

**EKO**

# INSTRUCTION MANUAL

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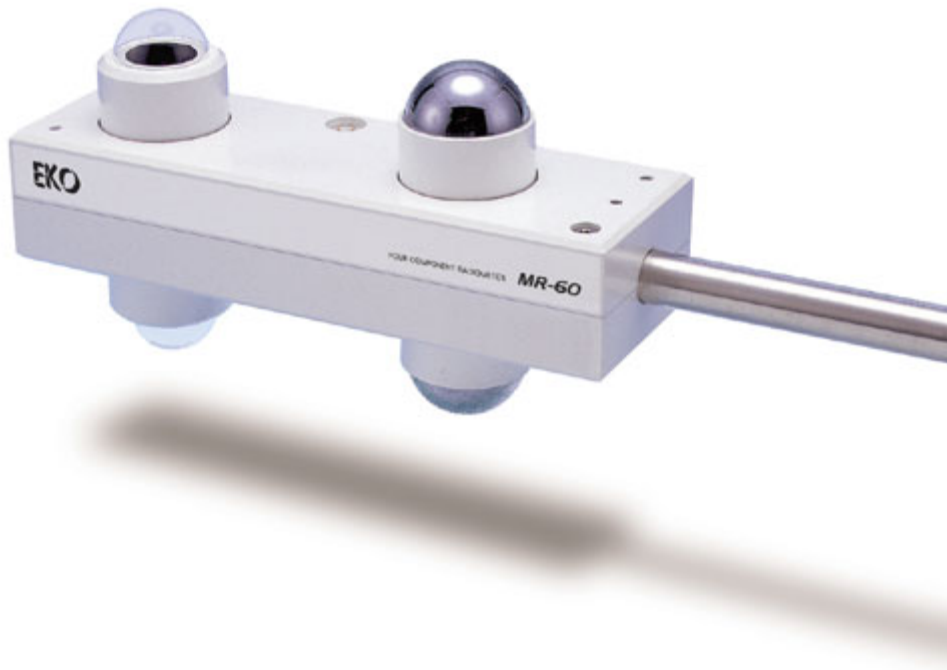
## Four-Component Radiometer

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**MR-60**

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Version : 2



ISO9001 CERTIFIED ISO14001 CERTIFIED ISO17025 CERTIFIED

**EKO** EKO INSTRUMENTS CO., LTD.

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## 2. Important User Information

Thank you for using EKO Products

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

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

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### 2-1. Contact Information

#### EKO INSTRUMENTS CO., LTD.

##### Asia, Oceania Region

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

##### Europe, Middle East, Africa Region

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

##### North & South America Region

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

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### 2-2. Warranty and Liability

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

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

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

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

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## 2-3. About Instruction Manual

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This manual was issued: 2015/03/16

Version Number: 2

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## 2-4. Environment

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

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

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

### 2. RoHS Directive 2002/95/EC

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

## 3. Safety Information

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



### WARNING CAUTION

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



### 3-1. WARNING/CAUTION

#### 1. Installation

- Mounting base/pole shall have enough durability to support the weight of this instrument; make sure to fix the instrument with bolts and nuts securely to the mounting base/pole. Mounting base/pole with insufficient durability or the instrument not securely fixed on the mounting base/pole may lead to unexpected accident by strong wind and/or earthquake.
- Make sure to install in a location where it is easy to access for maintenance. Installation in a location where it is difficult to reach may lead to unexpected accidents and injury.

#### 2. Disassembling the Instrument

This instrument is designed and manufactured so that the main body temperature and the sensor temperature will be at the same temperature; disassembling and taking out the sensor by user will lead to malfunction of the instruments. Thus DO NOT disassemble the instrument.

## 4. Introduction

Four-Component Radiometer MR-60 is an instrument to individually measure 4 radiation components, which are the short-wave radiation in the visible to near/mid-infrared area and long wave radiation in far-infrared area in upwards and downwards direction.

MR-60 can measure albedo, short-wave radiation balance, long-wave radiation balance, amount of radiation balance, estimated sky temperature, and estimated land surface temperature.

Short-wave radiation is measured by the two pyranometers (short-wave radiation sensors) for the downward and upward radiations. The pyranometer for downward radiation measures the short-wave radiation amount which incident from the sky (field of view 180°), and the pyranometer for upward radiation measures the downward radiation which reflected from the ground.

Long-wave radiation is measured by the two pyrgeometers (long-wave radiation sensors) for downward and upward radiations. The pyrgeometer for downward long-wave radiation amount which incident from the sky (field of view 180), and the pyrgeometer for upward radiation measures the downward radiation which reflected from the objects (i.e. soil, rocks and water) on land.

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### 4-1. Main Functions

#### 1. High Measurement Precision

For the 0.285~50 $\mu$ m range radiation balance measurement MR-60 takes individual measurement of downward and upward radiation, which the pyranometer covers 0.285~3 $\mu$ m range and pyrgeometer covers 3~50 $\mu$ m.

The pyranometers used in this instrument are ISO standard second class pyranometers.

#### 2. High Durability

MR-60 has a high durability since it is designed for all-weather use. Especially for the sensor part, glass dome is used; therefore, it does not require frequent replacement like the other competitor products, which are made with plastic domes. MR-60 can be used for a long-term with less maintenance frequency.

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## 4-2. Package Contents

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

Table 4-1 Package Contents

Standard Items	Qty.	Remarks
MR-60	1	Standard Cable Length 10m
Inspection Report	1	
Instruction Manual	1	

# 5. Getting Started

## 5-1. Parts Name and Descriptions

Each part name and its main functions are described below.

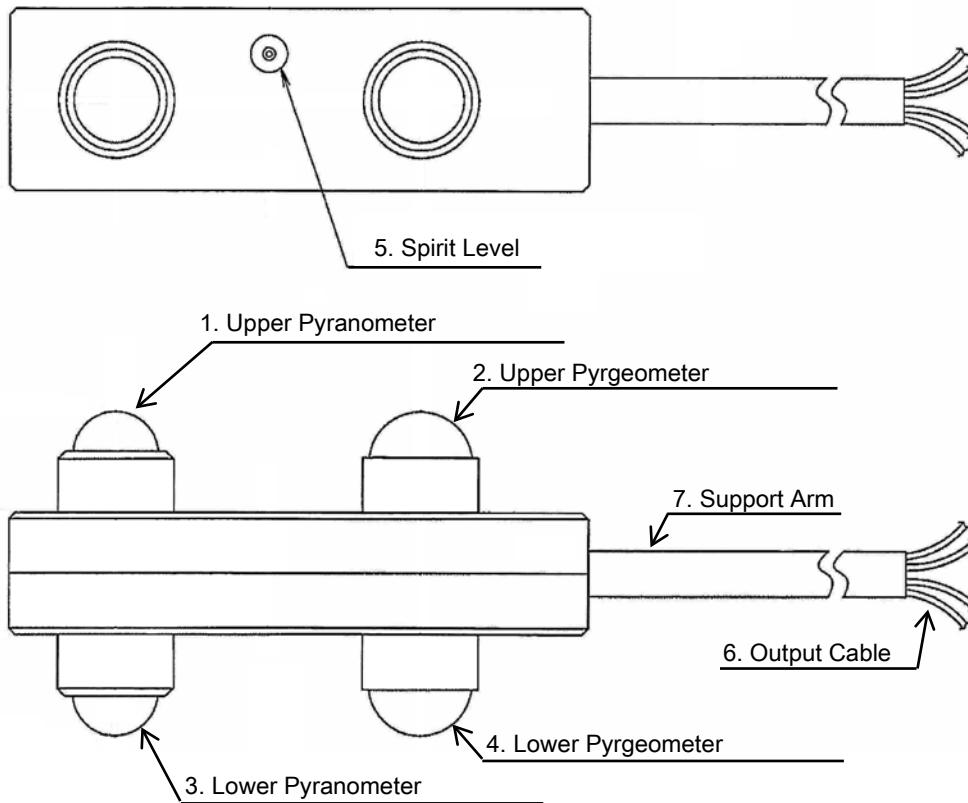


Figure 5-1. MR-60 Parts Name and Descriptions

Table 5-1. Parts Name and Descriptions

	Parts Name	Functions
1	Upper Pyranometer	Measures the downward short-wave radiation
2	Upper Pyrgeometer	Measures the downward long-wave radiation
3	Lower Pyranometer	Measures the upward short-wave radiation
4	Lower Pyrgeometer	Measures the upward long-wave radiation
5	Spirit Level	Use this to level the MR-60 in horizontal position
6	Output Cable	2-pin Cable x 2: Output cable for upper/lower Pyranometer 6-pin Cable x 2: Output cable for upper/lower Pyrgeometer and temperature.
7	Support Arm	Arm to install and fix the MR-60



## 5-2. Installation

### 1. Installation Location

When installing MR-60, there are few key points to take into account in determining the installation location and method for higher accuracy measurements.

Installation location should be a location where it is easy to access for daily maintenance (glass dome cleaning, checking the spirit level) and free from any obstacles, such as large buildings and their shades in the MR-60 sensor field of view.

MR-60 weights approximately 2.8kg; the mounting pole or base should be installed with consideration of the weight balance.

In order to take even higher accuracy measurements, it is recommended to install MR-60 on a mounting pole at high position, such as more than 1.5m, above ground.

### 2. Installation Procedure

#### 1) Fix the Main Unit

Use the MR-60 Support Arm (15mm in diameter) to fix the MR-60 main unit on the mounting base/pole. The side with Spirit Level is the upper side (Figure 5-2-1).



Figure 5-2-1. Spirit Level & Upper/Lower Positions

In the Northern Hemisphere, install the MR-60 with the Pyranometer side pointing towards South (Support Arm pointing towards North). In the Southern Hemisphere, the north and south position will be in opposite. (Figure 5-2-2)

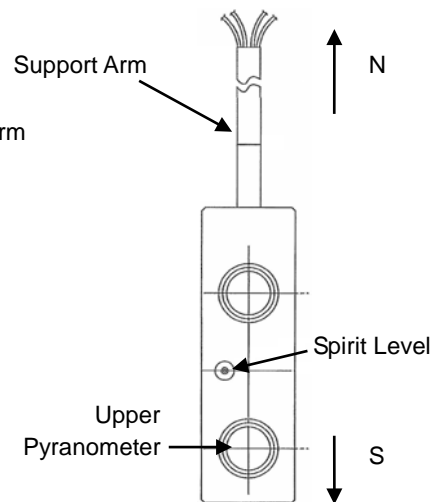


Figure 5-2-2.

Orientation of the Instrument  
(When installed in Northern Hemisphere,  
Looking at MR-60 from the top)

#### 2) Leveling

Adjust the MR-60 position making sure the air bubble inside the Spirit Level comes to the center of red circle then securely fix the MR-60 to the mounting base/pole



Figure 5-2-3. Leveling Spirit Level

## 5-3. Wiring

### 1. MR-60 Structure

Below shows the block diagram of MR-60.

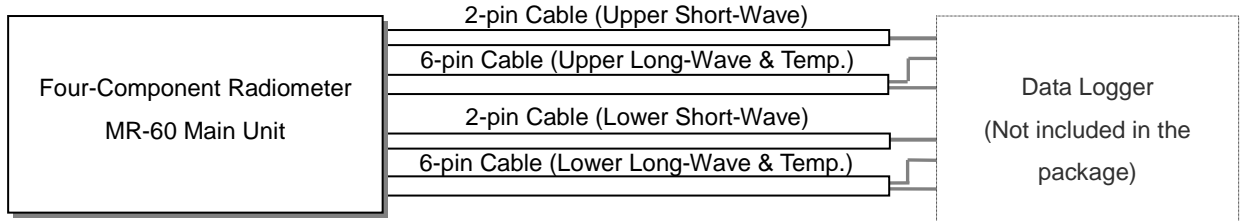


Figure 5-3-1. Block Diagram

### 2. Wiring

Each cable colors and functions are as described on the table below. Connect the Signal Cable from the MR-60 to the data logger according to the table.

Table 5-2. Cable Color and Function

Cable Tag	Pin	Cable Color	Crimp Color	Functions	Connect to
SW.UPP	2-pin	White	Red	Upper Pyranometer Signal Voltage +	A Data Logger
		Orange	Blue	Upper Pyranometer Signal Voltage -	B Data Logger
LW.UPP	6-pin	Pink + Red	Red	Upper Pyrgeometer Signal Voltage +	C Data Logger
		Pink + Black	Blue	Upper Pyrgeometer Signal Voltage -	D Data Logger
		White + Red	Red	Upper Pt Temp. Signal Current +	E Data Logger
		White + Black	Red	Upper Pt Temp. Signal Voltage +	F Data Logger
		Yellow + Red	Blue	Upper Pt Temp. Signal Voltage -	G Data Logger
		Yellow + Black	Blue	Upper Pt Temp. Signal Current -	H Data Logger
SW.LOW	2-pin	White	Red	Lower Pyranometer Signal Voltage +	I Data Logger
		Orange	Blue	Lower Pyranometer Signal Voltage -	J Data Logger
LW.LOW	6-pin	Pink + Red	Red	Lower Pyrgeometer Signal Voltage +	K Data Logger
		Pink + Black	Blue	Lower Pyrgeometer Signal Voltage -	L Data Logger
		White + Red	Red	Lower Pt Temp. Signal Current +	M Data Logger
		White + Black	Red	Lower Pt Temp. Signal Voltage +	N Data Logger
		Yellow + Red	Blue	Lower Pt Temp. Signal Voltage -	O Data Logger
		Yellow + Black	Blue	Lower Pt Temp. Signal Current -	P Data Logger

To identify the cables for the long-wave/ short-wave and upper/lower radiometer signals, there are identification tags attached to the cables. (Figure 5-3-2) The definitions of the tags are as follows:

- SW.UPP: Upper Pyranometer
- LW.UPP: Upper Pyrgeometer
- SW.LOW: Lower Pyranometer
- LW.LOW: Lower Pyrgeometer

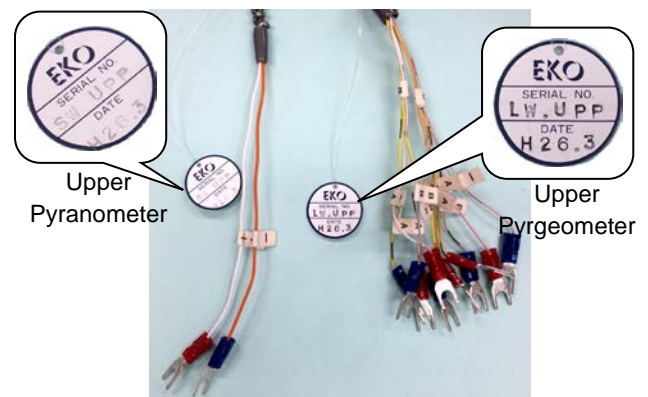


Figure 5-3-2. Cable Tags

Below Figure 5-3-3 shows the wiring drawing for the MR-60.

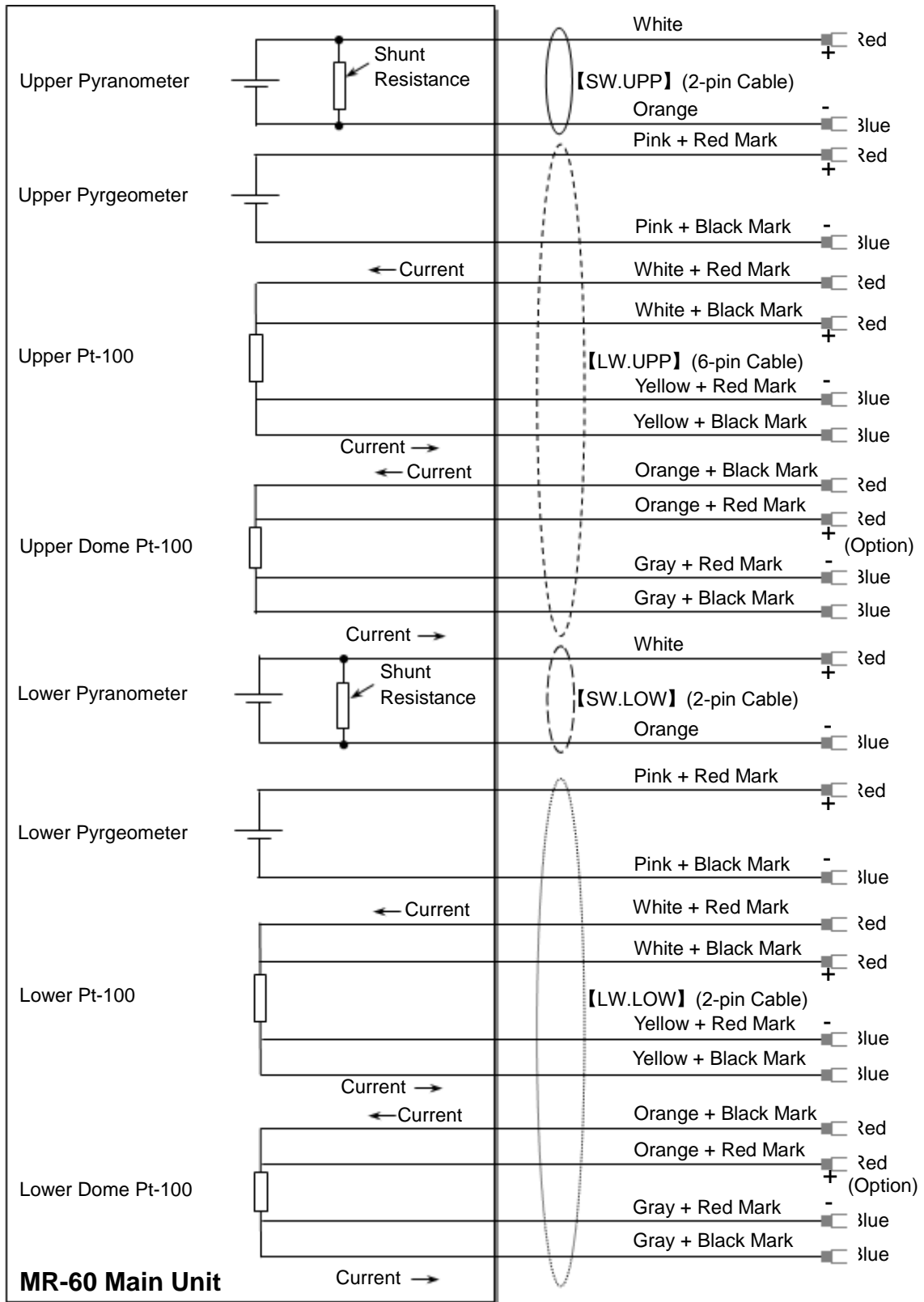


Figure 5-3-3. MS-60 Wiring

Prepare an appropriate data logger for the voltage to be measured. MR-60 will require a data logger with 4 channels for DC voltage channels and 2 channels for Pt temperature measurement. The signal voltage of each radiometer to be connected to the DC voltage channel is maximum of 10mV.

The connecting cable ends should be connected securely by soldering and insulate it by wrapping with insulating tape.

Secure the cables with cable strap and so on so that the cable does not swing by the wind.

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## 5-4. Calculation of the Radiations

By measuring the two pyranometers for short-wave radiation, two pyrgeometers for long-wave radiation, and temperature sensor for calculating the infrared independently, each radiation amount, radiation balance amount, albedo, etc. can be determined.

### 1. Solar Radiation

To calculate the short-wave radiation amount ( $W/m^2$ ) from the voltage output ( $\mu V$ ) acquired by the pyranometer, use the following formula:

$$R_{sw} = V_{sw} / C$$

Where	$R_{sw}$ :	Short-Wave Radiation ( $W/m^2$ )
	$V_{sw}$ :	Output Voltage from Pyranometer ( $\mu V$ )
	$C$ :	Pyranometer Sensitivity ( $\mu V/Wm^{-2}$ )

The sensitivity  $C$  is stated on the product label attached on the MR-60 main unit.

### 2. Infrared Radiation

To calculate the long-wave radiation amount ( $W/m^2$ ) from the voltage output ( $\mu V$ ) acquired by the pyrgeometer and temperature sensor (Pt-100), use the following formula:

$$R_{lw} = V_{lw} / C + \sigma T^4$$

Where	$R_{lw}$ :	Long-Wave Radiation ( $W/m^2$ )
	$V_{lw}$ :	Output Voltage from Pyrgeometer ( $\mu V$ )
	$C$ :	Pyrgeometer Sensitivity ( $\mu V/Wm^{-2}$ )
	$\sigma$ :	Stefan Boltzman Constant( $=5.67 \times 10^{-8} Wm^{-2}K^{-4}$ )、
	$T$ :	Absolute temperature from the Temperature Sensor (Pt-100) (K; Celsius Temperature +273.15)

The sensitivity  $C$  is stated on the product label attached on the MR-60 main unit.

### 3. Radiation Amount of Each Type

From the calculated values of the solar radiation and infrared radiation in above section, following radiation amount can be determined:

Table 5-3. Calculation for Radiation Amount of Each Type

Calculation Item	Unit	Formula	Remarks
Albedo A	-	$A=R_{sw.lower}/R_{sw.upper}$	Reflection rate of the short-wave radiation on the ground
Short-Wave Radiation Balance Amount NR <sub>sw</sub>	Wm <sup>-2</sup>	$NR_{sw}=R_{sw.upper}-R_{sw.lower}$	
Long-Wave Radiation Balance Amount NR <sub>lw</sub>	Wm <sup>-2</sup>	$NR_{lw}=R_{lw.upper}-R_{lw.lower}$	
Radiation Balance Amount NR	Wm <sup>-2</sup>	$NR=(R_{sw.upper}+R_{lw.upper})-(R_{sw.lower}+R_{lw.lower})$	Radiation balance amount for both short-wave and long-wave radiations
Estimated Sky Temperature ST	K	$ST=\{R_{lw.upper}/(5.67 \times 10^{-8})\}^{1/4}$	
Estimated Land Surface Temperature GT	K	$GT=\{R_{lw.lower}/(5.67 \times 10^{-8})\}^{1/4}$	

Where

- R<sub>sw.upper</sub>: Radiation measured by MR-60 upper pyranometer.
- R<sub>sw.lower</sub>: Radiation measured by MR-60 lower pyranometer.
- R<sub>lw.upper</sub>: Radiation measured by MR-60 upper pyrgeometer
- R<sub>lw.lower</sub>: Radiation measured by MR-60 lower pyrgeometer

Estimated Sky Temperature (ST) and Estimated Land Surface Temperature (GT) refer to the estimated temperature when the sky or land surface is considered as perfect black body with emissivity = 1.

# 6. Maintenance & Troubleshooting

## 6-1. Maintenance

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

Figure 6-1. Maintenance

Check Item	Frequency	How To	Effect of Neglecting Maintenance
Clean Glass Dome	Several Times per week (at least once per week)	Clean the glass dome by wiping with soft cloth and alcohol.	Sensor output will be measured less due to the radiation not being able to reach the sensor sufficiently with dirty on the dome.
Check Glass Dome Condition	Weekly	Check for cracks and scratches on the glass dome and its area around.	Any damages on the glass dome and its area around may lead to water leakage, which cause damages to the MR-60 sensors and internal parts.
Check Spirit Level	Weekly	Check if the MR-60 is in horizontal position. Adjust the level if the MR-60 is tilted.	If the MR-60 is not leveled correctly, it will lead to measurement errors in cosine/directional responses corresponding to the amount of tilted angle.
Check Cable Conditions	Weekly	Check for any damages on the cable, or the cable is not swinging by the wind.	Disconnected cable will cause failure of measurements or sporadic reading errors. If the cable is swinging by the wind, it may generate noise in the measurements.
Check Mounting Base/Pole	Weekly	Check to make sure the MR-60 is mounted correctly and securely, and check for any deterioration and loose parts on the mounting base/pole.	Fall of the mounting base/pole or drop of MR-60 may lead to damages to the sensor parts and/or may cause injury.
Recalibration of Sensors	Every 2 years	It is recommended to recalibrate the sensor sensitivity. (Contact EKO for further details)	Due to the degradation of the sensor sensitivity, it may lead to output measurement error. Refer to the next section for determining whether recalibration is needed.

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## 6-2. Recalibration

It is recommended to recalibrate the instrument once every 1~2 years. For further information about the calibration and recalibration, please contact EKO.

To determine whether the recalibration is needed by the user, follow below procedure:

1) Pyranometer

On a sunny clear day, install the MR-60 upper and lower sides in upside down position. Check the difference in output voltage values between the pyranometers for downward radiation and upward radiation. If there are more than 5% difference confirmed, MR-60 needs to be recalibrated.

2) Pyrgeometer

Install the MR-60 upper and lower sides in upside down position. Check the difference in output voltage values between the pyrgeometers for downward infrared and upward infrared radiations. If there are more than 5% difference confirmed, MR-60 needs to be recalibrated.

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## 6-3. Troubleshooting

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

Table 8-1. Troubleshooting

Failure	Action
There is no pyranometer output	In order to verify the output cable is connected properly or disconnected, measure the pyranometer impedance between the + and – of output cable, and check whether it satisfies the specification (see 7. Specifications).
	Check whether the measuring device has the appropriate measurement range for the MR-60.
There is no pyrgeometer output	In order to verify the output cable is connected properly or disconnected, measure the pyranometer impedance between the + and – of output cable, and check whether it satisfies the specification (see 7. Specifications)
Temperature sensor output is showing abnormal value	Measure the resistance value of the temperature sensor. If it measures approximately 110Ω at 25~26°C, the temperature sensor is in a good condition.

# 7. Specification

## 7-1. Specifications

Table 7-1. Main Unit Specification

Characteristics	Details
Number of Channels	4 channels for mV range, 2 channels for 4-wire type Pt-100
Cable Length	Standard Lengths: 10m Optional Length: 20m, 30m, 50m
Operation Temperature	-40 to +70°C
Dimension	60(W) x 190(D) x 106(H) mm (without the Support Arm)
Weight	2.8kg (10m cable included)

Table 7-2. Pyranometer Specification

Characteristics	Details
ISO Standard Classification	Second Class
Response Time (95%)	Approximately 17 seconds
Sensitivity	4 to 10 $\mu$ V/W $\cdot$ m <sup>2</sup>
Zero Offset	Less than 10W/m <sup>2</sup> for 200W/m <sup>2</sup> heat radiation Less than 6W/m <sup>2</sup> for 5K/h ambient temperature change
Stability	Less than 1.7%/ year
Non-Linearity	Less than 1.5% @ 1000W/m <sup>2</sup>
Temperature Response	Less than 2% (-10 to +40°C)
Tilt Response	2%
Impedance	20 to 140 $\Omega$
Wavelength Range	285~3000nm



Table 7-3. Pyrgeometer Specification

Characteristics	Details
Response Time (95%)	18 seconds
Sensitivity	2 to 15 $\mu$ V/W $\cdot$ m <sup>2</sup>
Stability	1%/year
Temperature Response	6% (-10 to +40°C)
Tilt Response	Maximum of 3% in downward direction
Field of View	180°
Impedance	20 to 140 $\Omega$
Wavelength Range	3 to 50 $\mu$ m
Window Offset	Maximum of 25W/m <sup>2</sup> @ solar radiation 1000W/m <sup>2</sup>

Table 7-4. Temperature Sensor Specification

Characteristics	Details
Temperature Sensor	4-Wire Type, Pt-100(JIS Standard: C-1604-1989 Class A)

## 7-2. Dimensions

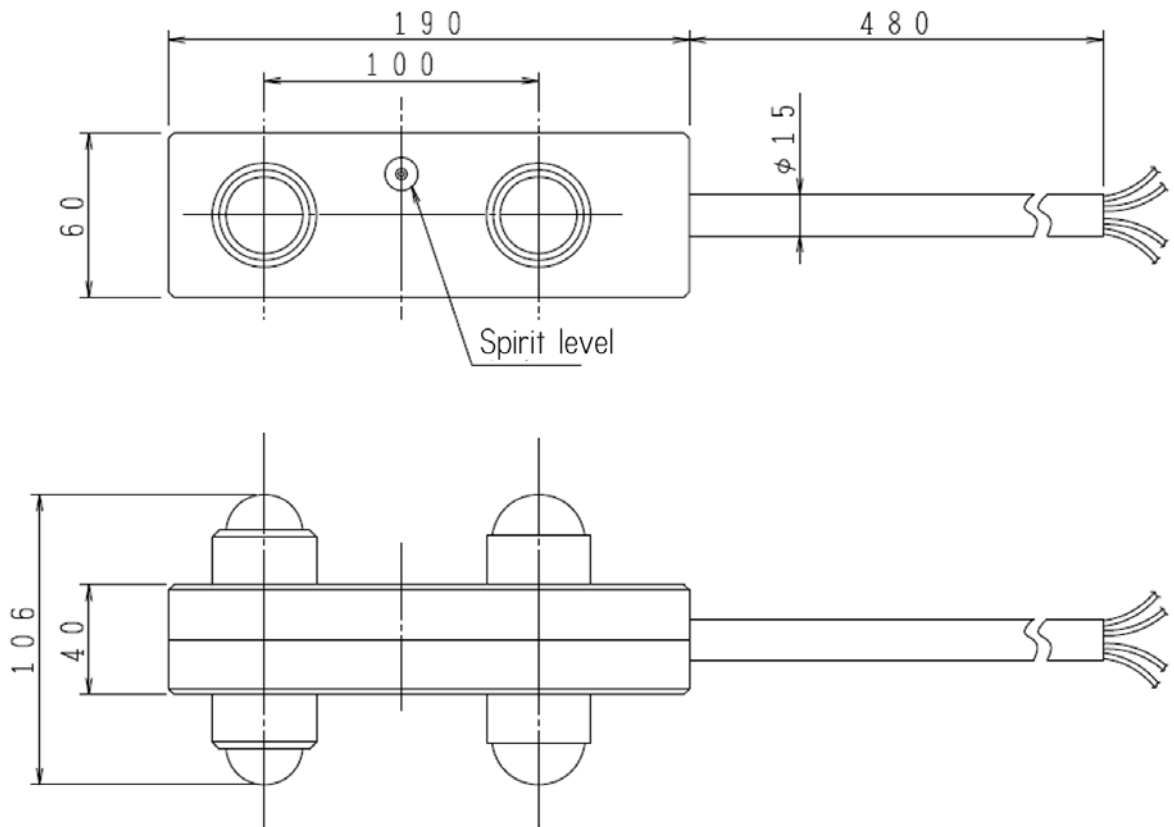


Figure 7-1. MR-60 Dimensions

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## 7-3. Accessories List

Table 7-5. Accessories List

Option Items	Remarks
Output Cable	20m, 30m, 50m



Japan: [www.eko.co.jp](http://www.eko.co.jp)

Europe: [www.eko-eu.com](http://www.eko-eu.com)

USA: [www.eko-usa.com](http://www.eko-usa.com)