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WHEN MEASUREMENTS MATTER

CS310
Quantum (PAR) Sensor

Full Spectrum

An accurate, stable, and durable PAR measurement under all light sources

Overview

The CS310 is a self-powered, analog full-spectrum quantum sensor with a 0 to 40 mV output. The sensor incorporates a blue-enhanced silicon photodiode and custom optical filters with a rugged, self-cleaning sensor housing design that includes an anodized aluminum body with an acrylic diffuser.

Typical applications include PPFD measurement over plant canopies in outdoor environments, greenhouses, and growth chambers, as well as reflected or under-canopy (transmitted) PPFD measurement in the same environments.

Benefits and Features

- Full-spectrum quantum sensor with a spectral range of 389 to 692 nm (±5 nm)
- Accurate measurements under all light sources including Light Emitting Diodes (LEDs)
- Dome-shaped anodized aluminum body designed to be rugged and self-cleaning for a longer life and lower maintenance
- IP68 rated connector provides extra assurance in wet and harsh environments
- Sensor head detachable from the cable with a marine-grade 316-L stainless-steel connector for fast, easy servicing
- Factory calibration data stored in the sensor so no sensor-specific calibration coefficients required for an accurate measurement
- Each sensor carefully calibrated in controlled conditions and traceable to NIST reference standards
- Four-year manufacturer warranty

Detailed Description

Radiation that drives photosynthesis is called photosynthetically active radiation (PAR) and is typically defined as total radiation across a range of 400 to 700 nm. PAR is often expressed as photosynthetic photon flux density (PPFD): photon flux in units of micromoles per square meter per second (µmol m^{-2} s^{-1}, equal to microEinsteins per square meter per second) summed from 400 to 700 nm (total number of photons from 400 to 700 nm). While Einsteins and micromoles are equal (one Einstein = one mole of photons), the Einstein is not an SI unit, so expressing PPFD as µmol m^{-2} s^{-1} is preferred.

Sensors that measure PPFD are often called quantum sensors due to the quantized nature of radiation. A quantum refers to the minimum quantity of radiation (one photon) involved in

physical interactions (for example, absorption by photosynthetic pigments). In other words, one photon is a single quantum of radiation.

Typical applications of quantum sensors include incoming PPFD measurement over plant canopies in outdoor environments or in greenhouses and growth chambers, and reflected or under-canopy (transmitted) PPFD measurement in the same environments.

The CS310 quantum sensor consists of a cast acrylic diffuser (filter), photodiode, and signal processing circuitry mounted in an anodized aluminum housing with a cable to connect the sensor to a measurement device. The CS310 quantum sensor is designed for continuous PPFD measurement in indoor or outdoor environments. It outputs an analog signal that is directly proportional to PPFD. The analog signal from the sensor is directly proportional to radiation incident on a planar surface (does not have to be horizontal), where the radiation emanates from all angles of a hemisphere.

References

- Federer, C.A., and C.B. Tanner, 1966. Sensors for measuring light available for photosynthesis. Ecology 47:654-657.
- Ross, J., and M. Sulev, 2000. Sources of errors in measurements of PAR. Agricultural and Forest Meteorology 100:103-125.
- Federer, C.A., and C.B. Tanner, 1966. Sensors for measuring light available for photosynthesis. Ecology 47:654-657.
- Inada, K., 1976. Action spectra for photosynthesis in higher plants. Plant and Cell Physiology 17:355-365.
- McCree, K.J., 1972a. The action spectrum, absorptance and quantum yield of photosynthesis in crop plants. Agricultural Meteorology 9:191-216.
- McCree, K.J., 1972b. Test of current definitions of photosynthetically active radiation against leaf photosynthesis data. Agricultural Meteorology 10:443-453.
- Sager, J.C., W.O. Smith, J.L. Edwards, and K.L. Cyr, 1988. Photosynthetic efficiency and phytochrome photoequilibria determination using spectral data. Transactions of the ASAE 31:1882-1889.

Spectral Response

Refer to the mean spectral response graph in the Images section of the web page. The graph shows the mean spectral response measurements of six replicate Apogee SQ100 and CS310 quantum sensors. Spectral response measurements were made at 10 nm increments across a wavelength range of 300 to 800 nm in a monochromator with an attached electric light source. Measured spectral data from each quantum sensor were normalized by the measured spectral response of the monochromator/electric light combination, which was measured with a spectroradiometer.

Specifications

Sensor	Blue-enhanced silicon photodiode and custom optical filters
Measurement Description	Measures photosynthetic photon flux density (PPFD) in both natural and artificial light
Power Supply	Self-powered
Sensitivity	0.01 mV per µmol m^{-2} s^{-1}
Calibration Factor (Reciprocal of Sensitivity)	100.0 µmol m^{-2} s^{-1} per mV
Calibration Uncertainty	±5% (for daily total radiation)
Calibrated Output Range	0 to 40 mV
Measurement Range	0 to 4000 µmol m^{-2} s^{-1}
Measurement Repeatability	< 1% (up to 4000 µmol m^{-2} s^{-1})
Long-Term Drift	< 2% per year
Non-Linearity	< 1% (up to 4000 µmol m^{-2} s^{-1})
Response Time	< 1 ms
Field of View (FOV)	180°
Spectral Range	389 to 692 nm ±5 nm (wavelengths where response is greater than 50% of maximum)
Spectral Selectivity	< 10% from 412 to 682 nm ±5 nm
Directional (Cosine) Response	±5% (at 75° zenith angle)
Azimuth Error	< 0.5%
Tilt Error	< 0.5%
Temperature Response	-0.11 ±0.04% per °C
Uncertainty in Daily Total	< 5%
Detector	Blue-enhanced silicon photodiode
Housing	Anodized aluminum body with acrylic diffuser
IP Rating	IP68
Operating Temperature Range	-40° to +70°C
Operating Environment	0 to 100% relative humidity
Cable	5 m of shielded, twisted-pair wire

	Additional cable available in multiples of 5 m; Santoprene rubber jacket (high water resistance, high UV stability, flexibility in cold conditions); pigtail lead wires

Warranty	4 years (against defects in materials and workmanship)
Diameter	2.4 cm (0.9 in.)
Height	3.5 cm (1.4 in.)
Weight	100 g with 5 m of lead wire (3.53 oz with 16.4 ft of lead wire)