INSTRUCTION MANUAL

CS106 Barometric Pressure Sensor

Revision: 5/16

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

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General

- Prior to performing site or installation work, obtain required approvals and permits. Comply with all governing structure-height regulations, such as those of the FAA in the USA.
- Use only qualified personnel for installation, use, and maintenance of tripods and towers, and any attachments to tripods and towers. The use of licensed and qualified contractors is highly recommended.
- Read all applicable instructions carefully and understand procedures thoroughly before beginning work.
- Wear a **hardhat** and **eye protection**, and take **other appropriate safety precautions** while working on or around tripods and towers.
- **Do not climb** tripods or towers at any time, and prohibit climbing by other persons. Take reasonable precautions to secure tripod and tower sites from trespassers.
- Use only manufacturer recommended parts, materials, and tools.

Utility and Electrical

- **You can be killed** or sustain serious bodily injury if the tripod, tower, or attachments you are installing, constructing, using, or maintaining, or a tool, stake, or anchor, come in **contact with overhead or underground utility lines**.
- Maintain a distance of at least one-and-one-half times structure height, 20 feet, or the distance required by applicable law, **whichever is greater**, between overhead utility lines and the structure (tripod, tower, attachments, or tools).
- Prior to performing site or installation work, inform all utility companies and have all underground utilities marked.
- Comply with all electrical codes. Electrical equipment and related grounding devices should be installed by a licensed and qualified electrician.

Elevated Work and Weather

- Exercise extreme caution when performing elevated work.
- Use appropriate equipment and safety practices.
- During installation and maintenance, keep tower and tripod sites clear of un-trained or non-essential personnel. Take precautions to prevent elevated tools and objects from dropping.
- Do not perform any work in inclement weather, including wind, rain, snow, lightning, etc.

Maintenance

- Periodically (at least yearly) check for wear and damage, including corrosion, stress cracks, frayed cables, loose cable clamps, cable tightness, etc. and take necessary corrective actions.
- Periodically (at least yearly) check electrical ground connections.

WHILE EVERY ATTEMPT IS MADE TO EMBODY THE HIGHEST DEGREE OF SAFETY IN ALL CAMPBELL SCIENTIFIC PRODUCTS, THE CUSTOMER ASSUMES ALL RISK FROM ANY INJURY RESULTING FROM IMPROPER INSTALLATION, USE, OR MAINTENANCE OF TRIPODS, TOWERS, OR ATTACHMENTS TO TRIPODS AND TOWERS SUCH AS SENSORS, CROSSARMS, ENCLOSURES, ANTENNAS, ETC.

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CS106 Barometric Pressure Sensor

1. Introduction

The CS106 measures barometric pressure for the range of 500 to 1100 mb. This range equates to from below sea level (as in a mine) to over 15,000 feet above sea level. Designed for use in environmental applications, the CS106 is compatible with all Campbell Scientific dataloggers.

NOTE This manual provides information only for CRBasic dataloggers. It is also compatible with many of our retired Edlog dataloggers. For Edlog datalogger support, see an older manual at *www.campbellsci.com/old-manuals* or contact a Campbell Scientific application engineer for assistance.

2. Precautions

- READ AND UNDERSTAND the *Safety* section at the front of this manual.
- Warning: Failure to protect the sensor from condensation may result in permanent damage.
- Warning: Improper wiring may damage the CS106 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 application engineer.
- Although the CS106 is rugged, it should be handled as a precision scientific instrument.

3. Initial Inspection

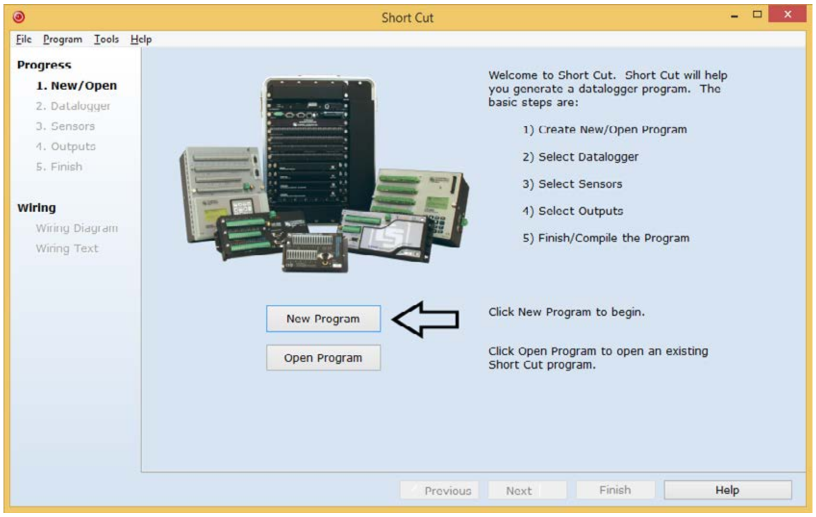
- Upon receipt of the CS106, inspect the packaging and contents for damage. File damage claims with the shipping company.

4. QuickStart

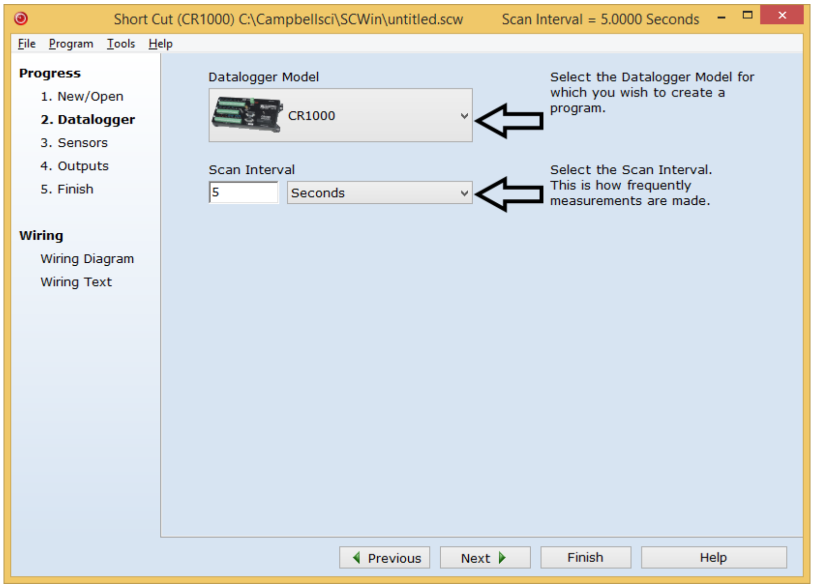
Short Cut is an easy way to program your datalogger to measure the CS106 and assign datalogger wiring terminals. *Short Cut* is available as a download on *www.campbellsci.com* and the *ResourceDVD*. It is included in installations of *LoggerNet*, *PC200W*, *PC400*, or *RTDAQ*.

Use the following procedure to get started.

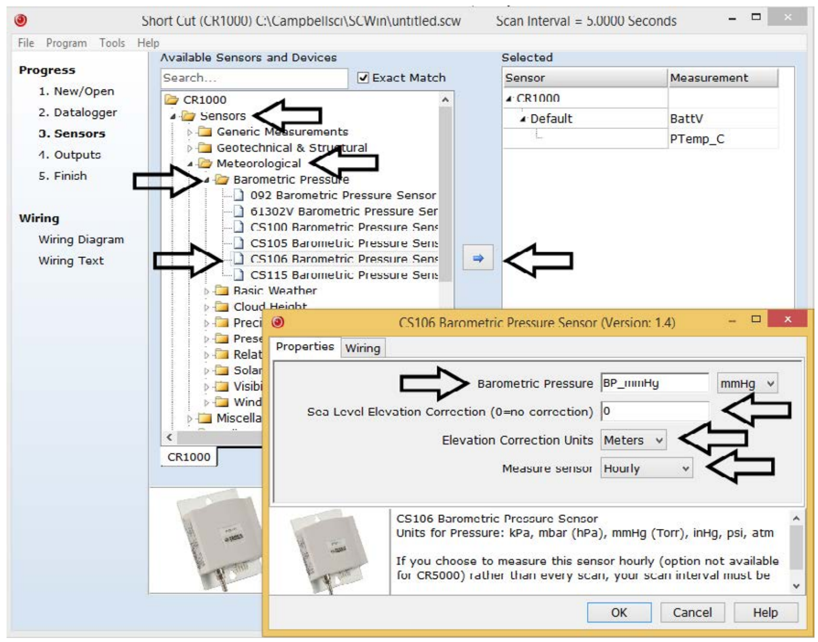
1. Open *Short Cut*. Click **New Program**.



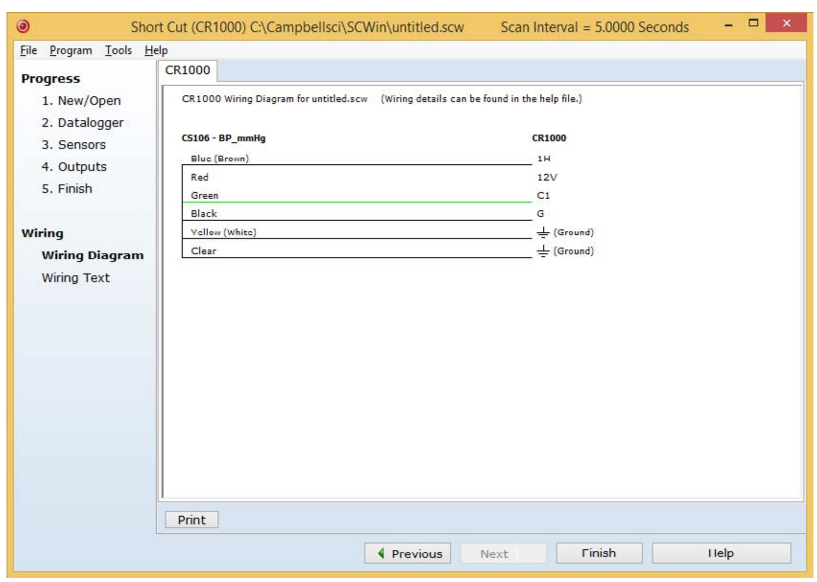
2. Select **Datalogger Model** and **Scan Interval** (default of 5 seconds is OK for most applications). Click **Next**.



3. Under the **Available Sensors and Devices** list, select **Sensors | Meteorological | Barometric Pressure** folder. Select **CS106 Barometric Pressure Sensor**. Click to move the selection to the **Selected** device window. Enter the **Sea Level Elevation Correction**. The default units for the sea level elevation correction is meters; this can be changed by clicking on the **Elevation Correction Units** box and selecting **Feet**. Defaults for the barometric pressure measurement and frequency of the measurement are **mmHg** and **Hourly**, consecutively. These can be changed by clicking the **Barometric Pressure** and **Measure sensor** boxes and selecting different values.



4. After selecting the sensor, click **Wiring Diagram** to see how the sensor is to be wired to the datalogger. The wiring diagram can be printed now or after more sensors are added.



5. Select any other sensors you have, then finish the remaining *Short Cut* steps to complete the program. The remaining steps are outlined in *Short Cut Help*, which is accessed by clicking on **Help** | **Contents** | **Programming Steps**.

6. If *LoggerNet*, *PC400*, *RTDAQ*, or *PC200W* is running on your PC, and the PC to datalogger connection is active, you can click **Finish** in *Short Cut* and you will be prompted to send the program just created to the datalogger.

7. If the sensor is connected to the datalogger, as shown in the wiring diagram in step 4, check the output of the sensor in the datalogger support software data display to make sure it is making reasonable measurements.

WARNING **Improper wiring may damage the CS106 beyond repair.**

5. Overview

The CS106 uses Vaisala's Barocap® silicon capacitive pressure sensor, which has been designed for accurate and stable measurement of barometric pressure. This barometer is encased in a plastic shell (ABS/PC blend) fitted with an intake valve for pressure equalization.

The CS106 outputs a linear 0 to 2.5 Vdc signal that corresponds to 500 to 1100 mb. It can be operated in a shutdown or normal mode (see Section 7.1, *Jumper Settings* ***(p. 6)***). In the shutdown mode, the datalogger switches 12 Vdc power to the barometer during the measurement. The datalogger then powers down the barometer between measurements to conserve power.

If the CS106 and datalogger will be housed in different enclosures, the CABLE5CBL-L should be used instead of the cable that is shipped with the CS106. 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.

6. Specifications

Features:

- Integral switching circuit limits power consumption to measurement cycle
- Compatible with Campbell Scientific CRBasic dataloggers: CR200(X) series, CR300 series, CR6 series, CR800 series, CR1000, CR3000, CR5000, and CR9000(X)

6.1 Operating Range

Pressure:	500 mb to 1100 mb
Temperature:	–40 to 60 °C
Humidity:	non-condensing

6.2 Accuracy

Total Accuracy[3]:	±0.3 mb @ 20 °C ±0.6 mb @ 0 to 40 °C ±1 mb @ –20 to 45 °C ±1.5 mb @ –40 to 60 °C
Linearity[1]:	±0.25 mb @ 20 °C
Hysteresis[1]:	±0.03 mb @ 20 °C
Repeatability[1]:	±0.03 mb @ 20 °C
Calibration Uncertainty[2]:	±0.15 mb @ 20 °C
Long-Term Stability:	±0.1 mb per year

[1] Defined as ±2 standard deviation limits of end-point non-linearity, hysteresis error, or repeatability error

[2] Defined as ±2 standard deviation limits of inaccuracy of the working standard at 1000 mb in comparison to international standards (NIST)

[3] Defined as the root sum of the squares (RSS) of end-point non-linearity, hysteresis error, repeatability error and calibration uncertainty at room temperature

6.3 General

Dimensions:	9.7 x 6.8 x 2.8 cm (3.8 x 2.7 x 1.1 in)
Weight:	90 g (3.2 oz)
Housing Material:	ABS/PC blend
Supply Voltage:	10 to 30 Vdc
Supply Voltage Control:	When the internal jumper is closed, the CS106 is on continually. When the jumper is open, the CS106 can be turned on/off with 5 Vdc/ 0 Vdc.
Supply Voltage Sensitivity:	negligible
Current Consumption:	<4 mA (active); <1 µA (quiescent)
Output Voltage:	0 to 2.5 Vdc
Warm Up Time:	1 s
Pressure Fitting:	barbed fitting for 1/8 in I.D. tubing
Overpressure Limit:	2000 mb

7. Installation

7.1 Jumper Settings

The CS106 can be operated in one of two modes: shutdown and normal. The mode is selected by a jumper located underneath the plastic cover of the barometer. When the jumper is not installed, the CS106 is in shutdown mode and the datalogger turns the CS106 on and off with a control port or excitation channel; to use the excitation channel the datalogger must be able to provide an excitation voltage of 5 Vdc. When the jumper is installed, the CS106 is in normal mode and powered continuously.

NOTE CS106s shipped from Campbell Scientific are configured for shutdown mode (jumper open).

The location of the jumper is shown in FIGURE 7-1.

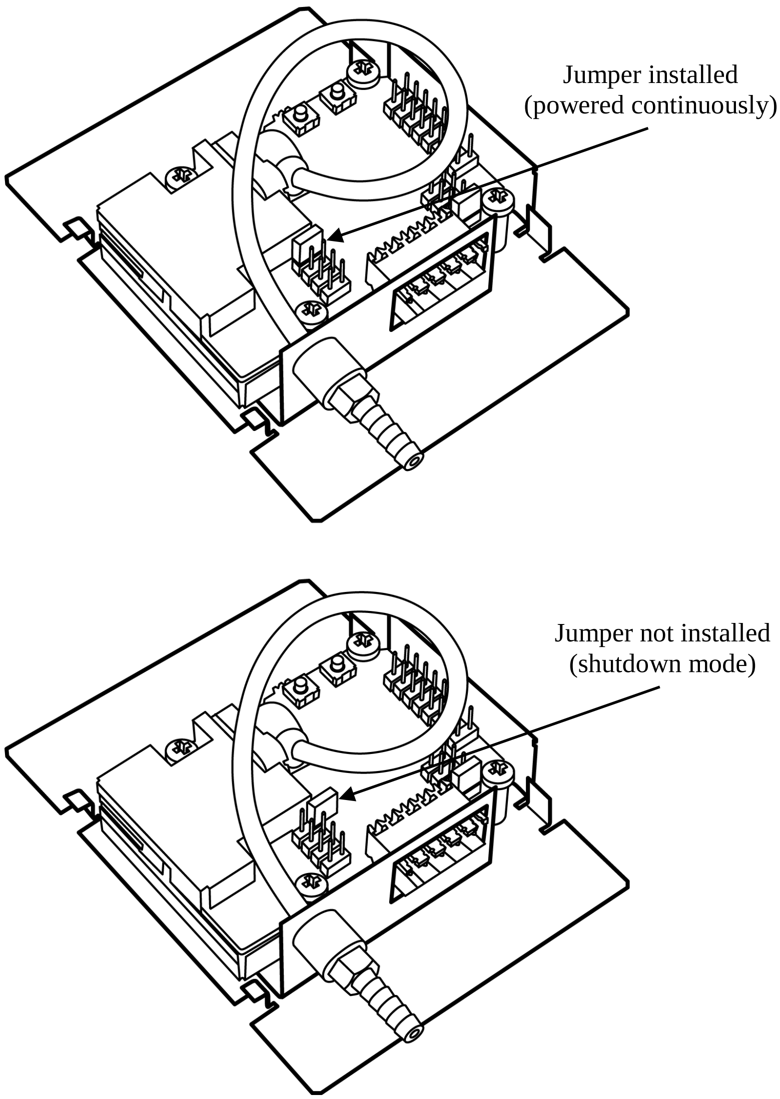


FIGURE 7-1. CS106 jumper settings

7.2 Mounting in the Enclosure

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 CS106 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 CS106 in its own enclosure (see FIGURE 7-2). The ENC100 is a 6.7-inch by 5.5-inch by 3.7-inch enclosure that includes a compression fitting for cable entry, a vent for equalization with the atmosphere, a backplate for mounting the CS106, and hardware for mounting the ENC100 to a tripod, tower, or pole.

FIGURE 7-2. ENC100 is a very small enclosure that can house one CS106

For the sensor to detect the external ambient pressure, the enclosure must vent to the atmosphere (not be hermetically sealed), which may require the addition of 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.

The mounting holes for the sensor are one-inch-centered (three inches apart), and will mount directly onto the holes on the backplate of 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.

7.3 Wiring

7.3.1 Datalogger Connection

To wire an Edlog datalogger, see an older manual at *www.campbellsci.com/old-manuals,* or contact a Campbell Scientific application engineer for assistance.

Before connecting the barometer to the datalogger, a yellow warning label must be removed from the pigtails. The warning label reminds the user of the importance of properly connecting the barometer to the datalogger. Wiring is shown in FIGURE 7-3 and Table 7-1.

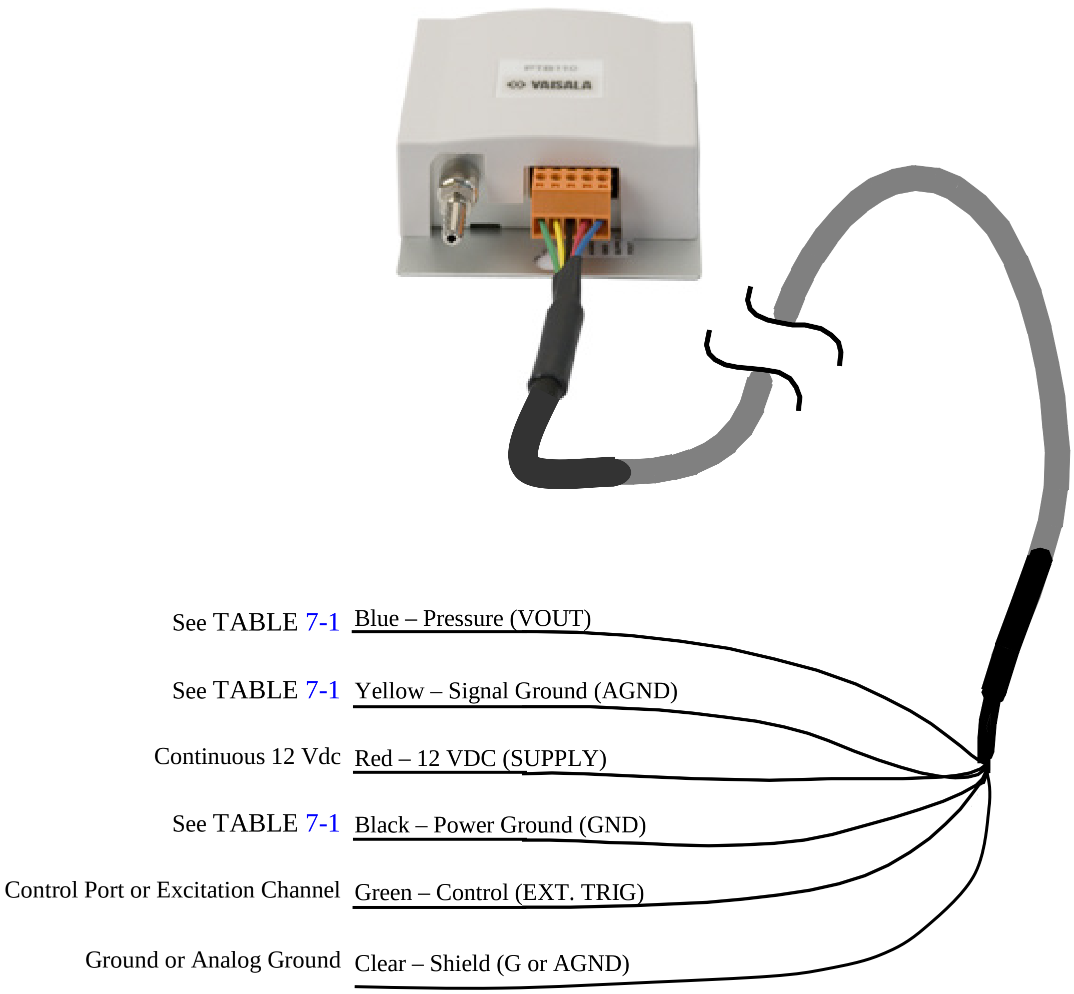


FIGURE 7-3. CS106 wiring diagram

TABLE 7-1. Signal and Ground Connectors for CS106

Wire	CS106 Terminal	Datalogger Single-Ended Measurement	Datalogger Differential Measurement
Blue	VOUT	S.E. Input	High side of differential input
Yellow	AGND	⏚	Low side of differential input
Black	GND	⏚ CR9000(X) **G** (other dataloggers)	⏚ (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	⏚	⏚

WARNING **Improper wiring may damage the CS106 beyond repair.**

7.3.2 5-pin Screw Terminal Plug Connector

The datalogger connects to the CS106 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 CS106 right side up (see FIGURE 7-4). When the connector is right side up, it will easily plug into the barometer.

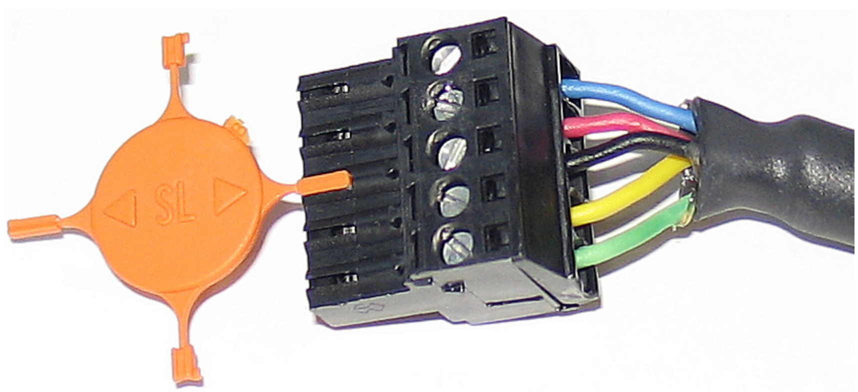


FIGURE 7-4. Connector key attached to 5-pin screw terminal plug connector

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

7.4 Programming

Short Cut is the best source for up-to-date datalogger programming code. Programming code is needed when:

- Creating a program for a new datalogger installation
- Adding sensors to an existing datalogger program

If your data acquisition requirements are simple, you can probably create and maintain a datalogger program exclusively with *Short Cut*. If your data acquisition needs are more complex, the files that *Short Cut* creates are a great source for programming code to start a new program or add to an existing custom program.

NOTE *Short Cut* cannot edit programs after they are imported and edited in *CRBasic Editor*.

A *Short Cut* tutorial is available in Section 4, *QuickStart* ***(p. 1)***. If you wish to import *Short Cut* code into *CRBasic Editor* to create or add to a customized program, follow the procedure in Appendix A, *Importing Short Cut Code Into CRBasic Editor* ***(p. A-1)***. Programming basics for CRBasic dataloggers are provided in the following sections; more detailed information about multiplier and offset calculations, conversion factors, long cable lengths, resolution, and correcting pressure to sea level is provided in Section 8, *Operations* ***(p. 11)***. Complete program examples for select dataloggers can be found in Appendix B, *Example Programs* ***(p. B-1)***.

7.4.1 CRBasic Instructions

The **VoltSE()** measurement instruction programs the datalogger to measure the CS106.

```
VoltSE(Dest, Reps, Range, SEChan, MeasOff, SettlingTime,
Integration, Multiplier, Offset)
```

At sea level, a multiplier of 0.24 and an offset of 500 will report the barometric pressure in mbar or hPa. The offset will need to be adjusted if the barometer is not at sea level (see Section 8.5, *Correcting Pressure to Sea Level* ***(p. 12)***). If different barometric pressure units are desired, see Section 8.2, *Conversion Factors* ***(p. 11)***.

Often the **TimeIntoInterval()** instruction is used to only power the barometer while making the measurements. Atmospheric pressure changes little with time. In most weather station applications, measuring the barometer pressure once an hour is adequate. See Appendix B, *Example Programs* ***(p. B-1)***, for more information.

8. Operations

8.1 Multiplier and Offset Calculation

The multiplier and offset in the **VoltSE()** CRBasic instruction convert millivolts to millibar or hPa. The output from the sensor is 0 to 2.5 V or 0 to 2500 mV and the sensor's operating range is from 500 to 1100 mbars (hPa). Equation 1 uses these values to calculate the multiplier:

$$\text{Multiplier m} = \frac{1100-500}{2500-0} = \frac{600}{2500} = 0.24 \qquad (1)$$

The offset is the barometric value at sea level (see Eq 2).

Offset: o= 500 (mbar or hPa)

The final result according to FIGURE 8-1 is:

$$y = 0.24\frac{mbar}{mV} + 500 \text{ mbar} \qquad (2)$$

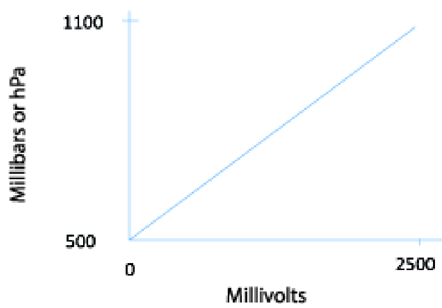


FIGURE 8-1. Point slope graph

8.2 Conversion Factors

In the example program, the pressure is reported in millibars (mb). To report pressure in different units, multiply the measured pressure by the appropriate conversion factor. This is done by including an expression in the CRBasic program. See TABLE 8-1 below for conversion factors.

TABLE 8-1. Conversion Factors for Alternative Pressure Units

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

8.3 Long Lead Lengths

There is a 0.06 mV/foot voltage drop in the CS106 signal leads. This voltage drop, in long lead lengths, will raise the barometric reading by approximately 1.44 mb per 100 feet.

For lead lengths greater than 20 feet, use the differential instruction (**VoltDiff()**) to measure the CS106.

8.4 Output Resolution

When storing the values from the CS106 to a data table, 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 7999. If you use this option with barometric data scaled in millibars (hPa), a reading above 799.9 mb will lose one digit of resolution. For example, at 900 mb, the resolution is limited to 1 mb.

To retain 0.01 mb resolution, you either need to subtract a fixed offset from the reading before it is stored to avoid exceeding the 799.9 threshold, or output the barometric reading in high resolution format. This can be done by using the IEEE4 format. The default data output format for CR200(X)-series datalogger is IEEE4.

8.5 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 3 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 (500 mb in our example programs) in the measurement instruction. U. S. Standard Atmosphere and dry air were assumed when Equation 3 was derived (Wallace, J. M. and P. V. Hobbes, 1977: *Atmospheric Science: An Introductory Survey*, Academic Press, pp. 59-61).

$$dP = 1013.25\left\{1-\left(1-\frac{E}{44307.69231}\right)^{5.25328}\right\} \quad (3)$$

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 (4) to convert feet to meters.

$$E(m) = \frac{E(ft)}{3.281 ft/m} \quad (4)$$

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

9. Maintenance and Calibration

NOTE All factory repairs and recalibrations require a returned material authorization (RMA) and completion of the "Declaration of Hazardous Material and Decontamination" form. Refer to the *Assistance* page at the beginning of this manual for more information.

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

- Visually inspect the cable connection to ensure it is clean and dry.
- Visually inspect the casing for damage.
- 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.

Vaisala recommends recalibration every two years under normal use. In areas where a lot of contaminants are present, recalibration every year is recommended.

You can purchase a replacement five terminal connector (pn 16004) from Campbell Scientific.

CAUTION The CS106 is sensitive to static when the backplate is removed. To avoid damage, take adequate anti-static measures when handling.

Appendix A. Importing Short Cut Code Into CRBasic Editor

This tutorial shows the following:

- How to import a *Short Cut* program into a program editor for additional refinement
- How to import a wiring diagram from *Short Cut* into the comments of a custom program

Short Cut creates files, which can be imported into *CRBasic Editor*. Assuming defaults were used when *Short Cut* was installed, these files reside in the C:\campbellsci\SCWin folder:

- .DEF (wiring and memory usage information)
- .CR2 (CR200(X)-series datalogger code)
- .CR300 (CR300-series datalogger code)
- .CR6 (CR6-series datalogger code)
- .CR8 (CR800-series datalogger code)
- .CR1 (CR1000 datalogger code)
- .CR3 (CR3000 datalogger code)
- .CR5 (CR5000 datalogger code)

Use the following procedure to import *Short Cut* code and wiring diagram into *CRBasic Editor*.

1. Create the *Short Cut* program following the procedure in Section 4, *QuickStart* *(p. 1)*. Finish the program and exit *Short Cut*. Make note of the file name used when saving the *Short Cut* program.
2. Open *CRBasic Editor*.
3. Click **File** | **Open**. Assuming the default paths were used when *Short Cut* was installed, navigate to C:\CampbellSci\SCWin folder. The file of interest has the .CR2, .CR300, .CR6, .CR8, .CR1, .CR3, or .CR5 extension. Select the file and click **Open**.
4. Immediately save the file in a folder different from C:\Campbellsci\SCWin, or save the file with a different file name.

NOTE Once the file is edited with *CRBasic Editor*, *Short Cut* can no longer be used to edit the datalogger program. Change the name of the program file or move it, or *Short Cut* may overwrite it next time it is used.

5. The program can now be edited, saved, and sent to the datalogger.
6. Import wiring information to the program by opening the associated .DEF file. Copy and paste the section beginning with heading “-Wiring for CRXXX–” into the CRBasic program, usually at the head of the file. After pasting, edit the information such that an apostrophe (') begins each line. This character instructs the datalogger compiler to ignore the line when compiling.

Appendix B. Example Programs

B.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) series, CR6 series, CR800 series, CR3000, and CR9000(X) are programmed similarly.

In the example, the CR1000 measures the CS106 once an hour. To do this, the CR1000 uses a control port to turn on the CS106 one minute before the top of the hour. On the hour, the datalogger measures the CS106, and then turns the CS106 off. This example assumes that the jumper is in the default position (open).

CRBasic Example B-1. CR1000 Program Using Sequential Mode

```
'CR1000

'Declare Variables and Units
Public BattV
Public PTemp_C
Public BP
Public BP_mmHg

Units BattV=Volts
Units PTemp_C=Deg C
Units BP = hPa
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)
  'CS106 Barometric Pressure Sensor measurement 'BP_mmHg'
  If TimeIntoInterval(59,60,Min) Then PortSet(1,1)
  If TimeIntoInterval(0,60,Min) Then
    VoltSe(BP,1,mV2500,1,1,0,_60Hz,0.240,500)
    BP_mmHg=BP*0.75006
    PortSet(1,0)
  EndIf
  'Call Data Tables and Store Data
  CallTable(Table1)
  CallTable(Table2)
  NextScan
EndProg
```

B.2 CR1000 Program Using Pipeline Mode

Although this example is for the CR1000, other CRBasic dataloggers, such as the CR200(X) series, CR6 series, CR800 series, CR3000, and CR9000(X) are programmed similarly. In the example, the CR1000 measures the CS106 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 "CS106_temp". Once the CS106 is turned on one minute before the hour, the CS106 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.

The program's integration parameter for the **VoltSE()** instruction is _60Hz. However, for Eddy Covariance programs or other datalogger programs that are executed at a higher frequency, the integration parameter should be 250 µs instead of _60Hz or _50Hz. This prevents skipped scans.

CRBasic Example B-2. CR1000 Program Using Pipeline Mode

```
'CR1000 Datalogger

Public CS106_temp, pressure
Units pressure = mbar

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

BeginProg
PipeLineMode
  Scan (1,sec,3,0)

'Measurement is made every scan outside the "If" statement
    VoltSE (CS106_temp,1,mV2500,1,False,0,_60Hz,0.240,500)

'Turn on CS106 one minute before the hour
    If (TimeIntoInterval (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 CS106 after the measurement
    If (TimeIntoInterval (0,60,min)) Then
      pressure = CS106_temp
      WriteIO (&b1000,&b0)
    EndIf

    CallTable met_data

  NextScan
EndProg
```

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