INSTRUCTION MANUAL

HC2S3 Temperature and Relative Humidity Probe

Revision: 10/12

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Model HC2S3 Temperature and Relative Humidity Probe

1. Introduction

The HC2S3 is a rugged, accurate temperature/RH probe that is ideal for long-term, unattended applications. The probe uses a Rotronic's IN1 capacitive sensor to measure RH and a 100 ohm PRT to measure temperature. For optimum results, the HC2S3 should be recalibrated annually.

Before using the HC2S3, please study

- Section 2, *Cautionary Statements*
- Section 3, *Initial Inspection*
- Section 4, *Quickstart*

More details are available in the remaining sections.

2. Cautionary Statements

- Care should be taken when opening the shipping package to not damage or cut the cable jacket. If damage to the cable is suspected, consult with a Campbell Scientific applications engineer.

- Although the HC2S3 is rugged, it should be handled as a precision scientific instrument.

- Do not touch the sensor element.

- 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.

3. Initial Inspection

- Upon receipt of the HC2S3, inspect the packaging and contents for damage. File damage claims with the shipping company.

- The model number and cable length are printed on a label at the connection end of the cable. Check this information against the shipping documents to ensure the correct product and cable length are received.

- Refer to the Ships With list to ensure that parts are included (see Section 3.1). The HC2S3 probe and its calibration card are shipped in a small box, with the box and PN 27731 Hex Plug attached to the cable.

3.1 Ships With

The HC2S3 ships with:

(1) 27731 Gill Radiation Shield Hex Plug
(1) Calibration Card
(1) Resource DVD

4. Quickstart

4.1 Step 1 — Mount the Probe

Review Section 7, *Installation* for complete instructions. To install the HC2S3, you will need:

- 41003-5 Radiation Shield
- 27731 Hex Plug (ships with HC2S3)

1. Insert the 27731 hex plug that ships with the HC2S3 probe into the underside of the 41003-5 base.

2. Attach the radiation shield to the tripod mast, crossarm, or tower leg using the supplied U-bolt. See FIGURE 4-1 and FIGURE 4-2 for examples of shield mounting.

3. Insert the probe into the radiation shield leaving about 2.5 cm (1 in.) exposed below the hex plug.

4. Tighten the hex plug such that it compresses against the body of the HC2S3 to hold it inside the radiation shield.

5. Attach the probe to the cable by aligning the keyed connectors, pushing the connectors together and tightening the knurled ring.

6. Route the cable to the datalogger, and secure the cable to the mounting structure using cable ties.

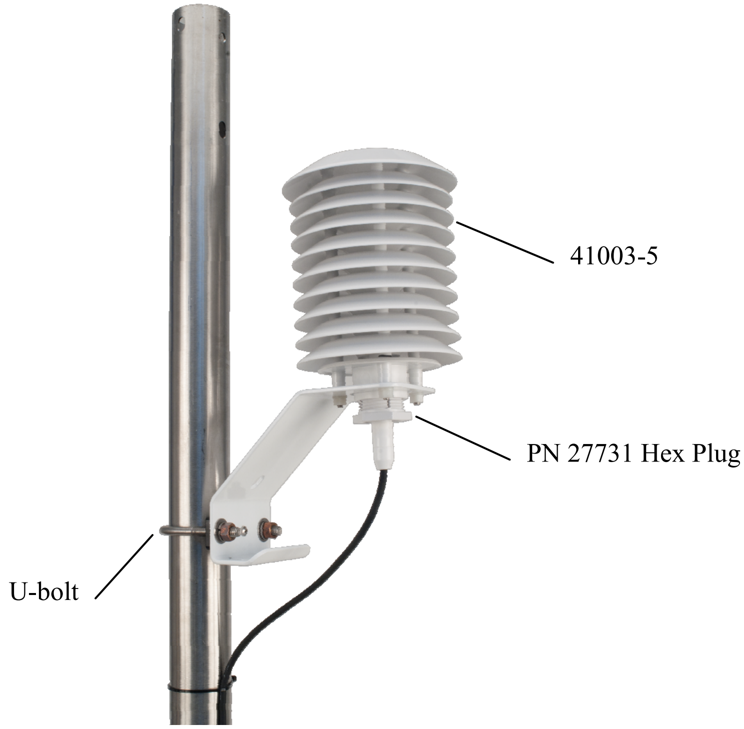


FIGURE 4-1. HC2S3 and 41003-5 Radiation Shield on a tripod mast

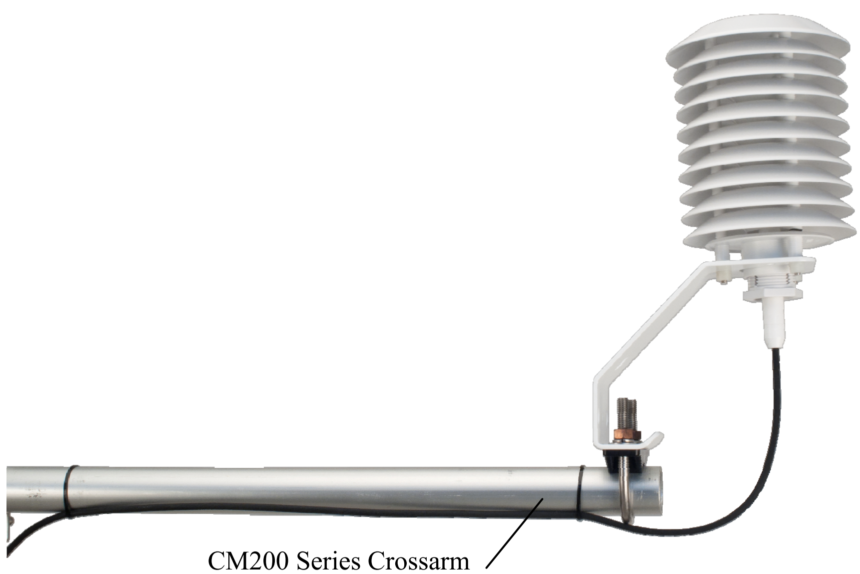


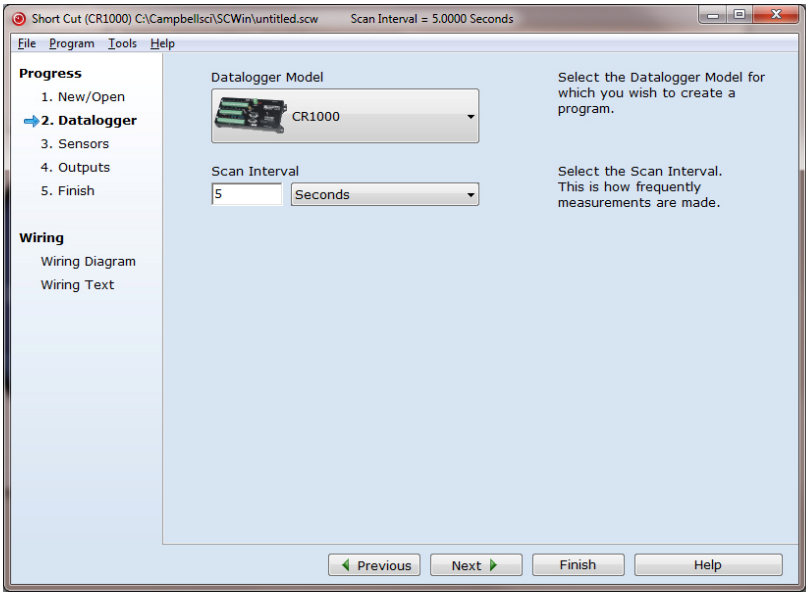
FIGURE 4-2. HC2S3 and 41003-5 Radiation Shield on a CM200 Series Crossarm

4.2 Step 2 — Use SCWin Short Cut to Program Datalogger and Generate Wiring Diagram

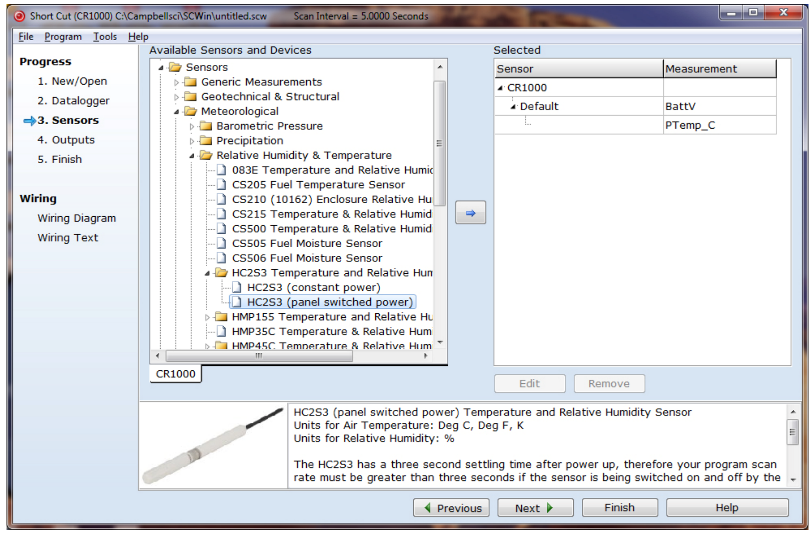
The simplest method for programming the datalogger to measure the HC2S3 is to use Campbell Scientific's SCWin Short Cut Program Generator.

1. Open Short Cut and click on **New Program**.

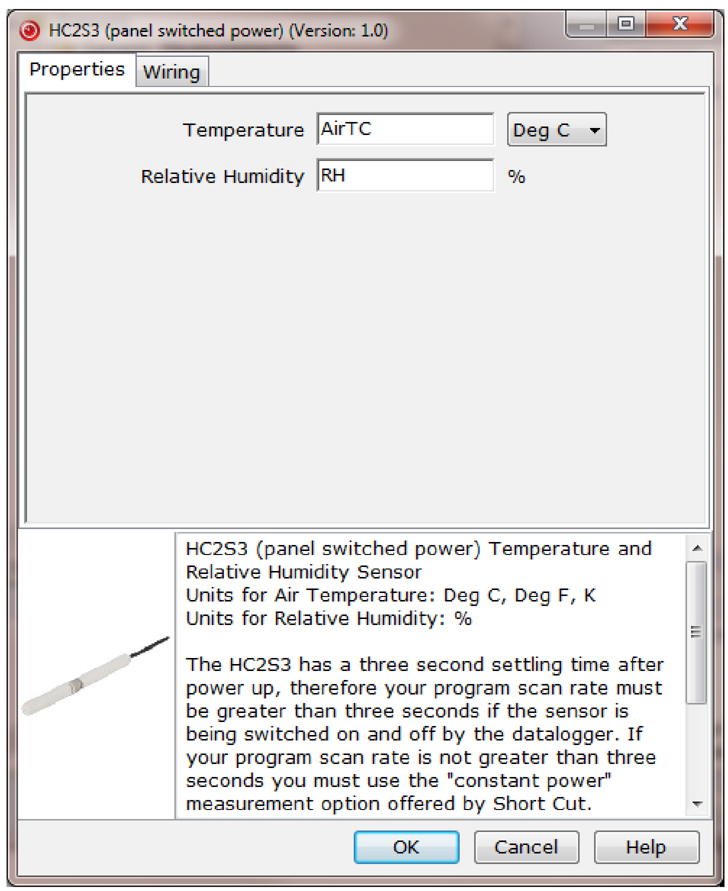
2. Select a datalogger and scan interval.



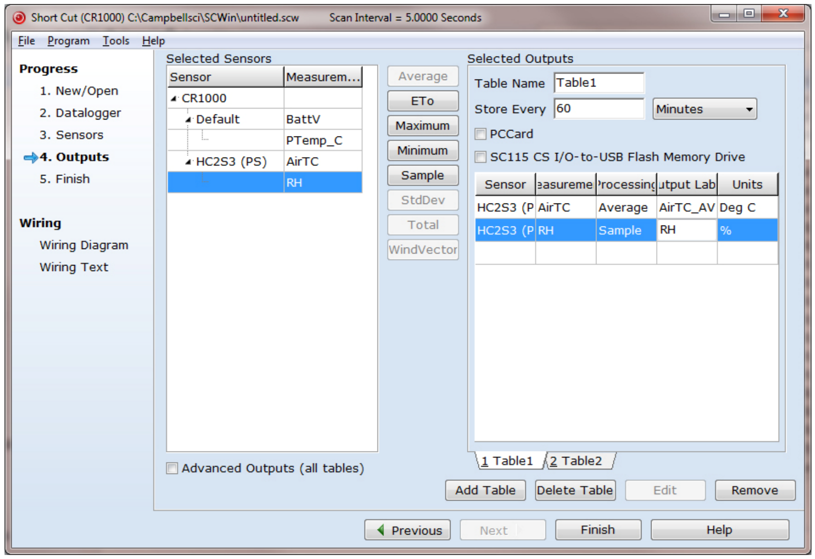
3. Select **HC2S3 Temperature and Relative Humidity Sensor** and choose either constant power or panel switched power (uses less current), then click the **right arrow** to add it to the list of sensors to be measured.



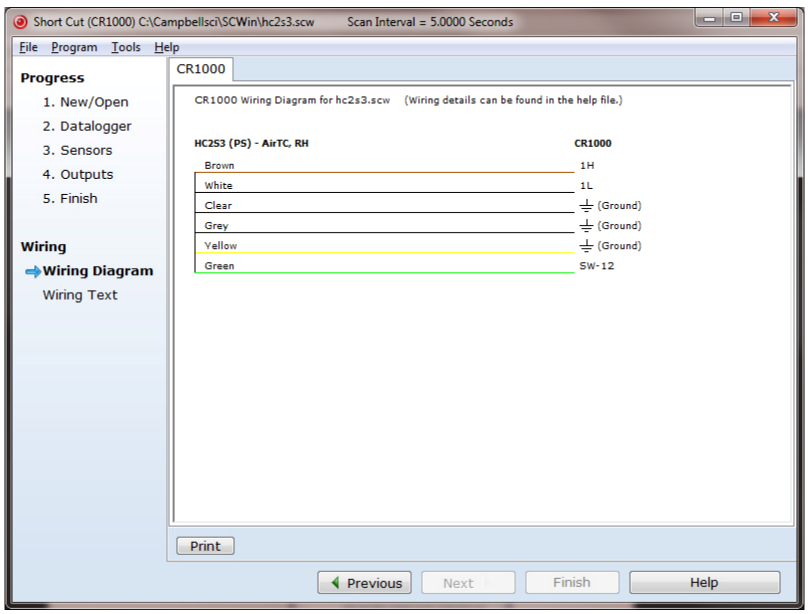
4. Define the name of the public variables. Variables default to **AirTC** and **RH** that hold the air temperature and relative humidity measurements. Select the desired units of measure. Units default to **Deg C**.



5. Choose the outputs for the AirTC and RH and then select finish.



6. Wire according to the wiring diagram generated by SCWin Short Cut.



5. Overview

The HC2S3 is a digital probe with 0 to 1 V linear output signals for temperature and humidity, and a UART serial interface. The voltage signals can be measured with two single-ended or two differential inputs on the datalogger. A special Rotronic cable and the SDM-SIO1 Serial I/O Module or MD485 RS-485 Interface is required to interface with the UART as described in Appendix B.

The D/A converter used to generate the analog output signals has 16-bit resolution. The default configuration is for temperature -40° to +60°C, and 0 - 100% relative humidity. Temperature range and other default settings can be changed as described in Appendix A.

A cable ordered through Campbell Scientific for the HC2S3 includes an internal voltage regulator that applies 3.3 V to the probe from a 5 to 24 V power source. 12V power is recommended for use with Campbell Scientific dataloggers. Where minimizing power use is important, power can be switched on and off for the measurement provided there is a three-second warm-up delay. Switching power avoids the constant current flow through datalogger ground, which can affect the accuracy of low level single-ended voltage measurements, primarily with older dataloggers such as the 21X.

Probes are polarity protected by the keyed connector and a diode in the connector interface provided with the Campbell Scientific cable.

Campbell Scientific offers two filters:

Polyethylene filter: Default filter, protection against fine dust particles, no water absorption or retention, good response time.

Teflon filter: Recommended for marine environments, slower response time than the polyethylene filter, ordered separately.

Campbell Scientific offers the HC2S3-L and HC2S3-QD. The HC2S3-L has a user-supplied cable length and several cable termination options. When the HC2S3-L is ordered, enter the cable length, in feet, after the –L; for example, HC2S3-L11 for a probe with an 11 foot cable. TABLE 5-1 gives the recommended lengths for various mounts.

TABLE 5-1. Recommended Lead Lengths

2 m Height		**Atop a tripod or tower via a 2 ft crossarm such as the CM202**							
Mast/Leg	**CM202**	**CM6**	**CM10**	**CM110**	**CM115**	**CM120**	**UT10**	**UT20**	**UT30**
9'	11'	11'	14'	14'	19'	24'	14'	24'	37'

Note: *Add two feet to the cable length if you are mounting the enclosure on the leg base of a CM106 or CM110 series tripod.*

The HC2S3-L's cable can terminate in:

- Pigtails that connect directly to a Campbell Scientific datalogger (cable termination option –PT; see Section 4).
- Connector that attaches to a prewired enclosure (cable termination option –PW).
- Connector that attaches to a CWS900 Wireless Sensor Interface (cable termination option –CWS). The CWS900 enables the probe to be used in a wireless sensor network.
- Connector that attaches to the Temp/RH connector on a CS110 Electric Field Meter or ET-series weather station (cable termination option –C).
- Military-style connector that attaches to the Temp/RH connector on a RAWS-P Permanent Remote Automated Weather Station (cable termination option –RQ).

The HC2S3-QD is included with the RAWS-F Quick Deployment Remote Automated Weather Station and can be ordered as a replacement part. Its cable has a 65-in. length and terminates in a military-style connector that attaches to the Temp/RH connector on the RAWS-F connector panel.

6. Specifications

Features:

- Well-suited for long-term, unattended applications
- Accurate and rugged
- Compatible with all Campbell Scientific dataloggers (including the CR200(X) series)

Compatibility:	CR200(X) series CR800 series CR1000 CR3000 CR5000 CR9000(X) CR7X CR510 CR10(X) CR23X 21X
Operating Limits at Electronics:	-40° to +100°C
Storage Temperature:	-50° to +100°C
Probe Length:	85 mm (3.3 in.), 183 mm (7.25 in.) including connector
Probe Diameter:	15 mm (0.6 in.)
Probe Weight:	10 g (0.35 oz)
Filter:	Polyethylene or Teflon (optional, ordered separately)

Power Consumption: <4.3 mA @ 5 V
<2.0 mA @ 12 V

Supply Voltage (using CSI cable): 5 to 24 Vdc (12 Vdc recommended)

Start-up time: 1.5 s typical (Rotronic specification, Campbell Scientific recommends 2 s at 60°C, 3 s at 0°C, 4 s at -40°C)

Maximum Startup Current: <50 mA during 2 µs

Maximum Lead Length: 300 m (1000 ft) with 12 V power, 3 m (10 ft) with 5 V power

Analog outputs
- **Offset at 0 V:** ±3 mV (maximum)
- **Deviation from Digital Signal:** < ±1 mV (0.1°C, 0.1% RH)

6.1 Temperature Sensor

Sensor: PT100 RTD, IEC 751 1/3 Class B, with calibrated signal conditioning

Temperature Measurement Range: -50° to +100°C (default -40° to + 60°C)

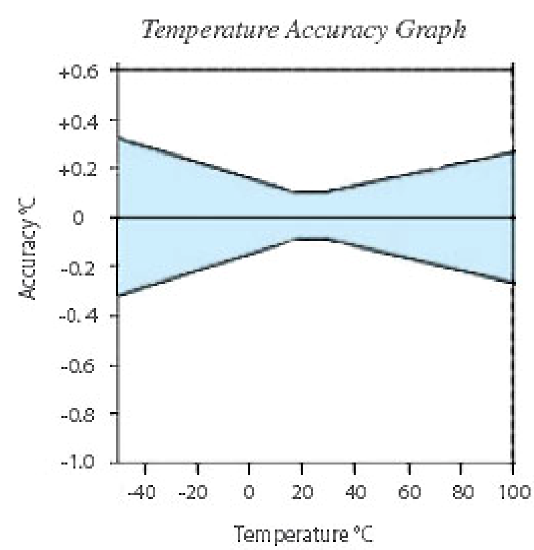
Temperature Output Signal Range: 0 to 1.0 V

Accuracy at 23°C: ±0.1°C with standard configuration settings

Long Term Stability: <0.1°C/year

Sensor Time Constant (63% step change (1 m/s air flow at sensor)): ≤22 s with PE filter, ≤30 s with Teflon filter

Temperature Accuracy over Temperature:



6.2 Relative Humidity Sensor

Sensor: ROTRONIC Hygromer® IN1

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

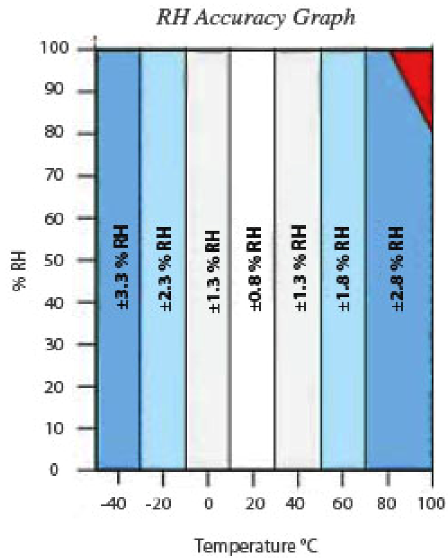
RH Output Signal Range: 0 to 1 Vdc

Accuracy at 23°C: ±0.8% RH with standard configuration settings

Typical Long Term Stability: <1% RH per year

Sensor Time Constant (63% of a 35 to 80% RH step change (1 m/s air flow at sensor)): ≤22 s with PE filter, ≤30 s with Teflon filter

RH Accuracy over Temperature:



CAUTION 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.

6.3 Default Settings and Digital Interface

Please refer to Appendices.

7. Installation

7.1 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 housed in a suitable radiation shield.

Standard measurement heights:

1.5 m (AASC)
1.25 to 2.0 m (WMO)
2.0 m (EPA)

See Section 10, *References* for a list of references that discuss temperature and relative humidity sensors.

7.2 Assembly and Mounting

Tools Required:

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

The HC2S3 probe and its calibration card are shipped in a small box, with the box and PN 27731 Hex Plug attached to the cable. PN 27731 is used to mount the probe inside the 41003-5 Radiation Shield as described in Section 4, *Quickstart*.

Attach the probe to the cable by aligning the keyed connectors, pushing the connectors together and tightening the knurled ring.

When exposed to solar radiation the probe must be housed in a radiation shield such as the 41003-5 naturally aspirated shield, or the 43502 motor aspiration shield (please refer to the 43502 product manual for details). The 41003-5 Radiation Shield has a U-bolt for attaching the shield to a tripod mast/tower leg or CM200 series crossarm (shown in FIGURE 4-1 and FIGURE 4-2 in the Quickstart section).

7.3 Wiring

Connections to Campbell Scientific dataloggers for measuring humidity and temperature using two single-ended or two differential analog inputs are given in TABLE 7-1 and TABLE 7-2. Use a single-ended analog measurement when the cable length is less than 6.1 m (20 ft), or if power is switched off between measurements. For cable lengths longer than 6.1 m or when the probe is continuously powered, use a differential analog measurement. See Section 7.5 for a discussion on errors caused by long cable lengths.

The HC2S3 draws approximately 2 mA powered from 12V. The HC2S3 can be continuously powered from the 12V terminal, or power can be switched with the SW12V terminal to conserve battery life. When power is switched, a three-second warm-up time is required. Using the SW12V terminal on the CR10X datalogger requires a user-supplied jumper wire connected between the SW 12V CTRL terminal and a Control Port (C1 to C8).

CAUTION When measuring the HC2S3 with single-ended measurements, the yellow and gray leads must both be connected to AG on the CR10(X) and CR500/CR510 or to ⏚ on the CR1000, CR5000, and 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. To avoid 2 mA flowing into analog ground, switch power on/off for its measurement.

TABLE 7-1. Connections for Single-Ended Measurements

Color	Description	CR1000, CR3000, CR800, CR5000, CR23X	CR10X CR10, CR510, CR500
Brown	Temperature Signal	Single-Ended Input	Single-Ended Input
White	Relative Humidity Signal	Single-Ended Input	Single-Ended Input
Yellow	Signal Reference	⏚	AG
Gray	Power Ground	⏚	AG
Clear	Shield	⏚	G
Green	Power	12V/*SW12V	12V/*SW12V
	*CR10X Power Control if using SW 12V		Jumper from SW 12V CTRL to Control Port

TABLE 7-2. Connections for Differential Measurements

Color	Description	CR1000, CR3000, CR800, CR5000, CR23X	CR10X CR10, CR510, CR500
Brown	Temperature Signal	Differential Input – H	Differential Input – H
Jumper to Yellow	Temperature Signal Reference	Differential Input – L	Differential Input – L
White	Relative Humidity Signal	Differential Input – H	Differential Input – H
Yellow	Signal Reference	Differential Input – L	Differential Input – L
Gray	Power Ground	G	G
Clear	Shield	⏚	G
Green	Power	12V/*SW12V	12V/*SW12V
	*CR10X Power Control if using SW 12V		Jumper from SW 12V CTRL to Control Port

7.4 Programming

NOTE This section is for users who write their own datalogger programs. You do not need to read this section if using our Short Cut Program Generator, or connecting the probe to a prewired enclosure, RAWS-P station, RAWS-F station, or CWS900 Wireless Sensor Interface. Our prewired enclosures, RAWS-P stations, and RAWS-F stations include a datalogger program. Refer to the Wireless Sensor Manual for programming information if using the probe with a CWS900.

The temperature and relative humidity signals from the HC2S3 are measured using either single-ended voltage instructions (**VoltSE()** in CRBasic or Instruction 1 in Edlog) or differential voltage instructions (**VoltDiff()** in CRBasic or Instruction 2 in Edlog). Differential measurements are recommended for cables longer than 6.0 m (20 ft) as discussed in Section 7.5.

NOTE When the probe is connected to a CS110 Electric Field Meter, the probe is measured by the CS110's internal CR1000 datalogger module using **VoltSE()** instructions. Relative humidity and temperature signals are measured on single-ended channels 1 and 2, respectively. The 250 µs integration should be used in the **VoltSE()** instructions.

The HC2S3 output scale is 0 to 1000 mV for the temperature range of -40° to +60°C and 0 to 1000 mV for the relative humidity range of 0 to 100%. Multipliers and Offsets for the measurement instructions to convert the measurement result (mV) to temperature and relative humidity are shown in TABLE 7-3 and TABLE 7-4.

TABLE 7-3. Temperature

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

TABLE 7-4. Humidity

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

7.4.1 Example Programs using Single-Ended Measurement Instructions

The example programs for the CR1000 and CR10X use the SW12V terminal to switch power to the probe, delay for 3 seconds and measure the output voltages using single-ended measurement instructions.

Relative humidity and temperature (deg C) are measured on single-ended input channels 1 and 2 respectively. The program sets relative humidity equal to 100 if the measured value is greater than 100 but less than 103%. Values greater than 103% are not set equal to 100, and indicate a problem with the sensor or its calibration.

TABLE 7-5. Wiring for Single-ended Measurement Examples

Color	Description	CR1000	CR10(X)
Brown	Temperature	SE 2	SE 2
White	Relative Humidity	SE 1	SE 1
Yellow	Signal Reference	⏚	AG
Gray	Power Ground	⏚	AG
Clear	Shield	⏚	G
Green	Power	SW12V	SW12V
			Jumper from SW 12V CTRL to Control Port

CR1000 program using single-ended measurements

```
'CR1000 program to measure HC2S3 with single-ended inputs

Public AirTC
Public RH
Units AirTC=Deg C
Units RH=%

DataTable(Table1,True,-1)
  DataInterval(0,60,Min,10)
  Average(1,AirTC,FP2,False)
  Sample(1,RH,FP2)
EndTable

BeginProg
  Scan(5,Sec,1,0)
    PortSet(9,1)                          'Turn on switched 12V
    Delay(0,3,Sec)                        '3-second delay
    'HC2S3 Temperature & Relative Humidity Sensor measurements AirTC and RH:
    VoltSE(RH,1,mV2500,1,0,0,_60Hz,0.1,0)
    VoltSe(AirTC,1,mV2500,2,0,0,_60Hz,0.1,-40)
    PortSet(9,0)                          'Turn off switched 12V
    If RH>100 AND RH<103 Then RH=100
    CallTable(Table1)

  NextScan
EndProg
```

CR10(X) program using single-ended measurement instructions

```
;{CR10X} program to measure HC2S3 with single-ended inputs

*Table 1 Program
  01:  5.0000        Execution Interval (seconds)

1: Do (P86)                                  ;Turn on switched 12V
  1:   41            Set Port 1 High         ;Jumper from C1 to SW 12V CTRL

2: Excitation with Delay (P22)               ;3-second delay
  1:   1             Ex Channel
  2:   0             Delay W/Ex (0.01 sec units)
  3:   300           Delay After Ex (0.01 sec units)
  4:   0             mV Excitation

;HC2S3 Temperature & Relative Humidity Sensor measurements AirTC and RH:

3: Volt (SE) (P1)
  1:   1             Reps
  2:   25            2500 mV 60 Hz Rejection Range
  3:   2             SE Channel
  4:   2             Loc [ AirTC ]
  5:   0.1           Multiplier
  6:   -40.0         Offset
```

```
4: Volt (SE) (P1)
   1:  1              Reps
   2:  25             2500 mV 60 Hz Rejection Range
   3:  4              SE Channel
   4:  1              Loc [ RH ]
   5:  0.1            Multiplier
   6:  0              Offset

5: Do (P86)                                   ;Turn off switched 12V
   1:  51             Set Port 1 Low

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

7: If (X<=>F) (P89)
   1:  1              X Loc [ RH ]
   2:  4              <
   3:  103            F
   4:  30             Then Do

8: Z=F x 10^n (P30)
   1:  100            F
   2:  0              n, Exponent of 10
   3:  1              Z Loc [ RH ]

9: End (P95)

10: End (P95)

11: If time is (P92)
   1:  0              Minutes (Seconds --) into a
   2:  60             Interval (same units as above)
   3:  10             Set Output Flag High (Flag 0)

12: Set Active Storage Area (P80)
   1:  1              Final Storage Area 1
   2:  101            Array ID

13: Real Time (P77)
   1:  1220           Year,Day,Hour/Minute (midnight = 2400)

14: Average (P71)
   1:  1              Reps
   2:  2              Loc [ AirTC ]

15: Sample (P70)
   1:  1              Reps
   2:  1              Loc [ RH ]
```

CR1000 program using single-ended measurements in Slow Sequence scan

The following program example has a 1-second main scan, and uses a Slow Sequence scan to measure the HC2S3 every 5 seconds. Every 5 seconds the program switches power to the HC2S3 on the SW-12 terminal, delays for a 3-second "warm-up", and measures relative humidity and temperature on single-ended channels 1 and 2 respectively. Because of the 3-second delay, the program must be run in SequentialMode. Please contact Campbell Scientific if your program must run in pipeline mode.

```
'CR1000 program

SequentialMode                                   'Required for Slow Sequence scan

Public AirTC
Public RH
Public Battery_volts
Public Ptemp
Units AirTC = C
Units RH = %
Units Batter_volts = V
Units Ptemp = C

DataTable (Table1,True,-1)
  DataInterval (0,60,Min,10)
  Average (1,Battery_volts,FP2,FALSE)
  Average (1,Ptemp,FP2,FALSE)
  Average (1,AirTC,FP2,FALSE)
  Sample 1,RH,FP2)
EndTable

BeginProg
  Scan (1,Sec,1,0)                               'Run main scan 1 second
    Battery (Battery_volts)
    PanelTemp (Ptemp_C,250)
    'add additional instructions to be executed every 1 second
    CallTable (Table1)
  NextScan

SlowSequence
  Scan (5,Sec,0,0)                               'Run slow sequence scan every 5 seconds
    PortSet (9,TRUE)                             'Turn on HC2S3
    Delay (0,3000,mSec)                          'Wait 3 seconds for HC2S3 to warm-
up
    VoltSe (AirTC,1,mV2500,2,0,0,_60Hz,0.1,-40)  'Measure HC2S3 temperature
    VoltSe (RH,1,mV2500,1,0,0,_60Hz,0.1,0)       'Measure HC2S3 relative humidity
    PortSet (9,FALSE)                            'Turn off probe
  NextScan
EndProg
```

7.4.2 Example Programs using Differential Measurement Instructions

Temperature and humidity are measured on differential input channels 1 and 2 respectively. The program sets relative humidity equal to 100 if the measured value is greater than 100 but less than 103%. Values greater than 103% are not set equal to 100, and indicate a problem with the sensor or its calibration.

TABLE 7-6. Wiring for Differential Measurement Examples

Color	Description	CR1000	CR10(X)
Brown	Temperature	1H	1H
Jumper to Yellow	Temperature Signal Reference	1L	1L
White	Relative Humidity	2H	2H
Yellow	Signal Reference	2L	2L
Gray	Power Ground	G	G
Clear	Shield	⏚	G
Green	Power	12V	12V

CR1000 program using differential measurements

```
'CR1000 program to measure HC2S3 with differential measurements

Public AirTC
Public RH

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

BeginProg
  Scan(1,Sec,1,0)
    'HC2S3 Temperature & Relative Humidity Sensor measurements AirTC and RH:
    VoltDiff (AirTC,1,mV2500,1,True,0,_60Hz,0.1,-40)
    VoltDiff (RH,1,mV2500,2,True,0,_60Hz,0.1,0)
    If RH>100 And RH<103 Then RH=100
    CallTable(Temp_RH)
  NextScan
EndProg
```

CR10(X) program using differential measurement instructions

```
;{CR10X}
*Table 1 Program
  01:  1.0000        Execution Interval (seconds)

;HC2S3 Temperature & Relative Humidity Sensor measurements AirTC and RH:

1: Volt (Diff) (P2)
  1:   1             Reps
  2:   25            2500 mV 60 Hz Rejection Range
  3:   1             DIFF Channel
  4:   3             Loc [ AirTC ]
  5:   0.1           Multiplier
  6:   -40           Offset
```

```
2: Volt (Diff) (P2)
   1:   1              Reps
   2:   25             2500 mV 60 Hz Rejection Range
   3:   2              DIFF Channel
   4:   4              Loc [ RH ]
   5:   0.1            Multiplier
   6:   0              Offset

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

4: If (X<=>F) (P89)
   1:   4              X Loc [ RH ]
   2:   4              <
   3:   103            F
   4:   30             Then Do

5: Z=F x 10^n (P30)
   1:   100            F
   2:   0              n, Exponent of 10
   3:   4              Z Loc [ RH ]

6: End (P95)

7: End (P95)

8: If time is (P92)
   1:   0              Minutes (Seconds --) into a
   2:   60             Interval (same units as above)
   3:   10             Set Output Flag High (Flag 0)

9: Set Active Storage Area (P80)
   1:   1              Final Storage Area 1
   2:   101            Array ID

10: Real Time (P77)
   1: 1220 Year,Day,Hour/Minute (midnight = 2400)

11: Average (P71)
   1: 1 Reps
   2: 3 Loc [ AirTC ]

12: Sample (P70)
   1: 1 Reps
   2: 4 Loc [ RH ]
```

7.5 Measuring Probes with Long Cables

For cable lengths longer than 6.1 m (20 ft), Campbell Scientific recommends measuring the voltage signals using differential inputs as discussed below. Connections for differential inputs are given in TABLE 7-2.

The signal reference (yellow) and the power ground (gray) are in common inside the HC2S3. When the HC2S3 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 power. There will be a voltage drop along those leads because the wire itself has resistance.

The HC2S3 draws approximately 2 mA when powered with 12 V. The wire used in the HC2S3 (P/N 27746) has resistance of 14.74 Ω/304.8 m (1000 ft). 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 14.74 Ω/304.8 m (1000 ft), or 7.37 Ω/304.8 m (1000 ft). Using Ohm's law, the voltage drop (V_d), along the signal reference/power ground, is given by Eq. (1).

$$\begin{aligned} V_d &= I * R \\ &= 2\,\text{mA} * 7.37\,\Omega / 304.8\,\text{m}\,(1000') \\ &= 14.7\,\text{mV} / 304.8\,\text{m}\,(1000') \end{aligned} \quad (1)$$

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 0.15°C and 0.15% per 30.5 m (100 ft) of cable length, respectively (assuming a temperature range of -40° to +60°C). When there are not enough inputs available on the datalogger to allow for differential measurements, single-ended measurements can be made and the errors associated with cable length subtracted as offsets.

8. Sensor Maintenance

Corroded, discolored or clogged filters should be replaced. To replace the filter, unscrew the filter from the probe and pull it straight away, being careful not to bend or damage the sensors. Before putting on the replacement filter check the alignment of the sensors with the probe, and if necessary, carefully correct the alignment before installing the filter.

The Teflon filter tip is recommended when the sensor is installed in close proximity to the ocean or other bodies of salt water. A coating of salt (mostly NaCl) may build up on the radiation shield, sensor, filter and even the sensors. A buildup of salt on the filter or sensors will delay or destroy the response to atmospheric humidity.

Long term exposure of the relative humidity sensor to certain chemicals and gases may affect the characteristics of the sensor and shorten its life. The resistance of the sensor depends strongly on the temperature and humidity conditions and the length of the pollutant influence.

In general, the HC2S3 requires minimal maintenance. The radiation shield should be kept clean and free of debris, and the sensor should be calibrated annually. Please obtain an RMA number before returning the HC2S3 to Campbell Scientific for calibration. Please refer to Warranty and Assistance sections at the beginning of the manual.

9. Troubleshooting

Symptom: -9999, NAN, -40°C, or 0 % relative humidity

1. Check that the sensor is wired to the correct analog input channels as specified by the measurement instructions.

2. Verify the voltage range code for the single-ended or differential measurement instruction is correct for the datalogger type.

3. Verify the green power wire is connected to the 12V, SW12V, or 5V terminal. When SW12V is used with a CR10X datalogger, verify the SW 12V CTRL is jumpered to the Control Port specified in the program. Cables longer than 3 m (10 ft) should be powered by the 12V, rather than the 5V terminal.

   A voltmeter can be used to check the output voltage for temperature and relative humidity on the brown and white wires respectively (temperature °C = mV * 0.1 – 40.0; relative humidity % = mV * 0.1).

Symptom: Incorrect temperature or relative humidity

1. Verify the multiplier and offset parameters are correct for the desired units (TABLE 7-3) and temperature range.

2. Default settings are listed in Appendix A, which include the setting "Limit humidity output to 100%". This setting is "disabled" for probes purchased through Campbell Scientific. Accuracy of the humidity measurement over temperature is shown in the graph in Section 6.2. For example, at -20°C the accuracy is ±2.3%, so a reading of 102.3% at 100% humidity is within the accuracy specification. Programs created by Short Cut set humidity values greater than 100% and less than 103% to 100%. Humidity values greater than 103% are left unchanged to indicate a problem with the probe or measurement.

10. References

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Appendix A. Absolute Humidity

The HC2S3 measures the relative humidity. Relative humidity is defined by the equation below:

$$RH = \frac{e}{e_s} * 100 \qquad \text{(A-1)}$$

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). Relative Humidity is relative to saturation above water, even below freezing point. This is why these sensors should not measure 100% RH below zero degrees C, as described in Section A.1.

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. (A-1) 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, there is more energy to vaporize the water. 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 often not useful. A more useful quantity is the mean vapor pressure. The mean vapor pressure can be computed by the datalogger program as shown in the following example.

TABLE A-1. Wiring for Vapor Pressure Examples

Color	Description	CR1000
Brown	Temperature	SE 2
White	Relative Humidity	SE 1
Yellow	Signal Reference	⏚
Gray	Power Ground	⏚
Clear	Shield	⏚
Green	Power	12V

CR1000 Program that Computes Vapor Pressure and Saturation Vapor Pressure

```
'CR1000 program that calculates Vapor Pressure

Public AirTC
Public RH
Public RH_Frac, e_Sat, e_kPa

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

BeginProg
  Scan(1,Sec,1,0)
    PortSet(9,1)                         'Turn on switched 12V
    Delay(0,3,Sec)                       '3-second delay
    'HC2S3 Temperature & Relative Humidity Sensor measurements AirTC and RH:
    VoltSE(AirTC,1,mV2500,2,0,0,_60Hz,0.1,-40.0)
    VoltSE(RH,1,mV2500,1,0,0,_60Hz,0.1,0)
    If RH>100 And RH<103 Then RH=100
    PortSet(9,0)                         'Turn off switched 12V
    'Calculate Vapor Pressure
    'Convert RH percent to RH Fraction
    RH_Frac = RH * 0.01
    'Calculate Saturation Vapor Pressure
    SatVP(e_Sat, AirTC)
    'Compute Vapor Pressure, RH must be a fraction
    e_kPa = e_Sat * RH_Frac
    CallTable(Temp_RH)
  NextScan
EndProg
```

A.1 Measurement Below 0°C

The HC2S3 provides a humidity reading that is referenced to the saturated water vapor pressure above liquid water, even at temperatures below 0°C, where ice might form. This is the common way to express relative humidity and is as defined by the World Meteorological Organization. If an RH value is required referenced to ice, the HC2S3 readings will need to be corrected.

One consequence of using water as the reference is that the maximum humidity that will normally be output by the sensor for temperatures below freezing is as follows:

100%RH at 0°C	82%RH at -20°C
95%RH at -5°C	78%RH at -25°C
91%RH at -10°C	75%RH at -30°C
87%RH at -15°C	

In practical terms this means that, for instance, at -20°C the air is effectively fully saturated when the sensor outputs 82%RH.

Appendix B. Changing the HC2S3 Settings

B.1 HC2S3 Default Settings

The HC2S3 probe has the following default settings, which can be changed as described in the following sections. Additional information can be found in Rotronic's User Manual: E-M-HC2 Probes-VXXXX, which can be downloaded from Rotronic's website www.rotronic-usa.com.

Default Settings:

Configurable Settings	**Factory Default**
Unit system (Metric or English)	Metric
Psychrometric calculation	None
Output 1 parameter, scale and unit	Humidity: 0..100% RH
Output 2 parameter, scale and unit	Temperature: -40...+60 deg C
Communications Protocol	RO-ASCII
RS-485 Address	0
Device name	Probe type
Humidity / temperature adjustment	
Device write protection	Disabled
Limit humidity output to 100% RH	Disabled
Out-of-limit value digital alarm	Disabled
Data recording	Enabled (loop mode - 10 min interval)
Automatic humidity sensor test	Disabled
Humidity sensor drift compensation	Disabled
Fail safe mode	Disabled
Simulator mode	Disabled

Digital Interface:

Interface Type: UART (Universal Asynchronous Receiver Transmitter)

Organization: Dialog, duplex

Default Configuration:

Baud rate: 19200
Parity: none
Data bits: 8
Stop fits: 1
Flow Control: none

Logical Levels:

Logical 0: <= 0.3V*VDD
Logical 1: <= 0.8V*VDD

B.2 Software and Hardware Requirements

For temperature (Analog Output 2), the HC2S3 default range is -40 to +60°C for 0 to 1V. Changing the range requires Rotronic HW4 Software (Version 2.1.0 or higher), and the Rotronic model AC3001 USB adapter cable. Power to the probe is provided by the USB port.

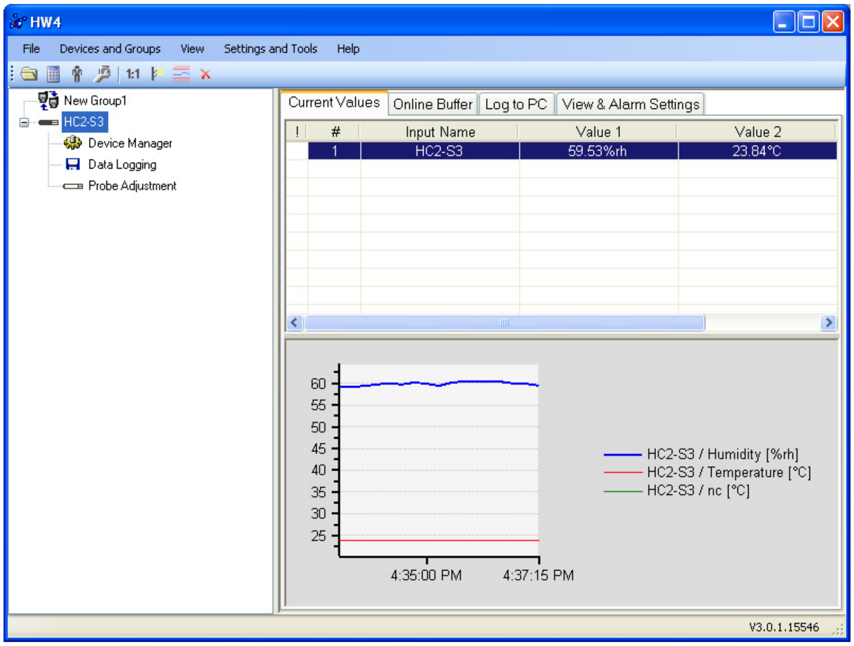
IMPORTANT Prior to using the AC3001 cable, the ROTRONIC USB driver must be installed on the PC. Both the driver and the installation instructions (document **E-M-HW4v3-Main**) are located on the HW4 CD.

B.3 Changing the Temperature Range

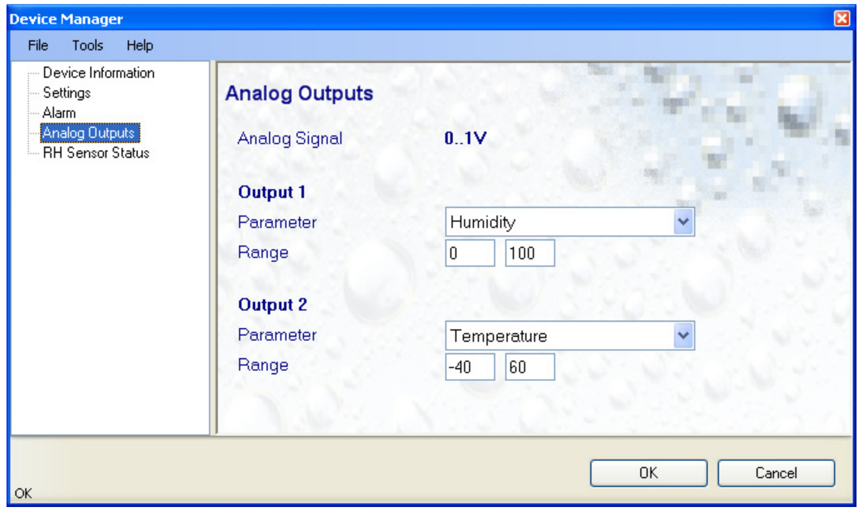
Install the HW4 software and drivers for the AC3001 USB cable on the PC. Connect the HC2S3 probe to the AC3001 cable, making sure the connectors are properly aligned before tightening the knurled ring. Plug the AC3001 cable into a USB port on the computer.

From the main screen, click on the "devices and groups", search for "master devices", USB masters.

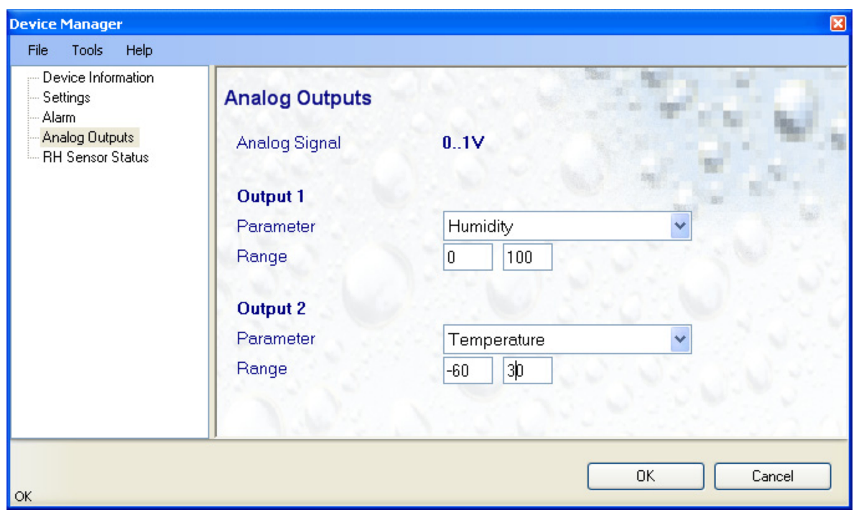
HW4 should find the probe, and show the current values:



Click on "Device Manager", select "Analog Outputs" to see the following screen:



Change the lower and upper range values and click "OK". The following screen shows the range -60 to +30:



B.4 Multiplier and Offsets for Temperature Range

Analog Output 2 is 0 to 1V (1000 mV) for the temperature range. If the range has been changed from the default (-40 to +60), then the multiplier and offset for the measurement instruction will have to be changed from those shown for the program examples in Section 7.4. For example, for a range of -60 to 30, the multiplier to convert the measurement result (mV) to temperature, is the full scale range of temperature divided by the full scale range of mV, and the Offset is -60.0 as shown below:

Multiplier = mV * (90°C/1000 mV)
= 0.09

Offset = -60.0

Example measurement instructions for CR1000 datalogger, with the sensor wired to SE channel 2:

```
Public AirTC
VoltSe (AirTC,1,mV2500,2,0,0,_60Hz,0.09,-60)
```

Example measurement instruction for CR10X datalogger:

```
1: Volt (SE) (P1)
   1:  1          Reps
   2:  5          2500 mV Slow Range
   3:  2          SE Channel
   4:  1          Loc [ AirTC ]
   5:  0.09       Multiplier
   6:  -60.0      Offset
```

Appendix C. HC2S3 Digital Communications

C.1 HC2S3 Digital Interface Specifications

The HC2S3 has a UART (Universal Asynchronous Receiver Transmitter) that provides two-way digital communications with the probe. Interface cables can be ordered through Rotronics for connecting the probe to an RS-485 port (Rotronic pn E2-05XX-MOD), a computer's RS-232 port (Rotronic pn AC3002), or USB port (Rotronic pn AC3001).

Connections to a CSI datalogger through an MD485 RS485 Interface or SDM-SIO1 Serial I/O Module with the Rotronic E2-05XX-MOD RS-485 cable are described in Section C.3 and C.4 respectively.

HC2S3 Digital Interface Specifications:

Interface Type: UART (Universal Asynchronous Receiver Transmitter)

Organization: Dialog, duplex

Default Configuration:
Baud rate: 19200
Parity: none
Data bits: 8
Stop fits: 1
Flow Control: none

Logical Levels:
Logical 0: <= 0.3V*VDD
Logical 1: <= 0.8V*VDD

C.2 HC2S3 Communications Protocol

Complete information on the HC2S3 Commands and Communication Protocol can be found in the Rotronic E-M-AC3000-CP_XX manual, available from Rotronic's website www.rotronic-usa.com.

The "RDD" command to "Read Values" is used in the example datalogger programs to get temperature and relative humidity values from the probe, and is described below.

RDD command: read values

Returns the measured and calculated values as well as the information necessary to interpret the data (calculated parameter type, engineering units, status, serial number and name of the device, etc.)

Command Format:

{	ID	Adr	RDD	Chksum or }	CR

Answer format:

{	ID	Adr	RDD	Chksum or }	CR

The data are returned according to the following structure:

Example	**Type**	**Description**
1..3	Byte	Probe type (1= digital probe, 2=analog probe, 3=pressure probe)
1234.56	Float	Relative humidity or analog value
%RH	String	Humidity or analog value engineering unit
0..1	Bool	Humidity or analog value alarm (out-of-limits)
+	Char	Humidity or analog value trend (+,-,= or " ")
1234.56	Float	Temperature value
°C	String	Temperature engineering unit
0..1	Bool	Temperature alarm (out-of-limits)
=	Char	Temperature trend (+,-,= or " ")
Dp	String	Calculated parameter type (nc: no calculation, Dp: dew point, Fp: frost point)
1234.56	Float	Calculated numerical value
°C	String	Calculated parameter engineering unit
0..1	Bool	Calculated parameter alarm (out-of-limits)
+	Char	Calculated parameter trend (+,-,= or " ")
1..255	Byte	Device type (HygroClip, Logger, HF, HM, …)
V1.0	String	Firmware version
12345678	String	Device serial number
Name	String	Device name
000…255	Byte	Alarm Byte: (Bit0=out-of-limits value, Bit5= sensor quality, Bit6 = humidity simulator, Bit7= temperature simulator)

Example data returned from the RDD command:

{F00RDD} CR

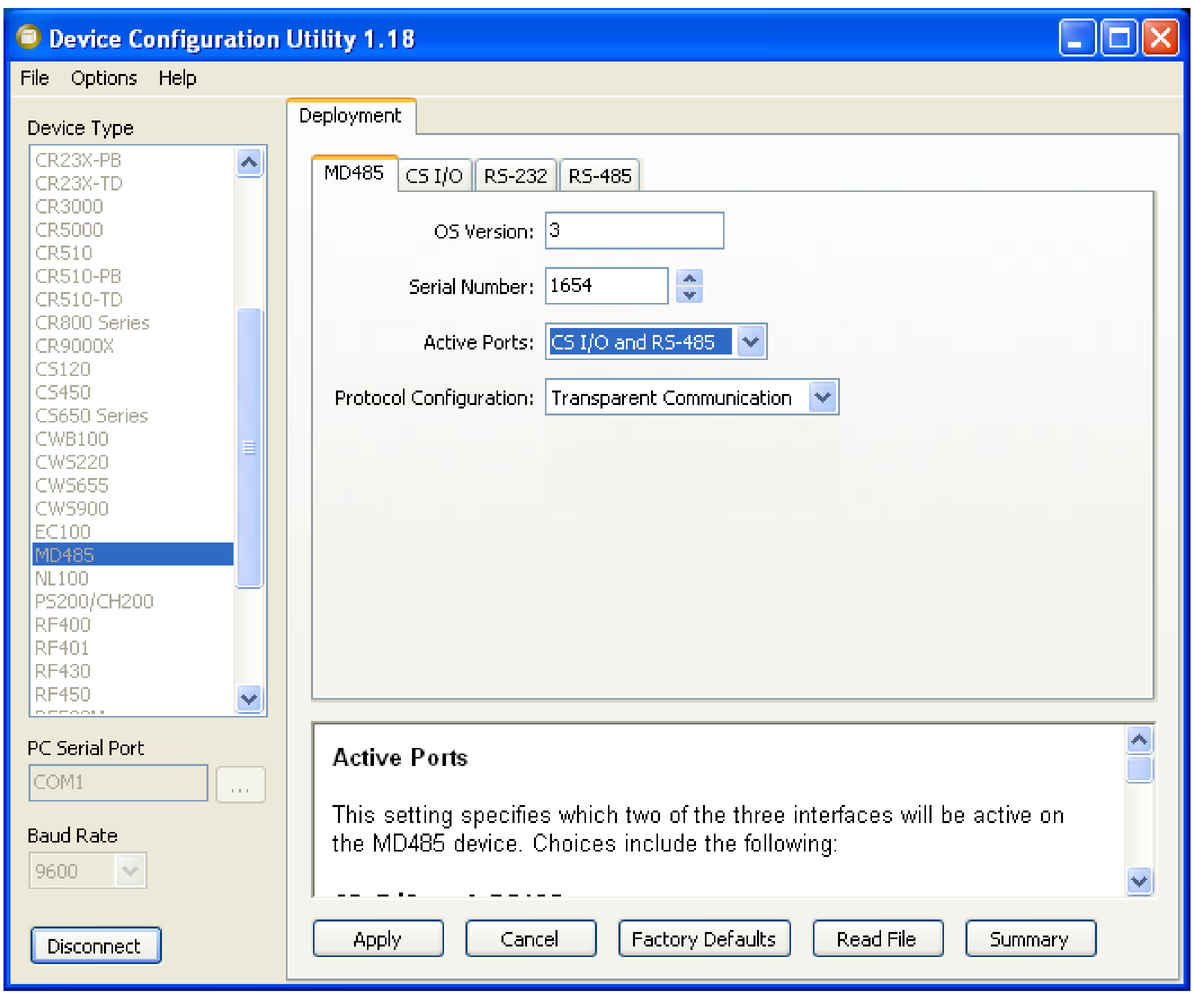
{F00rdd 001; 4.45;%RH;000;=; 20.07;°C;000;=;nc;---.-;°C;000; ;001;V1.7-1;0060568338;HC2-S3 ;000;4

C.3 RS-485 Communications using an MD485 RS-485 Interface

The HC2S3 can be interfaced to a CSI datalogger through an MD485 RS-485 Interface using the Rotronic E2-05XX-MOD RS485 cable as described below. Settings for the RS485 port on the MD485 must be configured to match the configuration of the HC2S3, which are 19200 baud, No Parity, 8 Data Bits, 1 Stop bit, and No Flow Control.

Device Configuration Utility (CSI software available as a free download) is used to configure the MD485. Configuration settings for the MD485 are shown below:

MD485 Tab: CS I/O AND RS-485
CS I/O Tab: SDC Address 7
RS485 Tab: RS485 baud 19200



Sensor Wiring:

E2-05XX-MOD Cable	MD485	CR1000
Blue	A	
Red	B	
Green		12V
Gray/Yellow		G
Clear		Ground Symbol

NOTE If the Rotronic cable includes brown and white wires (voltage signals for temperature and humidity), CSI recommends "capping" them with PN 27749 or equivalent insulated caps to prevent the possibility of shorting.

Connect the CS I/O port of MD485 to CS I/O port on CR1000 with an SC12 cable.

The following example CR1000 program configures the CS I/O port as COMSDC7 using the SerialOpen instruction, sends the RDD (Read Values) command "|{F00RDD}CR" to the probe, and parses temperature and relative humidity values from the data string returned by the probe.

Example CR1000 Program:

```
'CR1000 Program
'Declare variables

Public SerialIndest As String * 100
Dim String_1 As String
Const CRLF=CHR(13)+CHR(10)
Dim HC2S3_Split(17) As String * 40
Alias HC2S3_Split(2) = RH_Str            'RH string.
Alias HC2S3_Split(6) = TempC_Str         'Temp string.
Alias HC2S3_Split(17) = HC2S3_SN_Str     'HC2S3 serial number string.
Public TempC, RH, NBytesReturned

DataTable (Table1,1,-1)
  DataInterval (0,15,Min,10)
  Average (1,TempC,FP2,False)
  Sample (1,RH,FP2)
EndTable

BeginProg
  SerialOpen (ComSDC7,19200,0,0,100)     'Configure CS I/O port
  String_1 = "|{F00RDD}"+CRLF            'RS485 command to send data

  Scan (5,Sec,0,0)
    SerialFlush (34)
    SerialOut (ComSDC7,String_1,0,2,100)  'Send command to send data
    Delay (0,500,mSec)
    'Get data from probe
    SerialInRecord (ComSDC7,SerialIndest,&H6464,0,&H3B48,NBytesReturned,01)
    'Parse RH and temp from string
    SplitStr (HC2S3_Split(),SerialIndest,";",17,7)
    RH=RH_Str
    TempC=TempC_Str

    CallTable Table1
  NextScan
EndProg
```

C.4 RS-485 Communications using an SDM-SIO1 Serial I/O Module

The HC2S3 can be interfaced to a CSI datalogger through an SDM-SIO1 Serial I/O Module using the Rotronic E2-05XX-MOD RS485 cable as described below.

The example program uses the SerialOpen instruction to configure the SDM-SIO1 for RS-485 half duplex, "COMport 32" at 19200 baud, no parity, 1 stop bit, and 8 data bits, and serial instructions to send the RDD command to get temperature and relative humidity data from the probe.

Sensor Wiring:

E2-05XX-MOD Cable	SDM-SIO1	CR1000
Blue	Z	
Red	Y	
Gray/Yellow		G
Green		12V
Clear		Ground

SDM-SIO1 Wiring:

SDM-SIO1	CR1000
C1	C1
C2	C2
C3	C3
G	G
12V	12V

NOTE If the Rotronic cable includes brown and white wires (voltage signals for temperature and humidity), CSI recommends "capping" them with PN 27749 or equivalent insulated caps to prevent the possibility of shorting.

Example CR1000 Program:

```
'CR1000 Program
'Declare variables
Public SerialIndest As String * 100
Dim String_1 As String
Const CRLF=CHR(13)+CHR(10)
Dim HC2S3_Split(17) As String * 40
Alias HC2S3_Split(2) = RH_Str                'RH string.
Alias HC2S3_Split(6) = TempC_Str             'Temp string.
Alias HC2S3_Split(17) = HC2S3_SN_Str         'HC2S3 serial number string.
Public TempC, RH, NBytesReturned
Const SensorPort=32                          'SDM-SIO1 rotary switch set at 0

DataTable (Table1,1,-1)
  DataInterval (0,15,Min,10)
  Average (1,TempC,FP2,False)
  Sample (1,RH,FP2)
EndTable

BeginProg
  SerialOpen (SensorPort,19200,51,100,200)   '51 is for half duplex
  String_1 = "|{F00RDD}"+CRLF                'RS485 command to send data

  Scan (5,Sec,0,0)
    SerialFlush (SensorPort)
    SerialOut (SensorPort,String_1,0,1,100)  'Send command to send data
    Delay (0,500,mSec)
    'Get data from probe
    SerialInRecord (ComSDC7,SerialIndest,&H6464,0,&H3B48,NBytesReturned,01)
    'Parse RH and temp from string
    SplitStr (HC2S3_Split(),SerialIndest,";",17,7)
    RH=RH_Str
    TempC=TempC_Str

    CallTable Table1
  NextScan
EndProg
```

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