TRICOR®

TCD 9100/9200 HART® Communication

TRICOR
Coriolis Technology

Manual-Version

TCD_COHA_S_EN_100428_E002

This document is supplied as standard in electronic media with the device. Latest version can be downloaded at www.tricorflow.com.

NOTE:

This manual applies to the Coriolis Flow Meter with the brand TRICOR.

Index

1. Introduction

1.1. Purpose of this Documentation

This manual contains all information needed to integrate the process instruments into a communications network. The manual is aimed at control system designers, system integrators, instrument engineers.

In order to operate safety and for more detailed information you need the product specific manual. Available for download from Flow documentation https://tricorflow.com/support/downloads/manuals/).

1.2. Purpose of this Documentation

This manual applies to the TRICOR TCD transmitter HART version only. The TRICOR TCD transmitter can be used in combination with the following sensors:

- TCMP Series
- TCMQ Series

In order to operate a Coriolis flow meter, you need also Operating Instructions.

1.3. Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

DANGER!

indicates that death or severe personal injury **will** result if proper precautions are not taken.

WARNING!

indicates that death or severe personal injury **may** result if proper precautions are not taken.

CAUTION!

indicates that minor personal injury can result if proper precautions are not taken.

NOTE:

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety

instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of KEM products

Note the following

WARNING!

KEM products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by KEM. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

NOTE:

Use in a domestic environment

This Class A Group 1 equipment is intended for use in industrial areas.
In a domestic environment this device may cause radio interference.

Trademarks

All names identified by ® are registered trademarks of KEM. The remaining trademarks in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owner.

Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

1.4. Purpose of this Documentation

Edition	Remarks	Product compatibility	Compatibility of device integration package
02/2020	First release	HW revision 03 Compact FW revision 4.xx.xx-xx Remote FW revision 4.xx.xx-xx	HART: Pactware DTM
			Defice integration package for Field Device Communicator: Handheld FC475

2. HART Communication Interface

2.1. HART Communication Interface

System communication

Manufacturer ID	**42 (2A Hex)**	**Manufacturer ID parameter**
Device type	34 (22 Hex)	Device type parameter
HART protocol revision	7.5	HART protocol revision parameter
Device revision	5	Device revision parameter

Tab. 1: HART protocol identification data

NOTE:

Version numbers and other references shown above are typical or example values.

Device description files

Available EDD drivers:

- FDT/DTM for Pactware
- 475 Field Communicator
- SIMATIC PDM (on request)

The drivers can be downloaded here: www.kem-kueppers.com/en/downloads/software-check.html

Configuration of the HART polling address

The HART address can be set either via hardware (DIP switch) or via software (HMI or Pactware).

The DIP switch is located on the transmitter cassette.

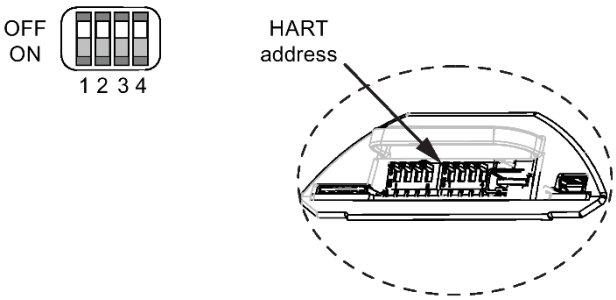


Fig. 1: HART slave address switch

- Configuration via DIP switch (HW polling address)
  Set 1 to 15 on the DIP switch if you wish to set a fixed (hardware-defined) HART polling address (SW polling address will be ignored). The configured HW polling address can be read via HMI in menu item 4.2.
- Configuration via HMI or Pactware (SW polling address)
  Disable the HW polling address by setting all switches to "OFF" on the HART DIP switch. The device starts up with default slave address = 0. The SW polling address can be changed to a value between 0 and 63 via HMI (menu item 4.1) or PDM for Pactware

DIP switch configuration

Address	Switch 1	Switch 2	Switch 3	Switch 4
"SW polling address"	Off	Off	Off	Off
1	On	Off	Off	Off
2	Off	On	Off	Off
3	On	On	Off	Off
4	Off	Off	On	Off
5	On	Off	On	Off
6	Off	On	On	Off
7	On	On	On	Off
8	Off	Off	Off	On
9	On	Off	Off	On
10	Off	On	Off	On
11	On	On	Off	On
12	Off	Off	On	On
13	On	Off	On	On
14	Off	On	On	On
15	On	On	On	On

Tab. 2: HW polling address

Mapping of measured process variables

The assignment of the measured process values to HART device variables (PV - primary variable; SV - secondary variable; TV - tertiary variable; and QV - quaternary variable) can be modified and assigned as desired via local user interface or via HART interface using Pactware.

PV: The process value assigned to current output 1 (HMI menu item 2.4.1.1) is automatically assigned to PV.

- Measured values for PV
  - Mass Flow
  - Volume Flow
  - Density
  - Process media temperature
  - Standard Volume Flow
  - Fraction flow Media A (mass or Volume Flow)
  - Fraction flow Media B (mass or Volume Flow)
  - Fraction A %
  - Fraction B %
  - Frame Temperature

SV, TV, QV: Freely selectable (HMI menu item 4.6) from the list below.

- Measured values for SV, TV and QV
  - Mass Flow
  - Volume Flow
  - Density
  - Process media temperature
  - Standard Volume Flow
  - Fraction A Mass Flow
  - Fraction A Volume Flow
  - Fraction B Mass Flow
  - Fraction B Volume Flow
  - Fraction A %
  - Fraction B %
  - Frame temperature
  - Totalized batch amount
  - Totalized value of totalizers 1, 2 or 3

Communication is via the HART protocol, using:

- HART Communicator (load 230 Ω to 500 Ω)
- PC with HART modem, on which appropriate software is installed, for example Pactware (load 230 to 500 Ω)
- Control system which can communicate via the HART protocol

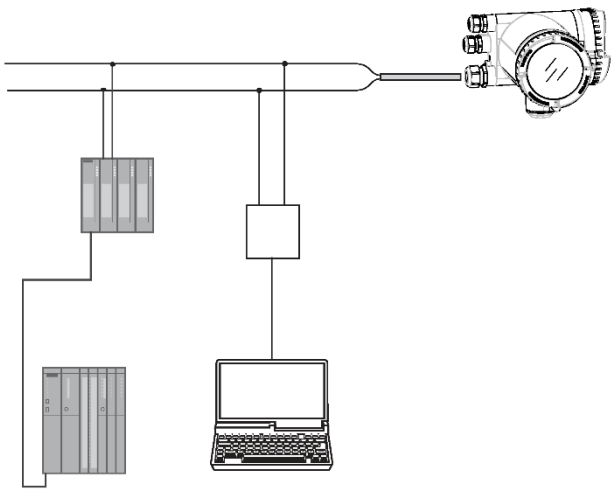


Fig. 2: Possible system configurations

① PLC system with HART interface
② PC with PDM or similar application
③ HART modem

2.2. Connecting the Current HART, CH1

NOTE:

4 to 20 mA output

It is not required to use shielded cables for the pure 4 to 20 mA current output.

NOTE:

HART communication

It is recommended by the FieldComm Group (FCG) to use shielded cables for the HART communication.

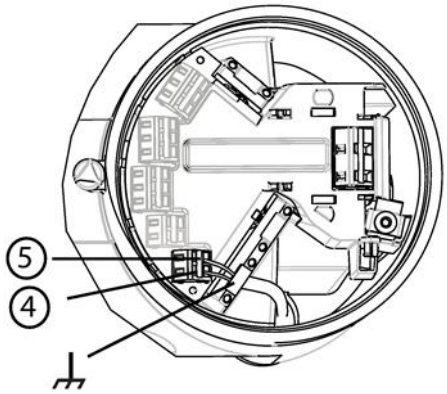
NOTE:

Passive channels only

Channel 1 power supply must be separated from that for channels 2 to 4.

Signal return (or common) can be joined.

1. Remove cap and ferrule from cable gland and slide onto cable.
2. Push cable through open gland and cable path.
3. Restore ferrule and tighten cap to lightly hold cable in place.
4. Signal cable screen is folded back over outer sheath and grounded beneath cable clamp.
5. Connect wires to terminals using wiring tool, field mount transmitter

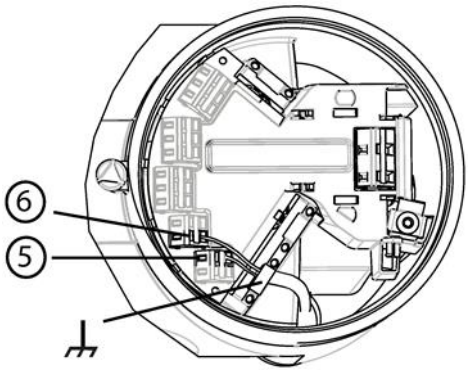


Active current output

⑤ C

④ Ca+

⏚ Functional Earth



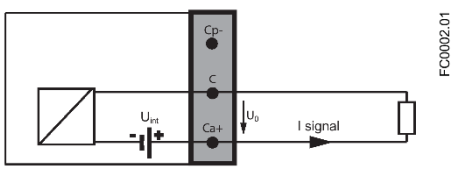
Passive current output

⑥ Cp-

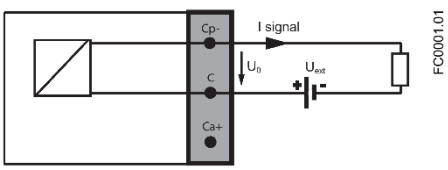
⑤ C

⏚ Functional Earth

Active current output



Passive current output



6. Tighten cable gland.

NOTE:

For Ex versions active or passive current output is preselected at ordering and cannot be changed.

Non-Ex versions can be connected as either active or passive.

NOTE:

Load

Signal output: < 500 Ω at 14 to 24 V DC (active), 14 to 30 V DC (passive)

Relay output: 30 V AC/V DC, 100 mA

Passive signal input: 15 to 30 V DC, 2 to 15 mA

Load [Ω]	Voltage (active Ex) [V]	Voltage (active non Ex) [V]	24 V DC Voltage supply (passive) [V] Ex and Non Ex
			Measured
100	3	3	17.7
200	5.9	5.9	19.6
500	11.4	14.9	21.0
1000	14.8	19.2	21.6
2000	17.4	20.1	21.9
5000	19.4	20.4	22.2
10000	20.3	21	22.3
20000	20	20.4	22.4
50000	20.4	20.6	22.5
100000	20.6	20.7	22.6

Tab. 3: HW polling address

3. HART commands

3.1. Device Variables

All four dynamic variables PV, SV, TV and QV are supported. Except for PV, they can all be freely mapped to all dynamic device variables. The following table shows the possible mappings.

Default values:

- PV = Mass Flow
- SV = Volume Flow
- TV = Density
- QV = Media temperature

Device Variable Number	Device Variable Name	PV	SV	TV	QV
0	Mass Flow	X	X	X	X
1	Volume Flow	X	X	X	X
2	Density	X	X	X	X
3	Fluid Temperature	X	X	X	X
4	Standard Volume Flow	X	X	X	X
5	Fractional Flow A	X	X	X	X
6	Fractional Flow B	X	X	X	X
7	Fractional Percentage Flow A	X	X	X	X
8	Fractional Percentage Flow B	X	X	X	X
9	Reference Density	X	X	X	X
10	Electronics Temperature TRN	X	X	X	X
11	Totalized Value 1		X	X	X
12	Totalized Value 2		X	X	X
13	Totalized Value 3		X	X	X
14	Frame Temperature	X	X	X	X
15	Totalized batch amount		X	X	X

Tab. 4: Device Variables

3.2. Universal commands

The device supports the following universal commands:

Command number	Function	Parameters	Read / Write / Command
0	Read Unique Identifier	254, device_type, request_preambles, universal_revision, transmitter_ revision, software_revision, hard-ware_revision <0xf8>, physical_ signaling_code <0x07>, device_flags, device_id, response_preambles, max_num_device_variables, con-fig_change_counter, extended_ fld_device_status, manufacturer_id, private_label_distributor, device_profile	Read
1	Read Primary Variable	PV.DEVICE_VARIABLE.DIGITAL_UNITS, PV.DEVICE_VARIABLE.DIGITAL_VALUE	Read
2	Read Loop Current And Percent Of Range	PV.DAQ.ANALOG_VALUE, PV.RANGING.PERCENT_RANGE	Read
3	Read Dynamic Variables And Loop Cur-rent	PV.DAQ.ANALOG_VALUE, PV.DEVICE_VARIABLE.DIGITAL_UNITS, SV.DEVICE_VARIABLE.DIGITAL_UNITS, SV.DEVICE_VARIABLE.DIGITAL_VALUE, TV.DEVICE_VARIABLE.DIGITAL_UNITS, TV.DEVICE_VARIABLE.DIGITAL_VALUE, QV.DEVICE_VARIABLE.DIGITAL_UNITS, QV.DEVICE_VARIABLE.DIGITAL_VALUE	Read
6	Write Polling Address	polling_address, loop_current_mode	Write
7	Read loop configuration	polling_address, loop_current_mode	Read
8	Read Dynamic Variable Classification	PV.DEVICE_VARIABLE.CLASSIFICATION, SV.DEVICE_VARIABLE.CLASSIFICATION, TV.DEVICE_VARIABLE.CLASSIFICATION, QV.DEVICE_VARIABLE.CLASSIFICATION	Read
9	Read Device Variable With Status		Read
11	Read Unique Identifier Associated With Tag	254, device_type, request_preambles, universal_revision, transmitter_revision, software_revision, hardware_revision <0xf8>, physical_signaling_code <0x07>, device_flags, device_id, response_preambles, max_num_device_variables, config_change_counter, extended_fld_device_status, manufacturer_id, private_label_distributor, device_profile	Read
12	Read Message	message	
13	Read Tag, Descriptor, Date	tag, descriptor, date	

Command number	Function	Parameters	Read / Write / Command
14	Read Primary Variable Transducer Information	PV.DEVICE_VARIABLE.SENSOR_SERIAL_NUMBER, PV.DEVICE_VARIABLE.DIGITAL_UNITS, PV.DEVICE_VARIABLE.UPPER_SENSOR_LIMIT, PV.DEVICE_VARIABLE.LOWER_SENSOR_LIMIT, PV.DEVICE_VARIABLE.MINIMUM_SPAN	
15	Read Device Information	PV.DAQ.ALARM_CODE, PV.RANGING.TRANSFER_FUNCTION, PV.RANGING.RANGE_UNITS, PV.RANGING.UPPER_RANGE_VALUE, PV.RANGING.LOWER_RANGE_VALUE, PV.DEVICE_VARIABLE.DAMPING_VALUE, write_protect, 250, PV.DAQ.ANALOG_CHANNEL_FLAGS	
16	Read Final Assembly Number	final_assembly_number	Read
17	Write Message	message	Write
18	Write Tag, Descriptor, Date	tag, descriptor, date	Write
19	Write Final Assembly Number	final_assembly_number	Write
20	Read Long Tag	longTag	Read
21	Read Unique Identifier Associated With Long Tag	254, device_type, request_preambles, universal_revision, transmitter_revision, software_revision, hardware_revision <0xf8>, physical_signaling_code <0x07>, device_flags, device_id, response_preambles, max_num_device_variables, config_change_counter, extended_fld_device_status, manufac-turer_id, private_label_distributor, device_profile	Read
22	Write Long Tag	longTag	Write
38	Reset Configuration Changed Flag		Command
48	Read Additional Device Status	device_specific_status_0, device_specific_status_1, device_specific_status_2, device_specific_status_3, device_specific_status_4, device_specific_status_5, extended_fld_device_status, 0x00	Read

Tab. 5: Universal commands

NOTE:

Command #15: Read Device Information / Write Protect Code

The device does not support Write Protection. Therefore the response to command #15 contains the Write Protect Code 251 (as specified in the HART specification).

3.3. Common practice commands

The device supports the following common practice commands:

Command number	Function
33	Read Device Variables
34	Write Primary Variable Damping Value
35	Write Primary Variable Range Values
36	Set Primary Variable Upper Range Value
37	Set Primary Variable Lower Range Value
40	Enter/Exit Fixed Current Mode
42	Perform Device Reset
44	Write Primary Variable Units
45	Trim Loop Current Zero
46	Trim Loop Current Gain
50	Read Dynamic Variable Assignments
51	Write Dynamic Variable Assignments
53	Write Device Variables Units
54	Read Device Variables Information
59	Write Number Of Response Preambles
60	Read Analog Channel And Percent Of Range
63	Read Analog Channel Information
70	Read Analog Channel Endpoint Values
95	Read Device Communications Statistics

Tab. 6: Common practice commands

3.4. Burst Mode

This device does not support Burst-Mode.

3.4.1. Catch Device Variable

This device does not support Catch Device Variable.

3.5. Device specific commands

3.5.1. Command #130: Read. User Login

Operation: READ

The access level of the HART fieldbus interface can be changed with this command.

By writing a wrong PIN or by timeout the HART-Access-Level falls back to the default access level.

The HART Access-Level is falling back to RUP after 10 minutes. Timeout is restarted with every Write-Access over HART.

Byte	Format	Description
None		

Byte	Format	Description
0...1 2	Unsigned-16 Enrum	Written User PIN Resulting Access-Level 16 (RUP) 32 (EUP) 64 (SUP)

Code	Class	Description	Explanation
0	Success	No Command-Specific Errors	
5	Error	Too few Data Bytes Received	Not enough data for User PIN
6	Error	Device Specific Command Error	

Quintessence

The device supports the following device-specific commands:

Command number	Function
130	User Login
131	Read Current HART Access Level
140	Read Parameter(s)
141	Write Parameter(s)
142	Read Unit Related Parameter(s)
143	Write Unit Related Parameter(s)
144	Read Device Variable Information
145	Read Unit Related Parameter(s)
146	Write Unit Related Parameter(s)

3.5.2. Command #131: Read, Current HART Access Level

Operation: READ

This command reads the currently set HART Access Level from the device.

Byte	Format	Description
None		

Byte	Format	Description
0	Enrum	Current Access Level 16 (RUP) 32 (EUP) 64 (SUP)

Code	Class	Description	Explanation
0	Success	No Command-Specific Errors	
6	Error	Device Specific Command Error	

3.5.3. Command #140: Read Parameter(s)

Operation: READ

This command is a general read access command, used to read one or more parameters from the device. The parameters to read are specified by MODBUS registers that are provided in the request data.

The value returned when reading a parameter is in its base unit e.g. m^3/s, kg/s, kg, m^3, °C (depending on the parameter definition).

For unit related readings of parameters see command #142.

Byte	Format	Description
0…1	Unsigned-16	MODBUS register of parameter 1
2…3	*Unsigned-16*	*MODBUS register of parameter 2*
*2*n-2… 2*n-1*	*Unsigned-16*	*MODBUS register of parameter n*

Tab. 7: Command #140: Read Parameter(s) - Request Data Bytes

Byte	Format	Description
0…?	<parameter-specific>	Value of parameter 1
	<parameter-specific>	*Value of parameter 2*
		…
	<parameter-specific>	*Value of parameter n*

Tab. 8: Command #140: Read Parameter(s) - Response Data Bytes

Code	Class	Description	Explanation
0	Success	No Command-Specific Errors	
2	Error	Invalid Selection	Register does not exist
5	Error	Too Few Data Bytes Received	Not enough data for a Modbus register
6	Error	Device Specific Command Error	
16	Error	Access Restricted	Modbus register is not readable
30	Error	Command Response Truncated	Response would be too large

3.5.4. Command #141: Write Parameter(s)

Operation: WRITE

This command is a general write access command, used to write one or more parameters to the device. The parameters to write are specified by MODBUS registers that are provided in the request data.

When writing floating-point values that are related to a unit (e.g. process value limits) the written value must be related to its base unit e.g. m³/s, kg/s, kg, m³, °C.

For unit related writings of parameters see command #143.

Byte	Format	Description
0…1	Unsigned-16	MODBUS register of parameter 1
2…?	<parameter-specific>	value of parameter 1 to be written
	Unsigned-16	*MODBUS register of parameter 2*
	<parameter-specific>	*value of parameter 2 to be written*
		…
	Unsigned-16	*MODBUS register of parameter n*
	<parameter-specific>	*value of parameter n to be written*

Tab. 9: Command #141: Write Parameter(s) - Request Data Bytes

Byte	Format	Description
0…1	Unsigned-16	MODBUS register of parameter 1
2…?	<parameter-specific>	value of parameter 1 as stored
	Unsigned-16	MODBUS register of parameter 2
	<parameter-specific>	*value of parameter 2 as stored*
		…
	Unsigned-16	*MODBUS register of parameter n*

Tab. 10: Command #141: Write Parameter(s) - Response Data Bytes

Code	Class	Description	Explanation
0	Success	No Command-Specific Errors	
2	Error	Invalid Selection	Register does not exist
3	Error	Parameter too large	Value is too large
4	Error	Parameter too small	Value is too small
5	Error	Too Few Data Bytes Received	not enough data for a Modbus register with data
6	Error	Device Specific Command Error	Invalid value
7	Error	Write Protected	Device is in write-protect-mode
8	Warning	Set to Nearest Possible Value	Value was adapted
16	Error	Access Restricted	Modbus register is not writeable

Tab. 11: Command #141: Write Parameter(s) - Command Specific Response Codes

3.5.5. Command #142: Write Parameter(s)

Operation: READ

This command is a general read access command, used to read one ore more parameters from the device in a specified unit (only for float-types, has no effect on other parameter types). The parameters to read are specified by MODBUS registers that are provided in the request data.

Byte	Format	Description
0..1	Unsigned-16	MODBUS register of parameter 1
2	Unsigned-8	Unit Classification to read parameter 1
3	Unsigned-8	Unit Code to read parameter 1
4…5	*Unsigned-16*	*MODBUS register of parameter 2*
6	*Unsigned-8*	*Unit Classification to read parameter 2*
7	*Unsigned-8*	*Unit Code to read parameter 2*
		…
*4*n-4… 4*n-3*	*Unsigned-16*	*MODBUS register of parameter n*
*4*n-2*	*Unsigned-8*	*Unit Classification to read parameter n*
*4*n-1*	*Unsigned-8*	*Unit Code to read parameter n*

Tab. 12: Command #142: Write Parameter(s) - Request Data Bytes

Byte	Format	Description
0…?	<parameter-specific>	Value of parameter 1
	<parameter-specific>	*Value of parameter 2*
		…
	<parameter-specific>	*Value of parameter n*

Tab. 13: Command #142: Write Parameter(s) - Response Data Bytes

Code	Class	Description	Explanation
0	Success	No Command-Specific Errors	
2	Error	Invalid Selection	• Register does not exist • Register is not readable • invalid unit classification/unit code combination
5	Error	Too Few Data Bytes Received	Not enough data for a Modbus register
6	Error	Device Specific Command Error	
30	Error	Command Response Truncated	Response would be too large

Tab. 14: Command #142: Write Parameter(s) - Command-Specific Response Codes

The product ignores the Unit Classification request bytes. They are kept for compatibility reasons.

The supported unit codes are listed in chapter 11 Supported Engineering Units.

3.5.6. Command #143: Write Parameter(s)

Operation: WRITE

This command is a general write access command, used to write one or more parameters in to the device in a specified unit (only for float-types, has no effect on other parameter types). The parameters to write are specified by MODBUS registers that are provided in the request data.

Byte	Format	Description
0..1	Unsigned-16	MODBUS register of parameter 1
2	Unsigned-8	Unit Classification to write parameter 1
3	Unsigned-8	Unit Code to write parameter 1
4…x	<parameter-specific>	value of parameter 1 to be written
	Unsigned-16	*MODBUS register of parameter 2*
	Unsigned-8	*Unit Classification to write parameter 2*
	Unsigned-8	*Unit Code to write parameter 2*
	<parameter-specific>	*value of parameter 2 to be written*
		…
	Unsigned-16	*MODBUS register of parameter n*
	Unsigned-8	*Unit Classification to write parameter n*
	Unsigned-8	*Unit Code to write parameter n*
	<parameter-specific>	*value of parameter n to be written*

Tab. 15: Command #143: Write Parameter(s) - Request Data Bytes

Byte	Format	Description
0..1	Unsigned-16	MODBUS register of parameter 1
2	Unsigned-8	Unit Classification of written parameter 1
3	Unsigned-8	Unit Code of written parameter 1
4…x	<parameter-specific>	value of parameter 1 as stored
	Unsigned-16	*MODBUS register of parameter 2*
	Unsigned-8	*Unit Classification of written parameter 2*
	Unsigned-8	*Unit Code of written parameter 2*
	<parameter-specific>	*value of parameter 2 as stored*
		…
	Unsigned-16	*MODBUS register of parameter n*
	Unsigned-8	*Unit Classification of written parameter n*
	Unsigned-8	*Unit Code of written parameter n*
	<parameter-specific>	*value of parameter n as stored*

Tab. 16: Command #143: Write Parameter(s) - Command-Specific Response Codes

Code	Class	Description	Explanation
0	Success	No Command-Specific Errors	
2	Error	Invalid Selection	• Register does not exist or • invalid unit classification/unit code combination
3	Error	Parameter too large	provided TRN parameter value is too large
4	Error	Parameter too small	provided TRN parameter value is too small

Code	Class	Description	Explanation
5	Error	Too Few Data Bytes Received	not enough data for a Modbus register with data
6	Error	Device Specific Command Error	Invalid value of SEN parameter
7	Error	Write Protected	Device is in write-protect-mode
8	Warning	Set to Nearest Possible Value	Value was adapted
16	Error	Access Restricted	Modbus register is not writeable

Tab. 17: Command #143: Write Parameter(s) - Response Data Bytes

The product ignores the Unit Classification request bytes. They are kept for compatibility reasons.

The supported unit codes are listed in chapter 11 Supported Engineering Units.

The unit code is only evaluated if the specified parameter is an floating-point parameter. If a unit code unequal to 0 is used for another data type the request is responded with an error.

3.5.7. Command #144: Read Device Variable Information

Operation: READ

The request is analog to HART Universal Command 9: For each requested PV send one byte defining the PV of interest, incl. the dynamic variables (see Common Table 34).

This command can be used to get the required information to use Commands 142+143 properly.

Byte	Format	Description
0	Unsigned-8	Device Variable Number for Slot 1
1	*Unsigned-8*	*Device Variable Number for Slot 2*
		…
n-1	*Unsigned-8*	*Device Variable Number for Slot n*

Tab. 18: Command #144: Read Device Variable Information - Request Data Bytes

Byte	Format	Description
0…1	Unsigned-16	MODBUS register of process value
2…3	Unsigned-16	MODBUS register of process value unit
4…5	Unsigned-16	MODBUS register of process value status
6	Unsigned-8	Unit Classification
7	Unsigned-8	Unit Code
8…11	Float	Process value related to the unit code
12	Unsigned-8	Process value status
13…16	Float	Lower process value limit related to the unit code
17…20	Float	Upper process value limit related to the unit code
21..41	<See 0…20>	Slot 2
		...
(n-1)*21 …(n*21)-1	<See 0…20>	Slot n

Tab. 19: Command #144: Read Device Variable Information - Response Data Bytes

Code	Class	Description	Explanation
0	Success	No Command-Specific Errors	
2	Error	Invalid Selection	Device Variable does not exist
5	Error	Too Few Data Bytes Received	At least one variable must be requested
6	Error	Device Specific Command Error	
30	Error	Command Response Truncated	Response would be too large

Tab. 20: Command #144: Read Device Variable Information - Command Specific Response Codes

3.5.8. Command #145: Read Unit Related Parameter(s)

This command is a general read access command, used to read one or more parameters from the device. Each unit related parameter has a reference to a unit parameter that is valid for the HART interface. The currently set unit is used to convert the returned parameter value (only for float-types, has no effect on other parameter types). The parameters to read are specified by HART registers that are provided in the request data.

Byte	Format	Description
0..1	Unsigned-16	HART register of parameter 1
2…3	*Unsigned-16*	*HART register of parameter 2*
		…
*2*n-2… 2*n-1*	*Unsigned-16*	*HART register of parameter n*

Tab. 21: Command #145: Read Unit Related Parameter(s) - Request Data Bytes

Byte	Format	Description
0…?	<parameter-specific>	Value of parameter 1
	<parameter-specific>	*Value of parameter 2*
		…
	<parameter-specific>	*Value of parameter n*

Tab. 22: Command #145: Read Unit Related Parameter(s) - Response Data Bytes

Code	Class	Description	Explanation
0	Success	No Command-Specific Errors	
2	Error	Invalid Selection	Register does not exist
5	Error	Too Few Data Bytes Received	Not enough data for a HART register
6	Error	Device Specific Command Error	
16	Error	Access Restricted	HART register is not readable
30	Error	Command Response Truncated	Response would be too large

Tab. 23: Command #145: Read Unit Related Parameter(s) - Command-Specific Response Codes

3.5.9. Command #146: Write Unit Related Parameter(s)

This command is a general read access command, used to read one or more parameters from the device. Each unit related parameter has a reference to a unit parameter that is valid for the HART interface. The currently set unit is used to convert the returned parameter value (only for float-types, has no effect on other parameter types). The parameters to read are specified by HART registers that are provided in the request data.

Byte	Format	Description
0...1	Unsigned-16	HART register of parameter 1
2...x	<parameter-specific>	value of parameter 1 to be written
	Unsigned-16	*HART register of parameter 2*
	<parameter-specific>	*value of parameter 2 to be written*
		...
	Unsigned-16	*HART register of parameter n*
	<parameter-specific>	*value of parameter n to be written*

Tab. 24: Command #146: Write Unit Related Parameter(s) - Request Data Bytes

Byte	Format	Description
0...1	Unsigned-16	HART register of parameter 1
2...x	<parameter-specific>	value of parameter 1 as stored
	Unsigned-16	*HART register of parameter 2*
	<parameter-specific>	*value of parameter 2 as stored*
		...
	Unsigned-16	*HART register of parameter n*
	<parameter-specific>	*value of parameter n as stored*

Tab. 25: Command #146: Write Unit Related Parameter(s) - Response Data Bytes

Code	Class	Description	Explanation
0	Success	No Command-Specific Errors	
2	Error	Invalid Selection	Register does not exist
3	Error	Parameter too large	provided value is too large
4	Error	Parameter too small	provided value is too small
5	Error	Too Few Data Bytes Received	not enough data for a HART register with data
6	Error	Device Specific Command Error	
7	Error	Write Protected	Device is in write-protect-mode
8	Warning	Set to Nearest Possible Value	Value was adapted
16	Error	Access Restricted	Parameter is not writeable

Tab. 26: Command #146: Write Unit Related Parameter(s) - Command-Specific Response Codes

3.6. Supported Engineering Units

The following table lists all engineering units supported by this device.

Byte	Format	Description
15	Volumetric Flow	cubic feet per minute
16	Volumetric Flow	US gallons per minute
17	Volumetric Flow	liters per minute
18	Volumetric Flow	imperial gallons per minute
19	Volumetric Flow	cubic meters per hour
22	Volumetric Flow	US gallons per second
23	Volumetric Flow	million US gallons per day
24	Volumetric Flow	liters per second
25	Volumetric Flow	million liters per day
26	Volumetric Flow	cubic feet per second
27	Volumetric Flow	cubic feet per day
28	Volumetric Flow	cubic meters per second
29	Volumetric Flow	cubic meters per day
30	Volumetric Flow	imperial gallons per hour
31	Volumetric Flow	imperial gallons per day
32	Temperature	Degrees Celsius
33	Temperature	Degrees Fahrenheit
34	Temperature	Degrees Rankine
35	Temperature	Kelvin
36	Voltage	millivolts
38	Frequency	Hertz
39	Current	milliamperes
40	Volume	US gallons
41	Volume	liters
42	Volume	imperial gallons
43	Volume	cubic meters
46	Volume	barrels (= 42 US gallons)
51	Time	seconds
57	Ratio	percent
60	Mass	grams
61	Mass	kilograms
62	Mass	metric tons
63	Mass	pounds
64	Mass	short tons
65	Mass	long tons
70	Mass Flow	grams per second
71	Mass Flow	grams per minute
72	Mass Flow	grams per hour
73	Mass Flow	kilograms per second
74	Mass Flow	kilograms per minute
75	Mass Flow	kilograms per hour
76	Mass Flow	kilograms per day
77	Mass Flow	metric tons per minute
78	Mass Flow	metric tons per hour

Byte	Format	Description
79	Mass Flow	metric tons per day
80	Mass Flow	pounds per second
81	Mass Flow	pounds per minute
82	Mass Flow	pounds per hour
83	Mass Flow	pounds per day
84	Mass Flow	short tons per minute
85	Mass Flow	short tons per hour
86	Mass Flow	short tons per day
87	Mass Flow	long tons per hour
88	Mass Flow	long tons per day
91	Density	grams per cubic centimeter
92	Density	kilograms per cubic meter
93	Density	pounds per US gallon
94	Density	pounds per cubic foot
95	Density	grams per milliliter
96	Density	kilograms per liter
97	Density	grams per liter
98	Density	pounds per cubic inch
99	Density	short tons per cubic yard
110	Volume	bushel
111	Volume	cubic yards
112	Volume	cubic feet
113	Volume	cubic inches
121	Standard Volumetric Flow	normal cubic meter per hour
122	Standard Volumetric Flow	normal liter per hour
123	Standard Volumetric Flow	standard cubic feet per minute
124	Volume	liquid barrels (= 31.5 US gallons)
125	Mass	ounces
130	Volumetric Flow	cubic feet per hour
131	Volumetric Flow	cubic meters per minute
132	Volumetric Flow	barrels (= 42 US gallons) per second
133	Volumetric Flow	barrels (= 42 US gallons) per minute
134	Volumetric Flow	barrels (= 42 US gallons) per hour
135	Volumetric Flow	barrels (= 42 US gallons) per day
136	Volumetric Flow	US gallons per hour
137	Volumetric Flow	imperial gallons per second
138	Volumetric Flow	liters per hour
146	Density	micrograms per liter
147	Density	micrograms per cubic meter
166	Standard Volume	normal cubic meters
167	Standard Volume	normal liters
168	Standard Volume	standard cubic feet
170	Density	milligrams per liter
	Volume	beer barrel
	Volumetric Flow	*beer barrel per second*
171	Standard Volume	standard liter
	Volumetric Flow	beer barrel per minute
172	Standard Volume	standard cubic meter
	Volumetric Flow	beer barrel per hour

Byte	Format	Description
173	Volumetric Flow	beer barrel per day
174	Standard Volumetric Flow	normal liter per day
175	Standard Volumetric Flow	normal liter per minute
176	Standard Volumetric Flow	normal liter per second
177	Standard Volumetric Flow	standard liter per day
178	Standard Volumetric Flow	standard liter per hour
179	Standard Volumetric Flow	standard liter per minute
180	Standard Volumetric Flow	standard liter per second
181	Standard Volumetric Flow	normal cubic meter per day
182	Standard Volumetric Flow	normal cubic meter per minute
183	Standard Volumetric Flow	normal cubic meter per second
184	Standard Volumetric Flow	standard cubic feet per day
185	Standard Volumetric Flow	standard cubic feet per hour
186	Standard Volumetric Flow	standard cubic feet per second
187	Standard Volumetric Flow	standard cubic meter per day
188	Standard Volumetric Flow	standard cubic meter per hour
189	Standard Volumetric Flow	standard cubic meter per minute
190	Corrected Volumetric Flow	standard cubic meter per second
235	Volumetric Flow	US gallons per day
236	Volume	hectoliters
253	Volume	Special (custom unit)
	Volumetric Flow	Special (custom unit)
	Standard Volumetric Flow	Special (custom unit)
	Mass	Special (custom unit)
	Mass Flow	Special (custom unit)

Tab. 27: Supported Engineering Units - Request Data Bytes

3.7. HART specific information table

In the following table available Modbus device parameters of the TRICOR TCD 9x00 are described.

Modbus register	Data type / Size in bytes	Para-meter	Description	Default value	Value range	Access level
2100	Unsigned / 1	Flow Direction	Define positive and negative flow direction. Default positive flow direction is indicated by the arrow on the sensor. Possible selections: 0: Negative: The flow is measured '+' in default negative direction and '-' in default positive direction. 1: Positive: The flow is measured '+' in default	1	0 to 1	Read/ Write

Modbus register	Data type / Size in bytes	Para-meter	Description	Default value	Value range	Access level
2130	Unsigned / 1	Process Noise Damping	Select process noise damping level: 0: 55 ms filtering (Centrifugal Pump) 1: 110 ms filtering (Triplex Pump) 2: 220 ms filtering (Duplex Pump) 3: 400 ms filtering (Simplex Pump) 4: 800 ms filtering (Cam Pump)	2	0 Low to 4 High	Read/ Write
2125	Float / 4	Low Mass Flow Cut-Off	Set Mass Flow limit for low flow cut-off. Below this limit Mass Flow output is forced to zero. If Low Flow Cut-Off is set to 0, the cut-off functionality is disabled. Notice: It is recommended to set a lower value for gas applica-tions.	Sensor size Specific	0 to 1023	Read/ Write
426	Float / 4	Mass Flow Correc-tion Factor	Specify correction factor for use in the Mass Flow calcula-tion	1	-1.999 to +1.999	Read/ Write

Tab. 28: HART specific information table - Operating conditions

Modbus register	Data type / Size in bytes	Para-meter	Description	Default value	Value range	Access level
2170	Float / 4	Low Volume-flow Cut Off	Define the numerical volu-meflow value below which the Volume Flow output is forced to zero.	Sensor size specific	0 to 0.177	Read/ Write

Tab. 29: HART specific information table - Volume Flow

Modbus register	Data type / Size in bytes	Para-meter	Description	Default value	Value range	Access level
2127	Float / 4	Empty Tube Limit	Define threshold value of empty tube	500 [kg/m^3]	-14 000 to +14 000	Read/ Write
2129	Unsigned / 1	Empty Tube Detection	Set automatic detection of Empty Tube On/Off 0 = off (Empty tube is off). 1 = on (a density value below Empty Tube Limit triggers an alarm. All flow rate values are forced to zero %).	0	0 to 1	Read/ Write
2442	Float / 4	Density Correc-tion Factor	Set density compensation value (gain) in order to make a density correction (scale factor). To increase the displayed density value with +0.5 %, set the density factor to 1.005. The displayed density value will now be 0.5 % higher than before	1	-1.999 to +1.999	Read/ Write
2444	Float / 4	Density Correc-tion Offset	Set density compensation value (offset) in order to make an offset on the measured density.	0 [kg/m^3]	-1 400 to +1 400	Read/ Write

Tab. 30: HART specific information table - Density

Modbus register	Data type / Size in bytes	Para-meter	Description	Default value	Value range	Access level
8303	Unsigned / 1	TOT1_SET	Control totalizer 1	0	0: TOTALIZE 1: RESET 2: PRESET 3: HOLD	Read/ Write
8403	Unsigned / 1	TOT2_SET	Control totalizer 2	0	0: TOTALIZE 1: RESET 2: PRESET 3: HOLD	Read/ Write
8503	Unsigned / 1	TOT3_SET	Control totalizer 3	0	0: TOTALIZE 1: RESET 2: PRESET 3: HOLD	Read/ Write

Tab. 31: HART specific information table - Totalizers

NOTE:

After the command Reset or Preset has been send to the device, the command Totalize must be send, to continue totalizing

Modbus register	Data type / Size in bytes	Para-meter	Description	Default value	Value range	Access level
7869	Unsigned / 1	ACTIVE_ FRACTION	Selection of the currently used fraction calibration parameter set	0	0: no fraction Standard Fractions: 1: American Petroleum Institute (API) number 2: Balling 3: Baumé light 4: Baumé heavy 5: Brix 6: Oechsle 7: Plato 8: Specific Gravity 9: Twaddell 10: % High Fructose Corn Syrup HFCS42 11: % High Fructose Corn Syrup HFCS55 12: % High Fructose Corn Syrup HFCS90 13: Ethanol-Water 0% to 20% 14: Ethanol-Water 15% to 35% 15: Ethanol-Water 30% to 55% 16: Ethanol-Water 50% to 100% 17...127: reserved Customized Fraction: 128: customized fraction	Read/ Write

Tab. 32: HART specific information table - Fraction

3.8. Example using HART command

3.8.1. Reset totalizer

Use the HART command 141: Write Parameter(s)

Command #141: Operation: WRITE

Byte	Format	Description
0...1	Unsigned-16	Modbus register of parameter 1
2...?	<parameter-specific>	value of parameter 1 to be written
	Unsigned-16	*Modbus register of parameter 2*
	<parameter-specific>	*value of parameter 2 to be written*
		...
	Unsigned-16	*Modbus register of parameter n*
	<parameter-specific>	*value of parameter n to be written*

Tab. 33: Reset totalizer - Request Data Bytes

Byte	Format	Description
0...1	Unsigned-16	Modbus register of parameter 1
2...?	<parameter-specific>	value of parameter 1 as stored
	Unsigned-16	*Modbus register of parameter 2*
	<parameter-specific>	*value of parameter 2 as stored*
		...
	Unsigned-16	*Modbus register of parameter n*
	<parameter-specific>	*value of parameter n as stored*

Tab. 34: Reset totalizer - Response Data Bytes

Code	Class	Description	Explanation
0	Success	No Command-Specific Errors	
2	Error	InHartvalid Selection	Register does not exist
3	Error	Parameter too large	provided value is too large
4	Error	Parameter too small	provided value is too small
5	Error	Too Few Data Bytes Received	not enough data for a HART-register with data
6	Error	Device Specific Command Error	
7	Error	Write Protected	Device is in write-protect-mode
8	Warning	Set to Nearest Possible Value	Value was adapted
16	Error	Access Restricted	HART-register is not writeable

Tab. 35: Reset totalizer - Command-Specific Response Codes

Request Data Bytes for Reset totalizer 1

Byte	Format	Description
0...1	Unsigned-16	206F
2...?	<parameter-specific>	01

Tab. 36: The HART information for Totalizer 1 is (8303 Dec) / (206F Hex)

Response Data Bytes for Totalize totalizer 1

Byte	Format	Description
0...1	Unsigned-16	206F
2...?	<parameter-specific>	01

Tab. 37: The HART information for Totalizer 1 is (8303 Dec) / (206F Hex)

3.9. Specification

This device has the following specifications:

Description	Specification	More information
Manufacturer ID	42 (2A Hex)	Manufacturer ID parameter
Device ID	34 (22 Hex)	Device type parameter
HART protocol revision	7.5	HART protocol revision parameter
Device revision	5	Device revision parameter
Number of device variables	16	Number of process values, both measured and derived
Physical layers supported	FSK	Frequency Shift Keyed

Tab. 38: Specification HART communication

4. Listings

4.1. List of Figures

4.2. List of Tables

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