User Guide
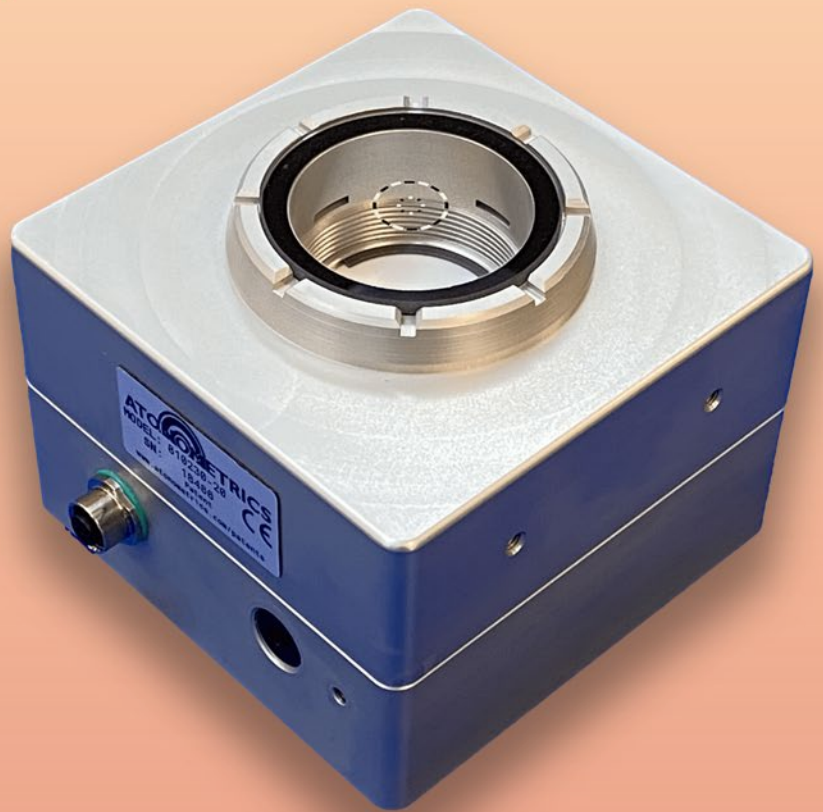
MARS
Soiling Sensor

Model 810230-20
HW Rev 01 (810230-20-01)

Document Number 880060-20 Rev. B, August 2023

ATONOMETRICS

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1 Product Overview

The 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.

This User Guide is for Mars™ model 810230-20, Hardware Revision 01 released August 2023 (810230-20-01), shown in **Figure 1-1**. This model replaces all earlier versions and model numbers. For information on earlier versions and models, please visit support.atonometrics.com.

The Mars™ unit has a single M12 user connection port. Use this M12 power and RS485 port to power your unit and record data via Modbus RTU over RS485. The Mars™ unit's aluminum enclosure provides for various mounting options.
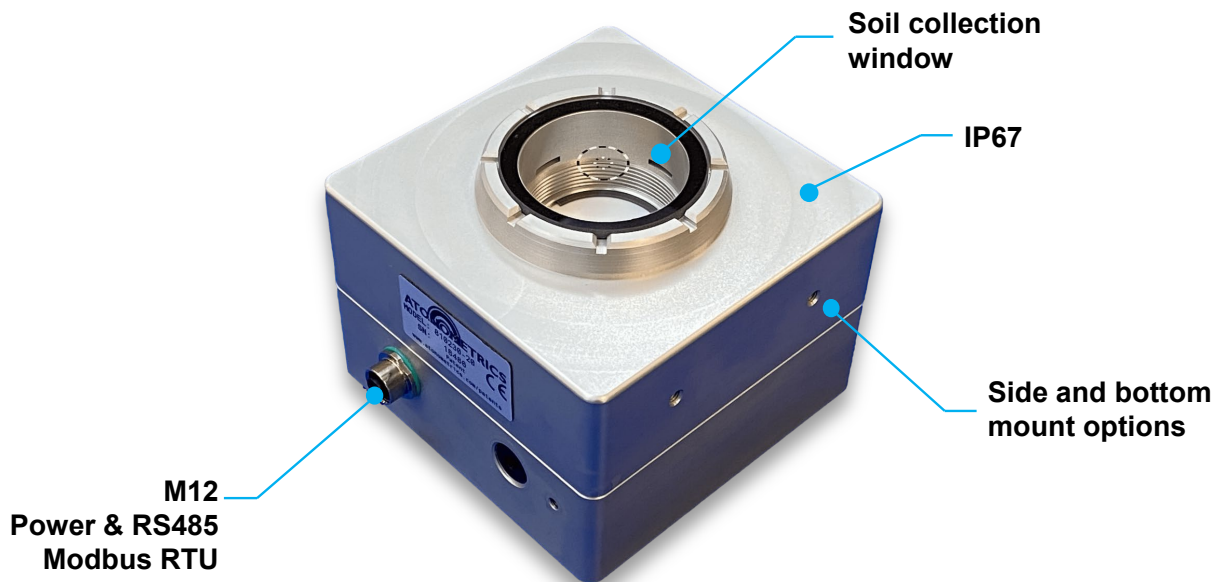
Figure 1-1: Mars™ Soiling Sensor (810230-20)

Note: Some photos and drawings in this document show the original 810230-20 version with an additional M12 connector port.

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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.

Certificate

Mars™ Soiling Sensor

Standard
Mounting Plate
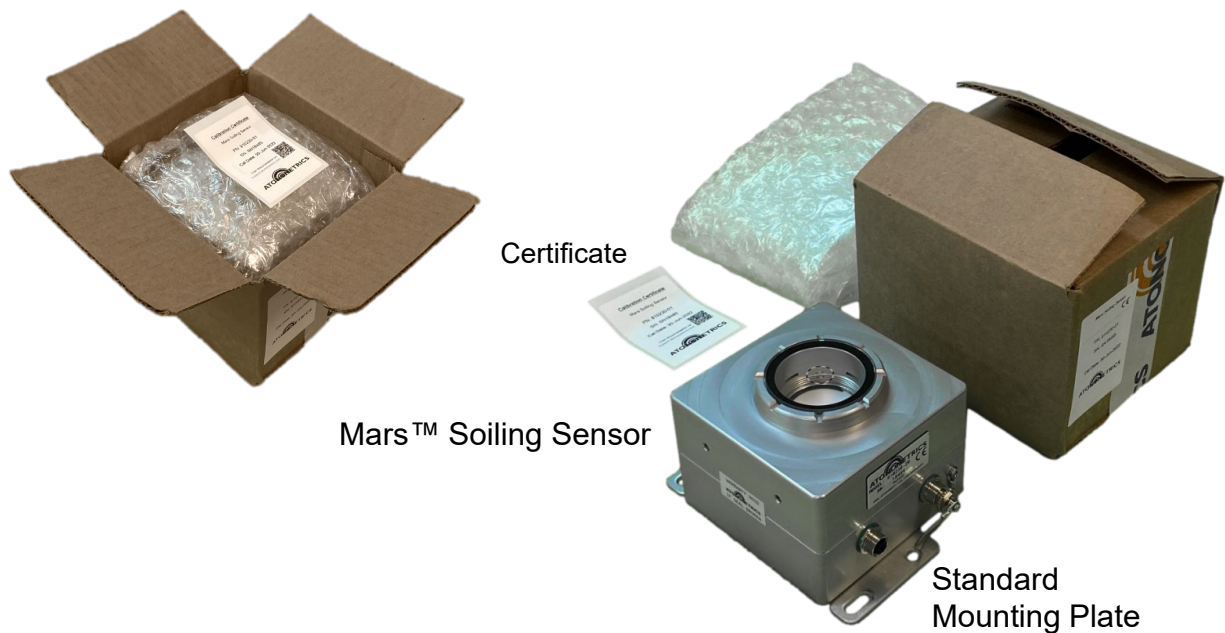
Figure 2-1: Unpacking your Mars™ unit

3 Configuration

3.1 Get the Latest Documentation and Software

Before starting configuration, visit 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 and test communication over the RS-485 port. Relevant kit contents are shown in **Figure 3-1**.

Figure 3-1: Using 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

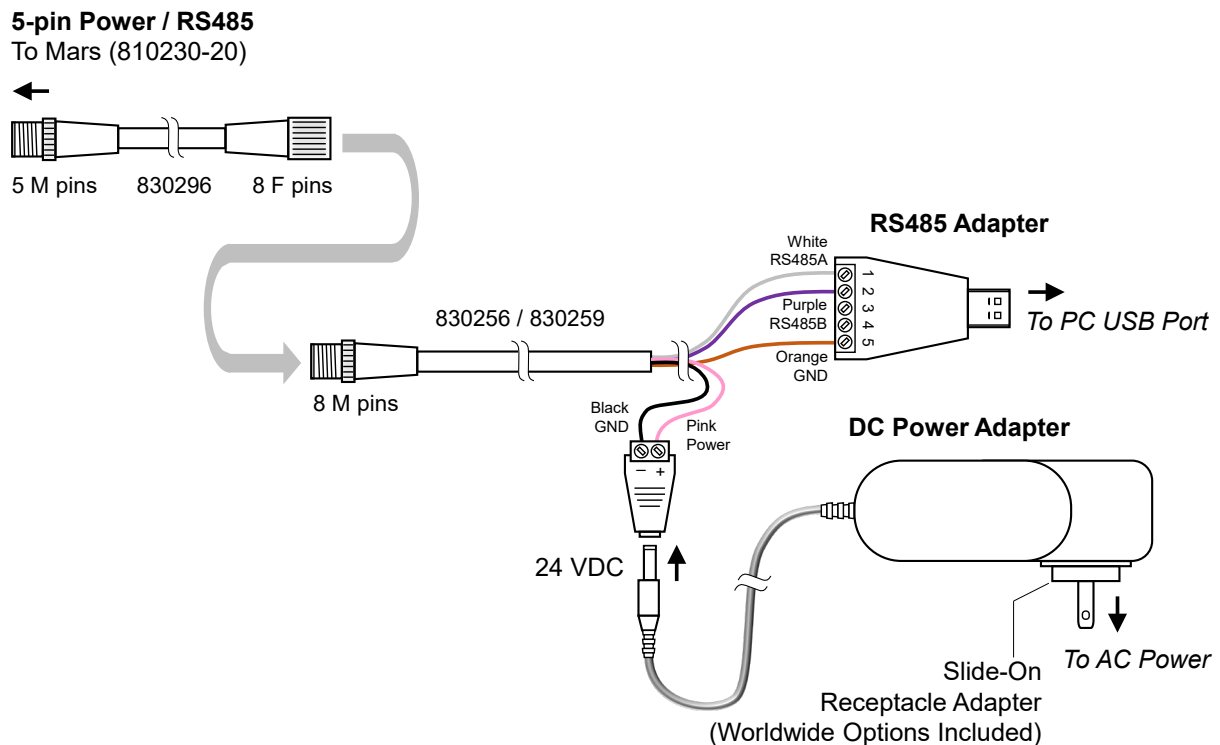- Insert the 24 VDC plug into the cable assembly as shown

- 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 is optional, for testing Modbus RTU. See below.)

- 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.

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 810276 Configuration Kit. The contents shown above support all required configuration needs for the product described in this User Guide.
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".

3.3 Accessing the Web-Based User Interface

To configure settings on Mars™ model 810230-20 HW Rev 01 (810230-20-01), described in this User Guide, use Wi-Fi to connect your smartphone or laptop PC to the devices' web-based user interface.

To access the web-based user interface:

- Power on the Mars unit. The unit's soil collection window will light up for a short time and then will go dark.

- Wait 1-2 minutes for the device to start it's Wi-Fi network for configuration.

- On your smartphone or laptop PC, use the network selection interface to select your Mars unit's Wi-Fi network. Your unit's SSID (network name) will be "Mars" followed by the last three digits of its serial number.

- For example, on a Windows PC you may see a dialog similar to **Figure 3-2** by accessing the network selection icon in the lower right corner of the screen.

- After selecting the Mars unit's network, enter the unit's Wi-Fi password (network security key). By default, the Wi-Fi password will be "marsXXXXX" where XXXXX is the unit's 5-digit serial number. Ignore any security warnings. If asked, select your PC to be non-discoverable.

- Launch a web browser, such as Chrome, Firefox, or Edge.

- Enter the Mars™ default IP address of 10.244.69.66 in the brower's URL field.

- You will then see the Mars™ web interface shown in **Figure 3-3**.
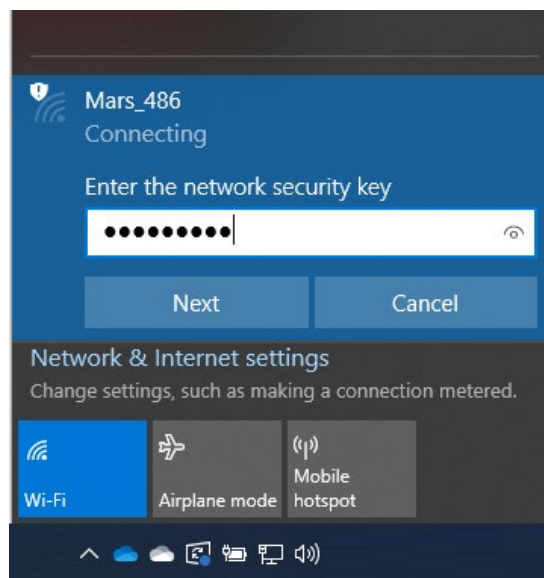
Figure 3-2: Selecting the Mars unit's Wi-Fi network for configuration
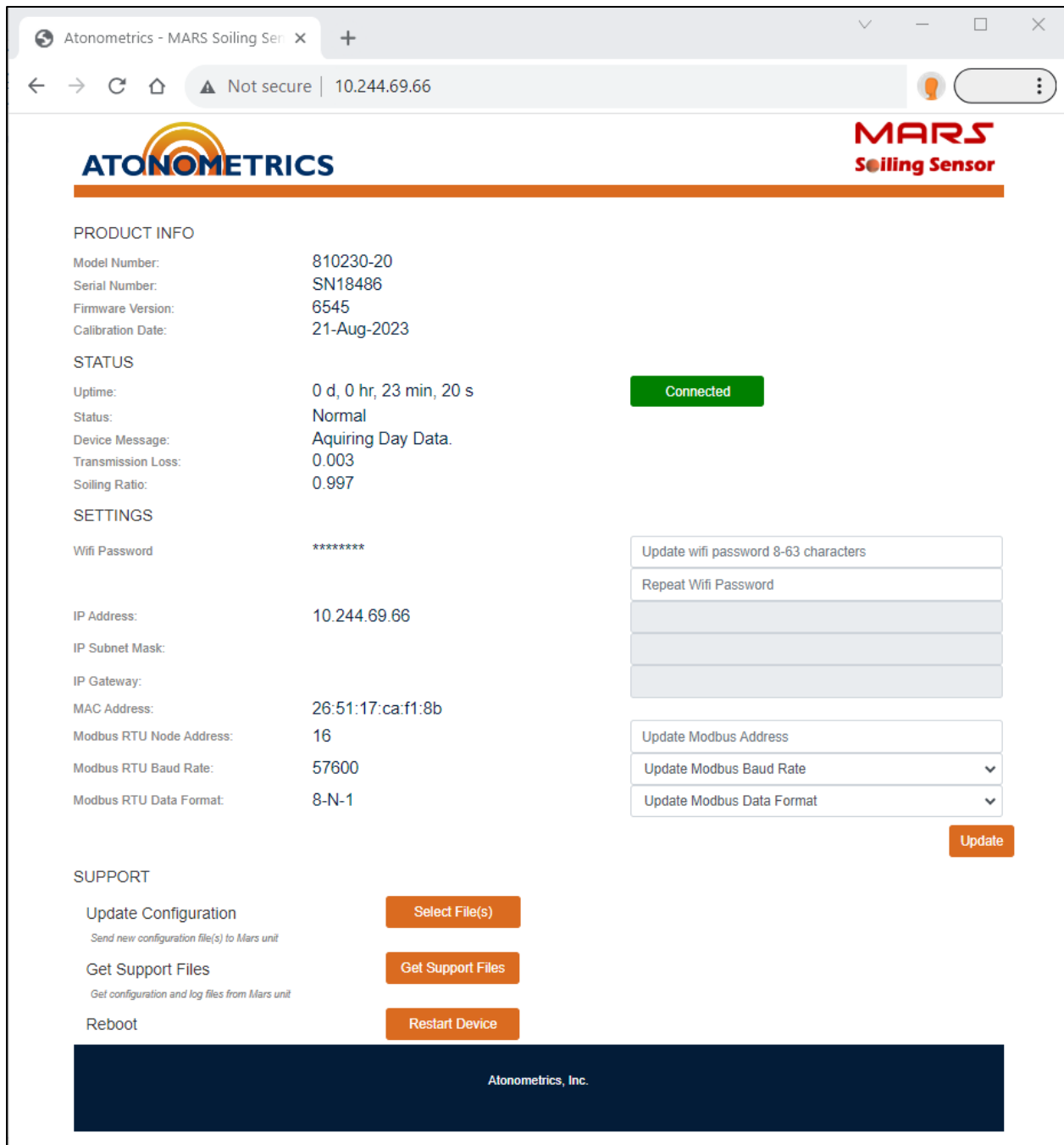
Figure 3-3: Web-based user interface

Note: The Mars Wi-Fi network will automatically disable after 60 minutes since power-up. This is a security feature. If needed, cycle power to the unit to regain access to the configuration screen.

Note: The default Wi-Fi password may be changed by the user. If the password has been changed and is unknown, see the password reset instructions or contact Atonometrics.

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 user interface (**Figure 3-3**). 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 interface. Following the prompts that will appear, select the previously downloaded firmware update file and transmit it to the Mars™ unit.

Note: The firmware file is transmitted directly to the Mars™ unit and is not user-openable, even though it has a .zip format.

3.4.2 Wi-Fi Password

You may change your unit's Wi-Fi network password if desired by using the Wifi password fields in the SETTINGS section of the user interface. After entering a new password, press the orange "Update" button to save it to the device. Cycle power to the device to make the new password take effect. Reconnect following the instructions in section 3.3 to verify the password is set.

Note: If the password has been changed and is unknown, see the reset instructions on our support website or contact Atonometrics.

3.4.3 IP Address, Subnet Mask, and Gateway

These settings cannot be changed on the Mars model referenced in this User Guide.

3.4.4 Setting Modbus RTU Settings

Configure the Modbus RTU settings for data logging over RS485.

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 3-3**), 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".

3.4.5 Checking Status

Check the Status field on the web user interface (**Figure 3-3**) 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 user interface will indicate current operations of the unit, including checking sky brightness, waiting, and acquiring data.

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.

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.

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.

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.

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

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

4 m (830303-004)
10 m (830303-010)
25 m (830303-025)
50 m (830303-050)
100 m (830303-100)

Ø 6 mm

1 **Brown:**   **10–30 VDC**
2 White: RS-485 B
3 **Blue:**   *No connect*
4 **Black:**   *Ground*
5 Gray: *RS-485 A*
   Shield / Ground
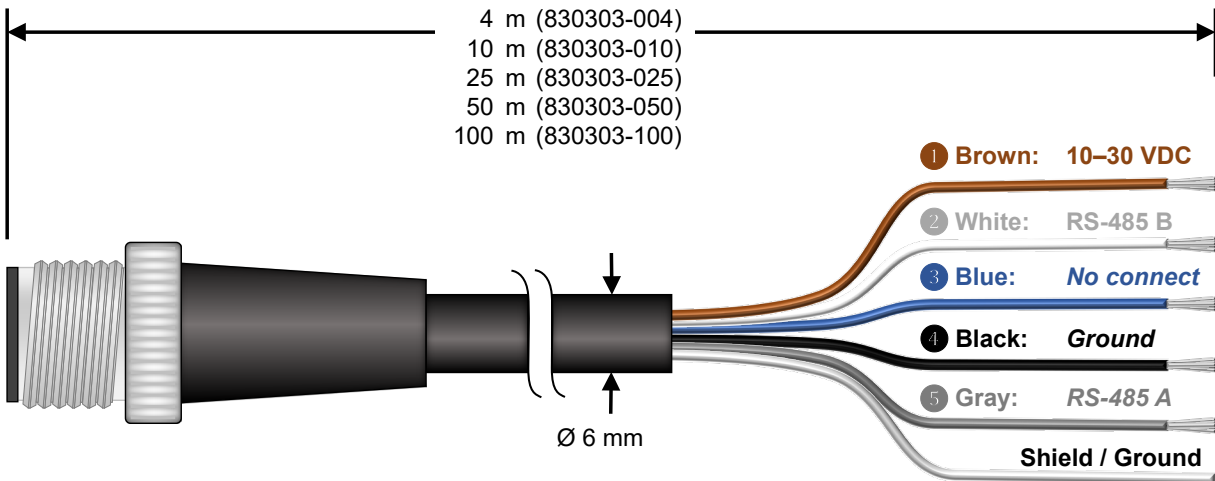
Figure 4-1: Wire colors for 830303 M12 power & RS485 cable

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

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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**.
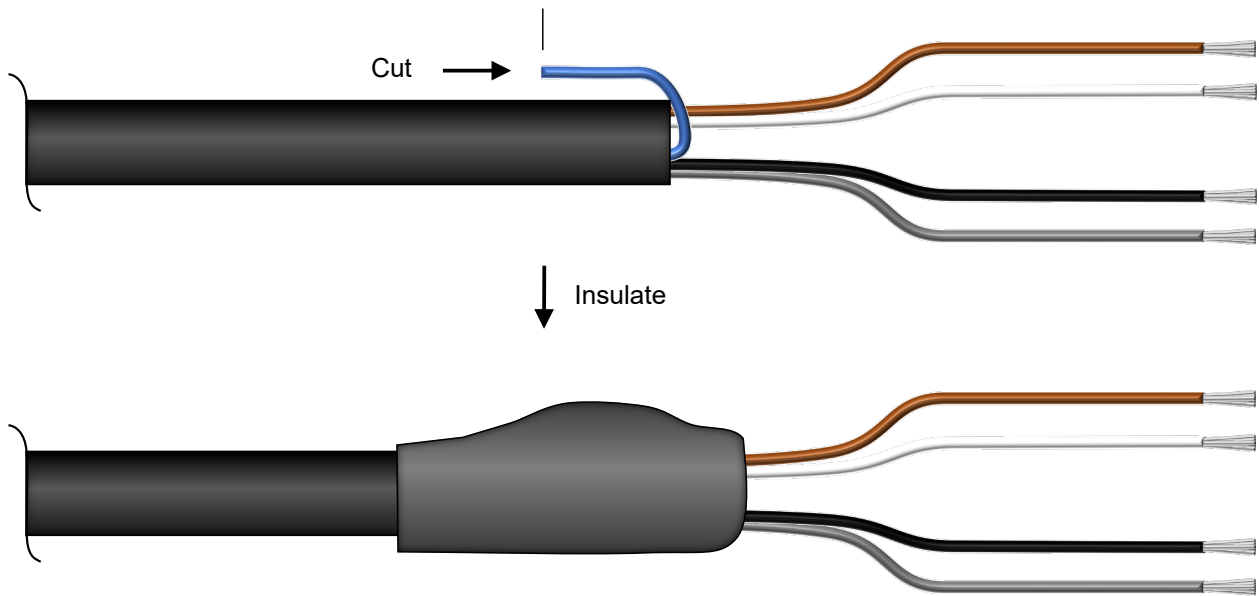

Figure 4-2: Protecting unused wires from accidental contact

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 ± 30° from the normal, as shown in **Figure 5-1**
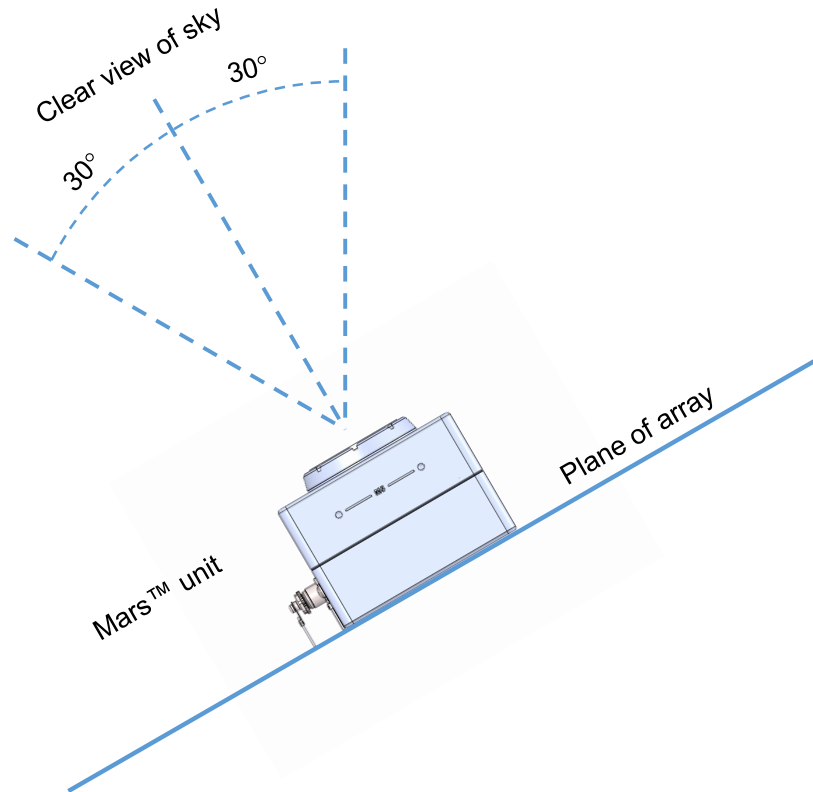
Figure 5-1: Mounting requirements and view of sky

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.

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.

2X Mounting Holes **4X Mounting Holes** **2X Mounting Holes**

Side View **Bottom View** **Side View**

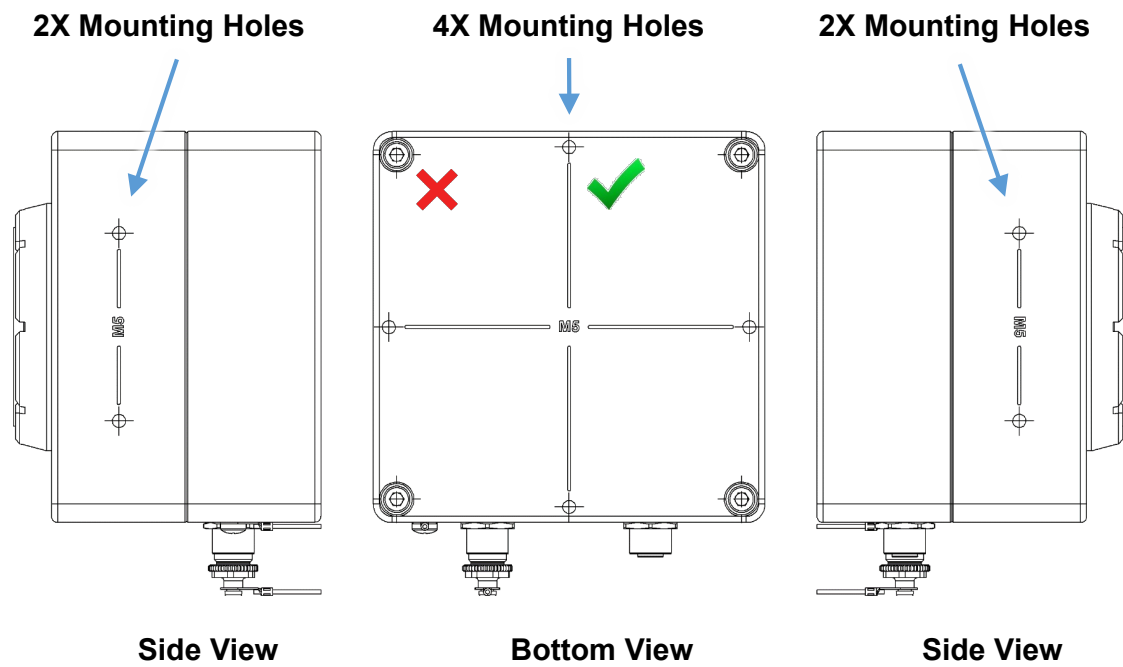**Figure 5-2: Mounting holes**
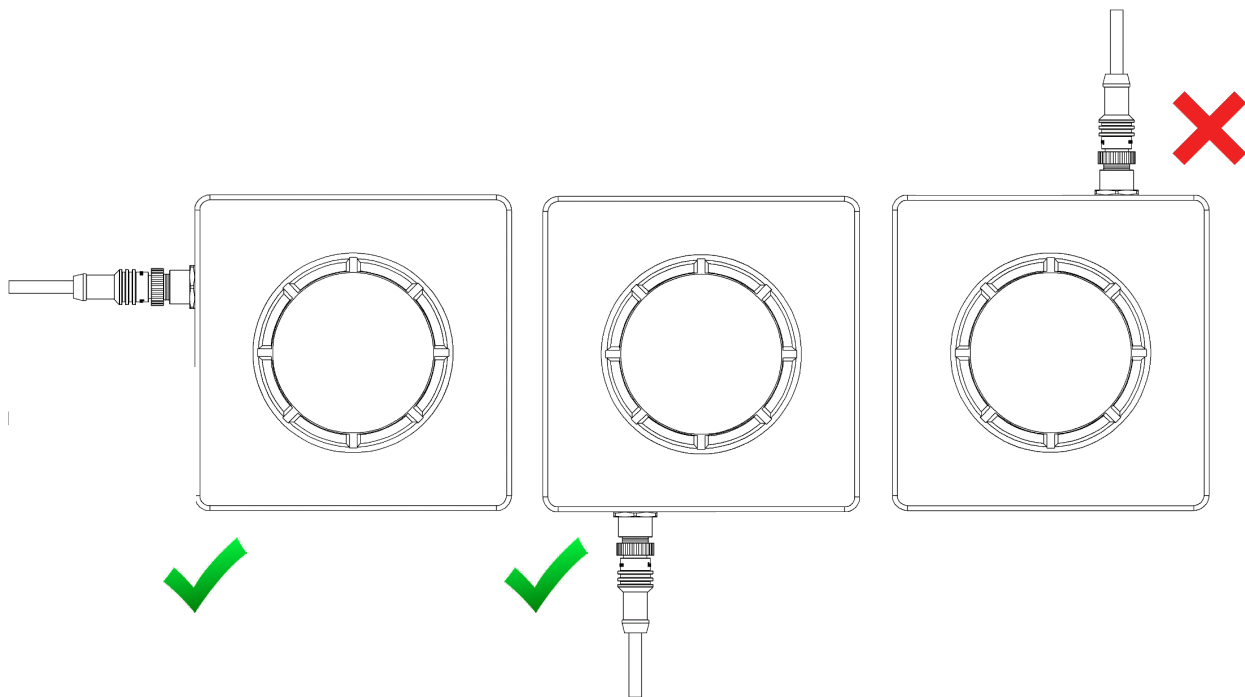
Figure 5-3: Mount with cables down or to the side

5.2　Dimensions

$\begin{bmatrix}4.92in\end{bmatrix}$ 125.0mm

$\left(\begin{bmatrix}.20in\end{bmatrix}\atop 5.0mm\right)$

$\begin{bmatrix}4.53in\end{bmatrix}$ 115.0mm

$\left(\begin{bmatrix}.20in\end{bmatrix}\atop 5.0mm\right)$

$\begin{bmatrix}4.53in\end{bmatrix}$ 115.0mm $\begin{bmatrix}4.92in\end{bmatrix}$ 125.0mm   **Bottom View**

$\begin{bmatrix}.43in\end{bmatrix}$ 11.0mm

MAX M5 X 0.8 X 10 MM
THREAD DEPTH
TYPICAL 4 PLACES

$\begin{bmatrix}.94in\end{bmatrix}$ 23.9mm

$\left(\begin{bmatrix}1.28in\end{bmatrix}\atop 32.5mm\right)$ $\begin{bmatrix}2.36in\end{bmatrix}$ 60.0mm

M5

$\begin{bmatrix}3.86in\end{bmatrix}$ 98.1mm   **Side View**

$\begin{bmatrix}2.54in\end{bmatrix}$ 64.5mm

MAX M5 X 0.8 X 10 MM
THREAD DEPTH
TYPICAL 2 PLACES

Figure 5-4: Mars™ 810230-20 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.

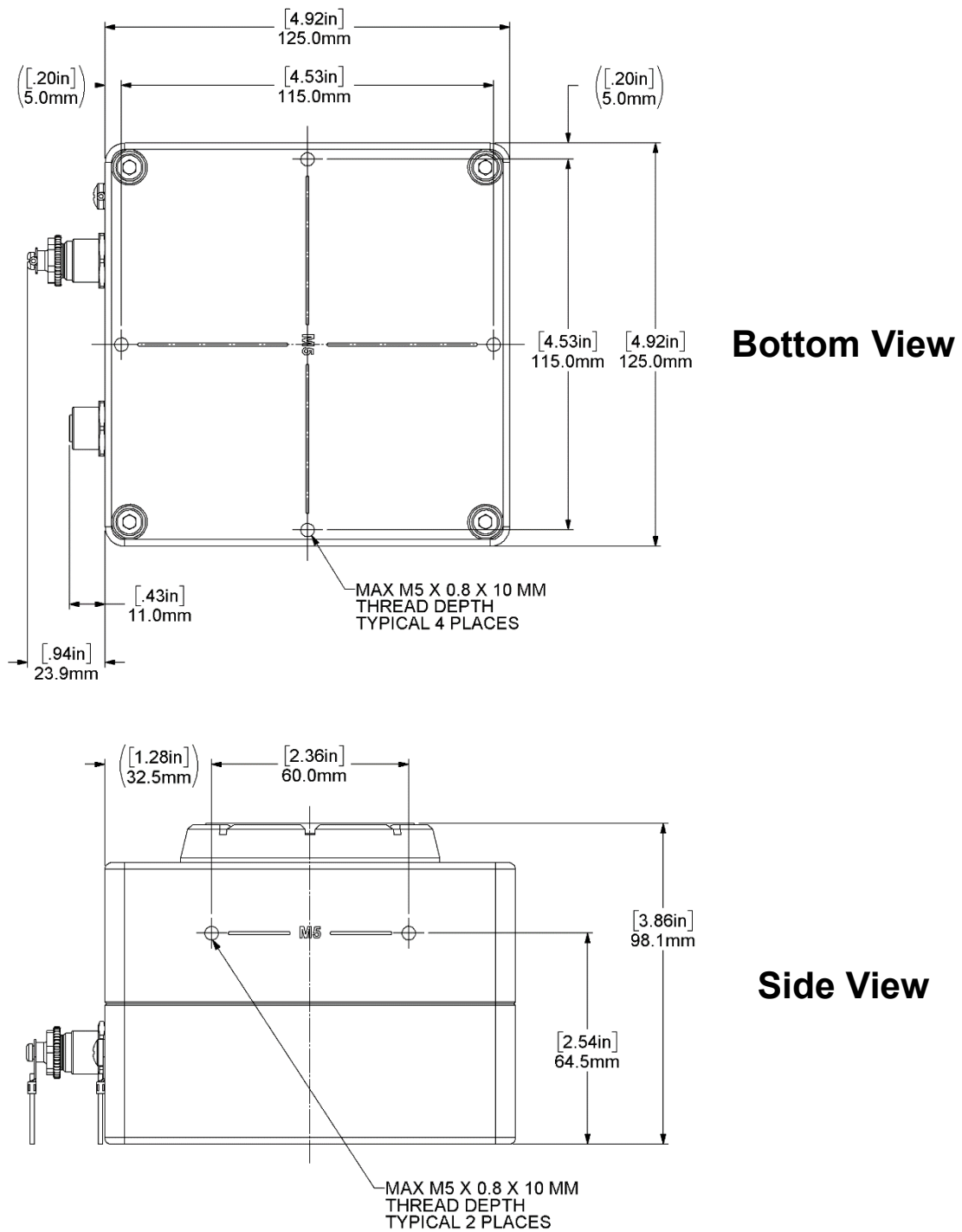**Standard Mounting Plate Included with Mars**

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.
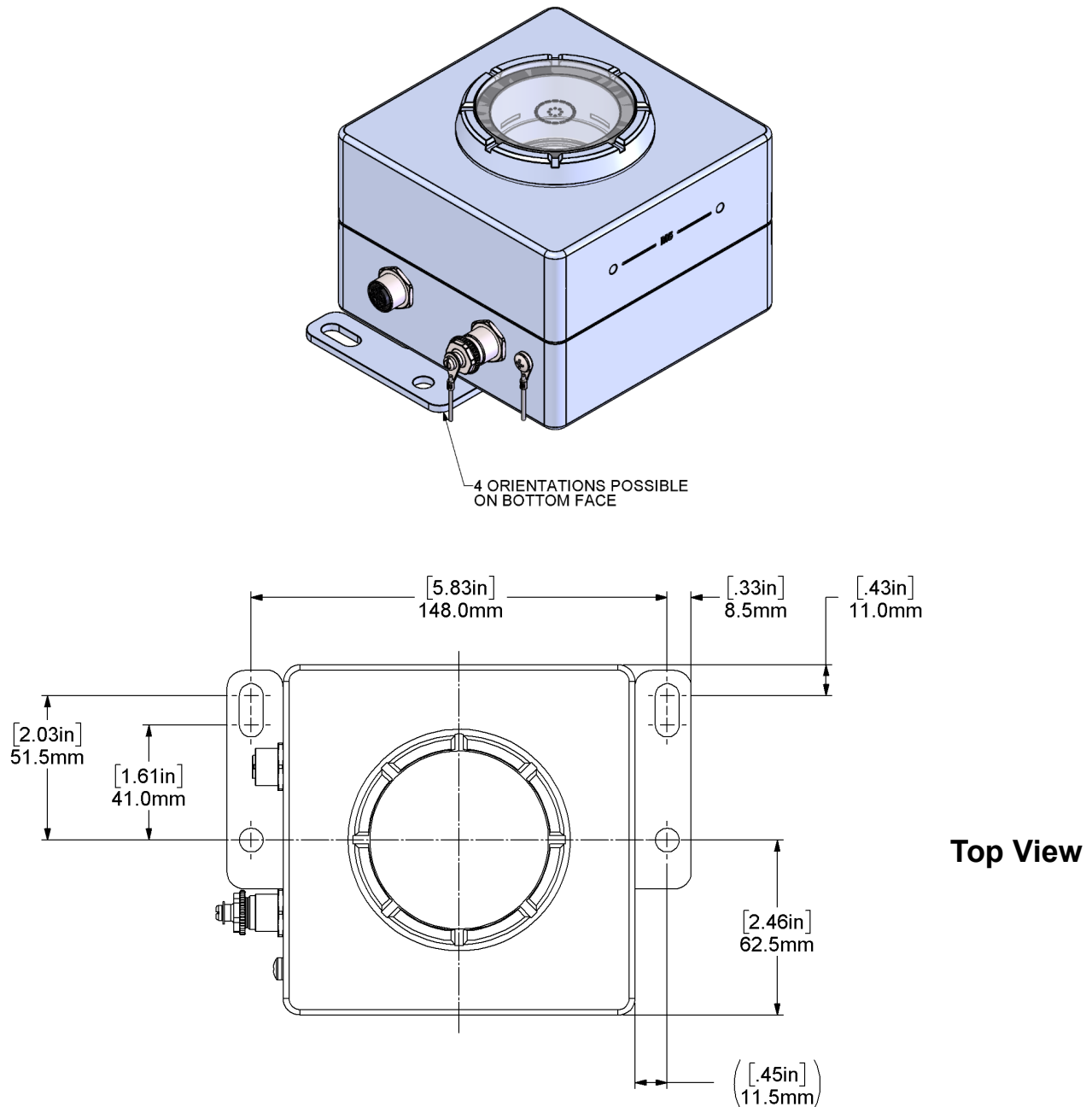
Bottom Mount Configuration

4 ORIENTATIONS POSSIBLE
ON BOTTOM FACE

Top View

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.
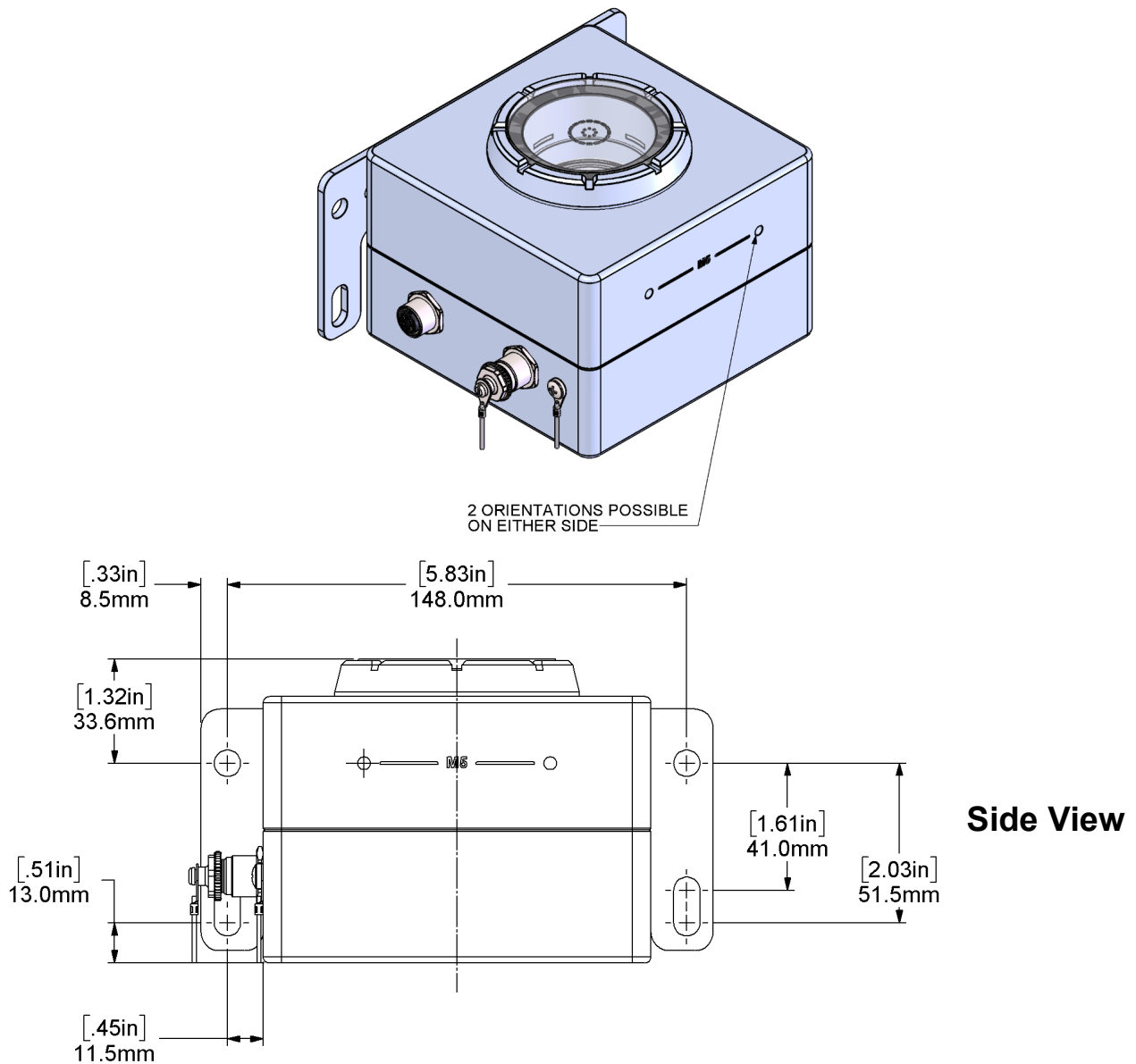
Side Mount Configuration

2 ORIENTATIONS POSSIBLE
ON EITHER SIDE

Side View

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.

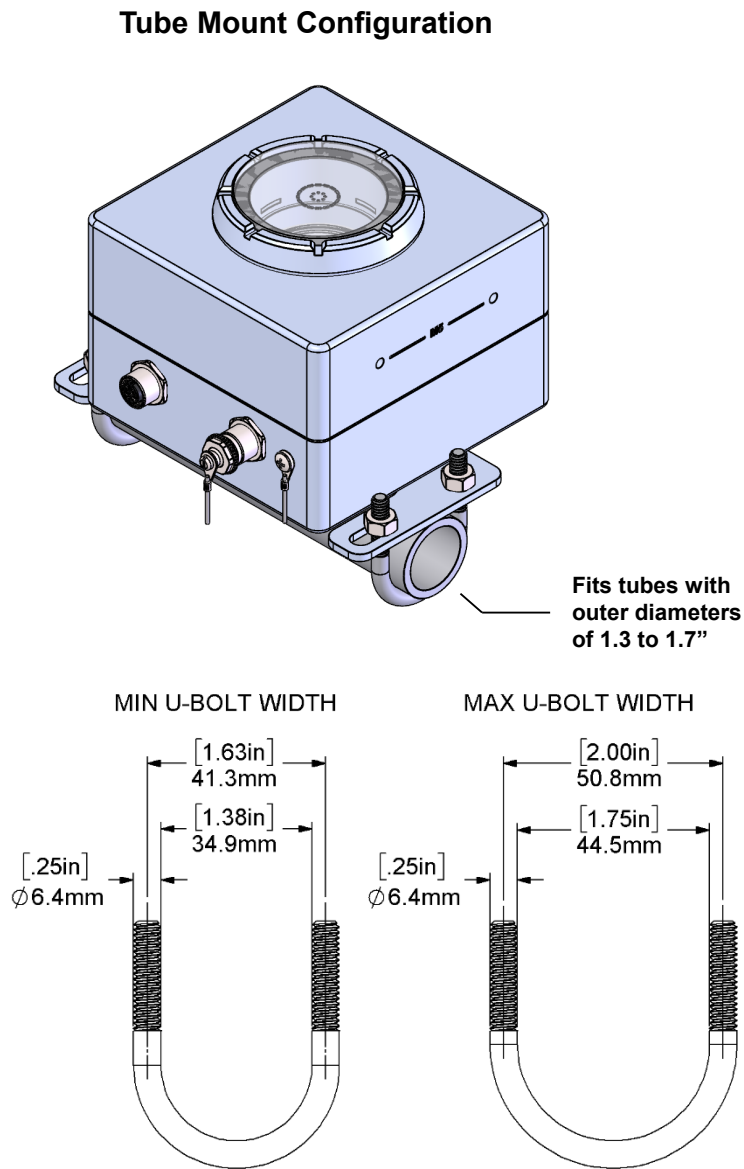**Note:** Note that options for U bolts are pictured but any U bolts are to be provided by the user.

Tube Mount Configuration

Fits tubes with outer diameters of 1.3 to 1.7"

MIN U-BOLT WIDTH   MAX U-BOLT WIDTH

Figure 5-8: Tube mount configuration

6 Modbus

Table 6-1 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.

Note: On some user data acquisition devices, it is necessary to add 1 to all the register values shown in **Table 6-1** to determine the Modbus address.

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

Table 6-1: Modbus map

Register Start	Register End	Parameter	Data Type	Bytes	Notes
1	2	Transmission Loss	Float[1]	4	Fractional loss of transmission due to soiling particles
3	4	Soiling Ratio	Float[1]	4	1 - Transmission Loss
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

[1] Float32 denotes single-precision 32-bit floating point per IEEE 754

7 Troubleshooting

Issue	Solutions
• Wi-Fi network not found during configuration attempt	• Confirm the unit is powered and has been on for less than 60 minutes. • Cycle power if needed to restart. Confirm window lights up for a short time and then turns dark. • Follow connection procedure (p. 7).
• Wi-Fi password forgotten	• See the password reset instructions or contact Atonometrics
• Modbus communication for logging unsuccessful	• Confirm Modbus register numbers (p. 21) • Verify whether register addresses require +1 offset for your client device (p. 21) • Confirm byte order (p. 21) • Confirm timeouts and polling rate (p. 21)
• Soiling ratio values out of expected range	• Confirm your Mars™ unit has the latest firmware (p. 9) • Confirm Mars™ unit is installed outdoors in desired plane of array with clear view of sky (p. 14) • Allow Mars™ unit to operate through at least one sunset and night and check the readings the next day (Chapter 8) • If needed, visually inspect unit for damage or fouling

8 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. See www.atonometrics.com/patents.

The Mars™ technology is illustrated in **Figure 8-1.** 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 8-1.** 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.
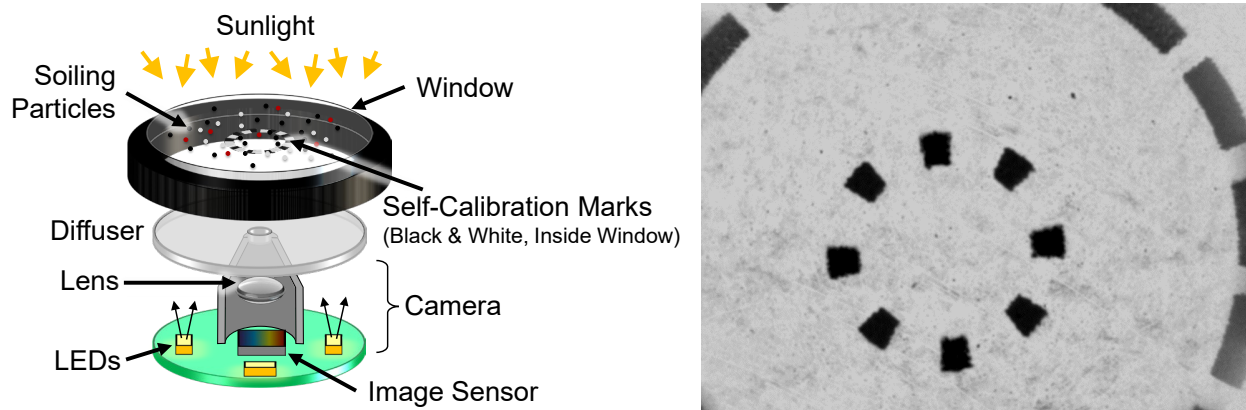

Figure 8-1: Mars™ technology

9 Specifications

CE

Table 9-1: Specifications

General	Model name	Mars Soiling Sensor™
	Part number	810230-20, HW Rev 01 (810230-20-01)
	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 RTU (RS-485)
Enclosure	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
Cables	Power & RS485	Shielded, weather resistant, UV-rated
		24 awg / 0.2 mm^2
		M12 circular connector, IP67