows a typical example:

- The process is controlled by a process control system or a programmable logic controller (PLC). The control system or PLC serves as a Class 1 master. It uses the cyclic services to acquire measurements and output control commands. The operating program, in this case Commuwin II, serves as a Class 2 master. It uses the acyclic services and serves to configure the bus participants during installation and normal operation.
- The PROFIBUS-DP system is used to handle the communication at the control level. Drives, remote I/Os etc. may all be found upon the bus. It is also possible to connect externally powered field devices to this level, e.g. the flowmeters Promass and Promag. PROFIBUS-DP ensures that data are quickly exchanged, whereby in mixed PROFIBUS-DP/PA systems the baudrate supported by the segment coupler is often the limiting factor.
- PROFIBUS-PA is used at field level. The segment coupler serves both as interface to the PROFIBUS-DP system and as power supply for the PROFIBUS-PA field devices. Depending upon the type of segment coupler, the PROFIBUS-PA segment can be installed in safe or hazardous areas.

# 2 PROFIBUS-DP Basics

As far as PROFIBUS systems in process engineering are concerned, the versions PROFIBUS-DP (variant DPV1) and PROFIBUS-PA are of interest. This chapter describes the basics of PROFIBUS-DP. The chapter is structured as follows:

- Synopsis
- Topology
- Bus access method
- Network configuration
- Applications in hazardous areas

## 2.1 Synopsis

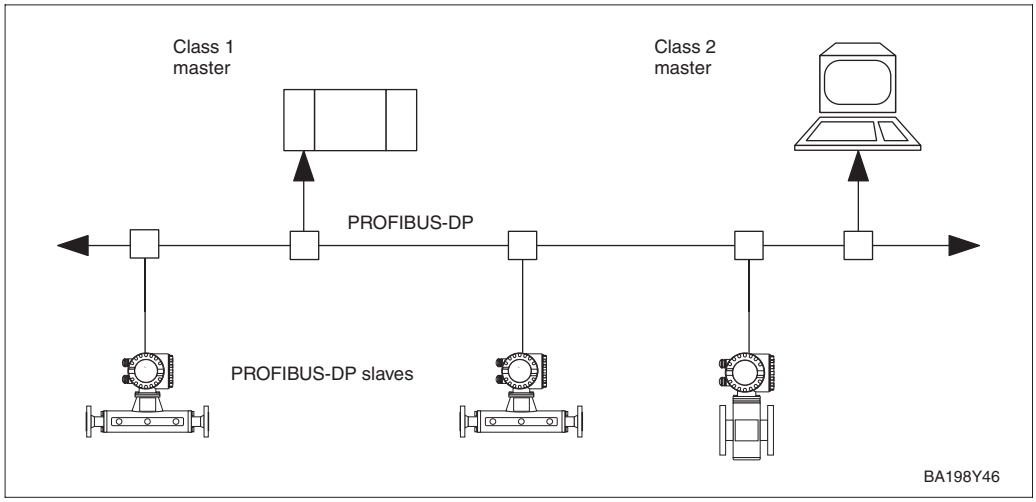


*Fig. 2.1*
*PROFIBUS-DP system, Version DPV1*

**Application**

PROFIBUS-DP is used primarily for factory automation. In PROFIBUS-PA systems for process automation, a PROFIBUS-DP system is used at the control level for quick transmission of the data. Here, a variant of PROFIBUS-DP, DPV1 is used. In addition to the cyclic exchange of data with a PLC, this allows the field devices to be configured via acyclic services. The principle technical data for DPV1 are listed in Table 2.1.

**Participants**

Depending upon the application at hand, the participants in a PROFIBUS-DP system might be frequency converters, remote I/Os, actuators, sensors, links, gateways etc. as well as the PLC or process control system. The following Endress+Hauser devices can be connected directly to a DP system:

- Flowmeters Promass 63 and Promag 33/35
- Display unit Memograph RSC 10 (listener function only)
- PROFIBUS-DP gateway.

Others are in preparation.

| | |
|---|---|
| Standard | EN 50170, Parts 1 - 3, Version DPV1 |
| Support | PROFIBUS User Organisation (PNO) |
| Physical layer | RS-485 and/or fibre optics |
| Max. length | 1200 m (copper) or several kilometres (optics) |
| Participants | Max. 126, including max. 32 as master |
| Transmission rate | up to 12 MBit/s |
| Bus access method | Token passing with master-slave |

*Table 2.1*
*Technical data PROFIBUS-DP*

## 2.2 Topology

PROFIBUS-DP is based on a linear topology. For lower data transmission rates, a tree structure is also possible.

**Cable**

EN 50 170 specifies two types of bus cable. For transmission rates up to 12 Mbit/s, cable type A is recommended. The specification is given in Table 2.2.

| | |
|---|---|
| Terminator | 135 Ω to 165 Ω at a measuring frequency of 3 MHz to 20 MHz |
| Cable capacitance | < 30pF per Meter |
| Core cross-section | >0.34 mm², corresponds to 22 AWG |
| Cable type | twisted pairs, 1x 2, 2x 2 or 1x 4 core |
| Loop resistance | 110 Ω per km |
| Signal attenuation | max. 9 dB over the entire Length of the segment |
| Screening | woven copper sheath or woven sheath and foil sheath |

*Table 2.2 Specifications of Cable Type A of the PROFIBUS-DP standard*

**Structure**

The following points should be noted when the bus structure is being planned:

- The max. permissible cable length depends upon the transmission rate. For PROFIBUS RS-485 cable of type A (see table 2.2) the dependency is as follows:

| Transmission rate (kBit/s) | 9.6 - 93.75 | 187.5 | 500 | 1500 | 300 – 12000 |
|---|---|---|---|---|---|
| Cable length (m) | 1200 | 1000 | 400 | 200 | 100 |

:

- A maximum of 32 participants per segment is allowed.
- A terminating resistance must be installed at both ends of every segment (ohmic load 220 Ω)
- The cable length and/or the number of participants can be increased by using repeaters.
- There must never be more than three repeaters between any two participants.
- The total number of participants in the system is limited to 126 – (2x number of repeaters).

**Spurs**

A spur is the cable connecting the field device to the T-box. As a rule of thumb:

- For transmission rates up to 1500 kbits/s, the total length (sum) of the spurs may not exceed 6.6 m.
- Spurs should not be used for transmission rates greater than 1500 kbits/s.

**Examples**

Figs 2.2 and 2.3 show examples for a linear and tree bus structure.

Fig 2.2. shows that three repeaters are necessary if the PROFIBUS-DP system is to be developed to the full. The maximum cable length corresponds to 4x the value quoted in the table above. Since three repeaters are used, the maximum number of participants is reduced to 120.

Fig 2.3 shows how several repeaters can be used to create a tree structure. The number of participants allowable per segment is reduced by one per repeater: the total number of participants is limited to 126 – (2x number of repeaters).

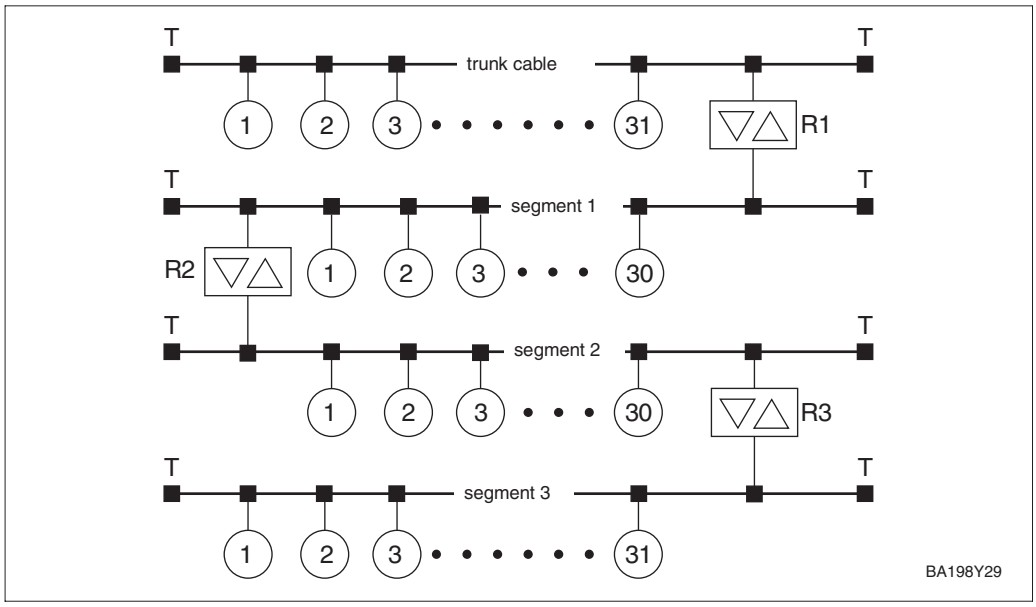


*Fig. 2.2*
*PROFIBUS-DP system with linear structure*
*T = terminator*
*R = repeater*
*1...n = max. number of field devices on a segment*

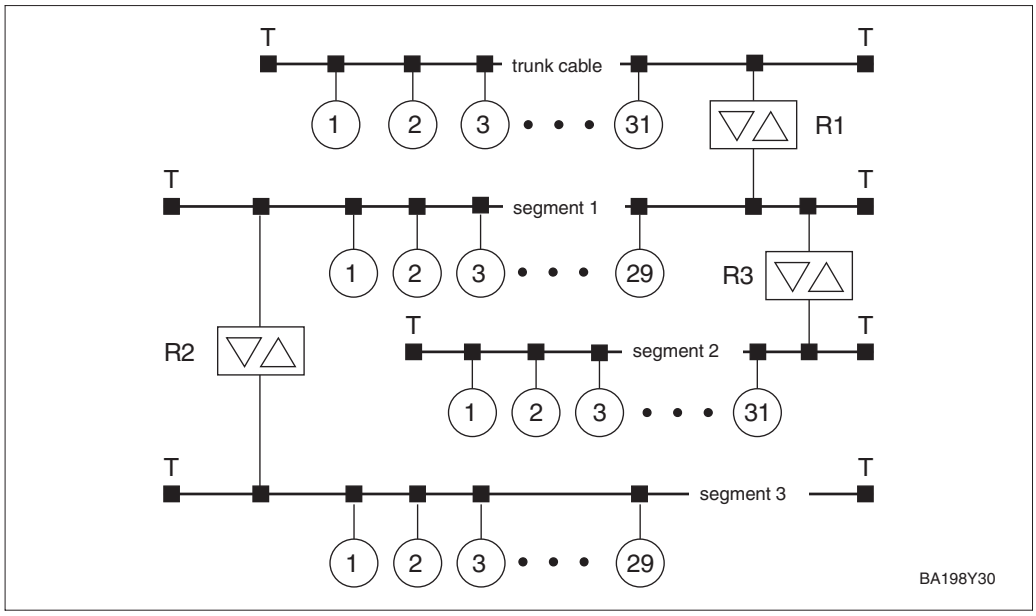


*Fig. 2.3*
*PROFIBUS-DP system with tree structure*
*T = terminator*
*R = repeater*
*1...n = max. number of field devices on a segment*

If the PROFIBUS-DP system has to be routed over large distances or in plant with heavy electromagnetic interference, then an optical or mixed optical/copper network can be used. Provided that all participants support them, very high transmission rates are possible. Fig. 2.4 shows a possible structure for an optical network, whereby the technical details can be taken from the PROFIBUS standard.

## Optical network

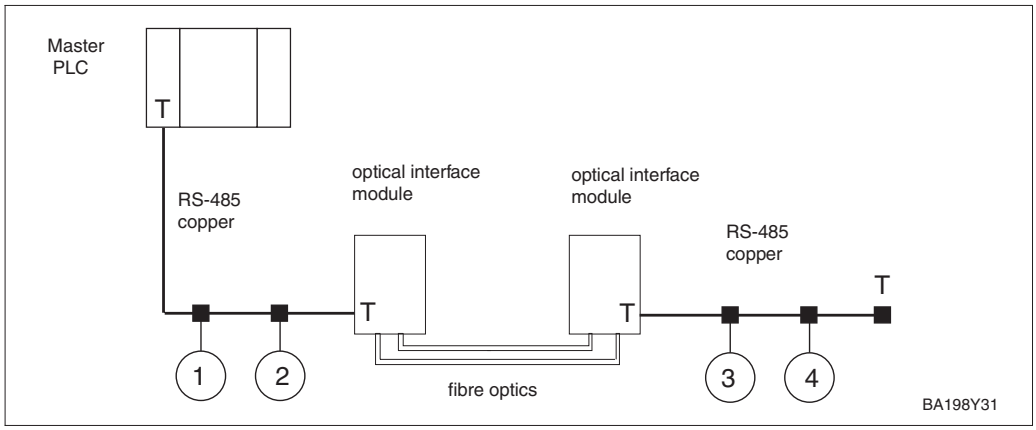


*Fig. 2.4*
*Example for a mixed optical/RS-485 network*
*T = terminator*
*1...n = field devices (slaves)*

## 2.3 Bus access method

PROFIBUS-DP uses a hybrid access method of centralised master/slave and decentralised token passing, see Fig.2.5.

- The masters build a logical token ring.
- When a master possesses the token, it has the right to transmit.
- It can now talk with its slaves in a master-slave relationship for a defined period of time.
- At the end of this time, the token must be passed on to the next active device in the token ring.

**Master class**

Version DPV1 of PROFIBUS-DP differentiates between two classes of master:

- A Class 1 master communicates cyclically with its slaves. The master communicates only with those slaves that are assigned to it. A slave may be assigned to only one Class 1 master. A typical class 1 master is a programmable logic controller (PLC) or a process control system.
- A Class 2 master communicates acyclically with its slaves, i.e. on demand. Its slaves may also be assigned to a Class 1 master. A typical example is a PC with corresponding operating software, e.g. Commuwin II. It is used for commissioning as well as for device configuration, diagnosis and alarm handling during normal operation.

If a PROFIBUS-DP network has more than one master e.g. because both cyclic and acyclic services are required, then it is a multi-master system. If, for example, a PLC only is used for control tasks, then the system is a mono-master system.

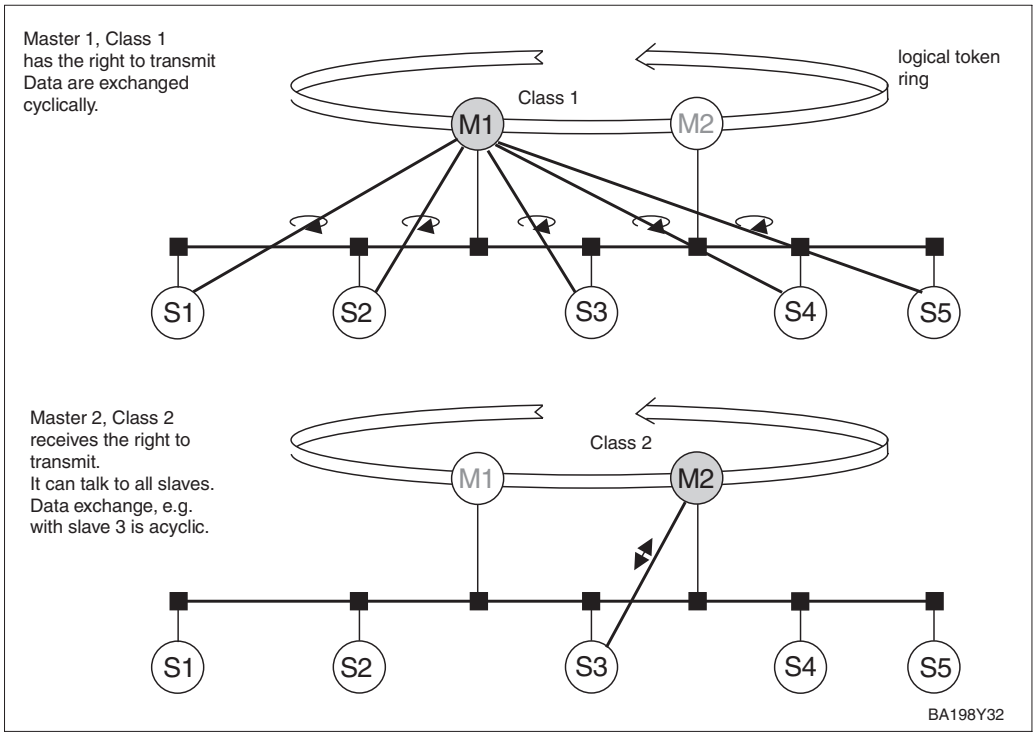


*Fig. 2.5*
*Data exchange in a PROFIBUS-DP multi-master system*
*M = master*
*S = slave*