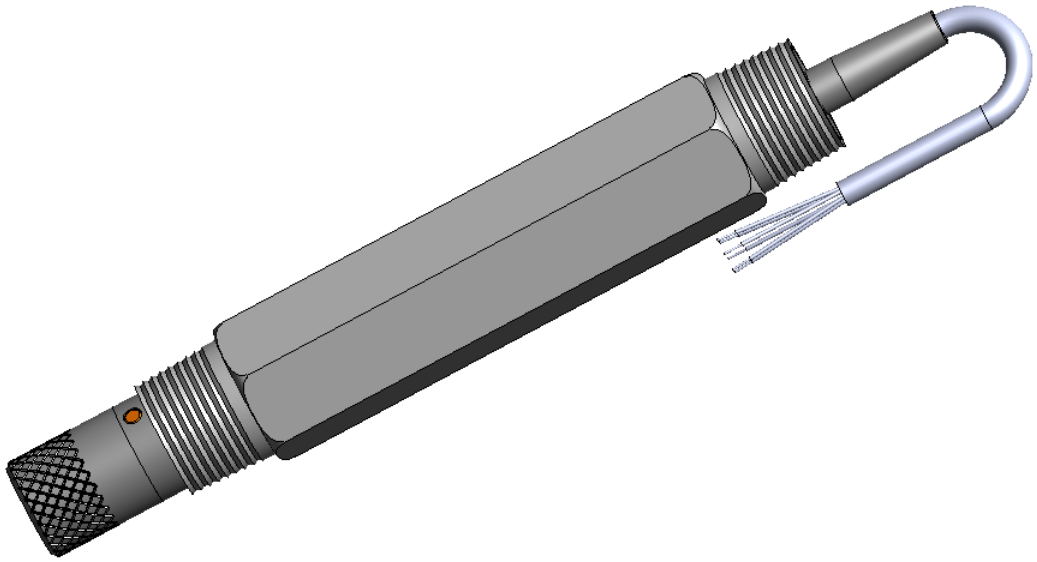
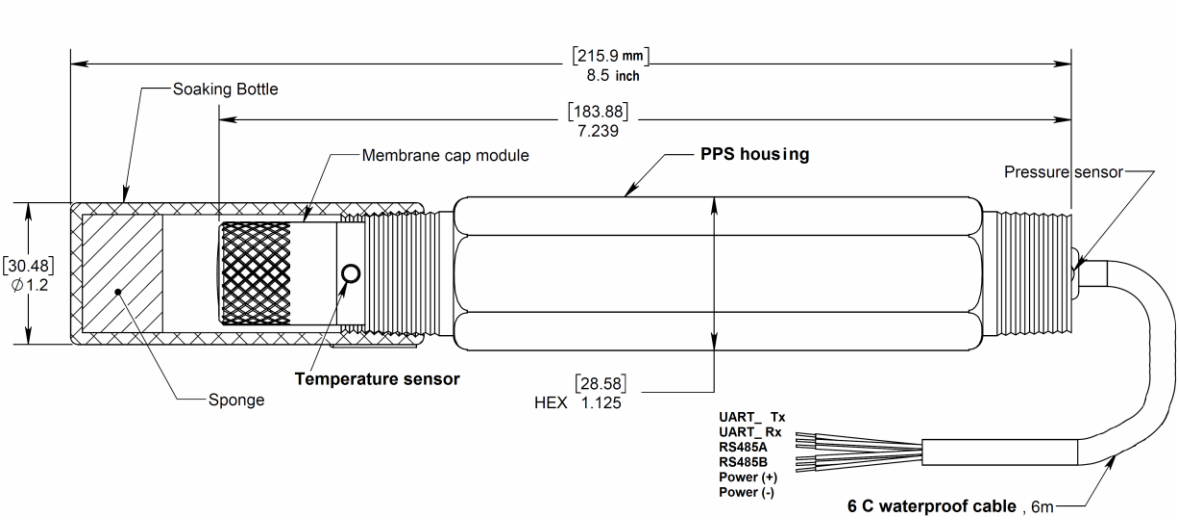
DOGB-0001 and 0002 Series Process Optical Dissolved Oxygen Probe

- Accurate and low maintenance optical dissolved oxygen technology (luminescent quenching).
- RS485/Modbus signal output.
- Industry standard, robust body housing with ¾" NPT on front and back.
- Flexible cable outlet: fixed cable (0001) and detachable cable (0002).
- Integrated (probe-mounted) waterproof pressure sensor.
- Automatic temperature and pressure compensation.
- Automatic salinity compensation with user-input conductivity/salinity concentration value.
- Convenient sensor cap replacement with integrated calibration.



Probe General Dimensions and Overview



Wiring information

Wire color	Description
Red	Power (4.5 ~ 32 V DC)
Black	GND
Green	UART_RX (for upgrading or PC connection)
White	UART_TX (for upgrading or PC connection)
Yellow	RS485A
Blue	RS485B

*Note: 1) Please check the wiring carefully before power on. **Wrong wiring** especially for **red** and **black** wires will result in **PCB burn out**.*

2) The two UART wires can be cut if users do not need firmware updates.

*3) Please **do not cut the cable**, since the drain wire of the cable was soldered onto the both end of the black wire. Please contact the Vendor if the user really needs to do so, otherwise no warranty.*

Cable outlet

DOGB-0001, fixed cable with IP68 rating.

DOGB-0002, detachable cable- with IP67 rating

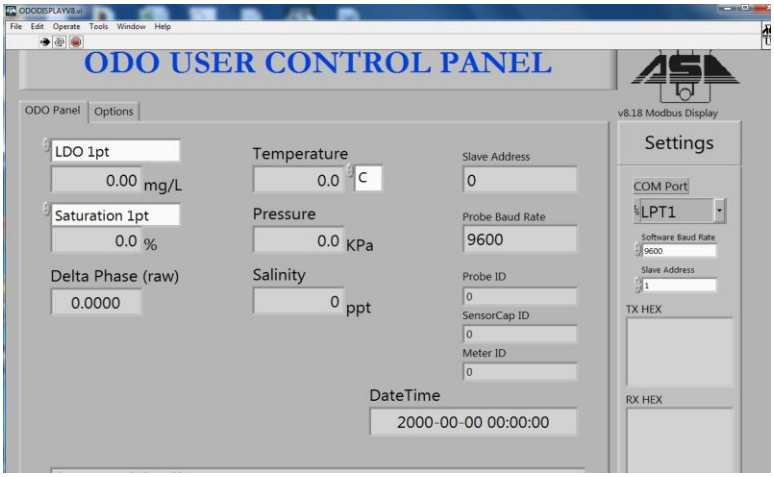
Preliminary Specifications:

<table>
<tr>
<td>Range:
DO Saturation %: 0 to 500%.
DO Concentration : 0 to 50 mg/L (ppm).
Operating Temperature: 0 to 50°C.
Storage Temperature: -20 to 70°C.
Operating Atmospheric Pressure: 40 to 115 kPa.
Maximum Bearing Pressure: 700 kPa.</td>
<td rowspan="2">DO Compensation Factors:
Temperature: automatic, full range.
Salinity: automatic with user-input (0 to 55 ppt).
Pressure: 1) compensation by instantaneous pressure value if pressure sensor is above water or less than 20cm of water.
2) Compensation by default pressure value if the pressure sensor is more than 20cm of water. The default is obtained by the pressure sensor in the last 1-point calibration and recorded in probe memory.</td>
</tr>
<tr>
<td>Response Time:
DO: T_{90} ~ 40s for 100 to 10%.
Temperature: T_{90} ~ 45s for 5 - 45°C (w/ stirring).</td>
</tr>
<tr>
<td>Accuracy
DO: 0-100% < ± 1 %.
100-200% < ± 2 %.
> 200% (20 -50 ppm) : 2 ~ 15 %
Temperature: ± 0.2 °C.
Pressure: ± 0.2 kPa.</td>
<td>Resolution:
Low range (<1 mg/L): ~ 1 ppb (0.001 mg/L).
Mid range (<10 mg/L): ~ 4-8 ppb (0.004-0.008 mg/L).
High range (>10 mg/L): ~10 ppb (0.01 mg/L).*
*The higher range, the lower resolution.</td>
</tr>
<tr>
<td>Input /output/protocol:
Input: 4.5 - 32 V DC.
Consumption: average 60 mA at 5V.
Output: RS485/Modbus or UART.</td>
<td>Expected Sensor Cap Life:
A useful life of up to 2 years is feasible in optimum situations.
Certifications: RoHs, CE, C-Tick.</td>
</tr>
<tr>
<td>Calibration:
1-point (100% cal point) in air-saturated water or water-saturated air (calibration bottle).
2-point: (Zero and 100% cal points).</td>
<td>Waterproof: IP68, 50M deep or continuously soaked for a week in the water of depth less than 50M.
Materials: Ryton (PPS) body.
Cable length: 6 m (options exist).</td>
</tr>
</table>

It is recommended to test probe by a computer and given software for ensuring function and performance. Then, connect the probe to the meter/controller for further handshake setup. The communication protocol is attached at the end of this instruction. If the meter/controller contains special or custom RS485/Modbus commands, please let us know and we can provide a revised protocol to match the customization.

Process to Install Software

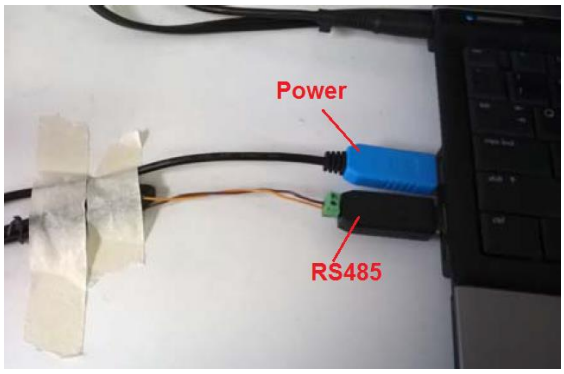
1) The test software “ODO for RS485.exe” is in the included Micro SD card. Copy them to your computer (Windows 7 or higher).
2) LabVIEW engine support is required. These supporting programs are also included in the SD card. Run and install “LVRTE90std.exe” first and then check to see if “ODO for RS485.exe” can be opened. If not, “Setup” and “LVRTE2013std” respectively, to make sure all the supporting programs are operable.



3) Once the supporting programs are functioning, double-click “ODO for RS485.exe” to open the following window. If problems persist, please contact us.

Connecting the Probe to the Computer

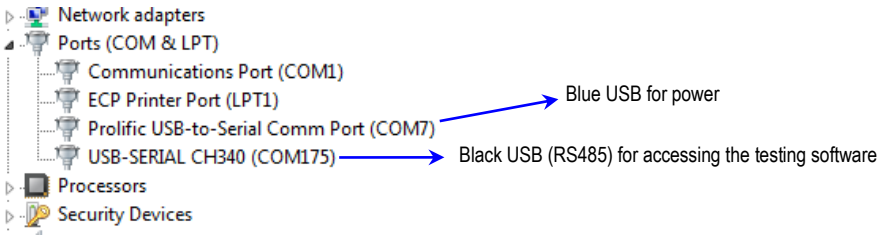
1) Connect the probe to the PC, for example of two USB connectors, one for power and the other for RS485 connection as shown below.



i) Plug the 2 USB connectors to the PC

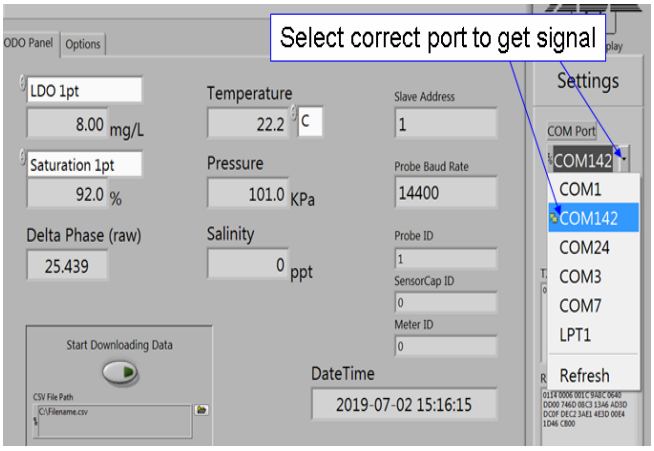
ii) The communication can be sensitive to the USB connection – use tape or otherwise secure the connection. Bad connection could lead to signal locking or inaccuracy.

Note: These 2 USB should be able to be automatically recognized by Windows 7 or higher OS . However for Windows XP, the device drivers need to be installed by users manually.

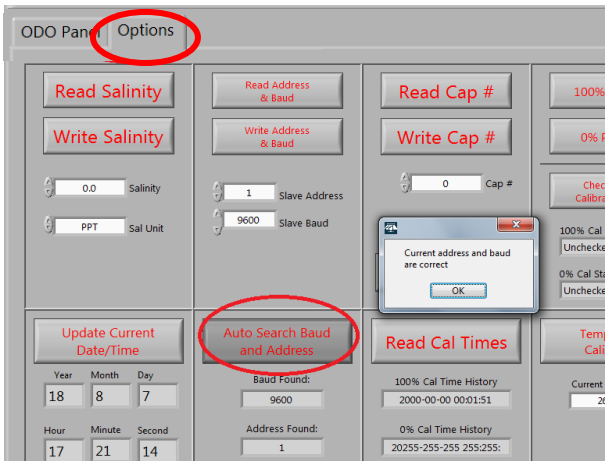


iii) After installing the corresponding drivers, the device manager should show the related Com Port. *(Check using Computer->Properties-> Device Manager, as shown in the above figure.)*

2a) Find the correct com port to get signals in "ODO for RS485". The readings should be displayed within a few seconds if the connection is ok. Please see Step 2b, if the PC has no connection with the probe. The test software has two tags, *ODO User Control Panel* and *Options*. The ODO User Control Panel displays the concentration and saturation of DO compensated for temperature, pressure and salinity as well as the slave address and baud rate. The raw signal related to DO saturation/concentration at the given temperature and pressure is also presented in "Delta Phase (raw)".



2b) If the readings are not shown up, please check the physical connection. Users could unplug/plug the two USB again to refresh the connection. For the first use, you may need to do the "Auto Search Baud and Address" in the *Options* tab. If there is a connection, the control panel will show the corresponding message as shown in the picture.



Calibration and Measurement

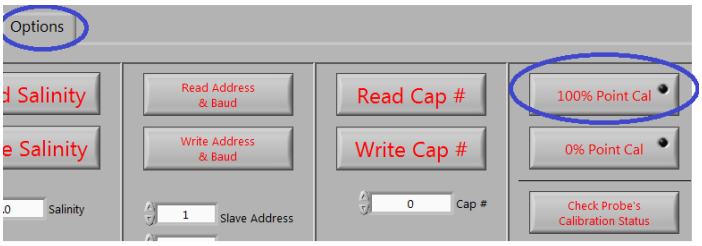
DO Calibration in Options

(1) 1-point calibration

1-point calibration means calibrating the probe in the point of100 % saturation, which can be obtained by one of the following means:

a) In air-saturated water (standard method).

The air-saturated water (for example of 500 mL) can be obtained by continuously (1) purging water with air using an air bubbler or some type of aeration about 3 ~ 5 minutes, or (2) stirring water by magnetic stirrer under 800 rpm for 1 hour.



After air-saturated water is ready, immerse the sensor cap and temperature sensor of the probe in the air-saturated water, and calibrate probe after the reading becomes stable (usually 1 ~ 3 minutes).

In testing software, the command of 1-point calibration can be seen in *Options →100% Point Cal*, as shown in the left Figure, click "*100% Point Cal*" and then the calibration can be completed successfully when the button returns to active (from gray). If the final reading is not in 100 ± 0.5%, please check if the stability of current testing environment or try again.

b) In water-saturated air (convenient method).

Alternatively, the 1-pt calibration can be easily done using water-saturated air, but 0 ~ 2% error might be caused depending on different operations. The recommended procedures are given as below:

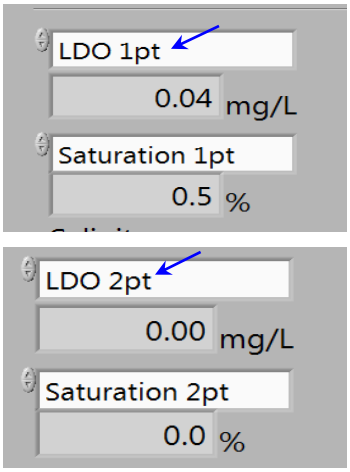
i) immerse the sensor cap and temperature sensor of the probe in fresh/tap water 1~2 minutes.

ii) get out the probe and quickly dip dry the water on the surface of sensor cap by tissue.

iii) install the sensor end in the calibration/storage bottle with a wet sponge inside. Avoid direct contact of the sensor cap with any water in the calibration/storage bottle during this calibration step. Keep the distance between the sensor cap and the wet sponge being ~ 2 cm.

v) wait for the readings to stabilize (2 ~ 4 minutes) and then trigger the 1-pt calibration command.

(2) 2-point calibration (100% and 0% saturation points)



(i) Put the probe in air-saturated water, click "100% Point Cal" after the DO reading stabilizes.

(ii) After DO reading becomes 100%, move the probe to zero oxygen water (use sodium sulfide added in excess to a water sample)

(iii) Click "0% Point Cal", after the DO reading stabilizes (~at least 2 mins).

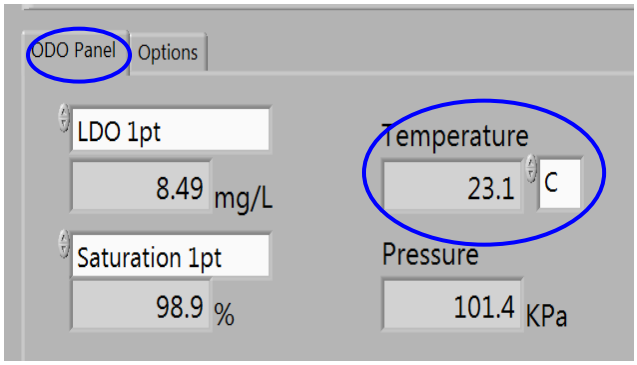
(iv) The ODO Control Panel can display the results of the 1- or 2 – point calibration.

Note: 1) 2-point cal is not necessary for most applications, unless users need a very accurate measurement in low DO concentration (<0.5 ppm).

2) Enforcement of "0% Point Cal" without "100% Point Cal" is not allowed.

(3) 1- point calibration for temperature

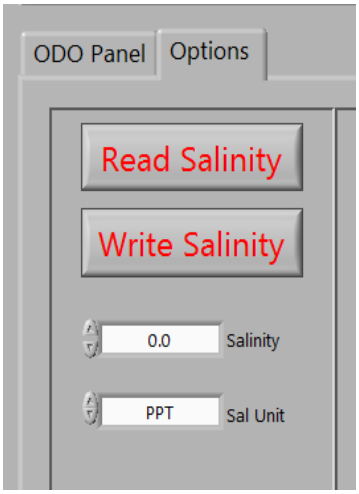
i) In the *Options* tab, input the ambient temperature of the probe in the "Current Temperature" field.



ii) Click the “Temperature Calibration” button.

iii) Check the Temperature reading in the ODO Control Panel. If it is equal to what you inputted, the calibration is done. If not, please try Step 2 again.

Salinity compensation



(i) In *Options*, click “Read Salinity” to show the current salinity value in “Salinity” or to input a new salinity value, then click “Write Salinity” to save the new settings.

(ii) The salinity compensation applies when the "Salinity” value is not zero and “Sal Unit” is not off.

(iii) The salinity value will not affect the DO reading until you click “Write Salinity”.

(iv) NOTE: The salinity compensation will continue until the user turns this compensation factor off, or inputting a zero salinity value.

Coefficient change after sensor cap replacement

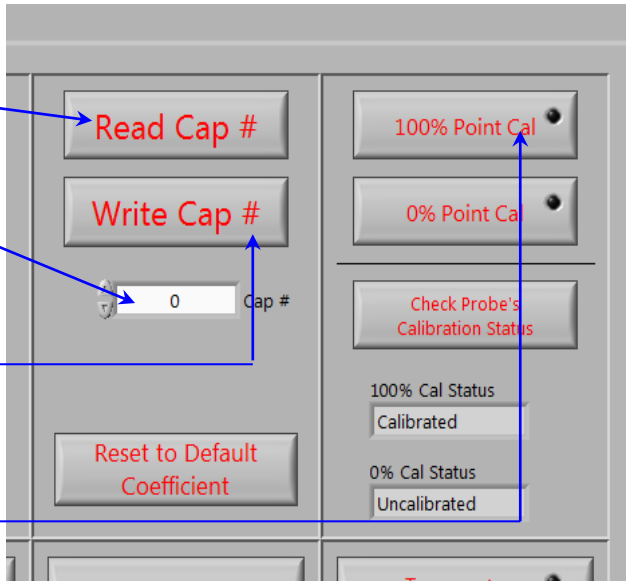
Each sensor cap has a 4-digit SN on the side and the last digit is the coefficient number. If the new sensor cap has a different last digit than the previously installed sensor cap, then the new coefficients needs to be installed. This operation is easily completed in the *Options* tab of the test software, as shown below.

i) Click “Read Cap” to show the number of current coefficients in the area of “cap #”

ii) Input the new coefficient # (the last digit of cap SN) in the area of “cap #”

iii) Click “Write Cap” to save the change.

iv) Perform a 1-point calibration to activate the new coefficients.



Maintenance and Precautions

Optical DO is pretty easy to maintain without complex operations, and most precautions are common sense for protecting an electronic product, such as avoiding wrong wiring; safekeeping the calibration/storage bottle; protecting, cleaning and replacing membrane cap; avoiding the operation to hurt the appearance of the probe; protecting the cable and barcode, the details as below.

1) When the probe is not in use, it is highly recommended to store the probe with its sensor cap installed and the calibration/storage bottle which was included in the original packaging, threaded onto the probe. A beaker of clean water or a moist/humid capping mechanism can also suffice if the calibration/storage bottle is not available. The sponge inside the calibration/storage bottle should be kept moist for best results.

2) Avoid sensor cap touching organic solvent, scratching, and abusive collisions to strengthen and lengthen the working life of the sensor cap. Special care should be taken to clean the coating of cap, to dip probe and cap in fresh water, and then to tap dry the surface with a tissue. Do not wipe the coating surface.

3) Replace the sensor cap, if the cap coating is faded or stripped away. **DO NOT touch the clear window on the probe tip after unscrewing the old cap.** If any contaminants or residue are present on the window or inside the cap, carefully remove them with a powder free wipe. Then re-screw the new sensor cap onto the probe.

4) The probe damages caused by human error should be avoided, since the warranty would not cover that.

5) Cutting or changing the cable is not allowed, unless it is approved by manufacturer, otherwise, no warranty.

6) Please do not cut the barcode tag bonded on the cable. If the user has to remove it, please take a picture for recording the barcode information for warranty. The customerized tag/barcode is also available; please discuses with the manufacturer for details.

7） The water proof rank of this probe is IP68. The detail is that the whole probe can be continuously soaked in water which is not more than 50 m depth for one week. Therefore, the user should take the probe out from water every week, clean the probe, screw on the calibration bottle, put in a dry place under room temperature for 3 ~ 4 hours, and then start the next continuously testing (soaking). This maintenance is very important for monitoring highly corrosive water like industrial waste. **Soaking the probe in water more than one week** is a kind of customer abuse and the resulting leakage would not be covered by warranty.

Appendix 1: Communication Interface

Command structure:

- Commands should not be sent sooner than 50mS from the completion of the last response.
- If the expected response from the slave is not seen for > 25mS, throw a communication error.
- Probe follows Modbus standard for functions:
    - 0x03 - Read Holding Registers
    - 0x06 - Write Single Register
    - 0x10 - Write Multiple Registers
    - 0x17 - Read/Write Multiple Registers

Serial Transmission structure:

- Data types are big endian, unless otherwise noted.
- Each RS485 transmission will have: one start bits, 8 data bits, no parity bit, and two stop bit.
- Default Baud rate: 9600 (some of probes may have Baud rate of 19200).
- The 8 data bits transmitted after the start bit are most significant bit first.
- Bit sequence:

Start bit	1	2	3	4	5	6	7	8	Stop bit

Timing:

- Firmware updates must be run within 5 seconds of power on or soft reset
    - Probe tip LED will be solid blue during this time
- First command cannot be run earlier than 5 seconds from power on or soft reset
- If there is no expected response from an issued command timeout occurs after 200ms

Appendix 2 : Address List

Register #	R/W	Details	Type	Notes
0x0000	R	Automatic Identification	Uint16	Note 9
0x0003	R	Concentration (mg/L) x100	Uint16	
0x0006	R	Saturation % x100	Uint16	
0x0008	R/W	Salinity (ppt) x100	Uint16	
0x0009	R/W	Pressure (kPa) x100	Uint16	Note 7
0x000A	R/W	Temperature (°C) x100	Uint16	
0x000F	R	Baud Rate	Uint16	Note 1
0x0010	R	Slave Address	Uint16	
0x0011	R	Probe ID	Uint32	
0x0013	R	Sensor Cap ID	Uint32	
0x0015	R	Probe Firmware Version x100	Uint16	Note 2
0x0016	R	Probe Firmware Minor Revision	Uint16	Note 2
0x0018	R	Concentration 2pt (mg/L) x100	Uint16	Note 8
0x0019	R	Saturation % 2pt x100	Uint16	Note 8
0x0063	W	Baud Rate	Uint16	Note 1
0x0064	W	Slave Address	Uint16	
0x0100	R	Concentration (mg/L)	Float	
0x0102	R	Saturation %	Float	
0x0104	R	Concentration 2pt (mg/L)	Float	Note 8
0x0106	R	Saturation % 2pt	Float	Note 8
0x0108	R	Pressure (kPa)	Float	
0x010A	R	Temperature (°C)	Float	
0x010C	R/W	Current Probe Datetime	6 bytes	Note 3
0x010F	R	Error bits	Uint16	Note 4
0x0117	R	Salinity (ppt)	Float	
0x0220	R/W	Calibration Bits	Uint16	Note 5
0x02CF	R/W	Membrane Cap Serial Number	Uint16	
0x0300	W	Soft restart	Uint16	Note 6

Note:

- Note 1: Baud rate values: 0=300, 1=2400, 2=2400, 3=4800, 4=9600, 5=19200, 6=38400, 7=115200.

- Note 2: Firmware version is address 0x0015 divided by 100, then a decimal then address 0x0016.
    - Example: if 0x0015 = 908 and 0x0016 = 29, then the firmware version is v9.08.29.

- Note 3: Probe has no RTC, if probe is not supplied continuous power or is reset all values will reset to 0.

- Datetime bytes are year, month, day, day, hour, minute, second. Most significant to least.
- Example: if the user writes 0x010C = 0x0102 0304 0506, then the Datetime will be set to February 3rd, 2001 4:05:06 am.

- Note 4: Bits are counted least significant to most, starting at 1:
  - Bit 1 = Measurement Calibration Error.
  - Bit 3 = Probe Temperature out of range, maximum 120 °C.
  - Bit 4 = Concentration out of range: minimum 0 mg/L, maximum 50 mg/L.
  - Bit 5 = Probe Pressure Sensor Error.
  - Bit 6 = Pressure Sensor out of range: minimum 10 kPa, maximum 500 kPa. Probe will use default pressure = 101.3 kPa.
  - Bit 7 = Pressure Sensor Communication error, Probe will use default pressure = 101.3 kPa.

- Note 5: Bits are counted least significant to most, starting at 0, only the least significant bit will be used:
  - Bit 0:
    - If read: 1 = 100% calibration is running.
    - If written: 1 = run 100% calibration.
  - Bit 1:
    - If read: 1 = 0% calibration is running.
    - If written: 1 = run 0% calibration.
  - Bit 3:
    - If read: 1 = 100% calibration has run, 0 = 100% calibration has not run.
    - If written: 1 = reset 100% calibration, all else ignored.
  - Bit 4:
    - If read: 1 = 0% calibration has run, 0 = 0% calibration has not run.
    - If written: 1 = reset 0% calibration, all else ignored.
  - Bit 5:
    - If read: 1 = temperature calibration has run, 0 = temperature calibration has not run.
    - If written: 1 = reset temperature calibration, all else ignored.

- Note 6: If 1 is written to this address a soft restart is performed, all other read/writes are ignored.

- Note 7: if the probe has a built in pressure sensor this is a read only address.

- Note 8: These Values are results of 2 point calibration, while the address of 0x0003 and 0x0006 present the results of 1 point calibration.

- Note 9: It is user for automatic identification. The value in address of 0x0000 is 15 (or 000F in hexadecimal format), indicating that it is an ODO probe.

Appendix 3: Example Transmissions

CMD: Automatic Identification

Raw Hex: 01 03 0000 0001 840A

Address	Command	Start Address	# of Registers	CRC
0x01	0x03	0x0000	0x0001	0x840A
1	Read	0	0x01	

Example 1 response from probe:

Raw Hex: 01 03 02 000F F840

"000F" indicates that a ODO is connected.

CMD: Read Probe Data

Raw Hex: 01 03 0003 0018 B5C0

Address	Command	Start Address	# of Registers	CRC
0x01	0x03	0x0003	0x0018	0xB5C0
1	Read	3	0x18	

Example 1 response from probe:

Raw Hex: 01 03 30 031B 0206 0000 2726 0208 0BB8 27AA 0AAA 0000 0000 0000 0BB8 0005 0001 0001 0410 0457 0000 038C 0052 0001 031D 2741 0000 FAD4

Concentration (mg/L)	Saturation %	Salinity (ppt)	Pressure (kPa)	Temperature (°C)	Concentration 2pt (mg/L)	Saturation % 2pt
0x031B	0x2726	0x0BB8	0x27AA	0x0AAA	0x031D	0x2741
7.95 mg/L	100.22%	30 ppt	101.54 kPa	27.30 °C	7.97 mg/L	100.49%

Example 2 response from probe:

Raw Hex: 01 03 30 0313 0206 0000 26F3 0208 0000 27AC 0AC8 0000 0000 0000 0000 0005 0001 0001 0410 0457 0000 038C 0052 0001 031A 2748 0000 5BC0

Concentration (mg/L)	Saturation %	Salinity (ppt)	Pressure (kPa)	Temperature (°C)	Concentration 2pt (mg/L)	Saturation % 2pt
0x0313	0x26F3	0x0000	0x27AC	0x0AC8	0x031A	0x2748
7.87 mg/L	99.71%	0 ppt	101.56 kPa	27.60 °C	7.94 mg/L	100.56 %

CMD: Run 100 % Calibration

Raw Hex: 01 10 0220 0001 02 0001 4330

Address	Command	Start Address	# of Registers	# of Bytes	Value	CRC
0x01	0x10	0x0220	0x0001	0x02	0x0001	0x4330
1	Write Multi	544	1	2	Run 100% Cal	

Example 1 response from probe:
Raw Hex: 01 10 0220 0001 01BB
Success!

CMD: Run 0 % Calibration

Raw Hex: 01 10 0220 0001 02 0002 0331

Address	Command	Start Address	# of Registers	# of Bytes	Value	CRC
0x01	0x10	0x0220	0x0001	0x02	0x0002	0x0331
1	Write Multi	544	1	2	Run 0% Cal	

Example 1 response from probe:
Raw Hex: 01 10 0220 0001 01BB
Success!

CMD: Update Salinity = 45.00 ppt, Pressure =101.00 kPa, and Temperature = 27.00 °C

Raw Hex: 01 10 0008 0003 06 1194 2774 0A8C 185D

Address	Command	Start Address	# of Registers	# of Bytes	Value	CRC
0x01	0x10	0x0008	0x0003	0x06	0x1194 2774 0A8C	0x185D
1	Write Multi	719	1	2	45, 101, 27	

Example 1 response from probe:
Raw Hex: 01 10 0008 0003 01CA
Success!

CMD: Update Cap Number with 1111

Raw Hex: 01 10 02CF 0001 02 0457 D751

Address	Command	Start Address	# of Registers	# of Bytes	Value	CRC
0x01	0x10	0x02CF	0x0001	0x02	0x0457	0xD751
1	Write Multi	719	1	2	1111	

Example 1 response from probe:
Raw Hex: 01 10 02CF 0001 304E
Success!