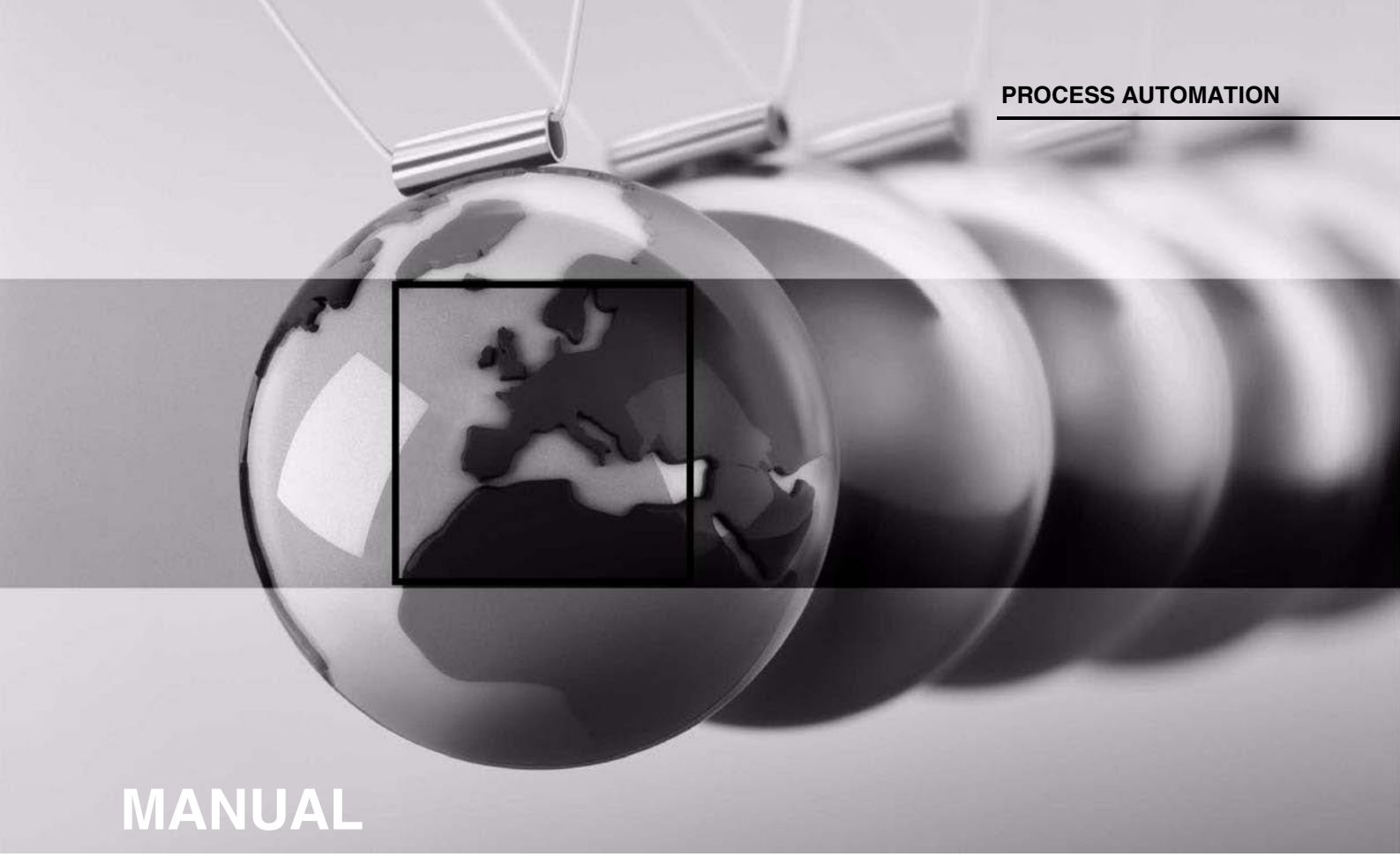
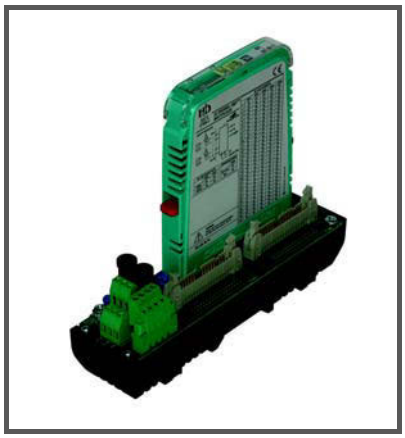


MANUAL

HART Multiplexer Master

HiDMux2700



ISO9001

SIL3

PEPPERL+FUCHS

PROTECTING YOUR PROCESS

With regard to the supply of products, the current issue of the following document is applicable: The General Terms of Delivery for Products and Services of the Electrical Industry, published by the Central Association of the Electrical Industry (Zentralverband Elektrotechnik und Elektroindustrie (ZVEI) e.V.) in its most recent version as well as the supplementary clause: "Expanded reservation of proprietorship"

DOCT-0250D 11/2014

DOCT-0250D 11/2014

1 Introduction

1.1 Aim of the manual

This manual should enable the user to install the HART Multiplexer Master, to commission it and to maintain it. It provides all the information required on status and fault messages and also provides a guide to fault diagnosis and rectification.


Note

In addition, the manual provides an introduction to HART communication. For additional information, the attention of the user is directed to the bibliography in the appendix and to other literature on the subject, including the publications of the HART Communication Foundation (www.hartcomm.org).

Where reference to the bibliography is made in this manual it is indicated thus: /3/.

The appendix also explains many terms and abbreviations used in this manual.

1.2 Responsibilities of the user

In order to avoid damage, incorrect operation and equipment failures, the user must make himself acquainted with the equipment and must have read and understood the manual before undertaking its installation and commissioning.

Warning

Repairs to the device must only be undertaken by specialist personnel and in compliance with the relevant regulations.

We strongly recommend that repairs are undertaken by the manufacturer. No guarantee claims will be accepted by Pepperl+Fuchs GmbH resulting from improper repair work.

2 Safety instructions

2.1 General safety instructions

The operator of the system is responsible in terms of planning, mounting, commissioning, operating and maintenance.

Installation and commissioning of all devices must be performed by a trained professional only.

Protection of operating personnel and the system is not ensured if the product is not used in accordance with its intended purpose.

Laws and regulations applicable to the usage or planned purpose of usage must be observed. Devices are only approved for proper usage in accordance with intended purpose. Improper handling will result in voiding of any warrantee or manufacturer's responsibility.

The Declaration of Conformity, Certificate of Compliance and data sheets are an integral part of this document. The data sheet contains the electrical data of the Declaration of Conformity and the Certificate of Compliance.

The documents mentioned are available from http://www.pepperl-fuchs.com or contact your local Pepperl+Fuchs representative.

2.2 Used symbols

Warning

This symbol indicates a warning about a possible danger. Failure to observe this warning may result in personal injury or death, or property damage or destruction.

Attention

This symbol warns of a possible fault. If the instruction given in this warning is not heeded, the device and any plants or systems connected to it could develop a fault or even fail completely.

Note

This symbol brings important information to your attention.

2.3 Declaration of Conformity

All products have been developed and manufactured taking into consideration applicable European standards and regulations

Note

A Declaration of Conformity can be requested from the manufacturer.

The manufacturer of this product, Pepperl+Fuchs GmbH in Mannheim, Germany, has a certified quality assurance system in conformity with ISO 9001.

DOCT-0250D 11/2014

2.4 Intended use

The HiDMux2700 (referred to as "Multiplexer" in the following sections) provides full HART access to up to 32 field devices and hence operation with the conventional 4 mA ... 20 mA current loops. It thus acts as a transparent gateway between the service station (PC or PCS (**P**rocess **C**ontrol **S**ystem) and the transmitters.

The Multiplexer can be used within zone 2 hazardous areas or in the safe area. Power is provided by a 24 V (nominal voltage) DC power supply. Connection to the PCS or PC is via an RS 485 interface.

Warning

It should be stressed that the Multiplexer is approved for use in zone 2 and therefore may not be used in zone 0 or 1 hazardous areas. If the equipment is used in conjunction with intrinsically safe or associated apparatus, then this use must take place in front of the Ex-barrier (e. g. transmitter power supply device).

Reference should be made to the statement of conformity.

Identification

The following identification is affixed to the Multiplexer:

Pepperl+Fuchs GmbH

Lilienthalstrasse 200, 68307 Mannheim, Germany

HiDMux2700

PF 09 CERT 1341 X

Ⓔx II 3 G Ex nA IIC T4 Gc

2.5 Maintenance

The device must not be cleaned with caustic fluids.

The devices are maintenance-free. However, to guarantee perfect operation of the complete system, check the operation, including all system parts, at least once a year.

2.6 Delivery, transport and storage

Check the packaging and contents for damage. In the event of damage, notify the postal service or express agent and inform the supplier.

Check the scope of supply for completeness and correctness using the order and delivery papers.

Keep the original packaging.

The device should always be stored or transported in the original packaging.

Always store the device in a dry and clean environment. Observe the permissible storage temperature (see data sheet).

2.7 Installation and Commissioning

2.7.1 Installation of the warning device

The device must only be installed **outside potentially explosive zones**. The device must not be installed in places with potentially aggressive vapors.

The device must be free of voltage during installation and maintenance. The warning system must only be connected to the supply voltage after complete mounting and connection of the sensors.

The name plate must not be removed.

2.8 Repair

The devices may not be repaired, changed or manipulated. If there is a defect, the product must always be replaced with an original part.

2.9 Disposal

Disposal of devices and their packaging material must be performed in compliance with the applicable laws and guidelines of the corresponding country.

The devices do not contain batteries which need to be disposed of separately from the products.

2.10 Applied standards and directives

See Declaration of Conformity.

DOCT-0250D 11/2014

3 Product specification

3.1 HART Multiplexer Master

3.1.1 Delivery package

Included in the delivery package of the device are:

- HART Multiplexer HiDMux2700
- Operating instructions

3.1.2 Accessories/product family

In addition to the HiDMux2700, the following items from the HART Multiplexer System family of products are available from Pepperl+Fuchs:

- HIDTB**, Termination Board, carrier board for Ex-isolator module
- Interface converter RS 485 <> RS 232 (Telebyte Model No. 285), converter RS 485 <> RS 232, Pepperl+Fuchs order code: Telebyte Model 285M


Note

The complete product family is described in the Pepperl+Fuchs product catalogs.

Please refer to the ordering instructions detailed in the catalogs.

3.1.3 Description of the hardware

The Multiplexer can operate up to 32 analog transmitters.

The external connections are shown in Figure 3.1 and Figure 3.2.

The power supply (24 V DC nominal voltage) is provided via the Termination Board. The analogue signals for each unit are connected separately via the terminals of the used Termination Board. The minimum load resistance of the analogue instrument circuits is 230 Ω (min. load resistance in accordance with the HART specification), the max. load resistance is 500 Ω. Load resistances of up to 1000 Ω are possible, however, resistance values greater than 500 Ω can interfere with the HART communication. A process control system or a PC can be connected via a RS 485 interface. Up to 31 Multiplexer can be operated on one RS 485 interface. The Termination Board can be used to connect additional stations. The 8-fold DIP-switch on the housing front is for the setting of the RS 485 address and the baud rate.

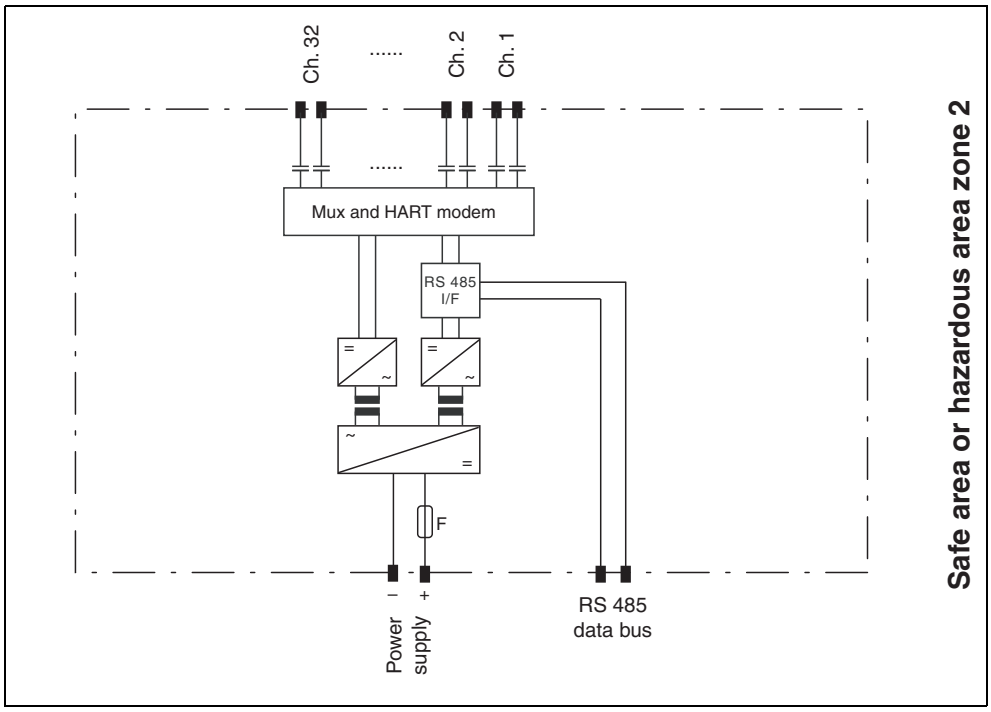


Figure 3.1 Connection diagram HiDMux2700

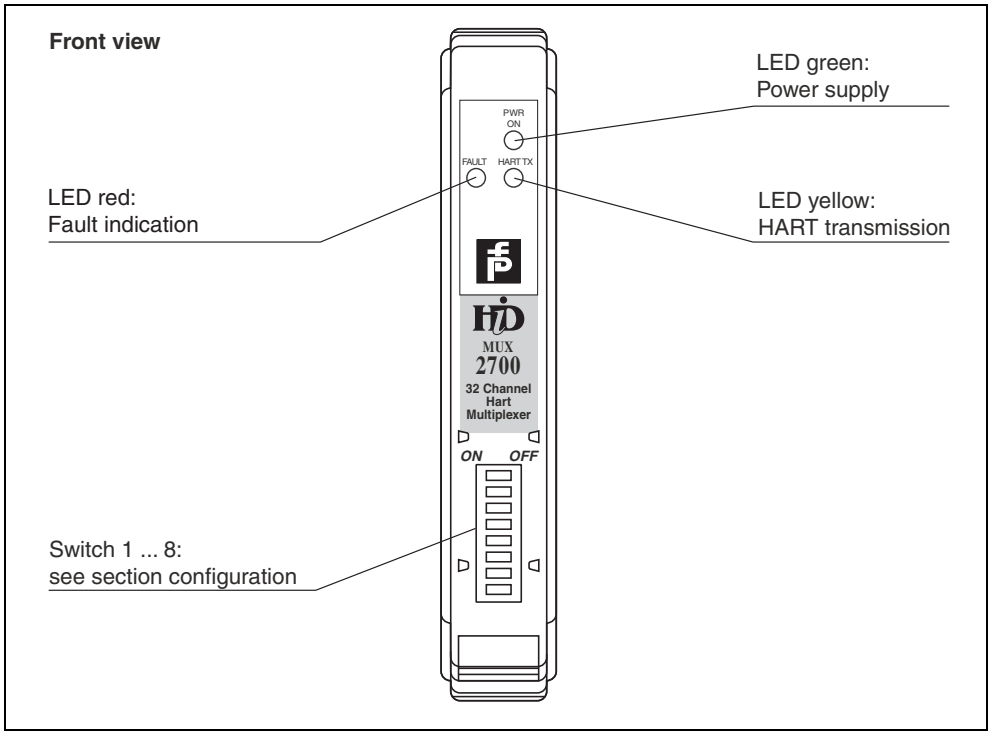


Figure 3.2 Position of the operating and display elements of the HiDMux2700

DOCT-0250D 11/2014

3.1.4 Galvanic isolation

The voltage supply, the analogue signals and the RS 485 interface are galvanically separated. This galvanic isolation is achieved through the use of transformers and opto couplers.

For the direct current components, the individual HART channels are isolated by means of two capacitors. Thus the 4 mA ... 20 mA signal is not affected. Due to the two capacitors it is also possible to attach mass-free current loops.

3.1.5 All the functions at a glance

The following list gives all the functions once again at a glance:

- 32 channels
- up to 992 loops per interface (31 Multiplexers with in each case 32 channels)
- automatic search of all existing HART field devices (REBUILD)
- facility for self-standing cyclic interrogation of the HART variables (SCAN)
- acts as a primary or secondary Master
- fast RS 485 interface (multidrop) with up to 38400 Baud
- integrated modem
- approval for zone 2

3.2 Description of the HART communication

The HART protocol (**H**ighway **A**ddressable **R**emote **T**ransducer) is supported by many conventional 4 mA ... 20 mA field devices, which thus enable digital communication for configuration and servicing purposes. Many device parameters and also the measured values themselves can thus be digitally transferred to and from the device. This digital communication runs in parallel with the 4 mA ... 20 mA signal on the same cable. This is possible through a current modulation, which is superimposed on the user signal.

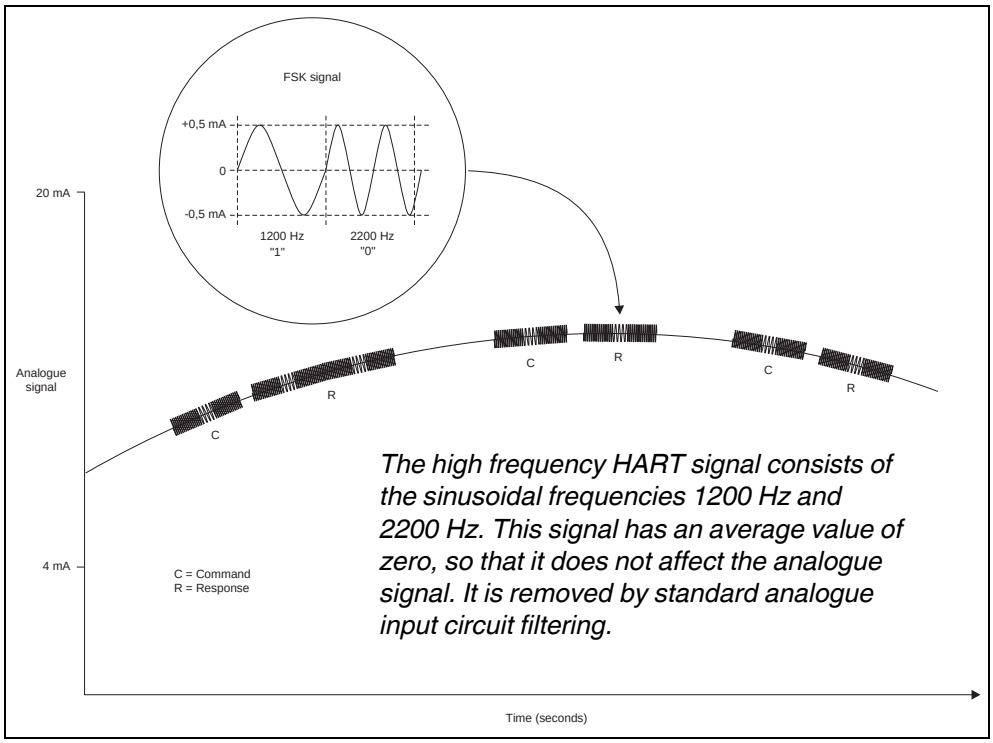


Figure 3.3 The modulated HART signal

HART is a Master-Slave protocol: a field device does only respond when requested (except in "Burst mode"). The message duration is several hundred milliseconds, so that between two and three messages can be transferred per second.

On HART, there are three groups of commands:

- The Universal commands; these must be supported by all field devices,
- the Common practice commands; these are pre-defined commands, suitable for many field devices, which, if they are supported by the device, must be implemented in the pre-defined form,
- device-specific commands; these are commands, which are particularly suitable for this field device.

The HART Multiplexer contains commands in all three groups. Details of the supported commands are given in section 8.1.

DOCT-0250D 11/2014

3.3 System construction

3.3.1 System description

In process engineering plants, there are many field devices distributed over a large area. The characteristic values of these field devices must be monitored, for example, in the context of ISO 9000 and recorded and adapted to changes in process parameters.

The HART Multiplex System from Pepperl+Fuchs enables on-line communication between a PC and "smart" field devices that support the HART protocol.

SMART transmitters and intelligent valve positioners enable information such as measurement range and tag number to be stored in the field device itself. Access to these data is usually obtained using a handheld terminal. This means, that when changes to information are required, connection to the field device must be carried out "by hand".

When specific data has to be recorded in the context of quality assurance - in accordance with ISO 9000 - this means that there is an increased demand on the process control system or the DCS. For example, the data has to be cyclically interrogated and then stored by the system in a database.

The HART Multiplex System from Pepperl+Fuchs provides the coupling between the PC and the intelligent "HART capable" field devices. All access to the field device takes place in parallel with the transfer of the 4 mA ... 20 mA measuring signal and therefore has no affect on the processing of measured values by the process control system.

The system thus provides a subordinate service interface. It is also possible to obtain measured values through the HART Multiplex System. On field devices, which are installed in hazardous areas, the coupling takes place on the safe area side of the current repeaters.

Pepperl+Fuchs can supply the appropriate SMART transmitter power supplies (e. g. HiC2025) and SMART repeater (e. g. HiC2031). Similarly, the HART Multiplex System can also be connected to other SMART Ex-isolation stages. This means that existing systems can be expanded very easily, thus taking full advantage of the HART communication system.

The system comprises a max. of 31 HART Multiplexers, which are connected to the PC via a RS 485 interface. Each Multiplexer can control up to 32 field devices.

Thus one PC can be used to address up to 992 field devices for the exchange of data. Operation using a handheld terminal also remains possible, since the HART protocol accepts two Masters in one system, i. e. PC and handheld terminal.

3.3.2 Service station

Besides the control system a PC is frequently used as the service station, with which the parameter functions or data logging functions can be carried out. Operating programs for the PC are available from various manufacturers (see section 3.3.3) to provide the necessary back-up for this purpose.

However, in some cases the communication is provided by a process control system via a RS 485 interface direct (via the HART Multiplexer) to the field devices without a connected service station. But the low speed of the HART communication imposes limitations on this method of operation.

3.3.3 Integration in the operating software (Asset Management Systems)

The full potential of the HART Multiplexer System is realized through integration in modern Asset Management Systems such as **PACT***ware*™ (open source), SIMATIC PDM (Siemens), AMS (Fisher-Rousemount), Cornerstone (Applied System Technologies) and Valve Manager (Neles Automation). These operating tools combine the device functions of the Multiplexer in the form of menu commands in a unified interface providing a very convenient method of operation. The presentation and description of the functions in the individual operating tools can be very different, however; thus a generally applicable presentation is not possible here.

Note

Information on the configuration, parameter assignment, operation and diagnostics options of the Multiplexer is provided in the documentation accompanying the various operating tools.

3.3.4 System assembly

The wiring of the single I/O components of the HART product portfolio is done via a Termination Board. Since a wide variety of Termination Boards is available, only the basic wiring options should be described here.

Note

Field devices and DCS are connected via Termination Boards in every case. More detailed information to connection layout can be found in the data sheet of the according Termination Board

External assembly

A Multiplexer is installed on a Termination Board, which transmits the signals via screw terminals. In this case the Termination Board provides the connection to the Multiplexer parallel or serial. This assembly method is completely independent of DCS and eventually used field barriers.

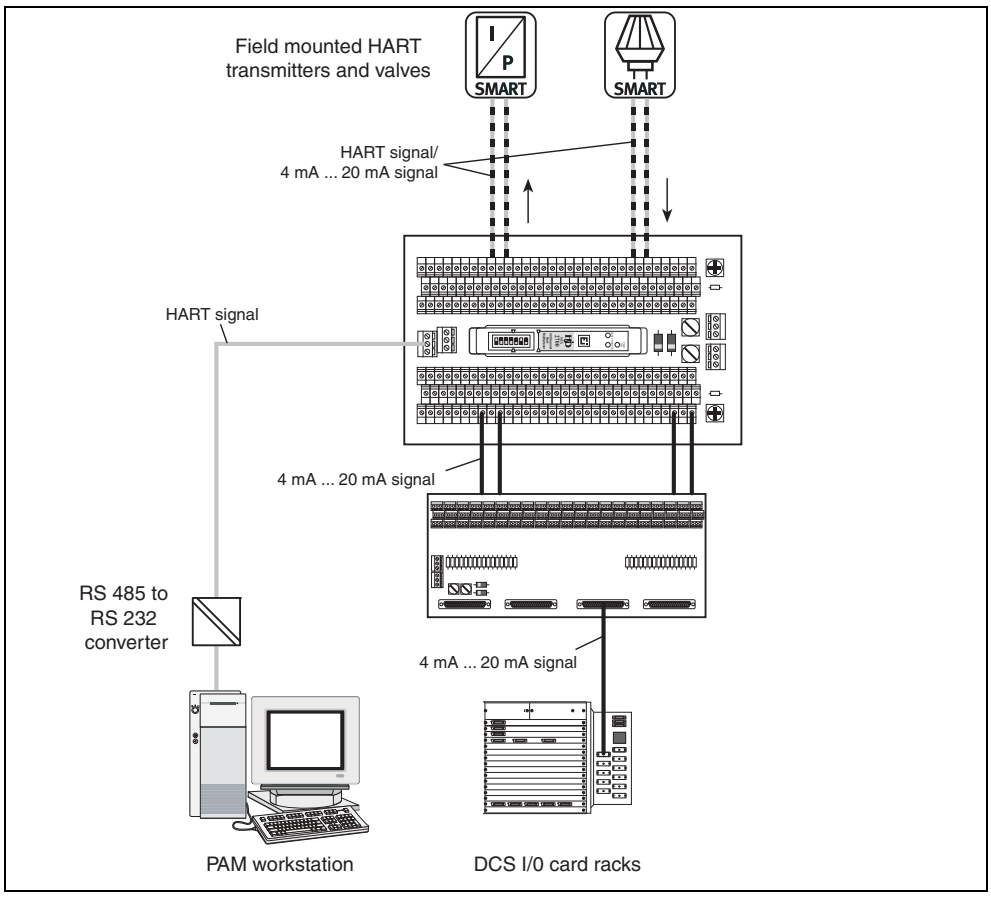


Figure 3.4 External assembly of Multiplexer

DOCT-0250D 11/2014

PEPPERL+FUCHS

Assembly integrated in the DCS

A Multiplexer is installed on a Termination Board, which transmits the signals via a system cable to the DCS. The Termination Boards are designed especially for individual DCS. Boards for the following DCS are available:

- ABB,
- Foxboro,
- Honeywell,
- Triconex,
- Siemens and
- Yokogowa

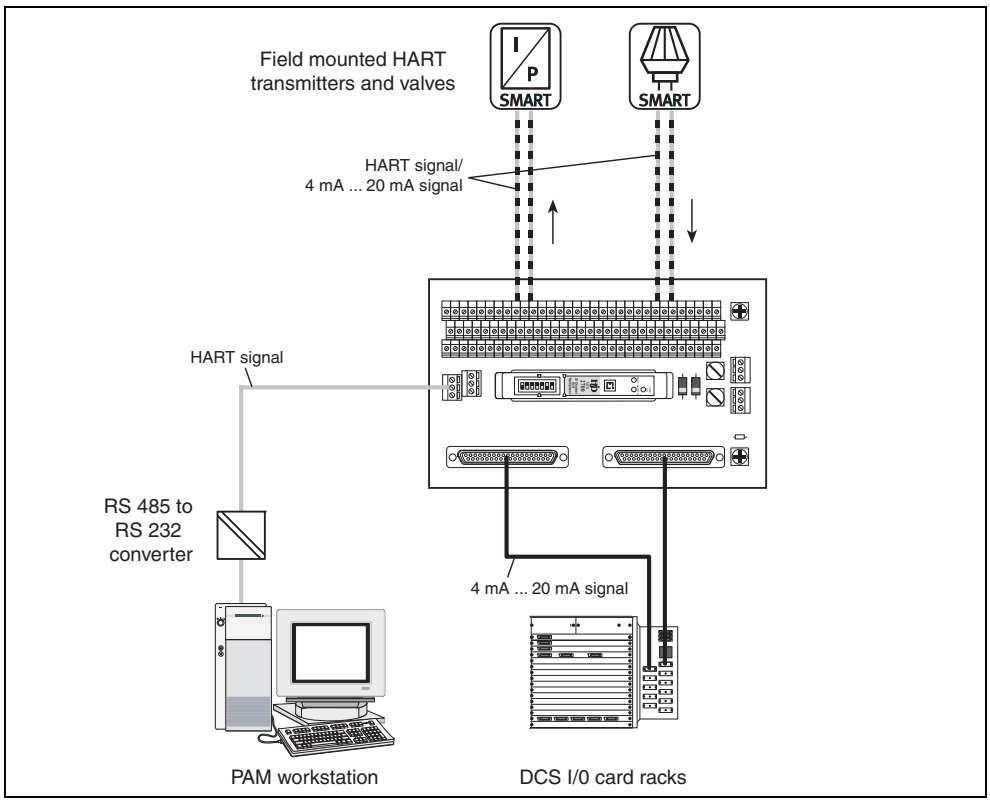


Figure 3.5 Assembly integrated in the DCS

Assembly integrated in the H-System

When using the H-System of Pepperl+Fuchs the signals can be transmitted directly from the Termination Boards of the H-System to a Termination Board for the Multiplexer via a system plug.

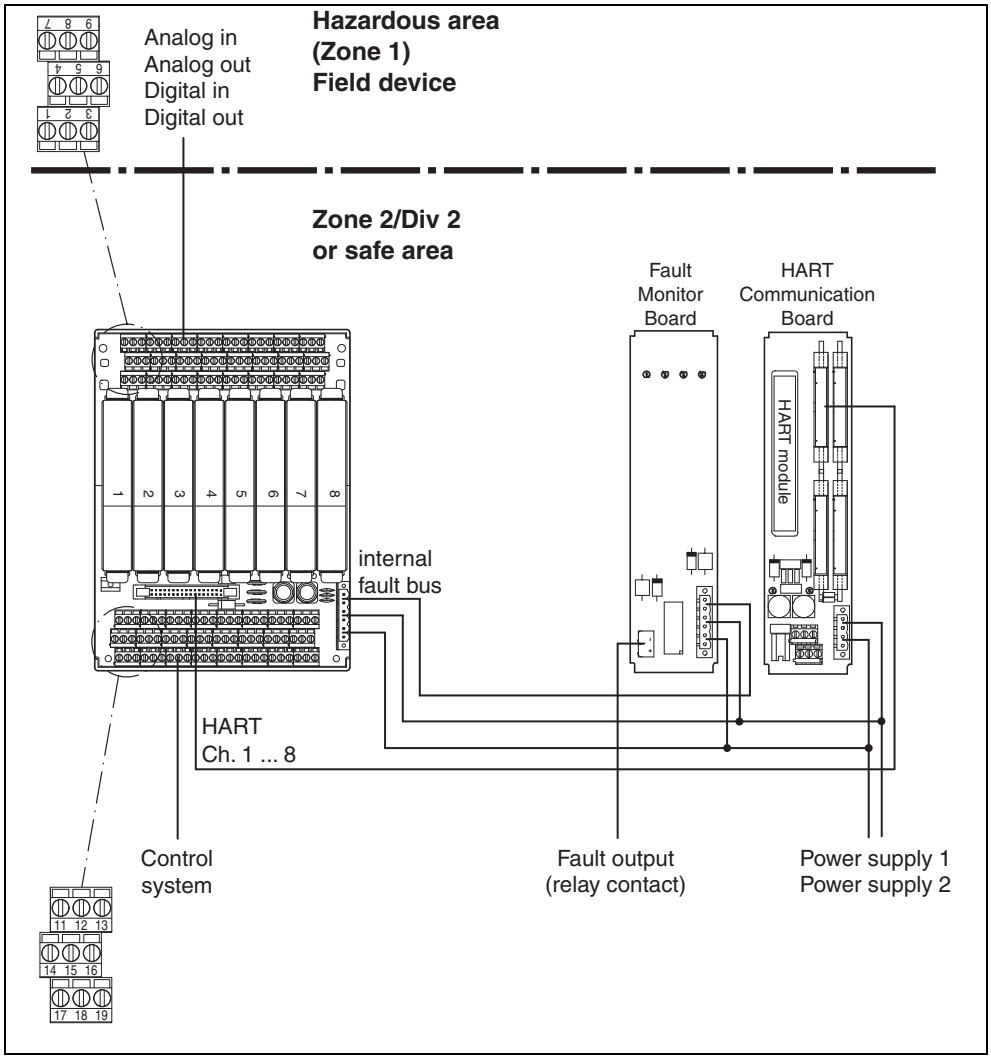


Figure 3.6 Assembly integrated in the H-System

3.3.5 Operation

The Multiplexer also functions as a HART device (see also section 5.3.5). However, due to the incorporation into the operating software of the service station (see section 3.3.3), this remains concealed from the user. The HART commands that are supported by the Multiplexer can be found in section 8.1.

For HART communication with the transmitters, the commands of the service station are passed through without modifications.

4 Installation

4.1 Mounting

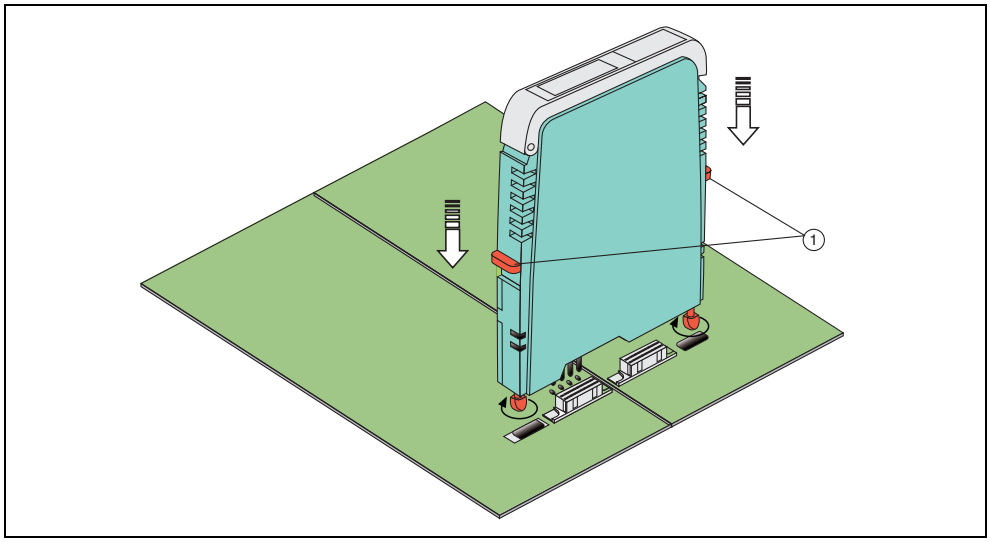
Some modules have a common fault output which is fed from the bus to the Termination Board. This transmits a collective error message per module.

Details for the coding of the modules can be found in system description H-System.

Mounting the device on the Termination Board:

- Please ensure that the red Quick Lok Bar (1) is in the upper position.
- Center the pins over the contacts on the termination board. Observe the plug orientation of the device.
- Carefully press the device into the contacts.
- Press the red Quick Lok Bar (1) down on either side of the device (see figure)

This completes the mounting work.



(1) Quick Lok Bar

Figure 4.1 Multiplexer mounting

4.2 Electrical connection

4.2.1 General notes for connection

Warning

Work on live installations and electrical connections must only be carried out by appropriately trained personnel.

When connecting the RS 485, reference should be made to the instructions in section 4.2.2.

4.2.2 Connection and connection assignment of RS 485

The connection of RS 485 is made via the Termination Board. Consider please the documentation of the used Termination Board.

Note

If the screen is grounded, the grounding should only be connected to one end of the cable, in order to avoid equipotential bonding currents. However, in all cases, existing guidelines and regulations must be observed.

Attention

To connect a standard PC with a RS 232 interface an interface converter RS 485 to RS 232 is required. A converter that has been tested and recommended by Pepperl+Fuchs is manufactured by Telebyte (Telebyte Model No. 285). This can be obtained from Pepperl+Fuchs under the part number "Telebyte Model 285M".

In accordance with the RS 485 specification up to 32 stations ("multidrop") can be connected to a up to 1200 m cable (for data rates less than 100 kBaud). Pepperl+Fuchs recommends that this length of cable is not exceeded. Even though problems seldom occur at these data rates, screened twisted two-wire cabling should be used.

In addition a terminating resistor should be connected to each end of the RS 485 cable. If the Multiplexer Master is such a device, i. e. the RS 485 cable ends here and is not routed to other devices, then the second available connection terminal for the RS 485 can be used for the connection of a terminating resistance. The terminating resistor terminates the cables with its characteristic impedance. At minimal baud rates and with short lengths of cable, in practice quite often no terminating resistors are used. If communication errors arise, or if these are to be positively excluded from the outset, terminating resistors typically of 120 Ω ... 220 Ω should be used.

Note

If an interface converter is used, a terminating resistor should be connected to the converter and another to the other end of the cable.

DOCT-0250D 11/2014

4.2.3 Connection of analog signals

The individual I/O components of the HART product family are connected by a the Termination Board. Because a large selection of Termination Boards is available, in the manual only the three most important wiring types are described (see section 3.3.4).

4.2.4 Location of electrical connections

The power supply (24 V DC nominal voltage) is provided via the Termination Board. The device is protected against reverse polarity by means of a protection diode.

The connection of a higher level control unit (PLC, PC) is achieved via an RS 485 interface at the appropriate terminals of the Termination Board. If a standard PC with an RS 232 interface is to be used, an interface converter is required (see section 3.1.2).

The analogue HART signals are connected to the current repeaters via the Termination Board.


Note

Further information for the connection of the Multiplexer on the Termination Board you can find on the data sheets of the Termination Boards and in the system description H-system.

4.2.5 Note on electromagnetic compatibility (EMC)

The device is intended for use in electrically conductive and earthed control cabinets. Leads that are fed into the control cabinet should be screened and the screen should be connected with the control cabinet at the point of entry, preferably directly in the cable gland. Unscreened leads in the control cabinet (e. g. power supply leads) should be fed via filters.

5 Commissioning

5.1 Commissioning check list

The commissioning of the Multiplexer Master is summarized in the following check list. You should follow the list through in sequence, actions that have already been carried out can be skipped. The steps required for commissioning the Multiplexer refer to the section in which the respective procedure is described in detail.

The usual commissioning procedure is as follows:

Installation

- Installation of the field devices
- Selection and connection of the Termination Boards (see also section 3.3.4)
- Selection and connection of the isolating modules
- Connection of the process control system
- Connection of the Multiplexer Master (see section 3.3.4)
- Connection of the service station. If necessary, install the interface converters. Set up the RS 485 address and set the baud rate (see section 5.3.2) Caution: Note the polarity of the RS 485 connection (see section 4.2.2).


Note

The device must be disconnected briefly from the power supply in order to accept the values set on the DIP switches.

Operation

- Wait for the start-up sequence to finish (see section 5.3.4)
- Start the parameter assignment (see section 5.3.5), in particular, establish the position of the Multiplexers that are being used in the module table (see section 6.1.2)
- Carry out the loop construction (REBUILD, see section 6.1.5)
- Activate the SCAN function, if required (see section 6.1.7)

5.2 Data access to the connected transmitters

The way in which data access to the connected field devices can take place depends on the operator tool that is being used.

In general, however, the field devices are to be found in a project tree under the HART Multiplexer Slaves (the Master integrates the Slave unit on Slave address 0), where device data, parameters and diagnostics can be accessed via menu functions. The construction of a project tree is decribed in the "Configuration HART Multiplexer Master" manual.

The data, parameters and diagnostic windows accommodate data for the underlying HART commands, which differ considerably, depending on the field device.

Only the Universal commands and general response codes have the same functions on all devices, so that information relating to the devices themselves, as well as the process values and several items of diagnostic information can be represented in a consistent manner.

DOCT-0250D 11/2014

5.3 Multiplexer configuration

5.3.1 Connection to the service station (PC, DCS/process control system)

The connection to the service station or to the control system is made via a multidrop-able RS 485 interface. The baud rate of this interface can be set to 9600, 19200 or 38400 Baud via the DIP switches 2 and 3 (see section 5.3.2). The device address for the communication via RS 485 is set by the DIP switches 4 to 8 (see section 5.3.2).


Attention

When setting the address, care should be taken to ensure that no address is assigned more than once, since this can lead to communication errors or even communication failure.

The adjusted baud rate must comply with the service station.

5.3.2 DIP switch settings

8 DIP switches are located on the top of the device. DIP switches 6 and 7 determine the baud rate of the RS 485 interface.

	SW6	SW7	SW8
9600	OFF	OFF	OFF
19200	ON	OFF	OFF
38400	OFF	ON	OFF

DIP switches 1 to 5 determine the RS 485 address. A value is assigned to each of the individual DIP switches for this purpose. The resulting address is given by the addition of the set values.

	SW1	SW2	SW3	SW4	SW5
1	ON	OFF	OFF	OFF	OFF
2	OFF	ON	OFF	OFF	OFF
3	ON	ON	OFF	OFF	OFF
4	OFF	OFF	ON	OFF	OFF
5	ON	OFF	ON	OFF	OFF
6	OFF	ON	ON	OFF	OFF
7	ON	ON	ON	OFF	OFF
8	OFF	OFF	OFF	ON	OFF
9	ON	OFF	OFF	ON	OFF
10	OFF	ON	OFF	ON	OFF
11	ON	ON	OFF	ON	OFF
12	OFF	OFF	ON	ON	OFF
13	ON	OFF	ON	ON	OFF
14	OFF	ON	ON	ON	OFF
15	ON	ON	ON	ON	OFF
16	OFF	OFF	OFF	OFF	ON
17	ON	OFF	OFF	OFF	ON
18	OFF	ON	OFF	OFF	ON
19	ON	ON	OFF	OFF	ON
20	OFF	OFF	ON	OFF	ON
21	ON	OFF	ON	OFF	ON
22	OFF	ON	ON	OFF	ON
23	ON	ON	ON	OFF	ON
24	OFF	OFF	OFF	ON	ON
25	ON	OFF	OFF	ON	ON
26	OFF	ON	OFF	ON	ON
27	ON	ON	OFF	ON	ON
28	OFF	OFF	ON	ON	ON
29	ON	OFF	ON	ON	ON
30	OFF	ON	ON	ON	ON
31	ON	ON	ON	ON	ON

Note

To accept the values set on the DIP switches, the device must be isolated briefly from power supply.

Condition on delivery

DIP switch	1	2	3	4	5	6	7	8	Meaning
Setting	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	Manufacturer test de-activated baud rate 9600 Baud RS 485 address 0

Note

The address 0 is set on the device when delivered. Care should be taken that no address is assigned more than once.

5.3.3 LED indicators

The device has three LEDs, located on the front of the housing.

The meaning of these LEDs is given in the following table:

Color	Meaning
Red	Error indications (detected during the initialization phase)
Green	Operating indications
Orange	HART communication with a field device

Note

During the initialization phase, the green LED flashes, the other two are off.

During the REBUILD function, the green LED is ON and the orange flashes.

*If all three LEDs flash one after the other, the DIP switch 1 (test) is in the **ON** position. Set the switch to **OFF** and repeat the commissioning.*

5.3.4 Start-up sequence

Following connection of the power supply, the device executes an initialization procedure with self test. The function is indicated by a flashing green LED, any errors detected are indicated by a red LED. Next a search is made of the Multiplexers in the Multiplexer table (command 157) for available HART compatible field devices (REBUILD). This function is indicated by a flashing orange LED. The REBUILD function can also be started via the service station, e. g. in order to include connected transmitters in the communication process during the operating phase. The duration of this function is dependent on the number of connected transmitters, Multiplexer Slaves and message repeats in the case of errors, or if an interrogation has not been answered. The factory setting for the number of repeats is **2**. The search duration for this lies between approx. 30 s and several minutes (full structure).

After finishing this phase the orange LED should be expired.

In addition, transient data are set to their pre-setting. Non-volatile stored data are retained, see section 5.3.5.

DOCT-0250D 11/2014

5.3.5 Device parameter, parameterization

For the identification and programming of the Multiplexer Master, this contains - as do other HART field devices - specific parameters that are in the non-volatile memory. The following list shows these parameters and how the programming must be carried out.

- Unambiguous device identification (see commands 0, 11)
  The device identification provides information about the device (type, type-ID, serial number and revision numbers) and the manufacturer and cannot be changed.
- Message (see commands 12 and 17)
  An arbitrary 32 character long item of text can be stored in the device under this parameter.
- Tag, description and date (see commands 13 and 18)
  A tag (8 characters), description (16 characters) and a date, can be saved under these parameters.
- The number of preambles in message responses (see command 59)
  This parameter is used to establish how many preambles are inserted in message responses. The pre-setting is 4, the setting range is 2 ... 20.
- Number of message repeats (retry) (see commands 144 and 145)
  The number of message repeats can be separately set for the repeats in the case of communication errors and for the response code **Busy** (see section 8.1.3). The range of adjustment is 0 ... 11 repeats. In the case of communication errors, the pre-setting is 2, in the case of the response code **Busy** it is 0.
- SCAN command (see section 6.1.7 and commands 146 and 147)
  Of the available SCAN parameters, only the SCAN command is stored by non-volatile means. It signifies which HART command (1, 2 or 3) is to be sent to the transmitter as the SCAN command.
- Master type (primary or secondary Master) (see command 151)
  This controls the priority for access to the HART field devices. A primary Master always initiates a connection with a field device. A secondary Master initiates a connection to a field device through an arbitration function (i. e. only when the primary Master does not achieve access). The pre-setting of the Multiplexer is **Primary Master**. A typical example of a secondary Master is a hand-held operating device.
- Loop type search (command 153)
  At present, the Multiplexer does not support a multidrop with HART, i. e. only one HART field device is connected to each HART channel. With loop construction (REBUILD, see above) the connected field devices are either always searched on the short address 0 (**single analogue**), or, in preparation for multidrop, on the short addresses 0 ... 15, in which the first one found is addressed (**single unknown**).
- Module table (see section 6.1.2 and command 157)
- Delay time on channel change (loop-switch delay) (see section 6.1.8 and command 161)

6 Operation

6.1 Device functions


Note

*The software functions described in this section are normally integrated into the operating software for the servicing station, i. e. the functions are **not** generally (de-)activated via the described HART commands. In contrast the operating software uses functions (menu commands) to control these procedures. However the basic HART commands are described as well, because the functions may be named different in the various operating softwares and the basic function may not be obvious. Information on the supported commands can be found in section 8.1.*

6.1.1 Channel number

The Multiplexer provides 32 channels for the connection of SMART transmitters or control devices, which support digital communication in accordance with the HART specification.

6.1.2 Multiplexer table (module table)

The Multiplexer and the connected Multiplexer Slaves must be designated as **available** in a Multiplexer table (command 157). Only those modules defined as **available** in this table are used in the communication process. The Multiplexer table consists of 16 Bit, one for each possible Multiplexer address (default: module 0 (Master) and 1 activated).

6.1.3 Interface

In this way, the Multiplexer acts as a transparent gateway between the service station (typically a PC with suitable software, see section 3.3.2) and the field devices. The service station is able to communicate with up to 31 Multiplexer via up to 38400 Baud RS 485 connection. Because each Multiplexer is able to communicate with 32 field devices, up to 992 field devices are controlable over a single RS 485 interface.

6.1.4 HART communication

As a digital communication system for servicing and configuration purposes, the HART protocol is supported by many field devices with conventional analogue 4 mA ... 20 mA current loops. The HART signal is thus modulated on the analogue current as an FSK signal (see section 3.2). The modulator/de-modulator circuitry (Modem) required for this is integrated in the Multiplexer. Only one HART transmitter can be connected at each Multiplexer HART connection (no multidrop functionality).

Special procedures in respect to HART communication:

- On the host side (RS 485) always the long frame address is used (except for command 0).
- On the field devices side, either the short address or the long frame address is used, depending on necessity.
- The operating modes **Primary Master** and **Secondary Master** and the corresponding time responses are supported on the field device side.
- On the host side, only the commands 0 ... 3 and 11 ... 13 are accepted from the secondary host. Other commands are not accepted/are ignored.
- Commands to connected field devices are only accepted by the primary host.
- Extended messages and messages in the Burst Mode are recognized and used, but not generated by the Multiplexer itself.
- An answer buffer is available for a delayed message response. This can be used to intermediately store a message, the command for which requires a long execution time.

DOCT-0250D 11/2014

6.1.5 Loop construction/REBUILD (Software function)

On power-up, the device searches the Multiplexers in the Multiplexer table for the connected HART field devices (commands 0 and 4[1]) and generates the internally required access tables. This function can also be carried out by the connected service station, as is necessary, for example, in communication with newly connected HART field devices. The duration of this function depends on the number of connected Multiplexer Slaves and HART field devices and also on the type of loop search (see command 153) and the permissible number of message repeats. With 16 HART devices (e. g. by using only one Master without Slaves) the duration is between 15 s and 30 s. The number of permissible message repeats is set to **2** in the factory setting and the loop search type to **single analogue**.

During the REBUILD phase, only certain read commands are accepted from the service station (commands 0, 1, 2, 3, 11, 12, 13, 48, and 129). All other commands are followed by the response **Busy**, until the REBUILD phase ends.

6.1.6 Cyclic data interrogation/SCAN (software function)

The Multiplexer can read cyclic data from up to 31 transmitters. In this case the SCAN option must be set for the transmitter (command 137) and the SCAN function activated in the Multiplexer (command 149, function 1). Which data is transferred is determined by the **SCAN command** option (command 147).

If the SCAN function is activated, the transmitters, on which the SCAN option is activated are regularly checked for data. In this case, the SCAN command is executed, with which one or more variables are read from the transmitter. If a field device does not respond, it is designated as having **disappeared** (see command 129), but it remains in the search list (i. e., it is searched for again on the next run sequence). If a device has disappeared, but responds correctly on the next search command, it is then listed as **appeared**. If, instead of this, another device has answered, then the status **mismatched** is assigned.

6.1.7 Variation on the SCAN function (special SCAN function)

The Multiplexer offers in addition a second SCAN function. With this special SCAN function (command 149, function 2) an additional parameter is used, which defines the minimum length of the expected number of data bytes. This can be different for each current loop, but must be set for each current loop that is to be scanned.

The SCAN function itself takes place as above, however, the response of the transmitter is compared with the expected data length. If the length of the response is less than the set minimum data length, the answer is rejected. If the minimum length is 0, the answer is always saved.

6.1.8 Delay on channel change/Loop switch delay (software function when used with RPI)

If the HART Multiplexer is used with a RPI HART control module, a pause time must be inserted when the Multiplexer channel is changed. This pause time is necessary, since the RPI HART control module has to monitor the communication channel of the Multiplexer and recognize the channel change. This pause time can be set by means of command 161.

[1] Command 4 is additionally used on transmitters which only support the old HART specifications up to 4.

6.1.9 All the functions at a glance

The following list gives all the functions once again at a glance:

- 32 channels
- up to 992 loops per interface (31 Multiplexers with in each case 32 channels)
- automatic search of all existing HART field devices (REBUILD)
- facility for self-standing cyclic interrogation of the HART variables (SCAN)
- acts as a primary or secondary Master
- fast RS 485 interface (multidrop) with up to 38400 Baud
- integrated Modem
- approval for zone 2

DOCT-0250D 11/2014

7 Diagnosis and fault elimination

7.1 General

This section provides operating instructions to be used if faults occur and describes the possible causes of such faults.


Note

Faults and failures are signalled via the following means:

- *LEDs (see section 5.3.3 and 7.2)*
- *Status/response code (see section 7.3)*
- *Extended device status (see section 7.4)*

7.2 LED indication

The following fault conditions can occur during the initialization phase after start-up:

Red	Green	Orange	Cause	Corrective action
Off	Off	Off	• No power supply available. • LED(s) defect	• Check power supply. • Select DIP switch 1, isolate power supply briefly. LEDs flash one after the other.
On	On	On	Fault in device hardware (CPU, ROM)	Send device to Pepperl+Fuchs for repair.
On	Off	Off	Fault in device hardware (CPU, ROM)	Send device to Pepperl+Fuchs for repair.
On	On	Off	• Fault in device hardware (CPU, RAM) • Device parameter assignment incorrect (parameter Loop Switch Delay, command 161)	• Send device to Pepperl+Fuchs for repair. • Parameterize device again. If this is not successful, the device must be sent to Pepperl+Fuchs for repair.

7.3 Status/response code (response code)

7.3.1 General

Two status bytes, also referred to as the "Response code“ are contained in every message from a field device. These contain three types of information:

- Communication errors
- Command responses and the
- Device status.

Depending on Bit 7, the first two types are contained in the first status byte. The device status is always transferred in the second byte.

7.3.2 Structure of the first byte

If Bit 7 is set (1), the first status byte contains a summary of the communication errors. This information is coded bit by bit.

If Bit 7 is cleared (0), the first status byte contains a summary of the command responses. This information is numbered consecutively and not coded bit by bit.

Communication error

This Byte contains information concerning the reception of a message.

The individual bits indicate a detected error, which has resulted in non-acceptance of the message. Thus neither can a response be given to the message. It is necessary to repeat the command, to check the connections, to use the terminating resistors or to reduce the baud rate.

Bit								Meaning
7	6	5	4	3	2	1	0	
1								Communication error, if Bit 7 = 1, coded bit by bit
1	1							Parity error
1		1						Overrun error
1			1					Message error
1				1				Checksum error
1					0			always 0 (reserved)
1						1		Input buffer overrun
1							1	(undefined)

Note

Details can be found in /1/.

Command responses

The first byte contains information relating to the execution of a command. The command-specific response code thus documents the execution of the command.

In contrast to the communication error, the command responses are not coded bit by bit, but are numbered consecutively from 0 to 127.

Of the command responses signalled by the Multiplexer, two instances are warnings (codes 8 and 31), in which the processing of the command is continued. In the other cases, errors are indicated, that means that the initiating command could not be correctly executed. Here, the remedy is given by the meaning of the code.

Note

All the codes that occur on the HART system are described in /1/.

The following response codes can occur on the Multiplexer:

Code	Description	Meaning	Can occur with commands ...
2	Invalid selection	The selected code/index is not permissible.	147, 149, 151, 153
3	The parameter value was too large		59, 129, 155
4	The parameter value was too small		59
5	Too few data bytes received	The message has no error, but it contains fewer bytes than expected for the execution of the command.	17, 18, 59, 129 ... 141, 145, 147, 149, 151, 153, 154, 155, 157
8	Warning	Here (132): Preamble length not within range 5 ... 20 and has been set to 5 or 20.	132
9	1st parameter too large	The first of the two parameters is too large.	145
11	2nd parameter too large	The second of the two parameters is too large.	145
16	Access restricted	The command has been ignored, since the current device status does not permit the command to be carried out correctly.	6, 17, 18, 38, 41, 42, 48, 59, 106, 128 ... 157
17	Too many items requested		131, 132, 133, 135 ... 141, 154
31	Warning	Here (137): SCAN value has not been changed, since it is identical.	137
32	Busy	The device is executing a function, which cannot be interrupted by this command.	6, 17, 18, 38, 41, 42, 59, 106, 128, 130 ... 157
64	Command not implemented	The command does not exist and therefore cannot be executed. This error message is also output if an error occurs that cannot be accurately specified by the device.	almost all
65	Not specified	Parameter not in the permissible range.	132, 137

7.3.3 Device status (structure of the second byte)

If a communication error is indicated in the first byte (Bit 7 = 1), the second byte described here has no significance (always 0).

In the other case, it contains the status of the field device in full, i.e. independent of commands.

The individual bits have the following meaning:

Bit	Description	Meaning	Corrective action
7	Error function of the field device (malfunction)	Hardware fault. The extended device status may provide further information (see section 7.4).	• Read extended device status (section 7.4). • Check LEDs (section 7.2). • Re-parameterize device.
6	Configuration changed (Configuration changed)	A write command has been executed.	This bit can be cleared by command 38.
5	Start-up sequence is running	The power supply has been connected or a reset has been activated. Transient data are reset to the preset values.	Wait for the start-up sequence, then parameterize the device.
4	Extended device status available	Further status messages are available and can be called up, see section 7.4.	Read extended device status (section 7.4).
3	Analogue output current fixed (primary variable)	The primary variable is fixed at the requested value and no longer follows the process.	always 1 (has no function on the Multiplexer, since there is no analogue output)
2	Analogue output current has reached its limit (primary variable)	The primary variable lies outside its limit value and therefore no longer corresponds to the process value.	always 0 (has no function on the Multiplexer)
1	Variables (not the primary one) outside the range	The values detected by the sensor (not for the primary variable) lie outside the operating range. The extended device status may yield additional information (see section 7.4).	always 0 (has no function on the Multiplexer)
0	Primary variable outside the range	The measured value detected by the sensor lies outside the operating range.	always 0 (has no function on the Multiplexer)

DOCT-0250D 11/2014

7.4 Extended device status

The extended device status can be called up via command 48. It provides five bytes of information, which are thematically arranged:

1st Byte Operation in progress

The Byte indicates which operation is in progress. The information is coded bit by bit. The coding is shown in the following table:

Bit	Operation in progress	Meaning
7	Reset	Start-up sequence running and must be completed.
6	REBUILD	REBUILD function is running and must be completed.
5	internal EEPROM write function	Switching off the power supply can result in loss of the parameter assignment.
4	SCAN	SCAN function is running and must be completed.
3	Self test (command 41)	The device self test is executed (as when the power supply is switched on); if no error occurs, the "Malfunction" status message (see section 7.3.3) clears (if it is set).
2 ... 0	reserved	Reserved.

2nd Byte Hardware fault

This Byte, which is also bit by bit coded, indicates any hardware faults that have been found. Hardware faults are only detected during the initialization sequence after the power supply has been switched on.

Bit	Detected hardware fault	Meaning/remedial action
7	Current loop	OR logic operation on all detected hardware faults in the current loops. Check the transmitter and its cabling, then execute REBUILD.
6	ROM error	Send device to Pepperl+Fuchs for repair.
5	EEPROM error	Send device to Pepperl+Fuchs for repair.
4 ... 0	reserved	Reserved.

3rd Byte SCAN error

The Byte indicates an OR logic operation for all errors that have been detected during the SCAN function.

Example: If a field device has been detected as having **disappeared** and another as **mismatched**, then these two Bits are set simultaneously.

The bit by bit coded information is shown in the following table:

Bit	State	Meaning	Corrective action
7	reserved	Reserved.	
6	Searching	Transmitter is searched for (due to having disappeared).	• Check cabling. • Check transmitter.
5	Disappeared	Transmitter no longer responds.	
4	Appeared	Transmitter responds again.	Check cabling.
3	Mismatched	Despite this, another transmitter has responded.	Transmitter has been exchanged for another type. Check type, rebuild loop.
2 ... 0	reserved	Reserved.	

8 Appendix

8.1 Supported commands

The following tables show the HART commands supported by the Multiplexer, ordered by three groups (see also section 3.2):

- Universal commands,
- Common-practice commands and
- Device specific commands.

The read commands are caracterized by 🕮 and the write commands by ✍.

The Universal and Common-practice commands are described in detail in /1/. In this section only the functions are explained, not the data structure of the lower layer of the HART protocol.

8.1.1 Universal commands

Command		Action	Meaning
0	🕮	Read unique identifier.	12 Bytes device identifier are given in the response.
1	🕮	Read HART variables (process values).	Commands are only supported for compatibility purposes and are without any meaning. Used with transmitters (e. g. SCAN function) they have the following meanings: 1: Read primary variable. 2: Read primary variable as current (in mA) and percent of range. 3: Read primary variable as current (in mA) and four (pre-defined) dynamic variables.
2	🕮		
3	🕮		
6	✍	Write polling address.	This command is never accepted and the messages "Access restricted" or "Busy" will be returned.
11	🕮	Read unique identifier associated with tag.	A response will contain 12 bytes device identifier, if the given tag complies to the tag of the Multiplexer.
12	🕮	Read "Message".	Read the 32 digit message (see also 17).
13	🕮	Read tag, description and date.	Read the 8 digit tag, the 16 digit description and the date.
17	✍	Write "Message".	Write the 32 digit message (see also 12).
18	✍	Write tag, description and date.	Write the 8 digit tag, the 16 digit description and the date.

DOCT-0250D 11/2014

8.1.2 Common-practice commands

Command		Action	Meaning
38	✍	Reset "Configuration changed" flag.	Reset the "Configuration changed" response code, see section 7.3.3.
41	✍	Perform device self test.	Initiates the self test function in the device (as during power up); if no error occurs the response code "malfunction" (see section 7.3.3) is cleared (if set).
42	✍	Perform device reset.	Immediately after the response the microprocessor of the device will be reset.
48	🕮	Read additional device status.	see section 7.4.
59	✍	Write number of the response preambles.	The number of preambles insert in response telegrams can vary from 2 to 20. Default setting is 4.
106	✍	Delete all delayed responses pending for the host.	All pending response telegrams are deleted. Because only one response buffer exists, the buffer is always deleted (independent from the initiating host) in accordance with the specification.

8.1.3 Device specific commands

Command		Action	Meaning
128	🕮	Read parameterization of the Multiplexer.	The actual parameterization is read out of the Multiplexer.
129	🕮	Read loop status.	With this command the status of the current loop can be read out. The following information is supplied: • Hardware fault • Rebuild running for this loop • SCAN activated for this loop • Searching transmitter (due to "disappeared") • Transmitter not responding ("disappeared") • Transmitter responding again ("appeared") • An other transmitter responded instead ("mismatched")
130	🕮	Read transmitter list (max. 49 entries, beginning with the given index).	The long frame addresses of up to 49 transmitters are returned beginning at the given index.
131	🕮	Read static data of up to 22 transmitters.	For the given long frame addresses the function returns the following transmitter data: • Current loop number (0 ... 15) • Polling address • Supported HART revision • Minimum count of required preambles (5 ... 20)
132	✍	Write static data of up to 22 transmitters.	Write static data (see 131). Values out of the range 5 ... 20 will be set to 5 or 20, respectively.
133	✍	Remove transmitter from transmitter list (max. 35 at the same time).	Transmitters with the given long frame addresses will be removed from the transmitter list (and the SCAN list).
134	🕮	Read SCAN list (max. 49 entries, beginning with the given index).	The long frame addresses of up to 49 transmitters are returned beginning at the given index.

Command		Action	Meaning
135	🕮	Read dynamic data of up to 7 transmitters.	For the given long frame addresses the function returns the following transmitter data: • The selected SCAN command • Long frame address • HART data
136	🕮	Read SCAN status of up to 31 transmitters.	For the given long frame addresses, this command returns the SCAN status of the transmitters (0 = SCAN disabled, 1 = SCAN enabled).
137	✍	Write SCAN status of up to 31 transmitters.	For the given long frame addresses, this command sets the SCAN status of the transmitters (0 = disable SCAN, 1 = enable SCAN).
138	🕮	Read cumulative responses of up to 27 transmitters.	This command returns the OR-combination of communication errors and status response bits.
139	✍	Reset cumulative responses of up to 35 transmitters.	This command resets the cumulative responses.
140	🕮	Read transmitter counts of tries and failures of up to 16 transmitters.	Communication statistic that contains the number of commands sent to the transmitter and the number of commands that failed.
141	✍	Reset transmitter counts of tries and failures of up to 16 transmitters.	Reset the communication statistic.
142	🕮	Read counts of host communications.	Communication statistic concerning the Multiplexer.
143	✍	Reset counts of host communications.	Reset the communication statistic.
144	🕮	Read retry limits.	Retries in case of "Busy": 0 ... 11 (default is 0), Retries in case of communication errors: 0 ... 11 (default is 2).
145	✍	Write retry limits.	
146	🕮	Read the selected SCAN command.	During SCAN the HART commands 1, 2 or 3 (see above) can be executed.
147	✍	Select SCAN command.	
148	🕮	Read SCAN status.	With these commands the status of the SCAN function is set or read, respectively (see section 7.4). 0: SCAN function disabled (default after power-up) 1: Normal SCAN function activated 2: Special SCAN function activated (see 158, 159)
149	✍	Write SCAN status.	
150	🕮	Read Master type (gender).	1 = Primary Master (default), 0 = Secondary Master.
151	✍	Write Master type (gender).	
152	🕮	Read loop search type.	The loop search type defines the polling address(es) for a transmitter that did not respond during several requests (disappeared) is searched (see also command 129). 0: Single transmitter, 4 mA ... 20 mA (single analogue) (only polling address 0) (default) 1: Single transmitter, unknown (single unknown) (first one of the polling addresses 0 to 15) **Note**: The search procedure without any connected transmitters is 16 times longer because all 16 polling addresses are checked! 2: Reserved for multidrop
153	✍	Write search type.	
154	✍	"Rebuild" up to 83 loops.	see section 6.1.5.
155	✍	Pass through host command to transmitter and transmitter response to host.	By this any command can be passed to a field device and the response can be evaluated - without any modification by the Multiplexer.

DOCT-0250D 11/2014

Command		Action	Meaning
156	🕮	Read Multiplexer table (module table) (16 Multiplexers).	This command returns the Multiplexer table (see 157).
157	✍	Write Multiplexer table (module table) (16 Multiplexers).	This is to select which of the Multiplexers (Master and 15 Slaves) are connected (2 bytes, bit coded).
158	🕮	Read special SCAN parameters.	For the given loop the actual special parameters and, if available, the transmitter data are returned. These are: • Loop number • Error flag (0 = OK, 1 = special SCAN not activated) • Polling address (always 0, no multidrop) • Threshold data length for special SCAN • Selected SCAN command • Long frame address • Number of available data bytes • The data bytes itself (if any)
159	✍	Write special SCAN parameters.	For the given current loop and polling address (has to be 0) the threshold data length (0 ... 62) and the SCAN command to be used can be written.
160	🕮	Read loop switch delay.	When the Multiplexer switches the communication channel (loop 0 ... 255) it can insert a delay time (0 ms ... 300 ms) before any HART commands are sent to the loop.
161	✍	Write loop switch delay.	

8.2 Literature

/1/ HART Communication Foundation:
HART – SMART Communications Protocol Specification
HCF SPEC-11, Revision 5.9
www.hartcomm.org

/2/ HART Communication Foundation:
HART Application Guide
HCF LIT 34
www.hartcomm.org

/3/ Romilly Bowden, Fisher-Rosemount:
HART- A technical Overview, August 1997
Fisher-Rosemount

8.3 Glossary

Address

In communications technology, the address of a device is used to identify that device, so that messages can be delivered correctly. HART uses two forms of addressing: a polling address in the range 0 to 15, and a unique identifier (long frame format address) of 38 bits. The polling address 0 is reserved for 4 mA ... 20 mA analogue transmitters in → point-to-point networks, polling addresses 1 ... 15 for transmitters in → multidrop networks.

Broadcast Mode

→ Burst Mode

Burst Mode

A communication mode in which a Master device instructs Slave devices to continuously broadcast process values (e. g. the → primary variable) until the Master instructs it to stop. The Multiplexer recognizes and supports this mode, but itself does not instruct field devices to use this mode.

FSK

Abbrev. for **F**requency **S**hift **K**eying. Method of coding the two digital signals "0" and "1" with two different frequencies.

HART

Abbrev. for **H**ighway **A**ddressable **R**emote **T**ransducer. Used to describe communications that complies to the HART specification. HART is a → Master-Slave system.

Host

Higher layer system, e. g. service station, PC or process control system.

Long frame address

→ Address

Master

A device (e. g. the process control system) in a → Master-Slave system that initiates all transactions and commands.

Master-Slave system

A communication system in which all message transactions and commands are always initiated by a → Master device and → Slave devices only respond to requests received.

Multidrop

In contrast to → point-to-point, more than two (field) devices are connected together to one segment (pair of wires) in a multidrop system. To correspond to each singe device it must have a unique → address. Because communication can only be established to one field device, cycle times are increasing proportional to the number of field devices. In HART multidrop operation the current through each field device is fixed at 4 mA to allow parallel operation of more than one device (up to 15 devices are possible).

Multimaster

HART allows connection of two Masters, a primary and a secondary Master. A high level station is configured as primary Master, usually this is the process control system or the main service station. A lower level station is configured as secondary Master, this may be a hand terminal or a service station. The difference between primary and secondary Master is the priority of the bus access: the primary Master has a higher priority than the secondary Master. Messages sent by the Masters are characterized by a Master bit, so that the Masters can recognize which responses are intended for them.

Point-to-point

In a point-to-point communcation system, only two communicating devices are connected together to one segment (pair of wires). A point-to-point system is for example the Master-Slave system Multiplexer-field device.

Primary Master

→ Multimaster

Primary variable

Process value measured by a field device. The unit depends on the used HART command (see commands 1, 2 and 3). The primary variable of a pressure sensor could contain for example the measured process pressure in the unit "bar".

Secondary Master

→ Multimaster

Secondary variable

Additional value (measured in the process) of a field device (up to four additional values are supported by HART). This variable can only be read by HART command 3.

Slave

A device (e. g. transmitter or valve) in a→ Master-Slave system that receives commands from a → Master device. A Slave is not able to initiate a transaction.

"Smart" field device

Microprocessor-based device that can be programmed, has memory, is capable of performing calculations and self-diagnostics and reporting faults, and can be communicated with from a remote location.

Tag

Unique tag (designation of the control engineering point) of the field device within the process plant.

DOCT-0250D 11/2014

PROCESS AUTOMATION – PROTECTING YOUR PROCESS

Worldwide Headquarters
Pepperl+Fuchs GmbH
68307 Mannheim · Germany
Tel. +49 621 776-0
E-mail: info@de.pepperl-fuchs.com

For the Pepperl+Fuchs representative
closest to you check www.pepperl-fuchs.com/contact

www.pepperl-fuchs.com

PEPPERL+FUCHS
PROTECTING YOUR PROCESS

DOCT-0250D
11/2014