

SDMS40

Multipoint Scanning Snowfall Sensor



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1. Introduction

The SDMS40 Multipoint Scanning Snowfall Sensor is a two dimensional (2D) multipoint-scanning snow gage, which scans its laser in a circular path on the snow's surface and measures the distance from each point on the path. Once it completes a set of measurements, the SDMS40 takes an intelligent average of the depths to provide a representative average snow depth of the target area. Communications options include SDI-12 and RS-232.

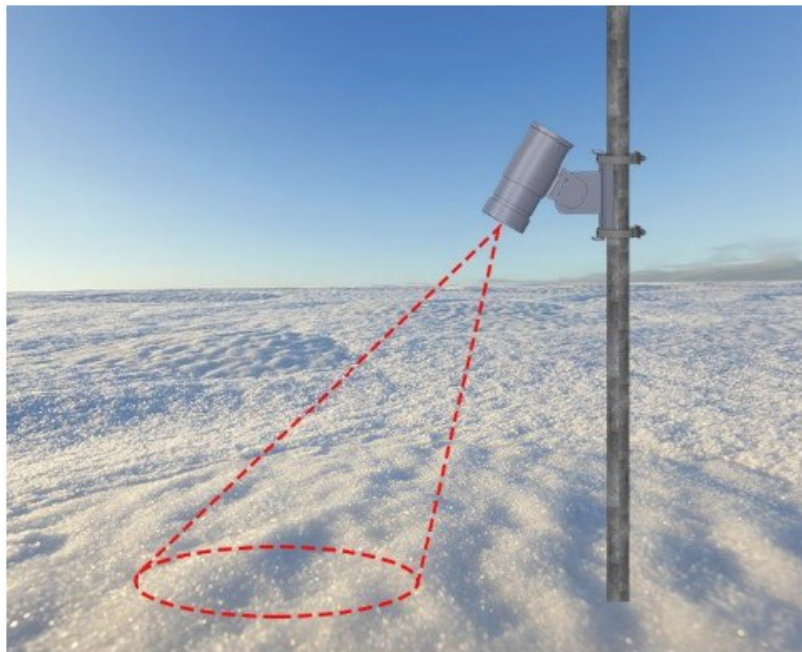


FIGURE 1-1. Laser area

FIGURE 1-1 (p. 1) demonstrates the oval pattern scanned by the sensor. Sophisticated filtering algorithms are implemented to provide reliable measurements in various weather and surface conditions.

The size of the target area varies depending on the height and tilt angle of the SDMS40.

2. Precautions



- READ AND UNDERSTAND the [Safety](#) section at the back of this manual.
- Although the SDMS40 is rugged, it should be handled as precision scientific instrument.
- To avoid shock or damage to the instrument, never apply power while working on wiring and connections.
- Never open the sensor when the power is turned on.
- The SDMS40 uses a Class 2 laser. Do not stare into the laser beam.

3. Initial inspection

- Upon receipt of the SDMS40, inspect the packaging and contents for damage. File any damage claims with the shipping company.
- Immediately check package contents against the shipping documentation. Contact Campbell Scientific about any discrepancies.
- Model number and cable length are printed on a label at the connection end of the cable (if a cable was purchased). Check the model number information against the shipping documents to ensure the expected product and cable length are received.
- Shipped with 4 screws, 2 lock washers, 2 band clamps, and mounting bracket.
- Ensure that the cable has a 1-Position Terminal Connector attached to the blue wire and another 1-Position Terminal Connector attached to the yellow wire. These connectors are used to individually isolate unused wires.

4. Quickstart

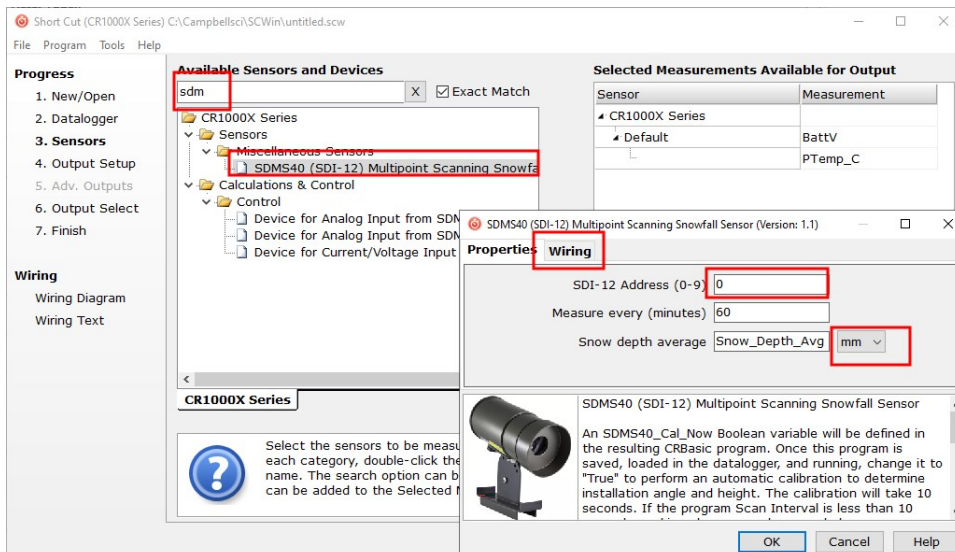
A video that describes data logger programming using *Short Cut* is available at:

www.campbellsci.com/videos/cr1000x-data-logger-getting-started-program-part-3 . *Short Cut* is an easy way to program your data logger to measure the sensor and assign data logger wiring terminals. *Short Cut* is available as a download on www.campbellsci.com . It is included in installations of *LoggerNet*, *RTDAQ*, and *PC400*.

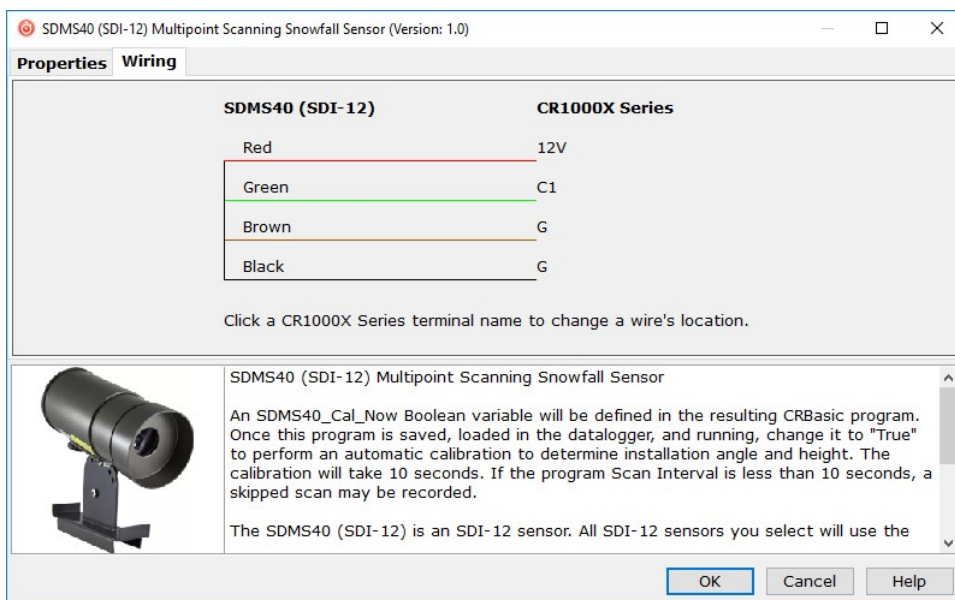
The following procedure also shows using *Short Cut* to program the sensor.

1. Open *Short Cut* and click **Create New Program**.
2. Double-click the data logger model.

- In the **Available Sensors and Devices** box, type SDMS40 or locate the sensor in the **Sensors | Miscellaneous Sensors** folder. Double-click **SDMS40 (SDI-12) Multipoint Scanning Snowfall Sensor**. The default average snow depth units are millimeters. This can be changed by clicking the **Snow depth average** box and selecting different units. Type the correct **SDI-12 Address**.

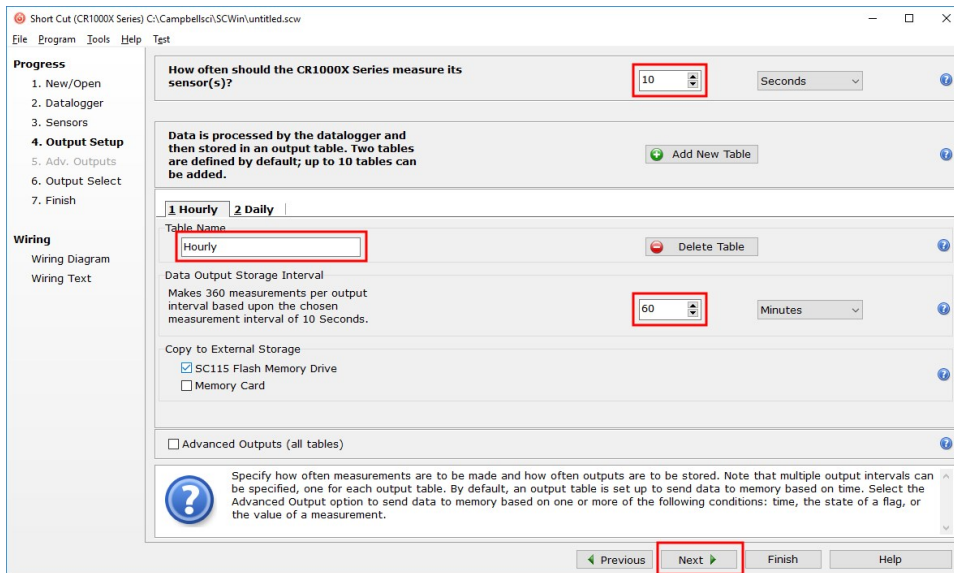


- Click the **Wiring** tab to see how the sensor is to be wired to the data logger. Click **OK** after wiring the sensor.

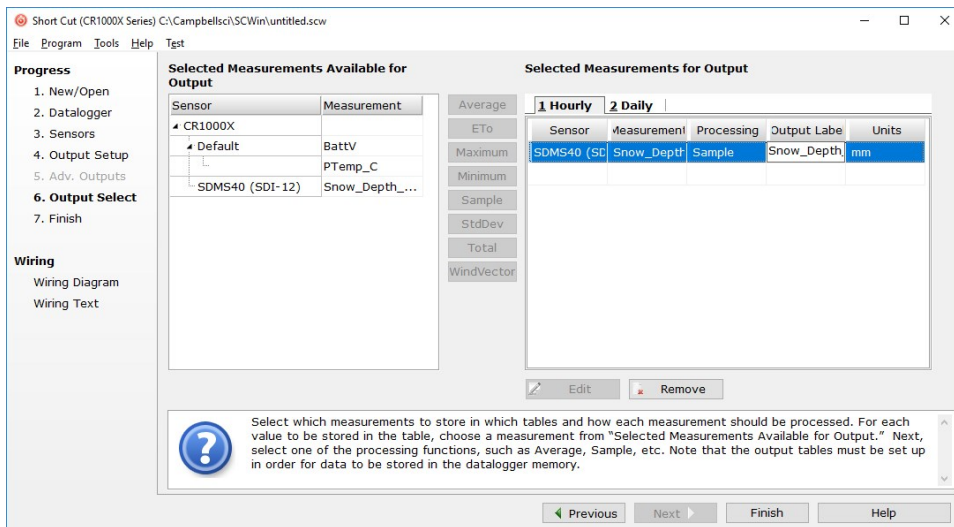


- Repeat step three for other sensors.

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



- Select the measurement and its associated output option.




- Click **Finish** and save the program. Send the program to the data logger if the data logger is connected to the computer.
- 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. Features

- Provides representative average snow depth of the target area
- Filters out erroneous measurement data caused by noise or foreign materials
- Detects new snowfall quickly and reliably
- Operates on natural ground or snow plate
- Compact and light
- Simple installation process
- After mounting, the sensor performs a fully automatic calibration process to calculate install angle and height
- Output data on SDI-12 or RS-232 serial data interface
- Compatible with Campbell Scientific CRBasic data loggers: CR200(X) series, CR300 series, CR6 series, CR800 series, CR1000, CR1000X series, CR3000, and CR5000

6. Specifications

Power supply:	Requires 12 to 15 VDC power supply capable of providing up to 2 A continuously.
Current draw	
Standby:	50 mA
Active:	250 mA
Heater:	1300 mA
Cable:	
Type:	3-Cond 20 AWG, 2 Pair 24 AWG
Maximum length:	14 m (45 ft)
Sensor	
Method:	Multipoint laser scanning
Number of scanning points:	36
Measurement range:	> 10 m (> 32.8 ft)
Mounting height:	1 to 5 m (3.3 to 16.4 ft) above maximum expected snowfall depth; maximum distance to target is > 10 m (> 32.8 ft)

Target area diameter:	30 to 200 cm (11.8 to 78.7 in) depending on installation height and angle
Gage pointing angle:	0 to 45° from vertical
Half angle:	6°
Resolution:	1 mm
Accuracy:	±3 mm
Communications protocols:	SDI-12, RS-232
General	
Operating temperature:	–40 to 50 °C (with sensor heat on)
Weight:	1.8 kg (3.9 lb)
Enclosure protection class:	IP67
Laser safety:	Class 2
Dimensions	
Height:	12 cm (4.72 in)
Length:	28 cm (11.02 in)
Width:	10 cm (3.94 in)
Compliance documents:	View at www.campbellsci.com/sdms40 

7. Installation

If you are programming your data logger with *Short Cut*, skip [Wiring](#) (p. 6) and [Programming](#) (p. 8). *Short Cut* does this work for you. See [Quickstart](#) (p. 2) for a tutorial.

7.1 Wiring

The SDMS40 requires a 12 to 15 VDC power supply capable of providing up to 2 A continuously. Ensure the power is turned off before connecting the sensor.

CAUTION:

To avoid damage to the instrument, ensure that the power is turned off while wiring.

Align markers on the male and female connectors to plug in the cable to the sensor. The cable comes with a 1-Position Terminal Connector attached to the blue wire and another 1-Position Terminal Connector attached to the yellow wire (FIGURE 7-1 (p. 7)).

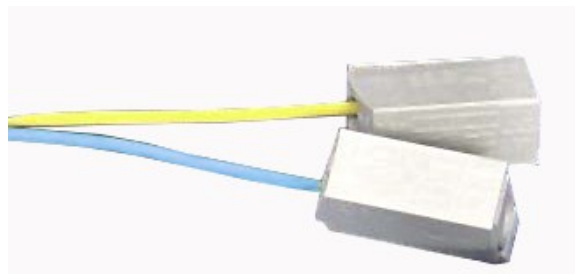


FIGURE 7-1. 1-Position Terminal Connectors individually isolate wires not used for SDI-12 measurements

If using RS-232, remove the connectors from the blue and yellow wires and attach the green wire to one of the connectors (FIGURE 7-2 (p. 7)).

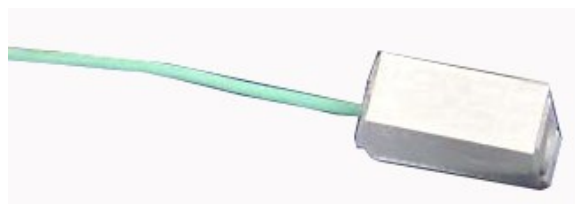


FIGURE 7-2. Position Terminal Connector isolates wire not used for RS-232 measurements

Table 7-1 (p. 7) provides SDI-12 wiring and Table 7-2 (p. 8) provides RS-232 wiring. Once mounting and wiring of the SDMS40 are complete, apply power to the SDMS40.

Table 7-1: SDI-12 sensor wire color, function, and data logger connection			
Wire color	Function	Power supply terminal	Data logger connection terminal
Black	Power ground	G	
Red	Power	12V	
Green	SDI-12 signal		C or U ¹ terminal configured for SDI-12
Brown	Signal ground		G

¹ **U** or **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 or U terminal. Each must have a unique SDI-12 address. Valid addresses are 0 through 9, a through z, and A through Z.

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 SDMS40 is connected to C3 on a CR1000X, C4 cannot be used in the `TimerInput()`, `PulseCount()`, or `WaitDigTrig()` instructions.


Wire color	Function	Power supply terminal	Data logger connection terminal
Red	Power	12V	
Black	Power ground	G	
Brown	Signal ground		⏏ (analog ground)
Blue	RS-232 Rx		C (odd numbered)
Yellow	RS-232 Tx		C (even numbered)

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. 23). Programming basics for CRBasic data loggers are provided in the following section. Downloadable example programs are available at www.campbellsci.com/downloads/sdms40-example-programs .

7.2.1 SDI-12 programming

The **SDI12Recorder()** instruction is used to measure an SDMS40 configured for SDI-12 measurements. The **SDI12Recorder()** instruction sends a request to the sensor to make a measurement and then retrieves the measurement from the sensor. See [SDI-12 sensor measurements](#) (p. 12) for more information. Downloadable example program for using the SDI-12 output is available at www.campbellsci.com/downloads/sdms40-example-programs.

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 quotes (for example, "A"). Also enclose the **SDICommand** in quotes 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. 12)).

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

7.2.2 RS-232 programming

The RS-232 instructions are shown in [Table 7-3](#) (p. 9). Downloadable example program for using the RS-232 output is available at www.campbellsci.com/downloads/sdms40-example-programs.

Instruction	Function
SerialFlush()	Clears the buffer.
Scan()	Establish a scan rate.
SerialOut()	Send command to the sensor Table 9-2 (p. 21).
SerialIn()	Set up the COM port to receive the incoming serial data. Note that in the beginning of the CRBasic program, the variable used in the SerialIn() instruction needs to be declared as an ASCII string format.
SplitStr()	Split out digital count value from the input string.

7.3 Mounting

The SDMS40 is environmentally sealed for outdoor installations. The enclosure provides protection from moisture and high humidity. It is not intended for operation under water. All that is required is an appropriate mounting fixture.

Position the SDMS40 about one meter above the maximum seasonal snow depth height (FIGURE 7-3 (p. 10), FIGURE 7-4 (p. 11)). This provides adequate height for required accuracy and resolution. Mounting procedure is provided in Table 7-4 (p. 11).

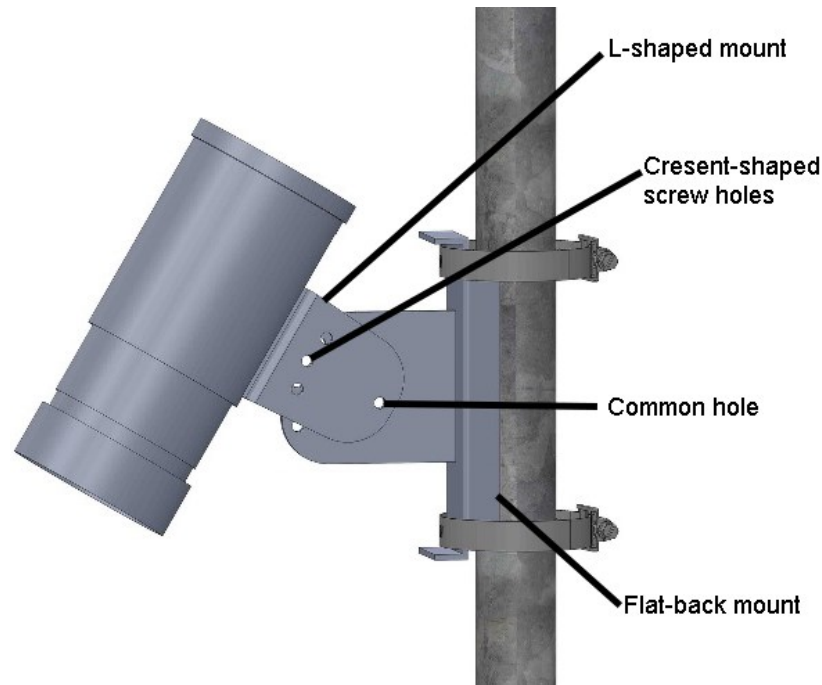


FIGURE 7-3. SDMS40 mounting holes

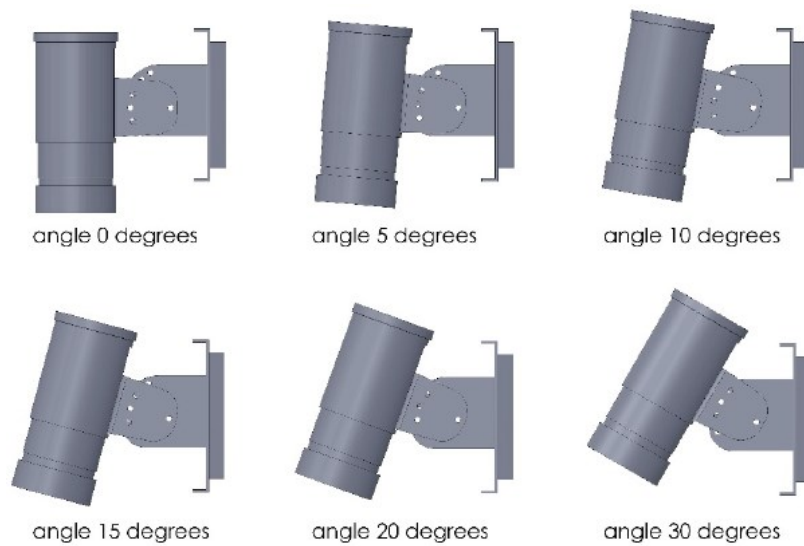


FIGURE 7-4. SDMS40 mounting angles

Table 7-4: SDMS40 mounting procedure	
Step	Procedure
1	Attach the L-shaped mount to the flat back mount using the common hole and crescent shaped screw holes.
2	Using FIGURE 7-4 (p. 11), decide which angle your sensor is to be mounted at.
3	Bolt the L-shaped mounting piece to the underside of the sensor. The big middle circle should line up with the cable connector.
4	Install sensor and mount 1 m above the maximum seasonal snow depth height. For mounting to poles, use the provided hose clamps.
5	Line up the connector end of the cable to the cable connector on the sensor. Lightly push the connector into place and screw the connector to secure.

7.3.1 Adjusting inclination angle or direction of the SDMS40

The SDMS40 can be installed at any angle between 0 and 45 degrees from the pole. After loosely tightening the screw on the common hole (FIGURE 7-3 (p. 10)), the inclination angle can be adjusted in 5 degree increments by matching one of the six holes on the flat backed mount attached to the pole (FIGURE 7-4 (p. 11)). Use the second screw to fix the inclination angle by tightening the screw through the SDMS40 part and the bracket. Completely tighten the common hole screw. See FIGURE 7-4 (p. 11) for mounting angle options.

8. Operation

8.1 SDI-12 sensor measurements

The SDMS40 responds to the SDI-12 commands shown in [Table 8-1](#) (p. 12). When using an **M!** 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. Because of the delays this command requires, it is only recommended in measurement scans of 10 seconds or more or use [SlowSequence](#).

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:

This section briefly describes using the SDI-12 commands. Additional SDI-12 information is available in [SDI-12 sensor support](#) (p. 24), or at www.sdi-12.org.

Commands ¹	Responses	Remarks
a!	a<CR><LF>	Acknowledge active.
a1!	"system info" <CR><LF>	SDI012 version, manufacturer, model, firmware version (e.g. 013wtherpiaSDMS40v6.111-24-2016).
aV!	"test result" <CR><LF>	System verification details.
aAB!	B<CR><LF>	Change address.
A?!	a<CR><LF>	Query sensor address.
aM!	0501<CR><LF>	Start measurement. Average depth value will be provided by aDO! following a service request.

Commands ¹	Responses	Remarks
aC1!	05041<CR> <LF>	Start concurrent measurement. Average depth and individual depth data at each sample point will be provided by aD0! through aD8!.
aD0!	depth<CR> <LF>	Average depth.
aD1! thru aD8!	36 individual sample data	Grouped in 8 packets.
aR0!	+depth<CR> <LF>	Similar to aD0 for continuous measurement mode.
aXA!	0601	Perform automatic calibration to determine installation angle and height.
aXTxx! Where xx is the desired threshold	xx<CR> <LF>	Set the heater threshold value (default is 0 °C). The heater will turn on when the internal temperature drops below this value and will remain on until the temperature climbs above the threshold. The allowed values range from -40 to 10 °C.
aXHxx Where xx is the height in mm	xx<CR> <LF>	Manually set the current sensor height in mm. This option would only be used if the automatic calibration fails due to problems in the target area.
aXGxx!	0501	Reset the sensor ground level. This command would be used with the offset if there is existing snow on the ground when the sensor is installed.

¹ "a" refers to the address of the sensor.

8.2 RS-232 sensor measurements

The SDMS40 measures the current snow depth at a user-programmable interval (minutes) and transmits data on its RS-232 serial data lines to an external device, such as a data logger. By default, the sensor is in polling mode, where measurements are triggered by request from a data logger.

Table 8-2 (p. 14) is a list of RS-232 commands in the command mode.

Table 8-2: RS-232 command list

Command usage	Default value	Function
@v (x) ↵	1	Set the verbose level: 0 – none/1 – show information. Keep the verbose level at 1 if using the RS-232 example program.
@i (x) ↵	0 (polling mode)	Set measurement interval in minutes. The sensor should be kept in polling mode for use with the sample RS-232 data logger program. Allowed values: 1, 2, 3, 4, 5, 6, 10, 20, 30, and 60.
@h (x)↵	2000 mm	Manually set the current gage height in millimeters. Use this command only if automatic calibration fails.
@g (x)↵ Where (x) is the existing snow depth	n/a	Reset the sensor ground level. This command would be used with the offset if there is existing snow on the ground when the sensor is installed.
@m↵	n/a	Run a round of measurements immediately.
@s↵	n/a	SDMS40 status. This shows various system information such as current firmware version and installation angle and height.
@ac↵	n/a	Perform automatic calibration to determine installation height and angle.
@history↵	n/a	Show measurement data from the last 24 hours.
@lowtempx↵ Where x is the desired threshold	0°C	To check the current threshold value, type “@lowtemp” ↵ .To modify the heater threshold value, include the value x. The heater will turn on when the internal temperature drops below this value and will remain on until the temperature climbs above the threshold. Allowed values range from -40°C to 10°C.
@b (x)↵ Where x is an index for the desired baud rate	3 (9600 bps)	Check or modify the baud rate of the serial port. To check current baud rate, type “@b”↵ . To modify the baud rate, include the desired index that follows. 0: 57600, 1: 38400, 2: 19200, 3: 9600, 4: 4800, 5: 2400, 6: 1200.
@d↵	n/a	Check and modify the current SDMS-40 date * to modify the SDMS-40 date, type “@d” ↵ and follow instructions.

Table 8-2: RS-232 command list

Command usage	Default value	Function
@t↵	n/a	Check and modify the current SDMS-40 time * to modify the SDMS-40 time, type "@t" ↵ and follow the instructions.
@ct xx ↵ Where XX is the new threshold	25	Change Threshold CT represents the difference in depth for two measurements in the same point
@vt↵ Where XX is the new threshold	15	Variance threshold VT is the difference in depth between two adjacent points in the same measurement

9. Maintenance, calibration, and troubleshooting

This section discusses the following:

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9.2 Calibration	16
9.3 Updating operating system	16
9.4 Error codes	21

9.1 Maintenance

Regular cleaning and inspection is required:

- Check to make sure the target area is free from any obstacles or foreign material.
- Remove any dust or foreign deposits from the window of the SDMS40. Clean the window glass with soft cleaning fabric or tissues, water, and soft cleaning detergents.
- Inspect the bracket and other mounting clamps for loosened screws or clamps.

9.2 Calibration

Once the SDMS40 is fully installed, calibrate it for proper operation. Calibration sets the height and angle of the sensor to ensure accurate measurements. This occurs automatically ([Automatic calibration](#) (p. 16)) or manually ([Manual calibration](#) (p. 16)).

9.2.1 Automatic calibration

SDMS40 supports a fully automatic calibration process, which calculates the height and inclination angle of the SDMS40. Calibration is required when you first set up the sensor and when you move the sensor. This is done by issuing a calibration request command (SDI-12 **aXA!** or RS-232 **@ac**). When using the RS-232 command, the sensor will ask to confirm the request. Enter **y** to proceed.

9.2.2 Manual calibration

Manual calibration is only required if automatic calibration fails. After installation, enter the height of the sensor and run a ground level resetting procedure.

Entering the height can be done by sending the appropriate command (SDI-12 **aXHxxxx!** or RS-232 **@h xxxx**, where xxxx is the sensor height). When using the RS-232 command, the sensor will ask to confirm the height. Enter **y** to proceed.

After entering the sensor height, initiate a ground level reset (SDI-12 **aXGxx!** or RS-232 **@g xx**, where xx is the initial snow depth). When using the RS-232 command, the sensor will ask to confirm the request. Enter **y** to proceed.

A downloadable example program that performs a manual calibration is available at www.campbellsci.com/downloads/sdms40-example-programs. This example program includes the sensor height and initial snow depth as constants and uses the following subroutine to make the calibration:

Sub Manual_Calibration

```
SDI12Recorder(SDI_Calibrate_Return,SDI12_PORT1,0,"XH"&Height&"!",1,0,-1,1)
```

```
Delay (1,1,Sec)
```


```
SDI12Recorder(SDI_Calibrate_Return,SDI12_PORT1,0,"XG"&Intial_Snow_Depth&"!",1,0,-1,1)
```

```
Delay (1,10,Sec)
```

```
EndSub
```

9.3 Updating operating system

To update the sensor operating system, download the operating system available from: www.campbellsci.com/sdms40. A terminal emulator software such as PuTTY Portable is

required to do this update. PuTTY Portable is available at no charge from https://portableapps.com/apps/internet/putty_portable .

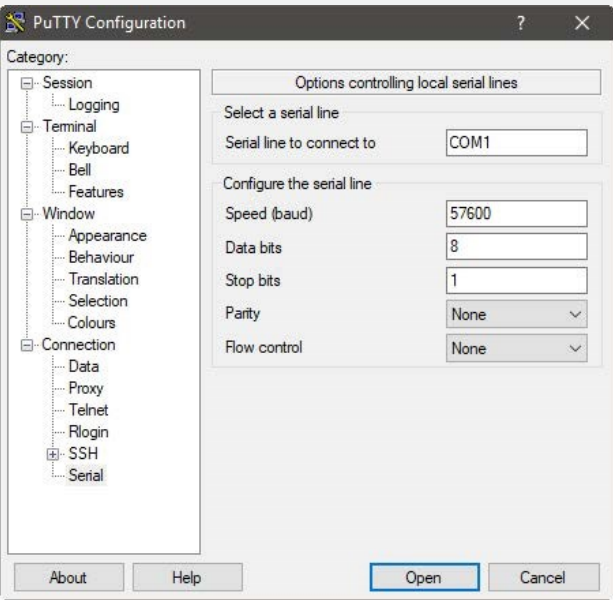
Step	Procedure
1	Wire the SDMS40 sensor to a DB9 female terminal block (see Table 9-2 (p. 21)).
2	Connect the DB9 female to your computer RS-232 port using a standard serial cable or to a USB port using a serial-to-USB adapter.
3	Extract the operating system .zip file (sdms-firmware-update-utility.zip) downloaded from the website and open PuTTYPortable.exe.
4	<p>Select the Session Category and set the parameters to the following:</p> <ol style="list-style-type: none"> Select a serial line: Use the COM port assigned to your serial cable. Speed (baud): 57600 Data bits: 8 Stop bits: 1 Parity: None Flow control: None 

Table 9-1: Updating operating system procedure

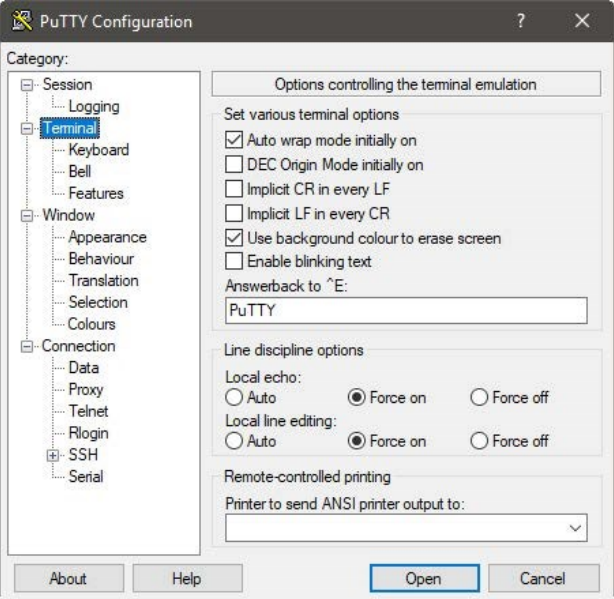
Step	Procedure
5	<p>Select the Terminal Category and select the Force on option for both the Local echo and Local line editing parameters.</p>  <p>The screenshot shows the PuTTY Configuration dialog box. On the left, the 'Terminal' category is selected in the tree view. On the right, under 'Options controlling the terminal emulation', the 'Local echo' and 'Local line editing' options are both set to 'Force on' via radio buttons. Other options like 'Auto wrap mode initially on' and 'Use background colour to erase screen' are checked, while 'DEC Origin Mode initially on', 'Implicit CR in every LF', and 'Implicit LF in every CR' are unchecked. The 'Answerback to ^E:' field contains 'PuTTY'. At the bottom, there are 'About', 'Help', 'Open', and 'Cancel' buttons.</p>

Table 9-1: Updating operating system procedure

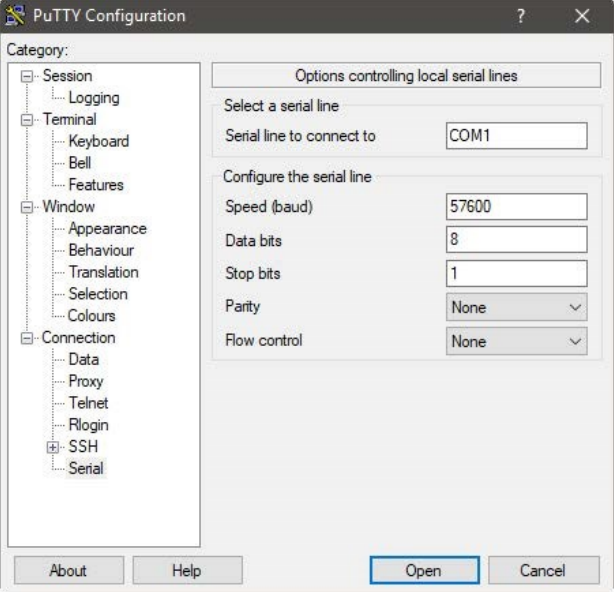
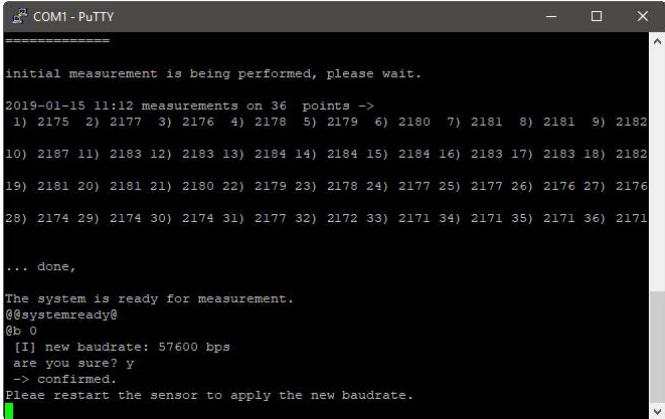
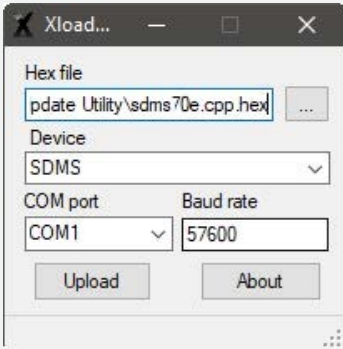
Step	Procedure
6	<p>Select the Serial Category and set the parameters to the following:</p> <ol style="list-style-type: none"> Select a serial line: Use the COM port assigned to your serial cable. Speed (baud): 57600 Data bits: 8 Stop bits: 1 Parity: None Flow control: None 
7	Click the Open button.
8	Once the PuTTY terminal emulator opens, apply power to the sensor.
9	Let the sensor initialize and perform its initial measurements. Proceed to step 10 after @@systemready@ is displayed.
10	Type @b 0 and press the return key.

Table 9-1: Updating operating system procedure


Step	Procedure
11	<p>Confirm the new baud rate of 57600 bps by typing y (lower case) then pressing the return key. If successful, the message -> confirmed. is displayed in the terminal window.</p> 
12	<p>Run the Xloader.exe program from the folder and set the parameters to the following:</p> <ol style="list-style-type: none"> Hex file: press the ... button and select the *.cpp.hex operating system file from the folder. Speed (baud): 57600 Device: SDMS Com port: Use the COM port assigned to your serial cable. Baud rate: 57600 
13	<p>Click the Upload button. The message Uploading ... will appear at the bottom of Xloader.</p>
<p>The operating system update may take a few minutes. Upon successful completion, an XXXXXX bytes uploaded message will appear.</p>	

Color	Function	Connection
White*	Operating system reset	Pin 4
Blue	RX	Pin 3
Yellow	TX	Pin 2
Brown	Ground	Pin 5

*Only use when resetting the operating system.

Color	Function	Connection
Red	Power	12 V
Black	Power Ground	G

9.4 Error codes

The following error codes are included as part of the normal reading and get stored in the snow depth average variable (Snow_Depth_Avg in manual calibration example program available at www.campbellsci.com/downloads/sdms40-example-programs )

Code	Description
-900	Sample is empty (initial state)
-901	No calibration data
-902	Invalid ground data
-903	No calibration data
-904	No ground data
-905	Spot is bad and configured to be skipped
-906	Motor positioning failure
-907	Not enough samples, the number of valid samples is less than 50% of the total samples

Table 9-4: Error codes

Code	Description
-910	Measurement interrupted by the user
-912	SDI-12 break or command has been received during the measurement
-920	Invalid data (determined by the filtering process)
-921	Too much change in a minute
-922	Filtration based on the amount of change compared to the average change first stage
-923	Filtration based on the amount of change compared to the average change second stage
-940	No response from the laser module
-941	General laser module error
-942	Distance data from the laser module is too small
-943	Distance data from the laser module is too big
-944	Invalid data received from the laser module
-945	No data has been received from the laser module
-946	Time out occurred while waiting for data from the laser module

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. 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.

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. 24).

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

Table B-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!	attn<CR><LF>
Start Measurement and Request CRC	aMC! aMC1! . . . aMC9!	attn <CR><LF>
Start Concurrent Measurement	aC! aC1! . . . aC9!	attnn<CR><LF>
Start Concurrent Measurement and Request CRC	aCC! aCC1! . . . aCC9!	attnn<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.		

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

ccccccc	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).	

B.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: *attn*<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

B.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.

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 *attn*<CR><LF>, where

a = sensor address

*t**t**t* = 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, *t**t**t*, 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 (*t**t**t*).

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 *attn*<CR><LF>, where

a = the sensor address

*t**t**t* = 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** 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.

B.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.

B.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 (see [SDI-12 transparent mode](#) (p. 30)), 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!**.

B.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.

B.1.12 Extended commands

Many sensors support extended SDI-12 commands. An extended command is specific to a make of sensor and tells the sensor to perform a specific task. They have the following structure. Responses vary from unit to unit. See the sensor manual for specifics.

Command: **aXNNNN!**

The command will start with the sensor address (**a**), followed by an **X**, then a set of optional letters, and terminate with an exclamation point.

Response: *a*<optional values><CR><LF>

The response will start with the sensor address and end with a carriage return/line feed.

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 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.

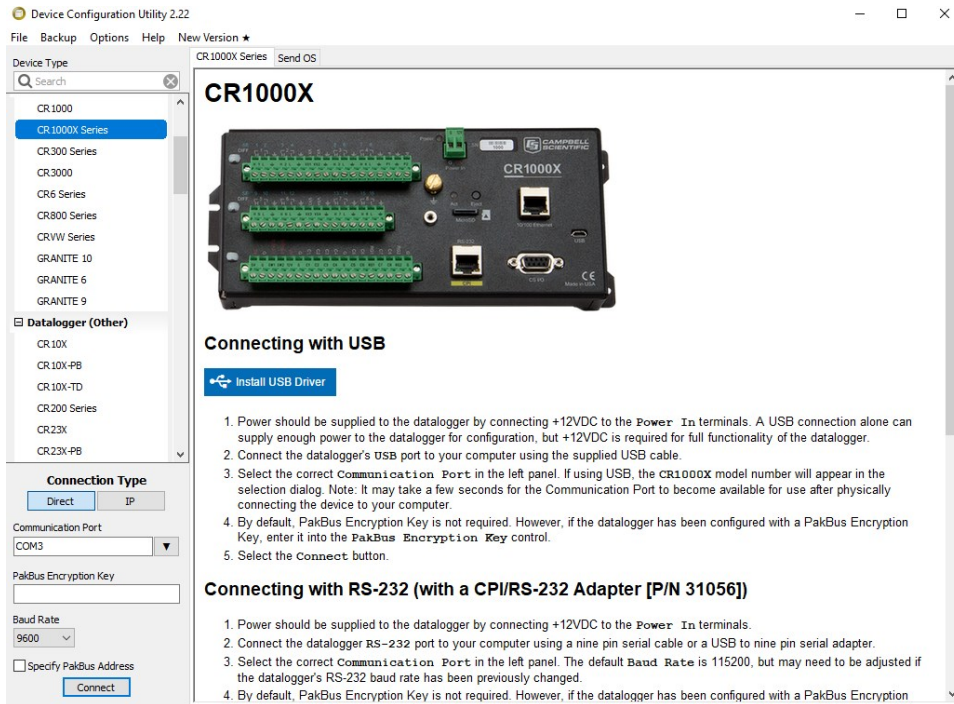
The following examples show how to enter transparent mode and change the SDI-12 address of an SDI-12 sensor. The steps shown in [Changing an SDI-12 address](#) (p. 31) are used with most Campbell Scientific data loggers.

B.2.1 Changing an SDI-12 address

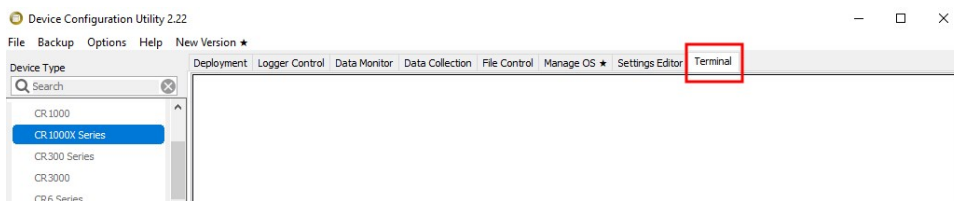
This example was done with a CR1000X, but the steps are only slightly different for CR6, CR3000, CR800-series, CR300-series, CR1000 data loggers.

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.

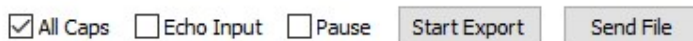
4. Select the correct **Communication Port** and click **Connect**.



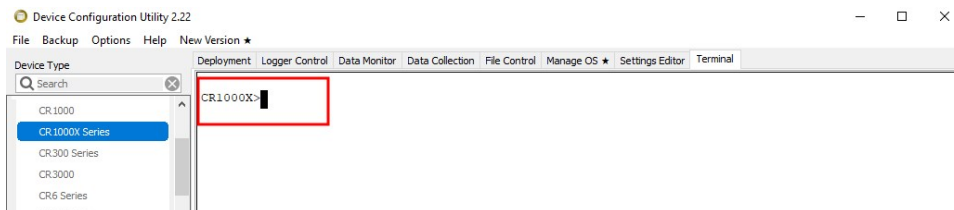
5. Click the **Terminal** tab.



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 CR6, CR3000, CR800-series, CR300-series, and CR1000 data loggers is similar to that shown for the CR1000X.

B.3 References

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

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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.

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.
- 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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