PRODUCT MANUAL

Sensor

BlackGlobe

Temperature Sensor for Heat Stress

Revision: 01/2025

RELIABLE MONITORING SINCE 1974

Campbell Scientific®

Please read first

About this manual

Please note that this manual was produced by Campbell Scientific Inc. primarily for the North American market. Some spellings, weights and measures may reflect this. 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 from Campbell Scientific it will be suitable for use in your country*.

Reference to some radio transmitters, digital cell phones and aerials (antennas) 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.

Recycling information for countries subject to WEEE regulations 2012/19/EU

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, per The Waste Electrical and Electronic Equipment (WEEE) Regulations 2012/19/EU. Campbell Scientific 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 support, please contact Campbell Scientific, or your local agent.

Table of contents

1. Introduction

The BlackGlobe Temperature Sensor for Heat Stress (BlackGlobe) measures radiant temperature. Radiant temperature is a representation of the ability of an object to exchange heat with its surroundings. This measurement, along with the measurement of ambient air and wet-bulb temperatures, is used to calculate the wet-bulb globe temperature (WBGT). The WBGT index combines the effects of temperature, humidity, radiant heat, and wind into one single index employed to express environmental heat stress. The measurement of heat stress is important because loss of physical and mental efficiency occurs under definable degrees of heat stress. Severe heat stress can lead to fatigue, exhaustion and possibly even disability or death.

Before installing the BlackGlobe, please study:

- Precautions (p. 1)
- Initial inspection (p. 1)

2. Precautions

READ AND UNDERSTAND the Safety section at the back of this manual.

Do not use the BlackGlobe with long cable lengths in an electrically noisy environment.

Santoprene® rubber, which composes the black outer jacket of the BlackGlobe 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.

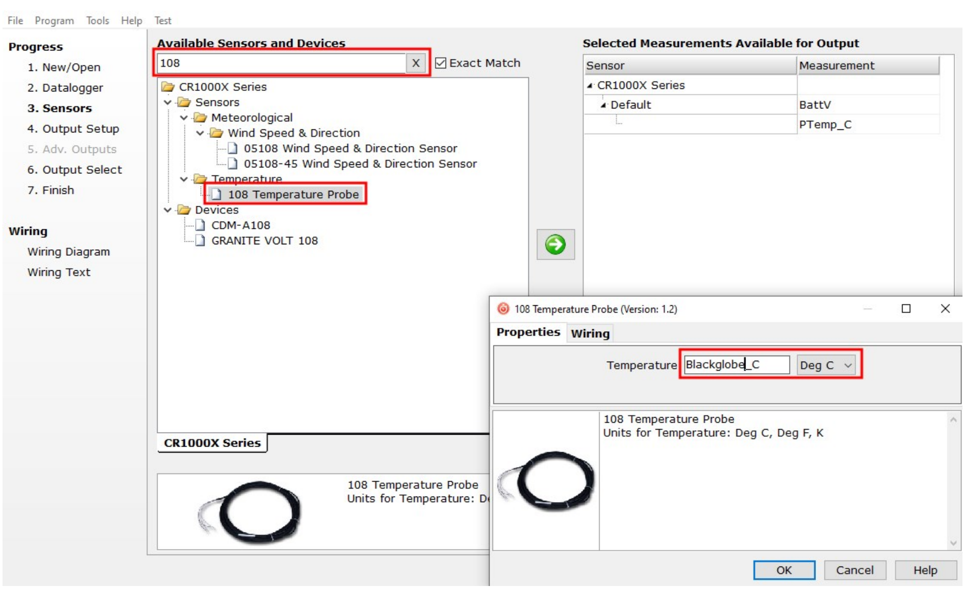
Check model information against the shipping documents to ensure the expected products and the correct lengths of cable are received. Model numbers are found on each product. On cables and cabled items, the model number is usually found at the connection end of the cable. Report any shortages immediately to Campbell Scientific.

4. QuickStart

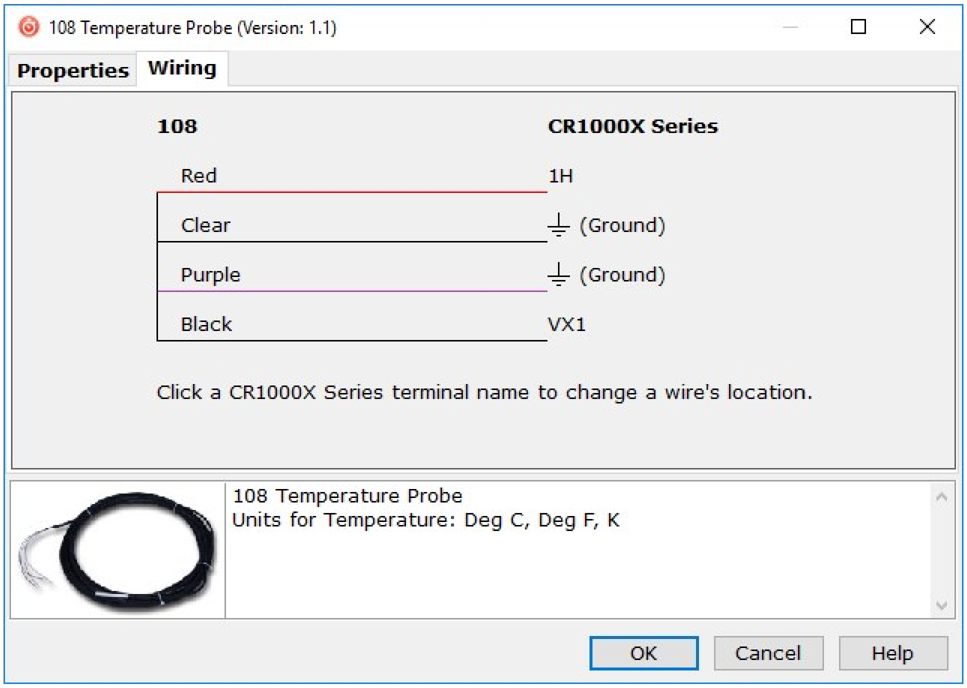
A video that describes data logger programming using ***Short Cut*** is available at: www.campbellsci.com/videos/cr1000x-data logger-getting-started-program-part-3. ***Short Cut*** is an easy way to program your data logger to measure the sensor and assign data logger wiring terminals. ***Short Cut***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

The following procedure shows using ***Short Cut*** to program the BlackGlobe and an air temperature and relative humidity sensor, then calculate dewpoint, wet-bulb, and WBGT index. Measurements from a temperature and relative humidity sensor are required for the wet-bulb temperature calculation.

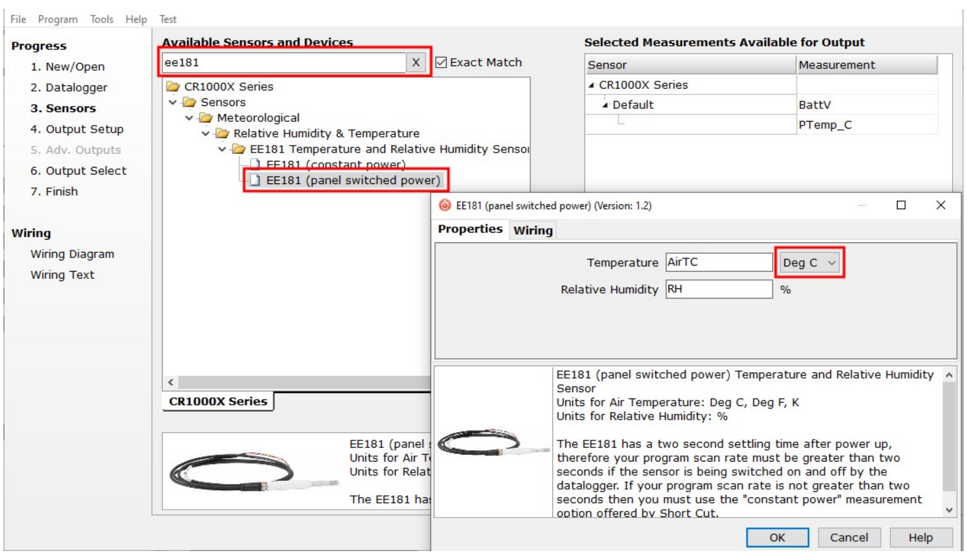
1. Open ***Short Cut*** and click **Create New Program**.
2. Double-click the data logger model.
3. In the **Available Sensors and Devices** box, type 108 (the temperature sensor inside the BlackGlobe) or find the 108 in the **Sensors** > **Temperature** folder. Double-click the **108 Temperature Probe**. Use the data defaults of degree Celsius, and type a more meaningful variable name such as BlackGlobe_C.



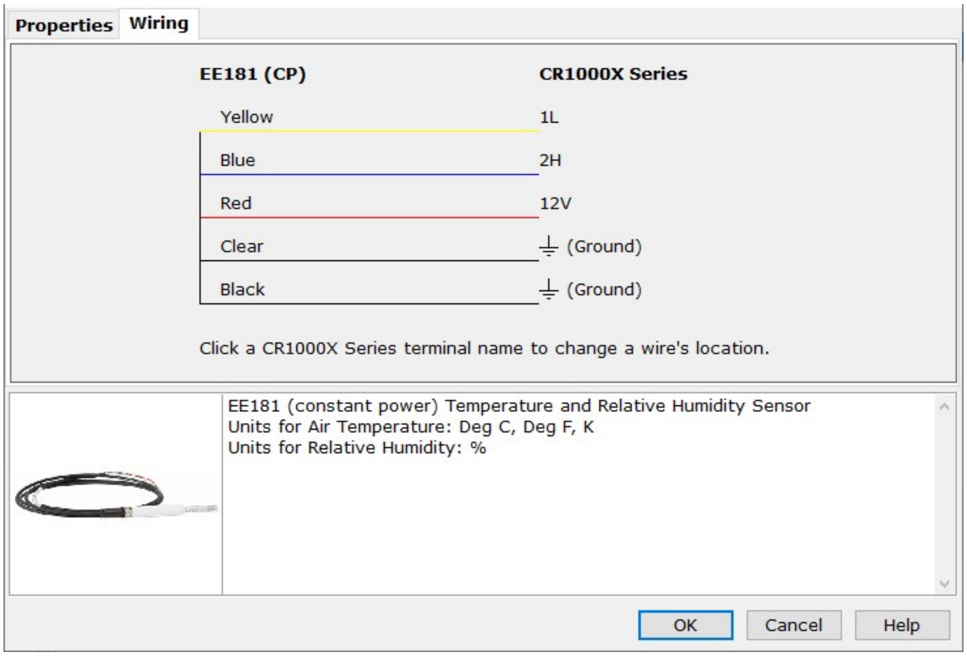
4. Click the **Wiring** tab to see how the sensor is to be wired to the data logger. Click **OK** after wiring the sensor.



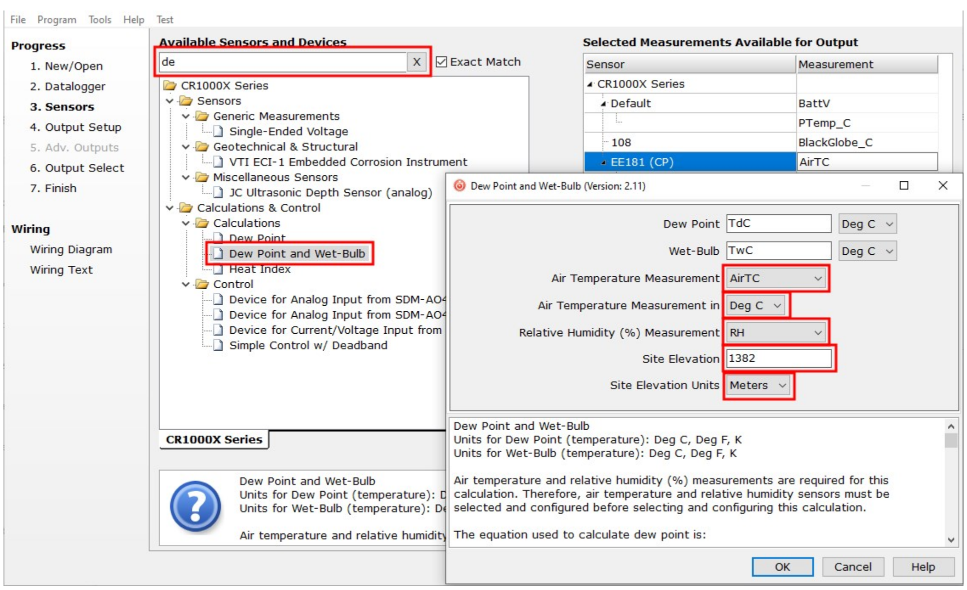
5. In the **Available Sensors and Devices** box, type your air temperature and relative humidity sensor (EE181 shown) or find the sensor in the **Sensors** > **Meteorological** > **Relative Humidity & Temperature** folder. Double-click the sensor. Use the default temperature units of degrees Celsius.



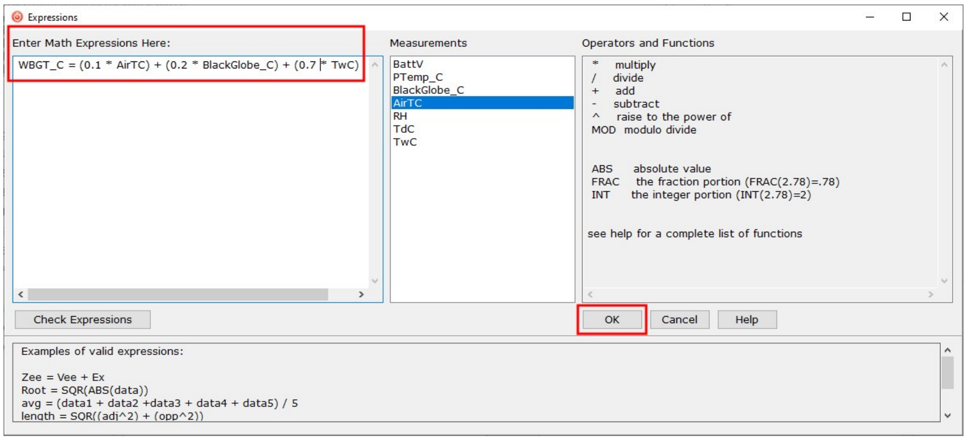
6. Click the **Wiring** tab to see how the sensor is to be wired to the data logger. Click **OK** after wiring the sensor.



7. In the **Available Sensors and Devices** box, type **Dew Point and Wet Bulb** or find the calculation under **Calculations & Control** > **Calculations** folder and double-click **Dew Point and Wet Bulb**. Type the **Site Elevation**; the elevation units default to meters. This can be changed by clicking on the **Site Elevation Units** box and selecting **Feet**. Select the variables from the temperature and RH sensor for the **Air Temperature Measurement** and **Relative Humidity (%) Measurement**. Use the default units of degree Celsius.

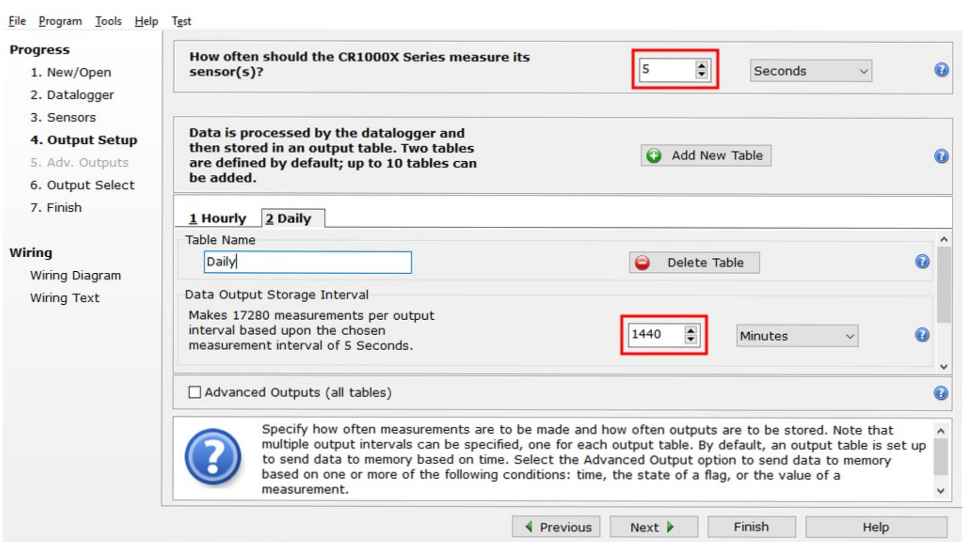


8. In the **Available Sensors and Devices** box, type **User Entered** or find the calculation under **Calculations & Control** > **Calculations** folder and double-click **User Entered**. Type WBGT_C = (0.1 * AirTC) + (0.2 * BlackGlobe_C) + (0.7 * TwC). AirTC is the air temperature variable from the temperature and relative humidity probe; BlackGlobe_C is the BlackGlobe temperature variable; TwC is the wet bulb temperature variable. Click **OK**.

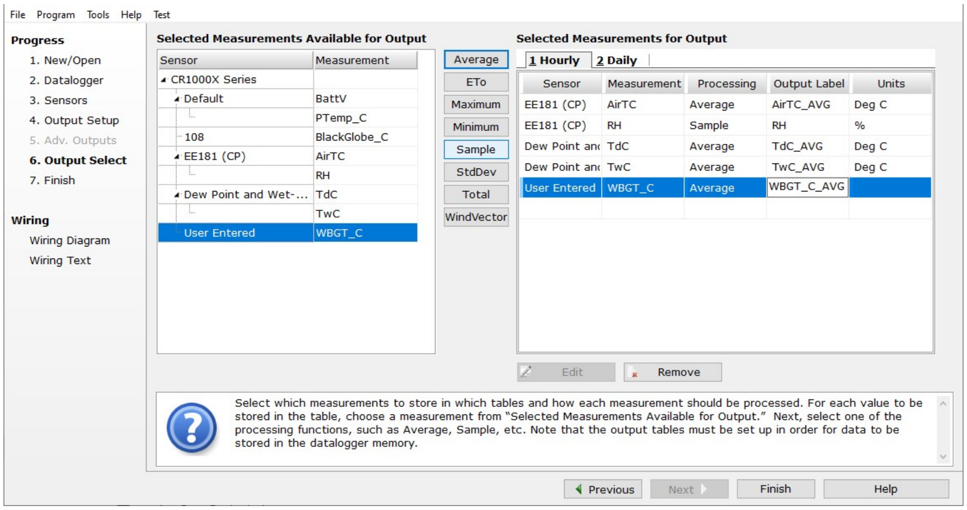


9. Repeat steps three and four for other sensors being measured. Click **Next**.

10. In **Output Setup**, type the scan rate, **Data Output Storage Intervals**, and meaningful table names.



11. Select the measurement and its associated output option.



12. Click **Finish** and save the program. Send the program to the data logger if the data logger is connected to the computer.

13. 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 BlackGlobe uses a thermistor inside a 15.24 cm (6 in) hollow copper sphere, painted black to measure radiant temperature. To calculate the wet-bulb-globe-temperature (WBGT) index, the measurement of the BlackGlobe (radiant heat), wet-bulb (evaporative heat), and ambient air (dry-bulb) temperatures are required. The wet-bulb temperature can be calculated using air temperature and relative humidity if a wet-bulb thermometer is not available. See Calculations (p. 15).

Features

- Helps manage heat stress
- Compatible with the following CRBasic data loggers: CR6, CR1000X, CR800-series, CR300-series, CR3000, CR1000

6. Specifications

BlackGlobe near normal emittance:	0.957
Thermistor Specifications	
Sensor element:	Measurement Specialties 100K6A1iA thermistor
Survival range:	–50 to 100 °C
Measurement range:	–5 to 95 °C
Time constant in air:	200 ± 10 s
Maximum cable length:	305 m (1000 ft)
Accuracy[1]	
Worst case:	±0.3 °C (–3 to 90 °C) ±0.7 °C (–5 to 95 °C)
Interchangeability error:	±0.10 °C (0 to 70 °C) ±0.14 °C at –5 °C ±0.25 °C at 85 °C ±0.35 °C at 95 °C
Steinhart-Hart equation error:	≤ ±0.01 °C (–35 to 50 °C)
Compliance:	View the EU Declaration of Conformity at ww.campbellsci.com/108

[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 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. 8) and Data logger programming (p. 12). ***Short Cut*** does this work for you. See QuickStart (p. 2) for a ***Short Cut*** tutorial.

7.1 Wiring to data logger

Table 7-1: Wire color, function, and data logger connection		
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)
[1]**U** terminals are automatically configured by the measurement instruction.		

7.2 Siting

The BlackGlobe must be mounted in a location that will not be shadowed and is representative of the environmental conditions to be measured.

CAUTION:
Research suggests orienting the cable gland vertically can introduce erroneous high readings at times of intense, direct sunlight (sunrise, evening).

TIP:
To ensure proper functioning, mount the BlackGlobe in an area that receives full sunlight and away from objects that might cast shadows throughout the day.

7.3 Assembly and mounting

Tools required for installing on a tripod or tower:

- Adjustable end wrench or 7/16 in. and 1/2 in. open end wrench
- Small screwdriver provided with the data logger
- Small pair of diagonal-cutting pliers
- UV resistant cable ties provided with the BlackGlobe

7.3.1 Mounting the BlackGlobe on the mounting arm

The BlackGlobe and mounting kit requires some assembly before installation. The mounting kit comes with (see Figure 7-1 [p. 9]):

- Mounting arm
- Mounting bolt
- Two lock washers
- Two nuts
- Two pipe clamps (not used when mounted to a horizontal pipe cross arm)
- U-bolt with associated nuts and washers

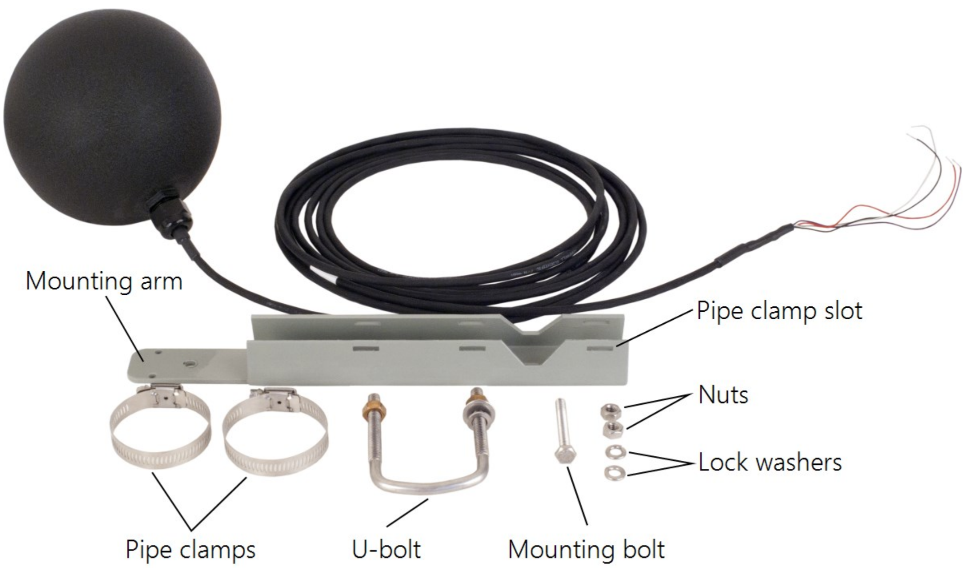


Figure 7-1. Mounting kit components

1. Place the mounting bolt through the hole in the mounting arm as shown in Figure 7-2 (p. 10).
2. Slide one of the lock washers against the mounting arm.

3. Thread both nuts about half way down the bolt and then slide on the last lock washer. The hardware should be arranged as shown in Figure 7-2 (p. 10).

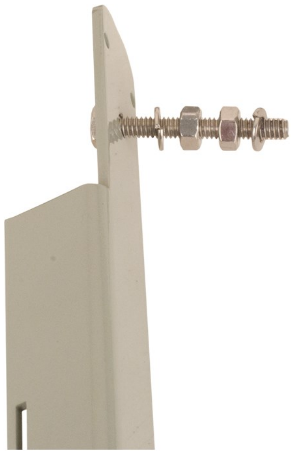


Figure 7-2. Nuts and lock washers on mounting bolt

4. Tighten down the nut closest to the mounting arm so the bolt is held firmly in place.
5. Thread the BlackGlobe fitting onto the bolt. Thread it as far down as it will go, but you may have to back it off a bit. The cable gland and cable should align with the mounting arm as shown in Figure 7-3 (p. 10).
6. Tighten down the nut closest to the BlackGlobe fitting. The BlackGlobe and mounting bolt should not move when the all the hardware is tightened down.

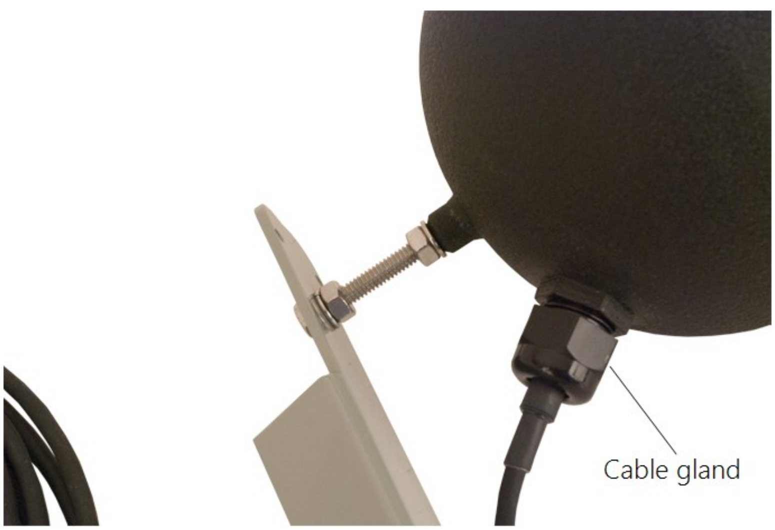


Figure 7-3. BlackGlobe fitting and cable alignment

7.3.2 Mounting the BlackGlobe assembly on a horizontal crossarm

The BlackGlobe assembly must be mounted on a horizontal crossarm.

1. Position the sensor so the cable gland is facing down, about 20 degrees off from vertical (Figure 7-3 [p. 10]).
2. Use the mounting hardware supplied to hold the sensor on the horizontal crossarm. Figure 7-4 (p. 11) and Figure 7-5 (p. 12) show a BlackGlobe mounted on a crossarm by using the U-bolts.
3. Use the wire ties provided with the unit to secure the cabling to the crossarm.
4. Leave a small loop of cable at the cable entry into the sensor to act as a drip line for any condensed moisture or rain (Figure 7-4 (p. 11)).

Figure 7-4. BlackGlobe mounted to a crossarm (front view)

Figure 7-5. BlackGlobe mounted to a crossarm (back view)

8. 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. 2). 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. 20). Programming basics are provided in the following section. Downloadable example program is available at www.campbellsci.com/downloads/blackglobe-example-program.

If the BlackGlobe 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. 14) and Long cable lengths (p. 15).

Details of BlackGlobe probe measurement and linearization of the thermistor output are provided in Measurement and output linearization (p. 14).

8.1 Therm108() instruction

The Therm108() 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. 14) for more information. Therm108() instruction and parameters are as follows:

```
Therm108(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. 14])
- Compensate for long cable lengths — Set SettlingTime to 20000 (see Long cable lengths [p. 15])

9. Operation

9.1 Sensor schematic

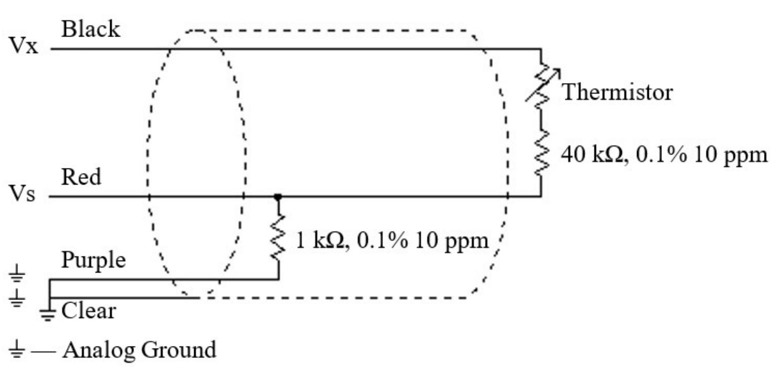


Figure 9-1. 108 thermistor probe schematic

9.2 Measurement and output linearization

CRBasic instruction `Therm108()` measures the 108 probe thermistor and automatically converts the result to temperature. With reference to the previous Figure 9-1 (p. 13), `Therm108()` applies 1000 mV excitation at the Vx line and measures the voltage drop across the 1 kΩ resistor at the Vs line.

The ratio of measured voltage (Vs) to excitation voltage (Vx) is related to thermistor resistance (Rs), and the 1 kΩ and 40 kΩ fixed resistors as described in the following equations:

$$Vs/Vx = 1000 / (Rs + 40000\ \Omega + 1000\ \Omega)$$

Solving for Rs:

$$Rs + 41000\ \Omega = 1000 \bullet (Vx/Vs)$$

$$Rs = 1000 \bullet (Vx/Vs) - 41000\ \Omega$$

The relationship of Rs to temperature is tabulated in Thermistor resistance and temperature (p. 21), but is calculated by `Therm108()` 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] = 8.271111E–4

B[1] = 2.088020E–4

C[1] = 8.059200E–8

[1]Coefficients provided by Measurement Specialties™.

9.3 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 using the F_{N1} (first notch frequency) parameter of the Therm108, instruction.

> **NOTE:**
> Older data logger models, such as the CR3000, CR1000, and CR800-series use an Integration parameter instead of F_{N1}. For these models, specify **_60Hz** for the Integration parameter to filter 60 Hz noise.

The following code snippet is for a CR6-series data logger and filters 60 Hz noise. Code for other data logger models will be similar; however, the terminal numbers and names may vary depending on the model.

```
Therm108(T108_C,1,U1,U10,0,60,1.0,0.0)
```

9.4 Long cable lengths

Long cable lengths (>50 ft) may require longer than normal analog measurement settling times. To address this, enter a longer settling time in the `SettlingTime` parameter of the Therm108() instruction. Campbell Scientific suggests doubling the settling time for every additional 50 ft. The following code snippet demonstrates how to increase the settling time by 20000 µs, by placing `20000` as the argument for the `SettlingTime` parameter. This snippet is for a CR6-series data logger. Code for other data logger models will be similar; however, the terminal numbers and names may vary depending on the model.

```
Therm108(T108_C,1,U1,U10,20000,60,1.0,0.0)
```

9.5 Calculations

9.5.1 Mean site barometric pressure calculation (SP_kPa)

The value of SP_{kPa} is in kilopascals and the site elevation, E, is in meters.

Use Eq. 1 (p. 15) to convert feet to meters.

$$E\,(m) = \frac{E(\mathrm{ft})}{3.281\mathrm{ft/m}} \qquad \text{Eq. 1}$$

The value for SP_{kPa} must be put into the data logger program.

The wet-bulb instruction needs mean barometric pressure which is closely related to elevation of the site. U.S. Standard Atmosphere and dry air were assumed when Eq. 2 (p. 15) was derived (Wallace & Hobbes, 1977).

$$\mathrm{SP_{kPa}} = 101.325 - 101.325\left\{1 - \left(1 - \frac{E}{44307.69231}\right)^{5.25328}\right\} \qquad \text{Eq. 2}$$

9.5.2 Saturated vapor pressure

Saturation vapor pressure over water is calculated by the data logger using Eq. 3 (p. 16).

$$P_{sw} = (A_0 + A_1 \times T + A_2 \times T^2 + A_3 \times T^3 + A_4 \times T^4 + A_5 \times T^5 + A_6 \times T^6) \times 0.1 \qquad \textbf{Eq. 3}$$

Where

T = air temperature (dry-bulb or ambient air temperature) (°C)

A_0 = 6.107799961

A_1 = 4.436518521E-1

A_2 = 1.428945805E-2

A_3 = 2.650648471E-4

A_4 = 3.031240396E-6

A_5 = 2.034080948E-8

A_6 = 6.136820929E-11

9.5.3 Vapor pressure

Vapor pressure is calculated by the data logger using Eq. 4 (p. 16).

$$P = RH \times P_{sw}/100 \qquad \textbf{Eq. 4}$$

where

RH = relative humidity (%)

P_{sw} = saturation vapor pressure (kPa) over water

9.5.4 Dewpoint

Eq. 5 (p. 16) is used to calculate dewpoint.

$$T_d = (241.88 \times \ln(P/0.61078))/(17.558 - \ln(P/0.61078)) \qquad \textbf{Eq. 5}$$

where

T_d = dewpoint (°C)

P = vapor pressure (kPa)

The equation is an inverse of a version of Teten's equation (Tetens, 1930), optimized for dewpoints in the range –35 to 50 °C, and is accurate to within plus or minus 0.1 °C within that range.

9.5.5 Wet-bulb

Wet-bulb is derived using an iterative process. The wet-bulb temperature lies somewhere between the dry-bulb temperature (air temperature) and the dewpoint temperature. The data logger uses Eq. 6 (p. 17) to calculate vapor pressure using the dry-bulb temperature and a wet-bulb temperature estimate:

$$P_{wt} = P_{swt} - (0.000660 \times (1 + 0.00115 \times T_w) \times (T - T_w) \times SP) \qquad \textbf{Eq. 6}$$

where

P_{wt} = wet-bulb temperature vapor pressure

P_{swt} = saturation vapor pressure (kPa) at the wet-bulb temperature (°C)

T_w = wet-bulb temperature (°C)

T = air temperature (dry-bulb temperature) (°C)

SP = standard air pressure (kPa) at the user entered elevation

The resulting vapor pressure is compared to the true vapor pressure (see above) and the difference determines the next wet-bulb temperature estimate. The process repeats until the difference between the current wet-bulb temperature estimate and the previous wet-bulb temperature estimate is only plus or minus 0.01 °C. The data logger thus derives the wet-bulb temperature.

9.5.6 Wet-bulb globe thermometer index (WBGT)

To calculate the WBGT index, a measurement of the BlackGlobe (radiant heat), wet-bulb (evaporative heat), and ambient air (dry-bulb) temperatures are required (Eq. 7 [p. 17]). Wet-bulb temperature is obtained using an iterative process, wherein the output from one iteration is used as an input for the following iteration, until the difference between the two values is negligible. To start this process, a guess is required to generate the first output.

In the approach discussed here, air temperature and relative humidity measurements are used to calculate the actual vapor pressure, and this vapor pressure is used to calculate the dewpoint temperature. This value serves as a lower limit to the wet-bulb temperature, and can be used as a starting input for the iterative process.

Campbell Scientific offers a variety of air temperature and relative humidity sensors that can provide the measurements required for this calculation.

Ultimately,

$$\text{WBGT} = (0.2 \times \text{BlackGlobe Temp}) + (0.7 \times \text{Wet-Bulb Temp}) + (0.1 \times \text{Dry-Bulb Temp}) \qquad \textbf{Eq. 7}$$

Dewpoint and wet-bulb temperature units include: °C, °F, K

10. 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.

10.1 Troubleshooting

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

Verify wires are connected to the terminals specified in the 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 are correct for the desired units (Data logger programming [p. 12]). 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. 14) and Long cable lengths (p. 15). Ensure the clear wire is connected to data logger ground, and the data logger is properly grounded.

10.2 Maintenance

The BlackGlobe requires minimal maintenance. Optimally, check weekly to ensure the sphere is free from dirt and debris. Clean with water and soft cloth if necessary. Do not use solvents as they may dissolve the paint.

10.3 Calibration

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

Calibration of the BlackGlobe probe is not necessary unless the accuracy needed in the sensor data requires correction of the thermistor interchangeability offset described in Specifications (p. 7).

11. 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.

Lowe, P.R. 1977. J. Appl. Meteor., 16:100-103

Tetens, O. 1930. Z. Geophys., 6:297

Wallace, J.M. and P.V. Hobbes, 1977: *Atmospheric Science: An Introductory Survey*, Academic Press, pp. 59 – 61

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. Thermistor resistance and temperature

Table B-1: 108 thermistor resistance and temperature[1]

Actual temperature (°C)	100K6A1iA thermistor resistance (Ω)	CRBasic Therm108() output (°C)
-10	612407	-10.00
-9	578366	-9.00
-8	546408	-8.00
-7	516394	-7.00
-6	488196	-6.00
-5	461695	-5.00
-4	436779	-4.00
-3	413346	-3.00
-2	391300	-2.00
-1	370551	-1.00
0	351017	0.00
1	332620	1.00
2	315288	2.00
3	298954	3.00
4	283555	4.00
5	269034	5.00
6	255335	6.00
7	242408	7.00
8	230206	8.00
9	218684	9.00

Table B-1: 108 thermistor resistance and temperature[1]		
Actual temperature (°C)	100K6A1iA thermistor resistance (Ω)	CRBasic Therm108() output (°C)
10	207801	10.00
11	197518	11.00
12	187799	12.00
13	178610	13.00
14	169921	14.00
15	161700	15.00
16	153921	16.00
17	146558	17.00
18	139586	18.00
19	132983	19.00
20	126727	20.00
21	120799	21.00
22	115179	22.00
23	109850	23.00
24	104795	24.00
25	100000	25.00
26	95449	26.00
27	91129	27.00
28	87027	28.00
29	83131	29.00
30	79430	30.00
31	75913	31.00
32	72569	32.00
33	69390	33.00
34	66367	34.00
35	63491	35.00

Table B-1: 108 thermistor resistance and temperature[1]		
Actual temperature (°C)	100K6A1iA thermistor resistance (Ω)	CRBasic Therm108() output (°C)
36	60755	36.00
37	58150	37.00
38	55670	38.00
39	53309	39.00
40	51060	40.00
41	48917	41.00
42	46875	42.00
43	44929	43.00
44	43073	44.00
45	41303	45.00
46	39615	46.00
47	38005	47.00
48	36467	48.00
49	35000	49.00
50	33599	50.00
51	32262	51.00
52	30984	52.00
53	29763	53.00
54	28596	54.00
55	27481	55.00
56	26415	56.00
57	25395	57.00
58	24420	58.00
59	23487	59.00
60	22594	60.00
61	21740	61.00

Table B-1: 108 thermistor resistance and temperature[1]		
Actual temperature (°C)	100K6A1iA thermistor resistance (Ω)	CRBasic Therm108() output (°C)
62	20922	62.00
63	20138	63.00
64	19388	64.00
65	18670	65.00
66	17981	66.00
67	17322	67.00
68	16689	68.00
69	16083	69.00
70	15502	70.00
71	14945	71.00
72	14410	72.00
73	13897	73.00
74	13405	74.00
75	12932	75.00
76	12478	76.00
77	12043	77.00
78	11625	78.00
79	11223	79.00
80	10837	80.00
81	10466	81.00
82	10109	82.00
83	9767	83.00
84	9437	84.00
85	9121	85.00
86	8816	86.00
87	8523	87.00

Table B-1: 108 thermistor resistance and temperature[1]		
Actual temperature (°C)	100K6A1iA thermistor resistance (Ω)	CRBasic Therm108() output (°C)
88	8241	88.00
89	7970	89.00
90	7708	90.00
91	7457	91.00
92	7215	92.00
93	6982	93.00
94	6758	94.00
95	6541	95.00
96	6333	96.00
97	6132	97.00
98	5939	98.00
99	5753	99.00
100	5573	100.00
[1]Data from Measurement Specialties™		

Limited warranty

Covered equipment is warranted/guaranteed against defects in materials and workmanship under normal use and service for the period listed on your sales invoice or the product order information web page. The covered period begins on the date of shipment unless otherwise specified. For a repair to be covered under warranty, the following criteria must be met:

1. There must be a defect in materials or workmanship that affects form, fit, or function of the device.

2. The defect cannot be the result of misuse.

3. The defect must have occurred within a specified period of time; and

4. The determination must be made by a qualified technician at a Campbell Scientific Service Center/ repair facility.

The following is not covered:

1. Equipment which has been modified or altered in any way without the written permission of Campbell Scientific.

2. Batteries; and

3. Any equipment which has been subjected to misuse, neglect, acts of God or damage in transit.

Campbell Scientific regional offices handle repairs for customers within their territories. Please see the back page of the manual for a list of regional offices or visit www.campbellsci.com/contact to determine which Campbell Scientific office serves your country. For directions on how to return equipment, see Assistance.

Other manufacturer's products, that are resold by Campbell Scientific, are warranted only to the limits extended by the original manufacturer.

CAMPBELL SCIENTIFIC EXPRESSLY DISCLAIMS AND EXCLUDES ANY IMPLIED WARRANTIES OF

MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. Campbell Scientific 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.

Campbell Scientific will, as a default, return warranted equipment by surface carrier prepaid. However, the method of return shipment is at Campbell Scientific's sole discretion. Campbell Scientific will not reimburse the claimant for costs incurred in removing and/or reinstalling equipment. This warranty and the Company’s obligation thereunder is in lieu of all other warranties, expressed or implied, including those of suitability and fitness for a particular purpose. Campbell Scientific is not liable for consequential damage.

In the event of any conflict or inconsistency between the provisions of this Warranty and the provisions of Campbell Scientific's Terms, the provisions of Campbell Scientific's Terms shall prevail. Furthermore, Campbell Scientific's Terms are hereby incorporated by reference into this Warranty. To view Terms and conditions that apply to Campbell Scientific, Logan, UT, USA, see Terms and Conditions. To view terms and conditions that apply to Campbell Scientific offices outside of the United States, contact the regional office that serves your country.

Assistance

Products may not be returned without prior authorization. Please inform us before returning equipment and obtain a **return material authorization (RMA) number** whether the repair is under warranty/guarantee or not. See Limited warranty for information on covered equipment.

Campbell Scientific regional offices handle repairs for customers within their territories. Please see the back page of the manual for a list of regional offices or visit www.campbellsci.com/contact to determine which Campbell Scientific office serves your country.

When returning equipment, a RMA number must be clearly marked on the outside of the package. Please state the faults as clearly as possible. 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, when equipment is returned to Campbell Scientific, Logan, UT, USA, it is mandatory that a "Declaration of Hazardous Material and Decontamination" form be received before the return can be processed. If the form is not received within 5 working days of product receipt or is incomplete, the product will be returned to the customer at the customer's expense. For details on decontamination standards specific to your country, please reach out to your regional Campbell Scientific office.

> NOTE:
> All goods that cross trade boundaries may be subject to some form of fee (customs clearance, duties or import tax). Also, some regional offices require a purchase order upfront if a product is out of the warranty period. Please contact your regional Campbell Scientific office for details.

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, 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, 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.

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.

Use and disposal of batteries

- Where batteries need to be transported to the installation site, ensure they are packed to prevent the battery terminals shorting which could cause a fire or explosion. Especially in the case of lithium batteries, ensure they are packed and transported in a way that complies with local shipping regulations and the safety requirements of the carriers involved.
- When installing the batteries follow the installation instructions very carefully. This is to avoid risk of damage to the equipment caused by installing the wrong type of battery or reverse connections.
- When disposing of used batteries, it is still important to avoid the risk of shorting. Do not dispose of the batteries in a fire as there is risk of explosion and leakage of harmful chemicals into the environment. Batteries should be disposed of at registered recycling facilities.

Avoiding unnecessary exposure to radio transmitter radiation

- Where the equipment includes a radio transmitter, precautions should be taken to avoid unnecessary exposure to radiation from the antenna. The degree of caution required varies with the power of the transmitter, but as a rule it is best to avoid getting closer to the antenna than 20 cm (8 inches) when the antenna is active. In particular keep your head away from the antenna. For higher power radios (in excess of 1 W ERP) turn the radio off when servicing the system, unless the antenna is installed away from the station, e.g. it is mounted above the system on an arm or pole.

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.

Global Sales and Support Network

A worldwide network to help meet your needs

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Website: www.campbellsci.fr

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Website: www.campbellsci.de

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Website: www.campbellsci.asia

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