Notice
Please read this manual before using the pyranometer.
The manufacturer shall not be liable for incidental or consequential damage in connection with the furnishing, performance or use of this manual and the sensor that is described in this manual.

Contents

1 General information

The pyranometer is an instrument for measuring solar radiation. It measures the solar energy that is received from the entire hemisphere (180 degrees field of view). The output is expressed in Watts per square metre.

The pyranometer is designed for continuous outdoor use. Its calibration is valid for natural sunlight only, but not for artificial light. For use with other spectra, e.g. under plant canopy or reflected solar radiation, higher accuracy thermopile pyranometers is suggested. Because of the fact that it is equipped with a silicon detector, the SP-LITE pyranometer cannot fulfill the specifications of ISO 9060 for instruments for measuring hemispherical solar radiation. This reflects the fact that the accuracy of the instrument is limited.

In its most frequent application the pyranometer is used for measuring the solar radiation emitting on the horizontal surface. It can however be used to measure in an inverted or in a tilted position.

Contrary to similar designs of other brands, the pyranometer is not equipped with a level. The reason is that for the kind of accuracy that this sensor can offer, leveling does not need to be accurate, and your own visual observation is sufficient to act as a guideline.

The SP-LITE fully complies CE with directive 89/336/EEC

1.1 Five minutes user guide

Requirements:

1. pyranometer
2. voltmeter with a range from 0 to 50 millivolt and an
3. input impedance of more than 5000Ω
4. light

- Connect the white wire to the voltmeter+, the green wire to the voltmeter-, the shield to the ground.
- Position the instrument as such that the sensor is parallel to the surface that you want to investigate.
- Put the voltmeter range to the most sensitive area.
- Darken the sensor. The signal should read zero.
- Expose the sensor to light. The signal should give a positive reading.
- Adjust the voltmeter range in such a way that the expected full scale output of the pyranometer fits the full scale input of the voltmeter. This can be done on theoretical considerations. (When the maximum expected radiation is 1500 Watts per square metre, and the sensitivity of the pyranometer is 100 microvolts per Watt per square metre, the expected output range of the pyranometer is 1500 times 100 makes 150000 microvolts or 0.15 volts.) Please note that the calibration is valid for natural sunlight only.
- Calculate the radiation intensity by dividing the pyranometer output (0.15 volts) by the calibration factor (0.00010 volt per watt per square metre).

- For permanent installation mounting should be done using the holes through the pyranometer body. The sensor should be mounted in a field which is free from obstructions. Under no condition a shadow should be cast upon it.

- Maintenance: the sensor should be kept clean, using water or alcohol.

- Recalibration is suggested every two years, preferably by letting a higher standard run parallel to it during two sunny days, and by comparing the daily totals.

2 Sensor properties

The pyranometer consists of a photodiode, a housing and a cable. The photodiode is shunted by a resistance. This is done to generate a voltage output. Most electrical specifications are determined by the photodiode and the resistor. Spectral specifications are determined by the photodiode and the material on top of it. The photodiode is encapsulated in the housing in such a way that it has a field of view of 180 degrees, and that its angular characteristics fulfill the so-called cosine response.

2.1 Electrical

The electrical circuit of the pyranometer is drawn in figure 1. The nominal output resistance of the pyranometer is 50 W. This implies that the input impedance of the readout equipment should be at least 5000 W in order to make an error of less than 0.1 percent.
Cable can be extended without problems to a length of 100 metres, provided that cable resistance is less than 0.1 percent of the input impedance of the readout equipment.
The electrical sensitivity of the photodiode changes with the temperature. A nominal value for this is 0.2 percent change per degree Celsius.
Calibration is done at 20 degrees Celsius.

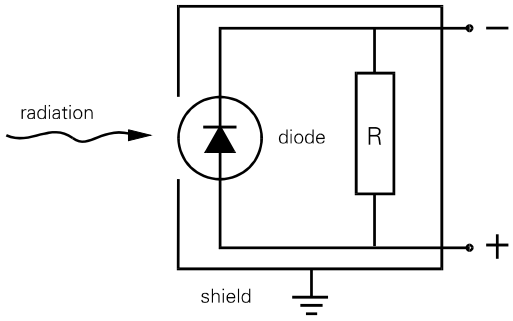
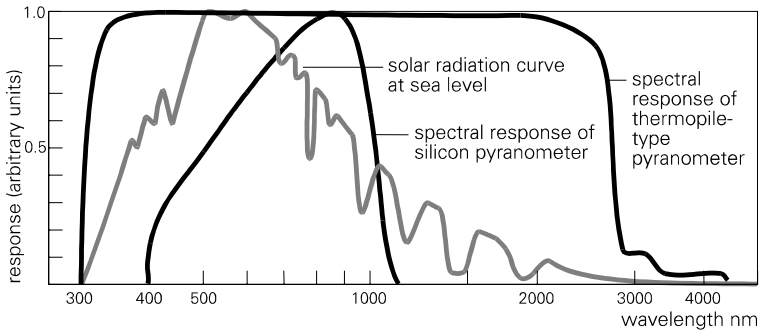


Figure 1 Electrical circuit of the pyranometer, white +.

2.2 Spectral

The spectral properties of the pyranometer are mainly determined by the properties of the photodiode. These are indicated in figure 2.

Figure 2. The spectral sensitivity of the pyranometer combined



with the spectrum of the sun under a clear sky.

The sensor has been calibrated for solar radiation under clear sky conditions. The spectrum under these circumstances is also drawn in figure 2.
Unfortunately, the solar spectrum varies as a function of cloud cover, season and solar elevation. As the pyranometer does not have a constant sensitivity across the whole solar spectrum, this causes errors. The range of these errors
however has proven to be small. An estimated error range is +/- 5 percent relative to calibration conditions.
Also the spectral sensitivity of the photodiode changes with temperature. It is difficult to estimate the consequences of this behaviour, also because it cannot easily be separated from the effects of the change of photodiode sensitivity with temperature.

2.3 Directional/Cosine response

The measurement of the solar radiation emitting on a surface (also called irradiance or radiative flux) requires two assumptions: that the surface is spectrally black (that it absorbs all radiation from all wavelenghts) and that it has a field of view of 180 degrees. Another way of expressing these directional properties is to say that the sensor has to comply with the cosine response.
A perfect cosine response will show maximum sensitivity (1) at an angle of incidence of 90 degrees (perpendicular to the sensor surface) and zero sensitivity at an angle of incidence of 0 degrees (radiation passing over the sensor surface). In between 90 and 0 degrees the sensitivity should be proportional to the cosine of the angle of incidence. Figure 3 shows the behaviour of a typical pyranometer. The vertical axis shows the deviation from ideal behaviour, expressed in percentage of the ideal value.

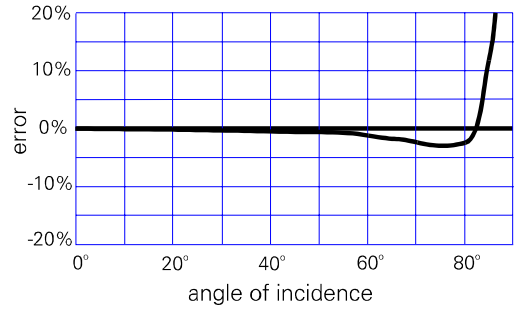


Figure 3. *The directional response or cosine response of the pyranometer. On the horizontal axis the zenith angle (0 degrees zenith angle equals 90 degrees angle of incidence). On the vertical axis the percentage deviation from ideal cosine behaviour.*

2.4 List of specifications

Electrical

• Impedance (nominal):	50 W
• Response time:	< 1 SEC
• Sensitivity (nominal):	100 µV/W/m^2
• Expected signal range under atmospheric conditions:	0 - 0.2 V
• Stability:	< ± 2% per year
• Non linearity:	< 1 % up to 1000 W/m^2
• Temperature dependence of sensitivity:	± 0.15 %/°C

Spectral

• Spectral range:	0.4 - 1.1 mm
• Detector type:	SILICON photo diode

Directional

- Cosine corrected between
  80° angle of incidence, error: within ±10 %
- Cosine errors averaged over opposite
  azimuth error (at 60° angle of incidence): within ±10 %
- Tilt response: no error

Mechanical

- Material of housing: Anodised Aluminium
- Material of cable: Poly Urethane
- Weight: 110 g
- Cable length: 3 metres
- Dimensions see figure 4

Environmental

- Working temperature range: -30 - +70 °C

2.5 Dimensions

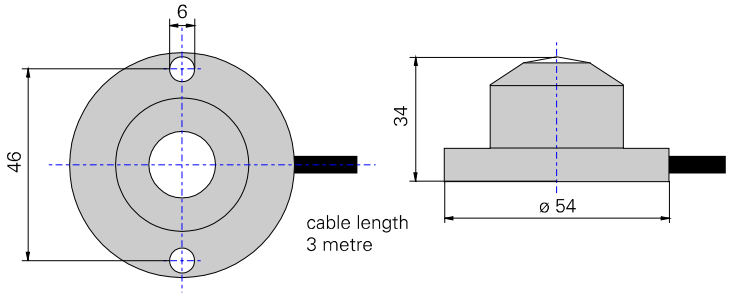


Figure 4. The dimensions of the pyranometer in mm, white lead positive, green lead negative.

3 Calibration

The primary standard for pyranometers is the World Radiometric Reference. The SP-lite pyranometers are calibrated against a Kipp & Zonen secondary standard under natural sunlight under clear sky conditions. Further reference conditions are as follows: temperature 20 degrees Celsius, irradiance 500 Watts per square metre and normal incidence radiation.

4 Installation and maintenance

When installed permanently, the pyranometer can be attached to its mounting platform using the holes that are drilled through the body. The holes are standardised to Kipp & Zonen design. Leveling can be based on your own visual observation.
Preferred orientation is with the cable pointing to the equator (this prevents excessive heating of the leads). When installed on a mast, preferred orientation is such that no shadow is cast on the pyranometer during any time of the day. On the northern hemisphere this implies that the pyranometer should be south of the mast.

The pyranometer can be used to measure reflected radiation, for instance when pointed towards the earth in the inverted position. One should however be aware of the fact that the spectrum of reflected radiation is not the same as the spectrum of the incident radiation. This might cause large errors. The same warning applies to measurement under plant canopy. When measuring reflected radiation it is advised to measure at a height of at least 1.5 meters above the surface in order to avoid shading effects and to promote spatial averaging.
The pyranometer is an all weather instrument.
Once installed the pyranometer needs little maintenance. It is suggested to clean the detector as part of a regular routine, using water or alcohol.

INSTALLATION AND MAINTENANCE

Recalibration is suggested every two years. This can be done in two ways. The first is by comparing with the measurement of a similar sensor at the same site. Preferably daily totals of several days should be compared. Calibration factor could be corrected if results differ by more than five percent.

The second way is to let a recalibration be performed at the SP-LITE factory.

If necessary, the sensitivity of the pyranometer can be adapted. This can be done by soldering a resistor between the + (white) and - (green) output wires. In this way the pyranometer is shunted. For the standard pyranometer, the internal resistance is 47 ohms, the cable resistance is 0.12 ohms per meter. Cable length is 3 meters. The cable resistance has to be multiplied by two, for the + and - wire. Total resistance is 47.7 ohms. In order to reduce the sensitivity by a factor of 10, when the full 3 meters of cable is used, a shunt resistor of 5.3 ohm can be made out of a 1and a 4.3 ohm resistor. The order of magnitude for the sensitivity will be 10 $\mu V/Wm^{-2}$

The general formula for establishing the proper resistor for trimming by a factor of 10, is (47 + (0.24*cable length))/9. The cable length is in meters, the resistance in ohms.

5 Trouble shooting

If your pyranometer does not seem to work at all, please follow the following procedure:

- Check if the pyranometer reacts to light, using the procedure in the "five minutes user manual".
- No result? Measure the impedance of the sensor across the white and the brown wires. This should be 50 ohms. If it is close to five ohms, there is a short circuit. If it is infinite, the circuit is blown.

If the pyranometer shows bigger or smaller results than expected, the following questions might help you out:

- Are you measuring under natural sunlight? If so the maximum expected radiation is 1500 Watts per square metre. Under lamps this might be more.
- Are you correcting for the calibration factor? Please note that this factor is an individual property and is different for each sensor. Do you divide by the factor? This is correct.
- What is the input impedance of your readout equipment? It should preferably be more than 5000 ohm. If smaller than 250 ohm you will notice errors.
- Is your readout equipment properly calibrated?

If still no satisfactory answer is found, please contact your supplier.

6 Delivery

Delivery includes:

1 pyranometer
1 calibration certificate
1 manual

7 Accessories

No options or accessories are available.