Table of Contents

1.0 Introduction ................................................................................................................................................. 4
1.1 System Description ........................................................................................................................................ 4
1.2 Serial Numbers ....................................................................................................................................... 5
1.3 Unpack the Probe ................................................................................................................................... 5
2.0 Calibrate the RDO PRO Probe ................................................................................................................ 6
  2.1 1-point Calibration ................................................................................................................................. 6
    2.1.1 Water-Saturated Air Calibration ........................................................................................................ 6
  2.2 2-point Calibration ................................................................................................................................. 7
    2.2.1 100% Calibration Point ................................................................................................................... 7
    2.2.2 0% Calibration Point ....................................................................................................................... 7
3.0 Sensor Deployment ..................................................................................................................................... 8
4.0 Care and Maintenance .................................................................................................................................. 9
  4.1 Clean the RDO Cap .................................................................................................................................. 9
    4.1.1 Clean the Optical Window ............................................................................................................... 9
  4.2 Clean the Probe ..................................................................................................................................... 9
  4.3 RDO Cap Storage ................................................................................................................................... 9
  4.4 Replace the RDO Cap ............................................................................................................................ 9
  4.5 Maintaining Desiccant .......................................................................................................................... 10
5.0 Controller Requirements and Connections .......................................................................................... 11
  5.1 Wiring Overview .................................................................................................................................... 11
  5.2 Analog (4-20 mA) 3-wire ...................................................................................................................... 12
  5.3 SDI-12 (3 wire) ..................................................................................................................................... 13
  5.4 Modbus Master with Built-in RS485 .................................................................................................... 14
  5.5 Modbus Master with Built-in RS232 (Converter Required) .............................................................. 15
    5.5.1 Converter ....................................................................................................................................... 15
    5.5.2 Power Connections ....................................................................................................................... 16
    5.5.3 Communications .......................................................................................................................... 16
    5.5.4 Additional Information ............................................................................................................... 16
6.0 Modbus Registers ...................................................................................................................................... 16
  6.1 Common Registers ............................................................................................................................... 16
  6.2 Sensor Status Registers ....................................................................................................................... 16
  6.3 Device Specific Measurement Registers ............................................................................................. 16
    6.3.1 Dissolved Oxygen Concentration Equations ............................................................................... 18
    6.3.2 Dissolved Oxygen, % Saturation Equations .............................................................................. 19
  6.4 Calibration Registers ............................................................................................................................ 20
  6.5 Entering Calibration Registers ........................................................................................................... 21
    6.5.1 Calibration Calculations .............................................................................................................. 22
7.0 Specifications ............................................................................................................................................... 23
8.0 Accessories and Replacement Parts ....................................................................................................... 24
9.0 Warranty and Service .............................................................................................................................. 24
  9.1 Warranty Provisions ........................................................................................................................... 24
  9.2 Obtain Repair Service ......................................................................................................................... 24
10.0 Appendix A – Communication Device ............................................................................................... 25
  10.1 Install and Open the Software .......................................................................................................... 25
  10.2 Connect the Probe to the Communication Device ............................................................................ 25
11.0 Declaration of Conformity .................................................................................................................... 26
1.0 Introduction

1.1 System Description

The RDO® Pro Probe is a rugged, reliable instrument designed to deliver accurate dissolved oxygen (DO) data across a wide measurement range and to reduce maintenance costs. The probe features the latest optical technology for DO measurement. The RDO PRO system consists of the following:

- **RuggedCable® System**
  - 10-m standard length with stripped-and-tinned ends
  - Customized lengths with titanium twist-lock connectors
- Black probe body with removable nose cone
- Optical DO sensor cap
- Titanium thermistor

With twist-lock connector and RuggedCable System:
1.2 Serial Numbers
The instrument serial number is engraved on the side of the unit. The cap serial number is programmed on the memory chip inside the cap.

1.3 Unpack the Probe
1. Remove the probe from the box and other packaging materials.
2. Unscrew the nose cone from the probe and remove the red protective dust cap from the sensor. Save the dust cap for later use.
3. Remove the RDO cap from the storage sleeve.
4. Align the arrow on the cap with the index mark on the probe and firmly press the cap onto the probe, without twisting, until it seals over the probe body.

- Do not allow moisture or atmospheric humidity inside the cap. Keep the cap in its sealed package until you are ready to install it. Install promptly. Ensure that the O-ring grooves are dry and the O-ring is not rolled or pinched inside the cap.

- The cap lifetime is one (1) year after the first reading has been taken. Install by the date printed on the package.

5. Reattach the nose cone.
2.0 Calibrate the RDO PRO Probe

Calibrate the probe with the Comm Kit Software and the Communication Device, or calibrate the sensor directly with your controller. See Appendix A – Communication Device.

2.1 1-point Calibration

2.1.1 Water-Saturated Air Calibration

1. Remove the storage cap from the top of the calibration chamber and replace with the vented calibration cap.

2. Place the sponge wafer in the bottom of the calibration chamber and saturate with approximately 10 mL of water.

3. Gently dry the probe and sensing element with a paper towel, ensure that no water or debris is on the probe or sensing element.

4. Place the probe in the calibration chamber so that the sensing element is about 2.5 cm (1 in.) above the water-saturated sponge.

   ☑ Ensure that the sensor surface is dry when you place the probe into the calibration chamber.

5. Wait 5 to 10 minutes for temperature stabilization prior to calibration. Do not leave the probe in the calibration chamber for more than 30 minutes. This can allow condensation to form on the surface of the sensing element, which will produce false low readings after calibration. If condensation does occur, remove the probe. Thoroughly dry the sensing element, the probe, and the thermistor before you perform the calibration procedure.
2.2 2-point Calibration

2.2.1 100% Calibration Point
Perform a water-saturated-air calibration as previously described.

2.2.2 0% Calibration Point
1. Remove the water-saturated sponge from the calibration chamber and fill the chamber to the fill line with approximately 60 mL of fresh sodium sulfite solution.

2. Place the probe into the solution. Leave at least 13 mm (0.5 in.) between the surface of the sensing element and the bottom of the chamber.

3. Ensure that the temperature sensor is completely submerged in the solution.

4. Wait at least 5 minutes for the temperature to stabilize prior to performing the calibration procedure.

5. Once the calibration is complete, remove the probe and thoroughly rinse to remove all of the sodium sulfite.
3.0 Sensor Deployment

The cable end of the RDO PRO Probe is internally threaded (1¼ – 11½ NPT) and can be attached to a male threaded pipe. When deployed, make sure that the nose cone and thermistor are completely submerged.
4.0 Care and Maintenance

4.1 Clean the RDO Cap

1. The cap and nose cone must remain on the probe.
2. Rinse the sensor with clean water from a squirt bottle or spray bottle.
3. Gently wipe with a soft-bristled brush or soft cloth if biofouling is present. Use Alconox® to remove grease.
4. If extensive fouling or mineral build-up is present, soak the cap end in vinegar for 15 minutes, then soak in deionized (DI) water for 15 minutes.
   Do not use organic solvents—they will damage the sensing element. Do not remove the cap from the sensor prior to cleaning.
5. After cleaning, perform a 1- or 2-point user calibration or calibration check.

4.1.1 Clean the Optical Window

Clean the optical window only when you change the cap. See full instructions in the sensor cap replacement kit.
Remove the cap and gently wipe the lens with the supplied lens cloth. Do not wet the lens area with water or any solution.
Use only the supplied lens cloth for cleaning. Do not use any other cloth or material.

4.2 Clean the Probe

With the RDO cap installed on the probe, gently scrub the probe with a soft-bristled brush or nylon dish scrubber. Use Alconox to remove grease or other matter. Soak in vinegar and DI water to remove mineral deposits or extensive fouling as described in step 4, above.

4.3 RDO Cap Storage

Prior to installation: Store in factory supplied container.
Installed: Store in the calibration chamber with the storage cap attached (see section 2.1.1) and a few drops of clean water.

4.4 Replace the RDO Cap

The RDO cap has a 1-year life after the sensor takes its first reading. Replacement caps are available from In-Situ Inc. or your authorized In-Situ distributor.
1. Remove the probe nose cone.
2. Use a lint-free cloth to remove any moisture from the probe.
3. Pull the used RDO cap off of the sensor, without twisting.
4. Remove the existing O-rings from the sensor.
   Ensure that there is no moisture in the O-ring grooves.
   Do not touch or clean the lens with anything other than the supplied lens wipe.
5. Use your finger to apply a very thin layer of lubricant around the O-ring grooves.
6. Place the O-rings on the sensor. Apply another thin layer of lubricant to the O-rings and grooves.
   Do not transfer grease to the lens or sensor pins.
7. Clean the sensor lens with the wipe provided in the kit and allow it to thoroughly dry. Inspect for scratches or dirt.

8. Remove the new cap from its sealed packaging and attach it to the sensor, being careful to press firmly, without twisting, until it seals over the lens. Make sure that the O-rings are not pinched or rolled between the cap and sensor. Replace the nose cone.

9. Perform a 1- or 2-point calibration.

4.5 Maintaining Desiccant

Desiccant installed in a controller or transceiver protects probe electronics from condensation. A desiccant pack changes color from blue to pink as it becomes saturated with moisture.

It is extremely important to use the proper size desiccant for your deployment and to change desiccant often. Desiccant should be changed before the entire pack has turned pink, and you should use enough to effectively keep cables and instruments dry until your next scheduled maintenance. Desiccant lifespan is dependent on site conditions.
5.0 Controller Requirements and Connections

The RDO PRO Probe may be connected to a controller or logger for communication via:

- Analog (4-20 mA) provides a configurable 4-20 mA current loop output
- SDI-12
- RS485 Modbus
- RS232 Modbus

5.1 Wiring Overview

Refer to diagrams on the following pages. Trim and insulate unused wires. The shielded wire should be wired to a chassis ground or earth ground.

<table>
<thead>
<tr>
<th>Signal</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground/Return</td>
<td>Black</td>
</tr>
<tr>
<td>External Power</td>
<td>Red</td>
</tr>
<tr>
<td>4-20 mA</td>
<td>Brown</td>
</tr>
<tr>
<td>RS485 (-)</td>
<td>Green</td>
</tr>
<tr>
<td>RS485 (+)</td>
<td>Blue</td>
</tr>
<tr>
<td>SDI-12</td>
<td>White</td>
</tr>
</tbody>
</table>

The inside of the controller must be kept free of moisture and humidity. Condensed moisture can migrate through the wiring and cause the probe to fail. Therefore, desiccant should be installed in the controller and be replaced on a regular basis.
5.2 Analog (4-20 mA) 3-wire

<table>
<thead>
<tr>
<th>Signal</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground/Return</td>
<td>Black</td>
</tr>
<tr>
<td>External Power (12-36 VDC)</td>
<td>Red</td>
</tr>
<tr>
<td>4-20 mA</td>
<td>Brown</td>
</tr>
</tbody>
</table>

- Cable length must not exceed 1219 m (4000 ft.)
- Analog signal must be enabled in Win-Situ® 5 Software or the Comm Kit Software prior to use.
### 5.3 SDI-12 (3 wire)

<table>
<thead>
<tr>
<th>Signal</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground/Return</td>
<td>Black</td>
</tr>
<tr>
<td>External Power (9.6-16 VDC)</td>
<td>Red</td>
</tr>
<tr>
<td>RS485 (-)</td>
<td>Green</td>
</tr>
<tr>
<td>RS485 (+)</td>
<td>Blue</td>
</tr>
<tr>
<td>SDI-12</td>
<td>White</td>
</tr>
</tbody>
</table>

- **Cable length must not exceed 60.96 m (200 ft.)**

![Diagram showing SDI-12 connections](image-url)
5.4 Modbus Master with Built-in RS485

<table>
<thead>
<tr>
<th>Signal</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground/Return</td>
<td>Black</td>
</tr>
<tr>
<td>External Power (12-36 VDC)</td>
<td>Red</td>
</tr>
<tr>
<td>RS485 (-)</td>
<td>Green</td>
</tr>
<tr>
<td>RS485 (+)</td>
<td>Blue</td>
</tr>
</tbody>
</table>

- Cable length must not exceed 1219 m (4000 ft.)
5.5 Modbus Master with Built-in RS232 (Converter Required)

<table>
<thead>
<tr>
<th>Signal</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground/Return</td>
<td>Black</td>
</tr>
<tr>
<td>External Power (12 VDC, voltage limited by converter)</td>
<td>Red</td>
</tr>
<tr>
<td>RS485 (-)</td>
<td>Green</td>
</tr>
<tr>
<td>RS485 (+)</td>
<td>Blue</td>
</tr>
</tbody>
</table>

- Cable between converter and master must not exceed 60.96 m (20 ft.)
- Cable between master and slave must not exceed 1219 m (4000 ft.)

5.5.1 Converter

Port-powered RS485 converter, such as B&B Electronics Model 485SD9TB

*** Required if port power is not available
5.5.2  **Power Connections**

The red wire provides power for all system modes. Analog output is disabled by default. However, the 4-20 mA current loop output can be continuous in Modbus or SDI-12 mode as long as Modbus device register 9507 is set to 1.

5.5.3  **Communications**

The device automatically switches between Modbus and SDI-12 modes depending on which of the two interfaces has activity. Modbus and SDI-12 cannot be used at the same time—whichever one is currently in use will block communication on the other.

5.5.4  **Additional Information**

For additional information on Modbus and SDI-12 communications, including the SDI-12 commands and Modbus registers, see the In-Situ Modbus Communication Protocol technical note, available at [www.in-situ.com](http://www.in-situ.com).

6.0  **Modbus Registers**

6.1  **Common Registers**

<table>
<thead>
<tr>
<th>Register</th>
<th>Size (registers)</th>
<th>Mode &amp; Access Level (R/W)</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>9001</td>
<td>1</td>
<td>R/W</td>
<td>ushort</td>
<td>Device Id (Device Id = 12 for RDO PRO)</td>
</tr>
<tr>
<td>9002</td>
<td>2</td>
<td>R/W</td>
<td>ulong</td>
<td>Device Serial Number</td>
</tr>
<tr>
<td>9004</td>
<td>3</td>
<td>R/W</td>
<td>time</td>
<td>Manufacture Date</td>
</tr>
</tbody>
</table>

6.2  **Sensor Status Registers**

<table>
<thead>
<tr>
<th>Register</th>
<th>Size (registers)</th>
<th>Mode &amp; Access Level (R/W)</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0005</td>
<td>3</td>
<td>R1</td>
<td>time</td>
<td>RDO cap start time, 0 = no cap</td>
</tr>
<tr>
<td>0008</td>
<td>3</td>
<td>R1</td>
<td>time</td>
<td>RDO cap exp. time, 0 = no cap</td>
</tr>
</tbody>
</table>

6.3  **Device Specific Measurement Registers**

<table>
<thead>
<tr>
<th>Register</th>
<th>Size (registers)</th>
<th>Mode &amp; Access Level (R/W)</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dissolved Oxygen Concentration</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0038</td>
<td>2</td>
<td>R1</td>
<td>float</td>
<td>Measured value, C₀</td>
</tr>
<tr>
<td>0040</td>
<td>1</td>
<td>R1</td>
<td>ushort</td>
<td>Parameter Id = 20</td>
</tr>
<tr>
<td>0041</td>
<td>1</td>
<td>R1/W2</td>
<td>ushort</td>
<td>Units Id 117 = mg/L (default) 118 = µg/L</td>
</tr>
<tr>
<td>0042</td>
<td>1</td>
<td>R1</td>
<td>ushort</td>
<td>Data Quality Id</td>
</tr>
<tr>
<td>0043</td>
<td>2</td>
<td>R1/W3</td>
<td>float</td>
<td>Off line sentinel value (default = 0.0)</td>
</tr>
<tr>
<td>0045</td>
<td>1</td>
<td>R1</td>
<td>16 bits</td>
<td>Available Units = 0x0030 (48)</td>
</tr>
</tbody>
</table>

<p>| Temperature |
| 0046     | 2                | R1                        | float     | Measured value |
| 0048     | 1                | R1                        | ushort    | Parameter Id = 1 |</p>
<table>
<thead>
<tr>
<th>Address</th>
<th>Count</th>
<th>Type</th>
<th>Description</th>
<th>Data Type</th>
<th>Format</th>
<th>Units Id</th>
<th>Default</th>
</tr>
</thead>
</table>
| 0049    | 1     | R1/W2  | *Units Id*                               | ushort    |        | 1 = °C (default)  
2 = °F  |
| 0050    | 1     | R1     | *Data Quality Id*                        | ushort    |        |           |           |
| 0051    | 2     | R1/W3  | *Off line sentinel value (default = 0.0)* | float     |        |           |           |
| 0053    | 1     | R1     | *Available Units = 0x0003 (3)*           | 16 bits   |        |           |           |

**Dissolved Oxygen %Saturation**

<table>
<thead>
<tr>
<th>Address</th>
<th>Count</th>
<th>Type</th>
<th>Description</th>
<th>Data Type</th>
<th>Format</th>
<th>Units Id</th>
<th>Default</th>
</tr>
</thead>
<tbody>
<tr>
<td>0054</td>
<td>2</td>
<td>R1</td>
<td><em>Measured value</em></td>
<td>float</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0056</td>
<td>1</td>
<td>R1/W2</td>
<td><em>Parameter Id = 21</em></td>
<td>ushort</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0057</td>
<td>1</td>
<td>R1/W2</td>
<td><em>Units Id</em></td>
<td>ushort</td>
<td></td>
<td>177 = percent saturation (default)</td>
<td></td>
</tr>
<tr>
<td>0058</td>
<td>1</td>
<td>R1</td>
<td><em>Data Quality Id</em></td>
<td>ushort</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0059</td>
<td>2</td>
<td>R1/W3</td>
<td><em>Off line sentinel value (default = 0.0)</em></td>
<td>float</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0061</td>
<td>1</td>
<td>R1</td>
<td><em>Available Units = 0x0001 (1)</em></td>
<td>16 bits</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Oxygen Partial Pressure**

<table>
<thead>
<tr>
<th>Address</th>
<th>Count</th>
<th>Type</th>
<th>Description</th>
<th>Data Type</th>
<th>Format</th>
<th>Units Id</th>
<th>Default</th>
</tr>
</thead>
<tbody>
<tr>
<td>0062</td>
<td>2</td>
<td>R1</td>
<td><em>Measured value</em></td>
<td>float</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0064</td>
<td>1</td>
<td>R1</td>
<td><em>Parameter Id = 2 (pressure)</em></td>
<td>ushort</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0065</td>
<td>1</td>
<td>R1/W2</td>
<td><em>Units Id</em></td>
<td>ushort</td>
<td></td>
<td>26 = torr (default)</td>
<td></td>
</tr>
<tr>
<td>0066</td>
<td>1</td>
<td>R1</td>
<td><em>Data Quality Id</em></td>
<td>ushort</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0067</td>
<td>2</td>
<td>R1/W3</td>
<td><em>Off line sentinel value (default = 0.0)</em></td>
<td>float</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0069</td>
<td>1</td>
<td>R1</td>
<td><em>Available Units = 0x0200 (512)</em></td>
<td>16 bits</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
6.3.1 Dissolved Oxygen Concentration Equations

DO concentration is internally calculated in mg/L. Conversion to other units is as follows:

\[ \mu g/L = 1000 \times mg/L \]

Oxygen concentration \( C_o \) (mg/L) is calculated as:

\[
C_o = 31.9988 \times 1E6 \times (\rho P_o/k_o M) \left(1 - \Theta_o\right) \times S_c
\]

Where:

\( P_o \) is the partial pressure of \( O_2 \) in atmospheres.

\( P_{torr} = 759.999876 \times P_{atm} \)

\( S_c \) is the salinity correction:

\[
\ln S_c = S(B_0 + B_1 T_s + B_2 T_s^2 + B_3 T_s^3) + C_0 S^2
\]

\[
B_0 = -6.246090 \times 10^{-3}
\]

\[
B_1 = -7.423444 \times 10^{-3}
\]

\[
B_2 = -1.048635 \times 10^{-2}
\]

\[
B_3 = -7.987907 \times 10^{-3}
\]

\[
C_0 = -4.679983 \times 10^{-7}
\]

\( T_s \) is the scaled temperature:

\[
T_s = \ln \left((298.15 - t) / (273.15 + t)\right)
\]

\( t \) is temperature in degrees C.

\( S \) is the salinity in PSU.

\( k_o \) is Henry’s constant:

\[
\ln k_o = 3.71814 + (5596.17/T) - (1,049,668/T^2)
\]

\( T \) is temperature in Kelvin.

\( \Theta_o \) is the negative of the second pressure coefficient:

\[
\Theta_o = 0.000975 - (1.426 \times 10^{-5} t) + (6.436 \times 10^{-8} t^2)
\]

\( t \) is temperature in degrees C.

\( \rho \) is the density of water in g/cm³:

\[
\ln \rho = -0.589581 + (326.785/T) - (45,284.1/T^2)
\]

\( T \) is the temperature in Kelvin.

Molar mass of water: \( M = 18.0152 \) g/mole

References:


6.3.2 Dissolved Oxygen, % Saturation Equations

\[ O_2\%Sat = \frac{O_2\text{Reading}}{O_2\text{100}\%\text{Sat}} \]

Where:

- \( O_2 \) reading is the mg/L reading from the RDO Sensor.
- \( O_2 \) 100% Sat is the theoretical saturation value in mg/L and is derived as:

\[
O_2\text{100}\%\text{Sat} = 31.9988 \times 10^6 \times \rho \left[ 0.20946 \times \left( P - P_{\text{wv}} \right) \times \left( 1 - \Theta_0 T \right) \times S_c \right] \\
\]

Where:

- \( \rho \) is the density of water in g/cm³:
  \[ \ln \rho = -0.589581 + \left( \frac{326.785}{T} \right) - \left( \frac{45,284.1}{T^2} \right) \]
- \( T \) is the temperature in Kelvin.
- \( P \) is the atmospheric pressure in atm.
- \( P_{\text{wv}} \) is the partial pressure of water vapor at saturation in atm:
  \[ \ln P_{\text{wv}} = 11.8571 - \left( \frac{3,840.70}{T} \right) - \left( \frac{216,961}{T^2} \right) \]
- \( k_o \) is Henry’s constant:
  \[ \ln k_o = 3.71814 + \left( \frac{5596.17}{T} \right) - \left( \frac{1,049,668}{T^2} \right) \]
- \( \Theta_0 \) is the negative of the second pressure coefficient:
  \[ \Theta_0 = 0.000975 - \left( 1.426 \times 10^{-5} t \right) + \left( 6.436 \times 10^{-8} t^2 \right) \]
- \( t \) is temperature in degrees C.
- \( S_c \) is the salinity correction:
  \[ \ln S_c = S \left( B_0 + B_1 T_s + B_2 T_s^2 + B_3 T_s^3 \right) + C_0 S^2 \]
  \[ B_0 = -6.246090 \times 10^{-3} \]
  \[ B_1 = -7.423444 \times 10^{-3} \]
  \[ B_2 = -1.048635 \times 10^{-2} \]
  \[ B_3 = -7.987907 \times 10^{-3} \]
  \[ C_0 = -4.679983 \times 10^{-7} \]

- \( T_s \) is the scaled temperature:
  \[ T_s = \ln \left[ \frac{\left( 298.15 - t \right)}{\left( 273.15 + t \right)} \right] \]
  \( t \) is temperature in °C.
- \( S \) is the salinity in PSU

References:

6.4 Calibration Registers

<table>
<thead>
<tr>
<th>Register</th>
<th>Size (registers)</th>
<th>Mode &amp; Access Level (R/W)</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0118</td>
<td>2</td>
<td>R1/W3</td>
<td>float</td>
<td>Live salinity value (PSU)</td>
</tr>
<tr>
<td>0120</td>
<td>2</td>
<td>R1/W3</td>
<td>float</td>
<td>Default salinity value (PSU, default = 0.0)</td>
</tr>
<tr>
<td>0122</td>
<td>2</td>
<td>R1/W3</td>
<td>float</td>
<td>Live barometric pressure (mbar)</td>
</tr>
<tr>
<td>0124</td>
<td>2</td>
<td>R1/W3</td>
<td>float</td>
<td>Default barometric pressure (mbar, default = 1013.25)</td>
</tr>
<tr>
<td>0126</td>
<td>2</td>
<td>R1/W3</td>
<td>float</td>
<td>100% saturation calibration reading (mg/L)</td>
</tr>
<tr>
<td>0128</td>
<td>2</td>
<td>R1/W3</td>
<td>float</td>
<td>100% saturation temperature reading (°C)</td>
</tr>
<tr>
<td>0130</td>
<td>2</td>
<td>R1/W3</td>
<td>float</td>
<td>100% saturation salinity value (PSU)</td>
</tr>
<tr>
<td>0132</td>
<td>2</td>
<td>R1/W3</td>
<td>float</td>
<td>100% saturation barometric pressure (mbar)</td>
</tr>
<tr>
<td>0134</td>
<td>2</td>
<td>R1/W3</td>
<td>float</td>
<td>0% saturation calibration reading (mg/L)</td>
</tr>
<tr>
<td>0136</td>
<td>2</td>
<td>R1/W3</td>
<td>float</td>
<td>0% saturation temperature reading (°C)</td>
</tr>
<tr>
<td>0138</td>
<td>2</td>
<td>R1/W3</td>
<td>float</td>
<td>Calibration slope (default = 1.0)</td>
</tr>
<tr>
<td>0140</td>
<td>2</td>
<td>R1/W3</td>
<td>float</td>
<td>Calibration offset (default = 0.0)</td>
</tr>
</tbody>
</table>

**Live Salinity Value**

The live salinity value is used to correct the oxygen concentration value for salinity. Values must be written in Practical Salinity Units (PSU) in the range 0 to 42 PSU. This is not a measured parameter.

**Default Salinity Value**

The default salinity value is loaded into the live salinity value register when power is first applied to the probe. The default salinity value is used in calculations until a live salinity value is written. This is not a measured parameter.

**Live Barometric Pressure**

The live barometric pressure is used in the calculation of percent saturation and to determine the theoretical saturation point during calibration. Values must be written in millibars in the range 506.625 to 1114.675 mbar. This is not a measured parameter.

**Default Barometric Pressure**

The default barometric pressure is loaded into the live barometric pressure register when power is applied to the probe. The default barometric pressure is used in calculations until a live barometric pressure is written. This is not a measured parameter.

**100% Saturation Calibration Values**

These values represent the sensor conditions while the probe is in a 100% saturation calibration environment. These are not measured values, they are written by the controller during the calibration process.

Writes to these registers are only accepted if the probe is in the calibration mode. The probe will return exception 0x85 (invalid device command sequence) if an attempt is made to write these registers when the calibration mode is off.
0% Saturation Calibration Values
These values represent the sensor conditions while the probe is in a 0% saturation calibration environment. These are not measured values, they are written by the controller during the calibration process.

Writes to these registers are only accepted if the probe is in the calibration mode. The probe will return exception 0x85 (invalid device command sequence) if an attempt is made to write these registers when the calibration mode is off.

Calibration Slope and Offset
These values represent the slope and offset that will be applied to the raw concentration reading from the sensor to generate the final values reported by the sensor parameters. These registers may be written independently of the normal internal calibration procedure.

6.5 Entering Calibration Registers
The sensor is calibrated using the following procedure:

1. **Optional:** Read the Sensor Data Cache Timeout register 9463 and store the value.

2. Write the Sensor Data Cache Timeout register 9463 to a value less than your intended sample rate and greater than 1000 milliseconds. This will ensure that you get new sensor readings during the stabilization process.

3. **Optional:** Read the temperature units register 0049 and saturation units register 0041 and store their values.

4. Write the temperature units register 0049 to its default value (1) and write the saturation units register 0041 to its default value (117).

5. Write the Calibration Mode On command (0xE000) to the sensor command register 9305.

6. Update the live salinity and barometric pressure registers if necessary.

7. Place the probe in a 100% saturation environment.

8. Read the DO concentration and temperature parameters. When these values have reached equilibrium, record them in their respective 100% saturation calibration registers. Write the current live salinity and barometric pressure readings to their respective calibration registers.

9. Prompt the user to place the sensor in a 0% saturation environment. When these registers have reached equilibrium, record them in their respective 0% saturation calibration registers. If a zero calibration is not to be performed, these registers can be set to zero or left at their previous values. **Note:** If you have a version of RDO PRO firmware that is earlier than 1.15, and you are not doing the zero calibration, you must set the 0% calibration registers to zero.

10. Write the Calibration Update command (0xE001) to the sensor command register. The sensor will calculate a new slope and offset, write the current time to the last user calibration time register, and set the next user calibration time register to zero (disabled). If the concentrations at 100% and 0% saturation are equal, the probe will return an exception response with code 0x97 (invalid calibration) and not attempt to compute a new slope and offset due to possible division by zero. If the slope does not calculate between 0.85 and 1.20 inclusive, or if the offset does not calculate between -0.2 and +0.2 inclusive, then the probe will return an exception response with code 0x97 (invalid calibration). The slope and offset will be available for read but will not be committed to flash.

11. **Optional:** Read the last user calibration time register, add the next calibration interval, and write the result to the next user calibration time register.
12. Write the Calibration Mode Off command (0xE002) to the sensor command register to place the sensor in normal operation. If the calibration mode is turned off without a calibration update command, or the calibration command returned an exception, the previous calibration shall be restored.

13. **Optional:** If you saved the temperature and saturation parameter units at the start of the process, write the original values back.

14. **Optional:** If you saved the Sensor Data Cache Timeout register 9463 at the start of the process, write the original value back.

### 6.5.1 Calibration Calculations

Calibrated oxygen reading:

\[
O_{RC} = c_0 + c_1 \times O_{RU}
\]

Where:

\[
c_1 = \frac{O_{2\text{100\%Sat}}}{O_{2\text{RUS}} - O_{2\text{RUZ}}}
\]

\[
c_0 = -c_1 \times O_{2\text{RUZ}}
\]

Where:

- \(O_{2\text{100\%Sat}}\) is the theoretical 100% saturation point
- \(O_{2\text{RUS}}\) is the un-calibrated reading at 100% saturation
- \(O_{2\text{RUZ}}\) is the un-calibrated reading at 0% saturation

### References:

## 7.0 Specifications

<table>
<thead>
<tr>
<th><strong>Optical RDO PRO Dissolved Oxygen Probe</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sensor type</strong></td>
</tr>
<tr>
<td><strong>RDO PRO Probe</strong></td>
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<tr>
<td></td>
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<tr>
<td></td>
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<tr>
<td><strong>RDO sensor cap</strong></td>
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<td></td>
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<tr>
<td><strong>Temperature sensor</strong></td>
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<td></td>
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<tr>
<td><strong>Transmitter/local display</strong></td>
</tr>
<tr>
<td><strong>Communications options</strong></td>
</tr>
<tr>
<td><strong>Max. power consumption</strong></td>
</tr>
<tr>
<td><strong>Measure current</strong></td>
</tr>
<tr>
<td><strong>Idle current (no measurement or communication)</strong></td>
</tr>
<tr>
<td><strong>Maximum cable length</strong></td>
</tr>
<tr>
<td><strong>Cable options</strong></td>
</tr>
<tr>
<td><strong>Internal mounting thread</strong></td>
</tr>
<tr>
<td><strong>IP rating</strong></td>
</tr>
<tr>
<td><strong>Compliance</strong></td>
</tr>
<tr>
<td><strong>Salinity compensation</strong></td>
</tr>
<tr>
<td><strong>Barometric pressure</strong></td>
</tr>
<tr>
<td><strong>Maximum pressure</strong></td>
</tr>
<tr>
<td><strong>Warranty</strong></td>
</tr>
<tr>
<td><strong>Methods</strong></td>
</tr>
</tbody>
</table>
8.0 Accessories and Replacement Parts

<table>
<thead>
<tr>
<th>Accessory</th>
<th>Order No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDO PRO Sensor Cap Replacement Kit</td>
<td>0084230</td>
</tr>
<tr>
<td>RDO PRO Calibration Kit</td>
<td>0088890</td>
</tr>
<tr>
<td>Manual, RDO PRO Probe</td>
<td>0089662</td>
</tr>
<tr>
<td>RDO PRO Communication Device Kit</td>
<td>0081100</td>
</tr>
</tbody>
</table>

9.0 Warranty and Service

9.1 Warranty Provisions

In-Situ Inc. provides a 3-year limited warranty on the RDO PRO Instrument. Complete warranty provisions and the return material authorization (RMA) form are located on the In-Situ website.

9.2 Obtain Repair Service

The RDO PRO contains no user-serviceable parts. Do not attempt to open the instrument case or service the unit yourself.

If you suspect that your probe is malfunctioning and repair is required, you can help assure efficient servicing by following these guidelines:

Call In-Situ Technical Support: 800-446-7488 or 970-498-1500 (option 3), or email: support@in-situ.com.

1. Have the product model and serial number handy. The probe serial number is engraved on the probe housing.
2. Be prepared to describe the problem, including how the instrument was being used and the conditions noted at the time of the malfunction.
3. If Technical Support determines that service is needed, they will ask that your company pre-approve a specified dollar amount for repair charges. When the pre-approval is received, Technical Support will assign an RMA (Return Material Authorization) number.
4. Clean the instrument, sensor, and cable. Pack in the original shipping box, if possible. Include any supporting information.
5. Mark the RMA number clearly on the outside of the box with a marker or label.
6. Send the package, shipping prepaid, to
   In-Situ Inc.
   ATTN: RMA (your RMA number here)
   221 East Lincoln Ave.
   Fort Collins, CO 80524

The warranty does not cover damage during transit. We recommend that the customer insure all shipments. Warranty repairs will be shipped back prepaid.
10.0 Appendix A – Communication Device
The Communication Device is an accessory product that can be used to calibrate and set up RDO probes.

10.1 Install and Open the Software
The Comm Kit Software must be installed on a computer before you connect to the probe.

10.2 Connect the Probe to the Communication Device
The Communication Device connects a stripped-and-tinned probe to a computer via USB connection.

1. Disconnect the instrument from the PLC.
2. The communication device includes an electrical connection diagram label. To attach the instrument to the communication device, depress a lever and insert the appropriate wire in the location specified by the diagram.
3. Attach the USB connector to a USB port on the computer. Follow the directions provided in the Communication Device Kit to set up the probe.
11.0 Declaration of Conformity

Manufacturer: In-Situ, Inc.
221 East Lincoln Avenue
Fort Collins, CO 80524
USA

Declares that the following product:

Product name: RDO PRO Optical Dissolved Oxygen Sensor
Model: RDO PRO Optical Dissolved Oxygen Sensor
Product Description: The RDO PRO measures dissolved oxygen and temperature in natural groundwater and surface water.

is in compliance with the following Directives:


and meets or exceeds the following international requirements and compliance standards:

- **Immunity**
  EN 61000-6-2, Electromagnetic Compatibility (EMC) – part 6-2: Generic standards – Immunity for industrial environments

- **Emissions**
  Class A requirements of CISPR 11: 2004, Specification for limits and methods of measurement of radio disturbance characteristics of industrial, scientific and medical (ISM) radio-frequency equipment

Supplementary Information:
The device complies with the requirements of the EU Directives 2004/108/EC and 73/23/EEC, and the CE mark is affixed accordingly.

Bob Blythe
President and CEO
In-Situ Inc.
October 2, 2008

The presence of the Waste Electrical and Electronic Equipment (WEEE) marking on the product indicates that the device is not to be disposed via the municipal waste collection system of any member state of the European Union.

For products under the requirement of WEEE directive, please contact your distributor or local In-Situ Inc. office for the proper decontamination information and take back program, which will facilitate the proper collection, treatment, recovery, recycling, and safe disposal of the device.