

INSTRUCTION MANUAL



CS470/CS471 Compact Bubbler System

Revision: 7/14



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General

- Prior to performing site or installation work, obtain required approvals and permits. Comply with all governing structure-height regulations, such as those of the FAA in the USA.
- Use only qualified personnel for installation, use, and maintenance of tripods and towers, and any attachments to tripods and towers. The use of licensed and qualified contractors is highly recommended.
- Read all applicable instructions carefully and understand procedures thoroughly before beginning work.
- Wear a **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.
- Comply with all electrical codes. Electrical equipment and related grounding devices should be installed by a licensed and qualified electrician.

Elevated Work and Weather

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

Maintenance

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

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CS470/CS471 Compact Bubbler System

1. Introduction

The CS470 and CS471 are designed for general liquid level measurements. They use SDI-12 or RS-232 communications protocols to communicate with a SDI-12 or RS-232 recorder simplifying installation and programming.

2. Cautionary Statements

- READ AND UNDERSTAND the *Precautions* section at the front of this manual.
- Remember that although the CS470/CS471 is designed to be a rugged and reliable device for field use, it is also a highly precise scientific instrument and should be handled as such.
- NEVER open the housing of the CS470/CS471. There are no user-serviceable parts inside the sensor housing and any attempt to disassemble the device will void the warranty.
- While connecting the tubing, keep contamination or moisture from entering the tubing.
- Do not damage or kink the tubing during installation.
- Always use a sharp knife instead of scissors to cut the tubing.

3. Initial Inspection

- Upon receipt of the CS470/CS471, 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.
- Care should be taken when opening the package not to damage or cut the polyethylene tubing (if ordered). If there is any question about damage having been caused to the tubing, a thorough inspection is prudent.
- The model number and serial number is printed on the housing. Check this information against the shipping documentation to ensure that the expected model number was received.
- Refer to Section 3.1, *Shipping Kit and Accessories*, to ensure you have all of the components

3.1 Shipping Kit and Accessories

3.1.1 Shipping Kit

The CS470/CS471 ships with:

- (1) Installation Kit (top DIN rail with fastening parts; screw terminal blocks, pin jumpers)
- (2) #505 Screws
- (2) #6044 Grommets
- (1) #1113 Flat-bladed screwdriver

3.1.2 Accessories

The following are ordered as Common Accessories:

- CABLE4CBL-L 4-Conductor 22 AWG Cable — used to connect the CS470/CS471 to a datalogger. Cable length is user-specified. This cable can either terminate in stripped and tinned leads that connect directly to the datalogger or a connector that mates with a prewired enclosure.
- Polyethylene Tubing, 3/8 inch OD, 1/8 inch ID (pn 25503) — used as the measuring tube and is submerged in the liquid. Specify length, in feet, when ordering.
- OTT EPS-50 Bubble Chamber (pn 25502) — includes an NPT adapter allows the bubble chamber to be connected to standard plumbing materials.

4. Quickstart

Short Cut is an easy way to program your datalogger to measure the sensor and assign datalogger wiring terminals. The following procedure shows using *Short Cut* to program the CS470/CS471.

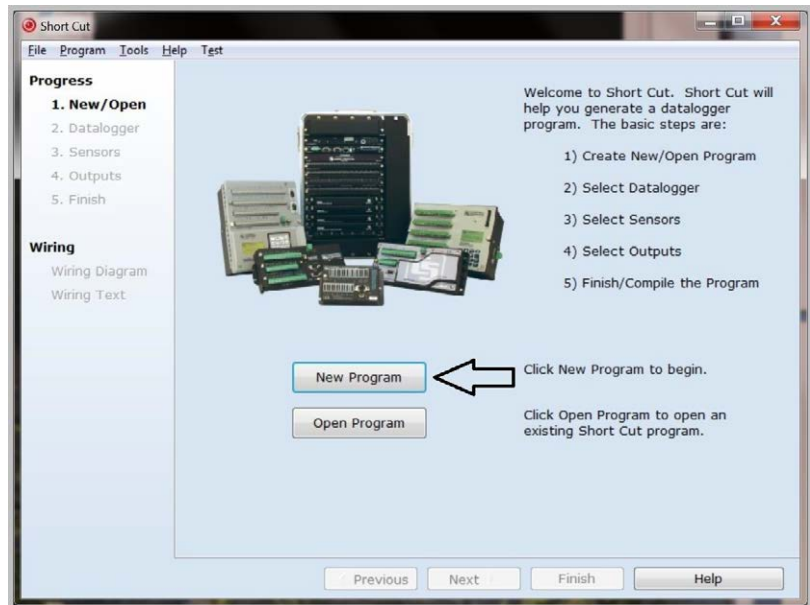
1. Install *Short Cut* by clicking on the install file icon. Get the install file from either www.campbellsci.com, the ResourceDVD, or find it in installations of *LoggerNet*, *PC200W*, *PC400*, or *RTDAQ* software.



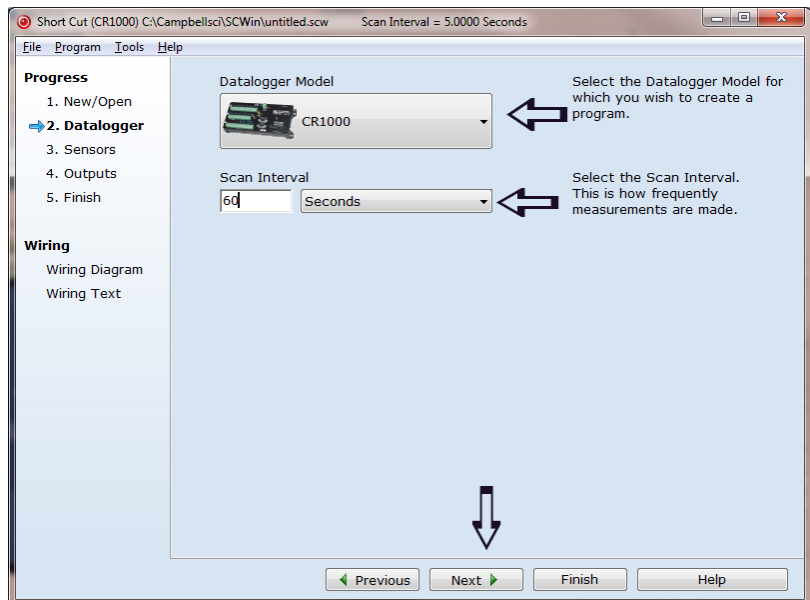
2. The *Short Cut* installation should place a *Short Cut* icon on the desktop of your computer. To open *Short Cut*, click on this icon.




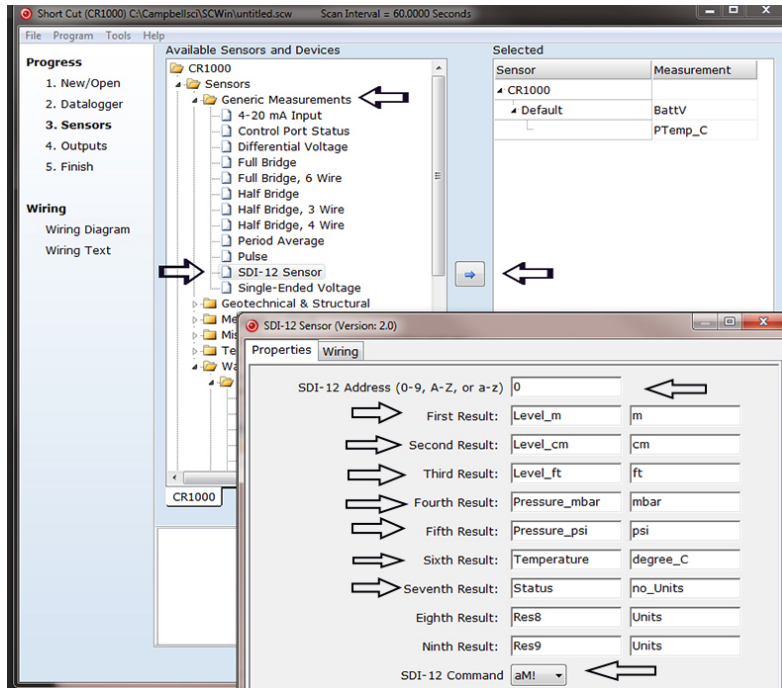
- When *Short Cut* opens, select **New Program**.



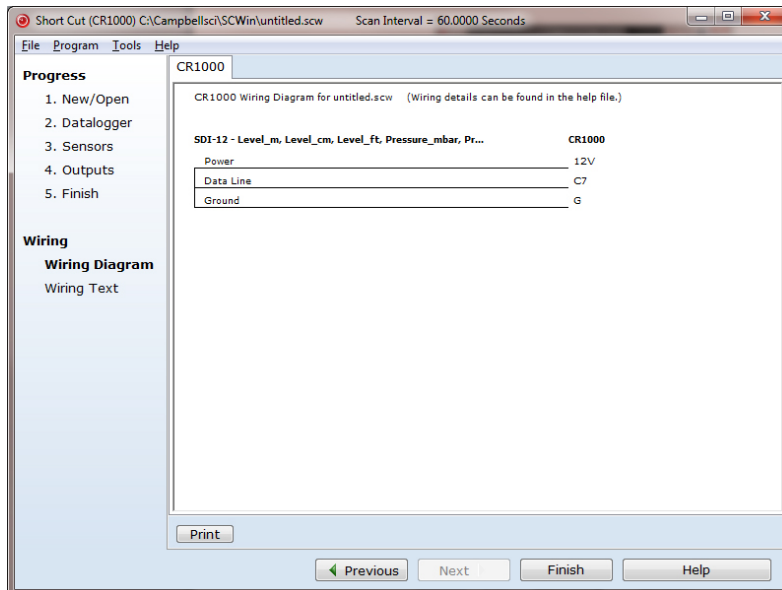
- Select **Datalogger Model** and **Scan Interval** (60 second or higher scan interval is recommended). Click **Next**.



- Under the **Available Sensors and Devices** list, select the **Sensors | Generic Measurements** folder. Select **SDI-12 Sensor**, click  to move the selection to the **Selected** device window. Enter the result names and units. The default SDI-12 address is 0 and the default SDI-12 command is **aM!**. The SDI-12 address should only be changed from the default when more than one sensor is connected to the same datalogger channel. The SDI-12 command can be changed by clicking the **SDI-12 Command** box and selecting one of the other options.



- 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.



7. 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**.
8. If *LoggerNet*, *PC400*, or *PC200W* is running on your PC, and the PC 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.
9. If the sensor is connected to the datalogger, as shown in the wiring diagram in step 6, check the output of the sensor in the datalogger support software data display to make sure it is making reasonable measurements.

5. Overview

The CS470 and CS471 use the air bubble principle for measuring liquid level. Generally, they measure ground or surface water level, but any liquid level can be measured. Typical applications include agricultural water level/flow, water wells, lakes, streams, and tanks. The CS470 and CS471 differ only in their measurement accuracy.

Compressed air produced by a piston pump flows via a measuring tube into the water to be measured. The pressure created in the measuring tube is directly proportional to the water column above the bubble chamber. The CS470/CS471 determines the barometric air and bubble pressure one after the other. By taking the difference between the two signals, the CS470/CS471 calculates the height of the water level above the bubble chamber.

The CS470/CS471 contains a purge function. This clears the measuring tube and the bubble chamber of any minor contamination by pumping a large volume of air into the measuring tube.

By using an intelligent pump strategy, no air drying unit is necessary.

The CS470/CS471 has three communication options: SDI-12, 4 to 20 mA, or RS-485 (SDI-12 protocol via a physical RS-485 interface). As an SDI-12 sensor, the CS470/CS471 is shipped with an address of 0.

The CS470 and CS471 are manufactured by OTT as model CBS.

6. Specifications

Features:

- Ideal for areas where submersed sensors can be damaged due to corrosion, contamination, flood-related debris, lightning, or vandalism
- Easy to maintain
- Robust pump design provides reliable operation
- Consistent accuracy ensured by drift-free measurements and offset compensation using relative measurement
- Purge function clears the measuring tube and the bubble chamber of contamination

- Does not use pressurized nitrogen tank — requiring less frequent attendance
- Existing tubes can be used
- Compatible with Campbell Scientific CRBasic dataloggers: CR200(X) series, CR800 series, CR1000, CR3000, and CR5000. Also compatible with Edlog dataloggers: CR500, CR510, CR10(X), and CR23X

Power Requirements:	10 to 30 Vdc (typically supplied by the datalogger)
Power Consumption:	Quiescent current < 0.25 mA Measurement/Communication Current: Typical 320 mAh/day with 1 minute query interval Typical 25 mAh/day with 15 min query interval
Measurement Time:	1 minute
Outputs:	SDI-12 (version 1.3) 1200 Baud 4 to 20 mA RS-484 (SDI-12 Protocol via RS-485 interface)
Measurement Ranges:	0 to 50 ft
Accuracy:	CS470 Standard: ± 0.02 ft CS471 High Accuracy: 0 to 15 ft: ± 0.01 ft 15 to 35 ft: $\pm 0.065\%$ of reading 35 to 50 ft: ± 0.02 ft
Resolution:	0.003 ft/0.014 psi
Operating Temperature:	-20 to 60 °C
Storage Temperature:	-40 to 85 °C
Relative Humidity:	10 to 95% non-condensing
Measuring tube:	1/8 in. I.D., 3/8 in. O.D., 100.6 m (330 ft) maximum length
Dimensions:	16.5 x 20.5 x 11.5 cm (6.5 x 8.1 x 4.5 in)
Weight:	1.5 kg (3.3 lb)

7. Installation

If you are programming your datalogger with *Short Cut*, skip Section 7.7, *Wiring*, and Section 7.8, *Programming*. *Short Cut* does this work for you. See Section 4, *Quickstart*, for a *Short Cut* tutorial.

7.1 DIP Switch Settings



The default DIP switch settings are shown in TABLE 7-1. The default settings support SDI-12 communications, which is the communication method typically used by our dataloggers. The DIP switch settings need to be changed if using 4 to 20 mA communications (see Appendix C, *4 to 20 mA Operation*).

SDI-12 Settings	Switch Settings
1	ON
2	ON
3	OFF
4	NA
5	NA
6	NA
7	NA
8	NA

7.2 Installation/Water Depth Considerations

The CS470/CS471 and bubble chamber should be installed so that the tubing has a continuous drop from the CS470/CS471 towards the bubble chamber. Otherwise, moisture can collect in a hollow and potentially block the tubing with the formation of drops.

The bubble chamber must be installed below the water at a fixed depth. The maximum water depth is determined by the maximum tube length, which is 15.24 m (50 ft).

For optimal measurement results, the bubble chamber should be horizontal and aligned in the direction of water flow (maximum tolerance $\pm 5^\circ$). The bubble chamber has a ball-and-socket joint that adjusts to 15° in any direction.

7.3 Mounting the CS470/CS471

The CS470/CS471 electronic box should be in a dry and dust-free location such as a Campbell Scientific enclosure. It mounts to an enclosure backplate using DIN rails (included with shipped material). With the supplied grommets and screws, connect the top DIN rails horizontally to the back panel of a Campbell Scientific enclosure (see FIGURE 7-1).

With the top DIN rails installed, first attach the CS470/CS471 on the upper edge of the top DIN rail and then press the underside against the top DIN rail until it clicks into place.

To dismount the CS470/CS471, first press one locking device downwards and pull the CS470/CS471 slightly forwards at this point. Press the second locking device downwards and remove the CS470/CS471 upwards from the top DIN rail.

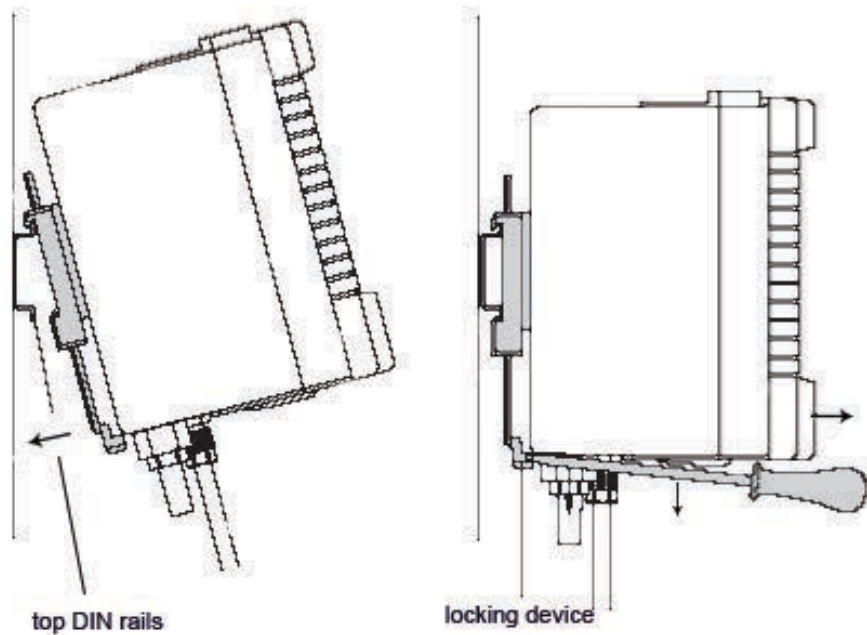
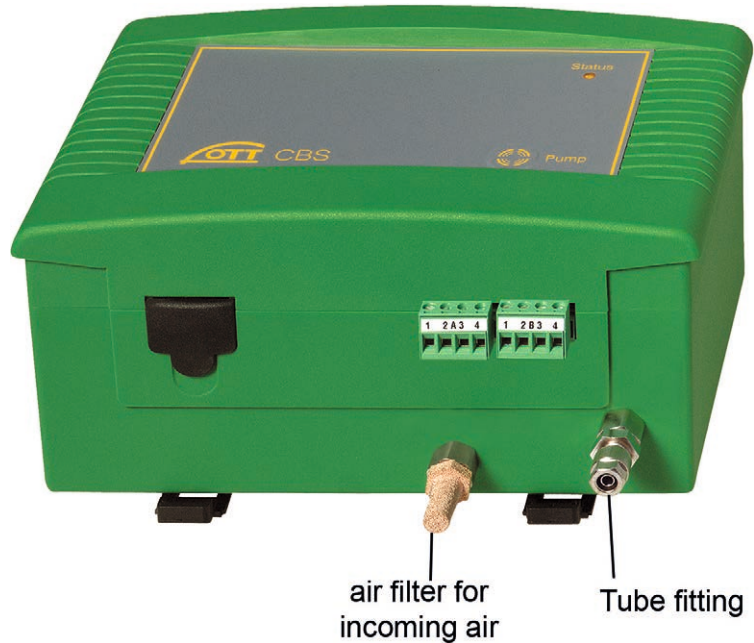


FIGURE 7-1. Securing the CS470/CS471 to a DIN Rail

7.4 Connect Tubing to the CS470/CS471

1. Cut the bubble tube at a 90° angle with a sharp knife (not scissors).
2. Insert the tubing as far as possible into the tube fitting.



3. Rotate the nut until finger tight.
4. Tighten the nut with a wrench about one and one-quarter turns.

7.5 Bubble Chamber Installation

1. Install conduit (metal or plastic) from the CS470/CS471 to where the bubble chamber will be located. There should be a continuous drop from the CS470/CS471 to the bubble chamber (see FIGURE 7-2).

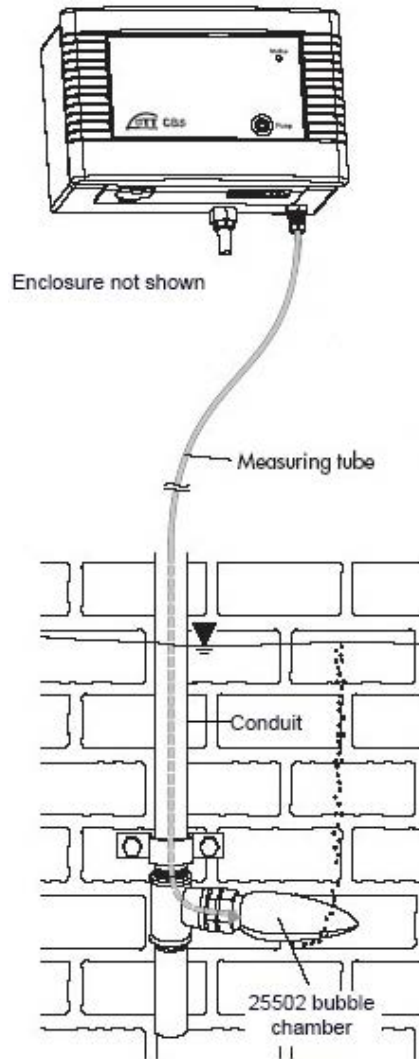


FIGURE 7-2. Bubble Chamber Installation

2. Fasten the conduit in place
3. Attach an elbow or tee joint at the bubble chamber location. The elbow or tee joint should terminate with a 2-inch NPT female threaded connection.
4. Route the tubing through the conduit.
5. Cut the tubing at a 90° angle with a sharp knife (not scissors).
6. Detach the NPT adapter from the bubble chamber by unscrewing the three hexagonal screws of the bubble chamber's flange (see FIGURE 7-3).

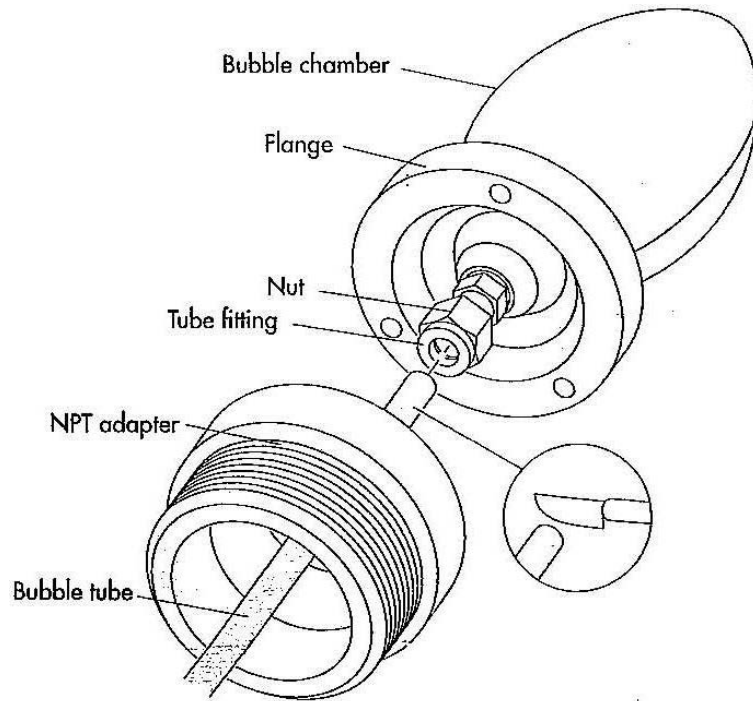


FIGURE 7-3. Connection of the Bubble Tube

7. Install the NPT adapter on the end of the elbow or tee joint.
8. Activate the CS470/CS471 while immersing the bubble chamber. The CS470/CS471 needs to be activated, so that the piston pump is operating during this procedure.
9. Insert the tubing as far as possible into the bubble chamber's tube fitting
10. Rotate the nut until finger tight.
11. While holding the bubble chamber steady, tighten the nut with a wrench about one and one-quarter turns.
12. Install the bubble chamber on the NPT adapter.

NOTE

For optimal measurement results, the bubble chamber must be adjusted to be horizontal and aligned in the direction of flow (maximum tolerance $\pm 5^\circ$). The 25502 bubble chamber has a ball-and-socket joint which allows for adjustments by 15° in any direction.

7.6 Purging Function

On the front of the CS470/CS471, there is a pump membrane button (see FIGURE 7-4). Pressing the button activates the purge function for as long as it is pressed. The *Status* LED lights for approximately 2 seconds. With an activated purge function, the sensor pumps a large amount of air through the

measuring tube for the required time period. The purge function can also be activated via an SDI-12 command.

NOTE Press the membrane button for at least one second as otherwise the error is called and displayed at the Status LED.



FIGURE 7-4. Purge Button and Status LED

7.7 Wiring

All electrical connections are made using two screw terminal strips (supplied) at terminal blocks A and B on the underside of the CS470/CS471 (see FIGURE 7-5).

Although the CS470/CS471 has three interfaces available, our dataloggers typically use SDI-12, and, therefore, only the SDI-12 connections will be addressed here (for information about 4 to 20 mA communication, see Appendix C).

It is recommended to power down your system before wiring the CS470/CS471. SDI-12 communication only requires a four-wire connection (see TABLE 7-2). Use CABLE4CBL-L 4-conductor 22 AWG cable.

NOTE The shield wire plays an important role in noise emissions and susceptibility as well as transient protection.



FIGURE 7-5. CS470/CS471 Screw Terminals

Terminal	Terminal Number	Function	CR800, CR850, CR1000, CR3000, CR23X, CR10(X), CR500, CR510	CR5000	CR200(X)
A	1	12 V power	12V	12V	Battery+
A	4	Power Ground	G	G	G
B	3	SDI-12 Data	Odd Numbered Control Port (C1, C3, ...)	SDI-12	C1/SDI-12
B	4	SDI-12 Ground	G	G	G

7.8 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
- when 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*. If you wish to import *Short Cut* code into either *Edlog* or *CRBasic Editor* to create or add to a customized program, follow the procedure in Appendix A.1, *Importing Short Cut Code into a Program Editor*. Programming basics for CRBasic and Edlog dataloggers are provided in the following sections. Complete program examples for select dataloggers can be found in Appendix B, *Example Programs*.

7.8.1 CRBasic Programming

The **SDI12Recorder()** measurement instruction programs CRBasic dataloggers (CR200(X) series, CR800 series, CR1000, CR3000, and CR5000) to measure the CS470/CS471 sensor. This instruction sends a request to the sensor to make a measurement and then retrieves the measurement from the sensor. See Section 8.1, *SDI-12 Commands*, for more information.

When using a CR200(X), the **SDI12Recorder()** instruction has the following syntax:

SDI12Recorder(*Destination, OutString, Multiplier, Offset*)

For the other CRBasic dataloggers, the **SDI12Recorder()** instruction has the following syntax:

SDI12Recorder(*Destination, SDIPort, SDIAddress, "SDICommand", Multiplier, Offset*)

7.8.2 Edlog Programming

Edlog dataloggers read the CS470/CS471 using the **SDI-12 Recorder (P105)** instruction.

Please note that Edlog only allocates one input location for the **SDI-12 Recorder (P105)** instruction. Seven input locations are required for the SDI-12 **M!** command. The additional input locations need to be inserted manually using the Input Location Editor. To get into the **Input Location Editor**, select **Edit/Input Labels** or press the **F5** key. Once in the **Input Location Editor**, do the following:

1. Choose **Edit/Insert Block**.
2. After the **Insert Block** dialog box appears, type in a base name for the input locations. Each input location will have the base name with an underscore and a consecutive number.
3. In the **Start Address** field, type in the number of the first input location.
4. In the **Number of InLocs** field, type in 7 and select **OK**.

8. Operation

8.1 SDI-12 Commands

NOTE

This section briefly describes using the SDI-12 commands. Additional SDI-12 information is available at Appendix D, *SDI-12 Sensor Support*, www.sdi-12.org, or www.youtube.com/user/CampbellScientific.

CRBasic instruction **SDI12Recorder()** measures the CS470/CS471 sensor using the Start Measurement (**aM!**) command. The “a” is the address of the sensor and “!” is the command terminator. The sensor returns the following seven values.

1. Level [m]; resolution: 0.001 m
2. Level [cm]; resolution: 1 cm
3. Level [ft]; resolution: 0.01 ft
4. Pressure [mbar]; resolution: 0.01 mbar
5. Pressure [psi]; resolution: 0.001 psi
6. Temperature [°C]; resolution: 0.1 °C
7. Status

A measurement is initiated with the **aM!** command. To this command, the sensor responds with the time until the measurement data are available and the number of values to be returned when one or more subsequent **ad!** commands are issued.

8.2 Measurements at Fast Scan Rates

Using the **SlowSequence()** function allows the SDI-12 instruction to run as a background process, causing minimum interference to other measurements that use the analog hardware. Measuring the sensor in a **SlowSequence()** section of the program allows faster programs to run as the main scan.

NOTE

For the CR5000, use a control port rather than the SDI-12 port to allow the SDI12recorder instruction to run in the slow sequence.

8.3 Long Cables

Digital data transfer eliminates offset errors due to cable lengths. However, digital communications can break down when cables are too long, resulting in either no response from the sensor or corrupted readings. The original SDI-12 standard specifies the maximum total cable length to be 61 meters (200 feet). To ensure proper operation with long cables, follow these guidelines:

- Use low capacitance, low resistance, screened cable (as fitted by Campbell Scientific) to reach distances of several hundred meters.
- Ensure that the power ground cable has low resistance and is connected to the same ground reference as the datalogger control ports.
- Be aware that “daisy-chaining” sensors reduces the maximum cable length roughly in proportion to the number of sensors connected in parallel.

8.4 Measuring Multiple SDI-12 Sensors

Up to ten CS470/CS471 sensors or other SDI-12 sensors can be connected to a single datalogger control port. Each SDI-12 device must have a unique SDI-12 address of 0 and 9, A to Z, or a to z. See Appendix D, *SDI-12 Sensor Support*, for more information.

9. Maintenance

Never open the CS470/CS471 housing! There are no adjustments or control elements inside the housing!

The CS470/CS471 itself is maintenance free. The manufacturer recommends checking the measuring tube and bubble chamber at regular intervals and cleaning as required. For every visit, you should do the following:

- Collect data.
- Visually inspect wiring and physical conditions.
- Check battery condition (inspect physical appearance and use a keyboard display or laptop to view the battery voltage).
- Check all sensor readings; adjust level offsets if necessary.
- Check recent data.
- Check the bubble chamber quarterly for sand buildup and weed infiltration. For light sand buildup, clean the bubble chamber using the purge function, and for heavier buildup or weed infiltration, clean the bubble chamber carefully manually (do not change the position of the bubble chamber).
- Activate the purge function by pressing the membrane button. Pump and check whether air bubbles rise out of the bubble chamber. If not, check whether the bubble chamber is blocked, and/or whether the measuring tube is leaking or blocked.

After 15 years of operation, test the measuring tube for tightness/pressure resistance; repeat this test roughly every two years thereafter.

9.1 Replacing Tubing

1. Untighten the nut securing the tubing to the hose connection.
2. Pull out tubing.
3. Untighten the nut securing the tubing to the bubble chamber.
4. Pull out tubing.
5. Follow procedures provided in Sections 7.4, *Connect Tubing to the CS470/CS471*, and 7.5, *Bubble Chamber Installation*, to reconnect the tubing.

10. Troubleshooting

10.1 Status LED

For the display of any error states that may occur, the CS470/CS471 has a *Status LED* on the front of the device.

The following error states can arise:

1 x flash	level too low (< 5 cm)
2 x flash	level too high (range exceeded)
3 x flash	power supply too low
4 x flash	pump motor overloaded
5 x flash	watchdog error
6 x flash	data memory defective
7 x flash	data bus defective
8 x flash	analog converter defective
9 x flash	measuring cell defective

The CS470/CS471 shows an error state when it arises and for approximately 2 minutes after pressing the pump membrane button.

The defective error states signify hardware problems that can only be rectified by the CS470/CS471 manufacturer repair center. The *watchdog error* error state means that the CS470/CS471 has been restarted. No intervention is necessary.

NOTE

Any error states arising can be displayed as follows:

Press pump membrane button briefly (< 1 sec). The LED lights once for a longer period as confirmation, then pauses. 1st error state arising, then pause. 2nd error state arising, then pause. LED lights continue until all error states arising have flashed. The CS470/CS471 repeats all error states arising for approximately two minutes.

The most common causes for erroneous data include:

- poor sensor connections to the datalogger
- damaged cables
- damaged transducers

Problem:

Unit will not respond when attempting serial communications.

Suggestion:

Check the power and signal lines to ensure proper connection to the datalogger. Check the datalogger program to ensure that the same port the SDI-12 data line is connected to is specified in the measurement instruction.

Appendix A. Importing Short Cut Code

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.

A.1 Importing *Short Cut* Code into a Program Editor

Short Cut creates files that can be imported into either *CRBasic Editor* or *Edlog* program editor. These files normally reside in the C:\campbellsci\SCWin folder and have the following extensions:

- .DEF (wiring and memory usage information)
- .CR2 (CR200(X) datalogger code)
- .CR1 (CR1000 datalogger code)
- .CR8 (CR800 datalogger code)
- .CR3 (CR3000 datalogger code)
- .CR5 (CR5000 datalogger code)
- .DLD (contain code for CR10(X), CR23X, CR500, or CR510 dataloggers)

The following procedures show how to import these files for editing.

A.1.1 CRBasic Datalogger

Use the following procedure to import *Short Cut* code into *CRBasic Editor* (CR200(X), CR1000, CR800, CR3000, CR5000 dataloggers).

1. Create the *Short Cut* program following the procedure in Section 4, *Quickstart*. Finish the program and exit *Short Cut*. Make note of the file name used when saving the *Short Cut* program.
2. Open *CRBasic Editor*.
3. Click **File | Open**. Assuming the default paths were used when *Short Cut* was installed, navigate to C:\CampbellSci\SCWin folder. The file of interest has a “.CR2”, “.CR1”, “.CR8”, “.CR3”, or “.CR5” extension, for CR200(X), CR1000, CR800, CR3000, or CR5000 dataloggers, respectively. Select the file and click **Open**.
4. Immediately save the file in a folder different from \Campbellsci\SCWin, or save the file with a different file name.

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.

5. The program can now be edited, saved, and sent to the datalogger.

6. 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 a ' character (single quotation mark) begins each line. This character instructs the datalogger compiler to ignore the line when compiling the datalogger code.

A.1.2 Edlog

Use the following procedure to import *Short Cut* code into the *Edlog* program editor (CR10(X), CR500, CR510, and CR23X dataloggers).

1. Create the *Short Cut* program following the procedure in Section 4, *Quickstart*. Finish the program and exit *Short Cut*. Make note of the file name used when saving the *Short Cut* program.
2. Open *Edlog*.
3. Click **File | Document DLD File**. Assuming the default paths were used when *Short Cut* was installed, navigate to C:\CampbellSci\SCWin folder. The file of interest has a “.DLD” extension. Select the file and click **Open**. The .dld file, which is a type of ASCII machine code, is imported, documented, and, when saved, given a “.CSI” extension.
4. Immediately save the file in a folder different from \Campbellsci\SCWin, or save the file with a different file name.

NOTE

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

5. The program can now be edited, saved, and sent to the datalogger.
6. 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 Edlog program, usually at the head of the file. After pasting, edit the information such that a ; (semicolon) begins each line, which instructs the datalogger compiler to ignore the line when compiling the datalogger code.

Appendix B. Example Programs

B.1 CRBasic Programs

B.1.1 Example CR200(X) Program

```
'CR200 Series

'Declare the variable for the water level measurement
Public CS470(7)

'Rename the variable names
Alias CS470(1)=Level_m
Alias CS470(2)=Level_cm
Alias CS470(3)=Level_ft
Alias CS470(4)=Pressure_mbar
Alias CS470(5)=Pressure_psi
Alias CS470(6)=Temperature_C
Alias CS470(7)=Status

'Define a data table for 60 minute maximum and minimums
DataTable(Hourly,True,-1)
  DataInterval(0,60,Min)
  Maximum(1,Level_ft,0,0)
  Minimum(1,Level_ft,0,0)
  Maximum(1,Temp_C,0,0)
  Minimum(1,Temp_C,0,0)
EndTable

'Read sensor every 60 seconds
BeginProg
  Scan(60,sec)

  'Code for SDI-12 measurements:
  SDI12Recorder(CS470,0M!,1,0)

  'Call the data table:
  CallTable(Hourly)

  NextScan
EndProg
```

B.1.2 Example CR1000 Program

```
'CR1000 Series Datalogger

'Declare the variable for the water level measurement
Public CS470(7)

'Rename the variable names
Alias CS470(1)=Level_m
Alias CS470(2)=Level_cm
Alias CS470(3)=Level_ft
Alias CS470(4)=Pressure_mbar
Alias CS470(5)=Pressure_psi
Alias CS470(6)=Temperature_C
Alias CS470(7)=Status

'Define a data table for 60 minute maximum and minimums
DataTable(Hourly,True,-1)
  DataInterval(0,60,Min,10)
  Maximum(1,Level_ft,FP2,0,0)
  Minimum(1,Level_ft,FP2,0,0)
  Maximum(1,Temperature_C,FP2,0,0)
  Minimum(1,Temperature_C,FP2,0,0)
EndTable

'Read sensor every 60 seconds
BeginProg
  Scan(60,sec,1,0)

  'Code for SDI-12 measurements:
  SDI12Recorder(CS470,"0","M!",1,0)

  'Call the data table:
  CallTable(Hourly)

  NextScan
EndProg
```


B.2 Edlog Program

Below is a portion of a CR10X program that measures the CS470/CS471.

NOTE The instructions below do not store data in final storage. Instruction 92, Instruction 77 and processing instructions such as Instruction 70 are required to store the data permanently.

```

;{CR10X}
;
*Table 1 Program
 01: 60          Execution Interval (seconds)

1: SDI-12 Recorder (P105)
 1: 0           SDI-12 Address
 2: 0           Start Measurement (aM0!)
 3: 1           Port ;this is where the SDI-12 signal wire is connected
 4: 1           Loc[Level_m      ]
 5: 1.0         Mult
 6: 0.0         Offset

*Table 2 Program
 02: 0.000      Execution Interval (seconds)

*Table 3 Subroutines

End Program

```

After this command is executed, the input location with the datalogger called “Level-m” holds the measured value for Level, reported in meters. The result may be further processed with the datalogger or stored to final storage memory. Note that Port 1 specifies that the SDI-12 data line is to be connected to the Port C1. Using the Inloc editor, allocate seven locations to allow for the entire string of variables that will be provided by the CS470/CS471.

Appendix C. 4 to 20 mA Operation

The load resistance connected to the CS470/CS471 must not exceed a specific maximum value. This value depends on the level of the supply voltage of the CS470/CS471. If the load resistance is greater, the output current can no longer be evaluated. Smaller load resistances are allowed.

- Read off the maximum load resistance for your power supply from FIGURE C-1.

Example: Power supply 18 volt max. load resistance 450 Ohm.

The CS470/CS471 delivers an output current corresponding to the measured value for a load resistance of up to 450 Ohm.

- Dimension the connected electrical circuit accordingly. Check the input resistance of the connected peripheral.

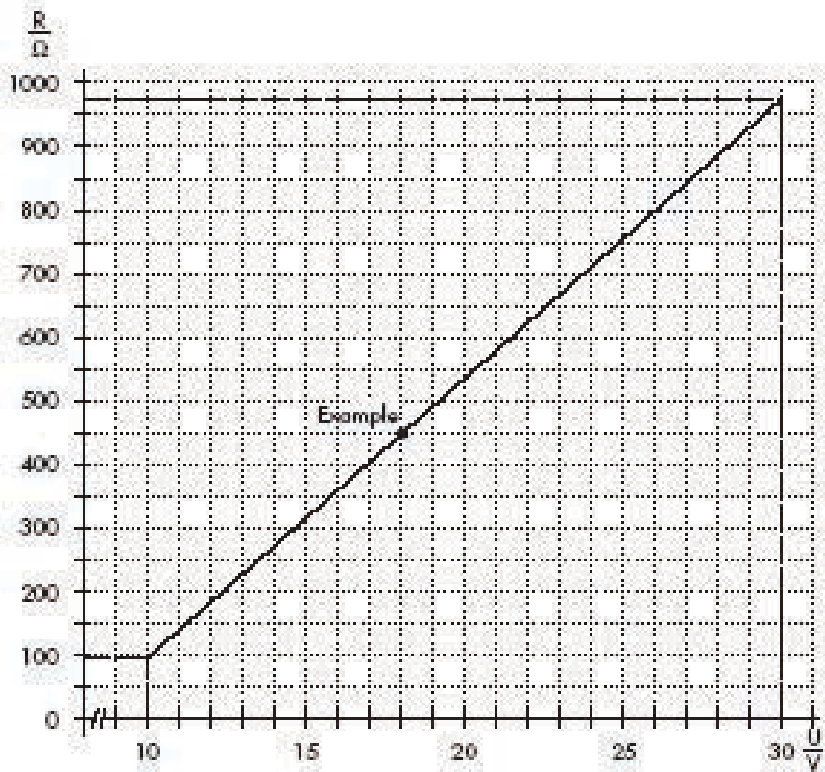


FIGURE C-1. Diagram to determine the maximum load resistance as a function of the power supply.

C.1 Setting Operating Parameters using DIP Switches

The following 4 to 20 mA operating parameters can be set with DIP switches. DIP switches 1, 2, and 3 are reserved for the SDI-12 interface.

Setting measurement type to level or depth

- Level Measurement – Set DIP Switch 4 to the OFF position.
- Depth Measurement – Set DIP Switch 4 to the ON position.

Scaling the measurement

With DIPS 5 and 6 you can scale the available measuring range to a smaller range. Where the whole measuring range is not required, this has the advantage of increasing the resolution.

- 50 ft (not scaled) – DIPS 5 and 6 to the ON position.
- 25 ft – DIP 5 to the OFF position, DIP 6 to the ON position.
- 12 ft – DIP 5 to the ON position, DIP 6 to the OFF position.
- 6 ft – DIPS 5 and 6 to the OFF position.

Setting the measurement system

Use DIP 7 to set the engineering units of the measurement.

- Metric – DIP 7 to OFF.
- Imperial – DIP 7 to ON.

Setting measurement type

Use DIP 8 to set water level or pressure units.

- Water Level – DIP 8 to OFF.
- Pressure – DIP 8 to ON.

Appendix D. SDI-12 Sensor Support

D.1 SDI-12 Command Basics

SDI-12 commands have three components:

Sensor address (a) – a single character, and is 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 (e.g., MI) – an upper case letter (the “command”) followed by alphanumeric qualifiers.

Command termination (!) – an exclamation mark.

An active sensor responds to each command. Responses have several standard forms and terminate with <CR><LF> (carriage return – line feed). Standard SDI-12 commands supported by the CS470/CS471 are listed in TABLE D-1. Appendix D.3 provides advanced commands.

Name	Command	Response
Acknowledge Active	a!	a<CR><LF>
Send Identification	aI!	alccccccmmmmmmvVVxxx...xx<CR><LF>
Change Address	aAb!	b<CR><LF>
Address Query	?!	a<CR><LF>
Start Measurement	aM!	attn<CR><LF>
Send Data	aD0!	a<values><CR><LF>
Start Verification	aV!	attn

D.1.1 Address Query Command (?!)

Command **?!** requests the address of the connected sensor. The sensor replies to the query with the address, *a*.

D.1.2 Change Address Command (aAb!)

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.

D.1.3 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.

An example of a response from the **aI!** command is:

130TT HACH CBS107

Where:

SDI-12 version =1.3

Manufacturer = OTT HACH

Sensor model = CBS

Sensor serial number = 107

D.1.4 Start Measurement Commands (**aM!**)

A measurement is initiated with **M!** commands. The response to each command has the form *attnn*, where

a = sensor address

ttt = time, in seconds, until measurement data are available

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

D.1.5 Aborting a Measurement Command

A measurement command (**M!**) is aborted when any other valid command is sent to the sensor.

D.1.6 Send Data Command (**aDv!**)

This command requests data from the sensor. It is normally issued automatically by the datalogger after measurement commands **aMv!**. In transparent mode, the user asserts this command to obtain data. If the expected number of data values are not returned in response to an **aD0!** command, the datalogger issues **aD1!**. TABLE D-2 shows the values returned when using the send data command.

TABLE D-2. Send Data Return Values		
SDI-12 Command	Number of Values Returned	Values Returned
D!	7	Level [m], Level [cm], Level [ft], Pressure [mbar], Pressure [psi], Temperature [°C], Status
D0!	1	Level [m]; resolution: 0.001 m
D1!	1	Level [cm]; resolution: 1 cm
D2!	1	Level [ft]; resolution: 0.01 ft
D3!	1	Pressure [mbar]; resolution: 0.01 mbar
D4!	1	Pressure [psi]; resolution: 0.001 psi
D5!	1	Temperature [°C]; resolution: 0.1 °C
D6!	1	Status

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

Transparent mode is entered while the PC is in telecommunications with the datalogger through a terminal emulator program. It is easily accessed through Campbell Scientific datalogger support software, but is also accessible with terminal emulator programs such as Windows HyperTerminal. 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*.

The following examples show how to use *LoggerNet* software to enter transparent mode and change the SDI-12 address of a CS470/CS471 sensor. The same steps are used to enter transparent mode with *PC200W* and *PC400* software after accessing the terminal emulator as previously described.

D.2.1 CR200(X) Series Datalogger Example

1. Connect a single CS470/CS471 to the CR200(X) (see TABLE 7-2)
2. In the *LoggerNet Connect* screen, navigate to the **Datalogger** menu and select **Terminal Emulator**. The terminal emulator window will open. In the **Select Device** menu, located in the lower left-hand side of the window, select the CR200Series station.
3. Click on the **Open Terminal** button.

4. Press the <enter> key until the datalogger responds with the *CR2XX*> prompt. At the *CR2XX*> prompt, make sure the **All Caps Mode** box is checked and enter the command **SDI12** <enter>. The response *SDI12*> indicates that the C470/CS471 is ready to accept SDI-12 commands.
5. To query the C470/CS471 for its current SDI-12 address, key in **?!** <enter> and the C470/CS471 will respond with its SDI-12 address. If no characters are typed within 60 seconds, then the mode is exited. In that case, simply enter the command **SDI12** again and press <enter>.
6. To change the SDI-12 address, key in **aAb!** <enter>, where *a* is the current address from the above step and *b* is the new address (see FIGURE D-1). The C470/CS471 will change its address and the datalogger will respond with the new address. To exit SDI-12 transparent mode, select the **Close Terminal** button.

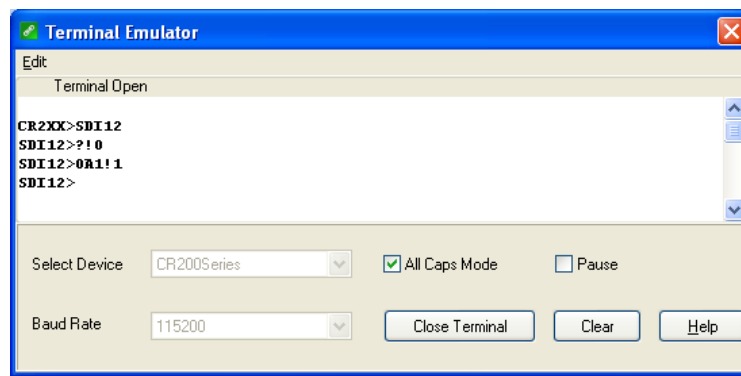


FIGURE D-1. CR200(X) example of using the SDI-12 transparent mode to change the SDI-12 address from 0 to 1.

D.2.2 CR1000 Datalogger Example

1. Connect a CS470/CS471 to the CR1000 (see TABLE 7-2).
2. In the *LoggerNet Connect* screen navigate to the **Datalogger** menu and select **Terminal Emulator**. The terminal emulator window will open. In the **Select Device** menu, located in the lower left-hand side of the window, select the CR1000 station.
3. Click on the **Open Terminal** button.
4. Press the <enter> key until the datalogger responds with the *CR1000*> prompt. At the *CR1000*> prompt, make sure the **All Caps Mode** box is checked and enter the command **SDI12** <enter>. At the *Enter Cx Port 1, 3, 5, or 7* prompt, key in the control port number where the CS470/CS471 is connected and press <enter>. The response *Entering SDI12 Terminal* indicates that the CS470/CS471 is ready to accept SDI-12 commands.
5. To query the CS470/CS471 for its current SDI-12 address, key in **?!** <enter> and the CS470/CS471 will respond with its SDI-12 address. If no characters are typed within 60 seconds, then the mode is exited.

In that case, simply enter the command SDI12 again, press <enter>, and key in the correct control port number when prompted.

- To change the SDI-12 address, key in **aAb!** <enter>, where *a* is the current address from the above step and *b* is the new address (see FIGURE D-2). The C470/CS471 will change its address and the datalogger will respond with the new address. To exit SDI-12 transparent mode, select the **Close Terminal** button.

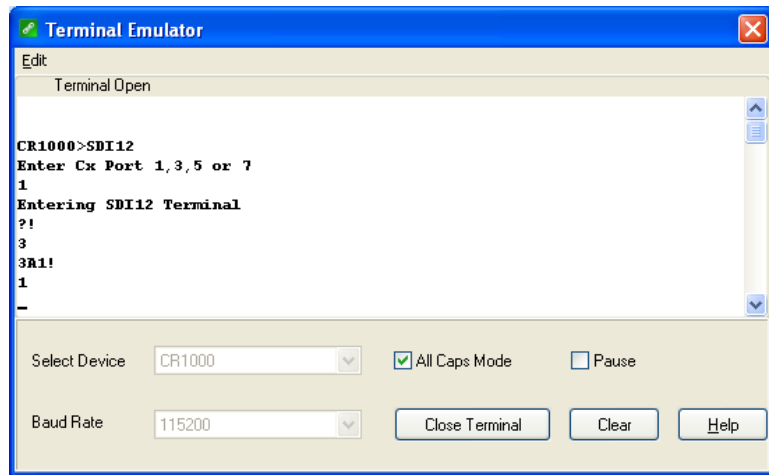


FIGURE D-2. CR1000 example of using the SDI-12 transparent mode to change the SDI-12 address from 3 to 1. Sensor is connected to control port 1.

D.2.3 CR10X Datalogger Example

- Connect a CS470/CS471 to the CR10(X) (see TABLE 7-2).
- Download a datalogger program that contains the SDI-12 Recorder (P105) instruction with valid entries for each parameter. Make sure that parameter 3 of the P105 instruction matches the control port number where the CS470/CS471 is connected.
- In the *LoggerNet Connect* screen navigate to the **Datalogger** menu and select **Terminal Emulator**. The terminal emulator window will open. In the **Select Device** menu, located in the lower left-hand side of the window, select the **CR10X station**.
- Click on the **Open Terminal** button.
- Press the <enter> key until the datalogger responds with the * prompt.
- To activate the SDI-12 Transparent Mode on control port *p*, enter **pX** <enter>. For this example, key in **1X** <enter>. The datalogger will respond with *entering SDI-12*. If any invalid SDI-12 command is issued, the datalogger will exit the SDI-12 Transparent Mode.

7. To query the CS470/CS471 for its current SDI-12 address, enter the command **?!**. The CS470/CS471 will respond with the current SDI-12 address.
8. To change the SDI-12 address, enter the command **aAb!**; where *a* is the current address from the above step and *b* is the new address. The CS470/CS471 will change its address and the datalogger will exit the SDI-12 Transparent Mode.
9. Activate the SDI-12 Transparent Mode on Control Port 1 again by entering **1X** <enter>. Verify the new SDI-12 address by entering the **?!** command. The CS470/CS471 will respond with the new address.
10. To exit the SDI-12 Transparent Mode, enter *****.

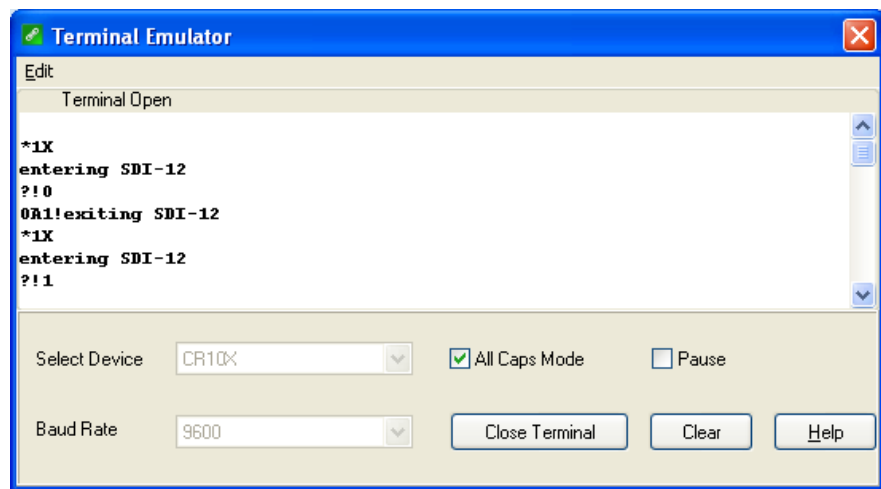


FIGURE D-3. CR10X example of using the SDI-12 transparent mode to change the SDI-12 address from 0 to 1. Sensor is connected to control port 1.

D.3 Advanced SDI-12 Commands

All advanced SDI-12 commands begin with O (the letter not zero).

Command	Response	Description
aOXP<value>!	aOXP<value><CR><LF>	Activate purge function. The parameter <value> represents the setting defined as follows: 0 = purge function deactivated 1 = purge function activated
aOXG<value>! or aOXG!	a<value><CR><LF>	Set/query value for local gravitational constant. Format: cb.aaaaaa c: Polarity (+ or -) bb: Number before the decimal point aaaaaa: Number after the decimal point (max. 6 digits) default setting: +9.80665
aOXT<value>! or aOXT!	a<value><CR><LF>	Set/query value for local water temperature. Format: cb.aaaaaa c: Polarity (+ or -) bb: Number before the decimal point aaaaaa: Number after the decimal point (max. 6 digits) default setting: +3.98

The CS470/CS471 either produces a value proportional to the pressure, or an actual water level compensated for the relative density of the water (using the default settings).

The correct water level measurement is calculated according to the following formula:

$$\text{Water level} = \text{mH}_2\text{O pressure at } 4^\circ\text{C} * \frac{1}{\text{Water density}} * \frac{9.80665}{\text{Local gravitational constant}}$$

Where: water density = $-6.017777e^{-6} t^2 + 0.0000408 t + 0.999841$ and

t = temperature in °C

The CS470/CS471 can calculate the water density at any time using the value for the local water temperature. You can enter the value for the local gravitational constant using the command **aOXG<value>!** and the value for the local temperature using the command **aOXT<value>!**.

Calculation of the correct value for the local gravitational constant

The gravitational acceleration at the earth's surface varies between 9.78036 m/s² at the equator and 9.83208 m/s² at the poles. Also, it decreases by

0.003086 m/s² for each kilometer above sea level. With the following formula the local gravitational constant g in m/s² can be calculated:

$$g = 9.780356 * (1 + 0.0052885 \sin^2 \alpha - 0.0000059 \sin^2 2 \alpha) - 0.003086 h$$

where α is the degrees of latitude and h the height above sea level in km. (Jursa, A.S., Ed., Handbook of Geophysics and the Space Environment, 4th ed., Air Force Geophysics Laboratory, 1985, pp. 14-17).

Example: At a height above mean sea level of 0.669 km and a latitude of 47.71°, a gravitational constant of 9.80659 m/s² results.

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