apogee
INSTRUMENTS

OWNER'S MANUAL

ULTRAVIOLET-A SENSOR

Models SU-200-SS

Rev: 19-Jul-2021

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CERTIFICATE OF COMPLIANCE

EU Declaration of Conformity

This declaration of conformity is issued under the sole responsibility of the manufacturer:

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

for the following product(s):

Models: SU-200
Type: Ultraviolet-A Sensor

The object of the declaration described above is in conformity with the relevant Union harmonization legislation:

2014/30/EU	Electromagnetic Compatibility (EMC) Directive
2011/65/EU	Restriction of Hazardous Substances (RoHS 2) Directive
2015/863/EU	Amending Annex II to Directive 2011/65/EU (RoHS 3)

Standards referenced during compliance assessment:

EN 61326-1:2013	Electrical equipment for measurement, control and laboratory use – EMC requirements
EN 50581:2012	Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances

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 lead (see note below), mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBB), polybrominated diphenyls (PBDE), bis(2-ethylhexyl) phthalate (DEHP), butyl benzyl phthalate (BBP), dibutyl phthalate (DBP), and diisobutyl phthalate (DIBP). However, please note that articles containing greater than 0.1% lead concentration are RoHS 3 compliant using exemption 6c.

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.

Signed for and on behalf of:
Apogee Instruments, July 2021

Bruce Bugbee
President
Apogee Instruments, Inc.

INTRODUCTION

Ultraviolet (UV) radiation constitutes a portion of the electromagnetic spectrum from 100 to 400 nm and is further subdivided into three wavelength ranges: UV-A (315 to 400 nm), UV-B (280 to 315 nm), and UV-C (100 to 280 nm). Much of the UV-B and all of the UV-C wavelengths from the sun are absorbed by Earth's atmosphere. There are also multiple artificial UV light sources available.

Most UV sensors designed for sunlight measurements are sensitive to UV radiation in the UV-A or UV-B ranges. Apogee Instruments SU-200 series UV-A sensors detect UV radiation from 300 to 400 nm and are calibrated in energy flux density units of watts per square meter (W m^{-2}, equal to Joules per second per square meter). The output can also be expressed in photon flux density units of micromoles per square meter per second (µmol m^{-2} s^{-1}).

Typical applications of UV sensors include incoming UV radiation measurement in outdoor environments or in laboratory use with artificial light sources (e.g., germicidal lamps).

Apogee Instruments SU-200 series UV-A sensors consist of a cast acrylic diffuser, photodiode, and signal processing circuitry mounted in an anodized aluminum housing and a cable to connect the sensor to a measurement device. SU-200 sensors are designed for continuous UV-A radiation measurement in indoor or outdoor environments. The SU-200 series outputs an analog voltage that is directly proportional to UV-A radiation incident on a planar surface (does not have to be horizontal) where the radiation emanates from all angles of a hemisphere.

SENSOR MODELS

This manual covers the unamplified model SU-200 UV-A sensor (listed below in bold). Additional models are covered in their respective manuals.

Model	Signal
SU-200	**0-10 mV**
SU-202	0- 2.5 V
SU-205	0- 5 V
SU-220	USB

Sensor model number and serial number are located on the bottom of the sensor. If you need the manufacturing date of your sensor, please contact Apogee Instruments with the serial number of your sensor.

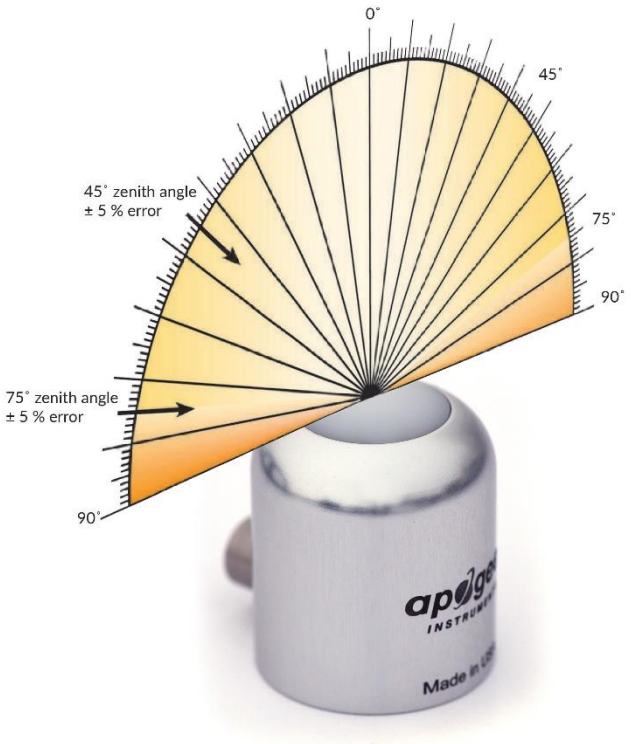
SPECIFICATIONS

	SU-200-SS
Power Supply	Self-Powered
Output (sensitivity)	0.1 mV per W m^{-2}; 0.03 mV per µmol m^{-2} s^{-1}
Calibration Factor (reciprocal of sensitivity)	10 W m^{-2} per mV; 30 µmol m^{-2} s^{-1} per mV
Calibration Uncertainty	± 10 %
Output Range	0 to 10 mV
Measurement Range	0 to 100 W m^{-2}
Measurement Repeatability	Less than 0.5 %
Long-term Drift	Less than 2 % per year
Non-linearity	Less than 1 %
Response Time	Less than 1 ms
Field of View	180°
Spectral Range	300 to 400 nm (wavelengths where response is greater than 10 % of maximum; see Spectral Response below)
Directional (Cosine) Response	± 2 % at 45°, ± 5 % at 70°
Temperature Response	Less than 0.1 % per C
Operating Environment	-30 to 85 C; 0 to 100 % relative humidity
Dimension	30.5 mm diameter, 37 mm height
Mass (5 m of cable)	140 g
Cable	5 m of shielded, twisted-pair wire; TPR jacket (high water resistance, high UV stability, flexibility in cold conditions); pigtail lead wires; stainless steel (316), M8 connector located 25 cm from sensor head

Calibration Traceability

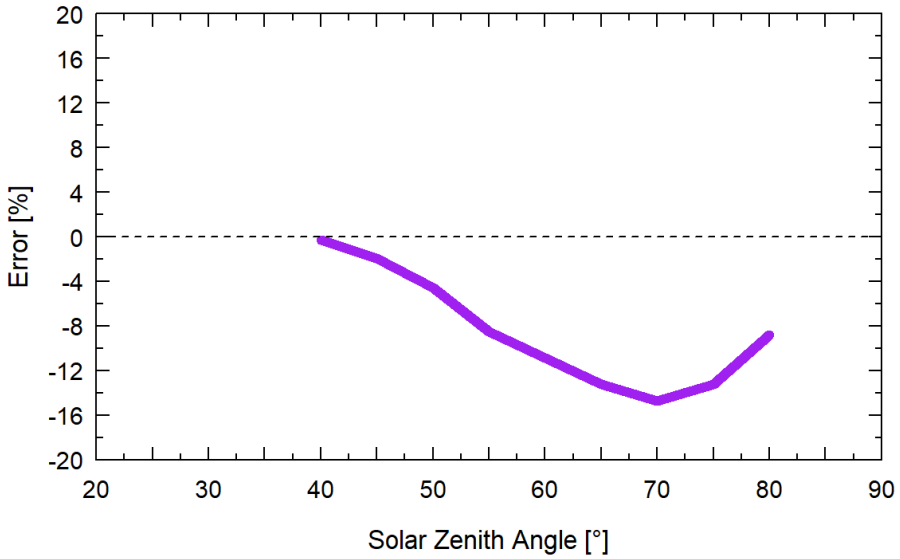
Apogee UV series sensors are calibrated through side-by-side comparison to the mean of four transfer standard UV sensors under UV-enhanced T5 fluorescent tubes. The transfer standard UV sensors are calibrated through side-by-side comparison to an Apogee model PS-300 spectroradiometer under sunlight (clear sky conditions) in Logan, Utah. The PS-300 is calibrated with a quartz halogen lamp traceable to the National Institute of Standards and Technology (NIST).

Cosine Response



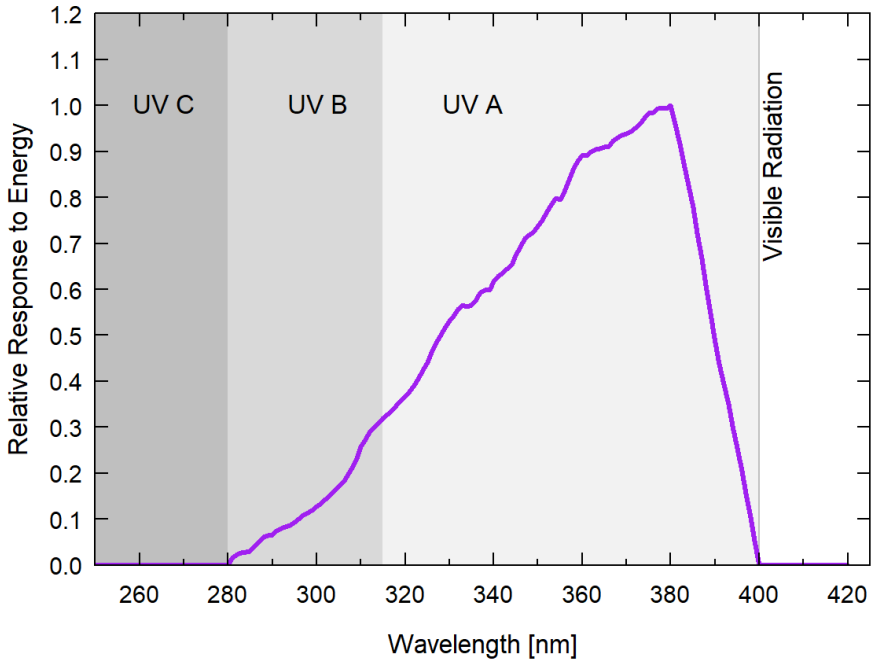
Directional, or cosine, response is defined as the measurement error at a specific angle of radiation incidence. Directional error for Apogee SU-200 series UV-A sensors is approximately ± 2 % and ± 5 % at solar zenith angles of 45° and 75°, respectively.

Cosine Response Graph



Mean cosine response of four Apogee UV-A sensors. Cosine response was calculated as the relative difference of UV-A sensors from the mean of replicate reference UV-A sensors deployed outdoors. These data are the average of the AM and PM response.

Spectral Response



Spectral response estimate of Apogee SU-200 UV-A sensors. Spectral response was modeled from sensitivity of the photodetector and transmittance of the diffuser.

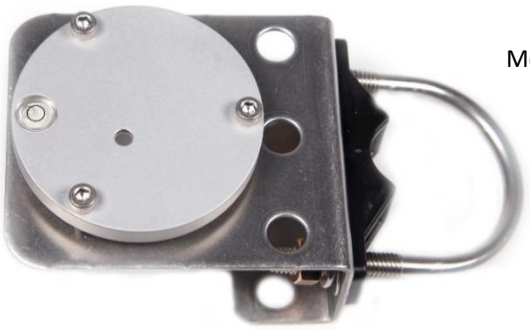
DEPLOYMENT AND INSTALLATION

Mount the sensor to a solid surface with the nylon mounting screw provided. To accurately measure UV-A incident on a horizontal surface, the sensor must be level. An Apogee Instruments model AL-100 Leveling Plate is recommended to level the sensor when used on a flat surface or being mounted to surfaces such as wood. To facilitate mounting on a mast or pipe, the Apogee Instruments model AL-120 Solar Mounting Bracket with Leveling Plate is recommended.

Nylon Screw: 10-32x3/8

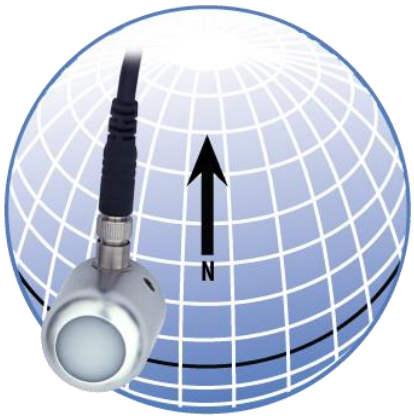
Model AL-100

Nylon Screw: 10-32x3/8



Model AL-120

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 black cap should be removed from the sensor.** The black cap can be used as a protective covering for the sensor when it is not in use.

CABLE CONNECTORS

Apogee sensors offer cable connectors to simplify the process of removing sensors from weather stations for calibration (the entire cable does **not** have to be removed from the station and shipped with the sensor).

The ruggedized M8 connectors are rated IP68, made of corrosion-resistant marine-grade stainless-steel, and designed for extended use in harsh environmental conditions.

Inline cable connectors are installed 30 cm from the sensor head (pyranometer pictured).

Instructions

Pins and Wiring Colors: All Apogee connectors have six pins, but not all pins are used for every sensor. There may also be unused wire colors inside the cable. To simplify connection to a measurement device, the unused pigtail lead wire colors are removed.

If a replacement cable is required, please contact Apogee directly to ensure ordering the proper pigtail configuration.

A reference notch inside the connector ensures proper alignment before tightening.

Alignment: When reconnecting a sensor, arrows on the connector jacket and an aligning notch ensure proper orientation.

Disconnection for extended periods: When disconnecting the sensor for an extended period of time from an installation, protect the remaining half of the connector still on the station from water and dirt with electrical tape or other method.

When sending sensors back for recalibration, only send the section of cable that is hard-wired to the sensor. The section of cable with the pigtail is not required.

Tightening: Connectors are designed to be firmly finger-tightened only. There is an O-ring inside the connector that can be overly compressed if a wrench is used. Pay attention to thread alignment to avoid cross-threading. When fully tightened, one to two threads may still be visible.

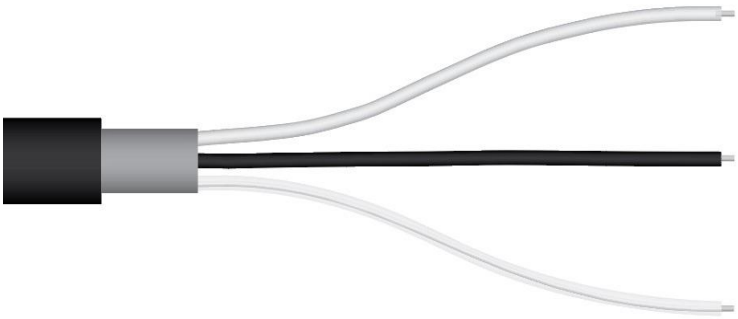
Finger-tighten firmly.

WARNING: Do not tighten the connector by twisting the black cable, only twist the metal connector.

OPERATION AND MEASUREMENT

Connect the sensor to a measurement device (meter, datalogger, controller) capable of measuring and displaying or recording a millivolt signal. An input measurement range of approximately 0-10 mV is required to cover the entire range of the SU-200 UV-A sensor. 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 UV sensor. **DO NOT connect the sensor to a power source. The sensor is self-powered and applying voltage will damage the sensor.**

Wiring for SU-200



White: Output Signal

Black: Ground

Clear: Shield

Sensor Calibration

The SU-200 has a standard UV calibration factor of exactly:

10.0 W m^{-2} per mV

Multiply this calibration factor by the measured mV signal to convert sensor output to UV-A in units of W m^{-2}:

Calibration Factor (10 W m^{-2} per mV) * Sensor Output Signal (mV) = UV-A (W m^{-2})

10 W m^{-2} per mV * 6 mV = 60 W m^{-2}

Example of UV-A measurement with an Apogee UV-A sensor. Full sunlight yields UV-A radiation on a horizontal plane at the Earth's surface of approximately 60 W m^{-2}. This yields an output signal of 6 mV. The signal is converted to UV-A radiation by multiplying by the calibration factor of 10 W m^{-2} per mV.

UV-A Measurements and Spectral Errors

Apogee Instruments model SU-200 UV-A sensors are calibrated to measure ultraviolet radiation from the sun between 315 and 400 nm in Watts per square meter. In addition to naturally occurring UV-A radiation from the sun, there are many electric light sources that emit UV-A radiation (e.g., cool white fluorescent, metal halide, mercury arc, and germicidal lamps). Although the relative wavelengths of UV-A radiation differ among sunlight and electric lights, the error estimates shown in the table below indicate the SU-200 provides reasonable estimates of UV-A radiation coming from electric lamps (table provides spectral error estimates for UV-A radiation measurements from radiation sources other than clear sky solar radiation). For most common lamps, the error is less than 10 %. The SU-200 is particularly useful for determining the UV-A filtering capacity of the transparent plastic and glass barriers that are commonly used below electric lamps.

Radiation Source (Error Calculated Relative to Sun, Clear Sky)	Expected EFD Error [%]	Expected PFD Error [%]
Clear Sky	0.0	0.0
Overcast	0.0	-1.1
Direct Normal	-0.2	-1.0
Diffused Blue Light	0.3	1.4
CWF T5	8.2	9.2
Metal Halide	1.2	-1.2
Quartz Halogen	-2.3	-3.8
Mercury Arc	16.2	16.9
T12 Fluorescent UV-A Enhanced	12.2	15.2
UV-A LED (365 nm Peak)	37.4	35.3
UV-A LED (386 nm Peak)	1.8	-3.9
UV-A LED (395 nm Peak)	-36.9	-41.2

MAINTENANCE AND RECALIBRATION

Blocking of the optical path between the target and detector can cause low readings. Occasionally, accumulated materials on the diffuser of the SU-200 UV-A sensor can block the optical path in three common ways:

1. Moisture or debris build-up on the diffuser.
2. Dust during periods of low rainfall.
3. Salt deposit accumulation from evaporation of sea spray or sprinkler irrigation water.

SU-200 series sensors have a domed diffuser and housing for improved self-cleaning from rainfall but active cleaning may be necessary. 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 cloth or cotton swab. **Never use solvents such as alcohol or acetone to clean the sensor.** Use only gentle pressure when cleaning the diffuser with a cotton swab or soft cloth, to avoid scratching the outer surface. The vinegar should be allowed to do the cleaning, not mechanical force. **Never use an abrasive material or cleaner on the diffuser**.

It is recommended that UV-A sensors be recalibrated every two years. See the Apogee webpage for details regarding return of sensors for recalibration (http://www.apogeeinstruments.com/tech-support-recalibration-repairs/).

TROUBLESHOOTING AND CUSTOMER SUPPORT

Independent Verification of Functionality

Apogee SU-200 sensors are self-powered devices and output a voltage signal proportional to incident UV-A radiation. A quick and easy check of sensor functionality can be determined using a voltmeter with millivolt resolution. Connect the positive lead of the voltmeter to the white wire from the sensor and the negative lead (or common) to the black wire from the sensor. Direct the sensor head toward the sun and verify the sensor provides a signal. Blocking all UV radiation from the sensor should force the sensor signal to zero.

Compatible Measurement Devices (Dataloggers/Controllers/Meters)

SU-200 UV-A sensors are calibrated with a standard calibration factor of 10.0 W m^{-2} per mV, yielding a sensitivity of 0.1 mV per W m^{-2}. Thus, a compatible measurement device (e.g., datalogger or controller) should have resolution of at least 0.1 mV to provide a measurement resolution of 1 W m^{-2}.

An example datalogger program for Campbell Scientific dataloggers can be found on the Apogee webpage at http://www.apogeeinstruments.com/content/UV-Sensor.CR1.

Zero Offset Error

With the use of certain dataloggers it is possible to measure a non-zero voltage (zero offset) when the sensor output should be zero (no UV irradiance incident on diffuser). This offset can be corrected by adding or subtracting the measured offset from the sensor output. However, if the offset is substantial, and your sensor is outputting unrealistic values then it may need to be recalibrated. In this case, contact Apogee customer support to recalibrate the sensor.

Cable Length

When the sensor is connected to a measurement device with high input impedance, sensor output signals are not changed by shortening the cable or splicing on additional cable in the field. Tests have shown that if the input impedance of the measurements device is greater than 1 mega-ohm there is negligible effect on the calibration, even after adding up to 100 m of cable. All Apogee sensors use shielded, twisted pair cable to minimize electromagnetic interference. For best measurements, the shield wire must be connected to an earth ground. This is particularly important when using the sensor with long lead lengths in electromagnetically noisy environments.

Modifying Cable Length

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

Unit Conversion

SU-200 series UV-A sensors are calibrated in energy flux units of W m^{-2}. It is possible to convert the energy flux value to photon flux units of µmol m^{-2} s^{-1} using a conversion factor. Below is an example of how to convert energy flux units to photon flux.

1) Calculate the sensor output in units of J m^{-2} s^{-1}.

$$6\ mV * 10\ \frac{W m^{-2}}{mV} = 60 \frac{W}{m^2} = 60 \frac{J}{m^2 s}$$

2) Multiply the energy flux units by the conversion factor. It's important to note that each light source needs a specific conversion factor. The conversion factor used in the example equation is the sunlight conversion factor.

$$\frac{60\ {}^{J}/_{m^2 s}}{0.327\ {}^{J}/_{\mu mol}} = 183.5\ \frac{\mu mol}{m^2 s}$$