

Operating manual

Pyranometer

LPPYRA12



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1 INTRODUCTION

LPPYRA12 pyranometer measures the irradiance on a flat surface (W/m^2). Thanks to the shadow-ring, LPPYRA12 measures the diffuse solar radiation eliminating the contribution of direct irradiance.

LPPYRA12 is equipped with a Spectrally Flat Class B (First Class) pyranometer (LPPY-RA02) in accordance with ISO 9060:2018 and with the criteria of the WMO "Guide to Meteorological Instruments and Methods of Observation".

The pyranometer is available in the following versions:

- **LPPYRA12:** PASSIVE.
The passive version can be connected to the instruments D09847 and HD31 by using VP 472 SICRAM module.
- **LPPYRA12AC:** ACTIVE with 4..20 mA CURRENT output (0...2000 W/m^2).
- **LPPYRA12AC4:** ACTIVE with 4..20 mA CURRENT output (0...4000 W/m^2).
- **LPPYRA12ACS:** ACTIVE with 4..20 mA CURRENT output (0...2000 W/m^2) and RS485 Modbus-RTU output.
- **LPPYRA12ACS4:** ACTIVE with 4..20 mA CURRENT output (0...4000 W/m^2) and RS485 Modbus-RTU output.
- **LPPYRA12AV:** ACTIVE with 0..1 or 0..5 or 0..10 V VOLTAGE output (0...2000 W/m^2) to be defined when ordering.
- **LPPYRA12AV4:** ACTIVE with 0..1 or 0..5 or 0..10 V VOLTAGE output (0...4000 W/m^2) to be defined when ordering.
- **LPPYRA12S:** With RS485 Modbus-RTU output.
- **LPPYRA12S12:** With SDI-12 output.

The pyranometer is supplied factory calibrated and with a calibration report. The calibration is carried out in accordance with the ISO 9847:1992 (type IIc) standard: "Calibration of field pyranometers by comparison to a reference pyranometer". The pyranometer is calibrated by comparison with the reference sample calibrated annually at WRC (World Radiation Center).

2 WORKING PRINCIPLE

LPPYRA12 pyranometer is 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. The pyranometer spectral range is determined by the transmission of the two glass domes type K5.

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.

In order to grant the thermopile a proper thermal insulation from the wind and reduce the sensitivity to thermal irradiance, LPPYRA12 is equipped with two concentric domes having 50 mm and 32 mm outer diameter. The domes protect the thermopile from the dust, which might change spectral sensitivity if it lies on the black surface.

The shadow ring prevents the direct solar radiation to reach the sensor the whole day long, so that only the diffuse solar radiation will be measured. Because the elevation of the sun changes day by day, **it is necessary to change the height of the shadow ring at least every two days.**

To prevent internal condensation forming on the internal side of the dome under certain climatic conditions, silica gel tablets are inserted inside the pyranometer to absorb humidity.

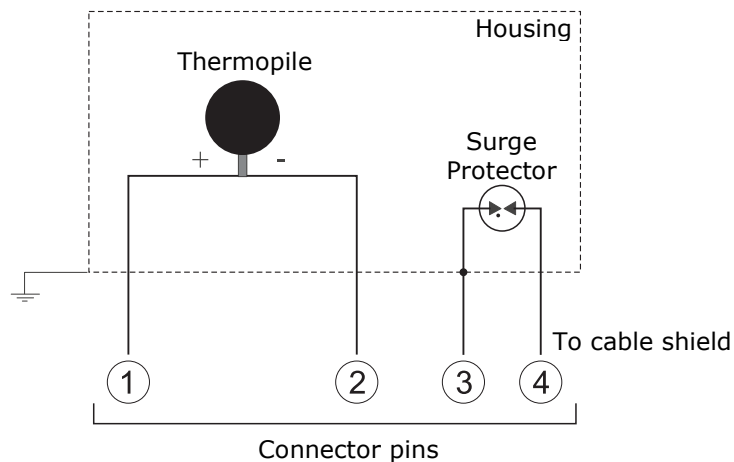


Fig. 2.1: scheme of principle LPPYRA12 (version with mV output)

3 INSTALLATION

Before installing the pyranometer, refill the cartridge containing silica-gel crystals. Silica gel absorbs humidity in the dome chamber and prevents, in particular climatic conditions, condensation on the internal walls of the domes 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. Loosen the three screws that fix the white shade disk.
2. Unscrew the silica gel cartridge using a coin.
3. Remove the cartridge perforated cap.
4. Open the sachet containing silica gel (supplied with the pyranometer).
5. Fill the cartridge with the silica gel crystals.
6. Close the cartridge with its own cap, paying attention that the sealing O-ring be properly positioned.
7. Screw the cartridge to the pyranometer body using a coin.
8. Check that the cartridge is screwed tightly (if not, silica gel life will be reduced).
9. Position the shade disk and screw it with the screws.
10. The pyranometer is ready for use.

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

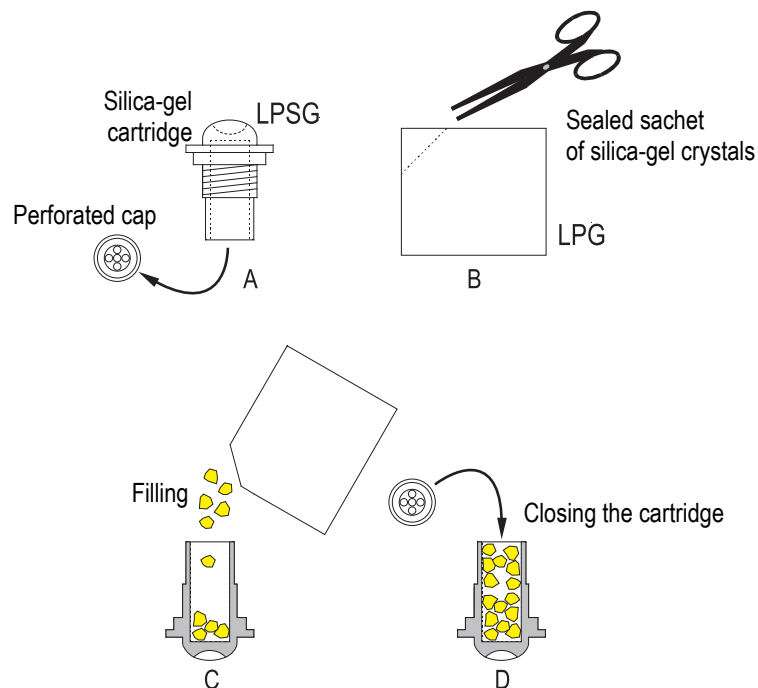


Fig. 3.1: filling the silica-gel cartridge

- The pyranometer must be mounted in an easy-to-reach location in order to clean the dome regularly and adjust the height of the shadow ring. At the same time, make sure that no buildings, constructions, trees or obstructions exceed the horizontal plane where the pyranometer lies. If this is not possible, select a site where obstructions in the path of the sun from sunrise to sunset do not exceed 5 degrees of elevation.
- The pyranometer must be located far from any kind of obstruction, which might alter the measurement of diffused light.
- In order to allow an accurate horizontal positioning, the pyranometer is equipped with a levelling device: the adjustment is made by means of the levelling screws that allow adjusting the pyranometer inclination.

3.1 MOUNTING THE SHADOW RING

LPPYRA12 is made up of two parts: the pyranometer and the shadow ring.

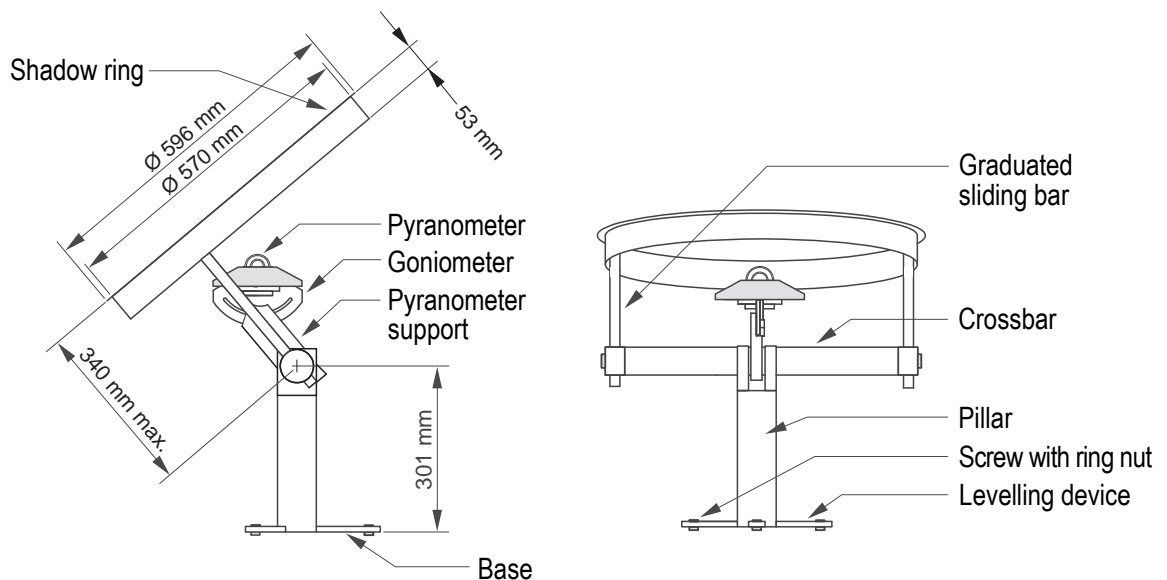


Fig. 3.2: LPPYRA12 dimensions and description

To make the transport easier, the shadow ring is disassembled in the following pieces:

- Base (composed of three spokes).
- Shadow ring with "L" profile.
- Sliding bars with graduated scale.
- Pillar + crossbar + pyranometer support + goniometer (factory assembled and aligned).

Mounting Instructions:

1. Screw the three spokes of the base to the pillar.
2. Screw the two sliding bars to the shadow ring.
3. Insert the sliding bars of the ring in the two slots at the crossbar ends (if correctly mounted, the ring axis crosses the pyranometer thermopile center).

3.2 POSITIONING THE INSTRUMENT FOR THE DIFFUSE RADIATION MEASUREMENT

The shadow ring particular geometry allows intercepting the solar direct radiation during the whole day without adjustments.

The base of the instrument has to be mounted parallel to the ground by adjusting the screw with ring nut and with the aid of the levelling device integrated in the instrument.

The shadow ring has to be positioned in such a way that its axis be parallel to the earth axis. To do this, follow two separate steps: first align the shadow ring along the North-South axis and then adjust the ring tilt.

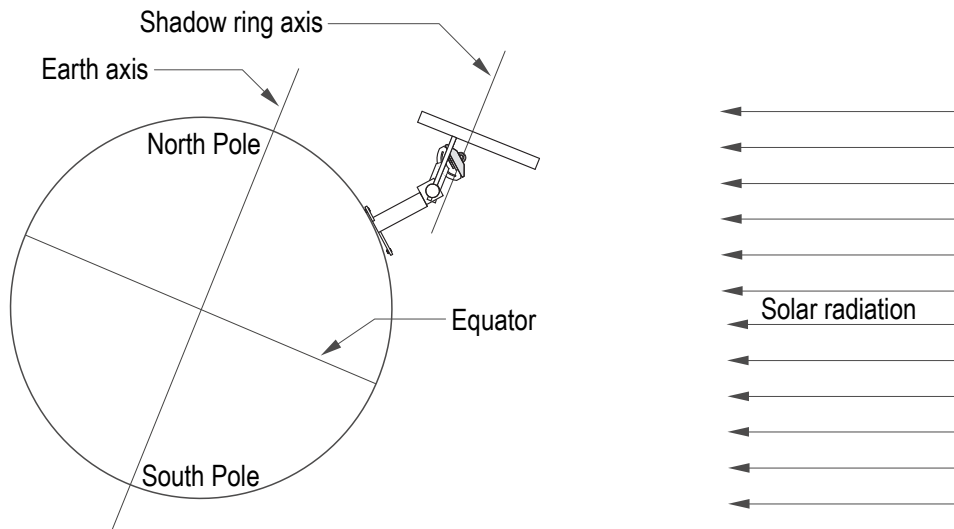


Fig. 3.3: positioning the instrument

Aligning the shadow ring along the North-South axis:

1. Wait for solar midday.
2. On the goniometer where the pyranometer is mounted there is a groove, rotate the shadow ring base until the sunbeams pass through the groove from both sides of the goniometer.

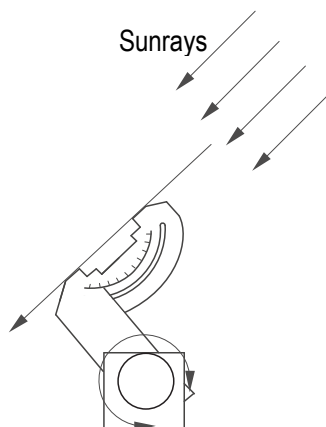


Fig. 3.4: shadow ring North-South alignment

As you get closer to the equator, this method involves an increasing uncertainty. For installations in sites nearby the equator, it is suggested to use a map to align the shadow ring along the North-South axis.

Adjusting the shadow ring tilt:

1. Check that the sliding bars and the long side of the pyranometer support be parallel (instruments are supplied factory aligned).
2. Mount and fix the pyranometer to the goniometer.
3. Position the goniometer in such a way to read on its scale the latitude of the installation site.

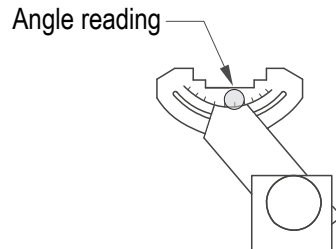


Fig. 3.5: shadow ring tilt adjustment

4. Rotate the crossbar (after loosening the screw that locks it) until the pyranometer is parallel to the ground. Use the levelling device on the pyranometer body.
5. If the operations have been carried out properly, the shadow ring axis will be parallel to the earth axis.

By now you just have to adjust the height of the sliding bars (loosening the locking screws) until the pyranometer big dome appears completely in the shade. To confirm that installation has been performed correctly, you can compare the reading on the sliding bar scale with the value listed in tables 1A and 1B. If the values match, the pyranometer and the shadow ring have been correctly installed.

The shadow ring position has to be adjusted at least once every two days.

TABLE 1A**VALID ONLY FOR PASSIVE LPPYRA12 (no AC/AV/S/S12 versions)**

The table shows the values to which the graduated sliding bars must be set for the different solar declinations and for the two hemispheres.

Solar declination	Date day/month		Value to be set on the sliding bars (mm) if installed in the Northern hemisphere	Value to be set on the sliding bars (mm) if installed in the Southern hemisphere
-23.26	21/12		101	121
-22	10/1	3/12	96	116
-20	21/1	22/11	87	107
-18	29/1	13/11	77	97
-16	5/2	6/11	68	88
-14	11/2	31/10	58	78
-12	17/2	25/10	49	69
-10	23/2	19/10	39	59
-8	28/2	14/10	29	49
-6	5/3	8/10	19	39
-4	10/3	3/10	10	30
-2	15/3	28/9	0	20
0	21/3	23/9	10	10
+2	26/3	18/9	20	0
+4	31/3	12/9	30	10
+6	5/4	6/9	39	19
+8	10/4	2/9	49	29
+10	16/4	27/8	59	39
+12	22/4	21/8	69	49
+14	28/4	15/8	78	58
+16	4/5	9/8	88	68
+18	12/5	1/8	97	77
+20	20/5	23/7	107	87
+22	31/5	12/7	116	96
+23.26	21/6		121	101

TABLE 1B**VALID FOR ACTIVE VERSIONS (AC/AV/S/S12)**

The table shows the values to which the graduated sliding bars must be set for the different solar declinations and for the two hemispheres.

Solar declination	Date day/month		Value to be set on the sliding bars (mm) if installed in the Northern hemisphere	Value to be set on the sliding bars (mm) if installed in the Southern hemisphere
-23.26	21/12		92	130
-22	10/1	3/12	87	125
-20	21/1	22/11	78	116
-18	29/1	13/11	68	106
-16	5/2	6/11	59	97
-14	11/2	31/10	49	87
-12	17/2	25/10	40	78
-10	23/2	19/10	30	68
-8	28/2	14/10	20	58
-6	5/3	8/10	10	48
-4	10/3	3/10	1	39
-2	15/3	28/9	9	29
0	21/3	23/9	19	19
+2	26/3	18/9	29	9
+4	31/3	12/9	39	1
+6	5/4	6/9	48	10
+8	10/4	2/9	58	20
+10	16/4	27/8	68	30
+12	22/4	21/8	78	40
+14	28/4	15/8	87	49
+16	4/5	9/8	97	59
+18	12/5	1/8	106	68
+20	20/5	23/7	116	78
+22	31/5	12/7	125	87
+23.26	21/6		130	92

4 ELECTRICAL CONNECTIONS

LPPYRA12, **LPPYRA12AC[4]** and **LPPYRA12AV[4]** have a 4-pole connector and use the **CPM12AA4... optional** cables, with 4-pole connector on one side and open wires on the other side.

LPPYRA12S and **LPPYRA12S12** have a 8-pole connector and use the **CPM12-8D... optional** cables, with 8-pole connector on one side and open wires on the other side.

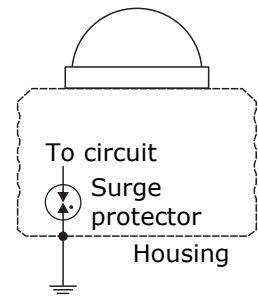
LPPYRA12ACS[4] has a 8-pole connector and uses the **CPM12-8DA... optional** cables, with 8-pole connector on one side and open wires on the other side.



The metallic housing of the pyranometer should preferably be grounded (\perp) 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 pyranometer, connect the wire of the cable corresponding to the housing to ground (\perp). Note: in LPPYRA12AV[4] the housing is not connected to the connector.

Inside the housing there is a surge protector connected between the housing itself and the electronic circuit (powered models) or the cable shield (passive model). Grounding the housing allows the correct protection function (in particular against lightning) of the surge protector.



4.1 LPPYRA12 CONNECTIONS

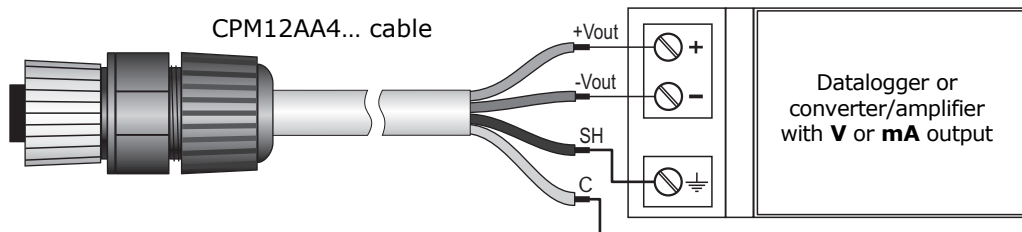
The pyranometer LPPYRA12 is passive and does not require power supply. It is to be connected either to a millivoltmeter or to a data acquisition system. Typically, the pyranometer output signal does not exceed 20 mV. In order to better exploit the pyranometer features, the readout instrument should have 1 μ V resolution.

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

Pyranometer M12 male connector



CPM12AA4... cable



Connect to ground only if it is not possible to ground locally the housing of the pyranometer

Fig. 4.1: LPPYRA12 connections

4.2 LPPYRA12AC[4] CONNECTIONS

The pyranometer LPPYRA12AC[4] 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 $\leq 500 \Omega$.

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

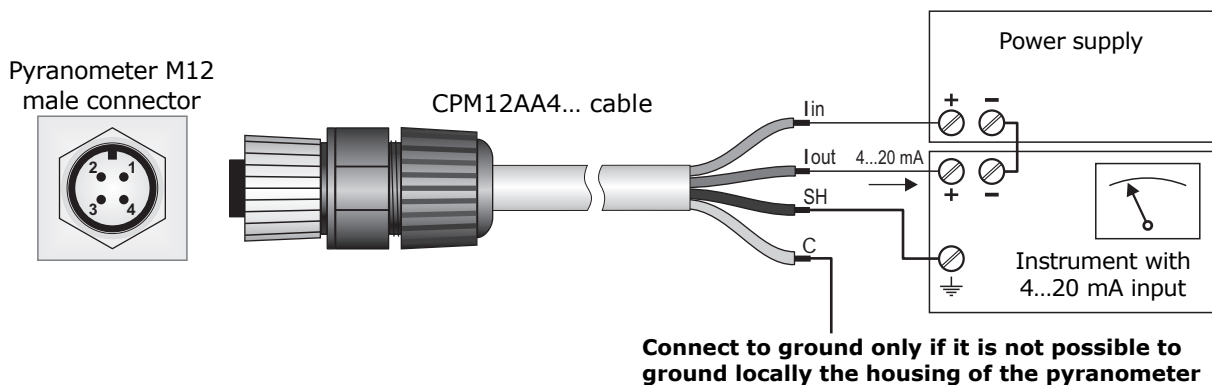


Fig. 4.2: LPPYRA12AC[4] connections

4.3 LPPYRA12AV[4] CONNECTIONS

The pyranometer LPPYRA12AV[4] 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 $\geq 100 \text{ k}\Omega$.

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

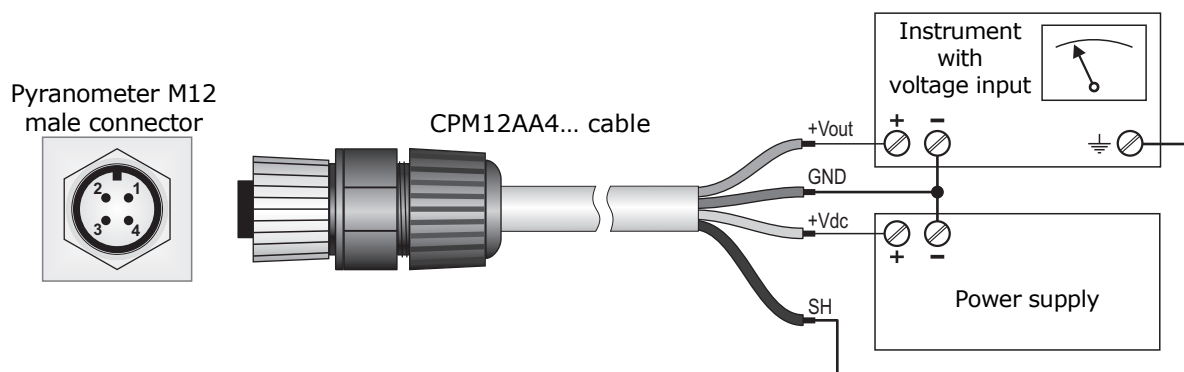


Fig. 4.3: LPPYRA12AV[4] connections

4.4 LPPYRA12S CONNECTIONS

The pyranometer LPPYRA12S 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	

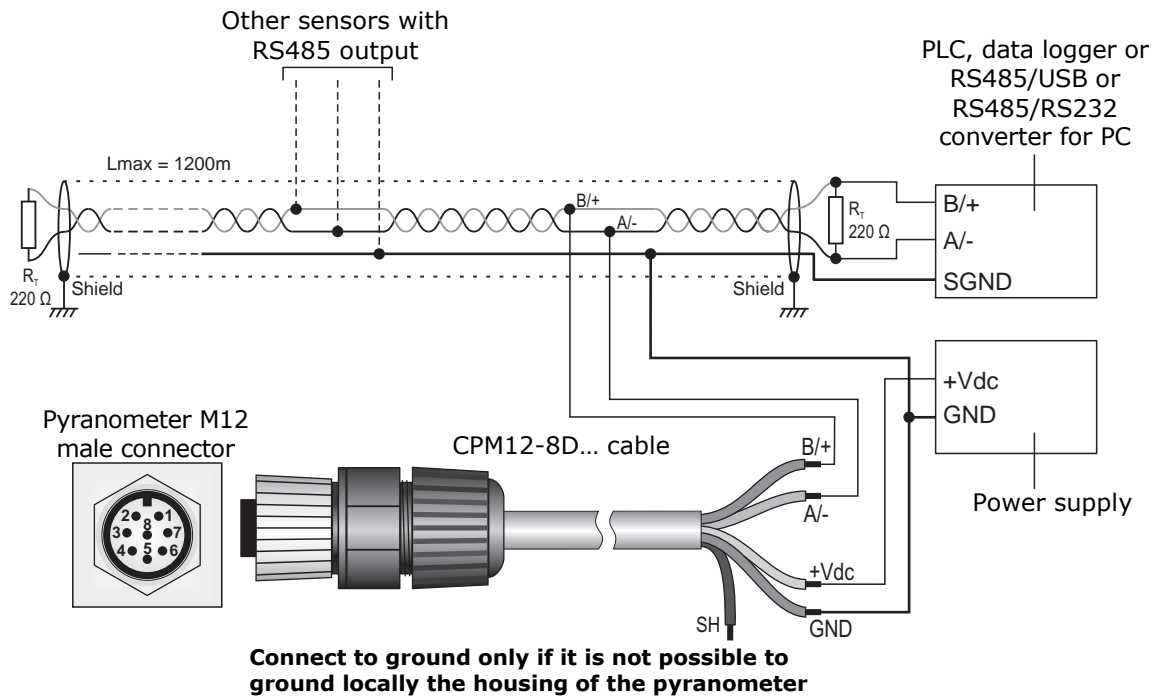


Fig. 4.4: LPPYRA12S connections

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

4.5 LPPYRA12S12 CONNECTIONS

The pyranometer LPPYRA12S12 has **SDI-12** output and requires **7...30 Vdc** external power supply. It is to be connected to a power supply and to an acquisition system (data logger) as shown in fig. 4.5.

Connector	Function	Cable color
1	Power supply negative (GND) SDI-12 output negative	Blue
2	Power supply positive (+Vdc)	Red
3	Not connected	
4	Not connected	
5	SDI-12 output positive	White
6	Housing / Cable shield (SH)	Black
7	Not connected	
8	Not connected	

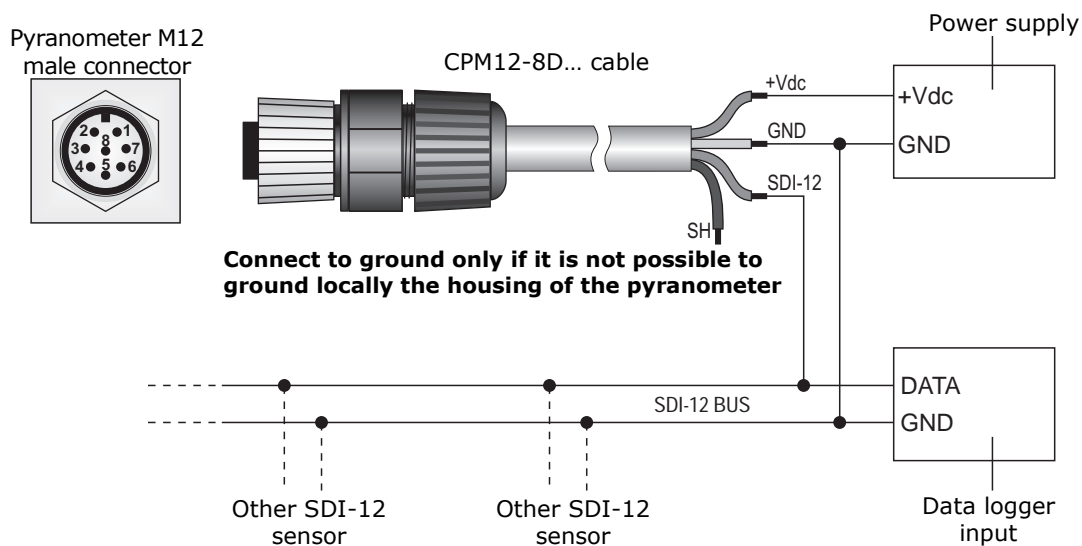


Fig. 4.5: LPPYRA12S12 connections

More SDI-12 sensors can be connected in parallel. The distance between a sensor and the acquisition system (data logger) should not exceed 60 m.

Due to its low power consumption ($< 200 \mu\text{A}$), LPPYRA12S12 is particularly suitable for battery/solar panel-powered data acquisition systems.

Before connecting the instrument to an SDI-12 network containing other sensors, set the address by using the proper SDI-12 command (see chapter 7).

4.6 LPPYRA12ACS[4] CONNECTIONS

The pyranometer LPPYRA12ACS[4] 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 $\leq 500 \Omega$.
- 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. 4.6. 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	

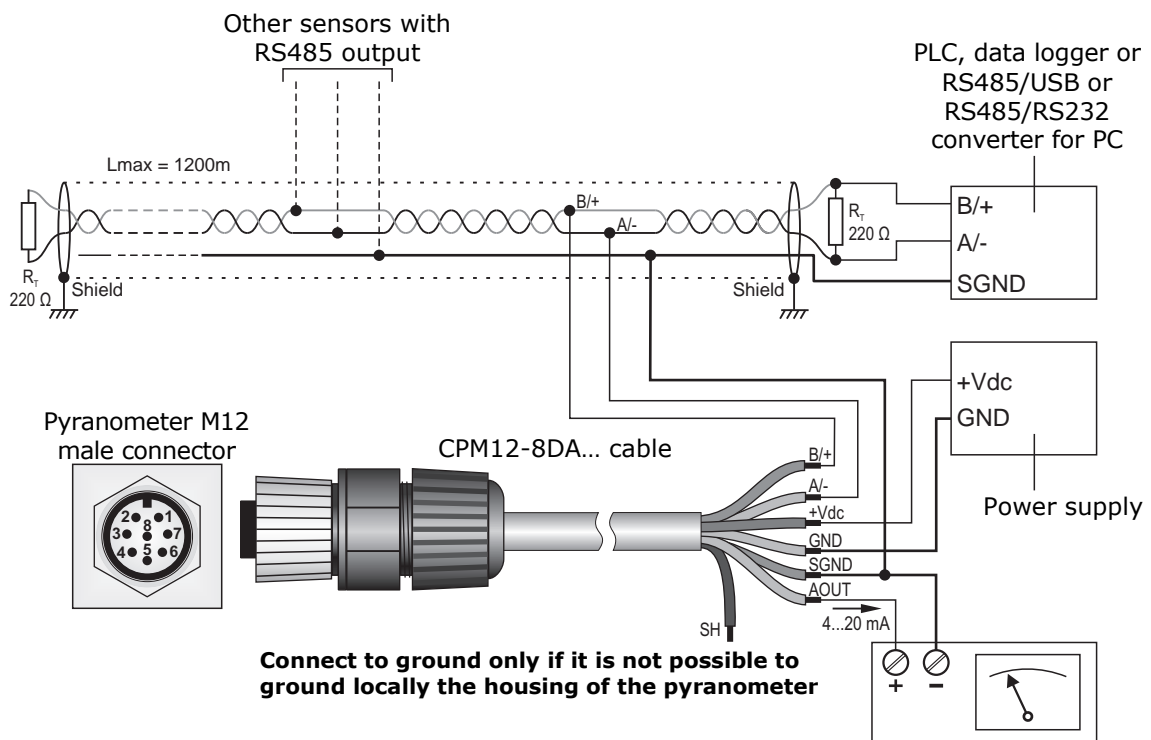


Fig. 4.6: LPPYRA12ACS[4] connections

Before connecting the pyranometer 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 global irradiance in the models with analog output LPPYRA12, LPPYRA12AC[S][4] and LPPYRA12AV[4].

5.1 LPPYRA12

Each pyranometer is distinguished by its own sensitivity (or calibration factor) **S** expressed in $\mu\text{V}/(\text{Wm}^{-2})$ and shown in the label on the pyranometer (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 pyranometer expressed in $\mu\text{V}/(\text{Wm}^{-2})$.

5.2 LPPYRA12AC[S][4]

The 4...20 mA output signal corresponds to 0...2000 W/m^2 (LPPYRA12AC[S]) or 0...4000 W/m^2 (LPPYRA12AC[S]4) 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:

$$E_e = 125 \cdot (I_{out} - 4) \text{ if f.s.} = 2000 \text{ W}/\text{m}^2$$

$$E_e = 250 \cdot (I_{out} - 4) \text{ if f.s.} = 4000 \text{ W}/\text{m}^2$$

where:

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

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

5.3 LPPYRA12AV[4]

The output signal (0...1 V, 0...5 V or 0...10 V depending on the version) corresponds to 0...2000 W/m^2 (LPPYRA12AV) or 0...4000 W/m^2 (LPPYRA12AV4) 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:

$$E_e = 2000 \cdot V_{out} \text{ for the version } 0...1 \text{ V with f.s.} = 2000 \text{ W}/\text{m}^2$$

$$E_e = 4000 \cdot V_{out} \text{ for the version } 0...1 \text{ V with f.s.} = 4000 \text{ W}/\text{m}^2$$

$$E_e = 400 \cdot V_{out} \text{ for the version } 0...5 \text{ V with f.s.} = 2000 \text{ W}/\text{m}^2$$

$$E_e = 800 \cdot V_{out} \text{ for the version } 0...5 \text{ V with f.s.} = 4000 \text{ W}/\text{m}^2$$

$$E_e = 200 \cdot V_{out} \text{ for the version } 0...10 \text{ V with f.s.} = 2000 \text{ W}/\text{m}^2$$

$$E_e = 400 \cdot V_{out} \text{ for the version } 0...10 \text{ V with f.s.} = 4000 \text{ W}/\text{m}^2$$

where:

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

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

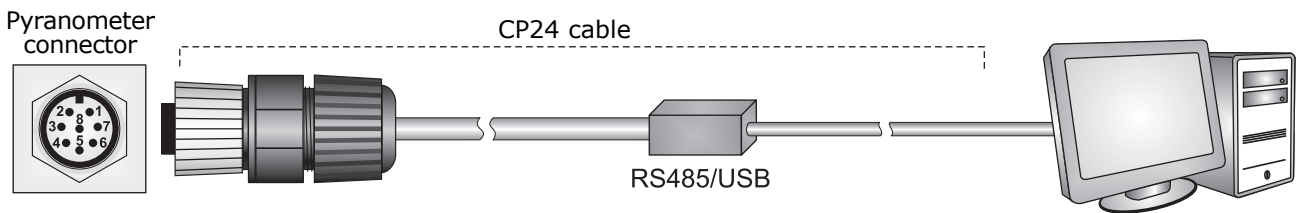
6 RS485 MODBUS-RTU OUTPUT

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

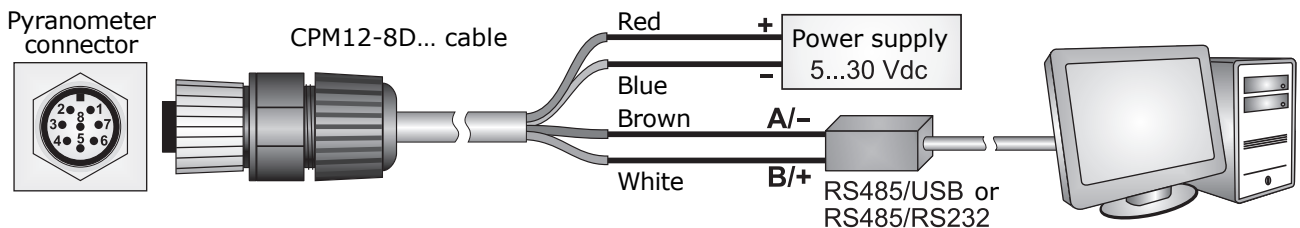
6.1 SETTING THE COMMUNICATION PARAMETERS

Connect the pyranometer 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 pyranometer 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 pyranometer 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 pyranometer 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 pyranometer will be connected.

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

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

Note: if the pyranometer 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 pyranometer.

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
CMA _{nnn}	&	Set RS485 address to nnn Ranging from 1 to 247 Preset on 1
CMB _n	&	Set RS485 Baud Rate n=0 ⇒ 9600 n=1 ⇒ 19200 n=2 ⇒ 38400 n=3 ⇒ 57600 n=4 ⇒ 115200 Preset on 1 ⇒ 19200
CM _{Pn}	&	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
CM _{Wn}	&	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	<i>Address</i>	Read RS485 address
RMB	<i>Baud Rate</i> (0,1)	Read RS485 Baud Rate 0 ⇒ 9600 1 ⇒ 19200 2 ⇒ 38400 3 ⇒ 57600 4 ⇒ 115200
RMP	<i>Tx Mode</i> (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	<i>Rx Mode</i> (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 pyranometer through the function code 04h (Read Input Registers). The following table lists the quantities available with the appropriate register 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 pyranometer enters RS485 MODBUS-RTU mode after 10 seconds from power on. In the first 10 seconds from power on the pyranometer does not reply to requests from the MODBUS master unit. After 10 seconds, it is possible to send MODBUS requests to the pyranometer.

7 SDI-12 OUTPUT

The LPPYRA12S12 pyranometers are compatible with version 1.3 of SDI-12 protocol.

The protocol communication parameters are: Baud rate = 1200. Data bits = 7, Parity = Even, Stop bits = 1.

The communication with the instrument is performed by sending a command in the following form:

<Address><Command>!

with <Address> = address of the instrument the command is sent to
 <Command> = type of operation requested to the instrument

The instrument reply is as follows:

<Address><Data><CR><LF>

with <Address> = address of the instrument which replies
 <Data> = information sent by the instrument
 <CR> = ASCII character *Carriage Return*
 <LF> = ASCII character *Line Feed*

The sensors come with a factory address preset to 0. The address can be modified by using the proper SDI-12 command reported in the following table.

The following table reports the SDI-12 commands available. For consistency with SDI-12 standard documentation, the instrument address is indicated in the table with the letter **a**.

SDI-12 Commands

Command	Instrument reply	Description
a!	a<CR><LF>	Verifies the presence of the instrument.
aI!	allccccccmmmmmmvvvsssssss<CR><LF> with: a = address of the instrument (1 character) ll = SDI-12 compliant version (2 characters) ccccccc = manufacturer (8 characters) mmmmmm = instrument model (6 characters) vvv = firmware version (3 characters) sssssss = serial number (8 characters) ⇒ Example of response: 013DeltaOhmLP-PYRA0016051518 with: 0 = instrument address 13 = SDI-12 version 1.3 compliant DeltaOhm = manufacturer's name LP-PYR = instrument model A00 = firmware version A.0.0 16051518 = serial number	Requests for information from the instrument.
aAb! Where: b =new address	b<CR><LF> Note: if the b character is not an acceptable address, the instrument responds with a instead of b.	Modification of the instrument address.

Command	Instrument reply	Description
?!	a<CR><LF>	Request of the address of the instrument. If more than one sensor is connected to the bus, a conflict occurs.
TYPE M (START MEASUREMENT) AND TYPE C (START CONCURRENT MEASUREMENT) COMMANDS		
Irradiance, signal internal level and internal temperature		
aM! aC!	atttn<CR><LF> with: ttt = number of seconds necessary for the instrument to make the measure available (3 characters) n = number of detected variables (1 character for aM!, 2 characters for aC!) Note: ttt = 000 means datum immediately available.	Request to execute the measurement.
aD0!	a+n+w...w+v...v+t...t<CR><LF> with: n = content of the status register w...w = irradiance in W/m ² v...v = signal internal level in mV t...t = internal temperature in the set unit of measurement (default °C) ⇒ Example of response: 0+0+228.7+3.294+25.0 probe address = 0 content of the status register = 0 irradiance = 228.7 W/m ² signal internal level = 3.294 mV internal temperature = 25.0 °C Note: the status register normally contains zero; a value different from zero indicates an error condition.	Reads the measurement.
Irradiance and internal temperature		
aM1! aC1!	atttn<CR><LF> with: ttt = number of seconds necessary for the instrument to make the measure available (3 characters) n = number of detected variables (1 character for aM1!, 2 characters for aC1!) Note: ttt = 000 means datum immediately available.	Request to execute the measurement.
aD0!	a+w...w+t...t<CR><LF> with: w...w = irradiance in W/m ² t...t = internal temperature in the set unit of measurement (default °C) ⇒ Example of response: 0+228.7+25.0 probe address = 0 irradiance = 228.7 W/m ² internal temperature = 25.0 °C	Reads the measurement.

Command	Instrument reply	Description
Internal temperature		
aM2! aC2!	attn<CR><LF> with: ttt = number of seconds necessary for the instrument to make the measure available (3 characters) n = number of detected variables (1 character for aM2!, 2 characters for aC2!) Note: ttt = 000 means datum immediately available.	Request to execute the measurement.
aD0!	a+t...t<CR><LF> with t...t = internal temperature in the set unit of measurement (default °C) ⇒ Example of response: 0+25.0 probe address = 0 internal temperature = 25.0 °C	Reads the measurement.
Signal internal level		
aM3! aC3!	attn<CR><LF> with: ttt = number of seconds necessary for the instrument to make the measure available (3 characters) n = number of detected variables (1 character for aM3!, 2 characters for aC3!) Note: ttt = 000 means datum immediately available.	Request to execute the measurement.
aD0!	a+v...v<CR><LF> with v...v = signal internal level in mV ⇒ Example of response: 0+3.294 probe address = 0 signal internal level = 3.294 mV	Reads the measurement.

In addition to the above-mentioned commands, the sensor also implements the corresponding commands with CRC, that require to add a 3-character CRC code at the end of the reply before <CR><LF>. The format of these commands is obtained from the previous by adding the letter C: aMC!, aMC1!, aMC2!, aMC3!, aCC!, aCC1!, aCC2!, aCC3!. The sensor **does not** implement the type R (Continuous Measurements) commands.

Extended SDI-12 Commands

Command	Instrument reply	Description
aXSCAL USER ON!	a> USER ENABLED!<CR><LF>	Enables the configuration mode.
aXSCFD!	a> &<CR><LF>	Sets °C as temperature unit of measurement.
aXSCFE!	a> &<CR><LF>	Sets °F as temperature unit of measurement.
aXSCAL END!	a> LOCKED!<CR><LF>	Disables the configuration mode.

The extended commands allow setting the temperature unit of measurement (if the temperature sensor is present). To change the unit of measurement:

- 1) Send the command **aXSCAL USER ON!** (note: **a**=instrument address).
- 2) Send the command **aXSCFD!** (to set °C) or **aXSCFE!** (to set °F).
- 3) Send the command **aXSCAL END!**

For more information about the SDI-12 protocol, visit the website "www.sdi-12.org".

8 MEASUREMENT CORRECTION

Diffuse radiation is measured by eliminating the contribution of direct radiation through the shadow ring. As besides the direct radiation the shadow ring intercepts part of the diffuse light, it is necessary to correct the measured values.

The percentage of diffuse radiation intercepted by the shadow ring changes during the year, because the position that the ring has with respect to the pyranometer changes. In tables 2 and 3 there are the correction factors to be applied to the measurements over the whole year and at different latitudes (table 2 for the Northern hemisphere, table 3 for the Southern hemisphere).

In order to get the "real" value E_e^v of diffuse irradiance, it is necessary to multiply the measured value E_e by the correction coefficient C listed in the tables:

$$E_e^v = E_e \cdot C$$

TABLE 2Correction factor **C** for installation in the **Northern** hemisphere.

Solar declination	Northern latitude									
	0	5	10	15	20	25	30	35	40	45
-23	1.11	1.10	1.09	1.09	1.08	1.07	1.06	1.05	1.04	1.03
-22	1.11	1.11	1.10	1.09	1.08	1.07	1.06	1.05	1.04	1.03
-20	1.12	1.11	1.10	1.10	1.09	1.08	1.07	1.06	1.05	1.04
-18	1.12	1.12	1.11	1.10	1.09	1.08	1.07	1.06	1.05	1.04
-16	1.12	1.12	1.11	1.10	1.10	1.09	1.08	1.07	1.06	1.05
-14	1.13	1.12	1.12	1.11	1.10	1.09	1.08	1.07	1.06	1.05
-12	1.13	1.12	1.12	1.11	1.10	1.10	1.09	1.08	1.07	1.06
-10	1.13	1.13	1.12	1.12	1.11	1.10	1.09	1.08	1.08	1.06
-8	1.13	1.13	1.13	1.12	1.11	1.11	1.10	1.09	1.08	1.07
-6	1.13	1.13	1.13	1.12	1.12	1.11	1.10	1.09	1.08	1.08
-4	1.14	1.13	1.13	1.13	1.12	1.11	1.11	1.10	1.09	1.08
-2	1.14	1.14	1.13	1.13	1.12	1.12	1.11	1.10	1.10	1.09
0	1.14	1.14	1.14	1.13	1.13	1.12	1.11	1.11	1.10	1.09
+2	1.14	1.14	1.14	1.13	1.13	1.13	1.12	1.11	1.10	1.10
+4	1.14	1.14	1.14	1.13	1.13	1.13	1.12	1.12	1.11	1.11
+6	1.13	1.13	1.14	1.13	1.13	1.13	1.13	1.12	1.11	1.11
+8	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.12	1.12	1.11
+10	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.12	1.12	1.12
+12	1.12	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.12	1.12
+14	1.12	1.12	1.13	1.13	1.13	1.13	1.13	1.13	1.12	1.12
+16	1.11	1.12	1.12	1.13	1.13	1.13	1.13	1.13	1.12	1.12
+18	1.11	1.11	1.12	1.12	1.12	1.13	1.13	1.13	1.12	1.12
+20	1.10	1.11	1.11	1.12	1.12	1.12	1.12	1.12	1.12	1.12
+22	1.10	1.10	1.11	1.11	1.11	1.12	1.12	1.12	1.12	1.12
+23	1.09	1.10	1.10	1.11	1.11	1.11	1.12	1.12	1.12	1.12

Solar declination	Northern latitude								
	50	55	60	65	70	75	80	85	90
-23	1.02	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00
-22	1.02	1.02	1.01	1.00	1.00	1.00	1.00	1.00	1.00
-20	1.03	1.02	1.01	1.00	1.00	1.00	1.00	1.00	1.00
-18	1.03	1.02	1.02	1.01	1.00	1.00	1.00	1.00	1.00
-16	1.04	1.03	1.02	1.01	1.00	1.00	1.00	1.00	1.00
-14	1.04	1.03	1.02	1.01	1.01	1.00	1.00	1.00	1.00
-12	1.05	1.04	1.03	1.02	1.01	1.00	1.00	1.00	1.00
-10	1.05	1.04	1.03	1.02	1.01	1.01	1.00	1.00	1.00
-8	1.06	1.05	1.04	1.03	1.02	1.01	1.00	1.00	1.00
-6	1.07	1.06	1.05	1.03	1.02	1.01	1.00	1.00	1.00
-4	1.07	1.06	1.05	1.04	1.03	1.02	1.01	1.00	1.00
-2	1.08	1.07	1.06	1.05	1.04	1.03	1.01	1.00	1.00
0	1.08	1.07	1.06	1.05	1.04	1.03	1.02	1.01	1.00
+2	1.09	1.08	1.07	1.06	1.05	1.04	1.03	1.02	1.01
+4	1.10	1.09	1.08	1.07	1.06	1.05	1.04	1.03	1.03
+6	1.10	1.09	1.08	1.07	1.06	1.06	1.04	1.04	1.04
+8	1.11	1.10	1.09	1.08	1.07	1.07	1.05	1.05	1.05
+10	1.11	1.10	1.09	1.09	1.08	1.08	1.07	1.07	1.06
+12	1.12	1.11	1.10	1.09	1.09	1.09	1.08	1.08	1.08
+14	1.12	1.11	1.10	1.10	1.09	1.10	1.09	1.09	1.09
+16	1.12	1.11	1.11	1.10	1.10	1.11	1.10	1.10	1.09
+18	1.12	1.12	1.11	1.11	1.11	1.11	1.11	1.11	1.10
+20	1.12	1.12	1.11	1.11	1.11	1.12	1.12	1.12	1.10
+22	1.12	1.12	1.12	1.12	1.12	1.12	1.13	1.12	1.11
+23	1.12	1.12	1.12	1.12	1.12	1.13	1.13	1.13	1.12

TABLE 3Correction factor **C** for installation in the **Southern** hemisphere.

Solar declination	Southern latitude									
	0	5	10	15	20	25	30	35	40	45
+23	1.11	1.10	1.09	1.09	1.08	1.07	1.06	1.05	1.04	1.03
+22	1.11	1.11	1.10	1.09	1.08	1.07	1.06	1.05	1.04	1.03
+20	1.12	1.11	1.10	1.10	1.09	1.08	1.07	1.06	1.05	1.04
+18	1.12	1.12	1.11	1.10	1.09	1.08	1.07	1.06	1.05	1.04
+16	1.12	1.12	1.11	1.10	1.10	1.09	1.08	1.07	1.06	1.05
+14	1.13	1.12	1.12	1.11	1.10	1.09	1.08	1.07	1.06	1.05
+12	1.13	1.12	1.12	1.11	1.10	1.10	1.09	1.08	1.07	1.06
+10	1.13	1.13	1.12	1.12	1.11	1.10	1.09	1.08	1.08	1.06
+8	1.13	1.13	1.13	1.12	1.11	1.11	1.10	1.09	1.08	1.07
+6	1.13	1.13	1.13	1.12	1.12	1.11	1.10	1.09	1.08	1.08
+4	1.14	1.13	1.13	1.13	1.12	1.11	1.11	1.10	1.09	1.08
+2	1.14	1.14	1.13	1.13	1.12	1.12	1.11	1.10	1.10	1.09
0	1.14	1.14	1.14	1.13	1.13	1.12	1.11	1.11	1.10	1.09
-2	1.14	1.14	1.14	1.13	1.13	1.13	1.12	1.11	1.10	1.10
-4	1.14	1.14	1.14	1.13	1.13	1.13	1.12	1.12	1.11	1.11
-6	1.13	1.13	1.14	1.13	1.13	1.13	1.13	1.12	1.11	1.11
-8	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.12	1.12	1.11
-10	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.12	1.12	1.12
-12	1.12	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.12	1.12
-14	1.12	1.12	1.13	1.13	1.13	1.13	1.13	1.13	1.12	1.12
-16	1.11	1.12	1.12	1.13	1.13	1.13	1.13	1.13	1.12	1.12
-18	1.11	1.11	1.12	1.12	1.12	1.13	1.13	1.13	1.12	1.12
-20	1.10	1.11	1.11	1.12	1.12	1.12	1.12	1.12	1.12	1.12
-22	1.10	1.10	1.11	1.11	1.11	1.12	1.12	1.12	1.12	1.12
-23	1.09	1.10	1.10	1.11	1.11	1.11	1.12	1.12	1.12	1.12

Solar declination	Southern latitude								
	50	55	60	65	70	75	80	85	90
+23	1.02	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00
+22	1.02	1.02	1.01	1.00	1.00	1.00	1.00	1.00	1.00
+20	1.03	1.02	1.01	1.00	1.00	1.00	1.00	1.00	1.00
+18	1.03	1.02	1.02	1.01	1.00	1.00	1.00	1.00	1.00
+16	1.04	1.03	1.02	1.01	1.00	1.00	1.00	1.00	1.00
+14	1.04	1.03	1.02	1.01	1.01	1.00	1.00	1.00	1.00
+12	1.05	1.04	1.03	1.02	1.01	1.00	1.00	1.00	1.00
+10	1.05	1.04	1.03	1.02	1.01	1.01	1.00	1.00	1.00
+8	1.06	1.05	1.04	1.03	1.02	1.01	1.00	1.00	1.00
+6	1.07	1.06	1.05	1.03	1.02	1.01	1.00	1.00	1.00
+4	1.07	1.06	1.05	1.04	1.03	1.02	1.01	1.00	1.00
+2	1.08	1.07	1.06	1.05	1.04	1.03	1.01	1.00	1.00
0	1.08	1.07	1.06	1.05	1.04	1.03	1.02	1.01	1.00
-2	1.09	1.08	1.07	1.06	1.05	1.04	1.03	1.02	1.01
-4	1.10	1.09	1.08	1.07	1.06	1.05	1.04	1.03	1.03
-6	1.10	1.09	1.08	1.07	1.06	1.06	1.04	1.04	1.04
-8	1.11	1.10	1.09	1.08	1.07	1.07	1.05	1.05	1.05
-10	1.11	1.10	1.09	1.09	1.08	1.08	1.07	1.07	1.06
-12	1.12	1.11	1.10	1.09	1.09	1.09	1.08	1.08	1.08
-14	1.12	1.11	1.10	1.10	1.09	1.10	1.09	1.09	1.09
-16	1.12	1.11	1.11	1.10	1.10	1.11	1.10	1.10	1.09
-18	1.12	1.12	1.11	1.11	1.11	1.11	1.11	1.11	1.10
-20	1.12	1.12	1.11	1.11	1.11	1.12	1.12	1.12	1.10
-22	1.12	1.12	1.12	1.12	1.12	1.12	1.13	1.12	1.11
-23	1.12	1.12	1.12	1.12	1.12	1.13	1.13	1.13	1.12

9 MAINTENANCE

In order to grant measurements high accuracy, it is important to keep the outer glass dome clean. Consequently, the more the dome 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 dome with water only.

Because of the high temperature changes between day and night, some condensation might appear on the pyranometer domes. In this case the performed reading is highly over-estimated. To minimize the condensation, the pyranometer 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 lose 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 pyranometer works.

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

10 TECHNICAL SPECIFICATIONS

Sensor	Thermopile
Typical sensitivity	6÷12 $\mu\text{V}/\text{Wm}^{-2}$
Impedance	33÷45 Ω
Measuring range	0÷2000 or 0÷4000 W/m^2 depending on model
Viewing angle	2 π sr
Spectral range (50%)	283÷2800 nm
Operating temperature/humidity	-40÷80 °C / 0÷100%
Output	Analog in $\mu\text{V}/\text{Wm}^{-2}$ (LPPYRA12) Analog 4÷20 mA (LPPYRA12AC[S]) Analog 0÷1 V, 0÷5 V or 0÷10 V (LPPYRA12AV) Digital RS485 Modbus-RTU (LPPYRA12[AC]S) Digital SDI-12 (LPPYRA12S12)
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) 7÷30 Vdc (SDI-12 output)
Consumption	< 200 μA for the version LPPYRA12S12
Connection	4 or 8-pole M12 connector depending on the model
Dimensions	Fig. 3.2
Weight	6.8 kg approx. (pyranometer + shadow ring)
Accuracy of levelling device	< 0.1°
Protection degree	IP 67
MTBF	> 10 years

Technical Specifications According to ISO 9060:2018

Classification	Spectrally Flat Class B
Response time (95%)	< 10 s
Zero offset	
a) response to a 200 W/m^2 thermal radiation	< $ \pm 10 \text{ W}/\text{m}^2$
b) response to a 5 K/h change in ambiente temperature	< $ \pm 4 \text{ W}/\text{m}^2$
c) total zero offset including the effects a), b) and other sources	< $ \pm 15 \text{ W}/\text{m}^2$
Long-term instability (1 year)	< $ \pm 1 \%$
Non-linearity	< $ \pm 1 \%$
Response according to the cosine law	< $ \pm 18 \text{ W}/\text{m}^2$
Spectral error	< $ \pm 0.5 \%$
Temperature response (-10...+40°C)	< 1.5 %
Tilt response	< $ \pm 2 \%$

11 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.

12 ACCESSORIES ORDERING CODES

LPSP1	UV-resistant shade disk (spare part).
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 LPPYRA12, LPPYRA12AC[4] and LPPYRA12AV[4].
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 LPPYRA12S and LPPYRA12S12.
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 LPPYRA12ACS[4].
CP24	PC connecting cable for the RS485 MODBUS parameters configuration of the LPPYRA...S pyranometers. 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.

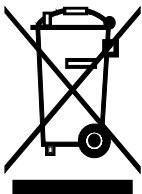
The manufacturer repairs the products that show defects of construction in accordance with the terms and conditions of warranty included in the manual of the product. For any dispute, the competent court is the Court of Padua. The Italian law and the "Convention on Contracts for the International Sales 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:
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Documents are in the process of being changed.