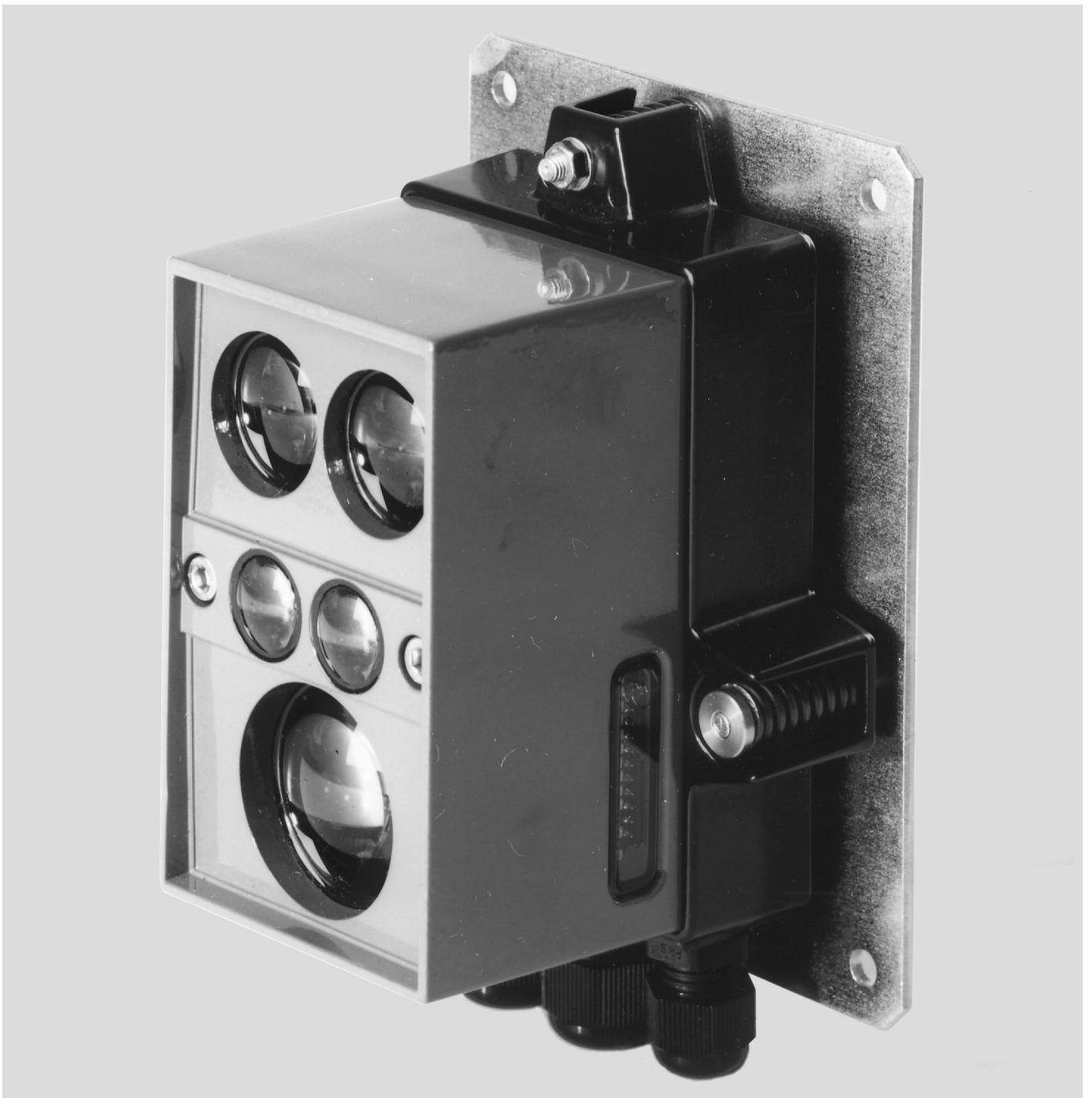




Serial Optical Data Transmission with Bus Capability DDL5 170

Technical Description



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We reserved the right to make changes for the technical improvement of the product.

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1 General Information

About this document

The DDLS 170 data transmission system available up to now has been further developed. This technical description covers the new, as well as the old, data transmission system.

- The further-developed DDLS 170 is documented in Chapters 2 - 9.
Designation: DDLS 170/xxx.1-xxxx or DDLS 170/xxx.2-xxxx
(x = place holder for defined order designation, such as range and bus system; further details can be found in Chapter 5 "Accessories / Order Designations").
- Device-specific details pertaining to the previous data transmission system can be found in the Appendix (Chapters A - E).
Designation: DDLS 170.1, or DDLS 170.2

1.1 Explanation of symbols

The following is an explanation to symbols used in this *technical description*:




Attention !


This symbol appears in front of text which must be observed without fail. Failure to observe the provided instructions could lead to personal injury or damage to equipment.



Notice:

This symbol indicates text which contains important information.

 This symbol refers you to other chapters or other literature.

 This symbol indicates activities which are to be carried out.

Italics To help you find information quickly, important terms and key words are listed in the left-hand column in italics.

1.2 Important terms

<i>DDLS 170</i>	Type designation for the optical data transmission system from Leuze electronic, consisting of two synchronized data transmission units.
<i>DDLS 170/xxx.1-xxxx</i> <i>DDLS 170/xxx.2-xxxx</i>	Type designation of the further-developed data transmission units. One data transmission system consists of two DDLSs.
<i>DDLS 170.1</i> <i>DDLS 170.2</i>	Type designation of the data transmission units available up to now. One data transmission system consists of two DDLSs.
<i>FSK modulation</i>	Modulation by means of frequency shift keying.
<i>FSK frequencies</i>	Frequencies at which data are transmitted between DDLS units. The DDLS 170/xxx.1-xxxx (DDLS 170.1) and DDLS 170/xxx.2-xxxx (DDLS 170.2) each have their own assigned frequency pairs.
<i>Full duplex</i>	Simultaneous transmission and reception of data.
<i>Half-duplex operation</i>	Data are alternately transmitted and received only.
<i>Transparent</i>	The data transmission units function as passive transmission members in a bus system. The telegram structure is transmitted optically without being altered. The transmitted data information are not subjected to interference.
<i>Remote multifunction display</i>	Two highly visible LEDs for displaying reception level during coarse adjustment.
<i>Bar graph</i>	Close-up multifunction display for displaying reception level during fine adjustment.
<i>INTERBUS</i>	Bus system according to DIN 19258.
<i>Profibus</i>	Bus system according to DIN 19245.
<i>Suconet K</i>	Transmission system produced by Klöckner Möller

1.3 Declaration of Conformity



The DDLS 170 data transmission system was designed and manufactured in accordance with applicable European normatives and guidelines.

Notice:

A corresponding Declaration of Conformity can be requested from the manufacturer.

The manufacturer of the product, Leuze electronic GmbH + Co. in D-73277 Owen/Teck, maintains a certified quality management system in accordance with ISO 9001.



2 Safety Notices

2.1 Safety standard

The DDLS optical data transmission system has been developed, tested and produced in compliance with applicable safety standards. It corresponds to the state of the art.

2.2 Intended use



Attention !

The protection of personnel and the device cannot be guaranteed if the device is operated in a manner not corresponding to its intended use.

Optical data transmission systems of the type DDLS 170 are designed for the optical transmission of data in the infrared range.

The data transmission units

- may not be used in areas where interruption of data transmission, e.g. as a result of blocked transmitter or receiver lens, could lead to damage or injury
- may not be operated in rooms with explosive atmospheres
- may not be used for medical purposes

Fields of application

The DDLS 170 optical data transmission system is designed, in particular, for the following applications:

- transmission of data output using the INTERBUS, Profibus and Suconet K field bus protocols
- use in automated high-bay warehouses
- anywhere where data transmission to and from fixed or moving objects and over large distances (up to 200 m) is required

2.3 Working safely



Attention !

Entering or making changes to the device, except where expressly described in this operating manual, is not permitted.

- Optics* Regularly clean transmission and reception windows on the DDLS 170. Observe Chapter 9, "Maintenance".
- Alignment* Use the bar graph regularly to check the alignment of the DDLS 170 (see Chapter 6.2.3 "Alignment").

2.4 Organizational measures

- Documentation* Observe all instructions in this "Technical Description" without fail, particularly the section entitled "Safety remarks".
- Carefully store this operating manual. It should be accessible at all times.
- Safety regulations* Observe the locally applicable legal regulations and the rules of the employer's liability insurance association.
- Qualified personnel* Mounting, commissioning and maintenance of the device may only be carried out by qualified personnel.
- Electrical work must be carried out by a certified electrician.
- Repair* Maintenance work must only be carried out by the manufacturer or by a service center authorized by the manufacturer.

3 Description

3.1 About the data transmission units of the DDLS 170 series

Where data have to be transmitted to and from moving objects, optical data transmission systems provide an ideal solution.

With the DDLS 170 series, Leuze electronic offers a range of efficient optical data transmission units. The data transmission units are robust and are not subject to wear.



Notice:

The DDLS data transmission system consists of two devices, each of which has a transmitter and a receiver:

e.g. DDLS 170/120.1-1110 and DDLS 170/120.2-1110

3.2 Characteristics of the DDLS 170

The widespread use of bus systems in nearly all branches of industry requires data transmission systems with high demands on:

- transmission security
- flexibility
- operation

The DDLS 170 data transmission unit from Leuze electronic is a high-performance transmission system. It enables transmission of the following bus protocols without any physical contact:

- INTERBUS
- Profibus / MPI / SINEC L2 - FMS / SINEC L2 - DP / mixed operation FMS - DP
- Suconet K (Klöckner Möller)
- RS422 - systems up to 500 kbit/s
- RS485 - systems up to 500 kbit/s (on request)

3.3 Benefits

The DDLS 170 is characterized by the following features:

- The DDLS 170 can be operated at temperatures as low as - 30°C.
- Interference-free data exchange in full-duplex operation, transmission rate up to 500 kbit/s at a max. range of 120 / 200 m and large functional reserves.
- High interference immunity through special constructions such as galvanically separated interfaces and FSK modulation.
- Fast and simple alignment by means of integrated remote multifunction display and bar graph. The angles can be set independently of one another thanks to the physical construction of the adjusting bracket.
- All installation work can be carried out from the front. The DDLS 170 system can be completely disassembled without removing the connection plate.

Switching off transmitter and receiver

- Both the transmitter and the receiver can be switched off separately.

Example: Changing aisles of high-bay storage and retrieval units. By switching off the transmitter and receiver during travel through curves, other optical systems are not influenced and faulty data transmission does not occur as the result of signals detected by the receiver which have been emitted by other optical sensors.

For Profibus only

Signal regeneration

- Several optical data transmission paths can be connected in series (see Chapter 3.7.4).
- Trouble-free data transmission with Profibus FMS-Systems in Multi-Master configuration (indirect series connection, see Chapter 3.7.4).
- Repeater function; signal regeneration increases the possible line lengths and the number of nodes in the system.

For Profibus only

Selector switch during loss of visual contact

- Shorter bus access times for Profibus systems in Multi-Master configuration on renewed visual contact (see Chapter 3.7.4).
- If the signal received by the data transmission unit receiver is inadequate, the transmitted and received data are switched off. In this way, undefined bus conditions occurring as the result of one-sided system accesses are prevented.

3.4 Construction

The DDLS 170 series data transmission units are durable, user-friendly and easy to service. A data path consists of two synchronized data transmission units:

e.g. DDLS 170/120.1-1110 and DDLS 170/120.2-1110

The data transmission unit consists of the following components:

- 1 Adjusting screws (2)
- 2 INTERBUS, Profibus (Suconet K) interface module
- 3 Bi-directional transmitter
- 4 Fastening screws (2)
- 5 Remote multifunction LED display: multifunction display, red, red blinking
- 6 Remote multifunction LED display: multifunction display, yellow
- 7 Receiver
- 8 Close-up multifunction display; bar graph for reception level (10 LEDs)
- 9 Interface monitor; LED red - transmit data
- 10 Interface monitor; LED green - receive data
- 11 Terminal strip

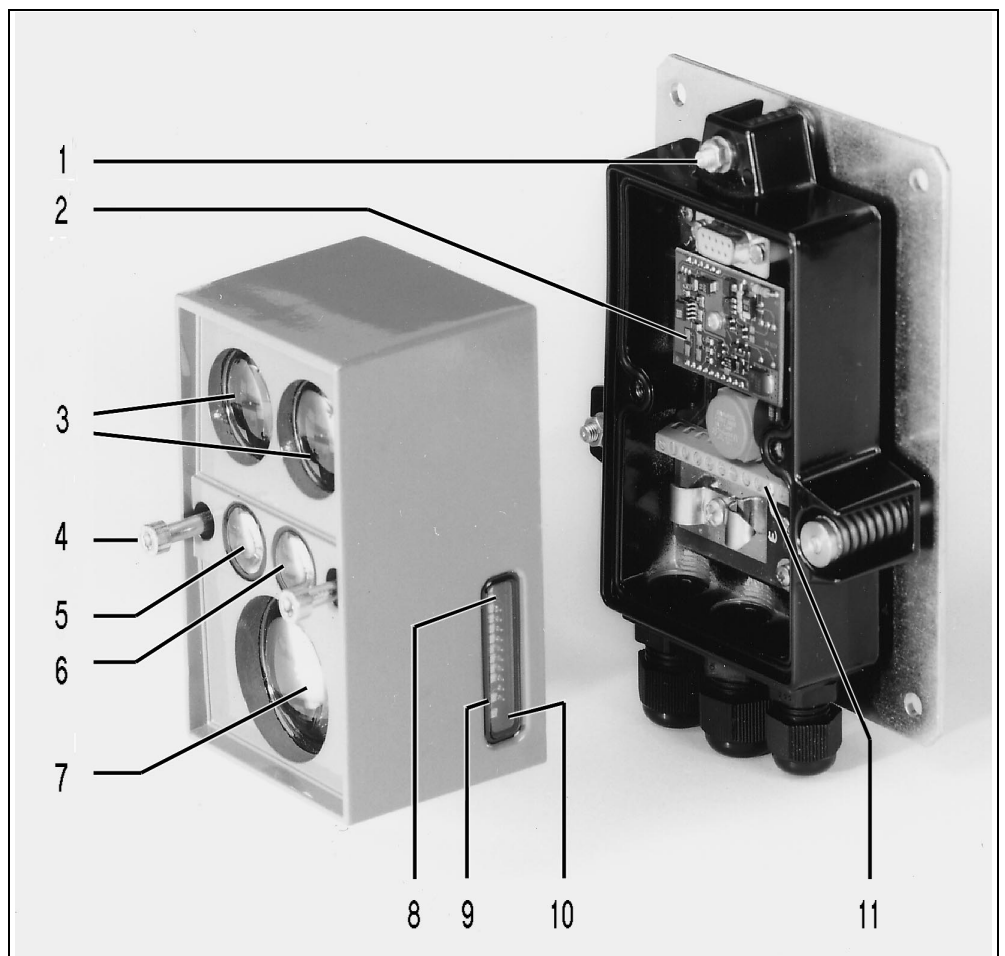


Fig. 1: DDLS 170 components

3.5 Interface characteristics

INTERBUS interface

The INTERBUS interface physically corresponds to an RS422 interface. It is characterized by the following features:

- Protocol* • Transmission of the INTERBUS protocol
- Transmission rates* • Transmission rates: 500 kbit/s with INTERBUS and 0 to 500 kbit/s with RS422 - systems
- Cable connection* • 4-wire
- Range of operation* • Can be used for:
 - bus operation (INTERBUS)
 - point-to-point connection (RS422)• See also Chapters 3.7.2 and 3.7.3

Profibus interface

The Profibus interface (e.g. SINEC L2) physically corresponds to an RS485 interface. It is characterized by the following features:

- Protocol* • Transmission of the following Profibus protocols is possible:
 - MPI Multi Point Interface (187.5 kbit/s)
 - FMS Field Message System
 - DP Decentralized periphery
 - FMS/DP Mixed operation
- Transmission rates* • Can be set to all common transmission rates:
 - in kbit/s
 - 9.60
 - 19.20
 - 38.40
 - 57.60
 - 93.75
 - 187.50
 - 375.00
 - 500.00
- Cable connection* • 2-wire
 - Terminator can be activated with slide switch
- Range of operation* • See Chapter 3.7.4

Suconet K interface

- Protocol* • Transmission of the Suconet K, K1 and K2 protocols
- Transmission rates* • Transmission rate of 187.5 kbit/s with Suconet K, K1 and K2
 - Transmission rate of 375 kbit/s with Suconet K
- Cable connection* • 2-wire
 - Terminator can be activated with slide switch
- Range of operation* • See Chapter 3.7.5

3.6 Function

- Transmit / Receive** The transmitter transforms the electric signals into light signals by means of an IR-LED. The receiver transforms the light signals back into electric signals by means of a photodiode.
- Carrier frequency** To ensure that there is no mutual interaction during data transmission in full-duplex operation, two different pairs of frequencies are used. These are identified by type designations1 ... and2

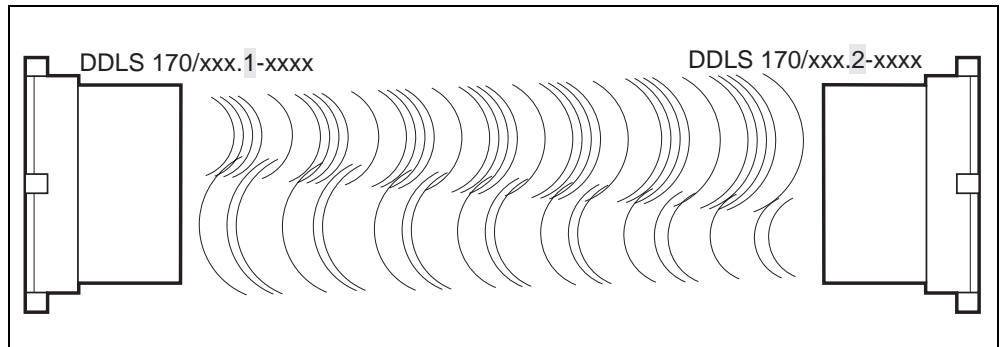


Fig. 2: Transmit - receive principle

- FSK modulation** Each device transmits its signal by means of frequency shift keying (FSK modulation). Information is bit-encoded in two frequencies.

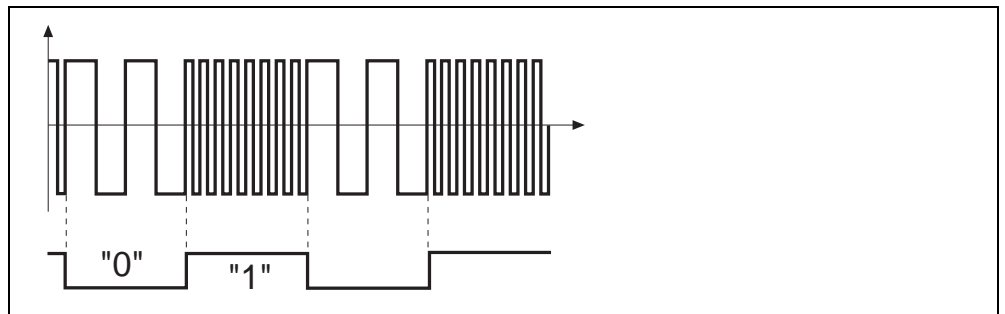


Fig. 3: FSK modulation

The receiver filters the frequencies from the received signal and transforms them back into bit sequence. Bit errors in the transmission, caused for example by light flashes from fluorescent tubes, are filtered out in this way.

- Transmission quality** The level of the received signals can be checked on both devices.
- Remote multifunction LED:
Multifunction display (red, red blinking or yellow) for coarse tuning.
 - Close-up multifunction display:
Bar graph for reception level (10 LEDs) for fine-tuning.
 - For PLC:
Data transmission good - terminal 9
Data transmission critical - terminal 8

- Monitoring** To monitor the aligned DDLS 170 or for contamination checks, connect both output terminal 9 and terminal 8 to a PLC program.

Remote multifunction LED / bar graph

Data transmission	LED (red)	LED (yellow)	Bar graph (LED bar)
none (no optical connection)	off	off	0 - 1 (red)
none (optical connection)	blinking	off	2 - 4 (red)
critical	on	off	5 + 6 (green)
good (with sufficient functional reserve)	off	on	7 - 10 (green)

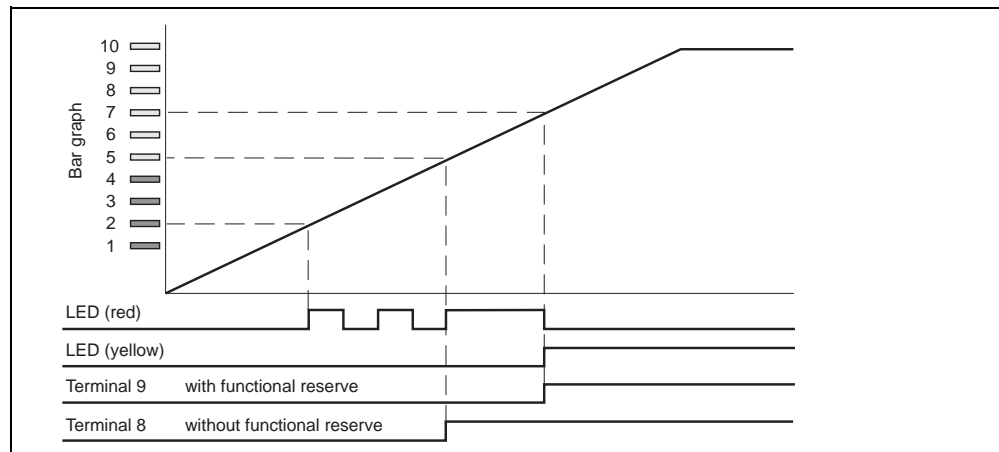


Fig. 4: Display of reception quality

Transmit / Receive

By means of an LED, each DDLS 170 indicates whether it is transmitting and/or receiving data at the moment:

- LED (1) red - Transmit data
- LED (2) green - Receive data
- LED (1) and (2) simultaneously - Data are being transmitted and received

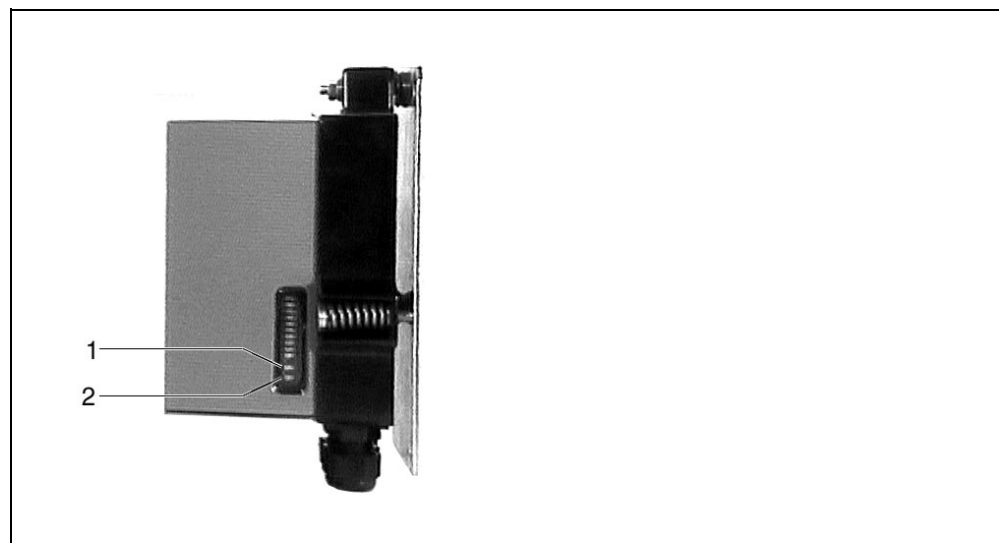


Fig. 5: Transmit / receive indicator

3.7 Application examples

Area of application Die DDLS 170 optical data transmission units are used wherever transmission devices using different systems are more elaborate, complicated, susceptible to interference, and expensive to operate and maintain.

Optical data transmission units replace e.g.:

- Collector wires
- Trailing cables
- Radio connections

When used in mobile applications, the travel speed and acceleration do not influence the transmission quality of the data.

In the application of optical data transmission, a distinction is made between

- Coupling to bus systems
- Point-to-point connections

3.7.1 Examples of use (in principle)

One data path - horizontal

For example, for controlling transport trucks

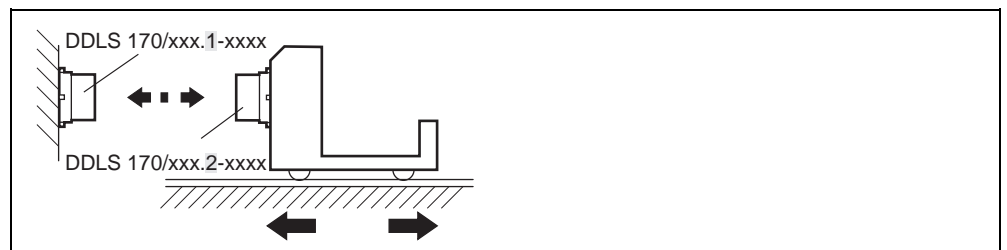


Fig. 6: Transport truck

Two data paths - horizontal

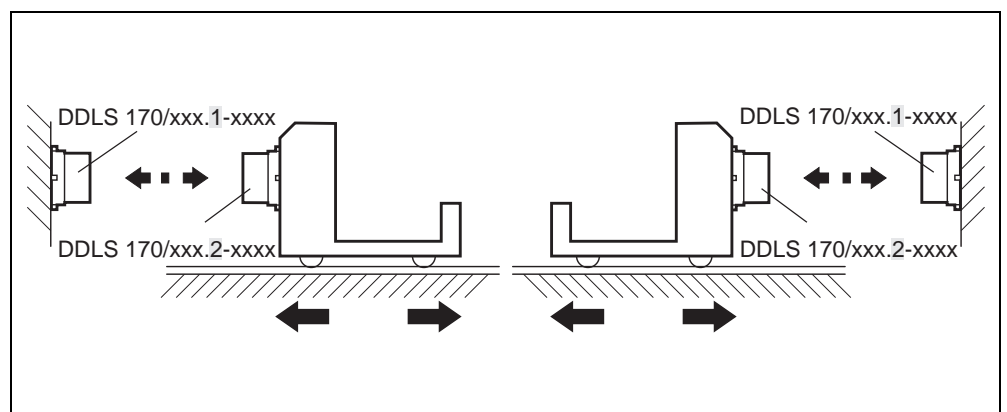


Fig. 7: Two transport trucks running one after the other

When arranging several transmission paths one after the other, the transmission frequencies must be alternated in order to prevent mutual interference (see Fig. 7).

One data path - vertical

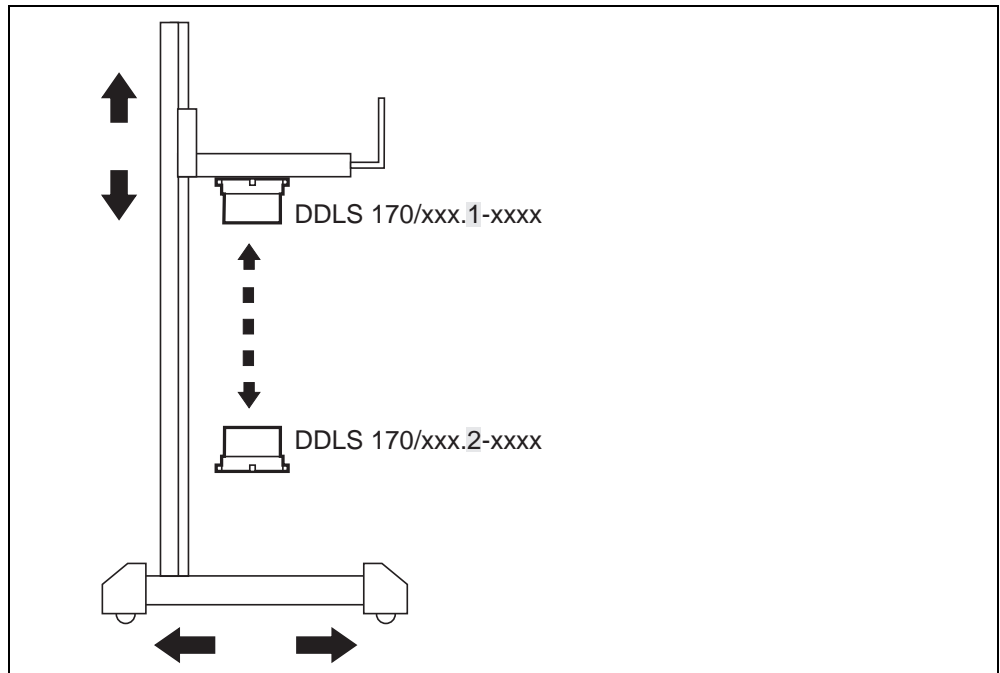


Fig. 8: High-bay warehouse - one data path

Two data paths - vertical and horizontal

For example, data transmission in a high-bay warehouse with several moving axes and several data transmission paths is possible: horizontal (movement in the aisle) and vertical (raising/lowering).

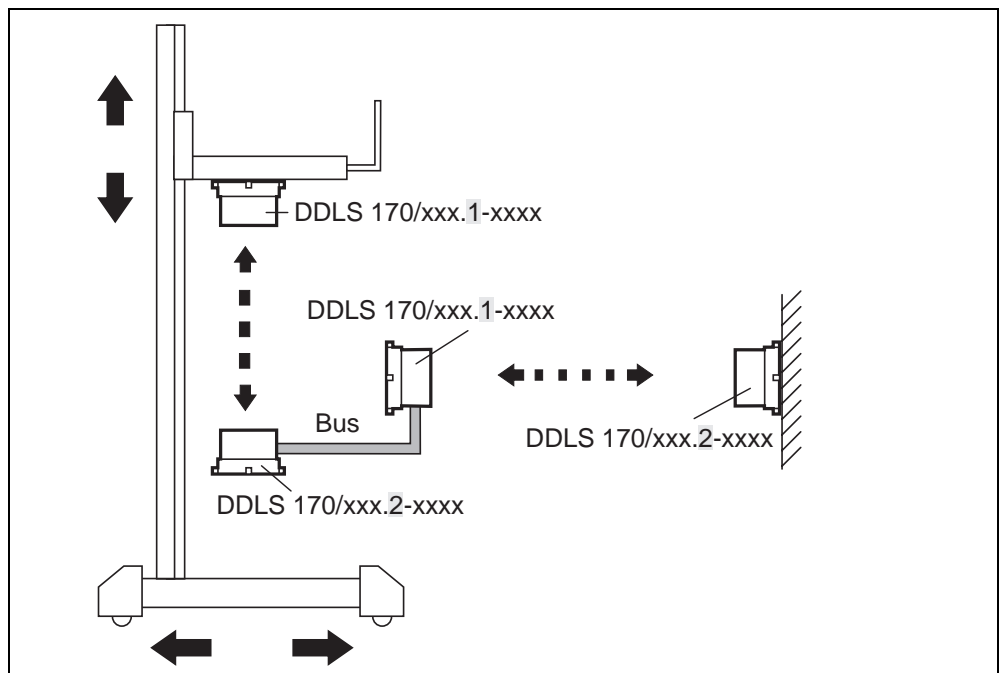


Fig. 9: High-bay warehouse - two data paths

3.7.2 INTERBUS

All bus elements that meet the INTERBUS standard can be connected:

- Order designation: DDLS 170/120.1-**2110** and DDLS 170/120.2-**2110** (120 m)
DDLS 170/200.1-**2110** and DDLS 170/200.2-**2110** (200 m)
- Interface: INTERBUS interface IM170-2000 (built into unit)
- Transmission rate: 500 kbit/s
- Full-duplex operation: transmit and receive data simultaneously

Examples:

- Transmission of control parameters, desired / actual values from the master to the node and vice versa
- Vehicle control in a stationary switch cabinet. Communication with DRIVECOM and ENCOM components via DDLS 170

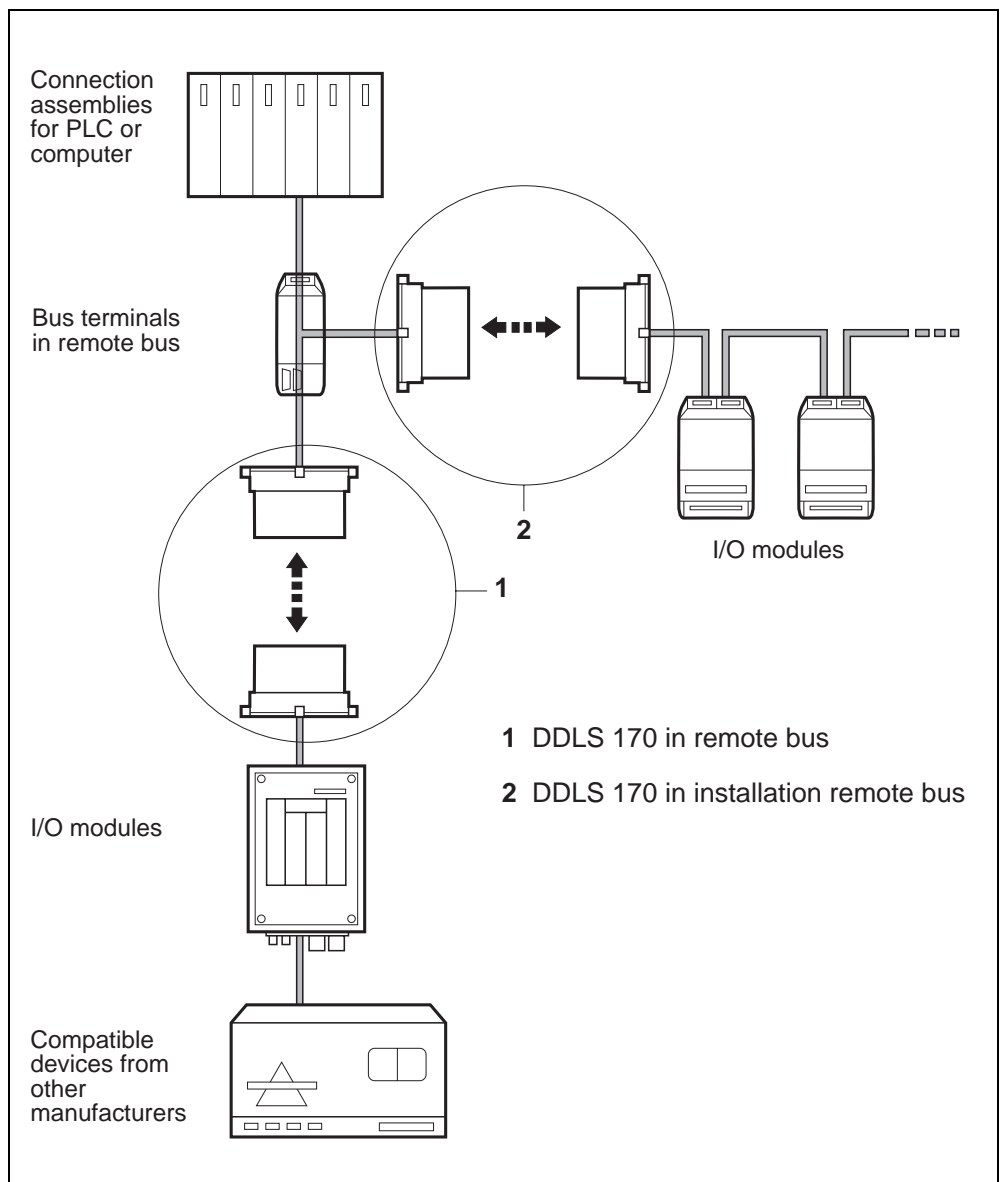


Fig. 10: DDLS in INTERBUS

3.7.3 RS422 Point-to-point connection

RS422 4-wire connection

- Order designation: DDLS 170/120.1-2110 and DDLS 170/120.2-2110 (120 m)
DDLS 170/200.1-2110 and DDLS 170/200.2-2110 (200 m)
- Interface: RS422 interface IM170-2000 (built into unit)
- Transmission rate: infinitely variable up to max. 500 kbit/s, no adjustment necess.
- Full-duplex operation: transmit and receive data simultaneously

Example of use

- Use on transport vehicles/sidetracking skates
e.g. control of trucks and cranes

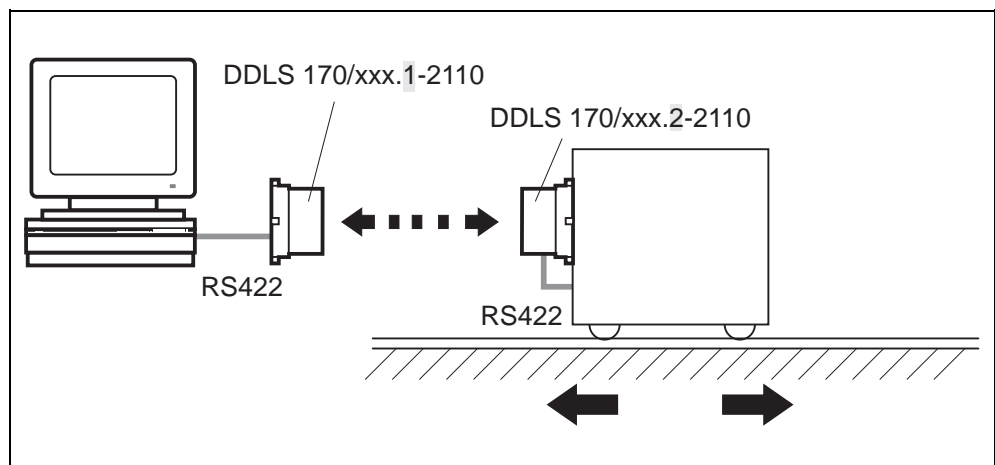


Fig. 11: Truck

Additional possibilities

- e.g. transmission of scale data to a printer or display, on-line connection between operating data acquisition and computer

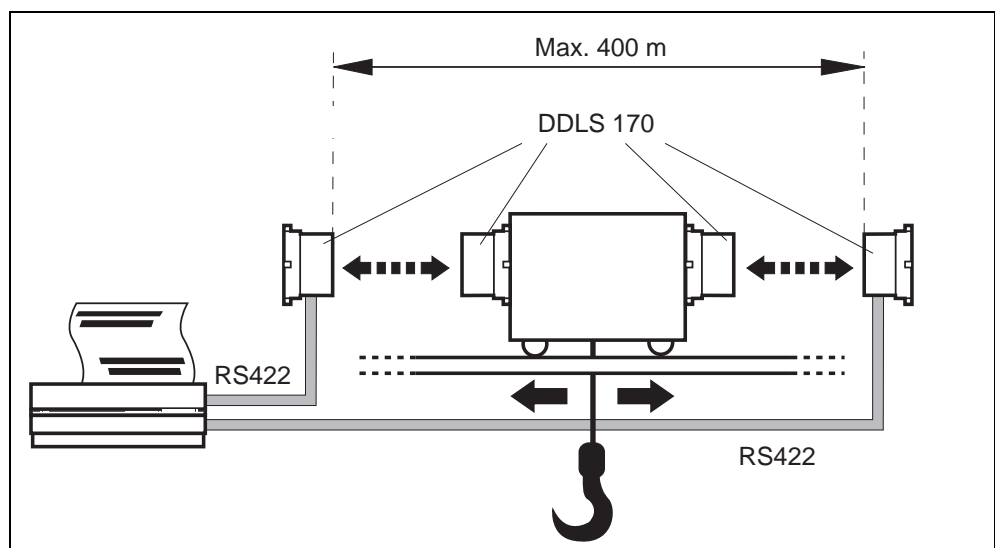


Fig. 12: Mobile crane system

3.7.4 Profibus, MPI, FMS, DP, mixed operation (FMS/DP)

- Order designation: DDLS 170/120.1-1110 and DDLS 170/120.2-1110 (120 m)
DDLS 170/200.1-1110 and DDLS 170/200.2-1110 (200 m)
- Interface: Profibus interface IM170-1000 (built into unit)
- Transmission rate: 9.6 kbit/s, 19.2 kbit/s, 38.4 kbit/s, 57.6 kbit/s, 93.75 kbit/s, 187.5 kbit/s, 375 kbit/s, 500 kbit/s (adjustable)
- Semi-duplex oper.: only serial transmission and reception of data possible

A high-performance, optical data transmission system is available with the DDLS 170 with which the following Profibus protocols can be transmitted:

- MPI Multi Point Interface (187.5 kbit/s)
- FMS Field Message System (in accord. with DIN 19245 Parts 1,2)
- DP Decentralized periphery (in accord. with DIN 19245 Part 3)
- FMS/DP Mixed operation (in accordance with DIN 19245)

Performance features

- All masters and/or slaves that meet the Profibus standard can be connected.
- If the signal received by the data transmission unit receiver is inadequate, the transmitted and received data are switched off.
In this way, undefined bus conditions occurring as the result of one-sided system accesses are prevented.

Signal regeneration

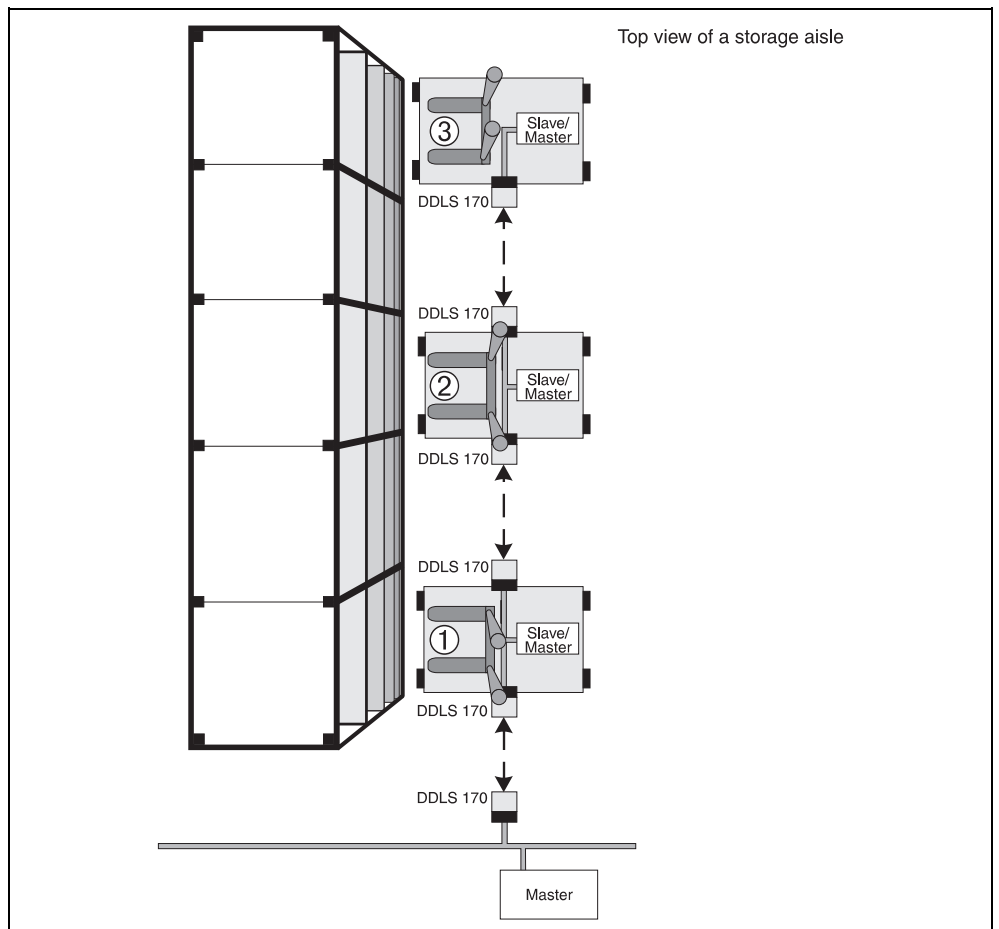


Fig. 13: Direct series connection

- Repeater function; signal regeneration increases the possible line lengths and number of nodes in the system.
- Several optical data transmission paths can be connected in series. In this way it is, for example, possible to transmit data between several high-bay storage and retrieval units in one storage aisle (see Fig. 13).
- Trouble-free data transmission with Profibus FMS systems in Multi-Master configuration. In this way it is, for example, possible to establish direct data communication between several high-bay storage and retrieval units located in different storage aisles (indirect series connection, see Fig. 14).

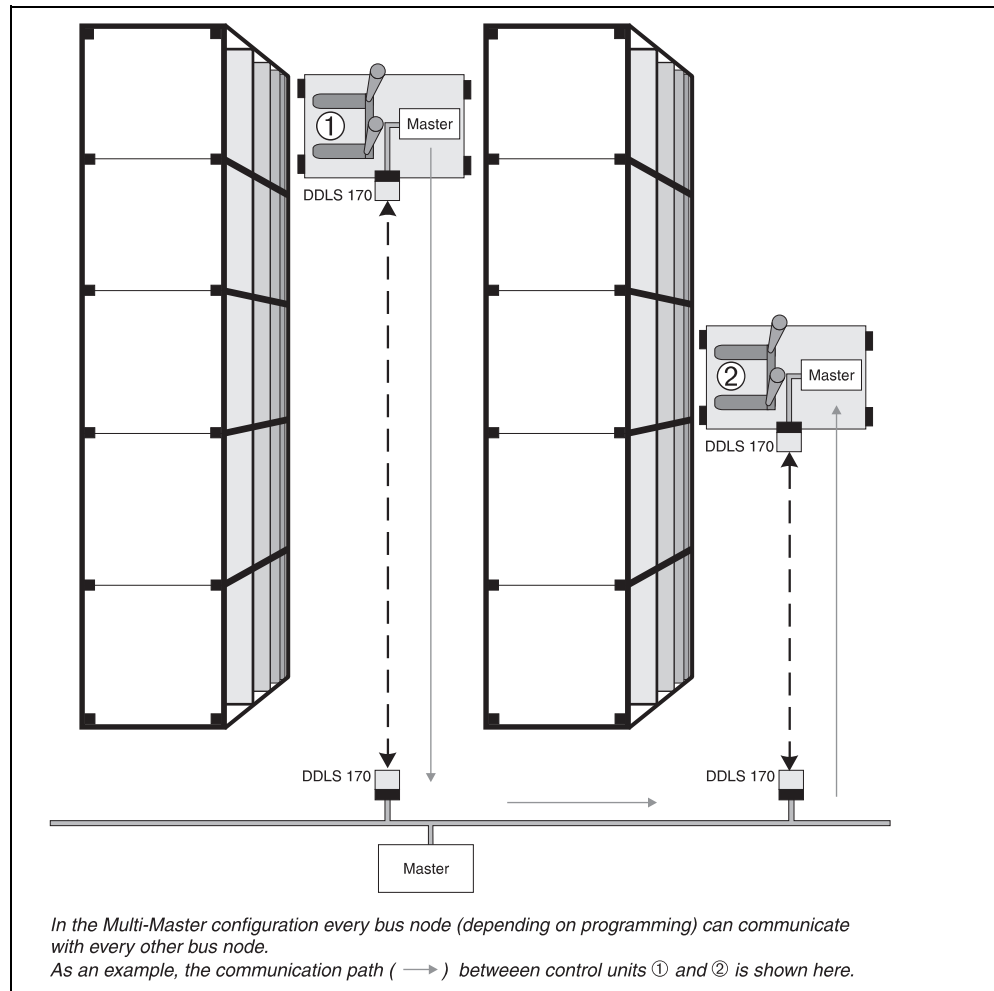


Fig. 14: Indirect series connection

Selector switch during loss of visual contact

Located on the Profibus module next to the DIP switches for baud rate adjustment (1, 2 and 3) is an additional DIP switch (4) which controls the behavior of the data transmission units in the event of loss of visual contact (see Chapter 7.3 "Settings on the Profibus interface module").

If DIP-switch 4 (switch position = 1) is activated and visual contact is lost, it can, for example on high-bay storage and retrieval units, prevent the formation of a token on the vehicle.

Compared with the standard setting (switch position = 0), this has the advantage that, upon re-establishment of visual contact, the system is again stable within a few milliseconds (see Fig. 15, next page).



Attention !

Switch 4 must not be activated if a Profibus system consisting of 2 or more nodes is installed on the other side of the data transmission units. Bus communication between the nodes would otherwise suffer interference.

Functionality of switch 4

- 0 The data lines are switched to high impedance (Tristate) when visual contact is lost. Tristate is the standard application case. The system behaves as it would in the event of a line interruption.
- 1 If the transmission path is interrupted, bus occupation is simulated until visual contact is re-established. Normal exchange of data then resumes. In this way, token regeneration on one of the interrupted nodes is prevented.

Advantages

- Shorter bus access times for Profibus systems in Multi-Master configuration once visual contact has been re-established. For example, when moving high-bay storage and retrieval units from one aisle to another, the interruption routine is carried out faster, thereby reducing the time required to make the entire system available after activating the switch.

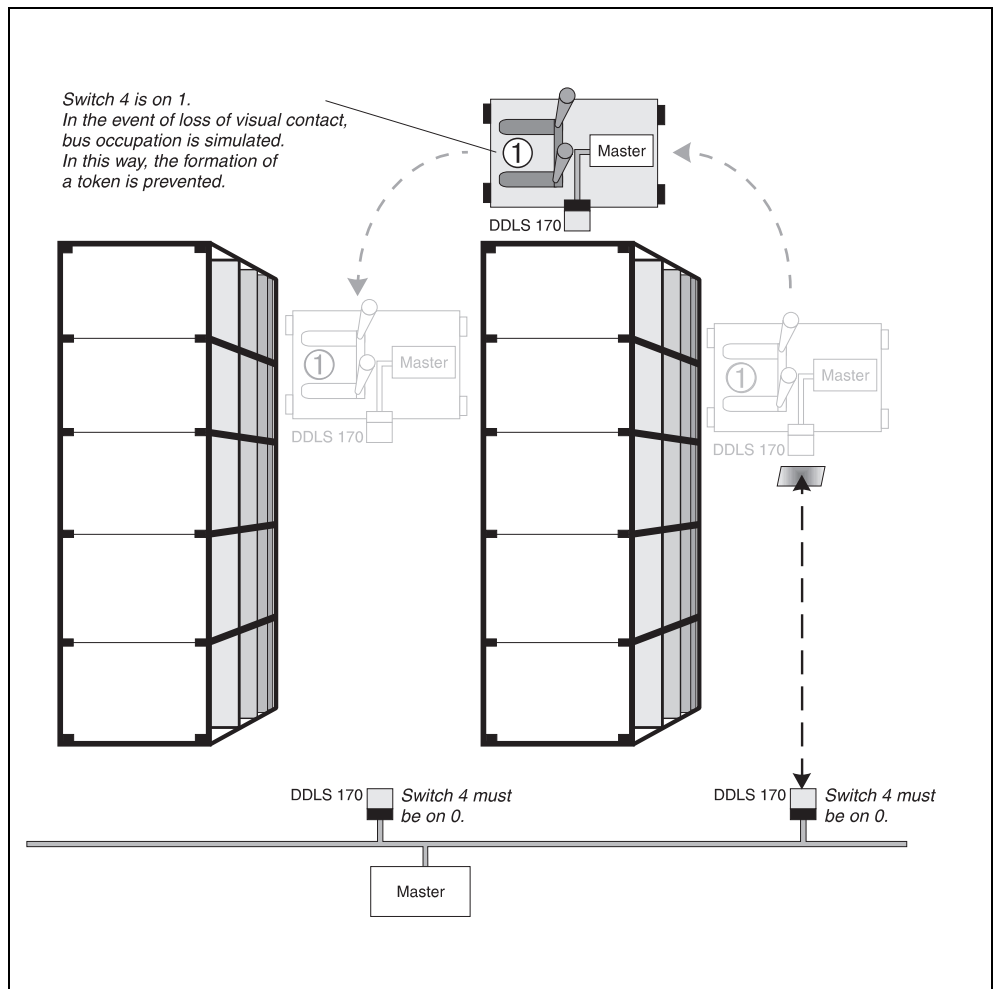


Fig. 15: Selector switch during loss of visual contact

Examples:

- Field Message System (FMS)
Transmission of FMS Master to FMS Slave (e.g. CP 5412, PG 750, PC)
- Decentralized periphery
Transmission from DP Master (e.g. CP 5412, IM 308B) to DP slave (e.g. ET 200, IM 318M).

3.7.5 Suconet K

- Order designation: DDLS 170/120.1-**1110** and DDLS 170/120.2-**1110** (120 m)
DDLS 170/200.1-**1110** and DDLS 170/200.2-**1110** (200 m)
- Interface: RS485 interface IM170-1000 (built into unit)
- Transmission rate: Suconet K, K1 and K2 with 187.5 kbit/s,
Suconet K with 375 kbit/s
- Semi-duplex oper.: Only serial transmission and reception of data

With the DDLS 170 the following protocols from Klöckner Möller can be transmitted:

- Suconet K, K1 and K2

3.7.6 Connection variants for Profibus (MPI, FMS, DP) and Suconet K

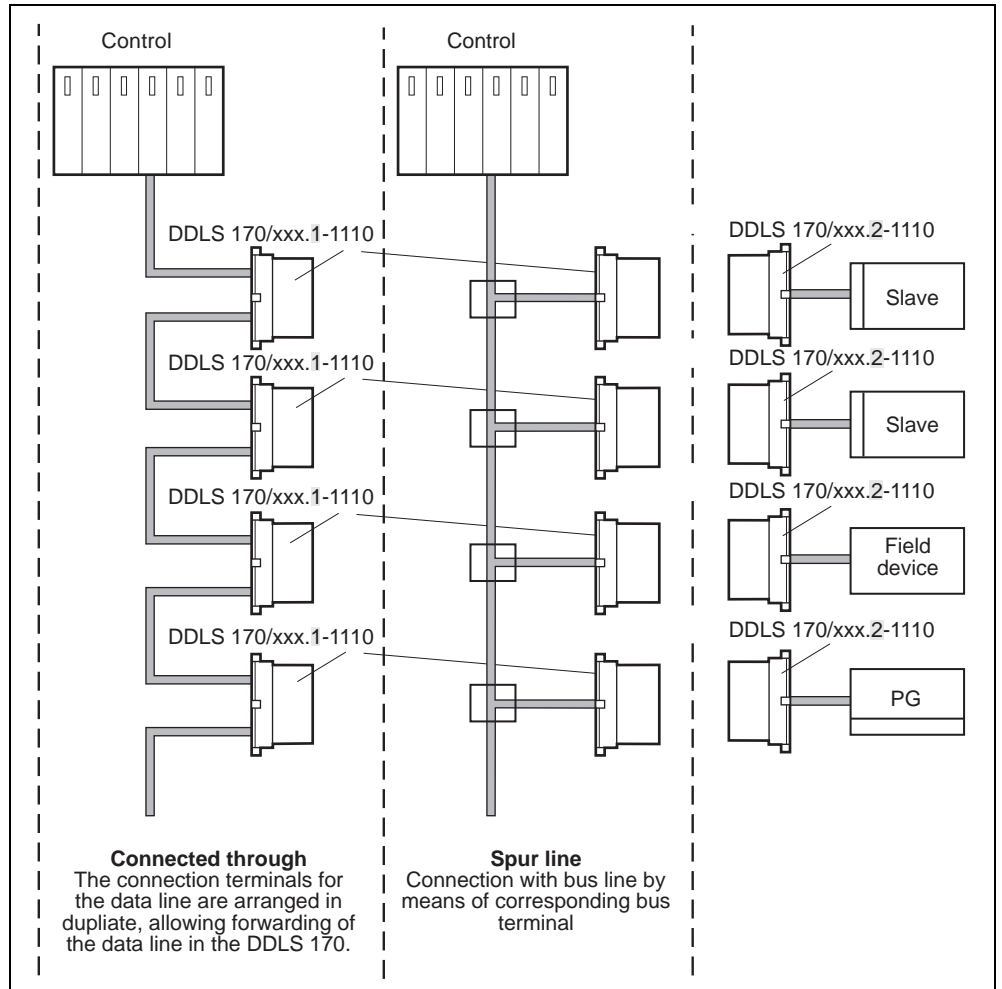


Fig. 16: Profibus (MPI / SINEC L2 - FMS / SINEC L2 - DP) and Suconet K

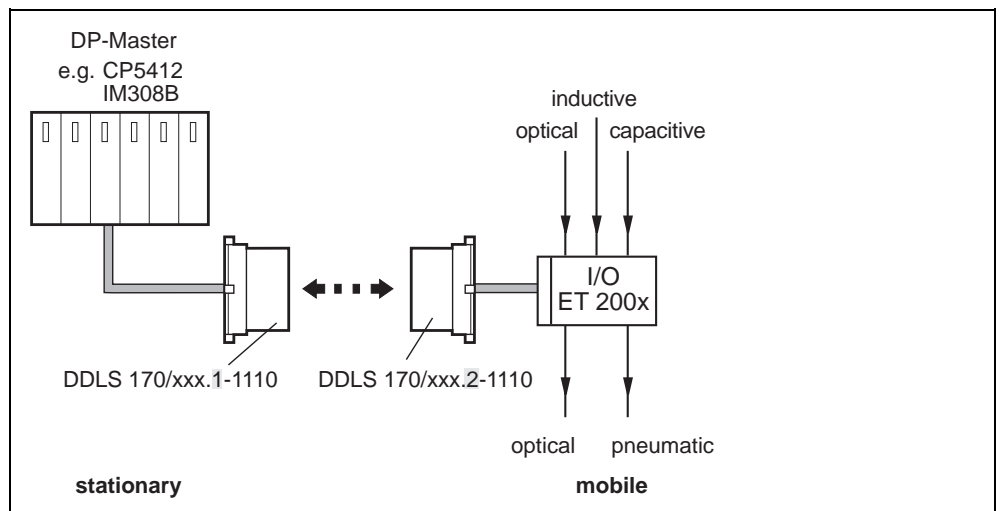


Fig. 17: Connection variant for I/O components

4 Specifications

4.1 General specifications

	Manufacturer	Leuze electronic GmbH & Co., D-73277 Owen/Teck
	Type	DDLS 170
	Range	0 to 120 m; Type designation DDLS 170/120.x-xxxx 0 to 200 m; Type designation DDLS 170/200.x-xxxx (... x-xxxx depending on carrier frequency and interface module). The listed range is the usable range with adequate functional reserve.
	Transmission rate	DC - 500 kbit/s
	Interfaces	Modular slot in the connection element 1) INTERBUS interface 2) Profibus interface (MPI, FMS, DP) 3) Suconet K interface (K, K1, K2)
	Power supply	
(Terminals 10, 11)	Operating voltage (U_B)	12 to 30 VDC filtered
	Residual ripple	$\leq 15\%$
	Current consumption	max. 420 mA (with interface module)
	Electr. connection	11-pole terminal strip
	Display	
	Remote multifunction display	LEDs with lenses
	Close-up multifunction display	Bar graph for reception level (10 LEDs) 2 LEDs for data transmission
	Inputs	
(Terminal 4)	Transmitter deactivation Input signal	Tx DIS + U_B transmitter inactive < 0.7 V transmitter active
(Terminal 5)	Receiver deactivation Input signal	Rx DIS + U_B receiver inactive < 0.7 V receiver active
	Outputs	
(Terminal 8)	Reception without functional reserve	PNP, plus switching $U_B - 2\text{ V}$
(Terminal 9)	Reception with functional reserve	PNP, plus switching $U_B - 2\text{ V}$
	Output load	max. 200 mA
	Safety wiring	against overcurrent and transients
	Mechanical data	
	Housing	Aluminum
	Protection class	IP 65
	Weight	1525 g

Lenses

Transmission medium	Modulated infrared light
Lenses	Glass
Optical beam angle	approx. $\pm 0.5^\circ$ to the optical axis

Environmental conditions

Operating temperature	-30 °C ... +60 °C
Storage temperature	-35 °C ... +70 °C

4.2 Dimensioned drawing

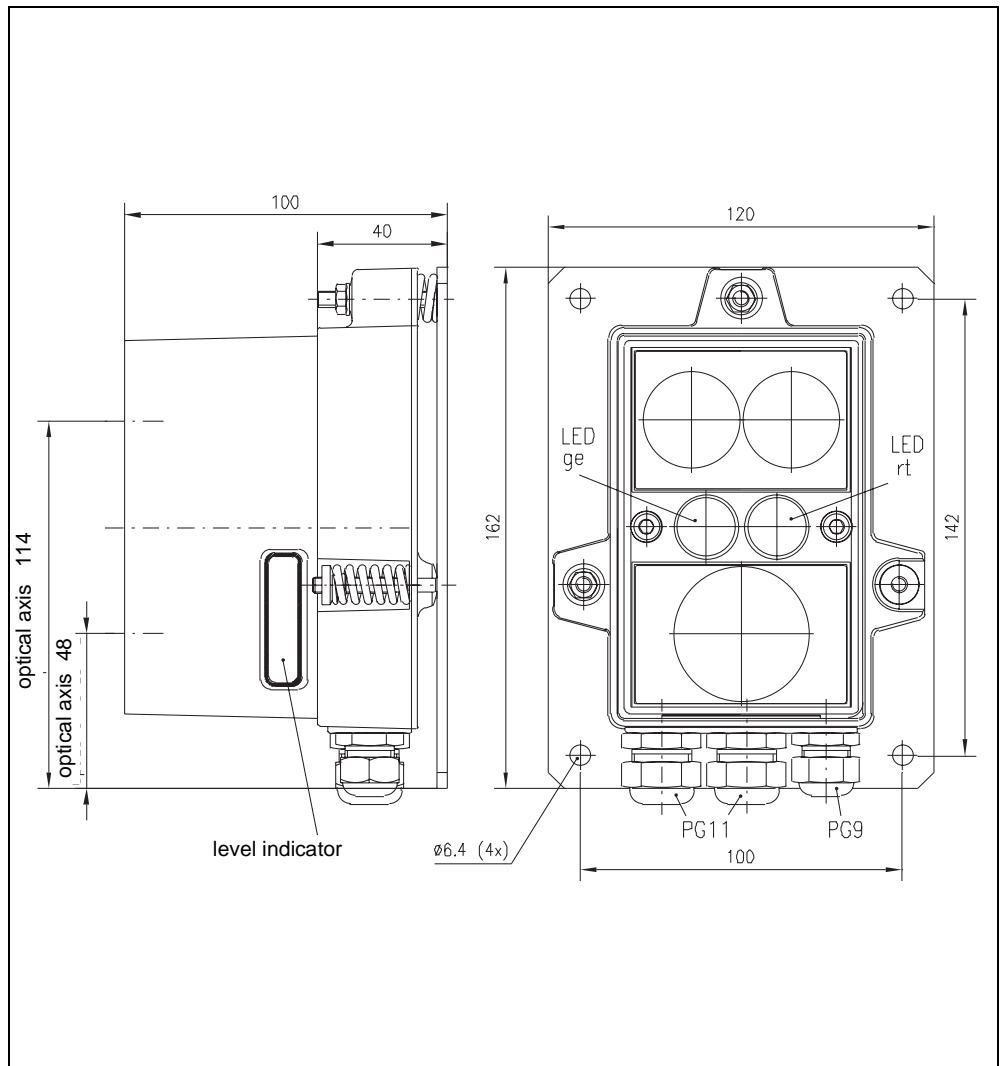


Fig. 18: Dimensioned drawing of DDLs 170

5 Accessories / Order Designations



Addresses for ordering

Products manufactured by Leuze electronic GmbH + Co. can be ordered from any of the distributor and service addresses listed on the reverse of the envelope.

Optical data transmission system DDLS 170/xxx.x-xxxx, order designation:

Explanation of the order designation

The order designation for the DDLS 170 is structured according to the following scheme:

DDLS 170/ A.-B-CDEF

The letters A through F represent the following device variants:

- **A** range /120 = 120 m range
/200 = 200 m range
- **B** FSK frequencies .1 = carrier frequency pair 1
.2 = carrier frequency pair 2
- **C** interface 0 = no interface
1 = Profibus, Suconet K, RS485
2 = INTERBUS, RS422
- **D** beam angle 0 = without optics unit
1 = $\pm 0.5^\circ$
- **E** conn. element 0 = without connection element
1 = Profibus/Suconet K/INTERBUS connection element
- **F** optics heating 0 = without optics heating
1 = reserved
2 = with optics heating



Notice:

The DDLS 170 is offered primarily as a complete unit. This means that the order designations denote complete units, and delivery includes connection element, interface module and optics unit.

Two complete units with different FSK frequencies (.1 and .2) must be ordered for each transmission path.

In addition, we offer the three components: connection element, interface module and optics unit individually for service and spare parts needs.

Order examples for complete units

<i>Order designations</i>	DDLS 170/120.1-1110	1 transmission pair, 120 m range,
	DDLS 170/120.2-1110	Profibus, RS485, Suconet K, $\pm 0.5^\circ$ beam angle
	DDLS 170/120.1-2110	1 transmission pair, 120 m range,
	DDLS 170/120.2-2110	INTERBUS, RS422, $\pm 0.5^\circ$ beam angle
	DDLS 170/200.1-1110	1 transmission pair, 200 m range,
	DDLS 170/200.2-1110	Profibus, RS485, Suconet K, $\pm 0.5^\circ$ beam angle
	DDLS 170/200.1-2110	1 transmission pair, 200 m range,
	DDLS 170/200.2-2110	INTERBUS, RS422, $\pm 0.5^\circ$ beam angle

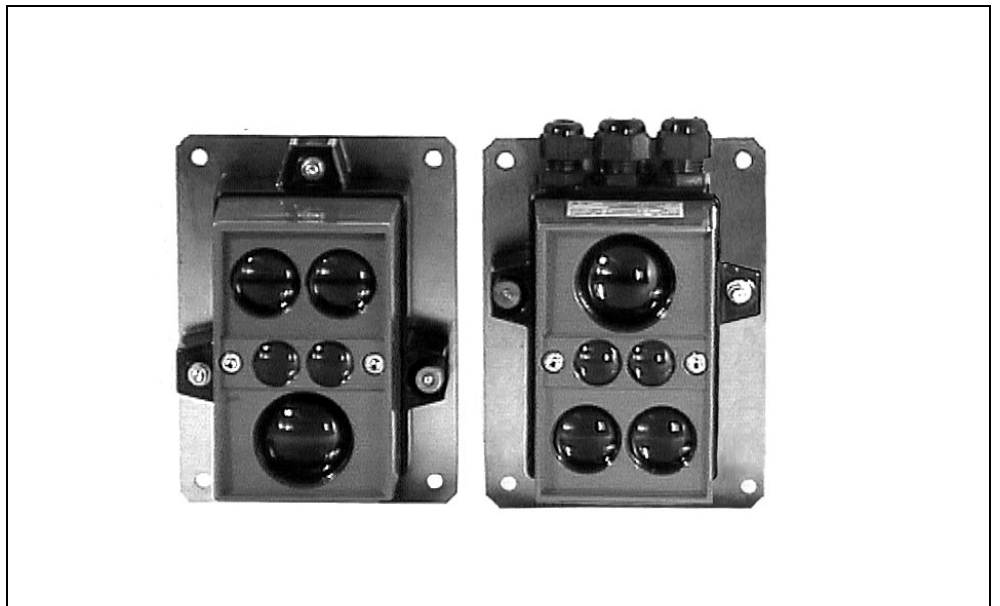


Fig. 19: complete DDLS 170 unit

5.1 Individual components

The following components can also be ordered individually for service and spare part needs:

Connection element

AT170-0010 Connection element with wobble plate for Profibus/Suconet K/INTERBUS

Interface modules

IM170-1000 Interface module for Profibus, RS485, Suconet K
IM170-2000 Interface module for INTERBUS, RS422

Optics units

OA170/120.1-0100 Optics unit 120 m
OA170/120.2-0100 Optics unit 120 m
OA170/200.1-0100 Optics unit 200 m
OA170/200.2-0100 Optics unit 200 m

A complete unit can be assembled from connection element, interface module and optics unit.

5.2 Recommended cable

Profibus, RS485, Suconet K

No special connection cables are necessary for the installation of the DDLS 170 supply and control lines. The Profibus standard specifies two cable types for the connection of the data lines into the FMS and DP systems.

Cable type A is particularly suited for high transmission rates and long ranges. Cable type B should be used only with short ranges and transmission rates up to 500 kbit/s.

	Cable type A	Cable type B
Intrinsic impedance	135...165 Ω (at 3...20 MHz)	130...135 Ω (at $f > 100$ kHz)
Cable capacitance	< 30 pF / m	typ. < 30 pF / m
Wire cross section	min. 0.34 mm ²	min. 0.22 mm ²
Cable type	twisted pairs, 1x2; 2x2; or 1x4 conductor	twisted pairs, 1x2; 2x2; or 1x4 conductor
Resistance	< 110 Ω / km	< 110 Ω / km
Signal loss	max. 9 dB over entire line length	max. 9 dB over entire line length
Shielding	copper-mesh shielding or mesh shielding and foil shielding	copper-mesh shielding or mesh shielding and foil shielding

INTERBUS, RS422

Cables with the following specifications are recommended for use in the INTERBUS system:

Designation	LI-YCY ...
Type	4-conductor, twisted pair
Wire cross section	0.14 mm ²
Resistance	< 140 Ω / km
Insulation resistance of the wires	min. 200 M Ω / km
Mutual capacitance	max. 120 nF / km
Test volt. wire / wire	1200 V
Test volt. wire / shielding	1200 V
Shielding	copper-mesh shielding or mesh shielding and foil shielding

6 Installation

6.1 Storing, transporting



Attention !

When transporting, package the device so that it is protected against collision and humidity. Optimal protection is achieved when using the original packaging. Heed the required environmental conditions specified in the technical data.

Unpacking

- Check the packaging for any damage. If damage is found, notify the post office or shipping agent as well as the supplier.
- Check the delivery contents against your order and the delivery papers:
 - delivered quantity
 - device type and model as indicated on the name-plate
 - accessories
 - operating manual(s)
- Save the original packaging in case the device must be stored or shipped at a later time.

Should you have questions, please contact your distributor or the responsible Leuze electronic sales office (see reverse of this operating manual).

- Observe the locally applicable regulations when disposing of the packaging materials.

Cleaning

- Before installing, clean the DDLS 170 lenses with a soft cloth. Remove all packaging remains, e.g. carton fibres or styrofoam balls.



Attention !

Do not use an aggressive cleaning material such as thinner or acetone to clean the device.

6.2 Mounting and aligning

6.2.1 Preparation

Observe the following points before installing the data transmission unit:

- For each data transmission path one device of type DDLS 170/xxx.1-xxxx and one of type DDLS 170/xxx.2-xxxx is required.
- The data transmission path can be oriented either horizontally or vertically.
- For trouble-free data transmission, ensure
 - unimpeded optical connection between transmitter and receiver
 - precise alignment
 - clean lenses
- Parallel operation of several data transmission paths:
When arranged with shifted frequencies, two parallel data paths can be operated with a separation 0.3 m (see Fig. 20).
The parallel distance to a third transmission path can be calculated as follows:
parallel distance = 0.025 x range (however, at least 2.5 m)

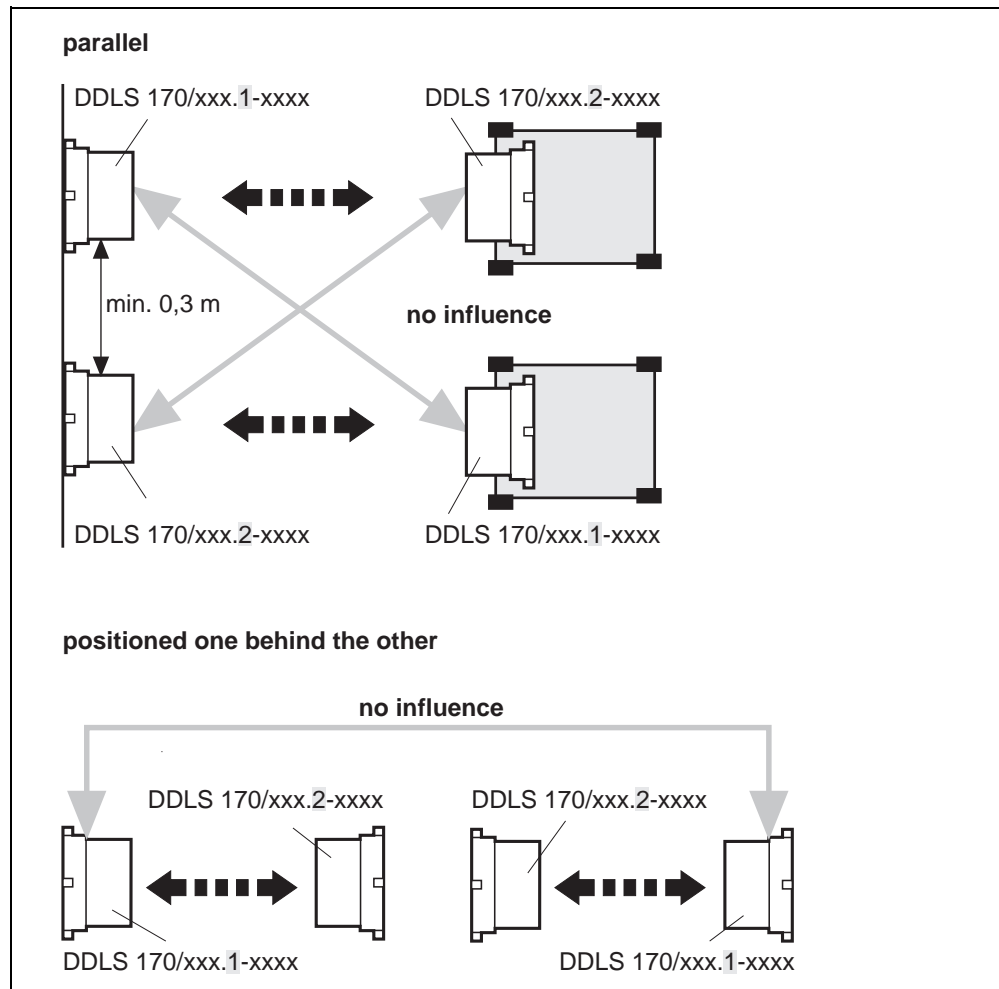


Fig. 20: Multiple data transmission paths

6.2.2 Installation

When preparing the installation sites, ensure that no vertical, lateral and angular offsets can develop between the two units.

- Drill fastening holes for the two adjusting brackets (1). For hole dimensions, see the dimensioned drawing in Chapter 4.2.
- Fasten adjusting brackets (1).
- Attach DDLS 170/xxx.1-xxxx and DDLS 170/xxx.2-xxxx to the adjusting brackets and secure with the hex socket-head screws (2).

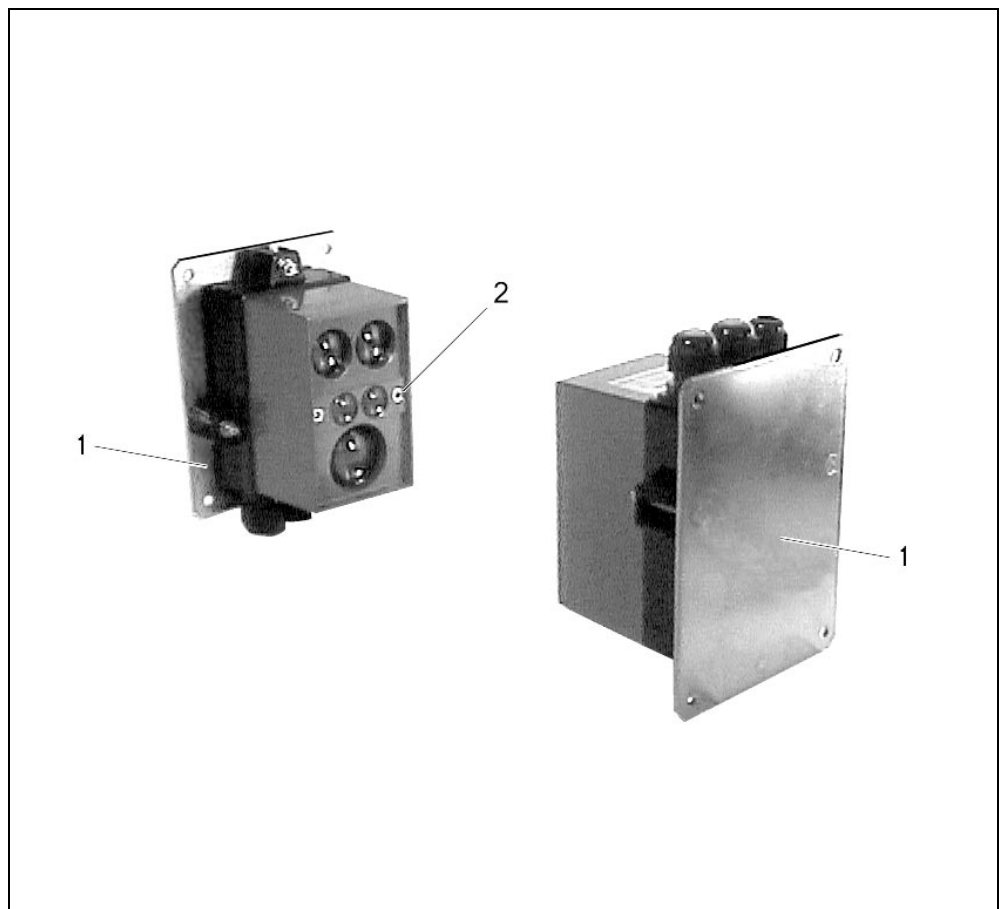


Fig. 21: Mounting DDLS 170

6.2.3 Alignment

Each DDLS 170 is equipped with two multifunction displays which can be used to simplify the alignment process:

- Remote multifunction display for coarse adjustment,
- Close-up multifunction display (bar graph) for fine adjustment.

Coarse adjustment

DDLS 170/xxx.1-xxxx transmits a signal to the DDLS 170/xxx.2-xxxx. The LED indicates the quality of the received signal. When adjusting the DDLS 170/xxx.1-xxxx, observe the LED on the DDLS 170/xxx.2-xxxx (and vice versa).

- Align the DDLS 170/xxx.1-xxxx with the unsprung screws (2) on the adjusting bracket (8 mm open-end wrench) until the remote multifunction display (1) on the DDLS 170/xxx.2-xxxx lights up yellow.

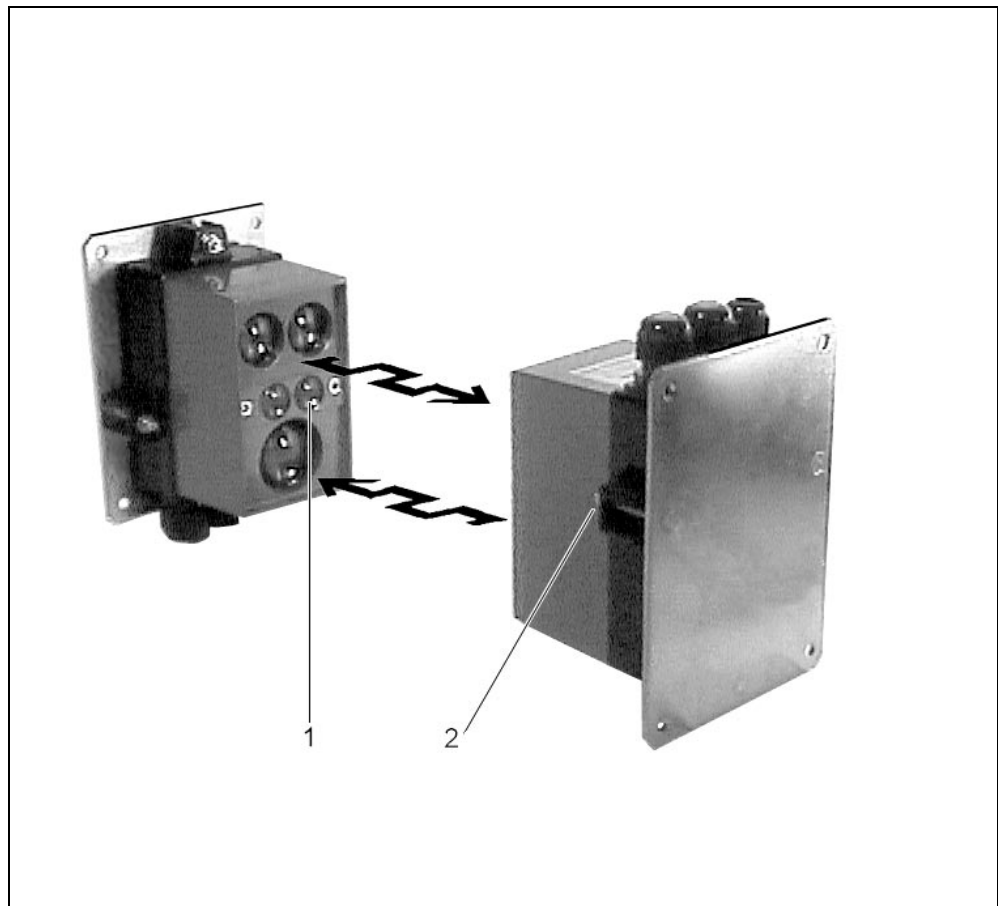


Fig. 22: DDLS 170 coarse adjustment

Check: The remote multifunction LED displays on both units must light up yellow for the entire path.

Fine adjustment

DDLS 170/xxx.1-xxxx transmits a signal to the DDLS 170/xxx.2-xxxx and vice versa. The bar graph indicates the quality of the received signal. When adjusting the DDLS 170/xxx.1-xxxx, observe the bar graph on the DDLS 170/xxx.2-xxxx.

The greater the distance between two DDLS 170, the weaker the receiving level. As a result, the bar graph will not reach its maximum level as the distance is increased.

The maximum range which can be indicated by the bar graph is approx. 20 m.

- ➔ Align DDLS 170/xxx.1-xxxx with the sprung screws (1) on the adjusting bracket (8 mm open-end wrench) until the maximum number of LEDs for this range light up on the bar graph.
- ➔ Align DDLS 170/xxx.2-xxxx in the same way as DDLS 170/xxx.1-xxxx.

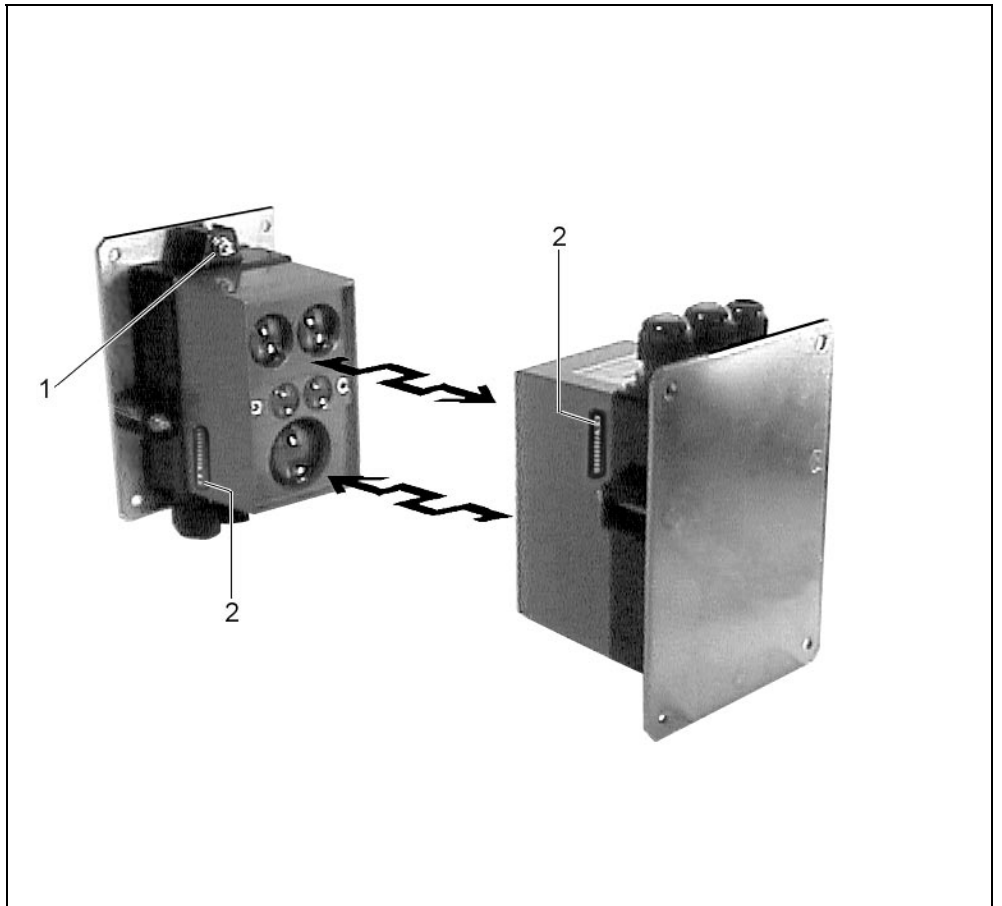


Fig. 23: Fine adjustment of DDLS 170

Alignment monitoring (functional reserve)

To monitor the aligned DDLS 170 with the aid of a PLC, use the output terminals 9 (with reserve) and 8 (without reserve), or test the LEDs on the unit (remote and close-up multifunction displays) at regular intervals (see Chapter 3.6, page 12).

6.3 Connection information



Attention !

The unit must only be connected by a qualified electrician.

If faults cannot be eliminated, the device should be removed from operation and protected against possible use.

Before connecting the device, be sure that the supply voltage is in agreement with the value printed on the name plate.

Be sure that the earthing conductor is correctly connected. Error-free operation is guaranteed only when the device is properly earthed.

Preparing bus lines → Prepare the cables for the lead and continuation of the bus line as described in Fig. 24. Guide the cables through the appropriate PG cable glands and make the connection.

Shielding clamps → Ensure that the bus cable shielding is connected at both ends and the clamps for the shielding are tightened.

Strain relief → For strain relief, finish by tightening the PG cable glands.

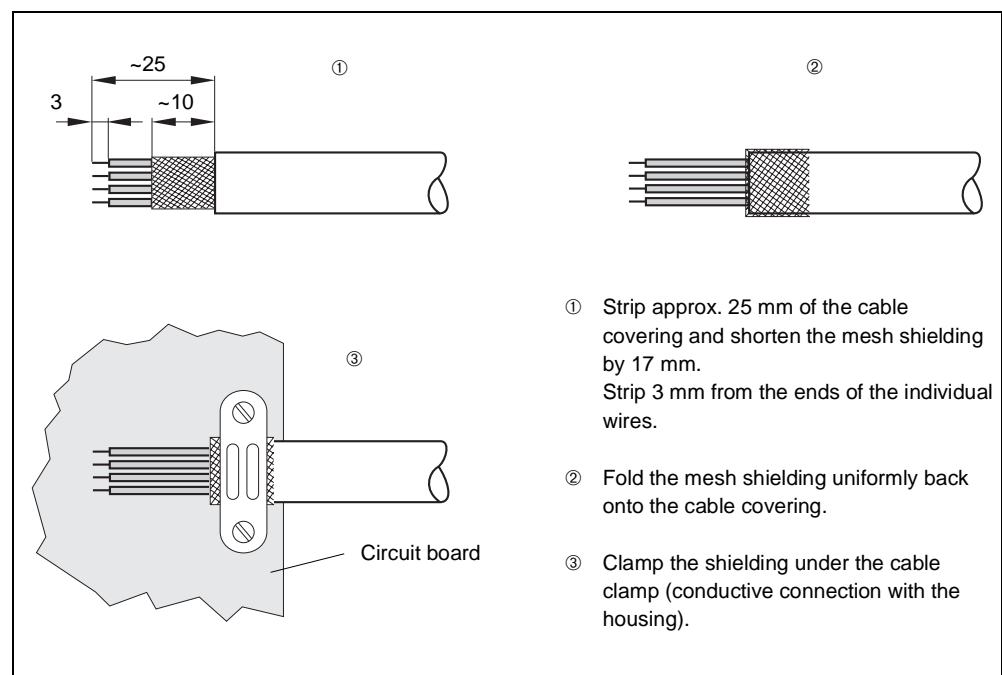


Fig. 24: Bus cable preparation and shielding connection

6.4 INTERBUS connection

6.4.1 Shielding



Attention !

Inadequate shielding can lead to operating errors. Therefore, observe the following points.

Data line shielding

- Connect shielding as shown in Fig. 25.
- Lay the shielding at both ends.
- Secure the shielding on the entire surface.
- Do not damage or squeeze any wires.
- Ensure that the shielding covers as much of the individual wires as possible in the unit.

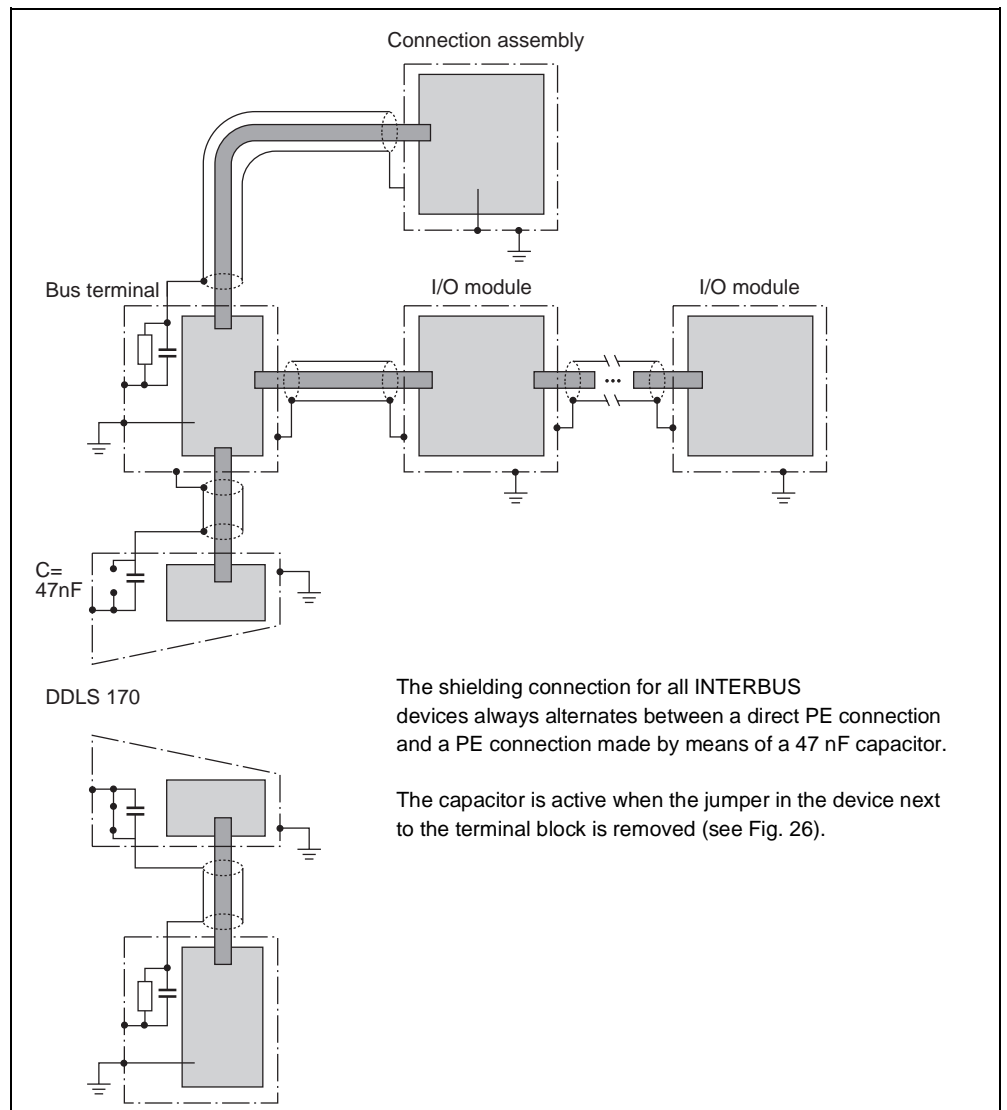


Fig. 25: DDLS 170 - INTERBUS shielding

6.4.2 Terminal configuration for INTERBUS, RS422 - connection terminals

- Connect the earthing line (PE) to the screw terminal provided for this purpose in the unit.
- Connect supply voltage in accordance with the specifications (see Chapter 4).

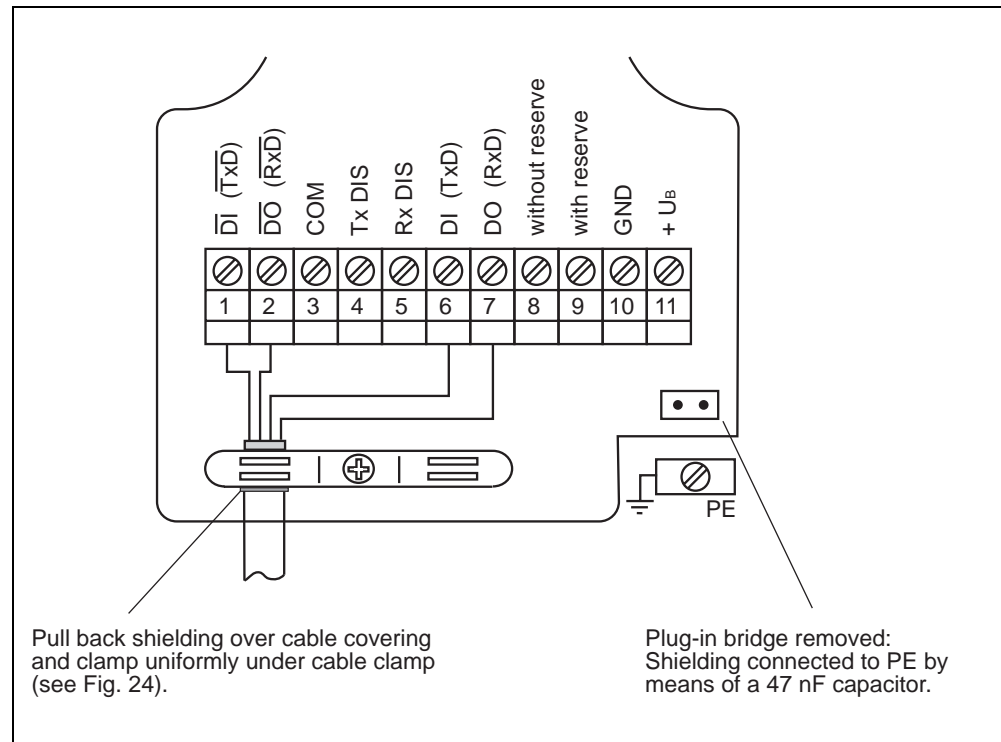


Fig. 26: INTERBUS, RS422 terminal configuration

Connection description

- Terminal 1** $\overline{\text{DI}}$ Data line INTERBUS - System / $\overline{\text{TxD}}$ for RS422 interface
- Terminal 2** $\overline{\text{DO}}$ Data line INTERBUS - System / $\overline{\text{RxD}}$ for RS422 interface
- Terminal 3** COM connection for data line - GND
- Terminal 4** Tx DIS transmitter deactivation (+ U_B transmitter inactive; < 0.7 V transmitter active)
- Terminal 5** Rx DIS receiver deactivation (+ U_B receiver inactive; < 0.7 V receiver active)
- Terminal 6** DI data line INTERBUS - System / TxD for RS422 interface
- Terminal 7** DO data line INTERBUS - System / RxD for RS422 interface
- Terminal 8** Data transmission without functional reserve
- Terminal 9** Data transmission with functional reserve
- Terminal 10** GND voltage supply 0 V
- Terminal 11** + U_B voltage supply 12 to 30 V DC

6.4.3 Connection examples

INTERBUS

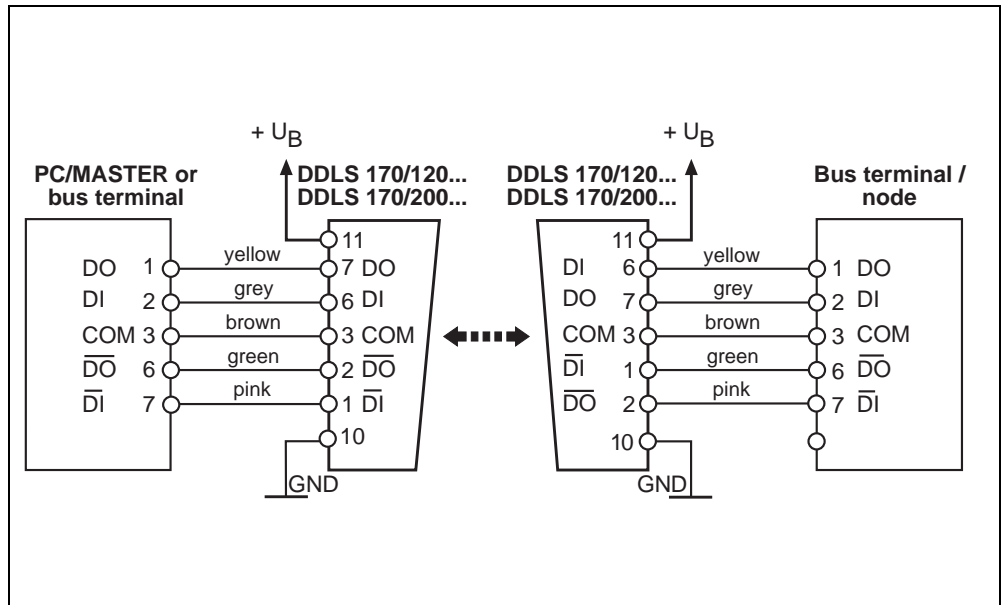


Fig. 27: Connection example DDLS 170 - INTERBUS

RS422 point-to-point connection

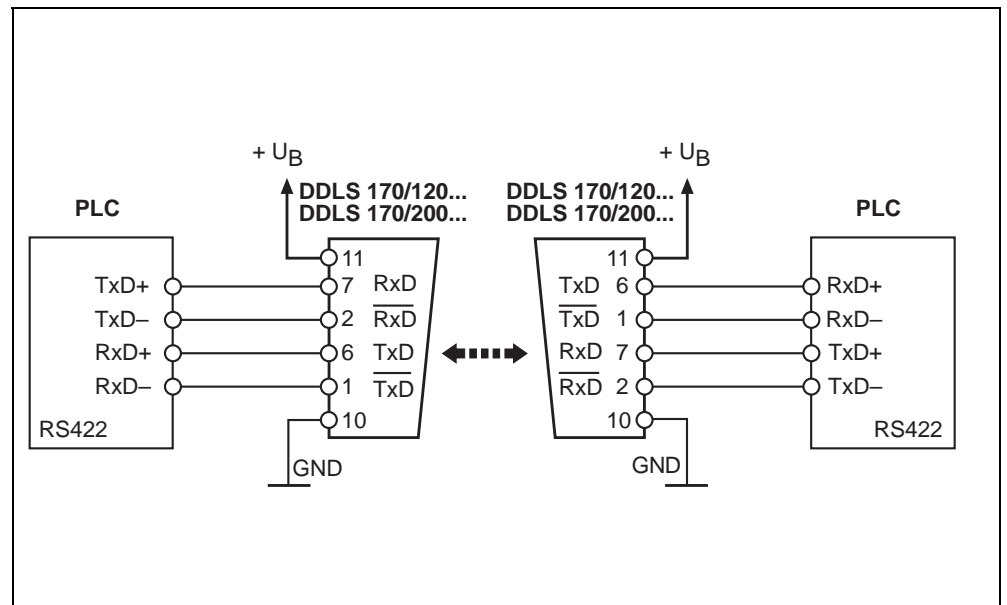


Fig. 28: Connection example DDLS 170 - RS422

6.5 Profibus, Suconet K connection

6.5.1 Terminal configuration for Profibus- (MPI, FMS, DP, FMS/DP), RS485- and Suconet K - connection terminals

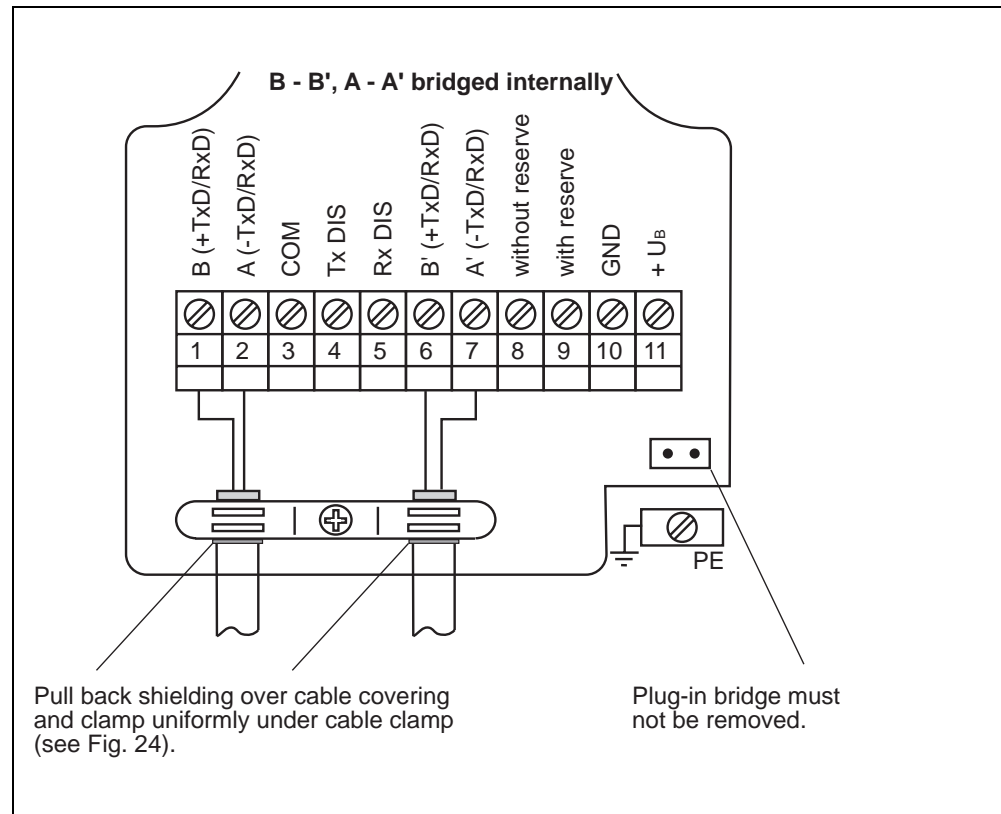


Fig. 29: Profibus, RS485 and Suconet K terminal configuration

Connection description

Terminal 1	B data line Profibus, RS485 (+TxD/RxD), Suconet K - System
Terminal 2	A data line Profibus, RS485 (-TxD/RxD), Suconet K - System
Terminal 3	COM connection for data line - GND
Terminal 4	Tx DIS transmitter deactivation (+ U _B transmitter inactive; < 0.7 V transmitter active)
Terminal 5	Rx DIS receiver deactivation (+ U _B receiver inactive; < 0.7 V receiver active)
Terminal 6	B' data line Profibus, RS485 (+TxD/RxD), Suconet K - System
Terminal 7	A' data line Profibus, RS485 (-TxD/RxD), Suconet K - System
Terminal 8	Data transmission without functional reserve
Terminal 9	Data transmission with functional reserve
Terminal 10	GND voltage supply 0V
Terminal 11	+ U _B voltage supply 12 to 30 V DC

6.5.2 Connection examples

DDLS 170 - Profibus connection

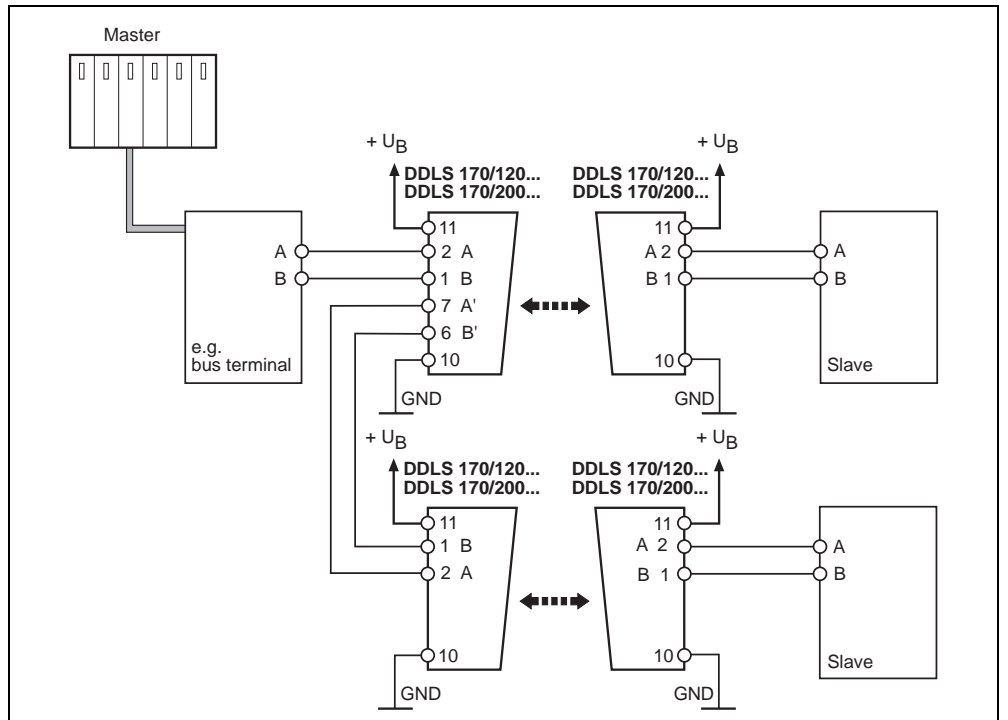


Fig. 30: Connection example DDLS 170 - Profibus (MPI, FMS, DP, FMS/DP)

DDLS 170 - Suconet K, K1 and K2 connection

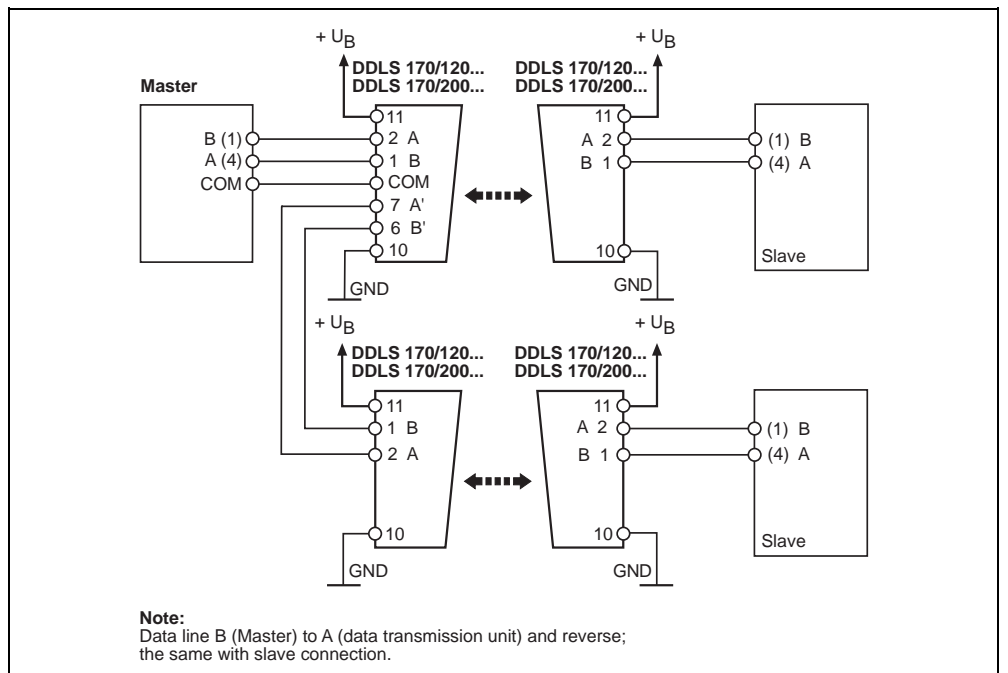


Fig. 31: Connection example DDLS 170 - Suconet K, K1 and K2

DDLS 170 - RS485 connection

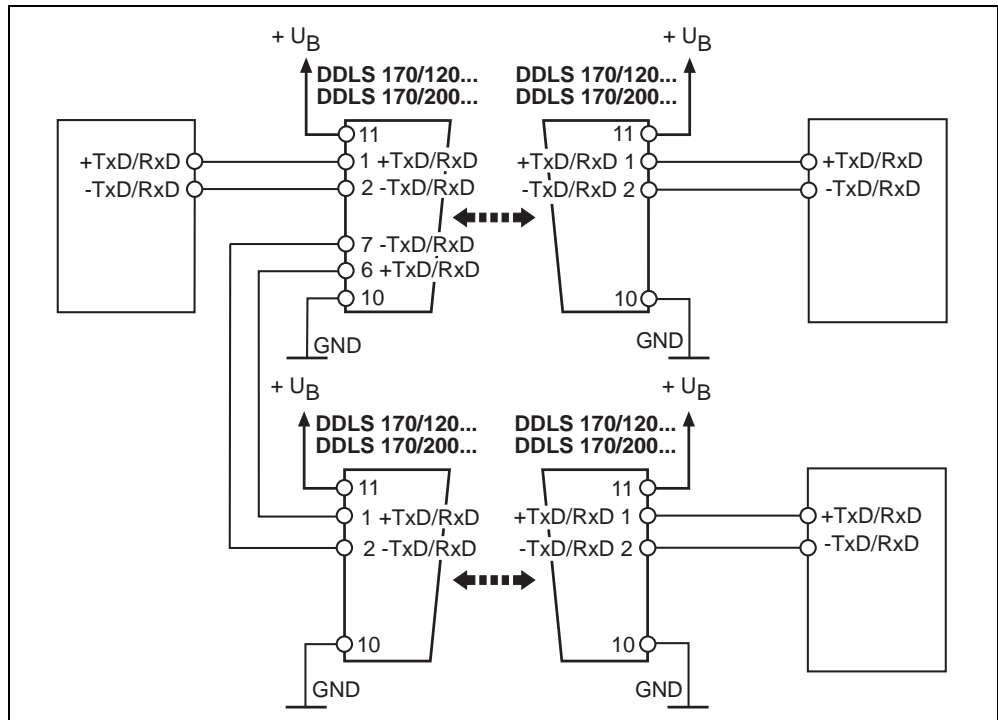


Fig. 32: Connection example DDLS 170 - RS485

7 Commissioning

7.1 Steps before the first commissioning

- Prior to the first commissioning, familiarise yourself with the operation and adjustment of the device(s)!
- Before switching on, recheck all connections and ensure that they have been properly made.

7.1.1 Switching on the operating voltage

Before you switch on the operating voltage, be certain that the unit has been properly connected and that the polarities of the data-signal and supply lines are correct.

☞ See Chapter 6.3 and the following

After switching on the operating voltage, the DDLS 170 is immediately ready for data transmission.

7.1.2 Alignment

- Align the units with one another as described in Chapter 6.2.3.

7.2 Settings on the INTERBUS interface module



Notice:

No settings are necessary.

The data transmission unit functions as a passive node; a system address is not necessary.

- Activating system control

Data paths with appropriate nodes are automatically registered in the system.

7.3 Settings on the Profibus-, RS485- and Suconet K-interface module

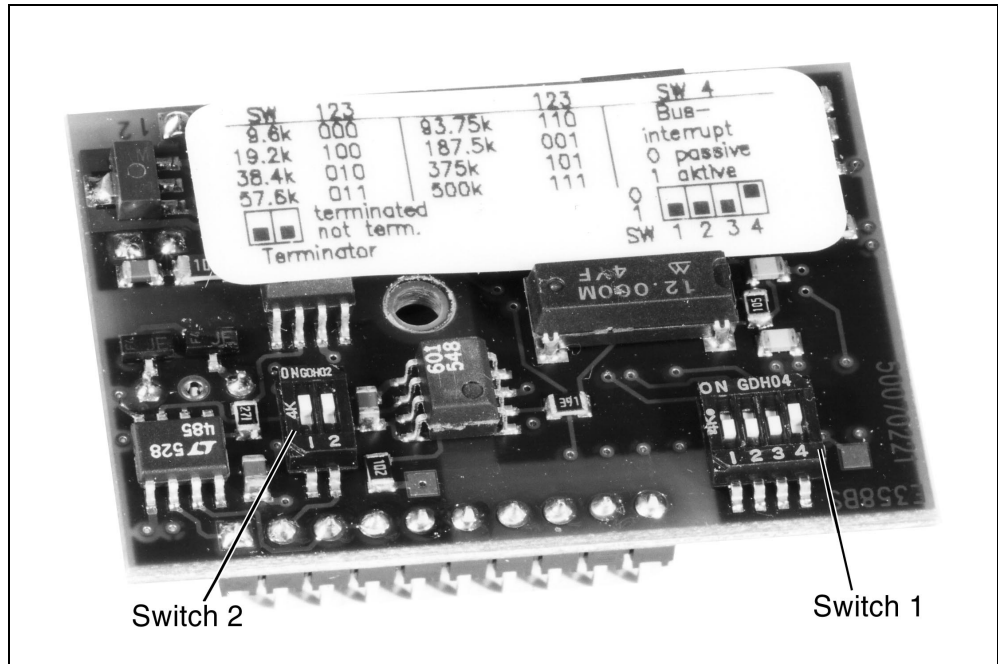


Fig. 33: Settings on the interface module

7.3.1 Setting the transmission rate (switch 1)

Set the desired transmission rate with DIP switches 1, 2, 3 on the connection circuit board (switch 1) (see Fig. 33).



Notice:

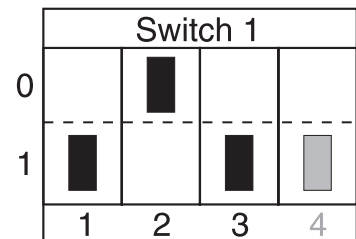
All listed baud rates are available for Profibus protocols FMS, DP, FMS/DP as well as for RS485.

The RS485 MPI protocol functions only at a transmission rate of 187.5 kbit/s.

The possible transmission rates for Suconet K are 187.5 and 375 kbit/s, for Suconet K1 and K2 only the transmission rate of 187.5 kbit/s is permitted.

DIP switches 1,2,3 Transmission rates in kbit/s

000	9.60
100	19.20
010	38.40
011	57.60
110	93.75
001	187.50
101	375.00
111	500.00



Thus, in the example a transmission rate of 375 kbit/s is selected.

7.3.2 Bus interruption (switch 1)

Bus interruption DIP switch 4 can be set to define how the data transmission unit should behave in the event of loss of visual contact (see Chapter 3.7.4, page 19).

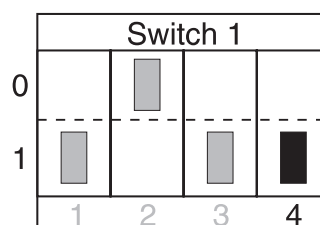
Set DIP switch 4 on the connection circuit board (switch 1) in accordance with your requirements (see Fig. 33).



Attention !

*For operation with Suconet K and the RS485 MPI protocol, the bus interruption switch must be deactivated (switch position 0).
If a Profibus system consisting of 2 or more nodes is located on the other side of the data transmission unit, the bus interruption switch must also be deactivated.*

DIP switch	4	Bus interruption
	0	No output to the bus if visual contact is lost : Tristate-condition; behaves as in the case of line interruption.
	1	If visual contact is lost bus occupation is simulated until visual contact with the data transmission units is re-established.



The setting for simulated bus access is shown in the example for the case of visual contact loss.

7.3.3 Termination (switch 2)

A terminating resistor must be connected at both ends of a bus segment line. If the data transmission unit is the last node of a bus segment, the terminating resistor must be activated.

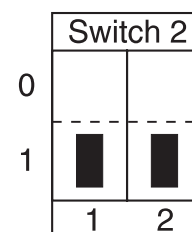
Use switch 2 of the connection circuit board to set the terminating resistances on DIP switches 1, 2 in accordance with your requirements (see Fig. 33).



Attention !

*Termination must not take place within a bus segment!
Both switches must be either on 1 or on 0.*

DIP switch	1, 2	Termination
	00	Switch position terminated
	11	Switch position not terminated



In the example, no termination is set.



Notice:

Should problems occur during commissioning or if the data transmission path cannot be put into service, refer to Chapter 8, "Error Diagnosis".

8 Error Diagnosis / Failures and Troubleshooting

General:

The DDLS 170 fulfills the conformity requirements for:

- Profibus
- INTERBUS
- Suconet K

Should errors occur during operation or during commissioning, the DDLS 170 offers a wide range of localization and correction options.

8.1 Errors during commissioning

Voltage supply polarities correct?

Error	Cause	Correction
Device does not respond (no LEDs light up)	supply voltage polarity false, possible line interruption or loose contacts on terminal blocks!	Connect supply voltage correctly, check lines and terminal blocks

Coarse adjustment carried out?

Error	Cause	Correction
Red LED on the remote multifunction display blinks	Strength of received signal insufficient! Notice: the yellow LED must light up over the entire travel area at the lens end.	Realign the device (see Chapter 6.2.3)

Fine adjustment carefully carried out?

Error	Cause	Correction
Less than two green LEDs light up on the close-up multifunction display	Strength of received signal insufficient! Notice: As a minimum the LEDs 1-4 (red) and LEDs 5-6 (green) must light up over the entire travel area	Realign the device (see Chapter 6.2.3)

Data transmission lines A and B connected correctly?

Error	Cause	Correction
No data exchange possible, only one of the control LEDs (red = transmit green = receive) on the side of the device lights up	Lines exchanged, or loose contacts on the device terminal blocks!	

Is the baud rate (Profibus) set correctly for all devices?

Error	Cause	Correction
Transmission error	The baud rates are either set falsely or not at all! Notice: If no baud rate is activated, the levels of the data signal shift.	Check the DIP switch settings on all devices, (see Chapter 7.3) Notice: Line length for 9.6 - 93.75 kbit/s up to 1.2 km, 187.5 kbit/s up to 600 m, 500 kbit/s up to 200 m

Are the terminating resistors correctly switched? (Profibus only)

Error	Cause	Correction
Transmission error	The terminating resistors are incorrectly switched! Notice: Devices must only be terminated at the beginning and end of a line!	Check DIP switch settings on all devices, DIP switches must both either be set to 0 or to 1 (see Chapter 7.3) Notice: if necessary measure the line terminations directly in the bus line (switch off mains). If the termination is considerably less than 110 Ohm, the data signal level deteriorates, harmonics are possibly occurring on the B-line at 0 signal.

Influence due to "cross talking"?

Error	Cause	Correction
Transmission error	Influence resulting from data transmission paths arranged adjacent to or one behind the other!	Check the minimum distance of the data transmission paths and ensure that paths are arranged with offset frequencies (see Chapter 6.2.1)

Is the shielding faulty (INTERBUS)?

Error	Cause	Correction
Transmission error	Earthing line not connected! Not all of the system's earthing lines are at the same potential, compensating currents are flowing!	Check earthing-line connections and shielding (see Chapter 6.4.1)

Are you using the correct cable?

Error	Cause	Correction
Transmission error	The cables have the wrong intrinsic impedance!	The cable must be selected with respect to the baud rate (see Chapter 5.2).

Have you installed the bus cable correctly?

Error	Cause	Correction
Transmission error	You have installed stub lines in your system!	The bus cable must be passed from one node to the next using serial connections

8.2 Other errors

Interference fields

Ensure that no strong electromagnetic fields are located in the immediate vicinity of the devices!

Light axes

The light axes must not be interrupted at any point in time!

9 Maintenance

9.1 General maintenance information

In normal use, the DDLS 170 optical data transmission system requires no operator servicing.

Cleaning → Should the DDLS 170 lenses become dirty, clean with a soft cloth.



Attention !

Do not use an aggressive cleaning material such as thinner or acetone to clean the device.

9.2 Repair, Maintenance

Repairs to the devices must only be carried out by the manufacturer.

☞ Contact your Leuze distributor or service organization should repairs be required. The addresses are listed on the reverse of this description.

Appendix

(applies only to DDLS 170.1 and DDLS 170.2)



These data are only valid for the previous data transmission systems DDLS 170.1 and DDLS 170.2!

A Construction

The data transmission units of the DDLS 170 series are durable, user-friendly and easy to service.

A data path consists of two synchronized data transmission units: DDLS 170.1 and DDLS 170.2.

The DDLS 170 is modular in design:

- 1 Main unit DDLS 170.1
- 2 Main unit DDLS 170.2
- 3 Connection unit with adjusting bracket and slot for interfaces
- 4 Interface module

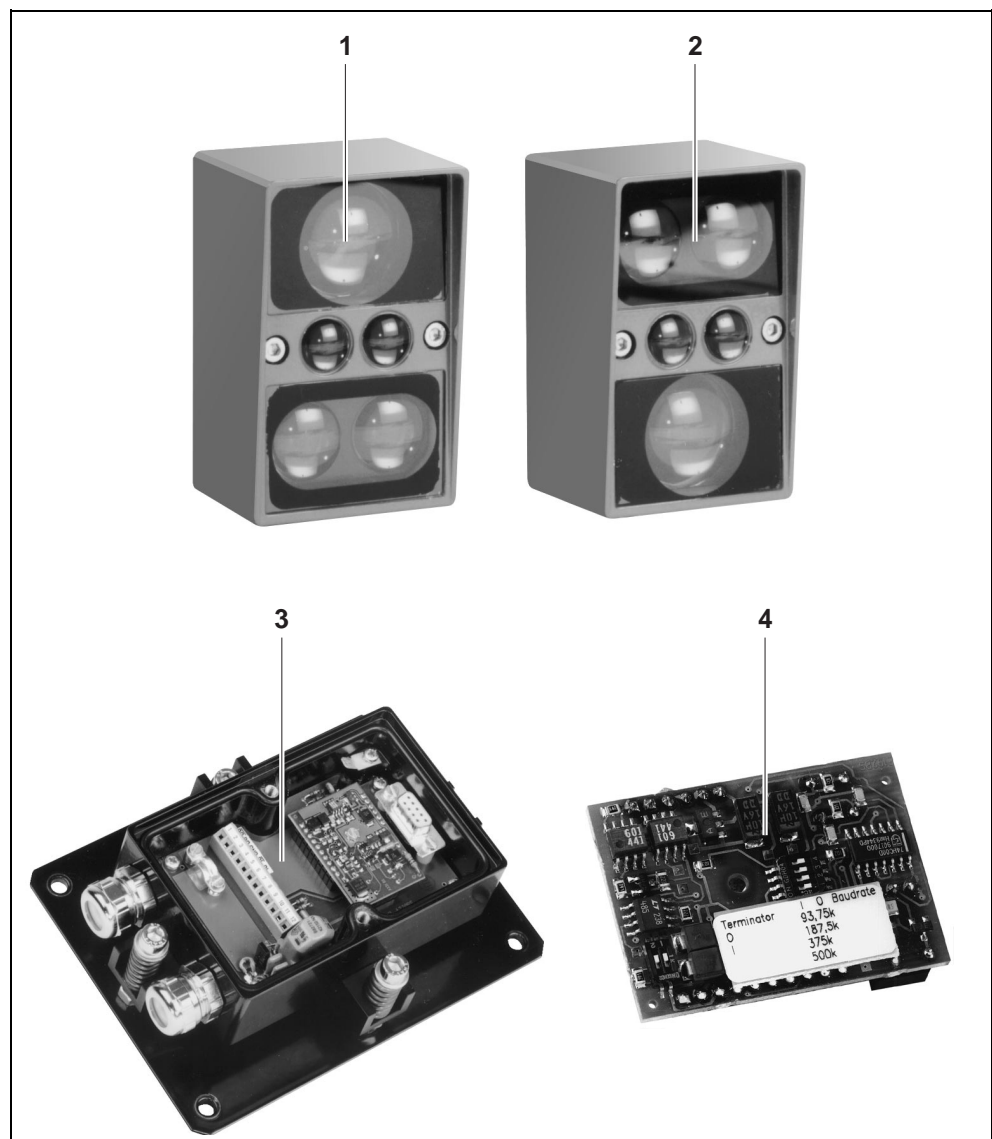


Fig. Appendix 1: DDLS 170 components



These data are only valid for the previous data transmission systems DDLS 170.1 and DDLS 170.2!

Components of the data transmission unit are:

- 1 Mounting bracket
- 2 Adjusting screws (2)
- 3 Connection module
- 4 Interface module
- 5 Alignment indicator
- 6 Bi-directional transmitter
- 7 Fastening screws (2)
- 8 Remote multifunction LED display: Multifunction display, red, red blinking
- 9 Remote multifunction LED display: Multifunction display, yellow
- 10 Receiver
- 11 Close-up multifunction display; Bar graph for reception level (10 LEDs)
- 12 Interface monitor; LED red - transmit data
- 13 Interface monitor; LED green - receive data
- 14 Terminal strip
- 15 PG cable glands
right: Signal lines and voltage supply
left: Data lines (PG cable glands with dual cable entries)

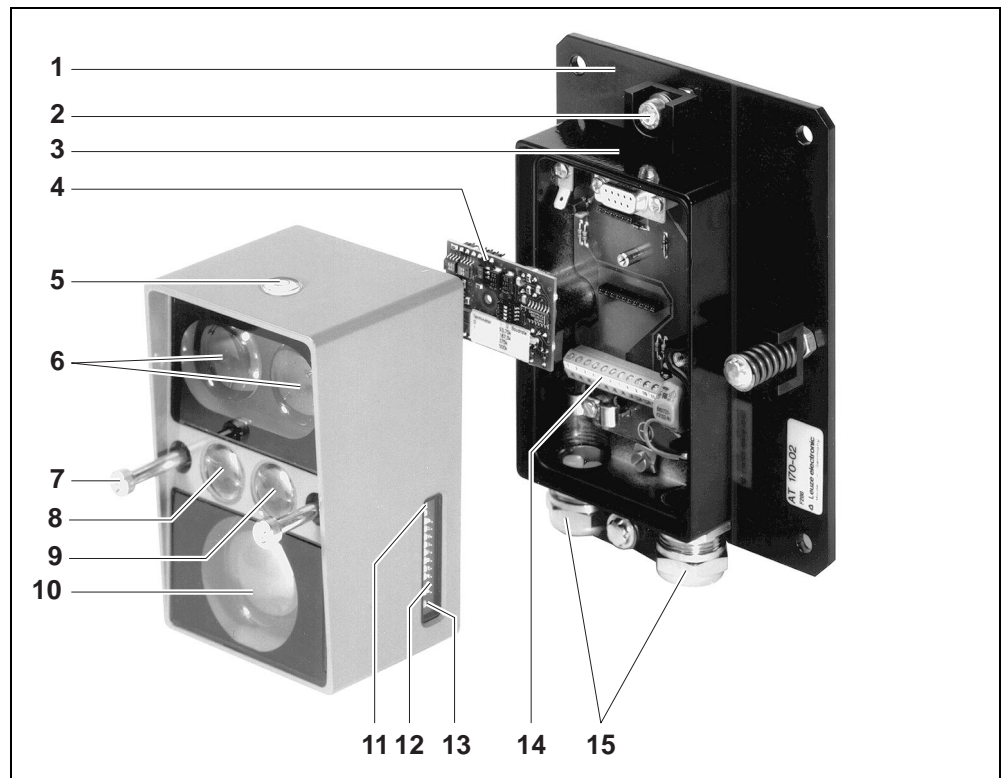


Fig. Appendix 2: Components of the DDLS 170



These data are only valid for the previous data transmission systems DDLS 170.1 and DDLS 170.2!

B Specifications

B.1 General specifications

Manufacturer	Leuze electronic GmbH + Co., D-73277 Owen/Teck
Type	DDLS 170
Range	0 to 200 m; The listed range is the usable operating range with adequate functional reserve
Transmission rate	DC - 500 kBit/s
Interfaces	Modular slot in bottom section of the strip (AT 170) 1) INTERBUS 2) Profibus/SINEC L2 plug-in module

Power supply

Operating voltage	12 to 30 VDC filtered
Residual ripple	≤ 15 %
Current consumption	max. 420 mA (with interface module)
Electr. connection	12-pole terminal strip

Display

Remote multifunction display	LEDs with lenses
Close-up multifunction display	Bar graph for reception level (10 LEDs) 2 LEDs for data transmission

Inputs

Receiver deactivation	Rx DIS (9)
Input signal	+ U _B receiver inactive, < 0.7 V receiver active

Outputs

(Terminal 7)	Reception without functional reserve	PNP, plus switching; U _B - 2 V at the corresponding reception level
(Terminal 6)	Reception with functional reserve	PNP, plus switching; U _B - 2 V at the corresponding reception level
	Output load	max. 200 mA
	Safety wiring	against overcurrent and transients

Mechanical data

Housing	Aluminum
Protection class	IP 65

Lenses

Transmission medium	Modulated infrared light
Lens	Glass, behind glass covers
Optical beam angle	approx. ± 0.5° to the optical axis

Environmental conditions

Operating temperature	-30 °C ... +60 °C
Storage temperature	-35 °C ... +70 °C



These data are only valid for the previous data transmission systems DDLS 170.1 and DDLS 170.2!

B.2 Dimensioned drawing

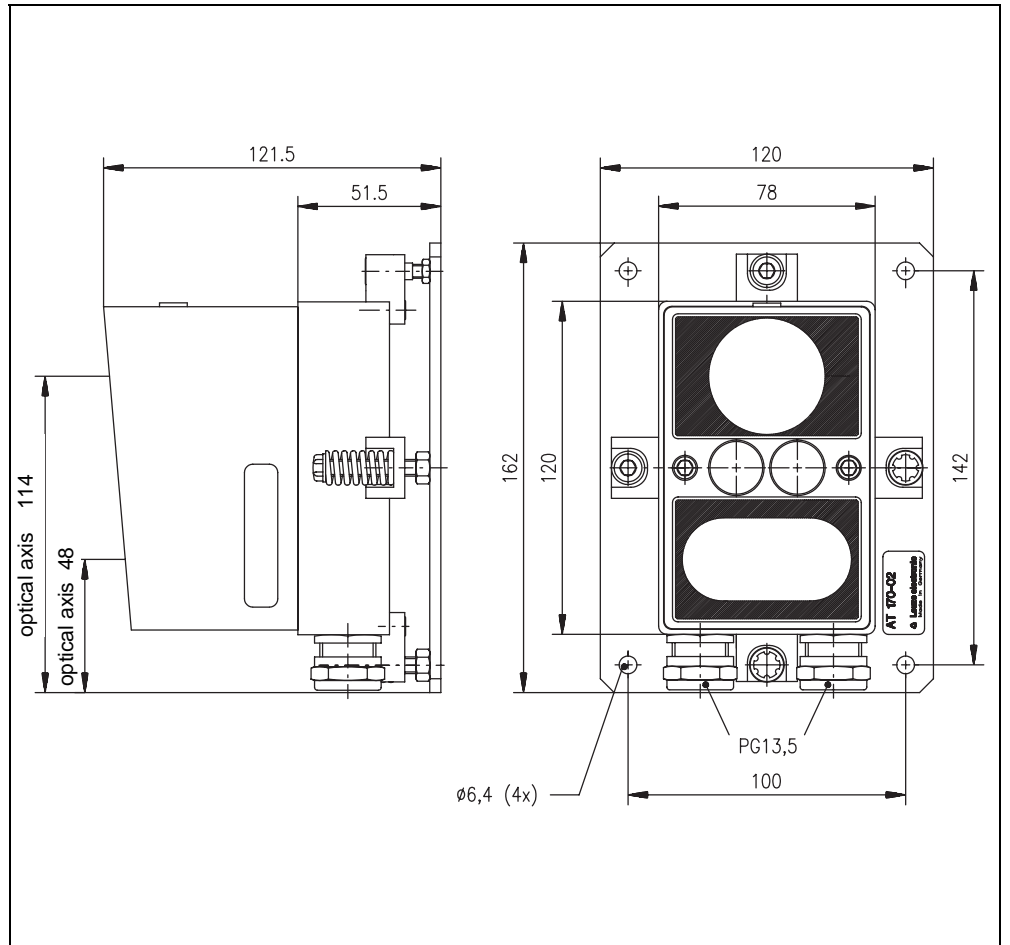


Fig. Appendix 3: Dimensioned drawing DDLS 170



These data are only valid for the previous data transmission systems DDLS 170.1 and DDLS 170.2!

B.3 Terminal configuration of interfaces

B.3.1 INTERBUS terminal configuration

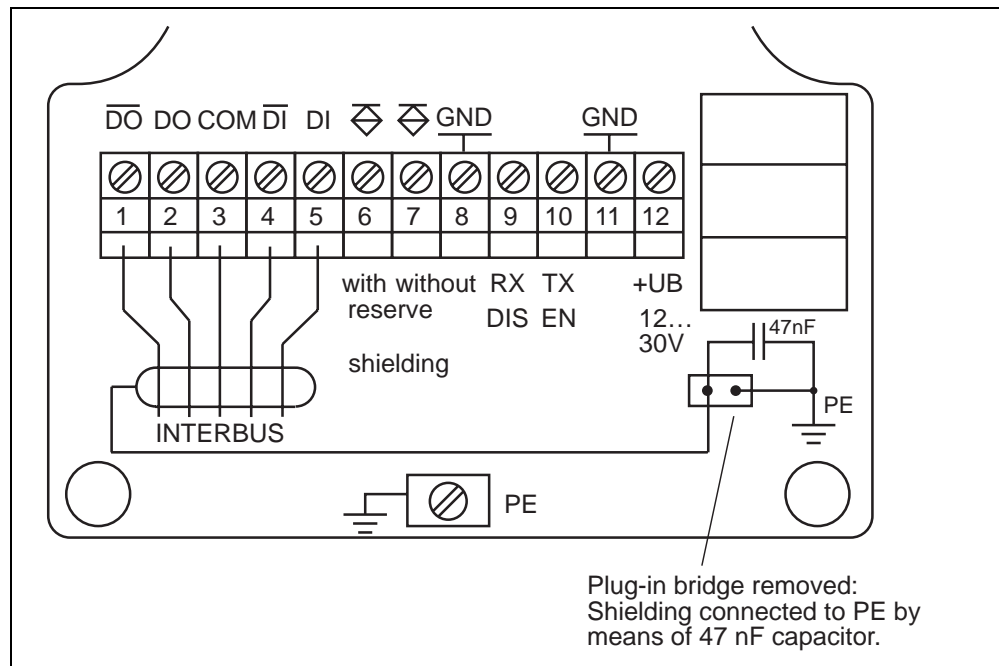


Fig. Appendix 4: INTERBUS terminal configuration

B.3.2 Profibus terminal configuration

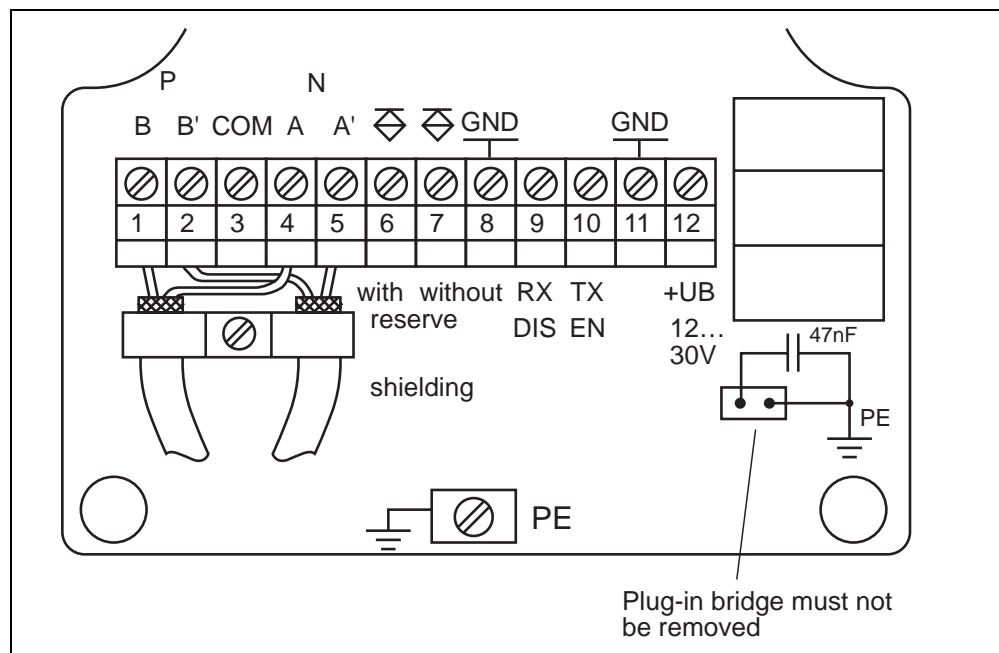


Fig. Appendix 5: Profibus terminal configuration



These data are only valid for the previous data transmission systems DDLS 170.1 and DDLS 170.2!

C Examples of connection

C.1 DDLS 170 – INTERBUS connection

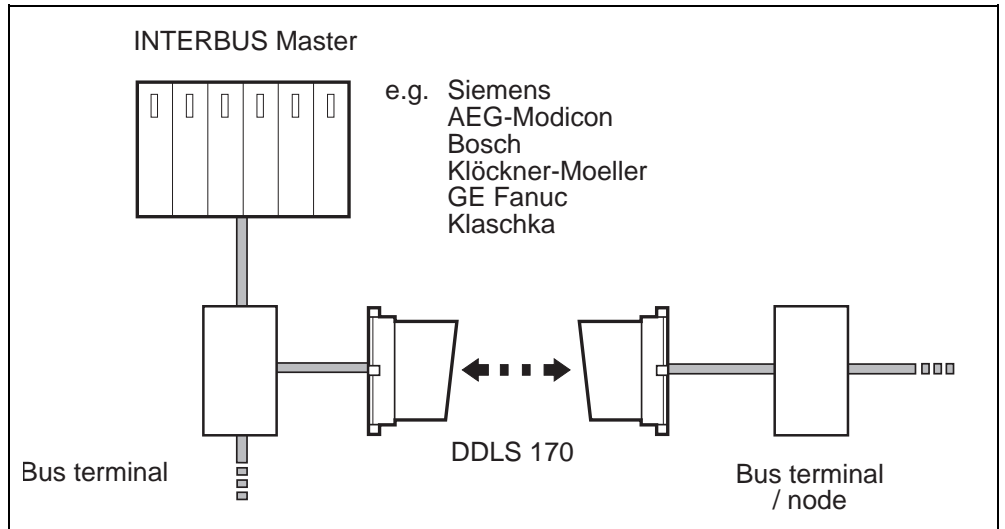


Fig. Appendix 6: DDLS 170 - INTERBUS connection

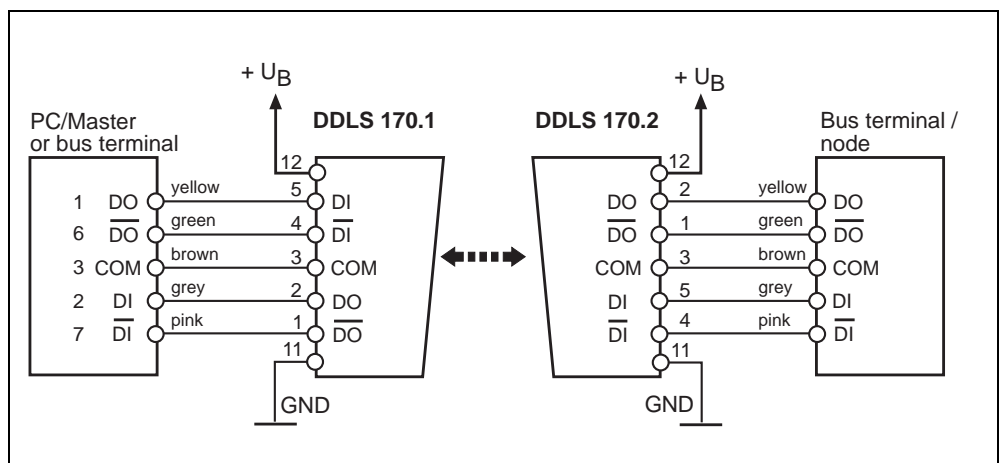


Fig. Appendix 7: Example of DDLS 170 – INTERBUS connection



These data are only valid for the previous data transmission systems DDLS 170.1 and DDLS 170.2!

C.2 RS422 point-to-point connection

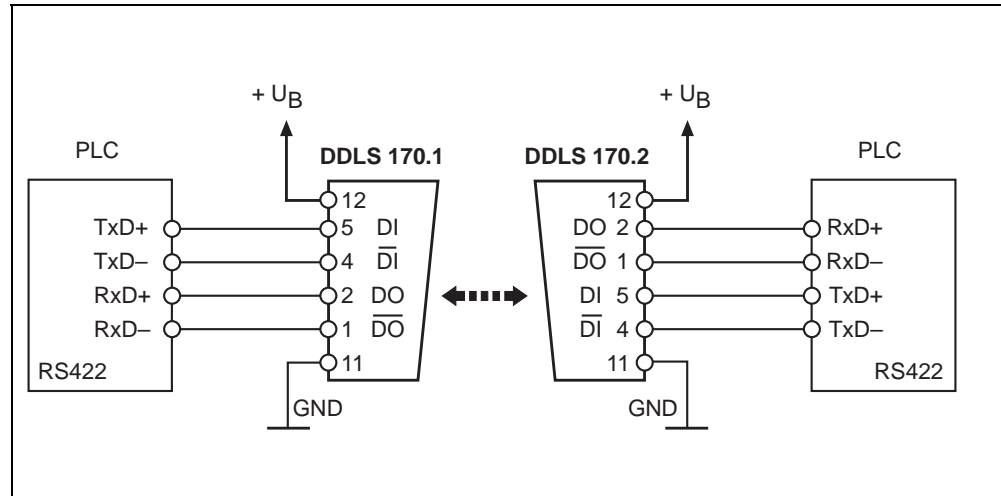


Fig. Appendix 8: Example of DDLS 170 – RS422 (INTERBUS module) connection

C.3 DDLS 170 – Profibus connection

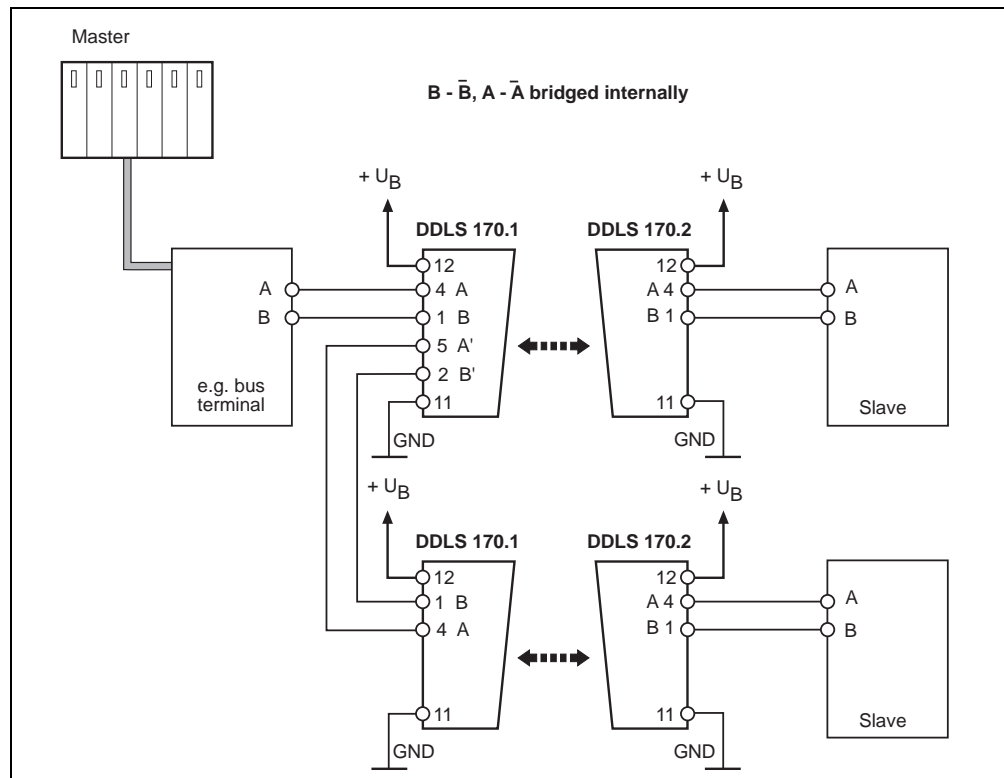


Fig. Appendix 9: Example of DDLS 170 – Profibus connection



These data are only valid for the previous data transmission systems DDLS 170.1 and DDLS 170.2!

D Installation and Commissioning

D.1 Preparation

Observe the following points before installing the data transmission unit:

- One device of each type (DDLS 170.1 and DDLS 170.2) is required per data transmission path.
- The data transmission path can be either horizontal or vertical.
- Ensure interference-free data transmission through
 - unimpeded optical connection between transmitter and receiver
 - precise alignment
 - clean lenses
- Parallel operation of several data transmission paths:
When arranged with shifted frequencies, two parallel data paths can be operated with a separation 0.3 m.
The parallel distance to a third transmission path can be calculated as follows:
parallel distance = $0.025 \times \text{range}$ (however, at least 2.5 m)

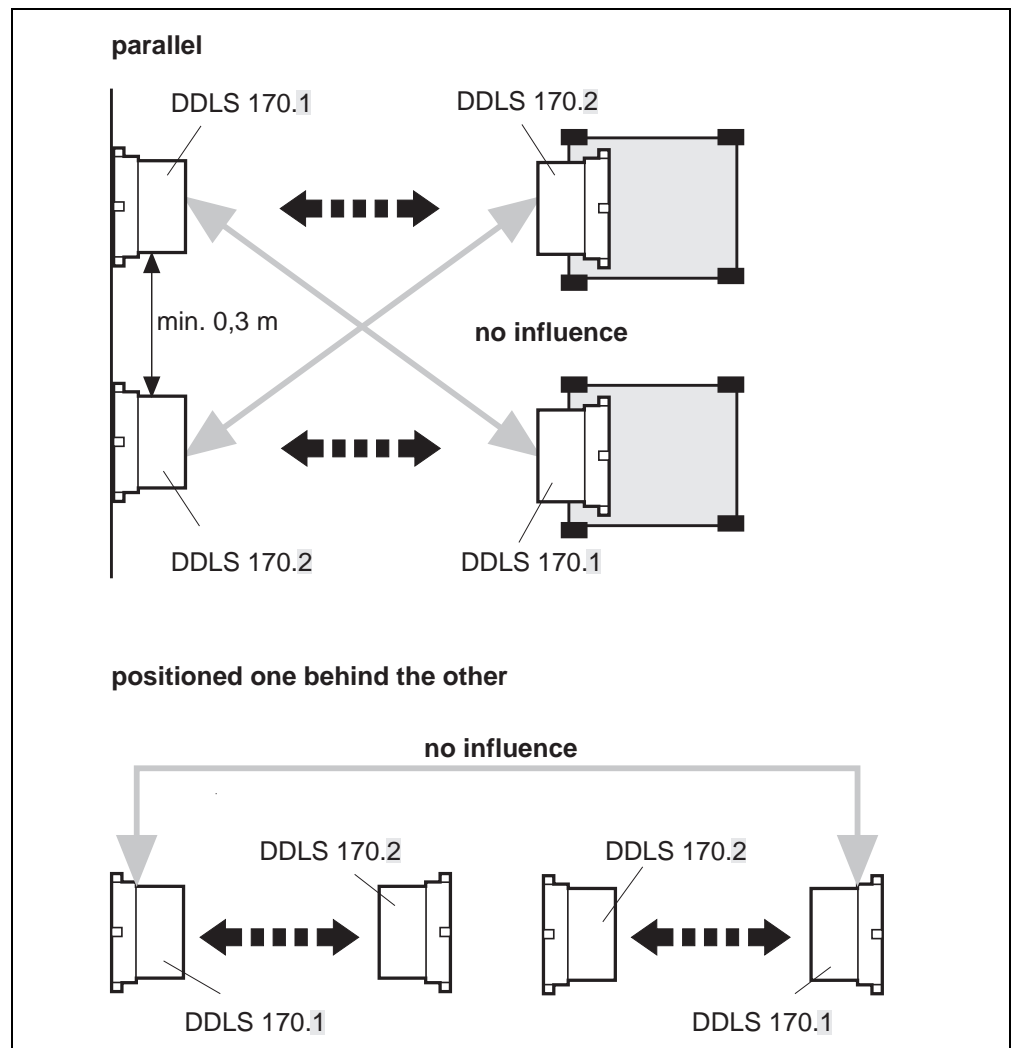


Fig. Appendix 10: Multiple data transmission paths



These data are only valid for the previous data transmission systems DDLS 170.1 and DDLS 170.2!

D.2 Installing the interface modules



Attention !

Improper installation of the interface modules leads to erroneous data transmission or component damage.

For this reason:

- Avoid electrostatic charging,
- Do not touch plug pins,
- Store interface modules only in their original packing,
- Install interface modules only when system is in a voltage-free state.

→ Lift up and remove DDLS 170.1/2.

→ Loosen mounting screw (1), install interface module (2) and tighten with the mounting screw.

→ Position and tighten down DDLS 170.1/2.

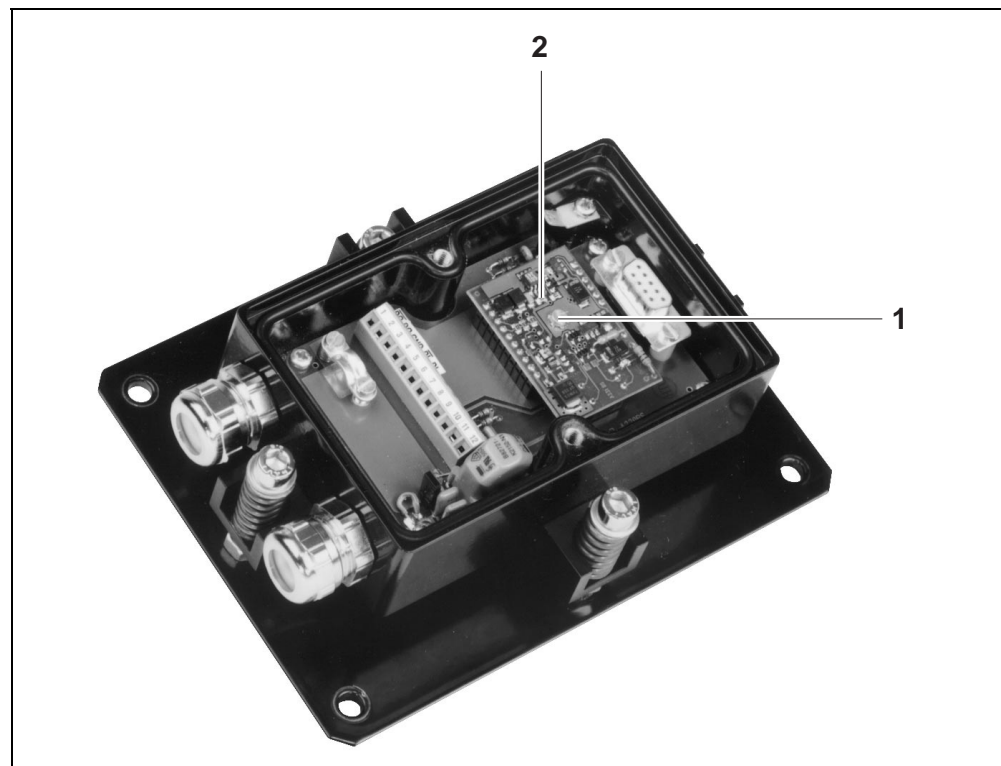


Fig. Appendix 11: Installing the interface module



These data are only valid for the previous data transmission systems DDLS 170.1 and DDLS 170.2!

D.3 Installation



Notice:

When preparing the installation sites, ensure that no vertical, lateral and angular offsets can develop between the two units.

Information regarding the alignment of the DDLS 170 can be found in the front part of this technical description (see Chapter 7).

- Drill fastening holes for the two adjusting brackets (1). For hole dimensions, see Fig. Appendix 3. Fasten adjusting brackets (2).
- Put the DDLS 170.1 and DDLS 170.2 onto the adjusting brackets so that the alignment indicators (1) point in the same direction. The alignment indicators point up for vertical installation.
- Fasten each DDLS 170.1 and 170.2 with the hex socket-head screws.
- When installing vertically, align both DDLS 170s with unsprung screws (3) on the adjusting bracket with the help of the alignment indicators.

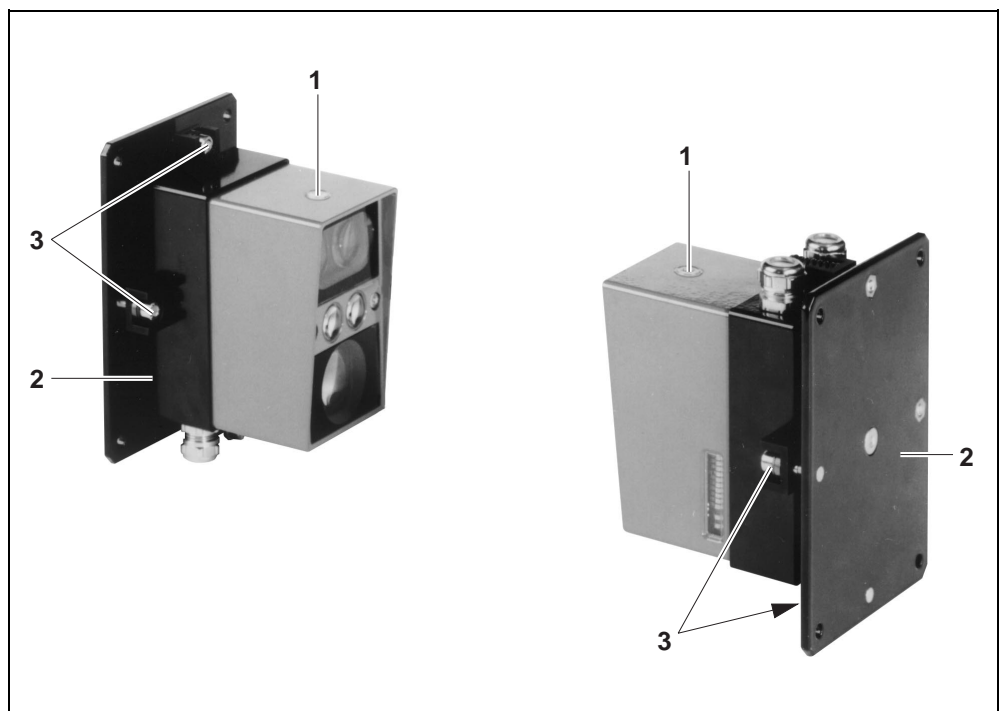


Fig. Appendix 12: Installation and horizontal alignment of DDLS 170



These data are only valid for the previous data transmission systems DDLS 170.1 and DDLS 170.2!

D.4 Commissioning

→ Connect data signal and power cables with the correct polarity.

Check the following points prior to commissioning.

- All cable and plug connections.
- Profibus interface settings (1)
- - Baud rate (2) on both DDLS 170s:
Desired transmission rate is set to 1, all others to 0.
- Terminator (3) on both DDLS 170s:
Both switches must be in the same position
0 = inactive
1 = active

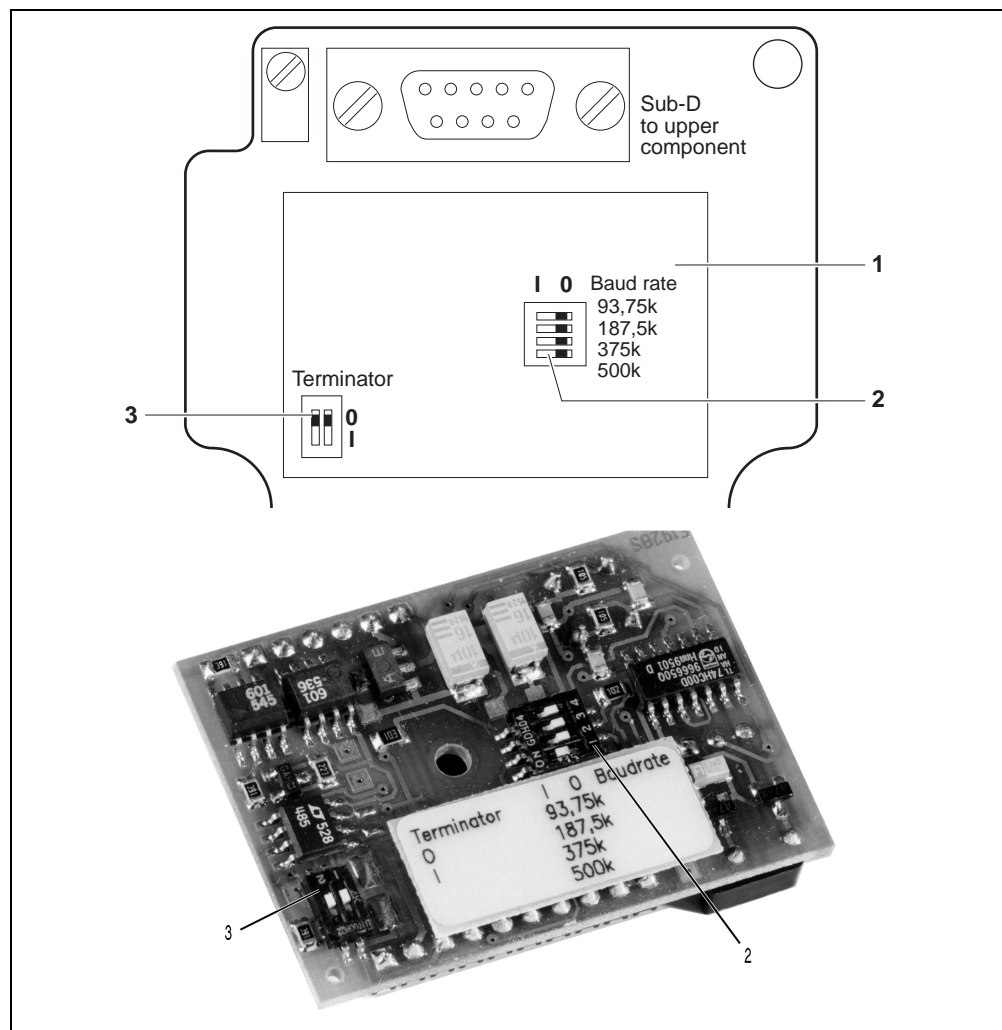


Fig. Appendix 13: Profibus interface module settings

→ Activate bus operation

If faults occur during commissioning or if the data transmission path cannot be activated, see Chapter "Error Diagnosis / Failures and Troubleshooting".



These data are only valid for the previous data transmission systems DDLS 170.1 and DDLS 170.2!

E Accessories / Order Designation

When ordering, specify:

- per data path one DDLS 170.1 and one DDLS 170.2 (see Fig. Appendix 14: points 1 and 2)
- 2 connection elements AT 170-02 with adjusting brackets (for each) (see Fig. Appendix 14: point 3)
- 2 interface modules (for each)
 - IM 02-IBS for INTERBUS cable, RS422
 - or
 - IM 02-P for Profibus (FMS, DP, mixed operation FMS/DP) (see Fig. Appendix 14: point 4)

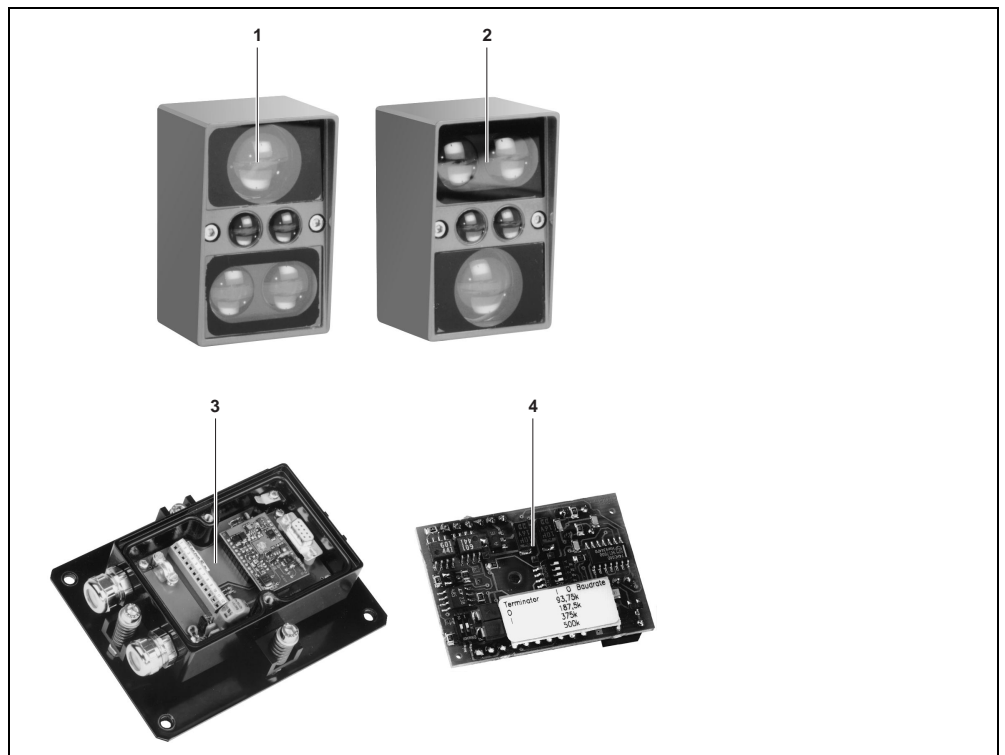


Fig. Appendix 14: DDLS 170 components

Components	Description	Type / Order Designation
Main unit	<i>Range</i>	<i>Transmission</i>
	200 m	500 kbit/s
	200 m	500 kbit/s
Interface plug-in module	INTERBUS plug-in module, RS422	IM 02-IBS
	Profibus plug-in module, RS485, Suconet K	IM 02-P
Connection elements	Connection element with screw terminals and adjusting bracket: Cable entry: 2 x PG 13.5	AT 170-02