HygroVUE™10

Temperature and Relative Humidity Sensor

RELIABLE
SINCE 1974
MONITORING

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Guarantee

This equipment is guaranteed against defects in materials and workmanship. We will repair or replace products which prove to be defective during the guarantee period as detailed on your invoice, provided they are returned to us prepaid. The guarantee will not apply to:

- Equipment which has been modified or altered in any way without the written permission of Campbell Scientific

- Batteries

- Any product which has been subjected to misuse, neglect, acts of God or damage in transit.

Campbell Scientific will return guaranteed equipment by surface carrier prepaid. Campbell Scientific will not reimburse the claimant for costs incurred in removing and/or reinstalling equipment. This guarantee and the Company's obligation thereunder is in lieu of all other guarantees, expressed or implied, including those of suitability and fitness for a particular purpose. Campbell Scientific is not liable for consequential damage.

Please inform us before returning equipment and obtain a Repair Reference Number whether the repair is under guarantee or not. Please state the faults as clearly as possible, and if the product is out of the guarantee period it should be accompanied by a purchase order. Quotations for repairs can be given on request. It is the policy of Campbell Scientific to protect the health of its employees and provide a safe working environment, in support of this policy a "Declaration of Hazardous Material and Decontamination" form will be issued for completion.

When returning equipment, the Repair Reference Number must be clearly marked on the outside of the package. Complete the "Declaration of Hazardous Material and Decontamination" form and ensure a completed copy is returned with your goods. Please note your Repair may not be processed if you do not include a copy of this form and Campbell Scientific Ltd reserves the right to return goods at the customers' expense.

Note that goods sent air freight are subject to Customs clearance fees which Campbell Scientific will charge to customers. In many cases, these charges are greater than the cost of the repair.

PLEASE READ FIRST

About this manual

Some useful conversion factors:

Area: 1 in^2 (square inch) = 645 mm^2

Length: 1 in. (inch) = 25.4 mm
1 ft (foot) = 304.8 mm
1 yard = 0.914 m
1 mile = 1.609 km

Mass: 1 oz. (ounce) = 28.35 g
1 lb (pound weight) = 0.454 kg

Pressure: 1 psi (lb/in^2) = 68.95 mb

Volume: 1 UK pint = 568.3 ml
1 UK gallon = 4.546 litres
1 US gallon = 3.785 litres

Recycling information

At the end of this product's life it should not be put in commercial or domestic refuse but sent for recycling. Any batteries contained within the product or used during the products life should be removed from the product and also be sent to an appropriate recycling facility.

Campbell Scientific Ltd can advise on the recycling of the equipment and in some cases arrange collection and the correct disposal of it, although charges may apply for some items or territories.

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

Safety

DANGER — MANY HAZARDS ARE ASSOCIATED WITH INSTALLING, USING, MAINTAINING, AND WORKING ON OR AROUND **TRIPODS, TOWERS, AND ANY ATTACHMENTS TO TRIPODS AND TOWERS SUCH AS SENSORS, CROSSARMS, ENCLOSURES, ANTENNAS, ETC**. FAILURE TO PROPERLY AND COMPLETELY ASSEMBLE, INSTALL, OPERATE, USE, AND MAINTAIN TRIPODS, TOWERS, AND ATTACHMENTS, AND FAILURE TO HEED WARNINGS, INCREASES THE RISK OF DEATH, ACCIDENT, SERIOUS INJURY, PROPERTY DAMAGE, AND PRODUCT FAILURE. TAKE ALL REASONABLE PRECAUTIONS TO AVOID THESE HAZARDS. CHECK WITH YOUR ORGANIZATION'S SAFETY COORDINATOR (OR POLICY) FOR PROCEDURES AND REQUIRED PROTECTIVE EQUIPMENT PRIOR TO PERFORMING ANY WORK.

Use tripods, towers, and attachments to tripods and towers only for purposes for which they are designed. Do not exceed design limits. Be familiar and comply with all instructions provided in product manuals. Manuals are available at www.campbellsci.eu or by telephoning +44(0) 1509 828 888 (UK). You are responsible for conformance with governing codes and regulations, including safety regulations, and the integrity and location of structures or land to which towers, tripods, and any attachments are attached. Installation sites should be evaluated and approved by a qualified engineer. If questions or concerns arise regarding installation, use, or maintenance of tripods, towers, attachments, or electrical connections, consult with a licensed and qualified engineer or electrician.

General
- Prior to performing site or installation work, obtain required approvals and permits. Comply with all governing structure-height regulations, such as those of the FAA in the USA.
- Use only qualified personnel for installation, use, and maintenance of tripods and towers, and any attachments to tripods and towers. The use of licensed and qualified contractors is highly recommended.
- Read all applicable instructions carefully and understand procedures thoroughly before beginning work.
- Wear a **hardhat** and **eye protection**, and take **other appropriate safety precautions** while working on or around tripods and towers.
- **Do not climb** tripods or towers at any time, and prohibit climbing by other persons. Take reasonable precautions to secure tripod and tower sites from trespassers.
- Use only manufacturer recommended parts, materials, and tools.

Utility and Electrical
- **You can be killed** or sustain serious bodily injury if the tripod, tower, or attachments you are installing, constructing, using, or maintaining, or a tool, stake, or anchor, come in **contact with overhead or underground utility lines**.
- Maintain a distance of at least one-and-one-half times structure height, or 20 feet, or the distance required by applicable law, **whichever is greater**, between overhead utility lines and the structure (tripod, tower, attachments, or tools).
- Prior to performing site or installation work, inform all utility companies and have all underground utilities marked.
- Comply with all electrical codes. Electrical equipment and related grounding devices should be installed by a licensed and qualified electrician.

Elevated Work and Weather
- Exercise extreme caution when performing elevated work.
- Use appropriate equipment and safety practices.
- During installation and maintenance, keep tower and tripod sites clear of un-trained or non-essential personnel. Take precautions to prevent elevated tools and objects from dropping.
- Do not perform any work in inclement weather, including wind, rain, snow, lightning, etc.

Maintenance
- Periodically (at least yearly) check for wear and damage, including corrosion, stress cracks, frayed cables, loose cable clamps, cable tightness, etc. and take necessary corrective actions.
- Periodically (at least yearly) check electrical ground connections.

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HygroVUE™10 Temperature and Relative Humidity Sensor

1. Introduction

The HygroVUE™10 Temperature and Relative Humidity Sensor is designed for general meteorological and other data logging applications. It will form part of a range of HygroVUE™10 sensors. It utilizes the SDI-12 communications protocol to communicate with any SDI-12 recorder, simplifying installation and programming.

Before using the HygroVUE™10 please study:

- Section 2, *Cautionary Statements (p. 1)*
- *Safety Page.*

2. Cautionary Statements

- When opening the shipping package, do not damage or cut the cable jacket. If damage to the cable is suspected, consult with a Campbell Scientific support engineer.

- Although rugged, the HygroVUE™10 should be handled as a precision scientific instrument.

3. Initial Inspection

- Check the packaging and contents of the shipment. If damage occurred during transport, immediately file a claim with the carrier. Contact Campbell Scientific to facilitate repair or replacement.

- Check model information against the shipping documents to ensure the expected products and the correct lengths of cable are received. Model numbers are found on each product. On cables and cabled items, the model number is usually found at the connection end of the cable. Report any shortages immediately to Campbell Scientific.

4. Quickstart

A video that describes data logger programming using Short Cut is available at: www.campbellsci.com/videos/cr1000x-datalogger-getting-started-program-part-3.

Short Cut is an easy way to program your data logger to measure the HygroVUE™10 sensor and assign data logger wiring terminals. *Short Cut* is available as a download from our website. It is included in installations of LoggerNet, PC200W, PC400, or RTDAQ.

The following procedure also shows using *Short Cut* to program the sensor.

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

2. Double-click the data logger model.

3. In the **Available Sensors and Devices** box, type HygroVUE10 or locate the sensor in the **Sensors** > **Meteorological > Relative Humidity & Temperature** folder. Double-click **HygroVUE5/HygroVUE10 Temperature & Relative Humidity Sensor**.

NOTE

If the HygroVUE does not appear in the list, upgrade ShortCut to the latest version from the Campbell Scientific website.
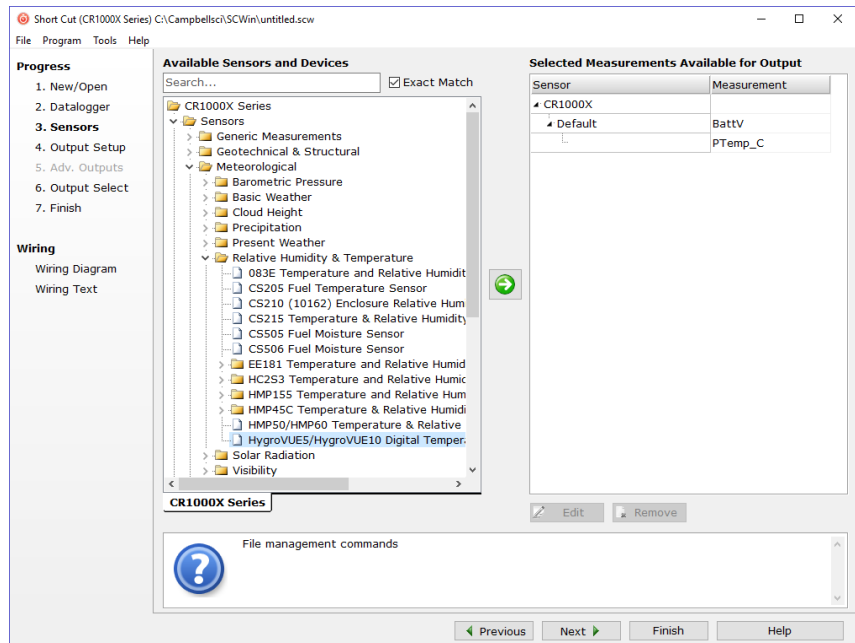
4. On selection a new window opens as shown in the following image. This has two tabs. In the properties tab you can change the name and units of measurement. Temperature units default to degrees Celsius. This can be changed by clicking the **Deg C** box and selecting **Deg F**, for degrees Fahrenheit, or **K** for Kelvin. **SDI-12 Address** defaults to 0. Enter the correct **SDI-12 Address** for the HygroVUE™10 if it has been changed from the factory-set default value.
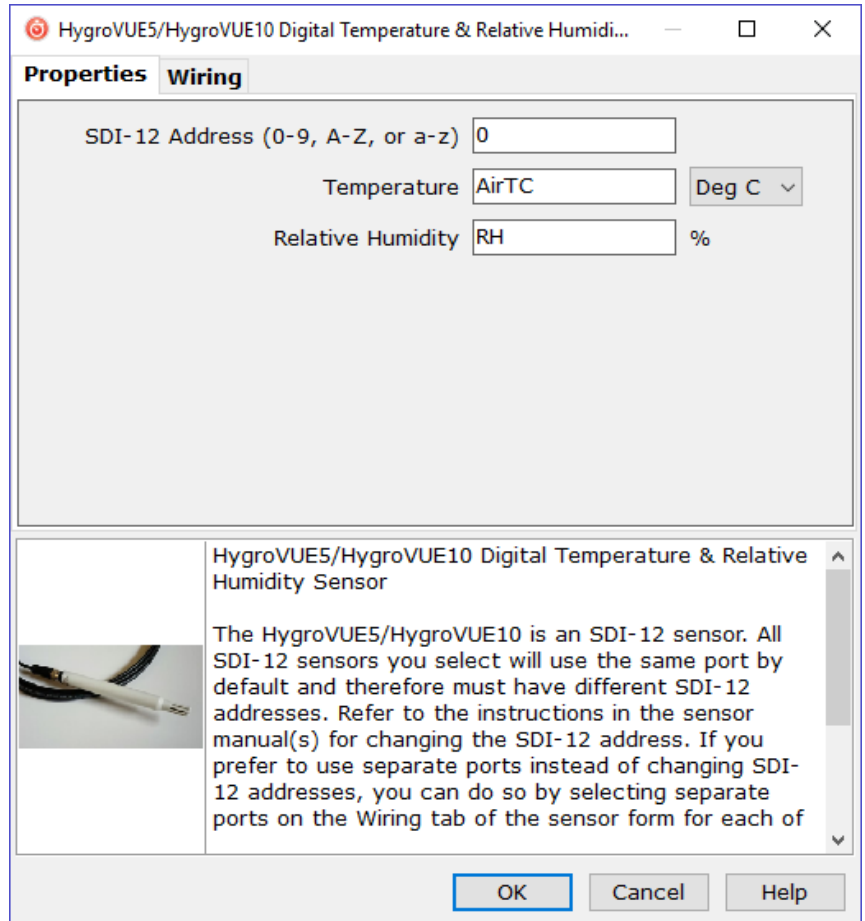
5. In the wiring tab the connections to the data logger are shown.
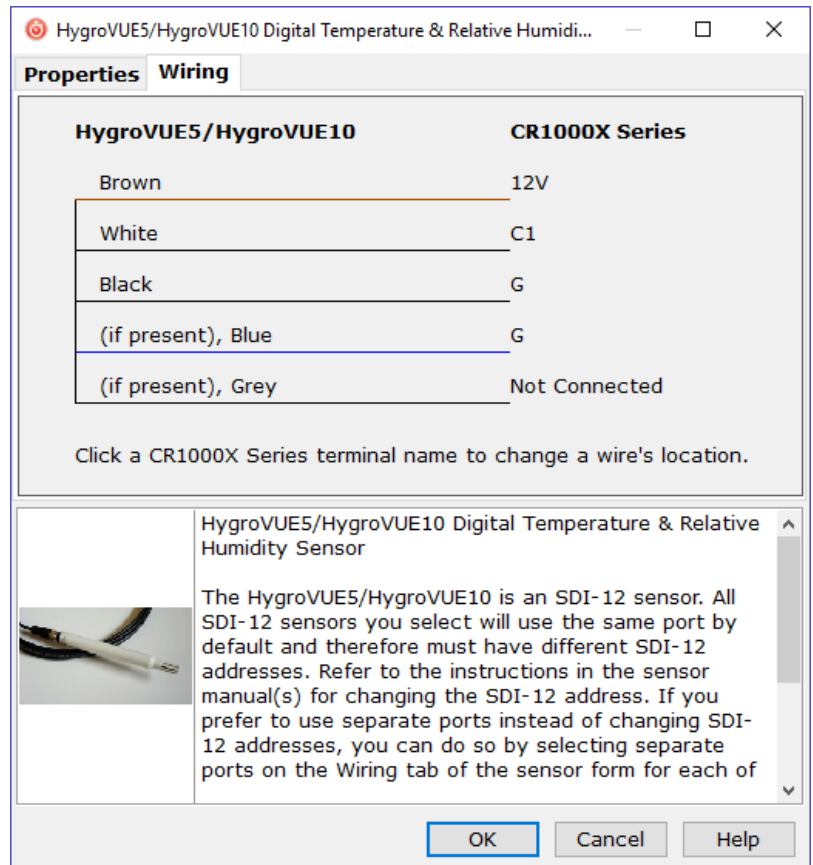
6. Select any other sensors you have, and then click **Next**. Fill in the measurement interval (note 5 seconds is the shortest interval recommended for the HygroVUE™10). Also set up the storage tables, then in the next screen the data to be stored. Then finish the remaining *Short Cut* steps to complete the program. The remaining steps are outlined in *Short Cut Help*, which is accessed by clicking **Help > Short Cut Help > Contents > Programming Steps**.

7. If *LoggerNet*, *PC400*, *RTDAQ*, or *PC200W* is running on your computer, and the computer to data logger connection is active, you can click **Finish** in *Short Cut* and you will be prompted to send the program just created to the data logger.

   If the sensor is connected to the data logger, as shown in the wiring diagram in step 5, check the output of the sensor in the data logger support software data display to make sure it is making reasonable measurements.

NOTE   Making measurements from the HygroVUE™10 more frequently than 5 seconds can result in small additional errors due to self-heating of the element. If the main scan rate needs to be faster than this please read Sections 8.1 and 8.2 about alternate programming techniques.
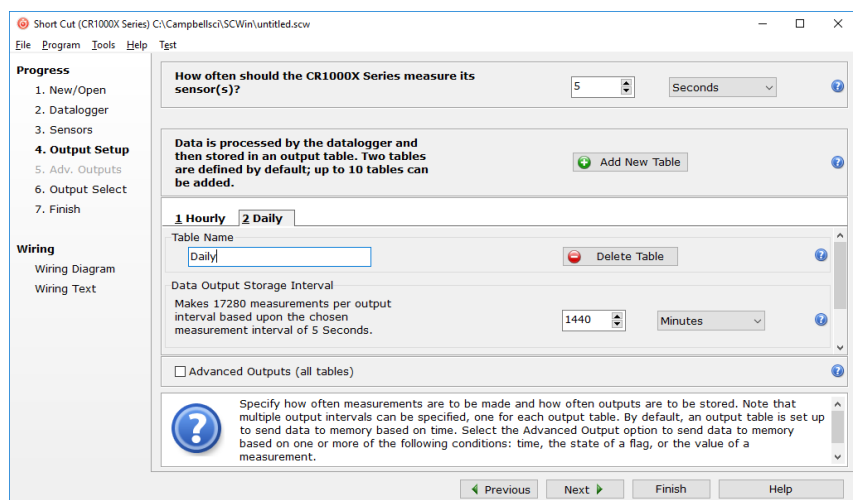
5.   Overview

The HygroVUE™10 sensor uses a single chip element that incorporates both a temperature and an RH sensor. Each element is individually calibrated with the calibration corrections stored on the chip. The element is easily changed in the field, reducing downtime and calibration costs.

Electronics within the HygroVUE™10 control the measurement made by the sensor element, apply temperature and linearization corrections to the readings, and present the data via SDI-12 to a data logger.

A stainless steel mesh filter minimizes the effects of dust and dirt on the sensor whilst allowing air exchange around the sensor element and reducing the chances of condensation remaining inside the filter cap. A small PTFE membrane filter is bonded to the surface of the element which prevents any finer dust or mould from directly influencing the measurement.

The sensor housing is designed to withstand permanent exposure to all weather and to fit into a range of radiation shields, including compact shields.

6.   Specifications

Compatibility:

- Compatible with Campbell Scientific data loggers CR200(X) series, CR300 series, CR6 series, CR800 series, CR1000, CR1000X series, CR3000, and CR5000.

- Digital SDI-12 output which is fully SDI-12 V1.3 compliant (verified with an SDI-12 Verifier (http://www.sdi-12-verifier.com/). It is compatible with SDI-12 V1.4 recorders.

Sensor element:	Sensirion SHT35 derivative
Calibration traceability:	NIST and NPL standards. See Appendix E for details of calibration traceability.
Supply voltage:	7 to 28 VDC
Current consumption:	50 µA quiescent, typical 0.6 mA during 0.5 s measurement typical
Warm-up time:	Sensor normally powered all the time, if power is switched allow 1.8 s for sensor power-up.
Diameter:	12.5 mm (0.49 in) at sensor tip, maximum 18 mm (0.71 in) at the cable end
Length:	180 mm (7.08 in), without cable connected
Housing material:	White PET-P
Housing classification:	IP67 (electronics housing)
Sensor protection:	Outer glass-filled polypropylene cap fitted with a stainless steel mesh dust filter with nominal pore size of <30 µm. The sensor element is fitted with a PTFE protective film with a filtration efficiency of >99.99% for particles of 200 nm or larger size.

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EMC compliance: Tested and conforms to IEC61326:2013

Calibration: The sensor element is individually calibrated during
                             manufacture.

6.1   Temperature Measurement

Operating range: –40 to +70 °C

Accuracy*:   Over the range -40 to +70 °C: ±0.2 °C
                             Over the range +20 to +60 °C: ±0.1 °C

Long term drift: <±0.03 °C/year

Reported resolution: 0.001 °C

Repeatability**:   0.04 °C

Response time: 130 s (63% response time in air moving at 1 m/s)

Units: Degrees Celsius

*The accuracy figures quoted are the 95% confidence limits relative to factory standards.

**Values are 3 standard deviations of 25 measurements at constant temperature.

6.2   Relative Humidity Measurement

Operating Range: 0 to 100% RH

Accuracy (at 25°C)*:   Over the range 0-80% RH: ±1.5%
                             Over the range 80-100% RH: ±2%

Temperature dependence: < ±1% RH (-40 to 60 °C)

Short term hysteresis: < ±1% RH

Long-term stability: ±0.5% per year (drift in clean air conditions)

Reported resolution: 0.001% RH

Repeatability**:   0.05% RH

Response time with filter: 8 s (63% response time in air moving at 1 m/s @
                             25 °C)

**Environmental
Performance:**   See Appendix C, *Environmental Performance (p. C-1)*

*The accuracy figures quoted are the 95% confidence limits relative to factory standards.

**Values are 3 standard deviations of 25 measurements at constant humidity.

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7. Installation

If you are programming your data logger with *Short Cut*, skip Section 7.1, *Wiring to Data logger (p. 8)*, and Section 7.2, *Data logger Programming (p. 9)*. *Short Cut* does this work for you. See Section 4, *Quickstart (p. 1)*, for a *Short Cut* tutorial.

7.1 Wiring to Data logger

The sensor uses an industry standard M12 connector and wire colour coding. The sensor may be supplied with different cables depending on the application and cable length. Normally the cable will be screened and have a polyurethane sheath. It can have between 3 and 5 conductors, although only three are required for operation so all may not be exposed at the free end of the cable.

Table 7-1. Wire Colour, Pin, Function, and Data logger Connection			
Pin	**Wire Colour**	**Wire Function**	**Data logger Connection Terminal**
1	Brown	Power	**12V**
2	White	SDI-12	**C terminal**[1] or **U terminal** configured for SDI-12[2]
3	Black	Power ground	**G**
4	Blue *(if present)*	Power ground	**G**
5	Grey *(if present)*	No function	**No Connection**
	Clear	Shield	**G**
	[1]Dedicated SDI-12 port on CR5000		
	[2]U terminals are automatically configured by the measurement instruction.		

To use more than one sensor per data logger, either connect the different sensors to different terminals on the data logger or change the SDI-12 addresses of the sensors and wire them to the same terminal. Using the SDI-12 address reduces the use of ports on the data logger and allows sensors to be connected in a "daisy-chain" fashion which can minimize cable runs in some applications. (See Section 8.3 for limits on the total cable length.)

For the CR6 and CR1000X triggering conflicts may occur when a companion terminal is used for a triggering instruction such as TimerInput(), PulseCount(), or WaitDigTrig(). For example, if the HygroVUE™10 is connected to C3 on a CR1000X, C4 cannot be used in the TimerInput(), PulseCount(), or WaitDigTrig() instructions.

The SDI-12 address of the HygroVUE™10 can be set two ways:

- by sending the required commands to the sensors via an SDI-12 recorder/data logger that allows talk through to the sensor.
- by loading a program into the recorder that sends the required commands.

See Appendix D SDI-12 Sensor Support, *(p. Error! Bookmark not defined.)*, for detailed instructions.

7.2   Data logger Programming

Short Cut is the best source for up-to-date data logger programming code. Programming code is needed:

- when creating a program for a new data logger installation
- when adding sensors to an existing data logger program.

If your data acquisition requirements are simple, you can probably create and maintain a data logger program exclusively with *Short Cut*. If your data acquisition needs are more complex, the files that *Short Cut* creates are a great source for programming code to start a new program or add to an existing custom program.

NOTE   *Short Cut* cannot edit programs after they are imported and edited in *CRBasic Editor*.

A *Short Cut* tutorial is available in Section 4, *Quickstart (p. 1)*. If you wish to import *Short Cut* code into *CRBasic Editor* to create or add to a customized program, follow the procedure in Appendix A.1, **Error! Reference source not found.**. *(p. Error! Bookmark not defined.)*. Programming basics for CRBasic data loggers are provided in the following sections. Complete program examples for select data loggers can be found in Appendix B, *Example Programs (p. B-1)*.

NOTE   Making measurements from the HygroVUE™10 more frequently than every 5 seconds can result in small additional errors due to self-heating of the element.   If the main scan rate needs to be faster than this please read Sections 8.1 and 8.2 about alternate programming techniques.

7.3   SDI12Recorder() Instruction

The **SDI12Recorder()** measurement instruction programs CRBasic data loggers to measure the HygroVUE™10 sensor. This instruction sends a request to the sensor to make a measurement and then retrieves the measurement from the sensor. See Section 8.1, *Sensor Measurement (p. 12)*, for more information.

```
SDI12Recorder(Dest, SDIPort, SDIAddress, "SDICommand", Mult, Offset,
FillNAN, WaitonTimeout)
```

For the **SDIAddress,** alphabetical characters need to be enclosed in quotes (for example, "A"). Also enclose the **SDICommand** in quotes as shown. Using the **M!** command the *Destination* variable must be an array of length 2, with the first index for air temperature (in °C) and the second for relative humidity (as a percent).

FillNAN and **WaitonTimeout** are optional parameters (refer to CRBasic Help for more information.

Variations:

Set SDICommand to "M!", "C!", or "R!" – see Section 8.1, *Sensor Measurement (p. 12)*, to determine which is best for your application.

7.4   Installation

The general guidance for standard meteorological stations is to locate the sensor over an open, level area at least 9 m (29.5 ft) (EPA) in diameter. The surface should be covered by short grass or the natural earth surface where grass does not

grow. Sensors should be located at a distance of at least four times the height of any nearby obstruction and at least 30 m (98.4 ft) (EPA) from large, paved areas. Sensors should be protected from thermal radiation and adequately ventilated. Protect the filter at the top of the sensor from exposure to liquid water (see below).

The sensor should be installed at a standard measurement height which varies depending on the guides being used:

- 1.5 m (4.92 ft) (AASC)
- 1.25 to 2.0 m (4.1 to 6.5 ft) (WMO)
- 2.0 m (6.5 ft) (EPA).

See Section 10, *(p. 19)*, for a list of references that discuss temperature and relative humidity sensors.

When used in the field, the HygroVUE™10 must be housed in a radiation shield. Typically, RAD10E ten-plate solar radiation shield is used. A RAD14 can also be used.

The white colour of these shields reflects solar radiation, and the louvered construction allows air to pass freely through, thereby keeping the sensor at or near ambient temperature. The RAD10E and RAD14 use a double-louvered design that offers improved sensor protection from insect intrusion and driving rain and snow. In addition, the RAD10E and RAD14 shields have lower self-heating in bright sunlight combined with higher temperatures (> 24 °C (75 °F)) and low wind speeds (< 2 m/s (4.5 mph)), giving a better measurement.

Each of these solar radiation shields attaches to a crossarm, mast, or user-supplied pipe with a 2.5 to 5.3 cm (1.0 to 2.1 inch) outer diameter.

Tools required for installing a radiation shield to a tripod or tower include:

- adjustable wrench (to suit 12 mm (½ inch) nuts)
- small screwdriver provided with data logger
- small Phillips screwdriver
- UV-resistant cable ties
- small pair of diagonal-cutting pliers
- adjustable wrench with a minimum 50 mm (2 inch) jaw size.

7.4.1 Installation in a RAD10E 10 Plate Shield or RAD14 14-Plate Shield

1. Loosen the nut on the entry gland at the bottom of the shield.

2. Insert the sensor into the gland. See Figure 7-1. The sensor should be pushed into the shield, so the tip of the sensor is approximately one third of the way down from the top of the shield, or as far as it can be pushed in if using the 14-plate shield.

3. First tighten the nut on the gland by hand until the sensor is held firmly in place. Ensure the gland tightens on the white body of the sensor, not the connector. Then use the large adjustable wrench to further tighten the gland by ½ to 1 turn. Do not overtighten the nut as you risk damaging the sensor body and also making service of the sensor more difficult in the future.

7.4.2 Mount the Shield

1. Attach the radiation shield to the tripod mast, crossarm, or tower leg using the supplied U-bolt or band clamp. See Figure 7-1 and Figure 7-2 for examples of shield mounting.

2. Route the cable to the data logger, and secure the cable to the mounting structure using cable ties.

CAUTION	Failure to secure the cable can lead to breakage of the wires due to fatigue caused by blowing back and forth in the wind.

Figure 7-1. HygroVUE™ 10 installed in a RAD10E Radiation Shield

Figure 7-2. HygroVUE™10 and RAD10E mounted on a pole

8. Operation

8.1 Sensor Measurement

The CRBasic instruction **SDI12Recorder()** measures the HygroVUE™10 sensor using the Start Measurement (**M**), Concurrent Measurement (**C**) or Continuous Measurement (**R**) commands. The SDI-12 commands relevant to taking measurements are shown in Table 8-1. Appendix D describes all the SDI-12 commands that are supported. Additional SDI-12 information is available at www.sdi-12.org.

Table 8-1. HygroVUE™10 SDI-12 Measurement Commands

SDI-12 Command (*a* is the address)	Values returned
*a*M!, *a*C!, *a*R0!	Temperature (°C), Relative Humidity (%)
*a*M1!, *a*R1!	Dewpoint (°C) of the air
*a*M3!, *a*R3!	Temperature (°C), Relative Humidity (%), dewpoint (°C) and Vapour Pressure (kPa)

When entering the command in a CRBasic program the address is entered as a separate parameter in the command (except for the CR200 series data loggers – see the CRBasic help for more details). The SDI-12 command is entered in a different parameter as a string, excluding the address but including the terminator character, e.g. "M!"

When a measurement is initiated with the **M or C** commands the sensor responds with the maximum time delay until the measurements are available and the number of values to be returned. The delay is 1 second for this sensor. For the **M** commands, Campbell Scientific data loggers interprets the response and automatically sends one or more **D** commands after the sensor indicates data is ready to read the data from the sensor and write it to the results variable. The whole measurement normally delays the data logger by about 400 msec with the standard "M" command.

The **C** command differs in that the data logger does not wait after sending the command and continues with other instructions in the program. It automatically collects the data the next time the **SDIRecorder()** instruction runs in the next scan. This allows measurements for several different sensors to be triggered and made concurrently but the measurements seen in the data logger are effectively one scan period old. For the HygroVUE™10 this instruction is rarely used because the instruction takes longer to execute than the **M** or **R** commands.

The **R** command switches the sensor to automatically make measurements every 10 seconds, based on the sensor's internal clock. Note this command must be entered as "**R0**" (a single R alone is invalid). For the data logger this instruction usually takes less than 220 milliseconds to execute so this causes the least delay to program execution. However, for programs which operate with scans longer than 10 seconds the power consumption by the sensor will be higher when using this mode of operation. The automatic measurement mode and its consequent power consumption can only be cancelled by powering down the sensor to reset it.

With the standard commands (**M**, **C** and **R0**) the sensor returns two values: temperature (°C) and relative humidity as a percentage (0 to 100). The sensor also supports some additional variants of the above measurement commands see Table 8-1 above.

Dewpoint and vapour pressure are calculated using formulae from:

Alduchov, O. A., and R. E. Eskridge, 1996: Improved Magnus form approximation of saturation vapour pressure. J. Appl Meteor., 35, 601-609.

These optional outputs are provided mainly for non-Campbell data logger applications. Campbell data loggers have built in functions to calculate these derived variables and making the calculations in the data logger will be quicker and take less power as it takes the sensor much longer to perform the calculations required than the data logger.

The HygroVUE™10 also supports the **MC**, **CC**, and **RC** instructions, which are the same as the instructions above, but where the C at the end of the instruction forces a validation for the data received from the sensor using a checksum. . Use of the checksum option is only normally necessary for long cable runs. The sensor also supports the alternative measurement options (1, 2 and 3 above) for the commands with the checksum option, e.g. MC1.

The factory-set SDI-12 address for the HygroVUE™10 is 0. See Appendix D.6, *Change Address Command* (aAb!) *(p. D-3)*, for instructions on changing the SDI-12 address through the data logger. Appendix D, *SDI-12 Sensor Support (p. D-1)*, all give full details of the additional commands and details of the SDI-12 protocol.

8.2   Measurements in programs with fast scan rates

Calling the SDI12Recorder instruction in a **SlowSequence()** allows the SDI-12 instruction to run as a background process, causing minimum interference to other measurements that use other hardware in the data logger. Code and measurements that need to run at higher speeds can run in the main scan.

NOTE	For the CR5000, use a control port rather than the SDI-12 port to allow the SDI12 recorder instruction to run in the slow sequence.

8.3 Long Cables

Digital data transfer eliminates offset and noise errors due to cable lengths. However, digital communications can break down when cables are too long, resulting in either no response from the sensor or corrupted readings. The original SDI-12 standard specifies the maximum total cable length of 60 metres (200 ft). Low power SDI-12 sensors such as the HygroVUE™10 have been used with longer cables than this, e.g. 300 m (1000 ft). To ensure proper operation with long cables, follow these guidelines:

- Use low capacitance, low resistance, screened cable (as fitted by Campbell Scientific) to reach distances of several hundred metres.

- Ensure that the power ground cable has low resistance and is connected to the same ground reference as the data logger control ports.

- Be aware that "daisy-chaining" or connecting sensors in parallel to the same SDI-12 port reduces the total cable length roughly in proportion to the number of sensors connected. For example, whilst it may be possible to use one cable run of 300 m (1000 ft) to a single sensor, the cable length would be limited to around 100 m (300 ft) per sensor if three sensors are connected to one port.

8.4 Power Conservation

The HygroVUE™10 draws less than 100 µA (50 µA typical) of current between measurements. In most applications this is insignificant compared to the data logger and other power draws, so the sensor can be permanently powered.

In very low-power applications, conserve battery power by turning the 12 V supply to the HygroVUE™10 on just before the measurement (allowing a warm-up time of at least 1.8 s) and then turning it off afterwards. If available, the switched 12 V output of the data logger can be used.

8.5 Measuring Multiple SDI-12 Sensors

Up to ten HygroVUE™10s or a combination of other SDI-12 sensors can be connected to a single data logger terminal. Each SDI-12 device must have a unique SDI-12 address between 0-9, A-Z, or a-z. See Appendix D.6, Change Address Command (aAb!) to change the HygroVUE™10 SDI-12 address from its default address of 0.

9. Troubleshooting and Maintenance

NOTE	All factory repairs and recalibrations require a returned material authorization (RMA) and completion of the "Declaration of Hazardous Material and Decontamination" form. Refer to the *Assistance* page at the beginning of this manual for more information.

9.1   Troubleshooting

Table 9-1. Symptoms, possible causes and solutions		
Symptom	**Possible cause**	**Solution**
Temperature is reported as –**9999** or **NAN**, and relative humidity is reported as **0** or as an unchanging value.	This indicates a problem with the SDI-12 communications with the sensor.	Recheck the sensor wiring. Check the voltage to the sensor is 12V with a digital voltage meter. Verify the sensor's SDI12 address matches the address entered for the **SDI12Recorder()** instruction.
Inaccurate temperature or relative humidity is reported.	Inadequate delay after power-up (only applicable if using SW12) The sensor element has been contaminated Electrical interference	Verify the program is allowing a power-up time of at least 100 ms. Clean the sensor tip with distilled water or replace it. Check that the sensor is not installed too close to a radio transmitter, e.g. Cellphone antenna.
Temperature and relative humidity read "-99.999"	This indicates a fault with the sensor element itself or communication between the sensor element and the electronics in the sensor body.	Check the sensor element is properly plugged in, with the correct orientation. Check for water being present under the sensor element connector and that there is no corrosion of the sensor pins or the socket. Swap the element for another one.

9.2   Maintenance

The HygroVUE™10 sensor requires minimal maintenance, but dust, debris, and salts on the filter cap will degrade sensor performance. Check the white filter on the end of the sensor for debris. If dirt or salt is ingrained in the filter, clean with distilled water or replace it. Make sure the filter is screwed onto the sensor firmly with your fingers – do not over tighten.

Check the radiation shield monthly to make sure it is free from dust and debris. To clean the shield, first remove the sensor. Dismount the shield. Brush all loose dirt off. If more effort is needed, use warm, soapy water and a soft cloth or brush to thoroughly clean the shield. Allow the shield to dry before remounting.

9.3   Calibration

The life of the sensor element is primarily limited by drift of the humidity sensor and your own acceptance of the errors incurred. Typical drift is less than 1% per year when used in 'clean' environments but can be higher than this in polluted air. Because it can be difficult to know what the sensor has been exposed to and because the element is relatively inexpensive, we recommend replacing the sensor element at the normal interval you would recalibrate similar sensors, e.g.,

annually. Replacing the element effectively brings the sensor back to a factory calibration state both for temperature and relative humidity.

If you wish to check an old element's calibration you can measure its performance by plugging it into another sensor body in your calibration laboratory.

NOTE   We cannot guarantee the accuracy of measurements if the sensor element is not changed every year.

9.4   Sensor Element Replacement

The replacement sensor element has a single row of 4 pins which mates into one side of an eight-way socket at the end of the probe. The element can be mounted into either side of the connector but the orientation of the sensor in relation to the pins is critical. Please refer to Figure 9.

Please note that these elements are NOT available off the shelf from any other supplier than Campbell Scientific as the small circuit boards are specially coated to ensure longer life at high humidity.

To replace the element:

1. Wash your hands to avoid getting dirt or grease on the element. If possible use cotton gloves and handle the element by the edges of the small circuit board. Avoid touching the square white filter on the surface of the small, black component on top of the circuit board.

NOTE   If dirt, salt or grease are left on the face of the sensor element during the process of handling the element, it may influence the measurements made.

2. Disconnect the sensor from the 12 V power supply.

3. Remove the filter by unscrewing it counter clockwise when looking towards the tip of the sensor.

CAUTION   The filter cap unscrews from the sensor. Attempting to pull it off may damage it.

4. Identify the sensor element. The element plugs into the black plastic socket that protrudes by about 2 mm from the end of the body of the sensor.

5. Grasp the body of the sensor (this also ensures you are at the same electrical potential as the element) and, holding the edge of the circuit board between your fingertips, pull the element out of the socket. Store the old element in electrostatic protective packaging if you wish to retain it. (Please avoid pink coloured electrostatic bags as they can emit chemicals which change the calibration of the sensor.)

6. With the element removed, check for dirt and/or corrosion around the socket. Clean any dirt away using a damp cloth to remove any salts that might be there.

7. Unpack the replacement element, avoiding static discharges to the element by making sure you touch the packaging before the element. The element can be inserted into either row of four holes in the socket, but it must be orientated so the sensing element with the white cover, is facing into the centreline of the socket, towards the empty row of holes (see Figure 9 below).

8. Hold the element by the sides of the circuit board. Carefully match the pins to the socket in the end of sensor. Gently push the pins into the socket until they will not go in any further.

9. Before replacing the filter element and turning on power to the sensor, double-check that the element is seated correctly.

CAUTION

If the element is not plugged into the socket correctly or there is contamination or excess water bridging the connections, it will not work. The element may draw excessive power from the supply and may be damaged if left powered in this state for more than a few seconds.

10. Screw the filter back onto the end of the sensor, making sure it clears the sensor element. If the element appears too close to the filter, there is a fair chance that it has been inserted in the incorrect orientation or that the legs of the element have been bent. Screw the filter onto the thread and tighten gently with your fingers.

CAUTION

Only tighten the filter approximately 1/8th of a turn by hand when the filter is fully screwed onto the thread. Over-tightening the filter will damage it and cause problems in inserting and removing the sensor from some shields.
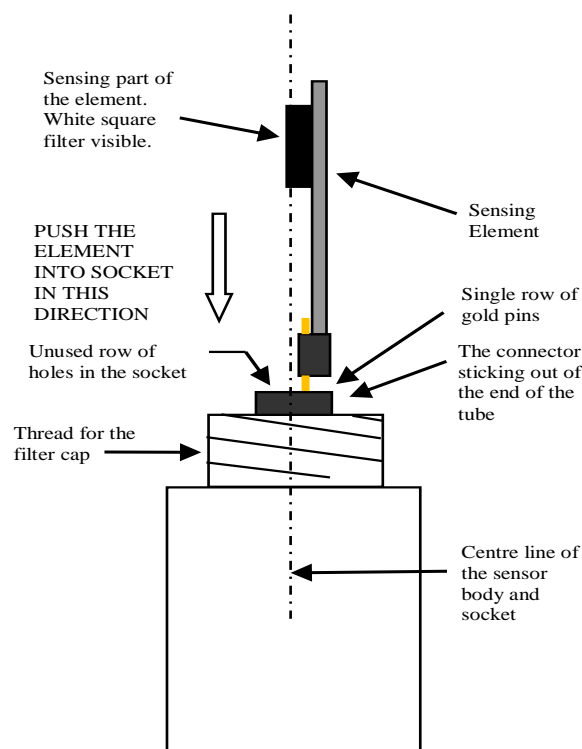
Figure 9a. Correct fit of the 4-pin sensor element (side view)

17
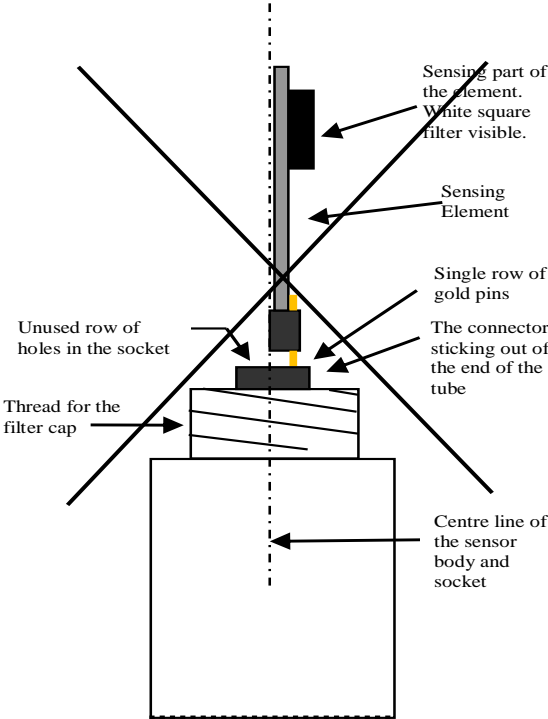
Figure 9b. Incorrect fit of the 4-pin sensor element (side view)

10. Attributions and References

AASC, 1985: The State Climatologist (1985) Publication of the American Association of State Climatologists: *Heights and Exposure Standards for Sensors on Automated Weather Stations*, v. 9, No. 4 October, 1985. (www.stateclimate.org/publications/state-climatologist/NOAA-NCY-SCBOOKS-SC77097/00000029.pdf)

Alduchov, O. A., and R. E. Eskridge, 1996: Improved Magnus form approximation of saturation vapour pressure. J. Appl Meteor., 35, 601-609.

EPA, 2008: *Quality Assurance Handbook for Air Pollution Measurement Systems*, Vol. IV, Meteorological Measurements, Ver. 2.0, EPA-454/B-08-002 (revised 2008). Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711.

Meyer, S. J. and K. G. Hubbard, 1992: Nonfederal Automated Weather Stations and Networks in the United States and Canada: A Preliminary Survey, *Bulletin Am. Meteor. Soc.*, **73**, No. 4, 449-457.

WMO, 2008. *Guide to Meteorological Instruments and Methods of Observation*. World Meteorological Organization No. 8, 7th edition, Geneva, Switzerland.

Appendix A. Importing Short Cut Code into CRBasic Editor

This tutorial shows:

- Importing a Short Cut program into a program editor for additional refinement
- Importing a wiring diagram from Short Cut into the comments of a custom program

Short Cut creates files, which can be imported into CRBasic Editor. Assuming defaults were used when Short Cut was installed, these files reside in the C:\campbellsci\SCWin folder:

- .DEF (wiring and memory usage information)
- .CR2 (CR200(X)-series datalogger code)
- .CR300 (CR300-series datalogger code)
- .CR6 (CR6-series datalogger code)
- .CR8 (CR800-series datalogger code)
- .CR1 (CR1000 datalogger code)
- .CR1X (CR1000X-series datalogger code)
- .CR3 (CR3000 datalogger code)
- .CR5 (CR5000 datalogger code)

Import Short Cut code and wiring diagram into CRBasic Editor:

1. Create the Short Cut program following the procedure in QuickStart (p. 1). Finish the program. On the Advanced tab, click the CRBasic Editor button. The program opens in CRBasic with the name noname.CR_. Provide a name and save the program.

NOTE   Once the file is edited with CRBasic Editor, Short Cut can no longer be used to edit the program it created.

2. The program can now be edited, saved, and sent to the data logger.

3. Import wiring information to the program by opening the associated .DEF file. By default, it is saved in the c:\campbellsci\SCWin folder. Copy and paste the section beginning with heading "–Wiring for CRXXX–" into the CRBasic program, usually at the head of the file. After pasting, edit the information such that an apostrophe (') begins each line. This character instructs the data logger compiler to ignore the line when compiling. You can highlight several lines of CRBasic code then right-click and select Comment Block. (This feature is demonstrated at about 5:10 in the CRBasic | Features video.)

Appendix B. Example Programs

B.1 CRBasic example program

This program can be adapted for use with the CR300, CR6, CR800 series, CR1000, CR1000X, CR3000, and CR5000 data loggers.

```
'Program measures one HygroVUE10 sensor every 10 seconds and stores the average
'temperature and a sample of relative humidity every 10 minutes.

'Wiring Diagram
'==============
'HygroVUE10

'  Wire
'  Colour                   Function    CR1000(X)
'  -----                    --------    -------
'  Brown                    Power (12V)  Battery +
'  White                    SDI-12 signalC1/SDI-12
'  Black                    Power ground G
'  Blue (if present)        Power ground G
'  Clear                    Shield       G

'Declare the variable array for the measurement
Public TRHData(2)

Alias TRHData(1)=AirTC
Alias TRHData(2)=RH

Units AirTC=Deg C
Units RH=%

'Define Data Tables
DataTable(TenMin,True,-1)
  DataInterval(0,10,Min,10)
  Average(1,AirTC,FP2,False)
  Sample(1,RH,FP2)
EndTable

'Main Program
BeginProg
  'Main Scan
  Scan(10,Sec,1,0)
    'HygroVUE10 Temperature & Relative Humidity Sensor measurements 'AirTC' and 'RH'
    SDI12Recorder(TRHData(),C1,"0","M!",1,0)
    'Call Data Tables and Store Data
    CallTable(TenMin)
  NextScan
EndProg
```

B.2 CRBasic example program for the CR200 Series.

This example program shows the measurement of a single HygroVUE™10 and can be used directly with CR200(X) series data loggers.

```
'CR200(X) Series Data logger
'Program measures one HygroVUE10 sensor every 30 seconds and stores the average
'temperature and a sample of relative humidity every 10 minutes.

'Wiring Diagram
'==============
'HygroVUE10

'  Wire
'  Colour    Function         CR200(X)
'  -----     --------         -------
'  Brown       Power (12V)    Battery +
'  White       SDI-12 signal  C1/SDI-12
'  Black       Power ground   G
'  Blue      Power ground     G (if present)
'  Clear       Shield         G

'Declare the variable array for the measurement
Public TRHData(2)

Alias TRHData(1)=AirTC
Alias TRHData(2)=RH

Units AirTC=Deg C
Units RH=%

'Define a data table for ten-minute data
DataTable(TenMin,True,-1)
  DataInterval(0,10,Min)
  Average(1,AirTC,False)
  Sample(1,RH)
EndTable

'Main Program
BeginProg
  Scan (30,Sec) 'Scan every 30 seconds
   'HygroVUE10 Temperature & Relative Humidity Sensor measurements 'AirTC' and 'RH'
   SDI12Recorder(TRHData(),"0M!",1,0)
   'Call Data Tables and Store Data
   CallTable TenMin
   NextScan
EndProg
```

Appendix C. Environmental Performance

This Appendix details tests and limitations of the sensor when exposed to extremes of the environment.

C.1 Exposure to Pollutants

All capacitive sensors are susceptible to pollutants to some degree. The vapours may interfere with the polymer layers used in the structure of the sensing element. The diffusion of chemicals into the polymer may cause temporary or even permanent shifts in both offset and sensitivity. As a general rule, the sensor will not be damaged by levels of chemicals which are not too dangerous to human health, so damage is not normally a problem in outdoor applications.

However, exposure to volatile organic compounds at high concentrations and for long exposure times and exposure to acids or bases may be harmful, but there is less sensitivity if the pH<9.

Corrosive substances at very low concentrations are not harmful to the sensor itself. However, they may attack the sensor contacts.

After low levels of exposure, in a clean environment most contaminants will slowly outgas and the sensor recovers.

If a sensor has been exposed to volatile organic compounds and is showing signs of drift it may be possible to recondition the sensors by heating the sensor to drive off the contaminants. Details of the procedure are given in Section C.2 below.

C.2 Operating Range of the RH Element

The RH sensor is specified to work over the entire humidity range of 0–100% RH for the temperature range –40 to 70 °C. The sensor will perform best in the mid-range of humidity in the range of 20-80% RH.

In common with most types of unheated, polymetric humidity sensors the sensor can exhibit a temporary change in calibration, sometimes called long term hysteresis, when it is subjected to prolonged periods of high humidity and condensation. The sensor calibration may be temporarily altered, normally resulting in a change of less than +3% RH. The combination of high humidity and high temperature accelerates this change. However, upon returning to more normal ambient conditions, the calibration will settle back to the normal calibration over the course of several hours or exceptionally a few days.

In laboratory conditions, it is possible to speed up the return to the normal calibration by reconditioning the element alone using this process:

1)   Bake the sensor at 100–105 °C at < 5% RH for 10 hours.
2)   Followed by re-hydration at 20–30 °C at ~ 75% RH for 12 hours.

The exact timing of these steps is not critical.

C.3 Measurement below 0 °C

The chemistry of the HygroVUE™10 sensor element results in the sensor outputting a humidity reading that is referenced to the saturated water vapour 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 to be referenced to ice, the HygroVUE™10 readings will need to be corrected. Please refer to standard text points on this matter for the correction required.

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

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

Appendix D. SDI-12 Sensor Support

D.1 SDI-12 Command Basics

SDI-12 commands have three components:

- **Sensor address (a)** – a single character and the first character of the command. Use the default address of zero (0) unless multiple sensors are connected to the same port.
- **Command body** – an upper-case letter (the "command"), optionally followed by one or more alphanumeric qualifiers.
- **Command termination (!)** – an exclamation mark.

An active sensor responds to each command. Responses have several standard forms and always terminate with <CR><LF> (carriage return and line feed). Standard SDI-12 commands are listed in Table D-1.

Table D-1. Campbell Scientific sensor SDI-12 command and response set		
Name	**Command**	**Response[1]**
Acknowledge Active	a!	a<CR><LF>
Send Identification	aI!	allcccccccccmmmmmmvvvxx x...xx <CR><LF>
Start Verification	aV!	atttn <CR><LF>
Address Query	?!	a<CR><LF>
Change Address	aAb!	b<CR><LF>
Start Measurement	aM! aM1!...aM9!	atttn<CR><LF>
Start Measurement and Request CRC	aMC! aMC1!...aMC9!	atttn <CR><LF>
Start Concurrent Measurement	aC! aC1!...aC9!	atttnn<CR><LF>
Start Concurrent Measurement and Request CRC	aCC! aCC1!...aCC9!	atttnn<CR><LF>
Send Data	aD0!...aD9!	a<values><CR><LF> or a<values><CRC><CR><LF>
Continuous Measurement	aR0!...aR9!	a<values><CR><LF>

Continuous Measurement and Request CRC	aRC0!...aRC9!	a\<values\>\<CRC\>\<CR\>\<LF\>
Extended Commands	aXNNN!	a\<values\>\<CR\>\<LF\>

[1] Information on each of these commands is given in the following sections.

NOTE The HygroVUE sensors do not support all variants of the commands given above.

D.2 Acknowledge active command (a!)

The Acknowledge Active command (`a!`) is used to test a sensor on the SDI-12 bus. An active sensor responds with its address.

D.3 Send identification command (aI!)

Sensor identifiers are requested by issuing command `aI!`. The reply is defined by the sensor manufacturer but usually includes the sensor address, SDI-12 version, manufacturer's name, and sensor model information. Serial number or other sensor specific information may also be included.

aI!	allccccccccmmmmmmvvvxxx...xx\<CR\>\<LF\>
a	Sensor SDI-12 address
ll	SDI-12 version number (indicates compatibility)
cccccccc	8-character vendor identification
mmmmmm	6 characters specifying the sensor model
vvv	3 characters specifying the sensor version (operating system)
xxx…xx	Up to 13 optional characters used for a serial number or other specific sensor information that is not relevant for operation of the data logger
\<CR\>\<LF\>	Terminates the response

Source: *SDI-12: A Serial-Digital Interface Standard for Microprocessor-Based Sensors* (see References).

D.4 Start verification command (aV!)

The response to a Start Verification command can include hardware diagnostics, but like the `aI!` command, the response is not standardized.

Command: `aV!`

Response:

atttn\<CR\>\<LF\> a

= sensor address

ttt = time, in seconds, until verification information is available

n = the number of values to be returned when one or more subsequent D!
commands are issued

D.5 Address query command(?!)

Command ?! requests the address of the connected sensor. The sensor replies to the
query with the address, *a*. This command should only be used with one sensor on
the SDI-12 bus at a time.

D.6 Change address command(aAb!)

Multiple SDI-12 sensors can connect to a single SDI-12 terminal on a data logger.
Each device on a single terminal must have a uniqueaddress.

A sensor address is changed with command aAb!, where *a* is the current address
and *b* is the new address. For example, to change an address from *0* to *2*, the
command is 0A2!. The sensor responds with the new address *b*, which in this case
is 2.

NOTE	Only one sensor should be connected to a particular terminal at a time when changing addresses.

D.7 Start measurement commands(aM!)

A measurement is initiated with the M! command. The response to each command
has the form

atttn<CR><LF>, where

a = sensor address

ttt = time, in seconds, until measurement data is available. When the data is ready,
the sensor notifies the data logger, and the data logger begins issuing D commands.

n = the number of values returned when one or more subsequent D commands are
issued. For the aM! command, n is an integer from 0 to 9.

When the aM! is issued, the data logger pauses its operation and waits until either it
receives the data from the sensor or the time, *ttt*, expires. Depending on the scan
interval of the data logger program and the response time of the sensor, this may
cause skipped scans to occur. In this case make sure your scan interval is longer than
the longest measurement time (*ttt*).

Table D-2. Example aM! sequence	
0M!	The data logger makes a request to sensor 0 to start a measurement.
00352<CR><LF>	Sensor 0 immediately indicates that it will return two values within the next 35 seconds.
0<CR><LF>	Within 35 seconds, sensor 0 indicates that it has completed the measurement by sending a service request to the data logger.
0D0!	The data logger immediately issues the first Dcommand to collect data from the sensor.
0+.859+3.54<CR><LF>	The sensor immediately responds with the sensor address and the two values.

D.8 Stopping a measurement command

A measurement command (M!) is stopped if it detects a break signal. A break signal is sent by the data logger before most commands.

A concurrent measurement command (C!) is aborted when another valid command is sent to the sensor before the measurement time has elapsed.

D.9 Send data command (aD0! … aD9!)

The Send Data command requests data from the sensor. It is issued automatically with every type of measurement command (aM!, aMC!, aC!, aCC!). When the measurement command is aM! or aMC!, the data logger issues the aD0! command once a service request has been received from the sensor. When the data logger is issuing concurrent commands (aC! or aCC!), the Send Data command is issued after the required time has elapsed (no service request will be sent by the sensor). In transparent mode (SDI-12 transparent mode), the user asserts this command to obtain data.

Depending on the type of data returned and the number of values a sensor returns, the data logger may need to issue aD0! up to aD9! to retrieve all data. A sensor may return up to 35 characters of data in response to a D command that follows an M! or MC! command. A sensor may return up to 75 characters of data in response to a D command that follows a C! or CC! command.

Command: aD0! (aD1! … aD9!)

Response: *a<values><CR><LF>* or *a<values><CRC><CR><LF>*

where:

a = the sensor address

<values> = values returned with a polarity sign (+ or –)

<CR><LF> = terminates the response

<CRC> = 16-bit CRC code appended if data was requested with aMC! or aCC!.

D.10 SDI-12 transparent mode

System operators can manually interrogate and enter settings in probes using transparent mode. Transparent mode is useful in troubleshooting SDI-12 systems because it allows direct communication with probes. Data logger security may need to be unlocked before activating the transparent mode.

Transparent mode is entered while the PC is communicating with the data logger through a terminal emulator program. It is accessed through Campbell Scientific data logger support software or other terminal emulator programs. Data logger keyboards and displays cannot be used.

The terminal emulator is accessed by navigating to the **Datalogger** list in PC200W, the **Tools** list in PC400, or the **Datalogger** list in the **Connect** screen of LoggerNet.

Watch the video: SDI-12 Sensors | TransparentMode.

The following examples show how to enter transparent mode and change the SDI-12 address of an SDI-12 sensor. The steps shown in Changing an SDI-12 address are used with most Campbell Scientific data loggers. Changing an SDI-12 address — CR200(X) Series lists the steps used for CR200(X)-series dataloggers.

D.10.1 Changing an SDI-12 address

The example below was done with a CR1000, but the steps are only slightly different for CR1000X- series, CR300-series, CR6-series, CR800-series, and CR3000 dataloggers. For CR200(X)-series dataloggers, see Changing an SDI-12 address — CR200(X) Series.

1. Connect an SDI-12 sensor to the CR1000.
2. In **LoggerNet Connect**, under **Datalogger**, click **Terminal Emulator**. The terminal emulator window opens.
3. Under **Select Device**, located in the lower left side of the window, select the **CR1000** station.
4. Click **Open Terminal**.
5. Select **All Caps Mode**.
6. Press Enter until the data logger responds with the **CR1000>** prompt.
7. Type **SDI12** and press Enter.
8. At the **Select SDI12 Port** prompt, type the number corresponding to the control port where the sensor is connected and press Enter. The response **Entering SDI12 Terminal** indicates that the sensor is ready to accept SDI-12 commands.
9. To query the sensor for its current SDI-12 address, type **?!** and press Enter. The sensor responds with its SDI-12 address. If no characters are typed within 60 seconds, the mode is exited. In that case, simply type **SDI12** again, press Enter, and type the correct control port number when prompted.
10. To change the SDI-12 address, type **aAb!**, where **a** is the current address from the above step and **b** is the new address (see Figure D-1). Press Enter. The sensor changes its address and responds with the new address.
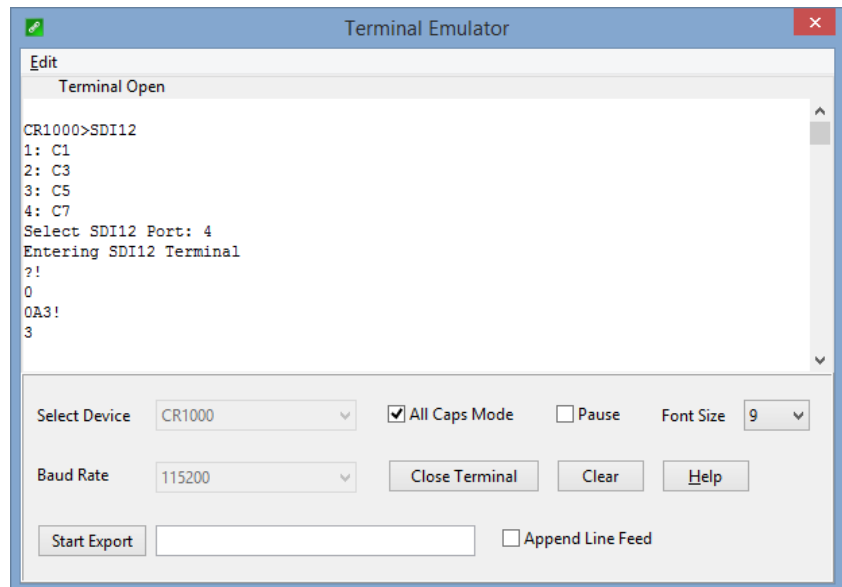11. To exit SDI-12 transparent mode, click **Close Terminal**.

Figure D-1. CR1000 example of using the SDI-12 transparent mode to change the SDI-12 address from 0 to 3. Sensor is connected to control port 1.

D.10.2 Changing an SDI-12 address — CR200(X) Series

1. Connect a single SDI-12 sensor to the CR200(X).
2. In **LoggerNet Connect**, under **Datalogger**, click **Terminal Emulator**. The terminal emulator window opens.
3. Under **Select Device**, located in the lower left side of the window, select the **CR200Series** station.
4. Click **Open Terminal**.
5. Select **All Caps Mode**.
6. Press Enter until the data logger responds with the **CR2XX>** prompt.
7. Type **SDI12** and press Enter.
8. The response **SDI12>** indicates that the sensor is ready to accept SDI-12 commands.
9. To query the sensor for its current SDI-12 address, type **?!** and press Enter. The sensor responds with its SDI-12 address. If no characters are typed within 60 seconds, the mode is exited. In that case, simply type **SDI12** again and press Enter.
10. To change the SDI-12 address, type **aAb!**, where **a** is the current address from the above step and **b** is the new address (see Figure D-2). Press Enter. The sensor changes its address and responds with the new address.
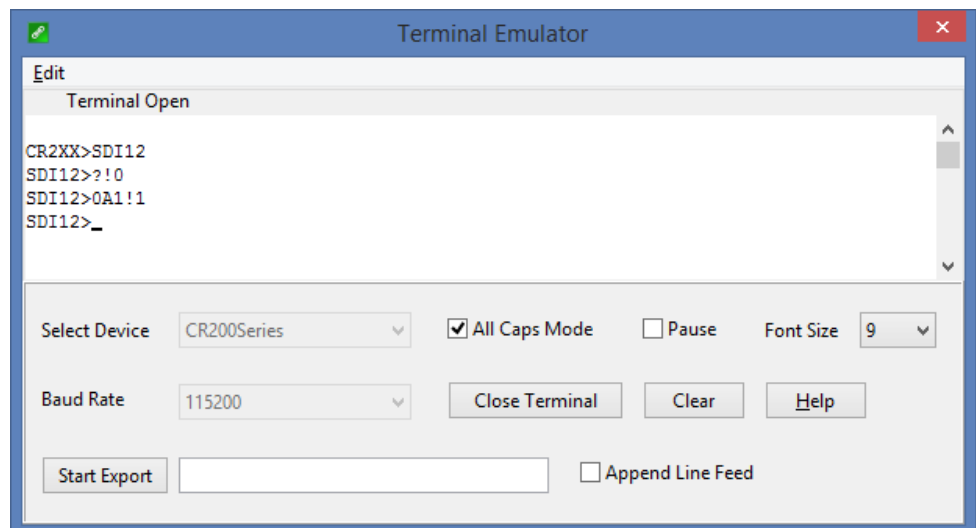11. To exit SDI-12 transparent mode, click **Close Terminal**.

Figure D-2. CR200(X) example of using the SDI-12 transparent mode to change the SDI- 12 address from 0 to 1

Appendix E. Sensor Element Calibration

The sensor elements are individually calibrated during manufacture. The manufacturer publishes a statement (see example below) as a description of and evidence of traceability of the calibration of the HygroVUE™10 sensor element.

Calibration Certification – **Digital Humidity- and Temperature Sensors**

SENSIRION
THE SENSOR COMPANY

Calibration Certification

Name and address of the manufacturer: Sensirion AG
Laubisruetistrasse 50
CH-8712 Switzerland

Description: Digital Humidity- and Temperature Sensors

- SHT1x
- SHT3x
- SHTC1
- STS21

- SHT2x
- SHT7x
- SHTW2
- STS3x

The above mentioned products are calibrated to meet the specifications according to the corresponding Sensirion data sheet. Each device is individually tested after its calibration.

Sensirion uses transfer standards for the calibration. These transfer standards are themselves subject to a scheduled calibration procedure. The calibration of the reference itself used for the calibration of the transfer standards is performed by an ISO/IEC 17025 accredited laboratory.

The accreditation body is full member of the International Laboratory Accreditation Cooperation (www.ilac.org). Calibration certificates issued by facilities accredited by a signatory to the ILAC Mutual Recognition Arrangement (MRA) are accepted by all signatories to the ILAC MRA.

This provides traceability of measurement to recognized national standards and to units of measurement realized at the "National Physical Laboratory" (NPL) or other recognized national standards laboratories like "Physikalisch-Technische Bundesanstalt" (PTB) or "National Institute of Standards and Technology" (NIST).

Staefa, February 2018

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Other Locations: Sales and support are provided in many other locations through an extensive network of international reps. For the full list, please visit **www.campbellsci.com/contact#dir**.

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