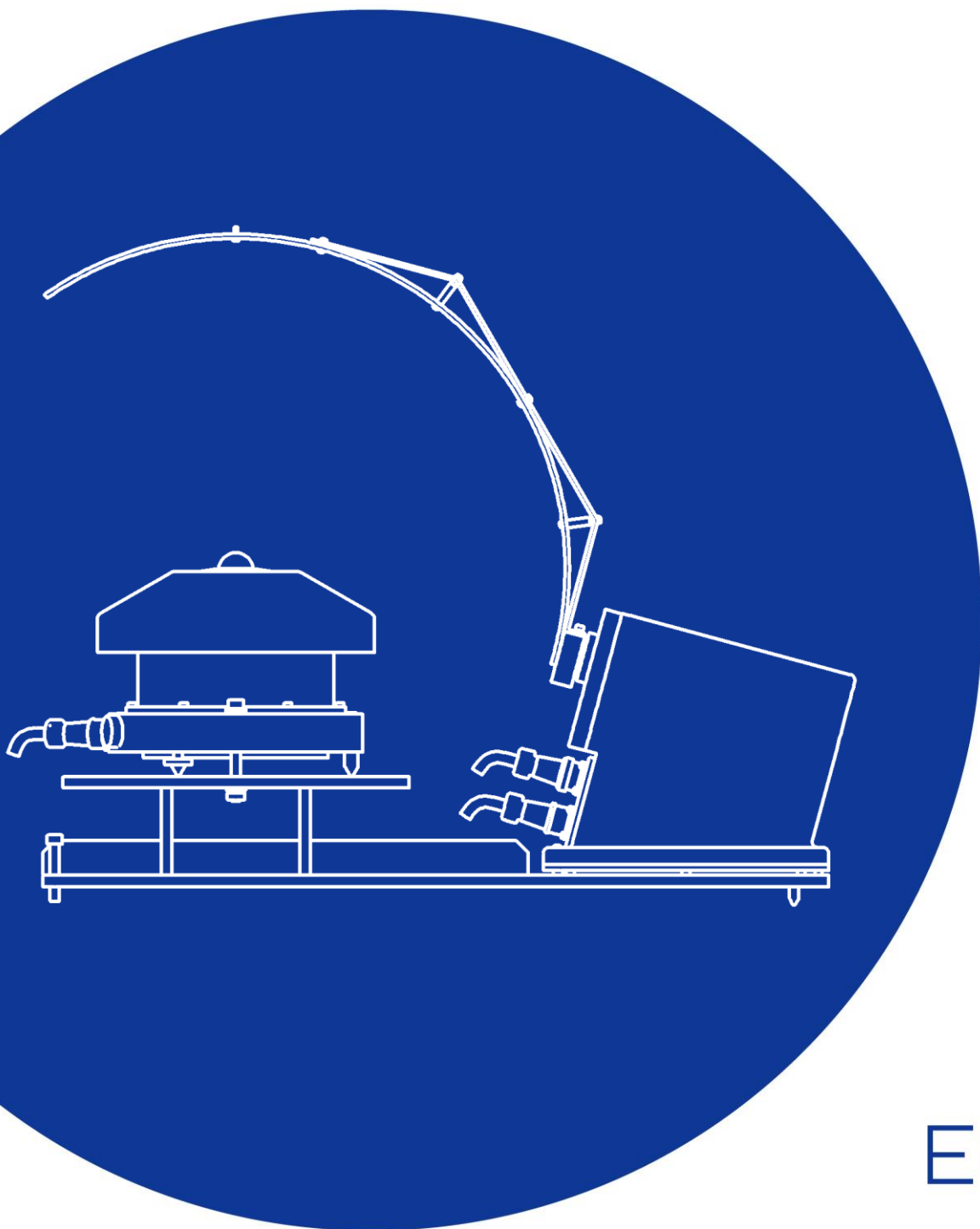


INSTRUCTION MANUAL

Rotating Shadow Band
For Spectroradiometers

RSB-01



EKO

1. Index

| | |
|---|-----------|
| 1. Index | 1 |
| 2. Important User Information | 2 |
| 2-1. Contact Information | 2 |
| 2-2. Warranty and Liability | 2 |
| 2-3. About Instruction Manual | 3 |
| 2-4. Environment | 3 |
| 2-5. CE Declaration | 4 |
| 3. Safety Information | 5 |
| 3-1. WARNING/CAUTION | 5 |
| 4. Introduction | 6 |
| 4-1. Main Functions | 6 |
| 4-2. Package Contents | 6 |
| 5. Getting Started | 7 |
| 5-1. Parts Name | 7 |
| 5-2. System Overview | 8 |
| 5-3. Setting | 8 |
| 5-4. Operations | 12 |
| 6. Measurement Principle | 13 |
| 6-1. Measurement Principle | 13 |
| 7. Maintenance & Troubleshooting | 14 |
| 7-1. Maintenance | 14 |
| 7-2. Troubleshooting | 15 |
| 8. Specification | 16 |
| 8-1. Main Unit | 16 |
| 8-2. Shadow Band | 16 |
| 8-3. Cables | 17 |
| 8-4. Dimensions | 18 |
| 8-5. Accessories List | 20 |
| APPENDIX | 21 |
| A-1. Communication Cable | 21 |
| A-2. Power Supply Cable | 21 |

2. Important User Information

Thank you for using EKO Products

Make sure to read this instruction manual thoroughly and to understand the contents before starting to operate the instrument. Keep this manual at safe and handy place for whenever it is needed.

For any questions, please contact us at one of the EKO offices given below:

2-1. Contact Information

EKO INSTRUMENTS CO., LTD.

Asia, Oceania Region

| | | |
|------------------|--|------------------------|
| www.eko-asia.com | EKO INSTRUMENTS Co., Ltd. | Tel: +81 (3) 3469-6713 |
| info@eko.co.jp | 1-21-8 Hatagaya, Shibuya-ku Tokyo, 151-0072 Japan | Fax: +81 (3) 3469-6719 |

Europe, Middle East, Africa, South America Region

| | | |
|-----------------|---|------------------------|
| www.eko-eu.com | EKO INSTRUMENTS Europe B.V. | Tel: +31 (0)70 3050117 |
| info@eko-eu.com | Lulofsstraat 55, Unit 32, 2521 AL, Den Haag, The Netherlands | Fax: +31 (0)70 3840607 |

North America Region

| | | |
|------------------|---|----------------------|
| www.eko-usa.com | EKO INSTRUMENTS USA Inc. | Tel: +1 408-977-7751 |
| info@eko-usa.com | 95 South Market Street, Suite 300 San Jose, CA 95113 USA | Fax: +1 408-977-7741 |

2-2. Warranty and Liability

For warranty terms and conditions, contact EKO or your distributor for further details.

EKO guarantees that the product delivered to customer has been verified, checked and tested to ensure that the product meets the appropriate specifications. The product warranty is valid only if the product has been installed and used according to the directives provided in this instruction manual.

In case of any manufacturing defect, the product will be repaired or replaced under warranty. However, the warranty does not apply if:

- Any modification or repair was done by any person or organization other than EKO service personnel.
- The damage or defect is caused by not respecting the instructions of use as given on the product brochure or the instruction manual.

2-3. About Instruction Manual

Copy Rights Reserved by EKO INSTRUMENTS CO., LTD. Making copies of whole or parts of this document without permission from EKO is prohibited.

This manual was issued: 2018/9/25
Version Number: 1

2-4. Environment

1. WEEE Directive 2002/96/EC (Waste Electrical and Electronic Equipment)

This product is not subjected to WEEE Directive 2002/96/EC however it should not be mixed with general household waste. For proper treatment, recovery and recycling, please take this product(s) to designated collection points.

Disposing of this product correctly will help save valuable resources and prevent any potential negative effects on human health and the environment, which could otherwise arise from inappropriate waste handling.

2. RoHS Directive 2002/95/EC

EKO Instruments has completed a comprehensive evaluation of its product range to ensure compliance with RoHS Directive 2002/95/EC regarding maximum concentration values for substances. As a result all products are manufactured using raw materials that do not contain any of the restricted substances referred to in the RoHS Directive 2002/95/EC at concentration levels in excess of those permitted under the RoHS Directive 2002/95/EC, or up to levels allowed in excess of these concentrations by the Annex to the RoHS Directive 2002/95/EC.

2-5. CE Declaration



IMPORTANT USER INFORMATION



DECLARATION OF CONFORMITY

We: EKO INSTRUMENTS CO., LTD
1-21-8 Hatagaya Shibuya-ku,
Tokyo 151-0072 JAPAN

Declare under our sole responsibility that the product:

Product Name: Rotating Shadow Band
Model No.: RSB-01

To which this declaration relates is in conformity with the following harmonized standards of other normative documents:

Harmonized standards:

EN 61326-1:2013 Class A (Emission)
EN 61326-1:2013 (Immunity)
ETSI EN 303 413 V1.1.1

Following the provisions of the directive:

EMC-directive: 89/336/EEC
Amendment to the above directive: 93/68/EEC

Date: Apr. 12, 2019

Position of Authorized Signatory: Technology Research Institute Director

Name of Authorized Signatory: Shuji Yoshida

Signature of Authorized Signatory: 

3. Safety Information

EKO Products are designed and manufactured with consideration for safety; however, please make sure to read and understand this instruction manual thoroughly to be able to operate the instrument safely in the correct manner.



WARNING CAUTION

Attention to user; pay attention to the instructions given on the instruction manual with this sign.



3-1. WARNING/CAUTION

1. Installation

- Installation base should have enough load capacity for instrument to be mounted, and securely fix the RSB-01 to the installation base with bolts and nuts; otherwise, the instruments may drop due to gale or earthquake and lead to unexpected accidents.
- Make sure the instruments are installed in a location where they are easily accessible for maintenance, or it may lead to unexpected accidents and injury.
- Using the standard Spectroradiometer connection cable, which is attached to RSB-01, with MS-712 will damage the MS-712. **When MS-712 is used, make sure to use the optional voltage conversion cable for MS-712.** Also using the optional voltage conversion cable for MS-712 to other spectroradiometer will damage the instruments and the cable.

2. Power Supply

- Always make sure to check the power supply voltage and type (AC/DC) before connecting and powering ON the instruments.

3. Approaching the RSB-01

- Approaching closer to and/or touching the RSB-01 during its operation may lead to your body and/or clothes get caught in the Shadow Band.

4. Instruction Manual

- In this instruction manual contains basic and important operation information for the use of RSB-01.
- Read this instruction manual and understand the contents well before operating RSB-01.
- Also, keep this instruction manual in handy location in case you need it.

5. Handling

- When transporting RSB-01, always remove the cables and Spectroradiometer from the Main Unit, and hold the base part securely with both hands.
- Pay close attention when handling the Shadow Band.

4. Introduction

Rotating Shadow Band RSB-01 is a device which can provide separate data for direct and diffuse spectral irradiance by using in combination with spectroradiometer.

4-1. Main Functions

RSB-01 is a rotating shadow band which is specially designed for spectroradiometers. By using this device, following measurements can be taken:

1. Global component of the solar spectrum can be measured by moving the shadow band to the band resting position which does not block the hemispherical field of view of the spectroradiometer.
2. Diffuse component of the solar spectrum can be measured by moving the shadow band to the sun position and blocking the direct component.
3. Diffused light which is excessively blocked by the shadow band can be compensated by combining the above 1 and 2 measurements, by measuring the global component with shadow band moved to arbitrary angle θ towards east and west from the sun position.

*In this text, above mentioned "arbitrary angle θ " is called as "edge angle".

4-2. Package Contents

Check the package contents first; if any missing item or damage is noticed, please contact EKO immediately.

Table 4-1 Package Contents

| Standard Items | Qty. | Remarks |
|------------------------------------|-------|---------------------------------------|
| RSB-01 Main Unit | 1 | |
| Shadow Band | 1 | |
| Spectroradiometer Connection Cable | 1 | 1m |
| Communication Cable | 1 | Standard Length: 10m |
| Power Supply Cable | 1 | Standard Length: 10m |
| Fixing Bolts & Nuts | 1 Set | M6 x 50 Bolt, Washer, Nut (3pcs each) |
| Inspection Report | 1 | |
| Instruction Manual | 1 | |

5. Getting Started

5-1. Parts Name

Each part name and its main functions are described below.

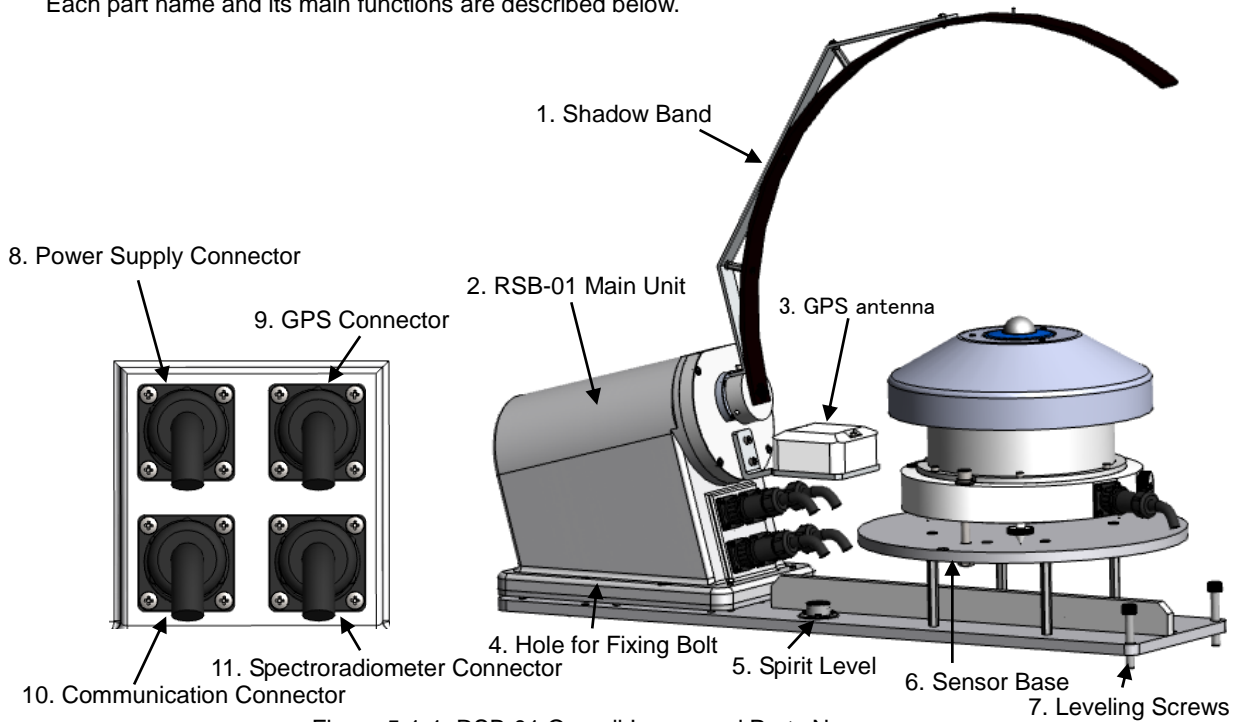


Figure 5-1-1. RSB-01 Overall Image and Parts Name

Table 5-1-1. Parts Name and Function

| Name | Functions |
|---------------------------------|--|
| 1. Shadow Band | Band to block the sun light. It is controlled by the main unit and blocks the light received by the spectroradiometer detector. |
| 2. RSB-01 Main Unit | Moves the shadow band based on the input information. |
| 3. GPS antenna | GPS antenna get location and time information. |
| 4. Hole for Fixing Bolt | Hole to secure the RSB-01 main unit. Make sure to fix the main unit at all time for safety. |
| 5. Spirit Level | Use the two leveling screws to position the bubble in this spirit level and adjust the leveling of this instrument. |
| 6. Sensor Base | Stage to place a spectroradiometer. For safety, make sure to fix the spectroradiometer at all time. |
| 7. Leveling Screws | Using the three-point-support method; use the 2 screws to adjust the level which leveling condition is shown on the spirit level. |
| 8. Power Supply Connector | Power supply for RSB-01 main unit and spectroradiometer. |
| 9. GPS Connector | Connector for GPS antenna. |
| 10. Communication Connector | Connector for RS-422 communication. |
| 11. Spectroradiometer Connector | Connector for connecting RSB-01 main unit and spectroradiometer. To use with MS-712, it requires a voltage conversion cable for MS-712, or the MS-712 will be damaged. |

5-2. System Overview

Below figure describes the system overview of RSB-01.

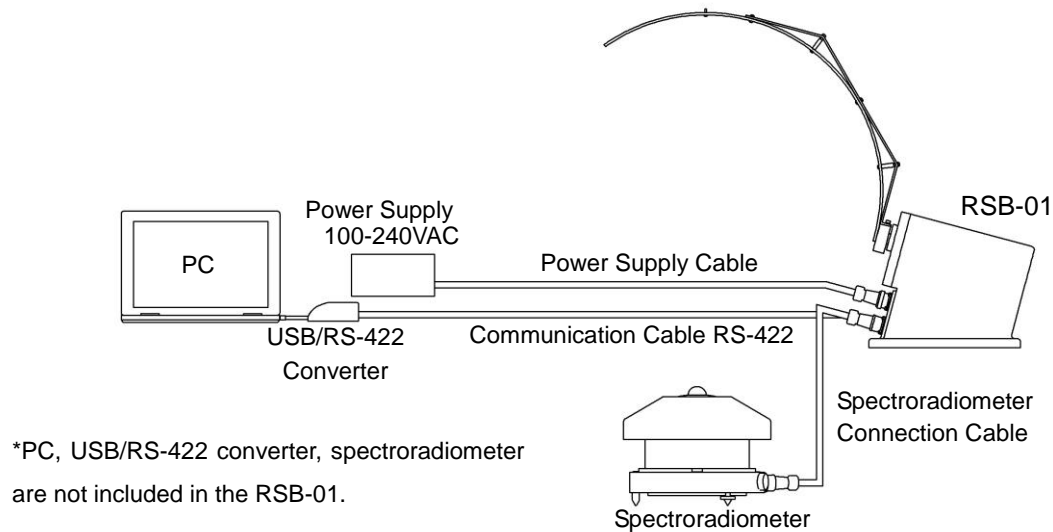


Figure 5-2-1. System Overview

5-3. Setting

1. Fixing the Main Unit

RSB-01 Main Unit is installed in true south side and shadow band is installed in the true north side (See Figure 5-3-1). Use the South/North arrow indicated on the top part of the RSB-01 Main Unit (indicated as "→ N")

1) Adjust to the Orientation of Installation

The orientation for installation needs to be adjusted at the "Culmination Time" when the sun comes to the true south position. Thus check the culmination time of the installation date before installation is started.

Following figure describes how to adjust the installation orientation.

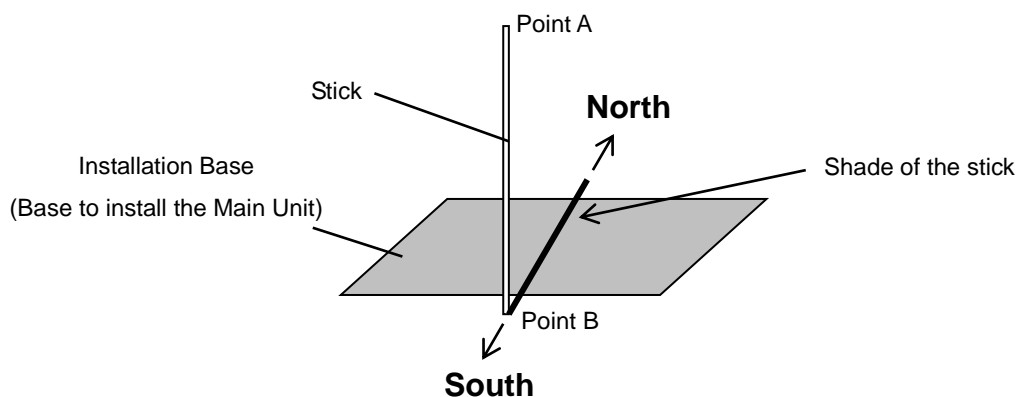


Figure 5-3-1. How to check the True North
(shade is shown in true north side at culmination time)

A) Prepare a firm and straight stick such as a ruler or a string with weight on one end. (In this text, a

stick is used as example.)

- B) Lift up the Point A of the stick and leave the Point B free so that the stick is just hanging in perpendicular position.
 - C) While keeping the above condition, move the stick to the position where the shade becomes long enough on the installation base.
 - D) When the culmination time comes, quickly mark a line of the shade made by the stick on the installation base.
 - E) Install the Main Unit so that the marked line and the “reference line for positioning (Figure 5-3-1)” on the Main Unit are in parallel position.
 - ✓ During midsummer, more than 1° error is made even by 1 minute difference. Quickly mark the line when the culmination time arrives.
 - ✓ It is difficult to adjust the accurate orientation using compass or map. Please reference the above described method to adjust the orientation. If the Main Unit is installed in inaccurate position, the shade of shadow band cannot block the light receiving part of spectroradiometer sensor correctly.
- 2) Adjust the Spirit Level
Adjust the spirit level on the Main Unit using the leveling screws.
- 3) Secure to the Installation Base
Secure the Main Unit to the installation base using the attached fixing bolts M6 x50.

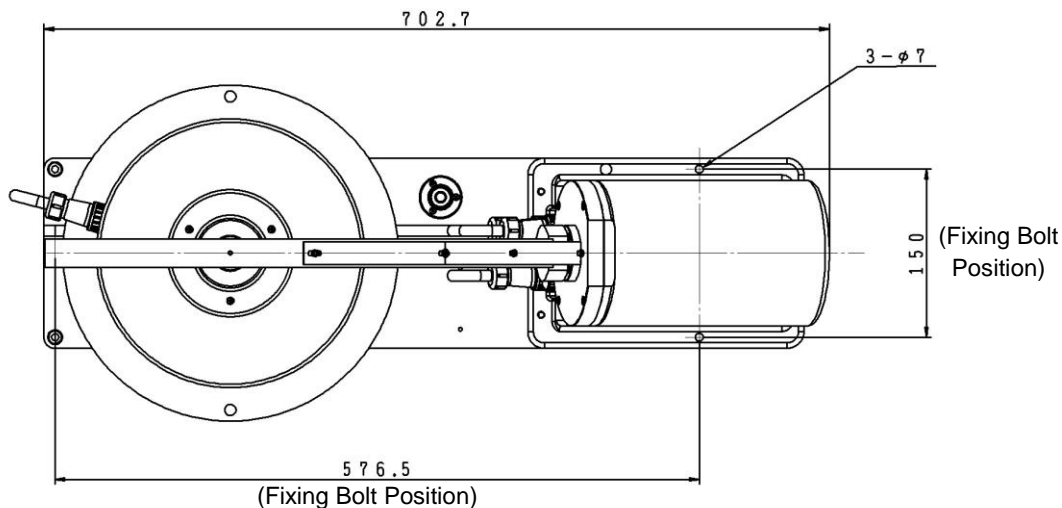


Figure 5-3-2. Location of the Holes for Fixing Bolt

2. Fixing the Shadow Band

- 1) Turn on the power and wait for a few seconds for the rotating shaft returns to the origin point.
- 2) Secure the upper side of the Shadow Band attaching part with a screw CAP M4 x 12.
- 3) Secure the shaft side of the Shadow Band attaching part with four screws CAP M3 x 10
- 4) If the band is tilted, follow below procedure to fine-tune.
 - A) Prepare a string with weight on one end.
 - B) Attach the other end of the string to the screw attached at the top of Shadow Band.
 - C) Loosen the 4 screws on the Shadow Band attaching part at the shaft side so that the Shadow Band can be fine-tuned.
 - D) Find a position where there are no difference in angle between the Shadow Band and the string with weight, then secure the Shadow Band again.
 - E) Finally, remove the string with weight.

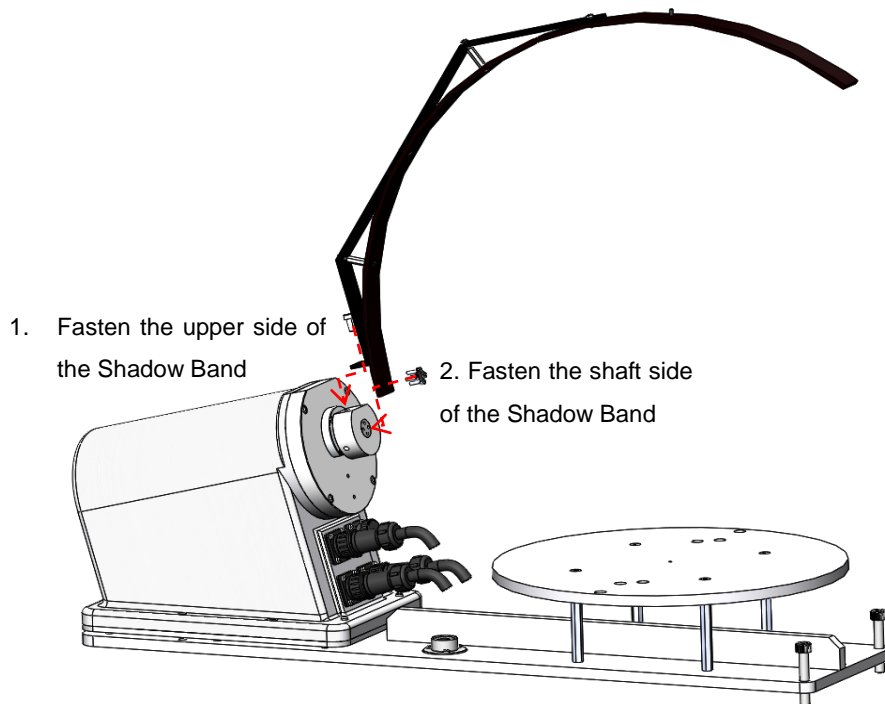


Figure 5-3-3. Fixing the Shadow Band

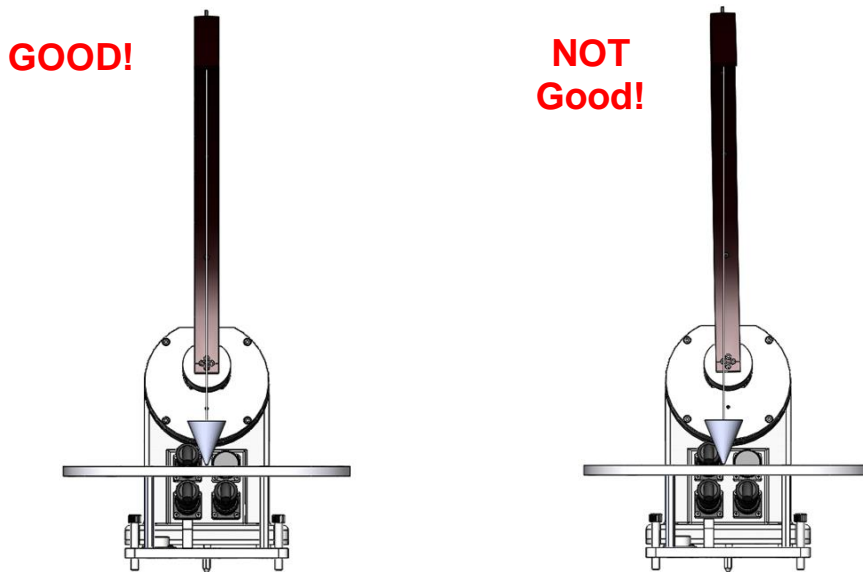


Figure 5-3-4. Fine-Tuning the Tilt on Shadow Band

3. Fixing the Spectroradiometer

- 1) Place the Spectroradiometer on the Sensor Base on the Main Unit.

At this point, make sure the connector of the Spectroradiometer faces towards north. If the connector is facing towards south, it may get in the movement of Shadow Band.

Also, temporarily secure the Spectroradiometer with fixing bolts to avoid dropping the Spectroradiometer.

- 2) Adjust the spirit level on the spectroradiometer.
- 3) Use the set of fixing bolts and nuts for the Spectroradiometer and secure the Spectroradiometer to the sensor base.

Table 5-3. Fixing Bolt Holes Pitch and Sensor Base Height

| | MS-711 | MS-712 |
|------------------------|------------|------------|
| Fixing Bolt Hole Pitch | 200mm | 280mm |
| Support Pillar Size | 75.5-M5/M5 | 68.5-M5/M5 |

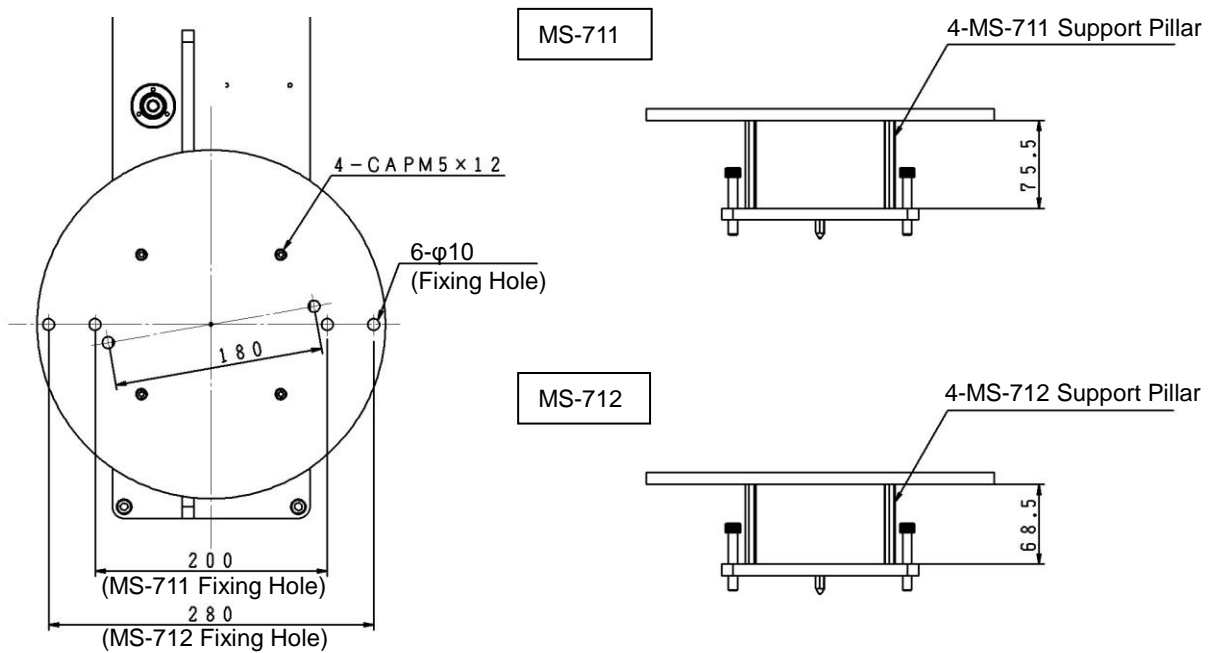


Figure 5-3-3. Fixing Holes for Spectroradiometer

4. Wiring

- 1) Connect the Main Unit and Spectroradiometer.
- 2) Connect the Main Unit and PC via RS-422 Port.

At this point, connect the Main Unit TX wire to PC TX terminal and Main Unit RX wire to PC RX terminal.

- 3) Connect the Main Unit power supply cable.

5-4. Operations

1. Operation Overview

Below figure shows the movement of the Shadow Band during measurements.

When using the zenith angle with RSB-01, the zenith is considered as zero (0°), east side as minus, and west side as plus. Also, the initial position of the Shadow Band is at zenith angle minus 135° , and the origin point of the Shadow Band is at zenith angle 0° .

The Shadow Band during measurements moves in the following manner in coordination with the Spectroradiometer: The edge angle θ can be setup by the user with the measurement software (SHDac.exe).

- 1) Shadow Band is stopped at initial position \Rightarrow Measure
- 2) Shadow Band moves from the sun position and stops at the sun position minus the edge angle θ towards east \Rightarrow Measure
- 3) Shadow Band stops at the sun position \Rightarrow Measure
- 4) Shadow Band moves from the sun position and stops at the sun position plus the edge angle θ towards west \Rightarrow Measure
- 5) Shadow Band returns to the initial resting position

*Below images are viewing the Shadow Band from the north direction.

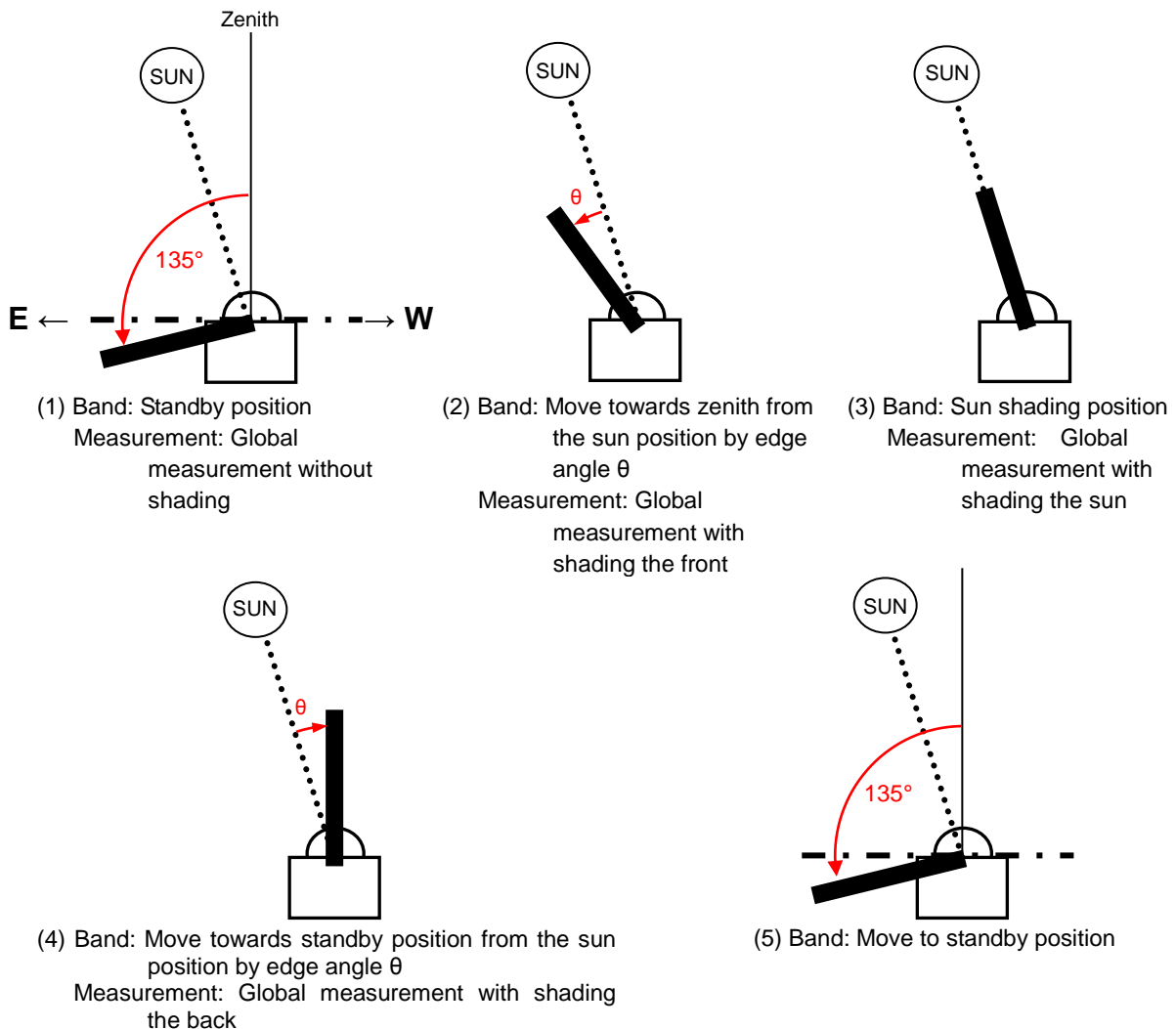


Figure 5-4-1. Operation Overview

6. Measurement Principle

6-1. Measurement Principle

The Rotating Shadow Band makes possible to measure the spectral global solar irradiance (GHI), spectral diffused solar irradiance (DHI), and spectral direct solar irradiance (DNI) by blocking the direct solar irradiance and diffuse solar irradiance, which incident into sensor, using the shadow band.

1. Spectral Global Solar Irradiance (GHI)

Move the Shadow Band to the position which does not interfere the solar radiation and perform the spectroradiometer measurement.

2. Spectral Diffused Solar Irradiance (DHI)

Diffuse solar irradiance is measured when the direct solar radiation is blocked by moving the Shadow Band to the position where the sun disc is in the sky (see Figure 5-4-1, (3)). Part of the diffuse solar radiation component which is blocked by the Shadow Band can be estimated by adding to the measured DHI in (3) the average between the (2) and (4) minus the GHI measurement from (1) in Figure 5-4-1 which corresponds to the amount of diffuse solar radiation excessively blocked by the shadow band, see eq. 1.

$$DHI_{\lambda_{\text{corr}}} = DHI_{\lambda} + \left(GHI_{\lambda} - \frac{IRR2_{\lambda} + IRR4_{\lambda}}{2} \right) \quad (1)$$

3. Spectral Direct Solar Irradiance (DNI)

Direct solar irradiance is the difference between the global solar irradiance and the diffused solar irradiance divided by the cosine of the solar zenith angle, see eq. 2.

$$DNI_{\lambda} = \frac{(GHI_{\lambda} - DHI_{\lambda})}{\cos(SZA)} \quad (2)$$

7. Maintenance & Troubleshooting

7-1. Maintenance

To maintain accurate measurement, it is recommended to check and do the following:

Table 7-1. Maintenance

| | Frequency | How To | If maintenance is neglected... |
|---|------------------|--|---|
| Clean the Glass Dome | Few times a week | Remove dusts and dirt using blower or wipe with soft cloth and alcohol. | Transmittance changes and sensor sensitivity drops due to dirty glass dome. |
| Check Glass Dome condition on Spectroradiometer | Every Week | Check for cracks and scratches on the glass dome. | Water may leak into the spectroradiometer and lead to damaging the sensor. |
| Check Shadow Band Condition | Every Week | Check for loose screws and any deform on the Shadow Band. | Shading part will shift if Shadow Band position is shifted, and it will lead to inaccurate measurements. |
| Check Spirit Level | Every Week | Check the spirit levels and maintain the instruments in leveled position. | Improper leveling will affect the Cosine and azimuth characteristics and lead to inaccurate measurements. |
| Check Cable Conditions | Every Week | Check the wiring condition of the power supply cable, communication cable, and spectroradiometer cable, making sure the cables are not stressed. | Disconnected cable may lead to inaccurate output and operation errors. Damaged cables may also lead to noise and electric shocks. |
| Fixing Condition of Sensor | Every Week | Make sure the Spectroradiometer is securely fixed to the sensor base. | Spectroradiometer may drop and lead to unexpected accidents. |
| Fixing Condition of the Installation Base | Every Week | Make sure the Main Unit is securely fixed to the installation base. | Main Unit may drop and lead to unexpected accidents. |
| Check and replace the Silica Gel | Every Week | Check the color of the silica gel; if the color is changed from blue to pink, remove the silica gel. Silica Gel cartridge can be removed easily by turning it anti-clockwise. It is recommended to change the Silica Gel on a day with low humidity. | During a long term use, moisture enters inside Spectroradiometer and cause condensation which may lead to decrease in output and malfunction. |
| Recalibration | Every 2 years | To maintain a good measurement condition, it is recommended to recalibrate the instruments every 2 years. Contact EKO for further details and assistance. | Sensitivity changes by aging and may lead to inaccurate measurements. |

7-2. Troubleshooting

Check the following items in case of trouble with the instrument. If any questions should remain, contact EKO for further technical support.

Table 7-2. Troubleshooting

| Failure | Action |
|--|---|
| <ul style="list-style-type: none">• Cannot operate by PC• Cannot take measurements | Communication between the PC and Spectroradiometer may be disconnected. <ol style="list-style-type: none">1) Check the communication cable between PC and Main Unit, connection cable between Main Unit and Spectroradiometer if they are properly connected.2) Check the PC and Main Unit power is turned ON.3) Check the COM Port on PC which the communication cable is connected.4) Reboot the software and make sure successfully communicate and operate by PC.5) If there are any cause of noise on power supply cable and communication cable, take measures to remove/reduce the noise. |
| <ul style="list-style-type: none">• Abnormal measurement value• Bad repeatability of measurement value• Measurement value is too small | Spectroradiometer glass dome may be significantly dirty. Clean the glass dome. <ol style="list-style-type: none">1) Shutter, spectrometer, and/or circuit board may be broken. If so, contact EKO.2) Shadow Band may not be blocking the Spectroradiometer properly. Check the Shadow Band for band alignment or any loose screws and so on. |
| Software behaves abnormally | PC and/or software may have malfunction, restart application or reboot the PC then run the software. |

8. Specification

8-1. Main Unit

Table 8-1. Main Unit Specification

| Characteristics | Details |
|--|---|
| Precision of Shadow Band Position | $\pm 2^\circ$ |
| Measurement Time (4 positions) | 20 to 50 seconds (depends on the exposure time) |
| Measurement Frequency (4 positions) | 1 rotation / minute |
| Operating Temperature Range | -10 to +50°C |
| Storage Temperature Range* | -25 to +80°C |
| Power Supply | 100-240VAC |
| Power Consumption | RSB: Standby status: 8W, Maximum 15W |
| | Spectroradiometer: Maximum 50W |
| Communication | RS-422 |
| Dimension (Shadow Band: Perpendicular position) | W300 x D702.7 x H587.5 mm |
| Weight | 11kg |

8-2. Shadow Band

Table 8-2. Shadow Band Specifications

| Characteristics | Details |
|--------------------|--------------|
| Shielding Angle | 5° |
| Shadow Band Radius | Radius 285mm |

8-3. Cables

Table 8-3 Cable Specifications

| Cables | Details | |
|------------------------------------|-----------------|-------------------------------|
| Communication Cable | Material: | PVC (Gray) |
| | Diameter: | 0.3 mm ² x 5pins |
| | Outer Diameter: | φ 7 mm |
| | Cable end | Pin Terminal (1.25Y-4) |
| Power Cable | Material: | PVC (Black) |
| | Diameter: | 0.75 mm ² x 3pins |
| | Outer Diameter: | φ 7mm |
| | Cable end | AC Plug (3P) |
| Spectroradiometer Connection Cable | Material: | PVC (Gray) |
| | Diameter: | 0.3 mm ² x 12 pins |
| | Outer Diameter: | φ 10 mm |
| | Cable end | Waterproof Plug (12P) |

8-4. Dimensions

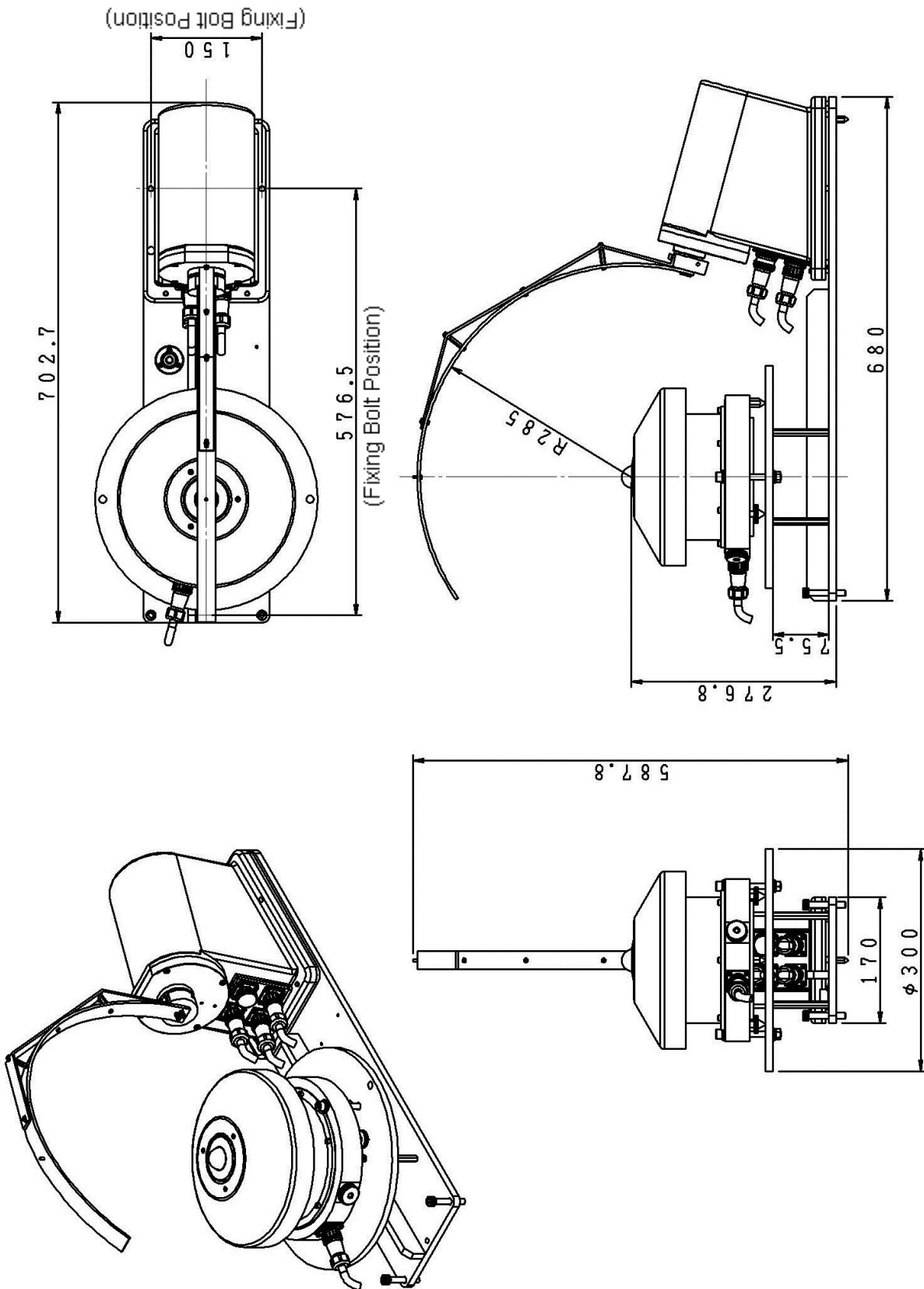


Figure 8-3-1. RSB-01S & MS-711

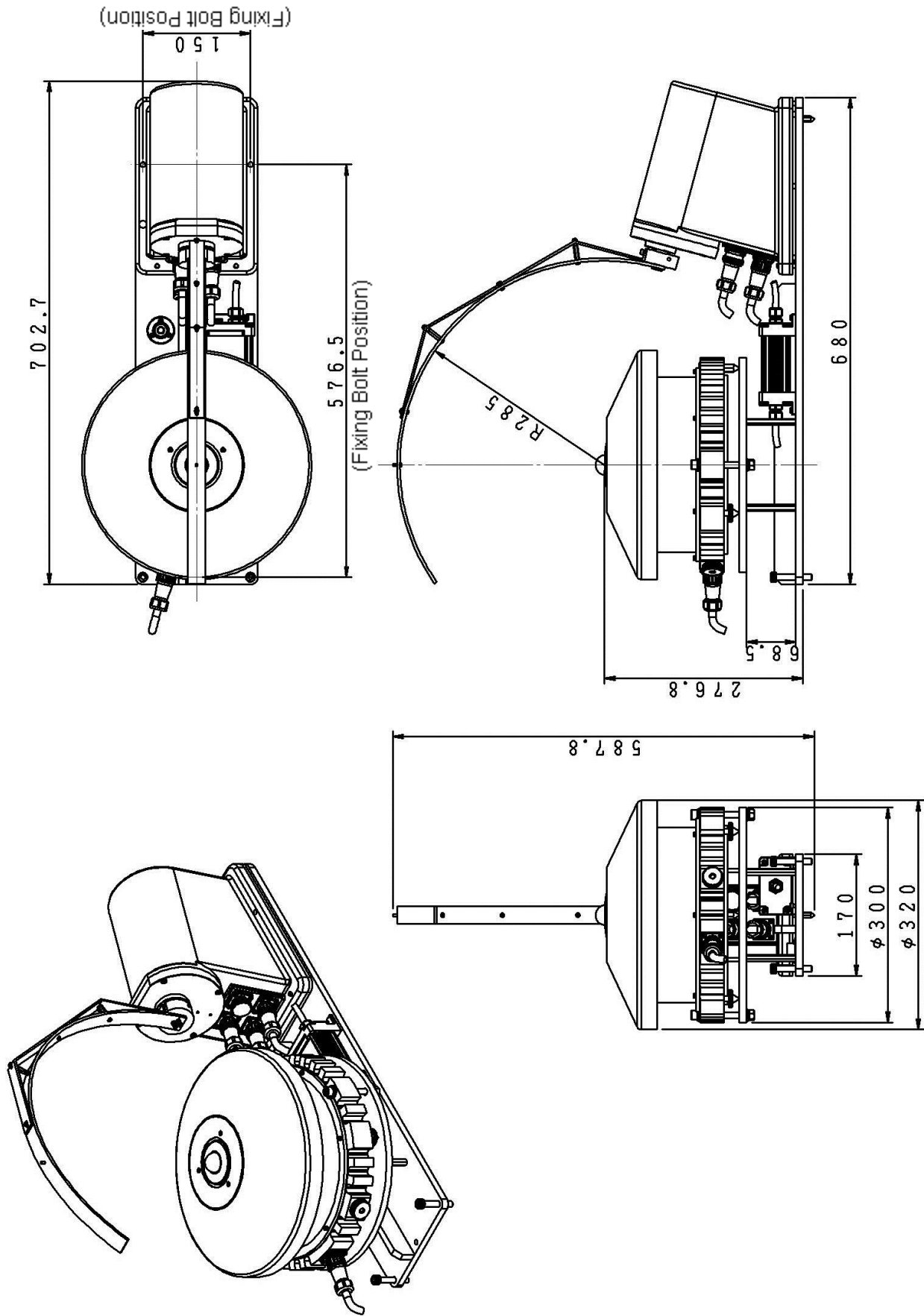


Figure 8-3-1. RSB-01S & MS-712

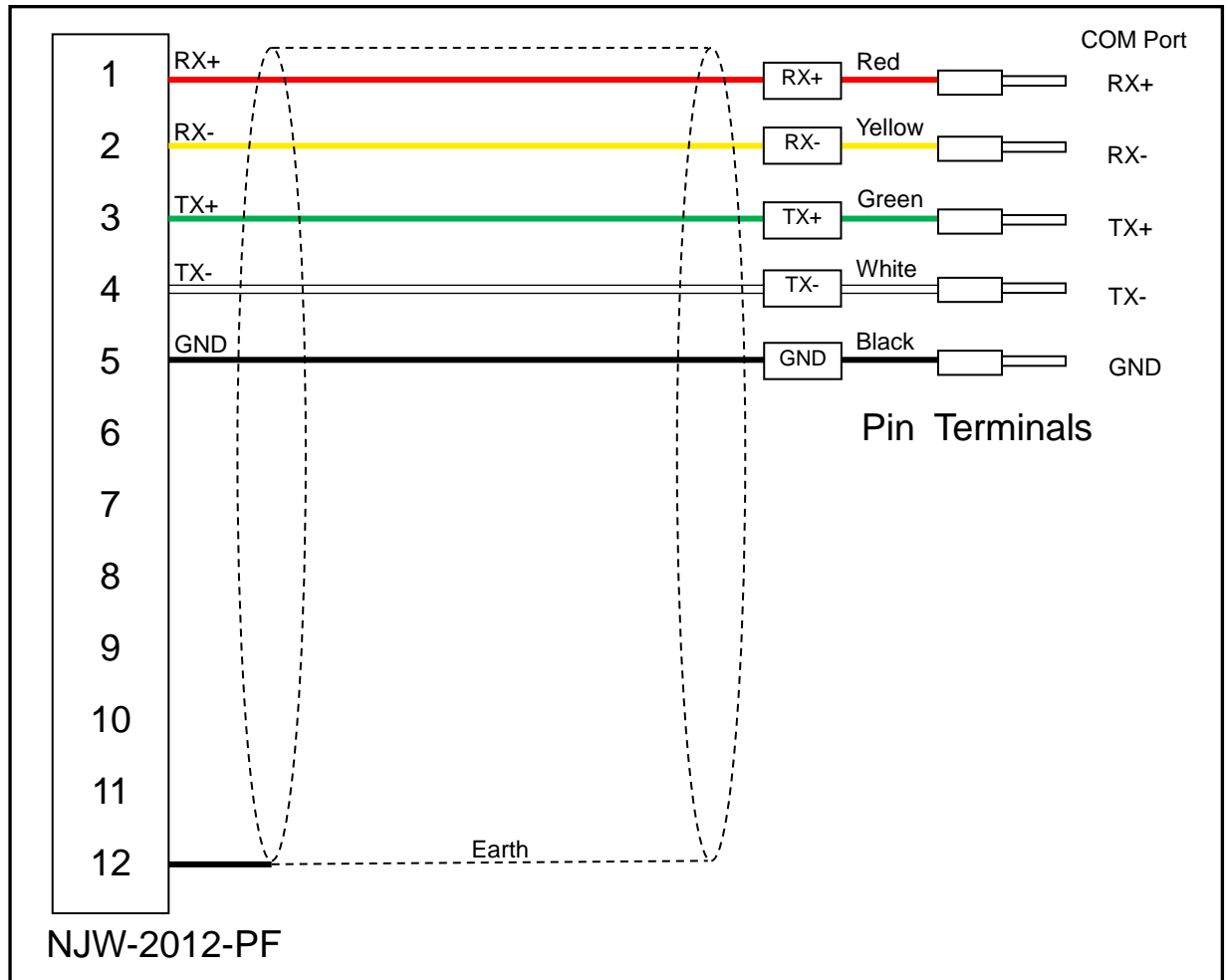
8-5. Accessories List

Table 8-4. Accessories List

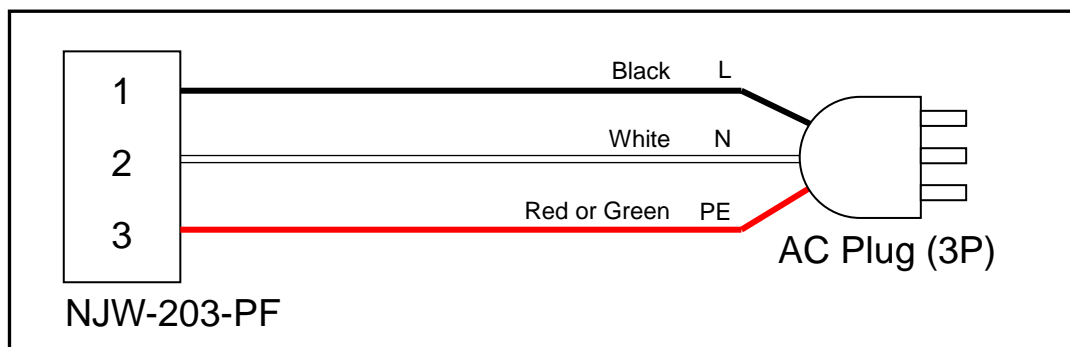
| Option Items | Remarks |
|-------------------------------------|---|
| Communication Cable | Cable Length: 20m, 30m, 50m |
| Power Supply Cable | Cable Length: 20m, 30m, 50m |
| Voltage Conversion Cable for MS-712 | MS-712 operates with different operating voltage; thus voltage conversion cable is required in order to operate MS-712 with RSB-01. Using standard cable attached to RSB-01 with MS-712 will damage the MS-712! |
| GPS antenna | GPS antenna can be attached to acquire RSB-01 latitude and longitude |

APPENDIX

A-1. Communication Cable



A-2. Power Supply Cable





EKO Asia, Oceania

1-21-8 Hatagaya,
Shibuya-ku, Tokyo
151-0072 Japan
P. +81.3.3469.6711
F. +81.3.3469.6719
info@eko-asia.com
www.eko.co.jp

EKO North America

111 South Market Street,
Suite 300, San Jose,
CA 95113, USA
P. +1-408-977-7751
F. +1-408-977-7741
info@eko-usa.com
www.eko-usa.com

**EKO Europe,
Middle East, Africa,
South America**

Lulofsstraat 55, Unit 28,
2521 AL, Den Haag,
The Netherlands
P. +31 (0)70 3050117
F. +31 (0)70 3840607
info@eko-eu.com
www.eko-eu.com