INSTRUCTION MANUAL

43347 RTD Temperature Probe, 43502 and 41003-5 Radiation Shields

Revision: 11/13

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43347 RTD Temperature Probe, 43502 and 41003-5 Radiation Shields

1. General

The -L option on the model 43347 RTD Temperature Probe (43347-L), and the 43502 Aspirated Radiation Shield (43502-L) indicates that the cable length is user specified. This manual refers to them as the 43347 probe and the 43502 radiation shield.

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(X). 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 center 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 43502 blower operates off a 115 Vac/12 Vdc transformer that is included with the shield, or from a user-provided 12 Vdc source. The blower has a 'Tachometer' output that can be measured with a control port or pulse counter input on the datalogger, and the output frequency stored as part of the data to insure the blower was operational.

Lead length for the 43347 and 43502 is specified when the probe/shield is ordered. Maximum cable length for the 43502 is 75 ft (22.8 m), which is based upon 22 AWG wire, 500 mA current draw, and an allowance for a 1 V voltage drop across the cable. Larger diameter wire could be used for longer cable lengths. With 18 AWG wire, the maximum length is 200 ft (60.9 m).

The 43347 probe ships with:

(1) Instruction Manual

2. Specifications

43502 ASPIRATED RADIATION SHIELD

Sensor Types: Accommodates sensors up to 24 mm (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 to 36 fps) depending on sensor size

Power Requirement: 12 to 14 Vdc @ 500 mA for blower

Tachometer Output: 0 to 5 Vdc square wave pulse, 2 pulses per revolution
Approximately 146 Hz (4380 rpm) @ 12 Vdc

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 to 50 mm (1.0 to 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
Aluminum 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 to 50 mm (1 to 2 in) diameter

Weight
Net Weight: 0.7 kg (1.5 lb)
Shipping Weight: 1.4 kg (3 lb)

43347 RTD TEMPERATURE PROBE

RM Young
Model Number: 41342

Dimensions
Probe Tip: 0.125 in diameter, 2.25 in long
Overall Length: 7 in

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 Ω/Ω/°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 to 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 in. 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, *43502 Aspirated Radiation Shield*, 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 to 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 115 Vac to 12 Vdc plug-in power supply adapter included. BE SURE TO OBSERVE CORRECT POLARITY. Red is positive, black is negative. The blower motor draws approximately 420 mA to 480 mA. 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-2). 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

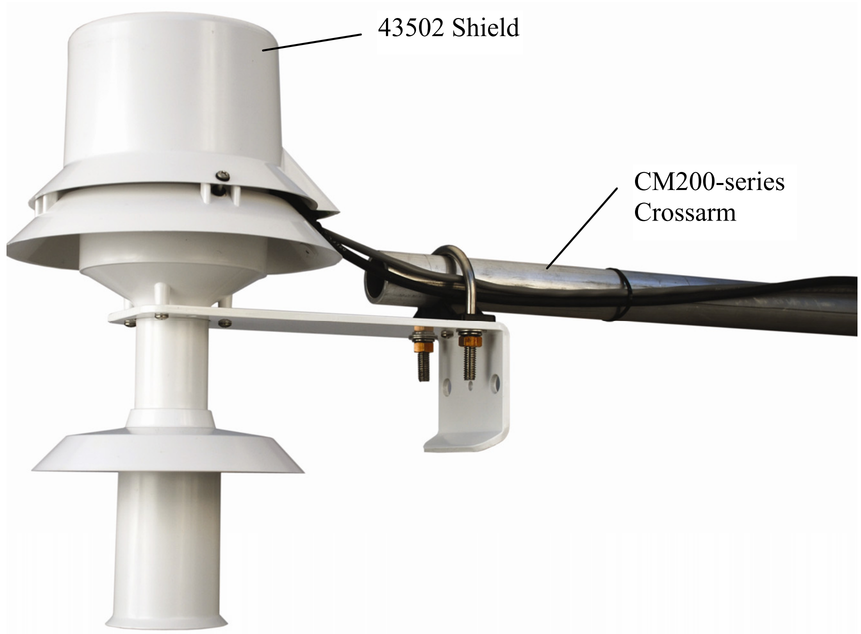


FIGURE 3-2. 43502 Radiation Shield mounted to a CM200-series Crossarm

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 (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.

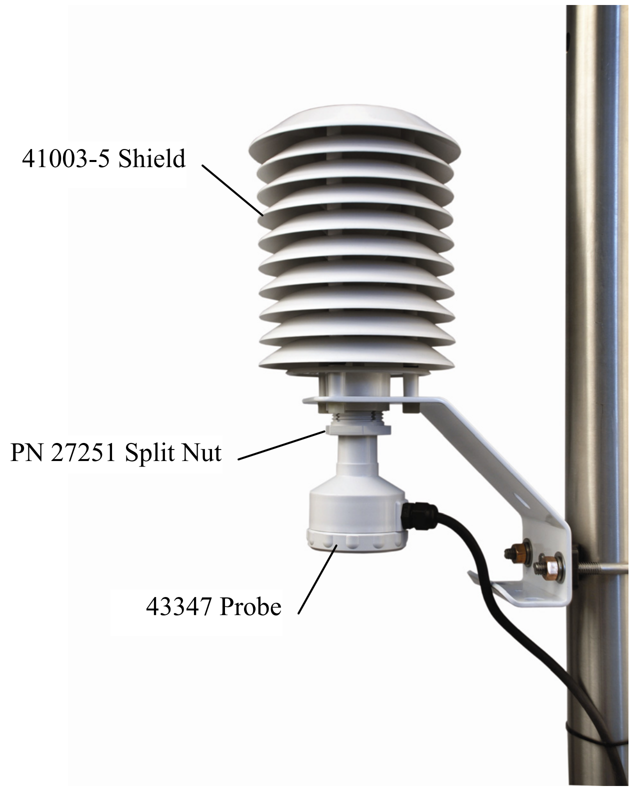


FIGURE 3-3. 41003-5 Radiation Shield mounted to tripod mast

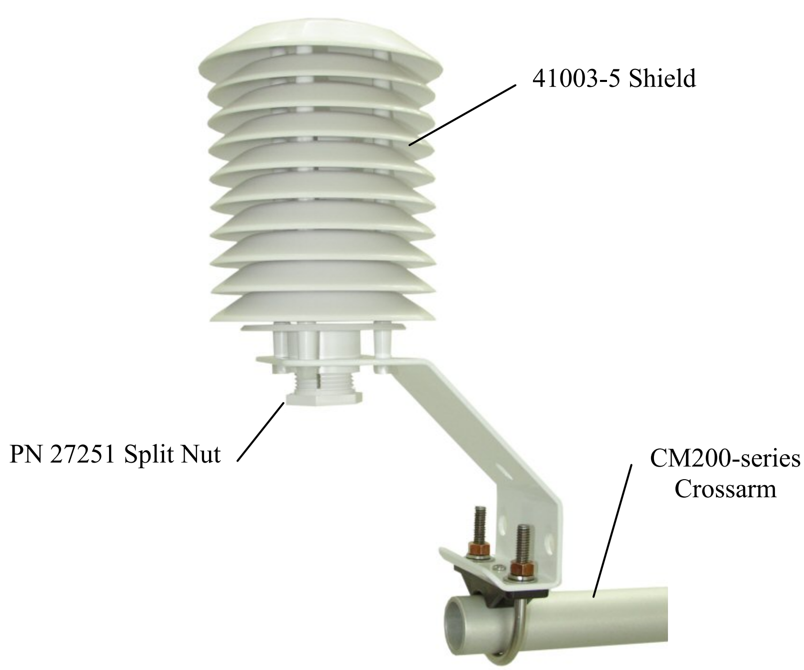


FIGURE 3-4. 41003-5 Radiation Shield mounted to a CM200-series Crossarm

4. Wiring

The 43347 comes in two versions—the "IX" version and the "VX" version. The "IX" version connects to dataloggers that can issue current excitation (CR3000, CR5000 only). The "VX" version can connect directly to dataloggers that only have voltage excitation (e.g., CR10(X), CR800, CR1000).

43347 probes with the –VX option are wired to the datalogger as described in Section 4, *Wiring*. 43347 probes with the –IX option are wired to the CR3000 or CR5000 dataloggers as described in Section 6, *43347-IX Measurement using Current Excitation*.

4.1 43347-VX Temperature Probe Wiring

The 43347-VX probe is configured as a four wire half bridge as shown in FIGURE 4-1. Each probe requires two differential inputs and one voltage 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. For example, 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 software is used to create the datalogger program, wire the sensor to the channels shown on the wiring diagram created by Short Cut.

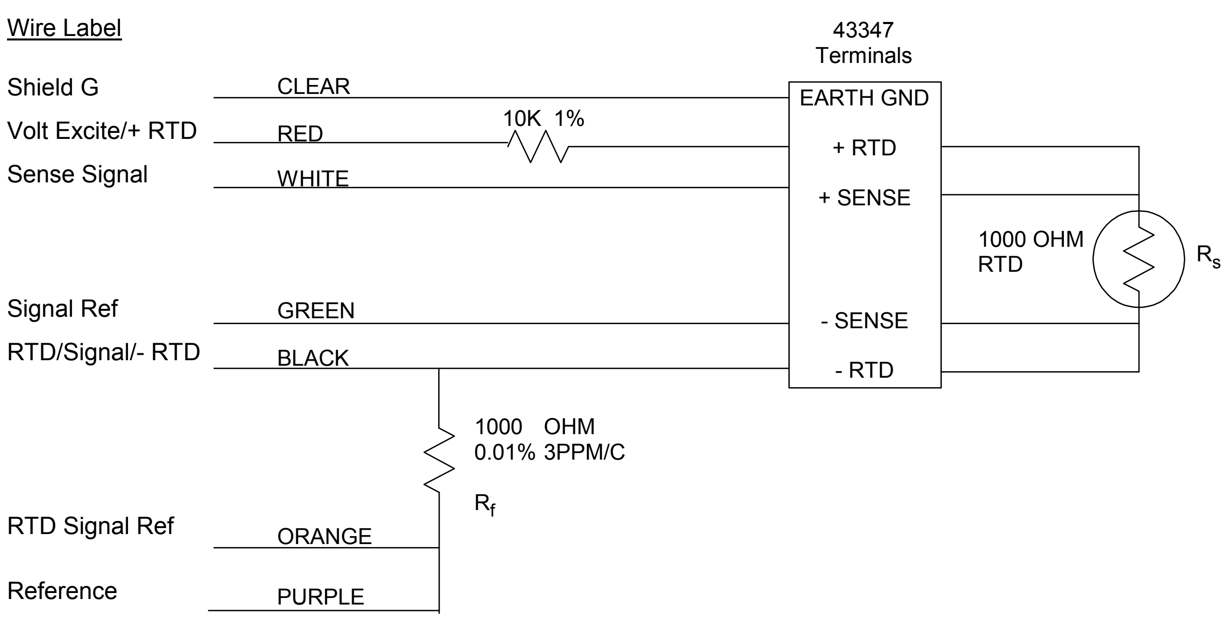


FIGURE 4-1. 43347-VX Temperature Probe wiring

TABLE 4-1. Datalogger Connections

Color	Wire Label	CR10(X), CR510	CR3000, CR1000, CR800, CR5000
Red	Volt Excite/+ RTD	Switched Excitation	Switched Excitation
White	Sense Signal	Differential (high)	Differential (high)
Green	Sense Signal Ref	Differential (low)	Differential (low)
Black	RTD Signal/- RTD	Differential (high)	Differential (high)
Orange	RTD Signal Ref	Differential (low)	Differential (low)
Purple	Excitation Reference	(AG)	⏚
Clear	Shield G	G	⏚

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 115 Vac/12 Vdc transformer. 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) as shown in FIGURE 4-2.

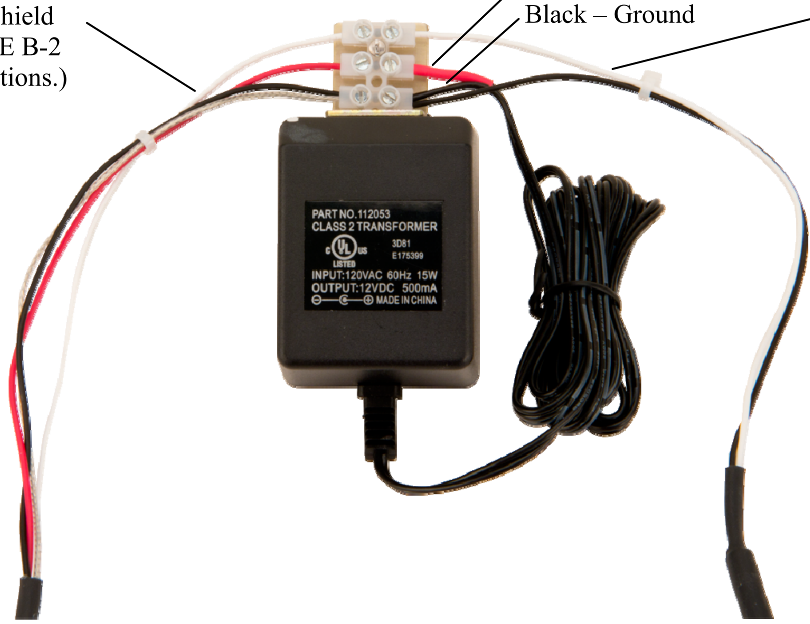


FIGURE 4-2. 43502 Aspirated Shield wiring

TABLE 4-2. 43502 Blower/Tachometer Connections

Color	43502	115 Vac/12 DC Transformer	*CR10X	*CR1000
Red	POS	terminal/wire with red heat shrink		
Black	NEG	terminal/wire without heat shrink	G	G
White	TACH	spare terminal	Control Port/ Pulse	Control Port/ Pulse
Clear	No Connect	terminal/wire without heat shrink	G	Ground (symbol)

* using CSI pn CABLE2CBL-L, or user-provided 2-conductor shielded cable

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 Scientific's Short Cut Program Builder software. You do not need to read this section to use Short Cut.

This section 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, *43347-IX Measurement using Current Excitation*.

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, *Programming for Calibrated 43347-VX Probes*), or the standard PRT resistance to temperature conversion for uncalibrated temperature probes (Section 5.2, *Programming for Uncalibrated 43347-VX Probes*).

The program examples include instructions to measure and store the tachometer output frequency (Hz) of the 43502 aspirated radiation shield. Storing the output frequency is a way to insure the blower is operational.

TABLE 5-1 shows the sensor wiring for the measurement examples in Section 5.1, *Programming for Calibrated 43347-VX Probes*, and Section 5.2, *Programming for Uncalibrated 43347-VX Probes*.

TABLE 5-1. Wiring for Measurement Examples

Color	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	Analog Reference	⏚ (AG) for CR10(X)
43502 Shield		
White	Tachometer	C1, C6 for CR10X
Red	*12V Power	
Black	Ground	

*wired to the 115 Vac/12 DC transformer supplied with the 43502, or separate 12 Vdc supply

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
Public 43502_Tach
Units 43502_Tach = Hz
```

```
'Define Data Tables
DataTable(Table1,True,-1)
  DataInterval(0,60,Min,10)
  Average(1,RTD_C,FP2,False)
  Sample (1,43502_Tach,FP2)
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,_60Hz,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)

  'Measure the 43502 tachometer output
  PulseCount (Tach_Hz,1,11,0,1,1.0,0)

    '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 (RF), 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:   24             250 mV 60 Hz Rejection Ex Range    ;CR23X (200 mV); 21X,CR7 (500 mV)
   3:   24             250 mV 60 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,_60Hz,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:  24          250 mV 60 Hz Rejection Ex Range   ;CR23X (200 mV); 21X,CR7 (500 mV)
  3:  24          250 mV 60 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

3: Pulse (P3)
  1:  1           Reps
  2:  6           Control Port 6
  3:  20          High Frequency, Output Hz
  4:  2           Loc [ Tach_Hz ]
  5:  1.0         Multiplier
  6:  0.0         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, *Measure Two 43347-IX Probes Using One Current Excitation Channel*, 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, *Resistance Measurement Instruction Details*.

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 software is used to create the datalogger program, wire the sensor to the channels shown on the wiring diagram created by Short Cut.

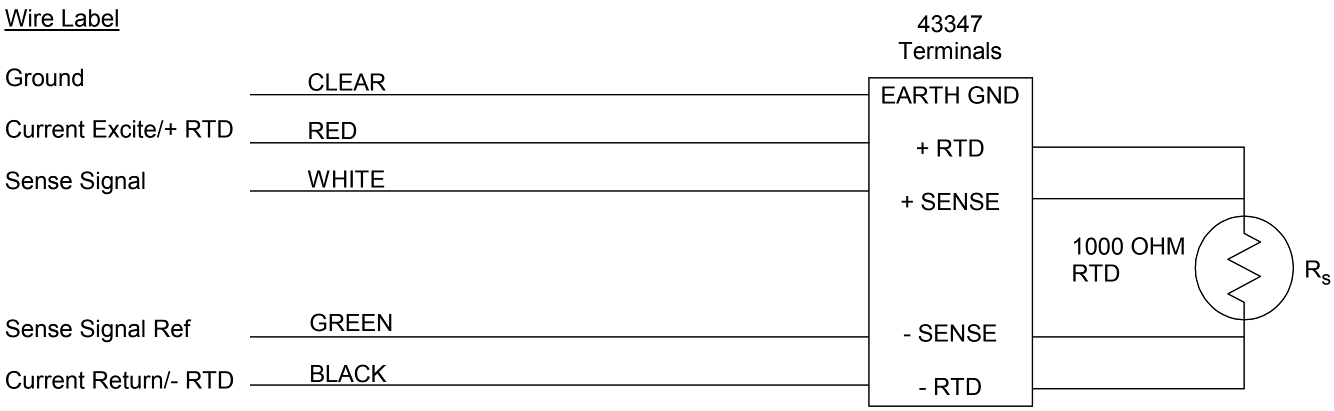


FIGURE 6-1. 43347-IX Temperature Probe schematic

TABLE 6-1. Datalogger Connections		
Color	**Wire Label**	**CR3000, CR5000**
Red	Current Excite/+ RTD	Switched Current Excitation
White	Sense Signal	Differential (high)
Green	Sense Signal Ref	Differential (low)
Black	Current Return/- RTD	Switched Current Excitation Return
Clear	Ground	Ground (⏚)
43502 Shield		
White	Tachometer	
Red	*12V power	
Black	*Gound	

*wired to the 115 Vac/12 DC transformer supplied with the 43502, or separate 12 Vdc supply

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

Color	**Function**	**CR3000, CR5000**
Red	Switched Current Excitation	IX1
White	Differential High	1H
Green	Differential Low	1L
Black	Excitation Return	IXR
Clear	Shield	⏚
	43502 Shield	
White	Tachometer	
Red	*12V power	
Black	*Gound	

*wired to the 115 Vac/12 DC transformer supplied with the 43502, or separate 12 Vdc supply

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
Public 43502_Tach
Units 43502_Tach = Hz

'Define Data Tables
DataTable(PRT_Data,1,1000)
  DataInterval(0,15,Min,1)
  Average (1,RTD_Cal_C,IEEE4,False)
  Sample (1,43502_Tach,FP2)
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,_60Hz,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)

  'Measure the 43502 tachometer output
  PulseCount (Tach_Hz,1,11,0,1,1.0,0)

  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
Public 43502_Tach
Units 43502_Tach = Hz
```

```
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)
  Sample (1,43502_Tach,FP2)
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,_60Hz,1,0)

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

  'Measure the 43502 tachometer output
  PulseCount (Tach_Hz,1,11,0,1,1.0,0)

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:

$$Ix = (\Delta T / RRTD\ \theta)^{1/2}$$

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

$$Ix = (.002\ °C / (1000\ \Omega * .05\ °C / .001W))^{1/2}$$

$$Ix = 200uA$$

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 20 mV).

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 ±200 mV input voltage range of the CR3000.
For a maximum voltage of 200 mV, the current Ix is:

$$Ix = 200mV/1150\ ohms$$

$$Ix \sim 170uA$$

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 analog inputs (RevDiff), as shown in the program examples in Section 6.2, *Datalogger Programming*.

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 (Section 5, *Datalogger Programming for the 43347-VX Probe*, and Section 6, *43347-IX Measurement using Current Excitation*). 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, *Wiring*), make sure the coefficients have been properly scaled and entered for Instruction 55. For uncalibrated temperature probes (Section 6.2, *Datalogger Programming*), 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, *Programming for Uncalibrated 43347-VX Probes*).

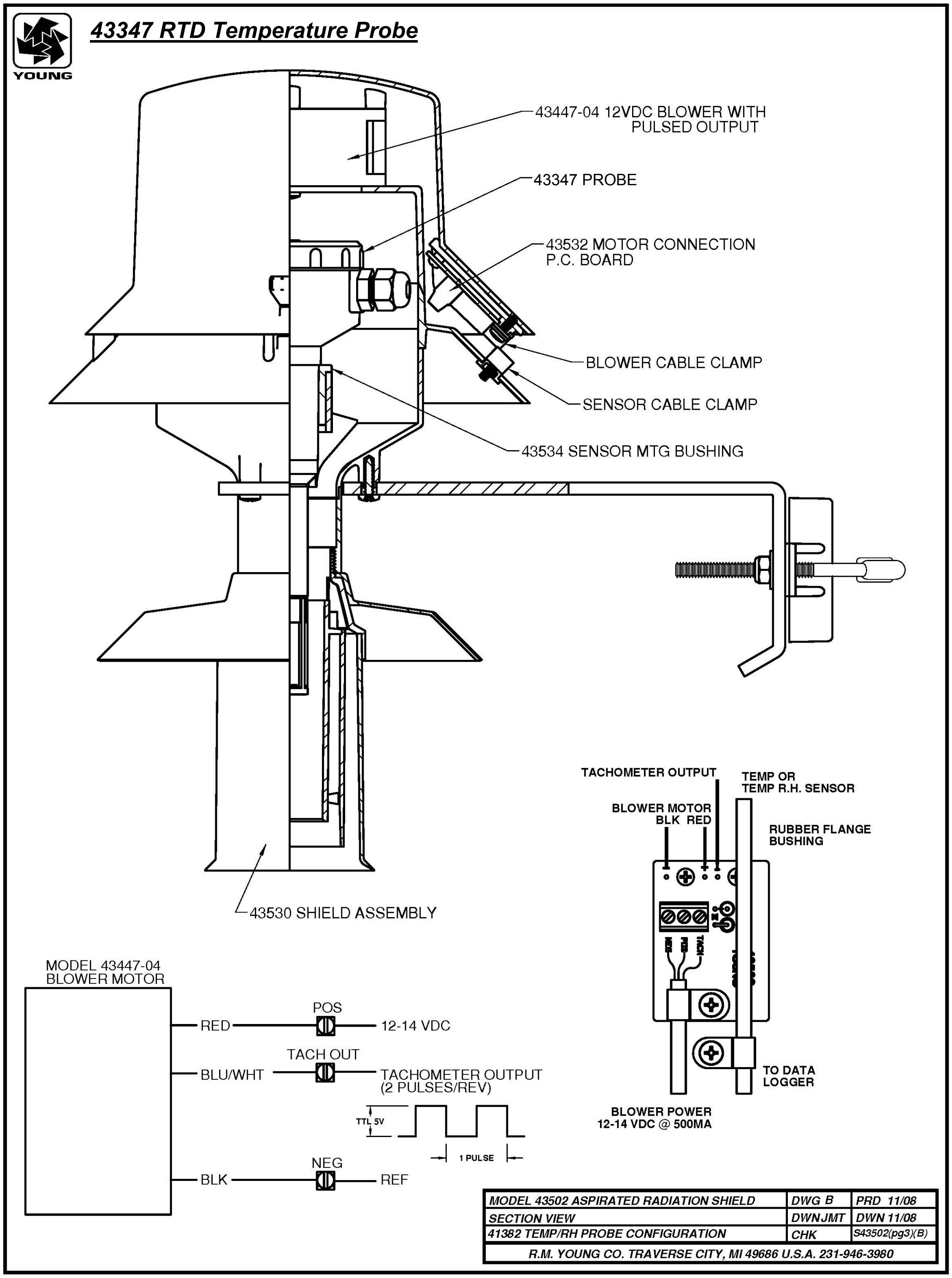
Procedure:

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, *Programming for Uncalibrated 43347-VX Probes*). 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



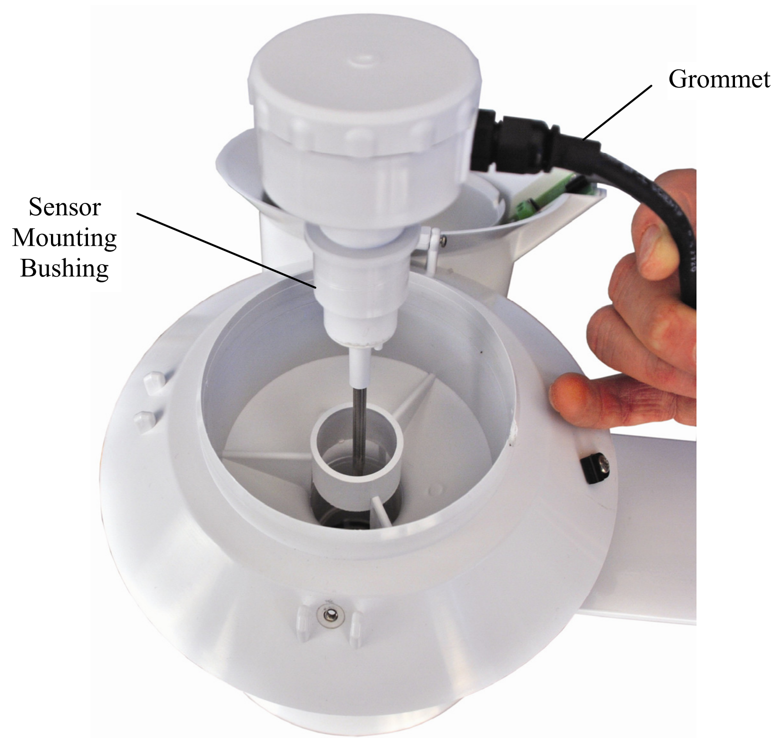
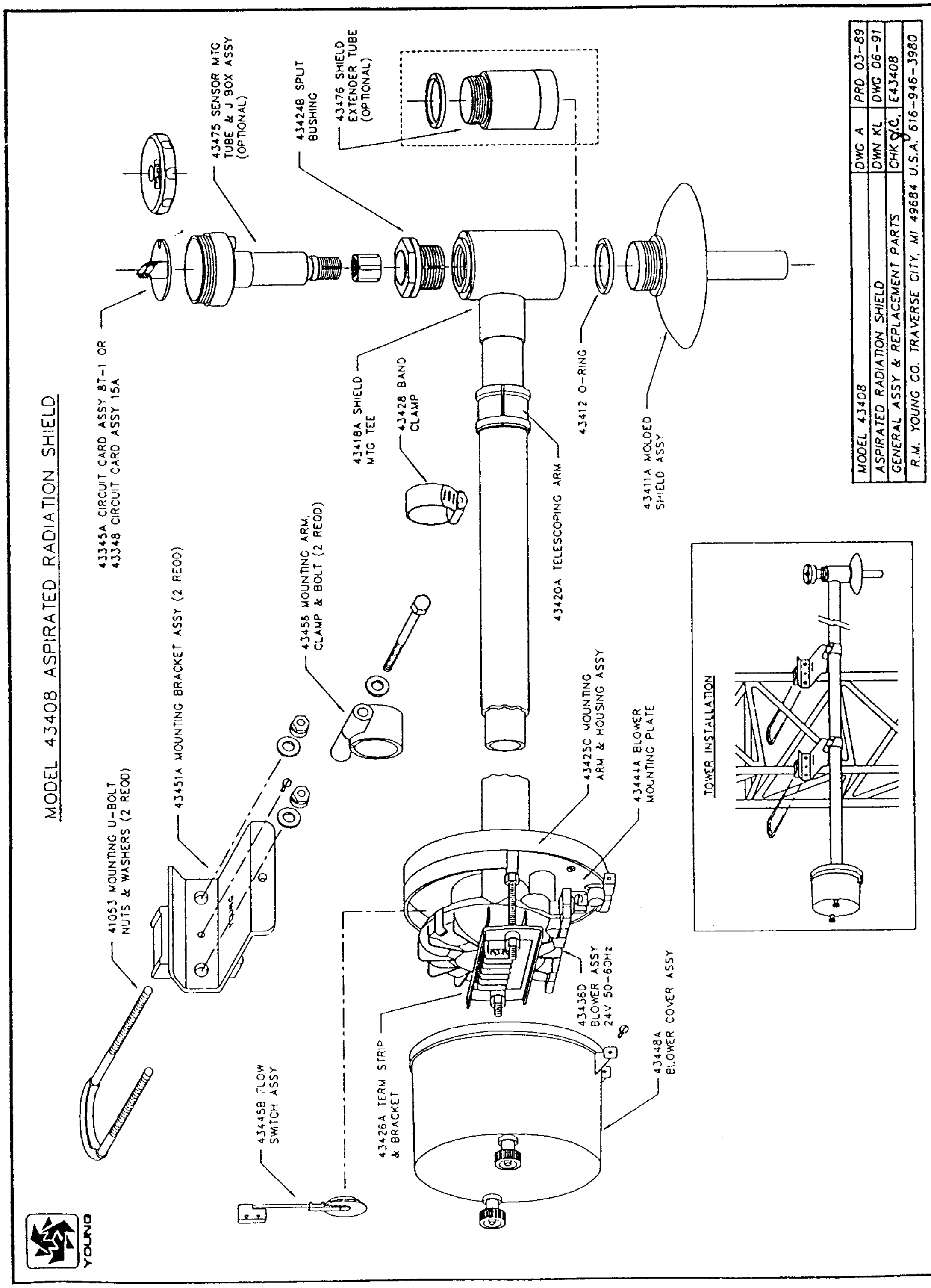


FIGURE B-1. 43347 probe and bushing

FIGURE B-2. 43347 probe mounted inside the 43502 shield

Appendix C. 43347 Aspirated Radiation Shield



The 43408 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 temperature probe mounts vertically in the center of the intake tubes.

A brushless 12 Vdc blower motor pulls ambient air into the shield and across the temperature probe to reduce radiation errors. The blower operates off a 115 Vac/12 Vdc transformer that is included with the shield.

C.1 Specifications

43408 ASPIRATED RADIATION SHIELD:

DIMENSIONS:
Length: 44 in, extendable to 75 in
Diameter of Blower Housing: 6 in

AIR FLOW RATE:
3 to 7 m/s depending on sensor size

TEMPERATURE RANGE: ±50°C

POWER REQUIRED:
12 to 14 Vac @ 420 to 480 mA
115 Vac/12 Vdc - 800 mA transformer supplied

RADIATION ERROR:
< 0.2°C radiation @ 1100 W/m^2 irradiance

LIFE EXPECTANCY ON BLOWER:
80,000 hrs @ 25°C

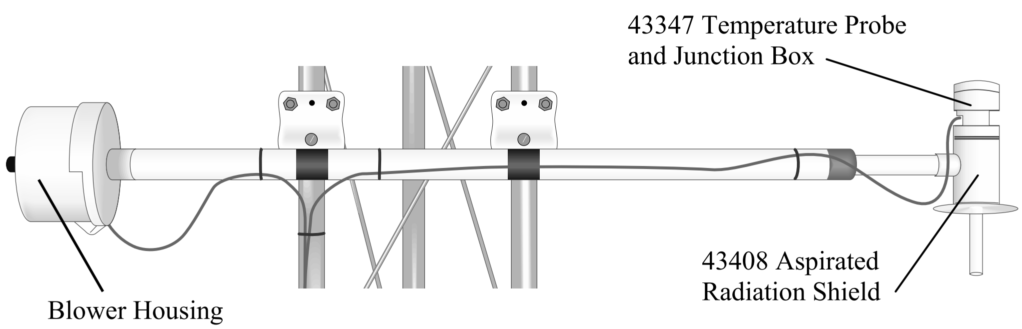


FIGURE C-1. 43347 RTD Temperature Probe and 43408 Aspirated Radiation Shield

C.2 Installation

Refer to the General Assembly drawing in the RM Young 43408 Instruction Manual (included) for reference to the names of shield components.

Thread the molded shield assembly into the appropriate threaded opening in the shield mounting tee at the end of the telescoping arm. Hand-tighten the shield to slightly compress the O-ring seal; do not crossthread or overtighten.

Insert the sensor mounting tube and junction box with its split bushing into the shield mounting tee. Tighten the threaded split bushing to secure the junction box in place; do not overtighten.

Two U-bolt brackets attach the radiation shield to horizontal, vertical, or diagonal tower members up to 2 inches in diameter, spaced 12 to 30 inches apart. Campbell Scientific pn 7515 10 m Aspirated Shield Mounting Bracket can be used to mount the shield to a single vertical pipe or mast, as shown in FIGURE C-2.

The mounting arm should be horizontal with the vent holes facing downward, with the probe end pointing towards the prevailing wind. Tighten the U-bolt brackets sufficiently for a secure hold without distorting the plastic v-blocks. Loosen the band clamp and extend the arm at least 24 inches. Rotate the shield so the intake tube is oriented vertically with the intake opening facing down. Tighten the band clamp and secure the sensor lead to the arm using UV resistant cable ties.

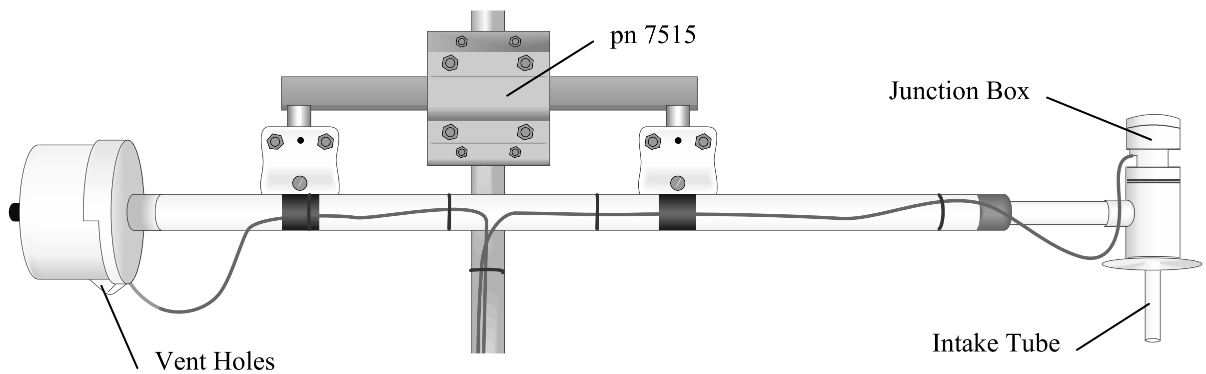


FIGURE C-2. PN 7515 10 m Aspirated Shield Mounting Bracket

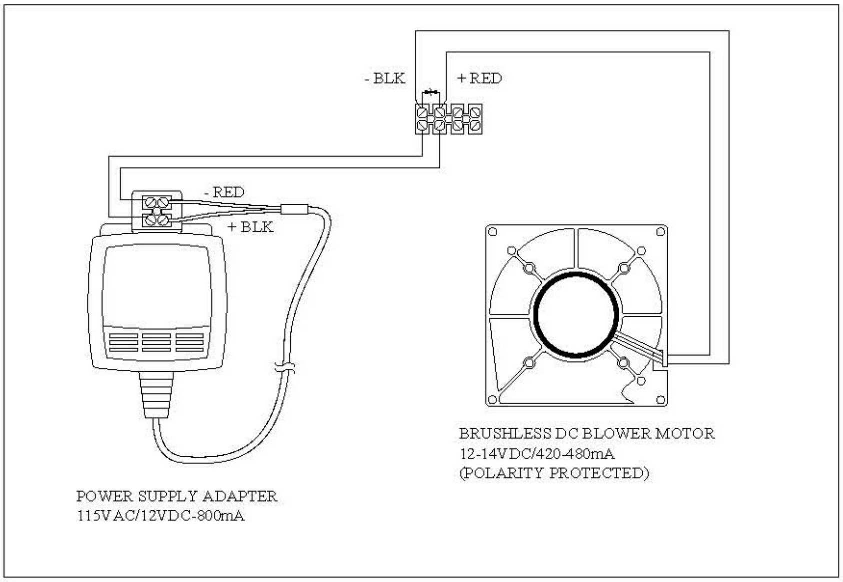


FIGURE C-3. 43408 Aspirated Radiation Shield wiring

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, *43347-IX Measurement using Current Excitation*). 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.

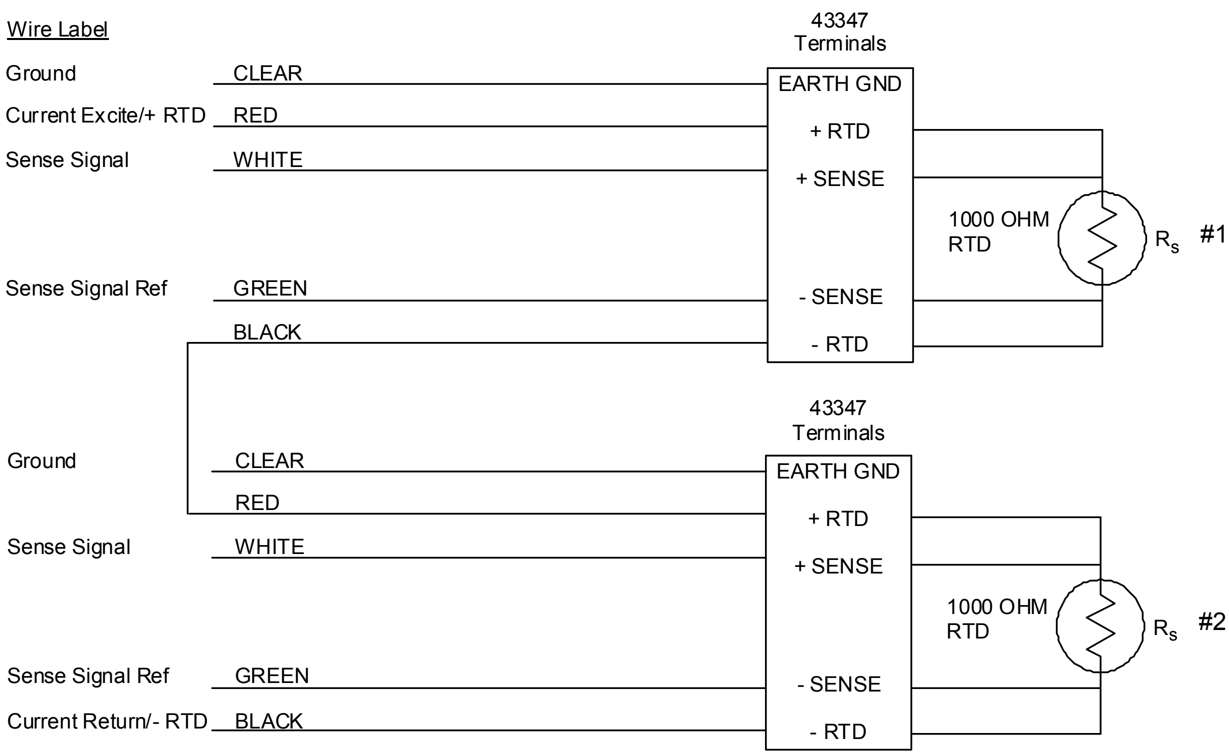


FIGURE D-1. Schematic for Two 43347-IX Temperature Probes

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		
Color	**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	⏚
	(2) 43502 Shields	
White	Tachometer	C1 for first probe, C2 for second
Red	*12V power	
Black	*Gound	

*wired to the 115Vac/12DC transformer supplied with the 43502, or separate 12Vdc supply

```
'CR3000 Series Datalogger

'Declare Variables and Units
Public RTD1_Res, RTD1_Cal_C
Public RTD2_Res, RTD2_Cal_C
Public 43502_Tach
Public 43502_Tach_1
Units 43502_Tach = Hz
Units 43502_Tach_1 = Hz

'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)
    Sample (1,43502_Tach,FP2)
    Sample (1,43502_Tach_1,FP2)
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

    'Measure the 43502 tachometer outputs
    PulseCount (Tach,1,11,0,1,1.0,0)
    PulseCount (Tach_1,1,12,0,1,1.0,0)

    NextScan
EndProg
```

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