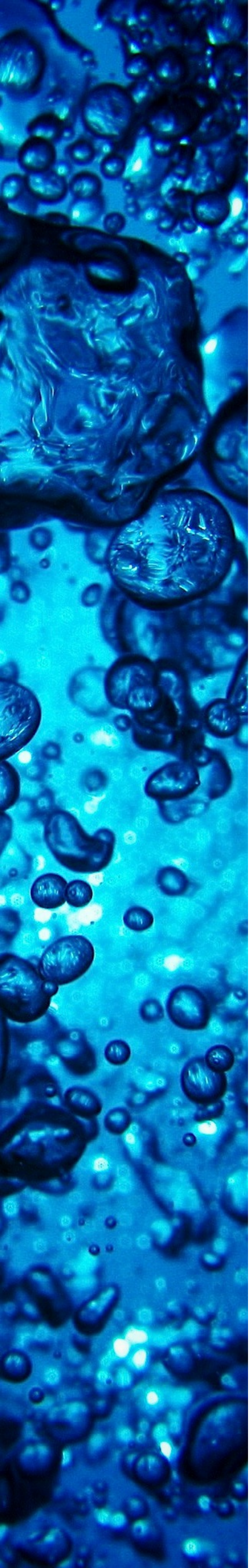

INTEGRON Poland EU
Research and Development Laboratory

USER MANUAL
Optical dissolved oxygen sensor

Model: OXY-DIOS-DSP

Applications:
- wastewater treatment plants
- water intakes
- fish farms
- composting plants
- monitoring of rivers and lakes

26-500 Szydłowiec POLAND Radomska 3 Phone +48 48 3703828
http://www.sensor.integron.pl

Date: 11-05-2016
Version: 1.33
Szydłowiec, POLAND

26-500 Szydłowiec POLAND Radomska 3 Phone +48 48 3703828
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- High stability
  - fluorescence quenching method
  - trigonometric measurement of the phase - DSP signal analysis
- Communication: CANopen, MODBUS, USB, current loop 4-20mA
- High resistance to environmental degradation
  - housing from acid-proof titanium stainless steel
  - measuring window from sapphire glass
  - no plastic components operating in the wastewater
- Operation without a flow of water / wastewater
- Built-in pneumatic system of measuring window cleaning
- Calibration without an additional equipment
  - built-in atmospheric / hydrostatic pressure sensor
  - built-in humidity sensor

Table 1. Technical specification

<table>
<tr><th>Parameter</th><th colspan="2">Description</th></tr>
<tr><td>Type</td><td colspan="2">Dissolved oxygen sensor in water</td></tr>
<tr><td>Model</td><td colspan="2">OXY-DIOS-DSP 150105061 INTEGRON Poland EU</td></tr>
<tr><td>Measurement method</td><td colspan="2">Optical – fluorescence quenching with frequency modulation excitation light, trigonometric measurement of the phase</td></tr>
<tr><td rowspan="3">Optical head</td><td colspan="2">447 / 650 nm with reference channel 617 nm, replaceable</td></tr>
<tr><td>Measuring interval</td><td>1, 2, 5, 10 s</td></tr>
<tr><td>The activation time fluorophore during the measurement</td><td>6 ms</td></tr>
<tr><td rowspan="5">Measuring window</td><td>Type</td><td>Porphyrin platinum closed in a polymer-glass matrix</td></tr>
<tr><td>Substrate</td><td>Sapphire glass dim. ϕ12.5 mm / 1 mm</td></tr>
<tr><td>Durability</td><td>Up to 2 year</td></tr>
<tr><td>Chemical resistance</td><td>Methanol, ethanol, isopropanol</td></tr>
<tr><td>No chemical resistance</td><td>Chloroform, benzene, toluene, xylene, acetone and other organic solvents</td></tr>
</table>

Parameter	Description	
	Drift	0.2 mg/L-O_2 by a year, (20°C - water saturated with oxygen)
Calibration	One point	0% - O_2, aqueous solution of sodium sulfite Na_2SO_3 or nitrogen 4.0
	Two point	0% / 20.946% O_2 (air - built-in barometer and humidity sensor) or air saturated with water vapour
Minimum flow	No need for flow of water / wastewater	
Working temperature	0 to 50°C	
Storage temperature	-20 to 70°C	
Maximum depth	30 m	
Measured parameters	Concentration, saturation, temperature, O_2 partial pressure, air / hydrostatic pressure, humidity	
Measuring range O_2	Partial pressure O_2	0 to 400 mBar
	Concentration	0 to 20 mg/L
	Saturation	0 to 200%
Measurement accuracy O_2	Range 0 to 5.0 mg/L, 20°C	+/-0.10 mg/L
	Range 5.0 to 20.0 mg/L , 20°C	+/-0.20 mg/L
Measurement resolution O_2	Range 0 to 1.0 mg/L	0.001 mg/L
	Range from 1.0 mg/L	0.01 mg/L
Response time	21% O_2 to 0% O_2 (20°C - nitrogen), T_{90} < 40 s, 21% O_2 to 0% O_2 (20°C - water), T_{90} < 60 s, membrane with improved mechanical strength	
Resistance to environmental factors	H_2S, pH, K+, Na+, Mg_2+, Ca_2+,NH_4+, Al_3+, Pb_2+, Cd_2+,An_2+, Cr, Fe_2+, Fe_3+, Mn_2+, Cu_2+, Ni_2+, CO_2+, CN-, NO_3-, $SO_4$2-, S_2-, $PO_4$3-, Cl-	
Barometric / hydrostatic pressure	Accuracy	0.3%
	Resolution	0.1 mBar
	Range	200 to 2500 mbar (absolute)
Temperature	Sensor type	Pt1000 class A
	Accuracy	+/- 0.2°C
	Resolution	0.01°C
	Range	-20 to +85°C
	Response time	T_{90} < 120 s

Parameter	Description	
Humidity	Accuracy	2.5%
	Resolution	0.01%
	Range	0 to 100%
Materials	stainless steel-titanium EN 1.4571, stainless steel EN 1.4301, sapphire glass AL_2O_3, FPM, silicone	
Dimensions	Diameter	35 mm
	Length	238 mm
Weight	900 g	
Mounting	Type	Thread M32x1.5, adapter M32-ϕ35 / L=80mm for welding in thin-walled pipe
	Sealing	2 x O-ring 26x2 FPM / Viton, recommended grease Loctite 8104
	Position	Minimum 30° from the vertical
Protection level	IP68	
Socket connection	Type	M12A, 8 pins, male, IP68
	Recomended plug	Binder 99 0486 12 08
Electromagnetic immunity	EN 61326 Class B	
Window cleaning system	Pneumatic - compressed gas, rotating nozzles	
	Medium	Air / Nitrogen
	Connection	Quick connector PA 6/4mm pipe
	Working pressure	0.7 bar + hydrostatic pressure
	Maximum pressure at the outlet nozzle	1.2 bar + hydrostatic pressure
	Maximum pressure at the input of the system	6 bar
Power	+24VDC, +/-20%	0.1A inactive current outputs
		1.1A active current outputs
	Electrical strength	max 80.0V
	Overvoltage protection	28.8V
	Under-voltage protection	18.2V
	Overcurrent protection	1.2A, electronic with auto restart

Parameter	Description	
	Battery RTC	Lithium Li/FeS2 1.5V / 1.5Ah AAA, recommended Energizer L92
Control outputs	24V/0.5A-Source, according IEC 61131-3, short circuit protection	
MODBUS (RS485) Communication	Mode	RTU, ASCII
	Speed (bps)	1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200, 230400, 460800, 921600
	Max number of devices	64 (½ unit load)
	Parity	None, even, odd
	Terminator	Built-in 120 Ohm, attached electronically
CANOPEN (CANBUS) Communication	Mode	SDO, PDO mapped
	Speed (kbps)	10, 20, 50, 100, 125, 250, 500, 800, 1000
	Max number of devices	112
	Suppresion	Common-mode filter
	Terminator	Built-in 120 Ohm, attached electronically
Current loop 4-20mA	Range	3.6 to 22mA, (4 to 20mA scalable)
	Resolution / Accuracy	5.5uA / 0.05%
	Supply voltage	max 28.8V
	Measurement resistance	>250 Ohm
	Galvanic isolation	1kV
	Alarm	NAMUR43 / 22mA
USB communication	Mode	USB 2.0 FS, virtual COM port, VT100 terminal emulation
	Supply voltage	4.0V to 5.8V / 500mA
Warranty	Sensor	3 years
	Measuring window	2 years
Expected lifetime	8 years for work in municipal wastewater	

2. Content of the set

Table 2. Content of the set

Position	Component	Quantity	Description	Code
1	Sensor	1	OXY-DIOS-DSP sensor for measuring dissolved oxygen concentration	**150105061**
2	Support adapter	1	M32x1.5 titankium acid-prof stainless steel EN 1.4571	**150105062**
3	USB/M12 cable	1	USB-B/M12A cable, length 1.5m	**150105063**
4	Wrench 27 / toothed	2	Wrench 27 / toothed - for nut head	**150105064**
5	Sodium sulfite	5	Hydrated sodium sulfite Na_2SO_3, tube 1g	**150105065**
6	Hex wrench	1	2	**150105066**
7	Hex wrench	1	2.5	**150105067**
8	Silicone grease	1	Grease Loctite 8104, syringe 1cm^3	**150105068**
9	Pneumatic quick plug	1	ϕ4mm	**150105069**
10	Flash memory / USB		8GB	**150105070**
11	Carrying case	1	Anti-static carrying case with polyurethane foam	**150105071**

3. Dimensional drawing

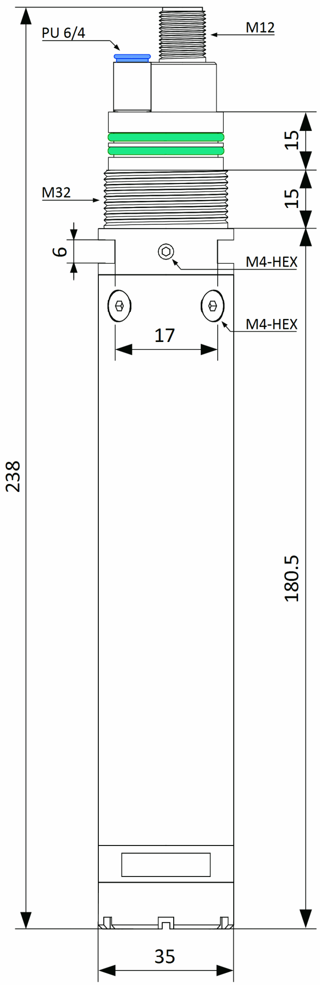
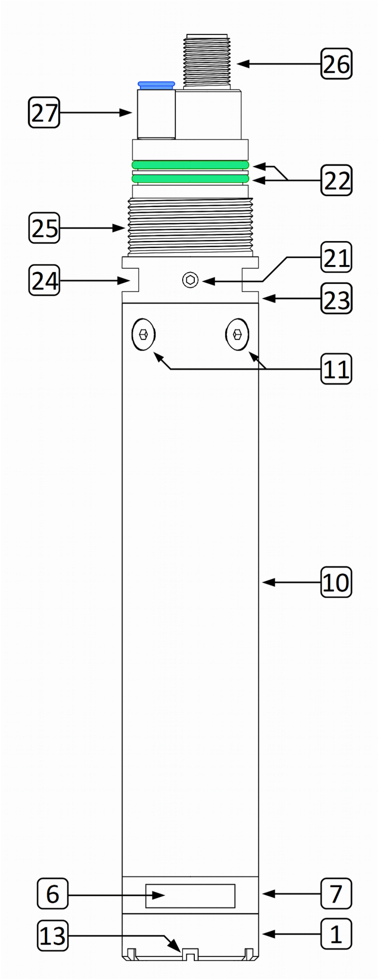


Figure 1. Dimensional drawing

4. Reference drawing



- **1** Nut head
- **7** Body head
- **10** Sensor housing
- **11** 4x M4x6 HEX conical screw
- **23** Sensor base
- **21** M4 port for measurement of hydrostatic pressure
- **22** 2x O-ring 26x2 base / handle
- **26** Connector M12A
- **27** Pneumatic quick connector PU6/4
- **25** M32x1.5 thread mounted of the support
- **24** Wrench slot 27 in the base
- **6** Wrench slot 27 in the head
- **13** Wrench socket in the nut head

Figure 2. The reference drawing

5. Assembly drawing

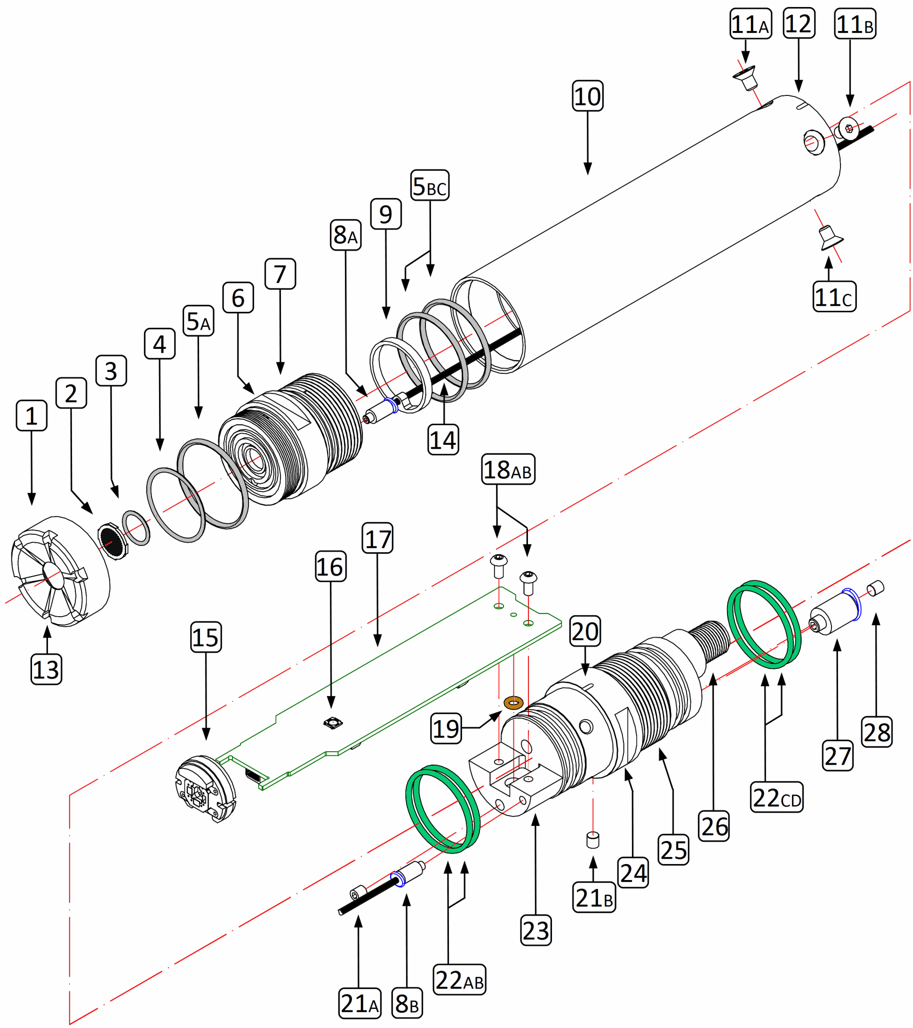


Figure 3. The assembly drawing

Table 3. List of components

No.	Description	Quantity	Type	Accessories	Code
1	Nut head	1			**150105000**
2	Measuring window	1	WPSPT3		**150105051**
3	O-ring a measuring window	1	1x10 FPM Viton		**150105002**
4	O-ring of a nut head	1	23x1.5 FPM Viton	Grease Loctite 8104	**150105003**
5	O-ring of a nut head, body head, housing	3	29x1.5 FPM Viton	Grease Loctite 8104	**150105004**
6	Wrench socket in a head body	1	Size 27		
7	Head body	1		Glue Loctite 641	**150105005**
8	Pneumatic quick connector	2	M3 2/1.2		**150105015**
9	Guide ring of the pneumatic pipe	1			**150105006**
10	Sensor housing	1			**150105008**
11	Fixing screw the housing to a base	4	M4-6 HEX conical	Wrench 2.5	**150105018**
12	Mouting marker housing / base	1			
13	Wrench socket (toothed) of a nut head				
14	Pnematic pipe of a cleaning system	1	2/1.2 PU		**150105017**
15	Optical head	1	HS20B447R617		**150105009**
16	Micro-switch S1 of an emergency mode of downloading firmware				
17	Mainboard	1			**150105011**
18	Fixing screw of a mainboard to a sensor base	2	M3-6 HEX overcoat		**150105012**
19	O-ring a pressure sensor	1	2.9x1.78 FPM Viton	Grease Loctite 8104	**150105016**
20	Mouting marker base / housing				
21	End cap of a measurement channel of a hydrostatic pressure	2	M4-4 HEX	Glue Loctite 641	**150105014**
22	O-ring housing / base / handle	4	26x2 FPM Viton	Grease Loctite 8104	**150105013**
23	Base of a sensor	1			**150105019**
24	Wrench slot in a sensor base	1	Size 27		
25	M32 thread base / support	1	M32x1.5		
26	M12A connector	1		Glue Araldite 2028-1 Silicon Sylgard 170	**150105021**
27	Pneumatic quick connector	1	M5 PU6/4		**150105022**
28	Through-hole screw	1	M4-4 HEX	Glue Loctite 641	**150105023**

6. Electrical connection

6.1. M12 connector

The M12 connector of the sensor enables to connect it to the **CANopen/CANBUS**, **MODBUS/RS485** communication buses or a **current loop 4-20mA**. The interface outputs are multiplexed at the 4/5 connector contacts.
A type of the connected bus is determined during a configuration of a sensor in the terminal mode. The sensor switches automatically to the terminal/USB mode after applying a voltage of +5V on the contact of the 8. pin of the M12 connector.

Before connecting the sensor, set the apropriate type of the communication bus !
The maximum voltage for the RS485RS485/MODBUS is 12V, for CANBUS/CANopen 24V, for 4-20mA loop 28,8V. If signal lines are connected to too high voltage, the sensor can be damaged.

Figure 4 shows a front view of the M12 socket. M12A 8pin coding.

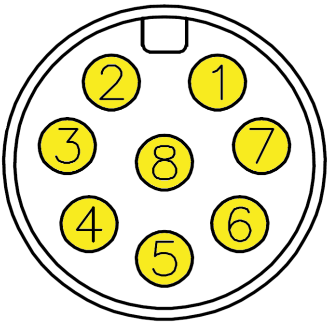


Figure 4. Socket M12A – connector front view.

Table 4. The description of the M12 socket signals

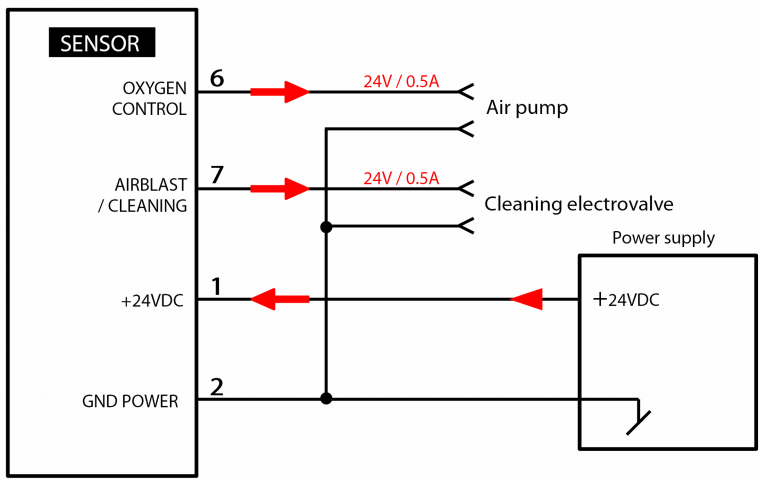
Pin	Name	Description
1	+24VDC	Power supply
2	GND POWER	Power ground

Pin	Name	Description
3	GND FIELDBUS	Fieldbus ground (shielding)
4	CANH / RS485B / LOOP+ / USB+	Fieldbus line 1
5	CANL / RS485A / LOOP- / USB-	Fieldbus line 2
6	OXYGEN CONTROL	Air blower control output +24V/0.5A
7	AIRBLAST / CLEANING	Control output of a cleaning window system +24V/0.5A
8	+5VDC USB POWER	Power supply +5V/0.5A from USB. Applying voltage >4.0V switches a sensor in the USB/Terminal mode.

6.2. Connecting the control outputs

Figure 5 shows how to connect the sensor to the cleaning and control air blower systems.

Figure 5. Connecting the control outputs



6.3. Connecting the CANopen / MODBUS fieldbuses

Figure 6 shows how to connect the sensor to **CANopen** i **MODBUS** fieldbuses. If the sensor works as the fieldbus end-device, it is necessary to connect a terminator. The sensor is equipped with the 120 Ohm built-in terminator that can be enabled during a configuration of the device.

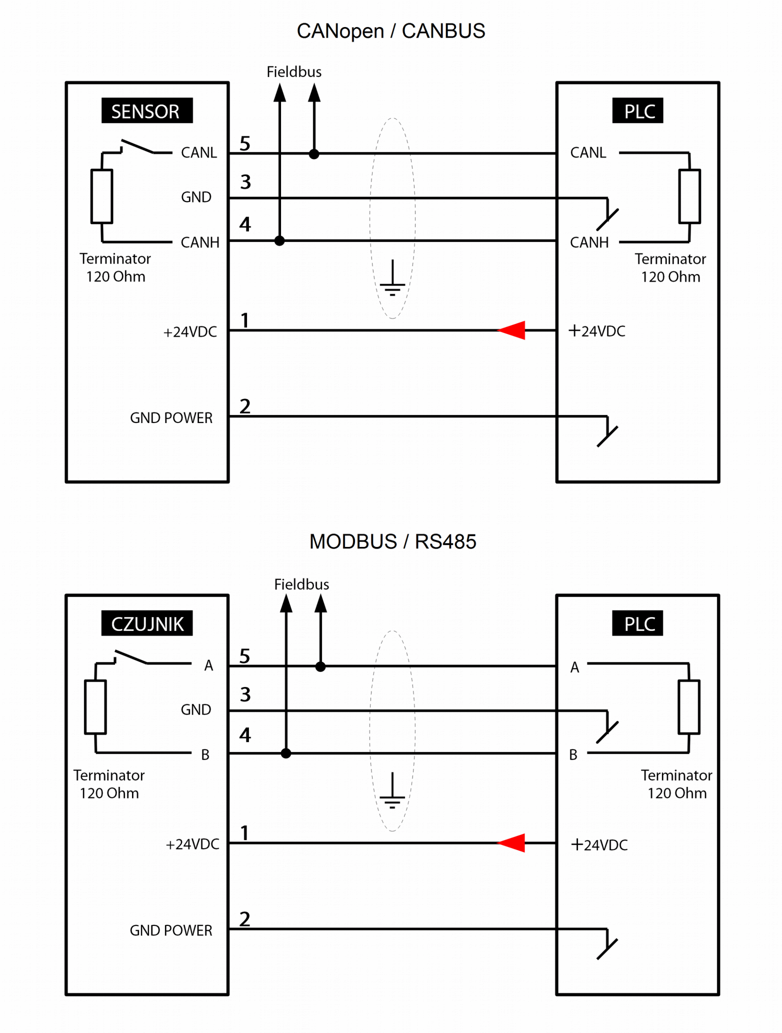


Figure 6. Connectiong the CANopen/MODBUS fieldbus

6.4. Connecting the current loop 4-20mA

The current loop circuits is electrically isolated from the sensor measurement systems.
Figure 7 shows how to connect a 3-wire cabling without galvanic isolation, and 4-wire with isolation. The recommended value of the standard resistor is 500 Ohm.

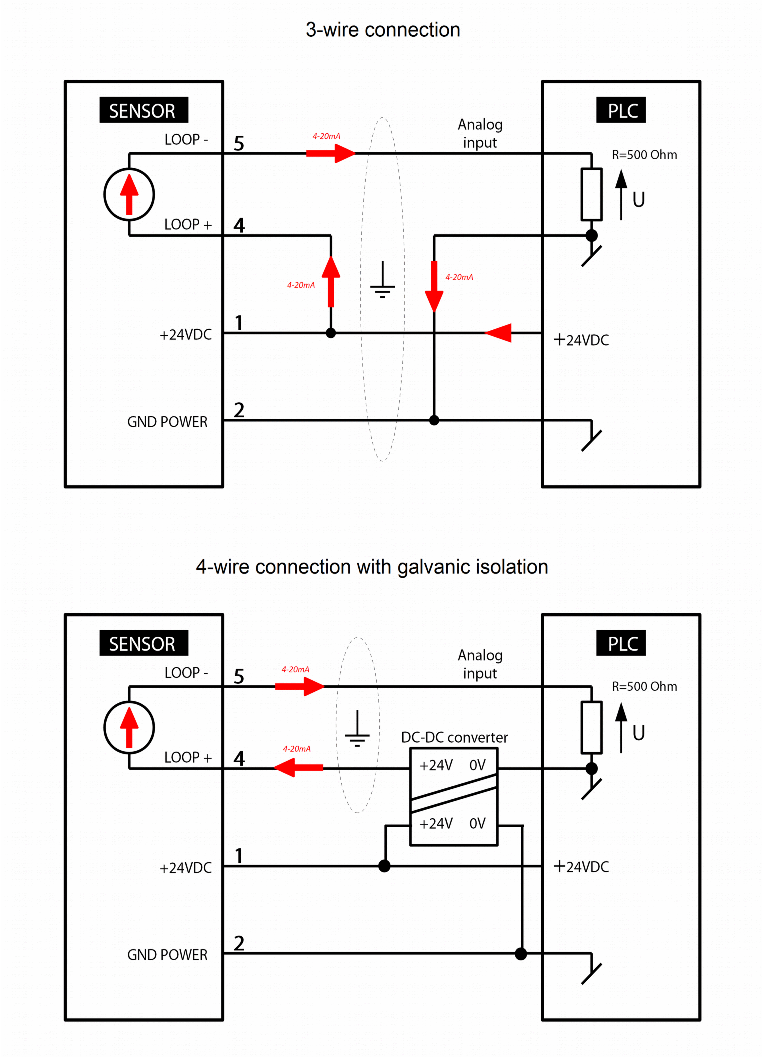


Figure 7. Connectiong the current loop 4-20mA

7. Disassembly / assembly of a sensor housing

An disassembly/assembly of a sensor housing should be performed only if necessary. The incorrectly performed assembly may result in a mechanical damage of its optical head.
Figure No. 2 (page 11) and Figure No. 3 (page 12) present the sensor structure.

The disassembly/assembly of the sensor housing is necessary when batteries of the RTC clock, the optical head, seals are replaced and the firmware is downloaded.

7.1. Disassembly

1. Unscrew bolts **11ABCD** which attach the housing **10** to the sensor base **23**. Use a 2.5 hex wrench included in the set.
2. Eject the sensor base **23** from the housing **10** for a distance of 55mm.
3. Disconnect pneumatic wire **14** from the quick connector **8B**. Push a blue flange of the quick connector and pull out the wire.
4. Eject the sensor base **23** from its housing **10**.

7.2. Assembly

1. Inspect the O-rings **22AB**. If they are fractured or torn, exchange them. Use silicone lubricant.
2. Insert the sensor base **23** to the housing **10** for a depth of 55mm. Adjust position **12** and **20** to each other. They must be positioned linearly.
3. Connect the pneumatic wire **14** to the quick connector **8B**. Use forceps.
4. Insert the sensor base **23** to the housing **10** so that there is no aperture between them.

If you use excessive force during installation, the optical head of the sensor can be damaged!

5. Screw bolts **11ABCD** whitch attach the housing.
6. Loose the head nut **1** (1mm aperture) so that a pressure inside the sensor is aligned. Proceed according to paragraph **8.1.2.** of this manual.
7. Tighten the head nut **1**. Proceed according to paragraph **8.2.6.** of this manual.

8. Measuring window

The measuring window is an operating element and it should be replaced for a new one on average once per two years.
A disassembly/assembly operations are also needed in the case of two-point calibration in the air procedure with a humidity correction from the internal sensor.
Figure No. 2 (page 11) and Figure No. 3 (page 12) present the sensor structure.

Figure 8. The measuring window

8.1. Disassembly

1. Dry the head using lint-free wipes.
2. Unscrew the head nut **1**. Use the wrenches included in the set. Put a round end of the toothed wrench on the socked of the head nut **13**, a flat end of the 27 wrench put on the socket in the head body **6**.

Do not put the wrench to the socket at the base of the sensor!

3. Remove the O-ring of the nut **4**.
4. Carefully dry the head socket with a lint-free wipe.

Do not touch the inner surface of the hole in the body of the measuring sensor!
The hole area is covered by a light absorbing layer.

5. Remove the measuring window **2**. Use forceps. Hold the window by its metal ring.

Do not touch the measuring window!
The upper black layer is covered with a gas-permeable membrane, and a bottom one with an anti-reflective coating.

---

6. Remove the O-ring of the window **3**.

8.2. Assembly

1. Dry the head socket using a lint-free wipe.

Do not touch the inner surface of the hole in the body of the measuring sensor!

---

2. Inspect the O-ring of the nut **5A**. If it is fractured or torn, exchange it. Use silicon lubricant.
3. Assembly the window O-ring **3**. Do not lubricte the O-ring.
4. Assembly the measuring window **2**. Use forceps. Hold the window by its metal ring.

Do not touch a surface of the measuring window!

---

5. Assembly the upper O-ring of the nut **4**. Use silicon lubricant.
6. Assembly the head nut **1**. Tighten the nut using the wrenches available in the set. A round end of the toothed wrench put on the socket of the head nut **13**, a flat end of the 27 wrench put on the socket in the head body **6**.

Do not put the wrench to the socket at the base of the sensor!
An aperture between the measuring window nut, and the head body must be reset to zero. If the nut is not properly tightened, the sensor can be flooded by water.

8.3. View of the measuring window and the head

Figure 9. The measuring window in the head

Figure 10. The optical head

9. Mounting the sensor at the support

The sensor body is adapted to assembling at the tube support with the M32 thread. The attached equipment includes the M32-ϕ35mm adapter to be welded into the acid-proof stainless thin-walled tube. Figure No. 2 (page 11) and Figure No. 3 (page 12) present the sensor structure. Figure No. 12 (page 23) show a structure of the support.

Figure 11. Installation of cables

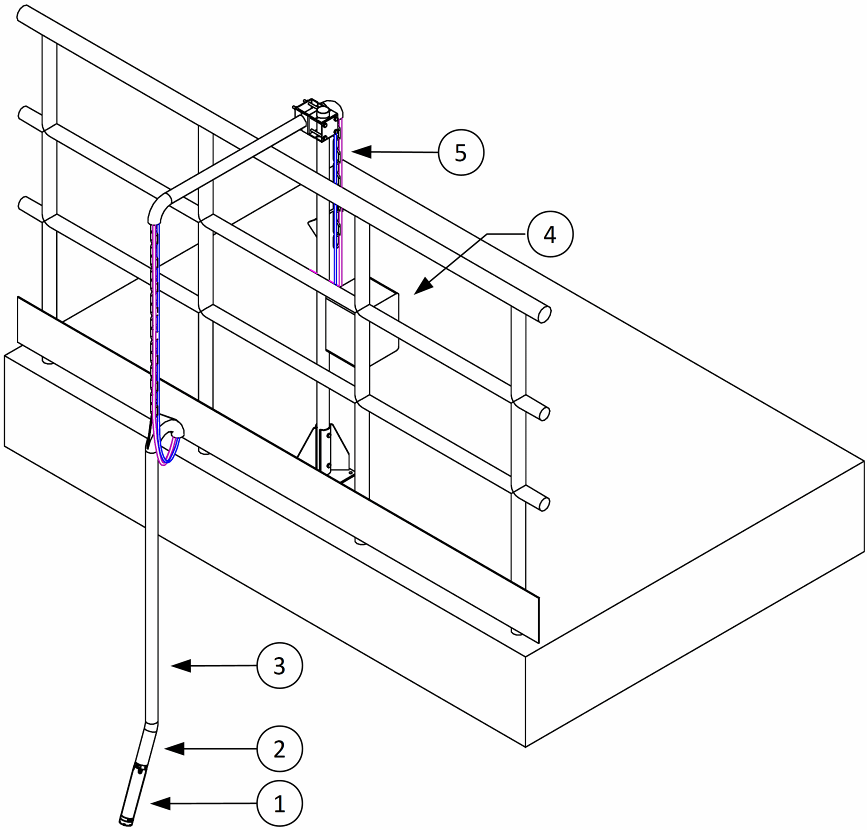
Assembly procedure:

1. Remove the electric and pneumatic wires from the support tube (M12, PU6/4).
2. Connect the M12 plug to the connector **26** in the sensor.
3. Insert the pneumatic wire to the quick connector **27**. If a cleaning option will not be used insert the end cap into the connection. It will prevent the support from flooding.

Blanked off the quick connector if the pneumatic wire is not connected !

4. Inspect the O-ring **22CD**. If they are fractured or torn, exchange them. Use silicone lubricant.
5. Screw manually the sensor into the M32 thread of the support. Be careful with the position of the wiring insife the tube. While screwing the wires should turn freely inside the tube.
6. Tighten the sensor suing the 27 wrench, included in the set. Put the wrench on the socket at the sensor base **24**.

Do not put the wrench to the socket in the head body!
The mainboard can be damaged mechanically.



1 - sensor, 2 - support adapter M32, 3 - support,
4 – cleaning system air compressor (option), 5 – chain / cables

Figure 12. Mounting the sensor on the support

10. Theory of operation

The OXY-DIOS-DSP sensor operates on the basis of the phenomenon of luminescence **quenching**.
Luminescence or "cold light" is an emission of light waves through certain bodies called luminophores (phosphors), inducted by the other cause than warming them up to high temperatures. Luminescence is characterised by a finite lighting time, i.e. it does not fade immediately after the excitation is stopped. A special case of luminescence is photoluminescence, inducted by an absorption of electromagnetic radiation from ultraviolet and visible light spectrum. This excitation is connected with jumping by an electron to an excited singlet state, and then, after it returns to a ground state, an emission of an excess energy amount as a photon flux. A wavelength of this radiation is higher than an absorbed wavelength because during the thermic and non-radiative transitions, a partial energy degradation occurs. Many substances exhibit photoluminescence. For measurements of oxygen concentrations mostly complex compounds of ruthenium and platinum porphyrins are applicable. This is due to a relatively long time of lighting: 5 - 60us and high quantum efficiency – luminosity brightness.
The fluorescence **quenching** phenomenon occurs during a collision of a quencher molecule with a "charged" fluorophore molecule. After the collision quencher molecules get rid of adopted energy in a form of thermal radiation. The small dimensions and a neutral charge of the oxygen molecules stimulate a diffusion speed, and in consequence it significantly increases a probability of collisions. Oxygen is a relatively good quencher of fluorescence. With the increase of the quencher concentration, increases effectiveness of the quenching process. The more oxygen molecules in the solution, the lower luminescence brightness of fluorophore and the shorter the decay time of the emission. **Figure 13** presents the mechanism of fluorescence quenching.

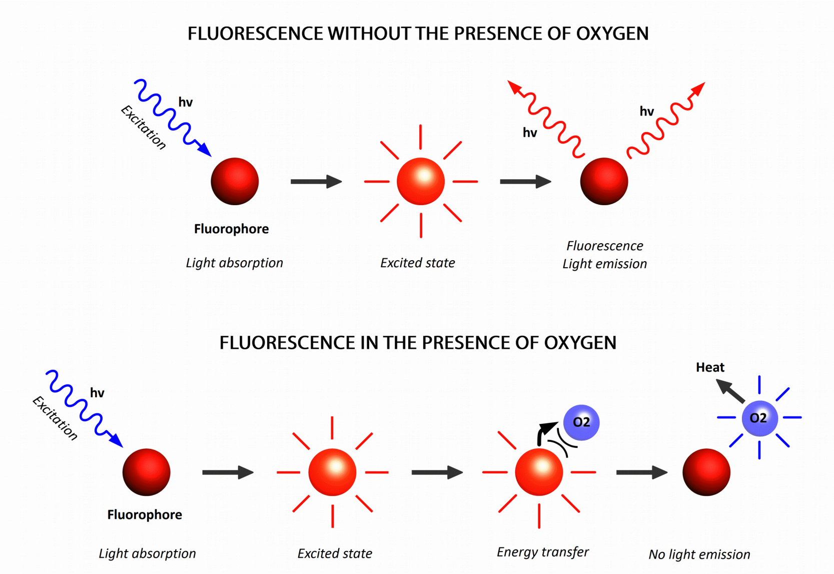


Figure 13. The mechanism of fluorescence quenching

There is a wide range of the measuring techniques connected with the fluorescence phenomenon. The simplest one consists in a measurement of the emission intensity in the presence of a quencher. Unfortunately due to the temperature changes and a degradation of fluorophores during their excitation, it is also the least accurate method. A specific feature of the excitation phenomenon is an exponential fading of light emission after the excitation is stopped. A slope of the curve depends on the quencher concentration, but independent from an excitation level and an emission level. **Figure 14** shows an emission fading as a function of time.

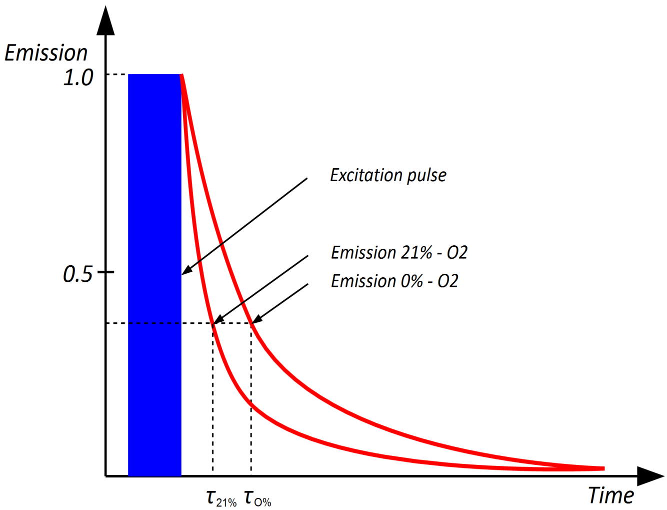


Figure 14. The fluorescense, decay emission.

Applying a time method in the case of fluorophores used to measuring a concentration of oxygen requires a significant sampling frequencies in the track of the emission measurement. This problem can be solved by transferring a signal detection from a time domain to a frequency domain. If the excitation light is modulated by a sinusoidal signal with a certain frequency, the emission light will have the same frequency, but a phase shift between the excitation and emission signal will be dependent only on the oxygen partial pressure. **Figure 15** presents the phase detection of the oxygen concentration.
In the frequency method a fluorescence decay time is described by the following equation:

$$\tau = \frac{\tan(\phi)}{2 \cdot \pi \cdot f_{mod}} \quad (10\ 1)$$

gdzie:

τ - fluorescense decay time [s]

ϕ - phase shift between the excitation and emission signal [°]

f_{mod} - frequency of the excitation signal [Hz]

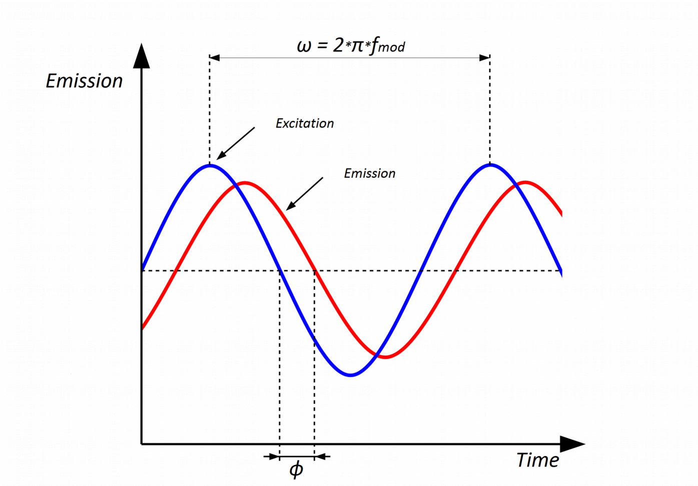
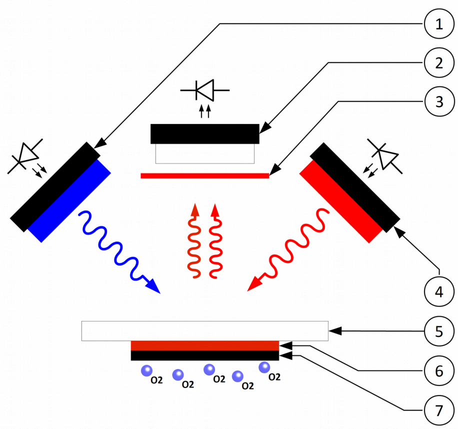


Figure 15. The phase detection of oxygen concentration

In order to eliminate a temperature influence on the electronic systems of the sensor its optical head is equipped with two light sources. Blue light stimulates fluorophore to the emission and the red one is used for measuring a phase shift introduced by the electronic systems. **Figure 16** presents the structure of the optical head of the sensor.



1-excitation light emitter, 2-photodiode, 3-excitation light blocking filter, 4-reference light emitter, 5-sapphire glass, 6-membrane with fluorophore, 7-membrane for blocking external light

Figure 16. The optical head structure

The phenomenon of fluorescence quenching delivers information about kinetic energy of the oxygen molecules which surround a fluorophore, i.e. a partial concentration. A dependence between a fluorescence decay time and a partial pressure is described by the following formula:

$$\frac{\tau_0[T]}{\tau}=1+K_{SV}[T]\cdot pO_2 \quad (10\ 2)$$

where:

- **τ_0**[T] - fluorescence decay time as a function of temperature (in the absence of quencher) [s]
- **τ** - decay time in the presence of quencher [s]
- **K_{SV}**[T] - *Stern-Volmer-a* constant as a function of temperature
- **pO_2** - oxygen artial pressure [Bar]
- **T** - temperature [°C]

Due to the properties of the membrane in which are placed the fluorophore molecules, in order to calculate a partial pressure the modified *Stern-Volmer* equation is applied. The equation is based on an assumption, that an activation of the fluorophore inside the membrane is non-linear. The **f** fraction describes an active party, and the **1-f** fraction the non-active one.

$$\frac{\tau_0[T]}{\tau}=\left(\frac{f}{1+K_{SV1}[T]\cdot pO_2}\cdot\frac{1-f}{1+K_{SV2}[T]\cdot pO_2}\right)^{-1} \quad (10\ 3)$$

where:

- **τ_0**[T] - fluorescence decay time as a function of temp. (in the absence of quencher) [s]
- **τ** - decay time in the presence of quencher [s]
- **K_{SV1}**[T] - quenching constant fraction **f** as a function of temperature
- **K_{SV2}**[T] - quenching constant fraction **1-f** as a function of temperature
- **f** - fractional coefficient
- **pO_2** - oxygen partial pressure [Bar]
- **T** - temperature [°C]

Temperature changes have a direct impact on the parameters of the measuring window. An increase of the temperature shortens a fluorescence decay time and decreases an amplitude of the dye emission. This dependency is heavily non-linear. The **τ_0**, **K_{SV1}**, **K_{SV2}** are a subject of an offset. The calibration curve of the **τ_0** coefficient as a function of temperature has a form of the following second degree multinomial:

$$\tau_0[T]=a_{\tau_0}\cdot T^2+b_{\tau_0}\cdot T+c_{\tau_0} \quad (10\ 4)$$

where:

- **τ_0[T]** - fluorescence decay time as a function of temp. (in the absence ofquencher) [s]
- **T** - temperature [°C]
- **$a_{\tau 0}$, $b_{\tau 0}$, $c_{\tau 0}$** - calibration coefficients a_{tau0}, b_{tau0}, c_{tau0}

The calibration curves of the **K_{SV1}**, **K_{SV2}** coefficients as a function of temperature have a form of the Arrhenius equation:

$$K_{SV1,2}[T]=K'_{SV1,2}\cdot e^{-\frac{EK_{SV1,2}}{R(T+273.15)}} \quad (10\ 5)$$

where:

$K_{SV1,2}$[T]	- quenching constant as a function of temperature
$K'_{SV1,2}$	- calibration coefficients of quenching constants
$EK_{SV1,2}$	- calibration coefficients sum of the activation energy of the membrane and the fluorophore
R	- gas constant 8.314459848 [J/(mol*K)]
T	- temperature [°C]

An application of the *Henry's law* allows for determining a weight concentration of the oxygen dissolved in water. The equation describes a dependency between an oxygen partial pressure and its concentration:

$$c_{O_2}=\frac{pO_2}{p_N}\cdot 20.946\cdot\alpha[T]\cdot 1000\cdot\frac{M[O_2]}{V_m} \quad (10\ 6)$$

where:

cO_2	- weight concentration of oxygen [mg/L]
pO_2	- oxygen partial pressure [Bar]
p_N	- normal atmospheric pressure 1.013 [Bar]
α[T]	- *Bunsen* gas solubility coefficient as a function of temperature
M$[O_2]$	- oxygen molar mass 32 [g/mol]
V_m	- molar volume 22.414 [L/mol]

A saturation of water with oxygen is described by the following equation:

$$s_{O_2}=\frac{c_{O2}}{c_{O2}max[T]}\cdot\frac{p_N}{p_{atm}-p_W}\cdot 100 \quad (10\ 7)$$

where:

sO_2	- saturation of water with oxygen [%]
cO_2	- oxygen concentration in the water [mg/L]
cO_2max[T]	- the oxygen concentration at full saturation of water durring the measurement temperature and atmospheric pressure 1.013Bar [mg/L] **Table21** (page57)
p_N	- normal atmospheric pressure 1.013 [Bar]
p_{atm}	- atmospheric pressure for dry air [Bar]
p_W	- partial pressure of water vapor contained in the air [Bar]

11. Calibration methodology

During a production process the sensor is a subject to a 30-point calibration of the partial pressure as a function of the fluorescence decay time **τ** and a temperature. The measured data set is used to generate the following calibration coefficients: **f**, **K'SV1**, **EKSV1**, **K'SV2** , **EKSV2**. These coefficients are determined using a non-linear regression on the basis of the modified *Stern-Volmer* equation (10 3).
The sensor is a highly stabile device however the membrane of the measuring window, similarly as every element of the measuring system, is a subject to the slow physical and chemical changes. Due to this during an installation of the sensor one should verify its indications. If they do not fall into the tolerance range of the device, it is necessary to perform a simplified calibration procedure. The simplified calibration procedure assumes a linear adjustment of the modified *Stern-Volmer* curve (10 3) to the two reference points: *0%-O_2 and 20.95%-O_2* at the foreseen operating temperature. This adjustment is of linear nature:

Offset:

$$tau_0[T]_{odczyt} = tau_0[T]_{pomiar} + cal_{tau_0} \quad (11\ 1)$$

Linearity:

$$pO_{2\ odczyt} = cal_{pO_2} \cdot pO_{2\ pomiar} \quad (11\ 2)$$

A correction of a zero fluorescence decay time **τ0** with a value of the calibration **calτ0** is a modification of the offset of the sensor indications in the zero anaerobic point. This correction describes a drift of the fluorescent dye due to its thermal ageing and a phenomenon of photo-bleaching. A determination of the **calτ0** coefficient is a basic calibration operation and it has a fundamental impact on an accuracy of indications within the entire range of the oxygen concentrations. The most accurate method is a calibration in pure nitrogen 4.0 or an aqueous solution of sodium sulfite Na_2SO_3. For calibration of the low reference point is used the **/ 6.1 Low point, 0% O2** menu option. This procedure has been described in the sub-chapter 12.6.6 (page 48).
A correction of the indications of the oxygen partial pressure by means of the **calpO2** calibration coefficient has a nature of the proportional adjustment of the *Stern-Volmer*'s curve slope to a value of the second calibration point. An impact of the **calpO2** coefficient on the accuracy of the sensor indications increases linearly as the oxygen partial pressure growth. If the sensor operates in the deoxygenated water with the oxygen content below 1mg/L conducting the two-point calibration is not required because it increases an accuracy to the small degree. For calibration of the high reference point is used the **/ 6.3 High point, 20.95% O2 in air** menu option. This procedure has been described in the sub-chapter 12.6.6 (page 48).
A drift of the sensor indicator is of the complex nature. It depends on the operating temperature, frequency of thermic cycles, a level of condensation of dissolved oxygen and a water contamination with organic solvents. The smallest drift is related to an operation at the operation temperatures from 10°C to 30°C, in the pure water with an oxygen content from 1.0mg/L to 12mg/L.. The drift increases by a few times while operating at the temperatures below 5°C, in the deoxygenated and contaminated water. In the first case the calibration should be conducted once a year, in the latter several times a year. The drift is of the increasing nature, the indications of the oxygen concentration are overestimated.

12. Configuration software

12.1. Drivers instalation

The **OXY-DIOS-DSP** sensor communicates with a computer by means of the USB interface and the *HyperTerminal* terminal software.

Procedure of installation in the "Windows 7" operating system:

1. Connect the sensor to the computer. Use the included USB/M12 cable.
2. The operational system will detect a mass storage device: "*INTEGRON MemoryDisk XXXX USB Device*" and a serial port device: VCOMXXXX. A virtual disc contains drivers, the *HyperTerminal* terminal software and an operating manual.
3. The system will ask to enter a path to the driver files. Indicate the detected USB disc.
4. If the system fails to install the VCOM device automatically, do it manually by means of the Windows *"Device Manager"*.
5. In the "*Other devices"* tab, select the "*VCOMXXXX*" device and an option: "*Update the … driver software.*".
6. When a window of the driver update creator appears, select *"Search and install a driver software manually".*
7. Indicate the USB disc in the "*Search a driver software in this location*" field.
8. If during an installation appears the window: "*Windows System Security*" and the following message: "*System Windows cannot verify this driver software;, select the option: "Despite this install a driver software".*
9. The following message: "*System Windows successfully installed/updated a software of the "INTEGRON USB VCOM*" driver" means a correct end of the installation.

The HyperTerminal software installed on the USB disc of the sensor has been pre-configured in the factory to enable communication with the COM8 port in the emulation mode of the VT100 terminal. If a number of the configured VCOM port is other than COM8 it is necessary to make a change in the system or in the settings of the *HyperTerminal.*

Procedure of changing a port number in the "Windows 7" operating system:

1. In the list of devices of the "*Device Manager*" search a section "*Ports (COM and LPT)*", and then the "*INTEGRON USB VCOM (COMX)*" device.
2. Find the "*Properties*" option.
3. In the "*Port settings*" tab, choose the "Advanced" option.
4. In the "*COM port number*" field select the COM8 port.

Procedure of changing the VCOM port in the *HyperTerminal*:

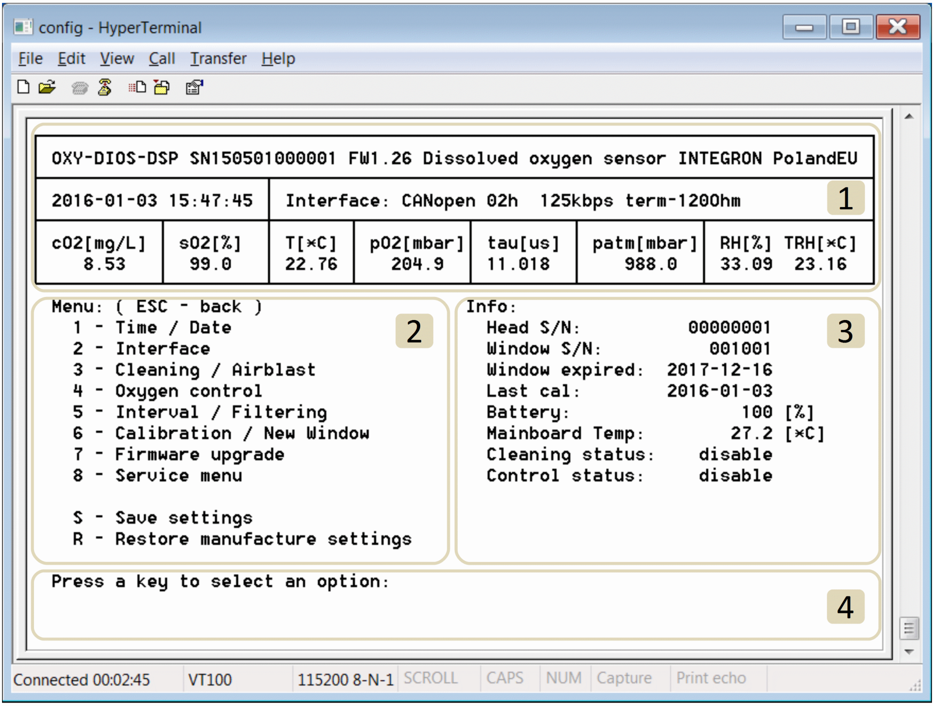
1. Launch the *HyperTerminal* from the USB by activating the "*OXY-DIOS-DSP.bat*" file.
2. In the "*File/Properties*" menu, in the "*Connecting using*" field select a port number. The port number can be read after starting the "*Device Manager*" Windows. In the device list, in the *"Ports (COM and LPT)*" section find the "*INTEGRON USB VCOM (COMx)*" device. A device name includes a proper port number.
3. In the "*Call*" menu select the "*Call*" option. It will be established a connection with the sensor.
4. *WARNING!* After disconnecting the sensor from the computer the fabric pre-settings of the *HyperTerminal* will be recovered. If a permanent change is needed, the *HyperTerminal* must be installed in the computer hard disc.

12.2. Application

The sensor communicates with the computer by means of the USB interface. The included USB/M12 wire is intended for providing a connection. Communication is provided in VT100 terminal mode by means of the *HyperTerminal* application.
In order to launch this terminal with predefined factory settings, one should activate the "*OXY-DIOS-DSP.bat*" file. The file is in the USB virtual disc available directly after connecting the sensor to the system.

12.3. Main screen

After the sensor is started up in the terminal mode the main screen of the application is available:



The application screen is divided into four parts:

- **1** information field which displays measurement values and main system settings,
- **2** "Menu" with options to be selected,
- **3** "Info" which displays additional parameters linked to an active menu,
- **4** status line and two lines intended for entering data.

The numerical and letter keys are for navigating between menu options.
The "**ESC**" key enables to return to the master menu.
The "**/**" key enables to return to the main menu.
In the case of the options which require to enter numerical data, a status line includes a tip with regard to format of entering and a permitted range. A parameter can be of an integral nature, e.g. 12345, a floating-point nature, e.g. 123.45 or of a scientific nature, e.g. -123E-6. Lowercases and uppercases are allowed.

Table 5 contains a description of the fields of the information box.

Table 5. Info box

Pole				Znaczenie
OXY-DIOS-DSP				Device name
SNXXXXXXXXXXXX				Device serial number
FWX.XX				Firmware version
Dissolved oxygen sensor				Device description - Optical dissolved oxygen sensor
RRRR-MM-DD HH:MM:SS				Date and time
INTEGRON PolandEU				Manufacturer
Interface				Settings communication interface
	Loop 4-20mA			Current loop 4-20mA
		Source		
			cO_2	Dissolved oxygen concentration
			sO_2	Saturation
			pO_2	Partial pressure
			tau	Fluorescence quenching time
			Temperature	Head temperature
		Alarm		Namur43 on / off
			Namur43	Alarm on
			no	Alarm off
	CANopen			CANopen fieldbus
		XXh		Sensor slave address
		XXXkbps		Transmission speed
		no term		Termination off
		term-120Ohm		Termination on
	MODBUS			MODBUS fieldbus

		XXh	Sensor slave address
		XXXXXXbps	Transmission speed
		RTU / ASCII	Transmission mode
		XYZ	X - number of data bits, Y - parity **N**-none, **E**-even, **O**-odd), Z - number of stop bits
		no term	Termination off
		term-120Ohm	Termination on
cO_2	*mg/L*	Dissolved oxygen concentration	
sO_2	*%*	The oxygen saturation [%] (in relative to dry air at atmospheric pressure)	
T	*°C*	Head temperature	
sO_2	*mBar*	Oxygen partial pressure	
tau	*us*	Fluorescence quenching time	
patm	*mBar*	Absolute atmospheric pressure during calibration or hydrostatic pressure at immersion in water	
RH	*%*	Relative humidity of ambient air during calibration or humidity inside the sensor during operation (leaks detection)	
TRH	*°C*	Humidity sensor temperature	

12.4. Activating the factory measuring window

The new sensor delivered by its manufacturer requires a one-time activation of the factory-made measuring window. During the first start-up of the terminal there is available only one menu option:

/1 Activate window An activation of the factory-made measuring window. This option requires entering a current date. An activation process adjusts physical and chemical changes which have been performer in the measuring window within a period between a production end and the first start-up of the sensor.

Enter the correct current date during activation of the factory-made measurement window !

If the date is not set correctly its subsequent correction will not be possible!
The sensor will report wearing of the measuring window.

12.5. Menu structure

The keyboard shortcuts provide a quick access to the menu functions.
Example: The "**/2.1**" shortcut - press key "**/**", press key "**2**", press key "**1**".

Table 6. The menu structure

Option name	**Keyboard shortcut**	**Page**
1 – Time / Date	**/1**	38
2 – Interface	**/2**	38
1 – Loop 4-20mA	**/2.1**	38
1 – Source	**/2.1.1**	39
1 – cO2	**/2.1.1.1**	39
2 – sO2	**/2.1.1.2**	39
3 – pO2	**/2.1.1.3**	39
4 – tau	**/2.1.1.4**	39
5 – Temperature	**/2.1.1.5**	39
2 – Range	**/2.1.2**	39
1 – cO2	**/2.1.2.1**	39
2 – sO2	**/2.1.2.2**	39
3 – pO2	**/2.1.2.3**	39
3 – Alarm	**/2.1.3**	39
1 – Namur43 – 22mA	**/2.1.3.1**	39
2 – no alarm	**/2.1.3.2**	39
2 – CANopen	**/2.2**	39
1 - Node ID	**/2.2.1**	41
2 – Speed	**/2.2.2**	41
1 – 10 kbps	**/2.2.2.1**	41
2 – 20 kbps	**/2.2.2.2**	41
3 – 50 kbps	**/2.2.2.3**	41
4 – 100 kbps	**/2.2.2.4**	41
5 – 125 kbps	**/2.2.2.5**	41

6 – 250 kbps	**/2.2.2.6**	41
7 – 500 kbps	**/2.2.2.7**	41
8 – 800 kbps	**/2.2.2.8**	41
9 – 1000 kbps	**/2.2.2.9**	41
3 – Termination	**/2.2.3**	41
1 – No termination	**/2.2.3.1**	41
2 – 120 Ohm termination	**/2.2.3.1**	42
3 – MODBUS	**/2.3**	42
1 – Address	**/2.3.1**	43
2 – Speed	**/2.3.2**	43
1 – 1200 bps	**/2.3.2.1**	43
2 – 2400 bps	**/2.3.2.2**	43
3 – 4800 bps	**/2.3.2.3**	43
4 – 9600 bps	**/2.3.2.4**	43
5 – 19200 bps	**/2.3.2.5**	43
6 – 38400 bps	**/2.3.2.6**	43
7 – 57600 bps	**/2.3.2.7**	43
8 – 115200 bps	**/2.3.2.8**	43
9 – 230400 bps	**/2.3.2.9**	43
A – 460800 bps	**/2.3.2.A**	43
B – 921600 bps	**/2.3.2.B**	43
3 – Mode	**/2.3.3**	43
1 – RTU	**/2.3.3.1**	43
2 – ASCII	**/2.3.3.2**	44
4 – Parity	**/2.3.4**	44
1 – None	**/2.3.4.1**	44
2 – Even	**/2.3.4.2**	44
3 – Odd	**/2.3.4.3**	44
5 – Termination	**/2.3.5**	44
1 - No termination	**/2.3.5.1**	44
2 – 120 Ohm termination	**/2.3.5.2**	44

1 – Low point, 0% O2	**/6.1**	48
2 – Get ppO2 in air	**/6.2**	49
3 – High point, 20.95% O2 in air	**/6.3**	49
4 – High point, saturated air	**/6.4**	49
5 – High point, ppO2 manually	**/6.5**	50
6 – Salinity	**/6.6**	50
New Window / Dye		
7 – Coding from file	**/6.7**	51
8 – Coding manually	**/6.8**	51
9 – Coefficients change	**/6.9**	51
1 – tau0-a	**/6.9.1**	53
2 – tau0-b	**/6.9.2**	53
3 – tau0-c	**/6.9.3**	53
4 – f	**/6.9.4**	53
5 – K'sv1	**/6.9.5**	53
6 – EKsv1	**/6.9.6**	53
7 – K'sv2	**/6.9.7**	53
8 – EKsv2	**/6.9.8**	53
9 – pbleach	**/6.9.9**	53
A – cal-pO2	**/6.9.A**	53
B – cal-tau0	**/6.9.B**	53
7 – Firmware upgrade	**/7**	53
Y – Enable USB disk drive device	**/7.1**	53
N - Exit	**/7.2**	53
8 – Service menu	**/8**	54
S – Save settings	**/S**	54
R – Restore manufacture settings	**/R**	54
Y – Restore manufacture settings	**/R.Y**	54
N - Exit	**/R.N**	54

12.6. Description of menu functions

Table 7. The main menu - Info box

Information fields		Meaning	
Head S/N		Head serial number	
Window S/N		Window serial number	
Window expired		Expected date of exchange of measuring window	
Last cal		Date of last calibration	
Battery	%	Battery level of real-time clock	
Mainboard Temp	°C	Motherboard temperature	
Cleaning status		Status of the cleaning system of measuring window	
		cleaning	Cleaning operations are in progress
		waiting	Waiting for cleaning
		disable	Cleaning system off
Control status		Status of the control system of air blower	
		running	Blower on
		waiting	Waiting for air blowing
		disable	Control system off

12.6.1. Date and time

/1 Time / Date Settings of time and date of the RTC clock.

A change is saved directly in the clock memory, a record of the sensor configuration is not required. It is possible to change a date format YYYY-MM-DD (year-month-date) or DD-MM-YYYY (day-month-year). The possible formats of time: HH:MM:SS (hour : minutes : seconds) or HH:MM (hour : minutes). Date and time can be entered simultaneously, you are just to separate them with a space character. The order of entering does not matter.

12.6.2. Loop 4-20mA, CANopen, MODBUS communication interfaces

/2 Interface Settings of a current loop communication 4-20mA and the CANopen, MODBUS fieldbuses.

/2.1 Loop 4-20mA Current loop 4-20mA.

This interface handles a system of the NAMUR43 alarms. A level of current below 3.6 mA means

no supply power or a sensor failure. A level of 22 mA means a measurement error, e.g. a total wearing of the measuring window.
The available sources of the signal is a **cO2** concentration, a **sO2** saturation, an oxygen partial pressure **pO2**, a luminescence quenching time **tau,** a temperature. For the measuring values of the **cO2**, **sO2** and **pO2** it is possible to set a mapping of the measurement range for the current range of the loop. Therefore it is possible to increase a measurement resolution at the result conversion from the digital to the analogue value.
Example. If a value of the condensation fluctuates within a scope of 7 mg/L and for a concerned operation environment it does not exceed 10 mg/L then setting the range to 10 mg/L instead of the default 20 mg/L allows for a two-fold increase of the resolution.

- **/2.1.1 Source** Selection of a signal source for a current loop.
  - **/2.1.1.1 cO2** Concentration ,
  - **/2.1.1.2 sO2** Saturation,
  - **/2.1.1.3 pO2** Partial pressure,
  - **/2.1.1.4 tau** Fluorescence quenching time,
  - **/2.1.1.1 temperature** Temperature.
- **/2.1.2 Range** Range of measuring value mapping for a current range of the loop.
  - **/2.1.2.1 cO2** Range from 10 to 40 mg/L,
  - **/2.1.2.2 sO2** Range from 100 to 400 %,
  - **/2.1.2.3 pO2** Range from 200 to 1000 mbar.
- **/2.1.3 Alarm** Turning on / off of the Namur43 alarm.
  - **/2.1.3.1 Namur43 – 22mA**
  - **/2.1.3.2 no alarm**

/2.2 CANopen The interface of the CANopen (CANBUS) fieldbus.

The sensor operates according to the **DS-301** standard, handles the **SDO** and **PDO** transmission. Maximally there are available four configurable **PDO** rounds. Each round may include two mapped measuring values.
The sensor supervises **Heartbeat, Nodeguard** and **NMT** states.
When power supply is turned on, the sensor is in the **NMT PREOPERATIONAL** mode and sends a message **NMT Boot-up** to the fieldbus. The **PDO** transmission starts its operations after switching the sensor to the **NMT OPERATIONAL** mode. A transition to the **NMT STOP** mode stops the **PDO** transmission.
The **Heartbeat** function launches its operations when a value of the register of the *Heartbeat time (1017h, 00h)* is higher than 0.
A detailed description of the CANopen fieldbus operation is available at http://www.can-cia.org.
The sensor has a built-in 120 ohm terminator connected electronically to the fieldbus.
If the sensor operates as an end-device it is possible to turn on an internal terminator and give up mounting a resistor in the M12 plug.
Time of the RTC clock is recorded in the UNIX format (4 bytes) in seconds from the beginning of the era, i.e. from 1st January 1970.

Table 8. Addressing the CANopen

Index	Subindex	Description	Unit	Type	R/W	Size (bytes)	Default value
1000h	00h	Device Type		Unsigned32	R	4	00000000h
1018h	01h	Vendor ID		Unsigned32	R	4	00000000h
1018h	02h	Product code		Unsigned32	R	4	4F585944h OXYD
1017h	00h	Heartbeat time	*ms*	Unsigned16	R/W	2	0000h
1200h	01h	SDO RX COB-ID		Unsigned32	R	4	-
1200h	02h	SDO TX COB-ID		Unsigned32	R	4	-
2000h	00h	Sensor status		Unsigned32	R	4	-
2001h	00h	**cO2** concentration	*mg/L*	Real32	R	4	-
2001h	01h	**sO2** saturation	*%*	Real32	R	4	-
2001h	02h	Head temperature	*°C*	Real32	R	4	-
2001h	03h	**pO2** O_2 partial pressure	*bar*	Real32	R	4	-
2001h	04h	**Tau** fluorescence decay time	*us*	Real32	R	4	-
2001h	05h	Atmospheric pressure / hydrostatic	*bar*	Real32	R	4	-
2001h	06h	Relative humidity inside the sensor	*%*	Real32	R	4	-
2001h	07h	Temperature of humidity sensor	*°C*	Real32	R	4	-
2001h	08h	Salinity	*ppt*	Real32	R	4	-
2001h	09h	Mainboard temperature	*°C*	Real32	R	4	-
2001h	0Ah	Sensor serial number		Unsigned64	R	8	-
2001h	0Bh	Date and time	*s*	Unsigned32	R	4	-
2001h	0Ch	Measuring window serial number		Unsigned16	R	2	-
2001h	0Dh	Expected date of exchange measuring window	*s*	Unsigned32	R	4	-

Index	Subindex	Description	Unit	Type	R/W	Size (bytes)	Default value
2001h	0Eh	Date of last calibration	*s*	Unsigned32	R	4	-
2001h	0Fh	RTC battery level	*%*	Unsigned16	R	2	-
2001h	10h	Supply power +24V	*V*	Real32	R	4	-

Table 9. CANOpen Status register (2000h, 00h)

Bit	Description	State "0"	State "1"
0	Correctness of indications	Incorrect	Correct
1	Range error	Range ok	Range exceeded
2	Measuring window status	Correct	Need to replace
3	Cleaning	Waiting	Cleaning in progress
4	Maintaining values after cleaning "**holding time**"	Real current value	Saved value
5	Output status **OXYGEN CONTROL**	Correct	Short circuit
6	Output status **AIRBLAST CLEANING**	Correct	Short circuit

/2.2.1 Node ID CANopen slave address of the sensor. Range from 0 to 127.

/2.2.2 Speed Transmission speed.

- **/2.2.2.1 10 kbps** 10 kbit/s.
- **/2.2.2.2 20 kbps** 20 kbit/s.
- **/2.2.2.3 50 kbps** 50 kbit/s.
- **/2.2.2.4 100 kbps** 100 kbit/s.
- **/2.2.2.5 125 kbps** 125 kbit/s.
- **/2.2.2.6 250 kbps** 250 kbit/s.
- **/2.2.2.7 500 kbps** 500 kbit/s.
- **/2.2.2.8 800 kbps** 800 kbit/s.
- **/2.2.2.9 1000 kbps** 1000 kbit/s.

/2.2.3 Termination 120 Ohm terminator. Enabled electronically.

- **/2.2.3.1 No termination** Disconnecting the terminator.

/2.2.3.2 120 Ohm termination Connecting the 120 ohm terminator.

/2.3 MODBUS The interface of the MODBUS (RS485) fieldbus.

A communication protocol is compatible with the **MODICON** format. The sensor handles both the **RTU** and **ASCII** mode. The registers are placed in the Holding Register (4XXXX) space with a shift of 1 000 addresses, i.e. from the 41000 address.

In the MODBUS protocol in the RTU mode, a character frame has always a length of 11 bits. Therefore the frame contains one bit of the stop if a parity is in the **even** mode or **odd** mode, or 2 bits of a stop if a parity is off.

In the ASCII mode, the frame lengths is always 10 bits. If a parity is set to **even** or **odd**, so a frame contains 1 bit of a stop, if a parity is turned off, the frame includes 2 bits of a stop.

The sensor has a built-in 120 ohm terminator connected electronically to the fieldbus.

If the sensor operates as an end-device it is possible to turn on an internal terminator and give up mounting a resistor in the M12 plug.

Table 10. Addressing the MODBUS

Address	Description	Unit	Type	R/W	Size (bytes)
41000	Sensor status		Long unsigned int	R	4
41002	**cO2** concentration	*mg/L*	Float	R	4
41004	**sO2** saturation	*%*	Float	R	4
41006	Head temperature	*°C*	Float	R	4
41008	**pO2** O_2 partial pressure	*bar*	Float	R	4
41010	Tau fluorescence decay time	*us*	Float	R	4
41012	Atmospheric pressure / hydrostatic	*bar*	Float	R	4
41014	Relative humidity inside the sensor	*%*	Float	R	4
41016	Humidity sensor temperature	*°C*	Float	R	4
41018	Salinity	*ppt*	Float	R	4
41020	Mainboard temperature	*°C*	Float	R	4
41022	Sensor serial number		Long long unsigned int	R	8
41026	Date and time	*s*	Long unsigned int	R	4
41028	Window serial number		Unsigned word	R	2
41029	Expected date of exchange measuring window	*s*	Long unsigned int	R	4

Address	Description	Unit	Type	R/W	Size (bytes)
41031	Date of last calibration	*s*	Long unsigned int	R	4
41033	RTC battery level	*%*	Unsigned word	R	2
41034	Supply power +24V	*V*	Float	R	4

Table 11. MODBUS Status register (41000)

Bit	Description	State "0"	State "1"
0	Correctness of indications	Incorrect	Correct
1	Range error	Range ok	Range exceeded
2	Measuring window status	Correct	Must be replaced
3	Cleaning	Waiting	Cleaning in progress
4	Maintaining values after cleaning "**holding time**"	Real current value	Saved value
5	Output status **OXYGEN CONTROL**	Correct	Short circuit
6	Output status **AIRBLAST CLEANING**	Correct	Short circuit

/2.3.1 Address Sensor slave address. Range 1 to 247.

/2.3.2 Speed Transmission speed.

- **/2.3.2.1 1200 bps** 1200 bit/s.
- **/2.3.2.2 2400 bps** 2400 bit/s.
- **/2.3.2.3 4800 bps** 4800 bit/s.
- **/2.3.2.4 9600 bps** 9600 bit/s.
- **/2.3.2.5 19200 bps** 19200 bit/s.
- **/2.3.2.6 38400 bps** 38400 bit/s.
- **/2.3.2.7 57600 bps** 57600 bit/s.
- **/2.3.2.8 115200 bps** 115200 bit/s.
- **/2.3.2.9 230400 bps** 230400 bit/s.
- **/2.3.2.A 460800 bps** 460800 bit/s.
- **/2.3.2.B 921600 bps** 921600 bit/s.

/2.3.3 Mode Fieldbus operation mode.

- **/2.3.3.1 RTU** Binary RTU.

/2.3.3.2 ASCII Text ASCII.

/2.3.4 Parity Parity.

/2.3.4.1 None

/2.3.4.2 Even

/2.3.4.3 Odd

/2.3.5 Termination 120 Ohm terminator. Turned on electronically.

/2.3.5.1 No termination Disconnecting the terminator.

/2.3.5.2 120 Ohm termination Connecting the 120 ohm terminator.

/2.3.6 Watchdog MODBUS Watchdog. Exceeding the time between frames addressed to the sensor restarts the interface/sensor.

Table 12. The **Watchdog** menu - Info box

Information fields		**Meaning**	
Watchdog		Watchdog state	
		enabled	On
		disable	Off
Reset type		Reboot type	
		interface	Reboot of fieldbus interface
		sensor	Reboot of sensor
Time	*s*	The maximum time between frames addressed to sensor.	

/2.3.6.1 Watchdog enable/disable Enable/Disable.

/2.3.6.2 Reset type Typ restartu.

/2.3.6.2.1 Reset interface Interface reboot.

/2.3.6.2.2 Reset sensor Sensor reboot.

/2.3.6.3 Time *[s]* Maximum time between the MODBUS frames addressed to the sensor. Range from 3 to 600 seconds. Exceeding reboots the interface/sensor.

12.6.3. Automatic cleaning of the measuring window

/3 Cleaning / Airblast Managing a system of the pneumatic window cleaning.

Table 13. The **Cleaning** / **Air blast** menu - Info box

Information fields		Meaning	
State		State of the cleaning system	
		enabled	On
		disable	Off
Start time	*hh:mm*	Enabling time	
Interval	*hh*	Time between starts of cleaning	
Duration	*s*	Duration of cleaning operation	
Holding time	*s*	Hold time of valid measurement values during cleaning	
Status		Status of cleaning system	
		waiting	Waiting for start cleaning
		cleaning	Cleaning in progress
Output state		Output state **AIRBALST / CLEANING**	
		off	Inactive
		on	Active
Output diagnostic		Output diagnostic **AIRBALST / CLEANING**	
		ok	Proper operating
		error	Short circuit

/3.1 Cleaning enable/disable On/off cleaning.

/3.2 Start time *[hh:mm] Start-up time.*

/3.3 Interval *[hh]* Time between start-ups. Range from 1 to 24 hrs.

/3.4 Duration *[s]* Duration of the cleaning operation. Range from 10 to 600 seconds. A default value is of 120 seconds.

/3.5 Holding time *[s]* Holding time of the correct measurement values during the cleaning. The cleaning with the compressed gas results in obtaining false indications of the sensor. In order to prevent against the improper operating of the PLC drivers connected to the fieldbus, the sensor maintains in the MODBUS/CANopen registers the latest valid measurement values. Holding time allows for stabilising the sensor indications after cleaning is finished. Default value 60 seconds.

/3.6 Output manual enable/disable Cleaning output on/off.
It allows for checking up a correctness of the system operating.

12.6.4. Control of air blower

/4 Oxygen control Managing a control system of the external air blower.
It is a two-status control with a hysteresis system. The control output enables the air blower if an oxygen concentration is lower than the **Target – Hysteresis** value. The pump operates until the oxygen concentration reaches the **Target + Hysteresis** value. The pump is disabled until the concentration reaches the **Target – Hysteresis** value again.

Table 14. Menu **Oxygen control** - Info box

Information fields		Meaning	
State		State of blowing system	
		enabled	On
		disabled	Off
Target	*mg/L*	Target value of the dissolved oxygen concentration	
Hysteresis	*mg/L*	System hysteresis	
Status		Status control system	
		waiting	Air blowing off
		running	Air blowing on
Output state		Output state **OXYGEN CONTROL**	
		off	Inactive
		on	Active
Output diagnostic		Output diagnostic **OXYGEN CONTROL**	
		ok	Correct operating
		error	Short circuit

/4.1 Oxygen control enable/disable Control system on/off.
/4.2 Target A target value of the dissolved oxygen concentration.Range from 0 to 20mg/L.
/4.3 Hysteresis A system hysteresis. Range from 0 to 4mg/L.
/4.4 Output manual enable/disable Control output on/off.
Enables to check up a correctness of system operations.

12.6.5. Measuring interval and the averaging filter

/5 Interval / Filtering Measuring frequency / Size of the averaging filter.

Table 15. The **Interval / Filtering** menu - Info box

Information fields		Meaning
Interval	*s*	Measuring interval
Filter size	*samples*	Averaging filter size

/1 Measurement interval Changing a measurement frequency. Performing a measurement is connected with charging dye molecules to the high-energy state. In this state the dye is strongly reactive. It partially combines with the oxygen molecules, and partially with the matrix molecules. It is a so called "**photo-bleaching**" phenomenon which decreases an ability of the fluorophore emission what in consequence results in a measurement drift. An increase of the interval between measurement decreases the sensor drift, but increases a reaction time for a change of the oxygen concentration.

- **/1 1s (default)** Measurement every second. Default value.
- **/2 2s** Measurement every 2 seconds.
- **/3 5s** Measurement every 5 seconds.
- **/4 10s (low drift)** Measurement every 10 seconds.

/2 Filter size A size of the averaging filter. The filter operates on the basis of the FIR digital model. With an increase of the filter size, a stability of the readouts is higher, but a reaction time of the sensor for a change of the oxygen concentration decreases.

- **/1 5 samples** Average from 5 measurements.
- **/2 10 samples** Average from 10 measurements.
- **/3 15 samples (default)** Average from 15 measurements Default value.
- **/4 30 samples** Average from 30 measurements.

12.6.6. Calibration and installation of the new measuring window

/6 Calibration / New Window Sensor calibration, an installation of the new measuring window.

Table 16. The **Calibration** / **New Window** menu - Info box

Information fields		Meaning
Window S/N		Measuring window serial number
Window expired		Expected date of exchange measuring window
Last cal		Date of last calibration
tau0-temperature	*us*	tau_0 coefficient after temperature compensation
ppH2O	*mBar*	Partial pressure of water vapor contained in the atmospheric air (during a calibration after removing the measuring window)
ppO2-ambient	*mBar*	Partial pressure of oxygen in the air
ppO2-saved	*mBar*	*ppO2* pressure in the air saved during calibration
Salinity	*ppt*	Correction of CO_2 caused by salinization
photobleach tau0	*ns*	Correction values tau0 caused by photo-bleaching
cal-pO2		Slope of calibration curve
cal-tau0	*us*	Coefficient of offset calibration curve

Calibration Linear calibration, one-point and two-point calibration.

/6.1 Low point, 0% O2 Calibration of the measurement curve offset, a reset of the indications. The low calibration point.

Procedure:

1. Prepare a calibration solution of sodium sulphite. Add sodium sulphite Na_2SO_3 from the test-tube, included in the set, to 500ml of demineralised water. Mix a solution until crystals are totally solved.
2. Place the sensor in the prepared solution.
3. Choose the **/6.1 Low point, 0% O2** menu option.
4. Wait 10 minutes until the sensor and solution temperatures are equal.
5. Check-up if on the surface of the measuring window are any air bubbles. If so, please incline the sensor so that they are removed.
6. Wait 5 minutes until an indication of cO_2 stops decreasing.
7. Press „**Y**”. The calibration will be finished. The indications of **cO_2**, **sO_2** and **pO_2** will be reset.
8. Save the configuration using the following menu: **/S Save settings**.

/6.2 Get ppO2 in air Measurement of oxygen partial pressure in the atmospheric air.

The value of **ppO_2** in the air is necessary to perform a two-point calibration.

Procedure:

1. Disassembly the measuring window. Dry the head socket using a dry cloth.

Do not touch the optical components head!

2. Put the sensor in the place where the body temperature is similar to the air temperature.
3. Select the following menu: **/6.2 Get ppO2 in air**. Wait 5 minutes. The indication of **ppO_2-ambient** should stabilise.
4. Press „**Y**”. The value of **ppO_2** will be saved in the memory. The measurement result will be possible to read out in the **ppO_2-saved** field.
5. Assembly the measuring window.

/6.3 High point, 20.95% O2 in air Calibration of the inclination of the measurement curve.

The high calibration point. The reference – partial oxygen pressure in the atmospheric air. It requires to perform a disassembly of the measuring window.

Procedure:

1. Perform a calibration of the low point - **/6.1 Low point, 0%O2** menu.
2. Perform a measurement of the oxygen partial pressure in the air – menu **/ 6.2 Get ppO2 in air**.
3. Put the sensor in the place where the body temperature will be similar to the air temperature.
4. Select **/6.3 High point, 20.95% O2 in air** menu. Wait 10 minutes.
5. Press „**Y**”. The calibration will be finished. The value of **pO2** should be equal to the value of the **ppO2-saved** field.
6. Save the configuration using the following menu: **/S Save settings**.

/6.4 High point, saturated air Calibration of the inclination of the measurement curve.

The high calibration point. The reference – partial oxygen pressure in the atmospheric air. It does not require to perform a disassembly of the measuring window.

Procedure:

1. Perform a calibration of the low point - menu **/6.1 Low point, 0%O2** and save a configuration.
2. Pour 20 mL of deionised water to the bag with a volume of 350ml.
3. Place the bag onto the sensor head and seal using a rubber seal. Water

which is in the bag cannot touch a surface of the measuring window.

4. Select **/6.4 High point, saturated air** menu.
5. Wait 15 minutes until the air inside the bag will saturate with the vapour. The temperature of the sensor head and air in the bag must be equal.
6. Press „**Y**". The calibration will be finished.
7. Save the configuration using the following menu: **/S Save settings**.

/6.5 High point, ppO2 manualy Calibration of the inclination of the measurement curve.
The high calibration point. The reference – partial oxygen pressure entered manually.

The calibration in the reference environment.
Procedure:

1. Perform a calibration of the low point - **/6.1 Low point, 0%O2** menu.
2. Place the sensor in the calibration environment. Wait 10 minutes, until the body temperature will be equal to the environment temperature.
3. Select **/6.4 High point, ppO2 manually** menu. Enter the value of the real oxygen partial pressure. The calibration will be finished.
4. Save the configuration using the following menu: **/S Save settings**.

Manual calibration in the air saturated with water vapour.
Procedure:

1. Perform a calibration of the low point - **/6.1 Low point, 0%O2** menu and save a configuration.
2. Disconnect the sensor form power supply.
3. Pour 20 mL of deionised water to the bag with a volume of 350ml.
4. Place the bag onto the sensor head and seal using a rubber seal. Water which is in the bag cannot touch a surface of the measuring window.
5. Wait 15 minutes until the air inside the bag will saturate with the vapour. The temperature of the sensor head and air in the bag must be equal.
6. Connect the sensor. On the basis of the temperature indications, read a value of the partial pressure of the water vapour **ppH_20** from **Table 19** (page 55).
7. Enter a value of the atmospheric pressure **patm** [mbar] **and ppH20** [mbar] to the following formula:

$$pO_2=(p_{atm}-pp_{H_2O})\cdot\frac{20.0946}{100}\quad[mBar]\quad(12.6\ 1)$$

5. Select **/6.4 High point, ppO2 manually** menu. Enter the calculated value of **pO_2**. The calibration will be finished.

11. Save the configuration using the following menu**: /S Save settings**.

/6.6 Salinity Salinity level. Range from 0 to 100 ppt.
A correction of salinity is related only to a measurement of cO_2. Salinity can be determined on the basis of the conductivity measurement using a conductometer.

Table 20 (page 56) allows for recalculating values.

New Window/Dye Installation of the measuring window.

Besides a mechanical exchange of the window it is necessary to enter calibration coefficients to the sensor. Every window is calibrated individually during a manufacturing process.

/6.7 Coding from file Installation of the window from the calibration file.

Procedure:

1. Check-up a time and date set in the sensor. If they are not valid enter new settings.

If during an installation of the measuring window a date is set incorrectly its subsequent correction will not be possible! The sensor will report wearing of the window.

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2. **Select "/6.7 Coding from file"** menu. A virtual USB disc will switch itself from the read-only mode to the read/save mode. **Do not delete any files**.
3. Copy the "*WindowXXXXXX.wdw*" file attached to the measuring window to the "Data" catalogue.
4. Press "Y". The window will be installed.

<u>After a correctly performed procedure of the window installation, the sensor will automatically save all setting to the non-volatile memory, removing the previous configuration.</u>

/6.8 Coding manualy Installation of the window by means of the calibration codes.

This option allows for a manual entering calibration coefficients using the text codes. A set of the codes consist of twelve items in the following format: 0-123456789. The codes can be entered manually or all at one time separating them by space characters. Dana comprise checksums. It is impossible to enter incorrect values.

Table 17. Menu **Coding manually** - Info box

Information fields	Meaning	
Code completeness	Status introduced calibration codes	
	+	Code entered correctly
	-	No-code or entered incorrectly

/6.9 Coefficients change Modification of calibration coefficients.

Options intended for a precise calibration performer in the laboratories. The sensor is based on the two-side activation of the luminophor. The modified *Stern-Volmer* equation has the following form:

$$\frac{tau_0[T]}{tau}=\left(\frac{f}{1+K_{SV1}[T]\cdot pO_2}\cdot\frac{1-f}{1+K_{KSV2}[T]\cdot pO_2}\right)^{-1} \quad (12.6\ 2)$$

Calibration curves of the K_{SV1} , K_{SV2} coefficients as a function of temperature have the following form:

$$K_{SV1,2}[T]=K'_{SV1,2}\cdot e^{-\frac{EK_{SV1,2}}{R(T+273.15)}} \quad (12.6\ 3)$$

Calibration curve of the tau_0 coefficient as a function of temperature have the following form:

$$tau_0[T]=a_{tau_0}\cdot T^2+b_{tau_0}\cdot T+c_{tau_0} \quad (12.6\ 4)$$

Non-linear regression allows for selecting the proper values of the coefficients.
The two-point calibration performer by a user is based on the linear adjustment of the *Stern-Volmer* curve to the *0%-O2* and *20.95%-O2* reference points.

$$pO_{2\ odczyt}=cal_{pO_2}\cdot pO_{2\ pomiar} \quad (12.6\ 5)$$

$$tau_0[T]_{odczyt}=tau_0[T]_{pomiar}+cal_{tau_0} \quad (12.6\ 6)$$

Table 18. Menu **Coefficients change** - Info box

Information fields		Meaning
Window S/N		Measuring window serial number
tau0-a		*a* coefficient of temperature calibration tau_0
tau0-b		*b* coefficient of temperature calibration tau_0
tau0-c	*s*	*c* coefficient of temperature calibration tau_0
f		*f* coefficient, two-side model *Stern-Volmer* equation
K'sv1		K'_{SV1} coefficient
EKsv1		EK_{SV1} energy activation coefficient
K'sv2		K'_{SV2} coefficient
EKsv2		EK_{SV2} energy activation coefficient
pbleach	m^2/W	Photo-bleaching correction coefficient

cal-pO2		Coefficient of inclination of linear calibration
cal-tau0	*s*	Coefficient of offset of linear calibration

/6.8.1 tau0-a	a_{tau0} coefficient modification
/6.8.1 tau0-b	b_{tau0} coefficient modification
/6.8.1 tau0-c	c_{tau0} coefficient modification
/6.8.1 f	f coefficient modification
/6.8.1 K'sv1	K'_{SV1} coefficient modification
/6.8.1 EKsv1	EK_{SV1} coefficient modification
/6.8.1 K'sv2	K'_{SV2} coefficient modification
/6.8.1 EKsv2	EK_{SV2} coefficient modification
/6.8.1 pbleach	*pbleach* coefficient modification
/6.8.1 cal-pO2	cal_{pO2} coefficient modification
/6.8.1 cal-tau0	cal_{tau0} coefficient modification

12.6.7. Downloading firmware

/7 Firmware upgrade	Firmware installation.
/7.Y Enable USB disk drive device	Enabling an upload mode of firmware.
/7.N Exit	Exit from menu.

The sensor is constructed so that it is possible to upgrade the firmware from the level of the factory functions of the internal processor. Due to this it is impossible to damage permanently the device if an operation of the firmware update has been unsuccessful. The procedure can be initiated by two means:

Procedure 1: Activation of the firmware download from the level of the terminal application.

1. Select **/7.Y Enable USB disk drive device** menu. After choosing this option, the sensor will switch from the terminal mode to the firmware download mode. A virtual USB disc named "**CRP DISABLD"** with the "**firmware.bin"** file will appear in the operational system of the computer.
2. Remove the "**firmware.bin"** file.
3. Copy the file with the proper firmware to the **"CRP DISABLD"** disc. It is impossible to overwrite "**firmware.bin"**. It will appear a message that there is no space.
4. Disconnect the sensor from the power supply for 5 seconds.

Procedure 2: Emergency activation of the firmware download mode.

1. Disassemble the sensor housing.
2. Find the **S1** button marked as **USBBOOT**.
3. Press the **S1** button and while holding it connect the USB wire to the computer. The device will switch to the firmware download mode. A virtual USB disc named "**CRP DISABLD"** with the

"**firmware.bin"** file will appear in the operational system of the computer.
4. Remove the "**firmware.bin"** file.
5. Copy the file with the proper firmware to the **"CRP DISABLD"** disc. It is impossible to overwrite "**firmware.bin"**. It will appear a message that there is no space.
6. Disconnect the sensor from the power supply for 5 seconds.

12.6.8. Service options

/8 Service menu Service options are available only to the authorised technicians.

12.6.9. Saving system settings

/S Save settings Saving system settings in the non-volatile memory of the sensor.

The changes of the sensor configurations in the terminal mode are of temporary nature. Every time after finishing the configuration it is necessary to save it manually to the NVM. Power outage without saving the configuration results in restoring the previously saved settings. An operation of the installation of the new measuring window is the only exception to this rule.

After a correctly performed procedure of the window installation, the sensor will automatically save all setting to the non-volatile memory, removing the previous configuration.

12.6.10. Restore manufacture settings

/R Restore manufacture settings Restoring manufacture settings. This option restores a manufacture configuration and initial coefficients of the installed measuring window.

/R.Y Restore manufacture settings Restores the fabric settings.

/R.N Exit Exit from a menu.

13. Annex

Table 19. Water vapor partial pressure, humidity 100%

Temperature [°C]	Pressure [mBar]	Temperature [°C]	Pressure [mBar]	Temperature [°C]	Pressure [mBar]
0,00	6,15	**14,00**	16,06	**28,00**	37,97
0,50	6,38	**14,50**	16,59	**28,50**	39,09
1,00	6,61	**15,00**	17,14	**29,00**	40,24
1,50	6,85	**15,50**	17,69	**29,50**	41,42
2,00	7,10	**16,00**	18,27	**30,00**	42,62
2,50	7,36	**16,50**	18,86	**30,50**	43,86
3,00	7,62	**17,00**	19,47	**31,00**	45,13
3,50	7,90	**17,50**	20,09	**31,50**	46,43
4,00	8,18	**18,00**	20,74	**32,00**	47,76
4,50	8,47	**18,50**	21,40	**32,50**	49,13
5,00	8,77	**19,00**	22,08	**33,00**	50,53
5,50	9,08	**19,50**	22,77	**33,50**	51,97
6,00	9,40	**20,00**	23,49	**34,00**	53,44
6,50	9,73	**20,50**	24,23	**34,50**	54,94
7,00	10,07	**21,00**	24,98	**35,00**	56,48
7,50	10,42	**21,50**	25,76	**35,50**	58,06
8,00	10,79	**22,00**	26,56	**36,00**	59,68
8,50	11,16	**22,50**	27,38	**36,50**	61,34
9,00	11,54	**23,00**	28,22	**37,00**	63,03
9,50	11,94	**23,50**	29,09	**37,50**	64,77
10,00	12,34	**24,00**	29,98	**38,00**	66,55
10,50	12,76	**24,50**	30,89	**38,50**	68,37
11,00	13,19	**25,00**	31,82	**39,00**	70,23
11,10	13,64	**25,50**	32,78	**39,50**	72.14

Temperature [°C]	Pressure [mBar]	Temperature [°C]	Pressure [mBar]	Temperature [°C]	Pressure [mBar]
12,00	14,10	**26,00**	33,77	**40,00**	74,09
12,50	14,58	**26,50**	34,78	**40,50**	76,08
13,00	15,05	**27,00**	35,82	**41,00**	78,13
13,50	15,55	**27,50**	36,88	**41,50**	82,36

Table 20. Conductivity - salinity, temperature 20°C

Conductivity [ms/cm]	Salinity [ppt]	Conductivity [ms/cm]	Salinity [ppt]	Conductivity [ms/cm]	Salinity [ppt]
1	0,55	**21**	14,08	**41**	29,41
2	1,14	**22**	14,81	**42**	30,21
3	1,74	**23**	15,55	**43**	31,01
4	2,36	**24**	16,29	**44**	31,82
5	3,00	**25**	17,03	**45**	32,62
6	3,64	**26**	17,78	**46**	33,44
7	4,30	**27**	18,53	**47**	34,25
8	4,96	**28**	19,29	**48**	35,07
9	5,62	**29**	20,05	**49**	35,89
10	6,30	**30**	20,81	**50**	36,72
11	6,98	**31**	21,57	**51**	37,55
12	7,67	**32**	22,34	**52**	38,38
13	8,36	**33**	23,11	**53**	39,21
14	9,06	**34**	23,89	**54**	40,05
15	9,76	**35**	24,67	**55**	40,89
16	10,47	**36**	25,45	**56**	41,73
17	11,18	**37**	26,24	**57**	42,57
18	11,90	**38**	27,02	**58**	43,42
19	12,62	**39**	27,81	**59**	44,27
20	13,35	**40**	28,61	**60**	45,13

Table 21. Oxygen concentration (**cO_2**) in the water, saturation, p_{atm} 1.013 Bar

Temperature [°C]	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
0	14,64	14,60	14,55	14,51	14,47	14,43	14,39	14,35	14,31	14,27
1	14,23	14,19	14,15	14,10	14,06	14,03	13,99	13,95	13,91	13,87
2	13,83	13,79	13,75	13,71	13,68	13,64	13,60	13,56	13,52	13,49
3	13,45	13,41	13,38	13,34	13,30	13,27	13,23	13,20	13,16	13,12
4	13,09	13,05	13,02	12,98	12,95	12,92	12,88	12,85	12,81	12,78
5	12,75	12,71	12,68	12,65	12,61	12,58	12,55	12,52	12,48	12,45
6	12,42	12,39	12,36	12,32	12,29	12,26	12,23	12,20	12,17	12,14
7	12,11	12,08	12,05	12,02	11,99	11,96	11,93	11,90	11,87	11,84
8	11,81	11,78	11,75	11,72	11,69	11,67	11,64	11,61	11,58	11,55
9	11,53	11,50	11,47	11,44	11,42	11,39	11,36	11,33	11,31	11,28
10	11,25	11,23	11,20	11,18	11,15	11,12	11,10	11,07	11,05	11,02
11	10,99	10,97	10,94	10,92	10,89	10,87	10,84	10,82	10,79	10,77
12	10,75	10,72	10,70	10,67	10,65	10,63	10,60	10,58	10,55	10,53
13	10,51	10,48	10,46	10,44	10,41	10,39	10,37	10,35	10,32	10,30
14	10,28	10,26	10,23	10,21	10,19	10,17	10,15	10,12	10,10	10,08
15	10,06	10,04	10,02	9,99	9,97	9,95	9,93	9,91	9,89	9,87
16	9,85	9,83	9,81	9,78	9,76	9,74	9,72	9,70	9,68	9,66
17	9,64	9,62	9,60	9,58	9,56	9,54	9,53	9,51	9,49	9,47
18	9,45	9,43	9,41	9,39	9,37	9,35	9,33	9,31	9,30	9,28
19	9,26	9,24	9,22	9,20	9,19	9,17	9,15	9,13	9,11	9,09
20	9,08	9,06	9,04	9,02	9,01	8,99	8,97	8,95	8,94	8,92
21	8,90	8,88	8,87	8,85	8,83	8,82	8,80	8,78	8,76	8,75
22	8,73	8,71	8,70	8,68	8,66	8,65	8,63	8,62	8,60	8,58
23	8,57	8,55	8,53	8,52	8,50	8,49	8,47	8,46	8,44	8,42
24	8,41	8,39	8,38	8,36	8,35	8,33	8,32	8,30	8,28	8,27
25	8,25	8,24	8,22	8,21	8,19	8,18	8,16	8,15	8,14	8,12
26	8,11	8,09	8,08	8,06	8,05	8,03	8,02	8,00	7,99	7,98
27	7,96	7,95	7,93	7,92	7,90	7,89	7,88	7,86	7,85	7,83

Temperature [°C]	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
28	7,82	7,81	7,79	7,78	7,77	7,75	7,74	7,73	7,71	7,70
29	7,69	7,67	7,66	7,65	7,63	7,62	7,61	7,59	7,58	7,57
30	7,55	7,54	7,53	7,51	7,50	7,49	7,48	7,46	7,45	7,44
31	7,42	7,41	7,40	7,39	7,37	7,36	7,35	7,34	7,32	7,31
32	7,30	7,29	7,28	7,26	7,25	7,24	7,23	7,21	7,20	7,19
33	7,18	7,17	7,15	7,14	7,13	7,12	7,11	7,09	7,08	7,07
34	7,06	7,05	7,04	7,02	7,01	7,00	6,99	6,98	6,97	6,96
35	6,94	6,93	6,92	6,91	6,90	6,89	6,88	6,87	6,85	6,83
36	6,83	6,82	6,81	6,80	6,79	6,78	6,77	6,75	6,74	6,73
37	6,72	6,71	6,70	6,69	6,68	6,67	6,66	6,65	6,64	6,63
38	6,61	6,60	6,59	6,58	6,57	6,56	6,55	6,54	6,53	6,52
39	6,51	6,50	6,49	6,48	6,47	6,46	6,45	6,44	6,43	6,42
40	6,41	6,40	6,39	6,38	6,37	6,36	6,35	6,34	6,33	6,32

14. Declaration of conformity CE

DECLARATION OF CONFORMITY

Product: OXY-DIOS-DSP optical dissolved oxygen sensor

Product description: *The optical-fluorescent sensor for measuring a concentration of dissolved oxygen in water and wastewater.*

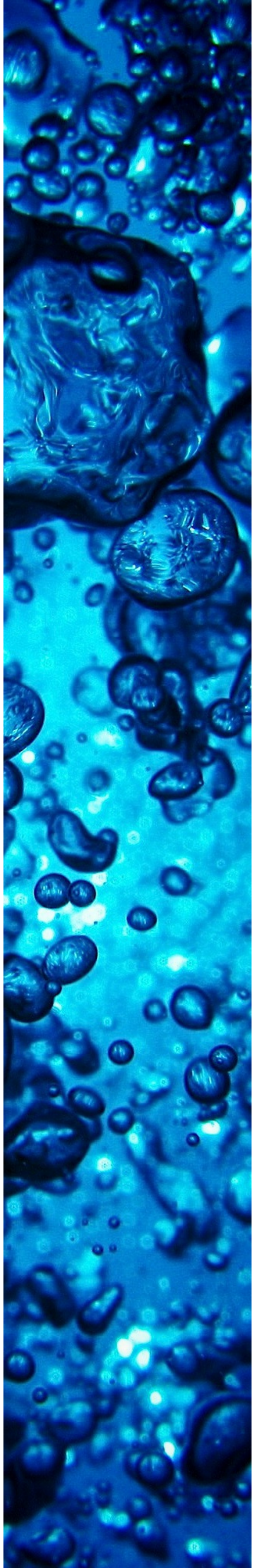
Manufacturer: INTEGRON Research and Development Laboratory
Radomska 3 Street
26-500 Szydłowiec POLAND
Phone +48 48 3703828
Fax +48 48 3703829

The product is compatible with European Union Directives:
2004/108/WE (EMC Directive), 2006/95/WE (LVD Low Voltage Directive)

The product is intended for use in industrial environments and is compliant with the following standards:
EN50081-2, EN50081-2, EN 61326-1

Szydłowiec, POLAND 02.11.2015
Karol Antonkiewicz, Main constructor

26-500 Szydłowiec POLAND ul. Radomska 3 Tel. +48 48 3703828
http://www.sensor.integron.pl



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