Product Manual

Sensor

CSIM11

pH and ORP Probes

Revision: 06/2022

CSL I.D - 677

RELIABLE SINCE 1974 MONITORING

CAMPBELL SCIENTIFIC

Guarantee

This equipment is guaranteed against defects in materials and workmanship. We will repair or replace products which prove to be defective during the guarantee period as detailed on your invoice, provided they are returned to us prepaid. The guarantee will not apply to:

- Equipment which has been modified or altered in any way without the written permission of Campbell Scientific
- Batteries
- Any product which has been subjected to misuse, neglect, acts of God or damage in transit.

Campbell Scientific will return guaranteed equipment by surface carrier prepaid. Campbell Scientific will not reimburse the claimant for costs incurred in removing and/or reinstalling equipment. This guarantee and the Company's obligation thereunder is in lieu of all other guarantees, expressed or implied, including those of suitability and fitness for a particular purpose. Campbell Scientific is not liable for consequential damage.

Please inform us before returning equipment and obtain a Repair Reference Number whether the repair is under guarantee or not. Please state the faults as clearly as possible, and if the product is out of the guarantee period it should be accompanied by a purchase order. Quotations for repairs can be given on request. It is the policy of Campbell Scientific to protect the health of its employees and provide a safe working environment, in support of this policy a "Declaration of Hazardous Material and Decontamination" form will be issued for completion.

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Note that goods sent air freight are subject to Customs clearance fees which Campbell Scientific will charge to customers. In many cases, these charges are greater than the cost of the repair.

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WHEN MEASUREMENTS MATTER

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About this manual

Please note that this manual was originally produced by Campbell Scientific Inc. primarily for the North American market. Some spellings, weights and measures may reflect this origin.

Some useful conversion factors:

Area:	1 in^2 (square inch) = 645 mm^2	**Mass:**	1 oz. (ounce) = 28.35 g 1 lb (pound weight) = 0.454 kg
Length:	1 in. (inch) = 25.4 mm 1 ft (foot) = 304.8 mm 1 yard = 0.914 m 1 mile = 1.609 km	**Pressure:**	1 psi (lb/in^2) = 68.95 mb
		Volume:	1 UK pint = 568.3 ml 1 UK gallon = 4.546 litres 1 US gallon = 3.785 litres

In addition, while most of the information in the manual is correct for all countries, certain information is specific to the North American market and so may not be applicable to European users.

Differences include the U.S standard external power supply details where some information (for example the AC transformer input voltage) will not be applicable for British/European use. *Please note, however, that when a power supply adapter is ordered it will be suitable for use in your country.*

Reference to some radio transmitters, digital cell phones and aerials may also not be applicable according to your locality.

Some brackets, shields and enclosure options, including wiring, are not sold as standard items in the European market; in some cases alternatives are offered. Details of the alternatives will be covered in separate manuals.

Part numbers prefixed with a "#" symbol are special order parts for use with non-EU variants or for special installations. Please quote the full part number with the # when ordering.

Recycling information

At the end of this product's life it should not be put in commercial or domestic refuse but sent for recycling. Any batteries contained within the product or used during the products life should be removed from the product and also be sent to an appropriate recycling facility.

Campbell Scientific Ltd can advise on the recycling of the equipment and in some cases arrange collection and the correct disposal of it, although charges may apply for some items or territories.

For further advice or support, please contact Campbell Scientific Ltd, or your local agent.

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Safety

DANGER — MANY HAZARDS ARE ASSOCIATED WITH INSTALLING, USING, MAINTAINING, AND WORKING ON OR AROUND **TRIPODS, TOWERS, AND ANY ATTACHMENTS TO TRIPODS AND TOWERS SUCH AS SENSORS, CROSSARMS, ENCLOSURES, ANTENNAS, ETC**. FAILURE TO PROPERLY AND COMPLETELY ASSEMBLE, INSTALL, OPERATE, USE, AND MAINTAIN TRIPODS, TOWERS, AND ATTACHMENTS, AND FAILURE TO HEED WARNINGS, INCREASES THE RISK OF DEATH, ACCIDENT, SERIOUS INJURY, PROPERTY DAMAGE, AND PRODUCT FAILURE. TAKE ALL REASONABLE PRECAUTIONS TO AVOID THESE HAZARDS. CHECK WITH YOUR ORGANIZATION'S SAFETY COORDINATOR (OR POLICY) FOR PROCEDURES AND REQUIRED PROTECTIVE EQUIPMENT PRIOR TO PERFORMING ANY WORK.

Use tripods, towers, and attachments to tripods and towers only for purposes for which they are designed. Do not exceed design limits. Be familiar and comply with all instructions provided in product manuals. Manuals are available at www.campbellsci.eu or by telephoning +44(0) 1509 828 888 (UK). You are responsible for conformance with governing codes and regulations, including safety regulations, and the integrity and location of structures or land to which towers, tripods, and any attachments are attached. Installation sites should be evaluated and approved by a qualified engineer. If questions or concerns arise regarding installation, use, or maintenance of tripods, towers, attachments, or electrical connections, consult with a licensed and qualified engineer or electrician.

General

- Prior to performing site or installation work, obtain required approvals and permits. Comply with all governing structure-height regulations, such as those of the FAA in the USA.
- Use only qualified personnel for installation, use, and maintenance of tripods and towers, and any attachments to tripods and towers. The use of licensed and qualified contractors is highly recommended.
- Read all applicable instructions carefully and understand procedures thoroughly before beginning work.
- Wear a **hardhat** and **eye protection**, and take **other appropriate safety precautions** while working on or around tripods and towers.
- **Do not climb** tripods or towers at any time, and prohibit climbing by other persons. Take reasonable precautions to secure tripod and tower sites from trespassers.
- Use only manufacturer recommended parts, materials, and tools.

Utility and Electrical

- **You can be killed** or sustain serious bodily injury if the tripod, tower, or attachments you are installing, constructing, using, or maintaining, or a tool, stake, or anchor, come in **contact with overhead or underground utility lines**.
- Maintain a distance of at least one-and-one-half times structure height, or 20 feet, or the distance required by applicable law, **whichever is greater**, between overhead utility lines and the structure (tripod, tower, attachments, or tools).
- Prior to performing site or installation work, inform all utility companies and have all underground utilities marked.
- Comply with all electrical codes. Electrical equipment and related grounding devices should be installed by a licensed and qualified electrician.

Elevated Work and Weather

- Exercise extreme caution when performing elevated work.
- Use appropriate equipment and safety practices.
- During installation and maintenance, keep tower and tripod sites clear of un-trained or non-essential personnel. Take precautions to prevent elevated tools and objects from dropping.
- Do not perform any work in inclement weather, including wind, rain, snow, lightning, etc.

Maintenance

- Periodically (at least yearly) check for wear and damage, including corrosion, stress cracks, frayed cables, loose cable clamps, cable tightness, etc. and take necessary corrective actions.
- Periodically (at least yearly) check electrical ground connections.

WHILE EVERY ATTEMPT IS MADE TO EMBODY THE HIGHEST DEGREE OF SAFETY IN ALL CAMPBELL SCIENTIFIC PRODUCTS, THE CUSTOMER ASSUMES ALL RISK FROM ANY INJURY RESULTING FROM IMPROPER INSTALLATION, USE, OR MAINTENANCE OF TRIPODS, TOWERS, OR ATTACHMENTS TO TRIPODS AND TOWERS SUCH AS SENSORS, CROSSARMS, ENCLOSURES, ANTENNAS, ETC.

Table of contents

1. Introduction

The CSIM11 measures the full pH range of liquids. The CSIM11-ORP measures oxidation reduction potential (ORP) of liquids. They can be submerged in water or inserted into tanks, pipelines, and open channels. The reference solutions and bulb configuration are optimized for natural water applications. Alternate reference solutions and bulb configurations are available. Contact Campbell Scientific for more information.

> **NOTE:**
> This manual provides information only for CRBasic data loggers. For retired Edlog data logger support, see an older manual at www.campbellsci.com/old-manuals.

2. Precautions

- READ AND UNDERSTAND the Safety section at the front of this manual.
- Do not store the sensor in distilled water, as the gel layer will become depleted. If this happens, the gel layer can often be rehydrated by soaking the sensor in the pH 4 buffer solution overnight.
- Platinum ORP probes should not be used for ozone or peroxide applications, where platinum will act as a catalyst and the expected potential will not form in the case of low concentrations. The use of gold, rather than platinum, is suitable in these applications.
- The CSIM11/CSIM11-ORP is intended for non-pressurized systems and is not designed for applications above 30 psi. Please contact Campbell Scientific for recommendations on probes suitable for installations in pressurized pipes.

3. Initial inspection

- Upon receipt of the CSIM11/CSIM11-ORP inspect the packaging and contents for damage. File damage claims with the shipping company.

- The CSIM11/CSIM11-ORP is shipped with a wetting cap covering the measuring end. This cap contains a solution of pH 4 buffer saturated with potassium chloride (KCl).
- While unpacking the CSIM11/CSIM11-ORP, carefully handle the electrodes.
- The model number and cable length are printed on a label at the connection end of the cable. Check this information against the shipping documents to ensure the expected product and cable length were received.

4. QuickStart

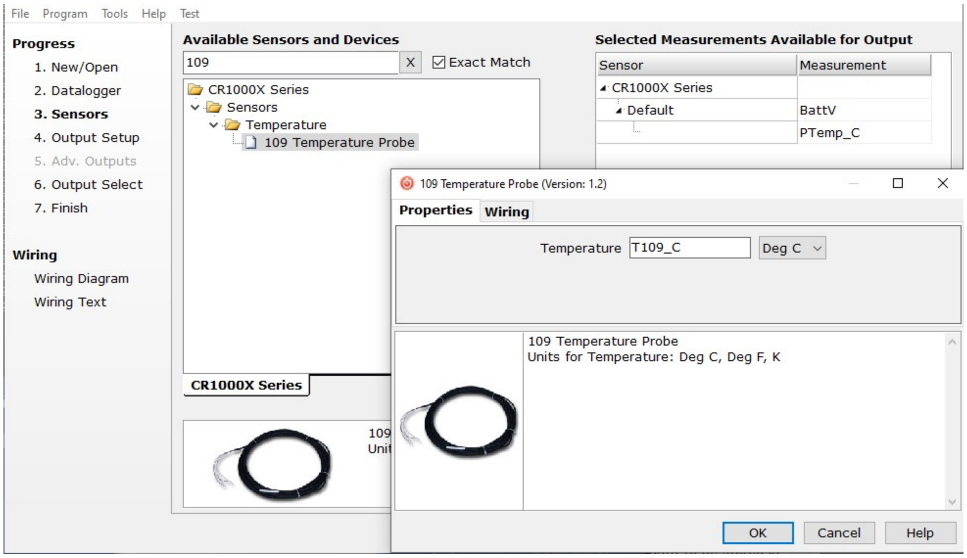
A video that describes data logger programming using ***Short Cut*** is available at: www.campbellsci.eu/videos/cr1000x-data logger-getting-started-program-part-3. ***Short Cut*** is an easy way to program your data logger to measure the sensor and assign data logger wiring terminals. ***Short Cut*** is available as a download on www.campbellsci.eu. It is included in installations of ***LoggerNet***, ***RTDAQ***, and ***PC400***.

The following procedure also shows using ***Short Cut*** to program the CSIM11/CSIM11-ORP.

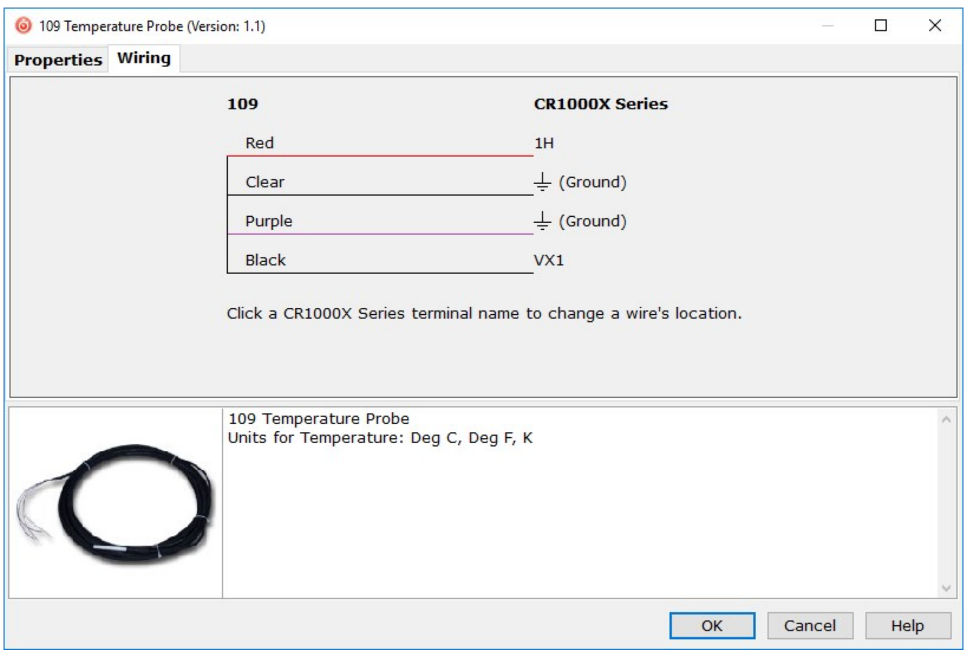
1. Open ***Short Cut*** and click **Create New Program**.
2. Double-click the data logger model.

> NOTE:
> The CSIM11 requires a reference temperature measurement for accurate readings. This example uses the 109 Temperature Probe. The CSIM11-ORP does not require a temperature reading.

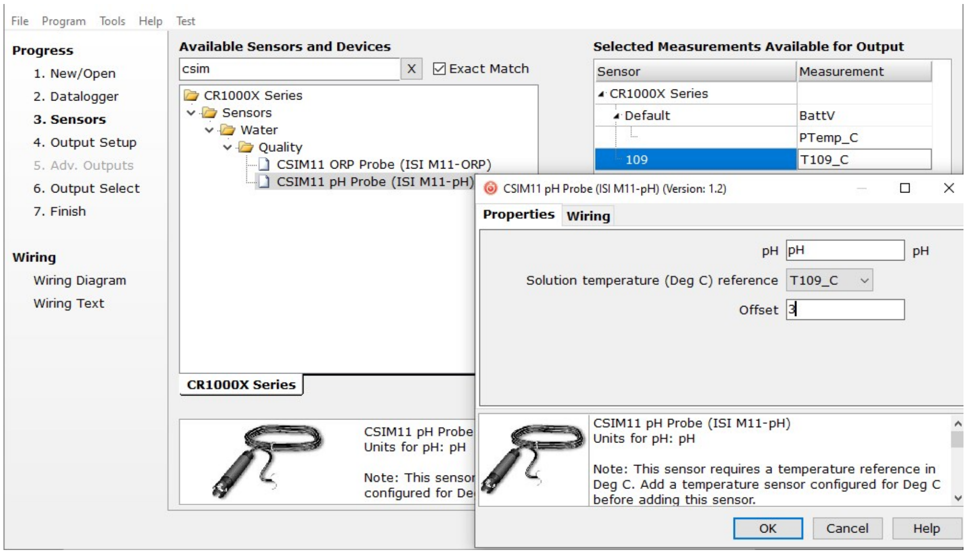
3. In the **Available Sensors and Devices** box, type 109 or find the 109 in the **Sensors** >**Temperature** folder. Double-click the **109 Temperature Probe**. Use the default of **Deg C**.



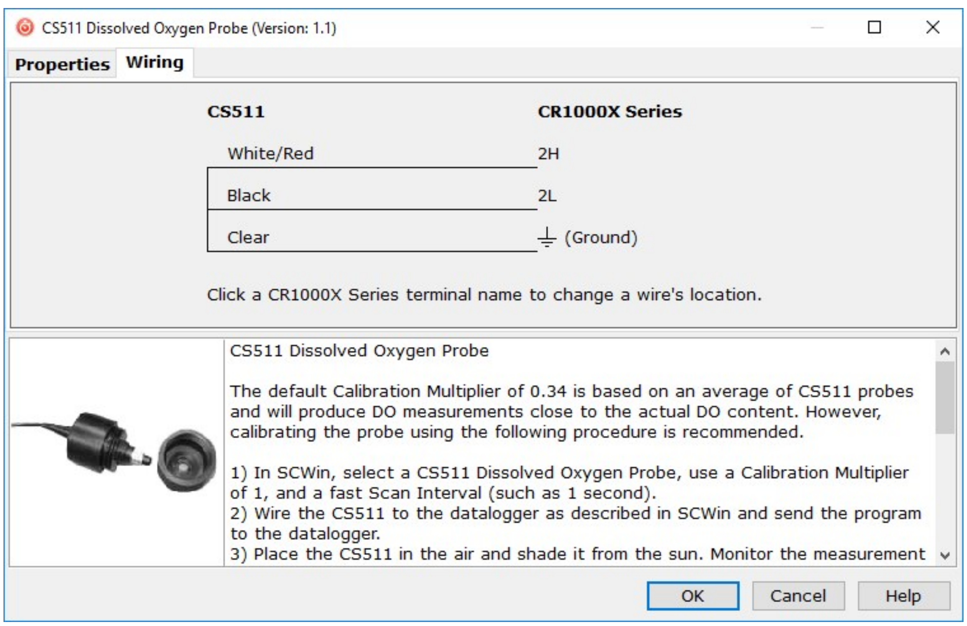
4. Click the **Wiring** tab to see how the sensor is to be wired to the data logger. Click **OK** after wiring the sensor.



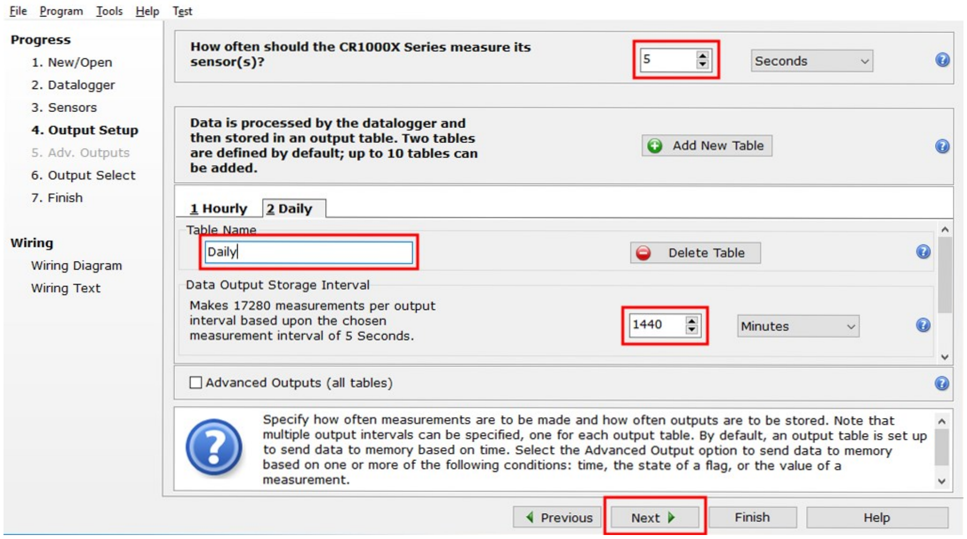
5. In the **Available Sensors and Devices** box, type CSIM11/CSIM11-ORP or locate the sensor in the **Sensors** > **Water** > **Quality** folder. Double-click the **CSIM11 pH Probe (ISI M11-pH)**. Click the **Solution temperature (Deg C) reference** box and select the reference temperature variable (**T109_C**). The white panel at the bottom of the **Properties** window provides a procedure for determining the value that should be entered in the **Offset** box.



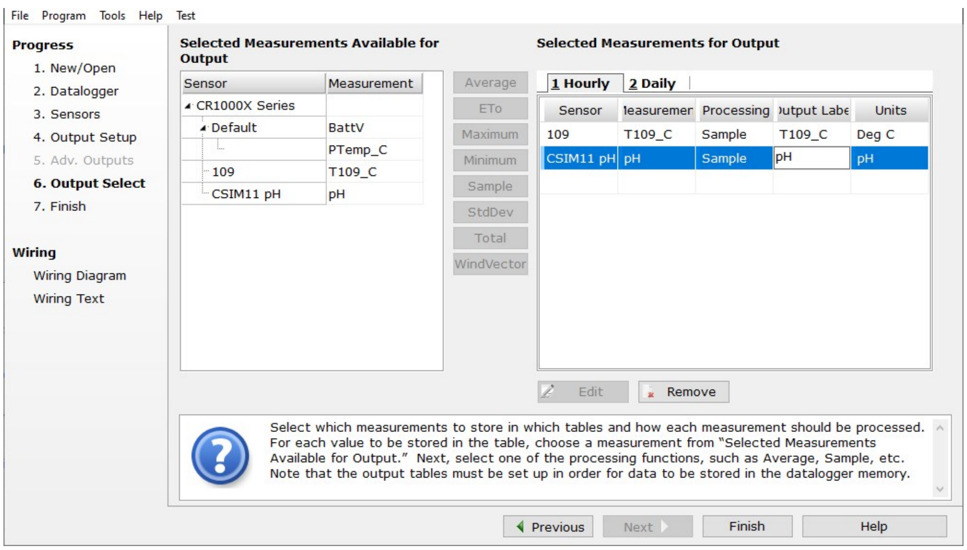
6. Click the **Wiring** tab to see how the sensor is to be wired to the data logger. Click **OK** after wiring the sensor.



7. In **Output Setup**, type the scan rate, meaningful table names, and **Data Output Storage Interval**. Click **Next**.



8. Select the measurement and its associated output option.



9. Click **Finish** and save the program. Send the program to the data logger if the data logger is connected to the computer.
10. If the sensor is connected to the data logger, check the output of the sensor in the data display in ***LoggerNet***, ***RTDAQ***, or ***PC400*** to make sure it is making reasonable measurements.

5. Overview

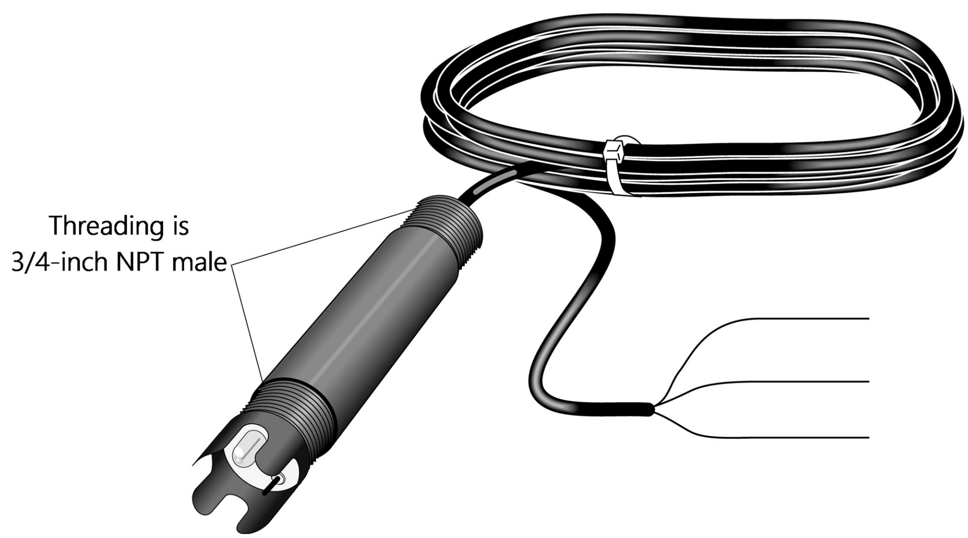
The CSIM11/CSIM11-ORP is manufactured by Wedgewood Analytical, and wired by Campbell Scientific.

The CSIM11/CSIM11-ORP has a plunger-style pH glass electrode that allows it to be mounted at any angle. Its porous polytetrafluoroethylene (PTFE) liquid junction is less susceptible to clogging as compared to conventional reference junctions.

The outer body is made of polyphenylene sulfide (PPS). A titanium ground rod runs inside the PPS outer body to eliminate ground loop errors. An internal amplifier boosts the signal, decreasing signal interference. The amplifier is powered by two internal lithium batteries, and thus does not require any power from the data logger. These batteries are designed to last the lifetime of the probes. The life expectancy of the CSIM11/CSIM11-ORP is between 6 months to 2 years, depending on the conditions of the water.

The CSIM11-ORP probe is identical to the CSIM11 pH probe except the measuring electrode uses a large surface area platinum band, making the probe responsive to the electron activity in the fluid. The platinum band helps prevent organic coating, a common source of error in many types of sensors. The practical range of the probe is –700 to +1100 mV, which is also the approximate range of ORP in natural and runoff waters.

Platinum ORP probes should not be used for ozone or peroxide applications, where platinum will act as a catalyst and the expected potential will not form in the case of low concentrations. The use of gold, rather than platinum, is suitable in these applications.



Features:

- Internal amplifier boosts the signal, decreasing signal interference
- Titanium ground rod runs inside the outer body to eliminate ground loop errors
- Porous PTFE liquid junction (patent number 4,128,468) is less susceptible to clogging as compared to conventional reference junctions
- Plunger-style pH glass electrode (patent number 4,333,812) allowing the probe to be mounted at any angle
- Compatible with Campbell Scientific CRBasic data loggers: CR6, CR1000X, CR800-series, CR3000, and CR1000

6. Specifications

pH sensor	
pH range:	0 to 14
Zero potential:	7.0 pH ±0.2 pH
Sodium error:	< 0.05 pH in 0.1 Molar Na+ ion at 12.8 pH
Output:	±59 mV/pH unit
ORP sensor	
ORP range:	–700 to +1100 mV
Temperature range:	0 to +80 °C
Pressure range:	0 to 30 psig
Accuracy:	±0.1% over full range
Impedance:	< 1 MΩ @ 25 °C
Reference cell:	Single Junction KCl/AgCl
Body material:	ABS
Wetted materials:	ABS, PTFE, FKM, Glass, Titanium
Cable jacket material:	Polyurethane
Response time:	95% of reading in 10 s
Drift:	< 2 mV per week

Power:	Two 3 VDC lithium batteries that should last the lifetime of the sensor
Length:	17.8 cm (7.0 in)
Diameter:	3.0 cm (1.2 in)
Weight with 15 ft cable:	0.5 kg (1 lb)

7. Installation

If you are programming your data logger with ***Short Cut***, skip Wiring (p. 8) and . ***Short Cut*** does this work for you. See QuickStart (p. 2) for a ***Short Cut*** tutorial.

7.1 Preparation for use

All electrodes are shipped with a wetting cap covering the measuring end. This cap contains a solution of pH 4 buffer saturated with potassium chloride (KCl).

Remove the wetting cap before calibration. There may be some dry KCl crystals forming on the outside of the cap. These deposits are expected over time and can be wiped or rinsed off. Save the cap for future long-term storage.

Rinse the electrode with distilled water and it is ready for use.

> **CAUTION:**
> Do not store the sensor in distilled water, as the gel layer will become depleted. If this happens, the gel layer can often be rehydrated by soaking the sensor in the pH 4 buffer solution overnight.

7.2 Wiring

The CSIM11/CSIM11-ORP is connected to differential terminals. The following table shows the connections to Campbell Scientific data loggers.

Table 7-1: Wire colour, function, and data logger connections		
Wire colour	Wire function	Data logger connection
Red	Signal high	**U** configured for differential input[1], **DIFF H** (differential high, analogue-voltage input)
Green	Signal reference	**U** configured for differential input[1], **DIFF L** (differential low, analogue-voltage input)
Brown	Signal ground	⏚ (analogue ground)
[1]**U** terminals are automatically configured by the measurement instruction.		

7.3 Programming

Short Cut is the best source for up-to-date programming code for Campbell Scientific data loggers. If your data acquisition requirements are simple, you can probably create and maintain a data logger program exclusively with ***Short Cut***. If your data acquisition needs are more complex, the files that ***Short Cut*** creates are a great source for programming code to start a new program or add to an existing custom program.

> NOTE:
> ***Short Cut*** cannot edit programs after they are imported and edited in ***CRBasic Editor***.

A ***Short Cut*** tutorial is available in QuickStart (p. 2). If you wish to import ***Short Cut*** code into ***CRBasic Editor*** to create or add to a customized program, follow the procedure in Importing Short Cut code into CRBasic Editor (p. 14). This document provides programming basics for CRBasic data loggers.

The CSIM11/CSIM11-ORP voltage output is measured with the `VoltDiff()` instruction. Choose a voltage range of 2500 mV or higher. Refer to the following section for information on determining the multiplier.

7.3.1 Temperature compensation of pH measurement

> NOTE:
> The CSIM11-ORP is typically not temperature compensated. Therefore, CSIM11-ORP users can skip this section.

The CSIM11 does not automatically correct for temperature effects. To compensate for temperature variations, install a submersible temperature probe (such as Campbell Scientific 109 air temperature sensor) next to the pH probe. Temperature compensation can be calculated after the data has been retrieved from the field data logger, or immediately using data logger processing instructions. The first method requires storing the raw pH measurement and the temperature measurement in data logger final storage. After retrieving data, raw values are processed to obtain compensated values. The second method is to program the data logger to process the raw data after each measurement sequence. Both the raw data and the temperature corrected pH can be saved at the user's discretion.

7.3.2 Offset

Do the following to calculate the offset:

1. Program the data logger by using an offset of 7 if using a CSIM11 or 0 if using a CSIM11-ORP; see QuickStart (p. 2) or Programming (p. 9).
2. Connect the CSIM11/CSIM11-ORP to the data logger.
3. Place the CSIM11/CSIM11-ORP in a standard solution for several minutes until the probe reaches equilibrium.
4. Record the measurement.
5. If using the CSMI11, calculate the offset by subtracting the observed pH from the pH of the standard solution (typically 7) and adding the result to 7 (for example, 7.00 – 6.98 + 7.00 = 7.02).
6. If using the CSIM11-ORP, calculate the offset by subtracting the observed ORP (mV) from the ORP (mV) of the standard solution.
7. Change the offset in the data logger program to the calculated number.

8. Maintenance

Developing an effective maintenance schedule is incumbent on understanding the process effects that are specific to your application. A pH sensor develops a millivolt potential directly proportional to the free hydrogen ion concentration in an aqueous solution. The sensor is composed of a reference electrode and its gelled reference electrolyte, a measurement electrode exposed to the process solution, and a porous junction that maintains electrical contact between the two. Porous PTFE is the newest technology in reference junctions. Wedgewood Analytical, Inc. offers a patented porous PTFE liquid junction which is chemically inert; and is chemically compatible with virtually all chemicals.

- High temperature causes:
  - Faster response / lower impedance
  - Aging acceleration, lithium ions leached from membrane
  - Short span
- Low temperature causes slower response / higher impedance
- Measurement greater than 10.0 pH causes alkaline / sodium ion error
- Coatings can cause:
  - Slower response
  - Zero offset increase
  - Dehydration
- Steam sterilization causes:
  - Dehydration
  - Ag/AgCl dissolving from silver reference element

8.1 Electrode cleaning

PH and ORP sensors require more maintenance than many other types of sensors. The ORP platinum band can foul with algae and other biological sources. Cleaning will be required approximately every 1 to 2 weeks. Fouling can be minimized by locating the probe in a very dark place.

A coated measurement electrode may cause slow response and large offsets. The best cleaning technique depends on the type of coating.

Soft coatings, like foodstuffs or bacterial films are best removed using a squirt bottle or the water jet from a faucet. If this is not successful, wipe the electrode with a soft wet cloth.

Hard coatings, like calcium or lime scale, are best removed with a solvent appropriate for the particular coating. Use a 5 per cent solution of HCl for the calcium scale. If unsure of the proper solvent to remove a hard mineral coating, alternate between 5 per cent HCI and 4 per cent NaOH for 10 minutes each. After treating the electrode with these strong acids or bases, rinse the electrode with water and soak it in pH 4 buffer for at least a half hour.

Use a a detergent solution or a solvent that will not attack the electrode body to remove greasy and oily coatings. Methanol and isopropyl alcohol are good choices for solvents. A soft toothbrush can be used with the detergent to remove stubborn coatings.

WARNING:
Acetone, MEK, THF, or trichloroethane will irreparably harm the electrode.

If surface cleaning does not restore proper function, the pores of the reference junction may be clogged. The electrode should then be heated to 60 °C in 3 molar KCl and allowed to cool in the same solution. Rinse it with distilled water and soak in pH 4 buffer for half an hour before testing. The electrolyte should be removed and replaced with fresh electrolyte before treating as above.

Electrodes age with time and eventually become desensitized. Extended periods of service at temperatures greater than 80 °C or exposure to deionized water accelerate this phenomenon. As a last resort, dip the electrode in a 10 per cent ammonium bifluoride solution for 10 to 20 seconds, then rinse it with tap water and soak it in 5-6 molar HCl for 30 seconds. Rinse it with tap water and soak it in pH 4 buffer for half an hour before testing.

The platinum sensing tip of an ORP electrode should be cleaned just like a pH electrode. The surface can also be cleaned with an abrasive as a last resort. Gently scour the platinum with a 600 grit wet emery cloth or preferably 1-3 micron alumina polishing powder.

8.2 Replacing reference electrolyte

Check the electrolytes when the readings start to drift.

Refill procedure:

1. Clean the probe tip as discussed in the maintenance procedures below.
2. Remove the reference reservoir plug. Place it where it will stay clean.
3. Rinse the reservoir with deionized water repeatedly to remove the old solution. Drain out all remaining water.
4. Completely fill the reservoir with the new reference solution. It does not take very much. Make sure you keep the bottle tip clean, and replace the bottle cap immediately after using the bottle.

   NOTE:
   The bottle of refill solution contains undissolved salts; this is to ensure the solution remains saturated.

5. Replace the red plug applying new pipe tape. Make sure the plug is screwed back in as far as it was originally.

Because the new reference solution is viscous, the reference solution may take a few minutes to settle. If necessary, take the probe in hand and gently swing it in a downward arc to speed the flow of solution and remove air pockets. Add more solution as needed to completely fill the reservoir.

8.3 Troubleshooting

Symptom: Probe pegs at 14 pH or drifts off scale high.

Possible reason: Open circuit in either glass electrode or reference electrode.

Check:

1. Visually inspect cable and connector looking for a crushed or broken cable jacket or a brittle cable jacket due to exposure to solar radiation. Discard electrode if damage is present.
2. Move wires at data logger to test for intermittent connection. Tighten connectors if necessary.
3. Visually inspect bulb for a coating. If coated, use an appropriate solvent or a high-quality detergent with a cotton swab to wipe bulb clean. Rinse well with distilled water; soak in 4.0 buffer for at least 10 minutes, retest. If electrode now responds, but erratically, soak in 10 per cent HCl solution for five (5) minutes, rinse well with distilled water; soak in 4.0 buffer for at least 10 minutes, retest.
4. Visually inspect reference junction (large white surface at front of sensor). If coated, clean by rinsing well; retest. If electrode still reads high, place sensor in 3.5 molar KCl, or water if KCl is not available, and heat to approximately 60 °C for 15 minutes; retest.

Symptom: Slow response and/or noisy, erratic readings.

Possible reason: Slow response is caused by a very high impedance in either glass or reference electrode.

Check:

1. Visually inspect pH bulb and reference junction for coating or clogging. If coated, clean as described in Electrode cleaning (p. 11).

Appendix A. Importing ***Short Cut*** code into ***CRBasic Editor***

Short Cut creates a .DEF file that contains wiring information and a program file that can be imported into the ***CRBasic Editor***. By default, these files reside in the C:\campbellsci\SCWin folder.

Import ***Short Cut*** program file and wiring information into ***CRBasic Editor***:

1. Create the ***Short Cut*** program. After saving the ***Short Cut*** program, click the **Advanced** tab then the **CRBasic Editor** button. A program file with a generic name will open in CRBasic. Provide a meaningful name and save the CRBasic program. This program can now be edited for additional refinement.

   > NOTE:
   > Once the file is edited with ***CRBasic Editor***, ***Short Cut*** can no longer be used to edit the program it created.

2. To add the ***Short Cut*** wiring information into the new CRBasic program, open the .DEF file located in the C:\campbellsci\SCWin folder, and copy the wiring information, which is at the beginning of the .DEF file.
3. Go into the CRBasic program and paste the wiring information into it.
4. In the CRBasic program, highlight the wiring information, right-click, and select **Comment Block**. This adds an apostrophe (') to the beginning of each of the highlighted lines, which instructs the data logger compiler to ignore those lines when compiling. The **Comment Block** feature is demonstrated at about 5:10 in the CRBasic | Features video ▶.

Appendix B. Example program

The following CR1000X program measures a CSIM11/CSIM11-ORP and 109 temperature sensor and has the data logger process the raw data after each measurement sequence.

CRBasic Example 1: CR1000X program that measures the CSIM11/CSIM11-ORP and 109

```
'CR1000X Series Data logger

'declare variables
Public pH, pHMult, TempC

'Define Data Tables
DataTable (pH,1,-1)
  DataInterval (0,1,Min,10)
  Sample (1,pH,FP2)
  Sample (1,TempC,FP2)
EndTable

'Main Program
BeginProg
  Scan (60,Sec,0,0)

    'measure water temperature
    Therm109 (TempC,1,3,Vx1,0,15000,1.0,0)

    'calculate the Multiplier for Temperature Correction
    pHMult = -1/ (((TempC + 273) / 298) * 59)

    'measure pH (note this is without the multiplier and offset)
    VoltDiff (pH,1,mV5000,1,True ,0,60,1.0,0)

    pH=pH*pHMult 'now apply Correction Multiplier to measured pH
    pH=pH + 7 '... and the offset -- initially with a value of 7, adjusting as
    'necessary during probe calibration

    CallTable pH 'output data once per minute
  NextScan
EndProg
```

Appendix C. Detailed calibration and manufacturer tips

CAUTION:
Good laboratory practices should be used and protective gloves and safety glasses should be worn while handling any solvents or chemicals. If you are unsure of the proper technique for handling a chemical or of its hazardous properties, it is best to discard the electrode eliminating the risk of danger.

Materials:

- Buffers
  - 4.01 pH (potassium bipthalate)
  - 7.00 pH (potassium phosphate)
  - 10.00 pH (sodium borate and carbonate)
- Thermometer
- Beakers
- Data logger programmed to read the pH probe

Procedure:

1. Fill beakers with appropriate buffers and continuously measure the temperature of the buffer in use. If possible, temperature should be at equilibrium (probe and buffers) before continuing with calibration.
2. Calculate the Nernst temperature compensation for the probe's current temperature and adjust the multiplier in the `VoltDiff()` instruction to the appropriate value. The slope change is usually taken to be –0.2 pH/mV/°C. Examples of adjusted multipliers would be the multiplicative inverse of the following slopes: –58 mV/pH at 20 °C, –59 mV/pH at 25 °C, and –60 mV/pH at 30 °C.
3. Zero the pH probe (pH 7 corresponds to 0.0 mV at 25 °C) by placing the electrode in a 7.0 buffer with the probe connected to the data logger. Place the data logger in real time monitor mode. Electrode should read 7.0 (or whatever the solution pH should be at the present temperature) ±0.2 pH.

4. Using the offset in the `VoltDiff()` instruction, adjust the data logger to read 7.0 pH, or whatever the solution pH should be at the present temperature.
5. Remove the probe from the pH buffer, rinse the electrode with distilled water, and place in 4.01 buffer.
6. Place data logger in real time monitoring mode. The electrode should read 4.01 ±0.2, depending on temperature.
7. Remove and rinse the electrode, then place it in the 10.00 buffer.

Tips and techniques:

- Stirring the buffers and samples improves the stability and speed of response of the measurement.
- Rinse the electrode with distilled water between samples and lightly blot the water on a paper towel before immersing it in the next sample. Never wipe the pH bulb since dust may scratch the delicate gel layer impairing response.
- Rinsing the electrode with a small amount of the sample before immersing it will eliminate any contamination of the sample.
- The simplest form of temperature compensation compensates for the change in the electrode's slope due to temperature, in accordance with the Nernst factor. It does not compensate for changes in the actual pH of the sample that occurs with a change in temperature. The pH of a sample at 25 °C is most likely different than the pH of that same sample at 75 °C.
- The temperature of the electrode, the sample, and the calibration buffers should be the same. Allow the electrode to come to temperature equilibrium with the sample before recording the measurement value. Measurements made more than 20 °C from the calibration temperature should include a one-point calibration at that temperature for maximum accuracy.
- Low ionic strength samples, highly viscous samples, and salt brine slow the speed of response of the electrode. While the electrode will be stable to a change in pH buffers after 10 to 15 seconds, it may take up to five minutes for the electrode to stabilize in a difficult sample.

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