INSTRUCTION MANUAL

109AM-L
Temperature Probe

August 2011

WARRANTY AND ASSISTANCE

This equipment is warranted by CAMPBELL SCIENTIFIC (CANADA) CORP. ("CSC") to be free from defects in materials and workmanship under normal use and service for **twelve (12) months** from date of shipment unless specified otherwise. ***** **Batteries are not warranted.** ***** CSC's obligation under this warranty is limited to repairing or replacing (at CSC's option) defective products. The customer shall assume all costs of removing, reinstalling, and shipping defective products to CSC. CSC will return such products by surface carrier prepaid. This warranty shall not apply to any CSC products which have been subjected to modification, misuse, neglect, accidents of nature, or shipping damage. This warranty is in lieu of all other warranties, expressed or implied, including warranties of merchantability or fitness for a particular purpose. CSC is not liable for special, indirect, incidental, or consequential damages.

Products may not be returned without prior authorization. To obtain a Return Merchandise Authorization (RMA), contact CAMPBELL SCIENTIFIC (CANADA) CORP., at (780) 454-2505. An RMA number will be issued in order to facilitate Repair Personnel in identifying an instrument upon arrival. Please write this number clearly on the outside of the shipping container. Include description of symptoms and all pertinent details.

CAMPBELL SCIENTIFIC (CANADA) CORP. does not accept collect calls.

Non-warranty products returned for repair should be accompanied by a purchase order to cover repair costs.

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Model 109AM-L Temperature Probe

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Model 109AM-L Temperature Probe

1. General

The 109AM-L Temperature Probe uses a thermistor to measure temperature. The -L option on the model 109AM-L Temperature Probe indicates that the cable length is user specified.

The 109AM-L is typically used to measure soil or water temperature using a Campbell Scientific datalogger and a multiplexer (i.e. AM16/32B). When using the 109AM-L with a multiplexer one pick off resistor is required for each single ended channel used. This will vary depending on the multiplexer configuration and the number of sensors measured.

The 109AM-L ships with:

(1) Resource CD

1.1 Specifications

Sensor:	US Sensor Corp. PR103J23 Thermistor
Temperature Measurement Range:	-50° to +70°C
Thermistor Inter-changeability Error:	Typically <±0.2°C over 0°C to 70°C; ±0.5 @ -50°C
Temperature Survival Range:	-50°C to +100°C
Linearization Error:	The Steinhart and Hart equation used to calculate temperature is fit to the range of 0 to 70°C; maximum error is 0.03°C at -50°C.
Time Constant In Air:	Between 30 & 60 seconds in a wind speed of 5 m s^{-1}
Maximum Lead Length:	1000 ft.

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 and the accuracy of the bridge resistor. The Steinhart and Hart equation used to calculate temperature has a negligible error (Figure 2-1). In a "worst case" the errors add to an accuracy of ±0.6°C over the range of -50° to 70°C and ±0.25°C over the range of -10°C to 70°C. The major error component is the interchangeability specification of the thermistor. The bridge resistor has a 0.1% tolerance with a 10 ppm temperature coefficient. Figure 2-2 shows the possible worst case probe and measurement errors.

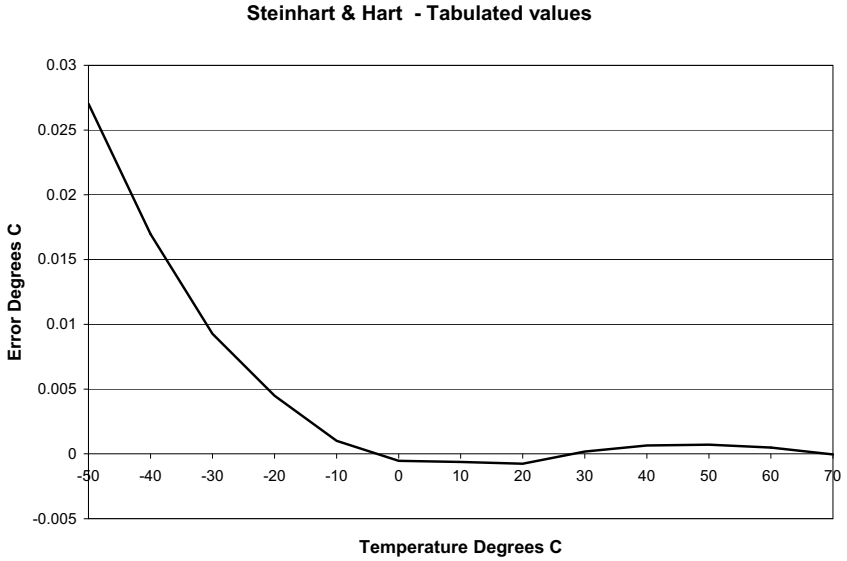

FIGURE 2-1. Steinhart and Hart

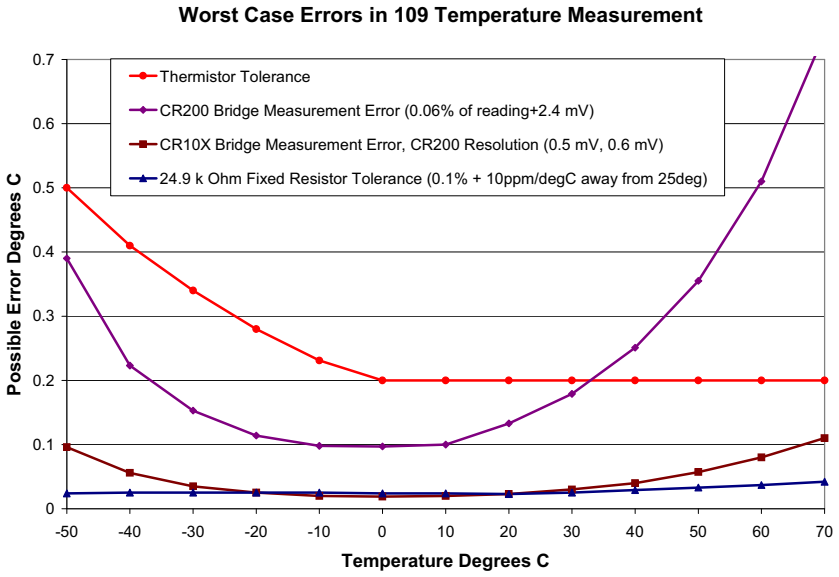

FIGURE 2-2. Possible Errors

3. Installation

3.1 Soil Temperature

The 109AM-L is suitable for burial. Whenever possible it should be placed horizontally at the desired depth to avoid thermal conduction from the surface to the thermistor. The recommended maximum burial depth is equivalent to 21 psi.

Placement of the cable inside a rugged conduit may be advisable for long cable runs, especially in locations subject to digging, mowing, traffic, use of power tools, or lightning strikes.

3.2 Water Temperature

The 109AM-L can be submerged to 50 feet. Please note that the 109AM-L is not weighted. Therefore, the installer should either add a weighting system or secure the probe to a fixed or submerged object.

4. Wiring

The 109AM-L is measured directly by the multiplexer (i.e. AM16/32B) with the use of the H & L input channels. A 24.9KΩ resistor assembly (RES24.9K-0.1) is required at the datalogger to complete the half bridge measurement at each of the single ended channels used. Additional information regarding multiplexer connections can be found in the multiplexer manual.

Table 4.1 shows the wiring for up to three 109AM-Ls for each of the COM terminals.

TABLE 4.1. 109AM-L, MUX & Datalogger Connections

Function	Colour	Multiplexer Connection	CR200(X) CR800 CR1000 CR3000	CR510 CR500 CR10(X)	CR5000 CR23X
109AM (1,2,3) Excitation*	Black	1H terminal			
109AM(1) Signal*	White	1L terminal			
109AM(2) Signal*	White	2H terminal			
109AM(3) Signal*	White	2L terminal			
109AM(1,2,3) Clear*	Shield	⏚			
Mux Power**	Red	12V	12V	12V	12V
Power Reference**	Black	GND	G	G	G
Mux Clock**	Green	CLK	C(1)	C(1)	C(1)
Mux Reset**	White	RES	C(2)	C(2)	C(2)
Shield**	Clear		⏚	G	⏚
Excitation Source†	Red	COM ODD H	Vx(1)	E(1)	Vx(1)
Signal Return(1)†	White	COM ODD L	SE(1)††	SE(1) ††	SE(1) ††
Signal Return(2)†	Black	COM EVEN H	SE(2) ††	SE(2) ††	SE(2) ††
Signal Return(3)†	Green	COM EVEN L	SE(3) ††	SE(3) ††	SE(3) ††
Shield†	Clear	COM ⏚	⏚	G	⏚

NOTES

* The wiring assumes that the datalogger in the "4x16" configuration.

**Connections are made with the FIN4COND(-L) on the Multiplexer at the "Control" Terminals and connect the corresponding terminals on the datalogger.

† Connections are made with a second FIN4COND(-L) on the multiplexer at the "COM" terminals and connect the corresponding terminals on the datalogger.

†† Each single ended channel used requires a RES24.9K-0.1 completion resistor assembly. The RES24.9K-0.1 must be connected between the single ended channel and Ground (i.e. ⏚ or G).

5. Programming

NOTE

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

Dataloggers that use CRBasic include our CR800, CR850, CR1000, CR3000, CR5000, and CR9000(X); see Section 5.1. Short Cut and CRBasic are included in our LoggerNet, PC400, and RTDAQ software.

If applicable, please read "Section 5.2—Electrically Noisy Environments" and "Section 5.3—Long Lead Lengths" prior to programming your datalogger. Measurement details are provided in Section 6.

5.1 CRBasic

In the CR800, CR850, CR1000, and CR3000 dataloggers, Instruction Therm109 is used to measure temperature. Therm109 provides excitation, makes a single ended voltage measurement, and calculates temperature.

The Therm109 instruction has the following form:

Therm109 (Dest, Repetitions, SE Chan, Ex Chan, Multiplier, Offset)

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.

The CR5000 and CR9000(X) use the BrHalf instruction to read the 109AM-L's resistance. The Steinhart-Hart equation is entered as an expression to convert the resistance to degrees Celsius.

Sample Program for CR1000 Datalogger & AM16/32B (4x16 mode)

Wiring for this example can be found in Table 4.1.

```
'CR1000

'Declare Variables and Units
Dim LCount_4
Public T109AM_C(6)

Units T109AM_C=Deg C

'Define Data Tables
DataTable(Table1,True,-1)
 DataInterval(0,60,Min,10)
 Average(6,T109AM_C(1),FP2,False)
EndTable


'Main Program
BeginProg
 Scan(5,Sec,1,0)

    'Turn AM16/32B Multiplexer On
    PortSet(2,1)
    Delay(0,150,mSec)
    'Switch to next AM16/32 Multiplexer channel set
    PulsePort(1,10000)
    '109AM Temperature Probe (3-wire) measurements T109AM_C(1,2,3) on the AM16/32B
    Therm109(T109AM_C(1),3,1,1,0,_60Hz,1,0)
    'Switch to next AM16/32 Multiplexer channel set
    PulsePort(1,10000)
    '109AM Temperature Probe (3-wire) measurements T109AM_C(4,5,6) on the AM16/32B
    Therm109(T109AM_C(4),3,1,1,0,_60Hz,1,0)

    'Turn AM16/32 Multiplexer Off
    PortSet(2,0)

    'Call Data Tables and Store Data
    CallTable(Table1)

    NextScan
EndProg
```

5.2 Electrically Noisy Environments

AC power lines, pumps, and motors, can be the source of electrical noise. If the 109AM-L probe or datalogger are located in an electrically noisy environment, the 109AM-L probe should be measured with the 60 or 50 Hz rejection option as shown in the Examples in Section 5.3.

5.3 Long Lead Lengths

Additional settling time may be required for lead lengths longer than 300 feet, where settling time is the delay before the measurement is made.

For the CR800, CR850, CR1000, and CR3000:

The 60 and 50 Hz integration options include a 3 ms settling time; longer settling times can be entered into the Settling Time parameter. The example Therm109 instruction listed below has a 20 mSec (20000 µSec) delay:

```
'Therm109 ( Dest, Reps, SEChan, ExChan, SettlingTime, Integ, Mult, Offset )
Therm109(T109AM_C,1,1,1,20000,_60Hz,1.0,0.0)
```

6. Measurement Details

Understanding the details in this section are not necessary for general operation of the 109AM-L Probe with CSI's dataloggers.

The Therm109 Instruction outputs a 2500 mV excitation and measures the voltage across the 24.9 K resistor (Figure 6-1). The thermistor resistance changes with temperature.

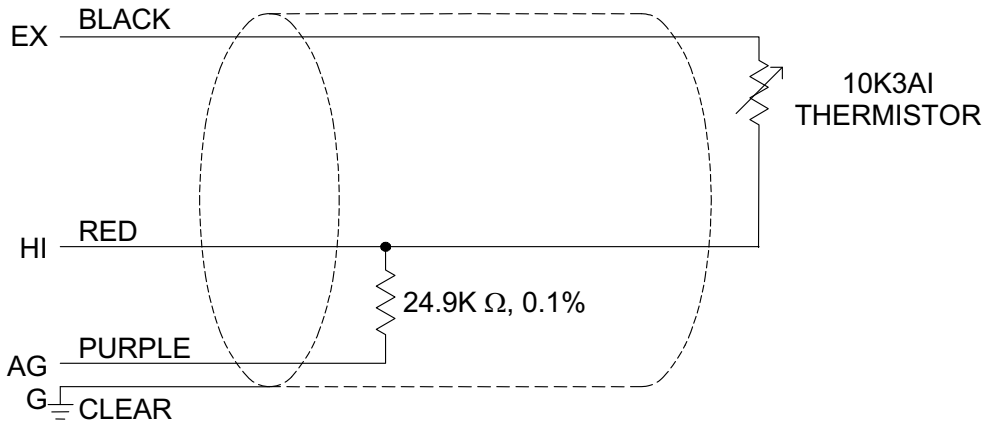

FIGURE 6-1. 109AM-L Thermistor Probe Schematic

The measured voltage, V, is:

$$V = V_{EX} \frac{24{,}900}{24{,}900 + R_t}$$

Where V_{EX} is the excitation voltage, 24,900 ohms is the resistance of the fixed resistor and R_t is the resistance of the thermistor

The resistance of the thermistor is:

$$R_t = 24{,}900\left(\frac{V_{EX}}{V} - 1\right)$$

The Steinhart and Hart equation is used to calculate temperature from Resistance:

$$T_K = \frac{1}{A + B\ln(R_T) + C(\ln(R_T))^3}$$

Where T_K is the temperature in Kelvin. The Steinhart and Hart coefficients used in the Therm109 instruction are:

A = 1.129241×10^{-3}
B = 2.341077×10^{-4}
C = 8.775468×10^{-8}

7. Maintenance and Calibration

The 109AM-L Probe requires minimal maintenance. Periodically check cabling for signs of damage and possible moisture intrusion. For all factory repairs and recalibrations, customers must get a returned material authorization (RMA). Customers must also properly fill out a "Declaration of Hazardous Material and Decontamination" form and comply with the requirements specified in it. Refer to the "Warranty and Assistance" page for more information.

8. Troubleshooting

Symptom: Temperature is NAN, -INF, -9999, -273

Verify the red wire is connected to the correct Single-Ended analog input channel as specified by the measurement instruction, the black wire is connected to the switched excitation channel as specified by the measurement instruction, and the purple wire is connected to datalogger ground, as described in Table 4-1.

Symptom: Incorrect Temperature

Verify the multiplier and offset parameters are correct for the desired units (Section 5). Check the cable for signs of damage and possible moisture intrusion.

Symptom: Unstable Temperature

Try using the 60 or 50 Hz integration options, and/or increasing the settling time as described in Sections 5.2 and 5.3. Make sure the clear shield wire is connected to datalogger ground, and the datalogger is properly grounded.

NOTE For all factory repairs, customers must get an RMA. Customers must also properly fill out a "Declaration of Hazardous Material and Decontamination" form and comply with the requirements specified in it. Refer to the "Warranty and Assistance" page for more information.