



LP PYRHE 16 PYRHELIOMETER

Introduction

The pyrheliometer LP PYRHE 16 (First Class Pyrheliometer according to ISO 9060 classification) is an instrument for direct measurement of solar irradiance (Watt/m²). The receiving surface must be positioned (via a solar tracker or else) perpendicularly to sun's rays. The use of apposite diaphragms allows only direct light to hit the surface of the sensor. According to WMO (Seventh edition 2008) and ISO 9069 regulations, the pyrheliometer has a field of view of 5°.

The pyrheliometer is produced in three versions:

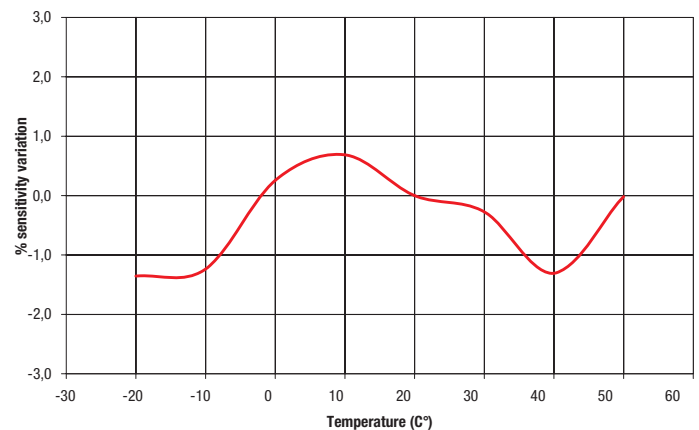
- LP PYRHE 16 PASSIVE
- LP PYRHE 16 AC ACTIVE with 4..20 mA CURRENT output
- LP PYRHE 16 AV ACTIVE with 0..1V or 0..5V or 0..10 V VOLTAGE output **to be defined at the time of the order**
- LP PYRHE S ACTIVE with RS485 serial output with MODBUS-RTU protocol

Working Principle

The pyrheliometer LP PYRHE 16 is based on a new passive thermopile sensor. The sensitive surface of the thermopile is coated with a matt black paint, which makes the instrument not selective to the different wave lengths. The spectral range of the pyrheliometer is determined by the transmission of the quartz window, whose function is to protect the sensor from dust and water. A special quartz allows to perform a 200nm-4000nm non-selective measurement.

The adopted sensor allows the response time to be lower than ISO9060 requirements for the classification of first class pyrheliometers (the response time is under 9 seconds while the standard requires a response time lower than 20 seconds).

Radiant energy is absorbed by the blackened surface of the thermopile, thus creating a difference in temperature between the hot junction and the cold junction of the pyrheliometer, which acts in this case as a cold junction. Thanks to the Seebeck effect, the difference in temperature between hot and cold junction is converted into a Difference of Potential. In order to reduce the variations of sensitivity depending on temperature and to fall within the specifications requested to a secondary pyrheliometer, the LP PYRHE 16 is provided with a passive compensation circuit. Graph 1 shows the typical variation of sensitivity at different temperatures.



Graph 1: % variation of sensitivity of the LP PYRHE 16 pyrheliometer with regard to sensitivity at 20 °C, in the temperature range from -20 to 50°C.

Deviations are calculated starting from sensitivity measured at 20°C.

The LP PYRHE 16 is a sealed instrument, for that reason a cartridge of Silica-gel crystals is provided to dry the air inside the instrument, in order to prevent condensation from forming on the quartz window of the instrument, invalidating the performed measurements.

The angular field of view is 5° in accordance with WMO regulations and the slope angle is 1° (figure 1).

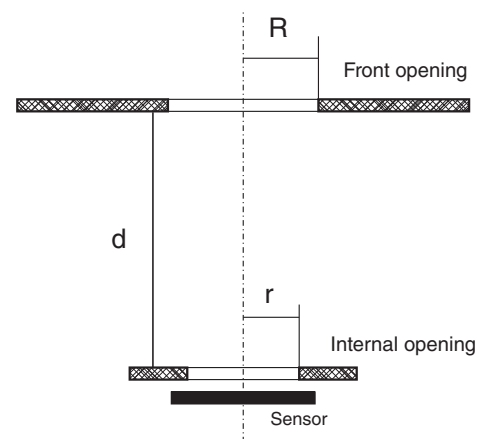


Fig.1: Field of view = $2 * \arctan (R/d)$
Slope angle = $\arctan ((R-r)/d)$

A light shield can be introduced in order to reduce light scattering contribution when reading the pyrheliometer.

For spectral measurements of direct solar radiance, which are useful for the determination of the spectral thickness in the atmosphere, the pyrheliometer LP PYRHE 16 can be provided with a kit consisting of an appropriate light shield (which allows assemblage of the filter wheel) plus a revolving filter wheel. The filter wheel is equipped with the filters below:

Filter Type	Cutoff wave length [nm]		Average transmission coefficient
	Lambda short waves	Lambda long waves	
OG 530	526	2900	0.92
RG 630	630	2900	0.92
RG 695	695	2900	0.92

It can be ordered separately as an accessory.

The pyrheliometer dimensions are shown in figure 2:

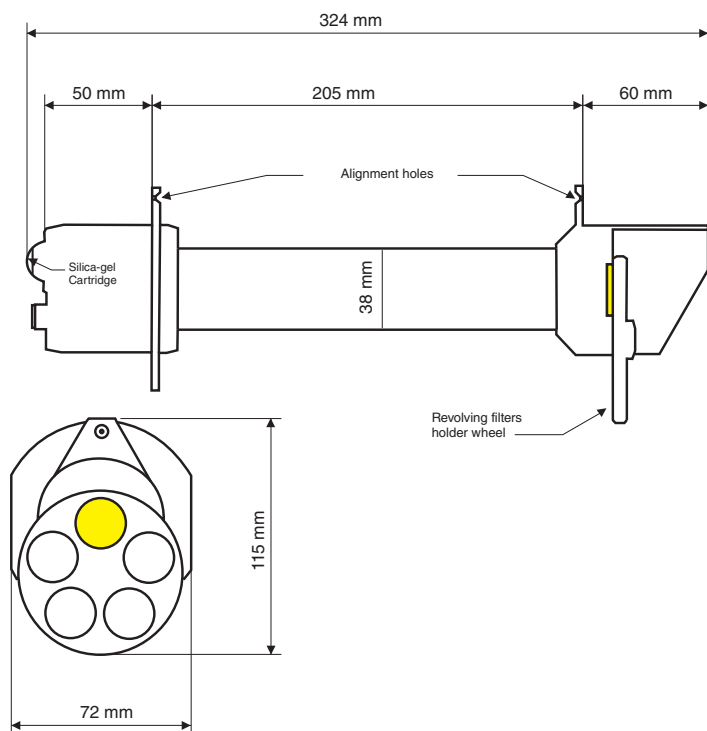


Fig. 2

Installing and assembling the pyrliometer for the measurement of direct solar radiance:

Before installing the pyrliometer, refill the cartridge with the silica-gel crystals. Silica-gel is used to absorb humidity inside the instrument, which – under particular climatic conditions – could lead to the formation of condensation on the internal wall of the quartz window, altering in this way the measurement. While refilling the silica-gel cartridge, avoid wetting it or touching it with your hands. The operations to be performed in a dry environment (as far as possible) are as follows:

- 1- Unscrew the silica-gel cartridge using a coin
- 2- Remove the perforated cap of the cartridge
- 3- Open the sachet (supplied with the pyrliometer) containing the silica-gel
- 4- Fill the cartridge with the silica-gel crystals
- 5- Close the cartridge with its own cap, making sure the O-ring is correctly positioned
- 6- Screw the cartridge to the pyrliometer body by means of a coin
- 7- Make sure the cartridge is screwed tight (or else the life of silica-gel crystal will be reduced)
- 8- the pyrliometer is ready for use

Figure 3 briefly explains the necessary steps to fill the cartridge with the silica-gel crystals.

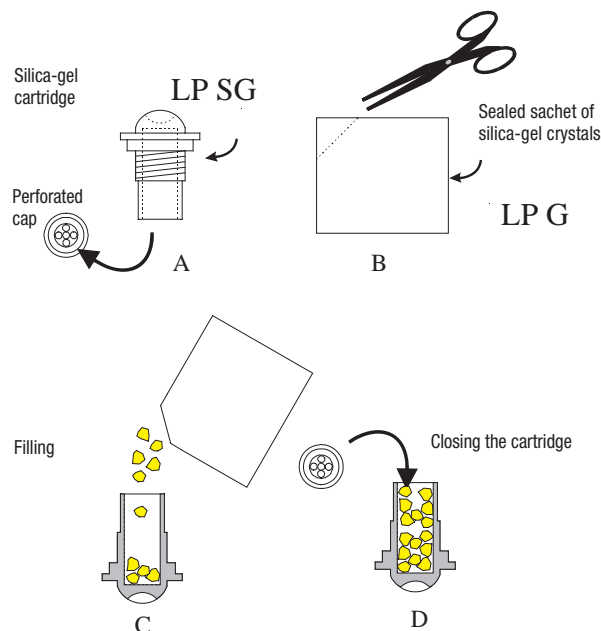


Fig. 3

LP PYRHE 16 should be mounted in an easily reachable place to allow periodic cleaning of the quartz window and maintenance. At the same time, make sure that no buildings, trees or any other obstacles intercept the sun's path during the day all year long.

To point the pyrliometer, the two holes in the front and back flange can be used. To properly align the instrument, just make sure that the sun's beams that pass through the first hole (on the front flange of the pyrliometer) reach the second hole (on the back flange).

Electric connections and electronic readout device requirements:

LP PYRHE 16 is produced in four versions: LP PYRHE 16, LP PYRHE 16 AC, LP PYRHE 16 AV, LP PYRA 16 S

- LP PYRHE 16 version is passive and requires no power supply.
- LP PYRHE 16 AC, AV, S versions are active and require power supply. The requested voltage is :
10-30 VDC for LP PYRHE 16 AC and LP PYRHE 16 AV versions with 0..1V and 0..5 V output.
15-30 VDC for LP PYRHE 16 AV version with 0..10V output.
5-30Vdc for version LP PYRHE 16 S with RS485 MODBUS-RTU output.
- All versions are provided with a 4-pole M12 output connector (8-poles for version S)
- The optional cable, with M12 connector at one end, is in UV-resistant PTFE, it is supplied with 3 wires plus shield, (4 wires plus shield for S version).



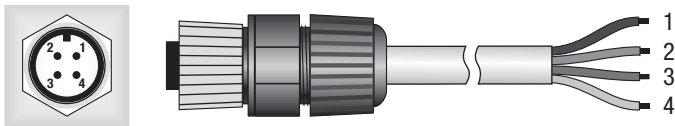


Fig. 4
LP PYRHE 16

Connector	Function	Color
1	Positive (+)	Red
2	Negative (-)	Blue
3	Housing (↗)	White
4	Shield (⊥)	Black

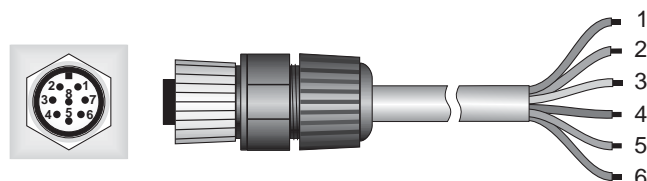
LP PYRHE 16 AC

Connector	Function	Color
1	Positive (+)	Red
2	Negative (-)	Blue
3	Shield (⊥)	White
4	Housing (↗)	Black

LP PYRHE 16 AV

Connector	Function	Color
1	(+) Vout	Red
2	(-) Vout and (-) Vcc	Blue
3	(+) Vcc	White
4	Shield (⊥)	Black

WIRING DIAGRAM LP PYRHE 16 S



Fixed 8-pole plug M12

Flying 8-pole M12

Connector	Function	Color
1	Negative power supply (-) Vcc	Black
2	Positive power supply (+) Vcc	Red
4	RS485 A/-	Brown
5	RS485 B/+	White
6	Not connected	Blue
8	Not connected	Green

- LP PYRHE 16 has to be connected either to a millivoltmeter or to a data acquisition system. Typically, the pyrheliometer output signal does not exceed 20 mV. In order to better exploit the pyrheliometer features, the readout instrument should have a 1μV resolution.

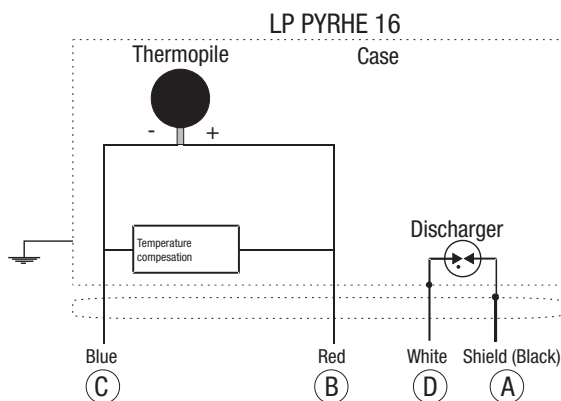


Fig. 5

An example of connection to a readout device is shown in figure 6.

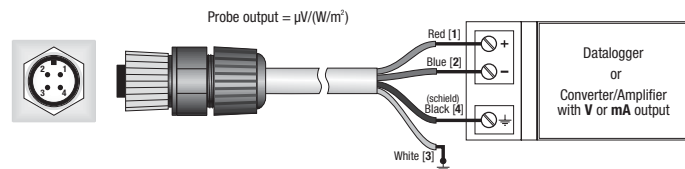


Fig. 6

- LP PYRHE 16 AC should be connected to a power supply device and to a multimeter according to the scheme below (figure 7), the load resistance for signal readout should be $\leq 500 \Omega$:

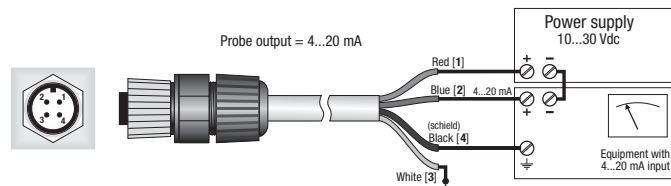


Fig. 7

- LP PYRHE 16 AV should be connected to a power supply device and to a multi-meter according to the scheme below (figure 8), the load resistance for signal readout should be $\geq 100 \text{ k}\Omega$:

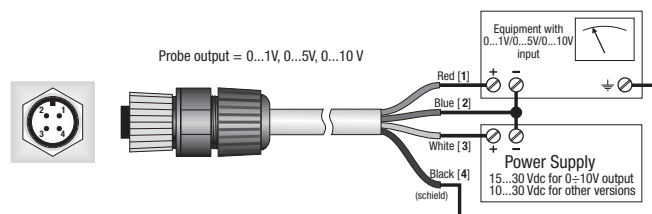


Fig. 8

- LP PYRHE 16 S should be connected according to the following scheme:

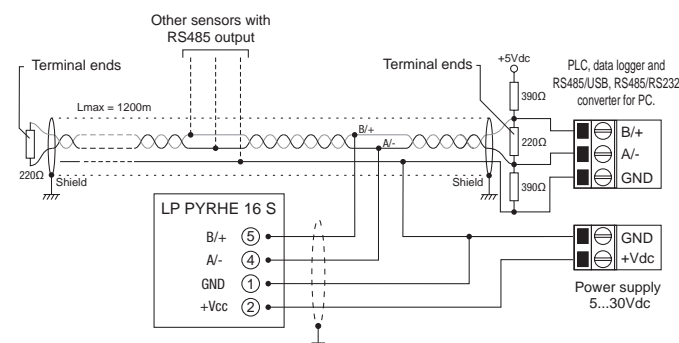


Fig. 9

Maintenance:

In order to grant high measuring accuracy, the quartz window should be kept always clean; consequently, the higher is the cleaning frequency, the more measurements will be accurate. Cleaning can be performed with standard lens paper and with water, or alternatively with pure ETHIL alcohol. After alcohol cleaning, the window must be washed again with water.

Due to thermal shocks between day and night, some condensation can form on the access window; in this case, the performed readout will be strongly underestimated. In order to reduce condensation forming, an apposite cartridge filled with absorbent material is introduced inside the pyrheliometer: Silica-gel. The efficiency of silica-gel crystals decreases with time while they absorb humidity. When silica-gel crystals are efficient, their color is **yellow**, while as they loose efficiency, they turn **white/translucent**; see instructions at paragraph 3 for replacement. Typically, silica-gel life varies from 4 to 12 months according to the environmental conditions the pyrheliometer operates in.

Calibration and Measurements:

LP PYRHE 16

The sensitivity **S** of the pyrheliometer (or calibration factor) allows to determine direct irradiance by measuring a signal in Volts at the thermopile ends. The **S** factor is given in $\mu\text{V}/(\text{W}/\text{m}^2)$.

- Once the difference of potential (DDP) has been measured at the ends of the probe, the E_g irradiance is obtained by applying the formula below:

$$E_g = \text{DDP}/S$$

where;

E_g : is the irradiance expressed in W/m^2 ,

DDP: is the difference of potential expressed in μV measured by the multimeter,

S: is the calibration factor in $\mu\text{V}/(\text{W}/\text{m}^2)$ shown on the pyrheliometer label (and mentioned in the calibration report).

LP PYRHE 16 AC

The sensitivity of the pyrheliometer is factory-set so that:

$$4..20 \text{ mA} = 0..2000 \text{ W}/\text{m}^2$$

In order to obtain the direct irradiance value, once the current (I_{out}) absorbed by the instrument is known, the formula below should be applied:

$$E_g = 125 \cdot (I_{\text{out}} - 4 \text{ mA})$$

where;

E_g : is the irradiance expressed in W/m^2 ,

I_{out} : is the mA current absorbed by the instrument

LP PYRHE 16 AV

The sensitivity of the pyrheliometer is factory-set so that, according to the chosen version, we have:

$$0..1 \text{ V} = 0..2000 \text{ W}/\text{m}^2$$

$$0..5 \text{ V} = 0..2000 \text{ W}/\text{m}^2$$

$$0..10 \text{ V} = 0..2000 \text{ W}/\text{m}^2$$

In order to obtain the irradiance value, once the instrument output voltage (V_{out}) is obtained, the formula below should be applied:

$$E_g = 2000 \cdot V_{\text{out}} \text{ for } 0..1 \text{ V version}$$

$$E_g = 400 \cdot V_{\text{out}} \text{ for } 0..5 \text{ V version}$$

$$E_g = 200 \cdot V_{\text{out}} \text{ for } 0..10 \text{ V version}$$

where;

E_g : is the irradiance expressed in W/m^2 ,

V_{out} : is the output voltage (in Volts) measured with a Voltmeter

Each Pyrheliometer is factory calibrated and typified by its own calibration factor. To fully exploit all LP PYRHE 16 features it is recommended to perform an annual calibration check.

The equipment of the DeltaOhm Photo-Radiometry metrological laboratory allows to calibrate pyrheliometers according to WMO specifications and makes measurements referable to the international standards (WRR).

Technical Specifications:

Typical sensitivity: $5 \mu\text{V}/(\text{W}/\text{m}^2)$ LP PYRHE 16, LP PYRA 16 S
 $4..20 \text{ mA}$ (0-2000 W/m^2) LP PYRHE 16 AC
 $0..1, 5, 10 \text{ V}$ (0-2000 W/m^2) LP PYRHE 16 AV

Impedance: $5 \Omega \div 50 \Omega$

Measuring range: 0-2000 W/m^2

Field of view: 5° (slope 1°)

Spectral range: $200 \text{ nm} \div 4000 \text{ nm}$ (50%)

Working Temperature: $-40^\circ \text{C} \div 80^\circ \text{C}$

Dimensions: figure 1

Weight: 1.5 Kg



Technical Specifications according to ISO 9060

1	Response time (95%):	<9 sec
2	Zero Off-set:	
	response to ambient temperature change of 5K/h:	< ± 3 W/m^2
3a	long term instability (1 year):	< ± 1 %
3b	Non-linearity:	< ± 0.5 %
3d	Spectral selectivity:	< ± 1 %
3e	Response depending on Temperature:	< ± 2 %
3f	Response depending on Tilt:	< ± 0.5 %

Ordering codes

LP PYRHE 16 : First class Pyrheliometer according to ISO 9060. Equipped with: light shield, cartridge for silica-gel crystals, 3 refills, 4-pole M12 connector and Calibration Report.

LP PYRHE 16 AC: First class Pyrheliometer according to ISO 9060. Equipped with: light shield, cartridge for silica-gel crystals, 3 refills, 4-pole M12 connector and Calibration Report. Current signal output 4..20 mA.

LP PYRHE 16 AV: First class Pyrheliometer according to ISO 9060. Equipped with: light shield, cartridge for silica-gel crystals, 3 refills, 4-pole M12 connector and Calibration Report. Voltage signal output 0..1Vdc, 0..5Vdc, 0..10Vdc, to be defined at the time of the order.

LP PYRHE 16 S: First class Pyrheliometer according to ISO 9060. Equipped with: light shield, cartridge for silica-gel crystals, 3 refills, 8-pole M12 connector and Calibration Report.

CPM12 AA 4.2: 4-pole M12 connector complete with UV-resistant cable, L=2 meters

CPM12 AA 4.5: 4-pole M12 connector complete with UV-resistant cable, L=5 meters

CPM12 AA 4.10: 4-pole M12 connector complete with UV-resistant cable, L=10 meters

CPM12 AA 8P.2: 8-pole cable, L=2 meters, M12 8-pole connector on one end and free wires on the other. Only or LP PYRHE 16 S.

CPM12 AA 8P.5: 8-pole cable, L=5 meters, M12 8-pole connector on one end and free wires on the other. Only or LP PYRHE 16 S.

CPM12 AA 8P.10: 8-pole cable, L=10 meters, M12 8-pole connector on one end and free wires on the other. Only or LP PYRHE 16 S.

CP24: PC connecting cable for the RS485 MODBUS-RTU parameters configuration of the LP PYRHE 16 S. With built-in RS485/USB converter. 8-pole M12 connector on instrument side and A-type USB connector on PC side. With CD-ROM including the USB drivers and a software for the Modbus connection to PC.

Kit 16.16: Kit consisting of revolving filter wheel (5positions) with 3 Shott filters (OG530, RG630, RG695), light shield and accessories to fix the wheel to the pyrheliometer.

