INSTRUCTION MANUAL

LI190SB Quantum Sensor

Revision: 3/08
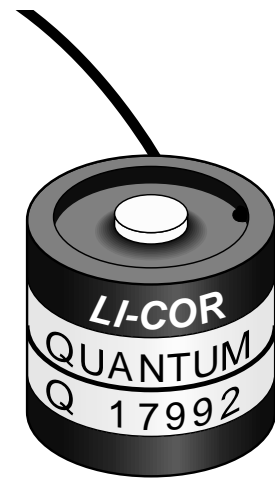
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> RMA#_____
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LI190SB Quantum Sensor

1. General Description

The LI190SB quantum sensor measures photosynthetically active radiation (PAR) in the 400 to 700 nm waveband. The unit of measurement is μmoles per second per square meter (μmol s^{-1}m^{-2}).

The quantum sensor is designed to measure PAR received on a plane surface. The indicated sensor response (Figure 1-1) is selected because it approximates the photosynthetic response of plants for which data are available. A silicon photodiode with an enhanced response in the visible wavelengths is used as the sensor. A visible bandpass interference filter in combination with colored glass filters is mounted in a cosine corrected head.

Measuring PAR within plant canopies, greenhouses, controlled environment chambers, confined laboratory conditions, or at remote environmental monitoring sites are all typical applications for this sensor.

During the night the LI190SB may output a slightly negative value, caused by RF noise. Negative values may be set to zero in the datalogger program.

A Calibration Certificate is shipped with each sensor that includes a serial number and calibration constant. The calibration constant is unique for each sensor, and is used to compute the multiplier for the measurement instruction in the datalogger program.
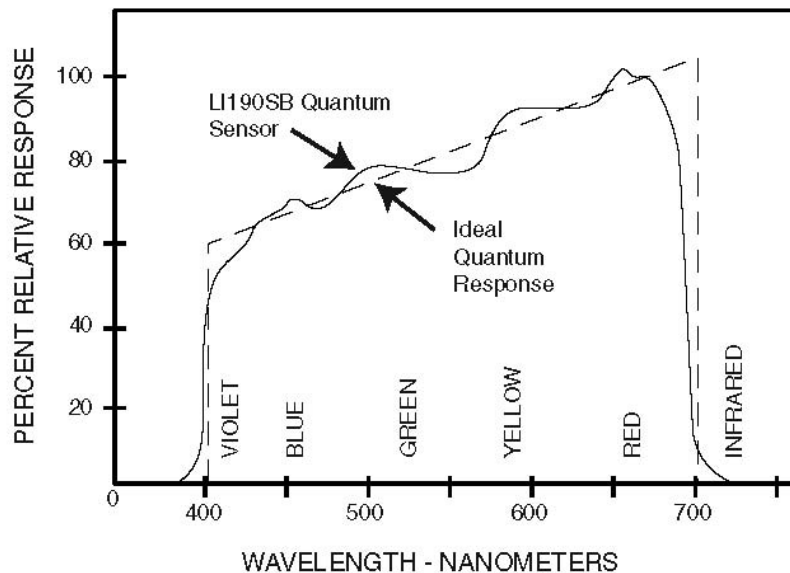

FIGURE 1-1. LI190SB Spectral Response

2. Specifications

Stability:	<±2% change over a 1 year period
Response Time:	10 μs
Temperature Dependence:	0.15% per °C maximum
Cosine Correction:	Cosine corrected up to 80° angle of incidence
Operating Temperature:	-40 to 65°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 x 2.54 cm);
Weight:	1 oz. (28 g)
Calibration:	±5% traceable to the U.S. National Institute of Standards Technology (NIST)
Sensitivity:	Typically 5 μA per 1000 μmoles $s^{-1}m^{-2}$
Linearity:	Maximum deviation of 1% up to 10,000 μmoles $s^{-1}m^{-2}$
Shunt Resistor:	604 ohms
Light Spectrum Waveband:	400 to 700 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.
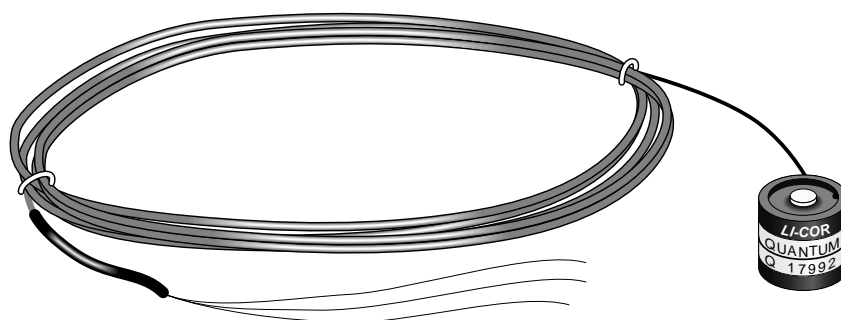

FIGURE 2-1. LI190SB Quantum Sensor

3. Installation

The LI190SB 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 LI190SB should be mounted using LI2003S base/leveling fixture. This base incorporates a bubble level and three adjustment screws. The LI190SB and base/leveling fixture are attached to a tripod or tower using one of three mounting configurations (see Figure 3-1 through 3-3).

Tools required for installation on a tripod or tower:

Small and medium Phillips screwdrivers
5/32" Allen wrench for NU-RAIL (Figure 3-3)
1/2" open end wrench for 015ARM or CM225 (Figures 3-1, 3-2)
Tape measure
UV-resistant wire ties
Side-cut pliers
Compass
Step ladder
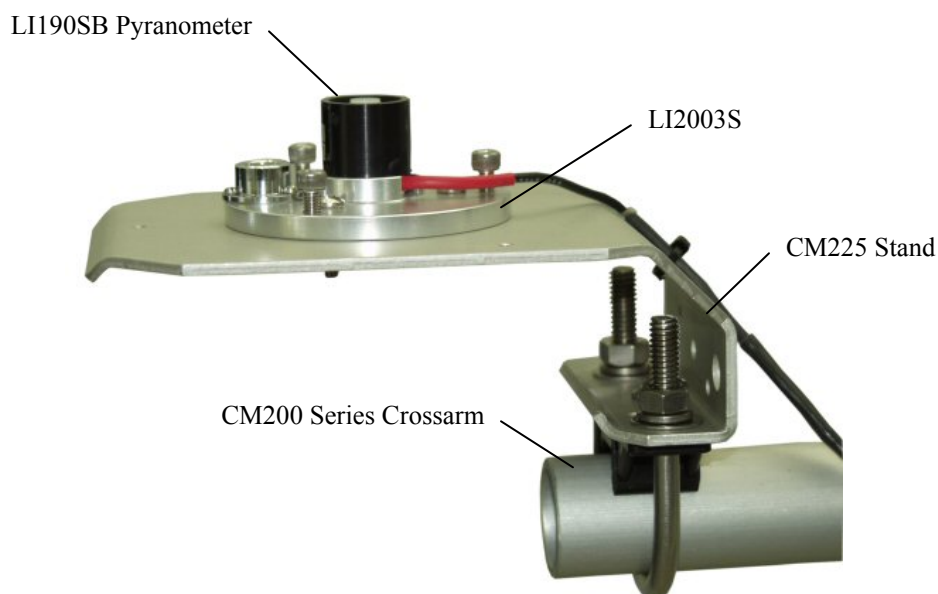
FIGURE 3-1. CM225 Pyranometer Mounting Stand and CM202 Crossarm

NOTE	Remove the red cap after installing the sensor. Save this cap for shipping or storing the sensor.
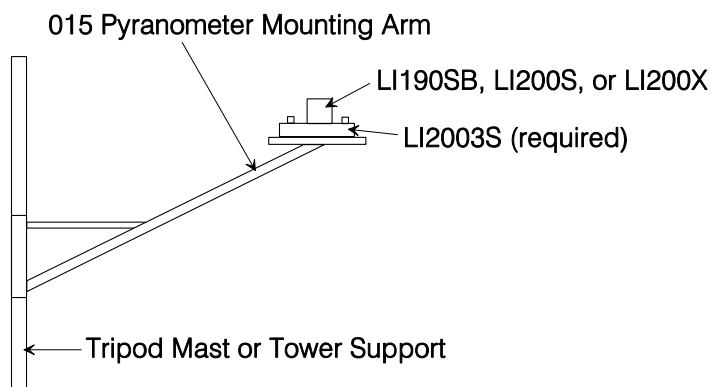
FIGURE 3-2. 015 Pyranometer Mounting Arm

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

4. Wiring

A schematic diagram of the LI190SB is shown in Figure 4-1.

Connections to Campbell Scientific dataloggers are given in Table 4-1. 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.

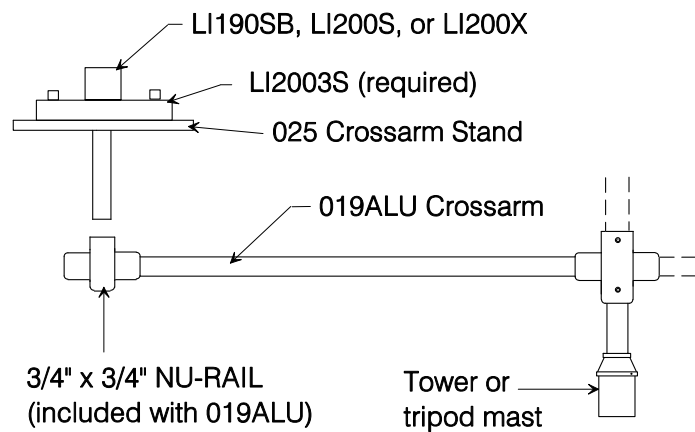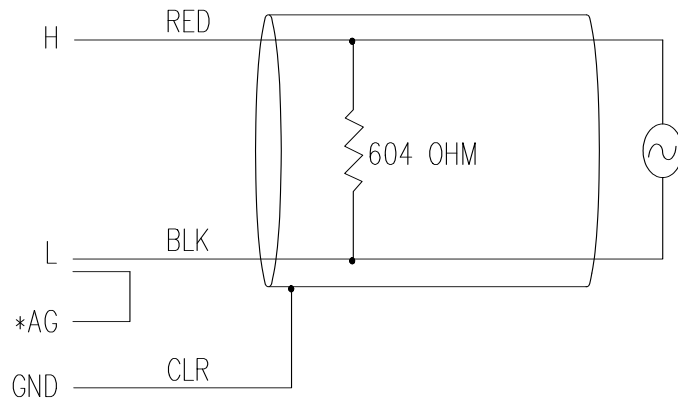|		**CR9000(X)** **CR5000** **CR3000** **CR1000** **CR800**	**CR510** **CR500**	**21X** **CR7**
Color	**Description**	**CR850**	**CR10(X)**	**CR23X**
Red	Signal	Differential High	Differential High	Differential High
Black	Signal Reference	Differential Low	Differential Low	Differential Low
Clear	Shield	$\perp$	G	$\perp$

TABLE 4-1. Connections to Campbell Scientific Dataloggers

*Jumper to AG or $\perp$ with user supplied wire.

FIGURE 4-1. LI190SB Schematic

NOTE   If a 21X is used to measure the LI190SB 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 $\pm$ 60 mV. Thus, single ended measurements should be avoided. The offset does not, however, affect differential measurements.

5. Programming

This section is for users who write their own datalogger programs. A datalogger program to measure the LI190SB can be created using the Short Cut software. You do not need to read the following section to use Short Cut.

Output from the LI190SB is a voltage raning from 0 to a maximum of 10 mV depending on sensor calibration and radiation level, which is measured by the datalogger using a Differential analog input channel. To measure the output, Edlog dataloggers (e.g. CR10X, CR23X) are programmed with Instruction 2 Volt(DIFF), CRBasic dataloggers (e.g. CR1000, CR3000) are programmed with the VoltDiff Instruction.

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 (μmole $s^{-1}m^{-2}$) or daily total flux density (mmoles m^{-2}). The appropriate multipliers are listed in Table 5-1. Programming examples are given for both average and daily total photosynthetically active radiation (PAR). Negative values are set to zero before being processed.

If a differential channel is not available, a single-ended measurement (Instruction 1) is a possibility. As a test, wire the LI190SB as shown in Figure 5-1 and make single-ended and differential measurements. Compare the results to determine the acceptability of a single ended measurement.
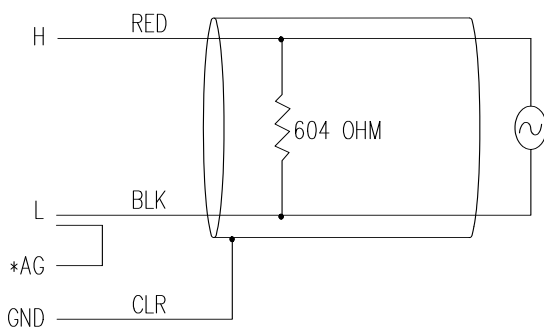

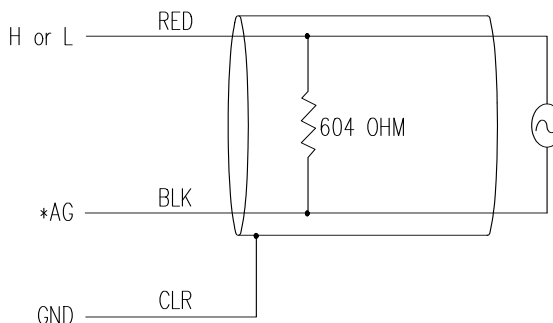*FIGURE 5-1. Differential Measurement Connection*

FIGURE 5-2. Single-ended Measurement Connection

5.1 Input Range

An example showing how to determine the optimum input range for a given sensor calibration and maximum photosynthetically active radiation (PAR) is given below. **This is an example only. Your values will be different.**

-Sensor Calibration: Assume the sensor calibration is 8 µA/1000 µmoles $s^{-1}m^{-2}$ (1000 µmoles = 1 mmole). The LI190SB outputs amperage which is converted to voltage by a 604 ohm shunt resistor in the cable. To convert the calibration from µA to millivolts, multiply the calibration by 0.604. The example calibration changes to 4.83 mV/mmole $s^{-1}m^{-2}$.

-Maximum PAR: A reasonable estimate of maximum PAR is 2 mmoles $s^{-1}m^{-2}$.

-Input Range Selection: An estimate of the maximum input voltage is obtained by multiplying the calibration by the maximum expected PAR. That product is 9.66 mV for this example. Select the smallest input range which is greater than the maximum expected input voltage. In this case, the 15 mV range for the 21X and CR7, and the 25 mV range for the CR10(X) and CR500 are selected.

Measurement integration time is specified in the input range parameter code. A more noise free reading is obtained with the slow or 60 Hz rejection integration. A fast integration takes less power and allows for faster throughput.

MULTIPLIER

The multiplier converts the millivolt reading to engineering units. Commonly used units and how to calculate the multiplier are shown in Table 5-1.

TABLE 5-1. Multiplier Required for Flux Density and Total Fluxes	
UNITS	**MULTIPLIER**
µmole s^{-1} m^{-2}	1000/C (flux density)
mmoles m^{-2}	(1/C)*t (total fluxes)
C = (LI-COR calibration)*0.604 t = datalogger program execution interval in seconds	
Unit Conversions microEinstien/µmole $(6.02 \times 10^{17}$ photons s^{-1} $m^{-2})/(µmoles$ s^{-1} $m^{-2})$	

5.2 Example Programs

The following programs measure the LI190SB every 10 seconds, and convert the mV output to μmoles $s^{-1}m^{-2}$ and mmoles m^{-2}. Both programs output an hourly average flux (μmoles $s^{-1}m^{-2}$) and a daily total flux density (mmoles m^{-2}). Wiring for the examples is given in Table 5-2. Multipliers in the example programs are based upon a sensor with a calibration constant of 6.45 μA/1000 μmoles $s^{-1}m^{-2}$.

TABLE 5-2. Wiring for Example Programs

Color	Description	CR1000	CR10X
Red	Signal	1H	1H
*Black	Signal Reference	1L	1L
Clear	Shield	⏚	G

*Jumper to AG or ⏚ with user supplied wire.

5.2.1 CR1000 Example Program

```
'CR1000

'Declare Variables and Units
Public PAR_Den
Public PAR_Tot

Units PAR_Den=µmol/s/m²
Units PAR_Tot=mmol/m²

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

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

'Main Program
BeginProg
    Scan(10,Sec,1,0)
        'LI190SB Quantum Sensor measurements PAR_Tot and PAR_Den:
        VoltDiff(PAR_Den,1,mV25,1,True,0,_60Hz,1,0)   'Use 20 mV range for CR3000, CR5000
        'Set negative values to zero
        If PAR_Den<0 Then PAR_Den=0
        PAR_Tot=PAR_Den*2.56686              'Multipliers will differ for each sensor and scan rate
        PAR_Den=PAR_Den*256.686
        'Call Data Tables and Store Data
        CallTable(Table1)
        CallTable(Table2)
    NextScan
EndProg
```

5.2.2 CR10X Example Program

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


;Measure LI190SB
1:  Volt (Diff) (P2)
  1:   1           Reps
  2:   23          25 mV 60 Hz Rejection Range    ;15 mV for 21X, CR7; 10 mV for CR23X
  3:   1           DIFF Channel
  4:   3           Loc [ PAR_Den   ]
  5:   1           Multiplier
  6:   0           Offset


;Set negative values to zero
2:  If (X<=>F) (P89)
  1:   3           X Loc [ PAR_Den   ]
  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 [ PAR_Den   ]

4:  End (P95)

;Convert mV to mmoles m^-2 for 10 second scan
5:  Z=X*F (P37)
  1:   3           X Loc [ PAR_Den   ]
  2:   2.56686     F                              ;Will differ for each sensor and scan rate
  3:   4           Z Loc [ PAR_Tot   ]

;Convert mV to µmoles s^-1 m^-2
6:  Z=X*F (P37)
  1:   3           X Loc [ PAR_Den   ]
  2:   256.686     F                              ;Will differ for each sensor
  3:   3           Z Loc [ PAR_Den   ]

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)
```

9

```
10:  Average (P71)
  1:   1              Reps
  2:   3              Loc [ PAR_Den   ]

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 [ PAR_Tot   ]

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

5.3 Output Format Considerations

If solar radiation is totalized in units of mmoles m^{-2}, there is a possibility of overranging the output limits. With the Edlog dataloggers (e.g. CR10X, CR23X, CR510) the largest number that the datalogger can output to final storage is 6999 in low resolution (default), and 99999 in high resolution.

The largest number that the datalogger can output is 6999 in low resolution and 99999 in high resolution (Instruction 78, set resolution). If the measurement value is totalized, there is some danger of overranging the output limits, as shown in the following example.

EXAMPLE

Assume that daily total flux is desired, and the datalogger scan rate is 1 second. With a multiplier that converts the readings to units of mmoles m^{-2} and an average PAR of 1 μmole s^{-1} m^{-2}, the maximum low resolution output limit will be exceeded in less than 2 hours (6999 seconds).

Solution #1 - Record average flux density and later multiply the result by the number of seconds in the output interval to arrive at total flux.

Solution #2 - Record total flux using the high resolution format. Another alternative is to record total flux using the high resolution format. Instruction 78 is used to switch to the high resolution in the Edlog dataloggers. Use the IEEE4 or Long data formats in the CR1000, CR5000, and CR9000 dataloggers. The disadvantage of the high resolution formats is that it takes more memory per data point.

6. Maintenance and Calibration

DO NOT use alcohol, organic solvents, abrasives, or strong detergents to clean the diffuser element.

The acrylic materials used in LI-COR light sensors can be crazed by exposure to alcohol or organic solvents, which will adversely affect the cosine response of the sensor.

Clean the sensor only with water and/or a mild detergent such as dishwashing soap. Vinegar can also be used to remove hard water deposits from the diffuser element, if necessary.

Keep the sensors clean and treat them as a scientific instrument in order to maintain the accuracy of the calibration. The vertical edge of the diffuser must be kept clean in order to maintain appropriate cosine correction.

The LI190SB should re recalibrated every two years. Obtain an RMA number before returning the sensor to Campbell Scientific, Inc. for recalibration.

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 $0 – 10$ 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.

8. Acknowledgements

Campbell Scientific, Inc. gratefully acknowledges the contribution of LI-COR to concepts, text, and images used in this manual.

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