Product Manual

Sensor

CS300 and CS301

Pyranometers

Revision: 9/18

RELIABLE SINCE 1974 MONITORING

CAMPBELL SCIENTIFIC

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Safety

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

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

General

- Prior to performing site or installation work, obtain required approvals and permits. Comply with all governing structure-height regulations, such as those of the FAA in the USA.
- Use only qualified personnel for installation, use, and maintenance of tripods and towers, and any attachments to tripods and towers. The use of licensed and qualified contractors is highly recommended.
- Read all applicable instructions carefully and understand procedures thoroughly before beginning work.
- Wear a **hardhat** and **eye protection**, and take **other appropriate safety precautions** while working on or around tripods and towers.
- **Do not climb** tripods or towers at any time, and prohibit climbing by other persons. Take reasonable precautions to secure tripod and tower sites from trespassers.
- Use only manufacturer recommended parts, materials, and tools.

Utility and Electrical

- **You can be killed** or sustain serious bodily injury if the tripod, tower, or attachments you are installing, constructing, using, or maintaining, or a tool, stake, or anchor, come in **contact with overhead or underground utility lines**.
- Maintain a distance of at least one-and-one-half times structure height, 20 feet, or the distance required by applicable law, **whichever is greater**, between overhead utility lines and the structure (tripod, tower, attachments, or tools).
- Prior to performing site or installation work, inform all utility companies and have all underground utilities marked.
- Comply with all electrical codes. Electrical equipment and related grounding devices should be installed by a licensed and qualified electrician.

Elevated Work and Weather

- Exercise extreme caution when performing elevated work.
- Use appropriate equipment and safety practices.
- During installation and maintenance, keep tower and tripod sites clear of un-trained or non-essential personnel. Take precautions to prevent elevated tools and objects from dropping.
- Do not perform any work in inclement weather, including wind, rain, snow, lightning, etc.

Maintenance

- Periodically (at least yearly) check for wear and damage, including corrosion, stress cracks, frayed cables, loose cable clamps, cable tightness, etc. and take necessary corrective actions.
- Periodically (at least yearly) check electrical ground connections.

WHILE EVERY ATTEMPT IS MADE TO EMBODY THE HIGHEST DEGREE OF SAFETY IN ALL CAMPBELL SCIENTIFIC PRODUCTS, THE CUSTOMER ASSUMES ALL RISK FROM ANY INJURY RESULTING FROM IMPROPER INSTALLATION, USE, OR MAINTENANCE OF TRIPODS, TOWERS, OR ATTACHMENTS TO TRIPODS AND TOWERS SUCH AS SENSORS, CROSSARMS, ENCLOSURES, ANTENNAS, ETC.

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CS300 and CS301 Pyranometers

1. Introduction

The CS300 and CS301 measure total sun and sky solar radiation for solar, agricultural, meteorological, and hydrological applications. Their spectral range of 360 to 1120 nanometers encompasses most of the shortwave radiation that reaches the Earth surface. These pyranometers connect directly to our dataloggers. Their output can be measured by all of our dataloggers.

The CS301 replaced the CS300 in August 2018. The CS301 has a stainless steel connector, a removable cable, different wire colors, and a serial number of 60051 or above. Both sensors are manufactured by Apogee Instruments.

NOTE This manual provides information only for CRBasic dataloggers. For retired Edlog datalogger support, you can access a retired manual at *www.campbellsci.com/old-manuals*.

2. Precautions

- READ AND UNDERSTAND the *Safety* section at the front of this manual.
- Carefully open the shipping package ensuring to not damage or cut the cable jacket. If the cable is damaged, consult with Campbell Scientific.
- Remove the green cap after installing the sensor. Save this cap for shipping or storing the sensor.
- Handle the sensor carefully when cleaning. Be careful not to scratch the surface of the sensor.
- The black outer jacket of the cable is Santoprene® rubber. This compound was chosen for its resistance to temperature extremes, moisture, and UV degradation. However, this jacket will support combustion in air. It is rated as slow burning when tested according to U.L. 94 H.B. and will pass FMVSS302. Local fire codes may preclude its use inside buildings.

3. Initial Inspection

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

4. QuickStart

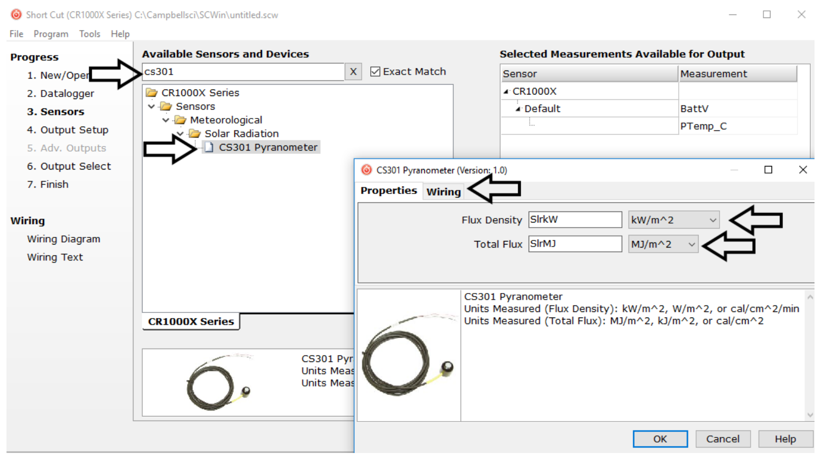
A video that describes datalogger programming using *Short Cut* is available at: *www.campbellsci.com/videos/cr1000x-datalogger-getting-started-program-part-3*. *Short Cut* is an easy way to program the datalogger to measure the pyranometer and assign datalogger wiring terminals. *Short Cut* is available as a download on *www.campbellsci.com*. It is included in installations of *LoggerNet*, *PC200W*, *PC400*, or *RTDAQ*.

The following procedure also describes programming with *Short Cut*.

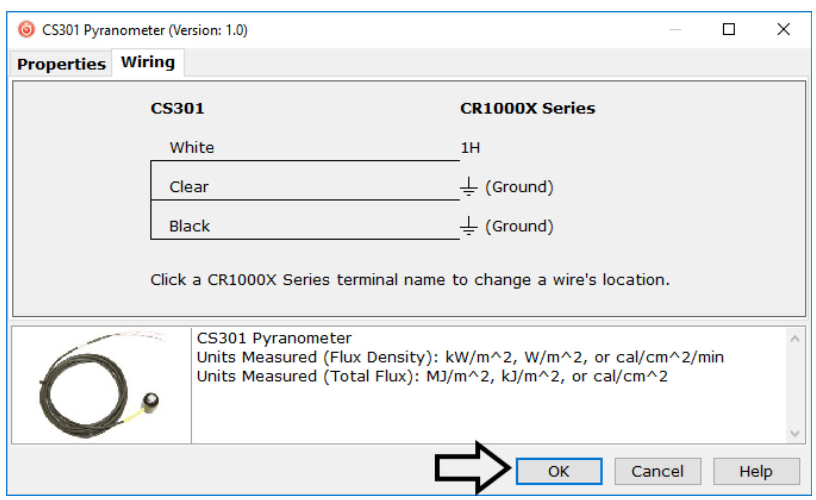
1. Open *Short Cut* and click **Create New Program**.

2. Double-click the datalogger model.

3. In the **Available Sensors and Devices** box, type CS301. Also locate the sensor in the **Sensors | Meteorological | Solar Radiation** folder. Double-click **CS301 Pyranometer**. Default units are kW/m² for flux density and mJ/ m² for total flux. These can be changed by clicking the **Flux Density** and **Total Flux** boxes and selecting different values.

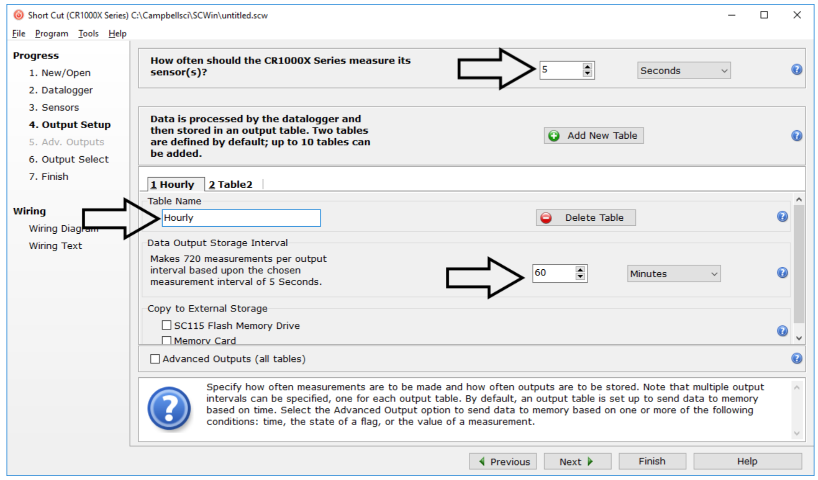


4. Click on the **Wiring** tab to see how the sensor is to be wired to the datalogger. Click **OK** after wiring the sensor.

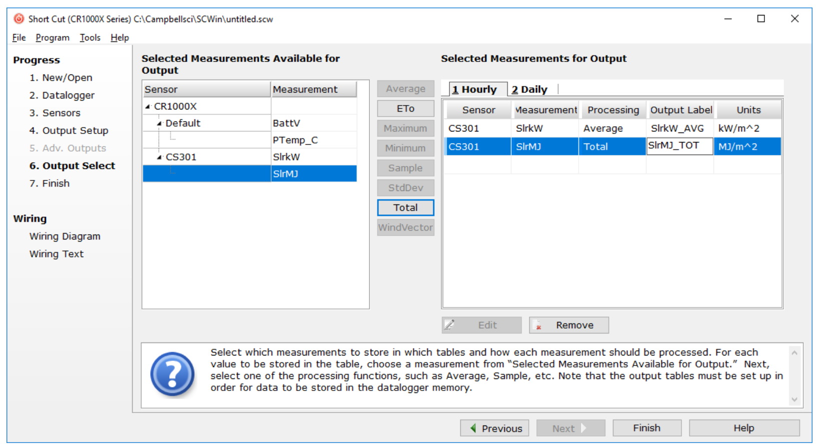


5. Repeat steps three and four for other sensors. Click **Next**.

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



7. Select the measurement and its associated output options.



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

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

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

5. Overview

The CS300 and CS301 measure incoming solar radiation with a silicon photovoltaic detector mounted in a cosine-corrected head. Output from the detector is a current, which is converted to voltage by a potentiometer potted in the sensor head. The resistance of the potentiometer is adjusted when the sensors are calibrated so that all sensors have the same output sensitivity.

The CS300 and CS301 are calibrated against a Kipp and Zonen CM21 under natural sunlight to accurately measure sun plus sky radiation (360 to 1120 nm). Do not use them under vegetation or artificial lights.

During the night, these pyranometers may read slightly negative incoming solar radiation. This negative signal is caused by noise passing through the photo-diode. Often, negative values are set to zero in the datalogger program.

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: CR200(X) series, CR300 series, CR6, CR800 series, CR1000X, CR1000, CR3000, CR5000, and CR9000(X)

Power requirements:	none, self-powered
Sensitivity:	5 W m^{-2} mV^{-1} (0.2 mV W^{-1} m^{-2})
Absolute accuracy:	±5% for daily total radiation
Cosine correction error:	±5% at 75° zenith angle ±2% at 45° zenith angle
Response time:	< 1 ms
Temperature response:	0.04 ± 0.04 % per C
Long-term stability:	< 2% per year
Operating temperature:	–40 to 70 °C
Relative humidity:	0 to 100%
Output:	0.2 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 cable

Measurement range:	0 to 2000 W m^{-2} (full sunlight ≈ 1000 W m^{-2})
Light spectrum waveband:	360 to 1120 nm (wavelengths where response is 10% of maximum)

7. Installation

If programming the datalogger with *Short Cut*, skip Section 7.3, *Wiring to the Datalogger* *(p. 8)*, and Section 7.4, *Programming* *(p. 8)*. See Section 4, *QuickStart* *(p. 1)*, for a *Short Cut* tutorial.

7.1 Siting

Mount the pyranometer such that no shadows or reflections are cast on it by the tripod/tower or other sensors, and point the cable 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:

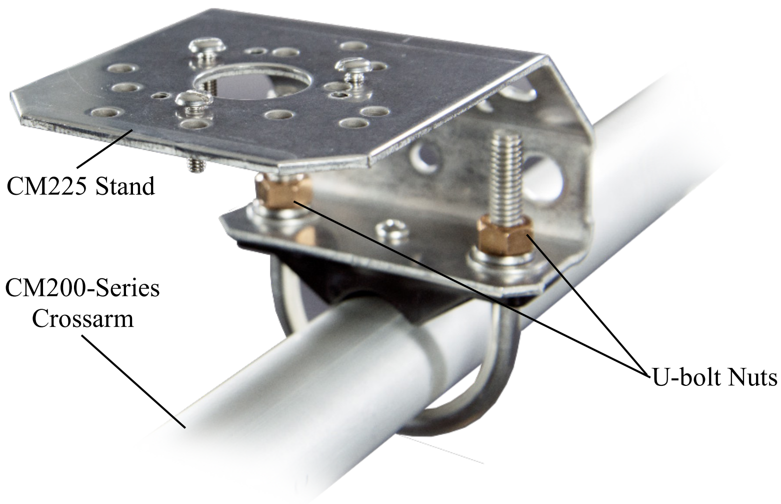
Small and medium Phillips screwdrivers
1/2 in open end wrench for CM225 or 015ARM
Tape measure
UV-resistant cable ties
Side-cut pliers
Compass
Step ladder

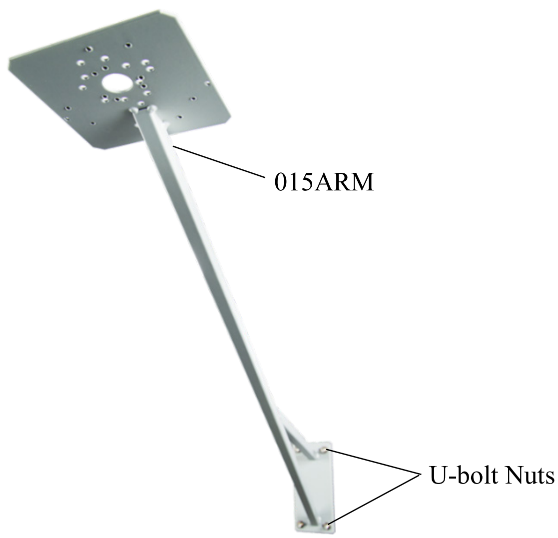
7.2.2 Mounting Procedure

CAUTION Never mount the CM225 directly to a vertical pipe. Instead, mount the CM225 to a crossarm. This avoids reflections from the vertical pipe onto the sensor.

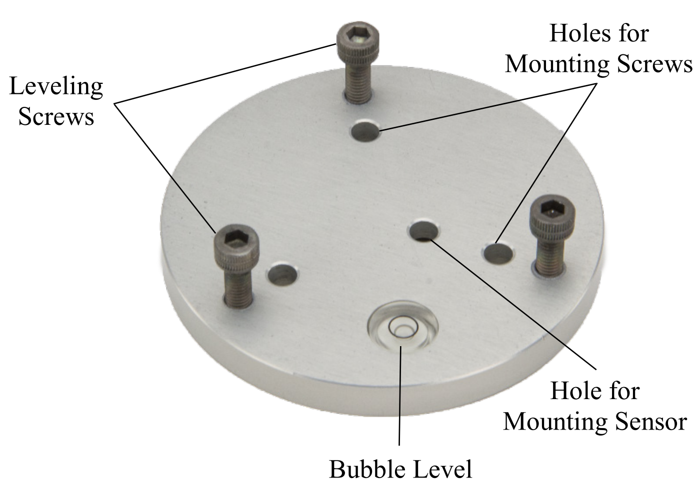
1. Mount the crossarm to the tripod or tower if using a CM225.

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

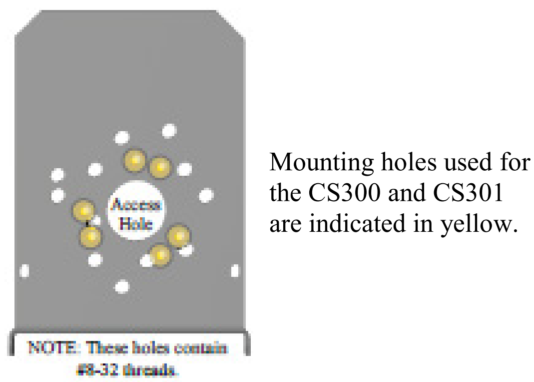




3. Place the pyranometer in the center of the pyranometer leveling base.



4. Loosely mount the pyranometer leveling base on the CM225 or 015ARM. 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 or 015ARM mounting arm to the tripod/tower, and to the instrument enclosure.

8. Secure the cable to the crossarm or 015ARM mounting arm and mast by 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

FIGURE 7-1 provides a schematic diagram.

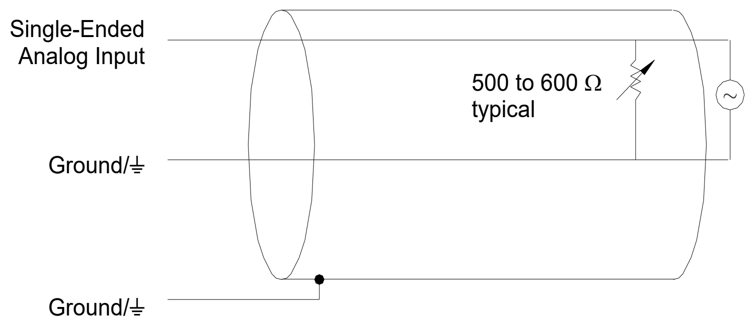


FIGURE 7-1. Schematic diagram

Connections to Campbell Scientific dataloggers are given in TABLE 7-1. When *Short Cut* is used to create the datalogger program, connect the sensor to the terminals shown in the wiring diagram created by *Short Cut*.

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

CS300 Wire Color	CS301 Wire Color	Wire Function	Datalogger Connection Terminal
Red	White	Signal	**U** configured for single-ended analog input[1], **SE** (single-ended, analog-voltage input)
Black	Black	Signal Reference	⏚ (analog ground)
Clear	Clear	Shield	⏚ (analog ground)

[1]**U** terminals are automatically configured by the measurement instruction.

7.4 Programming

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

If data acquisition requirements are simple, a datalogger program can probably be created and maintained exclusively with *Short Cut*. If the 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)*. To import *Short Cut* code into *CRBasic Editor* to create or add to a customized program, follow the procedure in Appendix A, *Importing Short Cut Code Into CRBasic Editor* *(p. A-1)*. Programming basics for CRBasic dataloggers are provided in the following sections. Complete program examples for select CRBasic dataloggers can be found in Appendix B, *Example Programs* *(p. B-1)*. Programming basics and programming examples for Edlog dataloggers are provided at *www.campbellsci.com\old-manuals.*

The output from the pyranometer is 0.2 mV per Wm^{-2}. Its voltage signal is measured by 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. Campbell Scientific recommends setting negative values to zero before those values are 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 • 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

*Joules/Cal ratio = 4.184 J/cal

Possible sources of electrical noise include nearby ac power lines, electric pumps, or motors. If the sensor or datalogger is located in an electrically noisy environment, use 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 over ranging the output limits. For CRBasic dataloggers, avoid this by using the IEEE4 or long data format.

8. Maintenance and Calibration

On a monthly basis, check the level of the pyranometer. Remove dust or debris from the sensor head by blasting the sensor head with compressed air or by cleaning 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 or CS301 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, NAN, or radiation values around 0

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

2. Verify that the range code is correct for the datalogger type.

3. Disconnect the sensor wires from the datalogger and use a DVM to check the voltage between the red (+) and the black (–) wires. No voltage indicates a problem with either the photodiode or the shunt resistor. Both 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} pyranometer sensitivity.

10. References

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

Appendix A. Importing Short Cut Code Into CRBasic Editor

This tutorial shows:

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

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

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

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

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

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

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

3. Import wiring information to the program by opening the associated .DEF file. By default, it is saved in the c:\campbellsci\SCWin folder. Copy and paste the section beginning with heading "–Wiring for CRXXX–" into the CRBasic program, usually at the head of the file. After pasting, edit the information such that an apostrophe (**'**) begins each line. This character instructs the datalogger compiler to ignore the line when compiling. You can highlight several lines of CRBasic code then right-click and select **Comment Block**. (This feature is demonstrated at about 5:10 in the *CRBasic | Features* video.)

Appendix B. Example Programs

The following programs measure the pyranometer every 10 s and convert the millivolt output to Wm^{-2} and MJm^{-2}. The scan interval is entered as a constant at the beginning of the program. This way the user changes the constant when they want to change their scan rate and it ripples through the program. 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

CS300 Wire Color	CS301 Wire Color	Description	CR1000X	CR6
Red	White	Signal	SE 1	U1
Black	Black	Signal Ground	⏚	⏚
Clear	Clear	Shield	⏚	⏚

B.1 CR1000X Program

CRBasic Example B-1. CR1000X Program Measuring the CS300 or CS301

```
'CR1000X

'Declare Constants
't=scan rate in seconds
Const t = 10
'Declare Variables and Units
Public BattV
Public PTemp_C
Public SlrW
Public SlrMJ
Units BattV=Volts
Units PTemp_C=Deg C
Units SlrW=W/m²
Units SlrMJ=MJ/m²

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

DataTable(Daily,True,-1)
  DataInterval(0,1440,Min,10)
  Minimum(1,BattV,FP2,False,False)
  Totalize(1,SlrMJ,IEEE4,False)
EndTable

'Main Program
BeginProg
  Scan(t,Sec,1,0)
    'Default Datalogger Battery Voltage measurement 'BattV'
    Battery(BattV)

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

```
    'Pyranometer measurements 'SlrMJ' and 'SlrW'
    VoltSe (SlrW,1,mV1000,1,1,0,60,1.0,0) 'Use mV250 for the CR800 series and CR1000

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

    'Convert mV to MJ/m²
    SlrMJ=SlrW*t*0.000005

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

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

B.2 CR6 Program

CRBasic Example B-2. CR6 Program Measuring the CS300 or CS301

```
'CR6 Series
'Declare Constants
't=scan rate in seconds
Const t = 10
'Declare Variables and Units
Public BattV
Public PTemp_C
Public SlrW
Public SlrMJ
Units BattV=Volts
Units PTemp_C=Deg C
Units SlrW=W/m^2
Units SlrMJ=MJ/m^2

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

DataTable(Daily,True,-1)
  DataInterval(0,1440,Min,10)
  Minimum(1,BattV,FP2,False,False)
  Totalize(1,SlrMJ,IEEE4,False)
EndTable

'Main Program
BeginProg
  'Main Scan
  Scan(t,Sec,1,0)
    'Default Datalogger Battery Voltage measurement 'BattV'
    Battery(BattV)

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

    'Pyranometer measurements 'SlrMJ' and 'SlrW'
    VoltSe(SlrW,1,mV1000,U1,1,0,60,1,0)

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

    'Convert mV to MJ/m²
```

```
    SlrMJ=SlrW*t*0.000005

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

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

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