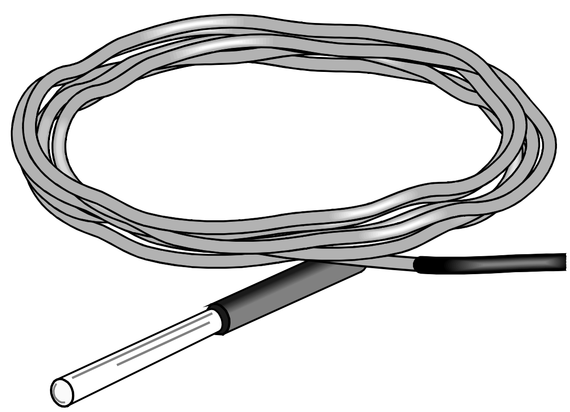
INSTRUCTION MANUAL

Model 109 Temperature Probe

Revision: 4/18



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Logan, Utah 84321-1784

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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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CRBasic Examples

Model 109 Temperature Probe

1. Introduction

The 109 Temperature Probe uses a thermistor to measure temperature in air, soil, and water. It is compatible with all CRBasic dataloggers except the CR9000(X). See Section 6, *Specifications* *(p. 4)*, 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 Campbell Scientific for assistance.

2. Precautions

READ AND UNDERSTAND the *Safety* section at the front of this manual.

Santoprene® rubber, which composes the black outer jacket of the 109 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

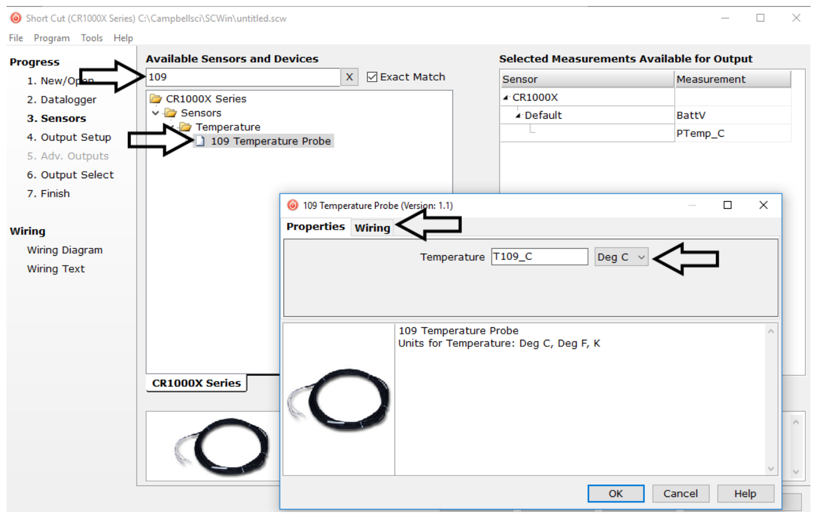
A video that describes programming using *Short Cut* is available at: *www.campbellsci.com/videos/cr1000x-datalogger-getting-started-program-part-3*. *Short Cut* is an easy way to program your datalogger to measure the 109 probe and assign datalogger wiring terminals. *Short Cut* is available as a download on *www.campbellsci.com*. It is included in installations of *LoggerNet*, *PC200W*, *PC400*, or *RTDAQ*.

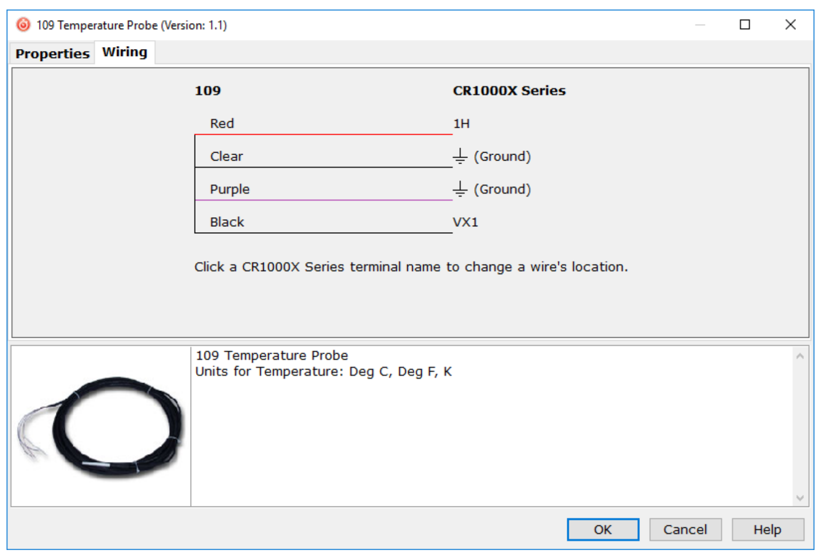
The following procedure also describes programming with *Short Cut*.

1. Open *Short Cut* and click **Create New Program**.

2. Double-click the datalogger model.

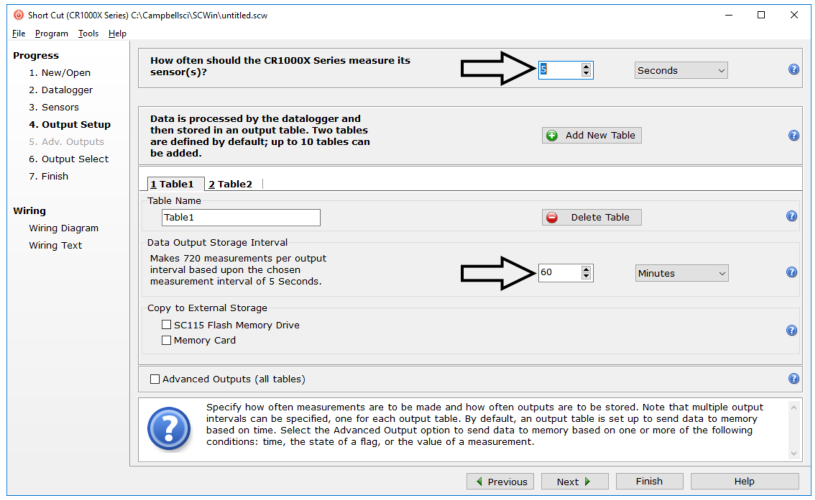
3. In the search box under the **Available Sensors and Devices** heading, type in 109 or find the 109 in the **Sensors | Temperature** folder. Double-click the **109 Temperature Probe**. Data defaults to degree Celsius. This can be changed by clicking the **Deg C** box and selecting **Deg F,** for degrees Fahrenheit, or **K,** for Kelvin. After entering the **Properties**, click on the **Wiring** tab to see how the sensor is to be wired to the datalogger.



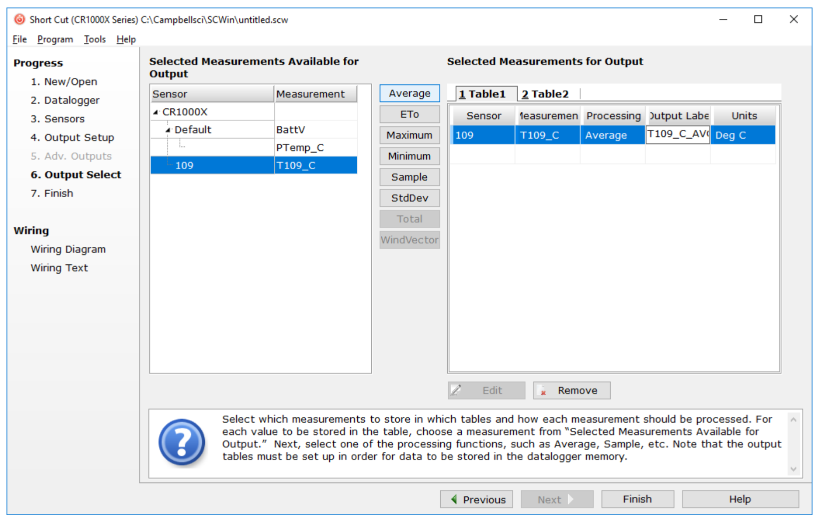


4. Select any other sensors you have, and then finish the remaining *Short Cut* steps to complete the program.

5. In **Output Setup**, enter the scan rate and **Data Output Storage Interval**.



6. Select the output option.



7. If *LoggerNet*, *PC400*, *RTDAQ*, or *PC200W* is running on your computer, and the computer 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.

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

5. Overview

The 109 is a rugged probe that accurately measures air, soil, or water temperature in a variety of applications. The sensor consists of a thermistor encapsulated in an epoxy-filled aluminum housing. This design allows the probe to be buried or submerged in water to 15 m (50 ft) or 21 psi. When measuring air temperature, a 41303-5A radiation shield is normally used to mount the 109 and limit solar radiation loading. See *Specifications* for a complete list of compatible dataloggers.

6. Specifications

Features:

- Measures air, soil, or water temperature
- Compatible with AM16/32-series multiplexers
- Easy to install or remove
- Durable
- Compatible with the following CRBasic dataloggers: CR200(X) series, CR300 series, CR6 series, CR800 series, CR1000, CR1000X series, CR3000, and CR5000

Sensor Element:	Measurement Specialties™ 10K3A1iA thermistor
Survival Range:	–50 to 100 °C
Measurement Range:	–50 to 70 °C
Time Constant in Air:	30 to 60 s in a wind speed of 5 m/s
Maximum Cable Length:	1000 ft
Accuracy[1]	
Worst case:	±0.60 °C (–50 to 70 °C) ±0.25 °C (–10 to 70 °C)
Interchangeability Error:	±0.10 °C (0 to 70 °C) ±0.13 °C at –10 °C ±0.15 °C at –20 °C ±0.18 °C at –30 °C ±0.20 °C at –40 °C ±0.50 °C at –50 °C
Steinhart-Hart Linearization Error:	≤ 0.03 °C (–50 to 70 °C)
Probe Weight and Dimensions	
Weight with 10 ft cable:	136 g (5 oz)
Length:	10.4 cm (4.1 in)
Diameter:	0.762 cm (0.3 in)

[1]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. If needed, an estimate of the interchangeability error for 0 to 50 °C, that can be used as the ***Offset*** parameter of the **Therm109()** instruction, can be determined with a 1-point or 2-point calibration.

7. Installation

If you are programming your datalogger with *Short Cut*, skip Section 7.1, *Wiring to Datalogger* *(p. 5)*, and Section 7.2, *Datalogger Programming* *(p. 5)*. *Short Cut* does this work for you. See Section 4, *QuickStart* *(p. 1)*, 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	⏚ (analog ground)
Clear	EMF shield	⏚ (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.

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 are provided in the following section. A complete program example can be found in Appendix B, *Example Programs (p. B-1)*.

If the 109 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 (p. 9)*, and Section 8.4, *Long Cable Lengths (p. 9)*.

Details of 109 probe measurement and linearization of the thermistor output are provided in Section 8.2, *Measurement and Output Linearization (p. 8)*.

7.2.1 Therm109() Instruction

The **Therm109()** measurement instruction programs CRBasic dataloggers to measure the 109 probe. It applies a precise excitation voltage, 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* *(p. 8)*, 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/Fnotch*** to the 60 Hz or 50 Hz option (see Section 8.3, *Electrically Noisy Environments* *(p. 9)*)
- Compensate for long cable lengths — Set ***SettlingTime*** to ***20000*** (see Section 8.4, *Long Cable Lengths* *(p. 9)*)

7.3 Air Temperature Installation

For air temperature measurements, locate probes over an open, level area at least 9 m (EPA; Section 10, *Attributions and References* *(p. 11)*) in diameter. The surface should be covered by short grass or the natural earth surface where grass does not grow. Probes should be located at a distance of at least four times the height of any nearby obstruction, and at least 30 m (EPA) from large paved areas. Sensors should be protected from thermal radiation, and adequately ventilated.

Standard air temperature measurement heights:

- 1.25 to 2.0 m (WMO; Section 10, *Attributions and References* *(p. 11)*)
- 2.0 m (EPA; Section 10, *Attributions and References* *(p. 11)*)
- 2.0 m and 10.0 m for temperature difference (EPA)

When exposed to sunlight, the 109 should be housed in a six-plate solar radiation shield. Six-plate shields offered by Campbell Scientific are models 41303-5A, 41303-5B, or RAD06.

The white color of these shields reflects solar radiation, and the louvered construction allows air to pass freely through, thereby keeping the probe at or near ambient temperature. The RAD06 uses a double-louvered design that offers improved sensor protection from insect intrusion and driving rain and snow. In addition, the RAD06 shield has lower self-heating in bright sunlight combined with higher temperatures (> 24 °C (75 °F)) and low wind speeds (< 2 m/s (4.5 mph)), giving a better measurement.

The 41303-5A and RAD06 attach to a crossarm, mast, or user-supplied pipe with a 2.5 to 5.3 cm (1.0 to 2.1 in) outer diameter. The 41303-5B attaches to a CM500-series pole or a user-supplied pole with a 5.1 cm (2.4 in) outer diameter.

Tools required for installing a radiation shield to a tripod or tower include:

- 1/2-inch open end wrench
- UV resistant cable ties
- adjustable wrench with a minimum 1-1/2 inch jaw size

FIGURE 7-1. Installing a 109 and 41303-5A Radiation Shield on a CM200-Series Crossarm

FIGURE 7-2. 109 and 41303-5A Radiation Shield on a tripod mast (left). 109 and RAD06 Radiation Shield on a CM200-Series Crossarm (right).

The 109 is held in the 41303-5A radiation shield by a mounting clamp at the bottom (FIGURE 7-1 and FIGURE 7-2 left). Loosen the mounting clamp screws, and insert the probe through the clamp. Tighten the screws to secure the sensor, and route the sensor cable to the instrument enclosure.

The 109 is held in the RAD06 radiation shield by inserting the sensor through the sensor gland at the bottom of the shield (FIGURE 7-2 right). Loosen the nut on the gland, and insert the probe into the shield. Tighten the nut on the sensor gland using an adjustable wrench until the sensor is securely held in place. Route the sensor cable to the instrument enclosure.

Secure the cable to the tripod or tower using cable ties.

7.4 Water Temperature Installation

109 probes can be submerged to 15 m (50 ft) or 21 psi. The 109 is not weighted, so a weighting system should be added, or the probe secured to a submerged object such as a piling.

7.5 Soil Temperature Installation

The 109 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

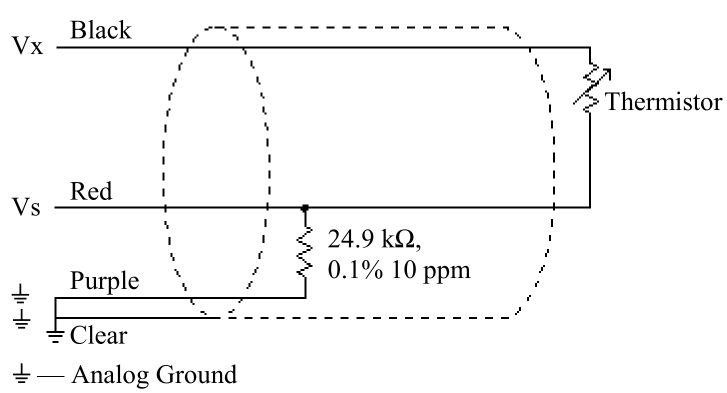


FIGURE 8-1. 109 Thermistor Probe Schematic

8.2 Measurement and Output Linearization

CRBasic instruction **Therm109()** measures the 109 probe thermistor and automatically converts the result to temperature. With reference to the previous

FIGURE 8-1, *109 Thermistor Probe Schematic*, **Therm109()** applies 2500 mV excitation at the Vx line and measures the voltage drop across the 24.9 kΩ resistor 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:

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

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

The relationship of Rs to temperature is tabulated in Appendix C, *Thermistor Resistance and Temperature* *(p. C-1)*, but is calculated by **Therm109()** using the Steinhart-Hart equation, described as follows:

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

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. This noise can usually be filtered out.

The following code snip examples filter 60 Hz noise.

CR6-series datalogger example:

```
Therm109(T109_C,1,U1,U10,20000,60,1.0,0.0)
```

CR800-series and CR3000 dataloggers example:

```
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 (>50 ft) 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. Campbell

Scientific suggests doubling the settling time every 50 ft. The following code snip examples increase settling time by 20000 µs by placing ***20000*** as the argument in the ***SettlingTime*** parameter:

CR6-series datalogger example:

```
Therm109(T109_C,1,U1,U10,20000,60,1.0,0.0)
```

CR800-series and CR3000 dataloggers example:

```
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* ***(p. 5)***). 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 50 Hz or 60 Hz options for the ***Fnotch*** parameter, and/or increasing the settling time as described in Section 8.3, *Electrically Noisy Environments* ***(p. 9)***, and Section 8.4, *Long Cable Lengths* ***(p. 9)***. Ensure the clear wire is connected to datalogger ground, and the datalogger is properly grounded.

9.2 Maintenance

The 109 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

If needed, an estimate of the interchangeability error for 0 to 50 °C, that can be used as the ***Offset*** parameter of the **Therm109()** instruction, can be determined with a 1-point or 2-point calibration. Calibration of the 109 probe is not necessary unless the accuracy needed in the sensor data requires correction of the thermistor interchangeability offset described in Section 6, *Specifications* ***(p. 4)***.

10. Attributions and References

Santoprene® is a registered trademark of Exxon Mobile Corporation.

Measurement Specialties™ is a trademarked global designer and manufacturer of sensors and sensor-based systems.

EPA installation standard: *Quality Assurance Handbook for Air Pollution Measurement Systems – Volume IV: Meteorological Measurements Version 2.0*

WMO standard: *WMO No. 8, Seventh edition, 6 Aug 2008 Guide to Meteorological Instruments and Methods of Observation*

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)
- .CR2 (CR200(X)-series datalogger code)
- .CR300 (CR300-series datalogger code)
- .CR6 (CR6-series datalogger code)
- .CR8 (CR800-series datalogger code)
- .CR1 (CR1000 datalogger code)
- .CR1X (CR1000X-series 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. On the **Advanced** tab, click the **CRBasic Editor** button. The program opens in CRBasic with the name **noname.CR_**. Now save the program with your desired name in any folder.

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.

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

3. Import wiring information to the program by opening the associated .DEF file. By default, it will be in the c:\campbellsci\SCWin folder. 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. You can highlight several lines of CRBasic code then right-click and select **Comment Block**. (This feature is demonstrated at about 5:10 in the *CRBasic | Features* video.)

Appendix B. Example Programs

This following example can be used directly with most of our CRBasic dataloggers.

CRBasic Example B-1. 109 Program Example for CR300-Series, CR800-Series, CR1000, CR1000X-Series, CR3000, and CR5000 Dataloggers

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

'Wiring Diagram
'==============
'  109
'  Probe
'  Lead                                            Datalogger
'  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 T109_C

'Define a data table for 60 minute averages:
DataTable(Hourly,True,-1)
  DataInterval(0,60,Min,0)
  Average(1,T109_C,IEEE4,0)
EndTable

BeginProg
  Scan(1,Sec,1,0)
    'Measure the temperature
    Therm109(T109_C,1,1,Vx1,0,_60Hz,1.0,0.0)
    'Call Data Table
    CallTable(Hourly)
  NextScan
EndProg
```

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

CRBasic Example B-2. 109 Program Example for CR6 Dataloggers

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

'Wiring Diagram
'==============
'  109
'  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 T109_C
```

```
'Define a data table for 60 minute averages:
DataTable(Hourly,True,-1)
  DataInterval(0,60,Min,0)
  Average(1,T109_C,IEEE4,0)
EndTable

BeginProg
  Scan(1,Sec,1,0)
    'Measure the temperature
    Therm109(T109_C,1,U1,U10,0,60,1.0,0.0)
    'Call Data Table
    CallTable(Hourly)
  NextScan
EndProg
```

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

CRBasic Example B-3. 109 Program Example for CR200(X)-Series Dataloggers

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

'Wiring Diagram
'==============
'  109
'  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 T109_C

'Define a data table for 60 minute averages
DataTable(Hourly,True,-1)
  DataInterval(0,60,min)
  Average(1,T109_C,False)
EndTable

BeginProg
  Scan(1,sec)
    'Measure the temperature
    Therm109(T109_C,1,1,Ex1,1.0,0)
    'Call Data Table
    CallTable Hourly
  NextScan
EndProg
```

Appendix C. Thermistor Resistance and Temperature

TABLE C-1. 109 Thermistor Resistance and Temperature[1]		
Actual Temperature (°C)	10K3A1iA Thermistor Resistance (Ω)	CRBasic Therm109() Output (°C)
-40	336098	-40.00
-39	314553	-39.00
-38	294524	-38.00
-37	275897	-37.00
-36	258563	-36.00
-35	242427	-35.00
-34	227398	-34.00
-33	213394	-33.00
-32	200339	-32.00
-31	188163	-31.00
-30	176803	-30.00
-29	166198	-29.00
-28	156294	-28.00
-27	147042	-27.00
-26	138393	-26.00
-25	130306	-25.00
-24	122741	-24.00
-23	115661	-23.00
-22	109032	-22.00
-21	102824	-21.00
-20	97006	-20.00
-19	91553	-19.00
-18	86439	-18.00
-17	81641	-17.00
-16	77138	-16.00
-15	72911	-15.00
-14	68940	-14.00
-13	65209	-13.00
-12	61703	-12.00
-11	58405	-11.00
-10	55304	-10.00
-9	52385	-9.00
-8	49638	-8.00
-7	47050	-7.00
-6	44613	-6.00
-5	42317	-5.00
-4	40151	-4.00
-3	38110	-3.00
-2	36184	-2.00
-1	34366	-1.00
0	32651	0.00
1	31031	1.00
2	29500	2.00
3	28054	3.00

4	26687	4.00
5	25395	5.00
6	24172	6.00
7	23016	7.00
8	21921	8.00
9	20885	9.00
10	19903	10.00
11	18973	11.00
12	18092	12.00
13	17257	13.00
14	16465	14.00
15	15714	15.00
16	15001	16.00
17	14324	17.00
18	13682	18.00
19	13073	19.00
20	12493	20.00
21	11943	21.00
22	11420	22.00
23	10923	23.00
24	10450	24.00
25	10000	25.00
26	9572	26.00
27	9165	27.00
28	8777	28.00
29	8408	29.00
30	8056	30.00
31	7721	31.00
32	7402	32.00
33	7097	33.00
34	6807	34.00
35	6530	35.00
36	6266	36.00
37	6014	37.00
38	5774	38.00
39	5544	39.00
40	5325	40.00
41	5116	41.00
42	4916	42.00
43	4724	43.00
44	4542	44.00
45	4367	45.00
46	4200	46.00
47	4040	47.00
48	3887	48.00
49	3741	49.00
50	3601	50.00
51	3467	51.00
52	3339	52.00
53	3216	53.00
54	3098	54.00
55	2985	55.00
56	2877	56.00
57	2773	57.00
58	2674	58.00
59	2579	59.00

60	2487	60.00
61	2399	61.00
62	2315	62.00
63	2234	63.01
64	2157	64.00
65	2082	65.00
66	2011	66.00
67	1942	67.00
68	1876	68.00
69	1813	68.99
70	1752	69.99
71	1693	71.00
72	1637	71.99
73	1582	73.01
74	1530	74.00
75	1480	75.00
[1]Data from Measurement Specialties™		

Campbell Scientific Worldwide Offices

Australia
Location: Garbutt, QLD Australia
Email: *info@campbellsci.com.au*
Website: *www.campbellsci.com.au*

Brazil
Location: São Paulo, SP Brazil
Email: *andread@campbellsci.com.br*
Website: *www.campbellsci.com.br*

Canada
Location: Edmonton, AB Canada
Email: *dataloggers@campbellsci.ca*
Website: *www.campbellsci.ca*

China
Location: Beijing, P. R. China
Email: *info@campbellsci.com.cn*
Website: *www.campbellsci.com.cn*

Costa Rica
Location: San José, Costa Rica
Email: *info@campbellsci.cc*
Website: *www.campbellsci.cc*

France
Location: Antony, France
Email: *info@campbellsci.fr*
Website: *www.campbellsci.fr*

Germany
Location: Bremen, Germany
Email: *info@campbellsci.de*
Website: *www.campbellsci.de*

South Africa
Location: Stellenbosch, South Africa
Email: *sales@csafrica.co.za*
Website: *www.campbellscientific.co.za*

Southeast Asia
Location: Bangkok, Thailand
Email: *info@campbellsci.asia*
Website: *www.campbellsci.asia*

Spain
Location: Barcelona, Spain
Email: *info@campbellsci.es*
Website: *www.campbellsci.es*

UK
Location: Shepshed, Loughborough, UK
Email: *sales@campbellsci.co.uk*
Website: *www.campbellsci.co.uk*

USA
Location: Logan, UT USA
Email: *info@campbellsci.com*
Website: *www.campbellsci.com*

Please visit *www.campbellsci.com/contact* to obtain contact information for your local US or international representative.