



**3S-SMS-MB & 3S-SMS-GW**

# Automatic Soiling Sensor

USER MANUAL

## USER MANUAL TABLE OF CONTENTS

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## 1. Introduction

### Structure of the Automatic Soiling Sensor

The Automatic Soiling Sensor consists of two irradiance sensors, one designated as clean and the other as soiled, a water tank equipped with a water pump that performs the cleaning process, and an electronic panel containing the sensor's electronic components.

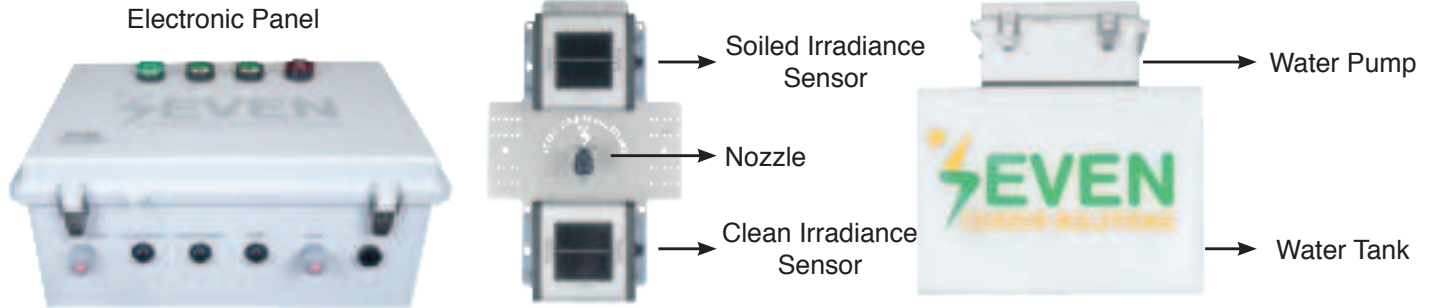


Figure 1 – Components of the Automatic Soiling Sensor

### Operating Principle and Calculation of Soiling Ratio

Once the field installation of the Automatic Soiling Sensor is completed, the soiled irradiance sensor is exposed to soiling under the same environmental conditions as the solar panels in the field, while the clean irradiance sensor is cleaned daily by the cleaning system. After installation, the sensor requires one day of data collection to calculate the soiling ratio. During this process, the sensor calculates the soiling ratio by filtering and comparing the data obtained from the soiled and clean irradiance sensors using its specialized software. The data filtering process adheres to the IEC 61724-1: 2021 standard. According to the standard, data collected within the two-hour time frame before and after local solar noon is considered. However, data with low irradiance values and unstable weather conditions are excluded from the calculation. Any data meeting these criteria is regarded as stable data.



**Note:** In the factory settings, the “Minimum Stable Data” required to calculate the soiling ratio is set to 20. This value can be adjusted by the user through the GUI.

When the required minimum number of stable data points is reached, the soiling ratio is calculated as a daily average value and presented to the user as the “Daily Average Soiling Level Percentage” after midnight. The soiling ratio displayed in the monitoring system reflects the value calculated for the previous day. However, if the minimum number of stable data points is not reached, the sensor will display the last calculated value until a new soiling ratio can be determined. If no previous calculation exists, the soiling ratio will be displayed as zero until suitable conditions are met.

### Cleaning Process and Water Tank Capacity

The Automatic Soiling Sensor is configured to clean the clean irradiance sensor once daily for five seconds, three hours before local solar noon by default. As per the user's request, the cleaning frequency can be increased to a maximum of three times per day via the GUI, and the cleaning times can be adjusted according to the user's selected schedule.



**Not:** The 18-liter water tank is sufficient for approximately 6 months with a cleaning frequency of once per day. However, if the cleaning frequency is increased, it should be noted that the water tank will deplete more quickly.

### Data Recording and User Access

The Automatic Soiling Sensor has the capacity to store collected data for up to one year. The recorded data includes the daily calculated soiling ratio, the number of stable data points collected each day, the water level status of the tank, and the dates when the sensor was powered on or off. These records can be viewed by the user through the GUI and downloaded when needed.



**Note:** SEVEN reserves the right to make changes to this document in its entirety without prior notice.

## 2. Installation Process

It is suggested that the system be operated at ground level to make sure that all components are working properly prior to installation. A general diagram of the progress of the installation steps is given below.

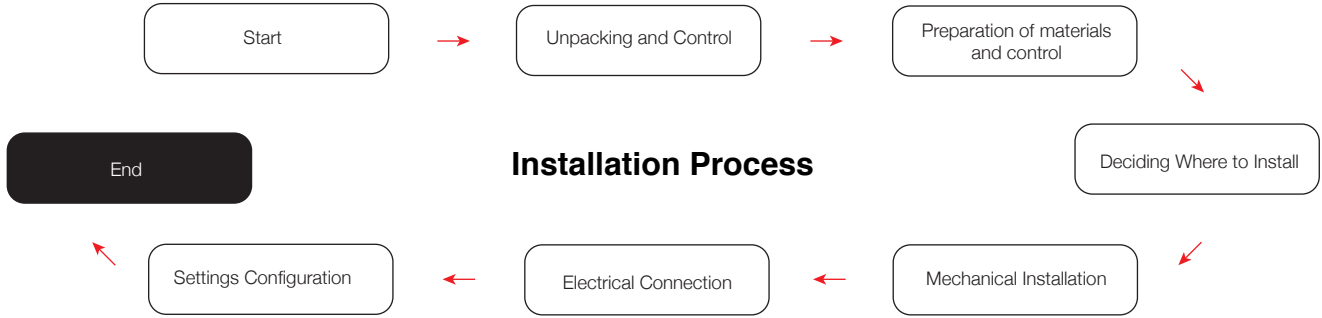


Figure 2 – Installation Process

## 3. Unpacking and Control

Upon receipt of the product, it must be carefully checked whether the package content is complete. SEVEN Sensor must be contacted if any of the components are missing, damaged or defective.









			
Qty 1	Qty 1	Qty 1	Qty 2
Irradiance Sensors	Electronic Panel	Water Tank	Irradiance Sensor Cables
			
Qty 1	Qty 1	Qty 1	Qty 1
Water Pump Cable	USB-RS485 Converter	Mounting Components	Clips

Figure 3 – 3S-SMS Packing List

Cable Lengths of the Automatic Soiling Sensor			
	Cable Type	Cable Connector	Cable Length
1	Power Cable	Cable Gland	3 m
2	Communication Cable	Cable Gland	3 m
3	Clean Irradiance Sensor Cable	6 Pin	5 m
4	Soiled Irradiance Sensor Cable	6 Pin	5 m
5	Water Pump Cable	4 Pin	5 m
6	Water Hose	-	5 m

Figure 4 – Cable Lengths



**Note:** Quantity and content of the received material may be different based on customer confirmed order.

## 4. Field Requirements and Considerations

Since each site has its own unique challenges, the installation of the Automatic Soiling Sensor may vary from one site to another. First and foremost, the location for the sensor installation must be determined. The soiled irradiance sensor on the Automatic Soiling Sensor should be exposed to the same level of soiling as the solar panels at the site. Therefore, it is important to avoid placing the sensor near elements like chimneys or ventilation systems that could generate additional dust sources. Furthermore, both the soiled and clean irradiance sensors should be positioned away from dark, reflective, or heat-absorbing surfaces.

For the Automatic Soiling Sensor to accurately measure the soiling ratio, the soiled irradiance sensor must be exposed to the same level of soiling as the solar panels on-site. Accordingly, it is recommended to perform site cleaning after the sensor installation is completed, if possible. If site cleaning cannot be performed immediately, measurements can still be initiated. However, in this case, it should be considered that the Automatic Soiling Sensor may be less soiled than the site, and measurement results should be evaluated accordingly. Additionally, whenever site cleaning is performed, the irradiance sensors of the Automatic Soiling Sensor must also be cleaned. This process is essential to ensure that the soiling ratio measurements accurately represent the current site conditions.

The Automatic Soiling Sensor performs a 5-second cleaning process every day in the morning, approximately three hours before noon, in the installed region. In Tracker systems, the clean Irradiance Sensor must be positioned downward during this cleaning process. Otherwise, if the clean Irradiance Sensor is positioned higher than the soiled Irradiance Sensor, the cleaning fluid may spill onto the soiled Irradiance Sensor. This could lead to inaccurate soiling ratio measurements, making it a critical point to consider. Therefore, it is essential to ensure that the Irradiance Sensor positions are correctly configured during system installation and maintenance procedures.

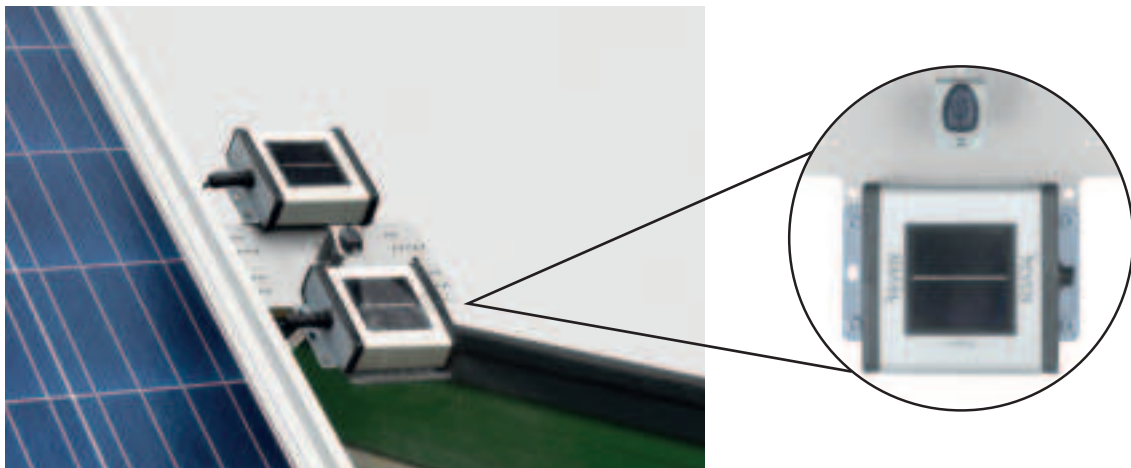


Figure 5 – Cleaning Process of the Irradiance Sensor

## 5. Installation and Setup

### 5.1. Installation of Irradiance Sensors

Mount the installation plate holding the irradiance sensors next to the solar panels, ensuring it is aligned at the same angle and orientation as the solar panels.

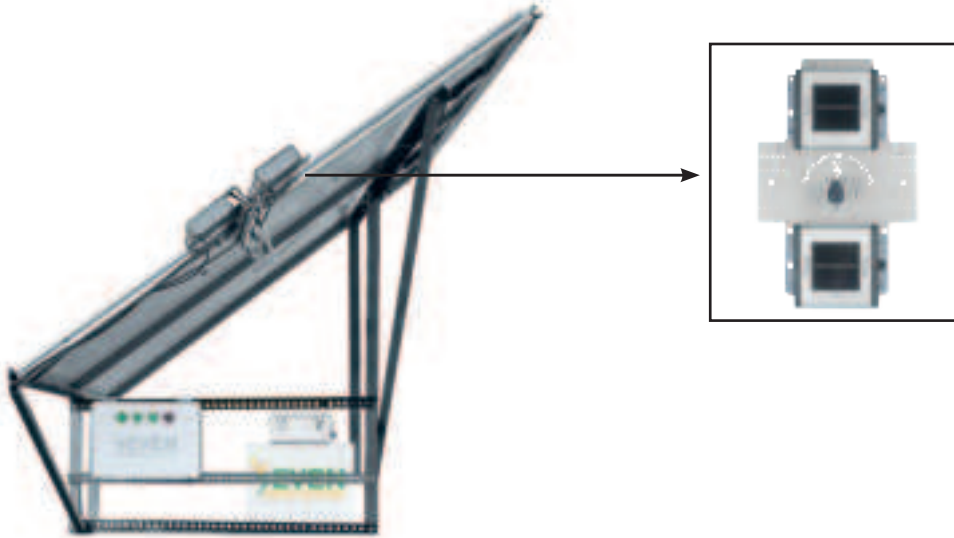


Figure 6 – Installation of Irradiance Sensors



**Note:** To ensure that the irradiance sensors are exposed to the same conditions as the solar panels on-site, they must be installed directly adjacent to the solar panels. Even if the sensors are mounted at the same angle and orientation as the panels, placing them away from the panels may result in soiling differences between the irradiance sensors and the solar panels.

### 5.2. Installation of the Water Tank

Place the water tank under the solar panel or in another suitable area to protect it from sunlight and reduce evaporation.

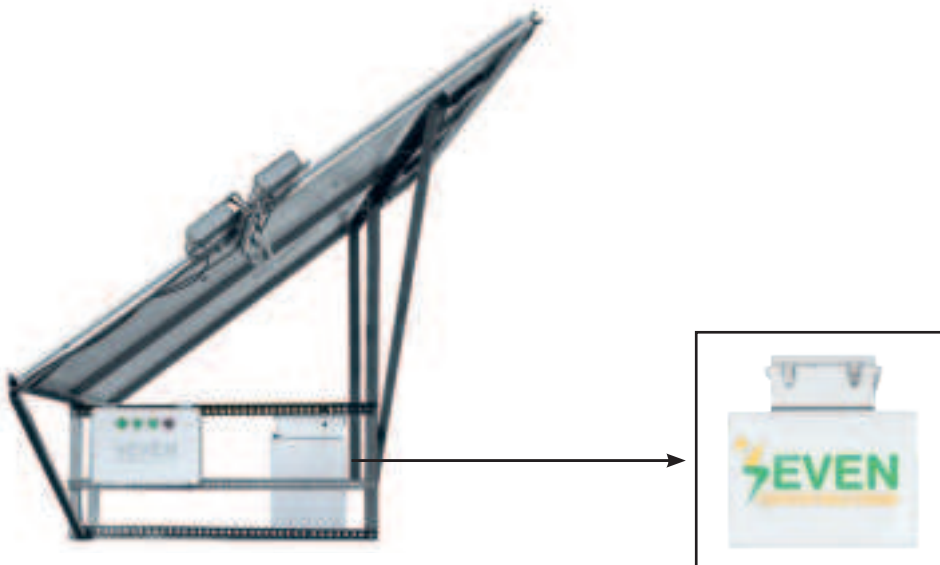


Figure 7 – Installation of the Water Tank



**Note:** Since the water tank contains plastic components, prolonged exposure to direct sunlight may cause discoloration.

If the ambient temperature is above 0°C, fill the water tank with 100% pure water. However, if the temperature is below 0°C, fill the tank with a mixture of 65% pure water and 35% antifreeze.





**Note:** Only pure water and high-quality antifreeze in the specified ratios for low temperatures should be used in the water tank. Otherwise, using regular water or low-quality antifreeze, or deviating from the specified ratios, may cause stains on the irradiance sensors, negatively affecting the accuracy of soiling ratio calculations.

Attach the water hose connected to the water pump box on the water tank to the nozzle on the plate where the irradiance sensors are mounted, and secure the connection point with a clip.

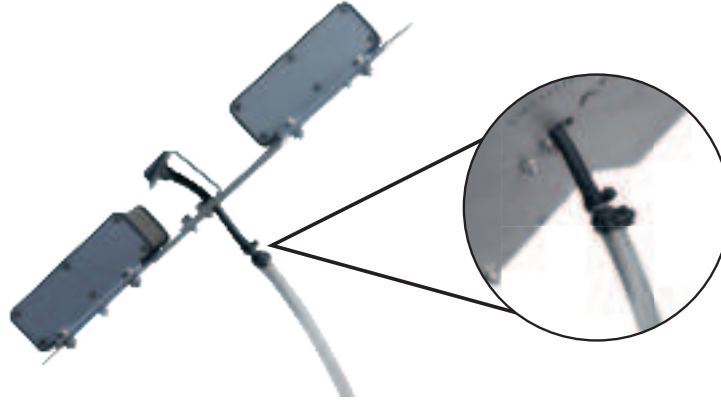


Figure 8 - Silicone Hose Assembly



**Note:** During installation, ensure the water hose is not bent. Hose bending can prevent the motor from generating the required pressure, resulting in an ineffective cleaning process.

### 5.3. Installation of the Electronic Panel

Mount the electronic panel under the solar panel or in another protected area using appropriate equipment and the mounting brackets on the back of the panel.



**Note:** During installation, no screwing or modifications should be made inside the electronic panel. Any mechanical alterations made by the user to the electronic panel, irradiance sensors, or water tank of the Automatic Soiling Sensor will void the warranty of the device.

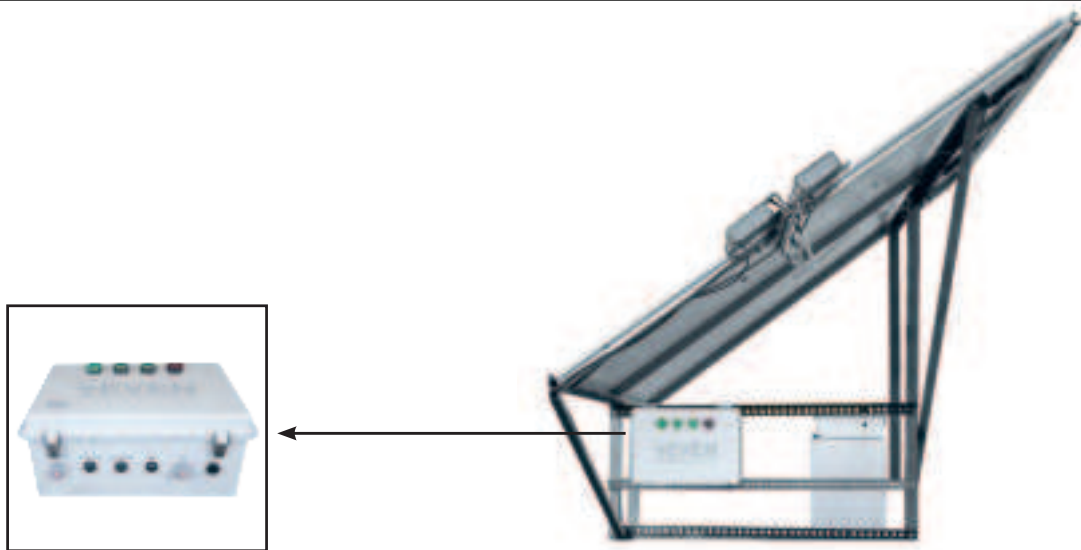


Figure 9 – Installation of the Electronic Panel



**Note:** The electronic panel must be installed in a protected area, as its plastic components may discolor if exposed to direct sunlight and, despite its IP65 protection rating, it could be at risk of water ingress when subjected to direct rainfall.

## 5.4. Connection of the Clean Irradiance Sensor Cable

Connect one end of the irradiance sensor cable, which has a 6-pin connector on both ends, to the “CLEAN SENSOR” connector on the electronic panel. Attach the other end to the connector located on the irradiance sensor cover marked with “CLEAN” on the sensor mounting plate.



Figure 10 – Connection of the Clean Irradiance Sensor Cable

## 5.5. Connection of the Soiled Irradiance Sensor Cable

Connect one end of the irradiance sensor cable, which has a 6-pin connector on both ends, to the “SOILED SENSOR” connector on the electronic panel. Attach the other end to the connector located on the irradiance sensor cover marked with “DIRTY” on the sensor mounting plate.



Figure 11 – Connection of the Soiled Irradiance Sensor Cable



## 5.6. Connection of the Water Pump Cable

Connect one end of the water pump cable, which has a 4-pin connector on both ends, to the “PUMP” connector on the electronic panel. Attach the other end to the connector located on the water pump box on the water tank.



Figure 12 – Connection of the Water Pump Cable

## 5.7. Connection of the Power Cable

The power cable of the Automatic Soiling Sensor is delivered pre-connected to the electronic panel, with a field assembly connector attached at its end. To supply power to the sensor, the necessary connections must be made via this field assembly connector. Based on the model of your Automatic Soiling Sensor, complete the sensor connections according to the instructions provided below.



**Note:** In the Automatic Soiling Sensor, a buzzer on the electronic panel will activate to provide an audible alert when the water tank is empty. Therefore, it is mandatory to fill the water tank before powering the sensor.

### 5.7.1. 3S-SMS-MB & 3S-SMS-GW Models

Connect pin 1 of the field mount connector to the mains phase line (L), pin 3 to the mains neutral line (N), and pin 5 to the mains ground line. After ensuring that all connections are correct and securely completed, connect the sensor to the mains voltage to enable its operation.

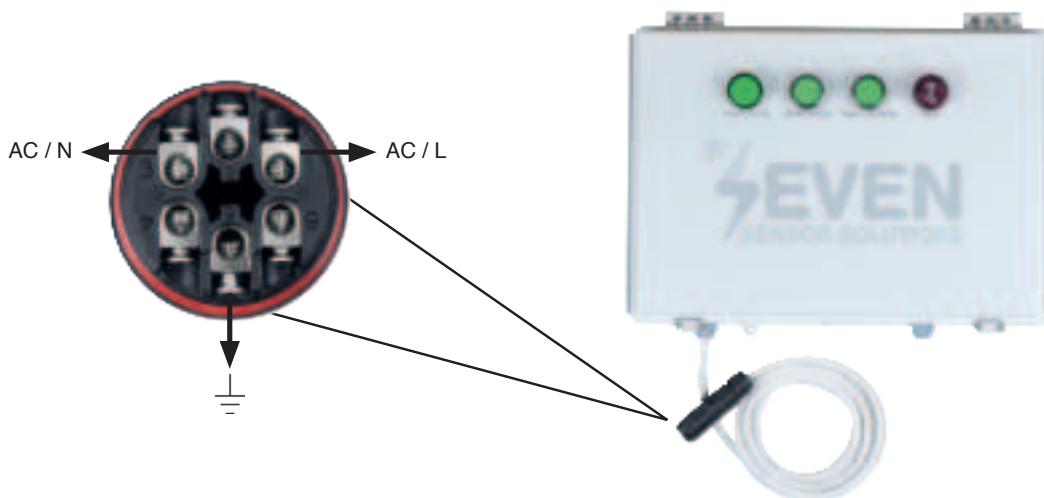


Figure 13 – Connection of the Power Cable

## 5.7.2. 3S-SMS-MB-24V & 3S-SMS-GW-24V Models

The 24-volt models of the Automatic Soiling Sensor operate with power supplies rated at 24V 5A. Before making the power connections for the 24-volt model, ensure that you have a compatible adapter with the required specifications.



**Note:** If an extension is added to the power cable, the voltage drop due to cable resistance must be considered. The sensor comes with a 3-meter-long cable with specifications of 3 x 1.5 mm<sup>2</sup>. An extension of up to 50 meters with the same specifications can be added. For extensions exceeding 50 meters, the voltage drop should be calculated, and if necessary, a cable with a larger diameter should be used. Otherwise, the cleaning system may not function properly.

Connect pin 1 of the field mount connector to the positive (+) terminal of the 24-volt power supply, pin 2 to the negative (-) terminal, and pin 3 to the ground line of the 24-volt power supply. After ensuring that all connections are correct and secure, activate the 24-volt power supply to operate the sensor.

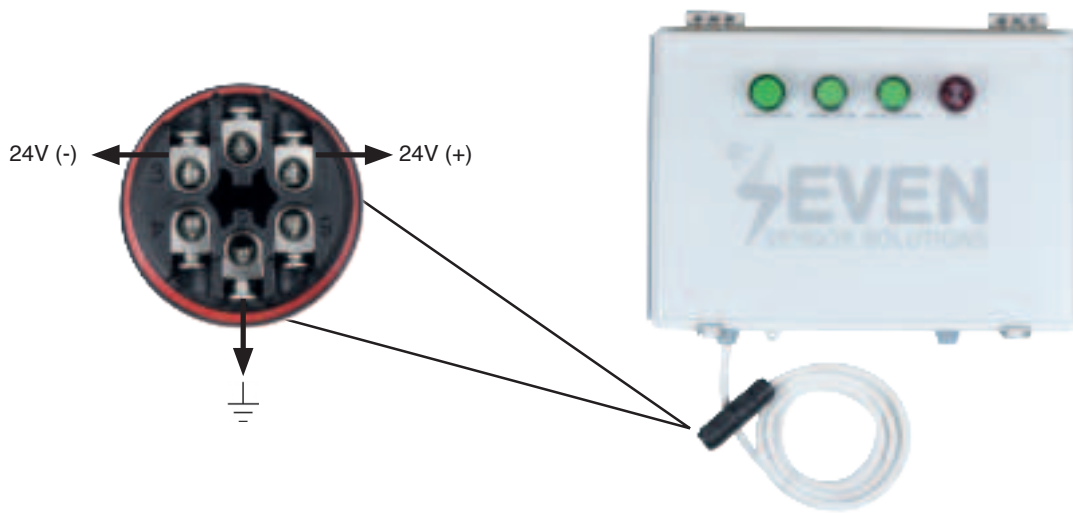


Figure 14 – 24V Power Cable Connection

## 5.8. Indicators and Buttons on the Electronic Panel

After powering the Automatic Soiling Sensor, some checks should be performed using the buttons and indicators on the electronic panel cover. These are explained as follows:

**1. SYSTEM ACTIVE:** The “SYSTEM ACTIVE” LED should light up when the sensor is powered on. This LED indicates that the sensor is receiving power.

**2. NORMALIZATION:** This button is not used during installation. It is activated when normalization is required between the Soiled and Clean irradiance sensors. The requirements and procedures for this process are explained in details in the “GUI User Manual”.



**Note:** Normalization should not be initiated outside its intended use. If the button is pressed for more than 5 seconds, the soiling ratio calculation will stop and will not restart until the normalization process is completed. In such a case, the issue can be resolved by turning the sensor off and on again.

**3. MANUAL CLEANING:** This button is used to manually operate the cleaning system. After powering the sensor, this button should be used to activate the water pump and verify that the cleaning system is functioning correctly.

**4. ERROR:** A buzzer is present to provide an audible warning when the water tank is empty. No action is required regarding the buzzer during installation.



Figure 15 – Indicators and Buttons on the Electronic Panel

## 5.9. Communication Cable Connection

After completing the installation and cable connections of the Automatic Soiling Sensor, the location and time parameters must be configured according to site-specific information to determine the local noon time used in soiling ratio calculations. To perform these settings, the Automatic Soiling Sensor must first be connected to a USB-RS485 Converter. The USB-RS485 Converter required for this process is included in the package provided by SEVEN Sensor.

The communication cable of the Automatic Soiling Sensor is delivered connected to the electronic panel. To connect the communication cable, connect the green wire to the Data (+) terminal of the USB-RS485 converter and the yellow wire to the Data (-) terminal of the USB-RS485 converter.

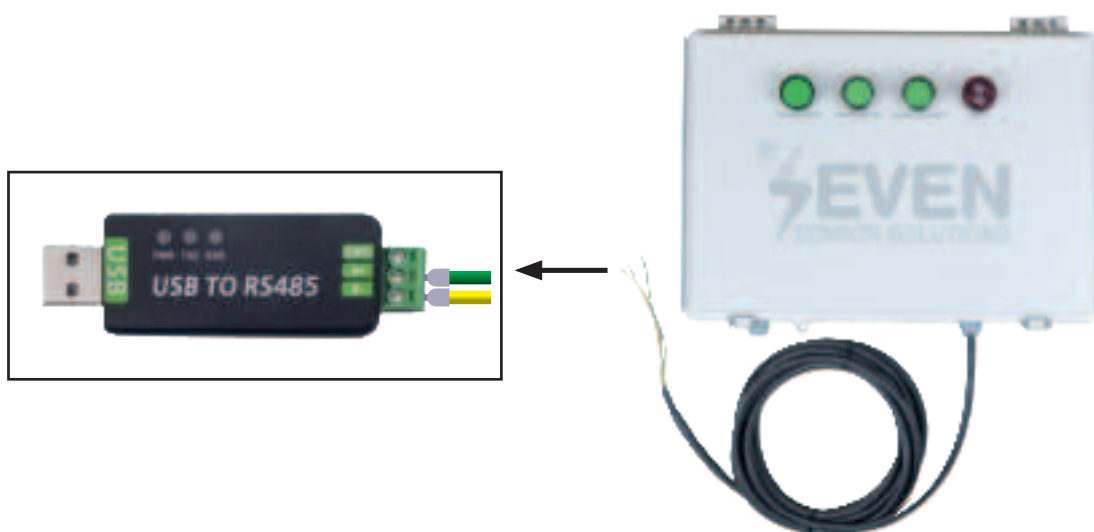


Figure 16– Communication Cable Connection

## 5.10. Configuration Tool Connection

After connecting the communication cable, a Windows® computer is required to configure the time and location settings for the Automatic Soiling Sensor based on site-specific information. Once you have the computer, connect the USB-RS485 converter to the USB port of your computer.

For your computer to recognize the USB-RS485 converter, it must be identified as a serial COM port. If your computer does not have a recognized RS485 COM port, download the 'GUI User Manual' document from the provided link and update your driver accordingly.

[https://www.sevensensor.com/files/d/en/3S-SMS-MB\\_Configuration\\_Tool.pdf](https://www.sevensensor.com/files/d/en/3S-SMS-MB_Configuration_Tool.pdf)

Download and install the 3S-SMS-MB Configuration Tool software on your computer. The download link is provided below.

[https://www.sevensensor.com/files/d/s/v4.0\\_3S-SMS-MB\\_Configuration\\_Tool.zip](https://www.sevensensor.com/files/d/s/v4.0_3S-SMS-MB_Configuration_Tool.zip)

When the 3S-SMS-MB Configuration Tool is launched, the following screen will appear.



Figure 17 – 3S-SMS-MB Configuration Tool

To connect the Automatic Soiling Sensor to the 3S-SMS-MB Configuration Tool, follow these steps:

- Select the serial COM port to which the USB-RS485 converter is connected.
- Enter the Modbus ID, Baud Rate, and Parity values of the Automatic Soiling Sensor in the “**Actual**” section under the “**Communication Settings**” area.
- Click the “Connect” button.



**Note:** The factory settings of the Automatic Soiling Sensor are as follows: Modbus ID: 1, Baud rate: 9600, Parity: None/1.

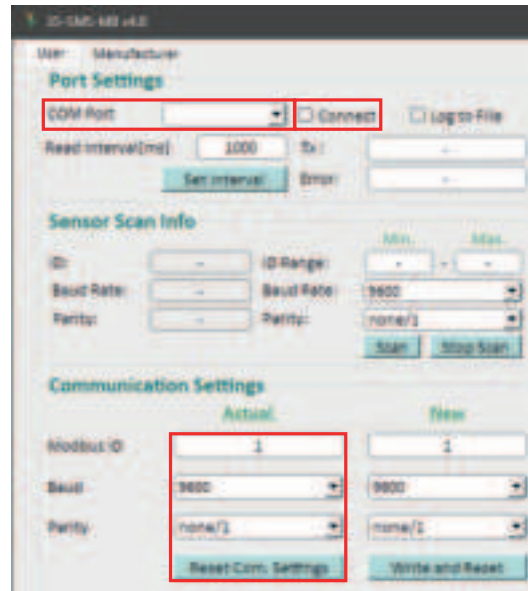


Figure 18 – Configuration Tool Connection



**Note:** The sensor must be powered so it can connect to the configuration tool. Without power, the sensor cannot connect to the configuration tool.

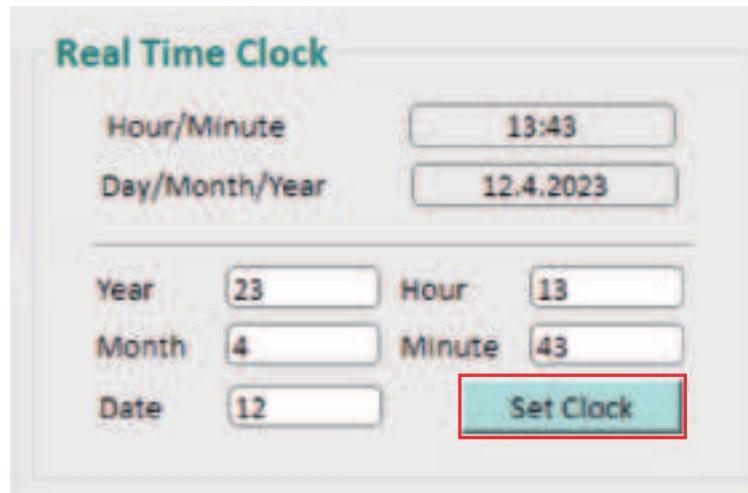
When the connection is successfully completed, the details of the Automatic Soiling Sensor will be displayed in the “**Device Information**” section, and the data retrieved from the sensor will be shown in the “**Sensor Data**” section



Figure 19 – Automatic Soiling Sensor Information



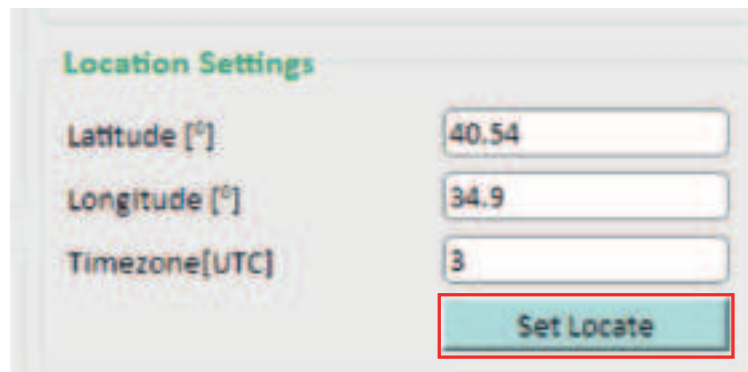
- Enter the values to be set in the “**Real Time Clock**” section as two digits in the respective fields.
- Click the “**Set Clock**” button.



The image shows a 'Real Time Clock' configuration window. It contains two summary fields at the top: 'Hour/Minute' with the value '13:43' and 'Day/Month/Year' with the value '12.4.2023'. Below these are individual input fields for 'Year' (23), 'Month' (4), 'Date' (12), 'Hour' (13), and 'Minute' (43). A red rectangular box highlights the 'Set Clock' button at the bottom right of the form.

Figure 20 – Setting Date and Time Information

- Enter the latitude and longitude values of the location to be set in the “**Location Settings**” section with two decimal places after the point. For the time zone value, include one decimal place after the point.
- Then click the “**Set Locate**” button.



The image shows a 'Location Settings' configuration window. It contains three input fields: 'Latitude [°]' with the value '40.54', 'Longitude [°]' with the value '34.9', and 'Timezone[UTC]' with the value '3'. A red rectangular box highlights the 'Set Locate' button at the bottom right of the form.

Figure 21 – Setting Location Information



**Note:** Actions such as modifying Modbus parameters, downloading retrieved data, increasing the number of cleaning cycles, and performing software updates can be carried out via the device's Configuration Tool (GUI). However, these actions are not mandatory during the “Installation and Configuration” process and should only be performed based on user requirements. If you wish to perform these actions, you can download the “GUI User Manual” document from the link below and follow the instructions provided in details.

[https://www.sevensensor.com/files/d/en/3S-SMS-MB\\_Configuration\\_Tool.pdf](https://www.sevensensor.com/files/d/en/3S-SMS-MB_Configuration_Tool.pdf)



## 5.11. Monitoring Sensor Data

Monitoring sensor data may require different procedures depending on the model of the Automatic Soiling Sensor. Follow the steps below accordingly.

### 5.11.1. 3S-SMS-MB & 3S-SMS-MB-24V Models

After all procedures are successfully completed, the Automatic Soiling Sensor is ready for use. At this stage, the USB-RS485 converter connected to the communication cable should be disconnected. The communication cable can then be connected to data loggers, SCADA systems, PLCs, or other devices that support the Modbus protocol, based on user preference.

During these connections, the green wire of the communication cable must be connected to the Data (+) terminal, the yellow wire to the Data (-) terminal, and the pink wire to the Data GND terminal.

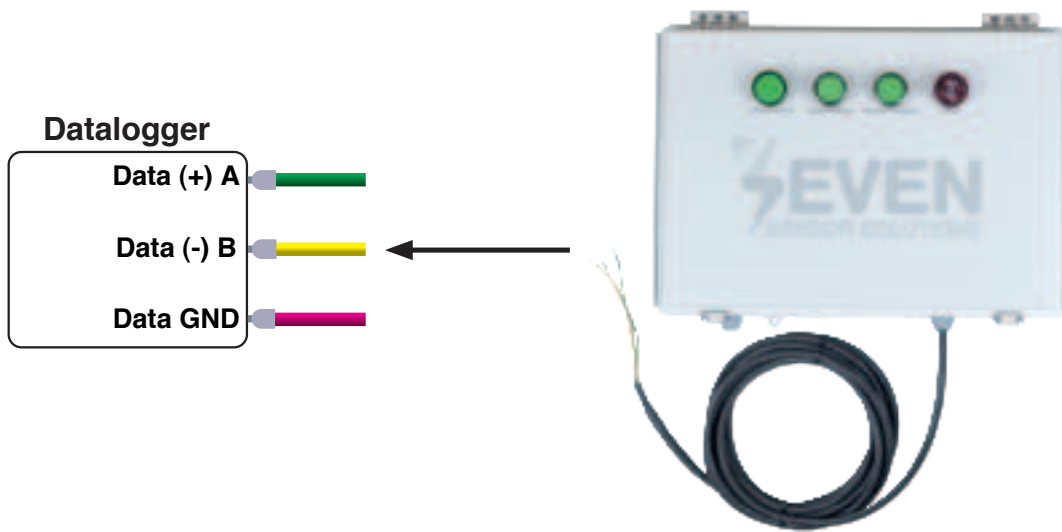


Figure 22 – Communication Cable Connection



**Note:** According to RS485 connection requirements, it is not recommended to extend the communication cable. The communication cable must be used as a single piece. The required cable length can be provided by SEVEN Sensor.

### 5.11.2. 3S-SMS-GW & 3S-SMS-GW-24V Models

In the Automatic Soiling Sensor Gateway models, the Gateway device to which the sensor will connect is located inside the electronic panel. To enable the Gateway device to send data to the V-Gen monitoring system, an M2M SIM card with a capacity of 100 MB must be obtained. The SIM card should be inserted into the Gateway device as shown below.

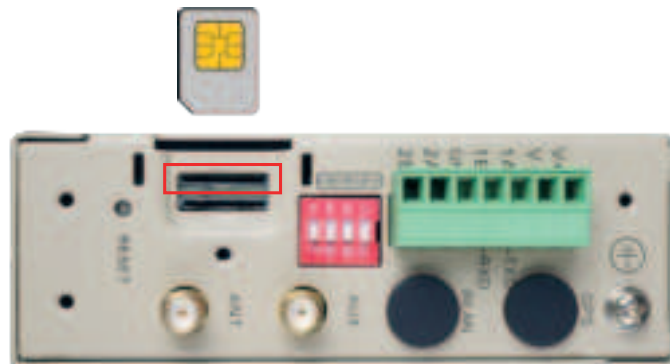


Figure 23 – SIM Card Connection to the Gateway Device

In the Gateway models of the Automatic Soiling Sensor, unlike other models, the communication cable is not connected to the electronic panel but is instead provided with a 2-pin connector cable. After inserting the SIM card into the Gateway device, the communication cable connected to the electronic panel must be removed. Following this, the switch inside the electronic panel that activates the communication of the Gateway device should be turned on. Once these steps are completed, place the antenna connected to the Gateway device at the highest point reachable by the cable length.



Figure 24 – Gateway Antenna Position

After completing all procedures related to the Gateway, use the link below to log in to the V-Gen Monitoring System.

<https://vgen.vtcenerji.com/>

The login details for the V-Gen Monitoring System will be provided to you by the SEVEN Sensor sales team. After logging into the V-Gen Monitoring System using your user credentials, the installation process will be complete. From this point on, you can monitor the data from the Automatic Soiling Sensor via the V-Gen Monitoring System.



Figure 25 - V-Gen Monitoring System

## 6. Modbus Map

The Modbus addresses and features required to configure the Automatic Soiling Sensor with systems such as data loggers are specified in the table below.

ID-Dec	ID-Hex	Parameter Name	Range	Resolution	Description
30006	0x06	Clean Irradiance Sensor Value	0...1600 W/m <sup>2</sup>	0.1 W/m <sup>2</sup>	Represents the irradiance value (W/m <sup>2</sup> ) obtained from the clean Irradiance Sensor of the Automatic Soiling Sensor, which is temperature-compensated and calibrated
30007	0x07	Soiled Irradiance Sensor Value	0...1600 W/m <sup>2</sup>	0.1 W/m <sup>2</sup>	Represents the irradiance value (W/m <sup>2</sup> ) obtained from the Soiled Irradiance Sensor of the Automatic Soiling Sensor, which is temperature-compensated and calibrated.
30047	0x2F	Daily Average Soiling Level Percentage	0 - 100 %	0.1%	Represents the daily soiling ratio calculated by the Automatic Soiling Sensor, expressed as a percentage (%).
30050	0x32	Water Tank Status	0-1	-	Represents the water tank's fill status. (1: full, 0: empty)
30335	0x14F	Stable Data Count	0-480	1	Represents the daily count of stable data recorded by the Automatic Soiling Sensor.

Figure 26 – Modbus Map



**Note:** The table above lists the addresses that need to be monitored by the user for the Automatic Soiling Sensor. If additional Modbus and SunSpec addresses or the software-specific features of these addresses are required, you can download the detailed Modbus map from the link below.

[https://www.sevensensor.com/files/d/s/3S-SMS\\_Modbus\\_Map.pdf](https://www.sevensensor.com/files/d/s/3S-SMS_Modbus_Map.pdf)

## 7. Inspection and Maintenance

To ensure the long-term efficient operation of the Automatic Soiling Sensor, regular maintenance and inspections are necessary. It is important to check the tightness of connection elements, the condition of cables, and for any damage, degradation, or disconnection in sensors and electrical enclosures. Additionally, observe the sensor enclosures for signs of moisture or pests and regularly inspect for potential issues such as loose cable connections or brittle connections.

When the water tank is depleted, approximately every six months, it is recommended to clean the inside of the tank before refilling. Failure to do so may result in the formation of algae or similar substances inside the tank, which can adversely affect the cleaning performance of the Soiled irradiance sensor.

According to the IEC 61724-1:2021 standard, the monitoring system should be inspected at least once a year, and preferably at more frequent intervals.

## 8. Contact Details

Please feel free to contact us if you face any difficulties during installation or configuration.

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Website	www.sevensensor.com