Sunshine Duration Sensor

MS-95S

EKO

1. Index

2. Important User Information

Thank you for using EKO Products

Reading this manual is recommended prior to the installation and operation of the product. Keep this 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 delivered to customers have been tested to ensure the instrument meets its published specifications. The warranty included in the conditions of delivery 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] occurs, the defected 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 other than EKO service personnel.
➢ The damage or defect is caused by disrespecting the specifications mentioned on the product brochure or instruction manual.

The warranty does not apply to the following:

➢ Spirit level
➢ Discoloration of the sunshine duration sensor body, sun screen, and cable within a range that does not affect the function and performance.

2-3. About the Instruction Manual

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This manual was issued: Nov. 17, 2022
Version Number: 1

2-4. Environmental Information

1. WEEE Directive 2002/96/EC
[Waste Electrical and Electronic Equipment]

In August of 2005, the European Union [EU] implemented the EU WEEE Directive 2002/96/EC and later the WEEE Recast Directive 2012/19/EU requiring Producers of electronic and electrical equipment [EEE] to manage and finance the collection, reuse, recycling and to appropriately treat WEEE that the Producer places on the EU market after August 13, 2005. The goal of this directive is to minimize the volume of electrical and electronic waste disposal and to encourage reuse and recycling at the end of life.

EKO products are subject to the WEEE Directive 2002/96/EC. EKO Instruments has labelled its branded electronic products with the WEEE Symbol [figure Trash bin] to alert our customers that products bearing this label should not be disposed of in a landfill or with municipal or household waste in the EU.

If you have purchased EKO Instruments branded electrical or electronic products in the EU and intend to discard them at the end of their useful life, please do not dispose of them with your other household or municipal waste. Disposing of this product correctly will help save valuable resources and prevent any potential negative effects on human health and the environment, which could otherwise arise from inappropriate waste handling.

2. RoHS Directive 2002/95/EC

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

EKO

CE

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: Sunshine Duration Meter
Model No.: MS-95S

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: Jan. 17. 2022

Position of Authorized Signatory: Manager of Quality Assurance Div.

Name of Authorized Signatory: Minoru Kita

Signature of Authorized Signatory: _M. Kita_

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 correctly.

⚠	**WARNING CAUTION**	User attention; please pay close attention to the 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. Set Up

➢ The installation base or mast should have enough load capacity to mount the instrument. Fix the sunshine duration sensor securely to the base or mast with bolts and nuts; otherwise, the instrument may drop 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 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, connect the shield wire of the output cable to the ground earth for the MS-95S. Noise may be included in the measurement data.

➢ 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 the following locations where strong electromagnetic waves are 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 an environment where corrosive gas, such as ammonia and sulfurous acid gas, is 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 aluminium

3. Run the cables through 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 of 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 485 / USB conversion cable and dedicated software.

2. Handling

➢ Be careful when handling instruments with glass domes. Strong impact to this part may damage the glass and could cause injury.

➢ When carrying any MS-95S model with the sun screen attached, always hold the instrument from 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 0.5A fuse connected to the power supply line in series. Without connecting the fuse, it has risks of generating heat and fire due to large-current flowing by the power supply when internal damage of the electronics occurs.

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 the MS-95S 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 RS-485 (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

The MS-95S sunshine duration sensor measures the total hours of sunshine.

Sunshine, as defined by the World Meteorological Organization (WMO), occurs when the amount of direct solar radiation exceeds 120 W/m2. Daylight hours are the total number of hours of sunshine at a given location and the total number of hours of sunshine per defined unit of time. For example, a climate index is the average of daily or monthly sunshine hours. Sunshine hour values are useful for monitoring seasonal changes and can be easily compared between different locations.

EKO previously offered the MS-093 rotational sunshine sensor, a highly accurate solution adopted by research institutes worldwide, including NOAA (National Oceanic and Atmospheric Administration) and AMeDAS (Automated Meteorological Data Acquisition System). However, rotational sunshine sensors are expensive to produce and require adjustments during installation and periodic calibration.

EKO developed the MS-95S as an alternative. With an optical sensor design built around a new fisheye lens that observes the sky in 180°, the MS-95S employs a unique method to distinguish and record direct beam radiation from total sky radiation. Unaffected by detector temperature effects, irradiance conditions, solar elevation angle or detector non-linearity, the MS-95S is the ultimate choice for maintenance-free, long-term operation.

4-1. MS-95S Features

➢ **Easy installation**

Most conventional sunshine duration sensors have a narrow field of view and need to be oriented or tilted depending on where they are installed.

In addition, because of seasonal variations in solar altitude, some sensors require data correction throughout the year. In contrast, the MS-95S is equipped with a fisheye lens with a viewing angle of 180°, allowing it to collect solar radiation from the entire sky. As a result, the solar radiation entering the sensor is contained within a single field of view. Therefore, this sensor does not require any setup in a particular direction, nor any adjustment for the sun's tilt. Even if the latitude and azimuth are unknown, the sensor can be used anywhere in the world simply by setting the sensor horizontally.

➢ **No recalibration required**

Conventional sunshine duration sensors require calibration and adjustment at each recommended cycle; the MS-95S does not require such calibration and adjustment for the following reasons:

① **Sunshine determination based on the output ratio of the quadrant sensor**

When using the voltage output (absolute value) of a detector, it is usually necessary to count changes in sensor output due to aging of a single detector or multiple detectors, so recalibration is required. The MS-95S, however, determines the presence or absence of sunshine by the ratio (relative value) of the voltage output of the direct component and the total voltage output of the four photodiodes on a single chip, and because the four elements of the four photodiodes have the same characteristics, it is possible to determine the presence or absence of sunshine by the ratio of the voltage output of the direct component and the total voltage output of the four photodiodes. The four sensors of the quadrant photodiode have the same characteristics, so they can always output a value that does not depend on changes in sensitivity or temperature. Therefore, the sensor is not affected by sensitivity change due to temperature change or aging.

② **Use of a range sufficiently low relative to the rated value**

The conditions of use for the quadrant silicon photodiode used in this sensor are sufficiently low light exposure relative to the maximum rated value, so there is virtually no load on the sensor and ageing degradation is unlikely to occur.

➢ **Smart 4-channel analog & digital Interface**

The MS-95S supports the following 4 output types:

- Digital output: Modbus RTU
- Digital output: SDI-12
- Analog output: 4-20mA
- Analog output: 0-1V (*100Ω shunt resistor required)

➢ **Test results**

It has passed all CE marking EMC tests, and with regard to lightning surge testing, it is resistant to surges at levels far exceeding CE marking EMC test standards.

4-2. Field Applications

Sunshine duration values contribute to climate research, meteorology and reporting, helping to monitor seasonal variations between different locations, and are a popular indicator to express the number of sunny hours at tourist locations and places of interest.

With multiple smart interfaces, the MS-95S can be used in applications in various fields such as agriculture, industry, construction, medicine, and solar energy. The digital output Modbus RTU / SDI-12 can be used in multi-sensor networks for on-site monitoring of large measurement systems.

The Hibi software allows for internal diagnostics, custom settings, and real-time acquisition of data from the MS-95S including sunshine conditions, humidity alerts, internal temperature, and tilt angle. This data can also be obtained when the MS-95S is connected via the data logger's serial communication port. Each sunshine duration sensor has its own communication address, allowing multiple sensors to be connected in a network.

With the addition of the 'S-Series' internal diagnostic system, the MS-95S provides users with remote visualisation of internal temperature, internal humidity alerts, tilt, and tilt angle. Helping to ensure optimal performance without the need for periodic inspections, the MS-95S's internal diagnostics help make it the perfect solution for monitoring stations with complex networks, difficult, or limited access.

4-3. 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-95S
Sunshine Duration Sensor	○
Output Cable	○[1]
Sun Screen	○
Instruction Manual	Not included in the package [Please download from EKO Website]
Setting Report	○[2]
Quick Start Guide	○
Fixing Bolts	[M5] x2 [Bolt Length: 75mm]
Washers	[M5] x4
Nuts	[M5] x2

(1) Standard length is 10m. 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-4.

Table 4-2. Accessories List

Option Items	Description
[1]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 MS-95S and allows to connect to PC via USB terminal. Cable Length:5m

[1] The standard cable length for MS-95S is 10 m.

5. Getting Started

5-1. Parts Name and Descriptions

Each part name and its main function is described below.

MS-95S
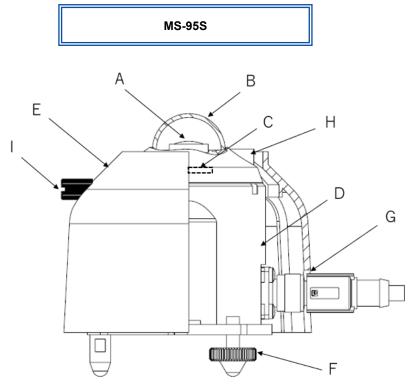
Table 5-1. Parts Name

Parts Name	
A.	Fisheye Lens
B.	Glass Dome
C.	Quadrant Sensor
D.	Body
E.	Sun Screen
F.	Levelling Screw
G.	Cable, Connector
H.	Spirit Level
I.	Knurling Screw

*Signal converter is built-in for MS-95S.
Figure 5-1. Sunshine duration sensor Parts Name

1. Glass Dome

A glass dome creates a sealed environment for the detector and protects it against dirt and rain.

2. Detector

At the heart of the product is a quadrant sensor. Light collected by the fisheye lens enters the quadrant sensor, which determines the sunlight conditions.

3. Sun Screen, Body

The MS-95S have 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 dusts.

4. Spirit Level

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

* Depending on the operating environment, bubbles may come out of the level gauge, liquid may be missing, the reference circles may fade out, or cracks may occur.

5. Drying Agents

Enclosed drying agents inside the sensor body keep the sensor inside dry, prevents condensation of humidity inside of the glass dome.

6. Cable and Cable Connector

The MS-95S are shipped with a 10-meter-long output cable as standard length*.

Durable materials are used for the cable and 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 by the self-fusing tape when the sunshine duration sensor is used in areas with a risk of salt damage.

5-2. Set Up

In order to obtain high quality measurements from sunshine duration sensors, 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 sunshine duration sensor 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 sunshine duration sensor.

A strong physical impact to the sunshine duration sensor can lead to product damage and/or may cause changes to the performance.

1. Installation

1) Check the installation base where the sunshine duration sensor 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.

Table 5-2. Fixing Hole Pitch and Bolt Size for sunshine duration sensors

	MS-95S
Fixing Hole Pitch	65 mm
Fixing Bolt Size	M5 x 75 mm

2) Remove a 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-95S 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 off from the sun screen.

3) Set up the sunshine duration sensor 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 sunshine duration sensor in a horizontal position by using the 2 levelling screws and observing the air bubble in the spirit level while manipulating the levelling screws. The instrument is levelled
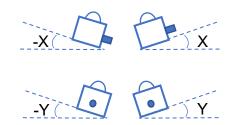

Figure 5.2 Tilt angle (-180 to 0º) and (0 to 180º)
Roll angle (-180 to 0º) and (0 to 180º)

horizontally if the air bubble is in the centre ring. The sensitivity of the bubble vial is (0.1º / mm). If the sunshine duration sensor is not levelled properly, the sunshine duration sensor readings are affected by cosine and azimuth errors. Periodically check the spirit level and adjust the sunshine duration sensor's position if necessary.

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

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 the plane of installation X' and Y'.

⚠️ **The sunshine duration sensor connector is an important reference for setup and corresponds to the X-axis reference plane.**

4) Fasten the sunshine duration sensor to the base with the 2 bolts [included] and put the sun screen back on the sunshine duration sensor.

5-3．Wiring

To extend the cable lifetime, make sure that the cables are not exposed to direct sunlight 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 by wind blowing. 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

The sunshine duration sensor housing is connected to the shield wire of the cable, so connect the shield wire to the ground on the measuring instrument side.
Do not connect the sunshine duration sensor housing to the ground. It will be a two-point ground and it cause a noise.

MS-95S

Cable shield wire

Measurement Device

FG

Connect the shield wire of the cable to FG on the measuring instrument side.
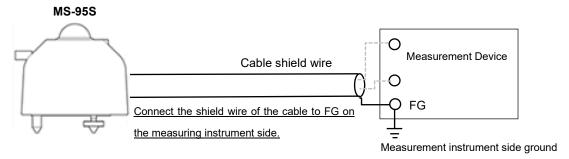
Measurement instrument side ground

Figure 5-3. MS-95S ground connection method

2. Wiring Procedure

Connect the output cable to the MS-95S: **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-95S is based on a digital Smart processing interface providing advanced measurement functions with 4 different industrial signal outputs (**Modbus RTU**, configurable **SDI-12**, **4-20mA** and **0-1V** with external shunt resistor 100Ω).

Table 5-3. MS-95S outputs

Output	Without Sunshine	With Sunshine
Modbus RTU (Default)	○	1
SDI-12	○	1
4 - 20 mA (Default)	4mA	20mA
0-1V$^{(*)}$	0V	1V

(*) With external shunt resistor 100Ω

Table 5-4 Output parameters by signal output mode

Output Parameters	Digital Output		Analog Output	
	Modbus RTU (Default)	SDI-12	4-20mA (Default)	0-1V$^{(*)}$
Sunshine Duration	○	○	○	○
Temperature	○	○	—	—
Tilt Position	○	○	—	—
Alerts for abnormal internal humidity of the sunshine duration sensor	○	○	—	—
Sensor Information	○	○	—	—

(*) With external shunt resistor 100Ω

1. Analog Output (4-20mA / 0-1V)

The MS-95S has two analog outputs (4-20mA and 0-1V). The 4-20mA output is default, the 0-1V(0-10mA) output can be enabled through the 'Hibi' software which can be downloaded from the EKO website (MS-95S product page). See appendix A-1 to change the current output settings. The current output can be converted into a voltage output when a shunt resistor is used in series. In combination with an external 100Ω resistor a 0-1V output can be made.

Current Output (4-20mA)

Connect the 3 wires with the corresponding colour to the input terminals of the current meter or data logger (figure 5-4). Connect the power terminals to a DC power supply [8 to 30 V]. We recommend using a fuse [0.5A] to the DC power supply line [+] for over-current protection.

> **Interconnect the power supply (-) and 4-20mA / 0-10mA (-) line. The MS-95S current output requires a 3-wire connection.**
> **To protect your equipment from noise and surges, the shield wire of the cable must be connected to the 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 sunshine duration sensor itself and to the enclosure.**
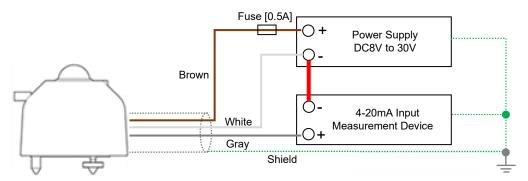> **Be sure to connect a fuse, as this may lead to a fire.**

Figure 5-4. How to connect 4-20mA output

Voltage Output (0-1V)

The current output can be converted into a voltage output when a shunt resistor is used in series. The default output is 4-20mA. The 0-10mA (0-1V) output is disabled. The settings can be changed when the MS-95S is connected to a PC through the Hibi software, see appendix A-1 for instructions.

Connect the 3 wires with the corresponding colour to the input terminals of the Voltmeter or data logger (figure 5-5). Connect the power terminals to a DC power supply [8 to 30 V]. We recommend using a fuse [0.5A] to the DC power supply line [+] for over-current protection. A shunt resistor 100Ω needs to be placed across the voltage input terminals of the measurement device.

> **Interconnect the power supply (-) and 4-20mA / 0-10mA (-) line.**
> **The MS-95S voltage output requires a 3-wire connection.**
> **To protect your equipment from noise and surges, the shield wire of the cable must be connected to the 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 sunshine duration sensor itself and to the enclosure.**
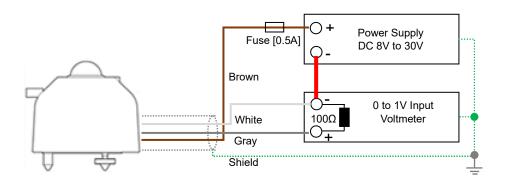> **Be sure to connect a fuse, as this may lead to a fire.**

Figure 5-5. How to connect MS-95S (0-1V output)

2. Digital Output (Modbus RTU / SDI-12)

The MS-95S can work in two digital output modes, respectively Modbus RTU and SDI-12. Modbus RTU output is set to default, SDI-12 output can be selected through the Hibi software.

PC Connection (Modbus RTU)

> ➢ **EKO can provide an optional and approved USB converter for connection with a PC. The converter cable is needed for set-up, 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 must be connected to the 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 sunshine duration sensor 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 5-6). Some converter cables provide a 5V supply voltage from the USB port, in such case no additional power supply is required. 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.
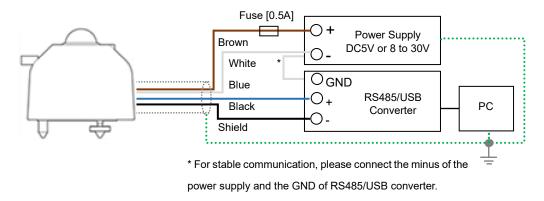

Figure 5-6. How to connect MS-95S (Modbus RTU)

> **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 5-7). Connect the power terminals to a DC power supply [8 to 30 V]. We recommend using a fuse [0.5A] to the DC power supply line [+] for over-current protection.
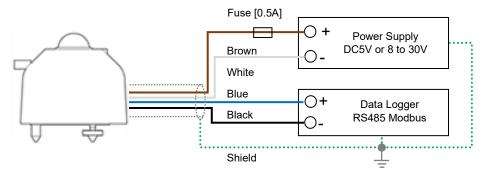

Figure 5-7. How to connect MS-95S (Modbus RTU RS485)

The MS-95S can be configured within a multi-sensor RS485 Modbus RTU communication network. Up to 31 sensors per one Master can be connected and assigned with a unique address. For a multi-sensor network, the sensors need to be configured according to the recommended RS485 configuration standards as shown in figure 5-7.

The master represents the data-logging device and slaves represent devices such as the MS-95S 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.
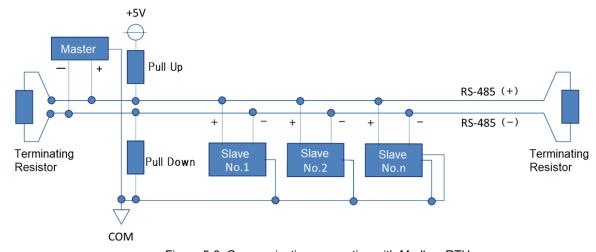

Figure 5-8. Communication connection with Modbus RTU

> - **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 Sunshine duration sensor, if the cable length exceeds 10 m, add an appropriate SPD or the like to protect the measurement system from lightning surges (see appendix A-5).**
- ➢ **Using Modbus RTU and SDI-12 in a network at the same time may cause communication problems.**

<u>Data Logger Connection (SDI-12)</u>

Connect the 3 wires 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 5-9). Connect the power terminals to a DC power supply [12 V]. We recommend using 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 in a network at the same time.**

> ➢ **Although a surge protection board is embedded inside the sunshine duration sensor, if the cable length exceeds 10 m, add an appropriate SPD or the like to protect the measurement system from lightning surges (see A-7).**
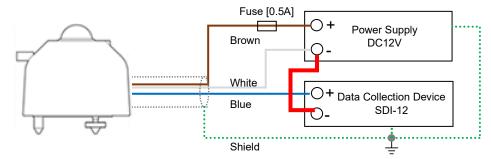

Figure 5-9. How to connect the MS-95S (SDI-12)

The MS-95S 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 multi sensor network the sensors need to be configured according to the recommended SDI-12 configuration standards as shown in figure 5-10. Make sure the cable length between the connecting slave and master be less than 60m.
The shield cable must be connected to the ground, otherwise noises may occur.
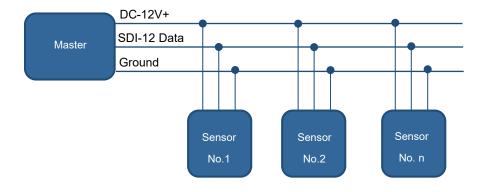(*) When connecting other SDI-12 communication devices, the upper limit may change.

Figure 5-10. Communication Connection with SDI-12

3. Overview Wire Assignments

Table 5-5. Colour Codes of cable

No.	Wire Color	Modbus RTU	SDI-12	4-20mA	0-1V[(*)]
1.	Brown (+)	5VDC(+) or 8 to 30VDC (+)	12VDC (+)	DC8 - 30V(+)	DC8 - 30V(+)
2.	White (-)	Vcc GND / RS485 GND	Vcc GND	4 - 20mA (-) / GND	0 - 10mA(-) / 0-1V(-) / GND
3.	Blue (+)	RS485 (+)	SDI-12 Data (+)	---	---
4.	Black (+)	RS485 (-)	---	---	---
5.	Gray (+)	---	---	4 - 20mA (+)	0 - 10mA(+) / 0-1V(+)
Shield	Shield	FG	FG	FG	FG

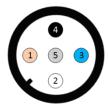(*) When 0-1V output is selected, a separate shunt resistor is required.

Figure 5-11. Connector pin number of the MS-95S

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

5-5. Measurements

1. Data Logger Settings

The output signal of sunshine duration sensor is measured by a measuring device such as a data logger. If sunshine duration 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 sunshine duration sensor. Depending on the sensor output which will be used, the data logger should be capable to measure the assigned output type.
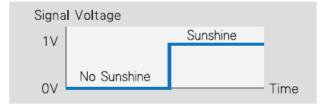
Table 5-6. Measuring ranges of data loggers

	0-1V[(*)]Output	4-20mA Output	Digital Output Modbus RTU / SDI-12
Measurement Range	1[V]	20[mA]	—
Output Range	0 - 1[V]	4 - 20[mA]	0 / 1

(*) Using external shunt resistor 100Ω

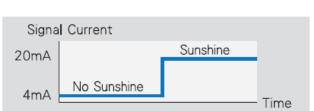The MS-95S outputs signals with and without sunshine as follows:

0-1V Output

At 1 V output : with sunshine
At 0 V output : no sunshine

4-20mA Output

At 20 mA output : with sunshine
At 4 mA output : no sunshine

Digital Output

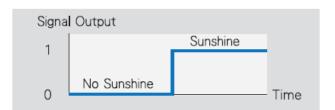At "1" output : with sunshine
At "0" output : no sunshine

Figure 5-12. Output method with/without sunshine

Loggers equipped with Modbus RTU or SDI-12 communication ports can also acquire data via digital output. In this case, Appendix A-2 or A-3 communication format must be supported and programming is required. If only one MS-95S is connected, Hibi software can be installed on a PC for measurement setup and data acquisition. With the optional EKO converter cable, operation is possible simply by connecting the PC and MS-95S via USB.

For long-term continuous measurement, it is common to connect the sunshine duration sensor to a data logger for measurement. In such cases, it is important to set the sampling interval and integration time of the measurement data appropriately, taking the data capacity into consideration. The amount of recorded data can also be reduced by averaging/integrating the data according to the purpose.

2. Sunshine Duration Sensor Default Settings

The MS-95S is based on 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-95S defaults settings and important parameters:

Table 5-7. MS-95S where to find the settings

MS-95S	Defaults Setting and Parameters
Modbus RTU (Default)	- Setting report (see appendix A-4 MS-95S setting report) - Modbus register o **Address (last two digits of serial number, 100 if '00')** o **Baud rate 19200** o **Parity Even**
SDI-12	- Setting report - SDI-12 register o **Address 0** o **Baud rate 1200** o **Parity Even**
4 - 20 mA (Default)	- Setting report o 4mA： Sunshine No Signal o 20mA： Sunshine Yes Signal
0 – 1V	- Setting report o 0V： Sunshine No Signal o 1V： Sunshine Yes Signal

The function can be switched by operating the dedicated software Hibi screen or by rewriting the registers of Modbus RTU and SDI-12 respectively. See the following section for details on the operating procedure.

Appendix A-1. Software (Hibi) 3. Software

Appendix A-2. Communication Specifications (Modbus RTU) A4-10. No. 101 or later registers

6. Maintenance & Troubleshooting

6-1. Maintenance

By using the MS-95S, accurate results can be obtained if the glass dome and the condition of the instrument are maintained properly. Regular maintenance can extend the lifetime of the sunshine duration sensors. However, environmental conditions can have a deteriorating effect on the materials. Therefore, proper maintenance is needed and has to be adapted to the local environmental conditions.

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

Table 6-1. Maintenance Items 1

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.	This may lead to shade on the detector and enhanced soiling.
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 if the base plate and/or table is securely fastened in a proper condition.	Loose instruments and/or mounting plates can lead to damage of the instruments and/or injury.
Check the 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.	This may lead to damaging the instrument and/or lead to increased measurement error due to temperature increase by the sun screen coming off.

Table 6-2. Maintenance Items 2 (Advanced remote check can be done on the MS-95S)

Maintenance Item	Frequency	How To	Effect
Data Validity	Weekly	Check the sunshine duration data and compare to previous days or adjacent the sunshine duration sensors.	When a large difference occurs, operating problems or installation issues can be detected.
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 relative internal humidity alert status of the sunshine duration sensor via Modbus RTU or SDI-12 output.	The condition of the drying agent can slightly change over time. If the relative humidity become 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.	The degree of tilt can be checked after installation. If the tilt is extremely large, level the unit with a level.

6-2. About the Maintenance Cycle

To maintain the accuracy of sunshine duration measurements, it is recommended that product maintenance be performed once every five years.

For more information on maintenance, please contact the EKO Customer Center.

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. In-field troubleshooting

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.
Sunshine duration is too short	The glass dome may be soiled with rain or dust. Clean the glass dome with demineralized water and a soft cloth. If the problem persists, please contact the EKO Customer Center.
Frequent changes to sunlight conditions	Check for loose shield connections. Check that the output cable is not flapping in the wind, and if necessary, secure it or run it through a metal tube. Check that there are no objects around the product or cable that generate electromagnetic waves.
A humidity alert was triggered	The humidity inside the sensor unit is high. The internal desiccant likely needs to be replaced, so please contact EKO.

Table 6-4. Hibi troubleshooting

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. - Reconnect the USB converter and refresh to search for new COM devices - Check for COM port settings in Windows settings - Install an appropriate driver
Settings changes not saved to sunshine duration sensor	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 sunshine duration sensor, some of the settings are effective after power off/on.

7. Specifications

7-1．Specifications

1. Sunshine Duration Sensor Specifications

Table 7-1 shows the specifications of the MS-95S.

Table 7-1. List of product specifications

Characteristics	Specifications
Measurement Accuracy	<±15 [%] (For threshold 120W/m^2) [1] > 90 [%] (monthly sunshine hours)
[2] Output [or signal]	Digital output 1. Modbus RTU 2. SDI-12 Analog output 3. 4-20mA 4. 0-1V (shunt resistor 100Ω)
Wavelength Range	400 to 1,100nm
[3] Operating Temperature	-40 to +80°C
Environmental Protection [IP Code]	IP67
Response Time	200 [ms]
Weight	0.4 [kg]
Input Power Supply	Modbus RTU: DC5V or DC8V to DC30V 0-1V/4-20mA: DC8V-DC30V SDI-12: DC9.6V - DC16V
Power Consumption	Digital output: < 0.2 [W] Analog output: < 0.7 [W]
Diagnostic Functions	Temperature/ humidity alarm/ tilt angle

[1] WMO compliant

[2] Sensor setting can be changed by connecting the sensor to a PC. Use the EKO Convertor Cable (option) and download the free configuration software "Hibi" from the EKO website.

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

Table 7-2. Power consumption supply Voltage specific

	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
Analog 4-20mA output	-	300mW (Approx. 30mA)	640mW (Approx. 27mA)	Shunt resistance 250Ω Value at 20mA continuous output
0-1V(*) Output	-	300mW (Approx. 30mA)	640mW (Approx. 27mA)	Shunt resistance 100Ω Value at 10mA continuous output

(*) Using external shunt resistor 100Ω

7-2. Dimensions

1. MS-95S

Table 7-3. Dimensions

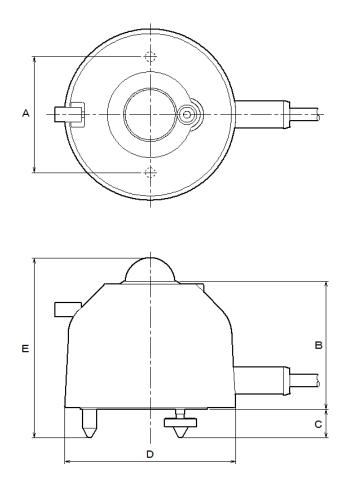|	MS-95S
A. Fixing Hole Pitch	65 mm
B. Body Height	73 mm
C. Levelling Screw Height	16 mm
D. Width [including sun screen/Cover]	⌀ 96 mm
E. Overall Height [approx.]	101mm

Figure 7-1. External Dimensions (MS-95S)

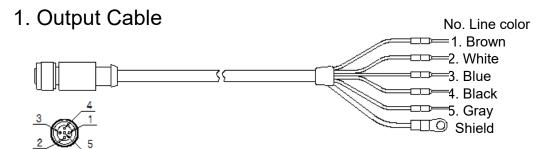# 7-3. Cables

See [5-2. Setup, 5-3. Wiring] for instruction

1. Output Cable

No. Line color
1. Brown
2. White
3. Blue
4. Black
5. Gray
Shield

Figure 7-2. Output Cables

2. EKO Converter Cable（Option）

USB Type-A

Figure 7-3. EKO Converter Cable

7-4. Accessories List

Table 7-4. Accessories List

Option Items	Description
[1]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-95S and allows to connect to PC via USB terminal. Cable Length: 5m

[1] The standard cable length for the MS-95S is 10m.

A-1. 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-95S using the Windows software downloadable from the EKO website (MS-95S 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 the MS-95S 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-95S to 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 the MS-95S 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 A1-1.)

(Terminal block)

MS-95S cable: Blue (+) RS485/USB Converter terminal: (+)

MS-95S cable: black (-) RS485/USB Converter terminal: (-)
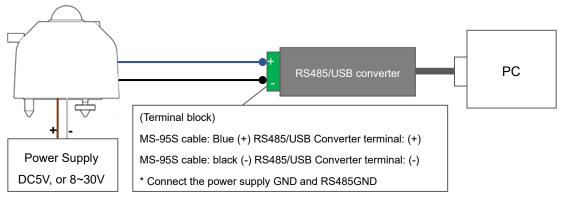
* Connect the power supply GND and RS485GND

Figure A1-1. Hardware preparation

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-95S can be supplied via USB. (See Figure A3-2).

* <u>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.</u>
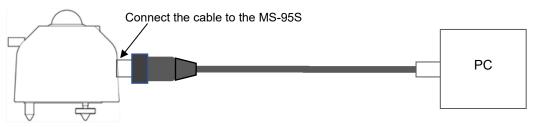

Connect the cable to the MS-95S

Figure A1-2. 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.)

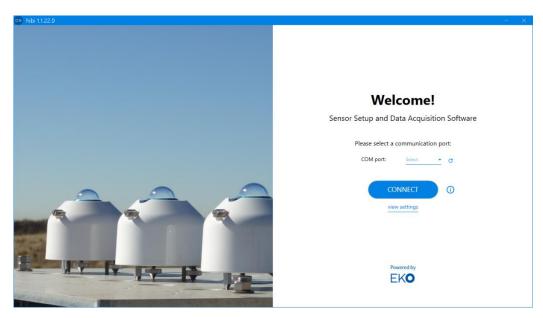2) After the software starts, the 'Welcome' window appears.

Figure A1-3. Welcome window

3) Automatic connection

When using the 'Auto-connect' function to connect MS-95S with the 'Hibi' software, select the COM port that the RS485/USB converter cable is connected to.
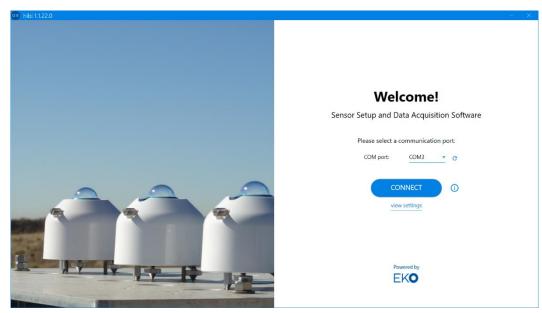

Figure A1-4. Com port select

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.

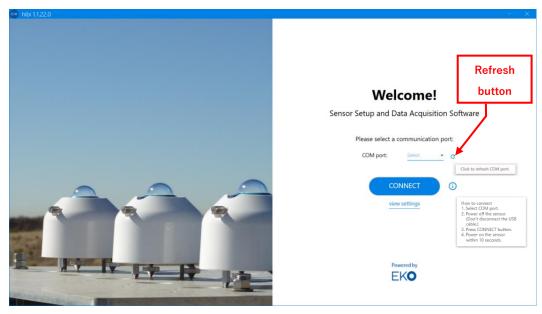If you can't find a selectable COM port, click the Refresh button and click Select again to try again.

Figure A1-5. Com port select

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

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

Power on the MS-95S within 10 seconds once the 'Connecting your sensor' message appears.

Figure A1-6. 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 'Sunshine duration sensor Connected'.
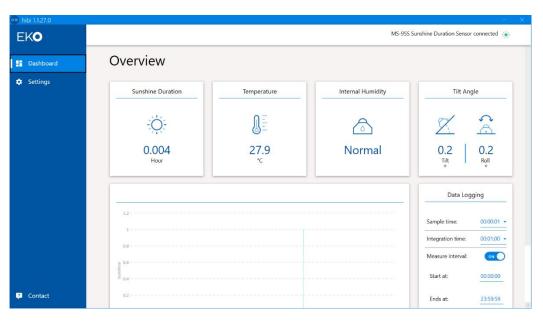

Figure A1-7. Dashboard

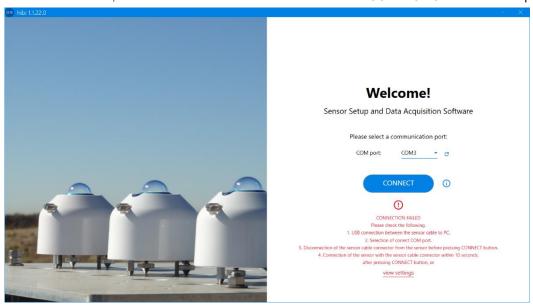If the connection fails, the screen returns to the 'Welcome' screen and 'CONNECTION FAILED' is displayed.

Figure A1-8. CONNECTION FAILED

Make sure the connection settings are correct. To perform the 'Auto-connection' again, turn off the power of the MS-95S, select 'COM port', and then click 'CONNECT', then Power ON to the MS-95S.

For manual connections, click 'view settings' at the bottom of 'CONNECTION FAILED' to go to the '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-95S, 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.)

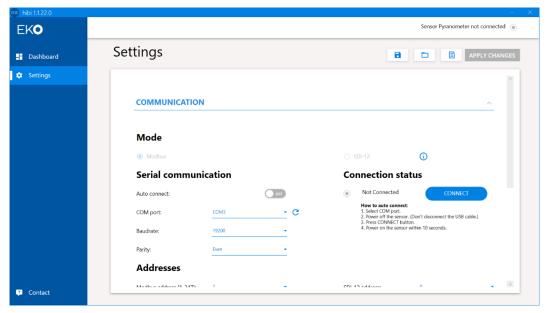After that, click the 'CONNECT' button under 'Connection status'.

Figure A1-9. Manual connection

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

'XXXX Sunshine Duration sensor Connected' is also shown in the upper-right corner of the display.
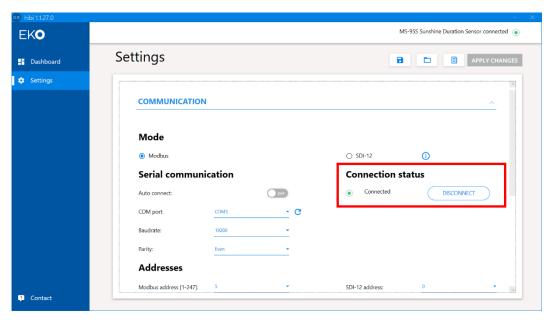
Figure A1-10. Disconnect appear

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

<u>When connection fail appears</u>

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.

Figure A1-11. Oops screen

After entering the settings, click 'APPLY CHANGES'
A confirmation window will be displayed.
Click 'YES, SAVE' to make the settings for the MS-95S.
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.
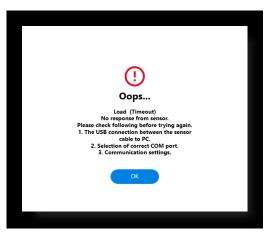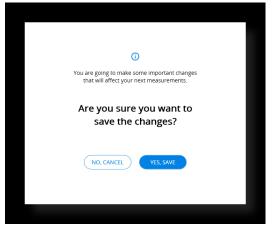- 'Output' button: Output the settings to CSV file

Figure A1-12. Apply changes screen

Figure A1-13. Settings screen
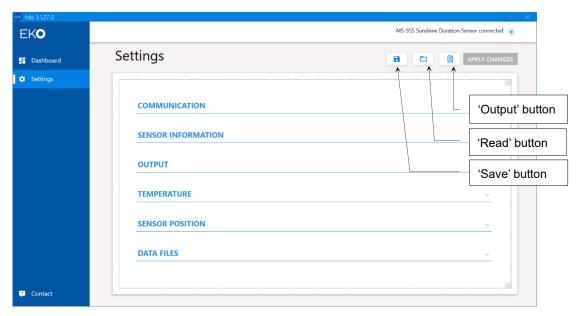
5) Setting Items

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 (the last 2 digits of the of serial number is the default address, 100 when '00')
	SDI-12 address	0 to 9 / A to Z / a to z
Connection status	---	Connected / Disconnect

Figure A1-14. Communication settings screen

2. 'SENSOR INFORMATION' setting items

Item name	Setting contents	Setting range
Model information	Model	Model name registered in the MS-95S (cannot be changed)
	Serial number	Serial number registered to the MS-95S (cannot be changed)
	MFG. date	Date of manufacturing (cannot be changed)
	Firmware version	Firmware version of the MS-95S (cannot be changed)
	Hardware version	Hardware version of the MS-95S (cannot be changed)

Figure A1-15. Sensor information settings

3. 'OUTPUT' setting items

Item name	Setting contents	Setting range
Analog output	Enable analog output	Analog output OFF/ON (selected with the radio button) Either 4-20mA or 0-1V power can be selected. * Default is 4-20mA.
	4-20mA	4mA±0.4mA：Sunshine No Signal 20mA±1.6mA：Sunshine Yes Signal
	0-1V (100Ω shunt resistor required)	0V±0.1V：Sunshine No Signal 1V±0.1V：Sunshine Yes Signal

Figure A1-16. Analog output settings

4. 'TEMPERATURE' setting items

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

Figure A1-17. Sensor settings screen

5. 'SENSOR POSITION' Setting Items

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

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

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

Clicking 'ZERO ADJUSTMENT' allows you to adjust Tilt (X axis) and Roll (Y axis) of Tilting items using the present tilt angle as 0°.

Figure A1-18. Sensor position setting

6. DATA FILES setting items

    [Measurements]

                <Save file to> Enter the name of the measurement data storage folder.
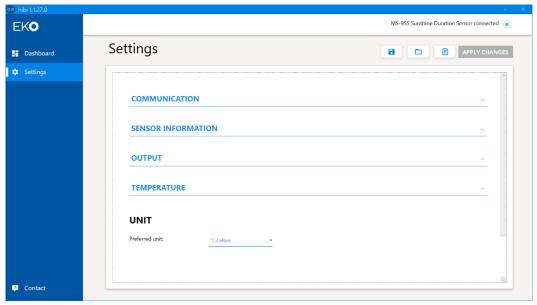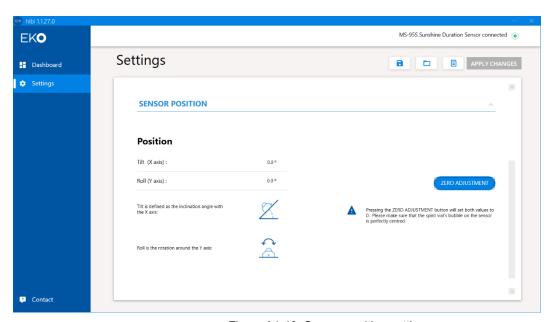
    [Sensor settings]

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

Figure A1-19. Data files setting

6) Measurement (Dashboard)

- Measurement data of irradiance, temperature, humidity, and tilt angle are read from MS-95S every 1 second
  and displayed.

Figure A1-20. Dashboard screen

<Sunshine Duration> Sunshine Duration measurement data (Unit: Hour)

<Temperature> Internal temperature measurement data.

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

<Internal Humidity> Indicates degradation of internal drying agent, "Normal" is displayed when no
replacement is required, and "Caution" is displayed when the humidity value is
abnormal.

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

【 Real time measurement-Sunshine duration 】
- Display measured sunshine duration 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.

Figure A1-21. Sunshine duration data in a graph

【 Data Logging 】

Logging function of measurement data

＜Sample time＞	Set the logging interval for measurement data.
	Setting range:　00:00:01
	00:00:05
	00:00:10
	00:00:15
	00:00:30
	00:00:36
	00:01:00

＜Integration time＞	Set the logging interval for averaged measurement data.
	Setting range:　00:01:00
	00:05:00
	00:10:00
	00:15:00
	00:30:00
	01:00:00

＜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 the [EKO Instruments] website appears in the browser.

Figure A1-22. EKO Instruments website contact page

8)   Sensor internal humidity abnormality alert

Hibi has a function to monitor the relative internal humidity of the sunshine duration sensor 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 sunshine duration sensor is left as is after the alert, the possibility of a problem such as condensation inside the sunshine duration sensor glass dome will increase, so please contact EKO.

Figure A1-23. Sensor internal humidity abnormality alert

9)   Exiting the software (Hibi)

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

A-2. Communication Specifications (Modbus RTU)

A2-1. 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 sett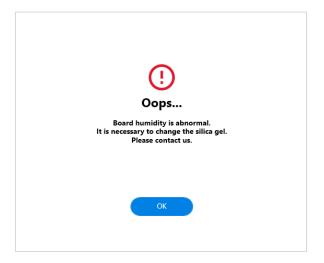ing, turn the power off and then on again to operate with SDI-12. To return to Modbus RTU mode again, change the setting from 'Hibi' software.

· It corresponds to RS485, half-duplex and double-wire multi-drop networks.

The communication specifications are as follows.

Table A2-1. 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.

A2-2. 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, and Input Register addresses start from '0'.

Table A2-2. 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

A2-3. 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 A2-3. 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

A2-4. Cable connection

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

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

A2-5. Data format

Table A2-4. 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 A2-5. Assignment of 8/16/32 bit value

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

Table A2-6. Assignment of 8/16 bits and F32

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

Table A2-7. 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 the Modbus register.

Table A2-8. Relationship between 32-bit values and Modbus registers

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

A2-6. 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.100 can be read or written to.

A2-7. 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.

Table A2-9. No. 0-49 Register S-series type (default)

0	Model	U16	Model number of the transmitter. (0x0140)
1	0	U16	Fixed value
2	Sunshine	U32	Yes (With Sunlight):1, No (Without Sunlight):0
3			
4	Alerts for abnormal internal humidity of the Sunshine duration sensor	U32	Alerts for abnormalities in the internal humidity of the Sunshine duration sensor
5			Normal: 0, Abnormality occurs: 1
6	Internal temperature	F32	Temperature measured by the internal temperature sensor
7			Unit: (°C)
8	X-axis tilt angle	F32	X-axis component of the tilt angle
9			Unit: °
10	Y-axis tilt angle	F32	Y-axis component of the tilt angle
11			Unit: °
12 to 49 are reserve			

A2-8. 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.

A2-9. 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 A2-13. Register No.50-95

50 to 95 are reserve

Table A2-14. Register No.96-99

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

A2-10. 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 the 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 A2-15. Register No.100-199

100 are 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 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)
165			Enter the number part excluding the alphabet S.
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 189 are reserve			
190	Cal. date	U32	Calibration date in YYYYMMDD format
191			
192 to 199 are reserve			

A2-11. 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.

A2-12. Register details

Table A2-16. Coil register

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

A-3. Communication Specification (SDI-12)

A3-1. 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 the '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 the 'Hibi' software.

· When SDI-12 is enabled, the unit operates in 'low power standby mode' with a power consumption of approx. 2.5mA (at 12V) during non-communication.

A3-2. Communication Specification

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

Table A3-1. 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

A3-3. Command List

· SDI-12 commands are listed below.

· The lowercase letter 'a' in the command list indicates the SDI-12 address number.

· SDI-12 address number that can be set is 0-9, A-Z, a-z.

Table A3-2. 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 from address number 'a' to 'b'.
aI!	Refer to the right section	Returns information. <Response example> 'a14EKOINST_MS-95SV3220000001\<CR>\<LF>' a: SDI-12 address 14: SDI-12 version (represents version 1.4) EKOINST: Company name (8 characters) MS-95S: Sensor model name (6 characters) V30: Sensor version (3 characters) 20000001: Serial number (8 characters)

aM!	a0001<CR><LF>	Request the device with the 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!	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: Yes (With Sunlight):1, No (Without Sunlight):0 D1: Internal temperature of Sunshine duration sensor body (°C) 1 digit after the decimal point D2: X-axis tilt angle (degree) 1 digit after the decimal point, forward/backwards with the connector facing back, positive value when the back is up, Y-axis tilt angle (degree) 1 digit after the decimal point, left/right with the connector facing back, negative value when the left is down D3: Alert to notify users of abnormality in the internal humidity of the Sunshine duration sensor 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 the SDI-12 standard for the content of CRC characters.
aMC!	a0011<CR><LF>	Request the device with address number 'a' to start the 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 the address number 'a'. Measurement is executed and a response is returned immediately. The answer is similar to the '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.
aXCD!	aYYYYMMDD<CR><LF>	Read the calibration date of this device. YYYY: AD, MM: month, DD: day.
METADATA	Variable depending on request data	Identify Measurement Commands and Identify Measurement Parameter Commands are supported.

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MS-95S Setting Report (Example)

Issue Date: 10－Apr-22

Factory Setting Data	
Sensor type	Sunshine duration sensor
Model name	MS-95S
Serial number (S********)	12345678
Manufacturing date	April 7, 2022
Hardware version	1
Firmware version (*.***)	4000

Current output mode of 4-20[mA]	Setting
Enable/Disable	Enable (Default)
Output range corresponding to 4-20 [mA].	4mA±0.4mA：Sunshine No Signal 20mA±1.6mA：Sunshine Yes Signal

Current output mode of 0-10[mA]	Setting
Enable/Disable	Disable (Default)
Output range corresponding to 0-10 [mA].	0mA±0.1mA：Sunshine No Signal 10mA±1.0mA：Sunshine Yes Signal

Modbus RTU	Setting
Enable/Disable	Enable (Default)
Address	1
Baudrate	19200
Parity	Even

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

A-5. Surge Protection

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

However, if the sunshine duration sensor cable is longer than 10m, or if multiple sunshine duration sensors 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 add an appropriate SPD to protect the measurement system.

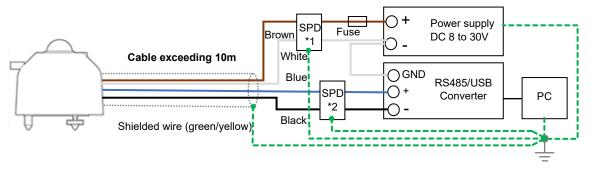## A. Modbus RTU Connection (when the cable length exceeds 10m)

Figure A5-1. Modbus RTU Connection (when the cable length exceeds 10m, etc.)

*1 *2

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

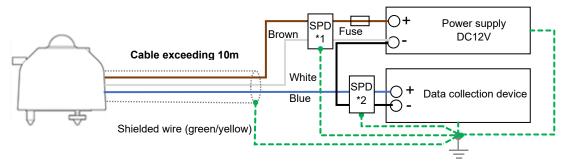## B. SDI-12 Connection (when the cable length exceeds 10m)

Figure A5-2. SDI-12 Connection (when the cable length exceeds 10m, etc.)

*1 *2

If the cable length exceeds 10m, it is recommended to set up an SPD for the communication line and an SPD for the DC power supply 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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