KROHNE

System Technology

Communication
Instructions
for
UFC 500

HART™ Smart Communications Protocol

UFC500 Ultrasonic Flowmeter
Transmitter-Specific Command Specification

Revision #2

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CONTENTS

CONTENTS 2

1. REFERENCED DOCUMENTS 5

2. EXPANDED DEVICE TYPE CODE 5

3. UFC500 CONFORMANCE AND COMMAND CLASS SUMMARY 6

4. ADDITIONAL RESPONSE CODE INFORMATION 8

4.1 Busy 8

4.2 Transmitter-Specific Command Error 8

4.3 Configuration Changed 8

4.4 More Status Available 8

4.5 Primary Variable Analog Output Fixed 8

4.6 Primary Variable Analog Output Saturated 8

4.7 Primary Variable Out Of Limits 9

5. GENERAL TRANSMITTER INFORMATION 10

5.1 Inputs/Outputs And Dynamic/Transmitter Variables 10

5.2 Damping Implementation 10

5.3 Nonvolatile Memory Data Storage 10

5.4 Multidrop Mode 10

5.5 Burst Mode 10

6. ADDITIONAL UNIVERSAL COMMAND SPECIFICATIONS 11

6.1 Command #0 Read Unique Identifier 11

6.2 Command #2 Read P.V. Current And Percent Of Range 11

6.3 Command #6 Write Polling Address 11

6.4 Command #14 Read Primary Variable Sensor Information 11

6.5 Command #15 Read Primary Variable Output Information 11

7. ADDITIONAL COMMON-PRACTICE COMMAND SPECIFICATIONS 12

7.1 Command #33 Read Transmitter Variables 12

7.2 Command #34 Write Primary Variable Damping Value 12

7.3 Command #35 Write Primary Variable Range Values 12

7.4 Command #44 Write Primary Variable Units 12

7.5 Command #48 Read Additional Transmitter Status 13

7.6 Command #50 Read Dynamic Variables Assignments 13

7.7 Command #53 Write Transmitter Variable Units 13

7.8 Command #60 Read Analog Output And Percent Of Range 14

7.9 Command #66 Enter/Exit Fixed Analog Output Mode 14

8. TRANSMITTER-SPECIFIC COMMANDS 15

8.1 Command #130 Read Meter Size 15

8.2 Command #131 Write Meter Size 16

8.3 Command #132 Read Frequency/Pulse Output Damping Control 17

8.4 Command #133 Write Frequency/Pulse Output Damping Control 18

8.5 Command #134 Read Analog Output Low Flow Cutoff Control And Values 19

8.6 Command #135 Write Analog Output Low Flow Cutoff Control And Values 20

8.7 Command #137 Reset Totalizers 21

8.8 Command #138 Read Analog Output Function 22

8.9 Command #139 Write Analog Output Function 23

8.10 Command #140 Read Current Output Parameters 25

8.11 Command #141 Write Current Output Parameters 26

8.12 Command #142 Read Frequency/Pulse Output Parameters 27

8.13 Command #143 Write Frequency/Pulse Output Parameters 28

8.14 Command #146 Read Flow Direction And Primary Head Constant 30

8.15 Command #147 Write Flow Direction And Primary Head Constant 31

8.16 Command #148 Read User Data 32

8.17 Command #149 Write User Data 34

8.18 Command #150 Enable/Disable Password Protection 36

8.19 Command #151 Control Zero Calibration 38

8.20 Command #152 Quit Errors 39

8.21 Command #153 Read Error List 40

8.22 Command #156 Read Device-Specific Units And Enumerators 41

8.23 Command #157 Write Device-Specific Units And Enumerators 43

8.24 Command #158 Read Transmitter Variable Range Values 45

8.25 Command #159 Write Transmitter Variable Range Values 47

9. TRANSMITTER-SPECIFIC TABLES 49

9.1 Primary Variable Unit Codes 49

9.2 Totalizer Unit Codes 49

9.3 Pulse/Volume Unit Codes 49

9.4 Pulse/Time Unit Codes 50

10. RELEASE NOTES 51

10.1 Changes from Rev.1 to Rev.2 51

1. Referenced Documents

HART Physical Layer Specification - Revision 8.0	HCF_SPEC-54
HART Data Link Layer Specification - Revision 7.1	HCF_SPEC-81
HART Command Summary Information - Revision 7.1	HCF_SPEC-99
HART Universal Command Specification - Revision 5.2	HCF_SPEC-127
HART Common-Practice Command Specification - Revision 7.1	HCF_SPEC-151
HART Common Tables - Revision 9.0	HCF_SPEC-183

2. Expanded Device Type Code

Manufacturer Identification Code	= 69	(0x45)
Manufacturer¥s Device Type Code	= 245	(0xF5)

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

Expanded Device Type Code = 17909

3. UFC500 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
11	Read Unique Identifier Associated with Tag
12	Read Message
13	Read Tag, Descriptor, Date
14	Read Primary Variable Sensor Information
15	Read Primary Variable Output Information
16	Read Final Assembly Number
CONFORMANCE CLASS #3	
	- UNIVERSAL
3	Read All Dynamic Variables and Current
	- COMMON-PRACTICE
33	Read Transmitter Variables
48	Read Additional Transmitter Status
50	Read Dynamic Variable Assignments
60	Read Analog Output and Percent of Range
	- TRANSMITTER-SPECIFIC
130	Read Meter Size
132	Read Frequency/Pulse Output Damping Value
134	Read Analog Output Low Flow Cutoff Control and Values
138	Read Analog Output Function
140	Read Current Output Parameters
142	Read Frequency/Pulse Output Parameters
146	Read Flow Direction and Primary Head Constant
148	Read User Data
153	Read Error List
156	Read Device-Specific Units and Enumerators
158	Read Transmitter Variable Range Values
CONFORMANCE CLASS #4	
	- COMMON-PRACTICE
34	Write Primary Variable Damping Value
35	Write Primary Variable Range Values
36	Set Primary Variable Upper Range Value
38	Reset Configuration Changed Flag
66	Enter/Exit Fixed Analog Output Mode
	- TRANSMITTER-SPECIFIC
133	Write Frequency/Pulse Output Damping Value
137	Reset Totalizers
150	Enable/Disable Password Protection
152	Quit Errors
159	Write Transmitter Variable Range Values
CONFORMANCE CLASS #5	

	-UNIVERSAL
6	Write Polling Address
17	Write Message
18	Write Tag, Descriptor, Date
19	Write Final Assembly Number
	- COMMON-PRACTICE
44	Write Primary Variable Units
53	Write Transmitter Variable Units
59	Write Number of Response Preambles
	- TRANSMITTER-SPECIFIC
131	Write Meter Size
135	Write Analog Output Low Flow Cutoff Control and Values
139	Write Analog Output Function
141	Write Current Output Parameters
143	Write Frequency/Pulse Output Parameters
147	Write Flow Direction and Primary Head Parameters
149	Write User Data
151	Control Zero Calibration
157	Write Device-Specific Units and Enumerators

4. Additional Response Code Information

FIRST BYTE

4.1 Busy

Bit #5

The Busy Response Code is implemented for **every** command despite of its type (Read, Write or Command) and is reported if an EEPROM-burning operation was activated (by some preceeding command of Write or Command type), that is not yet concluded. The burning time cannot exceed 700 msec (the worst case), though normally is carried out within TT0 interval (256 ms). A confirming response is made before the execution begins (but after validation of a request data).

4.2 Transmitter-Specific Command Error

Response code value 6 for UFC500 implies that device is controllled directly via its keypad and is reserved for further transmitter revisions. For the present revision this response is overriden by the Busy Response Code: when the instrument is operated manually, HART application layer doesnít get control.

SECOND BYTE

All the flags that are implemented by transmitter, are listed below.

4.3 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.

4.4 More Status Available

Bit #4

The instrument status can be masked while handling this flag. The mask depends of the value of variable *ErrorMessageControl* (refer to Command #156). Bit #4 is set when the logical ìorî of the status and mask is nonzero. Note, that the bytes responded on Command #48, are not masked.

4.5 Primary Variable Analog Output Fixed

Bit #3

This flag is set under two conditions: when the function of current output is switched ìOffî or when fixed current mode is entered via bus request (Command #66).

4.6 Primary Variable Analog Output Saturated

Bit #2

Handled as specified.

4.7 Primary Variable Out Of Limits

Bit #0

This flag is set whenever the *FlowRate* Transmitter Variable (refer to section 5.1) 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 UFC500 instrument has one current output and one frequency/pulse output.

The UFC500 transmitter handles seven measurement-related variables, hence Transmitter Variablesí set is composed from variables with indices:

0 - *FlowRate*
1 - *PositiveTotalizer*
2 - *NegativeTotalizer*
3 - *Totalizersí Sum*
4 - *TransitTime*
5 - *Direction/ErrorIndication*
6 - *Off.*

Any variable except totalizer-related ones (with indices 1..3) can be mapped onto any of the two outputs. To keep Primary Variable always meaningful/informative it is set to *FlowRate* in case the function of current output is switched ìOffî. Therefore the Primary Variable codes belong to subset {0, 4, 5}, whilst Secondary Variable codes - to subset {0, 4, 5, 6}. Tertiary and Fourth Variables are mapped onto logical slots (no more outputs) and are fixed to *PositiveTotalizer* and *NegativeTotalizer* correspondingly.

5.2 Damping Implementation

The UFC500 transmitter implements the following scheme of analog/digital damping:

- When the *FlowRate* Transmitter Variable is a Primary one, both digital/analog dampings are the same and are handled via Command #34, Write Primary Variable Damping Value.
- When the current output is not related to flowrate measurements, it has no damping. Still the Command #34 immediately affects the *FlowRate* damping. After the *FlowRate* becomes a Primary variable, the current output will be damped with the same damping as digital variable.
- *TransitTime* Transmitter Variable has no damping. When it is mapped onto any output, the latter is not damped.
- Totalizer-related Transmitted Variables have all only digital presentation and one and the same damping: either 40 msec or the damping value of *FlowRate.* It depends on the value of *FreqPulseDampingControl* variable (refer to Command #132).
- When the *FlowRate* variable is a Secondary one (i.e. is mapped onto frequency/pulse output), the output uses either flowrate measurements damped with 40 msec, or *FlowRate* damping value. It depends on the value of *FreqPulseDampingControl* variable (refer to Command #132).

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 command or Command-type command #36. Command #39, EEPROM Control, is not implemented.

5.4 Multidrop Mode

This revision of the UFC500 does not support Multidrop Mode.

5.5 Burst Mode

This revision of the UFC500 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 10-bytes ASCII number (Service Fct. 5.1.4, ìSerial Nmbî). Hence only three (low significant) bytes of this number (after it is transferred to digital value) are ìvisibleî to HARTÆ-requester.

6.2 Command #2 Read P.V. Current And Percent Of Range

If the Primary Variable is assigned to *Direction* variable, the Percent of Range value is replied as Not-a-Number.

6.3 Command #6 Write Polling Address

This revision of the transmitter has an active current output and is not conformant with multidrop mode hardware requirements. Still the command can be used in point-to-point communication. The multidrop software support will not be changed when the further firmware release meets all specification restrictions.

On entering of multidrop mode shutdown of device current is performed: a fixed range of 4-20 mA is set and the function of Primary Variable current output is switched ìOffî. Refer to Commands #50, Read Dynamic Variable Assignments, #138, Read Analog Output Function, and #140, Read Current Output Parameters.

When multidrop mode is exited, all the parameters of the current output are restored.

6.4 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.

6.5 Command #15 Read Primary Variable Output Information

Upper Range Value depends on the meter diameter. When the latter is changed, Upper Range Value for *FlowRate* 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). No such correction is done when Primary Variable is set to *TransitTime*. In the latter case meter-conformant Range Values should be assigned via Command #159, Write Transmitter Variable Range Values.

Write Protect Code variable (Data byte #15 of response packet) depends on the setting made for device variable Entry Code, Menu 3.5.2. It can be altered via Command #150, Enable/Disable Password Protection.

7. Additional Common-Practice Command Specifications

The UFC500 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..7) in arbitrary set.

7.2 Command #34 Write Primary Variable Damping Value

The UFC500 will accept any IEEE value in the range 0.04 to 3600 seconds for the damping value.

7.3 Command #35 Write Primary Variable Range Values

Despite of the actual Primary Variable assignment (*FlowRate, TransitTime, Direction*), this command **always** handles **only** the *FlowRate* range specifiers for **forward** flow. Similar parameters for *TransitTime* and reverse flow are controlled via Commands #158/#159, Read/Write Transmitter 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 *FlowRate* measurements, when the latter are mapped onto the frequency/pulse output. *PulseValue* upper limit is based on the value of Primary Variable Upper Range. Besides, the reverse flow can be scaled with its own Upper Range, though it cannot exceed the Primary Variable Upper Range. To handle correctly these situations, the predefined set of response codes for Command #35 was augmented by the following multi-definable warnings:

112, Pulse Value Exceeded Max and Was Corrected
113, Pulse Value Surpassed Min and Was Corrected
114, Reverse Range Exceeded Max and Was Corrected
115, Reverse Range Surpassed Min and Was Corrected

Note, that each subsequent correction carried out overrides the reported response code. At first Reverse Range is checked. Therefore if response codes 114/115 are registered then only the updated Reverse Range should be reread from device. For response codes 112/113 both Pulse Value and Reverse Range should be reread though the last variable could remain unchanged.

For additional information refer to Command #142, Read Pulse Output Parameters.

Lower Range Value is always assumed to be zero for UFC500. 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 #44 Write Primary Variable Units

Despite of the actual Primary Variable assignment (*FlowRate, TransitTime, Direction/ErrorIndication* or *Off*), this command **always** handles **only** the *FlowRate* units: *TransitTime* variable has a fixed unit and the rest have none.

The Primary Variable Unit Codes accepted by transmitter include all the HCF units for volumetric flow except the ones for gaseous media, and are listed in Table 9.1.
As soon as transmitter supports incomparably enlarged unitsí set as opposed to the instrumentís display module, the impact on the device remote/direct control is straightforward and as follows: transmitter units are made completely

independent from the display units and hence are stored separately in the device EEPROM. Hence it is worth noting that remote user **mustnët expect** any changes in data presentation on the device local screen when any units are changed externally (from the HARTÆ bus).
It must be also noted that PV units are shared with configuration parameters having volumetric flow units (*Full Scale*, sensor limits, etc.).

7.5 Command #48 Read Additional Transmitter Status

Reads 2 bytes of status data from the transmitter. Unlike Command #153, Read Error List, this command returns a combined error list: some of them are actual at response time while the others are no more active but were not still presented to master since the last ìQuitî action (Command #152).

In designations used Bit #0 corresponds to LSBit, Bit #7 - to MSBit.

Data byte #0:

- Bit #7 Fuse error
- Bit #6 Data error in EEPROM 2 (totalizer)
- Bit #5 Current calibration values in EEPROM 1+2 are different
- Bit #4 Current output overranged
- Bit #3 Frequency/pulse output overranged
- Bit #2 US path 2 faulted
- Bit #1 Empty pipe
- Bit #0 US path 1 faulted

Data byte #1:

- Bit #7 Checksum error in ROM
- Bit #6 Checksum error in RAM
- Bit #5 NVRAM error
- Bit #4 Calibration data lost
- Bit #3 Data error in EEPROM 1 (parameters)
- Bit #2 Irregular flow
- Bit #1 Counts lost or totalizer overflow
- Bit #0 Power failure

7.6 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 - depends on the function of the current output and is either of {0, 4, 5}; variable setting. In case current output is switched ìOffî (on startup or during normal instrument operation), PV is set to *FlowRate.*
Secondary Variable Code - depends on the function of the frequency/pulse output and is either of {0, 4, 5, 6}; variable setting.
Tertiary Variable Code = 1, *PositiveTotalizer*; permanent setting.
Fourth Variable Code = 2, *NegativeTotalizer*; permanent setting.

Output functions are available via Command #138, Read Analog Output Function.

NOTE: Command #51, Write Dynamic Variables Assignment, is not implemented. Primary/Secondary Variable Codes are affected by Command #139, Write Analog Output Function. Therefore to provide consistency in device-master data sets, Command #50 **must** be reissued after Command #139 is processed.

7.7 Command #53 Write Transmitter Variable Units

If Transmitter Variable Code equals to ì0î, 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.

Note that for totalizer measurements transmitter supports all the HCF units for volume except the ones for gaseous media. The device display can make use only of some small subset of corresponding HCF/transmitter units. The impact of these on the instrument remote/direct control is detailed in section 7.4, ìWrite Primary Variable Unitsî.

7.8 Command #60 Read Analog Output And Percent Of Range

If the requested output currently deals with *Direction* or *Off* variable, the Percent of Range value is replied as Not-a-Number.

The output value for the pulse output is responded either in manufacturer specific units ì249î, ìpulses per secondî - for *FlowRate* or *TransitTime* variables, or in ìVoltsî (58) - for *Direction* or *Off* variables.

7.9 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. The instrument will accept any IEEE value in the range 0.0 to 22.0 as a desirable fixed current level.

While testing pulse output, set Analog Output Number Code to ì2î and Analog Output Units - to ì249î, ìpulses per secondî. The instrument will accept any IEEE value in the range 0.0 to 10000.0 as a desirable fixed output level.

Without external stimulus the instrument will leave HART-activated fixed output mode in 2 minutes.

8. Transmitter-Specific Commands

8.1 Command #130 Read Meter Size

Returns the meter size of the converter (Menu 3.1.5).

REQUEST DATA BYTES

NONE

RESPONSE DATA BYTES

#0	#1	#2	#3
METER SIZE MSB			METER SIZE LSB

Data Byte #0-#3 Meter size, IEEE 754, in meters.

COMMAND-SPECIFIC RESPONSE CODES

0	No Command-Specific Errors
1-5	Undefined
6	Local Device User
7-127	Undefined

8.2 Command #131 Write Meter Size

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 1.1.1, 3.1.1) and *PulseValue* (Menu 3.4.3). 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	#1	#2	#3
METER SIZE MSB			METER SIZE LSB

RESPONSE DATA BYTES

#0	#1	#2	#3
METER SIZE MSB			METER SIZE LSB

Data Byte #0-#3 Meter size, IEEE 754, in meters. Allowed settings: 0.025 to 4 meters (0.98 to 157.48 inches).

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	Local Device User
7	In Write Protect Mode
8-113	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

8.3 Command #132 Read Frequency/Pulse Output Damping Control

Returns the control variable for the damping to be used on device frequency/pulse output.

REQUEST DATA BYTES

NONE

RESPONSE DATA BYTES

#0	#1	Ö	#13
PULSE DAMPING CONTROL	FW IDENT NUMBER		FW IDENT NUMBER
#14	Ö	#23	
RELEASE DATE		RELEASE DATE	

Data Byte #0 Damping control for the frequency/pulse output:
0 - Damping value is fixed to 40 ms,
1 - The same as for current output (Primary Variable Damping Value).

Data Byte #1..#13 Device firmware identification number, ASCII, e.g. ì 6.97.002.87 ì.

Data Byte #14..#23 Device release date, ASCII, e.g. ì09.07.2001î .

COMMAND-SPECIFIC RESPONSE CODES

0	No Command-Specific Errors
1-5	Undefined
6	Local Device User
7-127	Undefined

8.4 Command #133 Write Frequency/Pulse Output Damping Control

Defines the damping value to be used on device frequency/pulse output.

REQUEST DATA BYTES

#0
FREQ/PULSE
DAMPING
CONTROL

RESPONSE DATA BYTES

#0
FREQ/PULSE
DAMPING
CONTROL

Data Byte #0	Damping control for the frequency/pulse output: 0 - Damping value is fixed to 40 ms, Any other value - The same as for current output (Primary Variable Damping Value).

COMMAND-SPECIFIC RESPONSE CODES

0	No Command-Specific Errors
1-4	Undefined
5	Too Few Data Bytes Received
6	Local Device User
7	In Write Protect Mode
8-127	Undefined

8.5 Command #134 Read Analog Output Low Flow Cutoff Control And Values

Reads low flow cutoff parameters of the requested output.

REQUEST DATA BYTES

#0
ANALOG OUTPUT NUMBER CODE

RESPONSE DATA BYTES

#0	#1	#2	#3
ANALOG OUTPUT NUMBER CODE	CUTOFF CONTROL	CUTOFF ON VALUE	CUTOFF OFF VALUE

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

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

Data Byte #2 Cutoff On Value, in % of the Primary Variable Upper Range Value. When cutoff is switched Off (Data Byte #1 = 1), the instrument still uses the cutoff option, but with defaulted On Value, namely 0.1%. Nevertheless, bus master will be presented with the On Value, that is stored in EEPROM, but is not currently in use.

Data Byte #3 Cutoff Off Value, in % of the Primary Variable Upper Range Value. When cutoff is switched Off (Data Byte #1 = 1), the instrument still uses the cutoff option, but with defaulted Off Value, namely 0.25%. Nevertheless, bus master will be presented with the Off Value, that is stored in EEPROM, but is not currently in use.

COMMAND-SPECIFIC RESPONSE CODES

0	No Command-Specific Errors
1	Undefined
2	Invalid Selection
3-4	Undefined
5	Too Few Data Bytes Received
6	Local Device User
7-127	Undefined

8.6 Command #135 Write Analog Output Low Flow Cutoff Control And Values

Writes low flow cutoff parameters for any of the two outputs.

REQUEST DATA BYTES

#0	#1	#2	#3
ANALOG OUTPUT NUMBER CODE	CUTOFF CONTROL	CUTOFF ON VALUE	CUTOFF OFF VALUE

RESPONSE DATA BYTES

#0	#1	#2	#3
ANALOG OUTPUT NUMBER CODE	CUTOFF CONTROL	CUTOFF ON VALUE	CUTOFF OFF VALUE

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

Data Byte #1 Cutoff control variable:
0 - enables cutoff option,
1 - disables cutoff option.
Even when the cutoff option is switched from On to Off, the rest data in request packet is processed and the On/Off Values will be altered in transmitter EEPROM.

Data Byte #2 Cutoff On Value, in % of the Primary Variable Upper Range Value. This byte is meaningful even if Data Byte #0 = 0. Value must belong to interval 1..19%.

Data Byte #3 Cutoff Off Value, in % of the Primary Variable Upper Range Value. This byte is meaningful even if Data Byte #0 = 0. Value must belong to interval 2..20%.

Refer also to comments for the previous command.

NOTE: Low flow cutoff settings can be altered only when the function of corresponding output is related to flowrate measurements. Refer to Command #138, Read Analog Output Function.

COMMAND-SPECIFIC RESPONSE CODES

0	No Command-Specific Errors
1	Undefined
2	Invalid Selection (of Analog Output)
3-4	Undefined
5	Too Few Data Bytes Received
6	Local Device User
7	In Write Protect Mode
8	Undefined
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	Undefined
15	Invalid Cutoff Control or Output Function
16-127	Undefined

8.7 Command #137 Reset Totalizers

Clears (sets to zero) either any of the two totalizers (positive and negative) or both of them.

REQUEST DATA BYTES

#0
TOTALIZER
RESET
CONTROL

RESPONSE DATA BYTES

#0
TOTALIZER
RESET
CONTROL

Data Byte #0 A control variable, selecting totalizer(s) to be reset:
1 - positive totalizer,
2 - negative totalizer,
3 - both totalizers, i.e. *Totalizersí Sum* variable.

NOTE: Response Code 16, Access Restricted, is returned when *EnableReset* control variable (Menu 3.5.10) is set to ìNoî. Refer to Commands #148/#149, Read/Write User-Defined Unit and Auxiliary Controls.

COMMAND-SPECIFIC RESPONSE CODES

0	No Command-Specific Errors
1	Undefined
2	Invalid Selection (of Totalizer)
3-4	Undefined
5	Too Few Data Bytes Received
6	Local Device User
7	In Write Protect Mode
8-15	Undefined
16	Access Restricted
17-127	Undefined

8.8 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 pulse output

Data Byte #1 Analog Output Function Code, depends on the output type:

For current output:
0 - Off.
1 - Direction indication.
2 - 1 Dir, output traces flowrate measurements only in one (positive) direction.
3 - Forward/reverse flow, the complete flowrate dynamic range (PV Upper Range Value + Reverse Range) is mapped onto the range of the output current. Refer also to the instrument Operating Manual and to Commands #140, Read Current Output Parameters, #158, Read Transmitter Variable Range Values.
4 - 2 Dir, output traces flowrate measurements in both directions, for every direction the corresponding flowrate dynamic range (PV Upper Range Value for positive direction and Reverse Range - for negative) is mapped onto the range of the output current. Refer also to the instrument Operating Manual and to Commands #140, Read Current Output Parameters, #158, Read Transmitter Variable Range Values.
5 - Transit time.

For frequency/pulse output:
0 - Off.
1 - Error indication.
2 - 1 Dir, output traces flowrate measurements only in one (positive) direction.
3 - 2 Dir, output traces flowrate measurements in both directions.
4 - Transit time.

COMMAND-SPECIFIC RESPONSE CODES

0	No Command-Specific Errors
1	Undefined
2	Invalid Selection (of Analog Output)
3-4	Undefined
5	Too Few Data Bytes Received
6	Local Device User
7-127	Undefined

8.9 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 frequency/pulse output

Data Byte #1 Analog Output Function Code, depends on the output type:

For current output:
0 - Off.
1 - Direction indication.
2 - 1 Dir, output traces flowrate measurements only in one (positive) direction.
3 - Forward/reverse flow, the complete flowrate dynamic range (PV Upper Range Value + Reverse Range) is mapped onto the range of the output current. Refer also to the instrument Operating Manual and to Commands #140, Read Current Output Parameters, #158, Read Transmitter Variable Range Values.
4 - 2 Dir, output traces flowrate measurements in both directions, for every direction the corresponding flowrate dynamic range (PV Upper Range Value for positive direction and Reverse Range - for negative) is mapped onto the range of the output current. Refer also to the instrument Operating Manual and to Commands #140, Read Current Output Parameters, #158, Read Transmitter Variable Range Values.
5 - Transit time.

For frequency/pulse output:
0 - Off.
1 - Direction indication.
2 - 1 Dir, output traces flowrate measurements only in one (positive) direction.
3 - 2 Dir, output traces flowrate measurements in both directions.
4 - Transit time.

NOTE: The Output Function Codes are mapped onto Primary/Secondary Variable Codes in a transparent way: flowrate-related values (ì1 Dirî, ìForward/Reverseî, ì2 Dirî) cause the assignment of corresponding Dynamic Variable to *FlowRate* Transmitter Variable (refer to section 5.1), the rest dependencies are straightforward. The only exclusion here is situation when the current output function is switched ìOffî ñ then PV code is set to *FlowRate*, thus preserving the valuable data to be delivered with Command #1. To maintain actual Dynamic Variablesí configuration, master have to use Command #139 in a pair with Command #50, Read Dynamic Variable Assignments.

Changes in Primary/Secondary Variable setting are reflected at the outputs after the command is processed.

Several transitions in Analog Output Function settings require some preliminary actions (i.e. reprogramming of frequency/pulse output) that are not automatically done by the HART transmitter. In these cases master is noticed about an action to be held via appropriate Response Code. Refer also to the instrument Operating Manual.

COMMAND-SPECIFIC RESPONSE CODES

0	No Command-Specific Errors
1	Undefined
2	Invalid Selection (of Analog Output)
3	Passed Parameter too Large (Analog Output Function Code)
4	Undefined
5	Too Few Data Bytes Received
6	Local Device User
7	In Write Protect Mode
8	Undefined
9	Disable Low Flow Cutoff for Current Output
10	Disable Low Flow Cutoff for Frequency/Pulse Output
11	In Multidrop Mode
12	Disable Low Flow Cutoff for Frequency/Pulse Output and Set Pulse Rate
13-127	Undefined

8.10 Command #140 Read Current Output Parameters

Reads a set of parameters for device current output.

REQUEST DATA BYTES

NONE

RESPONSE DATA BYTES

#0	#1	#2	#3
FIXED	CURRENT	CURRENT	CURRENT
VAR	MAX	ZERO	HUNDRED
RANGE		PCT	PCT
INDIC		FLOW	FLOW

Data Byte #0 Fixed/variable range indicator:
0 - Variable range,
1 - Fixed range 0 - 20 mA,
2 - Fixed range 4 - 20 mA.

Data Byte #1 Maximal possible output current, in mA.

Data Byte #2 The value of current in mA, that corresponds to 0% flow (percents are related to Primary Variable Upper Range Value).

Data Byte #3 The value of current in mA, that corresponds to 100% flow (percents are related to Primary Variable Upper Range Value for the forward flow, or to the Reverse Range for the backward flow).

COMMAND-SPECIFIC RESPONSE CODES

0	No Command-Specific Errors
1-5	Undefined
6	Local Device User
7-127	Undefined

8.11 Command #141 Write Current Output Parameters

Writes a set of parameters for device current output.

REQUEST DATA BYTES

#0	#1	#2	#3
FIXED	CURRENT	CURRENT	CURRENT
VAR	MAX	ZERO	HUNDRED
RANGE		PCT	PCT
INDIC		FLOW	FLOW

RESPONSE DATA BYTES

#0	#1	#2	#3
FIXED	CURRENT	CURRENT	CURRENT
VAR	MAX	ZERO	HUNDRED
RANGE		PCT	PCT
INDIC		FLOW	FLOW

Data Byte #0 — Fixed/variable range indicator:
0 - Variable range,
1 - Fixed range 0 - 20 mA,
2 - Fixed range 4 - 20 mA.

Data Byte #1 — Maximal possible output current, in mA. For variable range must obey inequality:
$I\_100\% \le \mathbf{Imax} \le 22$ mA.

Data Byte #2 — The value of current in mA, that corresponds to 0% flow (percents are related to Primary Variable Upper Range Value). For variable range must simultaneously obey two inequalities:
$0 \text{ mA} \le \mathbf{I\_0\%} \le 16$ mA,
$I\_100\% - \mathbf{I\_0\%} \ge 4$ mA.

Data Byte #3 — The value of current in mA, that corresponds to 100% flow (percents are related to Primary Variable Upper Range Value for the forward flow, or to the Reverse Range for the backward flow). For variable range must simultaneously obey two inequalities:
$\mathbf{I\_100\%} \le Imax$,
$\mathbf{I\_100\%} - I\_0\% \ge 4$ mA.

NOTE: When a fixed range is chozen (Data Byte #0 ≠ 0) all the data in request packet except the first byte is ignored, and corresponding parameters of current output are set in accordance with the required range: $I\_100\% = 20$ mA, $Imax = 22$ mA, and $I\_0\%$ equals to either 0 or 4 mA depending on the value of range indicator. The response data packet **always** contains the actual data accepted by the instrument.

COMMAND-SPECIFIC RESPONSE CODES

0	No Command-Specific Errors
1-4	Undefined
5	Too Few Data Bytes Received
6	Local Device User
7	In Write Protect Mode
8	Undefined
9	I 0% too High
10	I 100% too High
11	In Multidrop Mode
12	I 100% too Low
13	I Max too High
14	Undefined
15	I Max too Low
16-127	Undefined

8.12 Command #142 Read Frequency/Pulse Output Parameters

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

REQUEST DATA BYTES

NONE

RESPONSE DATA BYTES

#0	#1		
PULSE TYPE	PULSE WIDTH		
#2	#3	#4	#5
PULSE RATE MSB			PULSE RATE LSB
#6	#7	#8	#9
PULSE VALUE MSB			PULSE VALUE LSB

Data Byte #0 Pulse type, defines how pulses are generated at the output:
0 - ìPulse/Timeî,
1 - ìPulse/Volumeî.
In the first case *PulseRate* represents frequency that will be observed at the output if the measured flowrate equals to the the Primary Variable Upper Range Value. In the second case one and the same number of pulses (established by *PulseValue*) correspond to a given volume unit.

Data Byte #1 Pulse width for frequences ≤ 10 Hz:
0 - 30 ms,
1 - 50 ms,
2 - 100 ms,
3 - 300 ms,
4 - 500 ms.

Data Byte #2-#5 Pulse value per time unit, IEEE 754, in device-specific *PulseRateUnits* (refer to Command #156).

Data Byte #6-#9 Pulse value per volume unit, IEEE 754, in device-specific *PulseVolumeUnits* (refer to Command #156).

COMMAND-SPECIFIC RESPONSE CODES

0	No Command-Specific Errors
1-5	Undefined
6	Local Device User
7-127	Undefined

8.13 Command #143 Write Frequency/Pulse Output Parameters

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

REQUEST DATA BYTES

#0	#1		
PULSE TYPE	PULSE WIDTH		
#2	#3	#4	#5
PULSE RATE MSB			PULSE RATE LSB
#6	#7	#8	#9
PULSE VALUE MSB			PULSE VALUE LSB

RESPONSE DATA BYTES

#0	#1		
PULSE TYPE	PULSE WIDTH		
#2	#3	#4	#5
PULSE RATE MSB			PULSE RATE LSB
#6	#7	#8	#9
PULSE VALUE MSB			PULSE VALUE LSB

Data Byte #0 Pulse type, defines how pulses are generated at the output:
0 - ìPulse/Timeî,
1 - ìPulse/Volumeî.
In the first case *PulseRate* represents frequency that will be observed at the output if the measured flowrate equals to the the Primary Variable Upper Range Value. In the second case one and the same number of pulses (established by *PulseValue*) correspond to a given volume unit.

Data Byte #1 Pulse width for frequences ≤ 10 Hz:
0 - 30 ms,
1 - 50 ms,
2 - 100 ms,
3 - 300 ms,
4 - 500 ms.

Data Byte #2-#5 Pulse value per time unit, IEEE 754, in device-specific *PulseRateUnits* (refer to Command #156).

Data Byte #6-#9 Pulse value per volume unit, IEEE 754. in device-specific *PulseVolumeUnits* (refer to Command #156).

NOTE: When *PulseType* is requested as ìPulse/Timeî, the *PulseVolume* variable in the request packet is ignored and the ìold valueî will be preserved and sent back. And vice versa - when ìPulse/Volumeî choice is made for *PulseType*, only *PulseVolume* variable of request packet is processed, while *PulseRate* device parameter remains unchanged.

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	Local Device User
7	In Write Protect Mode
8-10	Undefined
11	Invalid Pulse Width
12-111	Undefined
112	Pulse Rate/Pulse Value Exceeded Max and Was Corrected
113	Pulse Rate/Pulse Value Surpassed Min and Was Corrected
114-127	Undefined

8.14 Command #146 Read Flow Direction And Primary Head Constant

Reads direction of the forward flow and the primary head constant.

REQUEST DATA BYTES

NONE

RESPONSE DATA BYTES

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

Data Byte #0 defines direction of the forward flow:
0 - Positive (corresponds to ì+î arrow on primary head),
1 - Negative.

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

COMMAND-SPECIFIC RESPONSE CODES

0	No Command-Specific Errors
1-5	Undefined
6	Local Device User
7-127	Undefined

8.15 Command #147 Write Flow Direction And Primary Head Constant

Writes direction of the forward flow and the primary head constant.

REQUEST DATA BYTES

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

RESPONSE DATA BYTES

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

Data Byte #0 defines direction of the forward flow:
0 - Positive (corresponds to ì+î arrow on primary head),
1 - Negative.

Data Byte #1-#4 Primary head constant GK, IEEE 754. See primary head nameplate. Range: 0.5 -14.0.

COMMAND-SPECIFIC RESPONSE CODES

0	No Command-Specific Errors
1	Undefined
2	Invalid Selection (of Flow Direction)
3	Passed Parameter too Large (Primary Constant)
4	Passed Parameter too Small (Primary Constant)
5	Too Few Data Bytes Received
6	Local Device User
7	In Write Protect Mode
8-127	Undefined

8.16 Command #148 Read User Data

Reads the majority of parameters combined into the User Data submenu (3.5) of the instrument.

REQUEST DATA BYTES

NONE

RESPONSE DATA BYTES

#0	#1	#2	
DISPLAY	OUTPUTS	TOTAL	
LANG	HOLD	RESET	
CODE		CONTROL	
#3	...	#8	
VOLUME		VOLUME	
UNIT		UNIT	
TEXT		TEXT	
BYTE #0		BYTE #5	
#9	#10	#11	
TIME		TIME	
UNIT		UNIT	
TEXT		TEXT	
BYTE #0		BYTE #2	
#12	#13	#14	#15
VOLUME			VOLUME
UNIT			UNIT
FACTOR			FACTOR
MSB			MSB
#16	#17	#18	#19
TIME			TIME
UNIT			UNIT
FACTOR			FACTOR
MSB			LSB

Data Byte #0 — Language used for text presentation on the local screen of the instrument:
0 - Gr.Britain/USA,
1 - German.

Data Byte #1 — Defines whether the device outputs are frozen during direct instrument control via keypad, or not:
0 - ìYesî,
1 - ìNoî.

Data Byte #2 — Totalizersí reset control:
0 - Reset is disabled,
1 - Reset is enabled.

Data Byte #3-#8 — ASCII-text, specifying user-defined volume unit. Say, for US barrels liquid it can be ìUS_Balî.

Data Byte #9-#11 — ASCII-text, specifying user-defined time unit. Say, for minutes it can be ìminî.

Data Byte #12-#15 — Scaling factor for user-defined volume unit, relative to cubic meters, IEEE 754. Say, for US barrels liquid it will be 8.36364.

Data Byte #16-#19 — Scaling factor for user-defined time unit, relative to seconds, IEEE 754. Say, for minutes it will be 60.

COMMAND-SPECIFIC RESPONSE CODES

0	No Command-Specific Errors
1-5	Undefined
6	Local Device User
7-127	Undefined

8.17 Command #149 Write User Data

Writes the subset of parameters combined into the User Data submenu (3.5) of the instrument.

REQUEST DATA BYTES

#0	#1	#2	
DISPLAY	OUTPUTS	TOTAL	
LANG	HOLD	RESET	
CODE		CONTROL	
#3	...	#8	
VOLUME		VOLUME	
UNIT		UNIT	
TEXT		TEXT	
BYTE #0		BYTE #5	
#9	#10	#11	
TIME		TIME	
UNIT		UNIT	
TEXT		TEXT	
BYTE #0		BYTE #2	
#12	#13	#14	#15
VOLUME			VOLUME
UNIT			UNIT
FACTOR			FACTOR
MSB			MSB
#16	#17	#18	#19
TIME			TIME
UNIT			UNIT
FACTOR			FACTOR
MSB			LSB

RESPONSE DATA BYTES

#0	#1	#2	
DISPLAY	OUTPUTS	TOTAL	
LANG	HOLD	RESET	
CODE		CONTROL	
#3	...	#8	
VOLUME		VOLUME	
UNIT		UNIT	
TEXT		TEXT	
BYTE #0		BYTE #5	
#9	#10	#11	
TIME		TIME	
UNIT		UNIT	
TEXT		TEXT	
BYTE #0		BYTE #2	
#12	#13	#14	#15
VOLUME			VOLUME
UNIT			UNIT
FACTOR			FACTOR
MSB			MSB

	#16	#17	#18	#19
	TIME UNIT FACTOR MSB			TIME UNIT FACTOR LSB

Data Byte #0 Language used for text presentation on the local screen of the instrument:
0 - Gr.Britain/USA,
1 - German.

Data Byte #1 Defines whether the device outputs are frozen during direct instrument control via keypad, or not:
0 - ìYesî,
Any other value - ìNoî.

Data Byte #2 Totalizersí reset control:
0 - Reset is disabled,
Any other value - Reset is enabled.

Data Byte #3-#8 ASCII-text, specifying user-defined volume unit.

Data Byte #9-#11 ASCII-text, specifying user-defined time unit.

Data Byte #12-#15 Scaling factor for user-defined volume unit, relative to cubic meters, IEEE 754. Refer to Table 9.3, Factors for Volume.

Data Byte #16-#19 Scaling factor for user-defined time unit, relative to seconds, IEEE 754. Refer to Table 9.4, 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, ì+î, ì-î 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	Local Device User
7	In Write Protect Mode
8-127	Undefined

8.18 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 **manually**-set password. Then the contents of *Password* field for Transaction #1 is ignored. It is **not possible** to change the password itself via bus!

TRANSACTION #0

REQUEST DATA BYTES

#0
WRITE
PROT
CONTROL

RESPONSE DATA BYTES

#0
WRITE
PROT
CONTROL

TRANSACTION #1

REQUEST DATA BYTES

#0	#1	...	#5
WRITE	PROT		PROT
PROT	CODE		CODE
CONTROL	BYTE #0		BYTE #4

RESPONSE DATA BYTES

#0
WRITE
PROT
CONTROL

Data Byte #0 — Write protect control, being a negation of the Write Protect Code (available via Command #15, Read Primary Variable Output Information):
0 - Password is enabled,
1 - Password is disabled.

Data Byte #1-#5 — The instrument password. The encoding scheme is as follows: the ìRightî-key of device keypad is coded by 0x8, ìEnterî-key - by 0x4 and ìUpî-key - by 0x1. Then the nine keystokes of the password are packed into 5 bytes in a straightforward way: the first password symbol is placed in the four most significant bits of Data Byte #1, the second password symbol - in the four least significant bits of Data Byte #1, etc. The last Data Byte #5 is zero terminated.
For example, some arbitrary key combination ìRight-Right-Up-Up-Up-Right-Enter-Up-Upî will result in a byte sequence 0x88, 0x11, 0x18, 0x41, 0x10.

NOTE: Any nonzero value of *WriteProtectControl* will be interpreted by transmitter as a request to disable protection and responded back as ì1î.

COMMAND-SPECIFIC RESPONSE CODES

0	No Command-Specific Errors
1-4	Undefined
5	Too Few Data Bytes Received
6	Local Device User
7-14	Undefined
15	Wrong Password
16-127	Undefined

8.19 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	#2	...	#5
CAL	CAL	CAL		CAL
CONTROL	STATUS	ZERO		ZERO
VAR		VALUE		VALUE
		MSB		LSB

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

Data Byte #1 Calibration status:
0 - No ìfreshî calibration data,
1 - Calibration is active or is over.
Refer to the note below.

Data Byte #2-#5 Zero value, IEEE 754, in % of Upper Range Value for forward flow.

NOTE: After a *StartCalibration* request is accepted, the device is triggered into a ìBusyî mode, that lasts about 20 seconds. All the telegrams received within this period will be rejected with the ìBusyî Response Code (32). During calibration process the device can be polled with Command #151 with *CalibrationControl* set to ì3î (Get calibration status). The first non-singular reply will supply master with calibration result. The obtained zero value is preserved in RAM until Command #151 will be received with *ExitCalibration*, *StartCalibration* or *StoreCalValue* value of control variable.

NOTE: A request to *StoreCalValue* when the *CalibrationStatus* is zero, will not cause any transmitter action.

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	Local Device User
7	In Write Protect Mode
8-127	Undefined

8.20 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
1-5	Undefined
6	Local Device User
7-127	Undefined

8.21 Command #153 Read Error List

Unlike Command #48, Read Additional Transmitter Status, where status information is ìmixedî, this command returns a complete list of error messages: the actual errors are being active at response time; errors that become inactive but are not quitted, are preserved in a list of ìstoredî errors.

Both actual and stored lists have identical structure. Therefore they are considered below together.

REQUEST DATA BYTES

NONE

RESPONSE DATA BYTES

#0	#1	#2	#3
ACTUAL ERRORS #1	ACTUAL ERRORS #2	STORED ERRORS #1	STORED ERRORS #2

Data Byte #0/#2 Bit-mapped actual/stored error byte #1 (bit #7 is MS bit):

- Bit #7 Fuse error
- Bit #6 Data error in EEPROM 2 (totalizer)
- Bit #5 Current calibration values in EEPROM 1+2 are different
- Bit #4 Current output overranged
- Bit #3 Frequency/pulse output overranged
- Bit #2 US path 2 faulted
- Bit #1 Empty pipe
- Bit #0 US path 1 faulted

Data Byte #1/#3 Bit-mapped actual/stored error byte #2 (bit #7 is MS bit):

- Bit #7 Checksum error in ROM
- Bit #6 Checksum error in RAM
- Bit #5 NVRAM error
- Bit #4 Calibration data lost
- Bit #3 Data error in EEPROM 1 (parameters)
- Bit #2 Irregular flow
- Bit #1 Counts lost or totalizer overflow
- Bit #0 Power failure

COMMAND-SPECIFIC RESPONSE CODES

0	No Command-Specific Errors
1-5	Undefined
6	Local Device User
7-127	Undefined

8.22 Command #156 Read Device-Specific Units And Enumerators

Reads device-specific units and controls.

REQUEST DATA BYTES

NONE

RESPONSE DATA BYTES

#0	#1	#2	#3
PLAUSIB ERROR	NUMBER PLAUSIB ERRORS MSB	NUMBER PLAUSIB ERRORS LSB	WEIGHT POINT OK

#4	#5
PULSE VOLUME UNITS	PULSE RATE UNITS

#6	#7	#8	#9
REV SCALE CONTROL	DISPLAY TOTAL CONTROL	ERROR MESSAGE CONTROL	DISPLAY TRANSIT TIME CONTROL

Data Byte #0 Error limit in % of measured value for plausibility statement.

Data Byte #1..#2 Limit value for the counter of incorrect measurements.

Data Byte #3 Weight factor for correct measurements.

Data Byte #4 Pulses per volume units, used **only** for scaling of *PulseVolume* parameter (refer to Command #142, Read Frequency/Pulse Output Parameters) and **do not** affect physical output. For unitsí codes refer to Table 9.3.

Data Byte #5 Pulse rate units, used **only** for scaling of *PulseRate* parameter (refer to Command #142, Read Frequency/Pulse Output Parameters) and **do not** affect physical output. For unitsí codes refer to Table 9.4.

Data Byte #6 Reverse scale control, defines whether the Upper Range Value for reverse flow is the same as for forward, or different:
0 - Different,
1 - Same as for forward flow.
In the first case the Upper Range Value for reverse flow can be accessed via Command #158, Read Transmitter Variable Range Values.

Data Byte #7 Display totalizer control, affects the local display of the instrument and the one of the HART communicator HC275:
0 - "+Totalizer",
1 - "-Totalizer",
2 - "+/-Totalizers",
3 - "Totalizers' sum",
4 - "All totalizers",
5 - "No display".

Data Byte #8	Display errorsí control, affects the local screen of the instrument and defines a mask for transmitter, that is used while handling a Bit #4, More Status Available, of the Field Device Status Byte: 0 - "No messages", 1 - "Ultrasonic errors", 2 - "Totalizer errors", 3 - "All errors".
Data Byte #9	Transmitter Variable *TransitTime* display control, affects the local display of the instrument and the one of the HART communicator HC275: 0 - "No display", 1 - "Display".

COMMAND-SPECIFIC RESPONSE CODES

0	No Command-Specific Errors
1-5	Undefined
6	Local Device User
7-127	Undefined

8.23 Command #157 Write Device-Specific Units And Enumerators

Writes device-specific units and controls.

REQUEST DATA BYTES

#0	#1	#2	#3
PLAUSIB ERROR	NUMBER PLAUSIB ERRORS MSB	NUMBER PLAUSIB ERRORS LSB	WEIGHT POINT OK
#4	#5		
PULSE VOLUME UNITS	PULSE RATE UNITS		
#6	#7	#8	#9
REV SCALE CONTROL	DISPLAY TOTAL CONTROL	ERROR MESSAGE CONTROL	DISPLAY TRANSIT TIME CONTROL

RESPONSE DATA BYTES

#0	#1	#2	#3
PLAUSIB ERROR	NUMBER PLAUSIB ERRORS MSB	NUMBER PLAUSIB ERRORS LSB	WEIGHT POINT OK
#4	#5		
PULSE VOLUME UNITS	PULSE RATE UNITS		
#6	#7	#8	#9
REV SCALE CONTROL	DISPLAY TOTAL CONTROL	ERROR MESSAGE CONTROL	DISPLAY TRANSIT TIME CONTROL

Data Byte #0	Error limit in % of measured value for plausibility statement. Valid range: 1..99.
Data Byte #1..#2	Limit value for the counter of incorrect measurements. Valid range: 0..10000.
Data Byte #3	Weight factor for correct measurements. Valid range: 1..50.
Data Byte #4	Pulses per volume units, used **only** for scaling of *PulseVolume* parameter (refer to Command #142, Read Frequency/Pulse Output Parameters) and **do not** affect physical output. For unitsí codes refer to Table 9.3.
Data Byte #5	Pulse rate units, used **only** for scaling of *PulseRate* parameter (refer to Command #142, Read Frequency/Pulse Output Parameters) and **do not** affect physical output. For unitsí codes refer to Table 9.4.
Data Byte #6	Reverse scale control, defines whether the Upper Range Value for reverse flow is the same as for forward, or different: 0 - Different, 1 - Same as for forward flow. In the first case the Upper Range Value for reverse flow can be accessed via Command #158, Read Transmitter Variable Range Values.

Data Byte #7 Display totalizer control, affects the local display of the instrument and the one of the HART communicator HC275:
0 - "+Totalizer",
1 - "-Totalizer",
2 - "+/-Totalizers",
3 - "Totalizers' sum",
4 - "All totalizers",
5 - "No display".
Any other value will be truncated and responded back as 5 ("No display").

Data Byte #8 Display errorsí control, affects the local screen of the instrument and defines a mask for transmitter, that is used while handling a Bit #4, More Status Available, of the Field Device Status Byte:
0 - "No messages",
1 - "Ultrasonic errors",
2 - "Totalizer errors",
3 - "All errors".
Any other value will be truncated and responded back as 3 ("All errors").

Data Byte #9 Transmitter Variable *TransitTime* display control, affects the local display of the instrument and the one of the HART communicator HC275:
0 - "No display",
1 - "Display".
Any other value will be truncated and responded back as 1 ("Display").

COMMAND-SPECIFIC RESPONSE CODES

0	No Command-Specific Errors
1-4	Undefined
5	Too Few Data Bytes Received
6	Local Device User
7	In Write Protect Mode
8-27	Undefined
28	Invalid Units Code (for any of the four units)
29-113	Undefined
114	Reverse Range Exceeded Max and was Corrected
115	Reverse Range Surpassed Min and was Corrected
116-127	Undefined

8.24 Command #158 Read Transmitter Variable Range Values

Reads the Upper/Lower Range Values of the Transmitter Variable. This command was introduced (instead of the support of Common-Practice Command #63, Read Analog Output Information) solely to resolve ambiguous situation when one and the same Transmitter Variable, namely *FlowRate*, has two pairs of Upper/Lower Range Values - for forward and reverse flow. Therefore Transmitter Variable set (refer to section 5.1) was augmented by a dummy variable *ReverseFlow* with index 10.

REQUEST DATA BYTES

#0
XMTR
VAR
CODE

RESPONSE DATA BYTES

#0	#1
XMTR	XMTR
VAR	VAR
CODE	RANGE
	UNITS

#2	#3	#4	#5
XMTR			XMTR
VAR			VAR
URV			URV
MSB			LSB

#6	#7	#8	#9
XMTR			XMTR
VAR			VAR
LRV			LRV
MSB			LSB

Data Byte #0 Transmitter Variable Code:
0 - *FlowRate*,
4 - *TransitTime*,
10 - *ReverseFlow*.
The *ReverseFlow* assignment is meaningful only for this and subsequent command (of Write type). The *FlowRate* value of TV Code will evoke response for forward flow.

Data Byte #1 The range units of the corresponding Transmitter Variable. For a set of supported flowrate units refer to the Table 9.1. Note that the ranges of *FlowRate* and *ReverseFlow* might have different units.
For *TransitTime* Transmitter Variable the manufacturer-specific units are used: 246, ìµsecî.

Data Byte #2-#5 Transmitter Variable Upper Range Value, IEEE 754, in the *RangeUnits*.

Data Byte #6-#9 Transmitter Variable Lower Range Value, IEEE 754, in the *RangeUnits*.

NOTE: For the *ReverseFlow* the Range values are meaningful only when the *ReverseScaleControl* (refer to Command #156) is set to zero (ìDifferentî) and the function of any output is set to either ìForward/reverse flowî or to ì2 Dirî (refer to Command #138).

COMMAND-SPECIFIC RESPONSE CODES

0	No Command-Specific Errors
1	Undefined
2	Invalid Selection (of Transmitter Variable)
3-4	Undefined
5	Too Few Data Bytes Received
6	Local Device User
7-127	Undefined

8.25 Command #159 Write Transmitter Variable Range Values

Write the Upper/Lower Range Values of the selected Transmitter Variable.

REQUEST DATA BYTES

#0	#1		
XMTR VAR CODE	XMTR VAR RANGE UNITS		
#2	#3	#4	#5
XMTR VAR URV MSB			XMTR VAR URV LSB
#6	#7	#8	#9
XMTR VAR LRV MSB			XMTR VAR LRV LSB

RESPONSE DATA BYTES

#0	#1		
XMTR VAR CODE	XMTR VAR RANGE UNITS		
#2	#3	#4	#5
XMTR VAR URV MSB			XMTR VAR URV LSB
#6	#7	#8	#9
XMTR VAR LRV MSB			XMTR VAR LRV LSB

Data Byte #0 Transmitter Variable Code, valid settings:
0 - *FlowRate*,
4 - *TransitTime*,
10 - *ReverseFlow*.
The *ReverseFlow* assignment is meaningful only for this and previous command (refer to ist comments). The *FlowRate* value of TV Code implies request for forward flow.

Data Byte #1 The range units of the corresponding Transmitter Variable. For *FlowRange* and *ReverseFlow* Range Values can be requested in any allowed flowrate unit (refer to the Table 9.1), the actual Range Units will not be altered. Transmitter Range Units can be changed via Command #157. Note that the ranges of *FlowRate* and *ReverseFlow* might have different units.
For *TransitTime* Transmitter Variable range units are fixed to manufacturer-specific ones (246, ìµsecî) and cannot be altered.

Data Byte #2-#5 Transmitter Variable Upper Range Value, IEEE 754, in the *RangeUnits*.

Data Byte #6-#9 Transmitter Variable Lower Range Value, IEEE 754, in the *RangeUnits*. For flowrate variables is assumed to be zero; hence this variable is ignored by transmitter and sent back as ì0î.

NOTE: For the *ReverseFlow* the Upper Range Value is stored in EEPROM (if accepted) but will be actually used by the instrument only when the *ReverseScaleControl* (refer to Command #156) is set to zero (ìDifferentî) and the function of any output is set to either ìForward/reverse flowî or to ì2 Dirî (refer to Command #138).

Refer also to comments for Command #35, Write Primary Variable Range Values.

COMMAND-SPECIFIC RESPONSE CODES

0	No Command-Specific Errors
1	Undefined
2	Invalid Selection (of Transmitter Variable)
3-4	Undefined
5	Too Few Data Bytes Received
6	Local Device User
7	In Write Protect Mode
8	Undefined
9	Lower Range Value too High
10	Undefined
11	Upper Range Value too High
12	Upper Range Value too Low
13-27	Undefined
28	Invalid Range Units
29-111	Undefined
112	Pulse Value Exceeded Max and was Corrected
113	Pulse Value Surpassed Min and was Corrected
114	Reverse Range Exceeded Max and was Corrected
115	Reverse Range Surpassed Min and was Corrected
116-127	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

15, cubic feet per minute
16, gallons per minute
17, liters per minute
18, imperial gallons per minute
19, cubic meter per hour
22, gallons per second
23, million gallons per day
24, liters per second
25, million liters per day
26, cubic feet per second
27, cubic feet per day
28, cubic meters per second
29, cubic meters per day
30, imperial gallons per hour
31, imperial gallons per day

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
137, imperial gallons per second
138, liters per hour
235, gallons per day

248, user defined

9.2 Totalizer Unit Codes

Subset of Table II, Unit Codes

40, gallons
41, liters
42, imperial gallons
43, cubic meters
46, barrels

110, bushels
111, cubic yards
112, cubic feet
113, cubic inches
124, liquid barrels
236, hectoliters

247, user defined

9.3 Pulse/Volume Unit Codes

0, pulses per gallon

1, pulses per liter
2, pulses per imperial gallon
3, pulses per cubic meter
4, pulses per barrel
5, pulses per bushel
6, pulses per cubic yard
7, pulses per cubic feet
8, pulses per cubic inch
9, pulses per liquid barrel
10, pulses per hectoliter
11, pulses per user volume unit

9.4 Pulse/Time Unit Codes

12, pulses per second
13, pulses per minute
14, pulses per hour
15, pulses per day
16, pulses per user time unit

10. RELEASE NOTES

The new revision of the given document is caused by the upgrade of the instrument transmitter SW. Each change from the previous revision is marked within the text with a vertical bar to the right of the indent with innovations. The next indent can serve as example.

Text with any change as compared with the previous revision: addition, removal, replacement, etc.

10.1 Changes from Rev.1 to Rev.2

Section 3; UFC500 Conformance and Command Class Summary

- Added commands dealing with Universal parameters: Message and Final Assembly Number.

Section 5; General Transmitter Information

- First paragraph is modified ñ for the new XMTR revision Primary Variable always traces some measurement process even if the function of the current output is switched ìOffî (automatically, as on entering multidrop mode or manually, via device keypad).

Section 6; Additional Universal Command Specifications

- Added comments on Command #0, Read Unique Identifier ñ the new XMTR revision supports the unique device ID linked with the newly invented instrument ìSerial Numberî (Ser. 5.1.4)
- Comments on Commands #16 .. #19 removed ñ all the data is processed as required by HARTÆ by the new XMTR revision..

Section 7; Additional Common-Practice Command Specifications

- Comments on Command #44, Write Primary Variable Units, changed ñ due to extended set of supported units.
- Comments on Command #53, Write Transmitter Variable Units, changed ñ due to extended set of supported units.
- Comments on Command #59, Write Number of Response Preambles, removed ñ command is processed as required by HARTÆ.

Section 8; Transmitter-Specific Commands

- Command #132, Read Frequency/Pulse Output Damping Control, changed ñ transaction is augmented with the two new parameters: device firmware identification number and device release date.
- Comments on Command #139, Write Analog Output Function, changed ñ due to new scheme of PV handling in case current output is switched ìOffî.
- Commands #156/#157, Read/Write Device-Specific Units and Enumerators, changed ñ due to the new unitsí handling scheme (they are all separated from the ones that used by device display ëcause augmented unitsí set is supported by XMTR); besides, three additional device parameters are involved in transactions.

Section 9; Transmitter-Specific Tables

- The transmitter variable unitsë tables (9.1, 9.2) are augmented with the new supported units.
- New unit tables are invented (9.3, 9.4) for Pulse Value.