Biospherical Instruments Inc.

Optical Instruments for Environmental Monitoring

QCP-2150™ Series with Digital Output

Quantum Irradiance PAR Sensor

Measuring Irradiance in water over the PAR Spectral Region[1]

The QCP-2150 is a fourth-generation **PAR sensor** with digital output. Compared to the original QCP-2100 model, the QCP-2150 offers a better signal-to-noise ratio, easy-to-interface ASCII output, and superior dynamic range. The QCP-2150 measures Photosynthetically Active Radiation (PAR) with a cosine-corrected irradiance collector optimized for use in water. The sensor has a flat quantum response over the PAR spectral region (400–700 nm). The spectral response is shaped by a combination of absorbing glass and custom dichroic filters to accurately cover the PAR spectral region and block out-of-band radiation. These sensors compliment a selection of Biospherical Instruments' sensors with digital and analog-linear outputs and "scalar collectors." An overview of these additional models is provided on the last page.

The QCP-2150 is designed for operation in natural waters to depths of up to 6,800 meters. Custom-housed versions of this sensor are also available for gliders and other undersea or monitoring applications.

Key Features:

- Ideal to measure **light available for photosynthesis** falling on a **flat surface,** also known as ***Photosynthetic Photon Flux Density*** (**PPFD**).
- **Compact**, **rugged**, and **low-cost**.
- Designed to measure PAR irradiance to depths of **6,800 meters**.
- Uses **optimized 24-bit ADC** for **large dynamic range**.
- ASCII text output for **easy integration with data acquisition systems**.
- **Sensor temperature** and line voltage may be enabled in the data stream.
- **Fast sampling**: time constant of sensor is < 0.01 s, sample rate is up to 250 Hz.
- **Logger2150 software** is included allowing direct connection to a PC or laptop computer using BSI's serial-to-USB converter.
- **Reduced power consumption** (<5 mA @ 6-15 V).
- Options for **networking multiple sensors**.
- Tested with cables > 200 meters in length.
- Versions **available for Teledyne Webb and iRobot gliders**. Other systems can readily be developed. Consult the systems manufacturer for details or consult Biospherical Instruments for new versions.

1 Several terms are in use to denote the physical quantity measured by a "*Quantum Irradiance PAR Sensor*" including: "*Photosynthetic Photon Flux Density*" (PPFD), "quantum flux density," and "PAR quantum irradiance."

QCP-2150 Specifications

Measurement Quantity

Quantum Irradiance for PAR (Photosynthetically Available Radiation or Photosynthetically Active Radiation). This quantity is typically referred to as PPFD (Photosynthetic Photon Flux Density). Alternative terms for PPFD are "quantum flux density," or "PAR quantum irradiance."

Optical Features

Irradiance Collector: Cosine-corrected acrylic diffuser optimized for in-water measurements.

Directional Response: Deviations from the ideal cosine response are:
< ±3% for incidence angles < 65°
< ±10% for incidence angles between 65° and 80°
Deviations from the ideal cosine response are substantially larger than indicated above if a QCP sensor is used in air. For in-air measurements a QCR sensor is recommended—see last page. Fig. 1 compares the directional response of an in-water QCP sensor with that of QSP sensors for measuring quantum *scalar* irradiance.

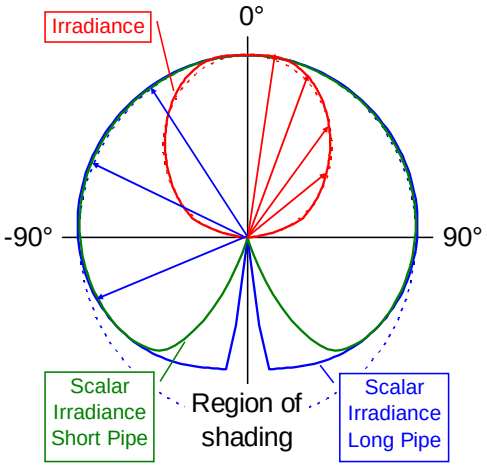

Fig 1. Comparison of the typical directional response of a QCP irradiance sensor (red) and two QSP scalar irradiance sensors, one equipped with a short (green) and one with a long (blue) light pipe. Thin broken lines indicate the ideal responses for the two geometries.

Spectral Response: Sensor approximates the spectral response of PAR. The ideal PAR response is zero below 400 nm and above 700 nm, and constant between 400 and 700 nm. No real sensors can emulate an instant transition from zero to a constant value at 400 and 700 nm. Each BSI PAR sensor is individually optimized to ensure that its spectral response falls within the lower and upper limits shown in Fig. 2.

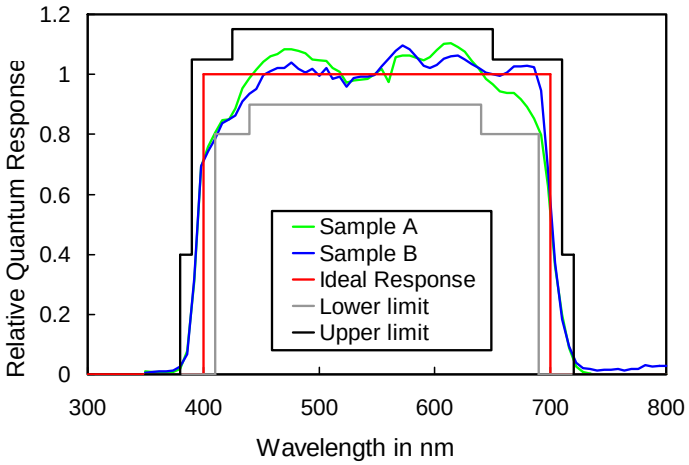

Fig 2. Typical spectral response of two PAR sensors (Sample A and B) compared with the ideal PAR response (red) and the acceptable range (lower and upper limit).

Electronic Features

Photodetector: High-reliability silicon photodiode designed for precision radiometry.

Time Constant: < 10 ms, limited by maximum sampling rate of 250 Hz. Large sampling rates require higher baud rates. Effective resolution declines as the sampling rate increases.

Stability of dark reading: < 0.003 µE m^{-2} sec^{-1} (tested between 0 to 50 °C)

Saturation: approximately 6000 µE m^{-2} sec^{-1} when immersed in water

Responsivity temperature coefficient: < 0.05% / °C

Power Requirement: 6-15 V, at typically 3.5 mA. These sensors were originally introduced as "port-powered" because most PCs at the time provided sufficient power from the control lines (DTR, RTS) of the serial port to run the instrument. More recently, these ports have disappeared from PCs and laptops entirely. Some "USB-to-serial" adaptors will supply sufficient power, but many do not, so Biospherical Instruments supplies specially modified USB-to-serial converters("dongles") at no cost that are ideal for connecting a QCP-2150 sensor to a USB port (see Options and Accessories).

Digitization: 24-bit analog to digital converter (ADC) operating at frequencies of 4 to up to 250 Hz with 1–65,000 samples averaged (user selectable) prior to transmission. When averaging 12 samples at 125 Hz, data are transmitted at approximately 10 Hz. Data acquisition and transmission rates are supported from < 2.8 10^{-4} Hz (60 minutes) to 250 Hz, but the useable sampling rate may depend on the configuration of the data logger or computer.

Physical specifications

Housing: Hard-anodized aluminum. Consult factory for other material options. The housings are connected via a 1 µF capacitor to ground potential.

Depth Rating: 6,800 meters

Temperature range: -10 to 50 °C

Dimensions: 5.0 cm in diameter, 15.25 cm long, not including the connector.

Weight: 0.68 kg

Calibration

Each sensor is calibrated using a National Institute of Standards and Technology (NIST) traceable 1000-watt type FEL Standard of Spectral Irradiance using procedures recommended by NIST. Annual recalibration is strongly recommended.

Sensors are shipped with a calibration certificate listing calibration factors to convert raw data measured in water to calibrated data in units of µE m^{-2} sec^{-1} or µE cm^{-2} sec^{-1}. An alternate pair of calibration factors is supplied for in-air measurements. Note that a µE or "microEinstein" is a micromole of quanta (6.023×10^{17} quanta). The software allows the user to change the calibration factor, along with other parameters such as sampling rate.

Data format

Data Format: RS-232 clear text ASCII, 9600-n-8-1. Other baud rates that can be selected including 19200, 38400, 57600, 115200, and 230400 baud. When auxiliary channels are enabled, data are comma separated.

Data Output: Data output may be chosen between volts, volts-offset (default), calibrated irradiance, or calibrated irradiance adjusted for immersion in water. Optionally, sensor temperature and line voltage may be included in the data stream. A preamble may be defined to the data frame to easily identify data in a multi-sensor environment. For example "$" may be used in a NEMA application. As delivered, the output is in volts-offset.

Typical output data stream: Displayed are irradiance in µE m^{-2} sec^{-1}, temperature in °C and line voltage in volts:
.013016, 16.06, 6.137
.012990, 16.06, 6.137
.012998, 16.06, 6.137
.013000, 16.06, 6.137

Modes of Operation / Multiple Sensor Operation

Sensor can be configured to be either **free running** at the desired rate **or polled** at up to the desired rate. Note, polling is only available on our most recent models, and can be retro-fitted at the factory on older models. Sampling at higher speeds require baud rates of larger than 9600 baud, and sampling at the highest speeds may not be achievable with polled sampling.

For applications needing multiple sensors, each sensor can be assigned a "tag" from the letters "ABCDEFGHIJK" to identify the sensor. The command "*" sent to all sensors is given to start sampling, followed by the command ">A" to retrieve data from sensor "A", ">B" for data from sensor "B", and so on. Multiple sensors can be cabled so that they share data in, data out, power and ground, terminating at a single serial port for monitoring multiple locations or depths.

Software

The sensor can either be operated with a generic **terminal emulation program** such as HyperTerminal or RealTerm, or with a dedicated software called **Logger2150**. Because the sensor output is in ASCII text, any program that can interface with a serial port and can parse ASCII text can be used to operate the instrument and record data. This includes **LabVIEW** and many popular **data loggers** that support serial data acquisition. Contact Biospherical Instruments for further information and recommendations.

Operation with terminal emulation program: Upon pressing “enter” in the terminal program, the following clear-text menu will be provided to allow sensor configuration, calibration constant setting and retrieval, dark correction, internal averaging, data output rate, and other features.

```
Biospherical Instruments Inc: Digital Log Engine v: 2.0beta
Model: QSP2150 70487
A to set number of samples averaged before update: 2
B to set the baudrate, now: 230400
C to set the Calibration Factor for digital output: 10.550001
D to set the description available for display in software: QSP
I to sent unit ID and serial number (password protected)
J to set the immersion factor (not automatically applied): 0.566400
K to set dark zero, currently dark = 0.000000v.
M to set the operating mode (0=streaming, 1=polled with tag= A) currently 0
O to configure the OUTPUTs, temperature is disabled, line voltage is disabled
P to set a preamble for the data transmission =
Q to toggle quiet mode at startup (no diagnostic messages=1): 1
R to set ADC sample rate: 250
S to send ADC diagnostic information
T will give the latest temperature reading
U sets the calibration units: uE/cm2sec
W to set the how calibration constants are used
Calibration Mode = D
Output is in VOLTS with NO OFFSET subtracted.
X to restart sampling
Sensor temperature: 27.68 C
Input Supply Voltage measures 7.515v
```

Logger2150: A sophisticated software package called Logger2150 is a available at no charge to customers who prefer to use dedicated software instead of a terminal emulation program. Logger2150 is a Windows-compatible data acquisition program supporting acquisition, display, graphics, and recording of data from 2150 series instruments. Note, the fastest data rates (typically over 40 Hz) may not be supported by Logger2150, depending on the PC's speed.

Options and Accessories

Connectors: The standard connector is a MCBH-4-MP. Other connector options are available on request.

Cable: Kevlar reinforced deployment cable (QSC-2100) , non-reinforced neoprene laboratory cable (QSC-2104).
Lengths up to 200 meters are available. “Dry” ends of cables are terminated with a DB-9F serial connector.

QSP-210: Lowering frame for profiling applications.

Biospherical Instruments serial to USB converter. This converter is specially modified to supply the optimal voltage for the sensor and ships with the instrument.

USB digital signal manifold: Allows to connect two QSP sensors to one USB port.

Biospherical Instruments Single Channel Sensor Configurations

Biospherical Instruments manufactures a full line of optical instruments for environmental research, ranging from simple single channel sensors to complex systems consisting of multiple radiometers and deployment options.

Depending on their configuration, single channel sensors are identified by a three-letter model designator followed by a four-digit *series* number.

The first letter is either **"Q"** or **"M"** and identifies the spectral response of the sensor. PAR-sensors measuring Photosynthetically Available (or Active) Radiation use the letter **"Q"** to denote a *quantum* response. The letter **"M"** stands for *monochromatic* and is used for sensors that employ a narrow-band channel with a bandwidth of typically 10 nm. Other responses may be available including photopic and "blue light hazard" responses—consult BSI for details.

The second letter is either **"S"**, **"C"**, or **"R"** and indicates the sensor's collector geometry. The three letters stand for *scalar irradiance*, *cosine irradiance,* and *radiance*, respectively.

The third letter is either **"P", "L", or "R"** and indicates the environment of operation. **"P"** specifies *profiling* sensors used for continuous immersion, typically in marine operations. The letter **"L"** is used for *laboratory* operations or near-surface field operations, and **"R"** stands for *reference* or non-submerged radiometers. Monitoring incident (surface) irradiance on a ship's mast or next an aquaculture pond is a typical application of a *reference* sensor.

The four-digit number of the model designator indicates the electrical interface of the sensor such as digital output or analog output, and connectorization.

2100 series: 24 bit analog to digital converter with binary output, fixed sampling rate of approximately 4 Hz. Designed for use with "Logger 2100" software.

2150 series: 24 bit analog to digital converter with improved noise and stability, variable sample rates ranging from 250 Hz down to 1 sample average per hour. Calibrated ASCII output, with optional inclusion of temperature in the data stream. Ideal for integration in multi-parameter monitoring systems. Designed for use with "Logger 2150" software.

2200 series: Linear analog voltage (0-5 volts) output. >16 bit analog to digital converter is recommended for optimum performance.

2300, 2350 series: Compressed analog voltage output. Uses a 24-bit analog to digital converter to sample the signal, the logarithm is computed and the result is converted into an analog voltage (0-5 V) that can be satisfactorily digitized by most data acquisition systems.

Other options include specialized connectors, direct photodiode current output (**-PD**), housings tailored for specific platforms (gliders), and different operating depth options for cosine collector-equipped sensors. Be sure to consult the data sheet for the specific model you are interested in or discuss your application with Biospherical Instruments.

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