INSTRUCTION MANUAL

# CSIM11 pH and ORP Probes

®

# *Limited Warranty*

The CSIM11 pH and ORP Probes are warranted for six (6) months subject to this limited warranty:

"Products manufactured by CSI are warranted by CSI to be free from defects in materials and workmanship under normal use and service for twelve months from the date of shipment unless otherwise specified in the corresponding product manual. (Product manuals are available for review online at *www.campbellsci.com*.) Products not manufactured by CSI, but that are resold by CSI, are warranted only to the limits extended by the original manufacturer. Batteries, fine-wire thermocouples, desiccant, and other consumables have no warranty. CSI's obligation under this warranty is limited to repairing or replacing (at CSI's option) defective Products, which shall be the sole and exclusive remedy under this warranty. The Customer assumes all costs of removing, reinstalling, and shipping defective Products to CSI. CSI will return such Products by surface carrier prepaid within the continental United States of America. To all other locations, CSI will return such Products best way CIP (port of entry) per Incoterms ® 2010. This warranty shall not apply to any Products which have been subjected to modification, misuse, neglect, improper service, accidents of nature, or shipping damage. This warranty is in lieu of all other warranties, expressed or implied. The warranty for installation services performed by CSI such as programming to customer specifications, electrical connections to Products manufactured by CSI, and Product specific training, is part of CSI's product warranty. **CSI EXPRESSLY DISCLAIMS AND EXCLUDES ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE**. **CSI hereby disclaims, to the fullest extent allowed by applicable law, any and all warranties and conditions with respect to the Products, whether express, implied or statutory, other than those expressly provided herein.**"

# *Assistance*

Products may not be returned without prior authorization. The following contact information is for US and international customers residing in countries served by Campbell Scientific, Inc. directly. Affiliate companies handle repairs for customers within their territories. Please visit *www.campbellsci.com* to determine which Campbell Scientific company serves your country.

To obtain a Returned Materials Authorization (RMA), contact CAMPBELL SCIENTIFIC, INC., phone (435) 227-9000. After an application engineer determines the nature of the problem, an RMA number will be issued. Please write this number clearly on the outside of the shipping container. Campbell Scientific's shipping address is:

**CAMPBELL SCIENTIFIC, INC.**
RMA#_____
815 West 1800 North
Logan, Utah 84321-1784

For all returns, the customer must fill out a "Statement of Product Cleanliness and Decontamination" form and comply with the requirements specified in it. The form is available from our web site at *www.campbellsci.com/repair*. A completed form must be either emailed to *repair@campbellsci.com* or faxed to (435) 227-9106. Campbell Scientific is unable to process any returns until we receive this form. If the form is not received within three days of product receipt or is incomplete, the product will be returned to the customer at the customer's expense. Campbell Scientific reserves the right to refuse service on products that were exposed to contaminants that may cause health or safety concerns for our employees.

# *Precautions*

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.com or by telephoning (435) 227-9000 (USA).  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, 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*

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# *CSIM11 pH and ORP Probes*

## 1. Introduction

The CSIM11 measures the full pH range of liquids, and 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.

## 2. Cautionary Statements

- READ AND UNDERSTAND the *Precautions* 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.

## 3. Initial Inspection

- Remove the CSIM11 or CSIM11-ORP from its package and check that it is undamaged. If damaged, contact your supplier for replacement.

- Care should be taken when unpacking and handling all electrodes.

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

## 4. Quickstart

*Short Cut* is an easy way to program your datalogger to measure the CSIM11 and CSIM11-ORP and assign datalogger wiring terminals. Use the following procedures to get started.

### 4.1 CSIM11 Tutorial

**NOTE**    A temperature measurement is required. For this tutorial, the 107-L thermistor is used.

1. Install *Short Cut* by clicking on the install file icon. Get the install file from either *www.campbellsci.com*, the ResourceDVD, or find it in installations of *LoggerNet*, *PC200W*, *PC400*, or *RTDAQ* software.

2. The *Short Cut* installation should place a *Short Cut* icon on the desktop of your computer. To open *Short Cut*, click on this icon.



3. When *Short Cut* opens, select **New Program**.
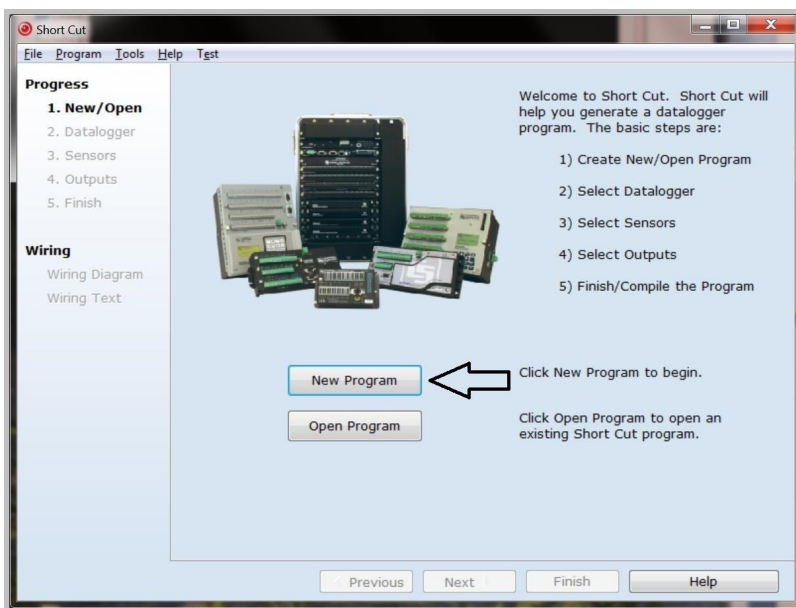


4. Select **Datalogger Model** and **Scan Interval** (default of 5 seconds is alright for most applications). Click **Next**.

5.  Under the **Available Sensors and Devices** list, select the **Sensors |
    Temperature** folder. Select **107 Temperature Probe**. Click ![arrow] to
    move the selection to the **Selected** device window. Use the data default of
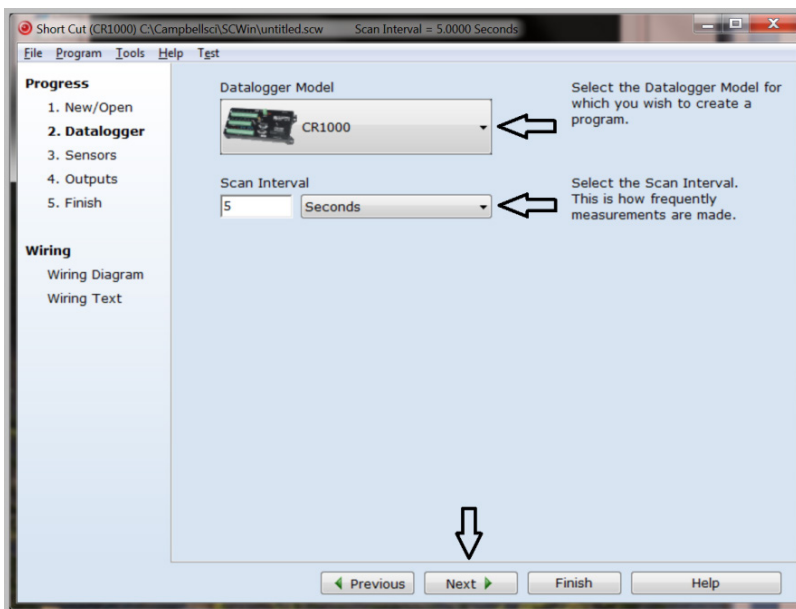    degree Celsius.
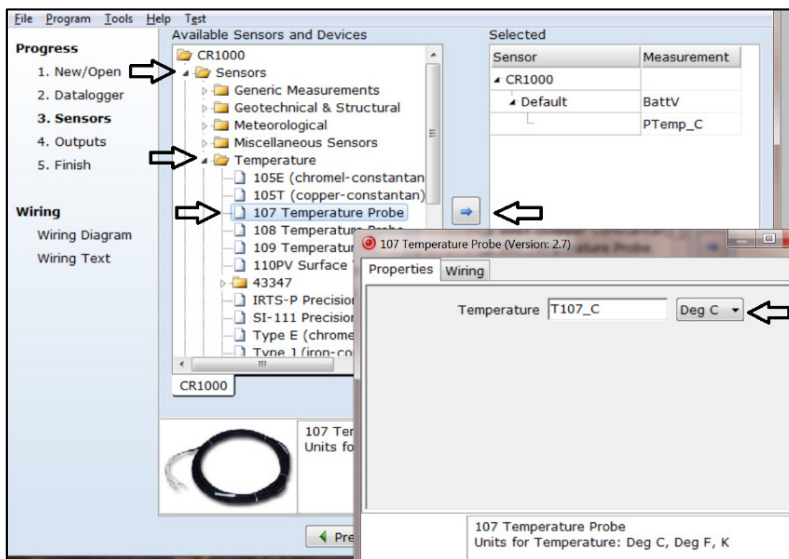


6.  Under the **Available Sensors and Devices** list, select the **Sensors | Water |
    Quality** folder. Select **CSIM11 pH Probe**. Click ![arrow] to move the
    selection to the **Selected** device window. Click on the **Solution
    temperature (Deg C) reference** box and select **T107_C**. The probe
    usually requires an offset adjustment. 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.

7. After selecting the sensors, click at the left of the screen on **Wiring Diagram** to see how the sensor is to be wired to the datalogger. The wiring diagram can be printed out now or after more sensors are added.



8. Select any other sensors you have, then finish the remaining *Short Cut* steps to complete the program. The remaining steps are outlined in *Short Cut Help*, which is accessed by clicking on **Help | Contents | Programming Steps**.

9. If *LoggerNet*, *PC400*, or *PC200W* is running on your PC, and the PC to datalogger connection is active, you can click **Finish** in *Short Cut* and you will be prompted to send the program just created to the datalogger.

10. If the sensor is connected to the datalogger, as shown in the wiring diagram in step 7, check the output of the sensor in the datalogger support software data display to make sure it is making reasonable measurements.

## 4.2 CSIM11-ORP Tutorial

1. Install *Short Cut* by clicking on the install file icon. Get the install file from either *www.campbellsci.com*, the ResourceDVD, or find it in installations of *LoggerNet*, *PC200W*, *PC400*, or *RTDAQ* software.

2.  The *Short Cut* installation should place a *Short Cut* icon on the desktop of your computer. To open *Short Cut*, click on this icon.



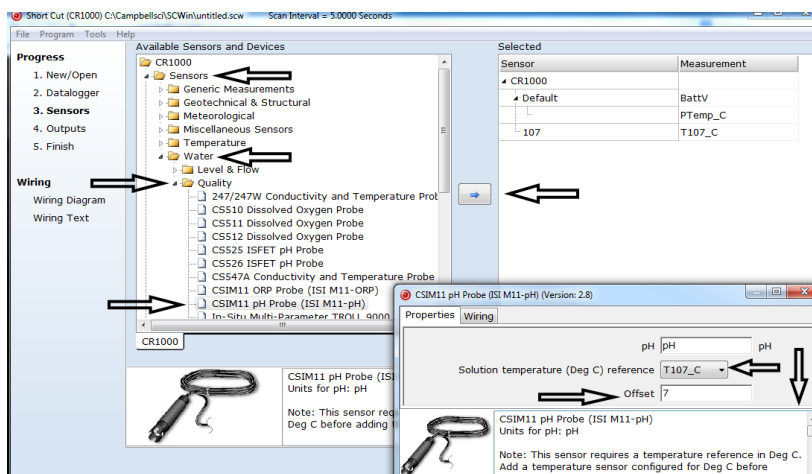3.  When *Short Cut* opens, select **New Program**.
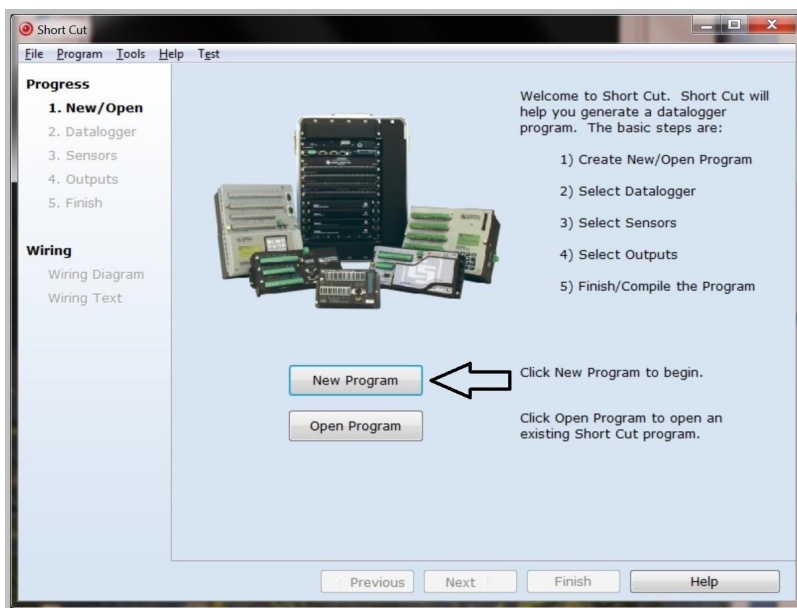


4.  Select **Datalogger Model** and **Scan Interval** (default of 5 seconds is alright for most applications). Click **Next**.
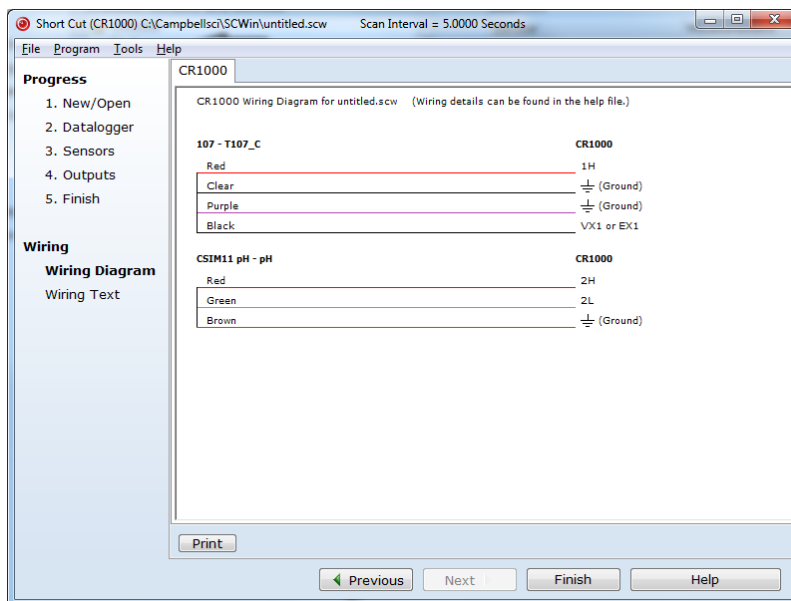
5.  Under the **Available Sensors and Devices** list, select the **Sensors | Water | Quality** folder.  Select **CSIM11 ORP Probe**.  Click [→] to move the selection to the **Selected** device window.  The probe usually requires an offset adjustment.  The white panel at the bottom of the **Properties** window provides a procedure for determining the value that should be entered in **Offset** box.
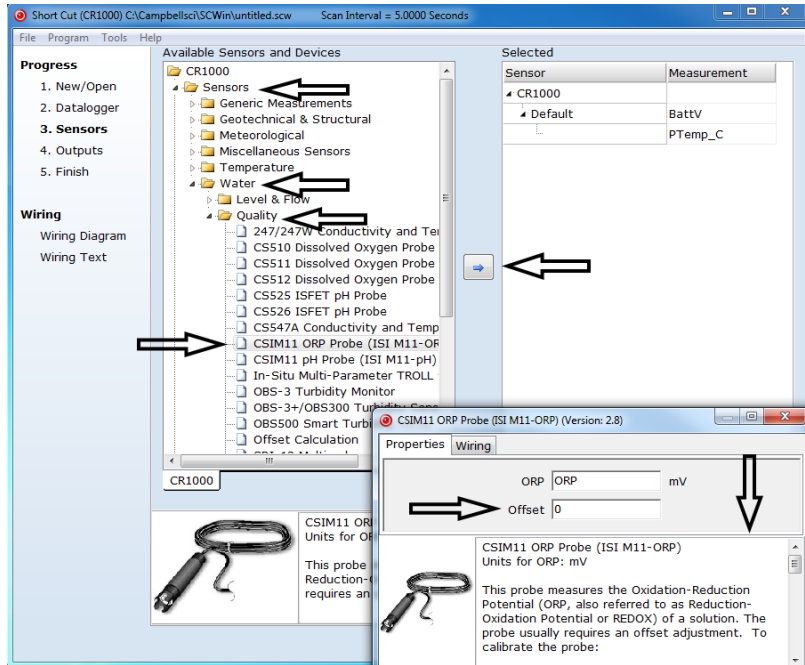


6.  After selecting the sensors, click at the left of the screen on **Wiring Diagram** to see how the sensor is to be wired to the datalogger.  The wiring diagram can be printed out now or after more sensors are added.
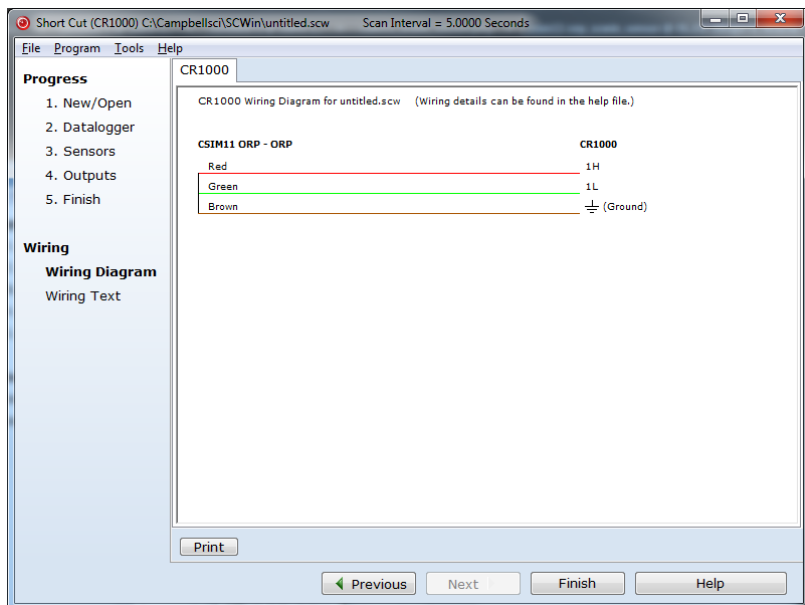
7. Select any other sensors you have, then finish the remaining *Short Cut* steps to complete the program. The remaining steps are outlined in *Short Cut Help*, which is accessed by clicking on **Help | Contents | Programming Steps**.

8. If *LoggerNet*, *PC400* or *PC200W* is running on your PC, and the PC to datalogger connection is active, you can click **Finish** in *Short Cut* and you will be prompted to send the program just created to the datalogger.

9. If the sensor is connected to the datalogger, as shown in the wiring diagram in step 6, check the output of the sensor in the datalogger support software data display to make sure it is making reasonable measurements.

# 5.   Overview

The CSIM11 and CSIM11-ORP are manufactured by Wedgewood Analytical, Inc. and wired by Campbell Scientific. They have a plunger-style pH glass electrode that allow them to be mounted at any angle. Their 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 their 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 datalogger. These batteries are designed to last the lifetime of the sensors. The life expectancy of these probes is between 6 months to 2 years, depending on the conditions of the water.

These probes are intended for non-pressurized systems and were not designed for applications above 30 psi. Please contact a Campbell Scientific water resources application engineer for recommendations on probes suitable for installations in pressurized pipes.

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.

Threading is
3/4 inch NPT
male
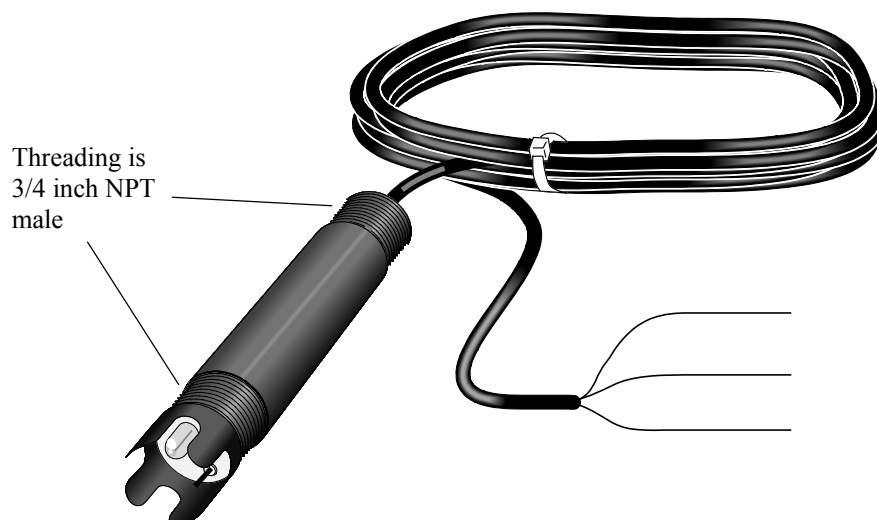
# 6. Specifications

**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 dataloggers: CR800 series, CR1000, CR3000, CR5000, and CR9000(X).  Also compatible with Edlog dataloggers: CR500, CR510, CR10(X), CR7, 21X, and CR23X

**Temperature Range:**  0 to +80 °C

**Pressure Range:**  0 to 30 psig (mounting to pressurized pipes or tanks requires a non-refillable variation of the sensor.  Contact Campbell Scientific for details)

**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) |

### 6.1.1  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 |

### 6.1.2  ORP Sensor

| | |
|---|---|
| **ORP Range:** | −700 to +1100 mV |

# 7.  Installation

If you are programming your datalogger with *Short Cut*, skip Section 7.3, *Wiring (p. 10)*, and Section 7.4, *Datalogger Programming (p. 10)*; *Short Cut* does this work for you.  See Section 4, *Quickstart (p. 1)*, 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.

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  Orientation

The CSIM11/CSIM11-ORP can be installed without regard to orientation. Unlike other pH/ORP sensors, the problem with air bubbles adversely affecting the measurement has been eliminated by Wedgewood Analytical's use of a gelled reference solution and a patented plunger technology.

## 7.3 Wiring

The CSIM11 and CSIM11-ORP are connected to differential channels. Connections to Campbell Scientific dataloggers are given in TABLE 7-1.

| | | **CR9000(X)** **CR5000** **CR3000** **CR1000** **CR800** | **CR510** **CR500** | **21X** **CR7** |
|---|---|---|---|---|
| **Color** | **Description** | **CR850** | **CR10(X)** | **CR23X** |
| Red | Signal | Differential High | Differential High | Differential High |
| Green | Signal Reference | Differential Low | Differential Low | Differential Low |
| Brown | Signal Ground | ⏚ | AG | ⏚ |

**TABLE 7-1. CSIM11/CSIM11-ORP Wiring**

Often Campbell Scientific's 107 temperature probe is used to compensate for thermal effects. TABLE 7-2 shows the connections to the 107 probe.

| | | **CR9000(X)** **CR5000** **CR3000** **CR1000** **CR800** | **CR510** **CR500** | **21X** **CR7** |
|---|---|---|---|---|
| **Color** | **Description** | **CR850** | **CR10(X)** | **CR23X** |
| Black | Voltage Excitation | EX or VX | EX | EX |
| Red | Temperature Signal | Single-ended channel | Single-ended channel | Single-ended channel |
| Purple | Signal Ground | ⏚ | AG | ⏚ |
| Clear | Shield | ⏚ | G | ⏚ |

**TABLE 7-2. 107 Wiring**

## 7.4 Datalogger Programming

*Short Cut* is the best source for up-to-date datalogger programming code. Programming code is needed,

- when creating a program for a new datalogger installation
- when adding sensors to an existing datalogger program

If your data acquisition requirements are simple, you can probably create and maintain a datalogger 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.

A *Short Cut* tutorial is available in Section 4, *Quickstart (p. 1)*.  If you wish to import *Short Cut* code into either *Edlog* or *CRBasic Editor* to create or add to a customized program, follow the procedure in Appendix A.1, *Importing Short Cut Code into a Program Editor (p. A-1)*.  Programming basics for CRBasic and Edlog dataloggers are provided in the following sections.  Complete program examples for select dataloggers can be found in Appendix B, *Example Programs (p. B-1)*.

### 7.4.1  Direct Measurement, Not Temperature Compensated

Make the measurement using a differential voltage instruction (**VoltDiff()** instruction in CRBasic or **Volt (Diff) (P2)** in Edlog).  An example from each language follows.  For ORP, the multiplier would be one and the offset would be zero.

**CRBasic**

```
VoltDiff (pH,1,mV2500,1,True ,0,_60Hz,-0.01695,7)
```

**Edlog**

```
1:  Volt (Diff) (P2)
  1:  1          Reps
  2:  5          2500 mV slow Range      ;Use 4 for 21X
  3:  1          IN Chan
  4:  1          Loc [ pH   ]
  5:  -.01695    Mult                    ;Mult = 1 for ORP
  6:  7          Offset                  ;Offset = 0 for ORP
```

### 7.4.2  Temperature Compensation of pH Measurement

The CSIM11 pH probe does not automatically correct temperature effects.  To compensate for temperature variations, install a submersible temperature probe (such as Campbell Scientific's 107 thermistor) next to the pH probe.  Temperature compensation can be calculated after the data has been retrieved from the field datalogger, or immediately using datalogger processing instructions.  The first method requires storing the raw pH measurement and the temperature measurement in datalogger final storage.  After retrieving data, raw values are processed to obtain compensated values.  The second method is to program the datalogger 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.

# 8.   Calibration/ORP Check

## 8.1   pH Sensor Calibration

Calibration should be carried out according to the detailed procedure later in this document (see Appendix C, *Detailed Calibration Procedure and Manufacturer Tips (p. C-1)*).  The following paragraphs are for general information.

The calibration should use two or more pH standards.  It is recommended that pH 7 buffer be used to check the zero point and at least an acid or alkaline buffer, that brackets the sample's pH value, be used to set the slope.

An electrode measuring many samples a day should be calibrated at least once a day.  The frequency of calibration will depend on the level of accuracy required and the coating/fouling nature of the samples being measured.

Electrodes that are continuously monitoring a sample should be checked at least once a week or whatever period experience dictates.

Grab Sample Calibration is a technique where the process electrode has been calibrated and placed on line for some period of time.  Its output is then verified by measuring the pH of a sample with another electrode.  The grab sample should be measured as soon as possible to avoid errors caused by changes in the sample's temperature or changes in the samples pH due to exposure to the atmosphere.

## 8.2   ORP Check

Check the ORP sensor when it's initially deployed and after three months of field service.  To check the sensor, place it in a known millivolt solution.  The sensor manufacturer offers +230 mV and +470 mV solutions.  If the sensor reading is within ±20 mV of the millivolt value of the solution, the sensor is operating properly.

# 9.   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 which causes 1) Faster Response / Lower Impedance; 2) Aging acceleration, Lithium Ions Leached from Membrane; 3) Short Span

- Low Temperature which causes Slower Response / Higher Impedance

- Measurement > 10.0 pH causes Alkaline / Sodium Ion Error

- Coatings can cause 1) Slower Response; 2) Zero Offset increase; 3) Dehydration

- Steam Sterilization causes 1) Dehydration; 2) Ag/AgCl dissolving from Silver Reference Element

## 9.1 Replacing Reference Electrolyte

Readings that drift indicate the electrolyte should be checked.

**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, you may need to wait a few minutes while the reference solution settles. 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.

## 9.2 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.

Slow response and large offsets may indicate the measurement electrode has become coated. The nature of the coating will dictate the type of cleaning technique that should be used.

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, then wiping with a soft wet cloth is the best choice.

Hard coatings, like calcium or lime scale are best removed with a solvent appropriate for the particular coating. A 5 percent solution of HCl would be a good choice for the calcium scale. If unsure of the proper solvent to remove a hard mineral coating, alternate between 5 percent HCl and 4 percent 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 1/2 hour.

Greasy and oily coatings are best removed with a detergent solution or a solvent that will not attack the electrode's body.  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.** |

The pores of the reference junction may become clogged and surface cleaning may not restore proper function.  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 1/2 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 percent 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 1/2 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.

# 10.  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 datalogger 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 percent 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 Section 9.2, *Electrode Cleaning (p. 13)*.

2.  Allowing a pH electrode to dry out raises the impedance dramatically. Soaking the electrode in 0.1 normal HCl for 1/2 hour and rinsing with distilled water should speed response (always keep electrodes wet).

3.  Chemical degradation of pH glass can occur rapidly in a high temperature or high pH environment.  This also increases impedance yielding sluggish response.

4.  Low temperature environments also increase impedance, with impedance doubling every 8 °C temperature drop from 25 °C.

5.  Test wiring for intermittent connections by moving wires at the connector on the datalogger wiring panel.  Tighten as necessary.  This is a common source of erratic signals.

**SYMPTOM:  No response to pH change.**

POSSIBLE REASON:  A cracked glass bulb.

CHECK:

If electrode reads between 5.8 and 6.2 pH in all solutions, visually inspect glass bulb for cracks.  Discard probe if it is cracked.

POSSIBLE REASON:  Short circuit.

CHECK:

If electrode reads 7.0 pH or 0.0 mV when connected to the datalogger, visually inspect cable for damage.  If there is no visible damage, test electrode in 4.0 buffer.

# *Appendix A.  Importing Short Cut Code*

This tutorial shows:

- How to import a *Short Cut* program into a program editor for additional refinement.
- How to import a wiring diagram from *Short Cut* into the comments of a custom program.

## A.1  Importing *Short Cut* Code into a Program Editor

*Short Cut* creates files that can be imported into either *CRBasic Editor* or *Edlog* program editor.  These files normally reside in the C:\campbellsci\SCWin folder and have the following extensions:

- .DEF (wiring and memory usage information)
- .CR1 (CR1000 datalogger code)
- .CR8 (CR800 datalogger code)
- .CR3 (CR3000 datalogger code)
- .CR5 (CR5000 datalogger code)
- .CR9 (CR9000(X) datalogger code)
- .DLD (contain code for CR10(X), CR23X, CR500, CR510, or 21X dataloggers)

The following procedures show how to import these files for editing.

### A.1.1  CRBasic Datalogger

Use the following procedure to import *Short Cut* code into *CRBasic Editor* (CR1000, CR800, CR3000, CR5000, or CR9000(X) dataloggers).

1. Create the *Short Cut* program following the procedure in Section 4, *Quickstart (p. 1)*.  Finish the program and exit *Short Cut*.  Make note of the file name used when saving the *Short Cut* program.

2. Open *CRBasic Editor*.

3. Click **File | Open**.  Assuming the default paths were used when *Short Cut* was installed, navigate to C:\CampbellSci\SCWin folder.  The file of interest has a ".CR1", ".CR8", ".CR3, ".CR5", or ".CR9" extension, for CR1000, CR800, CR3000, CR5000, or CR9000(X) dataloggers, respectively.  Select the file and click **Open**.

4. Immediately save the file in a folder different from \Campbellsci\SCWin, or save the file with a different file name.

**NOTE**     Once the file is edited with *CRBasic Editor*, *Short Cut* can no longer be used to edit the datalogger program.  Change the name of the program file or move it, or *Short Cut* may overwrite it next time it is used.

5. The program can now be edited, saved, and sent to the datalogger.

6. Import wiring information to the program by opening the associated .DEF file. Copy and paste the section beginning with heading "-Wiring for CRXXX–" into the CRBasic program, usually at the head of the file. After pasting, edit the information such that a **'** character (single quotation mark) begins each line. This character instructs the datalogger compiler to ignore the line when compiling the datalogger code.

## A.1.2  Edlog

Use the following procedure to import *Short Cut* code into the *Edlog* program editor (CR10(X), CR500, CR510, 21X, and CR23X dataloggers).

1. Create the *Short Cut* program following the procedure in Section 4, *Quickstart (p. 1)*.  Finish the program and exit *Short Cut*.  Make note of the file name used when saving the *Short Cut* program.

2. Open *Edlog*.

3. Click **File** | **Document DLD File**.  Assuming the default paths were used when *Short Cut* was installed, navigate to C:\CampbellSci\SCWin folder. The file of interest has a ".DLD" extension.  Select the file and click **Open**.  The .dld file, which is a type of ASCII machine code, is imported, documented, and, when saved, given a ".CSI" extension.

4. Immediately save the file in a folder different from \Campbellsci\SCWin, or save the file with a different file name.

| | |
|---|---|
| **NOTE** | Once the file is edited with *Edlog*, *Short Cut* can no longer be used to edit the program.  Change the name of the program file or move it, or *Short Cut* may overwrite it. |

5. The program can now be edited, saved, and sent to the datalogger.

6. Import wiring information to the program by opening the associated .DEF file. Copy and paste the section beginning with heading "-Wiring for CRXXX–" into the Edlog program, usually at the head of the file.  After pasting, edit the information such that a **;** (semicolon) begins each line, which instructs the datalogger compiler to ignore the line when compiling the datalogger code.

# *Appendix B.  Example Programs*

## B.1  CRBasic Program

The following CR1000 program measures a CSIM11 and 107 temperature probe and has the datalogger process the raw data after each measurement sequence.

```
'CR1000 Series Datalogger

'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
    Therm107 (TempC,1,3,Vx1,0,250,1.0,0)

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

    'measure pH  (note this is without the multplier and offset)
    VoltDiff (pH,1,mV2500,1,True ,0,_60Hz,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
```

# B.2 Edlog Programs

The following CR10X programs measure a CSIM11 and 107 temperature probe and have the datalogger process the raw data after each measurement sequence.  The first program uses Edlog's expression editor to apply the temperature correction multiplier to the measured pH.  The second program uses a series of instructions to apply the temperature correction multiplier.

## B.2.1  CR10X Program using Edlog's Expression Editor

```
;Measure Water Temperature

1:  Temp (107) (P11)
  1:   1          Reps
  2:   3          SE Channel
  3:   1          Excite all reps w/E1
  4:   1          Loc [ TempC    ]
  5:   1.0        Mult
  6:   0.0        Offset

;Calculate the Multiplier for Temperature Correction
;using Edlog's Expression Writer

pHMult= -1 / (((TempC + 273)  / 298) * 59)

;Note:  When a datalogger program that contains an expression is compiled,
;the appropriate instructions are automatically incorporated into the .DLD file.
;See Appendix B for a program not using the Expression Editor

;Measure pH

2:  Volt (Diff) (P2)
  1:   1          Reps
  2:   5          2500 mV Slow Range
  3:   1          DIFF Channel
  4:   2          Loc [ pH       ]
  5:   1.0        Mult
  6:   0.0        Offset

;Apply the Temperature Correction Multiplier to the Measured pH

pH=pH * pHMult

;The following instruction applies an Offset to the pH.  Use an Offset of 7
;initially as shown below.  Adjust the Offset if necessary during probe calibration.

3:  Z=X+F (P34)
  1:   2          X Loc [ pH       ]
  2:   7          F
  3:   2          Z Loc [ pH       ]

;Example (One Minute) Output Processing Instructions

4:  If time is (P92)
  1:   0          Minutes (Seconds --) into a
  2:   1          Interval (same units as above)
  3:   10         Set Output Flag High (Flag 0)

5:  Real Time (P77)
  1:   0110       Day,Hour/Minute (midnight = 0000)

6:  Sample (P70)
  1:   1          Reps
  2:   2          Loc [ pH       ]
```

```
*Table 2 Program
  02: 0.0000     Execution Interval (seconds)

*Table 3 Subroutines

End Program
```

## B.2.2   CR10(X) Example using Instructions Instead of Edlog's Expression Editor

```
;Measure Water Temperature

1:  Temp (107) (P11)
  1:  1          Reps
  2:  1          SE Channel
  3:  1          Excite all reps w/E1
  4:  1          Loc [ TempC    ]
  5:  1.0        Mult
  6:  0.0        Offset

;Calculate the Multiplier for Temperature Correction
;Note: See Section 4.2 for a program using Edlog's Expression Editor

2:  Z=F (P30)
  1:  298        F
  2:  0          Exponent of 10
  3:  4          Z Loc [ K_25C    ]

3:  Z=X+F (P34)
  1:  1          X Loc [ TempC    ]
  2:  273        F
  3:  3          Z Loc [ pHMult   ]

4:  Z=X/Y (P38)
  1:  3          X Loc [ pHMult   ]
  2:  4          Y Loc [ K_25C    ]
  3:  3          Z Loc [ pHMult   ]

5:  Z=X*F (P37)
  1:  3          X Loc [ pHMult   ]
  2:  59         F
  3:  3          Z Loc [ pHMult   ]

6:  Z=1/X (P42)
  1:  3          X Loc [ pHMult   ]
  2:  3          Z Loc [ pHMult   ]

7:  Z=X*F (P37)
  1:  3          X Loc [ pHMult   ]
  2:  -1.0       F
  3:  3          Z Loc [ pHMult   ]
;Measure Ph

8:  Volt (Diff) (P2)
  1:  1          Reps
  2:  5          2500 mV Slow Range
  3:  1          DIFF Channel
  4:  2          Loc [ pH       ]
  5:  1.0        Mult
  6:  0.0        Offset

;Apply the Temperature Correction Multiplier to the Measured pH
```

```
9:  Z=X*Y (P36)
  1:  2          X Loc [ pH         ]
  2:  3          Y Loc [ pHMult     ]
  3:  2          Z Loc [ pH         ]

;The following instruction applies an Offset to the pH.  Use an Offset of 7
;initially as shown below.  Adjust the Offset if necessary during probe calibration.

10:  Z=X+F (P34)
  1:  2          X Loc [ pH         ]
  2:  7          F
  3:  2          Z Loc [ pH         ]

;Example (One Minute) Output Processing Instructions

11:  If time is (P92)
  1:  0          Minutes (Seconds --) into a
  2:  1          Interval (same units as above)
  3:  10         Set Output Flag High (Flag 0)

12:  Real Time (P77)
  1:  0110       Day,Hour/Minute (midnight = 0000)

13:  Sample (P70)
  1:  1          Reps
  2:  2          Loc [ pH         ]

*Table 2 Program
  02: 0.0000     Execution Interval (seconds)

*Table 3 Subroutines

End Program
```

# Appendix C.  Detailed Calibration Procedure and Manufacturer Tips

## C.1  Calibration

| | |
|---|---|
| **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

a)  4.01 pH (potassium bipthalate)
b)  7.00 pH (potassium phosphate)
c)  10.00 pH (sodium borate and carbonate)

Thermometer
Beakers
Datalogger 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 differential voltage instruction (**VoltDiff()** in CRBasic or **Volt (Diff) (P2)** in Edlog) 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 datalogger.  Place the datalogger 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 differential voltage instruction (**VoltDiff()** or **Volt (Diff) (P2)**), adjust the datalogger 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 datalogger 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.

8.  In the datalogger real time monitor mode, the electrode should read 10.00 pH, ±0.2, depending on temperature.

9.  If the readings in Steps 6 and 8 show a slope error (error proportional to the difference between the buffer pH and 7), then the probe has a slight slope error, which should be easy to correct by adjusting the multiplier in **VoltDiff()** or **Volt (Diff) (P2)**.

# C.2  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 brines 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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