

# Instruction Manual

RaZON<sup>+</sup> • ALL-IN-ONE Solar Monitoring System



## Important User Information

Dear customer, thank you for purchasing a Kipp & Zonen instrument. Completely reading this manual is essential for understanding the proper use and safe operation of this product.

Should you have any comments on this manual please send them to:

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Kipp & Zonen reserves the right to make changes to the specifications without prior notice.

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Modifications made by the user can affect the validity of the CE declaration.

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## Declaration of Conformity



**Kipp & Zonen B.V.**

Delftechpark 36, 2628 XH Delft  
P.O. Box 507, 2600 AM Delft  
The Netherlands

declares under our sole responsibility that the product

**RaZON<sup>+</sup> Solar Monitoring System**

to which this declaration relates, is in conformity with European Harmonised Standards  
as published in the Official Journal of the EC, based on the following standard

[EMC - Emissions] **EN 61326-1:2013** and **EN 61326-2-1:2013**

[EMC - Immunity] **EN 61326-1:2013** and **EN 61326-2-1:2013**

[Electrical safety] **EN 61010-1:2010**

following the provisions

EMC-directive **2014/30/EU**

LV-directive **2014/35/EU**

RED directive **2014/53/EU**

also, this device complies to

[EMC - FCC] **Title 47CFR part 15**

Delft, 1<sup>st</sup> September 2016



E. van Houten - CFO  
Kipp & Zonen B.V.



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# 1. General information

Throughout this manual the following symbols are used to indicate to the user important information.



General warning about conditions, other than those caused by high voltage electricity, which may result in physical injury and/or damage to the equipment or cause the equipment to not operate correctly.

**Note**

Useful information for the user

## 1.1 Introduction to the RaZON<sup>+</sup>

### ALL-IN-ONE

The RaZON<sup>+</sup> Solar Monitoring System measures all required components of the Solar Radiation to accurately monitor a Solar Energy Power Plant. It provides Global, Diffuse and Direct radiation, as well as Sunshine Duration, solar angles and status information. The integrated data logger and GPS receiver store accurately time stamped 1 minute logging averages. Multiple interfaces are available to retrieve the data from the RaZON<sup>+</sup> to the network or PC. A tripod or pole-mount is included as standard, a Wi-Fi interface is optional.

### Easy set-up and operation

Set-up and installation is easy via Ethernet or Wi-Fi communication. The RaZON<sup>+</sup> has its own web page to communicate with the user.

### Low maintenance

The PR1 and PH1 pyranometer and pyrhelimeter are specially designed for the RaZON<sup>+</sup> and recommended for their anti-soiling design. They have an integrated desiccant that lasts for 5 year. The RaZON<sup>+</sup> tracker is maintenance free.

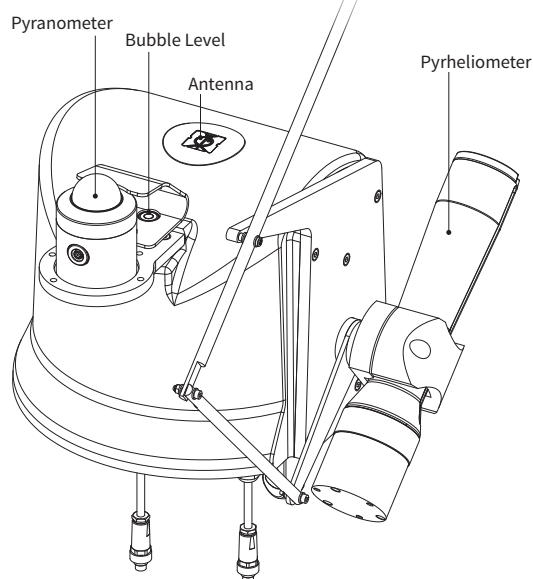
### Accurate data

The RaZON<sup>+</sup> calculates the Global radiation from Diffuse and Direct. This is the most accurate way because the directional error and offsets are less.

### Future extensible

Other Smart radiometers from Kipp & Zonen can be selected to upgrade the system. A Modbus<sup>®</sup> input for extra sensors or weather station is available.

A standard RaZON<sup>+</sup> with its key components in top- and bottom-view are shown below.



A standard RaZON<sup>+</sup> with its key components



### **1.2 Included with the RaZON<sup>+</sup> All-IN-ONE**

The RaZON+ is supplied with the following parts

- RaZON<sup>+</sup> tracker
- Tripod or Pole Mount plus screws (depending on the order) where a Pole Mount will be shipped in a separate box
- Shading Assembly (bars and disc plus the required screws)
- DC power connector
- Tools for mounting shading assembly and tripod
- When ordered the PR1 and PH1 these will be pre-mounted



## 2. Specifications

### 2.1 Specifications of the RaZON<sup>+</sup> All-IN-ONE

Pointing accuracy	0.2°
Payload	Sufficient for 1 pyranometer and 1 pyrliometer
Angular velocity	30°/s
Rotation	110° zenith, 600° azimuth
Protection against over rotation	Physical limit stops
Supply voltage	20 to 30 VDC
Power	13 W
Operating temperature range	-20 °C to +50 °C
Weight	9 kg
Dimensions (WxDxH)	60x60x48 cm
Accuracy of bubble level	< 0.1°
Ingress Protection (IP) rating	65
CE/FCC compliance	Yes
RoHS	Yes
Transmission	Gear drives
Power connections	DC power
Communication interface	RS-485 Modbus® for external sensor/system RS-485 to host, Modbus® or ASCII Ethernet RJ-45 web based Modbus® TCP Wi-Fi (accessory adapter)
Data logging	1 s sampling, 1 minute average logging
GPS, location and time/date	Standard
Installation	Plug-and-play, Wi-Fi enabled device used
Functional self-test	Standard
Test/diagnostic facility	Standard via Ethernet connection
Sun tracking mode	Standard
PC system requirements	Ethernet connection, web browser
Firmware update possible	Flash memory
Maintenance	No scheduled maintenance required Annual inspection recommended
Restart after power interruption	Automatic

### 2.2 Specifications of the PR1 Smart Pyranometer

Classification to ISO 9060:1990	Second Class
Response time (95%)	< 0.2 s
Response time (63%)	< 0.1 s
Spectral range (50% points)	310 to 2700 nm
Zero offsets	
(a) thermal radiation (at 200 W/m <sup>2</sup> )	1 W/m <sup>2</sup>
(b) temperature change (5 K/h)	1 W/m <sup>2</sup>
Non-linearity (100 to 1000 W/m <sup>2</sup> )	< 0.3 %
Directional response	< 20 W/m <sup>2</sup>
(up to 80° with 1000 W/m <sup>2</sup> beam)	
Temperature response	< 1 % (-20 °C to +50 °C)
Field of view	180°
Measurement range	0 to 1500 W/m <sup>2</sup>
Operating temperature range	-40 °C to +80 °C
Ingress Protection (IP) rating	67

### 2.3 Specifications of the PH1 Smart Pyrliometer

Classification to ISO 9060:1990	Second Class
Response time (95%)	< 0.2 s
Response time (63%)	< 0.1 s
Spectral range (50% points)	310 to 2700 nm
Zero offsets	
(b) temperature change (5 K/h)	1 W/m <sup>2</sup>
Temperature response	< 1 % (-20 °C to +50 °C)
Non-linearity (100 to 1000 W/m <sup>2</sup> )	< 0.3 %
Field of view	5° ±0.2°
Slope angle	1° ±0.2°
Measurement range	0 to 1500 W/m <sup>2</sup>
Operating temperature range	-40 °C to +80 °C
Ingress Protection (IP) rating	67



### 3. Installation

This chapter explains the installation of the RaZON<sup>+</sup> including the connection of the power cable. The installation is explained step by step in the following paragraphs. Once the mechanical mounting is finished and power is connected the fine tuning and final check can be done via Ethernet or Wi-Fi with a PC, tablet or smartphone.

- Required tools for RaZON<sup>+</sup> mounting
- Site preparations
- Mounting and operating area
- Connecting the tripod stand
- Connecting the pole mount
- Tracker orientation
- Pyrheliometer mounting
- Pyrheliometer mounting
- Shading Assembly mounting
- Levelling
- Connecting DC Power cable
- Set-up using Ethernet or optional Smart Wi-Fi device
- Securing the tripod
- Cable routing

Apart from the creation of the tripod support base, the levelling and the fine adjustment is only a matter of minutes. However a clear sun is required to do this. It is important that the above steps are carried out in this order.

RaZON<sup>+</sup> will have various accessories to enhance and expand its operation

Extra Smart pyranometer (e.g. in plane of array)

Modbus<sup>®</sup> compact weatherstation

Modbus<sup>®</sup> temperature sensor (PV panel temperature)

In the first (2016) release of the RaZON<sup>+</sup>, this feature is not yet implemented.

#### 3.1 Required tools for RaZON<sup>+</sup>

For installation on site the following tools are required for mounting the RaZON<sup>+</sup>.

for Pyrheliometer mounting (PH1 comes pre-mounted): **5 mm Allen key**

for Pyranometer mounting (PR1 comes pre-mounted): **3 mm Allen key**

Shading arm: **2.5 mm Allen key, 5.5 mm wrench and Philips screwdriver**

Tripod: **3 mm Allen key and 3.5 mm Allen key (for adjustable feet)**

Pole Mount: **3 mm Allen key (upper flange) and 6 mm Allen key (lower flange)**

Shading assembly: **2.5 mm Allen key, Philips screwdriver and 5.5 mm wrench**

Small screwdriver for connection of power cable to the connector

Flexible cable for 24 VDC power connection of the RaZON<sup>+</sup>

Flexible data cable for RS-485 or Ethernet

Compass to find geographical East

Depending on the surface where the RaZON<sup>+</sup> is mounted, the material to secure the tripod or pole mount to the floor or pole is required.

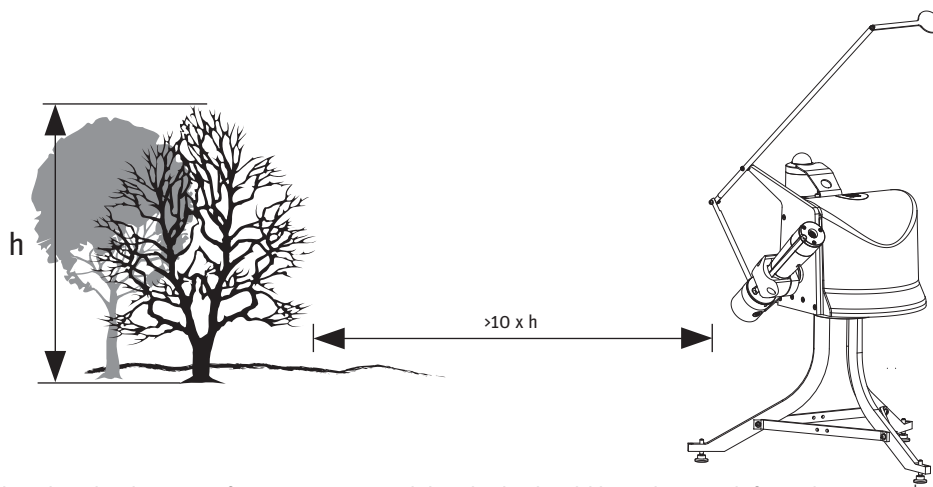
### 3.2 Site preparations

Before installation of a RaZON<sup>+</sup> the site must be prepared. The following points need to be checked.

The site where the RaZON<sup>+</sup> is placed must be free of obstructions, in order to have the best possible 360 degrees field of view .

Building of a concrete or steel horizontal platform is required for mounting the RaZON<sup>+</sup> tripod or pole mount on. Ensure that the surface on which the RaZON<sup>+</sup> will be mounted is reasonably level, but above all it is very important to create a very firm base to stand upon. This is a requirement for (years of) accurate tracking. Both the tripod and pole mount need to be fixed with bolts to the surface where they are mounted on. Diameters and distances of these mounting holes are given in the next paragraphs.

Make sure that the RaZON<sup>+</sup> is located in such a way that shadows will not be cast onto the radiometers at any time. If a meteorological mast is placed near the RaZON<sup>+</sup>, make sure the position is such that the location of the mast is between the RaZON<sup>+</sup> and the nearest pole (North- or South pole). In this way the mast will never block the direct radiation.



A rule of thumb is that the distance of a mast or tree with height 'h' should be at least 10 h from the RaZON<sup>+</sup>.

Make sure that the RaZON<sup>+</sup> will be easily accessible for maintenance purposes.

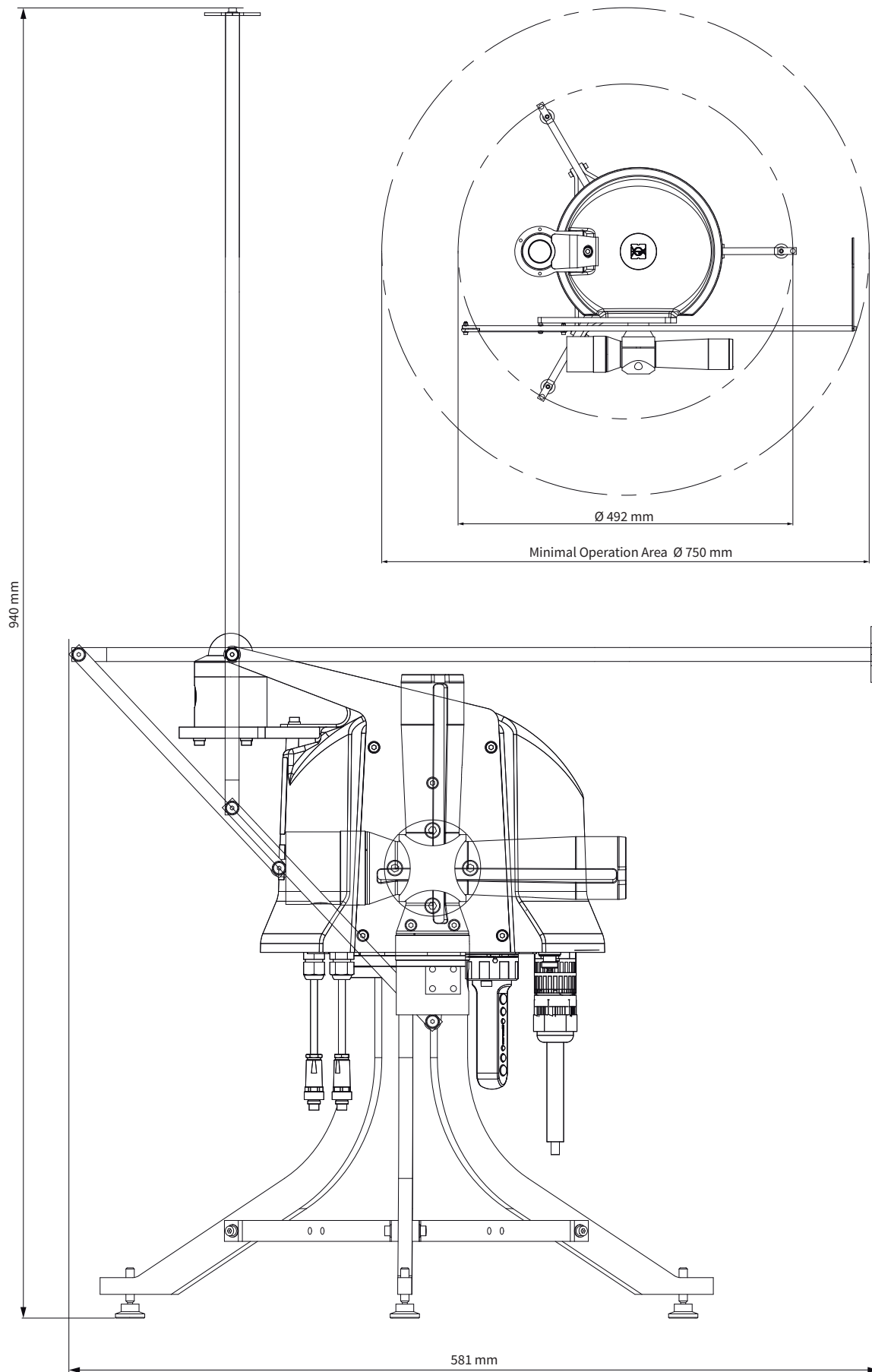
### 3.3 Mounting and operating area

RaZON<sup>+</sup>, complete with all the accessories attached, requires a substantial amount of unobstructed area to operate properly. This should be kept in mind when deciding where and how the unit is going to be installed. Figures on the next page show the minimum operating area with respect to both the Azimuth and Zenith axis of a RaZON<sup>+</sup> complete with all accessories including Tripod Stand and Shading Ball Assembly.

**Note** Keep in mind that the angle of Azimuth (horizontal) rotation changes during the year.

A RaZON<sup>+</sup> installed in the winter will rotate further during summer, so make sure no objects will block its movement. To test / prevent blocking from its movement it is advised before connecting the power, to rotate the RaZON<sup>+</sup> by hand, fully right and left. This is to check if the RaZON<sup>+</sup> does not hit any nearby obstacles and if its cables are long enough and can move freely.



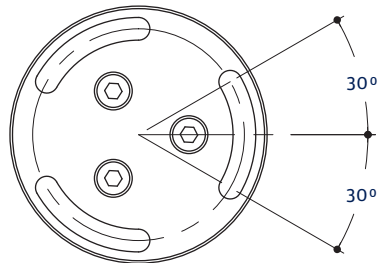


Minimum Operating Area (with Shading Assembly)

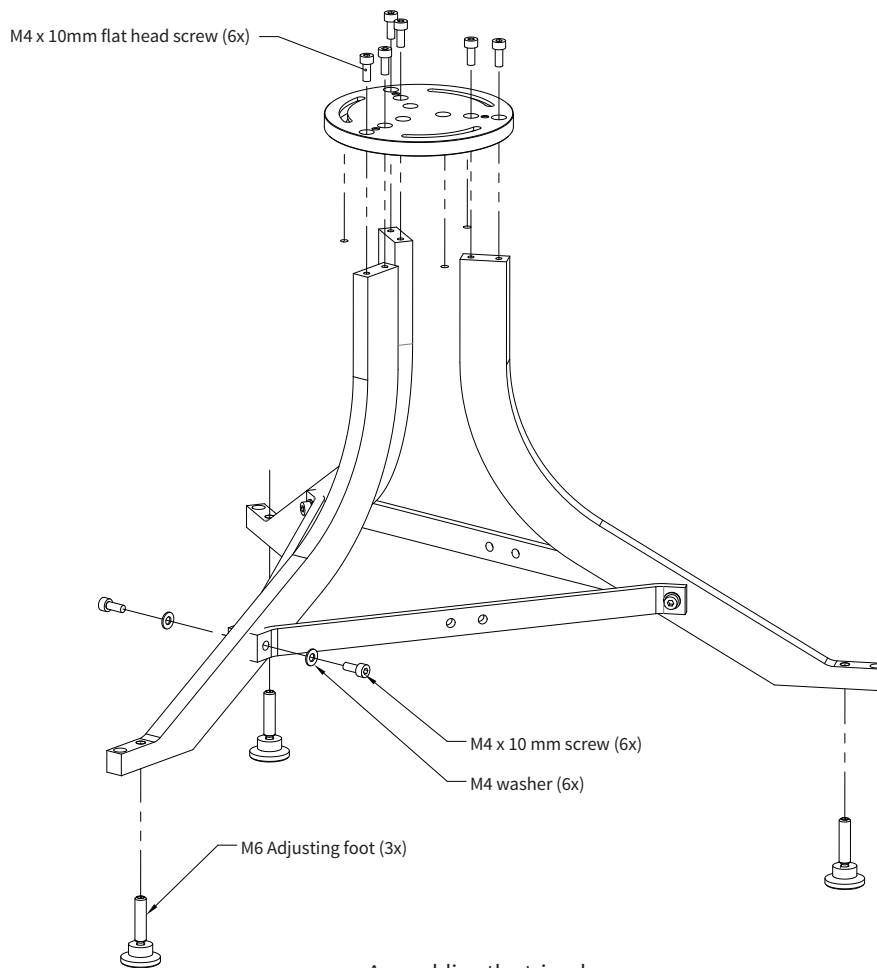
### 3.4 Mounting the tripod stand

The tripod comes as a kit that needs to be assembled, all bolts and washers are provided.

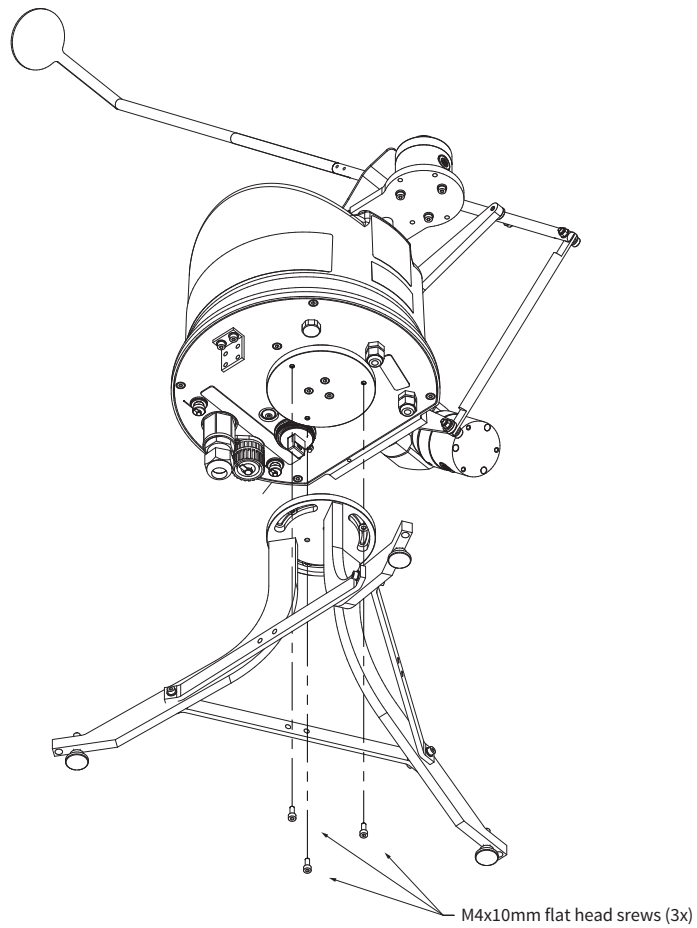
The RaZON<sup>+</sup> bottom flange has a 3-hole M4 mounting pattern to match the Tripod Stand with levelling feet. The tripod has 3 slots for mounting the 3 M4 bolts to the bottom flange. The E mark on the bottom flange must point East when the RaZON<sup>+</sup> is mounted. Ideally the bolts should be in the middle of the slots when the tripod is mounted to the RaZON<sup>+</sup>. This allows adjustment of the position afterwards (-30° to +30°).



+/- 30° play on the tripod mounting before final adjustment



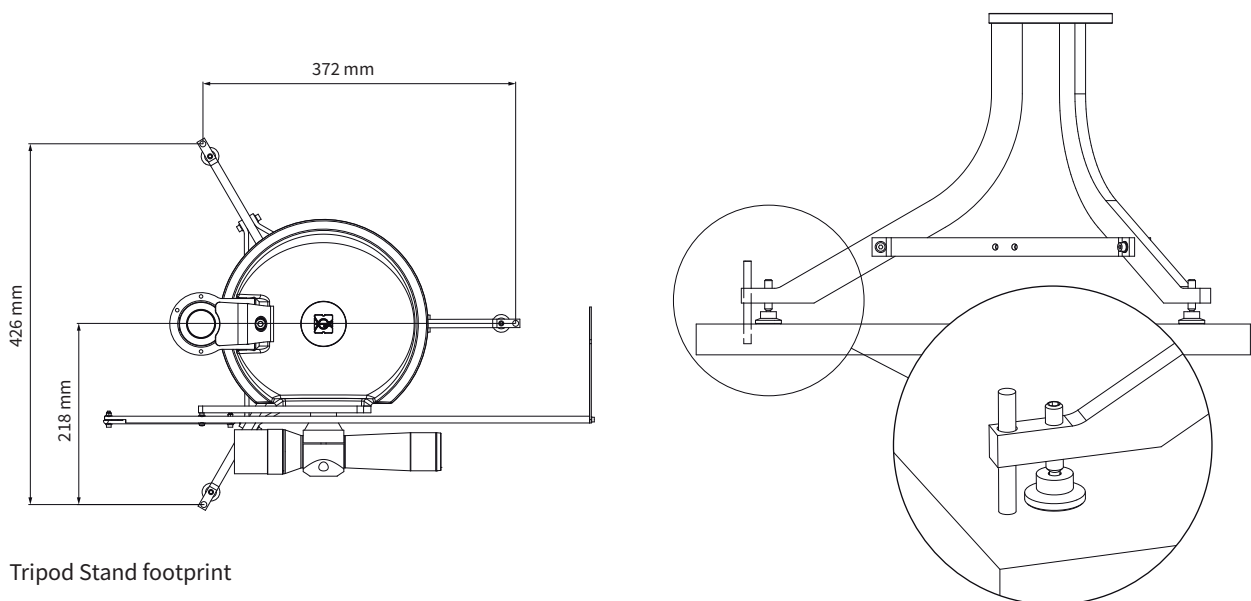
Assembling the tripod



Mounting RaZON<sup>+</sup> on the tripod

**Note** From the RaZON<sup>+</sup> bottom flange the E-marking and one tripod leg have to be pointed to the East!

The tripod feet have 7 mm mounting holes to fix the RaZON<sup>+</sup> to a firm base. It is required to perform the levelling and alignment during installation of the RaZON<sup>+</sup> first, before actually tightening the tripod feet to the base.



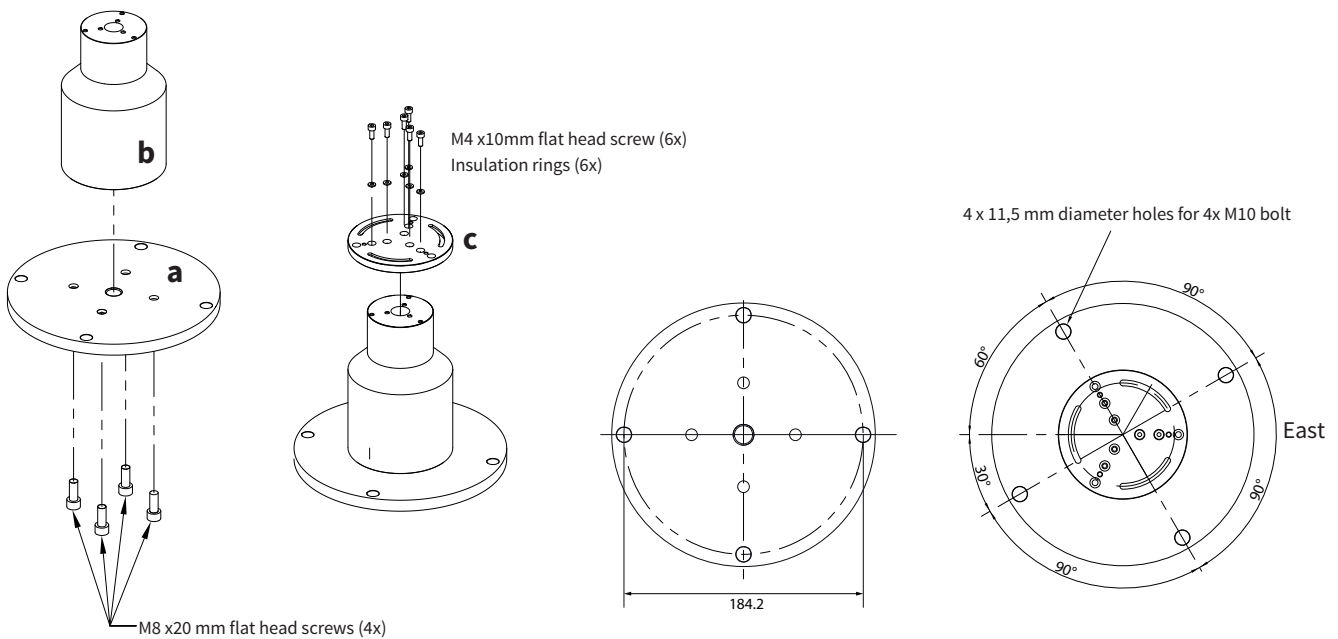
Tripod Stand footprint

### 3.5 Mounting the Pole Mount

The pole mount can be used to install the RaZON<sup>+</sup> on a small surface like an extension tube or pole. The bottom flange of the pole mount has 4 holes for M10 bolts to secure it to the pole or tube.

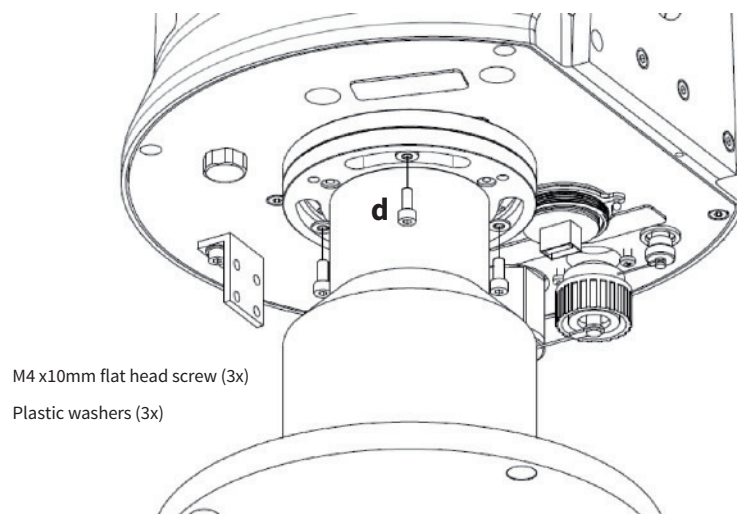
The levelling is done with the 3 (tilt) screws in the top plate of the pole mount. Once properly mounted the 3 bolts connecting it to the RaZON<sup>+</sup> can be fastened. This should be done after the complete installation of the RaZON<sup>+</sup> is ready. Always check the levelling afterwards.

Please follow the next steps to mount the pole mount to your RaZON<sup>+</sup>

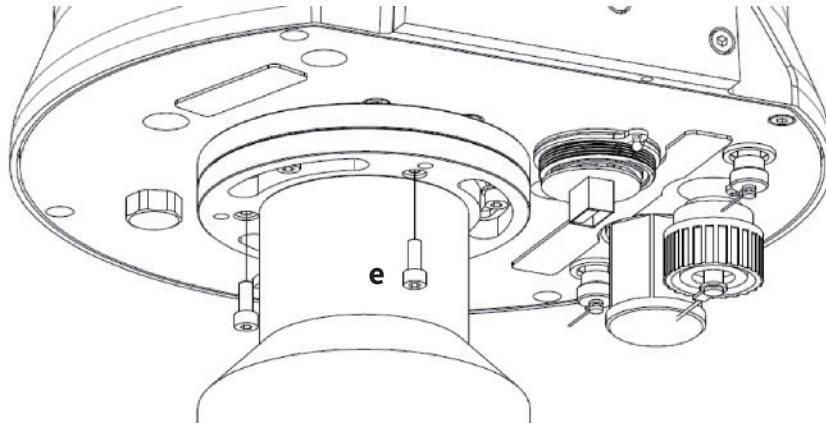


Step 1: Fit the bottom flange (a) to the pillar (b) with the 4 supplied screws

Step 2: Fit the top flange (c) to the pillar with the 6 supplied screws and washers



Step 3: Secure the top plate to the bottom flange of the RaZON<sup>+</sup> (d) but only loosely as the RaZON<sup>+</sup> still needs to be turned and levelled a bit later on.



Step 4: Add the 3 levelling screws (e) to the top flange of the pole mount. There is thread in the top flange and screwing the adjustment screws in through the flange will raise the RaZON<sup>+</sup> on that side. Enabling the levelling of the RaZON<sup>+</sup>.

Only after finishing the levelling and azimuth adjustment the RaZON<sup>+</sup> can be secured fully by tightening the screws (4) from step 3.



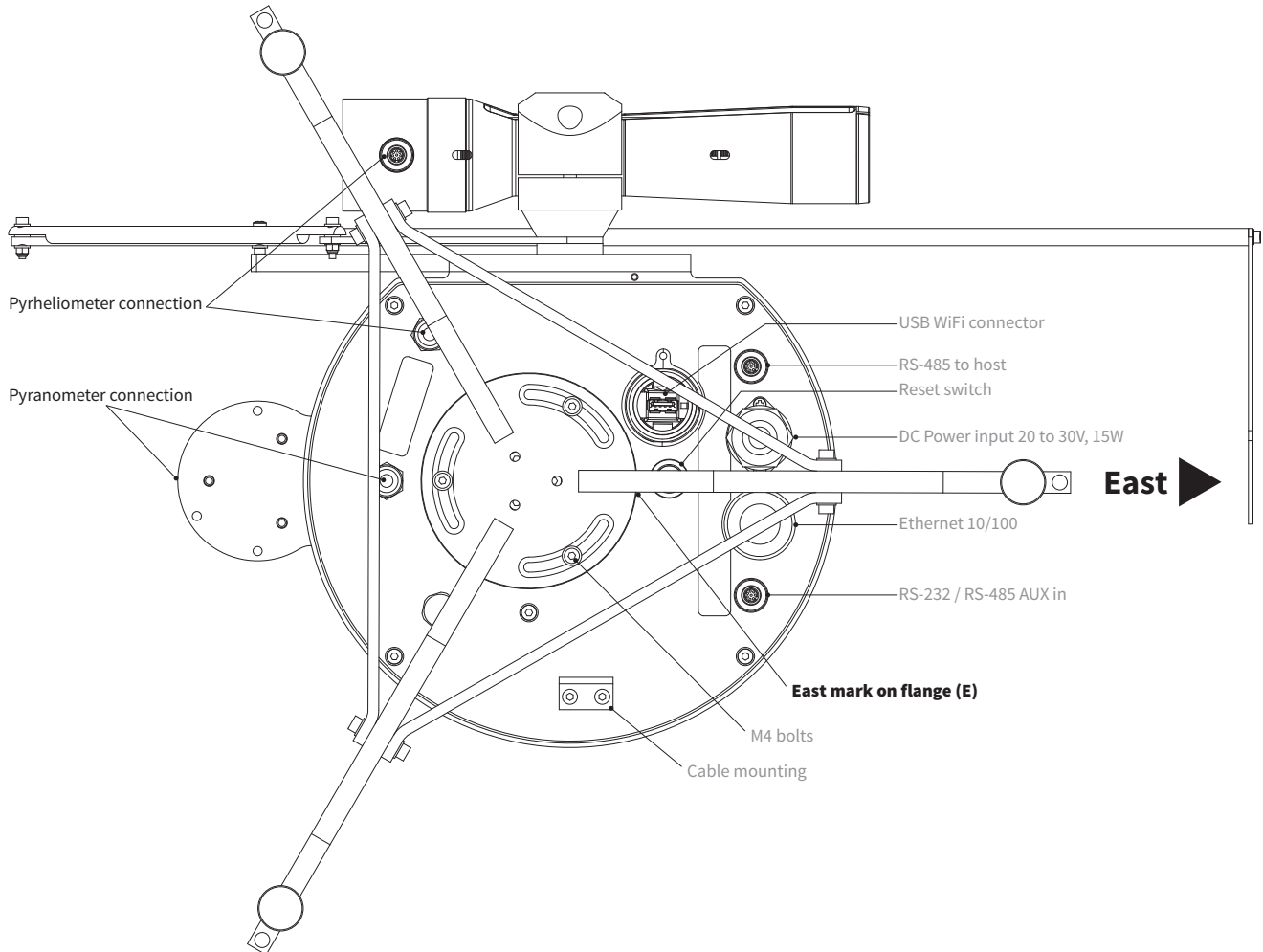
When different mounting screws (4) are used they must not protrude through the bottom flange of the RaZON<sup>+</sup>



When installed an initial Azimuth orientation due East with the help of a compass (smartphone) will do. When the RaZON<sup>+</sup> is powered later on, exact positioning can be performed via Ethernet or Wi-Fi, when sun is available.

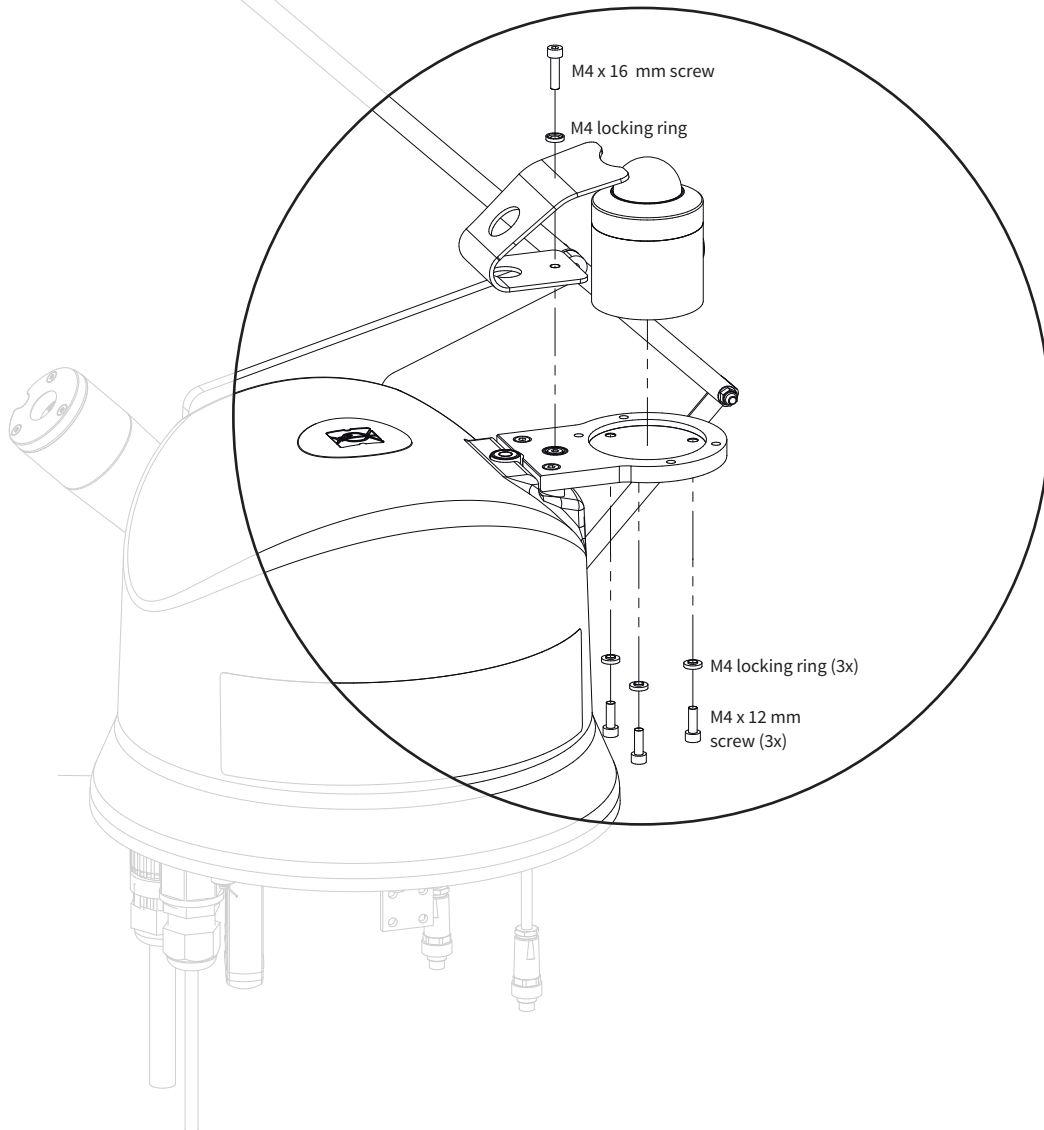
### 3.6 Tracker orientation

The RaZON<sup>+</sup> should be mounted in such a way that one leg of the tripod is pointing East. The pole mount should be orientated such that the E-marking on the RaZON<sup>+</sup> bottom flange is pointing East. Both mounting devices allow a plus and minus 30 degree play (slit hole) to fine adjust the RaZON<sup>+</sup> after the mounting is fixed.



### 3.7 Pyranometer mounting

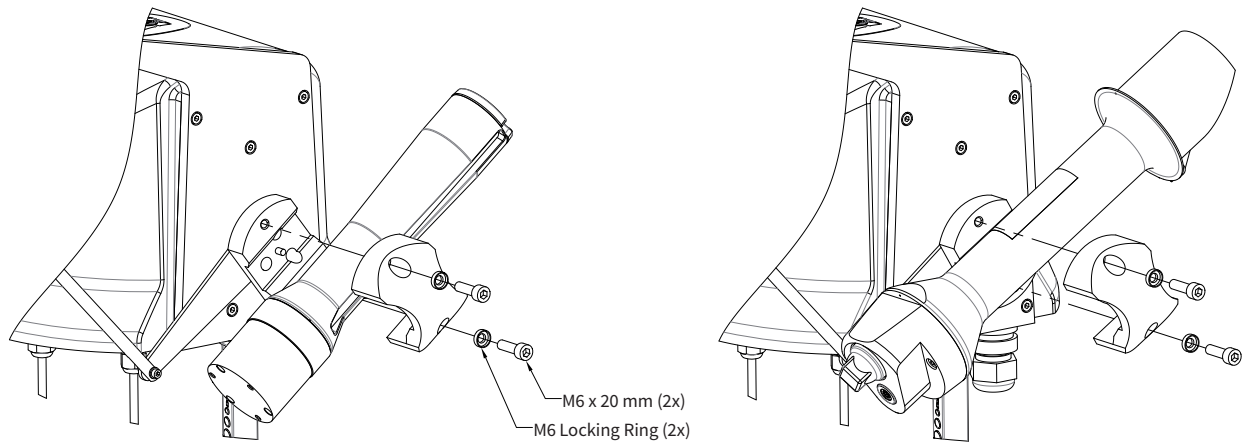
The PR1 is pre-mounted with 3 M3 bolts to the pyranometer mounting plate on top of the RaZON<sup>+</sup>. If any other SMP pyranometer has to be mounted the standard supplied M5 x 80 bolts have to be used.



### 3.8 Pyrheliometer mounting

The PH1 comes pre-fitted on the side of the RaZON<sup>+</sup>. If the RaZON<sup>+</sup> is ordered with a SHP1 it has to be mounted using 2 x 5 mm bolts and washers.

For the SHP1 it is important to mount it with the 2 alignment target on top. The PH1 alignment target is on the (outer) side of the pyrheliometer.



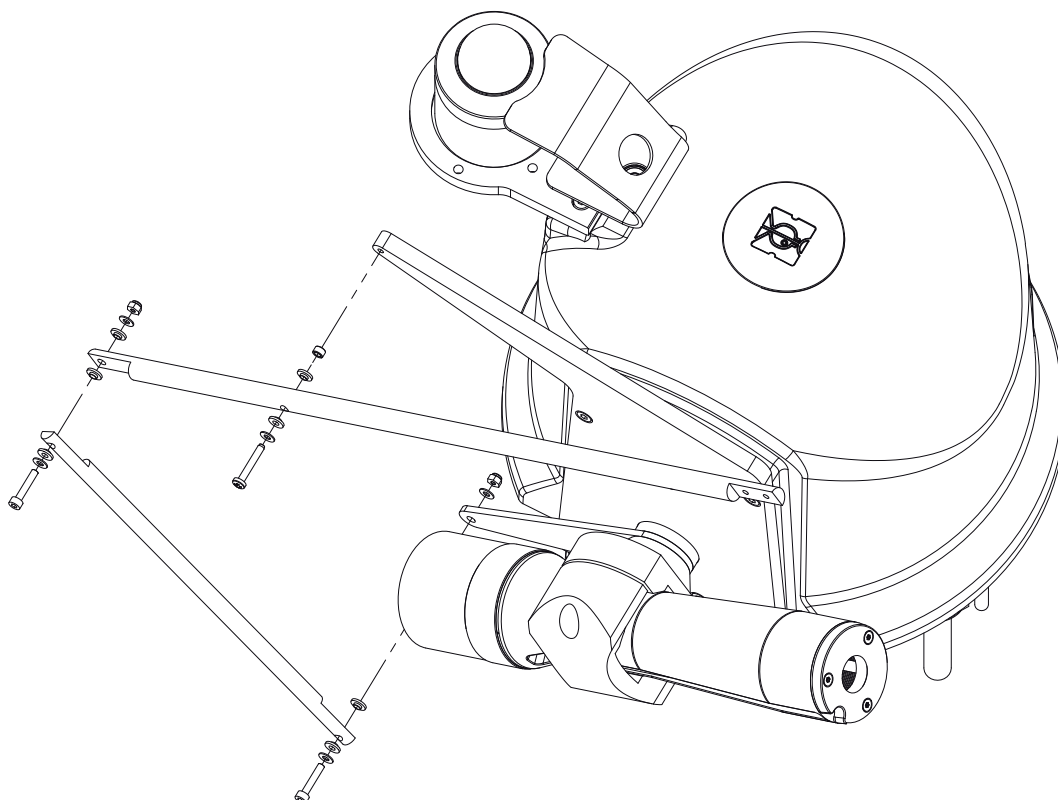
Pyrheliometer PH1 or SHP1 mount on the RaZON<sup>+</sup>



### 3.9 Shading assembly mounting

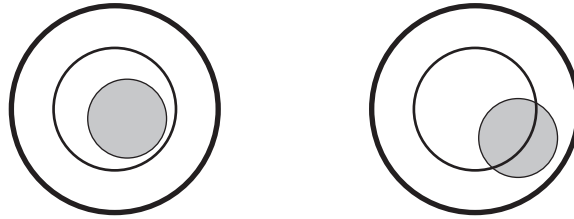
The shading assembly needs to be completed by adding the long rod and shading disc to the RaZON<sup>+</sup>. The shading disc falls in a groove at the end of the rod, with a 2.5 mm Allen key it can be fastened. A 5.5 mm wrench and Philips screw driver are required to mount the long rod to the RaZON<sup>+</sup>.

It is important to mount the rotating joints of the shading arm in such a way that they have no play but can move freely.



### 3.10 Levelling

Prior to activating the RaZON<sup>+</sup>, it must be levelled on its mounting surface. To help accomplish this task, the RaZON<sup>+</sup> is equipped with a high accuracy bubble on top of the housing. Adjust the levelling feet on the tripod stand or the tilting bolts in the pole mount to move the bubble into the centre of the level. The levelling feet can be easily adjusted using a 3.5 mm Allen key, the tilting bolts of the pole mount need a 5 mm Allen Key. The accuracy of the RaZON<sup>+</sup> is within 0.1° when the bubble is at least half within the circle.



mm

When a different pyranometer like SMP10 with its own bubble level is mounted it is advised to use the RaZON<sup>+</sup>'s bubble level and not the level of the pyranometer.

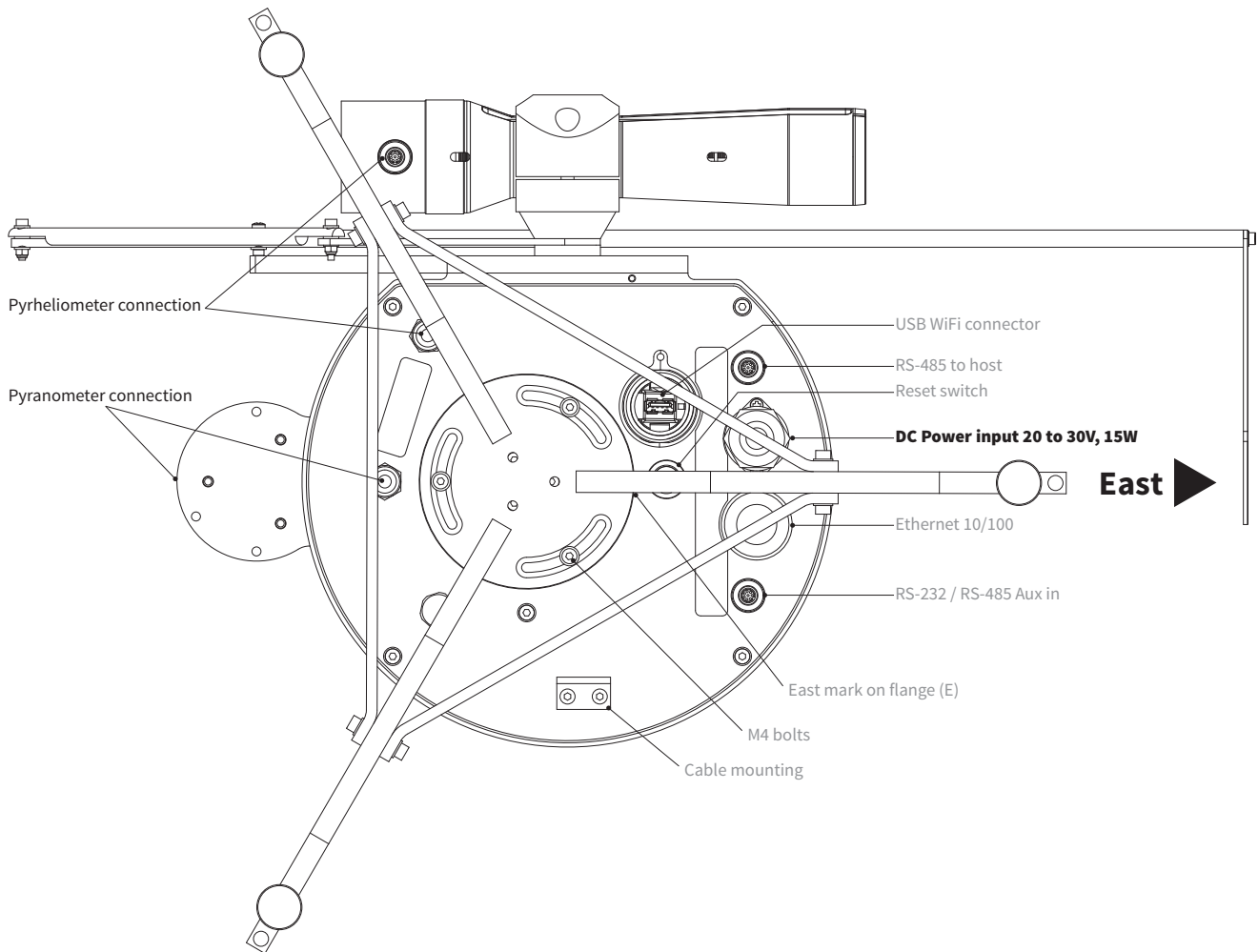
Because the pyranometer on the RaZON<sup>+</sup> measures only diffuse the accuracy of levelling has much less effect than for direct measurement.

Rotating the RaZON<sup>+</sup> on its tripod is possible before the 3 M8 bolts are placed. The bubble level will move when the tracker is rotated 180 degrees. We recommend adjusting the levelling (feet) in such a way that the average bubble position is in the middle.

**Tip**

### 3.11 Connecting DC power cable

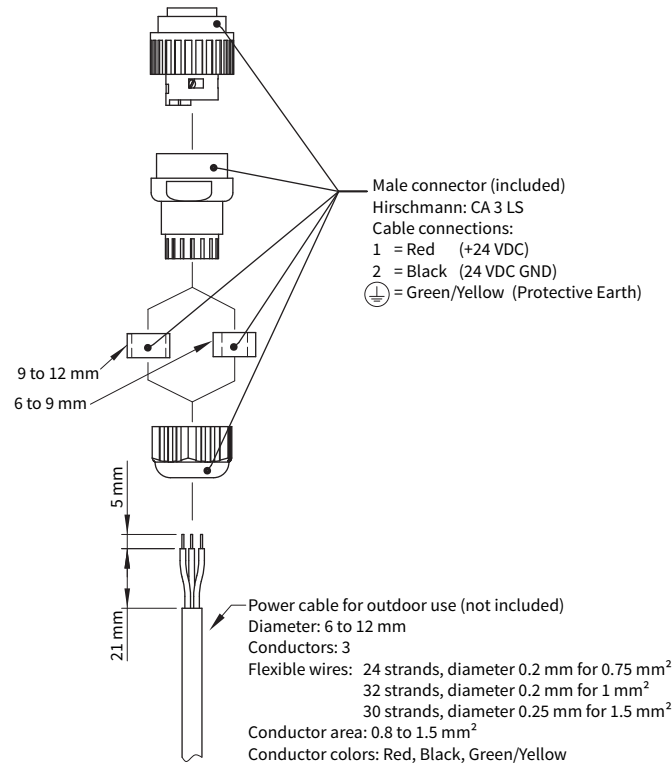
This section will explain how to make and connect your power cable to power the RaZON<sup>+</sup>.



RaZON<sup>+</sup> is supplied with a waterproof connector for 24 VDC power. This connector is in accordance with safety regulations for outdoor usage. The voltage drop over the cable should not cause the supplied voltage to be out of the operating limits (VDC should be between 20 to 30 VDC). The 24 VDC power connector is male (chassis part is female). The DC power connector is suitable for cable diameters between 6 and 12 mm. For 6 to 9 mm and 9 to 12 mm different sealing rings are used. The DC power connector is a male type Hirschmann CA 3 LS connector. The maximal cable resistance should be less than  $2 \times 0.5 \Omega$ .

Please make sure the used cable is flexible enough to withstand the daily movement of the tracker. The number of strands per wire is specified on the next page.

The pin numbers and ground connection for the individual wires are visible inside the connector. The ground connection is raised slightly above the other connections.



Power Cable Connector for 24 VDC



Pin 1: +24 VDC  
Pin 2: GND  
Pin 3: not used  
Pin Earth: Protected Earth  
(GND and Protected Earth are connected)

Pin numbering in male power connector

As indicated in the drawing showing the bottom view, up to 4 cables can be connected to the bottom of the RaZON<sup>+</sup>. A connection point is created on the side of the bottom plate to start the cable loop that moves down to the tripod or pole mount. The length of this cable loop is indicated as well.

When power is connected the RaZON<sup>+</sup> will first find its reference position and checks proper operation of all internal components. It can take up to 5 minutes before it is fully operational (including GPS fix) and follows the sun.



Please understand that the RaZON<sup>+</sup> can rotate plus and minus 300° (depending on its location) from its home position. Before power is applied it is advised to rotate the RaZON<sup>+</sup> by hand the full 600° and so checking the required cable length for all connected cables.

### 3.12 Set-up without using Ethernet or Wi-Fi enabled Smart device

It is possible to set-up the RaZON<sup>+</sup> without any PC or communication, under the following conditions:

- RaZON<sup>+</sup> is in factory default mode (press reset button for 10 seconds during power on)
- RaZON<sup>+</sup> is levelled
- One leg of the tripod is pointing East (or E-marking on the pole mount)
- E-marking on bottom flange of the RaZON+ is pointing East
- Power is connected at least for 5 minutes to have a proper GPS fix.
- M4 mounting screws are inserted but not tightened
- Direct radiation is above 300 W/m<sup>2</sup>, to allow alignment

Once the RaZON<sup>+</sup> starts tracking, rotate the Razon+ on its mount until the alignment target of the pyrhelimeter is aligned with the sun. This is indicated by the beam of light falling through the first hole, making a light spot around the second hole. Then, while checking the levelling, the 3 M4 mounting bolts can be tightened. During the fixation of the mounting to the ground (platform) re-check the levelling.

### 3.13 Set-up using Ethernet or Wi-Fi enabled Smart device

The benefit of communication during set-up are extra options to configure, it will guide you through the set-up process. Also the fine adjustment of the Azimuth position can be done via the web interface. The RaZON<sup>+</sup> can be accessed via Ethernet or optional Wi-Fi.

#### Ethernet

A standard Ethernet cable can be used to connect to the local LAN. When this connection is for permanent use, a proper flexible outdoor cable needs to be used and waterproof connected as described in section 6.1. For one time use, any short (straight) UTP cable will do. Once connected use your PC (connected to the same LAN) and open your browser.

Enter: <http://razon<serialnumber>>

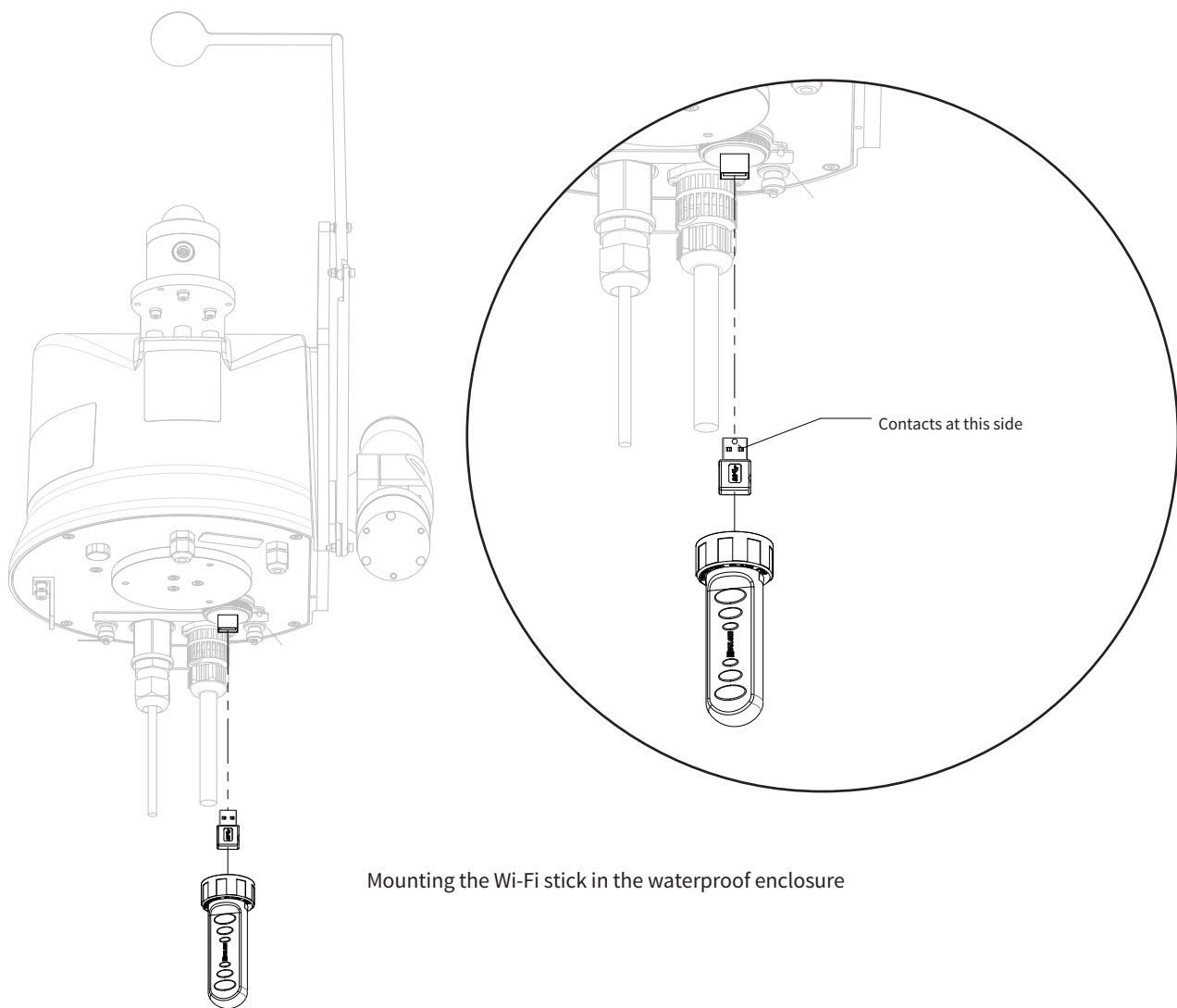
The browser will open the RaZON<sup>+</sup> dashboard.

#### Wi-Fi

When the optional Wi-Fi connection is used the Wi-Fi stick needs to be mounted in the USB connector in the bottom plate. Turn off the power, unscrew the waterproof cover of the USB connector and mount the stick.



Check if the Wi-Fi stick is suitable and approved for your network and region.



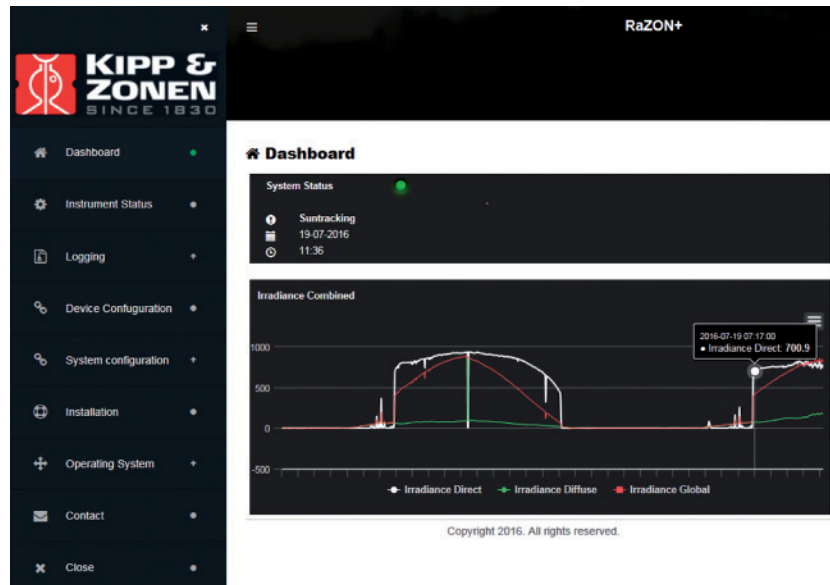
Mounting the Wi-Fi stick in the waterproof enclosure

Re-mount the waterproof cover. After power on the Wi-Fi connection will be available within 1 or 2 minutes. The RaZON<sup>+</sup> has its own web page and acts like a hot spot, but has no real Internet connection. To connect open the Wi-Fi setting on your smart device or PC and look for the SSID of the RaZON<sup>+</sup> (it is razon<serial number>).


Connect and enter the password (default is "RaZON<serial number>"). Once connected go to your web browser and enter any (not stored) domain in the title bar (like: razon.nl). The browser will then open the RaZON<sup>+</sup> dashboard where you can start.

### 3.14 Web interface

#### 3.14.1 Menu bar and Dashboard



The above screen shows the menu bar and its first item, the dashboard.

The menu bar on the left can be opened (and closed) with the  icon on top of the page and shows all options you can choose from. The dashboard on the right gives on top an overview of its operating status. When the System Status LED is green, the RaZON<sup>+</sup> is functioning correctly. If red or orange, the next item in the menu bar (Instrument status) give you detailed information about the individual components. The showed time and date is UTC.

The chart on the bottom right shows the combined irradiance over the last day. By clicking on the type of irradiance below the chart you can switch its graph on or off. Zooming is possible by clicking and dragging over the desired part (or pinch on Smart device). Clicking on an individual point in the chart shows its date, time and value.

Under Logging and Chart more graphic data options are available.

### 3.14.2 Instrument Status

The second item from the menu bar shows the status of all different RaZON+ parts, including the connected sensors. For correct operation all item states should be green (Success).

When the radiometers for Direct and Diffuse (Device) are not connected they do not show up, so don't give an error.

#### Instrument Status

Suntracking

##### Device

Description	Serial no	Value	Unit	State
SMP10	130004	177.9	W/m2	Success
PH-1	110001	770.5	W/m2	Success

##### Motor

Type	Description	State
Azimuth	Connected (port opened and configured), I/O ok, Communicates, Motor powered,	Success
Zenith	Connected (port opened and configured), I/O ok, Communicates, Motor powered,	Success

##### GPS

Fix	Description	State
3D fix	Longitude and latitude ok, Altitude ok	Success

##### Timing

Timing	Description	State
Operating as expected	System synchronized to GPS or Internet	Success



### 3.14.3 Logging

The logging menu has two options, Export or Chart.

Export will download and save the data over the selected time interval. You are prompted for the start and end date of the data to be exported. You can enter the date yourself or click on the agenda for an overview. The present date is indicated in blue, the selected date will show up in orange.

**Export Log File**

Start date: 2016-07-11

End date: |

Filename: RaZON-logfile

Calendar view for July 2016:

Sun	Mon	Tue	Wed	Thu	Fri	Sat
26	27	28	29	30	1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31	1	2	3	4	5	6

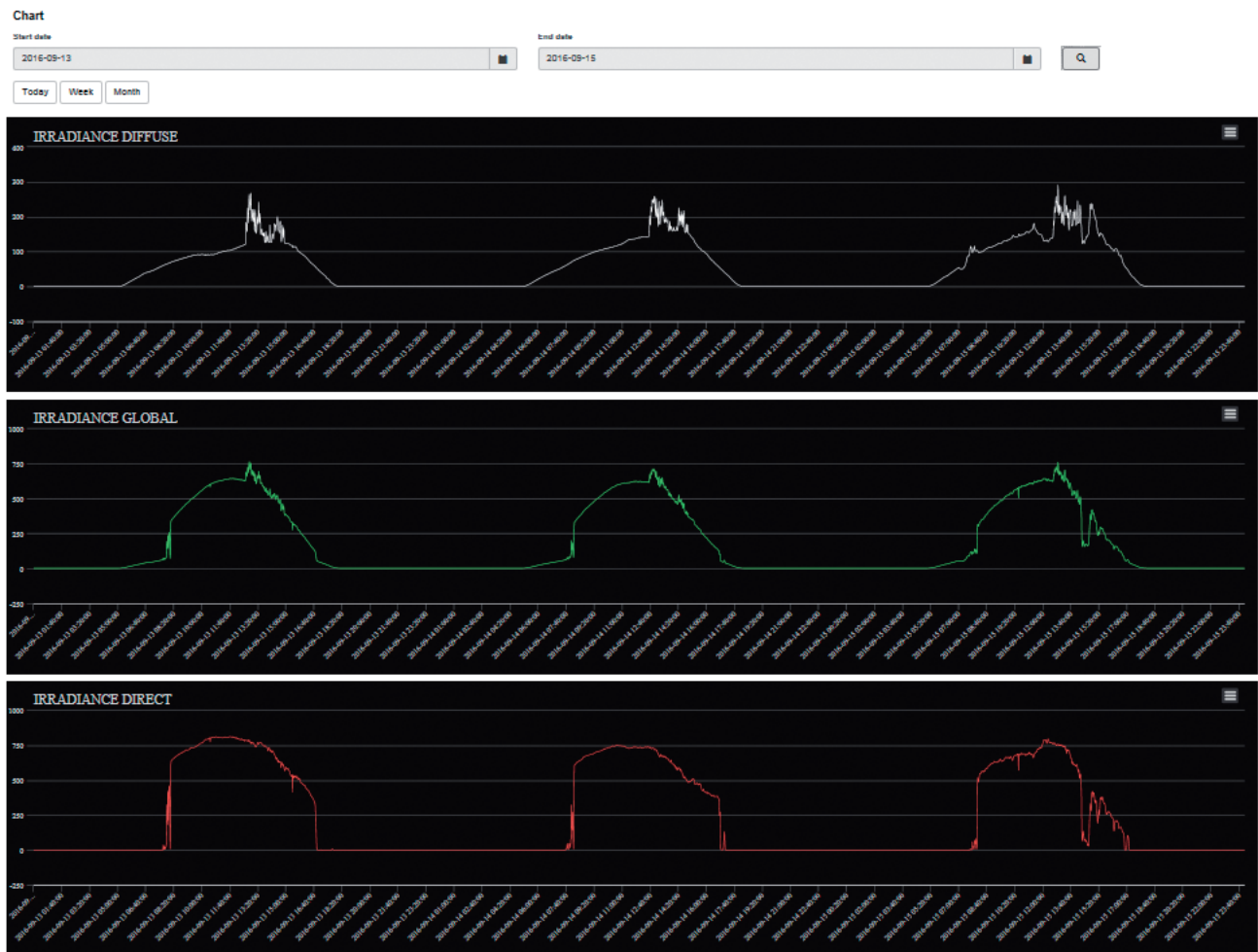
Before clicking the save icon you can change the file name. Once downloaded you can save it (save as) in the directory you want.

In Appendix an example of the logged data is given

### 3.14.4 Chart

Chart allows you to show and save a graph.

The buttons Today / Week / Month will give you a quick view over the selected interval. Or a specific start and end date can be entered. The download is done per graph by clicking on the icon in the top right hand corner. The graphs will be transferred in .png format.



### 3.14.5 Device configuration

Device configuration shows the connected sensors with serial number and Modbus® address and allows you to add a new device. The Add Device button shows a list of sensors you can choose from and prompts you for an (unused) Modbus® address. After adding the new device it should appear in the configuration list as last device. Devices with identical Modbus® addresses will not be accepted.

Configuration				
Type	Serial no	Modbus address		
SMP10	130004	1		
PH-1	110001	2		

Add Device

The added device has to be connected to the RS-485 port (AUX in) on the bottom of the RaZON+ (planned for 2017).

### 3.14.6 System configuration

The System Configuration menu has two options, Tracker mode and Communication.

#### 3.14.6.1 Tracker mode

### ⚙ Tracker mode

With the tracker modes the tracker can be set in a (special) functional mode

Switching between normal and demo mode takes 10 minutes. When this option is selected the tracker will move to the position of the selected mode.

- ☒ Sun Tracking mode
- ☐ Demo mode (10 minutes/day)
- ☐ Demo mode (5 minutes/day)


The Demo Mode is also a good way to check (simulate) your cable movement over a full swing, don't forget to switch back to Sun Tracking mode afterwards.

**RaZON+ Demo Mode**

3.14.6.2 Communication

This page allows you to set the communication parameters of the RS-485 communication to your Host (PC, PLC or data collecting device). Also the protocol can be set to either ASCII or Modbus®. Save will store these settings. Details about the communication protocol are given in the chapter about the serial interface.

The 2/4 wire transmission setting switches on/off the local echo.

 **Communication settings**

Port 4 Isolated RS485

Protocol

☐ ASCII

☒ MODBUS

Baudrate

19200

Parity

☐ None

☒ Even

☐ Odd

Databits

☐ 7

☒ 8

Stopbits

☒ 1

☐ 2

Transmission

☒ 2-Wire


☐ 4-Wire

Save

3.14.7 Installation

The Installation menu is used to assist you during the set-up of the RaZON+. It allows you to do all the required checks to set it up and align it to the sun.

The menu will guide you through 5 steps. Each step can be confirmed with Done ✓ when completed or return to the Installation menu, with Back. Each item gives you instructions what to check before completion.

 **Installation**

Welcome

Device

Last installed:  
15-07-2016, 10:20

✓

GPS

Last installed:  
19-07-2016, 11:27

✓

Azimuth Raw

Last installed:  
15-07-2016, 10:20

✓

Leveling / Cable routing

Last installed:  
15-07-2016, 10:21


✓

Azimuth Fine

Last installed:  
18-06-2016, 07:26

✓

This menu guides you through the mechanical installation in 5 steps. The above listed boxes need to be checked, in the given order to properly install the RaZON+. Per item the "Done" box has to be checked to indicate completion. "Back" will return to the installation welcome menu when not complete.



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### 3.14.7.1 Device

Here the correct operation of the connected radiometers can be checked. All connected devices should show up and their status should be green (Success)

Installation


Device

Back

Done ✓

Check the connection and status function of all connected devices. Under device configuration extra devices can be added.

All devices should be green. If not, check the cable between the radiometers and the RaZON+ if it is properly fastened. The connectors for the pyranometer and pyrhelimeter are indicated on the bottom of the RaZON+



Device

Device

Serial no

State

Irradiance

SMP10

130004

Success

178.7

Device

Device

Serial no

State

Irradiance

PH-1

110001

Success

708.1

### 3.14.7.2 GPS

A proper 3D fix is required for proper operation. The RaZON+ needs to know where it is and have an accurate clock. Remember that indoor operation (for testing) can lead to unpredictable results when the location and clock are not synchronised. When GPS Status shows a 3D fix, your local longitude and latitude are shown below.

Installation

GPS


Back

Done ✓

After power on it can take up to 20 minutes before a proper 3D satellite fix is available.

Only after a proper fix, the GPS position and time will be used in the RaZON+.

Remember that when using the RaZON+ indoor a GPS fix can be difficult or impossible. In that case the RaZON+ will use the last stored position and time.



GPS Status

Latitude

Longitude

3D fix

51.9975902222

4.386787

Longitude and latitude ok, Altitude ok

37

### 3.14.7.3 Raw Azimuth

When the raw Azimuth position is found, with the E-marking pointing East, the bolts from the tripod or pole mount can be fastened. With Azimuth fine the fine tuning can be done via Ethernet or Wi-Fi connection.

#### Installation

##### Raw Azimuth

[Back](#) [Done ✓](#)

RaZON+ is supplied with a tripod or pole mount. Both have 3 slots for mounting the M4 bolts to the bottom flange. Both the E mark on the bottom flange and one of the tripod legs must point to the East when mounting the RaZON+. Initial Azimuth orientation due East with the help of a compass will do. The bolts should be in the middle of the slots when the tripod is mounted to the RaZON+. The M4 bolts can be fastened during this first part of the installation because fine tuning is possible later on. With the last step Azimuth fine the RaZON+ position can be fine tuned when sun is available.

### 3.14.7.4 Levelling / Cable routing

Before fine adjustment can be done the RaZON<sup>+</sup> should be levelled (see 3.10). To prevent further handling afterwards, also the cable routing is recommended in this stage, this requires that all cables are present on the bottom of the RaZON<sup>+</sup>. See section cable routing (3.16).

#### Installation

##### Leveling / Cable routing

[Back](#) [Done ✓](#)

The RaZON+ tripod has 3 levelling feet. It is advised to put the height adjustment screw of one feet in the middle and level the RaZON+ only with the other two. When power is removed, the tracker can be rotated by hand over 180 degrees. We recommend adjusting the levelling (feet) in such a way that the average bubble position is in the middle. During installation we recommend to keep the bubble inside the ring. However, if the bubble is half out of the ring the RaZON+ is still within 0.1°.



### 3.14.7.5 Azimuth Fine

Important: Before starting the alignment please verify the following conditions:

- RaZON<sup>+</sup> needs to be supplied with power (24 VDC)
- RaZON<sup>+</sup> is sun tracking (not demo mode)
- Sun with unobstructed sky (DNI >300 W/m<sup>2</sup>) is required
- The RaZON<sup>+</sup> is correctly levelled (RaZON<sup>+</sup> bubble level in center)
- E-marking on flange is pointing East
- The 3 M4 bolts in the tripod / pole mount are fastened

#### Installation

##### Azimuth Fine

[Back](#) [Done ✓](#)

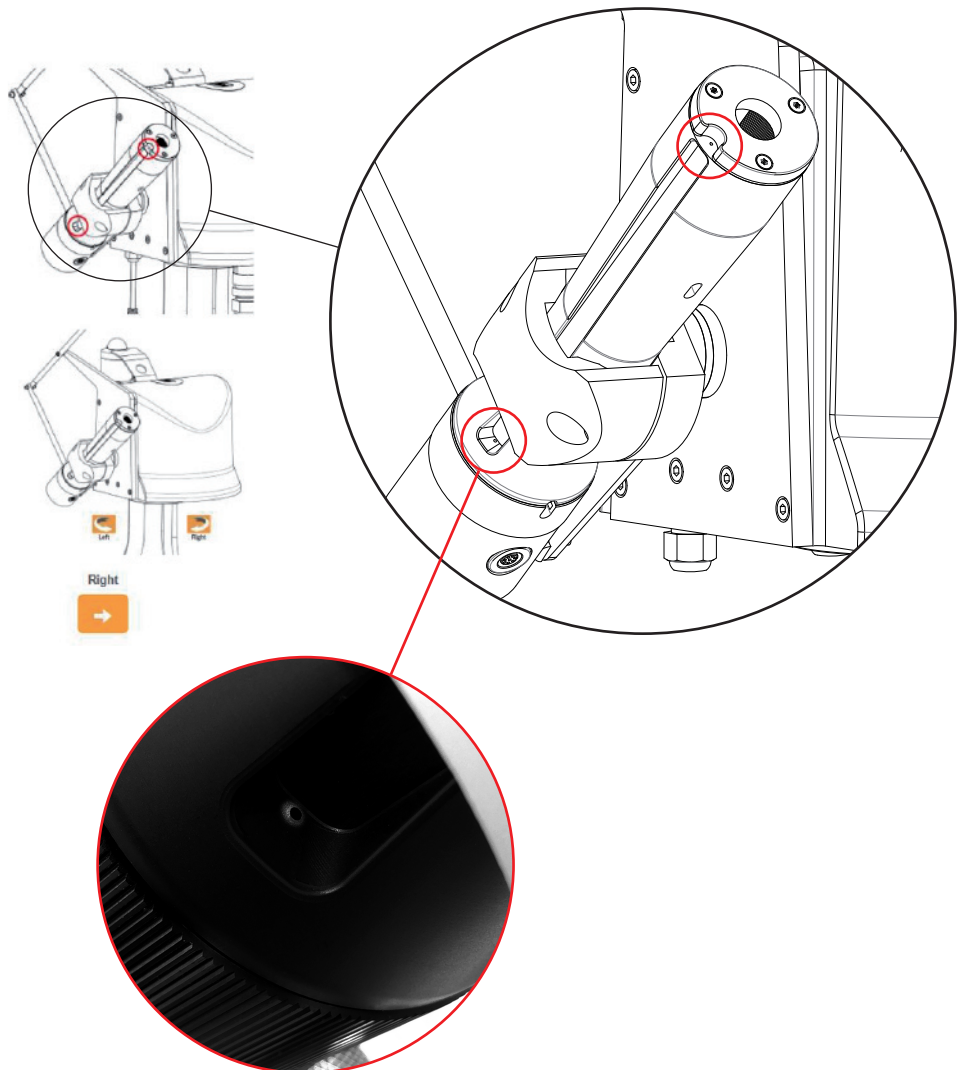
The pyrheliometer is now roughly pointing towards the sun. This part of the installation will fine adjust the azimuth position. Use the arrow buttons to microstep the pyrheliometer in the azimuth direction until the alignment target of the pyrheliometer shows a circle of light around the (second) alignment hole.

The maximum angle to adjust is +/-10 degrees. You can finalize (and store) this adjustment by selecting the "Done" checkbox.

When the Azimuth fine adjustment blocks (either left or right) the 3 x M4 bolt from the tripod need to be readjusted.



Offset  
0.25



When the above requirements are met, the final adjustment can be made by rotating the RaZON<sup>+</sup> with the buttons on the screen until the sun falling through the first alignment target hole from the pyrheliometer makes a round spot of light around the second alignment target hole. It takes about 10 seconds for the RaZON<sup>+</sup> to react on the left/right buttons. Confirm the correct setting with [Done ✓](#). The vertical adjustment of the side mounting plate is a factory setting and should be OK.

### 3.14.8 Operating System

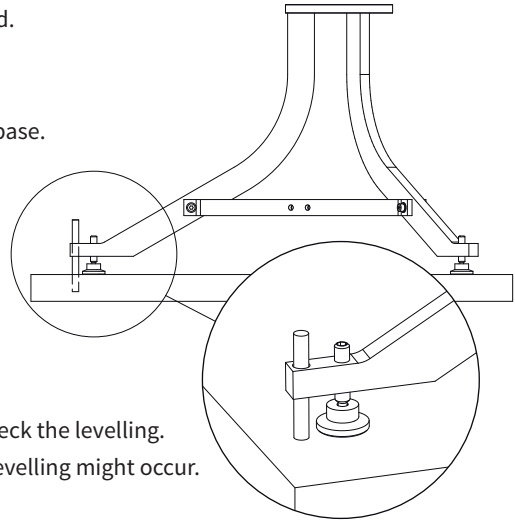
This shows a list with system information, hardware and software revisions and serial number. This information is good to have at hand when communicating about the RaZON<sup>+</sup> with our local distributor or Kipp & Zonen offices.

### 3.14.9 Contact

On this page our Kipp & Zonen offices locations and contact details are listed.

### 3.15 Securing the tripod

After the RaZON<sup>+</sup> is levelled and aligned, it's time to fix the tripod feet to its base.

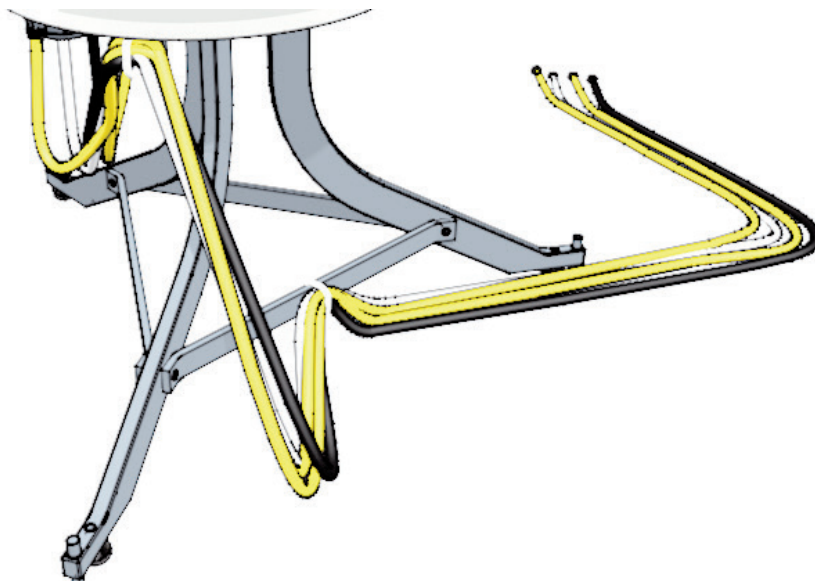


During the fixation of the RaZON<sup>+</sup>'s mounting bolts it is recommended to check the levelling. When the tension of the 3 legs or bolts is different a slight distortion of the levelling might occur. Applying the right (same) amount of force on the 3 bolts will solve this.

### 3.16 Cable routing

When all communication, sensor and power cables are connected, the cable routing should be created correctly.

- Disconnect the power
- Combine all outgoing cables together on the cable clamp on the bottom of the RaZON<sup>+</sup>
- Strap them with a tie-rop together (outgoing side facing down)
- Rotate the RaZON<sup>+</sup> to its home position, this is the middle of the maximum clock-wise and counter clock-wise position.
- For the tripod create a loop and tie this down to the middle of the nearest horizontal bar of the tripod. The length of the loop between the 2 connection points is ~45 cm.
- For the pole mount secure the end of the loop to one of the nearest screws on to bottom of the pole mount.





## 4. Using a solar panel to power RaZON<sup>+</sup>

It is possible to run the RaZON<sup>+</sup> from a PV Solar Panel. To create a reliable power source that will be functioning the whole year, some conditions have to be checked.

If the system is operating on solar power please be aware of the reduced number of hours of sunlight during the winter. On cloudy days less than 50% of the normal radiation comes in. Rule of thumb is to use 10 times as much solar panel power as the consumption of the system.

Add the power consumption of each additional instrument or any other device together with the power consumption of the RaZON<sup>+</sup> and multiply this by 10.

Power consumption RaZON<sup>+</sup> including its pyranometer and pyrliometer is 13W

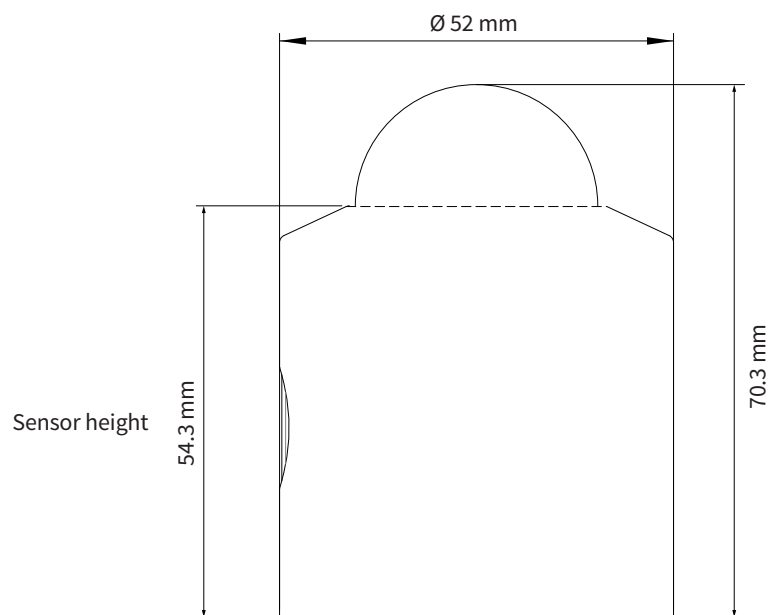
If no other power is available, also a few days without sun should be covered by the back-up battery.  
Two 12 V backup batteries can be used in series for the RaZON<sup>+</sup> (24 V).



## 5. RaZON<sup>+</sup> PR1 Pyranometer

The RaZON<sup>+</sup> standard pyranometer is the PR1. This pyranometer is equipped with a quartz diffusor, spherical dome and a fast detector. It has the smart interface to communicate over RS-485, Modbus<sup>®</sup> RTU with the RaZON<sup>+</sup>. Because it has no integrated bubble level and levelling feet, it is intended only to be used on the RaZON<sup>+</sup>. The PR1 and PH1 are almost identical (apart from dome and tube) the communication with the PR1 is fully identical to the PH1.

Classification to ISO 9060:1990	Second Class
Response time (95%)	< 0.2 s
Response time (63%)	< 0.1 s
Spectral range (50% points)	310 to 2700 nm
Zero offsets	
(a) thermal radiation (at 200 W/m <sup>2</sup> )	1 W/m <sup>2</sup>
(b) temperature change (5 K/h)	1 W/m <sup>2</sup>
Non-linearity (100 to 1000 W/m <sup>2</sup> )	< 0.3 %
Directional response (up to 80° with 1000 W/m <sup>2</sup> beam)	< 20 W/m <sup>2</sup>
Temperature response	< 1 % (-20°C to +50°C)
Field of view	180°
Measurement range	0 to 1500 W/m <sup>2</sup>
Operating temperature range	-40 °C to +80 °C
Ingress Protection (IP) rating	67



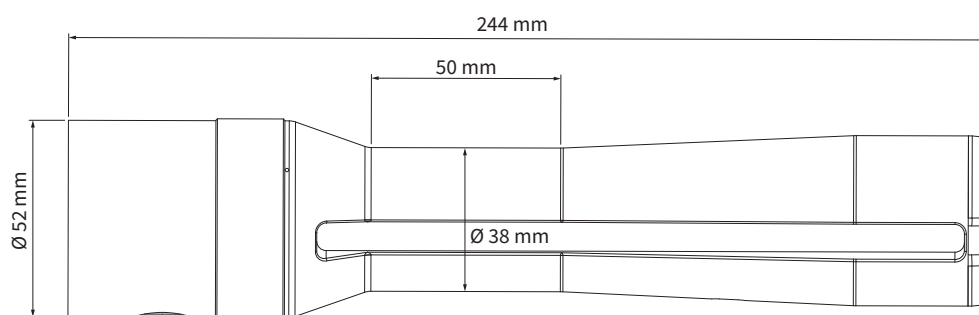
Dimensions PR1



## 6. RaZON<sup>+</sup> PH1 Pyrheliometer

The RaZON<sup>+</sup> standard pyrheliometer is the PH1. This pyrheliometer has a quartz diffusor, fast detector and removable collimation tube. The reason the detector part and the tube can be separated it to check whether the detector is clean. The anti-soiling design of the collimation tube keeps dust and dirt from the detector. This significantly increases the cleaning interval required for the PH1. Communication is done via its smart interface with Modbus<sup>®</sup> RTU over RS-485.

Classification to ISO 9060:1990	Second Class
Response time (95%)	< 0.2 s
Response time (63%)	< 0.1 s
Spectral range (50% points)	310 to 2700 nm
Zero offsets (b) temperature change (5 K/h)	1 W/m <sup>2</sup>
Temperature response	< 1 % (-20 °C to +50 °C)
Non-linearity (100 to 1000 W/m <sup>2</sup> )	< 0.3 %
Field of view	5° ± 0.2°
Slope angle	1° ± 0.2°
Measurement range	0 to 1500 W/m <sup>2</sup>
Operating temperature range	-40 °C to +80 °C
Ingress Protection (IP) rating	67



Dimensions PH1

### 6.1 Electrical connection PR1 and PH1

Both the 8 pin connector and the RS-485 Modbus<sup>®</sup> communication of the PR1 and PH1 are identical to the SMP pyranometers. Please refer to the SMP manual (section 2.9 – 2.94) for details if you want to connect the PR1 and PH1 as separate instruments.

### 6.2 Internal desiccant

To keep the detector and electronics dry and to prevent condensation forming inside the instruments with temperature changes a desiccant is used to absorb humidity. For the PR1 and PH1 this desiccant is internal and lasts for 5 year. The desiccant will be exchanged when the instruments comes back to a Kipp & Zonen service location for re-calibration.



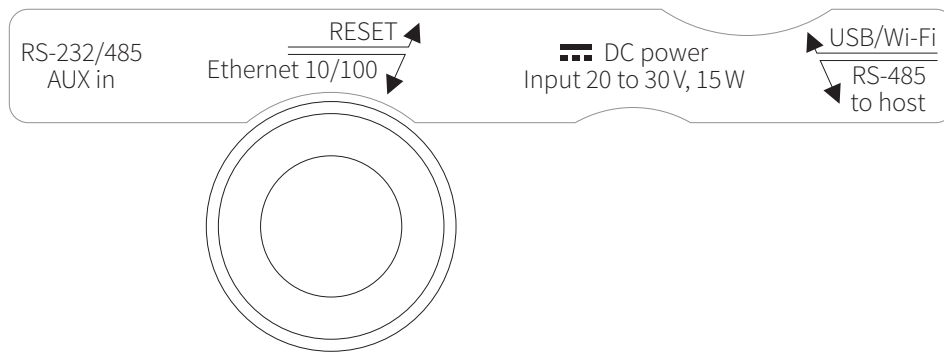
## 7. Communication to the host

The RaZON<sup>+</sup> has 2 communication ports to communicate with its host. An Ethernet connection and an isolated RS-485 port. Both options are described below and how to connect the cables.

The second RS-232/485 interface (AUX in) is for connecting extra smart radiometers or a compact (Modbus<sup>®</sup>) weather station.

### 7.1 Ethernet interface

This section describes how to mount the Ethernet cable and how to communicate with the RaZON<sup>+</sup> via Ethernet



Prepare the Ethernet cable for use in the RaZON<sup>+</sup>.

First locate the supplied cable gland for the Ethernet cable (water proof cable gland is supplied, the cable is not).

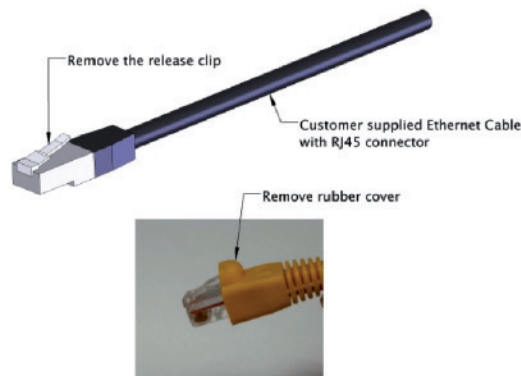
Make sure the cable you are using is meant for outdoor use and flexible enough for continuous rotation.

Remove the plastic plug from the Ethernet cable entry.

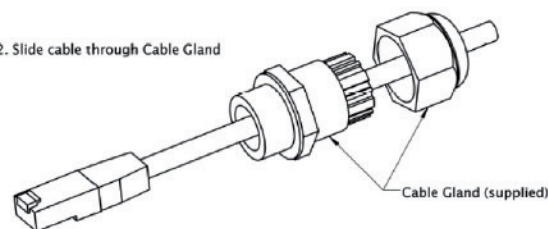
The Ethernet connector is fitted with a plastic plug (screw cap) to make it waterproof. If this cap is removed a RJ-45 connector can be fitted. The cable is ideally of the Cat 5E type and should be shielded. To make the connection waterproof the supplied cable gland for the connector should be fitted to seal the connector against water ingress.

#### Installation Instructions Ethernet Cable

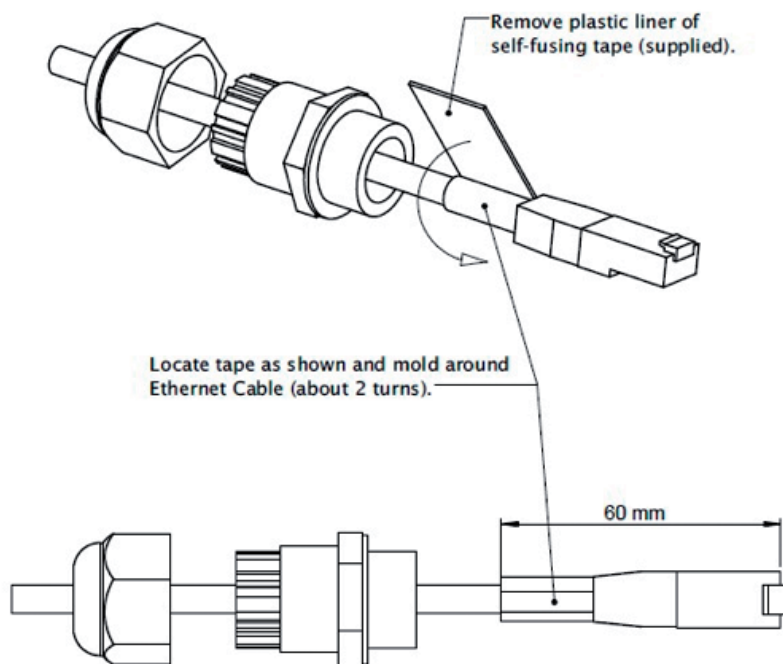
1. Remove the release clip (and rubber cover) of the Ethernet Cable



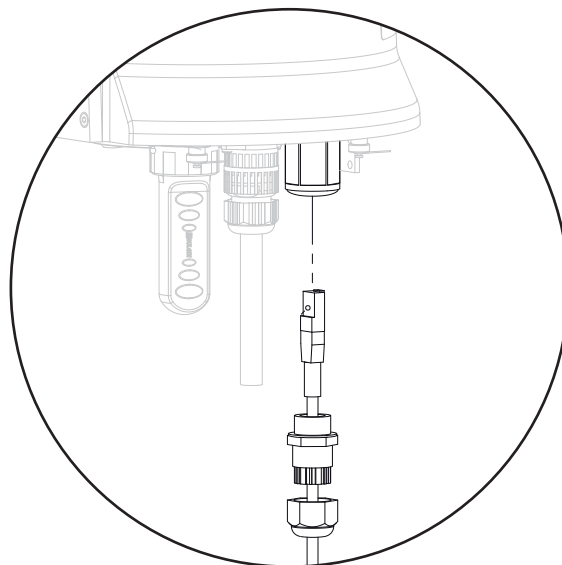
2. Slide cable through Cable Gland



### 3. Apply self-fusing tape



Mounting the upper part of the Ethernet cable gland and nut



After the Ethernet connector is properly inserted the upper part of the Ethernet cable gland can be screwed in the housing. Push the cable upwards, so the connector remains in place. Please note that only the lower part (nut) of this connector needs to be unscrewed when removing the connector / cable again.

Finally tighten the nut, check if the tape around the cable is still in place, and tighten the nut to make the connection waterproof.

#### **Warning!**



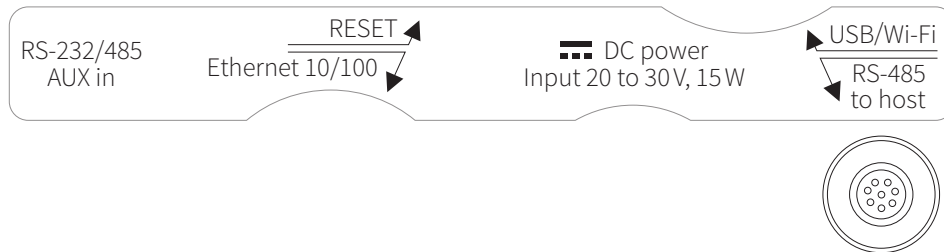
Communication with the RaZON<sup>+</sup> is established via its network interface. The Ethernet connection is suitable for permanent use, however, the RaZON<sup>+</sup> is not protected by an internal firewall. Therefore, the network connected must be secured properly, to avoid hacking of the RaZON<sup>+</sup>.



## 7.2 Serial interface to host

This chapter describes the physical RS-485 connection between the RaZON<sup>+</sup> and the host. This can be a PC or other connected device like server or data logger.

The serial communication is based on client-server architecture. The RaZON<sup>+</sup> is the server, providing the information. The PC is the client, sending commands to or receiving data from the instrument.



Location of RS-485 connector to host on bottom of RaZON<sup>+</sup>

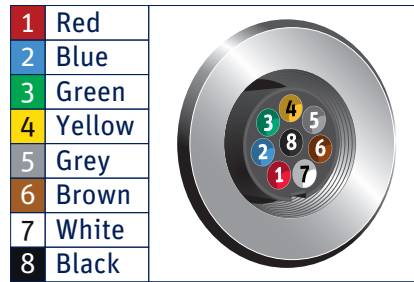
The communication protocol has three main roles:

- Transmission of the instrument's data (status info) to the PC
- Firmware update
- Instrument hardware configuration

The RaZON<sup>+</sup> is equipped with a 4-wire RS-485 isolated serial interface. The following communication parameters can be set. Bold are factory defaults:

- Protocol: **Modbus (Modbus® address 1)**, ASCII
- Baud rate: 9600, 14400, **19200**, 28800, 34800, 56000, 576000, 115200
- Parity: None, **Even**, Odd.
- Data bits: 7, **8**
- Stop bits: **1**, 2

### Pin Layout (instrument)



Via the RaZON<sup>+</sup> web interface under System configuration/communication, the communication parameters can be changed. A complete description of the serial communication protocol can be found in the Appendices.

Pin	Color	Signal	Direction	Description	Host connection
1	Red				
2	Blue				
3	Green				
4	Yellow	RD+	input	RS-485 Receive data (B)	RS-485 Transmit Data (Z)
5	Grey	RD-	input	RS-485 Receive Data (A)	RS-485 Transmit Data (Y)
6	Brown	SG		RS-485 signal ground	RS-485 signal ground
7	White	TD+	output	RS-485 Transmit Data (Z)	RS-485 Receive data (B)
8	Black	TD-	output	RS-485 Transmit Data (Y)	RS-485 Receive Data (A)

Pin description of the RS-485 connector to HOST interface

The indicated colors above apply to the standard yellow 8 wire cable as used for the SMP pyranometers (with 8 pin Binder 712 connector). To use this port as 2 wire RS-485, connect the RD+ and TD+ together (as D+) and the RD- and TD- together (as D-) and select in the webpage under system configuration/ Communication / Transmission, the 2-wire option. This switches local echo off.

### 7.3 Serial interface, AUX in port

The AUX IN port is intended for connection of sensors or weather stations that use the Modbus<sup>®</sup> RTU protocol. In the first (2016) release of the RaZON<sup>+</sup>, this feature is not yet implemented.

#### **7.4 RaZON<sup>+</sup> connecting to the web interface**

The RaZON<sup>+</sup> needs no PC software. Both the Ethernet connection and the Wi-Fi connection use the RaZON<sup>+</sup> web interface and your standard web browser.

##### **7.4.1 Wi-Fi connection**

When using the optional Wi-Fi connection the Wi-Fi stick needs to be mounted in the USB port, located on the bottom of the RaZON<sup>+</sup>. The RaZON<sup>+</sup> acts as a hotspot, but is not connected to the Internet. With the connecting device the SSID name of the RaZON<sup>+</sup> has to be searched in the list of available Wi-Fi devices. The SSID name will be “RaZON, followed by its serial number” Once connected the password has to be entered. Default password is the same as its SSID name (RaZON and its serial number, e.g. RaZON160012

Once connected enter a not stored site name in the address bar of your browser (like razon.nl) and start search [by pressing enter]. The browser will come up with the RaZON<sup>+</sup> dashboard page.

##### **7.4.2 Ethernet**

For Ethernet connection the RaZON<sup>+</sup> has to be connected to the local LAN with a standard (straight) UTP cable. Communication with a cross cable directly to a PC is not supported. Once the Ethernet cable is plugged in you can connect with your PC or Laptop to the same LAN.

Open your Internet browser and enter:

`http://razon<serialnumber>`

The browser will open the RaZON<sup>+</sup> dashboard

See Appendices for ASCII TCP and Modbus<sup>®</sup> TCP protocol.



## 8. Maintenance

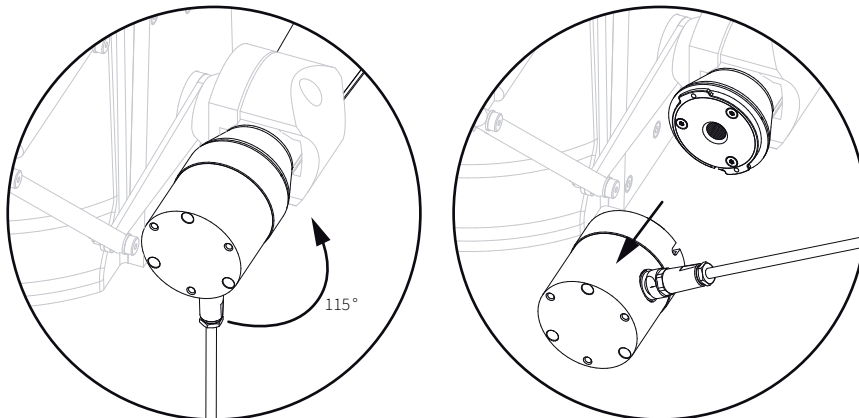
The RaZON<sup>+</sup> itself does not need any maintenance. The following things can be checked on visiting intervals:

- Periodically check the condition of all cables and connectors
- Check if bubble level is still within range
- Check the alignment of the pyrliometer
- Check the radiometers and clean if required
  - Clean pyranometer dome with water or alcohol
  - Clean PH1 by unscrewing the sensor part and clean the diffusor with water or alcohol
  - Check the PH1 tube for dirt and clean if required
  - Remount the sensor part by entering in the slot and rotate until it blocks

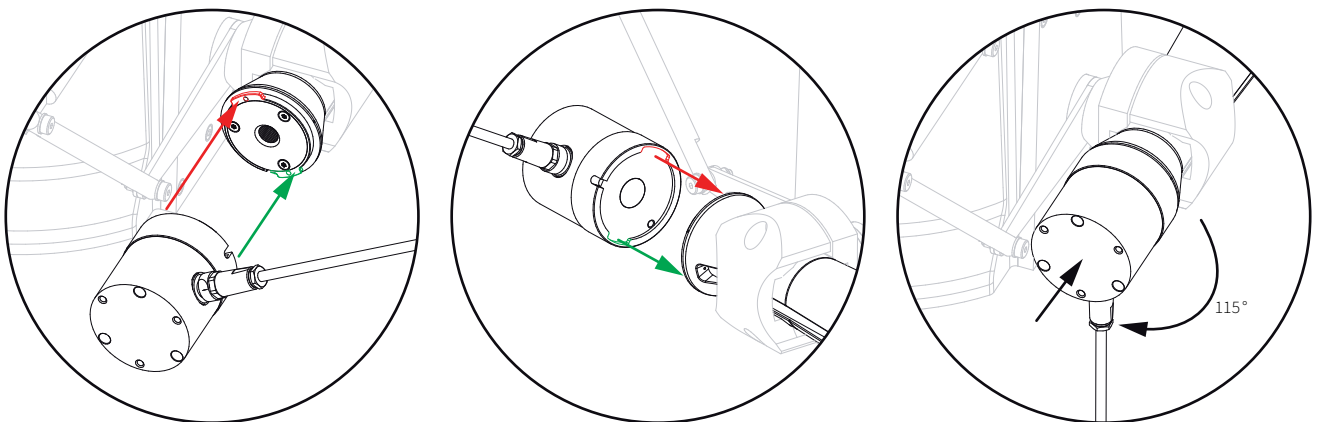
The RaZON<sup>+</sup> itself does not need re-calibration. However we suggest having the measuring instruments, used on the RaZON<sup>+</sup>, re-calibrated every two years.

The PH1 and PR1 have internal desiccant that needs to be replaced every 5 years. When sending the instruments back to Kipp & Zonen for calibration we will always renew the desiccant.

The label on the radiometers shows the last calibration date. Therefore it also indicates if the desiccant is still active.



The PH1 detector part has a Bayonet connection with the PH1 collimation tube. To open the PH1 rotate the detector part 115 degree counter clock wise and pull it off.



To close the PH1, push the detector part with a little force in the tube opening and rotate the detector 115 degree clock wise. The detector will click in position when in place.



## 9. Trouble shooting

The RaZON<sup>+</sup> is designed for long periods of operation with no operator maintenance. However, if a problem occurs that cannot be corrected by using the standard operating information supplied in the preceding sections of this manual, use the information in this chapter to identify and solve the problem.

If the problem cannot be corrected, contact Kipp & Zonen. When contacting Kipp & Zonen with technical assistance questions, ensure you have the following information available to aid the technician in solving your problem:

- The serial number of the RaZON<sup>+</sup>, this information is listed on the serial number label, located on the bottom of the unit, or via the web interface under Operating System / OS Overview.
- Mounted instruments and options
- Problem description
- Example of the erroneous data

If you cannot solve the problem by the tips on the next pages, email the problem description to [support@kippzonen.com](mailto:support@kippzonen.com), call us at +31 15 2755 210, or contact the nearest Kipp & Zonen distributor, as listed on our website [www.kippzonen.com](http://www.kippzonen.com).

### 9.1 Problem check-list

Check the items in the following list. If these do not help, see the following section on troubleshooting.

Check:

Power is supplied to the unit.

Via the Ethernet or Wi-Fi connection the instrument status.

GPS reception is possible; the GPS antenna should not be obstructed by instruments or nearby objects. (also testing in a building can block reception)

The RaZON<sup>+</sup> does not follow the sun properly, what can be wrong?

- GPS does not have a good fix (check via Ethernet or Wi-Fi)
- Check bubble level if the bubble is still at least half in the ring
- Is alignment target (from Pyrheliometer) correctly pointing at the sun?
- Is the RaZON<sup>+</sup> sun tracking (not in demo mode)

## 9.2 FAQ

Q: I have a problem with the aligning the RaZON<sup>+</sup>

A: Proper placement of the RaZON<sup>+</sup> is important when installing it, as it requires a specific amount of free space to operate.

Make sure the tripod is placed on a solid base.

Keep in mind that final alignment is only possible when the sun is shining.

The following steps are required to align the RaZON<sup>+</sup>. In the previous paragraphs additional information is available for each step.

1. Position the tripod with one leg pointing East.
2. Put the RaZON<sup>+</sup> on the tripod with the E-marking on the bottom flange pointing East.
3. Level the RaZON<sup>+</sup> by adjusting the tripod feet and checking the bubble level.
4. Connect power to the RaZON<sup>+</sup> and let it start tracking.
5. Rotate the RaZON<sup>+</sup> on its tripod (adjust azimuth) until the alignment target from the pyrliometer points exactly at the sun.

Q: Can the RaZON<sup>+</sup> be moved by hand?

A: Moving the RaZON<sup>+</sup> by hand, powered or un-powered is possible. The gear drive inside does allow this. When the RaZON<sup>+</sup> has to be moved, azimuth or zenith, it is preferred to switch power off.

Q: What Wi-Fi stick is used in the RaZON<sup>+</sup>?

A: Chipset: BCM43143

Protocols: 802.11b/g/n

Speed: 150Mbps maximum throughput

CE and FCC certified (ID:2ABCB-WLU6331)



## 10. Software overview

The software used in the RaZON<sup>+</sup> contains open source components that is listed on our website.

### 10.1 Solar position algorithm

The Solar Position Algorithm the RaZON<sup>+</sup> is using is developed by Ibrahim Reda and Afshin Andreas from NREL. Their report (NREL/TP-560-34302) describes a procedure for a Solar Position Algorithm (SPA) to calculate the solar zenith and azimuth angle with uncertainties equal to  $\pm 0.0003^\circ$  in the period from the year -2000 to 6000.

One of the inputs for this algorithm is time. The RaZON<sup>+</sup> has a built in GPS receiver that constantly synchronizes the internal clock with the satellite clock.

Both Solar Position Algorithm and the data logging have the GPS clock accuracy. The difference between the Universal Time (UT or GMT) and GPS time (o.a. leap seconds) is corrected for.

The data logger uses the Universal Time (UT or GMT).

### 10.2 Firmware

Kipp & Zonen is always looking for implementing improvements by changing the hardware or firmware.

It's advised to check our website on a regular base for the latest version of the firmware. It can be upgraded using the network connection available on the RaZON<sup>+</sup>.

We strongly advise to perform these updates even when your RaZON<sup>+</sup> seems to operate correct. It can prevent any unwanted situations in the future.

To download the latest firmware update, please check the RaZON<sup>+</sup> webpage under downloads

### 10.2.1 Firmware upgrade

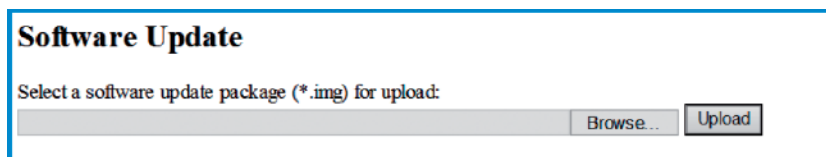
#### RaZON<sup>+</sup> firmware update procedure

##### Tools

- Windows computer
  - Browser, preferably Chrome, it displays upload progress. Other browsers may be used
  - Standard Ethernet cable
- RaZON<sup>+</sup> system

##### Perform the update

- Connect the RaZON<sup>+</sup> with a (straight) Ethernet cable to your LAN
- Make sure the RaZON<sup>+</sup> receives an IP address from your DHCP server
- Browse on your PC to <http://razonyynnnn:81>, where yynnnn is the serial number
- The software update page appears



**Software Update**

Select a software update package (\*.img) for upload:

- Press browse and select the new firmware image to be installed. i.e. S:\\RaZON2.07-20160728160000.img
- Press Upload
- Wait till ready
  - When ready a new page appears
- Press reboot
- It takes up to 5 minutes to install the update and resume normal operation
- On the web interface (<http://razonyynnnn>), verify that the new firmware image has been activated.

Dashboard → Operating System → OS Overview → Image

# Appendices

## Modbus® RTU slave application protocol

### Introduction

This document describes the Modbus® RTU slave application protocol of RaZON<sup>+</sup>. The purpose of the protocol is to make instrument measurements, status and identification available for logging using the Modbus® protocol.

The protocol does not allow configuring the instrument or interface. Configuration must be done using the instrument's user interface.

The detailed status flags and/or errors of the underlying hardware (motors, processor board, radiometers etc.) is reduced to simple 'ok', 'warning' and 'error' indicators.

### Supported commands

The Modbus® RTU slave application protocol supports the following Modbus® function codes:

- 01 (0x01) Read Coils
- 02 (0x02) Read Discrete Inputs
- 03 (0x03) Read Holding Registers
- 04 (0x04) Read Input Registers
- 08 (0x08) Diagnostics
- 17 (0x11) Report Server ID

### Formatting

#### Endianness

Modbus® itself uses big-endian representation for addresses and values. When in this protocol registers are composed of multiple registers, such as a 32-bit floating point number or a 32-bit date value, they are represented in big-endian format too. The most significant 16-bit word is sent first.

#### Floating point numbers

Modbus® does not specify a floating point data type. However, they are being used in this protocol. Floating point numbers are formatted according IEEE-754.

#### Strings

Modbus® does not specify a string data type. However, strings are being used in this protocol. Each 16-bit register holds 2 characters. The first character is sent first. Unused (trailing) characters must be set to the NULL character.

## Overview

### Input/holding registers

#### Identification block

Id	#	Register Name	RW	T	Description	Default
0	1	DEVICE_TYPE	R	U16	Device type of RaZON+	700
1	1	DATAMODEL_VERSION	R	U16	Version of the object data model	100
2	12	SERIAL_SYSTEM	R	C2	24-character type and serial number text	-
14	12	SERIAL_PYRANO	R	C2	24-character type and serial number text	-
26	12	SERIAL_DIRECT	R	C2	24-character type and serial number text	-

#### Measurement data and status block

Id	#	Register Name	RW	T	Description	Default
100	2	IV_DATE	R	U32	Date at end of averaging interval	19700101
102	2	IV_TIME	R	U32	Date at end of averaging interval	000000
104	2	IV_SOLAR_AZIMUTH	R	F32	Solar azimuth in degrees at end of averaging interval	90.0
106	2	IV_SOLAR_ZENITH	R	F32	Solar zenith in degrees at end of averaging interval	90.0
108	2	IV_LATITUDE	R	F32	Latitude in degrees north at end of averaging interval	0.0
110	2	IV_LONGITUDE	R	F32	Longitude in degrees east at end of averaging interval	0.0
112	2	IV_AIR_PRESSURE	R	F32	Derived air pressure at end of averaging interval	1013.25
114	2	IV_IRR_DIFFUSE	R	F32	Mean diffuse irradiance in W/m <sup>2</sup>	0.0
116	2	IV_IRR_DIRECT	R	F32	Mean direct irradiance in W/m <sup>2</sup>	0.0
118	2	IV_IRR_GLOBAL	R	F32	Mean global irradiance in W/m <sup>2</sup>	0.0
120	2	IV_TEMP_PYRANO	R	F32	Mean temperature of pyranometer in degrees Celsius	0.0
122	2	IV_TEMP_DIRECT	R	F32	Mean temperature of pyrhelimeter in degrees Celsius	0.0
124	2	IV_SUNSHINE_DURATION	R	F32	Sunshine duration in hours of this day	0.0
126	2	IV_GLOBAL_SUM	R	F32	Global sum in kWh/m <sup>2</sup> of this day	0.0
128	1	IV_LEN	R	U16	Averaging interval in seconds	60
129	1	IV_SUNSHINE_COUNT	R	U16	Number of seconds sunshine in this interval	0
130	1	IV_STATUS_TRACKING	R	U16	Most severe system status during averaging interval	0
131	1	IV_STATUS_PYRANO	R	U16	Most severe pyranometer status during averaging interval	0
132	1	IV_STATUS_DIRECT	R	U16	Most severe pyrhelimeter status during averaging interval	0

#### Discrete inputs/coils

Id	Input Name	RW	Description	Default
0	PYRANO_DIFFUSE	R	Pyranometer measures diffuse irradiance	1

#### Diagnostics

Only loopback data is supported.

#### Report Server ID

Reports the slave ID, i.e. Modbus® address. The run indicator is always 0xFF and there is no device specific additional data.

## Description

### Input/holding registers

#### Identification block

The identification block holds information about system, instrument and device identification. Updating the contents is a background task, which typically happens once per minute.

#### *DEVICE\_TYPE*

The device type identifies the type of RaZON+ system. The register address is identical across Kipp & Zonen Modbus® devices. The register values are unique w.r.t. other Kipp & Zonen Modbus® devices such as the smart interface. Currently smart interface device types are numbered from 600 to 699. RaZON+ device types will be numbered from 700 to 799.

Value	Description
700	Initial RaZON+ device

#### *DATAMODEL\_VERSION*

The datamodel defines the Modbus® register map and the device's application protocol behavior. The datamodel version identifies the version of this datamodel. The register address is identical across Kipp & Zonen Modbus® devices. The register values are unique w.r.t. other Kipp & Zonen Modbus® devices such as the smart interface. Smart interface datamodel versions are numbered from 100 to 199 (1.00 – 1.99). RaZON+ datamodel versions are numbered from 200 to 299 (2.00 – 2.99).

Value	Description
200	Datamodel version 2.00 as described in this document

#### *SERIAL\_SYSTEM*

SERIAL\_SYSTEM is a 24 character device type and serial number text identifying the RaZON+ base system. In case the system cannot translate the device type to a text string, it will be translated as 'T<device type value>'. Typical values would be 'RaZON+ 150001' or 'T700 150001'. See paragraph 0 for formatting strings.

#### *SERIAL\_PYRANO*

SERIAL\_PYRANO is a 24 character device type and serial number text identifying the radiometer measuring diffuse or global irradiance. In case the system cannot translate the device type to a text string, it will be translated as 'T<device type value>'. Typical values would be 'SMP10-V 140186' or 'T651 200865'. See paragraph 0 for formatting strings.

#### *SERIAL\_DIRECT*

SERIAL\_DIRECT is a 24 character device type and serial number text identifying the radiometer measuring direct irradiance. In case the system cannot translate the device type to a text string, it will be translated as 'T<device type value>'. Typical values would be 'SHP1-V 140189' or 'T661 200963'. See paragraph 0 for formatting strings.

### Measurement data and status block

The measurement data and status block holds information which is updated atomically at a predefined interval. Register IV\_LEN indicates the length of the interval.

#### IV\_DATE

IV\_DATE holds the date at the end of the averaging interval. The date is stored as a 32-bit unsigned integer according the format 'YYYYMMDD' using the formula:

$$IV\_DATE = YYYY * 10000 + MM * 100 + DD$$

Where:

- YYYY is the 4-digit year
- MM is the 2-digit month
- DD is the 2-digit day of month

#### IV\_TIME

IV\_TIME holds the time at the end of the averaging interval. The time is stored as a 32-bit unsigned integer according the format 'HHMMSS' using the formula:

$$IV\_TIME = HH * 10000 + MM * 100 + SS$$

Where:

- HH is the 2-digit 24 hour based hour
- MM is the 2-digit minute
- SS is the 2-digit second

#### IV\_SOLAR\_AZIMUTH

IV\_SOLAR\_AZIMUTH is the solar azimuth angle in degrees at the end of the averaging interval. The value is calculated using a solar positioning algorithm, location, altitude, date and time and does not include any adjustments.

#### IV\_SOLAR\_ZENITH

IV\_SOLAR\_ZENITH is the solar zenith angle in degrees at the end of the averaging interval. The value is calculated using a solar positioning algorithm, latitude, longitude, altitude, date and time and does not include any adjustments.

#### IV\_LATITUDE

IV\_LATITUDE is the latitude in degrees north at the end of the averaging interval. This is the value being used by the internal sun tracking process. It is a moving average over 30 seconds and only updated if the distance to the currently active horizontal location is more than 100 m. When there is no GPS fix, the last known value remains in effect.

#### IV\_LONGITUDE

IV\_LONGITUDE is the longitude in degrees east at the end of the averaging interval. This is the value being used by the internal suntracking process. It is a moving average over 30 seconds and only updated if the distance to the currently active horizontal location is more than 100 m. When there is no GPS fix, the last known value remains in effect.

#### **IV\_AIR\_PRESSURE**

IV\_AIR\_PRESSURE is the derived air pressure at the end of the averaging interval. This is the value being used by the internal sun tracking process and derived from the mean altitude. The mean altitude is a moving average over 30 seconds and only updated if deviating more than 50 m from the currently active altitude. When there is no GPS fix, the last known air pressure remains in effect. The following barometric formula is being used to convert from altitude to air pressure.

$$IV\_AIR\_PRESSURE = 1013 \cdot e^{(-altitude / 7400)}$$

- Pressure at sea level is 1013 mBar
- The scale height is 7400 m
- The altitude in m
- IV\_AIR\_PRESSURE in mbar

#### **IV\_IRR\_DIFFUSE**

IV\_IRR\_DIFFUSE is the mean diffuse irradiance in W/m<sup>2</sup>. Register IV\_LEN indicates the length of the averaging interval. The sample rate is 1/s. Input PYRANO\_DIFFUSE indicates whether samples in this register are being calculated or measured. When the samples are being calculated, the following formula is used.

$$I_{diffuse} = I_{global} - I_{direct} \cdot \cos(ze)$$

Where:

- $I_{global}$  is the calculated global irradiance in W/m<sup>2</sup>
- $I_{diffuse}$  is the measured diffuse irradiance in W/m<sup>2</sup>
- $I_{direct}$  is the measured direct irradiance in W/m<sup>2</sup>
- $ze$  is the zenith angle in radians or degrees

#### **IV\_IRR\_DIRECT**

IV\_IRR\_DIRECT is the mean direct irradiance in W/m<sup>2</sup>. Register IV\_LEN indicates the length of the averaging interval. The sample rate is 1/s.

#### **IV\_IRR\_GLOBAL**

IV\_IRR\_GLOBAL is the mean global irradiance in W/m<sup>2</sup>. Register IV\_LEN indicates the length of the averaging interval. The sample rate is 1/s. Input PYRANO\_DIFFUSE indicates whether samples in this register are being calculated or measured. When the samples are being calculated, the following formula is used.

$$I_{global} = I_{diffuse} + I_{direct} \cdot \cos(ze)$$

Where:

- $I_{global}$  is the calculated global irradiance in W/m<sup>2</sup>
- $I_{diffuse}$  is the measured diffuse irradiance in W/m<sup>2</sup>
- $I_{direct}$  is the measured direct irradiance in W/m<sup>2</sup>
- $ze$  is the zenith angle in radians or degrees

#### **IV\_TEMP\_PYRANO**

IV\_TEMP\_PYRANO is the mean temperature in degrees Celsius of the radiometer measuring diffuse or global irradiance. Register IV\_LEN indicates the length of the averaging interval. The sample rate is 1/s.

#### **IV\_TEMP\_DIRECT**

IV\_TEMP\_DIRECT is the mean temperature in degrees Celsius of the radiometer measuring direct irradiance. Register IV\_LEN indicates the length of the averaging interval. The sample rate is 1/s.

#### ***IV\_SUNSHINE\_DURATION***

IV\_SUNSHINE\_DURATION is the sunshine duration in hours since solar midnight or system startup. Direct irradiance samples of more than 120 W/m<sup>2</sup> contribute to sunshine duration. The sample rate is 1/s.

#### ***IV\_GLOBAL\_SUM***

IV\_GLOBAL\_SUM is the global irradiance based energy in kWh/m<sup>2</sup> since solar midnight or system startup. Calculated or measured global irradiance samples are being used to calculate the global sum. The sample rate is 1/s.

#### ***IV\_LEN***

IV\_LEN is the length in seconds of the averaging interval.

#### ***IV\_SUNSHINE\_COUNT***

IV\_SUNSHINE\_COUNT is the sunshine duration in seconds of the averaging interval. Direct irradiance samples of more than 120 W/m<sup>2</sup> contribute to sunshine duration. The sample rate is 1/s.

#### ***IV\_STATUS\_TRACKING***

IV\_STATUS\_TRACKING is the most severe system status that occurred during the averaging interval. Register IV\_LEN indicates the length of the averaging interval. A warning indicates a potential problem, but measurements are still correct. During an error measurements must be considered void.

Value Description

- |   |                |
|---|----------------|
| 0 | System ok      |
| 1 | System warning |
| 2 | System error   |

Detailed status information is only available on the user interface.

#### ***IV\_STATUS\_PYRANO***

IV\_STATUS\_PYRANO is the most severe pyranometer status that occurred during the averaging interval. Register IV\_LEN indicates the length of the averaging interval. A warning indicates a potential problem, but measurements are still correct. During an error measurements must be considered void.

Value Description

- |   |                     |
|---|---------------------|
| 0 | Pyranometer ok      |
| 1 | Pyranometer warning |
| 2 | Pyranometer error   |

Detailed status information is only available on the user interface.

#### ***IV\_STATUS\_DIRECT***

IV\_STATUS\_DIRECT is the most severe pyrheliometer status that occurred during the averaging interval. Register IV\_LEN indicates the length of the averaging interval. A warning indicates a potential problem, but measurements are still correct. During an error measurements must be considered void.

Value Description

- |   |                       |
|---|-----------------------|
| 0 | Pyrheliometer ok      |
| 1 | Pyrheliometer warning |
| 2 | Pyrheliometer error   |

Detailed status information is only available on the user interface.



## Discrete inputs/coils

### *PYRANO\_DIFFUSE*

PYRANO\_DIFFUSE indicates whether the diffuse irradiance is being calculated or measured.

Value	Description
-------	-------------

0	Diffuse irradiance calculated, global irradiance measured using the pyranometer
---	---

1	Global irradiance calculated, diffuse irradiance measured using the pyranometer
---	---

## **MODBUS TCP Slave Application Protocol**

### **Introduction**

This section describes the MODBUS TCP slave application protocol of the RaZON<sup>+</sup>. The protocol is a subset of the MODBUS RTU slave application protocol. The differences are highlighted.

### **Supported commands**

The MODBUS TCP slave application protocol supports the following MODBUS function codes:

- (0x01) Read Coils
- (0x02) Read Discrete Inputs
- (0x03) Read Holding Registers
- (0x04) Read Input Registers

### **Communication parameters**

The default communication parameters are:

- TCP port 502
- Number of connections 10
- Slave ID 1

When the server has 10 socket connections and receives a new connection request it will accept the new connection and drop the oldest connection. The oldest connection is determined on base of the 'alive' time. The 'alive' time is initially set to the connection accept time and is updated upon each request. The HOST application must be able to handle disconnection or shutdown of the connection by the server.

The used Input/holding registers and Discrete inputs/coils are identical with the serial MODBUS RTU slave application protocol.

## ASCII Serial Communication Protocol Description

### Introduction

This appendix describes the serial communication protocol between the RaZON<sup>+</sup> and the HOST.

- The RaZON<sup>+</sup> is referred to as the instrument.
- Data provided by the instrument is collected and processed by the HOST.
- The HOST can be either: a personal computer, an intelligent controller directly connected to the instrument, or a remote server connected to a network.

The serial communication is based on client-server architecture. The instrument is the server, providing the information. The HOST is the client, sending commands to or receiving data from the instrument.

**Note** The instrument will regularly send status messages to the host, so the host is kept up to date regarding the current status of the instrument. The interval of the status messages is 1 second.

The communication protocol has two main roles:

1. Sending recovery commands to the instrument.
2. Transmission of the instrument's data (status info) to the HOST.

### Firmware release

This document is valid for the RaZON<sup>+</sup> firmware release 2.06 and up. In case a higher firmware release supports a changed version of the serial protocol, a new version of this document will describe the new protocol and state the differences.

### Instrument hardware configuration

The instrument is equipped with an isolated configurable 2- or 4-wire RS-485 serial interface.

### The protocol layer

#### Communication parameters

##### Default communication parameters

The default communication parameters are:

Baud rate : 19200 bps  
Parity : none  
Data bits : 8  
Stop bits : 1  
Flow control : none

### Miscellaneous

Command, request and response lines are terminated by a linefeed <LF>. Carriage returns <CR> are discarded in commands and requests.

### Client server protocol

The instrument provides the information and will send a response on every command from the HOST. Every request from the HOST is acknowledged by 0, 1 or more responses and a prompt. See examples 1 to 3. The instruments transmit a status message periodically. A status message should not be acknowledged by the HOST (see example 4).

Direction	Client (host)		Server (instrument)	
Example 1	Action host	Request	Response	Action instrument
→	Transmit request	Request		Process request
←			Prompt	Acknowledge
Example 2				
→	Transmit request	Request		Process request
←			Response	Send response
←			Prompt	Acknowledge
Example 3				
→	Transmit request	Request		Process request
←			Response1	Send response 1 to 3
←			Response2	
←			Response3	
←			Prompt	Acknowledge
Example 4				
←			Status	Send status

### The application protocol

- Presentation: All data transfers will use 7 bit or 8 bit printable ASCII code.
- Application: The application protocol is a set of commands and responses.

### Command structure

Commands, also referred as requests, are sent from the HOST to the instrument. After each request a response is sent by the instrument. Commands are processed after receiving the linefeed. Carriage returns are discarded. Commands are case sensitive. Commands must start with a dot .

Optional parameters are separated by spaces or semicolons.

The instrument will send the **.OK;** prompt, after every command or response.

### Show hostname

The command: **.show hostname;** will show the network hostname of the instrument. The hostname is a text string consisting of the instrument type and a 6-character serial number: <type><serial>

### Arguments (none)

#### Example

Request:

.show hostname;

Response:

.hostname=RaZON140123; .ok;

### **Description of the messages**

This chapter describes the definition of the status messages. Each different record type has a unique record ID to specify the selected type.

### **Message types**

The following message types are defined:

#### ***Message type***

- |    |                               |
|----|-------------------------------|
| 0  | Simple status message         |
| 1+ | Reserved for future expansion |

### **Status messages**

Status messages are sent automatically every minute when an averaging interval ends or more often when instrument or system status changes.

## Simple status message

### Description

Message Type 0		Simple status message
Pos	Field name	Description
0	Message type	0
1	Device type	700
2	Hostname	Instrument hostname
3	Serial number pyranometer	Pyranometer identification
4	Serial number pyrliometer	Pyrheliometer identification
5	Date	Date at end of averaging interval, YYYY-MM-DD
6	Time	Time at end of averaging interval, HH:MM:SS
7	Solar angle azimuth	Calculated solar angles in degrees at end of averaging interval
8	Solar angle zenith	North 0 degrees, east 90 degrees Sky 0 degrees, horizon 90 degrees
9	Latitude	Latitude in degrees north at end of averaging interval
10	Longitude	Longitude in degrees east at end of averaging interval
11	Air pressure	Derived air pressure at end of averaging interval
12	Irradiance diffuse	Mean diffuse irradiance in W/m <sup>2</sup>
13	Irradiance direct	Mean direct irradiance in W/m <sup>2</sup>
14	Irradiance global	Mean global irradiance in W/m <sup>2</sup>
15	Temperature pyranometer	Mean temperature of pyranometer in degrees Celsius
16	Temperature pyrliometer	Mean temperature of pyrliometer in degrees Celsius
17	Sunshine duration	Sunshine duration in hours of this day
18	Global sum	Global sum in kWh/m <sup>2</sup> of this day
19	Averaging interval	Averaging interval in seconds
20	Sunshine count	Number of seconds sunshine in this interval
21	Status code system	Overall system status code. See paragraph 0.
22	Status code pyranometer	Pyranometer status code. See paragraph 0.
23	Status code pyrliometer	Pyrheliometer status code. See paragraph 0.
24	Pyranometer function	Pyranometer function: Global (0) or diffuse (1) irradiance.
25	Checksum	CRC-16 reverse bit order with seed of 0 and XOR polynomial of 0xA001. The checksum is calculated over all characters till (not including) the first character of the checksum. The value is in hexadecimal notation (0x<hex>).

### Example

#### Response

```
.status=0;700;RaZON140123;PR-1 10001;PH-1 160004;2016-07-06;08:22:00;106.82;48.81; 51.997000;4.386300;1010.81;5.10;  
3.10;7.10;23.5;24.1;0.000;0.009;60;0;0;0;1;0x4AEB;<LF>
```

### Status code

A status code has the following states:

State	Value	Description
OK	0	Operates according specification
WARNING	1	Indicates a potential problem, measurements are still correct
ERROR	2	Problem during which measurements must be considered void

## **ASCII TCP communication protocol description**

### **Introduction**

The ASCII TCP protocol is a subset of the serial communication protocol. This document highlights the differences.

### **Communication parameters**

TCP port : 15001

Number of connections : 10

When the server has 10 socket connections and receives a new connection request it will accept the new connection and drop the oldest connection. The oldest connection is determined on base of the 'alive' time. The 'alive' time is initially set to the connection accept time and is updated when any character is received from the HOST.

In order to keep the connection alive at the application level, the HOST may send a character to the server regularly. However, this is not mandatory.

The HOST application must be able to handle disconnection or shutdown of the connection by the server.

### **Description of the commands**

The ASCII TCP interface does not support commands or requests.

### **Description of the messages**

No difference with the serial protocol.

## Logging file examples

Example of a logged ASCII data file over RS-485 and terminal program:

```
.status=0;700;RaZON150002;SMP10 130004;SHP1110001;2016-08-01;13:00:00;208.99;36.94;51.997000;4.386300;1013.25;-0.40;-0.20;-0.50;27.8;25.9;0.000;0.002;60;0;0;0;0;1;0xD0B3;  
.status=0;700;RaZON150002;SMP10 130004;SHP1110001;2016-08-01;13:01:00;209.36;37.01;51.997000;4.386300;1013.25;-0.00;-0.10;-0.10;27.8;26.0;0.000;0.002;60;0;0;0;0;1;0x6D06;  
.status=0;700;RaZON150002;SMP10 130004;SHP1110001;2016-08-01;13:02:00;209.74;37.09;51.997000;4.386300;1013.25;-0.50;-0.20;-0.60;27.9;26.0;0.000;0.002;60;0;0;0;0;1;0x3FAC;  
.status=0;700;RaZON150002;SMP10 130004;SHP1110001;2016-08-01;13:03:00;210.11;37.16;51.997000;4.386300;1013.25;-0.50;-0.10;-0.60;27.9;26.0;0.000;0.002;60;0;0;0;0;1;0xB55C;
```

Example of a log information as downloaded over the web interface.

### Export Log File

Start date: 2016-07-11

End date: |

Filename: RaZON-logfile

Calendar view for July 2016:

Sun	Mon	Tue	Wed	Thu	Fri	Sat
26	27	28	29	30	1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31	1	2	3	4	5	6

sep=,

SystemName: RaZON150002

SerialNumber: 150002

Date (dd-mm-yyyy), Time (hh:mm:ss), SolarAzimuth (Degrees), SolarZenith (Degrees), Latitude (Degrees), Longitude (Degrees), AirPressure (mBar), IrrDiffuse (W/m2), TempDiffuse (Degrees celcius), IrrDirect (W/m2), TempDirect (Degrees celcius), IrrGlobal (W/m2), Sunshine (number of seconds in this interval), SunshineDuration (hours of today), GlobalSum (KWh/m2)

```
2016-07-18,00:00:00,2.7631,106.9831,51.9969,4.3856,1014.58,-6.4,19.7,-0.6,17.1,-6.4,0.0,3.2569,4.0334  
2016-07-18,00:01:00,3.0070,106.9755,51.9969,4.3856,1014.58,-6.4,19.7,-0.6,17.1,-6.4,0.0,0.0000,-0.0001  
2016-07-18,00:02:00,3.2509,106.9672,51.9969,4.3856,1014.58,-6.5,19.7,-0.6,17.0,-6.5,0.0,0.0000,-0.0002  
2016-07-18,00:03:00,3.4948,106.9583,51.9969,4.3856,1014.58,-6.5,19.7,-0.6,17.0,-6.5,0.0,0.0000,-0.0003  
2016-07-18,00:04:00,3.7386,106.9487,51.9969,4.3856,1014.58,-6.6,19.7,-0.6,17.0,-6.6,0.0,0.0000,-0.0004  
2016-07-18,00:05:00,3.9824,106.9385,51.9969,4.3856,1014.58,-6.6,19.7,-0.6,17.0,-6.6,0.0,0.0000,-0.0005
```







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