

OPERATING MANUAL

PYRAsense

LPS12 / LPS13 series

Pyranometers



EN

V1.2



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1 Introduction

LPS12... and **LPS13...** consist of a pyranometer equipped with a shadow ring for the measurement of **diffuse irradiance** on a flat surface (W/m^2). The use of the shadow ring allows eliminating the contribution of direct solar irradiance from the measurement of the sensor.

LPS12... uses an LPS02... **Spectrally Flat Class B** pyranometer, while **LPS13...** uses an LPS10... **Spectrally Flat Class A** pyranometer according to ISO 9060:2018 standard.

The LPS02 and LPS10 pyranometers meet the requirements of the WMO "Guide to Instruments and Methods of Observation".

The internal temperature, relative humidity and pressure **diagnostic sensors** integrated in the LPS12Mxx and LPS13Mxx models allow keeping the pyranometer operating conditions under control all the time and foresee any maintenance intervention in advance, thus ensuring always reliable measurements.

The integrated bubble level and the adjustable feet facilitate horizontal positioning during installation. As option, the LPS12Mxx and LPS13Mxx models can be equipped with a **tilt sensor** (option T in the ordering code) which, in addition to facilitating the installation of the pyranometer, allows continuous monitoring of the correct installation.

The various models are distinguished by the type of output available and by the presence or absence of the "tilt" sensor:

Model	Output		Tilt
	Digital RS485 Modbus-RTU	Analog	
LPS12M00 / LPS13M00	√	--	--
LPS12M0T / LPS13M0T			√
LPS12MA0 / LPS13MA0	√	Configurable 4...20 mA (default), 0...20 mA, 0...1 V, 0...5 V or 0...10 V	--
LPS12MAT / LPS13MAT			√
LPS120C0 / LPS130C0	--	2-wire (current loop) 4...20 mA	--
LPS120P0 / LPS130P0	--	mV	--

The irradiance range for the analog output is user configurable in the LPS12Mxx and LPS13Mxx models.

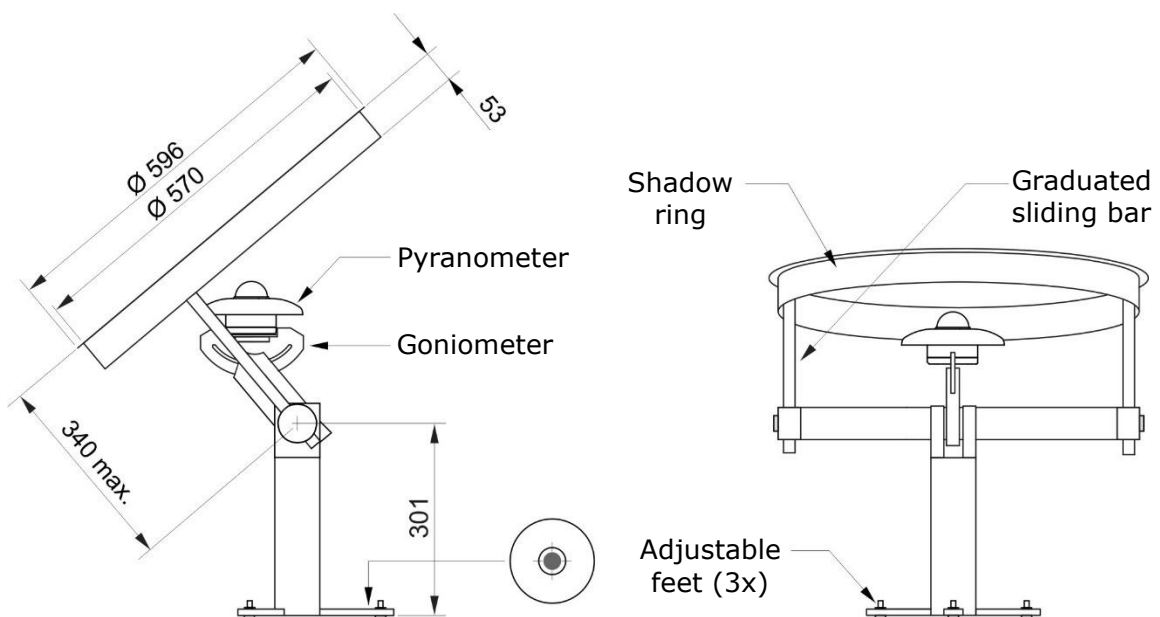
The pyranometers are factory calibrated in accordance with the ISO 9847:2023 (Type A1) standard: "Calibration of pyranometers by comparison to a reference pyranometer". The calibration is performed by comparison with the reference sample calibrated annually at WRC (World Radiation Center).

The **DATAsense** PC application software, downloadable from the website and usable with the LPS12Mxx and LPS13Mxx models, allows configuring the sensor (e.g., Modbus parameters, measuring range for the analog output, etc.), monitor the measurements in real time, even graphically for the irradiance, and save the values detected during the connection in a file.

2 Technical specifications

Sensor		Thermopile
Typical sensitivity		6...12 $\mu\text{V}/\text{Wm}^{-2}$
Measuring range		-200...4000 W/m^2 The irradiance range for the analog output is 0...2000 W/m^2 by default, and is configurable in LPS1xMxx
Resolution		0.1 W/m^2
Viewing angle		2π sr
Spectral range (50%)		283...2800 nm
Output	LPS1xM0x LPS1xMAX LPS1x0C0 LPS1x0P0	Isolated RS485 Modbus-RTU Isolated RS485 Modbus-RTU + analog configurable 4...20 mA (default), 0...20 mA, 0...1 V, 0...5 V or 0...10 V 2-wire (current loop) 4...20 mA passive in mV
Power supply		7...30 Vdc for RS485 output 10...30 Vdc for analog output (except 0...10 V) 15...30 Vdc for 0...10 V output
Consumption	LPS1xM0x LPS1xMAX	15 mA @ 24 Vdc / 21 mA @ 12 Vdc 37 mA @ 24 Vdc & Iout=22 mA / 43 mA @ 12 Vdc & Iout=22 mA
Connection		5-pole M12 (except LPS1xMAX) / 8-pole M12 (only LPS1xMAX)
Weight		6.8 kg approx. (pyranometer + support + shadow ring)
Operating conditions		-40...+80 °C / 0...100 %RH / Max. altitude 6000 m
Bubble level accuracy		< 0.2°
Protection degree		IP 67
Materials	Pyranometer Ring and stand	Housing: anodized aluminum / Screen: ASA Dome: optical glass Aluminum alloy and stainless steel
MTBF		> 10 years

Dimensions (mm) and description



Technical Specifications According to ISO 9060:2018

	LPS12	LPS13
Classification	Spectrally Flat Class B	Spectrally Flat Class A
Response time (95%)	< 10 s	< 2 s
Zero offset		
a) response to a 200 W/m ² thermal radiation	< ±10 W/m ²	< ±7 W/m ²
b) response to a 5 K/h change in ambient temperature	< ±4 W/m ²	< ±2 W/m ²
c) total zero offset including the effects a), b) and other sources	< ±15 W/m ²	< ±10 W/m ²
Long-term instability (1 year)	< ±1 %	< ±0.5 %
Non-linearity	< ±1 %	< ±0.2 %
Directional response (up to 80° with 1000 W/m ² beam)	< ±18 W/m ²	< ±10 W/m ²
Spectral error	< ±0.5 %	< ±0.2 %
Temperature response (-10...+40°C)	< ±1.5 %	< ±0.5 %
Tilt response	< ±1 %	< ±0.2 %

Diagnostic sensors (only LPS12Mxx / LPS13Mxx)

Internal Temperature	
Measuring range	-40...+80 °C
Resolution	0.1 °C
Accuracy	±0.5 °C (0...60 °C)
Internal Relative Humidity	
Measuring range	0...100%
Resolution	0.1%
Accuracy	±3% @ T=25 °C & RH=20...80%
Internal pressure	
Measuring range	300...1100 hPa
Resolution	0.1 hPa
Accuracy	±1 hPa (0...60 °C)

Tilt sensor (only LPS12MxT / LPS13MxT)

Measuring range	0...180°
Resolution	0.1°
Accuracy	< 0.5°

3 Measuring principle

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

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

The pyranometer spectral range is determined by the transmission of the two concentric glass domes, with 50 and 30 mm outer diameters, which also grant the thermopile a proper thermal insulation from the wind and reduce the sensitivity to thermal irradiance. Furthermore, the domes protect the thermopile from the dust which, depositing on the blackened part, could change its spectral sensitivity.

The special material used to manufacture the domes allows the spectral range to be extended to short wavelengths starting from 283 nm.

Considering a standard solar spectrum, the portion of solar irradiation detected by the pyranometer is greater than 99.8%. Figure 3.1 shows the relative spectral sensitivity of the pyranometer (**blue line**) and the standard solar spectrum (**red line**).

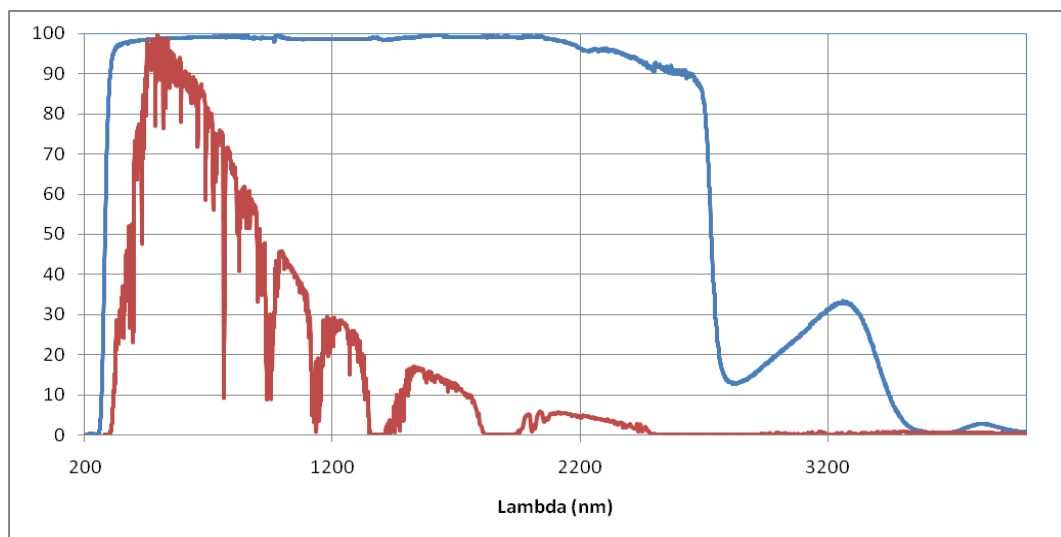


Fig. 3.1: LPS02... relative spectral sensitivity and standard solar spectrum

An internal compensation circuit minimizes the change of sensitivity with temperature.

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 condensation from forming on the internal side of the dome under certain climatic conditions, silica-gel is inserted inside the pyranometer to absorb moisture.

4 Installation

- 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.

4.1 Assembly

For transportation, the shadow ring, the graduated sliding bars and the three spokes composing the stand base are supplied disassembled. Proceed as follows

1. Screw the three spokes composing the base to the bottom of the stand, using 6 M6x16 mm screws (supplied).
2. Screw the two graduated bars to the shadow ring, using 1 M6x16 mm screw (supplied) for each bar.
3. Insert the two graduated bars in the two slots at the crossbar ends. Pay attention to the correct insertion direction: the ring must be mounted so that its vertical axis passes through the center of the pyranometer dome. The small knobs at the ends of the crossbar allow the bars to be locked in place.

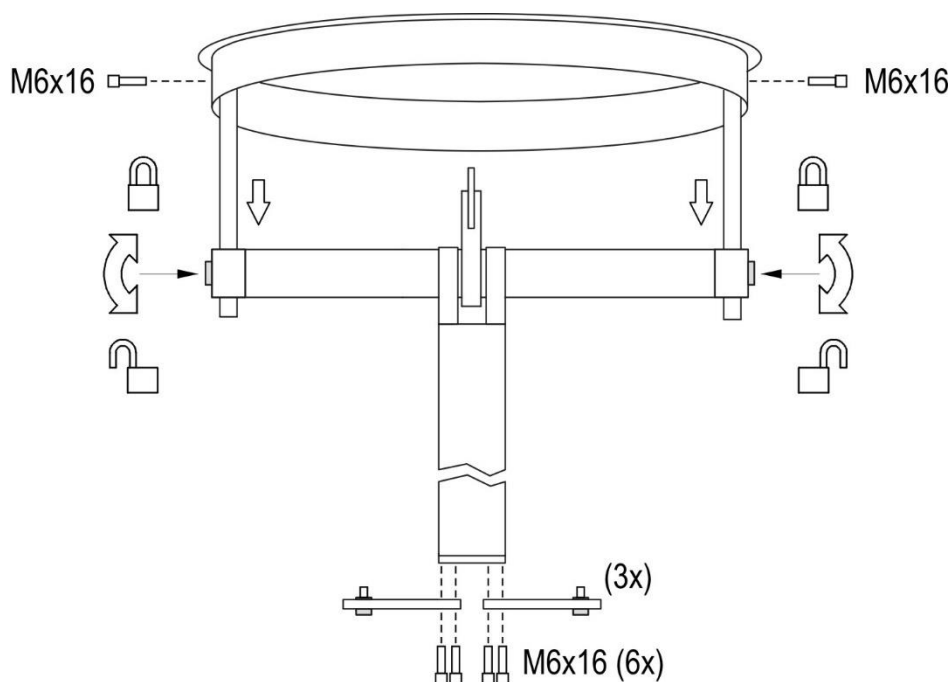


Fig. 4.1: ring and base assembly

4.2 Positioning

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

The shadow ring must be positioned so that its axis is parallel to the earth axis. Proceed in two steps: first align the shadow ring along the North-South axis, then adjust the

ring tilt.

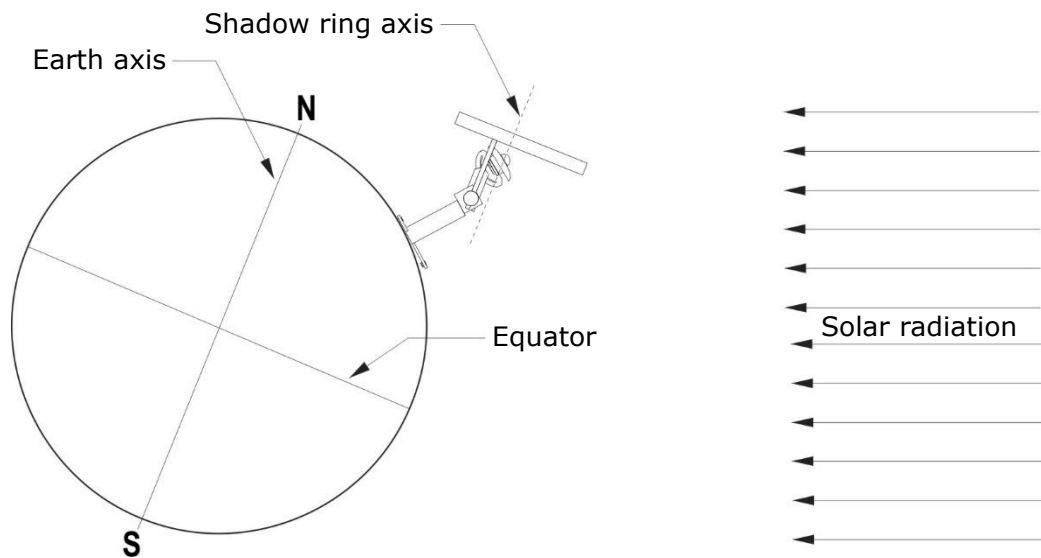


Fig. 4.2: positioning the instrument

Aligning the shadow ring along the North-South axis:

1. Wait for solar midday.
2. With the index of the goniometer indicating 90° , turn the complete stand until the ideal extension of the sunbeams is parallel to the groove in the goniometer, as shown in the figure below.

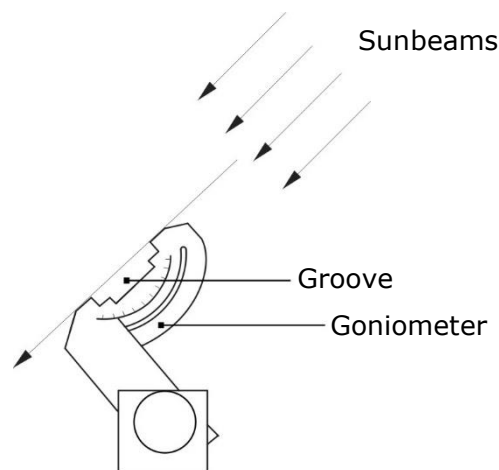


Fig. 4.3: North-South alignment

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.

The stand base must be positioned parallel to the ground, by adjusting the feet height with the aid of the bubble level integrated in the base.

After alignment and leveling, the complete stand can eventually be permanently fastened to a surface, with M8 bolts (not supplied), using the 3 clearance holes in the base.

Adjusting the shadow ring tilt:

1. Make sure that the graduated bars and the long side of the goniometer support are parallel (by default, they are already factory aligned).
2. Fix the pyranometer. The pyranometer is fixed to the goniometer by means of an adapter plate. The plate is fixed to the goniometer by means of 2 M5x10 mm countersunk screws (supplied). Next, the base of the pyranometer is attached to the plate using 2 M5x10 mm Allen screws (supplied).

Note: by fixing the plate to the goniometer first and then the pyranometer to the plate, it is not necessary to remove the pyranometer screen for fixing.

3. Adjust the goniometer so that the index indicates the latitude of the installation site on the goniometer scale.

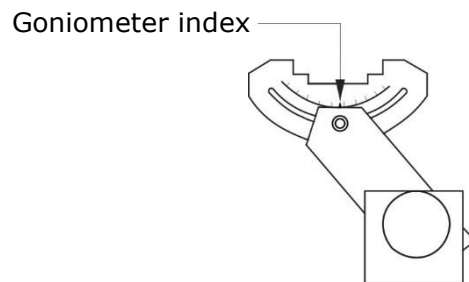


Fig. 4.4: goniometer adjustment

4. Loosen the crossbar fastening screw and rotate the crossbar until the pyranometer is parallel to the ground, using the bubble level on the pyranometer body as a reference; then, secure the crossbar with the fastening screw.

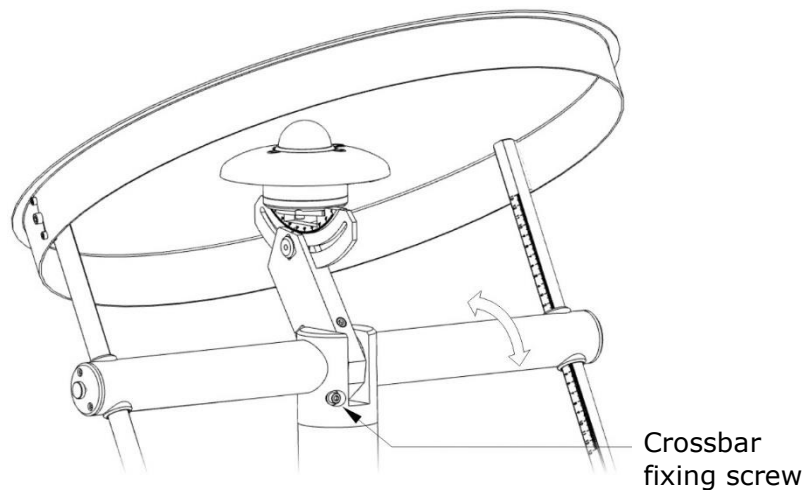


Fig. 4.5: pyranometer horizontal alignment

Note: it is preferable to use the bubble level also in models equipped with a tilt sensor, as it is more accurate; use the tilt sensor for positioning monitoring after installation.

Adjusting the shadow ring height:

Loosen the small knobs at the ends of the crossbar and slide the graduated bars until the large dome of the pyranometer appears fully shaded, then tighten the knobs to lock the bars.

To confirm correct installation, you can compare the reading on the scale of the graduated bars with the value given in Table 1: if the values match, the pyranometer and shadow ring have been installed correctly.

The shadow ring height must be adjusted at least once every two days.

TABLE 1

The table shows the values to which the graduated 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 graduated bars (mm) if installed in the Northern hemisphere	Value to be set on the graduated 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

4.3 Electrical connections

⚠ Warning!

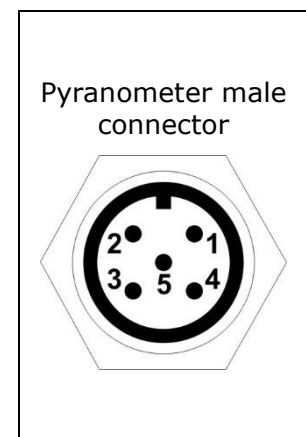
The metallic housing of the pyranometer should preferably be grounded locally. The CPM12... cable shield is connected to the connector shell and then to the metallic housing of the pyranometer. Do not connect the yellow/green wire (cable shield) to ground, unless it is not possible to ground the pyranometer 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:

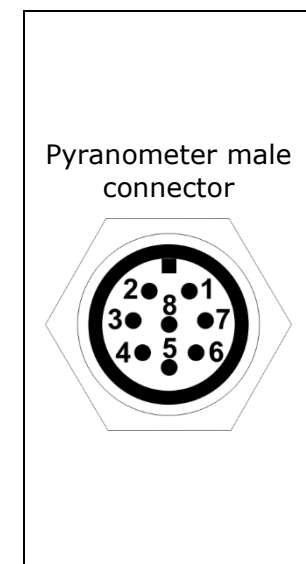
LPS1xM0x / LPS1x0C0 / LPS1x0P0

Pin	Function			CPM12-5... wire color
	LPS1xM0x	LPS1x0C0	LPS1x0P0	
1	+Vdc	Iin (+)	+Vout	Brown
2	GND	Iout (-)	-Vout	White
3	DATA +	NC	NC	Blue
4	DATA -	NC	NC	Black
5	DGND	NC	NC	Grey
	Connector shell / Cable shield Pyranometer housing			Yellow/Green



LPS1xMAx

Pin	Function	CPM12-8... wire color
1	GND (Power supply negative)	White
2	+Vdc (Power supply positive)	Brown
3	DGND (Digital ground)	Green
4	DATA - (RS485)	Yellow
5	DATA + (RS485)	Grey
6	AGND (Analog ground)	Pink
7	AOUT (Analog output positive)	Blue
8	NC	Red
	Connector shell / Cable shield Pyranometer housing	Yellow/Green



LPS1xMxx connections:

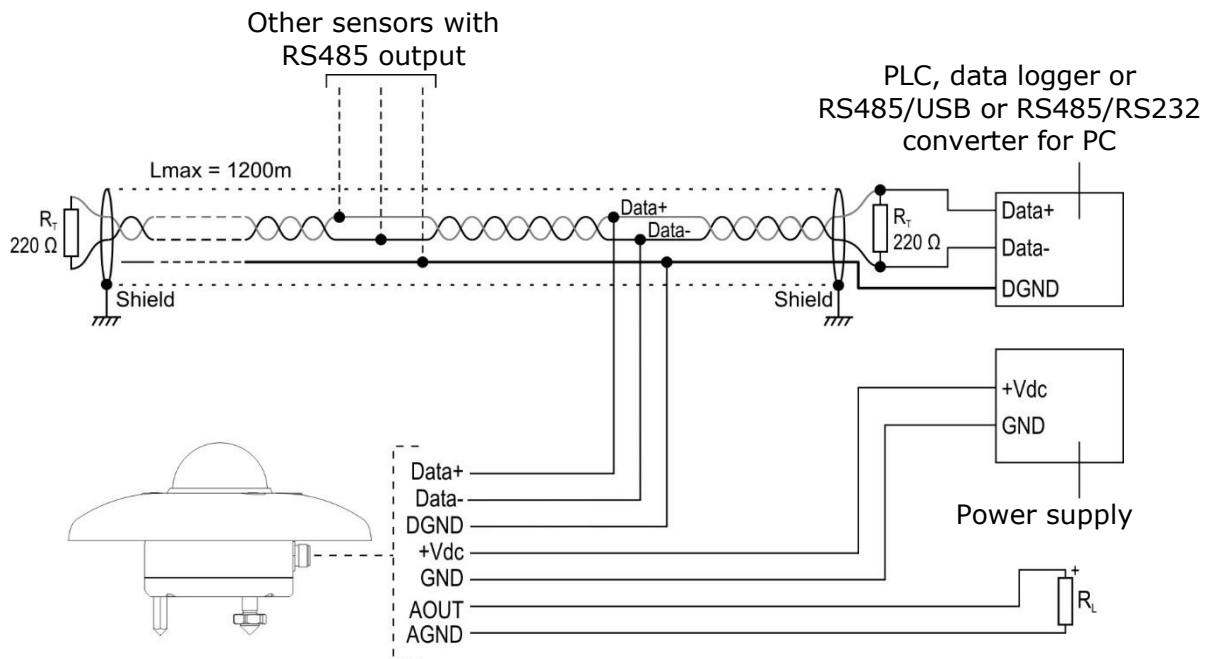


Fig. 4.6: LPS1xMxx connection diagram

RS485 output:

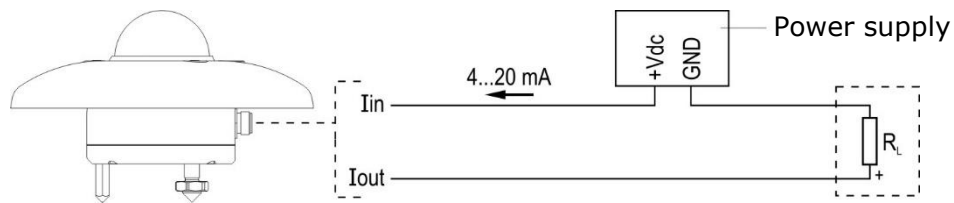
The RS485 output is isolated. Before connecting the pyranometer to the RS485 network, set the address and the communication parameters, if different from the factory preset (see "Configuration" chapter).

Analog output:

In the LPS1xMxx models the type of analog output is configurable (default 4...20 mA, see "Configuration" chapter). The pyranometer power supply and the load resistance vary according to the type of analog output configured:

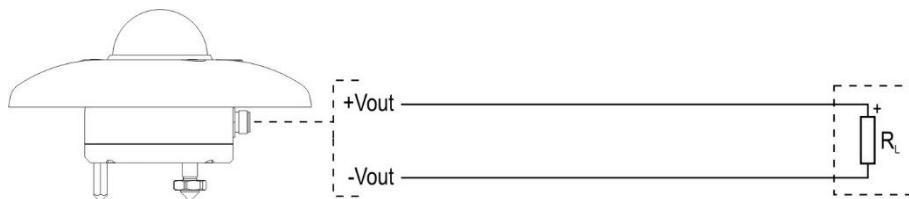
Analog output	Power supply required	Load resistance
0...20 mA	10...30 Vdc	≤ 500 Ω
4...20 mA	10...30 Vdc	≤ 500 Ω
0...1 V	10...30 Vdc	≥ 100 kΩ
0...5 V	10...30 Vdc	≥ 100 kΩ
0...10 V	15...30 Vdc	≥ 100 kΩ

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 or 22 mA if the output is 4...20 mA).

LPS1x0C0 connections:**Fig. 4.7: LPS1x0C0 connection diagram**

Pyranometer power supply: 10...30 V_{dc}. 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.

LPS1x0P0 connections:**Fig. 4.8: LPS1x0P0 connection diagram**

The pyranometer does not require power supply. The typical output impedance of the sensor is $<50 \Omega$.

The output signal typically does not exceed a few tens of mV. The recommended resolution of the reading instrument is $1 \mu\text{V}$.

5 Configuration (LPS1xMxx)

It is possible to change the serial communication parameters (Modbus address, Baud Rate, parity/stop bit) and, for LPS1xMAx models, the configuration of the analog output.

The configuration of the pyranometer can be done:

- With the aid of **DATAsense** PC application software (see the software online help), downloadable from the website.
- By sending serial commands from a PC, via a standard communication program (see the chapter "ASCII proprietary protocol").
- Via the "Holding Registers" in MODBUS-RTU mode (only for the serial communication parameters, see the chapter "Modbus-RTU protocol").

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

Analog output (only LPS1xMAx):

By default, the analog output is 4...20 mA → 0...2000 W/m².

It is possible:

- to associate the analog output to a different global irradiance range, within the full measuring range;
- change the output type (**only via DATAsense software**; default output 4...20 mA, possible alternatives 0...20 mA, 0...1 V, 0...5 V or 0...10 V);
- to reverse the direction of the output, so that the output decreases as the measurement increases.

Connection to PC:

To connect the pyranometer to a PC USB port, to check or change the configuration, the **CP24B-5** (LPS1xM0x) or **CP24B-8** (LPS1xMAx) optional cables can be used, which also allow the pyranometer to be powered via the USB port.

To use the CP24B-x cables, 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 pyranometer separately (the minimum supply voltage is 7 V).

6 ASCII proprietary protocol (LPS1xMxx)

To communicate with the pyranometer via the ASCII proprietary protocol:

1. Connect the pyranometer 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 pyranometer is connected.
3. Power the pyranometer (or power cycle if already powered) and send the command @ within 5 seconds from the instrument power on (the pyranometer replies &| if the command @ is recognized).
Note: if the CP24B-x cable is used, to power cycle the pyranometer, disconnect the cable for a few seconds from the PC USB port, then reconnect it.
4. Send the command **CAL USER ON** (the pyranometer replies CAL USER ON;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 tables 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.

Ping:

Command	Reply	Description
P0	P0;&	Ping.

Pyranometer general information:

Command	Reply	Description
G0	G0;model	Model
G1	G1;sub-model	Sub-model
G2	G2;nnnnnnnn	Serial number
G3	G3;xx.yy	Firmware revision
G4	G4;yyyy/mm/dd	Firmware revision date
G5	G5;xx.yy	Hardware revision
G6	G6;nnnnn	Operating time in days from first power on
G7	G7;nnnnn	Operating time in days from last power on
GD	GD;yyyy/mm/dd hh:mm:ss	Factory calibration date and time

User code:

The user code is an alphanumeric string of up to 8 characters that the user can set to identify the pyranometer with a mnemonic name.

Command	Reply	Description
CUCnnnnnnnn	CUC;&	Sets nnnnnnnn as user code. Default= <i>blank</i>
RUC	RUC;nnnnnnnn	Reads the user code.

RS485 Modbus-RTU communication parameters:

Command	Reply	Description
CMA _n	CMA;&	Sets the Modbus-RTU address (1...247) to n. Default=1
RMA	RMA;n	Reads the Modbus-RTU address.
CMB _n	CMB;&	Sets the Baud Rate: <ul style="list-style-type: none"> ▪ 9600 if n=0 ▪ 19200 if n=1 (<i>default</i>) ▪ 38400 if n=2 ▪ 57600 if n=3 ▪ 115200 if n=4
RMB	RMB;n	Reads Baud Rate setting.
CMP _n	CMP;&	Sets parity and stop bits (data bits = 8 fixed): <ul style="list-style-type: none"> ▪ 8N1 if n=0 ▪ 8E1 if n=2 (<i>default</i>) ▪ 8O1 if n=4 ▪ 8N2 se n=1 ▪ 8E2 se n=3 ▪ 8O2 se n=5
RMP	RMP;n	Reads the setting of parity and stop bits.
CMW _n	CMW;&	Sets waiting time after transmission with Modbus-RTU protocol: <ul style="list-style-type: none"> ▪ Immediate reception if n=0 (violates protocol) ▪ Waiting 3.5 characters if n=1 (respects protocol) <i>Default</i> : Waiting 3.5 characters (n=1)
RMW	RMW;n	Reads the setting of waiting time after transmission with Modbus-RTU protocol.

Analog output (only LPS1xMAx):

Command	Reply	Description
RAS	RAS;n	Reads the type of analog output set. <i>Note: the type of analog output can be changed via DATAsense software.</i>
CAInnnn	CAI;&	Sets nnnn as irradiance minimum value in W/m ² for the analog output. Min=-200, default=0
RAI	RAI;nnnn	Reads the irradiance minimum value in W/m ² for the analog output.
CAFnnnn	CAF;&	Sets nnnn as irradiance maximum value in W/m ² for the analog output. Max=4000, default=2000
RAF	RAF;nnnn	Reads the irradiance maximum value in W/m ² for the analog output.
CAin	CAi;&	Sets the direct or reversed correspondence between analog output and irradiance: <ul style="list-style-type: none"> ▪ If n=0: Min. output ⇒ Min. irradiance Max. output ⇒ Max. irradiance ▪ If n=1: Min. output ⇒ Max. irradiance Max. output ⇒ Min. irradiance <i>Default</i> : Direct correspondence (n=0)
RAi	RAi;n	Reads the type of correspondence (direct or reversed) between analog output and irradiance.

Units of measurement:

Changing the temperature units of measurement affects the Modbus protocol only. The temperature measurement provided by the ASCII proprietary protocol (commands S0/S1) is always in °C.

Command	Reply	Description
TTn	WUT;&	Sets the temperature unit of measurement: <ul style="list-style-type: none"> ▪ °C if n=0 (<i>default</i>) ▪ °F if n=1 ▪ K if n=2
RUT	RUT;n	Reads the temperature unit of measurement.

Measurements reading:

Command	Reply	Description
S0	S0;meas	Prints the measurements in the following sequence: <ul style="list-style-type: none"> ▪ Temperature compensated irradiance in W/m² (<i>it takes into account the change in sensor sensitivity as temperature changes</i>) ▪ Nominal irradiance in W/m² (<i>calculated considering the sensor nominal sensitivity at the calibration temperature: ~23 °C</i>) ▪ Signal in mV generated by the thermopile ▪ Internal temperature in °C ▪ Internal relative humidity in % ▪ Internal pressure in hPa ▪ Tilt angle (<i>only LPS02MxT</i>) ▪ Power supply voltage <p>If the automatic sending of the measurements is enabled (command S1), sending S0 disables the automatic sending.</p>
S1	S1;meas	Enables the automatic sending of the measurements, once per second.

Diagnostics alarm thresholds:

Command	Reply	Description
WAL1n...n	WAL1;&	Sets to n...n the operating time alarm threshold from first power on (0...65535 days, default=730 days → 2 years).
AL1	AL1;n...n	Reads the operating time alarm threshold from first power on.
WAL2n...n	WAL2;&	Sets to n...n the operating time alarm threshold from last power on (0...65535 days, default=730 days → 2 years).
AL2	AL2;n...n	Reads the operating time alarm threshold from last power on.
WAL3n...n	WAL3;&	Sets to n...n, in the set unit of measurement, the internal temperature alarm threshold (0...150 °C, default=80 °C).
AL3	AL3;n...n	Reads the internal temperature alarm threshold.
WAL4n...n	WAL4;&	Sets to n...n% the internal relative humidity alarm threshold (0...100%, default=25%).
AL4	AL4;n...n	Reads the internal relative humidity alarm threshold.

Command	Reply	Description
WAL5n...n	WAL5;&	Sets to n...n hPa the internal pressure alarm threshold (800...1100 hPa, default=1100 hPa).
AL5	AL5;n...n	Reads the internal pressure alarm threshold.

All alarm thresholds are integer values with resolution 1 (1 day, 1 °C/°F/K, 1 %RH, 1 hPa).

The alarm condition occurs when the parameter becomes greater than the set threshold.

7 Modbus-RTU protocol (LPS1xMxx)

By default, the pyranometer has Modbus address **1** and communication parameters 19200, 8E1. The address and the communication parameters can be changed by using the appropriate serial commands of the proprietary protocol or, alternatively, directly with Modbus commands by changing the value of the Holding Registers described later.

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

The delay between the reception of a query from the master device and the start of the pyranometer reply is less than 10 ms.

Below is the list of registers.

Input Registers:

Address	Description	Format
MEASUREMENTS		
1 + 2	Temperature compensated irradiance in W/m ² (x10) <i>(it takes into account the change in sensor sensitivity as temperature changes)</i>	32-bit Integer
3 + 4	Nominal irradiance in W/m ² (x10) <i>(calculated considering the sensor nominal sensitivity at the calibration temperature: ~23 °C)</i>	32-bit Integer
6	Internal relative humidity in % (x10)	16-bit Integer
7	Internal temperature in the set unit of measurement (x10)	16-bit Integer
8	Internal pressure in hPa (x10)	16-bit Integer
9 + 10	Signal in mV generated by the thermopile (x1000)	32-bit Integer
11	Tilt angle (<i>only LPS02MxT</i>) (x10)	16-bit Integer
PYRANOMETER GENERAL INFORMATION		
16...25	Model (20 characters)	String
26...35	Sub-model (20 characters)	String
36...39	Serial number (8 characters)	String
40...43	Firmware revision (8 characters)	String
44...47	Hardware revision (8 characters)	String
CALIBRATION HISTORY		
50 + 51	Sensitivity of last calibration in $\mu\text{V}/\text{Wm}^{-2}$ (x1000)	32-bit Integer
52...55	Date of last calibration (yyyymmdd)	String
56 + 57	Sensitivity of historical calibration 1 in $\mu\text{V}/\text{Wm}^{-2}$ (x1000)	32-bit Integer
58...61	Date of historical calibration 1 (yyyymmdd)	String
62 + 63	Sensitivity of historical calibration 2 in $\mu\text{V}/\text{Wm}^{-2}$ (x1000)	32-bit Integer
64...67	Date of historical calibration 2 (yyyymmdd)	String
68 + 69	Sensitivity of historical calibration 3 in $\mu\text{V}/\text{Wm}^{-2}$ (x1000)	32-bit Integer
70...73	Date of historical calibration 3 (yyyymmdd)	String
74 + 75	Sensitivity of historical calibration 4 in $\mu\text{V}/\text{Wm}^{-2}$ (x1000)	32-bit Integer

Address	Description	Format
76...79	Date of historical calibration 4 (yyyymmdd)	String
80 + 81	Sensitivity of historical calibration 5 in $\mu\text{V}/\text{Wm}^{-2}$ (x1000)	32-bit Integer
82...85	Date of historical calibration 5 (yyyymmdd)	String
OPERATING TIME		
100	Operating time in days from first power on	16-bit Integer
101	Operating time in days from last power on	16-bit Integer

Notes on the registers format:

- 1) To read a **32-bit integer** value, the two consecutive registers indicated must be accessed. The register with lower address contains the most significant bits.

Example: the temperature compensated irradiance, for ex. $50.1 \text{ W}/\text{m}^2$, is available in the registers with address 1 and 2.

Register address	1	2
Register content (Hex)	0000	01F5
Read value	0x000001F5 = 501 = $50.1 \text{ W}/\text{m}^2$	

- 2) The alphanumeric **strings** are contained in a series of 16-bit registers. Each register contains 2 characters of the string: the most significant 8 bits contain the ASCII code of the first character, the least significant 8 bits contain the ASCII code of the next character. The start character of the string is in the register of the series with the lowest address.

Example: the pyranometer model, for ex. LPS02MAT, is available in the registers with address from 16 to 25.

Register address	16	17	18	19	20	21	22	23	24	25
Register content (Hex)	4C50	5330	324D	4154	0000	0000	0000	0000	0000	0000
Read value	L	P	S	0	2	M	A	T		

Discrete inputs:

Address	Description	Format
0	Operating time alarm from first power on	Bit
1	Operating time alarm from last power on	Bit
2	Internal temperature alarm	Bit
3	Internal relative humidity alarm	Bit
4	Internal pressure alarm	Bit

The value of a "Discrete input", normally at 0, becomes 1 when the alarm threshold set with the relative "Holding register" is exceeded.

Holding Registers:

Address	Description	Format
0	RS485 Modbus-RTU Baud Rate: 0=9600 1=19200 (default) 2=38400 3=57600 4=115200	16-bit Integer
1	RS485 Modbus-RTU parity and stop bits: 0=8N1 1=8N2 2=8E1 (default) 3=8E2 4=8O1 5=8O2	16-bit Integer
2	Modbus-RTU address (1...247, default=1).	16-bit Integer
5	Temperature unit of measurement: 0=°C (default) 1=°F 2=K	16-bit Integer
6	Operating time alarm threshold from first power on (0...65535 days, default=730 days → 2 years)	16-bit Integer
7	Operating time alarm threshold from last power on (0...65535 days, default=730 days → 2 years)	16-bit Integer
8	Internal temperature alarm threshold in the set unit of measurement (0...150 °C, default=80 °C)	16-bit Integer
9	Internal relative humidity alarm threshold in % (0...100 %, default=25%)	16-bit Integer
10	Internal pressure alarm threshold in hPa (800...1100 hPa, default=1100 hPa)	16-bit Integer
30002	Enabling writing in Holding Register: 9876=Enabled 8888=Disabled	16-bit Integer

All alarm thresholds are integer values with resolution 1 (1 day, 1 °C/°F/K, 1 %RH, 1 hPa).

To change the settings via the Holding Registers, it is first necessary to enable the writing by entering the value 9876 in the register with address 30002.

8 Measurement with analog output

LPS1x0P0:

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

LPS1xMAx / LPS1x0C0:

Calculation of the global irradiance **E_e** (W/m^2) as a function of the analog output value **V_{out}** (in V) or **I_{out}** (mA).

Analog output	Global irradiance
0...20 mA	$E_e = E_{is} + [(E_{fs} - E_{is}) \cdot I_{out}/20]$
4...20 mA	$E_e = E_{is} + [(E_{fs} - E_{is}) \cdot (I_{out} - 4)/16]$
0...1 V	$E_e = E_{is} + [(E_{fs} - E_{is}) \cdot V_{out}]$
0...5 V	$E_e = E_{is} + [(E_{fs} - E_{is}) \cdot V_{out}/5]$
0...10 V	$E_e = E_{is} + [(E_{fs} - E_{is}) \cdot V_{out}/10]$

Where **E_{is}** and **E_{fs}** are respectively the global irradiance (in W/m^2) corresponding to the analog output initial and full scale.

Considering the default values **E_{is}** = 0 and **E_{fs}** = 2000 W/m^2 , the previous formulas can be simplified into the following ones:

Analog output	Global irradiance
0...20 mA	$E_e = 100 \cdot I_{out}$
4...20 mA	$E_e = 125 \cdot (I_{out} - 4)$
0...1 V	$E_e = 2000 \cdot V_{out}$
0...5 V	$E_e = 400 \cdot V_{out}$
0...10 V	$E_e = 200 \cdot V_{out}$

9 Measurement correction

Since in addition to direct radiation the shadow ring intercepts some of the diffused radiation, 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 2

Correction 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 3

Correction 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

10 Use of the diagnostic sensors (LPS1xMxx)

The internal temperature, relative humidity, pressure and tilt (only LPS1xMxT) **diagnostic sensors** allow keeping the pyranometer operating conditions under control all the time and foresee any maintenance intervention in advance, thus ensuring always reliable measurements.

Internal temperature

As a rule, the internal temperature of the pyranometer is on average 5 to 10 °C higher than the external ambient temperature. Temperatures that are excessively lower or higher than indicated may be a sign of malfunctions.

Monitoring the internal temperature therefore makes it possible to determine whether the irradiance measurement can be considered reliable.

Internal relative humidity

To minimize condensation and keep measurements accurate, desiccant silica-gel is provided inside the pyranometer base to absorb moisture. The silica-gel life is at least 10 years. The long-term monitoring of the internal relative humidity of the pyranometer allows the efficiency of the silica-gel to be checked. A progressive upward trend in relative humidity indicates the progressively decreasing ability of silica-gel to absorb moisture.

The internal relative humidity depends not only on the saturation level of the silica-gel but also on the temperature of the pyranometer; therefore, short-term humidity monitoring is not particularly significant in determining the condition of the silica-gel. Relative humidity monitoring can be annual.

It is advisable to detect the relative humidity during the night, when the temperature is lower and the relative humidity is higher.

Silica-gel can be considered close to saturation when the internal relative humidity is persistently above 50% at temperatures below 20 °C.

Internal pressure

Monitoring the internal pressure of the pyranometer allows the housing to be checked for tight seal (no leakage). The pressure/temperature ratio should remain approximately constant.

Tilt

Monitoring the inclination angle of the pyranometer installation allows for the detection of unwanted displacements that may occur in the long term or as a result of impacts suffered by the installation.

Take the measurement of the Tilt sensor immediately after installation and consider it as a reference for subsequent measurements.

Alarm thresholds

Thresholds can be defined for internal temperature, relative humidity and pressure. When the thresholds are exceeded an alarm condition is generated, which can be read via the Modbus "Discrete inputs" or the DATAsense software.

The thresholds can be set via the Modbus "Holding registers", the WAL3/WAL4/WAL5 serial commands or the DATAsense software.

11 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.

To minimize condensation and keep measurements accurate, desiccant silica-gel is provided inside the pyranometer base to absorb moisture. The silica-gel life is at least 10 years and can be replaced by the user.

To replace the silica-gel, unscrew the 4 screws that fix the base to the main body of the pyranometer; remove the silica-gel sachet and insert a new sachet, then screw the pyranometer base back on.

Warning!

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

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

The pyranometer provides the operating time in days since first and last power on, and allows time alarm thresholds to be set to alert the user of the need for periodic verification or maintenance. The exceeding of thresholds can be read via Modbus "Discrete inputs" or DATAsense software. The thresholds can be set via Modbus "Holding registers", WAL1/WAL2 serial commands, or DATAsense software.

12 Safety instructions

The pyranometer 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.

13 Accessories ordering codes

The pyranometer is supplied with support base with ring, solar radiation protection screen, M12 female free connector (only if the optional cable is not ordered), calibration report and **DATAsense** PC application software downloadable from Delta OHM website.

Cables and fixing accessories must be ordered separately.

Installation cables

CPM12-5... Cable with 5-pole M12 connector on one end, open wires on the other end. Length 5 m (CPM12-5.5) or 10 m (CPM12-5.10). **For LPS1xM0x, LPS1x0C0 and LPS1x0P0.**

CPM12-8... Cable with 8-pole M12 connector on one end, open wires on the other end. Length 5 m (CPM12-8.5) or 10 m (CPM12-8.10). **For LPS1xMAx.**

PC connecting cables

CP24B-5 PC connecting cable for the configuration of the pyranometer. With built-in RS485/USB converter. 5-pole M12 connector on sensor side and A-type USB connector on PC side. **For LPS1xM0x.**

CP24B-8 PC connecting cable for the configuration of the pyranometer. With built-in RS485/USB converter. 8-pole M12 connector on sensor side and A-type USB connector on PC side. **For LPS1xMAx.**

Spare parts

LPSP1A UV-resistant solar radiation protection screen.

LPG Silica-gel (5 sachets).

NOTES

WARRANTY

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

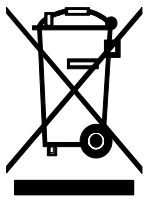
The manufacturer repairs the products that show defects of construction in accordance with the terms and conditions of warranty included in the manual of the product. For any dispute, the competent court is the Court of Padua. The Italian law and the "Convention on Contracts for the International Sales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

TECHNICAL INFORMATION

The quality level of our instruments is the result of the continuous product development. This may lead to differences between the information reported in the manual and the instrument you have purchased.

We reserve the right to change technical specifications and dimensions to fit the product requirements without prior notice.

DISPOSAL INFORMATION



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

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



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