PRODUCT MANUAL



HygroVue[™]10

Digital Temperature and Relative Humidity Sensor



Revision: 04/2025 Copyright © 2019 – 2025 Campbell Scientific, Inc.





Please read first

About this manual

Please note that this manual was produced by Campbell Scientific Inc. primarily for the North American market. Some spellings, weights and measures may reflect this. In addition, while most of the information in the manual is correct for all countries, certain information is specific to the North American market and so may not be applicable to European users. Differences include the U.S. standard external power supply details where some information (for example the AC transformer input voltage) will not be applicable for British/European use. Please note, however, *that when a power supply adapter is ordered from Campbell Scientific it will be suitable for use in your country*.

Reference to some radio transmitters, digital cell phones and aerials (antennas) may also not be applicable according to your locality. Some brackets, shields and enclosure options, including wiring, are not sold as standard items in the European market; in some cases alternatives are offered.

Recycling information for countries subject to WEEE regulations 2012/19/EU



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, per The Waste Electrical and Electronic Equipment (WEEE) Regulations 2012/19/EU. Campbell Scientific 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 support, please contact Campbell Scientific, or your local agent.

Table of contents

1. Introduction	1
2. Precautions	1
3. Initial inspection	1
4. QuickStart	
5. Overview	5
6. Specifications	
6.1 Temperature measurement 6.2 Relative humidity measurement	
7. Installation	7
 7.1 Wiring to data logger 7.2 Data logger programming 7.3 CRBasic programming 7.4 Siting 7.5 Installation in a radiation shield 7.6 Mount the shield 	7 8 9 9 11 11
8. Operation	
 8.1 Sensor measurement 8.2 Measurements in programs with fast scan rates 8.3 Long cables 8.4 Power conservation 8.5 Measuring multiple SDI-12 sensors 	
9. Troubleshooting and maintenance	
9.1 Troubleshooting 9.2 Maintenance 9.3 Calibration	16 17 17
9.4 Sensor element replacement	

10. Attributions and references	20
Appendix A. Importing Short Cut code into CRBasic Editor	21
Appendix B. CRBasic example program	22
Appendix C. Environmental performance	24
C.1 Exposure to pollutants	24
C.2 Operating range of the RH element	24
C.3 Measurement below 0 °C	25
Appendix D. SDI-12 sensor support	26
D.1 SDI-12 command basics	26
D.1.1 Acknowledge active command (a!)	27
D.1.2 Send identification command (al!)	27
D.1.3 Start verification command (aV!)	28
D.1.4 Address query command (?!)	28
D.1.5 Change address command (aAb!)	28
D.1.6 Start measurement commands (aM!)	29
D.1.7 Start concurrent measurement commands (aC!)	29
D.1.8 Start measurement commands with cyclic redundancy check (aMC! and aCC	:!) 31
D.1.9 Stopping a measurement command	31
D.1.10 Send data command (aD0! aD9!)	32
D.1.11 Continuous measurement command (aR0! aR9!)	32
D.2 References	32
D.3 SDI-12 transparent mode	33
D.3.1 Changing an SDI-12 address	33
Appendix E. Sensor element calibration	

1. Introduction

The HygroVue[™]10 Temperature and Relative Humidity Sensor is designed for general meteorological and environmental applications. It is part of a range of HygroVue sensors. The HygroVue sensors feature a low maintenance design with a highly stable and accurate replaceable RH chip that will lower the total cost of deployment throughout a network. The HygroVue 10 uses the SDI-12 communications protocol to communicate with any SDI-12 recorder, simplifying wiring and programming. A cable termination option is available that allows the HygroVue 10 to connect to a Campbell Scientific Aspen 10 Edge Device.

2. Precautions

- READ AND UNDERSTAND the Safety section at the back of this manual.
- 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-data logger-getting-started-program-part-3 . *Short Cut* is an easy way to program your data logger to measure the sensor and assign data logger wiring terminals. *Short Cut* is available as a download on www.campbellsci.com . It is included in installations of *LoggerNet*, *RTDAQ*, and *PC400*.

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. 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.

Progress	Available Sense	ors and Devices		Selected Measureme	ents Available for Output
1. New/Open	hygr	×	Exact Match	Sensor	Measurement
2. Datalogger	CR1000X Ser	ies		 CR1000X Series 	
3. Sensors	V D Sensors			 Default 	BattV
4. Output Setup	v 🔄 Meteor	ological tive Humidity & Tem	perature		PTemp_C
5. Adv. Outputs	ГЛ	ygroVUE5/HygroVUE	E10 Digital Temper		
6. Output Select					
7. Finish					
		6 Hya	roVUE5/HygroVUE10 Digital	Temperature & Relative Humidity	Sensor (Versio — 🗆 🗙
Wiring		Bronor	rtios winter	interiperature of neutricine mannany	
Wiring Diagram		Prope	rues Wiring		
Wiring Text			SDI-12 Address	(0-9, A-Z, or a-z) 0	
				Temperature AirTC	Deg C V
				Relative Humidity RH	%
			HygroVL	JE5/HygroVUE10 Digital Tem	perature & Relative Humidity
	CB1000X Corris	-	Sensor		
	CRIDUUX Serie	<u></u>	The Hyg	roVUE5/HygroVUE10 is an S	DI-12 sensor. All SDI-12
		C	sensors therefor	you select will use the sam e must have different SDI-:	e port by default and 12 addresses. Refer to the
			instructi	ons in the sensor manual(s) for changing the SDI-12
			address SDI-12	. If you prefer to use separ: addresses, vou can do so b	v selecting separate ports on
			the Wiri	ng tab of the sensor form fo	or each of your SDI-12
			sensors.		

4. Click the **Wiring** tab to see how the sensor is to be wired to the data logger. The default control terminal for SDI-12 is **C1**. To change to another terminal, click the terminal name and select another terminal. Click **OK** after wiring the sensor.

HygroVUE5	5/HygroVUE10 Digi	tal Temperature & Relative Humidity Sensor (Version	n: 1.0) — 🗆	×
Properties	Wiring			
		HygroVUE5/HygroVUE10	CR1000X Series	
		Brown	12V	
		White	C1	
		Black	G	
		(if present), Blue	G	
		(if present), Grey	Not Connected	
		Click a CR1000X Series terminal nar HygroVUE5/HygroVUE10 Digital Tempe The HygroVUE5/HygroVUE10 is an SDI port by default and therefore must ha the sensor manual(s) for changing the instead of changing SDI-12 addresses tab of the sensor form for each of you	me to change a wire's location. rature & Relative Humidity Sensor -12 sensor. All SDI-12 sensors you select will use the same we different SDI-12 addresses. Refer to the instructions in s SDI-12 address. If you prefer to use separate ports t, you can do so by selecting separate ports on the Wiring ur SDI-12 sensors.	
		Note: An optional FillNAN parameter is	used in the resulting CRBasic SDI12Recorder instruction. A	,

- 5. Repeat steps three and four for other sensors you want to measure. Click Next.
- 6. In **Output Setup**, type the scan rate (5 seconds or longer), meaningful table names, and the **Data Output Storage Interval**. Click **Next**.

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 Sensor measurement (p. 13) and Measurements in programs with fast scan rates (p. 14) about alternate programming techniques.

Drogrocc			
1. New/Open	How often should the CR1000X Series measure its sensor(s)?	Seconds ~] (
2. Datalogger			
3. Sensors			
4. Output Setup	then stored in an output table. Two tables		
5. Adv. Outputs	are defined by default; up to 10 tables can	v lable	
6. Output Select	be added.		
7. Finish	<u>1</u> Hourly <u>2</u> Daily		
Wining	Table Name		
Wiring Diagram	Daily Delete T	able	0
Wiring Text	Data Output Storage Interval		
wining text	Makes 17280 measurements per output		
	interval based upon the chosen 1440	Minutes ~	0
	Advanced Outputs (all tables)		(
	Specify how often measurements are to be made and how often outputs multiple output intervals can be specified, one for each output table. By to send data to memory based on time. Select the Advanced Output opt based on one or more of the following conditions: time, the state of a fla measurement.	are to be stored. Note f default, an output table ion to send data to mem g, or the value of a	that is set up iory

7. Select the measurement and its associated output option.

Progress	Selected Measureme	ents Available for Outp	ut	Selected Mea	surements fo	Output			
1. New/Open	Sensor	Measurement	Average	1 Table1	2 Table2				
2. Datalogger	 CR1000X Series 		ETo	Sensor	Measurement	Processing	Output Label	Units	5
3. Sensors	 Default 	BattV	Maximum	HygroVUE5/H	AirTC	Average	AirTC_AVG	Deg C	
4. Output Setup	L.	PTemp_C	Minimum	HygroVUE5/H	RH	Sample	RH	%	
5. Adv. Outputs	 HygroVUE5/Hygro 	VU AirTC	Sample						
6. Output Select	- The	RH	StdDev						
7. Finish			Total						
			iotai						
Wiring			windvector						
Wiring Diagram									
Wiring Text									
				Z Edit	Rem	N/A			

- 8. Click **Finish** and save the program. Send the newly created program to the data logger if the data logger is connected to the computer.
- 9. If the sensor is connected to the data logger, check the output of the sensor in the data display in *LoggerNet*, *RTDAQ*, or *PC400* to make sure it is making reasonable measurements.

5. Overview

The HygroVue 10 sensor uses a single-chip element that incorporates both a temperature and a Relative Humidity (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 using SDI-12 to a data logger.

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

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

6. Specifications

Compatibility:	Fully SDI-12 V1.3-compliant digital output (verified with an SDI-12 Verifier (www.sdi-12-verifier.com 1).
	Compatible with SDI-12 V1.4 recorders including Campbell Scientific CR6, CR3000, CR1000X, CR800-series, CR300-series, and CR1000 data loggers.
	A cable termination option allows the HygroVue 10 to connect to an Aspen 10 Edge Device.
Sensor element:	Sensirion SHT35 derivative
Calibration traceability:	NIST and NPL standards. See Sensor element calibration (p. 36) 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 (0.7 in) at connector
Length:	180 mm (7.1 in), sensor only, without cable
Sensor body weight:	50 g (1.8 oz)
Weight:	250 g (8.8 oz) with 5 m (16.4 ft) cable
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 $<30 \ \mu$ m. 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.
Sensor cable connector:	M12, male, 4-pole, A-coded
EMC compliance:	Tested and conforms to IEC61326:2013
Calibration:	The sensor element is individually calibrated during manufacture.
Compliance documents:	View at www.campbellsci.com/hygrovue10 🗹

6.1 Temperature measurement

Operating range:	–40 to 70 °C
Accuracy*:	±0.2 °C (–40 to 70 °C) ±0.1 °C (20 to 60 °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 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)*:	±1.5% (0 to 80% RH) ±2% (80 to 100% RH)
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 Environmental performance (p. 24)

*The accuracy figures quoted are relative to factory standards.

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

7. Installation

If you are programming your data logger with *Short Cut* or are using an Aspen 10 Edge Device, skip Wiring to data logger (p. 7) and Data logger programming (p. 8). See QuickStart (p. 2) for a *Short Cut* tutorial. Refer to the Aspen 10 manual, available at www.campbellsci.com/aspen10 2, for information about using the Aspen 10 with the HygroVue 10.

7.1 Wiring to data logger	. 7
7.2 Data logger programming	. 8
7.3 CRBasic programming	. 9
7.4 Siting	. 9
7.5 Installation in a radiation shield	.11
7.6 Mount the shield	11

7.1 Wiring to data logger

The sensor has an industry-standard M12 connector for attaching the cable. The wiring of the sensor is shown in Table 7-1 (p. 8).

Table 7-1: Wire color, pin, function, and data logger connection							
Pin	Wire color	Wire function	Data logger connection terminal				
1	Brown	Power	12V				
2	White	SDI-12	C terminal or U terminal configured for SDI-12 ¹				
3, 4 ²	Black	Power ground	G				
	Clear	Shield	G				
¹ C or U terminals are automatically configured by the SDI-12 measurement instruction.							
² Both pin 3 and pin 4 are tied to ground, so either pin to ground works.							

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. Utilizing the SDI-12 address reduces the use of terminals on the data logger and allows sensors to be connected in a daisy-chain fashion that can minimize cable runs in some applications. (See Long cables [p. 14] 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 SDI-12 sensor support (p. 26) for detailed instructions.

7.2 Data logger programming

Short Cut is the best source for up-to-date programming code for Campbell Scientific data loggers. 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 QuickStart (p. 2). If you wish to import *Short Cut* code into *CRBasic Editor* to create or add to a customized program, follow the procedure in Importing Short Cut code into CRBasic Editor (p. 21). Programming basics for CRBasic data loggers are provided in the following section. A complete program example can be found in CRBasic example program (p. 22).

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 Sensor measurement (p. 13) and Measurements in programs with fast scan rates (p. 14) about alternate programming techniques.

7.3 CRBasic programming

A complete program example can be found in CRBasic example program (p. 22).

The **SDI12Recorder()** instruction is used to measure a HygroVue 10 configured for SDI-12 measurements. The **SDI12Recorder()** instruction sends a request to the sensor to make a measurement and then retrieves the measurement from the sensor. See Sensor measurement (p. 13) for more information.

For most data loggers, the **SDI12Recorder()** instruction has the following syntax:

```
SDI12Recorder(Destination, SDIPort, SDIAddress, "SDICommand", Multiplier, Offset,
FillNAN, WaitonTimeout)
```

Valid values for the **SDIAddress** are 0 through 9, a through z, and A through Z; alphabetical characters need to be enclosed in quotation marks (for example, "A"). Also, enclose the **SDICommand** in quotation marks, as shown. The **Destination** parameter must be an array. The required number of values in the array depends on the command; see Table 8-1 (p. 13).

FillNAN and WaitonTimeout are optional parameters (refer to *CRBasic Editor* help for more information).

7.4 Siting

The general EPA guidance for standard meteorological stations is to locate the sensor over an open, level area at least 9 m (29.5 ft) in diameter. The surface should be covered by short grass or the natural earth 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.

NOTE:

The connector at the base of the removable sensing element is susceptible to corrosion in locations where salt spray or corrosive gases are present. To protect the connector and avoid corrosion, Campbell Scientific recommends applying a small amount of high-vacuum grease around the pins of the connector. That type of grease is designed to have low levels of volatiles and to not outgas.

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 Attributions and references (p. 20) 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, the RAD10E or RAD14 unventilated or the TS100SS fan-aspirated solar radiation shield is used.

The white color 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 have a double-louvered design that offers improved sensor protection from insect intrusion and driving rain and snow. In addition, compared to shields of a similar appearance, the RAD shields have lower self-heating in bright sunlight combined with low wind speeds giving a better measurement. The RAD14 shield performs slightly better in these conditions than the smaller RAD10E shield. The RAD shields attach to a crossarm, mast, or user-supplied pipe with a 2.5 to 5.3 cm (1.0 to 2.1 inch) outer diameter.

The Apogee Instruments aspirated TS100SS shield can also be used where minimal solar errors and a fast speed of response is desired. A special adapter is available to allow the HygroVue 10 to fit within the shield. Refer for the documentation for the TS100SS shield for further installation instructions.

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

- Adjustable wrench (to suit 12 mm (1/2 in) 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 in) jaw size

7.5 Installation in a radiation 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 (p. 11). 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, by hand, the nut on the radiation shield gland until the sensor is held firmly in place. Ensure the gland tightens on the white body of the sensor, not the connector.
- 4. Use the large adjustable wrench to further tighten the gland by 1/2 to 1 turn. Do not overtighten the nut, as you risk damaging the sensor body and making service of the sensor more difficult in the future.



Figure 7-1. Cut away view shows HygroVue 10 insertion in a RAD shield

7.6 Mount the shield

- Attach the radiation shield to the tripod mast, crossarm, or tower leg using the supplied U-bolt or band clamp. See the following image for an example of shield mounting.
- 2. Connect the cable to the sensor.

3. Route the cable to the data logger or Aspen 10, 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 7-2. HygroVue 10 installed in a RAD10E radiation shield on a pole

8. Operation

8.1 Sensor measurement	.13
8.2 Measurements in programs with fast scan rates	.14
8.3 Long cables	.14
8.4 Power conservation	15
8.5 Measuring multiple SDI-12 sensors	15

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 making measurements are shown in Table 8-1 (p. 13). SDI-12 sensor support (p. 26) 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			
aM!, aC!, aR0!, aMC!, aCC!, aROC!	Temperature (°C), relative humidity (%)			
aM1!, aR1!, aMC1!, aRC1!	Dewpoint (°C) of the air			
aM3!, aR3!, aMC3!, aRC3!	Temperature (°C), relative humidity (%), dewpoint (°C), and vapor pressure (kPa)			

When entering the command in a CRBasic program, the address and command are entered as separate parameters. The SDI-12 command is entered as a string, excluding the address but including the terminator character (for example "M!").

When a measurement is initiated with the M! or C! commands, the sensor responds with the maximum time delay for measurement availability and the number of values to be returned. The delay is 1 second for this sensor. For the M! commands, Campbell Scientific data loggers interpret the response and automatically send one or more D! commands after the sensor indicates data is ready and writes it to the result variables. The whole measurement normally delays the data logger by about 400 milliseconds with the standard M! command.

The **C**! command differs as 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 internal clock. Note, this command must be entered as **RO** (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 canceled by powering down the sensor to reset it.

With the standard commands (M!, C!, and RO!), 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 measurement commands; see Table 8-1 (p. 13).

Dewpoint and vapor pressure are calculated using formulas 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 M!, C!, and R! instructions, but a cyclic redundancy check (CRC) is added that validates the data. Use of the checksum option is only normally necessary for long cable runs.

The factory-set SDI-12 address for the HygroVue 10 is 0. See Change address command (aAb!) (p. 28) for instructions on changing the SDI-12 address through the data logger. SDI-12 sensor support (p. 26) gives full details on 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 in the data logger. Code and measurements that need to run at higher speeds can run in the main scan.

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 meters (200 ft). Low power SDI-12 sensors, such as the HygroVue 10, have been used with longer cables up to 300 m (1000 ft). This model of sensor is normally only supplied with cables up to 10 m in length. If the cable is to be extended, follow these guidelines:

- Use low capacitance, low resistance, screened cable (as fitted by Campbell Scientific) to reach distances of several hundred meters.
- Ensure 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, while 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 μ A (50 μ A 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, battery power can be conserved 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 Change address command (aAb!) (p. 28) 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 "Statement of Product Cleanliness and Decontamination" form. Refer to the Assistance page for more information.

9.1 Troubleshooting	16
9.2 Maintenance	17
9.3 Calibration	. 17
9.4 Sensor element replacement	17

9.1 Troubleshooting

Table 9-1: Symptoms, possible causes and solutions					
Symptom	Possible cause	Solution			
		Recheck the sensor wiring.			
Temperature is reported as –9999 or NAN, and relative	This indicates a problem with the SDI-12	Check the voltage to the sensor is 12V with a digital voltage meter.			
humidity is reported as 0 or an unchanging value.	communications with the sensor.	Verify the sensor SDI-12 address matches the address entered for the SDI12Recorder() instruction.			
Inaccurate temperature or relative humidity is	Inadequate delay after	Verify the program is allowing a power-up time of at least 1.8 s.			
	if using SW12)	Clean the sensor tip with distilled water or replace it.			
reported.	been contaminated	Ensure the sensor is not installed too			
	Electrical interference	close to a radio transmitter or cell phone.			
	This indicates a fault with the sensor element itself or	Check the sensor element is properly plugged in with the correct orientation.			
Temperature and relative humidity read –99.999	communication between the sensor element and the	Check for water being present under the sensor element connector and			
	electronics in the sensor body.	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.

CAUTION:

The HygroVue 10 sensor body is sealed and filled with a potting compound to totally protect the electronics from any water ingress. This means there are no serviceable parts within the sensor body.

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 cleaner environments but can be higher in polluted air. Because it can be difficult to know what the sensor has been exposed to, and because the element is relatively inexpensive, Campbell Scientific recommends replacing the sensor element 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

Campbell Scientific offers a replacement temperature/RH element and cap for the HygroVue 10. The replacement element is only available from Campbell Scientific. It includes a small circuit board that is coated to ensure longer life at high humidity. A single row of four gold pins inserts into one side of an eight-way socket at the end of the sensor.

The replacement element must be correctly installed for the sensor to work properly. Follow these steps to correctly 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.

CAUTION:

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 cap by unscrewing it counter clockwise when looking towards the tip of the sensor.

CAUTION:

Only unscrew the filter cap. Attempting to pull the filter cap off the sensor may damage the filter cap.

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.



Figure 9-1. Correct fit of the 4-pin sensor element (side view)

- Grasp the sensor body to ensure you are at the same electrical potential as the element. Hold the edge of the circuit board between your fingertips and pull the element out of the socket. Store the old element in electrostatic protective packaging if you wish to retain it. (Please avoid pink colored electrostatic bags, as they can emit chemicals which change the calibration of the sensor.)
- 6. With the element removed, check for dirt and corrosion around the socket. Use a damp cloth to remove dirt or salts that might have collected.
- 7. Unpack the replacement element, avoiding static discharges to the element by making sure you touch the packaging before the element.
- 8. Hold the replacement element by the sides of the circuit board. The element has four gold pins. Carefully match the gold pins to a row of holes in the socket with the sensing module facing the socket center towards the empty row of holes (see Figure 9-1 [p. 18]). Gently push the pins down into the socket until they will not go in any further.
- 9. Before replacing the filter cap and turning on power to the sensor, double-check the element is seated correctly with the sensing module facing the socket center, towards the empty row of holes (see Figure 9-1 [p. 18]).

CAUTION:

Conditions that will cause the sensor to not work include an improperly oriented element, contamination, or water bridging the connections. The element may draw excessive power, possibly damaging the element, when powered under these conditions for more than a few seconds.

10. Screw the filter cap onto the sensor, ensuring it clears the sensor element. If the element appears too close to the filter cap, the element likely has been inserted in the incorrect orientation, or the element gold pins are bent. Screw the filter onto the thread and gently finger tighten.

CAUTION:

Only finger tighten the filter approximately 1/8th of a turn after 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.

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-SC77097/0000029.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

Short Cut creates a .DEF file that contains wiring information and a program file that can be imported into *CRBasic Editor*. By default, these files reside in the C:\campbellsci\SCWin folder.

Import *Short Cut* program file and wiring information into *CRBasic Editor*.

1. Create the *Short Cut* program, then save it. Click the *Advanced* tab then the *CRBasic Editor* button. Your program file will open in CRBasic with a generic name. Provide a meaningful name and save the CRBasic program. This program can now be edited for additional refinement.

NOTE:

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

- 2. To add the *Short Cut* wiring information into the new CRBasic program, open the .DEF file located in the C:\campbellsci\SCWin folder. Copy the wiring information found at the beginning of the .DEF file.
- 3. Go into the CRBasic program and paste the wiring information at the beginning of the program.
- In the CRBasic program, highlight the wiring information, right-click, and select Comment Block. This adds an apostrophe (') to the beginning of each of the highlighted lines, which instructs the data logger compiler to ignore those lines when compiling. The Comment Block feature is demonstrated at about 5:10 in the CRBasic | Features video .

Appendix B. CRBasic example program

This CR1000X program can be adapted for use with the CR6, CR3000, CR800-series, CR300-series, and CR1000 data loggers. For a CR200(X)-series program, see an older manual at www.campbellsci.com/old-manuals \Box .

```
CRBasic Example 1: CR1000X program measuring the HygroVue 10
'Program measures one HygroVue 10 sensor every 10 seconds and stores the
'average temperature and a sample of relative humidity every 10 minutes.
'Wiring Diagram
'==================
'HygroVue 10
' Wire
' Color Function CR1000X
 ----- ------
' Brown Power (12V) Battery +
'White SDI-12 signal C1/SDI-12
'Black 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
```

CRBasic Example 1: CR1000X program measuring the HygroVue 10

Scan(10,Sec,1,0)
 'HygroVue 10 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

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	24
C.2 Operating range of the RH element	24
C.3 Measurement below 0 °C	25

C.1 Exposure to pollutants

All capacitive sensors are susceptible to pollutants to some degree. The vapors 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 long periods 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 will recover.

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 Operating range of the RH element (p. 24).

C.2 Operating range of the RH element

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

when the sensor 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 to 105 °C at < 5% RH for 10 hours.
- 2. Then re-hydrate at 20 to 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 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 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 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

Serial Data Interface at 1200 baud (SDI-12) is a protocol developed to simplify sensor and data logger compatibility. Only three wires are necessary—serial data, ground, and 12 V. With unique addresses, multiple SDI-12 sensors can connect to a single SDI-12 terminal on a Campbell Scientific data logger.

This appendix discusses the structure of SDI-12 commands and the process of querying SDI-12 sensors. For more detailed information, refer to version 1.4 (January 2019) of the SDI-12 protocol, available at www.sdi-12.org

For additional information, refer to the SDI-12 Sensors | Transparent Mode And SDI-12 Sensors | Watch or Sniffer Mode Videos and the SDI-12 Sensors Troubleshooting Tips application note.

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 (p. 26).

Table D-1: Campbell Scientific sensor SDI-12 command and response sets					
Name ¹	Command	Response			
Acknowledge active	a!	a <cr><lf></lf></cr>			
Send identification	aI!	allccccccccmmmmmmvvvxxxxx <cr> <lf></lf></cr>			

Table D-1: Campbell Scientific sensor SDI-12 command and response sets					
Name ¹	Command	Response			
Start verification	aV!	atttn <cr><lf></lf></cr>			
Address query	?!	a <cr><lf></lf></cr>			
Change address	aAb!	b <cr><lf></lf></cr>			
Start measurement	aM! aM1!aM9!	atttn <cr><lf></lf></cr>			
Start measurement and request CRC	aMC! aMC1!aMC9!	atttn <cr> <lf></lf></cr>			
Start concurrent measurement	aC! aC1!aC9!	atttnn <cr><lf></lf></cr>			
Start concurrent measurement and request CRC	aCC! aCC1!aCC9!	atttnn <cr><lf></lf></cr>			
Send data	aDO!aD9!	a <values><cr><lf> or a<values><crc><cr><lf></lf></cr></crc></values></lf></cr></values>			
Continuous measurement	aR0!aR9!	a <values><cr><lf></lf></cr></values>			
Continuous measurement and request CRC	aRCO!aRC9!	a <values><crc><cr><lf></lf></cr></crc></values>			
¹ Information on each of these commands is given in the following sections.					

D.1.1 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.1.2 Send identification command (al!)

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. Source: *SDI-12: A Serial-Digital Interface Standard for Microprocessor-Based Sensors* (see References [p. 32]).

Command: aI!

```
Response: allcccccccmmmmmvvv<CR><LF>
```

Where

a = sensor address ll = SDI-12 version number (indicates compatibility) cccccccc = 8-character vendor identification mmmmmm = sensor model vvv = 3 characters specifying the sensor version (operating system) <CR><LF> = terminates the response

D.1.3 Start verification command (aV!)

The response to start verification (**aV**!) can include hardware diagnostics, but like the **aI**! command, the response is not standardized.

Command: aV!

```
Response: atttn<CR><LF>
```

Where

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

<*CR*><*LF*> = terminates the response

D.1.4 Address query command (?!)

Command **?!** requests an address of the connected sensor. The sensor responds 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.1.5 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 unique address.

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.1.6 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!** command is issued, the data logger pauses its operation and waits until either it receives 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. To avoid this, ensure the scan interval is greater than the longest measurement time (*ttt*).

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

D.1.7 Start concurrent measurement commands (aC!)

A concurrent measurement (**aC**!) command follows the same pattern as the **aM**! command with the exception that it does not require the data logger to pause its operation, and other SDI-12

sensors may take measurements at the same time. The sensor will not issue a service request to notify the data logger the measurement is complete. The data logger will issue the **aD0**! command during the next scan after the measurement time reported by the sensor has expired. To use this command, the scan interval should be 10 seconds or less. The response to each command has the form attin < CR > < LF >, where

a = the sensor address

ttt = time, in seconds, until the measurement data is available

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

See the following example. A data logger has three sensors wired into terminal **C1**. The sensors are addresses **X**, **Y**, and **Z**. The data logger will issue the following commands and receive the following responses:

Table D-3: Example aC! sequence	
XC !	The data logger makes a request to sensor X to start a concurrent measurement.
X03005 <cr><lf></lf></cr>	Sensor X immediately indicates it will have 5 (05) values ready for collection within the next 30 (030) seconds.
YC!	The data logger makes a request to sensor Y to start a concurrent measurement.
Y04006 <cr><lf></lf></cr>	Sensor Y immediately indicates it will have 6 (06) values ready for collection within the next 40 (040) seconds.
ZC!	The data logger makes a request to sensor Z to start a concurrent measurement.
Z02010 <cr><lf></lf></cr>	Sensor Z immediately indicates it will have 10 values ready for collection within the next 20 (020) seconds.
ZD0 !	After 20 seconds have passed, the data logger starts the process of collecting the data by issuing the first D command to sensor Z.
Z+1+2+3+4+5+6+7+8+9+10 <cr><lf></lf></cr>	Sensor Z immediately responds with the sensor address and the 10 values.

Table D-3: Example aC! sequence	
XD0 !	10 seconds later, after a total of 30 seconds have passed, the data logger starts the process of collecting data from sensor X by issuing the first D command.
X+1+2+3+4+5 <cr><lf></lf></cr>	The sensor immediately responds with the sensor address and the 5 values.
YDO !	Ten seconds later, after a total of 40 seconds have passed, the data logger starts the process of collecting data from sensor Y by issuing the first D command.
Y+1+2+3+4+5+6 <cr><lf></lf></cr>	The sensor immediately responds with the sensor address and the 6 values.

D.1.8 Start measurement commands with cyclic redundancy check (aMC! and aCC!)

Error checking is done by using measurement commands with cyclic redundancy checks (**aMC**! or **aCC**!). This is most commonly implemented when long cable lengths or electronic noise may impact measurement transmission to the data logger. When these commands are used, the data returned in response to **D**! or **R**! commands must have a cyclic redundancy check (CRC) code appended to it. The CRC code is a 16-bit value encoded within three characters appended before the <CR> <LF>. This code is not returned in the data table but is instead checked by the data logger as it comes. The code returned is based on the SDI-12 protocol. See the SDI-12 communication specification for version 1.4 (January 2019) available at www.sdi-12.org \Box to learn more about how the CRC code is developed.

D.1.9 Stopping a measurement command

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

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

D.1.10 Send data command (aD0! ... aD9!)

The send data command (**aD**!) requests data from the sensor. It is issued automatically with every type of measurement command (**aM**!, **aMC**!, **aC**!, **aCC**!). When the measurement command is a**M**! or a**MC**!, the data logger issues the **aDO**! command once a service request has been received from the sensor or the reported time has expired. 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 (see SDI-12 transparent mode [p. 33]), 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 **aDO**! up to **aD9**! to retrieve all data. A sensor may return up to 35 characters of data in response to an **aD**! command that follows an **aM**! or **aMC**! command. A sensor may return up to 75 characters of data in response to a **aD**! command that follows an **aC**! or **aCC**! command. Data values are separated by plus or minus signs.

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.1.11 Continuous measurement command (aR0! ... aR9!)

Sensors that are able to continuously monitor the phenomena to be measured can be read directly with the R! commands (R0! ... R9!). The response to the R! commands mirrors the Send Data command (aD0!). A maximum of 75 characters can be returned in the <*values* > part of the response to the R! command.

D.2 References

SDI-12 Support Group. 2017 "SDI-12: A Serial-Digital Interface Standard for Microprocessor-Based Sensors – Version 1.4." River Heights, Utah. https://sdi-12.org/specification 2.

D.3 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 computer 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 through Campbell Scientific *Device Configuration Utility* software.

Watch videos/sdi12-sensors-transparent-mode 🕨 from our website.

Data loggers from other manufacturers will also have a transparent mode. Refer to those manuals on how to use their transparent mode.

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 (p. 33) are used with most Campbell Scientific data loggers.

D.3.1 Changing an SDI-12 address

This example was done with a CR1000X, but the steps are only slightly different for Granite-series, CR6, CR800-series, and CR300-series data loggers.

- 1. Connect an SDI-12 sensor to the CR1000X.
- 2. Open Device Configuration Utility.
- 3. Under **Device Type**, type the data logger model and double-click on the model type. This example uses a CR1000X directly connected to the computer USB port.

4. Select the correct Communication Port and click Connect.



5. Click the Terminal tab.

Device Configuration Utility 2.22									—	×
File Backup Options Help No	w Version ★									
Device Type	Deployment	Logger Control	Data Monitor	Data Collection	File Control	Manage OS ★	Settings Editor	Terminal		
Q Search										
CR 1000										
CR 1000X Series										
CR300 Series										
CR3000										
CR6 Series										

6. Select All Caps Mode.

All Caps	Echo Input	Pause	Start Export	Send File	

7. Press Enter until the data logger responds with the data logger (CR1000X>) prompt.

Device Configuration Utili File Backup Options Hel	ty 2.22 Ip Ne	w Version ★								-	×
Device Type		Deployment	Logger Control	Data Monitor	Data Collection	File Control	Manage OS *	Settings Editor	Terminal		
Q Search	\otimes		-	6							
CR 1000	^	CR1000X:	>								
CR 1000X Series		<u> </u>									
CR300 Series											
CR3000											
CR6 Series											

- 8. Type SDI12 and press Enter.
- 9. At the **Select SDI12 Port** prompt, type the number corresponding to the control port where the sensor is connected and press **Enter**. In this example, the sensor is connected to C3. The

response **Entering SDI12 Terminal** indicates the sensor is ready to accept SDI-12 commands.

```
CR1000X>
CR1000X>SDI12
1: C1
2: C3
3: C5
4: C7
Select SDI12 Port: 2
```

10. 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.

?! 0

- To change the SDI-12 address, type aAb!, where a is the current address from the previous step and b is the new address. Press Enter. The sensor changes its address and responds with the new address. In the following example, the sensor address is changed from 0 to B.
 SDI12
 SDI12
 SDI12>0AB!B
- 12. To exit SDI-12 transparent mode, click Close Terminal.

NOTE:

The transparent mode for the Granite-series, CR6, CR3000, CR800-series, and CR300-series data loggers is similar to that shown for the CR1000X.

Appendix E. Sensor element calibration

The sensor elements are individually calibrated during manufacturing. The manufacturer provides a statement (see Figure E-1 [p. 36]) as both a description and proof of the HygroVue 10 sensor element's calibration traceability.

Calibration Certification – Digital Humidity- and T	SENSIRION THE SENSOR COMPANY	
Calibration Certification		
Name and address of the manufacturer:	Sensirion AG Laubisruetistrasse 50 CH-8712 Switzerland	
Description:	Digital Humidity- and Ten	nperature Sensors
	 SHT1x SHT3x SHTC1 STS21 	 SHT2x SHT7x SHTW2 STS3x
The above mentioned products are calibra Sensirion data sheet. Each device is indivi	ated to meet the specificat dually tested after its calib	ions according to the corresponding ration.
Sensirion uses transfer standards for the to a scheduled calibration procedure. The transfer standards is performed by an ISO	calibration. These transfe calibration of the reference /IEC 17025 accredited lab	er standards are themselves subject e itself used for the calibration of the oratory.
The accreditation body is full member (<u>www.ilac.org</u>). Calibration certificates isso Recognition Arrangement (MRA) are acce	of the International Lal ued by facilities accredited pted by all signatories to t	boratory Accreditation Cooperation d by a signatory to the ILAC Mutual he ILAC MRA.
This provides traceability of measuremer ment realized at the "National Physical Lal tories like "Physikalisch-Technische Bund nology" (NIST).	t to recognized national a poratory" (NPL) or other re esanstalt" (PTB) or "Natio	standards and to units of measure- ecognized national standards labora- nal Institute of Standards and Tech-
Staefa, February 2018		
Herhan let	Ver	2 te
Stephan Weber, Director	Volker	Born
Head of Quality Management, Sensirion A	G Head	of Quality Engineering, SensirionAG

Figure E-1. Calibration certificate

Limited warranty

Covered equipment is warranted/guaranteed against defects in materials and workmanship under normal use and service for the period listed on your sales invoice or the product order information web page. The covered period begins on the date of shipment unless otherwise specified. For a repair to be covered under warranty, the following criteria must be met:

1. There must be a defect in materials or workmanship that affects form, fit, or function of the device.

2. The defect cannot be the result of misuse.

3. The defect must have occurred within a specified period of time; and

4. The determination must be made by a qualified technician at a Campbell Scientific Service Center/ repair facility.

The following is not covered:

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

2. Batteries; and

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

Campbell Scientific regional offices handle repairs for customers within their territories. Please see the back page of the manual for a list of regional offices or visit www.campbellsci.com/contact to determine which Campbell Scientific office serves your country. For directions on how to return equipment, see Assistance.

Other manufacturer's products, that are resold by Campbell Scientific, are warranted only to the limits extended by the original manufacturer.

CAMPBELL SCIENTIFIC EXPRESSLY DISCLAIMS AND EXCLUDES ANY IMPLIED WARRANTIES OF

MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. Campbell Scientific hereby disclaims, to the fullest extent allowed by applicable law, any and all warranties and conditions with respect to the products, whether express, implied, or statutory, other than those expressly provided herein.

Campbell Scientific will, as a default, return warranted equipment by surface carrier prepaid. However, the method of return shipment is at Campbell Scientific's sole discretion. Campbell Scientific will not reimburse the claimant for costs incurred in removing and/or reinstalling equipment. This warranty and the Company's obligation thereunder is in lieu of all other warranties, expressed or implied, including those of suitability and fitness for a particular purpose. Campbell Scientific is not liable for consequential damage.

In the event of any conflict or inconsistency between the provisions of this Warranty and the provisions of Campbell Scientific's Terms, the provisions of Campbell Scientific's Terms shall prevail. Furthermore, Campbell Scientific's Terms are hereby incorporated by reference into this Warranty. To view Terms and conditions that apply to Campbell Scientific, Logan, UT, USA, see Terms and Conditions 1. To view terms and conditions that apply to Campbell Scientific offices outside of the United States, contact the regional office that serves your country.

Assistance

Products may not be returned without prior authorization. Please inform us before returning equipment and obtain a **return material authorization (RMA) number** whether the repair is under warranty/guarantee or not. See Limited warranty for information on covered equipment.

Campbell Scientific regional offices handle repairs for customers within their territories. Please see the back page of the manual for a list of regional offices or visit

www.campbellsci.com/contact 🗹 to determine which Campbell Scientific office serves your country.

When returning equipment, a RMA number must be clearly marked on the outside of the package. Please state the faults as clearly as possible. 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, when equipment is returned to Campbell Scientific, Logan, UT, USA, it is mandatory that a "Declaration of Hazardous Material and Decontamination" form be received before the return can be processed. If the form is not received within 5 working days of product receipt or is incomplete, the product will be returned to the customer at the customer's expense. For details on decontamination standards specific to your country, please reach out to your regional Campbell Scientific office.

NOTE:

All goods that cross trade boundaries may be subject to some form of fee (customs clearance, duties or import tax). Also, some regional offices require a purchase order upfront if a product is out of the warranty period. Please contact your regional Campbell Scientific office for details.

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.com 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

- Protect from over-voltage.
- Protect electrical equipment from water.
- Protect from electrostatic discharge (ESD).
- Protect from lightning.
- 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, 6 meters (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.
- Only use power sources approved for use in the country of installation to power Campbell Scientific devices.

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.

Internal Battery

- Be aware of fire, explosion, and severe-burn hazards.
- Misuse or improper installation of the internal lithium battery can cause severe injury.

• Do not recharge, disassemble, heat above 100 °C (212 °F), solder directly to the cell, incinerate, or expose contents to water. Dispose of spent batteries properly.

Use and disposal of batteries

- Where batteries need to be transported to the installation site, ensure they are packed to prevent the battery terminals shorting which could cause a fire or explosion. Especially in the case of lithium batteries, ensure they are packed and transported in a way that complies with local shipping regulations and the safety requirements of the carriers involved.
- When installing the batteries follow the installation instructions very carefully. This is to avoid risk of damage to the equipment caused by installing the wrong type of battery or reverse connections.
- When disposing of used batteries, it is still important to avoid the risk of shorting. Do not dispose of the batteries in a fire as there is risk of explosion and leakage of harmful chemicals into the environment. Batteries should be disposed of at registered recycling facilities.

Avoiding unnecessary exposure to radio transmitter radiation

• Where the equipment includes a radio transmitter, precautions should be taken to avoid unnecessary exposure to radiation from the antenna. The degree of caution required varies with the power of the transmitter, but as a rule it is best to avoid getting closer to the antenna than 20 cm (8 inches) when the antenna is active. In particular keep your head away from the antenna. For higher power radios (in excess of 1 W ERP) turn the radio off when servicing the system, unless the antenna is installed away from the station, e.g. it is mounted above the system on an arm or pole.

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.

WHILE EVERY ATTEMPT IS MADE TO EMBODY THE HIGHEST DEGREE OF SAFETY IN ALL CAMPBELL SCIENTIFIC PRODUCTS, THE CUSTOMER ASSUMES ALL RISK FROM ANY INJURY RESULTING FROM IMPROPER INSTALLATION, USE, OR MAINTENANCE OF TRIPODS, TOWERS, OR ATTACHMENTS TO TRIPODS AND TOWERS SUCH AS SENSORS, CROSSARMS, ENCLOSURES, ANTENNAS, ETC.

Global Sales and Support Network

A worldwide network to help meet your needs



Campbell Scientific Regional Offices

Australia

Garbutt, QLD Australia
61.7.4401.7700
info@campbellsci.com.au
www.campbellsci.com.au

Brazil

Location:São Paulo, SP BrazilPhone:11.3732.3399Email:vendas@campbellsci.com.brWebsite:www.campbellsci.com.br

Canada

Location:	Edmonton, AB Canada
Phone:	780.454.2505
Email:	dataloggers@campbellsci.ca
Website:	www.campbellsci.ca

China

Location:	Beijing, P. R. China
Phone:	86.10.6561.0080
Email:	info@campbellsci.com.cn
Website:	www.campbellsci.com.cn

Costa Rica

Location:	San Pedro, Costa Rica
Phone:	506.2280.1564
Email:	info@campbellsci.cc
Website:	www.campbellsci.cc

France

Location:	Montrouge, France
Phone:	0033.0.1.56.45.15.20
Email:	info@campbellsci.fr
Website:	www.campbellsci.fr

Germany

Location:Bremen, GermanyPhone:49.0.421.460974.0Email:info@campbellsci.deWebsite:www.campbellsci.de

India

Location:New Delhi, DL IndiaPhone:91.11.46500481.482Email:info@campbellsci.inWebsite:www.campbellsci.in

Japan

Location:Kawagishi, Toda City, JapanPhone:048.400.5001Email:jp-info@campbellsci.comWebsite:www.campbellsci.co.jp

South Africa

Location:	Stellenbosch, South Africa
Phone:	27.21.8809960
Email:	sales@campbellsci.co.za
Website:	www.campbellsci.co.za

Spain

Location:	Barcelona, Spain
Phone:	34.93.2323938
Email:	info@campbellsci.es
Website:	www.campbellsci.es

Thailand

Location:Bangkok, ThailandPhone:66.2.719.3399Email:info@campbellsci.asiaWebsite:www.campbellsci.asia

UK

Location:	Shepshed, Loughborough, UK
Phone:	44.0.1509.601141
Email:	sales@campbellsci.co.uk
Website:	www.campbellsci.co.uk

USA

Location:	Logan, UT USA
Phone:	435.227.9120
Email:	info@campbellsci.com
Website:	www.campbellsci.com