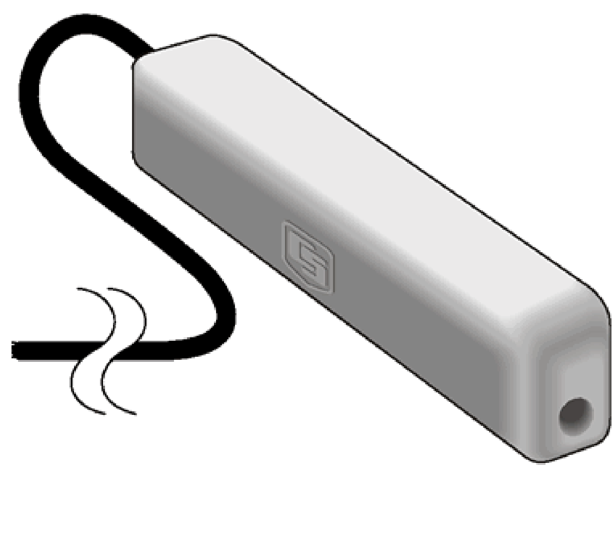
INSTRUCTION MANUAL

CS547A Conductivity and Temperature Probe and A547 Interface

Revision: 11/16



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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PLEASE READ FIRST

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

Length: 1 in. (inch) = 25.4 mm
1 ft (foot) = 304.8 mm
1 yard = 0.914 m
1 mile = 1.609 km

Mass: 1 oz. (ounce) = 28.35 g
1 lb (pound weight) = 0.454 kg

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.

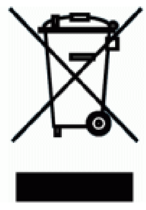
Differences include the U.S standard external power supply details where some information (for example the AC transformer input voltage) will not be applicable for British/European use. *Please note, however, that when a power supply adapter is ordered it will be suitable for use in your country.*

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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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.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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CRBasic Examples

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 datalogger using the A547 interface. This probe is compatible with most Campbell Scientific dataloggers.

NOTE This manual provides information only for CRBasic dataloggers. It is also compatible with our retired Edlog dataloggers. For Edlog datalogger support, see an older manual at *www.campbellsci.com/old-manuals* or contact a Campbell Scientific application engineer for assistance.

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 lead lengths in an electrically noisy environment.

3. Initial Inspection

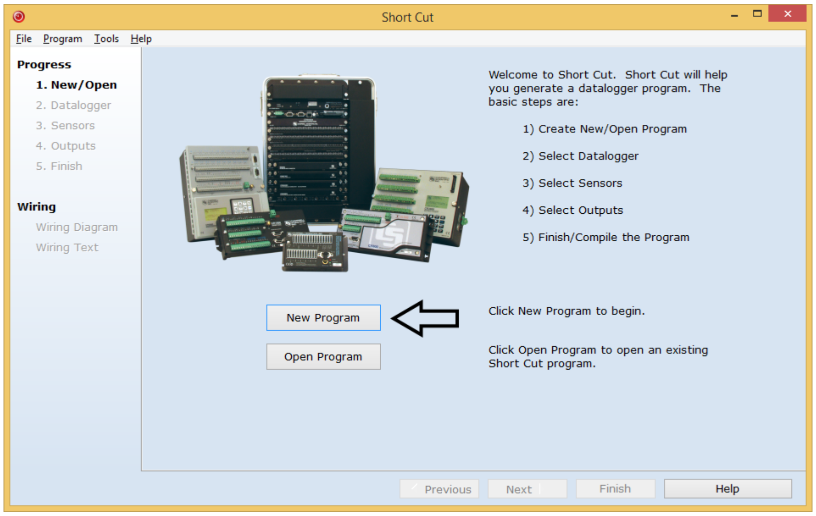
- Upon receipt of the CS547A and A547, inspect the packaging and contents for damage. File damage claims with the shipping company.
- Immediately check package contents against the shipping documentation. Contact Campbell Scientific about any discrepancies.

4. QuickStart

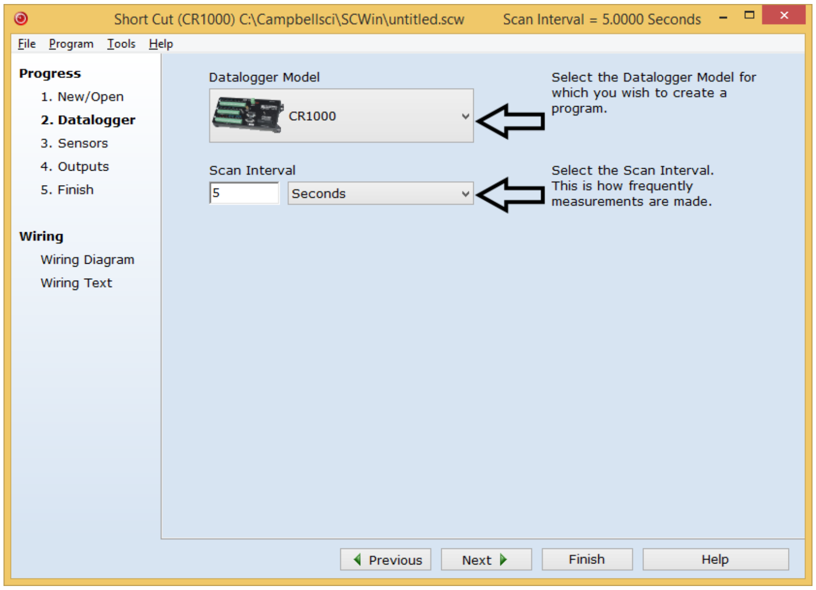
Short Cut is an easy way to program your datalogger to measure the CS547A and assign datalogger wiring terminals. *Short Cut* is available as a download on *www.campbellsci.com* and the *ResourceDVD*. It is included in installations of *LoggerNet*, *PC200W*, *PC400*, or *RTDAQ*.

Use the following procedure to get started.

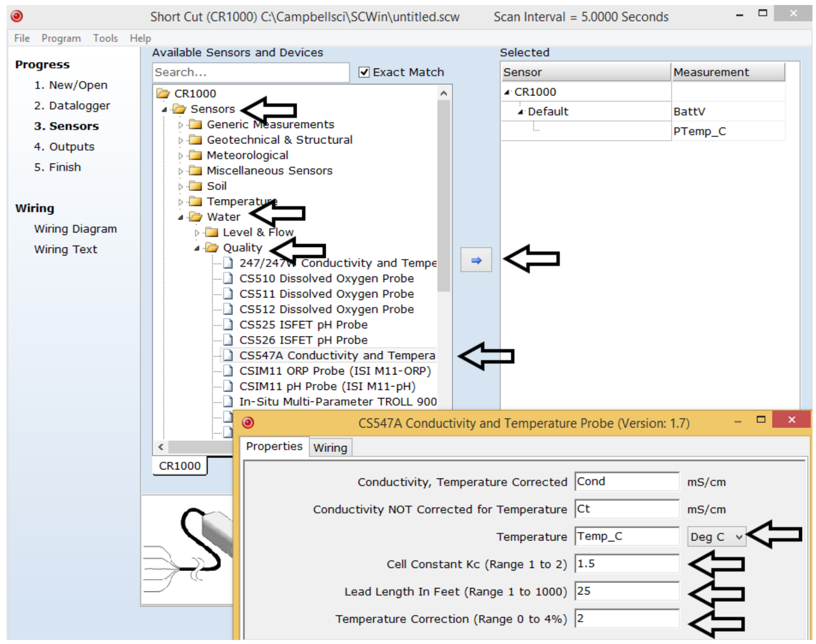
1. Open *Short Cut*. Click **New Program**.



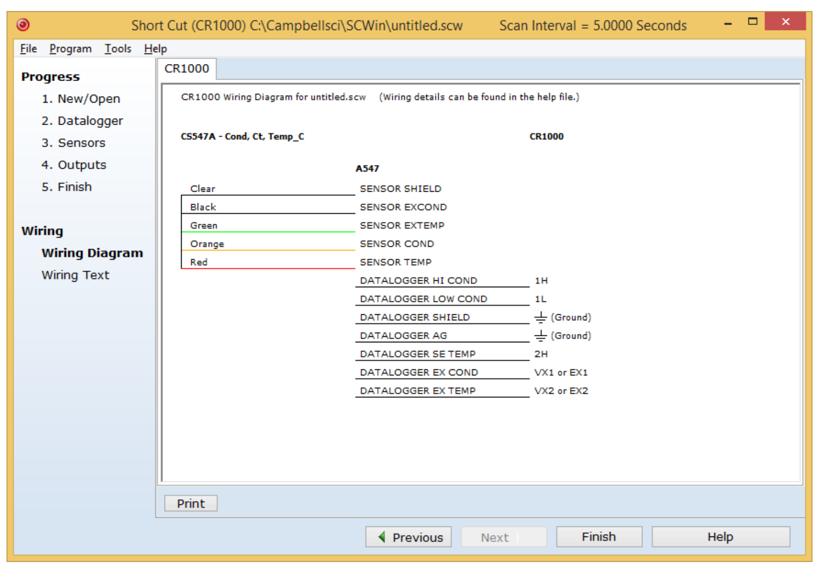
2. Select **Datalogger Model** and **Scan Interval** (default of **5** seconds is **OK** for most applications). Click **Next**.



3. Under the **Available Sensors and Devices** list, select the **Sensors | Water | Quality | CS547A Conductivity and Temperature Probe**. Click [→] to move the selection to the selected device window. Enter 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. 13*)). 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. After selecting the sensor, click **Wiring Diagram** to see how the sensor is to be wired to the A547 and datalogger. The wiring diagram can be printed now or after more sensors are added.



5. 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**.

6. If *LoggerNet*, *PC400, RTDAQ*, 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.

7. If the sensor is connected to the datalogger, as shown in the wiring diagram in step 4, check the output of the sensor in the datalogger support software data display to make sure it is making reasonable measurements.

5. Overview

The CS547A is compatible with all CRBasic dataloggers except the CR200(X) series, which does not issue negative excitations. The CS547A is also compatible with our AM16/32(B) multiplexers. One A547 interface is required for each CS547A when used directly with the datalogger; 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_2SO_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.

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 center 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.

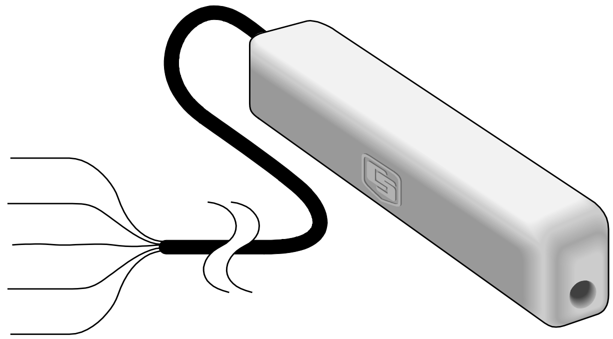


FIGURE 5-1. CS547A Conductivity and Temperature Probe

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 datalogger, 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 datalogger enclosure.

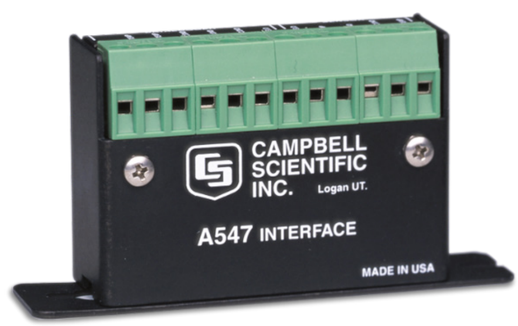


FIGURE 5-2. A547 Interface

6. Specifications

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 dataloggers: CR6 series, CR800 series, CR1000, CR3000, CR5000, and CR9000(X)

6.1 CS547A Probe

Housing:	Epoxy
Length:	89 mm (3.5 in)
Width:	25.4 mm (1 in)
Height:	19 mm (0.75 in)
Minimum Pipe ID in which CS547A Fits:	28 mm (1.1 in)
Maximum Cable Length:	305 m (1000 ft). The sensor must be ordered with desired length as cable cannot be added to existing probes.
Depth Rating:	305 m (1000 ft) maximum
pH Range:	Solution pH of less than 3.0 or greater than 9.0 may damage the stainless steel housing.
Electrodes:	Passivated 316 SS with DC isolation capacitors.
Cell Constant:	Individually calibrated. The cell constant (K_c) is found on a label near the termination of the cable.
Operating Temperature Range:	0 to 50 °C
EC Range:	~ 0.005 to 7.0 mS cm^{-1}.
Accuracy:	In KCl and Na_2SO_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. 12)).

7. Installation

If you are programming your datalogger with *Short Cut*, skip Section 7.3, *Wiring* *(p. 7)*, and Section 7.4, *Programming* *(p. 8)*. *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 (pn #7421) on the cable to minimize strain. The split mesh sleeve is recommended for cable lengths over 100 ft.

The A547 interface is usually mounted in the datalogger enclosure.

7.3 Wiring

Wiring is shown in FIGURE 7-1.

WARNING **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 datalogger, each conductivity excitation must use a separate excitation port. However, you can wire multiple temperature excitation lines into the same excitation port.**

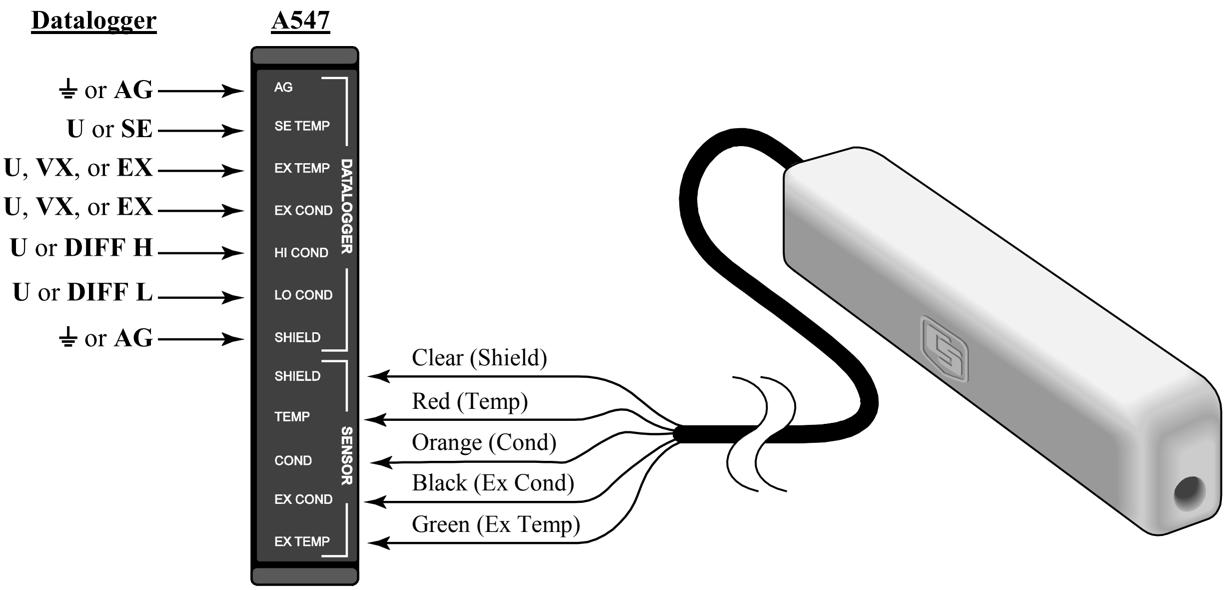


FIGURE 7-1. CS547A wiring diagram

7.4 Programming

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

- Creating a program for a new datalogger installation
- 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.

NOTE *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 dataloggers are in the following section. Complete program examples for select CRBasic dataloggers can be found in Appendix B, *Example Programs* *(p. B-1)*. Programming basics and programming examples for Edlog dataloggers are provided at *www.campbellsci.com\old-manuals*.

7.4.1 Programming Overview

Typical datalogger 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. 14)*, and Section 8.4.2, *Long Lead Lengths Temperature* *(p. 15)*.

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, Na_2SO_4, $NaHCO_3$, and NaCl.

3. Correction of temperature errors in EC measurements

   Temperature on 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. 13)*, 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 is best 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 $mS \cdot cm^{-1}$ and $\mu S \cdot cm^{-1}$ are the commonly used units of EC, the SI base unit is $S \cdot m^{-1}$. The result of the example programs is $mS \cdot cm^{-1}$.

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 $mg \cdot l^{-1}$ / $mS \cdot cm^{-1}$ 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 $mS \cdot cm^{-1}$ by 500 to produce ppm or $mg \cdot l^{-1}$.

8.1.2 Typical Ranges

Single distilled water will have an EC of at least 0.001 $mS \cdot cm^{-1}$. ECs of melted snow usually range from 0.002 to 0.042 $mS \cdot cm^{-1}$. ECs of stream water usually range from 0.05 to 50.0 $mS \cdot cm^{-1}$, 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 $cm \cdot cm^{-2}$. 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 datalogger using the wiring described in Section 7.3, *Wiring* *(p. 7)*. Program the datalogger 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 to 7.0 mS cm^{-1}
   < 8.0%, 0.005 to 0.45 mS 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, 07, 1.413, 2.070, 3.920, and 7.0 mS cm^{-1}.

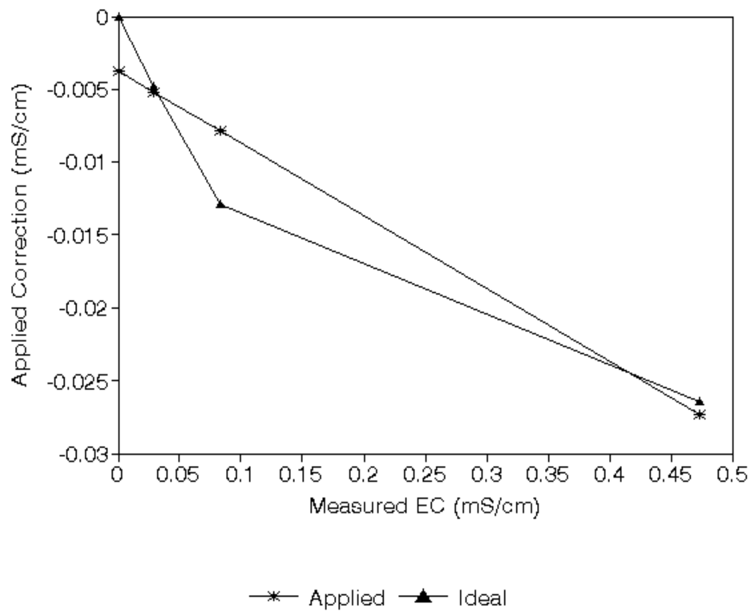


FIGURE 8-1. Plot of ideal and actual correction between 0 and 0.44 mS cm^{-1}

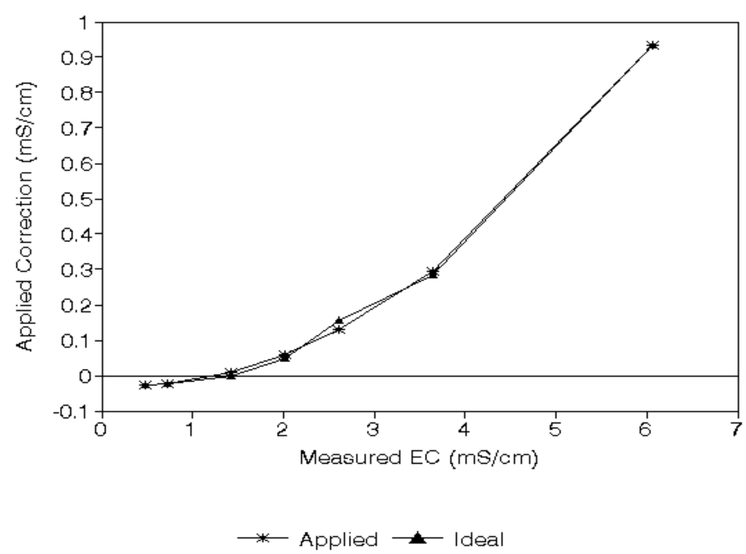


FIGURE 8-2. Plot of ideal and actual correction between 0.44 and 7.0 mS cm^{-1}

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 8-1. Thermistor Interchangeability Specification Temperature

Temperature (°C)	Tolerance (± °C)
–40	0.40
–30	0.40
–20	0.32
–10	0.25
0 to 50	0.20

TABLE 8-2. Polynomial Error

–40 to 56	<±1.0 °C
–38 to 53	<±0.5 °C
–24 to 48	<±0.1 °C

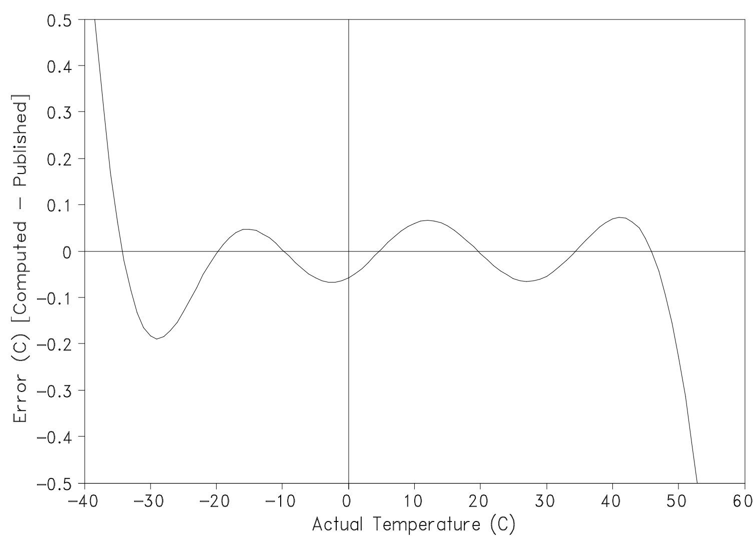


FIGURE 8-3. Error produced by polynomial fit to published values

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 datalogger 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 in the formula in Step 4.

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

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

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 dataloggers.

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 = 1000/(Rs+249000+1000)

where Rs is the resistance of the thermistor.

See the measurement section of the datalogger 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)•800. Resistance and datalogger output at several temperatures are shown in TABLE 8-4.

TABLE 8-3. Polynomial Coefficients

Coefficient	Value
C0	–53.4601
C1	9.08067
C2	-8.32569×10^{-01}
C3	5.22829×10^{-02}
C4	-1.67234×10^{-03}
C5	2.21098×10^{-05}

TABLE 8-4. Temperature , Resistance, and Datalogger Output		
0.00	351017	–0.06
2.00	315288	1.96
4.00	283558	3.99
6.00	255337	6.02
8.00	230210	8.04
10.00	207807	10.06
12.00	187803	12.07
14.00	169924	14.06
16.00	153923	16.05
18.00	139588	18.02
20.00	126729	19.99
22.00	115179	21.97
24.00	104796	23.95
26.00	95449	25.94
28.00	87026	27.93
30.00	79428	29.95
32.00	72567	31.97
34.00	66365	33.99
36.00	60752	36.02
38.00	55668	38.05
40.00	51058	40.07
42.00	46873	42.07
44.00	43071	44.05
46.00	39613	46.00
48.00	36465	47.91
50.00	33598	49.77
52.00	30983	51.59
54.00	28595	53.35
56.00	26413	55.05
58.00	24419	56.70
60.00	22593	58.28

8.4.1 Electrically Noisy Environments

AC power lines can be the source of electrical noise. If the datalogger 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,1,3,2,0,_60Hz,1.0,0.0)
```

8.4.2 Long Lead Lengths Temperature

If the lead 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 lead 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,1,3,2,20000,_60Hz,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.

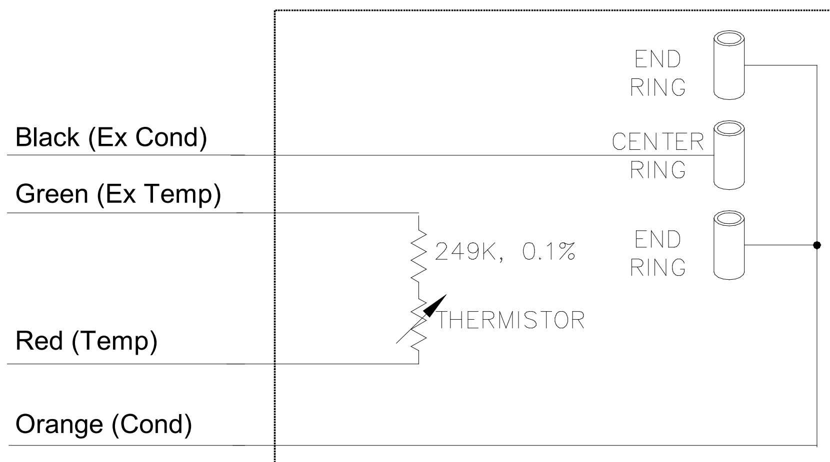


FIGURE 8-4. CS547A Conductivity and Temperature circuit diagram

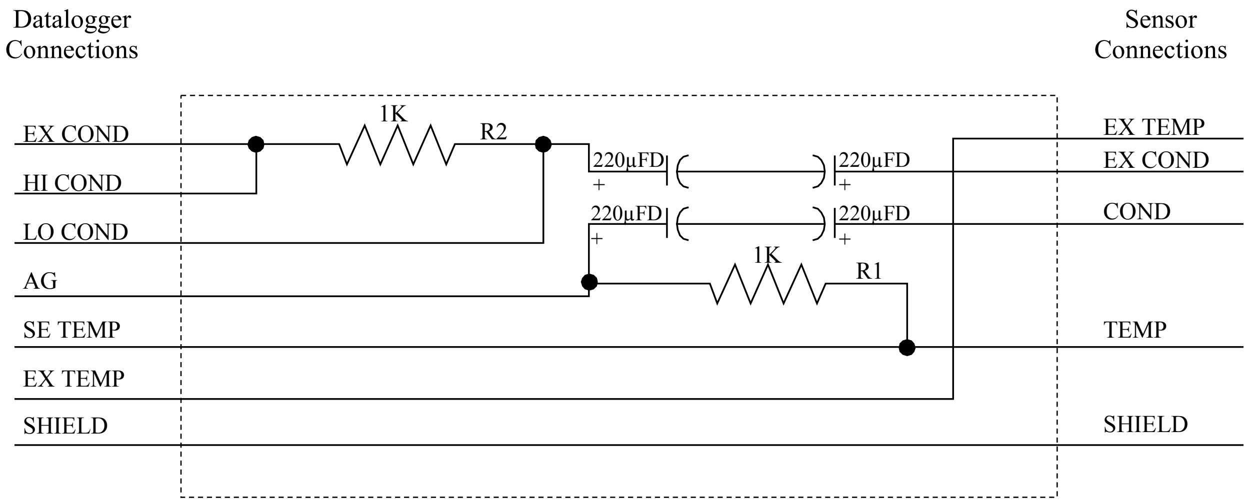


FIGURE 8-5. A547 Interface circuit diagram

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

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

Short Cut creates files, which can be imported into *CRBasic Editor*. Assuming defaults were used when *Short Cut* was installed, these files reside in the C:\campbellsci\SCWin folder:

- .DEF (wiring and memory usage information)
- .CR6 (CR6-series datalogger code)
- .CR8 (CR800-series datalogger code)
- .CR1 (CR1000 datalogger code)
- .CR3 (CR3000 datalogger code)
- .CR5 (CR5000 datalogger code)

Use the following procedure to import *Short Cut* code and wiring diagram into *CRBasic Editor*.

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 the .CR6, .CR8, .CR1, .CR3, or .CR5 extension. Select the file and click **Open**.
4. Immediately save the file in a folder different from C:\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 an apostrophe (**'**) begins each line. This character instructs the datalogger compiler to ignore the line when compiling.

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 CR1000 and assume that datalogger is wired to the A547 interface as follows: the LO COND lead is connected to **1L**, the HI COND to **1H**, the EX COND to **VX1** or **EX1**, the EX TEMP to **VX2** or **EX2**, and the SE TEMP to **SE3**.

Public Variable Declarations

Definitions for the following program:

Rs	Solution resistance
Rp	Resistance of leads/cable and blocking caps
Ct	Solution EC with no temp. correction
Temp_degC	Solution temperature in °C
C25mScm_1	EC corrected for temperature

B.1 Measurement Program

CRBasic Example B-1. Measurement Program

```
'Program name: CS547A.CR1

'\\\\\\\\\\\\\\\\\\\\\\\\\ DECLARATIONS /////////////////////////
Public Rcable, Rp, CellConstant, TempCoef
Public Rs, Ct
Public TempDeg_C
Public C25mScm_1
Dim OneOvrRs, Ct100, A, TC_Proces

'\\\\\\\\\\\\\\\\\\\\\\\\\ OUTPUT SECTION ////////////////////////
DataTable (ECSample,True,-1)
  DataInterval (0,60,Min,10)
  Sample (1,Ct,FP2)
  Sample (1,TempDeg_C,FP2)
  Sample (1,C25mScm_1,FP2)
EndTable

'\\\\\\\\\\\\\\\\\\\\\\\\\\\\ PROGRAM ////////////////////////////
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, mV2500, 1, VX1, 1, 2500, True, True, 0, 250, -0.001, 1)
    Rs = 1*Rs/(1.0-Rs)
    'test the initial measurement to then make a more accurate measurement
    Select Case Rs
      Case Is < 1.8
      BRHalf(Rs, 1, mV2500, 2, VX1, 1, 2500, True, 0, 250, 1, 0)
      Rs = (Rs/(1-Rs))
```

```
      Case Is < 9.25
      BRFull(Rs, 1, mV2500, 1, VX1, 1, 2500, True, True, 0, 250, -0.001, 1)
      Rs = Rs/(1-Rs)

      Case Is < 280
      BRFull(Rs, 1, mV250, 1, VX1, 1, 2500, True, True, 0, 250, -0.001, 1)
      Rs = Rs/(1-Rs)

    EndSelect

'Subtract resistance errors (Rp) caused by the blocking capacitors
'(0.005Kohm and the cable length (0.000032Kohm/ft)

    Rp = -Rcable * (0.000032) - 0.005
    Rs = Rs + Rp

'EC is then calculated by multiplying the reciprocal of the resistance,
'which is conductance, by the cell constant

    OneOvrRs = 1 / Rs
    Ct = OneOvrRs * CellConstant

'the following corrects for errors of ionization in the EC measurement

    If (Ct < 0.474) Then
      Ct = (Ct * 0.95031) - 0.00378
    Else
      Ct= -0.02889 + 0.98614 * Ct + 0.02846 * Ct²
    EndIf

'correct errors in the EC measurement due to temperature

    Therm107 (TempDeg_C,1,3,Vx2,0,250,1,0)
    C25mScm = (Ct * 100)/(((TempDeg_C-25) * TempCoef) + 100)

    'end scan loop by calling output table
    CallTable ECSample

  NextScan
EndProg
```

B.2 Calibration Program

CRBasic Example B-2. Calibration Program

```
'CR1000 Datalogger
'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 footage of actual lead length
    Rp = 25 'feet
  Scan (10,Sec,0,0)
    BrHalf(Rs, 1, mV2500, 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,_60Hz,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
```

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