**HAMILT⊕N**®

# VisiFerm™ DO SU

# Modbus RTU
# Programmer's Manual

Firmware version:
# ODOUM074

**Important Notice**

| Rev. | Revision Date | Author | Change Description |
|------|---------------|--------|--------------------|
| 00 | 02.07.2018 | CS | Initial version ODOUM070 |
| 01 | 11.08.2020 | GRi | Update to version ODOUM073 |
| 02 | 10.09.2021 | MBa | Update to version ODOUM074 |

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# Table of Content

# 1    Modbus RTU General Information

## 1.1    Introduction

This document describes in detail the VisiFerm DO SU Modbus RTU interface. It is addressed to software programmers.

The general information about Modbus command structures and its implementation in the Hamilton Arc product family is described in detail in Chapter 1 of the

**"VisiFerm DO Modbus RTU Programmer's Manual"** (Ref 624179).

If you need this general information about Modbus programming, then please consult Ref 624179.

In the present manual, only the specific command structure for the VisiFerm DO SU is described. It is valid beginning with firmware version:

ODOUM070

Please check the firmware version by reading register 1032.

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

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# 2    VisiFerm DO SU Commands in Modbus RTU

## 2.1    General

In order to communicate with a VisiFerm DO SU 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 Organization (www.modbus.org/tech.php) provides other links to a wide variety of Modbus terminal software.

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 SU 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.

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| 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, "VisiFerm DO Modbus RTU Programmer's Manual" (Ref 624179)).


## 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:
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)

### 2.4.1 Available Analog Interfaces

VisiFerm DO SU 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, Conducell Arc Sensors, Conducell PW Arc Sensors, EDO Arc Sensors and ORP Arc Sensors which have AO1 and AO2, VisiFerm DO SU Sensorsonly have AO1 !

### 2.4.2 Description of the Analog Interface 1

VisiFerm DO SU has one single physical analog output interface (AO1) that can be used  as a 4-20 mA standard interface.

⚠ Attention:
VisiFerm DO SU has no ECS!

Reading the description of the analog interface:

| Start register | Number of registers | Reg1 to 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-Interface** | | | | |

Figure 2.4.2.2: Example to read the description of the analog output interface AO1. It is "mA--Interface".

### 2.4.3 Selection of an Analog Interface Mode

With register 4322, the available analog interface modes for AO1 are defined.

| 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 SU** | Description |
|---|---|---|
| 0x0000 | 4-20 mA inactive | Analog interface deactivated |
| 0x0001 | 4-20 mA fixed | Set to a constant output value for current loop testing |
| 0x0002 | 4-20 mA linear | Linear output of measurement (PMC1 / 6) |
| 0x0004 | 4-20 mA bilinear | Bilinear output of measurement(PMC1 / 6) |

Figure 2.4.3.2: Definition of the analog interface modes (see Figure 2.4.4.6.3 and Figure 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 | |
| Format: | Hex | Hex | Hex | Hex | |
| Value: | **0x0007** | **0x0** | **0x0** | **0x0** | |

Figure 2.4.3.3: Example to read register 4322 with VisiFerm DO SU. The return value of this Modbus register is 0x0007, all modes defined in Figure 2.4.3.2 are available..

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:
VisiFerm DO SU has no ECS (in contrast to VisiFerm DO)!

## 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.

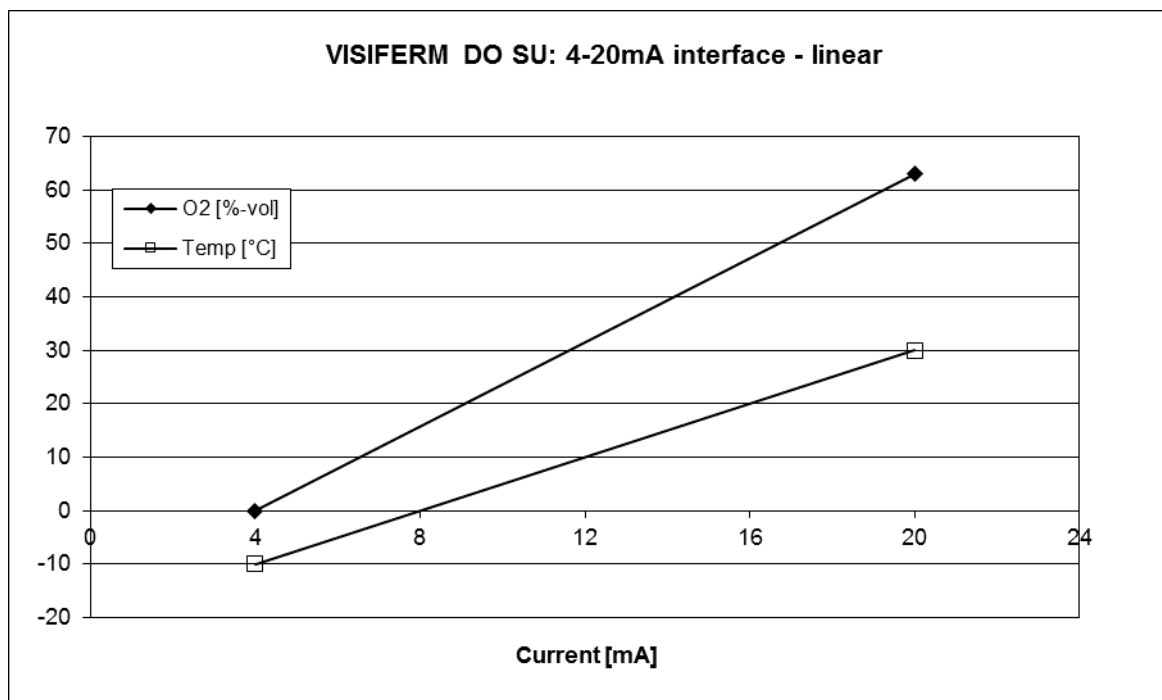| Current | Oxygen | Temperature |
|---------|--------|-------------|
| 4 mA | 0 %-vol | -10°C |
| 20 mA | 62.85 %-vol | +30°C |
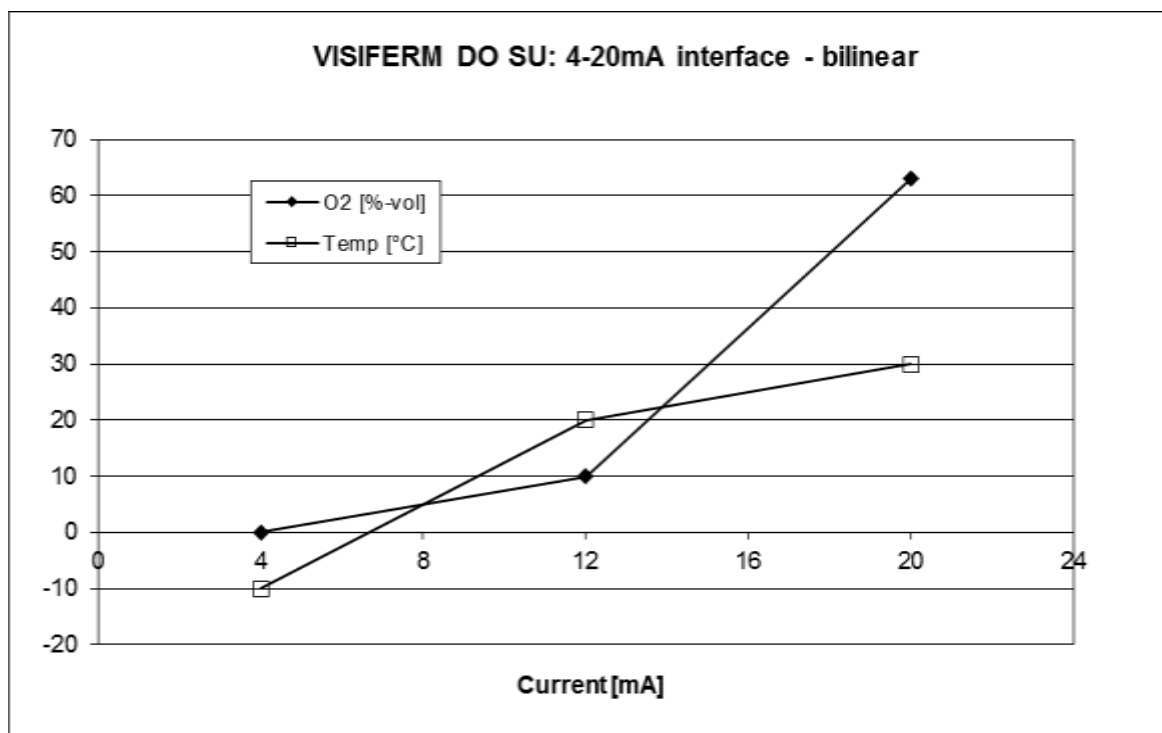


Figure 2.4.4.6.4: Example of bilinear 4-20 mA output characteristics for Oxygen or Temperature.

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

⚠ 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.

The 4-20 mA analog output freezes if

- the measurement interval (PA13) is equal to zero.
  or
- the current temperature is outside the user defined measurement temperature range (reg. 4624).

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 DO SU 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 |
| | | not available |
| 16 | 0x010000 | Warning continuous output |
| | | 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.

The default settings are:
Code 0x01, current "warnings" 3.5 mA, current "errors" 3.5 mA and current "T exceed" 3.5 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: | **0x010001** | **3.5** | **3.5** | **3.5** |

Figure 2.4.4.8.3: Example: Read the settings for the 4-20mA interface in case of warnings and errors. Warning code 0x010001 corresponds to the continuous output current warning mode (code 0x010000) and continuous output current "error" (code 0x01) of 3.5 mA. The output current "Temperature exceed" is 3.5 mA.

## 2.4.5  Reading the Internally Measured Output Current

Reg. 4414 provides internal parameters of the analog output interface AO1:
- 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] | Internally measured current AO1 [mA] | 3, 4 | U/A/S | none |

Figure 2.4.5.1: Definition of register 4414.

| Command: Int. values AO1 | | Modbus address: **4414** | Length: **4** | Type: **3** | Read |
|---|---|---|---|---|---|
| Parameter: | Set point [mA] | Internally measured [mA] | | | |
| Format: | Float | Float | | | |
| Value: | **9.99186** | **9.99742** | | | |

Figure 2.4.5.2: Example to read the internal values AO1, depending on the analog interface mode.

## 2.5 Measurement

### 2.5.1 Definition of Measurement Channels and Physical Units

The VisiFerm DO SU 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 SU |
|---|---|---|---|
| **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 |
| | | … | 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 DOSU 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 to 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.

### 2.5.2.3   Reading the measurement value of PMC1

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

| Start reg. | Num-ber of reg. | Reg1 / Reg2 | Reg3 / Reg4 | Reg5 / Reg6 | Reg7 / Reg8 | Reg9 / Reg10 | Modbus function code | Read access | Write access |
|---|---|---|---|---|---|---|---|---|---|
| 2090 | 10 | Selected physical unit | Measure-ment value of PMC1 [1] | Measure-ment 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.

If no ODO Cap is mounted, the primary measurement value PMC1 is automatically set to a value of -999.

## 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 to 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. | Num-ber of reg. | Reg1 / Reg2 | Reg3 / Reg4 | Reg5 / Reg6 | Reg7 / Reg8 | Reg9 / Reg10 | Modbus function code | Read access | Write access |
|---|---|---|---|---|---|---|---|---|---|
| 2410 | 10 | Selected physical unit | Measure-ment value of PMC6 [1] | Measure-ment 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** | **-0** | **60** | |

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 0 (°C), Max allowed value is 60 (°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.

If no ODO Cap is mounted, the primary measurement value PMC6 is automatically set to a value of -999.

**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 SU.

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 user defined measurement temperature 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 SU |
|---|---|---|---|
| **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** | **Minimum number of sub-measurements in the automatic mode** |
| 11 | 0x0800 | PA12 | not available |
| **12** | **0x1000** | **PA13** | **Measurement interval** |
| **13** | **0x2000** | **PA14** | **Sensor cap part number** |
| 14 | 0x4000 | PA15 | not available |
| 15 (MSB) | 0x8000 | PA16 | not available |

Figure 2.6.1.2: Bitwise definition of all parameters PA1 to PA16, valid for VisiFerm DO SU.

| Command: Available parameters | | Modbus address: **3072** | Length: **2** | Type: **3** | Read |
|---|---|---|---|---|---|
| Parameter: | Measurement parameters | | | | |
| Format: | Hex | | | | |
| Value: | **0x3703** | | | | |

Figure 2.6.1.3: Example to read the available Parameters with operator level S. The hex value 0x3703 corresponds to 0x0001 (PA1) + 0x0002 (PA2) + 0x0100 (PA9) + 0x0200 (PA10) + 0x0400 (PA11) + 0x1000 (PA13) + 0x2000 (PA14).

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 SU 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 SU 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.
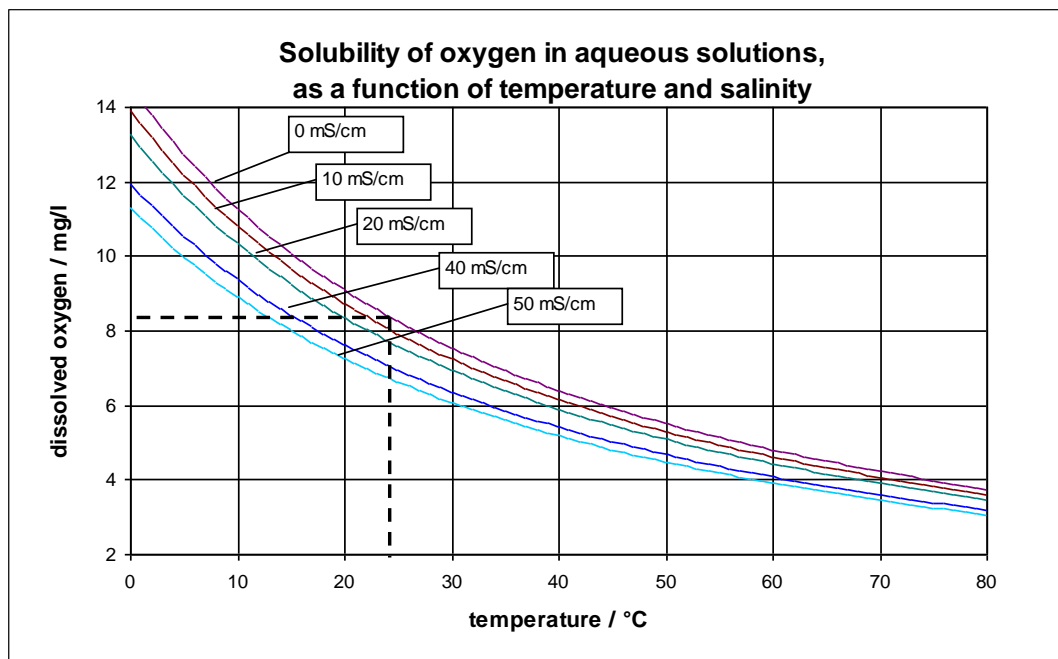


Figure 2.6.2.1: Solubility of oxygen as a function of temperature and salinity, in air saturated aqueous solution. Temperature range is from 0-85 °C. Salinity can be entered from 0-50 mS/cm.

### 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 to 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".

**HAMILT⊕N**

### 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 SU 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.
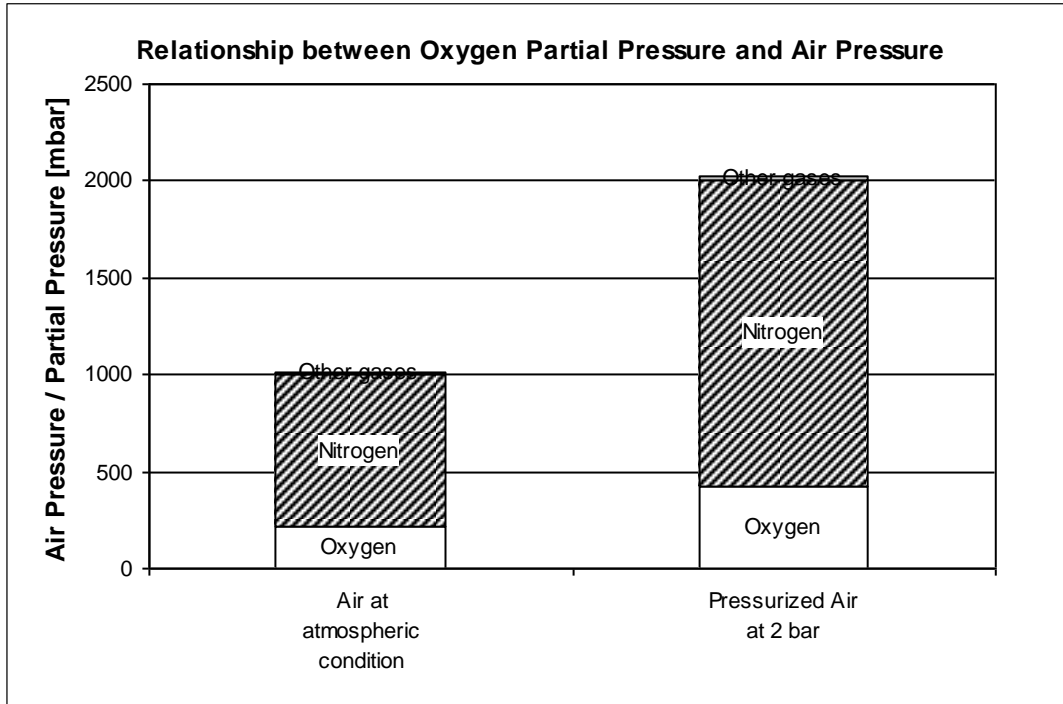


Figure 2.6.3.1: Influence of air pressure on the partial pressure of oxygen. Doubling the air pressure also doubles the oxygen partial pressure.

### 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 to 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 SU calculates new oxygen readings with a measurement interval defined in PA13. One has the possibility to smoothen the oxygen reading (PMC1) by means of a moving average.
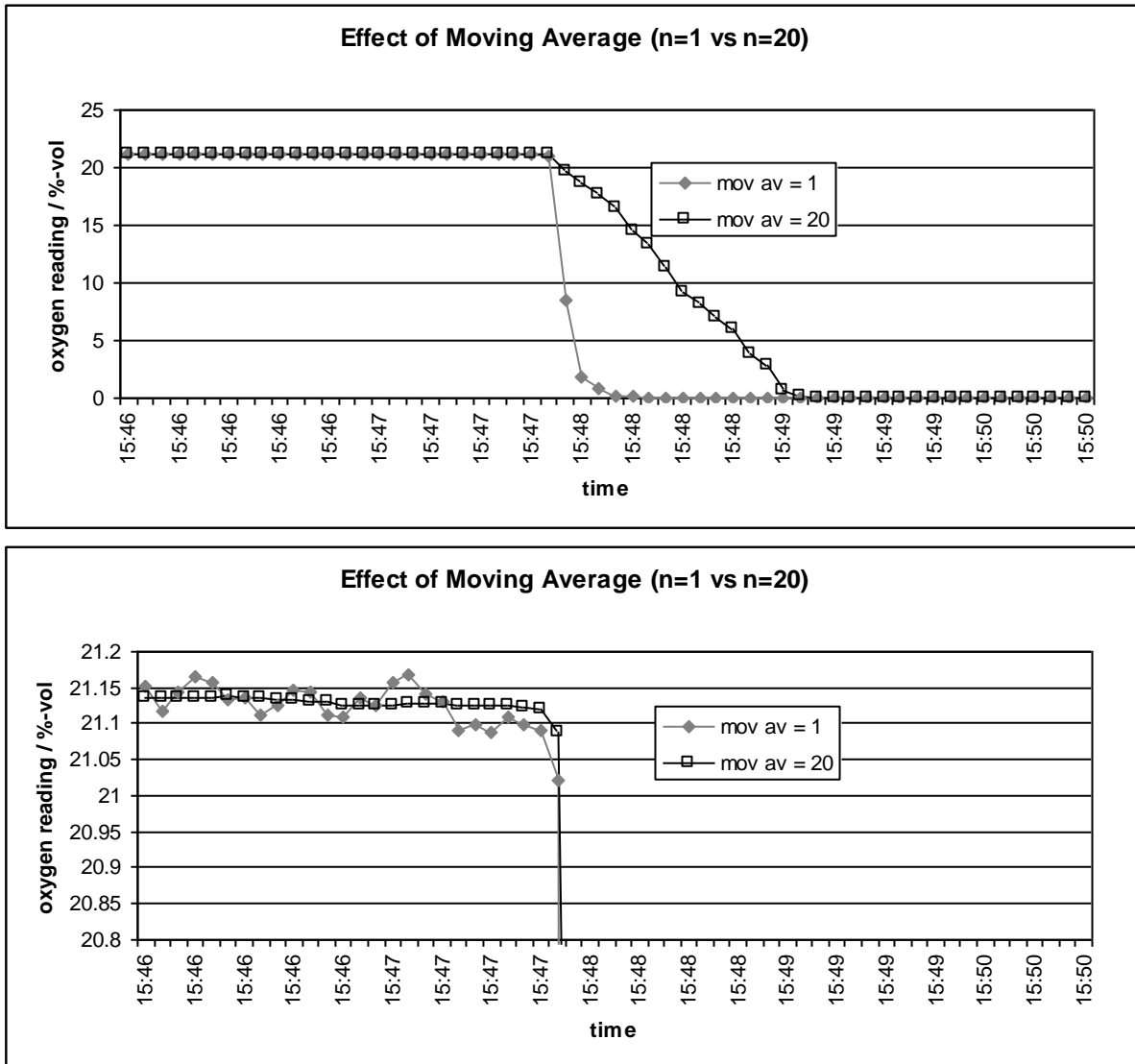


Figure 2.6.4.1: Comparison of the response of VisiFerm DO SU to a change from air to zero oxygen, using no moving average (n=1) or a moving average over 20 readings (PA13 = 3s).

Using moving average, the short term signal stability can be improved; on the other hand, the response time of the sensor increases with increasing moving average. A moving average over 20 samples results in a response time of at least 20 times the measurement interval defined in PA13.

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 to 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 30 times the value of the measurement interval.

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 value of VisiFerm DO SU in each measurement interval is on itself an average over 16 (or less) individual sub-measurements. With PA10, the number of sub-measurements can be set between 1 and 16, where 0 activates the automatic mode. The advantage of using a smaller amount of sub-measurements is a shorter exposure of the luminophore to the excitation light. Photo bleaching of the luminophore will be reduced. The disadvantage is a reduced signal quality.

In case of a measurement interval (PA13) of 1 or 2 seconds, the resolution has a maximum of 3 sub-measurements. The number of sub-measurements will be automatically set if the measurement interval is set to 1 or 2 seconds and the resolution was greater than 3.
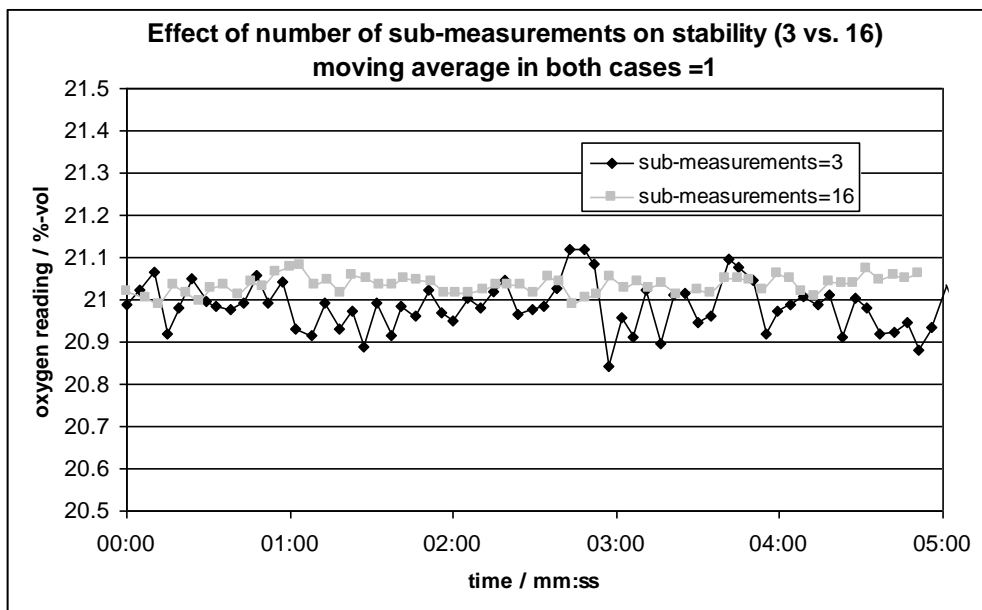


Figure 2.6.5.1: Comparison of the signal stability of VisiFerm DO SU when using number of sub-measurements = 16 or number of sub-measurements = 3.

### 2.6.5.1 Description of PA10 (Number of Sub-Measurements)

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

| Start register | Number of registers | Reg1 to 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 for the number of sub-measurements will be activated, where the sensor continuously adjusts the value between the limits defined by PA11 (lower limit) and 16 (upper limit).

| 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, PA11-16; default: 0) | 16 | none | S |

Figure 2.6.5.2.3: Definition of register 3402. Only one bit for the physical unit can be set and the value: 0 = auto, 1-16 = 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** | **1** | **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 1 to 16.

Note:

The limits for the minimum number of sub-measurements (PA11) in dependency of the measurement interval (PA13):

| | PA13 < 3 | PA13 ≥ 3 |
|---|---|---|
| Fixed mode | 1 to 3 | 1 to 16 |
| Automatic mode | PA11 to 3 | PA11 to 16 |

⚠ Attention:

If PA13 (Measurement Interval) is set to one or two, PA10 (Number of sub-measurements) will be limited from one to three.

### 2.6.6   PA11: Minimum Number of Sub Measurements in the Automatic Mode

If PA10 is set to 0, i.e. the number of sub-measurements is set to auto, this parameter (PA11) defines the lower limit for the number of sub-measurements in the automatic mode. A value of 3 is the factory setting.
With a high value on this parameter, the measurement is more precise but the luminophore has more degeneration. With a low value, the measurement is more imprecise but the life expectancy is higher.
In case the measurement interval is set to 1 or 2 seconds, this parameter is limited to 1 to 3. If previously a value greater than 3 is active, the parameter will be reset to 3. If the previous value is between 1 and 3, this parameter keeps its value.

#### 2.6.6.1   Description of PA11 (Minimum Number of Sub-Measurements for Automatic Mode)

In register 3424, a plain text ASCII description of PA11 is given.

| Start register | Number of registers | Reg1 to Reg8<br>16 ASCII characters | Modbus function code | Read access | Write access |
|---|---|---|---|---|---|
| 3424 | 8 | Description of PA11 | 3, 4 | U/A/S | none |

Figure 2.6.6.1.1: Definition of register 3424.

| Command: Min auto resol. text | | Modbus address: **3424** | Length: **8** | Type: **3** | Read |
|---|---|---|---|---|---|
| Parameter: | Text | | | | |
| Format: | Character | | | | |
| Value: | **Min auto resol.** | | | | |

Figure 2.6.6.1.2: Example to read the description. It is "Min auto resol. ".

#### 2.6.6.2   Selecting the Physical Unit and Writing the Value for PA11

In register 3432, the available physical units for PA11 are defined.

| Start register | Number of registers | Reg1 / Reg2<br>(bitwise defined) | Modbus function code | Read access | Write access |
|---|---|---|---|---|---|
| 3432 | 2 | Available physical units for PA11 | 3, 4 | U/A/S | none |

Figure 2.6.6.2.1: Definition of register 3432.

| Command:Min resol. available units | | Modbus address: **3432** | Length: **2** | Type: **3** | Read |
|---|---|---|---|---|---|
| Parameter: | Units | | | | |
| Format: | Hex | | | | |
| Value: | **0x01** | | | | |

Figure 2.6.6.2.2: Example to read the available physical units for PA11. The only one available here is "none" (0x01). For the definition of the physical units see chapter 2.5.1.

By writing to register 3434, the active physical unit of PA11 can be selected, by choosing one of the physical units that are defined in register 3432. Also the value of the parameter can be set.

| Start register | Number of registers | Reg1 / Reg2 (bitwise defined) | Reg3 / Reg4 | Modbus function code | Read access | Write access |
|---|---|---|---|---|---|---|
| 3434 | 4 | Select physical unit for PA11 | Value for PA11 (0, 1-16; default: 3) | 16 | none | S |

Figure 2.6.6.2.3: Definition of register 3434. Only one bit for the physical unit can be set and the value: 1-16.

| Command: Min auto resol. | | Modbus address: **3434** | Length: **4** | Type: **16** | Write |
|---|---|---|---|---|---|
| Parameter: | Unit | Value | | | |
| Format: | Hex | Decimal | | | |
| Value: | **0x01** | **4** | | | |

Figure 2.6.6.2.4: Example to set the physical unit of PA11 to "none" (0x01) and the value for the minimum number of sub-measurements in the automatic mode to 4.

### 2.6.6.3  Reading all Values for PA11

By reading register 3434, the active physical unit, the selected value, and the min and max values can be read.

| Start register | Number of registers | Reg1 / Reg2 | Reg3 / Reg4 | Reg5 / Reg6 | Reg7 / Reg8 | Modbus function code | Read access | Write access |
|---|---|---|---|---|---|---|---|---|
| 3434 | 8 | Physical unit | Current value | Min value | Max value | 3, 4 | U/A/S | none |

Figure 2.6.6.3.1: Definition of register 3434.

| Command: Sub-Measurements | | Modbus address: **3434** | Length: **8** | Type: **3** | Read |
|---|---|---|---|---|---|
| Parameter: | Unit | Value | Min value | Max value | |
| Format: | Hex | Decimal | Decimal | Decimal | |
| Value: | **0x01** | **4** | **1** | **16** | |

Figure 2.6.6.3.2: Example to read PA11. The physical unit is 0x01 ("none"), the value is 4.

⚠ Attention:
If PA13 (Measurement Interval) is set to one or two, PA11 (Minimum number of sub-measurements in the automatic mode) will be limited from one to three.

## 2.6.7   PA13: Measurement Interval

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

Note:
1) When using the brewery mode, the measurement interval is limited between 3 and 60 s.
2) When a CP1/CP2 calibration is initiated and the current measurement interval is greater than 3s or equals 0s, the measurement interval is temporarily set to 3s. The measurement interval is automatically reset to the original value 10 min after the last calibration command, or after power up. See chapter 2.7.3 for more details.
3) When a CP6 calibration is performed, the measurement interval is not changed by the sensor. If the measurement interval is 0 s, initial measurement on CP6 will not be executed as the DO measurement is not running.

### 2.6.7.1   Description of PA13 (Measurement Interval)

In register 3488, a plain text ASCII description of PA13 is given.

| Start register | Number of registers | Reg1 to Reg8 16 ASCII characters | Modbus function code | Read access | Write access |
|---|---|---|---|---|---|
| 3488 | 8 | Description of PA13 | 3, 4 | U/A/S | none |

Figure 2.6.7.1.1: Definition of register 3488.

| Command: Meas. interval | | Modbus address: **3488** | Length: **8** | Type: **3** | Read |
|---|---|---|---|---|---|
| Parameter: | Text | | | | |
| Format: | Character | | | | |
| Value: | **Meas. interval** | | | | |

Figure 2.6.7.1.2: Example to read the description. It is "Meas. interval ".

### 2.6.7.2   Selecting the Physical Unit and Writing the Value for PA13

In register 3496, the available physical units for PA13 are defined.

| Start register | Number of registers | Reg1 / Reg2 (bitwise defined) | Modbus function code | Read access | Write access |
|---|---|---|---|---|---|
| 3496 | 2 | Available physical units for PA13 | 3, 4 | U/A/S | none |

Figure 2.6.7.2.1: Definition of register 3496.

| Command:Meas. Int. available units | | Modbus address: **3496** | Length: **2** | Type: **3** | Read |
|---|---|---|---|---|---|
| Parameter: | Units | | | | |
| Format: | Hex | | | | |
| Value: | **0x01** | | | | |

Figure 2.6.7.2.2: Example to read the available physical units for PA13. The only one available here is "none" (0x01). For the definition of the physical units see chapter 2.5.1.

By writing to register 3498, the active physical unit of PA13 can be selected, by choosing one of the physical units that are defined in register 3496. Also the value of the parameter can be set.

| Start register | Number of registers | Reg1 / Reg2 (bitwise defined) | Reg3 / Reg4 | Modbus function code | Read access | Write access |
|---|---|---|---|---|---|---|
| 3498 | 4 | Select physical unit for PA13 | Value for PA13 (0-300; default: 3) | 16 | none | S |

Figure 2.6.7.2.3: Definition of register 3496. Only one bit for the physical unit can be set and the value: 0-300.

| Command: Meas. Interval | | Modbus address: **3498** | Length: **4** | Type: **16** | Write |
|---|---|---|---|---|---|
| Parameter: | Unit | Value | | | |
| Format: | Hex | Decimal | | | |
| Value: | **0x01** | **30** | | | |

Figure 2.6.7.2.4: Example to set the physical unit of PA13 to "none" (0x01) and the measurement interval to 30.

### 2.6.7.3    Reading all Values for PA13

By reading register 3498, the active physical unit, the selected value, and the min and max values can be read.

| Start register | Number of registers | Reg1 / Reg2 | Reg3 / Reg4 | Reg5 / Reg6 | Reg7 / Reg8 | Modbus function code | Read access | Write access |
|---|---|---|---|---|---|---|---|---|
| 3498 | 8 | Physical unit | Current value | Min value | Max value | 3, 4 | U/A/S | none |

Figure 2.6.7.3.1: Definition of register 3498.

| Command: Meas. Interval | | Modbus address: **3498** | Length: **8** | Type: **3** | Read |
|---|---|---|---|---|---|
| Parameter: | Unit | Value | Min value | Max value | |
| Format: | Hex | Decimal | Decimal | Decimal | |
| Value: | **0x01** | **30** | **0** | **300** | |

Figure 2.6.7.3.2: Example to read PA13. The physical unit is 0x01 ("none"), and the measurement interval is 30 seconds.

⚠️  Attention:

Setting PA13 to 0 deactivates DO reading completely. Temperature readings are still active. Bit 31 of "Warning Measurement" is set which means "Measurement not running".
The DO value is frozen on the analog and digital output.

Note:
If the measurement interval is set to 1s or 2s, the current values of PA10 and PA11 are overwritten to 3 if the values were greater than 3.
If the measurement interval is set to a value greater than 2s, PA10 and PA11 remain unchanged.

## 2.6.8   PA14: Sensor Cap Part Number

The VisiFerm DO SU can be used with different sensor cap types. Each sensor cap type has its specific measurement characteristics. The measurement parameter PA14 allows configuring the sensor cap type used by entering the corresponding part number which can be found engraved on the sensor cap.

### 2.6.8.1   Description of PA14 (Sensor Cap Part Number)

In register 3488, a plain text ASCII description of PA14 is given.

| Start register | Number of registers | Reg1 to Reg8 16 ASCII characters | Modbus function code | Read access | Write access |
|---|---|---|---|---|---|
| 3520 | 8 | Description of PA14 | 3, 4 | U/A/S | none |

Figure 2.6.8.1.1: Definition of register 3488.

| Command: SensorCap PartNr | | Modbus address: **3520** | Length: **8** | Type: **3** | Read |
|---|---|---|---|---|---|
| Parameter: | Text | | | | |
| Format: | Character | | | | |
| Value: | **SensorCap PartNr** | | | | |

Figure 2.6.8.1.2: Example to read the description. It is "SensorCap PartNr".

### 2.6.8.2   Selecting the Physical Unit and Writing the Value for PA14

In register 3528, the available physical units for PA14 are defined.

| Start register | Number of registers | Reg1 / Reg2 (bitwise defined) | Modbus function code | Read access | Write access |
|---|---|---|---|---|---|
| 3528 | 2 | Available physical units for PA14 | 3, 4 | U/A/S | none |

Figure 2.6.8.2.1: Definition of register 3528.

| Command: SensorCap PartNr available units | | Modbus address: **3528** | Length: **2** | Type: **3** | Read |
|---|---|---|---|---|---|
| Parameter: | Units | | | | |
| Format: | Hex | | | | |
| Value: | **0x01** | | | | |

Figure 2.6.8.2.2: Example to read the available physical units for PA14. The only one available here is "none" (0x01). For the definition of the physical units see chapter 2.5.1.

By writing to register 3530, the active physical unit of PA14 can be selected, by choosing one of the physical units that are defined in register 3528. Also the value of the parameter can be set. Only valid sensor cap part numbers are accepted by the sensor.

By default the following sensor cap part numbers are defined:
243461: ODO Cap S0

| Start register | Number of registers | Reg1 / Reg2 (bitwise defined) | Reg3 / Reg4 | Modbus function code | Read access | Write access |
|---|---|---|---|---|---|---|
| 3530 | 4 | Select physical unit for PA14 | Value for PA14 (0-1000000; default: 243461) | 16 | none | S |

Figure 2.6.8.2.3: Definition of register 3530. Only one bit for the physical unit can be set and the value: 0-1000000. Only valid sensor cap part numbers are accepted by the sensor.

| Command: SensorCap PartNr | | Modbus address: **3530** | Length: **4** | Type: **16** | Write |
|---|---|---|---|---|---|
| Parameter: | Unit | Value | | | |
| Format: | Hex | Decimal | | | |
| Value: | **0x01** | **243461** | | | |

Figure 2.6.8.2.4: Example to set the physical unit of PA14 to "none" (0x01) and the sensor cap part number to 243461.

### 2.6.8.3    Reading all Values for PA14

By reading register 3530, the active physical unit, the selected value, and the min and max values can be read.

| Start register | Number of registers | Reg1 / Reg2 | Reg3 / Reg4 | Reg5 / Reg6 | Reg7 / Reg8 | Modbus function code | Read access | Write access |
|---|---|---|---|---|---|---|---|---|
| 3530 | 8 | Physical unit | Current value | Min value | Max value | 3, 4 | U/A/S | none |

Figure 2.6.8.3.1: Definition of register 3530.

| Command: SensorCap PartNr | | Modbus address: **3530** | Length: **8** | Type: **3** | Read |
|---|---|---|---|---|---|
| Parameter: | Unit | Value | Min value | Max value | |
| Format: | Hex | Decimal | Decimal | Decimal | |
| Value: | **0x01** | **243461** | **0** | **1000000** | |

Figure 2.6.8.3.2: Example to read PA14. The physical unit is 0x01 ("none"), and the sensor cap part number is 243461.

## 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 SU |
|---|---|---|---|
| 0 (LSB) | 0x01 | CP1 | not available |
| 1 | 0x02 | CP2 | not available |
| 2 | 0x04 | CP3 | not available |
| 3 | 0x08 | CP4 | not available |
| 4 | 0x10 | CP5 | not available |
| **5** | **0x20** | **CP6** | **Product calibration** |
| 6 | 0x40 | 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: | **0x20** | | | |

Figure 2.7.1.3: Example to read the available CPs. 0x20 (CP6).

### 2.7.2  Definitions of Calibration Points

#### 2.7.2.1  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 during initial measurement 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 2.7.2.1.1: 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 2.7.2.1.2: Example to read the limits of CP6. The physical unit of the limits is the unit of PMC1 at the time of initial measurement. In this example it 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 not be updated to the new physical unit. Temperature, atmospheric pressure and salinity are compensated.

## 2.7.3 Calibration Procedure

The standard calibration routine for oxygen sensors is based upon on the relationship between phase at zero oxygen and Stern-Volmer coefficient:
- phase at zero oxygen (at reference temperature, +25°C)
- Stern-Volmer coefficient (at reference temperature, +25°C)
- reference temperature, 298.15K (fixed value).

These calibration coefficients has to be programmed into VisFerm DO SU. If not, a warning bit "Verify / Set Calibration Data" is indicating this calibration status.

As long, this warning bit is active no product calibration is possible.
An active product calibration is deactivated automatically, when a new and valid set of calibration coefficients are entered into VisFerm DO SU.

More or detailed information regarding entering the calibration coefficients and the behavior of the VisiFerm DO SU can be found in chapter 2.7.8.

### 2.7.3.1 Calibration Point 6 (Product Calibration)

The product calibration is a process in order to adjust the measurement of a correctly calibrated VisiFerm DO SU to specific process conditions. As previous mentioned, the correct calibration coefficients has to be programmed before (the warning bit "Verify / Set Calibration Data" is deactivated), otherwise no product calibration is possible.

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 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 SU is still running on its prior entered calibration coefficient while the initial measurement data for the ongoing product calibration is kept in the VisiFerm DO SU's 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 SU.

   The VisiFerm DO SU 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 prior entered calibration coefficient.

If a product calibration is still active and new calibration coefficients are enter into the VisiFerm DO SU 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 SU is still running on the first product calibration (old CP6) until a valid assignment has been done (new CP6).

What happens to the calibration function upon product calibration (CP6)?
The product calibration changes the Stern-Volmer coefficient of the calibration function.
For more flexibility the product calibration procedure allows a deviation of the Stern-Volmer coefficient of ±40 %. from the entered calibration coefficients.
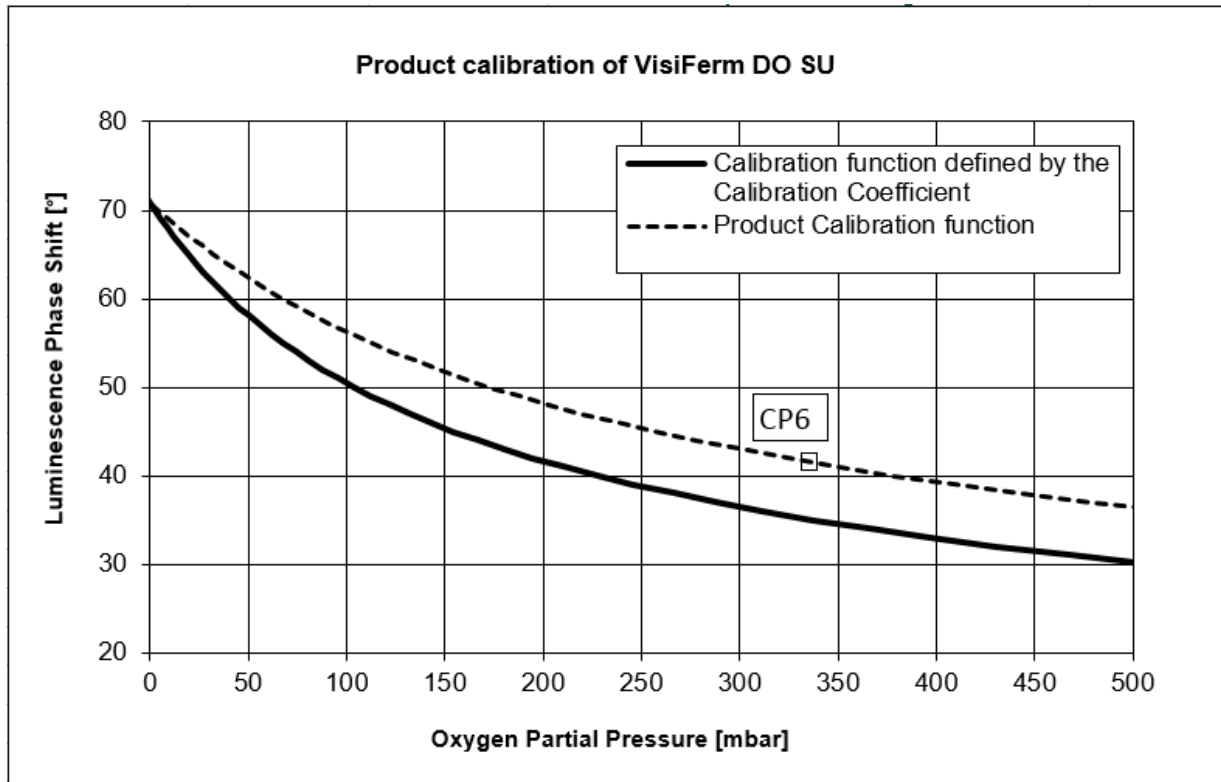
Figure 2.7.3.1.1: Effect of the product calibration CP6 on an existing standard calibration function defined by the calibration coefficients.

The calibration function is described by two parameters: the phase at zero oxygen and the Stern-Volmer coefficient (these two values can be read in register 5448, see chapter 2.7.8).
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 Stern-Volmer coefficient. The phase at zero oxygen remains unchanged. ,

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 SU measurement range.
- the oxygen content is within the calibration limits defined for CP6 (see above)
- the parameters for the product calibration are in the following range:
  - the phase at zero oxygen remains the same
  - the Stern-Volmer coefficient does not deviate from the one defined prior the product calibration by more than ±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 2.7.3.1.2: 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 2.7.3.1.2 | 3, 4, 16 | A/S | A/S |

Figure 2.7.3.1.3: Definition of register 5340

### 2.7.3.1.1   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 2.7.3.1.1.1: 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: Initial measurement" (0x08000000) (see Figure 2.7.4.1.1).
The sensor continues measuring using the prior stored calibration coefficients.

Note:
If the measurement interval is equal to 0, the initial measurement command has no effect.

### 2.7.3.1.2   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 unit of PMC1 during initial measurement (floating) | 16 | none | A/S |

Figure 2.7.3.1.2.1: Definition of register 5322

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

Figure 2.7.3.1.2.2: Example to assign a calibration value to the above performed initial measurement. This is achieved by writing the correct oxygen value in the unit of PMC1 during initial measurement (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 2.7.4.1.1).

### 2.7.3.1.3   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 2.7.3.1.3.1: 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 stored calibration coefficients.

The sensor's calibration status will be reading 0x00 again (see Figure 2.7.4.1.1).

**2.7.3.1.4   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 2.7.3.1.4.1: 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 stored calibration coefficients.
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 2.7.4.1.1).

**2.7.3.1.5   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 2.7.4.1.1), 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 2.7.3.1.5.1: 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 2.7.4.1.1) 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 CP6

A product calibration is not always successful. In order to analyze what has gone wrong, the calibration status register 5318 can be read.

| Bit # | Hex value | Definition in VisiFerm DO |
|---|---|---|
| 0 (LSB) | 0x00000001 | not available |
| … | | 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 |
| … | | not available |
| 31 | 0x80000000 | not available |

Figure 2.7.4.1.1: Definition of the status for register 5318  (see also Figure 2.7.4.2.1).

### 2.7.4.2   Reading the Calibration Status of CP6 (Product Calibration)

The calibration status and the current state of the VisiFerm DO SU 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.

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### 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 stored calibration coefficients.

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 stored calibration coefficients 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 stored calibration coefficients.

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 prior stored calibration coefficients 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 prior stored calibration coefficients 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) based on the calibration coefficients.
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 register 5324 (CP6) the currently active calibration parameters part 1 are stored. This register contains 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 |
|---|---|---|---|---|---|---|---|---|
| 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 5324 for CP6.

Note: the "operating hour" for CP6 is the moment of the "initial measurement".

| 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 2.7.5.2: 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 CP6 is 12 and the operating hour is 379.51 (h).

## 2.7.6  Currently active Calibration Parameters part 2

In register 5332 (CP6) the current calibration parameters part 2 are stored. This register 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 |
|---|---|---|---|---|---|---|---|---|
| 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 5332 for CP6.

| Command: Calibration CP6 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** | **0** | |

Figure 2.7.6.2: 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 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 |
|---|---|---|---|---|---|---|---|---|
| 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 5560.

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

Figure 2.7.7.2: 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 Currently active Calibration Parameters part 4

The PMC1 (DO) calibration coefficient values can be read and written with register 5448.
By entering the calibration coefficient values into the VisiFerm DO SU via register 5448, the module returns an indication:

1.) Calibration coefficients are valid (within the limits):
The VisiFerm DO SU will immediately use new calibration coefficients for the measurement. Furthermore, the status bit "Verify / Set Calibration Data" and an active product calibration are accordingly cancelled.

2.) Calibration coefficients are invalid in case that,
   i. the calibration coefficients are out of limits,
   ii. no ODO cap is detected by the VisiFerm DO SU or
   iii. a power up of the VisiFerm DO SU was performed.
   Furthermore, the prior valid calibration coefficients inside the VisiFerm DO SU used for the measurement and the warning bit "Verify / Set Calibration Data" is immediately activated.

| Start register | Number of registers | Reg1 / Reg2 | Reg3 / Reg4 | Reg5 / Reg6 | Modbus function code | Read access | Write access |
|---|---|---|---|---|---|---|---|
| 5448 | 6 | Phi0 (°) | $c_{SV}$ | $T_{ref}$ (°C) | 3, 4 | U/A/S | nA/S |

Figure 2.7.8.1: Definition of register 5448.

| Command: Calculated cali values | Modbus address: **5448** | Length: **6** | Type: **3** | Read |
|---|---|---|---|---|
| Parameter: | Phi0, Phase at zero oxygen | Stern-Volmer coefficient $c_{SV}$ | Reference Temperature | |
| Format: | Float | Float | Float | |
| Value: | **70.68** | **0.023** | **25** | |

Figure 2.7.8.2: Example to read register 5448: Phi0 at 25°C is 70.68° and the corresponding Stern-Vollmer coefficient has a value of 0.023. The reference temperature is 25°C.

For the PMC1 calibration coefficient values, register 5480 documents limits of Phi0, Stern-Volmer coefficient ($c_{Sv}$) and Reference Temperature.

| Start register | Number of registers | Reg1 / Reg2 | Reg3 / Reg4 | Reg5 / Reg6 | Reg7 / Reg8 | Modbus function code | Read access | Write access |
|---|---|---|---|---|---|---|---|---|
| 5480 | 8 | Min Phi0 [°] | Max Phi0 [°] | Min $c_{Sv}$ [none] | Max $c_{Sv}$ [none] | 3, 4 | U/A/S | none |

Figure 2.7.8.3: Definition of register 5480.

| Command: Limits of calc. cali values | Modbus address: **5480** | Length: **8** | Type: **3** | Read |
|---|---|---|---|---|
| Parameter: | Min Phi0 [°] | Max Phi0 [°] | Min $c_{Sv}$ [none] | Max $c_{Sv}$ [none] |
| Format: | Float | Float | Float | Float |
| Value: | **62** | **75** | **0.01** | **0.035** |

Figure 2.7.8.4: Example to read register 5480: Phi0 is allowed from 62 to 75°; $c_{Sv}$ is allowed from 0.01 to 0.035.

## 2.7.9  Currently active Calibration Parameters part 5

In register 5342 the system time of the calibration is stored. The system time is explained in chapter 2.8.2.

Note: for CP6, the system time is set during the action "initial measurement".

| Start register | Number of registers | Reg1 / Reg2 | Modbus function code | Read access | Write access |
|---|---|---|---|---|---|
| 5342 | 2 | System Time CP6 | 3, 4 | U/A/S | none |

Figure 2.7.9.1: Definition of register 5182 for CP1, 5214 for CP2 and 5342 for CP6.

| Command: System Time CP6 | | Modbus address: **5342** | Length: 2 | Type: **3** | Read |
|---|---|---|---|---|---|
| Parameter: | System Time CP6 | | | | |
| Format: | u-int | | | | |
| Value: | **1334131200** | | | | |

Figure 2.7.9.2: Example to read the system time of CP6. The initial measurement of the product calibration has been performed on April 11th 2012 at 8:00.

## 2.8    VisiFerm DO SU Status

### 2.8.1  Temperature Ranges

In registers 4608, 4612, 4616 and 4624 four different temperature ranges are defined:
- Operation is the maximum temperature range to which the VisiFerm DO SU can be exposed to during operation and storage. If the current temperature is out of this range, the corresponding bit in the measurement status register is set, see chapter 2.5.4.
- Measurement – is the maximum allowable range where DO measurement is possible.
- Calibration – in this range the VisiFerm DO SU can be calibrated.
- User defined measurement – the specialist can adjust the range in which DO reading is active. The user defined measurement temperature range is a sub range of the measurement temperature range.

| 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 |
| 4624 | 4 | User defined measurement temperature min [°C] | User defined measurement temperature max [°C] | 3, 4, 16 | U/A/S | S |

Figure 2.8.1.1: Definition of register 4608, 4612, 4616 and 4624.

| 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: | **0** | **60** | | | |

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: | **4** | **50** | | | |

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: | **4** | **50** | | | |

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

| Command: User measurement T | | Modbus address: **4624** | Length: **4** | Type: **16** | Write |
|---|---|---|---|---|---|
| Parameter: | User measurement T min [°C] | User measurement T max [°C] | | | |
| Format: | Float | Float | | | |
| Value: | **4** | **50** | | | |

Figure 2.8.1.5: Example set the user defined measurement temperature range. Below 4°C and above 50°C, the sensor will not perform DO reading and the analog and digital output for DO are frozen.

Note: Temperature reading is active at any time, regardless of the current temperature.

## 2.8.2  Operating Hours, Counters and System Time

In register 4676 are stored:
- 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 8232 is stored
- system time counter.
  When the VisiFerm DO SU is powered up, the system time is set to 0. A value between 0 and $2^{32}$ can be written into this register. From this value, the sensor increments this value every second.
  We recommend to use as base date the so-called UNIX timestamp (hint: www.epochconverter.com) which starts at 1st of January 1970 GMT. When a calibration is performed the system time value will be copied to the 5342 for CP6 (after the action "initial measurement"). With this copied value, the absolute time of calibration can be recovered, even if the sensor has powered down in the meantime.
  Be sure to update this register if needed after every power up of the sensor.

| 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 |
| 8232 | 2 | System Time Counter | | | 3, 4, 16 | U/A/S | S |

Figure 2.8.2.1: Definition of register 4676, 4682 and 8232.

| 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: System Time | | Modbus address: **8232** | Length: **2** | Type: **16** | Write |
|---|---|---|---|---|---|
| Parameter: | System Time | | | | |
| Format: | Decimal | | | | |
| Value: | **1334137383** | | | | |

Figure 2.8.2.4: Example to write the system time into the sensor. On the basis of January 1st 1970, this value represents the 11th of April 2012 at 09:43:03.

| Command: System Time | | Modbus address: **8232** | Length: **2** | Type: **16** | Read |
|---|---|---|---|---|---|
| Parameter: | System Time | | | | |
| Format: | Decimal | | | | |
| Value: | **1334150836** | | | | |

Figure 2.8.2.5: Example to read the system time into the sensor. On the basis of January 1st 1970, this value represents the 11th of April 2012 at 13:27:16.

Note:
Accuracy of the system time, if not updated by the operator: The deviation of the system time is less than one minute per 24h.

### 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

The history of warnings is not implemented in VisiFerm DO SU.

### 2.8.3.3 Definition of Warnings

| Bit # | Hex code | Description |
|---|---|---|
| 0 (LSB) | 0x01 | PMC1 DO reading below lower limit |
| | The oxygen reading is too low (DO < 0%-sat). | |
| 1 | 0x02 | PMC1 DO reading above upper limit |
| | The oxygen reading is too high (DO > 300%-sat). | |
| 2 | 0x04 | PMC1 DO reading unstable |
| | The DO measurement is unstable (Standard deviation > 1 °). If continuously happening, use a new cap. If the problem still appears, call our Technical Support. | |
| 25 | 0x02000000 | PMC6 T reading below lower limit |
| | The temperature is below the user defined measurement temperature range. If outside this range, the sensor will not perform DO readings. | |
| 26 | 0x04000000 | PMC6 T reading above upper limit |
| | The temperature is above the user defined measurement temperature range. If outside this range, the sensor will not perform DO readings. | |
| 31 | 0x80000000 | Measurement not running |
| | Either the measurement interval (PA13) is set to 0 or the measurement temperature is out of range. | |

Figure 2.8.3.3.1: Definition of warnings "measurement".

| Bit # | Hex code | Description |
|-------|----------|-------------|
| 0 (LSB) | 0x01 | PMC1 DO product calibration recommended |
| | | Perform a product calibration in order to ensure reliable measurement. |
| 2 | 0x04 | PMC1 DO replace sensor cap |
| | | The ODO cap of VisiFerm DO SU must be replaced and the sensor needs to be recalibrated with the new cap. This warning is active as long as the sensor quality is below 35% |
| 3 | 0x08 | PMC1 Verify / Set calibration data |
| | | A ODO cap is detected by the VisiFerm DO SU and the verification of the calibration data not yet performed. |

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 |
| | | The measurement value is below the lower limit of the 4–20 mA interface output. Reconfigure the 4-20mA interface. |
| 1 | 0x02 | 4-20 mA value above 20 mA |
| | | The measurement value is above the upper limit of the 4–20 mA interface output. Reconfigure the 4-20mA interface. |
| 2 | 0x04 | 4-20 mA current set-point not met |
| | | The sensor's 4–20 mA interface is not able to regulate the current requested for the current measurement value according to your 4–20 mA interface configuration. Check the 4–20 mA wiring and supply voltage. |

Figure 2.8.3.3.3: Definition of warnings "interface".

| Bit # | Hex code | Description |
|-------|----------|-------------|
| 0 (LSB) | 0x01 | Sensor supply voltage too low |
| | | The sensor supply voltage is too low for the sensor to operate correctly. Ensure stable supply voltage within the sensors specifications. |
| 1 | 0x02 | Sensor supply voltage too high |
| | | The sensor supply voltage is too high for the sensor to operate correctly. Ensure stable supply voltage within the sensors specifications. |

Figure 2.8.3.3.4: Definition of warnings "hardware".

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## 2.8.4   Errors

An "Error" message indicates a serious problem of the sensor which does not allow further proper functioning of the VisiFerm DO SU. 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 measure-ment (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

The history of errors is not implemented in VisiFerm DO SU.

### 2.8.4.3   Definition of Errors

| Bit # | Hex code | Description |
|---|---|---|
| 0 (LSB) | 0x00000001 | PMC1 DO reading failure |
| | ODO cap is missing or the PMC1 has failed. In this case, please call our Technical support. | |
| 1 | 0x00000002 | PMC1 DO p(O2) exceeds air pressure |
| | Measured partial pressure of oxygen is higher than the air pressure set by the operator. Reconfigure the air pressure parameter (PA2). | |
| 25 | 0x02000000 | PMC6 T sensor defective |
| | The internal temperature sensor is defective. | |

Figure 2.8.4.3.1: Definition of errors "measurement".

| Bit # | Hex code | Description |
|---|---|---|
| 0 (LSB) | 0x01 | PMC1 ODO cap missing |
| | The ODO cap has been removed. Do not place a sensor showing this error in a measurement solution. The sensor needs to be equipped with a ODO cap and calibrated in order to perform reliable measurement. | |

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

| Bit # | Hex code | Description |
|---|---|---|
| | | Not available |

Figure 2.8.4.3.3: Definition of errors "interface".

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| Bit # | Hex code | Description |
|---|---|---|
| 0 (LSB) | 0x000001 | Sensor supply voltage far too low |
| | The sensor supply voltage is below 6V. Please check your power supply. | |
| 1 | 0x000002 | Sensor supply voltage far too high |
| | The sensor supply voltage is above 40V. Please check your power supply. | |
| 2 | 0x000004 | Temperature reading far below min |
| | The measured temperature is below the operation temperature (Reg. 4608) | |
| 3 | 0x000008 | Temperature reading far above max |
| | The measured temperature is above the operation temperature (Reg. 4608) | |
| 16 | 0x010000 | Red channel failure |
| | Measurement channel failure. Please call our Technical Support. | |

Figure 2.8.4.3.4: Definition of errors "hardware".

## 2.8.5 Reading the ODO Cap Quality

In register 5472 the ODO cap quality (0-100%) is given.

The quality indicator is influenced by:
- Product Calibration (quality indicator set to 0-100%)
- Warning "Verify / Set Calibration Data" (sets immediately quality indicator to 30%)
- Errors (set immediately quality indicator to 0%)

| Start register | Number of registers | Reg1 / Reg2 | Modbus function code | Read access | Write access |
|---|---|---|---|---|---|
| 4872 | 2 | Quality [%] | 3, 4 | U/A/S | none |

Figure 2.8.5.1: Definition of register 4872.

| Command: ODO cap quality | | Modbus address: **4872** | Length: **2** | Type: **3** | Read |
|---|---|---|---|---|---|
| Parameter: | Quality [%] | | | | |
| Format: | Float | | | | |
| Value: | **100** | | | | |

Figure 2.8.5.2: Example to read the membrane status. The ODO cap quality is 100 %.

## 2.9 Identification and Information

### 2.9.1 General Information

General information about the VisiFerm DO SU is available as shown in the figure below.

| Start register | Number of registers | Reg1 to Reg8 16 ASCII characters | Example of content | Modbus function code | Read access | Write access |
|---|---|---|---|---|---|---|
| 1024 | 8 | Userend FW Date | 2021-08-31 | 3, 4 | U/A/S | none |
| 1032 | 8 | Userend FW | ODOUM074 | 3, 4 | U/A/S | none |
| 1040 | 8 | Userend BL Date | 2006-01-01 | 3, 4 | U/A/S | none |
| 1048 | 8 | Userend BL | BL1UA001 | 3, 4 | U/A/S | none |
| 1056 | 8 | Userend Ref | 242099 | 3, 4 | U/A/S | none |
| 1064 | 8 | Userend SN | 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 FW Date | not available | 3, 4 | U/A/S | none |
| 1096 | 8 | Frontend FW | not available | 3, 4 | U/A/S | none |
| 1104 | 8 | Frontend BL Date | not available | 3, 4 | U/A/S | none |
| 1112 | 8 | Frontend BL | not available | 3, 4 | U/A/S | none |
| 1120 | 8 | Frontend Ref | not available | 3, 4 | U/A/S | none |
| 1128 | 8 | Frontend SN | 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: Userend FW | | Modbus address: **1032** | Length: **8** | Type: **3** | Read |
|---|---|---|---|---|---|
| Parameter: | Text | | | | |
| Format: | Character | | | | |
| Value: | **ODOUM074** | | | | |

Figure 2.9.1.2: Example to read register 1032.

### 1.1.1 VisiFerm DO SU Identification

| Start register | Number of registers | Reg1 to Reg8 16 ASCII characters | Example of content | Modbus function code | Read access | Write access |
|---|---|---|---|---|---|---|
| 1152 | 8 | Sensor Ref | 10078255 | 3, 4 | U/A/S | none |
| 1160 | 8 | Sensor Name | VisiFerm DO SU | 3, 4 | U/A/S | none |
| 1168 | 8 | Sensor Lot | 3456817 | 3, 4 | U/A/S | none |
| 1176 | 8 | Sensor Lot date | 2018-07-11 | 3, 4 | U/A/S | none |
| 1184 | 8 | Sensor SN | 1000 | 3, 4 | U/A/S | none |
| 1192 | 8 | Manufacturer part 1 | HAMILTON Bonaduz | 3, 4 | U/A/S | none |
| 1200 | 8 | Manufacturer part 2 | AG Switzerland | 3, 4 | U/A/S | none |
| 1208 | 8 | Module type | Arc o. DO Module | 3, 4 | U/A/S | none |
| 1216 | 8 | Power supply | 007..030V 0500mW | 3, 4 | U/A/S | none |
| 1224 | 8 | Pressure range | not available | 3, 4 | U/A/S | none |
| 1232 | 8 | Sensor ID | 10078255-1000 | 3, 4 | U/A/S | none |
| 1240 | 8 | a-length | 120 | 3, 4 | U/A/S | none |
| 1248 | 8 | (space holder) | not available | 3, 4 | U/A/S | none |
| 1256 | 8 | Electrical connection | VP 8.0 | 3, 4 | U/A/S | none |
| 1264 | 8 | Process connection | PG 13.5 | 3, 4 | U/A/S | none |
| 1272 | 8 | Sensing material | not available | 3, 4 | U/A/S | none |

Figure 1.1.1.1: Definition of registers containing VisiFerm DO SU information.

| Command: Firmware date | | Modbus address: **1032** | Length: **8** | Type: **3** | Read |
|---|---|---|---|---|---|
| Parameter: | Text | | | | |
| Format: | Character | | | | |
| Value: | **ODOUM070** | | | | |

Figure 1.1.1.2: Example to read register 1032.

### 2.9.2 SU ODO Cap Identification

| Start register | Number of registers | Reg1 to Reg8 16 ASCII characters | Example of content | Modbus function code | Read access | Write access |
|---|---|---|---|---|---|---|
| 1280 | 8 | ODO Cap Ref | 243461 | 3, 4 | U/A/S | none |
| 1288 | 8 | ODO Cap name | ODO S0 | 3, 4 | U/A/S | none |
| 1296 | 8 | ODO Cap Lot | 1354271 | 3, 4 | U/A/S | A/S |
| 1304 | 8 | ODO Cap Lot date | 2018-07-11 | 3, 4 | U/A/S | A/S |
| 1312 | 8 | ODO Cap SN | 2076 | 3, 4 | U/A/S | A/S |
| 1320 | 8 | Manufacturer part 1 | HAMILTON Bonaduz | 3, 4 | U/A/S | none |
| 1328 | 8 | Manufacturer part 2 | AG Switzerland | 3, 4 | U/A/S | none |
| 1336 | 8 | ODO Cap type | o. DO Sensor | 3, 4 | U/A/S | none |
| 1344 | 8 | Power supply | not available | 3, 4 | U/A/S | none |
| 1352 | 8 | Pressure range | 00010..12000mBar | 3, 4 | U/A/S | A/S |
| 1360 | 8 | ODO Cap ID | 243461-2076 | 3, 4 | U/A/S | A/S |
| 1368 | 8 | a-length | | 3, 4 | U/A/S | A/S |
| 1376 | 8 | (space holder) | not available | 3, 4 | U/A/S | none |
| 1384 | 8 | Electrical connection | not available | 3, 4 | U/A/S | none |
| 1392 | 8 | Process connection | | 3, 4 | U/A/S | A/S |
| 1400 | 8 | Sensing material | ODO S0 | 3, 4 | U/A/S | none |

Figure 2.9.2.1: Definition of registers containing SU ODO Cap identification.

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## 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 to 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 | 243461-2076 | 3, 4, 16 | U/A/S | A/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. Among other information, this register identifies individual VisiFerm DO SU displayed on the Arc Air App.

⚠ 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 VisiFerm DO SU manufacturer values (interfaces, calibration data and passwords). By sending the recall value "732255" or "911", 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" or "911" | 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: | **911** | | | | |

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 |
| SU | Single Use |

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