INSTRUCTION MANUAL

CS470/CS471 Compact Bubbler System

Revision: 4/09

Warranty and Assistance

The **CS470/CS471 COMPACT BUBBLER SYSTEM** is warranted by CAMPBELL SCIENTIFIC, INC. to be free from defects in materials and workmanship under normal use and service for twelve (12) months from date of shipment unless specified otherwise. Batteries have no warranty. CAMPBELL SCIENTIFIC, INC.'s obligation under this warranty is limited to repairing or replacing (at CAMPBELL SCIENTIFIC, INC.'s option) defective products. The customer shall assume all costs of removing, reinstalling, and shipping defective products to CAMPBELL SCIENTIFIC, INC. CAMPBELL SCIENTIFIC, INC. will return such products by surface carrier prepaid. This warranty shall not apply to any CAMPBELL SCIENTIFIC, INC. products which have been subjected to modification, misuse, neglect, accidents of nature, or shipping damage. This warranty is in lieu of all other warranties, expressed or implied, including warranties of merchantability or fitness for a particular purpose. CAMPBELL SCIENTIFIC, INC. is not liable for special, indirect, incidental, or consequential damages.

Products may not be returned without prior authorization. The following contact information is for US and International customers residing in countries served by Campbell Scientific, Inc. directly. Affiliate companies handle repairs for customers within their territories. Please visit www.campbellsci.com to determine which Campbell Scientific company serves your country. To obtain a Returned Materials Authorization (RMA), contact CAMPBELL SCIENTIFIC, INC., phone (435) 753-2342. After an applications engineer determines the nature of the problem, an RMA number will be issued. Please write this number clearly on the outside of the shipping container. CAMPBELL SCIENTIFIC's shipping address is:

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

CAMPBELL SCIENTIFIC, INC. does not accept collect calls.

CS470/CS471 Table of Contents

PDF viewers note: These page numbers refer to the printed version of this document. Use the Adobe Acrobat® bookmarks tab for links to specific sections.

1. Introduction 1
   - 1.1 Initial Inspection and Handling Guidelines 1

2. Specifications 2

3. Configuration 3
   - 3.1 Connection 3
     - 3.1.1 SDI-12 Transparent Mode 3
   - 3.2 Configurable Settings 4
     - 3.2.1 SDI-12 Addresses 4
   - 3.3 SDI-12 Commands 5

4. Installation 6
   - 4.1 Preparing the CS470 for Installation 6
   - 4.2 Fastening the CS470 6
   - 4.3 Connecting the Measuring Tube 7
     - 4.3.1 Installation to the CS470 7
     - 4.3.2 Installation to the Bubble Chamber 7
   - 4.4 Water Depth 9
   - 4.5 Purging Function 9

5. Wiring 10
   - 5.1 SDI-12 10
     - 5.1.1 Connect Power Supply 11
     - 5.1.2 Signal 11

6. Programming 11
   - 6.1 Using SCWIN 11
   - 6.2 Using CRBasic, Edlog, or the Keyboard/Display 11
     - 6.2.1 CRBasic Program 12
     - 6.2.2 Edlog Program 14

7. Maintenance 14

8. Troubleshooting 15
   - 8.1 Status LED 15

Appendices

A. 4 to 20 mA Operation A-1

A.1 Setting Operating Parameters using DIP Switches A-2

B. Advanced SDI-12 Commands................................ B-1

Figures

3-1. Terminal Emulator... 4
4-1. Securing the CS470 to a Hat Rail.. 7
4-2. Connection of the Bubble Tube... 8
4-3. Overview of the CS470 9
5-1. CS470 Screw Terminals 10
A-1. Diagram to determine the maximum load resistance as a function of the power supply. A-1

Tables

3-1. SDI-12 Commands 5
4-1. Dip Switch Settings for SDI-12 Communications.................................. 6
5-1. Datalogger Wiring.. 11
6-1. SDM-12 aM! Command Return Output 11
10-1. Status LED... 15
B-1. Advanced SDI-12 Commands B-1

CS470/CS471 Compact Bubbler System

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

1. Introduction

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. The CS470 and CS471 differ only in their measurement accuracy. Throughout the manual, CS470 will represent both systems unless specified otherwise.

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 determines the barometric air and bubble pressure one after the other. By taking the difference between the two signals, the CS470 calculates the height of the water level above the bubble chamber.

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

1.1 Initial Inspection and Handling Guidelines

Upon receipt of the CS470, 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.

The CS470 ships with:

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

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.

Remember that although the CS470 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. There are no user serviceable parts inside the sensor housing and any attempt to disassemble the device will void the warranty.

2. Specifications

Power Requirements:	10 to 30 Vdc
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 4-20 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 - 15 ft: ±0.01 ft 15 - 35 ft: ±0.065% of reading 35 - 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” I.D. x 3/8” O.D.
Dimensions:	6.5” x 8.1” x 4.5” (165 mm x 205 mm x 115 mm)
Weight:	3.3 lbs (1500 g)

3. Configuration

3.1 Connection

Communicating with the CS470 requires the sensor to be connected with a SDI-12 Recorder, which includes; CR510, CR10X, CR200 Series, CR800 Series, CR1000, and CR3000 dataloggers.

3.1.1 SDI-12 Transparent Mode

Transparent Mode allows direct communication with the CS470. This may require waiting for programmed datalogger commands to finish before sending responses. While in the transparent mode, datalogger programs may not execute. 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 most easily accessed through Campbell Scientific datalogger support software, but is also accessible with terminal emulator programs such as Windows HyperTerminal®.

To enter the SDI-12 transparent mode, enter Terminal Emulator from LoggerNet, PC400 or PC200W datalogger support software. When a terminal emulator screen is displayed, click the "Open Terminal" button. A green "Active" indicator will appear (see Figure 3-1).

For CR800 series, CR1000, CR3000 dataloggers, press <Enter> until the datalogger responds with the prompt ("CR1000>" for the CR1000). Type "SDI12" at the prompt (without quotes) and press <Enter>. In response, the query "Enter Cx Port 1,3,5 or 7" will appear. Enter the control port integer to which the CS470 is connected. An "Entering SDI12 Terminal" response indicates that SDI-12 Transparent Mode is active.

For CR10X and CR510 dataloggers, the datalogger telecommunications command to enter SDI-12 transparent mode is "nX<Enter>", where n is the control port being used for SDI-12. For example, when the selected control port is C1, the command should be "1X<Enter>". In response, the datalogger opens the link to control port 1 and responds with a prompt. CR10X and CR510 dataloggers reply with "entering SDI-12".

Now check for response from the sensor with address zero by typing the SDI-12 Identify command "0I!<Enter>" (that's a zero, not the letter O). The sensor should respond with an identification string similar to "13OTT HACH CBS107".

NOTE The SDI-12 standard allows for multiple probes to be connected to one datalogger control port. If you have another SDI-12 probe on the C1 that has address 7, you could issue the identify command "7I!<Enter>".

Only one sensor of the same address can be connected when using the change address command.

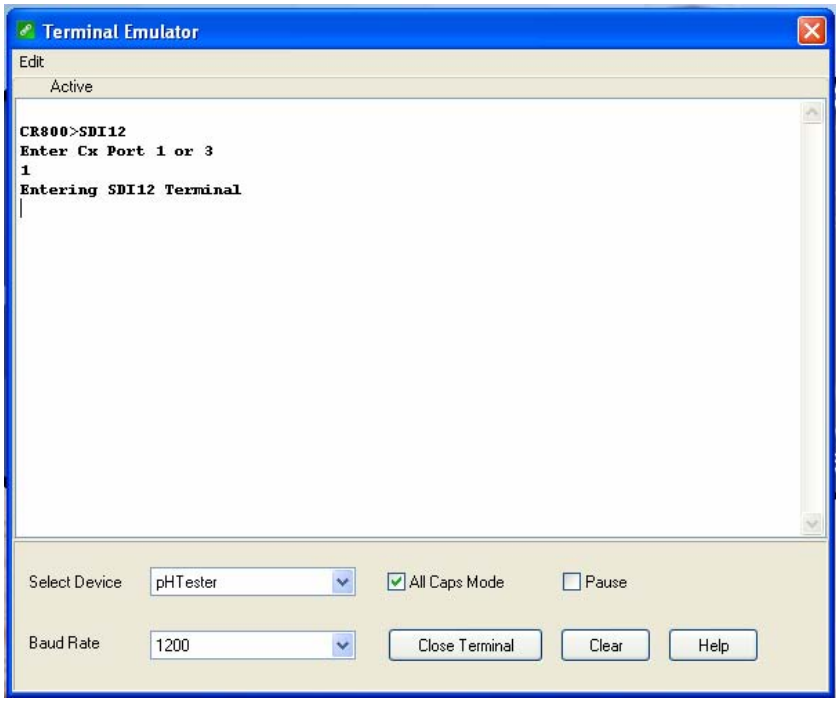

FIGURE 3-1. Terminal Emulator

3.2 Configurable Settings

3.2.1 SDI-12 Addresses

The CS470 can be set to one of ten addresses (0 to 9) which allows up to ten sensors to be connected to a single digital I/O channel (control port) of the SDI-12 recorder; most Campbell Scientific dataloggers support SDI-12.

The CS470 is shipped from the factory with the address set to 0. The address on the CS470 can be changed by sending an SDI-12 change address command 'aAb!', where a is the current SDI-12 address and b is the desired SDI-12 address. The change address command can be issued from most SDI-12 recorders.

To change the address of a sensor that has a default address of 0 to the address of 1 the following command can be sent:

"0A1!"

When it is necessary to measure more than one CS470, it is easiest to use a different control port for each CS470 instead of changing the address. If additional control ports are not available, then the address will need to be changed.

3.3 SDI-12 Commands

The CS470 uses an SDI-12 compatible hardware interface and supports a subset of the SDI-12 commands. The most commonly used command is the aM! command, issued by the datalogger. Here, ‘a’ represents the sensor address (0-9). The communication sequence begins with the datalogger waking the sensor and issuing the aM! command. The transducer responds to the logger indicating that one measurement will be ready within sixty (60) seconds. Subsequent communications handle data reporting from the sensor to the datalogger.

The SDI-12 protocol has the ability to support various measurement commands. The standard SDI-12 commands that are listed in Table 3-1. Advanced SDI-12 Commands are listed in Appendix B.

TABLE 3-1. SDI-12 Commands

SDI-12 Command	Command Function	Values Returned
a!	Acknowledge active	Address?
aI!	Send Identification	13OTT HACH CBS107
aAb!	Change Address	New address
?!	Address Query	Address
aM!	Start measurement	atttn were a = address, ttt = time in seconds until the sensor is ready, n = number of measured values.
aD0!	Send data	a<wert
aV!	Start verification	atttn

For more information on the SDI-12 standard commands, refer to; *A Serial-Digital Interface Standard for Microprocessor-Based Sensors; Version 1.3* (see Internet page www.sdi-12.org).

As the measurement data is transferred between the probe and datalogger digitally, there are no offset errors incurred with increasing cable length as seen with analog sensors. However, with increasing cable length there is still a point when the digital communications will break down, resulting in either no response or excessive SDI-12 retries and incorrect data due to noise problems. Using SDI-12 commands like aMC!, which adds a CRC check, can significantly improve incorrect data issues.

4. Installation

The CS470 is designed for water level measurements. Typical applications include agricultural water level/flow, water wells, lakes, streams and tanks.

CAUTION Never open the housing of the CS470! There are no adjustments or control elements inside the housing!

4.1 Preparing the CS470 for Installation

If necessary and you have not already done so, set operating parameters with the DIP switches. The switches are set for SDI-12 communication. If this mode of communication is desired, no further changes need to be made. For further instruction for changes required for 4-20 mA communications, see Appendix A.

TABLE 4-1. Dip Switch Settings for SDI-12 Communications

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

4.2 Fastening the CS470

The CS470 is designed only to be installed on top hat rails (included with shipped material). Choose a dry and dust free location for the installation. Campbell Scientific enclosures provide this desired environment. With the supplied grommets and screws, connect the top hat rails horizontally to the back panel of a Campbell Scientific enclosure (see Figure 4-1).

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

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

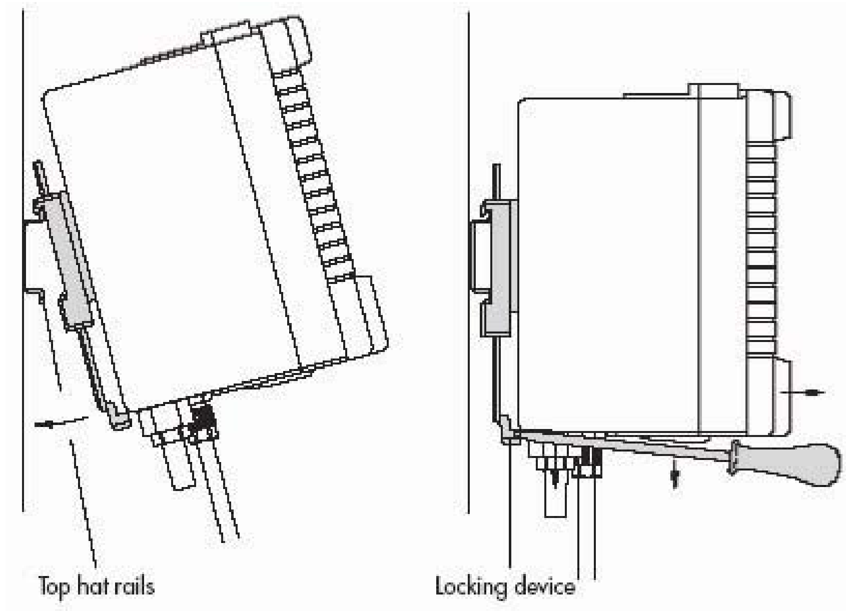

FIGURE 4-1. Securing the CS470 to a Hat Rail

4.3 Connecting the Measuring Tube

4.3.1 Installation to the CS470

- Cut the bubble tube at a 90° angle with a sharp blade (see Figure 4-2). *Do not use scissors*.
- Insert the bubble tube as far as possible into the tube fitting. Rotate the nut until finger-tight. Tighten the nut with a wrench about one and one-quarter turns.

4.3.2 Installation to the Bubble Chamber

- Install a conduit (metal or plastic) from the CS470 to the location where the bubble chamber will be installed. The conduit should be fixed in place and terminate with a 2-inch NPT female threaded connection at the bubble chamber location.
- Lead the bubble tube through the conduit.
- Cut the bubble tube at a 90° angle with a sharp blade (see Figure 4-2). Do not use scissors.
- Detach the NPT adapter from the bubble chamber by unscrewing the three hexagonal screws of the bubble chamber's flange.
- Install the NPT adapter on the end of the conduit.

- Insert the bubble tube as far as possible into the tube fitting. Rotate the nut until finger-tight. While holding the bubble chamber steady, tighten the nut with a wrench about one and one-quarter turns.

- To disconnect the tube, untighten the nut and pull out the tube. Trim the tube before connecting it again and to ensure it has a uniform surface.

- Install the bubble chamber on the NPT adapter.

Ensure the following points are noted during installation:

- No contamination or moisture may be allowed into the measuring tube.

- When immersing the bubble chamber, the CS470 must be activated, so that the piston pump is operating during this procedure.

- Do not damage or kink the measuring tube during installation.

- Lay the measuring tube such that there is a continuous drop from the CS470 towards the bubble chamber. Otherwise moisture could collect in a hallow and potentially block the tube with the formation of drops.

NOTE For optimal measurement results the bubble chamber must be adjusted to be horizontal and aligned in the direction of flow (max. tolerance +/- 5°). The EPS 50 has a ball-and-socket joint which allows for adjustments by 15° in any direction.

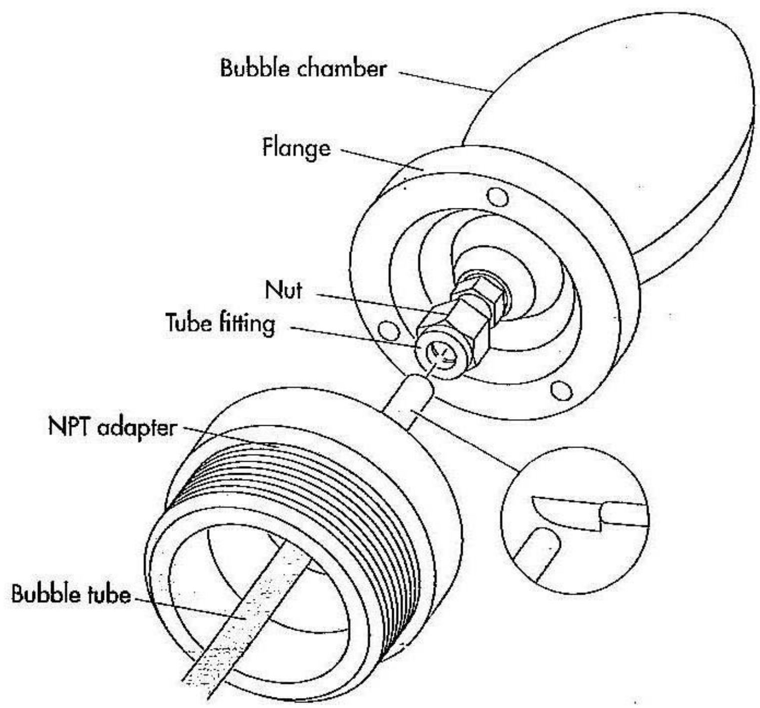

FIGURE 4-2. Connection of the Bubble Tube

4.4 Water Depth

For water level measurements, the bubble chamber must be installed below the water at a fixed depth. The water depth range is determined by the maximum tube length, which is 50 feet.

4.5 Purging Function

On the front of the CS470 there is a Pump membrane button (see Figure 4-3). 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 CS470 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.

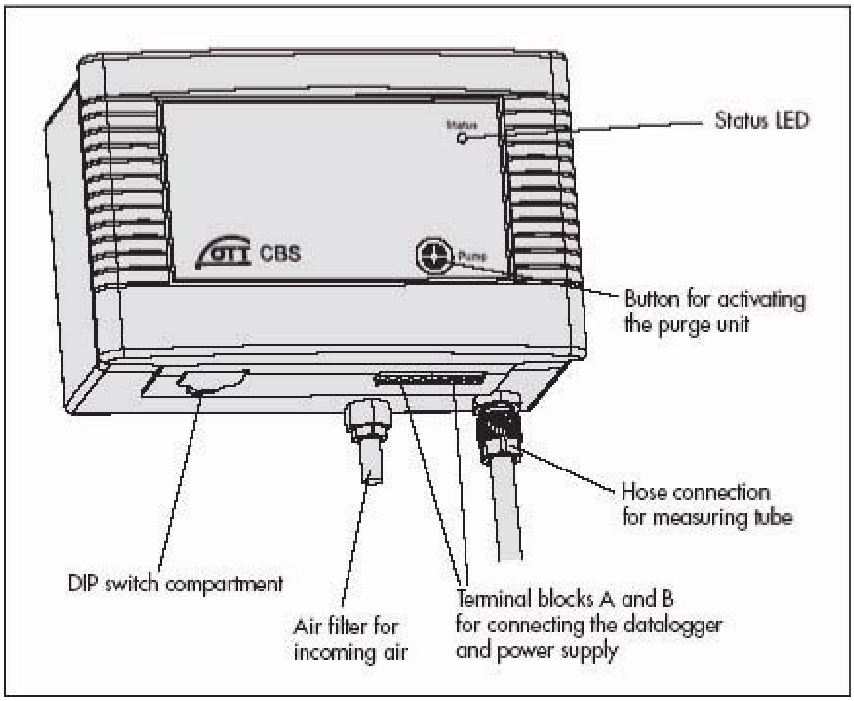

FIGURE 4-3. Overview of the CS470

5. Wiring

5.1 SDI-12

It is recommended to power down your system before wiring the CS470. The shield wire plays an important role in noise emissions and susceptibility as well as transient protection.

All electrical connections are made using two screw terminal strips (supplied) at terminal blocks A and B on the underside of the CS470 (see Figure 5-1).

Although the CS470 has three interfaces available, only the connection for SDI-12 communication will be addressed here (for information about 4-20 mA communication see Appendix A).

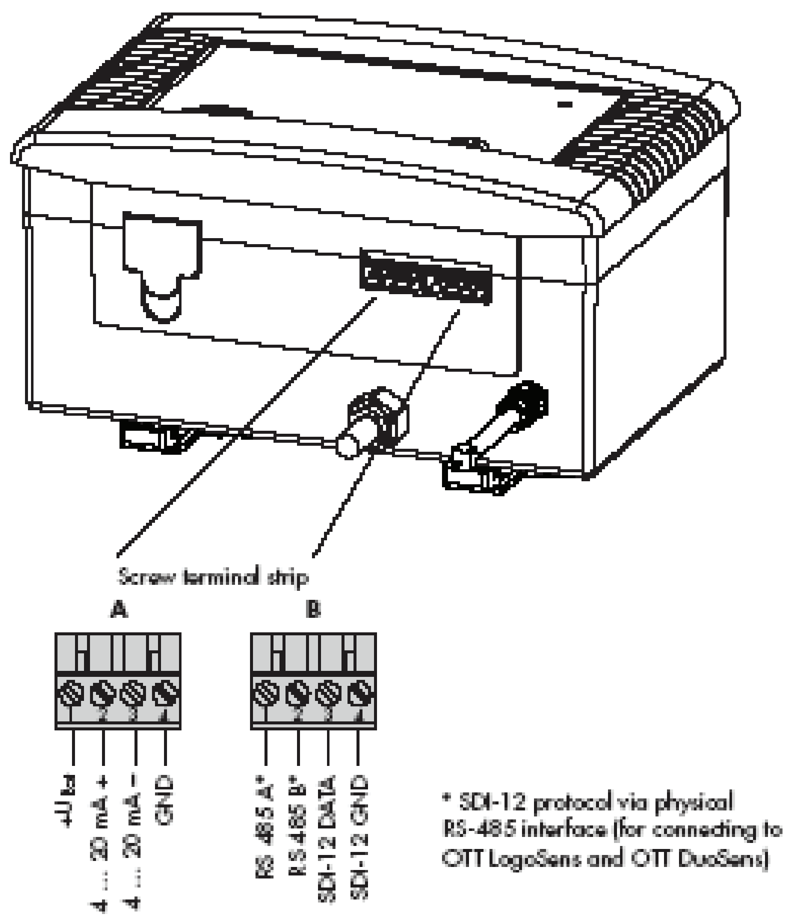

FIGURE 5-1. CS470 Screw Terminals

5.1.1 Connect Power Supply

The CS470 requires a power supply of 10 to 30 Vdc. This power supply is commonly provided by the datalogger's 12 V supply.

5.1.2 Signal

SDI-12 communication only requires a four wire connection. Use PN CABLE4CBL-L.

TABLE 5-1. Datalogger Wiring

CS470 Terminal Connector	**CR10(X), CR800,CR1000**	**CR200**
Terminal A +User	12V	Battery+
Terminal A GND	G	G
Terminal B SDI-12 DATA	Control Port	C1/SDI-12
Terminal B SDI-12 GND	G	G

6. Programming

6.1 Using SCWIN

SCWIN is the easiest and typically the preferred method for programming the datalogger. SCWIN generates a wiring diagram that shows how to connect the CS470 to your Campbell Scientific datalogger.

NOTE The sections that immediately follow are for CRBasic, Edlog and Keyboard/Display users. SCWIN users can jump ahead to the Maintenance section.

6.2 Using CRBasic, Edlog, or the Keyboard/Display

The SDI-12 aM! command results in the return of 7 outputs:

TABLE 6-1. SDM-12 aM! Command Return Outputs

D0	Level [m]; resolution: 0.001 m
D1	Level [cm]; resolution: 1 cm
D2	Level [ft]; resolution: 0.01 ft
D3	Pressure [mbar]; resolution: 0.01 mbar
D4	Pressure [psi]; resolution: 0.001 psi
D5	Temperature [°C]; resolution: 0.1 °C
D6	Status

6.2.1 CRBasic Program

In the CR200 Series dataloggers, Instruction SDI12Recorder is used to read SDI-12 Sensors. A multiplier of 1.0 and an offset of 0.0 should be used.

The SDI12Recorder instruction has the following form:

SDI12Recorder(Destination, Output String, Multiplier, Offset)

Sample Program for CR200 Series Datalogger

```
'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
```

In the CR1000/CR800/CR850 Series dataloggers, Instruction SDI12Recorder is used to read SDI-12 Sensors. A multiplier of 1.0 and an offset of 0.0 should be used.

The SDI12Recorder instruction has the following form:

SDI12Recorder(Dest, SDIPort, SDIAddress, “SDICommand”, Multiplier, Offset)

Sample Program for CR100 Series Datalogger

```
‘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
```

6.2.2 Edlog Program

The following is an example of the P105 SDI-12 Sensor instruction used by mixed-array dataloggers to interrogate an SDI-12 sensor.

Use Instruction 105 to read the CS470. Your datalogger manual has a detailed explanation of Instruction 105.

```
;{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 logger called “Level-m” holds the measured value for Level, reported in meters. The result may be further processed with the logger 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.

7. Maintenance

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

The CS470 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, PDA, 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 2 years thereafter.

8. Troubleshooting

8.1 *Status* LED

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

The following error states can arise:

TABLE 10-1. Status LED

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 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 manufacturer Repaircenter. The *watchdog error* error state means that the CS470 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 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 logger. Check the logger program to ensure that the same port the SDI-12 data line is connected to is specified in the measurement instruction.

Appendix A. 4 to 20 mA Operation

The load resistance connected to the CS470 must not exceed a specific maximum value. This value depends on the level of the supply voltage of the CS470. 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 A-1.

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

The CS470 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.

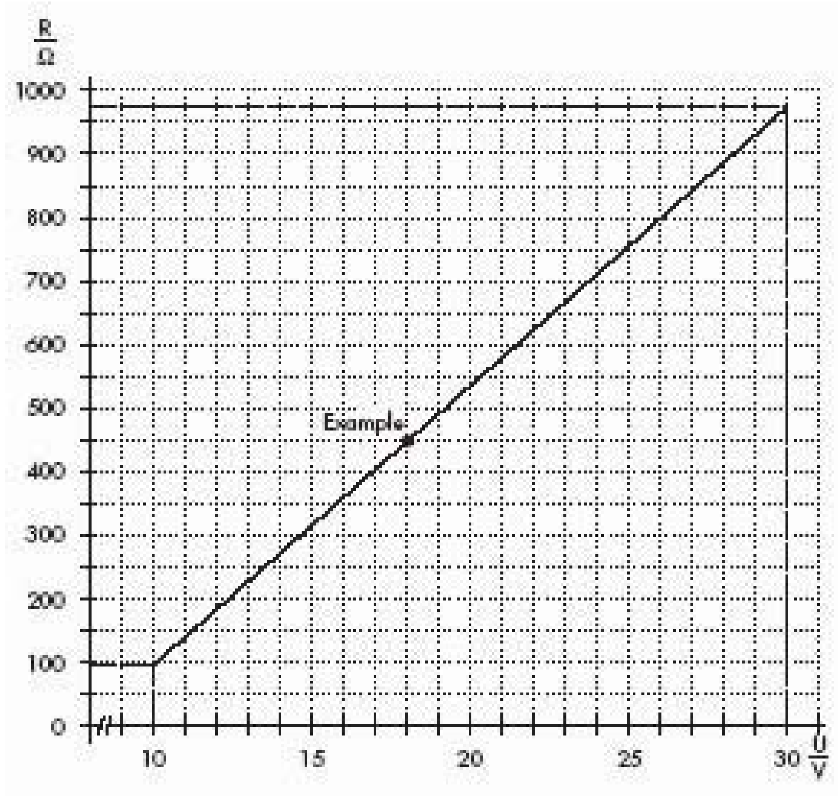

FIGURE A-1. Diagram to determine the maximum load resistance as a function of the power supply.

A.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 B. Advanced SDI-12 Commands

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

TABLE B-1. Advanced SDI-12 Commands

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 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:

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

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

t = temperature in °C

The CS470 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/s^2 at the equator and 9.83208 m/s^2 at the poles. Also, it decreases by 0.003086 m/s^2 for each kilometer above sea level. With the following formula the local gravitational constant g in m/s^2 can be calculated:

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

where $\propto$ is the degrees of latitude and h the height above seal 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 seal level of 0.669 km and a latitude of 47.71°, a gravitational constant of 9.80659 m/s^2 results.

Campbell Scientific Companies

Campbell Scientific, Inc. (CSI)
815 West 1800 North
Logan, Utah 84321
UNITED STATES
www.campbellsci.com • info@campbellsci.com

Campbell Scientific Africa Pty. Ltd. (CSAf)
PO Box 2450
Somerset West 7129
SOUTH AFRICA
www.csafrica.co.za • cleroux@csafrica.co.za

Campbell Scientific Australia Pty. Ltd. (CSA)
PO Box 444
Thuringowa Central
QLD 4812 AUSTRALIA
www.campbellsci.com.au • info@campbellsci.com.au

Campbell Scientific do Brazil Ltda. (CSB)
Rua Luisa Crapsi Orsi, 15 Butantã
CEP: 005543-000 São Paulo SP BRAZIL
www.campbellsci.com.br • suporte@campbellsci.com.br

Campbell Scientific Canada Corp. (CSC)
11564 - 149th Street NW
Edmonton, Alberta T5M 1W7
CANADA
www.campbellsci.ca • dataloggers@campbellsci.ca

Campbell Scientific Centro Caribe S.A. (CSCC)
300 N Cementerio, Edificio Breller
Santo Domingo, Heredia 40305
COSTA RICA
www.campbellsci.cc • info@campbellsci.cc

Campbell Scientific Ltd. (CSL)
Campbell Park
80 Hathern Road
Shepshed, Loughborough LE12 9GX
UNITED KINGDOM
www.campbellsci.co.uk • sales@campbellsci.co.uk

Campbell Scientific Ltd. (France)
Miniparc du Verger - Bat. H
1, rue de Terre Neuve - Les Ulis
91967 COURTABOEUF CEDEX
FRANCE
www.campbellsci.fr • info@campbellsci.fr

Campbell Scientific Spain, S. L.
Psg. Font 14, local 8
08013 Barcelona
SPAIN
www.campbellsci.es • info@campbellsci.es

Please visit www.campbellsci.com to obtain contact information for your local US or International representative.