INSTRUCTION MANUAL

CS300 Pyranometer

Revision: 1/11

Warranty and Assistance

The **CS300 PYRANOMETER** is warranted by Campbell Scientific, Inc. to be free from defects in materials and workmanship under normal use and service for twelve (12) months from date of shipment unless specified otherwise. Batteries have no warranty. Campbell Scientific, Inc.'s obligation under this warranty is limited to repairing or replacing (at Campbell Scientific, Inc.'s option) defective products. The customer shall assume all costs of removing, reinstalling, and shipping defective products to Campbell Scientific, Inc. Campbell Scientific, Inc. will return such products by surface carrier prepaid. This warranty shall not apply to any Campbell Scientific, Inc. products which have been subjected to modification, misuse, neglect, accidents of nature, or shipping damage. This warranty is in lieu of all other warranties, expressed or implied, including warranties of merchantability or fitness for a particular purpose. Campbell Scientific, Inc. is not liable for special, indirect, incidental, or consequential damages.

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To obtain a Returned Materials Authorization (RMA), contact Campbell Scientific, Inc., phone (435) 753-2342. After an applications 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 “Declaration of Hazardous Material and Decontamination” form and comply with the requirements specified in it. The form is available from our website at www.campbellsci.com/repair. A completed form must be either emailed to repair@campbellsci.com or faxed to 435-750-9579. Campbell Scientific will not 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.

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CS300 Pyranometer

1. General Description

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 (300 to 1100 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: An integrating pyranometer for climatological observer stations and mesoscale networks. J. Appl. Meteor., 6, 688-694.

2. Specifications

Power requirements:	none, self-powered
Absolute accuracy:	±5% for daily total radiation
Cosine response:	±4% at 75° zenith angle ±1% at 45° zenith angle
Temperature response:	<1% at 5° to 40°C
Long-term stability:	<2% per year
Operating temperature:	-40° to +55°C
Relative humidity:	0 to 100%
Output:	0.2 mV per W m^{-2}
Dimensions:	0.9" (2.4 cm) diameter, 1.0" (2.5 cm) height
Weight:	2.3 oz (65 g) with 2 m lead wire
Measurement range:	0 to 2000 W m^{-2} (full sunlight ≈ 1000 W m^{-2})
Light spectrum waveband:	300 to 1100 nm

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.

3. Installation

The CS300 should be mounted such that it is never shaded by the tripod/tower or other sensors. The sensor should be mounted with the cable pointing towards the nearest magnetic pole, e.g., 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.

To ensure accurate measurements, the CS300 should be mounted using PN 18356 base/leveling fixture, which incorporates a bubble level and three adjustment screws. The CS300 and base/leveling fixture are attached to a tripod or tower using one of three mounting configurations (see Figures 3-1 and 3-2).

CAUTION Newer CS300 pyranometers have a bulge in their cable that contains a circuit board (located 18” from the sensor head). The bulge should be mounted on the underside of the mounting arm to give some protection from direct sunlight. To prevent the circuit board from being moved or stressed, cable tie each side of the bulge to the mounting arm.

Tools required for installation on a tripod or tower:

Small and medium Phillips screwdrivers
1/2” open end wrench for CM225 or 015ARM (Figures 3-1, 3-2)
Tape measure
UV-resistant cable ties
Side-cut pliers
Compass
Step ladder

NOTE Remove the red cap after installing the sensor. Save this cap for shipping or storing the sensor.

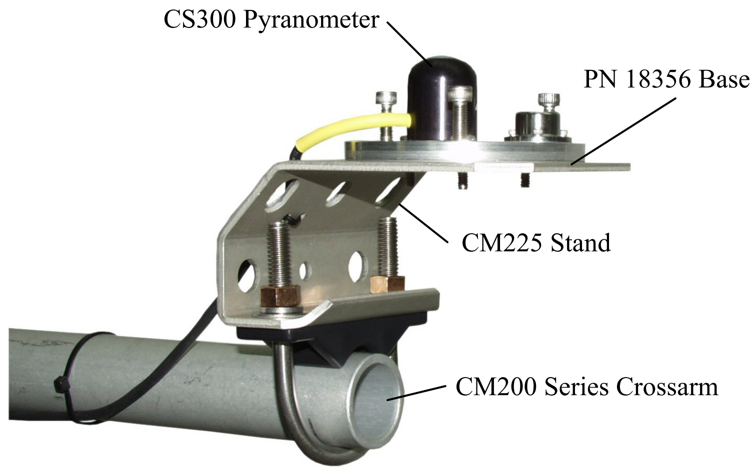

FIGURE 3-1. CM225 Pyranometer Mounting Stand and CM202 Crossarm

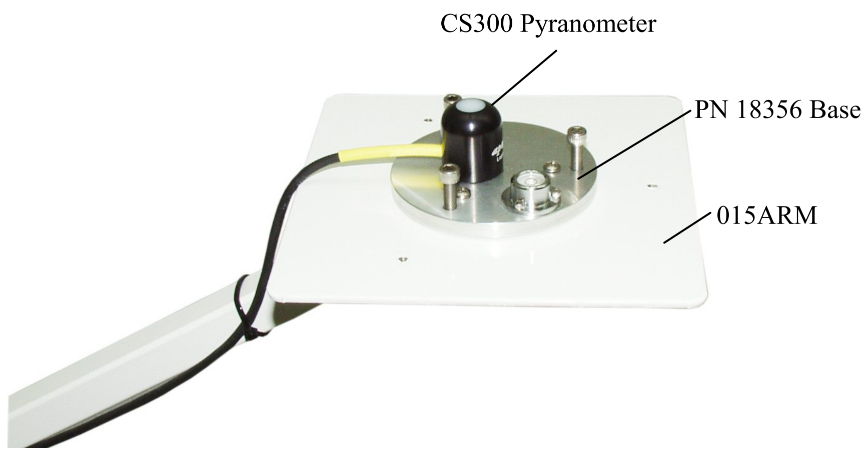

FIGURE 3-2. 015ARM Pyranometer Mounting Arm

4. Wiring

A schematic diagram of the CS300 is shown in Figure 4-1.

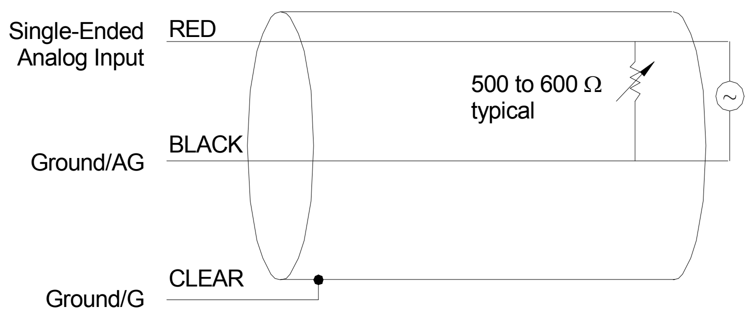

FIGURE 4-1. CS300 Schematic

Connections to Campbell Scientific dataloggers are given in Table 4-1. When Short Cut for Windows software 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 4-1. Connections to Campbell Scientific Dataloggers

Color	Wire Label	CR9000(X) CR5000 CR3000 CR1000 CR800 CR850	CR510 CR500 CR10(X)	21X CR7 CR23X	CR200(X)
Red	Signal	SE Analog	SE Analog	SE Analog	SE Analog
Black	Signal Reference	⏚	AG	⏚	⏚
Clear	Shield	⏚	G	⏚	⏚

5. Programming

This section is for users who write their own datalogger programs. A datalogger program to measure this sensor can be created using Campbell Scientific's Short Cut Program Builder software. You do not need to read this section to use Short Cut.

The output from the CS300 is 0.2 mV per Wm^{-2}. The voltage signal from the CS300 is measured using the single-ended voltage instruction (VoltSE in CRBasic or Instruction 1 in Edlog). Dataloggers that use CRBasic include the CR200(X), CR800, CR850, CR1000, CR3000, CR5000, and CR9000(X). Dataloggers that use Edlog include CR7, CR10(X), CR510, and CR23X. Both CRBasic and Edlog are included in PC400 and LoggerNet datalogger support software.

Solar radiation can be recorded as an average flux density (W m^{-2}) or daily total flux density (MJ m^{-2}). The appropriate multipliers are listed in Table 5-1. Negative values should be set to zero before being processed.

TABLE 5-1. 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.

5.1 Example Programs

The following programs measure the CS300 every 10 seconds and convert the mV 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 5-2.

TABLE 5-2. Wiring for Example Programs

Color	Description	CR1000	CR10X
Red	Signal	SE 1	SE 1
Black	Signal Ground	⏚	AG
Clear	Shield	⏚	G

5.1.1 CR1000 Example 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
          'Set negative values to zero                mV 2500 range for > 1200 w/m2 intensities.
          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
```

5.1.2 CR10X Example Program

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

; Measure CS300 pyranometer

1:  Volt (SE) (P1)
  1:   1            Reps
  2:   24            250 mV 60 Hz Rejection Range  ; use 500 mV range for the CR7 and 21X,
                                                    1000 mV range for the CR23X.  For the
  3:   1            SE Channel                      CR10X, use range code 0 or 25 for
  4:   1            Loc [ SlrW      ]               > 1200 w/m2 intensities.
  5:   1.0          Multiplier
  6:   0.0          Offset
```

```
; Set negative values to zero

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

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

4:  End (P95)

; Convert mV to MJ/m2 for 10 second execution interval

5:  Z=X*F (P37)
   1:   1            X Loc [ SlrW     ]
   2:   .00005       F
   3:   2            Z Loc [ SlrMJ    ]

; Convert mV to W/m2

6:  Z=X*F (P37)
   1:   1            X Loc [ SlrW     ]
   2:   5            F
   3:   1            Z Loc [ SlrW     ]

7:  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)

8:  Set Active Storage Area (P80)
   1:   1            Final Storage Area 1
   2:   101          Array ID

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

10:  Average (P71)
   1:   1            Reps
   2:   1            Loc [ SlrW     ]

11:  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)

12:  Set Active Storage Area (P80)
   1:   1            Final Storage Area 1
   2:   102          Array ID
```

```
13:  Real Time (P77)
  1:   1220          Year,Day,Hour/Minute (midnight = 2400)

14:  Resolution (P78)
  1:   1             High Resolution

15:  Totalize (P72)
  1:   1             Reps
  2:   2             Loc [ SlrMJ     ]

16:  Resolution (P78)
  1:   0             Low Resolution
```

5.2 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 density 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 density the datalogger can record in low resolution and dividing by the total hourly flux density.

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

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

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.

6. 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. Obtain an RMA number before returning the CS300 to Campbell Scientific, Inc. for recalibration.

7. 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 – 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 can not 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.

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