Product Manual

CS547A
Conductivity and Temperature Probe and A547 Interface
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.

When returning equipment, the Repair Reference Number must be clearly marked on the outside of the package. Complete the “Declaration of Hazardous Material and Decontamination” form and ensure a completed copy is returned with your goods. Please note your Repair may not be processed if you do not include a copy of this form and Campbell Scientific Ltd reserves the right to return goods at the customers’ expense.

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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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:

<table>
<thead>
<tr>
<th>Area: 1 in² (square inch)</th>
<th>Mass: 1 oz. (ounce) = 28.35 g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length: 1 in. (inch) = 25.4 mm</td>
<td>1 lb (pound weight) = 0.454 kg</td>
</tr>
<tr>
<td>1 ft (foot) = 304.8 mm</td>
<td>Pressure: 1 psi (lb/in²) = 68.95 mb</td>
</tr>
<tr>
<td>1 yard = 0.914 m</td>
<td>Volume: 1 UK pint = 568.3 ml</td>
</tr>
<tr>
<td>1 mile = 1.609 km</td>
<td>1 UK gallon = 4.546 litres</td>
</tr>
<tr>
<td>1 US gallon = 3.785 litres</td>
<td></td>
</tr>
</tbody>
</table>

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.
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.
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CS547A Conductivity and Temperature Probe and A547 Interface

1. Introduction

The CS547A probe monitors the electrical conductivity (EC) and temperature of fresh water. It connects to a Campbell Scientific data logger using the A547 interface. This probe is compatible with most Campbell Scientific data loggers.

NOTE

This manual provides information only for CRBasic data loggers. It is also compatible with our retired Edlog 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.
- The CS547A and A547 are precision instruments. Please handle them with care.
- CAUTION: Rapid heating and cooling of the CS547A, such as leaving it in the sun and then submersing it in a cold stream, may cause irreparable damage.
- Do not use the CS547A with long cable lengths in an electrically noisy environment.

3. Initial Inspection

- Upon receipt of the CS547A and A547, inspect the packaging and contents for damage. File damage claims with the shipping company.
- Immediately check package contents against the shipping documentation. Contact Campbell Scientific about any discrepancies.

4. QuickStart

A video that describes data logger programming using Short Cut is available at: www.campbellsci.eu/videos/cr1000x-datalogger-getting-started-program-part-3. Short Cut is an easy way to program your data logger to measure the CS547A 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, PC400, or PC200W.
CS547A Conductivity Probe and Temperature Probe and A547 Interface

Use the following procedure to program the CS547A.

1. Open Short Cut and click Create New Program.

2. Double-click the data logger model.

3. In the Available Sensors and Devices box, type CS475A or locate the sensor in the Sensors | Water | Quality | CS547A Conductivity and Temperature Probe folder. Double click on the CS547A Conductivity and Temperature Probe. Type the Cell Constant Kc (printed on the sensor label), Lead Length in Feet, and Temperature Correction (Section 8.3, Deriving a Temperature Compensation Coefficient (p. 12)). Temperature defaults to degree Celsius. This can be changed by clicking the Deg C box and selecting Deg F, for degrees Fahrenheit, or K for Kelvin.

4. Click on the Wiring tab to see how the sensor is to be wired to the A547 and data logger.
5. In **Output Setup**, type the scan rate, meaningful table names, and **Data Output Storage Interval**. Click **Next**.

6. Select the measurement and its associated output option.

7. Click **Finish** and save the program. Send the program to the data logger if the data logger is connected to the computer.

8. Connect the sensor to the data logger, check the output of the sensor in the data display in **LoggerNet**, **RTDAQ**, **PC400**, or **PC200W** to make sure it is making reasonable measurements.

### 5. Overview

One A547 interface is required for each CS547A when used directly with the data logger; multiple CS547A probes can connect to one AM16/32B multiplexer and one A547 interface.

Electrical conductivity (EC) of a solution is a simple physical property, but measurements can be difficult to interpret. This manual instructs the user how to make EC measurements with the CS547A. Accuracy specifications apply to measurements of EC in water containing KCl, Na\(_2\)SO\(_4\), NaHCO\(_3\), and/or NaCl, which are typical calibration compounds, and to EC not yet compensated for temperature effects.
Statements made on methods of temperature compensation or estimating dissolved solids are included to introduce common ways of refining and interpreting data, but are not definitive. Authoritative sources to consult include the USGS Water-Supply Paper 1473, The pH and Conductivity Handbook published by OMEGA Engineering, physical chemistry texts, and other sources.

**Features:**
- Compatible with AM16/32-series multiplexers allowing measurement of multiple sensors
- Rounded ends facilitate installation and removal
- Easy to clean
- Corrosion resistant
- Weighted option available for stand-alone submersion
- Compatible with Campbell Scientific CRBasic data loggers: CR6, CR3000, CR1000X, CR800-series, CR1000

### 5.1 EC Sensor

The CS547A consists of three stainless steel rings mounted in an epoxy tube (FIGURE 5-1). Resistance of water in the tube is measured by excitation of the centre electrode with positive and negative voltage. This electrode configuration eliminates the ground looping problems associated with sensors in electrical contact with earth ground. Temperature is measured with a thermistor in a three-wire half-bridge configuration.

![FIGURE 5-1. CS547A Conductivity and Temperature Probe](image-url)

### 5.2 Conductivity Interface

The A547 interface (FIGURE 5-2) consists of blocking capacitors and bridge completion resistors housed in a metal case. Screw terminals are provided for connecting the data logger, and a water conductivity probe or multiplexer. Keep the interface in a non-condensing environment that is maintained within the temperature range of the unit. Typically, the A547 is housed in the data logger enclosure.
6. Specifications

6.1 CS547A Probe

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Housing</td>
<td>Epoxy</td>
</tr>
<tr>
<td>Length</td>
<td>89 mm (3.5 in)</td>
</tr>
<tr>
<td>Width</td>
<td>25.4 mm (1 in)</td>
</tr>
<tr>
<td>Height</td>
<td>19 mm (0.75 in)</td>
</tr>
<tr>
<td>Minimum Pipe ID in which CS547A Fits</td>
<td>28 mm (1.1 in)</td>
</tr>
<tr>
<td>Maximum Cable Length</td>
<td>305 m (1000 ft). The sensor must be ordered with desired length as cable cannot be added to existing probes.</td>
</tr>
<tr>
<td>Depth Rating</td>
<td>305 m (1000 ft) maximum</td>
</tr>
<tr>
<td>pH Range</td>
<td>Solution pH of less than 3.0 or greater than 9.0 may damage the stainless steel housing.</td>
</tr>
<tr>
<td>Electrodes</td>
<td>Passivated 316 SS with DC isolation capacitors.</td>
</tr>
<tr>
<td>Cell Constant</td>
<td>Individually calibrated. The cell constant ($K_c$) is found on a label near the termination of the cable.</td>
</tr>
<tr>
<td>Operating Temperature Range</td>
<td>0 to 50 °C</td>
</tr>
<tr>
<td>EC Range</td>
<td>~ 0.005 to 7.0 mS cm$^{-1}$.</td>
</tr>
</tbody>
</table>
| Accuracy                   | In KCl and Na$_2$SO$_4$, NaHCO$_3$, and NaCl standard solutions at 25 °C:  
|                           | ±5% of reading 0.44 to 7.0 mS cm$^{-1}$.       |
|                           | ±10% of reading 0.005 to 0.44 mS cm$^{-1}$.    |
| Weight with 4 ft Cable     | 120 g (4.2 oz)                               |
6.2 A547 Interface

- **Length:** 64 mm (2.5 in)
- **Height:** 46 mm (1.8 in)
- **Width:** 23 mm (0.9 in)
- **Weight:** 45 g (2 oz)
- **Temperature Rating:** –15 to 50 °C

6.3 Temperature Sensor

- **Thermistor:** Betatherm 100K6A1
- **Range:** 0 to 50 °C
- **Accuracy:** Error ±0.4 °C (see Section 8.2.2, Temperature Measurement Error (p. 11)).

7. Installation

If you are programming your data logger with *Short Cut*, skip Section 7.3, *Wiring* (p. 6), and Section 7.4, *Programming* (p. 7). *Short Cut* does this work for you. See Section 4, *QuickStart* (p. 1), for a *Short Cut* tutorial.

7.1 Site Selection

The CS547A measures the EC of water inside the hole running through the sensor, so detection of rapid changes in EC requires the probe be flushed continuously. To do this in flowing streams, simply orient the sensor parallel to the direction of flow. In stilling wells and ground wells, however, diffusion rate of ions limits the response time.

7.2 Mounting

The housing and sensor cable are made of water impervious, durable materials. Mount the probe so that it avoids contact with abrasives and moving objects. Because of slight positive buoyancy, either secure the sensor to a fixed or retractable object or use the weighted cable option.

You can use the split mesh strain relief sleeve on the cable to minimize strain. The split mesh sleeve is recommended for cable lengths over 30 m (100 ft).

The A547 interface is usually mounted in the data logger enclosure.

7.3 Wiring

Wiring is shown in FIGURE 7-1.
Wire the conductivity excitation and temperature excitation lines in different excitation ports or measurement errors will occur. If multiple CS547A/A547s are wired to one data logger, each conductivity excitation must use a separate excitation port. However, you can wire multiple temperature excitation lines into the same excitation port.

**Figure 7-1. CS547A wiring diagram**

### 7.4 Programming

*Short Cut* is the best source for up-to-date data logger programming code.

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.

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

A *Short Cut* tutorial is available in Section 4, *QuickStart* (p. 1). If you wish to import *Short Cut* code into CRBasic Editor to create or add to a customized program, follow the procedure in Appendix A, *Importing Short Cut Code Into CRBasic Editor* (p. A-1). Programming basics for CRBasic data loggers are in the following section. Complete program examples for select CRBasic data loggers can be found in Appendix B, *Example Programs* (p. B-1). Programming basics and programming examples for Edlog data loggers are provided at [www.campbellsco.com/old-manuals](http://www.campbellsco.com/old-manuals).
7.4.1 Programming Overview

Typical data logger programs to measure the CS547A consist of four parts:

1. Measurement of EC and temperature

   EC: Resistance across the electrodes is computed from the results of the BrFull or BrHalf instructions (chosen automatically as part of the autoranging feature) followed by the bridge transformation algorithm.

   Temperature: Use the Temp107 CRBasic instruction. If pertinent, see Section 8.4.1, Electrically Noisy Environments (p. 13), and Section 8.4.2, Long Cable Lengths Temperature (p. 14).

2. Correction of ionization errors in EC measurements

   Ionization caused by the excitation of the CS547A can cause large errors. Campbell Scientific has developed a linear correction for conductivity between 0.005 and 0.44 mS cm⁻¹, and a quadratic correction for conductivity between 0.44 and 7.0 mS cm⁻¹. Corrections were determined in standard salt solutions containing KCl, Na₂SO₄, NaHCO₃, and NaCl.

3. Correction of temperature errors in EC measurements

   Temperature of the sample solution can cause large errors in the EC measurement. A method of correcting for temperature is to assume a linear relationship between temperature and EC. This method generally produces values within 2% to 3% of a measurement made at 25 °C.

   The best corrections are made when the temperature coefficient is determined at a temperature near field conditions. See Section 8.3, Deriving a Temperature Compensation Coefficient (p. 12), for details on how to determine the temperature coefficient. If determining the temperature coefficient is not possible, use a value of 2% / °C as a rough estimate.

4. Output processing

   Over large ranges, EC is not linear and it is recommended to use the Sample CRBasic instruction. In limited ranges, averaging measurements over time may be acceptable; this is accomplished by using the Average instruction in CRBasic. Convention requires that the temperature at the time of the measurement be reported.

8. Operation

8.1 Calibration

8.1.1 Conversion Factors

1 S (Siemens) = 1 mho = 1/ohm

Although mS·cm⁻¹ and µS·cm⁻¹ are the commonly used units of EC, the SI base unit is S·m⁻¹. The result of the example programs is mS·cm⁻¹.
EC measurements can be used to estimate dissolved solids. For high accuracy, calibration to the specific stream is required. However, for rough estimates, values between 550 and 750 mg·l⁻¹ / mS·cm⁻¹ are typical with the higher values generally being associated with waters high in sulfate concentration (USGS Water-Supply Paper #1473, p. 99). A common practice is to multiply the EC in mS·cm⁻¹ by 500 to produce ppm or mg·l⁻¹.

8.1.2 Typical Ranges

Single distilled water will have an EC of at least 0.001 mS·cm⁻¹. ECs of melted snow usually range from 0.002 to 0.042 mS·cm⁻¹. ECs of stream water usually range from 0.05 to 50.0 mS·cm⁻¹, the higher value being close to the EC of sea water (USGS Water-Supply Paper 1473, p. 102).

8.1.3 Factory Calibration

The CS547A is shipped with a cell constant calibrated in a 0.01 molal KCl solution at 25.0 °C ±0.05 °C. The solution has an EC of 1.408 mS cm⁻¹.

8.1.4 Field Calibration

The cell constant is a dimensional number expressed in units of cm⁻¹. The unit cm⁻¹ is slightly easier to understand when expressed as cm·cm⁻². Because it is dimensional, the cell constant as determined at any one standard, will change only if the physical dimensions inside the CS547A probe change. Error due to thermal expansion and contraction is negligible. Corrosion and abrasion, however, have the potential of causing significant errors.

A field calibration of the CS547A cell constant can be accomplished as follows:

1. Make a 0.01 molal KCL solution by dissolving 0.7456 g of reagent grade KCl in 1000 g of distilled water, or purchase a calibration solution.

2. Clean the probe thoroughly with the black nylon brush shipped with the CS547A and a small amount of soapy water. Rinse thoroughly with distilled water, dry thoroughly, and place in the KCl solution.

3. Connect the CS547A and A547 or probe and interface to the data logger using the wiring described in Section 7.3, Wiring (p. 6). Program the data logger to make the field calibration (see Appendix B.2, Calibration Program (p. B-3)).

The calibration solution temperature must be between 1 and 35 °C; a polynomial is used to correct for temperature errors within this range. The solution constant of 1.408 mS cm⁻¹ (for prepared solution mentioned above), is valid only for a 0.01 molal KCl solution.

8.2 Analysis of Errors

8.2.1 EC Measurement Error

1. Bridge Measurement Error: < 1.0%

2. Calibration Error:
   bridge measurement: < 0.5%
   calibration solution: < 1.0%
3. Ionization Error of KCl and Na+ Solutions After Correction:
   \(< 2.0\%, \ 0.45 \text{ to } 7.0 \ \text{mS} \ \text{cm}^{-1}\)
   \(< 8.0\%, \ 0.005 \text{ to } 0.45 \ \text{mS} \ \text{cm}^{-1}\)

**Correction of Ionization Errors:** figure 8-1 and figure 8-2 show the amount of correction applied by the example program to compensate for ionization effects on the measurements. Also shown is an ideal correction. Factors were derived by measuring the standard solutions with values of 0.0234, 0.07, 0.4471, 0.7, 1.413, 2.070, 3.920, and 7.0 mS cm\(^{-1}\).

*FIGURE 8-1. Plot of ideal and actual correction between 0 and 0.44 mS cm\(^{-1}\)*

*FIGURE 8-2. Plot of ideal and actual correction between 0.44 and 7.0 mS cm\(^{-1}\)*
8.2.2 Temperature Measurement Error

The overall probe accuracy is a combination of the thermistor’s interchangeability specification, the precision of the bridge resistors, and the polynomial error. In a worst case, all errors add to an accuracy of ±0.4 °C over the range of –24 to 48 °C and ±0.9 °C over the range of –38 to 53 °C. The major error component is the interchangeability specification of the thermistor, tabulated in TABLE 8-1. For the range of 0 to 50 °C, the interchangeability error is predominantly offset and can be determined with a single point calibration. Compensation can then be done with an offset entered in the measurement instruction. The bridge resistors are 0.1% tolerance with a 10 ppm temperature coefficient. Polynomial errors are tabulated in TABLE 8-2 and plotted in FIGURE 8-3.

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>Tolerance (± °C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>−40</td>
<td>0.40</td>
</tr>
<tr>
<td>−30</td>
<td>0.40</td>
</tr>
<tr>
<td>−20</td>
<td>0.32</td>
</tr>
<tr>
<td>−10</td>
<td>0.25</td>
</tr>
<tr>
<td>0 to 50</td>
<td>0.20</td>
</tr>
</tbody>
</table>

TABLE 8-1. Thermistor Interchangeability Specification

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>Tolerance (± °C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>−40 to 56</td>
<td>&lt;±1.0 °C</td>
</tr>
<tr>
<td>−38 to 53</td>
<td>&lt;±0.5 °C</td>
</tr>
<tr>
<td>−24 to 48</td>
<td>&lt;±0.1 °C</td>
</tr>
</tbody>
</table>

TABLE 8-2. Polynomial Error

FIGURE 8-3. Error produced by polynomial fit to published values
8.3 Deriving a Temperature Compensation Coefficient

1. Place the CS547A in a sample of the solution to be measured. Bring the sample and the probe to 25 °C.

2. Enter the example program from Appendix B.1, *Measurement Program* (p. B-1), in the data logger and record the Ct at 25 °C. This number will be $C_{25}$ in the formula in Step 4.

3. Bring the solution and the probe to a temperature (t) near the temperature at which field measurements will be made. This temperature will be $t$ (in °C) in the formula. Record Ct at the new temperature. This number will be $C_t$ in the formula in Step 4.

4. Calculate the temperature coefficient (TC) using the following formula.

$$TC = 100 \cdot \frac{(C - C_{25})}{(t - 25) \cdot C_{25}} = \%/°C$$

Enter TC in the appropriate variable as shown in the program segment in Appendix B.1, *Measurement Program* (p. B-1).

8.4 Therm107 Instruction Details

Understanding the details in this section is not necessary for general operation with our data loggers.

The **Therm107** instruction outputs a precise 2 VAC excitation and measures the voltage drop due to the sensor resistance. The thermistor resistance changes with temperature. The instruction calculates the ratio of voltage measured to excitation voltage ($Vs/Vx$) which is related to resistance, as shown below:

$$Vs/Vx = \frac{1000}{Rs+249000+1000}$$

where $Rs$ is the resistance of the thermistor.

See the measurement section of the data logger manual for more information on bridge measurements.

Temperature is calculated using a fifth order polynomial equation correlating $Vs/Vx$ with temperature. The polynomial coefficients are given in TABLE 8-3. The polynomial input is ($Vs/Vx$)$\times$800. Resistance and data logger output at several temperatures are shown in TABLE 8-4.

<table>
<thead>
<tr>
<th>TABLE 8-3. Polynomial Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coefficient</td>
</tr>
<tr>
<td>C0</td>
</tr>
<tr>
<td>C1</td>
</tr>
<tr>
<td>C2</td>
</tr>
<tr>
<td>C3</td>
</tr>
<tr>
<td>C4</td>
</tr>
<tr>
<td>C5</td>
</tr>
</tbody>
</table>
### TABLE 8-4. Temperature, Resistance, and Data Logger Output

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>Resistance (Ω)</th>
<th>Data Logger Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>351017</td>
<td>-0.06</td>
</tr>
<tr>
<td>2.00</td>
<td>315288</td>
<td>1.96</td>
</tr>
<tr>
<td>4.00</td>
<td>283558</td>
<td>3.99</td>
</tr>
<tr>
<td>6.00</td>
<td>255337</td>
<td>6.02</td>
</tr>
<tr>
<td>8.00</td>
<td>230210</td>
<td>8.04</td>
</tr>
<tr>
<td>10.00</td>
<td>207807</td>
<td>10.06</td>
</tr>
<tr>
<td>12.00</td>
<td>187803</td>
<td>12.07</td>
</tr>
<tr>
<td>14.00</td>
<td>169924</td>
<td>14.06</td>
</tr>
<tr>
<td>16.00</td>
<td>153923</td>
<td>16.05</td>
</tr>
<tr>
<td>18.00</td>
<td>139588</td>
<td>18.02</td>
</tr>
<tr>
<td>20.00</td>
<td>126729</td>
<td>19.99</td>
</tr>
<tr>
<td>22.00</td>
<td>115179</td>
<td>21.97</td>
</tr>
<tr>
<td>24.00</td>
<td>104796</td>
<td>23.95</td>
</tr>
<tr>
<td>26.00</td>
<td>95449</td>
<td>25.94</td>
</tr>
<tr>
<td>28.00</td>
<td>87026</td>
<td>27.93</td>
</tr>
<tr>
<td>30.00</td>
<td>79428</td>
<td>29.95</td>
</tr>
<tr>
<td>32.00</td>
<td>72567</td>
<td>31.97</td>
</tr>
<tr>
<td>34.00</td>
<td>66365</td>
<td>33.99</td>
</tr>
<tr>
<td>36.00</td>
<td>60752</td>
<td>36.02</td>
</tr>
<tr>
<td>38.00</td>
<td>55668</td>
<td>38.05</td>
</tr>
<tr>
<td>40.00</td>
<td>51058</td>
<td>40.07</td>
</tr>
<tr>
<td>42.00</td>
<td>46873</td>
<td>42.07</td>
</tr>
<tr>
<td>44.00</td>
<td>43071</td>
<td>44.05</td>
</tr>
<tr>
<td>46.00</td>
<td>39613</td>
<td>46.00</td>
</tr>
<tr>
<td>48.00</td>
<td>36465</td>
<td>47.91</td>
</tr>
<tr>
<td>50.00</td>
<td>33598</td>
<td>49.77</td>
</tr>
<tr>
<td>52.00</td>
<td>30983</td>
<td>51.59</td>
</tr>
<tr>
<td>54.00</td>
<td>28595</td>
<td>53.35</td>
</tr>
<tr>
<td>56.00</td>
<td>26413</td>
<td>55.05</td>
</tr>
<tr>
<td>58.00</td>
<td>24419</td>
<td>56.70</td>
</tr>
<tr>
<td>60.00</td>
<td>22593</td>
<td>58.28</td>
</tr>
</tbody>
</table>

### 8.4.1 Electrically Noisy Environments

AC power lines can be the source of electrical noise. If the data logger is in an electronically noisy environment, use the 60 Hz or 50 Hz option for the `Integration/fnotch` parameter of the `Therm107` instruction. The 60 and 50 Hz integration options impose a long 3 ms integration, which is needed for electronically noisy environments.
This example `Therm107` instruction uses the 60 Hz integration:

```
Therm107(TempDeg_C,1,3,Vx,2,0,60,1.0,0.0)
```

### 8.4.2 Long Cable Lengths Temperature

If the cable length is more than 300 feet, use the *60Hz* or *50Hz* option for the `Integration/fnotch` parameter of the `Therm107` instruction. The 60 and 50 Hz integration options force a 3 ms settling time, which accommodates long cable lengths. You can also enter longer settling times.

This example `Therm107` instruction uses a 20 ms (20000 µs) settling time and the 60 Hz integration:

```
Therm107(TempDeg_C,1,3,Vx,2,20000,60,1.0,0.0)
```

### 8.5 Schematics

The CS547A schematic is provided in FIGURE 8-4, and the A547 schematic is provided in FIGURE 8-5.

*FIGURE 8-4. CS547A Conductivity and Temperature circuit diagram*
9. **Maintenance**

Routine maintenance includes thoroughly cleaning the orifice of the CS547A probe with the black nylon brush provided and some soapy water. Rinse thoroughly.
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 Programs

Example programs may require modification by the user to fit the specific application’s wiring and programming needs. The programs are for the CR1000X and assume that data logger is wired to the A547 interface as follows: LO COND connects to 1L, the HI COND to 1H, the EX COND to VX1, the EX TEMP to VX2, and the SE TEMP to SE3.

Public Variable Declarations

Definitions for the following program:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rs</td>
<td>Solution resistance</td>
</tr>
<tr>
<td>Rp</td>
<td>Resistance of cable and blocking caps</td>
</tr>
<tr>
<td>Ct</td>
<td>Solution EC with no temp. correction</td>
</tr>
<tr>
<td>Temp_degC</td>
<td>Solution temperature in °C</td>
</tr>
<tr>
<td>C25mScm_1</td>
<td>EC in mS/cm corrected for temperature</td>
</tr>
</tbody>
</table>

B.1 Measurement Program

<table>
<thead>
<tr>
<th>CRBasic name B-1. Measurement Program</th>
</tr>
</thead>
<tbody>
<tr>
<td>’Program name: CS547A.CR1X</td>
</tr>
<tr>
<td>’\\\\\\\ DECLARATIONS ///////////</td>
</tr>
<tr>
<td>Public Rcable, Rp, CellConstant, TempCoef</td>
</tr>
<tr>
<td>Public Rs, Ct</td>
</tr>
<tr>
<td>Public TempDeg_C</td>
</tr>
<tr>
<td>Public C25mScm_1</td>
</tr>
<tr>
<td>Dim OneOvrRs</td>
</tr>
<tr>
<td>’\\\\\\\ OUTPUT SECTION ///////////</td>
</tr>
<tr>
<td>DataTable (ECSample, True, -1)</td>
</tr>
<tr>
<td>DataInterval (0, 60, Min, 10)</td>
</tr>
<tr>
<td>Sample (1, Ct, FP2)</td>
</tr>
<tr>
<td>Sample (1, TempDeg_C, FP2)</td>
</tr>
<tr>
<td>Sample (1, C25mScm_1, FP2)</td>
</tr>
<tr>
<td>EndTable</td>
</tr>
<tr>
<td>’\\\\\\\ PROGRAM ///////////</td>
</tr>
</tbody>
</table>

BeginProg

‘evaluate and edit each of these 3 user specific values
Rcable = 25  'edit this value to the actual footage of cable on your sensor
CellConstant = 1.50  'edit this value with the Cell Constant (Kc) printed on the label of each sensor
TempCoef = 2  'see section 8 of the manual for an explanation of how to more precisely determine the value of this coefficient

Scan(5, Sec, 3, 0)  'make a preliminary measurement of resistance to determine best range code
BrFull(Rs, 1, mV5000, 1, VX1, 1, 2500, True, True, 0, 250, -0.001, 1)  'test the initial measurement to then make a more accurate measurement
Select Case Rs  Case Is < 1.8
    BRHalf(Rs, 1, mV5000, 2, VX1, 1, 2500, True, 0, 250, 1, 0)
    Rs = (Rs/(1-Rs))
Case $I_S < 9.25$
\[ \text{BRFull}(Rs, 1, 	ext{mV5000}, 1, VX1, 1, 2500, 	ext{True}, 	ext{True}, 0, 250, -0.001, 1) \]
\[ Rs = \frac{Rs}{1-Rs} \]

Case $I_S < 280$
\[ \text{BRFull}(Rs, 1, 	ext{mV200}, 1, VX1, 1, 2500, 	ext{True}, 	ext{True}, 0, 250, -0.001, 1) \]
\[ Rs = \frac{Rs}{1-Rs} \]

EndSelect

'Subtract resistance errors ($R_p$) caused by the blocking capacitors
'(0.005Kohm and the cable length (0.000032Kohm/ft)
\[ R_p = -R_{\text{cable}} \times (0.000032) - 0.005 \]
\[ Rs = Rs + R_p \]

'EC is then calculated by multiplying the reciprocal of the resistance,
'which is conductance, by the cell constant
\[ \text{OneOvrRs} = \frac{1}{Rs} \]
\[ Ct = \text{OneOvrRs} \times \text{CellConstant} \]

'the following corrects for errors of ionization in the EC measurement
\[ \text{If} (\text{Ct} < 0.474) \text{ Then} \]
\[ \text{Ct} = (\text{Ct} \times 0.95031) - 0.00378 \]
\[ \text{Else} \]
\[ \text{Ct} = -0.02889 + 0.98614 \times \text{Ct} + 0.02846 \times \text{Ct}^2 \]
\[ \text{EndIf} \]

'correct errors in the EC measurement due to temperature
\[ \text{Therm107 (TempDeg}_{C}, 1, 3, \text{Vx}2, 0, 250, 1, 0) \]
\[ C_{25mScm}_1 = \frac{(\text{Ct} \times 100)}{(((\text{TempDeg}_{C} - 25) \times \text{TempCoef}) + 100)} \]

'end scan loop by calling output table
\[ \text{CallTable ECSample} \]

NextScan
EndProg
### B.2 Calibration Program

**CRBasic Example B-2. Calibration Program**

```crbasic
'CR1000X Data Logger
'Field Calibration program to determine new Cell Constant (Kc) for CS547A conductivity probe
Public Rs, Rp, T
Dim T_25, f_of_T
Public Conductivity, Kc
Const CalSolution = 1.408 'for 0.01 molal KCL solution
'Data Table not required for Field Calibration – monitor “Kc” in Public table
'Main Program
BeginProg
'edit cable length (Rp) to reflect actual cable length
    Rp = 25 'feet
Scan (10,Sec,0,0)
    BrHalf(Rs, 1, mV5000, 2, VX1, 1, 2500, True, 0, 250, 1, 0)
    Rs = (Rs/(1-Rs))
'correct for resistance of cabling
    Rs = Rs + (((Rp*.00032)* -0.1) - 0.005)
'compensate for temperature effects
    Therm107 (T,1,3,Vx2,0,60,1.0,0)
    T_25 = (T-25) * 0.01
    f_of_T = 0.99124-(1.8817*T_25)+(3.4789*T_25^2)-(3.51*T_25^3)-(1.2*T_25^4)-(43*T_25^5)
    Conductivity = (1/f_of_T)*CalSolution
    Kc = Conductivity * Rs
NextScan
EndProg
```