

CS106

Barometric Pressure Sensor



Revision: 7/19

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CAMPBELL SCIENTIFIC, INC.

RMA# _____
815 West 1800 North
Logan, Utah 84321-1784

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- 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.

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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 data loggers.

NOTE

This manual provides information only for CRBasic data loggers. For retired Edlog data logger support, access a retired manual at www.campbellsci.com/old-manuals.

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 support and implementation engineer.
- Although the CS106 is rugged, it should be handled as a precision scientific instrument.

3. Initial Inspection

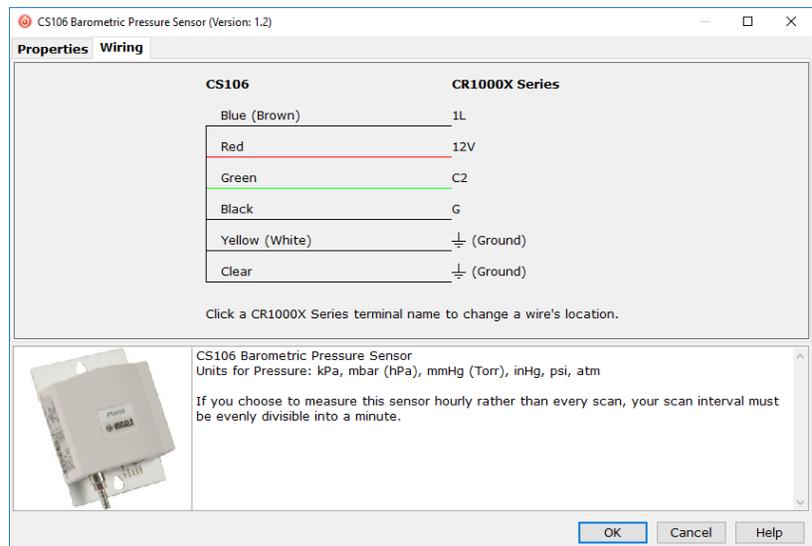
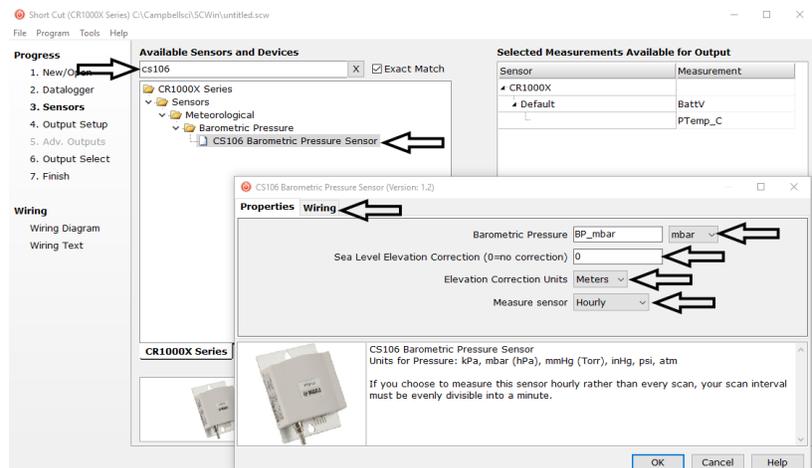
- Upon receipt of the CS106, inspect the packaging and contents for damage. File damage claims with the shipping company.

4. QuickStart

A video that describes data logger programming using *Short Cut* is available at: www.campbellsci.com/videos/cr1000x-datalogger-getting-started-program-part-3. *Short Cut* is an easy way to program your data logger to measure the CS106 and assign data logger wiring terminals. *Short Cut* is available as a download on www.campbellsci.com. It is included in installations of *LoggerNet*, *PC200W*, *PC400*, or *RTDAQ*.

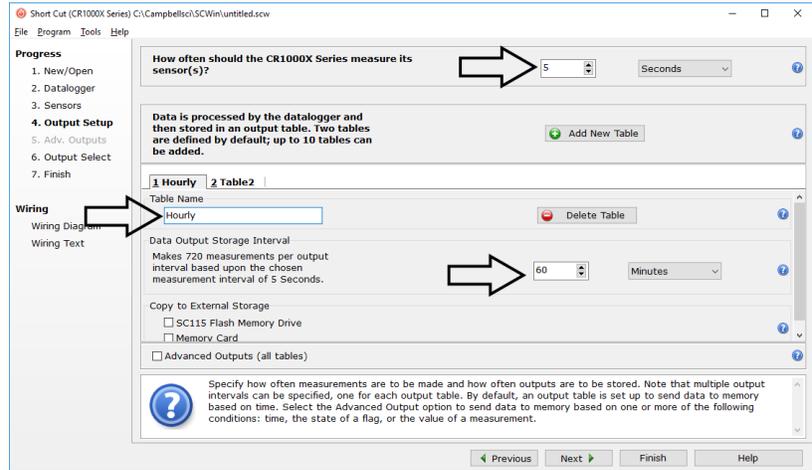
The following procedure also describes programming with *Short Cut*.

1. Open *Short Cut* and click **Create New Program**.
2. Double-click the data logger.
3. In the **Available Sensors and Devices** box, type CS106. You can also locate the sensor in Sensors | **Meteorological** | **Barometric Pressure** folder. Double-click **CS106 Barometric Pressure Sensor**. Type 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 **mbar** and **Hourly**, consecutively. These can be changed by clicking the **Barometric Pressure** and **Measure sensor** boxes and selecting different values. Click on the **Wiring** tab to see how the sensor is to be wired to the data logger.

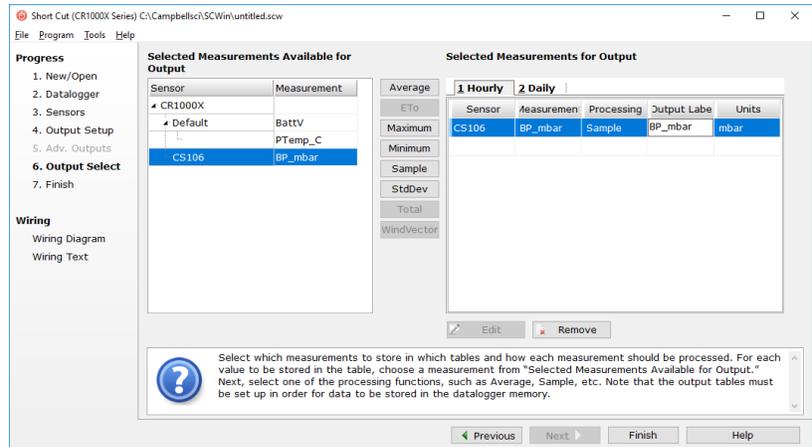


4. Repeat step three for other sensors.

- In **Output Setup**, type the scan rate, meaningful table names, and the **Data Output Storage Interval**.



- Select the measurement and its associated output options.



- Click **Finish** and save the program. Send the program to the data logger if the data logger is connected to the computer.
- If the sensor is connected to the data logger, check the output of the sensor in the data display in *LoggerNet*, *PC400*, *RTDAQ*, or *PC200W* to make sure it is making reasonable measurements.

WARNING

Improper wiring may damage the CS106 beyond repair.

5. Overview

The CS106 uses the Vaisala 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. 5)*). In the shutdown mode, the data logger switches 12 VDC power to the barometer during the measurement. The data logger then powers down the barometer between measurements to conserve power.

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

6. Specifications

Features:

- Integral switching circuit limits power consumption to measurement cycle
- Compatible with Campbell Scientific CRBasic data loggers: CR200(X) series, CR300 series, CR6 series, CR800 series, CR1000, CR1000X series, 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 Accuracy³:	±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
Linearity¹:	±0.25 mb @ 20 °C
Hysteresis¹:	±0.03 mb @ 20 °C
Repeatability¹:	±0.03 mb @ 20 °C
Calibration Uncertainty²:	±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 continuously. 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 μ A (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

If you are programming your data logger with *Short Cut*, skip Section 7.3, *Wiring* (p. 7), and Section 7.4, *Programming* (p. 9). *Short Cut* does this work for you. See Section 4, *QuickStart* (p. 1), for a *Short Cut* tutorial.

7.1 Jumper Settings

A jumper, located underneath the plastic cover of the barometer, selects whether the CS106 is in the shutdown or normal mode (FIGURE 7-1). When the jumper is not installed, the CS106 is in shutdown mode and the data logger turns the CS106 on and off with a control or excitation terminal; to use the excitation terminal the data logger 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).

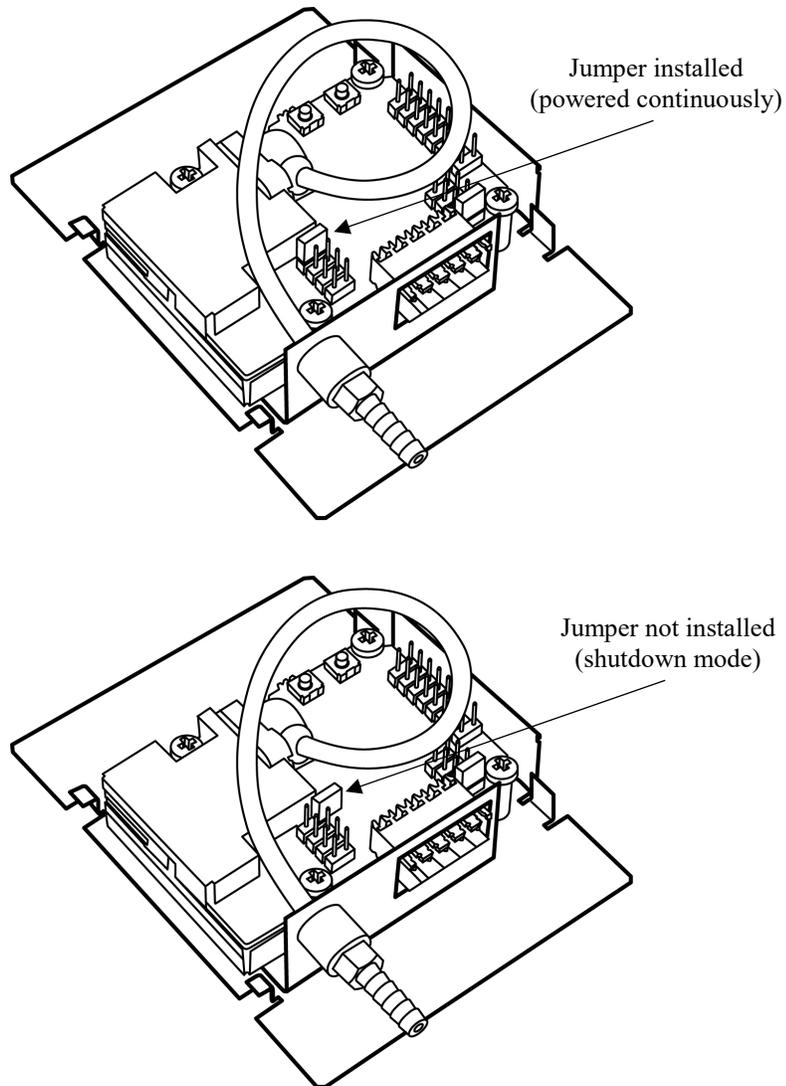


FIGURE 7-1. CS106 jumper settings

7.2 Mounting in the Enclosure

To prevent condensation, install the sensor in an environmentally protected enclosure, complete with desiccant. Change desiccant 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 data logger. 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.

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 Data Logger Connection

Remove the yellow warning label from the pigtails before connecting the barometer to the data logger. The warning label emphasizes the importance of properly connecting the barometer to the data logger. Wiring is shown in [FIGURE 7-3](#) and [Table 7-1](#).

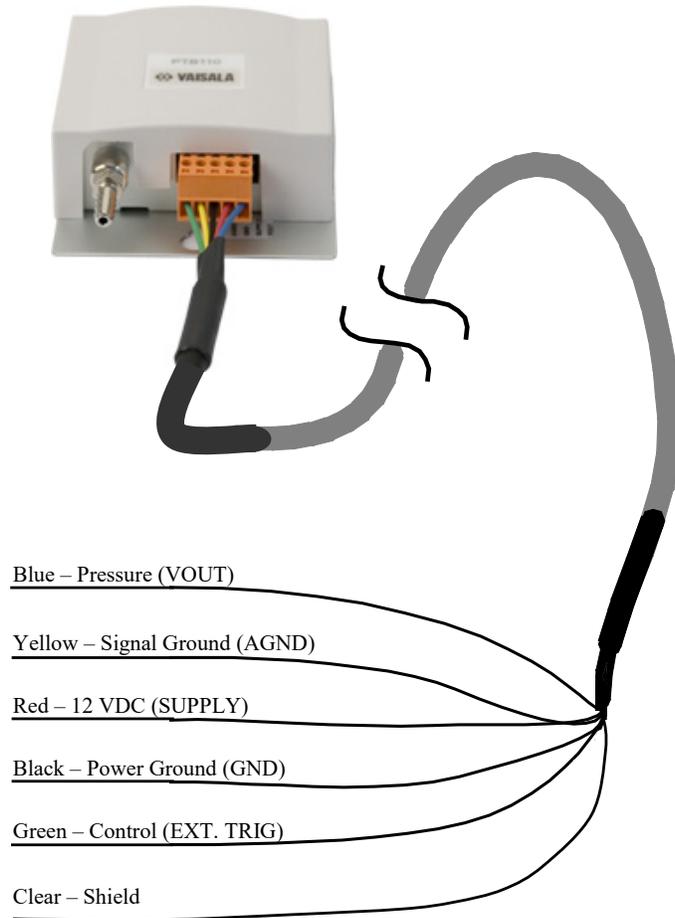


FIGURE 7-3. CS106 wiring diagram

TABLE 7-1. Wire Color, CS106 Connection, and Data Logger Connection			
Wire Color	CS106 Terminal	Data Logger Terminal, Single-Ended Measurement	Data Logger Terminal, Differential Measurement
Blue	VOUT	U configured for single-ended analog input ¹ , SE (single-ended, analog-voltage input)	U configured for differential high ¹ , DIFF H (differential high, analog-voltage input)
Yellow	AGND	⊥ (analog ground)	U configured for differential low ¹ , DIFF L (differential low, analog-voltage input)
Black	GND	G ²	G ²
Green	EXT TRIG	U configured to turn power on/off ¹ , C (control)	U configured to turn power on/off ¹ , C (control)
Red	SUPPLY	12V	12V
Shield	Shield	⊥	⊥

¹ U terminals are automatically configured by the measurement instruction.

² For the CR9000(X), the black wire connects to ⊥.

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

7.3.2 5-pin Screw Terminal Plug Connector

The data logger connects to the CS106 by using 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 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.

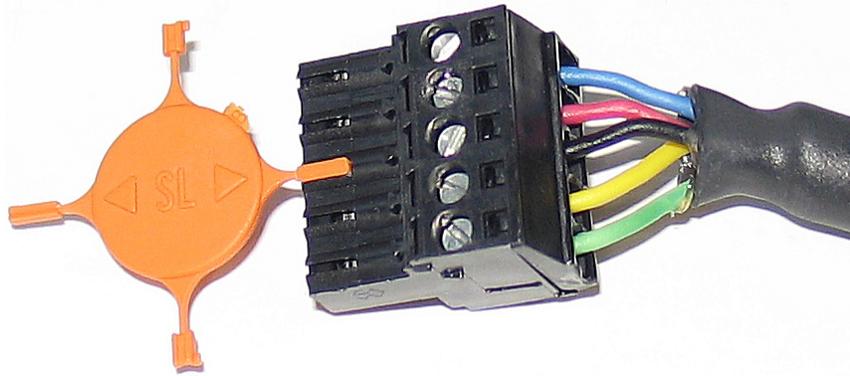


FIGURE 7-4. Connector key attached to 5-pin screw terminal plug connector

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 data logger programming code.

If your data acquisition requirements are simple, you can probably create and maintain a data logger 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* data loggers 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. 10). Complete program examples for select data loggers can be found in Appendix B, *Example Programs* (p. B-1).

7.4.1 CRBasic Instructions

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

VoltSE(Dest, Repts, Range, SEChan, MeasOff, SettlingTime, Integ/FNotch, 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. 11)*). 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 operating range is from 500 to 1100 mbars (hPa). Equation 1 uses these values to calculate the multiplier:

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

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

Offset = 500 (mbar or hPa)

The final result according to FIGURE 8-1 is:

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

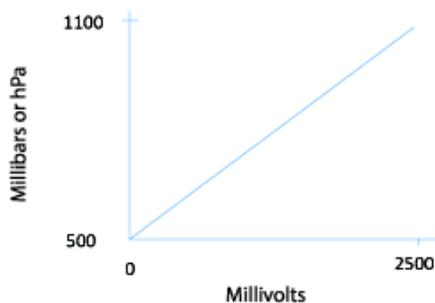


FIGURE 8-1. Point slope graph

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 (TABLE 8-1).

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

Use an expression in the CRBasic program to convert the values. For example, the following expression converts the pressure to mm of Hg:

```
BP_mmHg=BP*0.75006
```

8.3 Long Cable Lengths

The CS106 cable has a 0.06 mV/foot voltage drop, which raises the barometric reading by approximately 1.44 mb per 100 feet.

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

8.4 Output Resolution

To retain 0.01 mb resolution, use the IEEE4 format; for example, Sample (1,BP_mmHG,IEEE4). The default data output format for CR200(X)-series data logger is IEEE4. See Appendix B, *Example Programs (p. B-1)*, for more information.

8.5 Correcting Pressure to Sea Level

The National 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.

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

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.

A replacement five terminal connector is available from:

www.campbellsci.com/order/p16004.

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

Short Cut creates a .DEF file that contains wiring and memory usage information, and a program file that can be imported into the *CRBasic Editor*. By default, these files reside in the C:\campbellsci\SCWin folder.

Import *Short Cut* program file and wiring information into *CRBasic Editor*:

1. Create the *Short Cut* program following the procedure in Section 4, *QuickStart* (p. 1). After saving the *Short Cut* program, click the **Advanced** tab then the **CRBasic Editor** button. A program file with a generic name will open in CRBasic. Provide a meaningful name and save the CRBasic program. This program can now be edited for additional refinement.

NOTE

Once the file is edited with *CRBasic Editor*, *Short Cut* can no longer be used to edit the program it created.

2. To add the *Short Cut* wiring information into the new CRBasic program, open the .DEF file located in the C:\campbellsci\SCWin folder, and copy the wiring information, which is at the beginning of the .DEF file.
3. Go into the CRBasic program and paste the wiring information into it.
4. In the CRBasic program, highlight the wiring information, right-click, and select **Comment Block**. This adds an apostrophe (') to the beginning of each of the highlighted lines, which instructs the data logger compiler to ignore those lines when compiling. The **Comment Block** feature is demonstrated at about 5:10 in the [CRBasic | Features](#) video .

Appendix B. Example Programs

B.1 CR1000X Program Using Sequential Mode

This CR1000X program uses the sequential mode, which is the simplest mode, and can be used for most meteorological applications. Although the example is for the CR1000X, other CRBasic data loggers are programmed similarly.

In the example, the CR1000X measures the CS106 once an hour. A control terminal turns on the CS106 one minute before the top of the hour. On the hour, the data logger measures the CS106, then turns the CS106 off. This example assumes that the jumper is in the default position (open).

NOTE The sensor has a warmup time of 1 second. However, powering the sensor for 1 minute instead of 1 second ensures that processing is not delayed.

CRBasic Example B-1. CR1000X Program Using Sequential Mode

```
'CR1000X

'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(Hourly,True,-1)
  DataInterval(0,60,Min,10)
  Sample(1,BP_mmHg,IIEEE4)
EndTable

DataTable(Daily,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 Data Logger Battery Voltage measurement 'BattV'
  Battery(BattV)
  'Default Wiring Panel Temperature measurement 'PTemp_C'
  PanelTemp(PTemp_C,60)
  'CS106 Barometric Pressure Sensor measurement 'BP_mmHg'
  If TimeIntoInterval(59,60,Min) Then PortSet(C1,1)
  If TimeIntoInterval(0,60,Min) Then
    VoltSe(BP,1,mV5000,1,1,0,_60Hz,0.240,500)
    BP_mmHg=BP*0.75006
    PortSet(C1,0)
  EndIf
  'Call Data Tables and Store Data
  CallTable(Hourly)
  CallTable(Daily)
NextScan
EndProg
```

B.2 CR1000X Program Using Pipeline Mode

Although this example is for the CR1000X, other CRBasic data loggers are programmed similarly. In the example, the CR1000X measures the CS106 once an hour in a program that runs at 1 Hz. To keep the CR1000X 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.

NOTE

The sensor has a warmup time of 1 second. However, powering the sensor for 1 minute instead of 1 second ensures that processing is not delayed and does not significantly increase the current drain.

The integration parameter for the **VoltSE()** instruction is **60**. However, for Eddy Covariance programs or other data logger programs that are executed at a higher frequency, the f_{notch} parameter should be **15000** instead of **60** or **50**. This prevents skipped scans.

CRBasic Example B-2. CR1000X Program Using Pipeline Mode

```
'CR1000X Data Logger

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,mV5000,1,False,0,60,0.240,500)

  'Turn on CS106 one minute before the hour
  TimeIsBetween(59,60,60,min)
  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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