WindSonic4
Two-Dimensional Sonic Anemometer with SDI-12 Output
Limited warranty

“Products manufactured by CSI are warranted by CSI to be free from defects in materials and workmanship under normal use and service for twelve months from the date of shipment unless otherwise specified in the corresponding product manual. (Product manuals are available for review online at www.campbellsci.com.) Products not manufactured by CSI, but that are resold by CSI, are warranted only to the limits extended by the original manufacturer. Batteries, fine-wire thermocouples, desiccant, and other consumables have no warranty. CSI’s obligation under this warranty is limited to repairing or replacing (at CSI’s option) defective Products, which shall be the sole and exclusive remedy under this warranty. The Customer assumes all costs of removing, reinstalling, and shipping defective Products to CSI. CSI will return such Products by surface carrier prepaid within the continental United States of America. To all other locations, CSI will return such Products best way CIP (port of entry) per Incoterms® 2010. This warranty shall not apply to any Products which have been subjected to modification, misuse, neglect, improper service, accidents of nature, or shipping damage. This warranty is in lieu of all other warranties, expressed or implied. The warranty for installation services performed by CSI such as programming to customer specifications, electrical connections to Products manufactured by CSI, and Product specific training, is part of CSI’s product warranty. CSI EXPRESSLY DISCLAIMS AND Excludes any implied warranties of merchantability or fitness for a particular purpose. CSI 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.”
Assistance

Products may not be returned without prior authorization. The following contact information is for US and international customers residing in countries served by Campbell Scientific, Inc. directly. Affiliate companies handle repairs for customers within their territories. Please visit www.campbellsci.com to determine which Campbell Scientific company serves your country.

To obtain a Returned Materials Authorization (RMA) number, contact CAMPBELL SCIENTIFIC, INC., phone (435) 227-9000. Please write the issued RMA number clearly on the outside of the shipping container. Campbell Scientific’s shipping address is:

CAMPBELL SCIENTIFIC, INC.
RMA#_____  
815 West 1800 North
Logan, Utah 84321-1784

For all returns, the customer must fill out a “Statement of Product Cleanliness and Decontamination” form and comply with the requirements specified in it. The form is available from our website at www.campbellsci.com/repair. A completed form must be either emailed to repair@campbellsci.com or faxed to (435) 227-9106. Campbell Scientific is unable to process any returns until we receive this form. If the form is not received within three days of product receipt or is incomplete, the product will be returned to the customer at the customer’s expense. Campbell Scientific reserves the right to refuse service on products that were exposed to contaminants that may cause health or safety concerns for our employees.
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.campbellsol.com or by telephoning (435) 227-9000 (USA). You are responsible for conformance with governing codes and regulations, including safety regulations, and the integrity and location of structures or land to which towers, tripods, and any attachments are attached. Installation sites should be evaluated and approved by a qualified engineer. If questions or concerns arise regarding installation, use, or maintenance of tripods, towers, attachments, or electrical connections, consult with a licensed and qualified engineer or electrician.

**General**

- Prior to performing site or installation work, obtain required approvals and permits. Comply with all governing structure-height regulations, such as those of the FAA in the USA.
- Use only qualified personnel for installation, use, and maintenance of tripods and towers, and any attachments to tripods and towers. The use of licensed and qualified contractors is highly recommended.
- Read all applicable instructions carefully and understand procedures thoroughly before beginning work.
- Wear a **hard hat** 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, 20 feet, or the distance required by applicable law, **whichever is greater**, between overhead utility lines and the structure (tripod, tower, attachments, or tools).
- Prior to performing site or installation work, inform all utility companies and have all underground utilities marked.
- Comply with all electrical codes. Electrical equipment and related grounding devices should be installed by a licensed and qualified electrician.

**Elevated Work and Weather**

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

**Maintenance**

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

**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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</tbody>
</table>
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 (p. iii) section at the front 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 (see Ships with (p. 2)). 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.

3.1 Ships with

The WindSonic4 is shipped with a mounting kit that includes:

- 34.93 cm (13.75 in) length of tubing
- Three #6-32 x 0.375 inch pan head screws
- CM220 Right Angle Mounting Kit

4. QuickStart

A video that describes data logger programming using Short Cut is available at: www.campbellsci.com/videos/cr1000x-datalogger-getting-started-program-part-3. Short Cut is an easy way to program your data logger to measure the 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, PC400, or PC200W.

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 as well as the CR200(X)-series and CR5000. 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 WindSonic4s with serial numbers of 0810001 or greater, and WindCom is used for WindSonic4s 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, CR3000, CR1000X, CR800 series, CR300 series, CR1000, CR200(X) series, and CR5000

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. 8) and Data logger programming (p. 8). Short Cut does this work for you. See QuickStart (p. 2) for a Short Cut tutorial.

7.1 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.
7.2 Mount the sensor

The WindSonic4 is mounted using the components of the mounting kit shipped with the WindSonic4 (see Ships with (p. 2)).

1. Thread the connector end of the cable through the tubing; 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 tubing using the three included pan-head screws.

4. Attach the tubing to a crossarm using the CM220 Right Angle Mounting Kit (see FIGURE 7-1 (p. 7)).

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. 7)). See Determining True North and sensor orientation (p. 15) for more information.

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.
7.3 WindSonic4 wiring

The WindSonic4 interfaces to a Campbell Scientific data logger using SDI-12 (Table 7-1 (p. 8)).

<table>
<thead>
<tr>
<th>Description</th>
<th>Color</th>
<th>Data logger</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDI-12 Data</td>
<td>Green</td>
<td>C, SDI-12</td>
</tr>
<tr>
<td>SDI-12 Power</td>
<td>Red</td>
<td>12V</td>
</tr>
<tr>
<td>SDI-12 Reference</td>
<td>Black</td>
<td>G</td>
</tr>
<tr>
<td>Shield</td>
<td>Clear</td>
<td>(analog ground)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Description</th>
<th>Color</th>
<th>Data logger</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDI-12 Data</td>
<td>Green</td>
<td>C, SDI-12, U configured for SDI-12</td>
</tr>
<tr>
<td>SDI-12 Power</td>
<td>Red</td>
<td>12V</td>
</tr>
<tr>
<td>SDI-12 Reference</td>
<td>Black</td>
<td>G</td>
</tr>
<tr>
<td>Shield</td>
<td>Clear</td>
<td>(analog ground)</td>
</tr>
</tbody>
</table>

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.

7.4 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.

7.4.1 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:

\[
\text{SDI12Recorder}(\text{Destination}, \text{SDIPort}, \text{SDIAddress}, \text{“SDICommand”}, \text{Multiplier}, \text{Offset}, \text{FillNAN}, \text{WaitonTimeout})
\]

For the SDIAddress, alphabetical characters need to be enclosed in quotes (for example, “A”). Also enclose the SDICommand in quotes as shown. The most appropriate SDI-12 command to retrieve data from the WindSonic4 is the Ro!, where o is the data format option (Table 7-2 (p. 9)). When using the "Ro!" command, the Destination parameter needs to be a variable array with three elements.

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

When using a CR200(X)-series data logger, the SDI12Recorder() instruction has the following syntax:

\[
\text{SDI12Recorder}(\text{Destination,”OutString”,Multiplier,Offset})
\]

OutString consists of the SDI-12 address and command. Enclose the OutString in quotes as shown.

<table>
<thead>
<tr>
<th>Option (o)</th>
<th>Output</th>
<th>Units</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>wind direction</td>
<td>degrees</td>
<td>Compass polar coordinate system</td>
</tr>
<tr>
<td></td>
<td>wind speed</td>
<td>m/s</td>
<td></td>
</tr>
<tr>
<td></td>
<td>status</td>
<td>unitless</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>u_x wind</td>
<td>m/s</td>
<td>Orthogonal right hand coordinate system</td>
</tr>
<tr>
<td></td>
<td>u_y wind</td>
<td>m/s</td>
<td></td>
</tr>
<tr>
<td></td>
<td>status</td>
<td>unitless</td>
<td></td>
</tr>
</tbody>
</table>
NOTE:
To support the Ro! command, a CR200(X)-series or CR5000 data logger need a current operating system. The most current data logger operating systems are available on the Campbell Scientific website at: www.campbellsci.com/downloads.

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

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

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.

The WindSonic4 can also use an M0! or M1! command. When using an M0! 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 M0! 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 WindSonic4 also supports the R0C!, R1C!, M0C!, and MC! commands, which are the same as the R! and M! 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 “Declaration of Hazardous Material and Decontamination” form. Refer to the Assistance (p. ii) page at the beginning 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 (p. ii)).
### Table 9-1: Status codes

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

### 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 (p. ii)).

### 10. Siting references

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


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)](image)

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.

![NOAA web calculator](Image)

**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>
<thead>
<tr>
<th>Name</th>
<th>Command</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acknowledge Active</td>
<td>a!</td>
<td>a&lt;CR&gt;&lt;LF&gt;</td>
</tr>
<tr>
<td>Send Identification</td>
<td>aI!</td>
<td>allccccccccmmmmmmmmvxxx...xx&lt;CR&gt;&lt;LF&gt;</td>
</tr>
<tr>
<td>Start Verification</td>
<td>aV!</td>
<td>attn &lt;CR&gt;&lt;LF&gt;</td>
</tr>
<tr>
<td>Address Query</td>
<td>?!</td>
<td>a&lt;CR&gt;&lt;LF&gt;</td>
</tr>
</tbody>
</table>
Table C-1: Campbell Scientific sensor SDI-12 command and response set

<table>
<thead>
<tr>
<th>Name</th>
<th>Command</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change Address</td>
<td>aAb!</td>
<td>b&lt;CR&gt;&lt;LF&gt;</td>
</tr>
<tr>
<td>Start Measurement</td>
<td>aM!</td>
<td>atttn&lt;CR&gt;&lt;LF&gt;</td>
</tr>
<tr>
<td>Start Measurement and Request CRC</td>
<td>aMC!</td>
<td>atttn &lt;CR&gt;&lt;LF&gt;</td>
</tr>
<tr>
<td>Start Concurrent Measurement</td>
<td>aC!</td>
<td>attttn&lt;CR&gt;&lt;LF&gt;</td>
</tr>
<tr>
<td>Start Concurrent Measurement and Request CRC</td>
<td>aCC!</td>
<td>attttn&lt;CR&gt;&lt;LF&gt;</td>
</tr>
<tr>
<td>Send Data</td>
<td>aD0!...aD9!</td>
<td>a&lt;values&gt;&lt;CR&gt;&lt;LF&gt; or a&lt;values&gt;&lt;CRC&gt;&lt;CR&gt;&lt;LF&gt;</td>
</tr>
<tr>
<td>Continuous Measurement</td>
<td>aR0!...aR9!</td>
<td>a&lt;values&gt;&lt;CR&gt;&lt;LF&gt;</td>
</tr>
<tr>
<td>Continuous Measurement and Request CRC</td>
<td>aRC0!...aRC9!</td>
<td>a&lt;values&gt;&lt;CRC&gt;&lt;CR&gt;&lt;LF&gt;</td>
</tr>
<tr>
<td>Extended Commands</td>
<td>aXNNN!</td>
<td>a&lt;values&gt;&lt;CR&gt;&lt;LF&gt;</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>aI!</th>
<th>allccccccccmmmmmmvxx...xx&lt;CR&gt;&lt;LF&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>Sensor SDI-12 address</td>
</tr>
<tr>
<td>II</td>
<td>SDI-12 version number (indicates compatibility)</td>
</tr>
<tr>
<td>ccccccccc</td>
<td>8-character vendor identification</td>
</tr>
</tbody>
</table>
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>

\[ a = \text{sensor address} \]

\[ ttt = \text{time, in seconds, until verification information is available} \]

\[ n = \text{the number of values to be returned when one or more subsequent D! commands are issued} \]

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>
<thead>
<tr>
<th>Table C-2: Example aM! sequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>0M!</td>
</tr>
<tr>
<td>00352&lt;CR&gt;&lt;LF&gt;</td>
</tr>
<tr>
<td>0&lt;CR&gt;&lt;LF&gt;</td>
</tr>
<tr>
<td>0D0!</td>
</tr>
<tr>
<td>0+.859+3.54&lt;CR&gt;&lt;LF&gt;</td>
</tr>
</tbody>
</table>

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>
<thead>
<tr>
<th>Table C-3: Example aC! sequence</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>XC!</strong></td>
</tr>
<tr>
<td><strong>X03005&lt;CR&gt;&lt;LF&gt;</strong></td>
</tr>
<tr>
<td><strong>YC!</strong></td>
</tr>
<tr>
<td><strong>Y04006&lt;CR&gt;&lt;LF&gt;</strong></td>
</tr>
<tr>
<td><strong>ZC!</strong></td>
</tr>
<tr>
<td><strong>Z02010&lt;CR&gt;&lt;LF&gt;</strong></td>
</tr>
<tr>
<td><strong>Z0!</strong></td>
</tr>
<tr>
<td><strong>Z+1+2+3+4+5+6+7+8+9+10&lt;CR&gt;&lt;LF&gt;</strong></td>
</tr>
<tr>
<td><strong>XD0!</strong></td>
</tr>
<tr>
<td><strong>X+1+2+3+4+5&lt;CR&gt;&lt;LF&gt;</strong></td>
</tr>
</tbody>
</table>
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 1.3 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 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 (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 aMC! 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 Datalogger list in PC200W, the Tools list in PC400, or the Datalogger list in the Connect screen of LoggerNet.

Watch the video: SDI-12 Sensors | Transparent Mode.

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. Changing an SDI-12 address — CR200(X) Series (p. 27) lists the steps used for CR200(X)-series data loggers.

C.2.1 Changing an SDI-12 address

This example was done with a CR1000, but the steps are only slightly different for CR1000X-series, CR300-series, CR6-series, CR800-series, and CR3000 data loggers. For CR200(X)-series data loggers, see Changing an SDI-12 address — CR200(X) Series (p. 27).

1. Connect an SDI-12 sensor to the CR1000.
2. In LoggerNet Connect, under Datalogger, click Terminal Emulator. The terminal emulator window opens.
3. Under Select Device, located in the lower left side of the window, select the CR1000 station.
4. Click Open Terminal.
5. Select All Caps Mode.
6. Press Enter until the data logger responds with the CR1000> prompt.
7. Type SDI12 and press Enter.
8. At the Select SDI12 Port prompt, type the number corresponding to the control port where the sensor is connected and press Enter. The response Entering SDI12 Terminal indicates that the sensor is ready to accept SDI-12 commands.
9. To query the sensor for its current SDI-12 address, type ?! and press Enter. The sensor responds with its SDI-12 address. If no characters are typed within 60 seconds, the mode is exited. In that case, simply type SDI12 again, press Enter, and type the correct control port number when prompted.
10. To change the SDI-12 address, type aAb!, where a is the current address from the previous step and b is the new address (see FIGURE C-1 (p. 27). Press Enter. The sensor changes its address and responds with the new address.
11. To exit SDI-12 transparent mode, click Close Terminal.
FIGURE C-1. CR1000 example of using the SDI-12 transparent mode to change the SDI-12 address from 0 to 3. Sensor is connected to control port 1.

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

C.2.2 Changing an SDI-12 address — CR200(X) Series

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

10. To change the SDI-12 address, type aAb!, where a is the current address from the previous step and b is the new address (see FIGURE C-2 (p. 28). Press Enter. The sensor changes its address and responds with the new address.

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

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