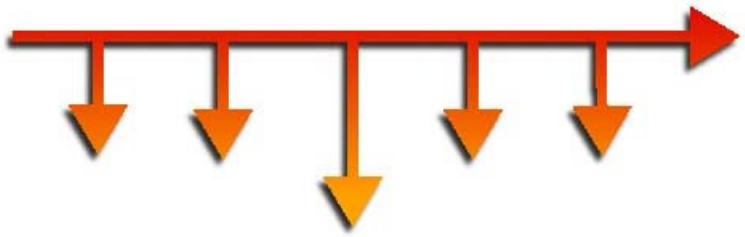
PROFIBUS
Cabling Guidelines



PROFIBUS Interface Center
Johnson City, Tennessee

Revision 0.4

Table of Contents

I. General

The first chapter contains some general information on how to build a reliable PROFIBUS network. Please read the instructions and recommendations carefully.
All information is based on the following documents:

EN 50170 Volume 2 PROFIBUS
PTO- PROFIBUS DP Implementation guide
SIMATIC NET PROFIBUS networks manual
ET 200 Distributed I/O System manual

A. Network Rules

PROFIBUS is based on RS 485 and therefore the limitation on number of nodes and length of the network is based on the RS 485 requirements.
A PROFIBUS network can be built in several segments with a segment consisting of the maximum number of stations and/or the maximum length of the network. To extend the network by building additional segments, repeaters or optical link modules are used.

1. Wiring

PROFIBUS is generally connected via a shielded twisted pair cable. The shield has to be connected to the protective housing of the connector which is then brought to ground via the connection on the device. Care must be taken when connecting the wires to the connectors that the shield and wires are properly installed.
The two wires usually come colored coded. Typically red and green are used. Red is used for the **B** Transmit/Receive Line and Green for the **A** Transmit/Receive Line. It is very important that the selection for A and B line is used consistently throughout the network to avoid improper operation. **This is the most common connection mistake in the field!**

2. Number of nodes per segment

A maximum of 30 (31) stations per segment is possible(see Repeater Chapter).

3. Number of segments

A maximum of 9 segments is possible(see Repeater Chapter).

4. Master nodes

PROFIBUS DP is usually a Mono Master system. Since PROFIBUS is based on a Token principle, more than one active station (Masters) is allowed. The overall controlling Master of the network should be node address “1”. The Master should be placed at the beginning of the network. Network address “0” should be reserved for monitoring and diagnostic devices.

5. Slave (I/O) nodes

Slave devices should start with address “3”. The slave devices shall be addressed in consecutive order by bus location traveling away from the master.

6. Termination

One important point when setting up a PROFIBUS network is where and how to place the termination. Each PROFIBUS segment needs to be terminated at the beginning and end of a segment.
The ideal case is to have one end of the network connected to the Master with the termination “on”. If the Master goes off for whatever reason, the control over the network will be gone anyway. At the other end would be a repeater (as long as you are using repeaters). An example of a two segment network is shown in Figure 1.

It is preferred that the master device be installed as the start of the network and as a termination point.
It is also preferred by using repeaters that the repeater is at the end and start of the network and is the termination point as well.

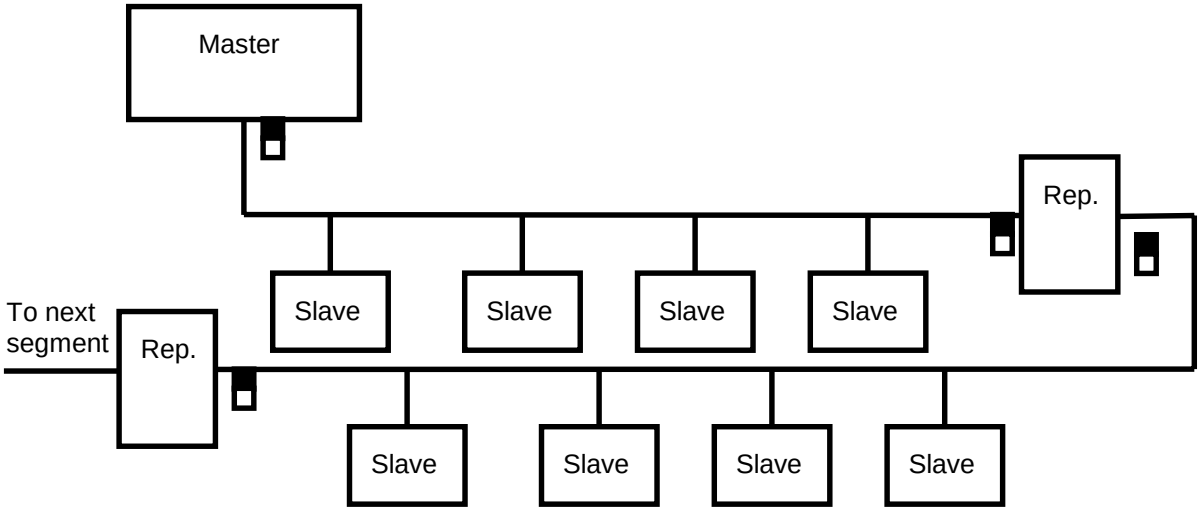


Figure 1: Master & Repeater at the two ends , Termination used at each Repeater & Master

In the situation where a repeater is not used or is in the last segment, the termination must be “on” at the last device. The termination is usually built into the connector. In order to use the termination at the device, power must be supplied to the terminating resistors. This means the last device needs to be **powered** at all times. If you have to replace the last device, the whole network could become unstable.
It is preferred that the master device be installed as the start of the network and as a termination point.

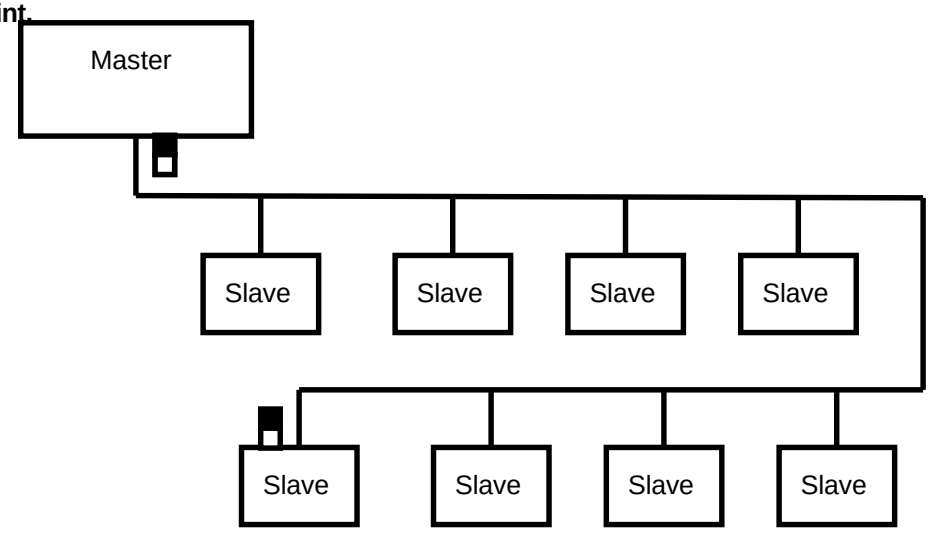


Figure 2: Master & Last Slave with termination on

In the situation where your construction requirements force the master to be in the middle of the network, you need to have the termination at the first and the last device on the network. In order to use the termination, the termination needs to be powered. This means the first and the last devices need to **be powered at all times**. If you have to replace one of them, the whole network could become unstable.

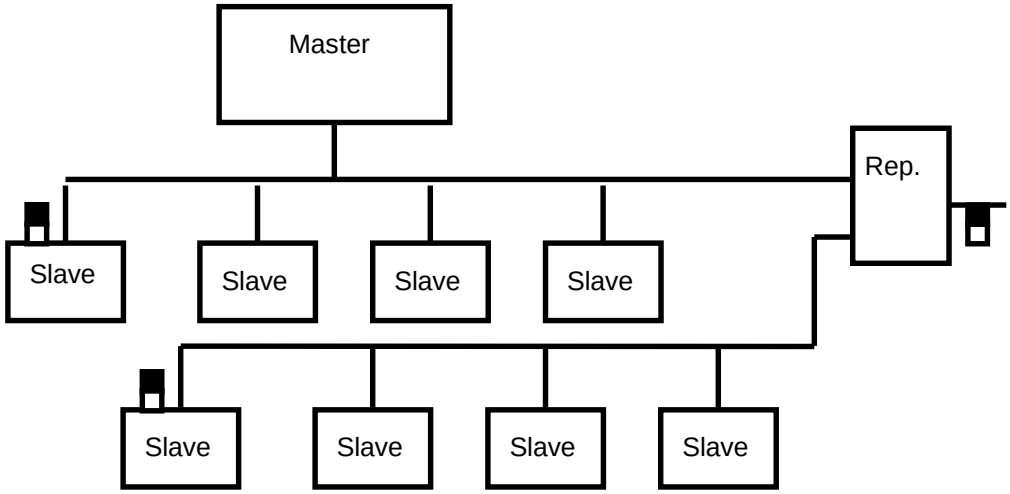


Figure 3: Master & Repeater in middle of network, Termination On at first and last Slave device .

-Termination on, Rep. -Repeater

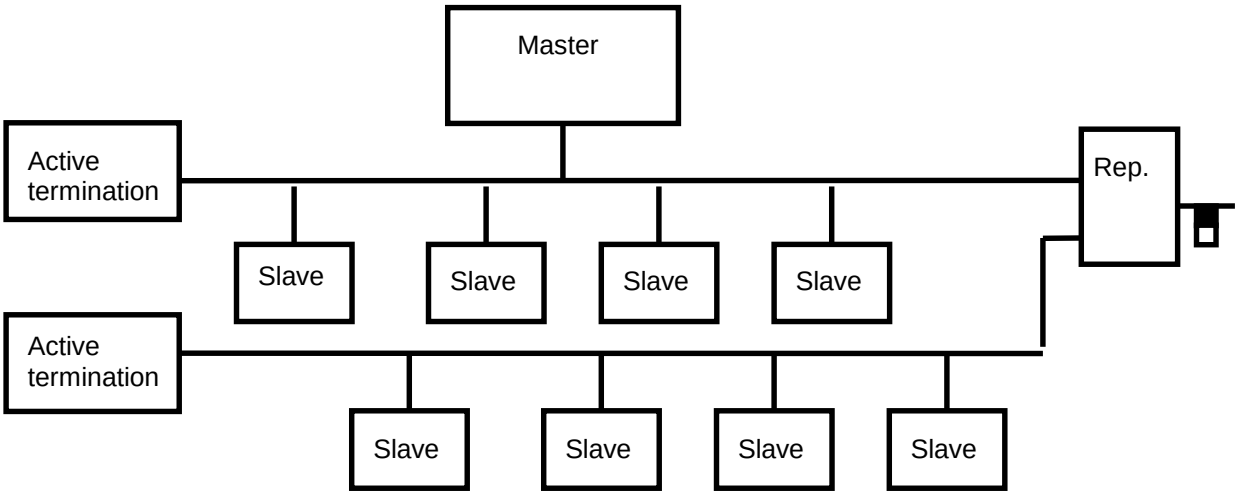


Figure 4: use of active termination

As an alternative active termination can be used. The active termination is connected to Power and needs to be powered at all time. The advantage is that all devices in between can be disconnected and replaced without interrupting the communication.

B. Diagnostic

To allow for network analysis and troubleshooting, each network segment is required to have AT LEAST one connector with a programming socket. There shall be adequate programmer connection sockets to effectively troubleshoot the bus. These sockets will be used so that PROFIBUS monitoring devices can be plugged in to analyze the network. At baud rates of 3 MBaud and higher, connect the monitoring device by means of programmer drop lines (active cable). You can use multiple drop lines with this cable in a bus configuration. Other drop lines are not permitted. Since the active cable needs power out from the device, the programmer socket needs to be connected to a device which supplies at least 90mA for connecting devices.

C. Special requirements for baudrates >1.5 MBaud

Use of baudrates greater than 1.5 MBaud requires special connectors. The connector must have built in Inductors in order to run with higher baudrates.

Spur lines are not allowed when using baud rates greater than 1.5 MBaud.

The maximum length between segments at 12 MBaud when using copper cable is:
100m / 327feet.
The maximum length between optical link components is:
300m / 981feet

In some applications, several bus connectors are used at electrically short distances. A minimum cable length between two stations of 1m/ 3feet is recommended.

II. Cabling on PROFIBUS

PROFIBUS is based on RS 485 communication. The standard EN 50170 specifies the cable for use with PROFIBUS.

The following specifications need to be fulfilled by the PROFIBUS cable:

Parameter	Line A - PROFIBUS DP
Impedance	135 to 165 Ohm / 3 to 20 MHz
Capacity	< 30 pF / m
Resistance	<110 Ohm / km
Wire gauge	> 0.64 mm
Conductor area	> 0.34 mm^2

The PROFIBUS cable is a shielded twisted pair cable. In order to fit the cable into the available connectors, the cable needs to have a surrounding diameter of 8.0 +/- 0.5 mm.

In general, there are two different types of cable available. The most commonly used cable has solid wire for the PROFIBUS line. When there is a need for more flexibility(bending) and higher environmental resistance, a cable with stranded wire for the PROFIBUS line and special jackets shall be used.

A. Installing PROFIBUS cables

In many automation systems, the I/O BUS cables are the most important connections between individual components in the system. Damage or breaks on the cable providing these connections lead to problems and often to a breakdown of the entire automation system.

To avoid accidental damage to I/O BUS cables, they shall be installed where they are clearly visible and separate from all other cables. This is to improve the EMC characteristics. I/O BUS cables shall be installed in their own cable channels or in metallic, electrically conductive conduits. These measures also make it easier to troubleshoot the cabling system.

When installing bus cables:
⇒ Do not twist them
⇒ Do not stretch them
⇒ Do not crimp them

The following conditions must also be adhered:
⇒ The permitted bending radii for single and repeated bending
⇒ The temperature range for laying and operating
⇒ The maximum permitted tensile stress

B. Cable shielding

Shielding is a means of weakening (attenuating) magnetic, electric and electromagnetic interference fields.
Interference currents on cable shields are diverted to ground via the shield bus bar, which forms a conductive connection with the housing. It is particularly important to ensure a low ohm connection to the protective conductor. Otherwise the interference currents themselves may become a source of interference.

Note the following points:
⇒ Use only cables with braided shields.

⇒ The shield density should be more than 80 %.
⇒ Always connect the cable shields at both ends.

It is only when the shielding is connected at both ends that interference suppression is effective at the high end of the frequency range. There are exceptions! It may be better to connect the shield at one end only if for some reason it is not possible to install potential equalization lines.

Note that if the shield is connected at one end only it can suppress low frequency interference.
If the system is installed for stationary operation, it is advisable to remove the insulation from the shielded cable without interruption and connect the cable to the shielding/protective conductor bus bar.

Note:
If a potential difference occurs between the grounding points, an equalization current can flow through a shield connected at both ends. In this case, install an additional potential equalization line.

C. Standard I/O BUS cable

This cable shall only be used in applications were there is no flexing of the cable and the cable is not exposed to a wet environment.

The Siemens PROFIBUS cable is intended for fixed installation in buildings or in an environment which is protected from the climate (in-house cabling).
The combination of twisted wires, foil shield and braid shield make the cable particularly suitable for industrial environments subject to electromagnetic interference.
The design of the cable also guarantees stable electrical and mechanical characteristics after the cable has been installed.
Permitted ambient conditions:

Operating temperature	– 40 °C + 60 °C
Transport/storage temperature	– 40 °C + 60 °C
Installation temperature	– 40 °C + 60 °C

Bending radii:

First and final bending	>= 75 mm
Repeated bending	>= 150 mm

D. Trailing cable

In contrast to the standard PROFIBUS cable, the cores of the trailing cable are of stranded copper. In conjunction with the special combination of braid shield, foil shield, fleece layer and the sheath material polyurethane, the cable is extremely flexible while retaining highly constant electrical characteristics.

The characteristics of the trailing cable differ from those of the standard I/O BUS cable as follows:
⇒ Extremely good resistance to abrasion
⇒ Resistant to mineral oils and grease
⇒ Extremely good resistance to UV radiation
⇒ Small bending radii for installation and operation
⇒ Due to the smaller copper diameter, the loop resistance and HF attenuation are greater
⇒ The sheath material is flame resistant

The trailing cable is designed for a minimum of 5 million bending cycles at the specified bending radius and a maximum acceleration of 4 m/s^2 and is therefore particularly suitable for installation in drag chains.

The stranded cores must be fitted with wire-end ferrules (0.5 mm^2 or 0.75 mm^2) before screwing them to the terminals.

Permitted ambient conditions:

Operating temperature	– 40 °C + 60 °C
Transport/storage temperature	– 40 °C + 60 °C
Installation temperature	– 40 °C + 60 °C

Bending radii:

First and final bending	>= 45 mm
Repeated bending	>= 65 mm

III. Connectors on PROFIBUS

A bus connector is used to interconnect the bus cable and the station. The design of the PROFIBUS connector (the data signals are looped through within the connector) ensures that stations can be connected to and unplugged from the PROFIBUS while the bus is operating and without interfering with other stations.

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).

Due to the integrated series inductors in the bus connector required for data transfer rates > 1500 kbit/s, all PROFIBUS connectors in the system should be attached to fieldbus devices to ensure that the necessary capacity load is provided by the station input capacitance.
The permanent availability of the connected PROFIBUS stations has a major influence on the fault-free operation of the plant. The quality of the user data signal on the bus cable is mainly affected by induced interference(if any), the bus physics of the fieldbus devices and **correct termination of the bus cable**. Therefore, each segment must be terminated at the beginning and the end of the segment.

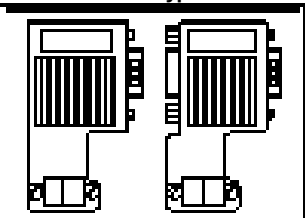
Data traffic on the entire bus can be affected if a station at the beginning or end of the bus segment fails or needs to be removed from the bus for maintenance. It is recommended to plan the bus system to avoid these sources of error. In this case, the terminating resistors are supplied with power by a repeater or an external power supply. See also the recommendation in chapter 1.

A. IP 20 devices with a 9 pin D-SUB connector

1. Applications and technical data of the bus connectors

You need bus connectors to connect the PROFIBUS to a station. Various types of IP20 bus connectors are available and are shown in table 3-1

Table 3-1 Connector Types

		
Order numbers	6ES7 972- 0BA10-0XA0 ... 0BB10-0XA0	6ES7 972- 0BA40- 0XA0 0BB40- 0XA0
Programmer socket	0BA10: no 0BB10: yes	0BA40- no, 0BB40- yes
Max. baud rate	12 Mbaud	12 MBaud
Terminating resistor	integrated on/off	yes
Outgoing cable	vertical Interfaces	45 ^{0}
PROFIBUS station	9-pole sub-D socket	9-pole sub-D socket
PROFIBUS bus cable	4 terminal blocks for wires up to 1.5 mm 2	4 terminal blocks for wires up to 1.5 mm 2
Connectable PROFI-BUS cable diameter	8 +/- 0.5 mm	8 +/- 0.5 mm
Dimensions (in mm)	15.8 x 54 x 34	

Disconnecting a station

Under certain circumstances, the bus connector enables you to disconnect a station from the bus without interrupting traffic on it.

Bus connector with programmer socket

Each segment needs to have at least one bus connector with a programmer socket. This is necessary for start up and diagnostic functions by using a programmer or a PC.

At baud rates of 3 MBaud and higher, connect the monitoring device by means of programmer drop lines (active cable). You can use multiple drop lines with this cable in a bus configuration. Other drop lines are not permitted.

2. Connecting bus cable to bus connectors ...

Preparing the bus cable

To connect the bus cable to a bus connector, proceed as follows:

1. Strip the ends of the cable conductors as shown in Fig. 3-2.

Cable type 6XV1 830–0AH10/-3BH10

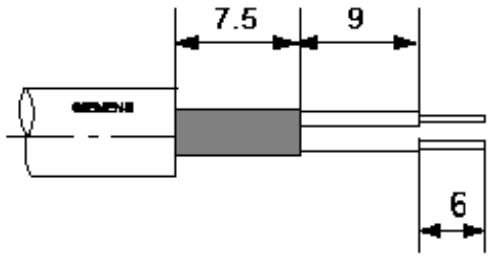


Figure 3-2 for connector type6ES7 972-0Bx10…

2.To open the housing of the bus connector, loosen the securing screws and lift off the cover.

3.Insert the green and red conductors in the screw terminals as shown in Fig. 3-3.

Make sure that you always connect the same conductors to the same terminal A or B (**always connect the green conductor to terminal A and the red conductor to terminal B**).
4.Press the cable sheath between the two retainers to hold the cable in position.
5.Tighten the screws to secure the conductors in their respective terminals.

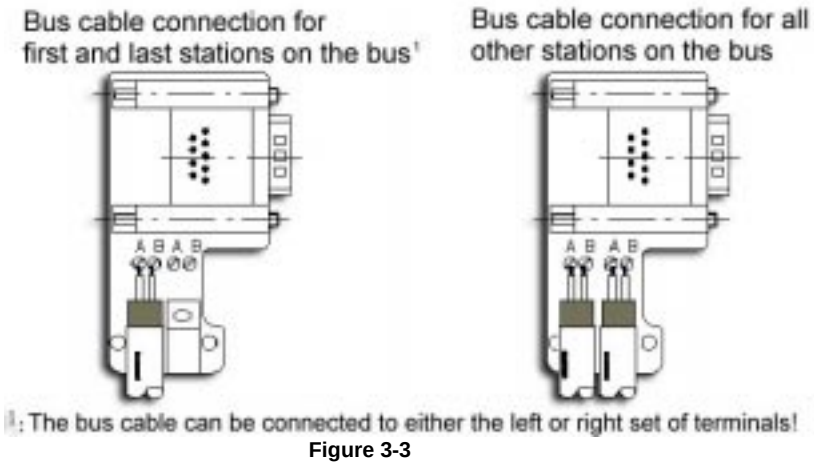


Figure 3-3

6. Tighten the housing screws.
Make sure that the naked cable shield is seated under the shield clamp.

3. Connecting the bus connector to the module

The procedure for connecting the bus connector is as follows:

1. Push the bus connector into position onto the module adapter.
2. Tighten the screws to secure the connector to the module.
3. If the bus connector is at the start or end of a segment, you must activate the terminating resistor (set switch to ”ON).

Make sure that the stations with active terminating resistors are always powered throughout power-up and operation.

If the bus cable is daisy-chained, you can disconnect bus connectors from the PROFIBUS-DP interface at any time without interrupting traffic on the bus.

Warning	Danger of disrupting data traffic on the bus. Each bus segment must always have a terminating resistor at each end. Note that this requirement is not satisfied if the last slave with a bus connector is powered off. The bus connector receives its power supply through the station connection, so the terminating resistor has no effect if the supply is shut off. Be careful to ensure an uninterrupted power supply to the stations in which the terminating resistors are in the circuit.

IV. Repeater

After reading this chapter, you will be able to identify the situations in which you must use the RS 485 repeater.
You will also be able to install and use the RS 485 repeaters.

1. The RS 485 repeater: scope of application

An RS 485 repeater amplifies data signals on bus lines and is the link between individual bus segments. To increase the number of nodes or to extend the cable length between two nodes, segments can be connected together using the RS 485 repeater. The RS 485 repeater can be set to all transmission rates from 9.6 kBaud to 12 MBaud.

A repeater needs to be used, if:

⇒ there is a need to connect more than 32 stations to the bus,
⇒ there is a need to operate bus segments as non-grounded segments, or
⇒ a segment exceeds the maximum permissible cable length depending of the baudrate.

Cascading of repeaters:

⇒ You **cannot** connect more than **nine** RS 485 repeaters in a cascade (in line).

2. Mechanical Design Of The RS 485 Repeater

Table 4-3 shows the RS 485 repeater.

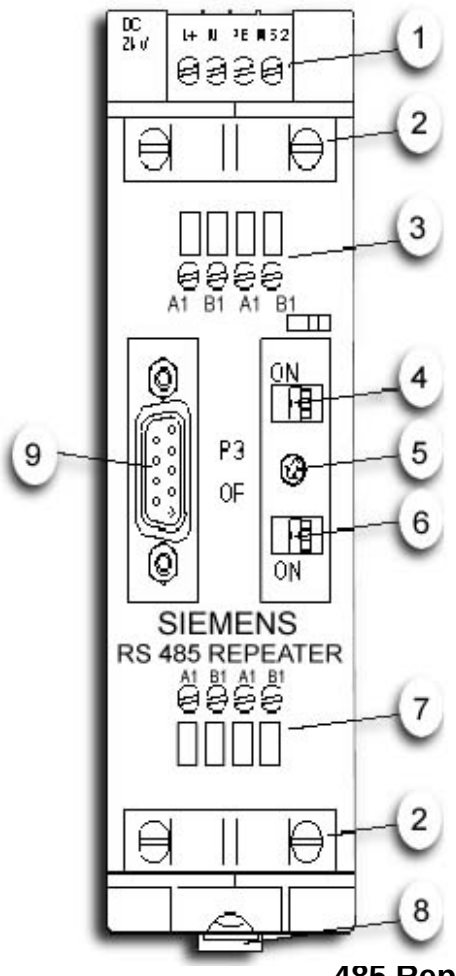


Table 4-3 Description And Functions Of The RS 485 Repeater

1	Terminals for power supply to the RS 485 repeater (pin M5.2 is the ground reference for measuring the voltage transient between A2 and B2).
2	Shield clamp for strain relief and grounding the bus cable of bus segment 1 or bus segment 2
3	Terminals for bus cable of bus segment 1
4	Terminating resistor for bus segment 1
5	Switch for baud rate. The positions are: 0: Bus segments disconnected 1: 9.6 kbaud 6: 1.5 Mbaud 2: 19.2 kbaud 7: 3 Mbaud 3: 93.75 kbaud 8: 6 Mbaud 4: 187.5 kbaud 9: 12 Mbaud 5: 500 kbaud
6	Terminating resistor for bus segment 2
7	Terminals for bus cable of bus segment 2
8	Clamp for securing the RS 485 repeater to standard-section busbar
9	Interface for programmer/OP on bus segment 1

signal

Note:
Terminal M5.2 of the power supply (see Table 4-3, No. 1) serves as a ground reference for measurements in the event of a fault and must not be wired.

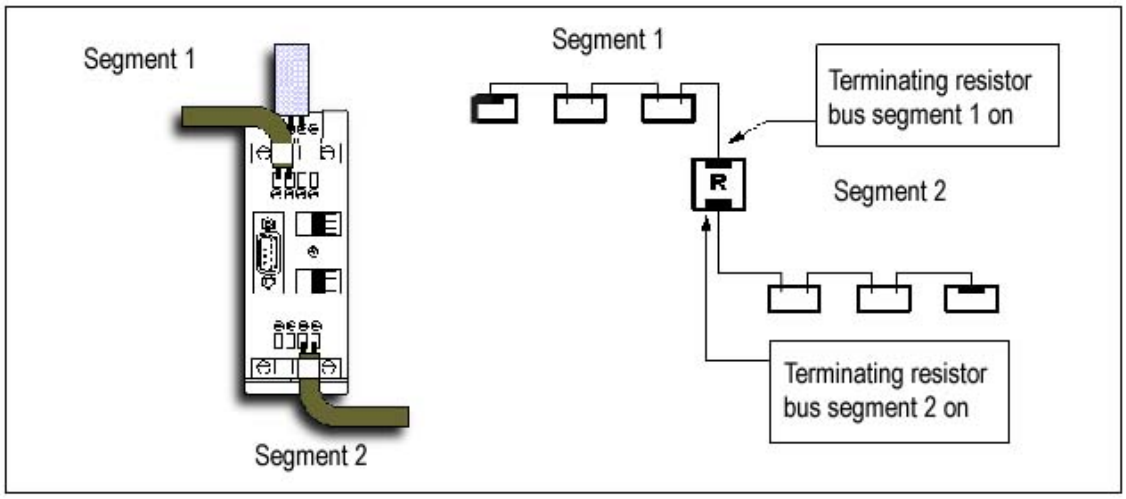
3. Configuration Options With The RS 485 Repeater

This section discusses the configuration options offered by the RS 485 repeater:

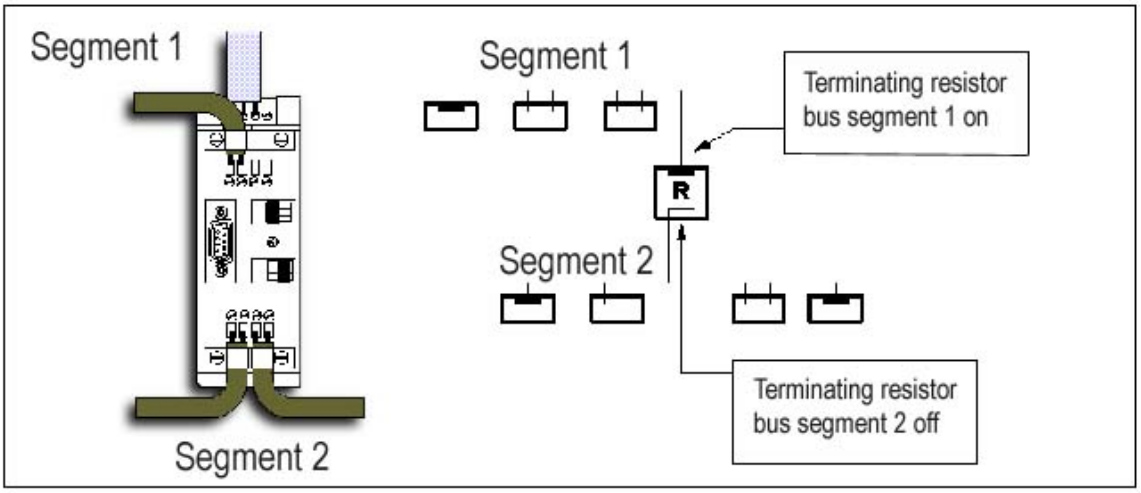
- Segment 1 and segment 2 terminating at the RS 485 repeater
- Segment 1 terminating at the RS 485 repeater and segment 2 looped through the RS 485 repeater, and
- Segment 1 and segment 2 looped through the RS 485 repeater.

It is preferred by using repeaters that the repeater is the end and start of the network and termination point as well (picture 1).

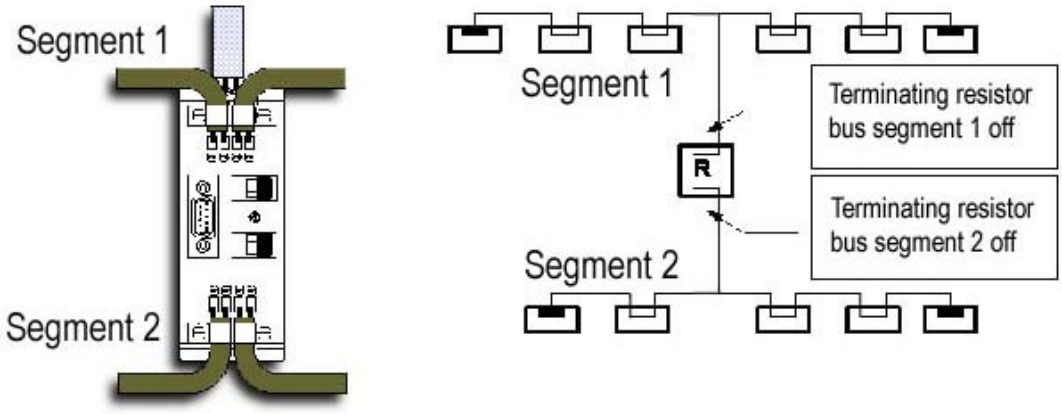
Picture 1 - Terminating At The Repeater



Picture 2 - Segment 1 Terminated, Segment2 Looped Through



Picture 3 - Both Segments Looped Through



4. Installing And Removing The RS 485 Repeater

You can install the RS 485 repeater on a standard-section bus bar.

If you want to mount the RS 485 repeater on a standard-section bus bar, make sure that the clamp is in position on the rear of the RS 485 repeater:
1. Engage the RS 485 repeater on the standard-section bus bar and
2. push it back until the clamp engages.

To disengage the RS 485 repeater from the standard-section bus bar:
1. Using a screwdriver, press the clamp at the bottom of the RS 485 repeater down and
2. swing the RS 485 repeater up and away from the standard-section bus bar.

5. Connecting The Voltage Supply

For the 24 VDC voltage supply, use flexible cables with a cross-section from 0.25 mm^2 to 2.5 mm^2 (AWG 26 to 14).

To connect the power supply of the RS 485 repeater:
1. Strip the ends of the 24 V DC cable conductors.
2. Connect the cable to the terminals marked ”L+”, ”M” and ”PE”.

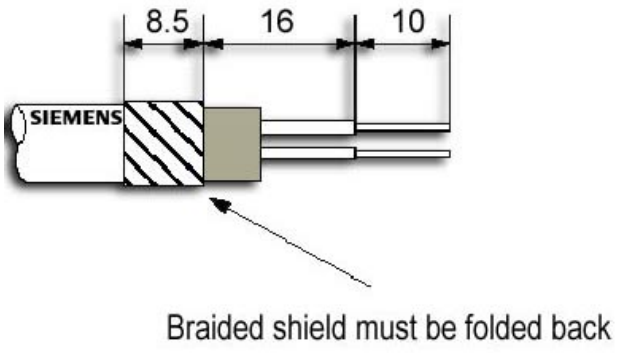
6. Connecting The Bus Cable

The PROFIBUS bus cable must satisfy the requirements given in section 2.

Connect the PROFIBUS bus cable to the RS 485 repeater as follows:
1. Cut the PROFIBUS bus cable to length.
2. Strip the ends of the PROFIBUS bus cable as shown in Fig. 4-4.
3. Fold back the braided shield over the end of the cable sheath. This is necessary to ensure that the shield clamp can function as strain relief and as a terminal for the shield.

Figure 4- 4 bus cable

6XV1 830–0AH10 (bus cable, solid)
6XV1 830–3BH10 (trailing cable)



4. Connect the PROFIBUS bus cable to the RS 485 repeater:
5. Connect the same conductor (green/red for PROFIBUS bus cable) to the same connections, A or B. **Always connect the green conductor to terminal A and the red conductor to terminal B**).
6. Tighten the shield clamps so that the naked shield is held firmly by the clamp.

V. Fiber Optic Components

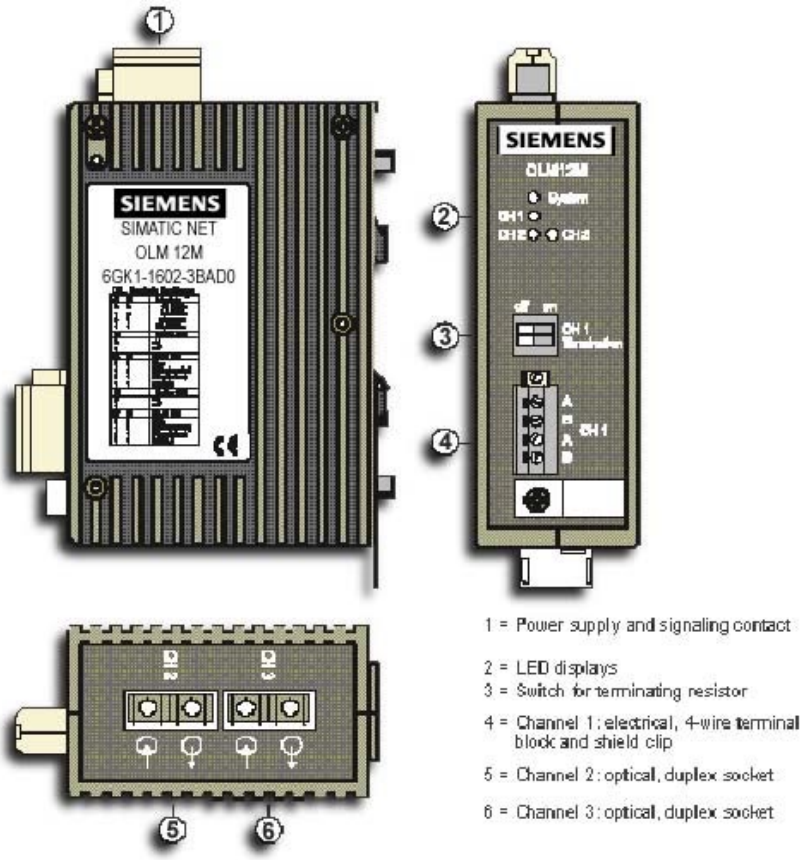
An optical fiber cable transfers data signals using electromagnetic waves at optical frequencies. The entire system or parts of the system which are subject to heavy electromagnetic interference can be optionally wired using optical fiber cables.

The following lists the main advantages of data transfer with optical fiber cable:

⇒ Larger distances between adjacent stations are possible.
⇒ Interference signals cannot propagate through the plant since galvanic isolation is present between all stations.
⇒ Immunity to electromagnetic interference.

1. Introduction

The SIMATIC NET OLM12M optical link modules are intended for use in optical PROFIBUS field bus networks. They allow the conversion of electrical PROFIBUS interfaces (RS 485) to optical PROFIBUS interfaces and vice-versa.
Each OLM12M has three independent channels consisting of a transmitter and receiver section. Channel 1 is an electrical port (RS 485) designed as a 4-wire terminal block with a shield clip. Channels 2 and 3 are the optical ports. The fiber-optic cables are connected via duplex sockets. The power supply is 24 VDC.
LEDs signal the current status and any faults/errors during operation.



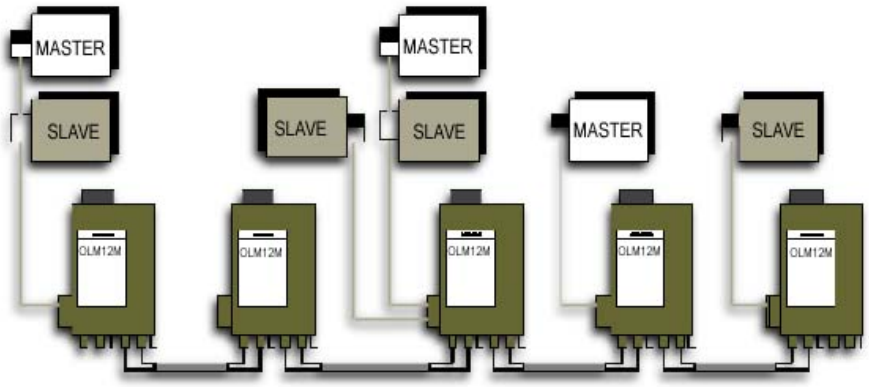
The distance between two modules connected by fiber-optic cables is shown in the table below.

Plastic cable 980/1000 µm	with maximum 200 dB/km path attenuation 0.1 m to 50 m
HCS cable 200/230 µm	with maximum 10 dB/km path attenuation 0.1 m to 300 m

The connectors required to connect the plastic FO cable are supplied. With HCS pre-assembled cables, cables sold by the meter and connector attachment tools are available.
Using a signaling contact (relay with floating contacts), various errors/faults on the modules can be signaled, for example, to a control room.
The module is constructed as a compact, stable metal casing that can be installed either on a standard rail or on any other flat surface. For the standard application, no adjustments are necessary when installing the module. For special applications, the module is configured with a maximum of ten easily accessible switches.

2. General Functions

Baudrate:
The SIMATIC NET OLM12M optical link modules support the transmission rates12 Mbps (standard setting), 1.5 Mbps, 500 Kbps and 187.5 Kbps.
Line Monitoring:
With the “Monitoring”, “Send Test Pulses” and “Monitor Echo” functions, the SIMATIC NET OLM12M optical link module can monitor the connected optical paths for breaks on the FO cable.
Monitoring:
The SIMATIC NET OLM12M optical link module monitors the bus activity on the optical receive channels. If there is no bus activity, for example due to a cable break, the system LED is switched to red and the signaling contact activated after approximately 200 ms on the single-fiber ring and after approximately 600 ms on the optical bus.
Line Topology:
The advantage of this topology is that large distances can be covered and that any number of active bus nodes (masters) and passive bus nodes (slaves) can be connected to each optical link module.



The individual SIMATIC NET OLM12M optical link modules are connected together in pairs by a duplex FO cable.
All the optical channels connected to the optical bus structure are switched to the “Line” mode.
The optical channels at the start and end of the bus must be switched to the “Inactive” mode if they are not used.

Individual DTEs or a complete PROFIBUS segment with a maximum of 25 nodes can be connected to each optical link module via the electrical channel with its RS 485 interface.
With the monitoring function, the individual FO cable sections can be monitored by the optical link modules connected to it.
If an optical link module drops out or if an FO cable breaks, the network is broken up into two subnetworks.

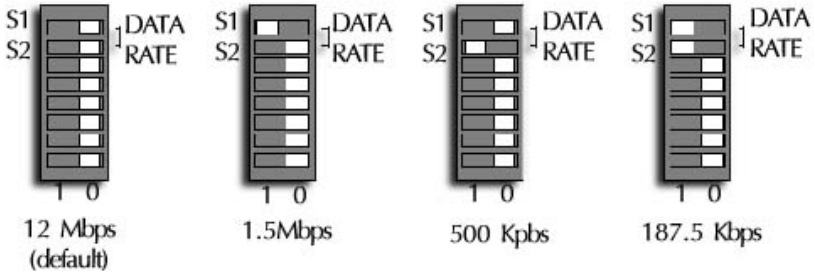
3. Starting Up

Check for the appropriate settings on the DIL switch:

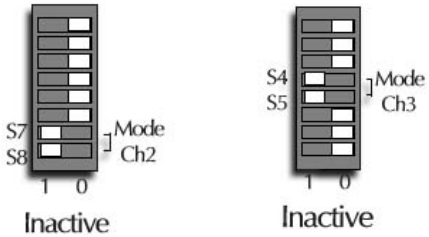
⇒ Set the OLM12M optical link module to the required transmission rate (default setting: 12 Mbaud).
⇒ Adapt the OLM12M optical link module to the required topology by setting the mode (default setting: Line).
⇒ Activate a terminating resistor combination on channel 1 if the OLM12M optical link module is the start or end of an RS 485 bus segment (default setting: terminating resistor combination deactivated).
⇒ Connect the optical LAN cables
⇒ Assemble the optical link modules
⇒ Connect the electrical RS 485 LAN cables
⇒ Connect the power supply and the signaling contact

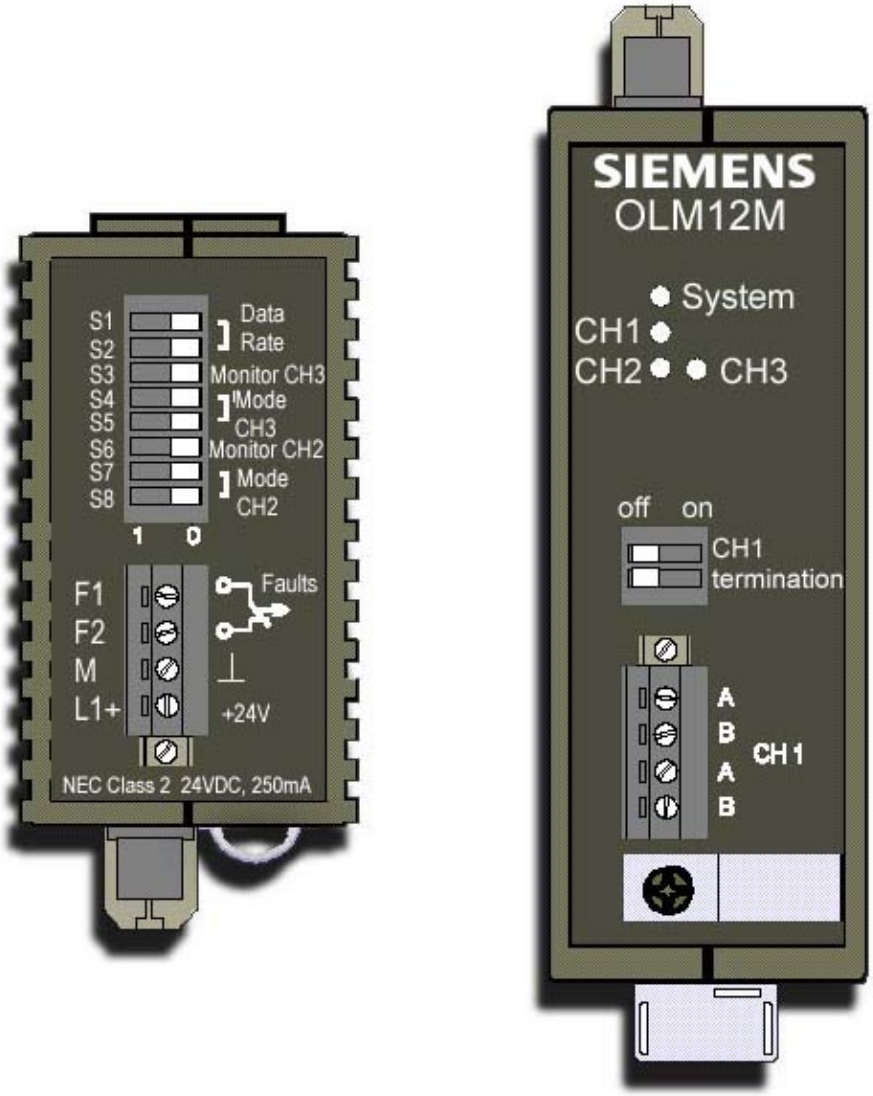
4. Setting The DIP Switches

The transmission rate is set with switches S1 and S2.
The following diagrams show the settings for the various transmission rates:



All other DIP switches remain in the default setting (line mode and monitor function on) except the inactive mode for an unused channel.



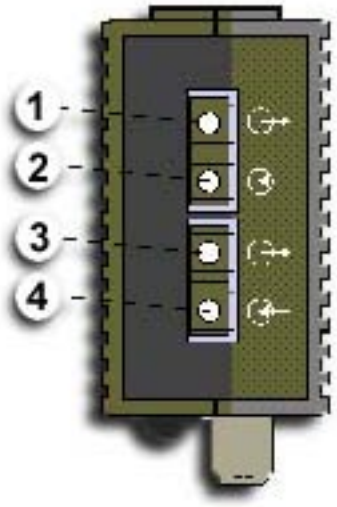


5. Setting the Terminating Resistors for Channel 1

The switch for setting the terminating resistors (termination) is located on the front panel of the OLM12M. Set both switches to the 'ON' setting **when the OLM12M is at the start or end of an RS 485 bus segment**.

Note that both switches must always be in the same position! Different settings for the two switches can lead to disturbed transmission.

6. Connecting The Optical Cable



1 = CH3, optical transmitter
2 = CH3, optical receiver
3 = CH2, optical transmitter
4 = CH2, optical receiver
Connect the optical link modules together using a duplex FO cable with duplex connectors or pairs of connectors.
Make sure that in each case an optical input is connected to an optical output (crossover connection).
Make sure that the strain relief for the FO cable is adequate and does not exceed the minimum bending radius of the FO cable.
Close unused fiber-optic sockets with the supplied dust caps. Extraneous light, particularly in brightly lit areas, can cause disturbances on the network.
Set all unused optical channels to the 'Inactive' mode.
Make sure that the length of the FO cable is within the limits set by the minimum and maximum lengths and that you use only the fiber types specified.
Make sure that no dust can infiltrate optical components. Dust in optical components can make them unusable.