Baumer

Passion for Sensors

HART® Field Device Specification

Baumer CombiLyz AFI4/AFI5

Revision 3

Document 81178189, rev. 3

Initial release: 8th of September 2015
Current release: 29th of October 2019

® HART is a registered trademark of the HART Communication Foundation

TABLE OF CONTENTS

1 INTRODUCTION

1.1 Scope

Baumer CombiLyz AFI4/AFI5 HART conductivity transmitter has built-in support for the HART 7.5 protocol. Since the HART version of the transmitter operates identically with the non-HART version of the transmitter, this document focuses solely on the HART functionalities of the transmitter. For all other operational aspects of the transmitter, please consult the data sheet and the user guide.
This document contains the necessary data for an operator, familiar with the HART protocol, to access all functions of the transmitter from a master system.

1.2 Purpose

This specification is designed to compliment other documentation (e.g., the *AFI4/AFI5 User Guide*) by providing a complete, unambiguous description of this Field Device from a HART Communication perspective.

1.3 Who should use this document?

The specification is designed to be a technical reference for HART capable Host Application Developers, System Integrators and knowledgeable End Users. It also provides functional specifications (e.g., commands, enumerations and performance requirements) used during Field Device development, maintenance and testing. This document assumes the reader is familiar with HART Protocol requirements and terminology.

1.4 Abbreviations and definitions

CT	Common Table
DT	Device Specific Table
uint8_t	8-bit unsigned integer, representing value 0 .. 255, can also be used for single bit flags
uint16_t	16-bit unsigned integer, representing value 0 .. 65,535
uint32_t	32-bit unsigned integer, representing value 0 .. 4,294,967,295
float_t	32-bit IEEE-754 (IEC 559) compatible single floating point variable
ASCII	ISO Latin-1 (ISO 8859) string text
packed	HART specific Packed ASCII format
PV	Primary Variable
SV	Secondary Variable
TV	Tertiary Variable
QV	Quaternary Variable
DAC	Digital to Analog Converter
RTD	Resistance Temperature Detector
TC, T/C	Thermocouple

1.5 References

HART Smart Communications Protocol Specification. HCF_SPEC-13: Available from the FCG.
CombiLyz AFI4/AFI5, Operating Instruction, Document 11126179 05: Available from www.baumer.com.

2 DEVICE IDENTIFICATION

Manufacturer Name:	Baumer	**Model Name(s):**	AFI4/AFI5 CombiLyz
Manufacture ID Code:	96 (60 Hex)	**Device Type Code:**	236 (EC Hex)
HART Protocol Revision	7.5	**Device Revision:**	2
Number of Device Variables	8		
Physical Layers Supported	FSK		
Physical Device Category	Transmitter, Current Output		

The name plate is located on top of the transmitter and indicates the model name. Type, material, serialnumber and production date is located on the side.

3 PRODUCT OVERVIEW

The CombiLyz AFI4/AFI5 is an externally powered 4-20mA current output conductivity transmitter, with an extra current output channel for temperature. The HART access to transmitter is via the conductivity current output channel.
The conductivity current output can be configured to output a concentration value for up to 4 different configurable media, internally calculated from the measured conductivity value.
Temperature compensation is fully configurable, and the temperature used for this is either the internally measured sensor tip temperature, fixed or provided by the HART master.
A 2-pin discrete input channel allows selecting 1 of 4 programmable ranges, which allows runtime switching between e.g. different zoom ranges or different concentration media. Selecting range with a HART command is also possible, overriding discrete input on these pins.

4 PRODUCT INTERFACES

4.1 Process Interface

4.1.1 Sensor Input Channels

The main conductivity sensor is mounted around the physical hole in the sensor.
A temperature sensor is located in the very tip of the sensor, providing an accurate temperature reading of the media temperature, which can be used for temperature compensation, as well as being output on the temperature current output channel.

4.2 Host interface

The transmitter has two 4-20mA current output channels. Each of these can be independently configured with linear over-range from 3.5 to 23 mA. The Conductivity current output channel supports HART Communication.
The error output current, to be used in case of transmitter error, is fully configurable in the range 3.5 to 23 mA, as well as which channel (or both) the error current is to be output on. The error current value is common for both channels, and cannot overlap the operating output current ranges of the selected error output channels.

	Direction	Values (percent of range)	Values (mA or V)
Linear over-range	Down	-3.13% to -0.01%	3.5 to 3.99 mA
	Up	+100.1% to 118.75%	20.01 to 23.00 mA
Device malfunction indication	Fixed value	-3.13% to 118.75%	3.50 to 23.00 mA
Maximum current		+118.75%	23.0 mA
Multi-Drop current draw			4.0 mA
Lift-off voltage			15.0 V

4.2.1 Analog Output 1: Process Conductivity / Concentration

The two-wire 4-20mA conductivity loop current output is connected on two terminals marked “4-20mA/Cond/Conc” (+/-). Refer to the Operating Instruction for connection details.
This output corresponds to Device Variable 4, which is the device variable for combined Conductivity and Concentration, depending on which operating mode is selected.
HART Communication is supported on this current loop output.

4.2.2 Analog Output 2: Process Temperature

The two-wire 4-20mA temperature loop current output is connected on two terminals marked “4-20mA/Temp” (+/-). Refer to the Operating Instruction for connection details.
This output corresponds to Device Variable 1, which is the device variable for the process temperature.
HART Communication is NOT supported on this current loop output.

4.3 Local Interfaces

4.3.1 Displays

The AFI4/AFI5 has a plug for direct mounting to the DFON touch display from Baumer. The connection is established by using the provided flat ribbon cable provided with the display unit. Please contact Baumer for more information.

4.3.2 Configuration

The AFI4/AFI5 can be configured using a Baumer FlexProgrammer connected the two com. terminals on the AFI4/AFI5. A PC and a Baumer FlexProgrammer 9701 must be used for this. During the configuration the data are transferred from the PC to the AFI4/AFI5, where it is stored in the internal memory.
FlexProgram, must be downloaded to the PC. The software is available at www.baumer.com. Standalone configuration with the FlexProgrammer is not possible on the AFI4/AFI5.
A 2-pin discrete input channel exists for selecting configurable ranges.
Please refer to the Operating Instruction manual for more information.

5 DEVICE VARIABLES

Seven Device Variables are implemented.

DV No.	Name	Description	Unit codes	Classification code
0, 246	Conductivity PV	Conductivity measurement with temperature compensation. Current Output capability on current output channels: 2 (indirectly via Dev. Var. 4)	66 mS/cm 67 µS/cm	87 Conductance
1, 247	Temperature SV	Sensor tip temperature measurement. Current Output capability on current output channels: 1	32 ^{0}C 33 ^{0}F	64 Temperature
2, 248	Concentration TV	Concentration value calculated from the Conductivity measurement. Current Output capability on current output channels: 2 (indirectly via Dev. Var. 4)	57 %	90 Concentration
3, 249	Raw Conductivity QV	Conductivity measurement without temperature compensation.	66 mS/cm	87 Conductance
4	Concentration / Conductivity	Mode dependent. Value, unit and classification fetched directly from either Device Variable 0 or Device Variable 2. Current Output capability on current output channels: 2	66 mS/cm 67 µS/cm 57 %	87 Conductance 90 Concentration
5	Reserved	Reserved.	250 Not used	0 Not Class'd
6, 244	Percent of Range	Output in % of full scale.	57 %	0 Not Class'd
7, 245	Loop Current	Loop Current associated with Device Variable 4, representing either Conductivity or Concentration	39 mA	84 Current
8	Loop Current (Secondary)	Loop Current associated with Device Variable 1, representing sensor temperature	39 mA	84 Current

Only Conductivity (PV) and Temperature (SV) allow changing of unit codes. Device Variable 4 automatically adapts the used Conductivity unit code.

6 DYNAMIC VARIABLES

Four Dynamic Variables are implemented.

Dyn var.	Meaning	Units
PV	Conductivity	µS/cm, mS/cm
SV	Temperature	^{0}C, ^{0}F
TV	Concentration	%
QV	Raw Conductivity	mS

7 STATUS INFORMATION

7.1 Device Status

The Field Device Status byte is contained in the second data byte in messages from the device. The following table defines the meaning of the different status bits.

Bit	Definition	Description
7	Device Malfunction	Is set if an electronic defect or memory defect is detected. This bit is set if a sensor break is detected.
6	Configuration Changed	Is set if a HART command results in writing new data to a configuration register.
5	Cold Start	Is set upon restart. It is reset for each master after responding to the first command from that specific master.
4	More Status Available	Is set if any of the Additional Device Status bits change status.
3	Loop Current Fixed	This bit is set if device is running in Fixed Current Mode (Command 40) or if Loop Current Signaling mode is turned off (e.g. in Multidrop Mode).
2	Loop Current Saturated	Is set if the output current associated to PV is capped by either the upper or lower current limits.
1	Non-Primary Variable Out of Limits	NOT USED
0	Primary Variable Out of Limits	Is set if PV is high or low limited.

Command #48 gives further detail. (See Section 7.3)

7.2 Extended Device Status

Extended Device Status is returned along with Additional Device Status by HART Command 48. Two bits are supported in this device.

Bit	Definition	Description
0	Maintenance Required	Is set if an electronic defect or memory defect is detected. This bit is set if a sensor break is detected.
1	Device Variable Alert	This bit is set if any Device Variable is simulated/fixed, or the environmental conditions are out of range. It will also be se if an electronic defect or memory defect is detected.
2	Critical Power Failure	Is set if the device detects that the power supply is not performing as expected.
3	Failure	Is set if an electronic defect, watchdog reset or if a memory defect is detected.

7.3 Additional Device Status (Command #48)

Command #48 returns 14 bytes of data, with the following status information:

Byte	Bit	Definition	Description
0	Device Specific Error Status Flags		
	7-1	NOT USED	
	0	Sensor Break	Is set if wire break is detected
1	Device Specific 0		
	7-0	NOT USED	
2	Device Specific 1		
	7-0	NOT USED	
3	Device Specific 2		
	7-0	NOT USED	
4	Device Specific 3		
	7-0	NOT USED	
5	Device Specific 4		
	7-0	NOT USED	
6	Extended Device Status		
	7-4	NOT USED	
	3	Failure	See Extended Device Status
	2	Critical Power Failure	See Extended Device Status
	1	Device Variable Alert	See Extended Device Status
	0	Maintenance Required	See Extended Device Status
7	NOT USED		
	7-0	NOT USED	
8	Standardized Status 0		
	7	Device Configuration Locked	NOT USED
	6	Electronic Defect	Is set in case of sensor break
	5	Environment Conditions out of Range	This bit is set if ambient temperatures is out of range.
	4	Power Supply Conditions out of Range	Is set if the device detects that the power supply is not performing as expected.

	3	Watchdog Reset Executed	This bit is set in case of the watchdog resetting the device, in case of firmware running into a software dead-lock.
	2	Non-volatile Memory Defect	This bit is set if a problem with the system memory is detected.
	1	Device Variable Simulation Active	Is set if any device variable is being simulated, e.g. by in-factory system test.
	0	NOT USED	
9	Standardized Status 1		
	7-3	NOT USED	
	2	Event Notification Overflow	This bit is set if the internal processor becomes overworked, not able to execute all tasks given within the allowed time.
	1	Discrete Variable Simulation	Is set if any device variable is being simulated, e.g. by in-factory system test.
	0	Simulation Active	Is set if any device variable is being simulated, e.g. by in-factory system test.
10	Analog Channel Saturated		
	7-2	NOT USED	
	1	Analog Channel 2	Is set if Analog Channel 2 is capped by either the upper or lower current limit.
	0	Analog Channel 1	Is set if Analog Channel 1 is capped by either the upper or lower current limit.
11	Standardized Status 2		
	7-0	NOT USED	
12	Standardized Status 3		
	7-0	NOT USED	
13	Analog Channel Fixed		
	7-2	NOT USED	
	1	Analog Channel 2	Is set if Analog Channel 2 is fixed by in-factory system test.
	0	Analog Channel 1	Is set if Analog Channel 1 is fixed by either Fixed Current Mode (Command 40) or if Loop Current Signaling mode is turned off (e.g. in Multidrop Mode). It can be caused by a running in-factory system test.

NOT USED bits are always set to 0.

These status bits are updated several times each second. They are set by any failure detected by the periodic status update routine.

8 UNIVERSAL COMMANDS

8.1 Supported Universal Commands

All Universal Commands are mandatory and are supported by the device. Following Universal Commands are implemented:

0	Read Unique Identifier
1	Read Primary Variable
2	Read Loop Current And Percent Of Range
3	Read Dynamic Variables And Loop Current
6	Write Polling Address
7	Read Loop Configuration
8	Read Dynamic Variable Classifications
9	Read Device Variables with Status
11	Read Unique Identifier Associated With Tag
12	Read Message
13	Read Tag, Descriptor, Date
14	Read Primary Variable Transducer Information
15	Read Device Information
16	Read Final Assembly Number
17	Write Message
18	Write Tag, Descriptor, Date
19	Write Final Assembly Number
20	Read Long Tag
21	Read Unique Identifier Associated With Long Tag
22	Write Long Tag
38	Reset Configuration Changed Flag
48	Read Additional Device Status

8.2 Special notes on Universal Commands

Command #3: Returns PV, SV, TV and QV. This totals in 24 data bytes.
Command #9: This command supports up to 8 device variables. This totals in up to 69 data bytes, including the time stamp.
Command #14: Transducer and sensor serial numbers are not supported. The units code for limits and minimum span is equal to that of the Primary Variable.
Since the physical transducer can be switched between different physical ranges, the returned transducer limits reflect those of the currently selected range's limits.
Command #15: Write protect is not implemented, and Write Protect Code is therefore always returned as "251" (None). The unit code for Primary Variable range values is the same as is used for the Primary Variable.
Command #48: Returns 14 bytes of data.

9 COMMON-PRACTICE COMMANDS

9.1 Supported Common Practice Commands

The following common-practice commands are implemented:

34	Write Primary Variable Damping Value
35	Write Primary Variable Range Values
36	Set Primary Variable Upper Range Value
37	Set Primary Variable Lower Range Value
40	Enter/Exit Fixed Current Mode
42	Perform Device Reset
43	Set Primary Variable Zero
44	Write Primary Variable Units
45	Trim Loop Current Zero
46	Trim Loop Current Gain
50	Read Dynamic Variable Assignment
53	Write Device Variable Units
60	Read Analog Channel And Percent Of Range

9.2 Special notes on Universal Commands

Command #35: Please see Common note 1.
Command #36: Please see Common note 1.
Command #37: Please see Common note 1.
Command #45: Prior to issuing this command, the loop current must be fixed at exactly 4.000mA (set with command 40).
Command #46: Prior to issuing this command, the loop current must be fixed at exactly 20.000mA (set with command 40).
Common note 1: Since this transmitter has several different physical measurement ranges, these commands only allows execution when the first range (Range 1) is selected either by discrete input pins R1 and R2 or by the designated Conductivity Family HART command (Command 208). If any other range is being used, this command will respond with error code 15 – “Non-Active Range Attempted Changed”.
Additionally, this device does not support reverse operation. This means that PV Upper Range Value must be bigger than PV Lower Range Value.

10 DEVICE-SPECIFIC CONDUCTIVITY COMMANDS

The following conductivity commands are added, since the original preliminary Conductivity Family Specification contains flawed command numbers. Additionally the original preliminary lacked vital features regarding ranges, used by many conductivity transmitter types.
Command description for all these new commands is added here, to minimize confusion of command specification is which.
For the sake of simplicity, all read commands are located in the range 150 to 199, while write commands are located from 200 to 253.
Additionally, the commands are divided the following 2 groups:
General Conductivity Device Family Commands (Read and Write)
These commands are much like commands for other device families, reading device information and status, as well as giving the master an overview of the capabilities of the device.
Programmable Range Conductivity Device Family Commands (Read and Write)
Many conductivity devices allow selecting different ranges at runtime, either by a discrete input, or via HART commands. These ranges most often can be programmed differently, ex. to perform special hardware zoom in certain situations, or ex. to select between concentration media setup. This section contains commands to read and write the setup of variables specifically concerning these ranges.

10.1 Supported Device Specific Conductivity Commands

The following conductivity device family commands are implemented:

10.1.1 General Conductivity Device Family Commands (Read)

150	Read Conductivity Status
151	Read Capabilities
152	Read Supported Status Mask
153	Read Conductivity Sensor Information
154	Read Device Variable Range and Label Capabilities
155	Read Conductivity Device Variables

10.1.2 Programmable Range Conductivity Device Family Commands (Read)

157	Read Range Hardware Range
158	Read Range Output Zoom
159	Read Range Temperature Compensation
160	Read Range Conductivity Medium Label
161	Read Range Concentration Table Points
162	Read Range Concentration Medium Label
163	Read Range Forced Status

10.1.3 General Conductivity Device Family Commands (Write)

200	Write Conductivity Sensor Information

10.1.4 Programmable Range Conductivity Device Family Commands (Write)

202	Write Range Hardware Range
203	Write Range Output Zoom
204	Write Range Temperature Compensation
205	Write Range Conductivity Medium Label
206	Write Range Concentration Table Points
207	Write Range Concentration Medium Label
208	Write Range Forced Status

10.2 Command 150 – Read Conductivity Status

This command reads out status for the specified Pressure Device Variable

Request data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)

Response data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)
1	uint-8	Conductivity Family Device Variable Status (FT 1)
2	uint-8	Conductivity Family Status 0 (FT 2)

Command specific response codes for command 150

Code	Type	Description
17	Error	Invalid Device Variable Index
19	Error	Device Variable Index Not Allowed For This Command

10.3 Command 151 – Read Capabilities

This command reads the capabilities of the Conductivity Device Family Variable. Some functions are optional and this command shows which ones are implemented. Each bit in the capability registers describes a feature.

Request data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)

Response data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)
1	uint-8	Family Definition Revision
2	uint-8	Conductivity Family Capabilities 0 (FT 3)
3	uint-8	Conductivity Family Capabilities 1 (FT 4)

Command specific response codes for command 151

Code	Type	Description
17	Error	Invalid Device Variable Index
19	Error	Device Variable Index Not Allowed For This Command

10.4 Command 152 – Read Supported Status Mask

This command reads out a bit mask, used to identify which corresponding status flags (read using Command 150 – Read Conductivity Status) are supported by the device.

Request data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)

Response data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)
1	uint-8	Supported Device Family Variable Status Bit Mask (FT 1)
2	uint-8	Supported Conductivity Status 0 Bit Mask (FT 2)

Command specific return codes for command 152

Code	Type	Description
17	Error	Invalid Device Variable Index
19	Error	Device Variable Index Not Allowed For This Command

10.5 Command 153 – Read Conductivity Sensor Information

This command reads out the sensor information of the physical transducer used to get data for use with the specified device variable.

Request data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)

Response data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)
1	uint-8	Sensor Type
2..5	float	Cell Constant

Command specific response codes for command 153

Code	Type	Description
17	Error	Invalid Device Variable Index
19	Error	Device Variable Index Not Allowed For This Command

Cell constant is not the accurate cell constant, but the typical cell constant of this cell type. The cell constant is given in the unit (cm^{-1}).

10.6 Command 154 – Read Device Variable Range and Label Capabilities

This command reads the Range capabilities for the specified device variable – which give an impression of how to configure ranges and labels.
Number of ranges specify how many ranges this device can switch between.
Number of labels specify how many labels are available in total for this device variable.
Number of labels for each range specify how many label are unique for each range for this device variable.
Range flags define some more special details for the device variables.

Request data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)

Response data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)
1	uint-8	Number of ranges
2	uint-8	Number of labels associated with this device variable
3	uint-8	Number of labels associated with each Range for this Device Variable
4	uint-8	Range flags (DT 10)

Command specific response codes for command 154

Code	Type	Description
17	Error	Invalid Device Variable Index
19	Error	Device Variable Index Not Allowed For This Command

10.7 Command 155 – Read Conductivity Device Variables

This command reads the all the standard conductivity device variables Conductivity Device Family Variable. This standard conductivity device command for some reason uses a device variable code to output standard values.

Request data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)

Response data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)
1..4	float	Conductivity
5..8	float	Temperature
9..12	float	Concentration
13..16	float	Raw Conductivity

Command specific response codes for command 155

Code	Type	Description
17	Error	Invalid Device Variable Index
19	Error	Device Variable Index Not Allowed For This Command

CombiLyz AFI4/AFI5 specific:
Only Device Variable Code 0 (and Primary Variable Code 245) is allowed in this device! The function therefore always returns Device Variable 0, 1, 2 and 3, which are Conductivity, Temperature, Concentration and Raw Conductivity.

10.8 Command 157 – Read Range Hardware Range

This command reads the hardware range of the specified range.

Request data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)
1	uint-8	Range number (DT 2)

Response data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)
1	uint-8	Range number (DT 2)
2	uint-8	Range unit (CT 2)
3..6	float	Lower hardware range input (DT 3)
7..10	float	Upper hardware range input (DT 4)

Command specific response codes for command 157

Code	Type	Description
15	Error	Invalid Programmable Range Number
17	Error	Invalid Device Variable Index
19	Error	Device Variable Index Not Allowed For This Command

Range unit defines the unit in which the values are returned.
CombiLyz AFI4/AFI5 specific:
Only usable on the Conductivity Family Device Variables.
All device variables share the same ranges.

10.9 Command 158 – Read Range Output Zoom

This command reads the zoom of the selected range.
The output is adjusted according to the following scaling: Lower range zoom value correspond to the Lower range loop output current value, and Upper range zoom value corresponding to the Upper range loop current value.

Request data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)
1	uint-8	Range number (DT 2)

Response data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)
1	uint-8	Range number (DT 2)
2	uint-8	Range unit (CT 2)
3..6	float	Lower range zoom
7..10	float	Upper range zoom
11..14	float	Lower range loop output current [mA]
15..18	float	Upper range loop output current [mA]

Command specific response codes for command 158

Code	Type	Description
15	Error	Invalid Programmable Range Number
17	Error	Invalid Device Variable Index
19	Error	Device Variable Index Not Allowed For This Command

Range unit specifies the unit in which the values are returned.

10.10 Command 159 – Read Range Temperature Compensation

This command reads the temperature compensation variables for the selected range.

Request data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)
1	uint-8	Range number (DT 2)

Response data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)
1	uint-8	Range number (DT 2)
2	uint-8	Temperature unit (CT 2)
3	uint-8	Temperature source (DT 7)
4..7	float	Compensation temperature
8..11	float	Linear compensation [%/K]
12..15	float	Exponential compensation [%/K^2]
16..19	float	Reference temperature

Command specific response codes for command 159

Code	Type	Description
15	Error	Invalid Programmable Range Number
17	Error	Invalid Device Variable Index
19	Error	Device Variable Index Not Allowed For This Command

Compensation temperature returned is the temperature used, from the specified source.
The Temperature unit is not necessarily the temperature unit used in the device, but the unit for the temperature values returned with this command.

10.11 Command 160 – Read Range Conductivity Medium Label

Many devices are able to assume the presence of a specific medium, if the conductivity is within a certain range.
This command reads the label string which is configured for the specified conductivity range.
Use conductivity label no. 0 (zero) to read the label used when outside of the other ranges.

Request data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)
1	uint-8	Range number (DT 2)
2	uint-8	Conductivity label no. (DT 5)

Response data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)
1	uint-8	Range number (DT 2)
2	uint-8	Conductivity label no. (DT 5)
3	uint-8	Conductivity unit (CT 2)
4..7	float	Lower limit for conductivity media label range
8..11	float	Upper limit for conductivity media label range
12..27	ASCII	Conductivity media label

Command specific response codes for command 160

Code	Type	Description
13	Error	Invalid Label Number
15	Error	Invalid Programmable Range Number
17	Error	Invalid Device Variable Index
19	Error	Device Variable Index Not Allowed For This Command

NOTE:
This command can only be used on Device Variables with Conductivity Classification.

CombiLyz AFI4/AFI5 specific:
This command can only be used on the Primary Device Variable.
All Ranges share the same media labels.

10.12 Command 161 – Read Range Concentration Table Points

This command reads the specified Conductivity/Concentration table points. It also returns the number of table points to use in total for this range. It is possible to read up to 8 table points with each issue of the command.
Point number specifies the first point to be read with this command, while Number of table points in message defines how many points are to be read with the command.
It is optional for a device to support more than one point for each command. It must be clearly stated in the device HART documentation how many points are supported for command 161, or if a very specific number of points are to be used.

Note: Command 161 and Command 206 must support the same amount of points per message.

Request data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)
1	uint-8	Range number (DT 2)
2	uint-8	Point number (point x)
3	uint-8	Number of table points in msg.

Response data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)
1	uint-8	Range number (DT 2)
2	uint-8	Point number (point x)
3	uint-8	Number of table points in msg.
4	uint-8	Number of table points to use
5	uint-8	Conductivity unit
6	uint-8	Concentration unit
7..10	float	Point x Conductivity value
11..14	float	Point x Concentration value
15..18	float	Point x+1 Conductivity value
19..22	float	Point x+1 Concentration value
23..26	float	Point x+2 Conductivity value
27..30	float	Point x+2 Concentration value
31..34	float	Point x+3 Conductivity value
35..38	float	Point x+3 Concentration value

Command specific response codes for command 161

Code	Type	Description
2	Error	Invalid Selection
15	Error	Invalid Programmable Range Number
17	Error	Invalid Device Variable Index
19	Error	Device Variable Index Not Allowed For This Command
29	Error	Invalid Table Point Selection

NOTE: The parameters with the grey background fill are only returned if at least one table point is read.

This command can only be used on Device Variables with Concentration Classification.
CombiLyz AFI4/AFI5 specific:
Points are denoted 1 .. 30.
Limited to 4 points in each message.

10.13 Command 162 – Read Range Concentration Medium Label

This command reads the concentration setup. It reads concentration mode status for the specified Concentration Device Variable, and reads the label string for the specified Range number.

Request data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)
1	uint-8	Range number (DT 2)

Response data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)
1	uint-8	Range number (DT 2)
2..17	ASCII	Concentration range label

Command specific response codes for command 162

Code	Type	Description
15	Error	Invalid Programmable Range Number
17	Error	Invalid Device Variable Index
19	Error	Device Variable Index Not Allowed For This Command

This command can only be used on Device Variables with Concentration Classification.

10.14 Command 163 – Read Range Forced Status

The active range is often selectable using a combination of + and - on digital input pins.
This command reads the status of the forced range used. NOT_USED is returned if it not forced.
This setting is volatile, and will be set to NOT_USED on reset!

Request data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)

Response data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)
1	uint-8	Range number (DT 2)

Command specific response codes for command 163

Code	Type	Description
17	Error	Invalid Device Variable Index
19	Error	Device Variable Index Not Allowed For This Command

CombiLyz AFI4/AFI5 specific:
This command reads the forced range for all Device Variables, no matter which Device Variable is targeted.
Only one range is selectable at a time for all Device Variables.

10.15 Command 200 – Write Conductivity Sensor Information

This command writes sensor type and cell constant.

Request data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)
1	uint-8	Sensor Type
2..5	float	Cell Constant

Response data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)
1	uint-8	Sensor Type
2..5	float	Cell Constant

Command specific response codes for command 200

Code	Type	Description
16	Error	Access Restricted
17	Error	Invalid Device Variable Index
19	Error	Device Variable Index Not Allowed For This Command

CombiLyz AFI4/AFI5 specific:
Changing sensor type and cell constant is not allowed on this device. Consequently, all correct commands always return return-code ACCESS_RESTRICTED!

Cell constant is not the accurate cell constant, but the typical cell constant of this cell type. The cell constant is given in the unit (cm^{-1}).

10.16 Command 202 – Write Range Hardware Range

This command writes the hardware range of the selected conductivity range.

Request data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)
1	uint-8	Range number (DT 2)
2	uint-8	Range unit (CT 2)
3..6	float	Lower hardware range input (DT 3)
7..10	float	Upper hardware range input (DT 4)

Response data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)
1	uint-8	Range number (DT 2)
2	uint-8	Range unit (CT 2)
3..6	float	Lower hardware range input (DT 3)
7..10	float	Upper hardware range input (DT 4)

Command specific response codes for command 202

Code	Type	Description
8	Warning	Set To Nearest Value
15	Error	Invalid Programmable Range Number
17	Error	Invalid Device Variable Index
18	Error	Invalid Units Code
19	Error	Device Variable Index Not Allowed For This Command

Range unit defines the unit in which the values are sent and returned. It does not setup the unit for the device variable.
To make it easier to find a valid hardware range, then the device should automatically set the range to the closest valid values, preferably with a bigger span, not truncating the requested hardware range.

CombiLyz AFI4/AFI5 specific:
Modifying Lower conductivity range input and Upper range input for the Conductivity variable zoom range will be limited by the hardware range selected with this command.

Modifying the hardware range will also set the Output Zoom range to this specific value.
This can be manually set afterwards using command Command 203 – Write Range Output Zoom.

If invalid value for either Lower Hardware Range Input or Lower Hardware Range Input is invalid, it will be set to nearest value, see Device Specific Table 3 and 4.

10.17 Command 203 – Write Range Output Zoom

This command writes the output zoom of the selected range for the specified device variable.
The output is adjusted according to the following scaling: Lower range zoom value correspond to the Lower range loop output current value, and Upper range zoom value corresponding to the Upper range loop current value.
The units allowed depend on the device variable number (and type).

Request data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)
1	uint-8	Range number (DT 2)
2	uint-8	Range unit (CT 2)
3..6	float	Lower range zoom
7..10	float	Upper range zoom
11..14	float	Lower range loop output current [mA]
15..18	float	Upper range loop output current [mA]

Response data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)
1	uint-8	Range number (DT 2)
2	uint-8	Range unit (CT 2)
3..6	float	Lower range zoom
7..10	float	Upper range zoom
11..14	float	Lower range loop output current [mA]
15..18	float	Upper range loop output current [mA]

Command specific response codes for command 203

Code	Type	Description
9	Error	Lower Range Value Too High
10	Error	Lower Range Value Too Low
11	Error	Upper Range Value Too High
12	Error	Upper Range Value Too Low
13	Error	Invalid Current Value
15	Error	Invalid Programmable Range Number
17	Error	Invalid Device Variable Index
18	Error	Invalid Units Code
19	Error	Device Variable Index Not Allowed For This Command
29	Error	Invalid Span

If there are no different ranges available (one single large range) for the specified Device Variable, then Range number 0 must be used.
Range unit specifies the unit in which the values are sent. It does not setup the unit for the device variable.

CombiLyz AFI4/AFI5 specific:
Lower range input and Upper range input for the Conductivity range will be limited by the selected hardware range.
Lower range loop output current must always be 4 mA.
Upper range loop output current must always be 20 mA.
If using Command 161 – Read Range Concentration Table Points then the zoom of the specified Concentration device variable may be set according to the table.

10.18 Command 204 – Write Range Temperature Compensation

This command writes the temperature compensation variables for the selected range.

Request data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)
1	uint-8	Range number (DT 2)
2	uint-8	Temperature unit (CT 2)
3	uint-8	Temperature source (DT 7)
4..7	float	Compensation temperature
8..11	float	Linear compensation [%/K]
12..15	float	Exponential compensation [%/K^2]
16..19	float	Reference temperature

Response data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)
1	uint-8	Range number (DT 2)
2	uint-8	Temperature unit (CT 2)
3	uint-8	Temperature source (DT 7)
4..7	float	Compensation temperature
8..11	float	Linear compensation [%/K]
12..15	float	Exponential compensation [%/K^2]
16..19	float	Reference temperature

Command specific response codes for command 204

Code	Type	Description
2	Error	Invalid Selection
3	Error	Passed Parameter Too Large
4	Error	Passed Parameter Too Small
15	Error	Invalid Programmable Range Number
17	Error	Invalid Device Variable Index
18	Error	Invalid Units Code
19	Error	Device Variable Index Not Allowed For This Command
29	Error	Invalid Coefficient

If Exponential compensation is not used, it should be set to zero.
If Reference temperature is not used, it should be set to 25°C, which is standard reference temperature.

The *Compensation temperature* sent to transmitter is ignored if it is set to use internal or HART temperature source. However, if it runs in Fixed temperature mode, the this is used to set the Fixed temperature.

Compensation temperature returned is the temperature used, from the specified source.

The Temperature unit is not the temperature unit to be used in the device, but the unit for the temperature values sent with this command.

CombiLyz AFI4/AFI5 specific:
The only temperature unit allowed for this command is ºC
There is no limit for either the temperature and compensation values that can be used for this command, error code Invalid Coefficient is therefore not used on AFIx
Using this function sets the Advanced compensation variable to enabled!

10.19 Command 205 – Write Range Conductivity Medium Label

Many devices are able to assume the presence of a specific medium, if the conductivity is within a certain range.
This command writes the label string for the specified conductivity range.
Use conductivity label no. 0 (zero) to write the label used when outside of the other ranges.

Request data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)
1	uint-8	Range number (DT 2)
2	uint-8	Conductivity label no. (DT 5)
3	uint-8	Conductivity unit (CT 2)
4..7	float	Lower limit for conductivity media label range
8..11	float	Upper limit for conductivity media label range
12..27	ASCII	Conductivity media label

Response data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)
1	uint-8	Range number (DT 2)
2	uint-8	Conductivity label no. (DT 5)
3	uint-8	Conductivity unit (CT 2)
4..7	float	Lower limit for conductivity media label range
8..11	float	Upper limit for conductivity media label range
12..27	ASCII	Conductivity media label

Command specific response codes for command 205

Code	Type	Description
9	Error	Lower Range Value Too High
10	Error	Lower Range Value Too Low
11	Error	Upper Range Value Too High
12	Error	Upper Range Value Too Low
13	Error	Invalid Label Number
15	Error	Invalid Programmable Range Number
17	Error	Invalid Device Variable Index
18	Error	Invalid Units Code
19	Error	Device Variable Index Not Allowed For This Command

NOTE:
This command can only be used on Device Variables with Conductivity Classification.

CombiLyz AFI4/AFI5 specific:
This command can only be used on the Primary Device Variable.
This command does the same to all “Ranges”, no matter which range is selected.
This command will report failure if writing a label in a range that overlaps another label range. Reduce the size of the range that is in the way to set the new label range.

10.20 Command 206 – Write Range Concentration Table Points

This command sets up the specified Conductivity/Concentration table points. It also specifies the number of table points to use in total for this range. It is possible to setup up to 8 table points with each issue of the command.
Point number specifies the first point to be changed with this command, while Number of table points in message defines how many points are included in the command message.
It is optional for a device to support more than one point for each command.
If command is issued with 0 points in the message, it is not necessary to send units.

Note: Command 161 and Command 206 must support the same amount of points per message.

Request data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)
1	uint-8	Range number (DT 2)
2	uint-8	Point number (point x)
3	uint-8	Number of table points in msg.
4	uint-8	Number of table points to use
5	uint-8	Conductivity unit
6	uint-8	Concentration unit
7..10	float	Point x Conductivity value
11..14	float	Point x Concentration value
15..18	float	Point x+1 Conductivity value
19..22	float	Point x+1 Concentration value
23..26	float	Point x+2 Conductivity value
27..30	float	Point x+2 Concentration value
31..34	float	Point x+3 Conductivity value
35..38	float	Point x+3 Concentration value

Response data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)
1	uint-8	Range number (DT 2)
2	uint-8	Point number (point x)
3	uint-8	Number of table points in msg.
4	uint-8	Number of table points to use
5	uint-8	Conductivity unit
6	uint-8	Concentration unit
7..10	float	Point x Conductivity value
11..14	float	Point x Concentration value
15..18	float	Point x+1 Conductivity value
19..22	float	Point x+1 Concentration value
23..26	float	Point x+2 Conductivity value
27..30	float	Point x+2 Concentration value
31..34	float	Point x+3 Conductivity value
35..38	float	Point x+3 Concentration value

Command specific response codes for command 206

Code	Type	Description
2	Error	Invalid Selection
15	Error	Invalid Programmable Range Number
17	Error	Invalid Device Variable Index
18	Error	Invalid Units Code
19	Error	Device Variable Index Not Allowed For This Command
28	Error	Command Data Overflow
29	Error	Invalid Table Point Selection

This command can only be used on Device Variables with Concentration Classification.
NOTE: The parameters with the blue background fill are only returned, if at least one table point is written.

CombiLyz AFI4/AFI5 specific:
Points are denoted 1 .. 30.
Points are limited to 4 points in each message.
If setting Concentration mode Enable for Device Variable 2, Device Variable 4 will output Concentration instead of Conductivity, and the Loop Current output will output the Conductivity output current.
There is no check on the conductivity and concentration values! It can cause erratic behavior if variables are not properly setup. Irrelevant response codes are therefore have a strike-through in the response code list.

10.21 Command 207 – Write Range Concentration Medium Label

This command writes the label string for the specified Range number.

Please note that this command can be issued with a one byte predefined media label number instead of a full media label string of 16 bytes. In either way, the response always returns the full written data string.

Request data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)
1	uint-8	Range number (DT 2)
2..17	ASCII	Concentration range label

Response data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)
1	uint-8	Range number (DT 2)
2..17	ASCII	Concentration range label

Command specific response codes for command 207

Code	Type	Description
15	Error	Invalid Programmable Range Number
17	Error	Invalid Device Variable Index
19	Error	Device Variable Index Not Allowed For This Command

This command can only be used on Device Variables with Concentration Classification.

CombiLyz AFI4/AFI5 specific:
No check of invalid characters is performed on the label.

10.22 Command 208 – Write Range Forced Status

The active range is often selectable using a combination on external pins.
This command sets up the active range to be forced to a certain range. Forced status is lost at restart.
Use NOT_USED to turn off forced mode.
This setting is volatile, and will be set to NOT_USED on reset!

Request data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)
1	uint-8	Forced range number (DT 2)

Response data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)
1	uint-8	Forced range number (DT 2)

Command specific response codes for command 208

Code	Type	Description
15	Error	Invalid Programmable Range Number
17	Error	Invalid Device Variable Index
19	Error	Device Variable Index Not Allowed For This Command

CombiLyz AFI4/AFI5 specific:
This command forces all Device Variables to the specified range, no matter which Device Variable is targeted. Only on range is selectable at a time for all Device Variables.

11 OTHER DEVICE-SPECIFIC COMMANDS

The following device specific commands are implemented:

130	Read Device Variable State
131	Write Device Variable State
132	Read Device Variable Output Channel Setup
133	Write Device Variable Output Channel Setup
134	Reset Configuration to Factory Settings
135	Trim Device Variable Zero
137	Reset Device Variable Trim
138	Read Production Date
139	Read Advanced Input Mode
140	Write Advanced Input Mode

11.1 Command 130 – Read Device Variable State

This command reads out the state whether the Device Variable is enabled or disabled.

Request data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)

Response data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)
1	uint-8	Device Variable State (DT 6)

Command specific response codes for command 130

Code	Type	Description
17	Error	Invalid Device Variable Index
19	Error	Device Variable Index Not Allowed For This Command

CombiLyz AFI4/AFI5 specific:
This command can only be used on Device Variables with Concentration Classification.

11.2 Command 131 – Write Device Variable State

This command writes the state whether the Device Variable is enabled or disabled.

Request data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)
1	uint-8	Device Variable State (DT 6)

Response data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)
1	uint-8	Device Variable State (DT 6)

Command specific response codes for command 131

Code	Type	Description
2	Error	Invalid Selection
17	Error	Invalid Device Variable Index
19	Error	Device Variable Index Not Allowed For This Command

CombiLyz AFI4/AFI5 specific:
This command is specifically used to enable and disable AFI4/AFI5's concentration mode.
This command can only be used on Device Variables with Concentration Classification.
Concentration enable is shared for Device Variable 2 and 4. If setting Concentration mode Enable for Device Variable 2, it will start outputting data (Outputs NOT_A_NUMBER when disabled), and Device Variable 4 will output Concentration instead of Conductivity.
This command cannot be used on Device Variable 4, since it is a multi-classification variable, and not Concentration classification.

11.3 Command 132 – Read Device Variable Output Channel Setup

This command reads the setup of the output for the specified device variable. This includes the current limits and the current to use in case of error, and which errors that may use this output as error channel.

Request data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)

Response data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)
1	uint-8	Output channel number (DT 8)
2..5	float	Lower channel output limit [mA]
6..9	float	Upper channel output limit [mA]
10	uint-8	Error output enable flags (DT 9)
11..14	float	Error current [mA]

Command specific response codes for command 132

Code	Type	Description
17	Error	Invalid Device Variable Index
19	Error	Device Variable Index Not Allowed For This Command

For device variables that cannot be assigned an output channel: Output Channel Number is set to NOT_USED, and floats are set to NOT_A_NUMBER. Error output flags are returned as zero.

11.4 Command 133 – Write Device Variable Output Channel Setup

This command sets up the Analog output channel source for the specified device variable and sets the limits which the output will not exceed in normal operation. It also sets up which errors are allowed to use this output channel, and what current an active error forces the output to.

Request data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)
1	uint-8	Output channel number (DT 8)
2..5	float	Lower channel output limit [mA]
6..9	float	Upper channel output limit [mA]
10	uint-8	Error output enable flags (DT 9)
11..14	float	Error current [mA]

Response data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)
1	uint-8	Output channel number (DT 8)
2..5	float	Lower channel output limit [mA]
6..9	float	Upper channel output limit [mA]
10	uint-8	Error output enable flags (DT 9)
11..14	float	Error current [mA]

Command specific response codes for command 133

Code	Type	Description
10	Error	Lower Limit Current Too Low
11	Error	Upper Limit Current Too High
15	Error	Invalid Error Current Value
17	Error	Invalid Device Variable Index
19	Error	Device Variable Index Not Allowed For This Command
29	Error	Invalid Span

CombiLyz AFI4/AFI5 specific:
The only allowed channel assignment is:
Device variable 1 – Temperature .. Channel 2
Device variable 4 – Combined Conductivity / Concentration .. Channel 1
No other device variables are allowed to have an assigned output channel.
Setting error current for either device variable 1 or 4, will set it for the other channel as well.
WARNING!: Error current is only checked for not overlapping the actual channel's limits – it may very well overlap another channel's limits.

11.5 Command 134 – Reset Configuration to Factory Settings

This command resets all configuration in the device to the state it was when shipped from the factory.

Request data frame

Byte	Format	Description
-	-	No request bytes

Response data frame

Byte	Format	Description
-	-	No response bytes

11.6 Command 135 – Trim Device Variable Zero

This command uses the provided parameter value and the actual measured device variable value and adjusts the internal zero compensation, so that the device variable output value matches the one sent with the command. It is possible to adjust the device variable zero with ±5% of the full range.

Request data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)
1	uint-8	Device Variable Unit (CT 2)
2..5	float	Externally measured value

Response data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)
1	uint-8	Device Variable Unit (CT 2)
2..5	float	Actual output Dev. Var. value

Command specific response codes for command 135

Code	Type	Description
3	Error	Passed Parameter Too Large
4	Error	Passed Parameter Too Small
17	Error	Invalid Device Variable Index
18	Error	Invalid Units Code
19	Error	Device Variable Index Not Allowed For This Command
29	Error	Invalid Span

CombiLyz AFI4/AFI5 specific:
This command is specifically designed for Device Variables 0 and 1.

11.7 Command 137 – Reset Device Variable Trim

This command resets any user trim of the Device Variable to factory settings.

Request data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)

Response data frame

Byte	Format	Description
0	uint-8	Device Variable Code (DT 1)

Command specific response codes for command 137

Code	Type	Description
17	Error	Invalid Device Variable Index
19	Error	Device Variable Index Not Allowed For This Command

CombiLyz AFI4/AFI5 specific:
This command is specifically designed for Device Variables 0 and 1.

11.8 Command 138 – Read Production Date

This command reads production date.

Request data frame

Byte	Format	Description
-	-	No request bytes

Response data frame

Byte	Format	Description
0	uint-8	Day
1	uint-8	Month
2..3	uint-16	Year

11.9 Command 139 – Read Advanced Input Mode

This command reads the variable which determines if advanced input mode is enabled.

Request data frame

Byte	Format	Description
-	-	No request bytes

Response data frame

Byte	Format	Description
0	uint-8	Advanced input mode enabled

11.10 Command 140 – Write Advanced Input Mode

This command writes the variable which determines if advanced input mode is enabled.

Request data frame

Byte	Format	Description
0	uint-8	Advanced input mode enabled

Response data frame

Byte	Format	Description
0	uint-8	Advanced input mode enabled

Command specific response codes for command 140

Code	Type	Description
5	Error	Too few data bytes

CombiLyz AFI4/AFI5 specific:
Advanced input mode allows the device running with a reference temperature different from 25 °C and a temperature compensation set by an exponential function, and a temperature sensor different than the internal sensor.

12 DEVICE-SPECIFIC CONDUCTIVITY TABLES

12.1 Cond. Family Device Spec. Table 1 – Conductivity Device Family Device Variable Status

Code	Description
0x01	Sensor Diagnostics Failure
0x02	Sensor Break (AFI4/AFI5specific)
0x04	Variable Not Generated (AFI4/AFI5 specific)
0x08	More Device Variable Status Available
0x30	Limit Status: 11 Constant (i.e. value cannot be changed by the process) 01 Low Limited (eg. A/D Converter has reached its lower limit) 10 High Limited (eg. A/D Converter has reached its upper limit) 00 Not Limited
0xC0	Process Data Quality Status: 11 Good 01 Poor accuracy (eg. value is beyond rated conductivity or hardware zoom, temperature out of range) 10 Manual / Fixed (eg. value is simulated or forced)

12.2 Conductivity Family Device Specific Table 2 – Conductivity Status 0

Code	Description
0x01	Conductivity Sensor Break
0x02	Process Temperature Sensor Break
0x04	Internal Temperature Sensor Break
0x08	Calibration Required
0x10	Conductivity Operating Range Exceeded
0x20	Process Temperature Operating Range Exceeded
0x40	Internal Temperature Operating Range Exceeded
0x80	Reserved

12.3 Conductivity Family Device Specific Table 3 – Conductivity Family Capabilities 0

Code	Description
0x01	Command 153 – Read Conductivity Sensor Information
0x02	Command 154 – Read Device Variable Range and Label Capabilities
0x04	Command 155 – Read Conductivity Device Variables
0x08	Command 200 – Write Conductivity Sensor Information
0x10	Reserved
0x20	Reserved
0x40	Reserved
0x80	Reserved

12.4 Conductivity Family Device Specific Table 4 - Conductivity Family Capabilities 1

Code	Description
0x01	Command 157/202 – Read/Write Range Hardware Range
0x02	Command 158/203 – Read/Write Range Output Zoom
0x04	Command 159/204 – Read/Write Range Temperature Compensation
0x08	Command 160/205 – Read/Write Range Conductivity Medium Label
0x10	Command 161/206 – Read/Write Range Concentration Table Points
0x20	Command 162/207 – Read/Write Range Concentration Medium Label
0x40	Command 163/208 – Read/Write Range Forced Status
0x80	Reserved

13 DEVICE-SPECIFIC TABLES

13.1 Sensor Type Codes

Sensor Type codes

Code	Description
0	Contacting
1	Inductive
2	Electrode

13.2 Unit Codes

(subset of HART Common Table 2, Unit Codes)
Unit Codes

Code	Description
32	ºC
33	ºF
39	mA
57	%
66	mS/cm
67	µS/cm

13.3 Internal Unit Conversion

Conductivity Unit Conversion
K[µS/cm] = K[mS/cm] * 1000
K[mS/cm] = K[µS/cm] / 1000
Temperature Unit Conversion
t[°C] = (t[°F] - 32) / 1.8
t[°F] = t[°C] * 1.8 + 32

14 PERFORMANCE

14.1 Sampling Rates

Typical sampling rates are shown in the following table.

Sensor	Sampling rate
Conductivity	Approx. 3 times per second
Temperature	Approx. 1 time per second

14.2 Power-Up

On power up, the transmitter runs through a startup initialization procedure, which takes approximately 5 seconds. During this period, the device will not be able to respond to HART commands, and the analog output is set at 3.5mA.
The first stable measurements are ready in less than 15 seconds, allowing valid Device Variable readouts. Fixed-current mode is cancelled upon startup / reset.

14.3 Reset

Command 42 - Perform Device Reset causes the device to reset its microprocessor. The resulting restart is identical to the normal power up sequence.

14.4 Self-Test

The CombiLyz AFI4/AFI5 does not support command 41 – Self Test. Self-testing is performed periodically during normal operation.

14.5 Command Response Times

HART command response time depends on the command number issued and the internal state of the device. In order to ensure power consumption all time is below 3.5 mA, the response might be delayed up to 140 ms, due to other power consuming modules.

Generalization	Response times
Minimum	5 ms
Typical	15 ms
Maximum	140 ms

14.6 Busy and Delayed-Response

The transmitter may respond with "busy" status if a further command is received while self-test is underway or device is processing another command.
Delayed-response is not used.

14.7 Long Messages

The largest data field used is in the response to Command 9: 69 data bytes plus status bytes and header etc.

14.8 Non-Volatile Memory

FLASH is used to hold the device's configuration parameters. New data is written to this memory immediately on execution of a write command.

14.9 Modes

Fixed current mode is implemented, using Command 40. This mode is cleared by power loss or reset.

14.10 Burst Mode

This Field Device does not support Burst Mode.

14.11 Write Protection

This Field Device does not support Write Protect.

14.12 Catch Device Variable

This Field Device does not support Catch Device Variable.

14.13 Damping

Damping is implemented for the PV and the other device variables depending on the PV value. This includes the conductivity/concentration output channel current, and if a concentration value is calculated (which always is done with respect to the PV value).

ANNEX. A CAPABILITY CHECKLIST

Manufacturer, model and revision	Baumer A/S, AFI4/AFI5 CombiLyz, rev. 2
Device type	Transmitter
HART revision	7.5
Device Description available	Yes
Number and type of sensors	2, One internal conductivity sensor One internal temperature sensor
Number and type of actuators	0
Number and type of host side signals	One 4 - 20mA analog output w/ HART One 4 - 20mA analog output
Number of Device Variables	8
Number of Dynamic Variables	4
Mappable Dynamic Variables?	No
Number of common-practice commands	13
Number of device family commands	21
Number of device-specific commands	10
Bytes of additional device status	14
Alternative operating modes?	No
Burst mode?	No
Write-protection?	No

ANNEX. B DEFAULT CONFIGURATION

Parameter	Default value
Poll Address	0
Loop Current Signaling Mode	Enabled
Conductivity / Concentration Mode	Conductivity Mode
Conductivity Current at 4 mA	Range 1..4: 0 µS/cm
Conductivity Current at 20 mA	Range 1: 200 mS/cm Range 2: 20 mS/cm Range 3: 2 mS/cm Range 4: 500 µS/cm
Temperature Current at 4 mA	-20 °C
Temperature Current at 20 mA	150 °C
Temperature compensation	Range 1..4: 2% / K
Error Channel	Both
Error Current	3.5 mA
Damping	0 sec

ANNEX. C REVISION HISTORY

A1. 2015-09-02 First revision 1.0

Document created.

A2. 2019-03-19 Second revision 2.0

Document updated due to HART revision 7.5.

Added commands 138, 139, 140

A3. 2019-10-29 Third revision 3.0

Document updated due to replacing commands 23xx-24xx to 150-199 & 200-253, after request from FCG.