MODEL 107 TEMPERATURE PROBE
INSTRUCTION MANUAL

REVISION: 4/03

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CAMPBELL SCIENTIFIC, INC.
RMA#_____
815 West 1800 North
Logan, Utah 84321-1784

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Model 107 Temperature Probe

1. General

The 107 Temperature Probe uses a thermistor to measure temperature. Custom lead lengths are available up to 1000 ft.

The 107 Temperature Probe is designed for measuring air/soil/water temperatures. For air temperature, a 41303 radiation shield is used to mount the 107 Probe and limit solar radiation loading. The probe is designed to be buried or submerged in water to 50' (21 ps).

1.1 Specifications

Temperature Measurement Range:	-35° to +50°C
Thermistor Interchangeability Error:	Typically <±0.2°C over 0°C to 60°C; ±0.4 @ -35°C
Temperature Survival Range:	-50°C to +100°C
Polynomial Linearization Error:	<±0.5°C over -35°C to +50°C
Time Constant In Air:	Between 30 and 60 seconds in a wind speed of 5 m s^{-1}

NOTE The black outer jacket of the cable is Santoprene® rubber. This compound was chosen for its resistance to temperature extremes, moisture, and UV degradation. However, this jacket will support combustion in air. It is rated as slow burning when tested according to U.L. 94 H.B. and will pass FMVSS302. Local fire codes may preclude its use inside buildings.

2. Accuracy

The overall probe accuracy is a combination of the thermistor's interchangeability specification, the precision of the bridge resistors, and the polynomial error. In a "worst case" all errors add to an accuracy of ±0.4°C over the range of -24° to 48°C and ±0.9°C over the range of -38°C to 53°C. The major error component is the interchangeability specification of the thermistor, tabulated in Table 2-1. For the range of 0° to 50°C the interchangeability error is predominantly offset and can be determined with a single point calibration. Compensation can then be done with an offset entered in the measurement instruction. The bridge resistors are 0.1% tolerance with a 10 ppm temperature coefficient. Polynomial errors are tabulated in Table 2-2 and plotted in Figure 2-1.

TABLE 2-1. Thermistor Interchangeability Specification	
Temperature (°C)	**Temperature Tolerance (±°C)**
–40	0.40
–30	0.40
–20	0.32
–10	0.25
0 to +50	0.20

TABLE 2-2. Polynomial Error	
-40 to +56	<±1.0°C
-38 to +53	<±0.5°C
-24 to +48	<±0.1°C

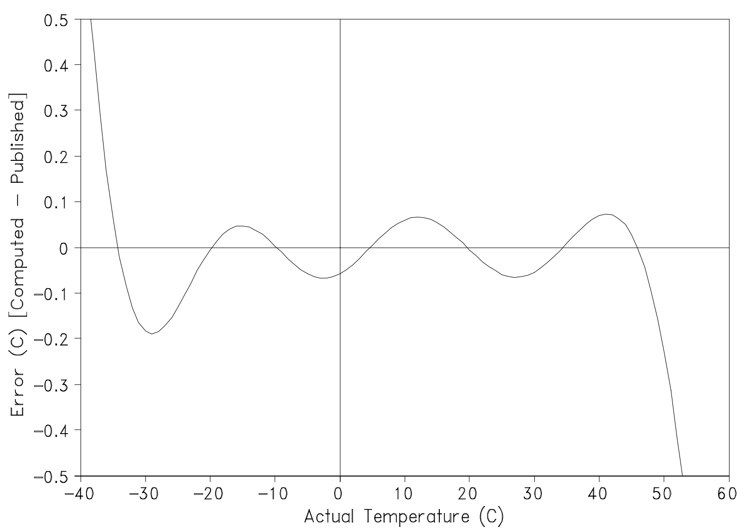

FIGURE 2-1. Error Produced by Polynomial Fit to Published Values

3. Installation and Wiring

For air temperature measurement, the 107 must be housed inside a radiation shield when used outdoors. The 41303 Radiation Shield (see Figure 3-1) mounts to a CM6 or CM10 tripod. The UT018 mounting arm and UT6P Radiation Shield mount to a UT30 tower.

The standard lead length of 6 feet and 9 feet allow the 107 to be mounted at a 2 meter height on the CM6/CM10 tripod or the UT30 tower respectively.

Connections to the datalogger for the 107 are shown in Figure 3-2 and Table 3-1.

The number of 107 probes per excitation channel is physically limited by the number of lead wires that can be inserted into a single excitation terminal (approximately 6).

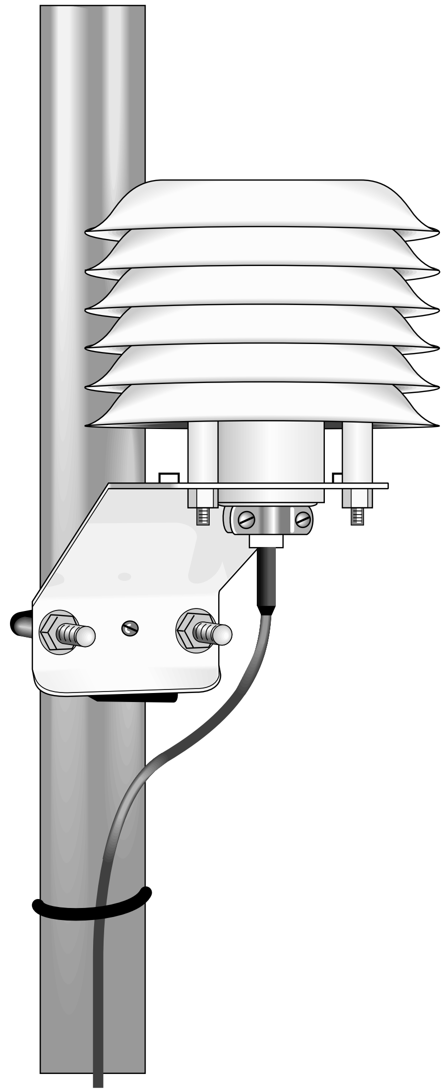

FIGURE 3-1. 107 and 41303 Radiation Shield on a CM6/CM10 Tripod Mast

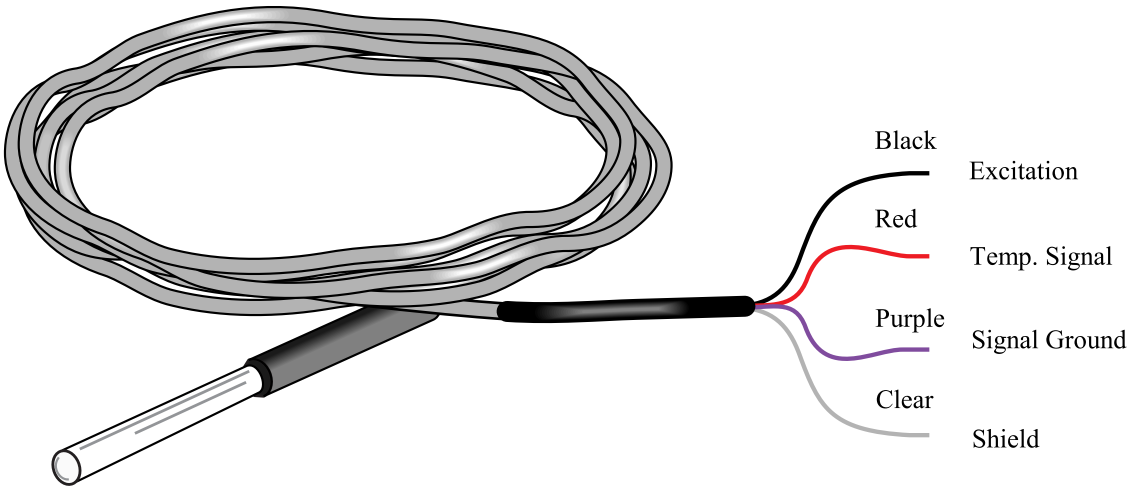

FIGURE 3-2. 107 Probe Datalogger Connections

TABLE 3-1. Sensor Wiring

Color	Function	CR10(X), CR510	21X, CR7,CR23X
Black	Excitation	Switched Excitation	Switched Excitation
Red	Signal	Single-Ended Channel	Single-Ended Channel
Purple	Signal Ground	AG	⏚
Clear	Shield	G	⏚

4. Programming

This section is for users who write their own datalogger programs. A datalogger program to measure this sensor can be created using Campbell Scientific's Short Cut Program Builder software. You do not need to read this section to use Short Cut.

Instruction 11 is used to measure temperature. Instruction 11 provides AC excitation, makes a single ended voltage measurement, and calculates temperature with a fifth order polynomial. A multiplier of 1.0 and an offset of 0.0 yields temperature in Celsius. For Fahrenheit, use a multiplier of 1.8 and an offset of 32.

TABLE 4-1. Wiring for Example Program

Color	Function	CR10(X)
Black	Excitation	Switched Ex Channel 3
Red	Signal	Single-Ended Channel 9
Purple	Signal Ground	AG
Clear	Shield	G

Example 1. Sample Program

```
1:  Temp (107) (P11)
  1:          1       Reps
  2:          9       SE Channel
  3:          3       Excite all reps w/E3
  4:          1       Loc [ Air_Temp  ]
  5:          1.0     Mult
  6:          0.0     Offset
```

Excitation/Integration Codes

Code	**Result**
0x	excite all rep with channel x
1x	increment chan x with each rep
2x	excite all reps with channel x, 60 Hz rejection, 10 ms delay
3x	excite all reps with channel x, 50 Hz rejection, 10 ms delay
4x	increment chan x with each rep, 60 Hz rejection, 10 ms delay
5x	increment chan x with each rep, 50 Hz rejection, 10 ms delay

5. Maintenance and Calibration

The 107 Probe requires minimal maintenance. Check monthly to make sure the radiation shield is free from debris.

For most applications it is unnecessary to calibrate the 107 to eliminate the thermistor offset. However, for those users that are interested, the following briefly describes calibrating the 107 probes.

A single point calibration can be performed to determine the 107 temperature offset (thermistor interchangeability). This calibration will not remove the polynomial error. The value of the offset must be chosen so that the probe outputs the temperature calculated by the polynomial, not the actual calibration temperature. For example, a 107 is placed in a calibration chamber that is at 0°C and the probe outputs 0.1°C. The offset is -0.16, because at 0°C the polynomial calculates a temperature of -0.06°C (Table 6-1).

6. Instruction 11 Details

Understanding the details in this section are not necessary for general operation of the 107 Probe with CSI's dataloggers.

Instruction 11 outputs a precise 2 VAC excitation (4 V with the 21X) and measures the voltage drop due to the sensor resistance (Figure 6-1). The thermistor resistance changes with temperature. Instruction 11 calculates the ratio of voltage measured to excitation voltage (Vs/Vx) which is related to resistance, as shown below:

$$Vs/Vx = 1000/(Rs+249000+1000)$$

where Rs is the resistance of the thermistor.

See the measurement section of the datalogger manual for more information on bridge measurements.

Instruction 11 then calculates temperature using a fifth order polynomial equation correlating Vs/Vx with temperature. The polynomial coefficients are given in Table 6-2. The polynomial input is (Vs/Vx)∗800. Resistance and datalogger output at several temperatures are shown in Table 6-1.

TABLE 6-1. Temperature, Resistance, and Datalogger Output

Temperature °C	Resistance OHMS	Output °C
-40.00	4067212	-39.18
-38.00	3543286	-37.55
-36.00	3092416	-35.83
-34.00	2703671	-34.02
-32.00	2367900	-32.13
-30.00	2077394	-30.18
-28.00	1825568	-28.19
-26.00	1606911	-26.15
-24.00	1416745	-24.11
-22.00	1251079	-22.05
-20.00	1106485	-20.00
-18.00	980100	-17.97
-16.00	869458	-15.95
-14.00	772463	-13.96
-12.00	687276	-11.97
-10.00	612366	-10.00
-8.00	546376	-8.02
-6.00	488178	-6.05
-4.00	436773	-4.06
-2.00	391294	-2.07
0.00	351017	-0.06
2.00	315288	1.96
4.00	283558	3.99
6.00	255337	6.02
8.00	230210	8.04
10.00	207807	10.06
12.00	187803	12.07
14.00	169924	14.06
16.00	153923	16.05
18.00	139588	18.02
20.00	126729	19.99
22.00	115179	21.97
24.00	104796	23.95
26.00	95449	25.94
28.00	87026	27.93
30.00	79428	29.95
32.00	72567	31.97
34.00	66365	33.99
36.00	60752	36.02
38.00	55668	38.05
40.00	51058	40.07
42.00	46873	42.07
44.00	43071	44.05
46.00	39613	46.00
48.00	36465	47.91
50.00	33598	49.77
52.00	30983	51.59
54.00	28595	53.35
56.00	26413	55.05
58.00	24419	56.70
60.00	22593	58.28

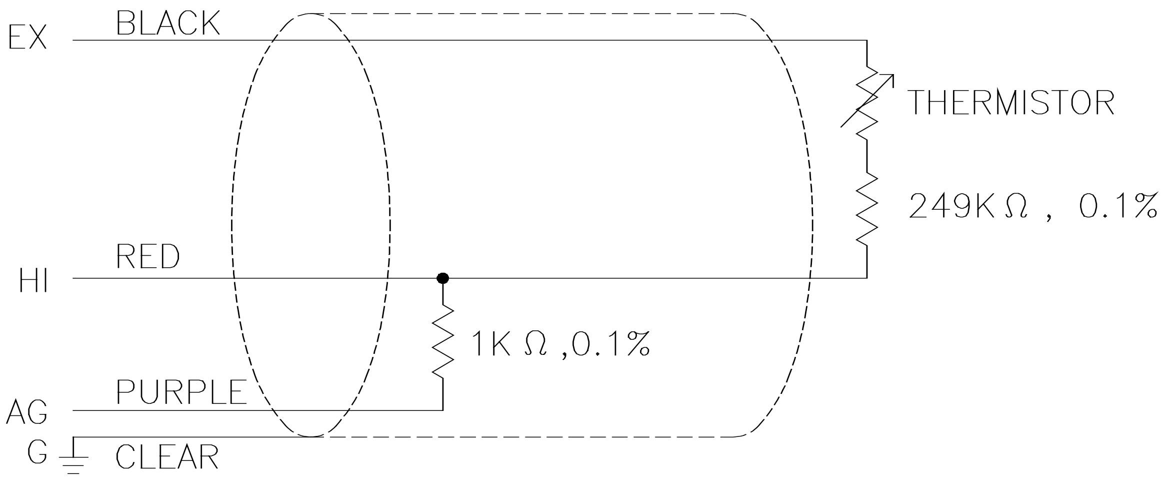

FIGURE 6-1. 107 Thermistor Probe Schematic

TABLE 6-2. Polynomial Coefficients

Coefficient	Value
C0	-53.4601
C1	90.807
C2	-83.257
C3	52.283
C4	-16.723
C5	2.211

7. Electrically Noisy Environments

AC power lines can be the source of electrical noise. If the datalogger is in an electronically noisy environment, the 107 temperature measurement should be measured with 60 Hz rejection. Sixty and 50 Hz rejection is available as an option in the Excitation Channel parameter of Instruction 11 for the CR10X, CR510, and CR23X dataloggers. For the CR10, CR21X and CR7, the 107 should be measured with the AC half bridge (Instruction 5).

Example 2. Sample CR10(X) Instructions Using AC Half Bridge

```
1:  AC Half Bridge (P5)
  1:           1        Reps
  2:          22        7.5 mV 60 Hz Rejection Range
  3:           9        SE Channel
  4:           3        Excite all reps w/Exchan 3
  5:        2000        mV Excitation ;Use 4000 mV on 21X and CR7
  6:           1        Loc [ Air_Temp  ]
  7:         800        Mult
  8:           0        Offset
```

```
2:  Polynomial (P55)
  1:          1        Reps
  2:          1        X Loc [ Air_Temp  ]
  3:          1        F(X) Loc [ Air_Temp  ]
  4:     -53.46        C0
  5:     90.807        C1
  6:    -83.257        C2
  7:     52.283        C3
  8:    -16.723        C4
  9:      2.211        C5
```

8. Long Lead Lengths

The 60 and 50 Hz rejection options for the CR10X, CR510, and CR23X include a delay to accommodate long lead lengths. For the CR10, 21X, and CR7, if the 107 has lead lengths of more than 300 feet, use the DC Half Bridge instruction (Instruction 4) with a 2 millisecond delay to measure temperature. The delay provides a longer settling time before the measurement is made. Do not use the 107 with long lead lengths in an electrically noisy environment.

Example 3. Sample Program CR10 Using DC Half Bridge with Delay

```
1:  Excite-Delay (SE) (P4)
  1:          1        Reps
  2:          2        7.5 mV Slow Range
  3:          9        SE Channel
  4:          3        Excite all reps w/Exchan 3
  5:          2        Delay (units 0.01 sec)
  6:       2000        mV Excitation ;Use 4000 mV on 21X and CR7
  7:          1        Loc [ Air_Temp  ]
  8:          .4       Mult ;Use 0.2 on 21X and CR7
  9:          0        Offset

2:  Polynomial (P55)
  1:          1        Reps
  2:          1        X Loc [ Air_Temp  ]
  3:          1        F(X) Loc [ Air_Temp  ]
  4:     -53.46        C0
  5:     90.807        C1
  6:    -83.257        C2
  7:     52.283        C3
  8:    -16.723        C4
  9:      2.211        C5
```