

# apogee

## INSTRUMENTS

OWNER'S MANUAL

# QUANTUM SENSOR

Models SQ-214 and SQ-224



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## DECLARATION OF CONFORMITY

### **CE and ROHS Certificate of Compliance**

We Apogee Instruments, Inc.  
721 W 1800 N  
Logan, Utah 84321  
USA

Declare under our sole responsibility that the products:

Models: SQ-214, SQ-224

Type: Quantum Sensor

are in conformity with the following standards and relevant EC directives:

Emissions: EN 61326-1:2013

Immunity: EN 61326-1:2013

EU directive 2004/108/EC, EMC

EU directive 2006/95/EC, Low Voltage Directive – Annex 1: Safety Objectives

EU directive 2002/95/EC, RoHS (Restriction of Hazardous Substances)

EU directive 2011/65/EU, RoHS2

Please be advised that based on the information available to us from our raw material suppliers, the products manufactured by us do not contain, as intentional additives, any of the restricted materials, including cadmium, hexavalent chromium, lead, mercury, polybrominated biphenyls (PBB), polybrominated diphenyls (PBDE).

Further note that Apogee Instruments does not specifically run any analysis on our raw materials or end products for the presence of these substances, but rely on the information provided to us by our material suppliers.

Bruce Bugbee  
President  
Apogee Instruments, Inc.  
June 2013

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## INTRODUCTION

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 ( $\mu\text{mol m}^{-2} \text{s}^{-1}$ , 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  $\mu\text{mol m}^{-2} \text{s}^{-1}$  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 (e.g., 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.

Apogee Instruments SQ series quantum sensors consist of a cast acrylic diffuser (filter), photodiode, and signal processing circuitry mounted in an anodized aluminum housing, and a cable to connect the sensor to a measurement device. Sensors are potted solid with no internal air space, and are designed for continuous PPFD measurement in indoor or outdoor environments. SQ series sensors output an analog signal that is directly proportional to PPFD under sunlight (e.g., model SQ-214) or electric lights (e.g., model SQ-224). 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.

## SENSOR MODELS

Apogee SQ series quantum sensor models covered in this manual are amplified versions that provide a current output, SQ-214 and SQ-224. Un-amplified models, which are self-powered and provide millivolt signals, are also available; see manuals SQ-100 and SQ-300. Additionally, amplified models that provide a 2.5 or 5 volt output, are available; see manual SQ-212 / SQ-222 / SQ-215 / SQ-225 quantum sensors.



Sensor model number, serial number, production date, and calibration factor are located near the pigtail leads on the sensor cable.

### Quantum Sensor Models

US Patent No. D519,860



Calibrated for sunlight; SQ-214



Calibrated for electric light; SQ-224

Located approximately 50cm from the sensor head is a casing that houses the 4-20 mA transmitter. Unplugging the case from the sensor head will disconnect the quantum sensor.



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## SPECIFICATIONS

**Power Supply:** 5-36 V DC with a maximum current drain of 22 mA (2 mA quiescent current drain)

**Sensitivity:** 0.0064 mA per  $\mu\text{mol m}^{-2} \text{s}^{-1}$

**Calibration Factor:** 156.0  $\mu\text{mol m}^{-2} \text{s}^{-1}$  per mV (reciprocal of sensitivity)

**Calibration Uncertainty:**  $\pm 5\%$  (see Calibration Traceability below)

**Measurement Repeatability:**  $< 1\%$

**Non-stability (Long-term Drift):**  $< 2\%$  per year

**Non-linearity:**  $< 1\%$  (up to 2500  $\mu\text{mol m}^{-2} \text{s}^{-1}$ )

**Response Time:**  $< 1$  ms

**Field of View:** 180°

**Spectral Range:** 410 nm to 655 nm (wavelengths where response is greater than 50 % of maximum; see Spectral Response below)

**Directional (Cosine) Response:**  $\pm 5\%$  at 75° zenith angle (see Cosine Response below)

**Temperature Response:**  $0.06 \pm 0.06\%$  per C (see Temperature Response below)

**Operating Environment:** -40 to 70 C  
0 to 100 % relative humidity  
Can be submerged in water up to depths of 30 m

**Dimensions:** SQ-214, SQ-224: 2.4 cm diameter and 2.8 cm height

**Mass:** SQ-214, SQ-224: 140 g (with 5 m of lead wire)

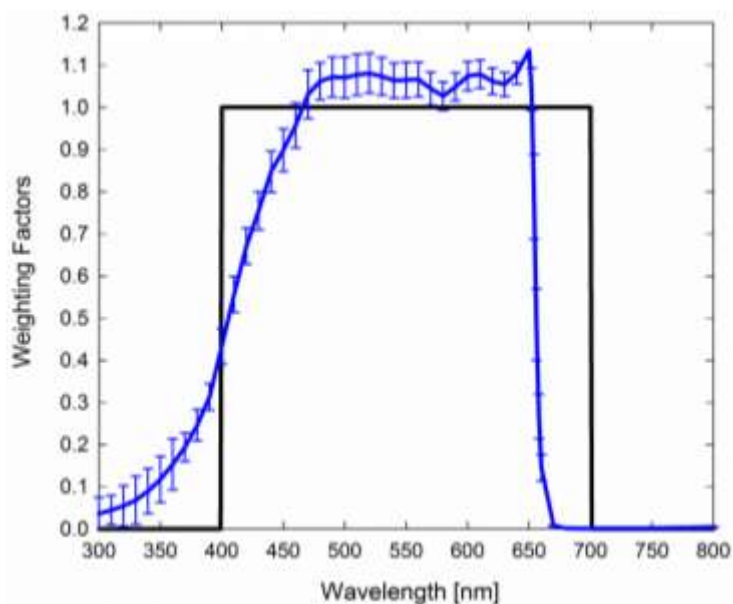
**Cable:** 5 m of shielded, twisted-pair wire.  
Additional cable available in multiples of 5 m  
Santoprene rubber jacket (high water resistance, high UV stability, flexibility in cold conditions)  
Pigtail lead wires

### Calibration Traceability:

Apogee SQ series quantum sensors are calibrated through side-by-side comparison to the mean of four Apogee model SQ-110 or SQ-120 transfer standard quantum sensors under high output T5

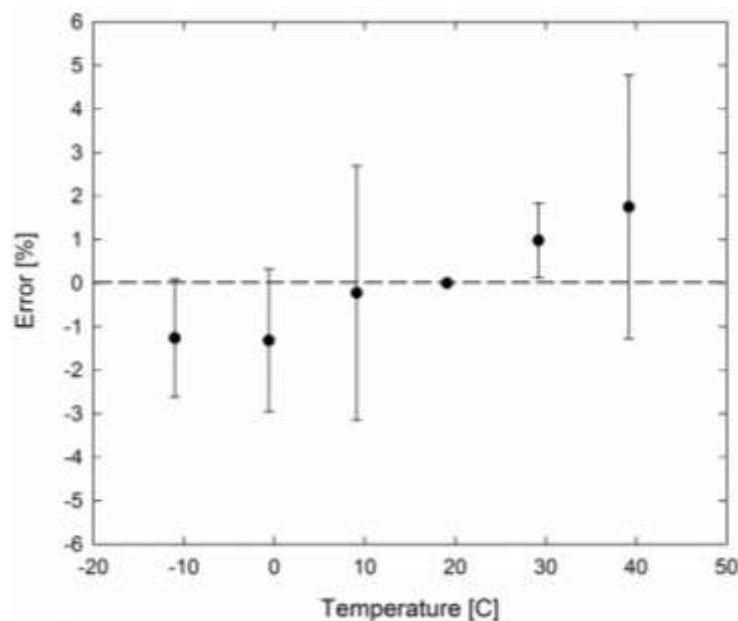
cool white fluorescent lamps. The transfer standard quantum sensors are calibrated through side-by-side comparison to the mean of at least three LI-COR model LI-190 reference quantum sensors under high output T5 cool white fluorescent lamps. The reference quantum sensors are recalibrated on a biannual schedule with a LI-COR model 1800-02 Optical Radiation Calibrator using a 200 W quartz halogen lamp. The 1800-02 and quartz halogen lamp are traceable to the National Institute of Standards and Technology (NIST).

### Spectral Response:



Mean spectral response of six SQ series quantum sensors (**error bars represent two standard deviations above and below mean**) compared to PPFD weighting function. 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.

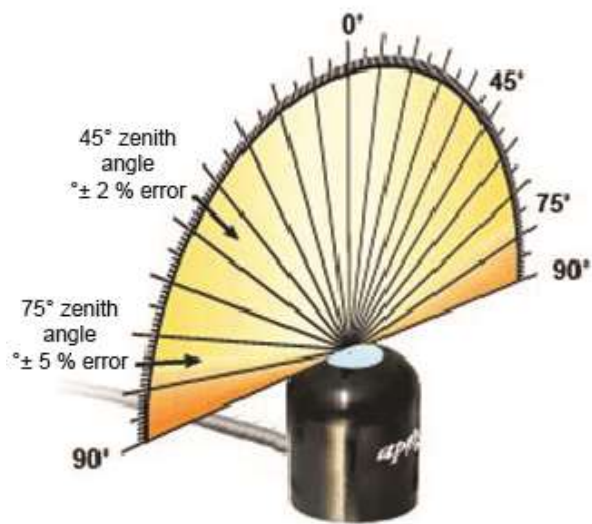
### Temperature response:



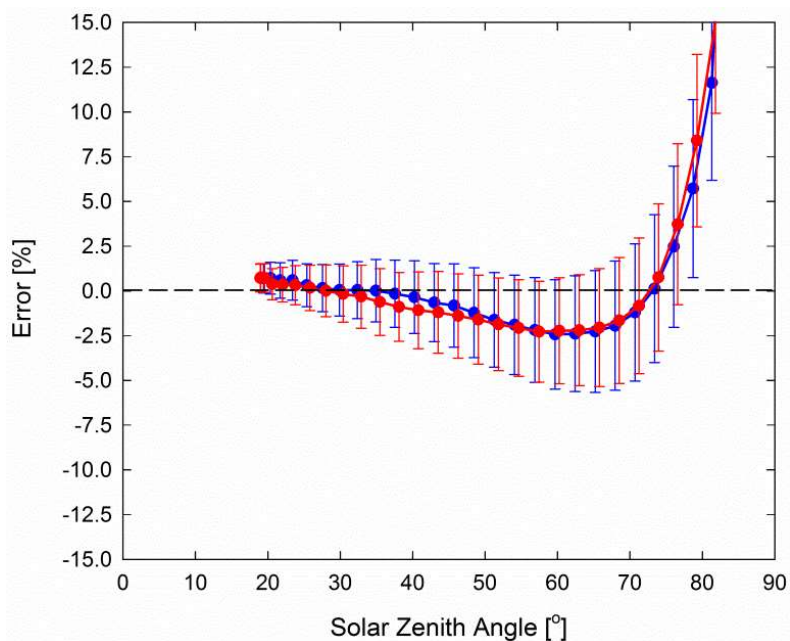
Mean temperature response of eight SQ series quantum sensors (**errors bars represent two standard deviations above and below mean**). Temperature response measurements were made at 10 C intervals across a temperature range of approximately -10 to 40 C in a temperature controlled chamber under a fixed, broad spectrum, electric lamp. At each temperature set point, a spectroradiometer was used to measure light intensity from the lamp and all quantum sensors were compared to the spectroradiometer. The spectroradiometer was mounted external to the temperature control chamber and remained at room temperature during the experiment.

## Cosine Response:

### Cosine Response of Apogee SQ Series Quantum Sensors



Directional, or cosine, response is defined as the measurement error at a specific angle of radiation incidence. Error for Apogee SQ series quantum sensors is approximately  $\pm 2\%$  and  $\pm 5\%$  at solar zenith angles of  $45^\circ$  and  $75^\circ$ , respectively.



Mean cosine response of twenty-three SQ series quantum sensors (**error bars represent two standard deviations above and below mean**). Cosine response measurements were made by direct side-by-side comparison to the mean of four reference thermopile pyranometers, with solar zenith angle-dependent factors applied to convert total shortwave radiation to PPF. Blue points represent the AM response and red points represent the PM response.

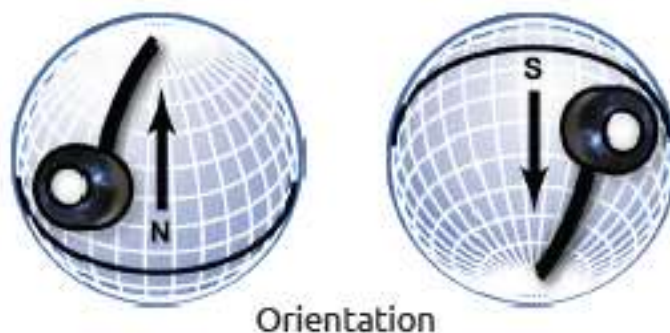


## DEPLOYMENT AND INSTALLATION

Mount the sensor to a solid surface with the nylon mounting screw provided. To accurately measure PPFD incident on a horizontal surface, the sensor must be level. An Apogee Instruments model AL-100 leveling plate is recommended for this purpose. To facilitate mounting on a cross arm, an Apogee Instruments model AM-110 mounting bracket is recommended.



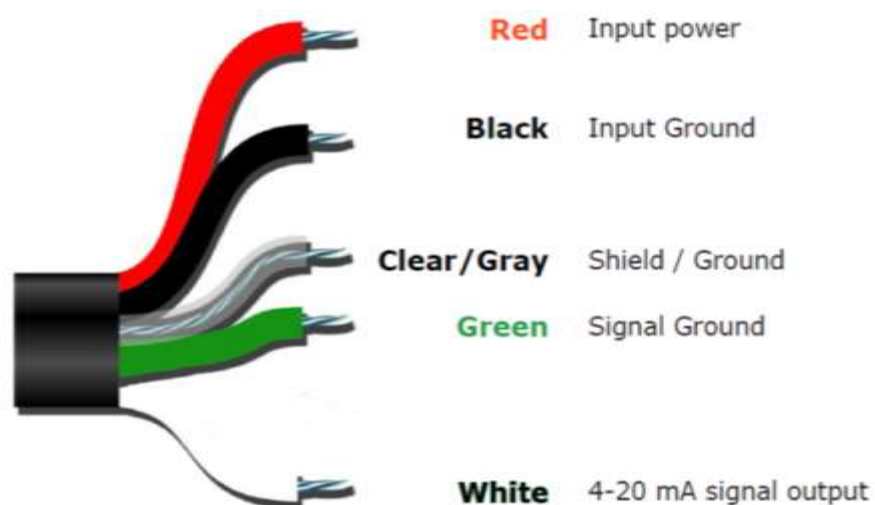
To minimize azimuth error, the sensor should be mounted with the cable pointing toward true north in the northern hemisphere or true south in the southern hemisphere. Azimuth error is typically less than 1 %, but it is easy to minimize by proper cable orientation.



In addition to orienting the cable to point toward the nearest pole, the sensor should also be mounted such that obstructions (e.g., weather station tripod/tower or other instrumentation) do not shade the sensor. **Once mounted, the green cap should be removed from the sensor.** The green cap can be used as a protective covering for the sensor when it is not in use.

## OPERATION AND MEASUREMENT

Connect the sensor to a measurement device (meter, datalogger, controller) capable of measuring and displaying a 4-20 mA signal. In order to maximize measurement resolution and signal-to-noise ratio, the input range of the measurement device should closely match the output range of the quantum sensor. **DO NOT connect the sensor to a power source greater than 36 V DC.**



### Sensor Calibration:

Apogee SQ-214, SQ-224 models have a standard PPFD calibration factor of exactly:

**156.0  $\mu\text{mol m}^{-2} \text{s}^{-1}$  per mA with a 4 mA offset**

Multiply this calibration factor by the difference of the measured mA signal and the 4.0 mA offset to convert sensor output to PPFD in units of  $\mu\text{mol m}^{-2} \text{s}^{-1}$ :

**Calibration Factor (156  $\mu\text{mol m}^{-2} \text{s}^{-1}$  per mA) \* [Sensor Output Signal (mA) – Offset (4.0 mA)] = PPFD ( $\mu\text{mol m}^{-2} \text{s}^{-1}$ )**

$$156 \quad * \quad (16.8 \quad - \quad 4) \quad = \quad 2000$$



Example of PPFD measurement with an Apogee quantum sensor. Full sunlight yields a PPFD on a horizontal plane at the Earth's surface of approximately  $2000 \mu\text{mol m}^{-2} \text{s}^{-1}$ . This yields an output signal of 16.82 mA. The signal is converted to PPFD by subtracting the 4.0 mA offset and then multiplying by the calibration factor of  $156 \mu\text{mol m}^{-2} \text{s}^{-1}$  per mA.

### Spectral Errors and Yield Photon Flux Measurements:

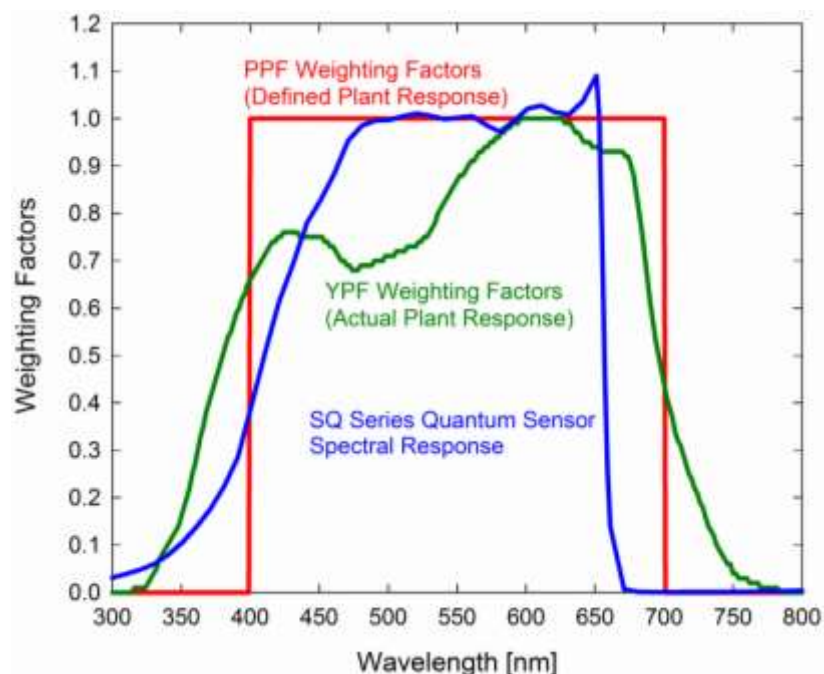
Apogee quantum sensors are calibrated to measure PPFD for either sunlight or electric light. The difference between the calibrations is 14 %. A sensor calibrated for electric lights (calibration source is T5 cool white fluorescent lamps) will read approximately 14 % low in sunlight.

In addition to PPFD measurements, Apogee SQ series quantum sensors can also be used to measure yield photon flux density (YFPD): photon flux density weighted according to plant photosynthetic efficiency (McCree, 1972) and summed. YFPD is also expressed in units of  $\mu\text{mol m}^{-2} \text{s}^{-1}$ , and is similar to PPFD, but has been reported to be more closely correlated to photosynthesis than PPFD in some studies. PPFD is usually measured and reported because the PPFD spectral weighting function (equal weight given to all photons between 400 and 700 nm; no weight given to photons outside this range) is easier to define and measure, and as a result, PPFD is widely accepted. The calibration factor for YFPD is 4.50 and 4.45  $\mu\text{mol m}^{-2} \text{s}^{-1}$  per mV for sunlight and electric light measurements, respectively.

The weighting functions for PPFD and YFPD are shown in the graph below, along with the spectral response of Apogee SQ series quantum sensors. The closer the spectral response matches the defined PPFD or YFPD spectral weighting functions, the smaller spectral errors will be. The table below provides spectral error estimates for PPFD and YFPD measurements from light sources different than the calibration source. The method of Federer and Tanner (1966) was used to determine spectral errors based on the PPFD and YFPD spectral weighting functions, measured sensor spectral response, and radiation source spectral outputs (measured with a spectroradiometer). This method calculates spectral error and does not consider calibration, cosine, and temperature errors.

Federer, C. A., and C. B. Tanner, 1966. Sensors for measuring light available for photosynthesis. *Ecology* 47:654-657.

McCree, K. J., 1972. The action spectrum, absorptance and quantum yield of photosynthesis in crop plants. *Agricultural Meteorology* 9:191-216.



Radiation weighting factors for PPFD (defined plant response to radiation), YPF (measured plant response to radiation), and Apogee SQ Series quantum sensors (sensor sensitivity to different wavelengths of radiation).

#### Spectral Errors for PPFD and YPF Measurements with Apogee SQ Series Quantum Sensors

Radiation Source (Error Calculated Relative to Sun, Clear Sky)	PPFD Error [%]	YPFD Error [%]
Sun (Clear Sky)	0.0	0.0
Sun (Cloudy Sky)	1.4	1.6
Reflected from Grass Canopy	5.7	-6.3
Reflected from Deciduous Canopy	4.9	-7.0
Reflected from Conifer Canopy	5.5	-6.8
Transmitted below Grass Canopy	6.4	-4.5
Transmitted below Deciduous Canopy	6.8	-5.4
Transmitted below Conifer Canopy	5.3	2.6
<b>Radiation Source (Error Calculated Relative to Cool White Fluorescent, T5)</b>		
Cool White Fluorescent (T5)	0.0	0.0
Cool White Fluorescent (T8)	-0.3	-1.2
Cool White Fluorescent (T12)	-1.4	-2.0
Compact Fluorescent	-0.5	-5.3
Metal Halide	-3.7	-3.7
Ceramic Metal Halide	-6.0	-6.4
High Pressure Sodium	0.8	-7.2
Blue LED (448 nm peak, 20 nm full-width half-maximum)	-12.7	8.0
Green LED (524 nm peak, 30 nm full-width half-maximum)	8.0	26.2
Red LED (635 nm peak, 20 nm full-width half-maximum)	4.8	-6.2
Red, Blue LED Mixture (85 % Red, 15 % Blue)	2.4	-4.4
Red, Green, Blue LED Mixture (72 % Red, 16 % Green, 12 % Blue)	3.4	0.2
Cool White Fluorescent LED	-4.6	-0.6
Neutral White Fluorescent LED	-6.7	-5.2
Warm White Fluorescent LED	-10.9	-13.0

Quantum sensors can be a very practical means of measuring PPFD and YPFD from multiple radiation sources, but spectral errors must be considered. The spectral errors in the table above can be used as correction factors for individual radiation sources.

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## MAINTENANCE AND RECALIBRATION

Moisture or debris on the diffuser is a common cause of low readings. The sensor has a domed diffuser and housing for improved self-cleaning from rainfall, but materials can accumulate on the diffuser (e.g., dust during periods of low rainfall, salt deposits from evaporation of sea spray or sprinkler irrigation water) and partially block the optical path. Dust or organic deposits are best removed using water, or window cleaner and a soft cloth or cotton swab. Salt deposits should be dissolved with vinegar and removed with a soft cloth or cotton swab. **Never use an abrasive material or cleaner on the diffuser.**

The Clear Sky Calculator ([www.clearskycalculator.com](http://www.clearskycalculator.com)) can be used to determine the need for quantum sensor recalibration. It determines PPF incident on a horizontal surface at any time of day at any location in the world. It is most accurate when used near solar noon in spring and summer months, where accuracy over multiple clear and unpolluted days is estimated to be  $\pm 4\%$  in all climates and locations around the world. For best accuracy, the sky must be completely clear, as reflected radiation from clouds causes incoming radiation to increase above the value predicted by the clear sky calculator. Measured values of PPF can exceed values predicted by the Clear Sky Calculator due to reflection from the sides and edges of clouds. This reflection increases the incoming radiation. The influence of high clouds typically shows up as spikes above clear sky values, not a constant offset greater than clear sky values.

To determine recalibration need, input site conditions into the calculator and compare PPF measurements to calculated PPF values for a clear sky. If sensor PPF measurements over multiple days near solar noon are consistently different than calculated values (by more than 6%), the sensor should be cleaned and re-leveled. If PPF measurements are still different after a second test, email [calibration@apogeeinstruments.com](mailto:calibration@apogeeinstruments.com) to discuss test results and possible return of sensor(s) for recalibration.

This calculator determines the intensity of radiation falling on a horizontal surface at any time of the day in any location in the world. The primary use of this calculator is to determine the need for recalibration of radiation sensors. It is most accurate when used near solar noon in the summer months.

This site developed and maintained by: **apogee**

**MODEL FOR PYRANOMETER**  
SHORTWAVE RADIATION

**MODEL FOR QUANTUM SENSOR**  
PHOTOSYNTHETIC PHOTON FLUX

• Apogee Instruments Product Notification Letter

Homepage of the Clear Sky Calculator. Two calculators are available: one for quantum sensors (PPFD) and one for pyranometers (total shortwave radiation).

**Clear Sky CALCULATOR FOR QUANTUM SENSORS**

- For best accuracy, comparison should be made on clear, non-polluted, summer days within one hour of solar noon.
- Enter input parameters in the blue cells at right. Definitions are shown below.
- Sensor must be level and perfectly clean. Enter your measured solar radiation in the blue "Measured PPF" cell at far right.
- Difference between the model and your sensor is shown in the yellow "DIFFERENCE FROM MODEL" cell at right.
- Use the model on multiple days. Contact Apogee for recalibration if the measured value is more than 5% different than the estimated value. You will be contacted within two business days.

For a discussion on model accuracy and sensitivity of input parameters, [CLICK HERE](#).

**INPUT AND OUTPUT DEFINITIONS**

**Latitude =** Latitude of the measurement site (degrees); for southern hemispheres, insert as a negative number; info may be obtained from <http://timeanddate.com/location.html>

**Longitude =** Longitude of the measurement site (degrees), expressed as positive degrees west of the standard meridian in Greenwich, England (e.g. 34° for New York, 340° for Bangkok, Thailand, and 300° for Paris, France).

**Input Parameters for Estimating Photosynthetic Photon Flux (PPF):**

Latitude =

Longitude =

Longitude<sub>2</sub> =

Elevation =  m

Day of Year =

Time of Day =  (H:MM + D.L.G.)

Daylight Savings =  (0)

Air Temperature =  °C

Relative Humidity =  %

**Output from Model:**

Model Estimated PPF =   $\mu\text{mol m}^{-2} \text{s}^{-1}$

Measured PPF =   $\mu\text{mol m}^{-2} \text{s}^{-1}$

**DIFFERENCE FROM MODEL = -2.9 %**

**CERTAINLY APPOUSE FOR RECALIBRATION**

Name:

Email:

Phone:

Serial #:

Comments:

Please include all requested information.

This site is developed and maintained by: **apogee**

[calibration@apogee-instr.com](mailto:calibration@apogee-instr.com)

Clear Sky Calculator for quantum sensors. Site data are input in blue cells in middle of page and an estimate of PPF is returned on right-hand side of page.

## TROUBLESHOOTING AND CUSTOMER SUPPORT

### **Independent Verification of Functionality:**

Apogee models SQ-214 and SQ-224 quantum sensors provide a 4-20 mA output that is proportional to incident PPF. A quick and easy check of sensor functionality can be determined using a DC power supply and an ammeter. Power the sensor with a DC voltage by connecting the positive voltage signal to the red wire from the sensor and the negative (or common) to the black wire from the sensor. Use the ammeter to measure across the white wire (signal output) and green wire (signal ground). Direct the sensor head toward a light source and verify the sensor provides a signal. Increase and decrease the distance from the sensor head to the light source to verify that the signal changes proportionally (decreasing signal with increasing distance and increasing signal with decreasing distance). Blocking all radiation from the sensor should force the sensor signal to 4 mA.

### **Compatible Measurement Devices (Data loggers/Controllers/Meters):**

SQ-214 and SQ-224 quantum sensors are calibrated with a standard calibration factor of 156  $\mu\text{mol m}^{-2} \text{s}^{-1}$  per mA, yielding a sensitivity of 0.0064 mA per  $\mu\text{mol m}^{-2} \text{s}^{-1}$ . Thus, a compatible measurement device (e.g., datalogger or controller) should have resolution of at least 0.0064 mA, in order to provide PPF resolution of 1  $\mu\text{mol m}^{-2} \text{s}^{-1}$ .

The 4-20 mA circuit design allows the output to drive a resistive load ( $R_L$ ) to within 2 volts of the supply voltage to the sensor ( $V_s$ ), at 20 mA (0.02 A). The equation to calculate resistive load is  $R_L = [V_s - 2 \text{ V}] / 0.02 \text{ A}$ . For example, a sensor with a supply voltage of 12 V DC can drive a maximum load of 500  $\Omega$  ( $R_L = [12 \text{ V} - 2 \text{ V}] / 0.02 \text{ A} = 500 \Omega$ ). The output voltage from the sensor is calculated by adding the wire resistance to the input resistance of the data collection system, and then multiplying by 0.02 A.

### **Effect of Cable Length:**

Shortening or splicing on additional cable in the field is generally not a problem for the current output of the SQ-214 and SQ-224. However, adding cable will result in a greater resistive load, which should be taken into consideration when determining the maximum resistive load that the sensor will drive (see section above on Compatible Measurement Devices). Apogee model SQ series quantum sensors use shielded, twisted pair cable, which minimizes electromagnetic interference. This is particularly important for long lead lengths in electromagnetically noisy environments.

### **Modifying Cable Length:**

See Apogee webpage for details on how to extend sensor cable length:  
(<http://www.apogeeinstruments.com/how-to-make-a-weatherproof-cable-splice/>).

### **Unit Conversion Charts:**



Apogee SQ series quantum sensors are calibrated to measure PPFD in units of  $\mu\text{mol m}^{-2} \text{s}^{-1}$ . It is possible to convert the PPFD value to units of light quantity (e.g., footcandles or lux), but it requires conversion factors that are specific to the radiation source of interest. These conversion factors can be found in the Knowledge Base on the Apogee website (<http://www.apogeeinstruments.com/knowledge-base/>; scroll down to Quantum Sensors section).

# RETURN AND WARRANTY POLICY

## RETURN POLICY

Apogee Instruments will accept returns within 30 days of purchase as long as the product is in new condition (to be determined by Apogee). Returns are subject to a 10 % restocking fee.

## WARRANTY POLICY

### What is Covered

All products manufactured by Apogee Instruments are warranted to be free from defects in materials and craftsmanship for a period of four (4) years from the date of shipment from our factory. To be considered for warranty coverage an item must be evaluated either at our factory or by an authorized distributor.

Products not manufactured by Apogee (spectroradiometers, chlorophyll content meters) are covered for a period of one (1) year.

### What is Not Covered

The customer is responsible for all costs associated with the removal, reinstallation, and shipping of suspected warranty items to our factory.

The warranty does not cover equipment that has been damaged due to the following conditions:

1. Improper installation or abuse.
2. Operation of the instrument outside of its specified operating range.
3. Natural occurrences such as lightning, fire, etc.
4. Unauthorized modification.
5. Improper or unauthorized repair.

Please note that nominal accuracy drift is normal over time. Routine recalibration of sensors/meters is considered part of proper maintenance and is not covered under warranty.

### Who is Covered

This warranty covers the original purchaser of the product or other party who may own it during the warranty period.

### What We Will Do

At no charge we will:

1. Either repair or replace (at our discretion) the item under warranty.
2. Ship the item back to the customer by the carrier of our choice.

Different or expedited shipping methods will be at the customer's expense.

### How To Return An Item

1. Please do not send any products back to Apogee Instruments until you have received a Return Merchandise Authorization (RMA) number from our technical support department by calling (435) 792-4700 or by submitting an online RMA form at [www.apogeeinstruments.com/tech-support-recalibration-repairs/](http://www.apogeeinstruments.com/tech-support-recalibration-repairs/). We will use your RMA number for tracking of the service item.

2. Send all RMA sensors and meters back in the following condition: Clean the sensor's exterior and cord. Do not modify the sensors or wires, including splicing, cutting wire leads, etc. If a connector has been attached to the cable end, please include the mating connector – otherwise the sensor connector will be removed in order to complete the repair/recalibration.
3. Please write the RMA number on the outside of the shipping container.
4. Return the item with freight pre-paid and fully insured to our factory address shown below. We are not responsible for any costs associated with the transportation of products across international borders.
5. Upon receipt, Apogee Instruments will determine the cause of failure. If the product is found to be defective in terms of operation to the published specifications due to a failure of product materials or craftsmanship, Apogee Instruments will repair or replace the items free of charge. If it is determined that your product is not covered under warranty, you will be informed and given an estimated repair/replacement cost.

**Apogee Instruments, Inc.**  
**721 West 1800 North Logan, UT**  
**84321, USA**

#### OTHER TERMS

The available remedy of defects under this warranty is for the repair or replacement of the original product, and Apogee Instruments is not responsible for any direct, indirect, incidental, or consequential damages, including but not limited to loss of income, loss of revenue, loss of profit, loss of wages, loss of time, loss of sales, accrual of debts or expenses, injury to personal property, or injury to any person or any other type of damage or loss.

This limited warranty and any disputes arising out of or in connection with this limited warranty ("Disputes") shall be governed by the laws of the State of Utah, USA, excluding conflicts of law principles and excluding the Convention for the International Sale of Goods. The courts located in the State of Utah, USA, shall have exclusive jurisdiction over any Disputes.

This limited warranty gives you specific legal rights, and you may also have other rights, which vary from state to state and jurisdiction to jurisdiction, and which shall not be affected by this limited warranty. This warranty extends only to you and cannot be transferred or assigned. If any provision of this limited warranty is unlawful, void or unenforceable, that provision shall be deemed severable and shall not affect any remaining provisions. In case of any inconsistency between the English and other versions of this limited warranty, the English version shall prevail.

This warranty cannot be changed, assumed, or amended by any other person or agreement.

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**TEL: (435) 792-4700 FAX: (435) 787-8268 WEB: APOGEEINSTRUMENTS.COM**

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