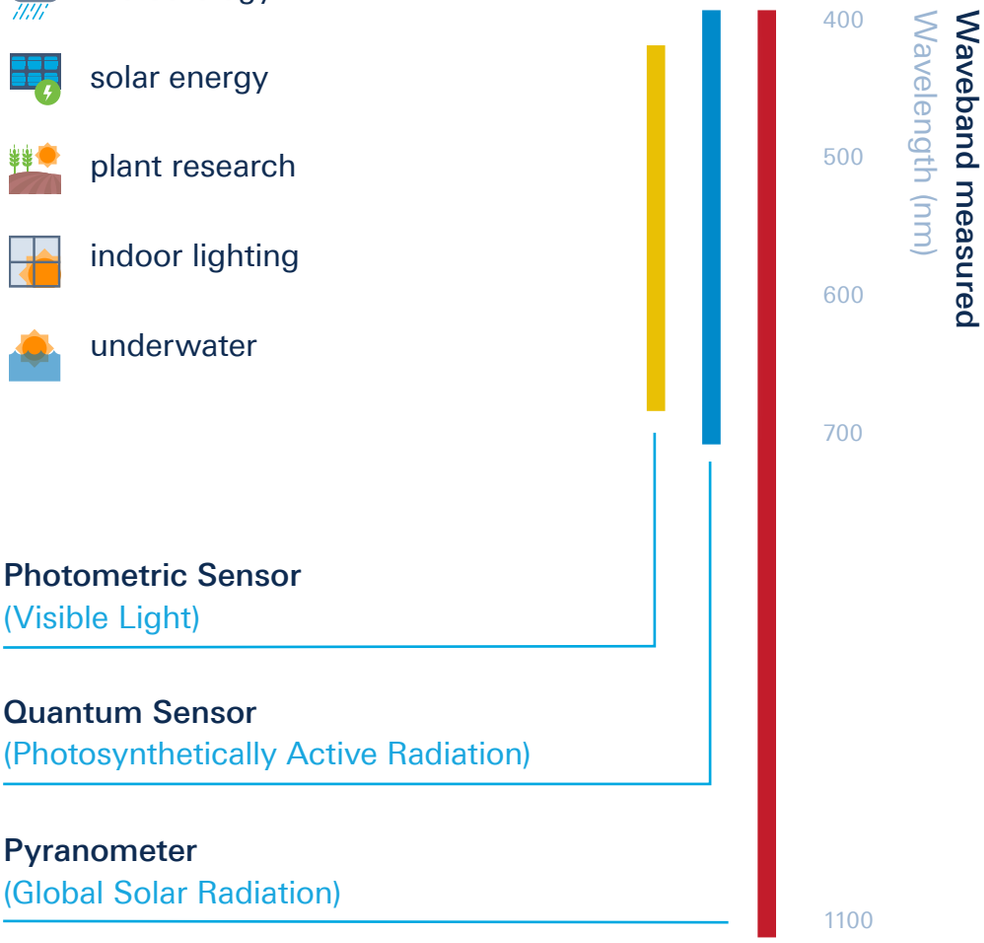
Light Measurement

The Standard for over 40 Years

Introduction

LI-COR radiation sensors measure the flux of radiant energy—the energy that drives plant growth, warms the earth, and lights our world. The properties of radiant flux depend on the wavelength of the radiation. Pyranometers are sensitive to the broadest waveband. Photometric sensors measure visible radiation (light). Quantum sensors measure Photosynthetically Active Radiation (PAR)—the radiant energy used in photosynthesis. These three sensor types cover a wide range of applications:

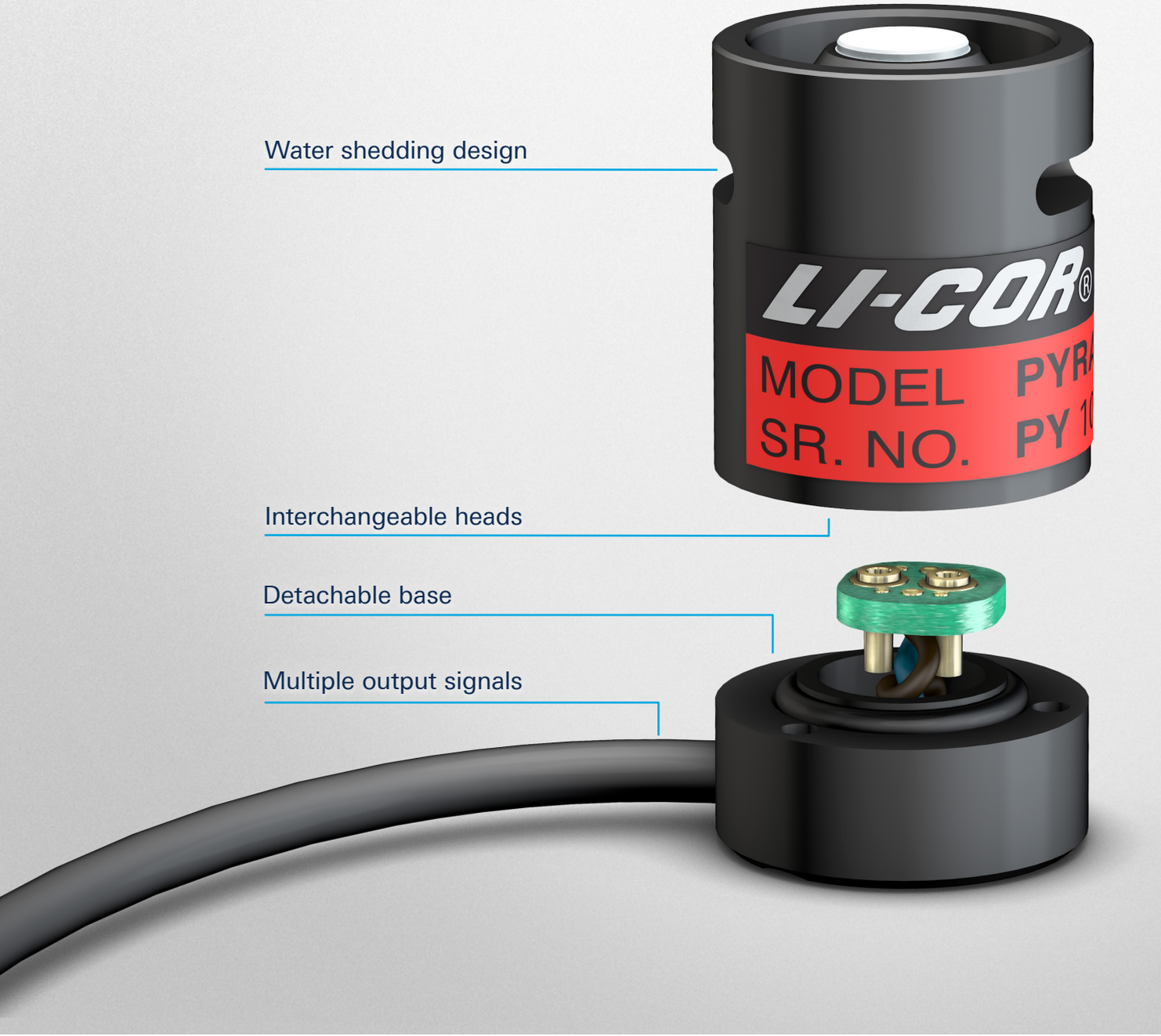
- ecology
- meteorology
- solar energy
- plant research
- indoor lighting
- underwater



The Sensors

LI-COR sensors are weather resistant, low maintenance, and cosine corrected. From the shape of the crown to the photodiodes and optical filter glass, every aspect is the result of scientific inquiry.

The sensor design features a large drain to shed water, and a more robust housing to help prevent water ingress, increasing the lifespan of the sensors and reducing measurement drift. A detachable sensor head allows for replacement and factory recalibration without removing the cable from the mounting structure.



LI-190R Quantum Sensor

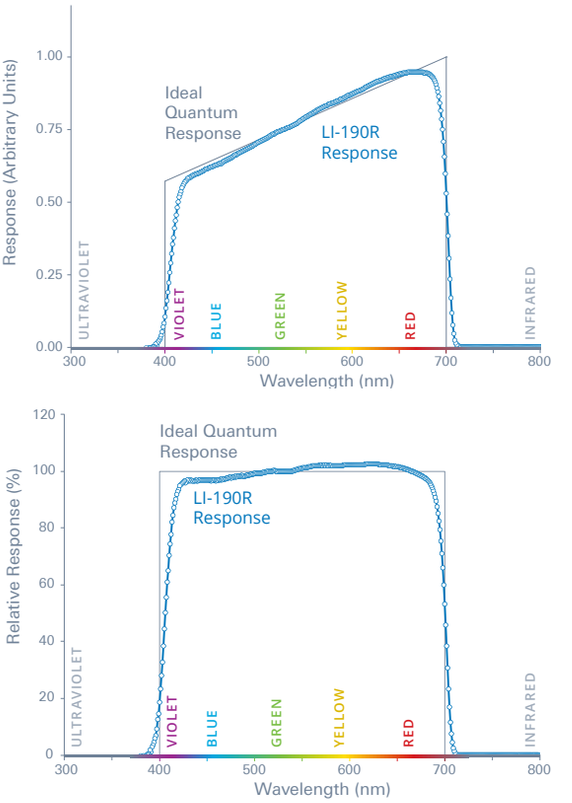
The LI-190R measures Photosynthetically Active Radiation (PAR, in µmol of photons m^{-2} s^{-1}). It provides accurate measurements—in the open, in greenhouses, under plant canopies, or in growth chambers—for most broad-spectrum light sources, including natural sunlight, artificial, or mixed sources.

Plants use light in the wavelength range from about 400 to 700 nm to drive photosynthesis. The efficiency with which plants use light varies somewhat across this range, but McCree[1] showed that measuring PAR provided a consistent way to predict plant photosynthetic response regardless of the spectrum of the light source.[2]

1. McCree, K.J., 1972. The action spectrum, absorptance and quantum yield of photosynthesis in crop plants. Agric. Meteorol. 9: 191-216.
2. McCree, K.J., 1972. Test of current definitions of photosynthetically active radiation against leaf photosynthesis data. Agric. Meteorol. 10: 443-453.

Why choose the LI-190R?

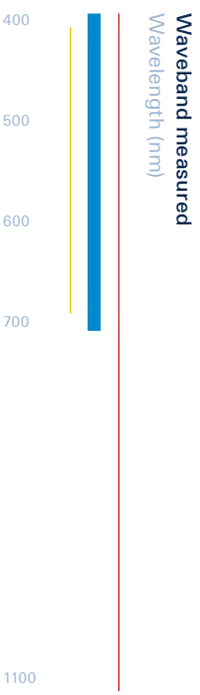
- Uniform sensitivity across the PAR waveband for accurate measurements outdoors, under vegetation, or in artificial lighting without changing the calibration
- Newly designed optical filter tailors the spectral response to an unprecedented performance standard
- Weather resistant and durable in high-temperature, high-humidity, long-term deployments
- Cosine correction is accurate even when the light source is not directly overhead
- Sensor heads are detachable and interchangeable for simplified installation, removal, and recalibration



The LI-190R quantum response and the ideal quantum response curve in energy units (top) and photon units (bottom).

How does it work?

A high-quality silicon photodiode is matched with a specially designed glass optical filter to create nearly uniform sensitivity to all the wavelengths within the PAR waveband (400 to 700 nm). This ensures accurate measurements irrespective of the light source. The glass filter excludes light with wavelengths outside the PAR waveband. Exclusion of wavelengths beyond 700 nm is critical for measurements under vegetation.



LI-190R Specifications

- Absolute Calibration: ± 5% traceable to the U.S. National Institute of Standards and Technology (NIST)
- Sensitivity: Typically 5 µA to 10 µA per 1,000 µmol s^{-1} m^{-2}
- Linearity: Maximum deviation of 1% up to 10,000 µmol s^{-1} m^{-2}
- Response Time: Less than 1 µs (2 m cable terminated into a 604 Ohm load)
- Temperature Dependence: ± 0.15% per °C maximum
- Cosine Correction: Cosine corrected up to 82° angle of incidence
- Azimuth: < ± 1% error over 360° at a 45° elevation
- Tilt: No error induced from orientation
- Operating Temperature Range: −40 °C to 65 °C
- Relative Humidity Range: 0% to 95% RH, Non-Condensing
- Detector: High stability silicon photovoltaic detector (blue enhanced)
- Sensor Housing: Weatherproof anodized aluminum body with acrylic diffuser and stainless steel hardware; O-ring seal on the sensor base
- Size: 2.36 cm diameter x 3.63 cm (0.93" x 1.43")
- Weight: 24 g head; 60 g base and cable assembly (2 m) with screws
- Cable Length: 2 m, 5 m, 15 m, 50 m (6.5', 16.4', 49.2', 164')

Specifications subject to change without notice.

Science

LI-COR terrestrial light sensors are cosine-corrected, following Lambert's cosine law. A cosine-corrected sensor provides the most accurate measurements of radiation on a flat surface from all angles. Cosine correction ensures accurate measurements under various conditions such as low light levels and low solar elevation angles.

The design of the sensor creates the proper cosine response at angles of incidence up to 82°. Radiation is received by an acrylic disc called a diffuser, or “eye”. When radiation strikes with a greater angle of incidence, more is received by the edge of the diffuser. This compensates for increasing reflection from the top surface as the angle of incidence grows larger. Beyond an angle of about 80°, the rim of the sensor begins to block some light in order to maintain the correct response as more radiation is received by the edge of the diffuser. At a 90° angle of incidence, the rim completely blocks the diffuser, in keeping with a proper cosine response.

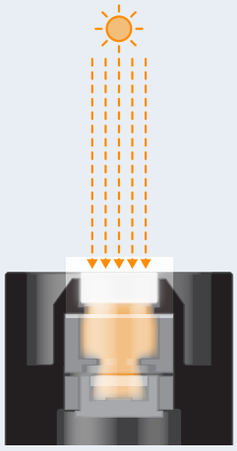
LI-COR light sensors create the proper cosine response at various angles of incidence.

1. 0°: Light is received only by the top surface of the sensor eye.

2. 60°: Light is received by the edge of the eye, compensating for increasing reflection from the top.

3. 80°: The rim of the sensor begins to block some light, preventing too much from striking the edge.

4. 90°: The rim completely blocks the sensor eye, in keeping with a proper cosine response.



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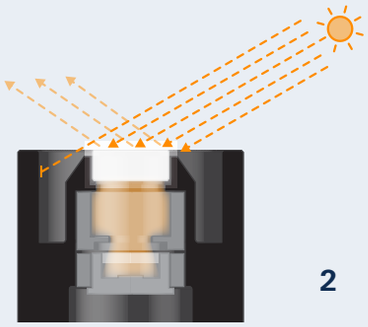

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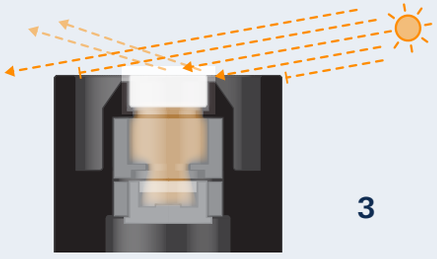

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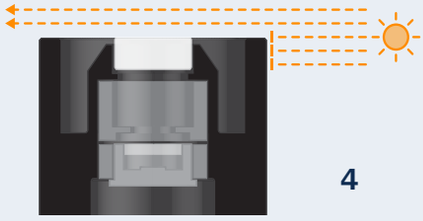

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LI-COR Calibration Standards

Calibration is an integral step in the manufacture of all LI-COR optical radiation-measuring instruments. Because of slight variation in internal optical components, it is necessary to characterize each individual sensor before it leaves LI-COR. This calibration data is supplied as a "calibration constant," which indicates the amount of sensor output for a given amount of measurable energy input.

Calibration constants are used to convert the raw signal into the appropriate units of solar radiation. A readout device such as the LI-1500 Light Sensor Logger or LI-250A Light Meter can store calibration multipliers to do this conversion automatically. Other loggers and meters must have their data scaled by a factor determined from the calibration constant to derive the appropriate units.

The characteristics of the optical components may be affected by environmental conditions. We recommend recalibration every two years to ensure correct measurements.

Pyranometer Calibration

LI-200R Pyranometers are calibrated against an Eppley® Precision Spectral Pyranometer (PSP) under natural daylight conditions. Calibration uncertainty under these conditions is estimated as ± 3% typical, within ± 60° angle of incidence.*

Quantum Sensor Calibration

Quantum sensors, including the LI-190R, LI-191R, LI-192, and LI-193, are calibrated using working standard quartz halogen lamps, which have been calibrated against reference standard lamps traceable to the U.S. National Institute of Standards and Technology (NIST). The absolute calibration specification for quantum sensors is ± 5% (typically ± 3%) traceable to NIST.

Photometric Sensor Calibration

The LI-210R photometric sensors are calibrated using 683 lumens per watt as a value of spectral luminous efficiency at a wavelength of 555 nm. This value conforms to the recommendations of the International Committee for Weights and Measures (CIPM). Calibration is performed using working standard quartz halogen lamps, which have been calibrated against reference standard lamps traceable to the NIST.

*Preliminary specification

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