HART® Field Device Specification:

VisiPro™ DO

HART Protocol: 7
Device Revision: 1

Important Notice

The contents of this manual are subject to change without notice. Technical changes reserved.

All efforts have been made to ensure the accuracy of the contents of this manual. However, should any errors be detected, Hamilton Bonaduz AG would greatly appreciate being informed of them.

The above notwithstanding, Hamilton Bonaduz AG can assume no responsibility for any errors in this manual or their consequences.

Rev.	Revision Date	Author	Change Description
80	28.05.2013	PWi	Initial version
00	07.09.2015	CSc	Release version

Table of Contents

1 Introduction

1.1 Scope

The Hamilton dissolved oxygen sensor VisiPro DO, Device Revision 1 complies with HART Protocol Revision 7. This document specifies all the device specific features and documents HART Protocol implementation details (e.g., the Engineering Unit Codes supported). The functionality of this Field Device is described sufficiently to allow its proper application in a process and its complete support in HART capable Host Applications.

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Product Name:	VisiPro DO	**Device Registered with HCF:**	Yes
Product Type:	Analytical	**DD Registered with HCF:**	Yes
HART Version:	7	**DD Revision:**	1
Manufacturer ID:	006063	**Enhanced DD:**	Yes
Device Type:	e1c4	Download DD Files	
Device Revision:	1	Registration Certificate	
Wireless Product:		Manufacturer Brochure	

The HART Communication Foundation has verified and released the VisiPro DO sensor including the corresponding DD, in November 2013.
The Information about the VisiPro DO sensor and DD has been posted on the FieldComm Group website and in the Product Catalog, the DD can be downloaded directly from this website.

1.2 Purpose

This specification is designed to complement other documentation (e.g., the *VisiPro DO Operating Instructions*) 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

ADC	Analog to Digital Converter
CIP	Cleaning In Place
CPU	Central Processing Unit (of microprocessor)
DAC	Digital to Analog Converter
DO	Dissolved Oxygen
EEPROM	Electrically-Erasable Read-Only Memory
ROM	Read-Only Memory
SIP	Sterilization In Place
CP1	Zero Oxygen Calibration Point
CP2	Air Calibration Point
CP6	Product Calibration Point

1.5 References

HART Smart Communications Protocol Specification (Available from the HCF):

- HCF_SPEC-13 HART Field Communications Protocol Specification
- HCF_SPEC-81 Data Link Layer Specification
- HCF_SPEC-99 Command Summary Specification
- HCF_SPEC-127 Universal Command Specification
- HCF_SPEC-151 Common Practice Command Specification
- HCF_SPEC-183 Common Tables Specification
- HCF_SPEC-307 Command Response Code Specification
- HCF_KIT-215 DDL Specifications

VisiPro DO Operating Instructions, Document 624611. Available from Hamilton Bonaduz.

2 Device Identification

Manufacturer Name:	Hamilton Bonaduz AG	Model Name:	VisiPro DO
Manufacturer ID Code:	24675 (0x6063)	Device Type Code:	57796 (0xE1C4)
HART Protocol Revision	7	Device Revision	1
Number of Device Variables	3		
Physical Layers Supported	FSK		
Physical Device Category	Transmitter		

3 Product Overview

VisiPro™ DO sensors were developed for the measurement of dissolved oxygen partial pressure, together with the following derived measurement parameters:

- Percent by volume oxygen
- Percent air saturation by oxygen
- Concentration of oxygen in liquids
- Concentration of oxygen in gas

The main application for VisiPro DO sensors is the in-line measurement under demanding conditions in biotechnology, ChemPharma and brewery. The main characteristic that makes
VisiPro DO sensors ideal for this application is their remarkable long-term stability, even after frequent sterilization.
Nevertheless, in many other application such as those found in the chemical industry, air surveillance, fish farming, water management, and sewage management, VisiPro DO sensors have also already proven their value.
During development, special attention was paid to an optimum sanitary design. All materials in contact with the solution meet FDA requirements.
VisiPro DO sensors provide standard 2-wire analog (4-20 mA) interface including digital HART communication. These are built into each sensor and are supported directly from the sensor head. They do not require additional equipment such as amplifier or transmitter.
The built-in temperature sensor can only be used for monitoring the sensor conditions, not for controlling the process temperature.

4 Product Interfaces

4.1 Process Interface

4.1.1 Sensor Input Channels

The VisiPro DO contains two built-in process measurement channels:

- *Optical DO Measurement*: The optical channel measures the partial pressure of the dissolved oxygen in the process.
- *Process Temperature:* The process temperature is measured for compensation of the DO measurement value (NTC 22kOhm).

For surveillance purposes a quality monitoring channel exists:

- *Quality Indicator*: The optical channel monitors the state of the luminophore, based on this a quality indicator value is computed.

4.2 Host Interface

4.2.1 Analog Output 1

The two-wire 4-to-20mA current loop is connected on pin 2 (HART-) and pin 3 (HART+) of the sensor's M12 connector. Refer to the Operating Instructions for connection details.

This is the only current output from the VisiPro DO Sensor and corresponds to the Primary Variable (PV). HART Communication is supported on this loop. This device has a Capacitance Number of 1.

The output current signal is in the range of 3.6mA to 23mA.

- Normal operation: 4 to 20mA
- The Loop Current is set to high or low Alarm Level according to the following priority order:
  - Process temperature above 130°C: 3.6mA
  - Device-specific error active: according to user's configuration of current in the event of error. It is possible to suppress this alarm signaling.
  - Device-specific warning active: according to user's configuration of current in the event of warning. It is possible to suppress this alarm signaling.

	Direction	Values (percent of range)	Values (mA)
Linear over-range	Down	Not implemented	Not implemented
	Up	Not implemented	Not implemented
Device malfunction indication	Down: less than	0.0%	4 mA
	Up: greater than	+100.0%	20 mA
Maximum current		+118.75%	23.0 mA
Multi-Drop current draw			4.0 mA
Lift-off voltage			18 V

4.3 Local Interfaces, Jumpers And Switches

4.3.1 Local Controls And Displays

This device has no external local controls or displays.

4.3.2 Internal Jumpers And Switches

This device has no jumpers or switches.

5 Device Variables

5.1 Device Variable 0: Dissolved Oxygen

This Device Variable holds the value of the dissolved oxygen partial pressure measured in the process, displayed in the user-defined unit.

Device Variable			
Number:	0	Name	Dissolved Oxygen
Classification:	see 14.12	Unit Codes	see 14.3
Device Family	see 14.13		
Device Family Commands	None		

5.1.1 Device Variable 0 Status

The Device Variable Status read in command #9 consists of:

- *Process Data Status*: indication for DO measurement reliability, based on Device Variable 2 "Quality Indicator"
  - 0x03 (good): if quality indicator > 60%
  - 0x01 (poor): if quality indicator > 25%
  - 0x00 (bad): otherwise
- *Limit Status*: indication whether the Device Variable value is limited and not responding to the process
  - 0x01 (low limited): if the DO value is below the LTL (lower transducer limit) (Sensor Status W1.1; see 7.1.2)
  - 0x02 (high limited): if the DO value is above the UTL (upper transducer limit) (Sensor Status W1.2; see 7.1.2)
  - 0x00 (not limited): otherwise
- *Device Family Status*: not used, set to 0x00

5.2 Device Variable 1 Temperature

This Device Variable holds the value of the temperature measured in the process, displayed in the user-defined unit. The built-in temperature sensor can only be used for monitoring the sensor conditions, not for controlling the process temperature.

Device Variable			
Number:	1	Name	Temperature
Classification:	see 14.12	Unit Codes	see 14.4
Device Family	see 14.13		
Device Family Commands	None		

5.2.1 Device Variable 1 Status

The Device Variable Status read in command #9 consists of:

- *Process Data Status*: indication for temperature measurement reliability
  - temperature sensor is defective (Sensor Status E1.26; see 7.1.1)
  - 0x00 (bad): if 0x03 (good): otherwise
- *Limit Status*: indication whether the Device Variable value is limited and not responding to the process
  - 0x01 (low limited): if the temperature value is below the LTL (lower transducer limit) (Sensor Status W1.26; see 7.1.2)
  - 0x02 (high limited): if the temperature value is above the UTL (upper transducer limit) (Sensor Status W1.27; see 7.1.2)
  - 0x00 (not limited): otherwise
- *Device Family Status*: not used, set to 0x00

5.3 Device Variable 2 Quality Indicator

This Device Variable holds the value of the Quality Indicator which is a derived value for monitoring the state of the luminophore.

Device Variable			
Number:	2	Name	Quality Indicator
Classification:	see 14.12	Unit Codes	see 14.5
Device Family	see 14.13		
Device Family Commands	None		

5.3.1 Device Variable 2 Status

The Device Variable Status read in command #9 consists of:

- *Process Data Status*: reliability of the quality indication
  - 0x03 (good): otherwise
  - 0x00 (bad): if sensor cap is missing
- *Limit Status*: not used, set to 0x00 (not limited)
- *Device Family Status*: not used, set to 0x00

6 Dynamic Variables

The sensor supports PV, SV and TV as dynamic variables. The assignment of device variables to dynamic variables is fixed and cannot be changed.

Dynamic Variable	Device Variable Number	Name
PV	0	Dissolved Oxygen
SV	1	Temperature
TV	2	Quality Indicator

7 Status Information

7.1 Sensor Status

The VisiPro DO has a Sensor Status implemented. It is subdivided into error and warning indications as well as grouped into thematic categories. The Sensor Status is kept up to date continuously, i.e. the error and warning bits are set and cleared without any user interaction.
The Sensor Status is mapped completely to the HART Additional Device Status (see 7.4). It is mapped partially to the Field Device Status and the Extended Device Status (see 7.2 and 7.3).
Depending on the user-defined Loop Current Configuration an active error or warning in the Sensor Status activates alarm signaling on the analog interface (see 4.2.1).

In order to help identifying the error and warning bits of the Sensor Status an ID has been assigned to every error or warning. Throughout this manual references to errors and warnings of the Sensor Status are made based on this ID.

7.1.1 Errors

Measurement Errors 1

Bit-Mask	ID	Name	Condition
0x01	E1.1	DO reading failure	Sensor cap is missing or the PMC1 has failed.
0x02	E1.2	p(O2) exceeds air pressure	Measured partial pressure of oxygen is higher than the air pressure set by the operator.
0x04	E1.26	T sensor defective	The internal temperature sensor is defective.

Measurement Errors 2

Bit-Mask	ID	Name	Condition
		This byte is reserved for future use and is set to 0x00.	

Calibration Errors 1

Bit-Mask	ID	Name	Condition
0x01	E2.1	DO sensor cap missing	The DO sensor cap has been removed.

Calibration Errors 2

Bit-Mask	ID	Name	Condition
		This byte is reserved for future use and is set to 0x00.	

Interface Errors

Bit-Mask	ID	Name	Condition
		This byte is reserved for future use and is set to 0x00.	

Hardware Errors

Bit-Mask	ID	Name	Condition
0x01	E4.3	T far below min.	The measured temperature is below the operation temperature.
0x02	E4.4	T far above max.	The measured temperature is above

			the operation temperature.
0x04	E4.17	Red channel failure	Measurement channel failure.
0x08	E4.24	Non-Volatile Memory Defect	Self-test has detected program memory corruption
0x10	E4.25	Internal communication failure	No communication to the measurement frontend

7.1.2 Warnings

Measurement Warnings 1

Bit-Mask	ID	Name	Condition
0x01	W1.1	DO reading below lower limit	The oxygen reading is too low (DO < 0%-sat)
0x02	W1.2	DO reading above upper limit	The oxygen reading is too high (DO > 300 %-sat).
0x04	W1.3	DO reading unstable	The DO measurement is unstable (Standard deviation > 1 °).
0x08	W1.26	T reading below lower limit	The temperature is below the user defined measurement temperature range. If outside this range, the sensor will not perform DO readings.
0x10	W1.27	T reading above upper limit	The temperature is above the user defined measurement temperature range. If outside this range, the sensor will not perform DO readings.
0x20	W1.32	Measurement not running	Either the measurement interval is set to 0 or the measurement temperature is out of range.

Measurement Warnings 2

Bit-Mask	ID	Name	Condition
		This byte is reserved for future use and is set to 0x00.	

Calibration Warnings 1

Bit-Mask	ID	Name	Condition
0x01	W2.1	DO calibration recommended	
0x04	W2.3	DO replace sensor cap	The sensor cap of VisiPro DO must be replaced and the sensor needs to be recalibrated with the new cap. This warning is active as long as the sensor quality is below 35%.

Calibration Warnings 2

Bit-Mask	ID	Name	Condition
		This byte is reserved for future use and is set to 0x00.	

Interface Warnings

Bit-Mask	ID	Name	Condition
0x01	W3.1	4-20mA value below 4mA	The measurement value is below the lower limit of the 4–20 mA interface output.
0x02	W3.2	4-20mA value above 20mA	The measurement value is above the upper limit of the 4–20 mA interface output.

Hardware Warnings

Bit-Mask	ID	Name	Condition
		This byte is reserved for future use and is set to 0x00.	

7.2 Field Device Status

The Field Device Status is transferred with every HART transaction. The bits in the Field Device Status bit-mask remain set as long as the condition in following table is active. If not stated otherwise, the bits are cleared as soon as the condition turns inactive.

Bit Mask	Name	Condition
0x80	Device Malfunction	Not used
0x40	Configuration Changed	An operation was performed that changed the device's configuration. This bit is cleared using command #38.
0x20	Cold Start	A power failure or device reset has occurred. This bit is cleared after the first HART transaction.
0x10	More Status Available	Additional status information is available via command #48. This bit is cleared using command #48. The additional status information is defined in 7.4.
0x08	Loop Current Fixed	Active if one of the following points applies: • Loop current mode is disabled (multi-drop operation) • Fixed current mode is enabled • Loop Current is set to high or low Alarm Level (see 4.2.1)
0x04	Loop Current Saturated	The Loop Current has reached its upper or lower endpoint limit and cannot increase or decrease any further. (Sensor Status W3.1 or W3.2; see 7.1.2)
0x02	Non-Primary Variable Out of Limits	A Device Variable not mapped to the PV is beyond its operating limits. (Sensor Status W1.26 or W1.27; see 7.1.2)
0x01	Primary Variable Out of Limits	The PV is beyond its operating limits. (Sensor Status W1.1 or W1.2; see 7.1.2)

7.3 Extended Device Status

The Extended Device Status is transferred with commands #0, #9 and #48. The bits in the Extended Device Status bit-mask remain set as long as the condition in following table is active.
In general the bits reflect the actual sensor condition and the flags are individual cleared automatically, as soon as the error or warning condition does not apply anymore.

Bit Mask	Name	Condition
0x04	Critical Power Failure	not used
0x02	Device Variable Alert	The Device Variable Status of Device Variable 0, 1 or 2 is in one of the following conditions(see 5.1.1, 5.2.1 and 5.3.1): • Process Data Status is bad • Limit Status high or low (Sensor Status W1.1, W1.2, W1.26 or W1.27; see 7.1.2)
0x01	Maintenance Required	Active if one of the following points applies: • DO Calibration Recommended (Sensor Status W2.1; see 7.1.2) • DO Replace Sensor Cap (Sensor Status W2.3; see 7.1.2)

7.4 Additional Device Status (Command #48)

Byte	Name	Detailed Description
0	Sensor Status: Measurement Warnings 1	see 7.1.2
1	Sensor Status: Measurement Warnings 2	see 7.1.2
2	Sensor Status: Calibration Warnings 1	see 7.1.2
3	Sensor Status: Calibration Warnings 2	see 7.1.2
4	Sensor Status: Interface Warnings	see 7.1.2
5	Sensor Status: Hardware Warnings	see 7.1.2
6	Extended Device Status	see 7.3
7	Device Operating Mode	see 7.4.1
8	Standardized Status 0	see 7.4.2
9	Standardized Status 1	see 7.4.3
10	Analog Channel Saturated	see 7.4.4
11	Standardized Status 2	see 7.4.5
12	Standardized Status 3	see 7.4.6
13	Analog Channel Fixed	see 7.4.7
14	Sensor Status: Measurement Errors 1	see 7.1.1
15	Sensor Status: Measurement Errors 2	see 7.1.1
16	Sensor Status: Calibration Errors 1	see 7.1.1
17	Sensor Status: Calibration Errors 2	see 7.1.1
18	Sensor Status: Interface Errors	see 7.1.1
19	Sensor Status: Hardware Errors	see 7.1.1
20-24	Reserved	set to 0x00

7.4.1 Byte 7: Device Operating Mode

This byte is reserved for future use and is set to 0x00.

7.4.2 Byte 8: Standardized Status 0

Bit-Mask	Name	Condition	Actions
0x01	Simulation Active	not used	
0x02	Non-Volatile Memory Defect	Sensor Status E4.24; see 7.1.1	
0x04	Volatile Memory Defect	not used	
0x08	Watchdog Reset Executed	not used	
0x10	Voltage Conditions Out Of Range	not used	
0x20	Environmental Conditions Out Of Range	not used	
0x40	Electronic Defect	not used	

7.4.3 Byte 9: Standardized Status 1

This byte is reserved for future use and is set to 0x00.

7.4.4 Byte 10: Analog Channel Saturated

Because the device only has one analog output this byte is set to 0x00.

7.4.5 Byte 11: Standardized Status 2

This byte is not used and is set to 0x00.

7.4.6 Byte 12: Standardized Status 3

This byte is not used and is set to 0x00.

7.4.7 Byte 13: Analog Channel Fixed

Because the device only has one analog output this byte is set to 0x00.

8 Universal Commands

8.1 Command #3:

Returns PV, SV and TV for a total of 19 bytes of response data.

8.2 Command #14:

- Sensor serial number is not used, and returns 0.
- Minimum span is not applicable and is set to 0x7fa00000 (NAN).

8.3 Command #15:

- Alarm Code is fixed and is set to 253 (special)
- Damping Value is fixed and is set to 0.
- The Write Protect Mechanism is not implemented. Write Protect Code always returns 251 (0xfb) “None”
- The PV Analog Channel Flag is set to 0x00.

8.4 Default Values

HART Universal Commands use a set of variables that have the following factory default values:

Variable	Default Value	Data Type	Read Cmd	Write Cmd
Tag	[S/N]	packed ASCII 8	#13	#18
Long Tag	[P/N]-[S/N] e.g. “243400-1234”	Latin-1 32	#20	#22
Descriptor	[Product Name] e.g. “VisiPro DO”	packed ASCII 16	#13	#18
Message	“”	packed ASCII 32	#12	#17
Date	[ProductionDate]	Date	#13	#18
Final Assembly Number	[S/N]	unsigned-24	#16	#19
Polling Address	0	unsigned-8	#6	#7
Loop Current Mode	1 (enabled)	enum	#6	#7

9 Common-Practice Commands

9.1 Supported Commands

9.1.1 Overview

The following common-practice commands are implemented:

Number	Name	Notes
33	Read Device Variables	
35	Write PV Range Values	• URV and LRV can be provided in any of the units defined in 14.3. • URV may be smaller than LRV in order to enable operation with reverse action. • There is no minimum span requirement
40	Enter/Exit Fixed Current Mode	
42	Perform Device Reset	See 13.3 for a detailed description of Device Reset.
44	Write PV Units	See 14.3 for a list of allowed units.
45	Trim Loop Current Zero	
46	Trim Loop Current Gain	
47	Write PV Transfer Function	See 14.11 for a list of implemented transfer functions
50	Read Dynamic Variable Assignments	
53	Write Device Variable Units	• See 14.3 for a list of allowed units for Device Variable 0 • See 14.4 for a list of allowed units for Device Variable 1 • See 14.5 for a list of allowed units for Device Variable 2
54	Read Device Variable Information	• Transducer serial number is not used, and returns 0. • There is no minimum span requirement. • Device Variable Classification is 0x00 “not classified” for all Device Variables. • Device Variable Family is 250 “Not used” for all Device Variables. • Update Time Period is fixed to 10 seconds.
59	Write Number Of Response Preambles	
72	Squawk	
80	Read Device Variable Trim Points	See 9.2 for a detailed description of calibration commands.
81	Read Device Variable Trim Guidelines	See 9.2 for a detailed description of calibration commands.
82	Write Device Variable Trim Point	See 9.2.1 for a detailed description of the standard calibration method and in 9.1.17 the command itself
83	Reset Device Variable Trim	See 9.2 for a detailed description of calibration commands.
89	Set Real-Time Clock	
90	Read Real-Time Clock	

95	Read Device Communications Statistics	
106	Flush Delayed Responses	

9.1.2 Command #33: Read Device Variables

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Slot 0: Device Variable Code (see 14.1 Device Variables)
1	Unsigned-8	Slot 1: Device Variable Code (see 14.1 Device Variables)
2	Unsigned-8	Slot 2: Device Variable Code (see 14.1 Device Variables)
3	Unsigned-8	Slot 3: Device Variable Code (see 14.1 Device Variables)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Slot 0: Device Variable Code (see 14.1 Device Variables)
1	Enum	Slot 0: Units Code (refer to 14.3 Dissolved Oxygen Unit Codes, 14.4 Temperature Unit Codes or 14.5 Quality Indicator Unit Code)
2-5	Float	Slot 0: Device Variable Value
6	Unsigned-8	Slot 1: Device Variable Code (see 14.1 Device Variables)
7	Enum	Slot 1: Units Code (refer to 14.3 Dissolved Oxygen Unit Codes, 14.4 Temperature Unit Codes or 14.5 Quality Indicator Unit Code)
8-11	Float	Slot 1: Device Variable Value
12	Unsigned-8	Slot 2: Device Variable Code (see 14.1 Device Variables)
13	Enum	Slot 2: Units Code (refer to 14.3 Dissolved Oxygen Unit Codes, 14.4 Temperature Unit Codes or 14.5 Quality Indicator Unit Code)
14-17	Float	Slot 2: Device Variable Value
18	Unsigned-8	Slot 3: Device Variable Code (see 14.1 Device Variables)
19	Enum	Slot 3: Units Code (refer to 14.3 Dissolved Oxygen Unit Codes, 14.4 Temperature Unit Codes or 14.5 Quality Indicator Unit Code)
20-23	Float	Slot 3: Device Variable Value

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection
3-4		Undefined
5	Error	Too Few Data Bytes Received
6-7		Undefined
8	Warning	Update Failure
9-15		Undefined
16	Error	Access Restricted
17-127		Undefined

9.1.3 Command #35: Write Primary Variable Range Values

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Upper and Lower Range Values Units Code (see Device Variable Codes Table in 14.3 1Dissolved Oxygen Unit Codes)
1-4	Float	Upper Range Value
5-8	Float	Lower Range Value

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Upper and Lower Range Values Units Code (see Device Variable Codes Table in 14.3 Dissolved Oxygen Unit Codes)
1-4	Float	Upper Range Value
5-8	Float	Lower Range Value

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection
3-4		Undefined
5	Error	Too Few Data Bytes Received
6-13		Undefined
14	Warning	Span Too Small (Device Accuracy May Be Impaired)
15		Undefined
16	Error	Access Restricted
17		Undefined
18	Error	Invalid Units Code
19-127		Undefined

9.1.4 Command #40: Enter/Exit Fixed Current Mode

Request Data Bytes

Byte	Format	Description
0-3	Float	Fixed Current Level (units of milliamperes)

Response Data Bytes

Byte	Format	Description
0-3	Float	Actual Current Level (units of milliamperes)

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-2		Undefined
3	Error	Passed Parameter Too Large
4	Error	Passed Parameter Too Small
5	Error	Too Few Data Bytes Received
6-10		Undefined
11	Error	Loop Current Not Active (Device in Multidrop Mode)
12-127		Undefined

9.1.5 Command #42: Perform Device Reset

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
None		

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-127		Undefined

9.1.6 Command #44: Write Primary Variable Units

Request Data Bytes

Byte	Format	Description
0	Enum	Primary Variable Units Code (refer to 14.3 Dissolved Oxygen Unit Codes)

Response Data Bytes

Byte	Format	Description
0	Enum	Primary Variable Units Code (refer to 14.3 Dissolved Oxygen Unit Codes)

Note: The value returned in the response data bytes reflects the value actually used by the device.

Command-Specific Response Codes

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

9.1.7 Command #45: Trim Loop Current Zero

Request Data Bytes

Byte	Format	Description
0-3	Float	Externally Measured Loop Current Level, units of milliamperes

Response Data Bytes

Byte	Format	Description
0-3	Float	Externally Measured Loop Current Level, units of milliamperes

Note: The value returned in the response data bytes reflects the rounded or truncated value actually used by the device.

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-2		Undefined
3	Error	Passed Parameter Too Large
4	Error	Passed Parameter Too Small
5	Error	Too Few Data Bytes Received
6-8		Undefined
9	Error	Incorrect Loop Current Mode or Value
10		Undefined
11	Error	Loop Current Not Active (Device in Multidrop Mode)
12-127		Undefined

9.1.8 Command #46: Trim Loop Current Gain

Request Data Bytes

Byte	Format	Description
0-3	Float	Externally Measured Loop Current Level, units of milliamperes

Response Data Bytes

Byte	Format	Description
0-3	Float	Externally Measured Loop Current Level, units of milliamperes

Note: The value returned in the response data bytes reflects the rounded or truncated value actually used by the device.

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-2		Undefined
3	Error	Passed Parameter Too Large
4	Error	Passed Parameter Too Small
5	Error	Too Few Data Bytes Received
6-8		Undefined
9	Error	Incorrect Loop Current Mode or Value
10		Undefined
11	Error	Loop Current Not Active (Device in Multidrop Mode)
12-127		Undefined

9.1.9 Command #47: Write PV Transfer Function

Request Data Bytes

Byte	Format	Description
0	Enum	Transfer Function Code (see 14.11 Transfer Function)

Response Data Bytes

Byte	Format	Description
0	Enum	Transfer Function Code (see 14.11 Transfer Function)

Note: The value returned in the response data bytes reflects the value actually used by the device.

Command-Specific Response Codes

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

9.1.10 Command #50: Read Dynamic Variable Assignments

Request Data Bytes

Byte	Format	Description
none		

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable assigned to the Primary Variable (see 14.1 Device Variables)
1	Unsigned-8	Device Variable assigned to the Secondary Variable (see 14.1 Device Variables)
2	Unsigned-8	Device Variable assigned to the Tertiary Variable (see 14.1 Device Variables)
3	Unsigned-8	Device Variable assigned to the Quarternary Variable (see 14.1 Device Variables)

Note: The device does not support a Quaternary Variable and therefore always a value of 250 (Not Used) will be returned in byte 3.

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-127		Undefined

9.1.11 Command #53: Write Device Variable Units

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (see 14.1 Device Variables)
1	Enum	Device Variable Units Code (refer to 14.3 Dissolved Oxygen Unit Codes, 14.4 Temperature Unit Codes or 14.5 Quality Indicator Unit Code)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (see 14.1 Device Variables)
1	Enum	Device Variable Units Code (refer to 14.3 Dissolved Oxygen Unit Codes, 14.4 Temperature Unit Codes or 14.5 Quality Indicator Unit Code)

Note: The value returned in the response data bytes reflects the value actually used by the device.

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-4		Undefined
5	Error	Too Few Data Bytes Received
6-10		Undefined
11	Error	Invalid Device Variable Code
12	Error	Invalid Units Code
13-127		Undefined

9.1.12 Command #54: Read Device Variable Information

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (see 14.2 Device Variable Information)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (see 14.2 Device Variable Information)
1-3	Unsigned-24	Device Variable Transducer Serial Number
4	Enum	Device Variable Limits/Minimum Span Units Code (refer to 14.3 Dissolved Oxygen Unit Codes and 14.4 Temperature Unit Codes)
5-8	Float	Device Variable Upper Transducer Limit
9-12	Float	Device Variable Lower Transducer Limit
13-16	Float	Device Variable Damping Value
17-20	Float	Device Variable Minimum Span
21	Enum	Device Variable Classification (see 14.12 Device Variable Classification)
22	Enum	Device Variable Family (see14.13 Device Variable Family)
23-26	Time	Update Time Period. The Update Time Period indicates the maximum period between Device Variable updates (see 14.14 Update Time Period).

Note1: The Transducer Serial Number is set to zero
Note2: The Device Variable Classification is not supported by this Device Variable and a value of 0 will be returned.
Note3: The Device Variable Family is not supported for all Device Variables and a value of 250 (0xFA) will be returned.
Note4: Additional device variable information for the Quality Indicator (TV) is not supported by this device. Instead an error code, invalid selection will be returned.

Command-Specific Response Codes

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

9.1.13 Command #59: Write Number Of Response Preambles

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Number of preambles to be sent with the response message from the Slave to the master

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Number of preambles to be sent with the response message from the Slave to the master

Note 1: The value returned in the response data bytes reflects the value actually used by the device.
Note 2: The value of number of preambles may be set to no smaller than 5 and no greater than 20.

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-2		Undefined
3	Error	Passed Parameter Too Large
4	Error	Passed Parameter Too Small
5	Error	Too Few Data Bytes Received
6-127		Undefined

9.1.14 Command #72: Squawk

Request Data Bytes

Byte	Format	Description
none		

Response Data Bytes

Byte	Format	Description
none		

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-127		Undefined

9.1.15 Command #80: Read Device Variable Trim Points

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (see 14.10 Device Variable to trim)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (see 14.10 Device Variable to trim)
1	Unsigned-8	Trim Point Units Code (see 14.3 Dissolved Oxygen Unit Codes)
2-5	Float	Lower or Single Trim Point (the most recent value used for the lower trim point)
6-9	Float	Upper Trim Point (the most recent value used for the upper trim point)

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-4		Undefined
5	Error	Too Few Data Bytes Received
4-16		Undefined
17	Error	Invalid Device Variable Index. The Device Variable does not exist in this Field Device.
18		Undefined
19	Error	Device Variable index not allowed for this command.
20-127		Undefined

9.1.16 Command #81: Read Device Variable Trim Guidelines

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (see Table 14.10 Device Variable to trim)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (see Table 14.10 Device Variable to trim)
1	Enum	Trim Point (see 14.9 Trim Point Code)
2	Enum	Trim Point Units Code (see 14.3 Dissolved Oxygen Unit Codes)
3-6	Float	Minimum Lower Trim Point Value (no value lower than this will be accepted by the instrument during a low trim procedure)
7-10	Float	Maximum Lower Trim Point Value (no value higher than this will be accepted by the instrument during a low trim procedure)
11-14	Float	Minimum Upper Trim Point Value (no value lower than this will be accepted by the instrument during a high trim procedure)
15-18	Float	Maximum Upper Trim Point Value (no value higher than this will be accepted by the instrument during a high trim procedure)
19-22	Float	Minimum Differential (minimum acceptable difference between upper and lower trim points)

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-4		Undefined
5	Error	Too Few Data Bytes Received
4-16		Undefined
17	Error	Invalid Device Variable Index. The Device Variable does not exist in this Field Device.
18		Undefined
19	Error	Device Variable index not allowed for this command.
20-127		Undefined

9.1.17 Command #82: Write Device Variable Trim Point

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (see 14.10 Device Variable to trim)
1	Unsigned-8	Trim Point (see 14.9 Trim Point Code)
2	Enum	Trim Point Units Code (see 14.3 Dissolved Oxygen Unit Codes)
3-6	Float	Trim Point Value (the presently applied process value for this Device Variable)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (see 14.10 Device Variable to trim)
1	Bits	Trim Point (see 14.9 Trim Point Code)
2	Enum	Trim Point Units Code (see 14.3 Dissolved Oxygen Unit Codes)
3-6	Float	Trim Point Value (the presently applied process value for this Device Variable)

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection
3	Error	Passed Parameter Too Large
4	Error	Passed Parameter Too Small
5	Error	Too Few Data Bytes Received
6-8		Undefined
9	Error	Applied Process Too High
10	Error	Applied Process Too Low
11-12		Undefined
13	Error	Computation Error, Trim Values Were Not Changed
14-16		Undefined
17	Error	Invalid Device Variable Index. The Device Variable does not exist in this Field Device.
18	Error	Invalid units code
19	Error	Device Variable index not allowed for this command.
20-127		Undefined

9.1.18 Command #83: Reset Device Variable Trim

Reset to the factory calibration settings. All calibration settings will be overwritten, except the amount of calibrations for CP1 (Zero Oxygen Calibration Point), CP2 (Air Calibration Point) and CP6 (Product Calibration Point).

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (see 14.10 Device Variable to trim)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (see 14.10 Device Variable to trim)

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-4		Undefined
5	Error	Too Few Data Bytes Received
6-16		Undefined
17	Error	Invalid Device Variable Index. The Device Variable does not exist in this Field Device.
18		Undefined
19	Error	Device Variable index not allowed for this command.
20-127		Undefined

9.1.19 Command #89: Set Real-Time Clock

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Time-set Code (see 14.15 Time-set Code)
1-3	Date	Date Code to set device's Real-Time Clock
4-7	Time	Time of Day to set device's Real-Time Clock
8-9	Unsigned-16	Should be set to 0. Two bytes to ensure request and response take equal amounts of time (compensates for transmission time of Response Code and Device Status in response)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Time-set Code (see 14.15 Time-set Code)
1-3	Date	Date Code to set device's Real-Time Clock
4-7	Time	Time of Day to set device's Real-Time Clock

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection
3	Error	Passed Parameter Too Large
4	Error	Passed Parameter Too Small
5	Error	Too Few Data Bytes Received
6-127		Undefined

9.1.20 Command #90: Read Real-Time Clock

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
1-3	Date	Current Date
4-7	Time	Current Time of Day
8-10	Date	Date clock last set
11-14	Time	Time clock last set
15	Bits	RTC Flags (see 14.16 Real-Time Clock Flags)

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection
3	Error	Passed Parameter Too Large
4	Error	Passed Parameter Too Small
5	Error	Too Few Data Bytes Received
6-127		Undefined

9.1.21 Command #95: Read Device Communications Statistics

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
0-1	Unsigned-16	Count of STX messages received by this device
2-3	Unsigned-16	Count of ACK messages sent from this device
4-5	Unsigned-16	Count of BACK messages sent from this device

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-127		Undefined

9.1.22 Command #106: Flush Delayed Responses

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
none		

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-127		Undefined

9.2 Calibration Implementation

The VisiPro Sensor has two different kinds of calibration methods implemented: the Standard Calibration and the Product Calibration.

9.2.1 Standard Calibration

The Standard Calibration has two points which must be calibrated for a good working sensor. A Zero Oxygen Calibration point (CP1), which can only be calibrated at zero oxygen and air calibration point (CP2), which can be calibrated at a large range of oxygen (from 20mbar to 550mbar DO partial pressure).
When initiating the calibration, the data set of the VisiPro DO is automatically traced back within the last 100 seconds and a decision is made immediately if the calibration is successful or not. The operator therefore gets an immediate result. The criteria for a successful calibration are:

- stability of phase and temperature over the last 100 seconds
- phase is in a reasonable phase window
- current oxygen content is within limits defined for zero oxygen - and air.

 Attention:

It is important that the VisiPro DO is in a defined calibration media at least 100 seconds BEFORE the calibration is started.

If the sensor has a measurement interval greater than 3 or equals 0 and / or the temperature is out of the user defined measurement temperature range, the procedure is as follows:

1. Send calibration command to the sensor. The sensor will return “drift oxygen”
2. Send calibration command after at least 100s again to the sensor. If the stability is ok, the sensor returns “calibration successful” (0x00 in the status register), if the stability is not ok, the sensor sets the corresponding bit in the calibration status register.

In the previous case, the sensor temporarily expands the measurement temperature range to the maximum allowed for the sensor and sets the measurement interval to 3 if greater than 3 or 0. 10 minutes after the last calibration command or after a power up, these settings are reset and the sensor runs with the originally entered values.

 Attention:

CP1 is fixed to a calibration in an oxygen-free medium (0 %-vol oxygen) – low point, and CP2 is fixed to a calibration between 2.045 %-vol (20mbar) and 56.242 %-vol (550mbar) oxygen – high point.
There is an automatic mode for both CP1 and CP2 when using 0 as parameter. In this mode, the operator declares that CP1 is performed in oxygen-free media, and CP2 in air or air-saturated water. The operator does not need to care about the physical units that are currently active.

9.2.2 Product Calibration

9.2.2.1 General

The product calibration (CP6) has the same functionality as CP2. When CP6 is active, the calibration coefficients are calculated the same way as with the standard calibration, but with CP1 and CP6. The calibration coefficients are being saved while CP6 is active. (See also 10.2 for a detailed description.)

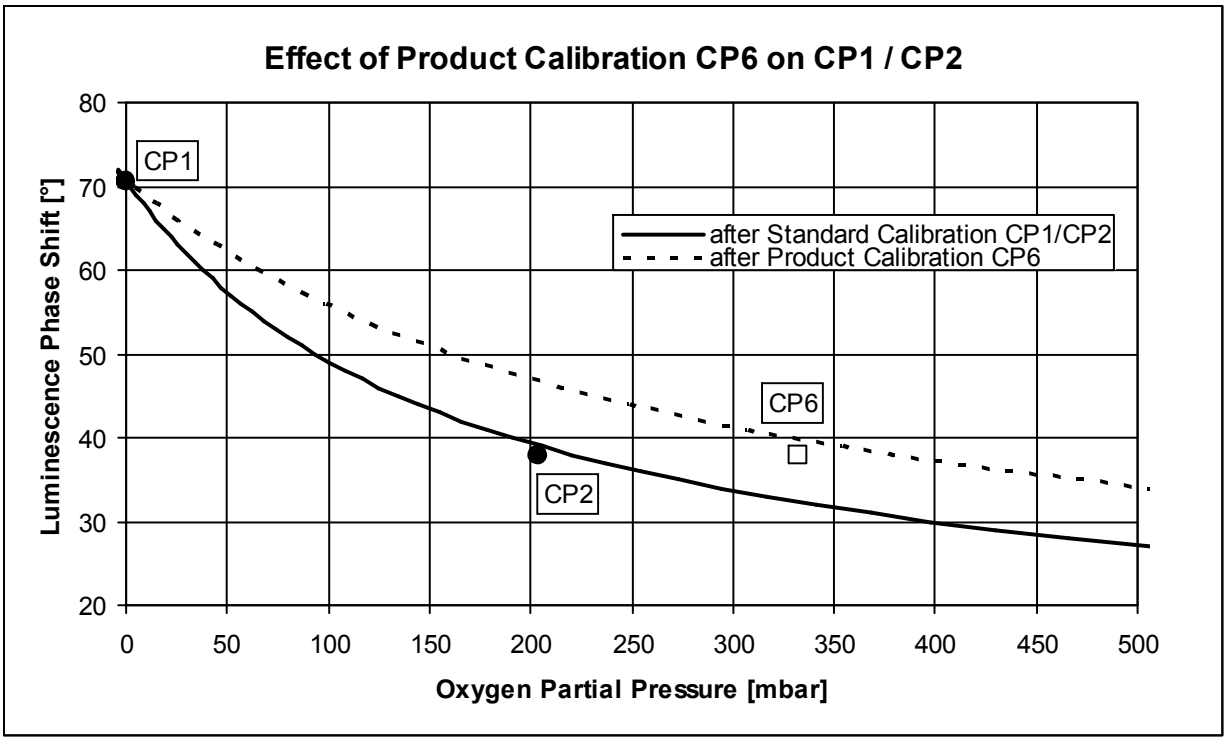


Figure 9.1: Effect of the product calibration on an existing standard calibration function defined by Calibration in zero oxygen and Calibration in air.

The operator starts with a standard calibration with calibration points CP1 and CP2:

CP1:	oxygen value: 0 mbar	temperature: 27.77°C measured phase red: 70.7°
CP2:	oxygen value: 203.92 mbar	temperature: 28.71°C measured phase red: 37.98°

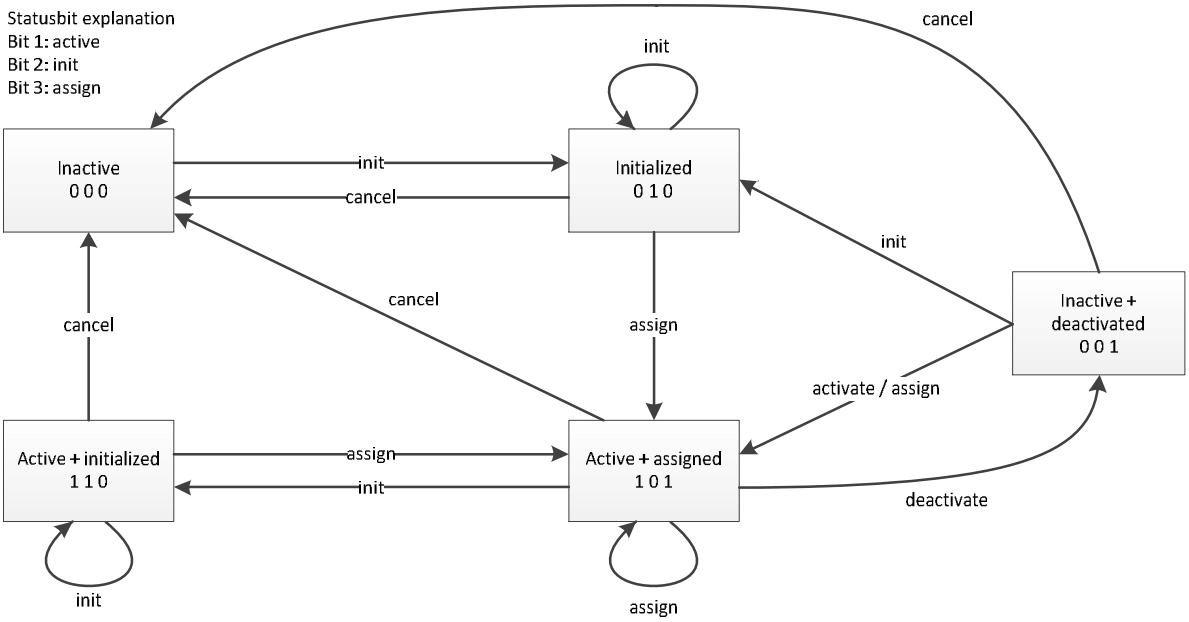
The sensor internally calculates the calibration function, using CP1 and CP2. The resulting calibration function, compensated to the standard temperature 25°C, is shown as a straight line. The calibration function is described by two parameters: the phase at zero oxygen and the Stern-Volmer coefficient.

As the process is running and no standard calibration can be performed under defined conditions in the lab, a product calibration can be performed, in other words adjusting the standard calibration function to the process conditions:

CP6:	oxygen value: 332 mbar	temperature: 28.79°C measured phase red: 37.99°

The sensor internally recalculates the calibration function at 25°C, using CP1 and CP6. The new calibration function, compensated to the standard temperature 25°C, is shown as a dotted line.

9.2.2.2 Product Calibration - Workflow



Commands:	Out of calibration range	Out of range	
Init	0/1	X	X: Current flag will not change
Assign	X	0/1	0: Not active
Cancel	0	0	1: Active
Activate	X	X	0/1: 0 in case of success, 1 in case of failure
Deactivate	X	X	

The product calibration knows 5 different states. These states are described as follows:

Inactive state: There is no product calibration initialized and no product calibration active.

- init command: The actual sensor values are taken and the product calibration switches into the initialized state.

Initialized state: The product calibration is initialized, but no value is assigned to these initialized values. The calibration is not active.

- Init: The initialized values are overwritten by the new actual values and the product calibration stays in the same state
- Cancel: Clears all the values and the product calibration switches into the inactive state
- Assign: Assigns an oxygen value to the initialized values and the product calibration switches into the state active and assigned.

Active and Assigned state: The product calibration is active and has an assigned value.

- Cancel: Clears all the values and the active product calibration (restores standard calibration) and the product calibration switches into the inactive state
- Init: Keeps the actual product calibration but makes a new product calibration init.
- Deactivate: Saves the actual product calibration values in the memory, restores the standard calibration
- Assign: Assigns a new oxygen value to the initialized values, immediately activates the new product calibration and the product calibration stays in the same state.

Inactive and deactivated: the standard calibration is active, but the product calibration values are still stored in the sensor.

- Cancel: Clears all the values and the product calibration switches into the inactive state.
- Assign: Assigns a new oxygen value to the initialized values in the memory, immediately activates the new product calibration and the product calibration switches into the state active and assigned.
- Activate: Restores the previous assigned product calibration and the product calibration switches into the active and assigned state

- Init: The initialized values are overwritten by the new actual values. The product calibration switches into the initialized state.

Active and initialized: A previous made product calibration is active, but there are new values initialized, which can be activated. If a new value is assigned, the present active calibration is lost.

- Cancel: Clears all the values and the active product calibration (restores standards calibration) and the product calibration switches into the inactive state
- Init: The initialized values are overwritten by the new actual values. The product calibration stays in the same state
- Assign: Assigns a new oxygen value to the initialized values in the memory, immediately activates the new product calibration. The product calibration switches into the active and assigned state.

Product Calibration status:

Out of Calibration Range:

Appears when an Initial Product Calibration is performed but the measurement values do not match the conditions for the sensor to proceed with the product calibration. The warning bit appears and the product calibration stays in the same status as it is.
Can be cleared either with a proper initialization or cancel command.

Out of Range:

Appears when an invalid oxygen value is assigned to the product calibration. The product calibration stays in this case in the same state.
This bit can be cleared either with a successful assign command or with the cancel command.

9.2.3 Read Additional Calibration Information

The following additional calibration information is available:

Name	Device Specific Command	Comment
Drift DO and Drift Temperature	#129	Read Set of Sensor Variables Float Further Information: ▪ see 14.6 Sensor Variable Sets Float ▪ see 10.3 Read Set of Sensor Variables Float
Number of zero point calibrations (CP1)	#131	Read Set of Sensor Variables UInt32 Further Information: ▪ see 14.7 Sensor Variable Sets UInt32 ▪ see 10.5 Read Set of Sensor Variables UInt32 ▪ see 10.6 Write Set of Sensor Variables UInt32
Number of calibrations (CP2)	#131	Read Set of Sensor Variables UInt32 Further Information: ▪ see 14.7 Sensor Variable Sets UInt32 ▪ see 10.5 Read Set of Sensor Variables UInt32 ▪ see 10.6 Write Set of Sensor Variables UInt32
Number of product calibrations (CP6)	#131	Read Set of Sensor Variables UInt32 Further Information: ▪ see 14.7Sensor Variable Sets UInt32 ▪ see 10.5 Read Set of Sensor Variables UInt32 ▪ see 10.6 Write Set of Sensor Variables UInt32

9.3 Damping Implementation

The device has a fixed damping value.

9.4 Burst Mode

This device does not support Burst Mode.

9.5 Catch Device Variable

This device does not support Catch Device Variable.

10 Device Specific Commands

10.1 Overview

The following device-specific commands are implemented:

Command	Description
128	Perform Product Calibration
129	Read Set of Sensor Variables Float
130	Write Set of Sensor Variables Float
131	Read Set of Sensor Variables UInt32
132	Write Set of Sensor Variables UInt32
133	Read Sensor Variable ASCII String
134	Write Sensor Variable ASCII String

10.2 Command #128: Perform Product Calibration

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Unsigned-8	Product Calibration Command Code (see 14.19 Product Calibration Command Code)
2	Enum	Product Calibration Units Code
3-6	Float	Calibration Value

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Bits	Product Calibration Response Code (see 14.20 Product Calibration Response Code)
2	Enum	Product Calibration Units Code
3-6	Float	Calibration Value

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection
3-15		Undefined
16	Error	Access Restricted
17-127		Undefined

10.3 Command #129: Read Set of Sensor Variables Float

4 Float Variables and 1 Byte interpreted as unit code are read directly from the sensor data base.
The Set Code from the function call indicates the information to read from the sensor, see 14.6.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Sensor Variable Set Code (see 14.6)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Sensor Variable Set Code (see 14.6)
1-4	Float	Sensor Variable 0
5-8	Float	Sensor Variable 1
9-12	Float	Sensor Variable 2
13-16	Float	Sensor Variable 3
17	Enum	Sensor Variable Set Units Code

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-4		Undefined
5	Error	Too Few Data Bytes Received
6-17		Undefined
17	Error	Invalid Sensor Variable Set Code
18-127		Undefined

10.4 Command #130: Write Set of Sensor Variables Float

4 Float Variables and 1 Byte interpreted as unit code are written directly into the sensor data base. The Set Code from the function call indicates the information to write into the sensor, see 14.6.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Sensor Variable Set Code (see 14.6)
1-4	Float	Sensor Variable 0
5-8	Float	Sensor Variable 1
9-12	Float	Sensor Variable 2
13-16	Float	Sensor Variable 3
17	Enum	Sensor Variable Set Units Code

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Sensor Variable Set Code (see 14.6)
1-4	Float	Sensor Variable 0
5-8	Float	Sensor Variable 1
9-12	Float	Sensor Variable 2
13-16	Float	Sensor Variable 3
17	Enum	Sensor Variable Set Units Code

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection
3-4		Undefined
5	Error	Too Few Data Bytes Received
6-17		Undefined
17	Error	Invalid Sensor Variable Set Code
18	Error	Invalid Sensor Unit Code
19-127		Undefined

10.5 Command #131: Read Set of Sensor Variables UInt32

4 Unsigned-32 Variables and 1 Byte interpreted as unit code are read directly from the sensor data base.
The Set Code from the function call indicates the information to read from the sensor, see 14.7.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Sensor Variable Set Code (see 14.7)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Sensor Variable Set Code (see 14.7)
1-4	Unsigned-32	Sensor Variable 0
5-8	Unsigned-32	Sensor Variable 1
9-12	Unsigned-32	Sensor Variable 2
13-16	Unsigned-32	Sensor Variable 3
17	Enum	Sensor Variable Set Units Code

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-4		Undefined
5	Error	Too Few Data Bytes Received
6-17		Undefined
17	Error	Invalid Sensor Variable Set Code
18-127		Undefined

10.6 Command #132: Write Set of Sensor Variables UInt32

4 Unsigned-32 Variables and 1 Byte interpreted as unit code are written directly into the sensor data base.
The Set Code from the function call indicates the information to write into the sensor, see 14.7.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Sensor Variable Set Code (see 14.7)
1-4	Unsigned-32	Sensor Variable 0
5-8	Unsigned-32	Sensor Variable 1
9-12	Unsigned-32	Sensor Variable 2
13-16	Unsigned-32	Sensor Variable 3
17	Enum	Sensor Variable Set Units Code

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Sensor Variable Set Code (see 14.7)
1-4	Unsigned-32	Sensor Variable 0
5-8	Unsigned-32	Sensor Variable 1
9-12	Unsigned-32	Sensor Variable 2
13-16	Unsigned-32	Sensor Variable 3
17	Enum	Sensor Variable Set Units Code

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection
3-4		Undefined
5	Error	Too Few Data Bytes Received
6-17		Undefined
17	Error	Invalid Sensor Variable Set Code
18	Error	Invalid Sensor Unit Code
19-127		Undefined

10.7 Command #133: Read Sensor Variable ASCII String

An ASCII code with a length of 16 bytes interpreted as Latin-1 is read directly from the sensor data base.
The Set Code from the function call indicates the information to read from the sensor, see 14.8.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Sensor Variable Code (see 14.8)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Sensor Variable Code (see 14.8)
1-16	Latin-1	ASCII text

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-4		Undefined
5	Error	Too Few Data Bytes Received
6-17		Undefined
17	Error	Invalid Sensor Variable Set Code
18-127		Undefined

10.8 Command #134: Write Sensor Variable ASCII String

An ASCII code with a length of 16 bytes interpreted as Latin-1 is written directly into the sensor data base.
The Set Code from the function call indicates the information to write into the sensor, see 14.8.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Sensor Variable Set Code (see 14.8)
1-16	Latin-1	ASCII text

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Sensor Variable Set Code (see 14.8)
1-16	Latin-1	ASCII text

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection
3-4		Undefined
5	Error	Too Few Data Bytes Received
6-17		Undefined
17	Error	Invalid Sensor Variable Set Code
18	Error	Invalid Sensor Unit Code
19-127		Undefined

11 Measurement Parameters

11.1 Overview

The following measurement parameters are available:

Name	Device Specific Command	Comment
Salinity	#129 #130	Read Set of Sensor Variables Float Write Set of Sensor Variables Float ▪ only Sensor Variable 0 can be modified Further Information: ▪ see 14.6 Sensor Variable Sets Float ▪ see 10.3 Read Set of Sensor Variables Float ▪ see 10.4 Write Set of Sensor Variables Float
Air Pressure	#129 #130	Read Set of Sensor Variables Float Write Set of Sensor Variables Float ▪ only Sensor Variable 0 can be modified Further Information: ▪ see 14.6 Sensor Variable Sets Float ▪ see 10.3 Read Set of Sensor Variables Float ▪ see 10.4 Write Set of Sensor Variables Float
Moving Average	#131 #132	Read Set of Sensor Variables UInt32 Write Set of Sensor Variables UInt32 ▪ only Sensor Variable 0 can be modified Further Information: ▪ see 14.7 Sensor Variable Sets UInt32 ▪ see 10.5 Read Set of Sensor Variables UInt32 ▪ see 10.6 Write Set of Sensor Variables UInt32
Number of Sub-Measurements (Resolution)	#131 #132	Read Set of Sensor Variables UInt32 Write Set of Sensor Variables UInt32 ▪ only Sensor Variable 0 can be modified Further Information: ▪ see 14.7 Sensor Variable Sets UInt32 ▪ see 10.5 Read Set of Sensor Variables UInt32 ▪ see 10.6 Write Set of Sensor Variables UInt32
Minimum Number of Sub Measurements in the Automatic Mode	#131 #132	Read Set of Sensor Variables UInt32 Write Set of Sensor Variables UInt32 ▪ only Sensor Variable 0 can be modified Further Information: ▪ see 14.7 Sensor Variable Sets UInt32 ▪ see 10.5 Read Set of Sensor Variables UInt32 ▪ see 10.6 Write Set of Sensor Variables UInt32

Measurement Interval	#131 #132	Read Set of Sensor Variables UInt32 Write Set of Sensor Variables UInt32 ▪ only Sensor Variable 0 can be modified Further Information: ▪ see 14.7 Sensor Variable Sets UInt32 ▪ see 10.5 Read Set of Sensor Variables UInt32 ▪ see 10.6 Write Set of Sensor Variables UInt32
Sensor Cap Part Number	#131 #132	Read Set of Sensor Variables UInt32 Write Set of Sensor Variables UInt32 ▪ only Sensor Variable 0 can be modified Further Information: ▪ see 14.7 Sensor Variable Sets UInt32 ▪ see 10.5 Read Set of Sensor Variables UInt32 ▪ see 10.6 Write Set of Sensor Variables UInt32

11.2 Salinity

The physical measurement of VisiPro DO is responding to the partial pressure of oxygen. For a given partial pressure of oxygen in air, the concentration of dissolved oxygen in saturated water is strongly dependent on temperature, as well as on its salinity. By measuring the partial pressure of oxygen and correcting for temperature and salinity, VisiPro DO can determine the concentration of oxygen in a sample.
At 25°C and in air saturated, pure water, the concentration of dissolved oxygen is 8.2 mg/l. The more salt, the lower is the solubility.

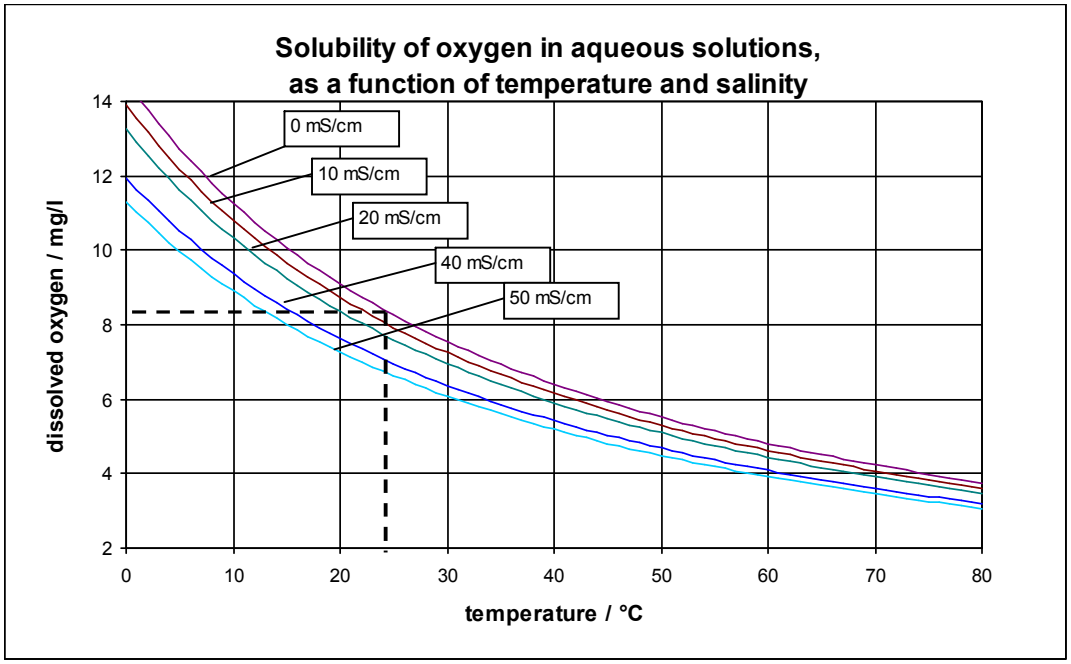


Figure 11.1: Solubility of oxygen as a function of temperature and salinity, in air saturated aqueous solution. Temperature range is from 0-85 °C. Salinity can be entered from 0-50 mS/cm.

11.3 Air Pressure

The VisiPro DO sensor measures the partial pressure of oxygen. The partial pressure of oxygen is proportional to the atmospheric pressure or the pressure of the air supply to the process. In order to compensate for changes in atmospheric pressure or pressure of air supply in the process, one can use measurement parameter air pressure.

Measurement parameter air pressure defines the current air pressure and this value is used for internal calculation.

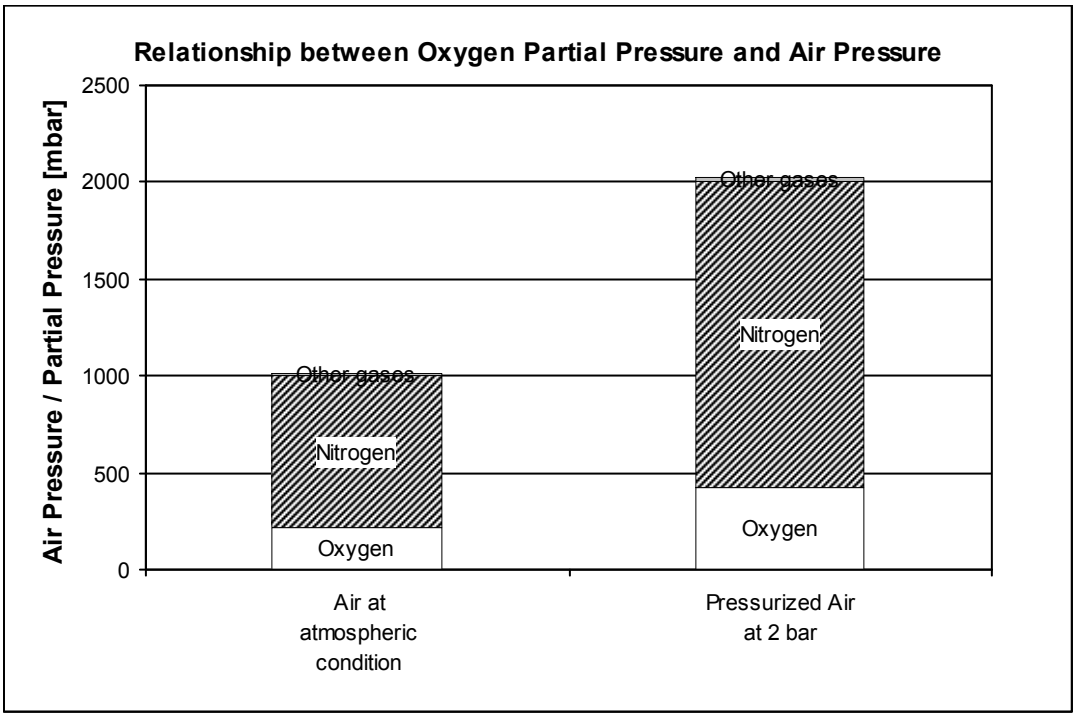


Figure 11.2: Influence of air pressure on the partial pressure of oxygen. Doubling the air pressure also doubles the oxygen partial pressure.

11.4 Moving Average

VisiPro DO calculates new oxygen readings with a measurement interval defined by the parameter measurement interval. One has the possibility to smoothen the oxygen reading (Device Variable 0) by means of a moving average.

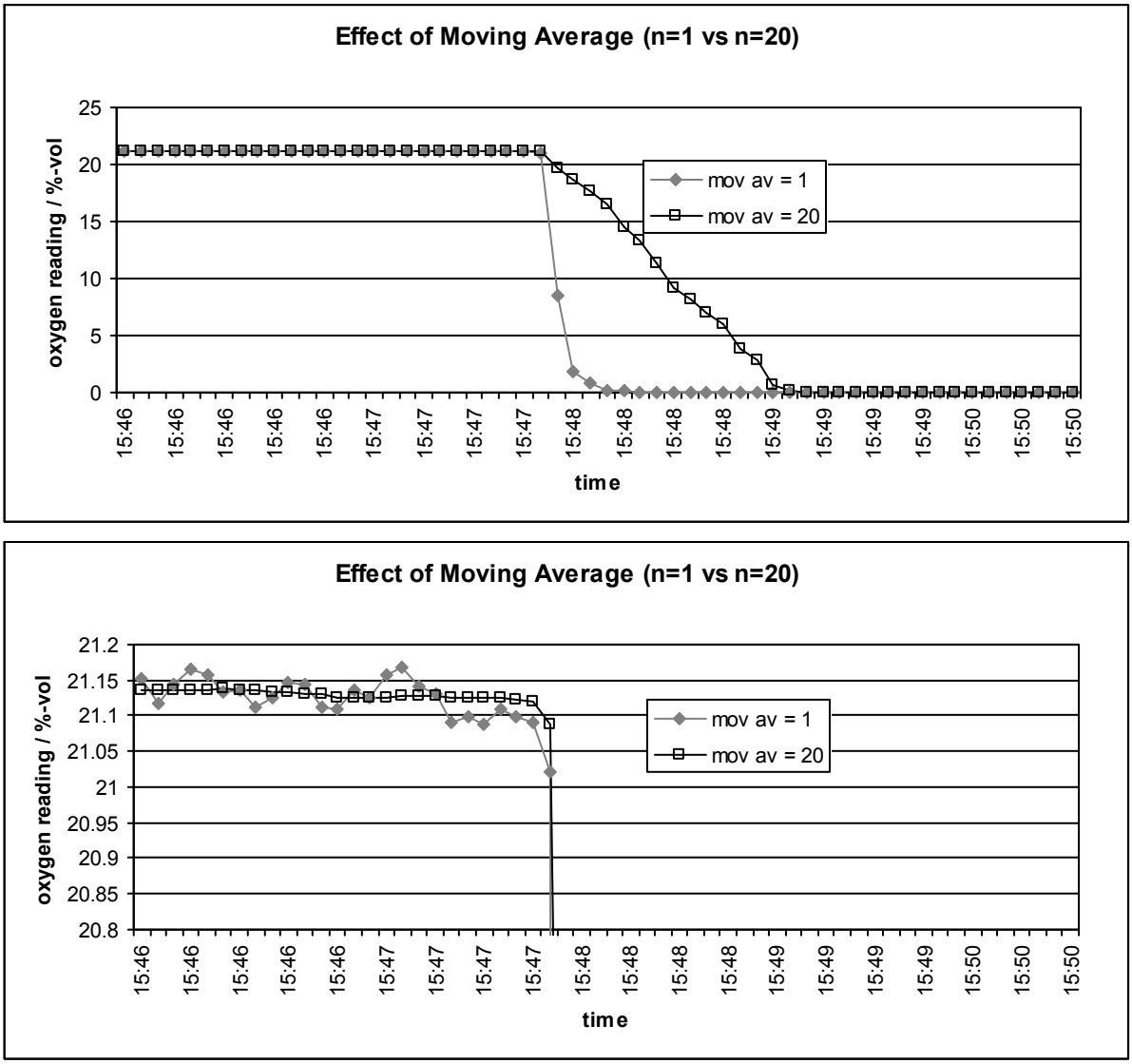


Figure 11.3: Comparison of the response of VisiPro DO to a change from air to zero oxygen, using no moving average (n=1) or a moving average over 20 readings (measurement interval = 3s).

Using moving average, the short term signal stability can be improved; on the other hand, the response time of the sensor increases with increasing moving average. A moving average over 20 samples results in a response time of at least 20 times the measurement interval defined in measurement interval.

11.5 Number of Sub-Measurements (Resolution)

The measurement value of VisiPro DO in each measurement interval is on itself an average over 16 (or less) individual sub-measurements. The Number of Sub-Measurements (Resolution) can be set between 1 and 16, where 0 activates the automatic mode. The advantage of using a smaller amount of sub-measurements is a shorter exposure of the luminophore to the excitation light. Photo bleaching of the luminophore will be reduced. The disadvantage is a reduced signal quality.
In case of a measurement interval of 1 or 2 seconds, the resolution has a maximum of 3 sub-measurements. The number of sub-measurements will be automatically set if the measurement interval is set to 1 or 2 seconds and the resolution was greater than 3.

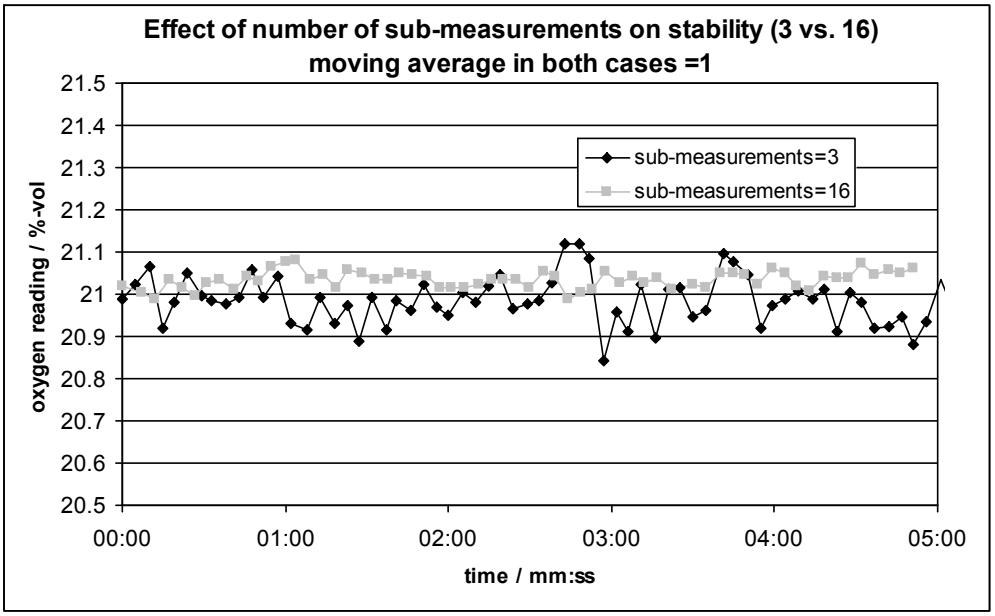


Figure 11.4: Comparison of the signal stability of VisiPro DO when using number of sub-measurements = 16 or number of sub-measurements = 3.

Attention:
If the Measurement Interval is set to one or two, Number of sub-measurements will be limited from one to three.

11.6 Minimum Number of Sub Measurements in the Automatic Mode

If Number of Sub-Measurements (Resolution) is set to 0 (auto), this parameter Minimum Number of Sub Measurements in the Automatic Mode defines the lower limit for the Number of Sub-Measurements in the Automatic Mode. A value of 3 is the factory setting.
With a high value on this parameter, the measurement is more precise but the luminophore has more degeneration. With a low value, the measurement is more imprecise but the life expectancy is higher. In case the measurement interval is set to 1 or 2 seconds, this parameter is limited to 1 to 3. If previously a value greater than 3 is active, the parameter will be reset to 3. If the previous value is between 1 and 3, this parameter keeps its value.

Attention:
If the Measurement Interval is set to one or two, Number of sub-measurements will be limited from one to three.

11.7 Measurement Interval

The measurement interval for the VisiPro can be set between 1s and 300s (5min). The DO measurement can also be deactivated by writing a 0 to the measurement interval register. When increasing the interval, the sensor cap respectively the luminophore is preserved better, but the reaction time for an oxygen change is slower.

Note:

1) When a standard calibration (CP1 – or CP2 calibration) is initiated and the current measurement interval is greater than 3s or equals 0s, the measurement interval is temporarily set to 3s. The measurement interval is automatically reset to the original value 10 min after the last calibration command, or after power up. See chapter 9.2.1 Calibration at zero oxygen and air (Standard Calibration) for more details.
2) When a product calibration is performed, the measurement interval is not changed by the sensor. If the measurement interval is 0 s, initial measurement on CP6 will not be executed as the DO measurement is not running.

 Attention:

Setting Measurement Interval to 0 deactivates DO reading completely. Temperature readings are still active. In this case warning “Measurement not running” is set, see also 7.1.2: Measurement Warnings 1 – value 0x20h (Measurement not running).
The DO value is frozen on the analog and digital output.

Note:
If the measurement interval is set to 1s or 2s, the current values of Number of Sub-Measurements (Resolution) and Minimum Number of Sub Measurements in the Automatic Mode are overwritten to 3 if the values were greater than 3.
If the measurement interval is set to a value greater than 2s, the Number of Sub-Measurements (Resolution) and Minimum Number of Sub Measurements in the Automatic Mode remain unchanged.

11.8 Sensor Cap Part Number

The VisiPro DO can be used with different sensor cap types. Each sensor cap type has its specific measurement characteristics. The measurement parameter Sensor Cap Part Number allows configuring the sensor cap type used by entering the corresponding part number which can be found engraved on the sensor cap.

12 Additional Features

12.1 Reading Definition of SIP and CIP

12.1.1 Overview

The following SIP and CIP information is available:

Name	Device Specific Command	Comment
SIP temperature profile	#129 #130	Read Set of Sensor Variables Float Write Set of Sensor Variables Float ▪ Sensor Variable 0, Sensor Variable 1 and Sensor Variable 2 can be modified Further Information: ▪ see 14.6 Sensor Variable Sets Float ▪ see 10.3 Read Set of Sensor Variables Float ▪ see 10.4 Write Set of Sensor Variables Float
CIP temperature profile	#129 #130	Read Set of Sensor Variables Float Write Set of Sensor Variables Float ▪ Sensor Variable 0, Sensor Variable 1 and Sensor Variable 2 can be modified Further Information: ▪ see 14.6 Sensor Variable Sets Float ▪ see 10.3 Read Set of Sensor Variables Float ▪ see 10.4 Write Set of Sensor Variables Float
Number of SIP cycles	#131	Read Set of Sensor Variables UInt32 Further Information: ▪ see 14.7 Sensor Variable Sets UInt32 ▪ see 10.5 Read Set of Sensor Variables UInt32
Number of CIP cycles	#131	Read Set of Sensor Variables UInt32 Further Information: ▪ see 14.7 Sensor Variable Sets UInt32 ▪ see 10.5 Read Set of Sensor Variables UInt32

12.1.2 SIP/CIP - Workflow

VisiPro DO is counting special cleaning events such as sterilizations or cleaning cycles by means of tracking typical temperature profiles.

The SIP – and CIP temperature profile can be read with the device specific command #129 and written with device specific command #130.
The number of SIP – and CIP cleaning cycles can be read with the device specific command #131.
The individual SIP – CIP temperature profiles and cleaning cycles are addressed with the particular device variable set code.

For the explanation the following values are given:

CIP temperature min: 80 °C	CIP temperature max: 100 °C	CIP time min: 30 minutes
SIP temperature min: 120 °C	SIP temperature max: 130 °C	SIP time min: 30 minutes

CIP / SIP time maximum values: 180 min

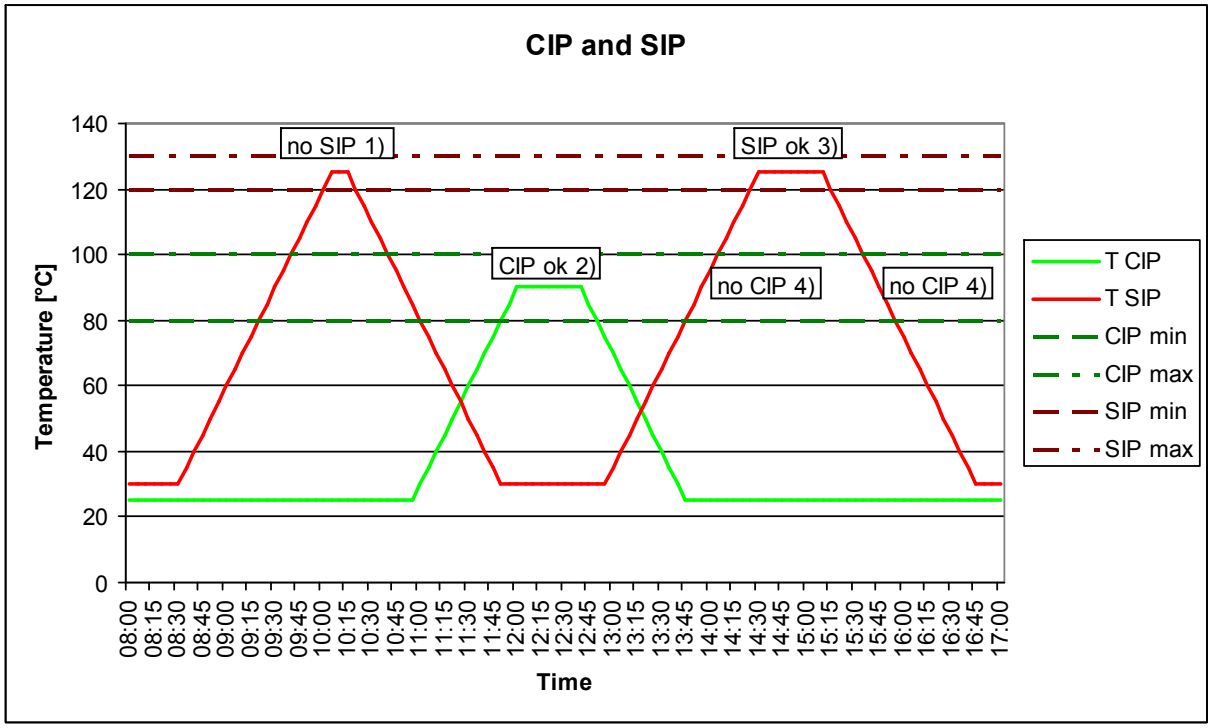


Figure 12.1: Definition of CIP and SIP cycles.

1) no SIP-cycle counted, because time too short less than 30 minutes.
2) CIP-cycle counted, because time greater than 30 minutes and in CIP temperature range.
3) SIP-cycle counted, because time greater than 30 minutes and in SIP temperature range.
4) no CIP-cycle counted, because of reaching the SIP-min limit.

12.2 4-20mA Interface

12.2.1 Overview

With this mechanism errors and warnings can be mapped to the analog output.
The following additional information for the 4-20mA Interface is available:

Name	Device Specific Command	Comment
Defining the current in case of warning and error	#129 #130	Read Set of Sensor Variables Float Write Set of Sensor Variables Float ▪ Sensor Variable 0 and Sensor Variable 1 can be modified Further Information: ▪ see 14.6 Sensor Variable Sets Float ▪ see 10.3 Read Set of Sensor Variables Float ▪ see 10.4 Write Set of Sensor Variables Float
Defining the Error and Warning Output of the 4-20 mA Interface	#129 #130	Read Set of Sensor Variables UInt32 Write Set of Sensor Variables UInt32 ▪ only Sensor Variable 0 can be modified ▪ see 14.17 Code for the 4-20 mA interface in case of errors and warnings Further Information: ▪ see 14.7 Sensor Variable Sets UInt32 ▪ see 10.5 Read Set of Sensor Variables UInt32 ▪ see 10.6 Write Set of Sensor Variables UInt32

12.3 Sensor Specific Information

12.3.1 Overview

The following additional sensor specific information is available:

Name	Device Specific Command	Comment
Measuring Point	#133 #134	Read Sensor Variable ASCII String Write Sensor Variable ASCII String ▪ max. 16characters Further Information: ▪ see 14.8 Sensor Variables ASCII String ▪ see 10.7 Read Sensor Variable ASCII String ▪ see 10.8 Write Sensor Variable ASCII String
Sensor Part Number	#133	Read Sensor Variable ASCII String Further Information: ▪ see 14.8 Sensor Variables ASCII String ▪ see 10.7 Read Sensor Variable ASCII String
Sensor Serial Number	#133	Read Sensor Variable ASCII String Further Information: ▪ see 14.8 Sensor Variables ASCII String ▪ see 10.7 Read Sensor Variable ASCII String

12.4 Switch Bluetooth On/Off

12.4.1 Overview

With this device specific command, the Bluetooth interface can be switched on and off.

Name	Device Specific Command	Comment
Bluetooth On/Off	#131 #132	Read Set of Sensor Variables UInt32 Write Set of Sensor Variables UInt32 ▪ only Sensor Variable 0 can be modified ▪ see 14.18 Bluetooth On/Off Further Information: ▪ see 14.7 Sensor Variable Sets UInt32 ▪ see 10.5 Read Set of Sensor Variables UInt32 ▪ see 10.6 Write Set of Sensor Variables UInt32

13 Performance

13.1 Sampling Rates

The DO value and the temperature value are updated with the same sampling rate. By default this is every 3 seconds.
The sampling period of DO and temperature measurements can be altered within the range 1 second to 300 seconds. This can be done by writing measurement parameter “Measurement Interval” (see 14.7 Sensor Variable Sets UInt32).

13.2 Power-Up

During power-up, the device will not respond to HART commands, and the analog output is set at 4mA. This period takes approximately 7 seconds.
Afterwards the sensor starts measuring DO and temperature.

During the power-up sequence, a self-test is executed by the device itself.
In case that the self-test fails, all live measurement data (PV, SV, TV and percent of range) are set to "Not A Number", and the analog output is set to the configured malfunction-indicating current. In case that the malfunction indicating current is switched off, the analog output will be set to 4mA.
The device variable will remain unchanged. The device will attempt to respond to any HART commands. Furthermore the measurement interval is automatically set to zero, that means the measurement is switched off.

Fixed-current mode is cancelled by power loss.

13.3 Reset

Command 42 ("Device Reset") causes the device to reset its microprocessor. The resulting restart is identical to the normal power up sequence (see Section 13.2).
Care must be taken by executing the device reset, because it can be that via Bluetooth interface a service attempts to write into the FLASH memory. This will cause a loss of non-volatile information.

13.4 Self-Test

The self-test as command itself is not implemented.
The power up sequence includes a self-test of the device, see 13.2

13.5 Command Response Times

Minimum	1 ms
Typical	8 ms
Maximum	100 ms

13.6 Busy and Delayed-Response

The sensor will respond within the normal command response times. Commands responding with delayed or busy within the command code, aren’t implemented.

13.7 Long Messages

The largest data field used is in the response to Command 21: 34 bytes including the two status bytes.

13.8 Non-Volatile Memory

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

13.9 Modes

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

13.10 Write Protection

Write-protection is not provided.

13.11 Damping

Damping is standard, affecting only the PV and the loop current signal. The device damping value is fixed to 1.

14 Tables

14.1 Device Variables

Code	Device Variable
0	PV - Dissolved Oxygen
1	SV - Temperature
2	TV - Quality Indicator
>3	>QV - Not supported

14.2 Device Variable Information

Code	Device Variable
0	PV - Dissolved Oxygen
1	SV - Temperature
>2	TV – not supported

14.3 Dissolved Oxygen Unit Codes

(Subset of HART Common Table 2, Unit Codes)

Code	DO Unit
8 (0x08)	mbar
139 (0x8B)	mg/l ppm
149 (0x95)	%-vol
169 (0xA9)	ug/l ppb
240 (0xF0)	%-sat
241 (0xF1)	ppm gas

14.4 Temperature Unit Codes

(Subset of HART Common Table 2, Unit Codes)

Code	DO Unit
32 (0x20)	°C
33 (0x21)	°F
35 (0x23)	K

14.5 Quality Indicator Unit Code

(subset of HART Common Table 2, Unit Codes)

Code	DO Unit
57 (0x39)	%

14.6 Sensor Variable Sets Float

Sensor Variable Set Code	Sensor Variable 0	Sensor Variable 1	Sensor Variable 2	Sensor Variable 3	Sensor Variable Unit
0	*)..SIP minimum temperature	*).. SIP maximum temperature	*) SIP minimum time	Not Used	Not Used
1	*) CIP minimum temperature	*) CIP maximum temperature	*) CIP minimum time	Not Used	Not Used
2	*) Drift DO	*) Drift Temperature	Not Used	Not Used	DO unit
3	*) Current in the event of warning	*) Current in the event of error	Not Used	Not Used	Not Used
4	*) Salinity	Salinity minimum value	Salinity maximum value	Not Used	Salinity unit
5	*) Air pressure	Air pressure minimum value	Air pressure maximum value	Not Used	Air pressure unit

*) These Variables can be modified

14.7 Sensor Variable Sets UInt32

Sensor Variable Set Code	Sensor Variable 0	Sensor Variable 1	Sensor Variable 2	Sensor Variable 3	Sensor Variable Unit
0	Number of SIP cycles	Not Used	Not Used	Not Used	Not Used
1	Number of CIP cycles	Not Used	Not Used	Not Used	Not Used
2	Number of zero point calibrations	Not Used	Not Used	Not Used	Not Used
3	Number of calibrations in air	Not Used	Not Used	Not Used	Not Used
4	Number of product calibrations	Not Used	Not Used	Not Used	Not Used
5	*) Mode in event of warning or error	Not Used	Not Used	Not Used	Not Used
6	*) Moving Average	Moving average minimum value	Moving average maximum value	Not Used	Not Used
7	*) Resolution	Resolution minimum value	Resolution maximum value	Not Used	Not Used
8	*) Min Auto Resolution	Min Auto resolution minimum value	Min Auto resolution maximum value	Not Used	Not Used

9	*) Measurement Interval	Measurement interval minimum value	Measurement interval maximum value	Not Used	Not Used
10	*) Sensor Cap Part Number	Sensor Cap Part minimum value	Sensor Cap Part maximum value	not used	not used
11	*) Bluetooth Mode	not used	not used	not used	not used

*) These Variables can be modified

14.8 Sensor Variables ASCII String

Sensor Variable Code	Sensor Variable
0	Measuring Point
1	Sensor Part Number
2	Sensor Serial Number

14.9 Trim Point Code

Trim Point	Description
1	Lower Trim Point supported - Calibration in Zero Oxygen
2	Upper Trim Point supported - Calibration in Air
3	Lower and Upper Trim Point Supported

14.10 Device Variable to Trim

Device Variable	Description
0	Dissolved Oxygen

14.11 Transfer Function

Code	Description
0	Linear Transfer Function

14.12 Device Variable Classification

Classification	Description
0	Not Classified

14.13 Device Variable Family

Family	Description
250 (0xFA)	Not Used

14.14 Update Time Period

Time Period	Description
10sec	The device must update the Device Variable at least once in the interval indicated by the Update Time Period. This Feature will only be used in Burst Mode. This device does not support Burst Mode.

14.15 Time-set Code

Code	Description
0	Read Receive Time
1	Write Date and Time

14.16 Real-Time Clock Flags

Code	Description
0	Clock Initialized
2	Clock Uninitialized

14.17 Code for the 4-20 mA interface in case of errors and warnings

Code	Description
0	None
1	Error active
65536 (0x10000)	Warning active
65537 (0x10001)	Error and Warning active

14.18 Bluetooth On/Off

Code	Description
1	On
2	Off

14.19 Product Calibration Command Code

Code	Command
0x01	init (start initialization of the product calibration)
0x02	assign (assign a value to the previously initialized calibration)
0x04	cancel (cancel the product calibration)
0x08	deactivate (restore the standard calibration)
0x10	activate (restore the previous valid product calibration)
0x20	read actual status (reads actual product calibration state)

14.20 Product Calibration Response Code

Code	Message
0x01	Product Calibration Active
0x02	Product Calibration Init
0x04	Product Calibration Assign
0x40	Out of Calibration Range (Init cannot be executed)
0x80	Out of Range (assign cannot be executed, wrong input value)

15 Annex A. Default Configuration

Parameter	Default Value
Measuring Point	[P/N]-[S/N] e.g. “243400-1234”
Tag	[S/N]
Long Tag	[P/N]-[S/N] e.g. “243400-1234”
Date	01/01/00
Descriptor	[Product Name] e.g. “VisiPro DO”
Message	
Final Assembly Number	[S/N]
Polling Address	0
Loop Current Mode	4 mA
Warn Value	3.6 mA
Error Value	3.6 mA
Warn Error Modu	Indicating error events only
Lower Range Value	0 %-vol
Upper Range Value	61.25 %-vol
PV Unit	%-vol (0x95)
SV Unit	°C (0x20)
Number of response preambles	20
Bluetooth Mode	On
Min. SIP Temperature	80 °C
Max. SIP Temperature	100 °C
Min. SIP Time	20.0 min
Number of SIP`s	0
Min. CIP Temperature	120 °C
Max. CIP Temperature	130 °C
Min. CIP Time	20.0 min
Number of CIP`s	0
Calibration Drift Oxygen	0.05 %/min
Calibration Drift Temperature	0.5 K/min

Measurement Parameter	Default Value
Salinity	0.0 mS/cm
Air Pressure	1013.0 mbar
Moving Average	5
Resolution	3
Min. Auto Resolution	3
Measurement Interval	3
Sensor Cap Part Number	243515

16 Annex B. Examples

The VisiPro DO sensor operated in a normal environment condition, which means in a lab environment (room temperature) and performing air measurement.
Therefore the expected measurement values for the primary variable (DO value) is approx. 20-21%-vol, for the secondary variable (Temperature) approx. 25°C and for the tertiary variable (Quality) approx.100%.

16.1 Command #3: Read Dynamic Variables And Loop Current

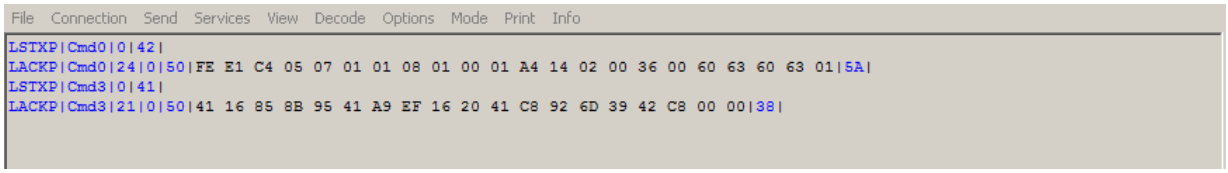


Figure above shows the structure of command 3, on byte level, by using the software FrameAlyst.

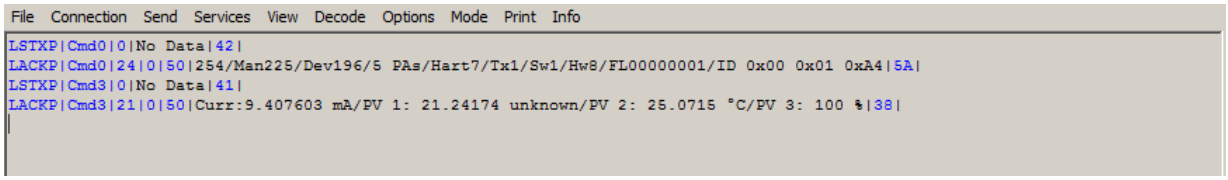


Figure above shows the same command sequence as before but the data sequences are decoded respectively in the software FrameAlyst (decoded data view).

Figure below describes the data sequence of the HART command 3 in detail.

Master - Slave Request			**Slave - Master Response**											
	0	1		0	1	2	3 - 6	7	8 - 11	12	13 - 16	17	18 - 21	22
Preamble	Unsigned-8	Unsigned-8	Preamble	Unsigned-8	Unsigned-8	Unsigned-8	Float	Enum	Float	Enum	Float	Enum	Float	Unsigned-8
	Byte Count **0**	Checksum **65 (0x41)**		Byte Count **21**	Response code **0**	Device status **80 (0x50)**	Primary Variable Loop Current **9.407**	Primary Variable Units Code **149**	Primary Variable **21.241**	Secondary Variable Units Code **32**	Secondary Variable **25.071**	Tertiary Variable Units Code **57**	Tertiary Variable **100.0**	Checksum **56 (0x38)**

	Expected Values	**Sensor Values (via HART)**
4-20mA	Approx. 10mA	9.4mA
PV (DO value)	Approx. 20-21 %-vol	21.241 %-vol
SV (Temperature)	Approx. 25 °C	25.07 °C
TV (Quality indicator)	100 %	100 %

16.2 Command #33: Read Device Variables

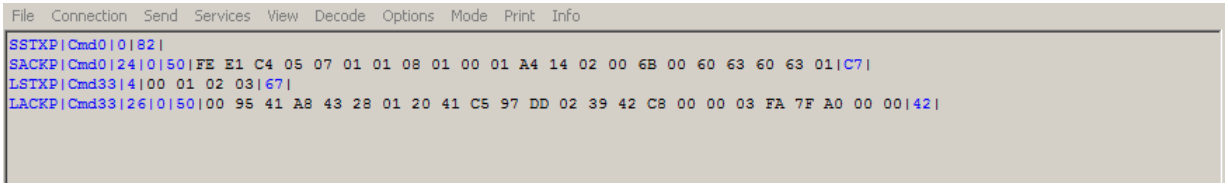


Figure above shows the structure of command 33, on byte level, by using the software FrameAlyst.

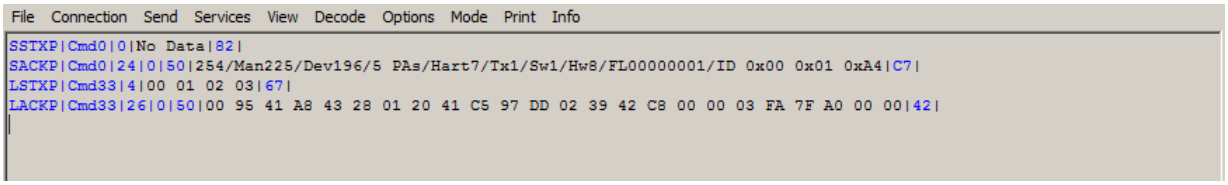


Figure above shows the same command sequence as before but the data sequences are decoded respectively in the software FrameAlyst (decoded data view). The HART command 33 can't be decoded by the software FrameAlyst respectively. The reason is that the software can only decode universal command data sequences.

Figure below describes the data sequence of the HART command 33 in detail.

Master - Slave Request							**Slave - Master Response**																			
	0	**1**	**2**	**3**	**4**	**5**		**0**	**1**	**2**	**3**	**4**	**5 - 8**	**9**	**10**	**8 - 11**	**15**	**16**	**17 - 20**	**21**	**22**	**23 - 26**	**27**
Preamble	Unsigned-8	Unsigned-8	Unsigned-8	Unsigned-8	Unsigned-8	Unsigned-8	Preamble	Unsigned-8	Unsigned-8	Unsigned-8	Unsigned-8	Enum	Float	Unsigned-8	Enum	Float	Unsigned-8	Enum	Float	Unsigned-8	Enum	Float	Unsigned-8
	4	**0**	**1**	**2**	**3**	**103 (0x67)**		**26**	**0**	**80 (0x50)**	**0**	**149**	**21.032**	**1**	**32**	**24.699**	**2**	**57**	**100.0**	**3**	**250**	**NAN**	**66 (0x42)**
	Byte Count	Device Variable Code	Device Variable Code	Device Variable Code	Device Variable Code	Checksum		Byte Count	Response code	Device status	Device Variable Code	Unit Code	Device Variable Value	Device Variable Code	Unit Code	Device Variable Value	Device Variable Code	Device Variable Value	Unit Code	Device Variable Code	Unit Code	Device Variable Value	Checksum

	Expected Values	**Sensor Values (via HART)**
Device Variable Code 0	Approx. 20-21 %-vol	21.241 %-vol
Device Variable Code 1	Approx. 25 °C	25.07 °C
Device Variable Code 2	100 %	100 %
Device Variable Code 3	NAN not used	NAN not used

16.3 Command #131: Read Set of Sensor Variables – Sensor Cap Part Number

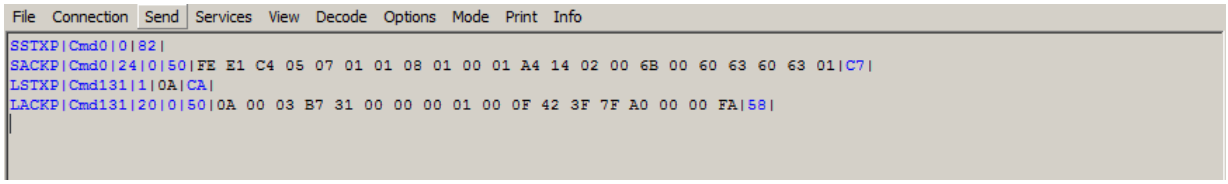


Figure above shows the structure of command 131, on byte level, by using the software FrameAlyst.

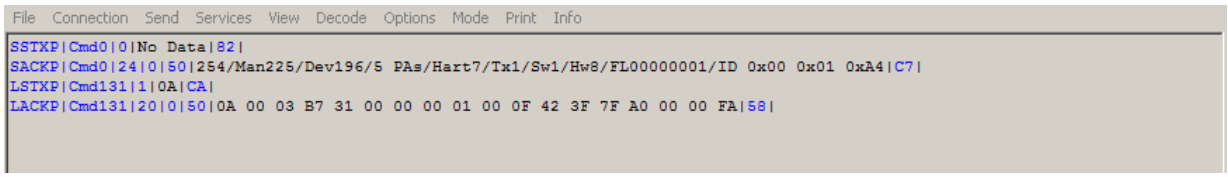


Figure above shows the same command sequence as before but the data sequences are decoded respectively in the software FrameAlyst (decoded data view). The HART command 131 can't be decoded by the software FrameAlyst respectively. The reason is that the software can only decode universal command data sequences.

Figure below describes the data sequence of the HART command 131 in detail.

Master - Slave ***Request***				**Slave - Master Response**										
	0	1	2		0	1	2	3	4 - 7	8 - 11	12 - 15	16 - 19	20	21
Preamble	Unsigned-8	Unsigned-8	Unsigned-8	Preamble	Unsigned-8	Unsigned-8	Unsigned-8	Unsigned-8	Unsigned-32	Unsigned-32	Unsigned-32	Unsigned-32	Unsigned-8	Unsigned-8
	1	**10**	**202 (0xCA)**		**20**	**0**	**80 (0x50)**	**10**	**243505**	**1**	**999999**	**NAN**	**250**	**88 (0x58)**
	Byte Count	Sensor Variable Set Code	Checksum		Byte Count	Response code	Device status	Sensor Variable Set Code	Sensor Variable 0	Sensor Variable 1	Sensor Variable 2	Sensor Variable 3	Sensor Variable Set Units Code	Checksum

	Expected Values	**Sensor Values (via HART)**
Device Variable 0	243505 (current used cap PN)	243505 (current used cap PN)
Device Variable 1	1 (min)	1 (min)
Device Variable 2	999999 (max)	999999 (max)
Device Variable 3	NAN	NAN
Device Variable Set Units Code	not used	not used

16.4 Command #132 Write Set of Sensor Variables – Sensor Cap Part Number

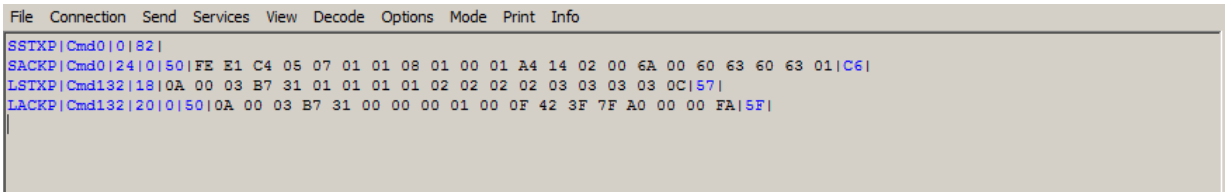


Figure above shows the structure of command 132, on byte level, by using the software FrameAlyst.

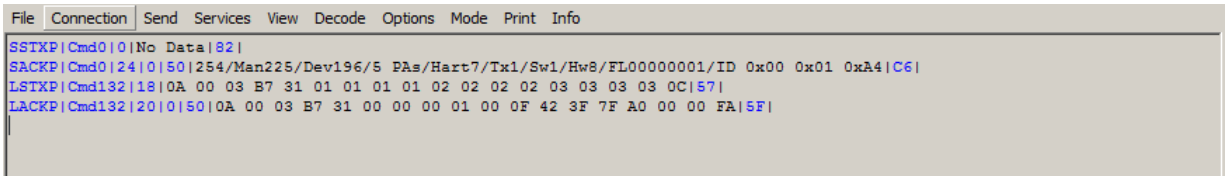


Figure above shows the same command sequence as before but the data sequences are decoded respectively in the software FrameAlyst (decoded data view). The HART command 132 can't be decoded by the software FrameAlyst respectively. The reason is that the software can only decode universal command data sequences.

Figure below describes the data sequence of the HART command 132 in detail.

Master - Slave ***Request***								
	0	1	2 - 5	6 - 9	10 - 13	14 - 17	18	19
Preamble	Unsigned-8	Unsigned-8	Unsigned-32	Unsigned-32	Unsigned-32	Unsigned-32	Unsigned-8	Unsigned-8
	18	**10**	**243505**	**16843009**	**33686018**	**50529027**	**12**	**87 (0x57)**
	Byte Count	Sensor Variable Set Code	Sensor Variable 0	*) Sensor Variable 1	*) Sensor Variable 2	*) Sensor Variable 3	Sensor Variable Set Units Code	Checksum

Slave - Master **Response**										
	0	1	2	3	4 - 7	8 - 11	12 - 15	16 - 19	20	21
Preamble	Unsigned-8	Unsigned-8	Unsigned-8	Unsigned-8	Unsigned-32	Unsigned-32	Unsigned-32	Unsigned-32	Unsigned-8	Unsigned-8
	20	**0**	**80 (0x50)**	**10**	**243505**	**1**	**999999**	**NAN**	**250**	**95 (0x5F)**
	Byte Count	Response code	Device status	Sensor Variable Set Code	Sensor Variable 0	Sensor Variable 1	Sensor Variable 2	Sensor Variable 3	Sensor Variable Set Units Code	Checksum

***)** Don't care

	Expected Values	**Sensor Values (via HART)**
Device Variable 0	243505 (current used cap PN)	243505 (current used cap PN)
Device Variable 1	1 (min)	1 (min)
Device Variable 2	999999 (max)	999999 (max)
Device Variable 3	NAN	NAN
Device Variable Set Units Code	not used	not used

17 Annex C. Software Utilities

SW Tool Name	Comments
FrameAlyst 7.x	Useful tool for: ▪ Monitoring HART frames for detecting errors in the device implementation ▪ Emulation of a master functionality ▪ Sending special frames and commands ▪ Etc.. A 30 days trial version can be directly downloaded from the Borst Automation homepage.
DD-IDE (HCF_KIT-225)	Device Description Integrated Development Environment is used for writing and testing Device Descriptions. The HCF_KIT-225 can be directly ordered from the HCF Communication foundation.

18 Annex C. Revision History

18.1 Revision 80, 28.05.2013

- Initial Revision of this document

18.2 Revision 00, 07.09.2015

- Release Version of this document

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