

# INSTRUCTION MANUAL



## CS450/CS455 Pressure Transducer

Revision: 1/13



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# **CS450/CS455 Pressure Transducer**

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*The CS450/CS455 Submersible Pressure Transducer is designed for general pressure measurements. It uses the SDI-12 or RS-232 communications protocols to communicate with an SDI-12 or RS-232 recorder to simplify installation and programming. The CS450/CS455 can be used with an A150 desiccated case allowing the transducer to be connected to a CWS900 wireless sensor or prewired enclosure.*

## **1. Introduction**

The CS450/CS455 Submersible Pressure Transducer provides reliable, accurate pressure/level measurements that are fully temperature compensated.

Combining the sensor, analog measurement, and signal processing within a single housing results in the integration of state-of-the-art sensor and measurement technology. 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-sensor 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 seconds. The sensor 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 utilizes a piezoresistive sensor housed in a 316L Stainless Steel (CS450) or Titanium (CS455) package to enhance reliability. The rugged construction makes the CS450/CS455 suitable for water-level measurement in irrigation applications, water wells, lakes, streams, and tanks. The Titanium package of the CS455 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 CS450/CS455 has two communication options: SDI-12 or RS-232. The CS450/CS455 is shipped from the factory with both communications options enabled; there is no configuration required. As an SDI-12 sensor, the CS450/CS455 is shipped with an address of 0.

Two values are output by the CS450/CS455, pressure/level and temperature. The CS450/CS455 is shipped from the factory to output pressure in psig and temperature in degrees Celsius.

### **1.1 Initial Inspection and Handling Guidelines**

Upon receipt of the CS450/CS455, 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 cable jacket. If there is any question about damage having been caused to the cable jacket, a thorough inspection is prudent.

The model number and pressure range is etched on the housing. Check this information against the shipping documentation to ensure that the expected model number and range were received.

Gauge pressure (Vented) devices must always have a desiccant tube attached. New desiccant is blue in color. As the desiccant material absorbs water vapor, it begins to turn pink, and eventually white when fully expired. Desiccant tubes should be inspected regularly (i.e., every two months) and historical information will help to baseline desiccant replacement requirements for a given application/climate.

#### **CAUTION**

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

Remember that although the CS450/CS455 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 and any attempt to disassemble the device will void the warranty.

## **2. Specifications**

<b>Power Requirements:</b>	6 to 18 Vdc
<b>Power Consumption:</b>	Quiescent current: < 80 µA Measurement/communication current: 8 mA for 1-s measurement Maximum peak current: 40 mA
<b>Measurement Time:</b>	Less than 1.5 s
<b>Outputs:</b>	SDI-12 (version 1.3) 1200 Baud RS-232 9600 Baud

#### **Measurement Ranges:**

Pressure (PSIG)	Pressure (kPa)	ft of fresh water
0 to 2.9	0 to 20	0 to 6.7
0 to 7.25	0 to 50	0 to 16.7
0 to 14.5	0 to 100	0 to 33.4
0 to 29	0 to 200	0 to 67
0 to 72.5	0 to 500	0 to 167
0 to 145	0 to 1000	0 to 334.5

**Accuracy:** ±0.1% FS TEB\* or  
±0.05% FS TEB\*\*

**Resolution:** 0.0035% FS

<b>Overpressure:</b>	2x pressure range
<b>Dry Storage Temperature:</b>	-10° to 80°C
<b>CAUTION</b>	Sensor will be damaged if it is encased in frozen liquid.
<hr/>	
<b>Operating Temperature:</b>	0° to 60°C
<b>Temperature Accuracy:</b>	±0.2°C
<b>Maximum Cable Length:</b>	SDI-12 — one sensor connected to a single port can communicate up to approximately 457 m (1500 ft). With 10 sensors connected to a single port, each sensor can have up to 60 m (200 ft). RS-232 — 15 m (50 ft).
<b>Cable Type:</b>	5 Conductor, 26 AWG Hytrel Jacket
<b>Body Material:</b>	CS450 – 316L Stainless Steel CS455 – Titanium
<b>Element Material:</b>	CS450 – 316L Stainless Steel CS455 – Hastelloy
<b>Top Cone Material:</b>	Delrin
<b>Dimensions:</b>	Length 213.36 mm (8.4 in) Diameter 21.34 mm (0.84 in)
<b>Distance from pressure-sensor interface (black line etched on housing) to:</b>	
<b>End of NPT fitting:</b>	2.86 cm (1.13 in)
<b>End of standard nose cone:</b>	4 cm (1.58 in)
<b>End of weighted nose cone:</b>	11.59 cm (4.56 in)
<b>Weight:</b>	CS450: 0.18 kg (0.40 lb) CS455: 0.11 kg (0.25 lb) Cable: 0.421 kg/m (0.283 lb/ft)

\* 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% FS accuracy not available in the 0 – 2.9 psig range.

### 3. Configuration

The CS450/CS455 is configured at the factory with default settings:

TABLE 3-1. Factory Settings	
SDI-12 Address	0
RS-232 Baud Rate	9600
Pressure/Level Units	PSIG
Temperature Units	Celsius

### 3.1 Connection

Communicating with the CS450/CS455 requires the sensor to be either connected to a PC or 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.

#### 3.1.1 Using the A200

The A200 or another device is required to connect the CS450/CS455 to a PC. This allows sensor settings to be changed via our Device Configuration Utility.

##### 3.1.1.1 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.

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**NOTE**

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

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The A200 drivers can be downloaded, at no charge, from:  
[www.campbellsci.com/downloads](http://www.campbellsci.com/downloads).

##### 3.1.1.2 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 3-1 and TABLE 3-2).

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.

##### 3.1.1.3 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 that is required to power the sensor.

##### 3.1.1.4 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, you can monitor the appearance of a new COM port in the list of COM ports offered in your

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 3-1. A200 Sensor-to-PC Interface

TABLE 3-2. 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

### 3.1.2 Device Configuration Utility (version 1.12 or higher)

The Device Configuration Utility (DevConfig) allows you to change the settings of the CS450/CS455. DevConfig is shipped on the CSI ResourceDVD included with the CS450/CS455.

To use DevConfig, the transducer needs to be connected to the PC via the A200 (see Section 3.1.1, *Using the A200*). After installing DevConfig and connecting the transducer to the PC, select CS450 from the Device Type list (see FIGURE 3-2).

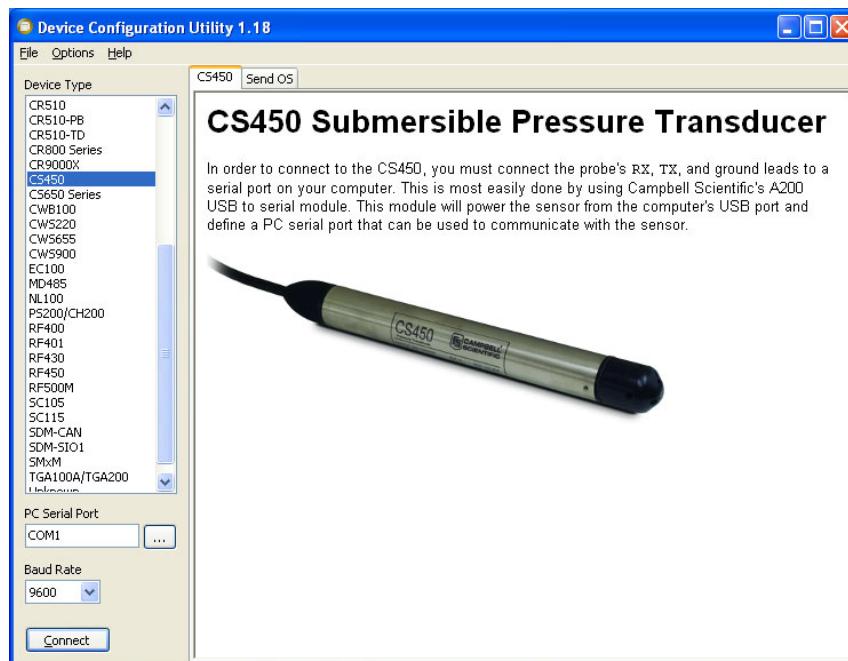


FIGURE 3-2. Device Configuration Utility

In the PC Serial Port box, select the COM port that was assigned to the A200 (see Section 3.1.1.4, *Determining which COMPort the A200 has been Assigned*). Click on the *Connect* button to enable communication with the sensor. Once successfully connected, the DevConfig screen should look like FIGURE 3-3.

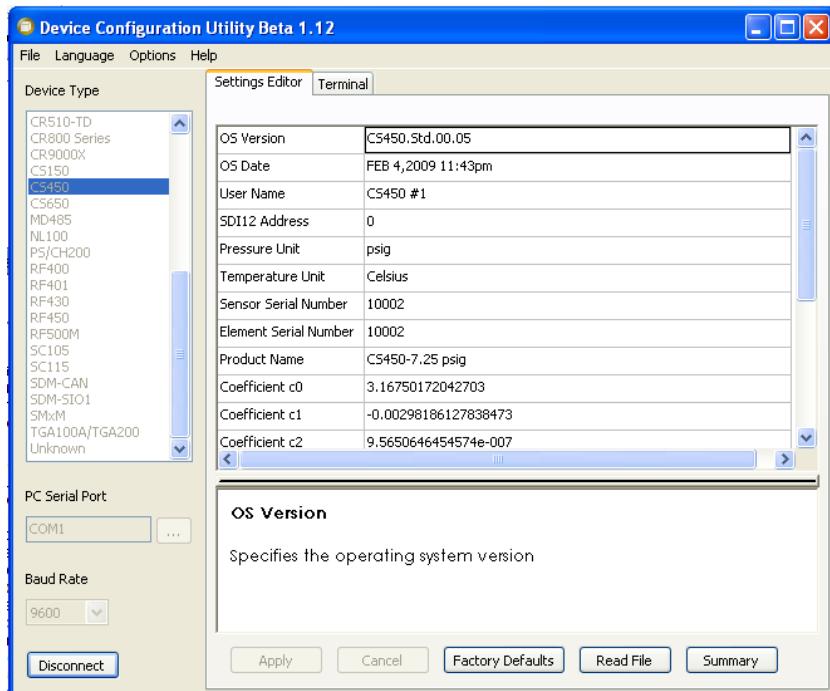


FIGURE 3-3. Connect screen

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 (see FIGURE 3-4).

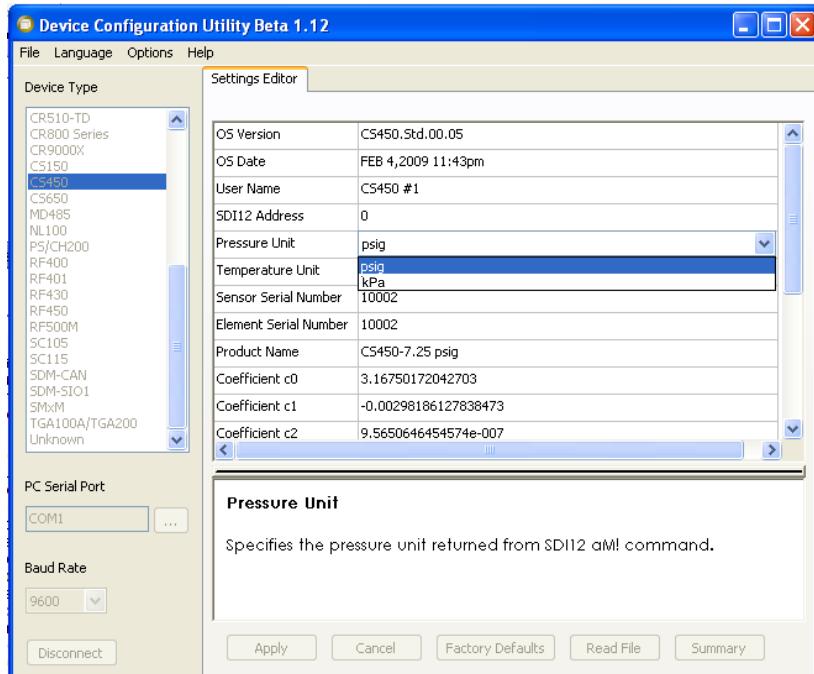


FIGURE 3-4. Configure units

### 3.1.3 SDI-12 Transparent Mode

Transparent Mode allows direct communication with the CS450/CS455. 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. A terminal-emulator screen is displayed. Click the “Close Terminal” button as shown in FIGURE 3-5.

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 quotation marks) 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 CR450 is connected. An “Entering SDI12 Terminal” response indicates that SDI-12 Transparent Mode is active.

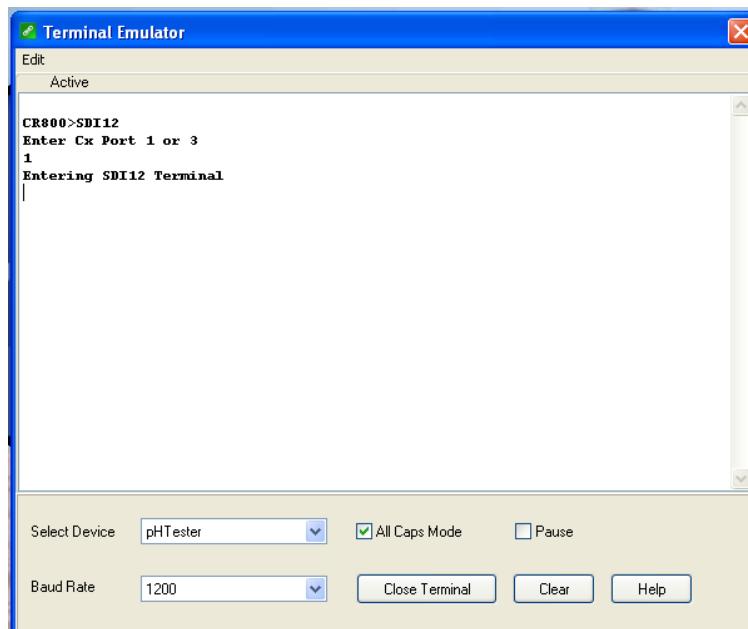


FIGURE 3-5. Terminal Emulator

For CR10X and CR510 standard, mixed-array 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. 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\_xxxxxxx”, 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.

### 3.1.4 RS-232 Connection via PC Terminal Software

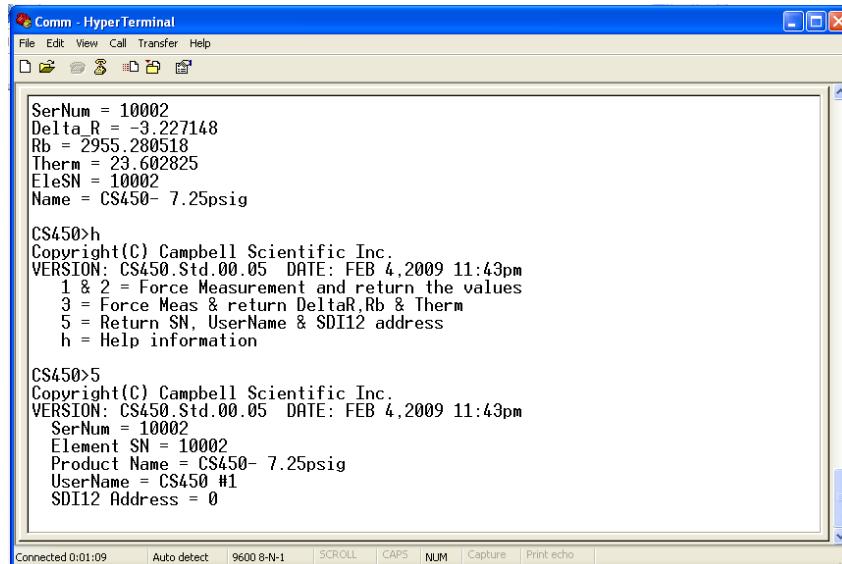
PC terminal software can be used to communicate with the CS450/CS455 via the RS-232 communication mode. For this example, HyperTerminal will be used (see FIGURE 3-6).

The CS450/CS455 is connected to the PC via the A200 (see Section 3.1.1, *Using the A200*).

Upon setup, HyperTerminal will request you enter the Communication connection; it defaults to a phone connection. Change the communication to the appropriate “Com” in the “Connect Using” box (see Section 3.1.4, *Determining which COM Port the A200 has been Assigned*, to determine the COM port that was assigned to the A200). HyperTerminal will then prompt for the proper “Port Settings”. These should be:

<b>TABLE 3-3. RS-232 Settings</b>	
Bits per second	9600
Data bits	8
Parity	None
Stop bits	1
Flow control	None

From the HyperTerminal screen, you will now be able to communicate with the CS450/CS455. At the prompt, push the Enter key several times. This will wake-up the RS-232 mode of the sensor. By default, the CS450/CS455 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 3-6. *HyperTerminal***TABLE 3-4. RS-232 Terminal Commands**

<b>Terminal Commands</b>	<b>Values Returned</b>
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

## 3.2 SDI-12 Commands

The CS450/CS455 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. 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 (2) 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 CS450/CS455 supports the commands that are listed in the following table.

TABLE 3-5. 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, R <sub>b</sub> , 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 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.)

### 3.2.1 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 CS450/CS455 is shipped from the factory with the address set to 0. The address on the CS450/CS455 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 CS450/CS455, it is easiest to use a different control port for each CS450/CS455 instead of changing the address. If additional control ports are not available, then the address will need to be changed.

### 3.2.2 Extended SDI-12 Commands

Extended SDI-12 commands can be used to configure the CS450/CS455 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, 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.

---

**NOTE**

Extended commands were introduced in Version 4. Versions previous to this did not have the extended commands.

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#### 3.2.2.1 Units

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;

where 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 instructions aM!, aM7!, and aM8! output the results obtained when using the multiplier and offset. The offset and multiplier is only applied to the pressure/level value, not to the temperature.

### 3.2.2.2 Sample Number

The extended SDI-12 command used to configure sample numbers 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 seconds 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 seconds.

## 4. Installation

The CS450/CS455 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 CS455 should be used in harsh-water applications, including salt water.

### 4.1 Vent Tubes

A vent tube incorporated in the cable vents the sensor diaphragm to the atmosphere. This eliminates the need to compensate for changes in barometric pressure.

To prevent water vapor from entering the inner cavity of the sensor, the vent tube opening should terminate inside a desiccated enclosure or a desiccant tube. Moisture inside the vent tube can cause erroneous data and damage to the sensor.

### 4.2 Dislodging Bubbles

While submersing the sensor, 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 CS450/CS455 while it is under water.

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**CAUTION**

Do not hit the sensor against the well casing or another solid surface while dislodging the bubbles; this could damage the sensor.

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### 4.3 Water Depth

For water-level measurements, the CS450/CS455 must be installed below the water at a fixed depth. This depth should be chosen so that the water pressure will never exceed the sensor’s pressure range. Otherwise, the output reading will not be correct, and the sensor can be damaged if pressure is excessive (2X full scale).

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

$$1 \text{ psi} = 2.31 \text{ feet of water}$$

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

## 4.4 Well Installations

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 (pn 25414).

Fasten the cable to the well head using cable ties or a weather proof strain-relief system (CSI #7421). The cable ties should wrap around the cable jacket; never suspend the CS450/CS455 from the connections at the top end of the cable. When securing the cable, care should be taken to avoid cable damage. 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 insure proper operations after installation.

## 4.5 Other Installations

The CS450/CS455 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. Strapping the transducer body with tie wraps or tape will not hurt it.

If the CS450/CS455 is being installed in a fluid environment other than water, check the compatibility of the fluid with the wetted parts of the probe and cable.

Because the CS450/CS455 is vented, a desiccant tube must always be attached to the CS450/CS455. When you receive the CS450/CS455, ensure that the desiccant is blue. Replace the desiccant if it is pink or white.

## 4.6 Calculate Offset

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 CS450 provides a reading of 5.76 psig, then:

$$5.76 \text{ psig} * 2.31 \text{ ft/psig} = 13.3056 \text{ ft.}$$

So, the offset is calculated:

$$2015.50 \text{ ft} - 13.3056 \text{ ft} = 2002.1944 \text{ ft}$$

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

## 5. Wiring

### 5.1 SDI-12

It is recommended to power down your system before wiring the CS450/CS455. The shield wire plays an important role in noise emissions and susceptibility as well as transient protection.

TABLE 5-1. SDI-12 Wiring				
Color	CS450/CS455 Function	CR800 CR5000 CR3000 CR1000	CR200 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

## 5.2 RS-232

TABLE 5-2. RS-232 Wiring			
Color	CS450/CS455 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	

## 5.3 A150/CWS900

The A150 desiccated case allows the CS450/CS455 to be connected to the CWS900 wireless sensor and then used in a wireless network. FIGURE 5-1 shows the CS450 wired to the A150's terminal block. The 26972 cable is included with the A150.

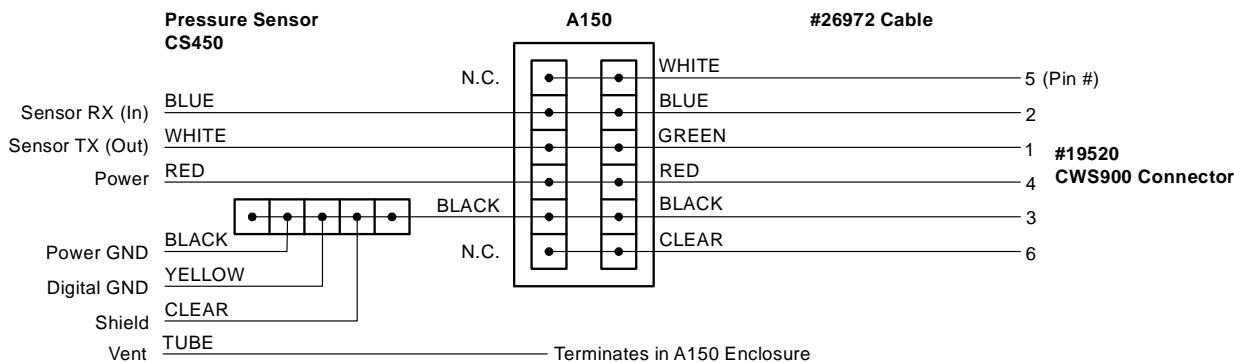


FIGURE 5-1. A150 wired for CS450 pressure sensor and CWS900 connector

# 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 CS450/CS455 to your Campbell Scientific 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.

## 6.2 Using CRBasic or Edlog

### 6.2.1 CRBasic Programming

Dataloggers that use CRBasic include our CR200-series, CR800, CR850, CR1000, CR3000, and CR5000. These dataloggers use the **SDI12Recorder()** to read the CS450/CS455. 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)**

#### Sample Program for CR200-Series Datalogger

```
'CR200 Series

'Declare the variable for the water level measurement
Public CS450(2)

'Rename the variable names
Alias CS450(1)=Level
Alias CS450(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(CS450,0M!,1,0)

        'Call the data table:
        CallTable(Hourly)

    NextScan
EndProg
```

### Sample Program for CR1000 Datalogger

```

'CR1000 Series Datalogger

'Declare the variable for the water level measurement
Public CS450(2)

'Rename the variable names
Alias CS450(1)=Level
Alias CS450(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(CS450,1,"0","M!",1,0)

    'Call the data table:
    CallTable(Hourly)

    NextScan
EndProg

```

### 6.2.2 Edlog Programming

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

These dataloggers use Instruction 105 to read the CS450/CS455. 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.

Below is a portion of a CR10X program that measures the CS450/CS455.

**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.

## 7. Maintenance

Campbell Scientific recommends that the CS450/CS455 be factory recalibrated and checked every 24 months. Before a CS450/CS455 sensor is sent to Campbell Scientific, the customer must get an RMA (returned material authorization) and fill out the Declaration of Hazardous Material and Decontamination form.

The CS450/CS455 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 CS450/CS455 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.
- An enclosure humidity indicator such as CSI pn 28878 Humidity Indicator Card.

## 7.1 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.

## 7.2 Every Two to Three Years or on a Rotating Schedule

- Send the CS450/CS455 in for inspection and have it serviced and/or replaced as needed.

# 8. 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***

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Each CS450/CS455 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 CS450/CS455 Submersible Pressure Transducer.

This document included both the Certificate of Calibration and Instrument Data Report. A sample for illustration is provided (FIGURE A-1).

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 [ $^{\circ}$ C] is the temperature inside the test chamber at the time of testing. Pressure After [kPa] represents the resulting measurement output by the CS450/CS455 at the given 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 CS450/CS455 is returned to CSI 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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## *Certificate of Calibration*

### Customer Information:

Contract/PO #: Enter PO here!

RMA #: N/A

Model: CS450

Serial Number: 20010003

Accuracy (%F.S. T.E.B.): 0.1

Test Panel Location: 1

CSI Calibration Number: 110174158

Calibration Procedures: TST22215A R01

### Instrument Calibration Condition

Received Disposition: N/A

Returned Disposition: In Tolerance

### Recommended Calibration Schedule

If the customer has not requested a calibration interval, a non-mandatory recommended interval is provided.

Based on past experience and assumed normal usage, it is recommended that this instrument be calibrated by the due date stated below to insure sustained accuracy and reliable performance.

Calibration Date: 04-Mar-09

Calibration Due Date: 04-Mar-11

### Report of Calibration Standards Used

Make/Model	Serial Number	Cal. Due Date	Trace Number
Ruska 7252	64219	25-Jul-09	226173

CSI certifies the above instrument meets or exceeds published specifications and has been calibrated using standards and instruments whose accuracies are traceable to the National Institute of Standards and Technology, an accepted value of a natural physical constant or a ratio calibration technique. The collective measurement uncertainty of the calibration process exceeds a 4:1 accuracy ratio. Policies and procedures at this facility comply with ISO-9001.

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# Instrument Data Report

## CS450 Pressure Output and Coefficients

S/N: 20010003

Accuracy (%F.S. T.E.B.): 0.1

Temperature Range: 0°C to 60°C

Test Run Results:

Pressure [kPa]	Temperature [°C]	Pressure Before [kPa]	Pressure After [kPa]	Deviation After [%F.S.]
0.0000	0.0	N/A	-0.0018	-0.009
0.0000	20.0	N/A	0.0036	0.018
0.0000	30.0	N/A	-0.0045	-0.023
0.0000	50.0	N/A	0.0022	0.011
0.0000	60.0	N/A	0.0013	0.007
4.0000	0.0	N/A	4.0018	0.009
4.0000	20.0	N/A	4.0023	0.012
4.0000	30.0	N/A	3.9990	-0.005
4.0000	50.0	N/A	4.0016	0.008
4.0000	60.0	N/A	3.9976	-0.012
8.0000	0.0	N/A	7.9988	-0.006
8.0000	20.0	N/A	8.0027	0.013
8.0000	30.0	N/A	7.9957	-0.021
8.0000	50.0	N/A	8.0028	0.014
8.0000	60.0	N/A	7.9982	-0.009
12.0000	0.0	N/A	11.9990	-0.005
12.0000	20.0	N/A	12.0020	0.010
12.0000	30.0	N/A	11.9961	-0.019
12.0000	50.0	N/A	12.0055	0.028
12.0000	60.0	N/A	12.0012	0.006
16.0000	0.0	N/A	15.9986	-0.007
16.0000	20.0	N/A	16.0040	0.021
16.0000	30.0	N/A	15.9954	-0.023
16.0000	50.0	N/A	16.0026	0.013
16.0000	60.0	N/A	15.9988	-0.006
20.0000	0.0	N/A	19.9991	-0.004
20.0000	20.0	N/A	20.0045	0.023
20.0000	30.0	N/A	19.9965	-0.017
20.0000	50.0	N/A	20.0008	0.005
20.0000	60.0	N/A	20.0002	0.001

bars = kPa / 100.0

psi = kPa \* 0.145

Calibration by: \_\_\_\_\_  
T. Forbush

Title: Electronic Technician

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*FIGURE A-1. Calibration certificate*





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