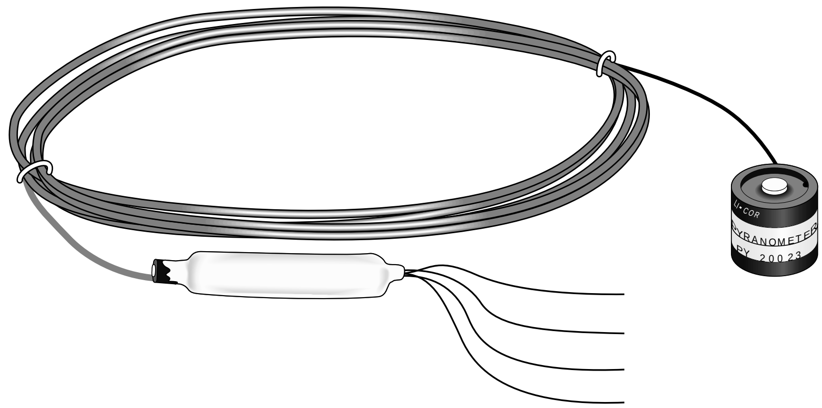
INSTRUCTION MANUAL

LI200X Pyranometer

Revision: 6/10



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LI200X Pyranometer

1. General Description

The LI200X measures incoming solar radiation with a silicon photovoltaic detector mounted in cosine-corrected head. The detector outputs current; a shunt resistor in the sensor cable converts the signal from current to voltage, allowing the LI200X to be measured directly by Campbell Scientific dataloggers. The LI200X is calibrated against an Eppley Precision Spectral Pyranometer to accurately measure sun plus sky radiation. Do not use the LI200X under vegetation or artificial lights, because it is calibrated for the daylight spectrum (400 to 1100 nm).

During the night the LI200X may read slightly negative incoming solar radiation. This negative signal is caused by RF noise. 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.

1.1 Specifications

Stability:	< ±2% change over a 1 year period
Response Time:	10 µs
Cosine Correction:	Cosine corrected up to 80°
Operating Temperature:	-40 to +65 °C
Temperature Dependence:	0.15% per °C
Relative Humidity:	0 to 100%
Detector:	High stability silicon photovoltaic detector (blue enhanced)
Sensor Housing:	Weatherproof anodized aluminum case with acrylic diffuser and stainless steel hardware
Size:	0.94" dia x 1.00" H (2.38 cm dia x 2.54 cm H)
Weight:	1 oz. (28 g)
Accuracy:	Absolute error in natural daylight is ±5% maximum; ±3% typical
Sensitivity:	0.2 kW m^{-2} mV^{-1}
Linearity:	Maximum deviation of 1% up to 3000 W m^{-2}
Shunt Resistor:	Adjustable, 40.2 to 90.2 Ω, factory set to give the above sensitivity
Light Spectrum Waveband:	400 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.

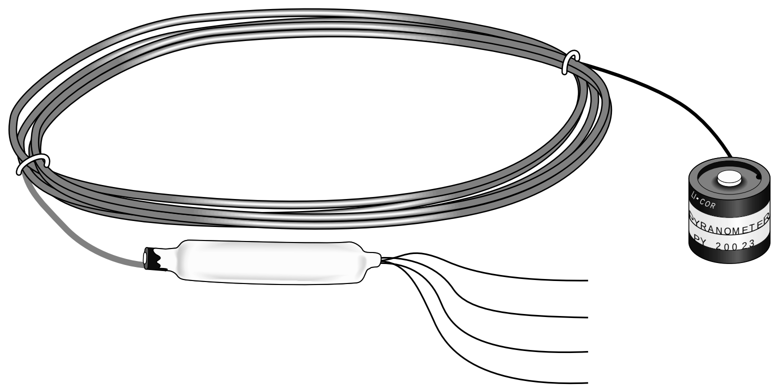

FIGURE 1-1. LI200X Pyranometer

2. Installation

The LI200X should be mounted such that it is never shaded by the tripod/tower or other instrumentation. The sensor should be mounted with the cable pointed towards the nearest magnetic pole, e.g. in the Northern Hemisphere point the cable towards 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 LI200X should be mounted using LI2003S base/leveling fixture. This base incorporates a bubble level and three adjustment screws. The LI200X and base/leveling fixture are attached to a tripod or tower using one of three mounting configurations (see Figure 2-1 through 2-3).

Tools required for installation on a tripod or tower:

Small and medium Phillips screwdrivers
5/32” Allen wrench for NU-RAIL (Figure 2-3)
1/2” open end wrench for 015ARM or CM225 (Figures 2-1, 2-2)
Tape measure
UV-resistant wire 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.

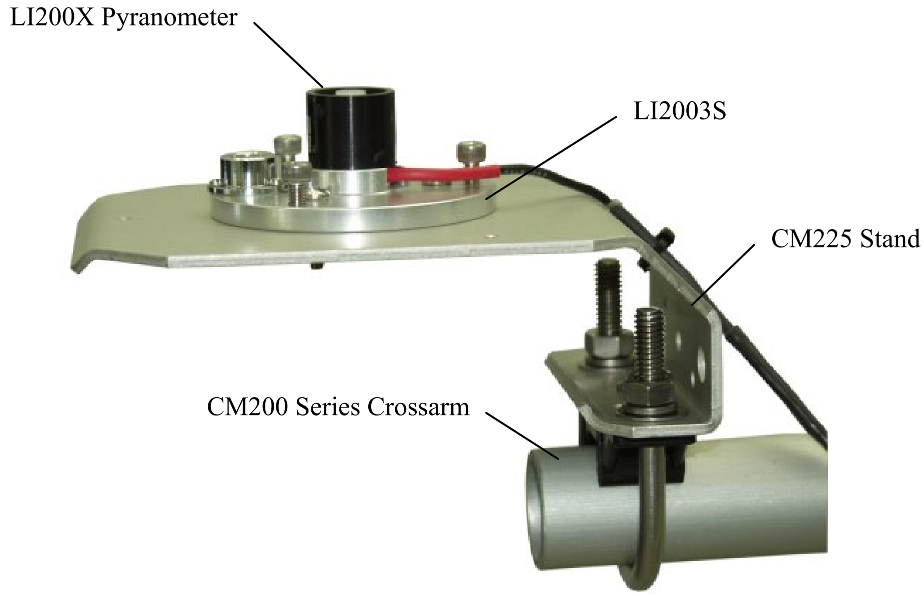

FIGURE 2-1. CM225 Pyranometer Mounting Stand and CM202 Crossarm

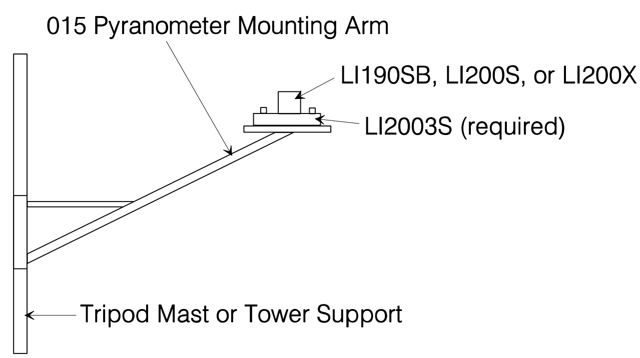

FIGURE 2-2. 015 Pyranometer Mounting Arm

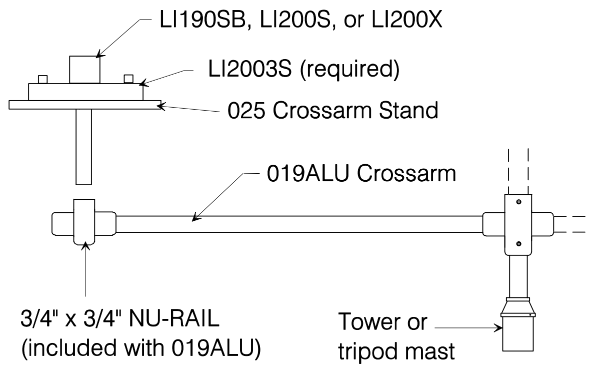

FIGURE 2-3. 025 Crossarm Stand and 019ALU Crossarm

3. Wiring

A schematic diagram of the LI200X is shown in Figure 3-1.

Connections to Campbell Scientific dataloggers are given in Table 3-1. When Short Cut 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 3-1. Connections to Campbell Scientific Dataloggers

Color	**Description**	**CR9000(X) CR5000 CR3000 CR1000 CR800 CR850**	**CR510 CR500 CR10(X)**	**21X CR7 CR23X**
Red	Signal	Differential High	Differential High	Differential High
Black	Signal Reference	Differential Low	Differential Low	Differential Low
White	Signal Ground	⏚	AG	⏚
Clear	Shield	⏚	G	⏚

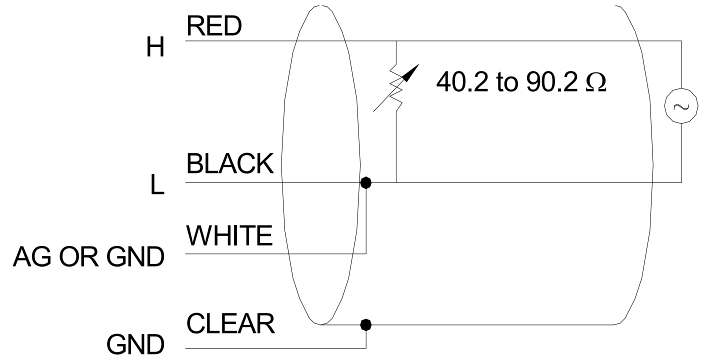

FIGURE 3-1. LI200X Schematic

NOTE If a 21X is used to measure the LI200X and powers a 12 VDC sensor, the current drawn by the 12 VDC sensor may cause a difference in ground potential between the 21X ground terminals and the reference ground point in the datalogger. This ground potential results in an offset on single ended measurements. This offset can be as large as ± 60 mV. Thus, single ended measurements should be avoided. The offset does not, however, affect differential measurements.

4. Programming

This section is for users who write their own datalogger programs. A datalogger program to measure the LI200X can be created using the Short Cut software. You do not need to read the following section to use Short Cut.

Output from the LI200X is 0.2 $kWm^{-2}mV^{-1}$, which is measured by the datalogger using the differential voltage instruction (VoltDiff in CRBasic or Instruction 2 in Edlog). Dataloggers that use CRBasic include the CR800, CR850, CR1000, CR3000, CR500, and CR9000(X). Dataloggers that use Edlog include the CR510, CR10(X), and CR23X. Both CRBasic and Edlog are included in PC400 and LoggerNet datalogger support software.

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.

Solar radiation can be reported as an average flux density (W m^{-2}) or daily total flux density (MJ m^{-2}). The appropriate multipliers are listed in Table 4-1. Programming examples are given for both average and daily total solar radiation. Negative values should be set to zero before being processed.

TABLE 4-1. Multipliers Required for Average Flux and Total Flux Density in Sl and English Units		
UNITS	**MULTIPLIER**	**PROCESS**
W m^{-2}	200	Average
MJ m^{-2}	t * 0.0002	Total
kJ m^{-2}	t * 0.2	Total
cal cm^{-2} min^{-1}	0.2 * (1.434)	Average
cal cm^{-2}	t * 0.2 * (0.0239)	Total
t = datalogger execution interval in seconds		

4.1 Example Programs

The following programs measure the LI200X 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 4-2.

TABLE 4-2. Wiring for Example Programs			
Color	**Description**	**CR1000**	**CR10X**
Red	Signal	1H	1H
Black	Signal Reference	1L	1L
White	Signal Ground	⏚	AG
Clear	Shield	⏚	G

4.1.1 CR1000 Example Program

In the CR1000 example, a daily total flux density is found. This total flux density is in MJ m^{-2} day^{-1}. Negative values are set to zero before they are added to the running total.

```
'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 the LI200X
        VoltDiff(SlrW,1,mV7_5,1,True,0,_60Hz,1,0)     'use 20mV range for
                                                      'CR5000 and CR3000

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

        'convert mV to MJ/m2 for 10 second execution interval
        SlrMJ=SlrW*0.002

        'convert mV to W/m2
        SlrW=SlrW*200.0

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

4.1.2 CR10X Example Program

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

; measure the LI200X

1:  Volt (Diff) (P2)
  1:  1             Reps
  2:  22            7.5 mV 60 Hz Rejection Range   ;use 15 mV range for the
                                                   ;21X and CR7,10 mV range for CR23X.
  3:  1             DIFF Channel
  4:  3             Loc [ SlrW    ] ; result in mV
  5:  1             Multiplier
  6:  0             Offset
```

```
; set negative values to zero

2:  If (X<=>F) (P89)
   1:   3              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:   3              Z Loc [ SlrW     ]

4:  End (P95)

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

5:  Z=X*F (P37)
   1:   3              X Loc [ SlrW     ]
   2:   0.002          F
   3:   4               Loc [ SlrMJ    ]

; convert mV to W/m2

6:  Z=X*F (P37)
   1:   3              X Loc [ SlrW     ]
   2:   200.0          F
   3:   3              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:   3              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:    4               Loc [ SlrMJ     ]

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

4.2 Total Solar Radiation

If the 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. The largest number that an Edlog datalogger can output to final storage is 6999 in low resolution 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 (see Example 2). 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, see Datalogger manuals for details). The disadvantage of the high resolution format is that it requires four bytes of memory per data point, consuming twice as much memory as low resolution.

5. Maintenance

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. Check that the drain hole next to the surface of the sensor is free of debris.

CAUTION Handle the sensor carefully when cleaning. Be careful not to scratch the surface of the sensor.

Recalibrate the LI200X every two years. Obtain an RMA number before returning the LI200X to Campbell Scientific, Inc. for recalibration.

6. Calibration

LI200X pyranometers output a current that is proportional to the incoming solar radiation. Each LI200X has a unique calibration factor. A variable shunt resistor in the cable converts the current to the voltage measured by the datalogger. Campbell Scientific sets the shunt resistor so that the pyranometer outputs 5 mV kW^{-1} m^2.

The resistor value is found using Ohms law. The resistance is found by dividing the desired output voltage by the calibrated current output. For example, a pyranometer with a calibration of 92 µA kW^{-1} m^2, will have the resistor set to:

$$54.35\ \Omega = 5\ mV\ kW^{-1}\ m^2 / 0.092\ mA\ \ kW^{-1}\ m^2.$$

7. Troubleshooting

Symptom: -9999 or radiation values around 0

1. Check that the sensor is wired to the Differential 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 – 5 mV for 0 to 1000 Wm^{-2} radiation. No voltage indicates a problem with the photodiode, cable, or the variable shunt resistor.

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.

Appendix A. LI200S Pyranometer

A.1 LI200S Pyranometer

LI200S pyranometers have a 100 ohm shunt resistor built into the cable. They can be directly measured by Campbell Scientific dataloggers. The input range and multipliers vary from one pyranometer to another. See Sections A.3 and A.4 for calculating the proper input range and multiplier.

A.1.1 Wiring

The red lead is connected to the high side (H) of a differential input channel and the black lead to the corresponding low side (L). On the CR10 a jumper wire is installed between the low side and analog ground (AG). The clear lead is connected to ground (G). On the 21X the jumper wire is installed between the low side and ground (G) and the clear lead is also connected to ground (G). The measurement is then made with Instruction 2 (see Section 4).

A.2 Unmodified Pyranometers

Pyranometers that do not have variable or fixed shunt resistors built into the cable can still be measured by Campbell Scientific dataloggers. This is done by wiring in a 100 Ω shunt resistor directly onto the datalogger wiring panel. The input range and multipliers vary from one pyranometer to another. See Sections A.3 and A.4 for calculating the proper input range and multiplier.

A.2.1 Wiring

Signal positive is connected into the high side(H) of a differential input channel and signal negative to the corresponding low side (L). A jumper wire is installed between the low side (L) and analog ground (AG) on the CR10 wiring panel or ground on the 21X. A 100 Ω 1% resistor (P/N 191) is installed on the wiring panel between the high and low sides the measurement channel. The measurement is then made with Instruction 2 (see Section 5).

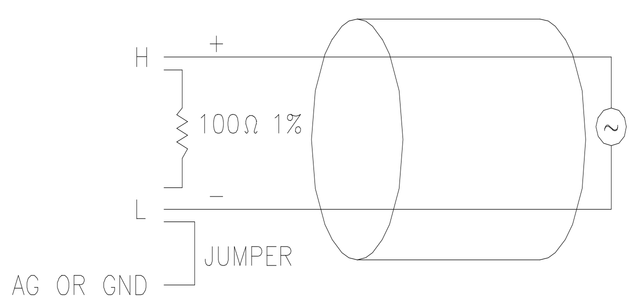

FIGURE A.2-1. Unmodified Pyranometer Wiring Schematic

A.3 Input Range

The following is an example of how to determine the optimum input range for a given sensor calibration and maximum expected irradiance. *This is an example only. Your values will be different.*

This example uses the calibration provided by LI-COR, Inc. Assume that the sensor calibration is 87 μA kW^{-1} m^2. The pyranometer outputs current which is converted to voltage by the 100 Ω shunt resistor in the cable or on the wiring panel. To convert the calibration from current to voltage, multiply the LI-COR calibration by 0.1 KΩ (shunt resistor). The example calibration changes to 8.7 mV kW^{-1} m^2.

A reasonable estimate of maximum of irradiance at the earth's surface is 1 kW m^{-2}. Thus, an estimate of the maximum input voltage is obtained by multiplying the calibration by the maximum expected irradiance. In this example that product is 8.7 mV. Now, select the smallest input range which is greater than the maximum expected input voltage. In this case the 25 mV slow range for the CR10 and 15 mV slow range for the 21X are selected.

A.4 Multiplier

The multiplier converts the millivolt reading to engineering units. The most common units and equations to calculate the multiplier are listed in Table A.4-1.

TABLE A.4-1. Multipliers Required for Average Flux and Total Flux Density for SI and English Units for a LI200S Pyranometer

UNITS	MULTIPLIER	PROCESS
W m^{-2}	(1/C) * 1000	Average
MJ m^{-2}	t * (1/C) * 0.001	Total
kJ m^{-2}	t * (1/C)	Total
cal cm^{-2} min^{-1}	(1/C) * (1.4333)	Average
cal cm^{-2}	t *(1/C) * (0.02389)	Total

C = (LI-COR calibration) ∗ 0.1
t = datalogger execution interval in seconds

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