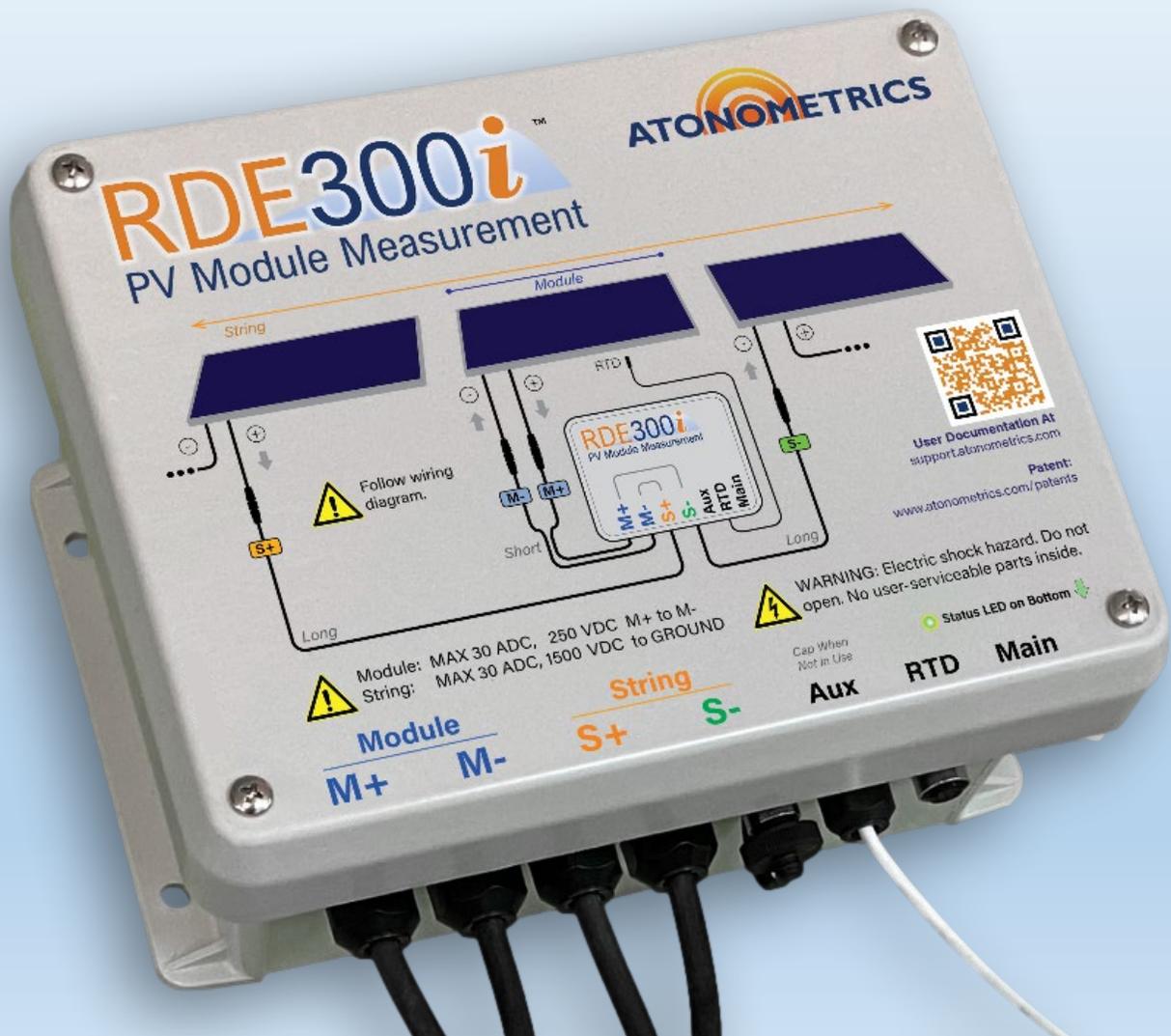


# RDE300i™ PV Module Measurement System

# User Guide



Document Number 880093 Rev. B2, January 2024



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# 1 Product Overview

The RDE300i™ PV Module Measurement System, shown in **Figure 1-1**, turns modules in your PV array into sensors for measuring PV array performance parameters, such as effective irradiance, soiling, bifacial gain, degradation, module output, and more. The RDE300i performs IV sweeps on your PV module to measure its power, voltage, current and other parameters, and processes these along with calibration data to enable measurement applications.

The in-line version of RDE300i (810275-01) can be wired directly into your PV array to measure the target module in-situ without removing the module from the array. This version has connections for both your target module and PV string. The standalone version (810275-02) omits the string connection and supports standalone reference modules only.

RDE300i features a wide input range for modules up to 30 A, 250 V, and 1500 W. An included self-adhesive Pt1000 RTD provides for back-of-module temperature measurements. Communication to your data logger or SCADA system is via Modbus RTU (RS485).

Each RDE300i measures a single PV module. For applications comparing multiple modules, configure one unit as a Leader and a second unit as a Follower connected to the Leader's auxiliary expansion port. See Section 3. RDE300i can also be combined with the Mars™ optical soiling sensor and the RC22™ PV reference cell to configure systems for various applications, as shown in more detail in document 880100 found at [support.atonometrics.com](http://support.atonometrics.com).

Patents apply. See [www.atonometrics.com/patents](http://www.atonometrics.com/patents).

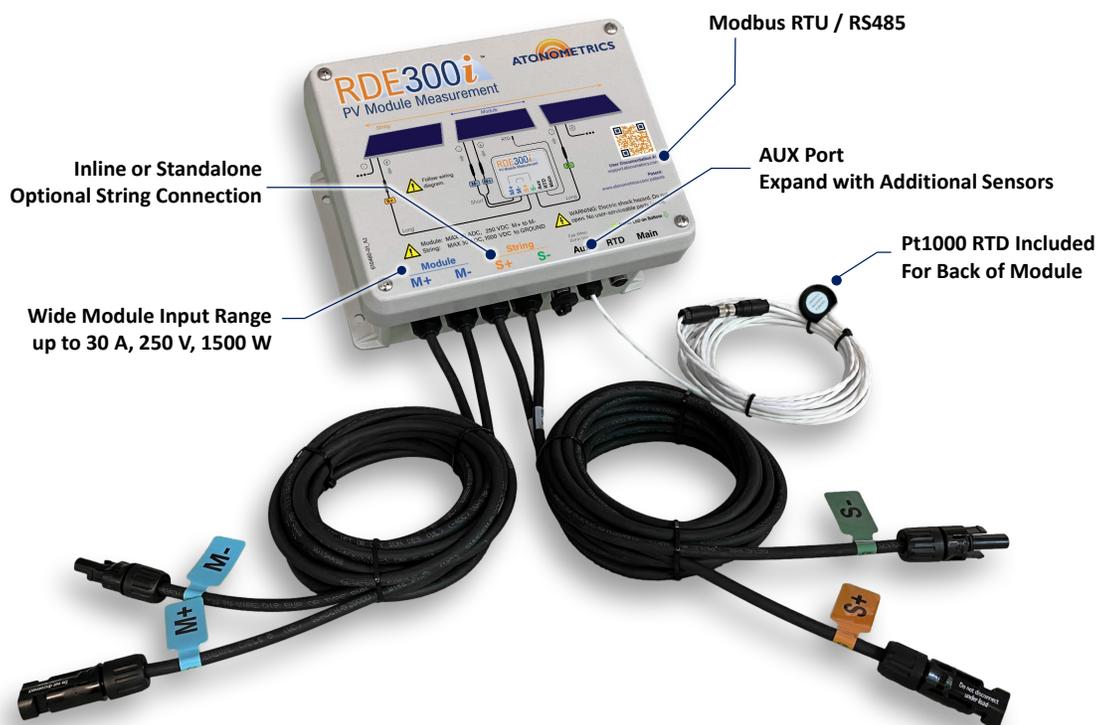


Figure 1-1: RDE300i

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## 2 Safety



- 
- WARNING: Observe safety precautions:** Failure to observe precautions may result in bodily injury and/or damage to the product or interconnected equipment.
- WARNING: Follow directions:** Operate this equipment only as directed in these instructions.
- WARNING: Inspect before using:** Inspect the equipment and note any damage or defects, including in wiring. Do not use the equipment if damaged or defective.
- WARNING: Hazardous voltages:** PV modules and strings may produce hazardous voltages and currents. The danger increases as multiple modules are connected. Hazardous voltages may be present within the product or its connections. Improper use risks fire or electric shock which could cause bodily injury.
- WARNING: Qualified personnel only:** The product should only be installed and serviced by trained and qualified personnel.
- WARNING: DO NOT INTERCHANGE MODULE AND STRING CABLES:** Follow the wiring diagram on the product enclosure carefully. Connections labelled “Module” or “M” must go to a single PV module. Do not interchange the Module and String inputs, which could result in serious damage to the product or interconnected equipment.
- WARNING: DO NOT CONNECT OR DISCONNECT PV MODULES UNDER LOAD:** PV strings must be disconnected from inverters and other power conversion systems during installation or servicing of this product.
- WARNING: Do not exceed the isolation voltage rating:** To prevent electrical hazards on the user power and communication input connections, ensure that the maximum string voltage never exceeds the product’s listed isolation voltage rating.
- WARNING: Do not exceed module voltage or current ratings:** To prevent damage to the product, ensure that the PV module connected to the Module inputs never exceeds the product’s listed voltage, current, and power ratings.
- WARNING: Secure PV module connections:** PV module connections must be properly mated and secured.
- WARNING: Do not open the enclosure:** There are no user-serviceable parts inside the product enclosure. Do not open it. Opening the enclosure may damage the product and/or interconnected equipment and risks bodily injury.
- WARNING: Follow standard safety rules:** Follow all other standard safety rules for your PV array installation, in addition to the specific precautions listed here.
-

# 3 Device Configurations

RDE300i™ may be user-configured to one of three different device configurations to support different system types and applications as listed in **Table 3-1**.

System diagrams and wiring information for some basic system types are provided in Section 7.

Set the Device Configuration using the RDE300i Configuration Manager software as explained in Section 8.

For more information on system configurations that integrate the RDE300i as a Leader with other sensors including additional RDE300i units, the Mars™ soiling sensor, and/or RC22™ PV reference cell, see Atonometrics document 880100 at [support.atonometrics.com](http://support.atonometrics.com).

**Table 3-1: Device configurations**

Device Configuration	How it Works	Applications
<b>Solo</b>	The RDE300i unit will work independently to capture Module data.	<ul style="list-style-type: none"> <li>• Monofacial and bifacial reference module irradiance measurements</li> <li>• Module and system performance monitoring</li> <li>• Degradation tracking</li> <li>• Recording IV curves</li> </ul>
<b>Follower</b>	The RDE300i provides Module data to a Leader unit which supervises it.	<ul style="list-style-type: none"> <li>• Comparing performance of two or more modules</li> <li>• Integrating with the Mars soiling sensor and/or RC22 PV reference cell(s)</li> </ul>
<b>Leader</b>	The RDE300i collects Module data from its own Module and from its Follower and/or other devices and generates Performance Index results	<ul style="list-style-type: none"> <li>• Soiling measurement</li> <li>• Bifacial gain measurements</li> <li>• Degradation tracking</li> <li>• Recording IV curves</li> </ul>

---

## 4 Unpacking

**Figure 4-1** shows an RDE300i™ unit with its shipping box.

In-line units (810275-01) will include Module and String cables as shown in the figure.

Standalone units (810275-02) do not include String connections.

All units will include an outdoor-rated self-adhesive Pt1000 RTD (230056) for back-of-module temperature measurements. The RTD is packaged with an alcohol wipe and installation instructions as a kit (810297).

Cables (see Section 7), configuration tools (see Section 8.2), and any other accessories not shown must be ordered separately.



**Figure 4-1: Unpacking your RDE300i unit**

---

## 5 Installation Procedure

Follow the steps below in the order listed to properly install your RDE300i™ unit.

For either the 810275-01 (in-line) or 810275-02 (standalone) versions, begin with these steps:

- Mount the RDE300i per Section 6
- Install power and communication cables per Section 7.1
- Connect the Module cables to a single PV module, per Section 7.2 and the wiring diagram in **Figure 7-4**
- Install the RTD on the Module, per Section 7.3

---

**WARNING: DO NOT INTERCHANGE MODULE AND STRING CABLES:** Follow the wiring diagram carefully. Connections labelled “Module” or “M” must go to a single PV module. Do not interchange the Module and String inputs, which could result in serious damage to the product or interconnected equipment.

---

For the 810275-01 in-line version with String cables, continue as follows:

- Disconnect the string from any load or inverter, for example, at your string combiner box
- Connect the String cables to complete the string circuit, per Section 7.2 and the wiring diagram in **Figure 7-4**
- Reconnect the string to your load or inverter, for example, at your string combiner box

---

**WARNING: DO NOT CONNECT OR DISCONNECT PV MODULES UNDER LOAD:** PV strings must be disconnected from inverters and other power conversion systems during installation or servicing of this product.

---

For more information on system configurations that integrate the RDE300i as a Leader with other sensors including additional RDE300i units, the Mars™ soiling sensor, and/or RC22™ PV reference cell, see Atonometrics document 880100 at [support.atonometrics.com](http://support.atonometrics.com).

# 6 Mounting

## 6.1 Location

Mount your RDE300i™ unit as close as possible to the target module to be measured. If possible, choose a shaded location underneath the modules. For applications using multiple RDE300i units and/or additional Atonometrics sensors, see additional recommendations in the [Configuration and Normalization Guides](#) (documents 880096-01 and 880096-02) and in [document 880100](#).

**Note:** Mounting more than a few meters from the target module may compromise operation.

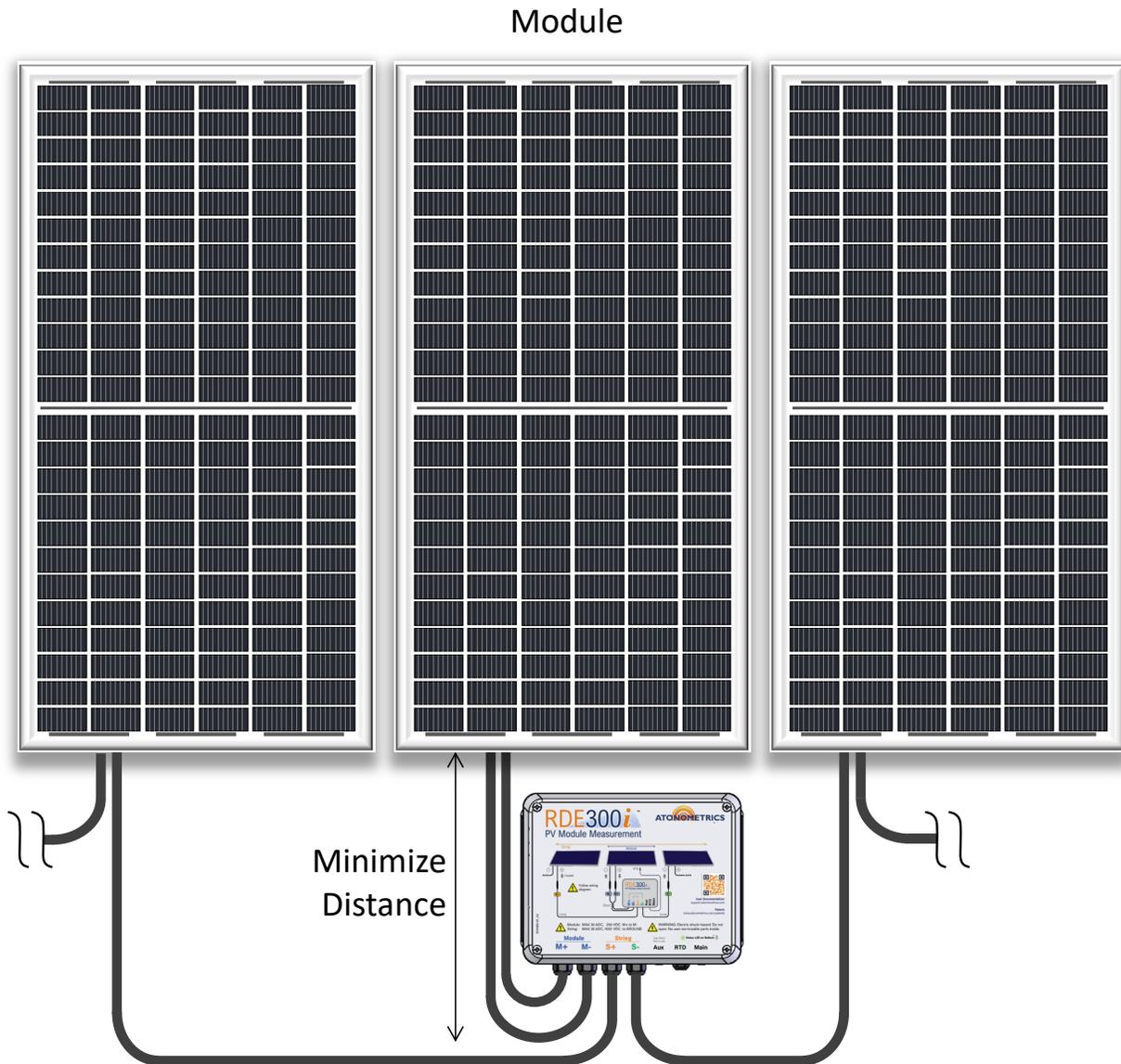


Figure 6-1: Minimize distance from RDE300i™ to module under test

## 6.2 Dimensions

Figure 6-2 shows the RDE300i™ enclosure dimensions and mounting hole positions. To mount the RDE300i use the 4 mounting holes on the rear flanges of the enclosure.

**Note:** Enclosure dimensions are approximate and may vary slightly due to material variations.

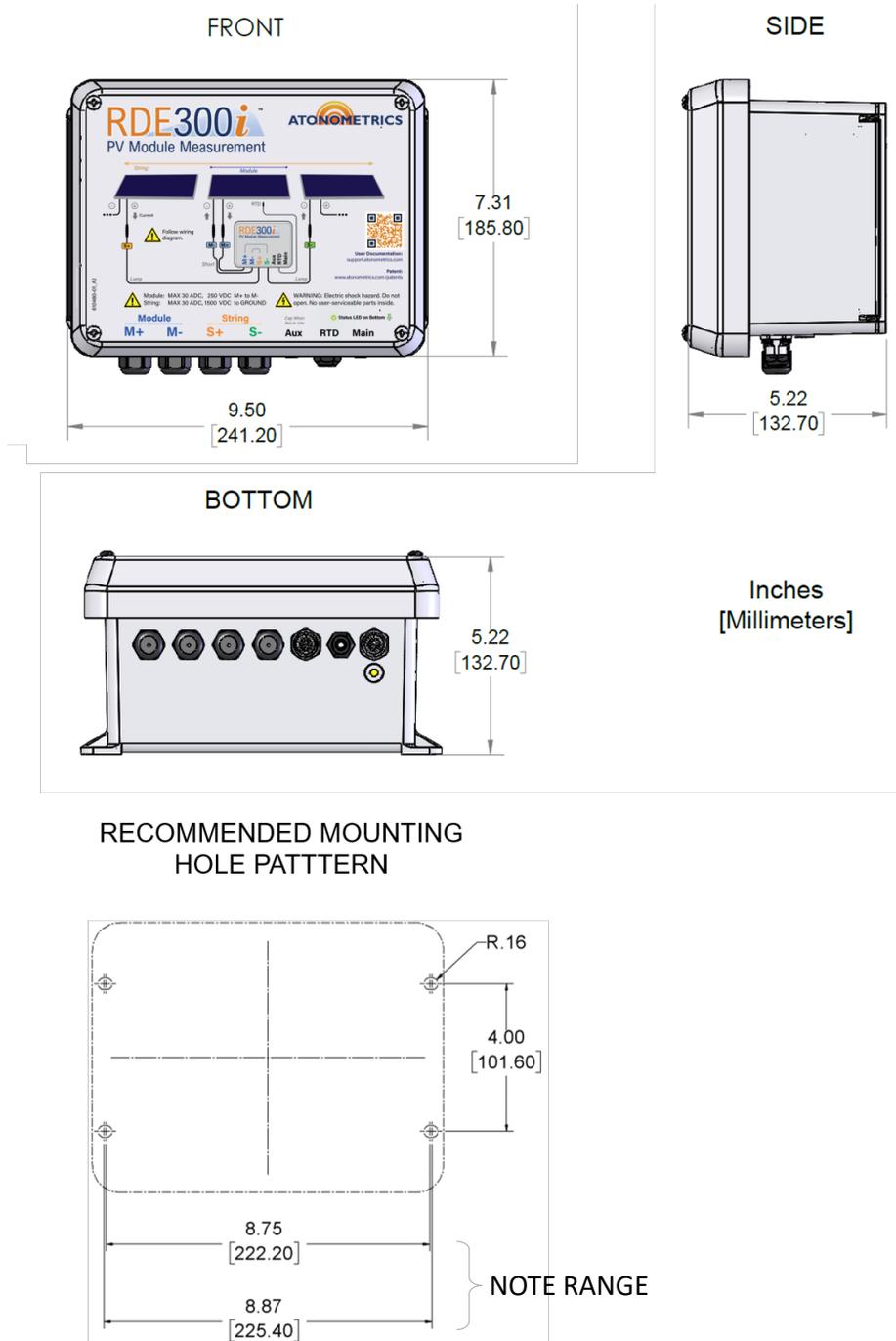
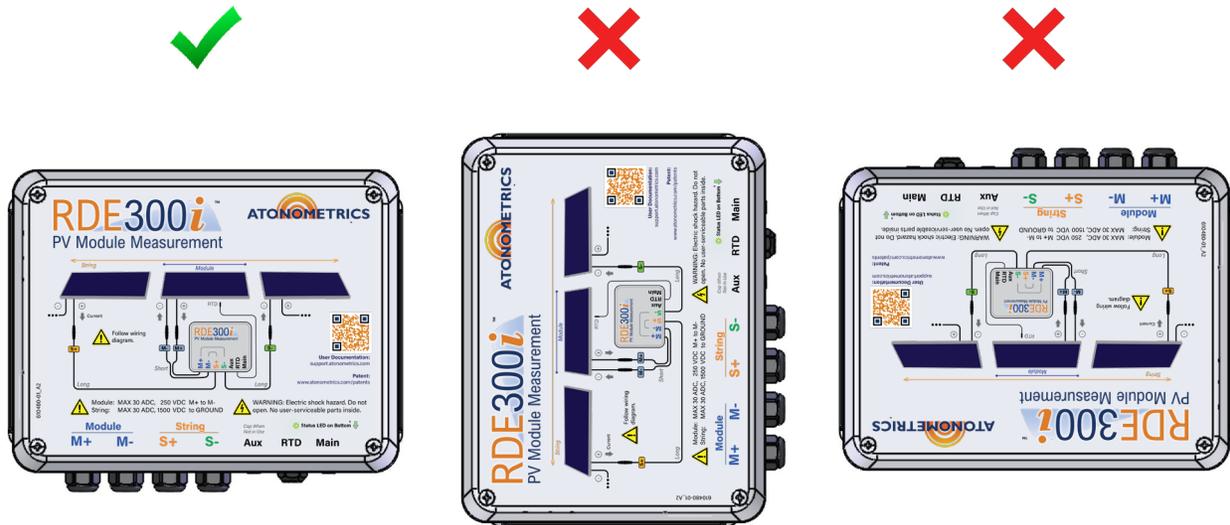


Figure 6-2: Dimensions, including mounting holes

## 6.3 Orientation

Always mount the RDE300i™ with the cable entry points facing down, as shown in **Figure 6-3**, to prevent water ingress along the cables.

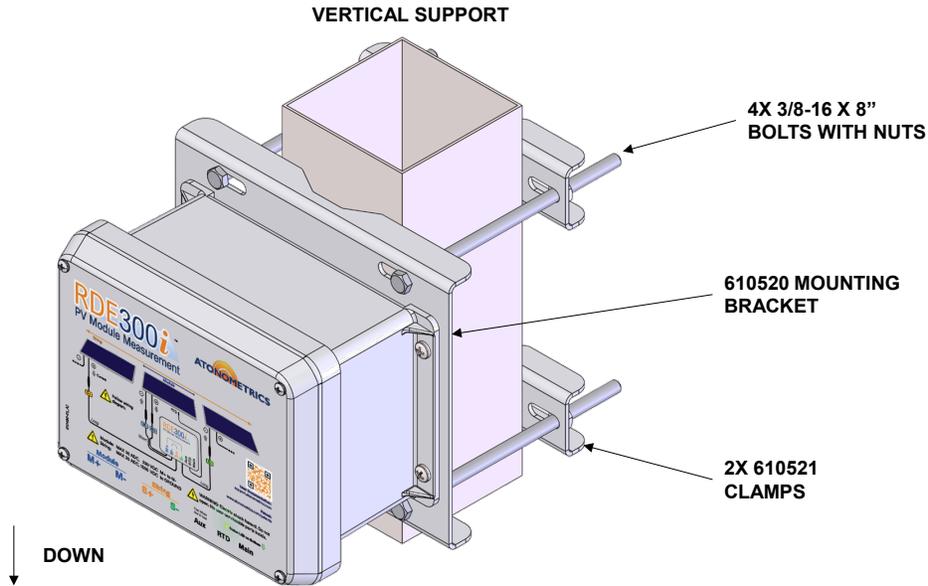


**Figure 6-3: Mount with cable entries facing down**

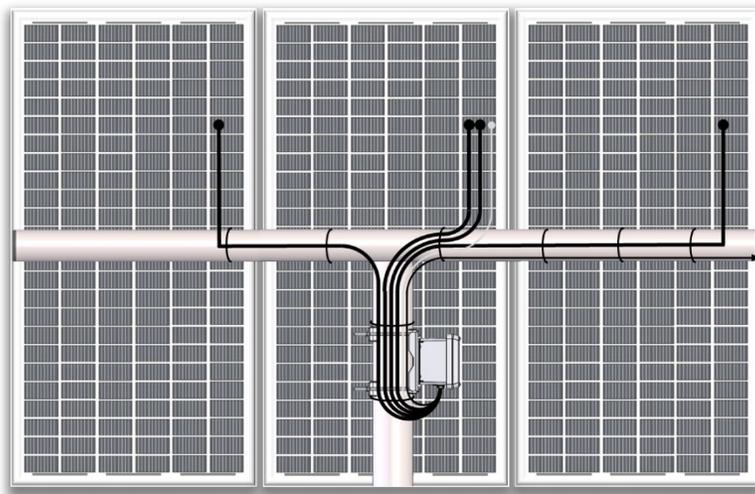
## 6.4 Mounting Clamp

The 810303 mounting clamp kit, sold separately, allows mounting your RDE300i unit on various types of PV system vertical supports including racking piles or columns. See **Figure 6-4**, **Figure 6-5**, and **Figure 6-6**.

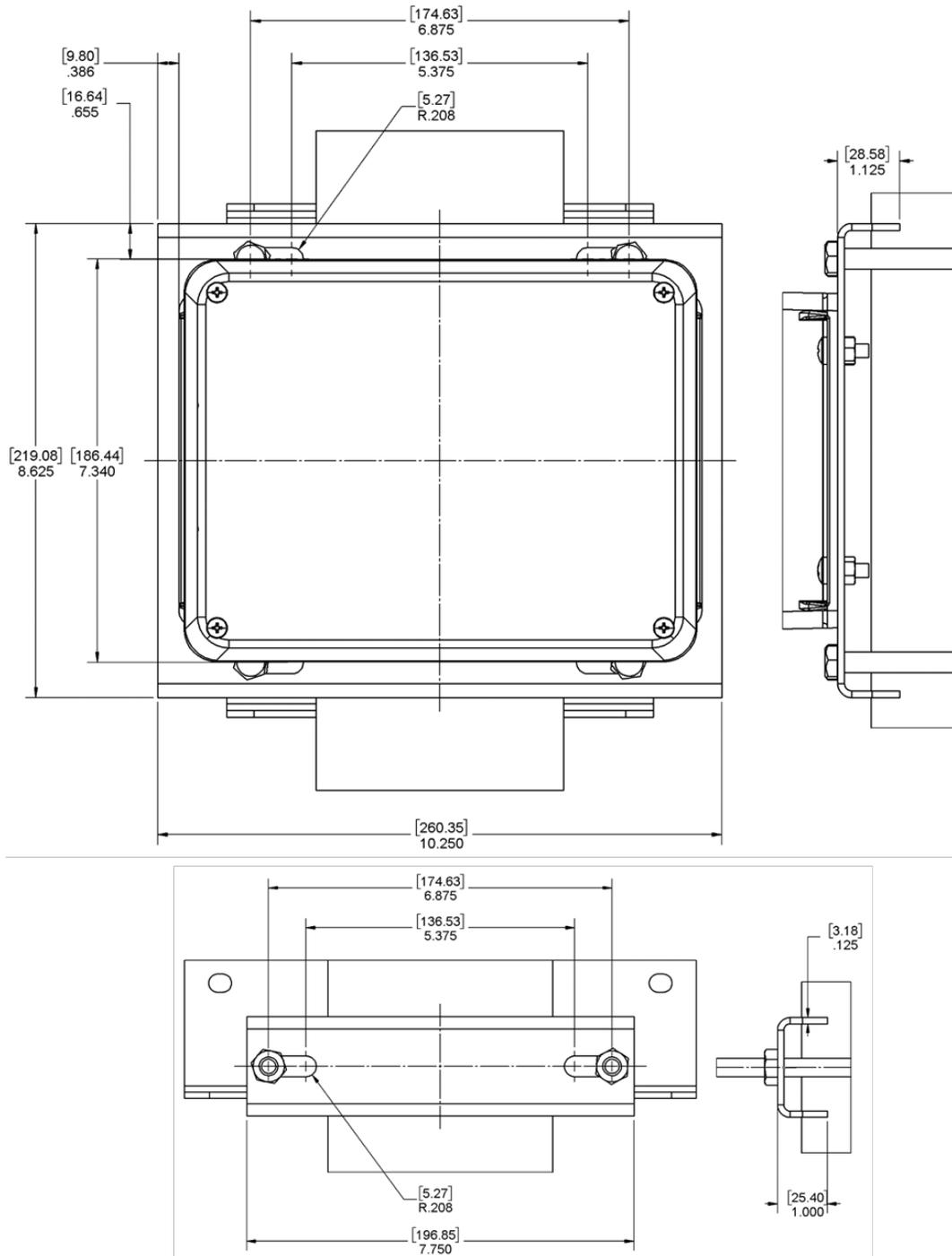
Mount your RDE300i to the mounting bracket with customer-supplied hardware, and then use the clamps to secure the bracket to your chosen vertical mounting structure. Secure cables, while assuring that cables have adequate service length for module motion if using a tracker.



**Figure 6-4: Mounting clamp kit (810303) used for RDE300i vertical mounting**

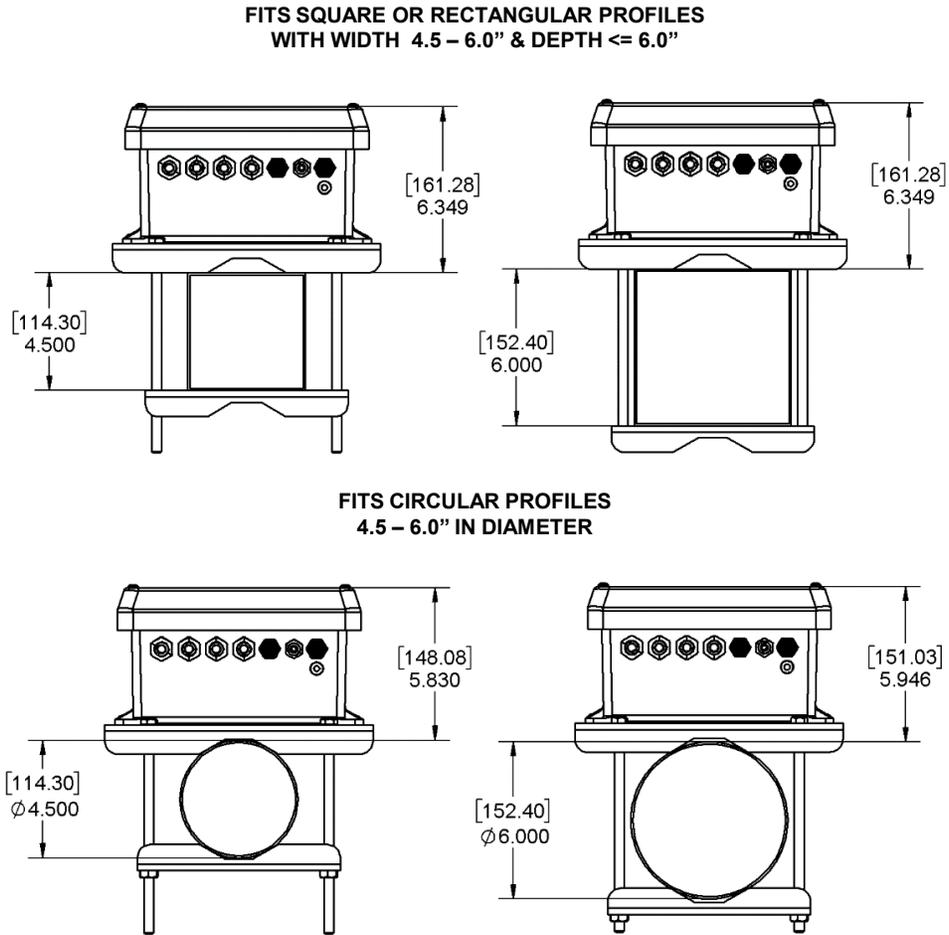


**Figure 6-5: Secure cables but leave service length for module motion on trackers**



**Figure 6-6: RDE300i mounting clamp (810303) dimensions**

The 810303 Mounting Clamp Kit can be used on vertical supports with a rectangular, square, or circular profile up to 6.0" across. Notice the orientation of the clamp for each profile, as shown in Figure 6-7.



**Figure 6-7: Mounting clamp kit (810303) supported profiles for vertical supports**

# 7 Wiring

## 7.1 Power & Communication

RDE300i™ requires 10-30 VDC input and draws ~1.5 W of power without devices connected to its Aux port.

Power supplies should be sized for >~2 times the required power to provide for startup currents.

Communication is via Modbus RTU protocol over RS485.

Both power and communication are applied to the RDE300i at the M12 connectorized port labeled Main. A second M12 connectorized port labeled Aux connects to expansion units and accessories.

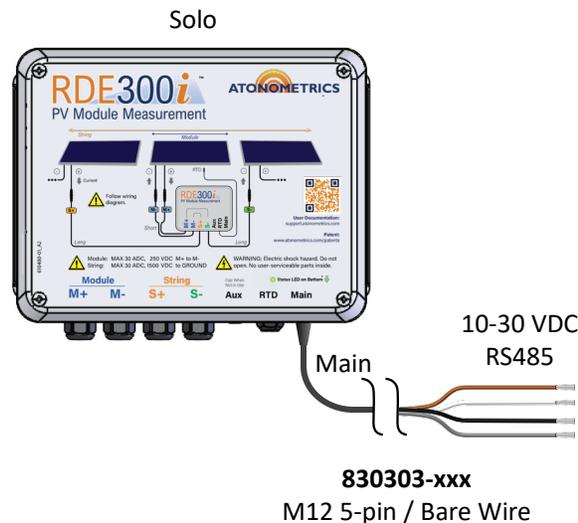
**Figure 7-1** shows wiring for a single RDE300i in the Solo configuration, and **Figure 7-2** shows wiring for a dual RDE300i system in Leader / Follower configurations. See M12 power and communication cables listed in **Table 7-1**. Cables must be ordered separately. For more information on the Solo, Leader, and Follower device configurations, see Section 3.

A single unit in the Solo configuration, or the Leader unit of a dual-unit system, must be connected to the user's power and communication equipment. Use cable series 830303, which connects to the Main port and provides bare wires for connection to the user's equipment. **Figure 7-3** lists the wire colors.

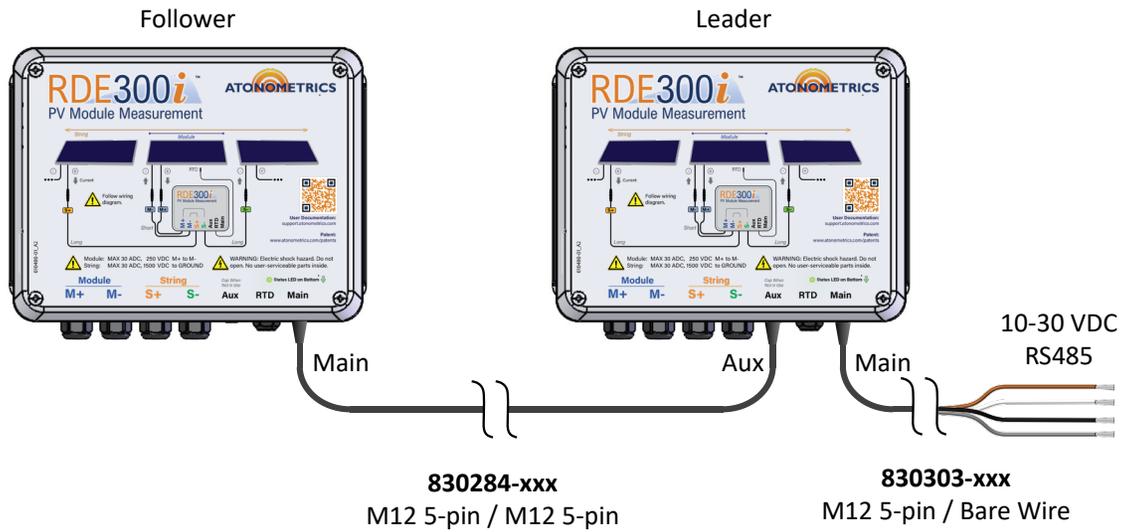
Connect the Main port of the Follower unit of a dual-unit system to the Aux port of the Leader using cable series 830284. The Leader provides power and communication to the Follower.

For long cables as shown in **Table 7-1**, place the 830331 RS485 termination accessory between the cable and the RDE300i Main input, for either the 830303 or 830284 series.

For additional wiring and power information regarding systems configured to have RDE300i integrated with one or more additional Atonometrics sensors, see the [Ordering Guide](#) (880100).



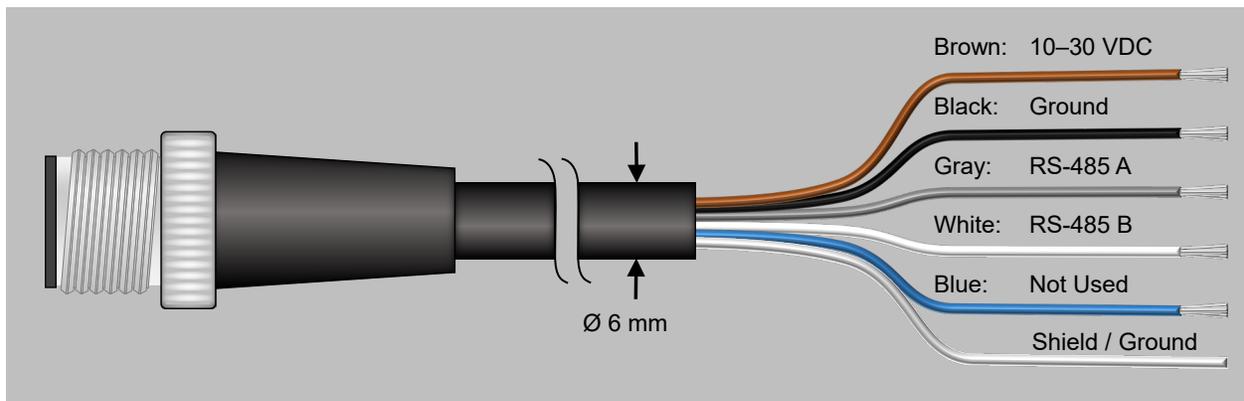
**Figure 7-1: Power and communication wiring for single RDE300i (Solo)**



**Figure 7-2: Power and communication wiring for dual RDE300i (Leader / Follower)**

**Table 7-1: M12 power and communication cables**

Length	Main to User's Power & RS485 (M12 5-pin / Bare Wire)	Minimum Power Supply Voltage	Leader Aux to Follower Main (M12 5-pin / M12 5-pin)	830331 RS485 Termination Required?
4 m	830303-004	12 VDC	830284-004	No
10 m	830303-010	12 VDC	830284-010	No
25 m	830303-025	15 VDC	830284-025	No
50 m	830303-050	24 VDC	830284-050	Yes
100 m	830303-100	24 VDC	830284-100	Yes



**Figure 7-3: Wire colors for 830303 cables**

---

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

**Note:** Connect the shield / ground wire of the 830303 cable to ground in your equipment cabinet.

**Note:** Cut the blue wire, which is not used in this product.

**Note:** For additional wiring and power information regarding systems configured to have RDE300i integrated with one or more additional Atonometrics sensors, see the [Ordering Guide](#) (880100).

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**WARNING: CHECK ALL WIRING BEFORE TURNING ON POWER: Incorrect wiring may damage the unit and/or your other equipment.**

---

## 7.2 Module and String

The PV Module and optional String cables must be connected per the wiring diagram in **Figure 7-4**. Note that the Module and String cables are labelled as shown in **Figure 7-5**. The cables are terminated with MC4 connectors (Multi-Contact part numbers 32.0017P0001-UR and 32.0016P0001-UR). Adapters may be required for your PV modules.

**WARNING: DO NOT INTERCHANGE MODULE AND STRING CABLES:** Follow the wiring diagram carefully. Connections labelled “Module” or “M” must go to a single PV module. Do not interchange the Module and String inputs, which could result in serious damage to the product or interconnected equipment.

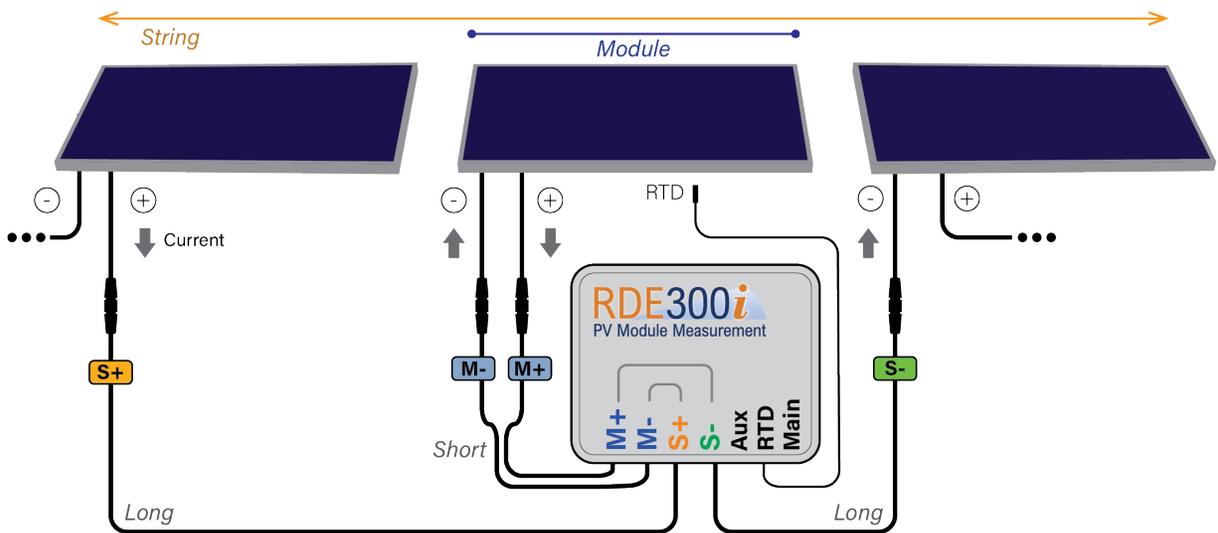


Figure 7-4: Wiring diagram for PV Module and String cables

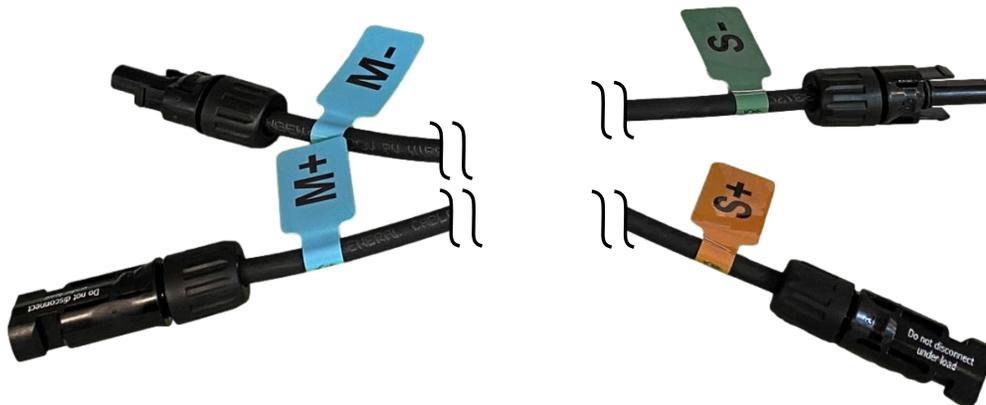


Figure 7-5: Module and String cable labels

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**WARNING: DO NOT CONNECT OR DISCONNECT PV MODULES UNDER LOAD:** PV strings must be disconnected from inverters and other power conversion systems during installation or servicing of this product.

---

**Note:** Do not use user-supplied PV extension cables. If PV extension cables are required, use the 810269-05 PV & RTD cable extension kit. See Section 7.4.

**Note:** Do not extend PV cables beyond 5 meters. The system may not function correctly.

**Note:** PV cables must run in straight paths. Do not coil extra cable material. This may interfere with the system operation.

---

## 7.3 RTD

Each RDE300i™ includes a self-adhesive Pt1000 RTD (230056) for measuring the Module temperature. As shown in **Figure 7-6**, the 230056 RTD probe assembly is packaged together with an alcohol wipe and an installation instruction card as a kit (810297). Follow the installation instruction card to apply the RTD to the back of the Module to be measured.

If using the 810269-05 five-meter cable extension kit (see Section 7.4), disconnect the RTD at the in-line M8 connector, connect the RTD extension cable from the kit, and connect the RTD to the end of the extension cable. Ensure that both connectors are tightly sealed to prevent water entry.

---

**Note:** Application of the self-adhesive RTD should be performed when the module temperature is between 21 °C and 38 °C to ensure proper adhesive bonding.

---



**Figure 7-6: Self-adhesive back-of-module Pt1000 RTD**

## 7.4 Cable Extensions

The RDE300i™ Module and String cables are approximately 2-3 m in length and the RTD cable is 3 m in length.

If necessary, either Module or String cables may be extended by 5 meters using an 810269-05 PV & RTD cable extension kit. The kit contains 2 PV extension cables and 1 RTD extension cable. One kit only extends the Module or String side, not both. When using the kit for the String side, the RTD in the kit will not be needed.

---

**Note:** **Do not use user-supplied PV extension cables.** If PV extension cables are required, use the 810269-05 PV & RTD cable extension kit.

**Note:** **Do not extend PV cables beyond 5 meters.** The system may not function correctly.

**Note:** **Do not coil extra PV cable.** PV cables must run in straight paths. Do not coil extra cable material. This may interfere with the system operation.

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# 8 Configuration

## 8.1 Documentation

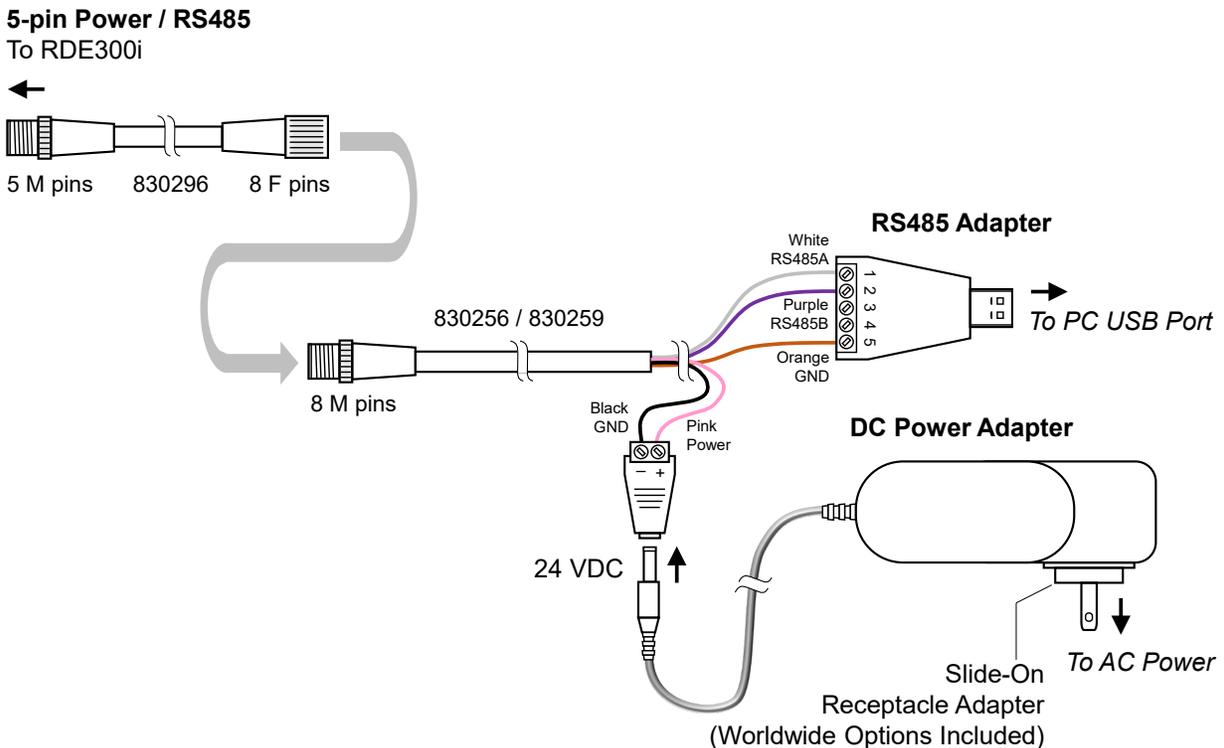
Before starting configuration, visit [support.atonometrics.com](http://support.atonometrics.com) and get the latest copy of this document ([RDE300i™ User Guide](#), document 880093).

When performing applications comparing module outputs with reference values, such as soiling or bifacial gain measurements, please follow instructions in the relevant [Configuration and Normalization Guide](#) (880096-01 or 880096-02).

For systems in which RDE300i is integrated with other Atonometrics sensors, see system details, including parts lists, cable diagrams, and power requirements, in the [Ordering Guide](#) (880100).

## 8.2 Configuration Kit

The Configuration Kit (810276), sold separately, allows you to conveniently power your RDE300i unit, perform configuration, and test communication and system status. The main kit contents used for RDE300i are shown in **Figure 8-1**.



**Figure 8-1: Configuration Kit (810276, sold separately)**

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

- Assemble the power/RS485 cable and connect to the Main input on your RDE300i™
- Connect the RS485 adapter cable to your PC's USB port.
- Allow Windows to detect the USB adapter and automatically install its driver.
- Select the included AC power receptacle adapter appropriate for your region and install it on the AC-DC power adapter. Connect the power adapter to AC power.

---

**Note:** The 810276 Configuration Kit supports multiple products. It may include some accessories that are not required for your RDE300i and are not shown here.

**Note:** Configuration Kits are optional. You may duplicate their functions with your own supplied equipment and cables if desired.

**Note:** For more information on the 810276 Configuration Kit, or to find software drivers, visit the [801276 configuration kit page](#) on [support.atonometrics.com](#).

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## 8.3 Configuration Manager Software

RDE300i Configuration Manager Software (500092) allows you to connect to your RDE300i, set communication and other configuration settings, and test system status.

The software runs on a Windows PC.

Obtain the software by visiting the [RDE300i Software Updates](#) page and install it per instructions found there.

## 8.4 Connect to RDE300i

Connect the Configuration Kit (or equivalent equipment) as described above in Section 8.2 and ensure the kit is powered.

Launch the RDE300i™ Configuration Manager Software on your PC.

From RDE300i Configuration Manager, use the Connect tab shown in **Figure 8-2** to connect to your RDE300i unit.

Select your PC's COM port corresponding to the USB/RS485 adapter of the Configuration Kit.

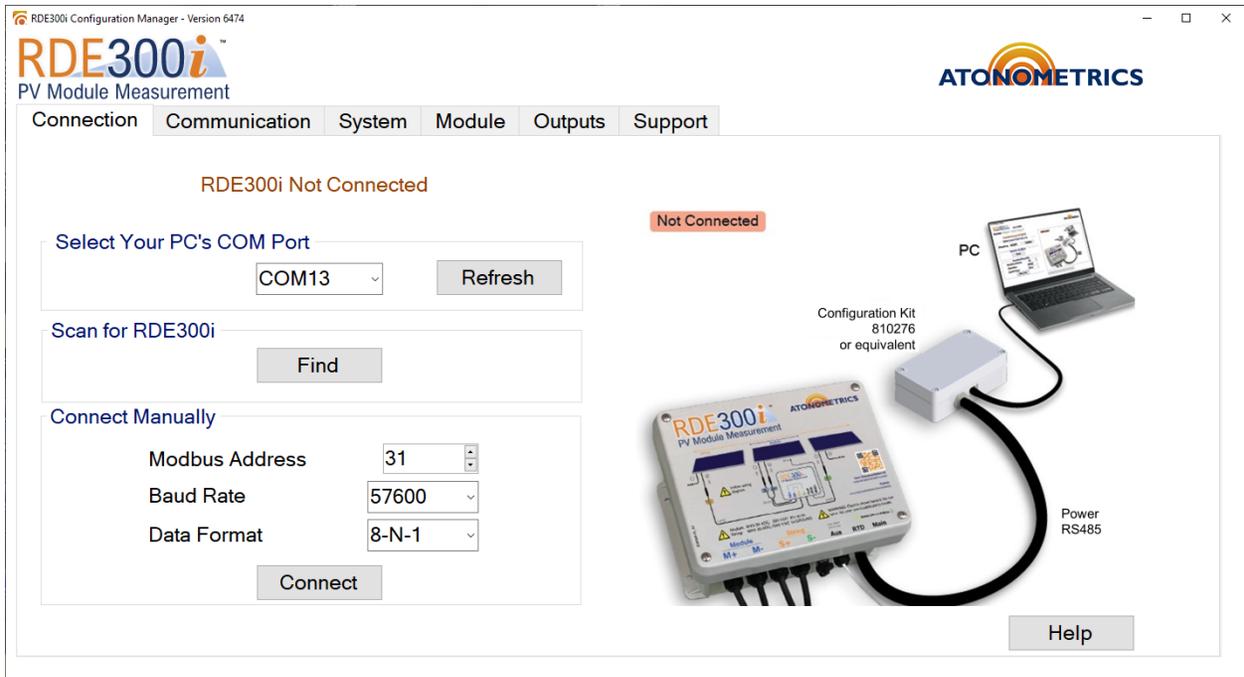
If the Modbus communication settings of your RDE300i are unknown, Scan for the RDE300i using the Find button. The software will attempt to discover your RDE300i address, baud rate, and data format.

If your Modbus communication settings are known, you may enter these in the Connect Manually box and press the Connect button.

---

**Note:** To determine the COM port of your RS485 adapter, check the COM ports drop down box with and without the adapter connected to your PC, using the Refresh button to update the list after connecting/disconnecting the adapter from the PC.

---



**Figure 8-2: Connecting to RDE300i**

Once your RDE300i unit is connected, the software will display the Connected status as shown in **Figure 8-3**.



**Figure 8-3: RDE300i connected**

## 8.5 Setting Communication Parameters

Your RDE300i™ unit's default Modbus serial communication parameters are Address = 30, Baud Rate = 57600, and Data Format = 8-N-1 (8 data bits, no parity, 1 stop bit).

To update the communication parameters, use the Communication tab of RDE300i Configuration Manager, shown in **Figure 8-4**.

Enter your new parameters in the Update Modbus Settings box and press Apply to transmit these to the unit.

Addresses from 1 to 247 are allowed.

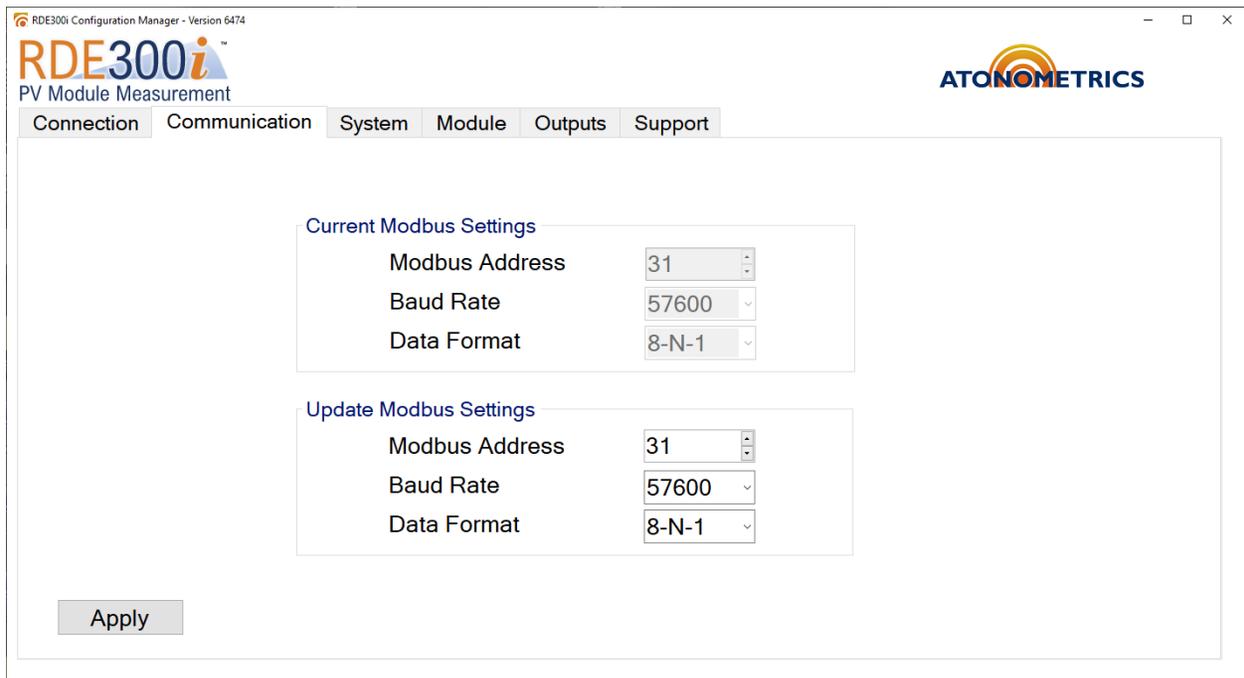
Supported baud rates are 9600, 19200, 38400, and 57600.

Supported data formats are 8-N-1, 8-N-2, 8-E-1, and 8-O-1.

---

**Note:** In the Follower device configuration, Modbus communication parameters are fixed to defaults and may not be changed by the user. See Section 8.6.2.

---



**Figure 8-4: Setting communication parameters**

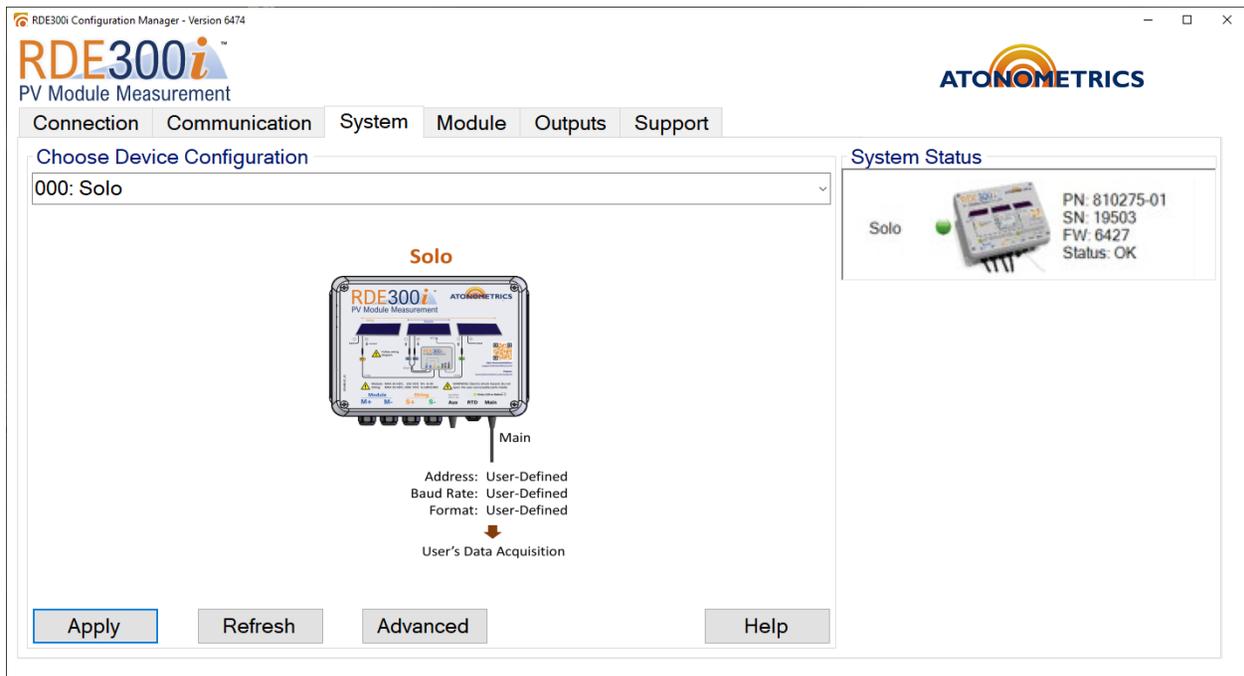
## 8.6 Setting Device Configuration

### 8.6.1 Solo Configuration

To set RDE300i™ to the Solo configuration, select Solo from the Choose Device Configuration drop-down in the Configure tab of RDE300i Configuration Manager, as shown in **Figure 8-5** and press Apply.

The diagram displayed on the tab provides visual confirmation of the Solo operation.

The System Status box displays the operation status of the connected RDE300i™ as well as its part number, serial number, and installed firmware version. For warning and error conditions, an Event Code may be displayed. For Event Code explanations, see the Help screen or refer to [RDE300i Event Codes](#).



**Figure 8-5: Solo Configuration**

## 8.6.2 Follower Configuration

To set RDE300i™ to the Follower configuration, select Follower from the Choose Device Configuration drop-down in the Configure tab of RDE300i Configuration Manager, as shown in **Figure 8-6**, and press Apply.

The diagram displayed on the tab provides visual confirmation of the Follower operation and illustrates how the Follower works with a Leader.

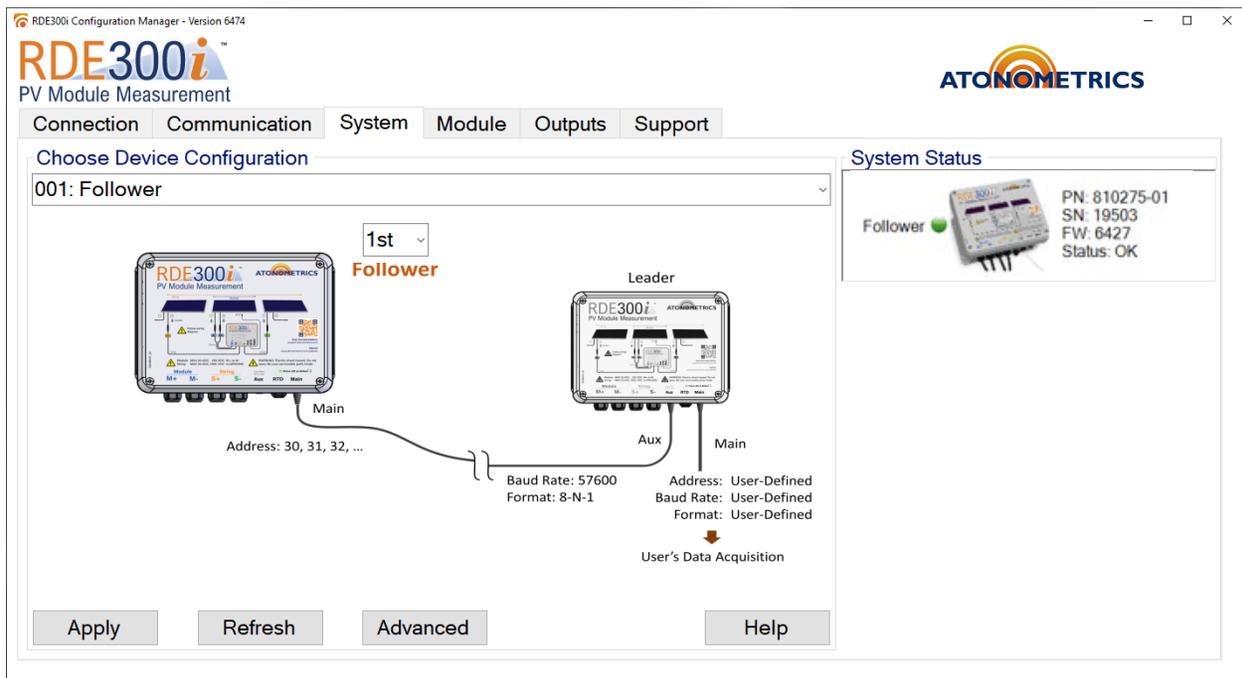
One RDE300i Leader can support up to 4 RDE300i Followers. Each Follower must be uniquely assigned a Follower number using the small dropdown above the orange “Follower” text in the Follower Configuration graphic. For configuration, you must individually connect to each Follower and program the Follower numbers in ascending order for stable communication to occur on the Aux network. The first Follower must always be set to “1<sup>st</sup>.” No gaps in numbering are allowed. Use the “Apply” button to program the Follower number selected in the dropdown into RDE300i.

The System Status box displays the operation status of the connected RDE300i as well as its part number, serial number, and installed firmware version. For warning and error conditions, an Event Code may be displayed. For Event Code explanations, see the Help screen or refer to [RDE300i Event Codes](#).

---

**Note:** When RDE300i is set to the Follower configuration, the unit will operate using default Modbus communication parameters as shown in the diagram below. These parameters are not user settable. The Follower operates on the Leader’s private Aux network, and user data acquisition is from the Leader only.

---



**Figure 8-6: Follower Configuration**

### 8.6.3 Leader Configuration

To set RDE300i™ to the Leader configuration, select Leader from the Choose Device Configuration drop-down in the Configure tab of RDE300i Configuration Manager, as shown in **Figure 8-7**, and press Apply.

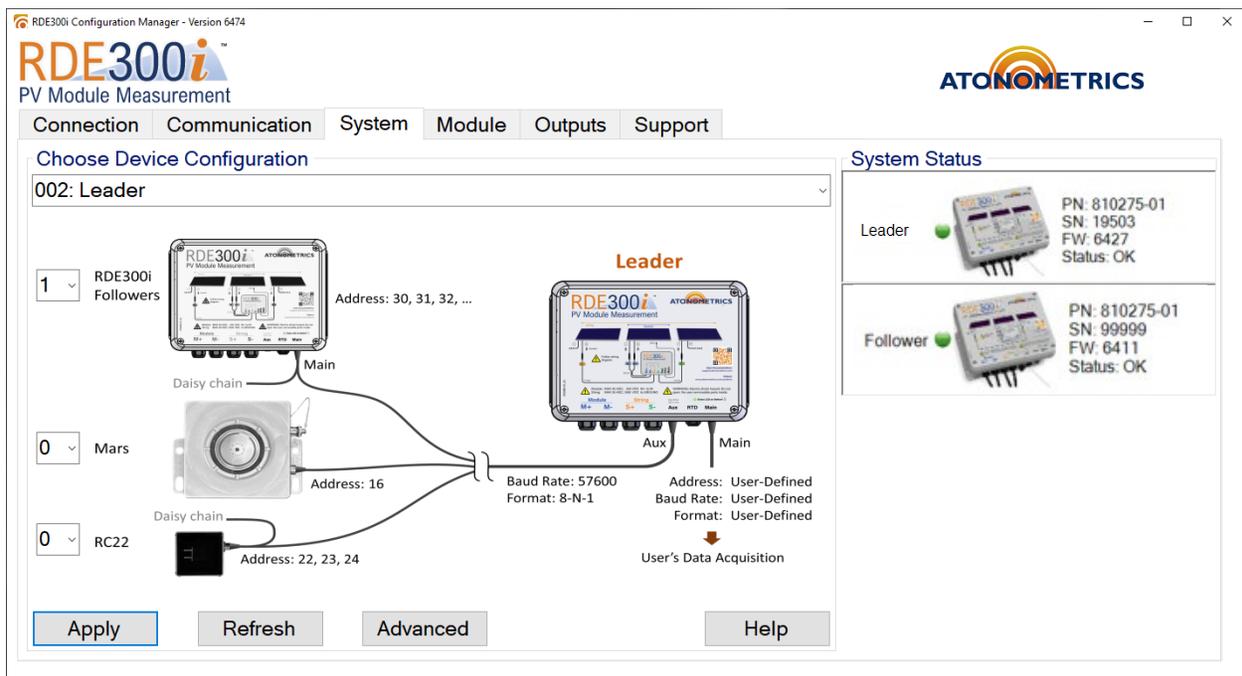
The diagram displayed on the tab provides visual confirmation of the Leader operation and illustrates how the Leader works with Followers and other sensors including Mars™ and RC22™ on its Aux network. Use the dropdowns to select the number of RDE300i Followers and other devices each device type as specified by the text and graphic next to the dropdowns.

The System Status box displays whether communication to the units on the Aux network is working properly and displays the operation status of the Leader and Followers and other devices as well their part numbers, serial numbers, and installed firmware versions. For warning and error conditions, an Event Code may be displayed. For Event Code explanations, see the Help screen or refer to [RDE300i Event Codes](#).

For more information on possible system configurations, see the [Ordering Guide](#) (880100).

**Note:** When RDE300i is set to the Leader configuration, its Modbus communication parameters may be set by the user, but devices on the Aux network must be operating at the default baud rate (57600) and data format (8-N-1). The Aux devices' Modbus addresses must be set correctly as well. For example, if you have one RC22 in your configuration, the RC22 Modbus address = 22 (default address for RC22). If you have three RC22 Followers in your configuration, the Modbus address for RC22 #1 = 22, RC22 #2 = 23, and RC22 #3 = 24, as show in the diagram below.

**Note:** If any Aux networked unit is not properly configured or connected, its status may be displayed with an error in the System Status box. To resolve this condition, connect to the Aux device according to its User Guide, configure the device to the required settings, and then reconnect the Leader's Aux port to the device or device network.



**Figure 8-7: Leader Configuration**

## 8.7 Advanced Configuration Options

Clicking the “Advanced” button on the System tab, shown in **Figure 8-7**, brings up the Advanced Configuration Options dialog, shown below in **Figure 8-8**. These settings control details of how RDE300i performs IV sweeps, including selection of full sweeps, mini sweeps, estimated IV curves, external trigger, and how data is filtered out of performance index calculations. Use the dropdown lists to change the settings.

The irradiance threshold only takes effect if RDE300i is configured as Leader. The rear irradiance uniformity threshold only takes effect if RDE300i is configured as Leader with two rear-facing RC22 units on the auxiliary line. Both of these parameters are used to filter out data from the performance indices. Performance indices are updated every 10 minutes.

The irradiance threshold determines if data from the most recent 10-minute period will be calculated into the performance index averages. The average irradiance from the 10-minute period must be greater than or equal to the irradiance threshold. A higher irradiance threshold means that higher irradiance levels are required to affect the performance index averages.

The rear irradiance uniformity is a measurement of how similar the irradiance levels detected by the two rear-facing RC22 units are. In the middle of the day, the irradiance readings will be close, whereas at the beginning or end of the day, one RC22 unit will experience significantly higher irradiance than the other. The Rear Irradiance Threshold equation is shown below:

U = Rear Irradiance Threshold

A = RC22 East Irradiance

B = RC22 West Irradiance

$$\frac{|A-B|}{A+B} * 100 \leq U$$

Data will be included in the calculation only when the inequality on the last line above is satisfied. Therefore, more data will be filtered out with smaller rear irradiance uniformity thresholds.

If full sweeps are enabled, RDE300i will perform a full IV sweep every 60 seconds.

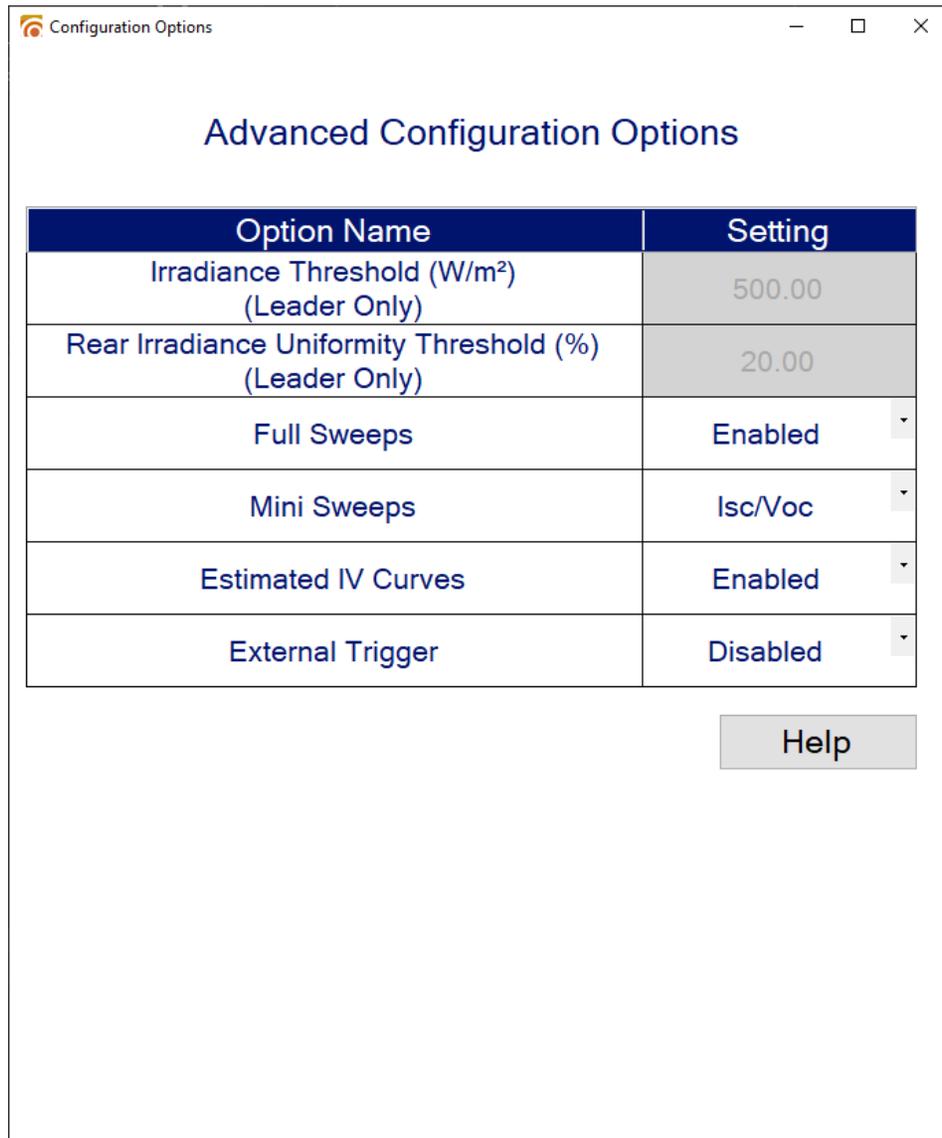
For mini sweeps, there are two types: Pmax and Isc/Voc. Pmax sweeps may only be enabled if the unit is inline. Pmax sweeps will not work on a standalone module. Pmax sweeps are performed every 10 seconds and will only obtain measurements from the knee of the IV curve so that Pmax can be found. Isc/Voc sweeps are available for both standalone and inline units. If enabled, Isc and Voc will be measured every second. This allows for irradiance readings every second.

If the estimated IV curves setting is enabled, data from mini sweeps will be used to estimate the complete IV curve using the mini sweep data together with the previous full sweep. Full sweeps must be enabled and mini sweeps must be set to Pmax, Isc/Voc, or Enabled for estimated IV sweeps to take effect.

When the external trigger is enabled, a Modbus write must be sent to the IV trigger register to initiate an IV sweep. This setting may only be enabled when RDE300i is configured as Solo. It is used to synchronize IV readout, so that there is no risk of reading out IV data from two separate sweeps. The setting is optional for IV readout when in Solo mode. It must be disabled when in Follower and Leader configuration.

Dropdowns will be disabled according to the current RDE300i device configuration (Solo, Follower, or Leader).

**Note:** After changing the settings, you must exit the Advanced Configuration Options dialog and press “Apply” on the System tab for the settings to take effect.



**Figure 8-8: Advanced Configuration Options**

You may click “Help” on the Advanced Configuration Options dialog for more detailed information regarding the Advanced settings, as shown in **Figure 8-9**.

Parameter	Value	Explanation
Irradiance Threshold (Leader only)	Numeric	Takes effect only when configured as Leader. Performance indices are updated every 10 minutes. If the average irradiance for those 10 minutes is greater than or equal to the irradiance threshold, performance indices will be calculated and will be included in the performance index averages. Otherwise, the performance indices will be NAN, and the performance index averages will not be updated with data from the last 10 minutes.
Rear Irradiance Uniformity Threshold (Leader only)	Numeric	Takes effect only when configured as Leader and two rear-facing RC22s are present on the Aux line. If: U = Rear Irradiance Uniformity Threshold A = RC22 Rear East Irradiance B = RC22 Rear West Irradiance Data are only used in Performance Index calculation when: $ A-B /(A+B)*100 \leq U$ .
Full Sweeps	Enabled	Perform a full IV sweep every 60 seconds.
	Disabled	Do not perform full IV sweeps.
Mini Sweeps	Pmax	Sweep the Pmax region every 10 seconds. Only choose this when the unit is inline with a string. This feature is not available on standalone PV modules.
	Isc/Voc	Measure Isc and Voc once every 1 second.
	Enabled	Perform both Pmax and Isc/Voc mini sweeps.
	Disabled	Do not perform mini sweeps
Estimated IV Curves	Enabled	Use mini sweep data to calculate estimated full sweeps for every mini sweep. For this setting to have effect, Full Sweeps must be Enabled and Mini Sweeps must be Pmax, Isc / Voc, or Enabled.
	Disabled	Do not calculate estimated full sweeps. Only report measured sweeps.
External Trigger	Disabled	Perform sweeps automatically. This is recommended for most users
	Enabled	Only can be enabled if in Solo mode. Wait for external Modbus commands to perform sweeps. This is only recommended to synchronize user readout of IV sweep data and is only available in Solo mode.

**Figure 8-9: Advanced settings help screen**

Some popular applications for RDE300i are soiling, irradiance, and IV curve measurement. For these applications, we recommend using settings as shown in the table below shown in **Figure 8-10**.

Option Name	Soiling	Irradiance	IV
Irradiance Threshold (Leader only, Solo/Follower: N/A)	500	500	500
Rear Irradiance Uniformity Threshold (Leader only, Solo/Follower: N/A)	20	20	20
Full Sweeps	Enabled	Enabled	Enabled
Mini Sweeps	Enabled	Isc/Voc	Disabled
Estimated IV Curves	Enabled	Enabled	Disabled
External Trigger	Disabled	Disabled	Solo: Optional  Leader/Follower: Disabled

**Figure 8-10: Recommended Advanced settings for soiling, irradiance, and IV**

## 8.8 Setting Module Parameters

RDE300i™ needs calibration data on its connected Module to calculate performance metrics.

Calibration parameters include the Module’s short-circuit current (Isc) and maximum power (Pmax) at reference conditions of irradiance and temperature. Typically reference irradiance and temperature are Standard Test Conditions (STC) of 1000 W/m<sup>2</sup> and 25 °C, but other conditions may be used. Isc and Pmax temperature coefficients must also be provided.

Use the Module tab to set these values, as shown in **Figure 8-11**. Enter the module parameters and press Apply.

You may use datasheet information for the Module parameters or enter these parameters from a calibration report, if available.

---

**Note:** For irradiance measurement using reference modules, module parameters must be calibrated to a traceable irradiance reference. Contact Atonometrics for details.

**Note:** For soiling, bifacial gain, or degradation tracking applications where module relative performance is compared to an initial value, you may calibrate each module to normalize Performance Index measurements during initial setup. Refer to the relevant [Configuration and Normalization Guide](#) (880096-01 or 880096-02) for directions or contact Atonometrics.

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RDE300i Configuration Manager - Version 6474

**RDE300i**  
PV Module Measurement

ATONOMETRICS

Connection Communication System **Module** Outputs Support

Module Calibration

Parameter	Value
Irradiance Ref (W/m <sup>2</sup> )	1000.000000
Temp Ref (°C)	25.000000
Pmax Ref (W)	600.000000
Isc Ref (A)	16.000000
Voc Ref (V)	45.000000
Imp Ref (A)	15.000000
Vmp Ref (V)	40.000000
Pmax Temperature Coefficient (%/°C)	-0.500000
Isc Temperature Coefficient (%/°C)	0.050000

Refresh Save Help

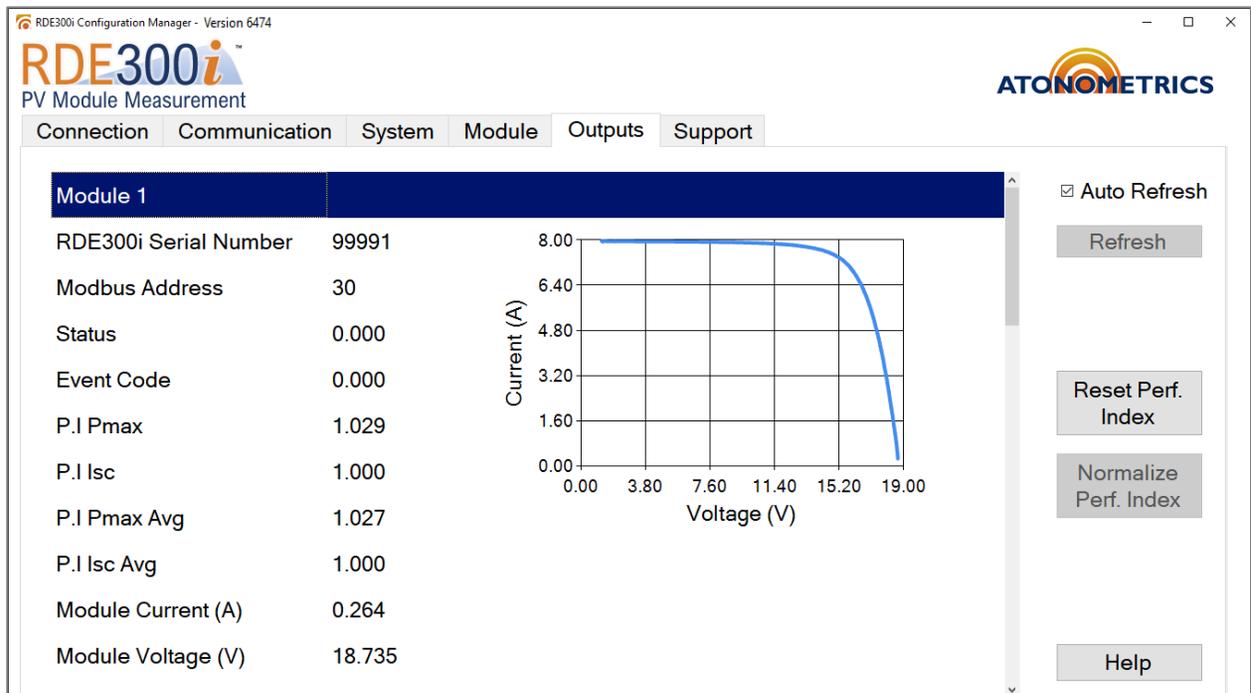
**Figure 8-11: Setting Module parameters**

## 8.9 Checking Output Data and IV Curves

Use the Outputs tab to check the measurement results from your system, as shown in **Figure 8-12**. The tab displays the most recently measured IV curve and the most recent readings of all the measured and calculated parameters, including Pmax, Isc, module voltages and currents, string data, performance indices, and more. Scroll through the tab to examine all the parameters.

For a Leader unit, the Leader's data are displayed as Module 1, Followers' data are displayed below that as Module 2, etc, and outputs of Mars™ and/or RC22™, if used, are displayed below that.

All the data displayed on the Outputs tab are available for data acquisition via the Modbus interface.



**Figure 8-12: Output Data and IV Curves**

## 8.10 Normalizing the Performance Index

When performing applications comparing modules to reference values for soiling measurement, bifacial gain, and other similar applications, you must initially calibrate modules against reference values to normalize Performance Index. You will use the Reset Perf. Index and Normalize Perf. Index buttons shown in **Figure 8-12**. Follow the detailed configuration and normalization instructions found in the relevant [Configuration and Normalization Guide](#) (880096-01 or 880096-02).

## 8.11 Support

To check for RDE300i™ Configuration Manager or RDE300i Firmware updates, use the software updates Check button on the Support tab, shown in **Figure 8-13**, or visit the [RDE300i Software Updates](#) page.

If new software is available, follow the installation instructions on the [RDE300i Software Updates](#) page. For more details on updating firmware, follow the instructions in the [Firmware Update Guide](#).

The Event Code Queue is useful to the Atonometrics support team for diagnosing issues with RDE300i. Press the View button to observe the real-time event code queue shown in **Figure 8-14**. Press the Pause button on the Event Code Queue screen to freeze the currently displayed event codes. Event codes are displayed with respect to time from newest (position 1) to oldest (position 60).

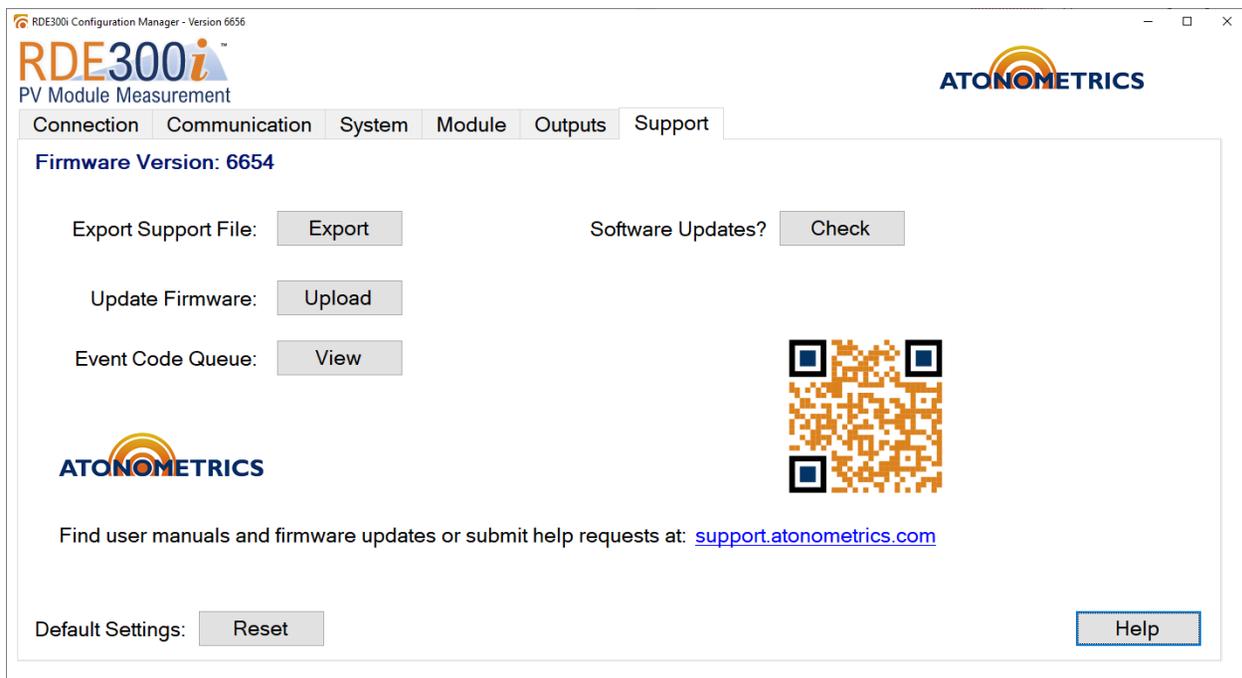
To reset the RDE300i to factory default settings, click the Default Settings “Reset” button.

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**Note:** If internet is available, the software updates Check button will determine if there is newer RDE300i software available. Otherwise, it will display a QR code that may be scanned with a cell phone to obtain RDE300i software versioning information.

**Note:** As shown below, the Support tab also provides convenient links to the Atonometrics support website for obtaining product documentation. In addition, it allows you to export device information to send to Atonometrics.

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**Figure 8-13: Support tab**

Help - □ ×

## ATONOMETRICS

### Real-time Event Code Queue

Position	1	2	3	4	5	6	7	8	9	10
<b>1-10</b>	100	100	100	100	100	100	100	100	100	100
<b>11-20</b>	100	100	100	100	100	100	100	100	100	100
<b>21-30</b>	100	100	100	100	100	100	100	100	100	100
<b>31-40</b>	100	100	100	100	100	100	100	100	100	100
<b>41-50</b>	100	100	100	100	100	100	100	100	100	100
<b>51-60</b>	100	100	100	100	100	100	100	100	100	100

### Event Code Legend

Event Code	Description
0	Normal
1	Check device power
2	Hardware error
3	Check RTD
4	Check Aux devices
5	High module current/voltage
6	High string current/voltage
7	Sweep timeout

[support.atonometrics.com](http://support.atonometrics.com)

**Figure 8-14: Real-time Event Code Queue**

# 9 Modbus Registers

RDE300i™ supplies data outputs using Modbus RTU protocol. For detailed information on Modbus protocols, please reference the specifications published by Modbus.org.

All parameters are returned as single-precision 32-bit floating point per IEEE 754, requiring four bytes. Modbus defines a register as a two-byte value. Therefore, each parameter occupies two successive registers. Bytes are returned big-endian: bytes *ABCD* are ordered from most to least significant, and the first register in a pair returns bytes *AB* while the second returns *CD*.

**Note:** On some user data acquisition devices, it is necessary to add 1 to all the register values shown in **Table 9-1** and **Table 9-2**.

**Note:** Recommended rates: scan period  $\geq 1$  s, timeout  $\geq 500$  ms, delay between polls  $\geq 30$  ms.

**Table 9-1** lists the main registers available for your client software to read data from the RDE300i. Available output registers depend on Device Configuration. (See Section 3.) Units in Leader mode will supply data for Followers and additional devices beginning at register 2001 as listed below.

**Table 9-1: Modbus registers for main outputs**

Parameter	Reg. Start	Count	Data Type	Units	Notes
<b>Solo or Leader</b>					
Status	1001	2	Float		0 = Normal 1 = Warning 2 = Error
Event Code	1003	2	Float		Warning and error event codes
<i>Reserved</i>	1005	2	Float		Reserved for future use
Performance Index Pmax (Use when paired with RC22(s))	1007	2	Float		Performance index (e.g. soiling ratio, bifacial gain, etc.) for Pmax during previous 10-minute interval.
Performance Index Isc (Use when paired with RC22(s))	1009	2	Float		Performance index (e.g. soiling ratio, bifacial gain, etc.) for Isc during previous 10-minute interval.
Performance Index Pmax Avg (Use when paired with RC22(s))	1011	2	Float		Performance index (e.g. soiling ratio, bifacial gain, etc.) average for Pmax during previous 24-hr interval.
Performance Index Isc Avg (Use when paired with RC22(s))	1013	2	Float		Performance index (e.g. soiling ratio, bifacial gain, etc.) average for Isc during previous 24-hr interval.
Module Current	1015	2	Float	A	
Module Voltage	1017	2	Float	V	

Parameter	Reg. Start	Count	Data Type	Units	Notes
Output Current	1019	2	Float	A	Output current from RDE300i to string. Typically equals module current.
Output Voltage	1021	2	Float	V	Output voltage from RDE300i to string. Typically equals module voltage.
Module Temperature	1023	2	Float	°C	Module temperature using selected temperature mode, either RTD or Voc. Used in performance calculations.
Module RTD Temperature	1025	2	Float	°C	Module temperature using the RTD
<i>Reserved</i>	1027	2	Float		Reserved for future use
<i>Reserved</i>	1029	2	Float		Reserved for future use
Module Pmax	1031	2	Float	W	
Module Imp	1033	2	Float	A	
Module Vmp	1035	2	Float	V	
Module Isc	1037	2	Float	A	
Module Voc	1039	2	Float	V	
Module Irradiance	1041	2	Float	W/m <sup>2</sup>	Effective irradiance from Module Isc
Front Irradiance Uncorrected	1043	2	Float	W/m <sup>2</sup>	Front irradiance from RC22, if used
Front Irradiance Corrected	1045	2	Float	W/m <sup>2</sup>	Front irradiance from RC22, if used, corrected by Mars transmission loss, if used
Rear Irradiance	1047	2	Float	W/m <sup>2</sup>	Average of two rear-facing RC22's, if used, multiplied by pmax bifaciality
<i>Reserved</i>	1049	2	Float		Reserved for future use
Total Effective Irradiance	1051	2	Float	W/m <sup>2</sup>	Effective irradiance from Module Isc or Aux Network Devices depending on configuration
<b>RDE300i Follower 1 Data read from Leader</b>					
Status	2001	2	Float		0 = Normal 1 = Warning 2 = Error
Event Code	2003	2	Float		Warning and error event codes
<i>Reserved</i>	2005	2	Float		Reserved for future use
Performance Index Pmax (Use when paired with 2 <sup>nd</sup> module)	2007	2	Float		Performance index (e.g. soiling ratio, bifacial gain, etc.) for Pmax during previous 10-minute interval.

Parameter	Reg. Start	Count	Data Type	Units	Notes
Performance Index Isc (Use when paired with 2 <sup>nd</sup> module)	2009	2	Float		Performance index (e.g. soiling ratio, bifacial gain, etc.) for Isc during previous 10-minute interval.
Performance Index Pmax Avg (Use when paired with 2 <sup>nd</sup> module)	2011	2	Float		Performance index (e.g. soiling ratio, bifacial gain, etc.) average for Pmax during previous 24-hr interval.
Performance Index Isc Avg (Use when paired with 2 <sup>nd</sup> module)	2013	2	Float		Performance index (e.g. soiling ratio, bifacial gain, etc.) average for Isc during previous 24-hr interval.
Module Current	2015	2	Float	A	
Module Voltage	2017	2	Float	V	
Output Current	2019	2	Float	A	Output current from RDE300i to string. Typically equals module current and string current.
Output Voltage	2021	2	Float	V	Output voltage from RDE300i to string. Typically equals module voltage.
Module Temperature	2023	2	Float	°C	Module temperature using selected temperature mode, either RTD or Voc. Used in performance calculations.
Module RTD Temperature	2025	2	Float	°C	Module temperature using the RTD
<i>Reserved</i>	2029	2	Float		Reserved for future use
Module Pmax	2031	2	Float	W	
Module Imp	2033	2	Float	A	
Module Vmp	2035	2	Float	V	
Module Isc	2037	2	Float	A	
Module Voc	2039	2	Float	V	
Module Irradiance	2041	2	Float	W/m <sup>2</sup>	Effective irradiance from Module Isc
<b>RDE300i Follower 2 Data read from Leader – Add 1000 to corresponding Follower 1 registers</b>					
<b>RDE300i Follower 3 Data read from Leader – Add 2000 to corresponding Follower 1 registers</b>					
<b>RDE300i Follower 4 Data read from Leader – Add 3000 to corresponding Follower 1 registers</b>					
<b>Mars Data read from Leader</b>					
Transmission Loss	10001	2	Float	W/m <sup>2</sup>	Soiling Loss obtained from Mars
<b>RC22 Data read from Leader</b>					
RC22 Front Irradiance	12001	2	Float	W/m <sup>2</sup>	Front Irradiance obtained from front-facing RC22

Parameter	Reg. Start	Count	Data Type	Units	Notes
RC22 Rear East Irradiance	13001	2	Float	W/m <sup>2</sup>	Rear Irradiance obtained from eastern rear-facing RC22 (bifacial application)
RC22 Rear West Irradiance	14001	2	Float	W/m <sup>2</sup>	Rear Irradiance obtained from western rear-facing RC22 (bifacial application)

**Table 9-2** lists registers for reading IV curve data points.

Readout of IV curve data points is only available for units configured in Solo and Leader mode. Set Device Configuration to Solo or Leader in RDE300i Configuration Manager. IV curve readout is not available in Follower mode.

When RDE300i is configured as Solo, you may externally trigger IV sweeps to ensure that sweeps are not performed during your readout communication requests, but triggering is not required. The external trigger should be disabled in the Leader configuration. Use the Advanced settings in the System tab of RDE300i Configuration Manager to set RDE300i to Trigger mode and send trigger commands from your data logger or SCADA system as listed below.

**Table 9-2: Modbus registers for reading IV curve data in Solo or Leader configuration**

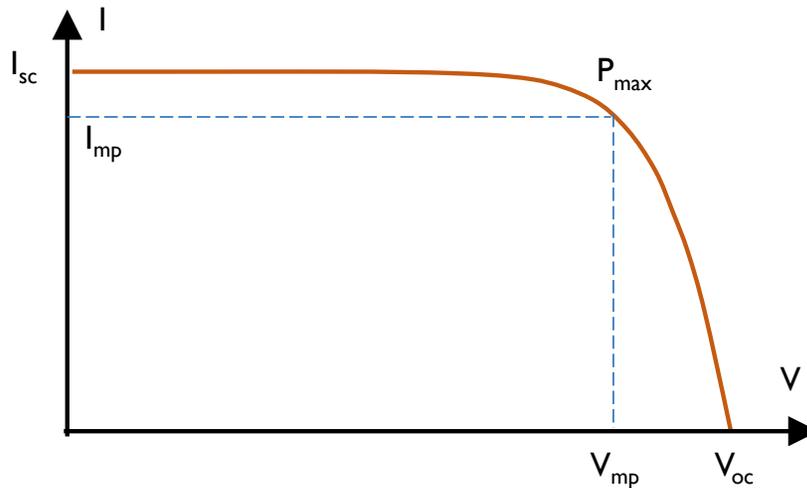
Parameter	Register		Data Type	Units	Notes
	Start	Count			
<b>Trigger (Solo only)</b>					
Trigger IV	101	2	Float		Write to trigger IV sweep, write a value of 1.00. Use with Solo configuration only.
<b>IV Curve (Solo and Leader only)</b>					
IV Curve Voltages	1123	200	Float	V	100 voltages of IV curve
IV Curve Currents	1323	200	Float	A	100 currents of IV curve

---

# 10 Theory of Operation

## 10.1 Measuring IV Curves

**Figure 10-1** illustrates a PV module IV curve and its key parameters of open-circuit voltage ( $V_{oc}$ ), short-circuit current ( $I_{sc}$ ), maximum power ( $P_{max}$ ), voltage at maximum power ( $V_{mp}$ ), and current at maximum power ( $I_{mp}$ ).



**Figure 10-1: PV Module IV curves and key parameters**

**Figure 10-2** illustrates how RDE300i™ measures IV curves on PV modules.

During normal operation, the Module connected to RDE300i is electrically connected to the rest of the string, if present. During this time the module current and voltage simply pass through the RDE300i.

Periodically RDE300i performs a rapid full-sweep IV curve measurement, in which its internal IV circuitry causes the module to sweep across its IV curve between open circuit and short circuit. During this time, the string current may bypass the Module through an included bypass circuit, so that string operation is never interrupted.

In Pmax mini-sweep mode (patent pending), the RDE300i can take IV sweeps while the module is continuously maintained near the string current, resulting in minimal change in string voltage during the sweep. In I<sub>sc</sub>/V<sub>oc</sub> mini-sweep mode (patent pending), the RDE300i can rapidly determine I<sub>sc</sub> and V<sub>oc</sub> and estimate Pmax.

By default, full IV sweeps are performed once per minute, Pmax mini sweeps are performed every 10 seconds, and I<sub>sc</sub>/V<sub>oc</sub> mini-sweeps are performed every 1 seconds.

Full sweeps, Pmax mini-sweeps, and I<sub>sc</sub>/V<sub>oc</sub> mini-sweeps can be individually enabled and disabled using the Advanced settings in the System tab.

In between IV sweeps RDE300i continuously measures the Module voltage and current and its output current and voltage delivered to the string connections, as well as the Module's temperature.

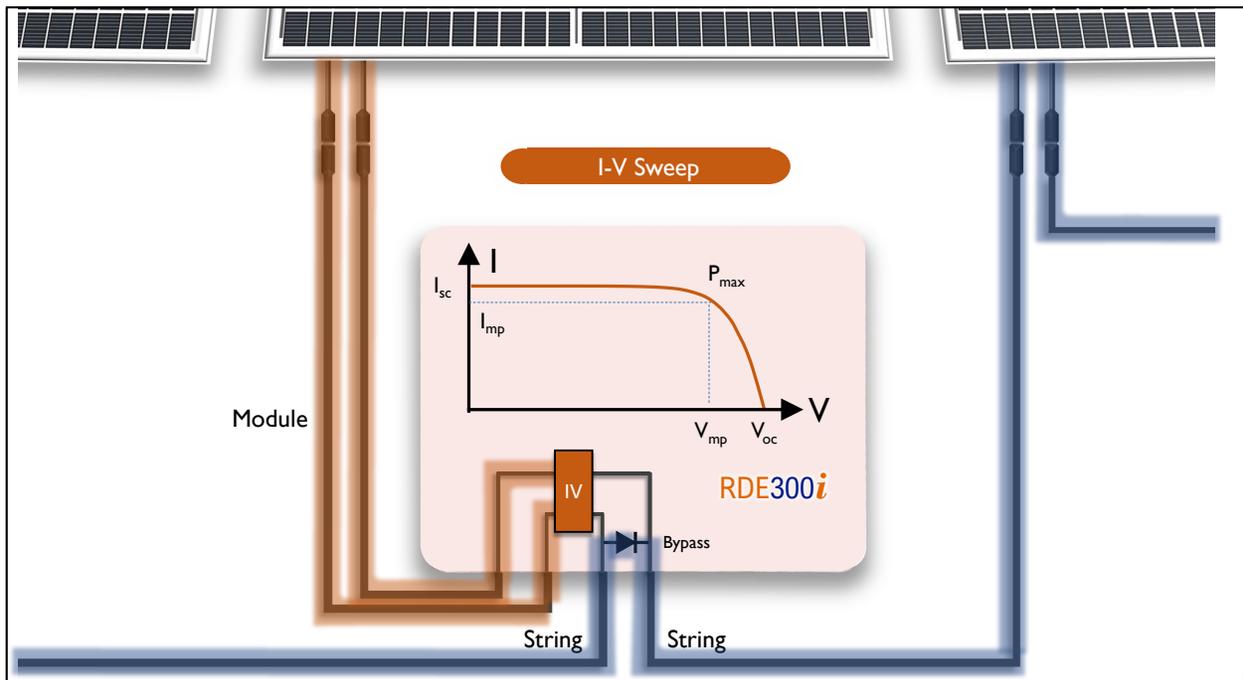
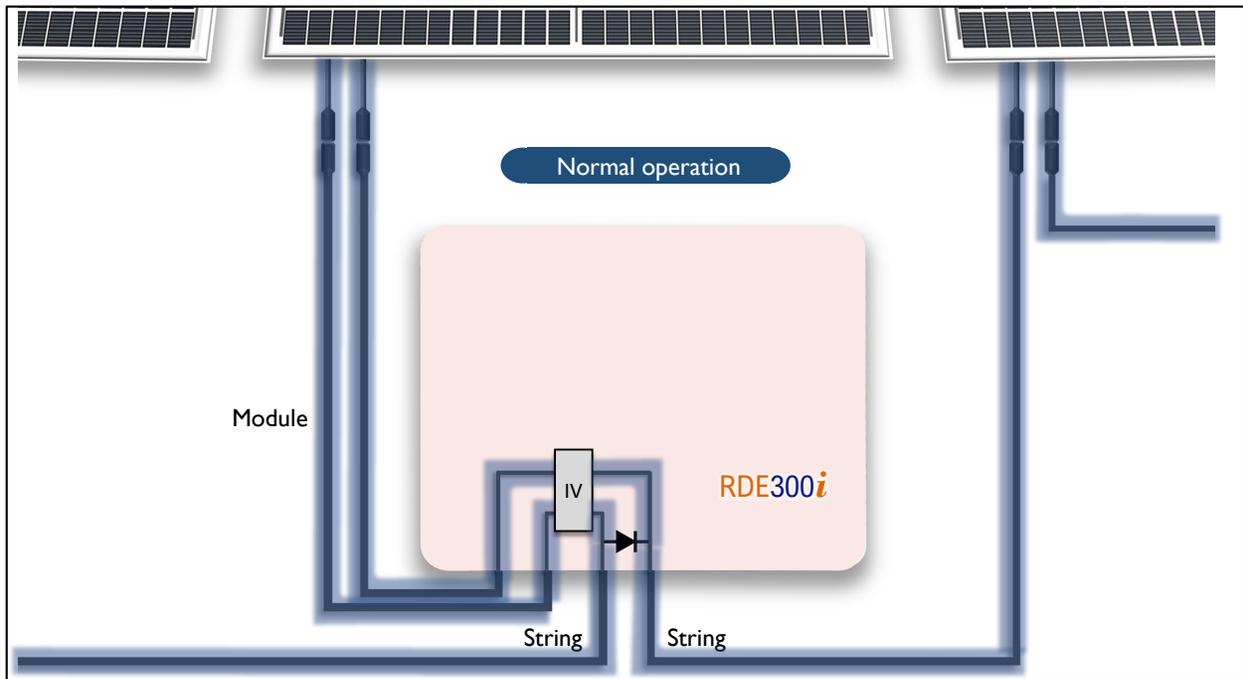


Figure 10-2: IV measurement by RDE300i

## 10.2 Applications

### 10.2.1 Irradiance Measurement

RDE300i™ can measure effective irradiance from monofacial or bifacial reference modules.

The temperature-corrected short-circuit current of a clean PV device is proportional to irradiance. After measuring the Module short-circuit current and temperature, RDE300i determines irradiance using the following equation:

$$Irr = Irr_{ref} \cdot \frac{I_{sc} \cdot (1 - \alpha \cdot (T - T_{ref}))}{I_{sc,ref}} \quad (1)$$

Here  $I_{sc}$  is the measured short-circuit current and  $T$  is the measured Module temperature. The other terms are constants for the device:  $I_{sc,ref}$  is the known short-circuit current at a reference condition (e.g. STC),  $T_{ref}$  is the temperature at the reference condition (e.g. 25 °C),  $Irr_{ref}$  is the reference condition irradiance (e.g. 1000 W/m<sup>2</sup>), and  $\alpha$  is the temperature-coefficient of short-circuit current. These constants for each connected Module are programmed into the RDE300i. See Section 8.7.

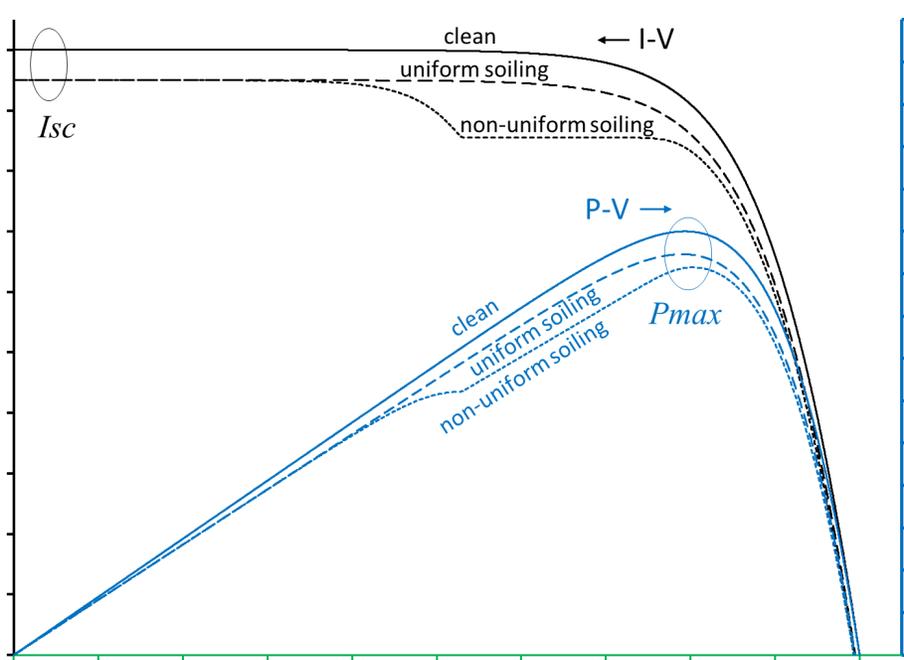
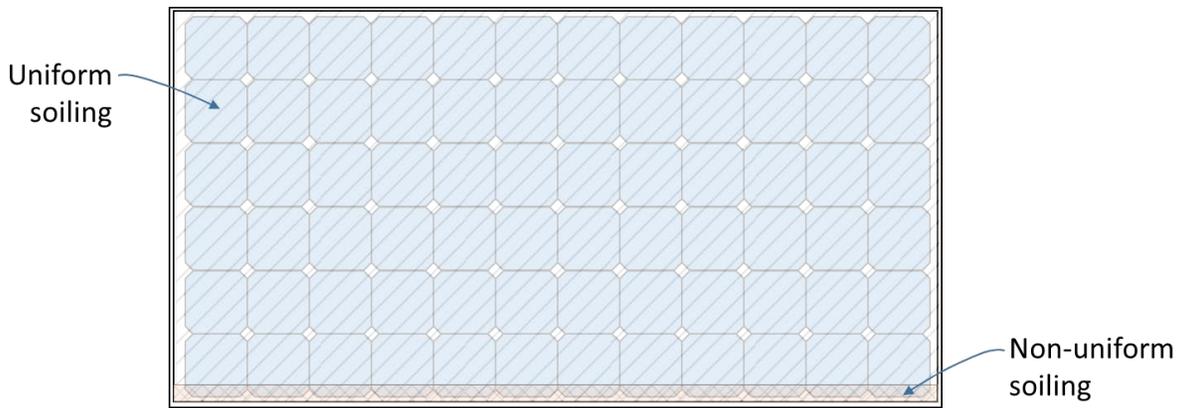
**For accurate irradiance measurements, the Module parameters must be calibrated using a traceable reference. Contact Atonometrics for details.**

### 10.2.2 Soiling Measurement

Soiling is the accumulation of dust, dirt, and other contaminants on the surfaces of PV modules, causing reduction of PV module output current and power.

**Figure 10-3** illustrates how soiling affects PV module output. Consider a 72-cell crystalline silicon PV module as shown in the upper part of **Figure 10-3**. When the module is clean, it produces the I-V and P-V curves shown by the solid lines in the graph in the lower part of the figure. If the module is uniformly soiled (as shown by the diagonal hatch marks across the entire module) to a level blocking 5% of the incident light, the short-circuit current,  $I_{sc}$ , and maximum power,  $P_{max}$ , each decrease by ~5%, as shown by the dashed lines in the graph. However, if in addition the module has non-uniform soiling consisting of a dirty strip across the bottom edge shading 10% of the bottom row of cells, as shown by the cross-hatched pattern on the diagram, the effect on the I-V and P-V curves is more complex, as shown by the dotted lines in the graph. The  $I_{sc}$  is not affected at all in this example, while the  $P_{max}$  is reduced by ~8.5% from the clean-state value. Therefore, it is important to measure the I-V curve and  $P_{max}$  value – as done by the RDE300i – to accurately measure this common type of soiling, rather than relying on short-circuit current reduction alone.

RDE300i can measure soiling losses by comparing a soiled Module on a Follower RDE300i to a clean Module on a Leader RDE300i.



**Figure 10-3: Illustration of soiled PV module and corresponding IV & PV curves**

RDE300i measures an IV curve of both the soiled (Follower) and clean (Leader) modules. It then calculates a Performance Index metric for the soiled module on the Follower, using an equation of the form:

$$PI = \frac{\text{Measured Output}}{\text{Expected Output}} \quad (2)$$

The “expected output” is the output expected if the module is free of soiling, such that the above ratio should equal 1 when the module is clean.

Note that the Performance Index is identical to the Soiling Ratio defined in IEC 61724-1 and referenced in the Atonometrics RDE300 Series products. Here we use the term Performance Index for greater generality with multiple applications, as discussed below.

RDE300i provides several  $PI$  metrics.

One metric is the  $PI^{I_{sc}}$  value, which is the ratio of the measured short-circuit current to the expected short-circuit current, calculated using the formula:

$$PI^{I_{sc}} = \frac{I_{sc}^{Follower}}{I_{sc,ref}^{Follower} \cdot (1 + \alpha \cdot (T^{Follower} - T_{ref})) \cdot (Irr/Irr_{ref})} \quad (3)$$

Here  $I_{sc}^{Follower}$  and  $T^{Follower}$  are the measured short-circuit current and temperature of the soiled module, while  $I_{sc,ref}^{Follower}$ ,  $T_{ref}$ ,  $\alpha$ , and  $Irr_{ref}$  are calibration values defined in Section 10.2.1.  $Irr$  is the irradiance determined by the RDE300i from the clean PV reference device on the Leader unit as explained in Section 10.2.1.

A second metric is the  $PI^{P_{max}}$  metric, which is the ratio of the measured power to the expected power, calculated using:

$$PI^{P_{max}} = \frac{P_{max}^{Follower}}{P_{max,ref}^{Follower} \cdot (1 + \gamma \cdot (T^{Follower} - T_{ref})) \cdot (Irr/Irr_{ref})} \quad (4)$$

Here  $P_{max}^{soiled}$  is the measured maximum power of the soiled module,  $P_{max,ref}^{soiled}$  is the module's known maximum power at the reference condition, and  $\gamma$  is the temperature-coefficient of maximum power.

$PI^{I_{sc}}$  captures uniform soiling conditions only, while  $PI^{P_{max}}$  captures both uniform and non-uniform soiling.  $PI^{P_{max}}$  is the value expected to track most closely with actual PV plant power loss due to soiling.

RDE300i calculates an instantaneous result for  $PI^{I_{sc}}$  and  $PI^{P_{max}}$ , as well as a 24-hr averaged version of these metrics. The 24-hr averaged version suppresses noise due to irradiance fluctuations and errors due to module angular alignment differences.

Calibration constants for both the Leader and Follower module may be initially entered based on module datasheets. However, an in-field calibration procedure can then be performed to normalize the Follower module data against the Leader. Contact Atonometrics for details.

### 10.2.3 Bifacial Gain Measurement

Bifacial gain measurement is conceptually similar to soiling measurement as described in Section 10.2.2. It involves comparing a Follower module to a Leader module using either of the Performance Index metrics described above.

### 10.2.4 Additional Applications

Contact Atonometrics for details on additional applications, including general system monitoring, module degradation tracking, and PV system real-time power potential measurements.

## 10.3 Clean Reference Irradiance

As discussed above, a clean irradiance reference is needed to calculate the Performance Indices. For each application, the clean reference is obtained differently. For more information about the configurations listed below, please see Atonometrics document 880100, available at [support.atonometrics.com](http://support.atonometrics.com).

### 10.3.1 Module-Module

In Module-Module applications, two or more RDE300i units are used to compare RDE300i Follower module(s) to an RDE300i Leader module.

The reference irradiance is obtained from the module to which the Leader is connected. The Leader module must be kept clean. In the Module-Module configuration, only the Follower Performance Indices are to be used for performance index analysis, since the Leader is the reference.

### 10.3.2 Module-Cell

In Module-Cell applications, an RC22 reference cells are used together with the RDE300i to provide the clean irradiance reference.

The reference irradiance is obtained from the RC22 units. The RC22 units must be kept clean. In the Module-Cell configuration, the Leader Performance Index may be used, since the Leader is not a reference.

### 10.3.3 Module-Cell-Optical

In the Module-Cell-Optical configuration, a Mars soiling sensor is used together with the RC22 to compensate the RC22 for any irradiance loss due to soiling.

This configuration functions similarly to the Module-Cell configuration, except the reference irradiance is obtained from the RC22 with the soiling compensation from Mars.

# 11 Specifications

**Table 11-1: Specifications**

<b>Models</b>	810275-01, Inline	Includes String Input
	810275-02, Standalone	No String Input
<b>Power</b>	Input Voltage	10-30 VDC
	Power Consumption	1.5 W (without AUX devices)
<b>Environmental</b>	Operating Temperature	-40 °C to 65 °C
<b>PV Measurement</b>	Module Voltage	0-250 VDC
	Module Current	0-30 ADC
	Module Power	0-1500 W (Inline), 0-1200 W (Standalone)
	Current Accuracy	<0.3% @ 5-30 A, 0.5% @ 1 A
	Voltage Accuracy	<0.3% @ 20-250 V, 0.5% @ 5 V
<b>PV Cables</b>	PV, Module Cables	MC4, 10 AWG (6 mm <sup>2</sup> )
	PV, String Cables	MC4, 10 AWG (6 mm <sup>2</sup> )
<b>Array Wiring</b>	Isolation	1500 VDC
<b>RTD</b>	Module RTD Probe	Pt1000, 3-wire, self-adhesive disc, 3m cable
	Accuracy	IEC 60751 Class A
<b>Power/Comm</b>	Main/AUX Cables	Shielded M12, 5-pin (Power, Ground, RS485A/B)
		Length options 4m, 10m, 25m 50m, 100m
<b>Communication</b>	Physical Layer	RS485
	Protocol	Modbus RTU
	Baud Rates	9600, 19200, 38400, 57600
	Data Formats	8N1, 8N2, 8E1, and 8O1
	Time Between IV Measurements	>=1 second
<b>Enclosure</b>	Material	Fiberglass
	Ingress Protection	IP66
<b>Dimensions</b>	Dimensions	9.31" x 7.31" x 4.92" (236 mm x 186 mm x 125 mm)
<b>Standards</b>	Measurement	IEC 61724-1 Class A