# Product Manual

# SP230 and SP230SS

## Heated Pyranometers

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# *Limited Warranty*

The SP230 is warranted for four (4) years subject to this 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.**"

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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.**
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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.

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## *CRBasic Examples*

# *SP230 and SP230SS Heated Pyranometers*

## 1. Introduction

The SP230 and SP230SS measure total sun and sky solar radiation for solar, agricultural, meteorological, and hydrological applications. Their spectral range of 360 to 1120 nanometers encompasses most of the shortwave radiation that reaches the Earth surface. Integrated heaters allow them to work in dew, ice, and snow conditions. Their heater is not sufficient to work in heavy riming conditions. Their output can be directly measured by all of our dataloggers.

The SP230SS replaced the SP230 in August 2018. The SP230SS has a stainless steel connector, a removable cable, different wire colors, and a serial number of 9898 or above. Both sensors are manufactured by Apogee Instruments.

**NOTE**    This manual provides information only for CRBasic dataloggers. For retired Edlog datalogger support, see an older SP230 manual at *www.campbellsci.com/old-manuals*.

## 2. Precautions

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

- 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.

- Remove the green cap after installing the sensor. Save this cap for shipping or storing the sensor.

- Handle the sensor carefully when cleaning. Be careful not to scratch the surface of the sensor.

- 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 pyranometer, inspect the packaging and contents for damage. File damage claims with the shipping company.

# 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 pyranometer 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*.

The SP230 and SP230SS have two heater modes of operation — constant or switched 12 Vdc. Switched heater mode uses less power than the constant mode and is recommended for dataloggers that have a switched 12V terminal. Use of the switched heater mode requires the addition of an air temperature and relative humidity sensor and a dewpoint calculation.

A temperature/relative humidity measurement and dewpoint calculation are required before selecting the pyranometer in switched mode. This example shows an EE181 Temp/RH sensor used with a CR1000X.

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 EE181 or locate the sensor in the **Sensors | Meteorological | Relative Humidity & Temperature | EE181 Temperature and Relative Humidity** folder. Double-click either **EE181 (constant power)** or **EE181 (panel switched power)**. Use the default of degrees C.
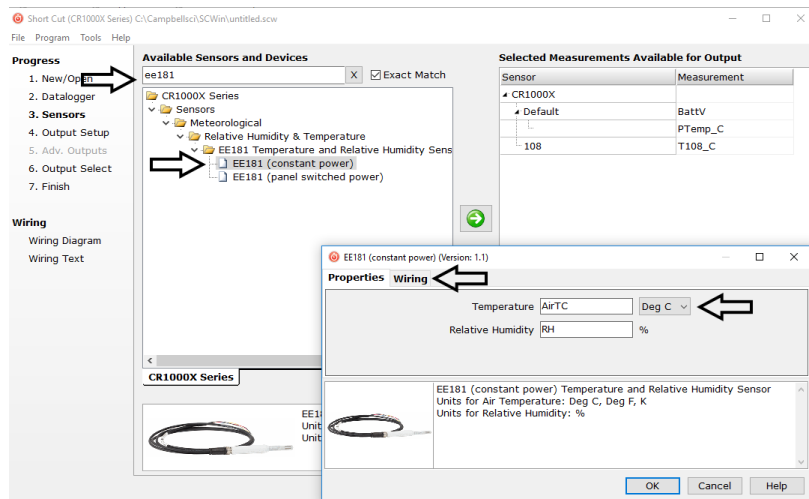
4. Click on the **Wiring** tab to see how the sensor is to be wired to the datalogger. Click **OK** after wiring the sensor.
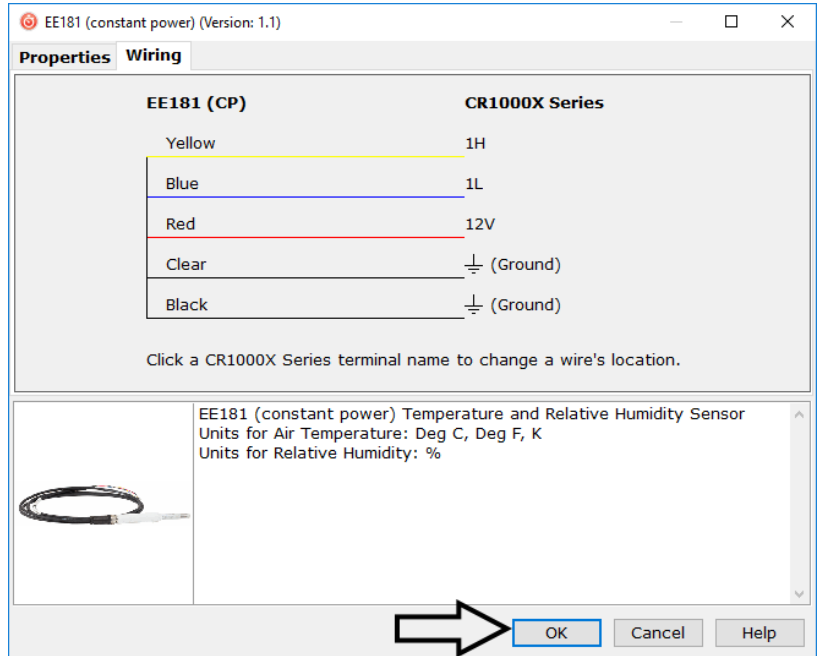


5. Type Dew Point or locate the calculation in the **Calculations & Control | Calculations** folder. Double-click **Dew Point**. Select the air temperature and relative humidity variables from the EE181. Click **OK**.
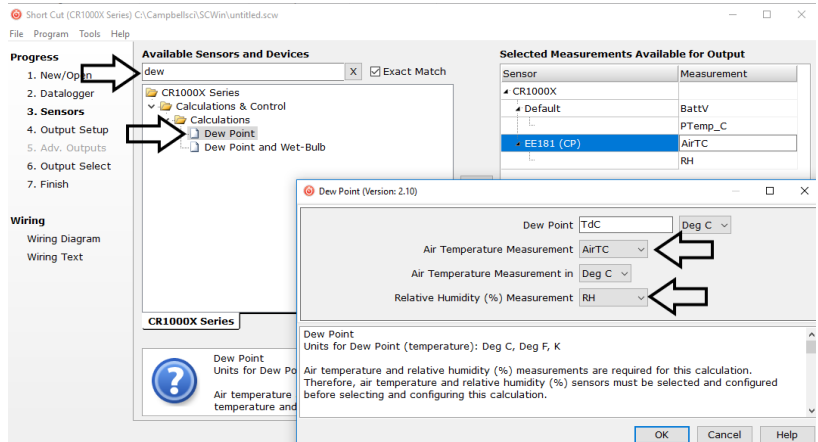
6. Type SP230SS in the **Available Sensors and Devices** box, or locate the pyranometer in the **Sensors | Meteorological | Solar Radiation | SP230SS Heated Pyranometer** folder. Dou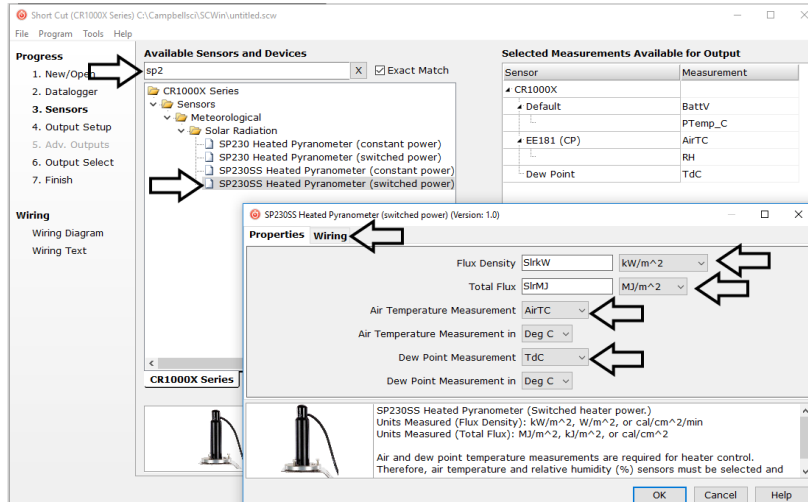ble-click **SP230SS (switched power)**. Default units are kW/m$^2$ for flux density units and mJ/m$^2$ for total flux. These can be changed by clicking the **Flux Density** and **Total Flux** boxes and selecting different values. Make sure that the selections for air temperature and dewpoint are correct.



7. Click on the **Wiring** tab to see how the sensor is to be wired to the datalogger. Click **OK** after wiring the sensor.

WARNING    **Wiring the sensor incorrectly could result in damage to the photodiode.**
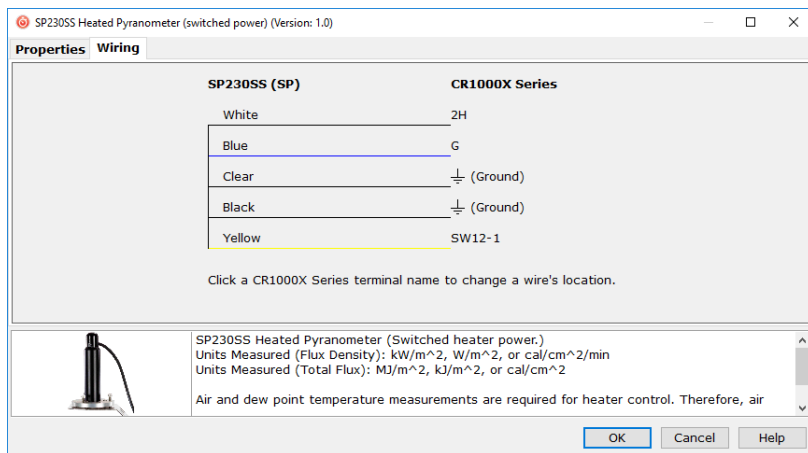


8. Repeat steps six and seven for other sensors. Click **Next**.

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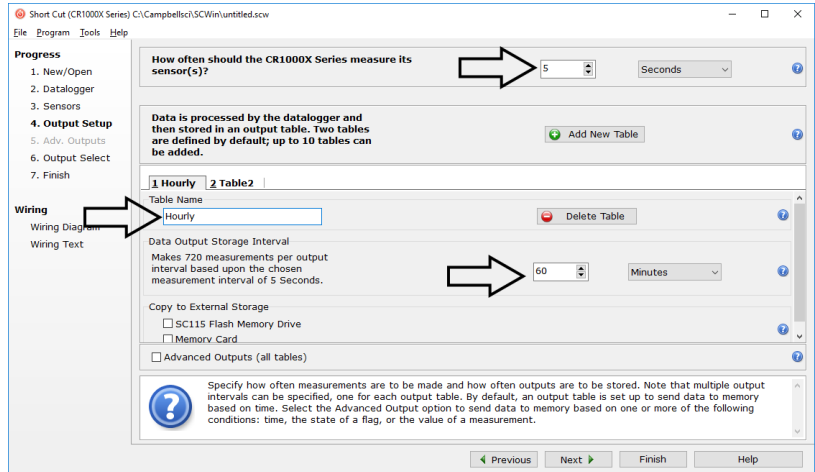


10. Select the measurement and its associated output options.
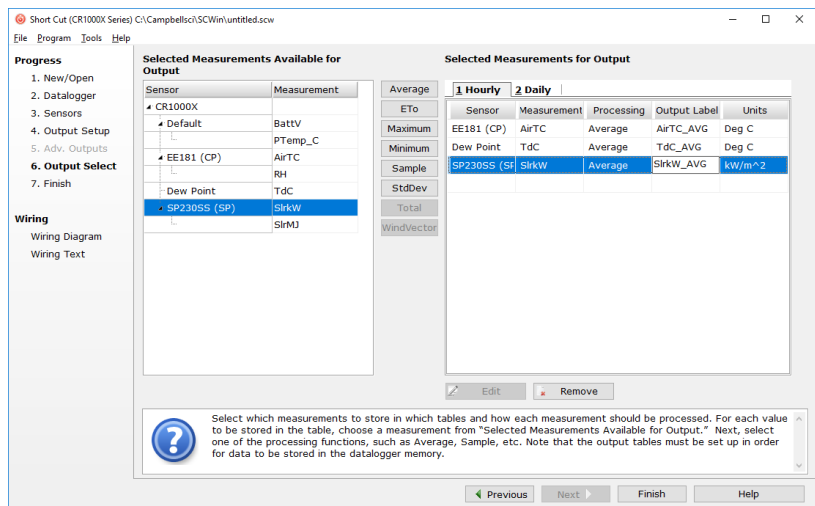


11. Click **Finish** and save the program. Send the program to the datalogger if the datalogger is connected to the computer.

12. 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.

**NOTE**    *Short Cut* uses the execution interval to make total flux calculations (TABLE 7-2). This needs to be taken into account while editing the *Short Cut* program.

# 5.    Overview

The SP230 and SP230SS measure incoming solar radiation with a silicon photovoltaic detector mounted in a cosine-corrected head. Output from the detector is a current, which is converted to voltage by a potentiometer potted in the sensor head. The resistance of the potentiometer is adjusted when the sensor is calibrated so that all sensors have the same output sensitivity.

The SP230 and SP230SS are calibrated against a Kipp and Zonen CM21 under natural sunlight to accurately measure sun plus sky radiation (360 to 1120 nm). They should not be used under vegetation or artificial lights.

During the night, the pyranometers may read slightly negative incoming solar radiation. This negative signal is caused by noise passing through the photodiode. Negative values may be set to zero in the datalogger program.

The SP230 and SP230SS have two integrated heaters to evaporate dew, frost, snow, and ice. When active, the heaters draw 15 mA at 12 Vdc. Care must be taken to ensure enough power is allocated to run the station and drive the heaters.

# 6.    Specifications

**Features:**
- Designed for continuous, long term, unattended operation in adverse conditions
- Dome-shaped head prevents water from accumulating on the sensor head
- Compatible with Campbell Scientific CRBasic dataloggers: CR300 series, CR6, CR200(X) series, CR800, CR850, CR1000X, CR1000, CR3000, CR5000, and CR9000(X)

| | |
|---|---|
| **Power requirements:** | integrated heaters = 12 Vdc with 15 mA current draw (0.18 W) |
| | solar sensing diode requires no power |
| **Sensitivity:** | 5 W m$^{-2}$ mV$^{-1}$ (0.2 mV W$^{-1}$ m$^{-2}$) |
| **Absolute accuracy:** | ±5% for daily total radiation |
| **Cosine response:** | ±5% at 75° zenith angle. ±2% at 45° zenith angle |
| **Response time:** | < 1 ms |
| **Temperature response:** | < 1% at 5 to 40 °C |
| **Long-term stability:** | < 2% per year |
| **Operating temperature:** | –40 to 70 °C |
| **Relative humidity:** | 0 to 100% |
| **Output (solar sensing photodiode):** | 0.2 mV per W m$^{-2}$ |

| | |
|---|---|
| **Diameter:** | 3.15 cm (1.24 in) |
| **Height:** | 12.75 cm (5.02 in) |
| **Weight:** | 142.0 g (5.01 oz) with 2 m lead wire |
| **Measurement range:** | 0 to 1750 W m$^{-2}$ (full sunlight $\approx$ 1000 W m$^{-2}$) |
| **Light spectrum waveband:** | 360 to 1120 nm (wavelengths where response is 10% of maximum) |

# 7. Installation

If you are programming your datalogger with *Short Cut*, skip Section 7.3, *Wiring to the Datalogger (p. 10)*, and Section 7.4, *Programming (p. 11)*. *Short Cut* does this work for you. See Section 4, *QuickStart (p. 2)*, for a *Short Cut* tutorial.

## 7.1 Siting

Mount the pyranometer so that no shadows or reflections are cast on it by the tripod/tower or other sensors. The cable should point towards the nearest magnetic pole. For example, in the Northern Hemisphere, point the cable toward the North Pole.

Mounting height is not critical for the accuracy of the measurement. However, pyranometers mounted at heights of 3 m or less are easier to level and clean.

## 7.2 Mounting to an Instrument Mount

### 7.2.1 Required Tools

Tools required for installation on a tripod or tower:

Small and medium Phillips screwdrivers
1/2 in open end wrench for CM225 or 015ARM
Tape measure
UV-resistant cable ties
Side-cut pliers
Compass
Step ladder

### 7.2.2 Mounting Procedure

| | |
|---|---|
| **CAUTION** | The CM225 should never be mounted directly to a vertical pipe. Instead the CM225 should be mounted to a crossarm. This avoids reflections from the vertical pipe onto the sensor. |

1. Mount the crossarm to the tripod or tower if using a CM225.

2. Secure the CM225 to the crossarm by placing the U-bolt in the bottom holes and tightening the U-bolt nuts. Secure the 015ARM to the mast by tightening the U-bolt nuts.

CM225 Stand

CM200-Series Crossarm

U-bolt Nuts

015ARM

U-bolt Nuts
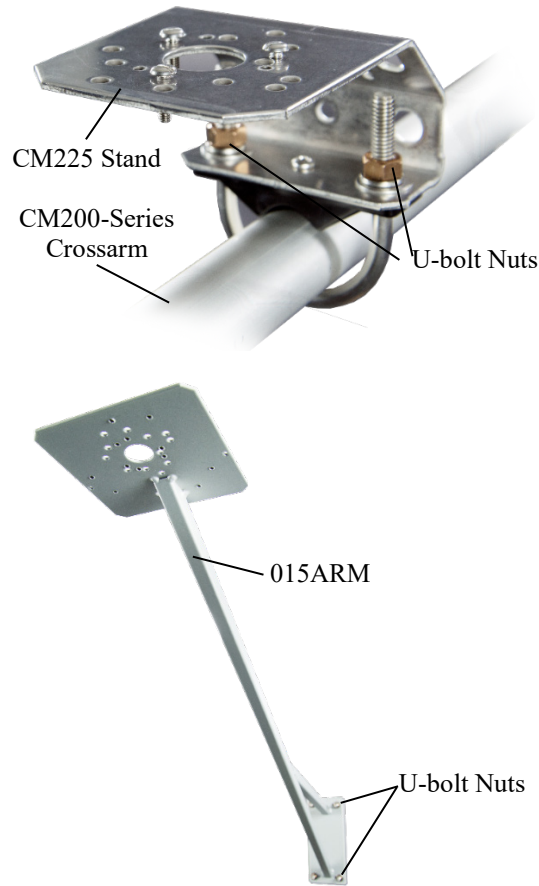
3. Place the pyranometer in the center of the pyranometer leveling base.

Holes for Mounting Screws

Leveling Screws

Hole for Mounting Sensor
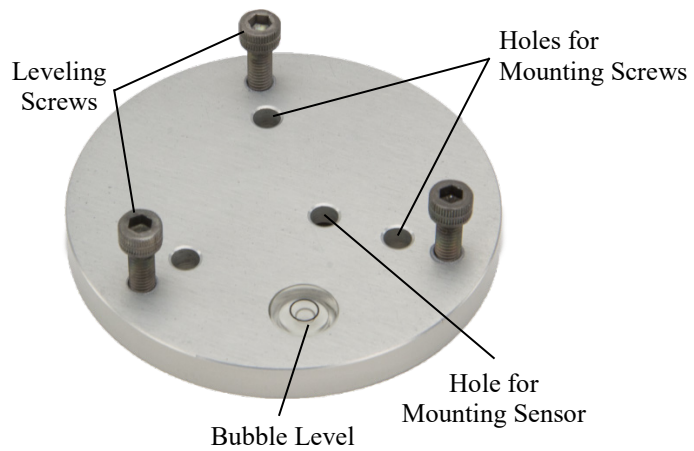
Bubble Level

4. Loosely mount the pyranometer leveling base on the CM225 or 015ARM. Do not fully tighten the three mounting screws.
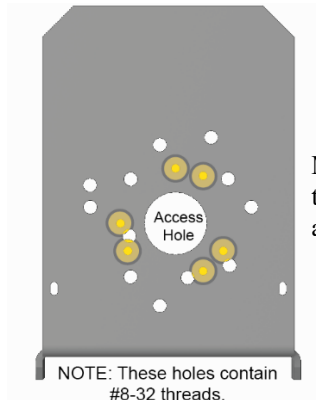


Mounting holes used for the SP230 and SP230SS are indicated in yellow.

NOTE: These holes contain #8-32 threads.

5. Turn the leveling screws as required to bring the bubble of the bubble level within the ring.

6. Tighten the mounting screws to secure the assembly in its final position. Check that the pyranometer is still correctly leveled and adjust as necessary.

7. Route the sensor cable along the underside of the crossarm or 015ARM mounting arm to the tripod/tower, and to the instrument enclosure.

8. Secure the cable to the crossarm or 015ARM and mast using cable ties.
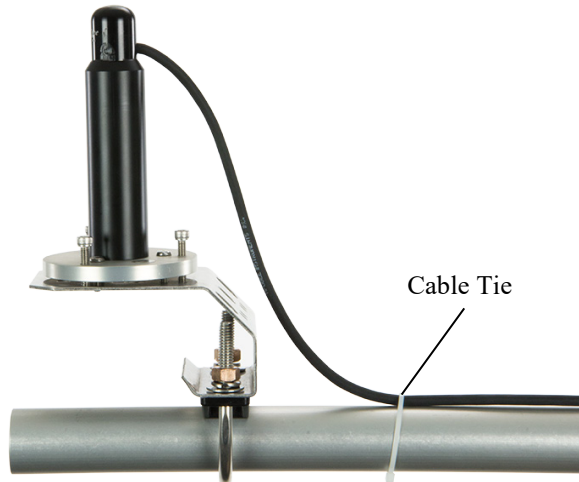


Cable Tie

9. Remove the green cap after installing the sensor. Save this cap for shipping or storing the sensor.

## 7.3 Wiring to the Datalogger

A schematic diagram of the pyranometer is shown in FIGURE 7-1.
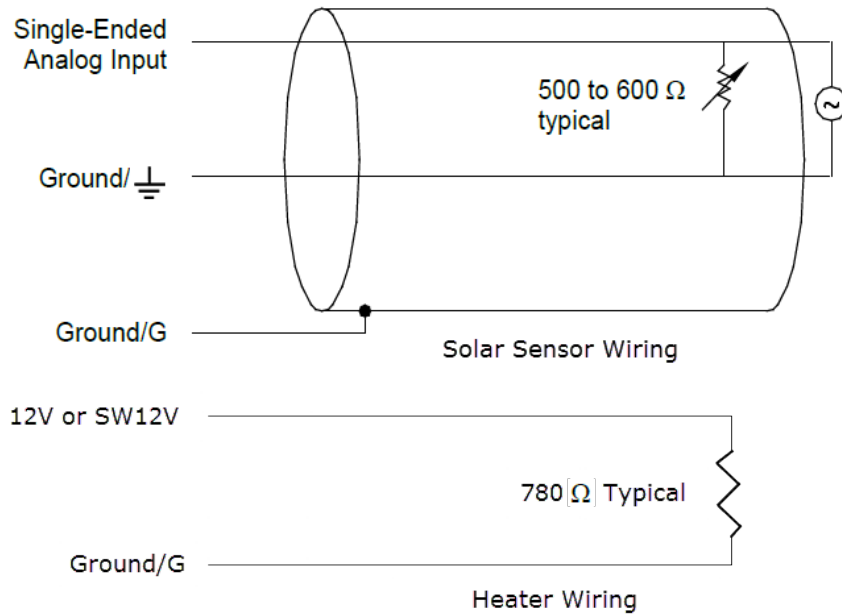


FIGURE 7-1. *Schematic diagram*

Connections to Campbell Scientific dataloggers are given in TABLE 7-1. The heater can be run in switched 12 Vdc or constant mode to conserve power. Whenever possible, run the heater in switched 12 Vdc mode to conserve power. When *Short Cut* is used to create the datalogger program, the sensor should be wired to the terminals shown in the wiring diagram created by *Short Cut*.

| SP230 Wire Color | SP230SS Wire Color | Wire Function | Switched Heater Power | Constant Heater Power |
|---|---|---|---|---|
| **TABLE 7-1. Wire Color, Function, and Datalogger Connection** | | | | |
| Red | White | Signal | **U** configured for single-ended analog input[1], **SE** (single-ended, analog-voltage input) | **U** configured for single-ended analog input[1], **SE** (single-ended, analog-voltage input) |
| Black | Black | Signal Reference | ⏚ (analog ground) | ⏚ (analog ground) |
| White | Yellow | Heater Power | **SW**, **SW12**, **SW12V**, **SW Battery** (switched 12 V) | **12V**, **Battery +** |
| Green | Blue | Heater Ground | G | G |
| Clear | Clear | Shield | ⏚ (analog ground) | ⏚ (analog ground) |
| [1]**U** terminals are automatically configured by the measurement instruction. | | | | |

## 7.4    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 provided in the following sections. Complete program examples for select CRBasic dataloggers can be found in Appendix B, *Example Programs (p. B-1)*. Programming basics and programming examples for Edlog dataloggers are provided at *www.campbellsci.com/old-manuals.*

The output from the pyranometer is 0.2 mV per Wm$^{-2}$. The voltage signal is measured using the **VoltSE** CRBasic instruction.

Solar radiation can be recorded as an average flux density (W m$^{-2}$) or daily total flux (MJ m$^{-2}$). The appropriate multipliers are listed in TABLE 7-2. Negative values should be set to zero before being processed.

<table>
<tr><th colspan="3">TABLE 7-2.  Multipliers Required for Average Flux<br>and Total Flux Density in SI and English Units</th></tr>
<tr><th>UNITS</th><th>MULTIPLIER</th><th>PROCESS</th></tr>
<tr><td>W m$^{-2}$</td><td>5.0</td><td>Average</td></tr>
<tr><td>MJ m$^{-2}$</td><td>t • 0.000005</td><td>Total</td></tr>
<tr><td>kJ m$^{-2}$</td><td>t • 0.005</td><td>Total</td></tr>
<tr><td>cal cm$^{-2}$ min$^{-1}$</td><td>0.005 • (1.434)</td><td>Average</td></tr>
<tr><td>cal cm$^{-2}$</td><td>t • 0.005 • (0.0239)</td><td>Total</td></tr>
<tr><td colspan="3">t = datalogger execution interval in seconds</td></tr>
</table>

Nearby AC power lines, electric pumps, or motors can be a source of electrical noise. If the sensor or datalogger is located in an electrically noisy environment, the measurement should be made with the 60 or 50 Hz rejection integration option as shown in the example programs.

### 7.4.1  Total Solar Radiation

If solar radiation is totalized in units of kJ m$^{-2}$, there is a possibility of overranging the output limits. You can avoid this by using the IEEE4 or long data format.

# 8. Maintenance and Calibration

On a monthly basis, the level of the pyranometer should be checked. Any dust or debris on the sensor head should be removed. The debris can be removed with a blast of compressed air or with a soft bristle, camel hair brush.

| CAUTION | Handle the sensor carefully when cleaning. Be careful not to scratch the surface of the sensor. |
|---|---|

Recalibrate the pyranometer every three years. Refer to the *Assistance* page at the beginning of this document for the process of returning the pyranometer to Campbell Scientific for recalibration.

# 9. Troubleshooting

Symptom: –9999 or radiation values around 0

1. Check that the sensor is connected to the single-ended terminal specified by the measurement instruction.

2. Verify that the range code is correct for the datalogger type (Appendix B, *Example Programs (p. B-1)*).

3. Disconnect the sensor wires from the datalogger and use a digital volt meter (DVM) to check the voltage between the signal (+) and signal reference (–) wires (TABLE 7-1). The voltage should be 0 to 200 mV for 0 to 1000 $Wm^{-2}$ radiation. No voltage indicates a problem with either the photodiode or the shunt resistor, both of which are potted in the sensor head and cannot be serviced.

Symptom: Incorrect solar radiation

1. Make sure the top surface of the sensor head is clean, and that the sensor is properly leveled.

2. Verify that the range code, multiplier and offset parameters are correct for the desired engineering units and datalogger type.

| NOTE | Jumps of 3 to 6 $Wm^{-2}$ are typical of CR200(X) measurements, due to the 0.6 mV CR200(X) resolution and the 0.2 mV/$Wm^{-2}$ sensitivity. |
|---|---|

Symptom: Heater not functioning

1. Check that the sensor is connected correctly and that the heater is receiving power.

2. Disconnect the heater power and ground wires from the datalogger and use a DVM to measure the resistance (TABLE 7-1). The resistance should be around 780 Ω. An open or short circuit indicates a damaged heater. The heater circuit is embedded in the head of the sensor which is potted and cannot be repaired.

# 10. References

For more theoretical information on the silicon photovoltaic detector see Kerr, J. P., G. W. Thurtell, and C. B. Tanner: 1967, "An integrating pyranometer for climatological observer stations and mesoscale networks", *J. Appl. Meteor.*, **6**, 688-694.

# *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)
- .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)
- .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.

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**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 Programs*

The SP230 and SP230SS can be measured in switched 12V or constant 12V mode. The following examples show how to work with both modes of operation.

## B.1 Switched 12V Example

To use the switched 12V mode, an air temperature and relative humidity measurement must be taken, as well as dewpoint calculation. This example uses the EE181 sensor for the temperature and humidity measurement. The major difference between this code and what is created by *Short Cut* is a **Histogram** instruction that stores the fraction of the table time that the heater is off and the heater is on in two separate elements in the data set.

Wiring for the switched 12V example is given in TABLE B-1 and TABLE B-2.

| TABLE B-1. Temperature/Relative Humidity Sensor Wiring for CRBasic Example B-1 | | |
|---|---|---|
| **EE181 Wire Color** | **Wire Function** | **CR1000X** |
| Red | Power | **12V** |
| Yellow | Temperature | **SE1** |
| Blue | Relative Humidity | **SE2** |
| Black | Signal Reference | ⏚ |
| Clear | Shield | ⏚ |

| TABLE B-2. Pyranometer Wiring for CRBasic Example B-1 | | | |
|---|---|---|---|
| **SP230 Wire Color** | **SP230SS Wire Color** | **Wire Function** | **CR1000X** |
| Red | White | Signal | **SE3** |
| Black | Black | Signal Reference | ⏚ |
| White | Yellow | Heater Power | **SW1** |
| Green | Blue | Heater Ground | G |
| Clear | Clear | Shield | ⏚ |

---

**CRBasic Example B-1.  CR1000X Switched 12V Program**

```
'CR1000X
PipeLineMode
'Program scan rate can be changed here and changes will automatically roll into the
'multiplier for megajoules. Must be defined as a constant.
Const SCANRATE = 10

'Declare Variables and Units
'Datalogger internal measurements.
Public BattV     : Units BattV    = Volts    'Battery voltage
Public PTemp_C   : Units PTemp_C  = Deg C    'Datalogger panel temperature

'EE181 temperature/relative humidity variables.
Public AirTempC  : Units AirTempC = Deg C    'Air temperature
Public RH  : Units RH  = %  'Relative humidity

'Heated pyranometer variables.
Public SlrW      : Units SlrW     = W/m^2    'Solar flux density
Public SlrMJ     : Units SlrMJ    = MJ/m^2   'Total solar flux
Public HtrCntrl As Boolean                   'Flag used to control the heater state.

'Dewpoint calculation variable.
Public DewPtC    : Units DewPtC   = Deg C    'Dewpoint temperature

'Miscellaneous
Dim AirDewDif  'Value used to store the difference between air temp and dewpoint.

'Define Data Tables
'Histogram instruction is used to indicate the fraction of the table period that the
'heater is switched off and switched on. A histogram instruction will not work directly with
'Boolean values so convert the value to a fixed number and change the sign. Boolean TRUE = -1,
'Boolean FALSE = 0: change it to 1 and 0 for use with the Histogram.
DataTable(Hourly,True,-1)
  DataInterval(0,60,Min,10)
  Average (1,AirTempC,FP2,False)
  Average (1,DewPtC,FP2,False)
  Average(1,SlrW,FP2,False)
  Histogram (HtrCntrl * -1,FP2,False,2,000,1,0,1)
  FieldNames ("FracHtrTimeOff,FracHtrTimeOn")
EndTable

'Histogram instruction is used to indicate the fraction of the table period that the
'heater is switched off and switched on.
DataTable(Daily,True,-1)
  DataInterval(0,1440,Min,10)
  Minimum (1,AirTempC,FP2,False,True)
  Maximum (1,AirTempC,FP2,False,True)
  Minimum (1,RH,FP2,False,True)
  Maximum (1,RH,FP2,False,True)
  Minimum (1,DewPtC,FP2,False,True)
  Maximum (1,DewPtC,FP2,False,True)
  Totalize(1,SlrMJ,IEEE4,False)  'Must be defined as IEEE4 so as not to overrun on a sunny day'
  Histogram (HtrCntrl * -1,FP2,False,2,000,1,0,1)
  FieldNames ("FracHtrTimeOff,FracHtrTimeOn")
  Minimum (1,BattV,FP2,False,False)
  Maximum (1,BattV,FP2,False,False)
  Minimum (1,PTemp_C,FP2,False,False)
  Maximum (1,PTemp_C,FP2,False,False)
EndTable

'Main Program
BeginProg
  'Main Scan
  Scan(SCANRATE,Sec,2,0)
    'Default Datalogger Battery Voltage measurement 'BattV'
    Battery(BattV)
```

**B-2**

```
      'Default Wiring Panel Temperature measurement 'PTemp_C'
      PanelTemp(PTemp_C,60)

      'EE181 (constant power) Temperature & Relative Humidity Sensor measurements
      'AirTempC' and 'RH'
      VoltSe(AirTempC,1,mV1000,1,0,0,60,0.1,-40)
      VoltSe(RH,1,mV1000,2,0,0,60,0.1,0)
      If RH>100 AND RH<103 Then RH=100

      'Dewpoint calculation 'DewPtC'
      DewPoint(DewPtC,AirTempC,RH)
      If DewPtC>AirTempC OR DewPtC=NAN Then DewPtC=AirTempC

      'Pyranometer measurements 'SlrMJ' and 'SlrW'
      'VoltSE can use AutoRange (intensities <= 1200 W/m²)
      'Otherwise, use mV1000 for the CR1000X, CR6, CR3000, CR5000, and CR9000X
      'Use mV2500 for the CR300-series, CR800-series, and CR1000
      VoltSe(SlrW,1,AutoRange,3,0,0,60,1,0)
      If SlrW < 0 Then SlrW = 0
      SlrMJ = SlrW * SCANRATE * 5E-6
      SlrW = SlrW * 5.0

      'Heater Control
      'Calculate difference between air temperature and dewpoint.
      AirDewDif = AirTempC - DewPtC
      'Only allow heater to operate if the battery voltage is greater than 11.7 Vdc.
      If BattV >= 11.7 Then
        'Perform this logic if heater is off.
        If HtrCntrl = False Then
          'Turn heater on regardless of dewpoint if air temperature is less than 2°C.
          If AirTempC <= 2 Then
            HtrCntrl = True
          Else
            'Turn heater on if air temperature is above 2°C and the difference between
            'air temperature and dewpoint is less than, or equal to, 2°C.
            If AirDewDif <= 2 Then HtrCntrl = True
          EndIf
        Else
          'If the heater is already on then check to see if the air temperature is greater than
          '3°C and if the difference between the air temperature and dewpoint is 3°C. If
          'it is then shut the heater off.
          If (AirTempC > 3) AND (AirDewDif >= 3) Then HtrCntrl = False
        EndIf
      Else
        'Shut the heater off if the battery voltage is less than 11.7 vdc.
        HtrCntrl = False
      EndIf
      'Switched 12V is controlled by the Boolean variable HtrCntrl. Controlling the SW1
      'instruction this way allows the program to run in PipeLine mode and possibly faster
      'execution speeds.
      SW12(SW12_1,HtrCntrl)

      'Call Data Tables and Store Data
      CallTable Hourly
      CallTable Daily
  NextScan
EndProg
```

# B.2 Constant 12V Example

Wiring for the constant 12V example is given in TABLE B-3.

| TABLE B-3. Wiring for Constant Power Example Program | | | |
|---|---|---|---|
| **SP230 Wire Color** | **SP230SS Wire Color** | **Wire Label** | **CR1000X** |
| Red | White | Signal | SE 1 |
| Black | Black | Signal Reference | ⏚ |
| White | Yellow | Heater Power | 12V |
| Green | Blue | Heater Ground | G |
| Clear | Clear | Shield | ⏚ |

**CRBasic Example B-2. CR1000X Constant 12V Program**

```
'CR1000X
'Program scan rate can be changed here and changes will automatically roll into the
'multiplier for megajoules. Must be defined as a constant.
Const SCANRATE = 10

'Declare Variables and Units
'Datalogger internal measurements.
Public BattV    : Units BattV   = Volts    'Battery voltage
Public PTemp_C  : Units PTemp_C = Deg C    'Datalogger panel temperature

'Heated pyranometer variables.
Public SlrW     : Units SlrW    = W/m^2    'Solar flux density
Public SlrMJ    : Units SlrMJ   = MJ/m^2   'Total solar flux

'Define Data Tables
DataTable(Hourly,True,-1)
  DataInterval(0,60,Min,10)
  Average(1,SlrW,FP2,False)
EndTable

'Histogram instruction is used to indicate the fraction of the table period that the
'heater is switched off and switched on.
DataTable(Daily,True,-1)
  DataInterval(0,1440,Min,10)
  Totalize(1,SlrMJ,IEEE4,False)   'Must be defined as IEEE4 so as not to overrun on a sunny day'
  Minimum (1,BattV,FP2,False,False)
  Maximum (1,BattV,FP2,False,False)
  Minimum (1,PTemp_C,FP2,False,False)
  Maximum (1,PTemp_C,FP2,False,False)
EndTable

'Main Program
BeginProg
  'Main Scan
  Scan(SCANRATE,Sec,2,0)
    'Default Datalogger Battery Voltage measurement 'BattV'
    Battery(BattV)

    'Default Wiring Panel Temperature measurement 'PTemp_C'
    PanelTemp(PTemp_C,60)

    'Pyranometer measurements 'SlrMJ' and 'SlrW'
```

```
      'VoltSE can use AutoRange (intensities <= 1200 W/m²)
      'Otherwise, use mV1000 for the CR1000X, CR6, CR3000, CR5000, and CR9000X
      'Use mV2500 for the CR300-series, CR800-series, and CR1000
VoltSe(SlrW,1,AutoRange,1,0,0,60,1,0)
    If SlrW < 0 Then SlrW = 0
    SlrMJ = SlrW * SCANRATE * 5E-6
    SlrW = SlrW * 5.0

    'Call Data Tables and Store Data
    CallTable Hourly
    CallTable Daily
  NextScan
EndProg
```

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