INSTRUCTION MANUAL

CS547 Conductivity and Temperature Probe and A547 Interface

Revision: 9/00

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CS547 Conductivity and Temperature Probe and A547 Interface

1. Overview

The CS547 conductivity and temperature probe, and A547 interface are designed for measuring the electrical conductivity, dissolved solids, and temperature of fresh water with Campbell Scientific dataloggers. They require the use of AC excitation, so they can be used with the CR10(X), 21X, and CR7 dataloggers but not with the BDR301 or BDR320. Use with multiplexers is possible.

Electrical conductivity (EC) of a solution is a simple physical property, but measurements can be difficult to interpret. This manual instructs the user how to make EC measurements with the CS547. Accuracy specifications apply to measurements of EC in water containing KCl, Na_2SO_4, $NaHCO_3$, and/or NaCl, which are typical calibration compounds, and to EC not yet compensated for temperature effects.

Statements made on methods of temperature compensation or estimating dissolved solids are included to introduce common ways of refining and interpreting data, but are not definitive. Authoritative sources to consult include the USGS Water-Supply Paper 1473, The pH and Conductivity Handbook published by OMEGA Engineering, physical chemistry texts, and other sources.

1.1 EC Sensor

The EC sensor consists of three stainless steel rings mounted in an epoxy tube as shown in Figure 4-1. Resistance of water in the tube is measured by excitation of the center electrode with positive and negative voltage.

This electrode configuration eliminates the ground looping problems associated with sensors in electrical contact with earth ground.

Temperature is measured with a thermistor in a three wire half bridge configuration.

1.2 A547 Interface

The interface contains the completion resistors and blocking capacitors. The interface should be kept in a non-condensing environment that is maintained within the temperature range of the unit.

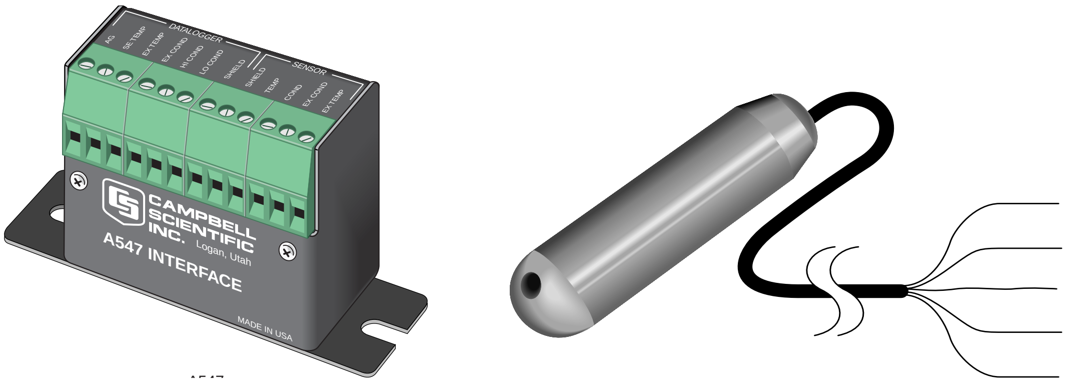

FIGURE 1-1. A547 Interface and CS547 Conductivity and Temperature Probe

2. Specifications

2.1 CS547 Probe

Construction	The probe housing is stainless steel
Size	Probe Length: 3.7 inches (94 mm) Diameter: 0.95 inches (24.13 mm)
Maximum Cable Length	1000 ft. The sensor must be ordered with desired length as cable cannot be added to existing probes.
Depth Rating	Maximum 1000 feet
pH Range	Solution pH of less than 3.0 or greater than 9.0 may damage the stainless steel housing.
Electrodes	Passivated 316 SS with DC isolation capacitors.
Cell Constant	Individually calibrated. The cell constant (K_c) is found on a label near the termination of the cable.
Temp. Range of Use	0° to 50°C.
EC Range	Approx. 0.005 to 7.0 mS cm^{-1}.
Accuracy	in KCl and Na_2SO_4, $NaHCO_3$, and NaCl standards at 25°C: ±5% of reading 0.44 to 7.0 mS cm^{-1}. ±10% of reading 0.005 to 0.44 mS cm^{-1}.

2.2 A547 Interface

Size	Dimensions: 2.5” x .875” x 1.750 Weight: 6 oz.
Temperature Rating	-15°C to +50°C

2.3 Temperature Sensor

Thermistor	Betatherm 100K6A1.
Range	0°C to 50°C.
Accuracy	Error ±0.4°C (See Section 8.2).

3. Installation

CAUTION Rapid heating and cooling of the probe, such as leaving it in the sun and then submersing it in a cold stream, may cause irreparable damage.

3.1 Site Selection

The EC sensor measures the EC of water inside the stainless steel tube, so detection of rapid changes in EC requires that the probe be flushed continuously. This is easy to accommodate in a flowing stream by simply orienting the sensor parallel to the direction of flow. In stilling wells and ground wells, however, diffusion rate of ions limits the response time.

3.2 Mounting

The stainless steel housing and sensor cable are made of water impervious, durable materials. Care should be taken, however, to mount the probe where contact with abrasives and moving objects will be avoided. Strain on cables can be minimized by using a split mesh strain relief sleeve on the cable, which is recommended for cables over 100 ft. The strain relief sleeve is available from Campbell Scientific as part number 7421.

The A547 is usually mounted in the datalogger enclosure.

4. Wiring

WARNING **The excitation channel used for EC must be separate from the one used for temperature or measurement errors will result.**

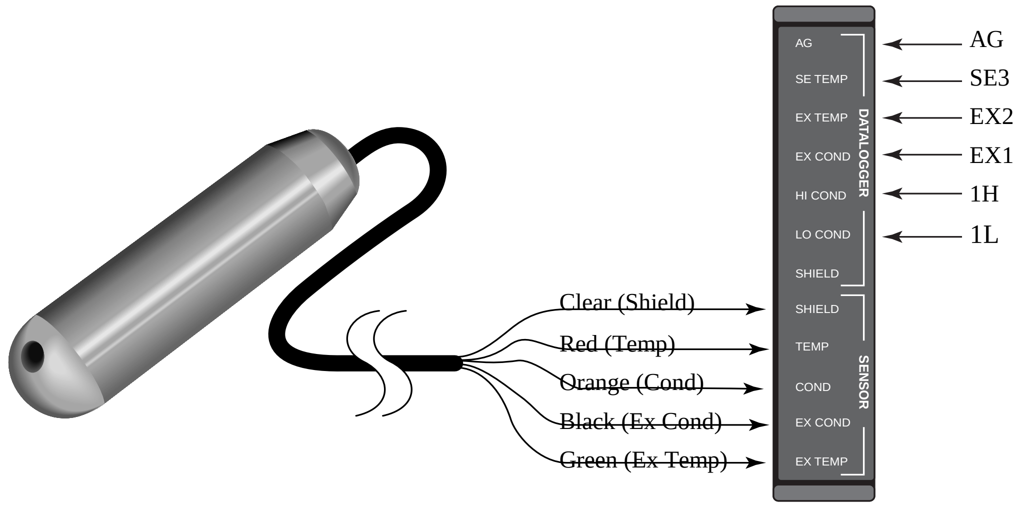

FIGURE 4-1. CS547 Wiring Diagram for Example Below

5. Programming

5.1 Programming Overview

Typical datalogger programs to measure the CS547 consist of four parts:

1. Measurement of EC and temperature
2. Correction of ionization errors in EC measurements
3. Correction of temperature errors in EC measurements
4. Output processing

All example programs may require modification by the user to fit the specific application's wiring and programming needs. All example programs in this manual are for the CR10(X) and assume that datalogger wire connections are as follows: the LO COND lead is connected to 1L, the HI COND to 1H, the EX COND to EX1, the EX TEMP to EX2, and the SE TEMP to SE3.

5.2 Measurement Programming.

EC: Results from Instructions 5 or 6 (chosen automatically as part of the autoranging feature of the following program segment) are processed with Instruction P59 to produce the resistance across the electrodes:

Input Location Labels

Definitions for the following program:

Rs	Solution resistance
Rp	Resistance of leads/cable and blocking caps
Ct	Solution EC with no temp. correction
C25mScm_1	EC corrected for temperature

```
*Table 1 Program
  01: 5          Execution Interval (seconds)

;Make a preliminary measurement of resistance for autoranging.

1:  Full Bridge (P6)
  1:  1          Reps
  2:  15         ±2500 mV Fast Range
  3:  1          DIFF Channel
  4:  1          Excite all reps w/Exchan 1
  5:  2500       mV Excitation
  6:  1          Loc [ Rs      ]
  7:  -.001      Mult
  8:  1          Offset

2:  BR Transform Rf [X/(1-X)] (P59)
  1:  1          Reps
  2:  1          Loc [ Rs      ]
  3:  1          Multiplier (Rf)
;
;Test the initial measurement to make a more accurate measurement.
;

3:  CASE (P93)
  1:  1          Case Loc [ Rs      ]

      4:  If Case Location < F (P83)
        1:  1.8        F
        2:  30         Then Do

            5:  AC Half Bridge (P5)
              1:  1          Reps
              2:  15         ±2500 mV Fast Range
              3:  2          SE Channel
              4:  1          Excite all reps w/Exchan 1
              5:  2500       mV Excitation
              6:  1          Loc [ Rs      ]
              7:  1.0        Mult
              8:  0.0        Offset

            6:  BR Transform Rf[X/(1-X)] (P59)
              1:  1          Reps
              2:  1          Loc [ Rs      ]
              3:  1          Multiplier (Rf)

      7:  End (P95)

      8:  If Case Location < F (P83)
        1:  9.25       F
        2:  30         Then Do
```

(cont.)

```
            9:  Full Bridge (P6)
              1:  1          Reps
              2:  15         ±2500 mV Fast Range
              3:  1          DIFF Channel
              4:  1          Excite all reps w/Exchan 1
              5:  2500       mV Excitation
              6:  1          Loc [ Rs      ]
              7:  -.001      Mult
              8:  1          Offset

            10:  BR Transform Rf[X/(1-X)] (P59)
              1:  1          Reps
              2:  1          Loc [ Rs      ]
              3:  1          Multiplier (Rf)

      11:  End (P95)

      12:  If Case Location < F (P83)
        1:  280        F
        2:  30         Then Do

            13:  Full Bridge (P6)
              1:  1          Reps
              2:  14         ±250 mV Fast Range
              3:  1          DIFF Channel
              4:  1          Excite all reps w/Exchan 1
              5:  2500       mV Excitation
              6:  1          Loc [ Rs      ]
              7:  -.001      Mult
              8:  1          Offset

            14:  BR Transform Rf[X/(1-X)] (P59)
              1:  1          Reps
              2:  1          Loc [ Rs      ]
              3:  1          Multiplier (Rf)

      15:  End (P95)

16:  End (P95)

;
;Subtract resistance errors (Rp) caused by the blocking capacitors
;(0.005Kohm) and the cable length (0.000032kohm/ft).  Enter cable lead
;length in nnn below.
;

17:  Z=F (P30)
  1:  nnn        F                              Enter cable length in feet.
  2:  00         Exponent of 10
  3:  5          Z Loc [ Rp      ]

18:  Z=X*F (P37)
  1:  5          X Loc [ Rp      ]
  2:  .00032     F
  3:  5          Z Loc [ Rp      ]
```

(cont.)

```
19:  Z=X*F (P37)
  1:  5          X Loc [ Rp      ]
  2:  -.1        F
  3:  5          Z Loc [ Rp      ]

20:  Z=X+F (P34)
  1:  5          X Loc [ Rp      ]
  2:  -.005      F
  3:  5          Z Loc [ Rp      ]

21:  Z=X+Y (P33)
  1:  1          X Loc [ Rs      ]
  2:  5          Y Loc [ Rp      ]
  3:  1          Z Loc [ Rs      ]
;
;EC is then calculated by multiplying the reciprocal of resistance,
;which is conductance, by the cell constant.
;

NOTE:  The cell constant (Kc) is printed on the label of each sensor or it can be calculated
(see Section 6.4).  It is entered in place of nnn below.

22:  Z=1/X (P42)
  1:  1          X Loc [ Rs      ]
  2:  2          Z Loc [ l_over_Rs ]

23:  Z=X*F (P37)
  1:  2          X Loc [ l_over_Rs ]
  2:  nnn        F                            Enter cell constant.
  3:  3          Z Loc [ Ct      ]
                                                                    (cont.)
```

Temperature: Temperature is measured with a single instruction, P11, that measures the thermistor resistance and calculates temperature. Output is °C when a multiplier of 1 and an offset of 0 is used. See Section 10 of datalogger manual for detailed information on the function of Instruction P11.

```
24:  Temp (107) (P11)
  1:  1          Reps
  2:  3          SE Channel
  3:  2          Excite all reps w/E2
  4:  4          Loc [ Temp_degC ]
  5:  1.0        Mult
  6:  0.0        Offset
                                                                    (cont.)
```

5.3 Correction of Ionization Errors in EC Measurement

Ionization caused by the excitation of the EC sensor can cause large errors. Campbell Scientific has developed a linear correction for conductivity between 0.005 and 0.44 mS cm^{-1}, and a quadratic correction for conductivity between 0.44 and 7.0 mS cm^{-1}. Corrections were determined in standard salt solutions containing KCl, Na_2SO_4, $NaHCO_3$, and NaCl.

The following program segment automatically chooses which correction to apply to the measurement.

```
;
;The following program set corrects for errors of ionization in the EC
;measurement.
;

25:  IF (X<=>F) (P89)
  1:   3            X Loc [ Ct       ]
  2:   4            <
  3:   .474         F
  4:   30           Then Do

        26:  Z=X*F (P37)
          1:   3            X Loc [ Ct       ]
          2:   .95031       F
          3:   3            Z Loc [ Ct       ]

        27:  Z=X+F (P34)
          1:   3            X Loc [ Ct       ]
          2:   -.00378      F
          3:   3            Z Loc [ Ct       ]

28:  Else (P94)

        29:  Polynomial (P55)
          1:   1            Reps
          2:   3            X Loc [ Ct       ]
          3:   3            F(X) Loc [ Ct       ]
          4:   -.02889      C0
          5:   .98614       C1
          6:   .02846       C2
          7:   .000000      C3
          8:   .000000      C4
          9:   .000000      C5

30:  End (P95)
                                                                  (cont.)
```

5.4 Correction of Temperature Errors

The effect of temperature on the sample solution can cause large errors in the EC measurement. A simple method of correcting for this effect is to assume a linear relationship between temperature and EC. This method generally produces values to within 2% to 3% of a measurement made at 25°C.

The best corrections are made when the temperature coefficient is determined at a temperature near field conditions. See Section 9 for details on how to determine the temperature coefficient. If determining the temperature coefficient is not possible, use a value of 2%/°C as a rough estimate.

The following program segment implements a previously determined temperature coefficient (TC) and calculates the corrected conductivity.

```
;This next program set will correct errors in the EC measurement resulting
;from temperature differences.
;

31:  Z=X+F (P34)
  1:  4           X Loc [ Temp_degC ]
  2:  -25         F
  3:  6           Z Loc [ A        ]

32:  Z=X*F (P37)
  1:  3           X Loc [ Ct       ]
  2:  100         F
  3:  7           Z Loc [ lOO_Ct   ]

33:  Z=X*F (P37)
  1:  6           X Loc [ A        ]
  2:  nnn         F                         Enter TC (%/°C) to correct cond. reading.
  3:  8           Z Loc [ TC_Proces ]

34:  Z=X+F (P34)
  1:  8           X Loc [ TC_Proces ]
  2:  100         F
  3:  8           Z Loc [ TC_Proces ]

35:  Z=X/Y (P38)
  1:  7           X Loc [ lOO_Ct   ]
  2:  8           Y Loc [ TC_Proces ]
  3:  9           Z Loc [ C25mScm_l ]       EC corrected for temperature.
                                                                      (cont.)
```

5.5 Output Processing

Over large ranges, EC is not linear and is best reported as samples using instruction P70. In limited ranges, averaging (P71) measurements over time may be acceptable. Convention requires that the temperature at the time of the measurement be reported.

```
;Output processing, convention states that the temperature be reported
;with the EC measurement.
;
36:  Do (P86)
  1:  10          Set Output Flag High (Flag 0)

37:  Sample (P70)
  1:  1           Reps
  2:  3           Loc [ Ct       ]

38:  Sample (P70)
  1:  1           Reps
  2:  4           Loc [ Temp_degC ]

39:  Sample (P70)
  1:  1           Reps
  2:  9           Loc [ C25mScm_l ]
                                                                      (cont.)
```

```
*Table 2 Program
  02: 0.0          Execution Interval (seconds)

*Table 3 Subroutines

End Program                                                    (End)
```

6. Calibration

6.1 Conversion Factors

1 S (Siemens) = 1 mho = 1/ohm

Although $mS \cdot cm^{-1}$ and $\mu S \cdot cm^{-1}$ are the commonly used units of EC, the SI base unit is $S \cdot m^{-1}$. The result of the example programs is $mS \cdot cm^{-1}$

EC measurements can be used to estimate dissolved solids. For high accuracy, calibration to the specific stream is required. However, for rough estimates, values between 550 and 750 $mg \cdot l^{-1}$ / $mS \cdot cm^{-1}$ are typical with the higher values generally being associated with waters high in sulfate concentration (USGS Water-Supply Paper #1473, p. 99). A common practice is to multiply the EC in $mS \cdot cm^{-1}$ by 500 to produce ppm or $mg \cdot l^{-1}$.

6.2 Typical Ranges

Single distilled water will have an EC of at least 0.001 $mS \cdot cm^{-1}$. ECs of melted snow usually range from 0.002 to 0.042 $mS \cdot cm^{-1}$. ECs of stream water usually range from 0.05 to 50.0 $mS \cdot cm^{-1}$, the higher value being close to the EC of sea water (USGS Water-Supply Paper 1473, p. 102).

6.3 Factory Calibration

The CS547 is shipped with a cell constant calibrated in a 0.01 molal KCl solution at 25.0°C ±0.05°C. The solution has a EC of 1.408 $mS\ cm^{-1}$.

6.4 Field Calibration

The cell constant is a dimensional number expressed in units of cm^{-1}. The unit cm^{-1} is slightly easier to understand when expressed as $cm \cdot cm^{-2}$. Because it is dimensional, the cell constant as determined at any one standard, will change only if the physical dimensions inside the CS547 probe change. Error due to thermal expansion and contraction is negligible. Corrosion and abrasion, however, have the potential of causing significant errors.

A field calibration of the CS547 cell constant can be accomplished as follows:

1. Make a 0.01 molal KCL solution by dissolving 0.7456 g of reagent grade KCl in 1000 g of distilled water, or purchase a calibration solution.
2. Clean the probe thoroughly with the black nylon brush shipped with the CS547 and a small amount of soapy water. Rinse thoroughly with distilled water, dry thoroughly, and place in the KCl solution.

3. Connect the CS547 and A547 or probe and interface to the datalogger using the wiring described in Section 4. Enter the following program into the datalogger.

The calibration solution temperature must be between 1°C and 35°C; the polynomial in step 11 (P58) corrects for temperature errors within this range. The solution constant of 1.408 mS cm^{-1} (for prepared solution mentioned above), entered in step 13 (P37), is valid only for a 0.01 molal KCl solution. Location 8 [Kc (cm-1)], generated by step 14, will contain the resultant cell constant.

```
01:  AC Half Bridge (P5)
  01:        1       Rep
  02:       15       2500 mV fast Range (5000 mV fast for 21X)
  03:        2       IN Chan
  04:        1       Excite all reps w/EXchan 1
  05:     2500       mV Excitation (5000 mV for 21X)
  06:        1       Loc [Rs       ]
  07:        1       Mult
  08:        0       Offset

02:  BR Transform Rf[X/(1-X)] (P59)
  01:        1       Rep
  02:        1       Loc [Rs       ]
  03:        1       Multiplier (Rf)

03:  Z=F (P30)
  01:      nnn       F                       Enter Cable Length in Feet
  02:       00       Exponent of 10
  03:        5       Loc [Rp       ]

04:  Z=X*F (P37)
  01:        5       Loc Rp
  02:          .00032  F
  03:        5       Loc [Rp       ]

05:  Z=X*F (P37)
  01:        5       Loc Rp
  02:        -.1     F
  03:        5       Loc [Rp       ]

06:  Z=X+F (P34)
  01:        5       Loc [Rp ]
  02:        -.005
  03:        5       Loc [Rp       ]

07:  Z=X+Y (P33)
  01:        1       X Loc Rs
  02:        5       Y Loc Rp
  03:        1       Z Loc [Rs       ]

08:  Temp 107 Probe (P11)
  01:        1       Rep
  02:        3       IN Chan
  03:        2       Excite all reps w/EXchan 2
  04:        2       Loc [t]
  05:        1       Mult
  06:        0       Offset
```

(cont.)

```
09:  Z=X+F (P34)
  01:          2        X Loc t
  02:        -25        F
  03:          3        Z Loc [(t-25).01]

10:  Z=X*F (P37)
  01:          3        X Loc (t-25).01
  02:           .01     F
  03:          3        Z Loc [(t-25).01]

11:  Polynomial (P55)
  01:          1        Rep
  02:          3        X Loc (t-25).01
  03:          4        F(X) Loc [f(t)      ]
  04:           .99124  C0
  05:         -1.8817   C1
  06:          3.4789   C2
  07:         -3.51     C3
  08:         -1.2      C4
  09:        -43        C5

12:  Z=1/X (P42)
  01:          4        X Loc f(t)
  02:          6        Z Loc [1/f(t)     ]

13:  Z=X*F (P37)
  01:          6        X Loc 1/f(t)
  02:          1.408    F                     EC of calibration solution
  03:          7        Z Loc [Act'l Con]

14:  Z=X*Y (P36)
  01:          7        X Loc Act'l Con
  02:          1        Y Loc Rs
  03:          8        Z Loc [Kc (cm-1)]
                                                                  End
```

7. Maintenance

Routine maintenance includes thoroughly cleaning the orifice of the CS547 probe with the black nylon brush provided and a little soapy water. Rinse thoroughly.

8. Analysis of Errors

8.1 EC Measurement Error

1. Bridge Measurement Error: < 1.0%
2. Calibration Error:
   bridge measurement: < 0.5%
   calibration solution: < 1.0%
3. Ionization Error of KCl and Na+ Solutions After Correction:
   < 2.0%, 0.45 to 7.0 mS cm^{-1}
   < 8.0%, 0.005 to 0.45 mS cm^{-1}

Correction of Ionization Errors: Figures 8.1-1 and 8.1-2 show the amount of correction applied by the example program to compensate for ionization effects on the measurements. Also shown is an ideal correction. Factors were derived by measuring the standard solutions described in Section 2.2 with values of 0.0234, 0.07, 0.4471, 07, 1.413, 2.070, 3.920, and 7.0 mS cm^{-1}.

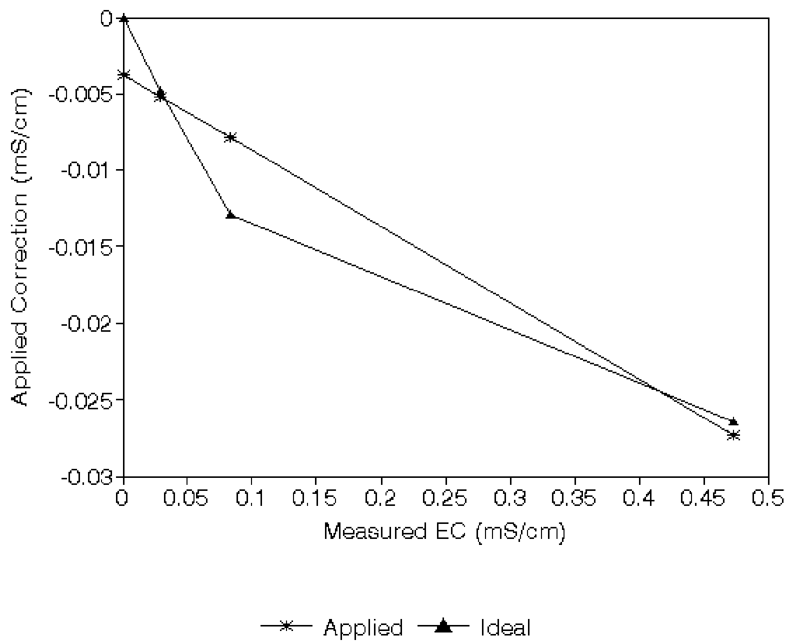

FIGURE 8.1-1. Plot of Ideal and Actual Correction between 0 and 0.44 mS cm^{-1}

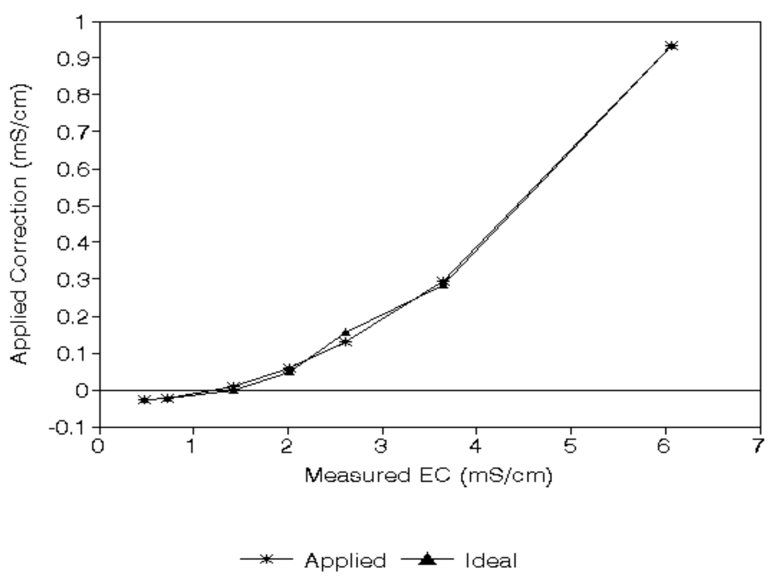

FIGURE 8.1-2. Plot of Ideal and Actual Correction between 0.44 and 7.0 mS cm^{-1}

8.2 Temperature Measurement Error

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 8.2-1. 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 8.2-2 and plotted in Figure 8.2-1.

TABLE 8.2-1. Thermistor Interchangeability Specification Temperature

Temperature (°C)	Tolerance (±°C)
–40	0.40
–30	0.40
–20	0.32
–10	0.25
0 to +50	0.20

TABLE 8.2-2. Polynomial Error

-40 to +56	<±1.0°C
-38 to +53	<±0.5°C
-24 to +48	<±0.1°C

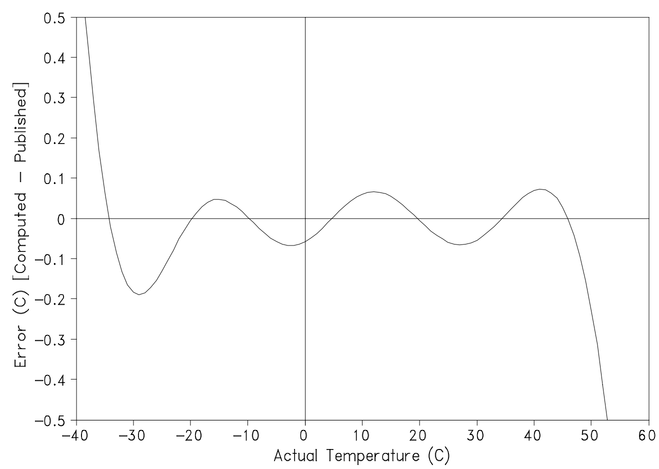

FIGURE 8.2-1. Error Produced by Polynomial Fit to Published Values

9. Deriving a Temperature Compensation Coefficient

1. Place the CS547 in a sample of the solution to be measured. Bring the sample and the probe to 25°C.

2. Enter the example program from Section 5.2 in the datalogger and record C_t at 25°C from Location 3. This number will be C_{25} in the formula in Step 4.

3. Bring the solution and the probe to a temperature (t) near the temperature at which field measurements will be made. This temperature will be t (in °C) in the formula. Record C_t at the new temperature from Location 3. This number will be C in the formula in Step 4.

4. Calculate the temperature coefficient (TC) using the following formula.

$$TC = 100 * \frac{(C - C_{25})}{(t - 25) * C_{25}} = \%/^\circ C$$

Enter TC in the appropriate location (nnn) as shown in the program segment in Section 5.4.

10. Instruction 11 Details

Understanding the details in this section are not necessary for general operation of the CS547 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. 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 10-2. The polynomial input is (Vs/Vx)*800. Resistance and datalogger output at several temperatures are shown in Table 10-1.

TABLE 10-1. Temperature , Resistance, and Datalogger Output

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 10-2. Polynomial Coefficients

COEFFICIENT	VALUE
C0	-53.4601
C1	9.08067
C2	-8.32569×10^{-01}
C3	5.22829×10^{-02}
C4	-1.67234×10^{-03}
C5	2.21098×10^{-05}

11. Electrically Noisy Environments

AC power lines can be the source of electrical noise. If the datalogger is in an electronically noisy environment, the 107/107B temperature measurement should be measured with the AC half bridge (Instruction 5) with the 60 Hz rejection integration option on the CR10(X) and slow integration on the 21X and CR7 (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(X) Instructions Using AC Half Bridge

```
01:  AC Half Bridge (P5)
  01:            1          Rep
  02:           22**        7.5 mV 60 Hz rejection Range
  03:            9*         IN Chan
  04:            3*         Excite all reps w/EXchan 3
  05:         2000**        mV Excitation
  06:           11*         Loc [:Air_Temp ]
  07:          800          Mult
  08:            0          Offset

02:  Polynomial (P55)
  01:            1          Rep
  02:           11*         X Loc Air_Temp
  03:           11*         F(X) Loc [:Air_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 datalogger channel and input location
   assignments.
** On the 21X and CR7 use the 15 mV input range and 4000 mV excitation.
```

12. Long Lead Lengths Temperature

If the CS547 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 CS547 with long lead lengths in an electrically noisy environment.

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

```
01:  Excite, Delay,Volt(SE) (P4)
  01:            1          Rep
  02:            2**        7.5 mV slow range
  03:            9*         IN Chan
  04:            3*         Excite all reps w/EXchan 3
  05:            2          Delay (units .01sec)
  06:         2000**        mV Excitation
  07:           11*         Loc [:Temp_C   ]
  08:             .4***     Mult
  09:            0          Offset
                                                              (cont.)
```

```
02:  Polynomial (P55)
   01:           1         Rep
   02:          11*        X Loc Temp_C
   03:          11*        F(X) Loc [:Temp_C   ]
   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 datalogger channel and input location
      assignments.
**    On the 21X and CR7 use the 15 mV input range and 4000 mV excitation.
***   Use a multiplier of 0.2 with a 21X and CR7.
```

13. CS547 Schematic

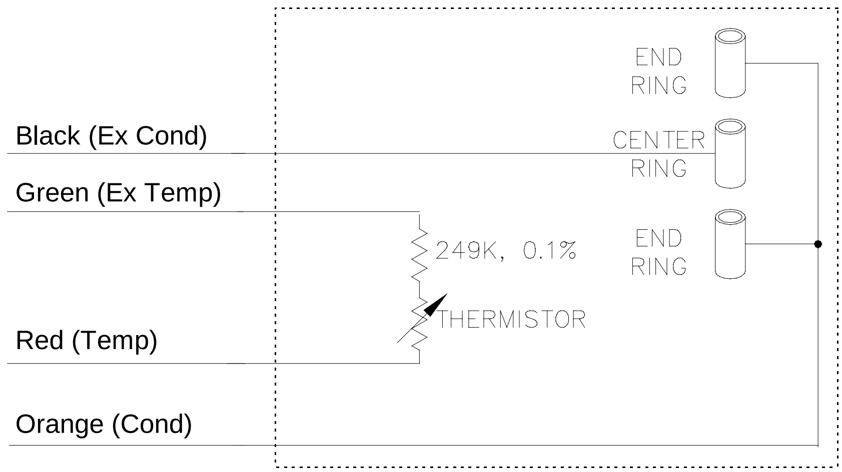

FIGURE 13-1. CS547 Conductivity and Temperature Circuit Diagram

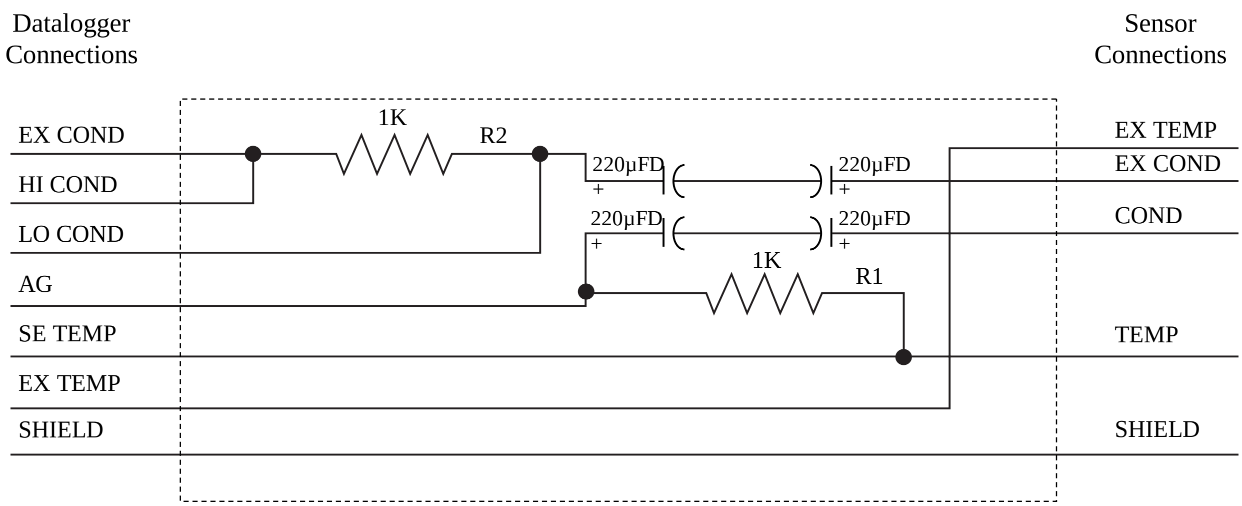

FIGURE 13-2. A547 Interface Circuit Diagram

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