RDO Trio
Instruction Manual

이 기기는 업무용 환경에서 사용할 목적으로 적합성평가를 받은 기기로서
가정용 환경에서 사용하는 경우 전파간섭의 우려가 있습니다.

For regulatory compliance information including local compliance representatives and the product Declaration of Conformity, see www.in-situ.com/compliance-information.

Contents

Introduction

Instrument Description

RDO Trio is a dissolved oxygen sensor that integrates the latest optical dissolved oxygen technology with built-in salinity compensation. An optional cleaning wiper is available to reduce fouling on the sensor faces and extend the amount of time between cleaning trips to the field.

EASY TO CONFIGURE AND CONNECT

The VuSitu mobile app makes it easy to calibrate and configure your instrument. You can also integrate the instrument with your own custom Modbus system.

INTEGRATED SALINITY COMPENSATION

Integrated salinity compensation provides accurate measurements in coastal or marine environments with a single, simple-to-use instrument.

RDO® TECHNOLOGY

The latest optical dissolved oxygen technology does not require membranes, electrolyte solution, or flow like traditional electrochemical methods. The RDO Cap requires minimal maintenance or calibration and is easy to replace.

ANTIFOULING TECHNOLOGY

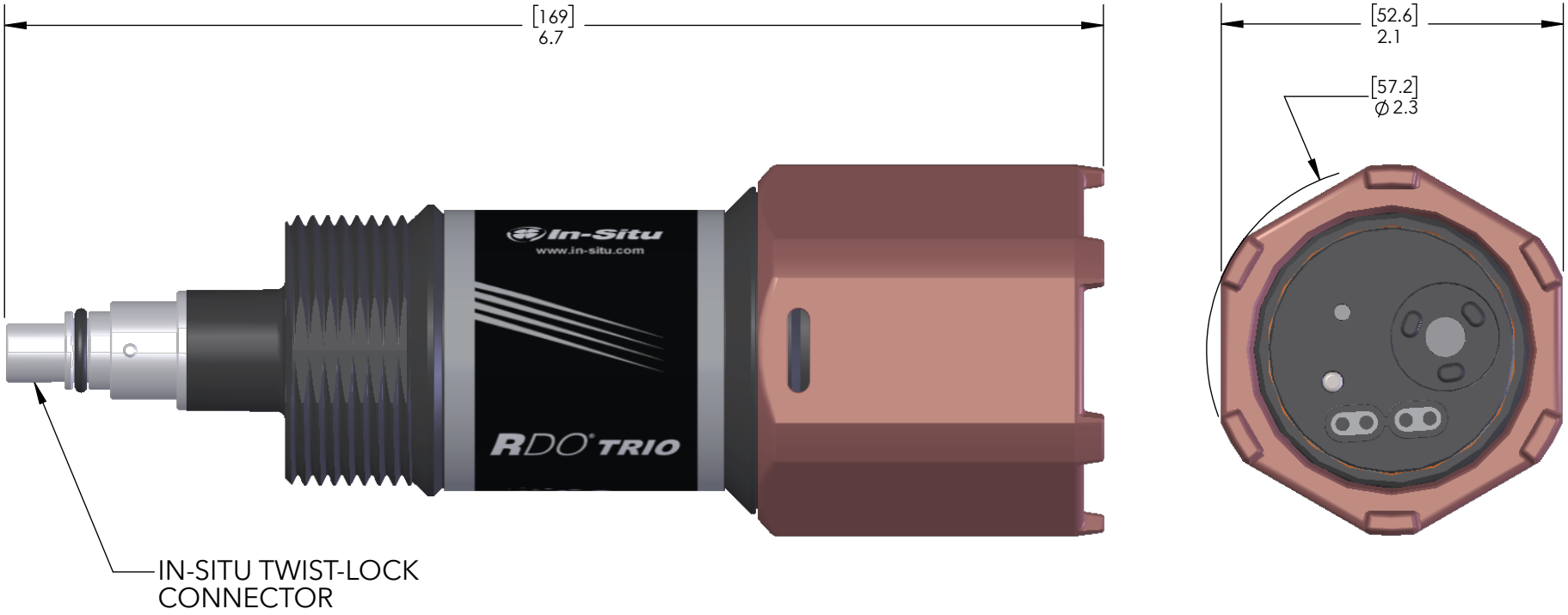
Reduce time between trips to the field with powerful antifouling technology. The copper-infused guard helps protect against fouling. Run the optional wiper on a scheduled interval, or trigger a thorough cleaning cycle based on a user-settable DO threshold.

Applications

RDO Trio is ideal for use in aquaculture and environmental applications where accurate dissolved oxygen measurements are critical in high-salinity or high-fouling environments:

- Inland Ponds
- Recirculating Aquaculture Systems (RAS)
- Open Ocean Aquaculture
- Coastal & Marine Monitoring
- Habitat Studies
- Hypoxia Monitoring

Mechanical Drawing



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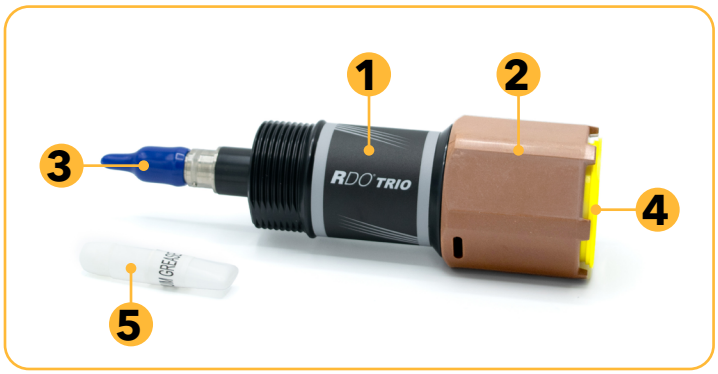
970-498-1500 FAX: 970-498-1519

PART NUMBER	DESCRIPTION	SCALE	SHT #	SIZE	REV
	RDO Trio	1:1	1 OF 1	A	

RDO Trio
Quick Start Guide

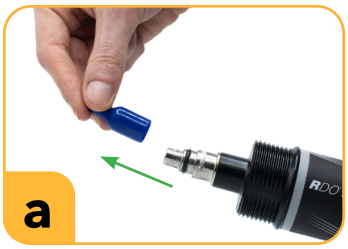


Contents

1. RDO Trio instrument with RDO-S Cap installed
2. Antifouling and weighted guard
3. Cable connector dust cap
4. RDO calibration cover and sponge
5. Grease

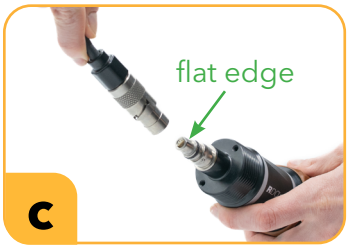
Getting Started

1 Connect cable.



Remove protective caps from instrument and cable.

Apply a small drop of grease to the O-ring if it is dry.



Align flat edges of cable and connector.

Push and then twist the sleeve until you hear a click.

2 Configure and deploy.

You must have the VuSitu mobile app to use the instrument with a mobile device. Download VuSitu from the Google Play Store or the Apple App Store.

Remove cover and sponge. Save these for calibrations.

Connect other end of cable to communication device.

Connect to the VuSitu mobile app.

Perform a 100% saturation calibration to adjust for changes in altitude or barometric pressure.

View the full instrument manual, help videos, compliance information, and more at www.in-situ.com.

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Safety

Safety and Damage Warnings

Read the safety information on this page before deploying or configuring your instrument. If you have questions, contact In-Situ Technical Support for assistance.

- Do not submerge the Twist-Lock connector or expose the connector to liquid when it is not attached to a cable.
- When not in use, store the instrument in a cool, dry area.
- Do not allow lubricant, debris, or water to get into the connector. Use the dust cap to protect the O-ring and connector when the cable is not attached.
- When changing the RDO Sensor Cap, ensure that the cap is fully installed in the instrument before submerging the instrument in liquid.
- Do not look directly at the sensor LED or point it at the eyes. Doing so can cause eye damage.
- Do not use organic solvents to clean the instrument. They will damage the sensing element.
- Do not use strong acids to clean the instrument. They will damage the guard.

Intended Use

The RDO Trio instrument is designed to be safe:

- during indoor or outdoor use;
- in ambient temperatures from -5 to 50° C;
- in any relative humidity levels;

If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

Technical Support

For service, repair, or technical support, scan the QR code or visit www.in-situ.com/technical-support to contact our skilled support team in your area by chat, email, or phone. Be sure to have the following information available:

- Product model
- Serial number located on the instrument label
- Description of the problem, including how the product was used and the conditions noted at the time of the malfunction

Your equipment was carefully inspected before shipping. Save packing materials for future storage and shipping of your equipment. Check the equipment for any physical damage sustained during shipment. Notify In-Situ and file a claim with the carrier if there is any such damage. Do not attempt to deploy or operate the equipment.

For regulatory compliance information including local compliance representatives and the product Declaration of Conformity, visit www.in-situ.com/compliance-information.

Mechanical Installation

The instrument is compatible with In-Situ mounting systems or threaded fittings for flexible, efficient deployments.

Mounting Options

You can mount your instrument using any of the systems below.

HANG FROM CABLE

Use the twist-lock connector to suspend the instrument. This is the simplest way to deploy the instrument.

HANG FROM BAIL

Connect bail kit to threaded holes, then use the bail to hang the instrument. Compatible with the same Instrument Bail Kit as Aqua TROLL 500/600/700.

THREADED FITTINGS

Install the instrument in your own custom system that accepts BSPP (ISO-228-1) 1-1/4 in threads.

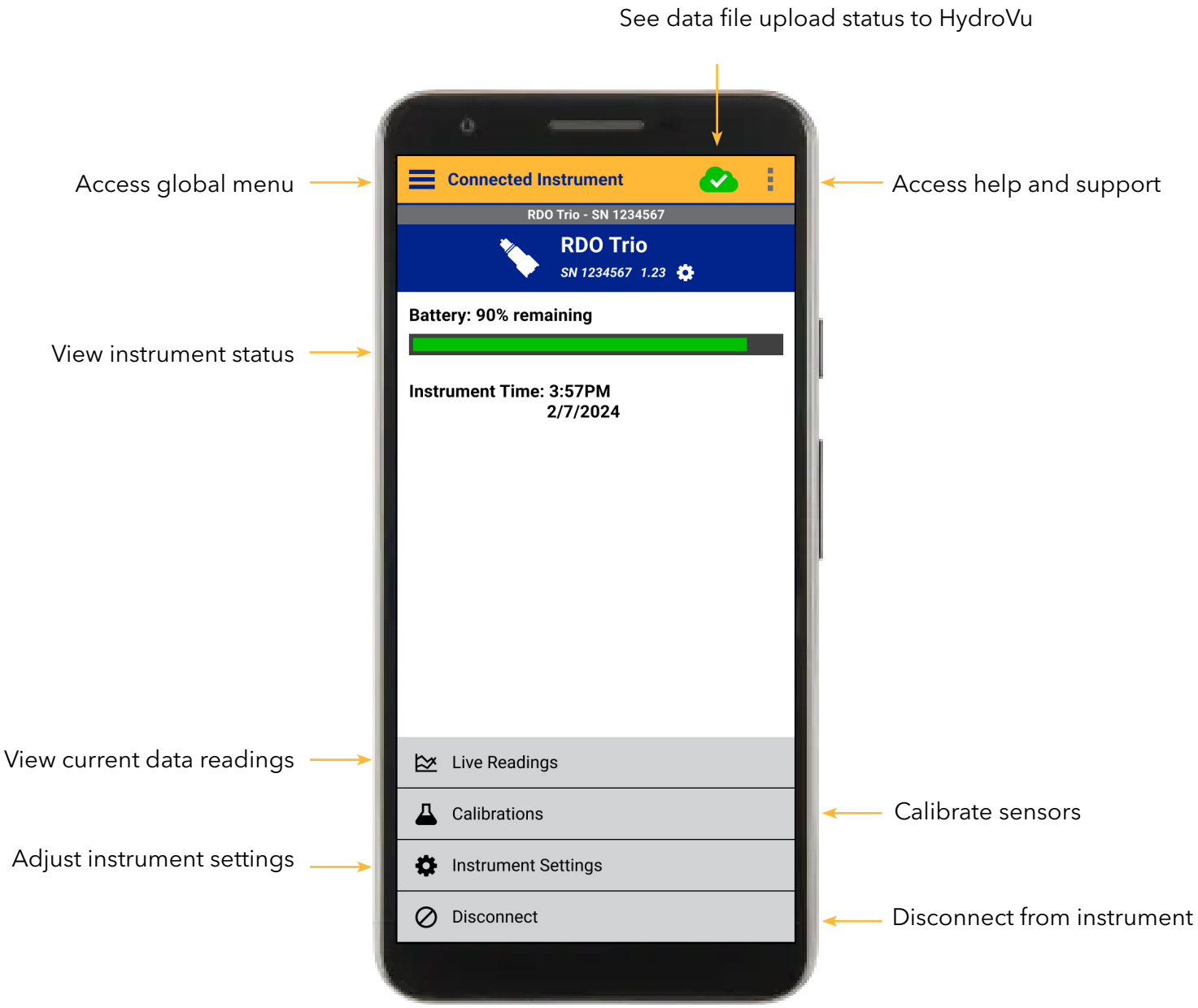
For all wiper units, ensure wiper brush is installed before deployment in order to maintain environmental rating.

VuSitu Mobile App

Use the VuSitu mobile app to program your instrument and view readings. You can download VuSitu from the Google Play Store or Apple App Store.

Connected Instrument Screen

You'll see the Connected Instrument screen every time you connect to your instrument in VuSitu. Here's how to access the main features on this screen:



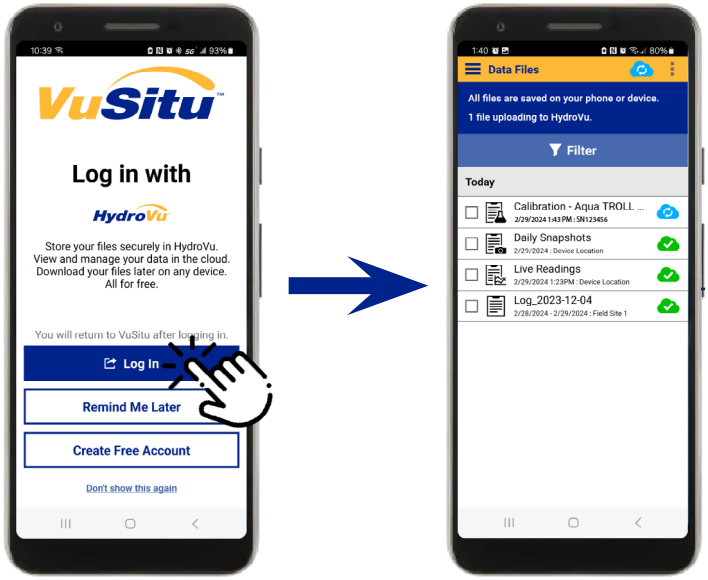
Logging in With HydroVu

You can log in with HydroVu when you first connect to VuSitu, or any time from the Log In & Connect page. As you work, any new data files you save will automatically upload to your HydroVu account when you have an internet connection so you can easily transfer and manage your data:

- Live Readings
- Daily Snapshots
- Calibration Reports
- Low-Flow Testing

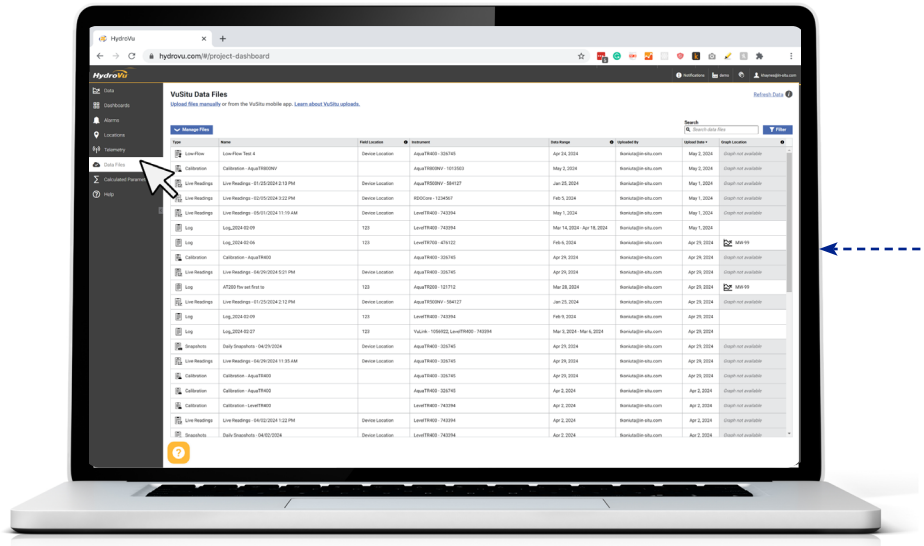
View, download, and manage your data at www.hydrovu.com.

Data files upload automatically as you work:



VuSitu HydroVu Cloud Connection

View and manage all of your data in HydroVu, from any device:



Instrument Settings

You can configure the settings below and find more settings in the **Instrument Settings** menu in VuSitu.

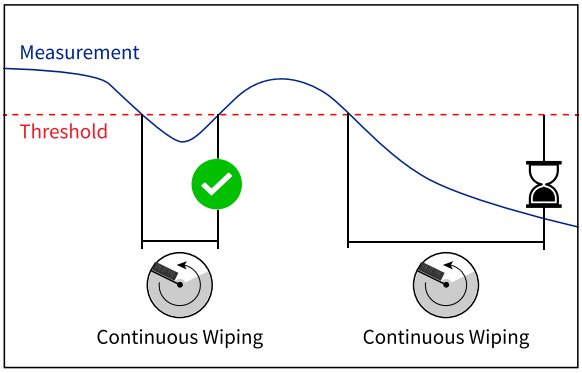
Wiper Interval

By default, the wiper cleans the sensors every 15 minutes. You can adjust this schedule from the **Interval** tab on the **Wiper Settings** page.

Auto-Clean at Threshold

You may be able to reduce false low DO events by configuring a DO threshold for a more thorough cleaning cycle. By default, the instrument will attempt to clean for up to 2 minutes when the dissolved oxygen concentration drops below 2 mg/L. The wiper will spin continuously until the measurement goes back above the threshold or the time limit is reached. You can adjust the measurement threshold from the **Threshold** tab on the **Wiper Settings** page.

Frequent continuous cleaning may reduce the lifespan of the wiper motor, especially if you are also using a short wiper interval.



If you are using this instrument for process control, set the Auto-Clean threshold to trigger before process changes. The instrument can attempt to clean the sensors first to prevent unnecessary cycling of process equipment.

Testing the Wiper

If you need to check wiper performance or troubleshoot errors, you can test the wiper from the **Test** tab on the **Wiper Settings** page.

During operation, the wiper may pass over the RDO sensor. This occurrence does not affect the accuracy or performance of the dissolved oxygen (DO) measurement.

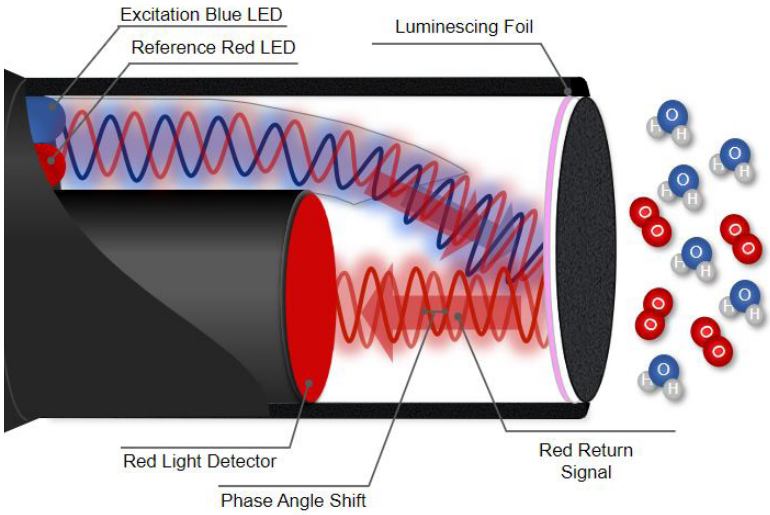
Derived Parameters - TDS

VuSitu can derive an estimate for Total Dissolved Solids (TDS) based on correlations with conductivity and temperature. Scale factors for derived parameters are unique for each deployment site, so they must be determined by laboratory analysis of grab samples. You can enable TDS under **Instrument Settings** > **Derived Parameters**.

How Rugged Dissolved Oxygen (RDO) Measurement Works

The sensor operates with a process called dynamic luminescence quenching. This technology is described in Standard Method 4500-O and In-Situ Methods 1002-8-2009, 1003-8-2009, 1004-8-2009 (EPA Approved).

The sensor uses a special RDO cap with a gas-permeable sensing foil. The sensing foil contains lumiphore molecules which fluoresce when excited by blue light. A blue LED inside the sensor emits blue light, and the sensing foil in turn emits red photons. If oxygen is present, the oxygen molecules quench this fluorescence, so fewer red photons are emitted. This method measures the phase shift (or delay) of the returned signal, and is thus based on the fluorescence lifetime rather than intensity. The phase difference between the blue light and the returned red light is used to calculate the concentration of oxygen in the water. Determination of DO concentration by luminescence quenching has a linear response over a range of concentrations.



RDO Technology uses a unique three-layer system to protect the luminescing layer, which extends the life of the sensor cap. This construction allows the cap to withstand rapid flow rates, high sediment loads and a wide range of demanding environments, lasting up to years of continuous use and cleaning. The cap is replaceable to extend the life of the overall sensor.

Dissolved Oxygen Concentration

Dissolved oxygen is most commonly measured in milligrams per liter (mg/L), percent saturation or parts per million (PPM). Milligrams per liter and parts per million indicate concentration—a quantitative measure of the amount of DO per given volume of water. The direct output from the factory-calibrated RDO cap is partial pressure of oxygen in torr. 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 Ptorr is partial pressure of oxygen in torr

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 barometric 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

Percent saturation is a relative measure of how much oxygen is present compared to the theoretical amount of oxygen a body of water can hold at equilibrium. 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). See also:

Benson, B.B. and D. Krause, Jr., The concentration and isotopic fractionation of gases dissolved in freshwater in equilibrium with the atmosphere, *Limnology and Oceanography*, 25(4), 662-671,1980.

García, H.E. and L.I. Gordon, Oxygen solubility in seawater: Better fitting equations, *Limnology and Oceaongraphy*, 37(6),1307-1312,1992.

Potential Interferents

Oxidizers (e.g., sodium permanganate or potassium permanganate) will give falsely high readings.

Dissolved Oxygen Compensation for Other Parameters

TEMPERATURE

Dissolved oxygen readings depend highly on temperature. The instrument has a built-in temperature sensor which is used in the calculation of DO concentration and saturation.

SALINITY

Dissolved oxygen readings include automatic salinity compensation by default. If you prefer to enter a custom value, you can input an estimated value for salinity in the VuSitu mobile app under **Instrument Settings > RDO Salinity Setting**.

BAROMETRIC PRESSURE

The barometric pressure is updated with every reading when using a VuLink with barometric compensation enabled.
If you are not using VuLink, the barometric pressure is updated during calibration. Calibrate the instrument every time there are significant changes in altitude or barometric pressure to ensure the barometric pressure is updated for the deployment site.

Temperature Measurement

The temperature thermistor (short for thermally sensitive resistor) is a raised titanium pin that changes electrical resistance with the temperature. The change in resistance is used by the instrument to calculate temperature. The temperature reading is used to compensate other measured or calculated parameters.

Conductivity Measurement

Conductivity is a measure of a solution's ability to conduct electricity. Since electricity needs charged particles in order to flow, a higher concentration of ions in a solution typically correlates with higher conductivity.

The RDO Trio conductivity sensor contains four electrodes in a conductivity cell. The cell contains two outer drive electrodes and two inner sensing electrodes driven by an alternating current. Conductance is calculated according to a modified version of Ohms Law: G=I/V, where G is conductance in siemens, V is voltage, and I is current. Conductance is then converted to conductivity in µS/cm or mS/cm using a cell constant which adjusts for the physical geometry of the measurement cell.

In-Situ's sensors are factory calibrated across their full range. Because of this, they tend to maintain very accurate readings without need for frequent user calibration. In-Situ's sensors use a cell constant (K-Cell Value) that is normalized to 1 based on the factory calibrated value. A sensor at factory defaults will have a cell constant of 1 which can be adjusted by calibration. 2-point calibrations also include an offset from the factory zero-point value.

Specfic Conductivity

Conductivity represents the reading measured directly by the sensor which will fluctuate as the temperature changes. Specific conductivity is normalized to a single reference temperature, so the specific conductivity will remain consistent even as the temperature of the solution changes. Because of this, specific conductivity is used for calibrations. Specific conductivity has the same units as conductivity.

By default, the conductivity sensor uses a reference temperature of 25° C. You can change the reference temperature to 20° C during conductivity calibration. The reference temperature used for calibration will be applied to all subsequent readings of conductivity taken by the sensor. You can view the current reference temperature by generating a Calibration Report in VuSitu.

Resistivity

Resistivity is simply the reciprocal of conductivity, converted to ohm*cm. Resistivity is often used to report measurement results instead of conductivity in high purity water applications.

Salinity

Salinity is a measure of salts dissolved in the water reported in the unitless value of PSU (Practical Salinity Units). By default, the instrument uses a method derived from Standard Method PSS78 to calculate salinity from conductivity and temperature.

You can also set the instrument to use Practical Salinity Scale 78 (2520 B) to derive salinity from conductivity, Temperature, and Pressure. For highest accuracy, confirm that your instrument has a pressure sensor if you wish to use this method. You can change the salinity calculation method under **Instrument Settings** in VuSitu.

Density

Density of water in g/cm^3 is calculated from salinity and temperature in accordance with Millero and Huang (2009)[1].

1 Millero, F.J. and F. Huang, The density of seawater as a function of salinity (5 to 70 g kg $^{-1}$) and temperature (273.15 to 363.15 K), *Ocean Science*, 5, 91–100, https://doi.org/10.5194/os-5-91-2009, 2009.

Total Dissolved Solids (TDS)

To find the scale factor, start by determining total dissolved solids. Then divide TDS by the specific conductivity reading: **Scale factor = TDS (in mg/L) ÷ Specific conductivity (in µS/cm)**

Total Dissolved Solids are any dissolved materials in water. These materials affect the water's conductivity. The instrument can derive an estimate for TDS based on a linear correlation with specific conductivity. The linear scale factor is unique to each deployment site and can change over time based on the nature of the specific solids. The default scale factor is 0.65[1]. You can adjust this scale factor to be more accurate for your deployment site based on laboratory analysis of grab samples. EPA Method 160.1 provides step-by-step guidance for finding the total dissolved solids of a grab sample. Once you have determined TDS and calcuated the scale factor, you can input the scale factor in VuSitu under **Instrument Settings** > **Derived Parameters**.

500 µS/cm * 0.65 = 325 mg/L

SPECIFIC CONDUCTIVITY | SCALE FACTOR | DERIVED TDS

1 Hem, J.D., Study and Interpretation of the Chemical Characteristics of Natural Water, 3rd Edition, USGS Water Supply Paper 2254, 67. https://doi.org/10.3133/wsp2254, 1985.

Calibration

Follow the instructions below to calibrate the instrument. The VuSitu mobile app includes on-screen instructions to guide you through each calibration

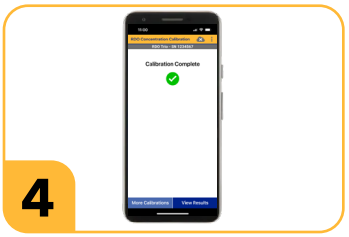
Perform a 100% saturation calibration after replacing the cap or moving the instrument to a new location to adjust for changes in altitude or barometric pressure. Always perform DO calibrations at stable temperature.

RDO 100% Saturation with Water-Saturated Air

Saturate the calibration sponge with water.

Place the sponge on the calibration cover and insert it into the guard.

Let the sponge sit for 10 minutes to humidify the chamber.



Follow the instructions in VuSitu to complete the calibration.

Do not allow moisture to collect on the sensor face during calibration.

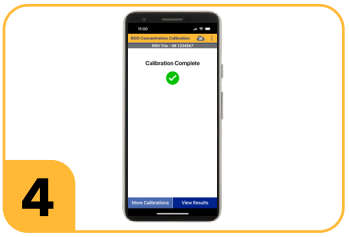
RDO 0% Saturation with Sodium Sulfite

Perform a two-point calibration for applications that require high accuracy in the 0-1 mg/L range. After calibration, rinse the sensors thoroughly before deployment.

Rinse and dry the instrument and guard.

Submerge the instrument in sodium sulfite solution.

Hold the instrument at an angle and tap to release any trapped bubbles.



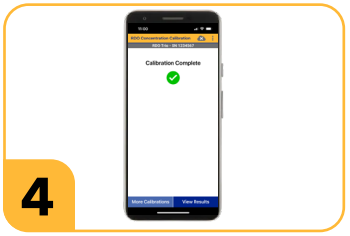
Follow the instructions in VuSitu to complete the calibration.

RDO Concentration with a Reference Sensor

Rinse and dry the instrument and guard.

Submerge the instrument next to a reference sensor.

Hold the instrument at an angle and tap to release any trapped bubbles.



Follow the instructions in VuSitu to complete the calibration.

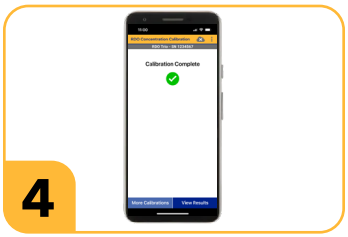
Conductivity

Calibration should always be performed in the same configuration as deployment. Install or remove the wiper during calibration to match the intended field setup.

Rinse and dry the instrument and guard.

Submerge the instrument in calibration standard.

Hold the instrument at an angle and tap to release any trapped bubbles.



Follow the instructions in VuSitu to complete the calibration.

When performing a 2-point conductivity calibration, start with the lowest concentration calibration standard and move to the highest calibration standard.

1-Point vs 2-Point Conductivity Calibrations

A 1-point calibration is sufficient for most applications. See below for guidance on when a 2-point calibration might be needed.

Use a 1-point calibration when the deployment environment has a narrow range of conductivity values and you are using In-Situ calibration standard.

Most applications with relatively stable conductivity only require a single-point calibration. In-Situ's sensors are factory calibrated across their full range, so there's no need to calibrate the sensor at more than one calibration point. You can choose **Restore Calibration Defaults** in VuSitu to return to the last factory calibration.

Use a 2-point calibration when the deployment environment has a wide range of conductivity values.

In environments like estuaries where the conductivity can vary significantly, perform a 2-point calibration spanning the full range of conductivity you expect to measure.

Use a 2-point calibration when you are trying to create a correlation to a third-party calibration standard.

Because there may be variations in calibration standards from different manufacturers, perform a 2-point calibration if you are using calibration standards from a different manufacturer.

Choosing Conductivity Calibration Standards

For 1-point calibrations, use the calibration standard closest to your expected deployment conditions.

For 2-point calibrations, use one calibration standard below the lowest end of the range you expect to measure, and one calibration standard above the highest end of the range you expect to measure. Always work from the lowest concentration standard to the highest.

Checking Calibration Quality

After calibration, check these indicators in the VuSitu Calibration Report. If you are logged in, Calibration Reports will automatically upload to HydroVu for secure storage and access from any device.

INDICATOR	ACCEPTABLE RANGE	NOTES
RDO Slope	0.7 to 1.3	The slope is normalized based on the factory calibrated value. A sensor at factory defaults will have a slope of 1.
RDO Offset	±0.3 mg/L	A sensor at factory defaults will have an offset of 0.
Cell Constant	0.7 to 1.3	The cell constant is normalized to 1 based on the factory calibrated value. A sensor at factory defaults will have a cell constant of 1.

If the values are outside of the ranges listed above, follow these troubleshooting steps. Then try the calibration again.

- Thoroughly clean, rinse, and dry the sensor, guard, and calibration equipment.
- Check that the RDO sensing foil, thermistor, and conductivity sensor are free from bubbles and condensation.
- For solution-based calibrations, make sure you are using enough calibration solution to fully submerge the sensor faces. Check that calibration solutions are not expired.
- Confirm that the calibration was performed with the guard and wiper installed as they will be deployed.
- From **Instrument Settings**, select **Restore Calibration Defaults.** Then try calibrating again.
- Follow the instructions in this manual to replace the RDO cap.
- Check whether the sensor is reaching the end of its expected life. It may be time to replace your sensor.

Additional Calibration Recommendations

Every RDO cap is factory-calibrated at 90 discrete points. The unique calibration coefficients for each cap are stored in a memory chip embedded in the cap. The sensor automatically loads the factory data when a new cap is intalled.

Perform a 100% saturation calibration whenever you change the cap, clean the sensor, or move the instrument to a new location with changes in altitude or barometric pressure.

RDO sensor user calibrations apply a slope and offset to the factory calibration. It's not necessary to calibrate both RDO concentration and saturation because they adjust the same slope and offset. For most applications, the factory calibration is the most accurate for the zero point. Perform a zero-point calibration only if you plan to measure very low dissolved oxygen levels (<2 mg/L).

Conductivity sensors are rigorously calibrated in our factory across their full range with the same NIST-traceable standards we offer for field calibrations. Because of this, they tend to maintain very accurate readings without need for frequent user calibration. You can calibrate conductivity to compensate for physical damage or deposits or if you have Standard Operating Procedures that require calibration. Prior to calibration, clean the sensor and insert it into a known Specific Conductivity standard to determine if the sensor is reading within the accuracy range required for your application. If the readings are within the required accuracy range, calibration is not necessary.

Factory Calibration

Factory calibration includes a thorough cleaning, full functionality check and sensor adjustments to all applicable sensors over the entire calibrated temperature range. We recommend a factory calibration every 12 months or when the unit appears to drift significantly.

Chemical Compatibility

Parameter Compensation

These parameters are automatically compensated by the instrument at the default settings.

DISSOLVED OXYGEN

Temperature, atmospheric pressure, salinity

CONDUCTIVITY

Temperature

RDO Cap Chemical Incompatibility

The following chemicals will damage the RDO sensing element.

- Alcohols > 5%
- Hydrogen peroxide > 3%
- Sodium hypochlorite (commercial bleach) > 3%
- Gaseous sulfur dioxide
- Gaseous chlorine
- Organic solvents (e.g., acetone, chloroform, methylene chloride, etc.)
- Ozone

Instrument Chemical Incompatibility

Do not use strong acids to clean the instrument or sensors. Do not soak the instrument in any acid for long periods of time. See the Cleaning section of the instrument manual for proper cleaning procedures.

Calibration Solutions Shelf Life

SOLUTION	SHELF LIFE - UNOPENED	SHELF LIFE - OPENED
Low Conductivity (147 µS/cm)	12 months	Hours (±1 µS/cm, check before use)
Other Conductivity	12 months	3 to 6 months
Sodium Sulfite	12 months	3 to 6 months
Deionized Water	24 months	Hours, check before use for calibration

Cleaning

Cleaning the Instrument

Do not use strong acids to clean the guard.

Wipe the instrument with a soft cloth, dish soap, and warm water.

Scrub the instrument with a soft bristle brush.

Soak the instrument for 30 minutes in household-strength vinegar. Then soak for 10 minutes in DI water.

Use a plastic scraper to remove solid fouling from the guard.

Cleaning the Sensors

Do not use organic solvents to clean the sensors. They will damage the RDO sensing element.

Scrub the sensor faces with a soft bristle brush, warm water, and dish soap.

Rinse the sensors thoroughly.

Gently dry the sensor faces.

Reinstall the guard before deployment.

Storage

Storing the Instrument

Store the instrument in a cool dry place when it is not in use. Install the dust cover to protect the cable connector.

Maintenance

Replacing the Wiper Brush

Replace wiper brush according to site needs when bristles are visibly bent, damaged, or fouled.

Pull the old wiper straight out of the instrument without twisting.

Insert the new wiper halfway into the port.

Push the wiper down gently and rotate it until it clicks.

Snap the wiper into place. Wiper should be flush with sensor face.

Replacing the RDO-S Cap

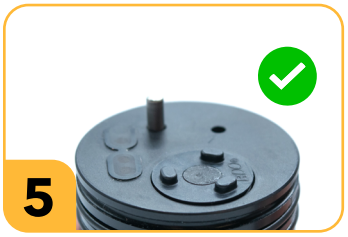
For best performance, replace the cap every 12 months, or sooner if frequent calibrations are required to correct drift.

If you have a wiper, pull it straight out of the instrument without twisting.

Use the black end of the installation tool to remove the existing RDO-S Cap.

Remove the yellow dust cover to expose the new cap.

Make sure port is dry and clear of debris. Twist the new cap into place.



Stop when the tool releases the cap. Cap will not be fully flush.

Insert the wiper halfway into the port.

Push the wiper down gently and rotate it until it clicks.

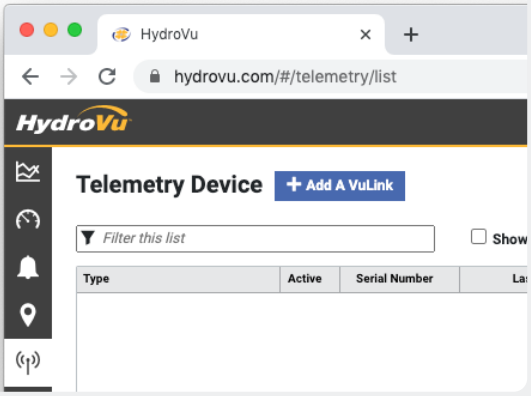
Snap the wiper into place. Wiper should be flush with sensor face.

The RDO Cap port contains fragile and sensitive material. Keep water and dirt out of the RDO Cap port. If liquid gets into the port while changing the cap, use compressed air to dry the port. Use the included foam swabs to remove any solid debris. Only touch contaminated surfaces to avoid spreading grease or debris around the port. Make sure the inside surface is completely clean before installing the new cap.

Remote Monitoring with VuLink

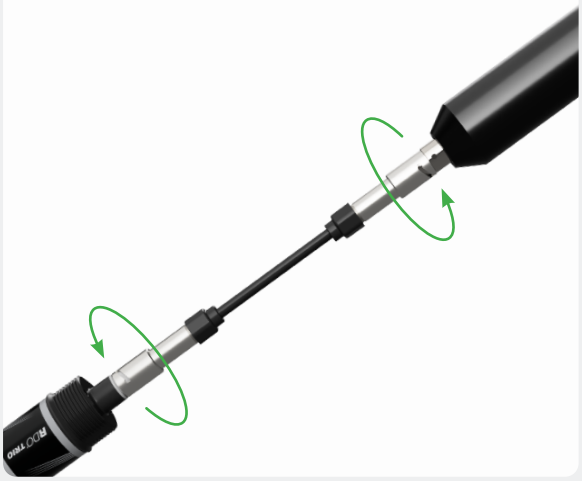
Use VuLink telemetry to upload data to HydroVu where you can view, manage, and share your data remotely. For more information on remote monitoring, refer to the VuLink manual at www.in-situ.com.

1 Activate VuLink.



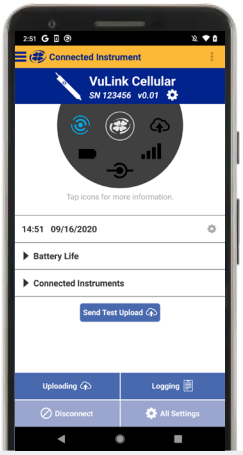
Log into your HydroVu account and add your VuLink from the Telemetry page.

2 Connect instrument.



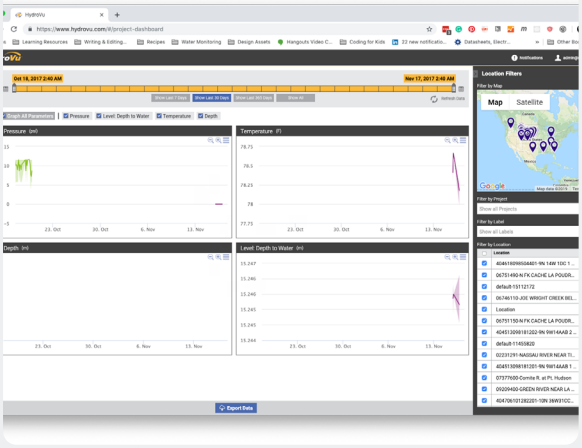
Connect the instrument to VuLink with a Rugged Twist-Lock Cable.

3 Configure and deploy.



Create a log and adjust instrument settings with the VuSitu mobile app. Then deploy the instrument.

4 View data in HydroVu.

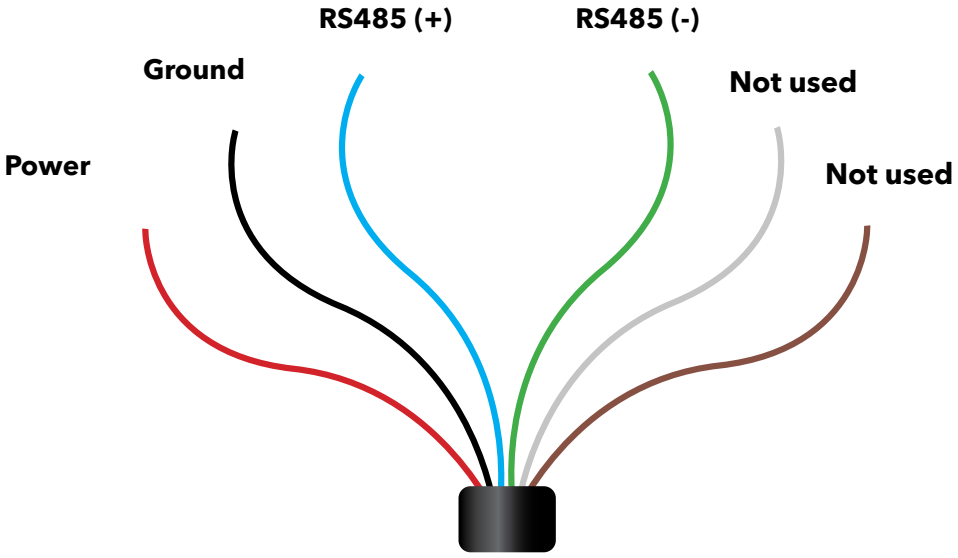


See graphs of your data and make changes to VuLink in HydroVu.

Connecting to a PLC or Data Logger

Flying Leads Wire Diagram

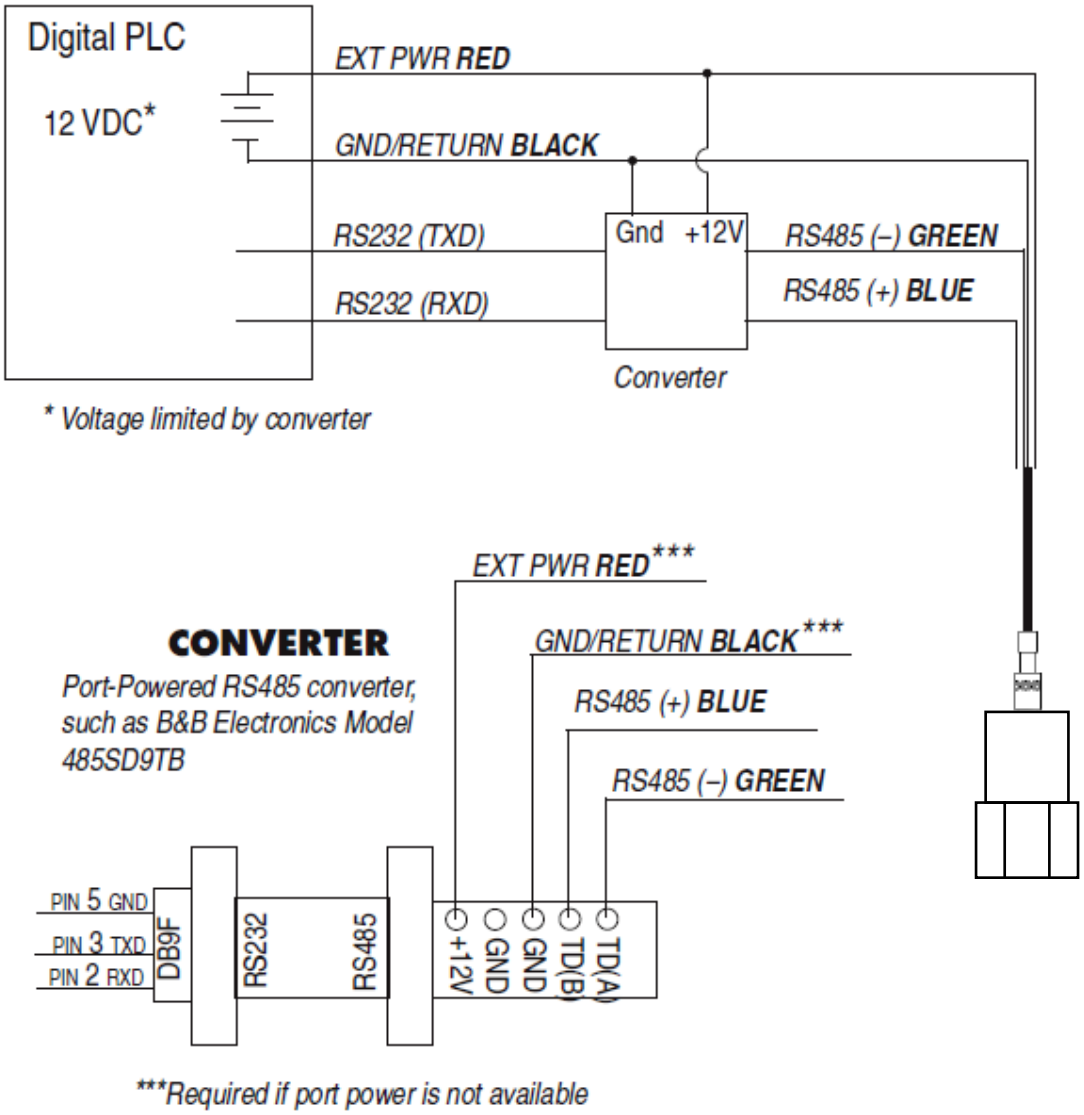
Refer to the diagrams on the following pages for PLC wiring diagrams. Unused leads should not be touching.



WIRE COLOR	SIGNAL
Red	External Power
Black	Ground
Blue	RS485 (+)
Green	RS485 (-)
White	Not used
Brown	Not used

Modbus (RS-485) Wiring Diagram

Modbus (RS-232 with converter) Wiring Diagram



Modbus PLC Interface

Overview

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

Programming the PLC

This setup uses 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.

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: 48 = RDO Trio
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 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 Dissolved Oxygen Concentration.

From the list in Appendix A, you can find that the starting register for Dissolved Oxygen Concentration is 45584. A reading from holding register number 45584 will return the measured value of Dissolved Oxygen Concentration.

Some PLC devices use the holding 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 holding register number 45586 will return the Data Quality ID for the most recent Dissolved Oxygen Concentration measurement. Likewise, holding register number 45587 will return the Units ID, which can be interpreted from Appendix B. Register number 45588 will return the Parameter ID, which can be interpreted from Appendix A. Register number 45589 will return the sentinel value for this parameter.

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 holding register number 45587 (Dissolved Oxygen Concentration Units ID) returns 117, Dissolved Oxygen 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 holding register number 45587.

Additional Commands

For additional information about configuring settings over Modbus, including programming a slope and offset for calibration, see the RDO Trio Open Modbus API Guide.

Accessories

The following accessories are commonly used with RDO Trio. Contact your sales representative for more information or to order any accessories.

Accessory Part Numbers

PART NUMBER	PART NAME
1026630	RDO Trio Calibration Cover Kit
1026640	RDO Trio Wiper Brush Kit
1011720	RDO-S Cap Replacement Kit
1022860	RDO-S Cap Install Tool - 4 Pack
1026660	RDO Trio Antifouling and Weighted Guard
0079780	Instrument Bail Kit - compatible with RDO Trio and Aqua TROLL 500/600/700
0032110	Dissolved Oxygen Calibration Kit – Includes 1 Liter DI Water, 1/2 Liter Sodium Sulfite
0017670	Sodium Sulfite, 500 mL
0032560	Conductivity Calibration Solution, 147 µS/cm, 1 Liter
0020680	Conductivity Calibration Solution, 1413 µS/cm, Liter
0020690	Conductivity Calibration Solution, 12890 µS/cm, Liter
0032580	Conductivity Calibration Solution, 58,670 µS/cm, 1 Liter
0032090	Conductivity Calibration Kit – Includes 1 Liter each: 147, 1413, 12890 µS/cm, DI Water
0032630	Conductivity Calibration Kit (Low) – Includes 2 Liters each: 147, 1413 µS/cm
0032640	Conductivity Calibration Kit (High) – Includes 2 Liters each: 12890, 58670 µS/cm

RDO® Trio

THE RDO TRIO COMBINES THE LATEST OPTICAL DISSOLVED OXYGEN TECHNOLOGY WITH INTEGRATED SALINITY COMPENSATION. FEATURING AN OPTIONAL WIPER AND THREE BUILT-IN SENSORS: DISSOLVED OXYGEN, CONDUCTIVITY, AND TEMPERATURE, IT DELIVERS RELIABLE, REAL-TIME DATA IN A COMPACT, EASY-TO-DEPLOY DESIGN.

COMPACT & COST EFFECTIVE

The RDO Trio offers an all-in-one design that simplifies deployment without compromising performance. Its compact footprint is ideal for installations with limited space, and the integrated sensor configuration reduces hardware requirements and overall system cost.

SHARED ECOSYSTEM

The RDO Trio is fully compatible with In-Situ's shared ecosystem, allowing for seamless integration with other instruments, cables, and VuSitu® mobile app. Cloud Connect automatically uploads all VuSitu data to your HydroVu® account for secure access in one central location.

INTELLIGENT WIPING

RDO Trio is the first DO sensor on the market that has a built-in way to self-clear a false low DO event due to fouling. Low DO levels automatically trigger a cleaning cycle. This avoids unnecessry usage of energy-hungry aerators, blowers, or pumps.

COMPLETE ANTIFOULING

The sensor's flat-face design resists debris buildup, allowing for quick, easy cleaning. An integrated wiper and a weighted, copper-infused guard further protects against fouling, ensuring consistent accuracy and reducing the need for frequent manual maintenance.

INTEGRATED SALINITY COMPENSATION

Real-time salinity compensation directly integrated into the device allows RDO Trio to maintain highly accurate DO measurements as salinity fluctuates, without the need to change salinity values between calibration and deployment.

OPEN MODBUS API

All RDO Trio instruments feature an open Modbus interface for seamless integration with SCADA systems, controllers, and telemetry devices. The RDO Trio includes a comprehensive public Modbus API guide to make setup fast and reliable. This feature supports plug-and-play configuration, improves data organization, and reduces troubleshooting time, especially in complex or large-scale deployments.

SMART SENSOR CAP

RDO sensors are calibrated at 90 discrete points, and the calibration coefficients are stored in the replaceable cap. Simply screw it in and you're ready to go—no data entry or extra steps needed.

ABRASION RESISTANCE

A unique, three-layer system provides unmatched chemical and abrasion resistance, extending the life of the sensor cap and expanding the range of compatible conditions.

EPA-APPROVED METHOD

RDO luminescence-quenching sensors have been proven effective through extensive lab testing, and the methodology has been approved by the United States EPA[1]. RDO sensors do not consume oxygen and do not require water movement for accurate measurements.

INSTANT HYDRATION CONDITIONING

The RDO formulation reads accurately within 90 seconds of going from dry to wet conditions.

Applications:

- **POND AQUACULTURE**
- **FISH TANKS & RACEWAYS**
- **RECIRCULATING AQUACULTURE SYSTEMS (RAS)**
- **OPEN OCEAN & OFFSHORE AQUACULTURE**
- **SURFACE WATER MONITORING**
- **COASTAL & MARINE MONITORING**
- **HYPOXIA & HARMFUL ALGAL BLOOM MONITORING**

GENERAL	RDO TRIO DISSOLVED OXYGEN	RDO TRIO TEMPERATURE	RDO TRIO CONDUCTIVITY
ACCURACY[2,3]	±0.1 mg/L from 0 to 20 mg/L ±5% from 20 to 60 mg/L ±1% of reading or ±1% of air saturation WIG from 0 to 200% ±5% of reading from 200 to 600%	± 0.1°C	± 0.5% from 1 to 100,000 µS/cm ±1% from 100,000 to 200,000 µS/cm ± 2% from 200,000 to 350,000 µS/cm
RANGE	0 to 60 mg/L 0 to 600% Saturation	-5 to 50°C	0 to 350,000 µS/cm
RESOLUTION / PRECISION	0.01 mg/L 0.1% air saturation	± 0.1°C	0.1 µS/cm
RESPONSE TIME T63	< 15 s	< 2 s	< 1 s
RESPONSE TIME T90	< 45 s	< 15 s	< 3 s
RESPONSE TIME T95	< 60 s	< 30 s	< 5 s
UNITS OF MEASURE	mg/L, %	Celsius or Fahrenheit	µS/cm
METHODOLOGY	Dissolved Oxygen: EPA-approved In-Situ Methods 1002-8-2009 Conductivity: Standard Methods 2510/EPA 120.1 Temperature: EPA 170.1 Salinity calculation methods: PSS-78 (default) or Standard Method 2520-B		
DERIVED PARAMETERS	Salinity, Total Dissolved Solids, Specific Conductivity		
WETTED MATERIALS	Polycarbonate/Acrylonitrile Butadiene Styrene (PC/ABS) blend, Polycarbonate/Acrylic, Titanium, Graphite, FKM Fluoroelastomer		
OPERATING TEMPERATURE	-5 to 50°C (23 to 122°F)		
STORAGE TEMPERATURE	-40 to 65°C (-40 to 149°F)		
DIMENSIONS	169 mm (6.70 in) height 57.2 mm (2.3 in) OD of guard		
WEIGHT	382 g (13.5 oz) Wiper version 357 g (12.6 oz) non-Wiper		
WEIGHT IN WATER (FRESHWATER, REDUCE BY ~3% FOR SEAWATER)	197 g (7.0 oz) Wiper version		
MAX PRESSURE RATING	150 PSI		
POWER INPUT	Input: 8 to 36 VDC (1.2 W) Reading: 7 mA @ 16 VDC Wiping: 20 mA @ 16 VDC Idle: 4 mA @16 VDC		
OUTPUT OPTIONS	Modbus RS-485		
ENVIRONMENTAL RATING	On all units: IP68 with RDO-S Cap installed and cable attached; IP67 without RDO-Cap installed or cable detached On wiper units: IP68 with wiper brush installed; IP67 without wiper brush installed		
SOFTWARE SUPPORT	VuSitu and HydroVu		
WARRANTY	2 years from date of shipment		

NOTES: [1]In-Situ, Inc., EPA Approves Optical RDO Method, In-Situ Technical Note, 1–4, https://media.in-situ.com/FDUAXN8W/as/q655hshq8r4b9jgmwxxjwjqs/EPA_Approves_RDO_Method_TechNote, n.d. [2]Published DO accuracy spec may require a user calibration to achieve. [3]Published Conductivity accuracy spec may require a user calibration to achieve. Accuracy above 350,000 µS/cm is unspecified, but the unit will continue to provide readings.

in-situ.com

Appendix

Appendix A: Parameter Numbers and Locations

ID	PARAMETER NAME	HOLDING REGISTER NUMBER	REGISTER ADDRESS	DEFAULT UNITS
1	Temperature	45451	5450	1 = °C
9	Actual Conductivity	45507	5506	65 = µS/cm
10	Specific Conductivity	45514	5513	65 = µS/cm
11	Resistivity	45521	5520	81 = ohm-cm
12	Salinity	45528	5527	97 = PSU
13	Total Dissolved Solids	45535	5534	114 = ppt
14	Density of Water	45542	5541	129 = g/cm^3
20	Dissolved Oxygen Concentration	45584	5583	117 = mg/L
21	Dissolved Oxygen % Saturation	45591	5590	177 = % Saturation
30	Oxygen Partial Pressure	45654	5653	26 = torr

Appendix B: Unit IDs

ID	ABBREVIATION	UNITS
TEMPERATURE		
1	C	Celsius
2	F	Fahrenheit
CONDUCTIVITY		
65	µS/cm	Microsiemens per centimeter
66	mS/cm	Millisiemens per centimeter
RESISTIVITY		
81	ohm-cm	Ohm-centimeters
SALINITY		
97	PSU	Practical Salinity Units
98	ppt	Parts per thousand salinity
TOTAL DISSOLVED SOLIDS		
113	ppm	Parts per million
114	ppt	Parts per thousand
CONCENTRATION		
117	mg/L	Milligrams per liter
118	µg/L	Micrograms per liter
DENSITY		
129	g/cm^3	Grams per cubic centimeter
DISSOLVED OXYGEN (DO) % SATURATION		
177	% sat	Percent saturation
PARTIAL PRESSURE		
26	torr	Torr