



EDO ARC Sensors

Modbus RTU Programmer's Manual

Firmware version:
EDOUM013

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1 Modbus RTU general information

1.1 Introduction

This document describes in detail the electrochemical dissolved oxygen (EDO) ARC Sensors Modbus RTU interface. It is addressed to software programmers.

The general information about Modbus command structures and its implementation in the HAMILTON ARC Sensor family is described in detail in Chapter 1 of the

“VISIFERM DO Modbus RTU Programmer’s Manual” (p/n 624179).

If you need this general information about Modbus programming, then please consult p/n 624179.

In the present manual, only the specific command structure for the EDO ARC Sensors is described. It is valid for the firmware version:

EDOUM013

Please check the software version by reading register 1032.

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

2 EDO ARC Sensor Commands in Modbus RTU

2.1 General

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

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

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



Attention:

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

2.2 Operator levels and Passwords

2.2.1 Reading / Setting Operator Level

An EDO ARC Sensor 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 (decimal)
U	User (lowest level)	0x03	0
A	Administrator	0x0C	18111978
S	Specialist	0x30	16021966

Figure 2.2.1.1: Definition of operator level and default passwords

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

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

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

Figure 2.2.1.2: Definition of register 4288.

Command: Active 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 0xC (Administrator). The correct password has to be sent.

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

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

2.2.2 Changing Passwords for Operator Level

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

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

Figure 2.2.2.1: Definition of register 4292.

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

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

2.3 Configuration of the serial RS485 Interface

Factory settings of the RS485:

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

2.4.1 Available Analog Interfaces

An EDO ARC Sensor has two individual physical analog interfaces that have identical functionalities, but can be configured independently from each other.

- Analog Output Interface 1 (AO1)
- Analog Output Interface 2 (AO2)

The number of analog interfaces is defined in register 4320.

Start register	Number of registers	Reg1 / Reg2	Modbus function code	Read access	Write access
4320	2	Available analog interfaces	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:	0x03				

Figure 2.4.1.2: Example to read the available analog interfaces. The answer is "0x03" meaning that there exists an Analog Interface 1 (AO1) and an Analog Interface 2 (AO2).

2.4.2 Available Analog Interface Modes

With register 4322, the available analog interface modes for AO1 and AO2 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 for AO1	Available Analog Interface Modes for AO2	reserved	reserved	3,4	U/A/S	none

Figure 2.4.2.1: Definition of register 4322. It defines the analog interface modes available for AO1 and AO2. The analog interface modes are described in Figure 2.4.2.2.

Code (Hex)	Analog Interface Mode	Description
0x00	4-20 mA inactive	Analog interface deactivated
0x01	4-20 mA fixed	Set to a constant output value for current loop testing
0x02	4-20 mA linear	Linear output of measurement (PMC1 / 6)
0x04	4-20 mA bilinear	Bilinear output of measurement (PMC1 / 6)

Figure 2.4.2.2: Definition of the analog interface modes, valid for both AO1 and AO2.

Command: Analog Interface Modes		Modbus address: 4322	Length: 8	Type: 3	Read
Parameter:	Available Analog Interface Modes for AO1	Available Analog Interface Modes for AO2	reserved	reserved	
Format:	Hex	Hex	Hex	Hex	
Value:	0x07	0x07	0x0	0x0	

Figure 2.4.2.3: Example to read register 4322: all modes defined in figure 2.4.2.2 are available for both AO1 and AO2.

2.4.3 Description of the Analog Interfaces 1 and 2

Register 4352 / 4480 contain the descriptions of AO1 / AO2 as plain text ASCII:

Start register	Number of registers	Reg1 ... Reg8 16 ASCII characters	Modbus function code	Read access	Write access
4352	8	Description of AO1	3, 4	U/A/S	none
4480	8	Description of AO2	3, 4	U/A/S	none

Figure 2.4.2.1: Definition of register 4352 and 4480

Command: Current interface text		Modbus address: 4352	Length: 8	Type: 3	Read
Parameter:	Text				
Format:	Character				
Value:	mA interface #1				

Figure 2.4.2.2: Example to read the description of AO1. The text is “mA interface #1”. Accordingly, AO1 is physically configured as a 4-20 mA current output.

Command: Current interface text		Modbus address: 4480	Length: 8	Type: 3	Read
Parameter:	Text				
Format:	Character				
Value:	mA interface #2				

Figure 2.4.2.3: Example to read the description of AO2. The text is “mA interface #2”. Accordingly, AO2 is physically configured as a 4-20 mA current output.



Attention:

- EDO ARC Sensors do not have an ECS (in contrast to VISIFERM DO)!
- Data structure: register address offset between AO1 and AO2 is always 128.

2.4.4 Selection of an Analog Interface Mode

The analog interface mode of AO1 / AO2 is selected by programming the analog interface mode in register 4360 / 4488.

Start register	Number of registers	Reg1 / Reg2	Modbus function code	Read access	Write access
4360	2	Active analog interface mode for AO1	3, 4, 16	U/A/S	S
4488	2	Active analog interface mode for AO2	3, 4, 16	U/A/S	S

Figure 2.4.4.1: Definition of register 4360 / 4488. Only one bit can be set.

Command: Active interface mode		Modbus address: 4360	Length: 2	Type: 16	Write
Parameter:	Mode				
Format:	Hex				
Value:	0x02				

Figure 2.4.4.2: Example to set the analog interface mode of AO1 to 0x02 (4-20 mA linear output).

2.4.5 Configuration of the 4-20 mA Interface

Note:

The configuration of AO1 / AO2 is only effective if register 4360 / 4488 (active analog interface mode) is set to the value 0x01, 0x02 or 0x04.

2.4.5.1 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 for AO1	3, 4	U/A/S	none
4490	2	Available Primary Measurement Channels for AO2	3, 4	U/A/S	none

Figure 2.4.5.1.1: Definition of register 4362 / 4490.

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

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

Figure 2.4.5.1.2: Code for selection of the primary measurement channel.

Command: Available PMC AO1		Modbus address: 4362		Length: 2	Type: 3	Read
Parameter:	Available PMC 20 mA					
Format:	hex					
Value:	0x21					

Figure 2.4.5.1.3: Example to read the available Primary Measurement Channels (PMC) for AO1. The hexadecimal value of "0x21" defines that PMC1 (oxygen) or PMC6 (temperature) can be mapped to AO1. Register 4490 contains the same value "0x21". Accordingly, PMC1 or PMC6 can be mapped to AO2 as well.

2.4.5.2 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 PMC for AO1	3, 4, 16	U/A/S	S
4492	2	Selected PMC for AO2	3, 4, 16	U/A/S	S

Figure 2.4.5.2.1: Definition of register 4364 / 4492. Only one bit can be set.

Command: Active PMC AO1		Modbus address: 4364		Length: 2	Type: 3	Read
Parameter:	Current PMC 20mA					
Format:	hex					
Value:	0x01					

Figure 2.4.5.2.2: Example to read the current primary measurement channel mapped to AO1, defined in register 4364. The value "0x01" is returned, saying that PMC1 is mapped to AO1 (factory setting).

The factory setting for register 4492 is "0x20", mapping PMC6 to AO2.

2.4.5.3 Reading the Minimum and Maximum Possible Physical Output Current

Start register	Number of registers	Reg1 / Reg2	Reg3 / Reg4	Modbus function code	Read access	Write access
4366	4	Min physical output current for AO1 [mA]	Max physical output current for AO1 [mA]	3, 4	U/A/S	none
4494	4	Min physical output current for AO2 [mA]	Max physical output current for AO2 [mA]	3, 4	U/A/S	none

Figure 2.4.5.3.1: Definition of register 4366 / 4494

Command: Limits AO1		Modbus address: 4366		Length: 4	Type: 3	Read
Parameter:	Min limit [mA]	Max limit [mA]				
Format:	Float	Float				
Value:	3.5	22				

Figure 2.4.5.3.2: Example to read the min and max output current of AO1. Min is fixed to 3.5 and Max is fixed to 22 mA (Currents above 20 and below 4 mA indicate erroneous measurements or errors).

The same values are stored in register 4494 for AO2.

2.4.5.4 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 for AO1 [mA]	Max output for measurement values for AO1 [mA]	Mid output (bilinear) for measurement values for AO1 [mA]	3, 4	U/A/S	none
4498	6	Min output for measurement value for AO2 [mA]	Max output for measurement values for AO2 [mA]	Mid output (bilinear) for measurement values for AO2 [mA]	3, 4	U/A/S	none

Figure 2.4.5.4.1: Definition of register 4370 / 4498

Command: MinMaxMid current AO1		Modbus address: 4370		Length: 6	Type: 3	Read
Parameter:	Min current [mA]	Max current [mA]	Mid current [mA]			
Format:	Float	Float	Float			
Value:	4	20	12			

Figure 2.4.5.4.2: Example to read the min, max and mid output current for measurement values for AO1. They are fixed to 4, 20 and 12 mA.

The same values are stored in register 4498 for AO2.

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.

2.4.5.5 Reading the Selected Physical Unit for Analog Interface

Start register	Number of registers	Reg1 / Reg2	Modbus function code	Read access	Write access
4376	2	Selected physical unit of AO1 (see chapter 2.5.1)	3, 4	U/A/S	none
4504	2	Selected physical unit of AO2 (see chapter 2.5.1)	3, 4	U/A/S	none

Figure 2.4.5.5.1: Definition of register 4376 / 4504.

Command: Avail unit AO1		Modbus address: 4376		Length: 2	Type: 3	Read
Parameter:	Available unit					
Format:	Hex					
Value:	0x000020					

Figure 2.4.5.5.2: Example to read the selected unit of the selected PMC of AO1. The value returned is "0x000020", accordingly, the unit is %-sat. The physical unit for PMC is defined in Reg. 2090 or 2410 and applies automatically for 4-20 mA output.

2.4.5.6 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 (4 mA) for AO1	Measurement value at Max Output Current (20 mA) for AO1	Measurement value at Mid Output Current (12 mA) for AO1	3, 4, 16	U/A/S	S
4506	6	Measurement value at Min Output Current (4 mA) for AO2	Measurement value at Max Output Current (20 mA) for AO2	Measurement value at Mid Output Current (12 mA) for AO2	3, 4, 16	U/A/S	S

Figure 2.4.5.6.1: Definition of register 4378 / 4506.

Command: MinMaxMid value AO1		Modbus address: 4378		Length: 6	Type: 16	Write
Parameter:	Min value	Max value	Mid value			
Format:	Float	Float	Float			
Value:	0	62.85	10			

Figure 2.4.5.6.2: 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 can be read in register 4376 / 4504 and in 2090 / 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.

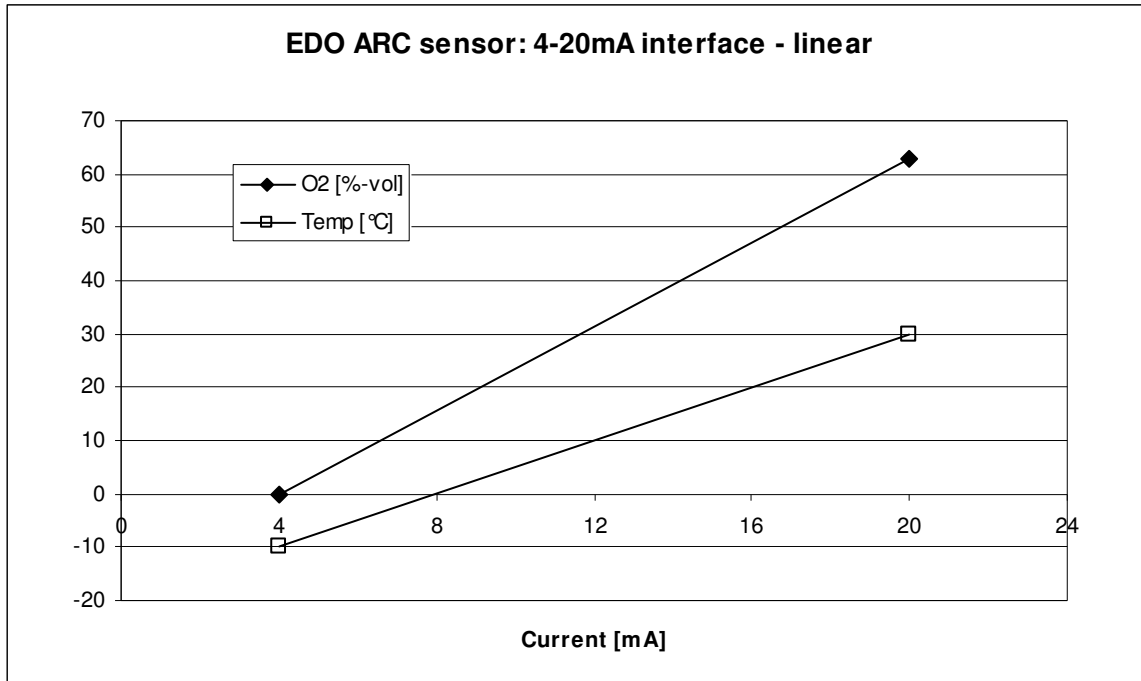


Figure 2.4.5.6.3: Example of linear 4-20 mA output characteristics for oxygen or temperature.

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

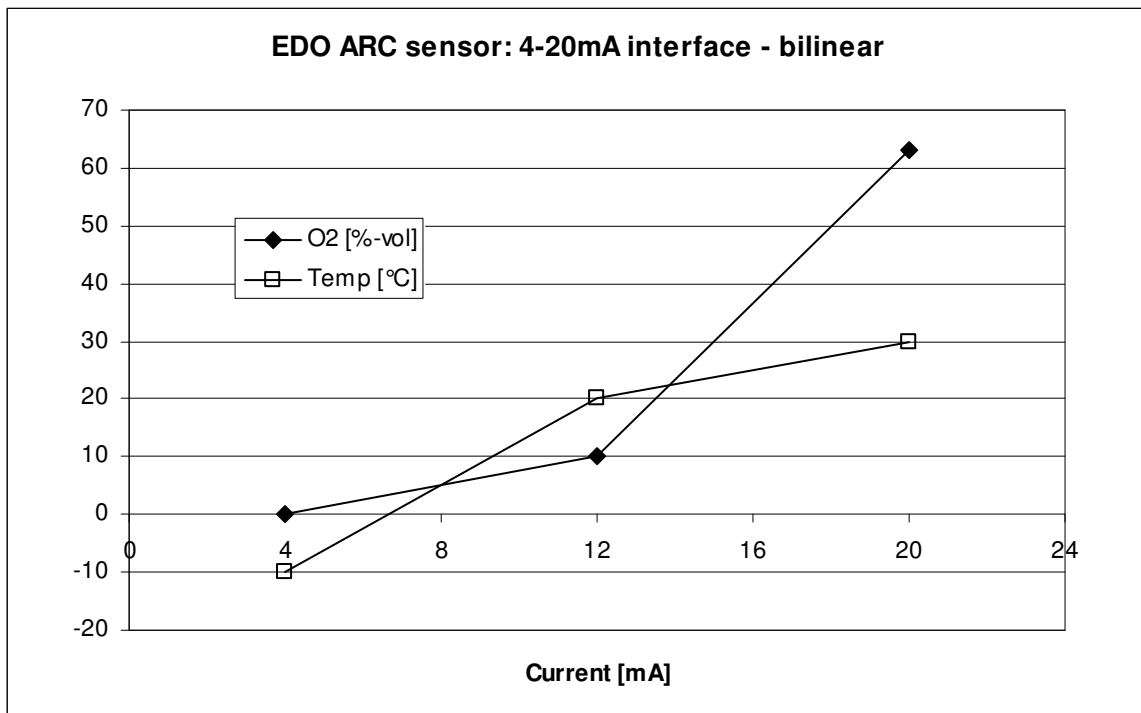


Figure 2.4.5.6.4: Example of bilinear 4-20 mA output characteristics for oxygen or temperature.

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 / 4506, you need to consider the following:

- The PMC you have mapped to AO1 / AO2 (register 4364 / 4492)
- The physical 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 / 4492, 2090 / 2410, the definitions of the register 4378 / 4506 should be reviewed. If not, the current output at the 4-20 mA interfaces may be wrong.

Note:

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

Example:

Register 4364 is set to 1 (PMC1 (oxygen) is mapped to AO1).

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.

2.4.5.7 Defining a Constant Current Output for Testing

Note:

For constant current output, the AO1 / AO2 must be set to analog interface mode 0x01:

Start register	Number of registers	Reg1 / Reg2	Modbus function code	Read access	Write access
4384	2	Constant current output value for AO1 [mA]	3, 4, 16	U/A/S	S
4512	2	Constant current output value for AO2 [mA]	3, 4, 16	U/A/S	S

Figure 2.4.5.7.1: Definition of register 4384 / 4512.

Command: Fixed value AO1		Modbus address: 4384		Length: 2	Type: 3	Read
Parameter:	Fixed value [mA]					
Format:	Float					
Value:	10					

Figure 2.4.5.7.2: Example to read the constant current output in mode 0x01 for AO1. It is set to 10 mA.

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

Errors and warnings can be mapped to the AO1 / AO2.

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) for AO1	Current in case of "warning" [mA] for AO1	Current in case of "error" [mA] for AO1	Current in case of "T exceed" [mA] for AO1	3, 4, 16	U/A/S	S
4514	8	Code of warnings and errors (see Figure 2.4.4.8.2) for AO2	Current in case of "warning" [mA] for AO2	Current in case of "error" [mA] for AO2	Current in case of "T exceed" [mA] for AO2	3, 4, 16	U/A/S	S

Figure 2.4.5.8.1: Definition of register 4386 / 4514.

Bit #	Code (hex)	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 2.4.5.8.2: 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 (=0x00), the respective options are inactive.

The default settings are:

- Code 0x01
- current in case of warnings: 3.5 mA
- current in case of errors: 3.5 mA
- current in case of temperature exceed: 3.5 mA

Command: ErrorWarnings AO1		Modbus address: 4386		Length: 8	Type: 3	Read
Parameter:	Warning code	Current in case of warning [mA]	Current in case of error [mA]	Current in case of temperature exceed [mA]		
Format:	Hex	Float	Float	Float		
Value:	0x010001	3.5	3.5	3.5		

Figure 2.4.5.8.4: Example: Read the settings for AO1 in case of warnings and errors. Warning code 0x010001 corresponds to the continuous output current in case of warning (0x010000) and continuous output current in case of error (0x01) of 3.5 mA. The output current in case of temperature exceed is 3.5 mA.

2.4.6 Reading the Internally Measured Output Current

Reg. 4414 / 4542 provides internal parameters of AO1 / AO2:

- 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 [mA] AO1	Internally measured [mA] AO1	3, 4	U/A/S	none
4542	4	Set point [mA] AO2	Internally measured [mA] AO2	3, 4	U/A/S	none

Figure 2.4.6.1: Definition of register 4414 / 4542.

Command: Internal 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 2.4.6.2: Example to read the internal values of AO1, depending on the analog interface mode.

2.5 Measurement

2.5.1 Definition of Measurement Channels and Physical Units

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

Bit #	Hex code	Description	Definition
0 (LSB)	0x000001	PMC1	Oxygen
1	0x000002	PMC2	not available
			not available
4	0x000010	PMC5	not available
5	0x000020	PMC6	Temperature
6	0x000040	SMC1	R cathode
7	0x000080	SMC2	not available
8	0x000100	SMC3	I cathode
9	0x000200	SMC4	not available
10	0x000400	SMC5	E ref vs. anode
11	0x000800	SMC6	not available
12	0x001000	SMC7	not available
13	0x002000	SMC8	DO act
14	0x004000	SMC9	T act
15	0x008000	SMC10	not available
		...	
21 (MSB)	0x200000	SMC16	not available

Figure 2.5.1.1: full list of PMC1 to 6 and SMC1 to 16.

In Register 2048, the available PMC and SMC are defined for a specific EDO ARC Sensors and a specific operator level.

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. PMC and SMC		Modbus address: 2048		Length: 2	Type: 3	Read
Parameter:	Avail. PMC and SMC					
Format:	Hex					
Value:	0x0161					

Figure 2.5.1.3: Example to read Reg. 2048 for EDO ARC Sensor.

In case of operator A/U, the value 0x0161 is returned. In other words the following PMC and SMC are available to A/U: PMC1 / PMC6 / SMC1 / SMC3

In case of operator S, the value 0x06561 is returned. In other words the following PMC and SMC are available to S: PMC1 / PMC6 / SMC1 / SMC3 / SMC5 / SMC8 / SMC9

The EDO ARC Sensor register structure uses the following physical units used for Primary or Secondary Measurement Channels.

Bit #	Hex code	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.

Command: Unit text		Modbus address: 1936	Length: 4	Type: 3	Read
Parameter:	Text				
Format:	Character				
Value:	%-vol				

Figure 2.5.1.5: Example to read the physical unit in plain text ASCII in register 1936

2.5.2 Primary Measurement Channel 1 (Oxygen)

2.5.2.1 Description of PMC1

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

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

Figure 2.5.2.1.1: Definition of register 2080.

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

Figure 2.5.2.1.2: Example to read the description. It is "DO".

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.

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 for the 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 AO1 / AO2, as the same physical unit is active for the analog outputs. All limits of the 4-20 mA analog output have to be redefined after changing the physical unit!

2.5.2.3 Reading the measurement value of PMC1

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

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

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

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

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

Command: PMC1 read		Modbus address: 2090		Length: 10	Type: 3	Read
Parameter:	Unit	Value	Status	Min limit	Max limit	
Format:	Hex	Float	Hex	Float	Float	
Value:	0x10	21.10335	0x00	0	62.85	

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 62.85 (%-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.

2.5.3 Primary Measurement Channel 6 (Temperature)

2.5.3.1 Description of PMC6

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

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

Figure 2.5.3.1.1: Definition of register 2400.

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

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

2.5.3.2 Selecting the Physical Unit for PMC6

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

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

Figure 2.5.3.2.1: Definition of register 2408.

Command: PMC6 available units		Modbus address: 2408	Length: 2	Type: 3	Read
Parameter:	Units				
Format:	Hex				
Value:	0x0E				

Figure 2.5.3.2.2: Example to read the available physical unit for PMC6. K (0x02), °C (0x04), °F (0x08), total 0x0E.

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).



Attention:

Changing the physical unit has also an influence on the output of AO1 / AO2, as the same physical unit is active for the analog outputs. All limits of the 4-20 mA analog output have to be redefined after changing the physical unit!

2.5.3.3 Reading the measurement value of PMC6

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

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

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

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

⁽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	24.35834	0x00	-20	130	

Figure 2.5.3.3.2: Example to read register 2410. Physical unit is set to °C (0x04), PMC6 is 24.35834 °C, Status is 0x00, Min allowed value is -20 °C, Max allowed value is 130 °C.

For definition of the measurement status see chapter 2.5.4.



Attention:

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

2.5.3.4 Input of an Externally Measured Temperature

Unlike to the VISIFERM DO, this feature is not available for EDO ARC Sensors.

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

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

2.5.5 Secondary Measurement Channels 1-16

EDO ARC Sensors do allow access to secondary measurement values (16 in total). The access to the individual SMC depends on the operator level. The available SMC are defined in register 2048 according to the selected operator level and the sensor type (see chapter 2.5.1).

2.5.5.1 Description of SMC

The registers defined here give a plain text ASCII description of each available SMC.

Start register	Number of registers	Reg1 ... Reg8 16 ASCII characters	Modbus function code	Read access	Write access
Address	8	Description of each SMC	3, 4	U/A/S	none

Figure 2.5.5.1.1: Definition of registers at Address

Description	Address	Plain Text (16 ASCII)	Description
SMC1	2464	R cathode	Resistance of the cathode
SMC3	2528	I cathode	Current of the cathode
SMC5	2592	E ref vs. anode	Polarization potential between cathode and anode
SMC8	2688	DO act	Current DO value (3-seconds-reading)
SMC9	2720	T act	Current T value (3-seconds-reading)

Figure 2.5.5.1.2: Full list of starting register addresses for the plain text ASCII description of each SMC

Example:

Command: SMC 1 text		Modbus address: 2464		Length: 8	Type: 3	Read
Parameter:	Text					
Format:	Character					
Value:	R cathode					

Figure 2.5.5.1.3: Example to read the description of SMC1 at address 2464. It is "R cathode".

2.5.5.2 Reading the measurement value of SMC

The registers defined here are used to read the measurement values of each SMC.

Start reg.	Number of reg.	Reg1 / Reg2	Reg3 / Reg4	Reg5 / Reg6	Modbus function code	Read access	Write access
Address	6	Physical unit	Measurement value of SMC	Standard deviation	3, 4	U/A/S	none

Figure 2.5.5.2.1: Definition of register at Address. Measurement value of each SMC.

Description	Address	Text	Unit	Min value	Max value
SMC1	2472	R cathode	kOhm	3	1000
SMC3	2536	I cathode	nA	0	1250
SMC5	2600	E ref vs. anode	mV	-900	900
SMC8	2696	DO act	mbar	0	1013
SMC9	2728	T act	K	253.15	403.15

Figure 2.5.5.2.2: Full list of register addresses for the measurement values of SMC1 to SMC9

Example:

Command: SMC1 read		Modbus address: 2472		Length: 6	Type: 3	Read
Parameter:	Unit	Value	Standard dev.			
Format:	Hex	Float	Float			
Value:	0x4000	133.695	0.02			

Figure 2.5.5.2.3: Example to read register 2472. Physical unit is kOhm (0x4000), the measurement value of SMC1 is 133.695 kOhm, standard deviation of SMC1 is 0.02 kOhm

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 EDO ARC Sensors
0 (LSB)	0x0001	PA1	Salinity
1	0x0002	PA2	Atmospheric pressure
			not available
7	0x0080	PA8	not available
8	0x0100	PA9	Moving average
9	0x0200	PA10	not available
10	0x0400	PA11	not available
11	0x0800	PA12	Moving average R
			not available
15 (MSB)	0x8000	PA16	not available

Figure 2.6.1.2: Bitwise definition of parameters PA1 to PA16, valid for EDO ARC Sensors

Command: Available parameters		Modbus address: 3072	Length: 2	Type: 3	Read
Parameter:	Measurement parameters				
Format:	Hex				
Value:	0x0903				

Figure 2.6.1.3: Example to read the available parameters. The value 0x0903 corresponds to 0x0001 (PA1) + 0x0002 (PA2) + 0x0100 (PA9) + 0x0800 (PA12). Parameter 1, 2, 9 and 12 are available.

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 EDO ARC sensors 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, EDO ARC sensors can determine the concentration of oxygen in a sample.

At 25°C and in air saturated, pure water, the concentration of dissolved oxygen is 8.2 mg/l. The more salt, the lower is the solubility.

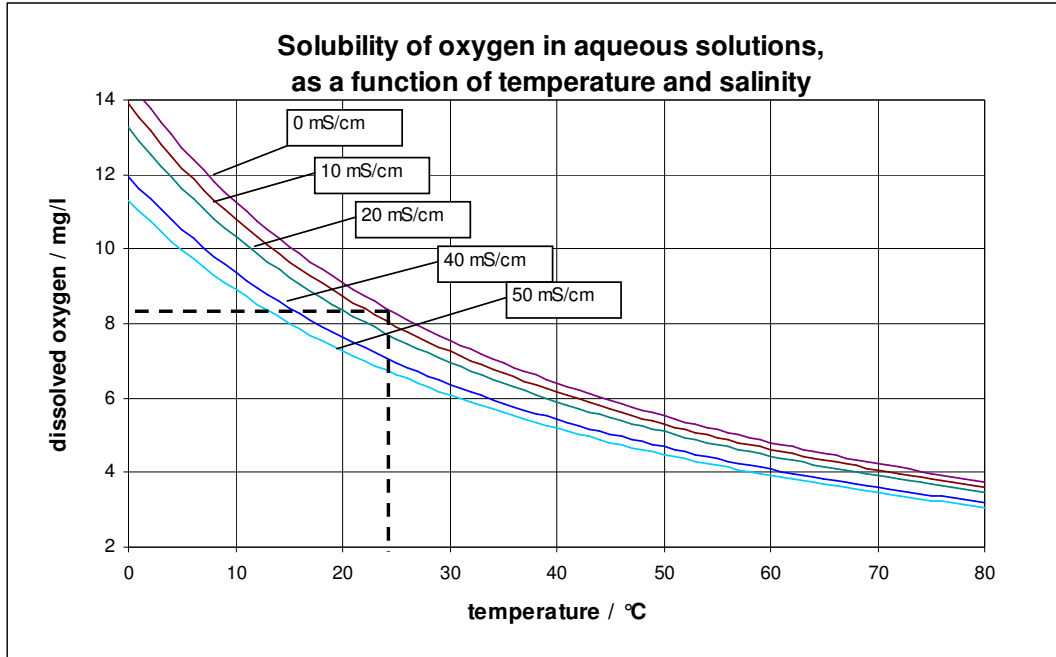


Figure 2.6.2.1: Solubility of oxygen as a function of temperature and salinity, in air saturated aqueous solution. Temperature range is from 0-85 °C. Salinity can be entered from 0-50 mS/cm.

2.6.2.1 Description of PA1 (Salinity)

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

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

Figure 2.6.2.1.1: Definition of register 3104.

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

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

2.6.2.2 Selecting the Physical Unit and Writing the Value for PA1

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

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

Figure 2.6.2.2.1: Definition of register 3112.

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

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

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

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

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

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

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

2.6.2.3 Reading all Values for PA1

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

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

Figure 2.6.2.3.1: Definition of register 3114.

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

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

2.6.3 PA2: Air Pressure

EDO ARC sensors measure the partial pressure of oxygen. The partial pressure of oxygen is proportional to the atmospheric pressure or the pressure of the air supply to the process. In order to compensate for changes in atmospheric pressure or pressure of air supply in the process, one can use parameter PA2.

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

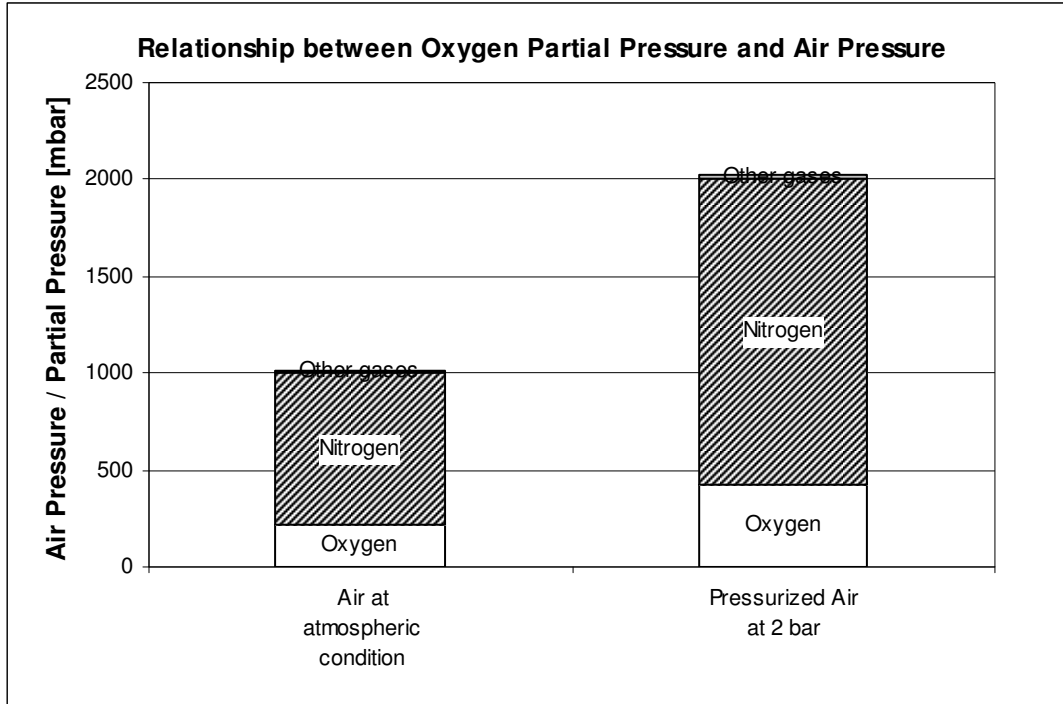


Figure 2.6.3.1: Influence of air pressure on the partial pressure of oxygen. Doubling the air pressure also doubles the oxygen partial pressure.

2.6.3.1 Description of PA2 (Air Pressure)

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

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

Figure 2.6.3.1.1: Definition of register 3136.

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

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

2.6.3.2 Selecting the Physical Unit and Writing the Value for PA2

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

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

Figure 2.6.3.2.1: Definition of register 3144.

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

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

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

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

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

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

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

2.6.3.3 Reading all Values for PA2

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

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

Figure 2.6.3.3.1: Definition of register 3146.

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

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

2.6.4 PA9: Moving Average

The EDO ARC Sensor provides new DO readings every 3 seconds. One has the possibility to smoothen the DO reading (PMC1) by means of a moving average applied to the 3-seconds-readings.

PA9 can be applied on 1 to 16 3-seconds-readings. The default value is 2.

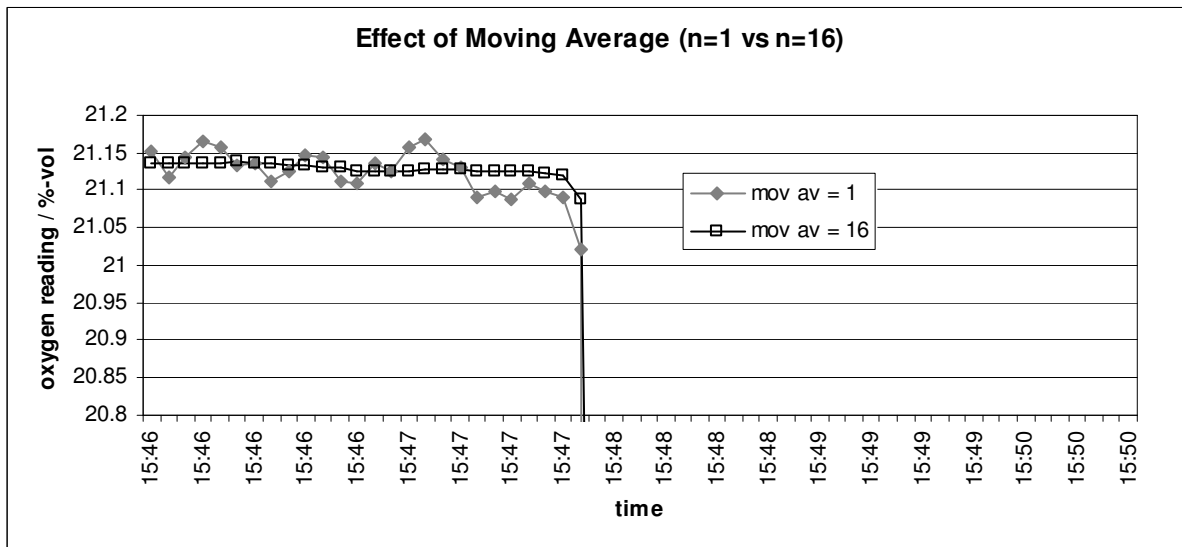
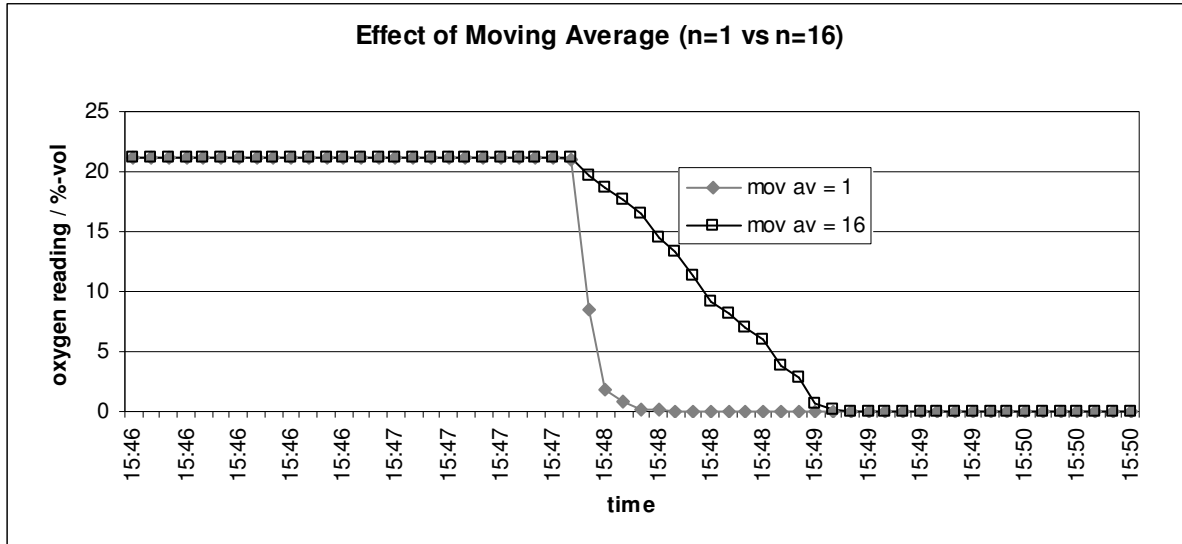


Figure 2.6.2.1: Comparison of the response of a EDO ARC Sensor to a change from air to zero oxygen, using no moving average (n=1) or a moving average over 16 3-seconds-readings.

Using moving average, the short term signal stability can be improved; on the other hand, the response time of the sensor increases with increasing moving average. A moving average over 16 samples results in a response time of at least 48 s.

Note:

- PA9 is applied to both PMC1 and PMC6.

2.6.4.1 Description of PA9 (Moving Average)

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

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

Figure 2.6.2.1.1: Definition of register 3360.

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

Figure 2.6.2.1.2: 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 2.6.2.2.1: Definition of register 3368.

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

Figure 2.6.2.2.2: 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 (1-16, default: 2)	16	none	S

Figure 2.6.2.2.3: Definition of register 3370. Only one bit for the physical unit can be set. PA9 can be set to the value 1-16. A value of 1 does not influence the response time of the sensor, a value of 16 increases the response time of the sensor to 48 s.

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

Command: Moving average		Modbus address: 3370	Length: 4	Type: 16	Write
Parameter:	Unit	Value			
Format:	Hex	Decimal			
Value:	0x01	12			

Figure 2.6.2.2.4: Example to set the physical unit of PA9 to "none" (0x01) and the value of the moving average to 12.

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.

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 2.6.2.3.1: 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	10	1	16		

Figure 2.6.2.3.2: Example to read PA9. The physical unit is 0x01 ("none"), the value is 10 and the limit is 1 to 16.

2.6.5 PA12: Moving Average R

EDO ARC Sensors allow to have a separate moving average on secondary measurement values:

- Cathode resistance

The moving average can be applied on 1 to 16 3-s measurement values. The default value is 4. Especially if high resistances are measured, it is recommended to choose a higher moving average.

2.6.5.1 Description of PA12 (Moving Average R)

In register 3456, a plain text ASCII description of PA12 is given.

Start register	Number of registers	Reg1 ... Reg8 16 ASCII characters	Modbus function code	Read access	Write access
3456	8	Description of PA12	3, 4	U/A/S	none

Figure 2.6.3.1.1: Definition of register 3456.

Command: Moving average text		Modbus address: 3456	Length: 8	Type: 3	Read
Parameter:	Text				
Format:	Character				
Value:	Moving average R				

Figure 2.6.3.1.2: Example to read the description for "Moving average R".

2.6.5.2 Selecting the Physical Unit and Writing the Value for PA12

In register 3464, the available physical units for PA12 are defined.

Start register	Number of registers	Reg1 / Reg2 (bitwise defined)	Modbus function code	Read access	Write access
3464	2	Available physical units for PA12	3, 4	U/A/S	none

Figure 2.6.3.2.1: Definition of register 3368.

Command: Moving average av. units		Modbus address: 3464	Length: 2	Type: 3	Read
Parameter:	Units				
Format:	Hex				
Value:	0x01				

Figure 2.6.3.2.2: Example to read the available physical units for PA12. 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
3466	4	Select physical unit for PA12	Value for PA12 (1-16, default: 4)	16	none	S

Figure 2.6.3.2.3: Definition of register 3466. Only one bit for the physical unit can be set. PA12 can be set to the values 1-16.

By writing to register 3466, the active physical unit for PA12 can be selected, by choosing one of the physical units that are defined in register 3464. The value of the parameter can be set as well.

Command: Moving average		Modbus address: 3466		Length: 4	Type: 16	Write
Parameter:	Unit	Value				
Format:	Hex	Decimal				
Value:	0x01	7				

Figure 2.6.3.2.4: Example to set the physical unit of PA12 to "none" (0x01) and the value of the moving average R to 7.

2.6.5.3 Reading all Values for PA12

By reading register 3466, the active physical unit of measurement, 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
3466	8	Physical unit	Current value	Min value	Max value	3, 4	U/A/S	none

Figure 2.6.3.3.1: Definition of register 3466.

Command: Moving average		Modbus address: 3466		Length: 8	Type: 3	Read
Parameter:	Unit	Value		Min value	Max value	
Format:	Hex	Decimal		Decimal	Decimal	
Value:	0x01	7		1	16	

Figure 2.6.3.3.2: Example to read PA12. The physical unit is 0x01 ("none"), the value is 7, and the limits are 1 to 16.

2.7 Calibration

2.7.1 Available Calibration Points

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

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

Figure 2.7.1.1: Definition of register 5120.

Bit #	Hex value	Description	Definition in ARC Sensors
0 (LSB)	0x01	CP1	Calibration Point 1
1	0x02	CP2	Calibration Point 2
2	0x04	CP3	not available
...	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:	0x23				

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

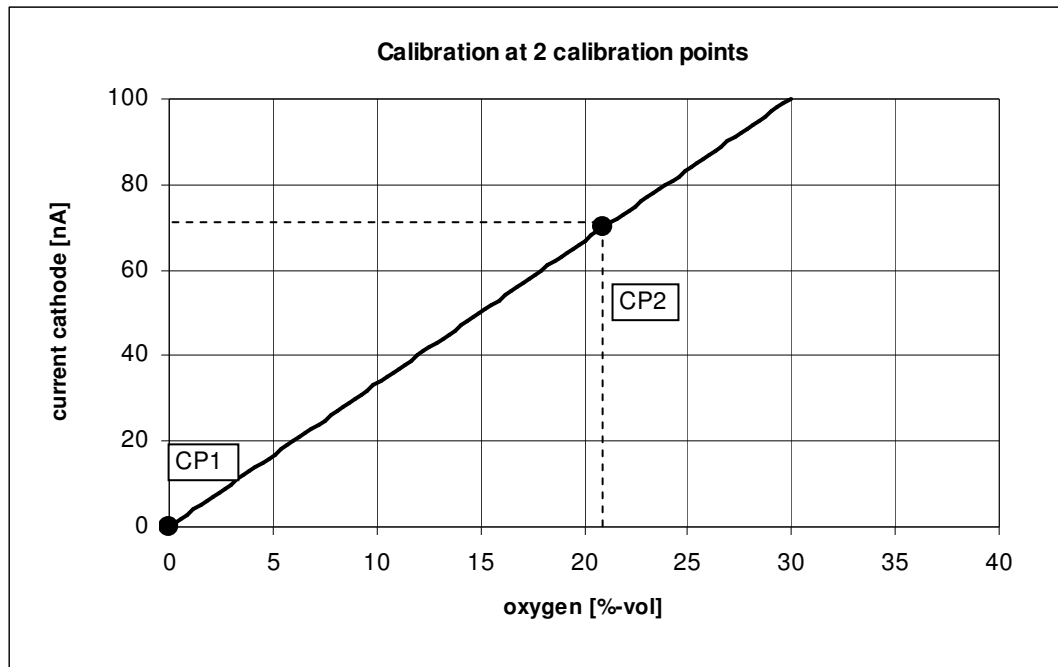


Figure 2.7.1.4: EDO ARC Sensors allow 3 calibration points:

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

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

2.7.2 Definitions of Calibration Points

2.7.2.1 Calibration Points 1 and 2 (Standard Calibration)

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

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

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

Command: Calibration limits CP1				Modbus address: 5152	Length: 6	Type: 3	Read
Parameter:	Unit	Min value	Max value				
Format:	Hex	Float	Float				
Value:	0x10	0	0				

Figure 2.7.2.1.2: Example to read the limits of CP1. Currently active physical unit is %-vol (0x10). The min and max values are both 0.

Command: Calibration limits CP2				Modbus address: 5184	Length: 6	Type: 3	Read
Parameter:	Unit	Min value	Max value				
Format:	Hex	Float	Float				
Value:	0x10	0	0				

Figure 2.7.2.1.3: Example to read the limits of CP2. The active physical unit is %-vol (0x10). The min and max values are both 0, indicating, that calibration at CP2 can be performed only using defined calibration standards having discrete oxygen values.

When initiating the calibration at CP1 and CP2, the measured oxygen and temperature have to be stable for at least 3 minutes. The stability criteria are defined in register 5128:

Start register	Number of registers	Reg1 / Reg2 (Float)	Reg3 / Reg4 (Float)	Modbus function code	Read access	Write access
5128	4	Max. Drift PMC1 oxygen [nA/min]	Max. Drift PMC6 Temperature [K/min]	3, 4, 16	U/A/S	S

Figure 2.7.2.1.4: Definition of register 5128.

Command: Read calibration stability		Modbus address: 5128		Length: 4	Type: 3	Read
Parameter:	Max drift oxygen [nA/min]	Max drift Temp [K/min]				
Format:	Float	Float				
Value:	0.5	0.5				

Figure 2.7.2.1.5: Example to read the calibration stability.

Command: Set calibration stability		Modbus address: 5128		Length: 4	Type: 16	Write
Parameter:	Max drift oxygen [nA/min]	Max drift Temp [K/min]				
Format:	Float	Float				
Value:	0.5	0.5				

Figure 2.7.2.1.6: Example to set the calibration stability.



Attention:

The stability criteria defined in register 5128 is valid for CP1 and CP2 only, but NOT for CP6.

2.7.2.2 Calibration Point 6 (Product Calibration)

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

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

Figure 2.7.2.2.1: Definition of register 5312 for CP6.

Command: Calibration limits CP6		Modbus address: 5312		Length: 6	Type: 3	Read
Parameter:	Unit	Min value	Max value			
Format:	Hex	Float	Float			
Value:	0x10	2	50.5			

Figure 2.7.2.2.2: Example to read the limits of CP6. The active physical unit is %-vol, the min value is 2 %-vol and the max value is 50.5 %-vol (between 20 and 550 mbar, respectively). When changing the active physical unit for PMC1 (using register 2090), the min and max value will be updated automatically to the new physical unit. Temperature, atmospheric pressure and salinity are compensated.

Note: the definition of min and max is different than the one for CP1 / CP2, because CP6 can be set to any oxygen value.

2.7.3 Calibration Procedure

2.7.3.1 Calibration at CP1 and CP2 (Standard Calibration)

The ARC Sensor family has a unique calibration routine. When initiating the calibration, the data set of the sensor is automatically traced back within the last 3 minutes and a decision is made immediately if the calibration is successful or not. The operator therefore gets an immediate result. The criteria for a successful calibration are:

- the stability of oxygen value and temperature over the last 3 minutes (see register 5128)
- the currently measured oxygen value fits to one of the calibration standards defined in the selected set of calibration standards
- the limits of compensated slope and offset at zero oxygen have to be met

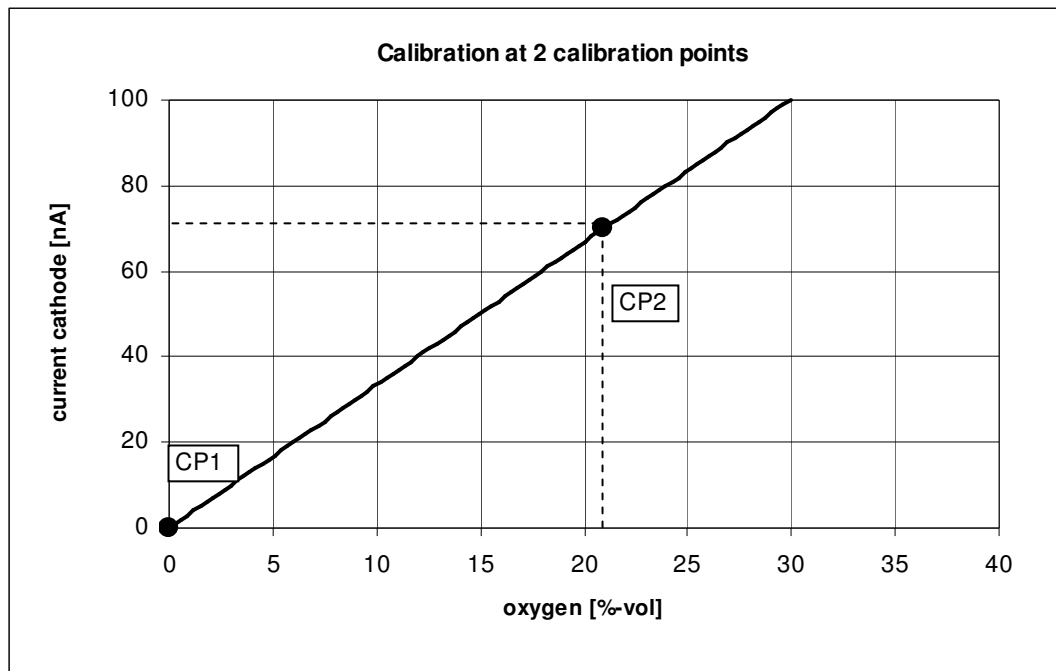


Figure 2.7.3.1.1: Standard Calibration using CP1 and CP2.

CP1 and CP2 define a linear relationship between the electrical current and the oxygen value. This linear calibration function is defined by an offset at zero oxygen [nA] and a slope [nA]. This slope is compensated to air saturated water at 25°C, 1013mbar and 0mS/cm. These two values are stored in register 5448.

Notes:

- In order to perform a standard calibration at CP1 and CP2, it is necessary to use calibration standards. The operator is restricted to use those standards that are defined in the six sets of calibration standards (see chapter 2.7.11).
- There are two ways of performing a standard calibration:
 - standard calibration with **automatic recognition** of the calibration standard: in this case, the sensor decides on itself in what calibration standard it is immersed. The criteria to decide on is the electrical current measured. The sensor checks the list of calibration standards that are available for automatic recognition (see chapter 2.7.11)
 - standard calibration with **manual selection** of the calibration standard: the operator is selecting the calibration standard in which the sensor is immersed.
- Factory calibration is zero oxygen at CP1 and air saturated water at 25°C, 1013mbar and 0mS/cm at CP2.

Standard Calibration with Automatic Recognition of the Standard

Prior to calibration, the specialist selects - for each set of calibration standards - a list of calibration standards allowed for automatic recognition (register 9530).

When the calibration is initiated, the sensor screens this list of allowed calibration standards and checks if the currently measured oxygen value is within the allowed range of oxygen values, defined for the individual calibration standards in this list.

If the sensor does find a corresponding calibration standard, the nominal oxygen value of the specific calibration standard is assigned to the currently measured electrical current. The temperature dependency of the calibration standard is considered during the assignment.

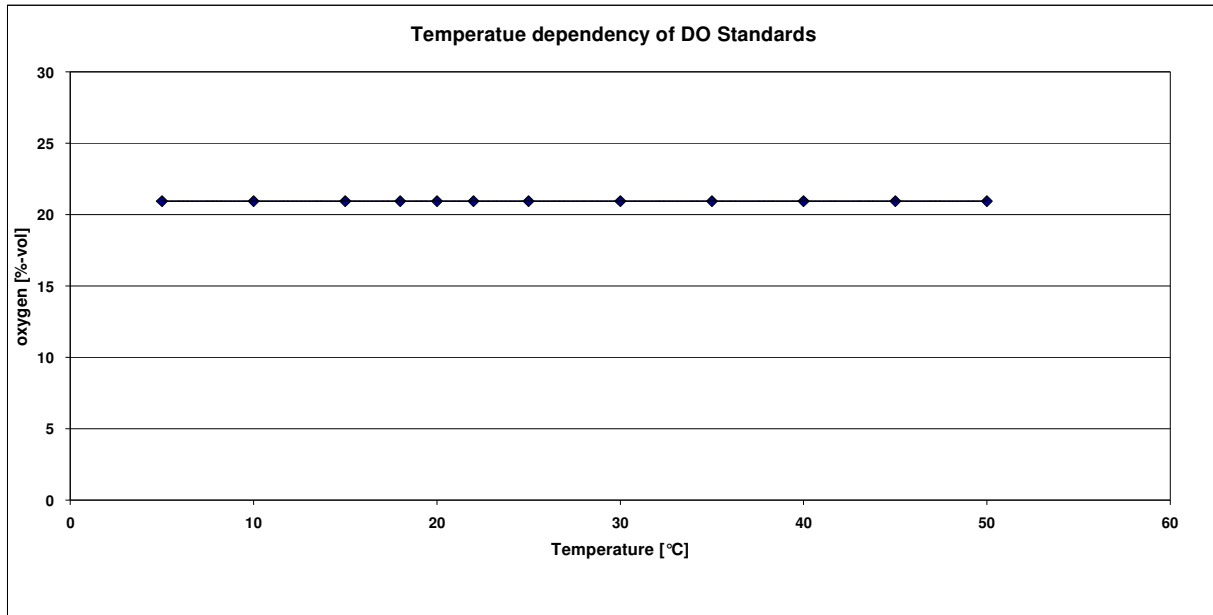


Figure 2.7.3.1.2: Temperature dependency of the oxygen value of DO Standards calibration standards.

If the sensor does not find any corresponding calibration standard, the bit representing the corresponding status “no matching calibration standard” is set in the calibration status register.

Note that only the nominal value of the calibration standard is used for calibration. The actual value of the calibration solution, which may deviate from the nominal value, is not taken into account and cannot be set by the operator.

Standard Calibration with Manual Selection of the Calibration Standard

If the operator knows in what calibration standard the sensor is immersed, he can initiate the calibration procedure by means of setting the oxygen value to the actual value of the calibration standard. The sensor now screens the list of calibration standards that are allowed for manual selection (register 9530). If the oxygen value entered by the operator fits in the allowed range of one of the allowed calibration standards, the entered oxygen value is assigned to the currently measured electrical current. The temperature dependency of the calibration standard is considered during the assignment.

If the sensor does not find any corresponding calibration standard, the bit representing the corresponding status “no matching calibration standard” is set in the calibration status register.

Note: using manual selection only, the actual oxygen value of the calibration standard can be set. However, the actual value must be within the given tolerance of the standard in use.

Perform the following steps to do a standard calibration at CP1 and CP2:

Step 1: Select the desired set of calibration standards (see chapter 2.7.11)

Step 2: Immerse the sensor into one of the calibration standards available in the selected set



Attention:

It is important that the EDO ARC Sensor is immersed in a defined calibration standard at least 3 minutes BEFORE the calibration is started.

Step 3: Choose one of the calibration points CP1 or CP2.



Attention:

The assignment of both CP1 and CP2 to the same oxygen value is rejected.

Step 4: Start the calibration (automatic recognition or manual selection)

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

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

Figure 2.7.3.1.3: Definition of register 5162 and 5194. You have two options to enter the oxygen value:
 Automatic recognition: oxygen value=0: the sensor tries to assign the measured electrical current to one of the calibration standards available for automatic calibration.
 Manual selection: enter the actual oxygen value at 25 °C (the value must be within the tolerance range of the nominal value of one of the calibration standards available for manual selection)

Step 5: Read the calibration status (see chapter 2.7.4)

Step 6: Check the EDO ARC Sensor's quality indicator

Examples: (Definitions of register 5158 and 5190 used in these examples are given in chapter 2.7.4.1, those for register 4872 in chapter 2.8.6)

Example to calibrate at CP1 with automatic recognition:

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

Figure 2.7.3.1.4: Example to start the calibration at CP1, setting a value of 0 for automatic recognition of the calibration standard.

Example to calibrate at CP2 with automatic recognition:

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

Figure 2.7.3.1.5: Example to start the calibration at CP2, setting a value of 0 for automatic recognition of the calibration standard.

Example to read the calibration status of CP1:

Command: Calibration status CP1		Modbus address: 5158	Length: 6	Type: 3	Read
Parameter:	Status	Unit	Value		
Format:	Hex	Hex	Float		
Value:	0x00000000	0x00000010	0		

Figure 2.7.3.1.6: Example to read the calibration status of CP1 after calibration CP1 at 0 = auto. All bits of CP1 are zero (0x00000000), indicating that the calibration was successful. The physical unit of the last calibration is %-vol (0x00000010) and the assigned DO value is 0 at 25°C.

Example to read the calibration status of CP2:

Command: Calibration status CP2		Modbus address: 5190	Length: 6	Type: 3	Read
Parameter:	Status	Unit	Value		
Format:	Hex	Hex	Float		
Value:	0x00000000	0x00000010	20.95		

Figure 2.7.3.1.7: Example to read the calibration status of CP2 after calibrating CP2 at 0 = auto. All bits of CP2 are zero (0x00000000), indicating that the calibration was successful. The physical unit of the last calibration is %-vol (0x00000010) and the DO value is 20.95.

Example to read the sensor's quality indicator:

Command: Quality indicator		Modbus address: 4872	Length: 2	Type: 3	Read
Parameter:	Quality [%]				
Format:	Float				
Value:	100				

Figure 2.7.3.1.9: Example to read the sensor's quality indicator

2.7.3.2 Calibration at CP6 (Product Calibration)

The product calibration is a process in order to adjust the measurement of a correctly calibrated EDO ARC Sensor to specific process conditions.

Product calibration is a two stage process:

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

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

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

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

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

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

What happens to the EDO ARC Sensor's calibration function upon product calibration (CP6)?
 A product calibration changes the compensated slope of the linear calibration function defined by the standard calibration at CP1 and CP2.

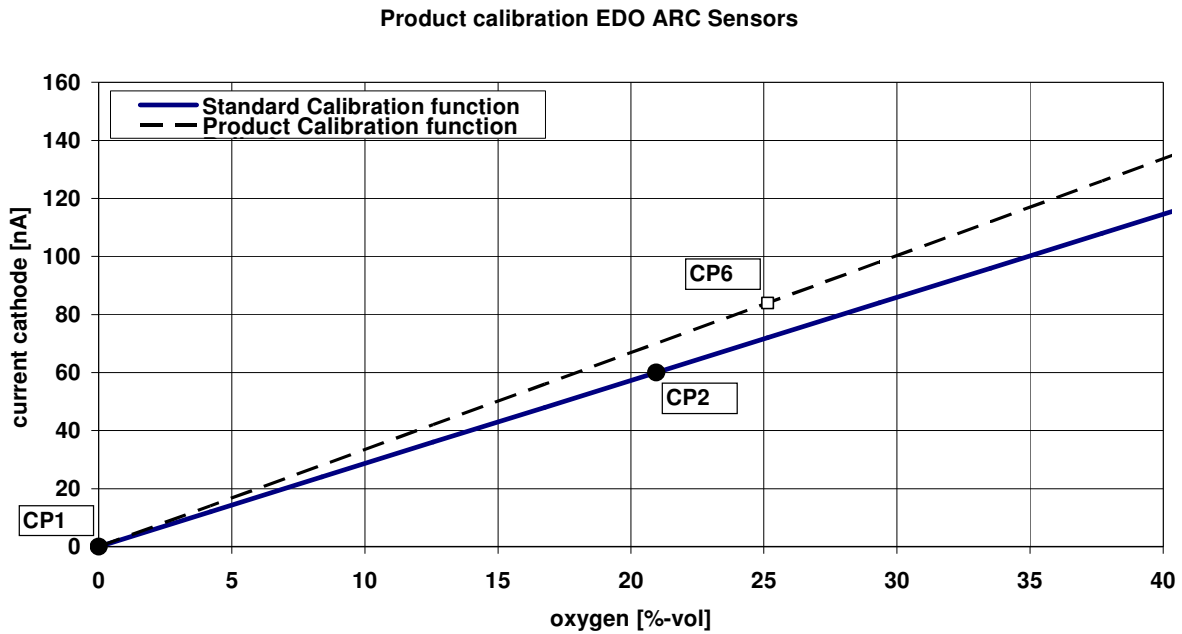


Figure 2.7.3.2.1: Effect of the product calibration CP6 on an existing standard calibration function defined by CP1 and CP2.

The operator starts with a Standard Calibration with calibration points CP1 and CP2:

CP1: DO value of calibration standard: 0 %-vol electrical potential: 0 nA
 CP2: DO value of calibration standard: 20.95 %-vol electrical potential: 60 nA

The sensor internally calculates the calibration function, using the calibration points **CP1** and **CP2**. The resulting calibration function, compensated to air saturated water at 25°C, 1013mbar and 0mS/cm, is shown as a straight line. The calibration function is described by two parameters: the offset at zero oxygen and the slope.

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 of product: 25%-vol electrical current: 85 nA

The sensor internally changes the slope of the calibration curve. The zero point 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”.

Note:

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

- the sensor is currently in an environment corresponding to the EDO ARC Sensors measurement range.
- the oxygen content is within the calibration limits defined for CP6 (see above)
- the parameters for the product calibration defined by CP1 and CP6 are in the following range:
 - the current at zero oxygen remains the same (since it is defined by CP1)
 - the new compensated slope compared to the slope defined by prior calibration (e.g. CP1/CP2) is not lower than 10% or higher than 1000%.

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 value 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:

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

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

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

Figure 2.7.3.2.3: Definition of register 5340

2.7.3.2.1 Product calibration: Initial measurement

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

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

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

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

After successful initial measurement the corresponding calibration status (register 5318, figure 2.7.4.2.1) is "CP6 initial measurement" (0x08000000) (see figure 2.7.4.1.1).

The sensor continues measuring using the prior standard calibration.

2.7.3.2.2 Product calibration: Assignment

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

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

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

Figure 2.7.3.2.2.1: Definition of register 5322

Command: CP6: Assignment		Modbus address: 5322	Length: 2	Type: 16	Write
Parameter:	Value				
Format:	Float				
Value:	30				

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

This is achieved by writing the correct oxygen value in the correct unit (here 30 %-vol)

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

The calibration status (register 5318) is 0x14000000 meaning that a correct value has been assigned and that the product calibration is active (see figure 2.7.4.1.1).

2.7.3.2.3 Product calibration: Cancel

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

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

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

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

The sensor's calibration status (register 5318) will be reading 0x00 again (see figure 2.7.4.1.1).

2.7.3.2.4 Product calibration: Restore standard calibration

If a product calibration is active this product calibration can be temporarily switched off by writing the command 0x03 to register 5340. Performing this action the values of the product calibration remain stored in the sensor's memory.

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

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

From now on the sensor is measuring using its prior CP1 / CP2 standard calibration. The sensor's calibration status (register 5318) 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).

2.7.3.2.5 Product calibration: Restore product calibration

If a valid but inactivated product calibration is available in the sensors memory, the calibration status is reading "CP6 assigned" (corresponding to 0x10000000, 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 2.7.3.2.5.1: Example to restore an available product calibration from an active standard calibration. Writing command 0x04 (restore product calibration) to register 5340.

From now on the sensor is measuring using its prior CP6 product calibration. The sensors calibration status (register 5318) 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 CP1 and CP2

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

- Register 5158 for CP1
- Register 5190 for CP2



Note

Registers 5158 and 5190 contain the same information!

Bit #	Hex value	Definition
0 (LSB)	0x00000001	not available
1	0x00000002	CP1: no matching calibration standard
2	0x00000004	CP1: actual temperature reading is too low
3	0x00000008	CP1: actual temperature reading is too high
4	0x00000010	CP1: temperature reading during calibration is not stable
5	0x00000020	CP1: current at zero oxygen is too low or slope is too low (see chapter 2.7.8)
6	0x00000040	CP1: current at zero oxygen is too high or slope is too high (see chapter 2.7.8)
7	0x00000080	CP1: oxygen reading during calibration is not stable
8	0x00000100	not available
9	0x00000200	CP2: no matching calibration standard
10	0x00000400	CP2: actual temperature reading is too low
11	0x00000800	CP2: actual temperature reading is too high
12	0x00001000	CP2: temperature reading during calibration is not stable
13	0x00002000	CP2: slope is too low (see chapter 2.7.8)
14	0x00004000	CP2: slope is too high (see chapter 2.7.8)
15	0x00008000	CP2: oxygen reading during calibration is not stable
...		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
30	0x40000000	CP2: incorrect measurement unit
31	0x80000000	CP1: incorrect measurement unit

Figure 2.7.4.1.1: Definition of the status for register 5158, 5190 and 5318 (see Figure 2.7.4.1.2 and 2.7.4.2.1).

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

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

Command: Calibration status CP1		Modbus address: 5158		Length: 6	Type: 3	Read
Parameter:	Status	Unit	Value			
Format:	Hex	Hex	Float			
Value:	0x00000080	0x00000010	0			

Figure 2.7.4.1.3: Example to read the calibration status of CP1 after calibration CP1 at 0 = auto. The status message is: "CP1 DO reading during calibration is not stable" (0x00000080). The physical unit of the last successful calibration is %-vol (0x00000010) and the last successful calibration has been performed at 0 %-vol.

Command: Calibration status CP2		Modbus address: 5190		Length: 6	Type: 3	Read
Parameter:	Status	Unit	Value			
Format:	Hex	Hex	Float			
Value:	0x00000080	0x00000010	20.95			

Figure 2.7.4.1.4: Example to read the calibration status of CP2 after calibrating CP2 at 0 = auto. All bits of CP2 are zero (0x00000080), indicating that the calibration was successful. The physical unit of the last calibration is %-vol (0x00000010) and the last successful calibration has been performed at 20.95 %-vol.

Please note that the status says: "CP1 Oxygen reading during calibration is not stable". This is a status bit for CP1. All bits of CP1 will remain unaffected when calibrating CP2.

Command: Calibration status CP2		Modbus address: 5190		Length: 6	Type: 3	Read
Parameter:	Status	Unit	Value			
Format:	Hex	Hex	Float			
Value:	0x00000180	0x00000010	20.95			

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

2.7.4.2 Reading the Calibration Status of CP6 (Product Calibration)

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

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

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

2.7.4.2.1 Product calibration: Initial measurement

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

Command: Calibration status CP6		Modbus address: 5318	Length: 6	Type: 3	Read
Parameter:	Status	Unit	Value		
Format:	Hex	Hex	Float		
Value:	0x01000000	0x00000010	25		

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" (0x01000000). The last successful calibration has been performed at 25 %-vol. The initial measurement in this case was **not** successful. The sensor is still running on its prior standard calibration.

Calibration status after successful initial measurement:

Command: Calibration status CP6		Modbus address: 5318	Length: 6	Type: 3	Read
Parameter:	Status	Unit	Value		
Format:	Hex	Hex	Float		
Value:	0x08000000	0x00000010	25		

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" (0x08000000). The last successful calibration has been performed at 25 %-vol. The initial measurement in this case was successful. The sensor is still running on its prior standard calibration until a valid calibration value has been assigned to this initial measurement values.

2.7.4.2.2 Product calibration: Assignment

Calibration status after invalid assignment:

Command: Calibration status CP6		Modbus address: 5318	Length: 6	Type: 3	Read
Parameter:	Status	Unit	Value		
Format:	Hex	Hex	Float		
Value:	0x0A000000	0x00000010	25		

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" (0x02000000) and "CP6: initial measurement" (0x08000000). The last successful calibration has been performed at 25 %-vol. The initial measurement in this case is still valid and available for further assignment of a product calibration value. The here performed assignment was **not** successful. The sensor remains running on its prior standard calibration.

Calibration status after valid assignment:

Command: Calibration status CP6		Modbus address: 5318	Length: 6	Type: 3	Read
Parameter:	Status	Unit	Value		
Format:	Hex	Hex	Float		
Value:	0x14000000	0x00000010	30		

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 to 30 %-vol. The status says: "CP6: active" (0x04000000) and "CP6: assigned" (0x10000000). The last successful calibration corresponding to the here performed assignment has been performed at 30 %-vol. 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	0x00000010	30			

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 reports no messages. The last successful calibration at CP6 has been performed at 30 %-vol.

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

2.7.4.2.4 Product calibration: Restore standard calibration

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

Command: Calibration status CP6		Modbus address: 5318		Length: 6	Type: 3	Read
Parameter:	Status	Unit	Value			
Format:	Hex	Hex	Float			
Value:	0x10000000	0x00000010	30			

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 last successful calibration at CP6 has been performed at 30 %-vol.

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

2.7.4.2.5 Product calibration: Restore product calibration

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

Command: Calibration status CP6		Modbus address: 5318		Length: 6	Type: 3	Read
Parameter:	Status	Unit	Value			
Format:	Hex	Hex	Float			
Value:	0x14000000	0x00000010	30			

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

The status says: "CP6: active" (0x04000000) and "CP6: assigned" (0x10000000). The last successful calibration corresponding to the here performed assignment has been performed at 30 %-vol.

The sensor is running on a valid product calibration again.

2.7.5 Currently active Calibration Parameters part 1

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

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

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

Command: Calibration CP1 values		Modbus address: 5164		Length: 8	Type: 3	Read
Parameter:	Unit of temperature	Temperature	Number of cali	Operating hour		
Format:	Hex	Float	Decimal	Float		
Value:	0x00000004	22.05521	6	73.78		

Figure 2.7.5.2: Example to read the calibration values for CP1. The physical unit is °C (0x00000004), the temperature is 22.05521 °C, the number of calibrations at CP1 is 6 and the operating hour is 73.78 h.

Command: Calibration CP2 values		Modbus address: 5196		Length: 8	Type: 3	Read
Parameter:	Unit of temperature	Temperature	Number of cali	Operating hour		
Format:	Hex	Float	Decimal	Float		
Value:	0x00000004	26.40778	31	135.49		

Figure 2.7.5.3: Example to read the calibration values for CP2. The physical unit is °C (0x00000004), the temperature is 26.40778 °C, the number of calibrations at CP1 is 31 and the operating hour is 135.49 h.

Command: Calibration CP6 values		Modbus address: 5324		Length: 8	Type: 3	Read
Parameter:	Unit of temperature	Temperature	Number of cali	Operating hour		
Format:	Hex	Float	Decimal	Float		
Value:	0x00000004	29.93368	9	102.81		

Figure 2.7.5.4: Example to read the calibration values 1 for CP6. The physical unit is °C (0x00000004), the temperature is 29.93368 (°C), the number of calibrations at CP1 is 9 and the operating hour is 102.81 (h).

2.7.6 Currently active Calibration Parameters part 2

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

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

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

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

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

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

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

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

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

2.7.7 Currently active Calibration Parameters part 3

In register 5520, 5528 and 5560 the oxygen value of the used calibration standards, the electrical current of the EDO ARC sensor and the temperature upon calibration are stored.

Start register	Number of registers	Reg1 / Reg2	Reg3 / Reg4	Reg5 / Reg6	Reg7 / Reg8	Modbus function code	Read access	Write access
5520	8	DO value of calibration standard at CP1 [mbar]	Electrical current at CP1 [nA]	Temp at CP1 [K]	free	3, 4	A/S	none
5528	8	DO value of calibration standard at CP2 [mbar]	Electrical current at CP2 [nA]	Temp at CP2 [K]	free	3, 4	A/S	none
5560	8	DO value of product at CP6 [mbar]	Electrical current at CP6 [nA]	Temp at CP6 [K]	free	3, 4	A/S	none

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

Command: Act calibration CP1		Modbus address: 5520		Length: 8	Type: 3	Read
Parameter:	DO CP1 [mbar]	Current CP1 [nA]	Temp CP1 [K]	Pressure CP1 [mbar]		
Format:	Float	Float	Float	Float		
Value:	0	0.02	297.1378	1013		

Figure 2.7.7.2: Example to read the actual calibration values of CP1.

Command: Act calibration CP2		Modbus address: 5528		Length: 8	Type: 3	Read
Parameter:	DO CP2 [mbar]	Current CP2 [nA]	Temp CP2 [K]	Pressure CP1 [mbar]		
Format:	Float	Float	Float	Float		
Value:	204.99	58.47	299.56	1013		

Figure 2.7.7.3: Example to read the actual calibration values of CP2.

Command: Act calibration CP6		Modbus address: 5560		Length: 8	Type: 3	Read
Parameter:	DO CP6 [mbar]	Current CP6 [nA]	Temp CP6 [K]	Pressure CP1 [mbar]		
Format:	Float	Float	Float	Float		
Value:	205.02	58.47	299.57	1013		

Figure 2.7.7.4: Example to read the actual calibration values of CP6.

2.7.8 Currently active Calibration Parameters part 4

For standard calibration (CP1 / CP2) register 5448 documents current at zero oxygen and compensated slope:

Start register	Number of registers	Reg1 / Reg2 (Float)	Reg3 / Reg4 (Float)	Reg5 / Reg6 (Float)	Modbus function code	Read access	Write access
5448	6	Current at zero oxygen [nA]	Compensated Slope [nA]	Reference temperature [K]	3, 4	U/A/S	none

Figure 2.7.8.1: Definition of register 5448.

Command: Calculated cali values		Modbus address: 5448		Length: 6		Type: 3		Read
Parameter:	Current at zero oxygen [nA]	Compensated slope [nA]	Ref temp [K]					
Format:	Float	Float	Float					
Value:	0.02	56.17	298.15					

Figure 2.7.8.2: Example to read register 5448: Current at zero oxygen is 0.02 nA; compensated slope is 56.17 nA; reference temperature is 298.15 K (=25°C)

For standard calibration (CP1 / CP2) register 5480 documents limits of current at zero oxygen and compensated slope:

Start register	Number of registers	Reg1 / Reg2	Reg3 / Reg4	Reg5 / Reg6	Reg7 / Reg8	Modbus function code	Read access	Write access
5480	8	Min value of current at zero oxygen [nA]	Max value of current at zero oxygen [nA]	Min value of compensated slope [nA]	Max value of compensated slope [nA]	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 value of current at zero oxygen [nA]	Max value of current at zero oxygen [nA]	Min value of compensated slope [nA]	Max value of compensated slope [nA]				
Format:	Float	Float	Float	Float				
Value:	-0.5	0.5	30	95				

Figure 2.7.8.4: Example to read register 5480: Current at zero oxygen is allowed from -0.5 to +0.5 nA; compensated slope is allowed from 30 to 95 nA.

2.7.9 Special Commands for Calibration with VISICAL

The VISICAL calibration device allows calibration of EDO ARC Sensors at CP1 or CP2. The EDO ARC Sensor's associated calibration parameters for CP1 and CP2 are those predefined and stored in corresponding registers of the sensor.

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



Attention:

- It is not possible to perform a product calibration using VISICAL.
- Physical unit is fixed to %-vol by definition.

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

Figure 2.7.9.1: Definition of register 5180 for CP1 and 5212 for CP2.

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

Figure 2.7.9.2: Example to read the oxygen value valid for CP1. It is 0 %-vol. Accordingly, the next time when a calibration is started using VISICAL at LOW, a calibration with manual selection is performed, using the calibration standard at zero oxygen.

Command: VISICAL CP2		Modbus address: 5212		Length: 2	Type: 16	Write
Parameter:	Value [%-vol]					
Format:	Float					
Value:	20.95					

Figure 2.7.9.3: Example to set the oxygen value valid for CP2.

Command: VISICAL CP2		Modbus address: 5212		Length: 2	Type: 3	Read
Parameter:	Value [%-vol]					
Format:	Float					
Value:	20.95					

Figure 2.7.9.4: Example to read the oxygen value valid for CP2. It is 20.95 %-vol. Accordingly, the next time when a calibration is started using VISICAL at HIGH, a calibration with manual selection is performed, using the calibration standard at 20.95 %-vol. The operator has to make sure that - within the selected set of calibration standards - a standard at 20.95 %-vol is selected for manual selection.

2.7.10 Calibration Standards

2.7.10.1 Available Sets of Calibration Standards

EDO ARC Sensors can store and operate six different sets of calibration standards each having max 12 calibration standards. Before calibration the operator has to select one defined set to operate with. Default setting is the DO Standards set of calibration standards.

The operator can change the selection of sets at any time, without compromising prior calibration data at CP1 / CP2.

In register 9472 the available sets of calibration standards are defined.

Start register	Number of registers	Reg1 / Reg2 (Bit, see Figure 2.7.10.1.2)	Modbus function code	Read access	Write access
9472	2	Available calibration standard sets	3, 4	U/A/S	none

Figure 2.7.10.1.1: Definition of register 9472.

Bit #	Hex value	Description	Definition
0 (LSB)	0x00000001	Set 1	DO Standards
1	0x00000002	Set 2	not available
2	0x00000004	Set 3	not available
3	0x00000008	Set 4	not available
4	0x00000010	Set 5	not available
5	0x00000020	Set 6	not available

Figure 2.7.10.1.2: Definition of available sets of calibration standards.

Command: Available cali sets		Modbus address: 9472	Length: 2	Type: 3	Read
Parameter:	Calibration sets				
Format:	Hex				
Value:	0x00000001				

Figure 2.7.10.1.3: Example to read the available calibration sets: Set 1 (0x00000001), in total 0x00000001.

In register 9474 the selected set of calibration standards is defined.

Start register	Number of registers	Reg1 / Reg2 (Bit, see Figure 2.7.10.1.2)	Modbus function code	Read access	Write access
9474	2	Selected set of calibration standard	3, 4	U/A/S	S

Figure 2.7.10.1.4: Definition of register 9474. Only one bit can be set.

Command: Selected set of cal stand.		Modbus address: 9474	Length: 2	Type: 3	Read
Parameter:	Calibration set				
Format:	Hex				
Value:	0x00000001				

Figure 2.7.10.1.5: Example to read the selected set of calibration standards. Set 1 (DO Standards) (0x00000001) is active.

Command: Select set of cal stand.		Modbus address: 9474	Length: 2	Type: 16	Write
Parameter:	Calibration set				
Format:	Hex				
Value:	0x02				

Figure 2.7.10.1.6: Example to set the calibration standard set to calibration set number 2 (currently not used) (0x02).

2.7.10.2 Definitions for Individual Sets of Calibration Standards

Once the operator has selected a set of calibration standards (register 9474) the register 9504 and following give all information on the selected set of calibration standards.

Start register	Number of registers	Reg1 ... Reg8 (16 ASCII characters)	Modbus function code	Read access	Write access
9504	8	Manufacturer of the selected set	3, 4	U/A/S	none
9512	8	Info 1 of the selected set	3, 4	U/A/S	none
9520	8	Info 2 of the selected set	3, 4	U/A/S	none

Figure 2.7.10.2.1: Definition of registers 9504 to 9520.

Command: manufacturer of set	Modbus address: 9504	Length: 8	Type: 3	Read
Parameter: Text				
Format: Character				
Value: DO Standards				

Figure 2.7.10.2.2: Example to read the description (in this case, the set 0x01 is selected)

Within one set of calibration standards, a maximum of 12 calibration standards are available. In the following registers, the details of each calibration standard are given:

Start register	Description
9536	Nominal value and tolerance of calibration standard 1
9552	Nominal value and tolerance of calibration standard 2
9568	Nominal value and tolerance of calibration standard 3
9584	Nominal value and tolerance of calibration standard 4
9600	Nominal value and tolerance of calibration standard 5
9616	Nominal value and tolerance of calibration standard 6
9632	Nominal value and tolerance of calibration standard 7
9648	Nominal value and tolerance of calibration standard 8
9664	Nominal value and tolerance of calibration standard 9
9680	Nominal value and tolerance of calibration standard 10
9696	Nominal value and tolerance of calibration standard 11
9712	Nominal value and tolerance of calibration standard 12

Figure 2.7.10.2.3: Definition for the register range from 9536 until 9720.

Start register	Number of registers	Reg1 / Reg2 (Float)	Reg3 / Reg4 (Float)	Reg5 / Reg6 (Float)	Reg7 / Reg8 (Float)	Modbus function code	Read access	Write access
9536, 9552, ...	8	Calibr. standard nominal value (manual) [%-vol]	Tolerance of nominal value (manual) (±) [%-vol]	Calibr. standard nominal value (automatic) [%-vol]	Tolerance of nominal value (automatic) (±) [%-vol]	3, 4	U/A/S	none

Figure 2.7.10.2.4: Definition for registers 9536 until 9720.

Command: Read standard 1		Modbus address: 9536		Length: 8	Type: 3	Read
Parameter:	Nominal value (manual) [%-vol]	Tolerance (manual) (±) [%-vol]	Nominal value (automatic) [%-vol]	Tolerance (automatic) (±) [%-vol]		
Format:	Float	Float	Float	Float		
Value:	20.95	20	20.95	5		

Figure 2.7.10.2.5: Example to read the values for calibration standard 1 within the "DO Standards" set. This standard has a nominal value of 20.95 %-vol.

During standard calibration with automatic recognition the sensor accepts a range of oxygen readings between 15.95 and 25.95 %-vol (20.95 ± 5 %-vol) to be assigned to this standard. Of course, the oxygen reading used for this assignment considers on the currently active current at zero oxygen and compensated slope.

During standard calibration with manual recognition only oxygen values between 0.95 and 40.95 %-vol (20.95 ± 20 %-vol) can be assigned to this standard.

Note: The decision, if this standard calibration is valid, is made after calculation of the current at zero oxygen and of the compensated slope. If one of those two parameters is out of limits, the calibration using this standard will be denied.

Note: Make sure that calibration standards selected for automatic calibration do not exhibit overlapping acceptance ranges!

Register 9528 defines for the selected set of calibration standards:

- the available calibration standards for manual selection of the oxygen value
- the available calibration standards for automatic recognition of the oxygen value

Start register	Number of registers	Reg1 / Reg2 (Bit, see figure 2.7.10.2.8)	Modbus function code	Read access	Write access
9528	2	Availability of the 12 cal. standards	3, 4	U/A/S	none

Figure 2.7.10.2.6: Definition of register 9528

Command: Available standards		Modbus address: 9528	Length: 2	Type: 3	Read
Parameter:	Standard fields				
Format:	Hex				
Value:	0x00010001				

Figure 2.7.10.2.7: Example to read the information of register 9528. For the definition of the bits, see Figure 2.7.10.2.8. The value 0x00010001 says that (for the selected set of calibration standards):

- first calibration standard is available for manual calibration
- first calibration standard is available for automatic recognition.

Bit	Hex code	Index of Calibration Standard within the selected set	Calibration type
0 (LSB)	0x00000001	1	manual selection
1	0x00000002	2	manual selection
2	0x00000004	3	manual selection
3	0x00000008	4	manual selection
4	0x00000010	5	manual selection
5	0x00000020	6	manual selection
6	0x00000040	7	manual selection
7	0x00000080	8	manual selection
8	0x00000100	9	manual selection
9	0x00000200	10	manual selection
10	0x00000400	11	manual selection
11	0x00000800	12	manual selection
12-15		not available	
16	0x00010000	1	automatic recognition
17	0x00020000	2	automatic recognition
18	0x00040000	3	automatic recognition
19	0x00080000	4	automatic recognition
20	0x00100000	5	automatic recognition
21	0x00200000	6	automatic recognition
22	0x00400000	7	automatic recognition
23	0x00800000	8	automatic recognition
24	0x01000000	9	automatic recognition
25	0x02000000	10	automatic recognition
26	0x04000000	11	automatic recognition
27	0x08000000	12	automatic recognition
28-31		not available	

Figure 2.7.10.2.8: Availability / Selection for the 12 calibration standards within one given set.

- Bit 0-11 define availability of standards 1-12 for manual calibration.
- Bit 16-27 define availability of standards 1-12 for automatic recognition
- Register 9528: the corresponding calibration standard is available if bit is set
- Register 9530: the corresponding calibration standard is selected if bit is set

By means of register 9530, the specialist can define for each available calibration standard if the specific standard is available.

Start register	Number of registers	Reg1 / Reg2 (Bit, see figure 2.7.10.2.8)	Modbus function code	Read access	Write access
9530	2	Selected standard fields	3, 4	U/A/S	S

Figure 2.7.10.2.9: Selected calibration standards within one given set.

Command:	Selected standard fields	Modbus address:	9530	Length:	2	Type:	3	Read
Parameter:	Standard fields							
Format:	Hex							
Value:	0x00010001							

Figure 2.7.10.2.10: Example to read the selected calibration standards. The value 0x00010001 says that:

- first calibration standard is selected for manual selection
- first calibration standard is selected for automatic recognition

Command:	Selected standard fields	Modbus address:	9530	Length:	2	Type:	16	Write
Parameter:	Standard fields							
Format:	Hex							
Value:	0x0007000F							

Figure 2.7.10.2.11: Example to set the standard fields to 4 calibration standards for manual calibration and calibration standard 1 (0x00010000), 2 (0x00020000) and 3 (0x00040000) for automatic recognition.

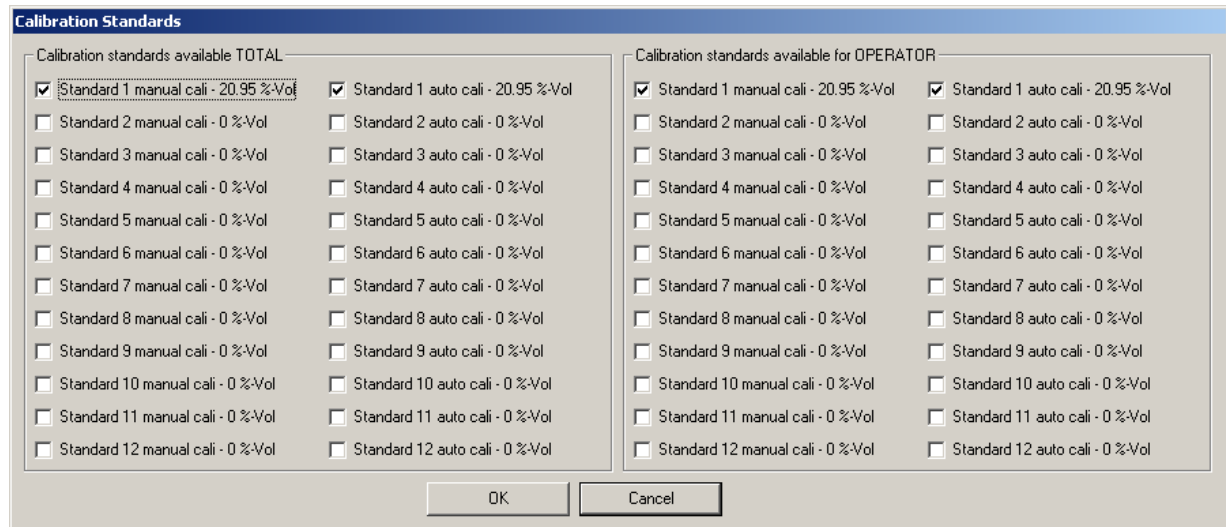


Figure 2.7.10.2.12: Illustration from the ARC Sensor Configurator software tool for registers 9528 and 9530. For this example, the DO Standards set of calibration standard is selected.

On the left half of the figure, the availability of the calibration standards 1-12 is shown, as defined in register 9528. In the left column, the availability for manual calibration is shown (calibration standard 1). In the right column, the availability for automatic recognition is given (calibration standard 1).

On the right half of the figure, the individual selection defined by the specialist is shown as read from register 9530. In the left column, the selection for manual selection is shown (calibration standard 1). In the right column the selection for automatic recognition is given (calibration standard 1).

2.8 Sensor Status

2.8.1 Temperature Ranges

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

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

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

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

Command: Operating T range		Modbus address: 4608		Length: 4	Type: 3	Read
Parameter:	Operating T min [°C]	Operating T max [°C]				
Format:	Float	Float				
Value:	-20	130				

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

Command: Measurement T range		Modbus address: 4612		Length: 4	Type: 3	Read
Parameter:	Measurement T min [°C]	Measurement T max [°C]				
Format:	Float	Float				
Value:	-20	130				

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:	5	50				

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

2.8.2 Operating Hours and Counters

In register 4676 are given:

- 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 the sensor's flash memory

In register 4688 are given:

- number of sterilizations in place (SIP) (see chapter 2.8.5)
- number of cleanings in place (CIP) (see chapter 2.8.5)

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

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

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

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

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

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

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

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

2.8.3 Warnings

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

2.8.3.1 Currently Active Warnings

The currently active warnings are stored in register 4736.

Start register	Number of registers	Reg1 / Reg2	Reg3 / Reg4	Reg5 / Reg6	Reg7 / Reg8	Modbus function code	Read access	Write access
4736	8	Active warning measurement (bitwise defined)	Active warning calibration (bitwise defined)	Active warning interface (bitwise defined)	Active warning 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: Active warning		Modbus address: 4736		Length: 8	Type: 3	Read
Parameter:	W Measurement	W Calibration	W Interface	W Hardware		
Format:	Hex	Hex	Hex	Hex		
Value:	0x00	0x00	0x00	0x00		

Figure 2.8.3.1.2: Example to read the currently active warnings.

2.8.3.2 History of Warnings

The history of warnings is not implemented in EDO ARC Sensors.

2.8.3.3 Definition of Warnings

Bit #	Hex	Description
		not available
30	0x40000000	Polarization timer active

Figure 2.8.3.3.1: Definition of warnings “measurement”.

Bit #	Hex	Description
0 (LSB)	0x0001	PMC1 (oxygen) calibration recommended
1	0x0002	PMC1 (oxygen) last calibration not successful

Figure 2.8.3.3.2: Definition of warnings “calibration”.

Bit #	Hex	Description
		not available

Figure 2.8.3.3.3: Definition of warnings “interface”. None is defined.

Bit #	Hex	Description
		not available

Figure 2.8.3.3.4: Definition of warnings “hardware”. None is defined.

2.8.4 Errors

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

2.8.4.1 Currently Active Errors

The currently active errors are stored in register 4800.

Start register	Number of registers	Reg1 / Reg2	Reg3 / Reg4	Reg5 / Reg6	Reg7 / Reg8	Modbus function code	Read access	Write access
4800	8	Active error measurement (bitwise defined)	Active error calibration (bitwise defined)	Active error interface (bitwise defined)	Active error 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: Active errors		Modbus address: 4800		Length: 8	Type: 3	Read
Parameter:	E Measurement	E Calibration	E Interface	E Hardware		
Format:	Hex	Hex	Hex	Hex		
Value:	0x00	0x00	0x00	0x00	0x00	

Figure 2.8.4.1.2: Example to read the currently active errors.

2.8.4.2 History of Errors

The history of errors is not implemented in EDO ARC Sensors.

2.8.4.3 Definition of Errors

Bit #	Hex	Description
0	0x0000001	DO reading failure (this error occurs, when any other error is active)
1	0x0000002	p(O2) exceeds air pressure
		not available
20	0x0100000	Cathode impedance too high
21	0x0200000	Cathode impedance too low
		not available
25	0x2000000	Temperature sensor defective

Figure 2.8.4.3.1: Definition of errors "measurement".

Bit #	Hex	Description
1	0x0000002	Sensor failure (Quality value < 15%)

Figure 2.8.4.3.2: Definition of errors "calibration".

Bit #	Hex	Description
		not available

Figure 2.8.4.3.3: Definition of errors "interface". None is defined.

Bit #	Hex	Description
		not available
24	0x1000000	Internal communication error (between front-end and user-end)

Figure 2.8.4.3.4: Definition of errors "hardware".

2.8.5 Reading Definition of SIP and CIP

EDO ARC Sensor are counting special cleaning events such as sterilizations or cleaning cycles by means of tracking typical temperature profiles (see chapter 2.8.2).

Register 4988 defines a typical temperature profile for SIP (sterilization in place) and register 4996 for CIP (cleaning in place). For the explanation the following values are given:

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

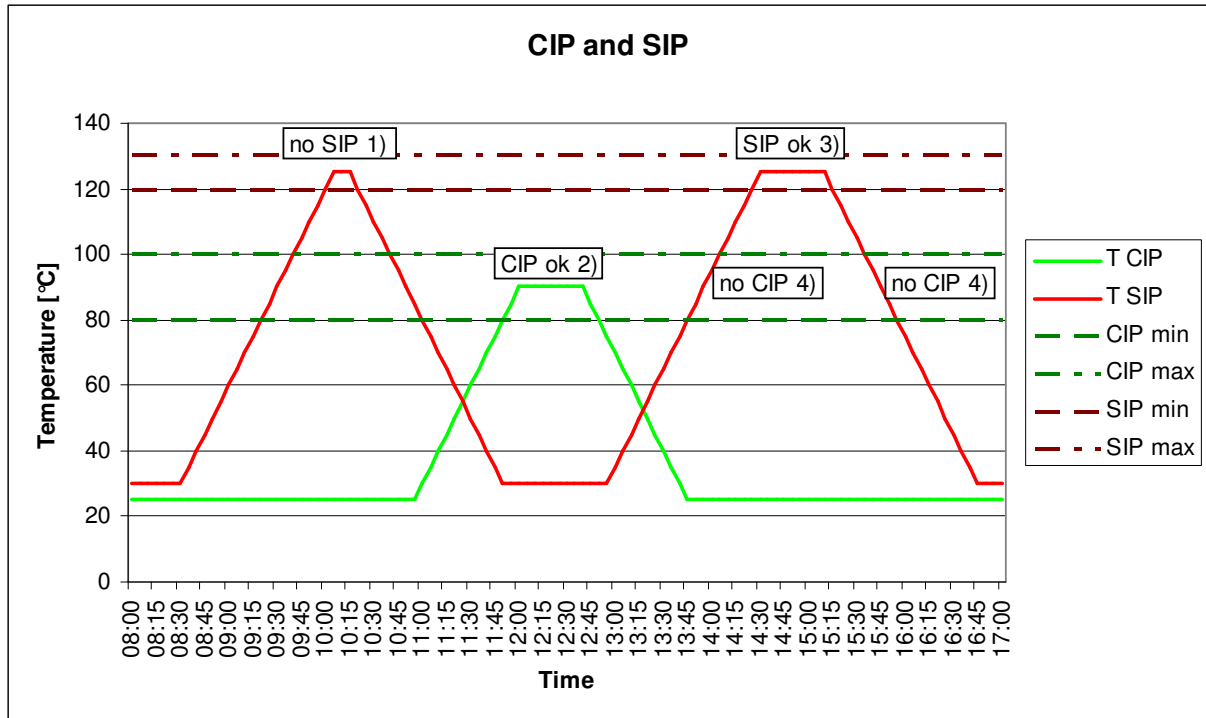


Figure 2.8.5.1: Definition of CIP and SIP cycles.

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

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

Figure 2.8.5.2: Definition of register 4988 and 4996.

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

Figure 2.8.5.3: Example to write the SIP definitions.

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

Figure 2.8.5.4: Example to read the SIP definitions.

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

Figure 2.8.5.5: Example to write the CIP definitions.

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

Figure 2.8.5.6: Example to read the CIP definitions.

2.8.6 Reading the Sensor's Quality Indicator

In register 4872 the sensor's quality indicator (0-100%) is given.

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

Figure 2.8.6.1: Definition of register 4872.

Command: Quality indicator		Modbus address: 4872		Length: 2	Type: 3	Read
Parameter:	Quality [%]					
Format:	Float					
Value:	100					

Figure 2.8.6.2: Example to read the sensor's quality indicator.

The sensor's quality indicator is influenced by:

- current at zero oxygen
- compensated slope
- errors

2.9 Sensor Identification and Information

2.9.1 General Information

General information about the sensor is available as shown in the figure below.

Start register	Number of registers	Reg1 ... Reg8 (16 ASCII characters)	Example of content	Modbus function code	Read access	Write access
1024	8	Userend FW Date	2011-06-30	3, 4	U/A/S	none
1032	8	Userend FW	EDOUM013	3, 4	U/A/S	none
1040	8	Userend BL Date	2009-09-18	3, 4	U/A/S	none
1048	8	Userend BL	BL0UX012	3, 4	U/A/S	none
1056	8	Userend P/N	242822	3, 4	U/A/S	none
1064	8	Userend S/N	not available	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	2010-03-10	3, 4	U/A/S	none
1096	8	Frontend FW	EDOFI011	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 P/N	242816	3, 4	U/A/S	none
1128	8	Frontend S/N	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 sensor information.

Command: Userend Firmware		Modbus address: 1032		Length: 8	Type: 3	Read
Parameter:	Text					
Format:	Character					
Value:	EDOUM013					

Figure 2.9.1.2: Example to read register 1032.

2.9.2 Sensor Identification

Start register	Number of registers	Reg1 ... Reg8 (16 ASCII characters)	Example of content	Modbus function code	Read access	Write access
1280	8	Part number	243110/00	3, 4	U/A/S	none
1288	8	Sensor name	Oxyferm FDA	3, 4	U/A/S	none
1296	8	Work order number	3214567	3, 4	U/A/S	none
1304	8	Work order date	2011-06-30	3, 4	U/A/S	none
1312	8	Serial number	0001001	3, 4	U/A/S	none
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	Sensor type	ARC e. DO Sensor	3, 4	U/A/S	none
1344	8	Power supply	007..030V 0150mW	3, 4	U/A/S	none
1352	8	Pressure range	0 ... 4 bar	3, 4	U/A/S	none
1360	8	Sensor ID	243110-0001001	3, 4	U/A/S	none
1368	8	a-length	120	3, 4	U/A/S	none
1376	8	(space holder)	not available	3, 4	U/A/S	none
1384	8	Electrical connection	VP 8.0	3, 4	U/A/S	none
1392	8	Process connection	PG 13.5	3, 4	U/A/S	none
1400	8	Sensing material	FDA Membrane	3, 4	U/A/S	none

Figure 2.9.2.1: Definition of registers containing sensor identification.

Command: Serial number		Modbus address: 1312	Length: 8	Type: 3	Read
Parameter:	Text				
Format:	Character				
Value:	0001001				

Figure 2.9.2.2: Example to read register 1312.

2.9.3 Free User Memory Space

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

Start register	Number of registers	Reg1 ... Reg8 (16 ASCII characters)	Example of content	Modbus function code	Read access	Write access
1536	8	Free user space U/A/S	*FREE_USERSPACE*	3, 4, 16	U/A/S	U/A/S
1544	8	Free user space U/A/S	*FREE_USERSPACE*	3, 4, 16	U/A/S	U/A/S
1552	8	Free user space U/A/S	*FREE_USERSPACE*	3, 4, 16	U/A/S	U/A/S
1560	8	Free user space U/A/S	*FREE_USERSPACE*	3, 4, 16	U/A/S	U/A/S
1568	8	Free user space A/S	*FREE_USERSPACE*	3, 4, 16	U/A/S	A/S
1576	8	Free user space A/S	*FREE_USERSPACE*	3, 4, 16	U/A/S	A/S
1584	8	Free user space A/S	*FREE_USERSPACE*	3, 4, 16	U/A/S	A/S
1592	8	Free user space A/S	*FREE_USERSPACE*	3, 4, 16	U/A/S	A/S
1600	8	Measuring point	243110-0001001	3, 4, 16	U/A/S	S
1608	8	Free user space S	*FREE_USERSPACE*	3, 4, 16	U/A/S	S
1616	8	Free user space S	*FREE_USERSPACE*	3, 4, 16	U/A/S	S
1624	8	Free user space S	*FREE_USERSPACE*	3, 4, 16	U/A/S	S
1632	8	Free user space others	*FREE_USERSPACE*	3, 4	U/A/S	none
1640	8	Free user space others	*FREE_USERSPACE*	3, 4	U/A/S	none
1648	8	Free user space others	*FREE_USERSPACE*	3, 4	U/A/S	none
1656	8	Free user space others	*FREE_USERSPACE*	3, 4	U/A/S	none
1664	8	Free user space others	*FREE_USERSPACE*	3, 4	U/A/S	none
1672	8	Free user space others	*FREE_USERSPACE*	3, 4	U/A/S	none
1680	8	Free user space others	*FREE_USERSPACE*	3, 4	U/A/S	none
1688	8	Free user space others	*FREE_USERSPACE*	3, 4	U/A/S	none
1696	8	Free user space others	*FREE_USERSPACE*	3, 4	U/A/S	none
1704	8	Free user space others	*FREE_USERSPACE*	3, 4	U/A/S	none
1712	8	Free user space others	*FREE_USERSPACE*	3, 4	U/A/S	none
1720	8	Free user space others	*FREE_USERSPACE*	3, 4	U/A/S	none
1728	8	Free user space others	*FREE_USERSPACE*	3, 4	U/A/S	none
1736	8	Free user space others	*FREE_USERSPACE*	3, 4	U/A/S	none
1744	8	Free user space others	*FREE_USERSPACE*	3, 4	U/A/S	none
1752	8	Free user space others	*FREE_USERSPACE*	3, 4	U/A/S	none

Figure 2.9.3.1: Definition of registers containing user information.

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



Attention:

The Free User Memory Space is located in a 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 (written in figure 2.9.1.6).

2.10 System Commands

2.10.1 Recall Sensor's Factory Settings

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

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

Figure 2.10.1.1: Definition of register 8192.

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

Figure 2.10.1.2: Example to write the restore command.

3 Abbreviations

AO	Analog Output Interface
CP	Calibration Point
ECS	Electrochemical Sensor Interface
PMC	Primary Measurement Channel
SMC	Secondary Measurement Channel



HAMILTON Bonaduz AG
Via Crusch 8
CH-7402 Bonaduz
Switzerland

Tel. +41 81 660 60 60
Fax +41 81 660 60 70

contact@hamilton.ch
www.hamiltoncompany.com

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