



VISIFERMTM DO **VISIFERMTM DO ARC**

Modbus RTU Programmer's Manual

Firmware version:
ODOUM040

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1 Modbus RTU General Information

1.1 Introduction

This document describes in detail the VISIFERM DO (ARC) Modbus RTU interface. It is addressed to software programmers.

Chapter 1 is a general description of the Modbus RTU interface and is therefore valid for all ARC Sensors: VISIFERM DO, VISIFERM DO ARC, pH ARC Sensors and Conducell ARC Sensors.

The following chapters contain the VISIFERM DO specific programming.

1.2 HAMILTON ARC Sensors: Modbus Command Structure

This definition of the command structure is valid for all members of the HAMILTON ARC Sensor family, having the following firmware versions:

- ODOUM040 (VISIFERM DO / VISIFERM DO ARC Sensor)
- EPHUM012 (pH ARC Sensors)
- CONUM012 (Conducell ARC Sensors)

Please check by reading register 1032 (see chapter 2.9.1).

This definition of the command structure is an additional document to the Operating Instructions of the specific sensors. Before reading this manual, the operating instructions of the sensors should be read and understood.

1.2.1 Modbus RTU: Definitions According to Modbus IDA

The definitions in chapter 1.2 are an excerpt from the document:

- "Modbus over serial line - Specification and Implementation Guide V1.02" and
- "Modbus Application Protocol Specification V1.1b"

For more detailed information please consult <http://www.Modbus-IDA.org>.



Attention:

- In this manual the register counting starts per definition at address 1. Some Modbus master protocols operate with register-count starting at address 0. Usually, the Modbus master software translates the addressing. Thus, the register address of 2088 will be translated by Modbus master software to 2087 which is sent to the sensor (Modbus slave). This must be observed during programming. Please check the specifications of the Modbus master that you are using.
- Representation of data formats in this document:
 - decimal values are displayed as numbers without any prefix, for example 256
 - hexadecimal values are displayed as: 0x2A
 - ASCII-characters or ASCII strings are displayed as: "Text"

1.2.2 Command Structure

The Modbus application protocol defines a simple **Protocol Data Unit (PDU)** independent of the underlying communication layers:

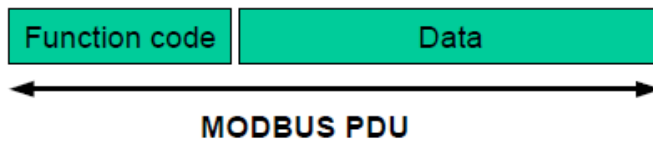


Figure 1.2.2.1: Modbus Protocol Data Unit.

The mapping of Modbus protocol on a specific bus or network introduces some additional fields on the **Protocol Data Unit**. The client that initiates a Modbus transaction builds the Modbus PDU, and then adds fields in order to build the appropriate communication PDU.

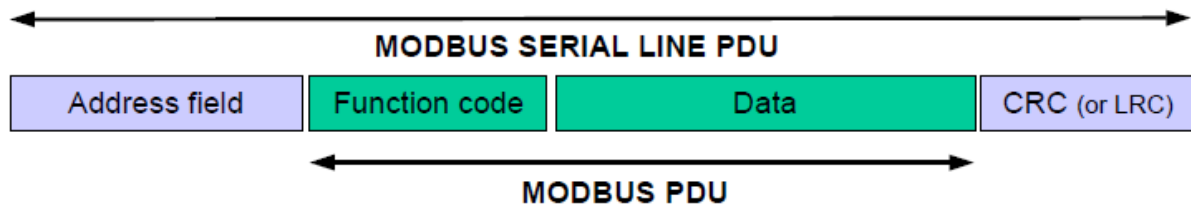


Figure 1.2.2.2: Modbus frame over Serial Line.

- On Modbus Serial Line, the Address field only contains the slave address.

Note:

ARC Sensors support only slave addresses 1 to 32.

A master addresses a slave by placing the slave address in the address field of the message. When the slave returns its response, it places its own address in the response address field to let the master know which slave is responding.

- The function code indicates to the server what kind of action to perform. The function code can be followed by a data field that contains request and response parameters.
- The CRC field is the result of a “Redundancy Checking” calculation that is performed on the message contents.

1.2.3 Modbus RTU Transmission Mode

When devices communicate on a Modbus serial line using the RTU (Remote Terminal Unit) mode, each 8-bit byte in a message contains two 4-bit hexadecimal characters. The main advantage of this mode is that its greater character density allows better data throughput than ASCII mode for the same baud rate. Each message must be transmitted in a continuous stream of characters.

The format (11bits) for each byte in RTU mode is:

Coding System: 8 bit binary
Bits per Byte: 1 start bit
 8 data bits, least significant bit sent first
 1 bit for parity completion
 1 stop bit

Remark: The use of no parity requires 2 stop bits.

How characters are transmitted serially:

Each character or byte is sent in this order (left to right):
Least Significant Bit (LSB)...Most Significant Bit (MSB)

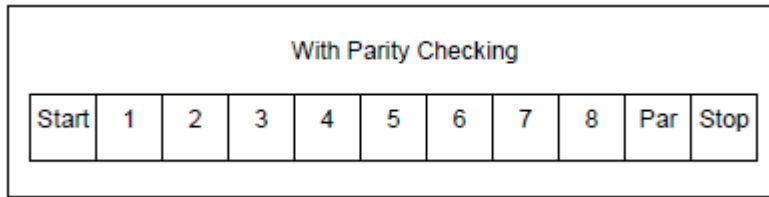


Figure 1.2.3.1: Bit sequence in RTU mode.

Frame Checking Field:

Cyclical Redundancy Checking (CRC)

Frame description:

| Slave Address | Function Code | Data | CRC |
|---------------|---------------|---------------------|----------------------------|
| 1 byte | 1 byte | 0 up to 252 byte(s) | 2 bytes CRC Low, CRC Hi |

Figure 1.2.3.2: RTU Message Frame.

=> The maximum size of a Modbus RTU frame is 256 bytes.

1.2.4 Modbus RTU Message Framing

A Modbus message is placed by the transmitting device into a frame that has a known beginning and ending point. This allows devices that receive a new frame to begin at the start of the message, and to know when the message is completed. Partial messages must be detected and errors must be set as a result.

In RTU mode, message frames are separated by a silent interval of at least 3.5 character times.

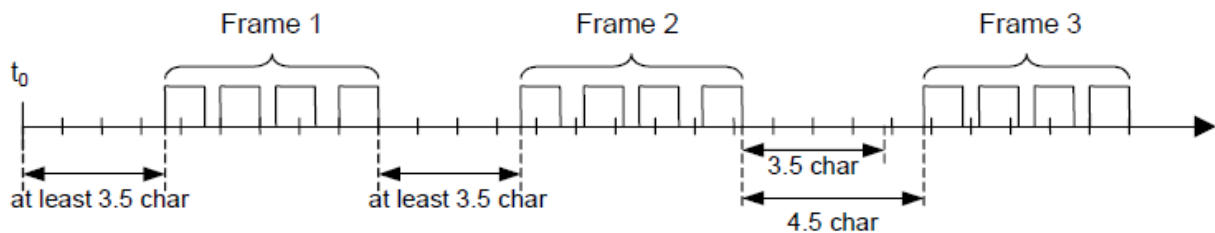


Figure 1.2.4.1: Valid frames with silent intervals.

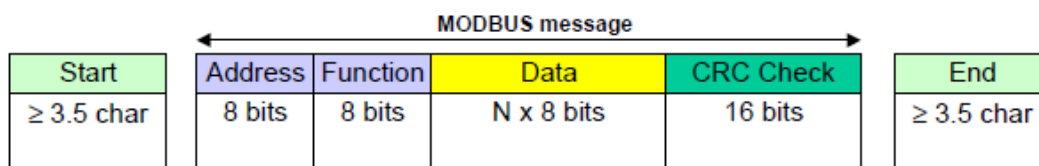


Figure 1.2.4.2: RTU Message Frame.

The entire message frame must be transmitted as a continuous stream of characters.

If a silent interval of more than 1.5 character times occurs between two characters, the message frame is declared incomplete and should be discarded by the receiver.

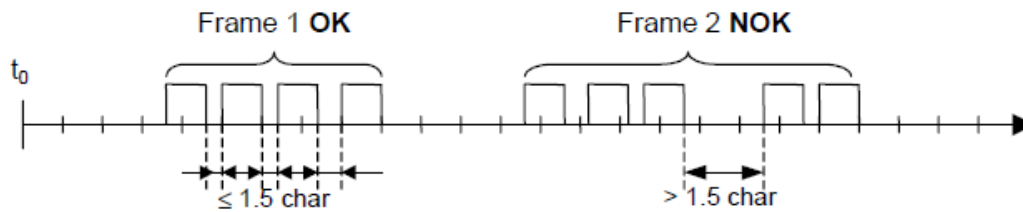


Figure 1.2 4.3: Data transmission of a frame.

1.2.5 Modbus RTU CRC Checking

The RTU mode includes an error-checking field that is based on a Cyclical Redundancy Checking (CRC) method performed on the message contents.

The CRC field checks the contents of the entire message. It is applied regardless of any parity checking method used for the individual characters of the message.

The CRC field contains a 16-bit value implemented as two 8-bit bytes.

The CRC field is appended to the message as the last field in the message. When this is done, the low-order byte of the field is appended first, followed by the high-order byte. The CRC high-order byte is the last byte to be sent in the message.

The CRC value is calculated by the sending device, which appends the CRC to the message. The receiving device recalculates a CRC during receipt of the message, and compares the calculated value to the current value it received in the CRC field. If the two values are not equal, an error results.

The CRC calculation is started by first pre-loading a 16-bit register to all 1's. Then a process begins of applying successive 8-bit bytes of the message to the current contents of the register. Only the eight bits of data in each character are used for generating the CRC. Start and stop bits and the parity bit do not apply to the CRC.

During generation of the CRC, each 8-bit character is exclusive OR-ed with the register contents. Then the result is shifted in the direction of the least significant bit (LSB), with a zero filled into the most significant bit (MSB) position. The LSB is extracted and examined. If the LSB was a 1, the register is then exclusive OR-ed with a preset, fixed value. If the LSB was a 0, no exclusive OR takes place.

This process is repeated until eight shifts have been performed. After the last (eight) shift, the next 8-bit byte is exclusive OR-ed with the register's current value, and the process repeats for eight more shifts as described above. The final content of the register, after all the bytes of the message have been applied, is the CRC value.

When the CRC is appended to the message, the low-order byte is appended first, followed by the high-order byte.

A detailed introduction to CRC generation can be found in the manual "MODBUS over Serial Line, Specification and Implementation Guide, V1.02" in chapter 6.2 "Appendix B - LRC/CRC Generation" from <http://www.Modbus-IDA.org>.

1.3 Implementation of Modbus RTU in HAMILTON ARC Sensors

According to the official Modbus definition, the start of a command is initiated with a pause of ≥ 3.5 characters. Also the end of a command is indicated with a pause of ≥ 3.5 char.

The device address and the Modbus function code have 8 bits.

The data string consists of $n \times 8$ bits. The data string contains the starting address of the register and the number of registers to read/write.

The checksum CRC is 16 bits long.

| | start | device address | function | data | Checksum | | end |
|-------|----------------------------------|----------------|---|--------------------------------|----------|-------|----------------------------------|
| value | no signal during ≥ 3.5 char | 1-32 | function code according to Modbus specs | data according to Modbus specs | CRC L | CRC H | No signal during ≥ 3.5 char |
| bytes | ≥ 3.5 | 1 | 1 | n | 1 | 1 | ≥ 3.5 |

Figure 1.3.1: Modbus definition for data transmission.

The RS485 interface is configured as follows:

| Modbus RTU implementation in Hamilton ARC Sensors | |
|---|--|
| Start Bits | 1 |
| Data Bits | 8 |
| Parity | none |
| Stop Bit | 2 |
| String length | 11 Bits |
| Baud Rate | 19200 (default), other baud rate can be configured |

Figure 1.3.2: RS485 definitions for ARC Sensors.

1.4 Modbus RTU Function Codes Used for ARC Sensors

ARC Sensors use only 3 Modbus function codes:

- # 3: Read Holding Registers
- # 4: Read Input Registers
- # 16: Write Multiple Registers

These three function codes are described below in detail using excerpts from "Modbus Application Protocol Specification V1.1b" (<http://www.Modbus-IDA.org>).

1.4.1 Modbus function code #3: Read Holding Registers

This function code is used to read the contents of a contiguous block of holding registers in a remote device. The Request PDU specifies the starting register address and the number of registers. The PDU Registers are addressed starting at zero. Therefore registers numbered 1 – 16 are addressed as 0 – 15.

The register data in the response message are packed as two bytes per register. For each register, the first byte contains the high order bits and the second contains the low order bits.

Request

| | | |
|-----------------------|---------|------------------|
| Function code | 1 Byte | 0x03 |
| Starting Address | 2 Bytes | 0x0000 to 0xFFFF |
| Quantity of Registers | 2 Bytes | 1 to 125 (0x7D) |

Response

| | | |
|----------------|--------------|--------|
| Function code | 1 Byte | 0x03 |
| Byte count | 1 Byte | 2 x N* |
| Register value | N* x 2 Bytes | |

*N = Quantity of Registers

Error

| | | |
|----------------|--------|----------------------|
| Error code | 1 Byte | 0x83 |
| Exception code | 1 Byte | 01 or 02 or 03 or 04 |

Figure 1.4.1.1: Definition of Holding Registers.

| Request | | Response | |
|---------------------|-------|-------------------------|-------|
| Field Name | (Hex) | Field Name | (Hex) |
| Function | 03 | Function | 03 |
| Starting Address Hi | 00 | Byte Count | 06 |
| Starting Address Lo | 6B | Register value Hi (108) | 02 |
| No. of Registers Hi | 00 | Register value Lo (108) | 2B |
| No. of Registers Lo | 03 | Register value Hi (109) | 00 |
| | | Register value Lo (109) | 00 |
| | | Register value Hi (110) | 00 |
| | | Register value Lo (110) | 64 |

Figure 1.4.1.2: Example of reading holding registers 108 – 110. The contents of register 108 are read as the two byte values 0x022B. The contents of registers 109 – 110 are 0x00 00 and 0x0064.

1.4.2 Modbus function code #4: Read Input Registers

The function code is used to read from 1 to 125 contiguous input registers in a remote device. The Request PDU specifies the starting register address and the number of registers. The PDU Registers are addressed starting at zero. Therefore input registers numbered 1 – 16 are addressed as 0 – 15.

The register data in the response message are packed as two bytes per register. For each register, the first byte contains the high order bits and the second contains the low order bits.

Request

| | | |
|-----------------------------|---------|------------------|
| Function code | 1 Byte | 0x04 |
| Starting Address | 2 Bytes | 0x0000 to 0xFFFF |
| Quantity of Input Registers | 2 Bytes | 0x0001 to 0x007D |

Response

| | | |
|-----------------|--------------|--------|
| Function code | 1 Byte | 0x04 |
| Byte count | 1 Byte | 2 x N* |
| Input Registers | N* x 2 Bytes | |

*N = Quantity of Input Registers

Error

| | | |
|----------------|--------|----------------------|
| Error code | 1 Byte | 0x84 |
| Exception code | 1 Byte | 01 or 02 or 03 or 04 |

Figure 1.4.2.1: Definition of Input Registers.

| Request | | Response | |
|---------------------------|-------|-----------------|-------|
| Field Name | (Hex) | Field Name | (Hex) |
| Function | 04 | Function | 04 |
| Starting Address Hi | 00 | Byte Count | 02 |
| Starting Address Lo | 08 | Input Reg. 9 Hi | 00 |
| Quantity of Input Reg. Hi | 00 | Input Reg. 9 Lo | 0A |
| Quantity of Input Reg. Lo | 01 | | |

Figure 1.4.2.2: Example of reading input register 9. The contents of input register 9 are read as the two byte value 0x000A.

1.4.3 Modbus Function Code #16: Write Multiple Registers

This function code is used to write a block of contiguous registers (1 to 123 registers) in a remote device. The requested values are specified in the request data field. Data is packed as two bytes per register. The response returns the function code, starting address, and quantity of registers written.

Request

| | | |
|-----------------------|--------------|------------------|
| Function code | 1 Byte | 0x10 |
| Starting Address | 2 Bytes | 0x0000 to 0xFFFF |
| Quantity of Registers | 2 Bytes | 0x0001 to 0x007B |
| Byte Count | 1 Byte | 2 x N* |
| Registers Value | N* x 2 Bytes | value |

*N = Quantity of Registers

Response

| | | |
|-----------------------|---------|------------------|
| Function code | 1 Byte | 0x10 |
| Starting Address | 2 Bytes | 0x0000 to 0xFFFF |
| Quantity of Registers | 2 Bytes | 1 to 123 (0x7B) |

Error

| | | |
|----------------|--------|----------------------|
| Error code | 1 Byte | 0x90 |
| Exception code | 1 Byte | 01 or 02 or 03 or 04 |

Figure 1.4.3.1: Definition of Write Multiple Registers.

| Request | | Response | |
|--------------------------|-------|--------------------------|-------|
| Field Name | (Hex) | Field Name | (Hex) |
| Function | 10 | Function | 10 |
| Starting Address Hi | 00 | Starting Address Hi | 00 |
| Starting Address Lo | 01 | Starting Address Lo | 01 |
| Quantity of Registers Hi | 00 | Quantity of Registers Hi | 00 |
| Quantity of Registers Lo | 02 | Quantity of Registers Lo | 02 |
| Byte Count | 04 | | |
| Registers Value Hi | 00 | | |
| Registers Value Lo | 0A | | |
| Registers Value Hi | 01 | | |
| Registers Value Lo | 02 | | |

Figure 1.4.3.2: Example of writing the value 0x000A and 0x0102 to two registers starting at address 2.

1.5 Data Formats Used in ARC Sensors

1.5.1 Float

Definition: Floating point according to IEEE 754 (Single Precision)

| | | | | |
|---------------|------|-----------|----------|-------|
| Explanation: | sign | exponent | mantissa | total |
| Bit: | 31 | 30 ... 23 | 22 ... 0 | 32 |
| Exponent bias | 127 | | | |

Figure 1.5.1.1: Definition Floating point Single Precision (4 bytes resp. 2 Modbus registers).

Example: translate the decimal value 62.85 into binary

Step 1: Conversion of the decimal value into binary fixed-point number

| | | | | | | | |
|---------------|--|-----------|-----|-----------------|---------------|---|-----|
| 62 / 2 | = 31 | residue 0 | LSB | 0.85 * 2 | = 1.70 | => 1 | MSB |
| 31 / 2 | = 15 | residue 1 | | 0.70 * 2 | = 1.40 | => 1 | |
| 15 / 2 | = 7 | residue 1 | | 0.40 * 2 | = 0.80 | => 0 | |
| 7 / 2 | = 3 | residue 1 | | 0.80 * 2 | = 1.60 | => 1 | |
| 3 / 2 | = 1 | residue 1 | | 0.60 * 2 | = 1.20 | => 1 | |
| 1 / 2 | = 0 | residue 1 | MSB | 0.20 * 2 | = 0.40 | => 0 | |
| | = 111110 | | | 0.40 * 2 | = 0.80 | => 0 | LSB |
| | | | | | | ... | |
| | | | | | | = 0.110110011001100110011001100... | |
| 62.85 | = 111110.110110011001100110011001100... | | | | | | |

Step 2: Normalising (in order to obtain 1 bit on the left side of the fraction point)

$$111110.110110011001100110011001100... \cdot 2^0 = 1.11110110110011001100110011001100... \cdot 2^5$$

Sep 3: Calculation of the dual exponent

2⁵ => Exponent **5**
 Exponent + Exponent bias = **5 + 127 = 132**
132 / 2 = 66 residue 0 LSB
 66 / 2 = 33 residue 0
 33 / 2 = 16 residue 1
 16 / 2 = 8 residue 0
 8 / 2 = 4 residue 0
 4 / 2 = 2 residue 0
 2 / 2 = 1 residue 0
 1 / 2 = 0 residue 1 MSB
 = **10000100**

Sep 4: Definition of the sign bit

Positive = 0
Negative = 1
= 0

Step 5: conversion into floating-point

1 Bit Sign + 8 Bit Exponent + 23 Bit Mantissa
0 10000100 11110110110011001100110 (corresponds to 0x427B6666)

One important note for the 23 Bit Mantissa: The first bit (so-called hidden bit) is not represented. The hidden bit is the bit to the left of the fraction point. This bit is per definition always 1 and therefore suppressed.

Example: translate the binary float 0100 0010 0111 1011 0110 0110 0110 0110 to a decimal value

Step 1: Separating the binary value into Sign, Exponent and Mantissa

0 10000100 11110110110011001100110

1 Bit Sign + 8 Bit Exponent + 23 Bit Mantissa

S: **0**_{binary} = **0** (positive sign)

$$\begin{aligned} \text{E: } 10000100_{\text{binary}} &= 1 \cdot 2^7 + 0 \cdot 2^6 + 0 \cdot 2^5 + 0 \cdot 2^4 + 0 \cdot 2^3 + 1 \cdot 2^2 + 0 \cdot 2^1 + 0 \cdot 2^0 \\ &= 128 + 0 + 0 + 0 + 0 + 4 + 0 + 0 \\ &= 132 \end{aligned}$$

M: **11110110110011001100110**_{binary} = **8087142**

Step 2: Calculate the decimal value

$$\begin{aligned} D &= (-1)^S \cdot (1.0 + M/2^{23}) \cdot 2^{E-127} \\ &= (-1)^0 \cdot (1.0 + 8087142/2^{23}) \cdot 2^{132-127} \\ &= 1 \cdot 1.964062452316284 \cdot 32 \\ &= \mathbf{62.85} \end{aligned}$$

1.5.2 Character

Definition:

The numerical representation of characters is defined in 8-Bit ASCII-Code-Table (ANSI X3.4-1986). Accordingly, each Modbus register in ARC Sensors can store two ASCII characters.

Example: translate the ASCII-string "2076" to Hex representation

The following interpretation is made according to the ASCII Codes-Table:

"2" => ASCII code table => 0x32 Low Byte

"0" => ASCII code table => 0x30

"7" => ASCII code table => 0x37

"6" => ASCII code table => 0x36 High Byte

"2076" => **0x36373032**

1.5.3 Decimal

Example: translate Decimal 2227169 to Hex

$$\begin{aligned} 2227169 / 16 &= 139198 \quad \text{residue 1 Low Byte} \\ 139198 / 16 &= 8699 \quad \text{residue 14 => E} \\ 8699 / 16 &= 543 \quad \text{residue 11 => B} \\ 543 / 16 &= 33 \quad \text{residue 15 => F} \\ 33 / 16 &= 2 \quad \text{residue 1} \\ 2 / 16 &= 0 \quad \text{residue 2 High Byte} \\ &= \mathbf{0x21FBE1} \end{aligned}$$

1.6 Modbus RTU Error Messages

Here are listed the Modbus standard error-codes we have implemented in ARC Sensors.

| Error-Code Hex | Status-Text |
|-------------------|----------------------|
| 0x00 | OK |
| 0x01 | Illegal function |
| 0x02 | Illegal data address |
| 0x03 | Illegal data value |
| 0X04 | Slave device failure |

Figure 1.6.1: implemented Error-Codes (see "Modbus_Application_Protocol_V1.1b" for details)

2 VISIFERM DO Commands in Modbus RTU

2.1 General

In order to communicate with a VISIFERM DO sensor over Modbus RTU protocol a Modbus master terminal application software is needed. The Modbus RTU is an open standard and a number of free and commercial application toolkits are available.

This manual contains examples and illustrations from WinTECH Modbus Master ActiveX Control tool: WinTECH (www.win-tech.com) "Modbus Master OCX for Visual Basic". The Modbus Organisation (www.modbus.org/tech.php) provides other links to a wide variety of Modbus terminal softwares.

In the present manual the addressing of the Modbus registers starts at 1. But the Modbus master protocol operates with register addresses starting at 0. Usually, the Modbus master software translates the addressing. Thus, the register address of 2090 will be translated by the Modbus master software to 2089 which is sent to the sensor (Modbus slave).



Attention:

When configuring and calibrating the sensor, please limit write operations to a reasonable number. More than 100'000 write operations will physically damage the memory of the sensor. Furthermore, for the Free User Memory Space (see chapter 2.9.3), the write operations are limited to 10'000.

2.2 Operator levels and Passwords

2.2.1 Reading / Setting Operator Level

VISIFERM DO can be operated in three different operator levels. Each operator level allows a defined access to a specific set of commands.

| Abbreviation | Description | Code (hex) | Password (default) (decimal) |
|--------------|---------------------|------------|------------------------------|
| U | User (lowest level) | 0x03 | 0 |
| A | Administrator | 0x0C | 18111978 |
| S | Specialist | 0x30 | 16021966 |

Figure 2.2.1.1: Definition of operator level and default passwords

At each power up or processor reset, the operator level falls back to the default level U.

The active operator level can be read and written in register 4288.

| Start register | Number of registers | Reg1 / Reg2 | Reg3 / Reg4 | Modbus function code | Read access | Write access |
|----------------|---------------------|----------------|-------------|----------------------|-------------|--------------|
| 4288 | 4 | Operator Level | Password | 3, 4, 16 | U/A/S | U/A/S |

Figure 2.2.1.2: Definition of register 4288.

| | | | | | | |
|-------------------------|----------------|-----------------------------|--|------------------|----------------|------|
| Command: Operator level | | Modbus address: 4288 | | Length: 4 | Type: 3 | Read |
| Parameter: | Operator level | Password | | | | |
| Format: | hex | decimal | | | | |
| Value: | 0x03 | 0 | | | | |

Figure 2.2.1.3: Example to read the active operator level (function code 3, start register address 4288, number of registers 4): The active operator level is 0x03 (User). The sensor does not report the password. The value 0 is returned instead.

| | | | | | | |
|-------------------------|----------------|-----------------------------|--|------------------|----------------|------|
| Command: Operator level | | Modbus address: 4288 | | Length: 4 | Type: 3 | Read |
| Parameter: | Operator level | Password | | | | |
| Format: | hex | decimal | | | | |
| Value: | 0x30 | 0 | | | | |

Figure 2.2.1.4: Example to read the active operator level: the active level is 0x30 (Specialist). The sensor does not report the password. The value 0 is returned instead.

| | | | | | | |
|-------------------------|----------------|-----------------------------|--|------------------|-----------------|-------|
| Command: Operator level | | Modbus address: 4288 | | Length: 4 | Type: 16 | Write |
| Parameter: | Operator level | Password | | | | |
| Format: | hex | decimal | | | | |
| Value: | 0x03 | 0 | | | | |

Figure 2.2.1.5: Example to set the operator level to 0x03 (User). The password 0 has to be sent.

| | | | | | | |
|-------------------------|----------------|-----------------------------|--|------------------|-----------------|-------|
| Command: Operator level | | Modbus address: 4288 | | Length: 4 | Type: 16 | Write |
| Parameter: | Operator level | Password | | | | |
| Format: | hex | decimal | | | | |
| Value: | 0x0C | 18111978 | | | | |

Figure 2.2.1.6: Example to set the active operator level to 0x0C (Administrator). The correct password has to be sent.

| | | | | | | |
|-------------------------|----------------|-----------------------------|--|------------------|-----------------|-------|
| Command: Operator level | | Modbus address: 4288 | | Length: 4 | Type: 16 | Write |
| Parameter: | Operator level | Password | | | | |
| Format: | hex | decimal | | | | |
| Value: | 0x0B | 18111978 | | | | |

Figure 2.2.1.7: Example for a Modbus error. If the level or the password is not correct, (Operator level = 0x0B), the sensor answers with a Modbus error message "Slave device exception response" (see chapter 1.6).

2.2.2 Changing Passwords for Operator Level

The passwords for accessing the operator levels A and S can be modified by S (Specialist) only. U (User) and A (Administrator) have no right to change any password. The new password will remain stored after power down.

| Start register | Number of registers | Reg1 / Reg2 | Reg3 / Reg4 | Modbus function code | Read access | Write access |
|----------------|---------------------|-------------|--------------|----------------------|-------------|--------------|
| 4292 | 4 | Level | New password | 16 | None | S |

Figure 2.2.2.1: Definition of register 4292.

| | | | | | | |
|-------------------|----------------|-----------------------------|--|------------------|-----------------|-------|
| Command: Password | | Modbus address: 4292 | | Length: 4 | Type: 16 | Write |
| Parameter: | Operator level | Pass number | | | | |
| Format: | Hex | Decimal | | | | |
| Value: | 0x30 | 12345678 | | | | |

Figure 2.2.2.2: Example to set the Password of operator level S (code 0x30) to 12345678.

2.3 Configuration of the serial RS485 Interface

Factory settings of the RS485 (see chapter 1.3):

Parity is none, 1 start bit, 8 data bits, 2 stop bits (in total: 11 bits).

2.3.1 Device Address

2.3.1.1 Reading and Writing the Device Address

The sensor specific device address can be read and written in register 4096.

| Start register | Number of registers | Reg1 / Reg2 | Modbus function code | Read access | Write access |
|----------------|---------------------|----------------|----------------------|-------------|--------------|
| 4096 | 2 | device address | 3, 4, 16 | U/A/S | S |

Figure 2.3.1.1.1: Definition of register 4096.

| | | | | | | |
|----------------------|----------------|-----------------------------|--|------------------|----------------|------|
| Command: Com address | | Modbus address: 4096 | | Length: 2 | Type: 3 | Read |
| Parameter: | Modbus address | | | | | |
| Format: | Decimal | | | | | |
| Value: | 1 | | | | | |

Figure 2.3.1.1.2: Example to read the device address.

The device address can be set by S (Specialist), default value is 1.

| | | | | | | |
|----------------------|----------------|-----------------------------|--|------------------|-----------------|-------|
| Command: Com address | | Modbus address: 4096 | | Length: 2 | Type: 16 | Write |
| Parameter: | Modbus address | | | | | |
| Format: | Decimal | | | | | |
| Value: | 3 | | | | | |

Figure 2.3.1.1.3: Example to set the device address to 3.

2.3.1.2 Reading the Device Address Limits

The device address limits can be read in register 4098.

| Start register | Number of registers | Reg1 / Reg2 | Reg3 / Reg4 | Modbus function code | Read access | Write access |
|----------------|---------------------|---------------------|---------------------|----------------------|-------------|--------------|
| 4098 | 4 | Min. device address | Max. device address | 3, 4 | U/A/S | none |

Figure 2.3.1.2.1: Definition of register 4098.

| | | | | | | |
|-----------------------------|-----------|-----------------------------|--|------------------|----------------|------|
| Command: Com address limits | | Modbus address: 4098 | | Length: 4 | Type: 3 | Read |
| Parameter: | Min value | Max value | | | | |
| Format: | Decimal | Decimal | | | | |
| Value: | 1 | 32 | | | | |

Figure 2.3.1.2.2: Example to read the device address limits: Min = 1, Max = 32.

2.3.2 Baud Rate

2.3.2.1 Reading and Writing the Baud Rate

The baud rate can be read and written in register 4102.

| Start register | Number of registers | Reg1 / Reg2 | Modbus function code | Read access | Write access |
|----------------|---------------------|---------------------------------------|----------------------|-------------|--------------|
| 4102 | 2 | Baud rate code (definition see below) | 3, 4, 16 | U/A/S | S |

Figure 2.3.2.1.1: Definition of register 4102.

The code for the baud rate is defined as follows:

| | | | | | | |
|-----------|------|------|-------|-------|-------|--------|
| Baud rate | 4800 | 9600 | 19200 | 38400 | 57600 | 115200 |
| Code | 2 | 3 | 4 | 5 | 6 | 7 |

Figure 2.3.2.1.2: Code for the baud rates.

| | | | | | | |
|------------------------|----------------|-----------------------------|--|------------------|----------------|------|
| Command: Com baud rate | | Modbus address: 4102 | | Length: 2 | Type: 3 | Read |
| Parameter: | Baud rate code | | | | | |
| Format: | Decimal | | | | | |
| Value: | 4 | | | | | |

Figure 2.3.2.1.3: Example to read the baud rate code, 4 corresponds 19200 baud.

The baud rate can be set by S (Specialist), default is 19200.

| | | | | | | |
|------------------------|----------------|-----------------------------|--|------------------|-----------------|-------|
| Command: Com baud rate | | Modbus address: 4102 | | Length: 2 | Type: 16 | Write |
| Parameter: | Baud rate code | | | | | |
| Format: | Decimal | | | | | |
| Value: | 5 | | | | | |

Figure 2.3.2.1.4: Example to set the baud rate to 38400 baud with code 5.

2.3.2.2 Reading the Baud Rate Limits

The baud rate limits can be read in register 4104.

| Start register | Number of registers | Reg1 / Reg2 | Reg3 / Reg4 | Modbus function code | Read access | Write access |
|----------------|---------------------|---------------------|---------------------|----------------------|-------------|--------------|
| 4104 | 4 | Min. Baud rate code | Max. Baud rate code | 3, 4 | U/A/S | none |

Figure 2.3.2.2.1: Definition of register 4104.

| | | | | | | |
|--------------------------|--------------------|-----------------------------|--|------------------|----------------|------|
| Command: Com baud limits | | Modbus address: 4104 | | Length: 4 | Type: 3 | Read |
| Parameter: | Min Baud rate code | Max Baud rate code | | | | |
| Format: | Decimal | Decimal | | | | |
| Value: | 2 | 7 | | | | |

Figure 2.3.2.2.2: Example to read the baud rate code limits: Min = 2, Max = 7 (see Figure 2.3.2.1.2).

2.4 Configuration of the Analog Interfaces (4-20 mA and ECS)

2.4.1 Available Analog Interfaces

VISIFERM has one physical analog output - defined in register 4320:

- Analog Output Interface 1 (AO1)

| Start register | Number of registers | Reg1 / Reg2 | Modbus function code | Read access | Write access |
|----------------|---------------------|--------------------------|----------------------|-------------|--------------|
| 4320 | 2 | Available analog outputs | 3, 4 | U/A/S | none |

Figure 2.4.1.1: Definition of register 4320.

| | | | | | | |
|----------------------------------|-----------------------------|-----------------------------|--|------------------|----------------|------|
| Command: Avail analog interfaces | | Modbus address: 4320 | | Length: 2 | Type: 3 | Read |
| Parameter: | Available analog interfaces | | | | | |
| Format: | Hex | | | | | |
| Value: | 0x01 | | | | | |

Figure 2.4.1.2: Example to read the available analog outputs. It is "0x01" meaning that there exists only one Analog Interface 1 (AO1).



Attention:

Unlike to pH ARC Sensors and Conducell ARC Sensors which have AO1 and AO2, VISIFERM DO / VISIFERM DO ARC Sensors only have AO1 !

2.4.2 Description of the Analog Interface 1

VISIFERM DO has one single physical analog output interface (AO1) that can be used in two different interface modes:

- 4-20 mA standard interface, or
- ECS - electrochemical sensor interface (HAMILTON proprietary)



Attention:

VISIFERM DO ARC has no ECS!

Reading the description of the analog interface:

| Start register | Number of registers | Reg1 ... Reg8 16 ASCII characters | Modbus function code | Read access | Write access |
|----------------|---------------------|---|----------------------|-------------|--------------|
| 4352 | 8 | Description of the analog interface AO1 | 3, 4 | U/A/S | none |

Figure 2.4.2.1: Definition of register 4352.

| | | | | | | |
|---------------------------------|-------------------------|-----------------------------|--|------------------|----------------|------|
| Command: Current interface text | | Modbus address: 4352 | | Length: 8 | Type: 3 | Read |
| Parameter: | Text | | | | | |
| Format: | Character | | | | | |
| Value: | mA/ECS-Interface | | | | | |

Figure 2.4.2.2: Example to read the description of the analog output interface AO1. It is "mA/ECS-Interface". For VISIFERM DO ARC, this text is "mA-Interface".

2.4.3 Selection of an Analog Interface Mode

As both interfaces (4-20 mA and ECS) are using the same physical output (AO1) of the sensor, only one interface can be operated at a time. The way the analog interface is operated, is called the “analog interface mode”.

The available analog interface modes are defined in register 4322.

| Start register | Number of registers | Reg1 / Reg2 | Reg3 / Reg4 | Reg5 / Reg6 | Reg7 / Reg8 | Modbus function code | Read access | Write access |
|----------------|---------------------|----------------------------------|-------------|-------------|-------------|----------------------|-------------|--------------|
| 4322 | 8 | Available Analog Interface Modes | reserved | reserved | reserved | 3,4 | U/A/S | none |

Figure 2.4.3.1: Definition of register 4322. Reg 1 / Reg 2 define what analog interface modes are available for AO1. The analog interface modes are described in Figure 2.4.3.2.

| Analog Interface Mode (Hex) | VISIFERM DO | VISIFERM DO ARC | Description |
|-----------------------------|-------------------------------|------------------|---|
| 0x0000 | Both 4-20 mA and ECS inactive | 4-20 mA inactive | Analog interface deactivated |
| 0x0001 | 4-20 mA fixed | 4-20 mA fixed | Set to a constant output value for current loop testing |
| 0x0002 | 4-20 mA linear | 4-20 mA linear | Linear output of measurement (PMC1 / 6) |
| 0x0004 | 4-20 mA bilinear | 4-20 mA bilinear | Bilinear output of measurement(PMC1 / 6) |
| 0x0100 | ECS fixed | Not available | Set to a constant output value for current loop testing |
| 0x0200 | ECS | Not available | nA output linked to oxygen reading (PMC1) |

Figure 2.4.3.2: Definition of the analog interface modes (see figure 2.4.4.6.3 and 2.4.4.6.4).

| | | | | | | |
|---------------------------------|----------------------------------|-----------------------------|------------|------------------|----------------|------|
| Command: Analog Interface Modes | | Modbus address: 4322 | | Length: 8 | Type: 3 | Read |
| Parameter: | Available Analog Interface Modes | reserved | reserved | reserved | reserved | |
| Format: | Hex | Hex | Hex | Hex | Hex | |
| Value: | 0x0307 | 0x0 | 0x0 | 0x0 | 0x0 | |

Figure 2.4.3.3: Example to read register 4322 with VISIFERM DO: all modes defined in Figure 2.4.3.2 are available. Note: VISIFERM DO ARC returns the value 0x0007.

The analog interface mode is selected by programming the analog interface mode register 4360.

| Start register | Number of registers | Reg1 / Reg2 | Modbus function code | Read access | Write access |
|----------------|---------------------|--------------------------------|----------------------|-------------|--------------|
| 4360 | 2 | Code for analog interface mode | 3, 4, 16 | U/A/S | S |

Figure 2.4.3.4: Definition of register 4360. Only one bit can be set.

| | | | | | | |
|--------------------------------|---------------|-----------------------------|--|------------------|-----------------|-------|
| Command: Active interface mode | | Modbus address: 4360 | | Length: 2 | Type: 16 | Write |
| Parameter: | Mode | | | | | |
| Format: | Hex | | | | | |
| Value: | 0x0002 | | | | | |

Figure 2.4.3.5: Example to set the analog interface mode of AO1 to 0x0002 (4-20 mA linear output).

**Attention:**

When the sensor is programmed to ECS mode (0x0100/0x0200), but the external wiring is done for driving a 4-20 mA current, the electronics of the sensor can be seriously damaged. Please be careful when modifying the analog interface mode! We recommend programming only while the sensor is not connected to any analog interface.

2.4.4 Configuration of the 4-20 mA Interface

Note:

The configuration of the 4-20 mA interface is only effective if register 4360 (analog interface mode) is set to the value 0x01, 0x02 or 0x04 (see chapter 2.4.3).

2.4.4.1 Reading the Available Primary Measurement Channels to be Mapped to the Analog Output

| Start register | Number of registers | Reg1 / Reg2 | Modbus function code | Read access | Write access |
|----------------|---------------------|--|----------------------|-------------|--------------|
| 4362 | 2 | Available Primary Measurement Channels | 3, 4 | U/A/S | none |

Figure 2.4.4.1.1: Definition of register 4362.

For the definition of the Primary Measurement Channels (PMC), see chapter 2.5.

| | | | | | | |
|--------------------------------|--------------------|-----------------------------|--|------------------|----------------|------|
| Command: Available PMC 4-20 mA | | Modbus address: 4362 | | Length: 2 | Type: 3 | Read |
| Parameter: | Avail. PMC 4-20 mA | | | | | |
| Format: | Hex | | | | | |
| Value: | 0x21 | | | | | |

Figure 2.4.4.1.2: Example to read the available Primary Measurement Channels (PMC). The hexadecimal value of "0x21" defines that Primary Measurement Channel 1 (oxygen) or Primary Measurement Channel 6 (temperature) can be mapped onto the 4-20 mA analog output (see chapter 2.4.4.2).

2.4.4.2 Selecting the Primary Measurement Channel to be Mapped to the Analog Interface

| Start register | Number of registers | Reg1 / Reg2 | Modbus function code | Read access | Write access |
|----------------|---------------------|--------------------------------------|----------------------|-------------|--------------|
| 4364 | 2 | Selected Primary Measurement Channel | 3, 4, 16 | U/A/S | S |

Figure 2.4.4.2.1: Definition of register 4364. Only one bit can be set.

| Code (hex) | Primary Measurement Channel (PMC) |
|------------|-----------------------------------|
| 0x01 | PMC1 (oxygen) |
| | not available |
| 0x20 | PMC6 (temperature) |

Figure 2.4.4.2.2: Code for selection of the primary measurement channel.

| | | | | | | |
|-----------------------------|-----------------|-----------------------------|--|------------------|----------------|------|
| Command: Active PMC 4-20 mA | | Modbus address: 4364 | | Length: 2 | Type: 3 | Read |
| Parameter: | Act PMC 4-20 mA | | | | | |
| Format: | Hex | | | | | |
| Value: | 0x01 | | | | | |

Figure 2.4.4.2.3: Example to read the current primary measurement channel. The Primary Measurement Channel 1 for oxygen is selected as the channel to be mapped to the 4-20 mA analog output (this is the factory setting).

2.4.4.3 Reading the Minimum and Maximum Possible Output Current for the 4-20 mA Interface

| Start register | Number of registers | Reg1 / Reg2 | Reg3 / Reg4 | Modbus function code | Read access | Write access |
|----------------|---------------------|----------------------------------|----------------------------------|----------------------|-------------|--------------|
| 4366 | 4 | Min physical output current [mA] | Max physical output current [mA] | 3, 4 | U/A/S | none |

Figure 2.4.4.3.1: Definition of register 4366.

| | | | | | | |
|-------------------------|----------------|-----------------------------|--|------------------|----------------|------|
| Command: Limits 4-20 mA | | Modbus address: 4366 | | Length: 4 | Type: 3 | Read |
| Parameter: | Min limit [mA] | Max limit [mA] | | | | |
| Format: | Float | Float | | | | |
| Value: | 2 | 22 | | | | |

Figure 2.4.4.3.2: Example to read the min and max output current. Min is fixed to 2 and Max is fixed to 22 mA (Currents above 20 and below 4 mA indicate erroneous measurements or errors).

2.4.4.4 Reading the Minimum, Maximum and Mid Current for Measurement Value Output

| Start register | Number of registers | Reg1 / Reg2 | Reg3 / Reg4 | Reg5 / Reg6 | Modbus function code | Read access | Write access |
|----------------|---------------------|----------------------------------|-----------------------------------|--|----------------------|-------------|--------------|
| 4370 | 6 | Min output for measurement value | Max output for measurement values | Mid output (bilinear) for measurement values | 3, 4 | U/A/S | none |

Figure 2.4.4.4.1: Definition of register 4370 (see figure 2.4.4.6.3).

| | | | | | | |
|---------------------------------|------------------|-----------------------------|------------------|------------------|----------------|------|
| Command: MinMaxMid curr 4-20 mA | | Modbus address: 4370 | | Length: 6 | Type: 3 | Read |
| Parameter: | Min curr 4-20 mA | Max curr 4-20 mA | Mid curr 4-20 mA | | | |
| Format: | Float | Float | Float | | | |
| Value: | 4 | 20 | 12 | | | |

Figure 2.4.4.4.2: Example to read the min, max and mid output current for measurement values. They are fixed to 4, 20 and 12 mA.

Note:

Mid current must always be defined. However, in linear output mode, the mid current value has no physical meaning and will not affect the 4-20 mA output.

2.4.4.5 Reading the Selected Physical Unit for 4-20 mA Output

| Start register | Number of registers | Reg1 / Reg2 | Modbus function code | Read access | Write access |
|----------------|---------------------|---|----------------------|-------------|--------------|
| 4376 | 2 | Selected physical unit of analog output (see chapter 2.5.1) | 3, 4 | U/A/S | none |

Figure 2.4.4.5.1: Definition of register 4376.

| | | | | | | |
|-----------------------------|----------------|-----------------------------|--|------------------|----------------|------|
| Command: Avail unit 4-20 mA | | Modbus address: 4376 | | Length: 2 | Type: 3 | Read |
| Parameter: | Available unit | | | | | |
| Format: | Hex | | | | | |
| Value: | 0x20 | | | | | |

Figure 2.4.4.5.2: Example to read the selected unit of primary measurement channel, 0x20 (%-sat).

The physical unit for PMC is defined in Reg. 2090 or 2410 and applies automatically for 4-20 mA output.

2.4.4.6 Defining the Measurement Values for 4, 12 and 20 mA Output

| Start register | Number of registers | Reg1 / Reg2 | Reg3 / Reg4 | Reg5 / Reg6 | Modbus function code | Read access | Write access |
|----------------|---------------------|---|---|---|----------------------|-------------|--------------|
| 4378 | 6 | Measurement value at Min Output Current | Measurement value at Max Output Current | Measurement value at Mid Output Current | 3, 4, 16 | U/A/S | S |

Figure 2.4.4.6.1: Definition of register 4378.

| | | | | | | |
|-------------------------------|-------------------|-----------------------------|-------------------|------------------|-----------------|-------|
| Command: MinMaxMid val 4-20mA | | Modbus address: 4378 | | Length: 6 | Type: 16 | Write |
| Parameter: | Min value 4-20 mA | Max value 4-20 mA | Mid value 4-20 mA | | | |
| Format: | Float | Float | Float | | | |
| Value: | 0 | 62.85 | 10 | | | |

Figure 2.4.4.6.2: Example to set the min value to 0 (for 4 mA), the max value to 62.85 (for 20 mA) and the mid value to 10 (for 12 mA). The corresponding physical unit is defined in Reg. 2090 or 2410.

Note:

Mid current must always be defined. However, in linear output mode, the mid current value has no physical meaning and will not affect the 4-20 mA output.

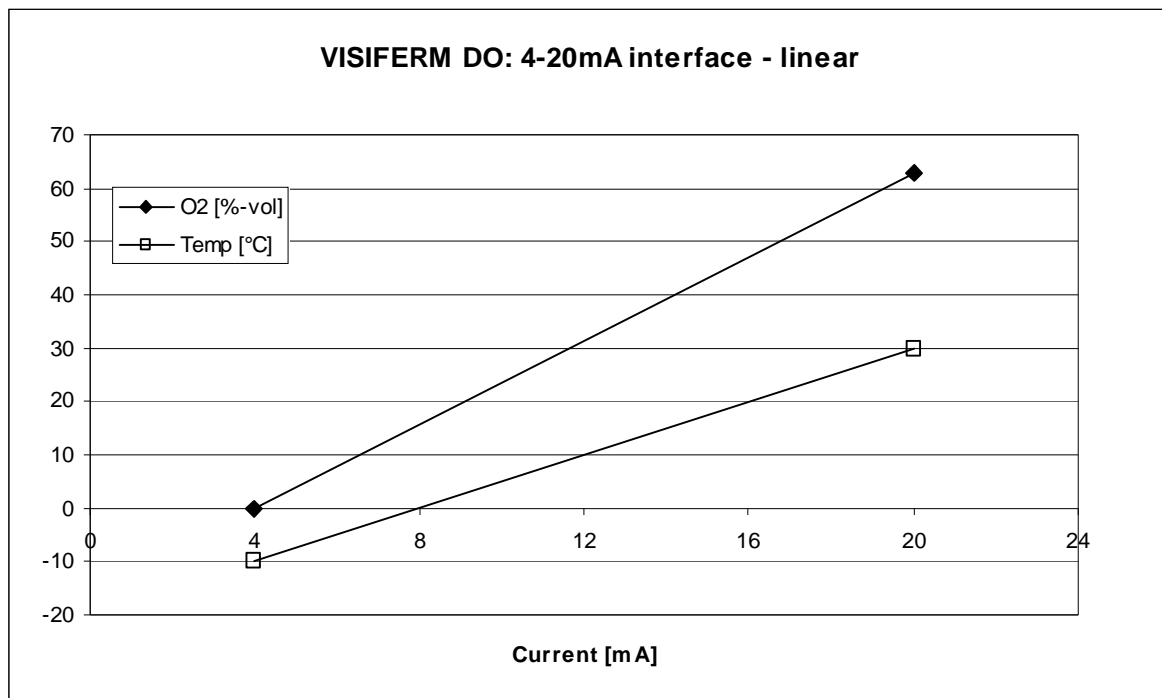


Figure 2.4.4.6.3: Example of linear 4-20 mA output characteristics for Oxygen or Temperature.

| | | |
|---------|-------------|-------------|
| Current | Oxygen | Temperature |
| 4 mA | 0 %-vol | -10°C |
| 20 mA | 62.85 %-vol | +30° |

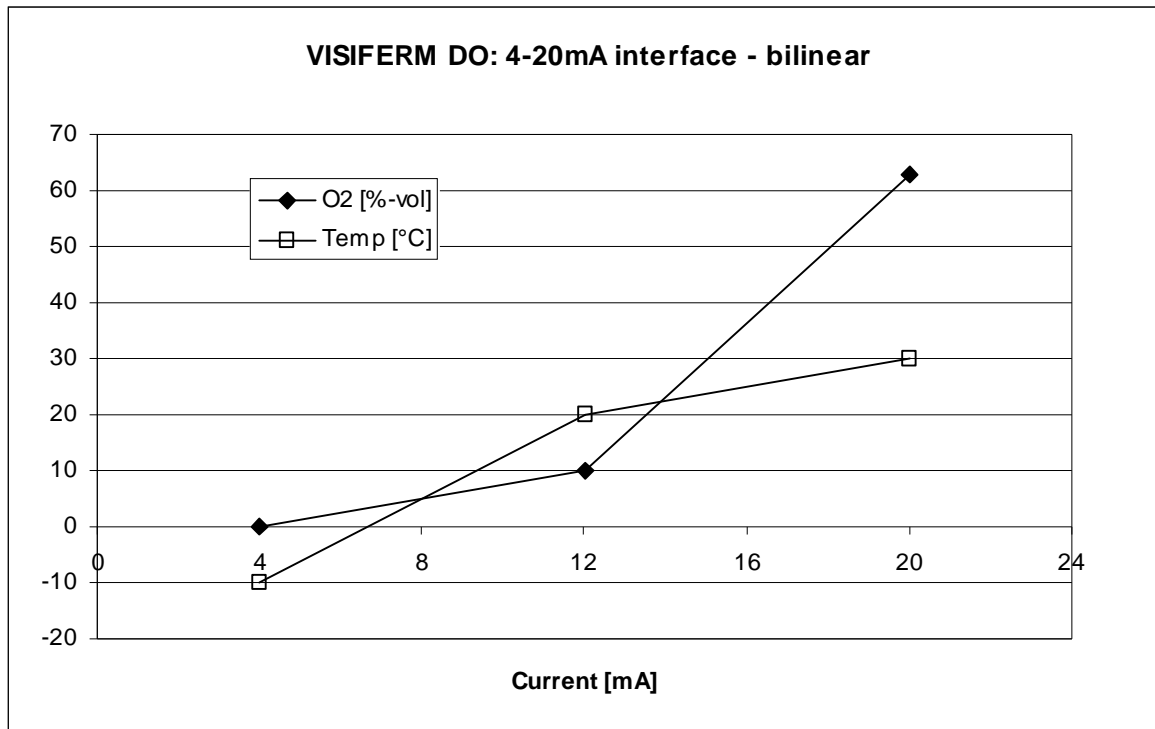


Figure 2.4.4.6.4: Example of bilinear 4-20 mA output characteristics for Oxygen or Temperature.

| Current | Oxygen | Temperature |
|---------|-------------|-------------|
| 4 mA | 0 %-vol | -10°C |
| 12 mA | 10 %-vol | +20°C |
| 20 mA | 62.85 %-vol | +30° |



Attention:

When assigning measurement values to 4-20 mA analog output by using register 4378, you need to consider the following:

- The PMC you have mapped to 4-20 mA analog output (register 4364)
- The unit currently in use for the selected PMC (register 2090 for PMC1 (oxygen) and register 2410 for PMC6 (temperature)).

Therefore, when the operator redefines one of the register 4364, 2090 or 2410, the definitions of the register 4378 should be reviewed. If not, the current output at the 4-20 mA interface may be wrong.

Note:

The physical unit of the analog output corresponds always to the unit that is set for the selected PMC (register 2090 for PMC1 or register 2410 for PMC6). Accordingly, not only oxygen partial pressure (mbar, %-vol, %-sat) is selectable at the 4-20 mA interface, but also oxygen concentration (mg/l, µg/l, ppb, ppm).

Example:

Register 4364 is set to 1 (PMC1 (oxygen) is mapped to 4-20 mA analog output).

Register 2090 is set to 16 (the unit “%-vol” is assigned to PMC1).

Register 4378 is set to 0 and 62.85 (4 mA = 0 %-vol, 20 mA = 62.85 %-vol).

In air, the sensor reads 20.95 %, the output at the 4-20 mA is accordingly 9.33 mA.

The operator now re-assigns register 2090 to the value of 32 (%-sat), but does not modify all other registers. The sensor reads now 100 %-sat. At the analog output, as 20 mA is programmed to a value of 62.85 by register 4378, the current will go to the maximum value of 20 mA. This will generate an interface warning.

2.4.4.7 Defining a Constant Current Output for Testing

Note:

For constant current output, VISIFERM must be set to analog interface mode 0x01 (see chapter 2.4.3):

| Start register | Number of registers | Reg1 / Reg2 | Modbus function code | Read access | Write access |
|----------------|---------------------|------------------------------------|----------------------|-------------|--------------|
| 4384 | 2 | Constant current output value [mA] | 3, 4, 16 | U/A/S | S |

Figure 2.4.4.7.1: Definition of register 4384.

| | | | | | | |
|------------------------------|------------------|-----------------------------|--|------------------|----------------|------|
| Command: Fixed value 4-20 mA | | Modbus address: 4384 | | Length: 2 | Type: 3 | Read |
| Parameter: | Fixed value [mA] | | | | | |
| Format: | Float | | | | | |
| Value: | 10 | | | | | |

Figure 2.4.4.7.2: Example to read the constant current output in mode 0x01. It is set to 10 mA.

2.4.4.8 Defining the Error and Warning Output of the 4-20 mA Interface

Errors and warnings can be mapped to the analog output.

| Start register | Number of registers | Reg1 / Reg2 | Reg3 / Reg4 | Reg5 / Reg6 | Reg7 / Reg8 | Modbus function code | Read access | Write access |
|----------------|---------------------|--|-----------------------------------|---------------------------------|------------------------------------|----------------------|-------------|--------------|
| 4386 | 8 | Code of warnings and errors (see Figure 2.4.4.8.2) | Current in case of "warning" [mA] | Current in case of "error" [mA] | Current in case of "T exceed" [mA] | 3, 4, 16 | U/A/S | S |

Figure 2.4.4.8.1: Definition of register 4386.

| Bit # | Hex Code | Behaviour of the 4-20 mA interface in case of errors and warnings |
|---------|----------|--|
| 0 (LSB) | 0x000001 | Error continuous output |
| 1 | 0x000002 | Error alternating output (see figure 2.4.4.8.3) 12 cycles (+1 mA for 12 sec and -1 mA for 12 sec) alternating around the current measurement value followed by 288 sec (12*2*12 sec) measurement value |
| | | not available |
| 16 | 0x010000 | Warning continuous output |
| 17 | 0x020000 | Warning alternating output (see figure 2.4.4.8.3) 12 cycles (+1 mA for 12 sec and -1 mA for 12 sec) alternating around the current measurement value followed by 288 sec (12*2*12 sec) measurement value |
| | | not available |

Figure 2.4.4.8.2: Code for the 4-20 mA interface in case of errors and warnings.

If the corresponding bits for the errors and warnings are not set (=0), the respective options are inactive.

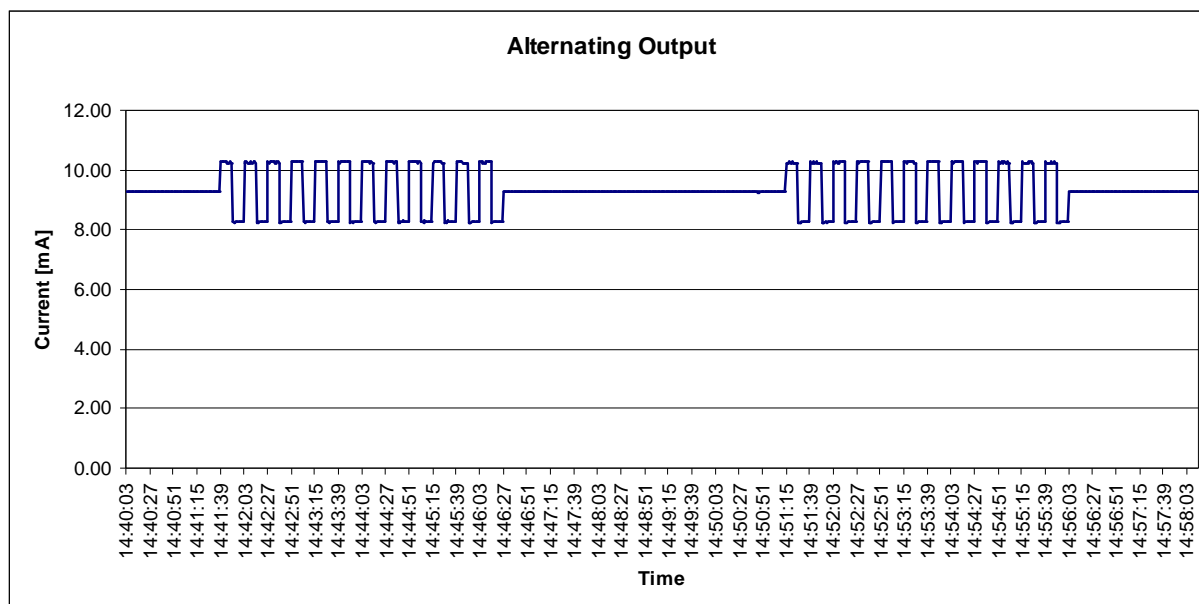


Figure 2.4.4.8.3: Example of the alternating current output in case of a warning or error.

The default settings are:

Code 1, current "warnings" 21 mA, current "errors" 22 mA and current "T exceed" 3 mA.

| Command: ErrorWarnings 4-20 mA | | Modbus address: 4386 | | Length: 8 | Type: 3 | Read |
|--------------------------------|-----------------|-----------------------------|----------------------|-------------------------|----------------|------|
| Parameter: | Warning code | Current "warning" [mA] | Current "error" [mA] | Current "T exceed" [mA] | | |
| Format: | Hex | Float | Float | Float | | |
| Value: | 0x020001 | 21 | 22 | 3 | | |

Figure 2.4.4.8.4: Example: Read the settings for the 4-20mA interface in case of warnings and errors.

Warning code 0x020001 corresponds to the alternating output current warning mode (code 0x020000) and continuous output current "error" (code 0x01) of 22 mA. The output current "Temperature exceed" is 3 mA.

2.4.5 Configuration of the ECS Interface

The ECS interface is used to emulate a classical electrochemical DO sensor, having a cathode and an anode, and a 22 kOhm NTC (temperature sensor). The 22 kOhm NTC is realized in the VISIFERM DO hardware and cannot be modified by software settings. The current on the cathode, however, can be modified by using the registers described below.



Attention

- The ECS interface does NOT exist in VISIFERM DO ARC
- The configuration of the ECS interface is only effective if register 4360 (analog interface mode) is set to the value of 0x0100 or 0x0200 (see chapter 2.4.3).
- Please note that – unlike to the 4-20 mA analog output – only PMC1 (“oxygen”) can be mapped to the ECS output.

2.4.5.1 Reading the Minimum and Maximum Possible Output Current at the ECS Interface

| Start register | Number of registers | Reg1 / Reg2 | Reg3 / Reg4 | Modbus function code | Read access | Write access |
|----------------|---------------------|----------------------------------|----------------------------------|----------------------|-------------|--------------|
| 4394 | 4 | Min physical output current [nA] | Max physical output current [nA] | 3, 4 | U/A/S | none |

Figure 2.4.5.1.1: Definition of register 4394.

| | | | | | | | |
|---------------------|----------------|----------------|-----------------------------|--|------------------|----------------|------|
| Command: Limits ECS | | | Modbus address: 4394 | | Length: 4 | Type: 3 | Read |
| Parameter: | Min limit [nA] | Max limit [nA] | | | | | |
| Format: | Float | Float | | | | | |
| Value: | 0 | 500 | | | | | |

Figure 2.4.5.1.2: Example to read the current range at the cathode. It is fixed to 0-500 nA.

2.4.5.2 Defining the Characteristics of the Emulated Electrochemical Sensor

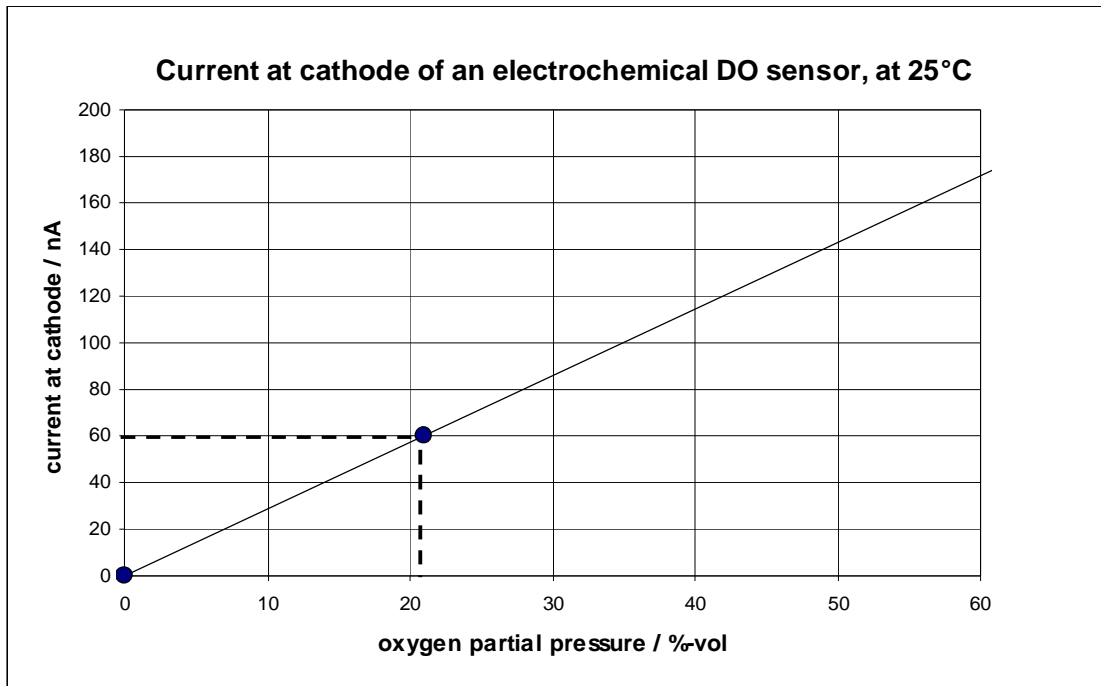


Figure 2.4.5.2.1: Typical characteristic of an electrochemical DO sensor at fixed temperature (here 25 °C): the current generated at the cathode by the reduction of oxygen is proportional to the oxygen partial pressure, here expressed as %-vol in a gas mixture. If no oxygen is present, the current is zero. The linear curve is defined by the current at zero oxygen and the current in air (20.95 %-vol). For a typical sensor, these values are 0 and 60 nA at 25 °C.

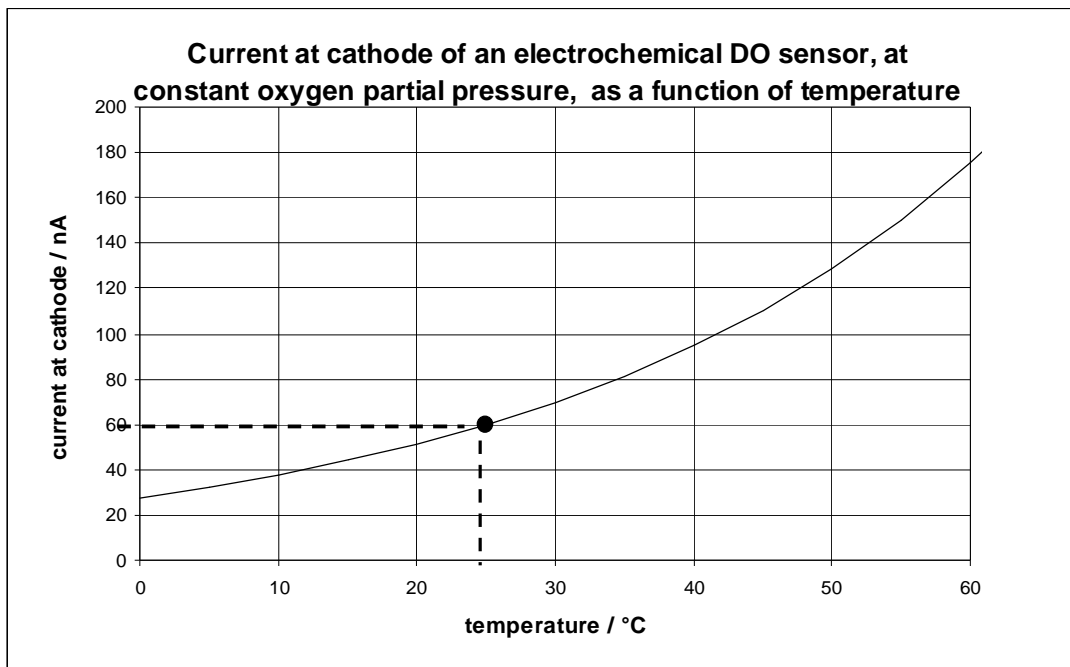


Figure 2.4.5.2.2: Measurement current of a typical electrochemical DO sensor as a function of temperature, at fixed oxygen partial pressure (here 20.95 %-vol). The current generated at the cathode is an exponential function of temperature. At 25 °C, the current is typically 60 nA.

The exponential function is defined as:

$$I_{T_{eff}} = I_{25^{\circ}\text{C}} * \text{EXP}(0.0306 * (T_{eff} - 25))$$

with:

$I_{25^{\circ}\text{C}}$: electrical current at 25 °C

$I_{T_{eff}}$: electrical current at effective temperature

T_{eff} : effective temperature in °C

The value of 0.0306 (unit %/°C) is the temperature coefficient for Hamilton DO sensors (Oxyferm, OxyGold, Oxsens). It can be different for sensors of other manufacturers.

Register 4398 defines the characteristics of ECS.

| Start register | Number of registers | Reg1 / Reg2 | Reg3 / Reg4 | Reg5 / Reg6 | Modbus function code | Read access | Write access |
|----------------|---------------------|--|--|--------------------------------|----------------------|-------------|--------------|
| 4398 | 6 | Electrical Current in zero oxygen at 25°C [nA] | Electrical Current in air at 25°C [nA] | Temperature coefficient [%/°C] | 3, 4, 16 | U/A/S | S |

Figure 2.4.5.2.3: Definition of register 4398: parameters of the electrochemical sensor to be simulated.

| | | | | | | |
|---------------------|------------------|-----------------------------|-------------------------------|------------------|----------------|------|
| Command: Output ECS | | Modbus address: 4398 | | Length: 6 | Type: 3 | Read |
| Parameter: | Zero Oxygen [nA] | Air [nA] | Temperature coefficient [%/K] | | | |
| Format: | Float | Float | Float | | | |
| Value: | 0 | 60 | 3.1 | | | |

Figure 2.4.5.2.4: Example to read the current in zero oxygen: 0 nA, the current in air: 60 nA and the temperature coefficient: 3.1 %/°C.

The ECS output current is calculated by VISIFERM DO sensor as follows:

$$I_{ECS} = I_{\text{Reg.4398/99}} + I_{\text{Reg.4400/01}} * \{ (PMC1 / 20.95) * \text{EXP}(TC_{\text{Reg.4402/03}} * (PMC6 - 25)) \}$$

$I_{\text{Reg.4398/99}}$: current defined in register 4398/99

$I_{\text{Reg.4400/01}}$: current defined in register 4400/01

$TC_{\text{Reg.4402/03}}$: temperature coefficient defined in register 4402/03

PMC1 : value of PMC1 in %-vol

PMC6 : value of PMC6 in °C

Note:

- It is not mandatory to program a temperature coefficient above 0. If set to 0, the current at the ECS output will be directly proportional to PMC1. No temperature compensation.
- The current at zero oxygen can be higher than 0.
- Changing the physical units for PMC1 (register 2090) has no effect on the current output at the ECS.

2.4.5.3 Defining a Constant Current Output for Testing

Note:

For constant ECS output current, VISIFERM must be set to the analog interface mode 0x0100 (see chapter 2.4.3).

| Start register | Number of registers | Reg1 / Reg2 | Modbus function code | Read access | Write access |
|----------------|---------------------|---------------------------|----------------------|-------------|--------------|
| 4404 | 2 | Constant current ECS [nA] | 3, 4, 16 | U/A/S | S |

Figure 2.4.5.3.1: Definition of register 4404.

| | | | | | | |
|--------------------------|------------------|-----------------------------|--|------------------|----------------|------|
| Command: Fixed value ECS | | Modbus address: 4404 | | Length: 2 | Type: 3 | Read |
| Parameter: | Fixed value [nA] | | | | | |
| Format: | Float | | | | | |
| Value: | 100 | | | | | |

Figure 2.4.5.3.2: Example to read the constant current output in mode 0x0100. It is set to 100 nA.

Note:

The constant output current is a test value and completely independent from oxygen reading and temperature.

2.4.5.4 Defining Error and Warning Output of ECS

Errors and warnings can be mapped to the ECS.

| Start register | Number of registers | Reg1 / Reg2 | Reg3 / Reg4 | Reg5 / Reg6 | Reg7 / Reg8 | Modbus function code | Read access | Write access |
|----------------|---------------------|--|-----------------------------------|---------------------------------|------------------------------------|----------------------|-------------|--------------|
| 4406 | 8 | Code of warnings and errors (Figure 2.4.5.4.2) | Current in case of "warning" [nA] | Current in case of "error" [nA] | Current in case of "T exceed" [nA] | 3, 4, 16 | U/A/S | S |

Figure 2.4.5.4.1: Definition of register 4406.

| Bit # | Code | 4-20 mA interface in case of errors and warnings |
|---------|----------|--|
| 0 (LSB) | 0x000001 | Error continuous output |
| | | not available |
| 16 | 0x010000 | Warning continuous output |
| | | not available |

Figure 2.4.5.4.2: Code for the ECS interface in case of errors and warnings. If the corresponding bit for the errors and warnings is not set (0), the respective Option is not active.

Note: Alternating current output at the ECS is not available.

The default settings are:

- code 0x00
- current in case of "warnings": 433 nA
- current in case of "errors": 466 nA
- current in case of "T exceed": 499 nA

| | | | | | | |
|-----------------------------|-----------------|-----------------------------|----------------------|-------------------------|----------------|------|
| Command: Error Warnings ECS | | Modbus address: 4406 | | Length: 8 | Type: 3 | Read |
| Parameter: | Warning code | Current "warning" [nA] | Current "error" [nA] | Current "T exceed" [nA] | | |
| Format: | Hex | Float | Float | Float | | |
| Value: | 0x010001 | 433 | 466 | 499 | | |

Figure 2.4.5.4.3: Example to read the settings for the ECS interface in case of errors and warnings.

code 0x010001 (0x010000 + 0x000001) is set and defines

- 433 nA continuous current in case of "warning",
- 466 nA continuous current in case of "error" and
- 499 nA continuous current in case of "T exceed".

2.4.6 Reading the Internally Measured Output Current

Reg. 4414 provides internal parameters of the analog output interface AO1 (both 4-20 mA or ECS):

- the setpoint to which the current is regulated in a closed loop control
- the electrical current the sensor is measuring to feed the closed loop control

These values are helpful in order to compare against the externally measured electrical current.

| Start register | Number of registers | Reg1 / Reg2 | Reg3 / Reg4 | Modbus function code | Read access | Write access |
|----------------|---------------------|----------------------------|--|----------------------|-------------|--------------|
| 4414 | 4 | Set point AO1 [mA] or [nA] | Internally measured current AO1 [mA] or [nA] | 3, 4 | U/A/S | none |

Figure 2.4.6.1: Definition of register 4414.

| | | | | | | |
|-----------------------------------|-----------------------|---------------------------------|--|------------------|----------------|------|
| Command: Int. values 4-20mA / ECS | | Modbus address: 4414 | | Length: 4 | Type: 3 | Read |
| Parameter: | Set point [mA] / [nA] | Internally measured [mA] / [nA] | | | | |
| Format: | Float | Float | | | | |
| Value: | 9.99186 | 9.99742 | | | | |

Figure 2.4.6.2: Example to read the internal values AO1 (4-20 mA or ECS), depending on the analog interface mode.

In order to know which current loop is active, please refer to chapter 2.4.3.

2.5 Measurement

2.5.1 Definition of Measurement Channels and Physical Units

The VISIFERM DO Modbus register structure allows the definition of 6 individual Primary Measurement Channels (PMC), and 16 individual Secondary Measurement Channels (SMC).

| Bit # | Hex value | Description | Definition in VISIFERM DO |
|-----------------|-----------------|--------------|---------------------------|
| 0 (LSB) | 0x000001 | PMC1 | Oxygen |
| 1 | 0x000002 | PMC2 | not available |
| | | | not available |
| 4 | 0x000010 | PMC5 | not available |
| 5 | 0x000020 | PMC6 | Temperature |
| 6 | 0x000040 | SMC1 | not available |
| | | | ... |
| 20 | 0x100000 | SMC15 | not available |
| 21 (MSB) | 0x200000 | SMC16 | not available |

Figure 2.5.1.1: Definition of PMC1 to 6 and SMC1 to 16.

In Register 2048, the available PMC and SMC are defined.

| Start register | Number of registers | Reg1 / Reg2 | Modbus function code | Read access | Write access |
|----------------|---------------------|---|----------------------|-------------|--------------|
| 2048 | 2 | Available measurement channels PMC and SMC (bitwise set) | 3, 4 | U/A/S | none |

Figure 2.5.1.2: Definition of register 2048.

| | | | | | | |
|--------------------------------|---------------------------------|-----------------------------|--|------------------|----------------|------|
| Command: Avail. meas. channels | | Modbus address: 2048 | | Length: 2 | Type: 3 | Read |
| Parameter: | Avail. meas. ch. PMC and SMC | | | | | |
| Format: | Hex | | | | | |
| Value: | 0x21 | | | | | |

Figure 2.5.1.3: Example to read Reg. 2048. The hex value 0x21 defines the channels PMC1 and PMC6.

The VISIFERM DO Modbus register structure uses the following physical units used for Primary or Secondary Measurement Channels.

| Bit # | Hex value | Physical unit | Start register. (8 ASCII characters, length 4 registers, Type 3, read for U/A/S) |
|----------|------------|---------------|--|
| 0 (LSB) | 0x00000001 | none | 1920 |
| 1 | 0x00000002 | K | 1924 |
| 2 | 0x00000004 | °C | 1928 |
| 3 | 0x00000008 | °F | 1932 |
| 4 | 0x00000010 | %-vol | 1936 |
| 5 | 0x00000020 | %-sat | 1940 |
| 6 | 0x00000040 | ug/l ppb | 1944 |
| 7 | 0x00000080 | mg/l ppm | 1948 |
| 8 | 0x00000100 | g/l | 1952 |
| 9 | 0x00000200 | uS/cm | 1956 |
| 10 | 0x00000400 | mS/cm | 1960 |
| 11 | 0x00000800 | 1/cm | 1964 |
| 12 | 0x00001000 | pH | 1968 |
| 13 | 0x00002000 | mV/pH | 1972 |
| 14 | 0x00004000 | kOhm | 1976 |
| 15 | 0x00008000 | MOhm | 1980 |
| 16 | 0x00010000 | pA | 1984 |
| 17 | 0x00020000 | nA | 1988 |
| 18 | 0x00040000 | uA | 1992 |
| 19 | 0x00080000 | mA | 1996 |
| 20 | 0x00100000 | uV | 2000 |
| 21 | 0x00200000 | mV | 2004 |
| 22 | 0x00400000 | V | 2008 |
| 23 | 0x00800000 | mbar | 2012 |
| 24 | 0x01000000 | Pa | 2016 |
| 25 | 0x02000000 | Ohm | 2020 |
| 26 | 0x04000000 | %/°C | 2024 |
| 27 | 0x08000000 | ° | 2028 |
| 28 | 0x10000000 | not used | 2032 |
| 29 | 0x20000000 | not used | 2036 |
| 30 | 0x40000000 | not used | 2040 |
| 31 (MSB) | 0x80000000 | SPECIAL | 2044 |

Figure 2.5.1.4: Definition of physical units used for PMC and SMC.

2.5.2 Primary Measurement Channel 1 (Oxygen)

2.5.2.1 Description of PMC1

In register 2080, a plain text ASCII description of PMC1 is given.

| Start register | Number of registers | Reg1 ... Reg8 16 ASCII characters | Modbus function code | Read access | Write access |
|----------------|---------------------|--------------------------------------|----------------------|-------------|--------------|
| 2080 | 8 | Description of PMC1 | 3, 4 | U/A/S | none |

Figure 2.5.2.1.1: Definition of register 2080.

| | | | | | | |
|---------------------|-----------|-----------------------------|--|------------------|----------------|------|
| Command: PMC 1 text | | Modbus address: 2080 | | Length: 8 | Type: 3 | Read |
| Parameter: | Text | | | | | |
| Format: | Character | | | | | |
| Value: | DO | | | | | |

Figure 2.5.2.1.2: Example to read the description. It is "DO" (Dissolved Oxygen).

2.5.2.2 Selecting the Physical Unit for PMC1

In register 2088, the available physical units for this channel are defined.

| Start register | Number of registers | Reg1 / Reg2 (bitwise defined) | Modbus function code | Read access | Write access |
|----------------|---------------------|----------------------------------|----------------------|-------------|--------------|
| 2088 | 2 | Available physical units of PMC1 | 3, 4 | U/A/S | none |

Figure 2.5.2.2.1: Definition of register 2088.

| | | | | | | |
|-------------------------------|-----------------|-----------------------------|--|------------------|----------------|------|
| Command: PMC1 available units | | Modbus address: 2088 | | Length: 2 | Type: 3 | Read |
| Parameter: | Units | | | | | |
| Format: | Hex | | | | | |
| Value: | 0x8000F0 | | | | | |

Figure 2.5.2.2.2: Example to read the available physical units of PMC1: %-vol (0x10), %-sat (0x20), ug/l ppb (0x40), mg/l ppm (0x80), mbar (0x800000). Total 0x8000F0. For the definition of the physical units see chapter 2.5.1.

In register 2090, the active physical unit for this channel can be selected, by choosing one of the physical units that are defined in register 2088.

| Start register | Number of registers | Reg1 / Reg2 (bitwise defined) | Modbus function code | Read access | Write access |
|----------------|---------------------|---------------------------------------|----------------------|-------------|--------------|
| 2090 | 2 | Selected active physical unit of PMC1 | 16 | none | S |

Figure 2.5.2.2.3: Definition of register 2090. Only one bit can be set.

| | | | | | | |
|------------------------|-------------|-----------------------------|--|------------------|-----------------|-------|
| Command: PMC1 set unit | | Modbus address: 2090 | | Length: 2 | Type: 16 | Write |
| Parameter: | Unit | | | | | |
| Format: | Hex | | | | | |
| Value: | 0x20 | | | | | |

Figure 2.5.2.2.4: Example to set the physical unit of PMC1 to %-sat (0x20).



Attention:

Changing the physical unit has also an influence on the output of the 4-20 mA analog output, as the same physical unit is active for 4-20 mA. All limits of the 4-20 mA analog output have to be redefined after changing the physical unit! See chapter 2.4.3 for more details.

Example 1: Reading the available physical units of PMC1 (Oxygen)

Read the available physical units of PMC1 at register 2088 with length 2 and function-code 3.

Request:

The command in HEX-format sent to the sensor:

0x 01 03 08 27 00 02 76 60

0x 01 Slave address (decimal "01")
0x 03 Function code "Read Holding Registers"
0x 08 27 Starting address (decimal "2087")
0x 00 02 Number of registers (decimal "02")
0x 76 60 CRC

Response:

The answer received in HEX-format from the sensor:

0x 01 03 04 00 F0 00 80 FB A0

0x 01 Slave address (decimal "01")
0x 03 Function code "Read Holding Registers"
0x 04 Data-Byte count (decimal "04")
0x 00 F0 Register 1 (decimal "240") Available physical unit – low register
0x 00 80 Register 2 (decimal "128") Available physical unit – high register
0x FB A0 CRC

Registers 2 and 1 together result in 0x 008000F0 which represents the available physical units %-vol (0x00000010), %-sat (0x00000020), ug/l ppb (0x00000040), mg/l ppm (0x00000080) and mbar (0x00800000), see chapter 2.5.1

Example 2: Writing the physical unit of PMC1 (Oxygen)

Writing to register 2090 with length 2 and function-code 16:

Request:

The command in HEX-format sent to the sensor:

0x 01 10 08 29 00 02 04 00 20 00 00 57 D7

0x 01 Slave address (decimal "01")
0x 10 Function code "Write Multiple Registers"
0x 08 29 Starting address (decimal "2089")
0x 00 02 Quantity of registers (decimal "2")
0x 04 Byte count (decimal "4")
0x 00 20 Register 1 (hex) Physical unit – low register
0x 00 00 Register 2 (hex) Physical unit – high register
0x 57 D7 CRC

Response:

The answer received in HEX-format from the sensor:

0x 01 10 08 29 00 02 92 60

0x 01 Slave address (decimal "01")
0x 10 Function code "Write Multiple Registers"
0x 08 29 Starting address (decimal "2089")
0x 00 02 Quantity of registers (decimal "2")
0x 92 60 CRC

2.5.2.3 Reading the measurement value of PMC1

Register 2090 is also used to read the measurement values of PMC1.

| Start reg. | Number of reg. | Reg1 / Reg2 | Reg3 / Reg4 | Reg5 / Reg6 | Reg7 / Reg8 | Reg9 / Reg10 | Modbus function code | Read access | Write access |
|------------|----------------|------------------------|--|-----------------------------------|----------------------------------|----------------------------------|----------------------|-------------|--------------|
| 2090 | 10 | Selected physical unit | Measurement value of PMC1 ⁽¹⁾ | Measurement status ⁽²⁾ | Min allowed value ⁽¹⁾ | Max allowed value ⁽¹⁾ | 3, 4 | U/A/S | none |

Figure 2.5.2.3.1: Definition of register 2090. Measurement value of PMC1.

⁽¹⁾ Value is always in the physical unit defined in register 2090.

⁽²⁾ Definition of the status see chapter 2.5.4. All bits set to zero means: no problem.

| | | | | | | |
|--------------------|-------------|-----------------------------|-------------|-------------------|----------------|------|
| Command: PMC1 read | | Modbus address: 2090 | | Length: 10 | Type: 3 | Read |
| Parameter: | Unit | Value | Status | Min limit | Max limit | |
| Format: | Hex | Float | Hex | Float | Float | |
| Value: | 0x10 | 21.10335 | 0x00 | 0 | 200 | |

Figure 2.5.2.3.2: Example to read register 2090. Physical unit is set to 0x10 (%-vol), PMC1 is 21.10 (%-vol), Status is 0x00, Min allowed value is 0 (%-vol), Max allowed value is 200 (%-vol).

| | | | | | | |
|--------------------|-------------|-----------------------------|-------------|-------------------|-----------------|------|
| Command: PMC1 read | | Modbus address: 2090 | | Length: 10 | Type: 3 | Read |
| Parameter: | Unit | Value | Status | Min limit | Max limit | |
| Format: | Hex | Float | Hex | Float | Float | |
| Value: | 0x20 | 100.5764 | 0x00 | 0 | 954.6541 | |

Figure 2.5.2.3.3: Example to read register 2090. Physical unit is set to 0x20 (%-sat), PMC1 is 100.57 (%-sat), Status is 0x00, Min allowed value is 0 (%-sat), Max allowed value is 954.65 (%-sat).

For the definition of the Measurement Status see chapter 2.5.4.



Attention:

You cannot read selectively the registers 3 and 4 for the measurement value only. You have to read the entire length of the command (10 registers) and extract the desired information.

Example: Reading PMC1 (Oxygen)

Reading register 2090 with length 10 and function-code 3 the five different values at once:

- Physical unit (registers 1 and 2) interpret as hex value
- Measurement value PMC1 (registers 3 and 4) transform to a floating point value
- Status (registers 5 and 6) interpret as hex value
- Min allowed value (registers 7 and 8) transform to a floating point value
- Max allowed value (registers 9 and 10) transform to a floating point value

Request:

The command in HEX-format send to the sensor:

0x 01 03 08 29 00 0A 16 65

0x 01 Slave address (decimal "01")
 0x 03 Function code "Read Holding Registers"
 0x 08 29 Starting address (decimal "2089")
 0x 00 0A Number of registers (decimal "10")
 0x 16 65 CRC

Response:

The answer received in HEX-format from the sensor:

0x 01 03 14 00 10 00 00 7B C4 41 A8 00 00 00 00 00 00 00 00 CF 8D 42 7B C0 30

0x 01 Slave address (decimal "01")
 0x 03 Function code "Read Holding Registers"
 0x 14 Data-Byte count (decimal "20")
 0x 00 10 Register 1 (hex) Physical unit – low register
 0x 00 00 Register 2 (hex) Physical unit – high register
 0x 7B C4 Register 3 (floating point) Measurement value PMC1 – low register
 0x 41 A8 Register 4 (floating point) Measurement value PMC1 – high register
 0x 00 00 Register 5 (hex) Status – low register
 0x 00 00 Register 6 (hex) Status – high register
 0x 00 00 Register 7 (floating point) Min allowed value – low register
 0x 00 00 Register 8 (floating point) Min allowed value – high register
 0x CF 8D Register 9 (floating point) Max allowed value – low register
 0x 42 7B Register 10 (floating point) Max allowed value – high register
 0x C0 30 CRC

Now extract the desired information:

- The physical unit 0x00000010 of registers 2 and 1 represents %-vol, see chapter 2.5.1.
- The measurement value 0x41A87BC4 of registers 4 and 3 transformed to a floating point figure results in the decimal value 21.06043.
- The status 0x00000000 of registers 6 and 5 indicate that there is no error or warning.
- The min allowed value 0x00000000 in registers 8 and 7 transformed to a floating point figure results in the decimal value 0.
- The max allowed value 0x427BCF8D in registers 10 and 9 transformed to a floating point figure results in the decimal value 62.95269.

2.5.3 Primary Measurement Channel 6 (Temperature)

2.5.3.1 Description of PMC6

In register 2400, a plain text ASCII description of PMC6 is given

| Start register | Number of registers | Reg1 ... Reg8 16 ASCII characters | Modbus function code | Read access | Write access |
|----------------|---------------------|--------------------------------------|----------------------|-------------|--------------|
| 2400 | 8 | Description of PMC6 | 3, 4 | U/A/S | none |

Figure 2.5.3.1.1: Definition of register 2400.

| | | | | | | |
|--------------------|-----------|-----------------------------|--|------------------|----------------|------|
| Command: PMC6 text | | Modbus address: 2400 | | Length: 8 | Type: 3 | Read |
| Parameter: | Text | | | | | |
| Format: | Character | | | | | |
| Value: | T | | | | | |

Figure 2.5.3.1.2: Example to read the description. It is "T" (Temperature).

2.5.3.2 Selecting the Physical Unit for PMC6

In register 2408, the available physical units of PMC6 are defined.

| Start register | Number of registers | Reg1 / Reg2 (bitwise defined) | Modbus function code | Read access | Write access |
|----------------|---------------------|----------------------------------|----------------------|-------------|--------------|
| 2408 | 2 | Available physical units of PMC6 | 3, 4 | U/A/S | none |

Figure 2.5.3.2.1: Definition of register 2408.

| | | | | | | |
|-------------------------------|-------------|-----------------------------|--|------------------|----------------|------|
| Command: PMC6 available units | | Modbus address: 2408 | | Length: 2 | Type: 3 | Read |
| Parameter: | Units | | | | | |
| Format: | Hex | | | | | |
| Value: | 0x04 | | | | | |

Figure 2.5.3.2.2: Example to read the available physical units of PMC6. The only one is °C (0x04). For the definition of the physical units see chapter 2.5.1.

In register 2410, the active physical unit of PMC6 can be selected, by choosing one of the physical units that are defined in register 2408.

| Start register | Number of registers | Reg1 / Reg2 (bitwise defined) | Modbus function code | Read access | Write access |
|----------------|---------------------|---------------------------------------|----------------------|-------------|--------------|
| 2410 | 2 | Selected active physical unit of PMC6 | 16 | none | U/A/S |

Figure 2.5.3.2.3: Definition of register 2410. Only one bit can be set.

| | | | | | | |
|------------------------|-------------|-----------------------------|--|------------------|-----------------|-------|
| Command: PMC6 set unit | | Modbus address: 2410 | | Length: 2 | Type: 16 | Write |
| Parameter: | Unit | | | | | |
| Format: | Hex | | | | | |
| Value: | 0x04 | | | | | |

Figure 2.5.3.2.4: Example to set the physical unit of PMC6 to °C (0x04).

2.5.3.3 Reading the measurement value of PMC6

Register 2410 is also used to read the measurement values of PMC6.

| Start reg. | Number of reg. | Reg1 / Reg2 | Reg3 / Reg4 | Reg5 / Reg6 | Reg7 / Reg8 | Reg9 / Reg10 | Modbus function code | Read access | Write access |
|------------|----------------|------------------------|--|-----------------------------------|----------------------------------|----------------------------------|----------------------|-------------|--------------|
| 2410 | 10 | Selected physical unit | Measurement value of PMC6 ⁽¹⁾ | Measurement status ⁽²⁾ | Min allowed value ⁽¹⁾ | Max allowed value ⁽¹⁾ | 3, 4 | U/A/S | none |

Figure 2.5.3.3.1: Definition of register 2410. Measurement value of PMC6.

⁽¹⁾ Value is always in the physical unit defined in register 2410, length 2.

⁽²⁾ For definition of the status see chapter 2.5.4. All bits set to zero means: no problem.

| | | | | | | | |
|--------------------|-------------|-----------------|-----------------------------|------------|-------------------|----------------|------|
| Command: PMC6 read | | | Modbus address: 2410 | | Length: 10 | Type: 3 | Read |
| Parameter: | Unit | Value | Status | Min limit | Max limit | | |
| Format: | Hex | Float | Hex | Float | Float | | |
| Value: | 0x04 | 27.42447 | 0x00 | -40 | 130 | | |

Figure 2.5.3.3.2: Example to read register 2410. Physical unit is set to °C, PMC6 is 27.42 (°C), Status is 0x00, Min allowed value is -40 (°C), Max allowed value is 130 (°C).

For definition of the measurement status see chapter 2.5.4.



Attention:

You cannot read selectively the registers 3 and 4 for the measurement value only. You have to read the entire length of the command (10 registers) and extract the desired information.

Example: Reading PMC6 (Temperature)

Reading register 2410 with length 10 and function-code 3:

- | | | |
|--------------------------|----------------------|-------------------------------------|
| • Physical unit | (registers 1 and 2) | interpret as hex value |
| • Measurement value PMC6 | (registers 3 and 4) | transform to a floating point value |
| • Status | (registers 5 and 6) | interpret as hex value |
| • Min allowed value | (registers 7 and 8) | transform to a floating point value |
| • Max allowed value | (registers 9 and 10) | transform to a floating point value |

Request:

The command in HEX-format send to the sensor:

0x 01 03 09 69 00 0A 16 4D

0x 01 Slave address (decimal "01")
 0x 03 Function code "Read Holding Registers"
 0x 09 69 Starting address (decimal "2409")
 0x 00 0A Number of registers (decimal "10")
 0x 16 4D CRC

Response:

The answer received in HEX-format from the sensor:

0x 01 03 14 00 04 00 00 2A E0 41 D1 00 00 00 00 00 C2 20 00 00 43 02 70 E5

0x 01 Slave address (decimal "01")
 0x 03 Function code "Read Holding Registers"
 0x 14 Data-Byte count (decimal "20")
 0x 00 04 Register 1 (hex) Physical unit – low register
 0x 00 00 Register 2 (hex) Physical unit – high register
 0x 2A E0 Register 3 (floating point) Measurement value PMC6 – low register
 0x 41 D1 Register 4 (floating point) Measurement value PMC6 – high register
 0x 00 00 Register 5 (hex) Status – low register
 0x 00 00 Register 6 (hex) Status – high register
 0x 00 00 Register 7 (floating point) Min allowed value – low register
 0x C2 20 Register 8 (floating point) Min allowed value – high register
 0x 00 00 Register 9 (floating point) Max allowed value – low register
 0x 43 02 Register 10 (floating point) Max allowed value – high register
 0x 70 E5 CRC

Now extract the desired information:

- The physical unit 0x00000004 of registers 2 and 1 represents °C, see chapter 2.5.1.
- The measurement value 0x41D12AE0 in registers 4 and 3 transformed to a floating point figure represents the decimal value 26.14594.
- The status 0x00000000 of registers 6 and 5 indicates that there is no error or warning
- The min allowed value 0xC2200000 in registers 8 and 7 transformed to a floating point figure represents the decimal value -40.
- The max allowed value 0x43020000 in registers 10 and 9 transformed into a floating point figure represents the decimal value 130.

2.5.3.4 Input of an Externally Measured Temperature

One has the possibility to feed the measurement value of an external temperature sensor to VISIFERM DO sensor.

External temperature data can be written into register 2410. The value has to be within the range of "measurement temperature min" and "measurement temperature max", see chapter 2.8.1 (register 4612). External temperature data will then be used for the internal calculations instead of the internally measured temperature. If the external reading exceeds the min-max measurement temperature range, the sensor will automatically fall back to the internal measurement. The same switch to internal temperature measurement will happen after sensor power on!

As soon as Reg. 2410 is written, the external temperature data is used for all calculation, interface and calibration procedures, except for warnings and errors.

| Start register | Number of Register | Reg1 / Reg2 | Reg3 / Reg4 | Modbus function code | Read access | Write access |
|----------------|--------------------|---------------------------------|----------------------|----------------------|-------------|--------------|
| 2410 | 4 | Physical unit (bitwise defined) | External temperature | 16 | none | S |

Figure 2.5.3.4.1: Definition of register 2410. Writing the physical unit and the external temperature.

| | | | | | | |
|-------------------|-------------|-----------------------------|--|------------------|-----------------|-------|
| Command: PMC6 set | | Modbus address: 2410 | | Length: 4 | Type: 16 | Write |
| Parameter: | Unit | Value | | | | |
| Format: | Hex | Float | | | | |
| Value: | 0x04 | 25 | | | | |

Figure 2.5.3.4.2: Example to set the physical unit to °C (0x04) and the value of the external temperature.



Attention:

Once the operator has written external temperature data to register 2410, he needs to guarantee regular data update.

2.5.4 Definition of the Measurement Status for PMC1 / PMC6

This is the definition of the status registers read in registers 2090 (PMC1) and 2410 (PMC6):

| Bit # | Hex value | Description |
|---------|-----------|--|
| 0 (LSB) | 0x01 | Temperature out of measurement range (see chapter 2.8.1) |
| 1 | 0x02 | Temperature out of operating range (see chapter 2.8.1) |
| 2 | 0x04 | Calibration status not zero (see chapter 2.7.4) |
| 3 | 0x08 | Warning not zero (see chapter 2.8.3) |
| 4 | 0x10 | Error not zero (see chapter 2.8.4) |

Figure 2.5.4.1: Definition of measurement status for Primary Measurement Channels.

2.6 Configuration of the Measurement

This chapter describes the configuration of PMC1 and PMC6 by means of measurement parameters (PA).

2.6.1 Available Parameters

In register 3072, all available parameters (PA) are given.

| Start register | Number of registers | Reg1 / Reg2 (bitwise defined) | Modbus function code | Read access | Write access |
|----------------|---------------------|---|----------------------|-------------|--------------|
| 3072 | 2 | Available parameters (see figure 2.6.1.2) | 3, 4 | U/A/S | none |

Figure 2.6.1.1: Definition of register 3072.

| Bit # | Hex value | Description | Definition in VISIFERM DO |
|----------------|---------------|-------------|-----------------------------------|
| 0 (LSB) | 0x0001 | PA1 | Salinity |
| 1 | 0x0002 | PA2 | Atmospheric pressure |
| 2 | 0x0004 | PA3 | not available |
| | | | not available |
| 7 | 0x0080 | PA8 | not available |
| 8 | 0x0100 | PA9 | Moving average |
| 9 | 0x0200 | PA10 | Number of sub-measurements |
| 10 | 0x0400 | PA11 | not available |
| | | | not available |
| 15 (MSB) | 0x8000 | PA16 | not available |

Figure 2.6.1.2: Bitwise definition of all parameters PA1 to PA16, valid for VISIFERM.

| | | | | | |
|-------------------------------|------------------------|-----------------------------|------------------|----------------|------|
| Command: Available parameters | | Modbus address: 3072 | Length: 2 | Type: 3 | Read |
| Parameter: | Measurement parameters | | | | |
| Format: | Hex | | | | |
| Value: | 0x0303 | | | | |

Figure 2.6.1.3: Example to read the available Parameters with operator level S. The hex value 0x0303 corresponds to 0x0001 (PA1) + 0x0002 (PA2) + 0x0100 (PA9) + 0x0200 (PA10).

General note:

- PA1 to PA8 use FLOAT as data format for its values
- PA9 to PA16 use UNSIGNED INT as data format for its values

2.6.2 PA1: Salinity

The physical measurement of VISIFERM 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, VISIFERM 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.

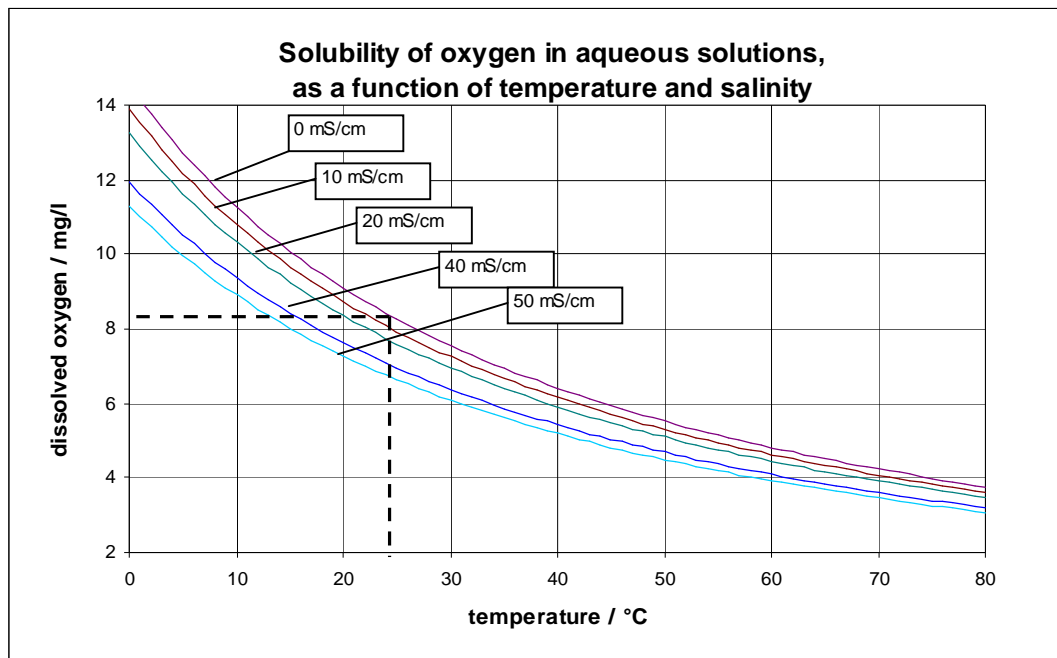


Figure 2.6.2.1: Solubility of oxygen as a function of temperature and salinity, in air saturated aqueous solution. Temperature range is from 0-85 °C. Salinity can be entered from 0-50 mS/cm.

2.6.2.1 Description of PA1 (Salinity)

In register 3104, a plain text ASCII description of PA1 is given.

| Start register | Number of registers | Reg1 ... Reg8 16 ASCII characters | Modbus function code | Read access | Write access |
|----------------|---------------------|--------------------------------------|-------------------------|----------------|-----------------|
| 3104 | 8 | Description of PA1 | 3, 4 | U/A/S | none |

Figure 2.6.2.1.1: Definition of register 3104.

| | | | | | | |
|------------------------|-----------------|-----------------------------|--|------------------|----------------|------|
| Command: Salinity text | | Modbus address: 3104 | | Length: 8 | Type: 3 | Read |
| Parameter: | Text | | | | | |
| Format: | Character | | | | | |
| Value: | Salinity | | | | | |

Figure 2.6.2.1.2: Example to read the description as an ASCII string. It is "Salinity".

2.6.2.2 Selecting the Physical Unit and Writing the Value for PA1

In register 3112, the available physical units for PA1 are defined.

| Start register | Number of registers | Reg1 / Reg2 (bitwise defined) | Modbus function code | Read access | Write access |
|----------------|---------------------|----------------------------------|----------------------|-------------|--------------|
| 3112 | 2 | Available physical units for PA1 | 3, 4 | U/A/S | none |

Figure 2.6.2.2.1: Definition of register 3112.

| | | | | | | |
|-----------------------------------|--------------|-----------------------------|--|------------------|----------------|------|
| Command: Salinity available units | | Modbus address: 3112 | | Length: 2 | Type: 3 | Read |
| Parameter: | Units | | | | | |
| Format: | Hex | | | | | |
| Value: | 0x400 | | | | | |

Figure 2.6.2.2.2: Example to read the available physical units for PA1. The only one available here is mS/cm (0x400). For the definition of the physical units see chapter 2.5.1.

By writing to register 3114, the active physical unit for PA1 can be selected, by choosing one of the physical units that are defined in register 3112. The value of the parameter can be set as well.

| Start register | Number of registers | Reg1 / Reg2 (bitwise defined) | Reg3 / Reg4 | Modbus function code | Read access | Write access |
|----------------|---------------------|-------------------------------|---------------------------|----------------------|-------------|--------------|
| 3114 | 4 | Select physical unit for PA1 | Value for PA1 (0-50mS/cm) | 16 | none | S |

Figure 2.6.2.2.3: Definition of register 3114. Only one bit for the physical unit can be set.

| | | | | | | |
|-------------------|--------------|-----------------------------|--|------------------|-----------------|-------|
| Command: Salinity | | Modbus address: 3114 | | Length: 4 | Type: 16 | Write |
| Parameter: | Unit | Value | | | | |
| Format: | Hex | Float | | | | |
| Value: | 0x400 | 10 | | | | |

Figure 2.6.2.2.4: Example to set the physical unit of PA1 to mS/cm (0x400) and the value to 10 (mS/cm).

2.6.2.3 Reading all Values for PA1

By reading register 3114, the active physical unit, the selected value, and the min and max allowed values can be read.

| Start register | Number of registers | Reg1 / Reg2 | Reg3 / Reg4 | Reg5 / Reg6 | Reg7 / Reg8 | Modbus function code | Read access | Write access |
|----------------|---------------------|---------------|---------------|-------------|-------------|----------------------|-------------|--------------|
| 3114 | 8 | Physical unit | Current value | Min value | Max value | 3, 4 | U/A/S | none |

Figure 2.6.2.3.1: Definition of register 3114.

| | | | | | | |
|-------------------|--------------|-----------------------------|-----------|------------------|----------------|------|
| Command: Salinity | | Modbus address: 3114 | | Length: 8 | Type: 3 | Read |
| Parameter: | Unit | Value | Min value | Max value | | |
| Format: | Hex | Float | Float | Float | | |
| Value: | 0x400 | 10 | 0 | 50 | | |

Figure 2.6.2.3.2: Example to read PA1. The unit is mS/cm (0x400), the value is currently set to 10 (mS/cm); the min is 0 (mS/cm) and the max is 50 (mS/cm).

2.6.3 PA2: Air Pressure

The VISIFERM 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 parameter PA2.

PA2 defines the current air pressure and this value is used for internal calculation.

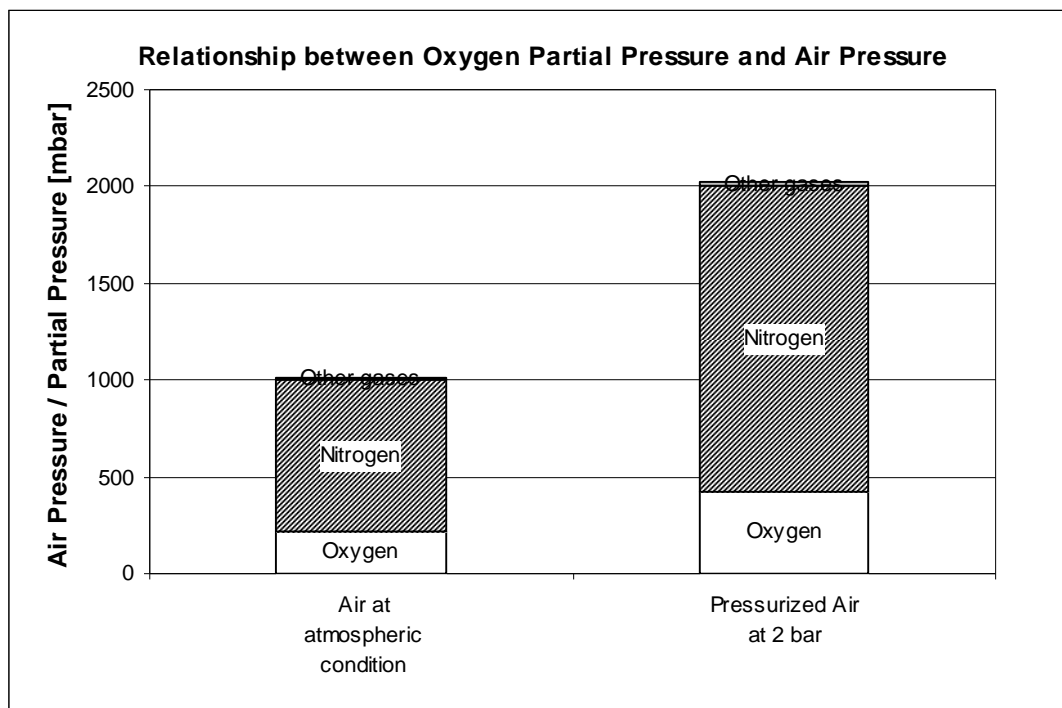


Figure 2.6.3.1: Influence of air pressure on the partial pressure of oxygen. Doubling the air pressure also doubles the oxygen partial pressure.

2.6.3.1 Description of PA2 (Air Pressure)

In register 3136, a plain text ASCII description of PA2 is given.

| Start register | Number of registers | Reg1 ... Reg8 16 ASCII characters | Modbus function code | Read access | Write access |
|----------------|---------------------|--------------------------------------|----------------------|-------------|--------------|
| 3136 | 8 | Description of PA2 | 3, 4 | U/A/S | none |

Figure 2.6.3.1.1: Definition of register 3136.

| | | | | | | |
|------------------------|---------------------|-----------------------------|--|------------------|----------------|------|
| Command: Pressure text | | Modbus address: 3136 | | Length: 8 | Type: 3 | Read |
| Parameter: | Text | | | | | |
| Format: | Character | | | | | |
| Value: | Air Pressure | | | | | |

Figure 2.6.3.1.2: Example to read the description. It is "Air Pressure".

2.6.3.2 Selecting the Physical Unit and Writing the Value for PA2

In register 3144, the available physical units for PA2 are defined.

| Start register | Number of registers | Reg1 / Reg2 (bitwise defined) | Modbus function code | Read access | Write access |
|----------------|---------------------|----------------------------------|----------------------|-------------|--------------|
| 3144 | 2 | Available physical units for PA2 | 3, 4 | U/A/S | none |

Figure 2.6.3.2.1: Definition of register 3144.

| | | | | | | |
|-----------------------------------|-----------------|-----------------------------|--|------------------|----------------|------|
| Command: Pressure available units | | Modbus address: 3144 | | Length: 2 | Type: 3 | Read |
| Parameter: | Units | | | | | |
| Format: | Hex | | | | | |
| Value: | 0x800000 | | | | | |

Figure 2.6.3.2.2: Example to read the available physical units for PA2. The only one available here is mbar (0x800000). For the definition of the physical units see chapter 2.5.1.

By writing to register 3146, the active physical unit for parameter 2 can be selected, by choosing one of the physical units that are defined in register 3144. The value of the parameter can be set as well.

| Start register | Number of registers | Reg1 / Reg2 (bitwise defined) | Reg3 / Reg4 | Modbus function code | Read access | Write access |
|----------------|---------------------|-------------------------------|-------------------------------|----------------------|-------------|--------------|
| 3146 | 4 | Select physical unit for PA2 | Value for PA2 (10-12000 mbar) | 16 | none | S |

Figure 2.6.3.2.3: Definition of register 3146. Only one bit for the physical unit can be set.

| | | | | | | |
|-------------------|-----------------|-----------------------------|--|------------------|-----------------|-------|
| Command: Pressure | | Modbus address: 3146 | | Length: 4 | Type: 16 | Write |
| Parameter: | Unit | Value | | | | |
| Format: | Hex | Float | | | | |
| Value: | 0x800000 | 1013 | | | | |

Figure 2.6.3.2.4: Example to set the physical unit of PA2 to mbar (0x800000) and the value to 1013 (mbar).

2.6.3.3 Reading All Values for PA2

By reading register 3146, the active physical unit, the selected value, and the min and max allowed values can be read.

| Start register | Number of registers | Reg1 / Reg2 | Reg3 / Reg4 | Reg5 / Reg6 | Reg7 / Reg8 | Modbus function code | Read access | Write access |
|----------------|---------------------|---------------|---------------|-------------|-------------|----------------------|-------------|--------------|
| 3146 | 8 | Physical unit | Current value | Min value | Max value | 3, 4 | U/A/S | none |

Figure 2.6.3.3.1: Definition of register 3146.

| | | | | | | |
|-------------------|-----------------|-----------------------------|-----------|------------------|----------------|------|
| Command: Pressure | | Modbus address: 3146 | | Length: 8 | Type: 3 | Read |
| Parameter: | Unit | Value | Min value | Max value | | |
| Format: | Hex | Float | Float | Float | | |
| Value: | 0x800000 | 1013 | 10 | 12000 | | |

Figure 2.6.3.3.2: Example to read PA2. The unit is mbar (0x800000), the value is 1013 (mbar), the min is 10 (mbar) and the max is 12000 (mbar).

2.6.4 PA9: Moving Average

VISIFERM DO calculates new oxygen readings every 3 seconds. One has the possibility to smoothen the oxygen reading (PMC1) by means of a moving average, applied to the 3-seconds-readings.

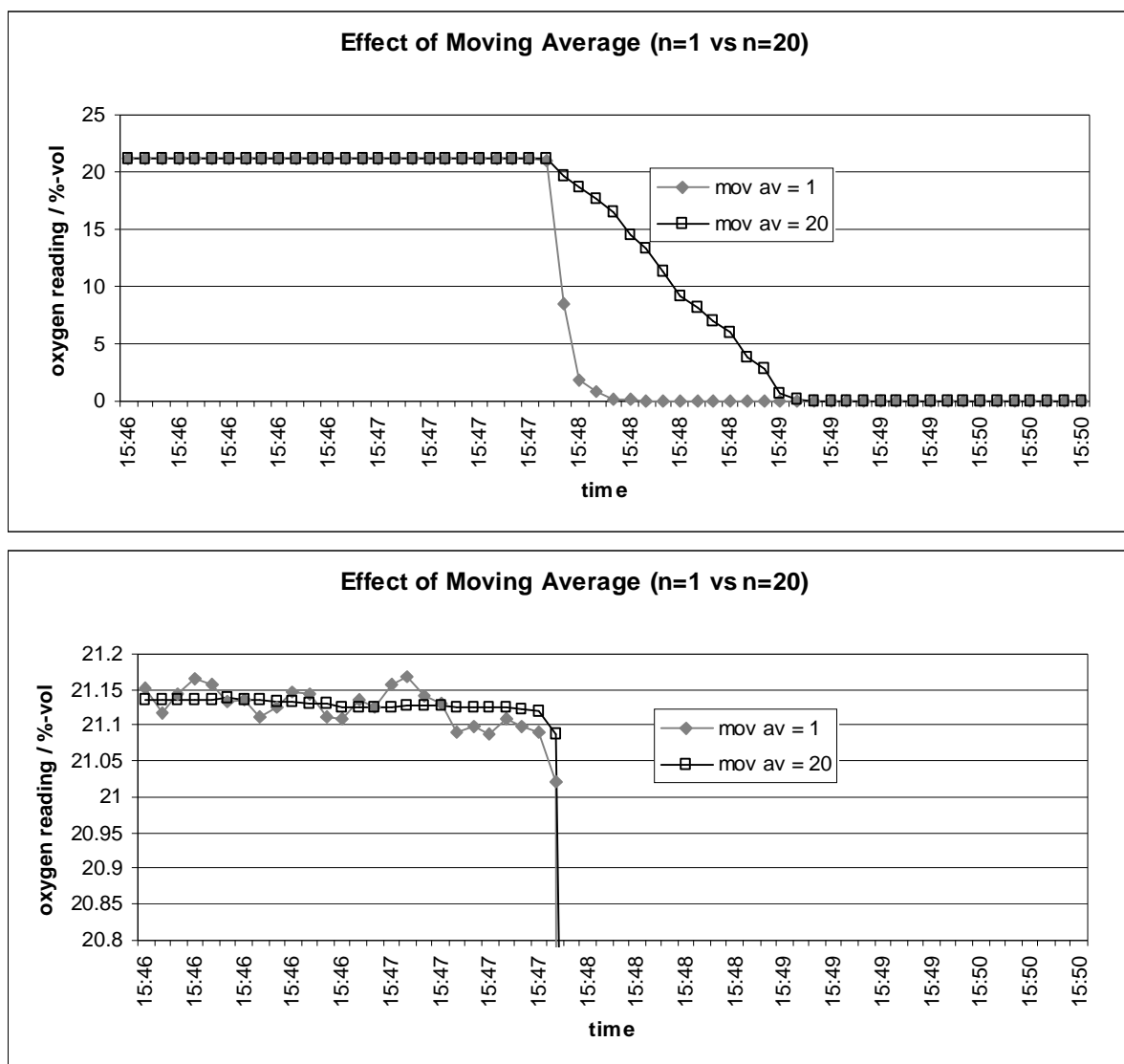


Figure 2.6.4.1: Comparison of the response of VISIFERM DO to a change from air to zero oxygen, using no moving average (n=1) or a moving average over 20 3 seconds-readings.

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 60 s.

Note:

The moving average defined by PA9 is applied to both PMC1 and PMC6

2.6.4.1 Description of PA9 (Moving Average)

In register 3360, a plain text ASCII description of PA9 is given.

| Start register | Number of registers | Reg1 ... Reg8 16 ASCII characters | Modbus function code | Read access | Write access |
|----------------|---------------------|--------------------------------------|----------------------|-------------|--------------|
| 3360 | 8 | Description of PA9 | 3, 4 | U/A/S | none |

Figure 2.6.4.1.1: Definition of register 3360.

| | | | | | | |
|------------------------------|-----------------------|-----------------------------|--|------------------|----------------|------|
| Command: Moving average text | | Modbus address: 3360 | | Length: 8 | Type: 3 | Read |
| Parameter: | Text | | | | | |
| Format: | Character | | | | | |
| Value: | Moving average | | | | | |

Figure 2.6.4.1.2: Example to read the description for "Moving average".

2.6.4.2 Selecting the Physical Unit and Writing the Value for PA9

In register 3368, the available physical units for PA9 are defined.

| Start register | Number of registers | Reg1 / Reg2 (bitwise defined) | Modbus function code | Read access | Write access |
|----------------|---------------------|----------------------------------|----------------------|-------------|--------------|
| 3368 | 2 | Available physical units for PA9 | 3, 4 | U/A/S | none |

Figure 2.6.4.2.1: Definition of register 3368.

| | | | | | | |
|-----------------------------------|-------------|-----------------------------|--|------------------|----------------|------|
| Command: Moving average av. units | | Modbus address: 3368 | | Length: 2 | Type: 3 | Read |
| Parameter: | Units | | | | | |
| Format: | Hex | | | | | |
| Value: | 0x01 | | | | | |

Figure 2.6.4.2.2: Example to read the available physical units for PA9. The only one available here is "none" (0x01). For the definition of the physical units see chapter 2.5.1.

| Start register | Number of registers | Reg1 / Reg2 (bitwise defined) | Reg3 / Reg4 | Modbus function code | Read access | Write access |
|----------------|---------------------|----------------------------------|----------------------------------|----------------------|-------------|--------------|
| 3370 | 4 | Select physical unit for PA9 | Value for PA9 (0-30, default: 0) | 16 | none | S |

Figure 2.6.4.2.3: Definition of register 3370. Only one bit for the physical unit can be set. PA9 can be set to the value: 0 = auto, 1-30 = fixed value. The value of 1 does not influence the response time of the sensor, the value of 30 increases the response time of the sensor to 90 s.

By writing to register 3370, the active physical unit for PA9 can be selected, by choosing one of the physical units that are defined in register 3368. The value of the parameter can be set as well.

By setting 0, the Automatic mode is activated. In this case the value is automatically and dynamically adjusted between 1 and 30.

| | | | | | | |
|-------------------------|-------------|-----------------------------|--|------------------|-----------------|-------|
| Command: Moving average | | Modbus address: 3370 | | Length: 4 | Type: 16 | Write |
| Parameter: | Unit | Value | | | | |
| Format: | Hex | Decimal | | | | |
| Value: | 0x01 | 0 | | | | |

Figure 2.6.4.2.4: Example to set the physical unit of PA9 to "none" (0x01) and the value of the moving average to auto (0).

2.6.4.3 Reading all Values for PA9

By reading register 3370, the active physical unit of measurement, the selected value, and the min and max values can be read.

When reading the register while PA9 is in automatic mode, an offset of 100 is added to the currently active value.

For example, the value 127 indicates:

- automatic mode is active
- currently, an average over 27 samples is applied

| Start register | Number of registers | Reg1 / Reg2 | Reg3 / Reg4 | Reg5 / Reg6 | Reg7 / Reg8 | Modbus function code | Read access | Write access |
|----------------|---------------------|---------------|---------------|-------------|-------------|----------------------|-------------|--------------|
| 3370 | 8 | Physical unit | Current value | Min value | Max value | 3, 4 | U/A/S | none |

Figure 2.6.4.3.1: Definition of register 3370.

| | | | | | | |
|-------------------------|-------------|-----------------------------|-----------|------------------|----------------|------|
| Command: Moving average | | Modbus address: 3370 | | Length: 8 | Type: 3 | Read |
| Parameter: | Unit | Value | Min value | Max value | | |
| Format: | Hex | Decimal | Decimal | Decimal | | |
| Value: | 0x01 | 130 | 1 | 30 | | |

Figure 2.6.4.3.2: Example to read PA9. The physical unit is 0x01 ("none"), the value is 130 – that means auto mode with 30 averages per reading, and the limits of 1 to 30.

2.6.5 PA10: Number of Sub-Measurements (Resolution)

The measurement of VISIFERM DO in each 3-seconds-interval is on itself an average over 16 (or less) individual sub-measurements. With PA10, the number of sub-measurements can be set between 3 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.

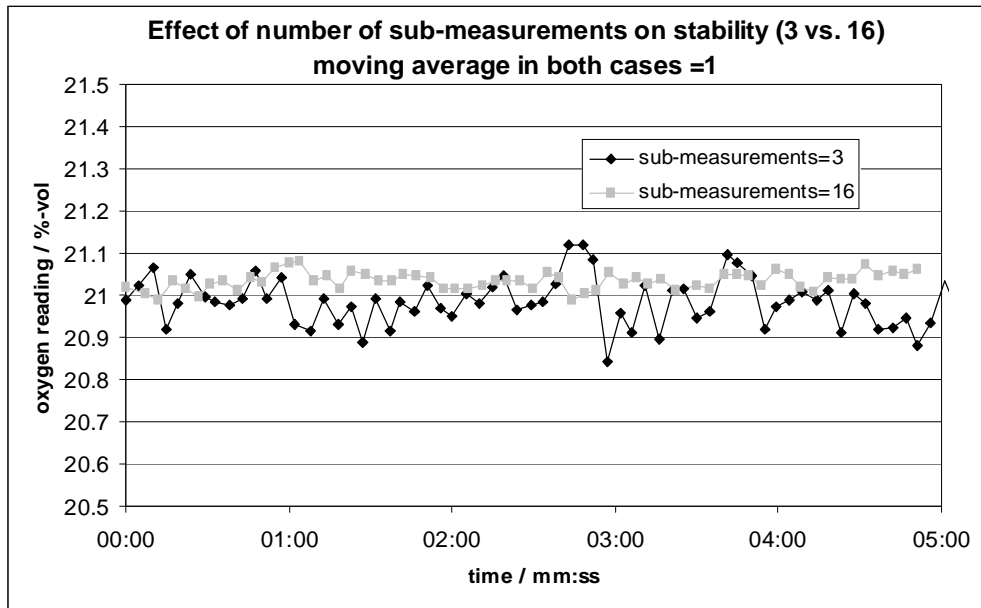


Figure 2.6.5.1: Comparison of the signal stability of VISIFERM DO when using Number of Sub-Measurements = 16 or Number of Sub-Measurements = 3.

2.6.5.1 Description of PA10 (Number of Sub-Measurement)

In register 3392, a plain text ASCII description of PA10 is given.

| Start register | Number of registers | Reg1 ... Reg8 16 ASCII characters | Modbus function code | Read access | Write access |
|----------------|---------------------|--------------------------------------|----------------------|-------------|--------------|
| 3392 | 8 | Description of PA10 | 3, 4 | U/A/S | none |

Figure 2.6.5.1.1: Definition of register 3392.

| | | | | | |
|--------------------------------|-------------------|-----------------------------|------------------|----------------|------|
| Command: Sub-Measurements text | | Modbus address: 3392 | Length: 8 | Type: 3 | Read |
| Parameter: | Text | | | | |
| Format: | Character | | | | |
| Value: | Resolution | | | | |

Figure 2.6.5.1.2: Example to read the description. It is "Resolution".

2.6.5.2 Selecting the Physical Unit and Writing the Value for PA10

In register 3400, the available physical units for PA10 are defined.

| Start register | Number of registers | Reg1 / Reg2 (bitwise defined) | Modbus function code | Read access | Write access |
|----------------|---------------------|-----------------------------------|----------------------|-------------|--------------|
| 3400 | 2 | Available physical units for PA10 | 3, 4 | U/A/S | none |

Figure 2.6.5.2.1: Definition of register 3400.

| | | | | | | |
|------------------------------------|-------------|-----------------------------|--|------------------|----------------|------|
| Command: Sub-Meas. available units | | Modbus address: 3400 | | Length: 2 | Type: 3 | Read |
| Parameter: | Units | | | | | |
| Format: | Hex | | | | | |
| Value: | 0x01 | | | | | |

Figure 2.6.5.2.2: Example to read the available physical units for PA10. The only one available here is "none" (0x01). For the definition of the physical units see chapter 2.5.1.

By writing to register 3402, the active physical unit of PA10 can be selected, by choosing one of the physical units that are defined in register 3400. Also the value of the parameter can be set.

By entering 0, the automatic mode will be activated, where the sensor automatically sets a value between the limits 3 and 16.

| Start register | Number of registers | Reg1 / Reg2 (bitwise defined) | Reg3 / Reg4 | Modbus function code | Read access | Write access |
|----------------|---------------------|-------------------------------|--------------------------------------|----------------------|-------------|--------------|
| 3402 | 4 | Select physical unit for PA10 | Value for PA10 (0, 3-16; default: 0) | 16 | none | S |

Figure 5.6.5.2.3: Definition of register 3402. Only one bit for the physical unit can be set and the value: 0 = auto, 3-16 = fixed value.

| | | | | | | |
|---------------------------|-------------|-----------------------------|--|------------------|-----------------|-------|
| Command: Sub-Measurements | | Modbus address: 3402 | | Length: 4 | Type: 16 | Write |
| Parameter: | Unit | Value | | | | |
| Format: | Hex | Decimal | | | | |
| Value: | 0x01 | 0 | | | | |

Figure 2.6.5.2.4: Example to set the physical unit of PA10 to "none" (0x01) and the value for the number of sub-measurements to auto (0).

2.6.5.3 Reading all Values for PA10

By reading register 3402, the active physical unit, the selected value, and the min and max values can be read.

When reading the register while PA10 is in automatic mode, an offset of 100 is added to the currently active value.

For example, the value 108 indicates:

- automatic mode is active
- currently, the number of sub-measurements is 8

| Start register | Number of registers | Reg1 / Reg2 | Reg3 / Reg4 | Reg5 / Reg6 | Reg7 / Reg8 | Modbus function code | Read access | Write access |
|----------------|---------------------|---------------|---------------|-------------|-------------|----------------------|-------------|--------------|
| 3402 | 8 | Physical unit | Current value | Min value | Max value | 3, 4 | U/A/S | none |

Figure 2.6.5.3.1: Definition of register 3402.

| | | | | | | |
|---------------------------|-------------|-----------------------------|-----------|------------------|----------------|------|
| Command: Sub-Measurements | | Modbus address: 3402 | | Length: 8 | Type: 3 | Read |
| Parameter: | Unit | Value | Min value | Max value | | |
| Format: | Hex | Decimal | Decimal | Decimal | | |
| Value: | 0x01 | 103 | 3 | 16 | | |

Figure 2.6.5.3.2: Example to read PA10. The physical unit is 0x01 ("none"), the value is 103 – that means auto mode with 3 numbers of sub-measurements, and the limits of 3 to 16.

2.7 Calibration

2.7.1 Available Calibration Points

In register 5120, the available number of Calibration Points (CP) for Primary Measurement Channel 1 (PMC1) is defined. 8 individual CP are theoretically possible.

| Start register | Number of registers | Reg1 / Reg2 (bitwise defined) | Modbus function code | Read access | Write access |
|----------------|---------------------|--|----------------------|-------------|--------------|
| 5120 | 2 | Available number of CP for PMC1 (see figure 2.7.1.2) | 3, 4 | U/A/S | none |

Figure 2.7.1.1: Definition of register 5120.

| Bit # | Hex value | Description | Definition in VISIFERM DO |
|----------------|-------------|-------------|-------------------------------|
| 0 (LSB) | 0x01 | CP1 | Calibration low point |
| 1 | 0x02 | CP2 | Calibration high point |
| 2 | 0x04 | CP3 | not available |
| ... | ... | ... | not available |
| 5 | 0x20 | CP6 | Product calibration |
| 6 | ... | CP7 | not available |
| 7 (MSB) | 0x80 | CP8 | not available |

Figure 2.7.1.2: Bitwise definition of CP1 to CP8.

| | | | | | |
|--------------------------------|-------------|-----------------------------|------------------|----------------|------|
| Command: Available cali points | | Modbus address: 5120 | Length: 2 | Type: 3 | Read |
| Parameter: | Points | | | | |
| Format: | Hex | | | | |
| Value: | 0x23 | | | | |

Figure 2.7.1.3: Example to read the available CPs. 0x23 = 0x01 (CP1) + 0x02 (CP2) + 0x20 (CP6).

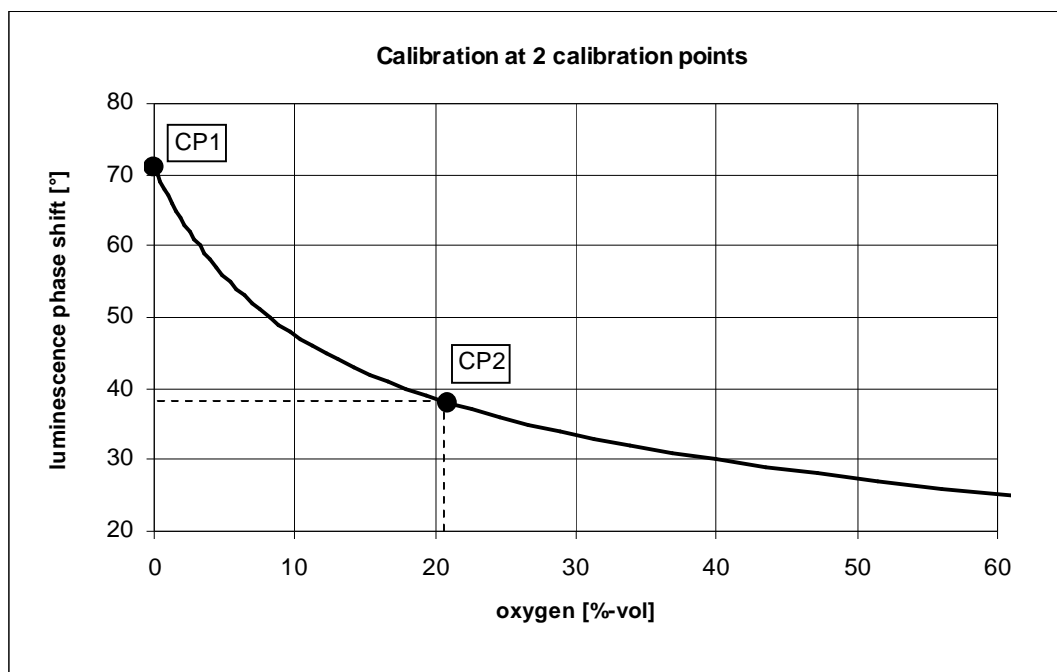


Figure 2.7.1.4: VISIFERM DO allows 3 calibration points:

CP1 and CP2 are used for standard calibration (shown in this figure).

The product calibration CP6 is used to adjust the standard calibration function to specific process conditions (the effect of CP6 is shown in Figure 2.7.3.2.1).

2.7.2 Definitions of Calibration Points

2.7.2.1 Calibration Points 1 and 2 (Standard Calibration)

The limits for the calibration point 1 are defined in register 5152, for calibration point 2 in register 5184.

| Start register | Number of registers | Reg1 / Reg2 | Reg3 / Reg4 | Reg5 / Reg6 | Modbus function code | Read access | Write access |
|----------------|---------------------|--|---|---|----------------------|-------------|--------------|
| 5152 | 6 | Physical unit currently active for CP1 | Min value for CP1 (in the physical unit as defined in Reg1 and 2) | Max value for CP1 (in the physical unit as defined in Reg1 and 2) | 3, 4 | U/A/S | none |
| 5184 | 6 | Physical unit currently active for CP2 | Min value for CP2 (in the physical unit as defined in Reg1 and 2) | Max value for CP2 (in the physical unit as defined in Reg1 and 2) | 3, 4 | U/A/S | none |

Figure 2.7.2.1.1: Definition of register 5152 for CP1 and 5184 for CP2.

| | | | | | | |
|---------------------------------|-------------|-----------------------------|-----------|------------------|----------------|------|
| Command: Calibration limits CP1 | | Modbus address: 5152 | | Length: 6 | Type: 3 | Read |
| Parameter: | Unit | Min value | Max value | | | |
| Format: | Hex | Float | Float | | | |
| Value: | 0x20 | 0 | 0 | | | |

Figure 2.7.2.1.2: Example to read the limits of CP1. Currently active physical unit is %-sat (0x20), the min and max value are both 0 (%-sat).

| | | | | | | |
|---------------------------------|-------------|-----------------------------|----------------|------------------|----------------|------|
| Command: Calibration limits CP2 | | Modbus address: 5184 | | Length: 6 | Type: 3 | Read |
| Parameter: | Unit | Min value | Max value | | | |
| Format: | Hex | Float | Float | | | |
| Value: | 0x20 | 9.729055 | 267.549 | | | |

Figure 2.7.2.1.3: Example to read the limits of CP2. Currently active physical unit is %-sat (0x20), the min value is 9.73 (%-sat) and the max value is 267.55 (%-sat). Explanation see figure 2.7.2.4.

| | | | | | | |
|---------------------------------|-----------------|-----------------------------|------------|------------------|----------------|------|
| Command: Calibration limits CP2 | | Modbus address: 5184 | | Length: 6 | Type: 3 | Read |
| Parameter: | Unit | Min value | Max value | | | |
| Format: | Hex | Float | Float | | | |
| Value: | 0x800000 | 20 | 550 | | | |

Figure 2.7.2.1.4: Example to read the limits of CP2. Currently active physical unit is mbar (0x800000), the min value is 20 (mbar) and the max value is 550 (mbar). When changing the active physical unit for PMC1 (using register 2090), the min and max value will be updated automatically to the new physical unit. Temperature, atmospheric pressure and salinity are compensated.

2.7.2.2 Calibration Point 6 (Product Calibration)

The limits for calibration point 6 are given in register 5312.

| Start register | Number of registers | Reg1 / Reg2 | Reg3 / Reg4 | Reg5 / Reg6 | Modbus function code | Read access | Write access |
|----------------|---------------------|--|---|---|----------------------|-------------|--------------|
| 5312 | 6 | Physical unit currently active for CP6 | Min value for CP6 (in the physical unit as defined in Reg1 and 2) | Max value for CP6 (in the physical unit as defined in Reg1 and 2) | 3, 4 | U/A/S | none |

Figure 2.7.2.2.1: Definition of register 5312 for CP6.

| | | | | | | |
|---------------------------------|-------------|-----------------------------|----------------|------------------|----------------|------|
| Command: Calibration limits CP6 | | Modbus address: 5312 | | Length: 6 | Type: 3 | Read |
| Parameter: | Unit | Min value | Max value | | | |
| Format: | Hex | Float | Float | | | |
| Value: | 0x20 | 9.729055 | 267.549 | | | |

Figure 2.7.2.2.2: Example to read the limits of CP6. Currently active physical unit is %-sat (0x20), the min value is 9.73 (%-sat) and the max value is 267.55 (%-sat) (between 20 and 550 mbar, respectively). When changing the active physical unit for PMC1 (using register 2090), the min and max value will be updated automatically to the new physical unit. Temperature, atmospheric pressure and salinity are compensated.

2.7.3 Calibration Procedure

2.7.3.1 Calibration at CP1 and CP2 (Standard Calibration)

VISIFERM DO has a unique calibration routine. When initiating the calibration, the data set of the VISIFERM DO is automatically traced back within the last 3 minutes 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:

- the stability of phase and temperature over the last 3 minutes
- the phase is in a reasonable phase window
- the oxygen content is in the limits defined for CP1 / CP2



Attention:

It is important that VISIFERM DO is in a defined calibration media at least 3 minutes BEFORE the calibration is started.

The calibration is initiated at CP1 by writing to register 5162 and at CP2 by writing to register 5194.

By entering 0 the automatic calibration for the respecting calibration point will be started, which calibrates at CP1 by 0 %-vol oxygen (low point) and at CP2 by 20.95 %-vol oxygen = in air (high point).

| Start register | Number of registers | Reg1 / Reg2 | Modbus function code | Read access | Write access |
|----------------|---------------------|---|----------------------|-------------|--------------|
| 5162 | 2 | Oxygen value at CP1 (physical unit as defined with register 2090) | 16 | none | A/S |
| 5194 | 2 | Oxygen value at CP2 (physical unit as defined with register 2090) | 16 | none | A/S |

Figure 2.7.3.1.1: Definition of register 5162 and 5194. The oxygen value (0 = auto) has to be given in the physical unit defined with register 2090.

| | | | | | |
|-------------------------------|----------|-----------------------------|------------------|-----------------|-------|
| Command: Make calibration CP1 | | Modbus address: 5162 | Length: 2 | Type: 16 | Write |
| Parameter: | Value | | | | |
| Format: | Float | | | | |
| Value: | 0 | | | | |

Figure 2.7.3.1.2: Example to start the calibration at CP1, giving a value of 0 for auto or oxygen (0 %-vol in this case).

| | | | | | |
|-------------------------------|----------|-----------------------------|------------------|-----------------|-------|
| Command: Make calibration CP2 | | Modbus address: 5194 | Length: 2 | Type: 16 | Write |
| Parameter: | Value | | | | |
| Format: | Float | | | | |
| Value: | 0 | | | | |

Figure 2.7.3.1.3: Example to start the calibration at CP2, giving a value of 0 for auto (20.95 %-vol in this case).

| | | | | | |
|-------------------------------|--------------|-----------------------------|------------------|-----------------|-------|
| Command: Make calibration CP2 | | Modbus address: 5194 | Length: 2 | Type: 16 | Write |
| Parameter: | Value | | | | |
| Format: | Float | | | | |
| Value: | 21.05 | | | | |

Figure 2.7.3.1.4: Example to start the calibration at CP2, giving a value of 21.05 (%-vol in this case). The value has to be inside the defined limits.



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.

Example 1:

Register 2090 is set to physical unit “mg/l ppm” (0x80).

| | | | | | |
|---------------------------------|-------------|-----------------------------|------------------|----------------|------|
| Command: Calibration limits CP2 | | Modbus address: 5184 | Length: 6 | Type: 3 | Read |
| Parameter: | Unit | Min value | Max value | | |
| Format: | Hex | Float | Float | | |
| Value: | 0x80 | 0.7544258 | 20.74671 | | |

Figure 2.7.3.1.5: Example: Accordingly, VISIFERM DO transforms the limits for CP2 (register 5184) from the defined range of 20-550 mbar to dissolved oxygen concentration at current salinity (0 mS/cm) and at current temperature (26.5 °C), which is 0.75-20.75 mg/l.

| | | | | | |
|-------------------------------|----------|-----------------------------|------------------|-----------------|-------|
| Command: Make calibration CP2 | | Modbus address: 5194 | Length: 2 | Type: 16 | Write |
| Parameter: | Value | | | | |
| Format: | Float | | | | |
| Value: | 8 | | | | |

Figure 2.7.3.1.6: Example: The calibration is performed by telling VISIFERM DO, that the oxygen concentration in the calibration media is 8 mg/l.

| | | | | | |
|---------------------|-------------|-----------------------------|-------------------|----------------|-----------------|
| Command: PMC 1 read | | Modbus address: 2090 | Length: 10 | Type: 3 | Read |
| Parameter: | Unit | Value | Status | Min limit | Max limit |
| Format: | Hex | Float | Hex | Float | Float |
| Value: | 0x80 | 7.99898 | 0x00 | 0 | 22.97096 |

Figure 2.7.3.1.7: Example: After calibration, the oxygen reading is then 8 mg/l, as desired.

Example 2:

Register 2090 is set to physical unit “mg/l ppm” (0x80).

| | | | | | | |
|-------------------------------|----------|-----------------------------|--|------------------|-----------------|-------|
| Command: Make calibration CP2 | | Modbus address: 5194 | | Length: 2 | Type: 16 | Write |
| Parameter: | Value | | | | | |
| Format: | Float | | | | | |
| Value: | 0 | | | | | |

Figure 2.7.3.1.8: Example: With the automatic mode (value = 0), the calibration at CP2 is started.

| | | | | | | |
|---------------------|-------------|-----------------------------|-------------|-------------------|-----------------|------|
| Command: PMC 1 read | | Modbus address: 2090 | | Length: 10 | Type: 3 | Read |
| Parameter: | Unit | Value | Status | Min limit | Max limit | |
| Format: | Hex | Float | Hex | Float | Float | |
| Value: | 0x80 | 7.602702 | 0x00 | 0 | 22.92315 | |

Figure 2.7.3.1.9: Example: As a result of the calibration, the oxygen reading is 7.6 (mg/l ppm), as the temperature reading at the same time is 26.5 °C. The theoretical concentration of DO in water with 26.5 °C and having a salinity of 0 mS/cm is 7.6 mg/l.

2.7.3.2 Calibration Point 6 (Product Calibration)

The product calibration is a process in order to adjust the measurement of a correctly calibrated VISIFERM DO sensor to specific process conditions.

Product calibration is a two stage process:

1. An initial measurement is performed while the operator takes a sample of the process solution. At that time point the VISIFERM DO sensor stores its raw measurement value, temperature and operating hour in the memory.

While the operator takes the sample to the analytics lab for reference analysis the VISIFERM DO sensor is still running on its prior standard calibration (CP1 and CP2) while the initial measurement data for the ongoing product calibration is kept in the VISIFERM DO sensors memory.

2. When the result of the reference analysis is available this value is assigned at a second time point to the former initial measurement data stored in the VISIFERM DO Sensor.

The sensor is now, after valid assignment, running on a calibration function which is compensated for the correct process conditions. The product calibration (CP6) is now active.

Performing a Cancel command for the product calibration (CP6) brings the sensor back to its still stored standard calibration (CP1 and CP2).

If a product calibration is still active and a standard calibration (CP1 or CP2) is performed the product calibration (CP6) is cancelled.

If the operator needs to overrun a active product calibration (old CP6) by a new product calibration (new CP6) the above process applies in the same way. After initial measurement the VISIFERM DO sensor is still running on the first product calibration (old CP6) until a valid assignment has been done (new CP6).

What happens to the VISIFERM DO calibration function upon product calibration (CP6)?

A product calibration for VISIFERM DO and VISIFERM DO ARC Sensors corresponds to a manual calibration at CP2. On active product calibration (CP6) the VISIFERM's calibration function is calculated from the data of Calibration point 1 and from the data of the product calibration (CP6).

For more flexibility the product calibration procedure allows larger deviations from the ARC Sensors current measurement than the standard calibration.

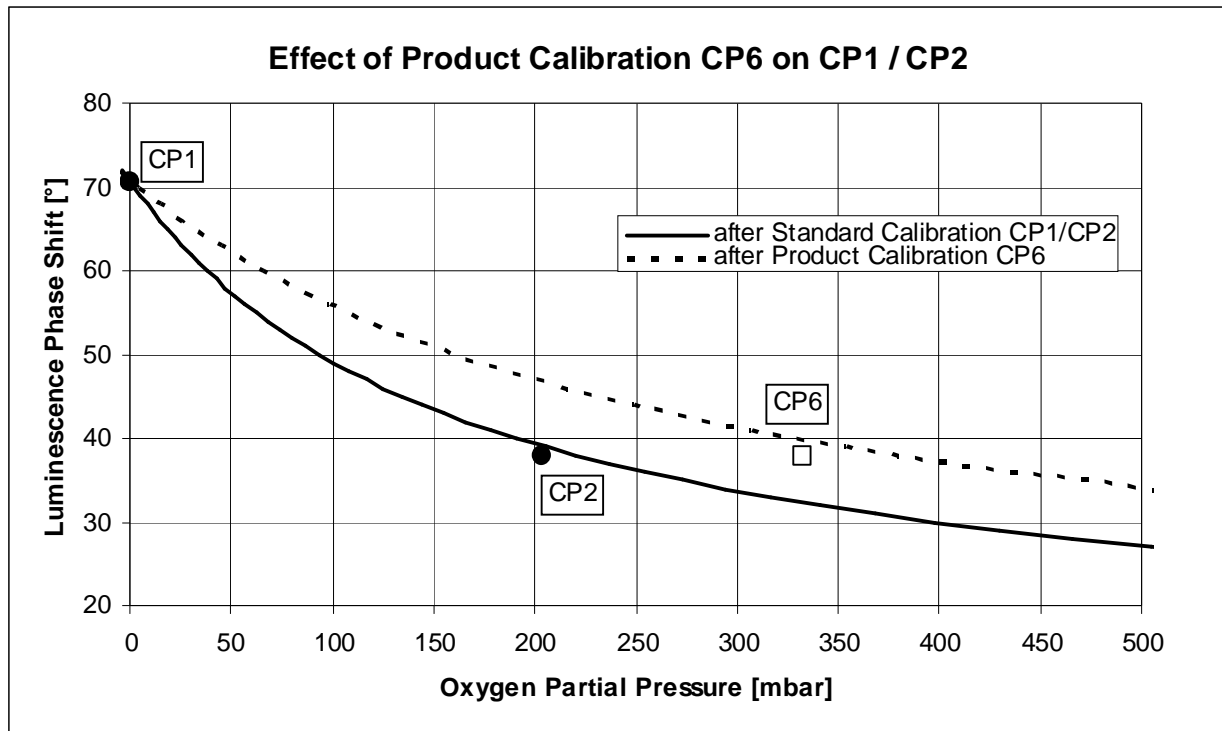


Figure 2.7.3.2.1: Effect of the product calibration CP6 on an existing standard calibration function defined by CP1 and CP2.

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 the calibration points **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.

Some weeks later, the operator believes that the standard calibration function is not correct anymore. As the process is running and he is not able to perform a standard calibration under defined conditions in the lab, he decides to perform a product calibration CP6, 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 the calibration points **CP1** and **CP6**. The new calibration function, compensated to the standard temperature 25°C, is shown as a dotted line.

Another special feature of this calibration point is to switch off and back on again a product calibration. These functions are called “restore standard calibration” and “restore product calibration”.

The sensor's internal criteria for a successful product calibration are:

- the sensor is currently in an environment corresponding to the VISIFERM DO's measurement range.
- the oxygen content is within the calibration limits defined for CP6 (see above)
- the parameters for the product calibration defined by CP1 and CP6 are in the following range:
 - the phase at zero oxygen remains the same (since it is defined by CP1)
 - the Stern-Volmer coefficient does not deviate from the one defined by prior (e.g. CP1/CP2) calibration by more than $\pm 40\%$.

The different functionalities of product calibration (CP6) are accessible through the following sensor commands:

- Initial measurement
- Assignment
- Cancel
- Restore standard calibration
- Restore product calibration

All commands are executed by writing a command to the register 5340 except for assignment where the calibration value is written to register 5322 (see below).

Definition of the commands for product calibration

The commands for register 5340 are defined as follows:

| Hex Code | Definition of commands |
|----------|---|
| 0x01 | Perform initial measurement |
| 0x02 | Cancel an active product calibration |
| 0x03 | Restore a standard calibration from an active product calibration |
| 0x04 | Restore a product calibration from an active standard calibration |

Figure 2.7.3.2.2: Definition of the commands related to the product calibration

| Start register | Number of registers | Reg1 / Reg2 | Modbus function code | Read access | Write access |
|----------------|---------------------|-------------------------------------|----------------------|-------------|--------------|
| 5340 | 2 | Code as defined in Figure 2.7.3.2.2 | 3, 4, 16 | A/S | A/S |

Figure 2.7.3.2.3: Definition of register 5340

2.7.3.2.1 Product calibration: Initial measurement

Upon process sample collection for laboratory analysis the command for initial measurement is sent to the sensor.

This is achieved by writing the command 0x01 to register 5340 which performs the initial measurement and stores the corresponding measurement values in the sensor.

| | | | | | |
|-----------------------------------|-------------|-----------------------------|------------------|-----------------|-------|
| Command: CP6: Initial measurement | | Modbus address: 5340 | Length: 2 | Type: 16 | Write |
| Parameter: | Command | | | | |
| Format: | Hex | | | | |
| Value: | 0x01 | | | | |

Figure 2.7.3.2.1.1: Example to start the product calibration procedure. Writing command 0x01 (initial measurement) to the CP6 command register 5340.

After successful initial measurement the corresponding calibration status is "CP6 assigned" (0x08000000) (see figure 2.7.4.1).

The sensor continues measuring using the prior standard calibration.

2.7.3.2.2 Product calibration: Assignment

After successful initial measurement a correct value must be assigned to the initially stored measurement data.

This is achieved by writing the correct calibration value to register 5322.

| Start register | Number of registers | Reg1 / Reg2 | Modbus function code | Read access | Write access |
|----------------|---------------------|---|----------------------|-------------|--------------|
| 5322 | 2 | Oxygen value in the correct unit (floating) | 16 | none | A/S |

Figure 2.7.3.2.2.1: Definition of register 5322

| | | | | | | |
|--------------------------|------------|-----------------------------|--|------------------|-----------------|-------|
| Command: CP6: Assignment | | Modbus address: 5322 | | Length: 2 | Type: 16 | Write |
| Parameter: | Value | | | | | |
| Format: | Float | | | | | |
| Value: | 195 | | | | | |

Figure 2.7.3.2.2.2: Example to assign a calibration value to the above performed initial measurement.

This is achieved by writing the correct oxygen value in the correct unit (here 195 mbar) to 5322.

From now on the sensor is measuring using the here performed product calibration.

The calibration status of the sensor is 0x14000000 meaning that a correct value has been assigned and that the product calibration is active (see figure 2.7.4.1).

2.7.3.2.3 Product calibration: Cancel

To cancel an active product calibration or an active initial measurement the command 0x02 is written to register 5340.

| | | | | | | |
|----------------------|-------------|-----------------------------|--|------------------|-----------------|-------|
| Command: CP6: Cancel | | Modbus address: 5340 | | Length: 2 | Type: 16 | Write |
| Parameter: | Command | | | | | |
| Format: | Hex | | | | | |
| Value: | 0x02 | | | | | |

Figure 2.7.3.2.3.1: Example to cancel an active product calibration or an initial measurement. Writing command 0x02 (cancel) to the CP6 command register 5340.

Performing this action the product calibration or any initial measurements are canceled. The values of the prior product calibration are removed from the sensor's memory. From now on the sensor is measuring using its prior CP1 / CP2 standard calibration.

The sensor's calibration status will be reading 0x00 again (see figure 2.7.4.1).

2.7.3.2.4 Product calibration: Restore standard calibration

If a product calibration is active this product calibration can be temporarily switched off by writing the command 0x03 to register 5340.

Performing this action the values of the product calibration remain stored in the sensor's memory.

| | | | | | |
|--------------------------------|-------------|-----------------------------|------------------|-----------------|-------|
| Command: CP6: Restore standard | | Modbus address: 5340 | Length: 2 | Type: 16 | Write |
| Parameter: | Command | | | | |
| Format: | Hex | | | | |
| Value: | 0x03 | | | | |

Figure 2.7.3.2.4.1: Example to restore a standard calibration from an active product calibration. Writing command 0x03 (restore standard calibration) to the CP6 command register 5340.

From now on the sensor is measuring using its prior CP1 / CP2 standard calibration.

The sensor's calibration status will be reading "CP6 assigned" (0x10000000) meaning that a valid assignment for a product calibration is available in the sensor's memory (see figure 2.7.4.1).

2.7.3.2.5 Product calibration: Restore product calibration

If a valid but inactivated product calibration is available in the sensors memory, the calibration status is reading 0x10000000 ("CP 6 assigned", see figure 2.7.4.1), this stored product calibration can be restored or reactivated by writing command 0x04 to register 5340.

| | | | | | |
|-------------------------------|-------------|-----------------------------|------------------|-----------------|-------|
| Command: CP6: Restore product | | Modbus address: 5340 | Length: 2 | Type: 16 | Write |
| Parameter: | Command | | | | |
| Format: | Hex | | | | |
| Value: | 0x04 | | | | |

Figure 2.7.3.2.5.1: Example to restore an available product calibration from an active standard calibration. Writing command 0x04 (restore product calibration) to the CP6 command register 5340.

From now on the sensor is measuring using its prior CP6 product calibration.

The sensors calibration status will be reading 0x14000000 (corresponding to "CP6 assigned" and "CP6 active" (see figure 2.7.4.1) again.

If this command is performed without available product calibration in the sensor's memory the sensor will respond with a Modbus exception since this command is not valid.

2.7.4 Reading the Calibration Status

2.7.4.1 Reading the Calibration Status of CP1 and CP2 (Standard Calibration)

A standard calibration is not always successful. In order to analyze what has gone wrong, two different calibration status registers can be read:

- Register 5158 for CP1
- Register 5190 for CP2



Note

Registers 5158 and 5190 contain the same information!

| Bit # | Hex value | Definition in VISIFERM DO / VISIFERM DO ARC |
|---------|------------|---|
| 0 (LSB) | 0x00000001 | CP1: Oxygen value to be calibrated at is too low (see register 5152) |
| 1 | 0x00000002 | CP1: Oxygen value to be calibrated at is too high (see register 5152) |
| 2 | 0x00000004 | CP1: current temperature reading is too low |
| 3 | 0x00000008 | CP1: current temperature reading is too high |
| 4 | 0x00000010 | CP1: temperature reading during calibration is not stable |
| 5 | 0x00000020 | CP1: Phase is too low for the oxygen value to be calibrated at |
| 6 | 0x00000040 | CP1: Phase too high for the oxygen value to be calibrated at |
| 7 | 0x00000080 | CP1: Phase reading during calibration is not stable |
| 8 | 0x00000100 | CP2: Oxygen value to be calibrated at is too low (see register 5184) |
| 9 | 0x00000200 | CP2: Oxygen value to be calibrated at is too high (see register 5184) |
| 10 | 0x00000400 | CP2: current temperature reading is too low |
| 11 | 0x00000800 | CP2: current temperature reading is too high |
| 12 | 0x00001000 | CP2: temperature reading during calibration is not stable |
| 13 | 0x00002000 | CP2: Phase is too low for the oxygen value to be calibrated at |
| 14 | 0x00004000 | CP2: Phase too high for the oxygen value to be calibrated at |
| 15 | 0x00008000 | CP2: Phase reading during calibration is not stable |
| 16-23 | ... | not available |
| 24 | 0x01000000 | CP6: out of calibration range |
| 25 | 0x02000000 | CP6: out of range |
| 26 | 0x04000000 | CP6: active |
| 27 | 0x08000000 | CP6: initial measurement |
| 28 | 0x10000000 | CP6: assigned |
| 29-31 | ... | not available |

Figure 2.7.4.1.1: Definition of the register at 5158, 5190 (and 5318) (see also Figure 2.7.4.1.2).

| Start register | Number of registers | Reg1 / Reg2 | Reg3 / Reg4 | Reg5 / Reg6 | Modbus function code | Read access | Write access |
|----------------|---------------------|-----------------------------------|--|---|----------------------|-------------|--------------|
| 5158 | 6 | Status CP1 (see figure 2.7.4.1.1) | Physical unit of the last successful calibration CP1 | Oxygen value of the last successful calibration CP1 | 3, 4 | U/A/S | none |
| 5190 | 6 | Status CP2 (see figure 2.7.4.1.1) | Physical unit of the last successful calibration CP2 | Oxygen value of the last successful calibration CP2 | 3, 4 | U/A/S | none |

Figure 2.7.4.1.2: Definition of register 5158 for CP1 and register 5190 for CP2.

| | | | | | | |
|---------------------------------|-------------|-----------------------------|----------|------------------|----------------|------|
| Command: Calibration status CP1 | | Modbus address: 5158 | | Length: 6 | Type: 3 | Read |
| Parameter: | Status | Unit | Value | | | |
| Format: | Hex | Hex | Float | | | |
| Value: | 0x80 | 0x800000 | 0 | | | |

Figure 2.7.4.1.3: Example to read the calibration status of CP1 after having tried to calibrate CP1 at 0 = auto. The status says: "CP1 Phase reading during calibration is not stable" (0x80). The physical unit of the last calibration is 0x800000 (mbar), the last successful calibration has been performed at 0 (mbar).

| | | | | | | |
|---------------------------------|-------------|-----------------------------|--------------|------------------|----------------|------|
| Command: Calibration status CP2 | | Modbus address: 5190 | | Length: 6 | Type: 3 | Read |
| Parameter: | Status | Unit | Value | | | |
| Format: | Hex | Hex | Float | | | |
| Value: | 0x80 | 0x10 | 20.95 | | | |

Figure 2.7.4.1.4: Example to read the calibration status of CP2 after calibrating CP2 at 20.95 %-vol. All bits of CP2 are zero, indicating that the calibration was successful. The physical unit of the last calibration is %-vol (0x10), the last successful calibration has been performed at 20.95 (%-vol). Please note that the status says: "CP1 Phase reading during calibration is not stable". This is a status bit for CP1. All bits of CP1 will remain unaffected when calibrating CP2.

| | | | | | | |
|---------------------------------|---------------|-----------------------------|--------------|------------------|----------------|------|
| Command: Calibration status CP2 | | Modbus address: 5190 | | Length: 6 | Type: 3 | Read |
| Parameter: | Status | Unit | Value | | | |
| Format: | Hex | Hex | Float | | | |
| Value: | 0x0180 | 0x10 | 20.95 | | | |

Figure 2.7.4.1.5: Example to read the calibration status of CP2 after attempt to calibrate CP2 at 1 %-vol, which is out of the allowed limit (register 5184). The value you see is 0x0180 = 0x080 + 0x0100. Shown is still 0x0080 of CP1 and new 0x0100 of CP2, which says: "CP2 Oxygen value is too low for calibration" (see register 5184).

2.7.4.2 Reading the Calibration Status of CP6 (Product Calibration)

The calibration status and the current state of the VISIFERM DO Sensor in the product calibration process (CP6) is read in the calibration status register for CP6 (5318).

| Start register | Number of registers | Reg1 / Reg2 | Reg3 / Reg4 | Reg5 / Reg6 | Modbus function code | Read access | Write access |
|----------------|---------------------|-----------------------------------|--|---|----------------------|-------------|--------------|
| 5318 | 6 | Status CP6 (see figure 2.7.4.1.1) | Physical unit of the last successful calibration CP6 | Oxygen value of the last successful calibration CP6 | 3, 4 | U/A/S | none |

Figure 2.7.4.2.1: Definition of register 5318 for CP6. For examples, see following chapters.

2.7.4.2.1 Product calibration: Initial measurement

Calibration status after initial measurement command under conditions outside the valid calibration range for CP6 (defined in register 5312):

| | | | | | | |
|---------------------------------|------------------|-----------------------------|------------|------------------|----------------|------|
| Command: Calibration status CP6 | | Modbus address: 5318 | | Length: 6 | Type: 3 | Read |
| Parameter: | Status | Unit | Value | | | |
| Format: | Hex | Hex | Float | | | |
| Value: | 0x1000000 | 0x800000 | 200 | | | |

Figure 2.7.4.2.1.1: Example to read the calibration status of CP6 after having performed an initial measurement at CP6 under measurement conditions outside the calibration range for CP6. The status says: "CP6: out of calibration range" (0x1000000). The physical unit of the last calibration is 0x800000 (mbar), the last successful calibration has been performed at 200 (mbar). The initial measurement in this case was **not** successful. The sensor is still running on its prior standard calibration.

Calibration status after successful initial measurement:

| | | | | | | |
|---------------------------------|------------------|-----------------------------|------------|------------------|----------------|------|
| Command: Calibration status CP6 | | Modbus address: 5318 | | Length: 6 | Type: 3 | Read |
| Parameter: | Status | Unit | Value | | | |
| Format: | Hex | Hex | Float | | | |
| Value: | 0x8000000 | 0x800000 | 200 | | | |

Figure 2.7.4.2.1.2: Example to read the calibration status of CP6 after having performed an initial measurement at CP6 under correct measurement conditions. The status says: "CP6: initial measurement" (0x8000000). The physical unit of the last calibration is 0x800000 (mbar), the last successful calibration has been performed at 200 (mbar). The initial measurement in this case was successful. The sensor is still running on its prior standard calibration until a valid calibration value has been assigned to this initial measurement values.

2.7.4.2.2 Product calibration: Assignment

Calibration status after invalid assignment:

| | | | | | | |
|---------------------------------|------------------|-----------------------------|------------|------------------|----------------|------|
| Command: Calibration status CP6 | | Modbus address: 5318 | | Length: 6 | Type: 3 | Read |
| Parameter: | Status | Unit | Value | | | |
| Format: | Hex | Hex | Float | | | |
| Value: | 0xA000000 | 0x800000 | 200 | | | |

Figure 2.7.4.2.2.1: Example to read the calibration status of CP6 after having performed a valid initial measurement at CP6 and an invalid assignment.

The status says: "CP6: out of range" and "CP6: initial measurement" (0xA000000). The physical unit of the last calibration is 0x800000 (mbar), the last successful calibration has been performed at 200 (mbar).

The initial measurement in this case is still valid and available for further assignment of a product calibration value. The here performed assignment was **not** successful. The sensor remains running on its prior standard calibration.

Calibration status after valid assignment:

| | | | | | | |
|---------------------------------|-------------------|-----------------------------|------------|------------------|----------------|------|
| Command: Calibration status CP6 | | Modbus address: 5318 | | Length: 6 | Type: 3 | Read |
| Parameter: | Status | Unit | Value | | | |
| Format: | Hex | Hex | Float | | | |
| Value: | 0x14000000 | 0x800000 | 195 | | | |

Figure 2.7.4.2.2.2: Example to read the calibration status of CP6 after having performed an initial measurement at CP6 and a valid assignment.

The status says: "CP6: active" and "CP6: assigned" (0x14000000). The physical unit of the last calibration is 0x800000 (mbar), the last successful calibration corresponding to the here performed assignment has been performed at 195 (mbar).

The here performed assignment was successful. The sensor is running using a valid product calibration.

2.7.4.2.3 Product calibration: Cancel

Calibration status after cancelling an active product calibration:

| | | | | | | |
|---------------------------------|-------------------|-----------------------------|------------|------------------|----------------|------|
| Command: Calibration status CP6 | | Modbus address: 5318 | | Length: 6 | Type: 3 | Read |
| Parameter: | Status | Unit | Value | | | |
| Format: | Hex | Hex | Float | | | |
| Value: | 0x00000000 | 0x800000 | 195 | | | |

Figure 2.7.4.2.3.1: Example to read the calibration status of CP6 after having performed a cancel command at CP6.

The status says: "no calibration status message" (0x00). The physical unit of the last calibration is 0x800000 (mbar), the last successful calibration at CP6 has been performed at 195 (mbar).

The sensor is running on a valid standard calibration and no product calibration is stored.

2.7.4.2.4 Product calibration: Restore standard calibration

Calibration status after restoring a standard calibration from an active product calibration:

| | | | | | | |
|---------------------------------|-------------------|-----------------------------|------------|------------------|----------------|------|
| Command: Calibration status CP6 | | Modbus address: 5318 | | Length: 6 | Type: 3 | Read |
| Parameter: | Status | Unit | Value | | | |
| Format: | Hex | Hex | Float | | | |
| Value: | 0x10000000 | 0x800000 | 195 | | | |

Figure 2.7.4.2.4.1: Example to read the calibration status of CP6 after having restored the standard calibration from an active product calibration (CP6).

The status says: "CP6: assigned" (0x10000000). The physical unit of the last calibration is 0x800000 (mbar), the last successful calibration at CP6 has been performed at 195 (mbar).

The sensor is running on a valid standard calibration but a valid product calibration is still available in the sensor.

2.7.4.2.5 Product calibration: Restore product calibration

Calibration status after restoring an available product calibration from an active standard calibration:

| | | | | | | |
|---------------------------------|-------------------|-----------------------------|------------|------------------|----------------|------|
| Command: Calibration status CP6 | | Modbus address: 5318 | | Length: 6 | Type: 3 | Read |
| Parameter: | Status | Unit | Value | | | |
| Format: | Hex | Hex | Float | | | |
| Value: | 0x14000000 | 0x800000 | 195 | | | |

Figure 2.7.4.2.5.1: Example to read the calibration status of CP6 after having restored an available product calibration (CP6) from an active standard calibration (CP1 / CP2).

The status says: "CP6: active" and "CP6: assigned" (0x14000000). The physical unit of the last calibration is 0x800000 (mbar), the last successful calibration corresponding to the here performed assignment has been performed at 195 (mbar).

The sensor is running on a valid product calibration again.

2.7.5 Currently active Calibration Parameters part 1

In registers 5164 (CP1), 5196 (CP2) and 5324 (CP6) the currently active calibration parameters part 1 are stored. These registers contain the values for temperature, number of calibrations and operating hour upon calibration.

| Start register | Number of registers | Reg1 / Reg2 | Reg3 / Reg4 | Reg5 / Reg6 | Reg7 / Reg8 | Modbus function code | Read access | Write access |
|----------------|---------------------|---|-----------------------------|-------------------------------|------------------------|----------------------|-------------|--------------|
| 5164 | 8 | Unit of temperature for CP1 (bitwise defined) | Value of temperature of CP1 | Number of calibrations at CP1 | Operating hour for CP1 | 3, 4 | U/A/S | none |
| 5196 | 8 | Unit of temperature for CP2 (bitwise defined) | Value of temperature of CP2 | Number of calibrations at CP2 | Operating hour for CP2 | 3, 4 | U/A/S | none |
| 5324 | 8 | Unit of temperature for CP6 (bitwise defined) | Value of temperature of CP6 | Number of calibrations at CP6 | Operating hour for CP6 | 3, 4 | U/A/S | none |

Figure 2.7.5.1: Definition of register 5164 for CP1, 5196 for CP2 and 5324 for CP6.

| | | | | |
|---|---------------------|-----------------|----------------|-----------------|
| Command: Calibration CP1 values 1 Modbus address: 5164 Length: 8 Type: 3 Read | | | | |
| Parameter: | Unit of temperature | Temperature | Number of cali | Operating hour |
| Format: | Hex | Float | Decimal | Float |
| Value: | 0x04 | 26.08493 | 2 | 162.3167 |

Figure 2.7.5.2: Example to read the calibration values 1 for CP1. The physical unit is °C (0x04), the temperature is 26.08 (°C), the number of calibrations at CP1 is 2 and the operating hour is 162.3 (h).

| | | | | |
|---|---------------------|-----------------|----------------|----------------|
| Command: Calibration CP2 values 1 Modbus address: 5196 Length: 8 Type: 3 Read | | | | |
| Parameter: | Unit of temperature | Temperature | Number of cali | Operating hour |
| Format: | Hex | Float | Decimal | Float |
| Value: | 0x04 | 26.86173 | 14 | 163.75 |

Figure 2.7.5.3: Example to read the calibration values 1 for CP2. The physical unit is °C (0x04), the temperature is 26.86 (°C), the number of calibrations at CP1 is 14 and the operating hour is 163.75 (h).

| | | | | |
|---|---------------------|-----------------|----------------|-----------------|
| Command: Calibration CP6 values 1 Modbus address: 5324 Length: 8 Type: 3 Read | | | | |
| Parameter: | Unit of temperature | Temperature | Number of cali | Operating hour |
| Format: | Hex | Float | Decimal | Float |
| Value: | 0x04 | 29.93368 | 12 | 379.5167 |

Figure 2.7.5.4: Example to read the calibration values 1 for CP6. The physical unit is °C (0x04), the temperature is 29.93 (°C), the number of calibrations at CP1 is 12 and the operating hour is 379.51 (h).

2.7.6 Currently active Calibration Parameters part 2

In registers 5172 (CP1), 5204 (CP2) and 5332 (CP6) the current calibration parameters part 2 are stored. These registers contain the values for atmospheric pressure and salinity.

| Start register | Number of registers | Reg1 / Reg2 | Reg3 / Reg4 | Reg5 / Reg6 | Reg7 / Reg8 | Modbus function code | Read access | Write access |
|----------------|---------------------|--|--------------------------|---|--------------------------|----------------------|-------------|--------------|
| 5172 | 8 | Unit of pressure for CP1 (bitwise defined) | Value of pressure of CP1 | Unit of salinity of CP1 (bitwise defined) | Value of salinity of CP1 | 3, 4 | U/A/S | none |
| 5204 | 8 | Unit of pressure for CP2 (bitwise defined) | Value of pressure of CP2 | Unit of salinity of CP2 (bitwise defined) | Value of salinity of CP2 | 3, 4 | U/A/S | none |
| 5332 | 8 | Unit of pressure for CP6 (bitwise defined) | Value of pressure of CP6 | Unit of salinity of CP6 (bitwise defined) | Value of salinity of CP6 | 3, 4 | U/A/S | none |

Figure 2.7.6.1: Definition of register 5172 for CP1, 5204 for CP2 and 5332 for CP6.

| | | | | |
|---|------------------|-------------|------------------|-----------|
| Command: Calibration CP1 values 2 Modbus address: 5172 Length: 8 Type: 3 Read | | | | |
| Parameter: | Unit of pressure | Pressure | Unit of salinity | Salinity |
| Format: | Hex | Float | Hex | Float |
| Value: | 0x800000 | 1013 | 0x400 | 10 |

Figure 2.7.6.2: Example to read the calibration values 2 for CP1. The physical unit is mbar (0x800000), the pressure is 1013 (mbar), the unit is mS/cm (0x400) and the salinity is 10 (mS/cm).

| | | | | |
|---|------------------|-------------|------------------|-----------|
| Command: Calibration CP2 values 2 Modbus address: 5204 Length: 8 Type: 3 Read | | | | |
| Parameter: | Unit of pressure | Pressure | Unit of salinity | Salinity |
| Format: | Hex | Float | Hex | Float |
| Value: | 0x800000 | 1013 | 0x400 | 10 |

Figure 2.7.6.3: Example to read the calibration values 2 for CP2. The physical unit is mbar (0x800000), the pressure is 1013 (mbar), the unit is mS/cm (0x400) and the salinity is 10 (mS/cm).

| | | | | |
|---|------------------|-------------|------------------|----------|
| Command: Calibration CP6 values 2 Modbus address: 5332 Length: 8 Type: 3 Read | | | | |
| Parameter: | Unit of pressure | Pressure | Unit of salinity | Salinity |
| Format: | Hex | Float | Hex | Float |
| Value: | 0x800000 | 1013 | 0x400 | 0 |

Figure 2.7.6.4: Example to read the calibration values 2 for CP6. The physical unit is mbar (0x800000), the pressure is 1013 (mbar), the unit is mS/cm (0x400) and the salinity is 0 (mS/cm).

2.7.7 Currently active Calibration Parameters part 3

In register 5520, 5528 and 5560 is stored the oxygen concentration, the luminescence shift, the temperature and the atmospheric pressure upon calibration.

| Start register | Number of registers | Reg1 / Reg2 | Reg3 / Reg4 | Reg5 / Reg6 | Reg7 / Reg8 | Modbus function code | Read access | Write access |
|----------------|---------------------|-------------|-------------|--------------|-------------------|----------------------|-------------|--------------|
| 5520 | 8 | C1 [mbar] | Phase 1 [°] | Temp. 1 [°C] | Pressure 1 [mbar] | 3, 4 | A/S | none |
| 5528 | 8 | C2 [mbar] | Phase 2 [°] | Temp. 2 [°C] | Pressure 2 [mbar] | 3, 4 | A/S | none |
| 5560 | 8 | C6 [mbar] | Phase 6 [°] | Temp. 6 [°C] | Pressure 6 [mbar] | 3, 4 | A/S | none |

Figure 2.7.7.1: Definition of register 5520, 5528 and 5560.

| | | | | | | |
|------------------------------|-----------------|-----------------------------|-----------------|------------------|----------------|------|
| Command: Act calibration CP1 | | Modbus address: 5520 | | Length: 8 | Type: 3 | Read |
| Parameter: | Cali CP1 [mbar] | Phase CP1 | Temp CP1 | Pressure CP1 | | |
| Format: | Float | Float | Float | Float | | |
| Value: | 0 | 70.80737 | 26.08493 | 1013 | | |

Figure 2.7.7.2: Example to read the current calibration values of CP1. The DO-concentration is 0 mbar, the phase is 70.81, the temperature is 26.08 °C and the pressure is 1013 mbar.

| | | | | | | |
|------------------------------|-----------------|-----------------------------|-----------------|------------------|----------------|------|
| Command: Act calibration CP2 | | Modbus address: 5528 | | Length: 8 | Type: 3 | Read |
| Parameter: | Cali CP2 [mbar] | Phase CP2 | Temp CP2 | Pressure CP2 | | |
| Format: | Float | Float | Float | Float | | |
| Value: | 204.8033 | 38.37107 | 26.86173 | 1013 | | |

Figure 2.7.7.3: Example to read the current calibration values of CP2. The DO-concentration is 204.80 mbar, the phase is 38.37, the temperature is 26.86 °C and the pressure is 1013 mbar.

| | | | | | | |
|------------------------------|-----------------|-----------------------------|-----------------|------------------|----------------|------|
| Command: Act calibration CP6 | | Modbus address: 5560 | | Length: 8 | Type: 3 | Read |
| Parameter: | Cali CP6 [mbar] | Phase CP6 | Temp CP6 | Pressure CP6 | | |
| Format: | Float | Float | Float | Float | | |
| Value: | 205.187 | 37.85284 | 29.93368 | 1013 | | |

Figure 2.7.7.4: Example to read the current calibration values of CP6. The DO-concentration upon initial measurement is 205.187 mbar, the phase is 37.85, the temperature is 29.93 °C and the pressure is 1013 mbar.

2.7.8 Special Commands for Calibration with VISICAL

The VISICAL calibration device allows calibration of VISIFERM DO sensors at CP1 or CP2. The VISICAL associated calibration parameters for CP1 and CP2 are those predefined and stored in corresponding registers of VISIFERM DO sensor.

Register 5164 defines the oxygen value for CP1 and register 5196 defines the oxygen value for CP2, which are only valid for use with VISICAL. The same calibration limits for the oxygen value are used as for standard calibration at CP1 and CP2 (register 5152 and 5184 respectively).



Attention:

- It is not possible to perform a product calibration using VISICAL.
- Physical unit is fixed to %-vol by definition. If the register 5180 and 5212 both contain a 0 for auto, the default physical unit is taken, independent from the definition in register 2090.

| Start register | Number of registers | Reg1 / Reg2 | Modbus function code | Read access | Write access |
|----------------|---------------------|--|----------------------|-------------|--------------|
| 5180 | 2 | Oxygen value at CP1 (physical unit is fixed to %-vol) (default: 0 %-vol) | 3, 4, 16 | U/A/S | S |
| 5212 | 2 | Oxygen value at CP2 (physical unit is fixed to %-vol) (default: 20.95 %-vol) | 3, 4, 16 | U/A/S | S |

Figure 2.7.8.1: Definition of register 5180 for CP1 and 5212 for CP2 with VISICAL.

| | | | | | | |
|----------------------|---------------|-----------------------------|--|------------------|----------------|------|
| Command: VISICAL CP1 | | Modbus address: 5180 | | Length: 2 | Type: 3 | Read |
| Parameter: | Value [%-vol] | | | | | |
| Format: | Float | | | | | |
| Value: | 0 | | | | | |

Figure 2.7.8.2: Example to read the oxygen value valid for CP1. It is 0 %-vol. Accordingly, the next time when a calibration is started using VISICAL at LOW, VISIFERM DO assumes that the oxygen value is 0 %-vol.

| | | | | | | |
|----------------------|---------------|-----------------------------|--|------------------|-----------------|-------|
| Command: VISICAL CP2 | | Modbus address: 5212 | | Length: 2 | Type: 16 | Write |
| Parameter: | Value [%-vol] | | | | | |
| Format: | Float | | | | | |
| Value: | 25 | | | | | |

Figure 2.7.8.3: Example to set the oxygen value valid for CP2 to 25 %-vol.

| | | | | | | |
|----------------------|---------------|-----------------------------|--|------------------|----------------|------|
| Command: VISICAL CP2 | | Modbus address: 5212 | | Length: 2 | Type: 3 | Read |
| Parameter: | Value [%-vol] | | | | | |
| Format: | Float | | | | | |
| Value: | 25 | | | | | |

Figure 2.7.8.4: Example to read the oxygen value valid for CP2. It is 25 %-vol. Accordingly, the next time when a calibration is started using VISICAL at HIGH, VISIFERM DO assumes that the oxygen value is 25 %-vol.

2.8 Sensor Status

2.8.1 Temperature Ranges

In registers 4608, 4612 and 4616 three different temperature ranges are defined:

- Operation – in this range the sensor will work properly (current output, Modbus communication), except the measurement, which is stopped until the temperature is back in the measurement range. In this case the last value of measurement will be frozen and sent to the analog interface.
- Measurement – in this range the sensor is able to measure.
- Calibration – in this range the sensor can be calibrated.

| Start register | Number of registers | Reg1 / Reg2 | Reg3 / Reg4 | Modbus function code | Read access | Write access |
|----------------|---------------------|----------------------------------|----------------------------------|----------------------|-------------|--------------|
| 4608 | 4 | Operating temperature min [°C] | Operating temperature max [°C] | 3, 4 | U/A/S | none |
| 4612 | 4 | Measurement temperature min [°C] | Measurement temperature max [°C] | 3, 4 | U/A/S | none |
| 4616 | 4 | Calibration temperature min [°C] | Calibration temperature max [°C] | 3, 4 | U/A/S | none |

Figure 2.8.1.1: Definition of register 4608, 4612 and 4616.

| | | | | | | |
|----------------------------|----------------------|-----------------------------|--|------------------|----------------|------|
| Command: Operating T range | | Modbus address: 4608 | | Length: 4 | Type: 3 | Read |
| Parameter: | Operating T min [°C] | Operating T max [°C] | | | | |
| Format: | Float | Float | | | | |
| Value: | -40 | 130 | | | | |

Figure 2.8.1.2: Example to read the operating temperature values min and max.

| | | | | | | |
|------------------------------|------------------------|-----------------------------|--|------------------|----------------|------|
| Command: Measurement T range | | Modbus address: 4612 | | Length: 4 | Type: 3 | Read |
| Parameter: | Measurement T min [°C] | Measurement T max [°C] | | | | |
| Format: | Float | Float | | | | |
| Value: | -20 | 85 | | | | |

Figure 2.8.1.3: Example to read the measurement temperature values min and max.

| | | | | | | |
|------------------------------|------------------------|-----------------------------|--|------------------|----------------|------|
| Command: Calibration T range | | Modbus address: 4616 | | Length: 4 | Type: 3 | Read |
| Parameter: | Calibration T min [°C] | Calibration T max [°C] | | | | |
| Format: | Float | Float | | | | |
| Value: | 0 | 60 | | | | |

Figure 2.8.1.4: Example to read the calibration temperature values min and max.

2.8.2 Operating Hours and Counters

In register 4676 you can read:

- total operating hours
- operating hours above max measurement temperature (see chapter 2.8.1)
- the operating hours above max operating temperature (see chapter 2.8.1)

In register 4682 are stored:

- number of power ups
- number of watchdog resets
- number of writing cycles to flash memory

In register 4688 you find:

- number of sterilization in place (SIP) (see chapter 2.8.5)
- number of cleaning in place (CIP) (see chapter 2.8.5)

| Start register | Number of registers | Reg1 / Reg2 | Reg3 / Reg4 | Reg3 / Reg4 | Modbus function code | Read access | Write access |
|----------------|---------------------|----------------------|---|---|----------------------|-------------|--------------|
| 4676 | 6 | Operating hours [h] | Operating hours above max measurement temperature [h] | Operating hours above max operating temperature [h] | 3, 4 | U/A/S | none |
| 4682 | 6 | Number of Power ups | Number of Watchdog resets | Number of Writing cycles to flash memory | 3, 4 | U/A/S | none |
| 4688 | 4 | Number of SIP cycles | Number of CIP cycles | - | 3, 4 | U/A/S | none |

Figure 2.8.2.1: Definition of register 4676, 4682 and 4688.

| | | | | | | |
|--------------------------|---------------------|---|---|------------------|----------------|------|
| Command: Operating hours | | Modbus address: 4676 | | Length: 6 | Type: 3 | Read |
| Parameter: | Operating hours [h] | Operating hours above max measurement temperature [h] | Operating hours above max operating temperature [h] | | | |
| Format: | Float | Float | Float | | | |
| Value: | 168.3667 | 0 | 0 | | | |

Figure 2.8.2.2: Example to read the total operating hours, the operating hours above the max measurement temperature and the operating hours above the max operating temperature.

| | | | | | | |
|---------------------------|---------------------|-----------------------------|--|------------------|----------------|------|
| Command: Power & watchdog | | Modbus address: 4682 | | Length: 6 | Type: 3 | Read |
| Parameter: | Number of Power ups | Number of Watchdog resets | Number of Writing cycles to flash memory | | | |
| Format: | Decimal | Decimal | Decimal | | | |
| Value: | 34 | 1 | 16 | | | |

Figure 2.8.2.3: Example to read the number of power ups, the number of watchdog resets and the number of writing cycles to flash memory.

| | | | | | | |
|--------------------|------------|-----------------------------|--|------------------|----------------|------|
| Command: SIP & CIP | | Modbus address: 4688 | | Length: 4 | Type: 3 | Read |
| Parameter: | SIP cycles | CIP cycles | | | | |
| Format: | Decimal | Decimal | | | | |
| Value: | 0 | 0 | | | | |

Figure 2.8.2.4: Example to read the number of SIP cycles and the number of CIP cycles. For the definition of SIP and CIP cycles see chapter 2.8.5.

2.8.3 Warnings

A “Warning” is a notification message which still allows further functioning of the system. This message alerts the operator of a possible problem that could lead to uncertain results.

2.8.3.1 Currently Active Warnings

The currently active warnings are stored in register 4736.

| Start register | Number of registers | Reg1 / Reg2 | Reg3 / Reg4 | Reg5 / Reg6 | Reg7 / Reg8 | Modbus function code | Read access | Write access |
|----------------|---------------------|---|--|---|--|----------------------|-------------|--------------|
| 4736 | 8 | Active warnings measurement (bitwise defined) | Active warnings calibration and membrane (bitwise defined) | Active warnings interface (bitwise defined) | Active warnings hardware (bitwise defined) | 3, 4 | U/A/S | none |

Figure 2.8.3.1.1: Definition of register 4736 (see chapter 2.8.3.3)

| | | | | | | |
|-------------------------|---------------|-----------------------------|-------------|------------------|----------------|------|
| Command: Warning active | | Modbus address: 4736 | | Length: 8 | Type: 3 | Read |
| Parameter: | W Measurement | W Cal & Membrane | W Interface | W Hardware | | |
| Format: | Hex | Hex | Hex | Hex | | |
| Value: | 0x00 | 0x00 | 0x00 | 0x00 | | |

Figure 2.8.3.1.2: Example to read the active warnings (see chapter 2.8.3.3)

2.8.3.2 History of Warnings

In register 4756 a record of the last 12 warning events is available.

With the parameter “Number of Reg.” One can retrieve the individual warning events between 1 (current) and 12 (old).

With setting “number” =0, you get a a so-called “all-time” list of warnings.

Every 3 seconds the warnings status is checked and refreshed.

| Start Reg. | Number of Reg. | Reg1 / Reg2 | Reg3 / Reg4 | Reg5 / Reg6 | Reg7 / Reg8 | Reg9 / Reg10 | Reg11 / Reg12 | Modbus function code | Read access | Write access |
|------------|----------------|------------------|---------------------|-------------------------------------|--|-----------------------------------|----------------------------------|----------------------|-------------|--------------|
| 4756 | 2 | Number (0, 1-12) | | | | | | 16 | none | U/A/S |
| 4756 | 12 | Number (0, 1-12) | Operating hours [h] | History warn. measurement (bit def) | History warn. cal and membrane (bit def) | History warn. interface (bit def) | History warn. hardware (bit def) | 3, 4 | U/A/S | none |

Figure 2.8.3.2.1: Definition of register 4756.

| | | | | | | |
|--------------------------|----------|-----------------------------|------------------|-------------------|----------------|-------------|
| Command: Warning history | | Modbus address: 4756 | | Length: 12 | Type: 3 | Read |
| Parameter: | Number | Operating hours [h] | W Measurement | W Cal & Membrane | W Interface | W Hardware |
| Format: | Decimal | Float | Hex | Hex | Hex | Hex |
| Value: | 0 | 0 | 0x2000000 | 0x02 | 0x02 | 0x00 |

Figure 2.8.3.2.2: Example to read the history of warnings (all-time-list) (Number = 0).

| | | | | | | |
|--------------------------|----------|-----------------------------|--|------------------|-----------------|-------|
| Command: Warning history | | Modbus address: 4756 | | Length: 2 | Type: 16 | Write |
| Parameter: | Number | | | | | |
| Format: | Decimal | | | | | |
| Value: | 1 | | | | | |

Figure 2.8.3.2.3: Example to set the Number to 1.

| | | | | | | |
|--------------------------|----------|-----------------------------|---------------|-------------------|----------------|-------------|
| Command: Warning history | | Modbus address: 4756 | | Length: 12 | Type: 3 | Read |
| Parameter: | Number | Operating hours [h] | W Measurement | W Cal & Membrane | W Interface | W Hardware |
| Format: | Decimal | Float | Hex | Hex | Hex | Hex |
| Value: | 1 | 163.5167 | 0x00 | 0x00 | 0x00 | 0x00 |

Figure 2.8.3.2.4: Example to read the history warnings in case of Number = 1.

2.8.3.3 Definition of Warnings

| Bit # | Hex code | Description |
|---------|------------|--|
| 0 (LSB) | 0x01 | PMC1 DO reading below lower limit (DO < 0 %-sat) |
| 1 | 0x02 | PMC1 DO reading above upper limit (DO > 300 %-sat) |
| 2 | 0x04 | PMC1 DO reading unstable (Standard deviation > 1 °) |
| | | not available |
| 25 | 0x02000000 | PMC6 T reading below lower limit (T < Tmin, chapter 5.8.1) |
| 26 | 0x04000000 | PMC6 T reading above upper limit (T > Tmax, chapter 5.8.1) |
| 27 | 0x08000000 | PMC6 T reading unstable |
| | | not available |

Figure 2.8.3.3.1: Definition of warnings "measurement".

| Bit # | Hex code | Description |
|---------|----------|---|
| 0 (LSB) | 0x01 | PMC1 DO calibration recommended (DO < -0.5 %) |
| 1 | 0x02 | PMC1 DO last calibration not successful |
| 2 | 0x04 | PMC1 DO replace sensor cap |
| | | not available |

Figure 2.8.3.3.2: Definition of warnings "calibration and membrane".

| Bit # | Hex code | Description |
|---------|----------|---|
| 0 (LSB) | 0x01 | 4-20 mA value below 4 mA |
| 1 | 0x02 | 4-20 mA value above 20 mA |
| 2 | 0x04 | 4-20 mA current set-point not met |
| | | not available |
| 5 | 0x20 | ECS value above upper limit |
| 6 | 0x40 | ECS current set-point not met |
| 7 | 0x80 | ECS external wiring not correct (short circuit) |
| | | not available |

Figure 2.8.3.3.3: Definition of warnings "interface".

| Bit # | Hex code | Description |
|---------|----------|-------------------------------|
| 0 (LSB) | 0x01 | Power supply voltage too low |
| 1 | 0x02 | Power supply voltage too high |
| | | not available |

Figure 2.8.3.3.4: Definition of warnings "hardware".

2.8.4 Errors

An “Error” message indicates a serious problem of the sensor which does not allow further proper functioning of the sensor. This problem must be solved.

2.8.4.1 Currently Active Errors

The currently active errors are stored in register 4800.

| Start register | Number of registers | Reg1 / Reg2 | Reg3 / Reg4 | Reg5 / Reg6 | Reg7 / Reg8 | Modbus function code | Read access | Write access |
|----------------|---------------------|---|--|---|--|----------------------|-------------|--------------|
| 4800 | 8 | Active errors measurement (bitwise defined) | Active errors calibration and membrane (bitwise defined) | Active errors interface (bitwise defined) | Active errors hardware (bitwise defined) | 3, 4 | U/A/S | none |

Figure 2.8.4.1.1: Definition of register 4800 (see chapter 2.8.4.3)

| | | | | | | |
|-------------------------|---------------|-----------------------------|-------------|------------------|----------------|------|
| Command: Errors current | | Modbus address: 4800 | | Length: 8 | Type: 3 | Read |
| Parameter: | E Measurement | E Cal & Membrane | E Interface | E Hardware | | |
| Format: | Hex | Hex | Hex | Hex | | |
| Value: | 0x00 | 0x00 | 0x00 | 0x00 | | |

Figure 2.8.4.1.2: Example to read the active errors.

2.8.4.2 History of Errors

In register 4820 a record of the last 12 errors is available.

With the parameter “Number of Reg.” One can retrieve the individual error events between 1 (current) and 12 (old).

With setting “number” =0, you get a so-called “all-time” list of errors.

Every 3 seconds the errors status is checked and refreshed.

| Start reg. | Number of reg. | Reg1 / Reg2 | Reg3 / Reg4 | Reg5 / Reg6 | Reg7 / Reg8 | Reg9 / Reg10 | Reg11 / Reg12 | Modbus function code | Read access | Write access |
|------------|----------------|------------------|---------------------|--------------------------------------|---|------------------------------------|-----------------------------------|----------------------|-------------|--------------|
| 4820 | 2 | Number (0, 1-12) | | | | | | 16 | none | U/A/S |
| 4820 | 12 | Number (0, 1-12) | Operating hours [h] | History errors measurement (bit def) | History errors cal and membrane (bit def) | History errors interface (bit def) | History errors hardware (bit def) | 3, 4 | U/A/S | none |

Figure 2.8.4.2.1: Definition of register 4820.

| | | | | | | |
|-------------------------|----------|-----------------------------|---------------|-------------------|----------------|-------------|
| Command: Errors history | | Modbus address: 4820 | | Length: 12 | Type: 3 | Read |
| Parameter: | Number | Operating hours [h] | E Measurement | E Cal & Membrane | E Interface | E Hardware |
| Format: | Decimal | Float | Hex | Hex | Hex | Hex |
| Value: | 0 | 0 | 0x01 | 0x01 | 0x00 | 0x00 |

Figure 2.8.4.2.2: Example to read the history of errors in case of the all-time-list (Number = 0).

| | | | | | | |
|-------------------------|----------|-----------------------------|--|------------------|-----------------|-------|
| Command: Errors history | | Modbus address: 4820 | | Length: 2 | Type: 16 | Write |
| Parameter: | Number | | | | | |
| Format: | Decimal | | | | | |
| Value: | 1 | | | | | |

Figure 2.8.4.2.3: Example to set the Number to 1.

| | | | | | | |
|-------------------------|----------|-----------------------------|---------------|-------------------|----------------|-------------|
| Command: Errors history | | Modbus address: 4820 | | Length: 12 | Type: 3 | Read |
| Parameter: | Number | Operating hours [h] | E Measurement | E Cal & Membrane | E Interface | E Hardware |
| Format: | Decimal | Float | Hex | Hex | Hex | Hex |
| Value: | 1 | 103.6667 | 0x01 | 0x01 | 0x01 | 0x01 |

Figure 2.8.4.2.4: Example to read the history errors in case of Number = 1.

2.8.4.3 Definition of Errors

| Bit # | Hex code | Description |
|---------|------------|---|
| 0 (LSB) | 0x00000001 | PMC1 DO reading failure |
| 1 | 0x00000002 | PMC1 DO p(O ₂) exceeds air pressure |
| | | not available |
| 25 | 0x02000000 | PMC6 T sensor defective |
| | | not available |

Figure 2.8.4.3.1: Definition of errors "measurement".

| Bit # | Hex code | Description |
|---------|----------|----------------------------|
| 0 (LSB) | 0x01 | PMC1 DO sensor cap missing |
| | | not available |

Figure 2.8.4.3.2: Definition of errors "calibration and membrane".

| Bit # | Hex code | Description |
|---------|----------|----------------------------------|
| 0 (LSB) | 0x01 | 4-20 mA defective, open circuit |
| 1 | 0x02 | 4-20 mA defective, short circuit |
| | | Not available |

Figure 2.8.4.3.3: Definition of errors "interface".

| Bit # | Hex code | Description |
|---------|-----------|---|
| 0 (LSB) | 0x0000001 | Sensor supply voltage far too low |
| 1 | 0x0000002 | Sensor supply voltage far too high |
| 2 | 0x0000004 | Temperature reading far below min |
| 3 | 0x0000008 | Temperature reading far above max |
| | | not available |
| 16 | 0x010000 | Red channel failure (average value red < 0.8) |
| | | not available |

Figure 2.8.4.3.4: Definition of errors "hardware".

2.8.5 Reading Definition of SIP and CIP

VISIFERM DO is counting special cleaning events such as sterilizations or cleaning cycles by means of tracking typical temperature profiles (see chapter 2.8.2).

Register 4988 defines the temperature profile for SIP (sterilization in place) and register 4996 the temperature profile for CIP (cleaning in place). 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

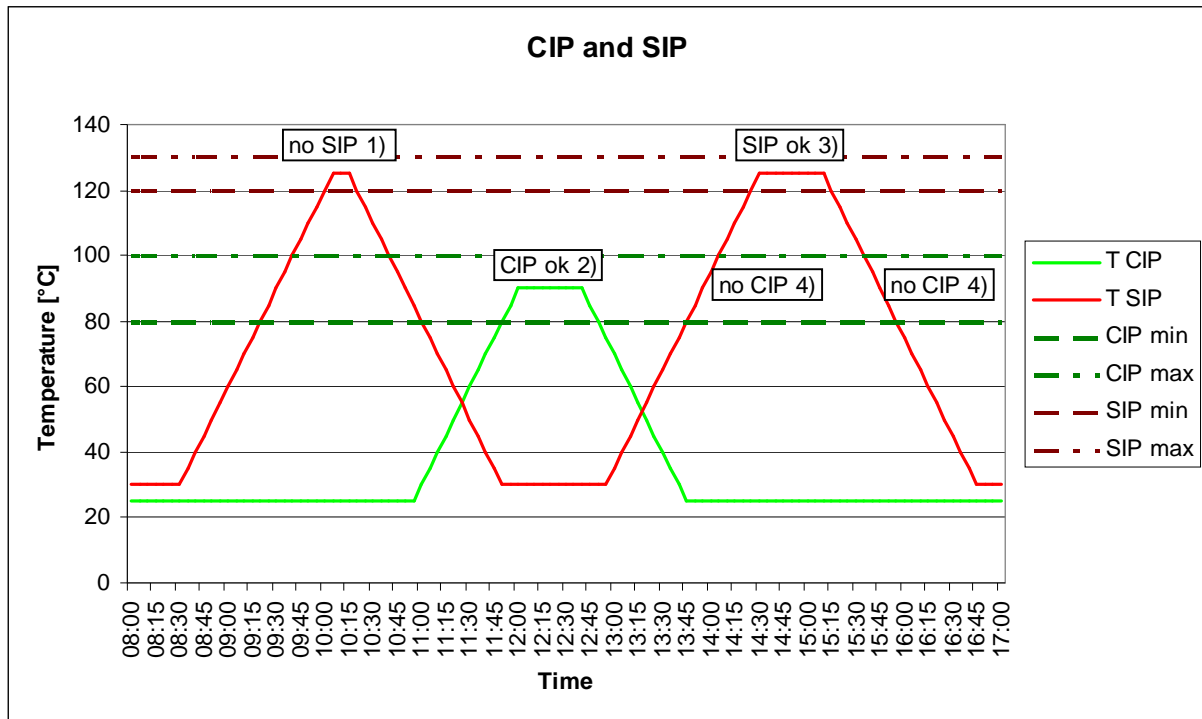


Figure 2.8.5.1: Definition of CIP and SIP cycles.

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

| Start register | Number of registers | Reg1 / Reg2 | Reg3 / Reg4 | Reg5 / Reg6 | Reg7 / Reg8 | Modbus function code | Read access | Write access |
|----------------|---------------------|--------------------------|--------------------------|----------------------------|-------------|----------------------|-------------|--------------|
| 4988 | 8 | SIP Temperature min [°C] | SIP Temperature max [°C] | SIP Process time min [min] | Empty | 3, 4 | U/A/S | S |
| 4996 | 8 | CIP Temperature min [°C] | CIP Temperature max [°C] | CIP Process time min [min] | Empty | 3, 4 | U/A/S | S |

Figure 2.8.5.2: Definition of register 4988 and 4996.

| | | | | | | |
|-------------------------|------------|-----------------------------|----------------|------------------|-----------------|-------|
| Command: SIP definition | | Modbus address: 4988 | | Length: 8 | Type: 16 | Write |
| Parameter: | T min [°C] | T max [°C] | Time min [min] | Empty | | |
| Format: | Float | Float | Float | Float | | |
| Value: | 120 | 130 | 30 | 0 | | |

Figure 2.8.5.3: Example to write the SIP definitions.

| | | | | | | |
|-------------------------|------------|-----------------------------|----------------|------------------|----------------|------|
| Command: SIP definition | | Modbus address: 4988 | | Length: 8 | Type: 3 | Read |
| Parameter: | T min [°C] | T max [°C] | Time min [min] | Empty | | |
| Format: | Float | Float | Float | Float | | |
| Value: | 120 | 130 | 30 | 0 | | |

Figure 2.8.5.4: Example to read the SIP definitions.

| | | | | | | |
|-------------------------|------------|-----------------------------|----------------|------------------|-----------------|-------|
| Command: CIP definition | | Modbus address: 4996 | | Length: 8 | Type: 16 | Write |
| Parameter: | T min [°C] | T max [°C] | Time min [min] | Empty | | |
| Format: | Float | Float | Float | Float | | |
| Value: | 80 | 100 | 30 | 0 | | |

Figure 2.8.5.5: Example to write the CIP definitions.

| | | | | | | |
|-------------------------|------------|-----------------------------|----------------|------------------|----------------|------|
| Command: CIP definition | | Modbus address: 4996 | | Length: 8 | Type: 3 | Read |
| Parameter: | T min [°C] | T max [°C] | Time min [min] | Empty | | |
| Format: | Float | Float | Float | Float | | |
| Value: | 80 | 100 | 30 | 0 | | |

Figure 2.8.5.6: Example to read the CIP definitions.

2.8.6 Reading the Sensor Cap Quality

In register 5472 the sensor cap quality (0-100%) is given. Hamilton recommends the replacement of the sensor cap at a value < 35 %, see chapter 2.8.3.3.

| Start register | Number of registers | Reg1 / Reg2 | Modbus function code | Read access | Write access |
|----------------|---------------------|-------------|----------------------|-------------|--------------|
| 5472 | 2 | Quality [%] | 3, 4 | U/A/S | none |

Figure 2.8.6.1: Definition of register 5472.

| | | | | | | |
|-----------------------------|-------------|-----------------------------|--|------------------|----------------|------|
| Command: Sensor cap quality | | Modbus address: 5742 | | Length: 2 | Type: 3 | Read |
| Parameter: | Quality [%] | | | | | |
| Format: | Float | | | | | |
| Value: | 100 | | | | | |

Figure 2.8.6.2: Example to read the membrane status. The sensor cap quality is 100 %.

2.9 Sensor Identification and Information

2.9.1 General Information

| Start register | Number of registers | Reg1 ... Reg8 16 ASCII characters | Example of content | Modbus function code | Read access | Write access |
|----------------|---------------------|--------------------------------------|--------------------|----------------------|-------------|--------------|
| 1024 | 8 | Userend Firmware Date | 2011-02-16 | 3, 4 | U/A/S | none |
| 1032 | 8 | Userend Firmware | ODOUM040 | 3, 4 | U/A/S | none |
| 1040 | 8 | Userend Bootloader Date | 2006-01-01 | 3, 4 | U/A/S | none |
| 1048 | 8 | Userend Bootloader | BL1UA001 | 3, 4 | U/A/S | none |
| 1056 | 8 | Userend PartNumber | 242998/04 | 3, 4 | U/A/S | none |
| 1064 | 8 | Userend SerialNumber | 9999 | 3, 4 | U/A/S | none |
| 1072 | 8 | Userend (space holder) | not available | 3, 4 | U/A/S | none |
| 1080 | 8 | Userend (space holder) | not available | 3, 4 | U/A/S | none |
| 1088 | 8 | Frontend Firmware Date | not available | 3, 4 | U/A/S | none |
| 1096 | 8 | Frontend Firmware | not available | 3, 4 | U/A/S | none |
| 1104 | 8 | Frontend Bootloader Date | not available | 3, 4 | U/A/S | none |
| 1112 | 8 | Frontend Bootloader | not available | 3, 4 | U/A/S | none |
| 1120 | 8 | Frontend PartNumber | not available | 3, 4 | U/A/S | none |
| 1128 | 8 | Frontend SerialNumber | not available | 3, 4 | U/A/S | none |
| 1136 | 8 | Frontend space holder | not available | 3, 4 | U/A/S | none |
| 1144 | 8 | Frontend space holder | not available | 3, 4 | U/A/S | none |

Figure 2.9.1.1: Definition of registers containing read-only information.

| | | | | | | |
|------------------------|-----------------|-----------------------------|--|------------------|----------------|------|
| Command: Firmware date | | Modbus address: 1032 | | Length: 8 | Type: 3 | Read |
| Parameter: | Text | | | | | |
| Format: | Character | | | | | |
| Value: | ODOUM040 | | | | | |

Figure 2.9.1.2: Example to read register 1032.

2.9.2 Sensor Identification

| Start register | Number of registers | Reg1 ... Reg8 16 ASCII characters | Example of content | Modbus function code | Read access | Write access |
|----------------|---------------------|--------------------------------------|--------------------|----------------------|-------------|--------------|
| 1280 | 8 | Part Number | 242163 | 3, 4 | U/A/S | none |
| 1288 | 8 | Sensor Name | VISIFERM DO | 3, 4 | U/A/S | none |
| 1296 | 8 | Work Order | 1354271 | 3, 4 | U/A/S | none |
| 1304 | 8 | Work Nrder Date | 2009-02-05 | 3, 4 | U/A/S | none |
| 1312 | 8 | Serial Number | 2076 | 3, 4 | U/A/S | none |
| 1320 | 8 | Manufacturer 1 | HAMILTON Bonaduz | 3, 4 | U/A/S | none |
| 1328 | 8 | Manufacturer 2 | AG Switzerland | 3, 4 | U/A/S | none |
| 1336 | 8 | Sensor Type | ARCo. DO Sensor | 3, 4 | U/A/S | none |
| 1344 | 8 | Power Supply | 007..030V 0500mW | 3, 4 | U/A/S | none |
| 1352 | 8 | Pressure | 00010..12000mBar | 3, 4 | U/A/S | none |
| 1360 | 8 | Sensor ID | 242163-2076 | 3, 4 | U/A/S | none |
| 1368 | 8 | a-length | 120 | 3, 4 | U/A/S | none |
| 1376 | 8 | (space holder) | not available | 3, 4 | U/A/S | none |
| 1384 | 8 | Electrical Connection | VP 8.0 | 3, 4 | U/A/S | none |
| 1392 | 8 | Process Connection | PG 13.5 | 3, 4 | U/A/S | none |
| 1400 | 8 | Sensing Material | FDA Membrane | 3, 4 | U/A/S | none |

Figure 2.9.2.1: Definition of registers containing read-only sensor identification.

2.9.3 Free User Memory Space

These registers can be used to store any customer specific information in the sensor. There are different registers which can be read by everybody, but only specific operators can write them.

| Start register | Number of registers | Reg1 ... Reg8 16 ASCII characters | Example of content | Modbus function code | Read access | Write access |
|----------------|---------------------|--------------------------------------|--------------------|----------------------|-------------|--------------|
| 1536 | 8 | Userspace | *FREE_USERSPACE* | 3, 4, 16 | U/A/S | U/A/S |
| 1544 | 8 | Userspace | *FREE_USERSPACE* | 3, 4, 16 | U/A/S | U/A/S |
| 1552 | 8 | Userspace | *FREE_USERSPACE* | 3, 4, 16 | U/A/S | U/A/S |
| 1560 | 8 | Userspace | *FREE_USERSPACE* | 3, 4, 16 | U/A/S | U/A/S |
| 1568 | 8 | Userspace | *FREE_USERSPACE* | 3, 4, 16 | U/A/S | A/S |
| 1576 | 8 | Userspace | *FREE_USERSPACE* | 3, 4, 16 | U/A/S | A/S |
| 1584 | 8 | Userspace | *FREE_USERSPACE* | 3, 4, 16 | U/A/S | A/S |
| 1592 | 8 | Userspace | *FREE_USERSPACE* | 3, 4, 16 | U/A/S | A/S |
| 1600 | 8 | Measuring Point | 242163-2076 | 3, 4, 16 | U/A/S | S |
| 1608 | 8 | Userspace | *FREE_USERSPACE* | 3, 4, 16 | U/A/S | S |
| 1616 | 8 | Userspace | *FREE_USERSPACE* | 3, 4, 16 | U/A/S | S |
| 1624 | 8 | Userspace | *FREE_USERSPACE* | 3, 4, 16 | U/A/S | S |
| 1632 | 8 | Userspace | *FREE_USERSPACE* | 3, 4 | U/A/S | none |
| 1640 | 8 | Userspace | *FREE_USERSPACE* | 3, 4 | U/A/S | none |
| 1648 | 8 | Userspace | *FREE_USERSPACE* | 3, 4 | U/A/S | none |
| 1656 | 8 | Userspace | *FREE_USERSPACE* | 3, 4 | U/A/S | none |
| 1664 | 8 | ext. OEM Sensor Name | *FREE_USERSPACE* | 3, 4 | U/A/S | none |
| 1672 | 8 | ext. OEM PartNumber | *FREE_USERSPACE* | 3, 4 | U/A/S | none |
| 1680 | 8 | ext. OEM Customer 1 | *FREE_USERSPACE* | 3, 4 | U/A/S | none |
| 1688 | 8 | ext. OEM Customer 2 | *FREE_USERSPACE* | 3, 4 | U/A/S | none |
| 1696 | 8 | Userspace | *FREE_USERSPACE* | 3, 4 | U/A/S | none |
| 1704 | 8 | Userspace | *FREE_USERSPACE* | 3, 4 | U/A/S | none |
| 1712 | 8 | Userspace | *FREE_USERSPACE* | 3, 4 | U/A/S | none |
| 1720 | 8 | Userspace | *FREE_USERSPACE* | 3, 4 | U/A/S | none |
| 1728 | 8 | Userspace | *FREE_USERSPACE* | 3, 4 | U/A/S | none |
| 1736 | 8 | Userspace | *FREE_USERSPACE* | 3, 4 | U/A/S | none |
| 1744 | 8 | Userspace | *FREE_USERSPACE* | 3, 4 | U/A/S | none |
| 1752 | 8 | Userspace | *FREE_USERSPACE* | 3, 4 | U/A/S | none |

Figure 2.9.3.1: Definition of registers containing user information.

An important register is 1600, as it is the description of the measuring point. The information of this register is displayed on the ARC View Handheld in order to identify individual sensors.



Attention:

The Free User Memory Space is located in memory which allows in total max 10'000 write operations.

| | | | | | | |
|--------------------|--------------------|-----------------------------|--|------------------|-----------------|-------|
| Command: Info user | | Modbus address: 1568 | | Length: 8 | Type: 16 | Write |
| Parameter: | Text | | | | | |
| Format: | Character | | | | | |
| Value: | Hello World | | | | | |

Figure 2.9.3.2: Example to write 16 ASCII characters to register 1568 with operator A or S.

| | | | | | | |
|--------------------|--------------------|-----------------------------|--|------------------|----------------|------|
| Command: Info user | | Modbus address: 1568 | | Length: 8 | Type: 3 | Read |
| Parameter: | Text | | | | | |
| Format: | Character | | | | | |
| Value: | Hello World | | | | | |

Figure 2.9.3.3: Example to read the register 1568, which text has been written in figure 2.9.3.2.

2.10 System Commands

2.10.1 Recall Sensor's Factory Settings

Using register 8192 you can recall the sensor manufacturer values (interfaces, calibration data and passwords), except the SIP and CIP data which remain unchanged. By sending the recall value "732255", all configuration values will be set to default.

| Start register | Number of registers | Reg1 / Reg2 | Modbus function code | Read access | Write access |
|----------------|---------------------|------------------------|----------------------|-------------|--------------|
| 8192 | 2 | Recall by value 732255 | 16 | none | S |

Figure 2.10.1.1: Definition of register 8192.

| | | | | | | |
|-----------------|---------------|-----------------------------|--|------------------|-----------------|-------|
| Command: Recall | | Modbus address: 8192 | | Length: 2 | Type: 16 | Write |
| Parameter: | Recall | | | | | |
| Format: | Decimal | | | | | |
| Value: | 732255 | | | | | |

Figure 2.10.1.2: Example to write the restore command.

3 Abbreviations

| | |
|-----|----------------------------------|
| AO | Analog Output Interface |
| DO | Dissolved Oxygen |
| CP | Calibration Point |
| ECS | Electrochemical Sensor Interface |
| PA | Parameter |
| PMC | Primary Measurement Channel |
| SMC | Secondary Measurement Channel |
| MC | Measurement Channel |
| SIP | Sterilization In Place |
| CIP | Cleaning In Place |



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