INSTRUCTION MANUAL

Using the CS400/CS405 (KPSI Series 169/173) Submersible Pressure Transducer with Campbell Scientific Dataloggers

Revision: 11/02

The CS400/405-L are manufactured by KPSI. KPSI's conditions of sale and return policy apply to these items.

Products may not be returned without prior authorization. To obtain an RMA number contact KPSI, phone (800) 328-3665. NOTE: if the product has been exposed to hazardous media, it must be fully decontaminated and neutralized prior to return to KPSI.

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Using the CS400/CS405 (KPSI Series 169/173) Submersible Pressure Transducer with Campbell Scientific Dataloggers

1. General Information

The CS400/CS405 (KPSI-PSI Series 169/173) submersible pressure transducer measures water levels in environmental and industrial applications. As the water depth changes over the transducer, so does the pressure. The CS400/CS405 contains a strain gauge element which senses the pressure and produces a corresponding mV analog output when an excitation current is provided. The datalogger measures the signal differentially and scales it to the excitation current. This current is detected by the datalogger by measuring the voltage drop across a 100-Ohm precision resistor such as Campbell Scientific's part #7977 in series with the black excitation wire. CS400/CS405 transducers are vented so that changes in barometric pressure are compensated for in the measurement.

The difference between the CS400 and CS405 is specified accuracy. The CS400 has an accuracy of 0.25% of the full scale output. The CS405 has an accuracy of 0.1% of the full scale output.

2. Specifications

Static Accuracy*	±0.25% FSO BFSL (CS400-L)
	±0.1% FSO BFSL (CS405-L)
Thermal Error**	0.022% FSO/°C worst case
Proof Pressure	1.5 X rated pressure
Burst Pressure	2.0 X rated pressure
Resolution	Infinitesimal

*Static accuracy includes the combined errors due to nonlinearity, hysteresis and nonrepeatability on a Best Fit Straight Line (BFSL) basis, at 25°C.

**Thermal error is the maximum allowable deviation from the Best Fit Straight Line due to a change in temperature.

Comp. temp. range	0°C to 27°C
Operating temp. range	-10°C to 70°C

Excitation	0.5 mA constant current
Zero offset, max	10 mV
Bridge impedance	3500 ohms nominal
Insulation resistance	100 megohms at 50 VDC

Output Voltage (mV) at 0.5 mA constant	PSI range
30	5
35	10
50	15-20
63	25
75	30
65	50

3. Installation

The CS400/CS405 should be limited to an 800' cable length. Also, remember to properly ground the datalogger to reduce the chances of damage from lightning and reduce radio frequency and other types of electromagnetic noise.

NOTE If Campbell Scientific's Short Cut computer program suits your datalogging needs, you should *run Short Cut to generate the datalogger program and wiring assignments* instead of stepping through the remainder of this document. Please refer to the Factory Calibration below for the multiplier you will need.

3.1 Vent Tubes

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

To prevent water vapor from entering the inner cavity of the sensor, the transducers are typically shipped with the vent tubes sealed. Before operation, visually confirm the vent tube is open. The vent tube opening must terminate inside a desiccated enclosure or a Campbell Scientific DES2 desiccant case.

NOTE The desiccant must be changed regularly.

3.2 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 pressure transducer while it's under water.

CAUTION Do not hit the sensor against the well casing or other solid surface while dislodging the bubbles, because the diaphragm could be damaged.

3.3 Transient Protection

Campbell Scientific recommends transient surge protection for sensors installed in lightning prone areas. No lightning protection is capable of withstanding a direct hit, but surge protectors afford a degree of protection for near misses. Surge protection can be provided by Campbell Scientific's SVP48 Surge Voltage Protector. When an electrical surge occurs, the surge protectors involved may need to be replaced.

3.4 Temperature Fluctuations

Temperature fluctuations can be minimized by using a minimum cable burial depth of six inches and a sensor submersion depth of one foot.

3.5 Sensor Connections

CS400/CS405	Datalogger	#7977 Resistor
	E1	Purple
	1H	Yellow
Black	1L	Black
Red	2H	
Green	2L	
White	AG	
Blue	G/ground	

3.6 BDR320

CS400/CS405	BDR320	#7977 Resistor
	EX	Purple
	CH1	Yellow
Black	CH2	Black
Red	CH3	
Green	CH4	
White	AG	
Blue	G/ground	

3.7 BDR301

The CS400/CS405 can be connected to the BDR301 by using a DES-2 Desiccant Box and replacing the DES-2's standard five-lead cable with a six-lead cable terminated with a ten-pin military connector. Figure 3-1 shows the DES-2 wiring format with placement of a #7977 resistor.

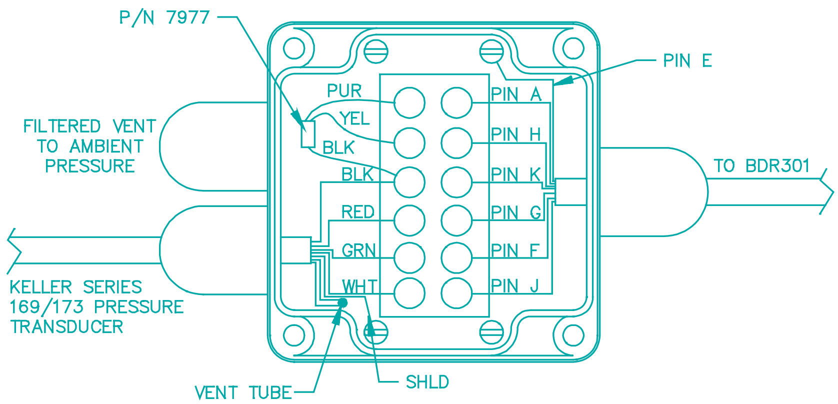

FIGURE 3-1. Wiring diagram for a CS400/CS405 and a DES-2 connected to a BDR301.

3.8 PST3/8

The PST3/8 has a #7977 built-in. Figure 3-2 shows the wiring for a CS400/CS405 and a DES-1 which can be connected to the PST3/8.

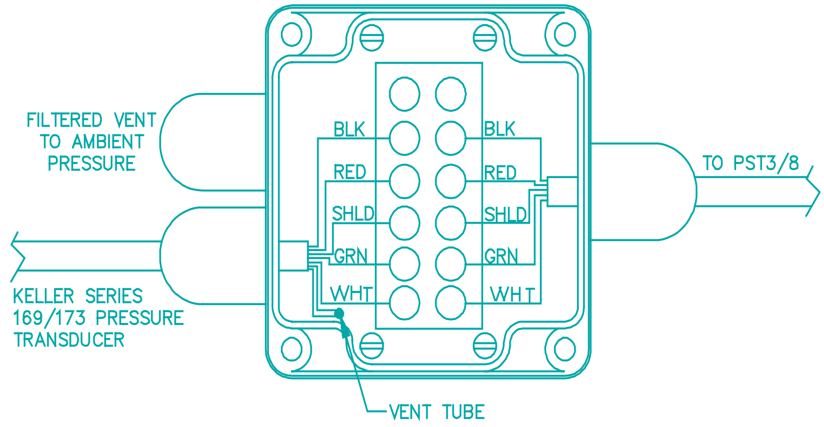

FIGURE 3-2. Wiring diagram for a CS400/CS405 and a DES-1 for use with the PST3/8.

4. Programming

The example programs below enable the datalogger to collect and process data and store it in input storage locations.

NOTE Additional instructions are needed to output data to final storage. For example, time periodic output might include instructions P92, P77, P70, etc.

Use Short Cut, Edlog, or the datalogger Keyboard/Display to program the datalogger to read these sensors. All programming methods require the “slope” provided on the “Calibration Report.” A Calibration Report should accompany every sensor received from KPSI. It is specific to the individual sensor; verify that the Report and the sensor have the same serial number, and retain the Report for your records.

4.1 Using Short Cut

Short Cut is the easiest and typically the preferred method for programming the datalogger. Short Cut will ask for the “slope” which is listed on the Calibration Report. From this value Short Cut will calculate the multiplier.

Short Cut for Windows has two additional modules for calculating the offset. Choose either the “Manual Offset” or “Automatic Offset” module to adjust the transducer reading to the current water level reading. Short Cut for DOS asks for a current water level reading to automatically calculate the offset. Review Short Cut’s (Windows or DOS) Help for more detail on using the offset.

Older versions of Short Cut for DOS required the transducer’s sensitivity be entered in the units of mV. Visit Campbell Scientific’s web site (www.campbellsci.com) or talk to an applications engineer to receive your free copy of the latest Short Cut release.

Short Cut stores the CS400/405 level data in the high resolution format. Short Cut also generates a wiring diagram that shows how to connect the transducer to your datalogger.

NOTE The sections that immediately follow are for Edlog and Keyboard/Display users. Short Cut users can jump ahead to the Maintenance section (page 10).

4.2 Using Edlog or the Keyboard/Display

Use two sequential Instruction 6s - Full Bridge Measurement. These Instructions require a multiplier and offset. Your datalogger manual has a detailed explanation of Instruction 6.

4.2.1 Calculating the Multiplier

Three multipliers are required in a datalogger program for a CS400/CS405. The multiplier for the first P6 instruction, parameter seven is 0.01, the multiplicative inverse of 100 (Ohms). The multiplier for the second P6 instruction, parameter seven is 0.5, the factory calibration current in mA. These first two multipliers are used for all CS400/CS405s.

The third multiplier (used in the P37 instruction, parameter two) is a calibration multiplier and is specific to each CS400/CS405. Before you begin programming, determine the third multiplier as outlined below. There are two different types of calibration; factory (manufacturer’s calibration sheet) and field (physical recalibration).

Factory calibration: Each CS400/CS405 transducer is shipped with a calibration report specific to that unit. The report specifies calibration conditions and actual data reflecting the transducer's static accuracy and thermal characteristics. Newer calibration reports from KPSI include a slope figure near the bottom of the page that may make the following calculations unnecessary.

NOTE Short Cut users may need to divide the KPSI calibration slope figure by 2.3065 to obtain PSI/mV for use in the Short Cut CS400/CS405 setup screen.

The following is an example from a five psi CS400 calibration report:

(BFSL = Best Fit Straight Line)

Test Pressure PSIG	BFSL Room Temperature Outputs
0.0001	0.01
1.0002	4.30
1.9997	8.59
2.9996	12.87
3.9996	17.16
5.0006	21.45

To determine a multiplier based on the two calibration end-points:

Full scale pressure

Minimum scale pressure

Density factor
(e.g., feet of water/PSI)

$$\text{Multiplier} = \frac{(5.006\ \text{PSI} - 0.0001\ \text{PSI}) * 2.3065\ \text{ft / PSI}}{21.45\ \text{mV} - 0.01\ \text{mV}} = 0.5380\ \text{ft / mV}$$

BFSL output at min. scale pressure

BFSL output at full scale pressure

A second way to calculate the multiplier is to run a linear regression on the data from the factory calibration report. In the regression, the BFSL output in mV would be the x axis or independent variable and test pressure in PSI the y or dependent variable. The slope would equal the multiplier and the intercept would be the offset.

Field calibration: If you do not have a factory calibration report, a multiplier can be determined by performing a field calibration. Wire the transducer and program the datalogger as described, using a multiplier of 1.0 and an offset of zero. Watch the measurement results using Mode *6 on the keyboard/display or the monitor mode on an attached computer. Record the CS400/CS405 signal output at two separate depths.

Field calibration hints:

1. Make the two depths as far apart vertically as practical within the pressure range of the transducer to minimize the slope error.

2. Repeated observations will increase your accuracy.

3. Allow several hours for the transducer to reach equilibrium in the water.

Record the voltage measurements and use the following equation to calculate the multiplier:

Multiplier = (depth 2 - depth 1)/(voltage 2 - voltage 1)

The offsets in parameter eight of both P6 instructions are always zero. The offset in parameter two of instruction P34 must be determined in the field after the sensor has been installed. Usually it is the difference between the initial datalogger reading with a zero offset and the actual water level (stage) as determined by a staff gauge or other reference point. However, another reference datum such as elevation is often used.

NOTE Large offsets may result in truncation of less significant digits. For example, a measurement of 70.0 feet or greater will only show depth to the nearest 0.1 ft using the default (low) resolution. If this is a problem, consider performing offset correction after the data is collected or storing the data in high resolution format using Instruction 78.

4.3 CR10(X), CR510, and CR500 Programming

Use an excitation voltage of 770 mV for a CR10 using a CS400/CS405 rated at or below 20 PSI. For a CS400/CS405 rated above 20 PSI use an excitation voltage of 430 mV.

NOTE If the value in MA_MEAS goes to -99999, your particular transducer may require a slightly lower excitation voltage. If this is the case, decrease the recommended millivolts excitation by 10 percent.

Using EDLOG:

```
1:  Full Bridge (P6)
  1:          1       Reps
  2:         23       25 mV 60 Hz Rejection Range
  3:          1       DIFF Channel
  4:          1       Excite all reps w/Exchan 1
  5:        770       mV Excitation          ;NOTE: use 430 if psi>20
  6:          1       Loc [ MA_MEAS   ]
  7:          0.01    Mult                   ;NOTE: first multiplier
  8:          0.0     Offset
```

```
2:  Full Bridge (P6)
  1:            1        Reps
  2:           23        25 mV 60 Hz Rejection Range
  3:            2        DIFF Channel
  4:            1        Excite all reps w/Exchan 1
  5:          770        mV Excitation          ;NOTE:  use 430 if psi>20
  6:            2        Loc [ MV_MA     ]
  7:            0.5      Mult                   ;NOTE: second multiplier
  8:            0.0      Offset

3:  Z=X/Y (P38)
  1:            2        X Loc [ MV_MA     ]
  2:            1        Y Loc [ MA_MEAS   ]
  3:            3        Z Loc [ MV        ]

4:  Z=X*F (P37)
  1:            3        X Loc [ MV        ]
  2:            0.538    F                      ;NOTE:  third multiplier (from calibration)
  3:            4        Z Loc [ HEAD_FT   ]

5:  Z=X+F (P34)
  1:            4        X Loc [ HEAD_FT   ]
  2:            0.0      F                      ;NOTE:  site/job specific offset
  3:            4        Z Loc [ HEAD_FT   ]
```

4.4 CR23X and 21X Programming

Use an excitation voltage of 1540 mV with a CS400/CS405 rated ≤20 PSI. For a CS400/CS405 rated >20 PSI use 860 mV.

NOTE If the value in MA_MEAS goes to -99999, your particular transducer may require a slightly lower excitation voltage. If this is the case, decrease the recommended millivolts excitation by 10 percent.

Using EDLOG:

```
1:  Full Bridge (P6)
  1:            1        Reps
  2:           12*       50 mV Fast Range
  3:            1        DIFF Channel
  4:            1        Excite all reps w/Exchan 1
  5:         1540        mV Excitation          ;NOTE:  use 860 if psi>20
  6:            1        Loc [ MA_MEAS   ]
  7:            0.01     Mult                   ;NOTE:  first multiplier
  8:            0.0      Offset
*For a 21X use Range Code 13.
```

```
2:  Full Bridge (P6)
  1:            1        Reps
  2:           12*       50 mV Fast Range
  3:            2        DIFF Channel
  4:            1        Excite all reps w/Exchan 1
  5:         1540        mV Excitation            ;NOTE:  use 860 if psi>20
  6:            2        Loc [ MV_MA     ]
  7:            0.5      Mult                     ;NOTE:  second multiplier
  8:            0        Offset
*For a 21X use Range Code 13.

3:  Z=X/Y (P38)
  1:            2        X Loc [ MV_MA     ]
  2:            1        Y Loc [ MA_MEAS   ]
  3:            3        Z Loc [ MV        ]

4:  Z=X*F (P37)
  1:            3        X Loc [ MV        ]
  2:            0.538    F                        ;NOTE:  third multiplier (from calibration)
  3:            4        Z Loc [ HEAD_FT   ]

5:  Z=X+F (P34)
  1:            4        X Loc [ HEAD_FT   ]
  2:            0.0      F                        ;NOTE:  site/job specific offset
  3:            4        Z Loc [ HEAD_FT   ]
```

4.5 BDR301/320 Programming

The BDR301/320 can be programmed to measure the CS400/CS405 by prompt programming. Select **6 WIR** for the measurement type. The multiplier must be multiplied by 0.05 for prompt programming the BDR: multiplier = 0.538 X 0.05 = 0.0269 for the above calibration. Example:

Input Table Number 01
Measurement Interval Mins 0001

Loc	Name	Units	Type	Chn	Mult	Offset
01	HEAD	FT	6WIR	001	+.0269	+0.0000
02			OPT?			

NOTE Remember to create an output table to store data for retrieval.

The BDR301/320 can also be programmed to measure the CS400/CS405 by direct programming. The multiplier for direct programming is the same as the multiplier for one of the other dataloggers. The following program was generated using EDLOG3 from PC300.

```
01:  Full Bridge (P6)
  01:           1        Rep
  02:           0        Autorange
  03:           1        In Chan
  04:           1        Loc [:MA_MEAS]
  05:           0.01     Mult
  06:           0.0      Offset
02:  Full Bridge (P6)
```

```
   01:          1         Rep
   02:          0         Autorange
   03:          2         In Chan
   04:          2         Loc [:MV_MA]
   05:          0.5       Mult
   06:          0.0       Offset

03:  Z=X/Y (P38)
   01:          2         X Loc MV_MA
   02:          1         Y Loc MA_MEAS
   03:          3         Z Loc [:MV    ]

04:  Z=X*F (P37)
   01:          3         X Loc MV
   02:          0.538     F                       ; Calibration multiplier.
   03:          4         Z Loc [:HEAD_FT]

05:  Z=X+F (P34)
   01:          4         X Loc HEAD_FT
   02:          0.0       F                       ; Site/job specific offset
   03:          4         Z Loc [:HEAD_FT]
```

NOTE Additional instructions are needed to output data to final storage. For example, time periodic output in BDR direct programming might include instructions P84, P70, etc.

4.6 PST3/8 Programming

The PST3/8 is preprogrammed. Please refer to the PST3/8 manual for instructions.

5. Maintenance

Periodic evaluation of the desiccant is vital for keeping the vent tube dry. To assess the effectiveness of the desiccant, use one of the following:

- An indicating desiccant that changes color when it’s losing its drying power
- An enclosure humidity indicator such as our #6571 humidity indicator card

5.1 Every Visit, At Least Monthly

- Collect data
- Visually inspect wiring and physical conditions
- Check indicating desiccant or enclosure humidity indicator; service desiccant if necessary
- Check battery condition (physical and *6 mode of the datalogger)

- Check all sensor readings (*6 mode of the datalogger); adjust transducer offsets if necessary
- Check recent data (*7 mode of the datalogger)
- Perform routine maintenance suggested by manufacturers

NOTE See datalogger manual for more information on *6 and *7 modes.

5.2 Every Three Months

- Change batteries (as needed--may be less often)
- Replace enclosure desiccants
- Check calibration of all sensors
- Inspect probe cable conditions for deterioration or damage
- Check wire connections ensuring they are still secure

5.3 Every Two to Three Years or on a Rotating Schedule

Send the transducers to the factory or laboratory for inspection and have them serviced and/or replaced as needed.

6. Troubleshooting

The most common causes of erroneous pressure transducer data include:

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

To troubleshoot, do the following:

- Check your connections to the datalogger. Look for loose or broken wires, and moisture at the points of connection.
- Inspect the pressure transducer cable for wear, stress, or other indications of damage.
- Check the vent tube for plugging and condensation.

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