PRODUCT MANUAL

Sensor

109SS

Stainless Steel Temperature Probe for Harsh Environments

Revision: 06/2023

CSL I.D - 1255

RELIABLE MONITORING SINCE 1974

Campbell SCIENTIFIC®

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.

Campbell Scientific Ltd,
80 Hathern Road,
Shepshed, Loughborough, LE12 9GX, UK
Tel: +44 (0) 1509 601141
Fax: +44 (0) 1509 270924
Email: support@campbellsci.co.uk
www.campbellsci.co.uk

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	**Mass:**	1 oz. (ounce) = 28.35 g 1 lb (pound weight) = 0.454 kg
Length:	1 in. (inch) = 25.4 mm 1 ft (foot) = 304.8 mm 1 yard = 0.914 m 1 mile = 1.609 km	**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.

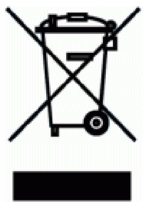
Differences include the U.S standard external power supply details where some information (for example the AC transformer input voltage) will not be applicable for British/European use. *Please note, however, that when a power supply adapter is ordered it will be suitable for use in your country.*

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.

Campbell Scientific Ltd, 80 Hathern Road, Shepshed, Loughborough, LE12 9GX,
UK Tel: +44 (0) 1509 601141 Fax: +44 (0) 1509 270924
Email: support@campbellsci.co.uk
www.campbellsci.co.uk

Safety

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

Use tripods, towers, and attachments to tripods and towers only for purposes for which they are designed. Do not exceed design limits. Be familiar and comply with all instructions provided in product manuals. Manuals are available at www.campbellsci.eu or by telephoning +44(0) 1509 828 888 (UK). You are responsible for conformance with governing codes and regulations, including safety regulations, and the integrity and location of structures or land to which towers, tripods, and any attachments are attached. Installation sites should be evaluated and approved by a qualified engineer. If questions or concerns arise regarding installation, use, or maintenance of tripods, towers, attachments, or electrical connections, consult with a licensed and qualified engineer or electrician.

General

- Prior to performing site or installation work, obtain required approvals and permits. Comply with all governing structure-height regulations, such as those of the FAA in the USA.
- Use only qualified personnel for installation, use, and maintenance of tripods and towers, and any attachments to tripods and towers. The use of licensed and qualified contractors is highly recommended.
- Read all applicable instructions carefully and understand procedures thoroughly before beginning work.
- Wear a **hardhat** and **eye protection**, and take **other appropriate safety precautions** while working on or around tripods and towers.
- **Do not climb** tripods or towers at any time, and prohibit climbing by other persons. Take reasonable precautions to secure tripod and tower sites from trespassers.
- Use only manufacturer recommended parts, materials, and tools.

Utility and Electrical

- **You can be killed** or sustain serious bodily injury if the tripod, tower, or attachments you are installing, constructing, using, or maintaining, or a tool, stake, or anchor, come in **contact with overhead or underground utility lines**.
- Maintain a distance of at least one-and-one-half times structure height, or 20 feet, or the distance required by applicable law, **whichever is greater**, between overhead utility lines and the structure (tripod, tower, attachments, or tools).
- Prior to performing site or installation work, inform all utility companies and have all underground utilities marked.
- Comply with all electrical codes. Electrical equipment and related grounding devices should be installed by a licensed and qualified electrician.

Elevated Work and Weather

- Exercise extreme caution when performing elevated work.
- Use appropriate equipment and safety practices.
- During installation and maintenance, keep tower and tripod sites clear of un-trained or non-essential personnel. Take precautions to prevent elevated tools and objects from dropping.
- Do not perform any work in inclement weather, including wind, rain, snow, lightning, etc.

Maintenance

- Periodically (at least yearly) check for wear and damage, including corrosion, stress cracks, frayed cables, loose cable clamps, cable tightness, etc. and take necessary corrective actions.
- Periodically (at least yearly) check electrical ground connections.

WHILE EVERY ATTEMPT IS MADE TO EMBODY THE HIGHEST DEGREE OF SAFETY IN ALL CAMPBELL SCIENTIFIC PRODUCTS, THE CUSTOMER ASSUMES ALL RISK FROM ANY INJURY RESULTING FROM IMPROPER INSTALLATION, USE, OR MAINTENANCE OF TRIPODS, TOWERS, OR ATTACHMENTS TO TRIPODS AND TOWERS SUCH AS SENSORS, CROSSARMS, ENCLOSURES, ANTENNAS, ETC.

Table of contents

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 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.

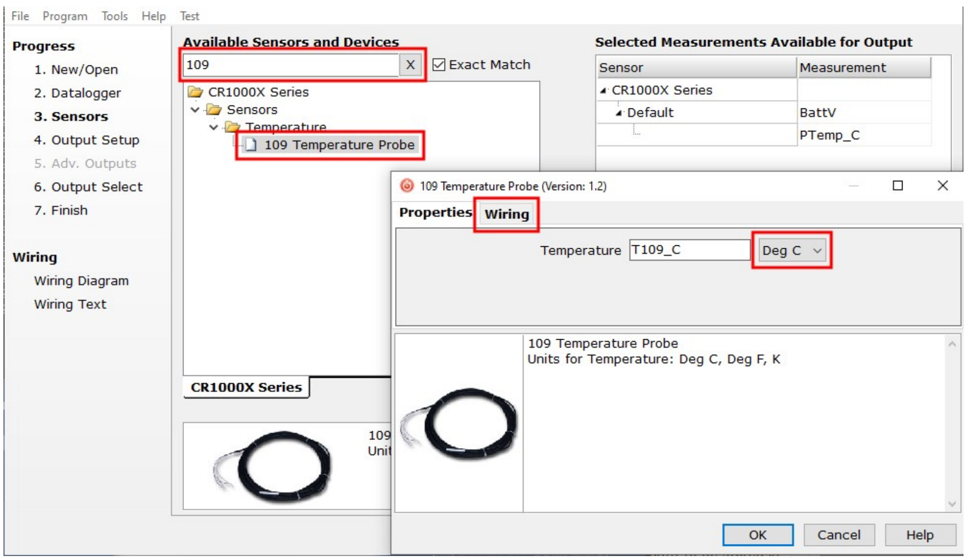
4. QuickStart

A video that describes data logger programming using ***Short Cut*** is available at: www.campbellsci.eu/videos/cr1000x-data logger-getting-started-program-part-3. ***Short***

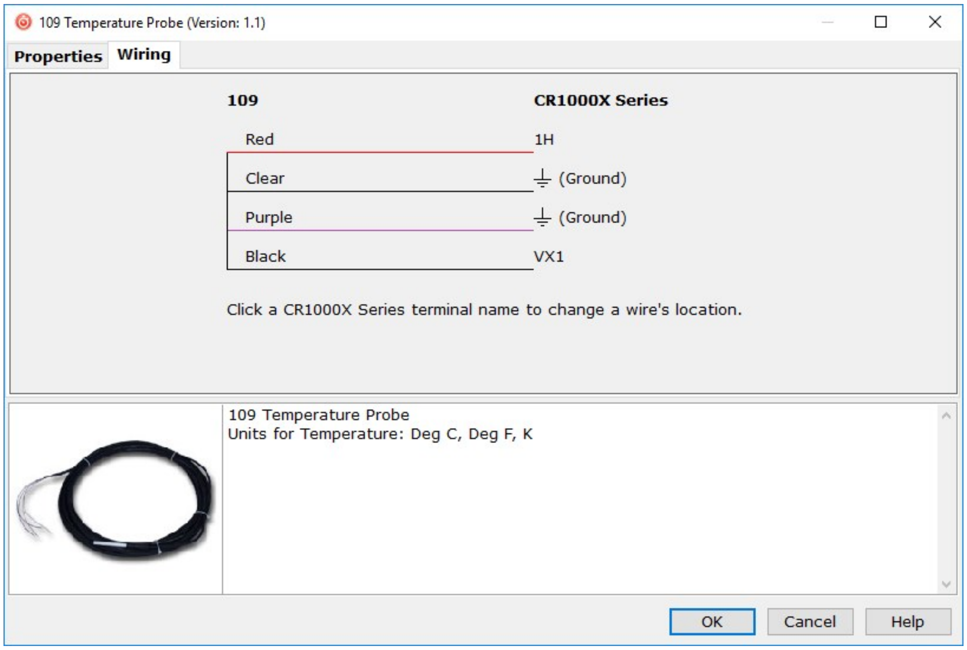
Cut is an easy way to program your data logger to measure the sensor and assign data logger wiring terminals. ***Short Cut*** is available as a download on www.campbellsci.eu. It is included in installations of ***LoggerNet***, ***RTDAQ***, and ***PC400***.

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

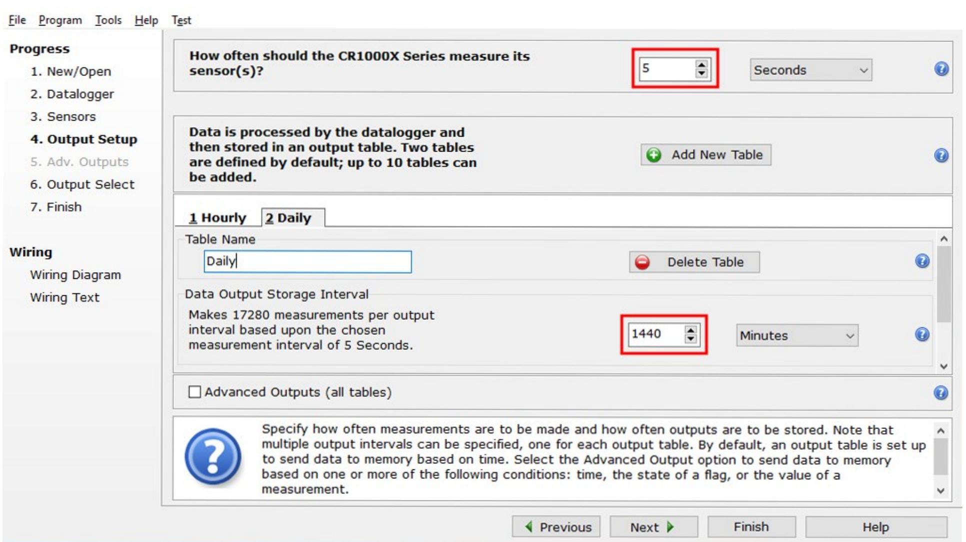
1. Open ***Short Cut*** and click **Create New Program**.
2. Double-click the data logger model.
3. In the **Available Sensors and Devices** box, type 109 or find the 109 in the **Sensors** > **Temperature** folder. Double-click the **109 Temperature Probe**. Data defaults to degree Celsius. This can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



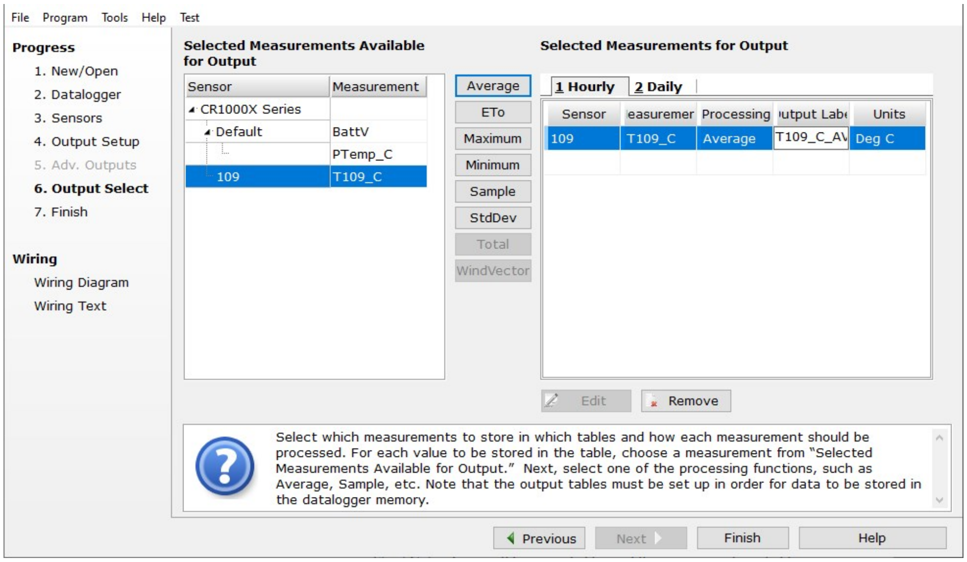
4. Click the **Wiring** tab to see how the sensor is to be wired to the data logger. Click **OK** after wiring the sensor.



5. Repeat steps three and four for other sensors being measured. Click **Next**.
6. 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.eu/109ss

[1]Overall 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 `Therm109()` 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

Table 7-1: Wire colour, function, and data logger connection

Wire colour	Wire function	Data logger connection terminal
Black	Voltage-excitation input	**U** configured for voltage excitation[1], **EX**, **VX** (voltage excitation)
Red	Analogue-voltage output	**U** configured for single-ended analogue input[1], **SE** (single-ended, analogue-voltage input)
Purple	Bridge-resistor	⏚ (analogue ground)
Clear	EMF shield	⏚ (analogue ground)

[1]**U** 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, Reps, SEChan, VxChan, SettlingTime, Integ/fN1, 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

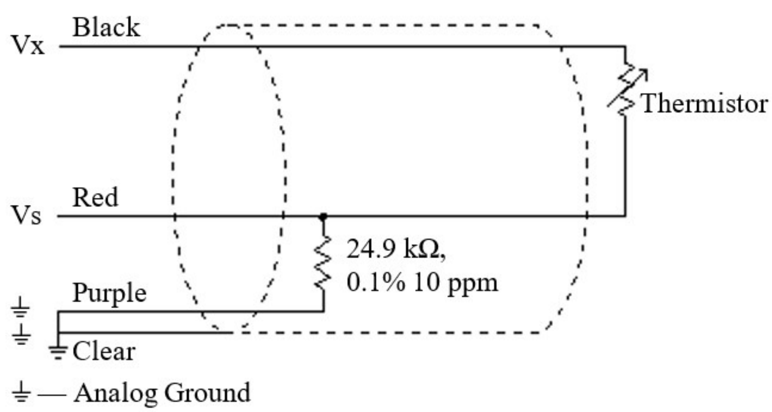


Figure 8-1. 109SS thermistor probe schematic

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 (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 Thermistor resistance and temperature (p. 14), 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. This noise can usually be filtered out.

The following code snip 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 analogue 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 µs 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 About this manual page at the front 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()` instruction: red to single-ended analogue 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 (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()` 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
' Colour   Function                  Terminal
'  -----   ---------                 ------
'  Black   Voltage-excitation input  VX1/EX1
'  Red     Analogue-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 temperature[1]

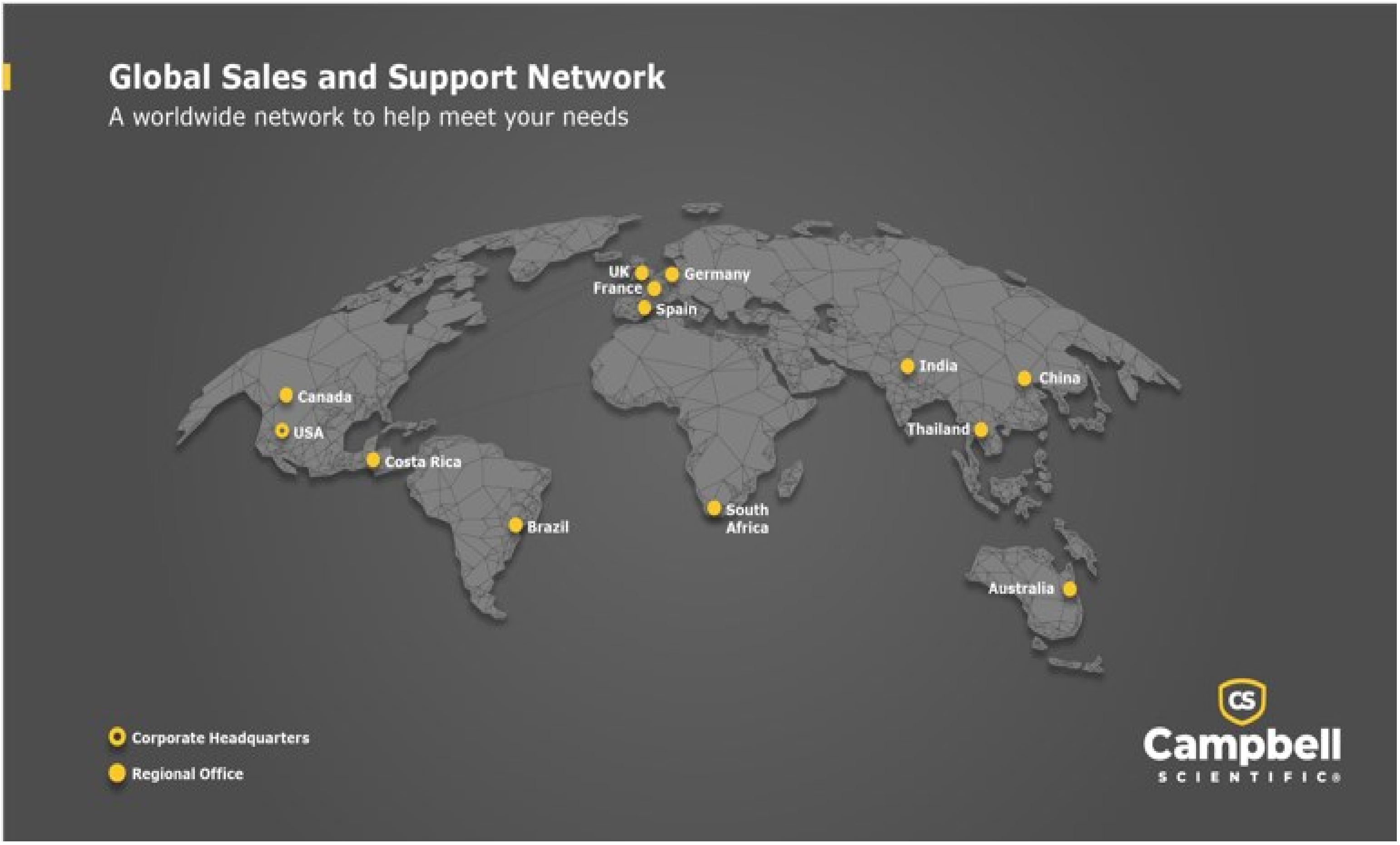
Actual temperature (°C)	10K3MCD1 thermistor resistance (Ω)	CRBasic Therm109() output (°C)
-40	336103.2	-40.00
-39	314558	-39.00
-38	294529.1	-38.00
-37	275900.8	-37.00
-36	258567	-36.00
-35	242430.2	-35.00
-34	227400.9	-34.00
-33	213396.6	-33.00
-32	200341.4	-32.00
-31	188165.5	-31.00
-30	176804.8	-30.00
-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

Table C-1: 109SS thermistor resistance and temperature[1]		
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 temperature[1]		
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 temperature[1]		
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 temperature[1]		
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
[1]Data from Measurement Specialties™		



Campbell Scientific Regional Offices

Australia

Location: Garbutt, QLD Australia
Phone: 61.7.4401.7700
Email: info@campbellsci.com.au
Website: www.campbellsci.com.au

Brazil

Location: São Paulo, SP Brazil
Phone: 11.3732.3399
Email: vendas@campbellsci.com.br
Website: www.campbellsci.com.br

Canada

Location: Edmonton, AB Canada
Phone: 780.454.2505
Email: dataloggers@campbellsci.ca
Website: www.campbellsci.ca

China

Location: Beijing, P. R. China
Phone: 86.10.6561.0080
Email: info@campbellsci.com.cn
Website: www.campbellsci.com.cn

Costa Rica

Location: San Pedro, Costa Rica
Phone: 506.2280.1564
Email: info@campbellsci.cc
Website: www.campbellsci.cc

France

Location: Montrouge, France
Phone: 0033.0.1.56.45.15.20
Email: info@campbellsci.fr
Website: www.campbellsci.fr

Germany

Location: Bremen, Germany
Phone: 49.0.421.460974.0
Email: info@campbellsci.de
Website: www.campbellsci.de

India

Location: New Delhi, DL India
Phone: 91.11.46500481.482
Email: info@campbellsci.in
Website: www.campbellsci.in

South Africa

Location: Stellenbosch, South Africa
Phone: 27.21.8809960
Email: sales@campbellsci.co.za
Website: www.campbellsci.co.za

Spain

Location: Barcelona, Spain
Phone: 34.93.2323938
Email: info@campbellsci.es
Website: www.campbellsci.es

Thailand

Location: Bangkok, Thailand
Phone: 66.2.719.3399
Email: info@campbellsci.asia
Website: www.campbellsci.asia

UK

Location: Shepshed, Loughborough, UK
Phone: 44.0.1509.601141
Email: sales@campbellsci.co.uk
Website: www.campbellsci.co.uk

USA

Location: Logan, UT USA
Phone: 435.227.9120
Email: info@campbellsci.com
Website: www.campbellsci.com