

## **CR10TCR THERMOCOUPLE REFERENCE**

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## 1. GENERAL

The Model CR10TCR Probe contains a thermistor for measuring temperature and is used as a reference temperature for thermocouples measured with the CR10. It is installed between the two terminal stripes in the wiring panel. After all the thermocouples are wired, the wiring panel cover is installed to minimize temperature gradients on the terminal strip.

add to an accuracy of  $\pm 0.4^{\circ}\text{C}$  over the range of  $-24^{\circ}$  to  $48^{\circ}\text{C}$  and  $\pm 0.9^{\circ}\text{C}$  over the range of  $-38^{\circ}\text{C}$  to  $53^{\circ}\text{C}$ . The major error component is the interchangeability specification of the thermistor, tabulated in Table 1. For the range of  $0^{\circ}$  to  $50^{\circ}\text{C}$  the interchangeability error is predominantly offset. The bridge resistors are 0.1% tolerance with a 10 ppm temperature coefficient. Polynomial errors are tabulated in Table 2 and plotted in Figure 1.

### 1.1 SPECIFICATIONS

Temperature Measurement Range:  $-35^{\circ}$  to  $+50^{\circ}\text{C}$

Thermistor Interchangeability Error: Typically  $\pm 0.2^{\circ}\text{C}$  over  $0^{\circ}\text{C}$  to  $60^{\circ}\text{C}$   $\pm 0.4$  @  $-35^{\circ}\text{C}$ .

Polynomial Linearization Error:  $< \pm 0.5^{\circ}\text{C}$  over  $-35^{\circ}\text{C}$  to  $+50^{\circ}\text{C}$ .

## 2. ACCURACY – TEMPERATURE SENSOR

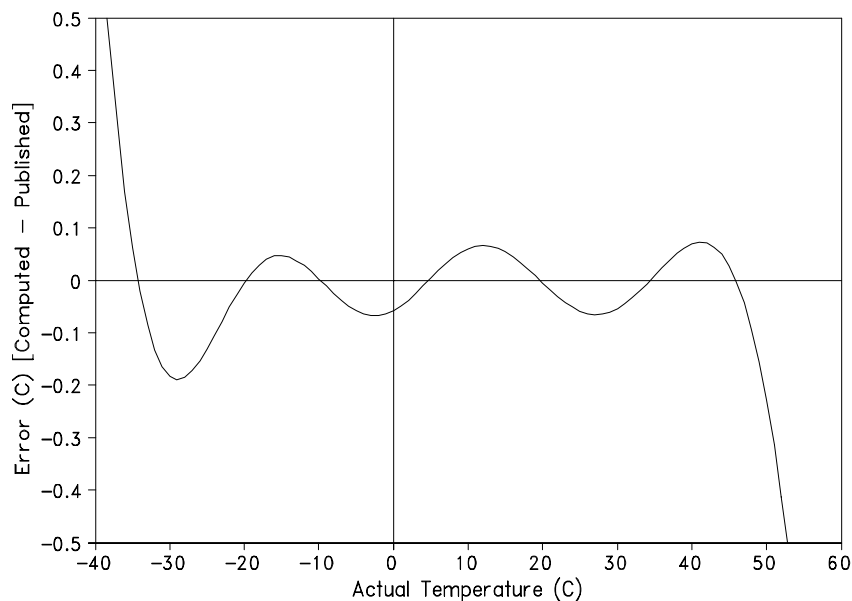
The overall probe accuracy is a combination of the thermistor's interchangeability specification, the precision of the bridge resistors, and the polynomial error. In a "worst case" all errors

**TABLE 1. Thermistor Interchangeability Specification**

Temperature ( $^{\circ}\text{C}$ )	Temperature Tolerance ( $\pm^{\circ}\text{C}$ )
-40	0.40
-30	0.40
-20	0.32
-10	0.25
0 to +50	0.20

**TABLE 2. Polynomial Error**

-40 to +56	$< \pm 1.0^{\circ}\text{C}$
-38 to +53	$< \pm 0.5^{\circ}\text{C}$
-24 to +48	$< \pm 0.1^{\circ}\text{C}$



**FIGURE 1. Error Produced by Polynomial Fit to Published Values**

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### 3. INSTALLATION AND WIRING

The wiring diagram for the CR10TCR is shown in Figure 1. The probe requires a single-ended analog input channel and an excitation channel. After the CR10TCR and thermocouple are connected to the datalogger, install the wiring panel cover (Figure 2 and 3).

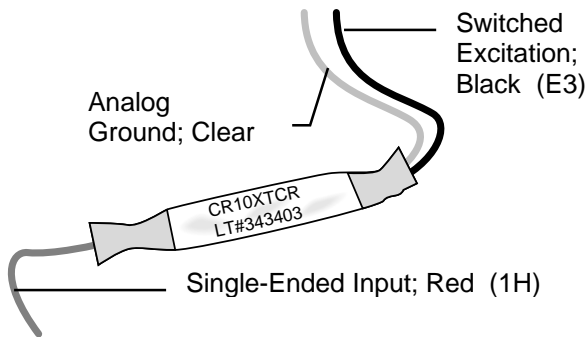


FIGURE 2. Wiring Diagram

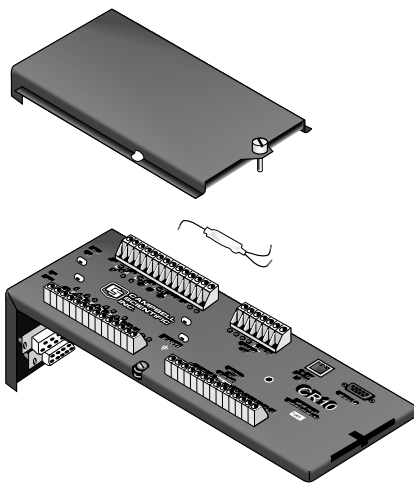


FIGURE 3. Wiring Panel, CR10TCR, and Wiring Panel Cover

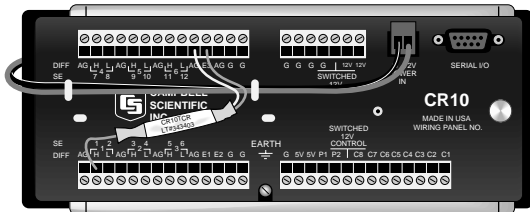


FIGURE 4. CR10TCR Installed on the CR10 Wiring Panel

### 4. PROGRAMMING

Instruction 11 is used to measure the CR10TCR. 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.

**CAUTION:** The reference temperature for thermocouples must be in degrees Celsius.

#### EXAMPLE 1. Sample CR10 Instructions

01:	P11	Temp 107 Probe
01:	1	Rep
02:	1	IN Chan
03:	3	Excite all reps w/EXchan 3
04:	15*	Loc [:Ref_Temp]
05:	1	Mult
06:	0	Offset

\* Proper entries will vary with program and input location.

### 5. INSTRUCTION 11 DETAILS

Understanding the details in this section are not necessary for general operation of the CR10TCR with Campbell Scientific's dataloggers.

Instruction 11 outputs a precise 2 VAC excitation and measures the voltage drop due to the sensor resistance (Figure 5). The thermistor resistance changes with temperature. Instruction 11 calculates the ratio of voltage measured to excitation voltage ( $V_s/V_x$ ) which is related to resistance, as shown below:

$$V_s/V_x = 1000/(R_s + 249000 + 1000)$$

where  $R_s$  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  $V_s/V_x$  with temperature. The polynomial coefficients are given in Table 3. The polynomial input is  $(V_s/V_x) \cdot 800$ .

Resistance and datalogger output at several temperatures are shown in Table 4.

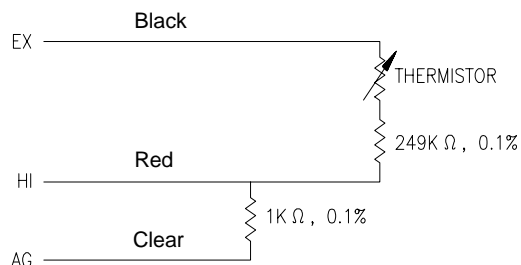


FIGURE 5. CR10TCR Reference Temperature Schematics

**TABLE 3. 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

**TABLE 4. Polynomial Coefficients**

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

## 6. ELECTRICALLY NOISY ENVIRONMENTS

AC power lines can be the source of electrical noise. If the datalogger is in an electronically noisy environment, the CR10TCR temperature measurement should be measured with the AC half bridge (Instruction 5) with the 60 Hz rejection integration option on the CR10 (see Section 13 of the datalogger manual for more information on noise). Instruction 11's fast integration will not reject 60 Hz noise.

### Example 2. Sample CR10 Instructions Using AC Half Bridge

01:	P5	AC Half Bridge
01:	1	Rep
02:	22	7.5 mV 60 Hz rejection Range
03:	1	IN Chan
04:	3	Excite all reps w/EXchan 1
05:	2000	mV Excitation
06:	15*	Loc [:Ref_Temp]
07:	800	Mult
08:	0	Offset
02:	P55	Polynomial
01:	1	Rep
02:	1*	X Loc Air Temp
03:	15*	F(X) Loc [:Ref_Temp]
04:	-53.46	C0
05:	90.807	C1
06:	-83.257	C2
07:	52.283	C3
08:	-16.723	C4
09:	2.211	C5

\* Proper entries will vary with program and input location assignments.

