

# INSTRUCTION MANUAL



## **SP230 Heated Pyranometer**

Revision: 10/17



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# Assistance

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# Precautions

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**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.ca](http://www.campbellsci.ca) or by telephoning (780) 454-2505 (Canada). 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 personnel (e.g. 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.
- 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, 6 meters (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 CLIENT 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.

# ***PLEASE READ FIRST***

## **About this manual**

Please note that this manual was originally produced by Campbell Scientific Inc. (CSI) primarily for the US market. Some spellings, weights and measures may reflect this origin.

Some useful conversion factors:

<b>Area:</b>	1 in <sup>2</sup> (square inch) = 645 mm <sup>2</sup>
<b>Length:</b>	1 in. (inch) = 25.4 mm
	1 ft (foot) = 304.8 mm
	1 yard = 0.914 m
	1 mile = 1.609 km
<b>Mass:</b>	1 oz. (ounce) = 28.35 g
	1 lb (pound weight) = 0.454 kg
<b>Pressure:</b>	1 psi (lb/in <sup>2</sup> ) = 68.95 mb
<b>Volume:</b>	1 US gallon = 3.785 litres

In addition, part ordering numbers may vary. For example, the CABLE5CBL is a CSI part number and known as a FIN5COND at Campbell Scientific Canada (CSC). CSC Technical Support will be pleased to assist with any questions.

## **About sensor wiring**

Please note that certain sensor configurations may require a user supplied jumper wire. It is recommended to review the sensor configuration requirements for your application and supply the jumper wire is necessary.



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# SP230 Heated Pyranometer

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## 1. Introduction

The SP230, manufactured by Apogee Instruments, measures total sun and sky solar radiation for solar, agricultural, meteorological, and hydrological applications. Its spectral range of 360 to 1120 nanometers encompasses most of the shortwave radiation that reaches the Earth's surface. This pyranometer connects directly to our dataloggers. Its output can be measured by all of our dataloggers.

Integrated heaters allow the sensor to work in dew, ice, and snow conditions. The heater is not sufficient to work in heavy riming conditions.

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### NOTE

This manual provides information only for CRBasic dataloggers. It is also compatible with most of our retired Edlog dataloggers. For Edlog datalogger support, see an older SP230 manual at [www.campbellsci.com/old-manuals](http://www.campbellsci.com/old-manuals).

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## 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, consult with a Campbell Scientific application engineer.
- 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 SP230, inspect the packaging and contents for damage. File damage claims with the shipping company.

## 4. QuickStart

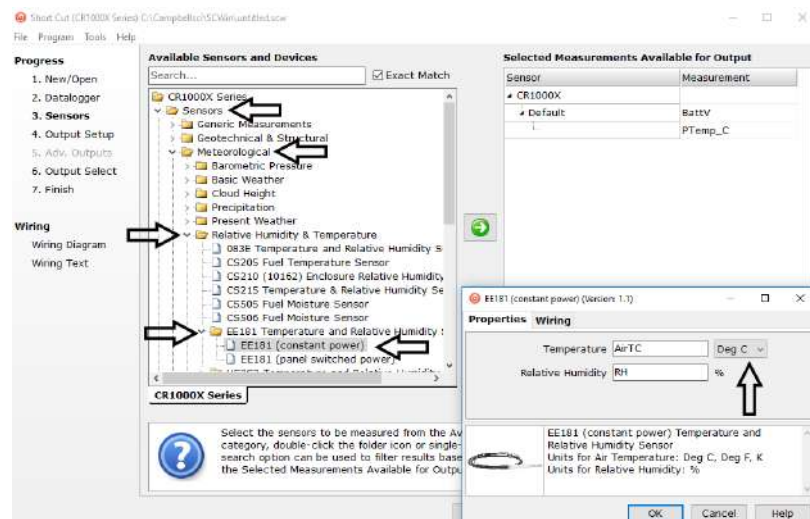
*Short Cut* is an easy way to program your datalogger to measure the SP230 and assign datalogger wiring terminals. *Short Cut* is available as a download on [www.campbellsci.com](http://www.campbellsci.com) and the *ResourceDVD*. It is included in installations of

LoggerNet, PC200W, PC400, or RTDAQ. The following procedure shows using *Short Cut* to program the SP230.

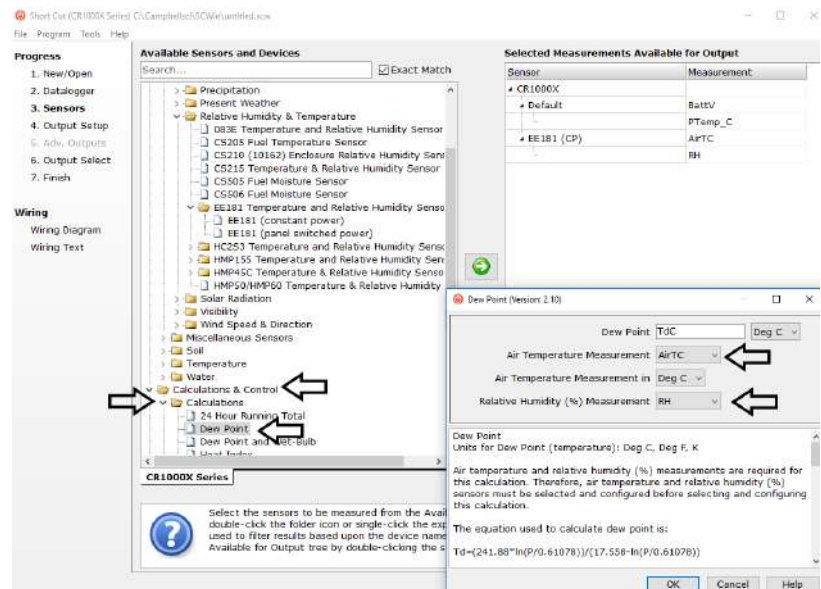
1. Open *Short Cut* and create a new program.
2. Double-click the datalogger model.
3. The SP230 has two heater modes of operation – constant or switched 12 Vdc. Switched heater mode is only available on dataloggers that have switched 12 Vdc capability and uses less power than constant. Switched heater mode is recommended for all dataloggers that have this capability but require the addition of an air temperature and relative humidity sensor and dewpoint calculation.

A temperature/relative humidity measurement and dewpoint calculation are required before selecting the SP230 in switched mode. This example shows an EE181 Temp/RH sensor used with a CR1000X.

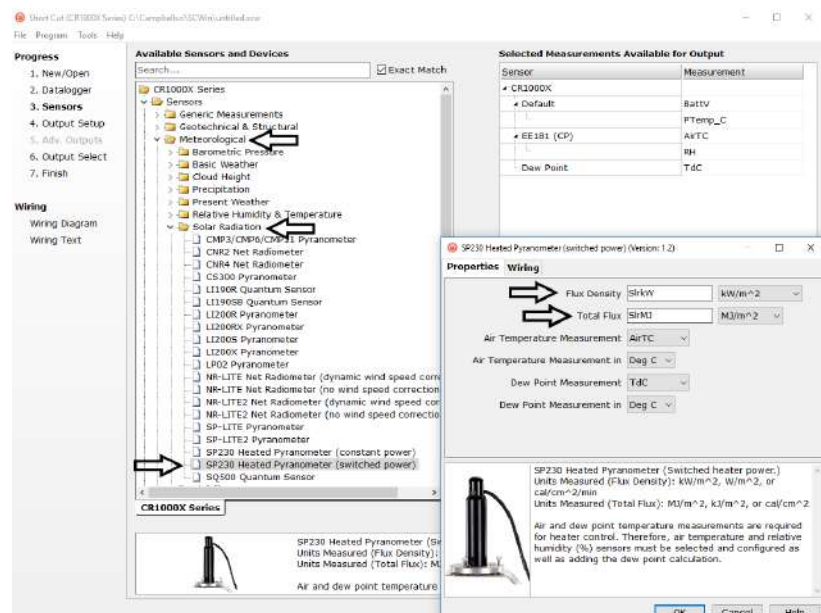
Under the **Available Sensors and Devices** list, select **Sensors | Meteorological | Relative Humidity & Temperature | EE181 Temperature and Relative Humidity** folder and double-click either **EE181 (constant power)** or **EE181 (panel switched power)**. Use the default of degrees C.



4. Select **Calculations & Control | Calculations** folder and double-click **Dew Point**. Select the air temperature and relative humidity variables from the EE181.



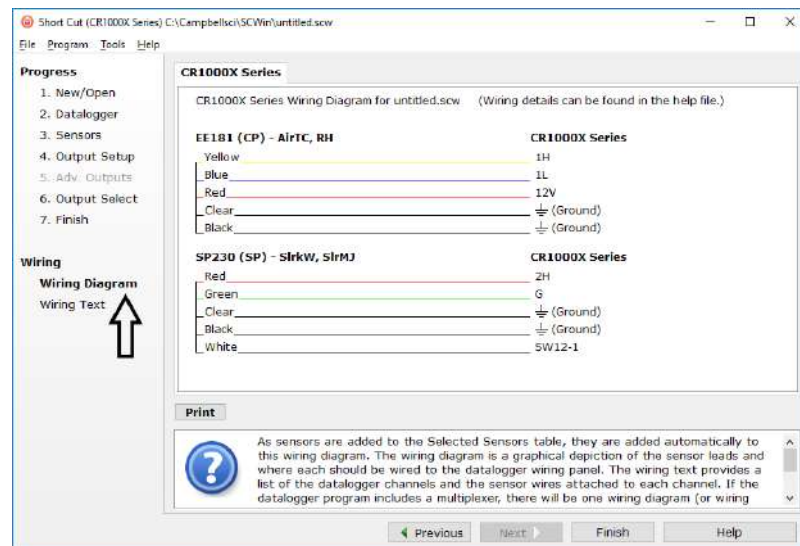
5. Under the **Available Sensors and Devices** list, select **Sensors | Meteorological | Solar Radiation | SP230 Heated Pyranometer** and double-click **SP230 (switched power)**. Default units are  $\text{kW/m}^2$  for flux density units and  $\text{mJ/m}^2$  for total flux. These can be changed by clicking the **Flux Density** and **Total Flux** boxes and selecting different values. Make sure that the selections for air temperature and dewpoint are correct.



6. After selecting the sensor, click at the left of the screen on **Wiring Diagram** to see how the sensor is to be wired to the datalogger. The wiring diagram can be printed out now or after more sensors are added.

**WARNING**

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



7. Select any other sensors you have, then finish the remaining *Short Cut* steps to complete the program. The remaining steps are outlined in *Short Cut Help*, which is accessed by clicking on **Help | Contents | Programming Steps**.
8. If *LoggerNet*, *PC400*, *RTDAQ*, or *PC200W* is running on your PC, and the PC to datalogger connection is active, you can click **Finish** in *Short Cut* and you will be prompted to send the program just created to the datalogger.
9. If the sensor is connected to the datalogger, as shown in the wiring diagram in step 6, check the output of the sensor in the datalogger support software data display to make sure it is making reasonable measurements.

## 5. Overview

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

During the night, the SP230 may read slightly negative incoming solar radiation. This negative signal is caused by RF noise passing through the photodiode. Negative values may be set to zero in the datalogger program.

The SP230 has 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.

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.

## 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)

<b>Power requirements:</b>	integrated heaters = 12 Vdc with 15 mA current draw (0.18 W)  solar sensing diode requires no power
<b>Sensitivity:</b>	5 W m <sup>-2</sup> mV <sup>-1</sup> (0.2 mV W <sup>-1</sup> m <sup>-2</sup> )
<b>Absolute accuracy:</b>	±5% for daily total radiation
<b>Cosine response:</b>	±5% at 75° zenith angle. ±2% at 45° zenith angle
<b>Response time:</b>	< 1 ms
<b>Temperature response:</b>	< 1% at 5 to 40 °C
<b>Long-term stability:</b>	< 2% per year
<b>Operating temperature:</b>	-40 to 70 °C
<b>Relative humidity:</b>	0 to 100%
<b>Output (solar sensing photodiode):</b>	0.2 mV per W m <sup>-2</sup>
<b>Diameter:</b>	3.15 cm (1.24 in)
<b>Height:</b>	12.75 cm (5.02 in)
<b>Weight:</b>	142.0 g (5.01 oz) with 2 m lead wire
<b>Measurement range:</b>	0 to 1750 W m <sup>-2</sup> (full sunlight ≈ 1000 W m <sup>-2</sup> )
<b>Light spectrum waveband:</b>	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. 8), 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 Siting

The SP230 should be mounted such that no shadows or reflections are cast on it by the tripod/tower or other sensors. The sensor should be mounted with the cable pointing 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:

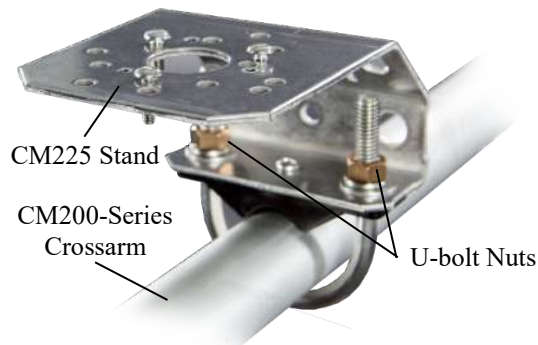
Small and medium Phillips screwdrivers  
 1/2 in open end wrench for CM225 or 015ARM  
 Tape measure  
 UV-resistant cable ties  
 Side-cut pliers  
 Compass  
 Step ladder

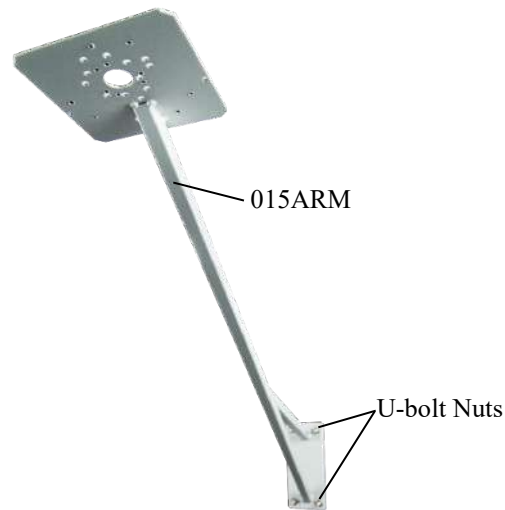
#### 7.2.2 Mounting Procedure

##### CAUTION

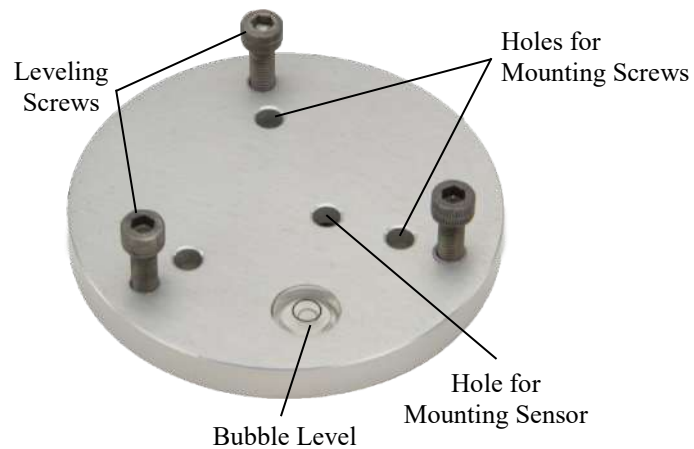
The CM225 should never be mounted directly to a vertical pipe. Instead the CM225 should be mounted to a crossarm. This avoids reflections from the vertical pipe onto the sensor.

1. Mount the crossarm to the tripod or tower if using a CM225.
2. Place the CM225's U-bolt in the bottom holes and secure the CM225 to the crossarm by tightening the U-bolt nuts. Secure the 015ARM to the mast by tightening the U-bolt nuts.

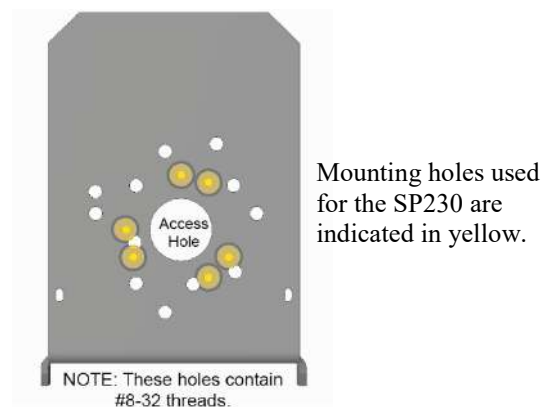




- Place the SP230 in the center of the 18356 base/leveling fixture.



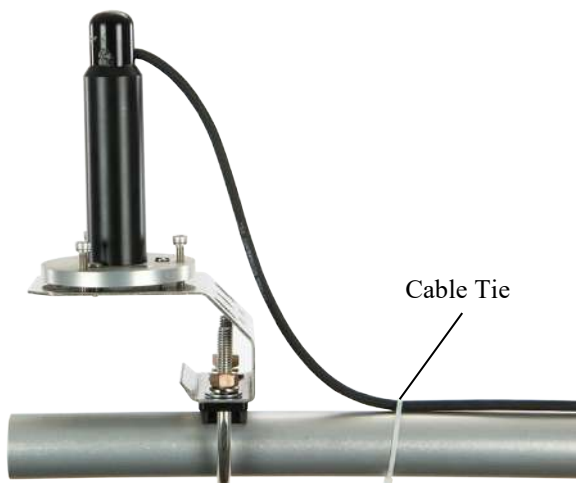
- Loosely mount the 18356 base/leveling fixture on the CM225 or 015ARM. Do not fully tighten the three mounting screws.



- 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.



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 SP230 is shown in FIGURE 7-1.

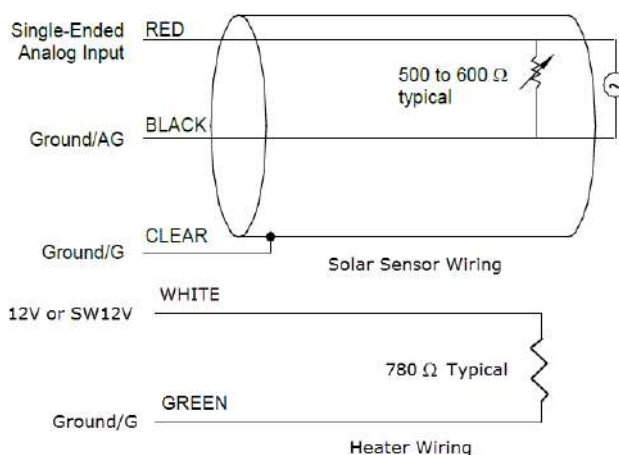


FIGURE 7-1. SP230 schematic

Connections to Campbell Scientific dataloggers are given in TABLE 7-1. The SP230 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 channels shown in the wiring diagram created by *Short Cut*.

**TABLE 7-1. Wire Color, Function, and Datalogger Connection**

Wire Color	Wire Function	Switched Heater Power	Constant Heater Power
Red	Signal	U configured for single-ended analog input <sup>1</sup> , SE (single-ended, analog-voltage input)	U configured for single-ended analog input <sup>1</sup> , SE (single-ended, analog-voltage input)
Black	Signal Reference	$\perp$ (analog ground)	$\perp$ (analog ground)
White	Heater Power	SW, SW12, SW12V, SW Battery (switched 12 V)	12V, Battery +
Green	Heater Ground	G	G
Clear	Shield	$\perp$ (analog ground)	$\perp$ (analog ground)
<sup>1</sup> U channels are automatically configured by the measurement instruction.			

## 7.4 Programming

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

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

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

### NOTE

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

A *Short Cut* tutorial is available in Section 4, *QuickStart* (p. 1). If you wish to import *Short Cut* code into *CRBasic Editor* to create or add to a customized program, follow the procedure in Appendix A, *Importing Short Cut Code Into CRBasic Editor* (p. A-1). Programming basics for CRBasic dataloggers are provided in the following sections. 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](http://www.campbellsci.com/old-manuals).

The output from the SP230 is 0.2 mV per  $\text{Wm}^{-2}$ . The voltage signal from the SP230 is measured using the **VoltSE** CRBasic instruction.

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

**TABLE 7-2. Multipliers Required for Average Flux and Total Flux Density in SI and English Units**

UNITS	MULTIPLIER	PROCESS
$\text{W m}^{-2}$	5.0	Average
$\text{MJ m}^{-2}$	$t \cdot 0.000005$	Total
$\text{kJ m}^{-2}$	$t \cdot 0.005$	Total
$\text{cal cm}^{-2} \text{ min}^{-1}$	$0.005 \cdot (1.434)$	Average
$\text{cal cm}^{-2}$	$t \cdot 0.005 \cdot (0.0239)$	Total
$t = \text{datalogger execution interval in seconds}$		

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  $\text{kJ m}^{-2}$ , 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 SP230 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 wired to the single-ended channel specified by the measurement instruction.
2. Verify that the range code is correct for the datalogger type.
3. Disconnect the sensor leads from the datalogger and use a digital volt meter (DVM) to check the voltage between the red (+) and the black (-)

wires. The voltage should be 0 to 200 mV for 0 to 1000  $\text{Wm}^{-2}$  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.

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**NOTE**

Jumps of 3 to 6  $\text{Wm}^{-2}$  are typical of CR200(X) measurements, due to the 0.6 mV CR200(X) resolution and the 0.2 mV/ $\text{Wm}^{-2}$  SP230 sensitivity.

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Symptom: Heater not functioning

1. Check that the sensor is wired correctly and that the heater is receiving power.
2. Disconnect the white and green wires from the datalogger and use a DVM to measure the resistance. The resistance should be around 780  $\Omega$ . 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.



# Appendix A. Importing Short Cut Code Into CRBasic Editor

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This tutorial shows:

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

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

- .DEF (wiring and memory usage information)
- .CR2 (CR200(X)-series datalogger code)
- .CR300 (CR300-series datalogger code)
- .CR6 (CR6 datalogger code)
- .CR8 (CR800-series datalogger code)
- .CR1X (CR1000X datalogger code)
- .CR1 (CR1000 datalogger code)
- .CR3 (CR3000 datalogger code)
- .CR5 (CR5000 datalogger code)
- .CR9 (CR9000(X) datalogger code)

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

1. Create the *Short Cut* program following the procedure in Section 4, *QuickStart* (p. 1). Finish the program and exit *Short Cut*. Make note of the file name used when saving the *Short Cut* program.
2. Open *CRBasic Editor*.
3. Click **File | Open**. Assuming the default paths were used when *Short Cut* was installed, navigate to C:\CampbellSci\SCWin folder. The file of interest has the .CR2, .CR300, .CR6, .CR8, .CR1X, .CR1, .CR3, .CR5, or .CR9 extension. Select the file and click **Open**.
4. Immediately save the file in a folder different from C:\Campbellsci\SCWin, or save the file with a different file name.

---

## NOTE

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

---

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



# Appendix B. Example Programs

The SP230 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 a Rotronic HC2S3 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.

TABLE B-1. Wiring for Switched-Power Example Program		
Color	Wire Label	CR1000
Rotronic HC2S3 Temperature/Relative Humidity Sensor (Always On)		
Green	Power	12V
Brown	Temperature	SE 1
White	Relative Humidity	SE 2
Yellow	Signal Reference	$\perp$
Gray	Power Ground	$\perp$
Clear	Shield	$\perp$
SP230 Heated Pyranometer		
Red	Signal	SE 3
Black	Signal Reference	$\perp$
White	Heater Power	SW12V
Green	Heater Ground	G
Clear	Shield	$\perp$



**CRBasic Example B-1. CR1000 Switched 12V Program**

```

'CR1000
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

'HC2S3 temperature/relative humidity variables.
Public AirTempC   : Units AirTempC   = Deg C   'Air temperature
Public RH         : Units RH         = %       'Relative humidity

'SP230 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 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 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)

```

```

'Default Wiring Panel Temperature measurement 'PTemp_C'
PanelTemp(PTemp_C,_60Hz)

'HC2S3 (constant power) Temperature & Relative Humidity Sensor measurements
'AirTempC' and 'RH'
VoltSe(AirTempC,1,mV2500,1,0,0,_60Hz,0.1,-40)
VoltSe(RH,1,mV2500,2,0,0,_60Hz,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

'SP230 Pyranometer measurements 'SlrMJ' and 'SlrW'
VoltSe(SlrW,1,AutoRange,3,0,0,_60Hz,1,0) 'Use mV1000 range code for the CR3000, CR5000,
If SlrW < 0 Then SlrW = 0 'and CR9000. Use AutoRange for the CR1000
SlrMJ = SlrW * SCANRATE * 5E-6 'or mV2500 range for > 1200 W/m² intensities.
SlrW = SlrW * 5.0

'SP230 Heater Control
'Calculate difference between air temperature and dewpoint.
AirDewDif = AirTempC - DewPtC
'Only allow heater to operate if the battery voltage is greater than 11.7vdc.
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 SW12
'instruction this way allows the program to run in PipeLine mode and possibly faster
'execution speeds.
SW12(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-2.

TABLE B-2. Wiring for Constant Power Example Program		
Color	Wire Label	CR1000
Red	Signal	SE 1
Black	Signal Reference	$\perp$
White	Heater Power	12V
Green	Heater Ground	G
Clear	Shield	$\perp$

### CRBasic Example B-2. CR1000 Constant 12V Program

```
'CR1000
'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

'SP230 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,_60Hz)

'SP230 Pyranometer measurements 'SlrMJ' and 'SlrW'
VoltSe(SlrW,1,AutoRange,1,0,0,_60Hz,1,0) 'Use mV1000 range code for the CR3000, CR5000,
```

```
If S1rW < 0 Then S1rW = 0 'and CR9000. Use AutoRange for the CR1000
S1rMJ = S1rW * SCANRATE * 5E-6 'or mV2500 range for > 1200 W/mÅ² intensities.
S1rW = S1rW * 5.0

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





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