

# User's Guide

## **MARS** **Soiling Sensor**

Model 810230-20



Document Number 880060-20 Rev. A1, May 2023



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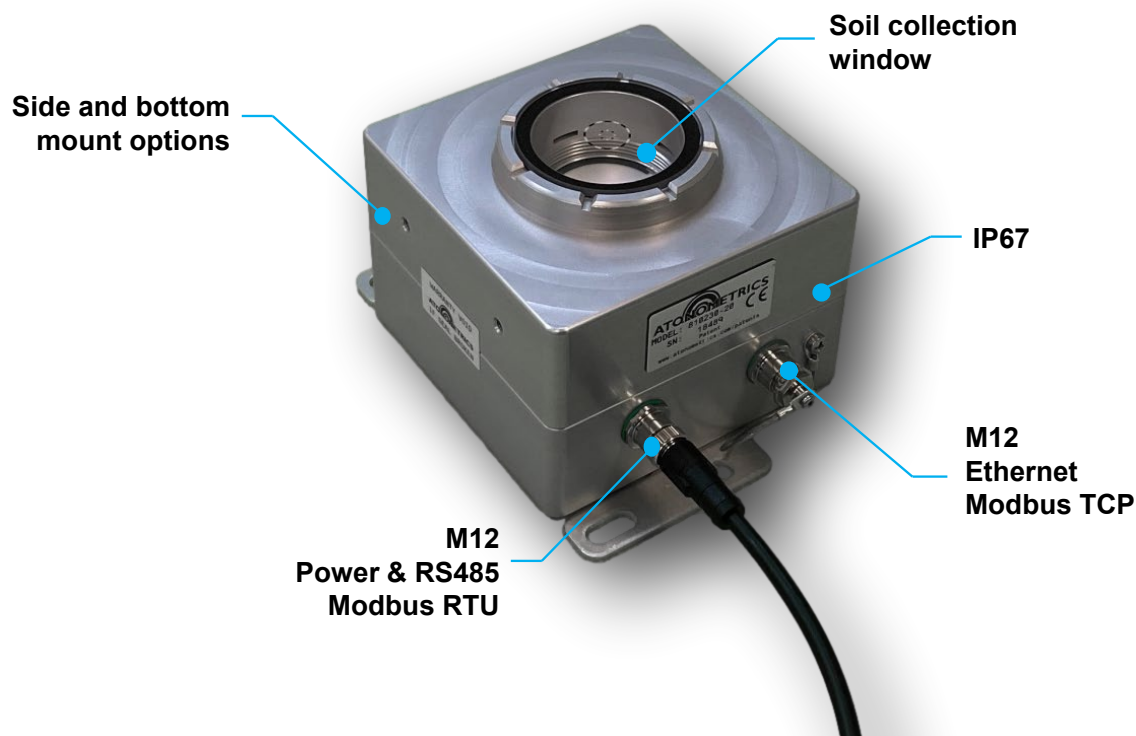
# 1 Product Overview

Mars™ Soiling Sensor provides simplified measurement of soiling losses for PV installations. Patented Mars™ technology detects accumulated soiling particles on a soil collection window using an internal camera. Mars™ units require no water, have no moving parts, are compact and easy to install, and do not require site-specific dust calibration or technician cleaning visits. They are suitable for a wide range of PV installations.

**Figure 1-1** shows Mars™ model 810230-20, which replaces previous model numbers 810230, 810230-01, and 810230-10.

Mars™ model 810230-20 has two connection ports. Use the M12 power and RS485 port to power your unit and record data via Modbus RTU over RS485. Use the M12 Ethernet port to configure the unit from its web user interface and optionally to record data via Modbus TCP over Ethernet.

The Mars™ unit and cable connections are IP67-rated for weather protection and the product is built in a machined aluminum enclosure that provides for various mounting options.



**Figure 1-1: Mars™ Soiling Sensor (810230-20)**

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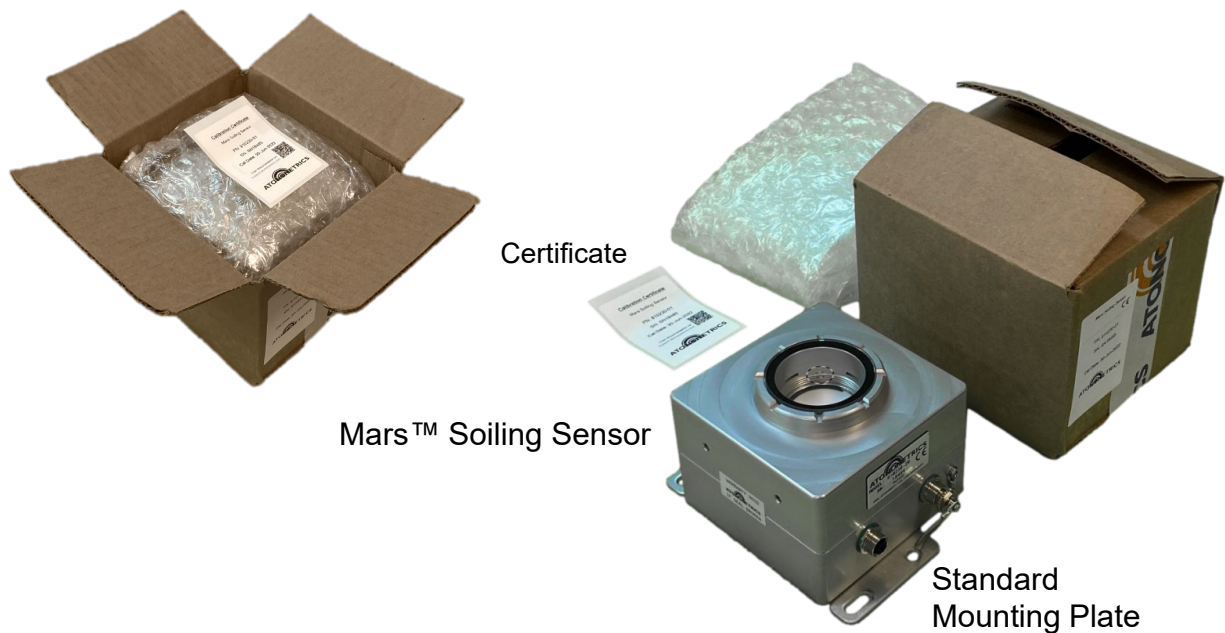
## 2 Unpacking

**Figure 2-1** shows a Mars™ unit with its shipping box and included accessories.

Each unit includes a u-shaped Standard Mounting Plate pre-attached in the bottom-mount configuration. See section 5 for alternate configurations.

Configuration tools (section 3) and cables (section 4) must be ordered separately.

Remove any protective film covering the soiling collection window.



**Figure 2-1: Unpacking your Mars™ unit**

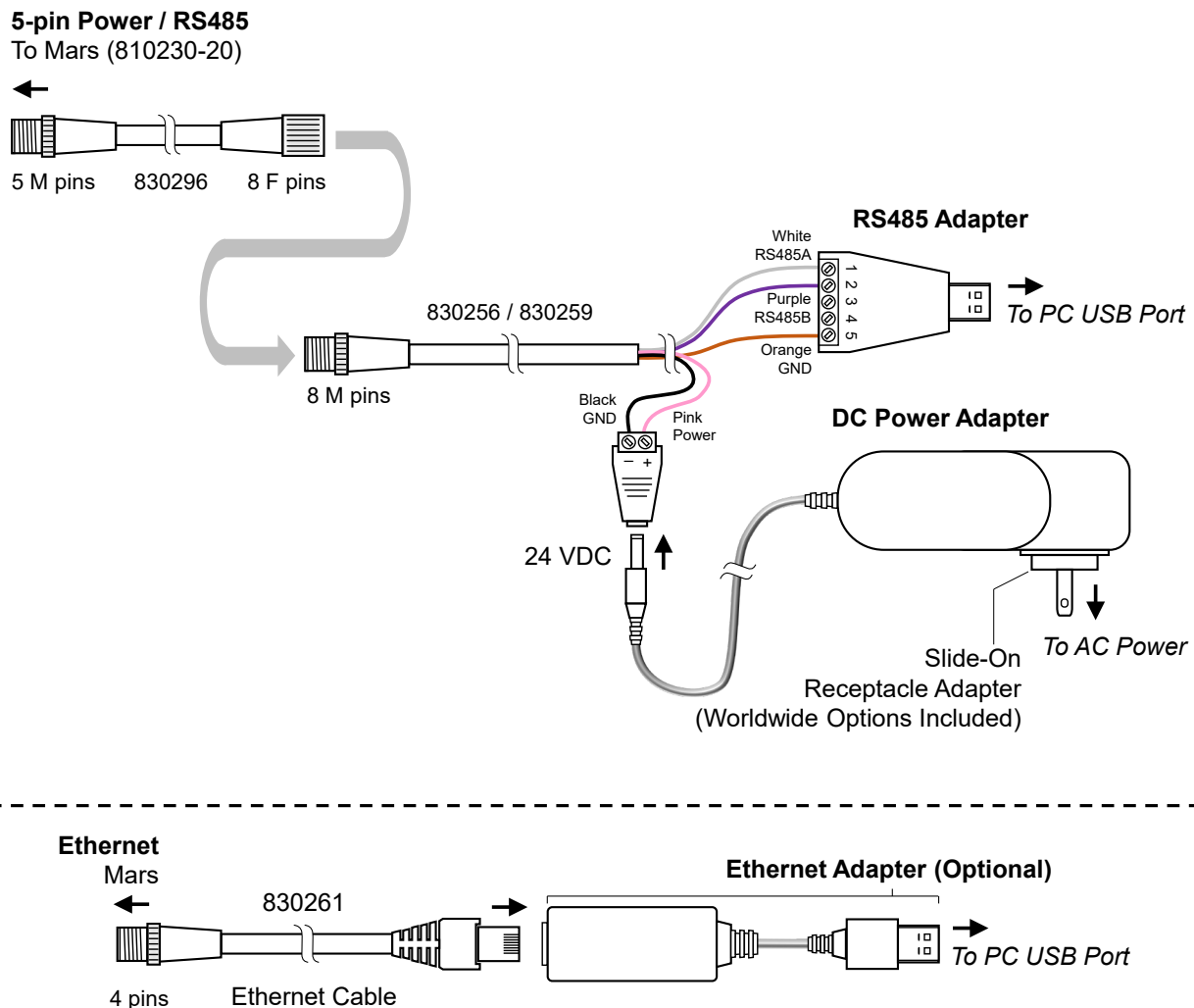
## 3 Configuration

### 3.1 Get the Latest Documentation and Software

Before starting configuration, visit [support.atonometrics.com](http://support.atonometrics.com) and download the latest versions of the Mars™ [firmware](#) (500079) and the [Mars User Guide](#) (this document, 880060-20).

### 3.2 Using Configuration Kit 810276

The optional Configuration Kit ([810276](#), sold separately) allows you to power your Mars™ unit, perform configuration via Ethernet, and test communication over the RS-485 port. Kit contents are shown in **Figure 3-1**.



**Figure 3-1: Contents of Configuration Kit 810276 (sold separately)**

To assemble and install the kit for use with your PC:

- Select and install the receptacle adapter appropriate for your country
- Insert the 24 VDC plug into the cable assembly as shown
- Connect the Power / RS485 cable to the Mars unit as shown. Note that the 8-pin to 5-pin adapter is required for the Mars version (810230-20) described in this User Guide.
- Insert the RS485 to USB adapter into your PC's USB port. (Note: this optional, for testing Modbus RTU. See below.)
- Connect the M12/RJ45 Ethernet cable to the Ethernet-to-USB adapter and to the Mars M12 Ethernet Connector; insert the adapter into one of your PC's USB ports; allow Windows to detect the adapter and automatically install its driver; configure the adapter address to 10.244.69.1. Optionally, you may omit the USB Ethernet Adapter and connect the 830261 M12 Ethernet Cable directly to your PC's Ethernet port, if available.
- Connect the power adapter to AC power
- Allow Windows Update to detect the RS-485 to USB adapter and automatically install its driver or install the driver from the CD included in the kit. You may also download the driver from the [810276 Configuration Kit](#) page on support.atonometrics.com.

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**Note:** The 810276 Configuration Kit supports multiple products. It may include some accessories that are not required for your 810230-20 Mars™ unit and/or are not pictured above.

**Note:** The 810276 Configuration Kit is optional. You may duplicate its functions with your own supplied equipment and cables prepared for your installation site, if desired.

**Note:** Previous versions of this document showed different contents for the 820176 Configuration Kit. The contents shown above support all required configuration needs.

**Note:** Using the USB / Ethernet adapter is optional. You may optionally connect the RJ45 end of the 830261 cable to an RJ45 Ethernet port on your computer.

**Note:** Connecting the USB cable between the Power & Communication Adapter and your PC is optional. It can be used for testing Modbus RTU over RS-485. See Atonometrics [application note 880084](#), "Testing Modbus Communication with Mars Soiling Sensor".

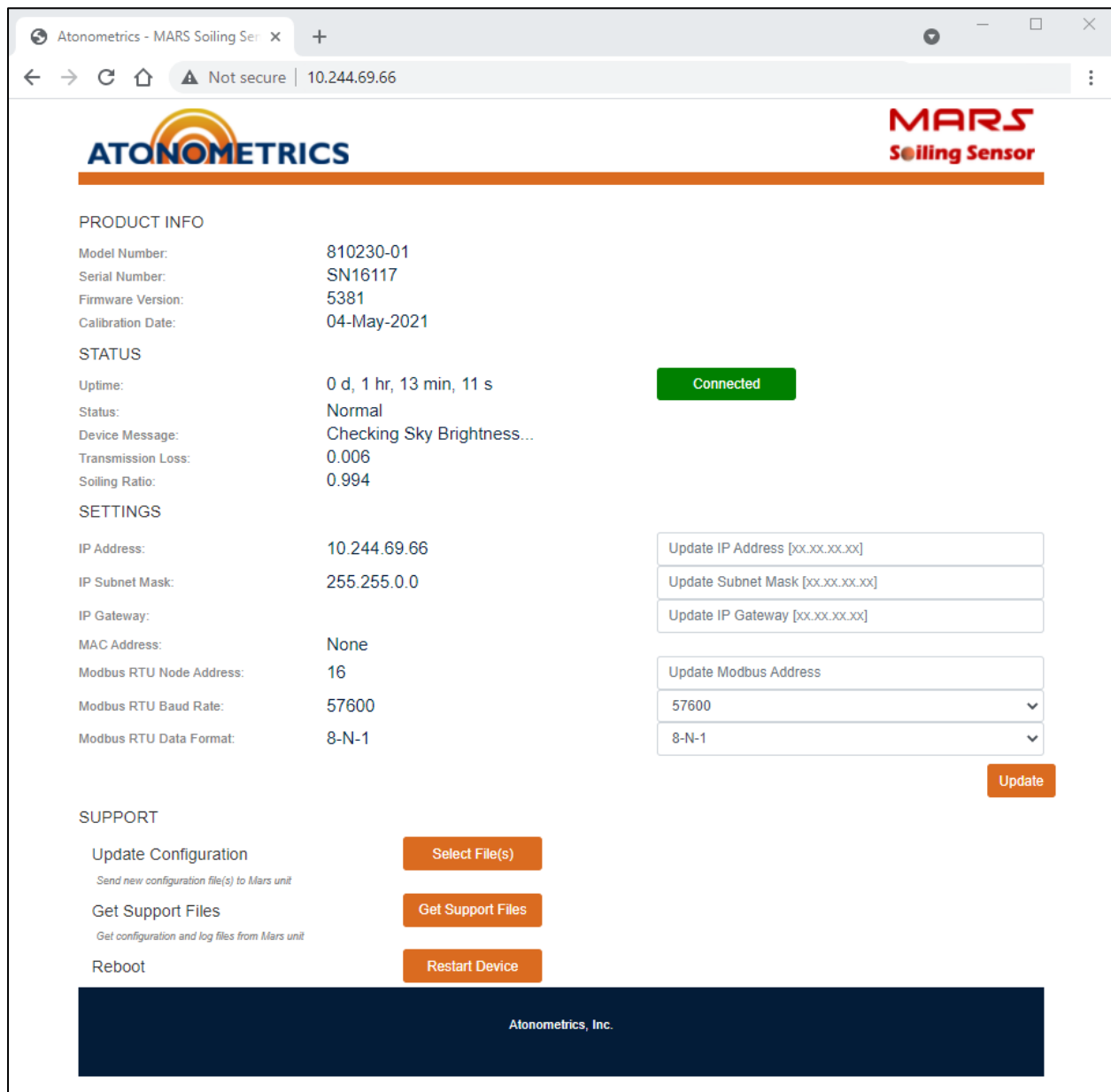
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### 3.3 Accessing the Web Interface

After power up, the Mars unit's soil collection window will light up for a short time and then will go dark. Wait 2-5 minutes for initialization to complete.

Configuration is performed by accessing the unit's internal web interface from your PC using a web browser, such as Chrome, Firefox, or Internet Explorer.

Launch the web browser on your PC and enter the Mars™ IP address (default = 10.244.69.66). You will then see the Mars™ web interface shown in **Figure 3-2**.



**Figure 3-2: Web interface**

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- Note:** If needed, configure the Ethernet adapter (either the USB-Ethernet adapter supplied with the Configuration Kit, or the Ethernet adapter on your PC) to operate on the same subnet as the Mars™ unit. The unit's default IP address upon shipment from Atonometrics is 10.244.69.66. Therefore, set your Ethernet adapter to 10.244.69.XX, where XX is any unused node (not .66). For instructions, consult Windows documentation or related help. When configuration is complete, return your PC's IP settings to their previous values.
- Note:** If the IP address of your Mars™ unit has been changed from the factory default, use the appropriate subnet and address corresponding to the Mars™ unit on your Ethernet adapter.
- Note:** If the IP address of your Mars™ unit is unknown, visit [support.atonometrics.com](http://support.atonometrics.com) and download the [Mars IP Address Discovery Tool](#). Instructions are provided with the software tool to help you recover the unit's IP address.
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## 3.4 Configuration Steps

### 3.4.1 Updating the Firmware

Your unit's current installed Firmware Version number is shown near the top of the web interface (**Figure 3-2**). If the version you downloaded in Step 3.1 is newer, update the firmware before proceeding.

To update the firmware, press "Select File(s)" next to "Update Configuration" near the bottom of the web interface. Following the prompts that will appear, select the previously downloaded firmware update file and transmit it to the Mars™ unit.

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- Note:** The firmware file is transmitted directly to the Mars™ unit and is not user-openable, even if it has a .zip format.
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### 3.4.2 Setting IP Address, Subnet Mask, and Gateway

Your Mars™ unit's default IP address upon shipment from Atonometrics is 10.244.69.66.

To change your Mars™ unit's IP address, enter the new address, as well as any desired subnet mask and gateway, using the web interface (**Figure 3-2**), then press "Update".

After setting the new IP address:

- Adjust the subnet of the Ethernet adapter on your PC, if required, to match
- Update the Mars™ IP address entered into your web browser
- Refresh your web browser to confirm that the new address is properly set.

### 3.4.3 Setting Modbus RTU Settings

If you will be using Modbus RTU for communication over RS-485, configure the Modbus RTU settings. Otherwise, you may leave these settings at their default values.

#### Modbus Node Address

- The unit's default node address for Modbus RTU upon shipment from Atonometrics is 16.



- To change the node address, enter the new address using the web interface (**Figure 3-2**), then press “Update”.
- Node addresses from 1 to 247 are allowed.

#### Baud Rate and Data Format

- From the web interface you may also select the serial communication parameters for baud rate and data format.
- Supported baud rates are 9600, 19200, 38400, 57600, and 115200.
- Supported data formats are 8-N-1, 8-N-2, 8-E-1, and 8-O-1.
- To change the settings, select the new values and press “Update”.

### 3.4.4 Checking Status

Check the Status field on the web interface (**Figure 3-2**) and confirm it reads “Normal”. If an error condition is shown, confirm all configuration settings. If the error persists, contact Atonometrics for support.

The “Device Message” portion of the web interface will indicate current operations of the unit, including checking sky brightness, waiting, and acquiring data.

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**Note:** Upon initial shipment, the Transmission Loss and Soiling Ratio fields will read the last measured values recorded during factory test; these will correspond to clean glass with near 0 loss. These fields will update once the unit is deployed outdoors in its installation location overnight.

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## 3.5 Checking Communication

For an example and guidance on checking Modbus communication using third-party software in your data logger or SCADA system, see the Atonometrics application note document [880084 “Testing Modbus Communication on the Mars™ Soiling Sensor”](#), available at [support.atonometrics.com](http://support.atonometrics.com).

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**Note:** Reading a value of NAN for Transmission Loss and Soiling Ratio is not a communication error condition. This value confirms that communication is correct but indicates that a measurement value is not available. The measurement value should update once the unit is deployed outdoors in its installation location overnight.

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## 4 Wiring

### 4.1 Power

The Mars™ unit requires 10-30 VDC and draws ~3 W of average power. However, it may draw up to 6 W on a transient basis.

### 4.2 Cable Assemblies

Options for cable assemblies are listed in **Table 4-1**, with wire colors for the 830303 M12 power and RS-485 cable shown in **Figure 4-1**.

**Note:** When using long power cables, voltage drop along the cable can be significant. Use adequate power supply voltage to compensate, as shown in **Table 4-1**.

**Note:** Atonometrics-supplied 830303 M12 Power and RS-485 cables include an additional wire not used for the Mars™ product. See Section 4.3.

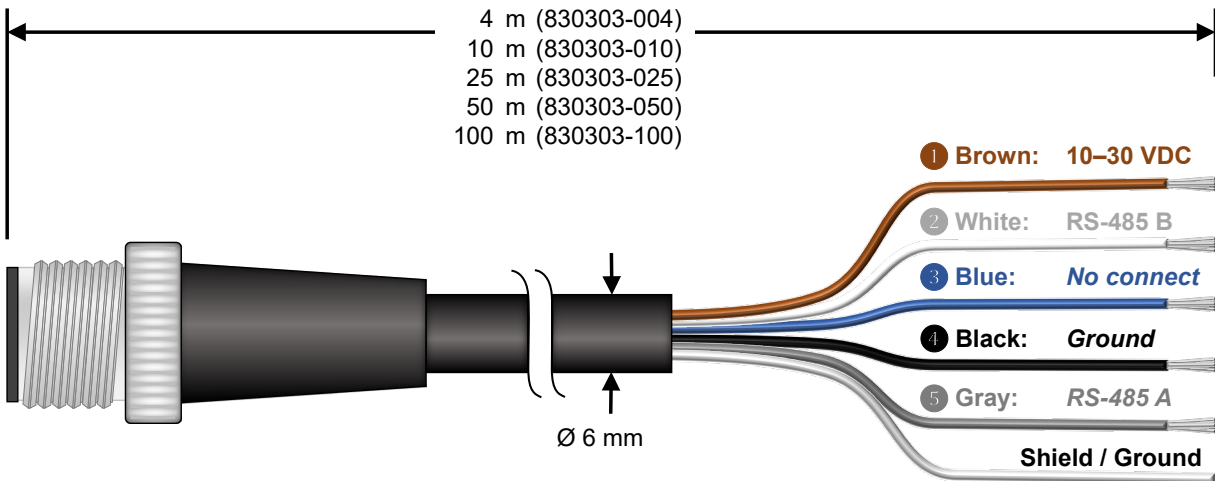
**Note:** \*\*When using the 830303 M12 Power and RS485 cable with length exceeding 50 m, Atonometrics recommends adding the 830331 RS485 termination accessory (sold separately) at the end of the cable near the Mars unit to prevent communication interference at high baud rates caused by cable-end reflections.

**Note:** Atonometrics-supplied 830261 Ethernet cables will have **one sealed M12 connector** for connection to the Mars™ unit. The other end of the cable will include a **non-sealed RJ45** for cable testing purposes. Remove this and use a user-supplied cable gland or sealed connector for installation to your outdoor equipment cabinet.

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**Table 4-1: Atonometrics-supplied cables (sold separately)**

Length	M12 Cable Power & RS485 24 AWG	Recommended Minimum Power Supply Voltage	M12 Cable Ethernet
4 m	830303-004	12 VDC	830261-004
10 m	830303-010	12 VDC	830261-010
25 m	830303-025	15 VDC	830261-025
50 m	830303-050**	24 VDC	830261-050
100 m	830303-100**	24 VDC	n/a



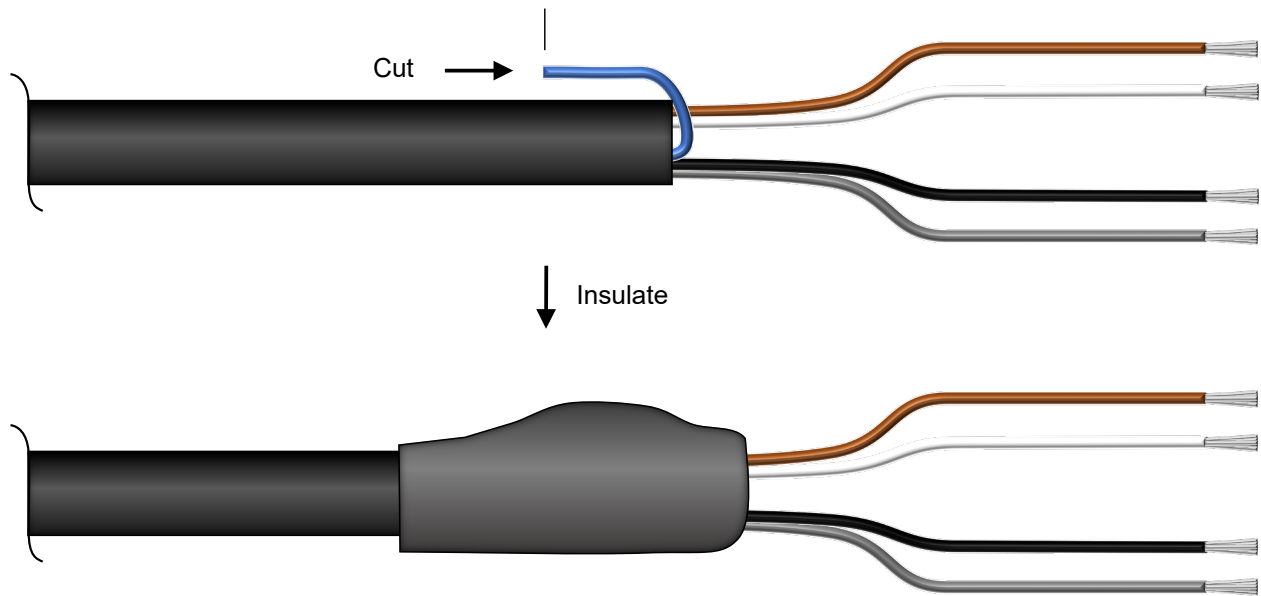
**Figure 4-1: Wire colors for 830303 M12 power & RS485 cable**

**Note:** Use only Atonometrics-supplied connectors or cable assemblies. Although other connectors may appear to fit, use of non-approved components may result in water penetration

**WARNING:** Check all wiring before turning on power. Incorrect wiring may damage the unit and/or your other equipment.

## 4.3 Protecting Unused Wires

Protect any unused wires from accidental contact by cutting to unequal lengths, folding back, and insulating, as shown in **Figure 4-2**.



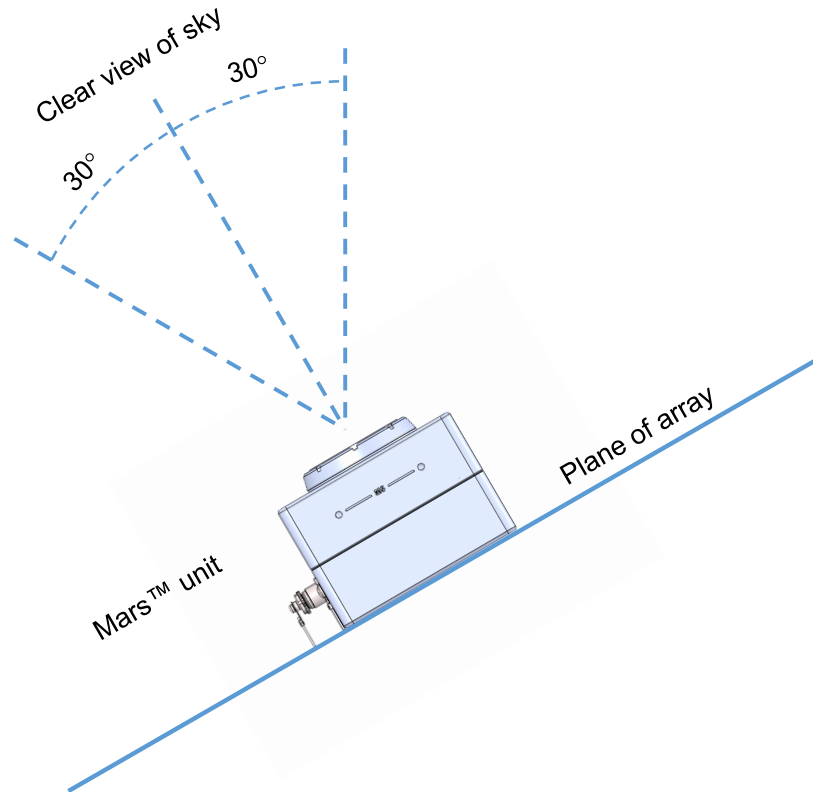
**Figure 4-2: Protecting unused wires from accidental contact**

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## 5 Mounting

### 5.1 Mounting Requirements

Mount the Mars™ unit in the plane of array of your PV modules, choosing a location where the unit will have a clear view of the sky within a cone at least  $\pm 30^\circ$  from the normal, as shown in **Figure 5-1**



**Figure 5-1: Mounting requirements and view of sky**

To mount the Mars™ unit, use the 6 threaded mounting holes on the enclosure, shown in **Figure 5-2**, or use the 4 mounting holes on the standard mounting plate, as shown in **Figure 5-5**.

To minimize the potential for water entry to the sealed housings, always mount the Mars™ unit with the cables facing down or to the side, as shown in **Figure 5-3**, and never with the cables facing up.

See **Figure 5-4** for dimensions.

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**Note:** Do not remove the screws on the bottom side of the unit, as this may compromise the weather-proof seal. Removing the screws will void the warranty.

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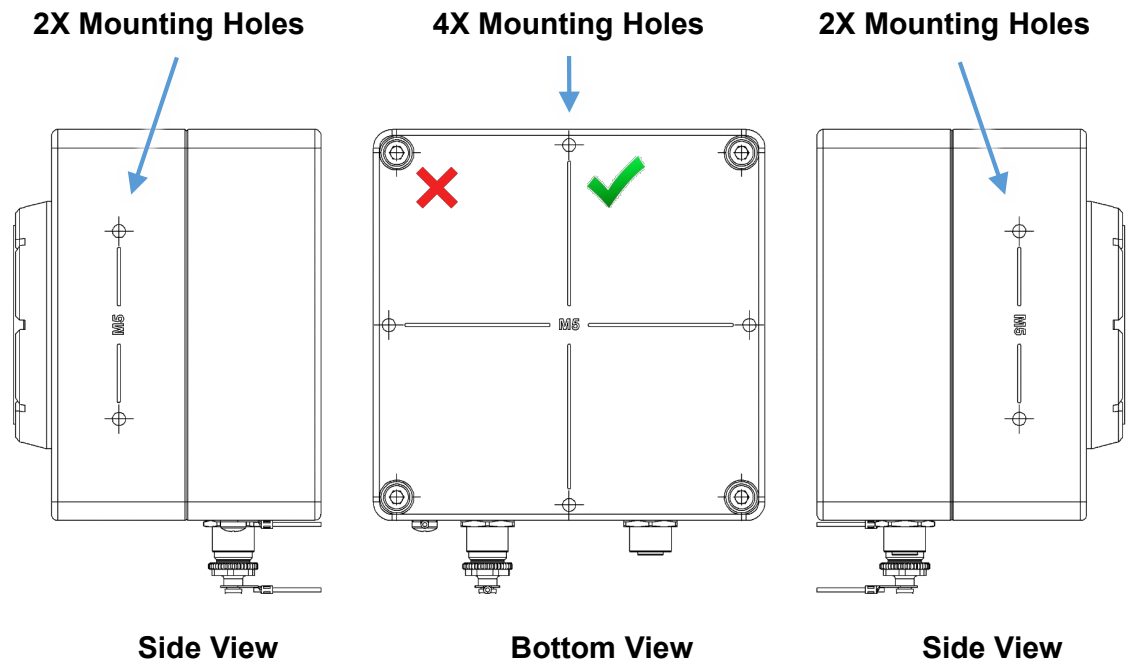


Figure 5-2: Mounting holes

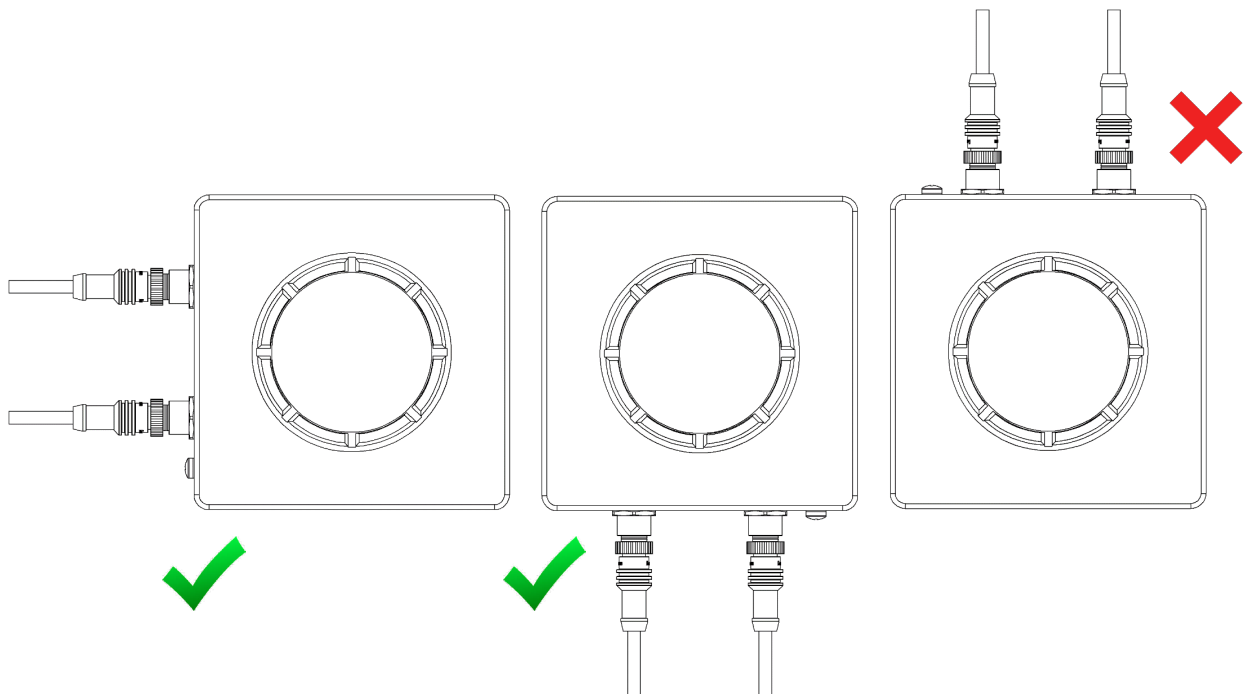
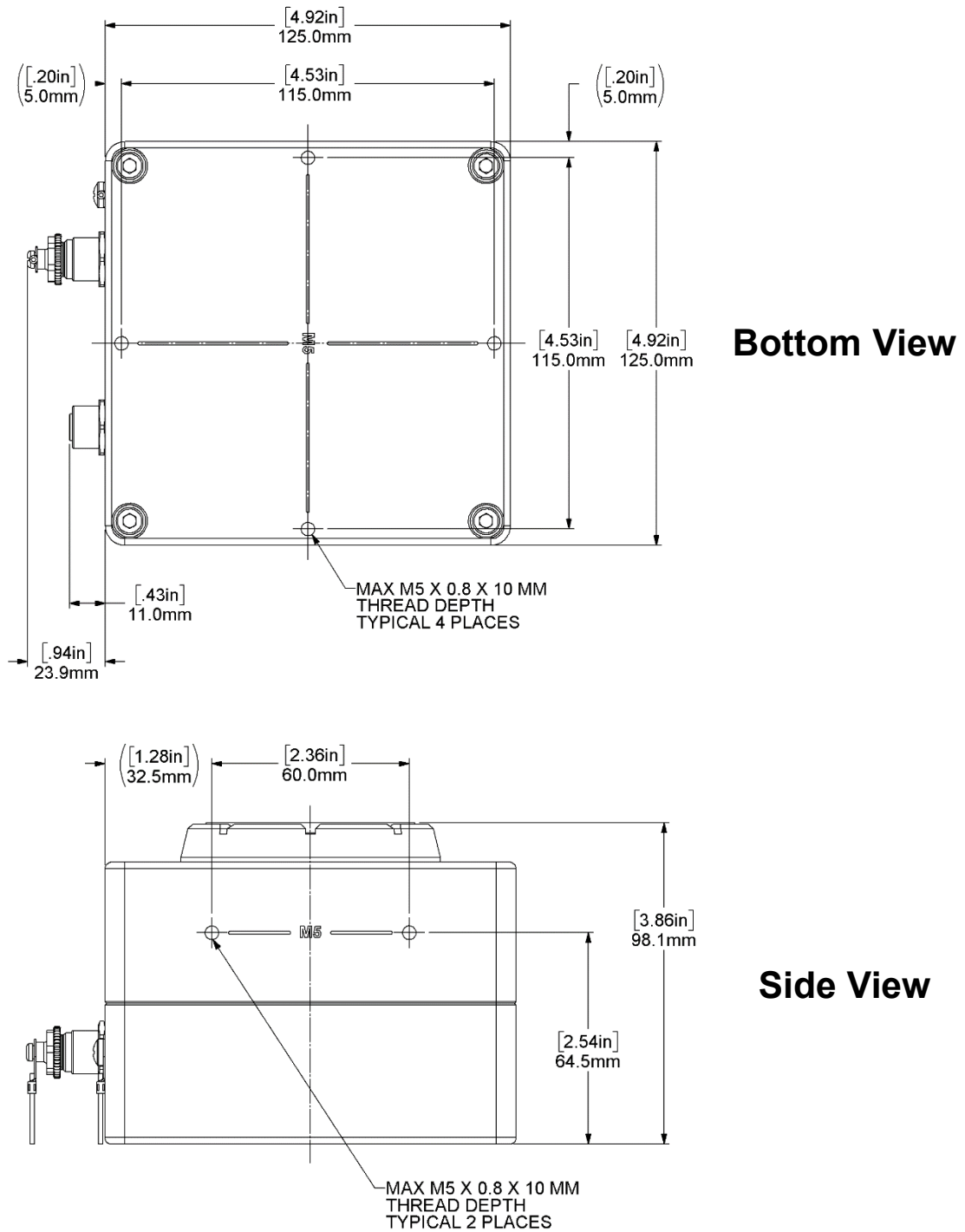


Figure 5-3: Mount with cables down or to the side

## 5.2 Dimensions

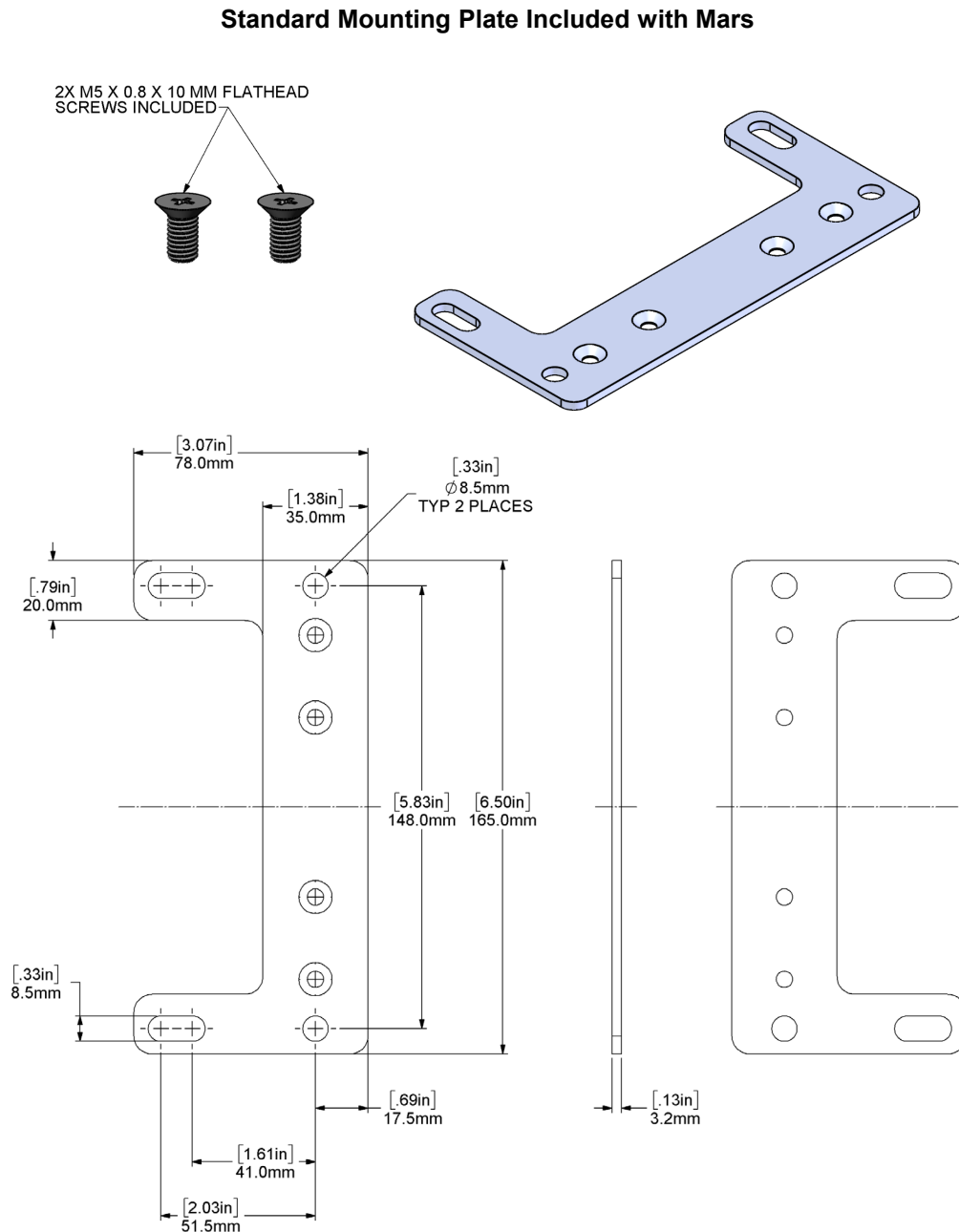


**Figure 5-4: Mars™ dimensions**

## 5.3 Mounting Accessories

### 5.3.1 Standard Mounting Plate

The standard mounting plate accessory, shown in **Figure 5-5**, is shipped with every Mars™ unit. It can be mounted in 4 orientations on the bottom of the enclosure and 2 orientations on either side of the enclosure. The plate will be pre-mounted to the Mars™ unit; remove and reposition it as desired.



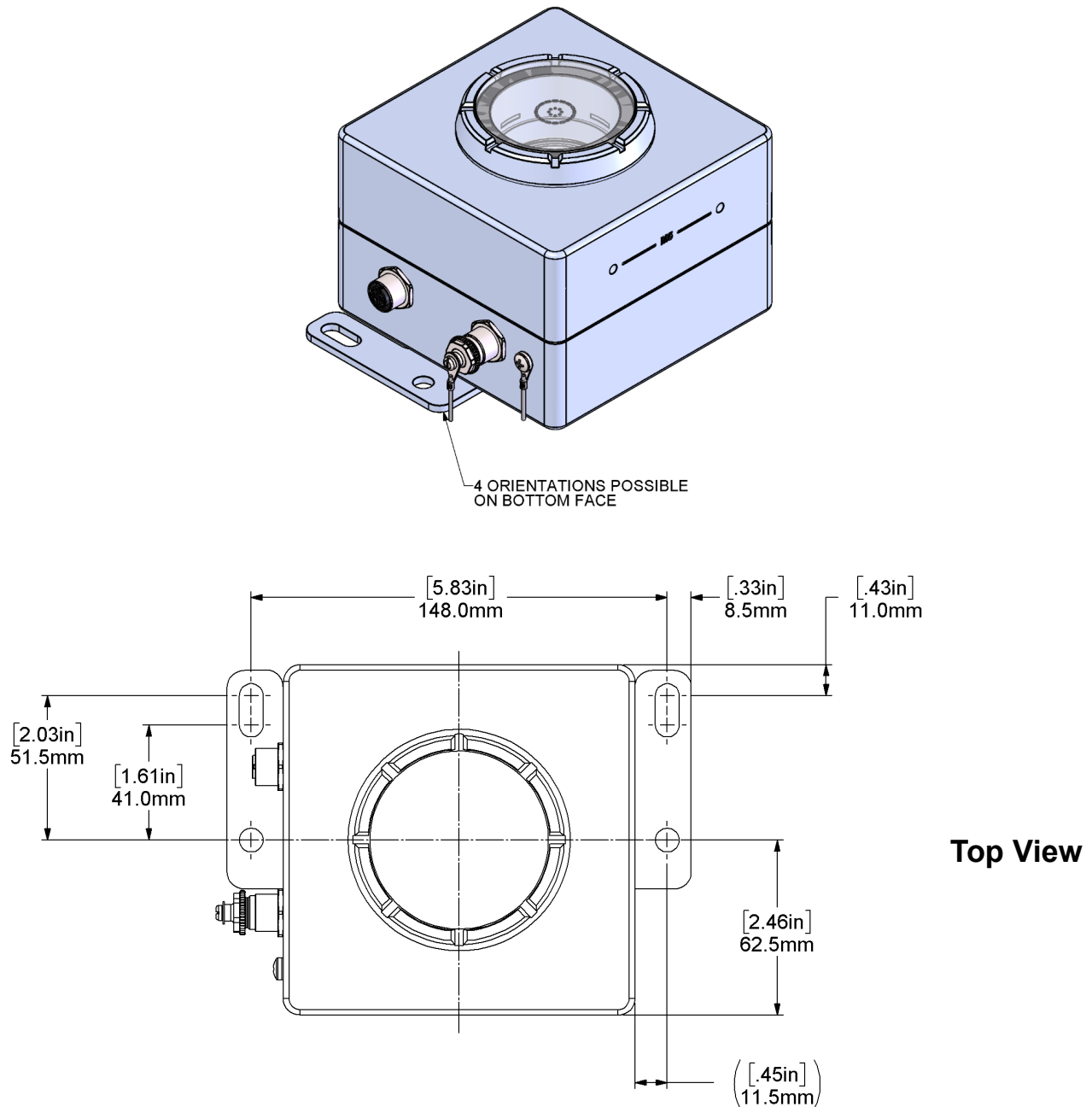
**Figure 5-5: Standard mounting plate dimensions**



### 5.3.2 Bottom Mount Configuration

The bottom mount configuration of the standard mounting plate, shown in **Figure 5-6**, enables the user to mount the Mars™ unit on surfaces parallel to the plane of array.

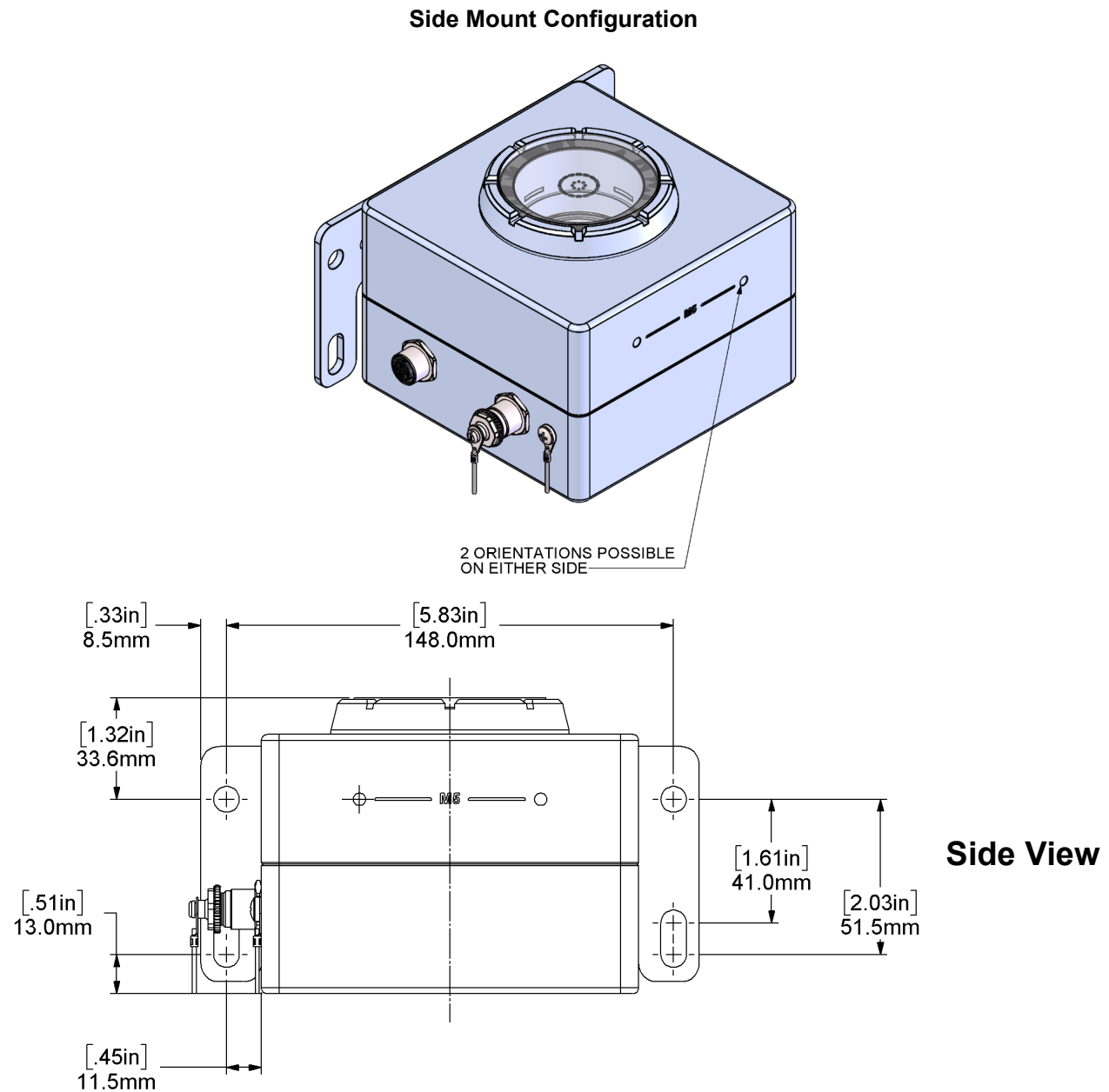
**Bottom Mount Configuration**



**Figure 5-6: Bottom mount configuration**

### 5.3.3 Side Mount Configuration

The side mount configuration of the standard mounting plate, shown in **Figure 5-7**, enables the user to mount the Mars™ unit on surfaces at a right angle to the plane of array.

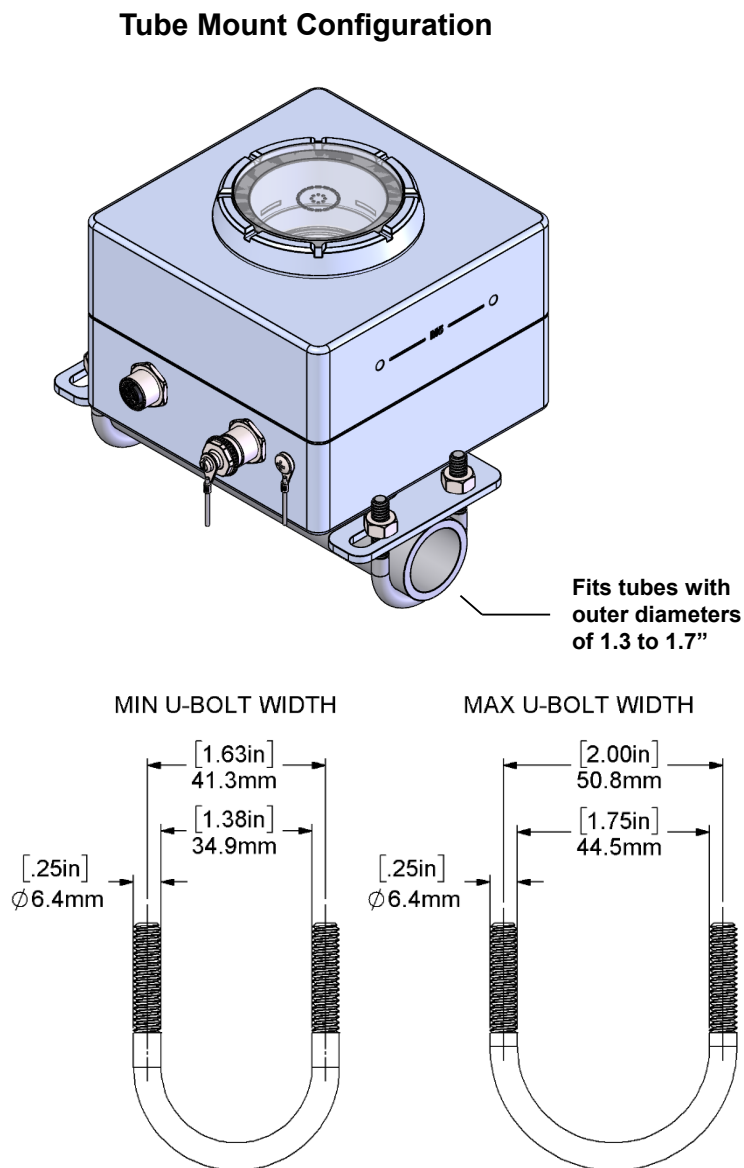


**Figure 5-7: Side mount configuration**

### 5.3.4 Tube Mount Configuration

The tube mount configuration of the standard mounting plate, shown in **Figure 5-8**, enables the user to mount the Mars™ unit on tubes for meteorological station applications.

**Note:** Note that options for U bolts are pictured but any U bolts are to be provided by the user.



**Figure 5-8: Tube mount configuration**

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## 6 Network Setup

To configure your Mars™ unit for use on an Ethernet network, set IP addresses and related communication parameters as directed in section 3.4.2.

In addition, you may need to open ports in your network firewall or set port forwarding on your cellular modem. See **Table 6-1**.

**Table 6-1: Mars IP ports**

Port Number	Protocol	Function
22	TCP	Atonometrics technical support, if needed
80	TCP	Access to web interface for configuration and status
2018	UDP	IP address recovery using Atonometrics Mars™ IP discovery tool

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**Note:** To use the IP address discovery tool, you must open necessary ports or temporarily disable your firewall.

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## 7 Modbus

**Table 7-1** lists the registers available for your client software to read data from the Mars™ unit.

Each numbered register in the table is a 16-bit (2-byte) register. Parameters requiring more than two bytes must be read from sequential registers as indicated by the Register Start and Register End columns. For a 4-byte value with bytes in the order *ABCD*, from most to least significant, the first register reads out bytes *AB* and the second reads out bytes *CD*.

For detailed information on Modbus protocols, please reference the specifications published by Modbus.org.

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**Note:** On some user data acquisition devices, it is necessary to add 1 to all the register values shown in **Table 7-1** to determine the Modbus address.

**Note:** Recommended parameters for Modbus communication are scan period  $\geq 1$  s, timeout  $\geq 500$  ms, delay between polls  $\geq 30$  ms. Do not poll the unit more than once per second. Using shorter timeouts may result in communication errors.

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**Table 7-1: Modbus map**

Register Start	Register End	Parameter	Data Type	Bytes	Notes
1	2	Transmission Loss	Float <sup>(1)</sup>	4	Fractional loss of transmission due to soiling particles
3	4	Soiling Ratio	Float <sup>(1)</sup>	4	1 - Transmission Loss
200	200	Modbus RTU Node Address	Uint16	2	1-247
203	206	IP Address	Uint16 x 4	8	4 registers: XX.XX.XX.XX
207	216	Part Number	Char x 10	20	String: 10 registers, 1 char each
217	224	Serial Number	Char x 8	16	String: 8 registers, 1 char each
225	225	Software Version	Uint16	2	Software version number
228	233	Calibration Date	Uint16 x 6	12	6 registers: Y, M, D, H, M, S
501	502	Uptime	Uint32	4	Seconds
503	503	Status Code	Uint16	2	0 = Normal

<sup>(1)</sup> Float32 denotes single-precision 32-bit floating point per IEEE 754

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## 8 Troubleshooting

Issue	Solutions
<ul style="list-style-type: none"><li>No communication, unit not responsive during configuration attempt</li></ul>	<ul style="list-style-type: none"><li>Confirm power wiring and power supply voltage range (Chapter 4)</li><li>Turn power off, then on again; confirm Mars™ window lights up for a short time and then turns dark</li><li>Wait 2-5 minutes after power-up for initialization to complete</li><li>Confirm correct IP address (p. 6)</li><li>Confirm PC's subnet and other IP settings are correct for Mars™ unit's IP address (p. 6)</li><li>Check firewall settings and ports (p. 20)</li></ul>
<ul style="list-style-type: none"><li>Lost the IP address of Mars™ unit</li></ul>	<ul style="list-style-type: none"><li>Download Mars™ IP address discovery tool from <a href="http://support.atonometrics.com">support.atonometrics.com</a>, and use tool to determine IP</li><li>Check firewall settings and ports (p. 20)</li></ul>
<ul style="list-style-type: none"><li>Modbus communication for logging unsuccessful</li></ul>	<ul style="list-style-type: none"><li>Confirm Modbus register numbers (p. 21)</li><li>Verify whether register addresses require +1 offset for your client device (p. 21)</li><li>Confirm byte order (p. 21)</li><li>Confirm timeouts and polling rate (p. 21)</li></ul>
<ul style="list-style-type: none"><li>Soiling ratio values out of expected range</li></ul>	<ul style="list-style-type: none"><li>Confirm your Mars™ unit has the latest firmware (p. 8)</li><li>Confirm Mars™ unit is installed outdoors in desired plane of array with clear view of sky (p. 13)</li><li>Allow Mars™ unit to operate through at least one sunset and night and check the readings the next day (Chapter 9)</li><li>If needed, visually inspect unit for damage or fouling</li></ul>

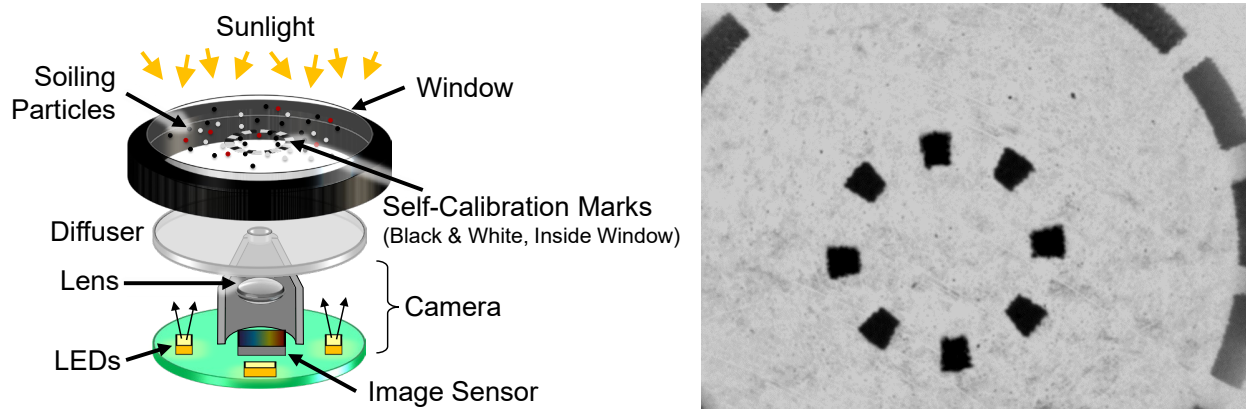
## 9 Theory of Operation

Mars™ soiling sensor technology is designed to simplify soiling measurement. The sensor requires no water, has no moving parts, is compact and easy to install, and has no site-specific dust calibration requirements. The sensor is designed to be operated unattended without service visits and is suitable for a wide range of PV installation types, including small commercial and industrial projects.

Mars™ technology is covered by patents US 10,171,029, US 10,715,081, US 10,886,876, US 10,937,139 and EP 3590187. Other patents may be pending. See [www.atonometrics.com/patents](http://www.atonometrics.com/patents).

The Mars™ technology is illustrated in **Figure 9-1**. The soiling sensor is exposed to soiling just the same as nearby PV modules in your PV array, causing soiling particles to accumulate on the sensor window over time, just as they accumulate on the PV modules. Sunlight illuminates the sensor window, and a camera system, consisting of an image sensor and microscope lens, captures an image of the shadows cast by the soiling particles on the window. An example image is shown on the right in **Figure 9-1**. A processor inside the Mars™ unit analyzes the image to determine the transmission loss (the soiling loss) due to the soiling particles. A series of self-calibration marks inside the window provides reference features in the image which aid analysis.

The Mars™ sensor works best in diffuse lighting. Therefore, the sensor automatically operates each day at sunset. The sensor's outputs for soiling measurements will update each day after sunset.



**Figure 9-1: Mars™ technology**

# 10 Specifications



Table 10-1: Specifications

<b>General</b>	Model name	Mars Soiling Sensor™
	Part number	810230-20
	Ambient working temperature	-20 to +60 °C
	Input power	10 to 30 VDC
	Power consumption	~3 W average (up to 6 W transient)
	Transmission loss accuracy	± 1%
	Local dust calibration	Not required
	Communication protocols	Modbus TCP (Ethernet) Modbus RTU (RS-485)
<b>Enclosure</b>	Material	Anodized aluminum housing
	Outdoor rating	IP67
	Dimensions	4.53 x 4.53 x 3.86 in. / 115.0 x 115.0 x 98.1 mm without connectors and mounting plate
	Weight	3.27 lbs. / 1.48 kg
	Mounting	6 mounting holes, M5 x 0.8 , 10 mm thread depth Standard mounting plate accessory: 4 mounting holes (two slots), dia. 0.33 in. / 8.5 mm
<b>Cables</b>	Power & RS485	Shielded, weather resistant, UV-rated 24 awg / 0.2 mm <sup>2</sup> M12 circular connector, IP67
	Ethernet	Shielded, weather resistant, UV-rated M12 circular connector, IP67