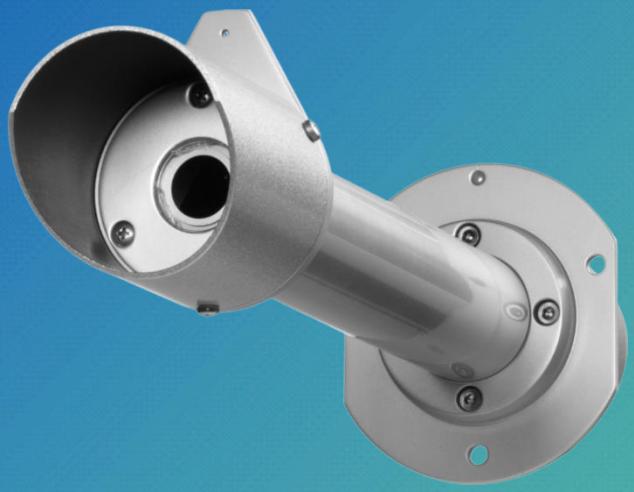
OPERATING MANUAL

LPPYRHE16 series

Pyrheliometers



EN

V2.4

senseca

Contents

1 Introduction

LPPYRHE16 series pyrheliometers measure direct solar irradiance (W/m^2).

The receiving surface must be positioned perpendicularly to sun's rays, via a solar tracker or else.

LPPYRHE16 series falls within the **Spectrally Flat Class B** pyrheliometers according to ISO 9060:2018 standard and meets the requirements of the WMO "Guide to Instruments and Methods of Observation".

The pyrheliometer has a field of view of 5°, in accordance with ISO 9060:2018 standard and WMO guide.

The various models are distinguished by the type of output available:

	Output	
Model	**Digital RS485 Modbus-RTU**	**Analog**
LPPYRHE16	--	mV
LPPYRHE16AC	--	2-wire (current loop) 4…20 mA
LPPYRHE16ACS	√	4…20 mA
LPPYRHE16AV		0…10 V
LPPYRHE16AV1	--	0…1 V
LPPYRHE16AV5	--	0…5 V
LPPYRHE16S	√	--

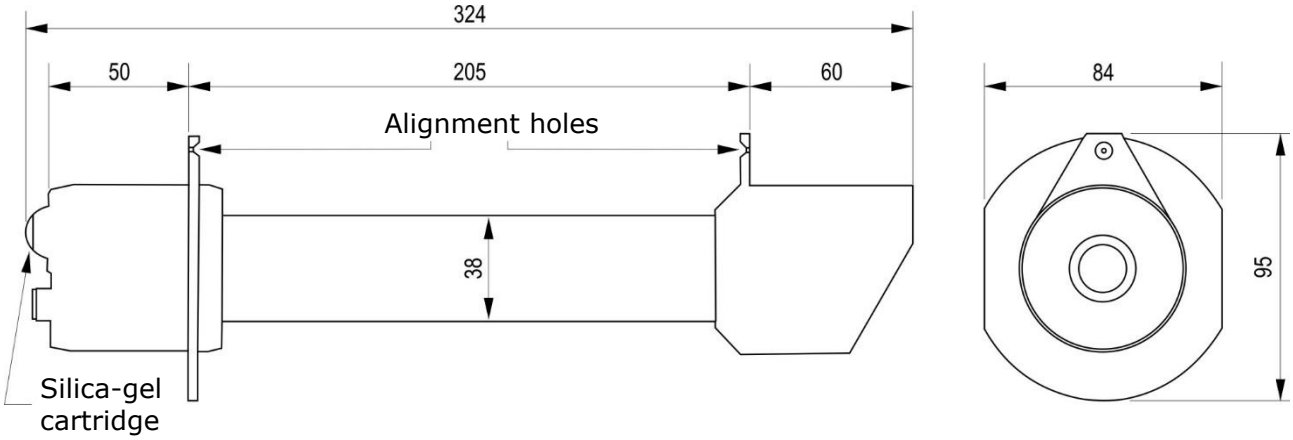
The irradiance range for the analog output is 0…2000 W/m^2.

The pyrheliometers are factory calibrated and supplied with a calibration report.

2 Technical specifications

Sensor	Thermopile
Typical sensitivity	5 µV/Wm-$^{-2}$
Measuring range	0…2000 W/m^2
Viewing angle	5° (slope 1°)
Spectral range (50%)	200…4000 nm
Output LPPYRHE16 LPPYRHE16AC LPPYRHE16ACS LPPYRHE16AV LPPYRHE16AV1 LPPYRHE16AV5 LPPYRHE16S	Passive in mV 2-wire (current loop) 4…20 mA RS485 Modbus-RTU + analog 4…20 mA 0…10 V 0…1 V 0…5 V RS485 Modbus-RTU
Power supply	5…30 Vdc for RS485 output 10…30 Vdc for analog output (except 0…10 V) 15…30 Vdc for 0…10 V output
Connection	4 or 8-pole M12 depending on model
Operating temperature/humidity	-40…+80 °C / 0…100 %RH
Dimensions	Fig. 3.2
Weight	1.5 kg approx.
Material	Aluminium

Dimensions (mm)



Technical Specifications According to ISO 9060:2018

Classification	Spectrally Flat Class B
Response time (95%)	< 9 s
Zero offset in response to a 5 K/h change in ambient temperature	< |±3| W/m^2
Long-term instability (1 year)	< |±1| %
Non-linearity	< |±0.5| %
Spectral error	< |±0.8| %
Temperature response	< |±2| %
Tilt response	< |±0.5| %

3 Measuring principle

The pyrheliometer is based on a thermopile sensor. The sensitive surface of the thermopile is coated with a matt black paint, which makes the pyrheliometer 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 non-selective measurement from 200 to 4000 nm.

The adopted sensor allows the response time to be lower than ISO 9060:2018 requirements for the classification of class B pyrheliometers (the response time is under 9 seconds while the standard requires a response time lower than 15 seconds).

Radiant energy is absorbed by the blackened surface of the thermopile, thus creating a difference in temperature between the hot junction and the body 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 class B pyrheliometer, the pyrheliometer is provided with a passive compensation circuit. Figure 3.1 shows the typical variation of sensitivity at different temperatures. Deviations are calculated starting from sensitivity measured at 20 °C.

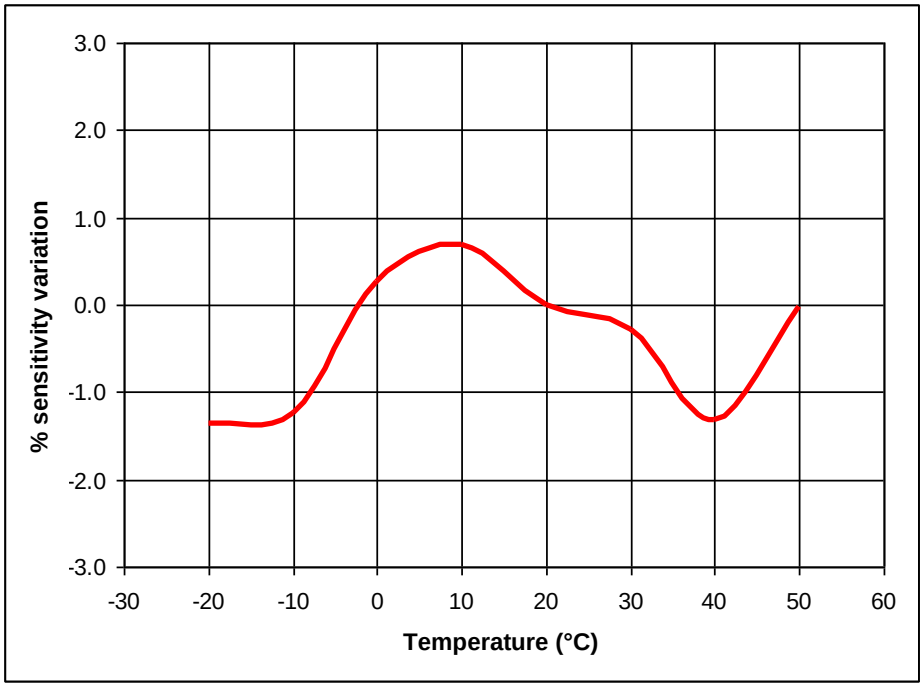


Fig. 3.1: % variation of sensitivity of the LPPYRHE16 pyrheliometer with regard to sensitivity at 20 °C in the temperature range from -20 to 50 °C

LPPYRHE16 is a sealed instrument, for that reason a cartridge of silica-gel crystals is provided to absorb humidity inside the instrument, in order to prevent condensation from forming on the quartz window of the instrument, invalidating the performed measurements.

In accordance with WMO regulations, the angular field of view is 5° and the slope angle is 1° (figure 3.2).

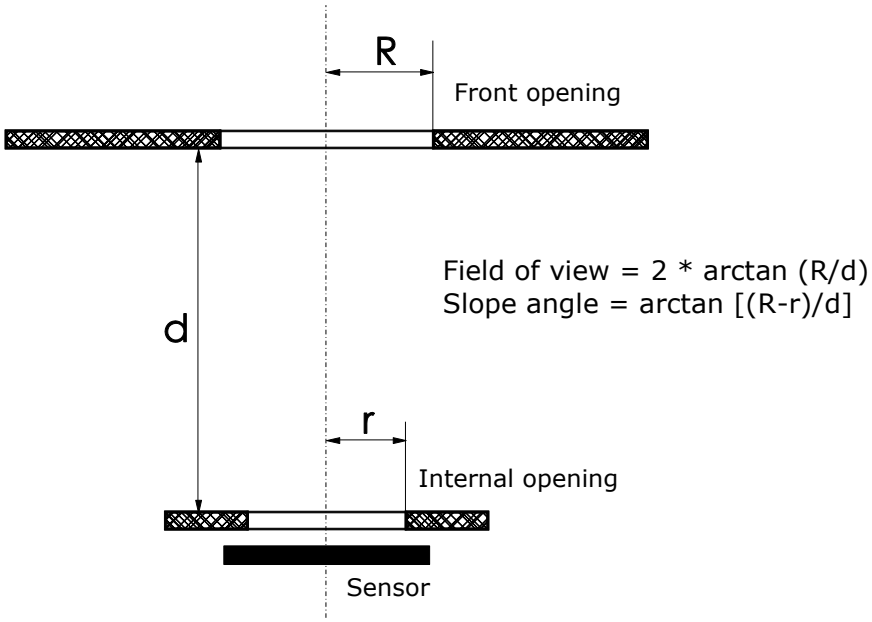


Fig. 3.2: field of view and slope angle

A light shield can be insert, in order to reduce light scattering contribution.

4 Installation

Before installing the pyrheliometer, refill the cartridge containing silica-gel crystals. Silica gel absorbs humidity inside the instrument and prevents, in particular climatic conditions, condensation on the internal wall of the quartz window and measurement alteration.

Do not touch the silica gel crystals with your hands while refilling the cartridge. Carry out the following instructions in an environment as drier as possible:

1. Unscrew the silica gel cartridge using a coin.
2. Remove the cartridge perforated cap.
3. Open the sachet containing silica gel (supplied with the pyrheliometer).
4. Fill the cartridge with the silica gel crystals.
5. Close the cartridge with its own cap, paying attention that the sealing O-ring be properly positioned.
6. Screw the cartridge to the pyrheliometer body using a coin.
7. Check that the cartridge is screwed tightly (if not, silica gel life will be reduced).
8. The pyrheliometer is ready for use.

The figure below shows the operations necessary to fill the cartridge with the silica gel crystals.

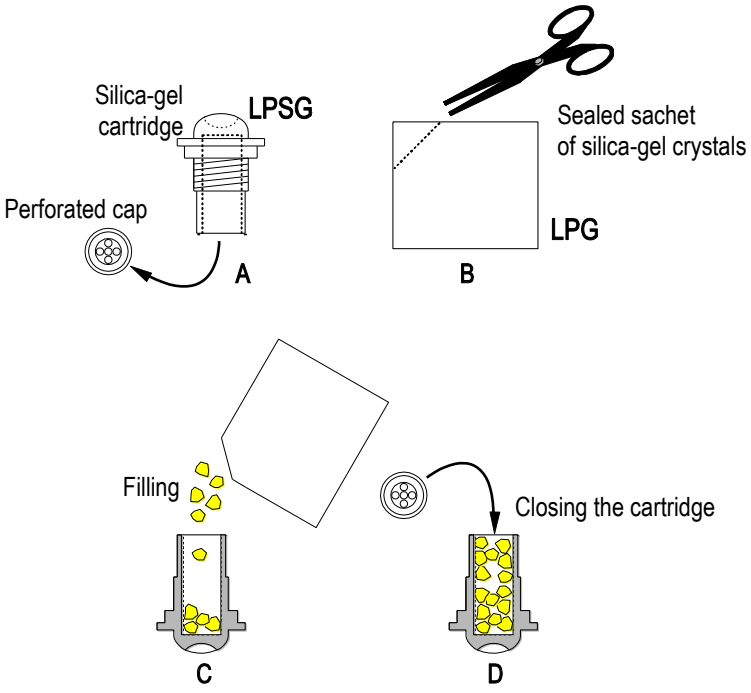


Fig. 4.1: filling the silica-gel cartridge

- The pyrheliometer must be mounted in an easy-to-reach location in order to clean the quartz window regularly and carry out maintenance. At the same time, make sure that no buildings, constructions, trees or obstructions intercept the sun's path during the day all year long.
- To point the pyrheliometer, the two holes in the front and back flange (see figure on page 4) are 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 pyrheliometer) reach the second hole (on the back flange).

4.1 Electrical connections

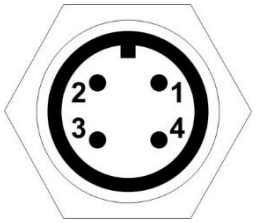
Warning!

> The metallic housing of the pyrheliometer should preferably be grounded locally. Do not connect the wire corresponding to the housing to ground, unless it is not possible to ground the pyrheliometer metallic housing locally via the support mast.

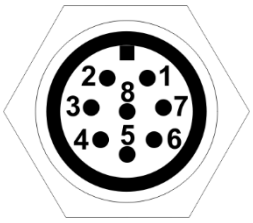
Internally there are surge protection devices connected to the housing. Grounding the housing allows the correct protection functionality of the devices.

Connector pinout:

LPPYRHE16 / LPPYRHE16AC / LPPYRHE16AVx

Pyrheliometer male connector (external view)		Function			CPM12AA4... wire color
		LPPYRHE16	LPPYRHE16AC	LPPYRHE16AVx	
	1	+Vout	Iin (+)	+Vout	Red
	2	-Vout	Iout (-)	GND	Blue
	3	Housing	Housing	+Vdc	White
	4	Cable shield	Cable shield	Cable shield	Black

LPPYRHE16S

Pyrheliometer male connector (external view)		Function	CPM12-8D... wire color
	1	GND (Power supply negative)	Blue
	2	+Vdc (Power supply positive)	Red
	3	NC	
	4	DATA – (RS485)	Brown
	5	DATA + (RS485)	White
	6	Housing / Cable shield	Black
	7	NC	
	8	NC	

LPPYRHE16ACS

Pyrheliometer male connector (external view)		Function	CPM12-8D… wire color
	1	GND (Power supply negative)	Blue
	2	+Vdc (Power supply positive)	Red
	3	SGND (Analog and digital ground)	Black
	4	DATA – (RS485)	Brown
	5	DATA + (RS485)	White
	6	Housing / Cable shield	Black (thick wire)
	7	AOUT (Analog output positive)	Green
	8	NC	

NC = Not connected

LPPYRHE16 connections:

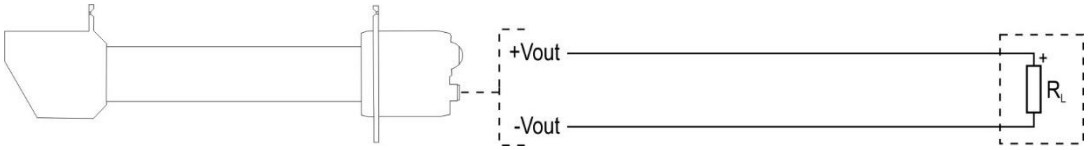


Fig. 4.2: LPPYRHE16 connection diagram

The pyrheliometer does not require power supply. The typical output impedance of the sensor is <50 Ω.

The output signal typically does not exceed a few mV. The recommended resolution of the reading instrument is 1 μV.

Connect the cable shield to the ground of the reading instrument.

LPPYRHE16AC connections:

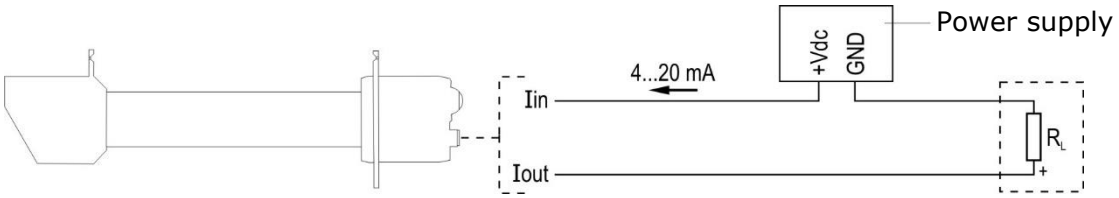


Fig. 4.3: LPPYRHE16AC connection diagram

Pyrheliometer power supply: 10…30 Vdc. Load resistance $R_L \leq 500$ Ω.

Connect the cable shield to the ground of the reading instrument.

In the event of an anomaly in the measurement (detected measurement outside the measuring range), the output goes to 22 mA.

LPPYRHE16AVx connections:

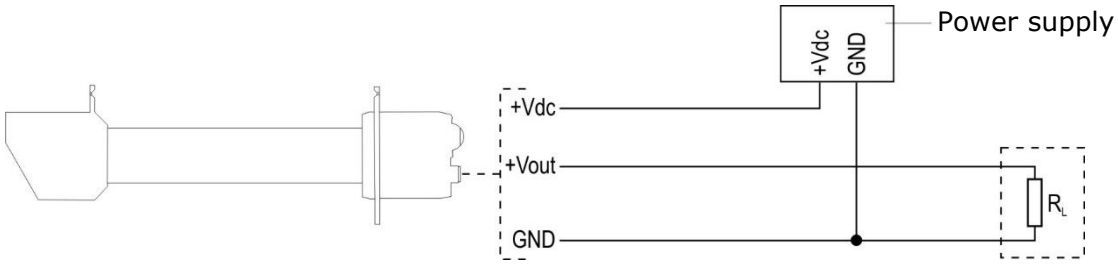


Fig. 4.4: LPPYRHE16AVx connection diagram

Pyrheliometer power supply: 10…30 Vdc for 0…1 V and 0…5 V outputs, 15…30 Vdc for 0…10 V output. Load resistance $R_L \geq 100$ kΩ.

Connect the cable shield to the ground of the reading instrument.

In the event of an anomaly in the measurement (detected measurement outside the measuring range), the output goes to a value 10% higher than the full scale (e.g., 11 V if the output is 0...10 V).

LPPYRHE16S connections:

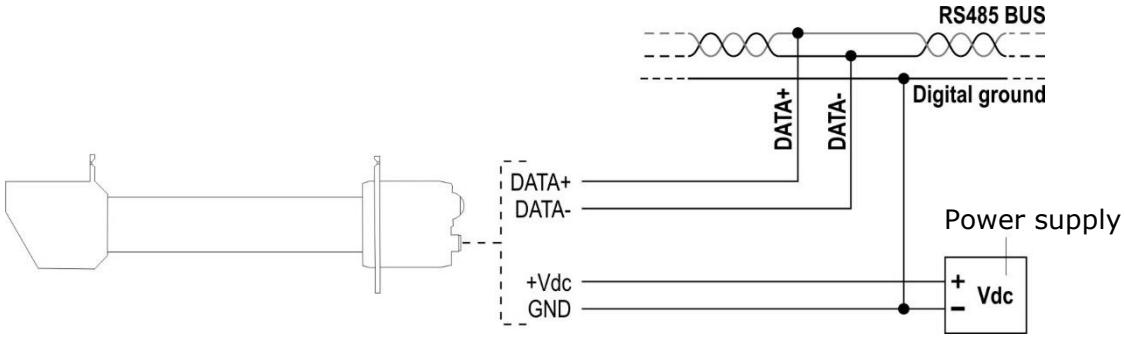


Fig. 4.5: LPPYRHE16S connection diagram

Pyrheliometer power supply: 5…30 Vdc

The RS485 output is not isolated. Before connecting the pyrheliometer to the RS485 network, set the address and the communication parameters, if different from the factory preset (see "Configuration" chapter).

LPPYRHE16ACS connections:

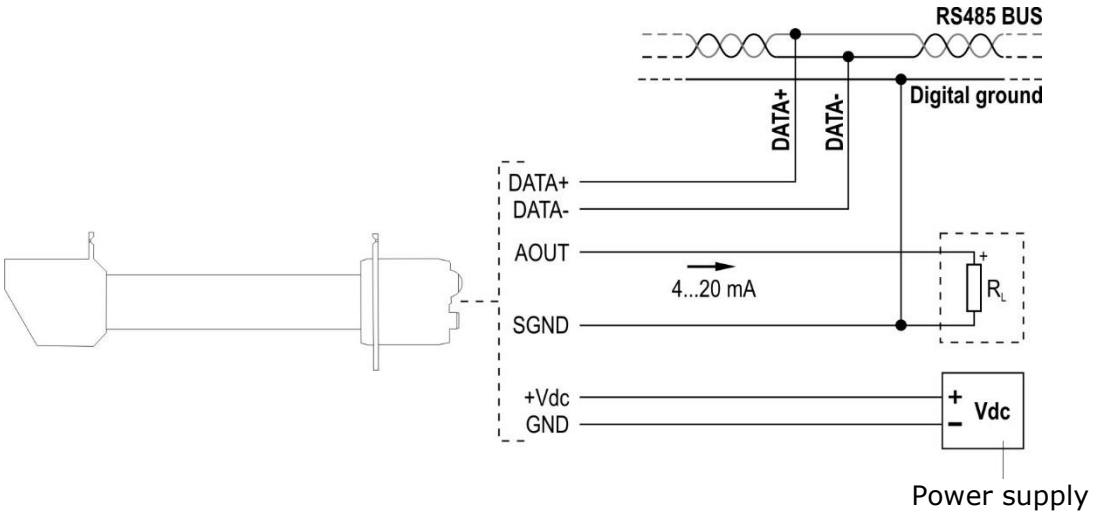


Fig. 4.6: LPPYRHE16ACS connection diagram

Pyrheliometer power supply: 5…30 Vdc for the RS485 output, 10…30 Vdc for the analog output.

The RS485 output is not isolated. Before connecting the pyrheliometer to the RS485 network, set the address and the communication parameters, if different from the factory preset (see "Configuration" chapter).

The analog output is 4…20 mA, load resistance $R_L \leq 500\ \Omega$. In the event of an anomaly in the measurement (detected measurement outside the measuring range), the output goes to 22 mA.

5 LPPYRHE16[AC]S configuration

Before connecting the pyrheliometer to the RS485 network, an address must be assigned and the communication parameters must be set, if different from the factory preset.

By default, the instrument has Modbus address **1** and communication parameters 19200, 8E1.

Connection to PC:

To connect the pyrheliometer to a PC USB port, to check or change the configuration, the **CP24** optional cable can be used, which also allows the pyrheliometer to be powered via the USB port.

To use the CP24 cable, the related USB drivers must be installed in the PC.

Alternatively, it is possible to use a standard RS485/USB or RS485/RS232 converter, powering the pyrheliometer separately.

Procedure:

1. Connect the pyrheliometer to the PC and start a standard serial communication program.
2. In the serial communication program, set the Baud Rate 57600, the parameters 8N2 and the COM port number to which the pyrheliometer is connected.
3. Power the pyrheliometer (or power cycle if already powered) and send the command **@** within 10 seconds from the instrument power on (the pyrheliometer replies **&|** if the command @ is recognized).

   Note: if the CP24 cable is used, to power cycle the pyrheliometer, disconnect the cable for a few seconds from the PC USB port, then reconnect it.
4. Send the command **CAL USER ON** to enable the configuration change. The command CAL USER ON is not required only for reading the settings.
5. Send the commands described in the table below.

The command CAL USER ON is automatically disabled after a few minutes of inactivity. The command CAL USER ON can be disabled immediately by sending the command CAL EXIT.

Command	Reply	Description
CMAn	&|	Sets the Modbus-RTU address (1…247) to n. Default=1
RMA	*Address*	Reads the Modbus-RTU address.
CMBn	&|	Sets the Baud Rate: ▪ 9600 if n=0 ▪ 19200 if n=1 (*default*) ▪ 38400 if n=2 ▪ 57600 if n=3 ▪ 115200 if n=4
RMB	*Baud Rate index*	Reads Baud Rate setting.
CMPn	&|	Sets parity and stop bits (data bits = 8 fixed): ▪ 8N1 if n=0 ▪ 8N2 se n=1 ▪ 8E1 if n=2 (*default*) ▪ 8E2 se n=3 ▪ 8O1 if n=4 ▪ 8O2 se n=5

Command	Reply	Description
RMP	*Parity and stop bits index*	Reads the setting of parity and stop bits.
CMWn	&|	Sets waiting time after transmission with Modbus-RTU protocol: ▪ Immediate reception if n=0 (violates protocol) ▪ Waiting 3.5 characters if n=1 (respects protocol) *Default* : Waiting 3.5 characters (n=1)
RMW	*Waiting time index*	Reads the setting of waiting time after transmission with Modbus-RTU protocol.

6 Modbus-RTU protocol

The Modbus-RTU protocol is active after a few seconds from the sensor power on.

Below is the list of registers.

Input Registers:

Address	Description	Format
0	Internal temperature in °C (x10)	16-bit Integer
1	Internal temperature in °F (x10)	16-bit Integer
2	Irradiance in W/m^2	16-bit Integer
3	Status register: bit0=1 ⇒ irradiance measurement error bit2=1 ⇒ configuration data error bit3=1 ⇒ program memory error	16-bit Integer
4	Average values of the last 4 irradiance measurements	16-bit Integer
5	Signal generated by the sensor in µV/10 (e.g., 816 means 8160 µV, the resolution is 10 µV)	16-bit Integer

7 Measurement with analog output

LPPYRHE16:

Each pyrheliometer is distinguished by its own sensitivity (or calibration factor) ***S*** expressed in μV/(Wm^{-2}), shown in the label on the pyrheliometer and in the calibration report.

The irradiance E_e is obtained by measuring with a multimeter the difference of potential ***DDP*** at the ends of the sensor and applying the following formula:

$$E_e = DDP / S$$

where:

E_e is the irradiance expressed in W/m^2;

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

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

LPPYRHE16AC:

The 4…20 mA output signal corresponds to the 0…2000 W/m^2 irradiance range.

The irradiance E_e is obtained by measuring with a multimeter the current I_{out} absorbed by the sensor and applying the following formula:

$$E_e = 125 \cdot (I_{out} - 4)$$

where:

E_e is the irradiance expressed in W/m^2;

I_{out} is the current expressed in mA absorbed by the pyrheliometer.

LPPYRHE16AVx:

The output signal (0…1 V, 0…5 V or 0…10 V depending on the model) corresponds to the 0…2000 W/m^2 irradiance range.

The irradiance E_e is obtained by measuring with a multimeter the output voltage V_{out} of the sensor and applying the following formula:

$E_e = 2000 \cdot V_{out}$ for LPPYRHE16AV1 (0…1 V output)

$E_e = 400 \cdot V_{out}$ for LPPYRHE16AV5 (0…5 V output)

$E_e = 200 \cdot V_{out}$ for LPPYRHE16AV (0…10 V output)

where:

E_e is the irradiance expressed in W/m^2;

V_{out} is the output voltage expressed in V measured by the multimeter.

8 Maintenance

In order to grant measurements high accuracy, it is important to keep the quartz window 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 window with water only.

To minimize condensation and keep measurements accurate, a cartridge of desiccant silica-gel is provided inside the pyrgeometer to absorb moisture. The efficiency of silica-gel decreases over time while absorbing humidity. Silica-gel crystals are efficient when their color is **yellow**, while they turn **white/translucent** as soon as they lose their efficiency. To replace silica-gel crystals, see chapter 4. Silica-gel typical lifetime goes from 2 to 6 months depending on the environment where the pyrheliometer operates.

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

9 Safety instructions

The pyrheliometer 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.

10 Accessories ordering codes

The pyrgeometer is supplied with light shade, sylica-gel cartridge, 3 spare sachets, M12 female free connector (only if the optional cable is not ordered) and calibration report.

The cables must be ordered separately.

Installation cables

CPM12AA4...	Cable with 4-pole M12 connector on one end, open wires on the other end. Length 5 m (CPM12AA4.5) or 10 m (CPM12AA4.10). **For LPPYRHE16, LPPYRHE16AC and LPPYRHE16AVx.**
CPM12-8D...	Cable with 8-pole M12 connector on one end, open wires on the other end. Length 5 m (CPM12-8D.5) or 10 m (CPM12-8D.10). **For LPPYRHE16S.**
CPM12-8DA...	Cable with 8-pole M12 connector on one end, open wires on the other end. Length 5 m (CPM12-8DA.5) or 10 m (CPM12-8DA.10). **For LPPYRHE16ACS.**

PC connecting cables

CP24	PC connecting cable for the configuration of the pyrheliometer. With built-in RS485/USB converter. 8-pole M12 connector on sensor side and A-type USB connector on PC side. **For LPPYRHE16S and LPPYRHE16ACS**.

Spare parts

LPG	Silica-gel (5 sachets).
LPSG	Cartridge to contain desiccant silica-gel crystals, complete with O-

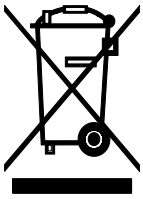
WARRANTY

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.

CE RoHS

senseca.com

Senseca Italy S.r.l.
Via Marconi, 5
35030 Selvazzano Dentro (PD)
ITALY
info@senseca.com