MANUAL

HART Multiplexer System
KFD*-HM*-16

ISO**9001**

CE

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DOCT-0120D 06/2014

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.

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.

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

STOP
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.

ISO**9001**

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2.4 Intended use

The KFD-HMM-16(referred to as "Multiplexer Master" or "Multiplexer" in the following sections) and the KFD0-HMS-16 (referred to as "Multiplexer Slave" or "Multiplexer" in the following sections) provides full HART access to up to 256 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.

STOP
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 Master:

Pepperl+Fuchs GmbH

Lilienthalstrasse 200, 68307 Mannheim, Germany

KFD2-HMM-16

PF07 CERT 1143 X

⟨Ex⟩ II 3 G Ex nA IIC T4 Gc

The following identification is affixed to the Multiplexer Slave:

Pepperl+Fuchs GmbH

Lilienthalstrasse 200, 68307 Mannheim, Germany

KFD0-HMS-16

PF07 CERT 1143 X

⟨Ex⟩ 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).

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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.

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3 Product specification

3.1 HART Multiplexer Master

3.1.1 Delivery package

Included in the delivery package of the KFD2-HMM-16 are:
- HART Multiplexer Master KFD2-HMM-16
- Operating instructions

Included in the delivery package of the KFD0-HMS-16 are:
- HART Multiplexer Slave KFD2-HMS-16
- Operating instructions

3.1.2 Accessories/product family

In addition to the HART Multiplexer Master, the following items from the HART Multiplexer System family of products are available from Pepperl+Fuchs:
- KFD0-HMS-16, HART Multiplexer Slave, for extending the HART channels
- KSD2-HC, HART RPI control module, for connecting the HART Multiplexer to the RPI product family
- K-HM14, cable Master <> Slave, for connecting the Master with the Slaves
- FI-***, HART flexible interface, handover interface of the analog signals between transmitter, Multiplexer and PLC/DCS (control system specific)
- K-HM26, cable Master/Slave <> FI-***/MB-***, for connection of Master/Slave with flexible interface FI-*** or motherboard MB-***, respectively
- Interface converter RS 485 <> RS 232 (Telebyte Model No. 285), converter RS 485 <> RS 232, Pepperl+Fuchs order code: Telebyte Model 285M

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

Please refer to the ordering instructions detailed in the catalogs.

Note

3.1.3 Description of the hardware

The HART Multiplexer can operate up to 256 analog transmitters. The built-in Slave unit operates the first 16 loops, and a maximum of a further 15 KFD0-HMS-16 Slaves can be connected.

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 Power Rail or terminals 17 and 18. The optional Slave units (KFD0-HMS-16) or the RPI control module (KSD2-HC) are connected with the Master via a 14-core flat cable (K-HM14). Its connector is placed on the same housing side as the terminals for the RS 485 interface and the voltage supply. The analog signals for each unit are connected separately via a 26-core cable. 16 leads are provided for the HART signals of the analog instrument circuits, the other 10 are connected to ground. The minimum load resistance of the analog 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. The connector for these connections is located on the top of the housing. A process control system or a PC can be connected via a RS 485 interface (terminals 13, 14 and 15). Up to 31 KFD2-HMM-16 can be operated on one RS 485 interface. Terminals 19, 20 and 21 can be used to connect additional stations to the RS 485 interface. The DIP switch on the housing front is for the setting of the RS 485 address and the baud rate.

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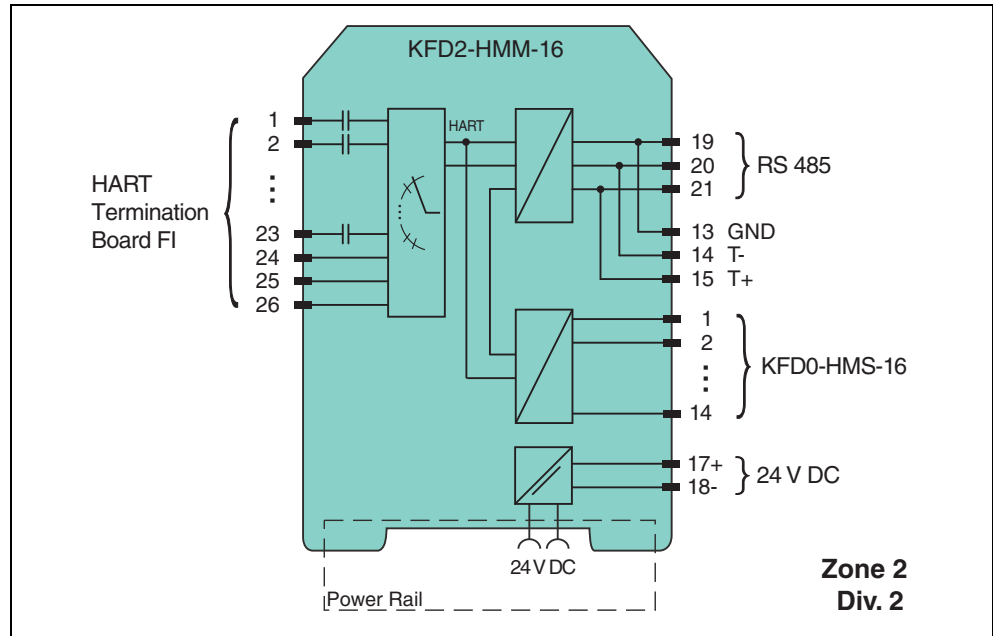
Figure 3.1   Connection diagram KFD2-HMM-16

Front view

LED red:
Fault signal

LED green:
Power supply

LED orange:
Operational

Removable terminals
green

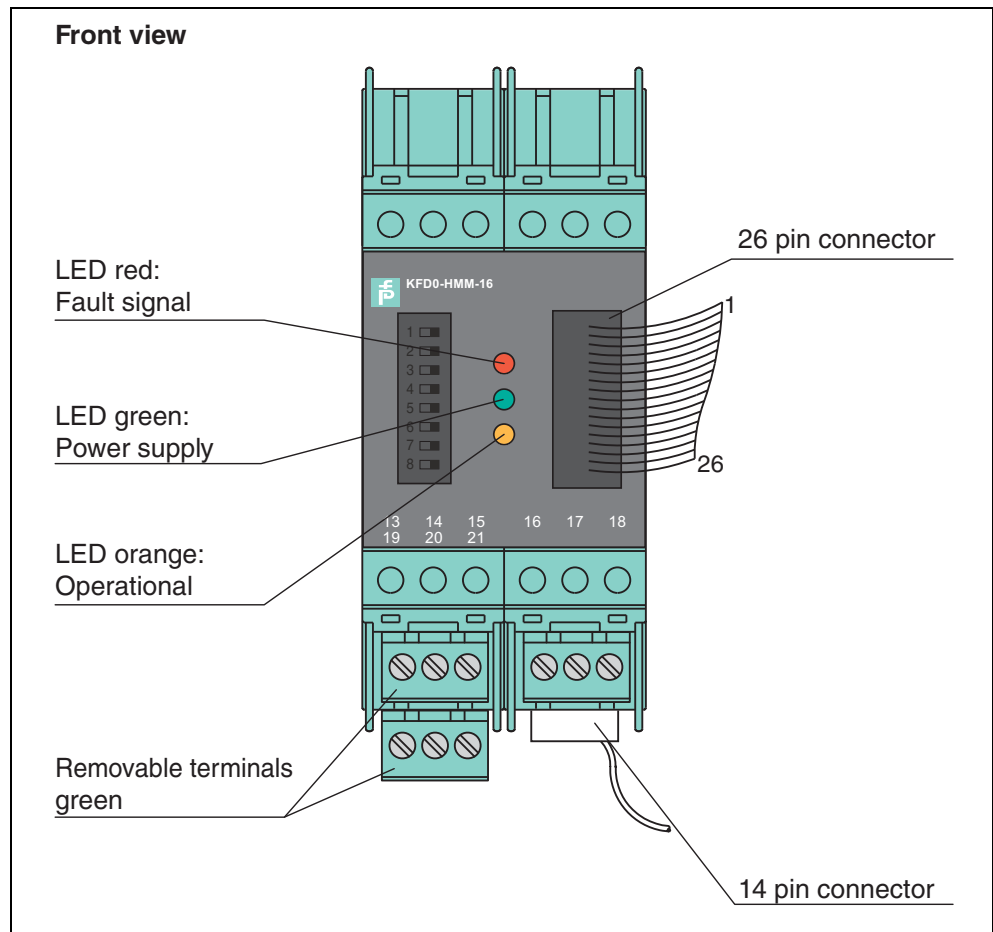26 pin connector

14 pin connector

Figure 3.2   Position of the operating and display elements of the KFD2-HMM-16

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3.1.4 Galvanic isolation

he voltage supply, the analog 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.

The connected current repeaters are galvanically interconnected unilaterally through the common ground connection of the analog signals.

If the galvanic isolation is to be properly maintained, the individual ground cables must be isolated by capacitors. Suitable FI and MB boards can be supplied by Pepperl+Fuchs for this purpose.

Attention

Notwithstanding the common ground connection of the analog signals from the Masters/Slaves, the galvanic isolation of the current repeaters is secured if

• FI and MB boards are used, which are fitted with capacitors.
• KFD2-STC4-Ex1 or KFD2-STC4-Ex2 Ex isolation modules are used as current repeaters.

3.1.5 All the functions at a glance

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

• 16 channels, extendable to 256 channels by the connection of up to 15 KFD0-HMS-16 Slaves
• up to 7936 loops per interface (31 Multiplexers with in each case 256 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
• removable terminals
• supply via Power Rail
• approval for zone 2

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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.
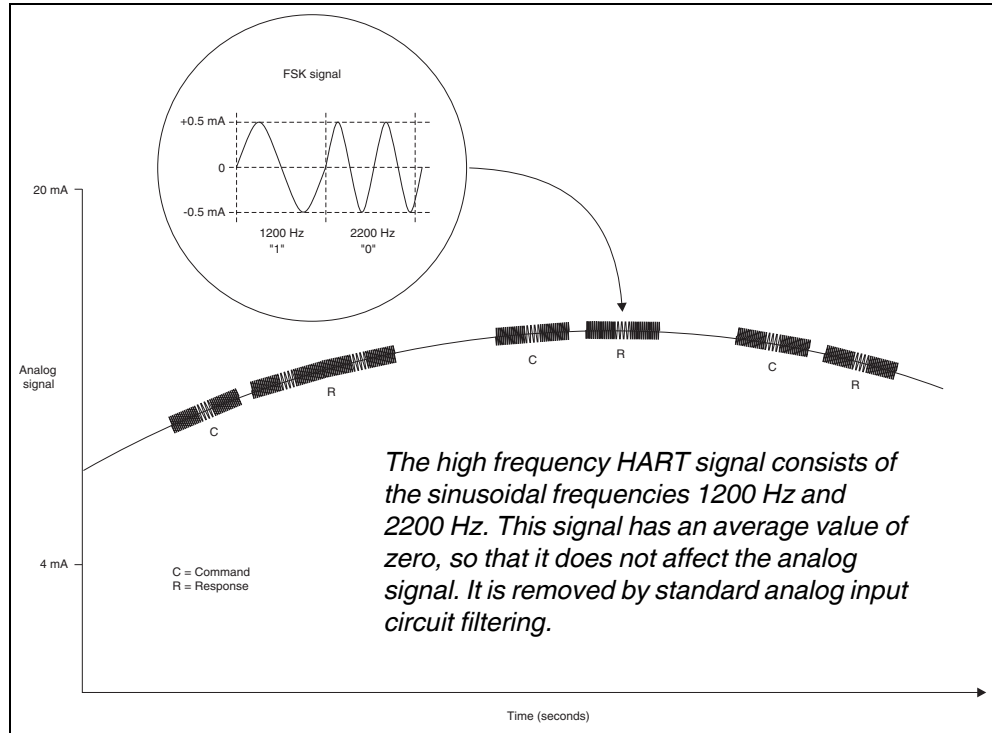

Figure 3.3   The modulated HART signal

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 9.1.

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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. KFD2-STC4-**) and SMART repeater (e. g. KFD2-STV4-**). 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 Multiplexer Masters, which are connected to the PC via a RS 485 interface. Each HART Multiplexer Master can control up to 15 HART Multiplexer Slaves. Each Multiplexer, irrespective of Master or Slave, can connect up to 16 transmitters.

Thus one PC can be used to address up to 7936 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 **PACTware**[TM] (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.

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

Note

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3.3.4 System construction

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.

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

Note

External assembly

Multiplexer Master and Slaves are installed on Flex Interfaces, 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.
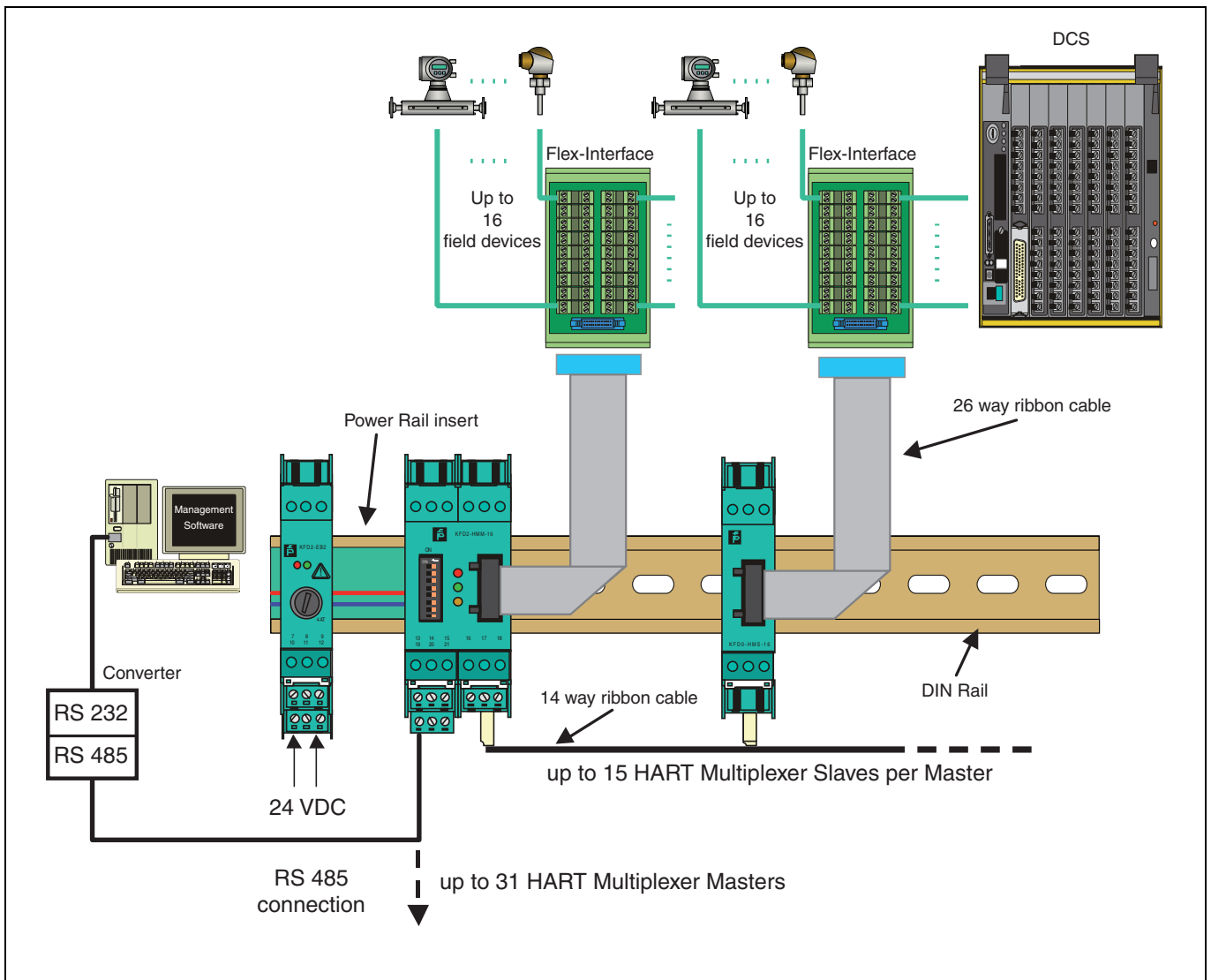

Figure 3.4   External assembly of Multiplexers

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Assembly integrated in the DCS

Multiplexer Master and Slaves are installed on Flex Interfaces, which transmits the signals via screw terminals and system cable to the DCS. In this case the Termination Board provides the connection to the Multiplexer parallel or serial. The Termination Boards are designed especially for individual DCS.
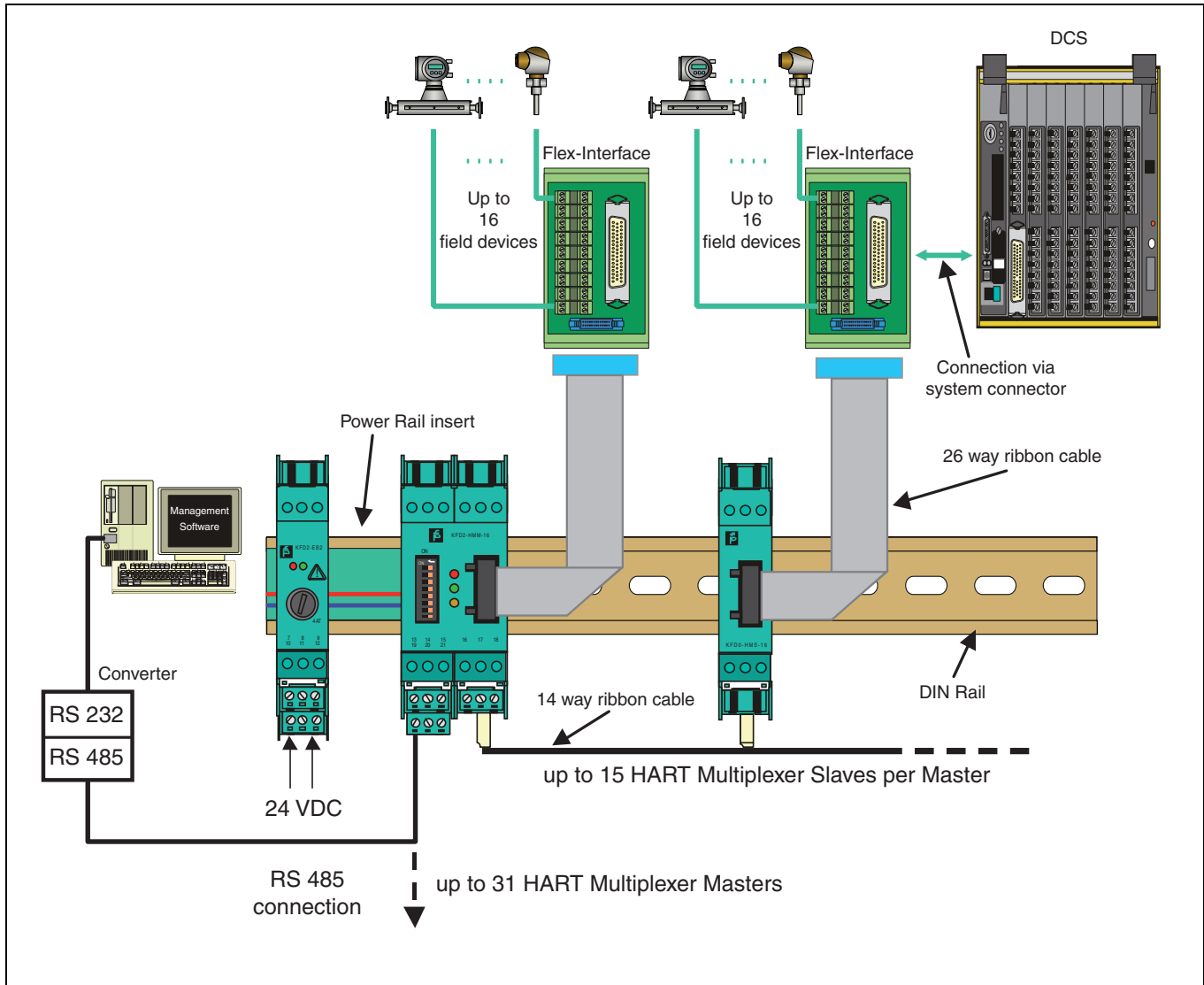

Figure 3.5   Assembly integrated in the DCS

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Assembly integrated in the K-System

When using the K-System of Pepperl+Fuchs the signals can be transmitted directly from the Termination Boards of the K-System to the Multiplexer Master or Slave via a system plug.
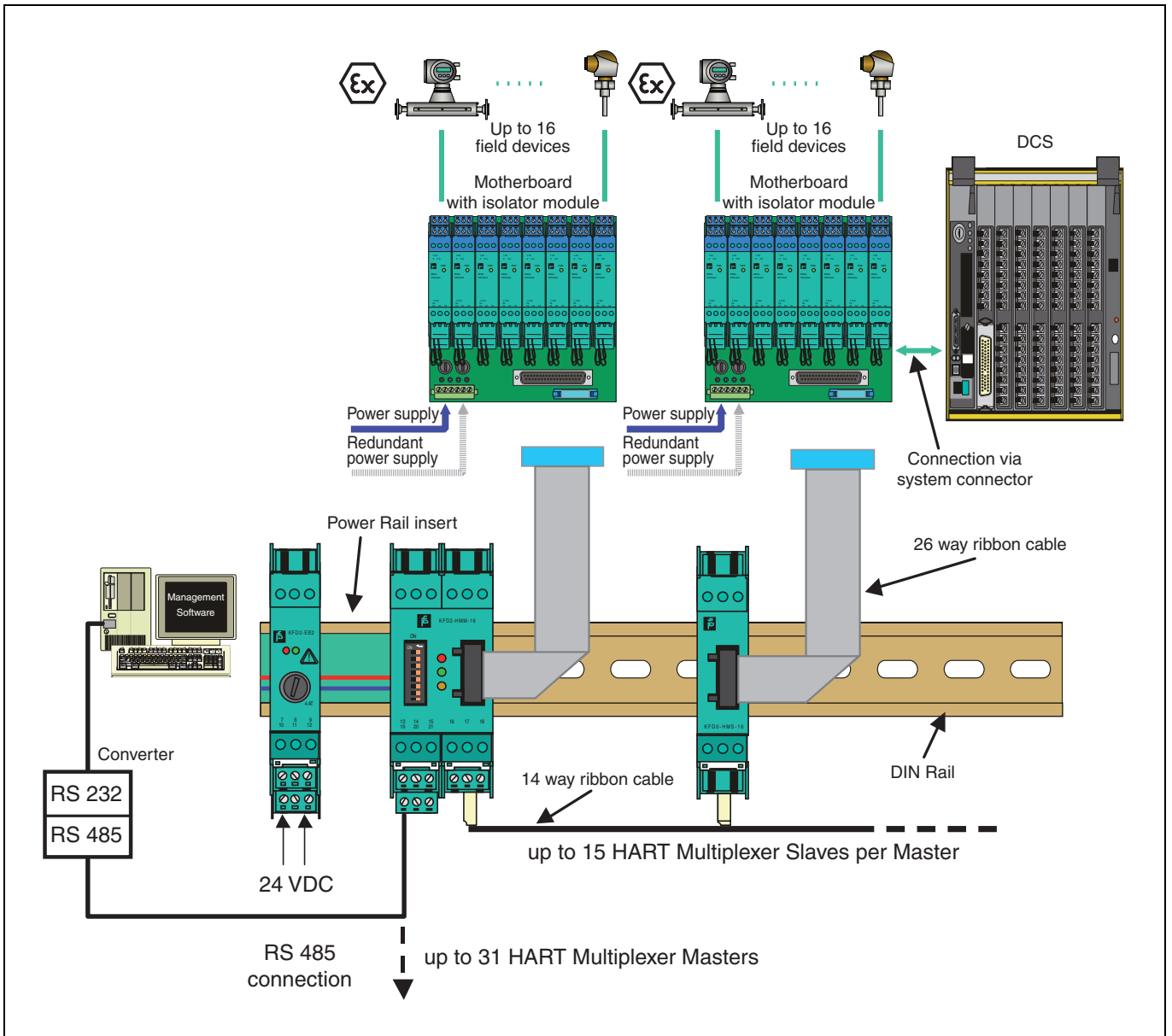

Figure 3.6   Assembly integrated in the K-System

3.3.5 HART Multiplexer Slave

The HART Multiplexer Slave is supplied from the HART Multiplexer Master via the 14-core flat cable. The contacting of the flat cable is provided via IDC connectors, so that the cable can be tapped at any position. By this means, the power supply and data cables are looped on from station to station. The address 1 ... 15 is set via a 16-step rotary switch. Address 0 is reserved for the Multiplexer Master and must therefore not be used. If a number of Slaves are operated on the KFD2-HMM-16, different addresses must be assigned. The sequence therefore plays no role in this.

The analog signals are fed via a 26 core flat cable into the KFD0-HMS-16. 16 of these are intended for the HART signal of the analog instrument circuit (the remaining 10 are to ground) (for the assignment, see section 9.2).

The minimum load resistance of the analog measuring circuit is 230 Ω (minimum load impedance in accordance with HART specification), the maximum resistive load being 500 Ω. Load resistances of up to 1000 Ω are possible, however, resistance values greater than 500 Ω can interfere with the HART communication.
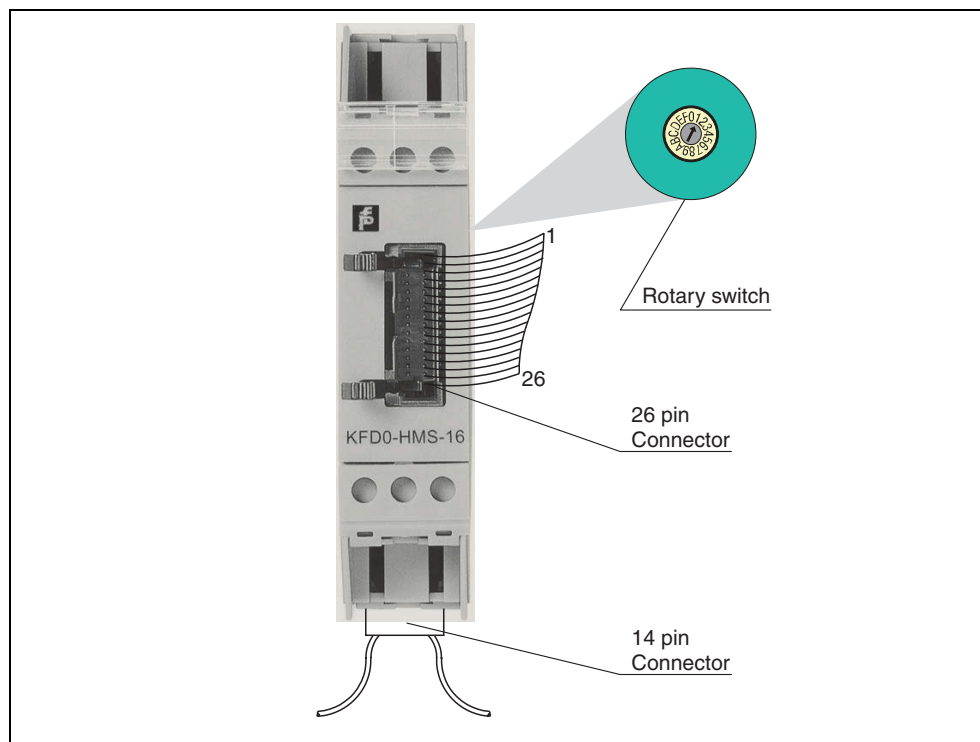

Figure 3.7   Front view HART Multiplexer Slave

Slave connection   HART Multiplexer Masters and Slaves must be connected together via a separate K-HM14 flat cable.

The length of cable required should be stated when ordering. Hence the wiring of the HART Multiplexer is significantly simplified and the danger of wiring faults is excluded.

3.3.6 Operation

The Multiplexer also functions as a HART device (see also section 5.4.5). 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 9.1.

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

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4 Installation

4.1 Mounting

The K-System allows three different types of mounting:

1. wall or panel mounting
2. mounting on 35 mm DIN EN 60715 mounting rail
   – TH 35-7.5 (installation height 7.5 mm)
   – TH 35-15 (installation height 15 mm, material thickness 1.5 mm)
3. mounting on 35 mm DIN rail with a Power Rail insert

Wall or panel mounting

Panel mounting is only recommended when a very small number of isolation components must be installed.

Mounting the device on the wall.
▸ Pull the two clip fasteners out of the back of the device until the clips audibly click into place.
▸ Fasten the device to the wall or panel with 3 mm screws.
   ↳ The device is mounted

Mounting on DIN rail

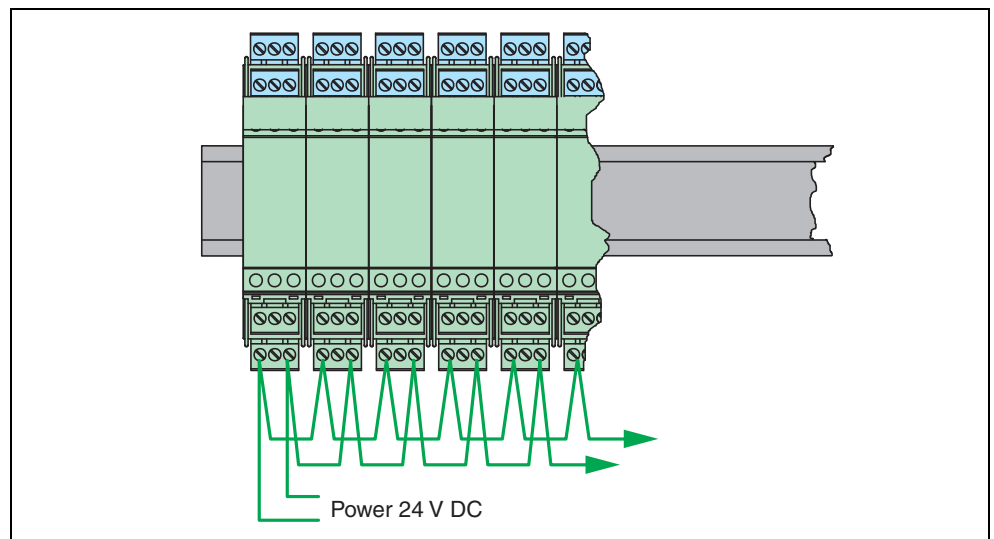When mounting on DIN rail, the device is simply snapped into place.

Power 24 V DC

Figure 4.1

The wiring effort for power supply with the isolation modules of the K-Systems can be greatly reduced by using Power Rail.

Note

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Mounting on DIN rail with Power Rail

The Power Rail UPR-03-* is an insert for a DIN rail which Pepperl+Fuchs has developed for this application.

The Power Rail provides two leads for power supply of the modules and one lead for centralized error messages. The devices of the K-System are supplied with power through these two leads.
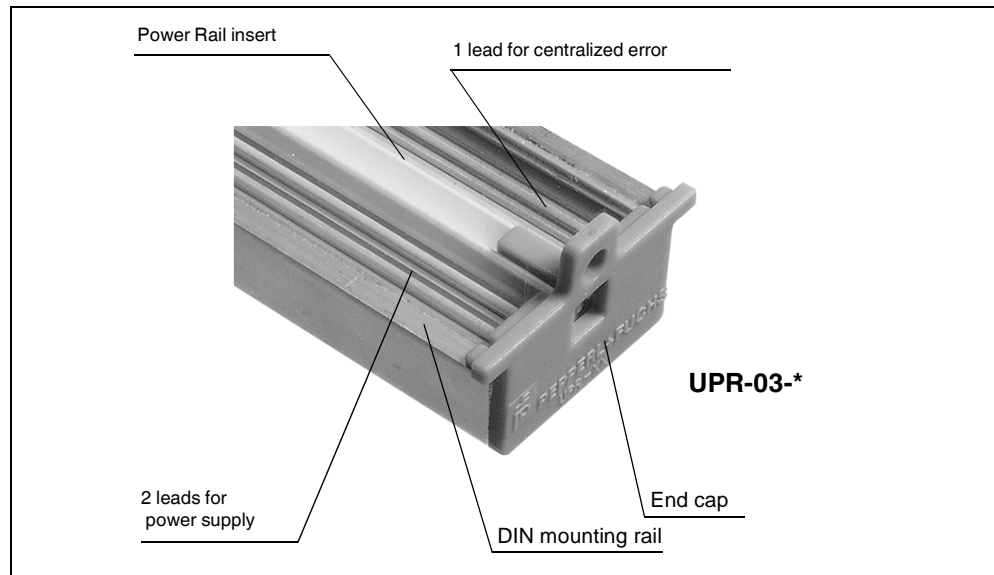

Figure 4.2

Standard devices of types KFD2-... and KCD2-... have gold-plated contacts to connect to the power supply rails of the Power Rail. By snapping it onto the DIN rail, the device automatically receives power. Thus separate wiring of the power supply is eliminated. An included cover provides for the mechanical and electrical protection of unused spaces. Furthermore, any reserved spaces are automatically connected to the power supply.

Third-party devices which can be mounted on a DIN EN 60715 mounting rail can easily be mounted on the Power Rail as well. Mixed devices from different device manufacturers are thus possible.
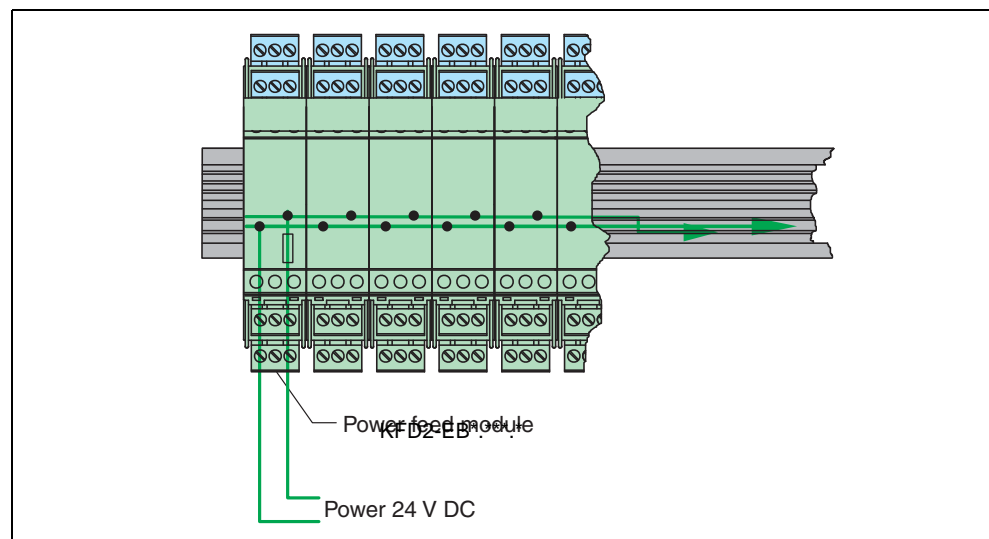

Figure 4.3

When supplying power via the Power Rail, the wiring effort is greatly reduced. Moreover, there is the option of the centralized error message and redundant power supply. Failure of the power supply is indicated through the message contact of the power supply component.

Note

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As shown in the figure, the isolation modules are snapped onto the Universal Power Rail in a vertical downward movement.

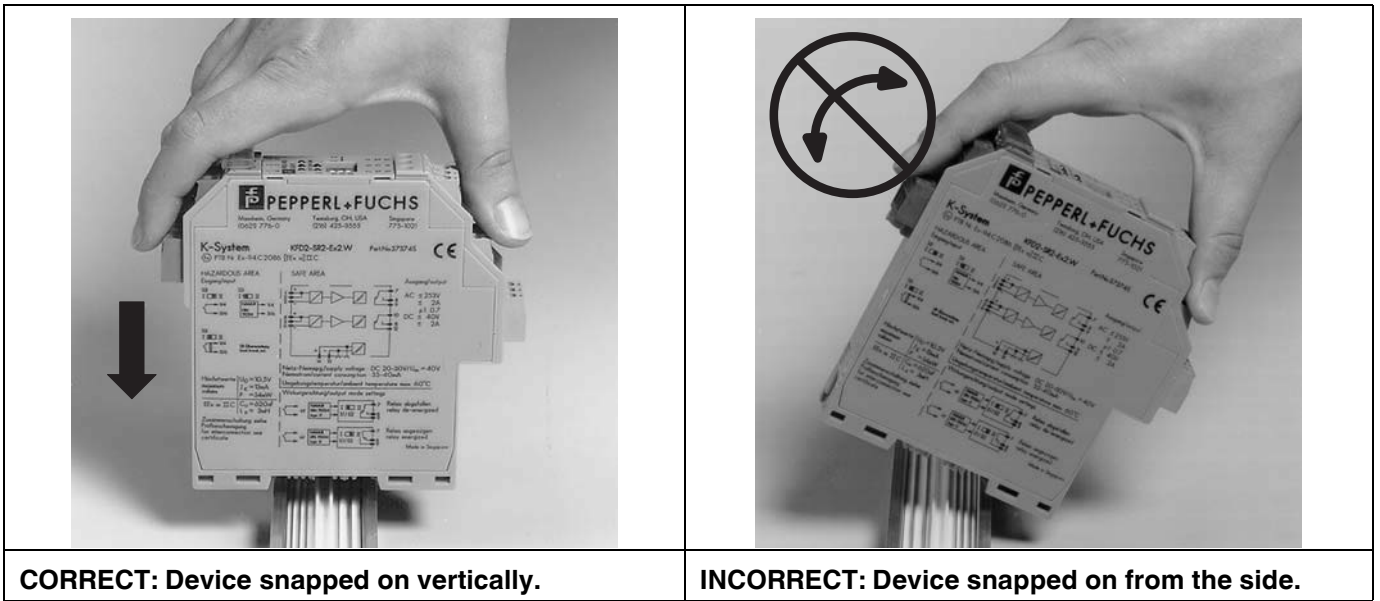| **CORRECT: Device snapped on vertically.** | **INCORRECT: Device snapped on from the side.** |

Figure 4.4

Power supply via Power Rail

There are two power supply concepts for supply via the Power Rail:
- single supply with the KFD2-EB2 power supply module
- redundant supply with two KFD2-EB2.R4A.B power supply module
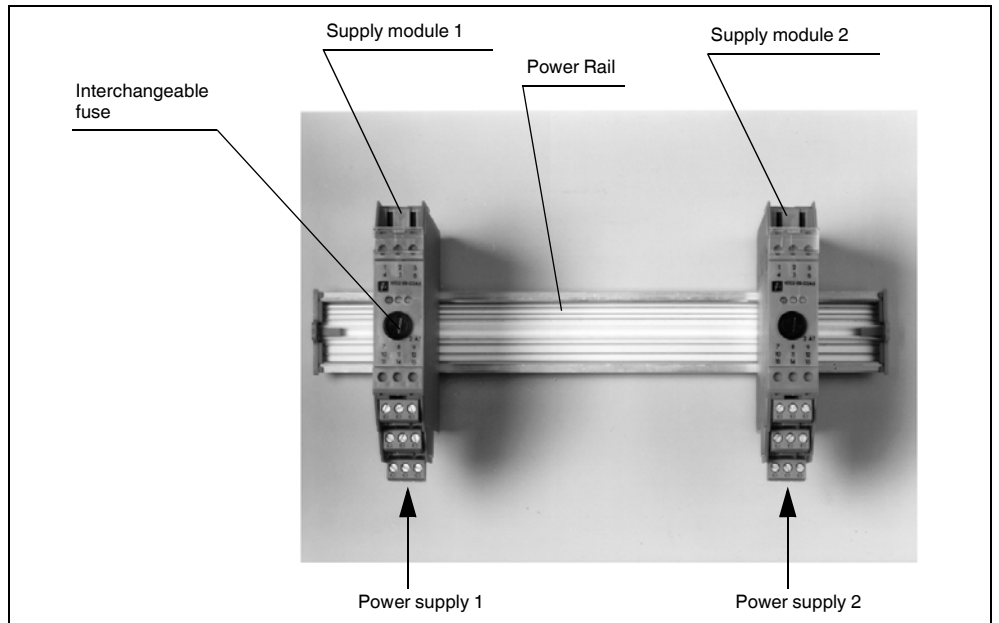
Figure 4.5

Redundant supply of the Power Rail with two power supply modules offers increased availability of device power. In this construction, not only the power supply is redundant, but also the fuse and the feed points on the Power Rail are provided twice. If one of the two mains fails, the second supply ensures continued operation of the system free of interruption. The malfunctioning power module indicates the error over a potential-free contact.

In conjunction with Power Rail the power supply to the interface modules is only permissible via a power feed module!

⚠ Attention

Collective error message via Power Rail

The collective error message enables lead breakage monitoring to be provided for many isolator modules without additional wiring costs. In fault conditions, an interrupt signal from the isolator module (i. e. KFD2-SR2.Ex2.2S) is transferred to the Power Rail. The power supply module evaluates the signal and passes the fault information to the PLC/control system using a potential-free contact.
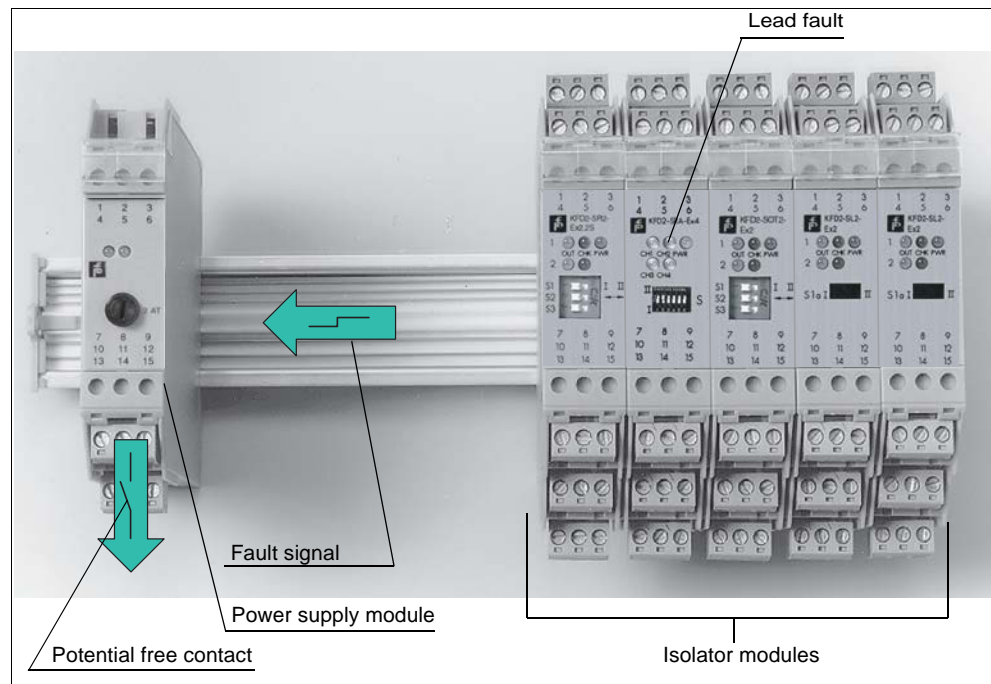

Figure 4.6

4.2 Electrical connection

4.2.1 General notes for connection

STOP
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

Connector assignment of the removable terminals:

Terminal	Description	Meaning
13, 19	Screen	Cable screening
14, 20	RxD/TxD - (RS 485 A-)	RS 485 differential signal
15, 21	RxD/TxD + (RS 485 B+)	

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".

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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.

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

Note

4.2.3 Cabling for the analog signals

The individual I/O components of the HART product family are connected by a single 26-pin system plug connector for the connection of the individual current repeaters (for plug pin assignment see section 9.2).

Pepperl+Fuchs provide specially developed connector units (HART interfaces type FI-***) for this purpose. As required, the connection to these units can be via a system cable or even by means of conventional screw connections. If the current repeaters are mounted on a motherboard (MB-***), the connection is made directly from the board to the Multiplexer via a flat cable type K-HM26.

The control system is connected via a system specific connector of the motherboard or the Flex-interface. Flex-interfaces with screw terminals are available for the purpose of individual wiring.

4.2.4 Location of electrical connections

The power supply (24 V DC nominal voltage) is provided via the Power Rail or terminals 17 (+) and 18 (-). 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 on terminals 13, 14 and 15. The RS 485 bus is looped through to terminals 19, 20 and 21. In this way, the three terminals can be used alternatively, or simultaneously, (for the connection of other devices with RS 485, or for the connection of a terminating resistor). If a standard PC with an RS 232 interface is to be used, an interface converter is required.

The connection of the KFDO-HMS-16 HART Multiplexer Slaves is via the 14 pin plug connector on the side of the device.

The analog HART signals are connected to the current repeaters via the 26 pin plug connector on the front of the device.

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 Motherboard and Flex Interface (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 5.4.2)
  Caution: Note the polarity of the RS 485 connection (see section 4.2.1).

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 5.4.4)
- Start the parameter assignment (see section 5.4.5), in particular, establish the position of the Multiplexers that are being used in the module table (see section 7.1.2)
- Carry out the loop construction (REBUILD, see section 7.1.5)
- Activate the SCAN function, if required (see section 7.1.7)

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 section 6.6.3.

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.

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5.3 FDT framework PACTware^TM

PACTware^TM is the first open source **P**rocess **A**utomation **C**onfiguration **T**ool with an open FDT interface (**F**ield **D**evice **T**ool). For the first time this enables **all** field buses and field devices in a system, independent of the manufacturer, to be configured and assigned parameters using a **single** engineering tool.

Representative example on the basis of PACTware^TM

The **PACTware^TM** user interface is divided into two parts: The project tree is located in the left part; the data and input fields being represented in the right.

The system structure is represented in the project tree. Above the HART Multiplexer there is a HART driver and above that a host system (PC). All the connected Multiplexer Slaves are to be found under the HART Multiplexer Master.

Under these Slave units there are the HART compatible field devices.

5.4 Multiplexer configuration

5.4.1 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 5.4.2). The device address for the communication via RS 485 is set by the DIP switches 4 to 8 (see section 5.4.2).

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.

Attention

The adjusted baud rate must comply with the service station.

5.4.2 DIP switch settings

8 DIP switches are located on the top of the device. DIP switch 1 is used by the manufacturer for testing the device and **must** therefore **always** be set to **OFF**.

DIP switch	1	Meaning
Setting	OFF	Normal status

DIP switches 2 and 3 determine the baud rate of the RS 485 interface.

DIP switch	2	3	Meaning
Setting	OFF	OFF	9600 Baud
	OFF	ON	19200 Baud
	ON	OFF	38400 Baud
	ON	ON	Not permitted

DIP switches 4 to 8 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.

DIP switch	4	5	6	7	8	Meaning
Setting	ON					Value 16
		ON				Value 8
			ON			Value 4
				ON		Value 2
					ON	Value 1
Example:	OFF	ON	ON	OFF	ON	address = 8 + 4 + 1 = 13

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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.

5.4.3 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.*

5.4.4 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 5.4.5.

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5.4.5 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 9.1.3). 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 7.1.7 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 7.1.2 and command 157)

- Delay time on channel change (loop-switch delay) (see section 7.1.8 and command 161)

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6 Configuration

6.1 PACTware^{TM} introduction

PACTware^{TM} is Pepperl+Fuchs latest generation of configuration software that makes it easy to program Pepperl+Fuchs's equipment. In addition to becoming single configuration tool, **PACTware^{TM}** interfaces with HART capable field instruments as well as bus systems such as PROFIBUS, Modbus and ControlNet.

PACTware^{TM} offers many features that allow users to simplify plant documentation, generate trend curves, and monitor signals using HART data. Our software uses **D**evice **T**ool **M**anagers (DTM) to provide the interface into **PACTware^{TM}**. Pepperl+Fuchs has created DTMs for HART capable instruments by converting their Device Description (DD) into the appropriate DTM for use with **PACTware^{TM}**.

6.2 Installing the software components

In order to be able to configure the device by means of a PC operating program, the following software components are required:

1. **Microsoft® .NET Framework 1.1**

2. **PACTware^{TM} 3.0** (**P**rocess **A**utomation **C**onfiguration **T**ool) or later
   PACTware^{TM} is used according to FDT Specification 1.2 (**F**ield **D**evice **T**ool Specification) as a framework program for the DTM (**D**evice **T**ype **M**anager), which is supplied by manufacturers of field devices as configuration software.

3. **DTM Collection HART Multiplexer**
   The DTM Collection comprises all Device DTMs required to parameterize the HART Multiplexer. The DTM are used to establish the communication with field devices using protocols, such as the HART or PROFIBUS protocol.

4. **HART Comm DTM**
   This package contains the HART communication DTMs which is necessary to establish communication between the HOST and the HART Multiplexer DTM.

5. **Generic HART DTM**
   The Generic HART DTM provides basic HART functionalities for field devices. It can be used for basic parameterization in case that no field device specific DTM is available. Therefore this DTM is recommended also in addition to field device specific DTMs.

6. **Field device specific DTMs**
   Vendors of field devices provide specific DTM for those. These DTMs allow access to all functions of the devices and therefore a detailed parameterization. For further information please refer to the specific vendors.

The software components are rendered available on CD or on the Internet at www.pepperl-fuchs.com in the product selector via **Software > PACTware**.

*For the **latest** software component, please access the product selector via* **Software > PACTware***.*

Note

For the HART Multiplexer DTM a licence is necessary. Without licence only one HART Multiplexer with one field device can be used. For getting a licence please refer to Pepperl+Fuchs.

Note

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➤ **Installing the software components**

The installation of the software components is described in the "**PACTware**^TM Installation Instructions" manual. Please observe the sequence of the installation steps and the instructions in the installation instructions.

▸ Install **Microsoft**® **.NET Framework**.

▸ Install **PACTware**^TM.

▸ Install the **DTM Collection HART Multiplexer**.

▸ Install **HART Comm DTM**.

▸ Install **Generic HART DTM**.

▸ Install field devices specific DTMs as necessary.

The cross-device properties of the software are described in the "**PACTware**^TM Process Automation Configuration Tool" manual. For the free manual written in several languages, please access our website at www.pepperl-fuchs.com/pa via **Software > PACTware**.

Below please find the device-specific settings for HART Multiplexer KFD2-HMM-16 only.

6.3 Connection with the device

➤ **Connect the PC to the device**

▸ Mount the device on the Termination Board (see section 4.1).

▸ Connect the device to the power supply.

▸ Use the RS232 / RS485 converter to connect the PC up to the device.
RS 232 side: COM interface on the PC
RS 485 side: corresponding terminals on the Termination Board

▸ Start the **PACTware**^TM as described in the "**PACTware**^TM Process Automation Configuration Tool" manual.
  ↳ The **PACTware**^TM main window is indicated.
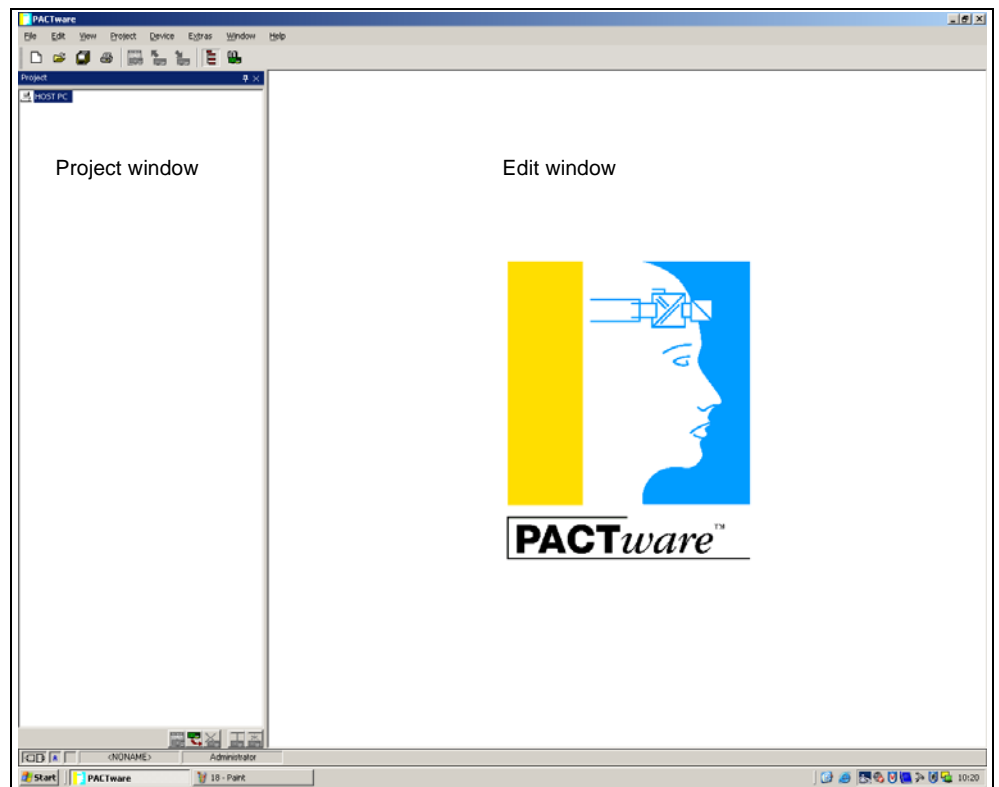
Figure 6.1 **PACTware**^TM main window

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The main window is divided into the project window and the edit window.

Project window

The current project tree for your system is constructed in the project window by adding the various components. Three buttons for adding, removing and editing components appear at the bottom of the window. Select the device you wish to edit, monitor, diagnose or simulate in the project manager. The selected object will be highlighted in different color.

Edit window

Various windows which are required for editing your system appear in the edit window. The edit process begins with the appearance of the selection window containing the drives and devices or the device catalog for setting up the system. The configuration and parameterization tabs for the drives and devices also appear in the edit window. During subsequent operation, the diagnostic, measured variable, trend and simulation menus appear in the edit window. The communication monitor for the communication protocol can also be opened in this window.

*For more information to **PACTware**^{TM}, please refer to the "**PACTware**^{TM} Process Automation Configuration Tool" manual.*

Note

In conjunction with the DTMs for HART Multiplexer, it is advisable to activate the **Memory-Optimized Operation** option.

Activate Memory-Optimized Operation
▶ Open the **Options** menu via **Device > Extras > Options**.
▶ Activate the **Memory-Optimized Operation** option.
↳ The **Online-Parameter** window is indicated.

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6.4 Adding the Communications DTM

In a **PACTware^{TM}** project the HART Multiplexer KFD2-HMM-16 can be addressed by Communications DTM **HART Communication** only. Please refer to the "**PACTware^{TM}** Process Automation Configuration Tool" manual to read how to create and edit a project.

*Do not use the Communications DTM **HARD Driver FDT**. This is an outdated IDL DTM.*

Note

If such a driver is not available in your project yet, use the device catalog to add it to the project

Adding the Communications DTM

▸ Click with right mouse button on **HOST PC**.
▸ Select **Add Device** in the context menu.
▸ Select the DTM **HART Communication** from the list.
   ↳   The Communications DTM is in the project.
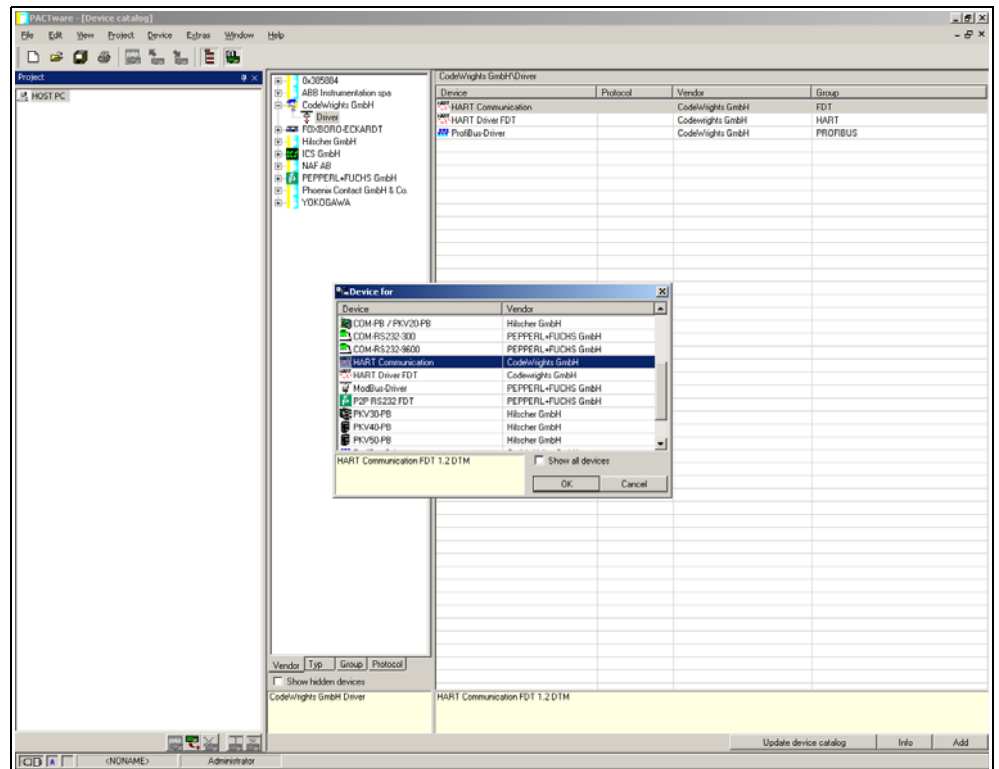
Figure 6.2   Device catalog

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Setting the parameters
▸ In the project window, use the mouse to double-click on the Communications DTM **HART Communication**.
  ↳ The **Parameter** window is indicated.

▸ Use the **OK** button to close the **Parameter** window.

The following parameters are adjustable:

• **Communication interface**: Select the option **HART Multiplexer** as communications means.

• Set as **Port** the interface, to which the HART Multiplexer has been connected.

• Select the **Baudrate** according to the settings of the DIP switches on the HART Multiplexer.

• **RTS Control**: Depending on the RS 232/RS 485 converter used, it may be necessary to switch on or off the request-to-send control in order to be able to switch over correctly between reception and transmitting mode.

• **Master**: Masters may be connected to one HART loop whereby the Masters have to be differentiated as primary and secondary Master by the parameterization. This setting is carried out here.

• **Preamble**: In keeping with the HART standard, a corresponding number of **FF characters** have to be sent in advance as preamble. The number of characters is defined here.

• **Number of communication retries**: The number of repeats of contact attempts in case of an error.

• **Address Scan – Start and End address**: Here the address range is set, in which the HART Communication DTM is to search for the HART Multiplexers connected to the RS 485 bus.
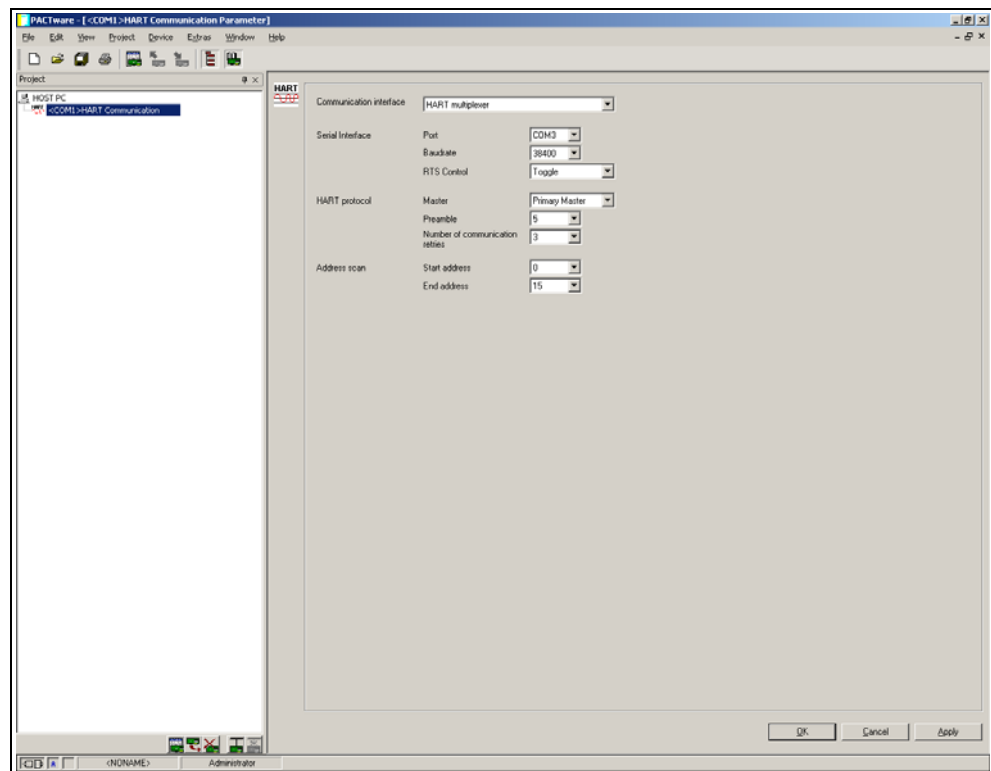
Figure 6.3   HART Communication Parameter window

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6.5 Adding the HART Multiplexer

In the Communications DTM, the function **Additional functions > Scan list** can be used to scan the connected HART Multiplexer.

Update Scan list

▸ Click in the project window with right mouse button on **HART Communication**.
▸ Select **Additional Function** in the context menu.
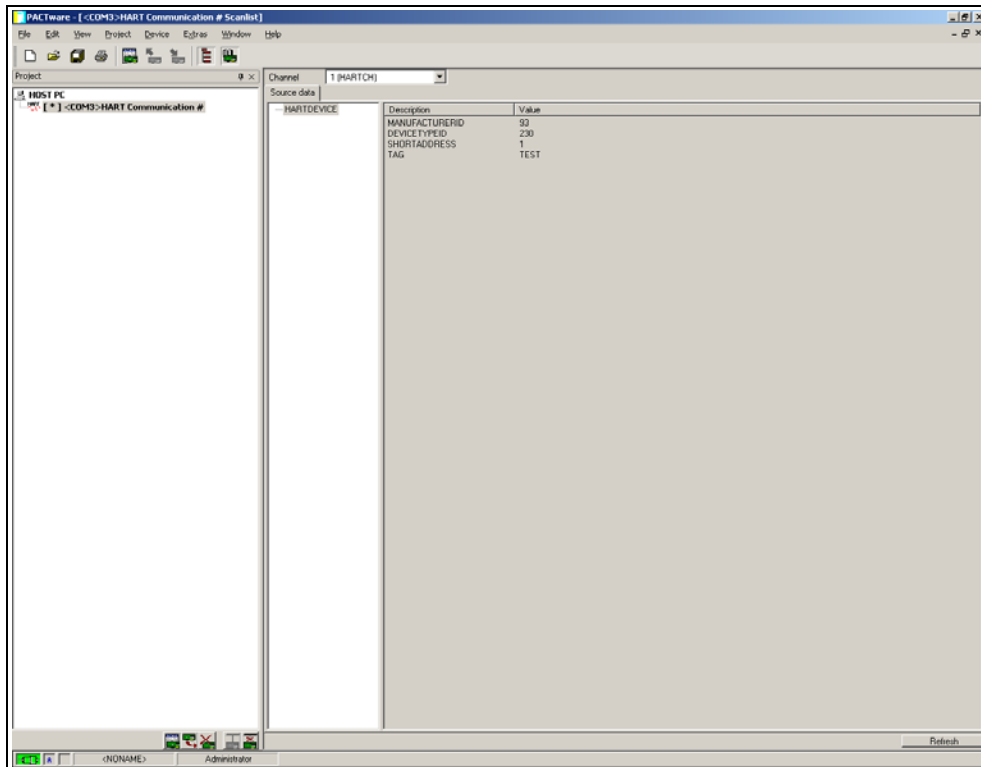▸ Select **Scan list**.
▸ Start the scan with **Refresh**.

Figure 6.4   HART Communication window, Scan list

At present, the addresses 0 ... 15 only are supported. Future versions will however support the entire address range from 0 ... 31.

Note

Adding the HART Multiplexer

The HART Multiplexers now have to be manually added to the project.

▸ Use drag-and-drop to drag the suitable DTM from the device catalog to the HART Communication DTM.

or

▸ Click in the project window with right mouse button on **HART Communication**.
▸ Select **Add Device** in the context menu.
▸ Select the DTM **KFD2-HMM-16** in the list.
  ↪   The Communications DTM is in the project.

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6.6 Setting the parameters of the HART Multiplexers

6.6.1 Parameterizing parameters off-line

> **Adjust the parameter of the Master**
> ▸ Double-Click in the project window with mouse button on Multiplexer.
> ▸ Open the **Master** menu.
>   ↳   The **Master** window is indicated.

The following parameters are adjustable:
- **RS485 address**: The RS485 address of the HART Multiplexer is set here.
- **Long-Address**: The distinct unchangeable long address of the HART Multiplexer is set here.
- **Master-Type**: One HART loop may include two Masters whereby the parameterization has to be set to differentiate between primary Master and secondary Master. These settings have to be carried out here.
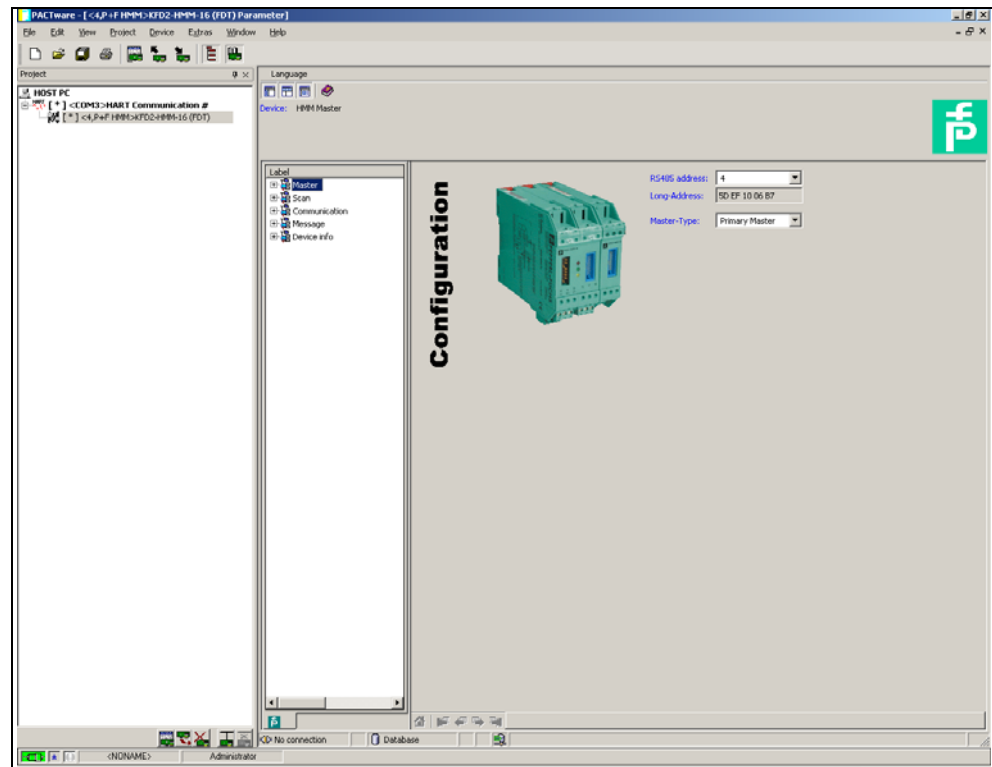
Figure 6.5   Multiplexer Parameter window

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6.6.2   Read-out the data

Use **Load from device** to read the parameters of the Multiplexer in order to establish a connection.

Is no standard online/off-line view as usually used for FDT DTMs.

Note
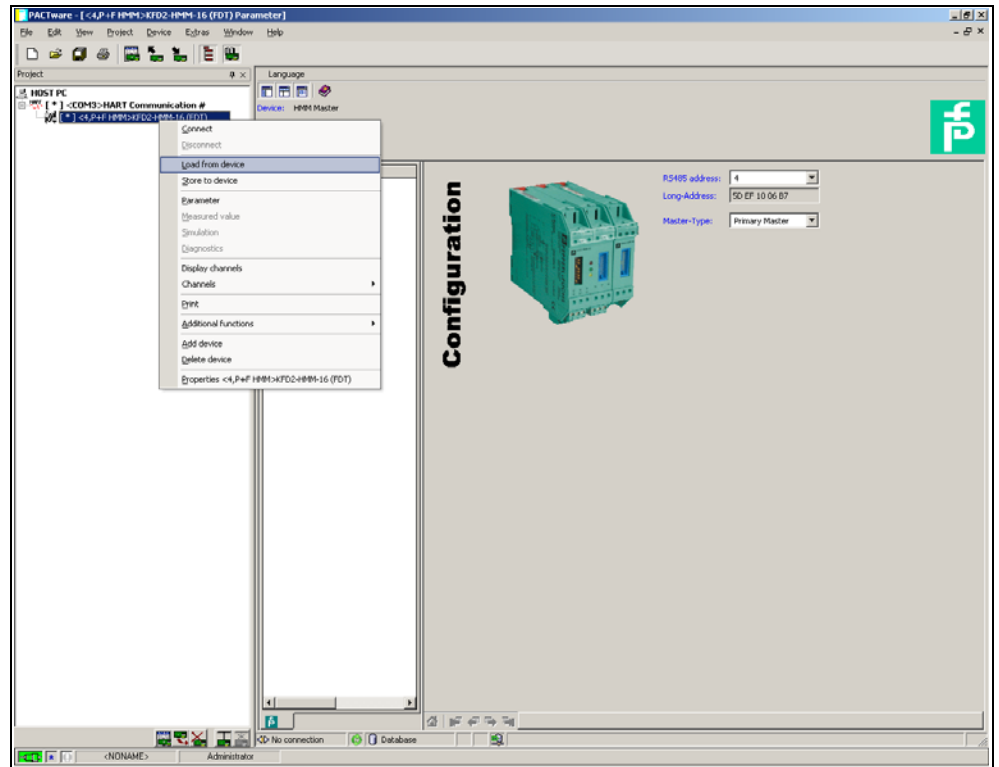
Figure 6.6   Read-out the Data

Parameterizing of the scan function
▶ Double-Click in the project window with mouse button on Multiplexer.
▶ Open the **Scan** menu.
   ↳ The **Scan** window is indicated.

The scan function is used by the HART Multiplexer to cyclically retrieve data from the connected field devices which are saved in the memory. When these values are queried by the control system, they can be retrieved faster because the device need not be read out as the values can be taken directly from the memory.

The following parameters are adjustable:

• **Mode**: The wireless scan is switched on or off here.
• **Command**: Here select which values are to be read from the field devices:
   – **Primary variable**: Now the primary variable only will be read-out.
   – **Current value**: The current value is read-out in mA.
   – **All variables**: All variables of the field device are read-out.
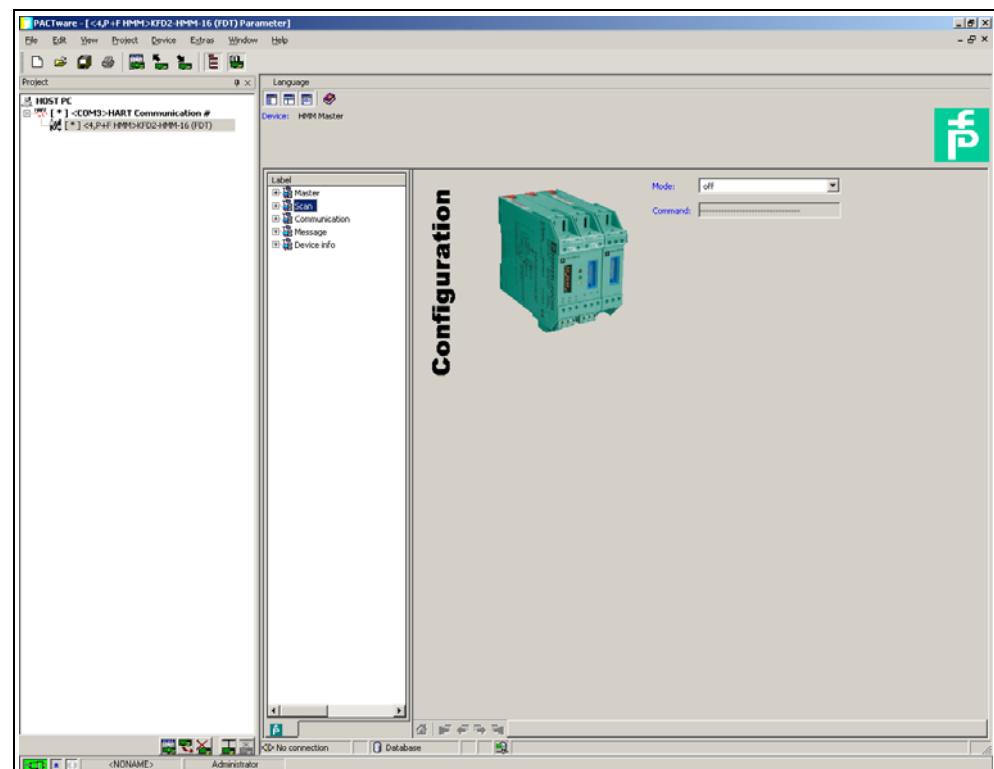
Figure 6.7   Scan function window

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▶ **Parameterizing of the communication**
▶ Double-Click in the project window with mouse button on Multiplexer.
▶ Open the **Communication** menu.
   ↳   The **Communication** window is indicated.

The **Communication** menu is used to set the communication parameters between the HART Multiplexer and the field device.

The following parameters are adjustable:

• **Retries on "Busy"**: Repeat attempts to establish a communication with the field device, if the field device transmits **Busy**.

• **Retries on error**: Repeat attempts to establish a communication with the field device, if an error occurs.

• **Searchmode**: Here the mode is determined which is used to search for other devices:

   – **single analog**: The HART Multiplexer uses only poll address 0 to search for connected devices.

   – **single unknown**: The HART Multiplexer searches for all short addresses between 0 and 7 and identifies the first device which responds.
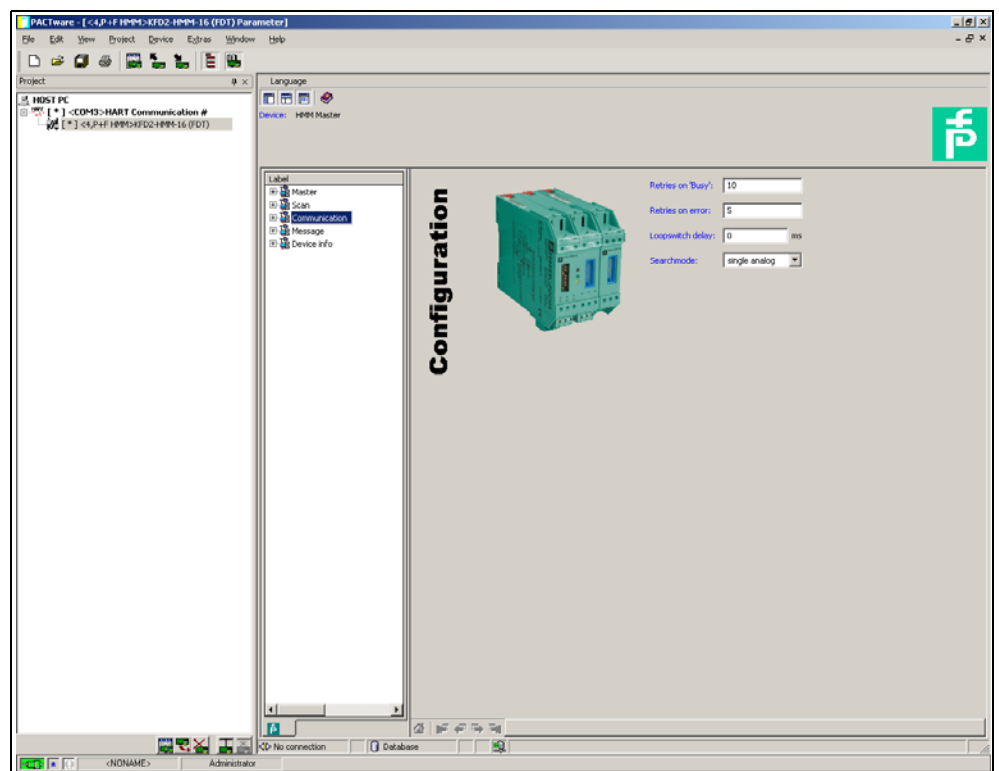
Figure 6.8   Communication window

▶ **Message menu**
  ▸ Double-Click in the project window with mouse button on Multiplexer.
  ▸ Open the **Message** menu.
      ↳ The **Message** window is indicated.

The **Message** menu can be used to give the HART Multiplexer an identification name.

• **Message**: Here a string can be defined, with which the HART Multiplexer can be identified.
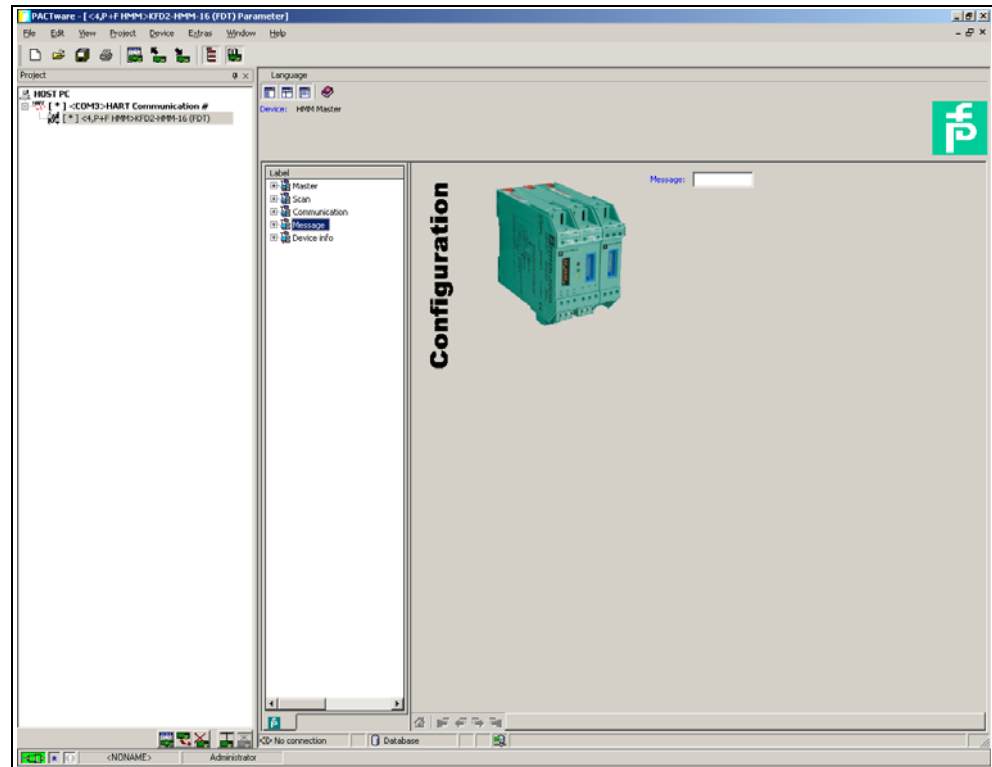
Figure 6.9   Message window

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Device info menu

▸ Double-Click in the project window with mouse button on Multiplexer.
▸ Open the **Device info** menu.
  ↳ The **Device info** window is indicated.

The **Device info** menu renders general information on the device:

- **Tag**: Tag to identify the HART Multiplexers
- **Description**: Description of the HART Multiplexer
- **Day of last parameterization** (read only): Day, on which the device parameter was changed last.
- **Serial number**: Serial number of the device
- **Universal revision**: Revision of the universal HART commands supported
- **Special revision**: Revision of the special HART commands supported
- **Software revision**: Firmware revision of the HART Multiplexers
- **Hardware revision**: Hardware revision of the HART Multiplexers
- **Preamble count**: Number of preambles
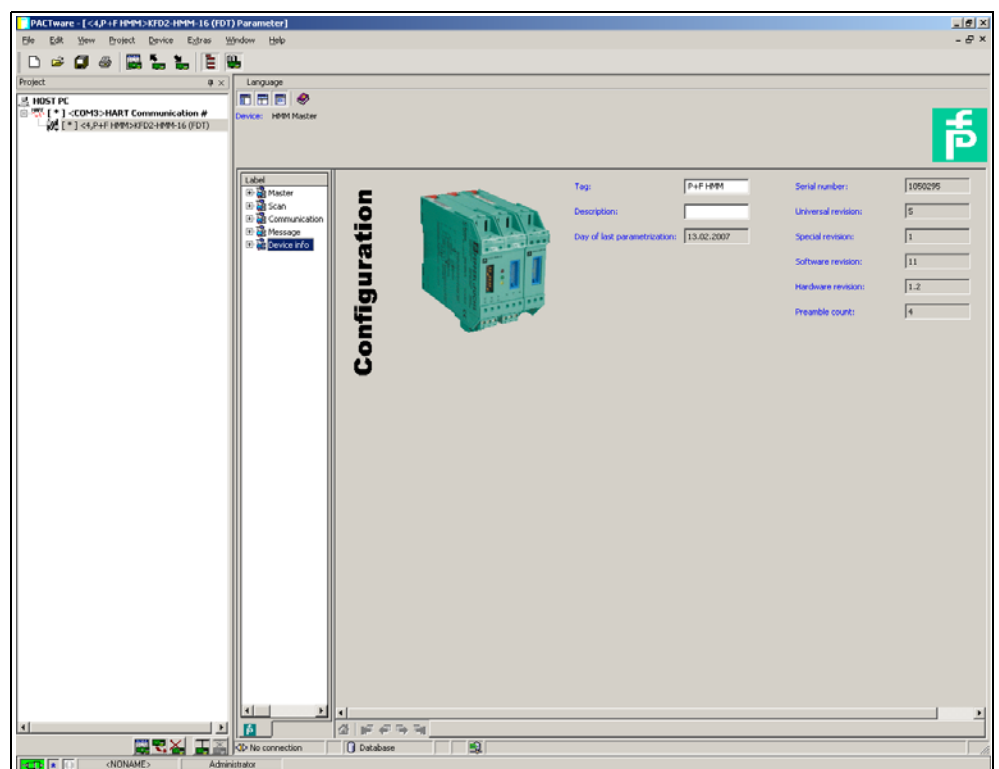
Figure 6.10   Device info window

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► **Active modules menu**
  ▸ Select the Multiplexer Master in the project window.
  ▸ Open the **Active modules** menu via **Device > Additional functions > Active modules**.
     ↳ The **Active modules** window is indicated.
  ▸ Select the active modules for each Multiplexer. As a standard, only the Master is activated; depending on the stage of completion, select the number of Slaves connected.
  ▸ Confirm the selection with **Download active modules**.
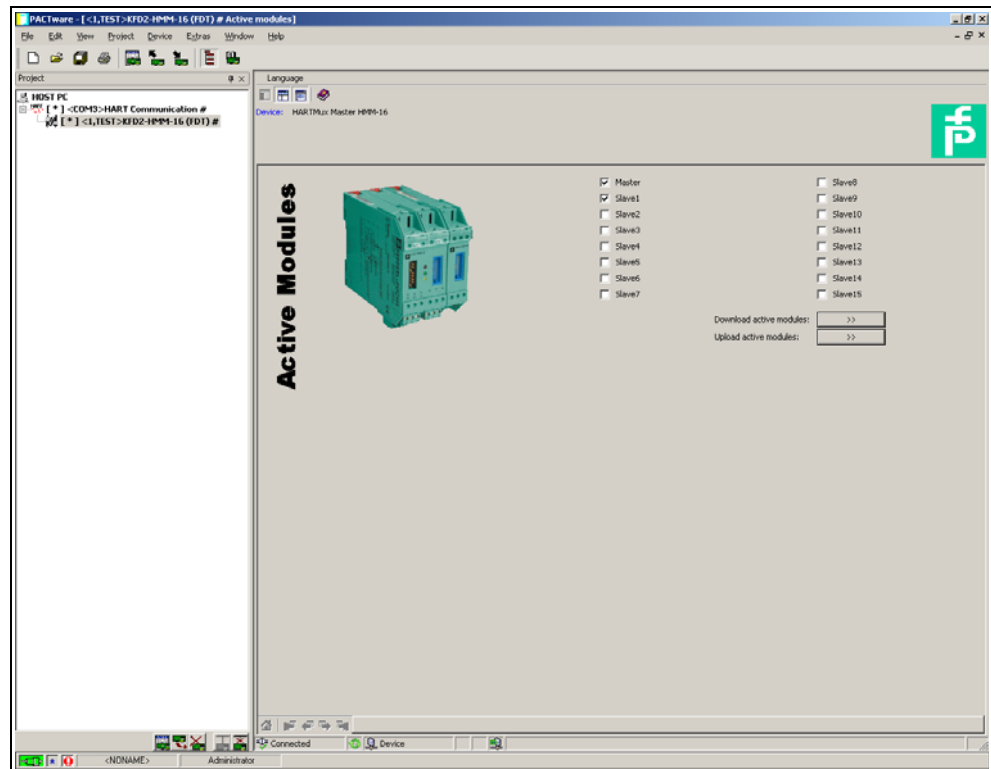
Figure 6.11   Active modules window

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6.6.3   HART Scan

Use a HART Scan to read in the entire project structure connected to the serial interface:

- HART Multiplexer Master
- HART Multiplexer Slaves
- Field devices

Start HART Scan function

▸ Select the Multiplexer Master in the project window.
▸ Start the **HART Scan** via **Device > Additional functions > HART Scan**.
  ↳ The **HART Scan** window is indicated.
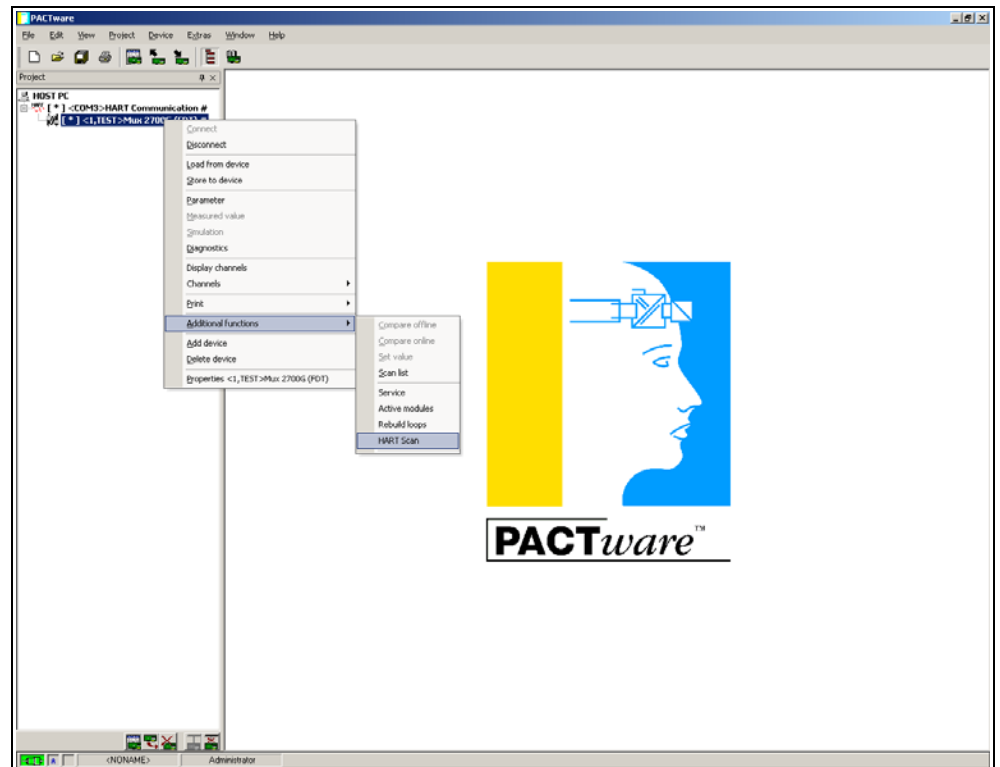
Figure 6.12   Activate HART Scan function

The HART scan function might not be supported by all frames or underly some limitations.

Note

Before start the HART Scan select the desired options:

▶ **Setting Scan functions**

▸ Open the Scan parameters via **Settings** folder.
  ↳ The **Settings** window is indicated.

The following parameters are adjustable:

• **Start Scanning for active slaves**: This option is used to determine whether a search for connected Slaves is to be run.
• **Add found slaves**: This option is used to determine that the Slaves found are added to the project.
• **Connect found slave DTMs**: An automatic connection is established to the Slaves found.
• **Make scanning for HART devices**: This option is used to determine whether a search for connected HART devices is to be run.
• **Automatically add found devices to project**: This option is used to determine that the HART devices found are added to the project.
• **Use generic HART DTM (In case if after scan no device DTM was assigned)**: If no HART DTM has been installed for the device found, the generic HART DTM will be added instead.
• **Use first available device DTM (In case if after scan more then on device DTM was assigned)**: If several DTMs have been installed for a device found, the first DTM found will be added to the project.
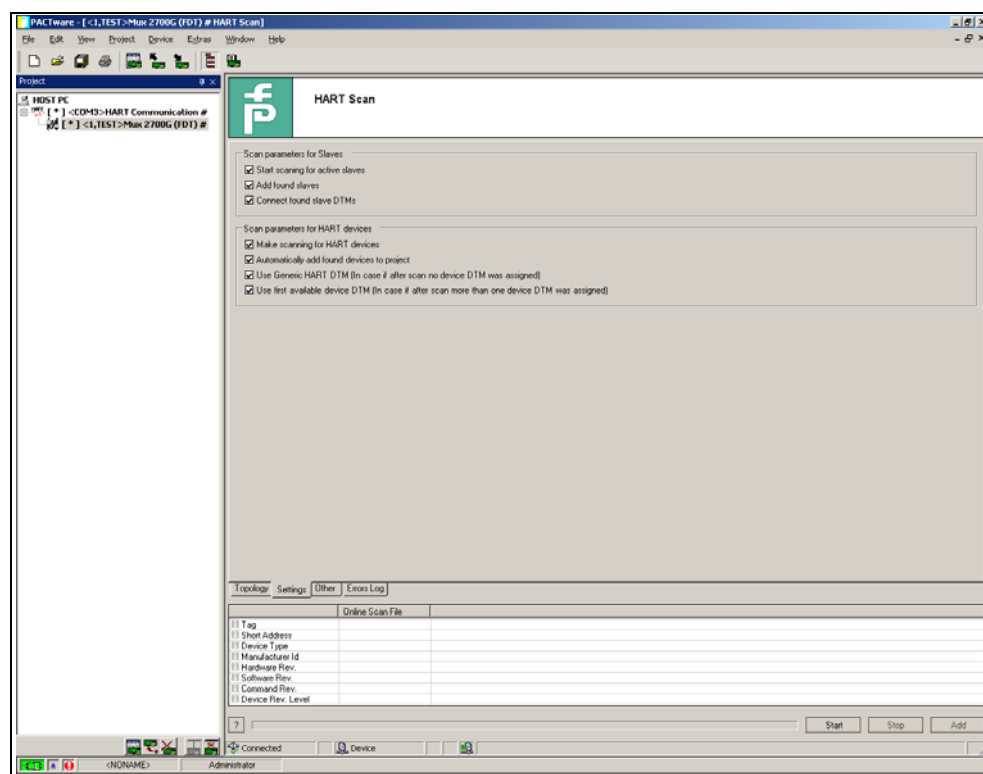
Figure 6.13 Parameterization of HART Scan function

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➤ **Setting of further Scan functions**
‣ Open further Scan functions via the **Other** folder.
   ↳ The **Other** window is indicated.

For some field devices (e. g. from VEGA) it may be necessary to render available additional information by means of an XML file. This can be added to the **Other** folder.

‣ Activate the **Use Additional .XML file to identify SubDeviceType** option.
‣ Open an explorer menu via the **Load** button.
‣ Select the requested XML file.
‣ To remove an XML file from the list, mark it and delete via the **Delete** button.
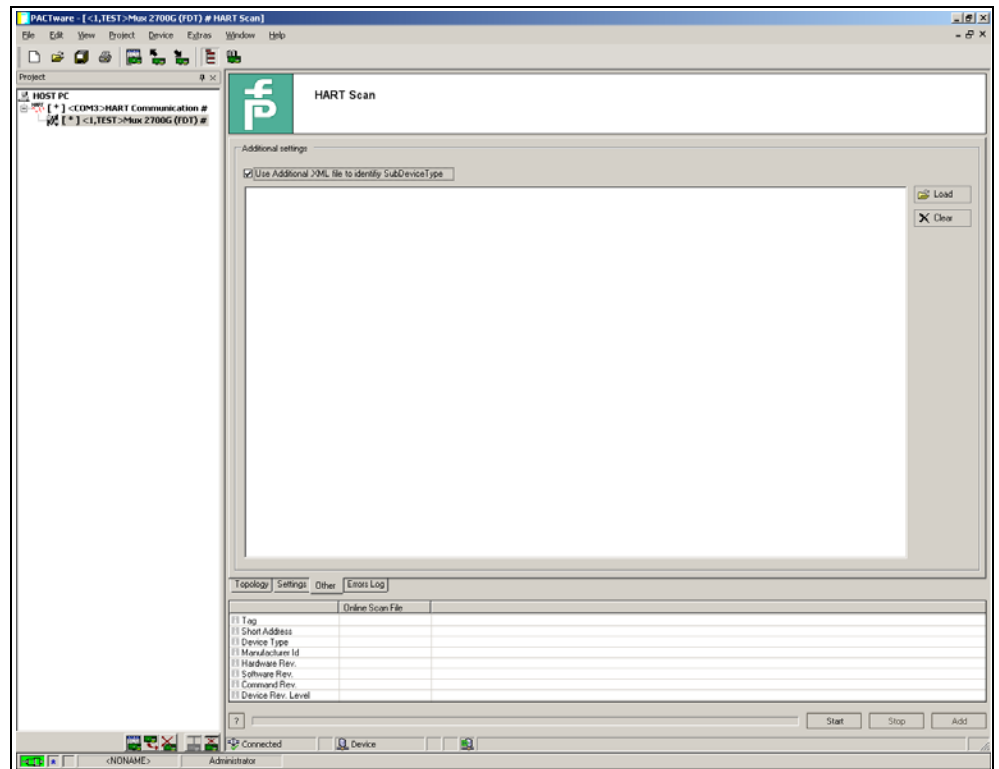
Figure 6.14   Parameterization of HART Scan function

The HART Scan queries the allocation table of the HART Multiplexer. The allocation table contains the loop number and the long frame address of the device connected to this loop. This is built up during the power on of the HART Multiplexer. If after the power on of the HART Multiplexer another device is connected, the allocation table can be built by means of the **Rebuild loops** option.
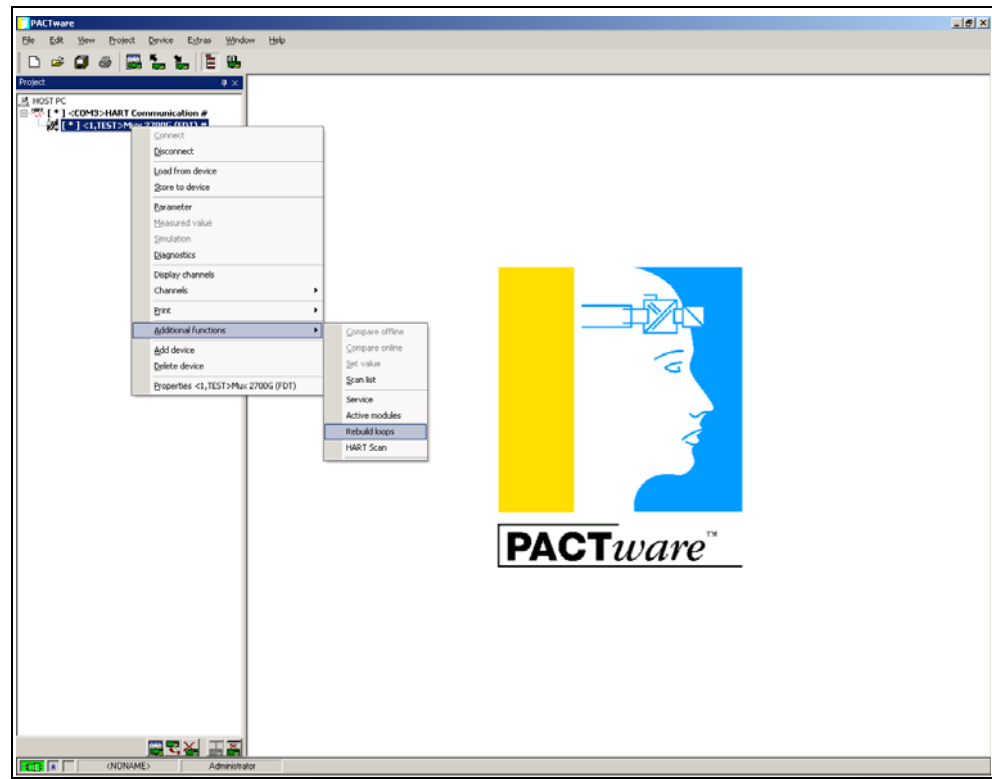
Figure 6.15   Activate Rebuild loops function

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The HART Scan is started by means of the **Start** button in the right lower corner. Now the topology of the connected devices is built by reading in the field devices connected to these devices by means of HART Multiplexer and HART Slaves.

- First of all, the activated Slaves are added now.
- After a Slave has been added, the individual loops are scanned, and the field devices found are automatically added to the structure.
- Some manufacturers have various DTMs for the same device family. In this case the correct DTM has to be chosen from the selection.
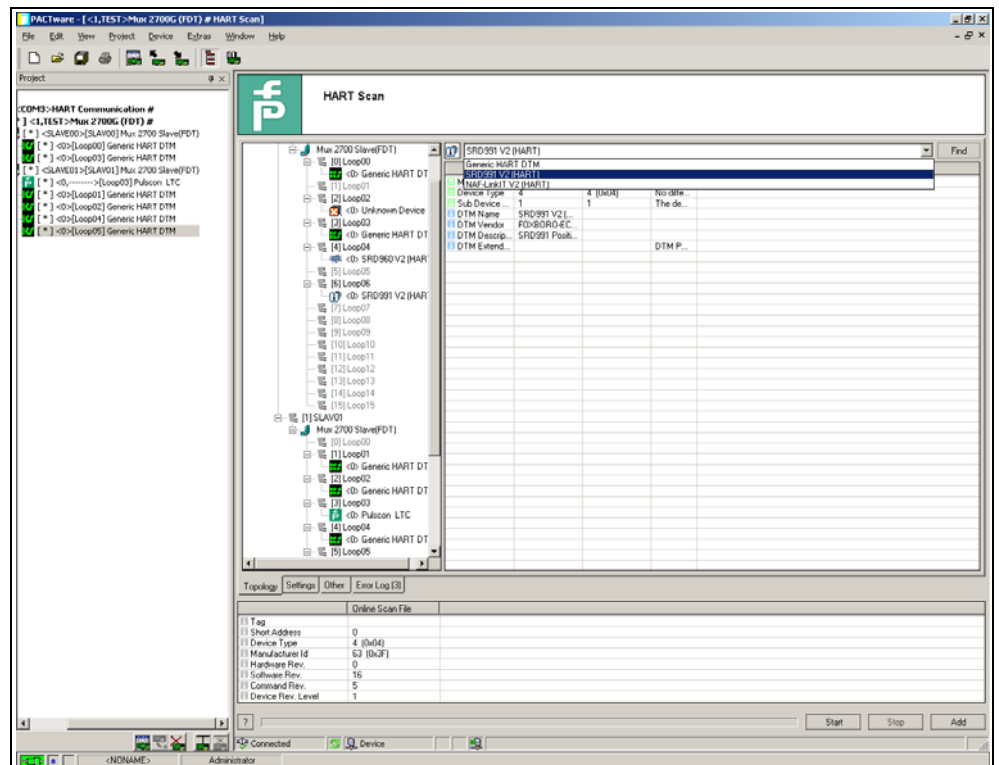
Figure 6.16   Start HART Scan function

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After the scan, the right table will show the following information on the DTM suggested:

- Manufacturer ID
- Device type
- Sub Device Type
- Name of the DTMs
- Manufacturer of the DTMs
- Description of the DTMs
- Extended description of the DTMs (e. g. version number)

Some DTMs do not provide this information, due to which an automatic allocation is not possible.
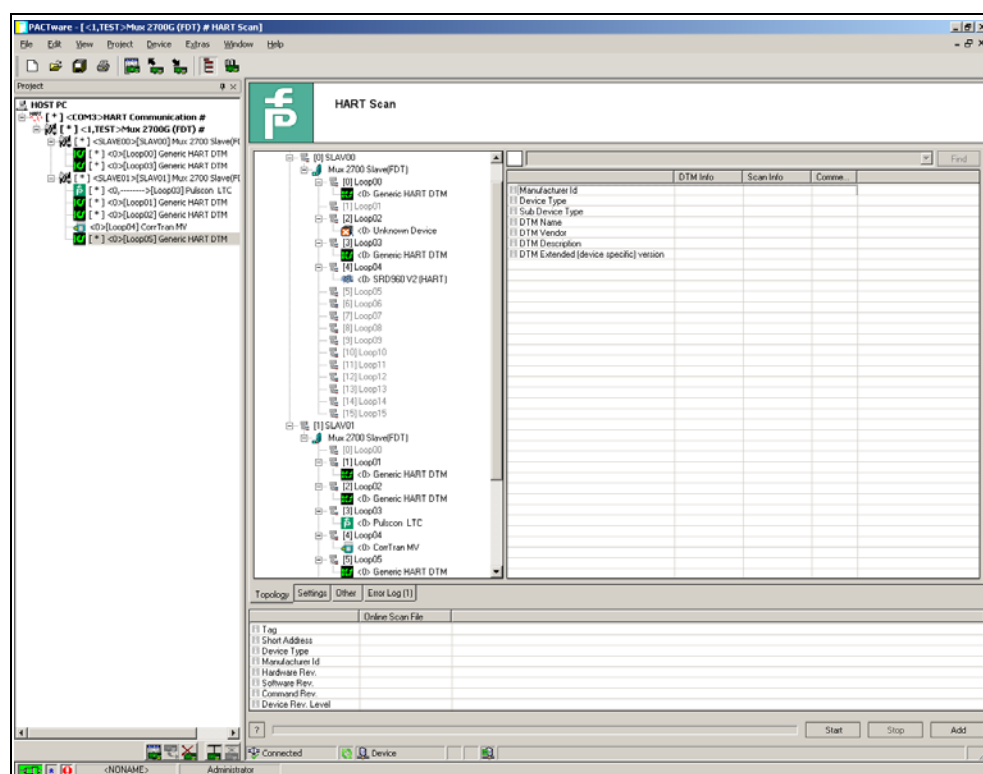
Note

Figure 6.17   Result of HART Scan

▶ Now the DTMs can be added to the project by using the **Add** button

It is also possible to add DTMs manually in the project tree.

Manual adding of DTMs
▶ Use the right mouse button to click on the Slave unit where the new device shall be added.
▶ Select the device which shall be added.
▶ Select the loop the device will be connected to.

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Read-out of parameters

▶ Read-out the device parameters via **Project > Upload**.
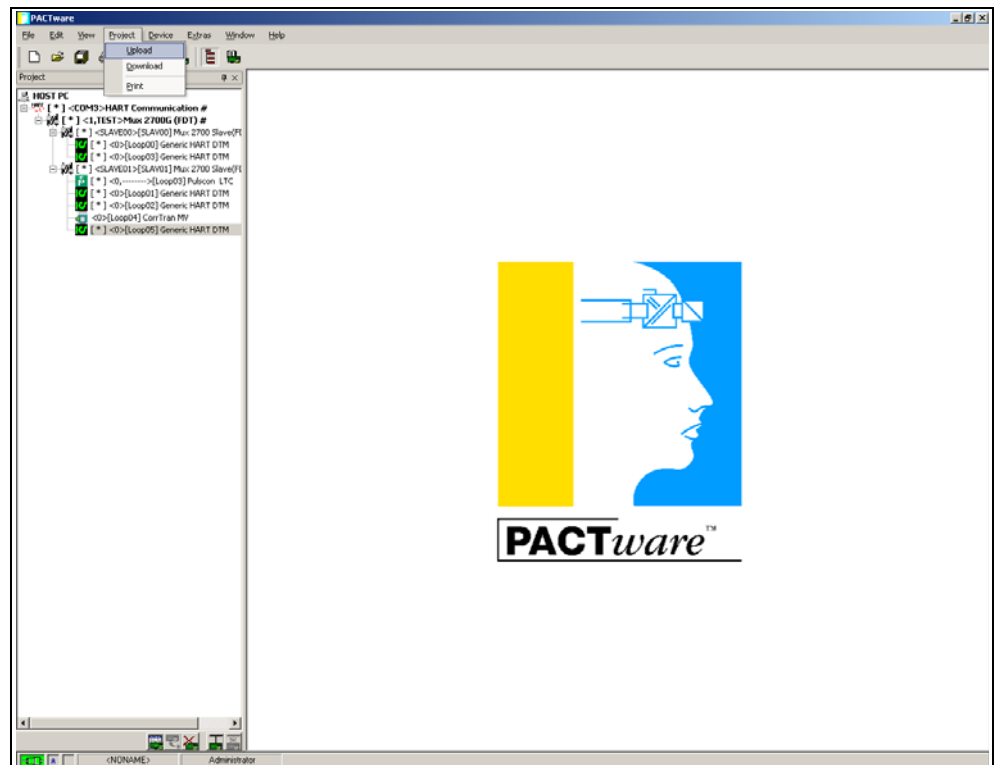
Figure 6.18   Read-out of parameters

The project is now complete and contains all required information.

If other Slaves are added later, the already existing Slaves can be excluded from the scan.

▸ Use the right mouse button to click on the Slave to be excluded.
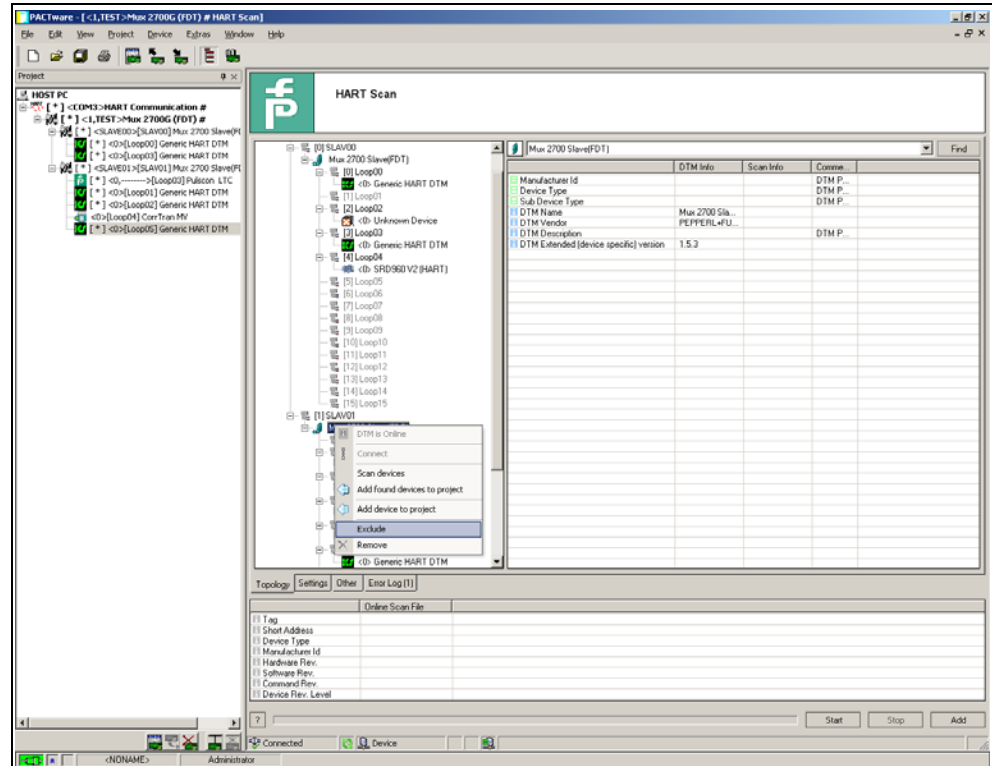▸ Activate the **Exclude** option.

Figure 6.19   Exclude existing Slaves from the scan

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7 Operation

7.1 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 9.1.

7.1.1 Channel number

The HART Multiplexer Master KFD2-HMM-16 provides 16 channels for the connection of SMART transmitters or control devices, which support digital communication in accordance with the HART specification. A maximum of 15 additional KFD0-HMS-16 Slaves can be connected, each of which in turn support 16 channels. Thus in a full assembly, a loop of 256 channels can be achieved with just one Master. When using the Multiplexer Master with the RPI product family, no Slave units are necessary. On RPI, communication takes place via the Power Rail.

7.1.2 Multiplexer table (module table)

The Multiplexer Master 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).

7.1.3 Interface

In this way, the Multiplexer Master 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 256 field devices, up to 7936 field devices are controllable over a single RS 485 interface.

7.1.4 HART communication

As a digital communication system for servicing and configuration purposes, the HART protocol is supported by many field devices with conventional analog 4 mA ... 20 mA current loops. The HART signal is thus modulated on the analog 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.

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- 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.

7.1.5   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.

7.1.6   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.

7.1.7   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.

7.1.8   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.

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

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7.1.9   All the functions at a glance

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

- 16 channels, extendable to 256 channels by the connection of up to 15 KFD0-HMS-16 Slaves
- up to 7936 loops per interface (31 Multiplexers with in each case 256 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
- removable terminals
- supply via Power Rail
- approval for zone 2

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8 Diagnosis and fault elimination

8.1 General

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

Faults and failures are signalled via the following means:

- *LEDs (see section 5.4.3 and 8.2)*
- *Status/response code (see section 8.3)*
- *Extended device status (see section 8.4)*

Note

8.2 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.

8.3 Status/response code (response code)

8.3.1 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.

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8.3.2   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)

Details can be found in /1/.

Note

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.

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

Note

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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

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8.3.3 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 8.4).	• Read extended device status (section 8.4). • Check LEDs (section 8.2). • 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 8.4.	Read extended device status (section 8.4).
3	analog 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 analog output)
2	analog 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 8.4).	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)

8.4 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 8.3.3) 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.	

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9 Appendix

9.1 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.

9.1.1 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:
2	📖		1: Read primary variable.
			2: Read primary variable as current (in mA) and percent of range.
3	📖		3: Read primary variable as current (in mA) and four (predefined) dynamic variables.
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.

9.1.2 Common-practice commands

| Command		Action	Meaning
38	✎	Reset "Configuration changed" flag.	Reset the "Configuration changed" response code, see section 8.3.3.
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 8.3.3) 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 8.4.
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.

9.1.3 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.

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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 8.4). 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 7.1.5.
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.

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.	

9.2   Terminal assignment of the 26 pin connector with analog HART signals

Pin	Signal	Pin	Signal
1	Analog ground	14	Analog ground
2	Analog ground	15	Analog ground
3	Analog ground	16	HART channel 9
4	Analog ground	17	HART channel 10
5	Analog ground	18	HART channel 11
6	HART channel 1	19	HART channel 12
7	HART channel 2	20	HART channel 13
8	HART channel 3	21	HART channel 14
9	HART channel 4	22	HART channel 15
10	HART channel 5	23	HART channel 16
11	HART channel 6	24	Analog ground
12	HART channel 7	25	Analog ground
13	HART channel 8	26	Analog ground

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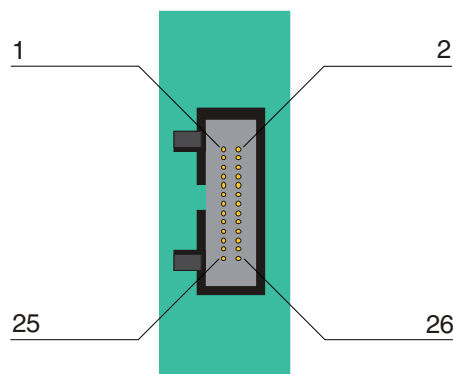
9.3   Literature

/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

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9.4 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 analog 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 continiously 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

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

HART

Abbreviation 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 communication 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

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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.

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