INSTRUCTION MANUAL

SP230 Heated Pyranometer

Revision: 1/15

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.**”

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), contact CAMPBELL SCIENTIFIC, INC., phone (435) 227-9000. After an application engineer determines the nature of the problem, an RMA number will be issued. Please write this 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 web site 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.

Precautions

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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SP230 Heated Pyranometer

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.

2. Cautionary Statements

- READ AND UNDERSTAND the *Precautions* 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.

3. Initial Inspection

- Upon receipt of the SP230, inspect the packaging and contents for damage. File damage claims with the shipping company.

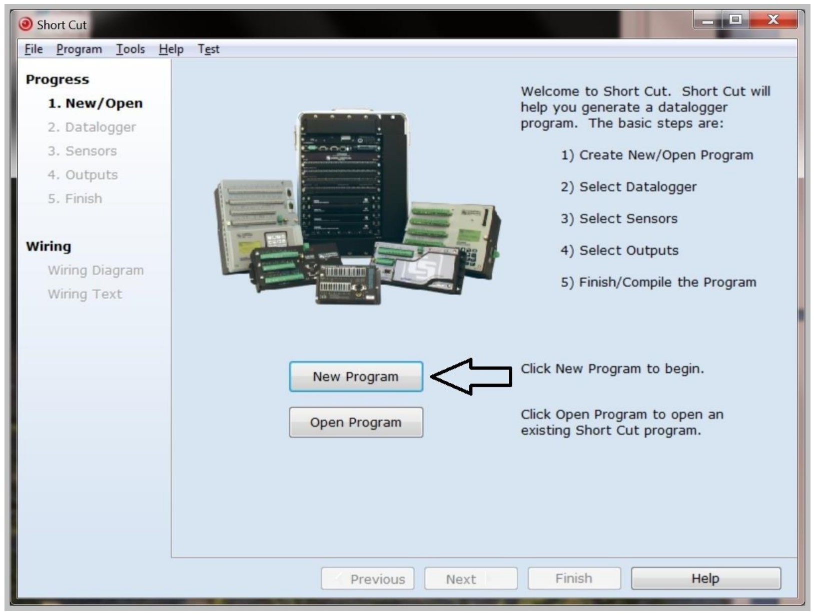
4. Quickstart

Short Cut is an easy way to program your datalogger to measure the SP230 and assign datalogger wiring terminals. Use the following procedure to get started.

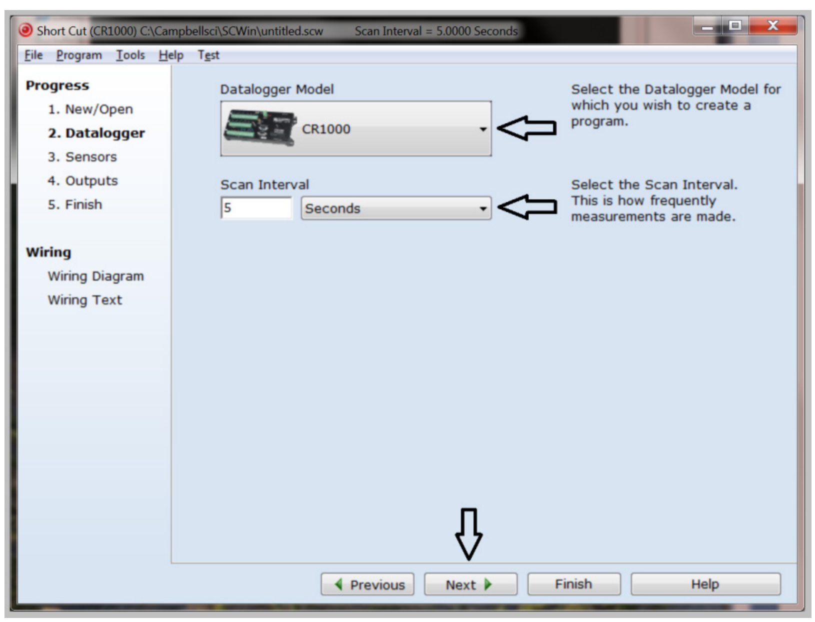
1. Install *Short Cut* by clicking on the install file icon. Get the install file from either *www.campbellsci.com*, the ResourceDVD, or find it in installations of *LoggerNet*, *PC200W*, *PC400*, or *RTDAQ* software.

2. The *Short Cut* installation should place a *Short Cut* icon on the desktop of your computer. To open *Short Cut*, click on this icon.

3. When *Short Cut* opens, select **New Program**.



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

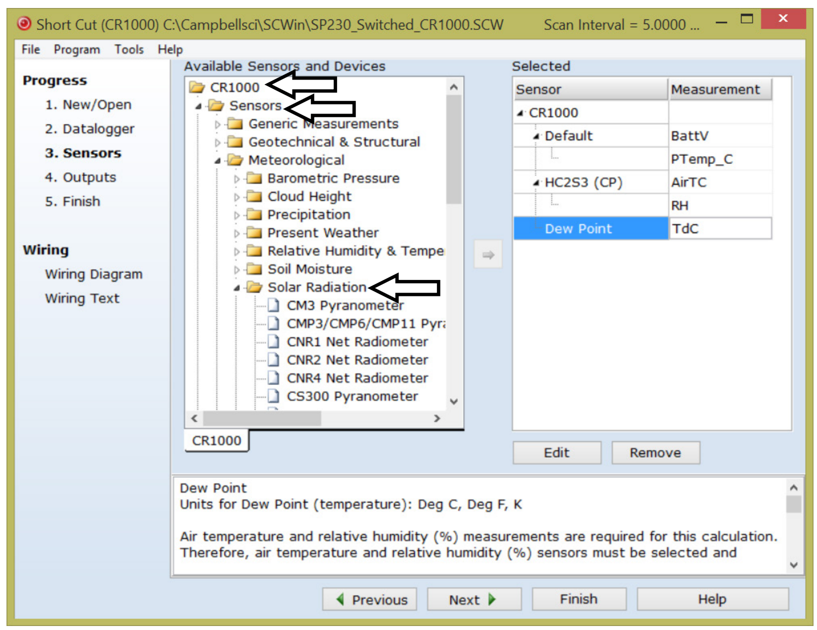


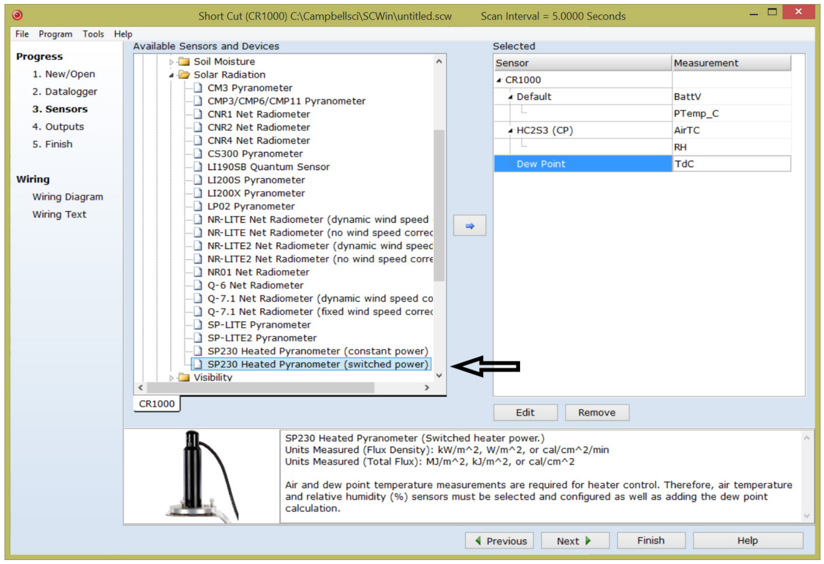
5. The SP230 has two heater modes of operation – constant or switched 12 Vdc. Switched heater mode is only available on dataloggers that have switched 12 Vdc capability and uses less power than constant. Switched heater mode is recommended for all dataloggers that have this capability but require the addition of an air temperature and relative humidity sensor and dewpoint calculation.

   An example using constant mode for a CR10 is given in Appendix B.2.2, *CR10 Constant 12V Program*.

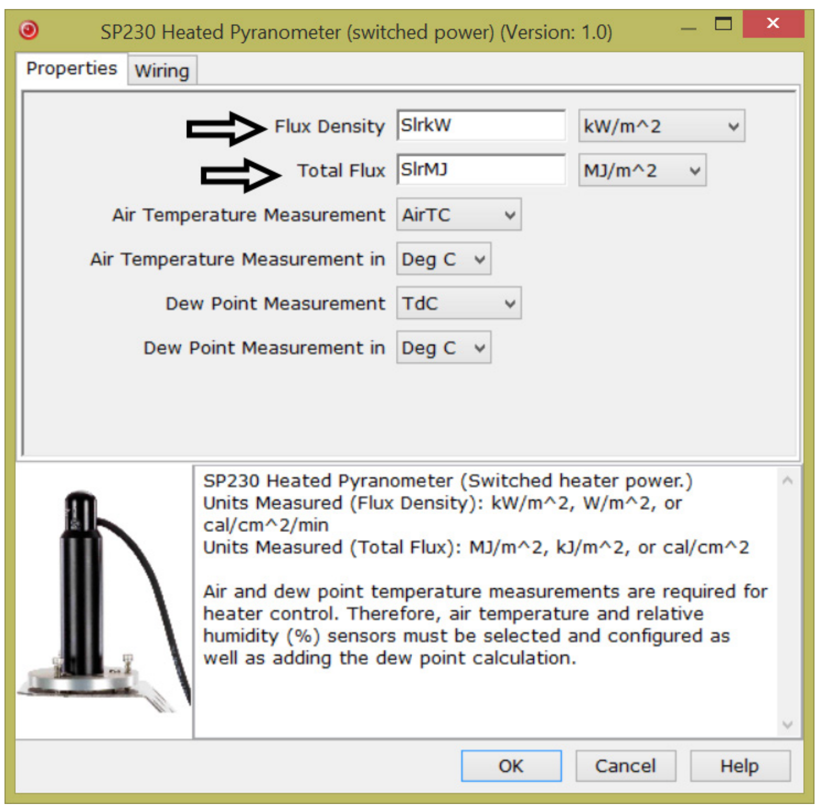
   Switched heater mode requires that a temperature/relative humidity sensor and dewpoint calculation must be added to *Short Cut* before adding the SP230 in switched mode. This example shows a HC2S3 Temp/RH sensor used with a CR1000.

   Under the **Available Sensors and Devices** list, select **Sensors | Meteorological | Solar Radiation | SP230 Heated Pyranometer | SP230 (switched power).**





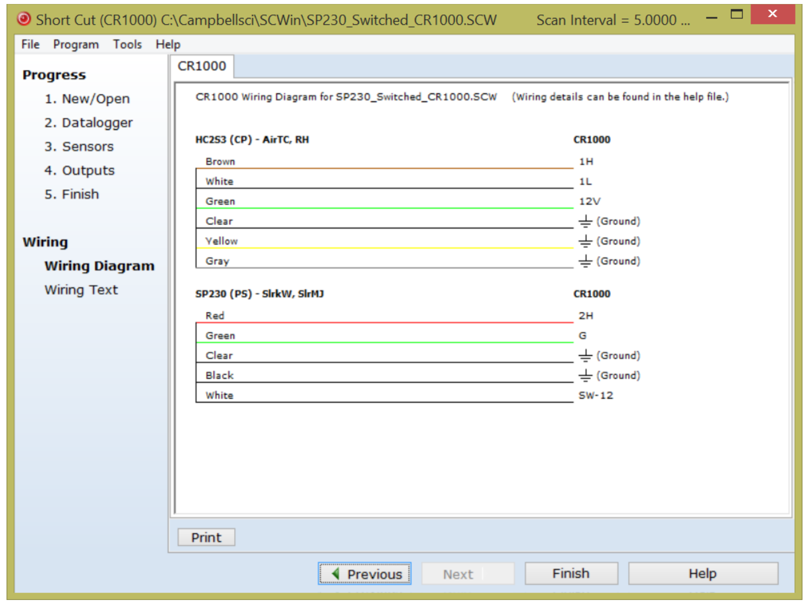
6. Click  to move the selection to the **Selected** device window. Default units are kW/m^2 for flux density units and mJ/m^2 for total flux. These can be changed by clicking the **Flux Density** and **Total Flux** boxes and selecting different values. Make sure that the selections for air temperature and dewpoint are correct.



7. 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.



8. 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**.

9. 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.

10. 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: CR6, CR200(X) series, CR800, CR850, CR1000, CR3000, CR5000, and CR9000(X). Also compatible with Edlog dataloggers: CR500, CR510, CR10(X), CR23X, CR7, and 21X

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 ≈ 1000 W m^{-2})

Light spectrum waveband: 360 to 1120 nm (wavelengths where response is 10% of maximum)

NOTE 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.

7. Installation

If you are programming your datalogger with *Short Cut*, skip Section 7.3, *Wiring to the Datalogger*, and Section 7.4, *Programming*. *Short Cut* does this work for you. See Section 4, *Quickstart*, 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

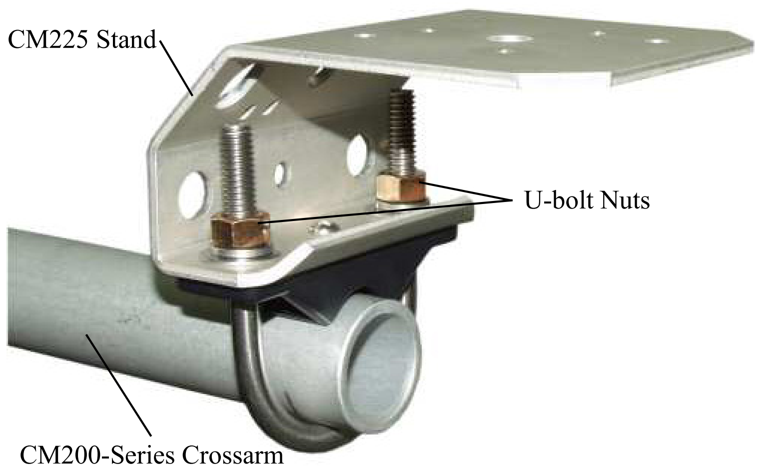
7.2.2 Mounting Procedure

7.2.2.1 CM225 Solar Sensor Mounting Stand

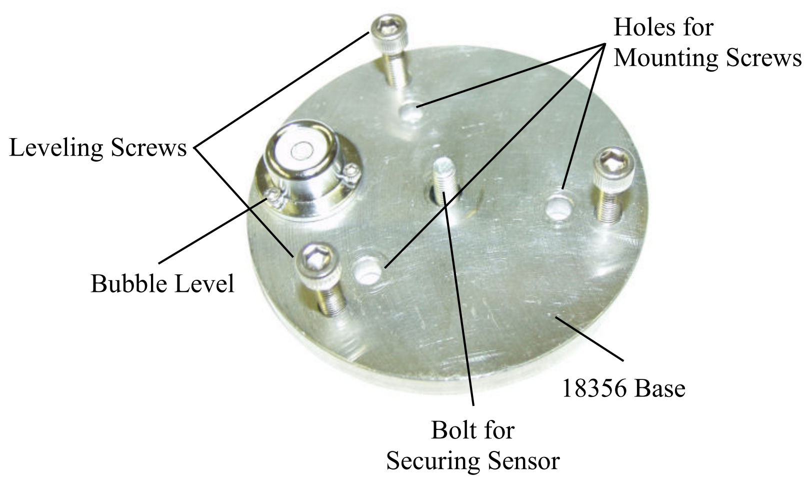
CAUTION The CM225 should never be mounted directly to a vertical pipe. Instead the CM225 should be mounted to a crossarm. This avoids reflections from the vertical pipe onto the sensor.

1. Mount the crossarm to the tripod or tower.

2. Place the CM225's U-bolt in the bottom holes and secure the CM225 to the crossarm by tightening the U-bolt nuts.



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



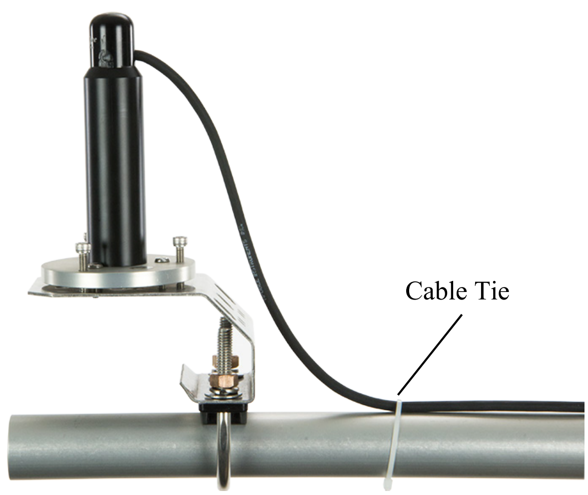
4. Loosely mount the 18356 base/leveling fixture on the CM225. Do not fully tighten the three mounting screws.

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 to the tripod/tower, and to the instrument enclosure.

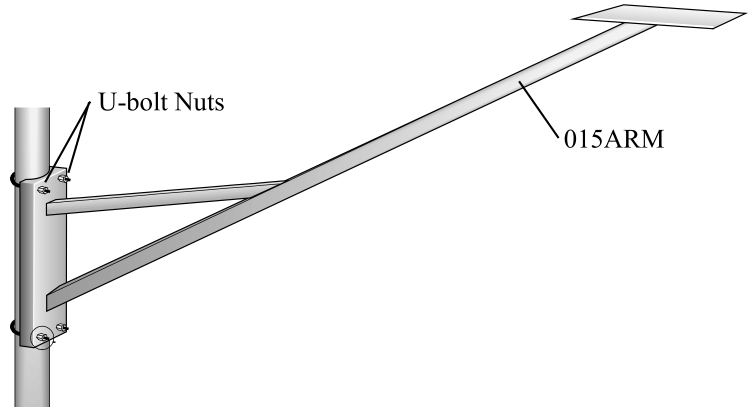
8. Secure the cable to the crossarm and mast using cable ties.



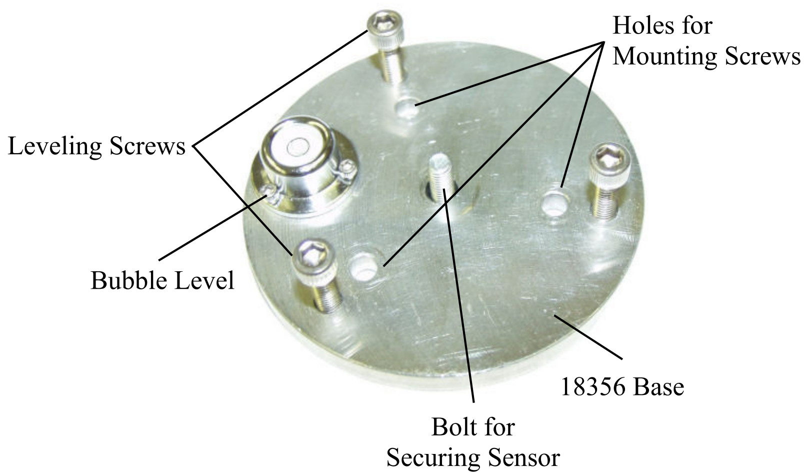
9. Remove the green cap after installing the sensor. Save this cap for shipping or storing the sensor.

7.2.2.2 015ARM

1. Secure the 015ARM to the mast by tightening the U-bolt nuts.



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



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

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

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

6. Route the sensor cable along the underside of the 015ARM's arm to the tripod/tower, and to the instrument enclosure.

7. Secure the cable to the mounting arm and mast using cable ties.

8. 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.

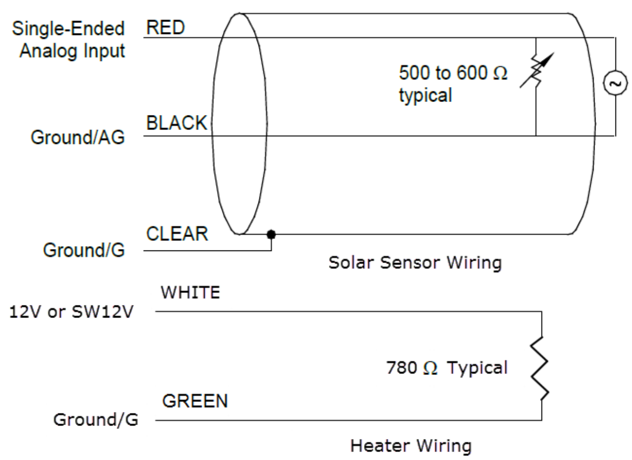


FIGURE 7-1. SP230 schematic

The SP230 heater can be run in switched 12 Vdc or constant mode. Whenever possible, run the heater in switched 12 Vdc mode to conserve power. TABLE 7-1 shows the wiring configurations for the dataloggers that can run in switched 12 Vdc mode. TABLE 7-2 shows the wiring configurations for constant 12 Vdc mode. 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. Connections to Campbell Scientific Dataloggers for Switched Heater Power

Color	Wire Label	CR9000(X) CR5000 CR3000 CR1000 CR850 CR800 CR6	CR200(X)	CR23X	CR10X
Red	Signal	SE Analog	SE Analog	SE Analog	SE Analog
Black	Signal Reference	⏚	⏚	AG	AG
White	Heater Pwr	SW12V	SW Battery	SW12	SW 12V (Jumper from Control Port (C1 – C8) to SW12V Ctrl)
Green	Heater Gnd	G	G	G	G
Clear	Shield	⏚	⏚	⏚	G

TABLE 7-2. Connections to Campbell Scientific Dataloggers for Constant Heater Power

Color	Wire Label	CR9000(X) CR5000 CR3000 CR1000 CR850 CR800 CR6	CR200(X)	21X CR10(X) CR23X CR500 CR510
Red	Signal	SE Analog	SE Analog	SE Analog
Black	Signal Reference	⏚	⏚	AG
White	Heater Pwr	12V	BATTERY +	12V
Green	Heater Gnd	G	G	G
Clear	Shield	⏚	⏚	⏚

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
- when 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*. If you wish to import *Short Cut* code into either *Edlog* or *CRBasic Editor* to create or add to a customized program, follow the procedure in Appendix A, *Importing Short Cut Code Into CRBasic or Edlog Editor*. Programming basics for CRBasic are provided below. Complete CRBasic and Edlog program examples are found in Appendix B, *Example Programs*.

The output from the SP230 is 0.2 mV per Wm^{-2}. The voltage signal from the SP230 is measured using the single-ended voltage instruction (**VoltSE** in CRBasic). Dataloggers that use CRBasic include the CR6, CR200(X), CR800, CR850, CR1000, CR3000, CR5000, and CR9000(X).

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 7-3. Negative values should be set to zero before being processed.

TABLE 7-3. Multipliers Required for Average Flux and Total Flux Density in SI and English Units

UNITS	MULTIPLIER	PROCESS
$W\ m^{-2}$	5.0	Average
$MJ\ m^{-2}$	t • 0.000005	Total
$kJ\ m^{-2}$	t • 0.005	Total
$cal\ cm^{-2}\ min^{-1}$	0.005 • (1.434)	Average
$cal\ cm^{-2}$	t • 0.005 • (0.0239)	Total
t = 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 kJ m^{-2}, there is a possibility of overranging the output limits. For CRBasic dataloggers, you can avoid this by using the IEEE4 or long data format. With the Edlog dataloggers the largest number that the datalogger can output to final storage is 6999 in low resolution (default), and 99999 in high resolution.

For Edlog dataloggers, if you assume that the daily total flux is desired in kJ m^{-2} and assume an irradiance of 0.5 kW m^{-2}, the maximum low resolution output limit will be exceeded in just under four hours. This value was found by taking the maximum flux the datalogger can record in low resolution and dividing by the total hourly flux.

$$3.9\ \text{hr} = \frac{6999\ \text{kJ m}^{-2}}{(0.5\ \text{kJ m}^{-2}\text{s}^{-1})(3600\ \text{s hr}^{-1})} \qquad (1)$$

To circumvent this limitation, record an average flux. During post processing, multiply the average flux by the number of seconds in the output interval to arrive at an output interval flux. Sum the output interval totals over a day to find a daily total flux.

Another alternative for Edlog dataloggers is to record total flux using the high resolution format. **Instruction 78** is used to switch to the high resolution. The disadvantage of the high resolution format is that it takes more memory per data point.

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. Obtain an RMA number before returning the SP230 to Campbell Scientific, Inc. 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 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} SP230 sensitivity.

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 **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.

Appendix A. Importing Short Cut Code Into CRBasic or Edlog Editor

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

A.1 Importing *Short Cut* Code into a Program Editor

Short Cut creates files that can be imported into either *CRBasic Editor* or *Edlog* program editor. These files normally reside in the C:\campbellsci\SCWin folder and have the following extensions:

- .DEF (wiring and memory usage information)
- .CR6 (CR6 datalogger code)
- .CR2 (CR200(X) datalogger code)
- .CR1 (CR1000 datalogger code)
- .CR8 (CR800 or CR850 datalogger code)
- .CR3 (CR3000 datalogger code)
- .CR5 (CR5000 datalogger code)
- .CR9 (CR9000(X) datalogger code)
- .DLD (contain code for CR10(X), CR23X, CR500, CR510, 21X, or CR7(X) dataloggers)

The following procedures show how to import these files for editing.

A.1.1 CRBasic Datalogger

Use the following procedure to import *Short Cut* code into *CRBasic Editor* (CR6, CR200(X), CR1000, CR800, CR850, CR3000, CR5000, CR9000(X) dataloggers).

1. Create the *Short Cut* program following the procedure in Section 4, *Quickstart*. 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 a ".CR6", ".CR2", ".CR1", ".CR8", ".CR3", ".CR5", or ".CR9" extension, for CR6, CR200(X), CR1000, CR800, CR3000, CR5000, or CR9000(X) dataloggers, respectively. **Select** the file and click **Open**.

4. Immediately **Save** the file in a folder different from \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 a **'** character (single quotation mark) begins each line. This character instructs the datalogger compiler to ignore the line when compiling the datalogger code.

A.1.2 Edlog

Use the following procedure to import *Short Cut* code into the *Edlog* program editor (CR10(X), CR500, CR510, CR23X, CR7, or 21X dataloggers).

1. Create the *Short Cut* program following the procedure in Section 4, *Quickstart*. Finish the program and **Exit** *Short Cut*. Make note of the file name used when saving the *Short Cut* program.

2. Open *Edlog*.

3. Click **File | Document DLD File**. Assuming the default paths were used when *Short Cut* was installed, navigate to C:\CampbellSci\SCWin folder. The file of interest has a ".DLD" extension. Select the file and click **Open**. The .DLD file, which is a type of ASCII machine code, is imported, documented, and, when saved, given a ".CSI" extension.

4. Immediately **Save** the file in a folder different from \Campbellsci\SCWin, or save the file with a different file name.

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

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 Edlog program, usually at the head of the file. After pasting, edit the information such that a **;** (semicolon) begins each line, which instructs the datalogger compiler to ignore the line when compiling the datalogger code.

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 Examples

To use the switched 12V mode, an air temperature and relative humidity measurement must be taken, as well as dewpoint calculation. These examples use 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 examples is given in TABLE B-1.

TABLE B-1. SP230 Connections to Campbell Scientific Dataloggers for Switched Heater Power

Color	Wire Label	CR1000	CR10X
Rotronic HC2S3 Temperature/Relative Humidity Sensor (Always On)			
Green	Power	12V	12V
Brown	Temperature	SE 1	SE 1
White	Relative Humidity	SE 2	SE 2
Yellow	Signal Reference	⏚	AG
Gray	Power Ground	⏚	AG
Clear	Shield	⏚	G
SP230 Heated Pyranometer			
Red	Signal	SE 3	SE 3
Black	Signal Reference	⏚	AG
White	Heater Power	SW12V	SW12V (Jumper from Control Port C1 to SW12V Ctrl)
Green	Heater Ground	G	G
Clear	Shield	⏚	G

B.1.1 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

'Micellaneous
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.1.2 CR10X Switched 12V Program

```
;{CR10X}
*Table 1 Program
  01:  10.0000  Execution Interval (seconds)

1:  Batt Voltage (P10)
  1:   1          Loc [ BattV     ]

2:  Internal Temperature (P17)
  1:   2          Loc [ CR10XTmpC ]

;Measure Rotronic HC2S3
3:  Volt (SE) (P1)
  1:   1          Reps
  2:   25         2500 mV 60 Hz Rejection Range
  3:   1          SE Channel
  4:   3          Loc [ AirTempC  ]
  5:   0.01       Multiplier
  6:   -40        Offset

4:  Volt (SE) (P1)
  1:   1          Reps
  2:   25         2500 mV 60 Hz Rejection Range
  3:   2          SE Channel
  4:   4          Loc [ RH        ]
  5:   0.01       Multiplier
  6:   0          Offset

;Calculate dewpoint.
5:  Saturation Vapor Pressure (P56)
  1:   3          Temperature Loc [ AirTempC  ]
  2:   9          Loc [ SVp       ]

6:  Z=X*Y (P36)
  1:   9          X Loc [ SVp       ]
  2:   4          Y Loc [ RH        ]
  3:   12         Z Loc [ Res2      ]

7:  Z=X*F (P37)
  1:   12         X Loc [ Res2      ]
  2:   0.01       F
  3:   10         Z Loc [ Vp        ]

8:  Z=X*F (P37)
  1:   10         X Loc [ Vp        ]
  2:   1.6373     F
  3:   11         Z Loc [ Res1      ]

9:  Z=LN(X) (P40)
  1:   11         X Loc [ Res1      ]
  2:   11         Z Loc [ Res1      ]

10:  Z=X*F (P37)
  1:   11         X Loc [ Res1      ]
  2:   241.88     F
  3:   12         Z Loc [ Res2      ]

11:  Z=F x 10^n (P30)
  1:   17.558     F
  2:   0          n, Exponent of 10
  3:   13         Z Loc [ Res3      ]

12:  Z=X-Y (P35)
  1:   13         X Loc [ Res3      ]
  2:   11         Y Loc [ Res1      ]
  3:   13         Z Loc [ Res3      ]
```

```
13:  Z=X/Y (P38)
  1:   12        X Loc [ Res2      ]
  2:   13        Y Loc [ Res3      ]
  3:   5         Z Loc [ DewPtC    ]

;Measure SP230 Heated Pyranometer
;Value returned from P1 instruction in millivolts.
14:  Volt (SE) (P1)
  1:   1         Reps
  2:   20        Auto 60 Hz Rejection Range (OS>1.09) ;Use 500mV range for CR7 and 21X.
  3:   1         SE Channel             ;Use 1000mV range for CR23X
  4:   7         Loc [ SlrW      ]      ;For the CR10X use AutoRange 0 or 20.
  5:   1         Multiplier             ;Or use code 25 for quicker execution
 6:    0         Offset                 ;and when solar is > 1200 W/m²

15:  If (X<=>F) (P89)
  1:   7         X Loc [ SlrW      ]
  2:   4         <
  3:   0         F
  4:   30        Then Do

    16:  Z=F x 10^n (P30)
      1:   0         F
      2:   0         n, Exponent of 10
      3:   7         Z Loc [ SlrW      ]

17:  End (P95)

;MJ/m² multiplier (m) = scan rate in seconds * 5E-6.
;Or m = 10 seconds * 5E-6 = 5E-5 or 0.00005.
18:  Z=X*F (P37)
  1:   7         X Loc [ SlrW      ]
  2:   0.00005   F
  3:   8         Z Loc [ SlrMJm2   ]

;Watts multiplier = 5
19:  Z=X*F (P37)
  1:   7         X Loc [ SlrW      ]
  2:   5         F
  3:   7         Z Loc [ SlrW      ]

;Calculate difference between air temperature and dewpoint.
20:  Z=X-Y (P35)
  1:   3         X Loc [ AirTempC  ]
  2:   5         Y Loc [ DewPtC    ]
  3:   6         Z Loc [ AirDewDif ]

;Only allow heater to operate if the battery voltage is greater than 11.7vdc.
21:  If (X<=>F) (P89)
  1:   1         X Loc [ BattV     ]
  2:   3         >=
  3:   11.7      F
  4:   30        Then Do

    ;Perform this logic if heater is off.
    22:  If Flag/Port (P91)
      1:   51        Do if Port 1 is Low
      2:   30        Then Do

        ;Turn heater on regardless of dewpoint if air temperature is less than 2°C.
        23:  If (X<=>F) (P89)
          1:   3         X Loc [ AirTempC  ]
          2:   4         <
          3:   2.01      F
          4:   30        Then Do

            24:  Do (P86)
              1:   41        Set Port 1 High
```

```
        25:  Else (P94)

            ;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.
            26:  If (X<=>F) (P89)
              1:   6          X Loc [ AirDewDif ]
              2:   4          <
              3:   2.01       F
              4:   41         Set Port 1 High

        27:  End (P95)

    28:  Else (P94)

        ;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 dew
        ;point is 3°C. If it is then shut the heater off.
        29:  If (X<=>F) (P89)
          1:   3          X Loc [ AirTempC  ]
          2:   3          >=
          3:   3.01       F
          4:   30         Then Do

            30:  If (X<=>F) (P89)
              1:   6          X Loc [ AirDewDif ]
              2:   3          >=
              3:   3          F
              4:   51         Set Port 1 Low

        31:  End (P95)

    32:  End (P95)

33:  Else (P94)

    ;Shut the heater off if the battery voltage is less than 11.7 vdc.
    34:  Do (P86)
      1:   51         Set Port 1 Low

35:  End (P95)

;Set input location HtrState to mimic port settings and use it for the histogram.
36:  If Flag/Port (P91)
  1:   41         Do if Port 1 is High
  2:   30         Then Do

    37:  Z=F x 10^n (P30)
      1:   1          F
      2:   0          n, Exponent of 10
      3:   14         Z Loc [ HtrState  ]

38:  End (P95)

39:  If Flag/Port (P91)
  1:   51         Do if Port 1 is Low
  2:   30         Then Do

    40:  Z=F x 10^n (P30)
      1:   0          F
      2:   0          n, Exponent of 10
      3:   14         Z Loc [ HtrState  ]

41:  End (P95)
```

```
42:  If time is (P92)
  1:   0         Minutes (Seconds --) into a
  2:   60        Interval (same units as above)
  3:   10        Set Output Flag High (Flag 0)

43:  Set Active Storage Area (P80)^12912
  1:   1         Final Storage Area 1
  2:   101       Array ID

44:  Real Time (P77)^17885
  1:   1220      Year,Day,Hour/Minute (midnight = 2400)

45:  Average (P71)^24037
  1:   1         Reps
  2:   3         Loc [ AirTempC  ]

46:  Average (P71)^17150
  1:   1         Reps
  2:   5         Loc [ DewPtC    ]

47:  Average (P71)^2198
  1:   1         Reps
  2:   7         Loc [ SlrW      ]

48:  Histogram (P75)^19324
  1:   1         Reps
  2:   2         No. of Bins
  3:   00        Form Code Option
  4:   14        Bin Select Value Loc [ HtrState  ]
  5:   0         Frequency Distribution
  6:   0         Low Limit
  7:   1         High Limit

49:  If time is (P92)
  1:   0         Minutes (Seconds --) into a
  2:   1440      Interval (same units as above)
  3:   10        Set Output Flag High (Flag 0)

50:  Set Active Storage Area (P80)^15013
  1:   1         Final Storage Area 1
  2:   102       Array ID

51:  Real Time (P77)^8384
  1:   1220      Year,Day,Hour/Minute (midnight = 2400)

52:  Minimum (P74)^4803
  1:   1         Reps
  2:   10        Value with Hr-Min
  3:   3         Loc [ AirTempC  ]

53:  Maximum (P73)^32314
  1:   1         Reps
  2:   10        Value with Hr-Min
  3:   3         Loc [ AirTempC  ]

54:  Minimum (P74)^5675
  1:   1         Reps
  2:   10        Value with Hr-Min
  3:   4         Loc [ RH        ]

55:  Maximum (P73)^19579
  1:   1         Reps
  2:   10        Value with Hr-Min
  3:   4         Loc [ RH        ]
```

```
56:  Minimum (P74)^6150
  1:  1         Reps
  2:  10        Value with Hr-Min
  3:  5         Loc [ DewPtC    ]

57:  Maximum (P73)^21856
  1:  1         Reps
  2:  10        Value with Hr-Min
  3:  5         Loc [ DewPtC    ]

58:  Resolution (P78)
  1:  1         High Resolution

59:  Totalize (P72)^16271
  1:  1         Reps
  2:  8         Loc [ SlrMJm2   ]

60:  Resolution (P78)
  1:  0         Low Resolution

61:  Histogram (P75)^13451
  1:  1         Reps
  2:  2         No. of Bins
  3:  00        Form Code Option
  4:  14        Bin Select Value Loc [ HtrState  ]
  5:  0         Frequency Distribution
  6:  0         Low Limit
  7:  1         High Limit

62:  Minimum (P74)^92
  1:  1         Reps
  2:  0         Value Only
  3:  1         Loc [ BattV     ]

63:  Maximum (P73)^31619
  1:  1         Reps
  2:  0         Value Only
  3:  1         Loc [ BattV     ]

64:  Minimum (P74)^17046
  1:  1         Reps
  2:  0         Value Only
  3:  2        Loc [ CR10XTmpC ]

65:  Maximum (P73)^20033
  1:  1         Reps
  2:  0         Value Only
  3:  2         Loc [ CR10XTmpC ]

*Table 2 Program
  01:  10.0000   Execution Interval (seconds)

1:  Serial Out (P96)
  1:  71        Storage Module

*Table 3 Subroutines

End Program

-Input Locations-
1 BattV     1 3 1
2 CR10XTmpC 1 2 1
3 AirTempC  1 7 1
4 RH        1 3 1
5 DewPtC    1 4 1
6 AirDewDif 1 2 1
7 SlrW      1 4 3
8 SlrMJm2   1 1 1
```

```
9 SVp       1 1 1
10 Vp        1 1 1
11 Res1      1 3 2
12 Res2      1 2 2
13 Res3      1 2 2
14 HtrState  1 2 2
```

B.2 Constant 12V Examples

Wiring for the constant 12V examples is given in TABLE B-2.

TABLE B-2. SP230 Connections to Campbell Scientific Dataloggers for Constant Power

Color	Wire Label	CR1000	CR10
Red	Signal	SE 1	SE 1
Black	Signal Reference	⏚	AG
White	Heater Power	12V	12V
Green	Heater Ground	G	G
Clear	Shield	⏚	G

B.2.1 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 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 SlrW < 0 Then SlrW = 0        'and CR9000. Use AutoRange for the CR1000
    SlrMJ = SlrW * SCANRATE * 5E-6  'or mV2500 range for > 1200 W/mÂ² intensities.
    SlrW = SlrW * 5.0

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

B.2.2 CR10 Constant 12V Program

```
;{CR10X}
*Table 1 Program
  01:  10.0000    Execution Interval (seconds)

1:  Batt Voltage (P10)
  1:   1          Loc [ BattV     ]

2:  Internal Temperature (P17)
  1:   2          Loc [ CR10XTmpC ]

;Measure SP230 Heated Pyranometer
;Value returned from P1 instruction in millivolts.
3:  Volt (SE) (P1)
  1:   1          Reps
  2:   20         Auto 60 Hz Rejection Range (OS>1.09) ;Use 500mV range for CR7 and 21X.
  3:   1          SE Channel             ;Use 1000mV range for CR23X
  4:   7          Loc [ SlrW      ]      ;For the CR10X use AutoRange 0 or 20.
  5:   1          Multiplier             ;Or use code 25 for quicker execution
  6:   0          Offset                 ;and when solar is > 1200 W/m²

4:  If (X<=>F) (P89)
  1:   7          X Loc [ SlrW      ]
  2:   4          <
  3:   0          F
  4:   30         Then Do

    5:  Z=F x 10^n (P30)
      1:   0          F
      2:   0          n, Exponent of 10
      3:   7          Z Loc [ SlrW      ]

6:  End (P95)

;MJ/m² multiplier (m) = scan rate in seconds * 5E-6.
;Or m = 10 seconds * 5E-6 = 5E-5 or 0.00005.
7:  Z=X*F (P37)
  1:   7          X Loc [ SlrW      ]
  2:   0.00005    F
  3:   8          Z Loc [ SlrMJm2   ]
```

```
;Watts multiplier = 5
8:  Z=X*F (P37)
  1:   7          X Loc [ SlrW      ]
  2:   5          F
  3:   7          Z Loc [ SlrW      ]

9:  If time is (P92)
  1:   0          Minutes (Seconds --) into a
  2:   60         Interval (same units as above)
  3:   10         Set Output Flag High (Flag 0)

10:  Set Active Storage Area (P80)^10231
  1:   1          Final Storage Area 1
  2:   101        Array ID

11:  Real Time (P77)^17885
  1:   1220       Year,Day,Hour/Minute (midnight = 2400)

12:  Average (P71)^2198
  1:   1          Reps
  2:   7          Loc [ SlrW      ]

13:  If time is (P92)
  1:   0          Minutes (Seconds --) into a
  2:   1440       Interval (same units as above)
  3:   10         Set Output Flag High (Flag 0)

14:  Set Active Storage Area (P80)^6568
  1:   1          Final Storage Area 1
  2:   102        Array ID

15:  Real Time (P77)^8384
  1:   1220       Year,Day,Hour/Minute (midnight = 2400)

16:  Resolution (P78)
  1:   1          High Resolution

17:  Totalize (P72)^16271
  1:   1          Reps
  2:   8          Loc [ SlrMJm2   ]

18:  Resolution (P78)
  1:   0          Low Resolution

19:  Minimum (P74)^92
  1:   1          Reps
  2:   0          Value Only
  3:   1          Loc [ BattV     ]

20:  Maximum (P73)^31619
  1:   1          Reps
  2:   0          Value Only
  3:   1          Loc [ BattV     ]

21:  Minimum (P74)^17046
  1:   1          Reps
  2:   0          Value Only
  3:   2          Loc [ CR10XTmpC ]

22:  Maximum (P73)^20033
  1:   1          Reps
  2:   0          Value Only
  3:   2          Loc [ CR10XTmpC ]

*Table 2 Program
  01:  10.0000    Execution Interval (seconds)
```

```
1:  Serial Out (P96)
  1:   71        Storage Module

*Table 3 Subroutines

End Program

-Input Locations-
1 BattV     1 2 1
2 CR10XTmpC 1 2 1
3 AirTempC  1 0 0
4 RH        1 0 0
5 DewPtC    1 0 0
6 AirDewDif 1 0 0
7 SlrW      1 4 3
8 SlrMJm2   1 1 1
9 SVp       1 0 0
10 Vp        1 0 0
11 Res1      1 0 0
12 Res2      1 0 0
13 Res3      1 0 0
14 HtrState  1 0 0
```

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