INSTRUCTION MANUAL

CS500 Temperature and Relative Humidity Probe

Revision: 7/04

Warranty and Assistance

The **CS500 TEMPERATURE AND RELATIVE HUMIDITY PROBE** is warranted by CAMPBELL SCIENTIFIC, INC. to be free from defects in materials and workmanship under normal use and service for twelve (12) months from date of shipment unless specified otherwise. Batteries have no warranty. CAMPBELL SCIENTIFIC, INC.'s obligation under this warranty is limited to repairing or replacing (at CAMPBELL SCIENTIFIC, INC.'s option) defective products. The customer shall assume all costs of removing, reinstalling, and shipping defective products to CAMPBELL SCIENTIFIC, INC. CAMPBELL SCIENTIFIC, INC. will return such products by surface carrier prepaid. This warranty shall not apply to any CAMPBELL SCIENTIFIC, INC. products which have been subjected to modification, misuse, neglect, accidents of nature, or shipping damage. This warranty is in lieu of all other warranties, expressed or implied, including warranties of merchantability or fitness for a particular purpose. CAMPBELL SCIENTIFIC, INC. is not liable for special, indirect, incidental, or consequential damages.

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CAMPBELL SCIENTIFIC, INC.
RMA#_____
815 West 1800 North
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CS500 Table of Contents

PDF viewers note: These page numbers refer to the printed version of this document. Use the Adobe Acrobat® bookmarks tab for links to specific sections.

Figures

Tables

CS500 Temperature and Relative Humidity Probe

1. General

The CS500 Temperature and Relative Humidity probe contains a Platinum Resistance Temperature detector (PRT) and a Vaisala INTERCAP® capacitive relative humidity sensor.

The -L option on the model CS500 Temperature and Relative Humidity probe (CS500-L) indicates that the cable length is user specified. This manual refers to the sensor as the CS500.

2. Specifications

Operating Temperature: -40°C to +60°C

Storage Temperature: -40°C to +80°C

Probe Length: 6.8 cm (2.66 in.)

Probe Body Diameter: 1.2 cm (0.47 in.)

Filter: 0.2 μm Teflon membrane

Filter Diameter: 1.2 cm (0.47 in.)

Housing Material: ABS Plastic

Power Consumption: <2 mA

Supply Voltage: 7 to 28 VDC

Settling Time after power is switched on: 1 second

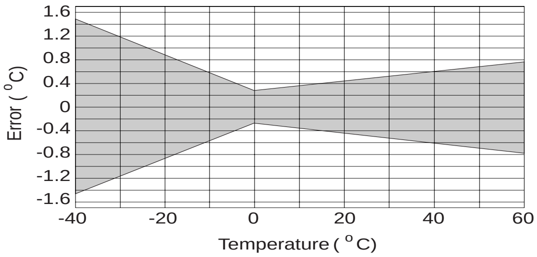
2.1 Temperature Sensor

Sensor: 1000 Ω PRT, DIN 43760B

Temperature Measurement Range: -40°C to +60°C

Temperature Output Signal range: 0 to 1.0 VDC

Temperature Accuracy:



2.2 Relative Humidity Sensor

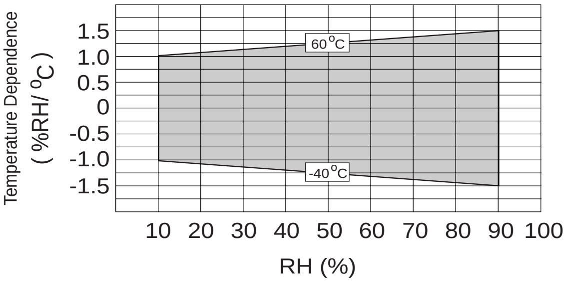
Sensor: INTERCAP®

Relative Humidity Measurement Range: 0 to 100% non-condensing

RH Output Signal Range: 0 to 1.0 VDC

Accuracy at 20°C
unspecified (0 to 10% Relative Humidity)
±3% RH (10 to 90% Relative Humidity)
±6% RH (90 to 100% Relative Humidity)

Temperature Dependence of Relative Humidity Measurement:



Typical Long Term Stability: Better than 1% RH per year

Response Time (at 20°C, 90% response to a steep change in humidity):
15 seconds with membrane filter

3. Installation

The CS500 must be housed inside a solar radiation shield when used in the field. The 41303 6-Plate Radiation Shield (Figure 1) mounts to a CM6/CM10 tripod or UT10 tower. The CS500 is held within the 41301 by a mounting clamp (Figure 2).

The 41003 10-Plate Radiation Shield (Figure 3) mounts to a CM6/CM10 tripod. The UT12VA 12-Plate Radiation Shield mounts to a UT10 or UT30 tower with the UT018 horizontal mounting arm.

The CS500 is held in place, within the 41003 or UT12VA Radiation Shield, via an adapter, Model 41381. The 41381 adapter is threaded onto the bottom of the CS500 (Figure 4). The 41004 12-Plate Radiation Shield, used with 207 probes, can be converted to a 41002 with P/N 6638.

NOTE The black outer jacket of the cable is Santoprene® rubber. This compound was chosen for its resistance to temperature extremes, moisture, and UV degradation. However, this jacket will support combustion in air. It is rated as slow burning when tested according to U.L. 94 H.B. and will pass FMVSS302. Local fire codes may preclude its use inside buildings.

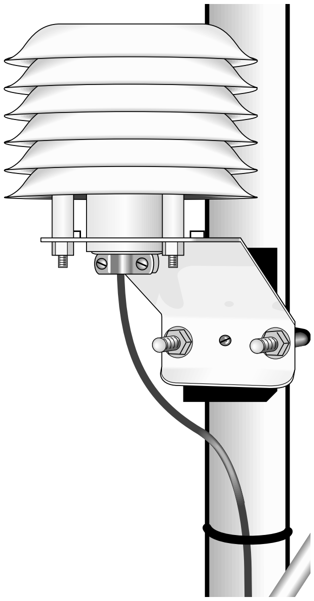


FIGURE 1. CS500 and 41301 Radiation Shield on a CM6/CM10 Tripod Mast

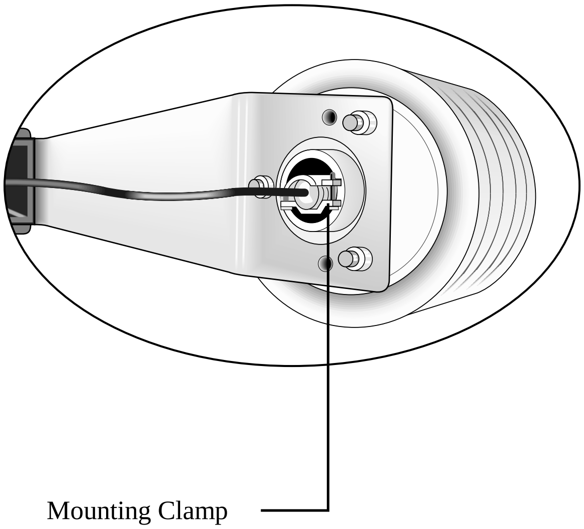


FIGURE 2. CS500 and 41303 Radiation Shield

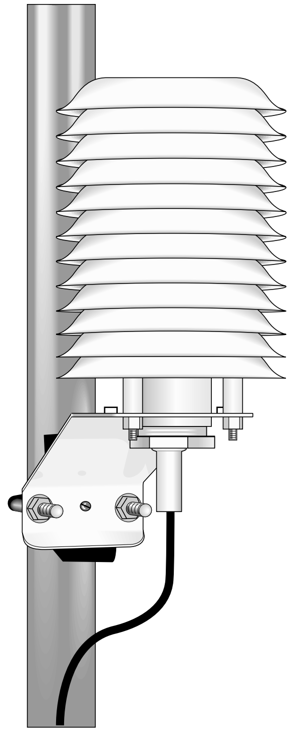


FIGURE 3. CS500 and 41003 Radiation Shield
on a CM6/CM10 Tripod Mast

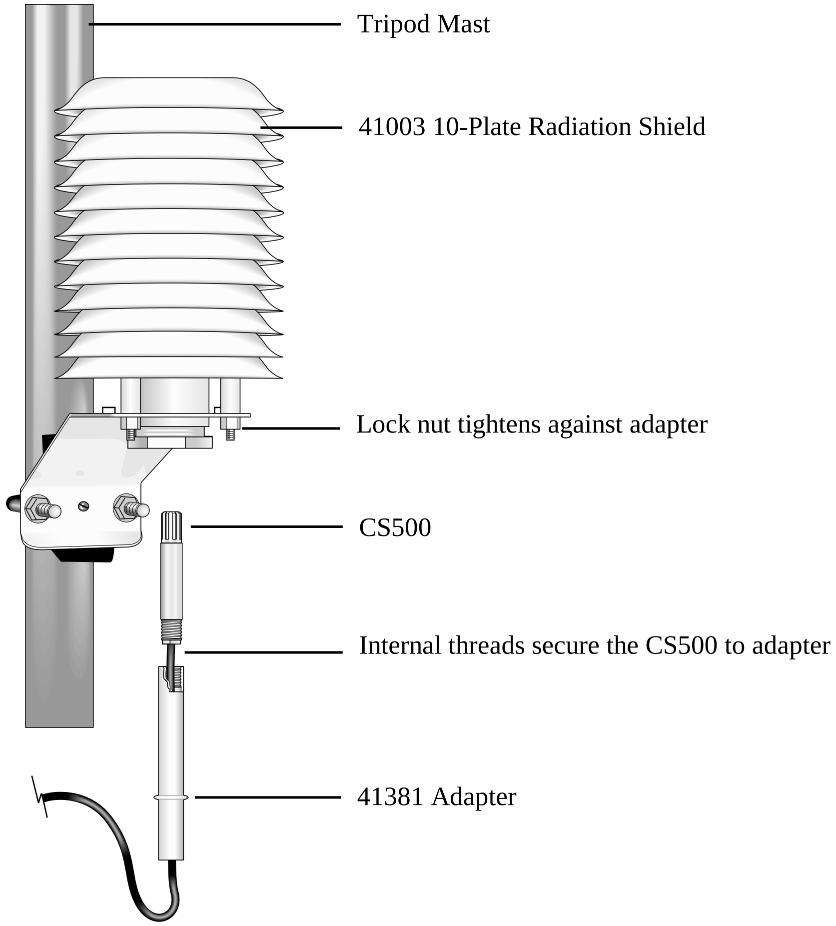


FIGURE 4. Radiation Shield, CS500, and 41381 Adapter

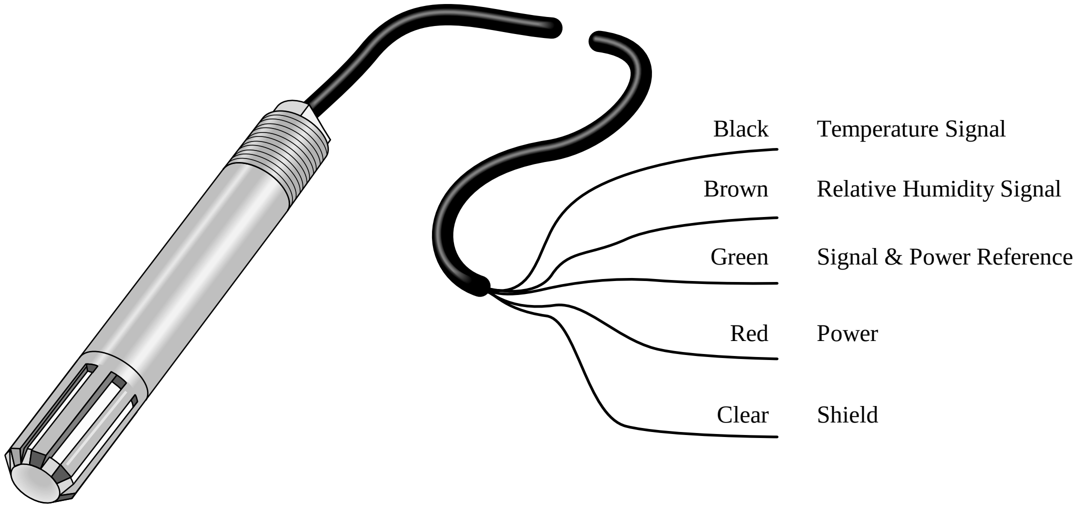


FIGURE 5. CS500 Wiring

TABLE 1. Datalogger Connections

Description	Color	CR23X/CR1000	CR10(X), CR510	21X, CR7
Temperature	Black	Single-Ended Input	Single-Ended Input	Single-Ended Input
Relative Humidity	Brown	Single-Ended Input	Single-Ended Input	Single-Ended Input
Signal & Power Reference	Green	G	G	⏚
Power	Red	12 V	12 V	12 V
Shield	Clear	⏚	G	⏚

4. Wiring

Connections to Campbell Scientific dataloggers are given in Table 1. The probe is measured by two single-ended analog input channels, one for temperature and one for relative humidity.

CAUTION Always connect the Green lead to the datalogger first, followed by the Black, Brown, and Clear leads. Connect the Red (Power) lead last.

5. Example Programs

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.

The temperature and relative humidity signals from the CS500 are measured using two single-ended analog measurements (Instruction 1).

The probe output scale is 0 to 1000 millivolts for the temperature range of -40°C to +60°C and for the relative humidity range of 0 to 100%. Tables 2 and 3 provide calibration information for temperature and relative humidity.

TABLE 2. Calibration for Temperature

Units	Multiplier (degrees mV^{-1})	Offset (degrees)
Celsius	0.1	-40
Fahrenheit	0.18	-40

TABLE 3. Calibration for Relative Humidity

Units	Multiplier (% mV^{-1})	Offset (%)
Percent	0.1	0
Fraction	0.001	0

TABLE 4. Wiring for CR1000 and CR10X Examples

Description	Color	CR1000	CR10(X)
Temperature	Black	SE 1	SE 3 (2H)
Relative Humidity	Brown	SE 2	SE 4 (2L)
Signal & Power Reference	Green	G	G
Power	Red	12 V	12 V
Shield	Clear	⏚	G

5.1 Example for CR1000

```
'CR1000
'Created by SCWIN (2.1)

Public AirTC
Public RH

DataTable(Table1,True,-1)
    DataInterval(0,60,Min,0)
    Average(1,AirTC,IEEE4,0)
    Sample(1,RH,IEEE4)
EndTable

BeginProg
    Scan(5,Sec,1,0)
        'CS500 Temperature & Relative Humidity Sensor measurements AirTC and RH:
        VoltSE(AirTC,1,mV2500,1,0,0,_60Hz,0.1,-40.0)
        VoltSE(RH,1,mV2500,2,0,0,_60Hz,0.1,0)
        If (RH>100) And (RH<108) Then RH=100
        CallTable(Table1)
    NextScan
EndProg
```

5.2 Example for CR10X

```
;Measure the CS500 temperature.
;
01:  Volt (SE) (P1)
  1:   1            Reps
  2:   5            2500 mV Slow Range         ;CR500 (2500 mV); CR23X (1000 mV); 21X,
                                               CR7 (5000 mV)
  3:   3            SE Channel                 ;Black wire (SE 3), Green wire (G)
  4:   1            Loc [ T_C      ]
  5:   .1           Mult                       ;See Table 2 for alternate multipliers
  6:   -40          Offset                     ;See Table 2 for alternate offsets
```

```
;Measure the CS500 relative humidity.
;
02:  Volt (SE) (P1)
  1:   1            Reps
  2:   5            2500 mV Slow Range          ;CR500 (2500 mV); CR23X (1000 mV); 21X,
                                                CR7 (5000 mV)
  3:   4            SE Channel                  ;Brown wire (SE 4), Green wire (G)
  4:   3            Loc [ RH_pct    ]
  5:   .1           Mult                        ;See Table 3 for alternate multipliers
  6:   0            Offset

;Limit the maximum relative humidity to 100%.
;
03:  If (X<=>F) (P89)
  1:   3            X Loc [ RH_pct    ]
  2:   3            >=
  3:   100          F
  4:   30           Then Do

04:  Z=F (P30)
  1:   100          F
  2:   0            Exponent of 10
  3:   3            Z Loc [ RH_pct    ]

05:  End (P95)
```

6. Long Lead Lengths

Long lead lengths cause errors in the measured temperature and relative humidity. The approximate error in temperature and relative humidity is 0.35°C and 0.35% per 100 feet of cable length, respectively.

When long lead lengths are required and the above errors in temperature and relative humidity are unacceptable, use the HMP45C temperature and humidity probe.

Understanding the following details are not required for the general operation of the CS500 with Campbell Scientific's dataloggers. The signal reference and the power ground (black) are the same lead in the CS500. When the CS500 temperature and relative humidity are measured, both the signal reference and power ground are connected to ground at the datalogger. The signal reference/power ground lead serves as the return path for 12 V. There will be a voltage drop along this lead because the wire itself has resistance. The CS500 draws approximately 2 mA when it is powered. The wire used in the CS500 (P/N 9720) has resistance of 17.5 Ω/1000 feet. Using Ohm's law, the voltage drop (V_d), along the signal reference/power ground lead, is given by Eq. (1).

$$\begin{aligned} V_d &= I * R \\ &= 2\text{ mA} * 17.5\ \Omega / 1000\text{ ft} \qquad (1) \\ &= 35\text{ mV} / 1000\text{ ft} \end{aligned}$$

This voltage drop will raise the apparent temperature and relative humidity because the difference between the signal and signal reference, at the datalogger, has increased by V_d. The approximate error in temperature and relative humidity is 0.35°C and 0.35% per 100 feet of cable length, respectively.

7. Absolute Humidity

The CS500 measures the relative humidity. Relative humidity is defined by the equation below:

$$RH = \frac{e}{e_s} * 100 \qquad (2)$$

where RH is the relative humidity, e is the vapor pressure in kPa , and e_s is the saturation vapor pressure in kPa. The vapor pressure, e, is an absolute measure of the amount of water vapor in the air and is related to the dew point temperature. The saturation vapor pressure is the maximum amount of water vapor that air can hold at a given air temperature. The relationship between dew point and vapor pressure, and air temperature and saturation vapor pressure are given by Goff and Gratch (1946), Lowe (1977), and Weiss (1977).

When the air temperature increases, so does the saturation vapor pressure. Conversely, a decrease in air temperature causes a corresponding decrease in saturation vapor pressure. It follows then from Eq. (2) that a change in air temperature will change the relative humidity, without causing a change in absolute humidity.

For example, for an air temperature of 20°C and a vapor pressure of 1.17 kPa, the saturation vapor pressure is 2.34 kPa and the relative humidity is 50%. If the air temperature is increased by 5°C and no moisture is added or removed from the air, the saturation vapor pressure increases to 3.17 kPa and the relative humidity decreases to 36.9%. After the increase in air temperature, the air can hold more water vapor. However, the actual amount of water vapor in the air has not changed. Thus, the amount of water vapor in the air, relative to saturation, has decreased.

Because of the inverse relationship between relative humidity and air temperature, finding the mean relative humidity is meaningless. A more useful quantity is the mean vapor pressure. The mean vapor pressure can be computed on-line by the datalogger (Example 1).

TABLE 5. CR10(X) Wiring for Example 1

Description	Color	CR10(X)
Temperature	Black	SE 3 (2H)
Relative Humidity	Brown	SE 4 (2L)
Signal & Power Reference	Green	G
Power	Red	12 V
Shield	Clear	G

Example 1. Sample CR10(X) Program that Computes Vapor Pressure and Saturation Vapor Pressure

```
;Measure the CS500 temperature.
;
01:  Volt (SE) (P1)
   1:  1            Reps
   2:  5            2500 mV Slow Range          ;CR500 (2500 mV); CR23X (1000 mV); 21X,
                                                CR7 (5000 mV)
   3:  3            SE Channel                  ;Black wire (SE 3), Green wire (G)
   4:  1            Loc [ T_C      ]
   5:  .1           Mult                        ;See Table 2 for alternate multipliers
   6:  -40          Offset                      ;See Table 2 for alternate offsets

;Measure the CS500 relative humidity.
;
02:  Volt (SE) (P1)
   1:  1            Reps
   2:  5            2500 mV Slow Range          ;CR500 (2500 mV); CR23X (1000 mV); 21X,
                                                CR7 (5000 mV)
   3:  4            SE Channel                  ;Brown wire (SE 4), Green wire (G)
   4:  2            Loc [ RH_frac   ]
   5:  .001         Mult                        ;See Table 3 for alternate multipliers
   6:  0            Offset

;Limit the maximum value of relative humidity
;to 1 (expressed as a fraction).
;
03:  If (X<=>F) (P89)
   1:  2            X Loc [ RH_frac   ]
   2:  3            >=
   3:  1            F
   4:  30           Then Do

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

05:  End (P95)

;Compute the saturation vapor pressure in kPa.
;The temperature must be in degrees Celsius.
;
06:  Saturation Vapor Pressure (P56)
   1:  1            Temperature Loc [ T_C      ]
   2:  3            Loc [ e_sat    ]
```

```
;Compute the vapor pressure in kPa.
;Relative humidity must be a fraction.
;
07:  Z=X*Y (P36)
   1:    3                  X Loc [ e_sat     ]
   2:    2                  Y Loc [ RH_frac   ]
   3:    4                  Z Loc [ e         ]
```

8. Maintenance

The CS500 Probe requires minimal maintenance. Check monthly to make sure the radiation shield is free from debris. The white screen at the tip of the probe should also be checked for contaminants.

When installed in close proximity to the ocean or other bodies of salt water (e.g., Great Salt Lake), a coating of salt (mostly NaCl) may build up on the radiation shield, sensor, filter and even the chip. NaCl has an affinity for water. The humidity over a saturated NaCl solution is 75%. A buildup of salt on the filter or chip will delay or destroy the response to atmospheric humidity.

The filter can be rinsed gently in distilled water. If necessary, the chip can be removed and rinsed as well. Do not scratch the chip while cleaning.

The offset and gain on the CS500 electronics can not be adjusted as part of a recalibration. Replace the RH chip as needed.

9. References

Goff, J. A. and S. Gratch, 1946: Low-pressure properties of water from -160° to 212°F, *Trans. Amer. Soc. Heat. Vent. Eng.*, **51**, 125-164.

Lowe, P. R., 1977: An approximating polynomial for the computation of saturation vapor pressure, *J. Appl. Meteor.*, **16**, 100-103.

Weiss, A., 1977: Algorithms for the calculation of moist air properties on a hand calculator, *Amer. Soc. Ag. Eng.*, **20**, 1133-1136.

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