



Compliant with IEC  
61724-1:2017 Class A

USER MANUAL

# sun[e]

Digital Secondary Standard Pyranometer



## Safety instructions and Warranty



Putting more than 30 Volt across the sensor wiring of the main power supply can lead to permanent damage to the sensor.



For proper instrument grounding: use sun[e] with its original factory-made cable.



Using the same Modbus address for more than one device will lead to irregular behavior of the entire network.



Do not operate with heater [ON] and ventilator [OFF]: secondary standard specifications may not be met.



Disconnect power while performing service or maintenance.

This system is designed according to the state-of-the-art accepted safety regulations. However, please note the following rules:

1. Before putting it into operation please read all respective manuals!
2. Please observe all internal and state-specific guidelines and/or rules for the prevention of accidents. If necessary, ask your responsible safety representative.
3. Use the system only as described in the manual.
4. Always have the manual at hand at the installation site.
5. Use the system within the specified operating condition. Eliminate influences, which might impair safety.
6. Prevent the ingress of unwanted liquids into the devices.

**Please note the loss that unauthorised manipulation of the system shall result in the loss of warranty and non-liability. Changes to system components require express written permission from LAMBRECHT meteo GmbH. These activities must be performed by a qualified technician.**

### The warranty does not cover:

1. Mechanical damage caused by external impacts (e. g. icefall, rockfall, vandalism).
2. Impacts or damage caused by over-voltage or electromagnetic fields which are beyond the standards and specifications of the device.
3. Damage caused by improper handling, e. g. by using the wrong tools, incorrect installation, incorrect electrical installation (incorrect polarity) etc.
4. Damage caused by using the device outside the specified operation conditions.

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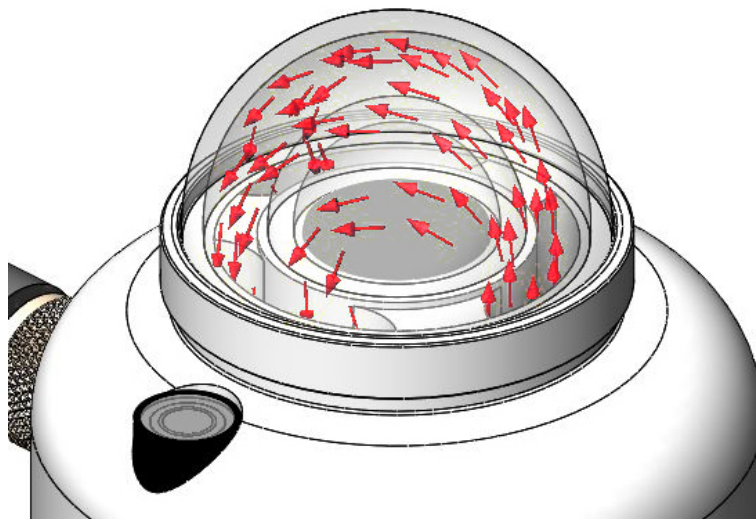
# Introduction

Welcome to the next level in solar radiation monitoring!

The all-digital sun[e] pyranometer offers the highest accuracy and highest data availability: using new Recirculating Ventilation and Heating (RVH™) technology, sun[e] outperforms all pyranometers equipped with traditional ventilation systems. sun[e] is the ideal instrument for use in PV system performance monitoring and meteorological networks.

The sun[e] measures the solar radiation received by a plane surface, in  $W/m^2$ , from a  $180^\circ$  field of view angle. The sun[e] is an ISO 9060 secondary standard pyranometer. It is employed where the highest measurement accuracy is required. The sun[e] offers several advantages over competing pyranometers:

- Heated for best data availability: new RVH™ technology outperforms traditional pyranometer ventilation
- The first pyranometer compliant in its standard configuration with the requirements for Class A monitoring systems of the new IEC 61724-1:2017 standard
- Low cost of ownership: remote diagnostics and supported by an efficient worldwide calibration and service organization
- The right paperwork: instruments are supplied with the ISO 9060 required test certificates



*Figure 0.1* Recirculating ventilation and heating between the inner- and outer dome is much more power-efficient than traditional ventilation systems.

## **Suggested use**

Suggested use for sun[e]:

- PV system performance monitoring
- scientific meteorological observations

## Features

- Heated for high data availability, featuring new RVH™ technology, 3 operating modes possible
  - standard operating mode with heater and ventilator both [ON];
  - operation in medium power mode; heater is switched [OFF]; most accurate measurement (if no danger of deposition of dew or frost)
  - operation in low power mode; both the ventilator and heater switched [OFF].
- Compliant with IEC 61724-1: 2017, Class A and B
- Low cost of ownership
  - low demand on infrastructure, sun[e]’s RVH™ requires only 2 W power, compared to 10 W for traditional ventilation systems
  - reduction of unnecessary on-site inspection by remote diagnostics
  - designed for efficient servicing; easy local diagnostics
  - supported by an efficient calibration and maintenance organization. LAMBRECHT meteo and Hukseflux offers local support in the main global economies: USA, EU, China, India, Japan and Brazil. Recalibration is recommended every 2 years, which is good practice in the industry.
- Liabilities covered: test certificates as required by ISO 9060 for secondary standard classification
- outstanding zero offset specifications, sun[e] also is the instrument of choice for high-accuracy diffuse radiation measurement.

# 1 Ordering and checking at delivery

## 1.1 Ordering sun[e]

Id-No. for standard configurations sun[e]:

Version 00.16130.501030:

digital ISO 9060 secondary standard pyranometer sensor with Modbus over RS-485

Common options / accessories are:

- |                                 |                        |
|---------------------------------|------------------------|
| • cable 5m, M12 plug connector  | Id-No. 32.14567.060030 |
| • cable 12m, M12 plug connector | Id-No. 32.14567.060000 |
| • cable 15m, M12 plug connector | Id-No. 32.14567.060010 |
| • cable 20m, M12 plug connector | Id-No. 32.14567.060040 |

Suitable data loggers:

- |            |                        |
|------------|------------------------|
| • met[LOG] | Id-No. 00.95800.010000 |
| • Ser[LOG] | Id-No. 00.95770.000000 |

## 1.2 Included items

Arriving at the customer, the delivery should include:

- pyranometer sun[e]
- sun screen
- cable of the length as ordered
- product certificate matching the instrument serial number, including:
  - calibration certificate
  - temperature response test report
  - directional response test report
  - tilt sensor test report
- any other options as ordered

Please store the certificates in a safe place.

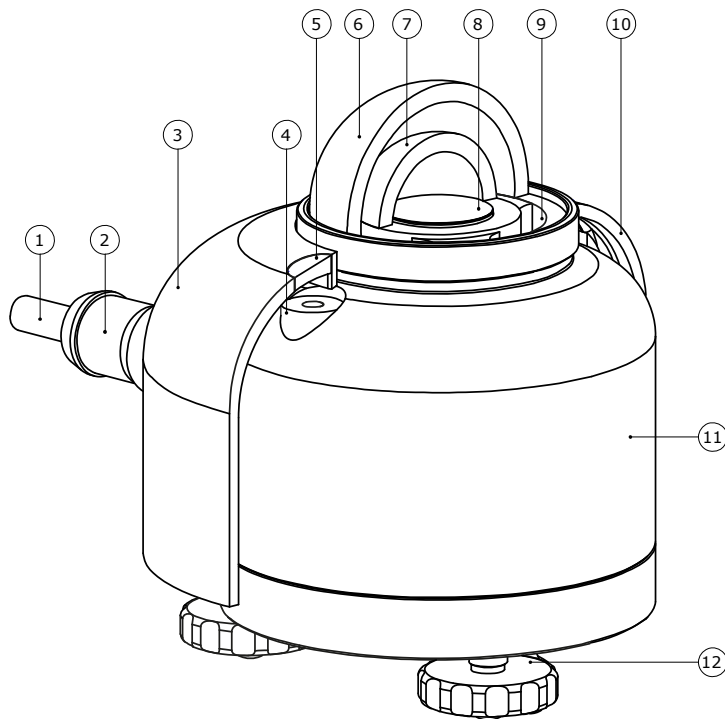
## 1.3 Quick instrument check

1. At power-ON the signal may have a temporary output level different from zero; an offset. Let this offset settle down; it is a normal part of the power-ON procedure.
2. Check if the sensor reacts to light: expose the sensor to a strong light source, for instance a 100 W light bulb at 0.1 m distance. The signal should read  $> 100 \text{ W/m}^2$  now. Darken the sensor either by putting something over it or switching off the light. The instrument irradiance output should go down and within one minute approach  $0 \text{ W/m}^2$ .
3. Inspect the instrument for any damage.
4. Check the instrument serial number as indicated by the label on the instrument against the certificates provided with the instrument.

## 2 Instrument schematic

sun[e]'s scientific name is pyranometer. A pyranometer measures the solar radiation received by a plane surface from a 180 ° field of view angle. This quantity, expressed in  $W/m^2$ , is called "hemispherical" solar radiation.

The solar radiation spectrum extends roughly from 285 to  $3000 \times 10^{-9}$  m. By definition a pyranometer should cover that spectral range with a spectral selectivity that is as "flat" as possible.



**Figure 2.0.1** Overview of sun[e]:

- (1) cable (standard length 5 meters, optional longer cable)
- (2) connector
- (3) sun screen
- (4) bubble level
- (5) bubble level window
- (6) outer dome
- (7) inner dome
- (8) thermal sensor with black coating
- (9) internal ventilation vents
- (10) quick release system of sun screen
- (11) instrument body
- (12) levelling feet

sun[e] pyranometer employs a state-of-the-art thermopile sensor with black coated surface, two domes and an anodized aluminum body. sun[e] offers a digital output via Modbus RTU over 2-wire RS-485. The pyranometer dome is heated by ventilating the area between the inner and outer dome using RVH™ - Recirculating Ventilation and Heating - technology.

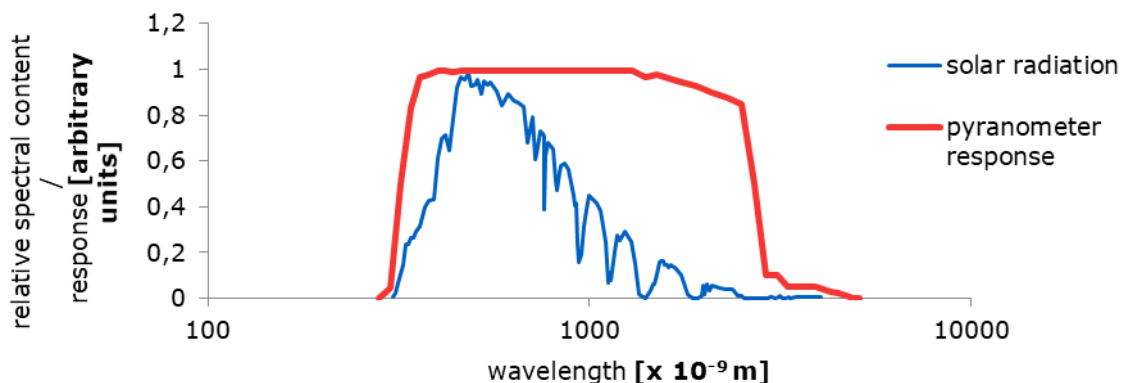
## 3 Specifications of sun[e]

### 3.1 Specifications of sun[e]

sun[e] measures the solar radiation received by a plane surface from a 180 ° field of view angle. This quantity, expressed in  $\text{W/m}^2$ , is called “hemispherical” solar radiation. sun[e] offers irradiance in  $\text{W/m}^2$  as a digital output. It must be used in combination with suitable power supply and a data acquisition system which uses the Modbus communication protocol over an RS-485 connection. When operated with both heater and ventilator [ON] or both [OFF], or with only the ventilator [ON] the instrument is classified as secondary standard according to ISO 9060. It should be used in accordance with the recommended practices of ISO, IEC, WMO and ASTM.

**Table 3.1.1** Specifications of sun[e] (continued on next pages)

| <b>sun[e] MEASUREMENT SPECIFICATIONS:</b>                            |   |
|--|---|
| ISO classification (ISO 9060:1990)                                   | secondary standard pyranometer              |
| WMO performance level (WMO-No. 8, seventh edition 2008)              | high quality pyranometer                    |
| Response time (95 %)   | 3 s   |
| Zero offset a (response to 200 $\text{W/m}^2$ net thermal radiation) |   |
| - in standard operating mode   | 2 $\text{W/m}^2$                            |
| - in medium power mode   | 2 $\text{W/m}^2$                            |
| - in low power mode  | 5 $\text{W/m}^2$                            |
| Zero offset b (response to 5 K/h change in ambient temperature)      | < 2 $\text{W/m}^2$                          |
| Non-stability  | < 0.5 % change per year                     |
| Non-linearity  | < 0.2 % (100 to 1000 $\text{W/m}^2$ )       |
| Directional response   | < 10 $\text{W/m}^2$                         |
| Directional response test of individual instrument                   | report included                             |
| Spectral selectivity   | < 3 % (0.35 to 1.5 $\times 10^{-6}$ m)      |
| Temperature response   | < 0.4 % (-30 to +50 °C)                     |
| Temperature response test of individual instrument                   | report included                             |
| Tilt response  | < 0.2 % (0 to 90 ° at 1000 $\text{W/m}^2$ ) |
| Measurement range  | -400 to 4000 $\text{W/m}^2$                 |
| Zero offset steady state   | < 1 $\text{W/m}^2$ (-40 to + 80 °C)         |
| Spectral range (20 % transmission points)                            | 285 to 3000 $\times 10^{-9}$ m              |



**Figure 3.1.1** Spectral response of the pyranometer compared to the solar spectrum. The pyranometer only cuts off a negligible part of the total solar spectrum.

| <b>sun[e] ADDITIONAL SPECIFICATIONS</b>               |  |
|---|--|
| <b>Measurand</b>                                      | hemispherical solar radiation  |
| Measurand in SI radiometry units                      | irradiance in W/m <sup>2</sup>   |
| Optional measurand                                    | sunshine duration  |
| Field of view angle                                   | 180 °  |
| Technology employed                                   | Recirculating Ventilation and Heating (RVH™)   |
| Heating   | included   |
| Ventilation   | included   |
| Output definition                                     | running average over 4 measurements, refreshed every 0.1 s   |
| Recommended data request interval                     | 1 s, storing 60 s averages   |
| <b>IEC 61724-1:2017 COMPLIANCE</b>                    |  |
| IEC 61724-1:2017 compliance                           | meets Class A PV monitoring system requirements<br>meets Class B PV monitoring system requirements   |
| Standards governing use of the instrument             | IEC 61724-1; Photovoltaic system performance monitoring – guidelines for measurement, data exchange and analysis<br>ISO/TR 9901:1990 Solar energy -- Field pyranometers -- Recommended practice for use<br>ASTM G183 - 05 Standard Practice for Field Use of Pyranometers, Pyrheliometers and UV Radiometers |
| <b>Measurand</b>                                      | sensor temperature   |
| Sensor temperature measurement accuracy               | 0.5 °C   |
| Rated operating temperature range                     | -40 to +80 °C  |
| <b>Measurand</b>                                      | sensor tilt angle  |
| Tilt measurement uncertainty                          | 1 ° (0 to 90 °)  |
| Tilt sensor detection limit                           | < 0.1 ° (smallest meaningfully detectable change in a time interval of < 10 min)   |
| Tilt sensor characterization of individual instrument | report included  |
| Levelling (see options)                               | bubble level and adjustable levelling feet are included  |
| Levelling accuracy                                    | < 0.1 ° bubble entirely in ring  |
| <b>Measurand</b>                                      | sensor internal relative humidity  |
| Humidity sensor uncertainty                           | 3 %  |
| <b>Measurand</b>                                      | sensor internal pressure   |
| sensor uncertainty                                    | 4 mbar   |
| <b>Measurand</b>                                      | heater current   |
| <b>Measurand</b>                                      | ventilator current   |
| <b>Measurand</b>                                      | ventilator speed in RPM  |
| Connector type  | M12-A, 5-pole, IP67  |
| Mounting  | 2 x M5 bolt at 46 mm distance on north-south axis  |
| IP protection class                                   | IP67   |
| Net weight including 5m cable                         | 0.64 kg  |
| <b>HEATING AND VENTILATION</b>                        |  |
| <b>Heater voltage</b>                                 | Internal 5 V (independent of supply voltage)   |
| <b>Rated heater current range</b>                     | 0.250 to 0.375 A   |
| <b>Rated ventilator speed</b>                         | 5,000 to 10,000 RPM (uncontrolled)   |
| <b>STANDARD OPERATING MODE</b>                        |  |
| <b>Standard operating mode</b>                        | heater [ON] and ventilator [ON]  |
| <b>Zero offset a</b>                                  | < 2 W/m <sup>2</sup>   |
| <b>Supply voltage range</b>                           | 8 to 30 VDC  |
| <b>Power consumption</b>                              | < 2.3 W at 12 VDC  |
| <b>MEDIUM POWER OPERATING MODE</b>                    |  |
| <b>Operating condition</b>                            | heater [OFF] and ventilator [ON]   |
| <b>Zero offset a</b>                                  | 2 W/m <sup>2</sup>   |
| <b>Supply voltage range</b>                           | 8 to 30 VDC  |
| <b>Power consumption</b>                              | < 0.6 W  |

| <b>LOW POWER OPERATING MODE</b>                     |  |
|---|--|
| Operating condition                                 | heater [OFF] and ventilator [OFF]  |
| Zero offset a                                       | 5 W/m <sup>2</sup>   |
| Supply voltage range                                | 5 to 30 VDC  |
| Power consumption                                   | < 0.1 W  |
| <b>CALIBRATION</b>                                  |  |
| Calibration traceability                            | to WRR   |
| Calibration hierarchy                               | from WRR through ISO 9846 and ISO 9847, applying a correction to reference conditions  |
| Calibration method                                  | indoor calibration according to ISO 9847, Type IIc   |
| Calibration uncertainty                             | < 1.2 % (k = 2)  |
| Recommended recalibration interval                  | 2 years  |
| Reference conditions                                | 20 °C, normal incidence solar radiation, horizontal mounting, irradiance level 1000 W/m <sup>2</sup> , heater and ventilator [ON]  |
| Validity of calibration                             | based on experience the instrument sensitivity will not change during storage. During use under exposure to solar radiation the instrument “non-stability” specification is applicable.                                    |
| <b>MEASUREMENT ACCURACY AND RESOLUTION</b>          |  |
| Uncertainty of the measurement                      | statements about the overall measurement uncertainty can only be made on an individual basis.  |
| WMO estimate on achievable accuracy for daily sums  | 2 %  |
| WMO estimate on achievable accuracy for hourly sums | 3 %  |
| Irradiance resolution                               | 0.05 W/m <sup>2</sup>  |
| <b>DIGITAL COMMUNICATION</b>                        |  |
| Digital output                                      | irradiance in W/m <sup>2</sup>   |
| House keeping data                                  | instrument body temperature in °C<br>instrument internal humidity in %r h<br>instrument internal pressure in Pa<br>instrument tilt angle in °<br>ventilator speed in RPM<br>ventilator current in A<br>heater current in A |
| Rated operating voltage range                       | 8 to 30 VDC  |
| Communication protocol                              | Modbus over 2-wire RS-485<br>half duplex   |
| Transmission mode                                   | RTU  |

### 3.2 Dimensions of sun[e]

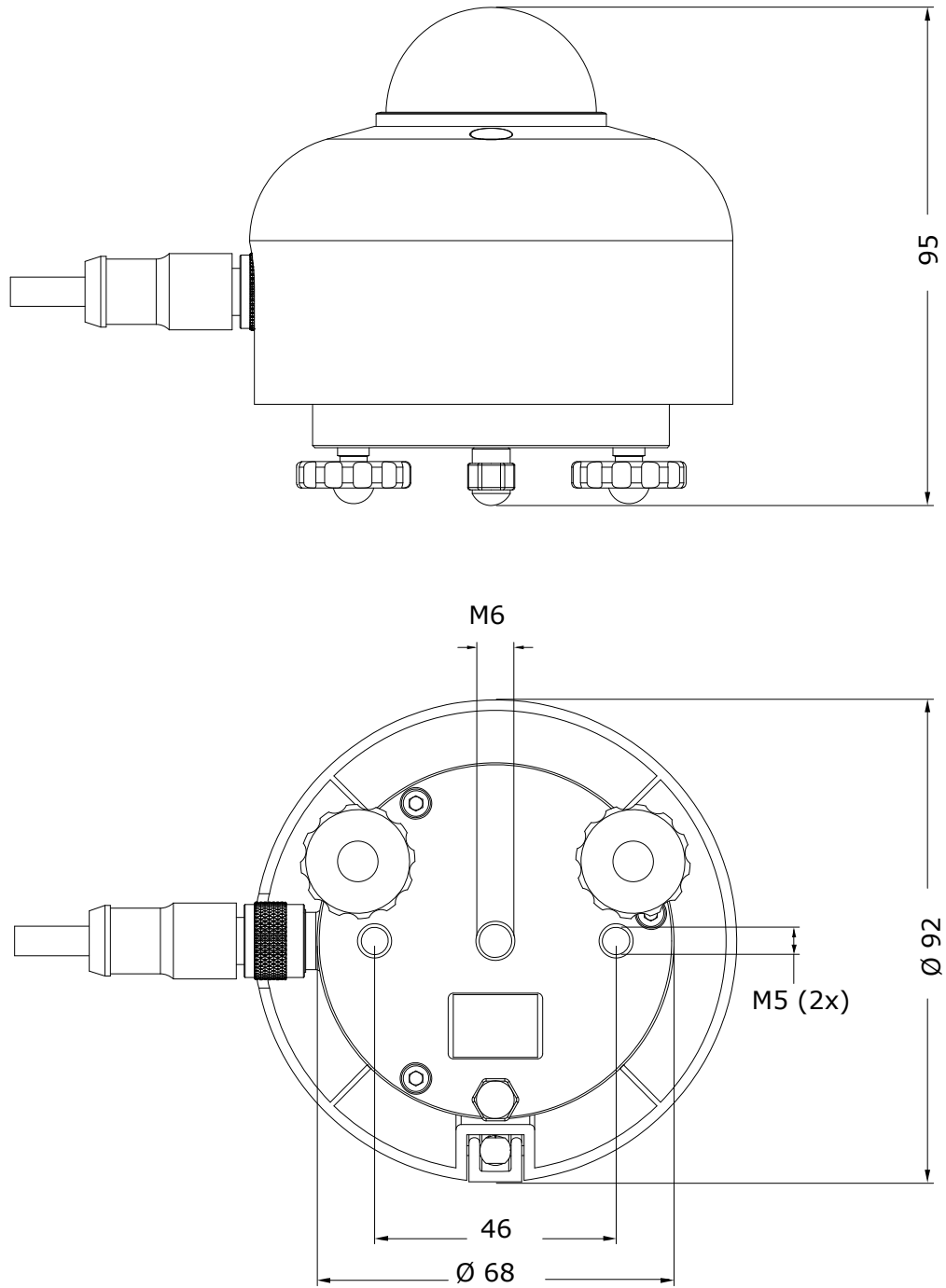


Figure 3.2.1 Dimensions of sun[e] in  $\times 10^{-3}$  m

## 4 Installation of sun[e]

### 4.1 Site selection and installation

**Table 4.1.1** Recommendations for installation of pyranometers

|  |   |
|--|---|
| Location                                 | The horizon should be as free from obstacles as possible. Ideally, there should be no objects between the course of the sun and the instrument.   |
| Mechanical mounting / thermal insulation | Use connection by bolts to the bottom plate of the instrument. A pyranometer is sensitive to thermal shocks. Do not mount the instrument with the body in direct thermal contact to the mounting plate (so always use the levelling feet also if the mounting is not horizontal), do not mount the instrument on objects that become very hot (black coated metal plates).  |
| Instrument mounting with 2 bolts         | 2 x M5 bolt at $46 \times 10^{-3}$ m centre to centre distance on north-south axis, connection from below under the bottom plate of the instrument.   |
| Instrument mounting with one bolt        | 1 x M6 bolt at the centre of the instrument, connection from below under the bottom plate of the instrument.  |
| Performing a representative measurement  | The pyranometer measures the solar radiation in the plane of the sensor. Some installations require a tilted or inverted position. The sensor bottom plate, parallel to the black sensor surface, should be mounted parallel to the plane of interest. In case a pyranometer is not mounted horizontally or in case the horizon is obstructed, the representativeness of the location becomes an important element of the measurement. See the chapter on uncertainty evaluation. |
| Levelling                                | In case of horizontal mounting, use the bubble level and levelling feet. The bubble level is visible and can be inspected at all times.   |
| Tilted installation                      | For tilted installation, the tilt sensor provides a sufficiently accurate measurement. The register "tilt angle" can be used when mounting and levelling the sensor.  |
| Instrument orientation                   | by convention: with the cable exit pointing to the nearest pole, so the cable exit should point north in the northern hemisphere, south in the southern hemisphere.   |
| Installation height                      | in case of inverted installation, WMO recommends a distance of 1.5 m between soil surface and sensor (reducing the effect of shadows and in order to obtain good spatial averaging).  |

## 4.2 Installation of the sun screen

The quick release system of sun[e]'s sun screen allows for easy and secure mounting of the sun screen on the sensor. Installation and removal of the connector can be done after removal of the sun screen.

Release sun screen: The system consists of a spring loaded lever opposite the bubble level window of the sun[e] sun screen. The bottom of the handle can be pulled out gently. Once the handle is pulled out and fully released, as shown in the figure below, the sun screen can be lifted off manually for removal.

Installing the sun screen: pull out the bottom of the quick release system handle so it is fully released, place the screen on sun[e] and, once it is positioned properly, press the handle of the quick release system until it is locked.



**Figure 4.2.1** sun[e]'s sun screen with its quick release system and bubble level window



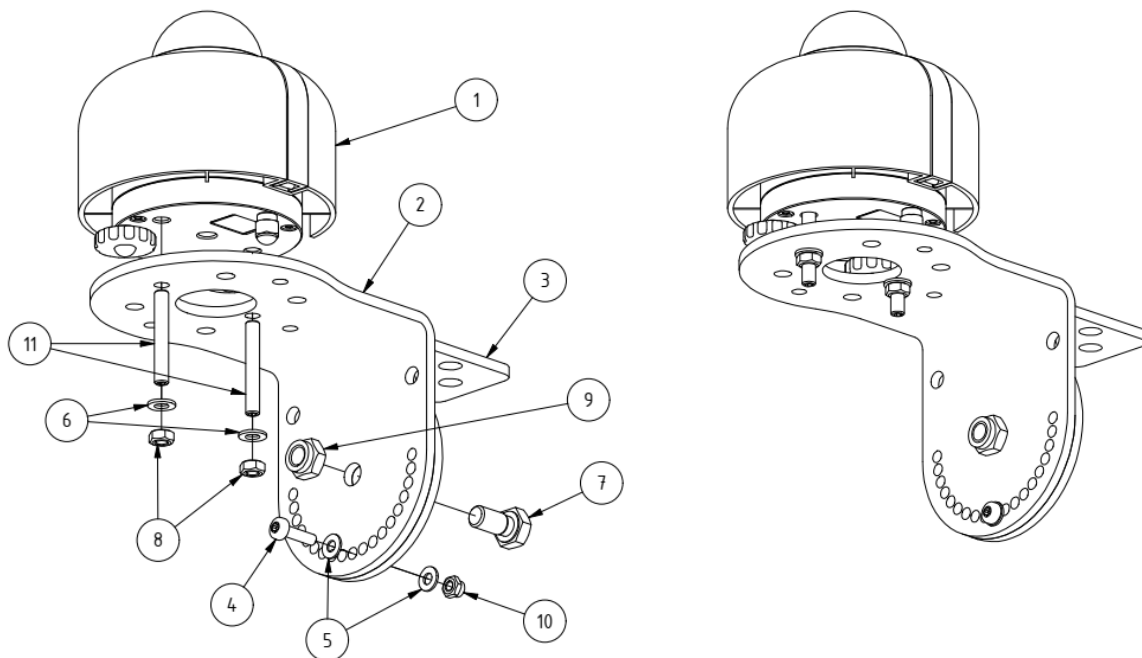
**Figure 4.2.2** Installation of sun[e]'s sun screen

### 4.3 Installation of pyranometer

LAMBRECHT meteo provides several mounting set for the sun[e] pyranometer.

|                        |  |
|------------------------|--|
| Id-No. 32.14627.003010 | Set for inclined mounting on traverse system 14627   |
| Id-No. 32.14627.003000 | Set for horizontal mounting on traverse system 14627 |
| Id-No. 33.14627.012000 | Set for wall mounting                                |

The picture below shows the installation of the sun[e] on the "Set for inclined mounting" as an example. The whole pattern for mounting the sun[e] is the same for all the sets mentioned above.



**Figure 4.3.1** Mounting of sun[e] on Set for inclined mounting on traverse system 14627

- (1) sun[e] pyranometer
- (2) mounting plate for pyranometer\*
- (3) fixation for mounting on traverse system 14627\*
- (4) TORX M4 x 16 TX20 DIN 7985 TX A2
- (5) washer 4.3 DIN 125 A A2
- (6) washer 5.3 DIN 125 A A2
- (7) hexagon screw M8 x 16 DIN 933 A2
- (8) nut M5 DIN 934 A2
- (9) nut M8 DIN 985 A2
- (10) nut M4 DIN 985 A4
- (11) setscrew M4 DIN 985 A4

\* Parts of the "Set for inclined mounting on traverse system 14627"

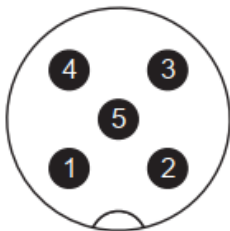
## 4.4 Electrical connection of sun[e]: wiring diagram

The instrument must be powered by an external power supply, providing an operating voltage in the range from 8 to 30 VDC. This is the main power supply for the sensor, using the brown and white wires. Do not put more than 30 Volt across these wires, this will damage the sensor.

**Table 4.4.1** *Wiring diagram of sun[e]*

| PIN | WIRE        | 00.16130.501030<br>Modbus over RS-485 |
|-----|-------------|---------------------------------------|
| 1   | Brown       | VDC [+]                               |
| 2   | White       | VDC [-]                               |
| 3   | Blue        | RS-485 B / B' [+]                     |
| 4   | Black       | RS-485 A / A' [-]                     |
| 5   | Grey        | not connected                         |
|     | Shield mesh | shield                                |

Note 1: At the connector-end of the cable, the shield is connected to the connector housing.



**Figure 4.4.1:** *Connector layout of sun[e], indicating PIN numbers (viewed from cable side)*

## 4.5 Grounding and use of the shield

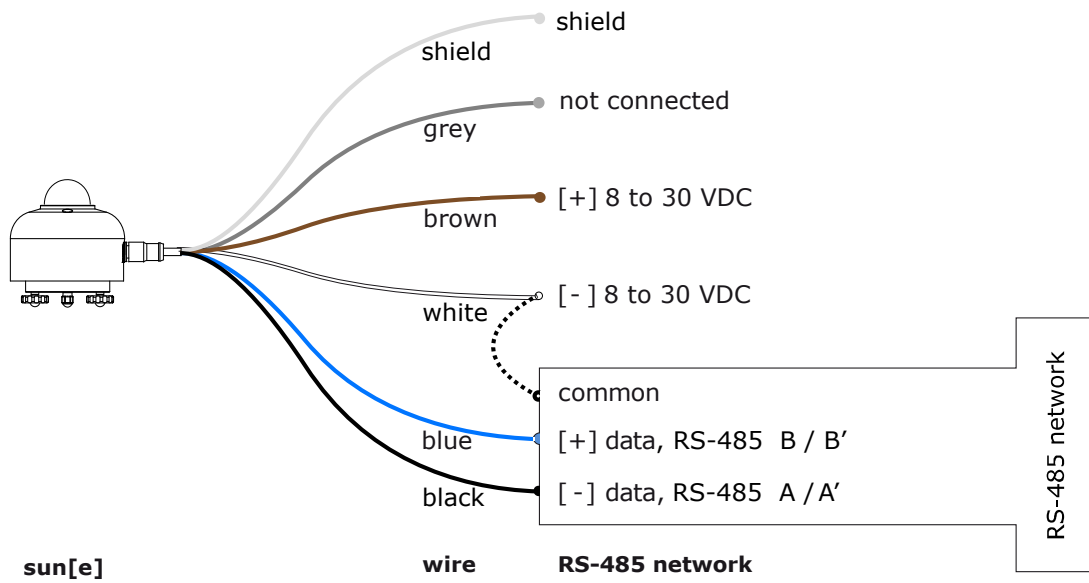
Grounding and shield use are the responsibility of the user. The cable shield (called shield in the wiring diagram) is connected to the aluminium instrument body via the connector. In most situations, the instrument will be screwed on a mounting platform that is locally grounded. In these cases, the shield at the cable end should not be connected at all. When a ground connection is not obtained through the instrument body, for instance in laboratory experiments, the shield should be connected to the local ground at the cable end. This is typically the ground or low voltage of the power supply or the common of the network. In exceptional cases, for instance when both the instrument and a datalogger are connected to a small size mast, the local ground at the mounting platform is the same as the network ground. In such cases ground connection may be made both to the instrument body and to the shield at the cable end.

## 4.6 Connecting to an RS-485 network

sun[e] is designed for a two-wire (half-duplex) RS-485 network. In such a network, sun[e] acts as a slave, receiving data requests from the master. An example of the connection to an RS-485 two-wire network is shown in the figure below. sun[e] is powered from 8 to 30 VDC. The power supply is not shown in the figure. The VDC [-] power supply ground must be connected to the common line of the network. [*Modbus over serial line specification and implementation guide V1.02 (www.modbus.org).*]

After the last nodes in the network, on both sides, line termination resistors (LT) are required to eliminate reflections in the network. According to the RS-485 standard, these LT have a typical value of 120 to 150  $\Omega$ . Never place more than two LT on the network and never place the LT on a derivation

cable. To minimize noise on the network when no transmission is occurring, a pull up and pull down resistor are required. Typical values for both resistors are in the range from 650 to 850  $\Omega$ .



**Figure 4.6.1** Connecting sun[e] to a typical RS-485 network

## 5 Communication with sun[e]

### 5.1 Modbus-protocol

The Lambrecht meteo Modbus sensors and the met[LOG] follow the specification of the Modbus organization: "MODBUS APPLICATION PROTOCOL SPECIFICATION V1.1b3". (See [www.modbus.org](http://www.modbus.org)).

### 5.2 Data encoding

MODBUS uses the "big-endian" format for addresses and data. This means that if a value is transmitted with a number format that is larger than a single byte, the "most significant byte" is sent first. For values that go beyond one register (e.g. 32 bit) this is not clearly specified for the Modbus. In these cases (32 bit or 64 bit) the LAMBRECHT Modbus sensors follow the big-endian number format.

#### Example Big-Endian:

Register size value

16 - Bits 0x1234 is transmitted in the order: 0x12 0x34.

#### Example big-endian (32bit or 64bit):

Register size value

32 - Bits 0x12345678 is transmitted in the order: 0x12 0x34 0x56 0x78.

### 5.3 Device-address

The addresses 1...247 are permitted for Modbus.

*Warning: Using the same Modbus address for more than one device will lead to irregular behaviour of the entire network.*

### 5.4 Standard configuration - default

Baud rate: 19200 Baud

Address: Each sensor type (or family) has its own default address.

**Table 5.4.1** Default addresses of the LAMBRECHT sensors

| Address | Sensor                                  |
|---------|---|
| 1       | Wind speed                              |
| 2       | Wind direction                          |
| 3       | Precipitation rain[e]                   |
| 4       | THP                                     |
| 5       | EOLOS IND                               |
| 6       | com[b]                                  |
| 7       | PREOS                                   |
| 8       | ARCO                                    |
| 9       | u[sonic]                                |
| 10      | Pyranometer 2nd Class                   |
| 11      | Secondary standard Pyranometer          |
| 12      | PT100 to Modbus converter (temperature) |

Byte frame according to MODBUS standard for RTU mode:

8E1 (1 start bit, 8 data bits, 1 parity bit (even parity), 1 stop bit)

## 5.5 Modbus command set

The Lambrecht Modbus sensors support the following commands:

- Read Input Register" command: 0x04 (Read measured data)
- Write Multiple Register" command: 0x10 (Write sensor data)

## 5.6 Measured value and parameter register

The Lambrecht meteo Modbus provides in the register range 30001 to the measured values. The registers Addresses 30001 to 35000 apply to all Lambrecht meteo Modbus sensors but are only available or valid if the respective sensor supports the corresponding values (e.g. a pure wind sensor does not provide any air humidity).

**Table 5.6.1** *Measured values provided by sun[e]*

| Register address | Parameter name  | Unit             | Factor | Description  |      |
|------------------|---|------------------|--------|--|------|
| 31401            | Global radiation instantaneous values                                       | W/m <sup>2</sup> | 10     | 1 decimal  | INT  |
| 31402            | Global radiation - average value since last retrieval                       | W/m <sup>2</sup> | 10     | 1 decimal  | INT  |
| 31403            | Global radiation - maximum value since last retrieval                       | W/m <sup>2</sup> | 10     | 1 decimal  | INT  |
| 31404            | Global radiation - minimum value since last retrieval                       | W/m <sup>2</sup> | 10     | 1 decimal  | INT  |
| 31501            | Global radiation instantaneous values (High-WORD) (temperature compensated) | W/m <sup>2</sup> | 100    | 2 decimal<br>The register 31501 + 31502 should be read in one sequence. (function code 0x04) | LONG |
| 31502            | Global radiation instantaneous values (Low-WORD) (temperature compensated)  |                  |        |  |      |
| 31591            | Global radiation instantaneous values (High-WORD) (uncompensated)           | W/m <sup>2</sup> | 100    | 2 decimal<br>The register 31591 + 31592 should be read in one sequence. (function code 0x04) | LONG |
| 31592            | Global radiation instantaneous values (Low-WORD) (uncompensated)            |                  |        |  |      |

Register 31501 + 31502, Global radiation instantaneous values (Irradiance), provides the solar radiation output in 0.01 W/m<sup>2</sup>. The value given must be divided by 100 to get the value in W/m<sup>2</sup>. MSW and LSW should be read together in one request.

**Note:** The values from the registers with the maximum values (31403) and minimum values (31404) are automatically reset as soon as the register (31402) with the mean values has been read out.

The Lambrecht sensors give 0xD8F1=-9999(16bit) or 0xFF676981=-9999999 (32bit) as error code or invalid value.

**Note:** Individual readout of related registers (e.g. 31501 and 31502) is not permitted.

## 5.7 Sensor parameters / configuration-parameters

**Table 5.7.1** Configuration registers

| Register address | Parameter name               | Unit | Divisor | Description  |     |
|------------------|------------------------------|------|---------|--|-----|
| 40001            | Modbus device address        |      | 1       | The addresses 1...247 are allowed.   | INT |
| 40200            | Baud rate                    |      | 0,01    | 96=9600<br>192=19200<br>384=38400  | INT |
| 46000            | Number of mapping-registers* |      | 1       | Contains the number of occupied mapping registers for the auto-configuration<br>sun[e] = 8 | INT |

\* For more information about the registers for auto-configuration see Appendix.

Register 40001, Modbus device address, contains the Modbus address of the sensor. This allows the Modbus master to detect the slave, sun[e], in its network. The address can be changed; the value of the address must be between 1 and 247. The default Modbus address is 11.

**Note:** The sensor needs to be restarted before changes become effective.

Register 40200, Baud rate, is used to enter the settings for the baud rate. The framing of the serial data transfer is 8 data bits, even parity and 1 stop bit. Default setting is 19200 baud.

**Note:** The sensor needs to be restarted before changes become effective.

**Table 5.7.2** Format of data

| FORMAT OF DATA | DESCRIPTION             |
|----------------|-------------------------|
| uINT           | Unsigned 16 bit integer |
| INT            | Signed 16 bit integer   |
| uLONG          | Unsigned 32 bit integer |
| LONG           | Signed 32 bit integer   |

The data format includes *signed* and *unsigned* integers. The difference between these types is that a *signed* integer passes on negative values, which reduces the range of the integer by half. Up to five 16 bit registers can be requested in one request; if requesting six or more registers, multiple requests should be used.

If the format of data is a signed or an unsigned 32 bit integer, the first register received is the most significant word (MSW) and the second register is the least significant word (LSW). This way two 16 bit registers are reserved for a 32 bit integer. MSW and LSW have to be read together in one request. This is necessary to make sure both registers contain the data of one internal measurement.

## 5.8 Network communication: getting started

Once it has the correct Modbus address and communication settings, sun[e] can be connected directly to an RS-485 network and a power supply.

Installing a sun[e] in the network also requires configuring the communication for this new Modbus device. This usually consists of defining a request that can be broadcast by the master.

Typical operation requires the master to make a request of irradiance data in registers 31501 + 31502 every 1 second and store the 60 second averages. The data format of register 31501 + 31502 is a signed 32 bit integer.

**Note:** Up to five 16 bit registers can be requested in one request. In case six or more registers are requested in just one request, sun[e] will not respond. If requesting six or more registers, multiple requests should be used: sun[e] will respond as expected.

## 5.9 Adapting the Modbus address and communication settings

Setting the instrument address and baud rate can be done in different ways:

- by connecting the sensor to the PC and using a Modbus testing tool. There are links to different solutions available at [www.modbus.org](http://www.modbus.org);
- by using the available network user interface software.

The Modbus address is stored in register 40001 and has a default value of 11. A user may change the address to a value in the range of 1 to 247. The address value must be unique in the network. The baud rate is stored in register 40200.

The default communication frame is 19200 baud, with even parity bit, 8 data bits and 1 stop bit. After a new address or communication setting is written the sensor must be restarted.

## 6 Maintenance and trouble shooting

### 6.1 Recommended maintenance and quality assurance

sun[e] can measure reliably at a low level of maintenance in most locations. Usually, unreliable measurements will be detected as unreasonably large or small measured values. As a general rule this means that regular visual inspection combined with a critical review of the measured data, preferably checking against other measurements, is the preferred way to obtain a reliable measurement.

**Table 6.1.1** Recommended maintenance of sun[e]. If possible, the data analysis and cleaning (1 and 2) should be done on a daily basis.

| MINIMUM RECOMMENDED PYRANOMETER MAINTENANCE |           |                       |   |
|---|-----------|-----------------------|---|
|   | INTERVAL  | SUBJECT               | ACTION  |
| 1   | 1 week    | data analysis         | compare measured data to maximum possible / maximum expected irradiance and to other measurements nearby (redundant instruments). Also historical seasonal records can be used as a source for expected values. Analyse night time signals. These signals may be negative (down to - 5 W/m <sup>2</sup> on clear windless nights), due to zero offset a. In case of use with PV systems, compare daytime measurements to PV system output. Look for any patterns and events that deviate from what is normal or expected. |
| 2   | 2 weeks   | cleaning              | use a soft cloth to clean the dome of the instrument, persistent stains can be treated with soapy water or alcohol  |
| 3   | 6 months  | inspection            | inspect cable quality, inspect connectors, inspect mounting position, inspect cable, clean instrument, clean cable, inspect levelling, change instrument tilt angle in case this is out of specification, inspect mounting connection, inspect interior of dome for condensation  |
| 5   | 2 years   | recalibration         | recalibration by side-by-side comparison to a higher standard instrument in the field according to ISO 9847   |
| 6   |           | lifetime assessment   | judge if the instrument should be reliable for another 2 years, or if it should be replaced   |
| 7   | > 5 years | desiccant replacement | desiccant replacement by manufacturer.  |
| 8   |           | parts replacement     | if applicable / necessary, replace the parts that are most exposed to ageing and weathering; cable, connector, sun screen, ventilator. NOTE: use manufacturer approved parts only. ventilator replacement by manufacturer.  |

## 6.2 Trouble shooting

**Table 6.2.1** *Trouble shooting for sun[e]*

|  |  |
|--|--|
| General  | <p>Inspect the instrument for any damage.</p> <p>Inspect if the connector is properly attached.</p> <p>Check the condition of the connectors (on chassis as well as the cable).</p> <p>Inspect if the sensor receives DC voltage power in the range of 8 to 30 VDC.</p> <p>Inspect the connection of the shield (typically not connected at the network side).</p> <p>Inspect the connection of the sensor power supply, typically the negative is connected to the network <i>common</i>.</p>   |
| Prepare for indoor testing                                   | <p>Install a Modbus tool on a PC. Equip the PC with RS-485 communication. Put DC voltage power to the sensor and establish communication with the sensor. At power-up the signal may have a temporary output level different from zero; an offset. Let this offset settle down.</p>  |
| The sensor does not give any signal                          | <p>Check if the sensor reacts to light: expose the sensor to a strong light source, for instance a 100 W light bulb at 0.1 m distance. The signal should read <math>&gt; 100 \text{ W/m}^2</math> now. Darken the sensor either by putting something over it or switching off the light. The instrument voltage output should go down and within one minute approach <math>0 \text{ W/m}^2</math>. Check the data acquisition by replacing the sensor with a spare sensor with the same address.</p>   |
| Not able to communicate with the sensor                      | <p>Check all physical connections to the sensor and try connecting to the sensor again. If communicating is not possible, try to figure out if the address and communication settings are correct. Analyse the cable performance by measuring resistance from pins to cable ends. The electrical resistance should be <math>&lt; 10 \Omega</math>. In case of doubt, try a new cable.</p> <p>If all physical connections are correct, and the sensor still cannot be found, please contact the factory to send the sensor to the manufacturer for diagnosis and service.</p> |
| sun[e] does not respond to a request for 6 or more registers | <p>It is not possible to request more than five 16 bit registers in one request. In case of requesting six or more registers in just one request, the sensor will not respond. If requesting six or more registers, use multiple requests: the sensor will respond as expected.</p>  |
| The sensor signal is unrealistically high or low             | <p>Note that night-time signals may be negative (down to <math>-5 \text{ W/m}^2</math> on clear windless nights in standard operating mode), due to zero offset a.</p> <p>Check if the pyranometer has clean domes.</p> <p>Check the location of the pyranometer; are there any obstructions that could explain the measurement result.</p> <p>Check the orientation / levelling of the pyranometer.</p> <p>Check the cable condition looking for cable breaks. Check the condition of the connectors (on chassis as well as the cable).</p>                                 |
| The sensor signal shows unexpected variations                | <p>Check the presence of strong sources of electromagnetic radiation (radar, radio).</p> <p>Check the condition and connection of the shield.</p> <p>Check the condition of the sensor cable.</p> <p>Check if the cable is not moving during the measurement.</p> <p>Check the condition of the connectors (on chassis as well as the cable)</p>   |
| The outer dome shows internal condensation                   | <p>In case there is a minor layer of moisture that is hardly visible: Arrange to send the sensor to the manufacturer for diagnosis and service.</p>  |
| The inner dome shows internal condensation                   | <p>Arrange to send the sensor to the manufacturer for diagnosis and service.</p>   |

## 7 Appendices

### 7.1 LAMBRECHT meteo – Auto-configuration

The Modbus sensors from Lambrecht meteo offer the possibility of auto-configuration. This is supported e.g. by the Lambrecht meteo data logger met[LOG]. For the auto-configuration, the register addresses of the measured values and sensor data available in the register range 30001 to 35000 are listed as successive values in the Lambrecht sensors in register range 46001 to 49000. Registers 46001 to 49000 can only be read out as a block! The length of the block or the number of available mapping registers is in holding register 46000.

**Table 7.1.1** *Number of mapping-registers*

| Register address | Parameter name              | Unit | Divisor | Description  |     |
|------------------|-----------------------------|------|---------|--|-----|
| 46000            | Number of mapping-registers |      | 1       | Contains the number of occupied mapping registers for the auto-configuration<br>sun[e] = 8 | INT |

Since the addresses from the range 30001 to 35000 apply to all Lambrecht sensors, an address from this range is also representative of a measured value type.

For example, register 30401 always contains the current value of the air temperature. If this register address is not included in the list in register range 46001 to 49000, the connected Modbus sensor does not supply an air temperature.

If the auto-configuration is started with the data logger met[LOG], it queries the available mapping registers on each COM interface in the device address range 1...25. For this purpose, the number of mapping registers is read from register 46000 and the register range starting at 46001 is read out as a block.

The following table contains the assignment of the configuration to the individual (possible) instantaneous value registers of the sensors. Some sensors deliver registers with mean (average), minimum and maximum values or additional values beyond this specification. Unknown register addresses (or registers that are not required) must therefore be ignored during auto-configuration.

**Table 7.1.2 Standard registers for auto-configuration**

| Register address | Parameter name  | Unit             | Factor | Description   | Data type | Function-code | Storage-type >16 bit |
|------------------|---|------------------|--------|---|-----------|---------------|----------------------|
| 30001            | Wind speed instantaneous value  | m/s              | 10     | 1 decimal place   | INT       | 0x04          | Big-Endian WORD      |
| 30201            | Wind direction instantaneous value  | °                | 10     | 1 decimal place   | INT       | 0x04          | Big-Endian WORD      |
| 30401            | Air temperature instantaneous value   | °C               | 10     | 1 decimal place   | INT       | 0x04          | Big-Endian WORD      |
| 30601            | Humidity instantaneous value  | %r.h.            | 10     | 1 decimal place   | INT       | 0x04          | Big-Endian WORD      |
| 30701            | Dew point instantaneous value   | °C               | 10     | 1 decimal place   | INT       | 0x04          | Big-Endian WORD      |
| 30801            | Air pressure instantaneous value  | hPa              | 10     | 1 decimal place   | INT       | 0x04          | Big-Endian WORD      |
| 31001            | Precipitation amount total  | mm               | 10     | 1 decimal place   | INT       | 0x04          | Big-Endian WORD      |
| 31101            | Precipitation amount total (High-WORD)                                      | mm               | 1000   | 3 decimal places<br>Registers 31101 + 31102 can only be read out together. (function code 0x04) | LONG      | 0x04          | Big-Endian LONG      |
| 31102            | Precipitation amount total (Low-WORD)                                       |                  |        |   |           | 0x04          |                      |
| 31201            | Precipitation intensity 1-minute sliding                                    | mm/min           | 1000   | = average (1-min.)<br>3 decimal places<br>Time base = 1 min.<br>Meas. rate =6x per min.         | INT       | 0x04          | Big-Endian WORD      |
| 31401            | Global radiation instantaneous value  | W/m <sup>2</sup> | 10     | 1 decimal place   | INT       | 0x04          | Big-Endian WORD      |
| 31501            | Global radiation instantaneous values (High-WORD) (temperature compensated) | W/m <sup>2</sup> | 100    | 2 decimal places<br>Registers 31501 + 31502 can only be read out together. (function code 0x04) | LONG      | 0x04          | Big-Endian WORD      |
| 31502            | Global radiation instantaneous values (Low-WORD) (temperature compensated)  |                  |        |   |           | 0x04          |                      |
| 31591            | Global radiation instantaneous values (High-WORD) (uncompensated)           | W/m <sup>2</sup> | 100    | 2 decimal places<br>Registers 31591 + 31592 can only be read out together. (function code 0x04) | LONG      | 0x04          | Big-Endian WORD      |
| 31592            | Global radiation instantaneous values (Low-WORD) (uncompensated)            |                  |        |   |           | 0x04          |                      |

Registers Address 46001-49000 containing for each sensor the available registers with measured values and sensor data from the range 30001-35000.

**The registers can only be read out as a block! The length of the block or the number of available mapping registers is in holding register 46000**

For example, in the sun[e], registers 46001 to 46008 contain valid addresses. The holding register 46000 contains the number of registers “8”, all 8 registers must be read out in the block with the function code 0x04. Too many registers or too few lead to an error message.

**Table 7.1.3 Mapping-Register for auto-configuration**

| Register address | Register value | Unit             | Factor | Description   |     |
|------------------|----------------|------------------|--------|---|-----|
| 46001            | 31401          | Register address | 1      | Global radiation instantaneous values                                       | INT |
| 46002            | 31402          | Register address | 1      | Global radiation - average value since last retrieval                       | INT |
| 46003            | 31403          | Register address | 1      | Global radiation - maximum value since last retrieval                       | INT |
| 46004            | 31404          | Register address | 1      | Global radiation - minimum value since last retrieval                       | INT |
| 46005            | 31501          | Register address | 1      | Global radiation instantaneous values (High-WORD) (temperature compensated) | INT |
| 46006            | 31502          | Register address | 1      | Global radiation instantaneous values (Low-WORD) (temperature compensated)  | INT |
| 46007            | 31591          | Register address | 1      | Global radiation instantaneous values (High-WORD) (uncompensated)           | INT |
| 46008            | 31592          | Register address | 1      | Global radiation instantaneous values (Low-WORD) (uncompensated)            | INT |

Note 1: Usually maximal up to five 16 bit registers can be requested from sun[e] in one request. Just the 8 mapping registers for the auto-configuration can be requested in one request. For all other registers applies “if requesting six or more registers, use multiple requests”.

## 7.2 EU declaration of conformity



We, LAMBRECHT meteo GmbH.  
Friedlaender Weg 65-67  
37085 Goettingen  
Germany

in accordance with the requirements of the following directive:

2014/30/EU The Electromagnetic Compatibility Directive

hereby declare under our sole responsibility that:

Product model: sun[e]  
Product type: Pyranometer

has been designed to comply and is in conformity with the relevant sections and applicable requirements of the following standards:

Emission: IEC/EN 61000-6-1, Class B, RF emission requirements, IEC CISPR11  
and EN 55011 Class B requirements  
Immunity: IEC/EN 61000-6-2 and IEC 61326 requirements  
Test date: 2 January 2017

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