INSTRUCTION MANUAL

Using the Keller Series 169/173 Submersible Pressure Transducer with Campbell Scientific Dataloggers Instruction Manual

preliminary

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1. General Information

The Keller (KPSI) 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 Keller 169/173 contains a silicon 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 # L7977 in series with the black excitation wire. Keller 169/173 transducers are vented so that changes in barometric pressure are compensated for in the measurement.

The difference between the Keller 169 and Keller 173 is specified accuracy. The Keller 169 has an accuracy of 0.25% of the full scale output. The Keller 173 has an accuracy of 0.1% of the full scale output.

2. Specifications

Static Accuracy*	±0.25% FSO BFSL (Keller 169)
	±0.1% FSO BFSL (Keller 173)
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 Keller 169/173 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.

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.

NOTE The desiccant must be changed when the color changes from blue to pink. Replacement desiccant tubes, part C1420, may be purchased from Campbell Scientific, or the desiccant tube may be opened to allow replacement of the desiccant directly.

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. If possible, submerge the sensor transducer-side up to minimize the possibility of bubbles becoming trapped. Once submerged, the transducer would be oriented according to your requirements.

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 SGB20 Spark Gap Board. 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

Keller 169/173	Datalogger	#L7977
	E1	Purple
	1H	Yellow
Black	1L	Black
Red	2H	
Green	2L	
White	AG	
Clear	G/ground	

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 Edlog, or the datalogger Keyboard/Display to program the datalogger to read these sensors. All programming methods require the "slope1" and "offset1" 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. (See Appendix A for a sample Calibration Report).

4.1 Using Edlog or the Keyboard/Display

Use two sequential Instruction 8s – Excite-Delay-Differential Voltage Measurements. Your datalogger manual has a detailed explanation of Instruction 8.

4.1.1 Multipliers

Five multipliers are required in a datalogger program for a Keller 169/173. The multiplier for the first P8 instruction, parameter eight, is 0.01, the multiplicative inverse of 100 (Ohms). The multiplier for the second P8 instruction, parameter eight, is 1. The third multiplier for the P30 is 0.5, the factory calibration current in mA. These first three multipliers are used for all Keller 169/173's.

The fourth multiplier (used in the P37 instruction, parameter two) is a calibration multiplier and is specific to each Keller 169/173. Before you begin programming, use the factory calibration sheet provided with your transducer to determine the fourth multiplier. The number you require is labeled "slope1" and is recorded in units of PSIG/mV.

A fifth multiplier is used to convert the PSIG value. Table 1 shows the conversion from PSIG to different units.

TABLE 1. Multipliers to convert the PSIG reading to different units

For	Multiply by
feet	2.3067
metres	0.70309
millimetres	703.09
inches	27.6804
PSI	1.0

4.1.2 Offsets

Two offsets are required in a datalogger program for a Keller 169/173. The first offset is a calibration offset and is specific to each Keller 169/173. Before you being programming, use the factory calibration sheet provided with your transducer to determine the first offset. The number you require is labeled "offset1" and is recorded in units of mV. It is used in the first P34 instruction (parameter two).

The second offset is optional. It is a site-specific offset, which allows you to offset your reading to reflect your site-specific requirements. It is used in the second P34 instruction (parameter two). For example, you may wish to record the fluctuation of the water level around a base level. You could take an initial reading, and then add this value to your program in order to have that reading be used as the base. Your recorded values would then be a change in level from your initial base reading.

4.2 CR10(X), CR510, and CR500 Programming

Use an excitation voltage of 2000 mV for a CR500, CR510, or CR10(X) using a Keller 169/73.

```
1:  Ex-Del-Diff (P8)
 1: 1        Reps
 2: 4        250 mV Slow Range
 3: 1        DIFF Channel
 4: 1        Excite all reps w/Exchan 1
 5: 10       Delay (0.01 sec units)              ;NOTE: delay 100ms for long cables
 6: 2000  mV Excitation
 7: 1        Loc [ Res100mA  ]
 8: 0.01   Mult                                  ;NOTE: first multiplier
 9: 0        Offset

2:  Ex-Del-Diff (P8)
 1: 1        Reps
 2: 4       250 mV Slow Range
 3: 2        DIFF Channel
 4: 1        Excite all reps w/Exchan 1
 5: 10       Delay (0.01 sec units)              ;NOTE: delay 100ms for long cables
 6: 2000  mV Excitation
 7: 2        Loc [ DepthmVmA ]
 8: 1        Mult                                ;NOTE: second multiplier
 9: 0        Offset

3:  Z=F x 10^n (P30)
1:  0.5      F                                   ;NOTE: third multiplier
2:  00       n, Exponent of 10
3:  3        Z Loc [ Cal_mA ]

4:  Z=X/Y (P38)            ;NOTE: Ratio:  factory and actual currents
 1: 3        X Loc [ Cal_mA ]
 2: 1        Y Loc [ Res100mA ]
 3: 4        Z Loc [ Res_Cal ]

5:  Z=X*Y (P36)
1:  2        X Loc [DepthmVmA ]
2:  4        Y Loc [ Res_Cal ]
3:  5        Z Loc [ PSI ]

6:  Z=X+F (P34)
 1: 5        X Loc [ PSI ]
 2: -.3072   F                                   ;NOTE: first offset (cal. report)
 3: 5        Z Loc [ PSI ]

7:  Z=X*F (P37)
 1: 5        X Loc [ PSI ]
 2: .2011    F                                   ;NOTE: fourth multiplier (cal. report)
 3: 5        Z Loc [ PSI ]

8:  Z=X*F (P37)
 1: 5        X Loc [ PSI ]
 2: 703.09   F                                   ;NOTE: fifth multiplier (table 1)
 3: 6        Z Loc [ DEPTH_MM  ]
```

```
9:  Z=X+F (P34)
 1: 6       X Loc [ DEPTH_MM  ]
 2: 0       F                                          ;NOTE: second (optional) offset
 3: 7       Z Loc [ SS_DEP_MM ]
```

4.3 CR23X and 21X Programming

Use an excitation voltage of 2000 mV for a 21X, or CR23X with a Keller 169/173.

```
1:  Ex-Del-Diff (P8)
 1: 1       Reps
 2: 23      200 mV, 60 Hz Reject, Slow Range        ;NOTE: 21X use range 4 (500mV slow range)
 3: 1       DIFF Channel
 4: 1       Excite all reps w/Exchan 1
 5: 10      Delay (0.01 sec units)                  ;NOTE : delay 100ms for long cables
 6: 2000    mV Excitation
 7: 1       Loc [ Res100mA  ]
 8: 0.01    Multiplier                              ;NOTE : first multiplier
 9: 0       Offset

2:  Ex-Del-Diff (P8)
 1: 1       Reps
 2: 23      200 mV, 60 Hz Reject, Slow Range        ;NOTE: 21X use range 4 (500mV slow range)
 3: 2       DIFF Channel
 4: 1       Excite all reps w/Exchan 1
 5: 10      Delay (0.01 sec units)                  ;NOTE : delay 100ms for long cables
 6: 2000    mV Excitation
 7: 2       Loc [ DepthmVmA ]                       ;NOTE : Second multiplier
 8: 1.0     Multiplier
 9: 0.0     Offset

3:  Z=F x 10^n (P30)
 1: .5      F                                       :NOTE : Third Multiplier
 2: 0       n, Exponent of 10
 3: 3       Z Loc [ Cal_mA    ]

4:  Z=X/Y (P38)                                     :NOTE : Ratio : factory and actual currents
 1: 2       X Loc [ DepthmVmA ]
 2: 1       Y Loc [ Res100mA  ]
 3: 4       Z Loc [ Res_Cal   ]

5:  Z=X*Y (P36)
 1: 2       X Loc [ DepthmVmA ]
 2: 4       Y Loc [ Res_Cal   ]
 3: 5       Z Loc [ PSI       ]

6:  Z=X+F (P34)
 1: 5       X Loc [ PSI       ]
 2: -.3072  F                                       :NOTE : first offset (cal. report)
 3: 5       Z Loc [ PSI       ]

7:  Z=X*F (P37)
```

```
 1: 5       X Loc [ PSI      ]
 2: .2011    F                                      ;NOTE: fourth multiplier (cal. report)
 3: 5       Z Loc [ PSI      ]

8:  Z=X*F (P37)
 1: 5       X Loc [ PSI      ]
 2: 703.09   F                                      ;NOTE : fifth multiplier (table)
 3: 6       Z Loc [ DEPTH_MM  ]

9:  Z=X+F (P34)
 1: 6       X Loc [ DEPTH_MM  ]
 2: 0.0      F                                      ;NOTE: second (optional) offset
 3: 7       Z Loc [ SS_DEP_MM ]
```

4.4 CRBasic Example for CR1000

```
'CR1000 Series Datalogger
' Example CR1000 Program for KELLER Pressure Transducer

'Declare constants
Const Slope = 0.4842    'Enter Slope1 value in PSIG/mV from KELLER calibration sheet here
Const Offset = 0.2737           'Enter Offset1 value in mV from KELLER calibration sheet here
Const SS_Offset_mm = 2000    'Enter the site specific offset here.  This is the depth of water
                               'between the tip of the KELLER pressure transducer to the
                               'bottom of the water source in mm.
Const MultDepth = 703.09       'Enter multiplier for required units, i.e. 703.09 for mm
Const Cal_mA = 0.5             'Constant Cal_mA remains the same for all KELLER
                               'pressure transducers

'Declare Public Variables
Public SS_Depth_mm
Public Depth_mm
Public PSI
Public Res100mA
Public DepthmVmA

'Define Data Tables
'This data table stores a ten minute average and sample of the site specific depth in mm
DataTable (TenMin,1,-1)
        DataInterval (0,10,Min,10)
        Average (1,SS_Depth_mm,FP2,False)
        Sample (1,SS_Depth_mm,FP2)
EndTable

'Main Program
BeginProg
        Scan (1,Sec,0,0)
                'Measure the KELLER pressure transducer.
                ExciteV (Vx1,2000,0)
                'Delay the measurement to allow the KELLER to stabilize
                Delay (100,0,mSec)
                VoltDiff (Res100mA,1,mV250,1,True ,0,_60Hz,0.01,0)
                ExciteV (Vx1,2000,0)
                VoltDiff (DepthmVmA,1,mV250,2,True ,0,_60Hz,1.0,0)
```

```
        'Convert the measured values into PSI
        PSI = ((DepthmVmA*(Cal_mA/Res100mA))-Offset)*Slope
        'Convert the PSI value into mm
        Depth_mm = PSI*MultDepth
        'Add the site specific offset in mm
        SS_Depth_mm = Depth_mm+SS_Offset_mm

        'Call the output table
        CallTable TenMin
    NextScan
EndProg
```

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 colour when it's losing its drying power
- An enclosure humidity indicator such as our # L6571 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:

- air bubbles beside the transducer silicon element
- poor sensor connections to the datalogger
- damaged cables
- damaged transducers
- moisture in the vent tube
- kinked or damaged vent tube cable
- vent tube still capped or disconnected from cable

To troubleshoot, do the following:

- Gently shake the transducer to dislodge any bubbles. If possible, invert the sensor so that the transducer head is facing upwards, then return to the proper orientation.
- 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.
- Check that the vent tube is uncapped, and still connected to the cable.