LI200X PYRANOMETER
INSTRUCTION MANUAL

REVISION: 2/97

WARRANTY AND ASSISTANCE

The **LI200X 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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CAMPBELL SCIENTIFIC, INC.
RMA#_____
815 West 1800 North
Logan, Utah 84321-1784

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Non-warranty products returned for repair should be accompanied by a purchase order to cover the repair.

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LI200X PYRANOMETER

1. GENERAL

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.

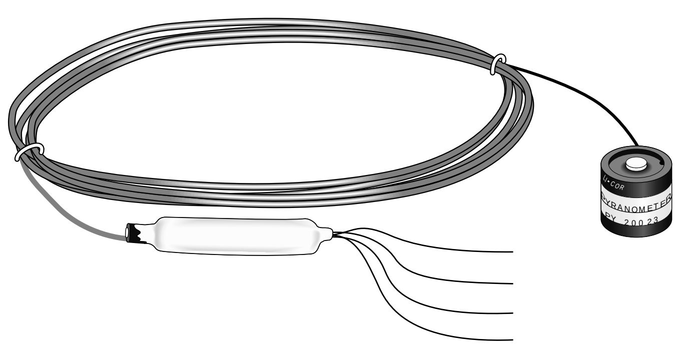

FIGURE 1-1. LI200X Pyranometer

2. INSTALLATION

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).

The LI200X should be mounted such that it is never shaded by the tripod/tower or other sensors.

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

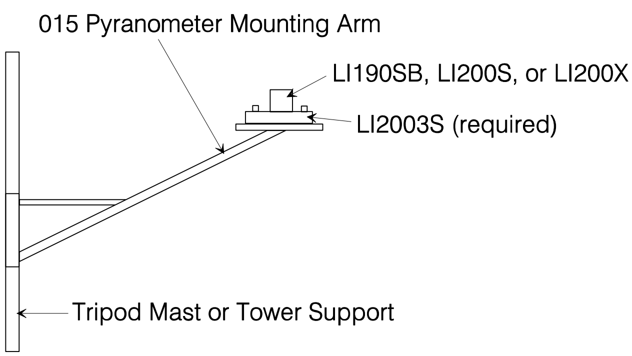

FIGURE 2-1. 015 Pyranometer Mounting Arm

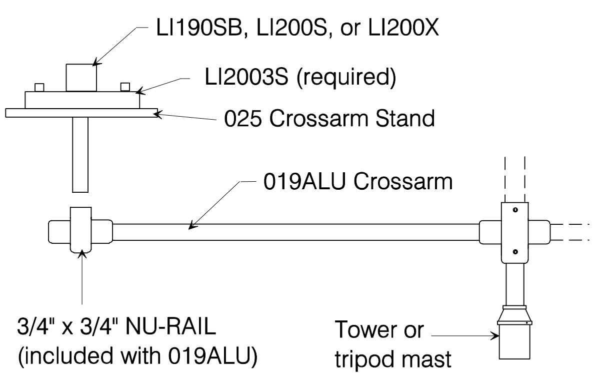

FIGURE 2-2. 025 Crossarm Stand and 019ALU Crossarm

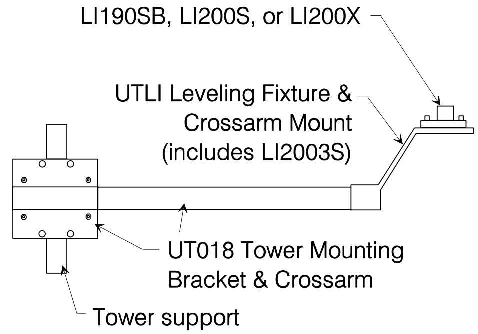

FIGURE 2-3. UTLI Leveling Fixture and Crossarm Mount and UT018 Tower Mounting Bracket and Crossarm

3. WIRING

Measure the LI200X with instruction Differential Voltage (P2). A schematic diagram of the LI200X is shown in Figure 3-1. The red lead is connected to the high side (H) of any differential channel. The black lead is connected to the corresponding low (L) side of the differential channel. On a CR10(X), the white lead is connected an analog ground (AG) and clear to ground (G). On a 21X the white and clear leads are connected to ground (G).

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.

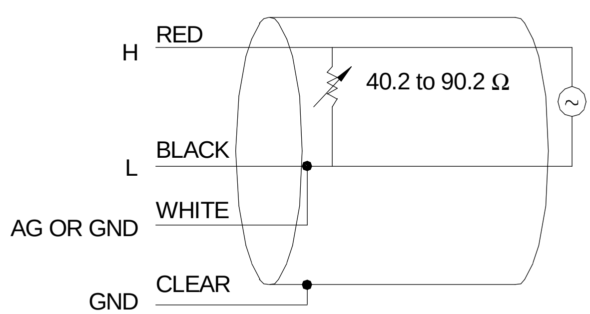

FIGURE 3-1. LI200X Schematic

4. PROGRAMMING

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.

The output from the LI200X is 0.2 kW m^{-2} mV^{-1}.

TABLE 4-1. Multipliers Required for Average Flux and Total Flux Density in SI 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 * (1.4333)	Average
cal cm^{-2}	t * 0.2 * (0.02389)	Total

t = datalogger execution interval in seconds

4.1 AVERAGE SOLAR RADIATION

Example 1 shows the program instructions used to measure the signal from the LI200X. A thirty minute average is calculated and stored in final storage.

EXAMPLE 1. Sample Instructions used to Measure an Average Flux with a CR10(X)/21X

```
;{CR10X}
;
*Table 1 Program
  01:          10          Execution Interval (seconds)

01:    Volt (Diff) (P2)
       1:       1          Reps
       2:      22**        ± 7.5 mV 60 Hz Rejection Range
       3:       1*         DIFF Channel
       4:       1*         Loc [ W_m2     ]
       5:     200***       Mult
       6:       0          Offset

;Set negative values to zero.
;
02:    If (X<=>F) (P89)
       1:       1*         X Loc [ W_m2     ]
       2:       4          <
       3:       0          F
       4:      30          Then Do

03:    Z=F (P30)
       1:       0          F
       2:       0          Exponent of 10
       3:       1*         Z Loc [ W_m2     ]

04:    End (P95)

05:    If time is (P92)
       1:       0          Minutes (Seconds --) into a
       2:      30          Interval (same units as above)
       3:      10          Set Output Flag High (Flag 0)

06:    Real Time (P77)
       1:    0110          Day,Hour/Minute
```

```
07:   Average (P71)
      1:     1         Reps
      2:     1*        Loc [ W_m2     ]

-Input Locations-
1 W_m2
```

* Proper entries will vary with program and input channel assignments.

** The 15 mV slow range is used with a 21X.

*** See Table 4-1 for alternative multipliers.

4.2 TOTAL SOLAR RADIATION

In Example 2 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.

4.2.1 Output Format Considerations

If the solar radiation is totalized in units of kJ m^{-2}, there is a possibility of overranging the output limits. The largest number that the datalogger can output to final storage is 6999 in low resolution and 99999 in high resolution (Instruction 78, Set Resolution).

Assume that the daily total flux density is desired in kJ m^{-2}. 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, record an average flux (see Example 1). 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 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.

EXAMPLE 2. Sample Instructions used to Measure a Daily Total Flux Density with a CR10(X)/21X

```
;{CR10X}
;
*Table 1 Program
  01:         10        Execution Interval (seconds)

01:   Volt (Diff) (P2)
      1:       1        Reps
      2:      22**      ± 7.5 mV 60 Hz Rejection Range
      3:       1*       DIFF Channel
      4:       1*       Loc [ MJ_m2    ]
      5:        .002*** Mult
      6:       0        Offset

;Set negative values to zero.
;
02:   If (X<=>F) (P89)
      1:       1*       X Loc [ MJ_m2    ]
      2:       4        <
      3:       0        F
      4:      30        Then Do

03:   Z=F (P30)
      1:       0        F
      2:       0        Exponent of 10
      3:       1*       Z Loc [ MJ_m2    ]

04:   End (P95)

05:   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)

06:   Real Time (P77)
      1:    0110        Day,Hour/Minute

07:   Totalize (P72)
      1:       1        Reps
      2:       1*       Loc [ MJ_m2    ]

-Input Locations-
1 MJ_m2
```

* Proper entries will vary with program and input channel assignments.

** The 15 mV slow range is used with a 21X.

*** See Table 4-1 for alternative multipliers.

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:

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

APPENDIX A

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).

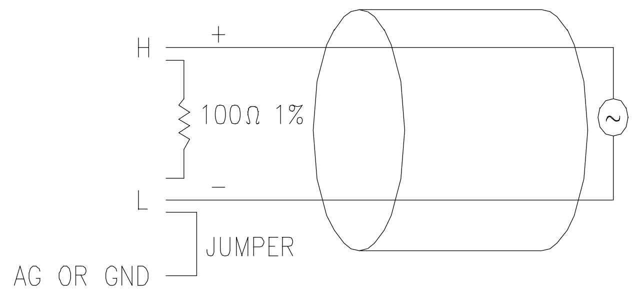

FIGURE A.2-1. Unmodified Pyranometer Wiring Schematic

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