

INSTRUCTION MANUAL



CS700 Tipping Bucket Rain Gage **and CS700H Heated Rain Gage**

Revision: 12/17



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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, 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.
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- 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.

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- 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.
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CS700 and CS700H Rain Gage

1. Introduction

The CS700 and CS700H tipping bucket rain gages catch rainfall in the 7.87 in. (200 mm) collection funnel. When 0.01 in. of rainfall is collected, the tipping bucket assembly tips and activates a dual reed switch. The switch closure is recorded by the datalogger. After the bucket tips, the water drains out the screened base of the gage. The CS700H is a heated version of the CS700 that can measure the water content of snow.

NOTE

This manual provides information only for CRBasic dataloggers. It is also compatible with our retired Edlog dataloggers. For Edlog datalogger support, see an older manual at www.campbellsci.com/old-manuals.

2. Precautions

- READ AND UNDERSTAND the *Safety* section at the front of this manual.
- The CS700 and CS700H are precision instruments. Please handle them with care.
- The black outer jacket of the cable is Santoprene[®] rubber. This compound was chosen for its resistance to temperature extremes, moisture, and UV degradation. However, this jacket will support combustion in air. It is rated as slow burning when tested according to U.L. 94 H.B. and will pass FMVSS302. Local fire codes may preclude its use inside buildings.
- While assembling the CS700H, ensure that the coiled cable and the neoprene jacket do not interfere with the tipping bucket mechanism when placing the funnel on the base.

3. Initial Inspection

- Upon receipt of the tipping bucket rain gage, inspect the packaging and contents for damage. File damage claims with the shipping company. Immediately check package contents against the shipping documentation (see Section 3.1, *Ships With*). Contact Campbell Scientific about any discrepancies.
- The model number and cable length are printed on a label at the connection end of the cable. Check this information against the shipping documents to ensure the expected product and cable length are received.

3.1 Ships With

The CS700 and CS700H ship with:

- (1) Allen Wrench from Original Manufacturer

CS700H-AC Version also ships with:

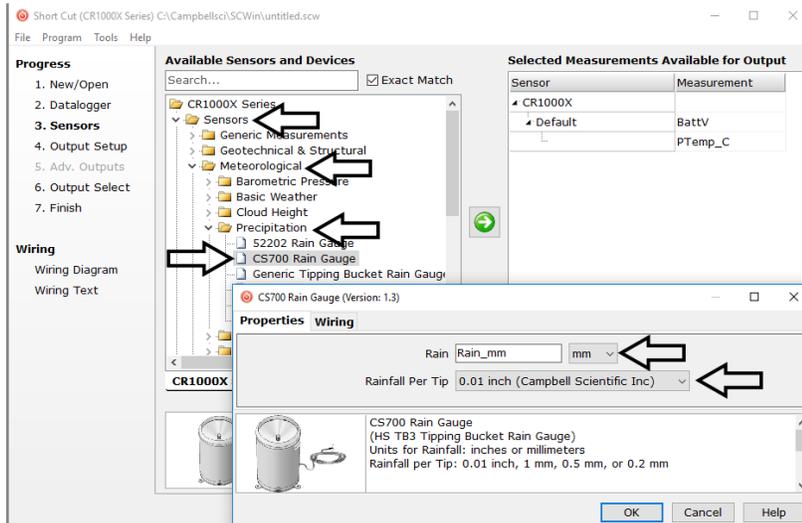
- (1) Power Supply and Mounting Hardware (Quint Power made by Phoenix Contact)

4. QuickStart

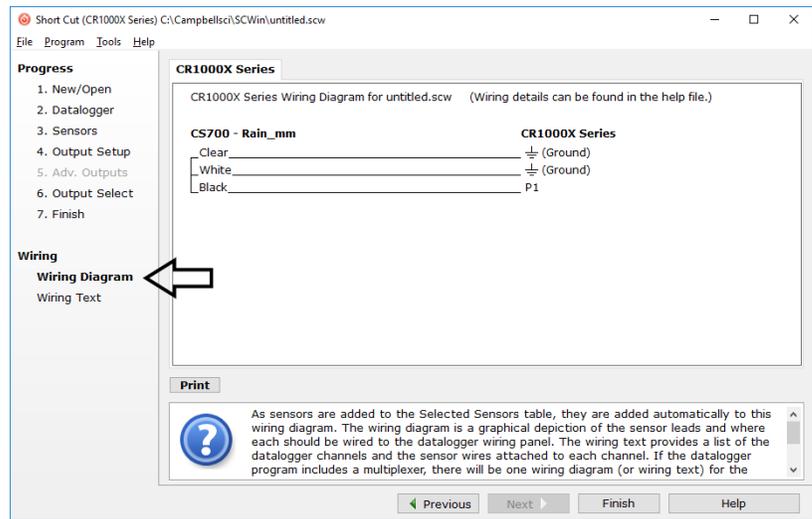
Short Cut is an easy way to program your datalogger to measure the CS700 and assign datalogger wiring terminals. *Short Cut* is available as a download on www.campbellsci.com. It is included in installations of *LoggerNet*, *PC200W*, *PC400*, or *RTDAQ*.

The following procedure uses *Short Cut* to program the CS700.

1. Open *Short Cut* and create a new program.
2. Double-click the datalogger model.
3. Under the **Available Sensors and Devices** list, select the **Sensors | Meteorological | Precipitation** folder and double-click **CS700 Rain Gauge**. The units default to millimeters, which can be changed by clicking the **Rain** box and selecting one of the other options. The default rainfall per tip value of 0.01 inches should be used if the sensor is purchased at Campbell Scientific (U.S. office).



- After selecting the sensor, click at the left of the screen on **Wiring Diagram** to see how the sensor is to be wired to the datalogger. The wiring diagram can be printed out now or after more sensors are added.



- Select any other sensors you have, then finish the remaining *Short Cut* steps to complete the program. The remaining steps are outlined in *Short Cut Help*, which is accessed by clicking on **Help | Contents | Programming Steps**.
- If *LoggerNet*, *PC400*, *RTDAQ*, or *PC200W* is running on your computer, and the computer to datalogger connection is active, you can click **Finish** in *Short Cut* and you will be prompted to send the program just created to the datalogger.
- If the sensor is connected to the datalogger, as shown in the wiring diagram in step 4, check the output of the sensor in the datalogger support software data display to make sure it is making reasonable measurements.

5. Overview

The CS700 and CS700H tipping bucket rain gages are manufactured by HS Hyquest Solutions Pty. Ltd. (Model TB-3), and modified for use with Campbell Scientific dataloggers (see FIGURE 5-1). They feature a heavy-duty, cast aluminum housing and base; a dual-reed switch potted in soft silicon rubber with varistor protection; and a siphon that allows the precipitation to flow at a steady rate regardless of rainflow intensity. The siphon reduces typical rain bucket errors and produces accurate measurements over a range of 0 to 700 mm/hr (0 to 27.6 in/hr).



FIGURE 5-1. The CS700 (left) and CS700H (right)

The CS700H includes a heater to melt snow. Two power configuration options (either AC or DC) are offered for powering the heater. With the AC option, a Phoenix Contact Power Supply is shipped with the CS700H (FIGURE 5-2). Appendix D, *Phoenix Contact Power Supply Specifications (p. D-1)*, provides more information about this power supply.



FIGURE 5-2. Phoenix Contact Power Supply

With the DC option, the CS700H is connected to a user-supplied battery. This option is ideal for remote sites using wind or solar power to recharge the battery. Battery capacity requirements vary according to the application and site location.

5.1 Wind Screen

The 260-953 Alter-Type Wind Screen can be used with the CS700 and CS700H to minimize the effects of strong winds. Siting information and the installation procedure for this wind screen is provided in our 260-953 manual.

6. Specifications

Features:

- More accurate measurement of high-intensity precipitation
- Extra-heavy metal construction for durability and long life
- High precision—tips at 0.01-in. increments
- Compatible with Campbell Scientific CRBasic Dataloggers: CR200(X) series (CS700 only), CR300 series (CS700 only), CR6 series, CR800 series, CR1000, CR1000X, CR3000, CR5000, and CR9000(X) (CS700 only)

Orifice Diameter:	200 mm (7.87 in)
Measurement Range:	0 to 700 mm/hr (0 to 27.6 in/hr)
Accuracy:	±2% @ < 250 mm/hr (9.8 in/hr); ±3% @ 250 to 500 mm/hr (9.8 to 19.7 in/hr)
Resolution:	0.01 in (0.254 mm)
Temperature Range	
CS700:	0 to 70 °C
CS700H:	-40 to 70 °C
Humidity:	0 to 100%
Contact:	Dual Reed Switch
Dimensions	
Height:	342 mm (13.5 in)
Diameter:	244 mm (9.6 in)
Weight:	3.4 kg (7.4 lb) w/ 25 ft signal cable

6.1 Heated Rain Gage

Snow Sensor and Heater	
Operating Temperature Range:	-20 to 5 °C
Output:	SDI-12
Voltage Requirements	
Main Power:	10 to 30 Vdc or 12 to 28 Vac
SDI-12 Power:	9.6 to 16 Vdc
Total Current Consumption	
Snow sensor off, heater off:	6 mA @ 12 V, 0.072 W
Snow sensor on, heater off:	12 mA @ 12 V, 0.144 W
Snow sensor on, heater on:	5.8 A @ 12 V, 70 W

NOTE

Specifications for the power supply used for the -AC option is provided in Appendix D, *Phoenix Contact Power Supply Specifications (p. D-1)*.

7. Installation

If you are programming your datalogger with *Short Cut*, skip Section 7.1, *Wiring* (p. 6), and Section 7.2, *Datalogger Programming* (p. 8). *Short Cut* does this work for you. See Section 4, *QuickStart* (p. 2), for a *Short Cut* tutorial.

7.1 Wiring

7.1.1 CS700 Connections

Wire Color	Wire Function	Datalogger Connection Terminal for Pulse Channel Input	Datalogger Connection Terminal for Control Port Input ¹
Black	Rain Signal	P, P_SW, or U ¹ (Pulse Channel)	C (Control Port)
White	Rain Signal Reference	⏏ (Analog Ground)	5 V (On Datalogger)
Clear	Shield	⏏ (Analog Ground)	⏏ (Analog Ground)

¹U channels are automatically configured by the measurement instruction.

7.1.2 CS700H Heated Rain Gage Connections

CAUTION

The CS700H will only communicate over SDI-12 when both its sensor cable and power cable are connected.

The CS700H has both a sensor cable and a power cable. The sensor cable connects to the datalogger (TABLE 7-2). The power cable connects to the power supply (see TABLE 7-3). FIGURE 7-1 shows the terminals for connecting the power cable to the Phoenix Contact Power Supply.

Wire Color	Wire Function	Datalogger Connection Terminal for Pulse Channel Input	Datalogger Connection Terminal for Control Port Input ¹
Green	SDI-12	Odd-numbered C or U ¹ configured for SDI-12	Odd-numbered C or U ¹ configured for SDI-12
Red	SDI-12 Power	12V	12V
Blue	SDI-12 Power Ground	G	G
Black	Rain Signal	P or U ¹ (Pulse Channel)	C ² (Control Port)

Wire Color	Wire Function	Datalogger Connection Terminal for Pulse Channel Input	Datalogger Connection Terminal for Control Port Input ¹
White	Rain Signal Reference	⏏ (Analog Ground)	5 V (On Datalogger)
Clear	Shield	⏏ (Analog Ground)	⏏ (Analog Ground)

¹U channels are automatically configured by the measurement instruction.

²When using a CR6 or CR1000X, a conflict occurs if the pulse measurement uses an even C terminal that immediately follows the SDI-12 terminal. For example, if C1 is used for the SDI-12 channel, do not use C2 for the pulse channel.

TABLE 7-3. CS700H Power Cable Wiring

Wire Color	Description	Power Supply
Red	+24 Vdc	+
Black	Ground	-

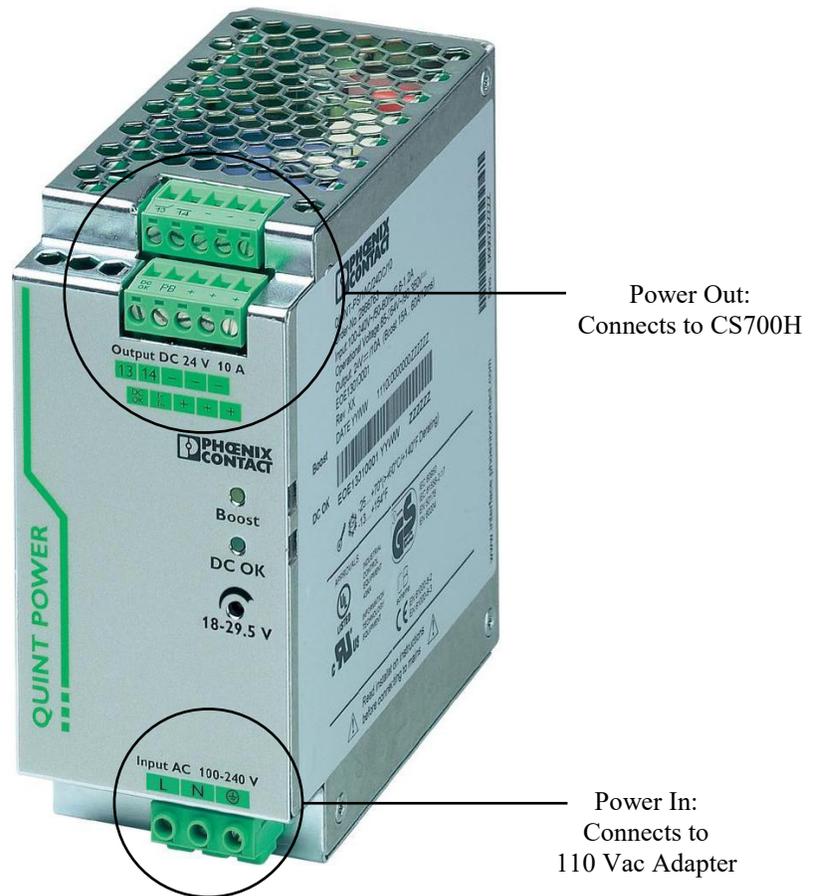


FIGURE 7-1. Phoenix Contact Power Supply

7.2 Datalogger Programming

Short Cut is the best source for up-to-date datalogger programming code. Programming code is needed when:

- Creating a program for a new datalogger installation
- Adding sensors to an existing datalogger program

If your data acquisition requirements are simple, you can probably create and maintain a datalogger 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 Section 4, *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 Appendix A, *Importing Short Cut Code Into CRBasic Editor* (p. A-1).

Programming basics for CRBasic dataloggers are in the following sections. Complete program examples for select CRBasic dataloggers can be found in Appendix B, *Example Programs* (p. B-1). Programming basics and programming examples for Edlog dataloggers are provided at www.campbellsci.com/old-manuals.

7.2.1 PulseCount Instruction

Both the CS700 and CS700H use a reed switch for measuring precipitation. The **PulseCount()** CRBasic instruction measures the reed switch.

PulseCount(Dest,Reps,PChan,PConfig,POption,Mult,Offset)

- Choose Switch Closure for the **PConfig** parameter. For the CR6 and CR1000X, choose Switch Closure with pull up.
- The **Multiplier** parameter determines the units in which rainfall is reported. A multiplier of 0.01 converts the output to inches and a multiplier of 0.254 converts the output to millimeters.

7.2.2 SDI12Recorder Instruction

When measuring a CS700H, the CRBasic program can include the **SDI12Recorder()** instruction to retrieve real-time status information stored in the CS700H's microprocessor.

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

The **Destination** parameter must be an array of length 9. **FillNAN** and **WaitonTimeout** are optional parameters (refer to *CRBasic Help* for more information). Appendix C, *CS700H Operation Details* (p. C-1), provides information about the SDI-12 commands and other operational details for the CS700H.

CAUTION The CS700H will only communicate over SDI-12 when both its sensor cable and power cable are connected (TABLE 7-2 and TABLE 7-3).

7.3 Siting

Mount the rain gage in a relatively level location representative of the surrounding area. Ensure that the orifice is horizontal, at least 1 m above the ground, and higher than the average snow depth.

Place the rain gage away from objects that obstruct the wind. The distance should be 2- to 4-times the height of the obstruction.

7.4 Mounting

The CS700 and CS700H have three equally-spaced pads for mounting the tipping buckets on a flat surface. Each pad includes a hole that fits a 3/8 inch (M8) bolt. The three holes form a 234 mm (9.21 in) diameter bolt circle.

Campbell Scientific offers the CM240 mounting bracket for installing and leveling the CS700 and CS700H (see FIGURE 7-2). The CM240 may be attached to a CM300-Series Mounting Pole or to a user-supplied 1.5 in. IPS (1.9 in. OD) unthreaded pipe.

The pole or pipe can be placed directly into a concrete foundation (see FIGURE 7-3), or attached to a concrete foundation using J-bolts or self-supporting with legs (see FIGURE 7-4). A concrete pad is recommended, but it should not be installed over large paved or concrete surface.



FIGURE 7-2. CM240 Mounting Bracket

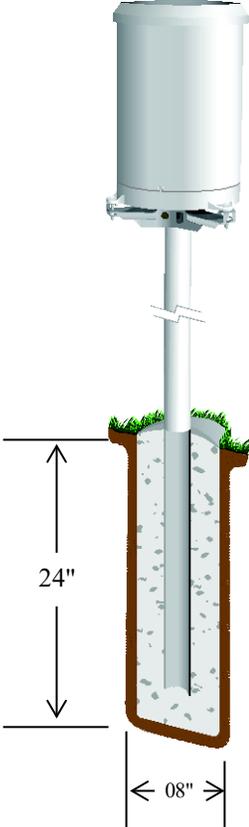


FIGURE 7-3. Typical Rain Gage Installation

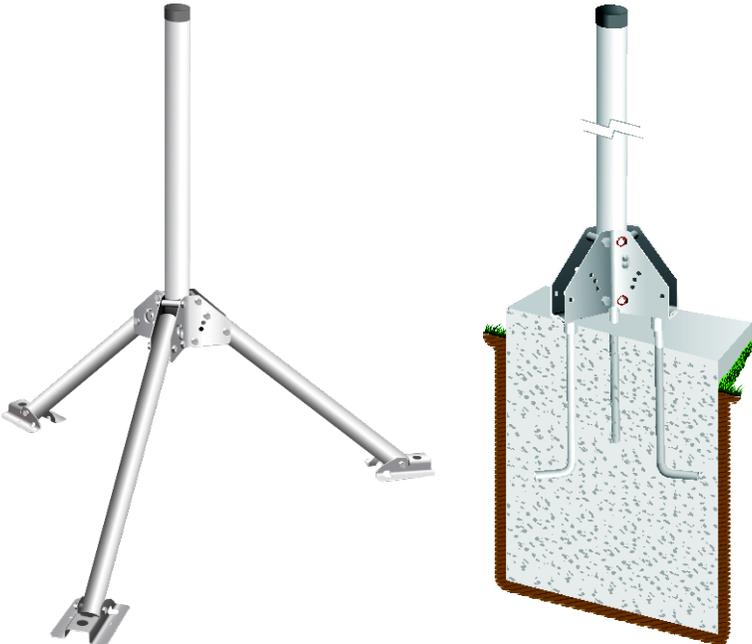


FIGURE 7-4. CM300 Pedestal Base Options

7.5 Leveling

After mounting the rain gage, use the following procedure to level it (FIGURE 7-4).

1. Remove the housing assembly from the base by loosening the three housing screws and lifting the housing upward.
2. Adjust the three nuts on the CM240 bracket to level the gage. A bullseye level is mounted on the rain gage's base to facilitate leveling (see FIGURE 7-5).
3. Remove the rubber shipping band and cardboard packing securing the tipping bucket assembly. Tip the bucket several times to ensure the tipping mechanism is moving freely.
4. Replace the housing assembly and tighten the three screws to secure the housing to the base.



FIGURE 7-5. Main Components of the CS700

7.6 CS700H Power Supply Installation

A CS700H with option –AC includes a Phoenix Contact Power Supply that must be housed in an environmental enclosure. A DIN rail mounting bracket is shipped with the CS700H for securing this power supply to an enclosure backplate. The DIN Rail mounts to the backplate using screws and grommets.

8. Operation

8.1 Sensor Schematic

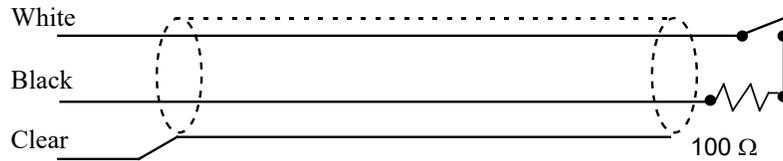


FIGURE 8-1. CS700 Rain Gage Schematic

8.2 Long Cable Lengths

Long cables have appreciable capacitance between the lines. A built up charge could cause arcing when the switch closes, shortening switch life. A 100 ohm resistor is connected in series at the switch to prevent arcing by limiting the current (FIGURE 8-1). This resistor is installed on all rain gages currently sold by Campbell Scientific.

8.3 CS700H Heated Rain Gage Operation

NOTE

This section provides a brief discussion of the CS700H heater operation. More in-depth information is provided in Appendix C, *CS700H Operation Details* (p. C-1).

The CS700H includes heating elements and an internal snow sensor, which is activated when the air temperature drops below 4 °C. If the snow sensor detects snow in the catch area (funnel), the heating elements automatically turn on and keep the funnel temperature at 10 °C. The heater goes into a wait mode when snow has not been detected for 18 minutes. It automatically deactivates when the air temperature drops below -20 °C.

As the ambient temperature falls below the *Active On Temperature* (default 4 °C), the heater will turn on to heat the funnel area of the rain gage. Once the funnel reaches the *Funnel Set Point Temp* (default 10 °C), the heater will begin cycling on and off with a duty cycle dependent on the ambient temperature, keeping the funnel temperature at or near 10 °C (FIGURE 8-2).

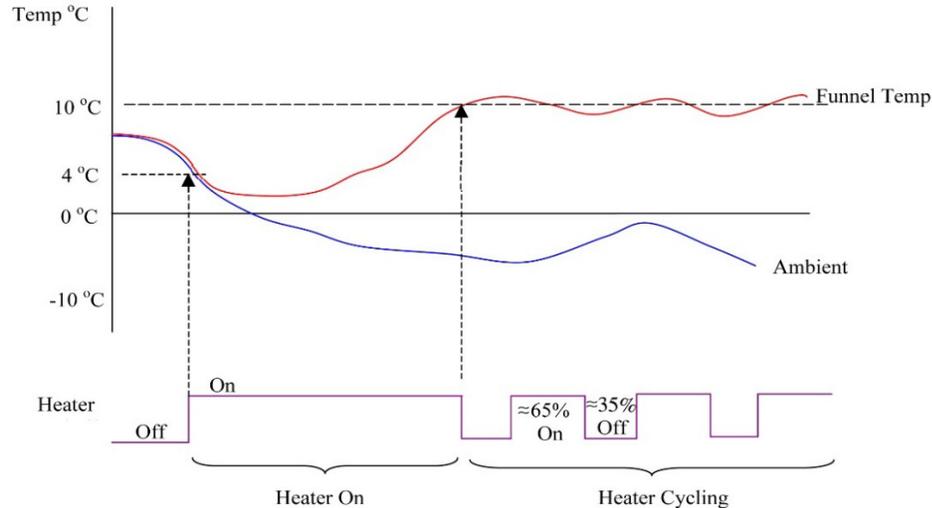


FIGURE 8-2. CS700H Heater Operation

8.3.1 SDI-12 Measurements

The **M!**, **C!**, and **R!** SDI-12 commands retrieve the following status information from the CS700H:

1. Ambient temperature (°C or °F)
2. Block temperature (°C or °F)
3. Units (0=°C, 1=°F)
4. 0=no snow; 1=snow detected
5. 0=snow sensor disabled; 1=snow sensor enabled
6. 0=heater elements off; 1=heater elements on
7. 0=automatic control; 1=manual control
8. 0=cycle disabled; 1=cycle enabled
9. Low Power Heater cycle time left (mins)

When using an **M!** command, the datalogger 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 datalogger 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.

A **C!** command follows the same pattern as an **M!** command with the exception that it does not require the datalogger to pause its operation until the values are ready. Rather, the datalogger picks up the data with the **D!** command on the next pass through the program. Another measurement request is then sent so that data are ready on the next scan.

An **R!** command switches the sensor to automatically make measurements and send data every 11 seconds, ± 2 seconds, based on the sensor's internal clock. 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 cancelled by powering down the sensor to reset it.

The CS700H also uses extended commands (X) to control the heater and change settings. Appendix C.6, *SDI-12 Sensor Support (p. c-5)*, describes the extended commands and provides detailed information about the SDI-12 interface. Additional SDI—12 information is also available at www.sdi-12.org, or www.youtube.com/user/CampbellScientific.

9. Troubleshooting and Maintenance

NOTE All factory repairs and recalibrations require a returned material authorization (RMA) and completion of the “Declaration of Hazardous Material and Decontamination” form. Refer to the [Assistance](#) page at the beginning of this manual for more information.

9.1 Troubleshooting

Symptom: No Precipitation

1. Check that the sensor is wired to the Pulse Channel specified by the pulse count instruction.
2. Verify that the Configuration Code (Switch Closure), and Multiplier and Offset parameters for the Pulse Count instruction are correct for the datalogger type.
3. Disconnect the sensor from the datalogger and use an ohm meter to do a continuity check of the switch. The resistance measured at the terminal block on the inside of the bucket between the black and white leads should vary from infinite (switch open) when the bucket is tipped, to less than an ohm when the bucket is balanced.

Symptom: CS700H not communicating over SDI-12

1. Ensure that both the sensor and power cables are properly connected (TABLE 7-2 and TABLE 7-3).

9.2 Maintenance

During each site visit, remove any debris, insects, sediment, etc. from the collection funnel, debris screen, siphoning mechanism, or tipping bucket assembly.

Verify the tipping bucket assembly moves freely, and that the datalogger records each bucket tip.

9.2.1 Dismantling for Cleaning

The following items should be checked regularly for cleanliness:

- Catch filter (see FIGURE 9-3)
- Siphon (see FIGURE 9-3)
- Interior of bucket (see FIGURE 9-1)
- Top surface of adjusting screws (see FIGURE 9-1)

- Housing locking screws; lightly lubricate after cleaning (see FIGURE 9-1)
- All insect screens (see FIGURE 9-1)

To access the above components, dismantle the CS700 using the following procedure:

1. Remove the housing assembly from the base by loosening the three locking screws and lifting the housing upward.



FIGURE 9-1. Components of CS700 Base

2. Separate the filter/siphon assembly from the funnel by pushing the filter while pulling the siphon (see FIGURE 9-2).

CAUTION

Do not twist the filter/siphon assembly while pushing and pulling.

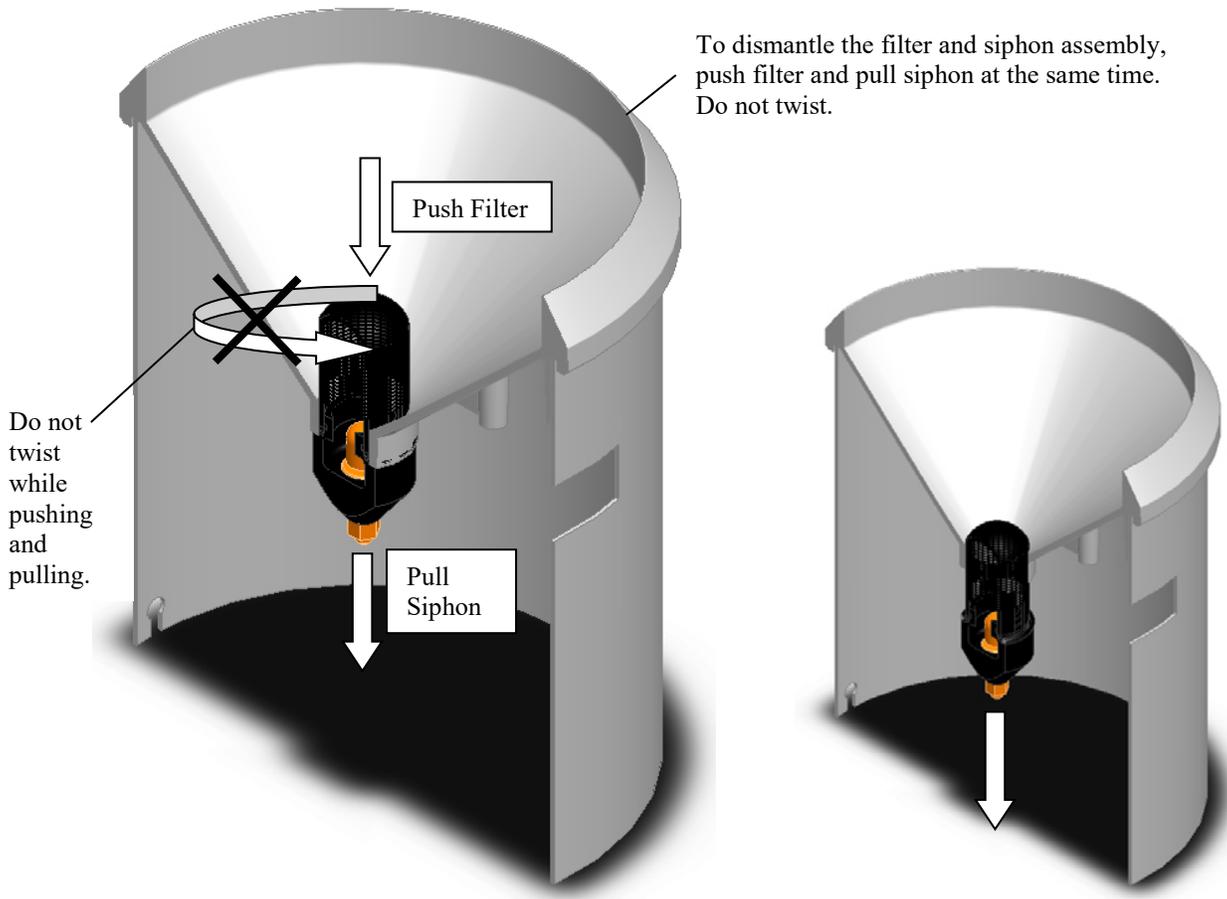


FIGURE 9-2. Dismantling the Filter/Siphon Assembly

3. Disassemble the filter/siphon assembly by doing the following (see FIGURE 9-3):
 - (a) Unscrew nut
 - (b) Lightly press stem down on surface until stem pops out of siphon body.
 - (c) Remove stem from siphon body.
 - (d) Unscrew cap
 - (e) Clean all items

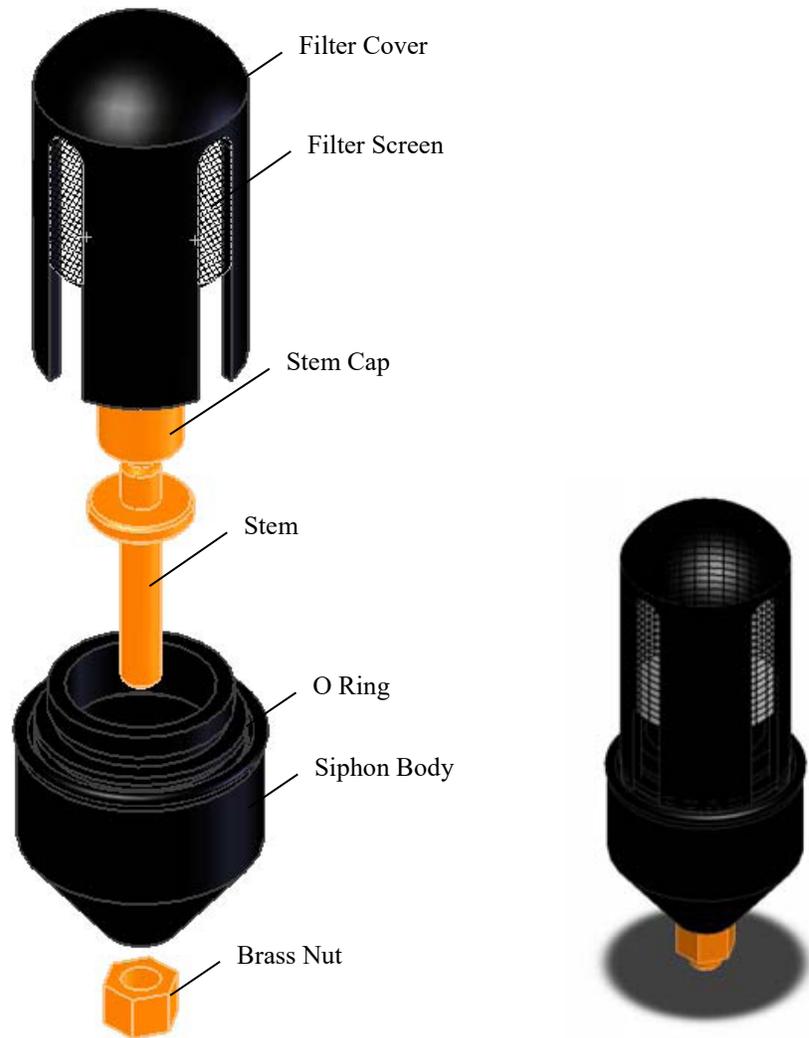


FIGURE 9-3. Filter/Siphon Assembly

9.2.2 Reassembling the CS700

1. Screw cap on stem, finger tighten only (see FIGURE 9-3).
2. Push stem into siphon body (see FIGURE 9-3).
3. Replace nut and tighten (see FIGURE 9-3).

CAUTION

Do not over tighten.

4. Push filter/siphon assembly back into place (see FIGURE 9-4).

CAUTION

Do not twist the filter/siphon assembly while putting it back into place.

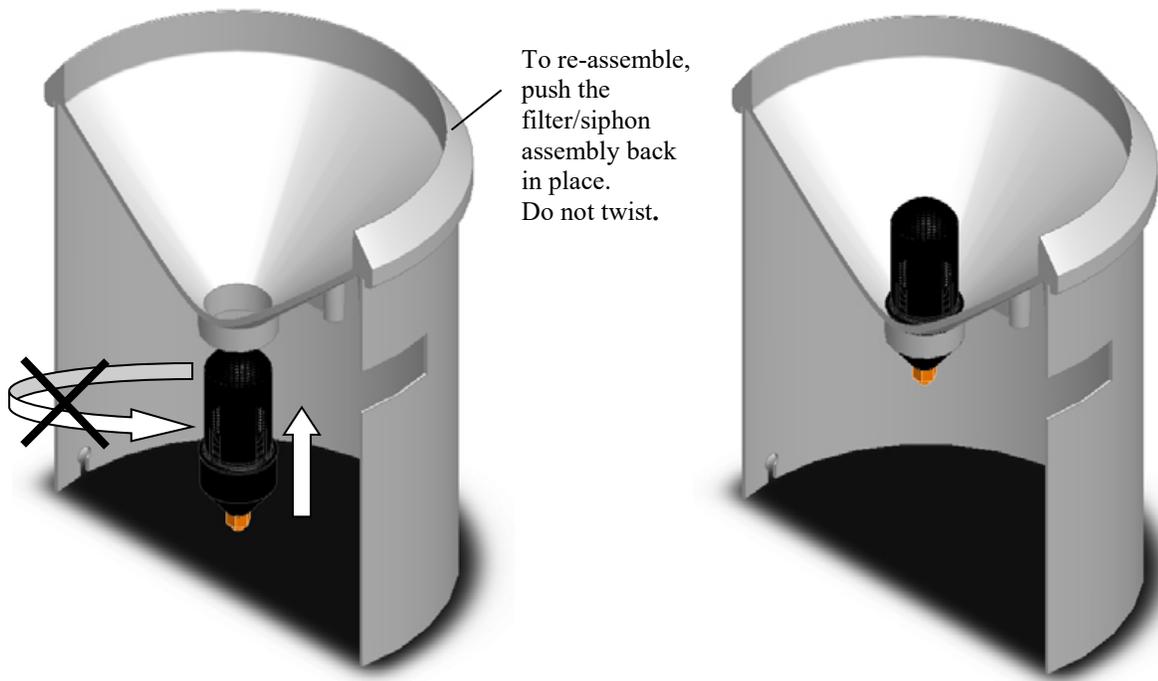


FIGURE 9-4. Reassembling the CS700

5. Place the housing assembly back onto the base and tighten the three screws that secure the housing onto the base.

9.3 Calibration

The sensor is factory calibrated; recalibration is not required unless damage has occurred or the adjustment screws have loosened.

Nevertheless, the following calibration check is recommended once every 12 months:

1. Remove the housing assembly from the base by removing the three screws and lifting upward on the housing.
2. Check the bubble level to verify the rain gage is level.
3. Pour water through the inner funnel to wet the two bucket surfaces. Using a graduated cylinder, slowly pour 314 cc (19.16 in³) of water, over a 15-minute period, into the collection funnel. This volume of water is equal to .39 in of rainfall (10 mm).

4. After the water has passed through the rain gage, the tipping bucket should have tipped 39 times.
5. If the rain gage fails to record the correct number of tips, return the unit to Campbell Scientific for recalibration.

9.3.1 Factory Calibration

If factory calibration is required, contact Campbell Scientific to obtain an RMA (see [Assistance](#) in the front of the manual).

Appendix A. Importing Short Cut Code Into CRBasic Editor

This tutorial shows:

- How to import a *Short Cut* program into a program editor for additional refinement
- How to import a wiring diagram from *Short Cut* into the comments of a custom program

Short Cut creates files, which can be imported into *CRBasic Editor*. Assuming defaults were used when *Short Cut* was installed, these files reside in the C:\campbellsci\SCWin folder:

- .DEF (wiring and memory usage information)
- .CR2 (CR200(X)-series datalogger code)
- .CR300 (CR300-series datalogger code)
- .CR6 (CR6-series datalogger code)
- .CR8 (CR800-series datalogger code)
- .CR1 (CR1000 datalogger code)
- .CR1X (CR1000X datalogger code)
- .CR3 (CR3000 datalogger code)
- .CR5 (CR5000 datalogger code)
- .CR9 (CR9000(X) datalogger code)

Use the following procedure to import *Short Cut* code and wiring diagram into *CRBasic Editor*.

1. Create the *Short Cut* program following the procedure in Section 4, *QuickStart* (p. 2). Finish the program. On the **Advanced** tab, click the **CRBasic Editor** button. The program opens in CRBasic with the name **noname.CR_**. Now save the program with your desired name in any folder.

NOTE

Once the file is edited with *CRBasic Editor*, *Short Cut* can no longer be used to edit the datalogger program. Change the name of the program file or move it, or *Short Cut* may overwrite it next time it is used.

2. The program can now be edited, saved, and sent to the datalogger.
3. Import wiring information to the program by opening the associated .DEF file. Copy and paste the section beginning with heading “-Wiring for CRXXX-” into the CRBasic program, usually at the head of the file. After pasting, edit the information such that an apostrophe (') begins each line. This character instructs the datalogger compiler to ignore the line when compiling.

Appendix B. Example Programs

B.1 CS700 Example Programs

B.1.1 CR6 Program for the CS700

In the following CR6 program, the CS700 is connected to universal channel 1, and the rain measurements are reported in inches. Battery voltage and panel temperature are also measured.

CRBasic Example B-1. CR6 Program Measuring the CS700

```
'Program measures one CS700

'Wiring Diagram
'=====
'CS700
'Wire
'Color   Function           Terminal
'-----
'Black   Rain signal         U1
'White   Rain signal ground Ground Symbol
'Clear   Shield             Ground Symbol

'Declare Variables and Units
Public BattV
Public PTemp_C
Public Rain_in

Units BattV = Volts
Units PTemp_C = Deg C
Units Rain_in = inch

'Define Data Tables
DataTable(OneMin,True,-1)
  DataInterval(0,1,Min,10)
  Totalize(1,Rain_in,FP2,False)
EndTable

DataTable(OneDay,True,-1)
  DataInterval(0,1440,Min,10)
  Minimum(1,BattV,FP2,False,False)
  Totalize(1,Rain_in,FP2,False)
EndTable

'Main Program
BeginProg
  Scan(5,Sec,1,0)
  'Default Datalogger Battery Voltage measurement BattV
  Battery(BattV)
  'Default CR1000 Datalogger Wiring Panel Temperature measurement 'PTemp_C'
  PanelTemp(PTemp_C,60)
  'CS700 Rain Gage measurement Rain_in
  PulseCount(Rain_in,1,U1,1,0,0.01,0)
  'Call Data Tables and Store Data
  CallTable OneMin
  CallTable OneDay
NextScan
EndProg
```

B.1.2 CR1000X Programs for the CS700

This section includes two CR1000X programs. In the first program, the CS700 is connected to pulse channel 1, and the rain measurements are reported in inches. Battery voltage and panel temperature are also measured. In the second program, the CS700 is connected to control port 1, and the rain measurements are reported in millimeters.

CRBasic Example B-2. CR1000X Program Using a Pulse Channel to Measure the CS700

```
'Program measures one CS700

'Wiring Diagram
'=====
'CS700
'Wire
'Color   Function           Terminal
'-----
'Black   Rain signal           P1
'White   Rain signal ground  Ground Symbol
'Clear   Shield              Ground Symbol

'Declare Variables and Units
Public BattV
Public PTemp_C
Public Rain_in

Units BattV = Volts
Units PTemp_C = Deg C
Units Rain_in = inch

'Define Data Tables
DataTable(OneMin,True,-1)
  DataInterval(0,1,Min,10)
  Totalize(1,Rain_in,FP2,False)
EndTable

DataTable(OneDay,True,-1)
  DataInterval(0,1440,Min,10)
  Minimum(1,BattV,FP2,False,False)
  Totalize(1,Rain_in,FP2,False)
EndTable

'Main Program
BeginProg
  Scan(5,Sec,1,0)
  'Default Datalogger Battery Voltage measurement BattV
  Battery(BattV)
  'Default CR1000X Datalogger Wiring Panel Temperature measurement 'PTemp_C'
  PanelTemp(PTemp_C,_60Hz)
  'CS700 Rain Gage measurement Rain_in
  PulseCount(Rain_in,1,P1,1,0,0.01,0)
  'Call Data Tables and Store Data
  CallTable OneMin
  CallTable OneDay
NextScan
EndProg
```

CRBasic Example B-3. CR1000X Program Using a Control Port to Measure the CS700

```

'CR1000X
'Program measures one CS700 using control port

'Wiring Diagram
'=====
'CS700
'Wire
'Color   Function           Terminal
'-----
'Black   Rain signal         C1
'White   Rain signal ground  5V
'Clear   Shield             Ground Symbol

'Declare Public Variables and Units
Public Rain_mm
Units Rain_mm=mm

DataTable (Rain,True,-1)
  DataInterval (0,60,Min,0)
  Totalize (1,Rain_mm,FP2,0)
EndTable

'Main Program
BeginProg
  Scan (1,Sec,1,0)
    PulseCount (Rain_mm,1,C1,2,0,.254,0)
    CallTable (Rain)
  NextScan
EndProg

```

B.2 CS700H Example Programs

B.2.1 CR6 Program for the CS700H

In the following CR6 program, the CS700H is connected to universal channel 1, and the rain measurements are reported in inches. This program does not retrieve real-time status information using the SDI-12 protocol. An example program that retrieves status information is provided in Appendix B.2.2, *CR1000X Programs for CS700H (p. B-5)*.

CRBasic Example B-4. CR6 Program Measuring the CS700H

```
'Program measures one CS700H

'Wiring Diagram
'=====
'CS700H
'Wire
'Color   Function           Terminal
'-----
'Black   Rain signal         U1
'White   Rain signal ground Ground Symbol
'Clear   Shield             Ground Symbol

'Declare Variables and Units
Public BattV
Public PTemp_C
Public Rain_in

Units BattV = Volts
Units PTemp_C = Deg C
Units Rain_in = inch

'Define Data Tables
DataTable(OneMin,True,-1)
  DataInterval(0,1,Min,10)
  Totalize(1,Rain_in,FP2,False)
EndTable

DataTable(OneDay,True,-1)
  DataInterval(0,1440,Min,10)
  Minimum(1,BattV,FP2,False,False)
  Totalize(1,Rain_in,FP2,False)
EndTable

'Main Program
BeginProg
  Scan(5,Sec,1,0)
  'Default Datalogger Battery Voltage measurement BattV
  Battery(BattV)
  'Default CR1000 Datalogger Wiring Panel Temperature measurement 'PTemp_C'
  PanelTemp(PTemp_C,60)
  'CS700H Rain Gage measurement Rain_in
  PulseCount(Rain_in,1,U1,1,0,0.01,0)
  'Call Data Tables and Store Data
  CallTable OneMin
  CallTable OneDay
NextScan
EndProg
```

B.2.2 CR1000X Programs for CS700H

This section includes two CR1000X programs that measure the CS700H heated tipping bucket rain gage. Both programs measure precipitation (mm), battery voltage, and panel temperature. The second program also retrieves real time status information by using SDI-12 protocol.

CRBasic Example B-5. CR1000X Program Measuring the CS700H

```
'Program measures one CS700H

'Wiring Diagram
'=====
'CS700H
'Wire
'Color   Function           Terminal
'-----
'Black   Rain signal           P1
'White   Rain signal ground  Ground Symbol
'Clear   Shield              Ground Symbol

'Declare Variables and Units
Public BattV
Public PTemp_C
Public Rain_in

Units BattV = Volts
Units PTemp_C = Deg C
Units Rain_in = inch

'Define Data Tables
DataTable(OneMin,True,-1)
  DataInterval(0,1,Min,10)
  Totalize(1,Rain_in,FP2,False)
EndTable

DataTable(OneDay,True,-1)
  DataInterval(0,1440,Min,10)
  Minimum(1,BattV,FP2,False,False)
  Totalize(1,Rain_in,FP2,False)
EndTable

'Main Program
BeginProg
Scan(5,Sec,1,0)
  'Default Datalogger Battery Voltage measurement BattV
  Battery(BattV)
  'Default CR1000 Datalogger Wiring Panel Temperature measurement 'PTemp_C'
  PanelTemp(PTemp_C,_60Hz)
  'CS700H Rain Gage measurement Rain_in
  PulseCount(Rain_in,1,P1,1,0,0.01,0)
  'Call Data Tables and Store Data
  CallTable OneMin
  CallTable OneDay
NextScan
EndProg
```

CAUTION

The CS700H will only communicate over SDI-12 when both its sensor cable and power cable are connected (TABLE 7-2 and TABLE 7-3).

CRBasic Example B-6. CR1000X Program Measuring the CS700H and Monitoring Heater

```

'Program measures one CS700H and monitors heater via SDI-12

'Wiring Diagram
'=====
'CS700H
'Wire
'Color   Function                Terminal
'-----
'Black   Rain signal              P1
'White   Rain signal ground      Ground Symbol
'Clear   Shield Ground          Symbol
'Green   SDI-12 signal           C1
'Red     SDI-12 power            12V
'Blue   SDI-12 ground            G

'Declare Variables and Units
Public BattV
Public PTemp_C
Public Rain_in
Public Info(9)
Alias Info(1)=CS700H_AirTemp      'CS700H air temperature measurement
Alias Info(2)=CS700H_BlockTemp    'Heater block temperature
Alias Info(3)=CS700H_CO_F1        'Temperature units: 0 = deg C, 1 = deg F
Alias Info(4)=CS700H_NoSnow0_Snow1 'Snow detection
Alias Info(5)=CS700H_SnwSnsrActv  'Snow sensor on or off
Alias Info(6)=CS700H_Htr_On_off   'Heater on or off
Alias Info(7)=CS700H_Control_Auto_Man 'Automatic or Manual heater control
Alias Info(8)=CS700H_Cycle_Dis_Ena 'Heater cycle disabled or enabled
Alias Info(9)=CS700H_HTimeLeft    'Heater cycle time left in minutes

Units BattV = Volts
Units PTemp_C = Deg C
Units Rain_in = inch

'Define Data Tables
DataTable(OneMin,True,-1)
  DataInterval(0,1,Min,10)
  Totalize(1,Rain_in,FP2,False)
  Sample(1,CS700H_AirTemp,FP2)
  Sample(1,CS700H_BlockTemp,FP2)
  Sample(1,CS700H_CO_F1,FP2)
  Sample(1,CS700H_NoSnow0_Snow1,FP2)
  Sample(1,CS700H_SnwSnsrActv,FP2)
  Sample(1,CS700H_Htr_On_off,FP2)
  Sample(1,CS700H_Control_Auto_Man,FP2)
  Sample(1,CS700H_Cycle_Dis_Ena,FP2)
  Sample(1,CS700H_HTimeLeft,FP2)
EndTable

DataTable(OneDay,True,-1)
  DataInterval(0,1440,Min,10)
  Minimum(1,BattV,FP2,False,False)
  Totalize(1,Rain_in,FP2,False)
EndTable

'Main Program
BeginProg
  Scan(5,Sec,1,0)
  'Default Datalogger Battery Voltage measurement BattV
  Battery(BattV)
  'Default CR1000 Datalogger Wiring Panel Temperature measurement 'PTemp_C'
  PanelTemp(PTemp_C,_60Hz)
  'CS700H Rain Gage measurement Rain_in
  PulseCount(Rain_in,1,P1,1,0,0.01,0)
  'SDI-12 Sensor measurements
  SDI12Recorder(Info(),C1,0,"M!",1,0)

```

```
'Call Data Tables and Store Data  
CallTable OneMin  
CallTable OneDay  
NextScan  
EndProg
```


Appendix C. CS700H Operation Details

CAUTION

Factory settings have been set to adequately measure precipitation during cold precipitation events. Changing these settings is not recommended, and doing so may change the data outcome or render the sensor inoperable.

TABLE C-1 shows the CS700H's factory default settings for adequately measuring precipitation during cold precipitation. Additionally, the default setting for the SDI-12 address is zero.

TABLE C-1. CS700H Default Values	
External Control Off (=> Auto)	(aX20! Command) = 0
Snow Sensor Enabled	(aX22! Command) = 1
Active On Temperature 4 °C	(aX23! Command)
Active Off Temperature 5 °C	(aX24! Command)
Low Off Temperature -20 °C	(aX25! Command)
Funnel Set Point Temp 10°C	(aX26! Command)
Snow Run-On Time 18 mins	(aX27! Command)
Units °C	(aX28! Command) = 0
SDI-12 Address 0	(aAb! Command to change address; ?! Command to query address)

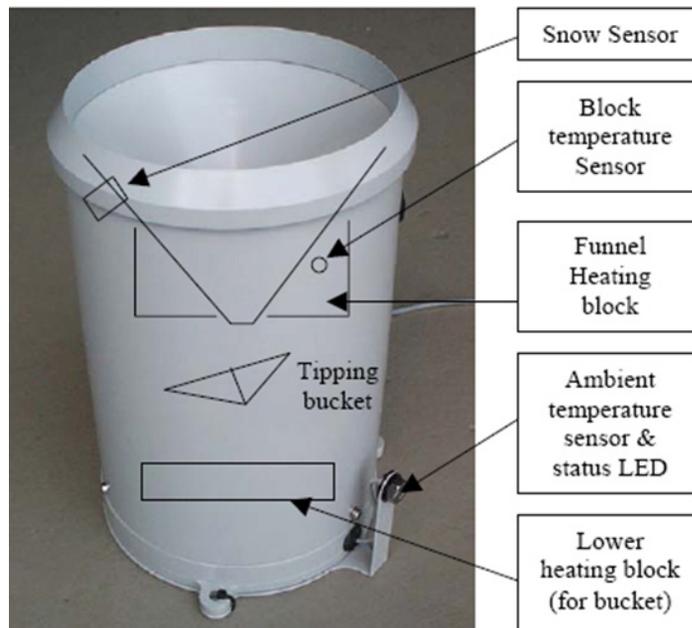


FIGURE C-1. Locations of the CS700H's Heater Components

When the CS700H is not active, the status LED flashes every 1.5 s.

When the ambient temperature sensor detects the temperature falling below the **Active On temperature (4 °C)** then the system becomes active and the snow sensor is enabled (see FIGURE C-2). The status LED flashes slightly faster at 2 flashes per second—indicating the system is active.

When the proximity sensor detects snow (for 5 s continuously), the heater elements are turned on and the block temperature sensor is monitored. The heaters are controlled so that the temperature inside the funnel reaches **the Set Point temperature (10 °C)**.

NOTE The actual block temperature will be higher than the set point as substantial heat is dissipated.

The lower heating block keeps the tipping bucket and the drain tubes from freezing up. While the heater elements are turned on, the status LED flashes even faster at eight flashes per second.

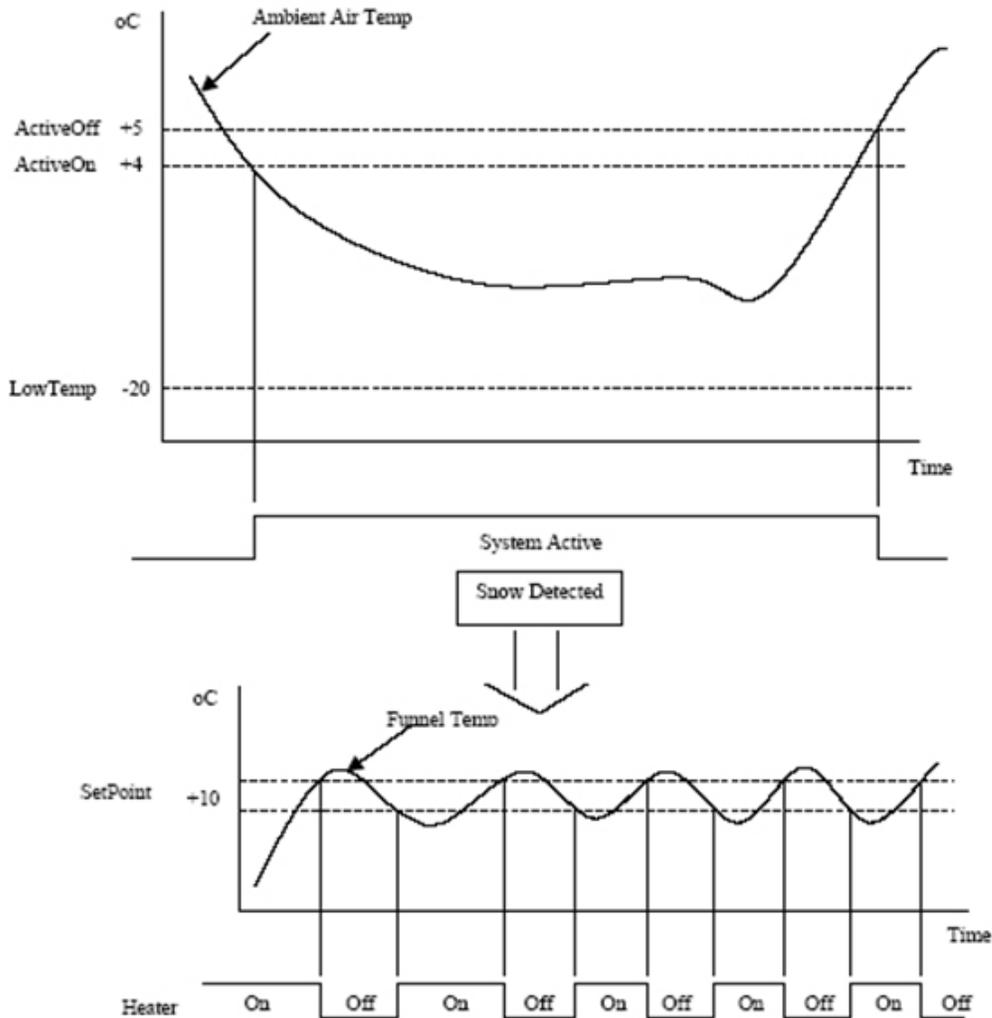


FIGURE C-2. Diagram Depicting Overall Operation

When snow is last detected, a timer is left running, to keep the heater cycling so that any snow built up on the funnel will be melted. The **Snow Run-on** timer is factory preset to 18 minutes but may be extended as required.

The heater will cycle on and off for the **Run-on** time or while ever snow is detected (see FIGURE C-3).

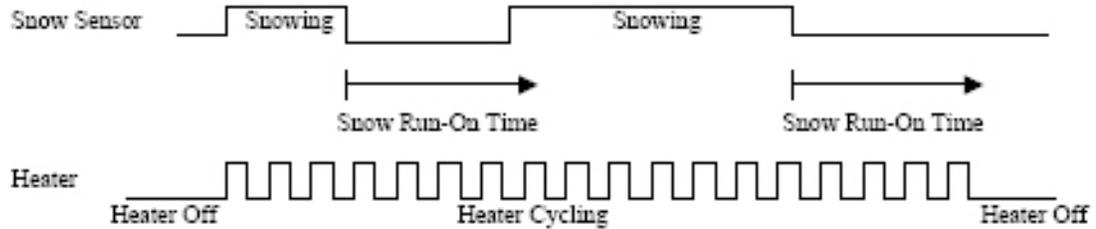


FIGURE C-3. Diagram showing how the “Snow Run-On” timer controls the heater.

C.1 High Power Operation

If the snow sensor is disabled (*aX22!* command set to 0), the heater will cycle continually when the ambient temperature falls below the **Active On** temperature (*aX23!* command) and is above the **Low Off Temperature** (*aX25!* command). This assumes the system is active. Because this mode consumes more power, high power operation is only recommended when the CS700H uses AC power.

C.2 External Control

The CS700H is set to by default to **Automatic control** – where the CS700H monitors the ambient temperature and the snow sensor and operates the heater automatically. Dataloggers in weather stations that monitor the ambient temperature and the snowfall can control the tipping bucket heaters directly. Set the *aX20!* command to 1 for **External Control**, and then use the *aX29!* command to enable the heaters to cycle on/off (=1) or disable the cycling (=0). The ambient temperature, block temperature, snow sensor and state of the heaters can be measured using the *aM!*, *aR!*, or *aC!* command, as normal.

NOTE

The **Setpoint Temperature** is the required temperature of the funnel – and not the block temperature read from *aM!* and *aR!* commands. The relationship between the funnel temperature, block temperature and ambient temperature has been determined through extensive testing.

There is an alternate external control mode, whereby the controlling system can actually turn the heating elements on and off. This is done using the *aX21!* command, with heater on (=1) and heater off (=0).

CAUTION

If the heating elements are left turned on, the funnel temperature may reach a point where the snow evaporates before it hits the funnel!

C.3 Status LED

The Status LED, within the ambient temperature sensor probe, flashes to indicate the mode that the CS700H is in (see TABLE C-2).

Mode	Flash Rate	Description
Long Flash	LED on for 0.5 s	Controller powering up.
Slow Flash	1 flash every 1.5 s	In standby mode waiting for a heating cycle.
Medium Flash	2 flashes per second	Within a heating cycle and the heating elements are presently turned off. Waiting for snow to be present before turning on heaters.
Fast Flash	8 flashes per second	Within a heating cycle and the heating elements are presently turned on.

C.4 Snow Sensor

The snow sensor is actually a capacitive proximity sensor that registers any material object within a few mm range. The sensor’s power is turned on and off to conserve power. TABLE C-3 lists the conditions that power is applied.

The state of the snow sensor (snow detected) is read using the measure (*aM!*) and data (*aD0!*) commands (fourth value).

NOTE

The snow sensor must detect snow continuously for 5 s before the detected flag is set to 1. And conversely, snow must be absent for 5 s continuously before the detected flag is reset to 0. This process prevents a premature heating cycle when in the automatic mode.

Mode (aX20! command)	Snow Enabled aX22! command	Description
Auto	0	Snow sensor isn't powered. Cannot detect real snow, instead it indicates snow is always present.
	1	Snow sensor only is powered only when the ambient temperature is below the Active On temperature. Only detects snow when the temperature is in this range.
Manual	0	Snow sensor isn't powered. Cannot detect real snow, instead it indicates snow is always present.
	1	Snow sensor always is powered, and can detect snow at any time.

C.5 Operating Modes

The CS700H can be put into automatic or manual operation modes. TABLE C-4 describes how the modes are entered and the operation of the modes.

Auto/ Manual X20	Cycle Enable X29	Heater On/Off X21	Snow Enabled X22	Snow	Description
0	X	X	1	0 / 1	Auto Mode: When the Ambient temperature falls below the Active On temperature X23, and Snow is detected, then a Heating Cycle is started. (That is, the heater elements are switched on and off to keep inside the funnel at the SetPoint temperature X26.) This is a low power mode, as the heater cycle only begins when snow is detected!
0	X	X	0	1	Auto Mode: Same as above, but because the snow sensor is disabled the snow detected flag is always set. The Heating Cycle is started when the Ambient temperature fall below the Active On temperature X23. This mode uses more power and should only be used when the system is supplied by mains power.

TABLE C-4. Operating Modes

Auto/ Manual X20	Cycle Enable X29	Heater On/Off X21	Snow Enabled X22	Snow	Description
1	0 / 1	0	X	X	Manual Mode: The Cycle Enable flag X29 is used to force a Heating Cycle. This is set or cleared by another system at the site – as it determines whether heating is required. When the Cycle Enable flag is “0” the heaters are off. When the Cycle Enable flag is “1” then the Heating Cycle is started. (That is, the heater elements are switched on and off to keep inside the funnel at the SetPoint temperature X26.) The snow sensor state can be read using the measure/data commands, but its state is ignored when controlling the heaters.
1	0	0 / 1	X	X	Manual Mode: The heater elements can be controlled directly with the Heater On/Off flag X21. When the flag is “0” the heaters are off, and when the flag is “1” the heaters are on. Note that the heaters must be cycled by the controlling system in order to control the funnel temperature. This mode must be used with caution!

(X = Don’t Care)

C.6 SDI-12 Sensor Support

NOTE The CS700H will only communicate over SDI-12 when both its sensor cable and power cable are connected (TABLE 7-2 and TABLE 7-3).

C.6.1 Introduction

SDI-12, Serial Data Interface at 1200 baud, is a protocol developed to simplify sensor and datalogger 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 datalogger.

This appendix discusses the structure of SDI-12 commands and the process of querying SDI-12 sensors. For more detailed information, refer to version 1.3 of the SDI-12 protocol, available at www.sdi-12.org.

C.6.2 SDI-12 Command Basics

SDI-12 commands have three components:

Sensor address (a) – a single character and the first character of the command. The default address of zero (0) can be used unless multiple sensors are connected to the same port.

Command body – an upper case letter (the “command”), optionally followed by one or more alphanumeric qualifiers.

Command termination (!) – an exclamation mark.

An active sensor responds to each command. Responses have several standard forms and always terminate with <CR><LF> (carriage return and line feed). Standard SDI-12 commands are listed in TABLE C-5. Information on each of these commands is given in following sections.

TABLE C-5. Campbell Scientific Sensor SDI-12 Command and Response Set		
Name	Command	Response
Acknowledge Active	a!	a<CR><LF>
Send Identification	a!	allccccccmmmmmmvvvxxx...xx <CR><LF>
Start Verification	aV!	attn <CR><LF>
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>

C.6.2.1 Acknowledge Active Command (a!)

The Acknowledge Active command (**a!**) is used to test a sensor on the SDI-12 bus. An active sensor responds with its address.

C.6.2.2. Send Identification Command (a!)

Sensor identifiers are requested by issuing command **a!**. 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.

a!	alccccccmmmmmmvvvxxx...xx<CR><LF>
a	Sensor's 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 (OS)
xxx...xx	An optional field up to 13 characters in length, used for a serial number or other specific sensor information that is not relevant for operation of the data recorder
<CR><LF>	Terminates the response.
Source: <i>SDI-12: A Serial-Digital Interface Standard for Microprocessor-Based Sensors</i> (see Appendix C.6.4, <i>References</i> (p. C-16).	

C.6.2.3 Start Verification Command (aV!)

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

Command: **aV!**

Response: *atttn*<CR><LF>

a = sensor address

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

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

C.6.2.4 Address Query Command (?!)

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

C.6.2.5 Change Address Command (aAb!)

Multiple SDI-12 sensors can be connected to a single SDI-12 port on a datalogger. Each device on a single terminal must have a unique address.

A sensor's 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.

C.6.2.6 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 = time, in seconds, until measurement data are available. If the data is ready before then, the sensor notifies the datalogger, and the datalogger begins issuing **D** commands.

n = the number of values to be 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 datalogger pauses its operation and waits until either it receives the data from the sensor or the time, *t*, expires.

Depending on the scan interval of the datalogger 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*).

TABLE C-6. Example aM! Sequence

0M!	The datalogger makes a request to sensor 0 to start a measurement.
00352<CR><LF>	Sensor 0 immediately indicates that it will return 2 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 datalogger.
0D0!	The datalogger immediately initiates the process of collecting the sensor's data by issuing the first D command.
0+.859+3.54<CR><LF>	The sensor immediately responds with the sensor address and the two values.

C.6.2.7 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 datalogger 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 datalogger that the measurement is complete. The datalogger will issue the **aD0!** command after the measurement time reported by the sensor has expired. The response to each command has the form *attn*<CR><LF>, where

a = the sensor address

t = time, in seconds, until the measurement data are available

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

See the following example. A datalogger has three sensors wired into terminal **C1**. The sensors are addresses X, Y, and Z. The datalogger will issue the following commands and receive the following responses:

TABLE C-7. Example aC! Sequence	
XC!	The datalogger 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 datalogger 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 datalogger 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 datalogger 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 datalogger starts the process of 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.
YD0!	Ten seconds later, after a total of 40 seconds have passed, the datalogger starts the process of data from sensor Y by issuing the first D command.
Y+1+2+3+4+5+6<CR><LF>	The sensor immediately responds with the sensor address and the 6 values.

C.6.2.8 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 datalogger. 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 will not be returned in the data table but checked by the datalogger as it comes. The code returned is based on the SDI-12 protocol. See the SDI-12 communication specification for version 1.3 available at www.sdi-12.org to learn more about how the CRC code is developed.

C.6.2.9 Stopping a Measurement Command

A measurement command (**M!**) is stopped if it detects a break signal. A break signal is sent by the datalogger before most commands.

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

C.6.2.10 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 datalogger issues the **aD0!** command once a service request has been received from the sensor. When the datalogger 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 (Appendix C.6.3, *SDI-12 Transparent Mode* (p. C-13)), the user asserts this command to obtain data.

Depending on the type of data returned and the number of values a sensor returns, the datalogger 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.

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

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

where:

a = the sensor address

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

<CR><LF> = terminates the response

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

C.6.2.11 Continuous Measurement Command (aR0! ... aR9!)

Sensors that are able to continuously monitor the phenomena to be measured can be read directly with the **R** commands (**R0!...R9!**). The response to the **R** commands mirrors the Send Data command (**aD0!**). A maximum of 75 characters can be returned in the *<values>* part of the response to the **R** command.

C.6.2.12 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.

TABLE C-8 shows the extended commands that are unique to the CS700H.

NOTE

In the following commands “a” is the address of the CS700H – set to “0” at the factory

TABLE C-8. Special X Commands

User ID aX04! aX04+12345!	– X04 Command Get the transducer ID using the aD0! Command Set the transducer ID to 12345. Acceptable values 0-65535. This value appears in the Identify command.
External Control aX20! aX20+0! aX20+1!	– X20 Command Get the heater state using the aD0! Command Set the Heater Control state to 0 => Heater Elements Off Set the Heater Control state to 1 => Heater Elements On (Changing this state forces X29 Cycle Enable to 0=>disabled)
Heater Control aX21! aX21+0! aX21+1!	– X21 Command (Only operates if “External Control” set to 1) Get the heater state using the aD0! Command Set the Heater Control state to 0 => Heater Elements Off Set the Heater Control state to 1 => Heater Elements On (Changing this state forces X29 Cycle Enable to 0=>disabled)
Snow Sensor Enabled aX22! aX22+0! aX22+1!	– X22 Command Get the snow sensor enabled state using the aD0! Command Set the Snow Sensor Enable state to 0 => Snow sensor Disabled (When snow sensor is disabled, the unit reports snow as detected to force a heating cycle when the ambient is less than the active on temperature when in automatic mode) Set the Snow Sensor Enable state to 1 => Snow Sensor Enabled

TABLE C-8. Special X Commands	
ActiveOn Temperature aX23! aX23+04.0! aX23+39.2!	– X23 Command Get the ActiveOn temperature using the aD0! Command Set the ActiveOn temperature to +4.0°C (if X28 set to 0) Set the ActiveOn temperature to +39.2°F (if X28 set to 1)
ActiveOff Temperature aX24! aX24+05.0! aX24+41.0!	– X25 Command Get the LowOff temperature using the aD0! Command Set the LowOff temperature to -20.0°C (if X28 set to 0) Set the LowOff temperature to -4.0°F (if X28 set to 1)
LowOff Temperature aX25! aX25-20.0! aX25-04.0!	– X25 Command Get the LowOff temperature using the aD0! Command Set the LowOff temperature to -20.0°C (if X28 set to 0) Set the LowOff temperature to -4.0°F (if X28 set to 1)
SetPoint Temperature aX26! aX26+10.0! aX26+50.0!	– X26 Command Get the funnel SetPoint temperature using the aD0! Command Set the funnel SetPoint temperature to +10.0°C (if X28 set to 0) Set the funnel SetPoint temperature to +50.0°F (if X28 set to 1)
Snow Run-On Time aX27! aX27+18!	– X27 Command Get the “Snow Run-on” time after snow is detected using aD0! Set the “Snow Run-on” time to 18 mins
Celcius / Farenheit aX28! aX28+0! aX28+1!	– X28 Command Get the °C / °F state using the aD0! Command Set to Celcius (data = 0) Set to Farenheit (data = 1)
Cycle Enable aX29! aX29+0! aX29+1!	– X29 Command (Only operates if “External Control” set to 1) Get the Cycle Enable state using the aD0! Command Set the Cycle Enable state to 0 => Heating Cycle Off Set the Cycle Enable state to 1 => Heating Cycle On (Changing this state forces X21 Heater Control to 0=> Off) (This command is only available in S/W Rev 4.1 and above)
Preset / Calibrate Ambient Temperature Sensor aX91! aX91+22.3! aX91+72.1!	– X91 Command Get the Ambient temperature sensor using the aD0! Command Set the Ambient temperature sensor to +22.3°C (if X28 set to 0) Set the Ambient temperature sensor to +72.1°F (if X28 set to 1)
Preset / Calibrate Funnel Temperature Sensor aX92! aX92+18.6! aX92+65.5!	– X92 Command Get the Funnel temperature sensor using the aD0! Command Set the Funnel temperature sensor to +18.6°C (if X28 set to 0) Set the Funnel temperature sensor to +65.5°F (if X28 set to 1)
Set Factory Defaults aX99+1!	– X99 Command Set the factory defaults (only when data is +1)

C.6.3 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. Datalogger security may need to be unlocked before transparent mode can be activated.

Transparent mode is entered while the computer is communicating with the datalogger through a terminal emulator program. It is accessed through Campbell Scientific datalogger support software or other terminal emulator programs. Datalogger keyboards and displays cannot be used.

The terminal emulator is accessed by navigating to the **Datalogger** menu in *PC200W*, the **Tools** menu in *PC400*, or the **Datalogger** menu in the *Connect* screen of *LoggerNet*.



Watch the video: [SDI-12 Sensors | 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 Appendix C.6.3.1, *Changing an SDI-12 Address (p. C-14)*, are used with most Campbell Scientific dataloggers. Appendix C.6.3.2, *Changing an SDI-12 Address – CR200(X) Series (p. C-15)*, lists the steps used for CR200(X)-series dataloggers.

C.6.3.1 Changing an SDI-12 Address

The example below was done with a CR1000, but the steps are only slightly different for CR300-series, CR6-series, CR800-series, and CR3000 dataloggers. For CR200(X)-series dataloggers, see Appendix C.6.3.2, *Changing an SDI-12 Address – CR200(X) Series (p. C-15)*.

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

Enter. The sensor will change its address and respond with the new address.

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

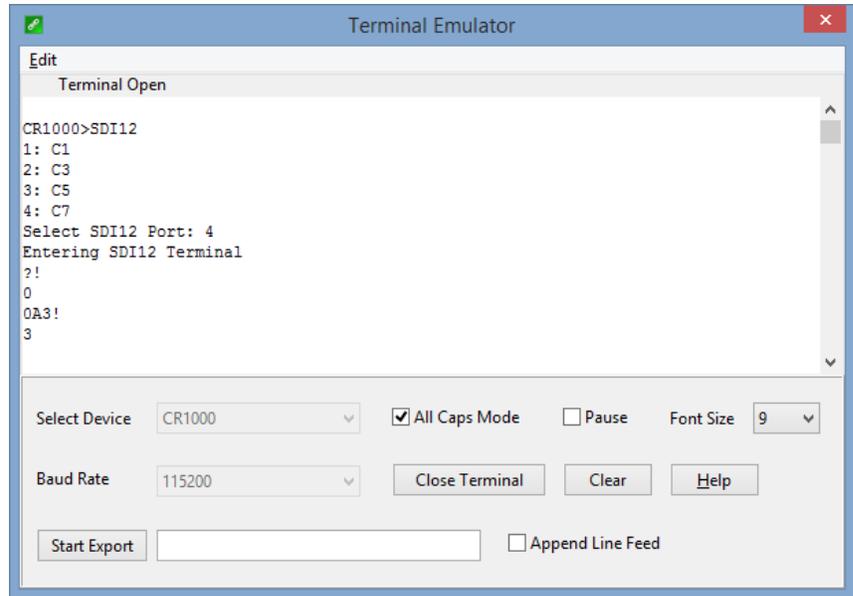


FIGURE C-4. CR1000 example of using the SDI-12 transparent mode to change the SDI-12 address from 0 to 3. Sensor is connected to control port 1.

C.6.3.2 Changing an SDI-12 Address – CR200(X) Series

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

10. To change the SDI-12 address, type **aAb!**, where *a* is the current address from the above step and *b* is the new address (see FIGURE C-4). Press Enter. The sensor will change its address and respond with the new address.
11. To exit SDI-12 transparent mode, click **Close Terminal**.

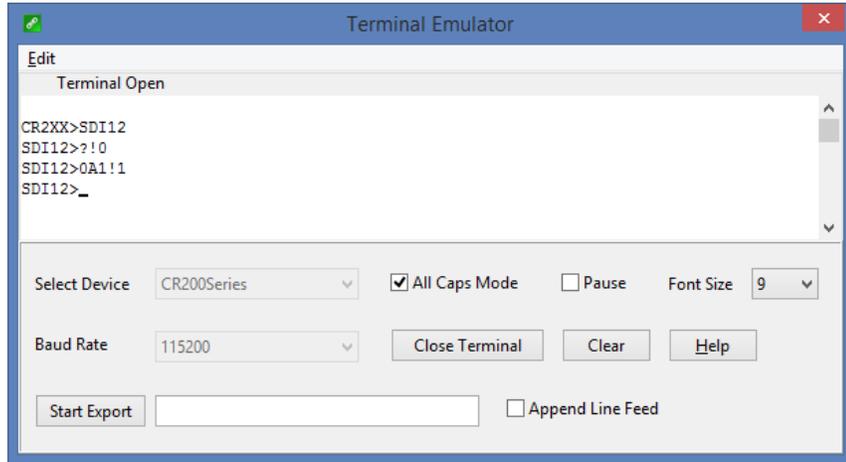


FIGURE C-5. CR200(X) example of using the SDI-12 transparent mode to change the SDI-12 address from 0 to 1

C.6.4 References

SDI-12 Support Group. *SDI-12: A Serial-Digital Interface Standard for Microprocessor-Based Sensors – Version 1.3*. River Heights, UT: SDI-12 Support Group, 2016. http://www.sdi-12.org/archives/SDI-12_version1_3%20January%2028,%202016.pdf.

Appendix D. Phoenix Contact Power Supply Specifications

The Phoenix Contact power supply is used for the –AC option for the CS700H only.

Model Name: Quint-PS/1AC/24DC/10

Input data

Nominal input voltage: 100 Vac to 240 Vac
AC input voltage range: 85 Vac to 264 Vac
Short-term input voltage: 300 Vac
AC frequency range: 45 Hz to 65 Hz
Name of protection: Transient surge protection
Protective circuit/component: Varistor

Output data

Nominal output voltage: 24 Vdc \pm 1%
Setting range of the output voltage: 18 Vdc to 29.5 Vdc (>24 V constant capacity)
Output current: 10 A (–25 to 60 °C, $U_{OUT} = 24$ Vdc)
15 A (with POWER BOOST, –25 to 40 °C permanently, $U_{OUT} = 24$ Vdc)
Derating: From 60 to 70 °C: 2.5% per Kelvin
Connection in parallel: Yes, for redundancy and increased capacity
Connection in series: Yes
Maximum power dissipation idling: 7 W
Power loss nominal load max.: 18 W

General data

Width: 60 mm (2.4 in)
Height: 130 mm (5.1 in)
Depth: 125 mm (4.9 in)
Weight: 1.1 kg (2.4 lb)
Efficiency: > 92.5% (for 230 Vac and nominal values)
Ambient temperature (operation): –25 to 70 °C (> 60 °C derating)
Ambient temperature (storage/transport): –40 to 85 °C
Max. permissible relative humidity (operation): 95% (at 25 °C, no condensation)

NOTE

Additional specifications are provided in Phoenix Contact's manual for the Quint-PS/1AC/24DC/10.

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