Pyranometer (Secondary standard & Second Class and Irradiance sensor)

A pyranometer measures the global horizontal solar irradiance (GHI);

which is composed of di\_use horizontal solar irradiance (DHI) from the

sky and direct normal solar irradiance (DNI) from the sun. If shaded

from the direct sun a pyranometer measures di\_use horizontal solar

irradiance (DHI). Direct normal irradiance DNI is measured by a

pyrheliometer continuously pointed at the centre of the sun by an

automatic sun tracker.

A pyranometer tilted in the plane of array (POA) of solar panels

provides critical input data to the calculation of performance ratios

and efficiencies in photovoltaic energy installations

Choice of Pyranometer

ISO 9060:1990 defines three classifications of pyranometer by their

key performance parameters; from second class, to first class, to

secondary standard and our top models considerably exceed ISO

secondary standard requirements. There is no primary standard

pyranometer. In e\_ect, this is the calculation of GHI from accurate

DHI and DNI measurements.

The most appropriate model for an application largely depends upon

the desired accuracy and performance, and the type of signal interface

required. We o\_er two ranges of pyranometers, the passive CMP and

the Smart SMP series, both widely acknowledged by meteorological

and solar energy customers.

Two pyranometers, mounted back-to-back, make an albedometer. The

albedo of a surface is the extent to which it di\_usely reflects solar

radiation. It is the ratio of the reflected radiation to the incoming

radiation.

[Wind Speed & Direction Sensor](https://www.mbcontrol.com/wind-speed-direction-sensor/)

Includes both wind speed and wind direction sensors. Rugged components stand up to hurricane‐force winds, yet are sensitive to a light breeze. Includes sealed bearings for long life. The range and accuracy specifications have been

verified in wind‐tunnel tests. In areas where icing of the anemometer is a problem, drip rings deflect water from the joint between moving parts.

The sensor uses a quick-connect sensor cable which may extend hundreds of feet without affecting measurement performance.

Features:

Compact design for minimum visual impact

• Long field life

• Durable aluminum and stainless steel

construction

• Low starting threshold

• Very low power operation

• Easy maintenance and re-alignment

• Sealed magnetic reed switch for wind speed

measurement

• Aluminum direction vane coupled to a precision

potentiometer

• Digital or analog measurement ability

Applications

• Ambient Monitoring

• Environmental Surveys

• Fence line Monitoring

Ambient Temperature And Relative Humidity Sensor

The Temperature/Humidity Sensors includes temperature and humidity sensors and a passive solar radiation shield , or a 24-Hour Fan-Aspirated Radiation Shield. The Temperature/ Humidity Sensor measures relative humidity and air temperature. The passive solar radiation shield is made of a

proprietary plastic designed for high thermal reflectance and low thermal conductivity. The 24-Hour Radiation Shield includes a solar- and battery-powered fan that pulls air up through the shield and over the sensors for highest

temperature accuracy.

**The Relative Humidity Sensor is a highly sensitive and stable temperature measurement tool that provides outstanding accuracy.** Itis reliable in the full range of relativehumidity conditions, from 0-100%,performing equally well in meteorological,industrial, laboratory and other demandingsettings. Model 085 is a combined relativehumidity/temperature sensor that uses adual element thermistor temperaturesensor. It can be used with a variety ofradiation shields.

FEATURES:

**All solid state construction, digital**

**Electronics**

**Fast response of less than 5 seconds to**

**90% of final value**

**Low power consumption of 4 mA at 12**

**VDC**

**Easily cleaned using distilled water**

**• 0-1V output for 0-100% RH**

**• Resistive output for temperature**

**• Will operate from a 12 VDC battery**

BAROMETRIC PRESSURE SENSORS

Features

**High Accuracy and Stability**

Accurate within ± 1.5 kPa across a pressure range of 15 to 115 kPa

(4.43 to 34.96 in Hg). Long-term non-stability has been measured

continuously indoors and in natural conditions (with sensors

mounted inside a datalogger enclosure) for multiple sensors and

is less than 0.5 % per year. Temperature effects on signal are less

than 1 % across a wide temperature range (-20 to 50 C).

**Low Power, Large Signal**

Pressure sensor power requirement is approximately 35 mW (7 mA

current draw at 5 V DC). Voltage output ranges from 0 to 5 V DC

for a pressure range of 15 to 115 kPa.

**Small Size**

Sensor is small and lightweight enabling easy deployment within a

datalogger enclosure, protecting the sensor from the elements.

• Compact size

• Weatherproof enclosure

• Digital and analog outputs

• Permanent calibration; no service required

• Customer configured output

**Applications**

• Ambient Air Monitoring

• Environmental Surveys

• Government Networks

## **PV Module Temperature Sensor**

Module and surface temperature sensors come equipped with a robust weatherproof cable. Thanks to the use of top quality components the sensors achieve very high accuracy and are ideal for use in industrial and field environments (PV module temperature).

If required, the sensors can be ordered with an inspection certificate 3.1 as per DIN EN 10204.

**Installation Instructions**

If mounted outdoors, avoid direct exposure to sunlight and rain to the sensor housing (Aluminium block) and

sensor case. If necessary, provide protection from the sun and rain.

The through holes can be used to fix the sensor to a stable and suitable surface shall be accessible when the

housing is opened. The tightening torque of the case cover is 180 Ncm.

The sensor element is mounted by gluing the Aluminium block directly to the measurement surface. The surface

must be dry, clean and degreased. It is also recommended using an extra fixing with silicon or Sikaflex, particularly

for module temperature above 75°C.

Note: The module temperature measurement can be optimised by completely covering the sensor element.

The sensor cable needs a cable grip close to the sensor housing.

**Maintenance**

The sensors should be checked once a year for damage, contamination and correct fitting.

[Rain Measurement Sensor](https://www.mbcontrol.com/rain-measurement-sensor/)

The Rain Collector is designed to meet the guidelines of the World Meteorological Organization. Rain enters the collector cone, passes through a debris-filtering screen, and collects in one chamber of the tipping bucket. The bucket tips when it has collected an amount of water equal to the increment in which the collector measures (0.01" or 0.2 mm). As the bucket tips, it causes a switch closure and brings the second tipping bucket chamber into position. The rain water drains out through the screened drains in the base of the collector.

The collector is designed for years of accurate, trouble-free service. The shape is aerodynamically designed to minimize rainfall catch reduction caused by high winds. The body and base of the collector are constructed of tough, UV resistant plastic; the tipping bucket pivots on bearings that minimize friction and wear. Stainless steel adjustment screws under each chamber of the tipping bucket allow you to fine-tune the calibration of the Rain Collector.

The 6465 rain collector comes with a mounting base that can be mounted to a pole or post. The 6463 model has a flat surface mount. 6465M and 6463M are factory-calibrated to report 0.2 mm per tip. The Rain Collector Cone and Heater (7721) is available for use with either of the Rain Collector units. This heater allows the Rain Collector to measure the moisture content of snowfall.

**Features**

• Self-emptying, dual chambered tipping bucket

• Roller on roller pivots

• Funnel screen system prevents debris from clogging gauge

• Anodized aluminum and stainless steel construction

• Bubble level & adjustable feet assure proper mounting

• Optional heating elements for frozen conditions

**Applications**

• Ambient Air Monitoring

• Environmental Surveys

• Government Networks

[Datalogger](https://www.mbcontrol.com/datalogger/)

Data loggers are electronic devices which automatically monitor and record environmental parameters over time, allowing conditions to be measured, documented, analysed and validated. The data logger contains a sensor to receive the information and a computer chip to store it. Then the information stored in the data logger is transferred to a computer for analysis.

Loggers in the Tinytag range monitor parameters including temperature, humidity, single and three phase power usage, CO2, mV, mA, voltage, pulses or counts.

Data acquisition is the sampling of the real world to generate data that can be manipulated by a computer. Sometimes abbreviated DAQ, data acquisition typically involves acquisition of signals and waveforms and processing of the signals to obtain desired information. The components of data acquisition systems include appropriate sensors that convert any measurement parameter to an electrical signal, which is acquired by data acquisition hardware (such as data loggers). Acquired data typically is displayed, analysed, and stored on a PC.

**Features**

**Compact, user-friendly and IP65 weatherproof**

**Low power, internal batteries or external DC supply**

**Analog and digital inputs**

**Connect up to 8 compatible Modbus® RTU devices**

**4G LTE remote data transmission built-in**

**Optimized for Kipp & Zonen and Lufft instruments**

* **4 differential and 4 single-ended analogue inputs, 4 digital inputs**
* **Connect up to 8 compatible Modbus® devices**
* **4G LTE modem with external antenna**
* **Send data to an e-mail address or FTP server**

Leaf & BUD Temperature sensor

Monitor Radiation Frost Events

On calm, clear nights surface temperature, including leaf and bud temperatures, can drop well below air temperature due to a net loss of longwave radiation to the clear sky. A radiation frost occurs when frost forms at the surface before the air temperature reaches freezing (0 C). Under cloudy and/or windy conditions, radiation frost events do not occur. The Apogee radiation frost detector is a combination of two high accuracy thermistors mounted in a single housing. One sensor is designed to mimic a leaf and sensor is designed to mimic a bud, providing estimates of leaf and bud temperatures and a direct means of monitoring radiation frost events.

Wide Range, Accurate Measurements

Thermistor accuracy is ± 0.1 C across a range of 0 to 70 C, providing accurate measurements at temperatures near zero where frost damage is likely to occur.

Output Options

Analog and digital output options are available. Analog version is an un-amplified voltage output. Digital version is SDI-12 communication protocol.

Quantum (PAR & EPAR) Sensors / Meters

[FULL-SPECTRUM QUANTUM SENSORS](https://www.apogeeinstruments.com/full-spectrum-quantum-sensor/)

**Light Source**  
Provides accurate PAR measurements under all light sources, including LEDs.

**Spectral Range**  
400 to 700 nm ± 5 nm (wavelengths where response is greater than 50 % of maximum)

**Output Options**  
Available in multiple analog and digital outputs including unamplified, SDI-12, Modbus communication protocols, attached to a hand-held meter with a digital output, as a "smart" sensor that uses USB communication and custom software, or with Apogee's new microCache device.

**Waterproof**

[EPAR SENSORS](https://www.apogeeinstruments.com/epar-sensors/)

**Light Source**  
Provides accurate measurements under all light sources.

**Spectral Range**  
400 to 750 nm ± 5 nm (wavelengths where the response is greater than 50 % of maximum)

**Output Options**  
Available in multiple analog and digital outputs including unamplified, SDI-12, Modbus communication protocols, attached to a hand-held meter with a digital output, as a "smart" sensor that uses USB communication and custom software, or with Apogee's new microCache device.

**Waterproof**

Infrared Radiometer

High-Accuracy Measurements

All Apogee IR sensors are NIST traceable and include a calibration certificate. Sensors are calibrated to a custom black-body cone with the **Research-Grade sensors** featuring a measurement uncertainty of ± 0.2 C from -30 to 65 C when the sensor (detector) temperature is within 20 C of the surface (target) being measured. **Commercial-Grade sensors** have a measurement uncertainty of ± 0.5 C from 0 to 50 C when the sensor is within 20 C of the surface target. Radiometers are only sensitive from 8 to 14 µm (atmospheric window) to minimize the influence of water vapor and CO2 on the measurement.

Field of View Options

**Research-Grade sensors** come in five fields of view (FOV), including: three circular and two horizontal apertures. **The Commercial-Grade sensor** comes in a single 22° half-angle FOV option.

Output Options

**Research-Grade sensors** are available in analog and digital outputs including unamplified voltage outputs, SDI-12, and Modbus communication protocols. Research-Grade sensors are also available attached to a hand-held meter with digital readout. **Commercial-Grade** models come in SDI-12 output only with an analog version coming soon.

Rugged Housing

All sensors have a rugged anodized aluminum body with fully-potted electronics. Both types feature a radiation shield to reduce rapid thermal fluctuations of the sensor body. The **Research-Grade sensor's** radiation shield is made from powder-coated aluminum with a polished interior for lower emissivity. The **Commercial-Grade sensor's** radiation shield is made from rugged, UV resistant, polished ASA plastic.

High Quality Cable

**Research-Grade** pigtail-lead sensors feature an IP68, marine-grade stainless-steel cable connector approximately 30 cm from the head to simplify sensor removal for maintenance and recalibration. Cable is shielded, twisted-pair wire with a TPR jacket for high water resistance, UV stability, and flexibiliy in cold conditions. **Commercial-Grade** pigtail lead sensors have the same high-quality cable, but do not have a stainless-steel connector.

Temperature Sensor

ST-150

The ST-150 does not include bridge resistors and therefore requires measurement with dataloggers or controllers that are capable of current excitation. Although the ST-150 can be used in a 2-wire or 3-wire measurement configuration, a 4-wire configuration is recommended for highest accuracy (4-wire measurement configuration eliminates the influence of lead wires). In the 4-wire configuration, an excitation current is applied across the PRT with two of the lead wires, voltage is measured across the other two lead wires using a differential measurement, and resistance of the PRT is calculated by dividing the measured voltage by the excitation current (Ohm’s Law). Current does not flow in the wires where voltage is measured, so resistance of the lead wires does not influence the measurement. Temperature of the PRT is calculated from resistance using equations (2) and (3) on page 13. If a half-bridge measurement is desired, the same wiring and bridge resistors detailed below in the ST-300 section can be used to make the measurement

ST-300 PRT

Connect the sensor to a measurement device (meter, datalogger, controller) capable of inputting 2.1 V DC, and measuring and displaying or recording a millivolt (mV) signal (an input measurement range of 16 to 27 mV is required to cover the entire temperature range of the 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 thermistor.

MAINTENANCE AND RECALIBRATION

When sensors are not in use, it is recommended that they be removed from the measurement environment, cleaned, and stored. ST series temperature sensors used to measure air temperature should be periodically cleaned to remove all dust and debris. Apogee ST-100 temperature sensors are weatherproof and can be submerged in water or buried in soil/porous media. ST-110 sensors are weatherproof and designed for air temperature measurements inside radiation shields. ST-200 series sensors are weather resistant, but not weatherproof. When sensors are not in use, it is recommended that they be removed from the measurement environment, cleaned, and stored. ST series temperature sensors used to measure air temperature should be periodically cleaned to remove all dust and debris.

Oxygen Sensor

Rugged Housing

Housed in a polypropylene body and electronics are fully potted, ideal for long-term deployment in porous media, including acidic environments (mine tailings). Two head options are available: a diffusion head that creates a small air pocket for measurement in porous media and a flow-through head with two adapters for tubing that allows measurement of gas flowing in lines.

Simple Calibration

Voltage output is linearly proportional to absolute amount of oxygen. Calibration is accomplished by measuring the voltage under ambient conditions (atmosphere is 20.95 % O2 and deriving a linear calibration factor (slope). A zero offset can be measured with N2 gas (recommended for measurements below 10 % O2).

Internal Temperature Sensor

All oxygen sensors have an internal thermistor (type-K thermocouple is available upon request) that allows for temperature monitoring and correction of signal for temperature effects.

Output Options

Analog version is an un-amplified voltage output. Oxygen sensors are also available to a hand-held meter with digital readout.

Chlorophyll Concentration

Linear Output

The Apogee chlorophyll concentration meter is calibrated to measure chlorophyll concentration in leaves with units of µmol of chlorophyll per m2. This eliminates problems with relative indexes of chlorophyll concentration. For reference and comparison purposes, the Apogee meter also outputs relative units [CCI or SPAD] if desired. For details see: *Parry, C., Blonquist Jr., J.M., & Bugbee, B. 2014. In situ measurement of leaf chlorophyll concentration: analysis of the optical/absolute relationship. Plant, Cell and Environment 37:2508-2520.*

Non-destructive Measurement

The meter measures the ratio of radiation transmittance from two wavelengths (red, strongly absorbed by chlorophyll, and near infrared, not absorbed by chlorophyll), making measurements non-destructive and nearly instantaneous (measurement time is less than 3 seconds). This facilitates rapid measurement of multiple leaves and monitoring of the same leaves over time.

Storage Capacity and Internal GPS

Memory allocated to data storage allows for 160,000 logged measurements. A mini USB port allows for direct connection to a computer to download data. Chlorophyll meter comes with a standard mini USB to USB cable for data download. New internal GPS allows field data to be geo-referenced. Storage capacity of geo-referenced data is 94,000 measurements.

Plant Species

Specific crop species settings in the meter include rice, wheat, soybean, barley, pepper, tomato, pea, kohlrabi, Walderman's green lettuce, buttercrunch lettuce, corn, sorghum, quaking aspen, European birch, paper birch, crimson king maple, Norway maple, Japanese maple, boxelder, crab apple, purple leaf sand cherry, lilac, forsythia, grapevine, cannabis, coffee, spinach, strawberry, cherry, hops, blackberry, and a general setting used for all other species.

Variable Sampling Area

The meter measures the relative chlorophyll concentration over an area of approximately 64 mm2 (circle with 9 mm diameter). A field of view reducer is included to reduce the sampling area of approximately 20 mm2 (circle with 5 mm diameter) for leaves narrower than 9 mm.

Photochemical Reflectance Index (PRI)

Mounting

The [AL-120 Solar Mounting Bracket with Leveling Plate](https://www.apogeeinstruments.com/al-120-solar-mounting-bracket-with-leveling-plate/) facilitates mounting the upward-looking sensor to a mast or pipe. The [AL-100 Solar Sensor Leveling Plate](https://www.apogeeinstruments.com/al-100-solar-sensor-leveling-plate/) is designed to level the sensor while sitting on a flat surface or mounting to a surface. The [AM-400 Two Band Radiometer Mounting Bracket](https://www.apogeeinstruments.com/am-400-two-band-radiometer-downward-looking-mounting-bracket/) is designed to mount the downward-looking sensors to a mast or pipe.

Output Options

Available in digital SDI-12 output or with an analog output.

High Quality Cable

Pigtail-lead sensors feature an IP68, marine-grade stainless-steel [cable connectors](https://www.apogeeinstruments.com/cable-connectors/) built directly into the sensor head to simplify sensor removal for maintenance and recalibration. Cable is shielded-twisted-pair wire with a TPR jacket for high water resistance, UV stability, and flexibility in cold conditions.

Soil Moisture & Heat Flux Sensor

The Watermark® Soil Moisture Sensor is an indirect, calibrated method of measuring soil water content. It is an electrical resistance type sensor. The Soil Moisture/Temperature Station converts the electrical resistance reading from the sensor into a calibrated reading of centibars of soil water suction with a range from 0 (wettest) to 200 (driest) centibars.

The Watermark Soil Moisture Sensor is a product of the Irrometer Company, Inc.

* Watermark® soil moisture sensor uses electrical resistance to measure the moisture level of the soil. Does not require periodic maintenance during the growing season. Simply bury at the desired depth, then monitor moisture levels throughout the season.
* The Soil Moisture Sensor must be connected via a Leaf & Soil Moisture/Temperature Station (#6345) (up to four sensors), or an EnviroMonitor Node.
* Includes 15′ (4.6m) cable.

### **The world’s most popular sensor for heat flux measurement**

HFP01 measures heat flux through the object in which it is incorporated or on which it is mounted, in W/m². The sensor in HFP01 is a thermopile. This thermopile measures the temperature difference across the ceramics-plastic composite body of HFP01. A thermopile is a passive sensor; it does not require power. Using HFP01 is easy. It can be connected directly to commonly used data logging systems. The heat flux in W/m² is calculated by dividing the HFP01 output, a small voltage, by the sensitivity. The sensitivity is provided with HFP01 on its calibration certificate. A typical measurement location is equipped with 2 or more sensors. HFP01 is the world’s most popular sensor for heat flux measurement in the soil as well as through walls and building envelopes.

### **Robust and stable**

Equipped with heavy-duty cabling, protective covers on both sides and potted so that moisture does not penetrate the sensor, HFP01 has proven to be very robust and stable. It survives longterm installation in soils, as well as repeated installation when a measuring system such as TRSYS01 is used at multiple locations.