

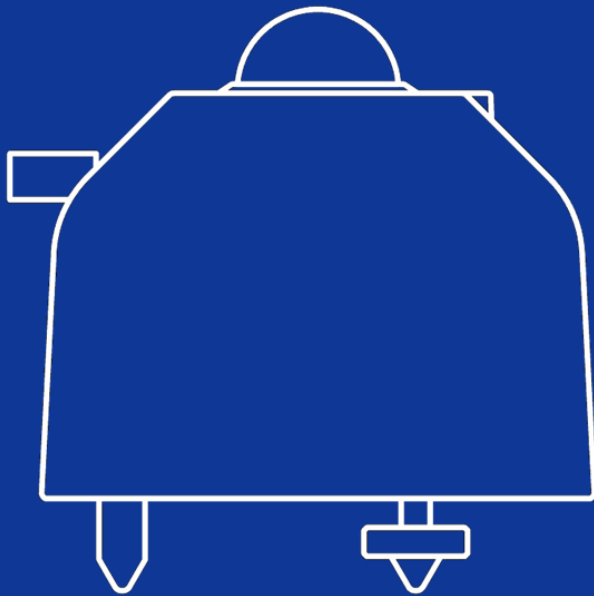
INSTRUCTION MANUAL

Pyranometer

ISO9060: 2018 Class A

'Fast response' & 'Spectrally flat'

MS-80SH



EKO

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2. Important User Information

Thank you for using EKO Products.

We recommended reading this manual prior to installation and operation of the product. Keep the manual in a safe and handy place for whenever it is needed. For any questions, please contact us at below:

2-1. Contact Information

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2-2. Warranty and Liability

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

EKO guarantees that all products have been tested to ensure the instrument meets its published specifications.

The product warranty is valid only if the product has been installed and used according to the instructions provided in this operating manual.

In case any manufacturing defect[s] will occur, the defective part[s] will be repaired or replaced under warranty; however, the warranty will not be applicable if:

- Any modification or repair has been done by anyone other than EKO service personnel.
- The damage or defect is caused by disrespecting the specifications published on the Product Sheet or Manual.
- The bubble level fails or stops working (this part will not be serviced or replaced by EKO under warranty)
- There is discoloration of the pyranometer body, sun shield, and cable within a range that does not affect the function and performance of the product.

2-3. About the Instruction Manual

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This manual was issued: Aug 4, 2023
Version Number: 4

2-4. Environment

1. WEEE Directive



[Waste Electrical and Electronic Equipment]

Although this product is not subject to the WEEE Directive 2002/96/EC, please make sure that it should not be disposed of in a landfill or with municipal or household waste. For proper processing, collection and recycling, please contact a specialist collection site or facility.

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

EKO Instruments has completed a comprehensive evaluation of its product range to ensure compliance with RoHS Directive 2011/65/EU+(EU)2015/863 regarding maximum concentration values for substances.

As a result, all products are manufactured using raw materials which concentration level are less than the hazardous substances specified in RoHS Directive 2011/65/EU+ (EU) 2015/863.

2-5. ISO/IEC 17025

EKO Instruments Co. Ltd. calibration laboratory is accredited by Perry Johnson Laboratory Accreditation, Inc. [PJLA] to perform pyranometer and pyrheliometer calibrations in accordance with the requirements of ISO/IEC17025, which are relevant to calibration and testing.

Based on the applied calibration methods EKO provides the best quality solar sensor calibrations compliant to the international standards defined by ISO/IEC17025 / 9847 [Indoor method] and ISO9059 [Outdoor method] [Certification: L13-94-R2 / www.pjlabs.com]

ISO/IEC17025 provides a globally accepted basis for laboratory accreditation that specifies management and technical requirements. With calibrations performed at the EKO Instruments laboratory we enable our customers to:

- Clearly identify the applied calibration methods and precision
- Be traceable to the World Radiation Reference [WRR] through defined industrial standards:
 - ISO9846 Calibration of a pyranometer using a pyrheliometer
 - ISO9847 Calibration of field pyranometer by comparison to a reference pyranometer
 - ISO9059 Calibration of field pyrheliometers by comparison to a reference pyrheliometer
- Obtain repeatable and reliable calibration test results through consistent operations

Our clients will obtain highly reliable data by using an ISO/IEC17025 calibrated sensor. Our Accredited lab is regularly re-examined to ensure that it maintains the required standard of technical expertise.

2-6. 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 : Pyranometer
Model No. : MS-80SH

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]

Following the provisions of the directive:
EMC-directive: 2014/30/EU

Date: July 13, 2022

Position of Authorized Signatory: Manager of Quality Assurance Div.

Name of Authorized Signatory: Minoru Kita

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 in the correct manner.



WARNING CAUTION

Attention to user; please pay close attention to instructions accompanied by this caution sign.



HIGH VOLTAGE WARNING

High voltage is used; please pay special attention to instructions accompanied by this high-voltage warning sign, to prevent electric leakage and/or electric shocks.



3-1. General Warnings

1. Setup

- The installation base or mast should have enough load capacity for the instrument to be mounted. Fix the pyranometer securely to the base or mast with bolts and nuts; to avoid the instrument dropping due to a gale, an earthquake or other unexpected events.
- Make sure to install the instrument and cables in a suitable location, and avoid submersion in water.
- Insert the output cable into the connector port on the back of the sensor unit and tighten it all the way. Push the connector in, and check to make sure the screw is tight. If the connection is loose, water can enter the unit and cause it to malfunction.
- When connecting this product to a measuring instrument, the shield wire of the output cable shall be connected to ground earth for the MS-80SH. Otherwise noise may occur in the measurement data. In addition, the surge protection circuit inside the pyranometer will not operate properly if the shield wire is not connected to ground earth.
- Make sure to install the provided leveling screws. If the bottom of the pyranometer directly contacts the mounting base, the dome heating effect cannot be fully satisfied.
- Although this product is tested to meet EMC Directive compliance requirements, it may not fully satisfy its primary specification/performance when using this product near locations where a strong electromagnetic wave is generated, for example:
 - Outdoor: High voltage power line, power receiver/distribution facility, etc.
 - Indoor: Large-size chiller, large rotation device, microwave, etc.
- Do not use this product in environments where corrosive gas, such as ammonia and sulfuric acid gas, are generated. It may cause malfunction.
- Do not install in an area likely to result in salt damage. It may cause malfunction by paint peeling or corrosion. When installing in an area at risk of salt damage, make sure to take the following measures:
 1. Wrap the connector with self-fusing tape
 2. Change the fixing screw to a bolt screw made of aluminum
 3. Run the cables in a plastic or metal pipe treated with salt-resistant paint such as molten zinc plating
 4. Periodically clean.

- Do not use this instrument in a vacuum environment.
- For proper grounding use the original cable provided.
- If the cable and main unit are at risk for getting damaged by birds and small animals, protect the cable and the main unit by using:
 1. Reflective tape
 2. Repellent
 3. Cable duct
 4. Installing bird-spikes
- The settings can be changed with the RS485 / USB conversion cable and dedicated software.

2. Handling

- Be careful when handling instruments with glass domes. Strong impact on this part may damage the glass and could cause injury.
- When carrying any MS-80 model with the sun screen attached, always hold the instrument at the bottom. Holding only the sun screen part may lead to dropping the sensor as it comes away from the sun screen.

3. Signal Cable

- Make sure to ground the signal cable. When grounding is insufficient, it may cause not only measurement error due to noise, but also cause electric shock and leakage accidents.
- Check the voltage and types of specified power supply before connecting this instrument. When improper power supply is connected, it may cause malfunction and/or accident.
- Use this instrument with a 0.5A fuse connected to the power supply line in series. Without connecting the fuse the large-current flowing through the power supply may generate heat, potentially leading to internal damage of the electronics and fire.

4. About RS485 Modbus RTU connection

- This product supports communication through the RS485 Modbus RTU.
- It is recommended to use the optional EKO converter cable when connecting MS-80SH to a PC.
- Depending on the USB-RS485 converter type, an additional termination resistor (120Ω) and/or pull-up/pull-down resistor (680Ω) is required for proper communication.
- When connecting to a RS485 (Modbus RTU) master peripheral device, an additional termination resistor (120Ω) and/or pull-up/pull-down resistor (680Ω) is required for proper communication.

4. Introduction

EKO's new generation sensor, the MS-80 broke the rules of traditional pyranometer architecture. The innovative design was inspired by the combination of latest technologies and state-of-the-art thermopile sensors, enabling a breakthrough in unprecedented low zero-offset behaviour, fast sensor response, high accuracy and over time measurement stability. The MS-80 remains a class-leader for ISO 9060:2018 Class A solar sensors today. It offers several advantages over the competition to perform the most accurate irradiance measurements against low cost of ownership. The compact sensor with single dome is immune to thermal offsets and integrates all value-added functions to reduce maintenance. The MS-80 pyranometer also no longer has a drying cartridge, with silica gel instead used inside to keep the sensor dry.

For the MS-80 series a range of accessories is available (MV-01 ventilator and heater, cable extensions and albedo mounting plates).

MS-80SH unique properties:

Dew and frost mitigation The dome heating function reduces dew and frost build-up on the dome. The dome heating function can be switched ON/OFF as needed, and when ON, the temperature of the glass dome is 1°C to 3°C higher than the ambient temperature.

IEC61724-1:2021 Photovoltaic system performance - Part 1: Monitoring requires for Class A systems, the effects of dew and frost accumulation on irradiance sensors shall be mitigated for locations where dew or frost is expected during more than 2 % of annual GHI-hours. To meet this requirement, MS-80SH has the dome heating function that mitigates dew or frost build-up on the glass dome.

Long term stability The long-term stability of the MS-80SH has been optimised thanks to the sensor's unique design, low sensitivity degradation properties, and enhanced airtightness..

Fast detector response The MS-80 series is based on the latest thermopile technology, with a response time of <0.5sec @95% or <1sec @99% for all models (ISO 9060:2018 Class A, Sub-category 'Fast response' and 'Spectrally flat'). Such a response time is suitable for measuring rapid changes in solar irradiance.

Excellent temperature coefficient The MS-80SH has an extremely low temperature error in a wide temperature range compared to most conventional pyranometers, and it provides linear output against solar irradiance.

Lowest zero off-set The MS-80SH has the lowest off-set errors compared to conventional pyranometers with a double-dome, additional ventilation and heating system.. The combination of the isolated thermopile detector architecture and optics keep the sensor in thermal balance within variable atmospheric conditions.

Warranty and re-calibration Unique in the market, the MS-80SH has a 5 year warranty and 5 year recommended re-calibration period due to the great long-term stability of the detector.

ISO 9060:2018 The international industry standard for pyranometer classification, was revised to the 2nd edition in 2018. Along with this revision, pyranometers are classified in order of the highest grade "Class A", "Class B", "Class C" and for pyranometers that meet the response time and spectral selectivity criteria, "fast response" and "spectrally flat" are classified as sub-categories. The MS-80SH is a Class A pyranometer that meets the sub category requirements for "fast response" and "spectrally flat".

4-1. About the Pyranometer Series

EKO pyranometers can meet all possible application requirements, ranging from PV module efficiency measurements to climatology research and material durability testing.

The MS-80SH, with dome heating function, offers excellent durability. The sensor is airtight and can be deployed with little maintenance since the desiccant is incorporated inside. Solar sensors are applied outdoors, hence the black surface of the detector, optical components and sensor mechanics are constantly exposed to solar radiation, temperature and pressure differences. UV radiation can be harmful to materials, leading to irreversible changes to the chemical properties of substances. In the case of the MS-80SH, the detector is totally isolated below the sensor optics surface, which is sealed, and can't be affected by a high dose of UV, moisture or pressure differences.

During production and inspection, the directional response and temperature dependency are measured and validated through a measurement report that comes with each sensor. Besides, EKO provides a unique calibration service for pyranometers compliant to the international standards defined by ISO/IEC17025 / 9847 [indoor method]. When an ISO/ IEC17025 calibrated sensor is purchased, EKO provides a calibrated sensor with a consistently low calibration uncertainty. Our accredited lab is regularly re-examined to ensure that it maintains the required standard of technical expertise.

A setting report is provided with all parameters which were set and tested during manufacturing (current range settings, digital output communication settings).

In case of the MS-80SH, the combination of optional MV-01 [ventilator + heater unit], further reduces the dew condensation and accumulation of dust and snow on the glass dome by continuously blowing heated air. The ventilation unit with heater is recommended when the sensor is deployed in locations with a high-chance of extreme condensation, snow or ice.

When using the MS-80SH in combination with the MV-01, the dome heating function of the MS-80SH should be switched off.

1. MS-80SH

MS-80SH features smart sensor technology and onboard diagnostic functions. 2 different output types can be selected, which is a great benefit for system integrators who work with various industrial standards. This new Smart transducer includes internal temperature and humidity sensors and a tilt sensor for remote sensor diagnostics. These internal sensors will help the user to monitor the stability of the irradiance sensors as well as to ensure proper installation and maintenance practices.

Up to 31 smart sensors per one Master can be connected in one network. The signal converter settings can be changed using the optional RS485 / USB converter cable and the configurator software.

Category of ISO9060: 2018

'Fast response and spectrally flat pyranometer of class A'

Key features:

- Response time [$<0.5s@95\%$, $<1s@99\%$]
- Excellent temperature response over a wide temperature range [-20 to $+50^{\circ}C$]
- Low offset characteristics
- 5 Year warranty and recalibration period
- Outputs (**Modbus RTU**, configurable **SDI-12**)
- Low power consumption
- Wide voltage-supply input range [5 to 30 VDC] / Dome heating function operates from 8 to 30 VDC (+)
- With built-in tilt / roll sensor to check the sensor position over time.
- Temperature and humidity sensors to monitor the inside temperature of the pyranometer and condition of the drying agent (silica gel) inside the pyranometer body.
- Dome heating function for dew and frost mitigation

4-2. Field applications

The MS-80SH with smart interface is designed for the solar energy industry, to be used in different applications; for PV research, plant monitoring and SCADA (Supervisory Control and Data Acquisition) controlled systems. The MS-80SH with digital (Modbus RTU / SDI-12) can be used in a multi sensor network for onsite monitoring of large PV plants. The digital sensor can be easily configured, with the MS-80SH, users can connect using a standard laptop and 'Hibi'; a custom built programme developed by EKO to give users real-time access to the internal diagnostics, custom settings, and data on irradiance, humidity, internal temperature and tilt angle from the sensor. This data can also be acquired when the pyranometer is connected through the data logger digital serial communication port. Each pyranometer has its own unique communication address. This way multiple pyranometers can be connected in a network.

The MS-80SH builds on the revolutionary qualities of the original MS-80 by adding internal diagnostics, giving users remote visibility over body temperature, internal humidity, tilt and roll angle; helping them to ensure optimum performance without the need for regular physical checks. Coupled with the 5-year recalibration interval and internal diagnostic capabilities, the MS-80SH is an ideal solution for complex networks, hard to reach locations, and monitoring stations with restricted access.

4-3. Application to the standards

MS-80 models are qualified to be used within any application which refers to an international standard according to:

- ISO9060: 2018 Fast response and spectrally flat pyranometer class A (Pyranometer classification)
- IEC 61724-1:2021 Class A (PV monitoring system requirement)
- ASTM 2848-11 (Test Method for Reporting Photovoltaic Non-Concentrator System Performance)
- WMO-No. 8, seventh edition 2008 High quality pyranometer (Meteorological system requirement)
- ISO/TR 9901:1990 (Solar energy field pyranometers recommended practice for use)
- ASTM G183 - 05 (Standard Practice for Field Use of Pyranometers)

MS-80 models comply to the international standards for calibration and traceable to the WRR:

- ISO 9847 Calibration of field pyranometers by comparison to a reference pyranometer
- ISO 9846 Calibration of a pyranometer using a pyrhelimeter
- ISO 17025 scope of accreditation

4-4. Package Contents

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

Table 4-1. Package Contents

Contents	MS-80SH
Pyranometer	○
Output Cable	○ ⁽¹⁾
Sun Screen	○
Instruction Manual	Not included in the package [Please download from EKO Website]
Setting Report	○ ⁽²⁾
Calibration Certificate	○
Cosine Response Report	○
Temperature Dependency Report	○
Quick Start Guide	○
Fixing Bolts	[M5] x2 [Bolt Length: 75mm]
Washers	[M5] x4
Nuts	[M5] x2

(1) The MS-80SH, standard length is 10m for both signal/power cables. For different length of cables [e.g., to meet your application needs] please contact EKO or your local distributor.

(2) Details about the setting report, see appendix A-9.

5. Getting Started

5-1. Parts Name and Descriptions

Each part name and its main function are described below.

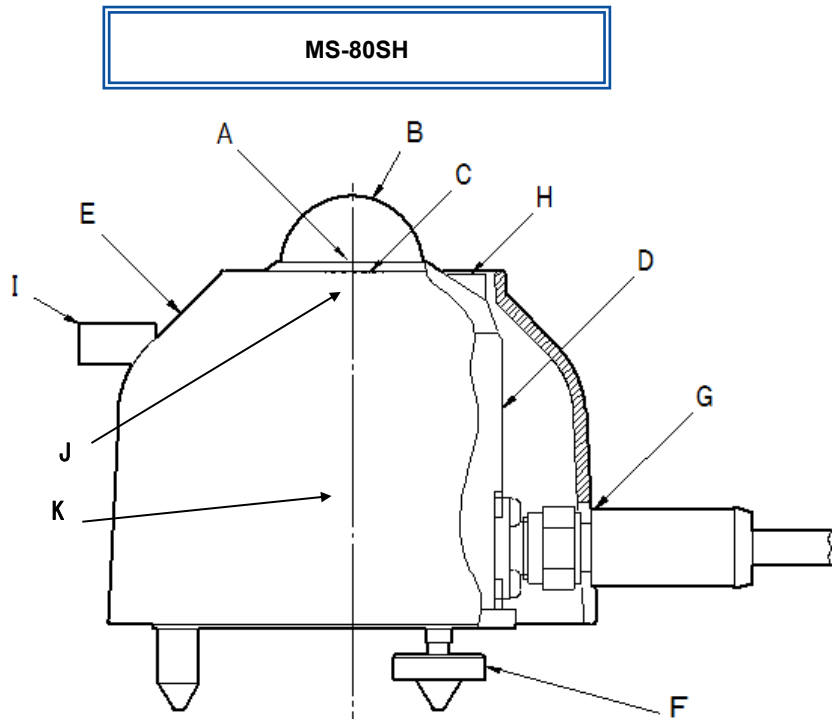


Table 5-1. Parts Name
[MS-80SH]

Parts Name	
A.	Diffuser
B.	Glass Dome
C.	Detector
D.	Body
E.	Sun Screen
F.	Levelling Screw
G.	Cable, Connector
H.	Spirit Level
I.	Knurling Screw
J.	Detector Temperature Sensor
K.	Internal Temperature Sensor

*Signal converter is built-in for MS-80SH.

Figure 5-1. Pyranometer Parts Name [MS-80SH]

1. Glass dome, Quartz diffuser

A glass dome creates a sealed environment for the detector and protects it against dirt and rain. The dome of the EKO pyranometers is only transparent for radiation emitted by the sun. The combination of the glass dome and the Quartz diffuser give a 180 degrees field of view and cosine response.

2. Detector

The thermopile detector, which is the heart of the pyranometer generates a voltage signal that is proportional to the solar irradiance. The fast response detector has a low temperature dependency and excellent long-term stability.

3. Sun screen, Body

The MS-80SH has a sun screen to prevent any excessive body temperature increase generated by direct sun light. Weather resistant metals are used to reduce the effects and degradation caused by heat radiation, rain, and windblown dust.

4. Spirit level

The integrated spirit level is used for setup and maintaining the sensor in a horizontally levelled position.

* Please note: Depending on the operating environment, the bubble may eventually disappear from the level gauge as the liquid dissipates. The reference circle may also fade out, or cracks may occur.

5. Drying agent

Enclosed drying agents inside the sensor body keep the internal components of the sensor dry, preventing condensation and humidity inside of the glass dome.

6. Cable and Cable connector

The MS-80SH is shipped with a 10-meter-long output cable as standard*.

Durable materials are used for the cable and cable connector, and pin terminals are attached at the end of the cable for easy connection with a data logger terminal block.

* If longer cables, round terminals or fork terminals are required, please contact EKO Instruments or your distributor. [Also see [7. Specification, 7-4. Accessories List] for optional items.]

The connector should be protected with self-fusing tape when the pyranometer is used in areas with a risk of salt damage.

5-2. Setup

In order to obtain high quality measurements from pyranometers, several criteria with respect to setup and mounting of the instruments have to be considered. Also see the Quick Start Guide for comprehensive setup instruction details.

The ideal mounting position for a pyranometer is a location which has a full hemispheric field-of-view without any obstructions [such as buildings, trees, and mountains]; however, it might be difficult to find such locations. Therefore, in practice, it is ideal to install in a position which is free from obstructions at 5° above horizon.

The setup location should be easily accessible for periodic maintenance [glass dome cleaning], and avoid surrounding towers, poles, walls or billboards with bright colours that can reflect solar radiation onto the pyranometer. A strong physical impact to the pyranometer can lead to product damage and/or may cause changes to the sensitivity.

1. Installing at Horizontal or Tilted Position

- 1) Check the installation base where the pyranometer has to be mounted and make sure it has two fixing holes with the appropriate pitch. The pitch sizes of the fixing holes are as follows [in mm]:

Table 5-2. Fixing Hole Pitch and Bolt Size for Pyranometers

	MS-80SH
Fixing Hole Pitch	65 mm
Fixing Bolt Size	M5 x 75 mm

- 2) Removing the sun screen

The sun screen can be removed by loosening the knurling screw and sliding it towards the spirit level direction.

*When carrying the MS-80SH with a sun screen attached, always hold the instrument from the bottom. Holding only the sun screen may lead to dropping the sensor as it comes away from the sun screen.

- 3) There are two ways to setup the pyranometer (Horizontal or inclined).

Installing in a horizontal position

Setup the pyranometer with the signal cable connector facing the nearest Earth's pole. In the Northern hemisphere, the connector should be orientated North, in the Southern hemisphere, the connector should be orientated South. Adjust the pyranometer in a horizontal position by using the 2 levelling screws observing the air bubble in the spirit level while manipulating the levelling screws. The instrument is levelled horizontally if the air bubble is in the centre ring. The sensitivity of the bubble vial is (0.1° / mm). If the pyranometer is not levelled properly, the pyranometer readings are affected by cosine and azimuth errors. Periodically check the spirit level and adjust the pyranometer's position if necessary.

Installing at an inclined angle

After the MS-80SH is adjusted to a horizontal position on a levelled surface, install it on a tilted mount.



When installing the pyranometer, do not remove the levelling feet or fixed feet. If the levelling feet are removed, it may induce offsets to output values due to the thermal effects from the mounting plate, or the dew frost mitigation effect may be reduced due to heat escaping to the mounting plate.

In the case of the MS-80SH, it is possible to acquire tilt information obtained from the built-in tilt position sensor through Modbus RTU. The sensor position can be measured in two different planes (X, Y).

<Tilt (X axis)> (180° to 0) and (0 to -180°)
 <Roll (Y axis)> (180° to 0) and (0 to -180°)

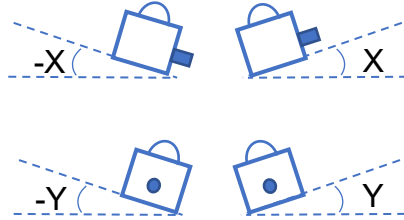


Figure 5.2A Tilt angle (-180 to 0°) and (0 to 180°)
 Roll angle (-180 to 0°) and (0 to 180°)

The tilt and roll angles are relative to the calibrated X and Y axis of the sensor and surface mounting plane X' and Y'. When the sensor is positioned in the same plane X = X' and Y = Y', the measured tilt and roll angles (X and Y) correspond to plane of installation X' and Y'.

The pyranometer connector is an important reference for setup and corresponds to the X-axis reference plane.



For setup at horizontal plane: Setup the pyranometer with the signal cable connector facing the nearest Earth's pole. In the Northern hemisphere, the connector should be orientated North, in the Southern hemisphere, the connector should be orientated South. If the cable is not oriented to the nearest pole, it does not affect the angle measurement. The angle measurement reflects the tilt and roll of the corresponding sensor position.

For setup at inclined plane: Setup the pyranometer with signal cable aligned with the installation platform (X', Y'), see figure 5-2B. When the sensor is not aligned, the tilt (X) and roll (Y) measurement does not reflect the angle X' and Y', see figure 5-2C.

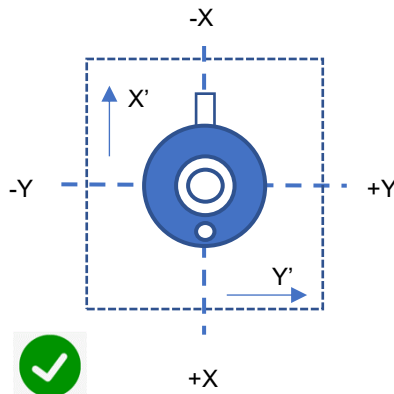


Figure 5-2B Tilt and roll angle corresponding to reference plane

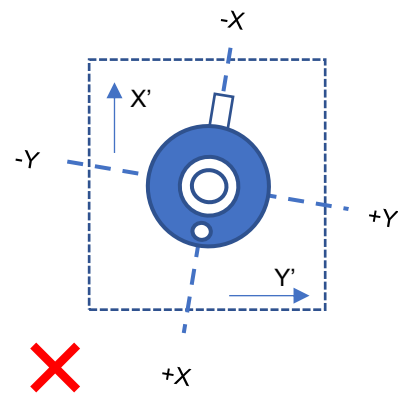


Figure 5-2C Tilt and roll angle not corresponding to reference plane

- Fasten the pyranometer to the base with the 2 bolts [included] and put the sun screen back on the pyranometer.

2. Setting of dome heating function

- 1) The initial setting of the dome heating function is ON.

To obtain a high condensation/frost reduction effect, always use it in the ON state.

It takes about 3 hours for the dome temperature to stabilise after switching ON the dome heating function.

For power-saving use, please set it to OFF.

The dome heating function can be switched ON/OFF by the following methods.

[Hibi]

The dome heating function can be switched ON/OFF using the radio button in the 'Settings' => 'HEATING' screen.

[Modbus RTU]

ON/OFF can be switched by directly rewriting the internal register of the MS-80SH from the control device using RS485 communication.

Register number: 151 ⇒ Set value: OFF = 0, ON = 1

[SDI-12]

ON/OFF can be switched by sending the following commands from the control device to the MS-80SH using SDI-12 communication.

Transmission command: OFF = 'aXHT0!', ON = 'aXHT1!'

5-3. Wiring

To extend the cable lifetime, make sure that the cables are not exposed to direct sun light or rain/wind by lining the cable through a cable conduit. Cable vibrations will potentially cause noise in the output signal. Fasten the cable so that the cable does not swing or move in the wind. Exposure of the signal cable to excessive electromagnetic emissions can cause noise in the output signal as well. Therefore, the cable should be lined at a safe distance from a potential source generating EMC noise, such as an AC power supply, high voltage lines or telecom antenna.

1. Ground connection



<MS-80SH>

The pyranometer housing is connected to the shield wire of the cable, so the shield wire shall be connected to the ground on the measuring instrument side. The surge protection circuit inside the pyranometer will not operate properly if the shield wire is not connected to ground. Also do not connect the pyranometer housing to ground. It will be a two-point ground and it causes a noise.

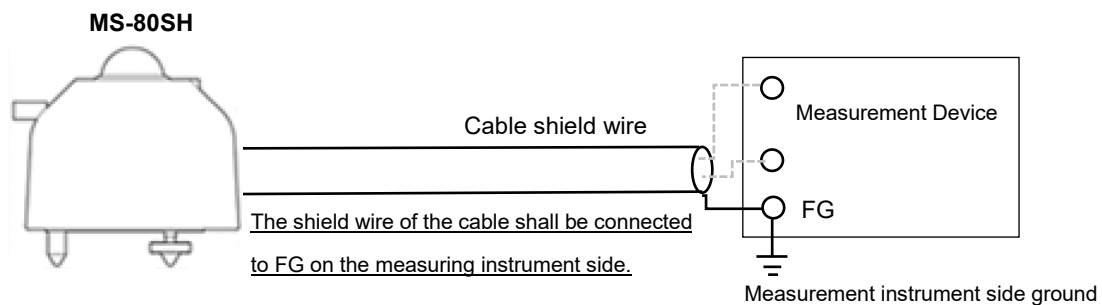


Figure 5-3. MS-80SH ground connection method

2. Wiring procedure

Connect the output cable to the MS-80SH: **Insert the output cable into the connector port on the back of the sensor unit, and twist clockwise to fasten it. Make sure to tighten the connector all the way.**



- 1) If the connection is loose, water can enter the unit and cause it to malfunction.
- 2) Secure the length of the cable to avoid it from being pulled loose.
- 3) Connect the power cable grounding wire to prevent electrical shocks.

5-4. Connections

The MS-80SH features a digital smart processing interface providing advanced measurement functions with 2 different industrial signal outputs (**Modbus RTU**, configurable **SDI-12**).

Table 5-3. Pyranometer output parameters

Output parameters	MS-80SH Modbus RTU / SDI-12
Irradiance	○
Temperature	○
Tilt position	○
Alerts for abnormal internal humidity of the pyranometer	○
Relative humidity	○
Alerts for abnormal dome heating of the pyranometer	○
Sensor information	○

1. Digital output (Modbus RTU / SDI-12)

The MS-80SH can work in two digital output modes, respectively Modbus RTU and SDI-12.

For MS-80SH with product serial number 'S23038500' or earlier, Modbus RTU output is set to default, the SDI-12 output can be selected through the Hibi software.

For MS-80SH with product serial number 'S23038501' or later, there is no default configuration value. Simply connect the desired output wires to automatically start communication.

To change the digital output mode, turn off the MS-80SH and change the wiring.

PC connection (Modbus RTU)



EKO can provide an optional and approved USB converter for connection with a PC. The converter cable is needed for setup, sensor diagnostics and data logging through the Hibi software. Depending on your region, the optional converter can be different.

- **To protect your equipment from noise and surges, the shield wire of the cable shall be connected to ground at a single point. If it is not connected, the electronic equipment may be damaged.**
- **The shield wire of the cable is connected to the surge protection circuit inside the pyranometer itself and to the enclosure.**
- **Be sure to connect a fuse, as this may lead to a fire.**

For any converter with screw terminals or open wires, connect the 4 wires of the sensor cable with the corresponding wire colour to the RS485 to USB converter (figure 5-4). Some converter cables provide a 5V supply voltage from the USB port, in such case no additional power supply is required. if the dome heating function is 'OFF' when the internal settings of the pyranometer are being changed. In any other case use an additional power supply. Connect the power terminals to a DC power supply [8 to 30 V]. We recommend to use a fuse [0.5A] to the DC power supply line [+] for over current protection.

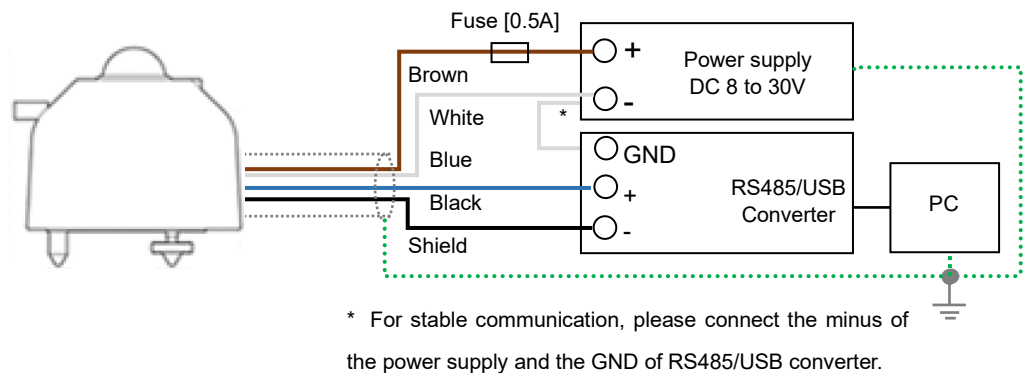


Figure 5-4. How to connect MS-80SH (Modbus RTU)



Depending on the converter type and design properties, some commercial RS485 to USB converters may not work properly. A termination resistor is required to prevent reflections from the end of the transmission line. Pull-up and pull-down resistors are necessary to keep the voltage level constant when the transmission line is in a high impedance state.

Data logger connection (Modbus RTU)

Connect the 4 wires of the sensor cable with the corresponding wire colour to the RS485 communication port of the data logger master and power supply unit (figure 5-5). Connect the power terminals to a DC power supply [8 to 30 V]. We recommend to use a fuse [0.5A] to the DC power supply line [+] for over current protection.

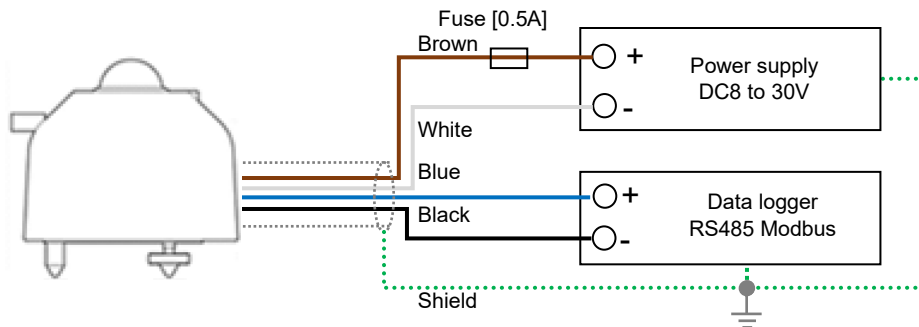


Figure 5-5. How to connect MS-80SH (Modbus RTU RS485)

The MS-80SH can be configured within a multi sensor RS485 Modbus RTU communication network. Up to 31 sensors per one Master can be connected and be assigned with a unique address. For a multiple sensor network the sensors need to be configured according to the recommended RS485 configuration standards as shown in figure 5-6.

The master represents the data-logging device and slaves represent devices such as the MS-80SH or other serial devices in the same network. Connect the communication wires of the slave to the Modbus RTU communication input of the master. Connect a 120Ω termination resistor at the end of the communication line. The master device may have an integrated termination resistor and pull-up and pull-down resistors. If any communication issues occur, apply those separately.

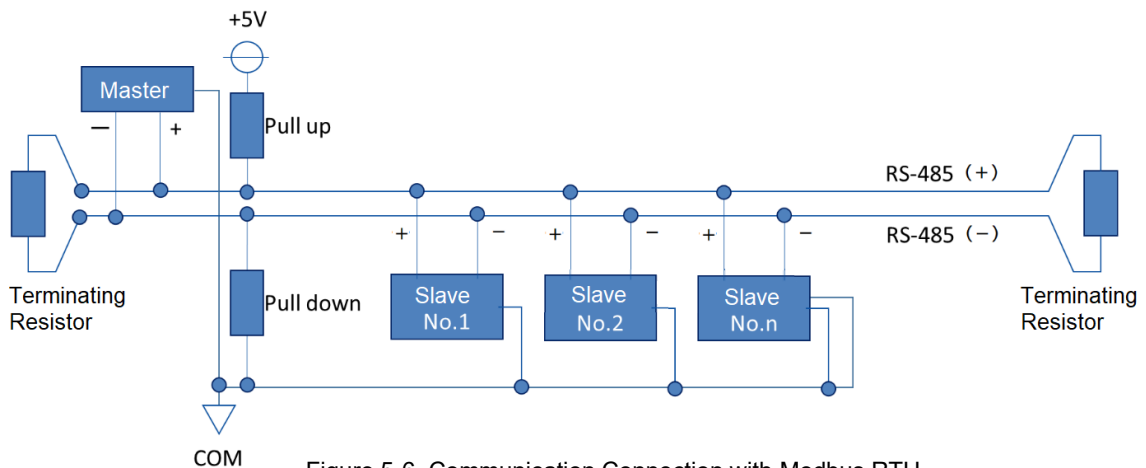


Figure 5-6. Communication Connection with Modbus RTU



Apply a termination resistor (typically 120 to 150Ω) : Typically, reflections occur on long lines, resulting in a receiver misreading logic levels. Proper termination prevents reflections, improving data integrity.

Apply pull-up and pull-down resistors (typically 680 to 850Ω): Necessary to keep the voltage level constant when the transmission line is in a high impedance state.



Communication errors may occur depending on the connection distance and the number of connections. In that case, please prepare and apply a RS485 booster or a repeater.
Communication problems may occur if Modbus and SDI-12 are used at the same time.



Although a surge protection board is embedded inside the pyranometer, if the cable length exceeds 10 m, an appropriate SPD or the like shall be added to protect the measurement system from lightning surges (see A-9).

Using Modbus RTU and SDI-12 at the same time may cause communication problems.

Data logger connection (SDI-12)

#1. For MS-80SH with product serial number 'S23038500' or earlier

Connect the 3 wires (Brown, White, Blue) of the sensor cable with the corresponding wire colour to the SDI-12 communication port of the data logger master and power supply unit (figure 5-7a). Connect the power terminals to a DC power supply [12 V]. We recommend to use a fuse [0.5A] to the DC power supply line [+] for over current protection.



Interconnect the power supply (-) and SDI-12 (-) line.

- **Communication problems may occur if Modbus RTU and SDI-12 are used at the same time.**



- **Although a surge protection board is embedded inside the pyranometer, if the cable length exceeds 10 m, an appropriate SPD or the like shall be added to protect the measurement system from lightning surges (see A-9).**

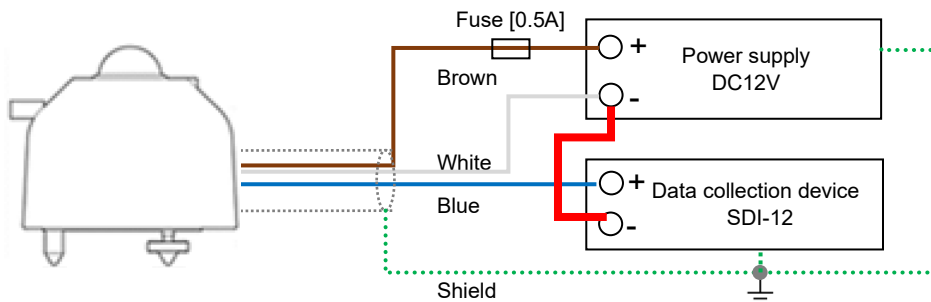


Figure 5-7a. How to connect MS-80SH (SDI-12)

#2. For MS-80SH with product serial number 'S23038501' or later

Connect the 3 wires (Brown, White, Gray) of the sensor cable with the corresponding wire colour to the SDI-12 communication port of the data logger master and power supply unit (figure 5-7b). Connect the power terminals to a DC power supply [12 V]. We recommend to use a fuse [0.5A] to the DC power supply line [+] for over current protection.



Interconnect the power supply (-) and SDI-12 (-) line.

- **Communication problems may occur if Modbus RTU and SDI-12 are used at the same time.**



- **Although a surge protection board is embedded inside the pyranometer, if the cable length exceeds 10 m, an appropriate SPD or the like shall be added to protect the measurement system from lightning surges (see A-9).**

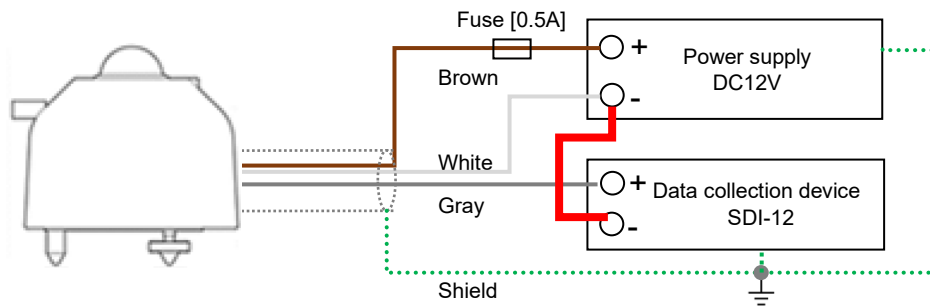


Figure 5-7b. How to connect MS-80SH (SDI-12)

The MS-80SH can be configured within a multi sensor SDI-12 communication network. Up to 20 units of S-series sensors can be connected and be assigned with a unique address (*). For a multiple sensor network, the sensors need to be configured according to the recommended SDI-12 configuration standards as shown in figure 5-8. Make sure the cable length between the connecting slave and master be less than 60m. The shield cable shall be connected to the ground, otherwise noises may occur. If the shield wire is not connected to ground, the surge protection circuit inside the pyranometer will not operate properly. (*) When connecting other SDI-12 communication devices, the upper limit may change.

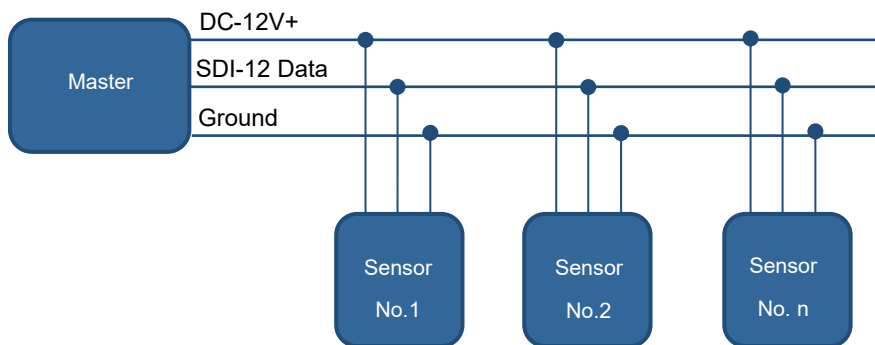


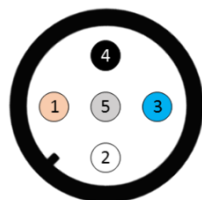
Figure 5-8. Communication Connection with SDI-12

2. Overview wire assignments

Table 5-4. Cable Colour Codes

No.	Wire Color	Modbus RTU	SDI-12	
			'S23038500' or earlier	'S23038501' or later
1.	Brown (+)	5VDC (+) ^(*) or 8 to 30VDC (+)	12VDC (+)	12VDC (+)
2.	White (-)	Vcc GND / RS485 GND	Vcc GND	Vcc GND
3.	Blue (+)	RS485 (+)	SDI-12 Data (+)	---
4.	Black (+)	RS485 (-)	---	---
5.	Gray (+)	---	---	SDI-12 Data (+)
Shield	Shield	FG	FG	FG

(*) Dome heating function is not available when operating with 5 VDC power supply.



Each number corresponds to the number in Table 5-4.

Figure 5-9. Connector pin number of the MS-80SH

5-5. Measurements

1. Data logger settings

The output signal of pyranometer is measured by a measuring device such as a data logger. If solar irradiance is measured continuously, it is recommended to use a data logger, which has sufficient memory to record data over a longer period and functions to process the measurement parameters of the pyranometer. Depending on the sensor output which will be used, the data logger should be capable to measure the assigned output type.

For the MS-80SH with digital output, Modbus RTU or SDI-12, the data logger should have those inputs. For the MS-80SH the input range, resolution and impedance are not critical, and considered as standard for any meteorological or industrial type data logger.

When configuring the data logger parameters, the sampling rate and data reduction methods can be defined right at the beginning of the data acquisition process. The response time that is given in the specifications of the EKO pyranometers states the amount of time, which is necessary to reach 95% of the final measurement value. It is also possible to define a 63.2% response [which is equal to $1-1/e$]. This time constant, represented by the symbol τ , is 3 times smaller than the values specified by EKO. The recommended^[1] sampling rate for pyranometers is smaller than τ . So, for EKO pyranometers, the sampling rates that have to be programmed in the data logger systems should not exceed the values as given in Table 7-1.

Performing averaging and/or integration of measurement data can be meaningful to, e.g., reduce the data volume or to meet application-specific requirement. Note that shorter sampling rates allow to use shorter averaging/integration times [In case of the MS-80: 10 Hz sampling rate, 1 minute averaging period]. It could also be meaningful to store not only average values, but to keep track of all statistical values during the averaging period, namely: average, integral, minimum and maximum values, and standard deviation. As a general recommendation, the averaging/integration period should be as short as possible, but long enough to reduce the data volume to store the processed data safely.

Recommendations for irradiance measurements are explained in ^[1]'Guide to Meteorological Instruments and Methods of Observation', WMO reference document No. 8.

2. Pyranometer default settings

The MS-80SH features a digital smart processing interface providing advanced measurement functions with different industrial signal outputs (**Modbus RTU**, configurable **SDI-12**).

Where to find information regarding the MS-80SH defaults settings and important parameters:

Table 5-5. Where to find the settings?

MS-80SH	Defaults setting and parameters
Sensitivity figure	<ul style="list-style-type: none"> - Calibration certificate - Modbus register - SDI-12 register
Modbus RTU (Default)	<ul style="list-style-type: none"> - Setting report (see appendix A-9of the MS-80SH setting report) - Modbus register <ul style="list-style-type: none"> o Address (last two digits of serial number, 100 if '00') o Baud rate 19200 o Parity Even
SDI-12	<ul style="list-style-type: none"> - Setting report - SDI-12 register <ul style="list-style-type: none"> o Address 0 o Baud rate 1200 o Parity Even
Dome heating function[*] (Default ON)	<ul style="list-style-type: none"> - Setting report - Modbus register

[*] The dome heating function is set to ON when the product is shipped. The function can be switched ON/OFF via Hibi or by rewriting the registers of Modbus RTU and SDI-12 respectively. See the following section for details on the operating procedure.

A-3. Software (Hibi) 3. Software 5) Setting items 3.'DOME HEATING' setting items

A-4. Communication Specifications (Modbus RTU) A4-10. No. 100 or later registers

3. Irradiance conversion

MS-80SH [Modbus RTU Output, SDI-12 Output]

When using the digital output (Modbus or SDI-12) by default the irradiance conversion is performed on-board and will be outputted as one of the measurement parameters within the data string.

4. Daily radiant energy

The total daily radiant energy in Joule per meter squared [J/m²] is obtained by integrating the solar irradiance over time. To calculate the total daily radiant energy in Joule per meter square [J/m²], multiply the averaged solar irradiance I [W/m²] by the averaging interval period [s]. Then sum-up the total data number [n] of averaged data points in one day.

Its physical unit is expressed with [J/m²] and can be calculated with $J = W \cdot S$

$$DTI = \sum_{k=1}^n I_k \times t^k$$

6. Maintenance & Troubleshooting

6-1. Maintenance

Using the MS-80SH, accurate results can be obtained if the glass dome and the condition of the instrument are maintained properly. Regular maintenance and scheduled re-calibrations can also extend the lifetime of the pyranometer. However, environmental conditions, can have a deteriorating effect on the materials. Therefore, proper maintenance, adapted to the local environmental conditions, is required.

The following table describes the common maintenance tasks that should be performed on a regular basis:

Table 6-1. Maintenance Items¹

Maintenance Item	Frequency	How To	Effect
Clean Glass Dome	Several times per week	Keep the glass dome clean by using demineralized water and wiping with a soft cloth dry and clean.	The irradiance measurement will be affected due to a change in transmittance.
Check Appearance Condition	Weekly	Check for cracks and scratches on the glass dome and body.	May lead to shade on the detector and enhanced soiling.
Check Spirit level	Weekly	Verify if the pyranometer is levelled by checking the bubble is in the centre ring of spirit level. [When the pyranometer is setup in horizontal position].	An additional cosine/azimuth error will be introduced.
Check Cable Condition	Weekly	Verify if the cable connector is properly connected, tightened to the instrument, and how the cable is lined; make sure the cable is not shaking from the wind.	A disconnected cable will cause sporadic reading errors or failure of operation. If the cable is damaged, it may lead to noise or electric shock.
Check Setup Base Condition	Weekly	Check if the instrument is tightened properly to the mounting base plate and the base plate and/or table is securely fastened in a proper condition.	Loose instruments and/or mounting plates can lead to damages of the instruments and/or injury.
Check Sun screen	Weekly, Before/ After Bad Weather	Verify if the sun screen is securely fixed on the body, and the knurling screw is securely tightened.	May lead to damaging the instrument and/or lead to increasing measurement error due to temperature increase by sun screen coming off.
Recalibration	Every 5 Years	To maintain the best possible measurement accuracy, recalibration of the pyranometer is recommended. Contact EKO for more details and requests for a recalibration and maintenance service.	Due to natural aging of materials the detector sensitivity of the pyranometer can gradually change over time.

Table 6-2. Maintenance Items2 (Advanced remote checks can be done on the MS-80SH)

Maintenance Item	Frequency	How To	Effect
Data validity	Weekly	Check the daytime irradiance data and compare to previous days or adjacent pyranometers.	When large difference occurs operating problems or installation issues can be detected.
Presence of noise	Weekly	Check night-time irradiance values	Night-time offsets and sensor stability issues can be revealed.
Check the temperature Inside	Weekly	Check the body temperature via Modbus RTU or SDI-12 output.	If the inside temperature becomes abnormally high, the life of the product will be shortened.
Check the effect of desiccant	Weekly	Check the internal relative humidity alert status of the pyranometer via Modbus RTU or SDI-12 output.	The condition of the drying agent can slightly change over time. If the relative humidity becomes high, the glass dome might be fogging up.
Check the tilt angle	Weekly	Check the tilt angle and roll angle via Modbus RTU or SDI-12 output.	Any change in tilt position after the installation can affect the measurements due to the cosine response of the sensor.
Dome heating current	Weekly	Check dome heating current alert register via Modbus RTU or SDI-12 output.	When the dome heating function is turned on, if the dome heating current is not energized properly, the dew and frost mitigation effect cannot be fully achieved.

6-2. Calibration and Measurement Uncertainty

It is recommended to recalibrate the MS-80SH once every 5 years in order to verify the good quality of the solar radiation measurements. In the following paragraph the calibration method of EKO pyranometers and their calibration uncertainty is explained. For further information about recalibration and maintenance procedures, please contact EKO or find out more on the EKO website [eko-instruments.com].

EKO can offer calibration service for pyranometers and pyrhemometers in-house. Based on the applied calibration methods EKO provides the best quality solar sensor calibrations compliant to the international standards defined by ISO/IEC17025 / 9847 [Indoor method] and ISO9059 [Outdoor method] [Certification: L13-94-R2 / www.pjilabs.com]

1. Calibration Method

MS-80SH is calibrated indoors according to the ISO 17025 / 9847 international standard against a 1000W/m² AAA class solar simulator radiation source and designated calibration facility.

Indoor Calibration Procedure

Both reference and field pyranometers are placed in horizontal position in the centre of the light beam at equal distance to the solar simulator light source. The pyranometers are alternatively exposed to the solar simulator beam hence the output is measured from each pyranometer for a specified time. From the reference pyranometer output [mV] and known sensitivity [$\mu\text{V}/\text{W}/\text{m}^2$] the sensitivity figure [$\mu\text{V}/\text{W}/\text{m}^2$] of the field pyranometer based on 10 data samples can be calculated.

Measurement Uncertainty of Indoor Calibration

The calibration uncertainty of the MS-80SH can be kept below (0.7%) as stated in the scope of accreditation and stated on each calibration certificate. Calibration in the lab is performed at a constant ambient temperature and ultra-stable light conditions. Hence the repeatability of the method and pyranometers under test can be well maintained. The pyranometer calibration uncertainty is determined with consideration of uncertainty of the reference pyranometer and maximum variation of incident light during the measurement of field pyranometer and reference pyranometer. The expanded calibration uncertainty of each calibrated MS-80 model, and its results are stated on the calibration certificate.

2. Calibration Traceability

The MS-80 reference pyranometer is traceable to the absolute cavity pyrhemometer maintained at EKO. The absolute cavity pyrhemometer is directly traceable to the WRR [World Radiometric Reference] which is the Primary Standard Group of Absolute Cavities maintained at PMOD (Davos, Switzerland). The logger system used for the calibration measurement is traceable to JEMIC [Japan Electric Meters Inspection Cooperation].

Every year the MS-80 reference pyranometer is calibrated against the absolute cavity pyrhemometer, together with 5 other units' part of the internal reference group of MS-80 pyranometers according the Shade / Unshaded Method [Method for Calibrating Reference and Field Pyranometers (1995)] Bruce W Forgan]. During the IPC the EKO absolute cavity is calibrated against the WRR every 5 years. Every year the EKO absolute cavity scale is examined during the NPC at NREL (Boulder, USA).

6-3. Troubleshooting

Read the following in case of any sensor trouble. If any questions should remain, please contact EKO for further technical support.

Table 6-3. Troubleshooting in field

Failure	Action
There is no output.	Make sure that the sensor is properly connected, and type of power supply and voltage values are appropriate. Also check the communication settings [i.e., port, baud rate, converter ID] are appropriate.
Output value is too low	The glass dome maybe soiled with rain or dust. Clean the glass dome with demineralized water and soft cloth. The output may decrease over time. Recalibrate periodically.
Negative output signal during night-time.	Pyranometers generate an output signal, which is proportional to the temperature differences between the sensor's so-called hot and cold junctions. Night-time offset can occur when the dome temperature will cool down below the temperature of the detector. A slight negative offset within the specification can be expected.
Unusual noise	Check the shield connection and make sure it is connected securely. Make sure if the output cable is not shaking from the wind; take necessary measure by fixing or lining the cables through metal pipe. Check for any objects, which emit electromagnetic wave around the instrument and or the cable.
Dome heating current alert	Check that the power supply voltage of the pyranometer is not less than 8VDC. (A power supply of 8VDC or more is required to use the dome heating function.)

Table 6-4. Troubleshooting Hibi

Failure	Action
No connection with PC	Make sure that the sensor is properly connected, and power supply and voltage levels are appropriate. Also check the communication settings [i.e., port, baud rate, converter ID] are correct.
No communication with USB cable	If no COM port shows up when Hibi software is started. <ul style="list-style-type: none"> - Reconnect the USB converter and refresh to search new COM devices - Check for COM port settings in Windows settings - Install an appropriate driver
Settings changes not saved to pyranometer	Make sure that the sensor is properly connected, and power supply and voltage levels are appropriate. Also check the communication settings [i.e., port, baud rate, converter ID] are correct. Power off/on the pyranometer, some of the settings are effective after power off/on.

7. Specifications

7-1. Specifications

1. Pyranometer Specifications

The comparison table below, Table 7-1, shows typical values for the characteristic parameters of the EKO pyranometers and the corresponding values of the ISO 9060: 2018 standard. The content of the characteristic item is partly changed from ISO 9060: 1990. Please also refer to 'A-2. Pyranometer Characteristics List'.

Table 7-1. Pyranometer specifications

Characteristics		MS-80SH
	ISO9060: 2018	Class A
	[ISO9060: 1990]	[Secondary Standard]
	Spectrally flat	Compliant
	Fast response	Compliant
Response time 95%	< 10 sec	< 0.5 sec
Response time 99%	---	< 1 sec
Zero offset A Thermal Radiation (200W/m ²)	±7 W/m ²	±1 W/m ²
Zero offset B Temperature change (5K/hr)	±2 W/m ²	±1 W/m ²
Zero offset C Total zero off-set	±10 W/m ²	±2 W/m ²
Non-stability	±0.8 %/1year	±0.5 %/5years
Non-linearity	±0.5 %	±0.2 %
Directional response	±10 W/m ²	±10 W/m ²
Spectral error	±0.5 %	±0.2 %
Spectral selectivity	±3 %	±3 %
Temperature response -10 to +40°C	±1 %	±0.5 % ⁽¹⁾
-20 to +50°C	---	±0.5 % ⁽¹⁾
-40 to +70°C	---	±2 %
Tilt response	±0.5 %	±0.2 %
Additional signal processing error	±2 W/m ²	±1 W/m ²

⁽¹⁾ The difference in temperature response when the dome heating function is ON and OFF is within ±0.1%.

Table 7-2. Other Specification

Characteristics	MS-80SH
Field of view	2π [sr]
Wavelength range	285 to 3,000nm
^[1] Operating temperature	-40 to +80°C Accuracy guaranteed temperature range: -20 to +50°C
^[2] Maximum irradiance	4,000W/m ²
Digital signal output	-200W/m ² to +2000W/m ²
Spirit level accuracy	0.1 °
Tilt sensor accuracy	<±1°
Humidity sensor accuracy	Nominal: ±2%RH
Temperature sensor of PCB (tolerance)	±0.5°C
Detector temperature sensor	Pt100 Class A ^[3]
Internal temperature sensor	±0.5°C
Environmental protection [IP Code]	IP67 [IEC60529]
Weight	0.41kg
Body	Anodized
Sensitivity	Approx. 10μV/W·m ²
Output cable	AWG22
[Outer diameter]	0.3mm ² x 5 pins [φ5.3-5.7mm]
Output cable terminal	Pin-Terminal [0.3-9.5]
Output [or Signal]	Modbus RTU (default), configurable SDI-12
Resolution	< 0.01W·m ⁻² ^[3]
Alert signal	Alert is issued when the internal humidity and current of the dome heating of the pyranometer is abnormal.
Input power supply	Modbus RTU: DC5V±5% (USB BusPower) ^[4] Without dome heating function or DC8V to DC30V±10% ^[5] With dome heating function SDI-12 : DC12V±10% With/without dome heating function
Power consumption	With heating : < 1.4W Without heating : < 0.2W
MTBF	10 years

^[1] When the instrument is used in the ambient temperature exceeding the accuracy assurance temperature range, the measurement error may increase.

^[2] The operational maximum irradiance is defined as the maximum irradiance exposure level. Beyond this point damage may occur to the sensor.

^[3] Temperature sensor is internally connected to Modbus electronics.

^[4] Sensor setting can be changed by connecting the sensor to a PC (Use the USB cable for MS-80S (option) and download the free configuration software from the EKO website.

^[5] Although the MS-80SH can operate from a DC 8V power supply, a DC 12V power supply or higher is recommended for long-term stable operation of the pyranometer, including the dome heating function.

Table 7-3. Power consumption supply voltage specific (Without dome heating function)

	5V DC	12V DC	24V DC	Remarks
During stand-by	75mW (Approx. 15mA)	90mW (Approx. 7.5mA)	110mW (Approx. 4.5mA)	-
Modbus RTU	170mW (Approx. 34mA)	180mW (Approx. 15mA)	190mW (Approx. 8mA)	Peak value during communication

Table 7-4. Power consumption supply voltage specific (With dome heating function)

	12V DC	24V DC	Remarks
During stand-by	1.1W (Approx. 90mA)	1.1W (Approx. 43mA)	-
Modbus RTU	1.1W (Approx. 95mA)	1.1W (Approx. 46mA)	Peak value during communication

7-2. Dimensions

1. MS-80SH

Table 7-5. Dimensions

	MS-80SH
A. Fixing Hole Pitch	65 mm
B. Body Height	73 mm
C. Levelling Screw Height	16 mm
D. Width [including Sun screen/Cover]	Φ96 mm
E. Overall Height [approx.]	101mm

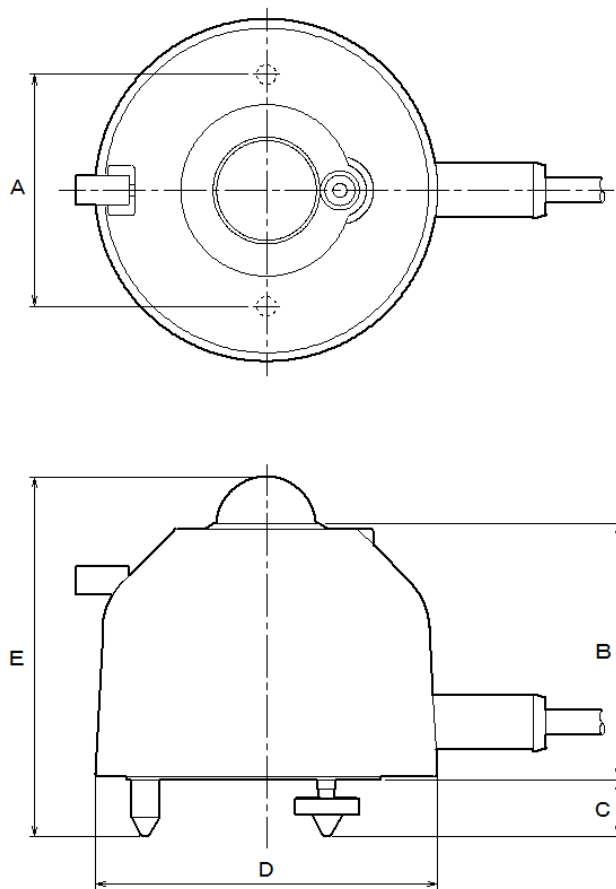


Figure 7-1. External Dimensions (MS-80SH)

7-3. Output Cables

See [5-2. Setup, 2. Wiring] for instruction

1. MS-80SH

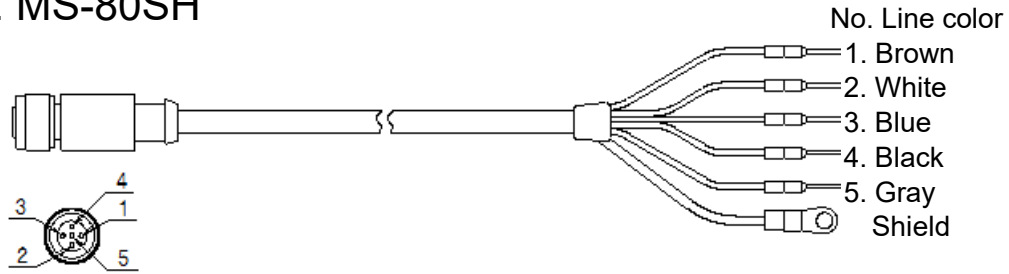


Figure 7-2. Output Cables

2. EKO Converter Cable (Option)

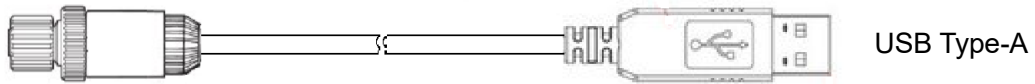


Figure 7-3. EKO Converter cable

7-4. Accessories List

Table 7-6. Accessories List

Option Items	Description
^[1] ^[2] Output Cable	Cable Length: 10m, 20m, 30m, 50m Terminals: Fork Terminals, Round Terminals, Pin Terminals
Ventilation Unit with Heater	MV-01 ventilator and heater
EKO Converter Cable	Converts from RS485 → USB for the communication with the MS-80SH and allows to connect to PC via USB terminal. Cable Length:5m

^[1] The standard cable length for the MS-80SH is 10 m.

^[2] When using the optional cable, a power supply voltage of 24VDC or higher is recommended.

APPENDIX

A-1. Radiometric Terms

Table A-1. Definitions of Terms

Global Solar Irradiance, Global Horizontal Irradiance [GHI]	Hemispherical solar irradiance received by a horizontal plane surface, expressed in units of W/m ² or kW/m ² .
Direct Solar Irradiance, Direct Normal Irradiance [DNI]	Normal-incidence solar irradiance received over a small solid angle which includes the circumsolar irradiance, expressed in units of W/m ² or kW/m ² .
Diffuse Solar Irradiance, Diffuse Horizontal Irradiance [DHI]	Global horizontal irradiance without the direct solar irradiance, i.e., indirect irradiance of the scattered solar radiation [by air molecules, aerosol particles, clouds, etc.], expressed in units of W/m ² or kW/m ² .
Pyranometer	A radiometer designed to measure the hemispheric solar irradiance over the wavelength range of about 300 to 3,000nm.
Pyrheliometer	A radiometer designed to measure the direct solar irradiance over a certain solid angle including the circumsolar irradiance.
World Meteorological Organization (WMO)	It is a specialized organization of the International Union that carries out international standardization and coordination of meteorological work. WMO: Abbreviation for World Meteorological Organization
World Radiation Reference [WRR]	Radiometric reference instrument system which has an uncertainty of less than +/-0.3%, expressed in SI units. This reference is maintained by the World Meteorological Organization [WMO], and it has been issued since January 1, 1980
ISO9060	An ISO norm [International Standard]. The first edition was published in 1990, then the second edition was revised in 2018. Based on the performance of each characteristic, Pyranometer is classified into three classes A, B, and C, and specifications of 'Spectrally flat radiometer' and 'Fast response radiometer' are set as sub-categories. Pyrheliometer is classified into 4 classes of AA, A, B and C based on the performance of each characteristic, and specifications of 'spectrally flat radiometer' and 'Fast response radiometer' are set as sub-categories.

A-2. Pyranometer Characteristics

Table A-2. Pyranometer Characteristics [see also ISO-9060:2018, CIMO Guide, WMO No. 8, 2008]

Response Time	The time [seconds] of a pyranometer sensor to reach 95% of its final output signal. [ISO 9060: 2018 added] If the response time reach to 95% is less than 0.5 seconds, 'fast response' is attached to the applicable class as a subcategory.
Zero Off-Set a	Response [dark-signal] to 200W/m ² net thermal radiation [ventilated]
Zero Off-Set b	Response [dark-signal] to 5K per hour change in ambient temperature
Total Off-set c	[ISO 9060: 2018 added] Total zero off-set including the effects a), b) and other sources
Non-Stability	Rate of change [%] of the pyranometer sensitivity per year.
Nonlinearity	Percentage deviation from the responsivity at 500W/m ² due to any change of irradiance within the range 100W/m ² to 1000W/m ² .
Directional Response	Also referred to as cosine error [W/m ²]; the range of errors caused by assuming that the normal incidence responsivity is valid for all directions when measuring, from any direction, a beam radiation whose normal incidence irradiance is 1000W/m ² [ISO 9060: 2018 modified] Include the zenith angle of zenith angle 90 ° or more.
Spectral Error	[ISO 9060: 2018 added] Maximum spectral mismatch error of Pyranometer [%] with respect to spectral irradiance at AM 1.5 and AM 5 under multiple atmospheric conditions on fine weather against the reference standard spectral irradiance defined by IEC60904-3: 2016 Photovoltaic devices - 'Measurement principles for terrestrial photovoltaic [PV] solar devices with reference spectral irradiance data.'
Spectral Selectivity	Percentage deviation of the product of spectral absorptance and spectral transmittance from the corresponding mean within the range 0.35µm to 1.5µm.
Spectrally Flat Pyranometer	[ISO 9060: 2018 added] If the spectral selectivity is less than 3 %, 'spectrally flat' is attached to the applicable class as a subcategory.
Temperature Response	[ISO 9060: 2018 modified] Percentage maximum output error due to any change of ambient temperature between -10 to 40°C against the output at 20°C.
Tilt Response	[ISO 9060: 2018 modified] Percentage deviation from the responsivity at 0 ° tilt [horizontal] due to change in tilt from 0 ° to 180 ° at 1000W/m ² .
Additional Signal Processing Errors	[ISO 9060: 2018 added] Error generated when converting the analog output of Pyranometer or Pyrhemliometer into a digital signal with a signal converter etc.

A-3. Software (Hibi)

'Hibi' means 'day by day' in Japanese, and with this program, users will be able to visualize detection signals, set communication parameters, and rapidly troubleshoot any issues from day one. You can change the settings of the MS-80SH using the Windows software downloadable from the EKO website (MS-80SH product page) and the optional USB cable.

1. Software Installation

Follow the steps below to install 'Hibi' configurator software.

- 1) Download the latest version of the 'hibi.zip' file [Compressed file: Zip format] from MS-80SH product page on the EKO website.
- 2) Unzip 'hibi.zip' file and check that the 'setup.exe' file exists.
- 3) Run the 'setup.exe' file to install 'Hibi' configurator software.

2. Hardware Preparation

After the software is installed, connect the MS-80SH with a PC to change the setting.

- 1) After installing the software, connect the USB connector of 'RS485/USB Converter cable' to the PC.
- 2) Connect the ends of the signal cable of MS-80SH to the communication terminal of 'RS485/USB converter'.
- 3) Connect the power lines of the signal cable to the power supply (DC5V or 8 to 30V), and turn on the power supply. (Refer to Figure A3-1.)

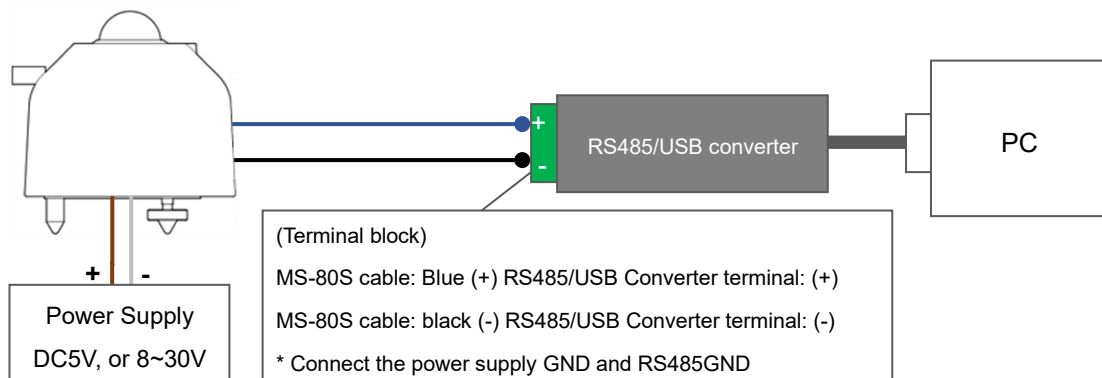


Figure A3-1. Hardware preparation

- 4) If you use the optional 'EKO Converter Cable', you can install it simply by inserting the cable connector into the main unit. Power for the MS-80SH can be supplied via USB. (See Figure A3-2).

* This conversion cable is for installation, so please avoid using it outdoors for a long time. Because the ground wire is not connected, surges can damage your PC during a lightning strike.

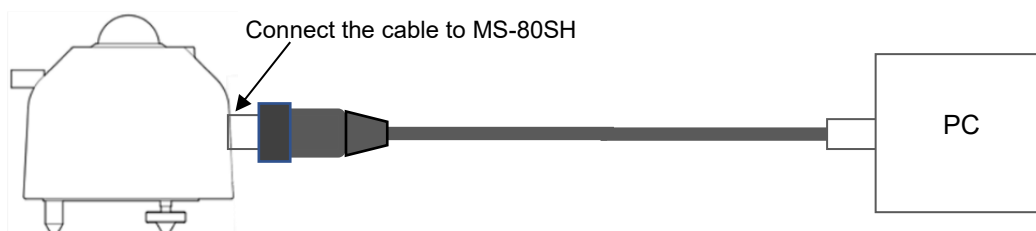


Figure A3-2. Using "EKO Converter cable"

3. Software

Start the 'Hibi' software and make the required settings.

- 1) Start 'Hibi' software. (Launch the software from 'hibi.exe' located in the shortcuts or installation folder.)
- 2) After the software starts, the 'Welcome' window appears.

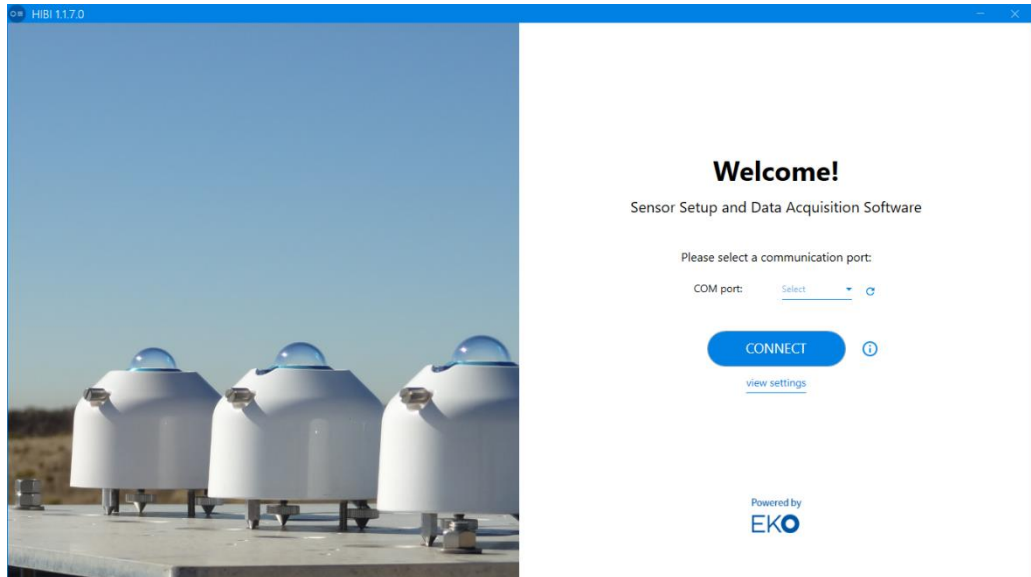


Figure A3-3. Welcome window

- 3) Automatic connection

When using the 'Auto-connect' function to connect the MS-80SH with the 'Hibi' software, select the COM port that the RS485/USB converter cable is connected to.

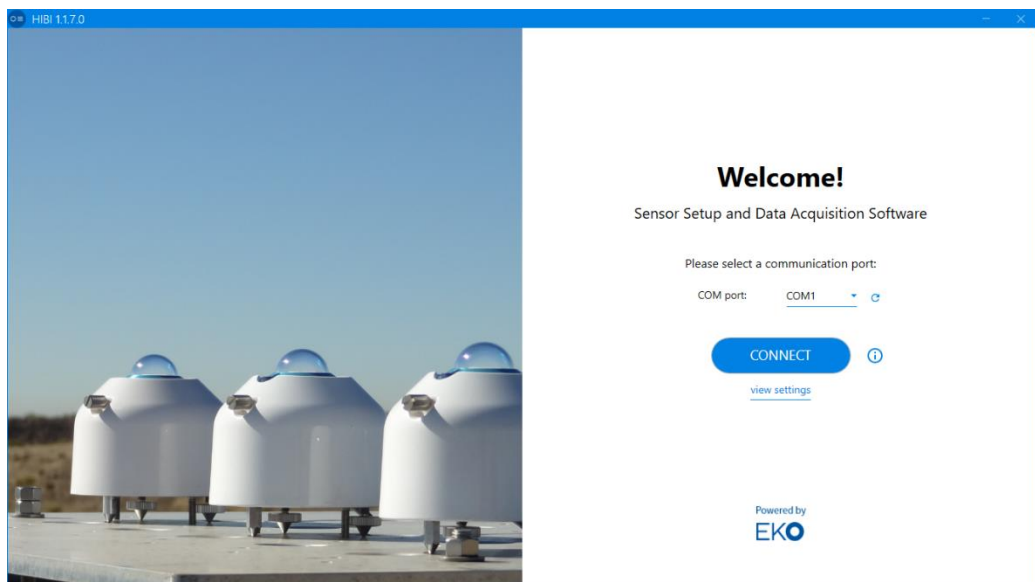


Figure A3-4. Com port select

Click 'Select' of 'COM port:' on the startup screen, and select the COM port number assigned to the RS485 / USB conversion cable from the displayed COM port numbers.

If you can't find a selectable COM port, click the Refresh button and click Select again to try again.

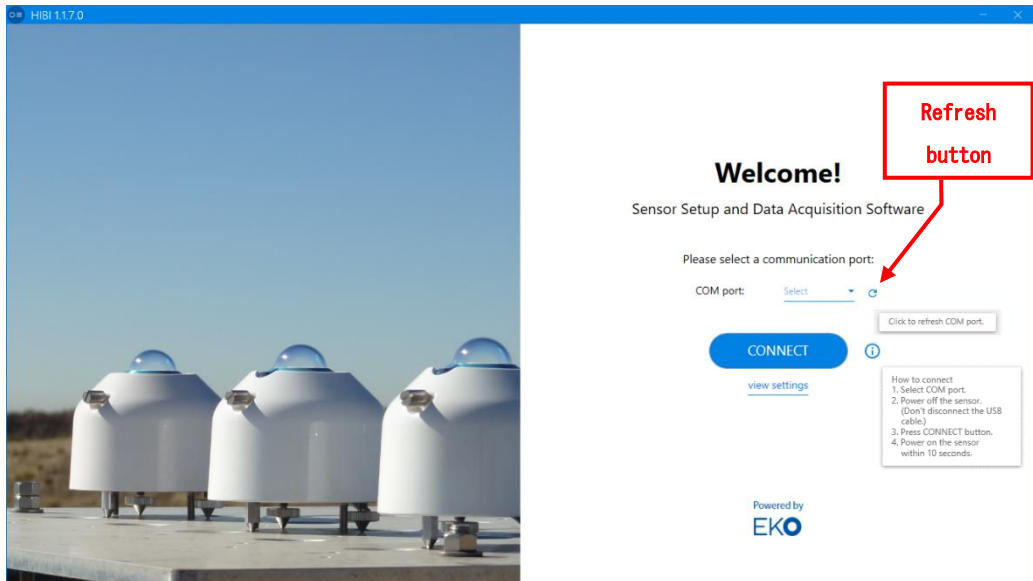


Figure A3-5. Com port select

Check that the power supply of the main unit is 'OFF'. Then, click 'CONNECT' button.

If the COM port is not recognized, press the refresh button and try again.

Power on the MS-80SH within 10 seconds once the 'Connecting your sensor' message appears.

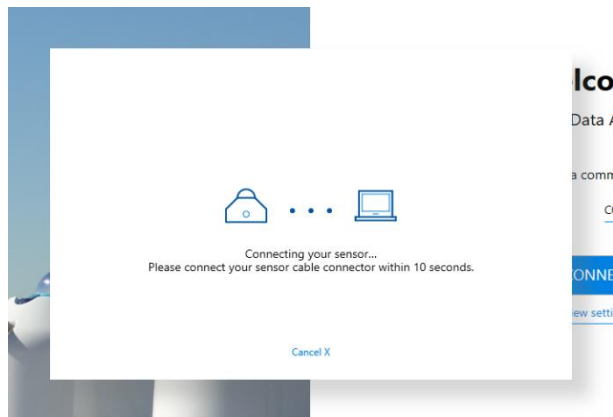


Figure A3-6. Connecting screen

When the connection is completed, the window automatically switches to the 'Dashboard' window. In the upper-right corner of the display changes to 'Pyranometer Connected'.

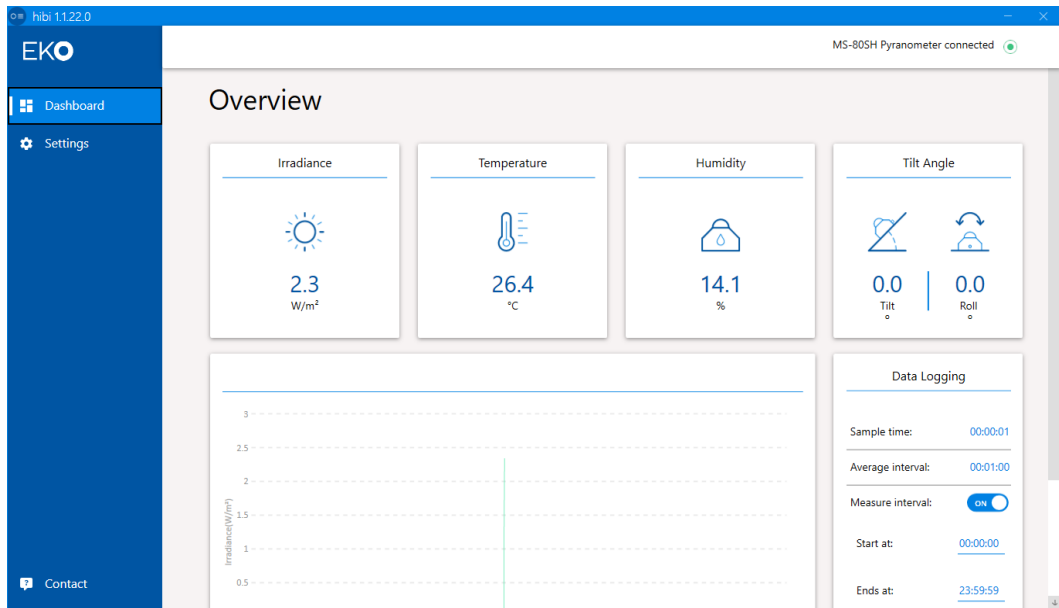


Figure A3-7. Dashboard

If the connection fails, the screen returns to the 'Welcome' screen and 'CONNECTION FAILED' is displayed.

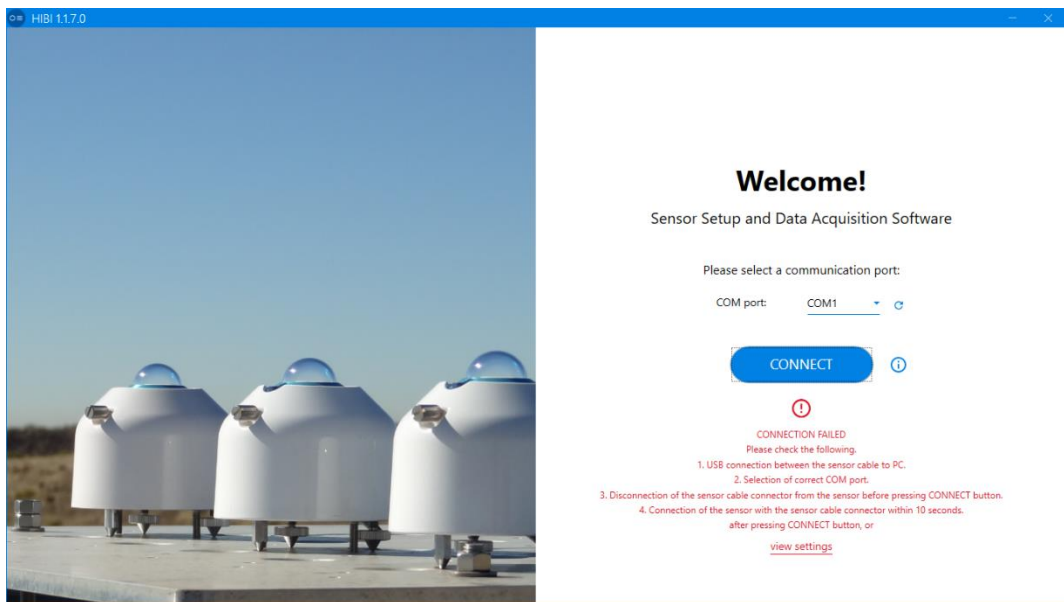


Figure A3-8. CONNECTION FAILED

Make sure the connection settings are correct. To perform the 'Auto-connection' again, turn off the power of the MS-80SH, select 'COM port', and then click 'CONNECT'.

For manual connections, click 'View settings' at the bottom of 'CONNECTION FAILED' to go to 'Settings screen'. (As for how to set and connect by 'Manual connection', refer to the procedures (4) Manual connection) from the next section.

4) Manual connection

After turning on the power of the MS-80SH, click 'CONNECT' without selecting 'COM port'.

Clicking 'view settings' at the bottom of the 'CONNECTION FAILED' screen moves to the 'Settings' screen. (The same screen appears even when the 'Auto-connection' fails. To perform manual connection, set and connect using this procedure.)

After that, click the 'CONNECT' button in Connection status.

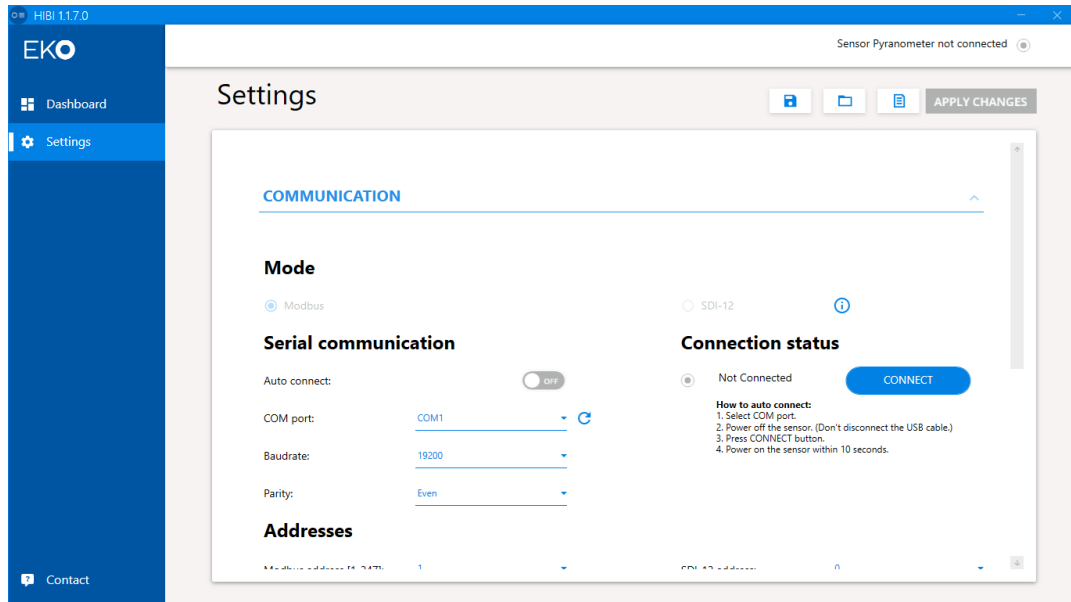


Figure A3-9. Manual connection

When the connection is completed, 'Connected' is displayed.

'XXXX Pyranometer connected' is also shown in the upper-right corner of the display.

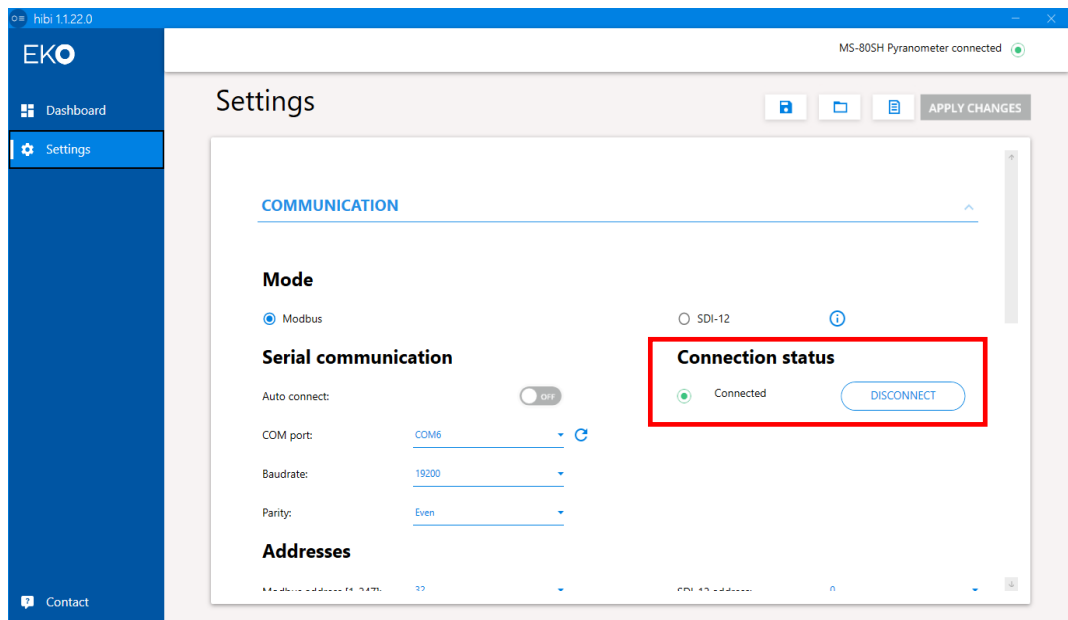


Figure A3-10. Disconnect appear

When the connection fails, the 'Oops...' screen is displayed with the cause of the connection failure.

When connection fail appears

Check that the cable connection, COM port and the communication requirements are correct.

When changing the connection condition after successful connection, set 'COM port', 'Baud rate' and 'Parity' in the 'Serial communication' setting of the 'COMMUNICATION' items and set 'Modbus address [1-247]' and 'Register Type' in the 'Addresses' setting.

After entering the settings, click 'APPLY CHANGES'. A confirmation window will be displayed.

Click 'YES, SAVE' to make the settings for the MS-80SH.

The settings in 'Settings' can be saved / read / exported to CSV files.

Click the button with icons in the upper-right corner of 'Settings' window.

- 'Save' button: Save the settings.
- 'Read' button: Read out the settings.
- 'Output' button: Output the settings to CSV file

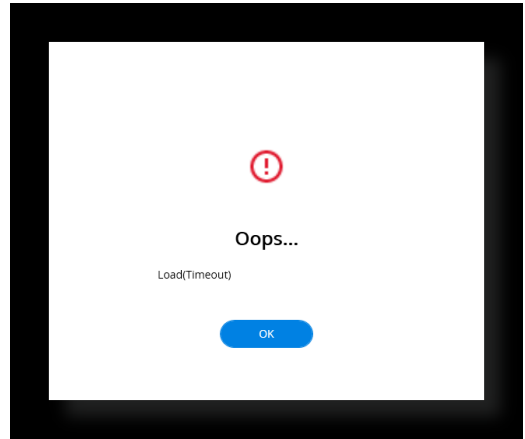


Figure A3-11. Oops screen

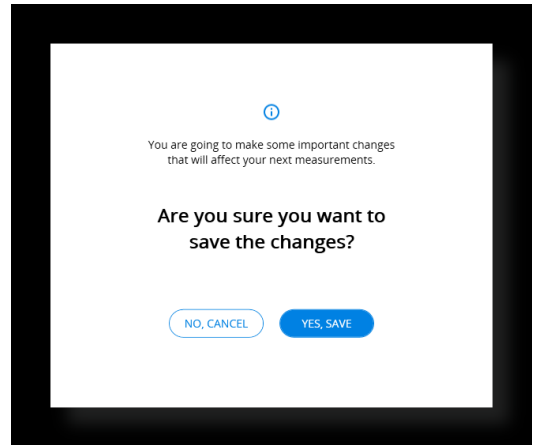


Figure A3-12. Apply changes screen

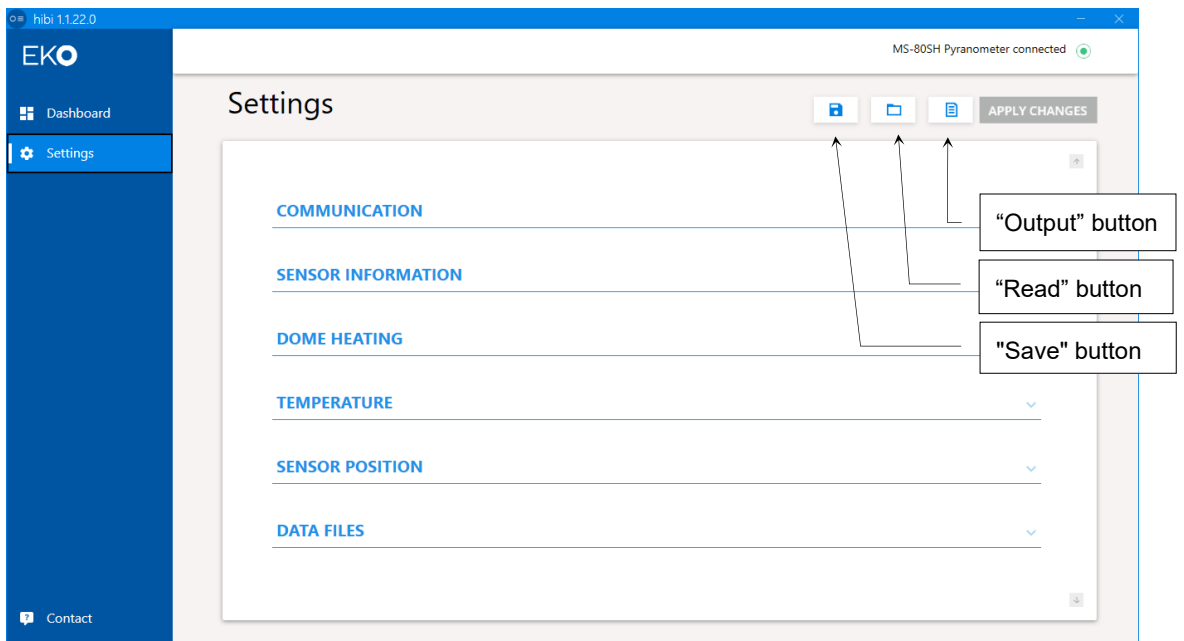


Figure A3-13. Settings screen

5) Setting items

1. COMMUNICATION setting items

Item name	Setting contents	Setting range
Mode (*)	Modbus RTU	Switch to Modbus RTU interface (Default)
	SDI-12	Switch to SDI-12 interface.
Serial communication	Auto search	OFF/ON: Manual-connect / Auto-connect
	COM Port	COM1 to COM256
	Baud rate	2400 / 4800 / 9600 / 19200 / 38400 / 115200bps
	Parity	Even / Odd / None
Addresses	Modbus address [1-247]	1 to 247 (last 2 digits of serial number is default address, 100 when '00')
	Register Type	S-series / M-series/ SMP-series/ SRD-series
	SDI-12 address	0 to 9 / A to Z / a to z
Connection status	---	Connected / Disconnect

(*) Mode setting is used only for MS-80SH with product serial number 'S23038500' or earlier.

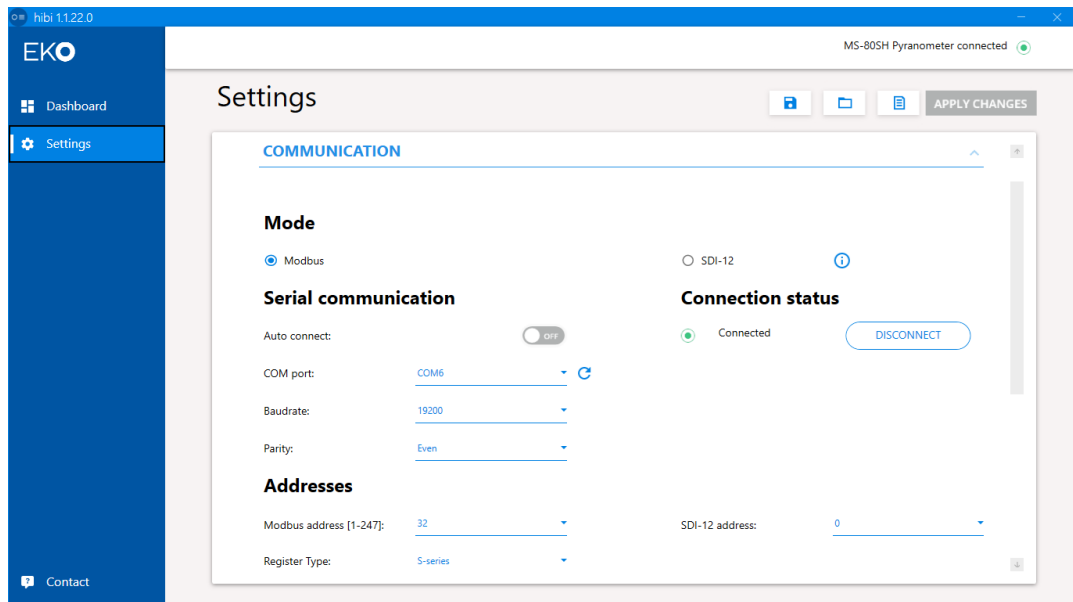


Figure A3-14. Communication setting screen

2. 'SENSOR INFORMATION' setting items

Item Name	Setting contents	Setting range
Model information	Model	Model name registered in the MS-80SH (cannot be changed)
	Serial number	Serial number registered to the MS-80SH (cannot be changed)
	MFG. date	Date of manufacturing (cannot be changed)
	Firmware version	Firmware version of MS-80SH (cannot be changed)
	Hardware version	Hardware version of MS-80SH (cannot be changed)
Calibration	Calibration date	Calibration date and time: Registered at the time of calibration by the manufacturer, but can also be registered by the user.
	Sensitivity [$\mu\text{V}/\text{W}/\text{m}^2$]	Sensitivity constant: Registered at the time of manufacturer calibration, but can also be registered at the user side.

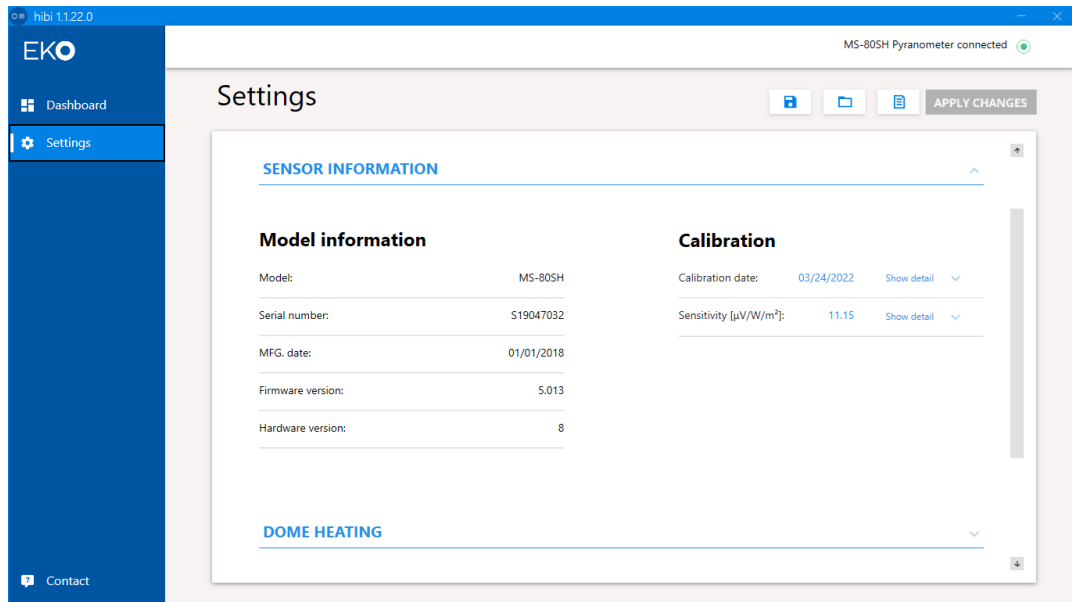


Figure A3-15. Sensor information settings

3. 'DOME HEATING' setting items

Item Name	Setting contents	Setting range
DOME HEATING	Enable DOME HEATING	DOME HEATING OFF/ON (selected with the radio button) * Default is ON.

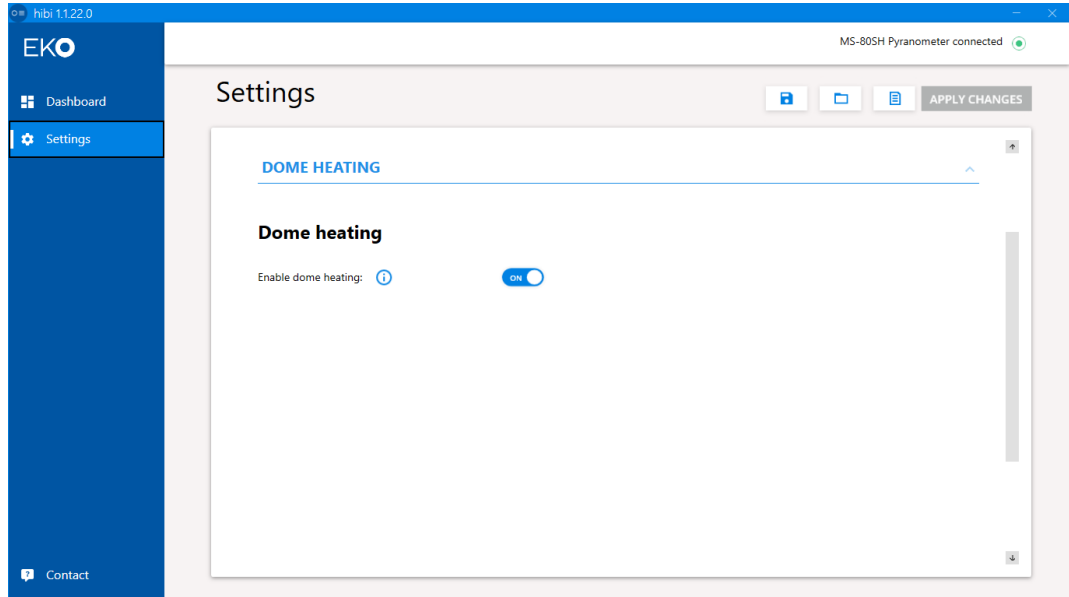


Figure A3-16. DOME HEATING settings screen

4. 'TEMPERATURE' setting items

Item Name	Setting contents	Setting range
UNIT	Preferred unit (Temperature unit setting)	°C -Celsius / °F -Fahrenheit / K-Kelvin

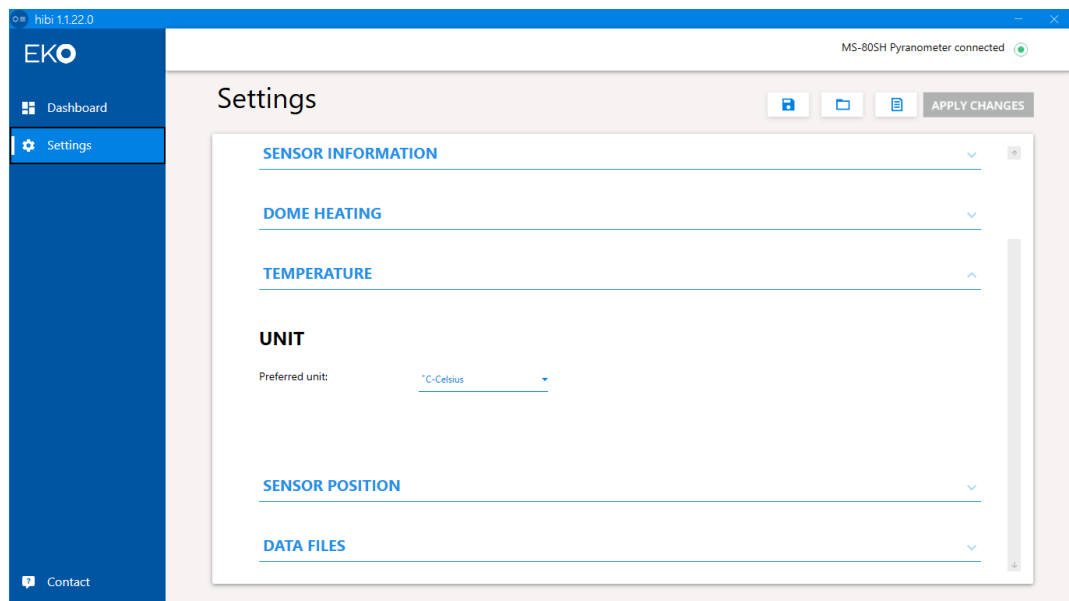


Figure A3-17. Sensor settings screen

5. 'SENSOR POSITION' setting items

The sensor position can be measured in two different planes (X, Y).

<Tilt (X axis)> (180° to 0) and (0 to -180°)

<Roll (Y axis)> (180° to 0) and (0 to -180°)

The tilt and roll angles are relative to the calibrated X and Y axis of the sensor and surface mounting plane X' and Y'. When the sensor is positioned in the same plane $X = X'$ and $Y = Y'$, the measured angles X and Y represent the corresponding plane of installation X' and Y'.



Clicking 'ZERO ADJUSTMENT' allows you to adjust Tilt (X axis) and Roll (Y axis) of Tilting items using the present tilt angle as 0°. The spirit vial can be used as a reference to readjust the tilt and roll position. The X and Y position of the MS-80SH is factory calibrated.

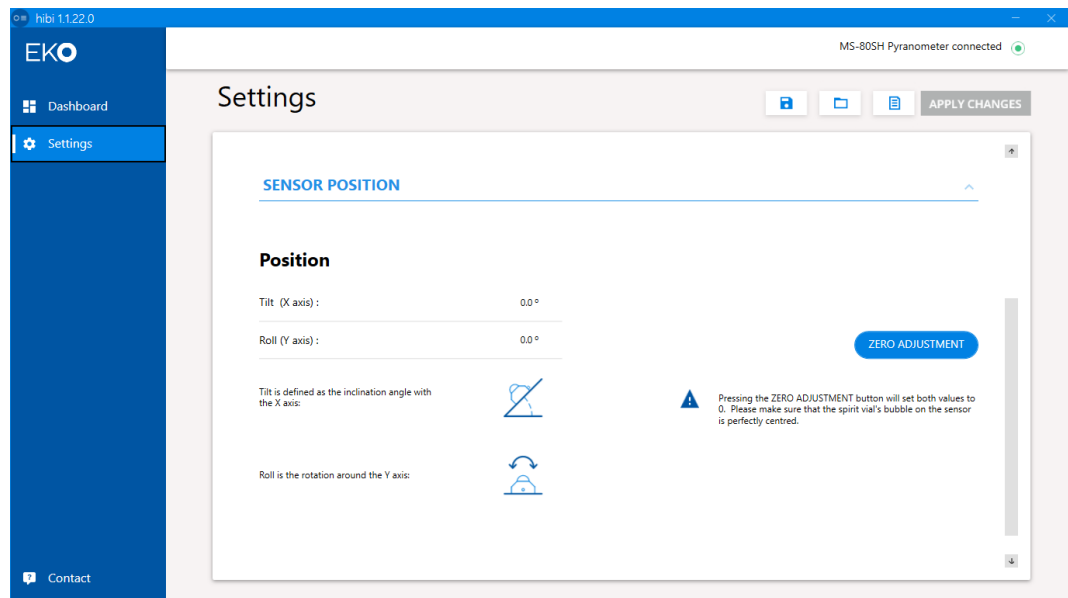


Figure A3-18. Sensor Position setting

6. DATA FILES setting items

[Measurements]

<Save file to> Enter the name of the measurement data storage folder.

[Sensor settings]

<Save file to> Enter the name of the setting file storage folder.

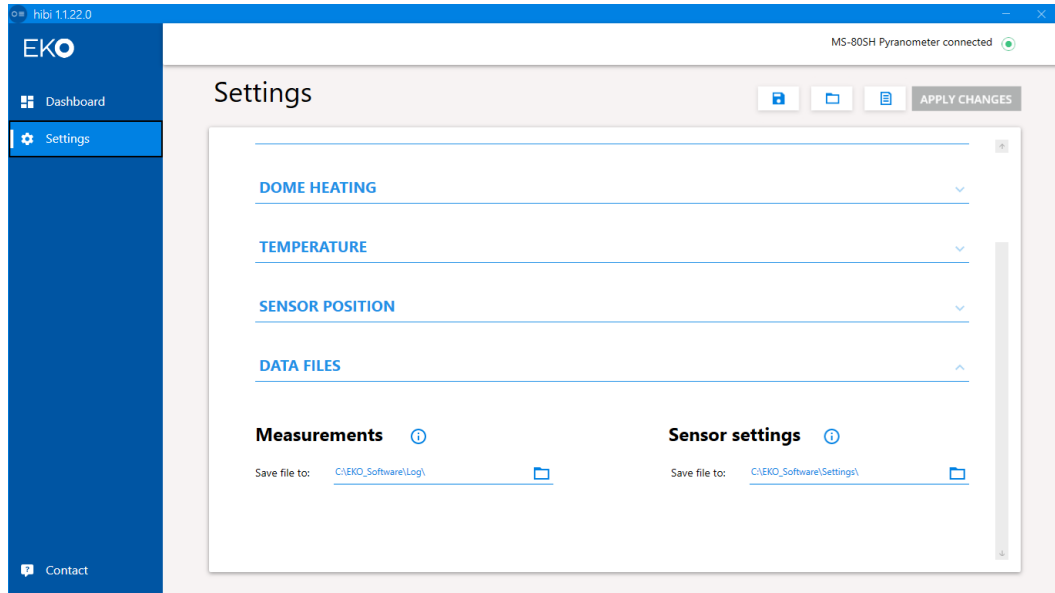


Figure A3-19. Data Files setting

6) Measurement (Dashboard)

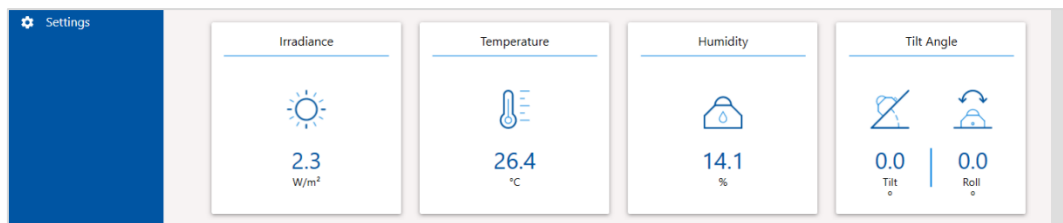


Figure A3-20. Dashboard screen

[Overview]

- Measurement data for irradiance, temperature, humidity, and tilt angle are read from the MS-80SH every 1 second and displayed.

<Irradiance> Irradiance measurement data (Unit: W/m²)

<Temperature> Internal temperature measurement data.

Unit: selected from °C (Celsius), °F (Fahrenheit) or 'K (Kelvin)'. (°C: default)

<Humidity> Humidity measurement data (Unit: '%RH')

<Tilt Angle> Tilt (X axis angle) and Roll (Y axis angle) data

[Real-time measurement view]



Figure A3-21. Real-time measurement view

<Real time measurement-Irradiance>

- Display measured irradiance data in a graph (1-second update).
- Drag the graph to change the horizontal axis position and use the mouse wheel to zoom in or out on the desired area.
- The time range of the graph is 00:00:00 to 23:59:59.
- Clicking 'Back to default' resets the change of the setting of the graph.

<Data Logging>

Logging function of measurement data

'Sample time:' Set the logging interval for measurement data.

Setting range: 00:01~01:00 (1 sec to 1 min)

'Average interval:' Set the logging interval for averaged measurement data.

Setting range: 00:01~01:00 (1 sec to 1 min)

'Measure intervals:' Set the time interval for data logging.

By checking 'Continue next days', it is also possible to keep setting after the next consecutive days.

'Start at:' Set the start time for data logging.

'Ends at:' Set the end time for data logging.

* Setting across the day is not possible. The start time must be earlier than the end time. (Start time < End time)

'LOG DATA buttons:' Click to start logging measurement data.

When 'STOP' is clicked while measurement data is being logged, logging stops.

7) Contact (Contact)

When you click the 'Contact' button, the contact page on [EKO Instruments] website appears in the Browser.

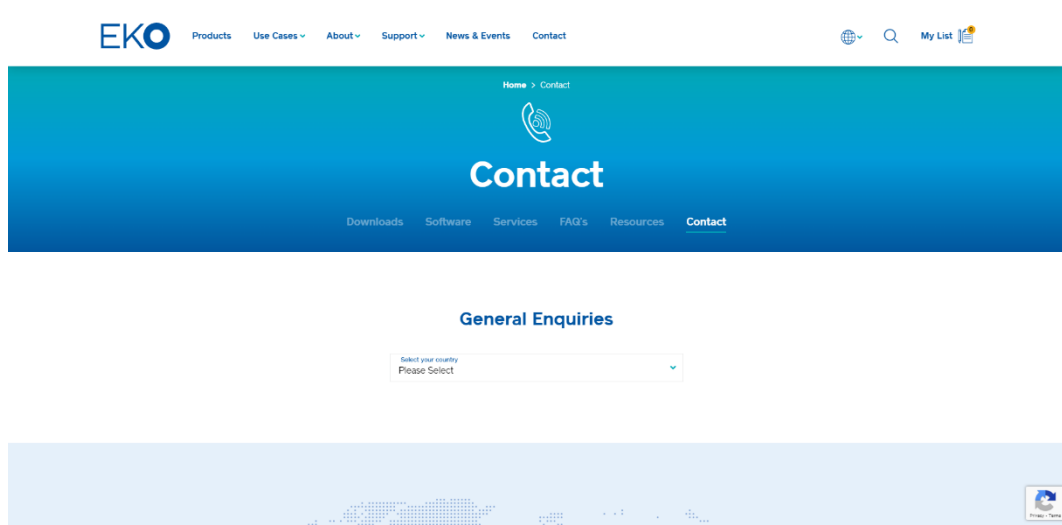


Figure A3-22. Contact page @ eko-instruments.com

8) Sensor internal humidity abnormality alert

Hibi has a function to monitor the relative internal humidity of the pyranometer at all times. When the internal relative humidity exceeds the standard value due to external failure or deterioration of drying agent over time, Hibi judges it to be abnormal and displays an alert. If a pyranometer is left as is after the alert, the possibility of a problem such as condensation inside the pyranometer glass dome will increase, so please contact EKO.

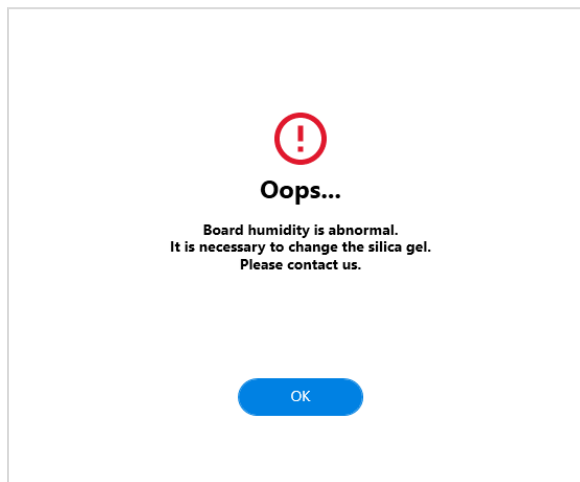


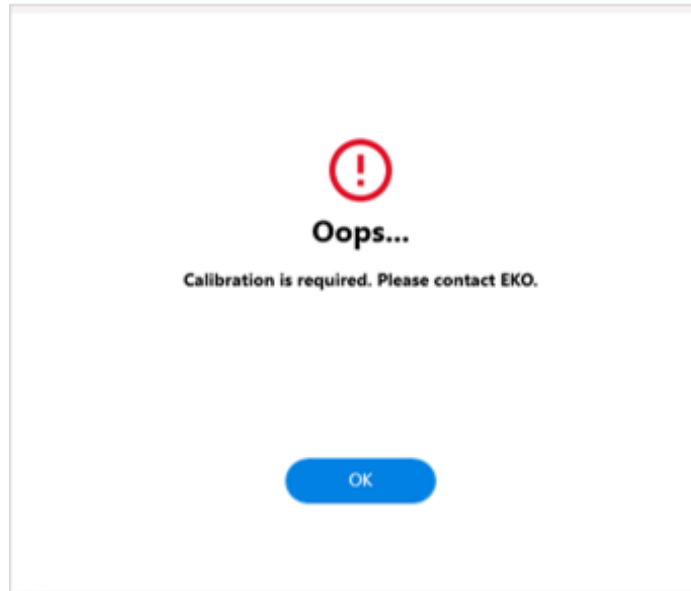
Figure A3-23. Sensor internal humidity abnormality alert

9) Recalibration recommendation notice

If Hibi detects that 5 years (1825 days) have passed since the initial calibration date, a recalibration recommendation notice will appear.

If the above notification is displayed, please contact EKO for recalibration.

* In the case of leap years, notifications will be displayed from the day before.



FigureA3-24. Recalibration recommendation notice

10) Exiting the software (Hibi)

To exit Hibi, click the 'X' in the upper-right corner of the window.

A-4. Communication Specifications (Modbus RTU)

A4-1. Outlines

- This device is compatible with Modbus RTU*. ASCII modes are not supported.
(* This is an open protocol for serial communication developed by Modicon.)
- The initial setting of the communication interface is Modbus RTU mode. To use the SDI-12 mode, change the settings from 'Hibi' software. After changing the setting, turn the power off and then on again to operate with SDI-12. To return to Modbus RTU mode again, change the setting from 'Hibi' software.
- It corresponds to RS485, half-duplex and double-wire multi-drop networks.

The communication specifications are as follows.

Table A4-1. Modbus RTU communication protocol

Optional item	Remarks
Electrical specifications	EIA-485
Connection form	Multi-drop method (1 for Master, 31 for Slave, 32 for total)
Communications protocols	Modbus RTU *1 (Slave)
Communication speed baud rate	2400, 4800, 9600, 19200 , 38400, 115200 bps
Data length	8 bit
Stop bit	1 bit/2 bit *2
Parity bit	None/Odd/ Even
Communication distance	Max.1000m (ideal value)
Error detecting system	CRC-16

*1: An open protocol developed by Modicon for serial communication.

*2: The value of the stop bit is determined automatically by the parity bit setting.

A4-2. Function code

- There is no distinction between Coil and Discrete Input addresses.
- There is no distinction between Holding Register and Input Register addresses.
- Coil, Discrete Input, Holding Register, Input Register addresses start from '0'.

Table A4-2. Supported Function Codes

Function code (hexadecimal)	Function
0x01	Read Coils
0x02	Read Discrete Inputs
0x03	Read Holding Registers
0x04	Read Input Register
0x05	Write Single Coil
0x06	Write Single Register
0x10	Write Multiple Registers

A4-3. Communication specification

- The address range can be used from 1 to 247.
- The maximum frame size that can be communicated at a time is 256 bytes (maximum read registers: 125, maximum write registers: 123).
- The baud rate (bit/sec) can be selected from 2400, 4800, 9600, 19200, 38400 and 115200.
- Parity can be selected from 'Even', 'Odd' or 'None'.
- The bit width is 8 bits, the stop bit is 1 bit when parity is present, and 2 bits when parity is absent.
- If the address and communication settings are changed, the equipment must be restarted.

Table A4-3. Communication setting

Setting No.	Bit rate	Parity
0	2400	None
1	2400	Even
2	2400	Odd
3	4800	None
4	4800	Even
5	4800	Odd
6	9600	None
7	9600	Even
8	9600	Odd
9	19200	None
10 (default)	19200	Even
11	19200	Odd
12	38400	None
13	38400	Even
14	38400	Odd
15	115200	None
16	115200	Even
17	115200	Odd

A4-4. Cable connection

- RS485 communication ground and the power ground are the same.

Be sure to connect the ground of RS485 communication interface to the power ground.

A4-5. Data format

Table A4-4. Data format to use.

Format	Abstract
U16	Unsigned 16bit Integer
S16	Signed 16bit Integer
U32	Unsigned 32bit Integer
S32	Signed 32bit Integer
F32	IEEE754 32bit floating point format
Str	ASCII characters string

- The byte order for communication is big endian.
2byte values are sent in the order of H byte → L byte
4byte values are sent in the order of H word → L word
Character strings are sent in the order of 1 byte from the beginning.
Allocation of each format is shown in the table below.

Table A4-5. Assignment of 8/16/32 bit value

8bit	0x12	0x34	0x56	0x78
16bit	0x1234(MSW)		0x5678(LSW)	
32bit	0x12345678			

Table A4-6. Assignment of 8/16 bits and F32

8bit	0x41	0x45	0x85	0x1E
16bit	0x4145(MSW)		0x851E(LSW)	
F32	12.345			

Table A4-7. Assignment of 8/16bit and Str

8bit	0x41	0x42	0x43	0x44
16bit	0x4142(MSW)		0x4344(LSW)	
Str	'ABCD'			

- Unless otherwise stated, the 32-bit register is in the order of high word (MSW) followed by low word (LSW).
The following table shows the cases where 0x12345678 is assigned to address n of Modbus register.

Table A4-8. Relationship between 32-bit values and Modbus registers

32-bit value	0x12345678
Modbus register (address n)	0x1234(MSW)
Modbus register (n+1)	0x5678(LSW)

A4-6. Outline of 1 Holding/Input register map

- The register map starts from address 0.
- The contents of registers No. 0 to 49 are switched according to the register type setting (No.103).
- Registers No. 0 to 99 are read-only.
- Registers after No.101 can be read or written to.

A4-7. No. 0-49 Register details

- The register map changes depending on the register type setting. The following table shows 4 register maps.
- See in parentheses for the unit.
- Fixed value if the content is numeric.
- The blank space is not used. It is filled with zero in U16 format.
- The abbreviations are as follows.

Addr: Modbus slave address (1-247)

Comp Irr: Irradiance value after compensation of temperature and linearity.

Raw.Irr: Irradiance before correction

AD: Input voltage

Sensitivity: Calibration factor

Cal. Date: Calibration date

Supply: Supply Voltage

Sensor Name: Sensor name (MS-80SH)

Firm Ver: Firmware version number

Hard Ver: Hardware version number

L. Coeff: Linearity compensation factor, set by No.182-189

Table A4-9. No. 0-49 Register S-series type (default)

0	Model	U16	Model number of the transmitter.(MS-80SH:0x0210)
1	0	U16	Fixed value
2	Comp.Irr	F32	Adjusted solar radiation intensity Unit: (W/m ²)
3			
4 to 7 are Reserve			
8	Pt100	F32	Sensor temperature Unit: (°C)
9			
10 to 13 are Reserve			
14	X-axis tilt angle	F32	X-axis component of the tilt angle Unit: (°)
15			
16	Y-axis tilt angle	F32	Y-axis component of the tilt angle Unit: (°)
17			
18	Raw.Irr	F32	Intensity of solar radiation before correction Unit: (W/m ²)
19			
20	ADmV	F32	Sensor output voltage Unit: (mV)
21			
22	Internal temperature	F32	Temperature measured by the internal temperature sensor Unit: (°C)
23			
24	Internal humidity	F32	Relative humidity measured by the internal humidity sensor Unit: (% RH)
25			
26	Alerts for abnormal internal humidity of the pyranometer	U32	Alerts for abnormalities in the internal humidity of the pyranometer Normal: 0, Abnormality occurs: 1
27			
28	Alerts for abnormal dome heating function of the pyranometer	U32	Alerts for abnormalities in the dome heating function of the pyranometer Normal: 0, Abnormality occurs: 1
29			
30 to 49 are Reserve			

Table A4-10. No.0-49 register M-series type

0	Serial number	U16	Serial No. 1st /2nd ASCII
1			Serial No. 3rd/4th ASCII
2			Serial No. 5th/6th ASCII
3			Serial No. 7th/8th ASCII
4			Serial No. 9th/10th ASCII
5			Serial No. 11st/12nd ASCII
6			Serial No. 13rd/14th ASCII
7			Serial No. 15th/16th ASCII
8	Model number	U16	Model No. 1st /2nd ASCII
9			Model No. 3rd/4th ASCII
10			Model No. 5th/6th ASCII
11			Model No. 7th/8th ASCII
12			Model No. 9th/10th ASCII
13	Minimum solar radiation intensity	U16	0 (fixed)
14	Maximum solar radiation intensity	U16	1600 (fixed)
15	Measurement Mode	U16	2(fixed)
16	Sensitivity ($\mu\text{V}/\text{W}\cdot\text{m}^{-2}$)	F32	Sensitivity (LSW)
17			Sensitivity (MSW)
18	Temperature unit	U16	Unit: °C、1 (fixed)
19	AD(mV)	F32	Input Voltage (LSW)
20			Input voltage (MSW)
21	Comp.Irr(W/m ²)	F32	Corrected insolation intensity (LSW)
22			Corrected insolation intensity (MSW)
23	Temp(°C)	F32	Sensor temperature (LSW)
24			Sensor temperature (MSW)
25	Password	U16	8355 (fixed)
26 to 33 are Reserve			
34	L.Coeff. k1	F32	Linearity correction factor 1-k1 (LSW)
35			Linearity correction factor 1-k1 (MSW)
36	L.Coeff. k2	F32	Linearity correction factor 2-k2 (LSW)
37			Linearity correction factor 2-k2 (MSW)
38	L.Coeff. k3	F32	Linearity correction factor 3-k3 (LSW)
39			Linearity correction factor 3-k3 (MSW)
40	L.Coeff. k4	F32	Linearity correction factor 4-k4 (LSW)
41			Linearity correction factor 4-k4 (MSW)
42	Addr	U16	Node number
43	BPS	F32	Communication speed (LSW)
44			Communication speed (MSW)
45	Parity	U16	Parity bit
46 to 49 are Reserve			

Table A4-11. No. 0-49 register SMP-series type

0	65535	U16	Fixed value
1	100	U16	Fixed value
2	1	U16	Fixed value
3	0	U16	Fixed value
4	1	S16	Fixed value
5	Comp.Irr (W/m ²)	S16	
6	Raw.Irr (W/m ²)	S16	
7	0	S16	Fixed value
8	Temp (0.1°C)	S16	Sensor temperature
9	Supply (0.1V)	S16	
10	0	S16	Fixed value
11	0	S16	Fixed value
12	0	S16	Fixed value
13	0	S16	Fixed value
14	0	S16	Fixed value
15	0	S16	Fixed value
16	0	U16	Fixed value
17	0	U16	Fixed value
18	AD(0.01uV)	S32	
19			
20	0	S32	Fixed value
21			Fixed value
22	0	S32	Fixed value
23			Fixed value
24	0	S32	Fixed value
25			Fixed value
26	0	U16	Fixed value
27	0	U16	Fixed value
28	0	U16	Fixed value
29	0	U16	Fixed value
30	0	U16	Fixed value
31	0	U16	Fixed value
32	0	U16	Fixed value
33	0	U16	Fixed value
34	0	S16	Fixed value
35 to 40 are Reserve			
41	2020	U16	Fixed value
42	0	U16	Fixed value
43	Firm Ver	U16	
44	Hard ver.	U16	
45	Address	U16	
46 to 49 are Reserve			

Table A4-12. No. 0-49 Registers SRD-series type

0	Address	U16	
1	Com.Set	U16	
2	Comp.Irr(0.01W/m ²)	S32	
3			
4	Raw.Irr(0.01W/m ²)	S32	
5			
6	Temp (0.01°C)	S16	Sensor temperature
7	0	U16	Fixed value
8	100	U16	Fixed value
9	100	U16	Fixed value
10	AD(nV)	S32	
11			
12 to 31 are Reserve			
32	Sensor Name	Str	
33			
34			
35			
36			
37			
38			
39			
40	0	U16	Fixed value
41	Sensitivity ($\mu\text{V}/\text{W}\cdot\text{m}^{-2}$)	F32	
42			
43	0	U16	Fixed value
44	0	U16	Fixed value
45	0	U16	Fixed value
46	Cal.date (YYYYMMDD)	U32	
47			
48 to 49 are Reserve			

A4-8. Measurement value register update cycle

- The sensor output and the tilt angle measurement value in the register are automatically updated.

The update cycle is about 110 msec. If the data read cycle is less than 110msec, the same data will be read multiple times. The data read cycle should be 110msec or more.

A4-9. Register details from No.50 to 99

- A fixed value of zero (U16) has been written to an address that is not used.
- The 'EKO' character is written as the company name registration in register No. 96 and 97.

Table A4-13. Register No.50-95

50 to 95 are Reserve

Table A4-14. Register No.96-99

96	Company name (0,1)		The company name in ASCII format 'EKO' is read.
97	Company name (2,3)	Str	Four 'EKO' characters, three 'EKO' characters and one space (0x20).
98	Firmware version	U16	Firmware version number.
99	Hardware version	U16	Various parts of hardware

A4-10. No. 101 or later registers

- Registers after No.101 are readable and writable, and values written are immediately reflected.
- To save the written data, use Discrete Coil shown below to save the data.
- The 2 registers, Modbus address (No.101) and serial communication setting (No.102) related to communication are not reflected in the operation after saving and rebooting.

Table A4-15. Register No.100-199

100 is Reserve			
101	Modbus Address	U16	Modbus slave address
102	Serial Communication Setting	U16	Set bit rate and parity, see Table A4-3. 'Communication setting'
103	Register Type	U16	No. Refer to the register type setting Table A4-9 - Table A4-12 of No.0-49 register.
104 to 150 are Reserve			
151	Dome Heating function	U16	OFF:0, ON:1 (Default)
152 to 161 are Reserve			
162	Date of manufacture	U32	Date of manufacture in YYYYMMDD format
163			
164	Serial number	U32	Serial number with 32-bit integer value (maximum value 4294967295) Enter the number part excluding the alphabet S.
165			
166	Sensor name (0,1)	Str	Sensor name according to ASCII format, up to 16 characters Null-terminated unless all 16 characters are used
167	Sensor name (2,3)		
168	Sensor name (4,5)		
169	Sensor name (6,7)		
170	Sensor name (8,9)		
171	Sensor name (10,11)		
172	Sensor name (12,13)		
173	Sensor name (14,15)		
174 to 181 are Reserve			
182	L.Coeff.k1	F32	Linear correction factor k1
183			
184	L.Coeff.k2	F32	Linear correction factor k2
185			
186	L.Coeff.k3	F32	Linear correction factor k3
187			
188	L.Coeff.k4	F32	Linear correction factor k4
189			
190	Cal.Date	U32	Calibration date in YYYYMMDD format
191			
192	Cal.Value	F32	Calibration value, $\mu\text{V}/\text{W} \cdot \text{m}^2$
193			
194 to 199 are Reserve			

Table A4-16. Register No.200-219

200	Cal.Date history0	U32	Calibration History, Date 0
201			
202	Cal.Value history0	F32	Calibration history, sensitivity constant 0
203			
204	Cal.Date history1	U32	Calibration History, Date 1
205			
206	Cal.Value history1	F32	Calibration History, Sensitivity Constant 1
207			
208	Cal.Date history2	U32	Calibration History, Date 2
209			
210	Cal.Value history2	F32	Calibration History, Sensitivity Constant 2
211			
212	Cal.Date history3	U32	Calibration History, Date 3
213			
214	Cal.Value history3	F32	Calibration History, Sensitivity Constant 3
215			
216	Cal.Date history4	U32	Calibration History, Date 4
217			
218	Cal.Value history4	F32	Calibration History, Sensitivity Constant 4
219			

A4-11. Linear correction factor

- Calculate the pyranometer output after linear correction using the following equation using the coefficient $k1/k2/k3/k4$ for the solar radiation meter output $V(\text{raw})$ after temperature correction.
- Linear post-correction sun photometer output $V(L) = k1 + (k2 \cdot V(\text{raw})) + (k3 \cdot V(\text{raw})^2) + (k4 \cdot V(\text{raw})^3)$
- The default value is $k2=1, k1=k3=k4=0$, so $V(L)=V(\text{raw})$, and the raw value is used for the corrected pyranometer output.

A4-12. Solar irradiance after correction

- After the linear correction and temperature correction written above, using the sensitivity value $S(\mu\text{V}/\text{W} \cdot \text{m}^2)$ for the output voltage, according to the following equation, calculate the irradiance value.

$$\text{Corrected solar irradiance: } I(C) = V(L) \times 1000/S$$

*Since the unit of $V(L)$ is millivolts, multiply it by 1000 to obtain the irradiance value.

A4-13. Outline of Coil / Discrete Input Registers

- Reboot the device and save the settings by writing a specified bit.
- Do not write to any Coil other than Reboot/Save.
- The readout is always zero.

A4-14. Register details

Table A4-17. Coil register

Addr	Parameter	R/W	Type
0	-	-	-
1	Reboot	W	Bit
2	-	-	-
3	Save	W	Bit
4	-	-	-
5	-	-	-
6	-	-	-
7	-	-	-

A-5. Communication specification (SDI-12)

A5-1. Abstract

- SDI-12 (Version:1.4) is supported.
- The initial setting of the communication interface is Modbus RTU. To use the SDI-12 interface, change the settings from 'Hibi' software. After changing the setting, turn the power off and then on again to operate with SDI-12 mode. To return to Modbus RTU mode again, change the setting from 'Hibi' software.
- When SDI-12 is enabled, the unit operates in 'low power standby mode' with power consumption of approx. 2.5mA (at 12V) during non-communication.

A5-2. Communication specification

- The communication specifications of SDI-12 are as follows.

Table A5-1. SDI-12 Communication Specifications

Item	Description
Communications protocols	SDI-12 Version 1.4
Baud rate	1,200 bps
Data length	7bit
Stop bit	1
Parity bit	Even
Communication distance	Within 60 m

A5-3. Command list

- SDI-12 commands are listed below.
- The lowercase letter 'a' in the command list indicates SDI-12 address number.
- SDI-12 address number that can be set is 0-9, A-Z, a-z.

Table A5-2. SDI12 Commands

Command	Response	Description
?!	a<CR><LF>	Check the address number of the connected device. NOTE: If more than one device is connected, it will not function properly. Be sure to use the device alone.
a!	a<CR><LF>	Verify that the device with address number 'a' is active.
aAb!	b<CR><LF>	Change the address number of the device with address number 'a' to 'b'.
a!	Refer to the right section	Returns information. <Response example> 'a14EKOINST_MS-80SHV3220000001<CR><LF>' a: SDI-12 address 14: SDI-12 version (represents version 1.4) EKOInst: Company name (8 characters) MS-80SH: Sensor model name (6 characters) V32: Sensor version (3 characters) 20000001: Serial number (8 characters)
aM!	a0001<CR><LF>	Request the device with address number 'a' to execute measurement. 0001: indicates the 3-digit measurement execution time (000 indicates instantaneous), and the 4th digit indicates the number of data to be returned (1 piece).
aD0! aD1! aD2! aD3! aD4!	a+1000.0<CR><LF>	Request to send data to the device with address number 'a'. The output value is always appended with a sign (+ or -). If there is more than one output, the sign is also the delimiter. D0: Irradiance (W/m ²) 1 digit after decimal point D1: Sensor output voltage (mV) 4 digits after decimal point and Sensor temperature (Celsius) 2 digits after decimal point D2: X-axis tilt angle (degree) 1 digit after decimal point, forward/backward with connector facing back, positive value when back is up, Y-axis tilt angle (degree) 1 digit after decimal point, left/right with connector facing back, negative value when left is down D3: Internal temperature of pyranometer body (°C) 1 digit after the decimal point, Humidity inside the enclosure (% RH) 1 digit after the decimal point. D4: Alert to notify users of abnormality in the internal humidity and dome heating function of the pyranometer returns 0 for a normal condition and 1 for an abnormal condition. If the pre-measurement command is 'MC', then three CRC characters are followed, please refer to SDI-12 standard for the content of CRC characters.

aMC!	a0011<CR><LF>	Request the device with address number 'a' to start measurement and request the CRC to confirm that the command is correctly accepted. The response format is the same as 'aM!'
aC!	a00101<CR><LF>	This device is the same as the 'aM!' command except for the difference in the number of response characters. The character following a indicates the number of seconds (3 digits) and the number of data (2 digits).
aCC!	a00101<CR><LF>	This transmitter is the same as the 'aMC!' command except for the difference in the number of response characters.
aR0!	a+0.0<CR><LF>	Request a measurement from the device with address number 'a'. Measurement is executed and a response is returned immediately. The answer is similar to 'aD0!' to 'aD2!' command.
aRC0!	a+0.0EmT<CR><LF>	Request measurement from the device with address number 'a' and request error detection to verify that the command was accepted correctly. Measurement is executed and the measured value with three CRC characters added at the end is returned instantly.
aXSE!	a+XX.XX<CR>><LF>	Read the sensitivity constant of this device. Two digits after the decimal point.
aXCD!	aYYYYMMDD<CR><LF>	Read the calibration date of this device. YYYY: AD, MM: month, DD: day.
aXHT!	a+1<CR><LF>>	Reads the dome heating function status. ON:1, OFF:0
aXHT1!	a<CR><LF>	Change the dome heating function setting to ON.
aXHT0!	a<CR><LF>	Change the dome heating function setting to OFF.
METADATA	Variable depending on request data	Identify Measurement Commands and Identify Measurement Parameter Commands are supported.

A-6. About recalibration

When recalibrating at a recalibration center other than EKO, the calibration scale of the other center may differ slightly from the pyranometer calibration scale and sensitivity constants ($\mu\text{V}/\text{W}\cdot\text{m}^{-2}$) obtained by EKO. The differences may be caused by differences in the calibration method, differences in the reference standard, measurement uncertainty, and measurement conditions.

If a new sensitivity constant was found and needs to be applied to the pyranometer, it can be applied in two ways:

- 1) (Post data correction) Multiply the relative difference of the irradiance value measured with the pyranometer. In this case, the original factory sensitivity value given by EKO remains unchanged. When the new sensitivity figure was found apply the ratio of the new and original calibration figure according to the formula below:

$$I_{new} [\text{W}/\text{m}^2] = \frac{E [\mu\text{V}]}{S_{original} [\mu\text{V}/\text{W}\cdot\text{m}^{-2}]} \times \frac{S_{original} [\mu\text{V}/\text{W}\cdot\text{m}^{-2}]}{S_{new} [\mu\text{V}/\text{W}\cdot\text{m}^{-2}]}$$

Example:

It was proven that there was a relative difference in irradiance measured by the MS-80SH and the reference pyranometer. In this example the irradiance measured by the MS-80SH was lower than the irradiance measured by the reference pyranometer, a new sensitivity value can be calculated and applied by the following equation.

$$S_{new} = I_{MS80SH} / I_{ref} \times S_{original}$$

S_{new}	NewMS-80SH Sensitivity ($\mu\text{V}/\text{W}/\text{m}^2$)
S_{origin}	MS-80SH Original Sensitivity ($\mu\text{V}/\text{W}/\text{m}^2$)
I_{MS80SH}	Irradiance measured by the MS-80SH (W/m^2)
I_{ref}	Irradiance measured by reference pyranometer (W/m^2)

- 2) (Change the sensitivity figure of the MS-80SH) Set a new sensitivity figure to the MS-80SH. This can be done via through the Hibi software. Connect the MS-80SH to a PC with a RS485/USB converter cable. In settings, the new sensitivity figure can be applied. The original sensitivity figure remains, but will be replaced by the 'last' sensitivity figure ($\mu\text{V}/\text{W}/\text{m}^2$). Multiple calibration figures can be stored inside the pyranometer, the 'last' sensitivity figure is the actual one to calculate the irradiance.

A-7. Temperature Response Measurement Test Report

Each MS-80SH Pyranometer is shipped with a unique 'Temperature Response Measurement Test Report'. The report shows the temperature response test data when the dome heating function is turned off (disabled).

The dome heating function of the MS-80SH can be toggled ON (enabled) or OFF (disabled).

The following figure (Figure A6-1) shows an example of temperature response test data obtained from a single MS-80SH with the dome heating function turned ON and OFF, respectively.

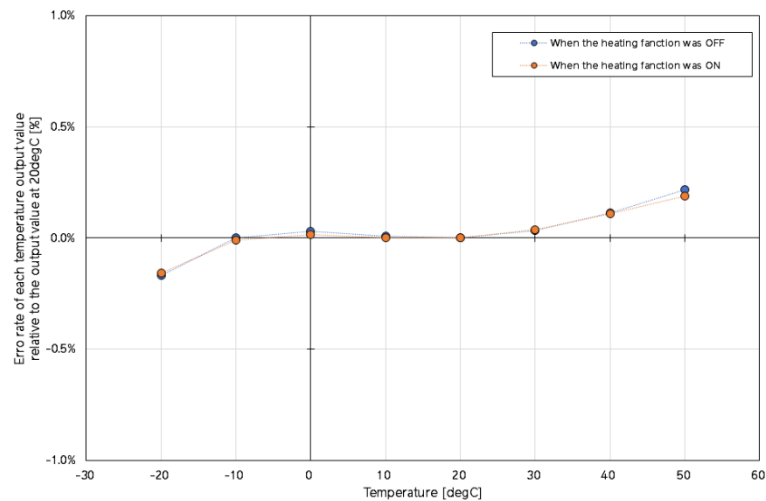


Figure A6-1: Comparison of temperature response when dome heating function is ON and OFF

The energy-efficient dome heating function of the MS-80SH heats the entire pyranometer housing and maintains the temperature of the glass dome above the outside temperature. The figure above (Figure A6-1) shows that the temperature increases of the housing, caused by the heating function, has almost no effect on the temperature response of the pyranometer.

The following figure (Figure A6-2) shows the difference in the error rate of the output value at each temperature setting relative to the output value at an ambient temperature of 20°C. This data shows the test results obtained for 10 units of the MS-80SH with the dome heating function ON and OFF, respectively.

The difference in temperature response error rate with the dome heating function ON and OFF in the temperature range from -20°C to +50°C is negligible, within $\pm 0.1\%$.

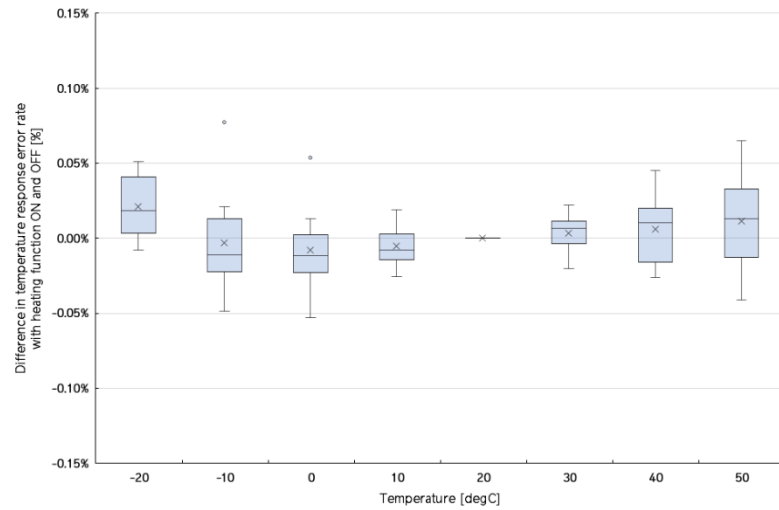


Figure A6-2: *Difference in temperature response error rates for 10 units of MS-80SH with heating function ON and OFF*

These results indicate that the temperature response test report data provided with the product is applicable in any case, regardless of whether the dome heating function is ON or OFF.

A-8. MS-80SH Setting Report



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SH-series Setting Report

Issue Date: 11-Jul-22

Factory setting data	
Sensor type	Pyranometer
Model name	MS-80SH
Serial number (S*****)	19047032
Manufacturing date	May 11, 2022
Calibration date	May 10, 2022
Analog sensitivity [μV/W/m ²]	11.15
Hardware version	8
Firmware version (*.***)	5030

Dome Heating Function	Setting
ON/OFF	ON (Default)

Modbus RTU	Setting
Enable/Disable ^(*)	Enable (Default)
Address	32
Baudrate	19200
Parity	EVEN
Reg. type	EKO-S

SDI-12	Setting
Enable/Disable ^(*)	Disable (Default)
Address	0
Baudrate	1200

^(*) Enable/Disable settings for Modbus RTU and SDI-12 are only available for MS-80SH with product serial number S23038500' or earlier.

A-9. Surge protection

Since a surge protection board is embedded inside the pyranometer, this alone provides strong protection against lightning surges.

However, if the pyranometer cable is longer than 10m, or if multiple pyranometer are connected and the total cable length exceeds 10m, the connected loggers, power supply, and other devices may be damaged by lightning surges.

Please refer to the figure below and an appropriate SPD shall be added to protect the measurement system.

A. Modbus RTU connection (when the cable length exceeds 10m)

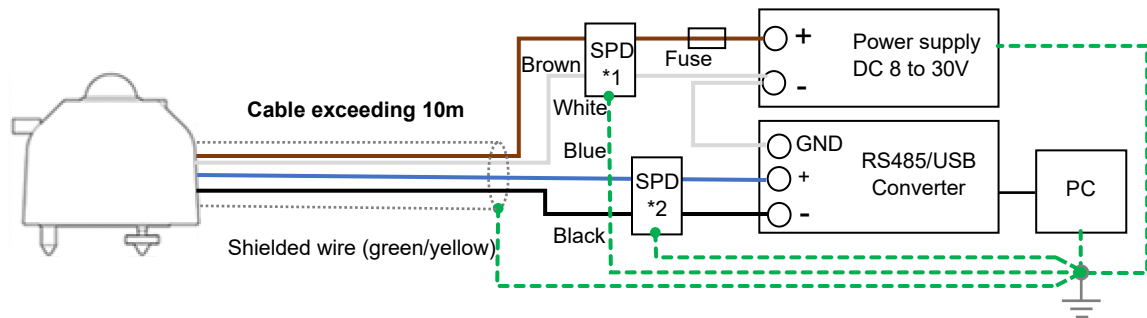


Figure A9-1. Modbus RTU connection (when the cable length exceeds 10m, etc.)

*1 *2

If the cable length exceeds 10m, an SPD for the communication line and an SPD for the DC power supply shall be set up because surges may enter from the communication line and the power supply line.

B. SDI-12 connection (when the cable length exceeds 10m)

B-1. For MS-80SH with product serial number 'S23038500' or earlier

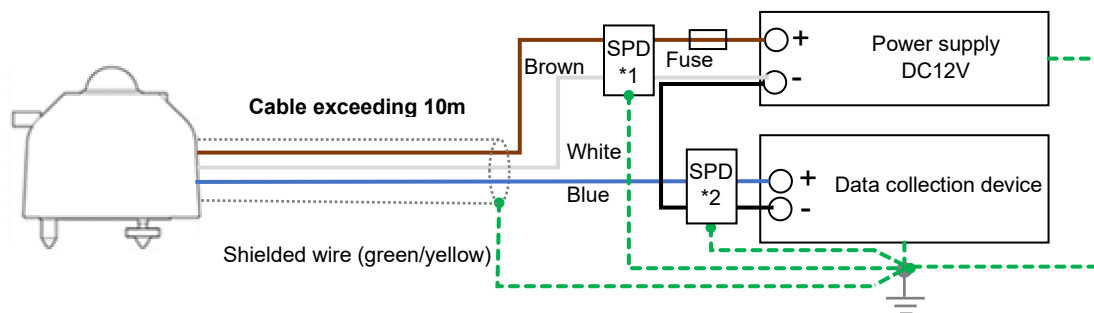


Figure A9-2. SDI-12 connection (when the cable length exceeds 10m, etc.)

*1 *2

If the cable length exceeds 10m, an SPD for the communication line and an SPD for the DC power supply shall be set up because surges may enter from the communication line and the power supply line.

B-2. For MS-80SH with product serial number 'S23038501' or later

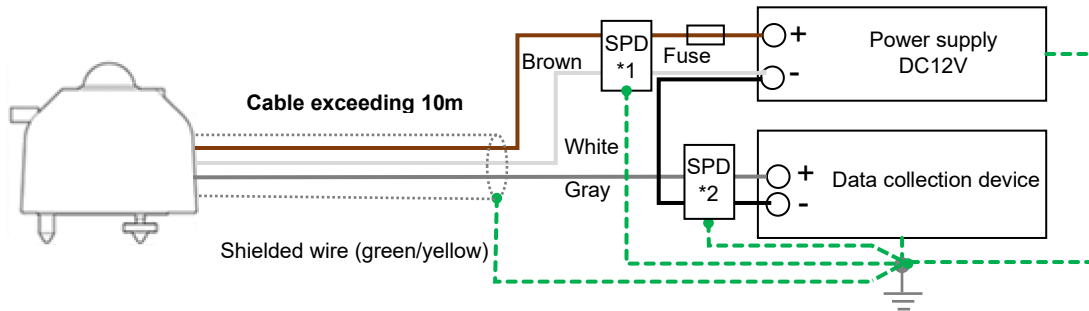


Figure A9-2. SDI-12 connection (when the cable length exceeds 10m, etc.)

*1 *2

If the cable length exceeds 10m, an SPD for the communication line and an SPD for the DC power supply shall be set up because surges may enter from the communication line and the power supply line.

In the case of lightning surges, the more countermeasure components are used, the lower the probability of failure. However, the type, rating, and connection method of the SPD to be used vary depending on the manufacturer, so please read the instruction manual of each manufacturer carefully.



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