Product Manual

Sensor

WindSonic4

Two-Dimensional Sonic Anemometer with SDI-12 Output

Revision: 01/2022

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RELIABLE SINCE 1974 MONITORING

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1. Introduction

The WindSonic4 is a two-dimensional ultrasonic anemometer for measuring wind speed and wind direction. It provides an alternative to traditional mechanical cup and vane or propeller and vane anemometers. Unlike mechanical anemometers, the WindSonic4 has no moving parts that need to be periodically replaced—minimizing routine maintenance costs.

The WindSonic4 outputs an SDI-12 signal.

> NOTE:
> This manual provides information only for CRBasic data loggers. For retired Edlog data logger support, see an older manual at www.campbellsci.com/old-manuals.

2. Precautions

- READ AND UNDERSTAND the Safety section at the back of this manual.
- The WindSonic4 is not recommended for conditions where rime, ice, or horizontal snow will occur. It is not heated.
- The WindSonic4 is a precision instrument. Please handle it with care.
- If the WindSonic4 is to be installed at heights over 2 m (6 ft), be familiar with tower safety and follow safe tower climbing procedures.
- DANGER—Use extreme care when working near overhead electrical wires. Check for overhead wires before mounting the WindSonic4 or before raising a tower.
- The black outer jacket of the cable is Santoprene® rubber. This compound was chosen for its resistance to temperature extremes, moisture, and UV degradation. However, this jacket will support combustion in air. It is rated as slow burning when tested according to U.L. 94 H.B. and will pass FMVSS302. Local fire codes may preclude its use inside buildings.

3. Initial inspection

- Upon receipt of the WindSonic4, 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.
- The model number and cable length are printed on a label at the connection end of the cable. Check this information against the shipping documents to ensure the expected product and cable length are received.

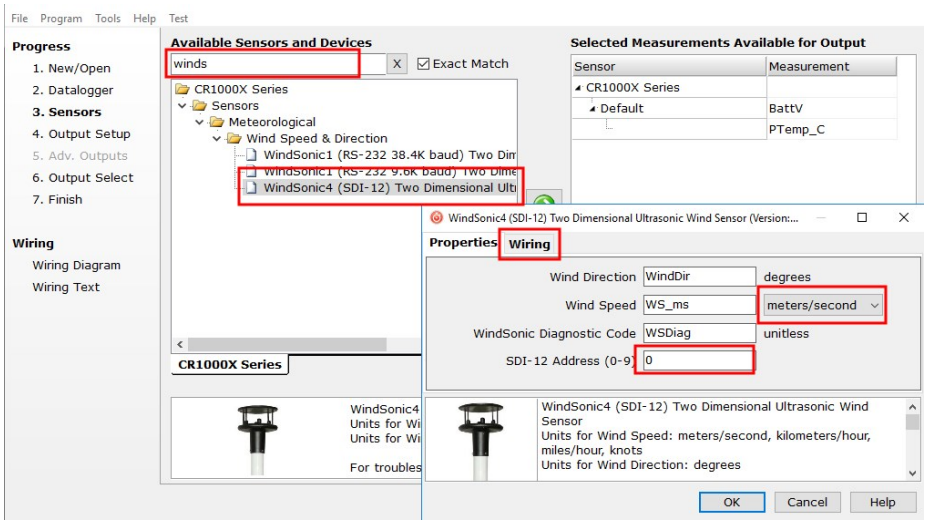
4. QuickStart

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***.

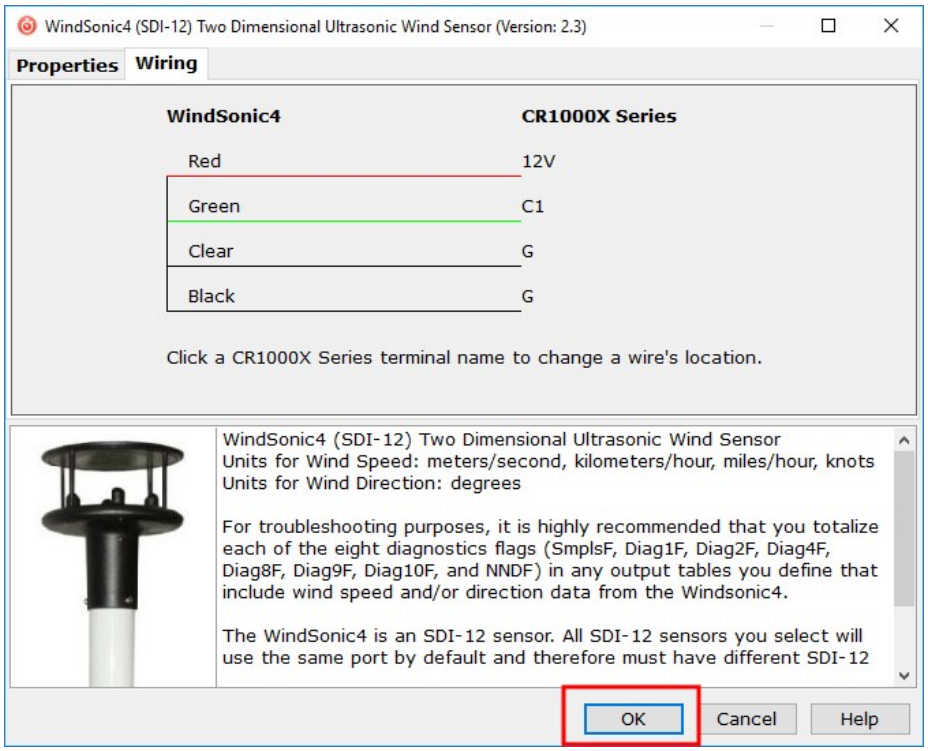
The following procedure also shows using ***Short Cut*** to program the WindSonic4.

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 WindSonic1 or locate the sensor in the **Sensors** > **Meteorological** > **Wind Speed & Direction** folder. Double-click the **WindSonic4 (SDI-12) Two Dimensional Ultrasonic Wind Sensor**. The wind speed defaults to meters per second. This can be changed by clicking the **Wind Speed** box and selecting one of the other options. Type the correct **SDI-12 Address**; default is 0.

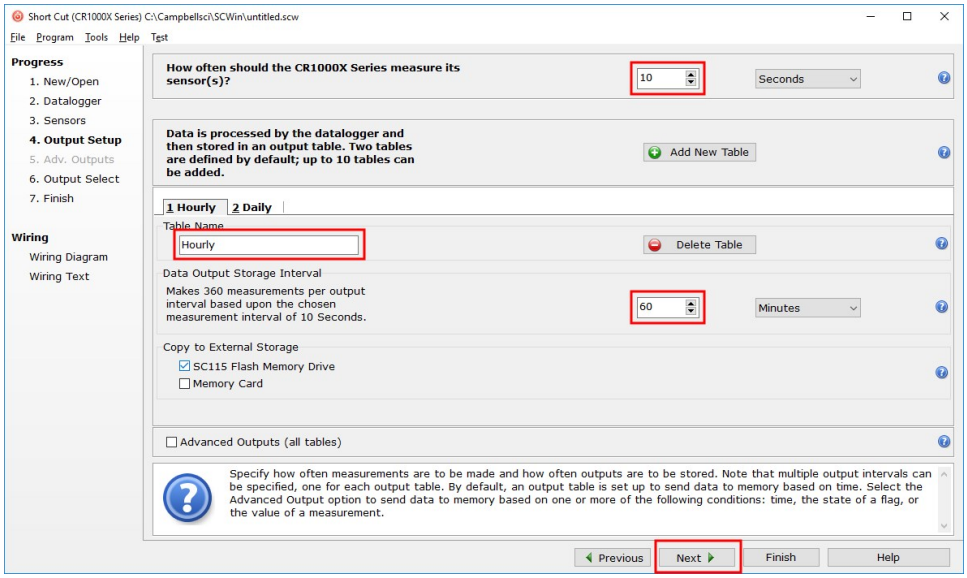


4. Click the Wiring tab to see how the sensor is to be wired to the data logger. Click **OK** after wiring the sensor.

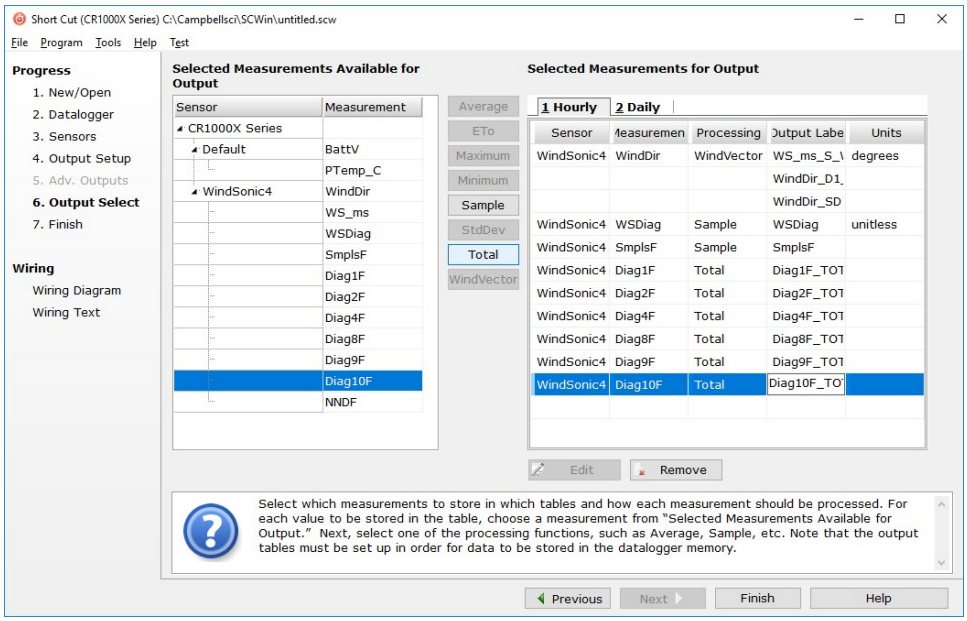


5. Repeat steps 3 and 4 for other sensors.

6. In **Output Setup**, type the scan rate, meaningful table names, and **Data Output Storage** Interval. Click **Next**.



7. Select the measurement and its associated output option.



8. Click **Finish** and save the program. Send the 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 data display in ***LoggerNet***, ***RTDAQ***, ***PC400***, or ***PC200W*** to make sure it is making reasonable measurements.

5. Overview

The WindSonic4 is manufactured by Gill Instruments, Ltd. It is an ultrasonic anemometer for measuring wind direction and wind speed. Two pairs of orthogonally oriented transducers sense horizontal wind. The transducers bounce the ultrasonic signal from a hood, minimizing the effects of transducer shadowing and flow distortion.

The WindSonic4 outputs data using the SDI-12 interface, which is compatible with all contemporary data loggers. SDI-12 is a three-wire digital interface standard used by processor-based sensors and digital recording devices.

The WindSonic4 includes a user-specified cable to interface to a Campbell Scientific data logger. A serial cable (WINDSONICRCBL-L) is available for interfacing a WindSonic4 to a computer running the manufacturer's computer support software. The cable and software are used during troubleshooting. A copy of this computer support software is available at www.gill.co.uk/main/software.html. WindView is used for WindSonic4 anemometers with serial numbers of 0810001 or greater, and WindCom is used for WindSonic4 anemometers with serial numbers that are less than 0810001.

Features:

- Low maintenance—no moving parts significantly reduces maintenance cost and time
- Minimum detectable wind speed of 0.01 meters per second
- Compatible with Campbell Scientific CRBasic data loggers: CR6, CR1000X, CR800 series, CR300 series, CR3000, and CR1000

6. Specifications

Output signal:	SDI-12 version 1.3; address factory set to 0
Output variables:	wind direction, wind speed, and diagnostic or u_x, u_y, and diagnostic
Measurement frequency:	40 Hz block averaged to a programmable output frequency, factory set to 1 Hz
Current drain:	<12 mA @ 12 V
Operating temperature:	–35 to 70 °C
Storage temperature:	–40 to 80 °C

Dimensions:	142 x 160 mm (5.6 x 6.3 in)
Weight:	500 g (1.1 lb)
Operating humidity:	<5% to 100% RH

6.1 Wind direction

Operating range:	0 to 359° (no dead band)
Accuracy:	±3°
Output resolution:	1°

6.2 Wind speed

Operating range:	0 to 60 m/s
Accuracy:	±2% @ 12 m/s
Output resolution:	0.01 m/s

7. Installation

If you are programming your data logger with ***Short Cut***, skip WindSonic4 wiring (p. 6) and Data logger programming (p. 7). ***Short Cut*** does this work for you. See QuickStart (p. 2) for a ***Short Cut*** tutorial.

7.1 WindSonic4 wiring

The WindSonic4 interfaces to a Campbell Scientific data logger using SDI-12 (Table 7-1 (p. 7)).

Table 7-1: WindSonic4 to data logger connections

Description	Color	Data logger
SDI-12 Data	Green	C, SDI-12, U configured for SDI-12[1]
SDI-12 Power	Red	12V
SDI-12 Reference	Black	G
Shield	Clear	G

[1]U and C terminals are automatically configured by the measurement instruction for Campbell Scientific CR6 data logger.

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. Each SDI-12 sensor connected to the same terminal must have a unique SDI-12 address. The factory-set address for the WindSonic4 is 0. Possible addresses are a number from 0 to 9. Using unique SDI-12 addresses 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. At a 1 Hz measurement rate, a maximum of four WindSonic4s can be measured by a data logger.

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 WindSonic4 is connected to C3 on a CR1000X, C4 cannot be used in the `TimerInput()`, `PulseCount()`, or `WaitDigTrig()` 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. 14). Programming basics for CRBasic data loggers are

provided in the following section. Downloadable example programs are available at www.campbellsci.com/downloads/windsonic4-program-examples.

7.2.1 CRBasic programming

The WindSonic4 updates the SDI-12 output at a frequency of 1 Hz. The `SDI12Recorder()` CRBasic instruction programs the data loggers to measure the WindSonic4. This instruction sends a request to the sensor to make a measurement and then retrieves the measurement from the sensor. For the most data loggers, the `SDI12Recorder()` instruction has the following syntax:

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

For the `SDIAddress`, alphabetical characters need to be enclosed in quotes (for example, "A"). Also enclose the `SDICommand` in quotes as shown. Typically, either the `"R0!"` or `"R1!"` SDI-12 command is used to retrieve data from the WindSonic4. The `SDI12Recorder()` `Destination` parameter needs to be a variable array with three elements in order to hold all three outputs from the sensor (see Table 7-2 (p. 8)).

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

Table 7-2: WindSonic4 SDI-12 commands and data format option

SDI-12 command	Output	Units	Format
`R0!`, `M!`, `RC!`, or `MC!`	wind direction	degrees	Option 0: Compass polar coordinate system
	wind speed	m/s	
	status	unitless	
`R1!`, `M1!`, `R1C!`, or `M1C!`	u_x wind	m/s	Option 1: Orthogonal right hand coordinate system
	u_y wind	m/s	
	status	unitless	

See SDI-12 measurement details (p. 10) for more information.

7.3 Siting

Locate the WindSonic4 away from obstructions such as trees and buildings. The distance between wind sensors and the nearest obstruction should be ten times the height of the obstruction. If it is necessary to mount the WindSonic4 on the roof of a building, the height of the

sensor, above the roofline, should be at least 1.5 times the height of the building. See Siting references (p. 12) for a list of references that discuss siting wind direction and speed sensors.

7.4 Mount the sensor

Mount the WindSonic4 using the WindSonic Mounting Pipe Kit, which consists of an aluminum mounting tube, three pan truss screws, CM220 Right Angle Mounting bracket, two U-bolts, and four nuts.

1. Thread the connector end of the cable through the mounting tube; start at the end without the three threaded holes.
2. Attach the female mating connector on the cable to the male mating connector located on the bottom of the WindSonic4.
3. Secure the WindSonic4 to the mounting tube using the three pan-head screws.
4. Attach the mounting tube to a crossarm using the the CM220 Right Angle Mounting bracket, U-bolts, and nuts (see FIGURE 7-1 (p. 9)).
5. Mount the crossarm to the tripod or tower.
6. Orient the WindSonic4 so that the colored North marker arrows point to True North (see FIGURE 7-1 (p. 9)). See Determining True North and sensor orientation (p. 15) for more information.

FIGURE 7-1. WindSonic4 mounted on a crossarm

7. Route the sensor cable along the underside of the crossarm to the tripod or tower, and to the instrument enclosure.
8. Secure the cable to the crossarm and tripod or tower using cable ties.

8. Operation

This section discusses the following:

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8.2 SDI-12 measurement details 10
8.3 Long cables 11

8.1 Sensor configuration

To mimic a mechanical anemometer, the WindSonic4 output frequency must match the data logger scan frequency. The factory setting for the WindSonic4 is 1 Hz, which is 1 output per second. The data output frequency of the WindSonic4 cannot be changed.

8.2 SDI-12 measurement details

Table 7-2 (p. 8) lists SDI-12 commands and output formats. The WindSonic4 typically uses an **R0!** or **R1!** command. When the data logger issues an **R0!** or **R1!** command, the WindSonic4 immediately begins transmitting the most current wind measurements to the data logger. After receiving the **R0!** or **R1!** command, it takes the WindSonic4 approximately 190 milliseconds ±10 milliseconds to transmit the data.

When using an **M!** or **M1!** command, the data logger waits for the time specified by the sensor, sends the **D!** command, pauses its operation, and waits until either it receives the data from the sensor or the sensor timeout expires. If the data logger receives no response, it will send the command a total of three times, with three retries for each attempt, or until a response is received. The **M!** or **M1!** command will take slightly longer to retrieve the data because of the additional handshaking required. For all practical purposes, a data logger can measure up to four WindSonic4s at 1 Hz.

The **R0C!**, **R1C!**, **MC!**, and **MC1!** commands are the same as the **R0!**, **R1!**, **M!**, and **M1!** commands, but a cyclic redundancy check (CRC) is performed that validates the data. Use of the checksum option is only necessary for long cable runs.

NOTE:
This section briefly describes using the SDI-12 commands. For additional SDI-12 information, refer to SDI-12 sensor support (p. 19). A complete list of SDI-12 commands supported by the WindSonic4 is available in the Gill WindSonic manual at www.gill.co.uk/products/anemometer/windsonic.htm.

8.3 Long cables

Although the SDI-12 standard specifies the maximum total cable length to be 61 m (200 ft), the WindSonic4 can have cable lengths up to 90 m (300 ft). Digital data transfer eliminates offset 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.

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 at the end of this manual for more information.

9.1 Troubleshooting

The WindSonic4 outputs a status code (Table 9-1 (p. 12)) along with each wind direction and speed measurement. The data logger program can filter out data when the status code is not 00. If the WindSonic4 is not powered, not connected, is using the wrong COM port/SDI-12 address, or has missed a sample, the wind direction and speed measurement will be NaN. The program can filter out these values and report the number of good samples that were used in computing the online statistics. If the total number of good samples is less than 98% of the expected samples, send the WindSonic4 to the factory for repair (see Assistance).

Table 9-1: Status codes

Code	Status	Comment
00	Okay	All okay
01	Axis 1 failed	Insufficient samples, possible path obstruction
02	Axis 2 failed	Insufficient samples, possible path obstruction
04	Both axes failed	Insufficient samples, possible path obstruction
08	NVM error	Nonvolatile Memory checksum failed
09	ROM error	Read Only Memory checksum failed
10	Maximum gain	Questionable wind measurements

9.2 Maintenance

There are no user-serviceable parts on the WindSonic4. Keep the transducer paths clear of any obstructions.

> **CAUTION:**
> When clearing the transducer paths, do not remove or damage the rubber caps on the transducers.

Use a cloth and mild detergent to gently clean the transducers.

> **CAUTION:**
> Do not use solvents and avoid scratching or damaging the rubber caps.

If the WindSonic4 is damaged, fails to output data, or sends a nonzero status number (Table 9-1 (p. 12)), return it to Campbell Scientific for repair (see Assistance).

10. Siting references

The following references give detailed information on siting wind direction and wind speed sensors.

EPA, 1987: *On-Site Meteorological Program Guidance for Regulatory Modeling Applications*, EPA-450/4-87-013, Office of Air Quality Planning and Standards, Research Triangle Park, NC, 27711.

EPA, 1989: *Quality Assurance Handbook for Air Pollution Measurements System*, Office of Research and Development, Research Triangle Park, NC, 27711.

The State Climatologist, 1985: *Publication of the American Association of State Climatologists: Height and Exposure Standards, for Sensors on Automated Weather Stations*, vol. 9, No. 4.

WMO, 1983: *Guide to Meteorological Instruments and Methods of Observation*, World Meteorological Organization, No. 8, 5th 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 the *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. After saving the *Short Cut* program, click the **Advanced** tab then the **CRBasic Editor** button. A program file with a generic name will open in CRBasic. 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 it created.

2. To add the *Short Cut* wiring information into the new CRBasic program, open the .DEF file located in the C:\campbellsci\SCWin folder, and copy the wiring information, which is at the beginning of the .DEF file.
3. Go into the CRBasic program and paste the wiring information into it.
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. Determining True North and sensor orientation

The orientation of the WindSonic4 north arrow markers is found by reading a magnetic compass and applying the site-specific correction for magnetic declination; where the magnetic declination is the number of degrees between true north and magnetic north. Obtain the magnetic declination for a specific site from a USGS map, local airport, or through a NOAA web calculator (Online magnetic declination calculator (p. 17)). A general map showing magnetic declination for the Conterminous United States is shown in FIGURE B-1 (p. 15).

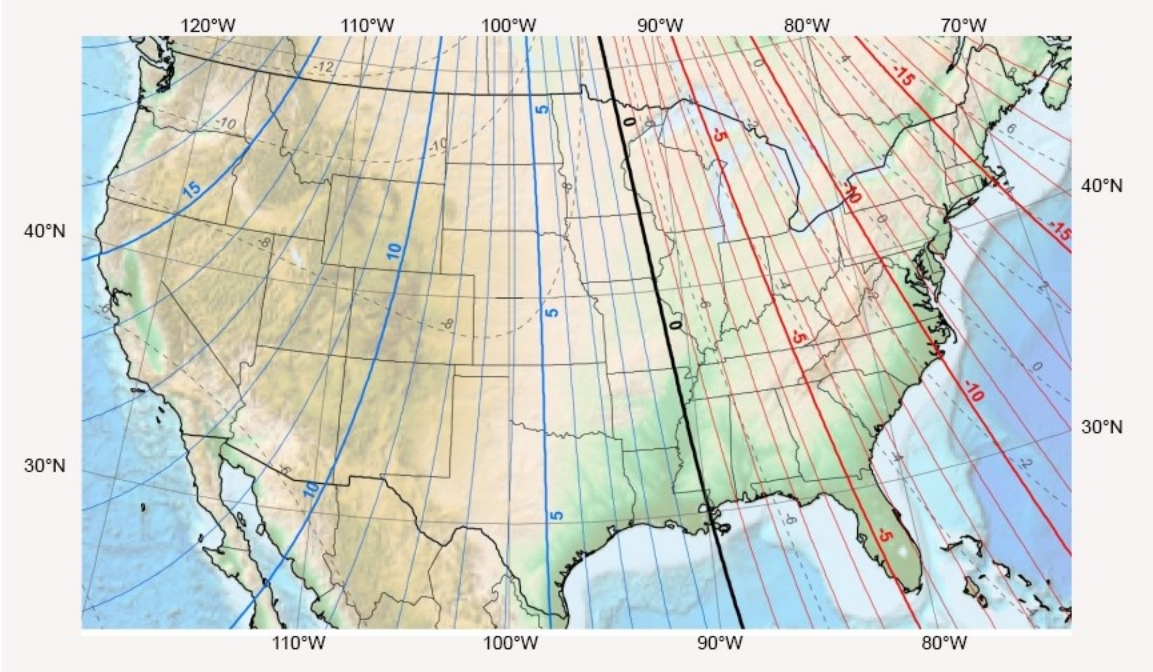


FIGURE B-1. Magnetic declination for the conterminous United States (2015)

Declination angles east of True North are considered negative, and are subtracted from 360 degrees to get True North as shown FIGURE B-2 (p. 16) (0° and 360° are the same point on a compass). Declination angles west of True North are considered positive, and are added to 0 degrees to get True North as shown in FIGURE B-3 (p. 16).

For example, the declination for Longmont, CO (10 June 2006) is 9.67°, thus True North is 360° – 9.67°, or 350.33° as read on a compass. Likewise, the declination for McHenry, IL (10 June 2006) is –2.68°, and True North is 0° – (–2.68°), or 2.68° as read on a compass.

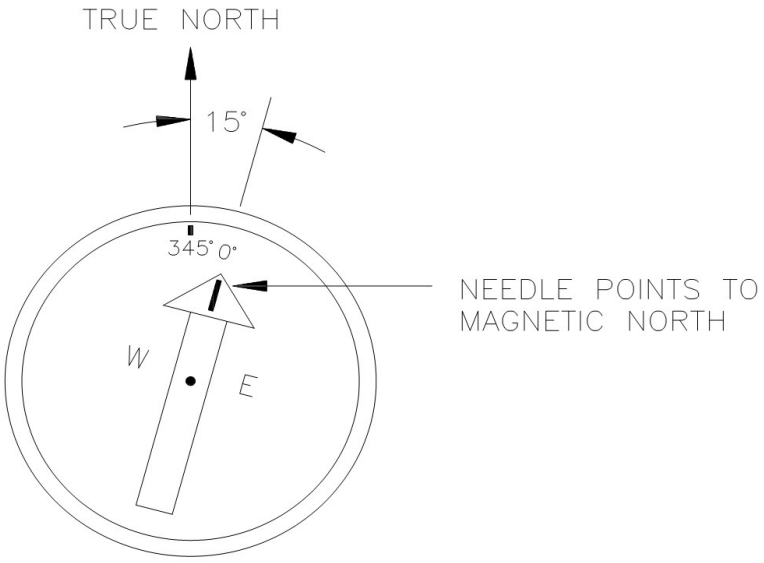


FIGURE B-2. A declination angle east of True North (positive) is subtracted from 360 (0) degrees to find True North

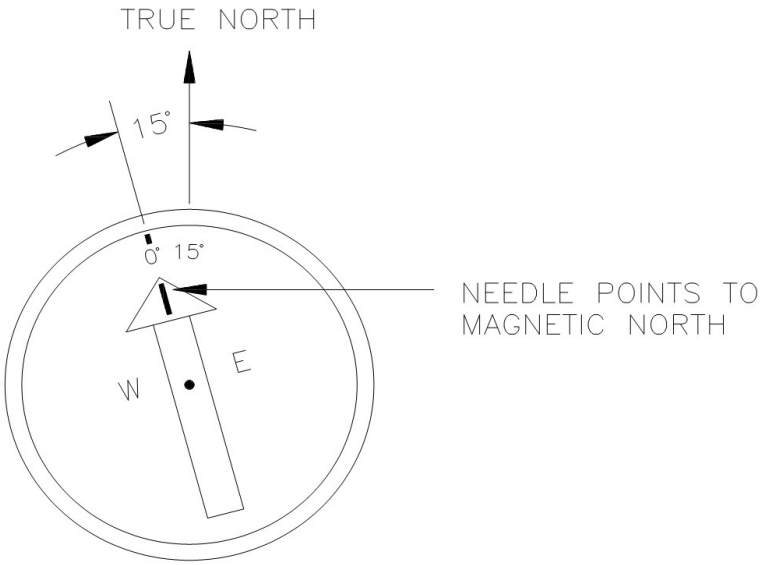


FIGURE B-3. A declination angle west of True North (negative) is subtracted from 0 (360) degrees to find True North

B.1 Online magnetic declination calculator

The magnetic declination web calculator published by NOAA's Geophysical Data Center is available at www.ngdc.noaa.gov/geomag-web. This web page calculates declination based on the latitude and longitude. You can look up your site's latitude and longitude by entering the **Zip Code** or the **Country** and **City**, and then clicking the **Get & Add Lat/Lon** button (FIGURE B-4 (p. 17)). Click the **Calculate** button to get the magnetic declination.

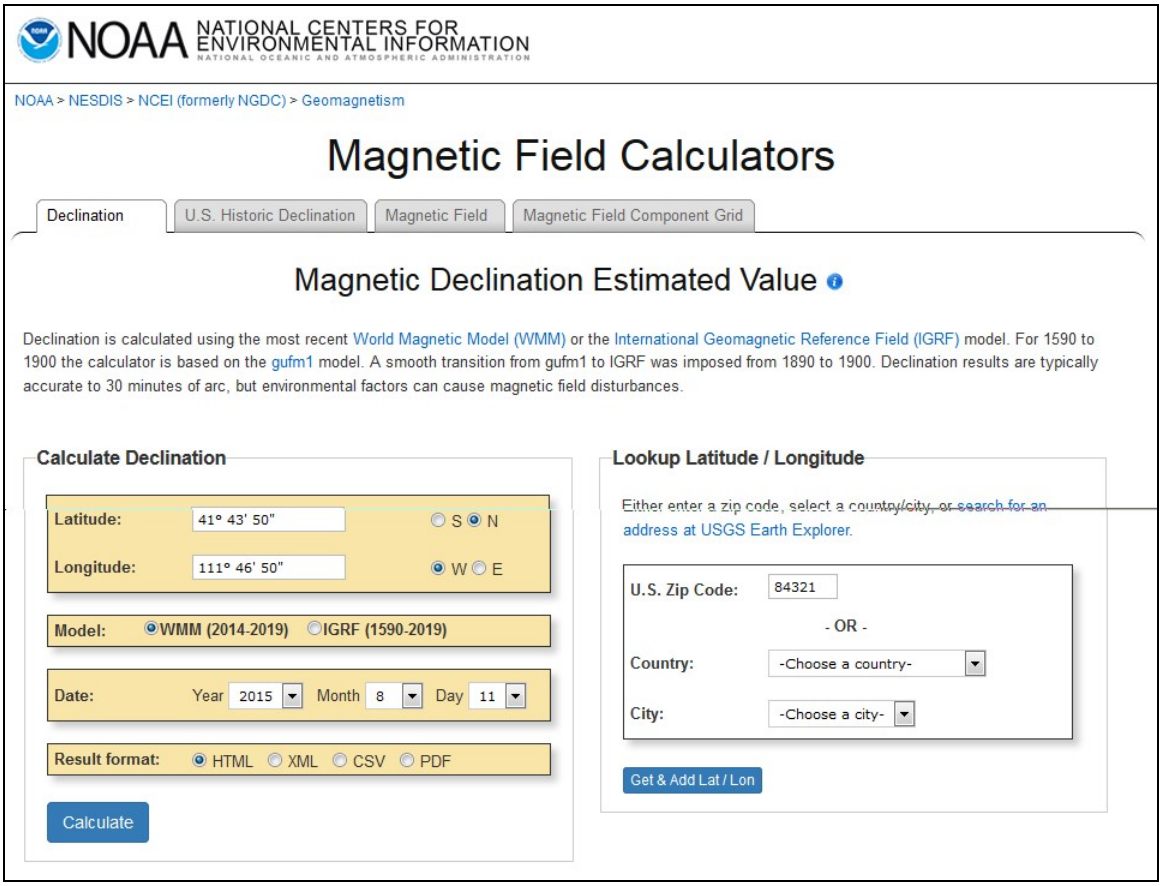


FIGURE B-4. NOAA web calculator

FIGURE B-5 (p. 18) shows that the calculated declination for Logan, UT is 11.78 degrees (11 August 2015). The declination for Utah is positive (east of north), so True North for this site is 360 – 11.78, or 348.22 degrees. The annual change is 6 minutes west per year.

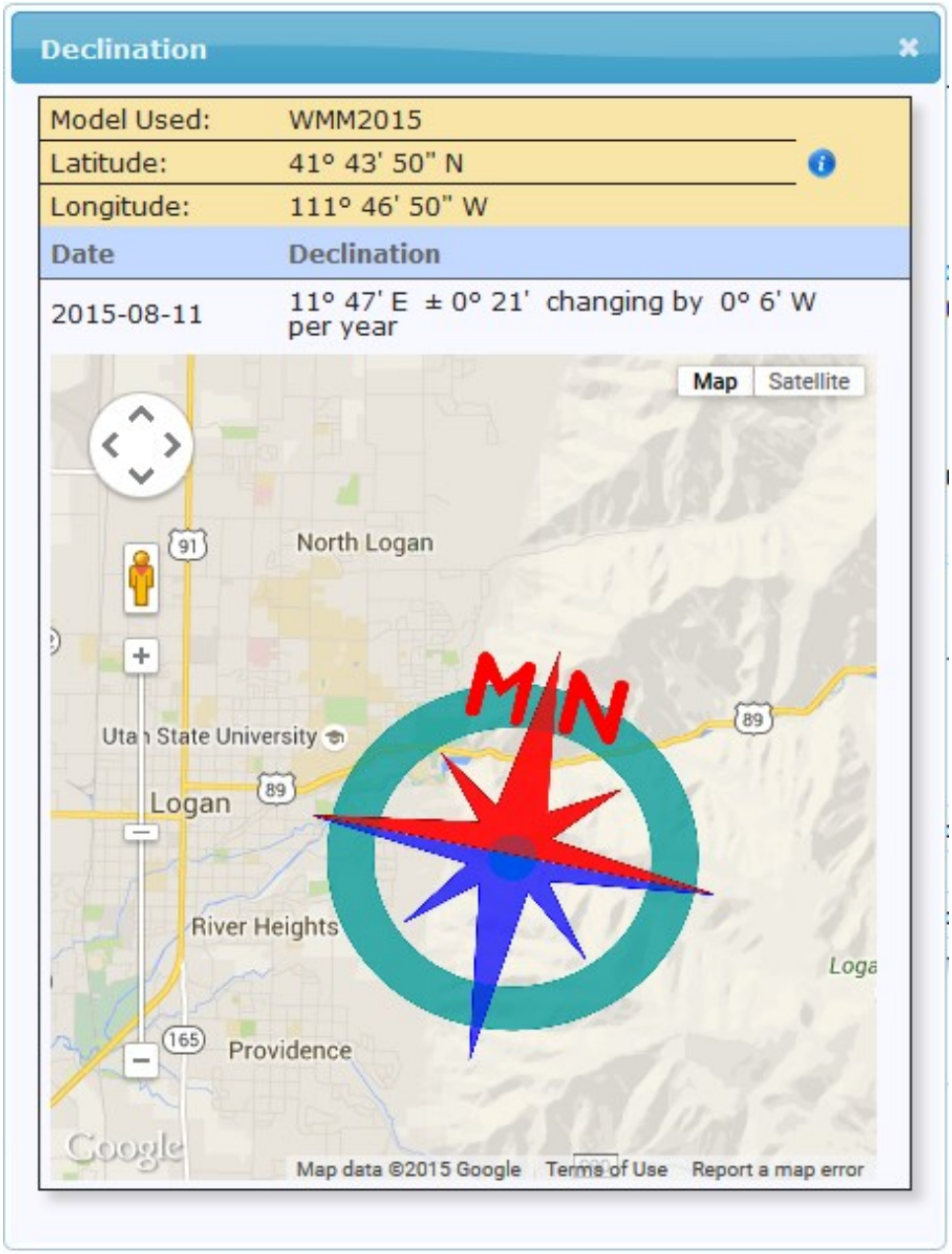


FIGURE B-5. NOAA calculated declination using HTML result format

Appendix C. SDI-12 sensor support

SDI-12, Serial Data Interface at 1200 baud, 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 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.

C.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 C-1 (p. 19).

Table C-1: Campbell Scientific sensor SDI-12 command and response set

Name	Command	Response[1]
Acknowledge Active	a!	a<CR><LF>
Send Identification	aI!	allccccccccmmmmmmvvvxxx...xx <CR><LF>
Start Verification	aV!	atttn <CR><LF>

Table C-1: Campbell Scientific sensor SDI-12 command and response set		
Name	Command	Response[1]
Address Query	?!	a<CR><LF>
Change Address	aAb!	b<CR><LF>
Start Measurement	aM! aM1!...aM9!	atttn<CR><LF>
Start Measurement and Request CRC	aMC! aMC1!...aMC9!	atttn <CR><LF>
Start Concurrent Measurement	aC! aC1!...aC9!	atttnn<CR><LF>
Start Concurrent Measurement and Request CRC	aCC! aCC1!...aCC9!	atttnn<CR><LF>
Send Data	aD0!...aD9!	a<values><CR><LF> or a<values><CRC><CR><LF>
Continuous Measurement	aR0!...aR9!	a<values><CR><LF>
Continuous Measurement and Request CRC	aRC0!...aRC9!	a<values><CRC><CR><LF>
Extended Commands	aXNNN!	a<values><CR><LF>
[1] Information on each of these commands is given in the following sections.		

C.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.

C.1.2 Send identification command (aI!)

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

aI!	allccccccccmmmmmmvvvxxx...xx<CR><LF>
a	Sensor SDI-12 address
ll	SDI-12 version number (indicates compatibility)

cccccccc	8-character vendor identification
mmmmmm	6 characters specifying the sensor model
vvv	3 characters specifying the sensor version (operating system)
xxx...xx	Up to 13 optional characters used for a serial number or other specific sensor information that is not relevant for operation of the data logger
<CR><LF>	Terminates the response
Source: *SDI-12: A Serial-Digital Interface Standard for Microprocessor-Based Sensors* (see References).	

C.1.3 Start verification command (aV!)

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

Command: **aV!**

Response: *atttn<CR><LF>*

a = sensor address

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

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

C.1.4 Address query command (?!)

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

C.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.

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

Table C-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.

C.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 C-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 C-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.

C.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 3 characters appended before the <CR><LF>. This code is not returned in the data table but 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 available at www.sdi-12.org to learn more about how the CRC code is developed.

C.1.9 Stopping a measurement command

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

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

The Send Data command requests data from the sensor. It is issued automatically with every type of measurement command (**aM!**, **aMC!**, **aC!**, **aCC!**). When the measurement command is a**M!** or a**MC!**, 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. 25)), the user asserts this command to obtain data.

Depending on the type of data returned and the number of values a sensor returns, the data logger may need to issue **aD0!** up to **aD9!** to retrieve all data. A sensor may return up to 35

characters of data in response to a **D** command that follows an **M!** or **MC!** command. A sensor may return up to 75 characters of data in response to a **D** command that follows a **C!** or **CC!** command. 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 a**MC!** or **aCC!**.

C.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.

C.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 by navigating to the **Tools** list in ***PC400*** or the **Datalogger** list in the **Connect** screen of ***LoggerNet***.

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

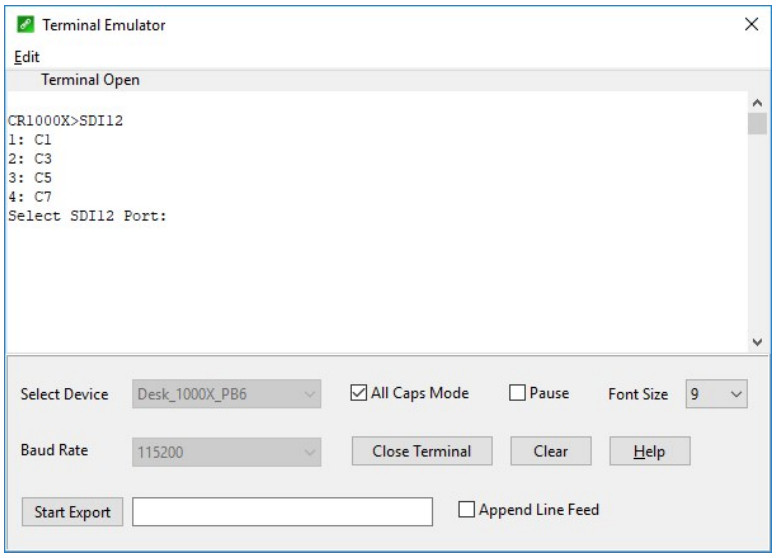
Data loggers from other manufacturers will also have a transparent mode. Refer to those manuals on how to use their transparent mode.

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. 26) are used with most Campbell Scientific data loggers.

C.2.1 Changing an SDI-12 address

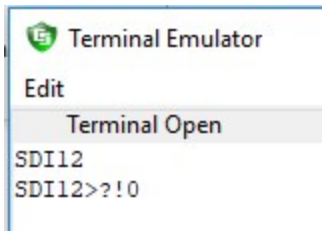
This example was done with a CR1000X, but the steps are only slightly different for CR6, CR800-series, CR300-series, CR3000, and CR1000 data loggers.

1. Connect an SDI-12 sensor to the CR1000X.
2. In **LoggerNet Connect**, under **Datalogger**, click **Terminal Emulator**. The terminal emulator window opens.
3. Under **Select Device**, located in the lower left side of the window, select the **CR1000X**
4. Click **Open Terminal**.
5. Select **All Caps Mode**.
6. Press Enter until the data logger responds with the **CR1000X>** prompt.
7. Type **SDI12** and press Enter.

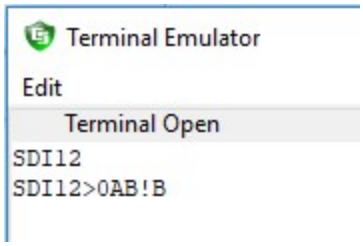


8. At the **Select SDI12 Port** prompt, type the number corresponding to the control port where the sensor is connected and press Enter. The response **Entering SDI12 Terminal** indicates that the sensor is ready to accept SDI-12 commands.

9. To query the sensor for its current SDI-12 address, type **?!** and press Enter. The sensor responds with its SDI-12 address. If no characters are typed within 60 seconds, the mode is exited. In that case, simply type **SDI12** again, press Enter, and type the correct control port number when prompted.



10. To change the SDI-12 address, type **aAb!**, where **a** is the current address from the 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.



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

> **NOTE:**
> The transparent mode for the CR6, CR800-series, CR300-series, CR3000, and CR1000 data loggers is similar to that shown for the CR1000X.

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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.

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- 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.
- 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.

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.

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.

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