RHE 2X/4X HART® Communication User Manual

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RHE 2X/4X
HART® Communication

Communication User Manual RHE21, 27, 28 and RHE4X Series

RHEONIK.

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1 Introduction

Transmitters of the Rheonik RHE2X and RHE4X Series can be ordered with a HART® communication option. HART® is a registered trademark of Rosemount Inc. This option adds an HART® Version 5 compatible hardware and software interface to the RHE2X and RHE4X devices.

This document describes the details of these interfaces.

1.1 Referenced Documents

The Rheonik RHE HART® implementation is based on following documents issued by the HART Communication Foundation:

1. HART® Physical Layer Specification – Revision 8.0, HCF_SPEC-54
2. HART® Data Link Layer Specification – Revision 7.1, HCF_SPEC-81
3. HART® Command Summary Information – Revision 7.1, HCF_SPEC-99
4. HART® Universal Command Specification – Revision 5.2, HCF_SPEC-127
5. HART® Common-Practice Command Specification – Revision 7.1, HCF_SPEC-151
6. HART® Common Tables – Revision 10.0 HCF_SPEC-183 Appendix 1 - HART®
7. Command-Specific Response Code Definitions - Revision 4.1, HCF_SPEC-307

These documents constitute the specification of the Version 5 of the HART® protocol. The extent of the implementation is detailed below.

Where possible and meaningful features of the Version 7 of the HART® protocol were added or used. These extensions are documented below, as well, and follow the specifications in following documents of the Version 7 document set:

8. HART® Command Summary Specification – Revision 9.0, HCF_SPEC-99
9. HART® Universal Command Specification – Revision 7.0, HCF_SPEC-127
10. HART® Common-Practice Command Specification – Revision 9.0, HCF_SPEC-151
11. HART® Common Tables Specification – Revision 18.0, HCF_SPEC-183
12. Command-Response Code Specification - Revision 6.0, HCF_SPEC-307

A basic knowledge of the HART® protocol and its commands is required in order to understand the details described in the chapters below as the information within this documents listed above is referenced but not repeated nor explained.

The contents of the Device Variables and other items are given as reference to Modbus register Names and addresses. These items are explained in detail in the

13. RHE2X Desktop Reference, Document No. 8.2.1.01
14. RHE4X Desktop Reference, Document No. 8.2.1.14

The use of the RHEComPro program to operate and configure an RHE transmitter via the HART interface is described in section 4. This program is documented in full in

15. RHEComPro Suite User Manual, Document No. 8.2.1.28

Since the RHE2X transmitter series consists of different transmitter types with different housings and terminal configurations the HART® connections are detailed in the installation documents applicable to the respective RHE transmitters as shown on the following table:.

Transmitter	Title	Document Number
RHE21	RHE21 Installation & Startup Guide	8.2.1.04
RHE22	RHE22 Installation & Startup Guide	8.2.1.05
RHE26/27	RHE26/27 Installation & Startup Guide	8.2.1.06
RHE28	RHE28 Installation & Startup Guide	8.2.1.07

1.2 Implementation Extent, Conformance

The RHE HART® implementation conforms to following HART® 5 conformance classes:

- Class 1, 1A
- Class 2
- Class 3
- Class 4
- Class 5 without Burst Mode and Transfer Services Commands

In general, all HART® 5 Universal and Common Practice Commands are supported except for

- Burst Mode,
- Transfer Services Commands, and the
- Setting of Serial Numbers.

In the HART® 7 specification the conformance classes were altered drastically. In terms of HART® 7 the RHE2X HART® protocol implementation conforms to following classes:

- Class 1
- Class 2
- Class 3 without Burst Mode and Writing to a Device Variable.

Following HART® 7 features are not supported:

- Burst Mode, commands 101 to 109,
- Catch-Mechanism, commands 113 and 114,
- Device Variable Trim, commands 80 to 83, and
- Event Mechanism, commands 115 to 119.

All unimplemented commands return the error code 64 “Not Implemented”. Since all implemented commands are either Universal or Common Practice Commands there is no need for a specific device description file to be used together with the RHE transmitters. A generic HART® 5 or 7 device description suffices.

1.3 Important Considerations

The implemented HART® commands mainly deal with the configuration of the 4-20mA interfaces. Note that a full configuration of RHE2X or the RHE4X type transmitters is not possible via the HART® interface. Use the HMI of the transmitter or the Modbus interface in combination with the RHECom PC tool to access the entire parameter set of the RHE transmitters. This is described in document number 13, see section 1.1.

For example, it is currently not possible to set the damping of digital transmitter variables via HART® commands 34 or 55. However, it is possible to set the additional damping for the analog outputs via command 64.

Units may be modified via HART® for all Device and Transmitter Variables where applicable. However, a change of a unit always affects units used for the HMI and the Modbus interfaces, as well. Thus, a change of a unit should be considered carefully.

Any change of the configuration done via HART® has an immediate effect and Common Practice Command 39 does not need to be issued. This is different form the “step by step” configuration philosophy valid for changes via the HMI and Modbus interfaces. Therefore, configuration changes or test settings should be done only by one interface at a given time in order to avoid inconsistencies and undetermined transmitter behavior. After a configuration change or a test is concluded it is strongly recommended to perform a commanded transmitter reset or a power cycle in order to get rid of all intermediate effects.

2 RHE HART® Hardware Interface

The RHE HART® interface may be wired in two different configurations. In one configuration the underlying 4-20mA interface is galvanically decoupled from the remaining electronics of the transmitter and must be powered from outside, e.g. from the HART® master device. In the other configuration the 24V power supply of the RHE transmitter is used to power the loop and the galvanic properties of this configuration depends on the galvanic properties of the power supply at the transmitter.

3 RHE HART® Protocol Details

This sections describes the implementation specifics of the RHE HART® protocol implementation. Here, the information is detailed which go beyond the HART® specifications.

3.1 Semantic Interrelation

HART® commands relate to following items and concepts

- Identity
- Device Management
- Analog Outputs
- (Transmitter) Device Variables
- Dynamic Variables

The effects of the commands on these items is not precisely defined in the HART® 5 specification. HART® 7 fills some of the semantic gaps but does still leaves some interrelations open to interpretation by the protocol implementation. For example, it renames the HART® "Transmitter Variables" consistently into "Device Variables". In this document we follow the HART® 7 terminology and avoid the term "Transmitter Variables".

The following subsections try to fill the gaps of the semantic definitions in the HART® documents.

3.1.1 Device variables

Device variables are results of measurements and related calculations in the RHE transmitter, such as Mass Flow, Volume Flow, (Tube) Temperature, and the Medium Density. Each device variable mentioned here may be mapped to an analog output, i.e. may be used to control an analog output. Both, device variable and analog output constitute a (true) HART® dynamic variable, see below.

The RHE features more device variables such as the totalizers which cannot be mapped to analog outputs.

Device variables have following features:

- a (measurement) value,
- a unit (see section 3.2),
- may allow zeroing,
- may have a damping (not for RHE2X HART®),
- and – where applicable – a sensor range defined by upper and lower bounds.

The commands related to device variables are found in section 3.5. The following table lists the device variables in the RHE2X transmitters which are accessible by the HART® interface:

Code	Modbus Name	Meaning	Effects of Zeroing, Command 52 (43)
0	MassFlowRate (0x4900)	Mass Flow Rate	Starts RHM Sensor Zeroing Procedure.
1	VolumetricFlowRate (0x4A00)	Volumetric Flow Rate	Starts RHM Sensor Zeroing Procedure.

Code	Modbus Name	Meaning	Effects of Zeroing, Command 52 (43)
2	StdDensity (0x480A)	Compensated Density or Standard Density depending on the density calculations modes.	None. Returns error code 6.
3	AdcTubeMeanTemp (0x4500)	Tube Temperature	None. Returns error code 6.
4	TotInvenMassNet (0x4B04)	Net Mass Total	Resets all totalizers to 0.
5	TotalMassFwd (0x4B00)	Forward Mass Total	Resets all totalizers to 0.
6	TotalMassRev (0x4B08)	Reverse Mass Total	Resets all totalizers to 0.
7	TotInvenVolNet (0x4B06)	Net Total Volume	Resets all totalizers to 0.
8	TotalVolFwd (0x4B02)	Forward Total Volume	Resets all totalizers to 0.
9	TotalVolFwd (0x4B0A)	Reverse Total Volume	Resets all totalizers to 0.
10	AdcTorBarMeanTemp (0x4502)	Torsion Temperature	None. Returns error code 6.
11	OnBrdTemp (0x4504)	Electronic Temperature	None. Returns error code 6.
12	DriveGain (0x440E)	Drive Gain	None. Returns error code 6.
13	AssuranceFactor (0x4026)	Assurance Factor	None. Returns error code 6.
14	SensorFrequency (0x4206)	Sensor Frequency	None. Returns error code 6.
15	[AnInputLeftCoil]	Left Pickup Coil Voltage	None. Returns error code 6.
16	[AnInputRightCoil]	Right Pickup Coil Voltage	None. Returns error code 6.
17	ZeroPoint (0x4702)	Zero Point	None. Returns error code 6.
18	LastZeroPoint (0x4708)	Last Zero Point	None. Returns error code 6.

Table 1: Device Variables

Only the device variables in the code range from 0 to 3 and with the codes 10, 12, and 13 may be mapped to an analog output. The change of some attributes, e.g. their bounds, is restricted to these device variables. The variables from 12 to 18 feature fixed units that cannot be changed, see Appendix A.7.

The functionality of the device variables is defined in the RHE2X Operating Manual where the Modbus Name and the respective Modbus Address is referenced.

When using the Device Variable Commands following special index codes allow the access of Dynamic Variables (see Table 34 in HCF_SPEC-181):

Code	Dynamic Variable
245	Loop Current
246	Primary Variable (PV)
247	Secondary Variable (SV)
248	Tertiary Variable (TV)
249	Quaternary Variable (QV)

Table 2: Special Device Variable Index Codes

When using these codes the effects of the Device Variable Command depend on Device Variable which is mapped to the respective Dynamic Variable

3.1.2 Analog Outputs

The RHE2X may be equipped with two analog output channels with HART® number codes 0 and 1. The channel with number code 0 optionally can be fitted with a HART® modem and allows the HART® communication described in this manual. When HART® communication is to be used during running operations the damping of the analog output shall not be set below 0.04s in order to avoid communication disturbances by fast-changing signals.

Analog output with number code 1 does not feature a HART® modem and may be operated without any damping in order to transmit rapid changes.

An analog output has following features:

- a nominal range consisting of a minimum and a maximum current, usually 4.0 and 20.0mA,
- an alarm (fire) mechanism or state,
- a trim and gain correction for calibration purposes,
- a device variable associated with it (or mapped to it),
- a device variable dependent range with lower and upper measurement limits to mapped to the current range to generate a signal-dependent output level, and
- a transfer function.

For the RHE transmitters the transfer function is limited to “linear”. The commands related to analog outputs and their features are listed in section 3.6.

3.1.3 Dynamic Variables

When a device variable is mapped to an analog output the result is a (true) Dynamic Variable which incorporates the features of the device variable and the analog output listed in sections. The analog output with code number 0 and its mapped device variable together become the Primary Variable (PV, the first Dynamic Variable) and the analog output with code number 1 and its mapped device variable becomes the Secondary Variable (SV, the second Dynamic Variable).

The commands related to the Dynamic Variables are found in section 3.7. The commands referring to the PV may be used to change the features and attributes of the mapped device variable and the analog output with number code 0. Since the effects of these commands and the other Dynamic Variable commands depend on the current mapping of device variables the use of the commands related to the Dynamic is discouraged. It is recommended to restrict the configuration efforts to the Device Variable and Analog Output commands.

Since legacy HART® Dynamic Variable Commands seem to imply a Tertiary and a Quaternary Variable (TV and QV) the RHE transmitters maps these Dynamic Variables to the Device Variables with codes 2 and 3, Medium Density and Temperature. This assignment is fixed and since they are not associated with analog outputs they are considered “pseudo” Dynamic Variables.

For example, when the Temperature Device Variable with code 3 is mapped to the analog output with code number 0 this will cause the PV and the QV to refer to the Temperature Measurement.

When the damping of a Dynamic Variable is changed this will affect the damping of the respective analog output, only. Currently, there is no means to change the damping of a Device Variable via HART® commands.

3.2 Device Identification- and Manufacturer-Codes

RHE4X and RHE2X transmitters before firmware release 2.08 use following identification codes:

Manufacturer Identification Code: **250** (= not used)
Manufacturer’s Device Type Code: **141**

In these cases the “Read Unique Identifier” command returns a Version 5 response.

With firmware release 2.08 and higher RHE4X and RHE2X transmitters return a Version 6/7 response upon a “Read Unique Identifier” command which allows extended manufacturer and device codes to be used. In this case the following identification is used:

Manufacturer Identification Code: **0x6132 (decimal 24882)**
Manufacturer’s Device Type Code RHE4X: **0xE4A0 (decimal 58528)**
Manufacturer’s Device Type Code RHE2X: **0xE4AC (decimal 58540)**

3.3 Unit Specification and Conversion

The RHE transmitter allows the specification of a unit for a Device or Dynamic Variable and will convert the respective values accordingly when read or written. However, there only one unit conversion for all variables, range values, etc. using the same unit base such as mass, value, mass flow, volume flow, or temperature. When changing the unit of one variable the unit of all other variables using the same unit base is changed as well. The respective unit is used system-wide including the HMI and the Modbus communication.

For example, when changing the unit of the “Net Mass Total” totalizer, Device Variable with code 4, the unit of all other Mass Totalizer variables is changed, as well. This includes the unit of respective range limits.

The tables in Appendix A show the HART® unit codes are supported for Mass, Mass Flow, Volume, Volumetric Flow, Temperature, and Density.

Whenever a new unit is to be set the RHE transmitter checks whether the respective Device Variable may use this unit. When the unit does not fit an error code 2 “Invalid Selection” is returned.

Since the RHE transmitter internally uses the Foundation Fieldbus unit codes it has to convert the HART® unit code into a Foundation Fieldbus unit code and vice-versa. In some instances a reconversion for a read-out of a unit code may return a different unit code than written. The arithmetic conversion factor of both unit codes are, however, identically. Examples are the “Specific Gravity” which may return “g/cm³”, “kg/l” or “tonne/m³” –which all have an identical conversion factor.

3.4 Effects of the Custody Transfer Lock on HART® Commands

The RHE transmitter features a custody transfer lock switch. When this switch is activated the transmitter will reject any attempt to modify a stored parameter or to influence any output. This includes the commands used to calibrate the analog outputs.

When commands are rejected due to an activated custody lock they return the error code 7, "Write Protected".

The state of the custody transfer lock may be determined by issuing command 15 "Read Device Information" and evaluating the byte at offset 15. When this byte has the value 1, the custody transfer switch is active.

3.5 Commands Related to Device Variables

The following table shows the HART® commands related to device variables which are implemented and functional.

Command	Name	Comment
9	Read Device Variables with Status	HART® 7 allows the reading of up to 8 device variables.
33	HART® 5: Read Transmitter Variables HART® 7: Read Device Variables	
50	Read Dynamic Variable Assignments	Only the assignment of a device variable to the analog outputs with number codes 0 (PV) and 1 (SV) are supported. See possible assignments below.
51	Write Dynamic Variable Assignments	Only the assignment of a device variable to the analog outputs with number codes 0 (PV) and 1 (SV) are supported. See possible assignments in Table 1.
52	HART® 5:Set Transmitter Variable Zero HART® 7:Set Device Variable Zero	Effect depends on the type of the Device Variable, see the last column of Table 1.
53	HART® 5: Set Write Transmitter Variable Units HART® 7: Set Write Device Variable Units	Returns error code 2 when a variable does not support the specified unit.
54	HART® 5: Read Transmitter Variable Information HART® 7: Read Device Variable Information	The response includes the time stamp added by HART V7 in the bytes 23 to 26.
55	HART® 7: Write Transmitter Variable Damping Value HART® 7: Write Device Variable Damping Value	Currently not supported. In order to be effective this would require a reset of the transmitter. The command returns an error code 16.

Table 3: Device Variable Commands

3.6 Commands Related to Analog Outputs

The following table shows the HART® commands related to analog outputs which are implemented and functional.

Command	Name	Comment
2	Read Loop Current And Percent Of Range	This refers to the analog output with number code 0 and the device variable mapped to it.
40	Enter/Exit Fixed Current Mode	Like command 66 restricted for the analog output with number code 0.
45	Trim Loop Current Zero	Like command 67 restricted for the analog output with number code 0.
46	Trim Loop Current Gain	Like command 68 restricted for the analog output with number code 0.
60	Read Analog Channel And Percent Of Range	
62	Read Analog Channels	
63	Read Analog Channel Information	
64	Write Analog Channel Additional Damping Value	This command sets the additional damping of the specified analog channel.
65	Write Analog Channel Range Values	
66	Enter/Exit Fixed Analog Channel Mode	
67	Trim Analog Channel Zero	
68	Trim Analog Channel Gain	
69	Write Analog Channel Transfer Function	Only the linear transfer function is supported.
70	Read Analog Channel Endpoint Values	

Table 4: Analog Channel Commands

The following table shows the HART® commands related to analog outputs which are implemented and functional.

3.7 Commands Related Dynamic Variables, PV, SV, TV, and QV

The following table shows the HART® commands related to Dynamic Variables which are implemented and functional.

Command	Name	Comment
1	Read Primary Variable	This refers to the device variable which is mapped to the analog output with number code 0.
3	Read Dynamic Variables And Loop Current	This refers to the analog output with number code 0 and the device variable mapped to it (PV), the device variable mapped to the analog output with number code 1 (SV), TV, and QV. 24 Bytes of data are returned.

Command	Name	Comment
8	Read Dynamic Variable Classifications	This refers to the device variables currently mapped to the analog outputs with number code 0 (PV) and 1 (SV), as well as the TV and QV.
14	Read Primary Variable Transducer Information	This refers to the device variable which is mapped to the analog output with number code 0.
15	HART® 5: Read Primary Variable Output Information HART® 7: Read Device Information	This refers to the device variable which is mapped to the analog output with number code 0. The response contains 16 Bytes of data (HART® 5).
34	Write Primary Variable Damping Value	This command currently cannot be used to modify the damping of digital variables. The (additional) damping of analog channels can be set with command 64.
35	Write Primary Variable Range Values	Affects the range of the analog output with number code 0.
36	Set Primary Variable Upper Range Value	Affects the range of the analog output with number code 0. New upper range must be greater than current lower range.
37	Set Primary Variable Lower Range Value	Affects the range of the analog output with number code 0. New lower range must be smaller than current upper range.
43	Set Primary Variable Zero	Effect depends on the device variable which is mapped to the primary variable, see Table 1.
44	Write Primary Variable Units	Affects all variables using the respective unit conversion including the Modbus variables.
47	Write Primary Variable Transfer Function	Only the linear transfer function is supported.
49	Write Primary Variable Transducer Serial Number	Command not supported. Returns error code 16.
50	Read Dynamic Variable Assignments	See comment in Table 1.
51	Write Dynamic Variable Assignments	See comment in Table 1.
61	Read Dynamic Variables And Primary Variable Analog Channel	This refers to the analog output with number code 0 and the device variable mapped to it (PV).
110	Read All Dynamic Variables	The result depends on the mapping of device variables to analog channels (PV, SV).

Table 5: Dynamic Variable Commands related to PV, SV, TV, and QV

3.8 Identity and Device Management Commands

The following table shows the HART® commands used to identify and manage a device which are implemented and functional.

Command	Name	Comment
0	Read Unique Identifier	Returns a HART® 7 version number and the respective amount of data (18 Bytes) since Firmware Release 2.08. Previous releases returned a HART® 5 response.
6	Write Polling Address	Follows the HART® 7 semantics when the Loop Current Mode is specified in byte 2 of the command.
11	Read Unique Identifier Associated With Tag	
12	Read Message	
13	Read Tag, Descriptor, Date	
16	Read Final Assembly Number	
17	Write Message	
18	Write Tag, Descriptor, Date	
19	Write Final Assembly Number	
38	Reset Configuration Changed Flag	May be used with the HART® 7 change counter. Implementation follows the HART® 7 semantics with separate configuration flags and change counter for primary and secondary masters.
39	EEPROM Control	Implemented but not needed.
41	Perform Self Test	Self-tests are performed permanently in the background.
42	Perform Device Reset	Causes a reset of the RHE2X transmitter.
48	Read Additional Device Status	May be used with known status in the command as defined for HART V7. The returned information is detailed in section 3.8.1.
57	Read Unit Tag, Descriptor, Date	
58	Write Unit Tag, Descriptor, Date	
59	Write Number Of Response Preambles	Range is limited from 5 to 20.
71	Lock Device	
72	Squawk	Inverts the configuration of the background LEDs of the display for 200ms. The effect is a blinking of the display.
73	Find Device	
76	Read Lock Device State	

Table 6: Device Management Commands

3.8.1 Additional Device Status Returned by Command 48

The implementation of the response returned by command 48 “Read Additional Device Status” follows the HART® 7 specification. The contents of some areas within the response are filled by Modbus status registers. Refer to the RHE2X or RHE4X Desktop Reference Manuals for the meaning of bits set in these registers. All Modbus registers are stored in big-endian fashion with the most significant byte first.

Bytes	Contents
0 - 3	Modbus Warnings register (0x401E).
4 - 5	16 Bit low word of the Modbus InfoStatus register (0x4020).
6	Extended Device Status. 0 – no maintenance, no alarm.
7	Device Operating Mode. 0 – normal.
8	Standardized Status 0. 0 – no defects.
9	Standardized Status 1. 0 – reserved by HART® 7.
10	Analog Channel Saturated: Bit 0: Analog output with number code 0 saturated. Bit 1: Analog output with number code 1 saturated. Bits 2 – 7: Reserved, 0.
11	Standardized Status 2. 0 – reserved by HART® 7.
12	Standardized Status 3. 0 – not a WirelessHART® device.
13	Analog Channel Fixed: Bit 0: Analog output with number code 0 fixed. Bit 1: Analog output with number code 1 fixed. Bits 2 – 7: Reserved, 0.
14 - 17	Modbus ErrorStatus register (0x401A).
18 - 21	Modbus SoftError register (0x401C).
22 - 23	16 Bit high word of the Modbus InfoStatus register (0x4020).
24	Reserved. Currently contains 0.

Table 7: Structure of the response to command 48

3.9 Universal Commands

This section contains lists of implemented HART® 5 and 7 Universal Commands. These are already mentioned above.

3.9.1 List of HART® 5 Universal Commands

Following Universal Commands out of the HART® 5 specification are implemented and functional:

Command	Name	Comment
0	Read Unique Identifier	Returns a HART® 5 version number and the respective amount of data (12 Bytes).
1	Read Primary Variable	This will refer to the device variable which is mapped to the analog output with number code 0.
2	Read Loop Current And Percent Of Range	This refers to the analog output with number code 0 and the device variable mapped to it.

Command	Name	Comment
3	Read Dynamic Variables And Loop Current	This refers to the analog output with number code 0 and the device variable mapped to it (PV), the device variable mapped to the analog output with number code 1 (SV), TV, and QV. 24 Bytes of data are returned.
6	Write Polling Address	Follows the HART® 7 semantics when the Loop Current Mode is specified in byte 2 of the command. See also comment for Command 7 in Table 9.
11	Read Unique Identifier Associated With Tag	
12	Read Message	
13	Read Tag, Descriptor, Date	
14	Read Primary Variable Transducer Information	This refers to the device variable which is mapped to the analog output with number code 0.
15	HART® 5: Read Primary Variable Output Information HART® 7: Read Device Information	This refers to the device variable which is mapped to the analog output with number code 0. The response contains 16 Bytes of data (HART® 5).
16	Read Final Assembly Number	
17	Write Message	
18	Write Tag, Descriptor, Date	
19	Write Final Assembly Number	

Table 8: HART® 5 Universal Commands

3.9.2 List of Additional HART® 7 Universal Commands

Aside from the supported HART® 5 Universal Commands following Universal Commands out of the HART® 7 specification are implemented and functional:

Command	Name	Comment
7	Read Loop Configuration	
8	Read Dynamic Variable Classifications	This refers to the device variables currently mapped to the analog outputs with number code 0 (PV) and 1 (SV), as well as the TV and QV.
9	Read Device Variables with Status	HART® 7 allows the reading of up to 8 device variables.
20	Read Long Tag	
21	Read Unique Identifier Associated With Long Tag	Returns only the HART® 5 amount of data (12 Bytes).
23	Write Long Tag	

Table 9: HART® 7 Universal Commands

3.10 Common Practice Commands

This section contains lists of implemented HART® 5 and 7 Common Practice. These commands are already listed above.

3.10.1 List of HART® 5 Common Practice Commands

Following Common Practice out of the HART® 5 specification are implemented and functional:

Command	Name	Comment
33	HART® 5: Read Transmitter Variables HART® 7: Read Device Variables	
34	Write Primary Variable Damping Value	This command currently cannot be used to modify the damping of digital variables. The (additional) damping of analog channels can be set with command 64.
35	Write Primary Variable Range Values	Affects the range of the analog output with number code 0.
36	Set Primary Variable Upper Range Value	Affects the range of the analog output with number code 0. New upper range must be greater than current lower range.
37	Set Primary Variable Lower Range Value	Affects the range of the analog output with number code 0. New lower range must be smaller than current upper range.
38	Reset Configuration Changed Flag	May be used with the HART® 7 change counter. Implementation follows the HART® 7 semantics with separate configuration flags and change counter for primary and secondary masters.
39	EEPROM Control	Implemented but not needed.
40	Enter/Exit Fixed Current Mode	Like command 66 restricted for the analog output with number code 0.
41	Perform Self Test	Self-tests are performed permanently in the background.
42	Perform Device Reset	Causes a reset of the RHE2X transmitter.
43	Set Primary Variable Zero	Effect depends on the device variable which is mapped to the primary variable, see Table 1.
44	Write Primary Variable Units	Affects all variables using the respective unit conversion including the Modbus variables.
45	Trim Loop Current Zero	Like command 67 restricted for the analog output with number code 0.
46	Trim Loop Current Gain	Like command 68 restricted for the analog output with number code 0.

Command	Name	Comment
47	Write Primary Variable Transfer Function	Only the linear transfer function is supported.
48	Read Additional Device Status	May be used with known status in the command as defined for HART V7. The returned information is detailed in section 3.8.1.
49	Write Primary Variable Transducer Serial Number	Command not supported. Returns error code 16.
50	Read Dynamic Variable Assignments	Only the assignment of a device variable to the analog outputs with number codes 0 (PV) and 1 (SV) are supported.
51	Write Dynamic Variable Assignments	Only the assignment of a device variable to the analog outputs with number codes 0 (PV) and 1 (SV) are supported. See also Table 1.
52	HART® 5:Set Transmitter Variable Zero HART® 7:Set Device Variable Zero	Effect depends on the type of the Device Variable, see the last column of Table 1.
53	HART® 5: Set Write Transmitter Variable Units HART® 7: Set Write Device Variable Units	Returns error code 2 when a variable does not support the specified unit.
54	HART® 5: Read Transmitter Variable Information HART® 7: Read Device Variable Information	The response includes the time stamp added by HART V7 in the bytes 23 to 26.
55	HART® 7: Write Transmitter Variable Damping Value HART® 7: Write Device Variable Damping Value	Currently not supported. In order to be effective this would require a reset of the transmitter. The command returns an error code 16.
57	Read Unit Tag, Descriptor, Date	
58	Write Unit Tag, Descriptor, Date	
59	Write Number Of Response Preambles	Range is limited from 5 to 20.
60	Read Analog Channel And Percent Of Range	
61	Read Dynamic Variables And Primary Variable Analog Channel	This refers to the analog output with number code 0 and the device variable mapped to it (PV).
62	Read Analog Channels	
63	Read Analog Channel Information	
64	Write Analog Channel Additional Damping Value	
65	Write Analog Channel Range Values	
66	Enter/Exit Fixed Analog Channel Mode	
67	Trim Analog Channel Zero	
68	Trim Analog Channel Gain	

Command	Name	Comment
69	Write Analog Channel Transfer Function	Only the linear transfer function is supported.
70	Read Analog Channel Endpoint Values	
110	Read All Dynamic Variables	The result depends on the mapping of device variables to analog channels (PV, SV).

Table 10: HART® 5 Comman Practice Commands

3.10.2 List of Additional HART® 7 Common Practice Commands

Aside from the supported HART® 5 Common Practice Commands following Common Practice Commands out of the HART® 7 specification are implemented and functional:

Command	Name	Comment
72	Squawk	Inverts the configuration of the background LEDs of the display for 200ms. The effect is a blinking of the display.

Table 11: HART® 7 Common Pratice Commands

3.10.3 Unsupported HART® 5 and 7 Common Practice Commands

The RHE transmitters do not support following features:

- Burst Mode,
- Events
- (I/O) Sub-Devices,
- Variable Catching,
- Trends,
- Device Variable Trim.

Therefore, the following Common Practice commands return the error code 64 “Not Implemented”.

Command	Name	HART® Version
56	Write Device Variable Transducer Serial No	7
71	Lock Device	6, 7
73	Find Device	6, 7
74	Read I/O System Capabilities	6, 7
75	Poll Sub-Device	6, 7
76	Read Lock Device State	6, 7
77	Send Command to Sub-Device	7
78	Read Aggregated Commands	7
79	Write Device Variable	6, 7
80	Read Device Variable Trim Points	6, 7
81	Read Device Variable Trim Guidelines	6, 7

Command	Name	HART® Version
82	Write Device Variable Trim Point	6, 7
83	Reset Device Variable Trim	6, 7
84	Read Sub-Device Identity Summary	7
85	Read I/O Channel Statistics	7
86	Read Sub-Device Statistics	7
87	Write I/O System Master Mode	7
88	Write I/O System Retry Count	7
89	Write Date and Time	7
90	Read Real-Time Clock	7
91	Read Trend Configuration	7
92	Write Trend Configuration	7
93	Read Trend	7
94	Read I/O System Client-Side Communication Statistics	7
95	Read Device Communications Statistics	7
101	Read Sub-device to Burst Message Map	7
102	Map Sub-device to Burst Message	7
103	Write Burst Period	7
104	Write Burst Trigger	7
105	Read Burst Mode Configuration	6, 7
106	Flush Delayed Responses	6, 7
107	Write Burst Device Variables	5
108	Write Burst Mode Command Number	5
109	Burst Mode Control	5
113	Catch Device Variable	6, 7
114	Read Caught Device Variable	6, 7
115	Read Event Notification Summary	7
116	Write Event Notification Bit Mask	7
117	Write Event Notification Timing	7
118	Event Notification Control	7
119	Acknowledge Event Notification	7
120	Configure Synchronous Sampling	7
121	Configure Delayed Command Execution	7

Table 12: Unsupported HART® 5 and 7 Common Pratice Commands

3.11 Proprietary Commands

The Rheonik HART implementation allows the access to the Cutoff Limit and K-Factor Parameters of the RHE transmitter via dedicated proprietary commands.

The layout of the Rheonik proprietary commands follow the standard specified in HCF_SPEC-81. Each command telegram is structured as described in section 5.1 of this document. In the start sequence of a command there is a command code and a byte count field. The command code field will contain one of the command codes listed in the following section headers. The byte count is 0 when no data follows or 4 for the size of a floating point number transferred for the “write”-type commands.

The layout of the respective responses follow the same conventions and its data field contain at least a command completion status byte and a Device Status byte, i.e. at least two bytes. Thus, the byte count in the response either contains the value 2 when no further data follows or a 6 when a 4-byte floating point value is returned. The Device Status byte is structured as defined in section 7.3.3 of HCF_SPEC-99. The possible values in the completion status are indicated in the command descriptions below.

The form of the command descriptions below follow the examples set by the HART documents, e.g. HCF_SPEC-127.

Note that a modification of the Cutoff Limit or a K-Factor must be activated by a reset of the RHE. This can be accomplished e.g. by issuing the standard HART command 42 “Perform Device Reset”.

3.11.1 Command 128 Read Cutoff Limit

Reads the Cutoff Limit parameter of the RHE.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
0..3	Float	Cutoff Limit IEEE Floating point number in big-endian byte order. This value has the same unit as device variable #0, Mass Flow.

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors.
64	Error	Command not implemented for earlier firmware versions.

3.11.2 Command 129 Write Cutoff Limit

Writes the Cutoff Limit parameter to the RHE.

Request Data Bytes

Byte	Format	Description
0..3	Float	Cutoff Limit IEEE Floating point number in big-endian byte order. This value has the same unit as device variable #0, Mass Flow.

Response Data Bytes

Byte	Format	Description
None		

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors.
5	Error	Less than four data bytes received.

Code	Class	Description
7	Error	Parameter space is write protected. Check custody transfer switch.
64	Error	Command not implemented for earlier firmware versions.

3.11.3 Command 130 Read K-Factor

Reads the Calibration Factor parameter of the RHE.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
0..3	Float	K-Factor IEEE Floating point number in big-endian byte order.

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors.
64	Error	Command not implemented for earlier firmware versions.

3.11.4 Command 131 Write K-Factor

Writes the Calibration Factor parameter to the RHE.

Request Data Bytes

Byte	Format	Description
0..3	Float	K-Factor IEEE Floating point number in big-endian byte order.

Response Data Bytes

Byte	Format	Description
None		

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors.
5	Error	Less than four data bytes received.
7	Error	Parameter space is write protected. Check custody transfer switch.
64	Error	Command not implemented for earlier firmware versions.

4 RHEComPro HART Communication for RHE2X and RHE4X Transmitters

The Rheonik "RHEComPro" PC tool usually used for Modbus communication with the RHE2X and RHE4X Series transmitters also supports the HART communication with these devices.

Please refer to the RHEComPro User Manual for the general handling and the features of this program. Here only the user interface to the HART related features is described.

In the Configuration Connection dialog the "Use HART Connection" button must be pressed to get access to the HART connection parameters. This is shown in Figure 1.

Select the COM port to which the HART modem is connected and the polling address set at the RHE transmitter. The latter usually is 0. When the "Connect" button is pressed the RHEComPro Program attempts to establish a HART communication connection to the RHE transmitter.

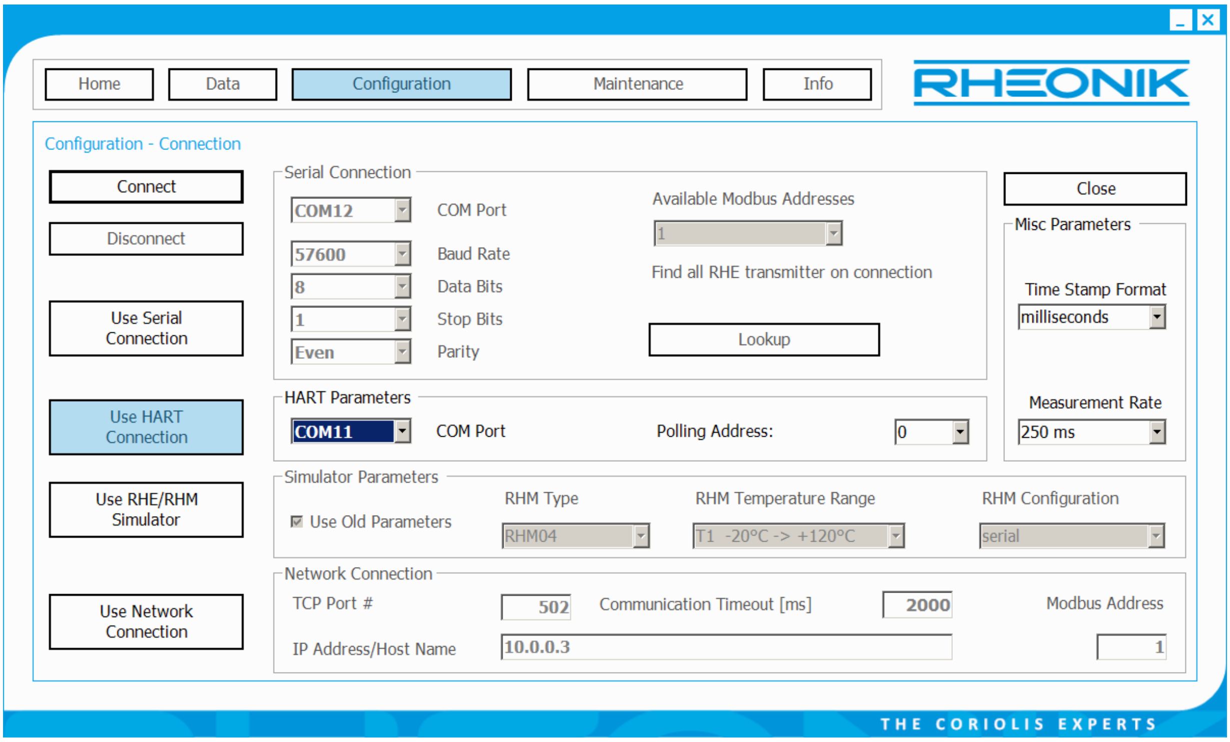

Figure 1: RHEComPro Connection Dialog for HART

When the connection could be established successfully the RHEComPro program displays the main HART dashboard as shown in Figure 2. This dashboard displays all measurement data available on the HART interface in addition to some status information.

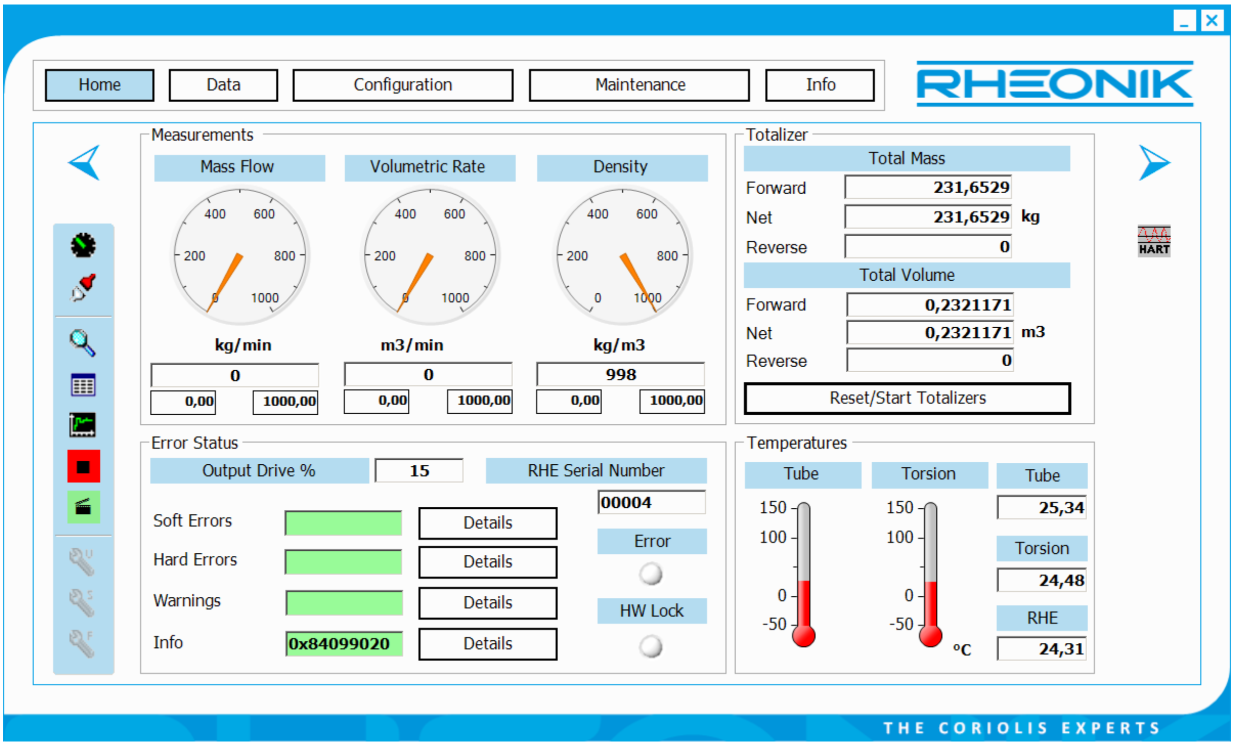

Figure 2: RHEComPro Main HART Dashboard

A second HART dashboard is displayed when the buttons with the symbols "≺" or "≻" are pressed, see Figure 3.

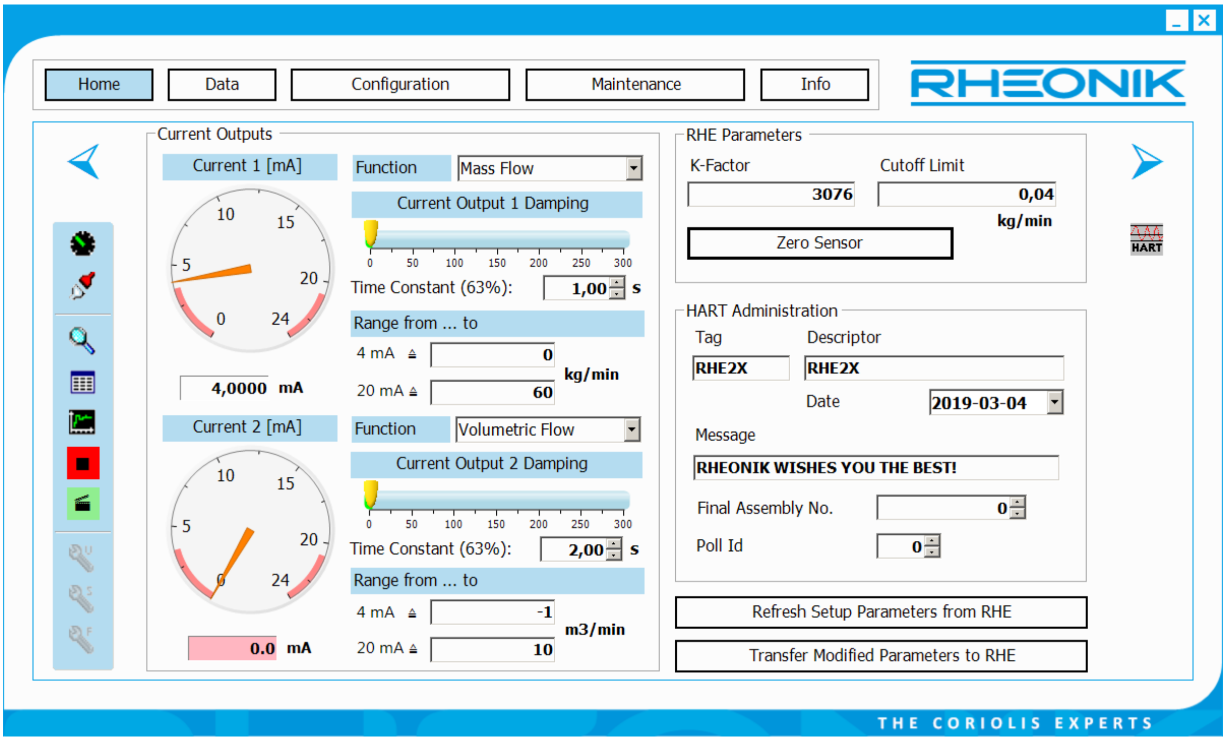

Figure 3: RHEComPro Second HART Dashboard

The second HART dashboard shows the status and the configuration of the current interfaces in addition to the standard HART administration parameters. When the HART Lock Switch is not active all parameters may be changed and transferred to the RHE transmitter.

Please note, that a simultaneous modification of the function assignment to a current output and it associated range is not possible. The function must be change and the changed assignment must be transferred to the RHE transmitter before the range can be changed because the RHE transmitter maintains different sets of ranges depending on the assigned function.

The field of any modified parameter will appear in a reddish color to indicate that it has been changed. When the button "Transfer Modified Parameter to RHE" is pressed all modified parameters are written to the RHE transmitter. When a modification is successful, the respective parameter field will revert to its original white background color.

In order to undo a modification which not yet has been transferred to the RHE transmitter, the button "Refresh Setup Parameters from RHE" can be used. This causes a reload of the current values stored in the transmitter into the displayed parameter fields.

Since the HART communication does not facilitate the access to all setup parameters of the RHE transmitter most configuration and maintenance functions are not available. It is, however, possible to change the units used by the RHE transmitter via the "Configuration" / "Unit Selection" menu. Furthermore, it is possible to calibrate the current output interface with the help of the submenu after the selection of "Maintenance" / "Standard Maintenance Activities".

Appendix A Units

A.1 Supported Mass Units

Code	Description
60	grams
61	kilograms
62	metric tons
63	pounds
64	short tons
125	ounce

Table 13: Mass Units

A.2 Supported Mass Flow Units

Code	Description
70	grams per second
71	grams per minute
72	grams per hour
73	kilograms per second
74	kilograms per minute
75	kilograms per hour
76	kilograms per day
77	metric tons per minute
78	metric tons per hour
79	metric tons per day
80	pounds per second
81	pounds per minute
82	pounds per hour
83	pounds per day
84	short tons per minute
85	short tons per hour
86	short tons per day

Table 14: Mass Flow Units

A.3 Supported Volume Units

Code	Description
40	gallons
41	liters
43	cubic meters
46	barrels
112	cubic feet
113	cubic inches
166	norm cubic meters
168	standard cubic feet

Code	Description
172	standard cubic meter since Release 2.1.0
236	hectoliters

Table 15: Volume Units

A barrel (bbl) equals 32 U.S. gallons.

A.4 Supported Volumetric Flow Units

Code	Description
15	cubic feet per minute
16	gallons per minute
17	liters per minute
19	cubic meter per hour
22	gallons per second
24	liters per second
26	cubic feet per second
27	cubic feet per day
28	cubic meters per second
29	cubic meters per day
121	norm cubic meters per hour
123	standard cubic feet per minute
130	cubic feet per hour
131	cubic meters per minute
132	barrels per second
133	barrels per minute
134	barrels per hour
135	barrels per day
136	gallons per hour
138	liters per hour
187	standard cubic meters per day since Release 2.1.0.
188	standard cubic meters per hour since Release 2.1.0.
189	standard cubic meters per minute since Release 2.1.0.
190	standard cubic meters per second since Release 2.1.0.
235	gallons per day

Table 16: Volumetric Flow Units

A barrel (bbl) equals 32 U.S. gallons.

A.5 Supported Temperature Units

Code	Description
32	Degrees Celsius
33	Degrees Fahrenheit
34	Degrees Rankine
35	Kelvin

Table 17: Temperature Units

A.6 Supported Density Units (Mass per Volume)

Code	Description
90	specific gravity units
91	grams per cubic centimeter
92	kilograms per cubic meter
93	pounds per gallon
94	pounds per cubic foot
95	grams per milliliter
96	kilograms per liter
97	grams per liter
98	pounds per cubic inch
102	degrees Baumé heavy
103	degrees Baumé light
104	degrees API
240	degrees Brix

Table 18: Density Units

A.7 Fixed Units

The following units are used for device variables. They are fixed and cannot be changed.

Code	Description
32	mV
38	Hz
57	%
242	8ns (Tick)

Table 19: Fixed Units

About Rheonik

Rheonik has but one single purpose: to design and manufacture the very best Coriolis meters available.

Our research and engineering resources are dedicated to finding new and better ways to provide cost effective accurate mass flow solutions that provide value to our customers. Our manufacturing group care for each and every meter we produce from raw materials all the way to shipping, and our service and support group are available to help you specify, integrate, start-up and maintain every Rheonik meter you have in service. Whether you own just one meter or have hundreds, you will never be just another customer to us. You are our valued business partner.

Need a specific configuration for your plant? Don't compromise with a "standard" product from elsewhere that will add extra cost to your installation. If we can't configure it from our extensive and versatile product range, our exclusive **AnyPipeFit Commitment** can have your flow sensor customized with any size/type of process connection and face to face dimension you need.

No matter what control system you use as the backbone in your enterprise, with our **AnyInterface Commitment**, you can be sure that connection and communication will not be a problem. Alongside a wide variety of discrete analog and digital signal connections, we can also provide just about any network/bus interface available (for example: HART, ProfibusDP, ProfiNet, EtherCAT, PowerLink, EtherNet/IP, CAN, ...) with our RHE 40 Series family of transmitters. Rheonik RHE 40 Series transmitters can connect to your system – no headache and no conversion needed.

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