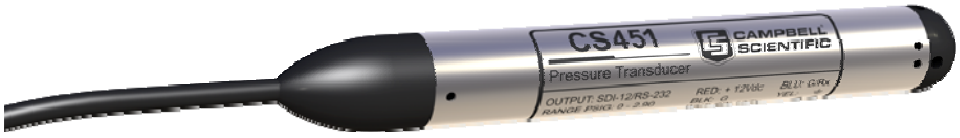
INSTRUCTION MANUAL

CS451/CS456 Submersible Pressure Transducer

Revision: 1/13



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Assistance

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.

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

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Table of Contents

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

Figures

Tables

CS451/CS456 Submersible Pressure Transducer

1. Introduction

The CS451/CS456 Submersible Pressure Transducer provides pressure and temperature measurements. It uses the SDI-12 or RS-232 communications protocols to communicate with an SDI-12 or RS-232 recorder simplifying installation and programming. The -L in the transducer's model name indicates user-specified cable length.

Before using the CS451/CS456 please study

- Section 2, *Cautionary Statements*
- Section 3, *Initial Inspection*
- Section 4, *Quickstart*

2. Cautionary Statements

- Sensor will be damaged if it is encased in frozen liquid.
- Although the CS451/CS456 is rugged, it is also a highly precise scientific instrument and should be handled as such. There are no user-serviceable parts and any attempt to disassemble the device will void the warranty.
- Care should be taken when opening the package not to damage or cut the cable jacket.
- Dropping the instrument or allowing it to "free fall" down a well may damage the transducer.
- Never suspend the CS451/CS456 from the connections at the top end of the cable. Sharp bends or excessive pinching of the cable can cause damage and may pinch off the vent tube causing measurement errors.
- Confirm the compatibility of the sensor and cable to non-water environments before installation.
- The CS456 should be used in harsh water applications, including salt water.

3. Initial Inspection

- Upon receipt of the CS451/CS456, 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 model number and pressure range is etched on the housing and the cable length is printed on the label near the connection end of the cable. Check this information against the shipping documentation to ensure that the expected product was received.

- The transducer comes with a desiccant tube attached to the cable.

4. Quickstart

This quickstart guide assumes:

- Default settings used (SDI-12 address 0, pressure reported in psig, temperature reported in C)
- ShortCut Program Generator for Windows (SCWin) used to program datalogger, calculate offset, and generate wiring diagram

For complete configuration, installation, wiring, and programming information, see Section 7, *Operation*.

4.1 Step 1 — Desiccant Check

CAUTION The desiccant tube is shipped with a black cap to cover the vent hole. This cap MUST be removed prior to installation.

Ensure the desiccant is blue; replace if not.

The desiccant tube must always be attached to the CS451/CS456.

4.2 Step 2 — Choose Appropriate Depth

The CS451/CS456 must be installed below the water at a fixed depth. This depth should be chosen so the water pressure will never exceed the transducer's pressure range (twice its pressure range).

CAUTION The output reading will not be correct, and the transducer can be damaged if pressure is excessive (2 x full scale).

Pressure can be converted to feet of fresh water using the following simple equation:

1 psi = 2.31 feet of water

For example, the maximum depth with a pressure range of 0 to 7.25 psig is 16.748 feet of water.

4.3 Step 3 — Dislodge Bubbles

While submersing the transducer, air bubbles may become trapped between the pressure plate and the water surface, causing small offset errors until the bubbles dissolve. Dislodge these bubbles by gently shaking the CS451/CS456 while under water.

CAUTION If bubbles are not removed by rotation and shaking underwater (or bleeding out the air in a closed system), the CS451/CS456 reading will drift lower by the distance of the gap as the bubbles are slowly dissolved into the water over time.

CAUTION Hitting against the well casing or other solid surface could damage the transducer.

4.4 Step 4 — Install Transducer

Lower the transducer to an appropriate depth.

CAUTION Do not drop the instrument or allow it to "free fall" down a well as this may damage the sensor.

With long drops it may be necessary to use the weighted nose cone (option -WN).

The transducer body can be strapped with tie wraps or tape. Campbell Scientific offers cable ties (pn 7421) that can be used to secure and strain relief the cable. If installing in a well, fasten the cable to the well head. Wrap the cable ties around the cable jacket.

CAUTION Never suspend the CS451/CS456 from the connections at the top of the cable. Sharp bends or excessive pinching of the cable can cause damage and may pinch off the vent tube causing measurement errors.

Several readings should be taken to ensure proper operations after installation.

4.5 Step 5 — Measure Initial Water Elevation

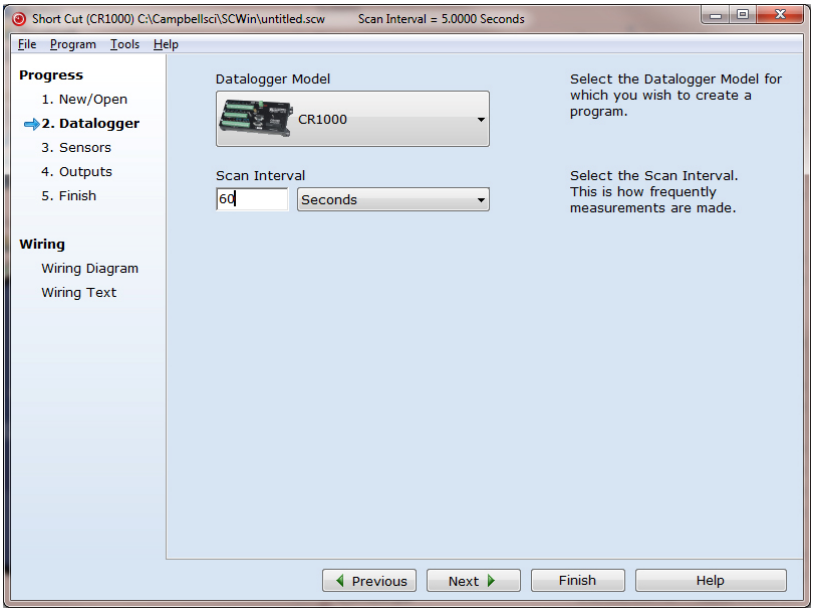
Use a staff gauge (or other device) to measure the initial elevation of water. This value is used to calculate an offset that corrects the final measurement for errors due to zero offset or installation. SCWin will make the offset calculation. Refer to Section 7.2.2, *Offset Calculation*, if not using SCWin to calculate the offset.

4.6 Step 6 — Use SCWin to Program Datalogger and Generate Wiring Diagram

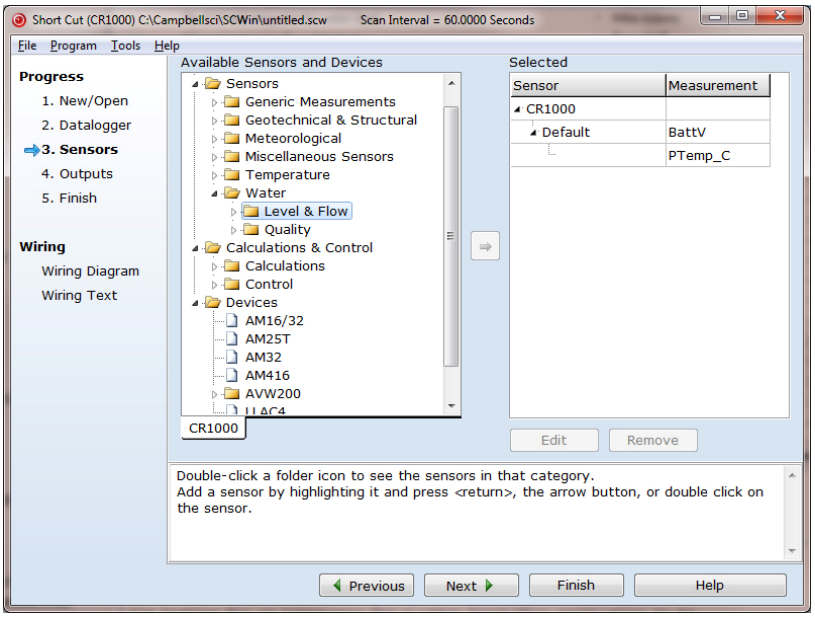
The simplest method for programming the datalogger to measure a CS451/CS456 is to use SCWin.

1. Open Short Cut and click on **New Program** then select **Next**.

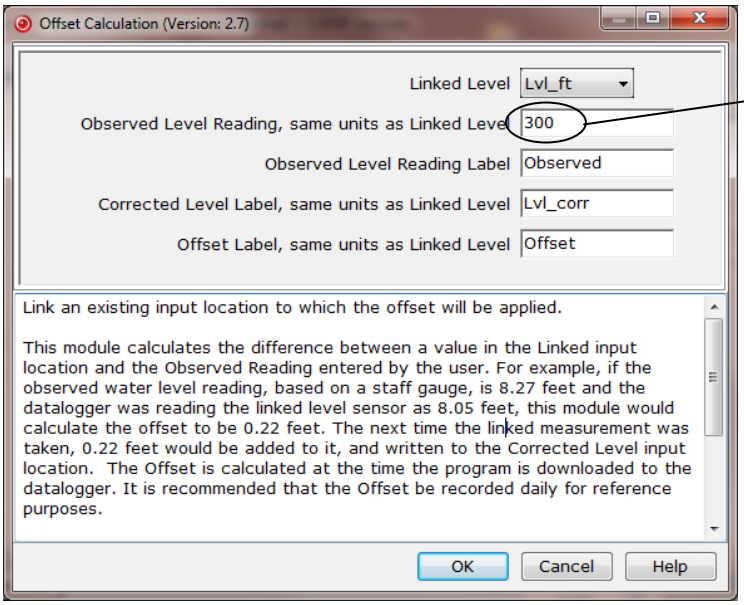
2. Select a datalogger and scan interval then select **Next**.



3. Select **CS451/CS456 Pressure Sensor**, click the **right arrow** to add it to the list of sensors to be measured, then select **Next**.



4. Select **Offset Calculation** then select **lvl_ft** for the **Linked Level** and enter the initial water level in the **Observed Level Reading** box.



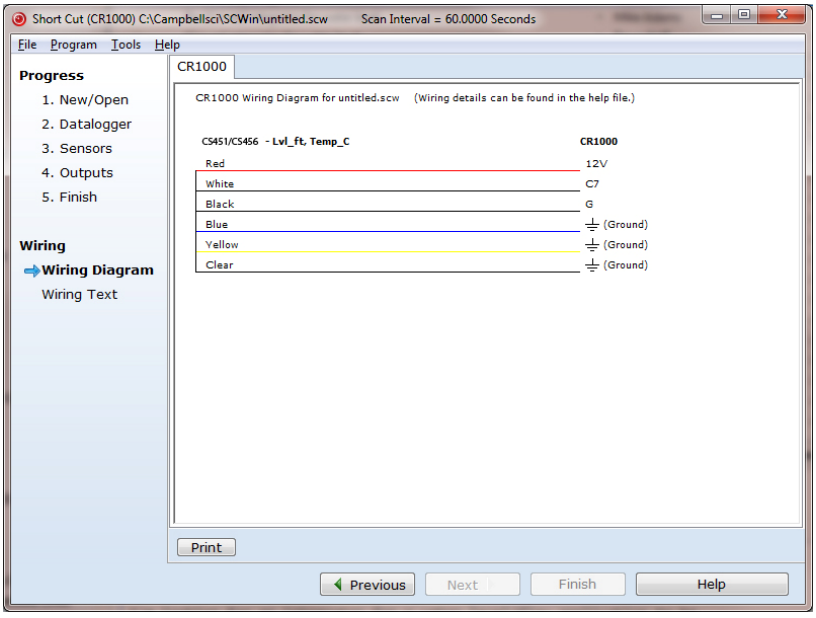
Enter initial water elevation here

5. Choose the outputs and then select **Finish**.

6. In the Save As window, enter an appropriate file name and select **Save**.

7. In the Confirm window, click **Yes** to download the program to the datalogger.

8. Click on **Wiring Diagram** and wire according to the wiring diagram generated by SCWin Short Cut.



NOTE Refer to Section 7, *Operation*, for wiring, offset calculation, and programming information if not using SCWin Short Cut.

5. Overview

The CS451/CS456 Submersible Pressure Transducer is designed to provide a reliable, accurate pressure/level measurement that is fully temperature compensated.

The 24 bit A/D has simultaneous 50/60 Hz rejection and automatic calibration for each measurement. A number of additional advanced measurement techniques are employed to harness the best possible performance available from today's state-of-the-art pressure transducer technology. The transducer reverts to a low power sleep state between measurements. A series of measurements are performed yielding a temperature and pressure value. This measurement cycle takes less than 1.5 second. The transducer can also be configured to output pressure only in less than 1 second. The measurement cycle is activated by commands via SDI-12 or RS-232 terminal commands.

The design uses a piezoresistive sensor housed in a 316L stainless-steel (CS451) or titanium (CS456) package to enhance reliability. The rugged construction makes the CS451/CS456 suitable for water level measurement in irrigation applications, water wells, lakes, streams and tanks. The titanium package of the CS456 makes it ideal for salt water or other harsh environments. The cable incorporates a vent tube to compensate for atmospheric pressure fluctuations and the jacket is made of rugged Hytrel®, designed to remain flexible and tough, even under harsh environmental conditions.

The CS451/CS456 has two communication options: SDI-12 or RS-232. The CS451/CS456 is shipped from the factory with both communications options enabled; there is no configuration required. As an SDI-12 sensor, the CS451/CS456 is shipped with an address of 0.

Two values are output by the CS451/CS456—pressure/level and temperature. The CS451/CS456 is shipped from the factory to output pressure in psig and temperature in degrees Celsius.

The CS451/CS456 has three nose cone options. FIGURE 5-1 shows the nose cone options. The weighted nose cone makes the transducer easier to submerge to depth. The NPT nose cone allows the transducer to be used in closed-pipe applications. The nose cones can be switched out later.

FIGURE 5-1. CS451 nose cone options

6. Specifications

Features:

- Output acceptable for recording devices with SDI-12 or RS-232 capability including Campbell Scientific dataloggers
- Quality construction that ensures product reliability
- Rugged stainless steel or titanium case that protects piezoresistive sensor
- Fully temperature compensated
- Low power sleep state between measurements that reduces power consumption
- Weighted nose cone offered that adds 0.2 kg (7.4 oz) to the transducer's weight. Additional weight makes submersion of the transducer easier

Compatible Dataloggers: CR200(X) series
CR800
CR850
CR1000
CR3000
CR5000
CR500
CR510
CR10(X)
CR23X

Power Requirements: 5 to 18 Vdc

Power Consumption: Quiescent current < 50 µA
Measurement/Communication Current: 8 mA for 1-s measurement
Maximum Peak Current: 40 mA

Measurement Time: Less than 1.5 s

Outputs: SDI-12 (version 1.3) 1200 bps
RS-232 9600 bps

Measurement Ranges:

Pressure (psig)	Pressure (kPa)	Depth of fresh water
0 to 2.9	0 to 20	0 to 2 m (6.7 ft)
0 to 7.25	0 to 50	0 to 5.1 m (16.7 ft)
0 to 14.5	0 to 100	0 to 10.2 m (33.4 ft)
0 to 29	0 to 200	0 to 20.4 m (67 ft)
0 to 72.5	0 to 500	0 to 50.9 m (167 ft)
0 to 145	0 to 1000	0 to 102 m (334.5 ft)

Accuracy: ±0.1% full scale range TEB* or
±0.05% full scale range TEB**

Resolution: 0.0035% full scale range

Overpressure: 2x pressure range

Dry Storage Temperature: −10° to 80°C

CAUTION Sensor will be damaged if it is encased in frozen liquid.

Operating Temperature: 0° to 60°C

Temperature Accuracy: ±0.2°C

Maximum Cable Length:
- **SDI-12 (one transducer connected to a single port):** ~475 m (1500 ft)
- **SDI-12 (10 transducers connected to a single port):** 60 m (200 ft)
- **RS-232:** 60 m (200 ft)

Cable Type: 5 Conductor, 26 AWG
Hytrel Jacket

Body Material: CS451 – 316L Stainless Steel
CS456 – Titanium

Element Material: CS451 – 316L Stainless Steel
CS456 – Hastelloy

Top Cone Material: Delrin

Dimensions: Length 213.36 mm (6.875 in)
Diameter 21.34 mm (0.84 in)

Distance from pressure sensor interface (black line etched on housing) to:
- **End of NPT fitting:** 2.54 cm (1 in)
- **End of standard nose cone:** 2.3 cm (0.9 in)
- **End of weighted nose cone:** 9.9 cm (3.9 in)

Air Gap
- **Standard and weighted nose cone:** 0.653 cm (0.257 in)
- **NPT fitting:** 2.72 cm (1.07 in)

Weight: CS451: 0.17 kg (0.37 lb)
CS456: 0.10 kg (0.23 lb)
Cable: 0.421 kg/m (0.283 lb/ft)

25431 Split Mesh Grip
- **Accepts cable diameter:** 4.57 to 6.35 mm (0.18 to 0.25 in)
- **Breaking Strength:** ~300 lb

* Total Error Band (TEB) includes the combined errors due to nonlinearity, hysteresis, nonrepeatability, and thermal effects over the compensated temperature range, per ISA S51.1.

** 0.05% full scale range accuracy not available in the 0 to 2.9 psig range.

7. Operation

7.1 Configuration

The CS451/CS456 is configured at the factory with default settings:

TABLE 7-1. Factory Settings	
SDI-12 Address	0
RS-232 Baud Rate	9600
Pressure/Level Units	PSIG
Temperature Units	Celsius

Communicating with the CS451/CS456 requires the sensor to be either connected to a PC or to an SDI-12 recorder. The sensor typically connects to a PC via the A200 sensor to PC interface. Many SDI-12 recorders allow communication to the sensor via a terminal screen. Configurable settings can be changed via SDI-12 commands or by using Campbell Scientific's software Device Configuration Utility.

7.1.1 PC Connection Using the A200

The A200 or another device is required to connect the CS451/CS456 to a PC. This allows sensor settings to be changed via our Device Configuration Utility.

7.1.1.1 Driver Installation

If the A200 has not been previously plugged into your PC and your PC operating system is not Windows 7, the A200 driver needs to be loaded onto your PC.

NOTE Drivers should be loaded before plugging the A200 into the PC.

The A200 drivers can be downloaded, at no charge, from: *www.campbellsci.com/downloads*.

7.1.1.2 Wiring

One end of the A200 has a terminal block while the other end has a type B female USB port. The terminal block provides 12V, G, TX, and RX terminals for connecting the sensor (see FIGURE 7-1 and TABLE 7-2).

A data cable (pn 17648) ships with the A200. This cable has a USB type-A male connector that attaches to a PC's USB port, and a type B male connector that attaches to the A200's USB port.

7.1.1.3 Powering the Sensor

The A200 provides power to the sensor when it is connected to a PC's USB port. An internal DC/DC converter boosts the 5 Vdc supply from the USB connection to a 12 Vdc output is required to power the sensor.

7.1.1.4 Determining which COM Port the A200 has been Assigned

When the A200 driver is loaded, the A200 is assigned a COM port number. This COM port number is needed when using the Device Configuration Utility or a PC terminal software such as HyperTerminal.

Often, the assigned COM port will be the next port number that is free. However, if other devices have been installed in the past (some of which may no longer be plugged in), the A200 may be assigned a higher COM port number.

To check which COM port has been assigned to the A200, watch for the appearance of a new COM port in the list of COM ports offered in the software package (e.g., LoggerNet) before and after the installation, or look in the Windows Device Manager list under the ports section (access via the control panel).

FIGURE 7-1. A200 Sensor-to-PC Interface

TABLE 7-2. A200 Wiring

Color	Sensor Cable Label	A200 Terminal
Red	12V	+12Vdc
Black	G	G
White	C	Tx
Blue	G	Rx
Yellow	G	G
Clear	Signal Ground	G

7.1.2 Device Configuration Utility (version 2.03 or higher)

The Device Configuration Utility allows you to change the settings of the CS451/CS456. Device Configuration Utility is shipped on the Campbell Scientific ResourceDVD included with the CS451/CS456.

To use Device Configuration Utility, the transducer needs to be connected to the PC via the A200 (see Section 7.1.1, *PC Connection Using the A200*). After installing Device Configuration Utility and connecting the transducer to the PC, select CS451 from the Device Type list on the left column of the screen.

In the PC Serial Port box, select the COM port that was assigned to the A200 (see Section 7.1.1.4, *Determining which COM Port the A200 has been Assigned*). Click on the **Connect** button to enable communication with the sensor. Once successfully connected, the screen should look like FIGURE 7-2.

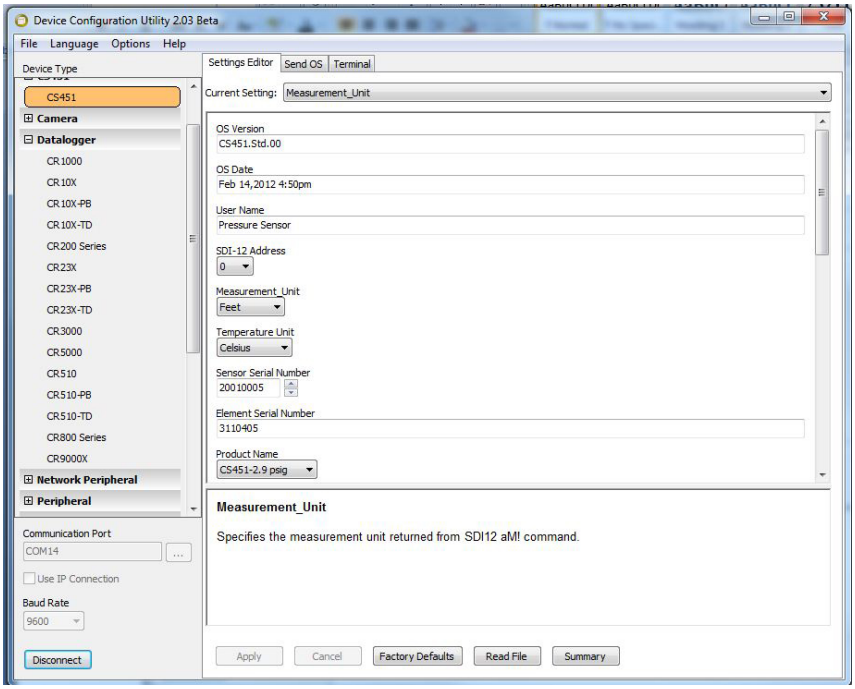


FIGURE 7-2. Connect screen

There are three settings that can be changed: SDI-12 address, Pressure/Level Units and Temperature Units. Double-click on the window of the units to be changed. This will open a pick menu box. Select the desired units and **Apply** the changes.

7.1.3 SDI-12 Transparent Mode

Transparent Mode allows direct communication with the CS451/CS456. 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 program.

To enter the SDI-12 transparent mode, enter Terminal Emulator from LoggerNet, PC400 or PC200W datalogger support software. A terminal emulator screen is displayed. Click the **Open Terminal** button.

For CR800-series, CR1000, CR3000 dataloggers, press <Enter> until the datalogger responds with the prompt ("CR800>" for the CR800). Type *SDI12* at the prompt 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 transducer is connected. An **Entering SDI12 Terminal** response indicates that SDI-12 Transparent Mode is active.

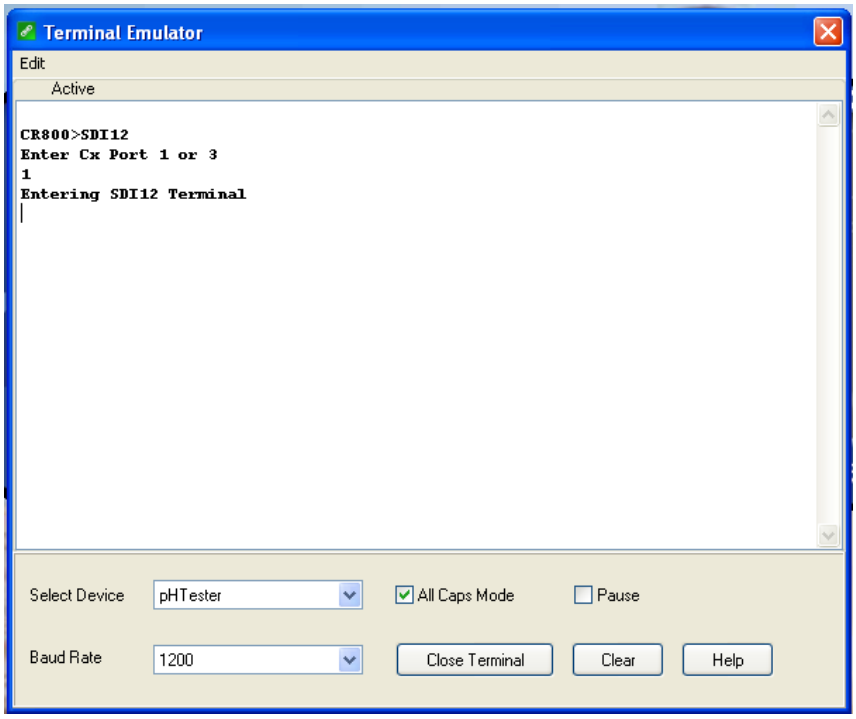


FIGURE 7-3. Terminal Emulator

For CR10X and CR510 standard mixed-array dataloggers, the telecommunications command to enter SDI-12 transparent mode is *nX<Enter>* where *n* is the control port being used for SDI-12. In this example, the selected control port is *C1*, so the command would 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**.

CR10X-PB and CR510-PB dataloggers require **#n* being entered at the prompt, where *n* is the control port being used.

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: *013CSI450.Std.01_xxxxxxxx*, where *xxxxxxxx* represents the eight digit serial number. Note that the SDI-12 standard allows for multiple probes to be connected to one datalogger control port. For example, 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.

7.1.4 RS-232 Connection via PC Terminal Software

PC terminal software can be used to communicate with the CS451/CS456 via the RS-232 communication mode (see FIGURE 7-4).

The CS451/CS456 is connected to the PC via the A200 (see Section 7.1.1, *PC Connection Using the A200*).

Upon setup, the terminal emulator software will request you enter the Communication connection; defaults to a phone connection. Change the communication to appropriate "Com" in the "Connect Using" box (see Section 7.1.1.4, *Determining which COM Port the A200 has been Assigned*, to determine the COM port that was assigned to the A200). The software will then prompt for the proper "Port Settings". TABLE 7-3 shows the RS-232 settings.

TABLE 7-3. RS-232 Settings

Bits per Second	9600
Data bits	8
Parity	None
Stop bits	1
Flow control	None

You will now be able to communicate with the CS451/CS456. At the prompt, push the <Enter> key several times. This will wake-up the RS-232 mode of the sensor. TABLE 7-4 shows the RS-232 commands that can be entered once it is in the RS-232 mode.

NOTE By default, the CS451/CS456 is in the SDI-12 mode for communication. Once in the RS-232 mode, if there is no communication for 20 seconds, the sensor will return to the SDI-12 mode.

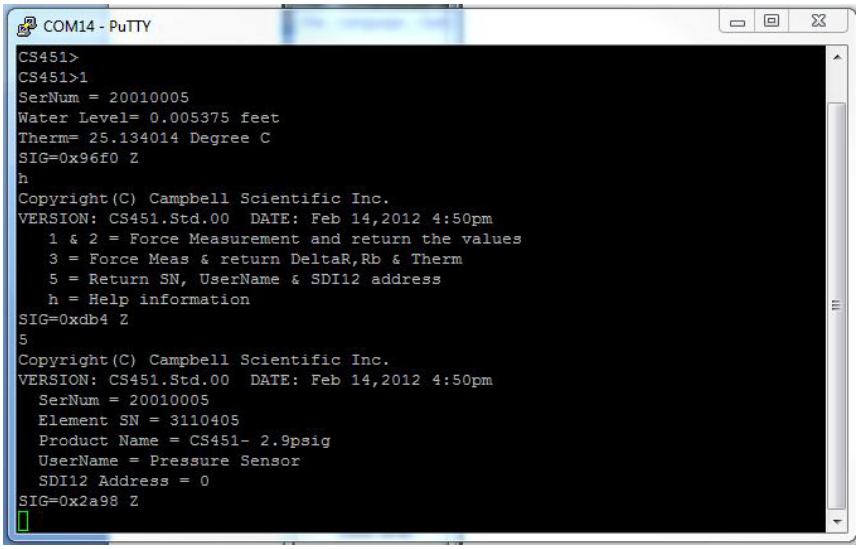


FIGURE 7-4. Terminal Emulator

TABLE 7-4. RS-232 Terminal Commands

Terminal Commands	Values Returned
1	Serial Number, Pressure/Level, Temperature (in configured units)
2	Serial Number, Pressure (kPa), Temperature (°C)
3	Serial Number, ΔR(ohms), Rb(ohms), Temperature (°C), Element Serial Number, Product Name
5	Copyright information, OS Version and Date, Serial Number, Element Serial Number, Product Name, User Defined Name (Station Name), SDI-12 Address
H or h	Help menu

7.1.5 SDI-12 Commands

The CS451/CS456 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, where *a* represents the sensor address. The communication sequence begins with the datalogger waking the sensor and issuing the *aM!* command. The transducer responds to the datalogger indicating that two measurements will be ready within two 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 CS451/CS456 supports the commands that are listed in TABLE 7-5.

TABLE 7-5. SDI-12 Commands		
SDI-12 Command	**Command Function**	**Values Returned**
aM!	Configured settings	Pressure/Level, Temperature
aM1!	PSIG, °C	Pressure, Temperature
aM2!	PSIG, °F	Pressure, Temperature
aM3!	kPa, °C	Pressure, Temperature
aM4!	kPa, °F	Pressure, Temperature
aM5!	Sensor's Serial Number	Serial Number
aM6!	Ohms, ohms, °C	ΔR, Rb, Temperature
aM7!	Configured settings (provides data in less than 0.8 seconds)	Pressure/Level
aM8!	Configured settings (provides average of data based on user selected samples)	Pressure/Level, Temperature

As 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 digital communications 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.)

7.1.5.1 SDI-12 Addresses

Multiple sensors can be connected to a single digital I/O channel (control port) on an SDI-12-compatible datalogger; each sensor must have a unique SDI-12 address. Possible addresses are 0 to 9, A to Z, and a to z.

The CS451/CS456 is shipped from the factory with the address set to 0. The address on the CS451/CS456 can be changed by sending an SDI-12 change address command 'aAb!', where a is the original address and b is the new 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 CS451/CS456, it is easiest to use a different control port for each CS451/CS456 instead of changing the

address. If additional control ports are not available, then the address will need to be changed.

7.1.5.2 Extended SDI-12 Commands

Extended SDI-12 commands can be used to configure the CS451/CS456 data output and sample number. These commands are used to select the temperature units (Celsius or Fahrenheit), pressure/level units (psig, kPa, bar, feet, meter, inches, or millimeter), and the integration time for each measurement. If level units are selected, they will represent level of fresh water. The multiplier (slope) and offset should be used to correct for relative density of water.

Sample number represents the number of values used to provide the output value received by the datalogger. This output value is an average of the samples.

The extended SDI-12 command used to configure output units is *aXCONFIG1=tt,pp,mmm.mm,000.00!* where *a* = the SDI-12 address of the sensor, *tt* = temperature units, *pp* = measurement unit, *mmm.mm* = multiplier (slope), and *000.00* = offset.

Valid entries for tt (temperature) are:

0 = Celsius
1 = Fahrenheit

and valid entries for pp (pressure/level) are:

0 = psig
1 = kPa
2 = Bar
3 = Feet
4 = Meter
5 = Inch
6 = Millimeter

Only SDI-12 instruction aM!, aM7!, and aM8! output the results obtained when using the multiplier and offset. The multiplier and offset are only applied to the pressure/level value, not to the temperature.

The extended SDI-12 command used to configure sample number is *aXCONFIG2=nnn!*, where nnn is the number of samples that will be measured to obtain the final output value, which is an average of the samples taken. This value only applies to the *aM8!* command. The integration time is a result of the number of samples selected. This value can be derived by adding 2 s to the number of samples. For example, if nnn = 50, then 50 samples would be averaged. The integration time for this process is 50 plus 2, or 52 s.

7.2 Installation Considerations

The CS451/CS456 is designed for water level measurements. Typical applications include agricultural water level/flow, water wells, lakes, streams and tanks. If the device is to be installed in a liquid other than water or in contaminated water, check the compatibility of the wetted material. The CS456 should be used in harsh water applications, including salt water.

7.2.1 Non-Vertical Installations

The CS451/CS456 can be installed in any position; however, when it leaves the factory it is tested in the vertical position. There will be an offset error if not installed vertically; contact Campbell Scientific for more information. Strapping the transducer body with tie wraps or tape will not hurt it.

7.2.2 Offset Calculation

The pressure created is directly proportional to the water column above the sensor. An offset is used to correct the final measurement to any error due to sensor zero offset or installation.

For example, if the correct elevation of the water, as measured by a staff gauge or other measurement device, is 2015.50 feet, and the CS451 provides a reading of 5.76 psig, then:

5.76 psig * 2.31 ft/psig = 13.3056 ft.

So, the offset is calculated:

2015.50 ft – 13.3056 ft = 2002.1944 ft

This offset can be accounted for in the program instruction of the SDI-12 recorder.

7.2.3 Split Mesh Cable Grip (pn 25431)

The 25431 Split Mesh Cable Grip is recommended for use in wells to center the cable and to provide a method of suspending the cable-reducing cable stretch. FIGURE 7-5 shows a transducer's cable suspended using the split mesh cable grip.

FIGURE 7-5. Transducer suspended with split mesh cable grip

7.3 Wiring

NOTE Power down your system before wiring the CS451/CS456. The shield wire plays an important role in noise emissions and susceptibility as well as transient protection.

7.3.1 SDI-12

TABLE 7-6. SDI-12 Wiring				
Color	**CS451/CS456 Function**	**CR800 CR5000 CR3000 CR1000**	**CR200(X) Series**	**CR510 CR23X CR10X**
Red	+12VDC	12V	Battery+	12V
Black	Power Ground	G	G	G
White	SDI-12 Signal	*Control Port	C1/SDI-12	Control Port
Blue	GND	GND	G	G
Yellow	GND	GND	G	G
Clear	Shield	GND	G	G

*dedicated SDI-12 port on CR5000

7.3.2 RS-232

TABLE 7-7. RS-232 Wiring			
Color	**CS451/CS456 Function**	**Connection**	**RS-232 9-pin**
Red	+12vdc	Power Source	
Black	Power Ground	Power Ground	
White	RS-232 Tx (Output)	Transmit	Pin 2 Rx (Input)
Blue	RS-232 Rx (Input)	Receive	Pin 3 Tx (Output)
Yellow	Digital Ground	Ground	Pin 5 GND
Clear	Shield GND	Ground	

7.4 Programming

NOTE SCWin is the preferred method for programming the datalogger. SCWin generates a wiring diagram that shows how to connect the CS451/CS456 to your Campbell Scientific datalogger. This section is for users who are using CRBasic or Edlog to program their datalogger.

NOTE The sections that immediately follow are for CRBasic and Edlog.

Keyboard/Display users and SCWin users can jump ahead to the Maintenance section.

7.4.1 CRBasic Programming

Dataloggers that use CRBasic include our CR200(X)-series, CR800, CR850, CR1000, CR3000, and CR5000. These dataloggers use the **SDI12Recorder()** to read the CS451/CS456. A multiplier of 1.0 and an offset of 0.0 yield water level in psig and temperature in degrees C.

The **SDI12Recorder()** instruction has the following form:

SDI12Recorder(*Destination, Output String, Multiplier, Offset***)**

7.4.1.1 Example Program for CR200(X)-Series Datalogger

```
'CR200(X) Series

'Declare the variable for the water level measurement
Public CS451(2)

'Rename the variable names
Alias CS451(1)=Level
Alias CS451(2)=Temp_C

'Define a data table for 60 minute maximum and minimums
DataTable(Hourly,True,-1)
  DataInterval(0,60,Min)
  Maximum(1,Level,0,0)
  Minimum(1,Level,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(CS451,0M!,1,0)

    'Call the data table:
    CallTable(Hourly)

  NextScan
EndProg
```

7.4.1.2 Example Program for CR1000 Datalogger

```
'CR1000 Series Datalogger

'Declare the variable for the water level measurement
Public CS451(2)

'Rename the variable names
Alias CS451(1)=Level
Alias CS451(2)=Temp_C

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

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

    'Code for SDI-12 measurements:
    SDI12Recorder(CS451,1,"0","M!",1,0)

    'Call the data table:
    CallTable(Hourly)

  NextScan
EndProg
```

7.4.2 Edlog Programming

Our CR500, CR510, CR10(X), and CR23X dataloggers are programmed with Edlog.

These dataloggers use Instruction 105 to read the CS451/CS456. Your datalogger manual has a detailed explanation of Instruction 105.

Please note that Edlog only allocates one input location for Instruction 105. Two input locations are required—one for the pressure measurement and one for the temperature measurement. The additional input location needs 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 steps:

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 2 and select OK.

7.4.2.1 Example Program for CR10(X) Dataloggers

Below is a portion of a CR10X program that measures the CS451/CS456.

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 white wire is connected
   4:   1            Loc[Data_1                    ]
   5:   1.0          Mult
   6:   0.0          Offset

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

*Table 3 Subroutines

End Program
```

After Instruction 105 is executed, the input location called "Data_1" will hold the measured pressure, reported in PSI, and the input location called Data_2 will hold the measured temperature, in degrees Celsius. The results can be further processed by the datalogger. Note that Port 1 specifies that the SDI-12 data line is to be connected to the Port C1.

8. Maintenance

Campbell Scientific recommends that the CS451/CS456 be factory recalibrated and checked every 24 months. Before a CS451/CS456 sensor is sent to Campbell Scientific, the customer must get an RMA (returned material authorization) number, and fill out the Declaration of Hazardous Material and Decontamination form.

The CS451/CS456 has no user-serviceable parts. Cable can be damaged by abrasion, rodents, sharp objects, twisting, crimping or crushing, and pulling. Take care during installation and use to avoid cable damage. If a section of cable is damaged, it is recommended that you send your sensor back to replace the bale harness assembly.

Periodic evaluation of the desiccant is vital for keeping the vent tube dry. The CS451/CS456 ships with the desiccant tube attached. To assess the effectiveness of the desiccant, use one of the following:

- The desiccant in the tube changes color from blue to pink when the drying power is lost.
- The Enclosure Accessory Humidity Indicator Card (pn 28878).

8.1 Every Visit

- Collect data
- Visually inspect wiring and physical conditions
- Check indicating desiccant or enclosure humidity indicator; service if necessary
- Check battery condition (inspect physical appearance and use a keyboard display, PDA, or laptop to view the battery voltage)
- Check all sensor readings: adjust transducer offsets if necessary
- Check recent data

8.2 Every Two to Three Years or on a Rotating Schedule

- Send the CS451/CS456 in for inspection.

9. Troubleshooting

The most common causes for erroneous pressure transducer data include:

- poor sensor connections to the datalogger
- damaged cables
- damaged transducers
- moisture in the vent tube

Problem:

Unit will not respond when attempting serial communications.

Suggestion:

Check the power (red is +V and black is ground) and signal (white is SDI-12 data) 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.

Problem:

Transducer appears to be operating properly but data shows a periodic or cyclic fluctuation not attributable to water level changes.

Suggestion:

A kinked or plugged vent tube will not effectively vent a gauge pressure (Vented) type of device. Normal changes in barometric pressure will appear as water level fluctuations and these types of errors are typically on the order of 1 foot of water level. If the desiccant chamber has not been properly maintained, water may have condensed in the vent tube and the device should be returned to the factory for service.

Appendix A. Calibration Certificate

Each CS451/CS456 has been calibrated to meet printed accuracy specification at multiple temperature and pressure ranges. If additional verification is required, a Calibration Certificate can be purchased for each CS451/CS456 Submersible Pressure Transducer.

The Instrument Data Report provides a list of the pressure and temperature at which the sensor was tested.

Pressure [kPa] is the pressure applied (listed in kilopascals) to the sensor. Temperature [°C] is the temperature inside the test chamber at the time of testing. Pressure After [kPa] represents the resulting measurement output by the CS451/CS456 at the give pressure and temperature. Finally, Deviation After [%F.S.], provides the difference between the actual pressure applied to the sensor and the pressure measurement output by the sensor. This value is listed as a percentage of the Full Scale range of the sensor.

When a CS451/CS456 is returned to Campbell Scientific for calibration, the sensor will be returned with an Instrument Data Report. This report will include values in the Pressure Before [kPa] column. These values represent the measured pressure the sensor returns at the specified pressure and temperature, BEFORE calibration.

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