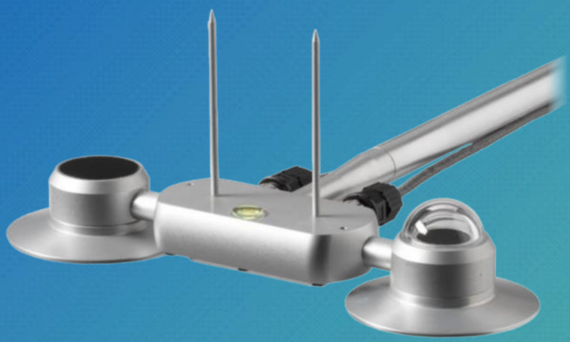
OPERATING MANUAL

LPNET14

Net irradiance meter



EN

V1.0

Contents

1 Introduction

LPNET14 is a 4-component net irradiance meter consisting of a pair of pyranometers, one for measuring global irradiance $E_{SW}\downarrow$ and one for measuring reflected irradiance $E_{SW}\uparrow$, and a pair of pyrgeometers, one for measuring infrared radiation from the sky $E_{FIR}\downarrow$ and one for measuring infrared radiation from the earth $E_{FIR}\uparrow$.

The net irradiance is measured in the spectral range from 0.3 to 45 µm.

The radiometer is equipped with an NTC temperature sensor. The measurement of the temperature is needed to compensate the infrared radiation measurement (pyrgeometer) for the temperature of the sensor.

The radiometer is suitable for outdoor use in all weather conditions and requires little maintenance.

Supplied with bird spikes and fixing shaft ∅16 mm, L=400 mm.

The radiometer is already factory calibrated and comes complete with calibration report.

The pyranometers are calibrated in accordance with the ISO 9847:2023 (Type A1) standard: ”Calibration of pyranometers by comparison to a reference pyranometer”. The calibration is performed by comparison with the reference sample calibrated annually at WRC (World Radiation Center).

The pyrgeometers are calibrated outdoors, for comparison with a reference standard pyrgeometer calibrated at WRC (World Radiation Center). The two instruments are kept outdoors for at least one night in the presence of clear sky. The data acquired by a data logger are then processed to obtain the calibration factor.

2 Technical specifications

Pyranometer Spectrally Flat Class C according to ISO 9060:2018

Typical sensitivity	5…15 μV/Wm^{-2}
Impedance	33…45 Ω
Measuring range	0…2000 W/m^2
Viewing angle	2π sr
Spectral range	300…2800 nm (50%) 335…2200 nm (95%)

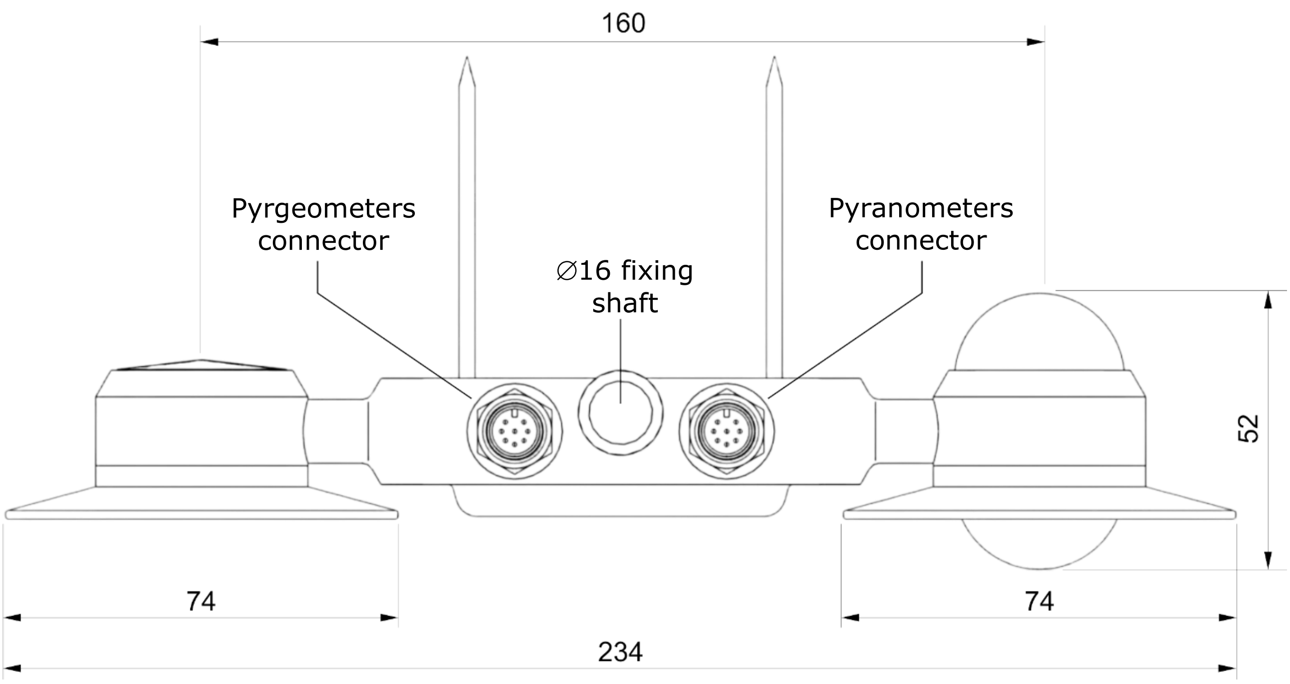
Pyrgeometer

Typical sensitivity	5…10 μV/Wm^{-2}
Impedance	33…45 Ω
Measuring range	-300…+300 W/m^2
Viewing angle	160°
Spectral range	5.5…45 μm (50%)

General specifications

Operating temperature	-40…+80 °C
Materials	Housing and fixing shaft: anodized aluminium Screen: ASA Pyranometer dome: optical glass Pyrgeometer window: silicon Salts compartment cover: polycarbonate Bird spikes: stainless steel
Degree of protection	IP 65

Dimensions (mm)



3 Measuring principle

The two pyranometers are based on a thermopile sensor. The thermopile sensitive surface is coated with a black matt paint, which allows the pyranometer not to be selective at different wavelengths.

Radiant energy is absorbed by the thermopile black surface, thus creating a difference of temperature between the center of the thermopile (hot junction) and the pyranometer body (cold junction). Thanks to the Seebeck effect, the difference of temperature between hot and cold junction is converted into a difference of potential.

The pyranometer spectral range is determined by the transmission of the glass dome

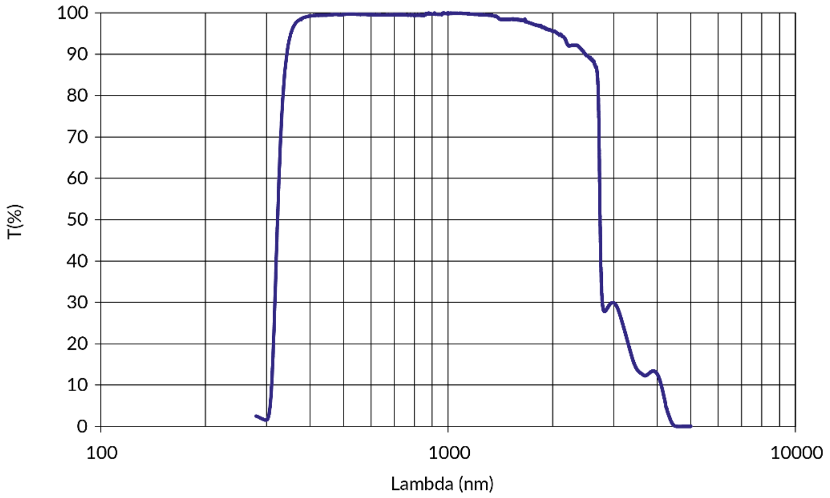


Fig. 3.1: pyranometer spectral range

The two pyrgeometers are also based on a thermopile. In this case, silicon discs are used to protect the thermopile.

Silicon is transparent to wavelengths longer than 1.1 μm; therefore, a filter is deposited on the inside of the window to block the radiation up to 4.5-5 μm.

The silicon external surface, which is exposed to weathering, is protected by a scratch-resistant coating (DLC) to ensure strength and durability in all weather conditions. The scratch-resistant coating offers the advantage that the surface can be cleaned without the danger of scratching the window. The transmission of the silicon window versus wavelength change is shown below.

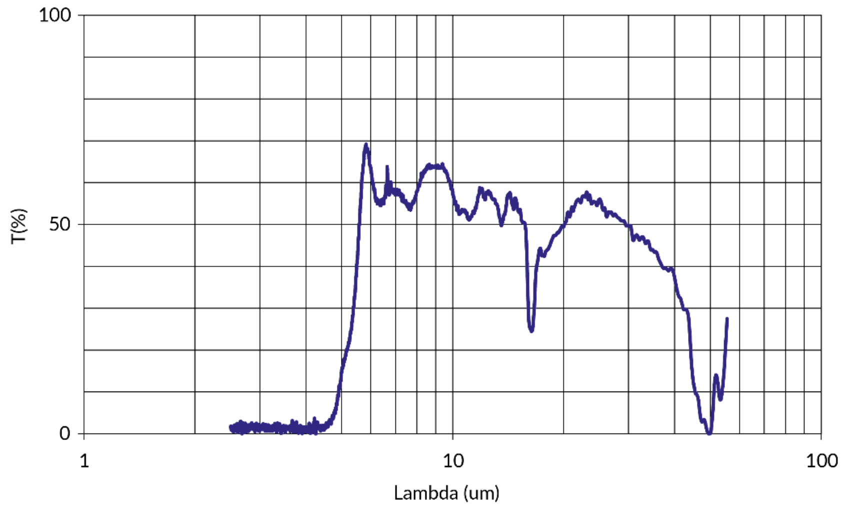


Fig. 3.2: pyrgeometer spectral range

Radiant energy is absorbed/radiated by the blackened thermopile surface, thus creating a difference of temperature between the center of the thermopile (hot junction) and the pyrgeometer body (cold junction). Thanks to the Seebeck effect, the difference of temperature between hot and cold junction is converted into a difference of potential.

If the pyrgeometer temperature is higher than the radiant temperature of the portion of sky or earth framed by the pyrgeometer itself, the thermopile will irradiate energy and the output signal will be negative (typical situation is clear sky); vice versa, if the pyrgeometer temperature is lower than that of the portion of sky or earth framed, the signal will be positive (typical situation is cloudy sky).

For the calculation of the infrared irradiance E_{FIR} ($E_{FIR}\downarrow$ or $E_{FIR}\uparrow$), besides the thermopile output signal, it is necessary to know the pyrgeometer temperature T_B, as reported in the following formula:

$$\mathbf{E_{FIR} = E_{TERM} + \sigma T_B^4}$$

Where:

- **E_{TERM}** = net irradiance (difference between the infrared irradiance reaching the pyrgeometer and the emission of the pyrgeometer itself) in W/m^2 measured by the pyrgeometer.
- **σ** = Stefan-Boltzmann constant (5.6704×10^{-8} $Wm^{-2}K^{-4}$).
- **T_B** = pyrgeometer temperature in K (Kelvin).

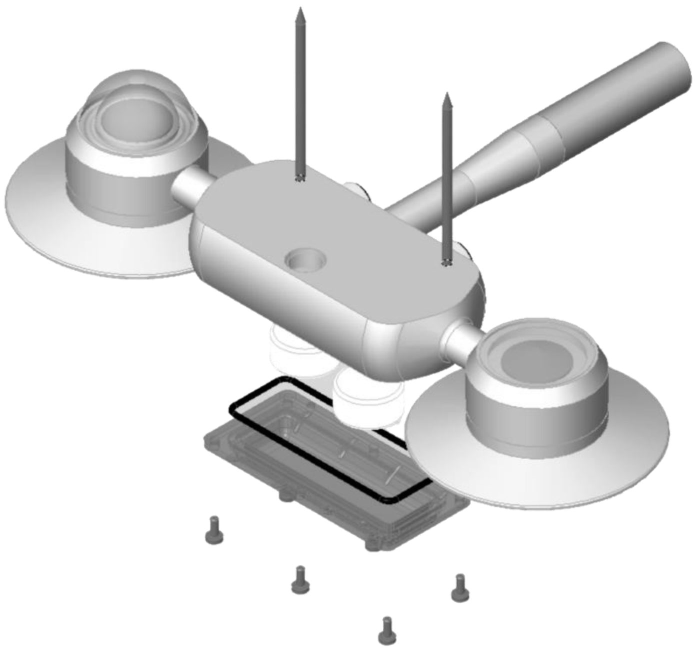
The second term of the formula is the radiation emitted by an object, assumed to have emissivity ε=1, at temperature T_B.

4 Installation

Before installing the radiometer, load the lower compartment with two silica-gel cartridges. Silica-gel absorbs humidity inside the instrument and prevents, in particular climatic conditions, condensation on the internal surface of the silicon windows and glass domes.

Carry out the following instructions in an environment as drier as possible:

1. Loosen the six screws that fix the lower cap of the radiometer.



2. Remove (if present) the old cartridges and the marker.
3. Open the envelope containing the silica-gel cartridges and the marker; trim the marker to match the 10% R.H. indicator (make sure that the dimensions are appropriate to the salts compartment).
4. Insert the cartridges in the salts compartment.
5. Insert the marker so that it can be easily checked without opening the salts compartment.
6. Tighten the six screws of the lid, making sure that the seal is positioned correctly.
7. The radiometer is ready for use.

The radiometer must be mounted in an easy-to-reach location in order to clean the glass domes and the silicon windows regularly. At the same time, make sure that no buildings, constructions, trees or obstructions exceed the horizontal plane where the radiometer lies. If this is not possible, select a site where obstructions do not exceed 10°.

When installed on a mast, the orientation should be such that no shadow is cast on the sensor at any time during the day. In the northern hemisphere, this implies that the radiometer should be mounted south of the mast, according to the ISO TR9901 standard and WMO recommendations.

Use the bubble level built into the radiometer for accurate horizontal positioning.

4.1 Electrical connections

Warning!

The metallic housing of the radiometer and the shield of the connecting cable (CPM12AA8N…) should be connected to ground (earth).

The radiometer has two 8-pole M12 connectors, one for the pyranometers and one for the pyrgeometers. To identify the two connectors, see the figure on page 4.

The radiometer is passive and does not need any power supply.

Connectors pinout:

<table>
<tr><th colspan="2" rowspan="2">Radiometer male connector (external view)</th><th colspan="2">Function</th><th rowspan="2">CPM12AA8N… wire color</th></tr>
<tr><th>Pyrgeometers</th><th>Pyranometers</th></tr>
<tr><td rowspan="8">
</td><td>1</td><td>$+V_{FIR}\downarrow$</td><td>$+V_{SW}\downarrow$</td><td>Red</td></tr>
<tr><td>2</td><td>$-V_{FIR}\downarrow$</td><td>$-V_{SW}\downarrow$</td><td>Blue</td></tr>
<tr><td>3</td><td>Cable shield</td><td>Cable shield</td><td>Shield</td></tr>
<tr><td>4</td><td>NC</td><td>NC</td><td>--</td></tr>
<tr><td>5</td><td>$-V_{FIR}\uparrow$</td><td>$-V_{SW}\uparrow$</td><td>Brown</td></tr>
<tr><td>6</td><td>NTC</td><td>NC</td><td>White</td></tr>
<tr><td>7</td><td>NTC</td><td>NC</td><td>Black</td></tr>
<tr><td>8</td><td>$+V_{FIR}\uparrow$</td><td>$+V_{SW}\uparrow$</td><td>Green</td></tr>
</table>

The typical output impedance of the sensor is <50 Ω.

The output signal is typically a few mV. The recommended resolution of the reading instrument (voltmeter or data logger) is 1 μV.

5 Measurement

It is necessary to measure the output signal of the four sensors and the resistance of the internal NTC temperature sensor.

The pyranometers and the pyrgeometers are distinguished by the sensitivity (or calibration factor) ***S*** expressed in μV/(Wm^{-2}), shown in the label on the sensor and in the calibration report.

The irradiance in W/m^2 of each sensor ($E_{SW}\downarrow$, $E_{SW}\uparrow$, $E_{FIR}\downarrow$, $E_{FIR}\uparrow$) is obtained by measuring with a multimeter the difference of potential ***DDP*** at the ends of the sensor and applying the following formulas:

For the pyranometers: $\mathbf{E_{SW} = DDP / S}$

For the pyrgeometers: $\mathbf{E_{FIR} = (DDP / S) + \sigma T_B^4}$

where:

DDP is the difference of potential expressed in μV measured by the multimeter (e.g., for $E_{FIR}\downarrow$ calculation, the DDP between the terminals $+V_{FIR}\downarrow$ and $-V_{FIR}\downarrow$ is measured).

S is the sensitivity of the sensor expressed in μV/(Wm^{-2}).

σ is the Stefan-Boltzmann constant (5.6704x10^{-8} Wm^{-2}K^{-4}).

$\mathbf{T_B}$ is the pyrgeometer temperature in K (Kelvin), obtained by the measurement of the NTC resistance.

The pyrgeometer temperature $\mathbf{T_B}$ (K) is obtained by measuring the NTC resistance $\mathbf{R_{NTC}}$ (Ω) and applying the following formula:

$$\frac{1}{\mathbf{T_B}} = \mathbf{a} + \mathbf{b}\log(\mathbf{R_{NTC}}) + \mathbf{c}\log(\mathbf{R_{NTC}})^3$$

Where:

a = 10297.2 x 10^{-7}

b = 2390.6 x 10^{-7}

c = 1.5677 x 10^{-7}

Table 5.1 indicates the correspondence between $\mathbf{T_B}$ and $\mathbf{R_{NTC}}$ for temperature values between -25 °C and +58 °C. To obtain the temperature value in Kelvin, add 273.15 to the temperature value in degrees Celsius in the table.

TAB. 5.1: correspondence between pyrgeometer temperature and NTC resistance

T_B (°C)	R_{NTC} (Ω)	T_B (°C)	R_{NTC} (Ω)	T_B (°C)	R_{NTC} (Ω)
-25	103700	3	25740	31	7880
-24	98240	4	24590	32	7579
-23	93110	5	23500	33	7291
-22	88280	6	22470	34	7016
-21	83730	7	21480	35	6752
-20	79440	8	20550	36	6499
-19	75390	9	19660	37	6258
-18	71580	10	18810	38	6026
-17	67970	11	18000	39	5804
-16	64570	12	17240	40	5592
-15	61360	13	16500	41	5388
-14	58320	14	15810	42	5193
-13	55450	15	15150	43	5006
-12	52740	16	14520	44	4827
-11	50180	17	13910	45	4655
-10	47750	18	13340	46	4489
-9	45460	19	12790	47	4331
-8	43290	20	12270	48	4179
-7	41230	21	11770	49	4033
-6	39290	22	11300	50	3893
-5	37440	23	10850	51	3758
-4	35690	24	10410	52	3629
-3	34040	25	10000	53	3505
-2	32470	26	9605	54	3386
-1	30980	27	9228	55	3386
0	29560	28	8868	56	3271
1	28220	29	8524	57	3161
2	26950	30	8195	58	3055

6 Maintenance

In order to grant measurements high accuracy, it is important to keep the radiometer silicon windows and glass domes clean. The higher the frequency of cleaning, the better the accuracy of measurements.

You can wash it using water and standard papers for lens. If necessary, use pure ETHYL alcohol. After using alcohol, clean again the silicon windows and the domes with water only.

To minimize condensation and keep measurements accurate, two cartridges of desiccant silica-gel are provided inside the radiometer to absorb moisture. The efficiency of silica-gel decreases over time while absorbing humidity. Silica-gel typical lifetime goes from 4 to 12 months depending on the environment where the radiometer operates. To easily evaluate the efficiency status of the silica-gel, within each recharge there is a marker, to be placed at the bottom of the salts compartment, so that it can be seen. When the marker indicates the presence of humidity, it is necessary to replace the salts.

Warning!

The silica-gel replacement must be done in an ESD-safe environment.

Hail of particular intensity/size may damage the silicon window; therefore, it is recommended to check the status of the window after an intense storm with hail.

To exploit all the radiometer features, it is highly recommended that the calibration be checked annually.

7 Safety instructions

The radiometer proper operation and operating safety can be ensured only in the climatic conditions specified in this manual and if all standard safety measures as well as the specific measures described in this manual are followed.

Do not use the instruments in places where there are:

- Corrosive or flammable gases.
- Direct vibrations or shocks to the instrument.
- High-intensity electromagnetic fields, static electricity.

User obligations

The instrument operator shall follow the directives and regulations below that refer to the treatment of dangerous materials:

- EU directives on workplace safety.
- National law regulations on workplace safety.
- Accident prevention regulations.

8 Accessories ordering codes

The radiometer is supplied with fixing shaft Ø16 mm / L=400 mm, 2 bird spikes, 5 recharges of desiccant (each consisting of 2 silica-gel cartridges and one marker), bubble level, 2 M12 female free connectors (only if the optional cables are not ordered) and calibration report.

Cables and accessories must be ordered separately. The radiometer requires two identical cables.

Installation cables

CPM12AA8N... Cable with 8-pole M12 connector on one end, open wires on the other end. Length 5 m (CPM12AA8N.5) or 10 m (CPM12AA8N.10).

Spare parts

LPG2 5 recharges of desiccant (each consisting of 2 silica-gel cartridges and one marker).

NOTES

WARRANTY

The manufacturer is required to respond to the "factory warranty" only in those cases provided by Legislative Decree 6 September 2005 - n. 206. Each instrument is sold after rigorous inspections; if any manufacturing defect is found, it is necessary to contact the distributor where the instrument was purchased from. During the warranty period (24 months from the date of invoice) any manufacturing defects found will be repaired free of charge. Misuse, wear, neglect, lack or inefficient maintenance as well as theft and damage during transport are excluded. Warranty does not apply if changes, tampering or unauthorized repairs are made on the product. Solutions, probes, electrodes and microphones are not guaranteed as the improper use, even for a few minutes, may cause irreparable damages.
The manufacturer repairs the products that show defects of construction in accordance with the terms and conditions of warranty included in the manual of the product. For any dispute, the competent court is the Court of Padua. The Italian law and the "Convention on Contracts for the International Sales of Goods" apply.

TECHNICAL INFORMATION

The quality level of our instruments is the result of the continuous product development. This may lead to differences between the information reported in the manual and the instrument you have purchased.
We reserve the right to change technical specifications and dimensions to fit the product requirements without prior notice.

DISPOSAL INFORMATION

Electrical and electronic equipment marked with specific symbol in compliance with 2012/19/EU Directive must be disposed of separately from household waste. European users can hand them over to the dealer or to the manufacturer when purchasing a new electrical and electronic equipment, or to a WEEE collection point designated by local authorities. Illegal disposal is punished by law.

Disposing of electrical and electronic equipment separately from normal waste helps to preserve natural resources and allows materials to be recycled in an environmentally friendly way without risks to human health.

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