Product Manual

Sensor

SR50A-Series

Sonic Ranging Sensors

Revision: 09/2021

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1. Introduction

The SR50A-series sonic ranging sensors provide a non-contact method for measuring snow depth. The sensor emits an ultrasonic pulse, measures the elapsed time between the emission and return of the pulse, then uses this measurement to determine snow depth. An air temperature measurement is required to correct for variations of the speed of sound in air.

Table 1-1 (p. 1) shows the differences between the models. Overview (p. 7) discusses these differences in more details. Throughout this document SR50A will refer to all of the models unless specified otherwise.

Table 1-1: SR50A model comparison

Model	Chassis material	Integrated heater	Air temperature sensor included[1]
SR50A	standard aluminum		
SR50A-EE	corrosion-resistant, type III anodized aluminum		
SR50AH	standard aluminum	X	
SR50AT	standard aluminum		X
SR50ATH	standard aluminum	X	X

[1] The air temperature sensor included with the SR50AT and SR50ATH is integrated in their cable (FIGURE 1-1 (p. 2)). This temperature sensor must be housed in a radiation shield, such as the RAD06.

FIGURE 1-1. SR50AT mounted to a crossarm with the temperature sensor housed in a RAD06 radiation shield

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

2. Precautions

- READ AND UNDERSTAND the Safety section at the back of this manual.
- Never open the sensor while it is connected to power or any other device.
- Always disconnect the sensor using the connector or disconnect the cable wires from their termination points.
- Never operate the sensor with the shield wire disconnected. The shield wire plays an important role in noise emissions and susceptibility as well as transient protection.
- Follow local regulations (see Compliance in Specifications (p. 8)).

3. Initial inspection

Upon receipt of the sensor, inspect the packaging for any signs of shipping damage and, if found, report the damage to the carrier in accordance with policy. The contents of the package should also be inspected and a claim filed if any shipping related damage is discovered.

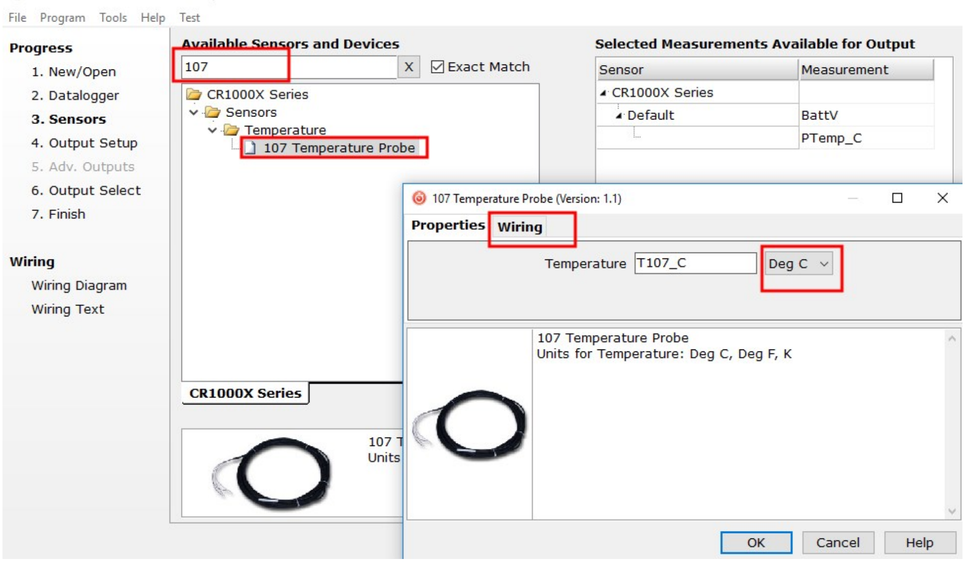
4. QuickStart

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***.

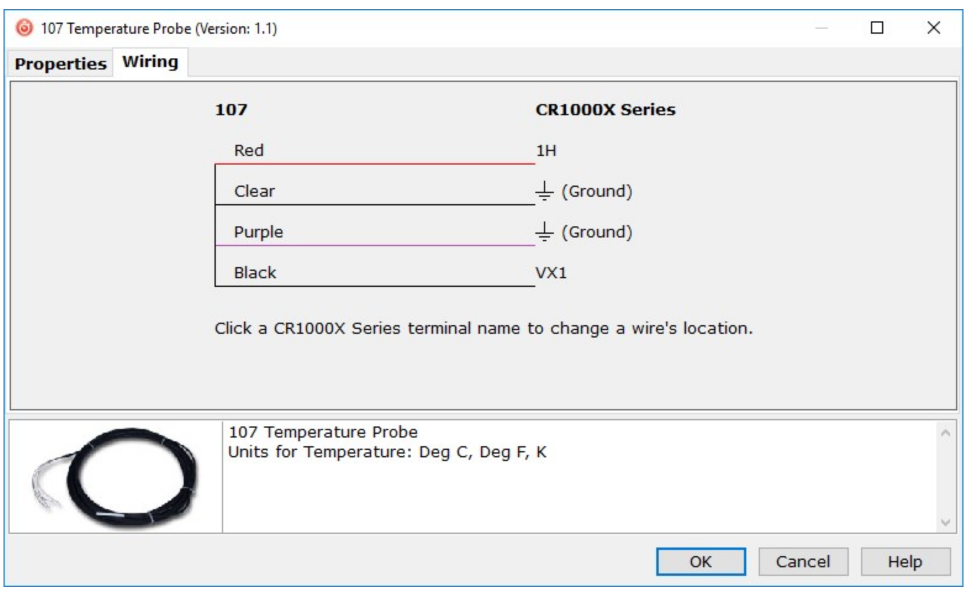
1. Open ***Short Cut*** and click **Create New Program**.
2. Double-click the data logger model.

> NOTE:
> Skip steps 3 and 4 if using an SR50AT or SR50ATH. Steps 3 and 4 use the 107 thermistor to provide the air temperature measurement required for the SR50A, SR50A-EE, or SR50AH.

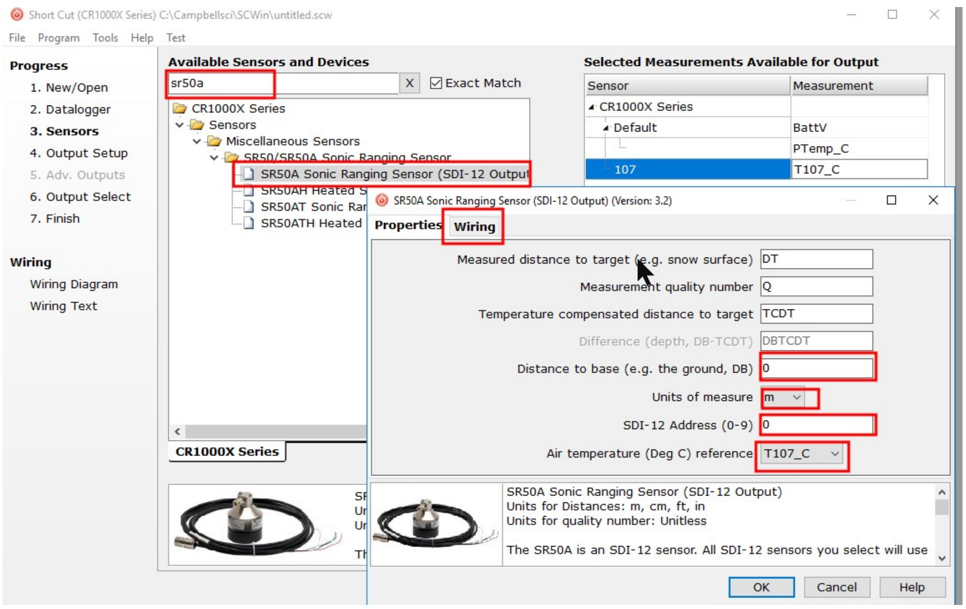
3. In the **Available Sensors and Devices** box, type 107 or find the 107 in the **Sensors** > **Temperature** folder. Double click the **107 Temperature Probe**. Use the default of **Deg C**.



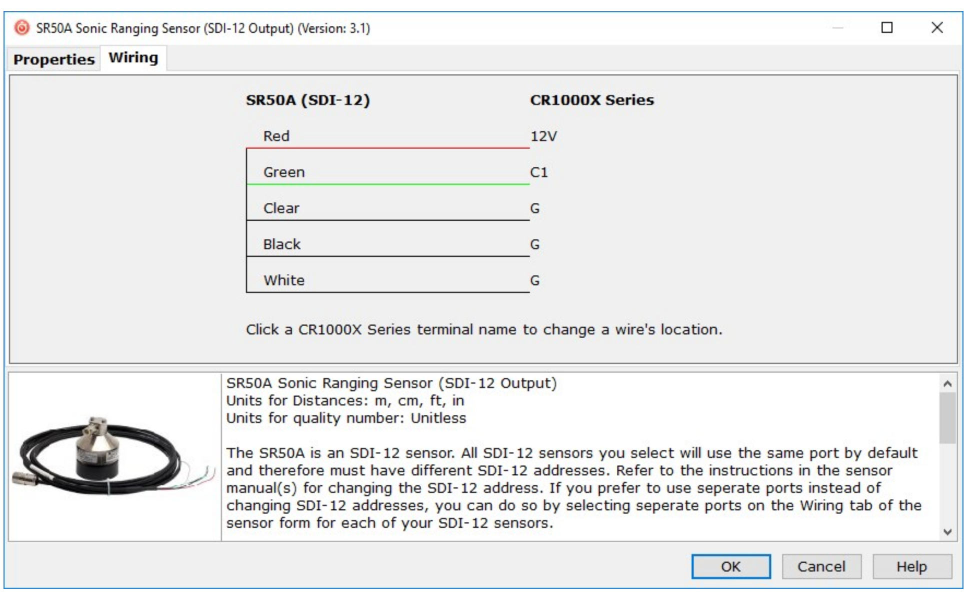
4. Click the **Wiring** tab to see how the sensor is to be wired to the data logger. Click **OK** after wiring the sensor.



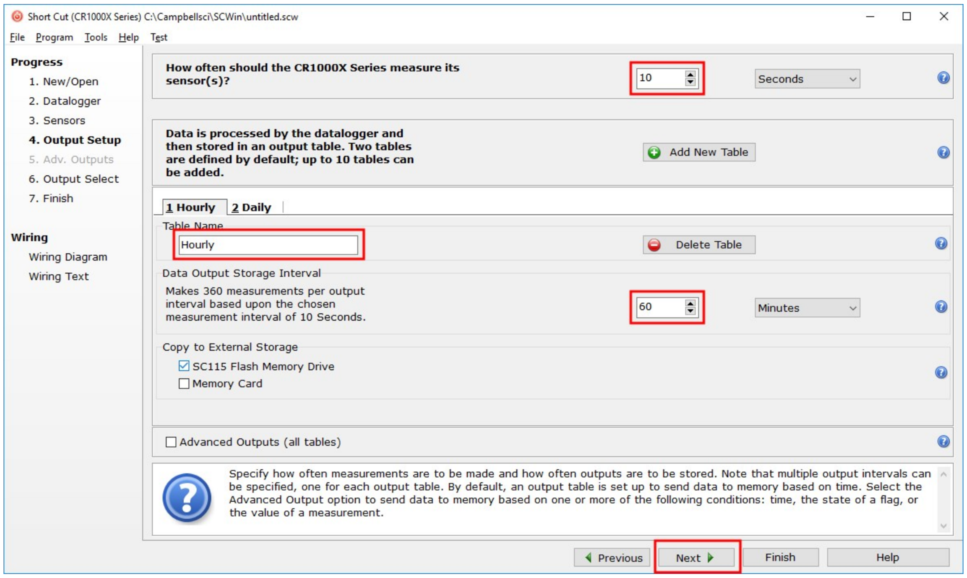
5. In the **Available Sensors and Devices** box, type SR50A. You can also find the sensor in the **Sensors** > **Miscellaneous Sensors** > **SR50/SR50A Sonic Ranging Sensor** folder. Double-click the sensor model; the SR50A-EE is programmed the same as the SR50A. Data defaults to meters, which can be changed by clicking the **Unit of measure box** and selecting **cm**, **ft**, or **in**. Type the **Distance to base**, which is the distance from the wire mesh face to the ground. **SDI-12 Address** defaults to 0. Type the correct **SDI-12 Address** if it has been changed from the factory-set default value. If using an SR50A, SR50A-EE, or SR50AH, click the **Air temperature (Deg C) reference** box and select the reference temperature variable (T107_C).



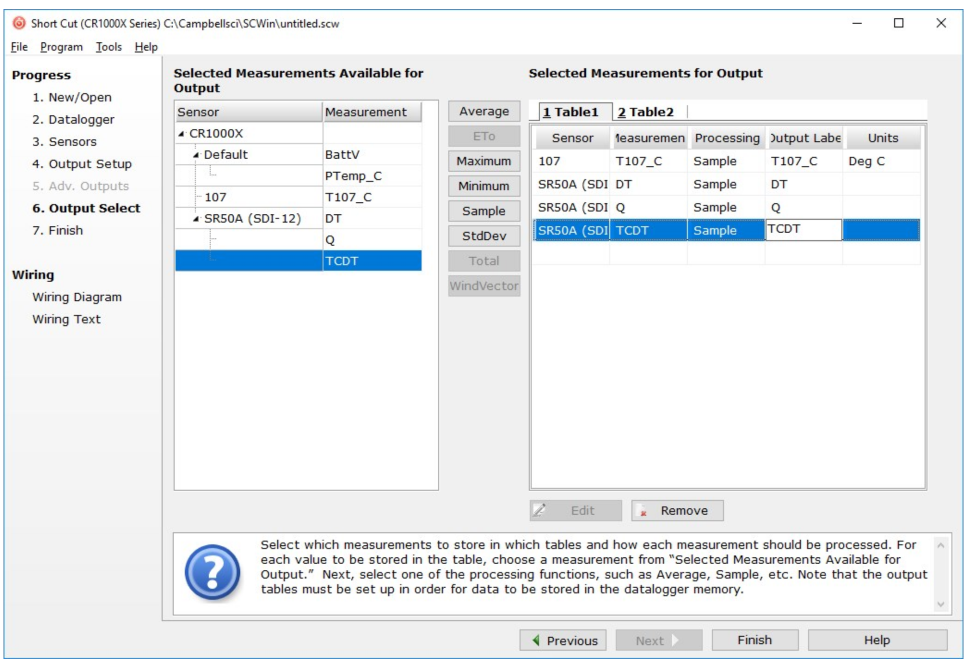
6. Click the **Wiring** tab to see how the sensor is to be wired to the data logger. Click **OK** after wiring the sensor.



7. Repeat steps five and six for other sensors. Click **Next**.
8. In **Output Setup**, type the scan rate, meaningful table names, and **Data Output Storage Interval**. Click **Next**. Because of the delays using SDI-12, Campbell Scientific recommends measurement scans of 10 seconds or more.



9. Select the output options.



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

11. If the sensor is connected to the data logger, check the output of the sensor in the data display in ***LoggerNet***, ***RTDAQ***, or ***PC400*** to make sure it is making reasonable measurements.

5. Overview

The SR50A-series sensors measure the distance from the sensor to a target. They determine the distance to a target by sending ultrasonic pulses (50 kHz) and listening for the returning echoes that are reflected from the target. The time from pulse transmission to return of the echo is the basis for obtaining the distance measurement. The SR50A-series sensors are capable of picking up small targets or targets that are highly absorptive to sound, such as low-density snow.

Since the speed of sound in air varies with temperature, an independent temperature measurement is required to compensate the distance reading. The SR50AT and SR50ATH include a temperature sensor to provide this measurement. The SR50A, SR50A-EE, and SR50AH require an external temperature sensor, such as the 107, to provide the measurement.

The SR50A-series sensors meet the stringent requirements of snow depth measurement making them well suited for a variety of applications. The SR50A, SR50AT, and SR50AH have a standard aluminum chassis that withstands many environments, but is not suitable for coastal environments. The SR50A-EESR50A has a type III anodized aluminum chassis with a rugged transducer that allow these sensors to be used in coastal environments

FIGURE 5-1. The anodized chassis of the SR50A-EE (right) protects the SR50A-EE in coastal environments.

The SR50AH and SR50ATH include integrated heaters that prevent ice from coating the transducer, but the heaters increase the power consumption of the sensor; see SR50AH heater operation (p. 44) for more information.

SDI-12, RS-232, and RS-485 output options are available for measuring the SR50A. The SR50A is factory configured as an SDI-12 sensor (address 0) because Campbell Scientific data loggers typically use the SDI-12 format. To use the RS-232 or RS-485 format, three jumpers inside the SR50A need to be moved (Disassembly/assembly procedures (p. 22) and Jumper settings (p. 29)). Refer to RS-232 and RS-485 operation (p. 30) for more information.

Features:

- Wide operating temperature range
- Uses a multiple echo processing algorithm to help ensure measurement reliability
- Can output a data value indicative of measurement quality (Quality numbers (p. 17))
- Compatible with Campbell Scientific CRBasic data loggers: GRANITE-series, CR6, CR3000, CR1000X, CR800 series, CR300-series, and CR1000

6. Specifications

Power requirements:	9 to 18 VDC
Quiescent power consumption (no heater)	
SDI-12 mode:	< 1.0 mA
RS-232/RS-485 modes:	< 1.25 mA (≤ 9600 bps), < 2.0 mA (> 9600 bps)
Active power consumption (no heater):	250 mA typical
Measurement time:	< 1.0 s typical for RS-232 or RS-485 measurements 1.2 s typical for SDI-12 measurements
Selectable outputs:	SDI-12 (version 1.3) RS-232 (1200 to 38400 bps) RS-485 (1200 to 38400 bps)
Measurement range:	0.5 to 10 m (1.6 to 32.8 ft)

Accuracy:	±1 cm (±0.4 in) or 0.4% of distance to target, whichever is greater Accuracy specification excludes errors in the temperature compensation. An external temperature compensation is required.
Resolution:	0.25 mm (0.01 in
Required beam angle clearance:	30 °
Operating temperature range:	–45 to 50 °C
Maximum cable length:	SDI-12 60 m (197 ft) RS-232 (9600 bps or less) 30 m (98 ft) RS-485 300 m (984 ft); power supply must not drop below 11.0 V or a heavier gage wire is required
Cable type:	4 conductor, 2-twisted pair, 22 awg Santoprene jacket
Chassis types:	Standard aluminum or corrosion-resistant, type III aluminum
Sensor length:	10.1 cm (4 in)
Sensor diameter:	7.6 cm (3 in)
Sensor weight (no cable)	
Standard aluminum chassis:	0.4 kg (0.88 lb)
Type III aluminum chassis:	0.36 kg (0.80 lb)
Cable weight (15 ft):	0.25 kg (0.55 lb)
IP rating	
Electrical housing:	IP67
Transducer:	IP64
Compliance:	This device complies with Part 15 of the USA Federal Communications Commission (FCC) Rules. Operation in the USA is subject to the following two conditions: 1. This device may not cause harmful interference. 2. This device must accept any interference received, including interference that may cause undesired operation.

Compliance documents:	View at www.campbellsci.com/sr50a www.campbellsci.com/sr50a-ee-l www.campbellsci.com/sr50at-l www.campbellsci.com/sr50ah-l www.campbellsci.com/sr50ath-l

6.1 Integrated temperature sensor

Accuracy:	±0.2 °C (0 to 50 °C); ±0.75 °C (–45 to 0 °C)

7. Installation

If you are programming your data logger with ***Short Cut***, skip Wiring (p. 10) and Programming (p. 11). ***Short Cut*** does this work for you. See QuickStart (p. 3) for a ***Short Cut*** tutorial.

7.1 Wiring

Table 7-1 (p. 10) provides wiring information when using the SDI-12 output. Refer to RS-232 and RS-485 operation (p. 30) for wiring information for the RS-232 or RS-485 outputs.

> CAUTION:
> Power down your system before wiring the sensor. Never operate the sensor with the shield wire disconnected. The shield wire plays an important role in noise emissions and susceptibility as well as transient protection.

Table 7-1: SDI-12 wire color, function, and data logger connection

Wire color	Wire function	Data logger connection terminal
Black	Power ground	**G**
Red	Power	**12V**
Green	SDI-12 signal	**C**[1], **SDI-12**, or **U** configured for SDI-12[1]
White	Ground	**G**
Clear	Shield	**G**

[1] **C** and **U** terminals are automatically configured by the measurement instruction.

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 such that each sensor has a unique SDI-12 address. Using unique SDI-12 addresses reduces the number of terminals used on the data logger and allows sensors to be connected in a daisy-chain that can minimize cable runs in some applications.

For the GRANITE-series, CR6, and CR1000X data loggers, triggering conflicts may occur when a companion terminal is used for a triggering instruction such as `TimerInput()`, `PulseCount()`, or `WaitDigTrig()`. For example, if the SR50A is connected to **C3** on a CR1000X, **C4** cannot be used in the `TimerInput()`, `PulseCount()`, or `WaitDigTrig()` instructions.

Regardless of the data logger, if enough terminals are available, avoid using the companion terminal for another device.

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. 3). ***Short Cut*** programming is only available for the SDI-12 output. 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. 28).

Programming basics for CRBasic data loggers are provided in the following sections. Downloadable example programs are available at:

www.campbellsci.com/downloads/sr50a-example-programs

www.campbellsci.com/downloads/sr50at-example-programs

www.campbellsci.com/downloads/sr50ah-example-programs

www.campbellsci.com/downloads/sr50ath-example-programs

7.2.1 SDI-12 programming

The `SDI12Recorder()` instruction is used to measure an SR50A 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 measurements (p. 19) for more information.

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

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

Valid values for the `SDIAddress` are 0 through 9, A through Z, and a through z; alphabetical characters need to be enclosed in 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 8-2 (p. 19)).

`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 7-2 (p. 12). Refer to RS-232 and RS-485 operation (p. 30) for detailed information about using the RS-232 output. Downloadable example programs for using the RS-232 output are available at www.campbellsci.com/downloads/sr50a-example-programs and www.campbellsci.com/downloads/sr50at-example-programs.

Table 7-2: Serial instructions

Instruction	Function
`SerialFlush()`	Clears the buffer.
`Scan()`	Establish a scan rate.
`SerialOut()`	Send command to the sensor.
`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.

7.2.3 RS-485 programming

The RS-485 output can be directly read by a CR6-series and CR1000X-series. Other Campbell Scientific data loggers can use an MD485 multidrop interface to read the RS-485 output. Refer to the MD485 manual for information about using the MD485.

Programming for RS-485 output uses the same instructions as the RS-232 output (Table 7-2 (p. 12)). Refer to RS-232 and RS-485 operation (p. 30) for detailed information about using the RS-485 output. Downloadable example programs for using the RS-485 output are available at www.campbellsci.com/downloads/sr50a-example-programs and www.campbellsci.com/downloads/sr50at-example-programs.

7.3 Beam angle

When mounting the SR50A, the beam angle needs to be considered. Mount the SR50A perpendicular to the intended target surface. The SR50A has a beam angle of approximately 30 degrees. This means that objects outside this 30-degree beam will not be detected nor interfere with the intended target. Any unwanted target must be outside the 30-degree beam angle.

Determine the required clearance for the beam angle using the following formula and FIGURE 7-1 (p. 13).

Clearance Radius formula:

$CONE_{radius} = 0.268(CONE_{height})$

Where,

$CONE_{height}$ = the distance to base (Reference point (p. 14))

$CONE_{radius}$ = clearance radius in the same measurement units as the $CONE_{height}$

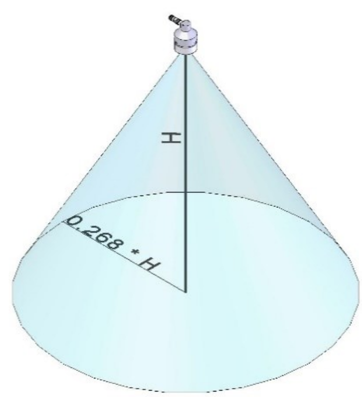


FIGURE 7-1. Beam angle clearance

7.4 Mounting height

Mount the SR50A so that the face of the transducer is at least 50 cm (19.7 in) away from the target. However, mounting the sensor too far from the target can increase the absolute error. For example, if your sensor is measuring snow depth in an area that will likely not exceed 1.25 m (4.1 ft), then a good height to mount the sensor will be 1.75 to 2.0 m (5.74 to 6.56 ft). Mounting the sensor at a 4 m (13.1 ft) height can result in larger snow depth errors.

7.4.1 Reference point

The front grill on the ultrasonic transducer is used as the reference for the distance values. Because of the difficulty of measuring from the grill, most users measure the distance from the target to the outer edge of the plastic transducer housing (FIGURE 7-2 (p. 14)) and then add 8 mm (0.3 in) to the measured distance.

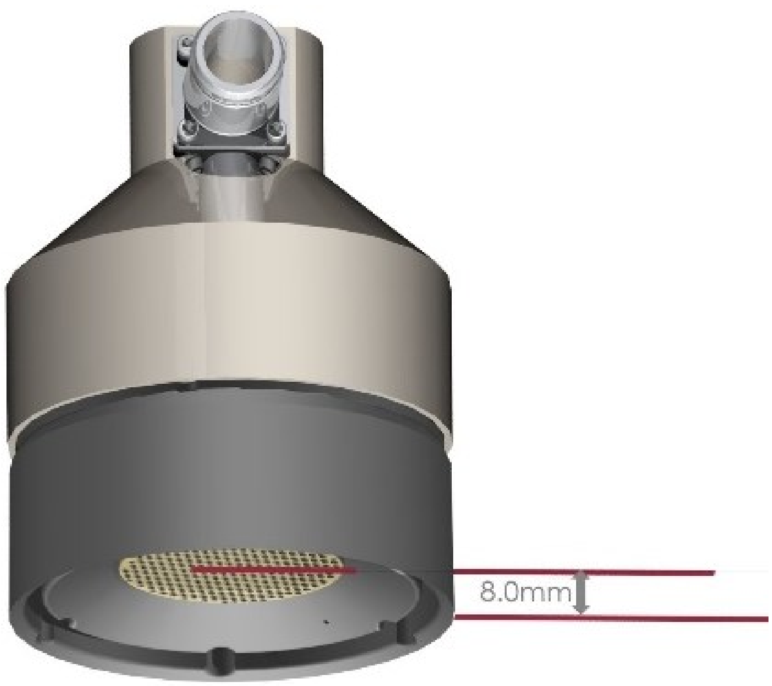


FIGURE 7-2. Distance from edge of transducer housing to grill

7.5 Mounting

To achieve an unobstructed view for the beam, the SR50A is typically mounted to a tripod mast, tower leg, or user-supplied pole, using the CM206 6-ft crossarm or a pipe with a 1-inch to 1.75-inch outer diameter. The SR50A Mounting Kit attaches directly to the crossarm or pipe. FIGURE 7-3 (p. 15) shows the SR50A mounted to a crossarm using the mounting kit. A U-bolt mounts the bracket to the crossarm and two screws fasten the SR50A to the bracket.

The SR50A Mounting Stem (FIGURE 7-4 (p. 15)) attaches to the crossarm using the 1-inch-by-1-inch Nu-Rail fitting (FIGURE 7-5 (p. 16)), CM220 right-angle mount, CM230 adjustable-angle mount, or CM230XL extended adjustable-angle mount. Use the CM230 or CM230XL if the ground surface is at an angle.

FIGURE 7-3. Two views of the crossarm installation using the SR50A mounting kit

FIGURE 7-4. SR50A mounting stem

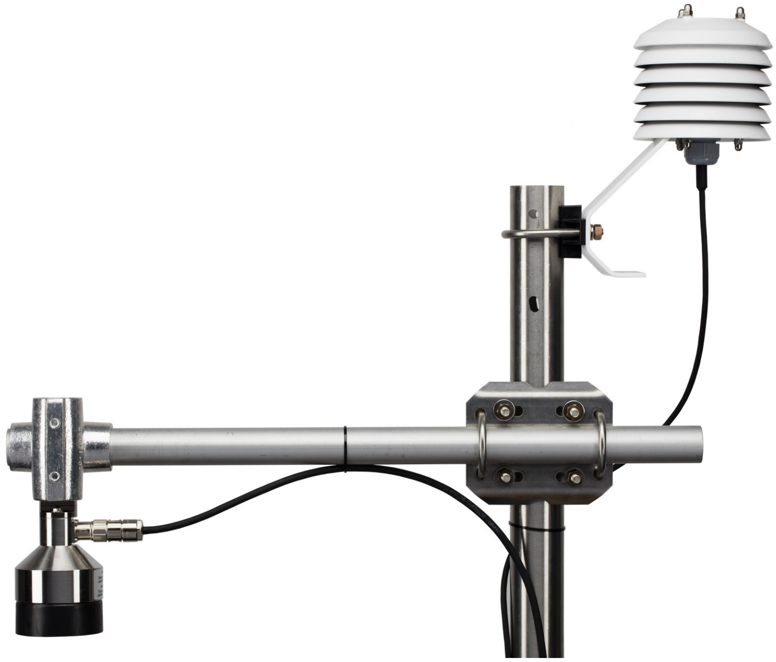


FIGURE 7-5. SR50AT mounted to a crossarm using the mounting stem and a 1-inch-by-1-inch Nu-Rail fitting with the temperature sensor housed in a RAD06 radiation shield

8. Operation

The SR50A bases every measurement on several readings and applies an algorithm to improve measurement reliability. The distance to target readings that are obtained from the sensor are referenced from the metal mesh on the face of the transducer. The SR50A transmits an ultrasonic beam that detects objects within a 30-degree field-of-view (see Beam angle (p. 13)).

The SR50A completes a measurement and outputs the data typically in 1 second. In RS-232 and RS-485 serial modes, the data is completed within one second for baud rates of 9600 bps and above. The total time for an SDI-12 measurement can be between 5 to 10 seconds due to the long communication times associated with the 1200 bps data rate.

The SR50A may reject readings from a moving target if the target distance changes at a rate of 4 centimeters per second or more. If the SR50A rejects a reading or does not detect a target, zero will be output for the distance to target or –999 for depth values.

8.1 Quality numbers

The following table describes the measurement quality numbers provided in the output data. These numbers indicate the measurement certainty. The quality number is calculated as the standard deviation of multiple readings used to return one distance value. Zero indicates the reading was not obtained. Numbers greater than 300 indicate a degree of uncertainty in the measurement. Causes of high numbers include:

- sensor is not perpendicular to the target surface
- target is small and reflects little sound
- target surface is rough or uneven
- target surface is a poor reflector of sound (extremely low-density snow)

Table 8-1: Quality number description

Quality number range	Quality range description
0	Not able to read distance
152 to 210	Good measurement quality numbers
210 to 300	Reduced echo signal strength
300 to 600	High measurement uncertainty

Although not necessary, quality numbers provide useful information such as surface density in snow monitoring applications. Please note that quality number values may increase during snowfall events consisting of low-density snow.

8.2 Temperature compensation

The SR50A and SR50AH do not include a temperature sensor to compensate for the speed-of-sound variations in air temperature (Table 1-1 (p. 1)). For these sensors, temperature corrections for the speed of sound must be applied to the readings by using measurements from a reliable and accurate temperature sensor, such as the 107. The temperature sensor needs to be housed in a radiation shield. Temperature compensation is applied to the SR50A output using the following formula:

$$DISTANCE = READING_{\mathbf{SR50A}}\sqrt{\frac{T^{\circ}KELVIN}{\mathbf{273.15}}}$$

CAUTION:
The SR50A and SR50AH calculate distance readings using the speed of sound at 0 °C (331.4 m/s). If the temperature compensation formula is not applied, the distance values will not be accurate for temperatures other than 0 °C.

The SR50AT and SR50ATH include a temperature sensor to compensate the speed of sound for variations in air temperature. The temperature sensor is incorporated into the cable as shown in FIGURE 8-1 (p. 18).

FIGURE 8-1. SR50AT-CBL

For the RS-232 and RS-485 modes, temperature correction using the integrated temperature probe measurement is applied to the readings by default. For the SDI-12 output mode, the data logger must include a measurement command that outputs temperature. Otherwise, the temperature correction will not be applied. SDI-12 M2, M3, M4, M7, and M8 commands automatically apply the temperature compensation to the readings. (See SDI-12 measurements (p. 19) for the complete list of SDI-12 commands.)

SDI-12 M9 command obtains a temperature measurement without a distance reading, which allows the SR50AT or SR50ATH to function as an SDI-12 temperature sensor.

For the RS-232 and RS-485 modes, the integrated temperature output setting can be turned off if you do not want to use the integrated-temperature probe for the temperature correction. SDI-

12 M, M1, M5, and M6 commands do not use the integrated temperature probe measurements to compensate for the speed of sound.

A radiation shield is required for the temperature probe integrated into the sensor cable. Without a radiation shield, heating of the probe from the sun radiation can cause large errors in the temperature reading, which causes erroneous distance measurements.

8.3 SDI-12 measurements

The SDI-12 protocol supports the SDI-12 commands listed in Table 8-2 (p. 19).

> **NOTE:**
> The SR50A needs to be powered for 1.5 s before it can receive an SDI-12 command.

The different commands are entered as options in the SDI-12 recorder instruction. The user can output the distance to target in either meters or feet, or to include the measurement quality numbers. If the SR50A is unable to detect a proper echo for a measurement, the sensor will return a zero value for the distance to target value.

Table 8-2: SDI-12 commands

SDI-12[1] command	Values returned or function	Units
`aM!`, `aC!`, `aMC!`	Distance	m
`aM1!`, `aC1!`, `aMC1!`	1. Distance 2. Quality number	1. m 2. N/A (not applicable)
`aM2!`, `aC2!`, `aMC2!`	1. Distance 2. Temperature	1. m 2. ° C
`aM3!`, `aC3!`, `aMC3!`	1. Distance 2. Quality number 3. Temperature	1. m 2. N/A 3. ° C
`aM4!`, `aC4!`, `aCC4!`	1. Snow depth 2. Quality number 3. Temperature	1. m 2. N/A 3. ° C
`aM5!`, `aC5!`, `aCC5!`	Distance	inch

Table 8-2: SDI-12 commands		
SDI-12[1] command	Values returned or function	Units
aM6!, aC6!, aCC6!	1. Distance 2. Quality number	1. inch 2. N/A
aM7!, aC7!, aCC7!	1. Distance 2. Quality number 3. Temperature	1. inch 2. N/A 3. ° C
aM8!, aC8!, aCC8!	1. Snow depth 2. Quality number 3. Temperature	1. inch 2. N/A 3. ° C
aM9!, aC9!, aCC9!	Temperature	° C
aD0!	Send Data	
aV!	S1, S2, V, WD S1 = Operating System Signature S2 = BootRom Signature V = Supply Voltage WD = Watch Dog Errors	
aI!	013CAMPBELLSR50A2.0SN SN = Serial number (5 digits)	
?!	SDI-12 address	
aAb!	Change address command; b is the new address	
aX+D.DDD! Extended command	Set the distance to ground parameter in the SR50A. The distance must be no more than three decimal places.	m
aXI+DDD.DD! Extended command	Set the distance to ground parameter in the SR50A. The distance must be no more than two decimal places.	inch
aXT+CC.CC! Extended command	Provide the SR50AT with a temperature value to perform onboard temperature compensation. The temperature must be in degrees Celsius with a maximum of seven characters including sign and decimal.	° C

Table 8-2: SDI-12 commands		
SDI-12[1] command	Values returned or function	Units
`aR0!`	Returns the distance to ground setting in the SR50AT.	m
`aR1!`	Returns the distance to ground setting in the SR50AT.	inches
`aR2!`	Returns the temperature sent to the SR50AT for internal temperature compensation. This value remains the same unless power is cycled or a new temperature value is sent.	° C
[1]Where a = address of SDI-12 device.		

When using the `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 20 seconds or more.

The `C!` command follows the same pattern as the `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 `R!` command switches the sensor to automatically make measurements and send data every 11 seconds, ±2 seconds, based on the internal clock of the sensor. If measurements are requested at 2 seconds or faster, the sensor will increase its measurement rate to approximately every 5 seconds. This instruction usually takes less than 300 milliseconds to execute. The automatic measurement mode can only be canceled by powering down the sensor to reset it.

The SR50A also supports the `MC!`, `CC!`, and `RC!` commands, which are the same as the previous instructions, but where the C at the end of the instruction forces a validation for the data received from the sensor using a checksum. If the checksum is invalid, the data logger will re-request the data up to three times. The checksum validation increases the measurement time by about 40 milliseconds if there are no errors. Retries will increase the measurement time in proportion to the number of retries.

See SDI-12 sensor support (p. 49) for details of the SDI-12 protocol.

8.4 Measuring multiple SDI-12 sensors

Multiple SDI-12 sensors can be connected to a single data logger terminal if they have unique SDI-12 addresses. However, it is easiest to use a different terminal for each SDI-12 sensor instead of changing the address.

The SR50A can have an SDI-12 address of 0 to 9. Some SDI-12 devices can have an SDI-12 address of 0 to 9, A to Z, or a to z. See Change address command (aAb!) (p. 51) to change the SDI-12 address from its default address of 0.

9. Maintenance and troubleshooting

The electrostatic transducer requires equal pressure on both sides. Vent holes in the transducer housing are used to equalize pressure. Desiccant placed inside the transducer housing helps prevent condensing humidity. Regularly inspect the desiccant and, if required, replace it. Desiccant capable of absorbing moisture is blue. Once the desiccant becomes saturated, the color changes from blue to pink. In humid environments, replace the desiccant more frequently. Inspection or replacement of the desiccant requires the SR50A to be disassembled (Disassembly/assembly procedures (p. 22)).

Replace the transducer assembly every three years if it is not in a humid environment. Replace the transducer housing assembly every year in humid environments.

- SR50A or SR50AT housing and maintenance kit
- SR50AH or SR50ATH housing and maintenance kit

9.1 Disassembly/assembly procedures

The following figures show the procedure for disassembling the SR50A. Disassembly is required to inspect or replace the desiccant, and to change the transducer and the option jumpers.

> **CAUTION:**
> Before proceeding with any maintenance, always retrieve the data first. Campbell Scientific also recommends saving the data logger program.

CAUTION:
Always disconnect the SR50A from the data logger or the connector before disassembling.

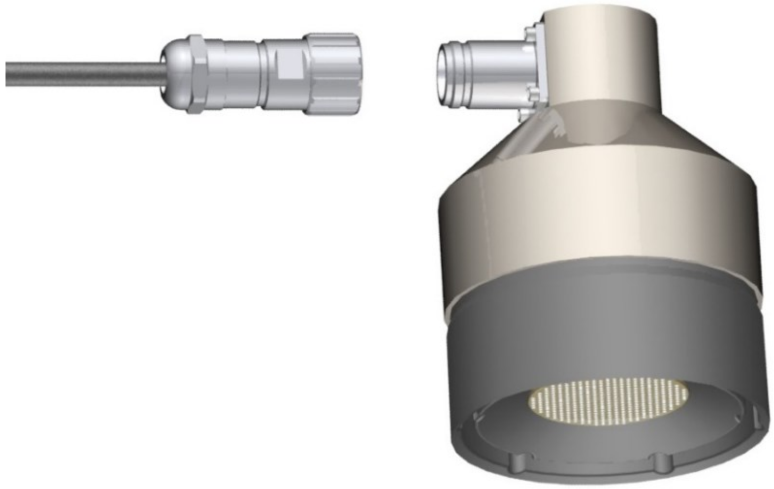


FIGURE 9-1. Disconnect Cable from Sensor

FIGURE 9-2. Remove six screws from the transducer housing

FIGURE 9-3. Remove transducer housing and disconnect wires

FIGURE 9-4. Location of desiccant in transducer housing assembly

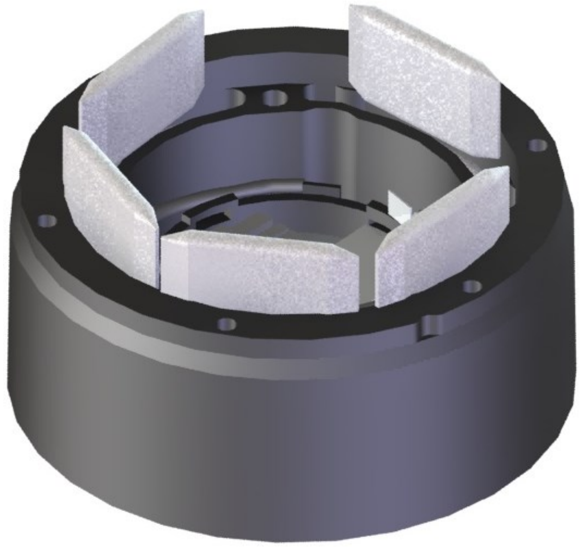


FIGURE 9-5. Remove and replace desiccant

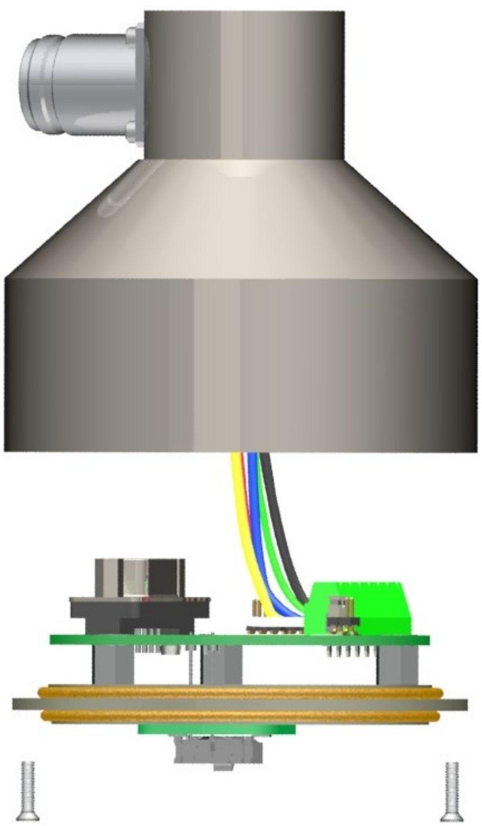


FIGURE 9-6. Remove the two flat Phillips screws to expose the PCB

Carefully reassemble in reverse order.

9.2 Data interpretation

Although not common, the SR50A can output invalid reading indicators if unable to obtain a measurement. For invalid distance-to-target values, 0 is returned to indicate an error. For snow depth outputs and temperature reading outputs, the error indicator value is -999. For snow depth applications, invalid readings can be easily filtered out when analyzing the data. Invalid readings should be detected and discarded in control-type applications.

9.3 Data filtering

The following scenarios can produce values with higher than expected errors:

1. Low-density snow results in weak echos returned to the sensor.
2. Weak signal, as indicated by an increased number of echo-quality numbers returned to the sensor.

Under these circumstances, an SR50A can under, or over, estimate snow depth. If the signal is too weak, the sensor will output a value of 0 for the distance to target. When the echoes are weak, the sensor automatically increases sensitivity, which makes the sensor prone to erroneous readings from flying debris, drifting snow, or obstruction near the beam angle.

The reason not to average values is that high-error values can skew the average. The best technique to eliminate errors and filter out high-error readings is to take the median value. This technique also helps to automatically filter out zero readings.

Table 9-1 (p. 26) shows a station that reads the SR50A every 5 seconds for 1 minute and takes the median value from the readings. The downloadable programs available on our website use this method for data filtering.

Table 9-1: Data filtering example

Consecutive snow-depth values	Values sorted from low to high
0.33	–1.1
0.34	0.10
0.35	0.28
–1.1 (erroneous reading)	0.32
2.0 (erroneous reading)	0.33
0.37	0.33
0.28	0.34

Table 9-1: Data filtering example	
Consecutive snow-depth values	Values sorted from low to high
0.36	0.35
0.10 (high error value)	0.36
0.33	0.37
0.32	2.0

The best course of action would be to ignore the five lowest values and take the sixth value (0.33).

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. Jumper settings

FIGURE B-1 (p. 29) shows the jumper locations of the SR50A.

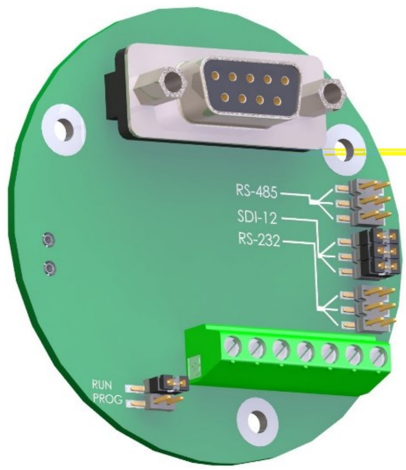


FIGURE B-1. Jumper settings

The SR50A can be configured with either SDI-12, RS-232 or RS-485 communications. Shunt jumpers can be located on any of the three sets of communication selection headers. Only place the three jumpers on one group at a time. Never install more than three jumpers and never mix the jumpers among the SDI-12, RS-232 or RS-485 locations.

The other jumper located on the SR50A places the sensor in either the normal operation mode or in the program update mode. The program mode is only used for updating the internal operating system of the sensor. During operation, have the jumper in the **RUN** position.

Appendix C. RS-232 and RS-485 operation

The SR50A sensor comes from the factory with the internal jumpers set to SDI-12 mode. To use the SR50A in the RS-232 or RS-485 mode of operation, the jumpers need to be set as outlined in Jumper settings (p. 29). Downloadable example programs are available at:

- www.campbellsci.com/downloads/sr50a-example-programs
- www.campbellsci.com/downloads/sr50at-example-programs

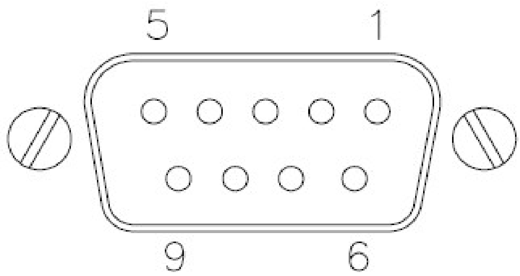
C.1 RS-232 wiring

Table C-1 (p. 30) shows RS-232 wiring when connecting the sensor directly to a CR1000X or CR6 data logger. FIGURE C-1 (p. 31) and Table C-2 (p. 31) show wiring for the SR50A when using a DB9-female-to-terminal block. In this situation, the ground used with the RS-232 connector (pin 5) must use the same ground as the SR50A. Use a jumper wire from pin 5 of the RS-232 connector to the data logger ground.

Table C-1: SR50A data logger COM terminal wiring

SR50A wire color	Function	Data logger Terminal
Red	+12 VDC power	**12V**
Black	Power ground	**G**
White	RS-232 (SR50A input)	**C**(odd)
Green	RS-232 (SR50A output)	(**C** (even)
Clear	Shield	**G**

Interface with Hood and Hardware Kit, DB9 Female to Terminal Block



Pin	Assignment
1	DCD
2	**RXD**
3	**TXD**
4	DTR
5	**GND**
6	DSR
7	RTS
8	CTS
9	N/A

Pins used for RS-232 communication in **bold** lettering.

FIGURE C-1. RS-232 DB9 Connector Description

Table C-2: SR50A RS-232 interface wiring

SR50A wire color	Function	Wiring location
Red	+12 VDC power	Power source (data logger: **12V**)
Black	Power ground	System ground and/or RS-232 receiver ground (data logger: **G**)
Green	RS-232 (SR50A output)	Pin 2 [RXD] (9-pin RS-232 interface connector)
White	RS-232 (SR50A input)	Pin 3 [TXD] (9-pin RS-232 interface connector)

Table C-2: SR50A RS-232 interface wiring		
SR50A wire color	Function	Wiring location
Clear	Shield	**G** (data logger)
Jumper wire		Pin 5 [**G**] (9-pin RS-232 interface connector)

C.2 RS-485 operation

The RS-485 on the SR50A supports half-duplex communications, which means the SR50A can receive and transmit data, but not simultaneously. Normally a master-slave relationship is used in most systems to avoid collisions between transmissions. For this reason, the **Auto Measure Output** is not recommended for RS-485 communications. It is much better to have a master initiate the communications by using the **Measure On Poll** or the **Auto Measure Polled Output** modes.

The CR6 and CR1000X data loggers can read the SR50A output without an interface such as the MD485. For other Campbell Scientific data loggers, the MD485 interface is required to connect one or more SR50A sensors. The RS-485 mode is useful for sensors that require cable lengths that exceed the limits of either RS-232 or SDI-12 communications.

C.3 RS-485 wiring for direct data logger connection

The following shows RS-485 wiring when connecting the sensor directly to a CR1000X or CR6 data logger.

Table C-3: RS-485 wire color, function, and data logger connection		
Color	Function	Data logger connection terminal
Black	Power ground	**G**
Red	Power	**12V**
Green	RS-485 A	**C** (odd)
White	RS-485 B	**C** (even)
Clear	Shield	⏚ (analog ground)

C.4 RS-485 wiring using an MD485

Table C-4 (p. 33) and FIGURE C-2 (p. 33) show the wiring for the SR50A when using an MD485 Multidrop Interface to read the RS-485 output.

Table C-4: Connections to MD485A Multidrop Interface		
Color	**Function**	**Connection**
Black	Power ground	System ground and/or RS-232 receiver ground (pin 5 of a computer (DTE) DB-9 connector)
Red	Power	Power source +12V
Green	RS-485 A	MD485 RS-485 **A** terminal
White	RS-485 B	MD485 RS-485 **B** terminal
Clear	Shield	Shield/earth ground

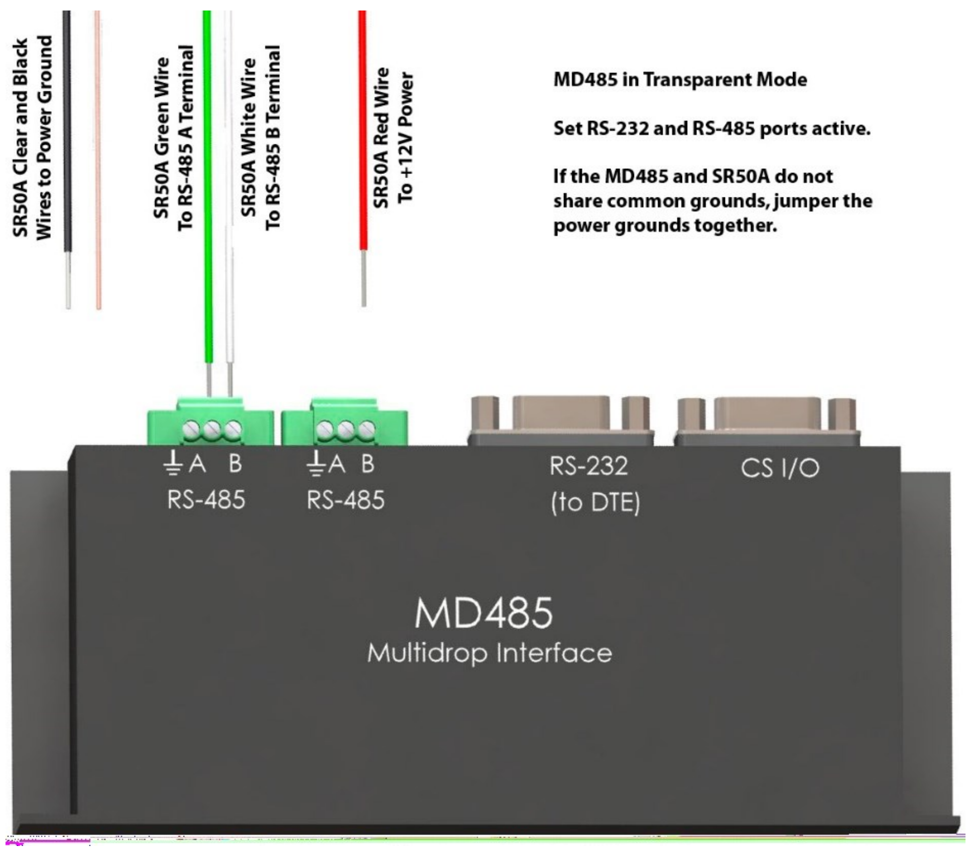


FIGURE C-2. SR50A to MD485 wiring

C.5 RS-232 and RS-485 settings

Once the jumpers are set for RS-232 operation, Device Configuration Utility is used to change factory defaults or existing settings. Use a terminal program that allows local echo. The following settings apply to Device Configuration Utility or any program used for communications.

Baud rate: Current SR50A setting (see NOTE)

Data bits: 8

Parity: None

Stop bits: 1

Flow control: None

Local echo: On

NOTE:
The factory default baud rate is 9600 bps. Once the baud rate is changed, the new baud rate must be used for further communications to the SR50A. Ensure to keep track of the baud rate setting on the SR50A. If the baud rate setting is unknown, try using the default value of 9600 bps. If that does not work, start the baud rate at 1200 bps and go through all the baud rate settings until the correct one is found.

Select the following when using Device Configuration Utility (FIGURE C-3 (p. 35)).

- Device Type: **Unknown**
- Choose the correct **COM port**.
- By default, the **baud rate** in the SR50A and Device Configuration Utility is set to 9600. Only change the baud rate if you know it has been changed in the SR50A.
- Click **Connect** in the lower left hand corner.
- Uncheck the **All Caps** box.
- Check **Echo Input**.

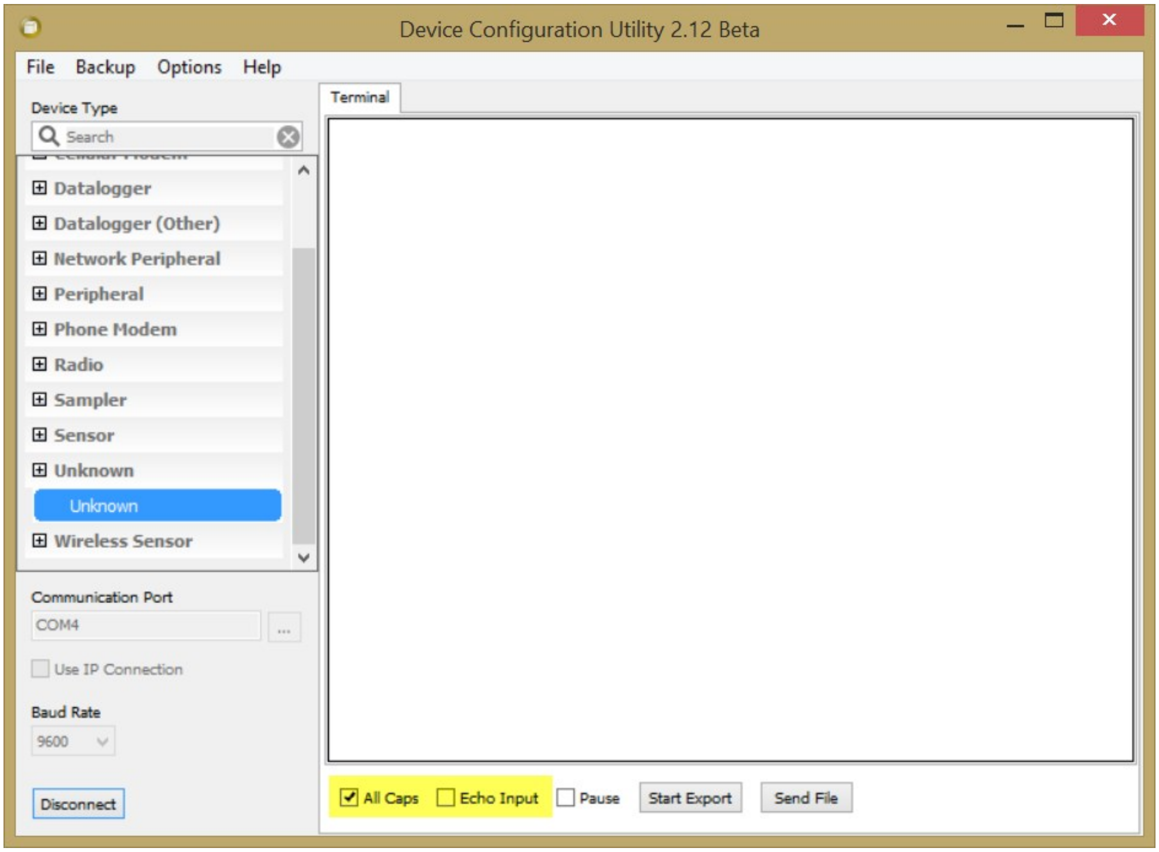


FIGURE C-3. Initial terminal window in Device Configuration Utility

To enter **Setup** mode, type **setup** in the terminal window and press the **Enter** key. The word **setup** and all options in the setup menu are not case sensitive.

The SR50A should respond with the setup menu shown in FIGURE C-4 (p. 36).

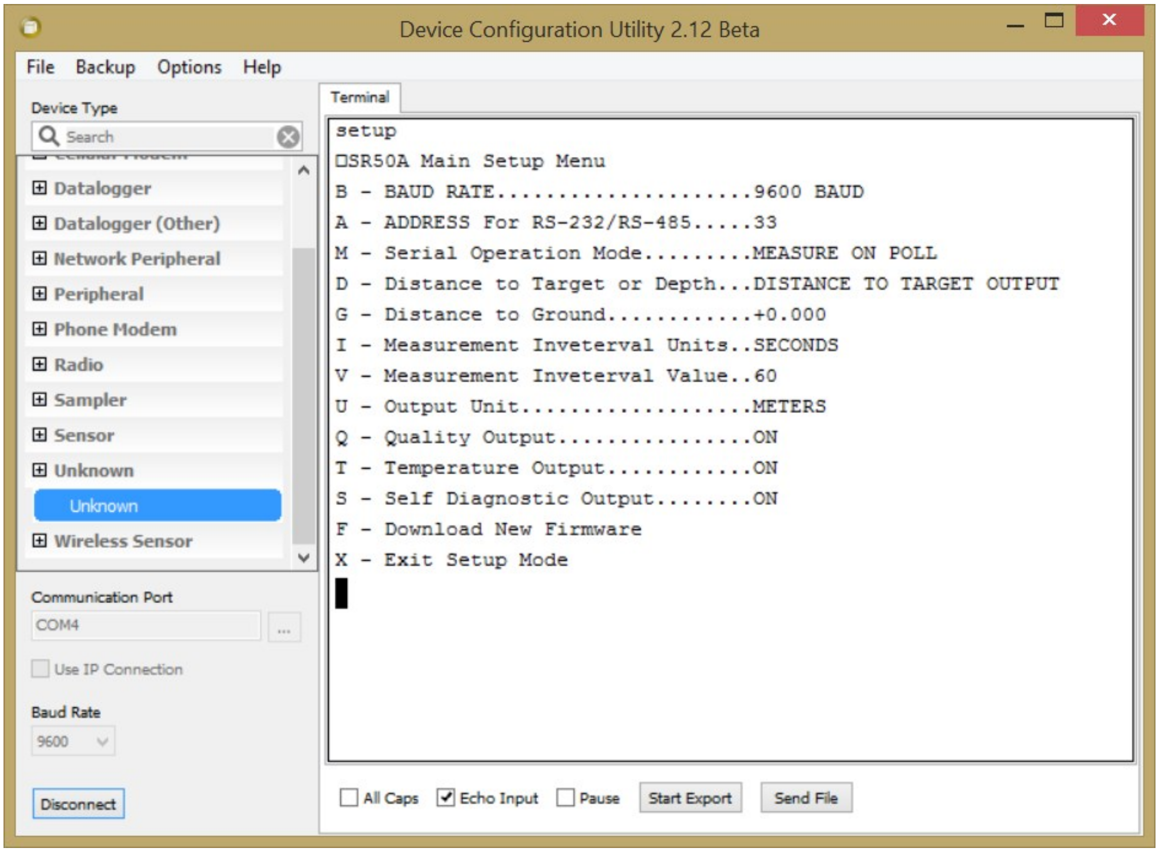


FIGURE C-4. SR50A Setup Menu

Table C-5 (p. 36) summarizes the settings that can be changed using the SR50A RS-232 or RS-485 operating modes. Recommended changes are shown in parenthesis.

Table C-5: RS-232 and RS-485 settings

Setting description	Options	Default value
Baud rate	1200 4800 9600 19200 38400	9600 bps
Address RS-232/RS-485	Any two alphanumeric characters	33
Serial operational mode	Measure on poll Auto-measure, Auto-output Auto-measure polled output	Auto measure auto output (Change this to measure on poll.)

Table C-5: RS-232 and RS-485 settings		
Setting description	**Options**	**Default value**
Distance to target or depth output	Distance to target depth	Distance to target
Distance to ground	Decimal value in meters	0.0
Measurement interval units	Seconds Minutes Hours	Seconds
Measurement interval value	Integer 1-255	60
Output unit	Meters Centimeters Millimeters Feet Inches	Meters
Quality output	On Off	Off (Change this to ON.)
Temperature output	On Off	Off Output valid only for the SR50AT
Diagnostics output	On Off	Off (Change this to ON.)

C.5.1 Baud rate setting

The factory default baud rate setting of 9600 bps is suitable for most applications. Lower baud rates (1200 or 4800 bps) may improve communication reliability or allow for longer cable lengths. Higher baud rates (19200 or 38400 bps) may be used where faster communications are required.

The quiescent current draw for the SR50A in serial mode is normally 1.25 mA for baud rates of 9600 or less. The current draw increases to 1.5 and 2.25 mA for the baud rates of 19200 or 38400 bps, respectively.

It is possible to download an operating system update to the SR50A via the RS-232 or RS-485 communication interface. Higher baud rates may be desirable to speed up this process.

It may take up to 30 minutes using a speed of 1200 bps, 7 minutes using 9600 bps, or 3 minutes using 38400 bps.

C.5.2 Address

The factory default address is 33. For RS-232 applications, use the factory default address. For RS-485 operation, multiple sensors can be polled individually if different addresses are assigned.

C.5.3 Operational mode setting

Three different operational mode settings are available on the SR50A. Overall system design and desired performance determine which mode to select. The following sections describe each of the three different modes as well as the advantages and disadvantages of each mode.

C.5.3.1 Measure in poll mode

In this mode, the SR50A remains idle until a measurement command is sent (`p33<CR>`) where 33 is the default serial address. After receiving the measurement command, the SR50A immediately begins a measurement and transmits the resulting data packet when the measurement is complete. Typically, the SR50A transmits the data packet within 1 second of receiving the command packet.

- The SR50A only performs a measurement when requested.
- The data output will lag the measurement command by 1 second.
- This configuration is conducive to a multidrop RS-485 system where individual sensors do not transmit data until they are addressed.

C.5.3.2 Auto measure auto output mode

In this mode, the SR50A automatically exits its low power mode, initiates a measurement, and outputs the data. The frequency that the SR50A performs these functions is set by adjusting the `Measurement Interval Units` and the `Measurement Interval Value` parameters.

- No command is required from an external device to obtain a measurement.
- The data recorder or equipment simply needs to read the incoming serial data from the SR50A.

C.5.3.3 Auto measure polled output mode

In this mode, the SR50A automatically exits its low power mode and initiates a measurement. The output data string is not sent until a poll command is received. When a poll command is received by the SR50A, the output data typically commences 100 ms after the poll command is sent.

The frequency that the SR50A performs the measurement is set by adjusting the `Measurement Interval Units` and the `Measurement Interval Value` parameters.

- The main advantage of this operating mode is that the receiving device will only have to wait 100 ms for the data instead of 1 second.
- This configuration is also more conducive to a multidrop RS-485 system where individual sensors do not transmit until they are addressed.

C.5.4 Distance to target or depth

The SR50A can output either distance to target values or calculate snow depth values. To obtain a valid snow depth value the parameter distance to ground must be included.

The SR50AT will compensate the readings for temperature.

Do not use this option on the SR50A sensor unless the SR50A is sent valid temperature reading via the `Temperature Input` command.

C.5.5 Distance to ground

A valid distance to ground must be entered when the SR50A is configured to output snow depth values. The value must be in meters regardless of the output units that are selected.

If the exact value cannot be obtained, it is better to slightly overestimate the value rather than underestimating it. If a `Distance to Ground` value is too small, the SR50A will output an error value as the snow surface should not be below the ground surface.

C.5.6 Measurement interval units

This setting is only applicable if either the `Auto Measure Polled Output` or the `Auto Measure Auto Output` modes are used. The options for the `Measurement Interval Units` are:

- Seconds
- Minutes
- Hours

Once a unit type is selected, the number of units for the interval is set by changing the `Measurement Interval Value` parameter. A 60 s interval can be set by setting the units to seconds and the `Measurement Interval Value` to 60. Alternately, the `Measurement Interval Unit` could be set to minutes and the `Value` could be set to 1. The `Value` setting can only range from 1 to 255.

C.5.7 Measurement interval value

This setting is only applicable if either the `Auto Measure Polled Output` or the `Auto Measure Auto Output` modes are used. The `Measurement Interval Value` can range from 1 to 255. The units used for the value is set by the `Measurement Interval Units`.

C.5.8 Quality output

The SR50A quality numbers can be optionally included in the data output string. The `Quality Output` setting can be set to `ON` or `OFF`.

C.5.9 Diagnostics output

The SR50A diagnostics numbers can be optionally included in the data output string. The `Diagnostics Output` setting can be set to `ON` or `OFF`.

C.6 Serial commands

The setup command places the SR50A in the serial setup mode. This command should only be sent to customize the sensor settings. Upper and lower case letters are accepted and a carriage return character must also terminate the string.

"setup<CR>"

The poll command is used to obtain the output values. The poll command consists of the upper or lower case letter "p" followed by the SR50A address (default 33). The command must also terminate with a carriage return character.

"pAA<CR>" – where AA is a two-character address and set from the factory to 33

"p33<CR>" – Poll command with factory address of 33

The information command is used to query information from the sensor that is not associated with the output of the sensor. For detailed information on the output refer to Data interpretation (p. 26).

The information command consists of the upper or lower case letter "i" followed by the SR50A address (default 33). The command must also terminate with a carriage return character.

"iAA<CR>" – where AA is a two-character address and set from the factory to 33

"i33<CR>" – information command with factory address of 33

The temperature input command is used to send the SR50A version of the sensor a temperature value that is to be used for temperature compensation. The value sent must be in degrees Celsius and should not exceed eight characters.

The command consists of the upper or lower case letter "t" followed by the SR50A address (default 33) a semicolon and the temperature value. The command must also terminate with a carriage return character (Type for Hyperterminal).

"tAA;-5.5<CR>" – where AA is a two-character address and set from the factory to 33 and –5.5 is the temperature in degrees C

"t33;tt.ttt<CR>" – Temperature command with factory address of 33 and a temperature value in Celsius.

C.7 RS-232/RS-485 data output format

The measurement output string for the SR50A is as follows:

<STX>aa;D.DDD;QQQ;TT.TT;VVVVV;CC<CR><LF><ETX>

<STX> is the hex character &h02 (2 in decimal)

aa
These two characters are the serial address of the sensor. The default is 33. Note this is two ASCII characters of &h33 in hexidecimal or 51 in decimal.

D.DDD
This is the distance to target reading. The units depend on the Output Units setting. The number of digits and decimal places also depend on the output unit that is selected. The decimal digits are as follows:

Meters:	D.DDD, 0.000 for no valid reading DD.DDD possible for values past 9.999 m
Centimeters:	DDD.DD DDDD.DD possible for values past 999.99 cm 000.00 output for no valid reading
Millimeters:	DDDD -999 output for no valid reading 9999 Maximum value
Feet:	DD.DDD 00.000 output for no valid reading
Inches:	DDD.DD 000.00 output for no valid reading

QQQ
This data value is the optional quality value output. The quality value is always a three-digit integer and varies from 152 to 600, where 600 is the poorest quality.

TT.TT
This setting must be set to Off. The SR50A will output a –999.00 if the Temperature Output option is set to ON.

VVVVV
This is the diagnostic output value. Each digit represents a pass or a fail on a diagnostic test.

XVVVV
If X is a 1, then the ROM Memory has passed the signature test.

VXVVV
If X is a 1, then no watchdog errors have occurred.

VVXXX
The three digits XXX are for factory use and should always read 111.

CC
This is a two-character checksum of the data packet. The checksum is the two's complement of the data packet sum including control characters.

The Least significant byte is used resulting in a two-character checksum.

<STX> = &h02 (Hexadecimal)
<CR> = &h0D (Hexadecimal)
<LF> = &h0A (Hexadecimal)
<ETX> = &h03 (Hexadecimal)

The following is a sample packet with proper checksum:

<STX>33;1838;194;11011;2C<CR><LF><ETX>
SUM =
02+33+33+3B+31+38+33+38+3B+31+39+34+3B+31+31+30+31+31
+3B+0D+0A+03
=0x3D4
Use Last byte only (D4) and calculate two's complement = 100 – D4 = 2C

<CR>
Carriage return character. 0x0d in hexadecimal or 13 in decimal

<LF>
Line feed character. 0x0a in hexadecimal or 10 in decimal

<ETX>
End of transmission character. 0x03 in hexadecimal or 3 in decimal

The information message output string for the SR50A is as follows:

<STX>aa;SSSSS;H.H;F.F;BBBBB;WWWWW<CR><LF><ETX>

<STX> is the hex character 0x02 (2 in decimal)

aa
These two characters are the serial address of the sensor. The default is 33. Note this is two ASCII characters of 0x33 in hexidecimal or 51 in decimal.

SSSSS
This is the serial number of the sensor.

H.H
This is the hardware version of the sensor.

F.F
This is the operating system version of the sensor.

BBBBB
This is the checksum of the boot code.

WWWWW
This is the checksum of the operating system.

CC
This is a two-character checksum of the data packet. The checksum is the two’s complement of the data packet sum including control characters.

The least significant byte is used resulting in a two-character checksum.

<STX> = &h02 (hexadecimal)
<CR> = &h0D (hexadecimal)
<LF> = &h0A (hexadecimal)
<ETX> = &h03 (hexadecimal)

The following is a sample packet with proper checksum:
<STX>33;1838;194;11011;2C<CR><LF><ETX>
SUM =
02+33+33+3B+31+38+33+38+3B+31+39+34+3B+31+31+30+31+31
+3B+0D+0A+03
=0x3D4
Use Last byte only (D4) and calculate two’s complement = 100 – D4 = 2C

<CR>
Carriage return character. &h0D in hexadecimal or 13 in decimal

<LF>
Line feed character. &h0A in hexadecimal or 10 in decimal

<ETX>
End of transmission character. &h03 in hexadecimal or 3 in decimal

Appendix D. SR50AH heater operation

The heater option on the SR50AH is intended for installations where rime ice is problematic. The heater will help to prevent the ice from forming on the transducer, which can impair proper operation of the sensor.

The heater option is easily identifiable as the transducer housing contains a cable port for the heater supply cable.

Always use the heater option wired to switched 12 VDC source. For battery-operated solar-powered sites, Campbell Scientific recommends that the heater power be turned off when icing conditions are not occurring to reduce power requirements. The heater power must be turned off when operating at temperatures of 25 °C or more.

Downloadable CRBasic programs that control the heater are provided at www.campbellsci.com/downloads/sr50ah-example-programs and www.campbellsci.com/downloads/sr50ath-example-programs.

D.1 Heater specifications

Heater resistance:	75 Ω
Nominal operating voltage:	12 V (ac or dc); use a properly conditioned, low-noise power source. A noisy power source will affect operation of the sensor.
Maximum rated wattage:	3 W
Maximum rated voltage:	15 V (ac or dc)
Maximum heater operating temperature:	25 °C; continued use of the heater when temperatures exceed 25 °C may cause permanent damage to the sensor. For proper control of the heating element, see www.campbellsci.com/downloads/sr50ah-example-programs and www.campbellsci.com/downloads/sr50ath-example-programs.

D.1.1 Heating cable requirements

Type:	2 conductor (twisted pair), shielded
Diameter:	4 to 6 mm (0.16 to 0.24 in)
Recommended gage:	22 AWG for lengths < 30 m (100 ft)

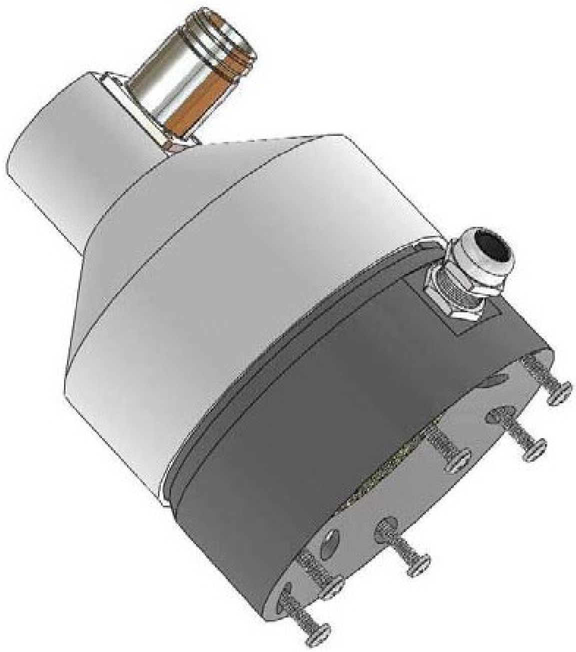
FIGURE D-1. SR50AH heater option

D.2 Heater maintenance

Most of the maintenance is the same as the maintenance for the standard SR50A Maintenance and troubleshooting (p. 22). However, the transducer and desiccant replacement is slightly different for the SR50AH. When ordering replacement transducers, ensure that the replacement transducer maintenance kit is specifically for the heated model.

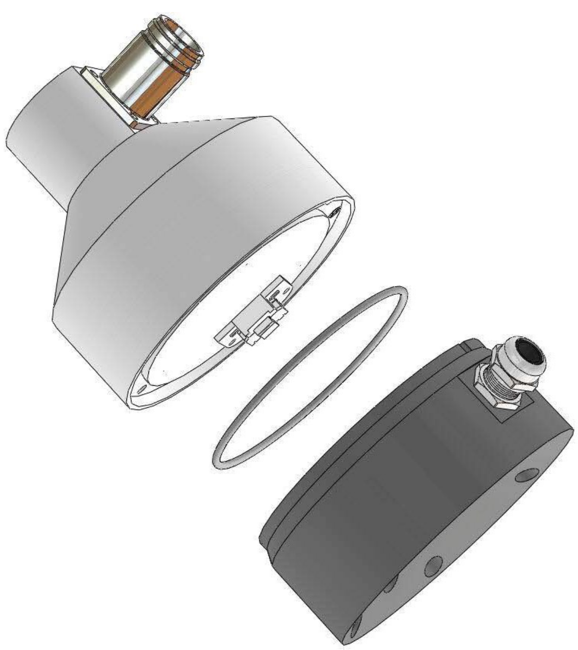
The procedure to disassemble the SR50AH for desiccant replacement or transducer replacement is as follows:

1. Remove the six Phillips screws on the outermost hole pattern.

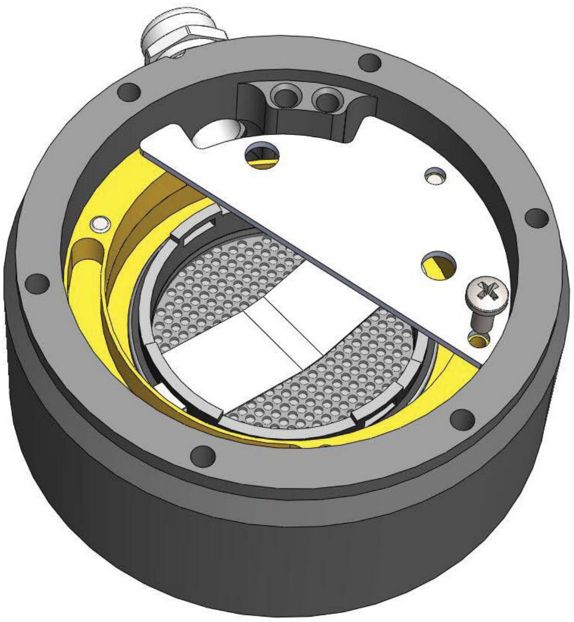


NOTE:
The screws used on the SR50A have changed from the slotted type to Phillips.

2. Separate the housing from the sensor body and disconnect the connector from the transducer to the main sensor body.



3. To replace the desiccant, remove the desiccant holder plate with the Phillips 4-40 screw. Cutting the tie strap will allow the old packets to be removed for replacement. During reassembly, ensure that the desiccant does not come in contact with the metal backing of the transducer. If only the desiccant is being inspected or replaced, steps 4 and 5 are not required. Steps 4 to 6 are required to replace the transducer only.



4. Your transducer kit comes with a replacement for the O-ring that seats between the main sensor body and the plastic transducer housing. Ensure that the new O-ring is used when reassembled.

5. Remove the three screws from the innermost hole pattern as shown.

6. Replace the transducer assembly and the second O-ring that seats under the transducer assembly.
7. Reassemble the sensor in the reverse order. Please observe the orientation of the parts, wiring, and desiccant.

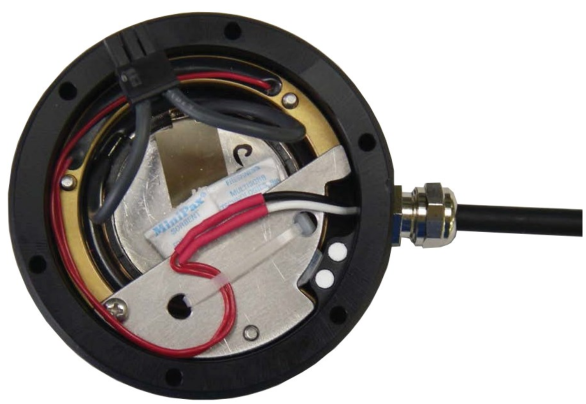


FIGURE D-2. Complete transducer assembly with power connection

Appendix E. 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.

E.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 E-1 (p. 49).

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

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

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

Name	Command	Response[1]
Address Query	`?!`	a<CR><LF>
Change Address	`aAb!`	b<CR><LF>
Start Measurement	`aM!` `aM1!...aM9!`	atttn<CR><LF>
Start Measurement and Request CRC	`aMC!` `aMC1!...aMC9!`	atttn <CR><LF>
Start Concurrent Measurement	`aC!` `aC1!...aC9!`	atttnn<CR><LF>
Start Concurrent Measurement and Request CRC	`aCC!` `aCC1!...aCC9!`	atttnn<CR><LF>
Send Data	`aD0!...aD9!`	a<values><CR><LF> or a<values><CRC><CR><LF>
Continuous Measurement	`aR0!...aR9!`	a<values><CR><LF>
Continuous Measurement and Request CRC	`aRC0!...aRC9!`	a<values><CRC><CR><LF>
Extended Commands	`aXNNN!`	a<values><CR><LF>

[1] Information on each of these commands is given in the following sections.

E.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.

E.1.2 Send identification command (aI!)

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

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

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

E.1.3 Start verification command (aV!)

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

Command: `aV!`

Response: *atttn<CR><LF>*

a = sensor address

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

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

E.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.

E.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.

E.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 E-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.

E.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 E-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 E-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.

E.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.

E.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.

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

The Send Data command requests data from the sensor. It is issued automatically with every type of measurement command (**aM!**, **aMC!**, **aC!**, **aCC!**). When the measurement command is a`M!` or a`MC!`, the data logger issues the **aD0!** command once a service request has been received from the sensor or the reported time has expired. When the data logger is issuing concurrent commands (**aC!** or **aCC!**), the Send Data command is issued after the required time has elapsed (no service request will be sent by the sensor). In transparent mode (see SDI-12 transparent mode (p. 55)), the user asserts this command to obtain data.

Depending on the type of data returned and the number of values a sensor returns, the data logger may need to issue **aD0!** up to **aD9!** to retrieve all data. A sensor may return up to 35 characters of data in response to a **D** command that follows an **M!** or **MC!** command. A sensor may return up to 75 characters of data in response to a **D** command that follows a **C!** or **CC!** command. Data values are separated by plus or minus signs.

Command: **aD0!** (**aD1!** ... **aD9!**)

Response: *a<values><CR><LF>* or *a<values><CRC><CR><LF>*

where:

a = the sensor address

<*values*> = values returned with a polarity sign (+ or –)

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

<*CRC*> = 16-bit CRC code appended if data was requested with a**MC!** or **aCC!**.

E.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.

E.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.

E.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.

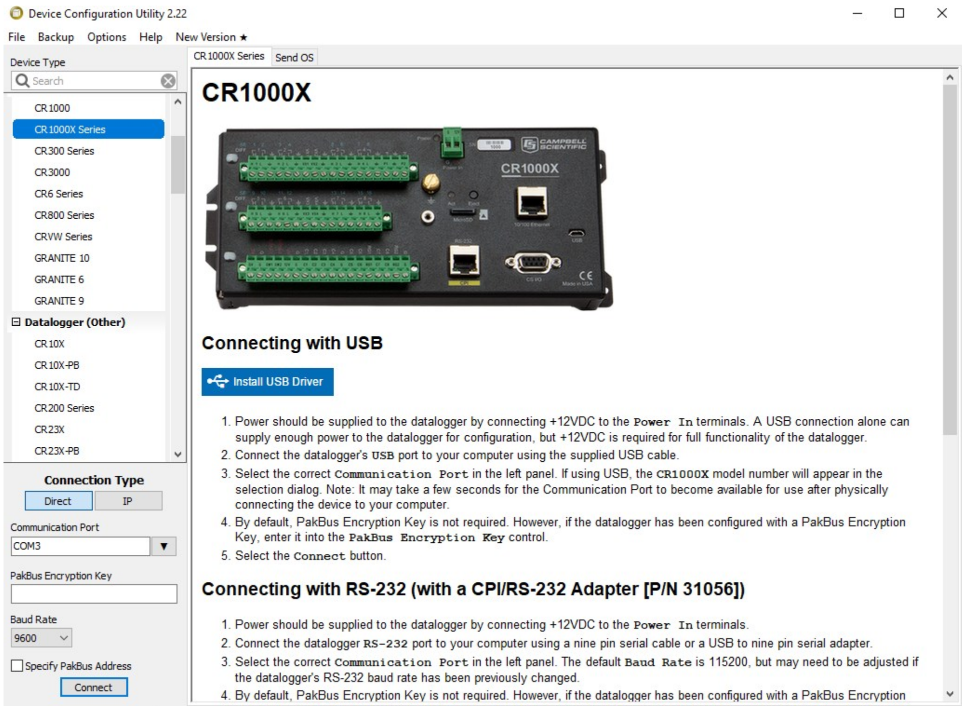
The following examples show how to enter transparent mode and change the SDI-12 address of an SDI-12 sensor. The steps shown in Changing an SDI-12 address (p. 56) are used with most Campbell Scientific data loggers.

E.2.1 Changing an SDI-12 address

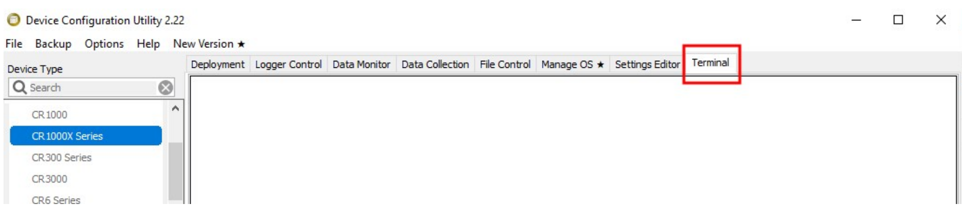
This example was done with a CR1000X, but the steps are only slightly different for CR6, CR3000, CR800-series, CR300-series, CR1000 data loggers.

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.

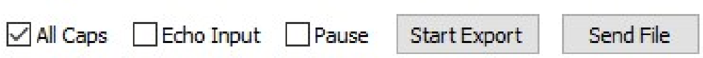
4. Select the correct **Communication Port** and click **Connect**.



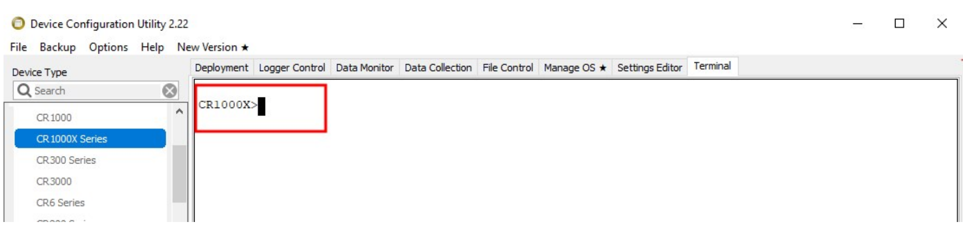
5. Click the **Terminal** tab.



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.

E.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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- Protect from lightning.
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- 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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