INSTRUCTION MANUAL

CS100 Barometric Pressure Sensor

Revision: 8/12

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CS100 Barometric Pressure Sensor

1. Introduction

The CS100 measures barometric pressure for the range of 600 to 1100 mb. This range equates to from below sea level (as in a mine) up to 12,000 feet above sea level. Designed for use in environmental applications, the CS100 is compatible with all Campbell Scientific dataloggers.

Before using the CS100, please study

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

More details are available in the remaining sections.

2. Cautionary Statements

- Warning: Failure to protect the sensor from condensation may result in permanent damage.
- Warning: Improper wiring may damage the CS100 beyond repair.
- Care should be taken when opening the shipping package to not damage or cut the cable jacket. If damage to the cable is suspected, consult with a Campbell Scientific applications engineer.
- Although the CS100 is rugged, it should be handled as a precision scientific instrument.
- The black outer jacket of the cable is Santoprene® rubber. This compound was chosen for its resistance to temperature extremes, moisture, and UV degradation. However, this jacket will support combustion in air. It is rated as slow burning when tested according to U.L. 94 H.B. and will pass FMVSS302. Local fire codes may preclude its use inside buildings.

3. Initial Inspection

- Upon receipt of the CS100, inspect the packaging and contents for damage. File damage claims with the shipping company.

4. Quickstart

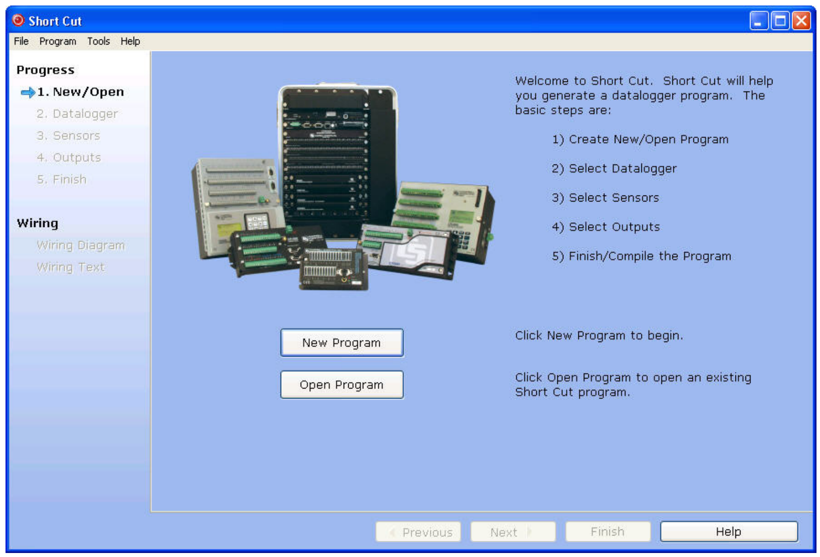
4.1 Step 1 — Mount Sensor to an Enclosure Backplate

The mounting holes for the sensor are one-inch-centered (three inches apart), and will mount directly onto the holes on the backplates of the Campbell Scientific enclosures. Mount the sensor with the pneumatic connector pointing vertically downwards to prevent condensation collecting in the pressure cavity, and also to ensure that water cannot enter the sensor.

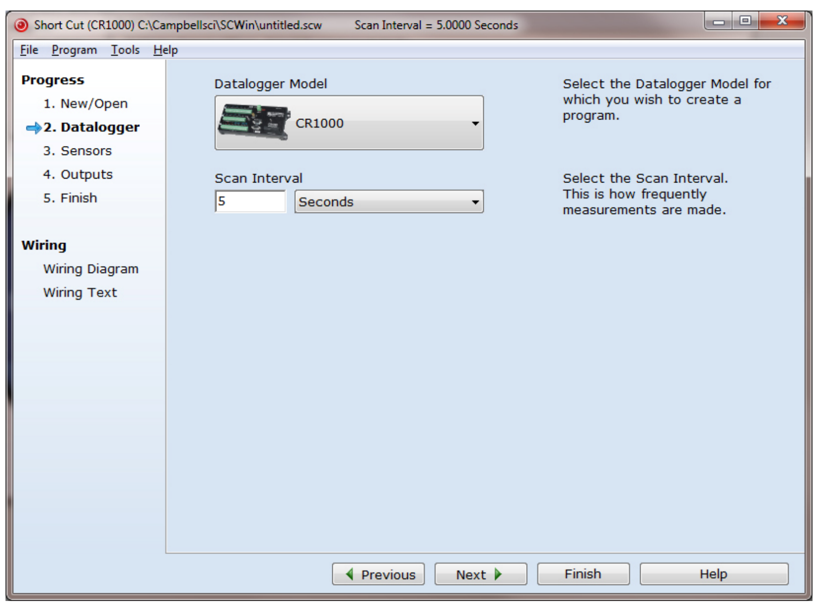
4.2 Step 2 — Use SCWin Short Cut to Program Datalogger and Generate Wiring Diagram

The simplest method for programming the datalogger to measure the CS100 is to use Campbell Scientific's SCWin Short Cut Program Generator.

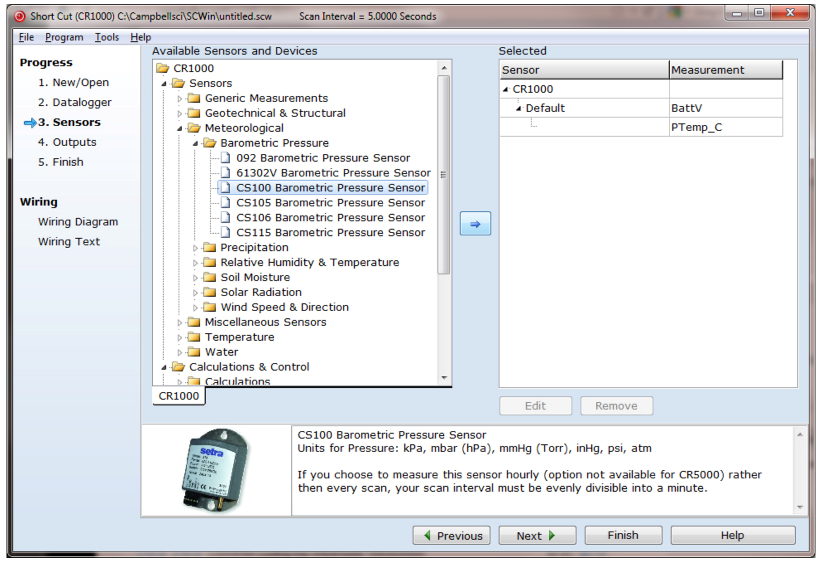
1. Open Short Cut and click on **New Program**.



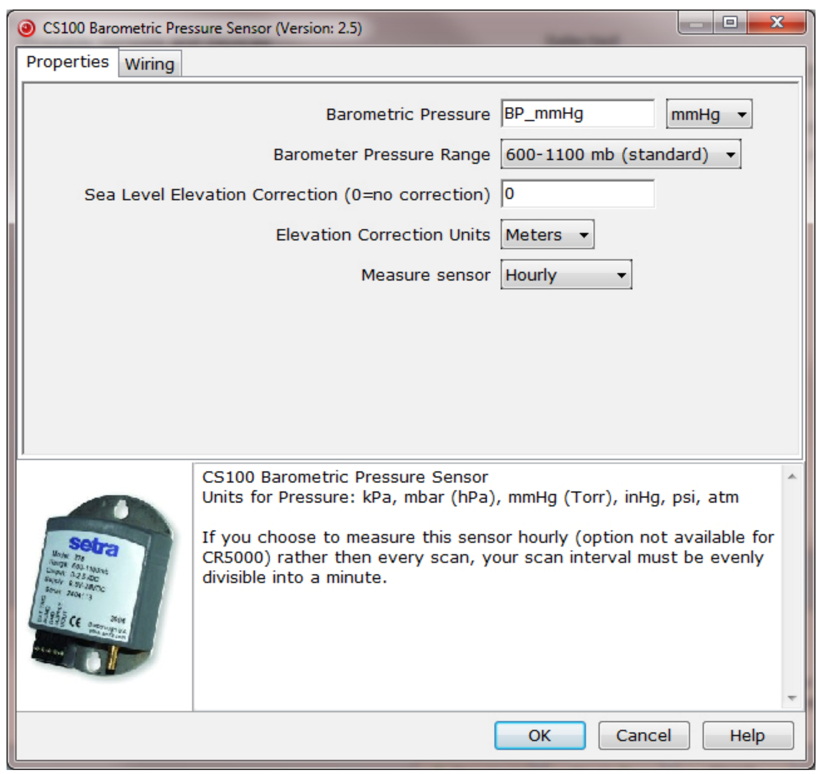
2. Select a datalogger and scan interval.



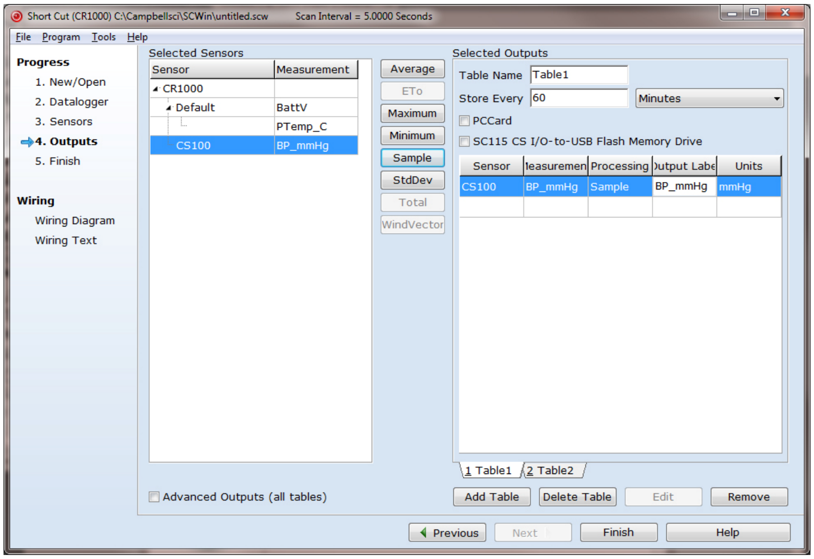
3. Select **CS100 Barometric Pressure Sensor** then click the right arrow in the middle of the page to add the sensor to the list of sensors to be measured.



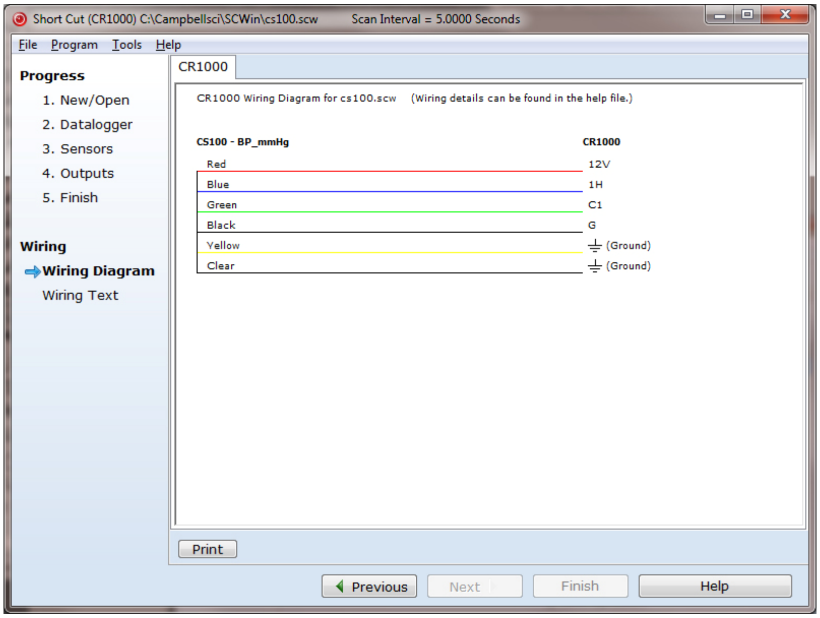
4. Define the name of the public variables. Variable defaults to **BP_mmHg** that holds the barometric pressure measurements. Select the desired units of measure, pressure range, sea level elevation correction, elevation correction units, and whether the sensor should be measured hourly.



5. Choose the outputs for the barometric pressure and then select finish.



6. Remove the yellow warning label from the pigtails and wire according to the wiring diagram generated by SCWin Short Cut.



WARNING **Improper wiring may damage the CS100 beyond repair.**

5. Overview

The CS100 is a capacitive pressure transducer that uses the Setra's electrical capacitor technology for barometric pressure measurements over the 600 to 1100 millibar range. The transducer’s compact and rugged polyester housing with stainless blackplate contains two closely-spaced, parallel, electricallyisolated metallic surfaces. One of the surfaces is essentially a diaphragm constructed of a Setra's proprietary compound of fused glass and ceramic (Setraceram™) or a low-hysteresis material, such as 17-4 PH SS. The diaphragm is capable of detecting a slight change in the applied pressure, which is then converted to an analog voltage signal by Setra's custom Application Specific Integrated Circuit (ASIC). The analog signal generated by the barometer can be directly measured by a Campbell Scientific datalogger.

The CS100 is supplied in the triggered mode, in which the datalogger switches 12 VDC power to the barometer before the measurement. The datalogger then powers down the barometer after the measurements to conserve power.

Other measurement range options such as 500 to 1100 millibar, and 800 to 1100 millibar are also available. Please contact Campbell Scientific, Inc. for ordering these special versions.

Campbell Scientific offers the CS100-QD, a version of the CS100 that includes a connector for use with a RAWS-F or RAWS-P weather station (refer to the RAWS-F and RAWS-P manuals for more information).

If the CS100 and datalogger will be housed in different enclosures, the CABLE5CBL-L should be used instead of the cable that is shipped with the CS100. The CABLE5CBL-L can terminate in:

- Pigtails that connect directly to a Campbell Scientific datalogger (option –PT).
- Connector that attaches to a prewired enclosure (option –PW). Refer to *www.campbellsci.com/prewired-enclosures* for more information.

FIGURE 5-1. CS100 Barometric Pressure Sensor

6. Specifications

Features:

- Integral switching circuit limits power consumption to measurement cycle
- Compatible with all Campbell Scientific dataloggers (including the CR200(X) series)
- Calibration NIST traceable
- Meets CE conformance standards

Compatibility Dataloggers:	CR200(X) series CR800 series CR1000 CR3000 CR5000 CR9000(X) CR7X CR510 CR10(X) CR23X 21X

6.1 Performance

6.1.1 Performance for “Standard” Range Option

Measurement Range:	600 mb to 1100 mb (hPa)
Operating Temperature Range:	-40° to +60°C (-40° to +140°F)
Storage Temperature Range:	-60° to +120°C (-76° to +248°F)
Proof Pressure:	1500 mb
Burst Pressure:	2000 mb
Humidity Range:	non-condensing (up to 95% RH)
Media Compatibility:	non-corrosive, non-condensing air or gas
Resolution:	0.01 mb
Total Accuracy[1]:	±0.5 mb @ 20°C ±1.0 mb @ 0° to +40°C ±1.5 mb @ -20° to +50°C ±2.0 mb @ -40° to +60°C
Linearity:	±0.4 mb
Hysteresis:	±0.05 mb
Repeatability:	±0.03 mb
Long-term Stability:	±0.1 mb per year

[1] The root sum squared (RSS) of end point non-linearity, hysteresis, non-repeatability and calibration uncertainty.

6.1.2 Performance for "500 to 1100 mb" Range Option

Measurement Range:	500 to 1100 mb
Total Accuracy[2]:	±0.6 mb @ 20°C ±1.2 mb @ 0° to +40°C ±2.0 mb @ -20° to +50°C ±2.5 mb @ -40° to +60°C
Linearity:	±0.5 mb
Hysteresis:	±0.06 mb
Repeatability:	±0.04 mb

6.1.3 Performance for "800 to 1100 mb" Range Option

Measurement Range:	800 to 1100 mb
Total Accuracy[3]:	±0.3 mb @ 20°C ±0.6 mb @ 0° to +40°C ±1.0 mb @ -20° to +50°C ±1.5 mb @ -40° to +60°C
Linearity:	±0.25 mb
Hysteresis:	±0.03 mb
Repeatability:	±0.02 mb

6.2 Electrical

Supply Voltage:	9.5 to 28 Vdc
Current Consumption:	3 mA nominal (operating mode) 1 µA quiescent (sleep mode)
Signal Output:	0 to 2.5 Vdc
Warm-up Time:	<1 s from shutdown mode
Response Time:	<100 ms

6.3 Physical

Dimensions (Main Box):	9.1 x 6.1 x 2.5 cm (3.6 x 2.4 x 1.0 in)
Weight:	135 g (4.8 oz)
Mounting Hole Centers:	7.62 cm (3 in)
Pressure Connector:	1/8 in ID barbed fitting

NOTE The black outer jacket of the cable is Santoprene® rubber. This compound was chosen for its resistance to temperature extremes, moisture, and UV degradation. However, this jacket will support combustion in air. It is rated as slow burning when tested according to U.L. 94 H.B. and will pass FMVSS302. Local fire codes may preclude its use inside building.

[2] The root sum squared (RSS) of end point non-linearity, hysteresis, non-repeatability and calibration uncertainty.

[3] The root sum squared (RSS) of end point non-linearity, hysteresis, non-repeatability and calibration uncertainty.

7. Installation

7.1 Enclosure Considerations

To prevent condensation, install the sensor in an environmentally protected enclosure, complete with desiccant, which should be changed at regular intervals.

CAUTION Failure to protect the sensor from condensation may result in permanent damage.

The CS100 is typically mounted in a Campbell Scientific enclosure next to the datalogger. Campbell Scientific also offers the ENC100 for situations where it is desirable to house the CS100 in its own enclosure. The ENC100 is a 6.7-in. x 5.5-in. x 3.7-in. enclosure that includes a compression fitting for cable entry, a vent for equalization with the atmosphere, a backplate for mounting the CS100, and hardware for mounting the ENC100 to a tripod, tower, or pole (see FIGURE 7-1).

FIGURE 7-1. ENC100 is a very small enclosure that can house one CS100

Remember that for the sensor to detect the external ambient pressure, the enclosure must vent to the atmosphere (i.e., not be hermetically sealed). Enclosures purchased from Campbell Scientific properly vent to the atmosphere.

NOTE For user-supplied enclosures, it may be necessary to make a vent hole on the outer wall. In this situation, do not make the hole on one of the vertical side walls, as wind blowing around it can cause transient changes in pressure.

7.2 Wiring

7.2.1 Datalogger Connection

Before connecting the barometer to the datalogger, a yellow warning label must be removed from the pigtails (see FIGURE 7-2). The warning label reminds the user of the importance of properly connecting the barometer to the datalogger. Proper wiring is shown in TABLE 7-1.

FIGURE 7-2. CS100 as removed from the box

TABLE 7-1. Signal and Ground Connectors for CS100			
Wire	**CS100 Terminal**	**Datalogger Single-Ended Measurement**	**Datalogger Differential Measurement**
Blue	VOUT	S.E. Input	High Side of Diff Input
Yellow	AGND	AG (CR10(X), CR500, CR510) ⏚ (Other Dataloggers)	Low Side of Diff. Input
Black	GND	⏚ (21X, CR7, CR9000(X)) G (Other Dataloggers)	⏚ (21X, CR7, CR9000(X)) G (Other Dataloggers)
Green	EXT TRIG	Control port (use to turn power on/off)	Control port (use to turn power on/off)
Red	SUPPLY	12 VDC	12 VDC
Shield	Shield	G (CR10(X), CR500, CR510) ⏚ (Other Dataloggers)	G (CR10(X), CR500, CR510) ⏚ (Other Dataloggers)

WARNING **Improper wiring may damage the CS100 beyond repair.**

7.2.2 5-pin Screw Terminal Plug Connector

The datalogger connects to the CS100 via a 5-pin screw terminal plug connector. This connector is removable and may be replaced. The replacement connector may come with a connector key attached to it to ensure that the connector is plugged into the CS100 right side up (see FIGURE 7-3). When the connector is right side up, it will easily plug into the barometer.

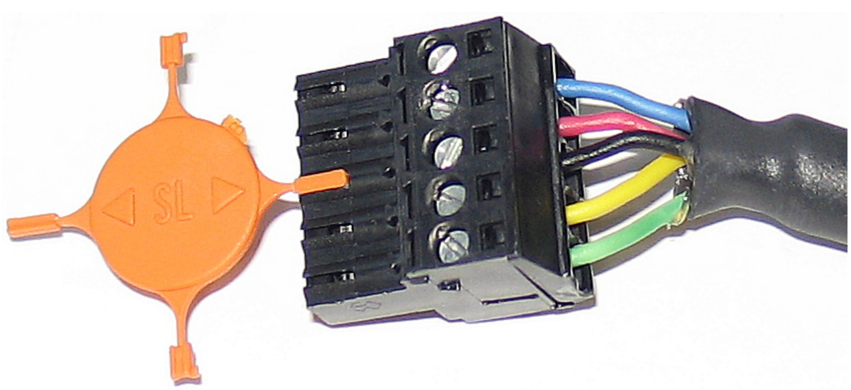


FIGURE 7-3. Connector key attached to 5-pin screw terminal plug connector

WARNING **A 5-pin screw terminal that is plugged in upside down will damage the sensor—perhaps beyond repair.**

7.3 Programming

The CS100 sensor is measured using the singled-ended voltage measurement instruction (**VoltSE()** in CRBasic and Instruction 1 in Edlog).

Atmospheric pressure changes little with time. In most weather station applications measuring pressure once an hour is adequate.

7.3.1 Conversion Factors

In the example programs, the pressure is reported in millibars (mb). To report pressure in different units, multiply the measured pressure by the appropriate conversion factor using the P37 (Z=X*F) instruction for CR500, CR510, CR10(X), CR23X, 21X, and CR7, or by adding an expression for CR200(X), CR800, CR850, CR1000, CR3000, CR5000, and CR9000(X) dataloggers. See TABLE 7-2 below for conversion factors.

TABLE 7-2. Conversion Factors for Alternative Pressure Units

To Find	Multiply by
hPa	1.0
kPa	0.1
mm of Hg	0.75006
in of Hg	0.02953
Psi	0.0145
Atm	0.00099
Torr	0.75006

7.3.2 Multipliers and Offsets for Different Measurement Range Options

Please refer to the table below for proper multipliers and offsets.

TABLE 7-3. Multipliers and Offsets

Range Options	Multiplier	Offset
600 to 1100 mb (Standard range)	0.2	600
500 to 1100 mb	0.24	500
800 to 1100 mb	0.12	800

7.3.3 Program Examples

The CS100 wiring instructions for the example programs are shown in TABLE 7-4 below.

TABLE 7-4. Wiring for Example Programs

Wire Color	Description	CR10(X)	CR1000
Blue	VOUT – Pressure Signal Out	SE6	SE15
Red	SUPPLY – 12 Vdc Power In	12V	12V
Black	GND – Power Ground	G	G
Yellow	AGND – Signal Ground	AG	⏚
Green	ETX. TRIG. – External Trigger	C8	C4
Clear	Shield	G	G

7.3.3.1 CRBasic Example 1: CR1000 Program Using Sequential Mode

This CR1000 program uses the sequential mode, which is the simplest mode and can be used for most meteorological applications. Although the example is for the CR1000, other CRBasic dataloggers, such as the CR200(X), CR800, CR850, CR3000, and CR9000(X) are programmed similarly. In the example, the CR1000 measures the CS100 once an hour. To do this, the CR1000 uses a control port to turn on the CS100 one minute before the top of the hour. On the hour, the datalogger measures the CS100, and then turns the CS100 off.

```
'CR1000

'Declare Variables and Units
Public BattV
Public PTemp_C
Public BP_mmHg

Units BattV=Volts
Units PTemp_C=Deg C
Units BP_mmHg=mmHg

'Define Data Tables
DataTable(Table1,True,-1)
  DataInterval(0,60,Min,10)
  Sample(1,BP_mmHg,FP2)
EndTable

DataTable(Table2,True,-1)
  DataInterval(0,1440,Min,10)
  Minimum(1,BattV,FP2,False,False)
EndTable

'Main Program
BeginProg
  'Main Scan
  Scan(5,Sec,1,0)
    'Default Datalogger Battery Voltage measurement 'BattV'
    Battery(BattV)
    'Default Wiring Panel Temperature measurement 'PTemp_C'
    PanelTemp(PTemp_C,_60Hz)
    'CS100 Barometric Pressure Sensor measurement 'BP_mmHg'
    If IfTime(59,60,Min) Then PortSet(4,1)
    If IfTime(0,60,Min) Then
      VoltSE(BP_mmHg,1,mV2500,15,1,0,_60Hz,0.2,600)
      BP_mmHg=BP_mmHg*0.75006
      PortSet(4,0)
```

```
    EndIf
    'Call Data Tables and Store Data
    CallTable(Table1)
    CallTable(Table2)
  NextScan
EndProg
```

7.3.3.2 CRBasic Example 2: CR1000 Program Using Pipeline Mode

Although this example is for the CR1000, other CRBasic dataloggers, such as the CR200(X), CR800, CR850, CR3000, and CR9000(X) are programmed similarly. In the example, the CR1000 measures the CS100 once an hour in a program that runs at 1 Hz. In order to keep the CR1000 running in a pipeline mode, the measurement instruction is placed outside the "If" statement. The measurement is made every scan, and the measured value is first written into a temporary variable called "CS100_temp". Once the CS100 is turned on one minute before the hour, the CS100 starts to make the correct pressure measurements. At the top of the hour, the correct value is copied into the current variable called "pressure", and the sensor is turned off immediately.

```
'CR1000 Datalogger

Public CS100_temp
Public pressure
Units pressure = mbar

DataTable (met_data,True,-1)
  DataInterval (0,60,min,10)
    Sample (1,pressure,IEEE4)
EndTable

BeginProg
  Scan (1,sec,3,0)

'Measurement is made every scan outside the "If" statement
    VoltSE (CS100_temp,1,mV2500,15,False,200,250,0.2,600)

'Turn on CS100 one minute before the hour
    If (IfTime (59,60,min)) Then WriteIO (&b1000,&b1000)

'Copy the correct value to a current variable called "pressure" at the top of the
hour
'Turn off CS100 after measurement
    If (IfTime (0,60,min)) Then
      pressure = CS100_temp
      WriteIO (&b1000,&b0)
    EndIf

    CallTable met_data

  NextScan
EndProg
```

7.3.3.3 Edlog Example — CR10X Program

Although this example is for a CR10X, other Edlog dataloggers, such as the CR510, CR23X, CR7, and 21X are programmed similarly. In the example, the CR10X datalogger turns on the CS100 one minute before the top of the hour using a control port. On the hour, the datalogger measures the CS100, and then it turns the CS100 off.

```
;{CR10X}
;
*Table 1 Program
  01: 1          Execution Interval (seconds)

;Turn on CS100 one minute before the hour
;
1:  If time is (P92)
  1:  59         Minutes (Seconds --) into a
  2:  60         Interval (same units as above)
  3:  48*        Set Port 8* High

;Measure CS100 at the top of the hour
;
2:  If time is (P92)
  1:  0          Minutes (Seconds --) into a
  2:  60         Interval (same units as above)
  3:  30         Then Do

3:  Volt (SE) (P1)
  1:  1          Reps
  2:  15         2500 mV Fast Range
  3:  6          SE Channel
  4:  1          Loc [ P_mb    ]
  5:  0.2        Multiplier
  6:  600        Offset

;Turn off CS100
;
4:  Do (P86)
  1:  58*        Set Port 8* Low

5:  End (P95)

6:  If time is (P92)
  1:  0          Minutes (Seconds --) into a
  2:  60         Interval (same units as above)
  3:  10         Set Output Flag High (Flag 0)

7:  Real Time (P77)
  1:  0110       Day,Hour/Minute (midnight = 0000)

;Store in high resolution mode to retain 0.01mb resolution
;
8:  Resolution (P78)
  1:  1          High Resolution
```

```
9:  Sample (P70)
   1:    1              Reps
   2:    1*             Loc [ P_mb      ]

*Table 2 Program
   02:  0.0000          Execution Interval (seconds)

*Table 3 Subroutines

End Program

-Input Locations-
1 P_mb

* Proper entries will vary with program and datalogger channel, and input location assignments.
```

7.3.4 Output Resolution

When storing the values from the CS100 to a data table or to a datalogger's final storage location, care must be taken to choose suitable scaling of the reading, or to store the value with adequate resolution to avoid losing useful resolution of the pressure measurement. The default resolution (low resolution) for Campbell Scientific dataloggers is limited to a maximum of four digits. Even then, the maximum digit value that can be displayed is 6999 for Edlog dataloggers, and 7999 for the CRBasic dataloggers. If you use this option with barometric data scaled in millibars (hPa), a reading above 799.9 mb for CRBasic dataloggers or 699.9 mb for Edlog dataloggers will lose one digit of resolution, e.g. at 900 mb, the resolution is limited to 1 mb.

To retain 0.01 mb resolution, you either need to deduct a fixed offset from the reading before it is stored to avoid exceeding the 799.9 for CRBasic dataloggers or 699.9 for Edlog dataloggers threshold, or output the barometric reading in high resolution format. This can be done by using the IEEE4 format for the CR800, CR850, CR1000, CR3000, CR5000, and CR9000(X) dataloggers or using the Resolution (P78) instruction for our Edlog dataloggers. The default data output format for CR200(X) series datalogger is IEEE4.

7.4 Correcting Pressure to Sea Level

The weather service, most airports, radio stations, and television stations adjust the atmospheric pressure to a common reference (sea level). Equation 1 can be used to find the difference in pressure between the sea level and the site. That value (*dP*) is then added to the offset (600 mb in our example programs) in the measurement instruction. U. S. Standard Atmosphere and dry air were assumed when Equation 1 was derived (Wallace, J. M. and P. V. Hobbes, 1977: *Atmospheric Science: An Introductory Survey*, Academic Press, pp. 59-61).

$$dP = 1013.25\left\{1-\left(1-\frac{E}{44307.69231}\right)^{5.25328}\right\} \qquad (1)$$

The value *dP* is in millibars and the site elevation, *E*, is in meters. Add *dP* value to the offset in the measurement instruction.

Use Equation (2) to convert feet to meters.

$$E(m) = \frac{E(ft)}{3.281ft/m} \tag{2}$$

The corrections involved can be significant: e.g. at 1000mb and 20°C, barometric pressure will decrease by 1.1mb for every 10 meter increase in altitude.

8. Maintenance and Calibration

Since the sensor is semi-sealed, minimum maintenance is required:

1. Visually inspect the cable connection to ensure it is clean and dry.

2. Visually inspect the casing for damage.

3. Ensure that the pneumatic connection and pipe are secure and undamaged.

The external case can be cleaned with a damp, lint-free cloth and a mild detergent solution.

Contact Campbell Scientific, Inc. (435-227-9000) for an RMA number before returning the sensor for recalibration. You may also return the unit directly to Setra for recalibration.

Should you lose the five terminal connector (p/n 16004), the replacement part can be purchased from Campbell Scientific, Inc. Contact Campbell Scientific, Inc. to purchase the part.

CAUTION The CS100 is sensitive to static when the backplate is removed. To avoid damage, take adequate anti-static measures when handling.

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