43347 RTD Temperature Probe and 43502 Aspirated Radiation Shield

User Manual

Issued 7.2.11

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WHEN MEASUREMENTS MATTER

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PLEASE READ FIRST

About this manual

Please note that this manual was originally produced by Campbell Scientific Inc. primarily for the North American market. Some spellings, weights and measures may reflect this origin.

Some useful conversion factors:

Area:	1 in^2 (square inch) = 645 mm^2
Length:	1 in. (inch) = 25.4 mm
	1 ft (foot) = 304.8 mm
	1 yard = 0.914 m
	1 mile = 1.609 km
Mass:	1 oz. (ounce) = 28.35 g
	1 lb (pound weight) = 0.454 kg
Pressure:	1 psi (lb/in^2) = 68.95 mb
Volume:	1 UK pint = 568.3 ml
	1 UK gallon = 4.546 litres
	1 US gallon = 3.785 litres

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 it will be suitable for use in your country.*

Reference to some radio transmitters, digital cell phones and aerials 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. Details of the alternatives will be covered in separate manuals.

Recycling information

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.

Campbell Scientific Ltd 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 advice or support, please contact Campbell Scientific Ltd, or your local agent.

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43347 RTD Temperature Probe and 43502 Aspirated Radiation Shield

1. General

This manual describes the 43347 temperature sensor and its use in various shields as supplied in the USA. In Europe the 43347 probe is only supplied in one variant, equivalent to the -IX version, supplied with a calibration certificate as described. If you use this probe with a datalogger that does not have a current excitation output you will need a 4WPB1K bridge module. This will make the probe equivalent to the 43347-VX probe described below. Please refer to the 4WPB1K manual for wiring details but refer to the programming examples below as this sensor is not a DIN standard sensor and needs a special calibration correction. The Shortcut program generator can also be used with these sensors, by selection of the appropriate 43347 sensor type.

This manual describes use of the 43347 sensor in the unaspirated 41003 shield. That shield can be supplied to special order in Europe, although it is functionally equivalent to the URS1 shield. Some of the arms and mounts may also differ from those shown, but the principles of use are similar.

The manual also describes the 43502 shield. In Europe this shield is supplied with two internal mounting bushings, one which is 24 mm in diameter which suits the 43347 probe. The other is a general purpose clamp suited to grip a sensor or probe 3-16 mm in diameter. This allows other temperature sensors, such as 107, 105E or PT100 sensors and some temperature and RH probes to be used in the shield (see Appendix C for mounting details).

The 43347 is a 1000 ohm Resistance Temperature Device (RTD) used to measure ambient air temperature and delta or gradient air temperature. The standard 43347 probe has an uncertainty of ±0.3°C. For increased accuracy the 43347 probe can be ordered with a three point calibration with an uncertainty of ±0.1°C.

There are two cable options for the 43347. Option –VX configures the probe as a 4-wire half bridge that requires a voltage excitation and two differential input channels, and can be used with all CSI dataloggers except the CR200. Option –IX configures the probe for use with the CR3000 or CR5000 dataloggers, and requires a current excitation and one differential input channel.

The 43347 can be housed in the 41003-5 naturally aspirated radiation shield, or the 43502 motor aspirated radiation shield. The 43502 radiation shield employs concentric downward facing intake tubes and a small canopy shade to isolate the temperature probe from direct and indirect radiation. The 43347 probe mounts vertically in the centre of the intake tubes. A brushless 12 VDC blower motor pulls ambient air into the shield and across the probe to reduce radiation errors. The blower operates off a 230 VAC/12 VDC transformer that is included with the shield.

2. Specifications

43502 ASPIRATED RADIATION SHIELD

Sensor Types:	Accommodates sensors up to 24mm (0.9 in) diameter
Radiation Error:	
Ambient Temp:	<0.2°C (0.4°F) RMS (@1000 W/m^2 intensity)
Delta T:	<0.05°C (0.1°F) RMS with like shields equally exposed
Aspiration Rate:	5 to 11 m/s (16-36 fps) depending on sensor size
Power Requirement:	12-14 VDC@500 mA for blower
Overall Height:	33 cm (13 in)
Overall Diameter:	20 cm (8 in)
Shield:	7 cm (2.7 in) dia. x 12 cm (4.7 in)
Blower Housing:	17 cm (6.7 in) dia. x 11 cm (4.3 in)
Mounting:	V-Block and U-Bolt for vertical pipe 25-50 mm (1.0-2.0 in) dia.

41003-5 RADIATION SHIELD

Sensor Types:	Accommodates temperature and humidity sensors up to 26 mm (1 in) diameter
Radiation Error:	@1080 W/m^2 intensity – Dependent on wind speed 0.4°C (0.7°F) RMS @ 3 m/s (6.7 mph) 0.7°C (1.3°F) RMS @ 2 m/s (4.5 mph) 1.5°C (2.7°F) RMS @ 1 m/s (2.2 mph)
Construction:	UV stabilized white thermoplastic plates Aluminium mounting bracket, white powder coated Stainless steel U-bolt clamp
Dimensions:	13 cm (5.1 in) diameter x 26 cm (10.2 in) high Mounting fits vertical pipe 25-50 mm (1-2 in) diameter
Weight	
Net weight:	0.7 kg (1.5 lb)
Shipping weight:	1.4 kg (3 lb)

43347 RTD TEMPERATURE PROBE

Dimensions	
Probe Tip:	0.125" diameter, 2.25" long
Overall length:	7"
Sensing Element:	HY-CAL 1000 ohm Platinum RTD
Temperature Range:	±50°C
Accuracy:	±0.3°C at 0° C ±0.1°C with NIST calibration
Temperature Coefficient:	.00375 ohm/°C

3. Installation

3.1 Siting

Sensors should be located over an open level area at least 9 m (EPA) in diameter. The surface should be covered by short grass, or where grass does not grow, the natural earth surface. Sensors should be located at a distance of at least four times the height of any nearby obstruction, and at least 30 m (EPA) from large paved areas. Sensors should be protected from thermal radiation, and adequately ventilated.

Standard measurement heights:

1.5 m +/- 1.0 m (AASC)
1.25 – 2.0 m (WMO)
2.0 m (EPA)
2.0 m and 10.0 m temperature difference (EPA)

3.2 Assembly and Mounting

Tools Required:

- 1/2” open end wrench
- small screw driver provided with datalogger
- small Phillips screw driver
- UV resistant cable ties
- small pair of diagonal-cutting pliers

3.3 43502 Radiation Shield Installation

The 43502 mounting bracket has a U-bolt configured for attaching the shield to a vertical tripod mast or tower leg up to 2” in diameter. By moving the U-bolt to the other set of holes the bracket can be attached to a CM200 series crossarm, e.g. the CM204. The CM204 crossarm includes the CM210 Mounting Kit for attaching the crossarm to a tripod mast or tower leg. For triangular towers (e.g. the UT30), an additional PN CM210 Crossarm Mounting Kit can be ordered for attaching the crossarm to two tower legs for additional stability.

Attach the 43502 to the tripod/tower or crossarm using the U-bolt. Tighten the U-bolt sufficiently for a secure hold without distorting the plastic v-block. See the drawings in Appendix B for reference to names and locations of shield components and position of sensor within the shield.

The blower cover is hinged to allow easy access for sensor installation and cable connections. Loosen the captive screw in the blower cover to open. The junction box provides terminals for cable connections and properly positions the sensor within the shield assembly.

With the blower cover open connect blower power (12-14 VDC) to the terminals on the underside of the cover (Figure B-2). Terminal designations positive (POS), negative (NEG), and optional tachometer (TACH), are marked on the printed circuit board. Blower power is normally provided by the plug-in power supply adapter included. BE SURE TO OBSERVE CORRECT POLARITY. Red is positive, black is negative. The blower motor draws approximately 420mA-480mA. Use sufficiently heavy gauge wire between the power supply adapter and the blower motor terminals to avoid significant voltage drop. Clamp the blower power cable with the cable clamp provided at the edge of the printed circuit card. When tying the cable to the mounting structure provide a sufficient loop in the cable to allow the blower cover to be opened and closed easily.

Install the 43347 probe inside the 43502 shield using the sensor mounting bushing (supplied with the 43502) as shown in Figure B-1. The sensor cable exits the side of the blower housing at the notches provided using the black grommet to provide a seal (Figure B-3). Clamp the cable to the lower flange of the housing to keep it in proper position when the cover is closed. Route the sensor cable to the instrument enclosure. Secure the cable to the tripod/tower using cable ties.

Figure 3-1. 43502 Radiation Shield Mounted to Tripod Mast

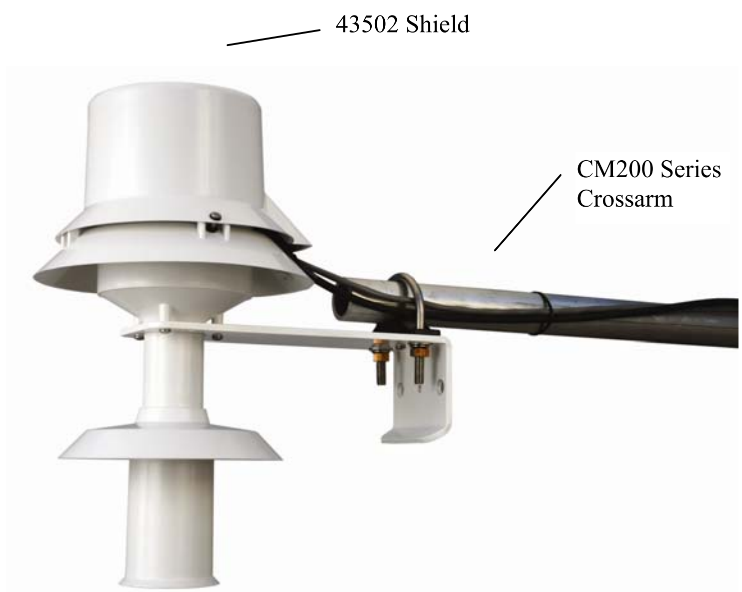

Figure 3-2. 43502 Radiation Shield Mounted to a CM200 Series Crossarm

3.4 41003-5 Radiation Shield Installation

The 41003-5 Radiation shield has a U-bolt for attaching the shield to tripod mast / tower leg (Figure 3-3), or CM200 series crossarm. The radiation shield ships with the U-bolt configured for attaching the shield to a vertical pipe. Move the U-bolt to the other set of holes to attach the shield it to a crossarm.

NOTE The split nut that ships with the 41003-5 shield must be replaced with split nut PN #27251 (which must be ordered separately), which has a slightly larger diameter to accommodate the 43347 probe.

Loosen the split-nut on the bottom plate of the 41003-5, and insert the 43347 into the shield. Tighten the split-nut to secure the sensor in the shield. Route the sensor cable to the instrument enclosure. Secure the cable to the tripod/tower using cable ties.

Figure 3-3. 41003-5 Radiation Shield Mounted to Tripod Mast

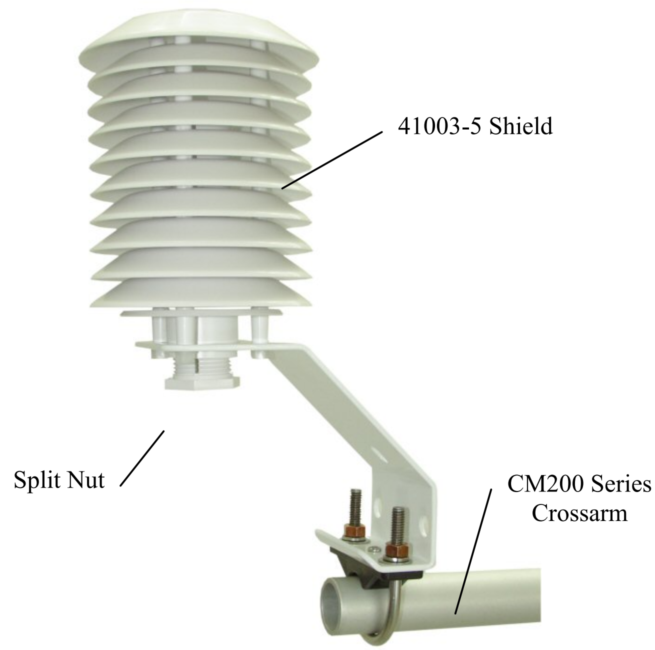

Figure 3-4. 41003-5 Radiation Shield Mounted to a CM200 Series Crossarm

4. Wiring

43347 probes configured with the –VX cable option are wired to the datalogger as described in Section 4. 43347 probes configured with the –IX cable option are wired to the CR3000 or CR5000 dataloggers as described in Section 6.

4.1 43347-VX Temperature Probe Wiring

The 43347-VX probe is configured as a four wire half bridge as shown in Figure 3-3. Each probe requires two differential inputs and one excitation channel (one excitation channel can be used for two probes). The black and orange wires connect to the first of two contiguous input channels (i.e. if channels 1 and 2 are used, the black and orange wires connect to 1H and 1L respectively, and the white and green wires connect to 2H and 2L respectively).

Connections to Campbell Scientific dataloggers are given in Table 4-1. When Short Cut for Windows software is used to create the datalogger program, the sensor should be wired to the channels shown on the wiring diagram created by Short Cut.

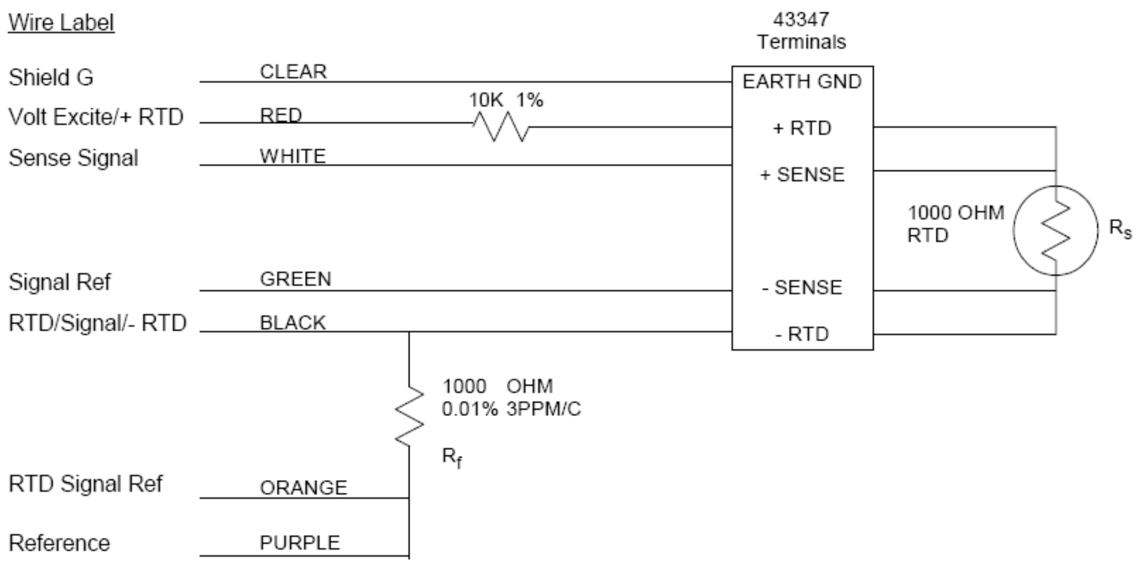

Figure 4-1. 43347-VX Temperature Probe Wiring

Table 4-1. Datalogger Connections

Colour	Description	CR10(X), CR510	CR3000, CR1000, CR800, CR5000, CR23X, 21X, CR7
Red	+ RTD	Switched Excitation	Switched Excitation
White	+ Sense	Differential (high)	Differential (high)
Green	- Sense	Differential (low)	Differential (low)
Black	- RTD	Differential (high)	Differential (high)
Orange	Reference Low	Differential (low)	Differential (low)
Purple	Excitation Return	(AG)	⏚
Clear	Shield	G	⏚

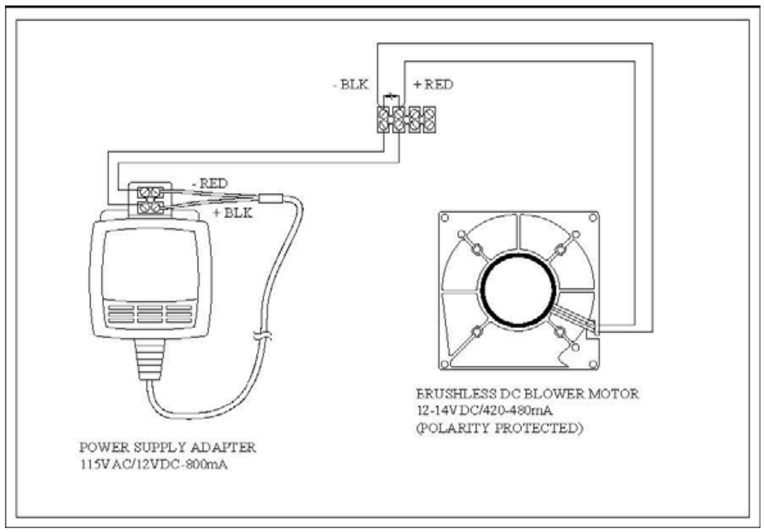

Figure 4-2. 43502 Aspirated Radiation Shield Wiring

NOTE Occasionally, a customer may need to connect an “IX” version of the sensor to a datalogger that has voltage excitation only (e.g., CR10(X), CR800, CR1000). The customer can do this by using a 4WPB1K terminal input module (refer to the 4WPB1K manual for more information).

4.2 43502 Aspirated Radiation Shield Wiring

The shield includes a 12 VDC transformer that plugs into 230 VAC. In most applications AC power is run to the tower or tripod and terminated in a junction box that is large enough to house the transformer(s).

Connect the red and black wires from the shield cable to the terminal block and transformer as shown in Figure 4-2.

5. Datalogger Programming for the 43347-VX Probe

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

Section 4 covers the 43347-VX probe, where the –VX specifies that the probe/cable is configured for a 4-wire half bridge measurement using an excitation voltage. Programming examples for the 43347-IX probe are covered in Section 6.

The 43347 temperature is measured with a four wire half-bridge measurement, Instruction BRHalf4W in CRBasic dataloggers, or Instruction 9 in Edlog dataloggers. The measurement applies an excitation voltage and makes two differential voltage measurements. The first measurement is made across the fixed resistor (Rf), the second is made across the RTD (Rs). The result is the ratio of the two resistances (Rs/Rf), which is not affected by lead length.

The result from the measurement is converted to temperature by a custom polynomial for calibrated temperature probes (Section 5.1), or the standard PRT resistance to temperature conversion for uncalibrated temperature probes (Section 5.2).

Table 5-1 shows the sensor wiring for the measurement examples Sections 5.1 and 5.2.

Table 5-1. Wiring for Measurement Examples

Colour	Function	Datalogger Channels used for Measurement Examples
Clear	Shield	⏚ (G) for CR10(X)
Red	Switched Excitation	E1
White	Differential High	2H
Green	Differential Low	2L
Black	Differential High	1H
Orange	Differential Low	1L
Purple	Analogue Reference	⏚ (AG) for CR10(X)

5.1 Programming for Calibrated 43347-VX Probes

Calibrated 43347 probes are provided with a calibration certificate from R.M. Young Co. that gives the relationship of resistance to temperature (°C) as Equation “T”.

$$T = -250.052585 + R \times 2.375187E\text{-}1 + R^2 \times 1.258482E\text{-}5$$

The measurement result of the instruction with a multiplier of 1.0 and an offset of 0.0 is R_s/R_f = the RTD resistance divided by 1000.

5.1.1 CR1000 Example for Calibrated 43347-VX Probes

Because the calibration coefficients are to convert sensor resistance (Rs) to temperature, the BrHalf4W measurement result (Rs/Rf) must be multiplied by 1000 (Rf), before the coefficients are applied.

```
'CR1000

'Declare Variables and Units
Public RTD_Res
Public RTD_Cal_C
Units RTD_Cal_C = Deg C

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

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

    'Measure 43347 (calibrated) probe and convert Rs/Rf to Rs
    BrHalf4W(RTD_Res,1,mV250,mV250,1,1,1,2500,True,True,0,_50Hz,1000,0)

    'Apply calibration coefficients (probe specific)
    '43347 calibration T=-250.052585+(R*2.375187e-1)+(R^2*1.258482e-5)
    RTD_Cal_C = -250.052585+(RTD_Res*2.375187e- 1)+((RTD_Res^2)* 1.258482e-5)

        'Call Data Tables and Store Data
        CallTable(Table1)
    NextScan
EndProg
```

5.1.2 CR10X Example for Calibrated 43347-VX Probes

Because the Full Bridge w/mv Excit (P9) resistance is divided by 1000, the coefficients given in Equation “T” can be entered into the polynomial without exponents. C0 is entered as given, C1 is divided by .001, and C2 is divided by .000001. For example:

Equation “T” from R.M. Young’s RTD Calibration Report:

T=		-250.052585
	+Rx	2.375187E-01
	$+R^2$	1.258482E-05

Scaled coefficients to be entered into Instruction 55:

C0 = -250.05
C1 = 237.52
C2 = 12.585

```
;{CR10X}
;
*Table 1 Program
  01:  5            Execution Interval (seconds)

;Measure the 43347 probe, result = Rs/Rf

1:  Full Bridge w/mv Excit (P9)
  1:   1            Reps
  2:   34           250 mV 50 Hz Rejection Ex Range    ;CR23X (200 mV); 21X,CR7 (500 mV)
  3:   34           250 mV 50 Hz Rejection Br Range    ;CR23X (200 mV); 21X,CR7 (500 mV)
  4:   1            DIFF Channel
  5:   1            Excite all reps w/Exchan 1
  6:   2500         mV Excitation                      ;CR23X (2000 mV); 21X,CR7 (5000 mV)
  7:   1            Loc [ RTD_C  ]
  8:   1            Mult
  9:   0            Offset

;Apply calibration coefficients (probe specific)
;43347 Calibration T = -250.052585,+(R*2.375187e-1)+(R^2*1.258482e-5)

2:  Polynomial (P55)
  1:   1            Reps
  2:   1            X Loc [ RTD_C  ]
  3:   1            F(X) Loc [ RTD_C  ]
  4:   -250.05      C0                                 ;Coefficients will differ for each probe
  5:   237.52       C1
  6:   12.585       C2
  7:   0.0          C3
  8:   0.0          C4
  9:   0.0          C5
```

5.2 Programming for Uncalibrated 43347-VX Probes

Instruction 9 applies an excitation voltage and makes two differential measurements. A multiplier of 1.0 on the four wire half-bridge measurement converts the measurement result to Rs/Ro (assuming Rf and Ro both equal 1000 ohms). The RTD temperature instruction converts Rs/Ro to temperature in accordance with DIN Standard 43760. Because the alpha of the RTD used in the temperature probe differs from DIN standard 43760, a multiplier of 1.0267 is required for Instruction 16.

5.2.1 CR1000 Example for Uncalibrated 43347-VX Probes

```
'CR1000

'Declare Variables
Public RTD_C

'Define Data Tables
DataTable(One_Hour,True,-1)
      DataInterval(0,60,Min,0)
      Sample(1,RTD_C,IEEE4)
EndTable

'Main Program
BeginProg
      Scan(1,Sec,1,0)
            '43347 RTD Temperature Probe (not calibrated) measurement RTD_C:
            BrHalf4W(RTD_C,1,mV250,mV250,1,Vx1,1,2500,True,True,0,_50Hz,1,0)
            PRT(RTD_C,1,RTD_C,1.0267,0)
            'Call Data Tables and Store Data
            CallTable(One_Hour)
      NextScan
EndProg
```

5.2.2 CR10X Example for Uncalibrated 43347-VX Probes

```
;{CR10X}
;
*Table 1 Program
   01:  5          Execution Interval (seconds)

;Measure the 43347 probe, result = Rs/Rf

1:  Full Bridge w/mv Excit (P9)
   1:   1          Reps
   2:   34         250 mV 50 Hz Rejection Ex Range    ;CR23X (200 mV); 21X,CR7 (500 mV)
   3:   34         250 mV 50 Hz Rejection Br Range    ;CR23X (200 mV); 21X,CR7 (500 mV)
   4:   1          DIFF Channel
   5:   1          Excite all reps w/Exchan 1
   6:   2500       mV Excitation                      ;CR23X (2000 mV); 21X,CR7 (5000 mV)
   7:   1          Loc [ RTD_C  ]
   8:   1          Mult
   9:   0          Offset
```

```
;Convert measurement result to Temperature deg C

2:  Temperature RTD (P16)
   1:    1              Reps
   2:    1              R/R0 Loc [ RTD_C  ]
   3:    1              Loc [ RTD_C  ]
   4:    1.0267         Mult ; (0.00385/0.00375)
   5:    0              Offset
```

6. 43347-IX Measurement using Current Excitation

The 43347-IX probe is measured with the Resistance measurement instruction with the CR3000 and CR5000 dataloggers. The Resistance measurement applies a switched current excitation and measures the voltage across the 1000 ohm RTD. Appendix D shows how a single current excitation channel can be used to excite as many as 25 43347 probes connected in series if the excitation current is 170 µA. Details on determining the excitation current and other parameter options are described in Section 6.3.

6.1 Wiring

The 43347-IX probe is configured as shown in Figure 6-1. Connections to the CR3000 and CR5000 dataloggers are shown in Table 6-1.

When Short Cut for Windows software is used to create the datalogger program, the sensor should be wired to the channels shown on the wiring diagram created by Short Cut.

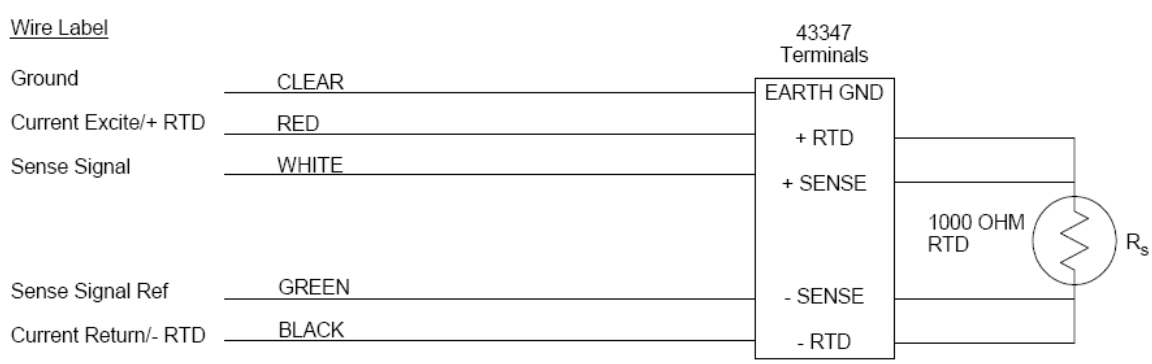

Figure 6-1. 43347-IX Temperature Probe Schematic

Table 6-1. Datalogger Connections

Colour	Description	CR3000, CR5000
Red	+RTD	Switched Current Excitation
White	+Sense	Differential (high)
Green	-Sense	Differential (low)
Black	-RTD	Switched Current Excitation Return
Clear	Shield	Ground (⏚)

NOTE Occasionally, a customer may need to connect an "IX" version of the sensor to a datalogger that has voltage excitation only (e.g., CR10(X), CR800, CR1000). The customer can do this by using a 4WPB1K terminal input module (refer to the 4WPB1K manual for more information).

6.2 Datalogger Programming

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

The 43347-IX is measured with the Resistance measurement instruction with the CR3000 and CR5000 dataloggers. The Resistance measurement applies a switched current excitation and measures the voltage across the 1000 ohm RTD. The result, with a multiplier of 1 and an offset of 0, is the RTD resistance in ohms. The measurement result is converted to temperature with the PRT instruction for uncalibrated probes, or with a polynomial equation for calibrated probes. Calibrated probes include a calibration certificate with the polynomial coefficients.

The Resistance and PRT Instructions with their parameters are listed below:

Resistance(Dest, Reps, Range, DiffChan, IexChan, MeasPEx, EXuA, RevEx, RevDiff, SettlingTime, Integ, Mult, Offset)

PRT(Dest, Reps, Source, Mult, Offset)

Table 6-2 shows the sensor wiring for the measurement examples.

Table 6-2. Wiring for Measurement Examples

Colour	Function	CR3000, CR5000
Red	Switched Current Excitation	IX1
White	Differential High	1H
Green	Differential Low	1L
Black	Excitation Return	IXR
Clear	Shield	⏚

6.2.1 Datalogger Programming for Calibrated 43347–IX Probes

Calibrated 43347-IX probes are provided with a calibration certificate that gives the relationship of resistance to temperature as Equation "T", as shown in the example below:

$$T = -250.052585 + R \times 2.375187E\text{-}1 + R^2 \times 1.258482E\text{-}5$$

The measurement result of the Resistance instruction (ohms) is converted to temperature with a polynomial equation and the coefficients from equation "T", as shown below.

The following example program measures a calibrated 43347-IX probe every 1 second and stores a 15 minute average temperature in degrees Celsius.

```
'CR3000

'Declare Variables and Units
Public RTD_Res
Public RTD_Cal_C

'Define Data Tables
DataTable(PRT_Data,1,1000)
    DataInterval(0,15,Min,1)
    Average (1,RTD_Cal_C,IEEE4,False)
Endtable

'Main Program
BeginProg
    Scan(1,Sec,10,0)

        'Measure the 43347-IX probe
        Resistance (RTD_Res,1,mV200,1,Ix1,1,170,True,True,0,_50Hz,1,0)

        'Convert RTD resistance to temperature
        '43347 calibration T=-250.052585+(R*2.375187e-1)+(R^2*1.258482e-5)
        RTD_Cal_C = -250.052585+(RTD_Res*2.375187e- 1)+((RTD_Res^2)* 1.258482e-5)

    CallTable PRT_Data

    Next Scan
EndProg
```

6.2.2 Datalogger Programming for Uncalibrated 43347-IX Probes

The measurement result of the Resistance instruction with a multiplier of 1.0 and an offset of 0.0 is the RTD resistance in ohms. For uncalibrated probes, the PRT instruction is used to convert the ratio Rs/Ro to temperature in accordance with DIN Standard 43760, where Rs is the measured resistance of the RTD, and Ro is the resistance of the RTD at 0 degrees C (1000 ohms). Because the alpha of the 43347 is 0.00375 and the alpha of DIN standard is 0.00385, a multiplier of 1.0267 (0.00385/0.00375) is required in the PRT instruction.

The PRT Instruction with its parameters is listed below:

PRT(Dest, Reps, Source, Mult, Offset)

The following example program measures an uncalibrated 43347-IX probe every 1 second and stores a 15 minute average temperature in degrees Celsius.

```
'CR3000

'Declare Variables and Units
Public RTD_Res
Public RTD_RsRo
Public RTD_C

Const RTD_Ro = 1000.00  'This is the actual RTD resistance for this sensor at 0.0°C

'Define Data Tables

DataTable(PRT_Data,1,1000)
    DataInterval(0,10,Min,1)
    Average (1,RTD_C,IEEE4,False)
Endtable

'Main Program
BeginProg
Scan(3,Sec,10,0)

    'Measure the 43347-IX Probe
    Resistance (RTD_Res,1,mV200,1,Ix1,1,170,True,True,0,_50Hz,1,0)

    'Convert RTD resistance to temperature
    RTD_RsRo = (RTD_Res / RTD_Ro)
    PRT (RTD_C,1,RTD_RsRo,1.0267,0.0)

CallTable PRT_Data

Next Scan
EndProg
```

6.3 Resistance Measurement Instruction Details

The Resistance instruction applies a switched current excitation to the 43347 probe, and makes two differential voltage measurements. The first differential voltage measurement is made across the RTD; the second is made across a precision 1000 Ω resistor in the CR3000 current excitation circuitry. The measurement result (X) = Vs/Ix = RTD resistance in ohms, where Vs is the measured voltage and Ix is the excitation current.

The maximum excitation current is ±2.5 mA. The parameters for the excitation current, measurement range, differential channel, and options to reverse the excitation current and switch the differential inputs are configurable, as discussed in the following sections.

6.3.1 Determining the Excitation Current

Current passing through the RTD causes heating within the RTD, which is referred to as “self-heating”, resulting in a measurement error. To minimize self-heating errors, use the minimum current that will still give the desired resolution. The best resolution is obtained when the excitation is large enough to cause the signal voltage to fill the measurement range.

The following example determines an excitation current that keeps self-heating effects below 0.002°C in still air.

Self heating can be expressed as

$\Delta T = (Ix^2 RRTD)\ \theta$

Where: ΔT = self heating in °C
Ix = current excitation
RRTD = 1000 Ω RTD resistance
θ = 0.05°C/mW self heating coefficient

Solving the above equation for Ix:

Ix = (ΔT / RRTD θ)^1/2

To keep self-heating errors below 0.002 °C, the maximum current Ix is:

Ix = (.002 °C / (1000 Ω *.05 °C / .001W)) ^1/2

Ix = 200uA

The best resolution is obtained when the excitation is large enough to cause the signal voltage to fill the measurement full scale range (the possible ranges are +/- 5000, 1000, 200, 50 and 20mV).

The maximum voltage would be at the high temperature or highest resistance of the RTD. At +40°C, a 1000 Ω RTD with α = 3.75 Ω/°C is about 1150 ohms.

Using Ohm's law to determine the voltage across the RTD at 40°C.

V = Ix R

Using an Ix value of 200uA, the voltage is:

V = 200uA * 1150 ohms

V= 230mV

This is just over the +/- 200mV input voltage range of the CR3000. For a maximum voltage of 200mV, the current Ix is:

Ix = 200mV/1150 ohms

Ix ~170uA

6.3.2 Reducing Measurement Noise

AC power lines, pumps, and motors can be the source of electrical noise. If the 43347 probe or datalogger is located in an electrically noisy environment, the measurement should be made with the 60 or 50 Hz rejection options.

Offsets in the measurement circuitry may be reduced by reversing the current excitation (RevEx), and reversing the differential analogue inputs (RevDiff), as shown in the program examples in Sections 6.2.

7. Maintenance

Inspect and clean the shield and probe periodically to maintain optimum performance. When the shield becomes coated with a film of dirt, wash it with mild soap and warm water. Use alcohol to remove oil film. Do not use any other solvent. Check mounting bolts periodically for possible loosening due to tower vibration.

8. 43347 RTD Temperature Probe Calibration

Calibration should be checked every 12 months. Probes used to measure a temperature gradient should be checked with respect to absolute temperature, and with respect to zero temperature difference. An excellent discussion on calibration procedures can be found in the Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV Meteorological Measurements[1].

9. Manufacturer's Information

Refer to the RM Young 43502 Instruction Manual for additional information such as replacement parts, assembly drawings, and electrical schematics.

10. Troubleshooting

-99999, NAN displayed in input location:

> Make sure the temperature probe is connected to the correct input channels (Sections 5 and 6). The input channel (Instruction 9) refers to the channel that the black and orange wires are connected to. The white and green wires connect to the next (higher) contiguous channel.

Unreasonable value displayed in input location:

> Make sure the multiplier and offset values entered for Instruction 9 are correct. For calibrated temperature probes (Section 6.1), make sure the coefficients have been properly scaled and entered for Instruction 55. For uncalibrated temperature probes (Section 6.2), make sure the multiplier and offset values have been properly entered for Instruction 16.

Temperature reading too high:

> Make sure the blower is working properly and there are no obstructions to the air flow in the sensor shield, telescoping arm, or vent holes. Also, check that the probe end of the shield points toward the prevailing wind.

11. References

[1]EPA, (1989). Quality Assurance Handbook for Air Pollution Measurement Systems Volume IV - Meteorological Measurements, EPA Office of Research and Development, Research Triangle Park, North Carolina 27711.

Appendix A. Example CR10(X) Program for Ice Bath Calibration

The following program can be used to calibrate 43347 probes (probes ordered without the 3-point RM Young calibration) for users wanting better than ±0.3 °C. The calibration computes a multiplier for the P9 measurement Instruction (Section 5.2).

Procedure:

Immerse the stainless steel tip of the 43347 probe in a properly prepared ice bath[1] and allow the temperature to stabilize (about an hour). Program the CR10X with the program listed below. Toggle Flag 1 high, which causes the 43347 probe to be measured 100 times. The average of the measurement result is placed into input location 2 and the reciprocal of location 2 is placed into input location 3. The value from location 3 is used as the multiplier for the P9 Instruction (Section 5.2). Typical values for locations 2 and 3 would be 1.0012 and 0.998 respectively.

```
;{CR10X}
;
*Table 1 Program
  01: 1           Execution Interval (seconds)

1: If Flag/Port (P91)
  1:  21          Do if Flag 1 is Low
  2:  0           Go to end of Program Table

2: Z=F (P30)
  1:  0           F
  2:  0           Exponent of 10
  3:  1           Z Loc [ counter   ]

3: Beginning of Loop (P87)
  1:  1           Delay
  2:  100         Loop Count

4: Full Bridge w/mv Excit (P9)
  1:  1           Reps
  2:  24          250 mV 60 Hz Rejection Ex Range
  3:  24          250 mV 60 Hz Rejection Br Range
  4:  1           DIFF Channel
  5:  1           Excite all reps w/Exchan 1
  6:  2500        mV Excitation
  7:  2           Loc [ result    ]
  8:  1.0         Mult
  9:  0           Offset

5: Z=Z+1 (P32)
  1:  1           Z Loc [ counter   ]
```

```
6:  If (X<=>F) (P89)
   1:   3               X Loc [ P9_mult   ]
   2:   3               >=
   3:   100             F
   4:   30              Then Do

7:  Do (P86)
   1:   10              Set Output Flag High (Flag 0)

8:  Do (P86)
   1:   21              Set Flag 1 Low

9:  End (P95)

10:  Set Active Storage Area (P80)
   1:   3               Input Storage Area
   2:   2               Loc [ result    ]

11:  Average (P71)
   1:   1               Reps
   2:   2               Loc [ result    ]

12:  Z=1/X (P42)
   1:   2               X Loc [ result    ]
   2:   3               Z Loc [ P9_mult   ]

13:  End (P95)
```

Appendix B. 43502 Aspirated Radiation Shield

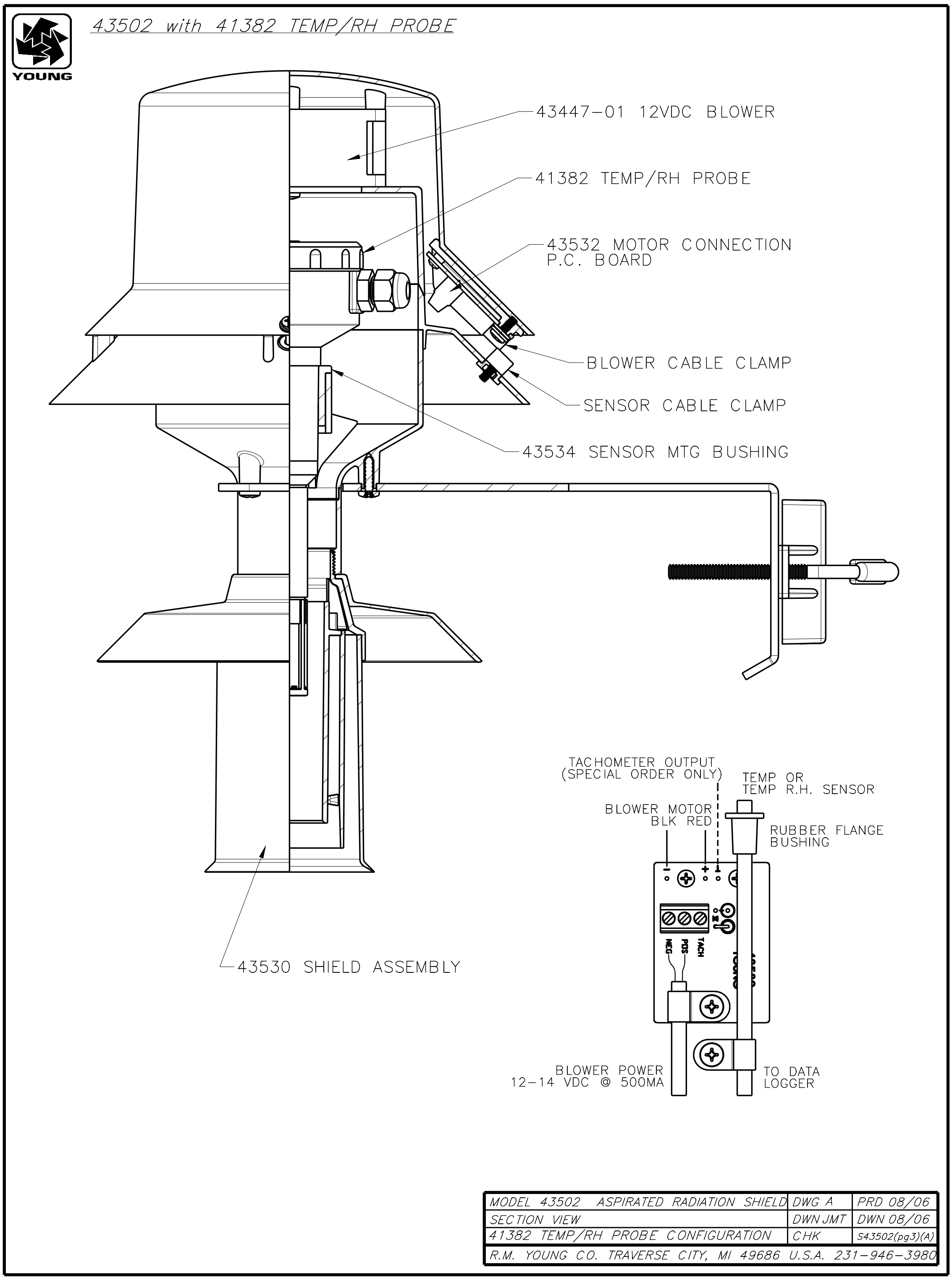

Figure B-1. 43347 Probe and Bushing

Figure B-2. 43502 Shield Power Connections

Figure B-3. 43347 Probe Mounted Inside the 43502 Shield

Appendix C. Using Other Sensors in the 43502 Shield

A universal (3-16 mm) clamp bushing is also supplied with the shield which can be used to mount other sensors. When using this it is important to position the end of the sensor approximately 60 mm for the bottom of the mounting tube, i.e. 60 mm from the bottom air intake. For many shorter sensors this means the clamp will not be able to grip around a rigid part of the sensor body but on the cable. If this is the case there is a risk the sensor tip will touch the side walls of the tube, which is not desirable. Various methods can be used to avoid this, which include:

a) putting a short length of plastic tube over the length of cable from the sensor up into clamp to stiffen it.

b) use three small cable ties around the body of the sensor, cut in length to form a triangular stand-off spacer (see figure C-1 below). The cable ties should not be positioned below or around the sensing part of the sensor. Any spacer should be as small as possible so as not to restrict air flow.

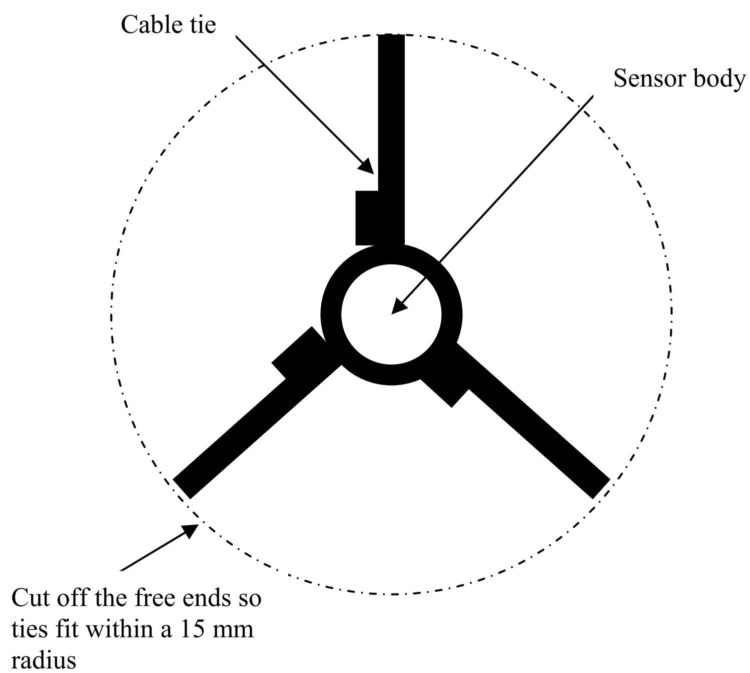

Fig. C-1 Triangular Stand-off Spacer

Appendix D. Measure Two 43347-IX Probes Using One Current Excitation Channel

One current excitation channel can excite multiple 43347 probes if the "Current Return" wire of the first probe is connected to the "Current Excitation" wire of the second probe.

In theory, a single Ix channel can excite up to 25 of the 43347−IX probes with 170 µA if all probes are at a temperature less than or equal to 45°C (see Section 6). At 45°C, the 43347 has a resistance of ~1175 ohms. The resistance increases as more probes are connected in series. The increase of resistance requires the Ix channel to raise the driving voltage to maintain the same current. The maximum voltage the Ix channel can drive is ±5 Vdc. Therefore, the maximum number of 43347 probes is:

Max. voltage/(current * resistance per probe at 45°C)

5 volts/(0.00017 amps * 1175 ohms) = 25

The CR3000's differential channel count limits the number of probes to 14 without a multiplexer.

One disadvantage to driving multiple probes with a single Ix channel is that if one probe shorts or opens then the measurements of all the probes on that Ix channel will be bad. If, for example, there are two probes at each of three levels, it might be best to drive one probe from each level on one Ix and then drive the remaining probes on a second Ix. This creates separate A and B systems, which allow maintenance to be done on one system while the other system continues to make good measurements.

D.1 Wiring

Wiring for two 43347-IX probes is shown in Figure D-1.

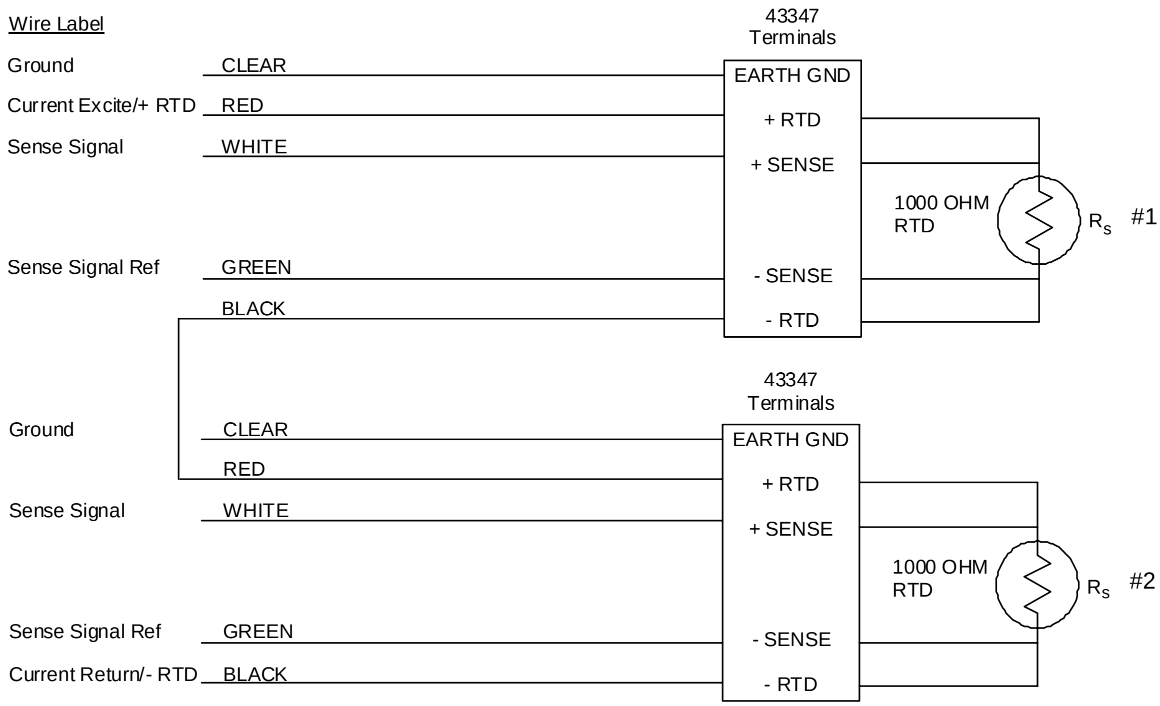

Figure D-1. Schematic for Two 43347-IX Temperature Probes

D.2 Example Program for two Calibrated 43347-IX Probes

This section includes an example CR3000 program that measures two calibrated 43347-IX probes. A CR5000 is programmed similarly. Wiring for the example program is shown in Table D-1.

Table D-1. Wiring for Two 43347-IX Probes Example

Colour	Function	CR3000, CR5000
Probe #1		
Red	Switched Current Excitation	IX1
White	Differential High	1H
Green	Differential Low	1L
Black	Excitation Return	Red of Probe #2
Clear	Shield	⏚
Probe #2		
Red	Switched Current Excitation	Black of Probe #1
White	Differential High	2H
Green	Differential Low	2L
Black	Excitation Return	IXR
Clear	Shield	⏚

```
'CR3000 Series Datalogger

'Declare Variables and Units
Public RTD1_Res, RTD1_Cal_C
Public RTD2_Res, RTD2_Cal_C

'Define Data Tables
DataTable (PRT_Data,1,1000)
    DataInterval (0,15,Min,1)
    Average(1,RTD1_Cal_C,IEEE4,False)
    Average(1,RTD2_Cal_C,IEEE4,False)
EndTable

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

        'Measure the 43347-IX probes
        Resistance(RTD1_Res,1,mV200,1,Ix1,1,170,True,True,0,_60Hz,1,0)
        Resistance(RTD2_Res,1,mV200,2,Ix1,1,170,True,True,0,_60Hz,1,0)

        'Convert RTD resistance to temperature
        '43347 #1 calibration T=-250.052585+(R*2.375187e-1)+(R^2*1.258482e-5)
        RTD1_Cal_C = -250.052585+(RTD1_Res*2.375187e-1)+((RTD1_Res^2)*1.258482e-5)
        '43347 #2 calibration T=-250.152585+(R*2.475187e-1)+(R^2*1.358482e-5)
        RTD2_Cal_C = -250.152585+(RTD1_Res*2.475187e-1)+((RTD1_Res^2)*1.358482e-5)
        CallTable PRT_Data

    NextScan
EndProg
```

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