KROHNE

System Technology

Communication
Instructions
for
IFC 010

HART® Communications Protocol

IFC010 Electromagnetic Flowmeter
Transmitter-Specific Command Specification

Revision #1

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1. Referenced Documents

HART Physical Layer Specification - Revision 7.0	D8900097
HART Data Link Layer Specification - Revision 7.0	D8900098
HART Command Summary Information - Revision 7.0	D9000048
HART Universal Command Specification - Revision 5.1	D8900038
HART Common-Practice Command Specification - Revision 7.0	D9000050
HART Common Tables - Revision 5.0	D9000051

2. Expanded Device Type Code

Manufacturer Identification Code = 69 (0x45)
Manufacturer¥s Device Type Code = 246 (0xF6)

The merger of these two 8-bit codes forms the 16-bit Expanded Device Type Code.

Expanded Device Type Code = 17910

3. IFC010 Conformance And Command Class Summary

Command Number	Description
CONFORMANCE CLASS #1	
	- UNIVERSAL
0	Read Unique Identifier
1	Read Primary Variable
CONFORMANCE CLASS #1A	
	- UNIVERSAL
0	Read Unique Identifier
2	Read Primary Variable Current and Percent of Range
CONFORMANCE CLASS #2	
	- UNIVERSAL
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-UNIVERSAL

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18 Write Tag, Descriptor, Date
19 Write Final Assembly Number

- COMMON-PRACTICE

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139 Write Analog Output Function
143 Write Pulse Output Parameters
145 Write Indication Function and Tripping Point
147 Write Primary Constant and Flow Direction
149 Write Language and User-Defined Unit
151 Control Zero Calibration
155 Write RS485 Communication Parameters

4. Additional Response Code Information

FIRST BYTE

4.1 Transmitter-Specific Command Error

Response code value 6 for IFC010 is not implemented. The IFC010 will respond and execute all commands at any time.

4.2 Update Failure

This response code (8) is returned if an EEPROM-burning process, activated via bus request, failed on any stage.

SECOND BYTE

4.3 Field Device Malfunction

Bit #7

This bit is set if any module of the standard instrument configuration: *ADC, I/O Standard* and *Display/Counter 1* - reports ìFatal Errorî. Refer also to Command #48, Read Additional Transmitter Status.

4.4 Configuration Changed

Bit #6

This flag is set whenever any configuration parameter is changed either via bus request or by direct instrument control via keypad. Note, that the instrument can run simultaneously two external protocols: via HART-bus and RS485-bus.

4.5 Primary Variable Analog Output Fixed

Bit #3

This flag is set under following conditions: when the function of current output is switched ìOffî or when fixed current mode is entered (Commands #40, #66).

4.6 Non-Primary Variable Out Of Limits

Bit #1

This flag is not implemented. The only non-primary variable having limits, namely *RawFlow* (refer to section 5.1), is limited as Primary Variable (*SmoothedFlow)* but is not damped. Therefore near the boundaries *RawFlow* might provide a random ìOut-of-Limitsî process.

4.7 Primary Variable Out Of Limits

Bit #0

This flag is set whenever the Primary Variable exceeds the Sensor Limits returned with Command #14, Read Primary Variable Sensor Information.

5. General Transmitter Information

5.1 Inputs/Outputs And Dynamic/Transmitter Variables

The IFC010 instrument has a fixed set of outputs: one current output, one frequency/pulse output and one binary status/indication output.

The IFC010 transmitter handles four measurement-related variables, hence Transmitter Variablesí set is composed from variables with indices:

0 - *RawFlow*
1 - *SmoothedFlow* (via damping)
2 - *PositiveTotalizer*
3 - *NegativeTotalizer.*

SmoothedFlow is always mapped onto the current output, thus providing a fixed setting for Primary Variable. The frequency/pulse output can deal with two possible assignments: *RawFlow* or *SmoothedFlow*. Therefore only values 0 and 1 are allowed as Secondary Variable code. Tertiary and Fourth Variables are mapped onto logical slots (no more outputs) and can therefore accept any allowed value (0..3).

5.2 Damping Implementation

The IFC010 transmitter implements damping on both the digital Primary Variable and its Analog Output. The Analog Output is calculated from the digital Primary Variable.

The rest Dynamic Variables have either the same Damping Value as Primary Variable, or no damping. It depends on the Secondary Variable Code (refer to Command #51, Write Dynamic Variable Assignments).

5.3 Nonvolatile Memory Data Storage

The Flags Byte of Command #0 will have Bit #1 (Command #39, EEPROM Control) set to 0, indicating that all data sent to the transmitter will be saved automatically in the device EEPROM upon receipt of the Write- or Command-type command, that require data storage. Command #39, EEPROM Control, is not implemented.

5.4 Multidrop Mode

This revision of the IFC010 supports Multidrop Mode.

5.5 Burst Mode

This revision of the IFC010 does not support Burst Mode.

6. Additional Universal Command Specifications

This section contains information pertaining to those commands that require clarification.

6.1 Command #0 Read Unique Identifier

Device Identification Number (Data bytes #9..#11 of response packet) is preserved in the instrument as a 4-bytes number. Hence only three (low significant) bytes of this number are ìvisibleî to HART-requester.

6.2 Command #14 Read Primary Variable Sensor Information

Sensor serial number is not stored within device and therefore is responded as Ñnot applicable to deviceì (zero value). Sensor parameters depend on the meter diameter and should be reread if the latter is changed.

6.3 Command #15 Read Primary Variable Output Information

Upper Range Value depends on the meter diameter. When the latter is changed, Upper Range Value will be automatically corrected if needed. In the last case bus master will be prompted about compulsory changes in correlated parameters via Warning-type Response Codes (refer to Command #131, Write Meter Diameter).

Write Protect Code variable (Data byte #15 of response packet) depends on the setting made for device variable Entry Code, Menu 3.4.

7. Additional Common-Practice Command Specifications

The IFC010 implements a subset of the Common-Practice Commands. This section contains information pertaining to those commands that require clarification.

7.1 Command #33 Read Transmitter Variables

Multiple transactions are supported: bus master can request from 1 to 4 Transmitter Variables (with codes 0..3) in arbitrary set.

7.2 Command #34 Write Primary Variable Damping Value

The IFC010 will accept any IEEE value in the range 0.2 to 99.9 seconds for the damping value.

7.3 Command #35 Write Primary Variable Range Values

Upper Range Value is rejected if it exceeds the Upper Sensor Limit or is below the Lower Sensor Limit (both Limits are available via Command #14). Rejection reason in these two cases is reported via predefined response codes, namely by code 11, Upper Range Value too High, or by code 12, Upper Range Value too Low. However, it might happen that a correct Upper Range Value for a given sensor causes the necessity to update the *PulseValue* variable of the instrument that plays the role of Upper Range Value for Secondary Variable and is based on the value of Primary Variable Upper Range. To handle correctly this situation, the predefined set of response codes for Command #35 was augmented by the two multi-definable warnings:

112, Pulse Value Exceeded Max and Was Corrected
113, Pulse Value Surpassed Min and Was Corrected

For additional information refer to Transmitter-Specific Commands #142/#143, Read/Write Pulsetype, Pulsewidth and Pulse Value.

Lower Range Value is always assumed to be zero for IFC010. Therefore this parameter in request packet is ignored. Transmitter returns zero value in response telegram without prompting master via special response code.

7.4 Command #40 Enter/Exit Fixed Primary Variable Current Mode

The instrument will accept any IEEE value in the range 3.5 to 25.0 mA as a desirable fixed current level. As required, zero value exits fixed current mode.

7.5 Command #43 Set Primary Variable Zero

An instant value of applied process (snapshot zero) is used to process this command. An alternative approach to calibration, when it is treated as a process, is realized via Transmitter-Specific Command #151, Control Zero Calibration.

7.6 Command #44 Write Primary Variable Units

The units selected for the Primary Variable (always *SmoothedFlow*) will also be the units for *RawFlow*. The latter variable depending on the settings made via Command #51, Write Dynamic Variable Assignments, can be mapped onto any Non-Primary Dynamic Variable, as described in section 5.1. Refer also to commentaries given for Command #51.

The Primary Variable Unit Codes accepted by this transmitter, are listed in Table 9.1.

NOTE: The transmitter software supports an expanded unitsí set for volumetrical flow, as compared with the software of the instrumentís display module. Therefore HART flowrate units are stored in the device EEPROM as *Full Scale Units* (Menus 1.1, 3.2.2) to avoid blank device screen when the latter displays flowrate measurements. Hence in the case of manual device control, the user will be initially presented with a blank screen for the *Full Scale Value* (in the Menus mentioned) if the HART master has set any expanded (for display module) unit. However, it mustnít bother - the actual value of *Full Scale* can be scrolled in all device internal units by the usage of *Up-key* on device keypad.

7.7 Command #45 Trim Primary Variable Current Dac Zero

The lower calibration point for the instrument is 4.0 mA. If this command is not preceded by command #40 with corresponding data field, the request will be rejected with Not In Proper Current Mode response code (9).

7.8 Command #46 Trim Primary Variable Current Dac Gain

The upper calibration point for the instrument is 20.0 mA. If this command is not preceded by command #40 with corresponding data field, the request will be rejected with Not In Proper Current Mode response code (9).

7.9 Command #48 Read Additional Transmitter Status

Reads 5 bytes of status data from the transmitter.
In designations used Bit #0 corresponds to LSBit, Bit #7 - to MSBit.

Data byte #0 - ADC module errors
- Bit #7 ADC fatal error
- Bit #6 Undefined
- Bit #5 Undefined
- Bit #4 Undefined
- Bit #3 Undefined
- Bit #2 Undefined
- Bit #1 Undefined
- Bit #0 Error in IMoCom configuration

Data byte #1 - Status of the blocks of global EEPROM
- Bit #7 Checksum error in the Device block
- Bit #6 Checksum error in the Communication block
- Bit #5 Checksum error in the Display block
- Bit #4 Checksum error in the Counter block
- Bit #3 Checksum error in the Control/Indicate block
- Bit #2 Checksum error in the Pulse/Frequency block
- Bit #1 Checksum error in the Current block
- Bit #0 Checksum error in the General block

Data byte #2 - Display module errors
- Bit #7 Display fatal error
- Bit #6 Undefined
- Bit #5 Undefined
- Bit #4 Undefined
- Bit #3 Undefined
- Bit #2 Undefined
- Bit #1 Undefined

Bit #0 Power fail detected

Data byte #3 - I/O module errors
Bit #7 Undefined
Bit #6 Undefined
Bit #5 Undefined
Bit #4 Undefined
Bit #3 Fatal error of Pulse Output
Bit #2 Undefined
Bit #1 Undefined
Bit #0 Undefined

Data byte #4 - I/O module errors
Bit #7 Undefined
Bit #6 Undefined
Bit #5 Undefined
Bit #4 Undefined
Bit #3 Undefined
Bit #2 Undefined
Bit #1 Fatal error of Status Output
Bit #0 Undefined

7.10 Command #50 Read Dynamic Variables Assignments

The possible mappings of Transmitter Variables into array of Dynamic Variables are already discussed in section 5.1, Inputs/Outputs and Dynamic/Transmitter Variables. On startup Dynamic Variables are configured as follows:

Primary Variable Code = 1, *SmoothedFlow*; permanent setting.
Secondary Variable Code = 0, *RawFlow*, or 1, *SmoothedFlow*, depending on the value of device variable *TimeConstantControl* (Menu 1.2), correspondingly *Only I* or *All*; variable setting.
Tertiary Variable Code = 2, *PositiveTotalizer*; variable setting.
Fourth Variable Code = 3, *NegativeTotalizer*; variable setting.

NOTE: Settings for Tertiary and Fourth Variables correspond to logical slots (not analog outputs) and therefore are stored in RAM. Hence any external changes in TV, QV code values will be actual until the first power-on or device-initiated reset.

7.11 Command #51 Write Dynamic Variables Assignments

Multiple transactions are supported. The sequence of request data bytes for every transaction is listed below.

TRANSACTION #0				
DATA BYTES	#0	#1	#2	#3
	PV	SV	TV	QV
	VAR	VAR	VAR	VAR
	CODE	CODE	CODE	CODE

TRANSACTION #1			
DATA BYTES	#0	#1	#2
	PV	SV	TV
	VAR	VAR	VAR
	CODE	CODE	CODE

TRANSACTION #2		
DATA BYTES	#0	#1
	PV	SV
	VAR	VAR
	CODE	CODE

TRANSACTION #3
DATA BYTES #0
PV
VAR
CODE

Changing of Dynamic Variable assignments must obey some restrictions (refer to sections 5.1, 7.10): Primary Variable Code must be ì1î, Secondary Variable Code must be either ì0î or ì1î,
Tertiary and Fourth Variables will accept any defined Transmitter Variable Code (from ì0î to ì3î). In the case of any error request packet will be rejected with response code 2, Invalid Selection.

7.12 Command #53 Write Transmitter Variable Units

If Transmitter Variable Code equals to ì0î or ì1î, flowrate units are changed (refer to Command #44). If Transmitter Variable Code corresponds to any totalizer (refer to section 5.1), the requested unit will affect all of them. The list of valid for this transmitter totalizersí unit codes is placed into Table 9.2.

7.13 Command #62 Read Analog Outputs

Two transactions are supported: bus master can request from 1 to 2 Analog Outputs (with codes ì1î for current output and ì2î - for pulse output) in arbitrary set. For pulse output the output value is responded in manufacturer specific units: ì249î, ìpulses per secondî.

7.14 Command #66 Enter/Exit Fixed Analog Output Mode

If this command is used to deal with current output, then Analog Output Number Code must be set to ì1î and Analog Output Units - to ì39î, mA. For details pertaining to Output Level refer to Command #40.

When Analog Output Units are set to ì57î (%) and any allowed Analog Output Number Code is selected, then a joint test of both outputs is carried out (Menu 2.1, Test Q). Itís **very important** that unlike Command #40, under this test the outputs behave as required by their functions, i.e. exactly as they will do in normal operating mode under the same circumstances. Say, if *FlowDirection* (Menu 3.2.6; Command #146, Read Primary Constant and Flow Direction) is set to ì- Dirî (logical positive direction) and the function of current output is set to *1 Dir* (Menu 1.5.1; Command #138, Read Analog Output Function), then for

flow = ± PV Upper Range Value

the output will be set to 20 mA value for ì+î measurements and to 4 mA - for ìnegativeî.

The Output Level defines a test value, in % of Primary Variable Upper Range Value, IEEE 754. Any value is accepted within the range -110%..+110%. If test value is out of this range, it is set to appropriate boundary; then responded value will reflect this.

As required, a request with NaN test level exits test mode.
NOTE: While exiting test mode, the Analog Output Units must be specified.

7.15 Command #67 Trim Analog Output Zero

Command can be used for calibration of the current output (Analog Output Number Code = 1). Refer to section 7.7.

7.16 Command #68 Trim Analog Output Gain

Command can be used for calibration of the current output (Analog Output Number Code = 1). Refer to section 7.8.

8. Transmitter-Specific Commands

8.1 Command #128 Read Hardware Information

Reads the identification code of every installed module/board.

REQUEST DATA BYTES

MODULE NUMBER CODE

RESPONSE DATA BYTES

#0	#1	#2	...	#11
MODULE NUMBER CODE	MODULE INST CODE	MODULE ID CODE BYTE #0		MODULE ID CODE BYTE #9

Data Byte #0 Module number code:
1 - Standard I/O module
2 - Enhanced I/O module
3 - Display/Counter module 1
4 - Display/Counter module 2
5 - Communication module
7 - ADC module

Data Byte #1 Module presence code:
0x00 - Module is installed
0xff - Module is not installed

Data Byte #2-#11 Moduleís identification data, ASCII. Data presentation is exactly the same as is used by the instrument display for the same goal: identification code for each module is transferred in a form ìX.XXXXX.XXî where ìXì corresponds to a decimal digit. An obtained value is meaningful only for installed modules.

NOTE: Module identification data is requested by HART software only on initialization stage (after power-on or hardware-driven reset).

COMMAND-SPECIFIC RESPONSE CODES

0	No Command-Specific Errors
1	Undefined
2	Invalid Selection
3-4	Undefined
5	Too Few Data Bytes Received
6-127	Undefined

8.2 Command #129 Read Device Implementation Code

Reads the implementation version of the instrument.

REQUEST DATA BYTES

NONE

RESPONSE DATA BYTES

#0

DEVICE
IMPLEM
CODE

Data Byte #0 Device implementation code:
0 - Ecoflux
1 - Aquaflux
15 - Special

COMMAND-SPECIFIC RESPONSE CODES

0	No Command-Specific Errors
1-127	Undefined

8.3 Command #130 Read Meter Diameter

Returns the meter size of the converter (Menu 3.2.1).

REQUEST DATA BYTES
NONE

RESPONSE DATA BYTES
#0
METER
SIZE
TABLE
INDEX

Data Byte #0 Diameter index of the meter size table 9.3.

COMMAND-SPECIFIC RESPONSE CODES

0	No Command-Specific Errors
1-127	Undefined

8.4 Command #131 Write Meter Diameter

Changes of the converter meter size **will force** the updating of sensor characteristics (returned by Command #14) and therefore might cause the automatic correction of the Primary Variable Upper Range Value (Menus 1.1, 3.2.2) and *PulseValue* (Menu 1.6.4). Master is prompted about corrections carried out via warning responses and **must** reread the updated data. For additional information refer to Command #35.

REQUEST DATA BYTES
#0
METER
SIZE
TABLE
INDEX

RESPONSE DATA BYTES
#0
METER
SIZE
TABLE
INDEX

Data Byte #0 Diameter index of the meter size table 9.3.

COMMAND-SPECIFIC RESPONSE CODES

0	No Command-Specific Errors
1-2	Undefined
3	Passed Parameter too Large
4	Passed Parameter too Small
5	Too Few Data Bytes Received
6	Undefined
7	In Write Protect Mode
8	Update Failure
9-113	Undefined
114	Range Exceeded Max and Was Corrected
115	Range Surpassed Min and Was Corrected
116	Both Range and Pulse Value Corrected
117-127	Undefined

8.5 Command #134 Read Low Flow Cutoff Control And Values

Reads low flow cutoff parameters (Menu 1.3).

REQUEST DATA BYTES

NONE

RESPONSE DATA BYTES

#0	#1	#2
CUTOFF CONTROL	CUTOFF ON VALUE	CUTOFF OFF VALUE

Data Byte #0 Cutoff control variable:
0 - cutoff option is switched Off
1 - cutoff option is switched On

Data Byte #1 Cutoff On Value, in 1/10% of the Primary Variable Upper Range Value (say, 5% will result in a value of 50 on a bus). When cutoff is switched Off (Data Byte #0 = 0), the instrument still uses the cutoff option, and the defaulted On Value is returned (that is not stored in EEPROM!). The latter might be either 0.1% or 1% depending on the *PulseType* value (refer to the instrument Operating Instructions.

Data Byte #2 Cutoff Off Value, in 1/10% of the Primary Variable Upper Range Value. When cutoff is switched Off (Data Byte #0 = 0), the instrument still uses the cutoff option, and the defaulted Off Value is returned (that is not stored in EEPROM!). The latter might be either 0.2% or 2% depending on the *PulseType* value (refer to the instrument Operating Instructions.

COMMAND-SPECIFIC RESPONSE CODES

0	No Command-Specific Errors
1-127	Undefined

8.6 Command #135 Write Low Flow Cutoff Control And Values

Writes low flow cutoff parameters.

REQUEST DATA BYTES

#0	#1	#2
CUTOFF CONTROL	CUTOFF ON VALUE	CUTOFF OFF VALUE

RESPONSE DATA BYTES

#0	#1	#2
CUTOFF CONTROL	CUTOFF ON VALUE	CUTOFF OFF VALUE

Data Byte #0 Cutoff control variable:
0 - to switch cutoff option Off ,
Any other value - to switch cutoff option On.
When the cutoff option is switched from On to Off, the rest data in request packet is ignored and therefore On/Off Values will not be altered in transmitter EEPROM.

Data Byte #1 Cutoff On Value, in 1/10% of the Primary Variable Upper Range Value (say, 5% will result in a value of 50 on a bus). This byte is meaningful only if Data Byte #0 ≠ 0. Value must belong to interval 10..190 (1..19%).

Data Byte #2 Cutoff Off Value, in 1/10% of the Primary Variable Upper Range Value. This byte is meaningful only if Data Byte #0 ≠ 0. Value must belong to interval 20..200 (2..20%).

Refer also to comments for the previous command.

COMMAND-SPECIFIC RESPONSE CODES

0	No Command-Specific Errors
1-4	Undefined
5	Too Few Data Bytes Received
6	Undefined
7	In Write Protect Mode
8	Update Failure
9	Off Value too High
10	Off Value too Low
11	On Value too High
12	On Value too Low
13	On Value not Lower than Off Value
14-127	Undefined

8.7 Command #136 Stop/Resume Totalizers

Depending on the value of control variable all totalizers are either frozen (regardless of measurement process) or resumed. After resumption frozen values are being initial ones for every totalizer. When totalizers are stopped, Commands #3, #33 will return for Transmitter Variables 2..3 corresponding constant (frozen) values.

REQUEST DATA BYTES

#0
TOTS CONTROL

RESPONSE DATA BYTES

#0
TOTS CONTROL

Data Byte #0 Totalizersí control variable:
0 - Stop totalizers,
Any other value - Resume totalizers.

COMMAND-SPECIFIC RESPONSE CODES

0	No Command-Specific Errors
1-4	Undefined
5	Too Few Data Bytes Received
6	Undefined
7	In Write Protect Mode
8	Update Failure
9-127	Undefined

8.8 Command #137 Reset Totalizers

Clears (sets to zero) both totalizers.

REQUEST DATA BYTES

NONE

RESPONSE DATA BYTES

NONE

COMMAND-SPECIFIC RESPONSE CODES

0	No Command-Specific Errors
1-6	Undefined
7	In Write Protect Mode
8	Update Failure
9-15	Undefined
16	Access Restricted
17-127	Undefined

8.9 Command #138 Read Analog Output Function

Reads the function of current/pulse output.

REQUEST DATA BYTES

#0
ANALOG
OUTPUT
NUMBER
CODE

RESPONSE DATA BYTES

#0	#1
ANALOG	ANALOG
OUTPUT	OUTPUT
NUMBER	FUNCTION
CODE	CODE

Data Byte #0 Analog Output Number Code, equals ì1î for current output and ì2î - for p ulse output

Data Byte #1 Analog Output Function Code:
0 - Off,
1 - 1 Dir, output traces flowrate measurements only in one direction,
3 - 2 Dir, output traces flowrate measurements in both directions.

COMMAND-SPECIFIC RESPONSE CODES

0	No Command-Specific Errors
1	Undefined
2	Invalid Selection

3-4	Undefined
5	Too Few Data Bytes Received
6-127	Undefined

8.10 Command #139 Write Analog Output Function

Writes the function of current/pulse output.

REQUEST DATA BYTES

#0	#1
ANALOG OUTPUT NUMBER CODE	ANALOG OUTPUT FUNCTION CODE

RESPONSE DATA BYTES

#0	#1
ANALOG OUTPUT NUMBER CODE	ANALOG OUTPUT FUNCTION CODE

Data Byte #0 Analog Output Number Code, equals ì1î for current output and ì2î - for pulse output

Data Byte #1 Analog Output Function Code, valid settings:
0 - Off,
1 - 1 Dir, output traces flowrate measurements only in one (forward) direction,
3 - 2 Dir, output traces flowrate measurements in both directions.

NOTE: In the case of incorrect function the request will be rejected with a response code 3, Passed Parameter too Large.

COMMAND-SPECIFIC RESPONSE CODES

0	No Command-Specific Errors
1	Undefined
2	Invalid Selection
3	Passed Parameter too Large
4	Undefined
5	Too Few Data Bytes Received
6	Undefined
7	In Write Protect Mode
8	Update Failure
9-127	Undefined

8.11 Command #142 Read Pulse Output Parameters

Reads adjustment parameters of the pulse output: *PulseType, PulseWidth, PulseValue.*

REQUEST DATA BYTES

NONE

RESPONSE DATA BYTES

#0	#1	#2	...	#5
PULSE TYPE	PULSE WIDTH	PULSE VAL MSB		PULSE VAL LSB

Data Byte #0 Pulse type, defines how pulses are generated at the output:

2 - 100 Hz
3 - 1000 Hz
8 - ìPulse/Volumeî
9 - ìPulse/Timeî.
For ìPulse/Volumeî setting one and the same number of pulses (established by *PulseValue*) correspond to a given volume unit. In the ìPulse/Timeî case *PulseValue* represents frequency that will be observed at the output if the measured flowrate equals to the the Primary Variable Upper Range Value. In both these cases maximal possible frequency depends on *PulseWidth* value.

Data Byte #1 — Pulse width, meaningful only for ìPulse/Volumeî or ìPulse/Timeî settings of *PulseType*:
5 - 50 msec
10 - 100 msec
20 - 200 msec
50 - 500 msec.

Data Byte #2-#5 — Pulse value per volume or time unit, depending on *PulseType* value, IEEE 754. Meaningful only for ìPulse/Volumeî or ìPulse/Timeî settings of *PulseType*. The related unit is based on Primary Variable Unit. Say, the latter is ìgal/minî. Then if *PulseType = 0*, *PulseValue* is responded in ìpulses per gallonî. For ìPulse/Timeî setting *PulseValue* is replied in ìpulses per minuteî unit.

NOTE: When *PulseType* is set to 100 Hz or 1000 Hz, the rest data fields in the response packet represent data that is not currently used by the instrument.

COMMAND-SPECIFIC RESPONSE CODES

0	No Command-Specific Errors
1-127	Undefined

8.12 Command #143 Write Pulse Output Parameters

Writes adjustment parameters of the pulse output: *PulseType*, *PulseWidth*, *PulseValue.*

REQUEST DATA BYTES

#0	#1	#2	...	#5
PULSE TYPE	PULSE WIDTH	PULSE VAL MSB		PULSE VAL LSB

RESPONSE DATA BYTES

#0	#1	#2	...	#5
PULSE TYPE	PULSE WIDTH	PULSE VAL MSB		PULSE VAL LSB

Data Byte #0 — Pulse type, defines how pulses are generated at the output:
2 - 100 Hz
3 - 1000 Hz
8 - ìPulse/Volumeî
9 - ìPulse/Timeî.

Data Byte #1 — Pulse width, meaningful only for ìPulse/Vo lumeî or ìPulse/Timeî settings of *PulseType*:
5 - 50 msec
10 - 100 msec
20 - 200 msec
50 - 500 msec.

Data Byte #2-#5 Pulse value per volume or time unit, depending on *PulseType* value, IEEE 754. Meaningful only for ìPulse/Volumeî or ìPulse/Timeî settings of *PulseType.* The related unit is based on Primary Variable Unit.

For more details refer to the previous section, 8.11.

CAUTION: *PulseWidth* should be changed only if the *PulseType* value is requested either as ìPulse/Volumeî or as ìPulse/Timeî!

NOTE: The requested *PulseWidth* value will be set to the nearest possible value within allowed set {5, 10, 20, 50}. If necessary, *PulseValue* will be set to the nearest possible value for a given *PulseWidth.* Master will be prompted about *PulseValue* corrections via warning-type response codes.

COMMAND-SPECIFIC RESPONSE CODES

0	No Command-Specific Errors
1	Undefined
2	Invalid Selection (of *PulseType*)
3-4	Undefined
5	Too Few Data Bytes Received
6	Undefined
7	In Write Protect Mode
8	Update Failure
9-111	Undefined
112	Pulse Value Exceeded Max and Was Corrected
113	Pulse Value Surpassed Min and Was Corrected
114-127	Undefined

8.13 Command #144 Read Indication Function And Tripping Point

Reads the function of the status indication output and tripping point.

REQUEST DATA BYTES

NONE

RESPONSE DATA BYTES

#0	#1	#2
STATUS INDICATION FUNCTION CODE	TRIPPING POINT MSB	TRIPPING POINT LSB

Data Byte #0 The function of the status binary output:
0 - All Errors,
1 - Fatal Error,
2 - Off,
3 - On,
4 - Forward/Reverse Indication,
5 - Tripping Point.

Data Byte #1-#2 Tripping point, unsigned integer, in 1/100% of the Primary Variable Upper Range Value (say, 5% will result in a value of 500 on a bus). The responded value is actually used by the instrument only when Data Byte #0 is set to ìTripping Pointî.

COMMAND-SPECIFIC RESPONSE CODES

0	No Command-Specific Errors
1-127	Undefined

8.14 Command #145 Write Indication Function And Tripping Point

Changes the function of the status indication output and tripping point value.

REQUEST DATA BYTES

#0	#1	#2
STATUS INDICATION FUNCTION CODE	TRIPPING POINT MSB	TRIPPING POINT LSB

RESPONSE DATA BYTES

#0	#1	#2
STATUS INDICATION FUNCTION CODE	TRIPPING POINT MSB	TRIPPING POINT LSB

Data Byte #0 The function of the status binary output:
0 - All Errors,
1 - Fatal Error,
2 - Off,
3 - On,
4 - Forward/Reverse Indication,
5 - Tripping Point.

Data Byte #1-#2 Tripping point, unsigned integer, in 1/100% of the Primary Variable Upper Range Value. The requested value will be stored in EEPROM (if correct) only when *StatusIndicationFunctionCode* equals to ìTripping Pointî. Otherwise this field is ignored by transmitter and replied back without any handling.
Valid settings: 200 ... 11500 (2% ... 115%).

COMMAND-SPECIFIC RESPONSE CODES

0	No Command-Specific Errors
1	Undefined
2	Invalid Selection (of *StatusIndicationFunctionCode*)
3	Passed Parameter too Large (*TrippingPoint*)
4	Passed Parameter too Small (*TrippingPoint*)
5	Too Few Data Bytes Received
6	Undefined
7	In Write Protect Mode
8	Update Failure
9-127	Undefined

8.15 Command #146 Read Primary Constant And Flow Direction

Reads the primary head constant GKL and the direction of flow related to the arrow on the primary head.

REQUEST DATA BYTES

NONE

RESPONSE DATA BYTES

#0	#1	#2	#3	#4
FLOW DIRECTION	PRIMARY HEAD VALUE MSB			PRIMARY HEAD VALUE LSB

Data Byte #0 0 - ì+ Dirî (corresponds to the arrow direction on primary head)
1 - ì- Dirî

Data Byte #1-#4 Primary head constant GKL, IEEE 754.

COMMAND-SPECIFIC RESPONSE CODES

0	No Command-Specific Errors
1-127	Undefined

8.16 Command #147 Write Primary Constant And Flow Direction

Writes the primary head constant GKL and flow direction.

REQUEST DATA BYTES

#0	#1	#2	#3	#4
FLOW DIRECTION	PRIMARY HEAD VALUE MSB			PRIMARY HEAD VALUE LSB

RESPONSE DATA BYTES

#0	#1	#2	#3	#4
FLOW DIRECTION	PRIMARY HEAD VALUE MSB			PRIMARY HEAD VALUE LSB

Data Byte #0 0 - ì+ Dirî (corresponds to the arrow direction on primary head)
1 - ì- Dirî

Data Byte #1-#4 Primary head constant GKL, IEEE 754. Valid settings: 1.0000 ... 9.9999 (refer to primary head nameplate).

COMMAND-SPECIFIC RESPONSE CODES

0	No Command-Specific Errors
1	Undefined
2	Invalid Selection (of *FlowDirection*)
3	Passed Parameter too Large (*PrimaryHeadValue*)
4	Passed Parameter too Small (*PrimaryHeadValue*)
5	Too Few Data Bytes Received
6	Undefined
7	In Write Protect Mode
8	Update Failure
9-127	Undefined

8.17 Command #148 Read Language And User-Defined Unit

Reads data defining user-created unit, and language that is used for text presentation on the local screen of the instrument.

REQUEST DATA BYTES

NONE

RESPONSE DATA BYTES

#0	#1	...	#5
DISPLAY	VOLUME		VOLUME

LANG CODE	UNIT TEXT BYTE #0		UNIT TEXT BYTE #4

#6 TIME UNIT TEXT BYTE #0	#7	#8 TIME UNIT TEXT BYTE #2	

#9 VOLUME UNIT FACTOR MSB	#10	#11	#12 VOLUME UNIT FACTOR MSB

#13 TIME UNIT FACTOR MSB	#14	#15	#16 TIME UNIT FACTOR LSB

Data Byte #0 Language:
0 - Gr.Britain/USA
1 - German
2 - French
3 - Purchased

Data Byte #1-#5 ASCII-text, specifying volume unit. Say, for US barrels liquid it can be ìUSBalî.

Data Byte #6-#8 ASCII-text, specifying time unit. Say, for minutes it can be ìminî.

Data Byte #9-#12 Scaling factor for volume unit, relative to cubic meters, IEEE 754. Say, for US barrels liquid it will be 8.36364.

Data Byte #13-#16 Scaling factor for time unit, relative to seconds, IEEE 754. Say, for minutes it will be 60.

COMMAND-SPECIFIC RESPONSE CODES

0	No Command-Specific Errors
1-127	Undefined

8.18 Command #149 Write Language And User-Defined Unit

Writes data defining user-created unit, and language that is used for text presentation on the local screen of the instrument.

REQUEST DATA BYTES

#0 DISPLAY LANG CODE	#1 VOLUME UNIT TEXT BYTE #0	...	#5 VOLUME UNIT TEXT BYTE #4

#6 TIME UNIT TEXT BYTE #0	#7	#8 TIME UNIT TEXT BYTE #2	

#9 VOLUME UNIT FACTOR MSB	#10	#11	#12 VOLUME UNIT FACTOR MSB
#13 TIME UNIT FACTOR MSB	#14	#15	#16 TIME UNIT FACTOR LSB

RESPONSE DATA BYTES

#0 DISPLAY LANG CODE	#1 VOLUME UNIT TEXT BYTE #0	...	#5 VOLUME UNIT TEXT BYTE #4
#6 TIME UNIT TEXT BYTE #0	#7	#8 TIME UNIT TEXT BYTE #2	
#9 VOLUME UNIT FACTOR MSB	#10	#11	#12 VOLUME UNIT FACTOR MSB
#13 TIME UNIT FACTOR MSB	#14	#15	#16 TIME UNIT FACTOR LSB

Data Byte #0 Language:
0 - Gr.Britain/USA
1 - German
2 - French
3 - Purchased

Data Byte #1-#5 ASCII-text, specifying volume unit.

Data Byte #6-#8 ASCII-text, specifying time unit.

Data Byte #9-#12 Scaling factor for volume unit, relative to cubic meters, IEEE 754. Refer to Table 9.4, Factors for Volume.

Data Byte #13-#16 Scaling factor for time unit, relative to seconds, IEEE 754. Refer to Table 9.5, Factors for Time.

NOTE: For ASCII-strings the following characters are allowed (i.e. will be interpreted by display module): A..Z, a..z, 0..9 and underscore symbol ì_î. Each text-field should be completely filled with acceptable symbols: say, for ìhoursî time unit ìhr_î-specifier should be used instead of ìhrî.

CAUTION: Scaling factors are not checked by transmitter and **must not** be zeroes!

COMMAND-SPECIFIC RESPONSE CODES

0	No Command-Specific Errors
1	Undefined
2	Invalid Selection (of *Language*)
3-4	Undefined
5	Too Few Data Bytes Received
6	Undefined
7	In Write Protect Mode
8	Update Failure
9-127	Undefined

8.19 Command #150 Enable/Disable Password Protection

Installs/uninstalls write protection. Two transaction are implemented: Transaction #1 disables write protection, in this case a correct password must be ìshownî to transmitter. If protection is disabled and device is open for write operations, any of two transactions can be used to enable factory-set password. Then the contents of *Password* field for Transaction #1 is ignored.

TRANSACTION #0

REQUEST DATA BYTES

#0
WRITE
PROT
CODE

RESPONSE DATA BYTES

#0
WRITE
PROT
CODE

TRANSACTION #1

REQUEST DATA BYTES

#0	#1	#2	#3	#4
WRITE	PROT			PROT
PROT	CODE			CODE
CODE	MSB			LSB

RESPONSE DATA BYTES

#0
WRITE
PROT
CODE

Data Byte #0 Write Protect Code, available via Command #15, Read Primary Variable Output Information:
0 - Not Write Protected
1 - Write Protected

Data Byte #1-#4 HART- encrypted password of the instrument, unsigned long. The encoding scheme is as follows: the ìRightî-key of device keypad is coded by digit ì0î, ìEnterî-key - by ì1î and ìUpî-key - by ì2î. For example, some arbitrary key combination ìRight-Right-Up-Up-Up-Right-Enter-Up-Upî will result in 2220122 (leading zeroes are defaulted for password operations anywhere).

NOTE: Any nonzero value of Write Protect Code will be interpreted by transmitter as a request to enable protection.

COMMAND-SPECIFIC RESPONSE CODES

0	No Command-Specific Errors
1-4	Undefined
5	Too Few Data Bytes Received
6-7	Undefined
8	Update Failure
9-14	Undefined
15	Wrong Password
16-127	Undefined

8.20 Command #151 Control Zero Calibration

Unlike Command #43, Set Primary Variable Zero, where an instant measurement is used to correct zero point, this command performs calibration exactly as if this process was activated via device keypad (Menu 3.3): 255 subsequent measurements are averaged before zero correction is done. The process lasts 3.5-5.5 sec (best and worse cases).

REQUEST DATA BYTES

#0
CAL
CONTROL
VAR

RESPONSE DATA BYTES

#0	#1
CAL	CAL
CONTROL	STATUS
VAR	

Data Byte #0 Calibration control variable:
0 - Exit calibration
1 - Start calibration
2 - Store calibration value
3 - Get calibration status

Data Byte #2 Calibration status corresponds to the number of iterations carried out. After 255 measurements are ìcollectedî, calibration as a process is finished, and calculated zero is preserved in RAM until Command #151 will be received with *StartCalibration* or *StoreCalValue* value of control variable.

NOTE: After calibration is activated, any subsequent *StartCalibration* request is ignored; for such requests zero is responded as *CalibrationStatus*. Until *StartCalibration* request is not concluded by either *ExitCalibration* or *StoreCalValue*, it will not be possible to start another calibration.

COMMAND-SPECIFIC RESPONSE CODES

0	No Command-Specific Errors
1	Undefined
2	Invalid Selection (Of Control Variable)
3-4	Undefined
5	Too Few Data Bytes Received
6	Undefined
7	In Write Protect Mode
8	Update Failure
9	No Zero Value (Iterationsí Number < 255)
10-127	Undefined

8.21 Command #152 Quit Errors

Delete/acknowledge error messages. Those errors will be deleted that became inactual, i.e. which reasons disappeared.

REQUEST DATA BYTES
NONE

RESPONSE DATA BYTES
NONE

COMMAND-SPECIFIC RESPONSE CODES

0	No Command-Specific Errors
1-7	Undefined
8	Update Failure
9-127	Undefined

8.22 Command #154 Read RS485 Communication Parameters

Reads the parameters of a serial communication that can run simultaneously with HART via RS485 interface.

REQUEST DATA BYTES
NONE

RESPONSE DATA BYTES

#0	#1
RS485 CONTROL BYTE	RS485 DEVICE ADDRESS

Data Byte #0 Bit-mapped control variable:

Bit #7..Bit #4 - RS485 baudrate:
0000 - ì1200î
0001 - ì2400î
0010 - ì4800î
0011 - ì9600î
0100 - ì19200î

Bit #3..Bit #0 - RS485 mode:
0000 - ìOffî
0100 - ìKROHNE Protocolî

Data Byte #1 The device bus address in RS485-based network.

COMMAND-SPECIFIC RESPONSE CODES

0	No Command-Specific Errors
1-127	Undefined

8.23 Command #155 Write RS485 Communication Parameters

Writes the parameters of a serial communication held via RS485 interface.

REQUEST DATA BYTES

#0	#1
RS485 CONTROL BYTE	RS485 DEVICE ADDRESS

RESPONSE DATA BYTES

	#0	#1
	RS485 CONTROL BYTE	RS485 DEVICE ADDRESS

Data Byte #0 Bit-mapped control variable:

Bit #7..Bit #4 - RS485 baudrate:
0000 - ì1200î
0001 - ì2400î
0010 - ì4800î
0011 - ì9600î
0100 - ì19200î

Bit #3..Bit #0 - RS485 mode:
0000 - ìOffî
0100 - ìKROHNE Protocolî

Data Byte #1 The device bus address in RS485-based network, valid settings: 0..249.

COMMAND-SPECIFIC RESPONSE CODES

0	No Command-Specific Errors
1-4	Undefined
5	Too Few Data Bytes Received
6-127	Undefined

9. Transmitter-Specific Tables

Refer to the Common Tables Document for all references in this section to ìSubset of Tableî.

9.1 Primary Variable Unit Codes

Subset of Table II, Unit Codes

24	liters/sec
17	liters/min
138	liters/hour
28	cubic meters/sec
131	cubic meters/min
19	cubic meters/hour
22	gallons/sec
16	gallons/min
136	gallons/hour
248	user defined

9.2 Totalizer Unit Codes

Subset of Table II, Unit Codes

40	gallons
41	liters
43	cubic meters

247 user defined

9.3 Meter Size Table

Index	Diameter	
	mm	inch
0	10	3/8
1	15	1/2
2	20	3/4
3	25	1
4	32	1 1/4
5	40	1 1/2
6	50	2
7	65	2 1/2
8	80	3
9	100	4
10	125	5
11	150	6
12	200	8
13	250	10
14	300	12
15	400	16
16	500	20
17	600	24
18	700	28
19	800	32
20	900	36
21	1000	40

NOTE: For Ecoflux implementation only the first 12 Table entries are possible (10 - 150 mm), while for Aquaflux any Table entry is allowable.

9.4 Factors For Volume

Unit	Factor
Cubic meters	1.0
Hectoliters	10.0
Deciliters	10 000.0
Centiliters	100 000.0
Milliliters	1 000 000.0
US gallons	264.172
Millions US gallons	0.000 264 172
Imperial gallons	219.969
Mega imperial gallons	0.000 219 969
Cubic feet	35.3146
Cubic inches	61 024.0
US barrels liquid	8.363 64
US barrels ounces	33 813.5

9.5 Factors For Time

Unit	Factor
Seconds	1
Minutes	60
Hours	3 600
Day	86 400

Year (=365 days)	31 536 000