

INSTRUCTION MANUAL



CS300 Pyranometer

Revision: 10/15



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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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CS300 Pyranometer

1. Introduction

The CS300, 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.

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 manual at www.campbellsci.com/old-manuals or contact a Campbell Scientific application engineer for assistance.

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 CS300, 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 CS300 and assign datalogger wiring terminals. Use the following procedure to get started.

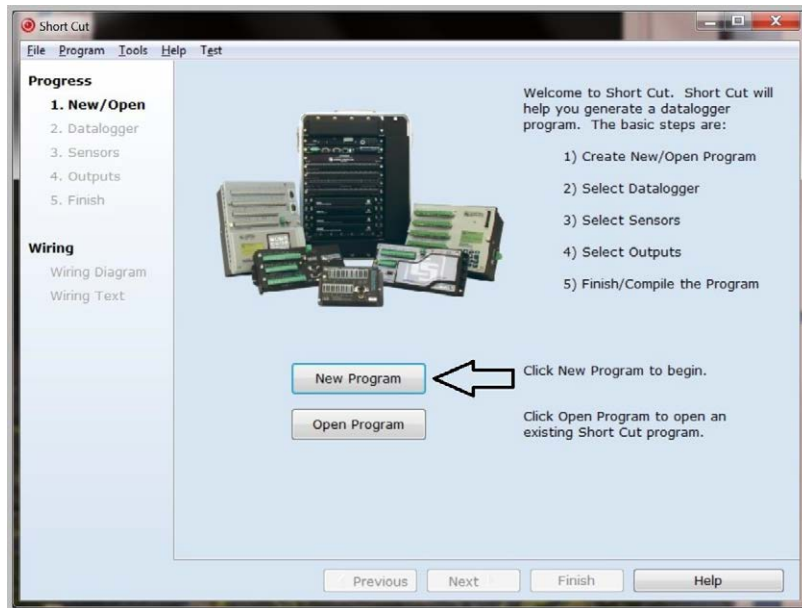
1. Install *Short Cut* by clicking on the install file icon. Get the install file from either www.campbellsci.com, the ResourceDVD, or find it in installations of *LoggerNet*, *PC200W*, *PC400*, or *RTDAQ* software.



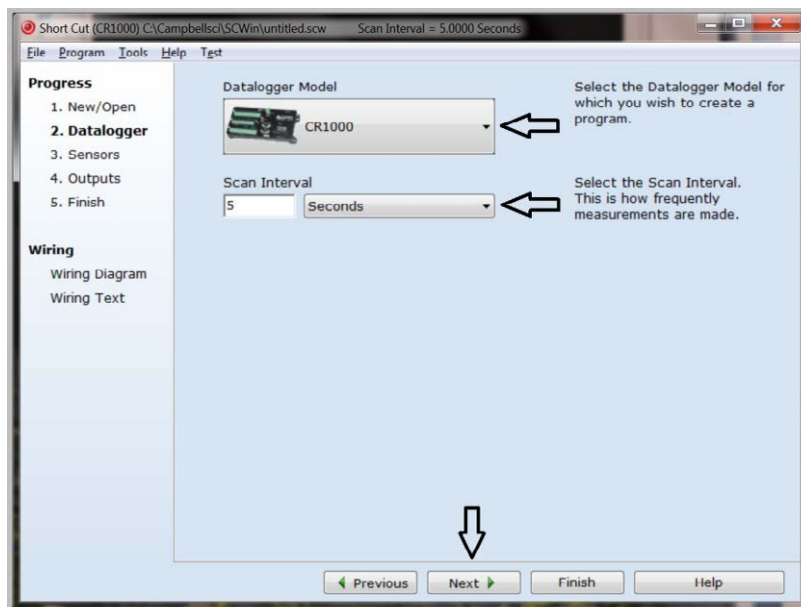
2. The *Short Cut* installation should place a *Short Cut* icon on the desktop of your computer. To open *Short Cut*, click on this icon.




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

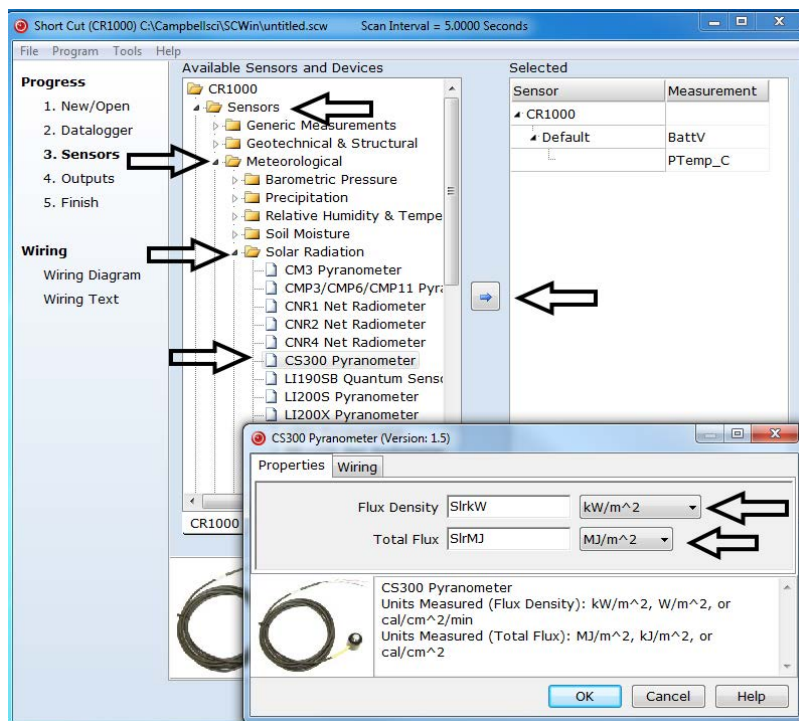


4. Select **Datalogger Model** and **Scan Interval** (default of 5 seconds is OK for most applications). Click **Next**.

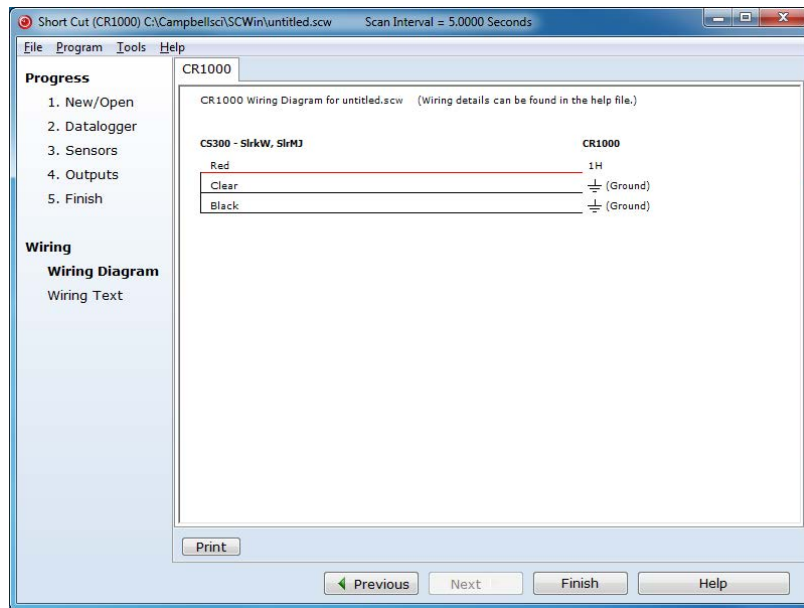


5. Under the **Available Sensors and Devices** list, select **Sensors | Meteorological | Solar Radiation** folder. Select **CS300 Pyranometer**.

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.



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.



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 CS300 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 CS300 is calibrated against a Kipp and Zonen CM21 under natural sunlight to accurately measure sun plus sky radiation (360 to 1120 nm). The CS300 should not be used under vegetation or artificial lights.

During the night, the CS300 may read slightly negative incoming solar radiation. This negative signal is caused by RF noise passing through the photo-diode. Negative values may be set to zero in the datalogger program.

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 the CWS900-series interfaces, allowing it to be used in a wireless sensor network
- Compatible with Campbell Scientific CRBasic dataloggers: CR6, CR200(X) series, CR800 series, CR1000, CR3000, CR5000, and CR9000(X)

Power requirements:	none, self-powered
Sensitivity:	$5 \text{ W m}^{-2} \text{ mV}^{-1}$ ($0.2 \text{ mV W}^{-1} \text{ m}^{-2}$)
Absolute accuracy:	$\pm 5\%$ for daily total radiation
Cosine response:	$\pm 5\%$ at 75° zenith angle $\pm 2\%$ at 45° zenith angle
Response time:	$< 1 \text{ ms}$
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:	$0.2 \text{ mV per W m}^{-2}$
Diameter:	2.4 cm (0.9 in)
Height:	2.5 cm (1.0 in)
Weight:	65 g (2.3 oz) with 2 m lead wire
Measurement range:	0 to 1750 W m^{-2} (full sunlight $\approx 1000 \text{ W m}^{-2}$)
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

The CS300 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

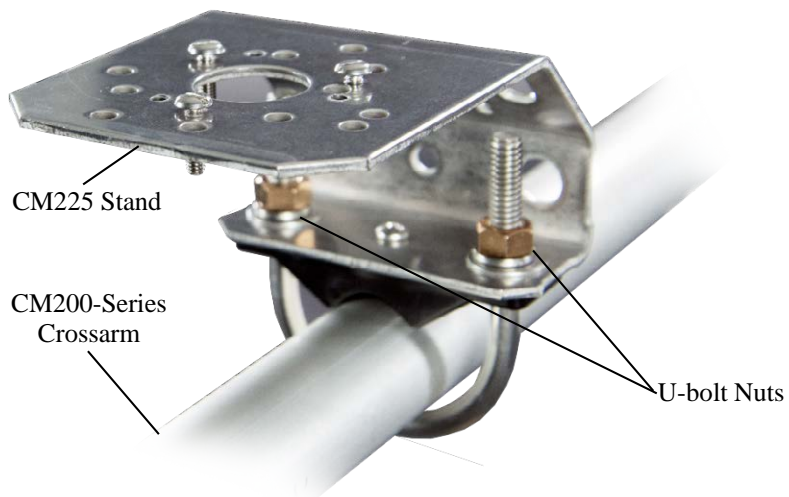
7.2.2.1 CM225 Solar Sensor Mounting Stand

CAUTION

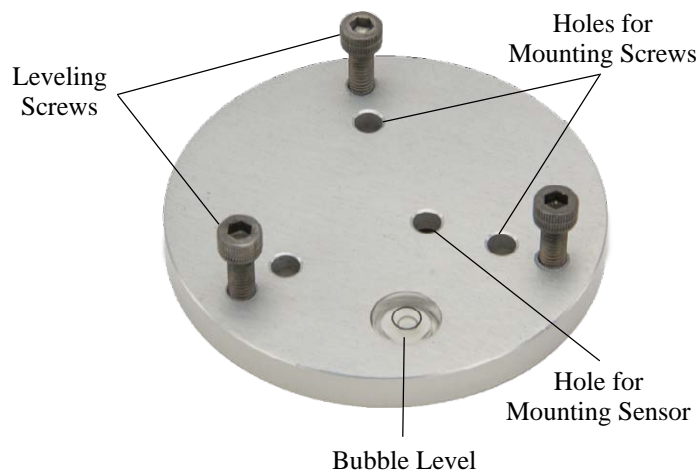
The CM225 should never be mounted directly to a vertical pipe. Instead the CM225 should be mounted to a crossarm. This avoids reflections from the vertical pipe onto the sensor.

1. Mount the crossarm to the tripod or tower.

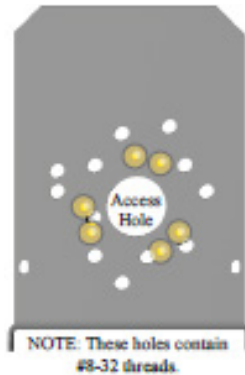
2. Place the CM225's U-bolt in the bottom holes and secure the CM225 to the crossarm by tightening the U-bolt nuts.



3. Place the CS300 in the center of the 18356 base/leveling fixture.



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

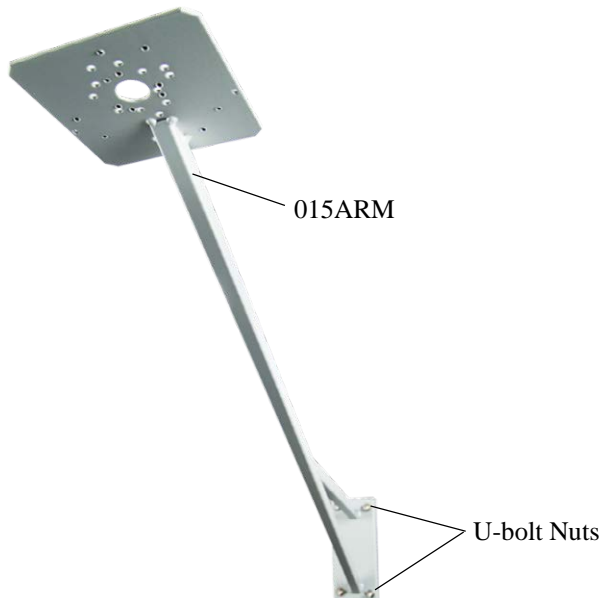


CM225 mounting holes used for the CS300 are indicated in yellow.

- Turn the leveling screws as required to bring the bubble of the bubble level within the ring.
- Tighten the mounting screws to secure the assembly in its final position. Check that the pyranometer is still correctly leveled and adjust as necessary.
- Route the sensor cable along the underside of the crossarm to the tripod/tower, and to the instrument enclosure.
- Secure the cable to the crossarm and mast using cable ties.
- Remove the green cap after installing the sensor. Save this cap for shipping or storing the sensor.

7.2.2.2 015ARM

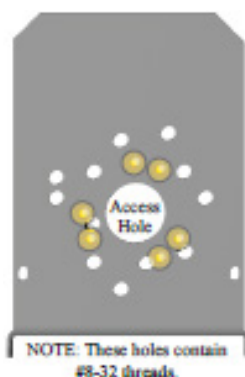
- Secure the 015ARM to the mast by tightening the U-bolt nuts.



2. Place the CS300 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.



CM225 mounting holes used for the CS300 are indicated in yellow.

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 CS300 is shown in FIGURE 7-1.

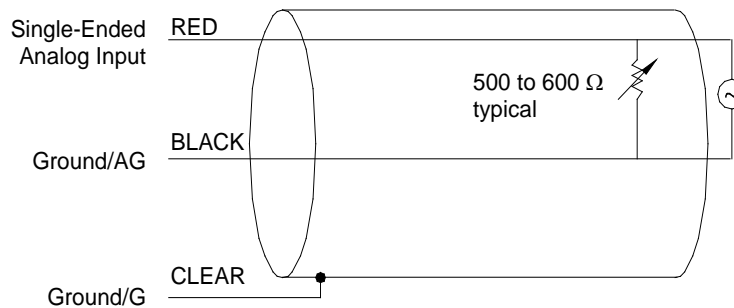


FIGURE 7-1. CS300 schematic

Connections to Campbell Scientific dataloggers are given in TABLE 7-1. 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	Datalogger Connection Terminal
Red	Signal	U configured for single-ended analog input ¹ , SE (single-ended, analog-voltage input)
Black	Signal Reference	AG or \perp (analog ground)
Clear	Shield	AG or \perp (analog ground)
¹ 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
- 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* (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 a Program 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 CS300 is 0.2 mV per W m^{-2} . The voltage signal from the CS300 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 7-2. 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}	$t \cdot 0.000005$	Total
kJ m^{-2}	$t \cdot 0.005$	Total
$\text{cal cm}^{-2} \text{ min}^{-1}$	$0.005 \cdot (1.434)$	Average
cal cm^{-2}	$t \cdot 0.005 \cdot (0.0239)$	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 totaled in units of kJ m^{-2} , there is a possibility of over-ranging the output limits. For CRBasic dataloggers, 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 CS300 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 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} CS300 sensitivity.

Appendix A. Importing Short Cut Code Into a Program 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

Short Cut creates files that can be imported into *CRBasic 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)

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

1. Create the *Short Cut* program following the procedure in Section 4, *QuickStart* (p. 2). 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 or CR850, 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.

Appendix B. Example Programs

The following programs measure the CS300 every 10 s and convert the millivolt output to Wm^{-2} and MJm^{-2} . Both programs output an hourly average flux (Wm^{-2}), and a daily total flux density (MJm^{-2}). Negative values are set to zero before being processed. Wiring for the examples is given in TABLE B-1.

TABLE B-1. Wiring for Example Programs			
Color	Description	CR1000	CR6
Red	Signal	SE 1	U1
Black	Signal Ground	\perp	\perp
Clear	Shield	\perp	\perp

B.1 CR1000 Program

```
'CR1000

'Declare Variables and Units
Public SlrW
Public SlrMJ

Units SlrW=W/m²
Units SlrMJ=MJ/m²

'Define Data Tables
DataTable(Table1,True,-1)
  DataInterval(0,60,Min,10)
  Average(1,SlrW,FP2,False)
EndTable

DataTable(Table2,True,-1)
  DataInterval(0,1440,Min,10)
  Totalize(1,SlrMJ,IEEE4,False)
EndTable

'Main Program
BeginProg
  Scan(10,Sec,1,0)

    'Measure CS300 Pyranometer
    VoltSe (SlrW,1,mV250,1,1,0,_60Hz,1.0,0) use 1000 mV range for the CR5000, CR9000
                                              For the CR1000, use the Auto Range or
                                              mV 2500 range for > 1200 w/m² intensities.

    'Set negative values to zero
    If SlrW<0 Then SlrW=0

    'Convert mV to MJ/m² for a 10 second scan rate
    SlrMJ=SlrW*0.00005

    'Convert mV to W/m²
    SlrW=SlrW*5.0

    'Call Data Tables and Store Data
    CallTable(Table1)
    CallTable(Table2)
  NextScan
EndProg
```

B.2 CR6 Program

```
'CR6 Series

'Declare Variables and Units
Public BattV
Public PTemp_C
Public SlrkW
Public SlrMJ

Units BattV=Volts
Units PTemp_C=Deg C
Units SlrkW=kW/m^2
Units SlrMJ=MJ/m^2

'Define Data Tables
DataTable(Table1,True,-1)
  DataInterval(0,60,Min,10)
  Totalize(1,SlrMJ,IEEE4,False)
EndTable

DataTable(Table2,True,-1)
  DataInterval(0,1440,Min,10)
  Minimum(1,BattV,FP2,False,False)
EndTable

'Main Program
BeginProg
'Main Scan
Scan(10,Sec,1,0)
'Default Datalogger Battery Voltage measurement 'BattV'
Battery(BattV)
'Default Wiring Panel Temperature measurement 'PTemp_C'
PanelTemp(PTemp_C,60)
'CS300 Pyranometer measurements 'SlrMJ' and 'SlrkW'
VoltSE(SlrkW,1,mV1000,U1,1,0,60,1,0)
If SlrkW<0 Then SlrkW=0
SlrMJ=SlrkW*5E-05
SlrkW=SlrkW*0.005
'Call Data Tables and Store Data
CallTable Table1
CallTable Table2
NextScan
EndProg
```


Campbell Scientific Companies

Campbell Scientific, Inc.

815 West 1800 North
Logan, Utah 84321
UNITED STATES

www.campbellsci.com • info@campbellsci.com

Campbell Scientific Canada Corp.

14532 – 131 Avenue NW
Edmonton AB T5L 4X4
CANADA

www.campbellsci.ca • dataloggers@campbellsci.ca

Campbell Scientific Africa Pty. Ltd.

PO Box 2450
Somerset West 7129
SOUTH AFRICA

www.campbellsci.co.za • cleroux@csafrica.co.za

Campbell Scientific Centro Caribe S.A.

300 N Cementerio, Edificio Breller
Santo Domingo, Heredia 40305
COSTA RICA

www.campbellsci.cc • info@campbellsci.cc

Campbell Scientific Southeast Asia Co., Ltd.

877/22 Nirvana@Work, Rama 9 Road
Suan Luang Subdistrict, Suan Luang District
Bangkok 10250
THAILAND

www.campbellsci.asia • info@campbellsci.asia

Campbell Scientific Ltd.

Campbell Park
80 Hathern Road
Shepshed, Loughborough LE12 9GX
UNITED KINGDOM

www.campbellsci.co.uk • sales@campbellsci.co.uk

Campbell Scientific Australia Pty. Ltd.

PO Box 8108
Garbutt Post Shop QLD 4814
AUSTRALIA

www.campbellsci.com.au • info@campbellsci.com.au

Campbell Scientific Ltd.

3 Avenue de la Division Leclerc
92160 ANTONY
FRANCE

www.campbellsci.fr • info@campbellsci.fr

Campbell Scientific (Beijing) Co., Ltd.

8B16, Floor 8 Tower B, Hanwei Plaza
7 Guanghua Road
Chaoyang, Beijing 100004
P.R. CHINA

www.campbellsci.com • info@campbellsci.com.cn

Campbell Scientific Ltd.

Fahrenheitstraße 13
28359 Bremen
GERMANY

www.campbellsci.de • info@campbellsci.de

Campbell Scientific do Brasil Ltda.

Rua Apinagés, n.br. 2018 — Perdizes
CEP: 01258-00 — São Paulo — SP
BRASIL

www.campbellsci.com.br • vendas@campbellsci.com.br

Campbell Scientific Spain, S. L.

Avda. Pompeu Fabra 7-9, local 1
08024 Barcelona
SPAIN

www.campbellsci.es • info@campbellsci.es

Please visit www.campbellsci.com to obtain contact information for your local US or international representative.