

# Pyranometers

for the Accurate Measurement of Solar Irradiance

The best and most reliable pyranometers available

A comprehensive range, from ISO 9060:1990 second class to secondary standard

Accurate and independent data for performance ratio calculations

5 year warranty upon registration

Installed around the world by national meteorology and climate networks

Reliable measurement for solar energy site prospecting and yield forecasting

Analogue and digital outputs

Best MTBF performance



Solar radiation drives almost every dynamic process on the Earth from ocean current circulation to weather, climate and the biosphere. It has a big impact on our life and existence and the determination of the radiation budget at the surface of the Earth is fundamental to understanding the Earth's climate system and weather patterns. If you want to measure solar radiation, you start with a pyranometer.

#### Solar Irradiance

Solar radiation is a great source of zero-emission renewable energy. High quality, reliable radiation data is crucial in the implementation of all solar energy sector projects in both photovoltaic (PV) and concentrating solar power (CSP) thermal systems. A pyranometer is a radiometer designed for measuring the irradiance in  $W/m^2$  resulting from radiant fluxes incident upon a plane surface from the hemisphere above, and integrated over a wavelength range of at least 300 to 3000 nanometers (nm).

#### The different components of solar radiation

A pyranometer measures the global horizontal solar irradiance (GHI); which is composed of diffuse 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 diffuse 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.

#### Solar energy

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.



## Kipp & Zonen Pyranometers

- since 1924
- market leader
- performance
- best available
- MTBF
- wide range
- accurate
- 5 year warranty
- user friendly
- all weather conditions

We have been manufacturing pyranometers since 1924. As the market leader, we produce models at all price and performance points, up to the very best available. All comply with the requirements of ISO 9060:1990 'Solar energy - Specification and classification of instruments for measuring hemispherical solar and direct solar radiation' and are fully traceable to the World Radiometric Reference (WRR) in Davos, Switzerland, where Kipp & Zonen instruments form part of the World Standard Group.

#### The best MTBF performance

Kipp & Zonen pyranometers are designed for simple maintenance and have a wide range of accessories available. The long operational life and reliability is proven by an MTBF (Mean Time Between Failures) of more than 10 years.

Kipp & Zonen pyranometers have been developed to be suitable for use in all environments, from the Antarctic to deserts. They are installed around the world for meteorology, hydrology, climate research, solar energy, environmental and materials testing, greenhouse control, building automation and many other applications.

Our top level pyranometers have individually optimised temperature compensation and individually measured directional response, with the test results provided. These important features ensure the highest accuracy measurements. To offer you the best accuracy when in the field a new calculator is available to provide you with the real-time uncertainty in your application.

#### 5 year warranty

All our pyranometers have a 2-year world-wide factory warranty. But, if you register your end-user details through our website and accept the terms and conditions, we will extend this to 5 years free of charge.

## 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 effect, 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 offer two ranges of pyranometers, the passive CMP and the Smart SMP series, both widely acknowledged by meteorological and solar energy customers.

## CMP Series

high quality durable accurate no power required  
remote sites analogue

Our CMP series pyranometers are well known around the world for their high quality, durability and accuracy. The instruments do not require any power and are ideal for remote sites with limited power availability or for field studies. Each has an individual calibration factor/sensitivity.

However, the signal output is a very low voltage, typically around 10 millivolts on a bright sunny day. To measure 1 W/m<sup>2</sup> of irradiance requires a data logger 'accuracy' of better than 10 microvolts. This normally means a specialised meteorological data logger. Industrial type analogue inputs do not usually have sufficient sensitivity and the SMP series should be used.

CMP3 and CMP10 have internal desiccant that lasts for at least 10 years to reduce maintenance costs. The other CMP models have self-indicating desiccant in an easily accessed drying cartridge that should be inspected monthly and the desiccant changed when necessary.

## Smart SMP Series

smart fast modbus® network data logging  
status monitoring digital accurate temperature correction  
advanced software internal desiccant high quality durable

Our SMP range of pyranometers is based on the proven technology of the CMP series, but has a micro-processor, memory and firmware that makes them Smarter and faster.

### Smart Interface

Modbus® interfaces directly to RTU's, PLC's, SCADA systems, industrial networks and controllers. Smart instruments are addressable, and up to 247 units can be connected to a single network. The measurement data is updated every second and the user can access the irradiance, the type and serial number, instrument settings, full calibration history, status information, and more. The digital signal avoids all the issues of analogue-to-digital conversion performance that arise with many industrial data loggers and input modules, preserving the accuracy of the pyranometer's 24-bit differential input ADC.

SMP Series pyranometers can operate from 5 to 30 VDC and the power input has both reverse polarity and over-voltage protection. They have

a feed-forward algorithm that makes them faster than our passive CMP series and an integrated temperature sensor and polynomial functions for better temperature correction.

### SmartExplorer Windows software

Our free, and easy to use, SmartExplorer Windows™ software allows configuration of the Smart pyranometers communication settings, monitoring of the measurements and status parameters, and logging of the data. Even if the communication parameters are lost, or unknown, the software is able to establish communication and set the instrument back to a defined state.

SMP models, except for the SMP11, have internal desiccant that lasts for at least 10 years to reduce maintenance costs. SMP11 has self-indicating desiccant in an easily accessed drying cartridge that should be inspected monthly and the desiccant changed when necessary.

All pyranometers with a Smart Interface also have a 0 to 1V (-V models) or 4 to 20mA (-A models) analogue output. These fixed analogue outputs eliminate the need to adjust the data logger after re-calibration.



## Second Class Pyranometers

CMP3 second class single dome small size low cost  
routine measurement monitoring SMP3

Our second class CMP3 pyranometer is smaller and lighter than the other CMP series pyranometers. It has a robust 4 mm thick glass dome to protect the thermopile from external influences. The small size and low cost make this the ideal choice for horticulture, entry-level weather stations and routine monitoring in solar energy installations. It does not have any compensation for change in sensitivity with temperature. A screw-in mounting rod is available for easy installation to a pole or mast.

SMP3 is the Smart version of CMP3 and is ideal for routine monitoring in solar energy installations. Because of the faster response, standardised digital Modbus® interface and the built in digital temperature compensation the SMP3 is superior to the CMP3.

## First Class Pyranometers

CMP6 first class double glass dome cost-effective  
good quality SMP6

CMP6 has a similar detector to CMP3, but has improved performance due to the increased thermal mass and the double glass dome construction, making it a First Class pyranometer. It is recommended for cost-effective, good quality, measurements in meteorological and hydrological networks and for agriculture.

SMP6 has similar applications to CMP6. Internal temperature compensation in all SMP's is over a large range from -40°C to +80°C and significantly reduces the measurement uncertainty.

## Secondary Standard Pyranometers

CMP10 long-term stability low thermal offset fast response  
CMP11 secondary standard industry standard CMP21 top level  
CMP22 high quality SMP10 SMP11 SMP21 SMP22 reliable

CMP10 uses a temperature compensated detector with a different technology to the CMP3 and CMP6. It has better linearity and long-term stability, lower thermal offset and faster response. It is a step up in performance and particularly suitable for upgrading meteorological networks. The faster response time meets the requirements for solar energy research and development applications. CMP10 is also ideal for use in sun tracker based solar monitoring stations. It has internal desiccant instead of the external drying cartridge fitted to the rest of the double dome CMP series.

CMP11 is the most widely used secondary standard pyranometer in the solar energy industry for site prospecting and plant performance monitoring. It has the same performance as CMP10 but has an external drying cartridge.

CMP21 is similar to CMP11 but has individually optimised temperature compensation. A sensor is fitted to monitor the housing temperature. Each instrument is supplied with its own temperature and directional

(cosine) response data. It is the choice for scientific use and in top level solar radiation monitoring networks such as the Baseline Surface Radiation Network (BSRN) and Global Atmospheric Watch (GAW) of the World Meteorological Organisation (WMO).

CMP22 has all the features of CMP21 but uses very high quality quartz domes for a wider spectral range, improved directional response, and reduced thermal offsets. Kipp & Zonen is confident that CMP22 is the best passive pyranometer currently available.

SMP10, SMP11, SMP21 and SMP22 are the Smart digital equivalents of the CMP series pyranometers. They have faster response and more flexible connectivity. For extreme climates, the digital polynomial temperature correction provides better performance than the passive correction in the CMP versions.

Internal temperature compensation in all SMP's is over a large range from -40°C to +80°C and significantly reduces the measurement uncertainty. SMP21 and SMP22 have individually measured and optimised temperature compensation and are supplied with directional (cosine) response data.

Go to page 6 and 7 to compare the specifications of our pyranometers.



## Building a System

The system capabilities of Kipp & Zonen pyranometers can be extended with our wide range of compatible products and accessories. Please refer to our website [www.kippzonen.com](http://www.kippzonen.com) for more information on the following products.

### Ventilation Unit

The CVF4 ventilation unit is designed for use with all CMP and SMP Series pyranometers (it is slightly less effective with the CMP3 and SMP3 because of the smaller dome diameter). Ventilation helps to keep the dome clean from soiling, evaporates dew and raindrops, and reduces infrared thermal offsets. The heating can be used to melt frost and snow. Ventilation provides better quality measurement data and reduces the frequency of cleaning, reducing maintenance costs.

### Sun Trackers

SOLYS sun trackers are all-weather reliable instruments used to accurately point a pyrheliometer at the sun for direct solar radiation measurements (DNI). When fitted with an optional shading assembly and a pyranometer they measure diffuse solar radiation (DHI) with no need for periodic manual adjustments. Adding a second pyranometer for global solar radiation (GHI) makes a complete high quality solar monitoring station.

### Shadow Ring

The combination of a pyranometer and a CM121 shadow ring offers a simple solution for measuring diffuse solar radiation from the sky. It does not require any power, but the ring requires a simple adjustment every few days to ensure that the shadow covers the pyranometer dome completely as the sun declination changes during the year.

### Mountings

We offer mounting fixtures for horizontal pyranometers. CMF1 is a small round plate with integral rod for mounting upward and/or downward facing pyranometers without a ventilation unit. CMF4 does the same for pyranometers fitted with the CVF4 ventilation unit. A screw-in rod is available for CMP3 and SMP3. CMB1 is a mounting bracket for attaching mounting rods to a mast, pole or wall.



### Data Loggers

Kipp & Zonen has a range of high performance products for use with CMP or SMP series pyranometers to acquire and store analogue or digital measurement data.

### Albedometer

Two pyranometers, mounted back-to-back, make an albedometer. The albedo of a surface is the extent to which it diffusely reflects solar radiation. It is the ratio of the reflected radiation to the incoming radiation.



### Adjustable Tilt Mounting Kit

Use the Adjustable Tilt Mounting Kit to securely and accurately mount a CMP or SMP pyranometer at a solar zenith angle between 0° and 90°, to measure tilted (POA) global radiation for fixed-angle PV arrays.

### Glare Screen Kit

A downward facing pyranometer used to measure reflected solar radiation should not see any radiation coming from the hemisphere above or from the sun when it is below the horizon of the detector. To prevent this, a glare screen kit is available for use with CMP and SMP series pyranometers (except the SMP3 and CMP3).

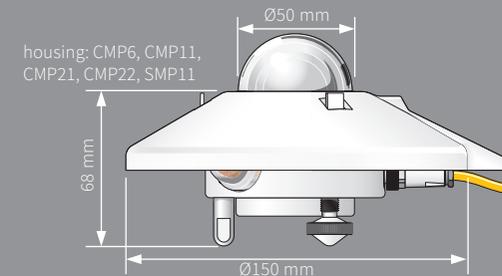
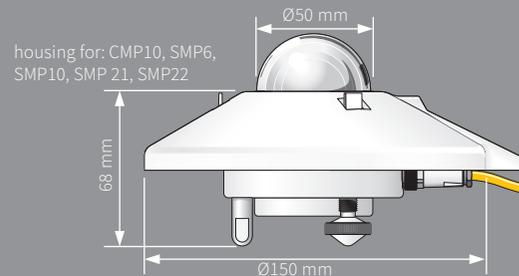
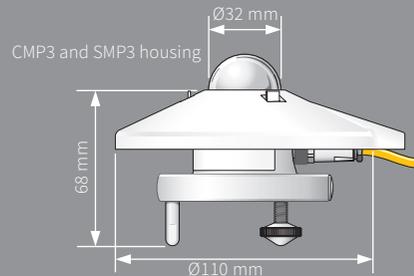


## CMP pyranometers

Specifications	CMP3	CMP6	CMP10 and CMP11	CMP21	CMP22	
Classification to ISO 9060:1990	Second Class	First Class	Secondary Standard	Secondary Standard	Secondary Standard	
Sensitivity	5 to 20 $\mu\text{V}/\text{W}/\text{m}^2$	5 to 20 $\mu\text{V}/\text{W}/\text{m}^2$	7 to 14 $\mu\text{V}/\text{W}/\text{m}^2$	7 to 14 $\mu\text{V}/\text{W}/\text{m}^2$	7 to 14 $\mu\text{V}/\text{W}/\text{m}^2$	
Impedance	20 to 200 $\Omega$	20 to 200 $\Omega$	10 to 100 $\Omega$	10 to 100 $\Omega$	10 to 100 $\Omega$	
Expected output range (0 to 1500 $\text{W}/\text{m}^2$ )	0 to 30 mV	0 to 30 mV	0 to 20 mV	0 to 20 mV	0 to 20 mV	
Maximum operational irradiance	2000 $\text{W}/\text{m}^2$	2000 $\text{W}/\text{m}^2$	4000 $\text{W}/\text{m}^2$	4000 $\text{W}/\text{m}^2$	4000 $\text{W}/\text{m}^2$	
Response time (63%)	< 6 s	< 6 s	< 1.7 s	< 1.7 s	< 1.7 s	
Response time (95%)	< 18 s	< 18 s	< 5 s	< 5 s	< 5 s	
Instrument accuracy	Spectral range (20% points)	285 to 3000 nm	270 to 3000 nm	270 to 3000 nm	270 to 3000 nm	210 to 3600 nm
	Spectral range (50% points)	300 to 2800 nm	285 to 2800 nm	285 to 2800 nm	285 to 2800 nm	250 to 3500 nm
	Zero offsets (unventilated) (a) thermal radiation (at 200 $\text{W}/\text{m}^2$ ) (b) temperature change (5 K/h)	< 15 $\text{W}/\text{m}^2$ < 5 $\text{W}/\text{m}^2$	< 10 $\text{W}/\text{m}^2$ < 4 $\text{W}/\text{m}^2$	< 7 $\text{W}/\text{m}^2$ < 2 $\text{W}/\text{m}^2$	< 7 $\text{W}/\text{m}^2$ < 2 $\text{W}/\text{m}^2$	< 3 $\text{W}/\text{m}^2$ < 1 $\text{W}/\text{m}^2$
	Non-stability (change/year)	< 1%	< 1%	< 0.5%	< 0.5%	< 0.5%
	Non-linearity (100 to 1000 $\text{W}/\text{m}^2$ )	< 1.5%	< 1%	< 0.2%	< 0.2%	< 0.2%
	Directional response (up to 80° with 1000 $\text{W}/\text{m}^2$ beam)	< 20 $\text{W}/\text{m}^2$	< 20 $\text{W}/\text{m}^2$	< 10 $\text{W}/\text{m}^2$	< 10 $\text{W}/\text{m}^2$	< 5 $\text{W}/\text{m}^2$
	Spectral selectivity (350 to 1500 nm)	< 3%	< 3%	< 3%	< 3%	< 3%
	Tilt response (0° to 90° at 1000 $\text{W}/\text{m}^2$ )	< 1%	< 1%	< 0.2%	< 0.2%	< 0.2%
	Temperature response	< 5% (-10°C to +40°C)	< 4% (-10°C to +40°C)	< 1% (-10°C to +40°C)	< 1% (-20°C to +50°C)	< 0.5% (-20°C to +50°C)
	Field of view	180°	180°	180°	180°	180°
Accuracy of bubble level	< 0.2°	< 0.1°	< 0.1°	< 0.1°	< 0.1°	
Temperature sensor output				10 k Thermistor (optional Pt-100)	10 k Thermistor (optional Pt-100)	
Detector type	Thermopile	Thermopile	Thermopile	Thermopile	Thermopile	
Operating and storage temperature range	-40°C to +80°C	-40°C to +80°C	-40°C to +80°C	-40°C to +80°C	-40°C to +80°C	
Humidity range	0 to 100%	0 to 100%	0 to 100%	0 to 100%	0 to 100%	
MTBF (Mean Time Between Failures)	> 10 years	> 10 years	> 10 years	> 10 years	> 10 years	
Ingress Protection (IP) rating	67	67	67	67	67	
Onsite pyranometer uncertainty	Calculate with Suncertainty App	Calculate with Suncertainty App	Calculate with Suncertainty App	Calculate with Suncertainty App	Calculate with Suncertainty App	
Recommended applications	Economical solution for routine measurements in weather stations, field testing	Good quality measurements for hydrology networks, greenhouse climate control	Meteorological networks, PV panel and thermal collector testing, materials testing	Meteorological networks, reference measurements in extreme climates, polar or arid	Scientific research requiring the highest level of measurement accuracy and reliability	

Note: The performance specifications quoted are worst-case and/or maximum values

Standard 10 k thermistor or optional Pt-100 temperature sensor with CMP21 and CMP22. Individual directional response and temperature dependence test data with CMP21 and CMP22



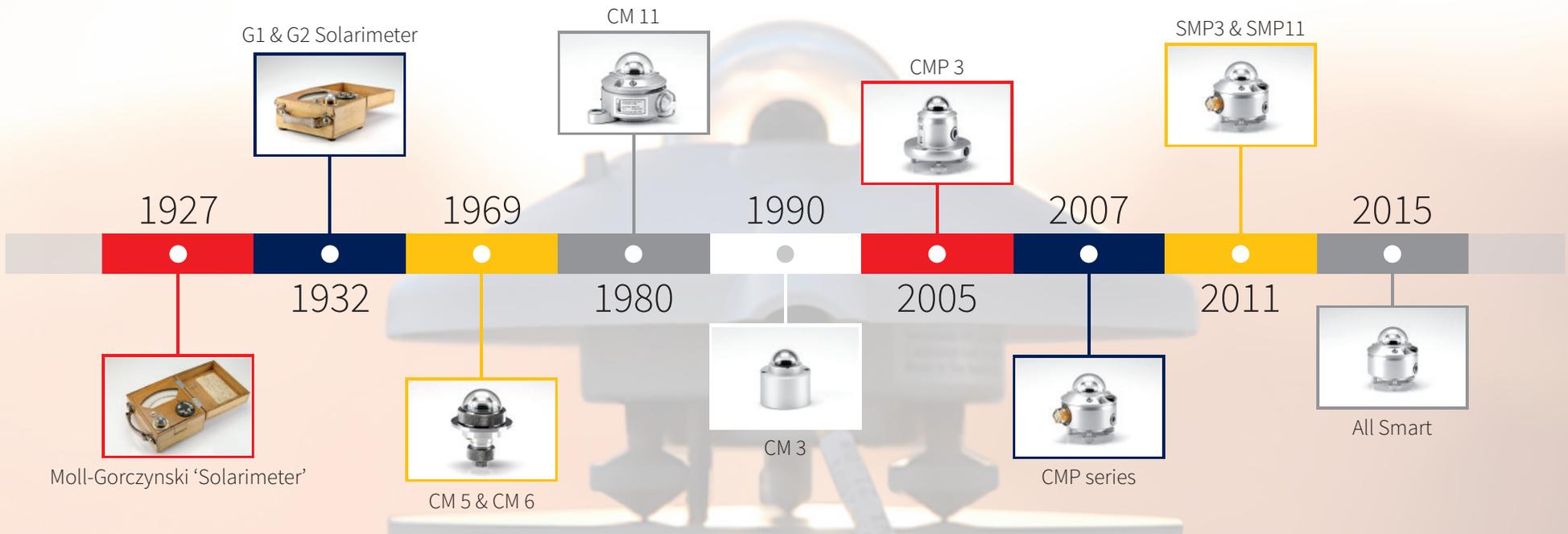
## SMP pyranometers

Specifications	SMP3	SMP6	SMP10 and SMP11	SMP21	SMP22	
Classification to ISO 9060:1990	Second Class	First Class	Secondary Standard	Secondary Standard	Secondary Standard	
Analogue output • V-version	0 to 1V	0 to 1V	0 to 1V	0 to 1V	0 to 1V	
Analogue output range*	-200 to 2000 W/m <sup>2</sup>	-200 to 2000 W/m <sup>2</sup>	-200 to 2000 W/m <sup>2</sup>	-200 to 2000 W/m <sup>2</sup>	-200 to 2000 W/m <sup>2</sup>	
Analogue output • A-version	4 to 20 mA	4 to 20 mA	4 to 20 mA	4 to 20 mA	4 to 20 mA	
Analogue output range*	0 to 1600 W/m <sup>2</sup>	0 to 1600 W/m <sup>2</sup>	0 to 1600 W/m <sup>2</sup>	0 to 1600 W/m <sup>2</sup>	0 to 1600 W/m <sup>2</sup>	
Serial output	RS-485 Modbus®	RS-485 Modbus®	RS-485 Modbus®	RS-485 Modbus®	RS-485 Modbus®	
Serial output range	-400 to 2000 W/m <sup>2</sup>	-400 to 2000 W/m <sup>2</sup>	-400 to 4000 W/m <sup>2</sup>	-400 to 4000 W/m <sup>2</sup>	-400 to 4000 W/m <sup>2</sup>	
Instrument accuracy	Response time (63%)	< 1.5 s	< 1.5 s	< 0.7 s	< 0.7 s	
	Response time (95%)	< 12 s	< 12 s	< 2 s	< 2 s	
	Spectral range (20 % points)	285 to 3000 nm	270 to 3000 nm	270 to 3000 nm	270 to 3000 nm	210 to 3600 nm
	Spectral range (50 % points)	300 to 2800 nm	285 to 2800 nm	285 to 2800 nm	285 to 2800 nm	250 to 3500 nm
	Zero offsets (unventilated) (a) thermal radiation (at 200 W/m <sup>2</sup> ) (b) temperature change (5 K/h)	< 15 W/m <sup>2</sup> < 5 W/m <sup>2</sup>	< 10 W/m <sup>2</sup> < 4 W/m <sup>2</sup>	< 7 W/m <sup>2</sup> < 2 W/m <sup>2</sup>	< 7 W/m <sup>2</sup> < 2 W/m <sup>2</sup>	< 3 W/m <sup>2</sup> < 1 W/m <sup>2</sup>
	Non-stability (change/year)	< 1%	< 1%	< 0.5%	< 0.5%	< 0.5%
	Non-linearity (100 to 1000 W/m <sup>2</sup> )	< 1.5%	< 1%	< 0.2%	< 0.2%	< 0.2%
	Directional response (up to 80° with 1000 W/m <sup>2</sup> beam)	< 20 W/m <sup>2</sup>	< 15 W/m <sup>2</sup>	< 10 W/m <sup>2</sup>	< 10 W/m <sup>2</sup>	< 5 W/m <sup>2</sup>
	Temperature response	< 2% (-20°C to +50°C) < 4% (-40°C to +70°C)	< 1.5% (-20°C to +50°C) < 3% (-40°C to +70°C)	< 1% (-20°C to +50°C) < 2% (-40°C to +70°C)	< 0.3% (-20°C to +50°C) < 0.3% (-40°C to +70°C)	< 0.3% (-20°C to +50°C) < 0.3% (-40°C to +70°C)
	Spectral selectivity (350 to 1500 nm)	< 1%	< 1%	< 1%	< 1%	< 2%
	Tilt response (0° to 90° at 1000 W/m <sup>2</sup> )	< 1%	< 1%	< 0.2%	< 0.2%	< 0.2%
	Field of view	180°	180°	180°	180°	180°
	Accuracy of bubble level	< 0.2°	< 0.1°	< 0.1°	< 0.1°	< 0.1°
Power consumption (at 12VDC)	V-version: 55 mW A-version: 100 mW	V-version: 55 mW A-version: 100 mW	V-version: 55 mW A-version: 100 mW	V-version: 55 mW A-version: 100 mW	V-version: 55 mW A-version: 100 mW	
Software, Windows™	Smart Sensor Explorer Software, for configuration, test and data logging	Smart Sensor Explorer Software, for configuration, test and data logging	Smart Sensor Explorer Software, for configuration, test and data logging	Smart Sensor Explorer Software, for configuration, test and data logging	Smart Sensor Explorer Software, for configuration, test and data logging	
Supply voltage	5 to 30VDC	5 to 30VDC	5 to 30VDC	5 to 30VDC	5 to 30VDC	
Detector type	Thermopile	Thermopile	Thermopile	Thermopile	Thermopile	
Operating and storage temperature range	-40°C to +80°C	-40°C to +80°C	-40°C to +80°C	-40°C to +80°C	-40°C to +80°C	
Humidity range	0 to 100%	0 to 100%	0 to 100%	0 to 100%	0 to 100%	
MTBF (Mean Time Between Failures) **	> 10 years	> 10 years	> 10 years	> 10 years	> 10 years	
Ingress Protection (IP) rating	67	67	67	67	67	
Onsite pyranometer uncertainty	Calculate with Suncertainty App	Calculate with Suncertainty App	Calculate with Suncertainty App	Calculate with Suncertainty App	Calculate with Suncertainty App	
Recommended applications	Economical solution for efficiency and maintenance monitoring of PV power installations, routine measurements in weather stations, agriculture, horticulture and hydrology	Good quality measurements for Solar Monitoring, hydrology networks, greenhouse climate control	High performance for PV panel and thermal collector testing, solar energy research, solar prospecting, materials testing, advanced meteorology and climate networks	Meteorological networks, reference measurements in PV monitoring, extreme climates, polar or arid	Scientific research requiring the highest level of measurement accuracy and reliability under all conditions	

\* adjustable with Smart Explorer Software

\*\* extrapolated after introduction in January 2012

Note: The performance specifications quoted are worst-case and/or maximum values



## HEAD OFFICE

**Kipp & Zonen B.V.**  
 Delftechpark 36, 2628 XH Delft  
 P.O. Box 507, 2600 AM Delft  
 The Netherlands  
 +31 15 2755 210  
 info@kippzonen.com  
 www.kippzonen.com

## SALES OFFICES

**Kipp & Zonen France S.A.R.L.**  
 88 Avenue de l'Europe  
 77184 Emerainville  
 France  
 +33 1 64 02 50 28  
 kipp.france@kippzonen.com  
 www.kippzonen.fr

**Kipp & Zonen Asia Pacific Pte. Ltd.**  
 10 Ubi Crescent Lobby E  
 #02-93 Ubi Techpark  
 Singapore 408564  
 +65 6748 4700  
 kipp.singapore@kippzonen.com  
 www.kippzonen.com

**Kipp & Zonen USA Inc.**  
 125 Wilbur Place  
 Bohemia NY 11716  
 United States of America  
 +1 631 589 2065  
 kipp.usa@kippzonen.com  
 www.kippzonen.com

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