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English

Operating manual

Pyranometer

LPPYRHE16

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TABLE OF CONTENTS

1 INTRODUCTION

The pyrheliometer LPPYRHE16 measure the direct solar irradiance (W/m^2).

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

LPPYRHE16 is a B class pyrheliometer in accordance with ISO 9060:2018 standard and with the criteria of the WMO "Guide to Meteorological Instruments and Methods of Observation'", seventh edition (2008).

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

The pyrheliometer is available in the following versions:

- **LPPYRHE16**: PASSIVE.
- **LPPYRHE16AC**: ACTIVE with 4..20 mA CURRENT output (0…2000 W/m^2).
- **LPPYRHE16ACS**: ACTIVE with 4..20 mA CURRENT output (0…2000 W/m^2) and RS485 Modbus-RTU output.
- **LPPYRHE16AV**: ACTIVE with 0..1 or 0..5 or 0..10 V VOLTAGE output (0…2000 W/m^2) to be defined when ordering.
- **LPPYRHE16S**: With RS485 Modbus-RTU output.

The pyrheliometer is supplied factory calibrated and with a calibration report.

2 WORKING PRINCIPLE

The pyrheliometer LPPYRHE16 is based on a passive 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 nm 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, LPPYRHE16 is provided with a passive compensation circuit. Figure 2.1 shows the typical variation of sensitivity at different temperatures. Deviations are calculated starting from sensitivity measured at 20 °C.

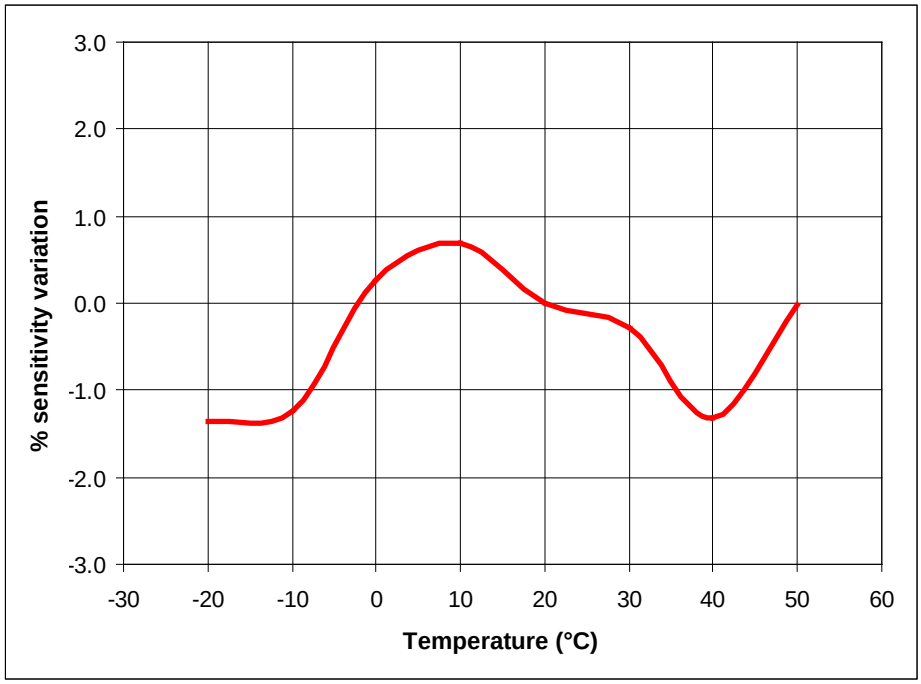


Fig. 2.1: % variation of sensitivity of the LPPYRHE16 pyrheliometer with regard to sensitivity at 20 °C in the temperature range from -20 to 50 °C

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 1).

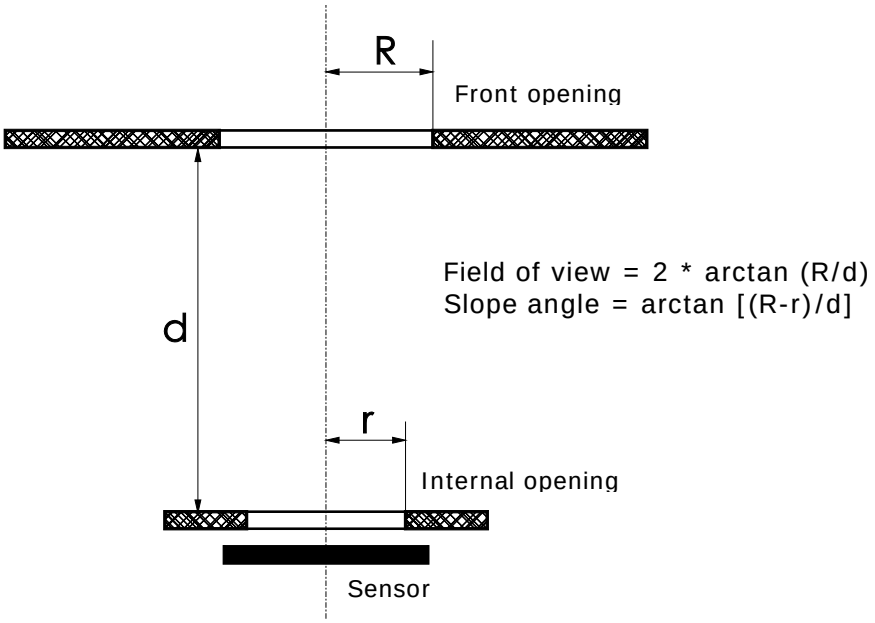


Fig. 2.2: field of view and slope angle

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

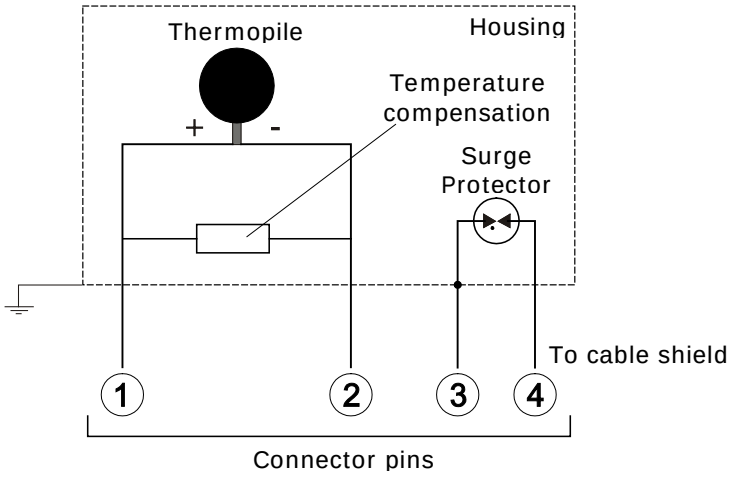


Fig. 2.3: scheme of principle LPPYRHE16 (version with mV output)

3 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.

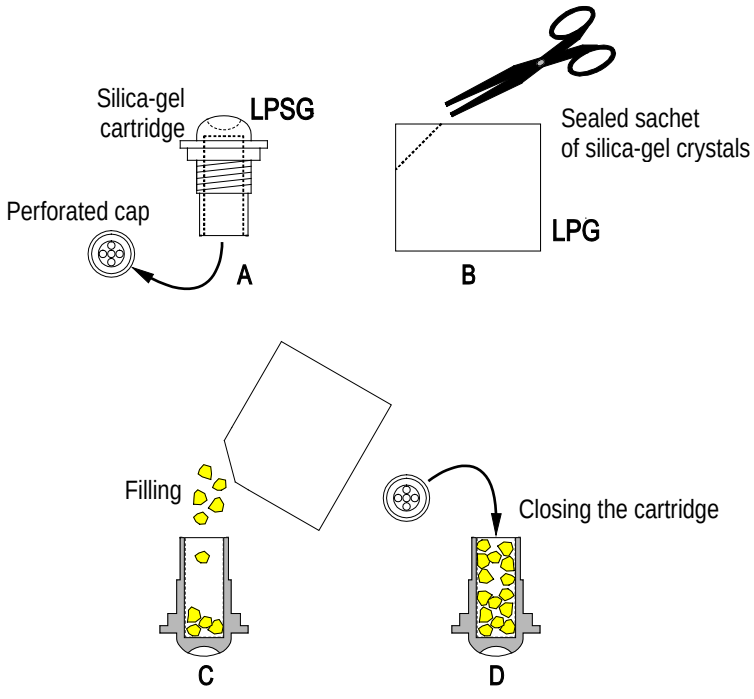


Fig. 3.1: filling the silica-gel cartridge

- 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 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).

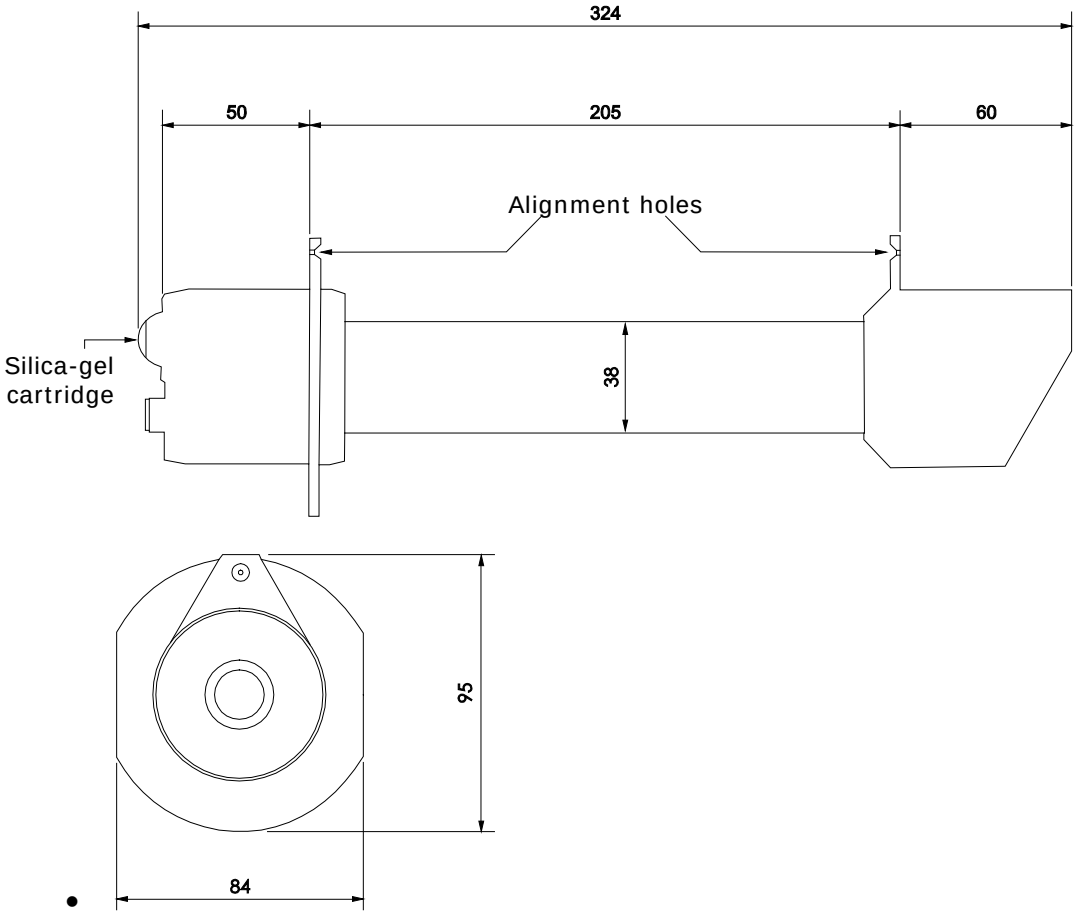


Fig. 3.2: description and dimensions in mm

4 ELECTRICAL CONNECTIONS

LPPYRHE16, **LPPYRHE16AC** and **LPPYRHE16AV** have a 4-pole connector and use the **CPM12AA4... optional** cables.

LPPYRHE16S and **LPPYRHE16ACS** have a 8-pole connector. **LPPYRHE16S** uses the **CPM12-8D... optional** cables, while **LPPYRHE16ACS** uses the **CPM12-8DA... optional** cables.

The metallic housing of the pyrheliometer should preferably be grounded (⏚) locally. In this case, do not connect the wire of the cable corresponding to the housing to prevent ground loops.

Only if it is not possible to ground locally the metallic case of the pyrheliometer, connect the wire of the cable corresponding to the housing to ground (⏚).

In the powered versions, internally there are surge protection devices connected to the housing. Grounding the housing allows the correct protection functionality, in particular against lightning.

4.1 LPPYRHE16 CONNECTIONS

The pyrheliometer LPPYRHE16 is passive and does not require power supply. It is to be connected either to a millivoltmeter or to a data acquisition system. Typically, the pyranometer output signal does not exceed 20 mV. In order to better exploit the pyrheliometer features, the readout instrument should have 1 μV resolution.

Connector	Function	Color
1	Vout (+)	Red
2	Vout (-)	Blue
3	Housing (C)	White
4	Cable shield (SH)	Black

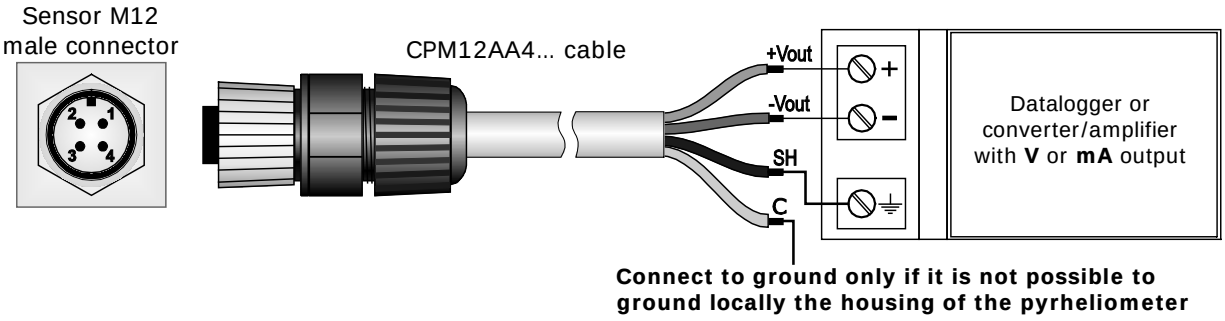


Fig. 4.1: LPPYRHE16 connections

4.2 LPPYRHE16AC CONNECTIONS

The pyrheliometer LPPYRHE16AC has **4…20 mA** output and requires **10…30 Vdc** external power supply. It is to be connected to a power supply and an instrument with 4…20 mA input as shown in fig. 4.2. The load resistance of the instrument reading the signal must be **≤ 500 Ω**.

Connector	Function	Color
1	Positive (Iin)	Red
2	Negative (Iout)	Blue
3	Housing (C)	White
4	Cable shield (SH)	Black

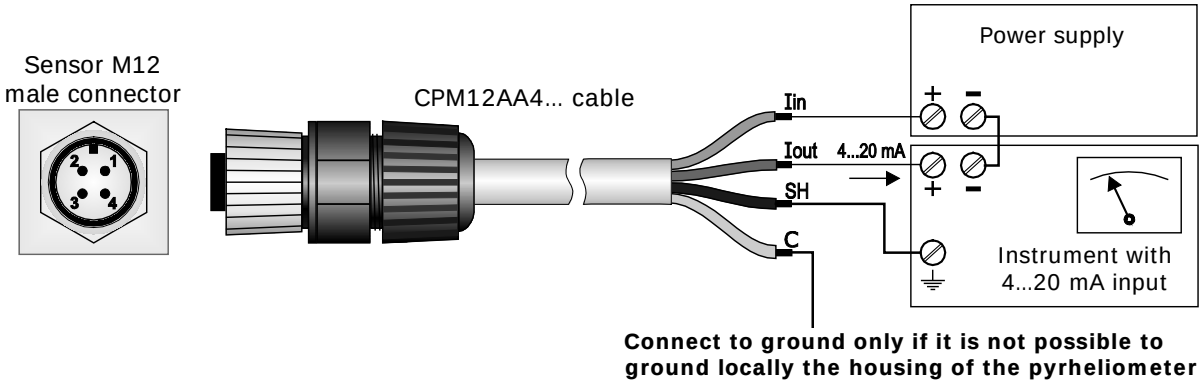


Fig. 4.2: LPPYRHE16AC connections

4.3 LPPYRHE16AV CONNECTIONS

The pyrheliometer LPPYRHE16AV has **0…1 V**, **0…5 V** or **0…10 V** output (depending on the ordered output) and requires external power supply: **10…30 Vdc** for 0…1 V and 0…5 V outputs, **15…30 Vdc** for 0…10 V output. It is to be connected to a power supply and an instrument with voltage input as shown in fig. 4.3. The load resistance of the instrument reading the signal must be **≥ 100 kΩ**.

Connector	Function	Color
1	Output positive (+Vout)	Red
2	Output negative Power supply negative (GND)	Blue
3	Power supply positive (+Vdc)	White
4	Cable shield (SH)	Black

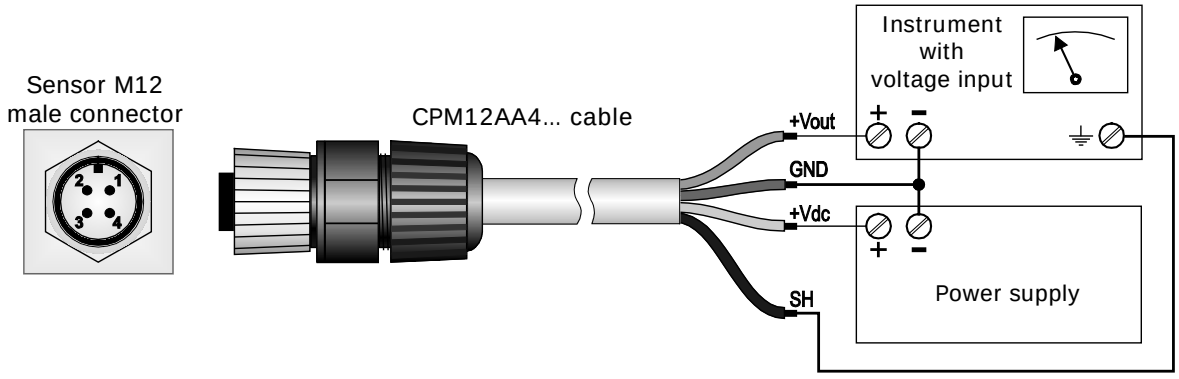


Fig. 4.3: LPPYRHE16AV connections

4.4 LPPYRHE16S CONNECTIONS

The pyrheliometer LPPYRHE16S has **RS485 Modbus-RTU** output and requires **5...30 Vdc** external power supply. It is to be connected to a power supply and to a PLC, a data logger or a RS485/USB or RS485/RS232 converter for PC as shown in fig. 4.4. The RS485 output is not isolated.

Connector	Function	Color
1	Power supply negative (GND)	Blue
2	Power supply positive (+Vdc)	Red
3	Not connected	
4	RS485 A/-	Brown
5	RS485 B/+	White
6	Housing / Cable shield (SH)	Black
7	Not connected	
8	Not connected	

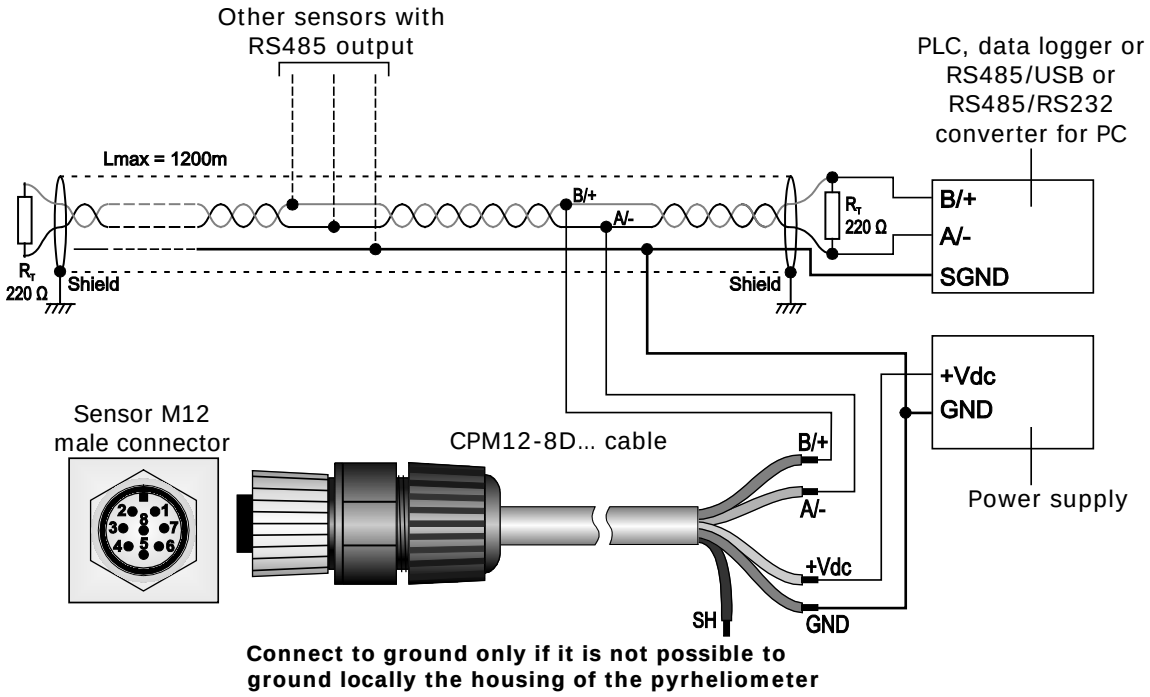


Fig. 4.4: LPPYRHE16S connections

Before connecting the pyrheliometer to the RS485 network, set the address and the communication parameters, if different from the factory preset (see chapter 6).

4.5 LPPYRHE16ACS CONNECTIONS

The pyrheliometer LPPYRHE16ACS has two outputs:

- One **4…20 mA** output, requiring **10…30 Vdc** external power supply. It is to be connected to a power supply and an instrument with 4…20 mA input as shown in fig. 4.6. The load resistance of the instrument reading the signal must be **≤ 500 Ω**.
- One **RS485 Modbus-RTU** output, requiring **5…30 Vdc** external power supply. It is to be connected to a power supply and to a PLC, a data logger or a RS485/USB or RS485/RS232 converter for PC as shown in fig. 4.5. The RS485 output is not isolated.

Connector	Function	Color
1	Power supply negative (GND)	Blue
2	Power supply positive (+Vdc)	Red
3	Digital and analog ground (SGND)	Black
4	RS485 A/-	Brown
5	RS485 B/+	White
6	Housing / Cable shield (SH)	Black (thick wire)
7	Analog output positive (AOUT)	Green
8	Not connected	

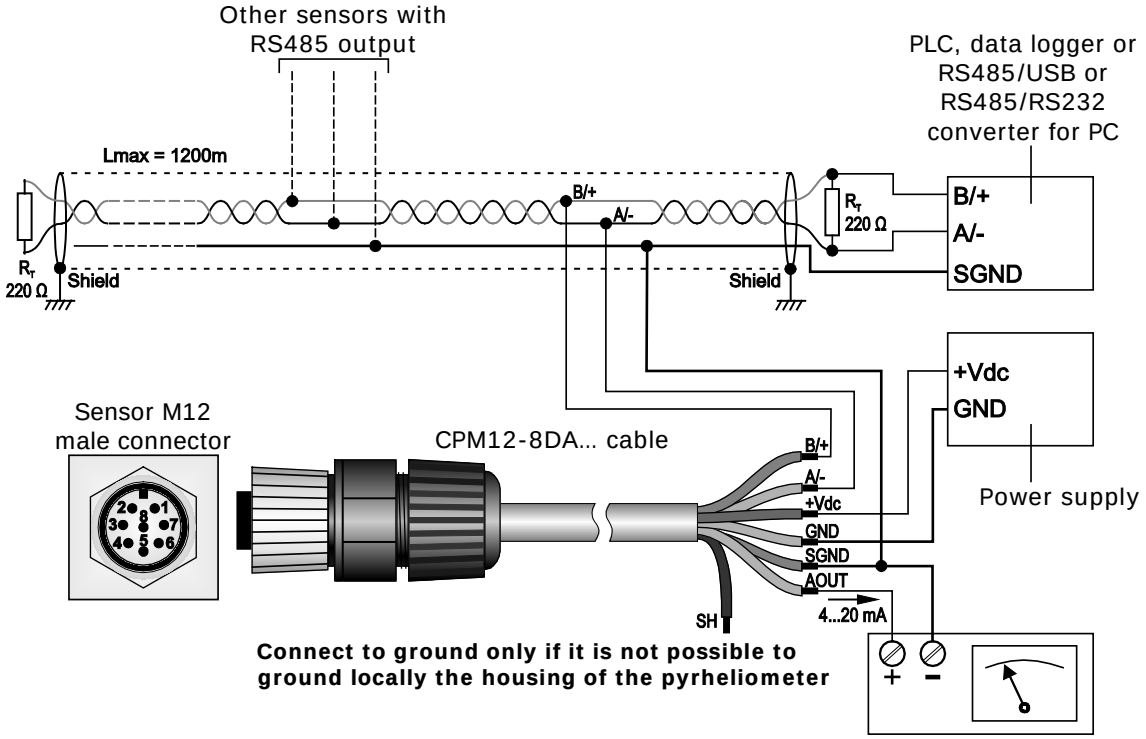


Fig. 4.6: LPPYRHE16ACS connections

Before connecting the pyrheliometer to the RS485 network, set the address and the communication parameters, if different from the factory preset (see chapter 6).

5 MEASUREMENT IN THE MODELS WITH ANALOG OUTPUT

Below are the ways to calculate the direct irradiance in the models with analog output LPPYRHE16, LPPYRHE16AC[S] and LPPYRHE16AV.

5.1 LPPYRHE16

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

5.2 LPPYRHE16AC[S]

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.

5.3 LPPYRHE16AV

The output signal (0...1 V, 0...5 V or 0...10 V depending on the version) 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 the version 0...1 V

$E_e = 400 \cdot V_{out}$ for the version 0...5 V

$E_e = 200 \cdot V_{out}$ for the version 0...10 V

where:

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

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

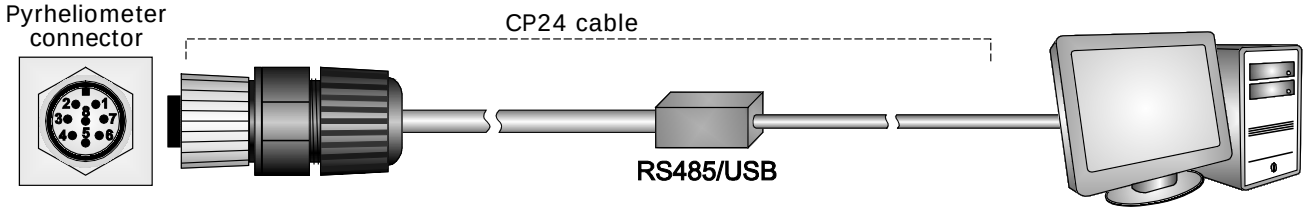
6 RS485 MODBUS-RTU OUTPUT

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.

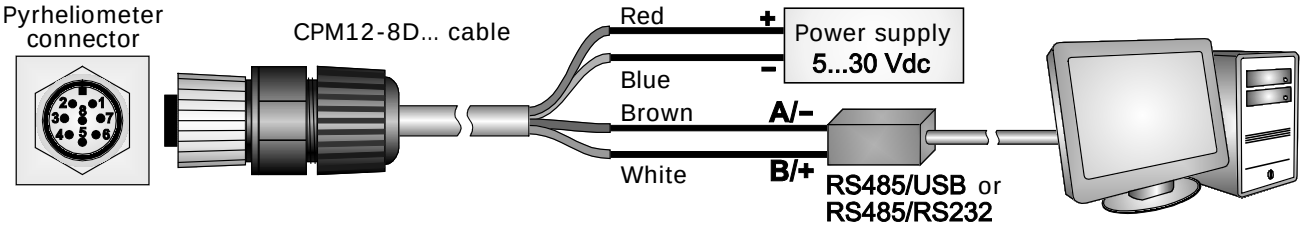
6.1 SETTING THE COMMUNICATION PARAMETERS

Connect the pyrheliometer to the PC in one of the following two ways:

A. By using the optional **CP24** cable, with built-in RS485/USB converter. In this connection mode, the sensor is powered by the PC USB port. To use the cable, it is necessary to install the related USB drivers in the PC.



B. By using the supplied 8-pole M12 female connector or the optional **CPM12-8D...** cable and a generic RS485/USB or RS485/RS232 converter. In this connection mode, it is necessary to power the pyrheliometer separately. If a RS485/USB converter is used, it is necessary to install the related USB drivers in the PC.



NOTES ON THE INSTALLATION OF UNSIGNED USB DRIVER: before installing unsigned USB driver into operating systems starting from Windows 7, it is necessary to restart the PC by disabling the driver signing request. If the operating system is 64-bit, even after installation the request of driver signing have to be disabled each time the PC is restarted.

Procedure:

1. Start with the pyrheliometer not powered (if the CP24 cable is used, disconnect one end of the cable).

2. In the PC, start a serial communication program. Set the Baud Rate to 57600 and set the communication parameters as follows (the pyrheliometer is connected to a COM type port):

Data Bits: 8
Parity: None
Stop Bits: 2

In the program, set the COM port number to which the pyrheliometer will be connected.

3. Switch the pyrheliometer on (if the CP24 cable is used, connect both ends of the cable).

4. Within 10 seconds from the pyrheliometer power on, send the **@** command and press **Enter**.

Note: if the pyrheliometer does not receive the **@** command within 10 seconds from power on, the RS485 MODBUS mode is automatically activated. In such a case, it is necessary to switch off and on again the pyrheliometer.

5. Send the command **CAL USER ON**.

Note: the command CAL USER ON is disabled after 5 minutes of inactivity.

6. Send the serial commands given in the following table to set the RS485 MODBUS parameters:

Command	Response	Description
CMAnnn	&|	Set RS485 address to nnn Ranging from 1 to 247 Preset on 1
CMBn	&|	Set RS485 Baud Rate n=0 ⇒ 9600 n=1 ⇒ 19200 n=2 ⇒ 38400 n=3 ⇒ 57600 n=4 ⇒ 115200 Preset on 1 ⇒ 19200
CMPn	&|	Set RS485 transmission mode n=0 ⇒ 8-N-1 (8 data bits, no parity, 1 stop bit) n=1 ⇒ 8-N-2 (8 data bits, no parity, 2 stop bits) n=2 ⇒ 8-E-1 (8 data bits, even parity, 1 stop bit) n=3 ⇒ 8-E-2 (8 data bits, even parity, 2 stop bits) n=4 ⇒ 8-O-1 (8 data bits, odd parity, 1 stop bit) n=5 ⇒ 8-O-2 (8 data bits, odd parity, 2 stop bits) Preset on 2 ⇒ 8-E-1
CMWn	&|	Set receiving mode after RS485 transmission n=0 ⇒ Violate protocol and go in Rx mode right after Tx n=1 ⇒ Respect protocol and wait 3.5 characters after Tx Preset on 1 ⇒ Respect the protocol

7. You can check the parameters setting by sending the following serial commands:

Command	Response	Description
RMA	*Address*	Read RS485 address
RMB	*Baud Rate* (0,1)	Read RS485 Baud Rate 0 ⇒ 9600 1 ⇒ 19200 2 ⇒ 38400 3 ⇒ 57600 4 ⇒ 115200
RMP	*Tx Mode* (0,1,2,3,4,5)	Read RS485 transmission mode 0 ⇒ 8-N-1 1 ⇒ 8-N-2 2 ⇒ 8-E-1 3 ⇒ 8-E-2 4 ⇒ 8-O-1 5 ⇒ 8-O-2
RMW	*Rx Mode* (0,1)	Read receiving mode after RS485 transmission 0 ⇒ Violate protocol and go in Rx mode right after Tx 1 ⇒ Respect protocol and wait 3.5 characters after Tx

Note: it is not required to send the CAL USER ON command to read the settings.

6.2 READING THE MEASURES WITH THE MODBUS-RTU PROTOCOL

In MODBUS mode, you can read the values measured by the pyrheliometer through the function code 04h (Read Input Registers). The following table lists the quantities available with the appropriate register number and address:

Number	Address	Quantity	Format
1	0	Internal temperature in °C (x10)	16-bit Integer
2	1	Internal temperature in °F (x10)	16-bit Integer
3	2	Solar radiation in W/m^2	16-bit Integer
4	3	Status register: bit0=1 ⇒ solar radiation measurement error bit2=1 ⇒ configuration data error bit3=1 ⇒ program memory error	16-bit Integer
5	4	Average values of the last 4 measurements	16-bit Integer
6	5	Signal generated by the sensor in µV/10 [e.g.: 816 means 8160 µV, the resolution is 10 µV]	16-bit Integer

Note: Register address = Register number - 1, as defined in the Modbus standard.

OPERATING MODE: the pyrheliometer enters RS485 MODBUS-RTU mode after 10 seconds from power on. In the first 10 seconds from power on the pyrheliometer does not reply to requests from the MODBUS master unit. After 10 seconds, it is possible to send MODBUS requests to the pyrheliometer.

7 TECHNICAL SPECIFICATIONS

Sensor	Thermopile
Typical sensitivity	5 µV/Wm^{-2}
Impedance	5÷50 Ω
Measuring range	0÷2000 W/m^2
Viewing angle	5° (slope 1°)
Spectral range (50%)	200÷4000 nm
Operating temperature/humidity	-40÷80 °C / 0÷100%
Output	Analog in µV/Wm^{-2} (LP PYRHE16) Analog 4÷20 mA (LPPYRHE16AC[S]) Analog 0÷1 V, 0÷5 V or 0÷10 V (LPPYRHE16AV) Digital RS485 Modbus-RTU (LPPYRHE16[AC]S)
Power supply	10÷30 Vdc (4÷20 mA, 0÷1 V and 0÷5 V outputs) 15÷30 Vdc (0÷10 V output) 5÷30 Vdc (RS485 Modbus-RTU output)
Connection	4 or 8-pole M12 connector depending on the model
Dimensions	Fig. 3.2
Weight	1.5 kg

Technical Specifications According to ISO 9060:2018

Response time (95%)	< 9 s
Zero offset in response to a 5 K/h change in ambiente 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| %

8 MAINTENANCE

In order to grant measurements high accuracy, it is important to keep the quartz window clean. Consequently, the more the window will be kept clean, the more measurements will be accurate.

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.

Because of the high temperature changes between day and night, some condensation might appear on the pyrheliometer window. In this case the performed reading is highly over-estimated. To minimize the condensation, the pyrheliometer is provided with a cartridge containing dessicant material (silica-gel). The efficiency of the silica-gel crystals 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 loose their efficiency. Read instructions at chapter 3 about how to replace the silica-gel crystals. Silica-gel typical lifetime goes from 2 to 6 months depending on the environment where the pyrheliometer works.

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

9 SAFETY INSTRUCTIONS

General safety instructions

The instrument has been manufactured and tested in accordance with the safety standard EN61010-1:2010 “Safety requirements for electrical equipment for measurement, control and laboratory use” and has left the factory in perfect safety technical conditions.

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

The instrument proper operation and operating safety can be ensured only in the climatic conditions specified in this manual.

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:

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

10 ACCESSORIES ORDERING CODES

CPM12AA4... Cable with 4-pole M12 connector on one end, open wires on the other end. Length 2 m (CPM12AA4.2), 5 m (CPM12AA4.5) or 10 m (CPM12AA4.10). For LPPYRHE16, LPPYRHE16AC and LPPYRHE16AV.

CPM12-8D... Cable with 8-pole M12 connector on one end, open wires on the other end. Length 2 m (CPM12-8D.2), 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 2 m (CPM12-8DA.2), 5 m (CPM12-8DA.5) or 10 m (CPM12-8DA.10). For LPPYRHE16ACS.

CP24 PC connecting cable for the RS485 MODBUS parameters configuration of the LPPYRHE16[AC]S pyrheliometers. With built-in RS485/USB converter. 8-pole M12 connector on instrument side and A-type USB connector on PC side.

LPSG Cartridge to contain desiccant silica-gel crystals, complete with O-ring and cap. Spare part.

LPG Pack of 5 sachets of silica-gel crystals.

DELTA OHM metrology laboratories LAT N° 124 are ISO/IEC 17025 accredited by ACCREDIA for Temperature, Humidity, Pressure, Photometry / Radiometry, Acoustics and Air Velocity. They can supply calibration certificates for the accredited quantities.

NOTES

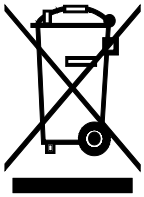
WARRANTY

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 reserves 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

Please note our new name:
Senseca Italy Srl
Via Marconi 5, 35030 Padua, Italy
Documents are in the process of being changed.