Product Manual

SI-111 and SI-111SS
Precision Infrared Radiometers

Revision: 9/18
Copyright © 2002 – 2018
Campbell Scientific, Inc.
Limited Warranty

“Products manufactured by CSI are warranted by CSI to be free from defects in materials and workmanship under normal use and service for twelve months from the date of shipment unless otherwise specified in the corresponding product manual. (Product manuals are available for review online at www.campbellsci.com.) Products not manufactured by CSI, but that are resold by CSI, are warranted only to the limits extended by the original manufacturer. Batteries, fine-wire thermocouples, desiccant, and other consumables have no warranty. CSI’s obligation under this warranty is limited to repairing or replacing (at CSI’s option) defective Products, which shall be the sole and exclusive remedy under this warranty. The Customer assumes all costs of removing, reinstalling, and shipping defective Products to CSI. CSI will return such Products by surface carrier prepaid within the continental United States of America. To all other locations, CSI will return such Products best way CIP (port of entry) per Incoterms ® 2010. This warranty shall not apply to any Products which have been subjected to modification, misuse, neglect, improper service, accidents of nature, or shipping damage. This warranty is in lieu of all other warranties, expressed or implied. The warranty for installation services performed by CSI such as programming to customer specifications, electrical connections to Products manufactured by CSI, and Product specific training, is part of CSI’s product warranty. CSI EXPRESSLY DISCLAIMS AND EXCLUDES ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. CSI hereby disclaims, to the fullest extent allowed by applicable law, any and all warranties and conditions with respect to the Products, whether express, implied or statutory, other than those expressly provided herein.”
Assistance

Products may not be returned without prior authorization. The following contact information is for US and international customers residing in countries served by Campbell Scientific, Inc. directly. Affiliate companies handle repairs for customers within their territories. Please visit www.campbellsci.com to determine which Campbell Scientific company serves your country.

To obtain a Returned Materials Authorization (RMA) number, contact CAMPBELL SCIENTIFIC, INC., phone (435) 227-9000. Please write the issued RMA number clearly on the outside of the shipping container. Campbell Scientific’s shipping address is:

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

For all returns, the customer must fill out a “Statement of Product Cleanliness and Decontamination” form and comply with the requirements specified in it. The form is available from our website at www.campbellsci.com/repair. A completed form must be either emailed to repair@campbellsci.com or faxed to (435) 227-9106. Campbell Scientific is unable to process any returns until we receive this form. If the form is not received within three days of product receipt or is incomplete, the product will be returned to the customer at the customer’s expense. Campbell Scientific reserves the right to refuse service on products that were exposed to contaminants that may cause health or safety concerns for our employees.
Safety

DANGER — MANY HAZARDS ARE ASSOCIATED WITH INSTALLING, USING, MAINTAINING, AND WORKING ON OR AROUND TRIPODS, TOWERS, AND ANY ATTACHMENTS TO TRIPODS AND TOWERS SUCH AS SENSORS, CROSSARMS, ENCLOSURES, ANTENNAS, ETC. FAILURE TO PROPERLY AND COMPLETELY ASSEMBLE, INSTALL, OPERATE, USE, AND MAINTAIN TRIPODS, TOWERS, AND ATTACHMENTS, AND FAILURE TO HEED WARNINGS, INCREASES THE RISK OF DEATH, ACCIDENT, SERIOUS INJURY, PROPERTY DAMAGE, AND PRODUCT FAILURE. TAKE ALL REASONABLE PRECAUTIONS TO AVOID THESE HAZARDS. CHECK WITH YOUR ORGANIZATION’S SAFETY COORDINATOR (OR POLICY) FOR PROCEDURES AND REQUIRED PROTECTIVE EQUIPMENT PRIOR TO PERFORMING ANY WORK.

Use tripods, towers, and attachments to tripods and towers only for purposes for which they are designed. Do not exceed design limits. Be familiar and comply with all instructions provided in product manuals. Manuals are available at www.campbellsci.com or by telephoning (435) 227-9000 (USA). You are responsible for conformance with governing codes and regulations, including safety regulations, and the integrity and location of structures or land to which towers, tripods, and any attachments are attached. Installation sites should be evaluated and approved by a qualified engineer. If questions or concerns arise regarding installation, use, or maintenance of tripods, towers, attachments, or electrical connections, consult with a licensed and qualified engineer or electrician.

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.
# Table of Contents

PDF viewers: These page numbers refer to the printed version of this document. Use the PDF reader bookmarks tab for links to specific sections.

1. Introduction ................................................................ 1
2. Precautions ................................................................ 1
3. Initial Inspection ......................................................... 1
4. QuickStart ................................................................... 2
5. Overview ..................................................................... 4
6. Specifications ................................................................ 5
7. Installation ..................................................................... 6
   7.1 Siting Considerations .............................................. 6
   7.2 Mounting to a Tripod, Tower, or Pole ...................... 6
   7.3 Wiring to the Datalogger .......................................... 7
   7.4 Datalogger Programming ......................................... 7
       7.4.1 Sensor Body Temperature Measurements .......... 8
       7.4.1.1 Therm109() Instruction ................................. 8
       7.4.2 Thermopile Detector ....................................... 8
       7.4.2.1 VoltDiff() Instruction .................................... 8
       7.4.3 Target Temperature Calculations ..................... 8
7.4.3 Target Temperature Calculations ......................... 8
8. Maintenance ............................................................... 9

Appendices

A. Importing Short Cut Code Into CRBasic Editor ... A-1
B. Example Program ................................................... B-1

Figure

- Figure 7-1. Protective cap on sensor head .................................................. 6

Tables

- Table 7-1. Wire Color, Function, and Datalogger Connections .............. 7
- Table B-1. Wiring for Example Program .................................................. B-1

CRBasic Example

- Table B-1 CR1000X Datalogger Program for Measuring SI-111 or
  SI-111SS ....................................................................................... B-2
SI-111 and SI-111SS Precision Infrared Radiometers

1. Introduction

The SI-111 and SI-111SS are precision infrared radiometers that determine the surface temperature of an object without physical contact. They measure both the surface temperature of the subject and the body temperature of the sensor. A Campbell Scientific datalogger uses these measurements to calculate the correct temperature of the subject.

The SI-111SS replaced the SI-111 in August 2018. The SI-111SS has a stainless steel connector, a removable cable, different wiring, and a serial number of 7283 or above. Both sensors are manufactured by Apogee Instruments.

2. Precautions

- READ AND UNDERSTAND the Safety section at the front of this manual.

- Although the SI-111 and SI-111SS are rugged, they are also highly precise scientific instruments and should be handled as such.

- Care should be taken when opening the shipping package to not damage or cut the cable jacket. If damage to the cable is suspected, contact Campbell Scientific.

3. Initial Inspection

- Upon receipt of the sensor, inspect the packaging for any signs of shipping damage and, if found, report the damage to the carrier in accordance with policy. The contents of the package should also be inspected and a claim filed if any shipping related damage is discovered.

- The model number is printed on a label on the cable. Check this information against the shipping documents to ensure the correct product is received.

- Each sensor is shipped with a calibration certificate that is unique for each sensor. Cross check the serial number listed on the calibration certificate against the serial number on your sensor to ensure that the given calibration coefficients correspond to your sensor.
4. QuickStart

A video that describes datalogger 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 datalogger to measure the sensor and assign datalogger 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 select to create a new program.

2. Double-click the datalogger model.

3. In the Available Sensors and Devices box, type SI-111SS or locate the sensor in the Sensors | Temperature folder. Double-click SI-111SS Precision Infrared Radiometer. Target temperature defaults to degree C. This can be changed by clicking the Deg C box and selecting Deg F, for degrees Fahrenheit, or K for Kelvin. Enter the mC0, mC1, mC2, bC0, bC1, and bC2 values listed on the calibration sheet. These values are unique to individual sensors.
4. Click on the **Wiring** tab to see how the sensor is to be wired to the datalogger. Click **OK** after wiring the sensor.

![Wiring tab](image)

5. Repeat steps three and four for other sensors. Click **Next**.

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

![Output Setup](image)
7. Select the measurement and its associated output options.

![Image](image.png)

8. Click **Finish** and save the program. Send the program to the datalogger if the datalogger is connected to the computer.

9. If the sensor is connected to the datalogger, check the output of the sensor in the data display in LoggerNet, PC400, RTDAQ, or PC200W to make sure it is making reasonable measurements.

5. **Overview**

The SI-111 and SI-111SS sense the infrared radiation emitted by the target and determines surface temperature of the target without physical contact. With contact sensors, it is difficult to avoid influencing the temperature, maintain thermal contact, and provide a spatial average. By mounting infrared sensors at an appropriate distance from the target, they can measure an individual leaf, a canopy, or any surface of interest.

The SI-111 and SI-111SS consist of a thermopile, which measures surface temperature, and a thermistor, which measures sensor-body temperature. The two temperature sensors are housed in a rugged aluminum body that contains a germanium window.

Both the thermopile and the thermistor output a millivolt signal that most of our dataloggers can measure. The datalogger uses the Stefan-Boltzman equation to correct for the effect of sensor body temperature on the target temperature. The corrected readings yield an absolute accuracy of ±0.2 °C from –10 to 65 °C.

The field-of-view for infrared sensors is calculated based on the geometry of the sensor and lens. The SI-111 and SI-111SS have a 22-degree half angle field of view (FOV). The FOV is reported as the half-angle of the apex of the cone formed by the target (cone base) and the detector (cone apex). The target is a circle from which 98% of the radiation viewed by the detector is being emitted.
6. Specifications

Features:
- Measures surface temperature continuously in the field
- Provides road surface, plant canopy, soil surface, snow surface, and water surface temperature measurements
- Avoids influencing the temperature providing more accurate measurements
- Ideal for providing spatial averages
- Rugged construction—two temperature probes housed in an aluminum body with a germanium window
- Compatible with Campbell Scientific CRBasic dataloggers: CR300 series, CR6 series, CR800 series, CR1000, CR1000X, CR3000, CR5000, and CR9000(X)

Input Power: 2.5 V excitation for thermistor

Absolute Accuracy:
- $\pm 0.2^\circ C$ @ –10 to 65 $^\circ C$
- $\pm 0.5^\circ C$ @ –40 to 70 $^\circ C$

Uniformity:
- $\pm 0.1^\circ C$ @ –10$^\circ$ to 65 $^\circ C$
- $\pm 0.3^\circ C$ @ –40$^\circ$ to 70 $^\circ C$

Repeatability:
- $\pm 0.05^\circ C$ @ –10 to 65 $^\circ C$
- $\pm 0.1^\circ C$ @ –40 to 70 $^\circ C$

Mass: 190 g

Length: 6.3 cm

Diameter: 2.3 cm

Response Time: Less than 1 second to changes in target temperature

Target Output Signal: 60 $\mu$V per $^\circ C$ difference from sensor body

Body Temperature Output Signal: 0 to 2500 mV

Optics: Germanium lens

Wavelength Range: 8 to 14 $\mu$m

Field of View: 22$^\circ$ half angle

Operating Environment: Highly water resistant, designed for continuous outdoor use; operating range is –55 to 80 $^\circ C$, 0 to 100% RH

1 Where target temperature is within 20 $^\circ C$ of sensor body temperature.
2 Where target temperature is greater than 20 $^\circ C$ of sensor body temperature.
7. Installation

If you are programming your datalogger with Short Cut, skip Section 7.3, Wiring to the Datalogger (p. 7), and Section 7.4, Datalogger Programming (p. 7). Short Cut does this work for you. See Section 4, QuickStart (p. 3), for a Short Cut tutorial.

7.1 Siting Considerations

Optical and atmospheric scatter and unwanted reflections from outside the field of view may influence the measurement. Under typical conditions, 95 to 98 percent of the infrared signal is from the field of view and 2 to 5 percent is from the area surrounding the field of view. If the target surface is small, for example a single leaf, try to mount the sensor close enough that the surface extends beyond the field of view.

7.2 Mounting to a Tripod, Tower, or Pole

A CM230, CM230XL, or CM220 mount can be used to mount the sensor to a CM200-series crossarm, tripod or tower mast, or a 0.75 inch-to-1-inch IPS pole. The CM230 and CM230XL are adjustable mounts that allow the sensor to be pointed at the target. The SI-111 and SI-111SS also include a hole threaded for a standard tripod camera mount screw (1/4-inch diameter; 20 threads per inch) for mounting them to a user-supplied support.

1. Remove the cap from the sensor (see FIGURE 7-1).

2. Mount the crossarm to the tripod or tower.

3. Tighten the two nuts on the U-bolt to secure the CM230, CM230XL, or CM220 on the crossarm, mast, or pole.

4. If using the CM230 or CM230XL, place the sensor in the U-bolt and adjust the U-bolt so that the sensor points to the target. Tighten the nuts.

5. If using the CM220, place the sensor in the U-bolt with the top of the sensor pointing to the target. Tighten the nuts.

6. Route the sensor cable along the underside of the crossarm to the tripod or tower, and to the instrument enclosure.

7. Secure the cable to the crossarm and tripod or tower using cable ties.
7.3 Wiring to the Datalogger

<table>
<thead>
<tr>
<th>TABLE 7-1. Wire Color, Function, and Datalogger Connections</th>
</tr>
</thead>
<tbody>
<tr>
<td>SI-111 Wire Color</td>
</tr>
<tr>
<td>-------------------</td>
</tr>
<tr>
<td>Red</td>
</tr>
<tr>
<td>Black</td>
</tr>
<tr>
<td>Clear</td>
</tr>
<tr>
<td>Green</td>
</tr>
<tr>
<td>Blue</td>
</tr>
<tr>
<td>White</td>
</tr>
</tbody>
</table>

\(^1\)U terminals are automatically configured by the measurement instruction.

7.4 Datalogger Programming

*Short Cut* is the best source for up-to-date datalogger programming code.

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. 2). 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 in the following section. Complete program examples for select CRBasic dataloggers can be found in Appendix B, *Example Program* (p. B-1). Programming basics and programming examples for Edlog dataloggers are provided at [www.campbellsci.com\old-manuals](http://www.campbellsci.com\old-manuals).
7.4.1 Sensor Body Temperature Measurements

7.4.1.1 Therm109() Instruction

CRBasic dataloggers measure the sensor body temperature (°C) using the Therm109() instruction:

```
Therm109(Dest, Reps, SEChan, Mult, Offset)
```

Use the default values for Mult and Offset, which output the temperature in °C.

7.4.2 Thermopile Detector

7.4.2.1 VoltDiff() Instruction

CRBasic dataloggers measure the thermopile detector using the VoltDiff() instruction:

```
VoltDiff(Dest, Reps, Range, DiffChan, RevDiff, SettlingTime, Integ/Fnotch, Mult, Offset)
```

The Range value should be mV200 (CR6, CR1000X), mV2_5 (CR800 series, CR1000), mV34 (CR300 series), mV50 (CR9000(X)). The Integ/Fnotch parameter is often set to the 60 Hz option. Use the default values for the RevDiff, SettlingTime, Mult, and Offset parameters.

7.4.3 Target Temperature Calculations

These calculations are entered in CRBasic as expressions. Calculate the target temperature using the following steps:

1. Calculate slope
2. Calculate intercept
3. Convert sensor body temperature (°C) to Kelvin.
4. Calculate target temperature (K)
5. If desired, convert target temperature (K) to degrees Celsius

Use Equation 1 to calculate slope:

\[ m = mC2 \cdot SBTempC^2 + mC1 \cdot SBTempC + mC0 \]  

Where,

- \( m \) = slope
- \( SBTempC \) = sensor body temperature in °C
- \( mC2 \) = slope polynomial coefficient (C2) from the calibration sheet
- \( mC1 \) = slope polynomial coefficient (C1) from the calibration sheet
- \( mC0 \) = slope polynomial coefficient (C0) from the calibration sheet

Use Equation 2 to calculate intercept:

\[ b = bC2 \cdot SBTempC^2 + bC1 \cdot SBTempC + bC0 \]  

Where,

- \( b \) = intercept
- \( bC2 \) = intercept polynomial coefficient (C2) from the calibration sheet
- \( bC1 \) = intercept polynomial coefficient (C1) from the calibration sheet
- \( bC0 \) = intercept polynomial coefficient (C0) from the calibration sheet
Where,  
\( b = \) intercept  
\( SBTempC = \) sensor body temperature in °C  
\( bC2 = \) intercept polynomial coefficient \((C2)\) from the calibration sheet  
\( bC1 = \) intercept polynomial coefficient \((C1)\) from the calibration sheet  
\( bC0 = \) intercept polynomial coefficient \((C0)\) from the calibration sheet  

Equation 3 converts the sensor body temperature from degrees Celsius to Kelvin.

\[ SBTempK = SBTempC + 273.15 \]  
(3)

Where,  
\( SBTempK = \) sensor body temperature in Kelvin  
\( SBTempC = \) sensor body temperature in °C  

Equation 4 calculates the target temperature \((K)\).

\[ TargTempK = ((SBTempK^4) + m \cdot TargmV + b)^{0.25} \]  
(4)

Where,  
\( SBTempK = \) sensor body temperature in Kelvin  
\( TargmV = mV \) output of the thermopile infrared detector  
\( m = \) slope  
\( b = \) intercept  

Equation 5 converts the target temperature from Kelvin to degrees Celsius.

\[ TargTempC = TargTempK – 273.15 \]  
(5)

Where,  
\( SBTempK = \) sensor body temperature in Kelvin  
\( SBTempC = \) sensor body temperature in degrees Celsius  

8. Maintenance  

A primary source of inaccurate measurements for any radiation sensor is blocking of the optical path to the detector. The window in the infrared sensor is inset and protected, but it can become partially blocked by the following:

- Spiders can make a nest in the entrance. Use a cotton swab to apply a spider repellent around the entrance to the aperture, but not on the sensor window.

- Calcium deposits can accumulate on the window if irrigation water sprays the head. These typically leave a thin white film on the surface and can be removed with a mild acid like vinegar. Solvents such as alcohol or acetone cannot remove calcium deposits.

- Dust and dirt can be deposited in the aperture in windy environments and are best cleaned with deionized water, rubbing alcohol, or in extreme cases, acetone.

Clean the inner threads and sensor window using a cotton swab dipped in the appropriate solvent. Only use gentle pressure on the window to avoid
scratching the thin optical coating on the window. Let the solvent do the cleaning, not mechanical force. Repeat the cleaning with a new cotton swab to ensure a completely clean window. In some environments, sensors can stay clean for many months, while in other environments, the sensor needs frequent cleaning.
Appendix A. Importing Short Cut Code Into CRBasic Editor

This tutorial shows:

- Importing a *Short Cut* program into a program editor for additional refinement
- Importing 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)
- .CR300 (CR300-series datalogger code)
- .CR6 (CR6-series datalogger code)
- .CR8 (CR800-series datalogger code)
- .CR1 (CR1000 datalogger code)
- .CR1X (CR1000X-series datalogger code)
- .CR3 (CR3000 datalogger code)
- .CR5 (CR5000 datalogger code)
- .CR9 (CR9000(X) datalogger code)

Import *Short Cut* code and wiring diagram into *CRBasic Editor*:

1. Create the *Short Cut* program following the procedure in Section 4, *QuickStart* (p. 2). Finish the program. On the *Advanced* tab, click the *CRBasic Editor* button. The program opens in CRBasic with the name *noname.CR_* Provide a name and save the program.

**NOTE**

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

2. The program can now be edited, saved, and sent to the datalogger.

3. Import wiring information to the program by opening the associated .DEF file. By default, it is saved in the c:\campbellsci\SCWin folder. 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. You can highlight several lines of CRBasic code then right-click and select *Comment Block*. (This feature is demonstrated at about 5:10 in the *CRBasic | Features* video.)
Appendix B. Example Program

The example datalogger program measures the thermistor to obtain the sensor body temperature and measure the thermopile to obtain the target-to-sensor body temperature difference.

After measuring the thermopile and thermistor outputs, the sensor body temperature is used to reference the target temperature.

Wiring for the example program is shown in TABLE B-1. The actual terminals used need to be adjusted for the actual installation and application.

<table>
<thead>
<tr>
<th>SI-111 Wire Color</th>
<th>SI-111SS Wire Color</th>
<th>Description</th>
<th>CR1000X</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>White</td>
<td>Diff. High</td>
<td>2H</td>
</tr>
<tr>
<td>Black</td>
<td>Black</td>
<td>Diff. Low</td>
<td>2L</td>
</tr>
<tr>
<td>Clear</td>
<td>Clear</td>
<td>Analog Ground</td>
<td>⇦</td>
</tr>
<tr>
<td>Green</td>
<td>Green</td>
<td>Single-ended</td>
<td>SE1</td>
</tr>
<tr>
<td>Blue</td>
<td>Blue</td>
<td>Analog Ground</td>
<td>⇦</td>
</tr>
<tr>
<td>White</td>
<td>Red</td>
<td>Excitation</td>
<td>VX1</td>
</tr>
</tbody>
</table>

This example CR1000X program measures the sensor every 5 seconds and outputs a sample once every 60 seconds. The actual measurement rate and output intervals need to be adjusted for the actual installation and application.

All calibration coefficients are sensor-specific; those listed below are examples and must be changed based on the sensor being used.
CRBasic Example B-1. CR1000X Datalogger Program for Measuring SI-111 or SI-111SS

'CR1000X Series Datalogger Program

'Declare public variables
Public PanelT, BattV, SBTempC, SBTempK, TargmV, m, b, TargTempK, TargTempC

'Declare constants (replace the listed values with coefficients received with sensor)
Const mC2 = 82213
Const mC1 = 7841000
Const mC0 = 1419700000
Const bC2 = 13114
Const bC1 = 185020
Const bC0 = -17215000

'Define data table (table is outputting data every 60 seconds)
DataTable (IRR,1,-1)
  DataInterval (0,60,Sec,10)
  Minimum (1,BattV,FP2,0,False)
  Sample (1,PanelT,FP2)
  Average (1,TargmV,FP2,False)
  Average (1,SBTempC,FP2,False)
EndTable

'Main program (program is making a measurement every 5 seconds)
BeginProg
  Scan (5,Sec,0,0)
    PanelTemp (PanelT,60)
    Battery (BattV)

  'Instruction to measure sensor body temperature
    Therm109 (SBTempC,1,1,Vx1,0,60,1.0,0)

  'Instruction to measure mV output of thermopile detector
    VoltDiff (TargmV,1,mV200,2,True ,0,60,1.0,0)

  'Calculation of m (slope) and b (intercept) coefficients for target temperature calculation
    m = mC2 * SBTempC^2 + mC1 * SBTempC + mC0
    b = bC2 * SBTempC^2 + bC1 * SBTempC + bC0

  'Calculation of target temperature
    SBTempK = SBTempC + 273.15
    TargTempK = ((SBTempK^4) + m * TargmV + b)^0.25
    TargTempC = TargTempK - 273.15

  'Call output tables
    CallTable IRR
  NextScan
EndProg
Campbell Scientific Worldwide Offices

**Australia**
Location: Garbutt, QLD Australia  
Email: info@campbellsci.com.au  
Website: www.campbellsci.com.au

**Germany**
Location: Bremen, Germany  
Email: info@campbellsci.de  
Website: www.campbellsci.de

**Brazil**
Location: São Paulo, SP Brazil  
Email: andread@campbellsci.com.br  
Website: www.campbellsci.com.br

**South Africa**
Location: Stellenbosch, South Africa  
Email: sales@csafrica.co.za  
Website: www.campbellscientific.co.za

**Canada**
Location: Edmonton, AB Canada  
Email: dataloggers@campbellsci.ca  
Website: www.campbellsci.ca

**Southeast Asia**
Location: Bangkok, Thailand  
Email: info@campbellsci.asia  
Website: www.campbellsci.asia

**China**
Location: Beijing, P. R. China  
Email: info@campbellsci.com.cn  
Website: www.campbellsci.com.cn

**Spain**
Location: Barcelona, Spain  
Email: info@campbellsci.es  
Website: www.campbellsci.es

**Costa Rica**
Location: San José, Costa Rica  
Email: info@campbellsci.cc  
Website: www.campbellsci.cc

**UK**
Location: Shepshed, Loughborough, UK  
Email: sales@campbellsci.co.uk  
Website: www.campbellsci.co.uk

**France**
Location: Antony, France  
Email: info@campbellsci.fr  
Website: www.campbellsci.fr

**USA**
Location: Logan, UT USA  
Email: info@campbellsci.com  
Website: www.campbellsci.com

Please visit [www.campbellsci.com/contact](http://www.campbellsci.com/contact) to obtain contact information for your local US or international representative.