RDO Pro-X

Instruction Manual

2025-12-03 | 0090102

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 for the proper decontamination information and take back program, which will facilitate the proper collection, treatment, recovery, recycling, and safe disposal of the device.

Contents

Optical RDO PRO-X Dissolved Oxygen Probe Specifications

Optical RDO PRO-X Dissolved Oxygen Probe

Sensor Type	Optical (luminescent) dissolved oxygen sensor
RDO PRO-X Probe	Range: 0 to 60 mg/L concentration Accuracy: ±0.1 mg/L from 0 to 20 mg/L ±2% of reading from 20-60 mg/L Resolution: 0.01 mg/L Response time: T90 < 45 sec; T95 < 60 sec @ 25°C Storage conditions: -5° to 60° C (23° to 140° F)
RDO Classic Cap RDO-X Sensor Cap RDO Fast Cap	Usage life: 2 years typical Storage conditions: 1° to 60° C (33° to 140° F), in factory container
Temperature sensor	Range: 0° to 50° C (32° to 122° F) Accuracy: ±0.1° C typical Resolution: 0.01° C
Transmitter/local display	Optional, or use with Con TROLL PRO System
Communications options	Modbus/RS485, 4-20 mA, SDI-12
Max. power consumption	50 mA at 12 VDC
Measure current	6 mA typical at 24 VDC
Idle current (no measurement or communication	160 µA typical at 24 VDC
Maximum cable length	Up to 1,219 m (4,000 ft) (for Modbus and 4-20 mA) or up to 60.96 (200 ft) for SDI-12
Cable options	10 m fixed stripped-and-tinned; Twist-lock connector with user-selectable cable length
Internal mounting thread	1¼ - 11 ½ NPT
IP rating	IP-67 with cap off, IP-68 with cap installed
Compliance	Heavy industrial, IEC 61000-6-2:2005
Salinity compensation	Fixed or real-time capable (using controller)
Barometric pressure	Fixed or real-time capable (using controller)
Maximum pressure	150 psi from 0 to 50° C; 300 psi @ 25° C
Warranty	Probe: 3 years from date of shipment RDO-X Sensor Cap: 2 years in typical applications
Methods	Standard Methods 4500-O; In-Situ Methods 1002-8-2009,1003-8-2009, 1004-8-2009 (EPA approved)

Introduction

The RDO PRO-X 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.

System Description

The RDO PRO-X system consists of the following items.

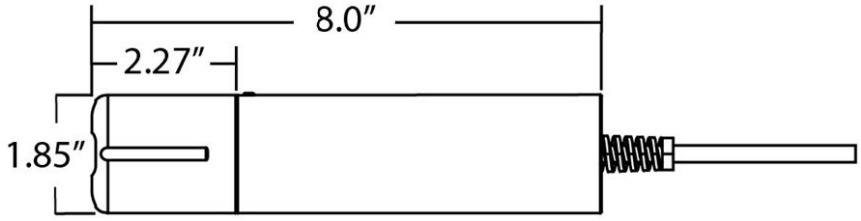
- Black probe body with removable nose cone
- Optical RDO-X Sensor Cap, Classic Cap, or Fast Cap
- Titanium thermistor

RuggedCable System

- 10-m standard length with stripped-and-tinned ends
- Customized lengths with titanium twist-lock connectors

1	Cable end, stripped-and-tinned
2	Nose cone
3	RDO-X Sensor Cap
4	Thermistor

1	Probe
2	Cable end, twist-lock connector and RuggedCable System



Serial Numbers

The probe serial number is engraved on the side of the unit. The cap serial number is programmed on the memory chip inside the cap.

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.

1	Dust cap
2	Nose cone

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.

1	Alignment arrow on cap
2	Cap installed over lens
3	Nose cone

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 O-ring grooves are dry and that the O-ring is not rolled or pinched inside the cap. The typical cap lifetime is two years after the first reading has been taken.

5. Reattach the nose cone.

Calibrate the RDO PRO-X Probe

Calibrate the sensor with Win-Situ 5 software or the VuSitu mobile app, or calibrate directly with your controller.

1-Point Calibration

Perform a 100% saturation calibration after replacing the cap or moving the instrument to a new location to adjust for changes in altitude or barometric pressure.

Water-Saturated Air

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

1	Storage cap
2	Vented calibration cap

2. Place the sponge wafer in the bottom of the calibration chamber and saturate with approximately 10 mL water.
3. Gently dry the instrument and sensing material with a paper towel, making sure there is no water or debris on the instrument or on the sensing surface.
4. Place the instrument into the calibration chamber about 2.5 cm (1 in.) above the water-saturated sponge.

5. Allow 5 to 10 minutes for temperature stabilization prior to starting the calibration procedure. Do not leave the instrument in the calibration chamber for more than 30 minutes. This can allow condensation to form on the sensing material, which will produce false low readings after calibration. If condensation does occur, remove the instrument, dry the sensing material, place the instrument in the chamber, and calibrate.

2-Point Calibration

Perform a two-point calibration for applications that require high accuracy in the 0-1 mg/L range.

100% and 0% Saturation

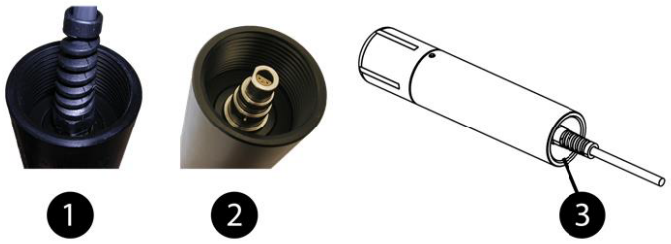
1. Set up the calibration procedure as previously described, and perform a water-saturated air calibration.
2. Remove the water-saturated sponge from the calibration chamber and fill the chamber to the fill line

1	Fill line
2	Temperature sensor

   with approximately 60 mL of fresh sodium sulfite solution.
3. Place the instrument into the solution. Leave at least 13 mm (0.5 in.) between the surface of the sensing material and the bottom of the chamber.
4. Ensure that the temperature sensor is completely submerged in the solution.
5. Allow at least 5 minutes for the temperature to stabilize prior to performing the calibration procedure.
6. Once calibration is complete, remove the sensor, and thoroughly rinse to remove all of the sodium sulfite.

Probe Deployment

The cable end of the RDO PRO-X 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.



1	10 m cable attached
2	Twist-lock Connector
3	1 1/4 NPT threading

Care and Maintenance

Clean the Sensor 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.
5. After cleaning, perform a 1- or 2-point user calibration or calibration check.

Do not use organic solvents—they will damage the sensing element. Do not remove the cap from the sensor prior to cleaning.

Clean the Optical Window

1. Clean the optical window only when you change the cap. See full instructions in the sensor cap replacement kit.
2. 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.

Clean the Probe

With the RDO cap installed on 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.

Sensor Cap Storage

Prior to installation—Store in factory supplied container.
Installed—Store in the calibration chamber with the storage cap attached and a few drops of clean water.

Replace the Sensor Cap

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 light layer of silicone-based 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.

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.
9. Replace the nose cone.
10. Perform a 1- or 2-point calibration.

Maintain 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 probes dry until your next scheduled maintenance. Desiccant lifespan is dependent on site conditions.

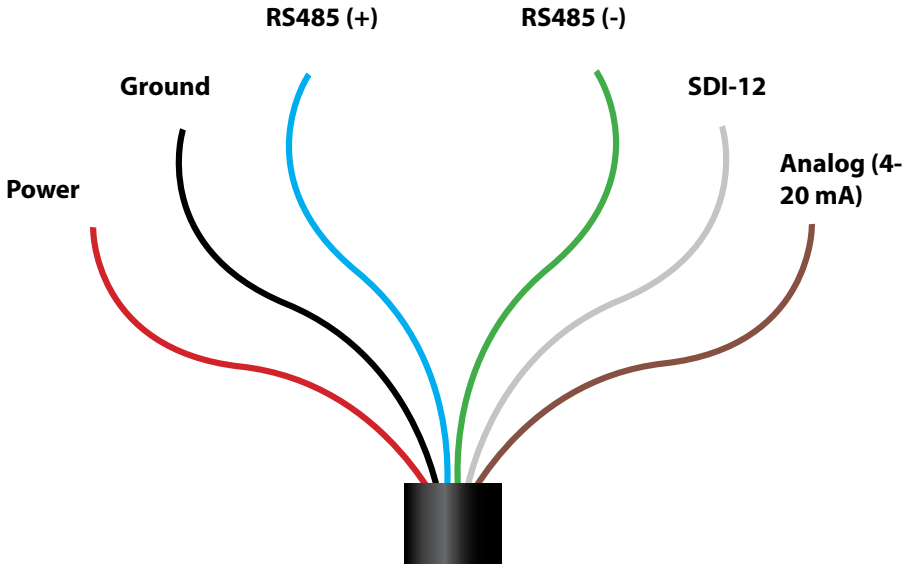
Controller Requirements and Connections

The RDO PRO-X Probe may be connected to a controller or logger for communication via the following options.

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

Wire Diagram

Refer to the diagrams on the following pages for PLC wiring diagrams. Unused leads should not be touching.



Cable Wire Legend

Wire Color	Signal
Red	External Power
Black	Ground
Blue	RS485 (+)
Green	RS485 (-)
White	SDI-12
Brown	Analog 4-20 mA

Power Connections

The red wire provides power for all system modes.

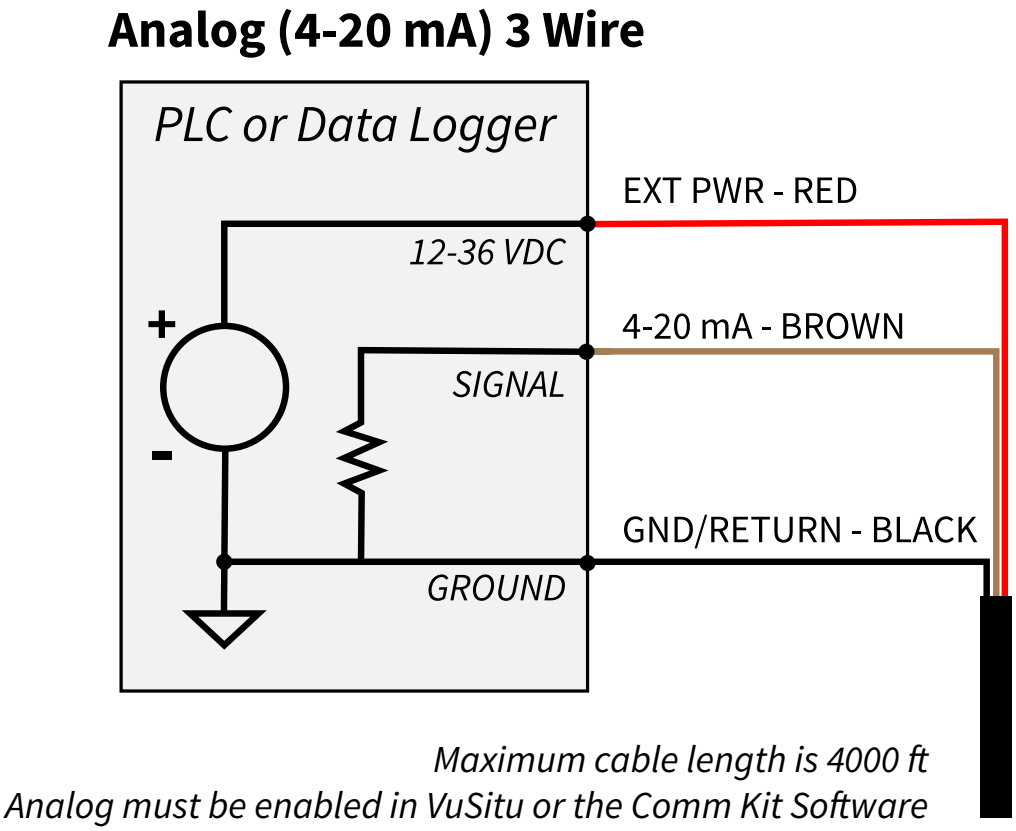
Communications

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. The 4-20 mA current loop output can be used in Modbus or SDI-12 mode as long as analog output is enabled.

Enabling analog output

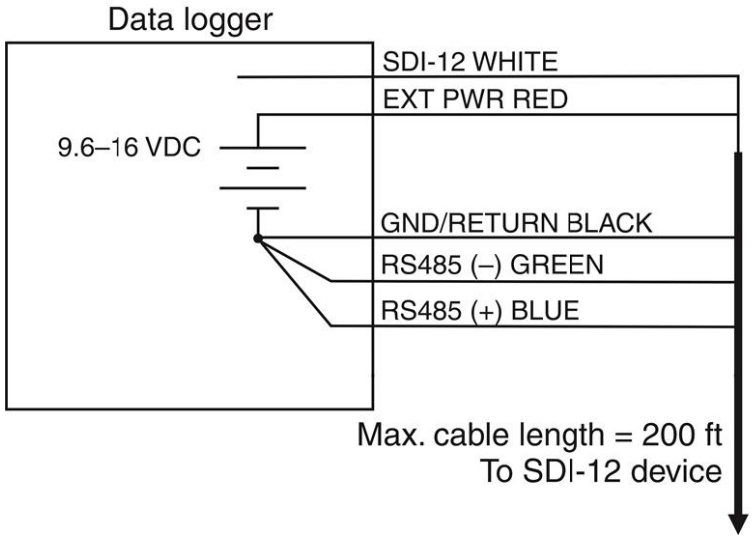
Analog output is disabled by default. Enable analog output from Comm Kit software or the settings tab in Win-Situ 5. Analog output can be enabled with a PLC by setting Modbus device register 9507 to 1.

Analog (4-20 mA) wiring diagram



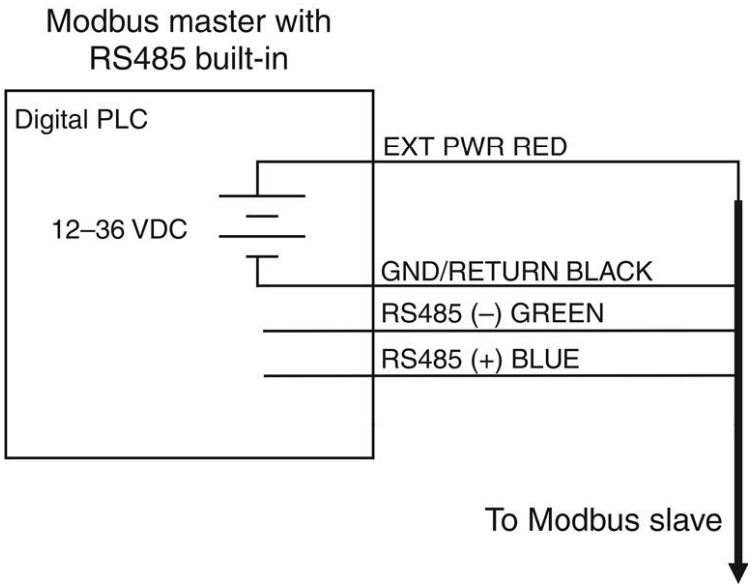
Maximum cable length is 4000 ft
Analog must be enabled in VuSitu or the Comm Kit Software

SDI-12 wiring diagram



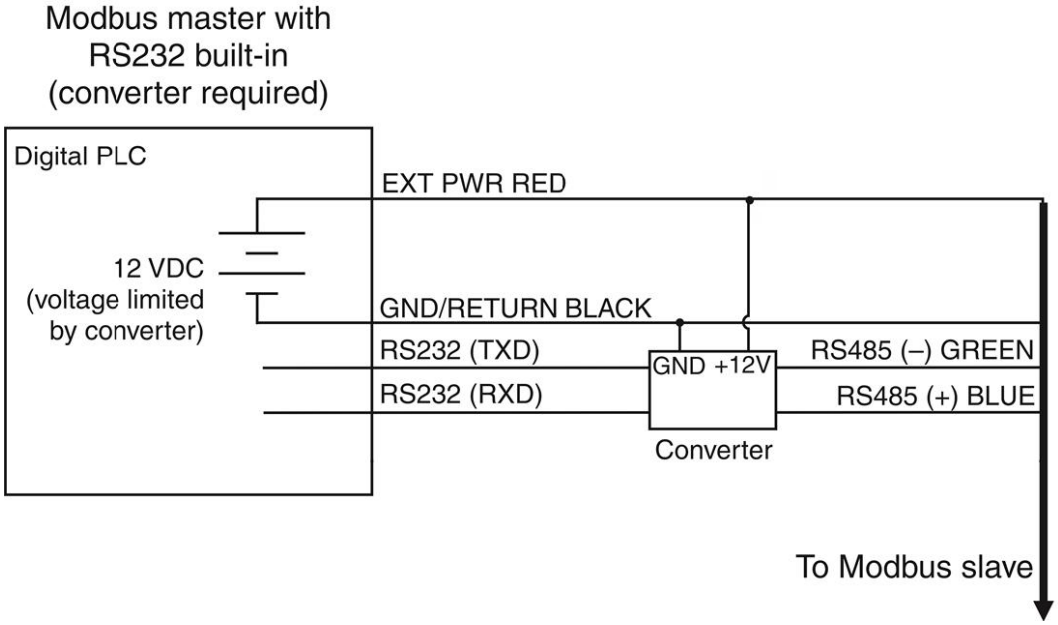
Cable length must not exceed 60.96 m (200 ft.)

Modbus (RS485) wiring diagram



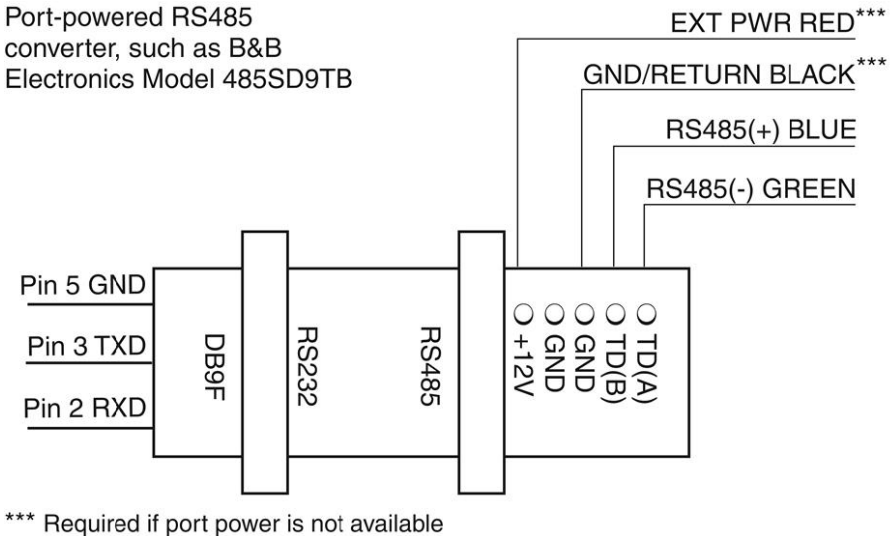
Cable length must not exceed 1219 m (4000 ft.)

Modbus (RS232 with converter) wiring diagram



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.)

Converter



*** Required if port power is not available

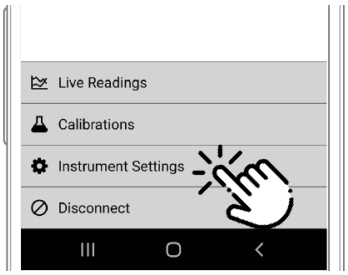
Configuring SDI-12 Settings

About SDI-12

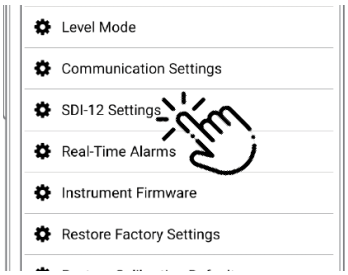
You can configure the list of SDI-12 parameters in VuSitu under **Instrument Settings.**

The RDO Pro-X conforms to the general SDI-12 Standard Version 1.3. For more information about SDI-12 commands, see the SDI-12 Standard Version 1.3 document from the SDI-12 Support Group Technical Committee.

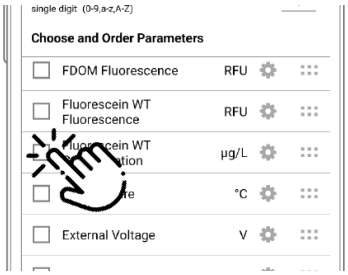
Configure SDI-12 Settings in VuSitu



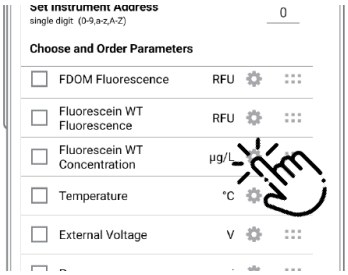
Connect to VuSitu and select **Instrument Settings.**



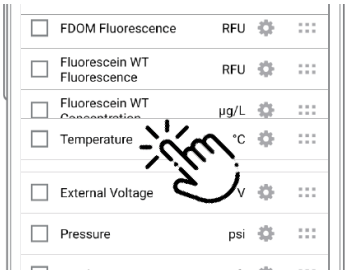
Choose **SDI-12 Settings.**



Use the checkboxes to select parameters to display.



Tap the gear icon to adjust the units for each parameter.



Drag and drop parameters to change the order.

Modbus PLC Interface

Overview

The Modbus PLC Interface is a simplified method of communicating with the RDO Pro-X using the Modbus protocol. For information about the specific Modbus registers and Unit IDs for your RDO Pro-X, see Appendices A and B. The RDO Pro-X conforms to the Modbus standard. For more information about Modbus communication, see www.modbus.org.

Setting Up Instrument

1. Connect power, and wire the instrument.
2. The setup below is using the instrument's factory default settings. Use VuSitu to reset the instrument to factory defaults if they have been changed. Take note of any changes in default units setup.

Programming the PLC

1. Set up the serial communication to match the instrument communication settings. Communication settings can be changed with the VuSitu mobile app. The default communication settings are:

Mode	Start Bit	Baud Rate	Data Bits	Parity	Stop Bit
RTU	1	19200	8	Even	1

2. Set the device address match the instrument address. The default device address is 1.
3. Set the PLC to wake-up the device by sending a carriage return (0x0D) or any Modbus command.
    a. Allow one second before sending a second command. The instrument needs this time to wake up.
    b. After the wake-up command, the next reading must be taken before the end of session timeout. If the reading interval exceeds the end of session timeout, send a new wake-up command before requesting a new reading. The default end of session timeout is 5 seconds, and may be longer if the instrument has been connected to VuSitu.
4. Select the register to read on the PLC using the information in the following sections.
    a. If your PLC requires a register address, subtract 40001 from the holding register number. For example: Holding Register Number 45451 corresponds to Register Address 5450.
5. Set the type of register to: 32-bit float
    a. If asked by the PLC this is 2 registers
6. Set the byte order to: Big Endian (MSB)
    a. This should be the default and may not be configurable on all PLCs

Reading Device Information

Use the following registers to read general information about the instrument.

Holding Register Number	Register Address	Size (Registers)	Data Type	Description
49001	9000	1	uint16	Device Id: 31 = RDO Pro-X
49002	9001	2	uint32	Serial Number
49007	9006	1	uint16	Firmware version (100 = 1.00)

Reading Parameters

Each parameter contains a block of 7 registers as shown in the table below. To read measurements for a specific parameter, look up the starting register for that parameter from the list of Parameter Numbers and Locations in Appendix A. Once you have the starting register, add the number of offset registers for additional information about the reading.

Register Offset	Size (Registers)	Mode (R/W)	Data Type	Description
0	2	R	float	The measured value from sensor
2	1	R	uint16	Data Quality ID: 0 = No errors or warnings 3 = Error reading parameter 5 = RDO Cap expired For additional errors or information, contact technical support.
3	1	R/W	uint16	Units ID for this parameter. See: Appendix B.
4	1	R	uint16	Parameter ID for this parameter. See: Appendix A.
5	2	R/W	float	Off line sentinel value: The value that's returned on error or if the parameter isn't available. The default sentinel is 0.0

For example, you can apply this information to collect a reading for DO Concentration.

From the list in Appendix A, you can find that the starting register for DO Concentration is 40038. A reading from register number 40038 (register address 0037) will return the measured value of DO Concentration.

Some PLC devices use the register number directly in programming statements, others use register addresses. Refer to PLC manufacturer instructions to determine which programming style to use.

You can use the register offsets listed in the table above to collect additional information about the reading. Adding the register offset of 2 to the starting register, you can find that register number 40040 (register address 0039) will return the Data Quality ID for the most recent DO Concentration measurement. Likewise, register number 40041 (register address 0040) will return the Units ID, which can be interpreted from Appendix B. Register number 40042 (register address 0041) will return the Parameter ID, which can be interpreted from Appendix A. Register number 40043 (register address 0042) will return the sentinel value.

The Units ID and Sentinel Value are writeable registers. Measurements can be changed to other units using the Units ID as shown in Appendix B. For example, if register number 40041 (DO Concentration Units ID) returns 117, DO Concentration is configured to report in mg/L. Looking at Appendix B, you can find that µg/L is also a valid unit which can be set by writing Units ID 118 to register number 40041.

Dissolved Oxygen Equations

Dissolved Oxygen Concentration

Oxygen concentration C_0 (mg/L) is calculated as follows:

$$C_O = 31.9988 \times 10^6 \times \frac{\rho_w P_O}{k_0 M_w}(1 - \theta_O P) \times S_c$$

Where:

ρ_w is the density of water in g/cm³

$\ln(\rho_w) = -0.589581 + (326.785/T) - (45{,}284.1/T^2)$

T is the temperature in Kelvin

P_0 is the partial pressure of O_2 in atmospheres:

$P_0 = P_{torr}/759.999876$

P_{torr} is the ppO_2 measured value

k_0 is Henry's law constant:

$\ln(k_0) = 3.71814 + (5596.17/T) - (1{,}049{,}668/T^2)$

T is the temperature in Kelvin

M_w is the molar mass of water:

$M_w = 18.0152$ g/mole

θ_0 is the negative of the second pressure coefficient in the virial expansion for the real gas behavior of oxygen:

$\theta_0 = 0.000975 - (1.426 \times 10^{-5} t) + (6.436 \times 10^{-8} t^2)$

t is temperature in °C

θ_0 is tied to the compressibility of pure oxygen at a given temperature and corrects for non-ideal gas behavior.

P is the total pressure in 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:

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

t is temperature in °C

S is the salinity in psu

Salinity correction is either taken from a conductivity sensor or input by a user.

Dissolved Oxygen Saturation

Oxygen saturation O_2%Sat is calculated as follows:

$$O_2\%Sat = \frac{O_2 Reading}{O_2 100\%Sat}$$

Where:

O_2Reading is the mg/L reading from the RDO sensor

$O_2$100%Sat is the theoretical saturation value in mg/L:

$$O_2 100\%Sat = 31.9988 \times 10^6 \times \frac{\rho_w[0.20946 \times (P - P_{wv})]}{k_0 M_w}(1 - \theta_O P) \times S_c$$

Where:

P_{wv} is the partial pressure of water vapor at saturation in atm:

$\ln(P_{wv}) = 11.8571 - (3840.70/T) - (216{,}961/T^2)$

All other variables are the same as defined for Dissolved Oxygen Concentration.

References

Per Standard Methods 4500-O(c), also see

Benson and Krause, Jr.
The concentration and isotopic fractionation of gases dissolved in freshwater in equilibrium with the atmosphere.
Limnol, Oceanogr, 25(4), 1980, 662-671

Gordon and Garcia
Oxygen Solubility in Seawater: Better Fitting Equations
Limnol, Oceaongr, 37(6), 1992, 1307-1312

Communication Device

The Communication Device is an accessory product that can be used to calibrate and set up RDO probes.

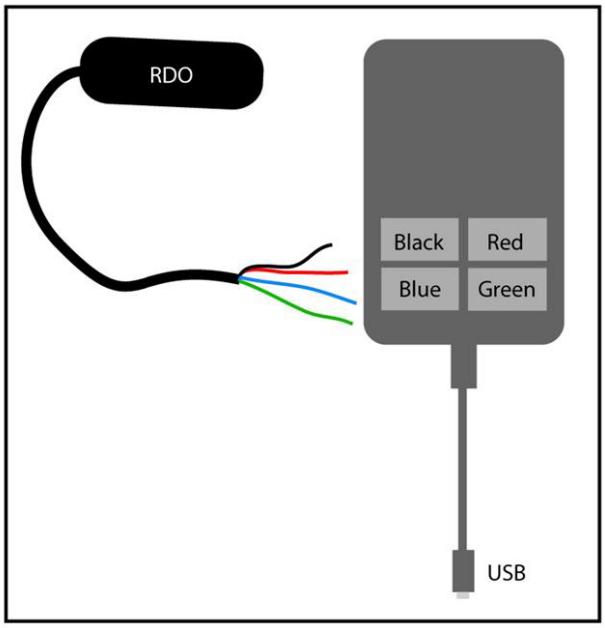
Install and Open the Software

The Comm Kit Software must be installed on a computer before you connect to the probe. You can download Comm Kit from www.in-situ.com.

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.



Service

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

RDO Software Troubleshooting

Sensor health diagnostics indicate when the RDO sensor has been damaged in the field. If the sensor has sustained moderate damage, the probe provides a DO value that includes a (DIS or Data Quality ID 5) warning. The same warning is included with readings taken after the sensor has reached its 24-month recommended lifespan.
However, if the sensor has been severely damaged, an error message is shown (ERR or Data Quality ID 3), a DO value is not provided and the sentinel value is shown. This prevents you from receiving an erroneous reading.

In-Situ

Innovations in Water Monitoring

CE 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-X**
Model: **RDO Pro-X**
Part Number: **0090930**
Product Description: The RDO Pro-X is a Dissolved Oxygen Sensor designed for deployment in surface and ground water as well as deployment in various processes.
Model Variants: There are two models of the RDO Pro-X and they differ by their connection type: one has an integrated cable which terminates in stripped and tinned wires and one has a twist-lock backend to accommodate an external TL cable.

is in compliance with the following Directive

- 2014/30/EU EMC Directive
- Restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS) Directive, 2011/65/EU and Commission Delegated Directive, (EU) 2015/863

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

EMC Standards:
EN 61326-1:2021

RoHS Standard:
EN 63000:2018

The CE mark is affixed accordingly.

David A. Bossie
Regulatory Compliance Manager
In-Situ, Inc.
July 13, 2022

CE FC

UKCA Declaration of Conformity

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

We declare that the performance of the following product:
Product name: **RDO Pro-X**
Model: **RDO Pro-X**
Part Number: **0090930**
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is in compliance with the following Regulations:

- EMC Regulation 2016
- Restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS) Regulation (S.I. 2012:3032)

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

- **EMC:** BS 61326-1:2021
- **RoHS:** BS 63000:2018

The UKCA mark is affixed accordingly.

David A. Bossie
Regulatory Compliance Manager
In-Situ, Inc.
July 12, 2022

Appendix

Appendix A: Parameter Numbers and Locations

ID	Parameter Name	Holding Register Number	Register Address	Default Units
1	Temperature	40046	0045	1 = °C
20	DO Concentration	40038	0037	117 = mg/L
21	DO Percent Saturation	40054	0053	177 = % Saturation
30	Oxygen Partial Pressure	40062	0061	26 = torr

Appendix B: Unit IDs

ID	Abbreviation	Units
Temperature		
1	C	Celsius
2	F	Fahrenheit
Pressure		
26	torr	Torr
Concentration		
117	mg/L	Milligrams per liter
118	µg/L	Milligrams per liter
Dissolved Oxygen (DO) % Saturation		
177	% sat	Percent saturation

Appendix C: Calibration Registers

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

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.

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. Prompt the user to place the probe in a 100% saturation environment.
8. Read the oxygen 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. 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.
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.

Calibration Calculations

Calibrated oxygen reading:

$$O_{2RC} = c_0 + c_1 \times O_{2RU}$$

Where:

$$c1 = (O_2100\%Sat)/(O_{2RUS} - O_{2RUZ})$$

$$c_0 = -c_1 \times O_{2RUZ}$$

Where:

$O_2100\%Sat$ is the theoretical 100% saturation point

O_{2RUS} is the un-calibrated reading at 100% saturation

O_{2RUZ} is the un-calibrated reading at 0% saturation

References:

Standard Methods for the Examination of Water and Wastewater. 20th Ed. 2008. 4500-0 C. Azide Modification. American Public Health Association, USA.