INSTRUCTION MANUAL

Model 109SS Temperature Probe

Revision: 11/14

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.**"

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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.

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Model 109SS Temperature Probe

1. Introduction

The 109SS Temperature Probe uses a thermistor to measure temperature in soil and water. It is compatible with all CRBasic dataloggers except the CR9000(X). See Section 6, *Specifications*, for a list of compatible CRBasic dataloggers.

For Edlog datalogger support, check the availability of an older manual at *www.campbellsci.com/old-manuals*, or contact a Campbell Scientific application engineer for assistance.

2. Cautionary Statements

- READ AND UNDERSTAND the *Precautions* section at the front of this manual.
- Santoprene® rubber, which composes the black outer jacket of the 109SS cable, will support combustion in air. It is used because of its resistance to temperature extremes, moisture, and UV degradation. It is rated as slow burning when tested according to U.L. 94 H.B. and passes FMVSS302. However, local fire codes may preclude its use inside buildings.

3. Initial Inspection

- Check the packaging and contents of the shipment. If damage occurred during transport, immediately file a claim with the carrier. Contact Campbell Scientific to facilitate repair or replacement.
- Check model information against the shipping documents to ensure the expected products and the correct lengths of cable are received. Model numbers are found on each product. On cables and cabled items, the model number is usually found at the connection end of the cable. Report any shortages immediately to Campbell Scientific.

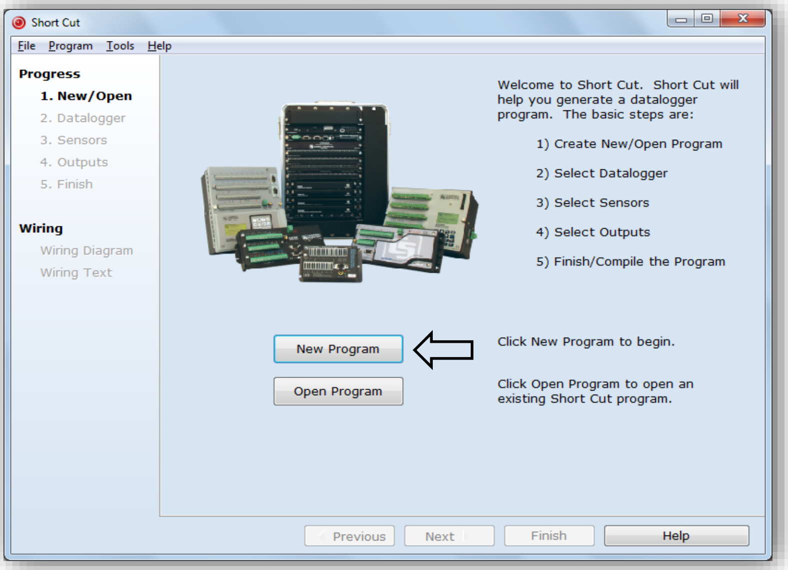
4. Quickstart

Short Cut is an easy way to program your datalogger to measure the 109SS probe and assign datalogger wiring terminals. Use the following procedure to get started.

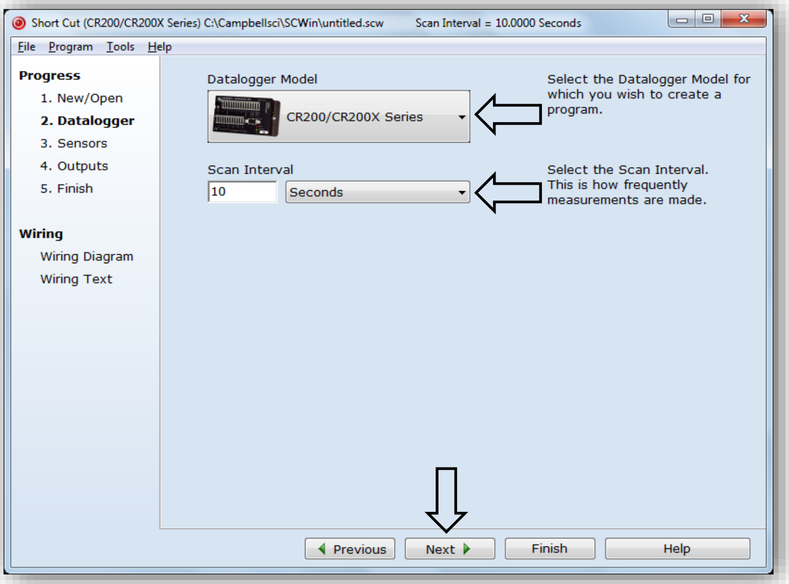
1. Install *Short Cut* by clicking on the install file icon. Get the install file from either *www.campbellsci.com*, the ResourceDVD, or find it in installations of *LoggerNet*, *PC200W*, *PC400*, or *RTDAQ* software.

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

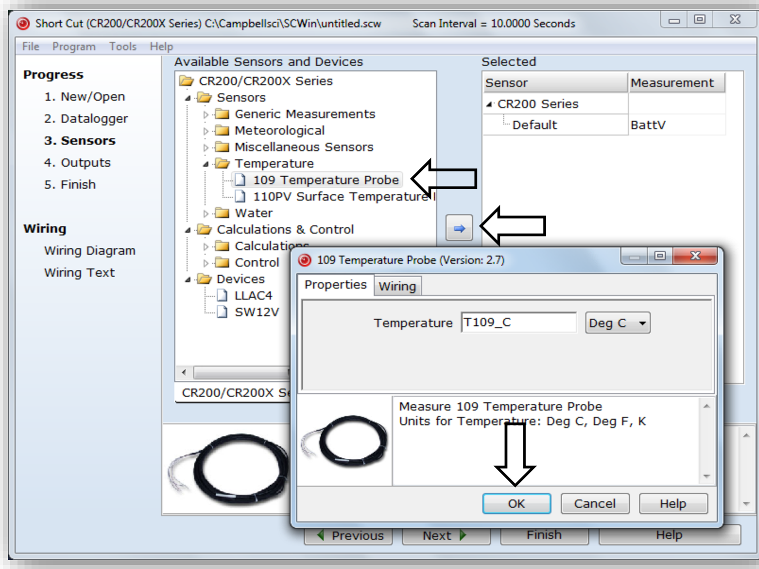
3. When *Short Cut* opens, select **New Program**.



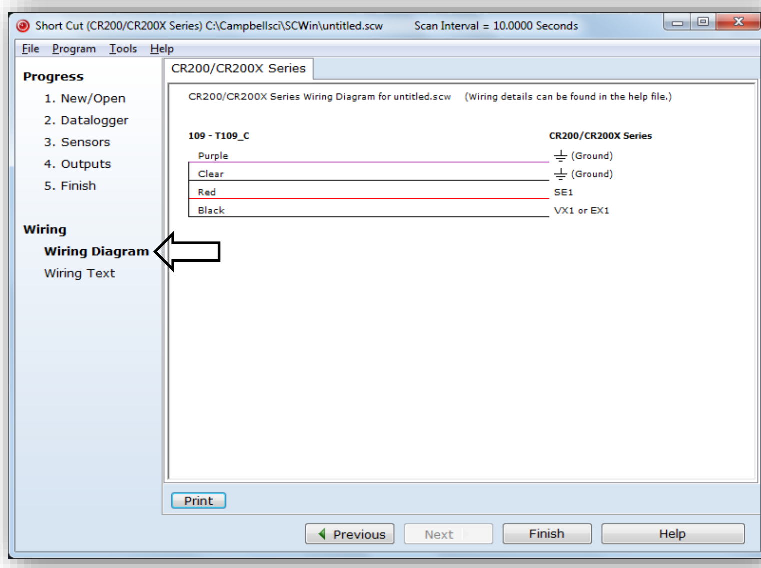
4. Select **Datalogger Model** and **Scan Interval** (default of **5** or **10** seconds is OK for most applications). Click **Next**.



5. Under the **Available Sensors and Devices** list, select the **Sensors** folder, then select the **Temperature** sub-folder. Select **109 Temperature Probe**. Click [icon] to move the selection to the **Selected** device window. Data 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.



6. After selecting the sensor, 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, and 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*, *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.

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 109SS is a rugged probe that accurately measures soil or water temperature in a variety of applications. The sensor consists of a thermistor encased in a stainless-steel sheath. This design protects the thermistor, allowing the 109SS to be buried or submerged in harsh, corrosive environments. It can be submerged in water to 45 m (150 ft) or 63 psi. See *Specifications* for a complete list of compatible dataloggers.

6. Specifications

Features:

- Measures soil or water temperature
- Compatible with AM16/32-series multiplexers
- Easy to install or remove
- Durable
- Compatible with the following CRBasic dataloggers: CR6, CR200(X), and CR800 series, CR1000, CR3000, and CR5000

Sensor Element:	Measurement Specialties Micro-BetaCHIP Thermistor Probe (MCD) 10K3MCD1
Survival Range	
Thermistor:	–50 to 100 °C
Overmolded Joint and Cable:	–50 to 70 °C
Measurement Range:	–40 to 70 °C
Time Constant:	31 s in still air 7.5 s in a wind speed of 3 m/s 0.5 s in rolling water or antifreeze
Maximum Cable Length:	1000 ft
Accuracy[1]	
Worst case:	±0.60 °C (–40 to 70 °C) ±0.49 °C (–20 to 70 °C)
Interchangeability Error:	±0.60 °C at –40 °C ±0.38 °C at 0 °C ±0.10 °C at 25 °C ±0.30 °C at 50 °C ±0.45 °C at 70 °C
Steinhart-Hart Linearization Error:	≤ 0.02 °C (–40 to 70 °C)

Stainless-Steel Sheath	
Diameter:	0.16 cm (0.063 in)
Length:	5.84 cm (2.3 in)
Overmolded Joint	
Diameter:	1.02 cm (0.40 in)
Length:	4.24 cm (1.67 in)
Cable:	Santoprene®, 0.220 in diameter
Cable/Probe Connection:	ATUM™ heat shrink Macromelt® overmolded joint
Weight:	0.2 lb per 10.5 ft cable

[1]See FIGURE 6-1, *Worst-case probe and measurement errors*, and FIGURE 6-2 *Steinhart-Hart linearization error*. Overall probe accuracy is a combination of thermistor interchangeability, bridge-resistor accuracy, and error of the Steinhart-Hart equation . Interchangeability is the principle component error and is predominantly offset. Offset can be determined with a single-point calibration. Offset can be entered in the **Therm109()** instruction ***Offset*** parameter. The bridge resistor has a 0.1% tolerance with a 10 ppm temperature coefficient. At temperature extremes, the possible error in the CR200(X) series datalogger measurement may be greater than the error that exists in the probe.

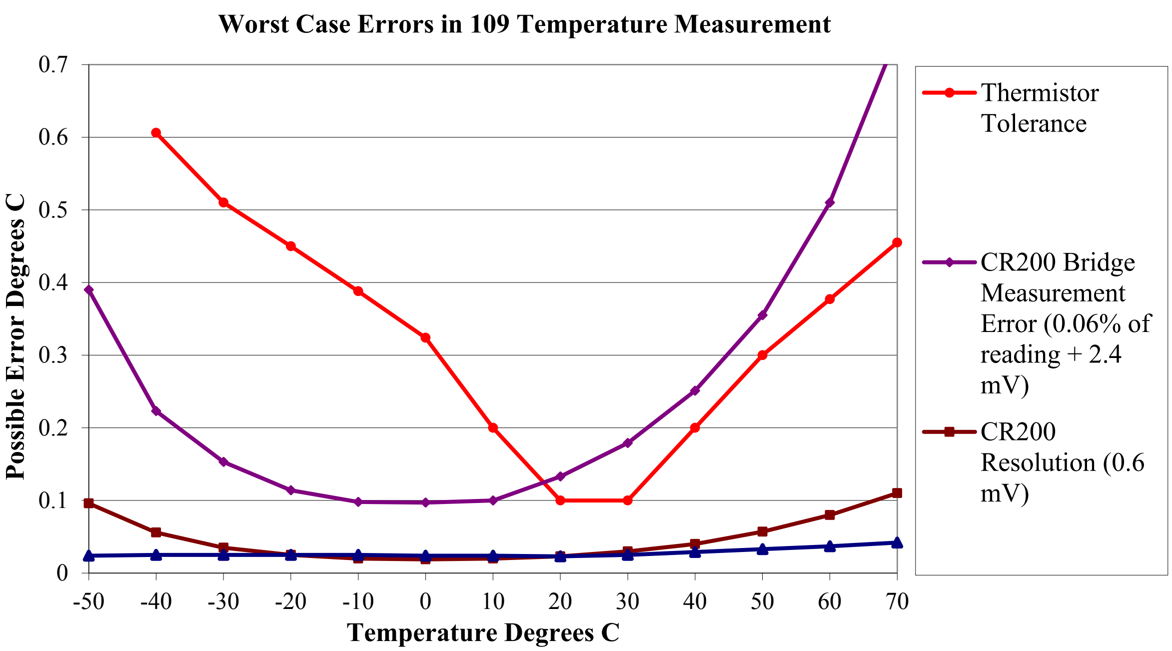


FIGURE 6-1. Worst-case probe and measurement errors

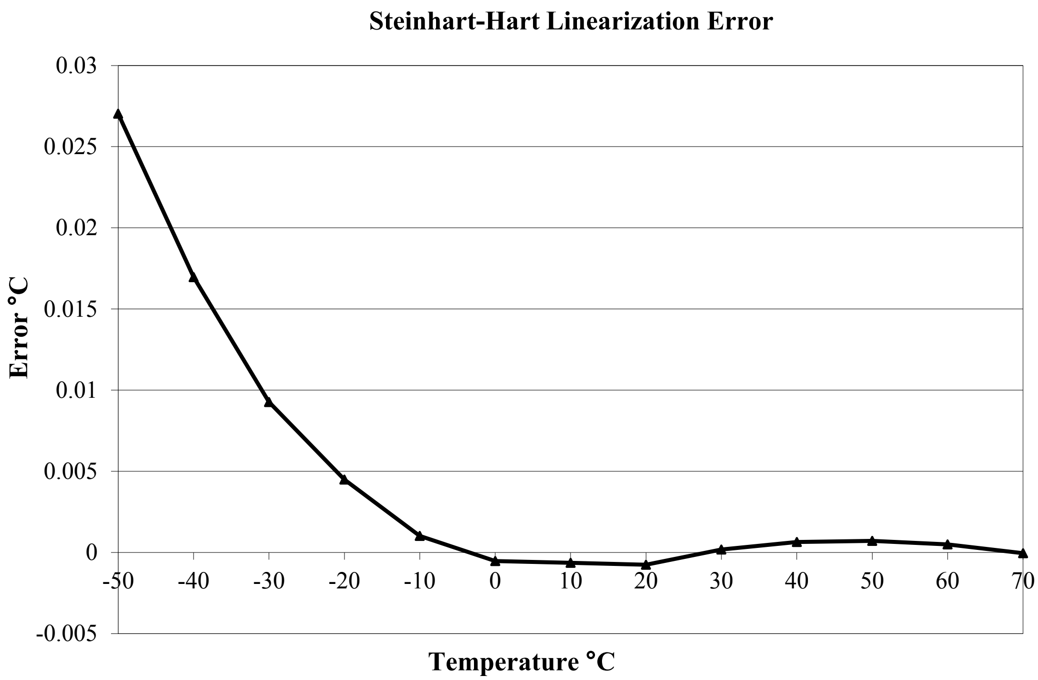


FIGURE 6-2. Steinhart-Hart linearization error

7. Installation

If you are programming your datalogger with *Short Cut*, skip Section 7.1, *Wiring to Datalogger*, and Section 7.2, *Datalogger Programming*. *Short Cut* does this work for you. See Section 4, *Quickstart*, for a *Short Cut* tutorial.

7.1 Wiring to Datalogger

TABLE 7-1. Wire Color, Function, and Datalogger Connection

Wire Color	Wire Function	Datalogger Connection Terminal
Black	Voltage-excitation input	**U** configured for voltage excitation[1], **EX**, **VX** (voltage excitation)
Red	Analog-voltage output	**U** configured for single-ended analog input[1], **SE** (single-ended, analog-voltage input)
Purple	Bridge-resistor lead	**AG** or ⏚ (analog ground)
Clear	EMF shield	**AG** or ⏚ (analog ground)

[1]**U** channels are automatically configured by the measurement instruction.

7.2 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
- 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*. 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.1, *Importing Short Cut Code into CRBasic Editor*. Programming basics are provided in the following section. A complete program example can be found in Appendix B, *Example Programs*.

If the 109SS probe is to be used with long cable lengths or in electrically noisy environments, consider employing the measurement programming techniques outlined in Section 8.3, *Electrically Noisy Environments*, and Section 8.4, *Long Cable Lengths*.

Details of 109SS probe measurement and linearization of the thermistor output are provided in Section 8.2, *Measurement and Output Linearization*.

7.2.1 Therm109() Instruction

The **Therm109()** measurement instruction programs most CRBasic dataloggers (CR6-, CR200(X)-, and CR800-series, CR1000, CR3000, CR5000) to measure the 109SS probe. It supplies 2500 mV excitation, makes a half-bridge resistance measurement, and converts the result to temperature using the Steinhart-Hart equation. See Section 8.2, *Measurement and Output Linearization*, for more information. **Therm109()** instruction and parameters are as follows:

```
Therm109(Dest, Reps, SEChan, VxChan, SettlingTime, Integ/Fnotch,
         Mult, Offset)
```

The instruction for CR200(X) series dataloggers excludes the ***SettlingTime*** and ***Integ*** parameters.

Variations:

- Temperature reported as °C — set ***Mult*** to ***1*** and ***Offset*** to ***0***
- Temperature reported as °F — set ***Mult*** to ***1.8*** and ***Offset*** to ***32***
- Ac mains noise filtering — set ***Integ/Integ*** to ***_60Hz*** or ***_50Hz*** (see Section 8.3, *Electrically Noisy Environments*)
- Compensate for long cable lengths — Set ***SettlingTime*** to ***20000*** (see Section 8.4, *Long Cable Lengths*)

7.3 Water Temperature Installation

109SS probes can be submerged to 45 m (150 ft) or 63 psi. The 109SS is not weighted, so a weighting system should be added, or the probe secured to a submerged object such as a piling.

7.4 Soil Temperature Installation

The 109SS tends to measure the average temperature over its length, so burying the probe such that the measurement tip is horizontal to the soil surface at the desired depth is usually preferred. The maximum burial depth for soil that could become saturated with water is dictated by the maximum water pressure allowed for the sensor, which is 21 psi.

One or two coils of cable should also be buried in a shallow installation. Burial of some cable mitigates the effect of solar heating of the above ground cable on the temperature measurement.

Placement of the cable inside a rugged conduit may be necessary for long cable runs, especially in locations subject to digging, mowing, traffic, use of power tools, or lightning strikes.

8. Operation

8.1 Sensor Schematic

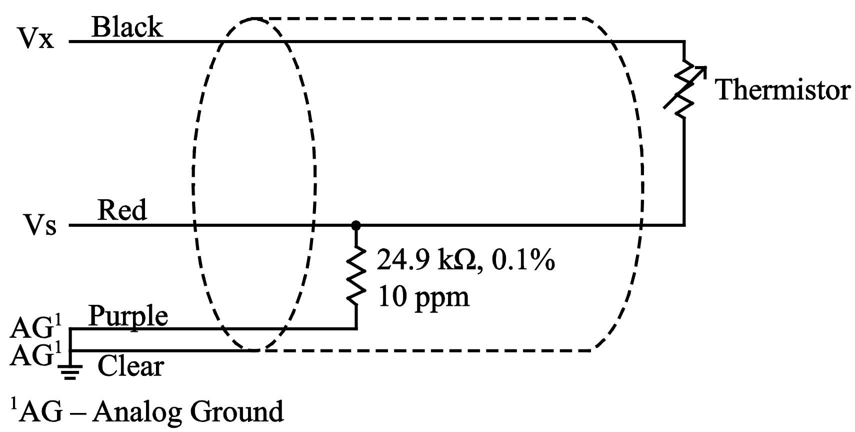


FIGURE 8-1. 109SS thermistor probe schematic

8.2 Measurement and Output Linearization

CRBasic instruction **Therm109()** measures the 109SS probe thermistor and automatically converts the result to temperature. With reference to the previous FIGURE 8-1, *109SS thermistor probe schematic*, a precise excitation voltage is applied at the Vx line and the voltage drop across the 24.9 kΩ resistor is measured at the Vs line.

The ratio of measured voltage (Vs) to excitation voltage (Vx) is related to thermistor resistance (Rs) and the 24.9 kΩ bridge resistor as described in the following equations:

$$Vs/Vx = 24900\ \Omega / (Rs + 24900\ \Omega)$$

Solving for Rs:

$$Rs + 24900\ \Omega = 24900\ \Omega \bullet (Vx/Vs)$$

$$Rs = 24900\ \Omega \bullet ((Vx/Vs) - 1)$$

The relationship of Rs to temperature is tabulated in Appendix C, *Conversion of Thermistor Resistance or Voltage Ratio to Temperature*, but is calculated by **Therm109()** using the Steinhart-Hart equation, described as follows:

$$T_c = (1 / (A + B \bullet \ln(R_s) + C \bullet (\ln(R_s))^3)) - 273.15$$

where:

T_c = temperature in degrees Celsius (°C)

A[1] = 1.129241E–3

B[1] = 2.341077E–4

C[1] = 8.775468E–8

[1]Coefficients provided by Measurement Specialties™.

8.3 Electrically Noisy Environments

EMF noise emanating from the ac mains power grid can be a significant source of measurement error. 60 Hz noise is common in the United States. 50 Hz noise is common in Europe and other regions. Depending on the datalogger model, this noise can usually be filtered out.

The following code snips filter 60 Hz noise by placing the ***_60Hz*** argument in the ***Integ/Fnotch*** parameter (in bold type).

For CR6 datalogger:

```
Therm109(T109_C,1,U1,U10,20000,_60Hz,1.0,0.0)
```

For CR800, CR1000, CR3000, and CR5000 dataloggers:

```
Therm109(T109_C,1,1,1,20000,_60Hz,1.0,0.0)
```

An integration parameter is not available for CR200(X) series dataloggers.

8.4 Long Cable Lengths

Long cable lengths may require longer than normal analog measurement settling times. Settling times are increased by adding a measurement delay to a datalogger program.

The 60 Hz and 50 Hz integration options include a 3 ms settling time; longer settling times can be entered into the ***Settling Time*** parameter. The following code snips increase settling time by 20000 µs by placing ***20000*** as the argument in the ***SettlingTime*** parameter:

For CR6 datalogger:

```
Therm109(T109_C,1,U1,U10,20000,_60Hz,1.0,0.0)
```

For CR800, CR1000, CR3000, and CR5000 dataloggers:

```
Therm109(T109_C,1,1,1,20000,_60Hz,1.0,0.0)
```

A setting time parameter is not available for CR200(X) series dataloggers.

9. Troubleshooting and Maintenance

NOTE All factory repairs and recalibrations require a returned material authorization (RMA) and completion of the “Declaration of Hazardous Material and Decontamination” form. Refer to the *Assistance* page at the beginning of this manual for more information.

9.1 Troubleshooting

Symptom: Temperature is reported as **NAN, –INF**, or incorrect temperature.

Verify wire leads are connected to the terminals specified in the **Therm109()** instruction: red to single-ended analog input (**SE** or **U**), black to switched excitation (**VX**/**EX** or **U**), and purple to ground (⏚).

Symptom: Incorrect temperature is reported.

Verify the ***Mult*** and ***Offset*** arguments in **Therm109()** are correct for the desired units (Section 7.2, *Datalogger Programming*). Check the cable for signs of damage and possible moisture intrusion.

Symptom: Unstable temperature is reported.

Probably a result of electromagnetic interference. Try using the ***_50Hz*** or ***_60Hz Integ*** or ***Fnotch*** options, and/or increasing the settling time as described in Section 8.3, *Electrically Noisy Environments*, and Section 8.4, *Long Cable Lengths*. Ensure the clear wire is connected to datalogger ground, and the datalogger is properly grounded.

9.2 Maintenance

The 109SS probe requires minimal maintenance. For air temperature measurements, check the radiation shield monthly to make sure it is clean and free from debris. Periodically check cabling for signs of damage and possible moisture intrusion.

9.3 Calibration

Calibration of the 109SS probe is not necessary unless the application requires removal of the thermistor interchangeability offset described in Section 6, *Specifications*.

10. Attributions and References

Santoprene® is a registered trademark of Exxon Mobile Corporation.

ATUM is a trademark of Tyco Electronics Corporation.

Macromelt® is a trademark of Henkel Corporation.

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 the following 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 datalogger code)
- .CR1 (CR1000 datalogger code)
- .CR2 (CR200X datalogger code)
- .CR8 (CR800 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*. 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, .CR1, .CR2, .CR8, .CR3, or .CR5 extension. 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 an apostrophe (') begins each line. This character instructs the datalogger compiler to ignore the line when compiling.

Appendix B. Example Programs

The following example can be used directly with CR200(X) series dataloggers.

```
'Program measures one 109SS temperature probe once a second and
'stores the average temperature every 60 minutes.

'Wiring Diagram
'==============
'  109SS
'  Probe
'  Lead                                      CR200(X)
'  Color      Function                       Terminal
'  -----      --------                       ------
'  Black      Voltage-excitation input       VX1/EX1
'  Red        Analog-voltage output          SE1
'  Purple     Bridge-resistor ground         Ground Symbol
'  Clear      Shield                         Ground Symbol

'Declare the variable for the temperature measurement
Public T109SS_C

'Define a data table for 60 minute averages
DataTable(Table1,True,-1)
    DataInterval(0,60,min)
    Average(1,T109SS_C,False)
EndTable

BeginProg
    Scan(1,sec)
        'Measure the temperature
        Therm109(T109SS_C,1,1,Ex1,1.0,0)
        'Call Data Table
        CallTable Table1
    NextScan
EndProg
```

This following example can be used directly with CR800 series, CR1000, CR3000, and CR5000 dataloggers.

```
'Program measures one 109SS temperature probe once a second and
'stores the average temperature every 60 minutes.

'Wiring Diagram
'==============
'  109SS
'  Probe
'  Lead                                      CR1000
'  Color      Function                       Terminal
'  -----      --------                       ------
'  Black      Voltage-excitation input       VX1 or EX1
'  Red        Analog-voltage output          SE1
'  Purple     Bridge-resistor ground         Ground Symbol
'  Clear      Shield                         Ground Symbol

'Declare the variables for the temperature measurement
Public T109SS_C

'Define a data table for 60 minute averages:
DataTable(Table1,True,-1)
    DataInterval(0,60,Min,0)
    Average(1,T109SS_C,IEEE4,0)
EndTable
```

```
BeginProg
    Scan(1,Sec,1,0)
        'Measure the temperature
        Therm109(T109SS_C,1,1,Vx1,0,_60Hz,1.0,0.0)
        'Call Data Table
        CallTable(Table1)
    NextScan
EndProg
```

The following example can be used directly with CR6 series dataloggers.

```
'Program measures one 109SS temperature probe once a second and
'stores the average temperature every 60 minutes.

'Wiring Diagram
'==============
'  109SS
'  Probe
'  Lead                                    CR6
'  Color      Function                     Terminal
'  -----      --------                     ------
'  Black      Voltage-excitation input     U10
'  Red        Analog-voltage output        U1
'  Purple     Bridge-resistor ground       Ground Symbol
'  Clear      Shield                       Ground Symbol

'Declare the variables for the temperature measurement
Public T109SS_C

'Define a data table for 60 minute averages:
DataTable(Table1,True,-1)
    DataInterval(0,60,Min,0)
    Average(1,T109SS_C,IEEE4,0)
EndTable

BeginProg
    Scan(1,Sec,1,0)
        'Measure the temperature
        Therm109(T109SS_C,1,U1,U10,0,_60Hz,1.0,0.0)
        'Call Data Table
        CallTable(Table1)
    NextScan
EndProg
```

Appendix C. Conversion of Thermistor Resistance or Voltage Ratio to Temperature

TABLE C-1. 109SS Thermistor Resistance and Temperature[1]

Actual Temperature (°C)	10K3MCD1 Thermistor Resistance (Ω)	CRBasic Therm109() Output (°C)
-40	336103.2	-40.00
-39	314558	-39.00
-38	294529.1	-38.00
-37	275900.8	-37.00
-36	258567	-36.00
-35	242430.2	-35.00
-34	227400.9	-34.00
-33	213396.6	-33.00
-32	200341.4	-32.00
-31	188165.5	-31.00
-30	176804.8	-30.00
-29	166199.8	-29.00
-28	156296.1	-28.00
-27	147043.2	-27.00
-26	138394.7	-26.00
-25	130307.6	-25.00
-24	122742.3	-24.00
-23	115662.2	-23.00
-22	109033.4	-22.00
-21	102824.6	-21.00
-20	97006.9	-20.00
-19	91553.3	-19.00
-18	86439.2	-18.00
-17	81641.4	-17.00
-16	77138.6	-16.00
-15	72911.1	-15.00
-14	68940.4	-14.00
-13	65209.7	-13.00
-12	61702.9	-12.00
-11	58405.5	-11.00
-10	55303.9	-10.00
-9	52385.2	-9.00
-8	49637.8	-8.00
-7	47050.6	-7.00
-6	44613.4	-6.00
-5	42316.7	-5.00
-4	40151.6	-4.00
-3	38110	-3.00
-2	36184	-2.00
-1	34366.6	-1.00
0	32650.9	0.00
1	31030.8	1.00

2	29500.5	2.00
3	28054.4	3.00
4	26687.5	4.00
5	25395	5.00
6	24172.5	6.00
7	23015.9	7.00
8	21921.2	8.00
9	20884.7	9.00
10	19903.2	10.00
11	18973.3	11.00
12	18092.2	12.00
13	17256.9	13.00
14	16464.9	14.00
15	15713.7	15.00
16	15000.9	16.00
17	14324.5	17.00
18	13682.3	18.00
19	13072.6	19.00
20	12493.3	20.00
21	11943	21.00
22	11419.9	22.00
23	10922.7	23.00
24	10449.8	24.00
25	10000	25.00
26	9572	26.00
27	9164.7	27.00
28	8777	28.00
29	8407.7	29.00
30	8056.1	30.00
31	7721	31.00
32	7401.7	32.00
33	7097.3	33.00
34	6807.1	34.00
35	6530.3	35.00
36	6266.2	36.00
37	6014.3	37.00
38	5773.8	38.00
39	5544.2	39.00
40	5325	40.00
41	5115.6	41.00
42	4915.6	42.00
43	4724.4	43.00
44	4541.7	44.00
45	4367	45.00
46	4200	46.00
47	4040.2	47.00
48	3887.4	48.00
49	3741.1	49.00
50	3601.1	50.00
51	3467	51.00
52	3338.7	52.00
53	3215.8	53.00
54	3098	54.00
55	2985.2	55.00
56	2877	56.00
57	2773.3	57.00

58	2673.9	58.00
59	2578.6	59.00
60	2487.1	60.00
61	2399.4	61.00
62	2315.2	62.00
63	2234.4	63.00
64	2156.8	64.00
65	2082.3	65.00
66	2010.8	66.00
67	1942.1	67.00
68	1876	68.00
69	1812.6	69.00
70	1751.6	70.00
71	1693	71.00
72	1636.6	72.00
73	1582.4	73.00
74	1530.2	74.00
75	1480.1	75.00

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