Sensor

TempVue™ 50

Precision Digital Water Temperature Sensor

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MONITORING
SINCE
1974

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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

The TempVue™50 represents the next generation of water-temperature measurement sensors.

Designed with the customer in mind, the TempVue 50 easily interfaces with Campbell Scientific or third-party data loggers. The housing protects the sensor, allowing it to be submerged in water. The TempVue 50 communicates with a data logger or RTU using the SDI-12 protocol.

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 TempVue 50 should be handled as a precision scientific instrument.
- Do not bend or damage the measurement tip of the TempVue 50 because this can affect the measurement quality and potentially damage the sensor.
- Do not modify or attempt to repair the TempVue 50 unit without consulting Campbell Scientific.
- This temperature probe meets UKCA and EU declarations of conformity, citing international standards applicable to the product.

3. Initial inspection

- Upon receipt of the TempVue 50, inspect the packaging and contents for damage. File damage claims with the shipping company.
- Immediately check package contents against the shipping documentation. Contact Campbell Scientific about any discrepancies.

- Table 3-1 (p. 2) shows the components typically shipped with the TempVue 50.

Table 3-1: TempVue 50 components			
Component	Quantity	Description	Image
TempVue 50	1	Measures water temperature	
Quick deploy guide	1	Provides siting, mounting, and wiring information	
Calibration sheet	1	Calibration values are unique to individual sensors.	

- Accessories and replacement parts are listed on the web site product page (see www.campbellsci.com/tempvue50 ☑).

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 shows using **Short Cut** to program the TempVue 50.

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 TempVue 50. You can also locate the sensor in the **Sensors** > **Temperature** folder. Double click the sensor model and output. Type the correct **SDI-12 Address** (default is 0) or **Modbus Address** (default is 1). The temperature defaults to degree C. This can be changed by clicking the **Temperature** box and selecting one of the other options.
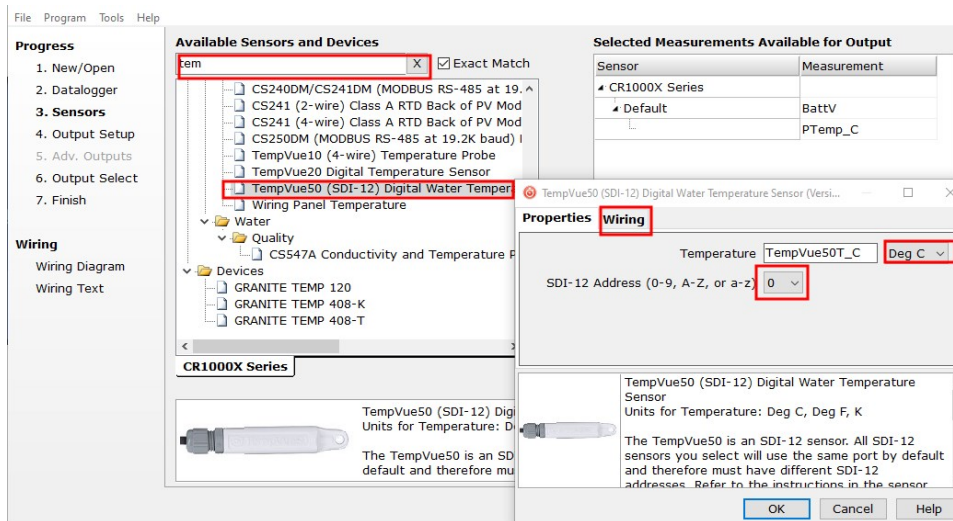
4. Click on the **Wiring** tab. Click **OK** after wiring the sensor.
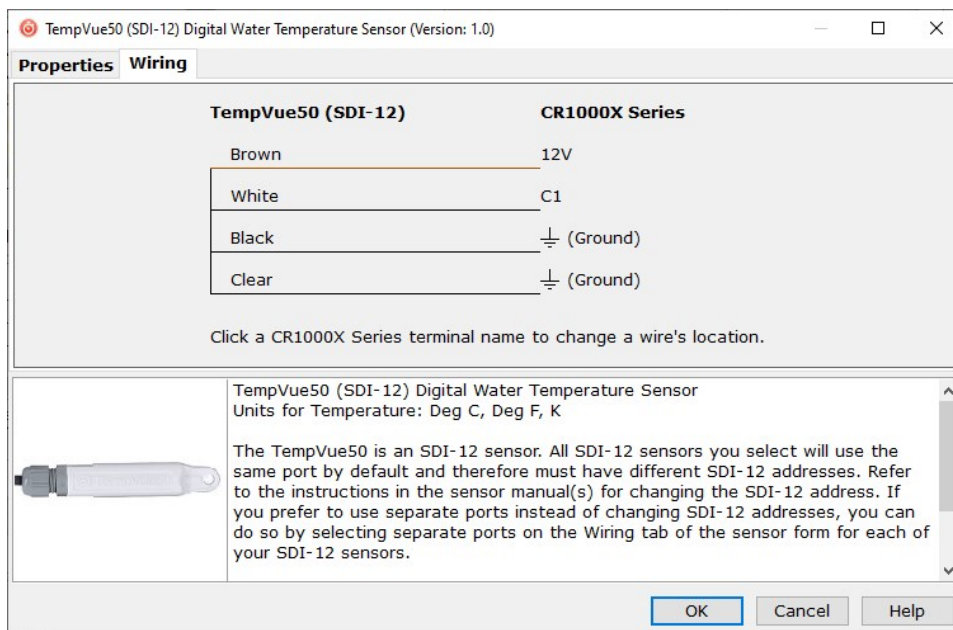
5. Repeat steps three and four for other sensors you want to measure. Click **Next**.

6. In **Output Setup**, type the scan rate, a meaningful table name, and the **Data Output Storage Interval**.

7. Select the measurement and its associated output option.

8. Click **Finish** and save the program. If the data logger is connected to the computer, send the program just created to the data logger.

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 TempVue 50 consists of a highly accurate band gap sensor enclosed in a water-tight housing. A loop at the top of the housing allows for pulling through conduit and attaching in the desired location. It is capable of fitting through tight bends including standard 1-inch conduit with an 8-inch bend radius. The TempVue 50 has an uncertainty of 0.1 °C for the range of –5 to +40 °C and a time constant of less than 35 seconds. This probe can be submerged in water to depths of up to 100 meters (328 ft).

Figure 5-1. TempVue 50

Features:

- Maintains high measurement stability over both time and temperature
- Incredibly easy to install or remove for calibration checks
- Highly durable, providing sensor element protection in even the harshest environmental conditions
- SDI-12 version directly connects to a Campbell Scientific Aspen 10 Edge Device
- Compatible with the A151 vented junction box.

- Compatible with any SDI-12 data logger/controller including Campbell Scientific GRANITE series, CR6, CR1000X, CR800 series, CR300 series, CR3000, and CR1000
- Allows for cable length adjustments without the need for calibration changes

6. Specifications

Sensor description:	Band gap sensor mounted to a circuit board
Measurement uncertainty:	0.1 °C (–0.5 to +40 °C)
Temperature measurement range:	–40 to +60 °C
Time constant:	<35 seconds
Resolution:	Two decimal places (0.01 °C)
Voltage range:	6 to 16 VDC
Average current:	150 µA
Signal type/output:	Digital output SDI-12 version 1.4
Maximum depth:	100 m (328 ft)
Default SDI-12 address:	0
Probe diameter:	1.7 cm (0.67 in)
Probe length:	9.5 cm (3.75 in)
Compliance:	View documents at:
⌧ C€ UK CA ⚠	www.campbellsci.com/tempvue50 ↗

7. Installation

If you are programming your data logger with *Short Cut* or are using the Aspen 10 Edge Device, skip Wiring (p. 7) and Programming (p. 7). See QuickStart (p. 2) for a *Short Cut* tutorial. Refer to the Aspen 10 manual, available at www.campbellsci.com/aspen10 ↗, for information about using the Aspen 10 with the TempVue 50.

7.1 Wiring

Table 7-1 (p. 7) provides connections to Campbell Scientific data loggers. Connect the wires in the order shown in the table.

Table 7-1: SDI-12 wire color, function, and data logger connection		
Wire color	Wire function	Data loggerconnection
White	SDI-12 signal	**C**, **SDI-12**, or CR6 **U** terminal configured for SDI-12[1]
Brown	Power	12V
Black	Power ground	G
Clear	Shield	G
[1]**U** and **C** terminals are automatically configured by the measurement instruction.		

If multiple SDI-12 sensors are connected to a data logger, Campbell Scientific recommends using separate terminals when possible. However, multiple SDI-12 sensors can connect to the same data logger control (**C**) or universal (**U**) terminal. Each must have a unique SDI-12 address. Valid addresses are 0 through 9, a through z, and A through Z.

For CR6 and CR1000X data loggers using SDI-12, triggering conflicts may occur when a companion terminal is used for a triggering instruction such as `TimerInput()`, `PulseCount()`, or `WaitDigTrig()`. For example, if this product is connected to **C3** on a CR1000X, **C4** cannot be used in the `TimerInput()`, `PulseCount()`, or `WaitDigTrig()` instructions.

Wire color	Function	Data logger[1] connection
Yellow	RS-485 A-	**C** (odd)
Blue	RS-485 B+	**C** (even)
Brown	12 VDC	12V
Black	Power and signal ground	G
Gray (if present)	Ground	G
Clear	Shield	⏚ (earth ground)

7.2 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. 15). Programming basics for CRBasic data loggers are provided in the following section.

7.2.1 CRBasic programming

Downloadable example programs are available at www.campbellsci.com/downloads/tempvue50-example-program ⬀.

The SDI12Recorder() instruction is used to measure a TempVue 50. The SDI12Recorder() instruction sends a request to the sensor to make a measurement and then retrieves the measurement from the sensor. See SDI-12 sensor measurements (p. 9) 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. 9].

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

7.3 Installation in water

A weighting system should be added or the TempVue 50 should be secured to a submerged object such as a piling. The cable is often routed through in a conduit to protect it. A loop at the top of the housing allows for pulling through conduit and attaching in the desired location. The TempVue 50 is capable of fitting through tight bends including standard 1-inch conduit with an 8-inch bend radius.

8. Operations

8.1 SDI-12 sensor measurements

The TempVue 50 responds to the SDI-12 commands shown in Table 8-1 (p. 9). The most recent 5760 measurements (one day worth) are stored in memory to be used to return statistical data. The memory buffer is emptied at power up. All temperatures are returned with two decimal places. Because of the internal measurement frequency, Campbell Scientific recommends measurement scans of 15 seconds or more.

The Campbell Scientific data logger follows the SDI-12 protocol and pauses its operation after sending the M! command then waits until either it receives a response from the sensor, or the sensor timeout expires. A C! command follows the same pattern as an M! command with the exception that it does not require the data logger to pause its operation until the values are ready. Rather, the data logger picks up the data with the D! command on the next pass through the program. Another measurement request is then sent so that data is ready on the next scan. The R0! command directly reads the sensor measurements and outputs all of its values.

> **NOTE:**
> SDI-12 sensor support (p. 16) describes the SDI-12 commands. Additional SDI-12 information is available at www.sdi-12.org ↗.

Table 8-1: SDI-12 command list

Commands[1]	Values returned or function
*a*R0!, *a*M!, or *a*C!	Temperature (°C)
*a*R1!, *a*M1!, or *a*C1!	Temperature (°F)

Table 8-1: SDI-12 command list	
Commands[1]	Values returned or function

*a*M2!, or *a*C2!	1. Temperature (°C)
	2. 60 s average temperature (°C)
	3. Minimum temperature (°C)[2]
	4. Maximum temperature (°C)[2]
	5. Average temperature (°C)[2]
	6. Measurement period (sec)
	7. Error flag, where
	    0 = No error
	    1 = Suspect reading
	    2 = Error reading
	    4 = Sensor stuck
	    8 = Sensor error

*a*M3!, or *a*C3!	1. Temperature (°F)
	2. 60 s average temperature (°F)
	3. Minimum temperature (°F)[2]
	4. Maximum temperature (°F)[2]
	5. Average temperature (°F)[2]
	6. Measurement period (sec)
	7. Error flag, where
	    0 = No error
	    1 = Suspect reading
	    2 = Error reading
	    4 = Sensor stuck
	    8 = Sensor error

*a*I!	*a*14CampbellTempVu50 SN=*nnnnn* Where, *nnnnn* = serial number
*a*V!	1. Hardware revision 2. Software revision 3. Uptime in seconds 4. Supply voltage

Table 8-1: SDI-12 command list	
Commands[1]	Values returned or function

*a*XLOADOS *rrrrr* CPU: *TEMPVUE_OS_Vn.nn.xobj*! where
 	
   rrrrr= baud rate; valid baud rates are 1200, 2400, 4800, and 9600
 	
   TEMPVUE_OS_Vn.nn.xobj = OS name
	Sends the new OS to the sensor; refer to Updating the operation system (OS) using XLOADOS SDI-12 command (p. 11)

*a*XHELP	Display a helpful description of the SDI-12 commands
[1]*a* is the SDI-12 address. In the `SDI12Recorder()` CRBasic instruction, the command parameter does not include the SDI-12 address because the address is a separate parameter. [2]The minimum, maximum, and average temperature values are over the measurement period.	

8.2 Updating the operation system (OS) using XLOADOS SDI-12 command

The SDI-12 extended command **XLOADOS!** sends the new operating system (OS) to the sensor.

> **NOTE:**
> Only the CR6, CR1000X, and CR300-series data loggers are compatible with the **XLOADOS!** functionality.

Verify that the data logger has been updated to the latest OS to ensure compatibility.

If a compatible data logger is not available to update the sensor, send the sensor to the factory to have Campbell Scientific update the OS. A returned material authorization (RMA) and completion of the "Statement of Product Cleanliness and Decontamination" form are required. Refer to the page near the end of this manual for more information.

The data loggers need the following OS versions:

- CR6: OS 11 or newer
- CR1000X: OS 5.0 or newer
- CR300 series: OS 10.05 or newer

The **XLOADOS!** OS update process requires access to the data logger terminal. Campbell Scientific *Device Configuration Utility* is recommended.

Although this update may be performed remotely, if the sensor is not communicating with the data logger, it must first be power cycled to regain communication and accept the new OS.

1. Download the update file from the Campbell Scientific website and run the self-extracting executable. The extraction takes only a moment, and a dialog box will indicate that the OS file has been saved on the computer in the C:\Campbellsci\Lib\OperatingSystems directory.

2. Upload the OS to the data logger CPU drive using *Device Configuration Utility*.

    a. Connect to the data logger.

    b. Open the **File Control** tab.

    c. Click **Send** and select the OS file from the **C:\Campbellsci\Lib\OperatingSystems** directory. File type may need to be changed to **All Files (*.*)** for the OS file to show up on the list.

    d. Verify that the file is now on the data logger CPU drive.

3. Connect the sensor to the data logger digital and power terminals. Note the terminal to which the sensor is connected.

4. Open a terminal interface to the data logger. Press Enter twice within the terminal window to get a command prompt.
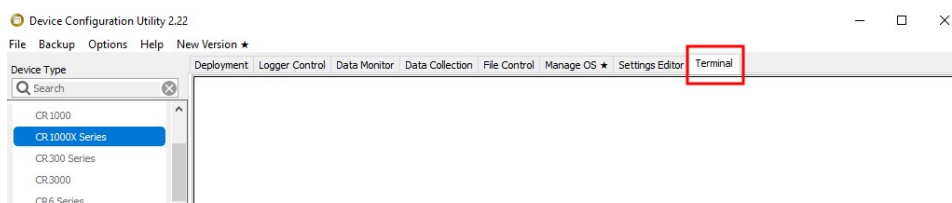
5. Within the terminal, run the following commands:

    a. Type **SDI12** at the prompt and then enter the corresponding number assigned to the digital terminal to which the sensor is connected.

    b. Identify the SDI-12 address of the sensor by typing **?!** at the prompt.

    c. Verify that the responding sensor is the TempVue 50 that you want to update by using the SDI-12 verify command **aI!**.

6. Send the OS to the sensor with the **XLOADOS!** extended command in the following format:

```
<SDI-12 address>XLOADOS <baud rate> CPU:<OS name>!
```

> **NOTE:**
> A baud rate of 9600 is typically used. CR300-series data loggers are case sensitive, and the file name must match the name used in the command. The **All Caps** checkbox on the bottom will need to be unchecked to allow lowercase letters.

7. When the OS update is complete, the file size, bytes sent, and the word **SUCCESS** are displayed. For example:

```
file size 117500, bytes sent 117304SUCCESS
```

8. Verify that the OS was updated with the verify command **aV!**, followed by the **aD0!** command to read the results.

9. Maintenance and troubleshooting

> **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 Maintenance

The TempVue 50 requires minimal maintenance. Periodically check cabling for proper connections, signs of damage, and possible moisture intrusion.

Ensure the TempVue 50 probe is clean and free of dirt or any soiling by wiping carefully with a lint free cloth and warm soapy water.

9.2 Troubleshooting

Symptom: Temperature is NAN, –INF, –9999, –273

Verify wiring of sensor to the data logger; cross-reference data logger program or the measurement system wiring diagram.

Symptom: Incorrect Temperature

Check the cable for signs of damage and possible moisture intrusion.

Symptom: Unstable Temperature

Make sure the shield and ground wires are connected to data logger ground, and the data logger is properly grounded.

10. References

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

WMO, 2021. *Instruments and Observing Methods, Generic Automatic Weather Station (AWS) Tender Specifications.*. World Meteorological Organization, Report 136, Geneva, Switzerland.

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)

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.

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.

4. 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. 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.

▌B.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 B-1 (p. 16).

Table B-1: Campbell Scientific sensor SDI-12 command and response sets		
Name[1]	Command	Response
Acknowledge active	a!	a<CR><LF>
Send identification	aI!	allcccccccccmmmmmmvvvxxx...xx <CR><LF>

Table B-1: Campbell Scientific sensor SDI-12 command and response sets		
Name[1]	Command	Response
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 concurrent measurement	aC! aC1!...aC9!	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>
[1] Information on each of these commands is given in the following sections.		

B.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.

B.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. 25]).

Command: aI!

Response: *allcccccccccmmmmmmmvvvxxx...xx<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)

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

B.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

B.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.

B.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.

B.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 that the scan interval is greater than the longest measurement time (*ttt*).

Table B-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 **D** command to collect data from the sensor.
`0+.859+3.54<CR><LF>`	The sensor immediately responds with the sensor address and the two values.

B.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 that 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 *atttn<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 B-3: Example aC! sequence	
XC!	The data logger makes a request to sensor X to start a concurrent measurement.
X03005<CR><LF>	Sensor X immediately indicates that 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>	Sensor Y immediately indicates that 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>	Sensor Z immediately indicates that 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>	Sensor Z immediately responds with the sensor address and the 10 values.
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>	The sensor immediately responds with the sensor address and the 5 values.

Table B-3: Example aC! sequence	
YD0!	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>	The sensor immediately responds with the sensor address and the 6 values.

B.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! 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 version 1.4 (January 2019) available at www.sdi-12.org ↗ to learn more about how the CRC code is developed.

B.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.

B.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 aM! or aMC!, the data logger issues the aD0! 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. 22]), 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 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!**.

B.2 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. 23) are used with most Campbell Scientific data loggers.

B.2.1 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, 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**.
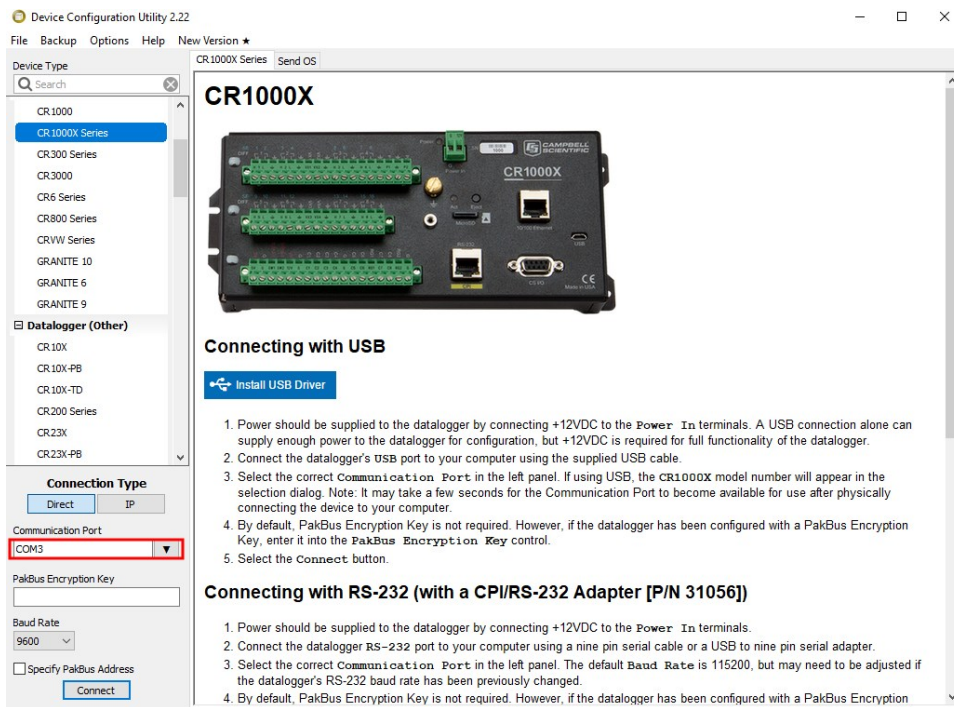
5. Click the **Terminal** tab.
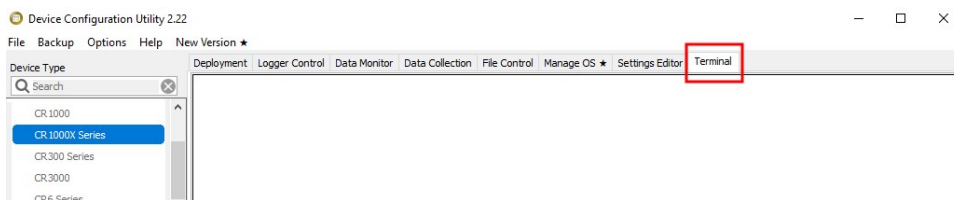
6. Select **All Caps Mode**.
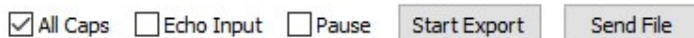
7. Press **Enter** until the data logger responds with the data logger (**CR1000X>**) prompt.
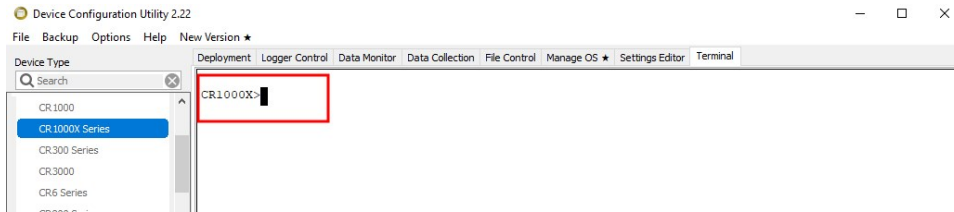
8. Type **SDI12** and press Enter.

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 that 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
```

11. 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>0AB!B
```

12. To exit SDI-12 transparent mode, click **Close Terminal**.

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

B.3 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 ↗.

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.

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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 ⬀. 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.

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