MODEL HMP45C
TEMPERATURE AND RELATIVE HUMIDITY PROBE
INSTRUCTION MANUAL

REVISION: 01/09/02

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Non-warranty products returned for repair should be accompanied by a purchase order to cover repair costs.

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Model HMP45C Temperature and Relative Humidity Probe

1. General Description

The HMP45C Temperature and Relative Humidity probe contains a Platinum Resistance Temperature detector (PRT) and a Vaisala HUMICAP® 180 capacitive relative humidity sensor.

The -L option on the model HMP45C Temperature and Relative Humidity probe (HMP45C-L) indicates that the cable length is user specified. This manual refers to the sensor as the HMP45C.

2. Specifications

Operating Temperature: -40°C to +60°C

Storage Temperature: -40°C to +80°C

Probe Length: 25.4 cm (10 in.)

Probe Body Diameter: 2.5 cm (1 in.)

Filter: 0.2 µm Teflon membrane

Filter Diameter: 1.9 cm (0.75 in.)

Power Consumption: <4 mA

Supply Voltage (via CSI switching circuit): 7 to 35 VDC

Settling Time: 0.15 seconds

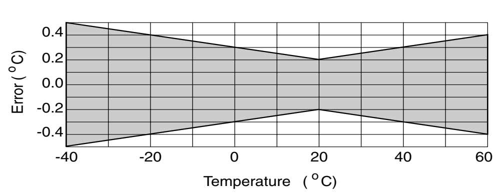
2.1 Temperature Sensor

Sensor: 1000 Ω PRT, IEC 751 1/3 Class B

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

Temperature Output Signal range: 0.008 to 1.0 V

Temperature Accuracy:



2.2 Relative Humidity Sensor

Sensor: HUMICAP® 180

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

RH Output Signal Range: 0.008 to 1 VDC

Accuracy at 20°C
±2% RH (0 to 90% Relative Humidity)
±3% RH (90 to 100% Relative Humidity)

Temperature Dependence of Relative Humidity Measurement: ±0.05% RH/°C

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

Response Time (at 20°C, 90% response): 15 seconds with membrane filter

3. Installation

The HMP45C must be housed inside a radiation shield when used in the field. The 41002 Radiation Shield (Figure 1) mounts to a CM6/CM10 tripod or UT10 tower. The UT018 mounting arm and UT12VA Radiation Shield mount to a UT30 tower (Figure 2).

A lead length of 6 feet allows the HMP45C to be mounted at a 2 meter height on a CM6/CM10 tripod. Use a lead length of 9 feet for the UT10 tower or a UT30 tower respectively.

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.

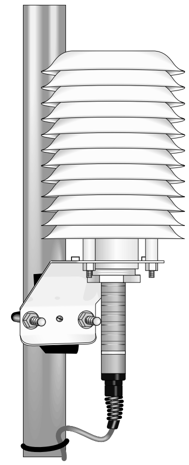


FIGURE 1. HMP45C and 41002 Radiation Shield on a CM6/CM10 Tripod Mast or UT10 Tower Leg

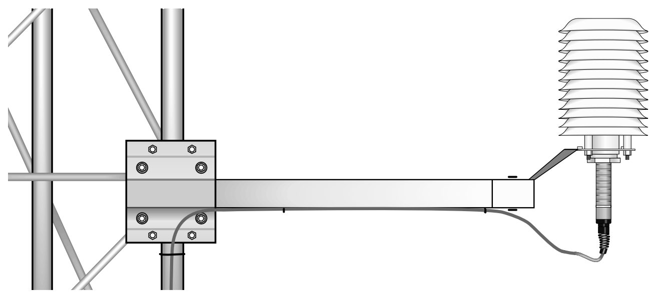


FIGURE 2. HMP45C with UT018 Mounting Bracket and Crossarm and UT12VA Radiation Shield Mounted on a UT30 Tower Leg

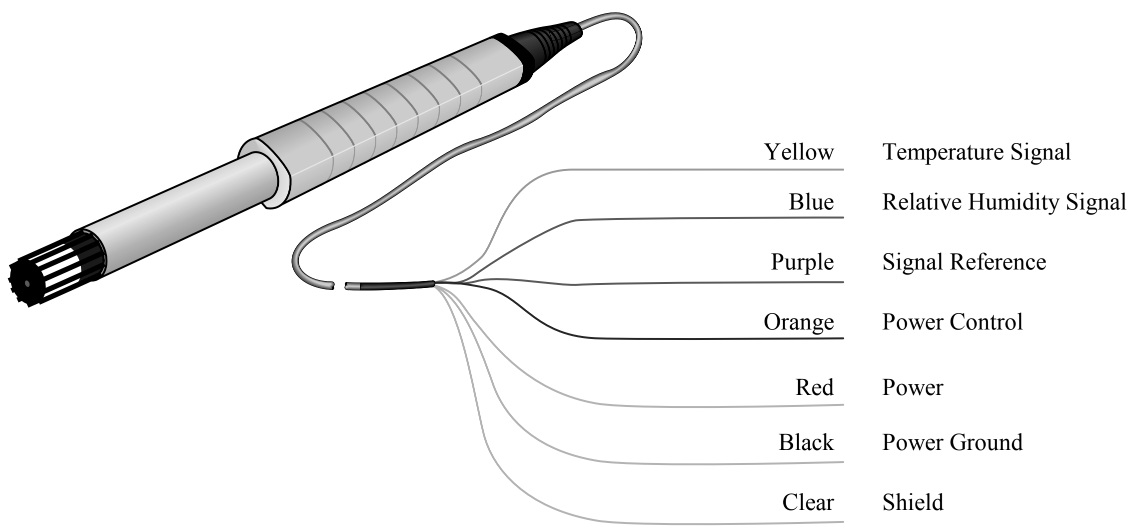


FIGURE 3. HMP45C Probe to Datalogger Connections

TABLE 1. Datalogger Connections for Single-Ended Measurements

Description	Color	CR10(X), CR500	CR23X, CR5000	21X, CR7
Temperature	Yellow	Single-Ended Input	Single-Ended Input	Single-Ended Input
Relative Humidity	Blue	Single-Ended Input	Single-Ended Input	Single-Ended Input
Signal Reference	Purple	AG	⏚	⏚
Power Control	Orange	Control Port	Control Port	Control Port
Power	Red	12 V	12 V	12 V
Power Ground	Black	AG	⏚	⏚
Shield	Clear	G	⏚	⏚

TABLE 2. Datalogger Connections for Differential Measurements

Description	Color	CR10(X), CR500	CR23X, CR5000	21X, CR7
Temperature	Yellow	Differential Input (H)	Differential Input (H)	Differential Input (H)
Signal Reference	Jumper to Purple	Differential Input (L)	Differential Input (L)	Differential Input (L)
Relative Humidity	Blue	Differential Input (H)	Differential Input (H)	Differential Input (H)
Signal Reference	Purple	Differential Input (L)	Differential Input (L)	Differential Input (L)
Power Control	Orange	Control Port	Control Port	Control Port
Power	Red	12 V	12 V	12 V
Power Ground	Black	G	G	⏚
Shield	Clear	G	⏚	⏚

4. Wiring

Connections to Campbell Scientific dataloggers are given in Table 1 and 2. The probe can be measured by two single-ended or differential analog input channels.

CAUTION When measuring the HMP45C with single-ended measurements, the purple and black leads must both be connected to AG on the CR10(X) and CR500/CR510 or to ⏚ on the CR23X. Doing otherwise will connect the datalogger's analog and power ground planes to each other, which in some cases can cause offsets on low-level analog measurements.

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 HMP45C can be measured using a single-ended analog measurement (Instruction 1) or a differential analog measurement (Instruction 2).

Use a single-ended analog measurement when the HMP45C signal lead length is less than 6.1 m (20 ft.) or if the probe will be turned on and off under datalogger control between measurements. For lead lengths greater than 6.1 m (20 ft.) or when the probe will be continuously powered, use a differential analog measurement. For a discussion on errors caused by long lead lengths see Section 6.

The HMP45C 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 3 and 4 provide calibration information for temperature and relative humidity.

TABLE 3. Calibration for Temperature

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

TABLE 4. Calibration for Relative Humidity

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

TABLE 5. Wiring for Example 1

Description	Color	CR10(X)
Temperature	Yellow	SE 3 (2H)
Relative Humidity	Blue	SE 4 (2L)
Signal Reference	Purple	AG
Power Control	Orange	C1
Power	Red	12 V
Power Ground	Black	AG
Shield	Clear	G

Example 1. Sample CR10(X) Program using Single-Ended Measurement Instructions

```
;Turn the HMP45C on.
;
01:  Do (P86)
   1:   41          Set Port 1 High              ;Orange wire (C1)

;Pause 150 mSec before making measurements so the
;probe can stabilize on true readings.
;
02:  Excitation with Delay (P22)
   1:   1           Ex Channel
   2:   0           Delay W/Ex (units = 0.01 sec)
   3:   15          Delay After Ex (units = 0.01 sec)
   4:   0           mV Excitation
```

```
;Measure the HMP45C temperature.
;
03:  Volt (SE) (P1)
   1:   1           Reps
   2:   5           2500 mV Slow Range     ;CR500 (2500mV); CR23X (1000mV); 21X, CR7 (5000mV)
   3:   3           SE Channel             ;Yellow wire (SE 3), Purple wire (AG)
   4:   1           Loc [ T_C     ]
   5:   .1          Mult                   ;See Table 3 for alternative multipliers
   6:   -40         Offset                 ;See Table 3 for alternative offsets

;Measure the HMP45C relative humidity.
;
04:  Volt (SE) (P1)
   1:   1           Reps
   2:   5           2500 mV Slow Range     ;CR500 (2500mV); CR23X (1000mV); 21X, CR7 (5000mV)
   3:   4           SE Channel             ;Blue wire (SE 4), Purple wire (AG)
   4:   2           Loc [ RH_pct   ]
   5:   .1          Mult                   ;See Table 4 for alternative multipliers
   6:   0           Offset

;Turn the HMP45C off.
;
05:  Do (P86)
   1:   51          Set Port 1 Low         ;Orange wire (C1)
```

6. Long Lead Lengths

This section describes the error associated with measuring the HMP45C with a single-ended measurement if the probe has a long cable. To avoid these problems, CSI recommends measuring the HMP45C using a differential analog measurement (Instruction 2) when long lead lengths are required. Generic datalogger connections for measuring the HMP45C using a differential measurement are given in Table 2.

Understanding the details in this section are not required for the general operation of the HMP45C with Campbell Scientific's dataloggers.

The signal reference (purple) and the power ground (black) are in common inside the HMP45C. When the HMP45C temperature and relative humidity are measured using a single-ended analog measurement, both the signal reference and power ground are connected to ground at the datalogger. The signal reference and power ground both serve as the return path for 12 V. There will be a voltage drop along those leads because the wire itself has resistance. The HMP45C draws approximately 4 mA when it is powered. The wire used in the HMP45C (P/N 9721) has resistance of 27.7 Ω/1000 feet. Since the signal reference and the power ground are both connected to ground at the datalogger, the effective resistance of those wires together is half of 27.7 Ω/1000 feet, or 13.9 Ω/1000 feet. Using Ohm's law, the voltage drop (V_d), along the signal reference/power ground, is given by Eq. (1).

$$V_d = I * R = 4 \text{ mA} * 13.9\,\Omega / 1000 \text{ ft} = 55.6 \text{ mV} / 1000 \text{ ft} \quad (1)$$

This voltage drop will raise the apparent temperature and relative humidity because the difference between the signal and signal reference lead, at the datalogger, has increased by V_d. The approximate error in temperature and relative humidity is 0.56°C and 0.56% per 100 feet of cable length, respectively.

TABLE 6. Wiring for Example 2

Description	Color	CR10(X)
Temperature	Yellow	3H
Jumper to 4L		3L
Relative Humidity	Blue	4H
Signal Reference	Purple	4L
Power Control	Orange	C1
Power	Red	12 V
Power Ground	Black	G
Shield	Clear	G

Example 2. Sample CR10(X) Program using Differential Measurement Instructions

```
;Turn the HMP45C on.
;
01:  Do (P86)
   1:   41          Set Port 1 High              ;Orange wire (C1)

;Pause 150 mSec before making measurements so the
;probe can stabilize on true readings.
;
02:  Excitation with Delay (P22)
   1:   1           Ex Channel
   2:   0           Delay W/Ex (units = 0.01 sec)
   3:   15          Delay After Ex (units = 0.01 sec)
   4:   0           mV Excitation

;Measure the HMP45C temperature.
;
03:  Volt (Diff) (P2)
   1:   1           Reps
   2:   5           2500 mV Slow Range           ;CR500 (2500mV); CR23X (1000mV); 21X, CR7 (5000mV)
   3:   3           DIFF Channel                 ;Yellow wire (3H), jumper (3L to 4L)
   4:   1           Loc [ T_C      ]
   5:   .1          Mult                         ;See Table 3 for alternative multipliers
   6:   -40         Offset                       ;See Table 3 for alternative offsets
```

```
;Measure the HMP45C relative humidity.
;
04:  Volt (Diff) (P2)
  1:  1           Reps
  2:  5           2500 mV Slow Range      ;CR500 (2500mV); CR23X (1000mV); 21X, CR7 (5000mV)
  3:  4           DIFF Channel            ;Blue wire (4H), Purple wire (4L)
  4:  2           Loc [ RH_pct    ]
  5:  .1          Mult                    ;See Table 4 for alternative multipliers
  6:  0           Offset

;Turn the HMP45C off.
;
05:  Do (P86)
  1:  51          Set Port 1 Low          ;Orange wire (C1)
```

7. Absolute Humidty

The HMP45C measures the relative humidity. Relative humidity is defined by the equation below:

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

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 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 3).

TABLE 7. Wiring for Example 3

Description	Color	CR10(X)
Temperature	Yellow	SE 3 (2H)
Relative Humidity	Blue	SE 4 (2L)
Signal Reference	Purple	AG
Power Control	Orange	C1
Power	Red	12 V
Power Ground	Black	AG
Shield	Clear	G

Example 3. Sample CR10(X) Program that Computes Vapor Pressure and Saturation Vapor Pressure

```
;Turn the HMP45C on.
;
01:  Do (P86)
   1:   41              Set Port 1 High              ;Orange wire (C1)

;Pause 150 mSec before making measurements so the
;probe can stabilize on true readings.
;
02:  Excitation with Delay (P22)
   1:   1               Ex Channel
   2:   0               Delay W/Ex (units = 0.01 sec)
   3:   15              Delay After Ex (units = 0.01 sec)
   4:   0               mV Excitation

;Measure the HMP45C temperature.
;
03:  Volt (SE) (P1)
   1:   1               Reps
   2:   5               2500 mV Slow Range           ;CR500 (2500mV); CR23X (1000mV); 21X, CR7 (5000mV)
   3:   3               SE Channel                   ;Yellow wire (SE 3), Purple wire (AG)
   4:   1               Loc [ T_C      ]
   5:   .1              Mult
   6:   -40             Offset

;Measure the HMP45C relative humidity.
;
04:  Volt (SE) (P1)
   1:   1               Reps
   2:   5               2500 mV Slow Range           ;CR500 (2500mV); CR23X (1000mV); 21X, CR7 (5000mV)
   3:   4               SE Channel                   ;Blue wire (SE 4), Purple wire (AG)
   4:   2               Loc [ RH_frac  ]
   5:   .001            Mult
   6:   0               Offset

;Turn the HMP45C off.
;
05:  Do (P86)
   1:   51              Set Port 1 Low               ;Orange wire (C1)
```

```
;Compute the saturation vapor pressure.
;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.
;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 HMP45C Probe requires minimal maintenance. Check monthly to make sure the radiation shield is free from debris. The black screen at the end of the sensor should also be checked for contaminates.

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.

Long term exposure of the HUMICAP® relative humidity sensor to certain chemicals and gases may affect the characteristics of the sensor and shorten its life. Table 8 lists the maximum ambient concentrations, of some chemicals, that the HUMICAP® can be exposed to. Detailed information on allowed concentrations can be requested from Vaisala representatives.

TABLE 8. Chemical Tolerances of HMP45C

Chemical	Concentration (PPM)
Organic solvents	1000 to 10,000
Aggressive chemicals (e.g. SO_2, H_2SO_4, H_2S, HCl, Cl_2, etc.)	1 to 10
Weak Acids	100 to 1000
Bases	10,000 to 100,000

Recalibrate the HMP45C annually. Obtain an RMA number before returning the HMP45C to Campbell Scientific for recalibration.

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.