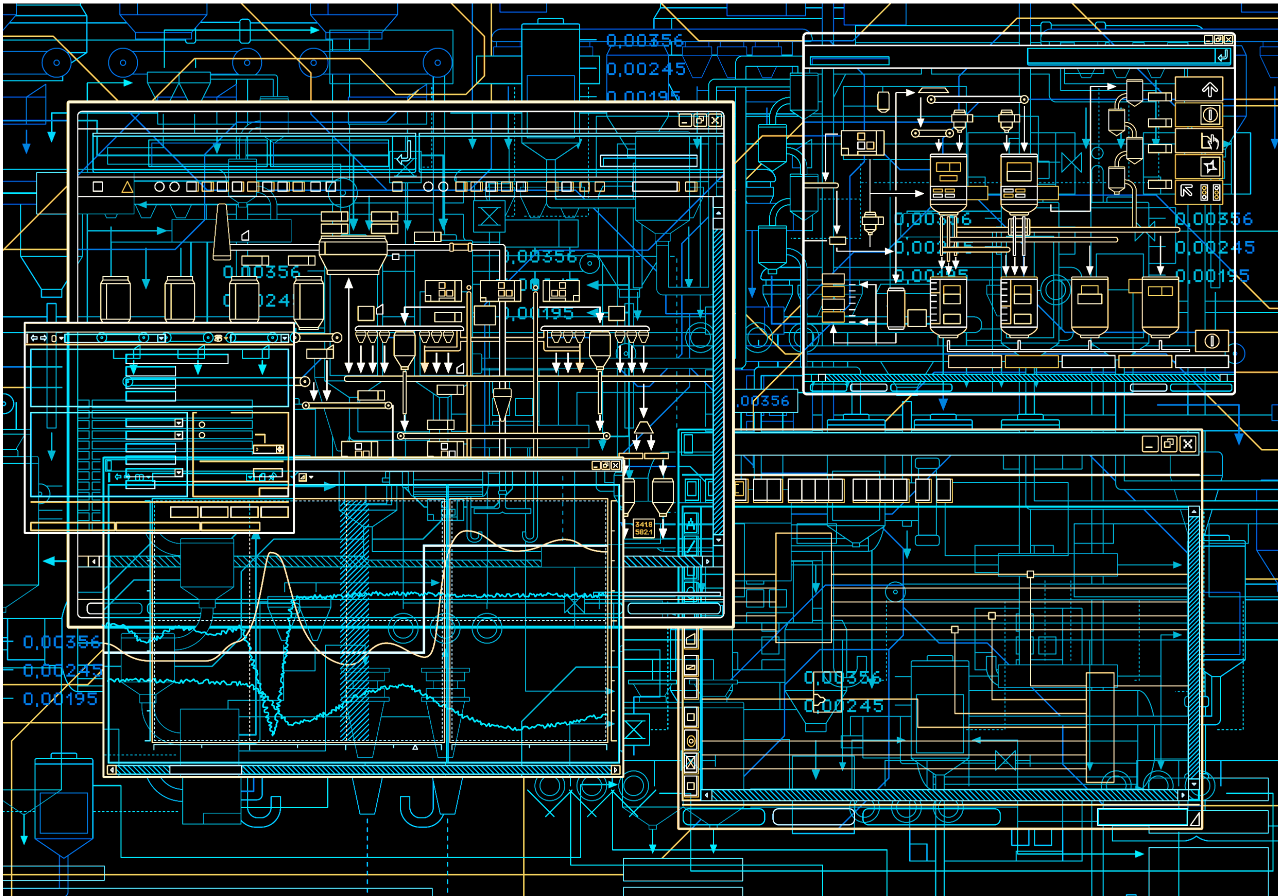

AC 800M

PROFIBUS DP

Installation

System Version 5.0, 5.1

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AC 800M

PROFIBUS DP
Installation

System Version 5.0, 5.1

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About This User Manual

General

Any security measures described in this User Manual, for example, for user access, password security, network security, firewalls, virus protection, etc., represent possible steps that a user of an 800xA System may want to consider based on a risk assessment for a particular application and installation. This risk assessment, as well as the proper implementation, configuration, installation, operation, administration, and maintenance of all relevant security related equipment, software, and procedures, are the responsibility of the user of the 800xA System.

This user manual provides application notes and advice for wiring and installation of PROFIBUS networks. It is intended to be used by Instruments Engineers, Instrument Technicians, Electricians and Installers for the wiring and associated components for the PROFIBUS applications.

The main areas covered in this manual are:

- Fieldbus topology and the redundancy concepts
- Transmission technologies
- Cable media and PROFIBUS components
- Design of a plant and the cable laying regulations
- Commissioning and testing of PROFIBUS equipment

For a list of documentation related to ABB PROFIBUS products, please see the Released User Manuals and Release Notes on page 14.

How to Use this User Manual

Section 1 Introduction gives a brief overview of the PROFIBUS protocols, technology terms, transmission technologies and the Fieldbus Intrinsically Safe Concept (FISCO).

Section 2 Transmission Technology provides detailed information about the PROFIBUS physics like RS485(-IS), MBP, fibre optics as well as basics of cable types, transmission rates, network limits and bus line length. This chapter is intended for users, they are not familiar with the basics of the PROFIBUS technology.

Section 3 Fieldbus Topologies describes PROFIBUS topologies, usable with certain transmission technology, described in section 2. This chapter is intended for readers, they know PROFIBUS basics and need an introduction to install PROFIBUS networks in connection with the AC 800M controller and the PROFIBUS master interface CI854(A). Also the readers get recommendations and important hints for installation work.

Section 4 Commissioning of PROFIBUS equipment describes additional hints on the installation of PROFIBUS networks. Furthermore this chapter provides detailed information to find errors and how to fix them.

For a list of documentation related to the products described in this user manual, see Released User Manuals and Release Notes on page 14.

User Manual Conventions

Microsoft Windows conventions are normally used for the standard presentation of material when entering text, key sequences, prompts, messages, menu items, screen elements, etc.

Warning, Caution, Information, and Tip Icons

This User Manual includes Warning, Caution, and Information where appropriate to point out safety related or other important information. It also includes Tip to point out useful hints to the reader. The corresponding symbols should be interpreted as follows:

Electrical warning icon indicates the presence of a hazard that could result in *electrical shock.*

Warning icon indicates the presence of a hazard that could result in *personal injury.*

Caution icon indicates important information or warning related to the concept discussed in the text. It might indicate the presence of a hazard that could result in *corruption of software or damage to equipment/property.*

Information icon alerts the reader to pertinent facts and conditions.

Tip icon indicates advice on, for example, how to design your project or how to use a certain function

Although Warning hazards are related to personal injury, and Caution hazards are associated with equipment or property damage, it should be understood that operation of damaged equipment could, under certain operational conditions, result in degraded process performance leading to personal injury or death. Therefore, fully comply with all Warning and Caution notices.

Terminology

A complete and comprehensive list of Terms is included in the *System 800xA, Engineering Concepts instruction (3BDS100972*)*. The listing includes terms and definitions that apply to the 800xA System where the usage is different from commonly accepted industry standard definitions and definitions given in standard dictionaries such as Webster's Dictionary of Computer Terms. Terms that uniquely apply to this User Manual are listed in the following table.

Term/Acronym	Description
AC 800M	ABB Controller 800M series, general purpose process controller series by ABB.
AC 800M Controller	Any controller constructed from the units and units connected to the AC 800M hardware platform.
Connector	A Connector is a coupling device used to connect the wire medium to a fieldbus device or to another segment of wire.
EMC	EMC is defined as the ability of a product to operate within its intended electromagnetic environment and to accept or emit RF disturbances within defined limits.
FDE	Fault Disconnection Electronic. The FDE in field devices ensures that the communication of the bus segment does not fail, even in case of a short circuit in a device.
Fieldbus	A fieldbus is used to interconnect field devices, such as I/O modules, smart sensors and actuators, variable speed drives, PLCs, or small single loop devices, and to connect these devices to the 800xA system.
GSD File	Gerätestammdaten, device communication database file for PROFIBUS devices.
Highway Addressable Remote Transducer (HART)	The HART protocol is a widely-used open protocol for communication with Smart devices.
IEC	International Electrotechnical Commission.
IS	Intrinsic Safety.
Linking Device	The linking device connects one or more ROFIBUS PA segments to PROFIBUS DP.

Term/Acronym	Description
MBP	Transmission technology **M**anchester Coding and **B**us **P**owered. This term replaces the previously common terms for intrinsically safe transmission “Physics in accordance with IEC 61158-2, 1158-2, etc.
NRZ	Non Return to Zero, a protocol behavior of the MBP transmission technology.
PROFIBUS	**PRO**cess **FI**eld**BUS.** PROFIBUS is a manufacturer-independent fieldbus standard for applications in manufacturing, process and building automation. The PROFIBUS family is composed of three types of protocol, each of which is used for different tasks. The three types of protocols are: PROFIBUS FMS, DP and PA.
PROFIBUS FMS	**F**ieldbus **M**essage **S**pecification. Is designed for communication at the cell level, where programmable controllers, such as PLCs and PCs primarily communicate with each other. It was the forerunner of PROFIBUS DP.
PROFIBUS DP	PROFIBUS DP is the communication protocol for Decentralized Peripherals. DP covers the versions DP-V0, DP-V1 and DP-V2.
PROFIBUS PA	PROFIBUS for Process Automation
PROFIBUS International (PI)	The international umbrella organization for PROFIBUS founded in 1995.
PROFIBUS User Organization e.V. (PNO)	The PNO is the trade body of manufacturers and users for PROFIBUS founded in 1989.
Redundancy	The existence of more than one capability of an item (system, equipment or component) to perform its intended function.
Remote I/O	Input/Output units connected to a controller via a fieldbus.

Term/Acronym	Description
RLM 01	**R**edundancy **L**ink **M**odule for PROFIBUS DP. The RLM 01 connects a non redundant PROFIBUS slave to the line redundant PROFIBUS.
RS485	A communication interface standard from EIA (Electronics Industries Association, USA), operating on voltages between 0V and +5V. RS485 is more noise resistant than RS232C, handles data transmission over longer distances, and can drive more receivers
Segment	A Segment is a section of a PROFIBUS DP fieldbus that is terminated in its characteristic impedance. Segments can be linked by Repeaters to form a longer PROFIBUS DP fieldbus. Each Segment can include up to 32 devices.
tbit	Time a bit needs to be transferred on PROFIBUS. This time depends on the transmission rate. tbit = 1/transmission rate.

Released User Manuals and Release Notes

A complete list of all User Manuals and Release Notes applicable to System 800xA is provided in *System 800xA Released User Manuals and Release Notes (3BUA000263*)*.

System 800xA Released User Manuals and Release Notes (3BUA000263)* is updated each time a document is updated or a new document is released. It is in pdf format and is provided in the following ways:

- Included on the documentation media provided with the system and published to ABB SolutionsBank when released as part of a major or minor release, Service Pack, Feature Pack, or System Revision.
- Published to ABB SolutionsBank when a User Manual or Release Note is updated in between any of the release cycles listed in the first bullet.

A product bulletin is published each time *System 800xA Released User Manuals and Release Notes (3BUA000263*)* is updated and published to ABB SolutionsBank.

For standards and commercially available PROFIBUS documentation please visit the PROFIBUS Web Site (http://www.profibus.com).

Section 1 Introduction

General Overview

Fieldbus systems are used as a means of communications for serial data exchange between decentralized devices on the field level and the controller of the process supervision level.

PROFIBUS means **PRO**cess **FI**eld**BUS**, designed as a fieldbus for process automation purposes for interconnecting **D**ecentralized **P**eripheral devices (PROFIBUS DP), and its extended version for **P**rocess **A**utomation (PROFIBUS PA). It is well known all over the world and the most popular fieldbus in Europe. Due to its high data transmission rates over short distances and moderate ones over long distances it is predominantly used for interconnecting I/O units like S800 / S900 or smart devices to PLCs and controller like AC 800M.

This user manual provides a brief overview of the PROFIBUS technology, to help you by planning, commissioning and testing. It does not release you from the necessity to observe the relevant standards. The valid version of the EMC directive and other PROFIBUS guidelines and the shield and grounding directives, particular for PROFIBUS-PA must be observed.

Data in this document are based on experiences, but do not replace however the relevant standards and regulations as there are for example:

British Standard BS EN 50170
Euro Standard EN 50170
International Electrotechnical Commission IEC 61158

PROFIBUS Specification 0.032, FMS, DP, PA Specification
PROFIBUS Guideline 2.112, PROFIBUS DP/FMS Installation Guideline
PROFIBUS Guideline 2.092, PROFIBUS PA User and Installation Guideline
PROFIBUS Guideline 2.021 (draft in german), Optical Transmission Technics

The PROFIBUS Protocols

PROFIBUS is a manufacturer-independent fieldbus standard for applications in manufacturing, process and building automation. PROFIBUS technology is described in fixed terms in DIN 19245 as a German standard and in EN 50170 / IEC 61158 as an international standard. It specifies the technical and functional properties of a serial bus system. The PROFIBUS standard is thus available to every provider of automation product.

PROFIBUS distinguishes between master and slave. The masters determine the data communication on the bus. A master can send messages without an external request if it has access rights to the bus (token). The slaves are peripheral devices. Typical slaves are I/O devices, valves, motors and transmitters. They have no bus access rights. They can only confirm received messages or send a message on the request of the master. Slaves are passive devices on the PROFIBUS.

PROFIBUS is composed of three types of protocol, each of which is used for different tasks. Of course, devices with all three protocols can communicate with each other in a complex system by means of a PROFIBUS network.

The three types of protocols are: PROFIBUS FMS, DP, PA.

Only the two protocol types DP and PA today are important for process automation and are supported within the 800xA System.

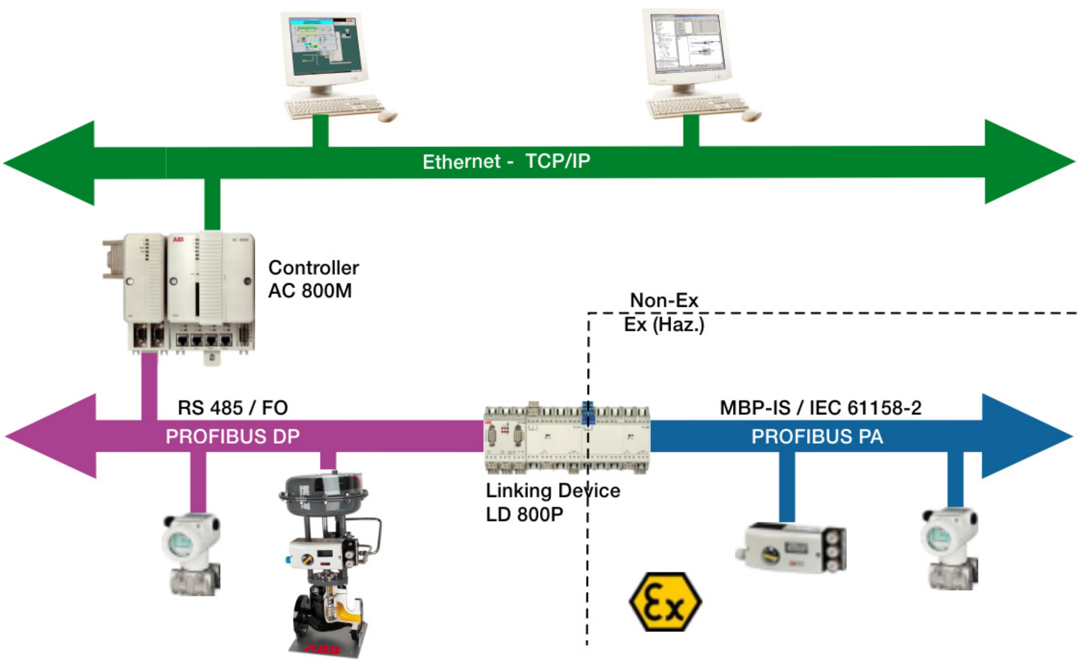


Figure 1. The PROFIBUS family embedded in Industrial IT

PROFOBUS DP: the bus for the Decentralized Periphery

The PROFIBUS DP (RS485) is responsible for communication between the Controller level of a process automation system and the decentralized periphery in the field, also intrinsic safety (RS485-IS) via DP-Ex barriers into hazardous area. One feature of PROFIBUS DP is its scalable high speed of transmission up to 12 Mbit/s.

PROFIBUS PA: extension for Process Automation

This PROFIBUS variant was developed for the process industry. PROFIBUS PA interacts with a fix transmission rate of 31,25 kbit/s and is designed for connection of bus-powered 2-wire field devices such as transmitters and actuators.

It correspond to IEC Standard 61158-2 and can be also applied to intrinsically safe installations (EEx i) in Zone 1 / Div.1.

Linking Devices are used to integrate PA bus lines into the PROFIBUS DP network. This ensures that all information is available in a continuously connected network through the complete PROFIBUS system (DP and PA).

PROFIBUS Technology Terms

ISO/OSI Reference Model

In accordance with the international ISO/OSI model, a fieldbus protocol can be uniquely described by means of up to 7 transmission levels. Specific tasks are assigned to each level in this system. PROFIBUS DP and PROFIBUS PA use only the first two levels as well as the user interface, which resides in level 7 and where application functions that can be utilized by the user are determined along with system and device behavior. Level 1 defines the physical aspect of transmission (physical layer). This includes, for example, the method of transmission, the transmission medium, and lengths of lines, while level 2 specifies the bus access protocol (data link layer).

Bus Access Control

The bus access control (MAC, Medium Access Control) is a specific procedure that determines at which point in time a PROFIBUS device can send data. While active devices (master) can start the exchange of information, passive devices (slaves) may only begin communication when prompted by an active device. A distinction is made between a controlled, deterministic access procedure with real-time capabilities (master-slave with PROFIBUS) and a random, non-deterministic access procedure (CSMA/CD with Ethernet)

Addressing

Each device, connected to a PROFIBUS network, needs an unique address for selectively identify a field device. For this purpose, PROFIBUS device addresses are assigned either by an address switch (hard addresses) or by parameter assignment during commissioning (soft addresses).

A 7-bit device address serves to identify the bus participants in the network. The addresses range from 0 to 127, and the following are reserved:

- Address 126: default for automatic address assignment via the master;
- Address 127: sending broadcast telegrams.

If the address 0 is used for the class-1 master, the addresses 1 to 125 are available for addressing the field devices. Therefore up to 126 DP or PA field devices (master and slaves) can be addressed. Each address can only be used once in a single PROFIBUS network.

Communication Protocols

At the protocol level, PROFIBUS offers a broad spectrum of options, which enables optimum communication between different applications. PROFIBUS DP is a fast and deterministic process data exchange between a PROFIBUS master and the assigned slave devices.

Presently the basic and extended functions supported with AC 800M/CI854(A) are:

- Basic function (V0):
  - Cyclic data transfer
  - Diagnostic
  - Configuration via GSD files
- Extended function V1:
  - Acyclic data transfer
  - Alarm handling (planned, but not supported yet)
  - FDT/DTM device management
  - Function blocks acc. IEC 61131-3

Transmission Technology Overview

Table 1. Transmission technologies at PROFIBUS

	RS485	RS485-IS	MBP	Fibre Optic
Data transmission	Digital, differential signals according to RS485, NRZ	Digital, differential signals according to RS485, NRZ	Digital, bit-synchronous, Manchester coding	Optical, digital, NRZ
Transmission rate	9,6 to 12000 kbit/s	9,6 to 1500 kbit/s	31,25 kbit/s	9,6 to 12000 kbit/s
Data security	HD=4, Parity bit, start/end delimiter	HD=4, Parity bit, start/end delimiter	Preamble, error-protected, start/end delimiter	HD=4, Parity bit, start/end delimiter
Cable	Shielded, twisted pair copper, cable type A	Shielded, twisted 4-wirer, cable type A	Shielded, twisted pair copper	- Multimode glass fibre, - single mode glass fibre - PCF - plastic
Remote feeding	Available over additional wire	Available over additional wire	Optional available over signal wire	Available over hybrid line
Protection type	None	Intrinsic safety (EEx ib)	Intrinsic safety (EEx ia/ib)	None
Topology	Line topology with termination	Line topology with termination	Line and tree topology with termination; also in combination	Star and ring topology typical, line topology possible
Number of stations	Up to 32 stations per segment without repeater, up to 126 stations with repeater	Up to 32 stations per segment without repeater, up to 126 stations with repeater	Up to 32 stations per segment, total sum of max 126 per network	Up to 126 stations per network
Number of repeaters	Max. 9 repeater with signal refreshing	Max. 9 repeater with signal refreshing	Max. 4 repeater	Unlimited with signal refreshing (time delay of signal)

FISCO (Fieldbus Intrinsically Safe Concept)

To render the proof of Intrinsic Safety as simple as possible, the so-called FISCO model was developed. FISCO stands for Fieldbus Intrinsically Safe COncept. The German Federal Physical Technical Institute (PTB) developed the FISCO model and has published it in Report PTB-W-53 "Examination of intrinsic safety for fieldbus systems“.

This model is based on the following prerequisites:

To transmit power and data, the bus system uses the physical configuration defined by IEC 61158-2. This is the case for PROFIBUS PA.

- Only one active source is permitted on a bus segment (in this case the Linking Device). All other components work as passive current sinks.
- The basic current consumption of a bus station is at least 10 mA.
- It must be ensured for each bus station that
  - Ui> Uo of the Linking Device/Power Link
  - Ii> Io of the Linking Device/Power Link
  - Pi> Po of the Linking Device/Power Link.
- Each bus station must fulfill the following requirement:
  - Ci < 5 nF
  - Li < 10 µH
- Total length of the PA segment, incl. spurs, to be kept
  - when using passive T-junctions in EEx ia IIC applications ≤ 1000 m
  - when using Multibarries or in non intrinsically safe areas ≤ 1900 m
- The permissible spur line length for Ex applications is 30 m per spur line. The definition of the spur line must be observed in this connection.
- The transmission line that is used must conform to the following cable parameters:
  - resistor coating: 15 Ohm/km < R’ < 150 Ohm/km
  - inductance coating: 0.4 mH/km < L’ < 1 mH/km

  – capacitance coating: 80 nF/km < C'< 200 nF/km (including the shield)

- Taking the shield into consideration, the capacitance coating is calculated as follows:
  – C' = C'conductor/conductor + 0.5 * C'conductor/shield if the bus line is potential free

    or

  – C' = C'conductor/conductor + C'conductor/shield if the shield is connected with a pole of the Linking Device/Power Link.
- The bus segment must be terminated on both ends of the line with a fieldbus terminator. According to the FISCO model the terminal bus resistance must conform to the following limits:
  – 90 Ohm < R < 100 Ohm
  – 0 µF < C < 2,2 µF

On condition that the points are **all** satisfied, the proof of intrinsic safety has been provided by means of the FISCO model. Devices that are certified in accordance with FISCO are proven to be intrinsically safe and can be used in a plant's hazardous areas without the need for additional calculation effort. If FISCO-approved devices are used, more devices can be operate on a single line and it is allowed to replace devices during runtime by devices of other manufacturer or to expand the bus line with additional devices.

The prerequisite for being allowed to bear the proof of intrinsic safety in accordance with the FISCO Model is, that the Linking Device **and** all fieldbus stations are certified according to FISCO.

Section 2 Transmission Technology

PROFIBUS is an industrial communication system that uses a range of media such as copper cable, fibre optics or wireless, with bit-serial transmission for coupling smart field devices to a control system.

This chapter describes the transmission technologies mostly used in connection with the AC 800M Controller. PROFIBUS provides different transmission technologies, based on international standards such as IEC 61158 and IEC 61784, which describes the digital data communications for measurement and control in fieldbus networks.

RS485 Transmission Technology

RS485 is the most commonly used transmission technology for PROFIBUS DP. It uses a shielded twisted pair copper cable and enables transmission rates up to 12 Mbit/s. Because of its simply installation it is cost-effective and requires no expert knowledge.

The bus structure allows adding or removing of field devices as well as step by step commissioning without influencing the system. Later extensions have no impact on devices that are already working on the bus. RS485 is scalable in its transmission rate from 9,6 kbit/s up to 12 Mbit/s, which is set in the PROFIBUS master.

AC 800M and CI854(A)

In connection with the AC 800M Controller, the Communication Interface CI854(A) interacts as PROFIBUS master and builds up a PROFIBUS network with RS 485 technology. Up to 12 CI854(A) modules can be placed at one AC 800M Controller and each interface works as a single PROFIBUS master, which can be configured with its own transmission rate. Supported transmission rates are 9.6; 19.2; 93.75; 187.5; 500; 1500; 3000; 6000 and 12000 kbit/s. Not support are the transmission rates 31.25 and 45.45 kbit/s. The default value is 1.5 Mbit/s. Higher values require careful consideration of correct cable installation. The PROFIBUS configuration tool within the 800xA system is the Control Builder M. This tool calculates the bus timing parameter and checks the configuration values, inserted by the user. For example a compilation warning occurs if a slave does not support the selected transmission rate. In this case the next lower supported transmission rate will be selected automatically. Changing the transmission rate may also require changing of other bus parameters to ensure successful communication. The automatic calculation will determine the right settings. The adjusted speed is valid for all connected devices on the bus, when commissioning the system.

A detailed description of the AC 800M and CI854(A) is available in their specific product manuals.

RS485 cable type and speed

The maximum permissible bus length depends on the transmission rate and the bus cable type. Different cable types (designation A to D) for different applications are available for connecting PROFIBUS devices either each other or to network elements (Linking Devices, Repeaters).

The electrical lines are shielded twisted two-wire cables with a circular cross-section. The RS 485 interface operates on voltage differences. It is therefore less sensitive to interference than a voltage or current interface. Depending on the transmission speed, segments can be implemented in lengths of from 100 meter to over 1000 meter. The bus cable to be used for the bus modules is specified in DIN 19245/EN 50170 as cable type A and can be used according to the following table:

Table 2. Basic data for a PROFIBUS DP reference cable

Parameter	**DP, Cable type A**
Cable design	Twisted pair and shielded
Surge impedance	135 ... 165 Ohm at f=3 ... 20 MHz
Operating capacity	=< 30 pF/m
Loop resistance	=< 110 Ohm/km

Table 2. Basic data for a PROFIBUS DP reference cable

Wire diameter	> 0.64 mm
Wire cross-section	> 0.34 mm^2

Project-specific requirements and limitations such as underground wiring, UV resistance, being free of halogen, etc. should be considered when selecting the cable. Cables may be used with deviate mechanically or electrically from the type A cable, but the surge impedance must be retained.

Note that cable for laying underground is not suitable for connecting to PROFIBUS connectors because of the typically 10 mm diameter of the coating. They can therefore only be connected to screw terminals of PROFIBUS devices.

Depending on the ambient EMC conditions, EN 50170 also allows for laying of unshielded cable. However, the following reasons argue in favour of always using shielded cable:
The only interference-free space is inside the switch cubicle, at best. As soon as a relay is located within the switch cubicle, this is no longer the case.
Unshielded cable requires additional protective measures at the bus inputs to protect against voltage overload.

From the line parameters specified above result the following bus segment lengths:

Table 3. Dependencies of bus length and transmission rate

Transmission rate in kbit/s	9.6	19.2	93.75	187.5	500	1500	12000
Range in m/segment	1200	1200	1200	1000	400	200	100

In a PROFIBUS DP installation, it must be chosen a data transfer rate which is supported by all devices connected to the bus. The chosen data transfer rate then determines the maximum segment lengths as shown above.

If other transmission rate shall be used which is not listed in the table above, an approximation can determine the permissible length through linear interpolation of two adjacent transmission rates from the table.

Calculation of a bus length against of two transmission rates:

A transmission rate of 3 Mbit/s shall be used. The transmission rates in the table close to this value are 1.5 Mbit/s with $l_{1,5Mbit/s}$ and 12 Mbit/s with $l_{12Mbit/s}$. Thus, you can calculate the line length $l_{3Mbit/s}$:

$$l_{3\text{Mbit/s}} := l_{1.5\text{Mbit/s}} + (3Mbit/s - 1.5Mbit/s) \times \frac{l_{1.5Mbit/s} - l_{12Mbit/s}}{1.5Mbit/s - 12Mbit/s}$$

$$l_{3\text{Mbit/s}} \approx 185m$$

RS485 network limits

Up to 32 nodes (master and slaves) can be grouped in a single segment. When using more than 32 nodes, several segments linked to each other through repeaters (power amplifiers) are needed. Note that the repeater has to be considered as another bus node, since the integrated bus drivers are an additional load on the bus. It is recommended to use not more than three series-connected repeaters on a line. However, the number of repeaters in a single PROFIBUS network is limited to 9.

The maximum admissible distance between two bus stations in each PROFIBUS network can be calculated as follows:

(Number of repeater + 1) * Segment length

Number of repeater = The maximum number of repeaters connected in series.

Example: The repeater manufacturer's specifications allow nine repeaters to be connected in series.

The maximum distance between two bus stations at a data transfer rate of 1500 kbit/s is then as follows:

=> (9 + 1) * 200 m = 2000 m

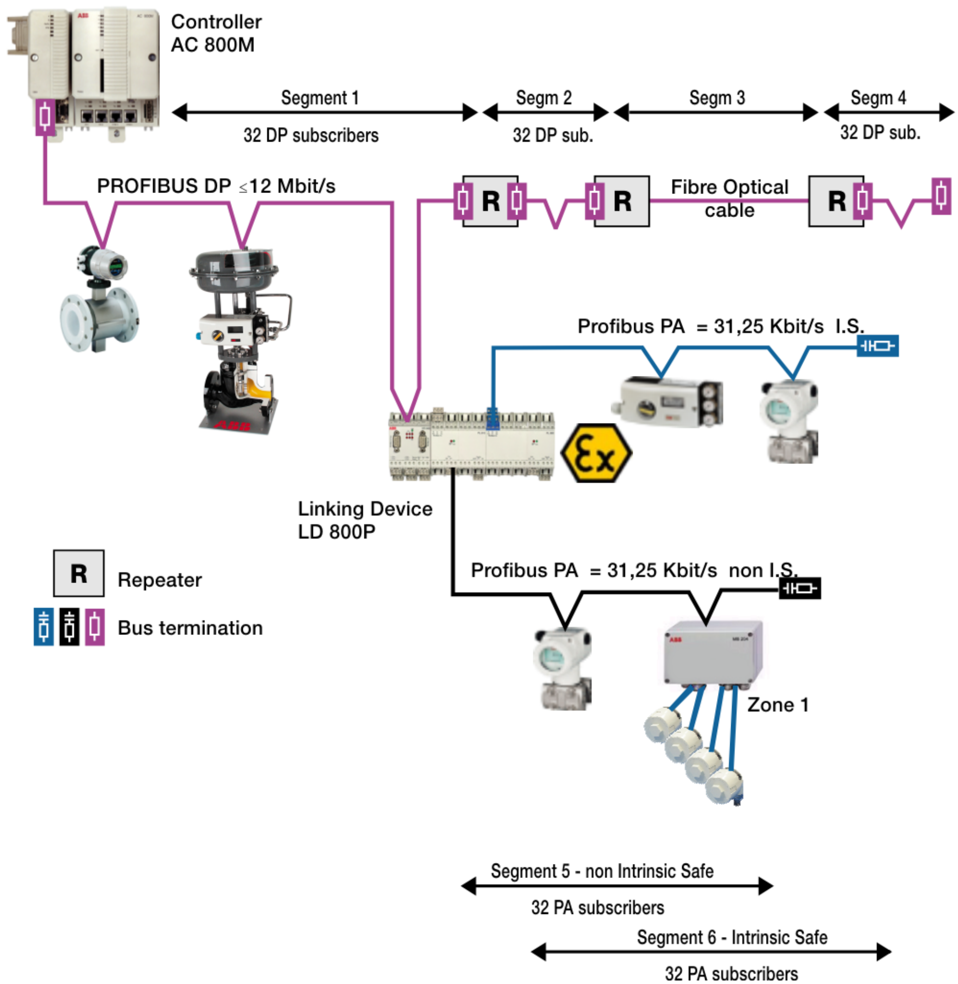


Figure 2. RS485 network limits

Adding field devices to the RS485 network

A shielded twisted-pair copper cable is the hardware required for RS485 transmission. It connects all devices to the bus structure (line). The bus structure allows for non-reactive coupling and decoupling of stations or step wise commissioning of a system. Later extensions have no impact on stations that are already working on the bus.

When connecting the field devices it must be ensured that the data lines are not reversed. Always use a shielded data line to ensure high interference immunity of the system against electromagnetic emissions. The shield should be grounded on both sides and large-area shield clamps should be used for grounding to ensure good conductivity. Furthermore the data lines should be laid separately and away from all power cables. Never use spur lines for transmission rates ≥ 1,5 Mbit/s (see also Line Topology with spurs on page 60).

A 9-pin D-Sub connector is primarily used to connect PROFIBUS devices on the bus, which complies with DIN 19245/ EN 50170. Normally connectors are used, which supports direct connection of the incoming and outgoing data cable.

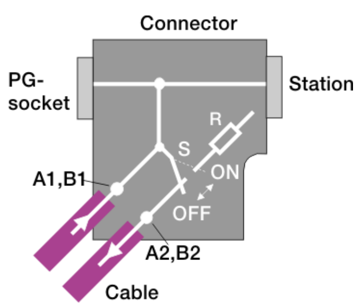


Figure 3. PROFIBUS connector

This eliminates the need for spur lines and the bus connector can be connected and disconnected to the field device at any time without interrupting data communication. The type of connector suitable for RS485 transmission technology depends on the degree of protection.

To avoid signal reflections on the bus line, the line structure must be terminated by a bus termination resistor network at either end. The bus is terminated at each end of a segment with an active bus termination. Both bus terminators have a permanent power supply to ensure error-free operation. The bus terminator is usually switched in the devices or in the connectors.

RS485 cycle time calculation

The bus cycle time should be shorter than the AC 800M program cycle time. However, a faster data throughput alone is not enough for successful implementation of a bus network. PROFIBUS DP only requires approx. 1 ms at 12 Mbit/s for the transmission of 512 bits of output data distributed over 32 stations. The following figure shows different bus cycle times of a DP mono-master system with 2 bytes in and output data per slave:

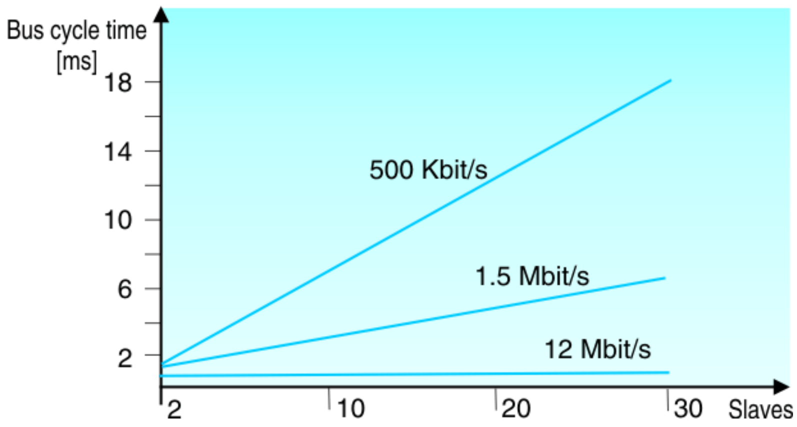


Figure 4. Bus cycle times of a DP mono-master system.
Boundary conditions: each slave has 2 bytes of input and output data

Each PROFIBUS master configuration tool (for example Control Builder M) automatically calculates the bus cycle time. The detailed calculation rules are described in the PROFIBUS specification.

RS485 installation recommendation

Problems with data transmission in PROFIBUS networks can be attributed to incorrect wiring or installation. These problems can often be solved using bus test equipment such as bus monitors, which are able to detect many typical wiring errors even before commissioning.

The list below helps to build up a RS485 network quick and accurate:

- Only use shielded and twisted-pair wiring as a RS485 bus line.
- Use a PROFIBUS bus connector plug to connect the RS485 bus segment.
- If the module is at the beginning or end of a bus segment, this connector must have an activated bus terminal resistor combination.
- Ensure that the bus segment connected to the RS485 interface is terminated at both ends.
- All PROFIBUS bus connector plugs in a network must be securely screwed onto the RS485 interfaces.
- Attaching or removing the bus connector plugs, inadequately attached bus connector plugs or loose bus wires within the plug can lead to malfunctions in the networks.
- Attach or remove the RS485 bus connector plug quickly and without twisting them.

RS485-IS Transmission technology

The RS485-IS transmission technology is based on RS485 with its fast transmission rate and simple usage, but additional for installation in intrinsically safe areas. RS485-IS is specified as a 4-wire medium in protection type EEx-i for use in potentially explosive areas. Therefore the specified level of power refer to the safety-relevant maximum values must not be exceeded in either individual devices or during interconnection in the system. An electrical circuit permits maximum currents at the specified voltage level. With RS485-IS all stations represent active sources, which is in contrast to the FISCO model, that only has one intrinsically safe source. Also it is possible to connect up to 32 devices to the intrinsically safe bus circuit.

More information about this technology is given in the guidelines and specification from the PROFIBUS International organization (http://www.profibus.com).

MBP (IEC 61158-2) Transmission Technology

The MBP transmission technology (Manchester Coded, Bus Powered), which is the new naming for the previous designation “IEC 61158-2 Physics”, is mostly used for applications in the process automation with a requirement for bus powering and intrinsic safety of devices. The reason for this name change is that, in its definitive version, the IEC 61158-2 describes several different connection technologies, including MBP technology, not being therefore unambiguous. Compared to the previously used procedure RS485-IS, the **F**ieldbus **I**ntrinsically **S**afe **Co**ncept (FISCO), which was specially developed for interconnection of intrinsically safe field devices, considerably simplifies planning and installation.

MBP cable type and speed

MBP is synchronous transmission with a fixed transmission rate of 31.25 Kbit/s and Manchester coding. This allows installation of PROFIBUS networks also in potentially explosive areas and be intrinsically safe. The intrinsically safe transmission technology MBP is usually limited to a specific segment (field devices in hazardous areas) of a plant, which is then to the RS485 bus line via PROFIBUS DP/PA Linking Device.

Tree or line structures as well as any combination of the two are supported by PROFIBUS with MBP transmission. The transmission medium for MBP is a shielded two-wire cable, normally covered by an black color cable sheath for non intrinsically safe areas and blue color for hazardous areas. The maximum permissible spur line lengths must be taken into account when calculating the overall PROFIBUS line length. In intrinsically safe applications a spur line has a maximum permissible length of 30m.

Table 4. Basic data for the PROFIBUS PA reference cable

Parameter	PA, Cable type A
Cable design	shielded twisted pair
Conductor cross section (nominal)	0,8 mm²
Loop resistor (direct current)	44 Ohm/km
Wave resistance at 31,25 kHz	100 Ohm ±20%
Wave attenuation at 39 kHz	3 dB/km
Capacitive asymmetry	2 nF/km
Group runtime distortion (7,9 ... 39) kHz	1,7 µs
Covering level of the shield	90%

The bus trunk cable has a passive line terminator at each end.

The Power Link Modules of the PROFIBUS Linking Device LD 800P possess an integrated bus terminator, which terminates the PROFIBUS PA line unilaterally and therefore eliminates the need for a separate bus terminator on the Power Link Modules. (see also PROFIBUS DP/PA Linking Device LD 800P on page 40

MBP network limits

The maximum of connected devices per single segment is limited to 32. This is a theoretical value, because this number can be further determined by the protection type selected and the bus power.

In intrinsically safe applications the power (maximum voltage and current) is defined with strict limits. For example the current in hazardous area's restricted to 100 mA and in non intrinsically safe networks to 400 mA. To determine the maximum line length, is necessary to calculate the power consumption of the connected devices and to specify a power supply and the line length for the selected cable type (see also MBP power and line length calculation on page 36).

The required current is summarized from the power consumption of all connected field devices plus a reserve of 9 mA per segment for the operating current of the FDE (Fault Disconnection Electronics). The FDE prevents faulty devices permanently blocking the bus.

Table 5. Limits of MBP networks

	intrinsically safe	**non intrinsically safe**
Measurement voltage	12,6 V ... 13,4 V	24 V ... 26 V
Measurement current	100 mA	400 mA
max. PROFIBUS PA slaves	10	32
max. line length	1000 m	1900 m

The maximum line length of the network comprises the total of the main line (trunk) and all spur lines.

A PROFIBUS PA field device requires a minimum input voltage of 9 V. With an unfavorable distribution of stations, for example if all PROFIBUS PA stations are widely removed from the Linking Device, it can happen that the voltage drop along the line is so great that the voltage level at the end is insufficient. This results in a shortening of the transmission line or the necessity of using cable with a larger cross-section.

MBP power and line length calculation

The distribution of stations on the PROFIBUS PA segment can have a negative effects on the maximum possible line length in certain circumstances. The following example is intended to clarify this point:

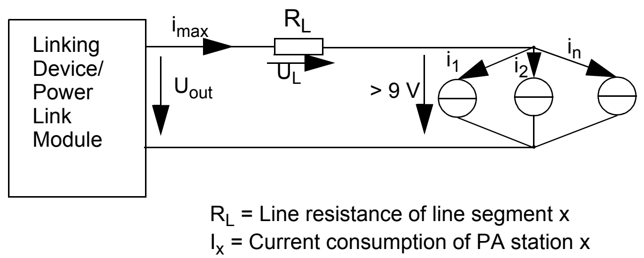


Figure 5. Voltage calculation and line length

The case in question is an Ex application. The result of the current calculation is that a maximum direct current including I_{FDE} of 100 mA is flowing. Type A cable is being used with a resistance coating of 44 Ohm/km.

A requirement for a PROFIBUS PA slave to be able to function properly is that the input voltage on the bus line must be at least 9 V. The following therefore applies to the maximum voltage drop over the lead:

$U_{Lmax} = U_{out}$ - 9 V

Currently U_{out} for LD 800P with an Ex interface PL 890 is at least 12.8 V (12.8 V ... 13.4). For the worst case consideration, U_{out} should be set to 12.8 V. This results in:

U_{Lmax} = 12.8 V - 9 V = **3.8 V**

Since all stations are connected at the end of the line, the maximum line resistance must be

$R_L = U_L/i_{max}$

R_L = 3.8 V / 100 mA = 38 Ohm

The maximum line length of the PROFIBUS PA segment is calculated as follow:

Max. line length = 38 Ohm / 44 (Ohm/km) = 0.863 km

Max. line length = 863 m

Since in practice the stations are not all connected compactly at the end of the transmission line, the resulting structure is as follows:

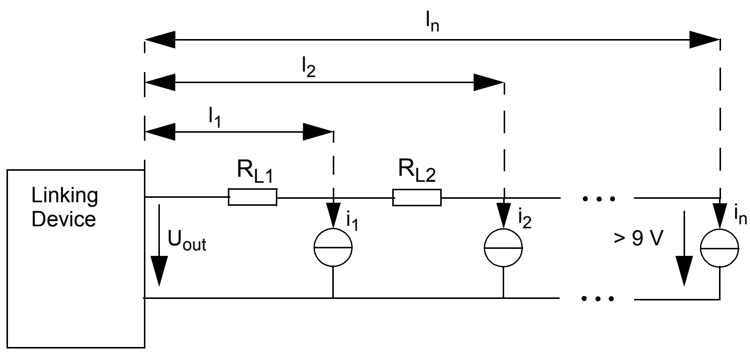


Figure 6. Voltage calculation and line length

Each station causes a voltage drop on the length segment through which its power supply current flows. For the first station, this would be:

$U_{RL1} = i_1 * R_{L1}$ or $U_{RL1} = i_1 * l_1 * r$; where r = the resistance coating of the line

For the second station, this appears as follows:

$U_{RL2} = i_2 * (R_{L1} + R_{L2})$ or $U_{RL2} = i_2 * l_2 * r$

In general, the equation for Ex applications is then as follows:

– $U_{RL} = r * \Sigma (i_x * l_x) < U_{out} - 9$ V

If the condition described above is not fulfilled,

a) the line has be shortened or

b) a line with reduced resistance coating has to be used.

When selecting the type of line, make certain that for Ex applications the requirements in terms of insulation voltage and single conductor insulation of EN 60079-14 and the characteristic values in accordance with the FISCO model are maintained.

Adding field devices to the MBP network

PROFIBUS PA devices are mostly connected to the network by using multibarries or T-junctions. The resulting spur has to be connected directly to the connector block inside the device. Sometimes also M12 plugs are used to connect the device to the network (see also Bus connector on page 67).

When using MBP technology, incorrect connection of a field device (for example polarity reversal) has no effect on the functionality of the bus as these devices are usually fitted with an automatic polarity detection function.

The Manchester signal used by fieldbus is an alternating voltage that changes polarity once or twice per bit. In self-powered networks only this alternating voltage exists.

In powered networks the alternating voltage is superimposed onto the DC voltage being used to power the devices. In either case, the fieldbus receive circuits look at only the alternating voltage. Positive voltage swings have one meaning, negative swings have the opposite meaning. Therefore, the fieldbus signal is polarized. Field devices must be connected so that they all see the signal in correct polarity. If a field device is connected “backwards” it will see an inverted version of the alternating voltage and won’t be able to communicate. However, there are non-polarized field devices available. This field devices can be connected in either polarity across the network. The non-polarized devices are invariably network-powered, which provides a clue as to how they can work with either polarity.

If a fieldbus network is build up to accept all possible devices, the signal polarity must be taken into account. All of the (+) terminals must be connected to each other. Similarly, all of the (-) terminals must be connected to each other. Color-coded wire makes this relatively easy. Polarized devices should always be marked or have keyed connectors. Non-polarized devices might not be marked. It may be possible to select devices with the intention of never having to consider polarity. But it may be safer to build polarity into the network at the outset and accept as a bonus any devices that can be blindly connected. This approach also lets to expand the network with polarized devices if needed later on. Bus powered field devices may also be polarized with respect to device power. These devices are designed so that signal polarity and power polarity are the same. Connecting the +DC to the (+) terminal automatically insures correct signal polarity. Non-polar bus powered field devices accept both signal and power of either polarity.

MBP cycle time calculation

The PROFIBUS-PA data telegrams of the MBP transmission is very similar to asynchronous RS-485 transmission. While the bytes are transmitted asynchronously in the form of UART characters over the RS 485 line, the transmission on the MBP segments is bit synchronous. Here, the telegram is additionally supplied with the preamble and the start and end delimiter.

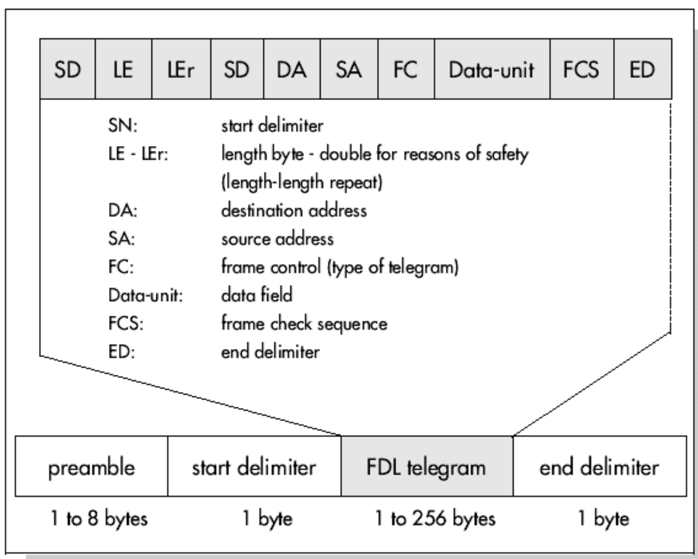


Figure 7. MBP data telegram

Fieldbus Data Link (FDL) defines the following telegrams:

- Telegrams without data field (6 control bytes)
- Telegrams with one data field of fixed length (8 data and 6 control bytes)

- Telegrams with a variable data field (0 to 244 data bytes and 9 to 11 control bytes)
- Brief acknowledgement (1 byte)
- Token telegram for bus access control (3 bytes)

With all data transmissions, the parity and block checking of the telegrams is used to reach a Hamming distance of HD=4, so that up to three errors can be detected with certainty.

A transmission rate of 31.25 kbit/s results in transmission times of 0.4 to 8.2 ms per telegram so that per user data byte an average of 0.4 ms and 34 ms is required.

This data transmission rate is sufficient, for example, to serve 10 control loops - including 10 sensors and 10 actuators respectively - within a control cycle time of approx. 210 milliseconds.

During the evaluation, it was assumed that only one cyclic value (5 bytes user data) must be transmitted per device. With each additional value, the minimum cycle time increases by (5 x 8 bits)/(31.25 kbit/s) = 1.3 ms.

For a first estimate, the following formula can be used:

cycle time ≥ 10 ms * number of devices
+ 10 ms (for acyclic class-2 master services)
+ 1.3 ms (for each additional cyclic value)

PROFIBUS DP/PA Linking Device LD 800P

Linking Devices are needed to connect PROFIBUS DP to PROFIBUS PA and vice versa. The PROFIBUS master module CI854(A) is designed exclusively for the connection of PROFIBUS DP nodes in RS485 technology. To link a PROFIBUS DP line to a PROFIBUS PA line, it is recommended to use the Linking Device LD 800P. The LD 800P Linking Device converts the physical bus characteristics of the RS 485 interface for PROFIBUS DP into PROFIBUS PA physical bus characteristics MBP according to IEC 61158-2, enables connected PROFIBUS PA devices to be supplied with power via the bus, and allows use in hazardous areas if so required.

Figure 8. PROFIBUS DP/PA Linking Device LD 800P

LD 800P performs the following tasks:

- Potential separation between the PROFIBUS DP and the PROFIBUS PA
- Conversion of the RS 485 physical arrangement of the PROFIBUS DP to the physical arrangement based on IEC 61158-2 of the PROFIBUS PA.
- Support of all standardized PROFIBUS transmission rates from 45.45 kbit/s up to 12Mbit/s
- Automatic detection of transmission rate
- Fully transparent in the PROFIBUS line
  - No configuration and commissioning
  - Direct access from PROFIBUS DP master to PROFIBUS PA slaves
  - Support of all cyclic and acyclic PROFIBUS protocol services (DP/V1)
  - No restriction in PROFIBUS data volume with full 244 Byte read/write access to each PA slave
- Optional PROFIBUS DP line redundancy
- Power Link Modules integrate bus termination, galvanic isolation and power supply
- Powering of PROFIBUS PA segments without additional power supply
- Optional Power Link Module with intrinsically safe interface [EEx ia] IIC

For more details, please read the LD 800P product documentation.

Fibre Optic Transmission Technology

Fibre-optic transmission is suitable for use in areas with high electromagnetic interference or where greater network distances are required. The PROFIBUS guideline (2.022) for fibre optic transmission specifies the technology available for this purposes. When determining these specifications, great care was naturally taken to allow problem-free integration of existing PROFIBUS devices in a fibre optic network without the need to change the protocol behavior of PROFIBUS.

All familiar network structures such as point-to-point connections, line and star structures as well as single-fiber ring or double-fiber ring can be set up with PROFIBUS. Mixed structures combining electrical and optical networks are possible. The transition between the two media is provided by an optical link module, which convert the RS485 to fibre optic transmission technology. In the communication between the stations on the bus, there is no difference between two-wire and fiber-optic technology.

Optical link modules mostly supports all the transmission rates defined in the EN 50170 standard.

Fibre optics cable type and speed

Fibre optics is an additional transmission technology for PROFIBUS DP. It uses a glass or plastic fibre cable and enables transmission rates in steps from 9.6 kbit/s to 12 Mbit/s, depending on the hardware. Fibre optic networks are mostly used in connection with RS485 to increase network distances of PROFIBUS DP, to avoid communication errors in areas with high electromagnetic interference or just to ensure galvanic insulation between different hardware units (master, slaves) connected to an RS485 networks. The fibre optic transmission technology is usually limited to a specific segment of a plant, which is then connected to the RS485 bus line via RS485/fibre optic converter.

Table 6 shows the different cable types, wave lengths and maximum distances, reachable with the certain fibre media.

Table 6. Basic data for fibre optic cable

Media	Wavelength	Fibre/Sheath diameter	Max. distance	Path attenuation
Plastic fibre	660 nm	980/1000 µm	0 ... 80 m (increased)	0.25 dB/m
Multi mode glass fibre	860 nm	50/125 µm 62.5/125 µm	0 ... 2 km 0 ... 2.8 km	3 dB/km 3.5 dB/km
Single mode glass fibre	1310 nm	62.5/125 µm 10/125 µm	0 ... 10 km 0 ... 15 km	1 dB/km 0.5 dB/km
PCF (HCS™)	1530 nm	200/230 µm	0 ... 30 m	5 dB/km

The path attenuation per km or meter is derived from the difference between the total admissible path attenuation minus the system reserve divided by the distance involved. The data in parentheses are (total path attenuation / system reserve).

In a ring structure (see Redundant Optical Ring on page 52), the maximum bridgeable distance between two components is a function of the transmission rate. A maximum of 15 km can be bridged at a transmission rate of 9.6 kBit/s; at 1.5 MBit/s, only 530 meters

For electrical media (half-duplex), an error in a single wire of the two-wire cable blocks data transfer for both transmission directions. To get the same functional behavior in case of a disturbed optical medium, the FO converter (full-duplex) must be able to switch off the receiver port when detecting an error at the transmit port and vice versa. Also hybrid cable, copper cables and fiber optic cables contained in one cable, are available. This means that by using hybrid cables the data and the power supply can be transferred together with one cable.

Fibre optic network limits

Fibre Optic transmission technology is mainly used to expand the existing RS485 technology over its distance limits and to prevent communication errors in EMC areas. However fibre optics are as well as RS485 limited in the distance and the transmission speed, depending on the used hardware and the cable type.

Between the DP/fibre optic converter are no PROFIBUS slaves connected.

PROFIBUS DP slaves are always connected to the RS485 network. Fibre optic transmission technology has to be converted in RS485 technology before, if DP slaves shall be connected.

There are several RS485/fibre optic converter available from different manufacturer. ABB recommends RS485/fibre optic converter from Hirschmann (OZD Profi 12M) and Phoenix Contact (PSI-MOS-PROFIB/FO). Optical link modules described in this document are based on the Hirschmann RS485/fibre optic converter. However, the components from Phoenix Contact are working in the same way as Hirschmann RS485/fibre optic converter.

Fibre cable types and its maximum distance are already described in Table 6.

Monitoring of the communication quality

Optical link modules mostly provide segment monitoring at the RS485 and fibre optic port.

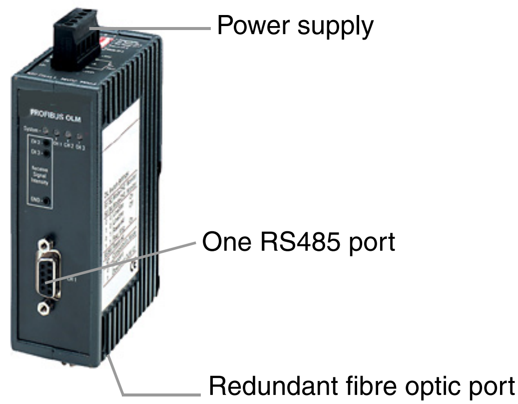


Figure 9. Optical link module with 1 RS485 port and redundant fibre optic ports

The following description of monitoring functionality can be build up with the optical link modules from Hirschmann and Phoenix Contact. Optical link modules from other manufacturer does not always support this functionality.

If the operating mode ”Electric port with segment monitoring“ is set at the RS485 port, each receiver monitors the RS485 bus segment connected to it for faulty frames or continuously busy networks. If faulty frames are received by the receiver, or if the network is busy for longer than the maximum permitted send time, forwarding of the received signals is blocked until frames can be received again correctly, or if no signal is received for one second.

Line monitoring with echoes

The optical link modules enable the connected optical paths to be actively monitored for interruptions in the fiber line by means of the functions ”Send echo“, ”Monitor echo“ and ”Suppress echo“.

- Send echo
  A frame which is received by a module via any port is transmitted to all other ports. If the receiving port is an optical port, the module sends the frame back to the corresponding optical sender.
- Monitor echo
  If a module sends a frame - no echo! – to an optical port, the module expects to receive an echo. If the echo is not received after a predefined time, an echo monitoring error is indicated.
- Suppress echo
  The relevant receiver is separated from the other ports from the moment a frame is sent until the echo has been received correctly.

Segmentation

If an echo monitoring error or a frame falsification arises at an optical port, the module assumes that the line is faulty and blocks this port for user data. The connected field bus partial network is then segmented (cut off). This segmentation causes the module at the other end of the optical fiber to be segmented as well.

Both modules connected to the segmented field bus partial network send test frames to the segmented ports. These test frames – which are to be received regularly – can be used by both modules to check the status of the field bus partial network. The segmentation is automatically lifted as soon as the test frames indicate to both modules that the segmented field bus partial network is no longer disturbed. If all active bus subscribers are deactivated in a previously active network, the modules are segmented cyclically in order to check the fiber links to the neighboring modules.

The next paragraph in this document describes the monitoring function within a certain fibre optic topology.

Basics of fibre optics topology technologies

Fibre optics topology technologies is part of Fieldbus Topologies with fibre optics on page 84. However, to understand the basics of the fibre optic transmission technology, the next pages show main topologies supported by fibre optics.

Line Topology

In a line structure, the individual optical link modules are connected together by dual-fiber optical fibers (transmit/receive fibres). Modules with one optical port are sufficient at the beginning and end of a line, between then modules with two optical ports are necessary. If single point-to-point connections are to be built up, this can be achieved using two modules each with one optical port.

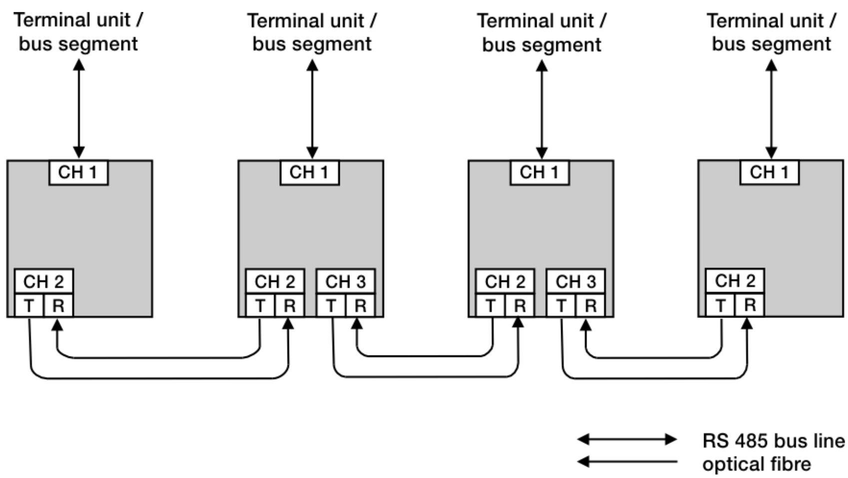


Figure 10. Network structure in an optical line topology

This operating mode should preferably be used if an interrupted fiber segment is to be separated from the rest of the network.

The following monitoring mechanisms shall be set on the optical link modules:

- Send echo: yes
- Monitor echo: yes
- Suppress echo: yes
- Monitor: yes
- Segmentation: yes

In this operating mode the individual fiber links are monitored by the two connected modules.

If a module fails, an optical fiber breaks or faults are determined on the optical transfer link, the fiber link between the two optical link modules is interrupted. The PROFIBUS network is divided into two partial networks, which remain functional independently of one other. The segmentation is lifted automatically as soon as both modules recognize that the field bus network is functioning correctly with the help of test frames.

If single point-to-point connections are to be built up, this can be achieved using two modules each with only one optical port.

The line topology can be realized with and without fiber link monitoring. If both operating modes are used within an optical fiber line, the operating mode ”Line topology without fiber link monitoring“ determines the availability of this fiber line. It is recommended that fiber link monitoring be used in homogeneous fibre optic networks.

If a module with two optical ports is used at the beginning or end of a line, the optical port which is not assigned must be switched to the operating mode “Line without fiber link monitoring”, so that it does not signal a break in the fiber line. Please note that optical ports which are not connected must always be fitted with protective caps to guard against extraneous light and dirt.

The following ambient conditions must be fulfilled to ensure that network configuration functions correctly:

- The parameters MIN T_{SDR} described in the PROFIBUS standard EN 50170 must be set to a value 11 on all terminals. This is usually the case, but the setting should be checked if communication malfunctions continuously arise.
- When configuring your network, select low bus subscriber addresses wherever possible. This ensures that master time-out times which may arise are kept as short as possible in the event of a malfunction.

Low bus subscriber addresses are not necessary for the bus configuration with ABB Control IT AC 800M in connection with CI854(A).

Line topology without optical fiber link monitoring

Use this operating mode if you connect an optical link module with another optical fiber network component, which does not send a frame echo and does not expect or is not compatible with a frame echo in accordance with PROFIBUS guidelines (optical/electrical converter).

Monitoring mechanisms, to be set on the optical link modules:

- Send echo: no
- Monitor echo: no
- Suppress echo: no
- Monitor: no
- Segmentation: no

Individual fiber links are not monitored in this operating.

Refer to the manufacturer’s manual of the optical link modules concerned for details about how to alter the settings.

Star Topology

In a star structure several optical link modules are combined to form an active PROFIBUS star coupler. Further optical link modules are connected to this by dual-fiber optical fiber lines (transmit/receive fibres). The modules of the star coupler are connected to one another via the electrical port (electrical star segment). Optical link modules for different fiber types (plastic, PCF, glass) can be combined using the electrical star segment.

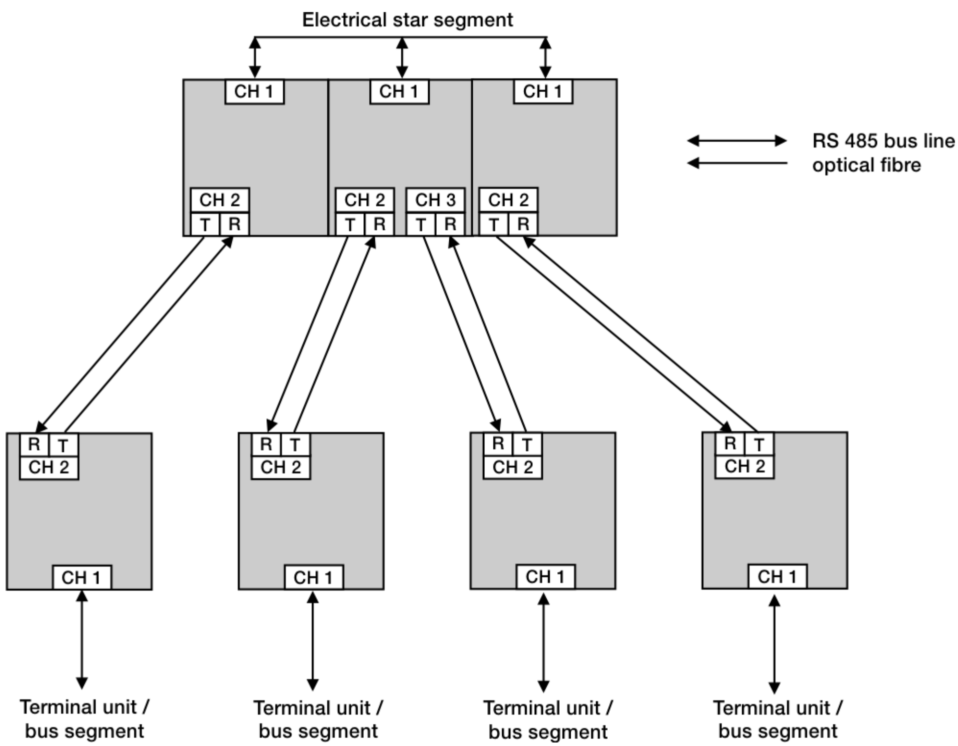


Figure 11. Network structure in an optical star topology

Please take the following recommendations into account:

- Ensure that the electrical star segment is wired carefully. Keep it as small as possible to avoid interference injection into the electrical star segment, and from here into the entire network. This can be achieved by laying out the optical link module in the electrical star segment directly next to each other on a hat rail.
- Switch on the terminating resistors in the bus port connectors at both ends of the electrical star segment.
- Do not connect a bus subscriber to the electrical star segment wherever possible.
- Modules with one or two optical ports can be used to create an active PROFIBUS star coupler. Modules with one optical port are sufficient for connecting a terminal or an RS 485 bus segment to the active star coupler.
- If the link monitoring on the optical ports is activated, the fiber optic links are monitored by the respectively connected optical link module.
- Optical ports which are not assigned (for instance, because they are reserved for a future system extension) indicate a fiber break if the link monitoring is activated. To prevent this error from being issued by activating the operating mode ”Line without fiber link monitoring “ at the non-assigned ports.
- Please note that optical ports which are not connected must always be fitted with protective caps to guard against extraneous light and dirt.

Redundant Optical Ring

The redundant optical ring structure represents a special form of line topology. A high degree of network operating safety is achieved by ”closing“ the optical line. A redundant optical ring can only be realized with modules supporting two optical ports of the same type.

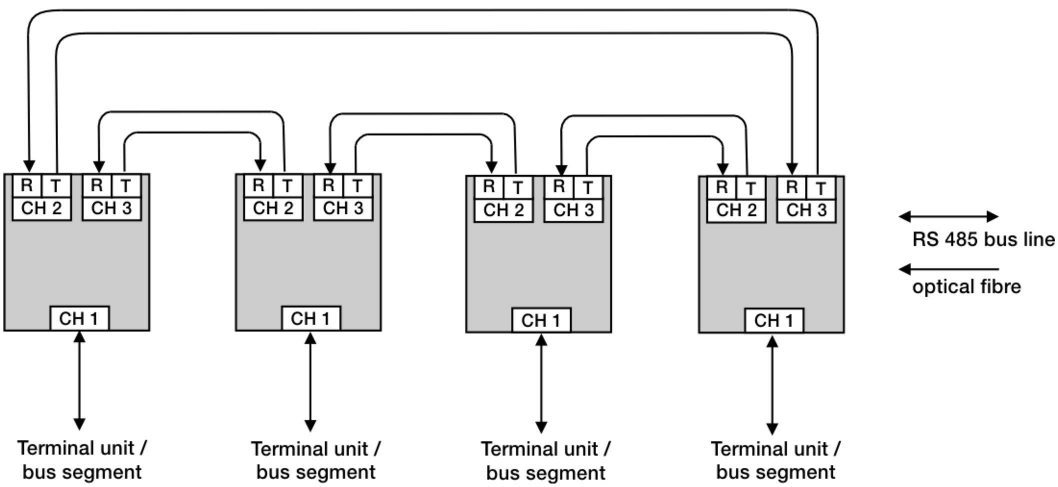


Figure 12. Network structure in a redundant optical ring topology

Monitoring mechanisms, to be set on the optical link modules:

- Send echo: yes
- Monitor echo: yes
- Suppress echo: yes
- Segmentation: yes

An interruption of one or both optical fibers between two modules is detected by the optical link module and the ring is transformed into an optical line.

If one module fails only those terminals connected to this module or the RS485 segment are uncoupled from the ring. The remainder of the network itself continues to function as a line.

The segmentation is lifted automatically as soon as both modules recognize that the segmented field bus network is functioning correctly with the help of test frames. The line forms itself into a ring.

The ambient conditions described in the topic line technology and the following conditions must be fulfilled to ensure that the network configuration functions correctly:

- The operating mode ”Redundant optical ring“ must be set at both optical ports of all the optical link modules (Hirschmann).
- All modules in a ring must be connected to one another by fiber lines. The ring may not include an RS485 bus line.
- If a redundancy case occurs (for example a line break), there is a switching time during that data cannot be correctly transmitted. In order to ensure a smooth transition, it is recommended that the frame repeat setting (Retry) on the PROFIBUS master shall be set to at least 3. After the error has been corrected, no frames should be present in the network when the optical line is transformed back into an optical ring to ensure that the process is completed smoothly. This condition can arise when a master selects a device whose address has been configured, but which does not physically exist.

The master tries to address this device cyclically and waits for a reply only until the configured slot time has been exceeded (”GAP request“). Most optical link modules recognizes this condition and closes the optical line to an optical ring in the middle of this request sequence. This results in two configuration requirements for the redundant optical ring:

- The value of the parameter **HSA** (Highest Station Address) must be set at least one value greater than the highest address of a subscriber connected to the bus segment

If this requirement is not fulfilled, the optical line will not be closed into a redundant optical ring after segmentation.

The **slot time** must be set to approximately twice the value required in a non-redundant network.

Calculation of transmission delay time T_{TD}

In case of a large PROFIBUS network with numerous optical link modules and long lines, allowance needs to be made when setting the monitoring times for the delay caused by network components and lines (transmission delay). This involves determining the transmission delay time (T_{TD}): The transmission delay time is the maximum time which elapses when transmitting a telegram on the transmission medium from transmitter to receiver.

In connection with the AC 800M and CI854(A) the T_{TD} delay time shall be added to the slot time (TSL) in the CI854(A) settings tab.

If the planning software being used to configure the PROFIBUS network does not support the PROFIBUS parameter T_{TD}, then the two times min. T_{SDR} and max. T_{SDR} are to be extended instead by 2 x T_{TD} (reaction time of responder is extended by the outward and return transmission delay time).

The first step is to determine the transmission link with the longest transfer time between telegram transmitter and receiver. No allowance is made for PROFIBUS users which do not communicate with one another (for example DP slave with DP slave).

Indicators of long transfer times are:

- Long optical fiber or copper lines
- High cascading level of active components

Delay time of optical fiber lines

The delay time is approx. 5 µs for each km of line. Converted to bit periods this gives:

Table 7. Delay times of optical fibre lines

Transmission rate in kbit/s	Delay time in tbit per km
9.6	0.05
19.2	0.10
93.75	0.47
187.5	0.94
500.0	2.50
1500.0	7.50

For calculating the line delay time, the maximum line length in km is multiplied by the delay time corresponding to the transmission rate (see table).

Delay time of Optical Link Modules

The processing time per module is 1.5 tbit. The overall processing delay results from the number of modules passed between telegram transmitter and receiver multiplied by 1.5 tbit.

Delay time of other active PROFIBUS network components

The delay time is to be taken from the respective product documentation.

Transmission delay time T_{TD}

The overall delay time is the sum total of the values determined in

- Delay time of optical fiber and RS 485 lines.
- Delay time of Optical Link Modules.
- Delay time of other active PROFIBUS network components.

Section 3 Fieldbus Topologies

Overview

Fieldbus systems are used as a means of communications for serial data exchange between decentralized devices on the field level and the controller of the process supervision level.

In addition to intelligent Transmitter and Actuators with a direct connection to the fieldbus, intelligent Remote I/Os are also used as interface systems for conventional 4...20 mA or HART field devices to record process data on the field level. All relevant signals such as input and output data, parameters, diagnostic information, configuration settings and – for a wide range of applications – the power required for operation can be carried over two wires (PROFIBUS PA).

There are several possible topologies for fieldbus networks. This section will illustrate some of these possible topologies and discuss some of the characteristics of each. Not every topology is applicable for each transmission technology like RS485 or fibre optics.

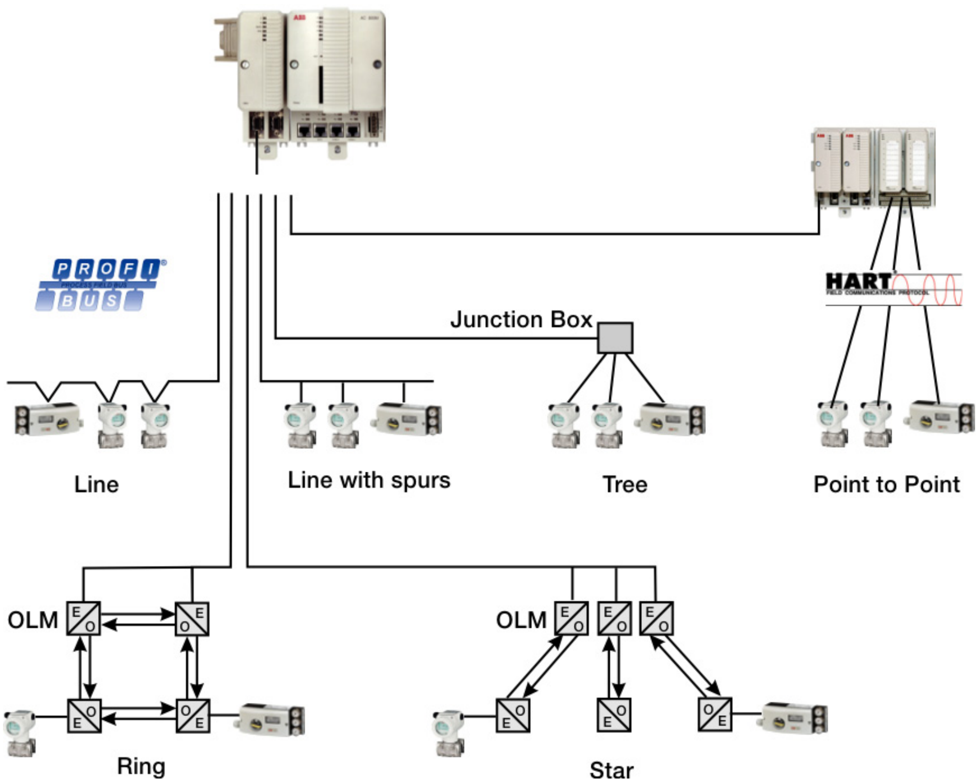


Figure 13. Possible topologies for fieldbus networks

Point-to-Point Topology

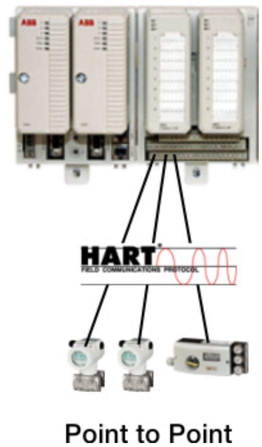


Figure 14. Point-to-Point Topology

Point-to-Point Topology means a connection and interaction of only two devices. This topology is mostly used in sub-segments for example to connect HART devices to Remote I/O. For the HART device the remote I/O operates as a master, however the remote I/O is part of the PROFIBUS network. Point-to-Point connection in PROFIBUS networks are not applicable, because it does not take advantage of the multi-device-per-bus-segment capability.

Line Topology

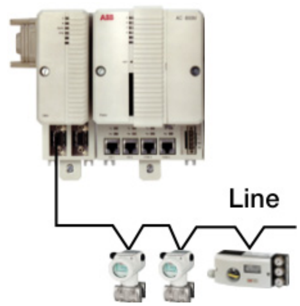


Figure 15. Line Topology

With this topology, the fieldbus cable is routed from device to device on this segment, and is interconnected at the terminals of each fieldbus device. Installations using this topology should use connectors or wiring practices such that disconnection of a single device is possible without disrupting the continuity of the whole segment.

Line Topology with spurs

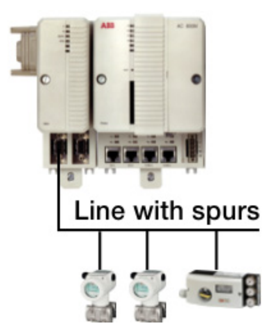


Figure 16. Line Topology with spurs

With this topology, the fieldbus devices are connected to the bus segment through a length of cable called a spur. A spur can vary in length from 1 m to 120 m. A spur that is less than 1 m in length is considered a splice.

PROFIBUS provides a wide range of possible transmission rates. The permissible lengths of possible spur cables depend upon the transmission rate used. No spurs are permitted for transmission rates over 1,5 Mbit/s. With transmission rates less than 1,5 Mbit/s the total length of all spur cables should be less than 6,6 m. When using spurs with low transmission rates (93,75 kbit/s), the ratio between spur cable length and next bus termination should be at least 1:20.

There is always a cable of several centimeters between a PROFIBUS connector and the transceiver of a node. When connecting 32 nodes to the bus, an important total spur cable length will result from this. If there should encounter transmission problems in the installation although everything works reliably at a low transmission rate, it is recommended to perform a dynamic bus analysis. This analysis will reliably detect mismatches.

Tree Topology

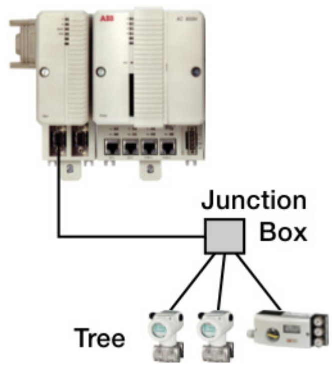


Figure 17. Tree Topology

With this topology, devices on a single fieldbus segment are connected via individual twisted wire pairs to a common junction box, terminal, or I/O card. This topology can be used at the end of a home run cable as well as in between. It is practical if devices on the same segment are well separated, but in the general area of the same junction box. When using this topology, the maximum spur length must be taken into consideration. Maximum spur lengths are discussed in Line Topology with spurs.

Combinations of the topologies above are possible. However, all rules for maximum fieldbus segments length, including spurs, must be taken into account for the calculation of the total bus length.

Star Topology

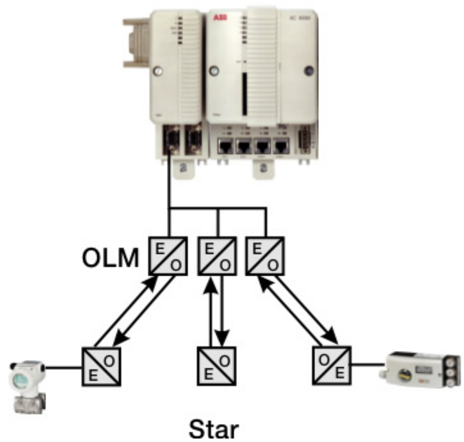


Figure 18. Star Topology

In a star structure several optical modules (for example optical link modules) are combined to form an active PROFIBUS star coupler. The modules of the star coupler are connected to one another via RS485 (PROFIBUS DP). In opposite to the tree topology the star topology contains more main components to build a structure like a tree.

This topology is also described in Basics of fibre optics topology technologies on page 46.

Ring Topology

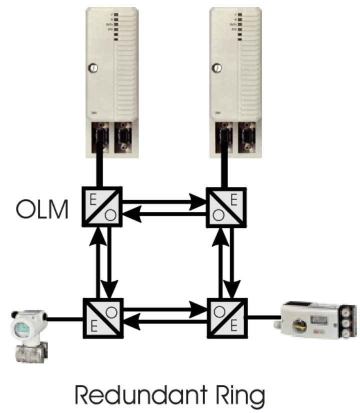


Figure 19. Redundant ring topology

The ring structure represents a special form of the line topology. A high degree of network operating safety is achieved by ”closing“ the line. A redundant ring can be also realized to increase the high availability. This structure is commonly used in connection with fibre optics and optical link modules.

This topology is also described in Basics of fibre optics topology technologies on page 46.

Fieldbus Topology with RS485 (PROFIBUS DP)

Bus length and speed

When a PROFIBUS network is installed, boundary conditions of the RS485 transfer technology must be observed. The electrical network uses a shielded, twisted pair cable. All subscribers are connected in a line-shaped bus. The transmission rate can be adjusted in steps from 9.6 kbit/s to 1.5 Mbit/s. For extremely time-critical PROFIBUS-DP applications, additional transmission rates of 3, 6 and 12 Mbit/s are possible.The maximum segment length depends on the transmission rate.

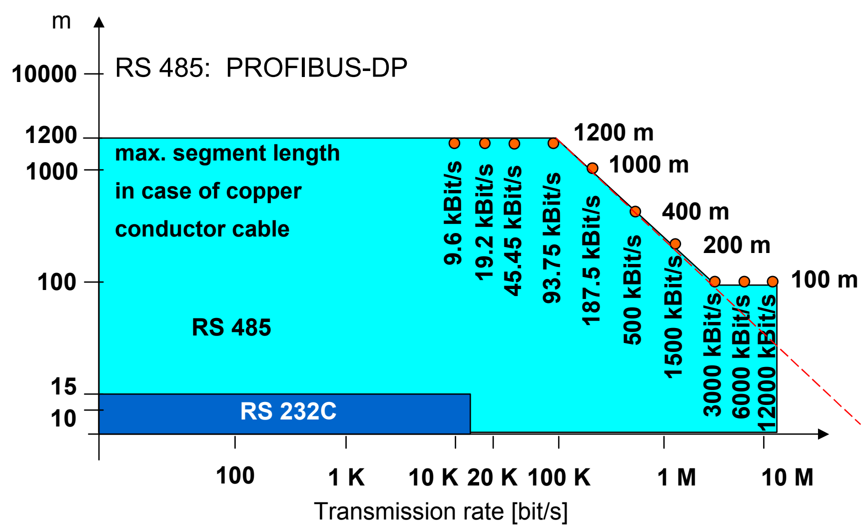


Figure 20. Bus length and speed

Bus termination

According to the PROFIBUS set-up instructions, the transmission line must be terminated actively on both ends to minimize line reflections and to ensure quiescent levels on the transmission lines. The RS485 interface operates on voltage differences. This network must be provided with a ground-free voltage of 5 volts. Depending on the device the required bus termination is already integrated into the device so that it can be inserted into the circuit easily if the device is located at the beginning or end of the line structure. According to the rules of certification, each PROFIBUS DP device needs a minimum voltage of 5 V.

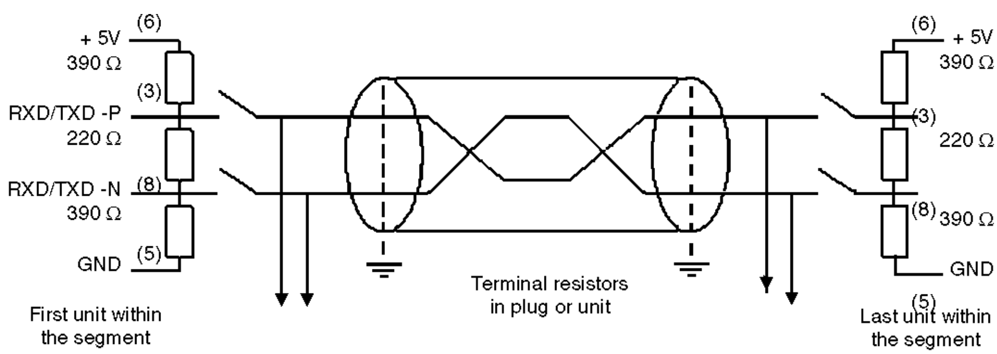


Figure 21. RS 485 Bus termination

If it is not sure from the very beginning that, for a planned installation, the required power supply for the active bus terminator will be ensured during plant operation, suitable measures must be taken. A typical example of this application is, if the bus participant supplying the terminating resistor with voltage, is switched idle repeatedly for operational reasons or separated from the bus when the plant is running. In that case, a bus terminator with external power supply or a repeater must be used for the respective bus termination of the bus.

Details about Repeater are described in Active network terminator and repeater on page 102.

Bus connector

A bus connector is used to connect the bus cable to the PROFIBUS device. Bus connectors are available with a variety of protection classes and mechanical designs. The choice of connector is mainly determined by the space available in the vicinity of the PROFIBUS device.

The bus connector must have a low-impedance connection to the cable shield.

A 9-pin D-Sub connector is primarily used to connect PROFIBUS devices on the bus, which complies with DIN 19245/ EN 50170.

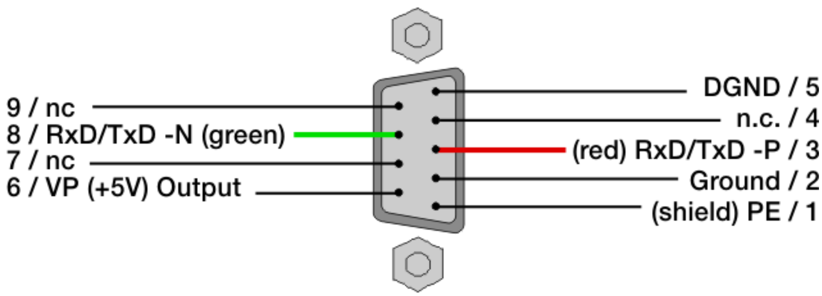


Figure 22. Electrical port - assignment of Sub-D sockets

To allow correct bus termination, each station must connect the signals DGND (Ground) and VP (5 V) to pins 5 and 6 of the connector, respectively. The 5 V supply for the terminating resistors (VP) should have a minimum current rating of 10 mA (the current load can increase to 12 mA if a NULL signal is sent through the bus).The current rating should be increased to approximately. 90 mA if you need to be able to supply other types of devices on the bus such as bus terminator and optical fiber cable drivers.

The **RxD/TxD-P** signal wire connected to pin 3 of the PROFIBUS module connector must be connected to the relevant signal wires with the same designation of all nodes. Proceed accordingly with the **RxD/TxD-N** signal lines on pin 8 of the connector.

All fieldbus devices which use a standard 9-pin Sub-D connector should provide the the VP and DGND signals on the bus connector in addition to the receive and transmit signals. The Sub-D plug, connected to the Sub-D connector of the device, needs only the receive and transmit signals for the communication transmission.

The connector shown below include a terminating resistor that can be turned on and off.

This type of connector can be used equally well at the beginning, end or middle of a PROFIBUS segment. The terminating resistor must be turned on in the connector for the first / last device on the bus segment. It must be turned off for the devices in the middle.

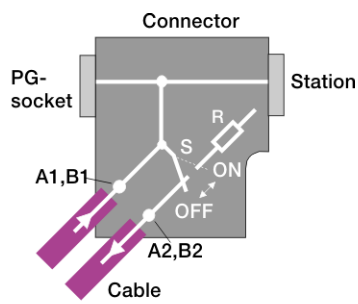


Figure 23. PROFIBUS connector

One connector with a PG socket should be used in the most accessible spot (at the beginning or end) for each line on every segment. This connector makes it possible to attach a diagnostic device for service access.

Be sure that the connector type used is suitable for the selected transmission rate.

Shielding and data line connection

To prevent EMC interference from entering the device, the cable shield should be connected to the functional ground of the device (generally the electrically conductive case). This is done by connecting the cable shield to the metal case of the Sub-D connector and the functional ground over a large area. With correct system installation, small external sources of interference are led to ground through the cable shield without causing interference in the data lines. Interference of this type can largely be avoided with appropriate EMC measures such as EMC-compliant system installation, EMC-compliant cable laying and measures that avoid large ground potential differences.

The cable shield must be connected to the functional ground at both ends of the cable by making a large-area connection to a grounded conductive surface. When laying the bus cables, particular care should be taken to ensure that the cable shield is connected to the shield grounding clamp over a large area.

The two PROFIBUS data lines are designated A and B. There are no regulations on which cable core color should be connected to which of the two data terminals on each fieldbus device; the sole requirement is to ensure that the same core color is connected to the same terminal (A or B) for all field devices throughout the entire system (**across all stations and bus segments**).

If the data transfer cable has data wires with red and green insulation, then the following assignment should be used:

- Green data cable - Connector pin A
- Red data cable - Connector pin B

This rule applies to both the incoming and the outgoing data lines.

Bus spur lines

The use of passive bus spur lines should be avoided.

Programming and diagnostic devices which are attached to the bus for example during commissioning are generally connected using their own cable which acts as a bus spur line. In such cases, you should use active bus tap-off devices (for example bus terminals, repeaters, active cables etc.).

RS485 limits and network design

As described in the PROFIBUS RS485 specification, each bus segment can have a maximum of 32 active devices. In order to be able to connect a larger number of PROFIBUS DP devices, it is necessary to segment the bus. The segments are then interconnected with repeaters which amplify and refresh the data signals. Repeaters can also be used for galvanic isolation of bus segments or bus sections. Each repeater allows the PROFIBUS system to be extended by an additional bus segment with the maximum admissible cable length and the maximum number of fieldbus devices. Repeaters increase the signal propagation times. This should be taken into account during planning.

Table 8. General Data PROFIBUS DP

Maximum number of stations participating in the exchange of user data	DP: 126 (addresses from 0 .. 125)									
Maximum number of stations per segment including repeaters	32									
Available data transfer rates in kbit/s	9.6	19.2	45.45	93.75	187.5	500	1500	3000	6000	12000
Max. RS485 segment length in m *	1200				1000	400	200	185 *	120 *	100
Max. spur lines length	Dependent on the data transmission rate. The use of passive bus spur lines should be avoided.									
Max. fibre optic cable length in m	44 (plastic),1700 (glass) up to 15000 (PCF)									
Max. number of segments in series	9 According to EN 50170, a maximum of 9 repeaters are allowed between any two stations.									

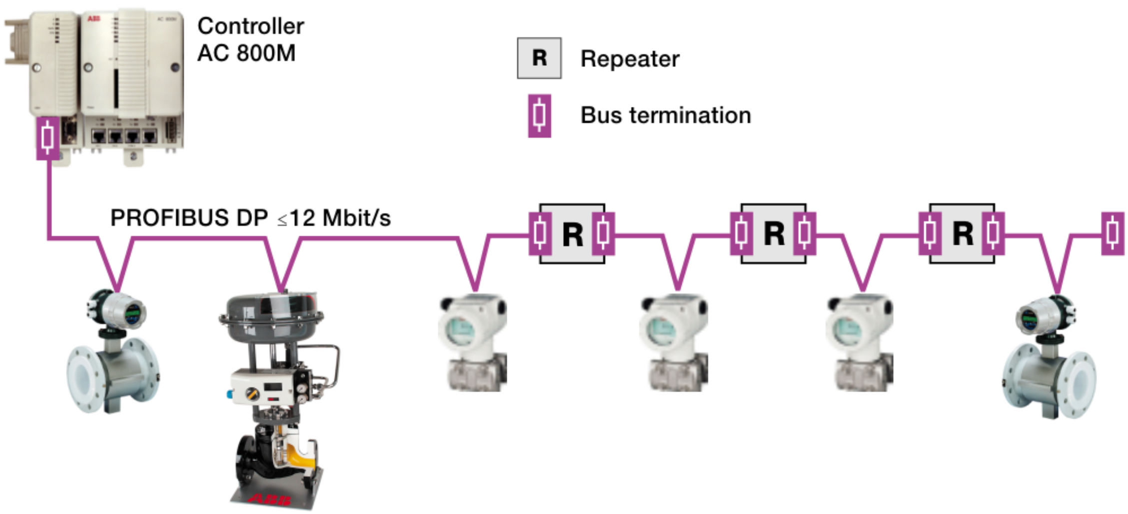


Figure 24. RS485 network design with bus termination and repeater

Fieldbus Topology with MBP (PROFIBUS PA)

PROFIBUS PA with MBA transmission technology is realized in tree or line structure, and any combination of the two. In the line structure, stations are connected to the trunk cable using T-junctions.

The tree topology is comparable to the classic field installation method. The multi-core cable is replaced by the two wire bus cable, the field distributor retains its function of connecting the field devices. By tree topology the maximum permissible spur line length must be taken into account when calculating the overall line length.

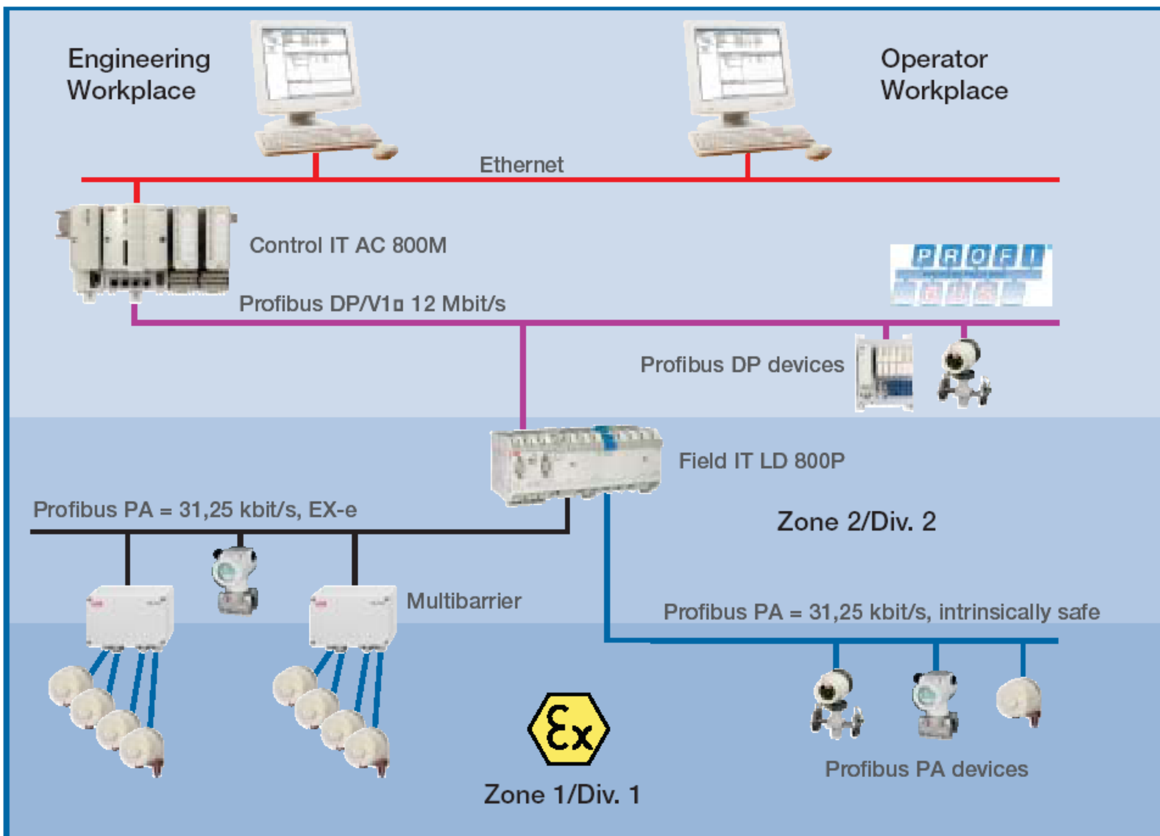


Figure 25. PROFIBUS PA embedded in 800xA

Bus length and speed

A twisted two-wire, shielded copper cable (type A) must be used as the transfer medium. It is also possible to exchange and extend devices during operation. The fixed, uniform transfer rate is 31.25 kBit/s. At this rate, cable lengths per segment of up to 1900 m are possible in non Ex(Haz.) case, or 1000 m in Ex(Haz.) cases.

If power is supplied to field devices via the PA bus, partial voltage drops on the bus lines must also be taken into consideration. This depends on the type of cable, the length of the line and the power consumption.

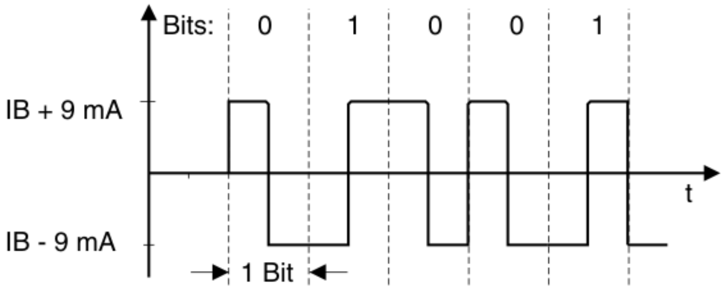
For non-intrinsically safe applications, a typical 24 V DC power supply is used, and there are only very minimal limitations on the total length of the line.

For intrinsically safe applications, the voltage of the power supply is approx. 12.8 V DC (LD 800P). The resulting permissible line lengths must be observed so that the necessary minimum operating voltage to the devices is not exceeded. The optimum design of a fieldbus segment requires detailed calculation of the partial voltage drops. By selecting a cable with a larger diameter it will be compensated to a certain extent (see also MBP power and line length calculation on page 36)

The number of subscribers that can be connected to a segment is limited to 32. An additional restriction in the Ex (Haz.) area results from the limited supply current that is available, which is determined by the type of explosion protection selected. In addition to the basic currents of the field devices, the modulation signal of 9 mA, the maximum current in the case of error of the device with the greatest power consumption and a reserve for dynamic power on procedures when the power is restored to the DP/PA Linking Devices must all be taken into account for calculating the required current. The assumption is also made here that the devices are equipped with an electronics system for limiting the current (FDE = Failure Detection Electronics).

Provided that maximum one FDE responds, the following condition must be fulfilled:

Supply current ≥ sum of individual currents (per device ≥ 10 mA)
+ Manchester current signal (9 mA)
+ FDE fault current (0 to 9 mA)



The maximum length of the line is restricted by the type of explosion protection and the drop in current over the bus line. The drop in current may result in a further limitation to the number of subscribers.

The time required for a complete cycle of data exchange depends essentially on the transmission rate, the number of subscribers and the size of the measurement (Value) and status values to be transmitted cyclically. Delay times, which arise through the Linking Devices and the field devices itself, must be taken into consideration as well.

For detailed information about power consumption and delay times, please read the specific user manuals of the field devices.

MBP and intrinsically safe installation

In the past, it was necessary to create time-consuming intrinsic safety audit trails in order to obtain permission to operate plants in Ex (Haz.) areas. Now, thanks to the use of the FISCO model (Fieldbus Intrinsically Safe Concept), you can easily design and operate your PROFIBUS PA system in Ex (Haz.) areas in no time at all.

Requirements are:

- Devices certified acc. to FISCO (EC type attestation of conformity)
- U, I and P acc. to EN 50 020
- Cable parameters observed (R, L, C)
- Bus termination existing and correct
- Total length of the PA segment, incl. spurs, to be kept
  - when using passive T-junction ≤ 1000 m
  - when using Multi Barrier ≤ 1900 m

A system certification is no longer required for a PA segment in the Ex (Haz.) area!

When using passive T-junction in the Ex (Haz.) area acc. FISCO up to 8 PA devices per segment are placeable, by using Multi Barrier up to 32 PA devices. The PROFIBUS DP/PA Linking Devices LD 800P corresponds to the FISCO Model.

Bus termination

The bus segment must be terminated on both ends of the line. According to the FISCO model the termination must conform to the following limits:

- 90 Ohm ≤ R ≤ 100 Ohm
- 0 μF ≤ C ≤ 2,2 μF

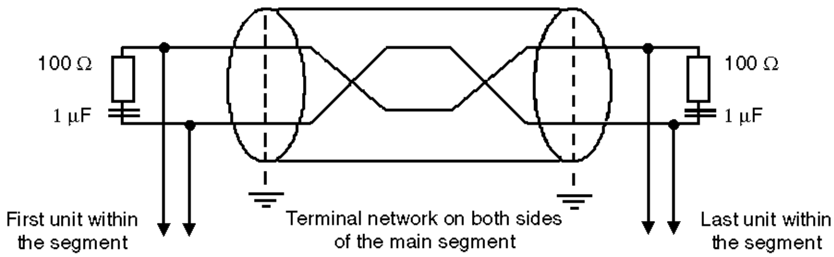


Figure 26. Bus termination according to FISCO

A fieldbus terminator is integrated into the Power Link Module PL 890 so that an external bus termination is only required on the other end of the bus.

PROFIBUS PA junctions and connectors

The PROFIBUS PA T-Connectors are available as Standard and Ex(Haz.) version. They are used for coupling 1 up to 4 transmitters to the PA trunk via spurs. The spurs can optionally be connected by an M 12 connection or directly via the EMC cable gland.

The following points shall be taken into account when selecting a junction or connector:

- Non-interrupted bus operation when exchanging or extending a PA transmitter
- External grounding cable
- Pressure-compensation element
- EMC cable gland
- Tension spring connection
- Non-Ex design (integrated bus termination, switchable)
- Ex(Haz.) design acc. to ATEX (external bus termination

Recommendation of mounting:

- Preparation of the PROFIBUS PA cable for M 12 connector:

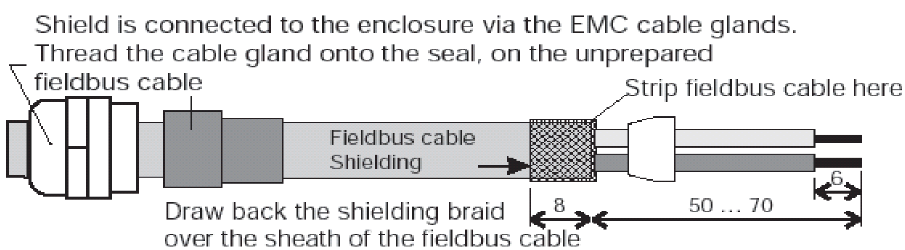


Figure 27. Preparation of the PROFIBUS PA cable for M 12 connector

- Usage of junction box (T-junction):

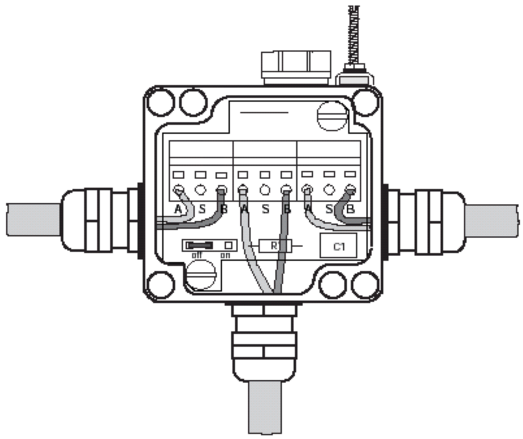


Figure 28. Junction box (T-junction)

The junction box retains its role as a central connection unit to build up a tree topology, where all field devices are connected in parallel.

The line topology offers connection points along the field bus cable. The cable can be looped through the individual field devices. The combination of tree and line topology permits the optimization of the fieldbus length and the adaption to existing system structures. It must be taken into account, that the limitation of the spur length for intrinsically safe installations according to FISCO bases on pure tree- or line topology. If a combination is used in a hazardous area, then the limit has to be applied to each connection between a field device and the trunk cable (via junction box). As an example, if the cable length between the trunk and the junction box is 20 m, then the cable length between the junction box any device connected to it must not exceed 10m (see also next topic “Bus spur lines”).

Shielding and data line connection

Shielding and grounding rules for MBP transmission technology has the following aspects to consider:

- Electromagnetic compatibility (EMC)
- Protection against explosion
- Protection of people

IEC 61158-2 specifies grounding as permanently connected to earth through a sufficiently low impedance and with sufficient carrying capability to prevent voltage build up which might result in undue hazard to connect equipment or people. Zero volt lines should be connected to ground, where they are galvanically isolated from the fieldbus trunk.

Field devices shall be able to function with the mid-point of one terminator or one inductive coupler directly to ground. Neither of the two conductors of the twisted-pair may be grounded at any point in the network. Signals shall be applied and preserved differentially throughout the network.

In addition to the handling of signal conductors particular attention should be paid to the cable shield and its connection to earth. Fieldbusses using signal frequencies > 10 kHz should be protected against electromagnetic fields. Therefore the cable shield and the metallic housing of the field devices and of any auxiliary equipment (for example connectors) shall make up a common shielding system, avoiding unnecessary gaps. Ideally the cable shields are connected to the field devices' housings (or other protective coverings), which are frequently made of metal.

The connections between the cable shield and the metallic housings as well as the connections between the shields of the different cable segments have to be low-impedance (for high frequencies). As far as unshielded devices are connected to a shield cable further methods may be applied to reduce the impact of noise (for example galvanic isolation or filtering).

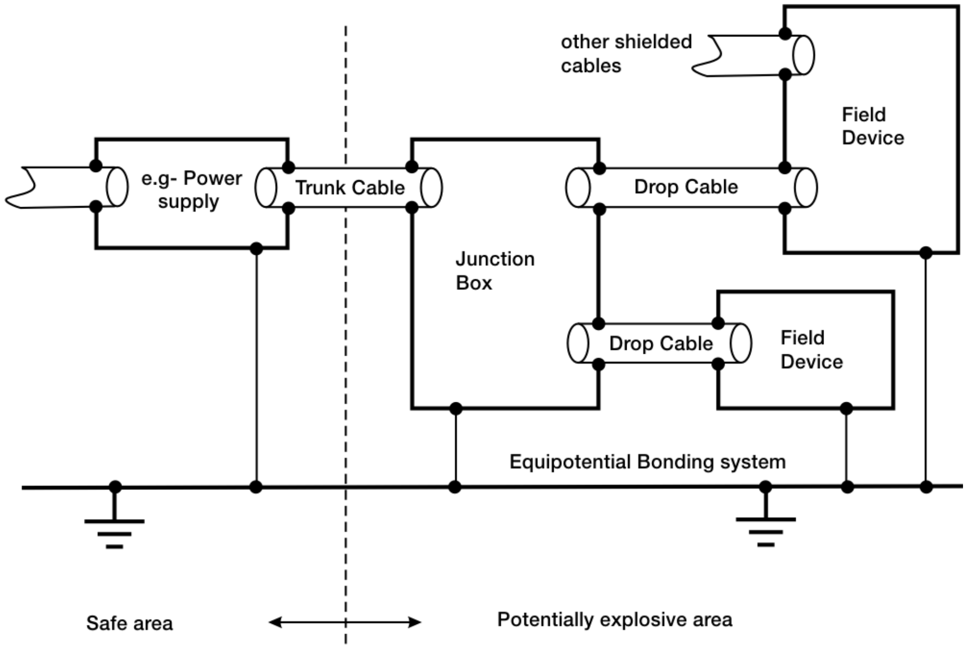


Figure 29. Ideal combination of shielding and grounding

If a sufficient potential equalization between the hazardous area and the safe area cannot be guaranteed, the cable shield shall be directly connected to the equipotential bonding earth only in the hazardous area. In the safe area the shield shall be connected to earth through a capacitor. The impedance of the connection should be minimized for high frequencies. However, the need for an electric envelope as complete as possible cannot be entirely fulfilled.

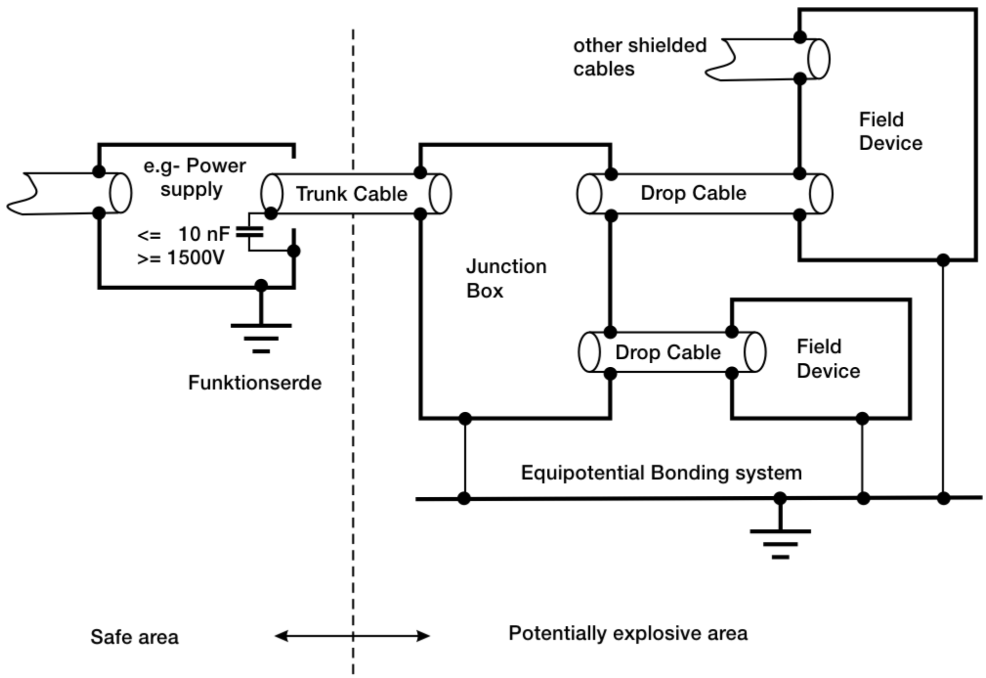


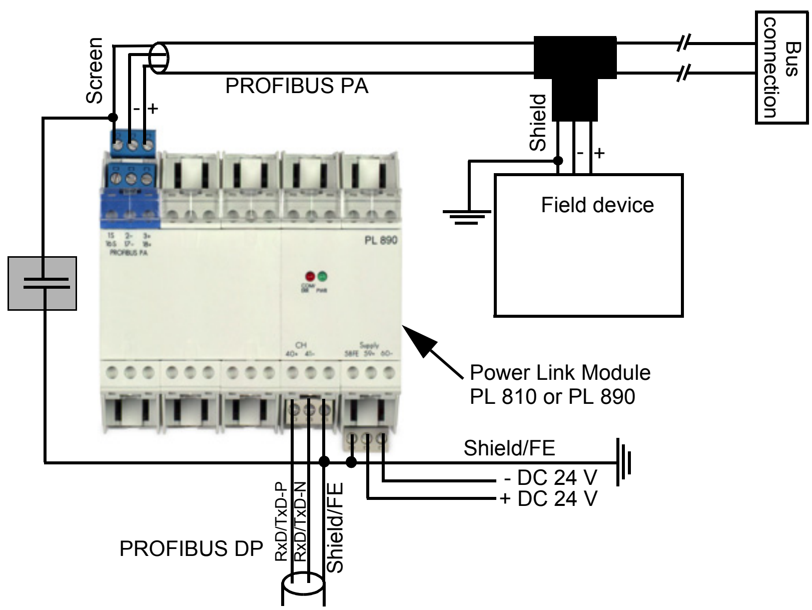
Figure 30. Capacitive grounding

The connection between both groundings through a capacitor may also be placed at an other position between power supply and the hazardous area (or between different hazardous areas), but it has always to be in a safe area.

The capacitor shall have the following requirements:

- solid dielectricum (for example ceramic)
- C ≤ 10 nF
- isolation voltage ≥ 1,5 kV

For PROFIBUS PA only shielded wires should be used. The shield should be hard-grounded at the Linking Device or the power link module and on all field devices. For intrinsically safe applications a potential compensation between the safe and hazardous areas is required.
If there is no potential compensation between the safe and hazardous areas, there is a possibility of capacitive grounding on the LD 800P Linking Device/Power Link Module.



Bus spur lines

PROFIBUS PA allows spur lines. The length of each spur line is determined by the number of PROFIBUS PA bus elements and by the area of application. The table below is specified for spur length using the MBP transmission technology with 31,25 kbit/s transmission rate:

Table 9. Recommended length of the spurs

Number of spur cables	Length of one spur cable (intrinsically safe)	Length of one spur cable (non intrinsically safe)
1 to 12	30 m	120 m
13 to 14	30 m	90 m
15 to 18	30 m	60 m
19 to 24	30 m	30 m
25 to 32	-	-

Please note that the permissible total line length (the total of the main line and all spur lines) must not be exceeded.

Fieldbus Topologies with fibre optics

Bus length and speed

An optical network can be implemented in a bus, star or ring topology using optical link modules. The maximum distance between two optical link modules can be up to 15 km with glass fiber-optic cables, 50 m with plastic fiber-optic cables and with PCF (Polymer Cladded Fiber) up to 300 m.

The transmission rate can be adjusted in steps from 9.6 kbit/s to 12 Mbit/s, depending on the hardware.

Mixed structures combining electrical and optical networks are possible. The transition between the two media is provided by the optical link module. In the communication between the stations on the bus, there is no difference between two-wire and fiber-optic technology. Up to 126 stations may be connected to a PROFIBUS network.

The optical transmission method offers the following advantages:

- Plastic, PCF or glass fiber-optic cables are insensitive to electromagnetic radiation and make the EMC measures necessary in electrical networks superfluous.
- In outdoor installations, there is no need for lightning protection measures.
- Fiber-optic cables make floating connections between the system components. This means that there is no need for expensive equipotential bonding measures.
- Fiber-optic cables can cover long distances between stations.
- Galvanic isolation.
- Either plastic, PCF or glass fiber-optic conductors can be implemented

The optical link modules are suitable for connecting glass or plastic fibre optical cables with BFOC/2.5 connectors. Depending on the topology, the fibre material, the fibre diameter, the wavelength of the light and the path attenuation, distances of up to 15 km and more can be bridged. For detailed information on the devices, please refer to the manufacturer's product descriptions and operating instructions.

Optical link modules and AC 800M in a star topology

The following diagram shows PROFIBUS DP with a fiber optical link for bridging long distances, for electrical isolation of parts of the system, or as a measure for protecting against lightning.

A redundant line structure is shown, however it is possible to build this star topology in a non redundant network.

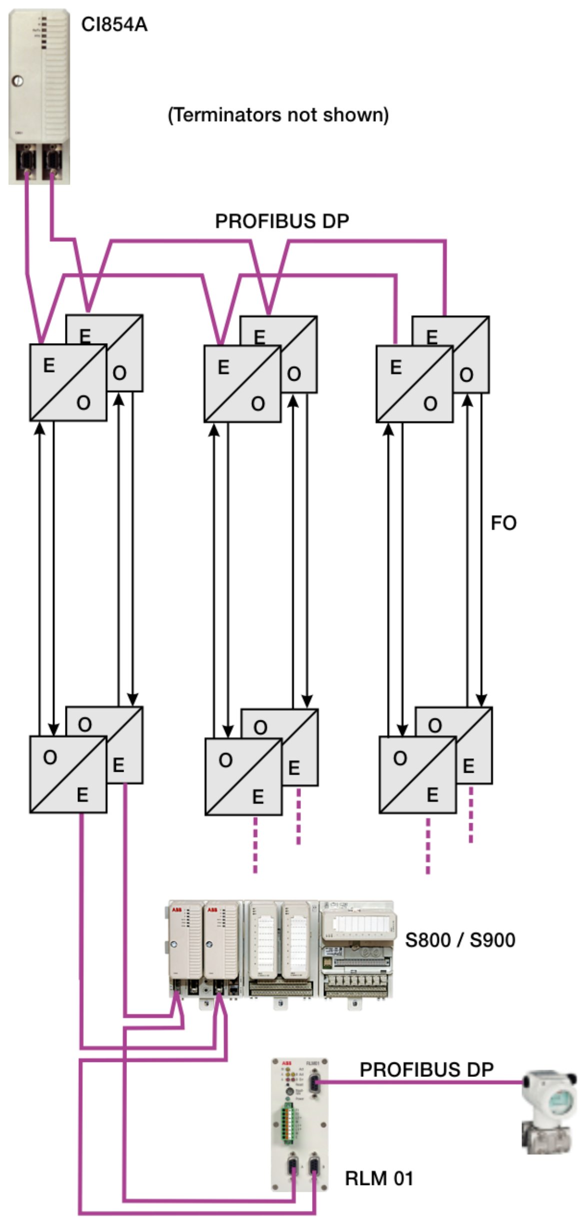


Figure 31. Fiber optical link for bridging long distances

Optical link modules and AC 800M in a ring topology

In comparison to the single-fiber ring, an optical double ring offers greater operating safety. The failure of a fibre optical cable or an optical interface has no effect on the availability of the network since the flow of data in both directions runs through the ring.

Optical ring and line redundancy can be used together in a mixed configuration as shown in Figure 32, Redundant optical ring. The line redundant interfaces of CI854A, RLM01, etc. can be connected to the ring by connecting each line to a separate optical link module.

It is also possible to configure the master and slave redundancy as an option. The figure shows both CI854A and CI840 in a redundant configuration. If they are used in a non redundant configuration it has to be taken into account, that the disturbance of one optical link module can cause a failure of the connected module.

The optical ring in combination with the line redundancy can only be set up by using the optical link module “OZD Profi 12M” from Hirschmann. Other optical link modules will get collisions of data frames that results in a complete disturbed communication on the PROFIBUS.

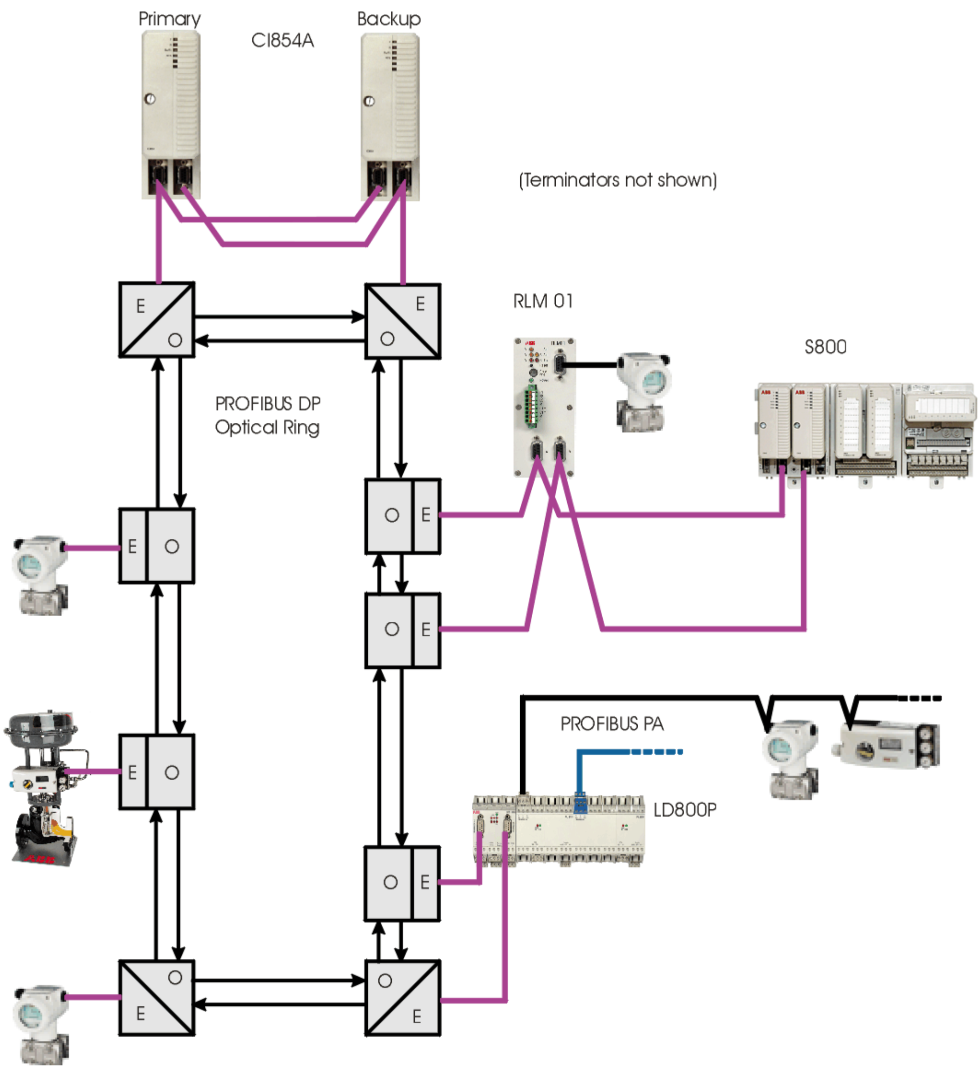


Figure 32. Redundant optical ring

Redundancy concepts

Using a redundant PROFIBUS system makes it possible to considerably increase the availability and thus the reliability in comparison with a single system. One particular advantage is scalable redundancy that begins with a redundant PROFIBUS transmission link, continues with a redundant master and ends with a redundant PROFIBUS slave.

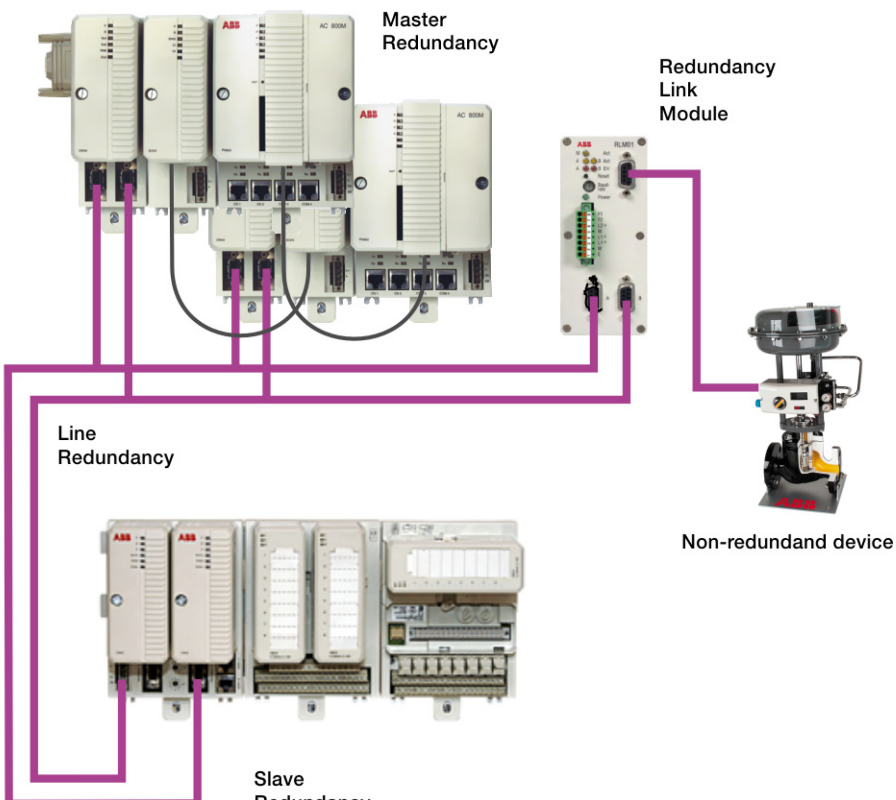


Figure 33. Redundancy concepts

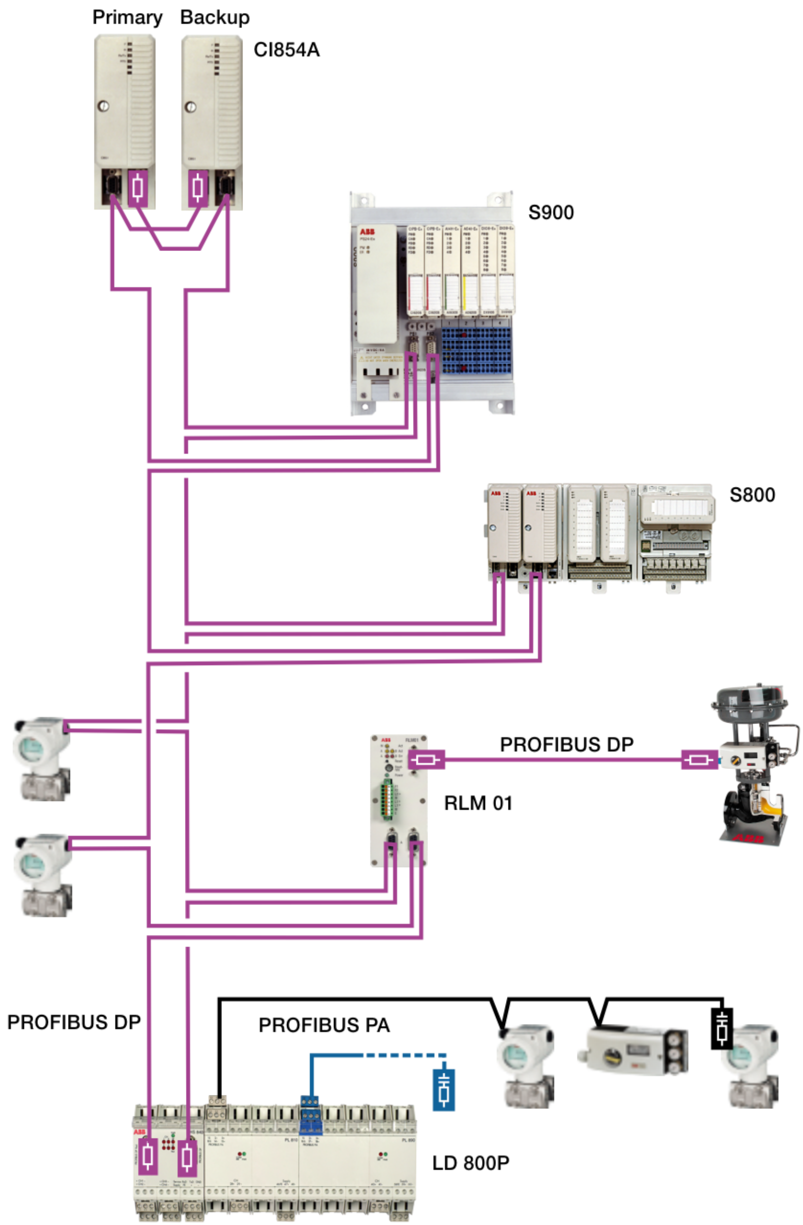


Figure 34. Master, Line and Slave Redundancy

Master redundancy

The AC 800M controller is linked to the PROFIBUS master module CI854A. When a CI854A module fails or bus communication is interrupted, the redundancy partner is automatically activated. A CI854A pair balances the data cyclically via the CEX bus.

Line redundancy

Line redundancy requires a redundant transmission medium and a redundant bus connection on the PROFIBUS master. The two transmission media are electrical cables in the simplest case, or fibre optical cables for higher requirements. For optimal usage of line redundancy, master/slaves/links with two bus terminals are required.

The ABB PROFIBUS master module CI854A has a build in line redundancy. For slaves with only a single PROFIBUS DP interface, the Redundancy link Module RLM 01 can be used to integrate the device in the redundant line structure.

The master, slave or link detects the failure of a line and continues communication over the intact redundant line. The requirements for line redundancy involve immunity to open circuit, short circuit and error adaptation in respect of cables, connectors, repeaters, media converters and links.

If the PROFIBUS slave has not been implemented a redundant PROFIBUS interface, and if, however, an analysis of the system availability shows the necessity of redundant PROFIBUS cabling, it is recommended to use a Redundancy Link Module RLM 01.

Slave redundancy

Slave redundancy refers to a situation in which at least redundant links/gateways and optionally redundant I/O modules are present. If a gateway module fails or a disturbance in communication occurs, the second gateway module takes over the task. The same principle applies to the I/O modules. The redundant module continues to record and/or output measured values in the case of an error. The connected sensors or actuators including the signal and command lines are generally only set single.

RLM 01 - Redundancy Link Module

The Redundancy Link Module RLM 01 converts two reciprocally redundant PROFIBUS DP/FMS lines into simple, non-redundant A/B lines and vice versa. The module works bidirectionally. It transmits and receives in parallel over both lines. The first incoming plausible data are routed to the output.

Figure 35. RLM 01 - Redundancy Link Module

RLM01 features:

- Use on PROFIBUS-DP/FMS lines
- Conversion of a non-red. PROFIBUS line into two redundant lines and vice versa
- Automatic line selection
- Transmission rate 9.6 kbit/s – 12 Mbit/s
- Monitoring of the communication
- Repeater functionality
- Redundant power supply connection
- Status and error display via LED
- Alarm contact

The RLM 01 can also be set to support line redundancy for a master with non-redundant PROFIBUS output.

RLM01 does not support master redundancy where one master only runs line A and the other one only line B. The bus communication is asynchronous, even if both masters are balanced with respect to each other on the program level.

Section 4 Commissioning of PROFIBUS equipment

For commissioning tasks you should also be familiar with all other sections. There are some additional hints about general limitations, cable lengths and laying regulations, bus terminations and spur lines. This must be observed in the planning phase and also during the commissioning phase.

Installation of data cables

Installation hints for electrical data cables

When connecting the devices, make sure that the data lines are not distorted or confounded. Data cables can only take a certain amount of stress.

The following hints will help you to avoid damage when installing data cables:

- Protect data cables during storage and transportation (shrink cap)
- Observe minimum and maximum ambient conditions
- Install data cables separately (separate cable duct)
- Protect data cables against potential mechanical damage
- Install redundant data cables in separate cable routes
- Do not exceed the maximum tensile strength
- Fit strain relief devices where necessary
- Avoid exceed stress from pressure
- Avoid exceed torsional stress
- Do not undercut the minimum bending radius

Preparing a PROFIBUS cable (RS485 and MBP)

- Cut the PROFIBUS cable type A to the required lengths. Strip off the insulation from the cable ends.
- Observe the manufacturer instructions for the PROFIBUS connector.
- Make sure not to confound feed and return wires. The incoming and outgoing signals must not be applied to the same pin.
- Connect the bare (non-insulated) wire ends to the appropriate pins. It is recommended to note down the wire color to avoid that the data lines will be confounded when the network will be extended at a later time.
  For RS 485 cable, the normal cases wire A / pin 8 has green color and wire B / pin 3 has red color.
- Make sure that the braid shield and, if applicable, the tape shield underneath it, is in good contact with the appropriate connector pin.
- Switch on the bus termination of the end connectors (no outgoing lines).
- Connect the cable shield to functional ground e.g. by using a grounding clamp.
- Put on the shield for every node of a line and make sure there is a good contact.
- To ensure RFI suppression in accordance with Class B to DIN/VDE install the ferrite ring RFI suppressor from for example Würth-Elektronik. The requirements of RFI suppression Class A are always met.

RFI suppression (Class B to DIN/VDE) is only ensured if the PROFIBUS cable is provided with the ferrite-type RFI suppressor specified above. For installation hints of RFI suppressor please read the specific manufacturer manual.

Installation hints for optical fibre cables

- Installation waste must be treated with care
- Do not look direct in open fibre ends
- Keep fibre optic cable plugs clean
- Do not stress fibre optic cables (stress increase the attenuation)
- Plan adequate attenuation reserves

An off-the-shelf interface converter is needed for the transition from RS485 bus technology to a fiber-optic cable. An FO cable consists of two glass fiber leads, one for transmit data and one for receive data.

Usually, the **RTS signal** on the PROFIBUS connector controls if data is transmitted or received.

Note that this signal and the **VP** and **GND** signals **additionally have to be applied to an interface converter**. Observe the instructions in the user manual delivered with your interface converter.

Use fiber optic cables wherever it is possible to improve the operational reliability and achieve optimal EMI shielding.

Always use fiber optic cables for links between buildings. Fiber optic cables provide for protective voltage separation and ensure lightning protection without requiring additional measures. Use multi-wire cable to reduce cable laying cost. As different for indoor cable links, multi-wire cables enable additional data links in future. Moreover, you can change over to an unused wire in case of wire-break.

Several outdoor cable types - e.g. gopher-protected or with a special steel or aramid reinforcement - are available. Note that steel-reinforced cables should only be used under special conditions for outdoor applications. In this case, the reinforcement are available. Note that steel-reinforced cables should only be used under special conditions for outdoor applications. In this case, the reinforcement must be grounded at both ends when entering the buildings to provide lightning protection.

For details on PROFIBUS with fiber optic cables refer to:

PROFIBUS, Technical Guideline Optical Transmission Technology, Catalog No. 2.022

Special conditions regarding the installation of PROFIBUS DP

When using PROFIBUS - DP, also in intrinsically safe zones with remote I/O modules, the following conditions regarding screening / earthing have to be observed:

- Electrical grounding of the PROFIBUS cable screen on two points at the AC 800M control station:
  - Connection at the 9-pole SUB-D plug on every device, for example CI854(A), CI840, CI920, etc.
  - Connection of the cable screen with a grounding clamp at the housing entry.
- If the installation contains areas with high potential differences, a **potential equalization cable** should be added to the data line **when using an RS485 PROFIBUS cable**. The potential equalization cable must have a minimum cross-sectional area of 16 mm^2 and must be linked with the shield of each node. This avoids compensation currents through the cable shield or data lines. A more flexible solution is provided by fiber-optic cables.
- Additionally, another screen grounding is required at each cubicle entry in non-intrinsically safe and intrinsically safe zones by a low impedance connection over a large surface via cable clips. The screen must continue between all DP devices (Master/slaves) connected to the PROFIBUS.
  Remark: The requirement for multiple screen grounding results from:
  - Requirement according to the PROFIBUS installation Guideline ("The cable shield should be connected to ground at both ends of the cable.")
  - The screen grounding of the bus cable on both sides is also possible in hazardous locations if there are no compensating currents on the screen which should be ensured in case of an optimum equipotential bonding according to VDE 0165.
- Connection of all earthing points via continuous low impedance equipotential bonding. In any case, it must be ensured that an adequate equipotential bonding is existing during the whole life of the system. If an adequate equipotential bonding cannot be ensured for the whole life of the system, an additional

equipotential bonding line must be laid, if possible, in parallel to the data line (e.g.: 16 mm^2). Under no circumstances, the line shield must be used as compensating line.

- Laying of the PROFIBUS cable in separate grid ducts to energy lines. If bus cables and energy lines are laid in parallel, a minimum distance of 30 cm is provided.
  The lines provided for the energy line (e.g. for converter actuators) are screened with a copper braiding. PROFIBUS International (PI) stipulates that the bus cable has additionally to be laid in a steel tube or in a tight sheet metal channel in case of extreme interference influencing. The tube or the channel must be earthed regularly and protected against corrosion (see also PROFIBUS installation Guideline).
- The grounding of field cable screens for wiring remote I/O housings with the field devices must be carried out in conformity with the requirements of the remote I/O suppliers.

Installation hints for CI854(A)

Use the following procedure to install the CI854(A) (for details see related product documentation):

1. Install a connector on the shielded twisted pair PROFIBUS DP cable. A connector with a switchable built-in bus termination is recommended. Connect the cable screen to the metal case of the connector to ground the screen via CI854(A). Connect the data cable wire A (green) to the terminal PIN8 (RxD/TxD-N) and the data cable wire B (red) to the terminal PIN3 (RxD/TxD-P).
2. Connect the cable shield for both lines to functional ground e.g. by using a grounding clamp.
3. Connect the PROFIBUS DP cable to one of the connectors PROFIBUS A or PROFIBUS B on the base plate. For support of Line Redundancy connect a second PROFIBUS DP cable to the other contact.
4. If the CI854(A) is at the end of the PROFIBUS DP cable, switch the bus termination ON. Otherwise leave the bus termination switched OFF.
5. If the CI854A is installed in a redundant configuration connect the PROFIBUS DP cable to primary and backup module. Do it like described in Figure 34. Switch the termination ON for the interface on primary or backup module that is at the end of the line.

Installing a Redundancy Link Module RLM 01

Use the following procedure to install the RLM 01(for details see related product documentation):

1. Connect the redundant PROFIBUS lines are connected to ports A and B. Port M is to be used for the not redundant PROFIBUS line to the master or one of the slaves. All three PROFIBUS ports, for example A, B and M, have the same 9-pin Sub-D connectors (sockets). The pin assignment is in accordance with the PROFIBUS standard.
2. If the A/B ports of an RLM 01 module are located at the start or end of a bus segment, two connector plugs with integrated bus terminating resistors must be provided. If the M port resides at the start or end of a PROFIBUS, one connector plug with integrated bus terminating resistors must be provided. It is preferable to use PROFIBUS terminals with an integrated resistor combination that can be turned on and off. A short-circuit-proof power supply to supply the resistors located in the connector is available on pins 5 (VP+) and 6 (DGND).
3. Use only shielded PROFIBUS connectors of suitable design. The connectors should preferably have a cable connection that is angled down at 35° and is no wider than 18 mm. The power supply and alarm lines are connected directly to the terminals labelled 1 to 8.
4. Set the transmission rate with the rotary switch on the front panel before turning on the power supply. You can select transmission rates of from 9.6 kbit/s to 12 Mbit/s. If the transmission rate is changed during ongoing operation, you should push the reset button once briefly to reset the control logic and the counters etc. to a defined initial state.
5. RLM 01 also tests whether the supply voltage is present at inputs L1+ and L2+. A single power supply with L1+ alone always requires a cable jumper from L1+ to L2+. This prevents an unwanted error message.

Installing the PROFIBUS DP/PA Linking Device LD 800P

The PROFIBUS module CI854(A) is designed exclusively for the connection of PROFIBUS DP nodes.

The Linking Device LD 800P is the interface between the PROFIBUS DP and the PROFIBUS PA. If an intrinsically safe PROFIBUS PA segment is used, the Power Link Module PL 890 with an intrinsically safe interface has to be used.

LD 800P supports both cyclic as well as acyclic PROFIBUS communication. The way in which LD 800P works is essentially transparent. This means that PROFIBUS DP masters have direct access to PROFIBUS PA slaves.

Use the following procedure to install the LD 800P (for details see related product documentation):

1. Snap the Head Station and the Power Link Modules of the channel 1 as well as the power supply unit onto the corresponding DIN Rail segment. Please note that the distance between the PROFIBUS DP socket of the head station and an intrinsically safe PROFIBUS PA connection of the Power Link Module PL 890 must be at least 50 mm measured straight.
2. If a 2- or 4-channel Head Station (HS 820 or HS 840) is being used snap the Power Link Modules of the channels 2 to 4 as well as the power supply units onto the corresponding DIN rail segments.
3. Connect the power supply to the LD 800P modules.
4. Connect the PROFIBUS DP transfer line to the Head Station.
5. If it is being used, connect the redundant PROFIBUS DP transfer line to the Head Station (HS 840).
6. Add the external bus termination if the head station is the last station on the PROFIBUS DP segment.
7. Connect the PROFIBUS PA transfer lines with the Power Link Modules provided for this purpose. The terminal resistances for the PROFIBUS PA segments are integrated into the Power Link Modules.
8. Connect the outputs for channels 2 through 4 of the head station with the terminals "Connection to the Head Station" **of one** Power Link Module of the corresponding channel. Connect the PROFIBUS PA terminals of all power link modules of one channel.

9. Connect the power pack.

The watch dog time TWD is set within the LD 800P to a default value of 5 sec.

This setting leads to a 5 sec. watchdog time of all underlying PA slave devices independent of the TWD settings within the PROFIBUS DP master. If a watchdog time adjustment of is not possible for the individual PA slave device there is a possibility to use a service tool and a serial connection to adjust the watchdog time for all PA slave devices within LD 800P.

10. Each PROFIBUS PA segment must be terminated at the end of the line. The terminating resistance required for the Linking Device LD 800P is already integrated into the power link modules PL 810 and PL 890.

11. The PROFIBUS PA cable shield must be grounded for reasons of EMC protection. This is possible in 2 ways:

    – Hard grounding at both ends of the PROFIBUS PA transmission line. This requires laying a potential compensation line.

    – Hard grounding on all field devices, potential compensation in the field, capacitive grounding on the Linking Device.

12. If the LD 800P is used, independently of whether or not it is a manufacturer specific or profile GSD, always use the DP-GSD. Some PROFIBUS PA field device manufacturers do not offer **any** PROFIBUS DP-GSDs. In this case, the existing PROFIBUS PA-GSD must be converted by using the LD 800P convert tool. The task of this conversion software is exclusively to enter the missing transfer rate and set specific bus parameters to values that allow for problem-free operation of the PROFIBUS DP.

Active network terminator and repeater

The active network components described below can be used to construct simple or complex PROFIBUS networks, and either electrical cables or optical fibre cables can be used as the transmission medium. Since most active components have IP20 protection, it will usually need a cabinet, a wall mounted cubicle or a comparable packing to protect the components. A DIN mounting rail is adequate for attachment.

Network devices cause a N x bit time delay of data telegrams. The delay times are device specific and depend upon the selected transmission rate. They must be taken into consideration in the bus configuration manually.

It may implement an external active bus terminator by means of a special bus terminator or a repeater. The external bus terminator relieves the bus subscriber from supplying the resistor network. Now the redundant master or the last subscriber on this transmission line can be switched idle without loss of communication.

Depending on the type, the module can be fed with 24 VDC or 230 VAC. The resistor network (terminator) is not placed in the module itself, but in the PROFIBUS connector.

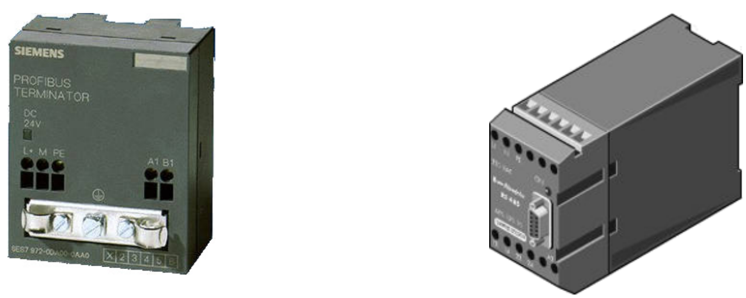


Figure 36. Active PROFIBUS Terminator from Kuhnke and Siemens

RS 485 Repeater

There are component under the type description "Repeater RS 485" available, that can be used to connect two electrical PROFIBUS segments with a maximum of 32 stations each. Nine repeaters can be included in a line. This makes it possible to increase the distance covered by a PROFIBUS network to 10 km (two-wire cable and 93.75 kBit/s) and the number of stations to 127 (with a maximum of 32 bus connections per segment).

Please find detailed information in the manufacturer's product description and operating instructions.

Figure 37. Repeater

Also the Redundancy Link Module RLM 01 has repeater functionality.

Grounding, Shields, Polarity

Always observe the following points when installing bus line grounding:

- Secure the shield braid using metal cable clamps.
- The clamps must fully enclose the shield and make good contact.
- Only connect the lines via the copper braid shield, and not via the aluminum foil shield. One side of the foil shield is attached to a plastic film to increase its tearing strength, and is therefore non-conductive!
- The shields of all cables which are routed into a cabinet from the outside must be clamped at the point of entry inside the cabinet and connected to the cabinet ground with a large contact surface area.
- When removing the cable jackets, it is important to ensure that the braid shield of the cables is not damaged. Tin-plated or galvanically stabilized surfaces are ideal for optimum contacting between grounding elements. With zinc-plated surfaces, suitable threaded connections must be provided for the required contacts. Painted surfaces at the contact points are unsuitable.
- Shield clamps/contact points should not be used as strain relief devices. Contact with the shield bus could otherwise deteriorate or break completely.

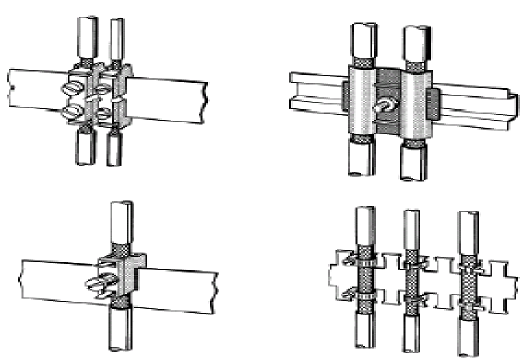


Figure 38. Securing shielded lines using cable clamps and tube clips (schematic diagram)

Testing the PROFIBUS bus cable and bus connectors

The measurements described below allow you to test an installed network and eliminate the most common errors, such as reversal of the cable polarity, open or short circuits of data cables or shield and incorrectly connected terminating resistors. The measurements should be carried out for each bus segment after installing the PROFIBUS cables and attaching the bus connectors.

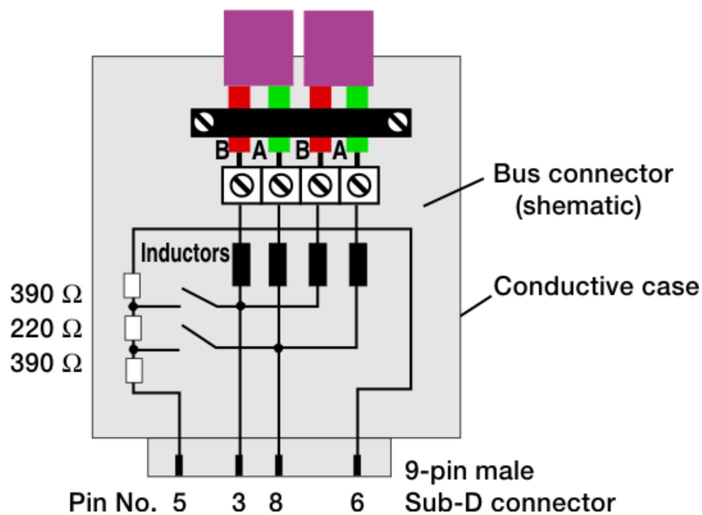


Figure 39. PROFIBUS DP Connector

Table 10. PROFIBUS DP Connector

PIN	Designation	Description
1	Shield	Shield/protective ground
2	–	Not Used
3	RxD/TxD-P	Receive/Transmit Data P-line (B-line, red)
4	CNTR-P	repeater control signal, indicates direction to repeater (TTL)
5	DGND	Digital Ground

Table 10. PROFIBUS DP Connector

PIN	Designation	Description
6	VP	+5 V, supply voltage for terminating resistors
7	–	Not Used
8	RxD/TxD-N	Receive/Transmit Data N-line (A-line, green)
9	DGND	Digital Ground

Use an ohmmeter to check the static characteristics of the ready made cable:

- Passage on pin 3 between all PROFIBUS connectors.
- Passage on pin 8 between all PROFIBUS connectors.
- Insulation between pin 3 and pin 8 with bus termination switched off.
- **one** bus termination switched on é around 390 ohms between pin 3 and 6
- **both** bus terminations switched on é around 195 ohms between pin 3 and 6
- **one** bus termination switched on é around 220 ohms between pin 3 and 8.
- **both** bus terminations switched on é around 110 ohms between pin 3 and 8
- **one** bus termination switched on é around 390 ohms between pin 8 and 5
- **both** bus terminations switched on é around 195 ohms between pin 8 and 5

In the values above we have unattended the loop resistance of typical 110 Ohm/km

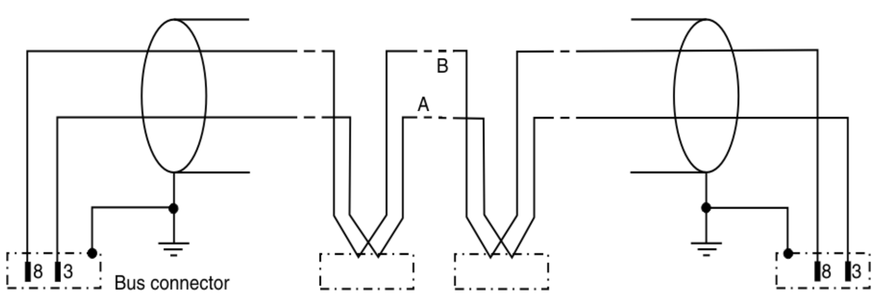
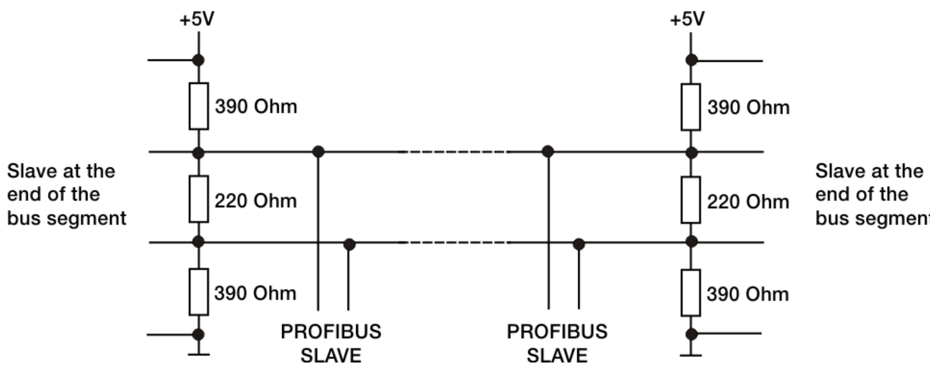


Figure 40. Schematic diagram of testing the PROFIBUS cable

The following pictures shows the correct installation as well as the common installation errors. Use an oscilloscope to check the voltage signals on the bus segment:

1. A correct PROFIBUS installation:



The measured voltage between the both transmission lines shall be **1,1 V**

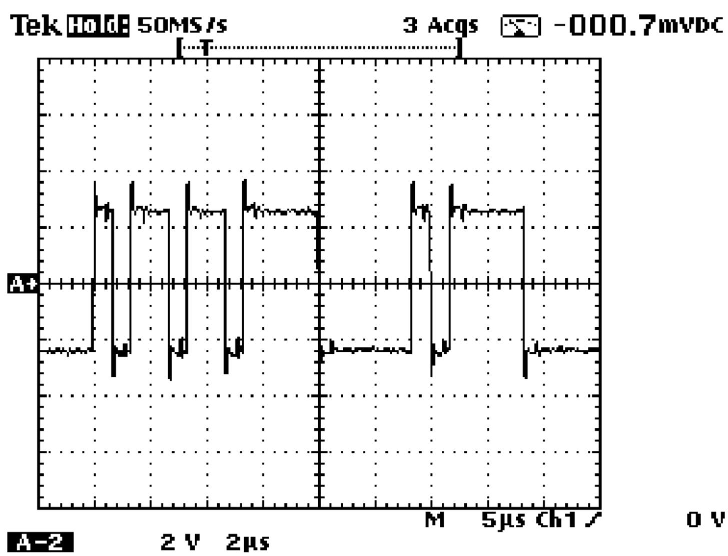
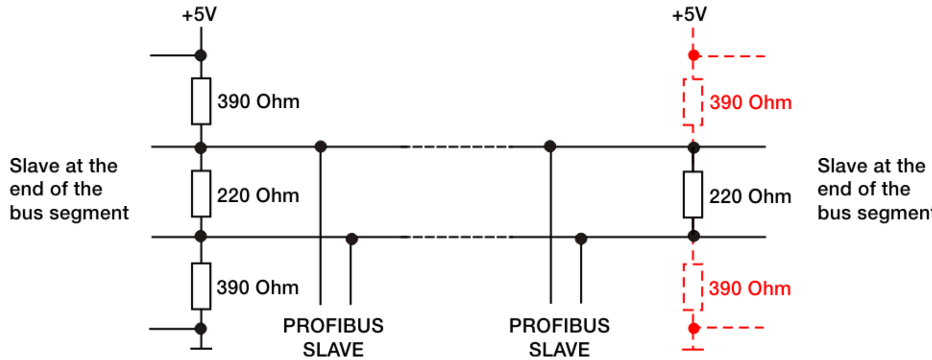


Figure 41. Correct terminated PROFIBUS line

2. One bus termination is not powered (5 V) (or two 390 Ohm resistors are missing):



The measured voltage between the both transmission lines is **0,62 V**

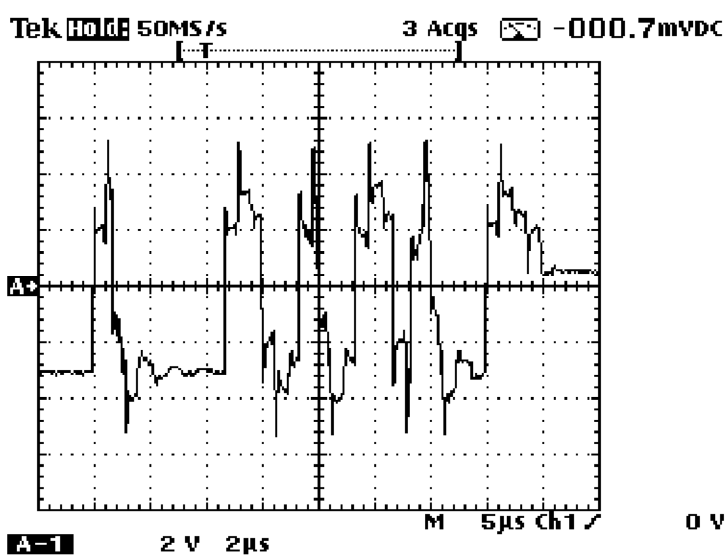
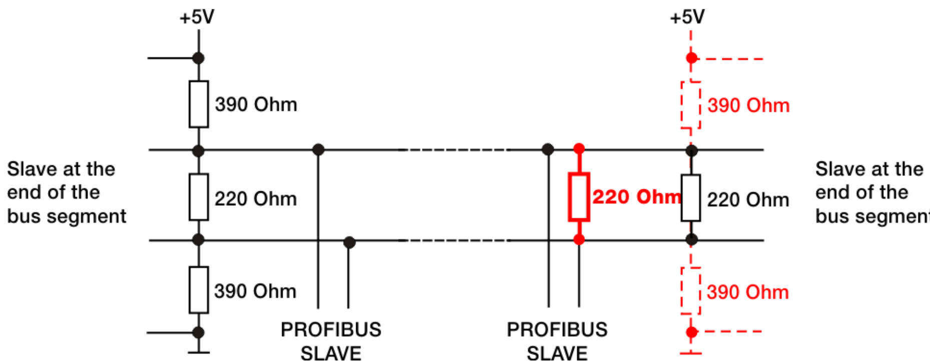


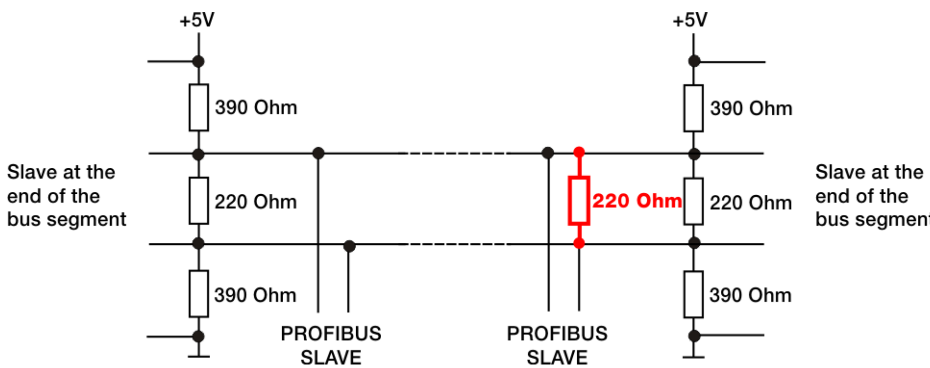
Figure 42. Incorrect terminated PROFIBUS line (termination only on one side)

3. One bus termination is not powered (5 V) (or two 390 Ohm resistors are missing) **and** one additional bus termination (220 Ohm) placed between the transmission lines:



– The measured voltage between the both transmission lines is **0,43 V**

4. One additional bus termination (220 Ohm) is placed between the transmission lines:



– The measured voltage between the both transmission lines is **0,79 V**

Tips on the most frequently asked installation issues

Are multiple devices with the default address 126, or with the same address connected to the bus?

- Make certain that there are no instances of multiple devices on the bus simultaneously with the same address. In case of doubt, attach one device after the other to the bus and assign the address you desire to each device, with the Web server of CI854(A). It is best to note the address on the device. If you proceed according to this method in assigning the address, make certain you can assign the installation location to the address.

Have you made note of the polarity for PROFIBUS DP?

- In contrast to PROFIBUS PA, you must ensure the correct polarity for PROFIBUS DP. When using a 9-pin D-SUB connector, the connector assignment is Pin No. 3 RxD/TxD-P (Receive/Transmit data-Plus) and Pin No. 8 RxD/TxD-N (Receive/Transmit data-N). If the question comes up, simply try switching polarity.

Are the bus connections present and active?

- Make certain that the bus segments are present on both sides in each segment.

How can I get more specific information on how to start - relative to my particular plant, application, and installed hardware?

- Contact PROFIBUS International (www.profibus.com) or your suppliers of choice. Training courses, additional reference materials, and consulting services are available to provide more detailed information on specific products from the appropriate supplier.

Where do I get the specs?

- The specifications (and additional documents) are available from PROFIBUS International. Standards documents are available from the IEC.

Where can I buy the correct wire, terminals, terminations, and other items required to install a fieldbus?

- ABB offers a complete portfolio of PROFIBUS network components. Please get in contact with your regional sales manager. PROFIBUS International offers additional references to the most comprehensive list of suppliers, devices, services, and other fieldbus related items.

How can I determine if the installed wire will work? Is there a test? Is there any test equipment I can rent, buy,...?

- A number of suppliers are developing products for simulating and testing fieldbus signals and devices. In addition, suppliers of hand-held communications network test equipment are currently offering fieldbus communications test devices that can be used to verify the quality of potential or operating fieldbus segments. A list of supplier is available on the PROFIBUS International web page (www.profibus.com).

Can I add new wire, and mix it with installed wire in the same fieldbus segment?

- YES! The suppliers of fieldbus cable will be able to provide assistance in the form of data sheets, training, and services.

How many devices can I put on one segment?

- It depends on several factors. The PROFIBUS segment is specified to handle a maximum number is 32 devices per segment. The controller capacity, power requirements and etc. may lower this amount. Refer to the specific documentation for operational capacity and consult the device manufacturer for individual field device’s power requirements.

I need a 3.2 kilometer long PROFIBUS PA network. How do I handle this requirement?

- The Physical Layer specification recommends a maximum length of 1900 m for cable type A wire. If this is not sufficient, up to 4 repeaters can be used to extend the total length to five times 1900 m, for a total of 9.5 kilometers.

What happens if the bus gets grounded on one side (or at one end)?

- A temporary short to ground may temporarily disrupt the bus, but any errors will be detected and handled by the fieldbus protocol. A permanent short to ground could disrupt the bus until the ground is removed (just as with present analog or digital communications).

I don't understand "termination". What is it, why do I need it, and is placement critical?

- Termination is the addition of the appropriate fieldbus "terminator" at (or near) the end of each fieldbus segment. The "terminator" has the same characteristic impedance as the bus, and is required to preserve the integrity of the signal. It is especially important on long segments, and placement is critical— one should be connected to the bus as close as possible to each end of the segment. Some devices (especially I/O and/or fieldbus test/simulation PC cards) include the option of using an internal terminator. It is important to know in this case whether it is connected.
- My PROFIBUS is not running properly.
  - Check the bus terminations
  - Check the connectors
  - Check the cabling (polarity, grounding, short-cuts, etc.)
  - Check the correct settings for all slave addresses (for example with the Web server of CI854)
  - Check the PROFIBUS master settings

For more details about the Web server of CI854(A) and the PROFIBUS master settings please read the specific product documentation.

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Revision History

Introduction

This section provides information on the revision history of this User Manual.

The revision index of this User Manual is not related to the 800xA 5.1 System Revision.

Revision History

The following table lists the revision history of this User Manual.

Revision Index	Description	Date
-	First version published for 800xA 5.0	October 2006
A	Second version published for 800xA 5.1	June 2010
B	Updated for 800xA 5.1 Rev A.	May 2011

Updates in Revision Index B

The following table shows the updates made in this User Manual for 800xA 5.1 Rev A.

Updated Section/Sub-section	Description of Update
Section 2 Transmission Technology/Fibre optic network limits	Information is modified to include Phoenix Contact (PSI-MOS-PROFIB/FO).

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