



109SS

Stainless Steel Temperature Probe for Harsh
Environments



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1. Introduction

The 109SS Temperature Probe uses a thermistor to measure temperature in soil and water. It easily interfaces with most Campbell Scientific data loggers and can be used in a variety of applications.

For Edlog data logger 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 back 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

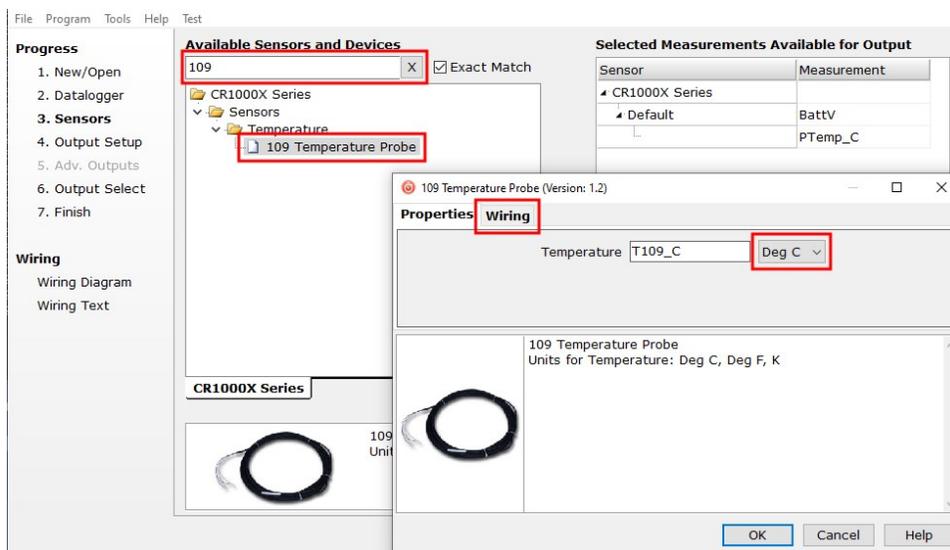
A video that describes data logger programming using *Short Cut* is available at:

www.campbellsci.com/videos/cr1000x-data-logger-getting-started-program-part-3 . *Short*

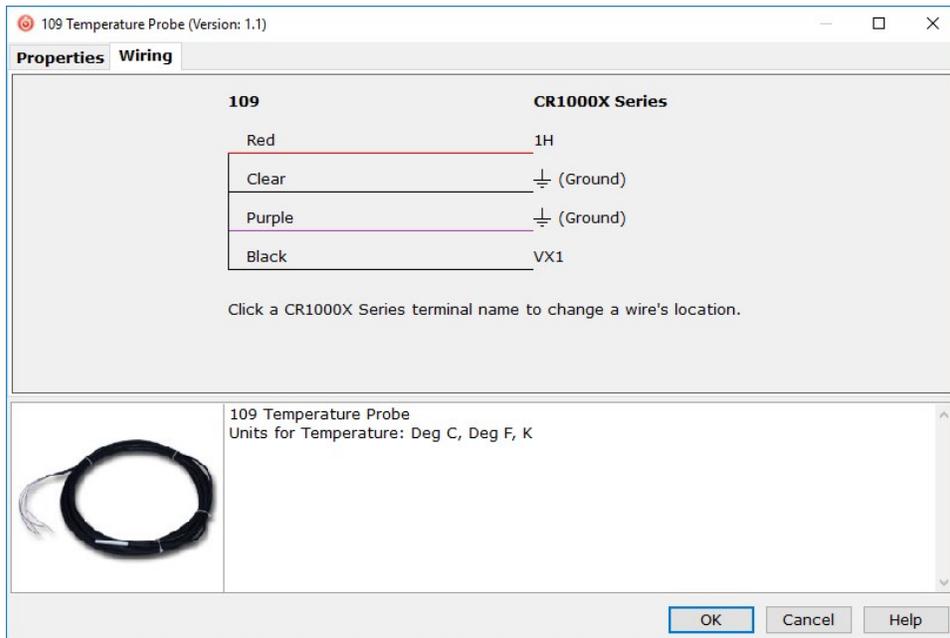
Cut is an easy way to program your data logger to measure the sensor and assign data logger wiring terminals. **Short Cut** is available as a download on www.campbellsci.com. It is included in installations of **LoggerNet**, **RTDAQ**, and **PC400**.

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

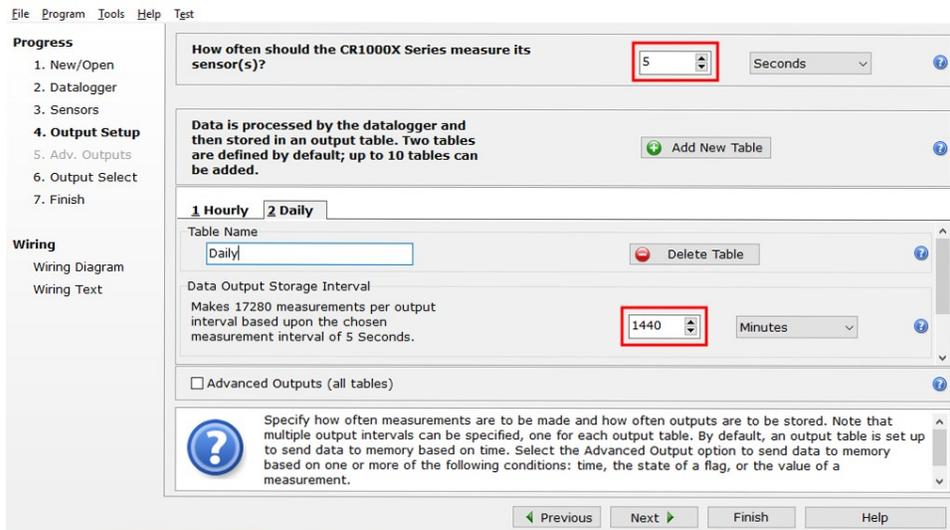
1. Open **Short Cut** and click **Create New Program**.
2. Double-click the data logger model.
3. In the **Available Sensors and Devices** box, type 109 or find the 109 in the **Sensors > Temperature** folder. Double-click the **109 Temperature Probe**. Data defaults to degree Celsius. This can be changed by clicking the **Deg C** box and selecting **Deg F**, for degrees Fahrenheit, or **K** for Kelvin.



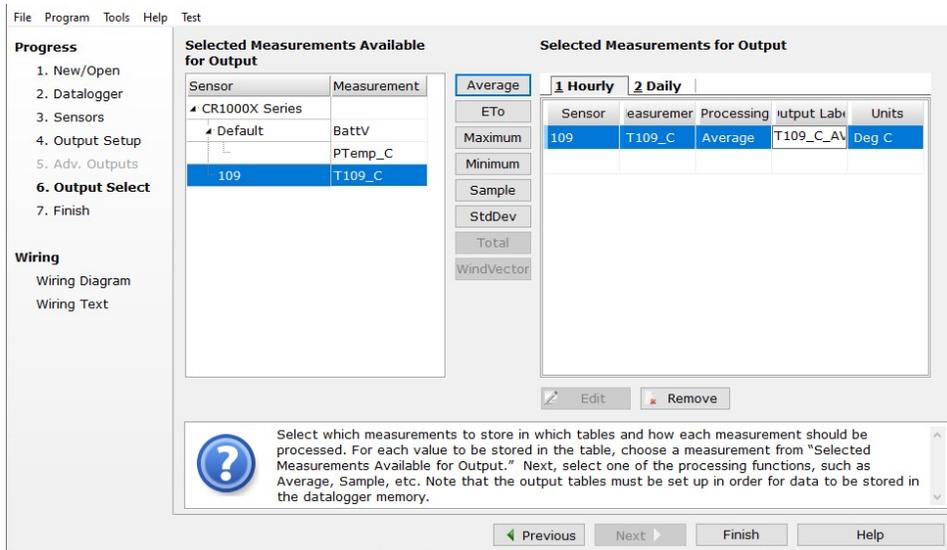
- Click the **Wiring** tab to see how the sensor is to be wired to the data logger. Click **OK** after wiring the sensor.



- Repeat steps three and four for other sensors being measured. Click **Next**.
- In **Output Setup**, type the scan rate, **Data Output Storage Intervals**, and meaningful table names.



7. Select the measurement and its associated output option.



8. Click **Finish** and save the program. Send the program to the data logger if the data logger is connected to the computer.
9. If the sensor is connected to the data logger, check the output of the sensor in the data display in *LoggerNet*, *RTDAQ*, or *PC400* 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.

Features:

- Measures soil or water temperature
- Compatible with AM16/32-series multiplexers
- Easy to install or remove
- Durable
- Compatible CRBasic data loggers: CR6, CR1000X, CR800 series, CR350 series, CR300 series, CR3000, CR1000

6. Specifications

Sensor element:	Measurement Specialties Micro-BetaCHIP 10K3MCD1 thermistor
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:	305 m (1000 ft)
Accuracy ¹	
Worst case:	±0.60 °C (–40 to 70 °C) ±0.49 °C (–20 to 70 °C)
Maximum submergence:	45 m (150 ft) (63 psi)
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 equation 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:	ATUMTM heat shrink

Macromelt® overmolded joint

Weight:

0.2 lb per 10.5 ft cable

Compliance:

View the EU Declaration of Conformity at

www.campbellsci.com/109ss 

¹Overall probe accuracy is a combination of thermistor interchangeability, bridge-resistor accuracy, and error of the Steinhart-Hart equation. Bridge resistors have 0.1% tolerance with a 10 ppm temperature coefficient. 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 **Therm109C** instruction, can be determined with a 1-point or 2-point calibration.

7. Installation

If you are programming your data logger with *Short Cut*, skip [Wiring to data logger](#) (p. 6) and [Data logger programming](#) (p. 6). *Short Cut* does this work for you. See [QuickStart](#) (p. 1) for a *Short Cut* tutorial.

7.1 Wiring to data logger

Wire color	Wire function	Data logger 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	⊥ (analog ground)
Clear	EMF shield	⊥ (analog ground)

¹U terminals are automatically configured by the measurement instruction.

7.2 Data logger programming

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

If your data acquisition requirements are simple, you can probably create and maintain a data logger program exclusively with *Short Cut*. If your data acquisition needs are more complex, the

files that *Short Cut* creates are a great source for programming code to start a new program or add to an existing custom program.

NOTE:

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

A *Short Cut* tutorial is available in [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 [Importing Short Cut code into CRBasic Editor](#) (p. 12). Programming basics are provided in the following section. A complete program example can be found in [Example program](#) (p. 13).

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 [Electrically noisy environments](#) (p. 9) and [Long cable lengths](#) (p. 9).

Details of 109SS probe measurement and linearization of the thermistor output are provided in [Measurement and output linearization](#) (p. 8).

7.2.1 Therm109() instruction

The [Therm109\(\)](#) measurement instruction programs CRBasic data loggers to measure this sensor. It applies a precise excitation voltage, makes a half-bridge resistance measurement, and converts the result to temperature using the Steinhart-Hart equation. See [Measurement and output linearization](#) (p. 8) for more information. [Therm109\(\)](#) instruction and parameters are as follows:

[Therm109](#)(Dest, Repts, SEChan, VxChan, SettlingTime, Integ/f_{N1}, Mult, Offset)

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/f_{N1}** to the 60 Hz or 50 Hz option (see [Electrically noisy environments](#) [p. 9])
- Compensate for long cable lengths — Set **SettlingTime** to 20000 (see [Long cable lengths](#) [p. 9])

7.3 Water temperature installation

109SS probes can be submerged to 305 m (1000 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 63 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

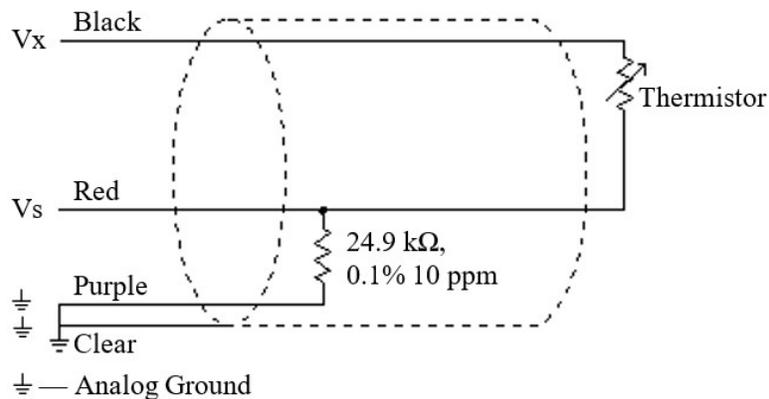


Figure 8-1. 109SS thermistor probe schematic

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](#) (p. 8), [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 (V_s) to excitation voltage (V_x) is related to thermistor resistance (R_s) and the 24.9 k Ω bridge resistor as described in the following equations:

$$V_s/V_x = 24900 \Omega / (R_s + 24900 \Omega)$$

Solving for R_s :

$$R_s + 24900 \Omega = 24900 \Omega \cdot (V_x/V_s)$$

$$R_s = 24900 \Omega \cdot ((V_x/V_s) - 1)$$

The relationship of R_s to temperature is tabulated in [Thermistor resistance and temperature](#) (p. 14), 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 ($^{\circ}\text{C}$)

$$A^1 = 1.129241\text{E}-3$$

$$B^1 = 2.341077\text{E}-4$$

$$C^1 = 8.775468\text{E}-8$$

¹Coefficients 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 snippet examples filter 60 Hz noise.

CR6-series data logger example:

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

CR800-series and CR3000 data loggers example:

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

8.4 Long cable lengths

Long cable lengths (>50 ft) may require longer than normal analog measurement settling times. Enter a longer settling time in the **SettlingTime** parameter of the [Therm109\(\)](#) instruction.

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

CR6-series data logger example:

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

CR800-series and CR3000 data loggers example:

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

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 back of this manual for more information.

9.1 Troubleshooting

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

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

Symptom: Incorrect temperature is reported.

Verify the **Mu1t** and **Offset** arguments in **Therm109(C)** are correct for the desired units ([Data logger programming](#) [p. 6]). 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 f_{N1} parameter, and/or increasing the settling time as described in [Electrically noisy environments](#) (p. 9) and [Long cable lengths](#) (p. 9). Ensure the clear wire is connected to data logger ground, and the data logger is properly grounded.

9.2 Maintenance

The 109SS probe requires minimal maintenance.

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\(C\)](#) instruction, can be determined with a 1-point or 2-point calibration. Calibration of the 109SS probe is not necessary unless the accuracy needed in the sensor data requires correction of the thermistor interchangeability offset described in [Specifications](#) (p. 5).

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.

ATUM is a trademark of Tyco Electronics Corporation.

Macromelt® is a trademark of Henkel Corporation.

Appendix A. Importing *Short Cut* code into *CRBasic Editor*

Short Cut creates a .DEF file that contains wiring information and a program file that can be imported into *CRBasic Editor*. By default, these files reside in the C:\campbellsci\SCWin folder.

Import *Short Cut* program file and wiring information into *CRBasic Editor*:

1. Create the *Short Cut* program, then save it. Click the **Advanced** tab then the **CRBasic Editor** button. Your program file will open in CRBasic with a generic name. Provide a meaningful name and save the CRBasic program. This program can now be edited for additional refinement.

NOTE:

Once the file is edited with *CRBasic Editor*, *Short Cut* can no longer be used to edit the program.

2. To add the *Short Cut* wiring information into the new CRBasic program, open the .DEF file located in the C:\campbellsci\SCWin folder. Copy the wiring information found at the beginning of the .DEF file.
3. Go into the CRBasic program and paste the wiring information at the beginning of the program.
4. In the CRBasic program, highlight the wiring information, right-click, and select **Comment Block**. This adds an apostrophe (') to the beginning of each of the highlighted lines, which instructs the data logger compiler to ignore those lines when compiling. The **Comment Block** feature is demonstrated at about 5:10 in the [CRBasic | Features](#) video .

Appendix B. Example program

This following example measures one 109SS temperature probe once a second and stores the average temperature every 60 minutes.

CRBasic Example 1: CR1000X program that measures the 109SS

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

```
'Wiring Diagram
```

```
'=====
```

```
' Probe  
' Wire Data logger  
' 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 variables for the temperature measurement
```

```
Public T109SS_C
```

```
'Define a data table for 60 minute averages:
```

```
DataTable(Hourly,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,Vx1,0,60,1.0,0.0)  
    'Call Data Table  
    CallTable(Hourly)
```

```
  NextScan
```

```
EndProg
```

Appendix C. Thermistor resistance and temperature

Table C-1: 109SS thermistor resistance and temperature¹

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

Table C-1: 109SS thermistor resistance and temperature¹

Actual temperature (°C)	10K3MCD1 thermistor resistance (Ω)	CRBasic Therm109() output (°C)
-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

Table C-1: 109SS thermistor resistance and temperature¹

Actual temperature (°C)	10K3MCD1 thermistor resistance (Ω)	CRBasic Therm109() output (°C)
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

Table C-1: 109SS thermistor resistance and temperature¹

Actual temperature (°C)	10K3MCD1 thermistor resistance (Ω)	CRBasic Therm109() output (°C)
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

Table C-1: 109SS thermistor resistance and temperature¹

Actual temperature (°C)	10K3MCD1 thermistor resistance (Ω)	CRBasic Therm109() output (°C)
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

¹Data from Measurement Specialties™

Limited warranty

Products manufactured by Campbell Scientific are warranted by Campbell Scientific 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 on the corresponding product webpage. See Product Details on the Ordering Information pages at www.campbellsci.com. Other manufacturer's products, that are resold by Campbell Scientific, are warranted only to the limits extended by the original manufacturer.

Refer to www.campbellsci.com/terms#warranty for more information.

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Assistance

Products may not be returned without prior authorization.

Products shipped to Campbell Scientific require a Returned Materials Authorization (RMA) or Repair Reference number and must be clean and uncontaminated by harmful substances, such as hazardous materials, chemicals, insects, and pests. Please complete the required forms prior to shipping equipment.

Campbell Scientific regional offices handle repairs for customers within their territories. Please see the back page for the Global Sales and Support Network or visit www.campbellsci.com/contact  to determine which Campbell Scientific office serves your country.

To obtain a Returned Materials Authorization or Repair Reference number, contact your CAMPBELL SCIENTIFIC regional office. Please write the issued number clearly on the outside of the shipping container and ship as directed.

For all returns, the customer must provide a "Statement of Product Cleanliness and Decontamination" or "Declaration of Hazardous Material and Decontamination" form and comply with the requirements specified in it. The form is available from your CAMPBELL SCIENTIFIC regional office. Campbell Scientific is unable to process any returns until we receive this statement. If the statement 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.

Safety

DANGER — MANY HAZARDS ARE ASSOCIATED WITH INSTALLING, USING, MAINTAINING, AND WORKING ON OR AROUND **TRIPODS, TOWERS, AND ANY ATTACHMENTS TO TRIPODS AND TOWERS SUCH AS SENSORS, CROSSARMS, ENCLOSURES, ANTENNAS, ETC.** FAILURE TO PROPERLY AND COMPLETELY ASSEMBLE, INSTALL, OPERATE, USE, AND MAINTAIN TRIPODS, TOWERS, AND ATTACHMENTS, AND FAILURE TO HEED WARNINGS, INCREASES THE RISK OF DEATH, ACCIDENT, SERIOUS INJURY, PROPERTY DAMAGE, AND PRODUCT FAILURE. TAKE ALL REASONABLE PRECAUTIONS TO AVOID THESE HAZARDS. CHECK WITH YOUR ORGANIZATION'S SAFETY COORDINATOR (OR POLICY) FOR PROCEDURES AND REQUIRED PROTECTIVE EQUIPMENT PRIOR TO PERFORMING ANY WORK.

Use tripods, towers, and attachments to tripods and towers only for purposes for which they are designed. Do not exceed design limits. Be familiar and comply with all instructions provided in product manuals. Manuals are available at www.campbellsci.com. 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

- Protect from over-voltage.
- Protect electrical equipment from water.
- Protect from electrostatic discharge (ESD).
- Protect from lightning.
- Prior to performing site or installation work, obtain required approvals and permits. Comply with all governing structure-height regulations.
- 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, 6 meters (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.
- Only use power sources approved for use in the country of installation to power Campbell Scientific devices.

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.

Internal Battery

- Be aware of fire, explosion, and severe-burn hazards.
- Misuse or improper installation of the internal lithium battery can cause severe injury.
- Do not recharge, disassemble, heat above 100 °C (212 °F), solder directly to the cell, incinerate, or expose contents to water. Dispose of spent batteries properly.

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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