



# DustVue 20

Solar-Module Soiling Sensor  
with a Full-Size PV Module



# Please read first

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## About this manual

Please note that this manual was produced by Campbell Scientific Inc. primarily for the North American market. Some spellings, weights and measures may reflect this. In addition, while most of the information in the manual is correct for all countries, certain information is specific to the North American market and so may not be applicable to Europe, Middle East, and Africa (EMEA) or Asia Pacific (APAC) users. Differences include the U.S. standard external power supply details where some information (for example the AC transformer input voltage) will not be applicable for EMEA or APAC use. Please note, however, *that when a power supply adapter is ordered from Campbell Scientific it will be suitable for use in your country.*

Reference to some radio transmitters, digital cell phones and aerials (antennas) may also not be applicable according to your locality. Some brackets, shields and enclosure options, including wiring, are not sold as standard items in the EMEA or APAC market; in some cases alternatives are offered.

## Recycling information for countries subject to WEEE regulations 2012/19/EU



At the end of this product's life it should not be put in commercial or domestic refuse but sent for recycling. Any batteries contained within the product or used during the product's life should be removed from the product and sent to an appropriate recycling facility, per [The Waste Electrical and Electronic Equipment \(WEEE\) Regulations 2012/19/EU](#). Campbell Scientific can advise on the recycling of the equipment and in some cases arrange collection and the correct disposal of it, although charges may apply for some items or territories. For further support, please contact Campbell Scientific, or your local agent.

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# 1. Introduction

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## NOTE:

An online version of this manual is available at [help.campbellsci.com/dustvue20/home.htm](http://help.campbellsci.com/dustvue20/home.htm) .

The DustVue™20, paired with a PV module, provides a soiling measurement designed to quantify photovoltaic (PV) power losses caused by the accumulation of dust and other contaminants on the paired PV module, representing PV modules in the surrounding area. The system uses a measurement methodology consistent with IEC 61724-1 to provide representative and reliable soiling data for solar PV power plants.

The DustVue 20 measures the complete current-voltage (I-V) characteristic of a full-size PV module supplied by the end user. This module serves as the soiled reference module and is installed so that it is exposed to the same environmental conditions as the PV modules within the plant, allowing it to accumulate soiling naturally. By measuring the full I-V curve, the DustVue 20 determines the maximum power available from the soiled reference module under prevailing operating conditions, in addition to a soiling ratio using the short-circuit current of the PV devices.

A clean reference cell measures irradiance to estimate the module's expected clean power under the same conditions. Comparing this estimate with the soiled module's measured power determines the soiling ratio and associated power loss.

This measurement approach enables the DustVue 20 to provide accurate, module-representative soiling measurements while maintaining a simple and user-friendly installation. Actual soiling losses are highly site-dependent and can be influenced by factors such as ambient temperature, humidity, precipitation, wind patterns, surrounding soil type and composition, agricultural or industrial activity, and other local environmental conditions. The chemical and physical characteristics of deposited particles, together with the spectral response of the PV cell technology, can also significantly affect soiling-related power losses.

The DustVue 20 is an industrial-grade digital sensor designed for reliable operation in utility-scale and commercial PV installations. Measurement data are available through the Modbus RTU protocol over an RS-485 interface, allowing straightforward integration with plant monitoring and data acquisition systems. The power and communication interfaces incorporate industrial Class 4 surge protection, providing enhanced protection against electrical transients and supporting continuous, reliable operation under the demanding environmental and electrical conditions commonly encountered at solar PV sites.

## 2. Precautions

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- READ AND UNDERSTAND the [Safety](#) section at the back of this manual.
- Before mounting, the installers should read the sensor manual and quick deploy guide thoroughly.
- The sensor can be configured using USB power only but is fully operational only with 12 to 32 VDC (24W or higher) applied through the M12-5 pin connector. Do NOT power the DustVue 20 using a Campbell Scientific data logger 12V port, an independent and appropriate power supply is required.
- Placement of the cable inside a rugged conduit is advisable for cable runs over 4.5 m (15 ft), especially in locations subject to digging, mowing, traffic, power tools, animals, or lightning strikes.
- The DustVue 20 should be installed in the same plane as the array of PV modules when used as a part of the operational performance monitoring station.
- The reference cells used do not have absolute radiometric calibration and hence the irradiance values will not match with other irradiance sensors at the site.
- These values are relative to each other and should be used as such.
- In-field calibration (offset correction) should be performed on a clear sky day during the offsets update period ( $\pm 1$  hr before and after solar noon). For most locations, this will need to be done at least four times per year.

## 3. Initial inspection

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- Upon receipt of the DustVue 20, inspect the packaging and contents for damage. File damage claims with the shipping company.
- The shipping package will contain the following items:
  - MC 4 connectors, 2 pcs
  - Back of module temperature sensor (CS241-QD)
  - Alcohol pad for wiping the module back sheet (see [Attach the BOM sensor to the solar module](#) [p. 37]).

- The DustVue 20 is ordered as a stand-alone sensor; cable and mounting hardware are purchased separately. See common accessories here: [www.campbellsci.com/products/dustvue20](http://www.campbellsci.com/products/dustvue20) .

## 4. QuickStart

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Figure 4-1 (p. 3) shows the key components of the sensor.

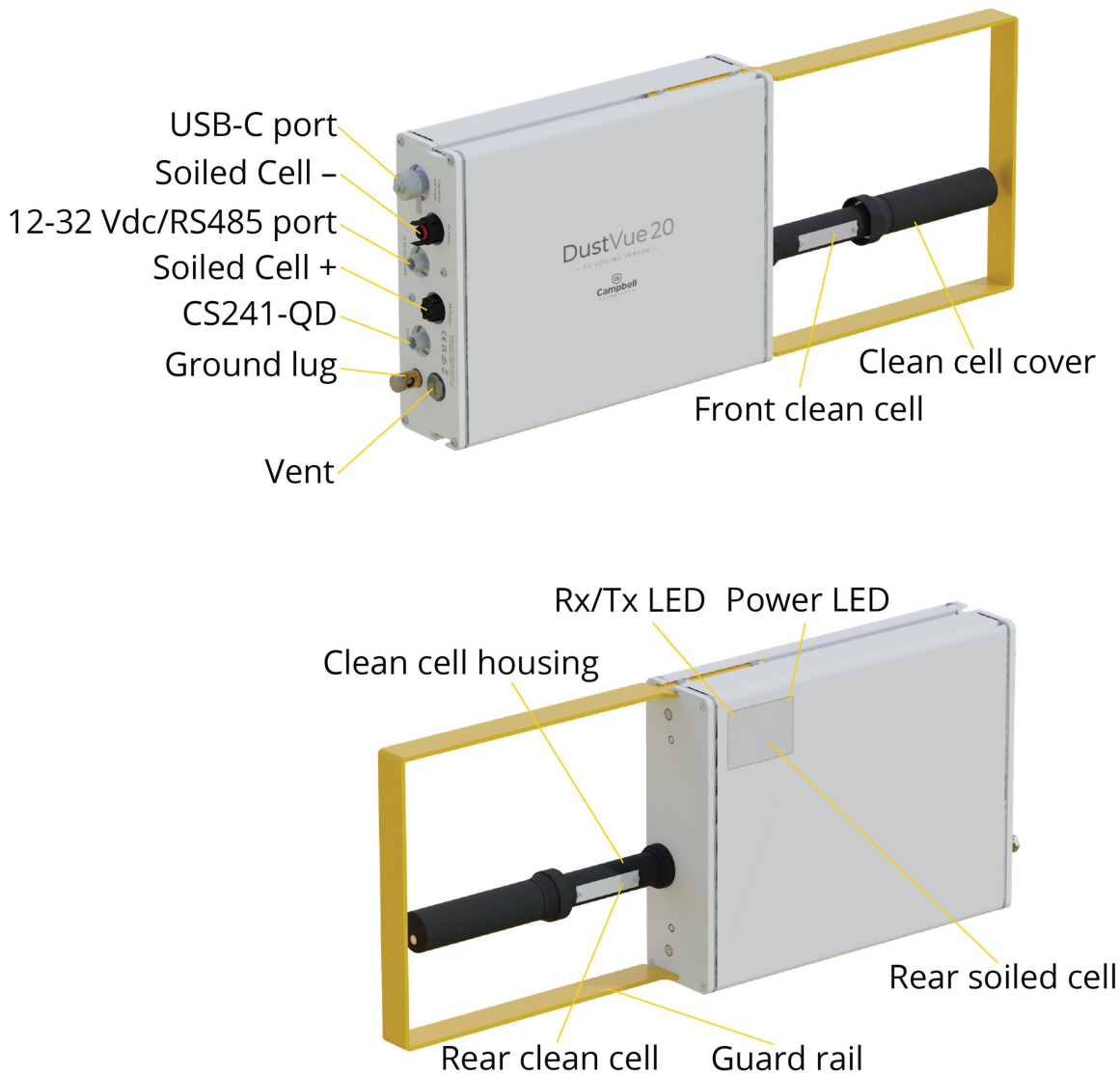


Figure 4-1. DustVue 20 components

1. **Connect** the DustVue 20 to a computer using a USB-C cable (not included). Charging-only USB cables cannot be used for communication with the device.
2. **Open a web browser** and in the address bar type [www.dustvue.linktodevice.com](http://www.dustvue.linktodevice.com) (or 192.168.96.1) to access the web user interface (Web UI) of the sensor for easy configuration.
3. **Configuration:** On first use, navigate to the **Configuration** tab ([Figure 4-2](#) [p. 4]).

Figure 4-2. Configuration tab

- a. Enter the device **parameters** ([Figure 4-3](#) [p. 5]).
  - i. **Name:** User assigned sensor name. This will be displayed on the **Dashboard**, in the **Modbus Map**, and in data tables. It is recommended to choose a name that will clearly identify this sensor, such as the location where it is installed.
  - ii. **Latitude:** Enter the site's latitude in decimal degrees ( $\pm xx.xxxxxx$ ). This parameter is necessary for correct solar noon calculation.
  - iii. **Longitude:** Enter the site's longitude in decimal degrees ( $\pm xx.xxxxxx$ ). This parameter is necessary for correct solar noon calculation.
  - iv. **Altitude (m):** Enter the site's altitude in meters (xxxx). This parameter is necessary for correct solar noon calculation.
  - v. **UTC Offset (hrs):** Enter the UTC offset in hours ( $\pm xx$ ) for the clock value of the DustVue 20 (see Step 4a, these values need to be in agreement), typically the

standard time in the time zone of the station. This parameter is necessary for correct solar noon calculation.

## Configuration

⬇️ Apply

☰ Config Report

### Parameters

Name ⓘ  
DustVue20\_xxx

Latitude (decimal degrees) ⓘ  
41.765

Longitude (decimal degrees) ⓘ  
-111.855

Altitude (m) ⓘ  
1320

UTC Offset (hrs) ⓘ  
-7

Figure 4-3. Configuring location parameters

- b. Click the **Measurements** tab (Figure 4-4 [p. 6]) to configure the **Soiling Measurement Settings** and **Solar Panel Settings**. Click on the info icon to display information on these settings.

The screenshot shows the 'Measurements' tab selected in the configuration interface. The 'Soiling Measurement Settings' section contains three fields: 'Sampling Window (hrs)' set to '+/- 1 hours from Solar Noon', 'Sampling Interval (min)' set to '15 minutes', and 'Irradiance Threshold (W/m²)' set to '0'. The 'PV Module Settings' section contains six fields: 'Short Circuit Current (Isc) STC (A)', 'Nominal Max Power (Pmax) STC (W)', 'Temperature Coefficient (Isc) (%/°C)', 'Temperature Coefficient (Pmax) (%/°C)', 'Bifacial' (set to 'True'), and 'Power Bifaciality (Pmax\_rear / Pmax\_front) (%)' set to '0'. The first four fields show 'Invalid value' in red text. A warning message is displayed below the 'Bifacial' dropdown, stating that soiling ratio uncertainty for bifacial modules is undetermined due to dependencies on mounting, albedo, and power bifaciality tolerance.

Figure 4-4. Configuring measurement and solar module settings

- i. The **Sampling Window (hrs)**: specifies the hours of the day during which the sensor attempts to collect soiling ratio measurements. Sampling attempts are made throughout the window at the configured **Sampling Interval**. If the irradiance is stable and exceeds the configured **Irradiance Threshold**, the sensor measures and records a soiling ratio sample. The Daily Soiling Ratio is calculated from the average of all samples collected during the **Sampling Window**.

For fixed tilt installations, select  $\pm 1$  hours from solar noon. For units installed on a tracker,  $\pm 2$  hours can be selected.

- ii. The **Sampling Interval (min)**: specifies the time between attempted soiling ratio samples during the **Sampling Window**. An interval of 15 minutes is recommended.
- iii. **Irradiance Threshold (W/m<sup>2</sup>)**: Soiling ratio samples will only be taken if the measured irradiance exceeds this threshold. Use this to minimize the exposure of the clean cells to the environment. The threshold is also used to prevent the sensor from taking measurements during cloudy or rainy conditions.

**0 = Auto**: If this setting is set to 0 (the default), the sensor will automatically determine the threshold to use based on the irradiance measured during the most recent offset update. The sensor will use 40% of that irradiance value as the threshold. Keeping this value set to auto, along with periodically running an offset update at the frequency recommended in the manual allows the threshold to stay updated to a value that works with the current site conditions.

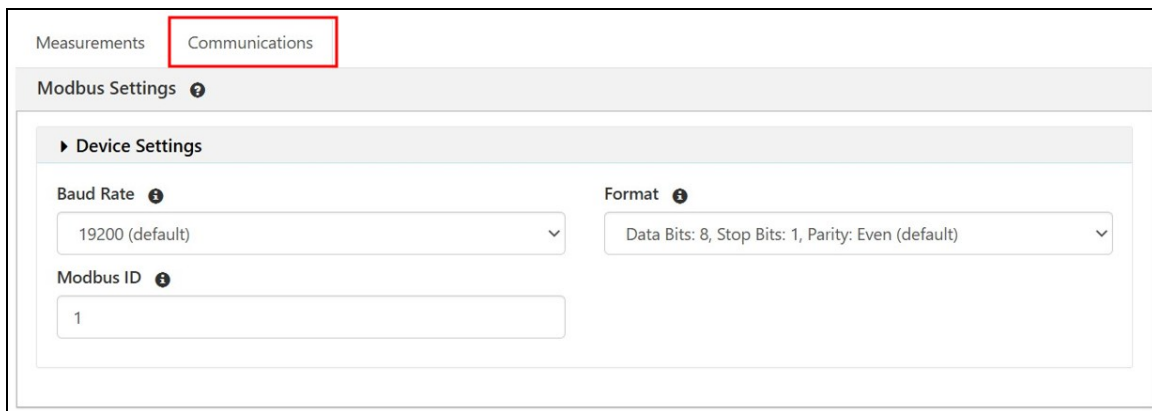
**Manual**: If the auto value does not work for your application, you can use this setting to set the threshold to something else.

**CAUTION:**

The reference cells have not been radiometrically calibrated, as this is not required for a soiling measurement. Therefore, if you are setting the threshold manually, it is important to use the irradiance value returned by the sensor under expected site conditions (on a clear day) to determine an appropriate value. 300W/m<sup>2</sup> to 500 W/m<sup>2</sup> is a good choice for most locations. The default value is 450 W/m<sup>2</sup>.

- iv. **Short Circuit Current (Isc) STC (A)**: Module short circuit current (Isc) under standard test conditions (in Amps)
- v. **Nominal Max Power (Pmax) STC (W)**: Module nominal maximum power (Pmax) under standard test conditions (in Watts)
- vi. **Temperature Coefficient (Isc) (%/°C)**: Module Temperature Coefficient (Isc) (in %/°C)
- vii. **Temperature Coefficient (Pmax) (%/°C)**: Module temperature coefficient (Pmax) under standard test conditions (in %/°C)
- viii. **Bifacial Module**: Set to true if the solar module connected to the device is bifacial. If this is set to true, the Power Bifaciality Factor must be set as well.
- ix. **Power Bifaciality factor (%)**: The bifaciality factor (in percent) of the PV module.

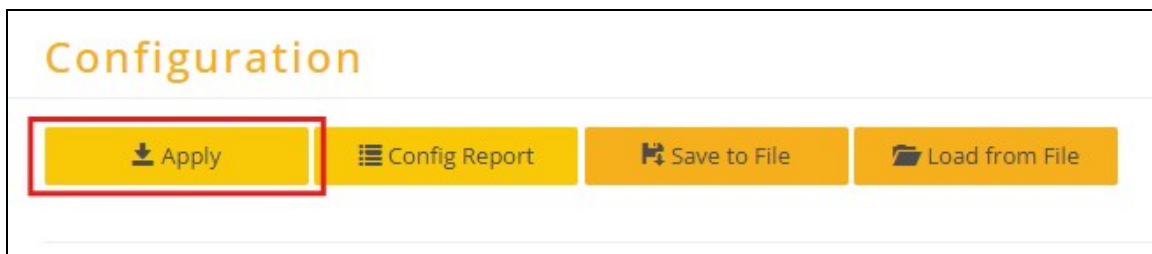
- c. Click the **Communications** tab. Make sure the settings of the sensor for the serial port are correct, and that the Modbus ID matches the Modbus address expected by the Modbus client.



The screenshot shows a web interface with two tabs at the top: "Measurements" and "Communications". The "Communications" tab is selected and highlighted with a red rectangular box. Below the tabs is a section titled "Modbus Settings" with a help icon. Under "Modbus Settings" is a sub-section titled "Device Settings". Inside "Device Settings", there are three configuration fields: "Baud Rate" with a dropdown menu showing "19200 (default)", "Format" with a dropdown menu showing "Data Bits: 8, Stop Bits: 1, Parity: Even (default)", and "Modbus ID" with a text input field containing the number "1".

*Figure 4-5. Configuring communications parameters*

- d. Click **Apply** after entering the values. The sensor will initialize after confirming your choices in the pop-up window.



The screenshot shows a web interface with a section titled "Configuration" in orange text. Below the title is a row of four yellow buttons. The first button, labeled "Apply" with a download icon, is highlighted with a red rectangular box. The other buttons are "Config Report" (with a list icon), "Save to File" (with a save icon), and "Load from File" (with a folder icon).

4. **Dashboard:** Navigate to the dashboard to see live sensor status, solar noon, sampling window, sampling interval, irradiance, and the most recent soiling ratio sample. The irradiance will update once per minute. Status messages indicate when next sample will be attempted. The soiling ratio will be NAN until a sample is taken.

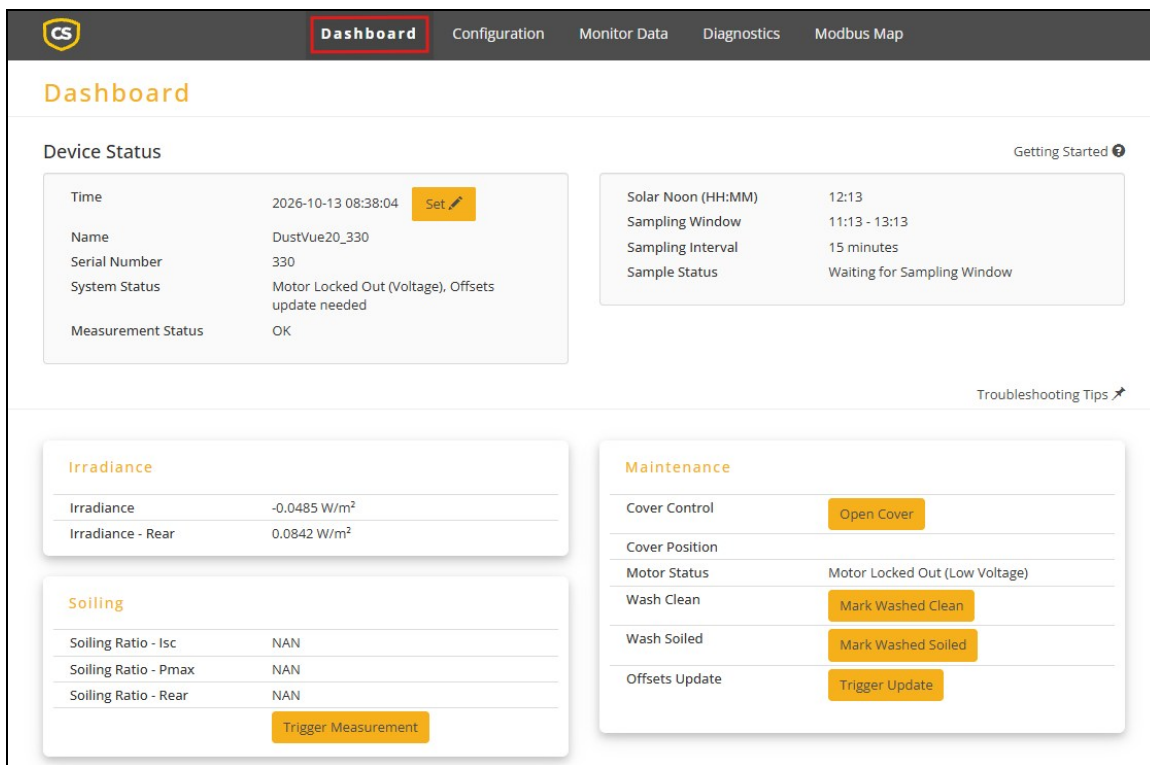


Figure 4-6. Dashboard tab displays current results and sensor status.

- a. **Time:** Set the time by clicking **Set**. Set it to local standard time. The clock can be synchronized with the computer clock or entered manually. The device time can also be set using Modbus registers 40103 to 40113 (see [Table 7-3](#) [p. 41]). We recommend programming a periodic clock set in your data acquisition or SCADA system.

**NOTE:**

Setting the device clock to the correct local time inputting the corresponding UTC offset is necessary for correct solar noon calculation and proper device operation.

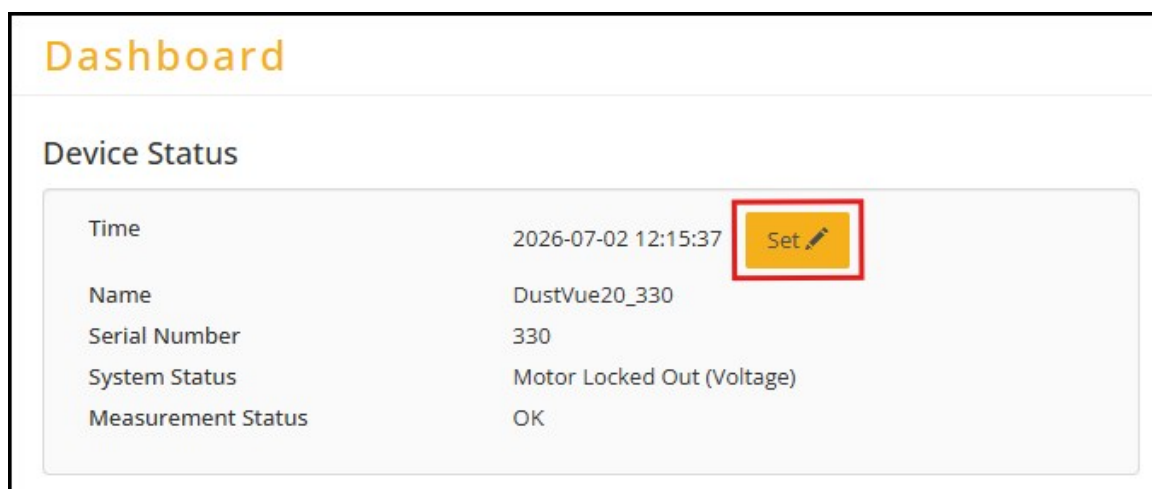


Figure 4-7. Set clock

- b. If desired, click **Trigger Measurement** under **Soiling** to force a soiling ratio measurement. The measurement will happen at the top of the minute.

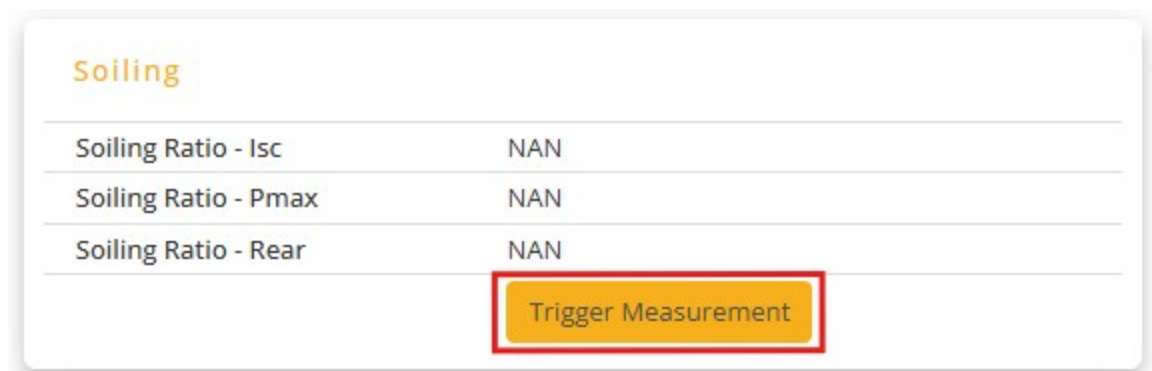


Figure 4-8. Soiling section on Dashboard tab

**NOTE:**

- **Sampling Interval:** Samples cannot occur more frequently than every 15 minutes. If triggered sooner, the system waits for the minimum interval to elapse.
- **Power:** The cover will not open if the device is powered only by USB.
- **Accuracy:** The soiling ratio will not be accurate until after an Offsets Update has been performed (See next step).

- c. **Offsets Update/Correction:** The Offsets Update calibrates the soiled module against the clean reference cell. To get accurate measurements, this update must be performed on site, after proper mounting and cleaning, when the sky is clear, and within  $\pm 1$ hr of solar noon. This self-calibration procedure should be performed throughout the year. It is needed at least four times per year.

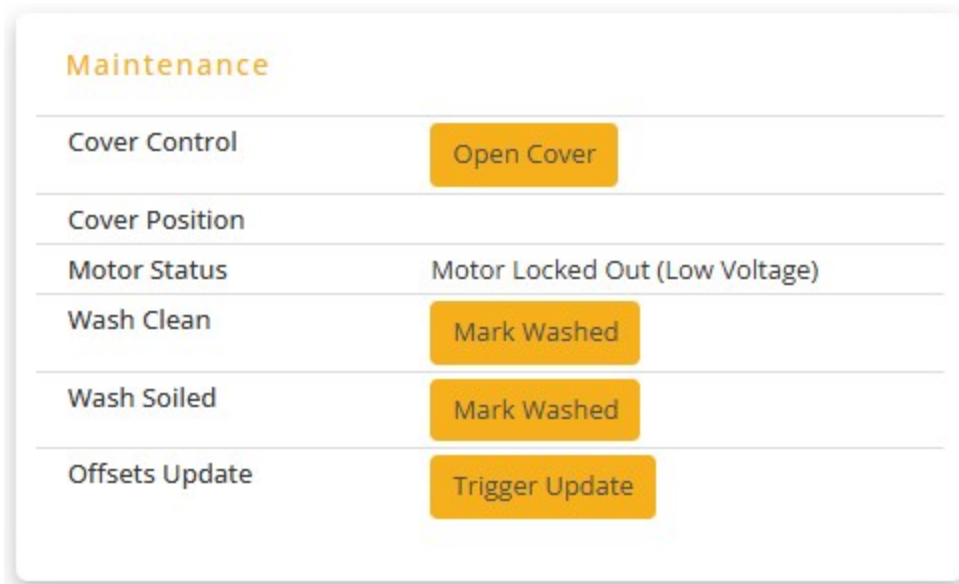


Figure 4-9. Maintenance section on the Dashboard

- i. Click **Open Cover** to expose the reference cells.
- ii. Clean the front and rear reference cells.
- iii. Click the **Cover** button again to close the cover. The cover will automatically close after 5 minutes if the button is not pressed.
- iv. Click **Wash Clean>Mark Washed**. This will log the cleaning date and time in a Modbus register.
- v. Clean the front and rear soiled cells
- vi. Click **Wash Soiled>Mark Washed**.
- vii. Click **Trigger Update** to trigger an **Offsets Update**. The **Dashboard** will indicate the Offsets Update status. If the Offsets Update is triggered outside  $\pm 1$  hour of solar noon, the sensor will wait until the next  $\pm 1$  hour period. If the irradiance threshold condition is met, the calibration will begin at the top of the minute.

The cover will open and stay open for about 1.5 minutes while the update completes. If the sensor detects instability, the cover will close and the update will be attempted again at the next minute.

5. The **Modbus Map** tab on the **web UI** displays the current Modbus map of the sensor.

| Register | Data Type | Measurement    | Signal              | Description    | Units | Minimum | Maximum |
|----------|-----------|----------------|---------------------|----------------|-------|---------|---------|
| 40005    | Str-32    | Manufacturer   | Campbell Scientific | Manufacturer   |       |         |         |
| 40021    | Str-32    | Model          | DustVue20           | Model          |       |         |         |
| 40045    | Str-16    | Version        | 1.04.04             | Version        |       |         |         |
| 40053    | Str-32    | Serial Number  | 330                 | Serial Number  |       |         |         |
| 40069    | U16       | Device Address | 1                   | Device Address |       |         |         |
| 40073    | Str-8     | Interface Name | RS-485              | Interface Name |       |         |         |

## 5. Overview

The DustVue 20 measures PV soiling losses by comparing the output of a soiled PV reference device with measurements from collocated clean PV reference cells. Two clean reference cells are housed within a dust-tight enclosure (see [Figure 4-1](#) [p. 3]). One cell faces upward to measure incident solar irradiance, while the second faces downward to measure irradiance reflected from the ground. These are referred to as the up-facing clean reference cell and the rear-facing clean reference cell, respectively.

A customer-provided, full-size PV module rated up to 700 W is physically installed alongside the modules in the PV array but is electrically isolated from the PV string. The module is exposed to the same environmental conditions as the PV array and is allowed to accumulate soiling naturally. For a monofacial PV module, the soiling ratio is determined using measurements from the soiled reference module and the up-facing clean reference cell. When a bifacial module is used, measurements from both the up-facing and rear-facing clean reference cells are incorporated into the calculation. The measurement uncertainty of the soiling ratio for bifacial modules depends on several site-specific factors and is expected to be slightly higher than the one published in this manual.

DustVue 20 also incorporates a downward-facing PV cell located on the rear of the sensor beneath a PV glass cover. The output of this cell is compared with that of the rear-facing clean reference cell to determine the rear soiling ratio, providing a measure of soiling on a downward-facing PV surface.

The **Sampling Window** and **Sampling Interval** settings define the time of day during which soiling measurements are permitted and the frequency at which measurements are performed. Short circuit current of the connected PV module is measured once per minute and is used to calculate the effective irradiance seen by it using the measured back of module (BOM) temperature. When the measured irradiance is sufficiently stable and exceeds the user-defined **Irradiance threshold** within the sampling interval, the protective cover opens to expose the clean reference cells. DustVue 20 then performs the full IV sweep and calculates maximum power point of the PV modules. The irradiance measured from the clean reference and measured BOM temperature is used to calculate the expected power from a clean PV module. A comparison of measured maximum power with expected maximum power provides the soiling ratio.

For sensors installed on single-axis trackers, clean-reference measurements are recommended within approximately  $\pm 2$  hours of solar noon. For fixed-tilt installations, measurements within approximately  $\pm 1$  hour of solar noon are recommended. Limiting the frequency and duration of clean-cell exposure reduces the potential for dust accumulation on the clean reference cells and can extend the period of operation between maintenance or cleaning events.

The soiling ratio ranges from 0 to 1, where a value of 1.0 represents no measurable loss due to soiling. For example, a soiling ratio of 0.80 corresponds to a 20% soiling loss.

DustVue 20 determines the soiling ratio using two methods described in IEC 61724-1:2021: short-circuit current ( $I_{sc}$ ) and maximum power ( $P_{max}$ ). The  $I_{sc}$  soiling ratio is determined by comparing the temperature-corrected, irradiance-equivalent response of the soiled reference module with the irradiance measured by the up-facing clean reference cell. The  $P_{max}$  soiling ratio is determined by comparing the measured maximum power of the soiled reference module with the maximum power expected from the module under equivalent clean conditions.

## 5.1 Soiling Ratio – $I_{sc}$

Effective Irradiance is calculated using the name plate parameters at STC using [Eq. 1](#) (p. 13).

$$G_{eff} = 1000 \times \frac{I_{SC,measured}}{I_{SC,STC}(1 + \alpha (T_{BOM} - 25))} \quad \text{Eq. 1}$$

Where:

$I_{sc,measured}$  is the instantaneous measured short circuit current,

$\alpha$  is the temperature coefficient of the short circuit current for the PV module used.

$I_{SC,STC}$  is the short circuit current at STC.

$T_{BOM}$  is measured back of module temperature.

A soiling ratio is calculated using the short circuit current of the PV module by comparing it with the irradiance of the clean reference using Eq. 2 (p. 14).

$$SR_{Isc} = \frac{G_{eff}}{Irrad_{clean}} \quad \text{Eq. 2}$$

Caution must be noted in interpreting these two values, as they can differ by a small percentage according to the available scientific literature on the topic. Short circuit current of a PV module is directly proportional to the irradiance seen by the cells. It is widely used as a measure of solar irradiance in reference cells.

## 5.2 Soiling Ratio - Pmax

At the time of measurement, a full sweep of the current and voltage characteristic (IV curve) of the PV module is performed and the IV curve is used to evaluate the PV maximum power.

Expected maximum power is calculated using the irradiance values and the PV module temperature using Eq. 3 (p. 14).

$$P_{max,ex} = P_{max,STC} \frac{Irrad_{clean}}{1000} (1 + \gamma(T_{BOM} - 25)) \quad \text{Eq. 3}$$

If a bifacial module is used, then Eq. 4 (p. 14) is used with the user supplied bifaciality factor  $\beta$ .

$$P_{max,ex} = P_{max,STC} \frac{(Irrad_{cleanup} + \beta \times Irrad_{cleanrear})}{1000} (1 + \gamma(T_{BOM} - 25)) \quad \text{Eq. 4}$$

Where:

$P_{max,ex}$  is the expected maximum power at Irradiance level of  $Irrad_{clean}$ .

$T_{BOM}$  is the temperature coefficient of power for the PV module used.

A soiling ratio is calculated by comparing the measured Pmax with the expected Pmax using Eq. 5 (p. 14).

$$SR_{pmax} = \frac{P_{max,meas}}{P_{max,ex}} \quad \text{Eq. 5}$$

The power generated by a PV module depends on solar irradiance as well as the cell temperature. This is reflected in larger temperature coefficient for power compared to the short circuit current. At higher temperatures, the power drop is smaller for a drop in irradiance.

The full IV curve is available via the Modbus registers.

## 5.3 Power and Activity LEDs

Power and activity LEDs are on the bottom side near the rear facing cells. When the sensor is powered, the **Power** LED will turn on according to the following power and sensor configuration states:

| Table 5-1: Power LED       |                                             |
|----------------------------|---------------------------------------------|
| LED state                  | Description                                 |
| Off                        | No power                                    |
| 1 flash every 10 seconds   | Fully powered system, sensor configured     |
| 3 flashes every 10 seconds | Powered using USB, sensor configured        |
| Always on                  | Powered but sensor not configured           |
| Flashing red and blue      | Firmware issue; contact Campbell Scientific |

## 5.4 Configuration

The following sections describe all the configurable device settings.

### 5.4.1 Device parameters

See [Figure 5-1](#) (p. 16).

**Name:** This is a user-assigned sensor name that will be displayed on the dashboard, the Modbus map, and in data tables. It is recommended to choose a name that will clearly identify the sensor, such as the location where it is installed.

**Latitude:** Enter the site latitude in decimal degrees. This parameter is used in the solar noon calculation. If it is not correct, the solar noon calculation will not be accurate, and the sensor will not open and sample during the correct time of day.

**Longitude:** Enter the site longitude in decimal degrees. This parameter is used in the solar noon calculation. If it is not correct, the solar noon calculation will not be accurate, and the sensor will not open and sample during the correct time of day.

**Altitude:** Enter the site altitude in meters. This parameter is used in the solar noon calculation. If it is not correct, the solar noon calculation will not be accurate, and the sensor will not open and sample during the correct time of day.

**UTC Offset:** Enter the site UTC offset in hours. Enter the offset that matches the sensor's current clock setting, preferably the local standard time of the sensor deployment. Consider whether the station is observing standard time or daylight savings time. **Important: This parameter is used in the solar noon calculation. If it is not correct, the solar noon calculation will not be accurate, and the sensor will not open and sample during the correct time of day.**

**Configuration**

Apply Config Report

**Parameters**

Name ⓘ  
DustVue20\_xxx

Latitude (decimal degrees) ⓘ  
41.765

Longitude (decimal degrees) ⓘ  
-111.855

Altitude (m) ⓘ  
1320

UTC Offset (hrs) ⓘ  
-7

Figure 5-1. Device parameters

## 5.4.2 Soiling measurement settings

Click the **Measurements** tab to see the Soiling Measurement Settings.

The screenshot shows a web interface with two tabs: 'Measurements' (selected) and 'Communications'. Below the tabs are two main sections: 'Soiling Measurement Settings' and 'PV Module Settings'.

**Soiling Measurement Settings:**

- Sampling Window (hrs):** A dropdown menu set to '+/- 1 hours from Solar Noon'.
- Sampling Interval (min):** A dropdown menu set to '15 minutes'.
- Irradiance Threshold (W/m²):** A text input field set to '0'.

**PV Module Settings:**

- Short Circuit Current (Isc) STC (A):** A text input field showing 'Invalid value'.
- Nominal Max Power (Pmax) STC (W):** A text input field showing 'Invalid value'.
- Temperature Coefficient (Isc) (%/°C):** A text input field showing 'Invalid value'.
- Temperature Coefficient (Pmax) (%/°C):** A text input field showing 'Invalid value'.
- Bifacial:** A dropdown menu set to 'True'. Below it is a warning: 'Warning! Soiling ratio uncertainty for bifacial modules is undetermined. Since the output of bifacial modules is highly dependent on mounting, albedo, and power bifaciality tolerance, the uncertainty of the calculated soiling ratio for bifacial modules is undetermined.'
- Power Bifaciality (Pmax\_rear / Pmax\_front) (%):** A text input field set to '0'. Below it is a note: 'Enter the Power Bifaciality as a percentage.'

Figure 5-2. Soiling measurement and solar module settings

**Sampling Window:** specifies the hours of the day during which the sensor attempts to collect soiling ratio measurements. Sampling attempts are made throughout the window at the configured **Sampling Interval**. If the irradiance is stable and exceeds the configured **Irradiance Threshold**, the sensor measures and records a soiling ratio sample. The Daily Soiling Ratio is calculated from the average of all samples collected during the **Sampling Window**.

For fixed tilt installations, select  $\pm 1$  hours from solar noon. For units installed on a tracker,  $\pm 2$  hours can be selected.

**Sampling Interval:** specifies the time between attempted soiling ratio samples during the **Sampling Window**. An interval of 15 minutes is recommended.

**Irradiance Threshold:** prevents the sensor from taking measurements during cloudy or rainy conditions. Soiling ratio samples are only taken when the measured irradiance exceeds this threshold, minimizing the exposure of the clean cells to the environment.

If this setting is **0** (the default), the sensor **automatically** determines the threshold based on the irradiance measured during the most recent Offsets Update. The sensor sets the threshold to 40% of that irradiance value. Keeping this setting on auto, along with performing Offsets Updates at the frequency recommended in the manual, ensures the threshold stays aligned with current site conditions.

If the auto value does not work for your application, you can **manually** set the threshold here.

**CAUTION:**

The reference cells have not been radiometrically calibrated as this is not required for a soiling measurement. So, if setting the threshold manually, it is important to use the irradiance value returned by the sensor during expected site conditions (on a clear day) to determine an appropriate value.

You can also set the threshold via Modbus. See register 40123 in [Table 7-3](#) (p. 41) for details.

**Short Circuit Current (Isc) STC (A):** Module short circuit current (Isc) under standard test conditions (in Amps)

**Nominal Max Power (Pmax) STC (W):** Module nominal maximum power (Pmax) under standard test conditions (in Watts)

**Temperature Coefficient (Isc) (%/°C):** Module Temperature Coefficient (Isc) (in %/°C)

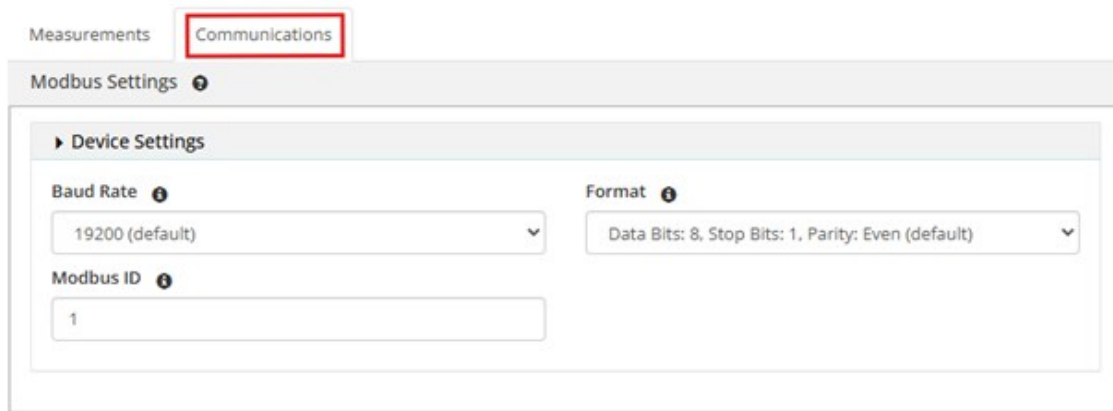
**Temperature Coefficient (Pmax) (%/°C):** Module temperature coefficient (Pmax) under standard test conditions (in %/°C)

**Bifacial Module:** Set to true if the solar module connected to the device is bifacial. If this is set to true, the Power Bifaciality Factor must be set as well.

**Power Bifaciality factor (%):** The bifaciality factor (in percent) of the PV module.

## 5.4.3 Communications settings

Click the **Communications** tab to see the **Modbus Settings**.



The screenshot shows a web interface with two tabs: 'Measurements' and 'Communications'. The 'Communications' tab is active and highlighted with a red rectangle. Below the tabs is a 'Modbus Settings' section with a help icon. This section is expanded to show 'Device Settings'. Within 'Device Settings', there are three fields: 'Baud Rate' (a dropdown menu showing '19200 (default)'), 'Format' (a dropdown menu showing 'Data Bits: 8, Stop Bits: 1, Parity: Even (default)'), and 'Modbus ID' (a text input field containing the number '1').

Figure 5-3. Modbus settings

In **Modbus Settings**, set the **Baud Rate**, **Format** (Data Bits, Stop Bits, and Parity), and **Modbus ID** to match the RS-485 Modbus network.

The unique **Modbus ID** (address) for this device will be used to respond to Modbus communications. The Modbus ID can be changed through a Modbus register, but the other Modbus settings (baud rate and format) must be changed using the Web UI.

## 5.4.4 Configuration buttons

Click **Apply** to apply the configuration. The configuration will not take effect until it has been applied. After applying, click **Config Report** to see a printable report of all the device settings. You can click **Save to File** to save the current configuration to a file that can be loaded again later. Click **Load from File** to load a previously saved configuration file.

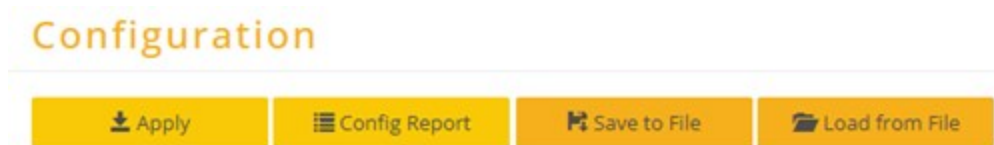


Figure 5-4. Configuration buttons

## 5.5 Offsets

To obtain a soiling ratio measurement, the sensor measures the attached solar module and the clean reference cell and compares them against each other. The attached solar module is allowed to soil while the clean cells remain clean. As the module soils, the soiling ratio will drop below 1. When the solar module and the clean cell are both clean, they should read the same value, thus producing a soiling ratio of 1. A periodic soiling ratio offset update, or calibration, must be performed to obtain an offset between the solar module and the clean cell.

This offset update must be performed on site after the unit has been installed under natural sunlight. Due to seasonal changes and natural degradation of the cells over time, the offsets update may need to be performed at least 4 times per year to achieve the best possible accuracy on the soiling ratio measurement.

### 5.5.1 To perform the offsets update

1. **Wash:** Before performing an offsets update, wash both the clean cell and the soiled module. To wash the clean cell, click **Open Cover** in the **Maintenance** section on the **Dashboard**. After the clean cell is washed, click the button again to close the cover. Both upward and rear side cells should be cleaned.

**NOTE:**

The cover will automatically close after 5 minutes if the **Open Cover** button is not pressed.

|                        |                                |
|------------------------|--------------------------------|
| <b>Maintenance</b>     |                                |
| Cover Control          | Open Cover                     |
| Cover Position         |                                |
| Motor Status           | Motor Locked Out (Low Voltage) |
| Wash Clean             | Mark Washed                    |
| Wash Soiled            | Mark Washed                    |
| Trigger Offsets Update | Trigger Update                 |

Figure 5-5. Maintenance section of dashboard

2. After washing the clean cell and the soiled modules, click **Mark Washed** next to the corresponding cell/module to log the event to device memory.

3. Once the clean cell and soiled modules have been washed and marked washed, the **Offsets Update** can then be triggered by clicking **Trigger Update**. Offsets update status will be shown on the **Dashboard**.

## 5.5.2 Sensor behavior during the offsets update

The update begins at the top of the minute, within  $\pm 1$  hour of solar noon, provided the **Irradiance Threshold** condition is met. If an **Offsets Update** is triggered outside this period, the sensor will wait until the next  $\pm 1$  hour period around solar noon before attempting the update. If the threshold condition is not met, the sensor continues to check the conditions at the top of each minute for the duration of the period.

During the offsets update, the protective cover opens, and multiple measurements of the clean reference cells and the PV module short-circuit current ( $I_{sc}$ ) are collected and averaged. A full I-V sweep of the PV module is also performed to determine its maximum power ( $P_{max}$ ). The cover then closes. The complete process takes approximately 1.5 minutes. If irradiance instability is detected during the measurement sequence, the cover closes immediately and the update is attempted again at the top of the next minute. Even thin clouds can cause an offset update to be aborted because of irradiance instability. The DustVue 20 continues attempting the offsets update until all required criteria are met, if necessary, over multiple days.

During the offsets update, the sensor also measures the irradiance using the clean reference cell and stores this measurement as the **expected clear sky irradiance**. If the **Irradiance Threshold** setting is set to **Auto**, the DustVue 20 uses a percentage of this expected clear sky irradiance value as the threshold. The protective cover will not open for a soiling-ratio measurement unless the measured irradiance exceeds the threshold.

Following a successful offsets update, the sensor performs a soiling ratio measurement. Because the offsets are established using the current clean-reference and PV-module measurements, the resulting soiling ratio is set to 1.0. The soiling ratio is then displayed on the dashboard.

## 5.5.3 Expected offset values

Following the offset update, the offset values can be viewed on the **Monitor Data** page. Navigate to the **Monitor Data** page and select the **OffsetData** table. The offset values are saved as **Offset\_Applied**. These are the multipliers that will be applied to each cell, and they should be close to "1". Values significantly different from each other, or less than or greater by 25% should be suspect. Doing a new offset calculation would be recommended. A factory reset will reset all offsets back to 1 (and erase all data, and settings). See [Resetting factory defaults](#) (p. 25).

**Offset\_G** is the clean cell irradiance value that was obtained during the offset. This is the expected clear sky irradiance value. If the **Irradiance Threshold** setting is set to **auto** (0), the device will use a percentage of this value for the threshold.

## 5.6 Solar noon

The device takes soiling ratio measurements during a specified period centered around solar noon. Accurate solar noon timing is essential for correct measurements. The calculated solar noon value can be viewed on the dashboard or accessed through Modbus registers.

|                    |                        |
|--------------------|------------------------|
| Solar Noon (HH:MM) | 12:13                  |
| Sampling Period    | 11:13 - 13:13          |
| Sample Interval    | 10 minutes             |
| Sample Status      | Time until next: 5 min |

### NOTE:

\*\*\*\*\* Important! If the solar noon value is not correct, verify that **latitude**, **longitude**, **altitude**, and **UTC Offset** settings are correct based on the installation site. Also, check that the device time is set correctly to the local standard time of the installation site. \*\*\*\*\*

## 5.7 Set the sensor time

The sensor clock must be set correctly to ensure an accurate solar noon calculation. Configure the clock via the **Dashboard** when setting up the device. Since the sensor clock may drift over time, periodically update it using either the dashboard or the **Time Set** Modbus registers. Always set the time to the local standard time of the installation site. Best practice recommendation is to program your data acquisition system or the SCADA system to synchronize the clock periodically.

## 5.7.1 Set time via dashboard

Click the **Set** button found under **Device Status** on the **Dashboard**.

### Device Status

|                    |                     |                                                                                              |
|--------------------|---------------------|----------------------------------------------------------------------------------------------|
| Time               | 2025-09-30 12:07:35 | <b>Set</b>  |
| Name               | DustVue10_206       |                                                                                              |
| Serial Number      | 206                 |                                                                                              |
| System Status      | OK                  |                                                                                              |
| Measurement Status | OK                  |                                                                                              |

A dialog will appear that allows you to set the device clock. The clock can be synchronized with the computer clock or entered manually.

### Set Date/Time

**Current Date/Time**  
2025-10-01 07:25:16

**Date/Time Source**

Sync with Computer

▼

Sync with Computer

Manually Specify

Cancel

Set

## 5.7.2 Set time via Modbus registers

The **Time Set** registers are used to set the date and time over Modbus. See [Modbus register map](#) (p. 39). The Time Set registers 40101 to 40111 need to be set to the current date and time. After writing values to these registers, the time can be updated by writing a 1 to the Time Set register 40113. This action will update the system date and time using the values in registers 40101 to 40111. The Time Set register will return to 0 once the update is complete. The current system date and time value can be found in read-only registers 40257 to 40267.

## 5.8 Soiling ratio sampling

### 5.8.1 Sampling window

The **Sampling Window** specifies the hours of the day during which the sensor attempts to collect soiling ratio measurements. Sampling attempts are made throughout the window at the configured **Sampling Interval**. If the irradiance is stable and exceeds the configured **Irradiance Threshold**, the sensor measures and records a soiling ratio sample. The Daily Soiling Ratio is calculated from the average of all samples collected during the **Sampling Window**.

For fixed tilt installations, select  $\pm 1$  hours from solar noon. For units installed on a tracker,  $\pm 2$  hours can be selected.

### 5.8.2 Sampling Interval

The **Sampling Interval** specifies the time between attempted soiling ratio samples during the **Sampling Window**. A sampling interval of 15 minutes is recommended.

### 5.8.3 Irradiance threshold

The **Irradiance Threshold** determines the irradiance that is required for the system to make a soiling sample. To prevent measuring during cloudy conditions, or opening the cover during rain, the sensor checks that the irradiance is above this threshold before sampling. The device will not open the cover and take a soiling ratio measurement unless the measured irradiance exceeds the threshold. Setting this value near the expected irradiance on a clear day will help to keep the clean reference from becoming soiled and will improve soiling ratio measurements by preventing samples during low light.

The value can be set to 0 to have the system automatically calculate a threshold. The auto threshold will be calculated during the **Offsets Update**. During the **Offsets Update**, the sensor will measure the irradiance of the clean cell and save it as the expected clear sky irradiance value. The auto threshold will be set to 40% of this irradiance value. Keeping this value set to auto (0), along with periodically running an **Offsets Update** at the frequency recommended, allows the threshold to stay updated to a value that works with the current site conditions.

If the auto value does not work for your application, you can use this setting to set the threshold to something else. A value in the range of  $400 \text{ W/m}^2$  and  $550 \text{ W/m}^2$  is a good choice for most locations but be aware that the expected on-site irradiance will change throughout the year.

#### CAUTION:

The reference cells have not been radiometrically calibrated as this is not required for a soiling measurement. So, if setting the threshold manually, it is important to use the irradiance value returned by the sensor during expected site conditions (on a clear day) to determine an appropriate value.

## 5.8.4 Soiling Ratio Sample vs Daily Soiling Ratio

The Sensor Web UI displays the “Soiling Ratio” for both the current front and rear measurements. These values are the sensor’s most recently calculated soiling ratios. During the sampling window this value will update after each soiling ratio that is performed on the sampling interval. At the end of the sampling window these values will persist until the next day. These values are also available in the Modbus Map as **Soiling Ratio Sample** and **Soiling Ratio Sample-Rear** (register 40351 and 40353).

At the end of the sampling window each day, the sensor calculates a **Daily Soiling Ratio** and **Daily Soiling Ratio-Rear** (Registers 40355 and 40357) from the soiling ratio measurements made that day during the sampling window. The sensor also reports the number of samples it used to generate the Daily Soiling Ratios. This number is reported in the **Daily Soiling Ratio Num Samples** register (Register 40359). On days with unstable solar irradiance, this number may be small. The quality of measurement will not be as good as on a day when all possible measurements are made. The number in this register can be used as a data quality check.

If there are no samples taken during the day (sampling window), the **Soiling Ratio Sample** value will not change, and the **Daily Soiling Ratio** will be set to NAN at the end of the period.

The **Soiling Ratio Sample** registers are provided for informational purposes, but for assessing soiling conditions, we recommend using the **Daily Soiling Ratio**. The **Daily Soiling Ratio** is recommended because it is calculated from the average of all individual samples collected during the day’s sampling window and provides the better representative indication of soiling.

## 5.9 Resetting factory defaults

A factory reset can be performed on the device by clicking the **Reset Factory Defaults** button. The button can be found on the **Configuration** page, but it is hidden. It can be displayed by clicking on the ellipses as shown in the following figure.

A factory reset will clear all settings, delete data tables, set all offsets to 1, clear the device memory, and stop the operation of the sensor until new settings are applied. If bad offsets somehow get saved to the device, it can cause unreasonable irradiance and soiling ratio values. A factory reset will erase bad offsets and can help get the sensor back to a known state.

Following a factory reset, the user will need to set and apply all configuration settings. Saving the current configuration settings to a file can simplify this process, see [Configuration buttons](#) (p. 19). An **Offsets Update** should be performed in the field after the unit has been installed to calibrate the soiling ratio measurement.

## 5.10 Status codes

There are several status code registers available in [Table 7-5](#) (p. 44). These are the **System Status**, **Measurement Status**, and **Measurement Flag** registers. These registers are bit fields, where each bit value has specific meaning. When there are no errors, all bits in the register will be cleared, and the register value will be 0 which indicates no error, or status OK. A value of 1 in any bit indicates an error or flag condition. If there is an error bit set, the register value will be an integer between 1-15 depending on the bit and its position value.

The **System Status** code describes system level problems, such as a cover operation error, or low voltage. The **Measurement Status** code describes issues that would be preventing a measurement from being taken, such as instability. And the **Measurement Flags** indicate potential problems with the reported measurement, such as uneven soiling being detected.

Convert the number in the status code to binary to see which bits are set. The following table describes the meaning of each bit in the status codes. [Table 7-5](#) (p. 44) also includes this error bit information.

| Bit position (value)       | System status                                  | Measurement status                      | Measurement flags                                      |
|----------------------------|------------------------------------------------|-----------------------------------------|--------------------------------------------------------|
| Bit 0 (Value = 1)          | Cover Operation Error                          | Irradiance below Threshold              | Soiling ratio measurement outside normal range         |
| Bit 1 (Value = 2)          | Motor Lockout (low voltage or low temperature) | Irradiance is not stable enough to open | Soiling ratio rear measurement is outside normal range |
| Bit 2 (Value = 4)          | Backup Battery Low Voltage                     | Open cover triggered by user            |                                                        |
| Bit 3 (Value = 8)          | Reserved                                       | Prevent Open triggered by user          |                                                        |
| Bits 4-15                  | Reserved                                       |                                         |                                                        |
| Bit 16 (Value = 65536)     | Potential module voltage limit detected        |                                         |                                                        |
| Bit 17 (Value = 131,072)   | Potential module current limit detected        |                                         |                                                        |
| Bit 18 (Value = 262,144)   | Potential module power limit detected          |                                         |                                                        |
| Bit 19                     | Reserved                                       |                                         |                                                        |
| Bit 20                     | ADC error                                      |                                         |                                                        |
| Bit 21 (Value = 2,097,152) | IV curve error                                 |                                         |                                                        |

### Decoding the Code Registers:

One way to decode the bits in the status codes is described here, with an example provided in the example program.

#### Method 1:

1. Take the value in the code register.
2. Subtract the largest possible bit value that does not make the result negative. That bit is set.
3. Subtract the next largest bit value from the remainder. That bit is set.

4. Continue this process until the result is zero. When the result reaches zero, the final bit is set, and the conversion is complete.

### Method 2 (iterative approach):

1. Start with the value in the code register.
2. Subtract the highest bit value. Evaluate the result:
  - If the result is zero: That bit is set. Conversion is complete.
  - If the result is positive: That bit is set. Take the remainder as the new result and move to the next iteration with the next highest bit value.
  - If the result is negative: That bit is not set. Keep the same result and move to the next iteration with the next highest bit value.
3. Repeat the process with each successive lower bit value until the result reaches zero, indicating the conversion is complete.

### Example 1:

If the System Status code register returns the value of 6, this indicates that both Bit 2 and Bit 1 are set.

Decoding: 6

6 – 8 (Bit 3 value) < 0 (the value of Bit 3 is 8 which is too large). Don't use

6 – 4 (Bit 2 value) = 2. So, bit 2 is set – Backup Battery voltage is low

2 – 2 (Bit 1 value) = 0. So, bit 1 is set – Motor Lockout (low voltage or low temperature)

(Bit 0 is not set since the remainder above was 0)

Conversion done

### Example 2:

If the Measurement Status register returns the value of 9, this indicates that Bit 3 and Bit 0 are set.

Decoding: 9

9 – 8 (Bit 3 value) = 1. Bit is set – Prevent Open triggered by user

1 – 4 (Bit 2 value) < 0. Don't use

1 – 2 (Bit 1 value) < 0. Don't use

1 – 1 (Bit 0 value) = 0. Bit is set – Irradiance below threshold

Conversion done. These bits indicate that a measurement will not occur because of those two conditions.

## 5.11 Control registers

The following Modbus registers are available to control function of the sensor and to create a record of sensor service events. Some of these control functions are also available via the **Web UI** as buttons. The control registers are:

- **Prevent Open:** Setting this register to 1 prevents the sensor from opening. This can be used by programming an external weather station to signal when conditions are not optimal for measurement (for example, when rain is expected).

The sensor also uses its own irradiance measurements to determine when it is inappropriate to open the cover, evaluating measurement stability and applying the **Irradiance Threshold**. Using this register gives the operator additional control to ensure that the clean reference remains protected from conditions that could cause soiling, such as rain or high winds that may stir up dust

- **Open Cover:** This allows the operator to open the clean reference cover to perform cleaning. The cover will remain open until the register is reset (set to 0) or the time out of 5 minutes expires. Set this register to 1 to open the cover. Clear it to 0 to allow normal operation by the sensor.
- **Wash Clean / Wash Soiled:** These registers can be set to 1 to trigger an update to the corresponding **Last Wash** registers with the current date and time that these service events were completed. Keeping an accurate record of these events will facilitate operators with maintenance scheduling. Set either of these registers to 1 to trigger an update to the **Last Wash** date registers.
- **Update Offsets:** The user can remotely trigger an **Offsets Update** by setting this register to 1. This will trigger the update to happen at the next available time. An Offsets Update is only allowed during  $\pm 1$ hr of solar noon and will only happen if the irradiance is above the **Irradiance Threshold**. If the update is triggered outside this window of time, the sensor will wait until the next day to attempt the update. If the irradiance is below the threshold, the sensor will keep trying for the remainder of the  $\pm 1$ hr window, and delay until the next day if the threshold is never met.

This register allows a remote update to the offsets, but it is not recommended to trigger an Offsets Update without a site visit. You should clean the soiled module and the clean reference before triggering an Offsets Update. Ideally, you would be on site at solar noon and trigger the Offsets Update using the Web UI as close as possible to solar noon.

- **Reboot:** Write 57005 to this register to reboot the device.

# 6. Specifications

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Soiling ratio uncertainty (front):  $\pm 1\%$

**NOTE:**

This uncertainty is for a mono-facial module. Rear side irradiance is highly dependent on the site conditions, layout. There is a seasonal variation as well. Due to all this, it is difficult to assign a maximum uncertainty number. Also, the maximum power of a PV module has a strong dependence on temperature. The accurate value of the temperature coefficient of power as well as the accuracy of temperature measurements are sources of additional errors in the soiling ratio measured from Pmax.

Soiling ratio uncertainty (rear):  $\pm 5\%$   
(site dependent)

Operating temperature range:  $-20\text{ }^{\circ}\text{C}$  to  $+70\text{ }^{\circ}\text{C}$

Storage/survival temperature range:  $-40\text{ }^{\circ}\text{C}$  to  $+70\text{ }^{\circ}\text{C}$   
(sensor will not be damaged;  
no soiling ratio will be measured  
below  $-20\text{ }^{\circ}\text{C}$ )

Input power: 12 to 32 VDC (24W or higher)

**Power consumption**

Idle:  $<1\text{ W}$  above  $5\text{ }^{\circ}\text{C}$   
 $\sim 13\text{ W}$  below  $5\text{ }^{\circ}\text{C}$  (when heater active)

Active:  $0.5\text{ A}$  at  $24\text{ V}$  (during measurement) above  $5\text{ }^{\circ}\text{C}$   
 $\sim 1.0\text{ A}$  at  $24\text{ V}$  (during measurement) below  $5\text{ }^{\circ}\text{C}$  (when  
heater active)

Active w/heater full on:  $\sim 24\text{ W}$

**NOTE:**

A small heater prevents the cover gasket from freezing shut to prevent damage to the gasket. The device will automatically activate the heater when the ambient temperature is below  $5\text{ }^{\circ}\text{C}$  and when humidity and temperature conditions could cause ice.

Communications: Modbus RTU over RS-485

# 7. Installation

---

**Pre-Construction site Assessment:** The DustVue 20 can be used for solar resource assessment campaigns as well as for operational performance monitoring purposes, although DustVue 10 will be a better sensor for these stations. For solar resource assessment applications, DustVue 20 should be installed in an appropriate plane of array (POA) or horizontal position. Care should be taken so that it does not impact other measurements.

**Post-Construction:** The DustVue 20 is a great addition to an operational performance monitoring station. If the site has single axis trackers, the DustVue 20 should be installed on the array torque tube close to other array-mounted weather monitoring stations. Campbell Scientific recommends that the sensor be sited within the array to measure a soiling loss representing the average losses over that region of the PV plant. This typically means that the DustVue 20, along with the PV module it is connected to, is positioned somewhere within the array. The torque tube mounting hardware will facilitate alignment of the DustVue 20 to the modules on the torque tube.

**Installation with other sensors:** When purchased as a part of an entire weather monitoring station like SunSentry, the sensor can be daisy chained with other pyranometers and back-of-module temperature sensors using our surge protection coupler. The DustVue 20 should be the first sensor in the chain to minimize the voltage drop caused by longer cable lengths. The maximum recommended cable length is 50 m (150 feet) with 24 VDC input supply. The cable length in a daisy chain can easily surpass this limit.

**Choosing Installation Location:** To get best representative measurement of soiling, the DustVue 20 should be installed near, and connected to, a PV module somewhere in the middle of the string. This module should be dedicated to soiling measurements and should not be power producing. A jumper PV cable should be used to bypass this module. In case a central PV module is not possible to use, it can be installed on the edge of the PV string located at the interior rows of the PV farm. A PV module at the edge of the farm may not give a representative measurement. Also, multiple sensors, strategically situated, should be located throughout the PV farm, based on size and terrain complexity of the site in accordance with IEC 61724-1 recommendations.

## 7.1 Mounting to tracker torque tubes

**NOTE:**

For a video demonstration of mounting to a torque tube, see:

[help.campbellsci.com/dustvue20/dustvue20/installation/mounting-torque-tube.htm](http://help.campbellsci.com/dustvue20/dustvue20/installation/mounting-torque-tube.htm) .

An offset torque tube mounting kit is available from Campbell Scientific to attach the DustVue 20 to a single-axis tracker torque tube.

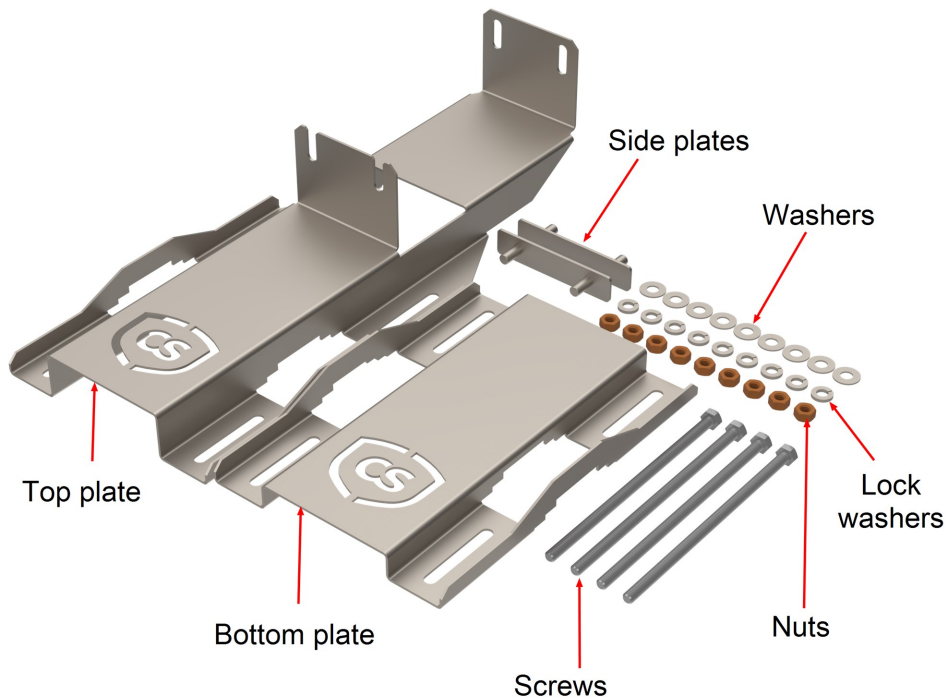


Figure 7-1. Tracker torque tube mounting bracket

1. Secure the bracket to the tracker torque tube by using the four screws, four nuts, eight washers, and eight lock washers (see [Figure 7-1](#) [p. 32] and [Figure 7-2](#) [p. 33]).

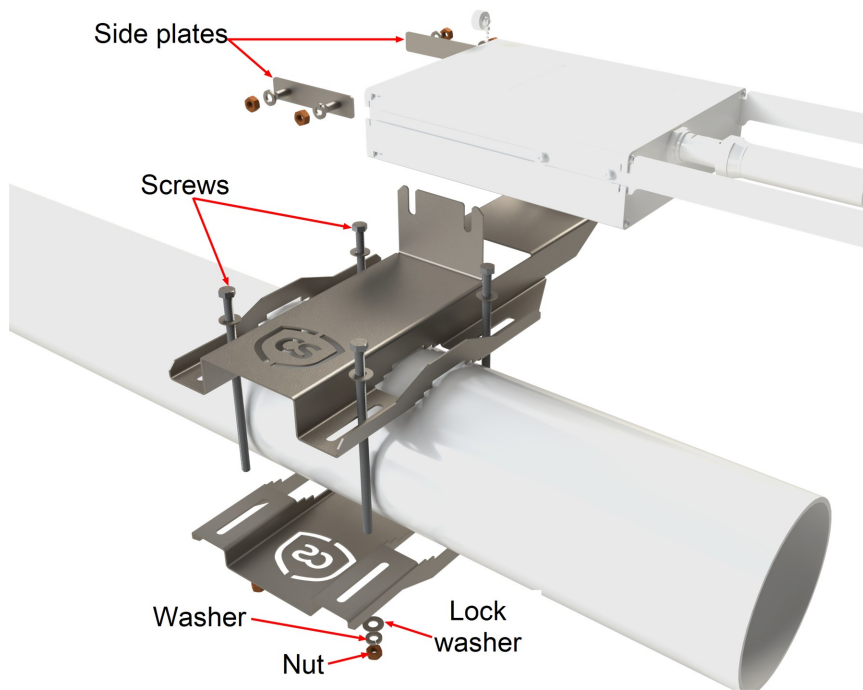


*Figure 7-2. Exploded view of mounting bracket*

2. Slide the side plates on the bracket (see [Figure 7-2](#) [p. 33]).

3. Fasten the DustVue 20 to the bracket using the nuts and washers.

**NOTE:**

The sensor should be mounted so that the cells on the bottom have a clear view of the ground below.

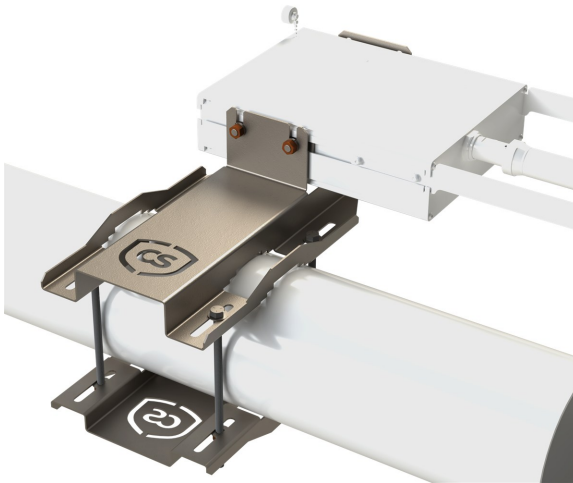


*Figure 7-3. DustVue 20 mounted to crossarm*

## 7.2 Mounting to a Unistrut

**NOTE:**

For a video demonstration of mounting to a Unistrut, see:

[help.campbellsci.com/dustvue20/dustvue20/installation/mounting-unistrut.htm](http://help.campbellsci.com/dustvue20/dustvue20/installation/mounting-unistrut.htm) .

The DustVue 20 can also be mounted to a Unistrut using a Unistrut mounting kit available from Campbell Scientific.

**NOTE:**

The sensor should be mounted so that the rear facing soiled cells and rear facing clean cells have a clear view of the ground below.

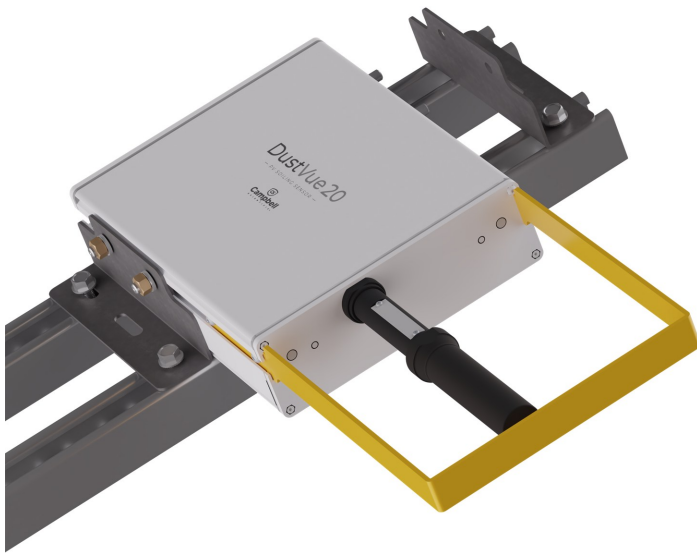


*Figure 7-4. DustVue 20 mounted on a Unistrut*

## 7.3 Mounting to a crossarm

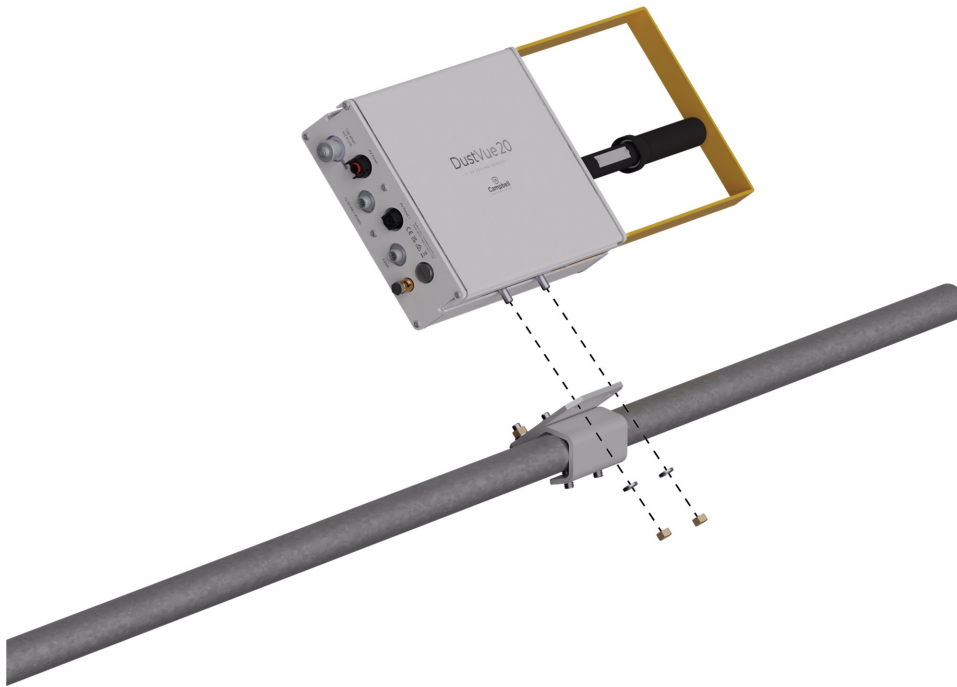
**NOTE:**

For a video demonstration of mounting to a crossarm, see:

[help.campbellsci.com/dustvue20/dustvue20/installation/mounting-crossarm.htm](http://help.campbellsci.com/dustvue20/dustvue20/installation/mounting-crossarm.htm) .

To mount the DustVue 20 to a crossarm:

1. Slide the DustVue 20 mount into the track on the bottom of the DustVue 20.
2. Attach the mounting bracket to the mount using the two supplied nuts and washers.



3. Slide the mounting bracket onto the end of the crossarm.
4. Align the DustVue 20 so that it is in the same plane as the solar panels.
5. Secure the mounting bracket to the crossarm by tightening the two set screws.



## 7.4 Connect a solar module

One solar module from the string should be disconnected and connected to DustVue 20. Attach the module to the DustVue 20 using the MC4 connectors. Use PV wires no longer than 3 meters (10 feet).

## 7.5 Attach the BOM sensor to the solar module

The included CS241-QD sensor is Campbell Scientific's BOM sensor, CS241, with extra lead length to be used with the DustVue 20. This should be attached to the back of the solar module roughly in the center of the module and centered on a PV cell. Please follow the same procedure as the CS241 for installation.

A pressure-activated adhesive mounting strip is adhered to the flat surface of the aluminum disk of the sensor.

### **CAUTION:**

Before mounting, the installers need to wash their hands, then clean the back of the PV module using the isopropyl alcohol pad shipped with the sensor.

To mount the sensor, remove the paper from the mounting strip and place the disk on the back of the PV module. Press the disk firmly for 2 to 3 seconds to initiate long-term bonding of the sensor to the surface. The mounting strip must be adhered to a clean surface for its adhesive to function properly.

### **CAUTION:**

Do not use epoxy to secure the sensor head to a PV module.

After mounting the sensor to the measurement surface, the cable must be properly strain-relieved. Use zip ties to fasten the cable to the edge of the PV module.

## 7.6 Wiring

Table 7-1 (p. 38) lists the cable pin-out numbers and their corresponding data logger connections.

| Table 7-1: Pin-out, function, and data logger connection              |                       |                                     |                         |
|-----------------------------------------------------------------------|-----------------------|-------------------------------------|-------------------------|
| Pin                                                                   | Wire function         | Data logger connection <sup>1</sup> | Power supply connection |
| 1                                                                     | Power in 12 to 32 VDC | NC                                  | +                       |
| 2                                                                     | RS-485 (B+)           | C Even                              |                         |
| 3                                                                     | RS-485 ground         | G                                   |                         |
| 4                                                                     | Power ground          | NC                                  | –                       |
| 5                                                                     | RS-485 (A–)           | C Odd                               |                         |
| <sup>1</sup> Assumes the sensor directly connects to the data logger. |                       |                                     |                         |

### NOTE:

Refer to the label on the cable for pin-out wire colors.

## 7.7 Long cable lengths

If running on 12 V supply, the cable length should be limited to 12 m (40 ft). A 24 V supply is required to use the maximum recommended cable length of 50 m (150 ft). Up to 32 V supply can be used to extend the distance greater than 50 m, if needed. Do not try to power the DustVue 20 using 12V output from the Campbell Scientific data loggers. There is not enough current available on these outputs.

### CAUTION:

Longer cable lengths are prone to noise pickup, especially in the electrically noisy environment of a PV solar farm.

## 7.8 CRBasic programming

The RS-485 output can be directly read by a CR6-series, CR1000X-series, CR350-series, or Modbus RTU RS-485 network. Other Campbell Scientific data loggers can use an MD485 multidrop interface to read the RS-485 output.

A CR6, CR1000X-series, or CR350-series data logger programmed as a Modbus client can retrieve the values stored in the input registers (see [Modbus register map](#) [p. 39]). To do this, the

CRBasic program requires the `SerialOpen()` instruction followed by `ModbusClient()` instruction.

**NOTE:**

`ModbusClient()` was formerly `ModbusMaster()`. Campbell Scientific, in conjunction with the Modbus Organization, is now using "client-server" to describe Modbus communications. The Modbus client(s) initiates communications and makes requests of server device(s). Server devices process requests and return an appropriate response (or error message). See <https://modbus.org>  for more information. Existing programs that use the old Modbus terminology will still compile in the data logger.

The `SerialOpen` instruction has the following syntax:

`SerialOpen` (ComPort, Baud, Format, TXDelay, BufferSize, Mode)

The **Format** parameter is typically set to logic 1 low; even parity, one stop bit, 8 data bits. The **Mode** parameter should configure the ComPort as RS-485 half-duplex, transparent.

The `ModbusClient()` instruction has the following syntax:

`ModbusClient` (Result, ComPort, Baud, Addr, Function, Variable, Start, Length, Tries, Timeout, [ModbusOption])

The **Addr** parameter must match the sensor Modbus address.

See [Example program](#) (p. 58) for more information.

## 7.9 Modbus register map

**Data Type:** All measurement parameters are reported with data type of 32-bit Float (ABCD). Some metadata have mixed formats (see [Table 7-2](#) [p. 40]). The Modbus map is also available on the **Modbus** tab of the Web UI.

**Server ID:** The Modbus ID is configurable on the **Configuration** page.

| Table 7-2: Modbus register map |           |            |                            |                                                           |
|--------------------------------|-----------|------------|----------------------------|-----------------------------------------------------------|
| Register                       | Data type | Read/Write | Measurement                | Description                                               |
| 40005                          | Str-32    | R          | Manufacturer               | Manufacturer                                              |
| 40021                          | Str-32    | R          | Model                      | Model                                                     |
| 40045                          | Str-16    | R          | Version                    | Version                                                   |
| 40053                          | Str-32    | R          | Serial Number              | Serial Number                                             |
| 40069                          | U16       | R          | Device Address             | Device Address (use Modbus ID setting register to change) |
| 40073                          | Str-8     | R          | Interface Name             | Interface Name                                            |
| 40077                          | U32       | R          | Baud Rate                  | Baud Rate                                                 |
| 40079                          | U16       | R          | Bits                       | Bits                                                      |
| 40080                          | U16       | R          | Parity                     | Parity (0=None; 1=Odd; 2=Even)                            |
| 40081                          | U16       | R          | Duplex                     | Duplex (1=Half)                                           |
| 40082                          | U16       | R          | Flow Control               | Flow Control (0=None)                                     |
| 40083                          | U16       | R          | Interface Type             | Interface Type (2=RS-485)                                 |
| 40084                          | U16       | R          | Protocol                   | Protocol (1=Modbus)                                       |
| 40087                          | Str-28    | R          | User Assigned Station Name | User Assigned Station Name                                |

**Table 7-3: Modbus settings registers**

| Register | Data type | Read/Write | Measurement                     | Description                                                                                                    | Units            |
|----------|-----------|------------|---------------------------------|----------------------------------------------------------------------------------------------------------------|------------------|
| 40101    | F32       | R/W        | Time Set - Year                 | Time Set - Year                                                                                                |                  |
| 40103    | F32       | R/W        | Time Set - Month                | Time Set - Month                                                                                               |                  |
| 40105    | F32       | R/W        | Time Set - Day                  | Time Set - Day                                                                                                 |                  |
| 40107    | F32       | R/W        | Time Set - Hour                 | Time Set - Hour                                                                                                |                  |
| 40109    | F32       | R/W        | Time Set - Minute               | Time Set - Minute                                                                                              |                  |
| 40111    | F32       | R/W        | Time Set - Second               | Time Set - Second                                                                                              |                  |
| 40113    | F32       | R/W        | Time Set                        | Time Set: Write a 1 in this register to set the device clock according to the values in the Time Set registers |                  |
| 40115    | F32       | R/W        | Latitude                        | Latitude                                                                                                       | decimal degrees  |
| 40117    | F32       | R/W        | Longitude                       | Longitude                                                                                                      | decimal degrees  |
| 40119    | F32       | R/W        | Altitude                        | Altitude                                                                                                       | m                |
| 40121    | F32       | R/W        | UTC Offset                      | UTC Offset                                                                                                     | hrs              |
| 40123    | F32       | R/W        | Irradiance Threshold            | Irradiance Threshold                                                                                           | W/m <sup>2</sup> |
| 40125    | F32       | R/W        | Modbus ID                       | Modbus ID                                                                                                      |                  |
| 40141    | F32       | R/W        | Short Circuit Current (Isc) STC | Short Circuit Current (Isc) STC                                                                                | A                |
| 40143    | F32       | R/W        | Nominal Max Power (Pmax) STC    | Nominal Max Power (Pmax) STC                                                                                   | W                |

| Table 7-3: Modbus settings registers |           |            |                                      |                                      |       |
|--------------------------------------|-----------|------------|--------------------------------------|--------------------------------------|-------|
| Register                             | Data type | Read/Write | Measurement                          | Description                          | Units |
| 40145                                | F32       | R/W        | Module Temperature Coefficient (Isc) | Module Temperature Coefficient (Isc) | %/°C  |
| 40147                                | F32       | R/W        | Module Temperature Coefficient (Pwr) | Module Temperature Coefficient (Pwr) | %/°C  |
| 40149                                | F32       | R/W        | Bifacial Module                      | Bifacial module (true/false)         |       |
| 40151                                | F32       | R/W        | Bifacial Power Factor                | Power Bifaciality of the module      | %     |

| Table 7-4: Modbus control registers |           |            |                             |                                                                                                                                |
|-------------------------------------|-----------|------------|-----------------------------|--------------------------------------------------------------------------------------------------------------------------------|
| Register                            | Data type | Read/Write | Measurement                 | Description                                                                                                                    |
| 40201                               | F32       | R/W        | Control Reg - Prevent Open  | User can set this register to 1 to prevent the cover from opening                                                              |
| 40203                               | F32       | R/W        | Control Reg - Open Cover    | 1 = open the cover<br>0 = normal operation (cover stays open 5 min. max)                                                       |
| 40205                               | F32       | R/W        | Control Reg - Wash Clean    | User can set this register to 1 to trigger an update to the Last Wash Clean registers                                          |
| 40207                               | F32       | R/W        | Control Reg - Wash Soiled   | User can set this register to 1 to trigger an update to the Last Wash Soiled registers                                         |
| 40209                               | F32       | R/W        | Control Reg - Update Offset | User can set this register to 1 to trigger an offsets update. This also triggers an update to the Last Offset Update registers |
| 40249                               | F32       | R/W        | Control Reg - Reboot        | User can write 57005 to this register to reboot the device                                                                     |

Table 7-5: Modbus system data registers

| Register | Data type | Read/Write | Measurement                     | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Units | Min. | Max |
|----------|-----------|------------|---------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|------|-----|
| 40251    | F32       | R          | Bitwise System Status Code      | <p>0 = Normal operation (Status OK)</p> <p>Convert the code from decimal to binary to see which bits are set.</p> <p>Bit 0: Cover Operation Error</p> <p>Bit 1: Motor lockout (low voltage or low temperature)</p> <p>Bit 2: Backup battery voltage is low</p> <p>Bit 16: Potential module voltage limit detected</p> <p>Bit 17: Potential module current limit detected</p> <p>Bit 18: Potential module power limit detected</p> <p>Bit 20: ADC error</p> <p>Bit 21: IV curve error</p> |       |      |     |
| 40253    | F32       | R          | Bitwise Measurement Status Code | <p>0 = Normal operation (nothing preventing sample) Convert the code from decimal to binary to see which bits are set</p> <p>Bit 0: Irradiance is below opening threshold</p> <p>Bit 1: Irradiance is not stable enough to open</p> <p>Bit 2: Open cover triggered by user (will not sample)</p> <p>Bit 3: Prevent open triggered by user (will not sample)</p>                                                                                                                          |       |      |     |

**Table 7-5: Modbus system data registers**

| Register | Data type | Read/Write | Measurement                | Description                                                                                                                                                                                                                                              | Units            | Min. | Max |
|----------|-----------|------------|----------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|------|-----|
| 40255    | F32       | R          | Bitwise Measurement Flags  | <p>0 = Normal operation (Measurement OK)<br/>Convert the code from decimal to binary to see which bits are set.</p> <p>Bit 0: Soiling ratio measurement is outside normal range</p> <p>Bit 1: Soiling ratio rear measurement is outside normal range</p> |                  |      |     |
| 40257    | F32       | R          | Time - Year                | Current Device Time - Year                                                                                                                                                                                                                               |                  |      |     |
| 40259    | F32       | R          | Time - Month               | Current Device Time - Month                                                                                                                                                                                                                              |                  |      |     |
| 40261    | F32       | R          | Time - Day                 | Current Device Time - Day                                                                                                                                                                                                                                |                  |      |     |
| 40263    | F32       | R          | Time - Hour                | Current Device Time - Hour                                                                                                                                                                                                                               |                  |      |     |
| 40265    | F32       | R          | Time - Minute              | Current Device Time - Minute                                                                                                                                                                                                                             |                  |      |     |
| 40267    | F32       | R          | Time - Second              | Current Device Time - Second                                                                                                                                                                                                                             |                  |      |     |
| 40269    | F32       | R          | Solar Noon - Hour          | Calculated solar noon - Hour                                                                                                                                                                                                                             | hr               | 0    | 23  |
| 40271    | F32       | R          | Solar Noon - Minute        | Calculated solar noon - Minute                                                                                                                                                                                                                           | min              | 0    | 60  |
| 40273    | F32       | R          | Sampling Window Status     | 1 = Sampling Window is open;<br>0 = Sampling Window is closed                                                                                                                                                                                            |                  | 0    | 1   |
| 40275    | F32       | R          | Irradiance                 | Irradiance                                                                                                                                                                                                                                               | W/m <sup>2</sup> |      |     |
| 40277    | F32       | R          | Irradiance - Rear          | Irradiance of rear-facing cell                                                                                                                                                                                                                           | W/m <sup>2</sup> |      |     |
| 40279    | F32       | R          | Soiling Ratio Sample Count | This register increments throughout the day every time a soiling ratio sample is taken                                                                                                                                                                   |                  |      |     |

**Table 7-5: Modbus system data registers**

| Register | Data type | Read/Write | Measurement              | Description                            | Units            | Min. | Max |
|----------|-----------|------------|--------------------------|----------------------------------------|------------------|------|-----|
| 40281    | F32       | R          | Cover Seal Heater Status | 1 = Heater On<br>0 = Heater Off        |                  | 0    | 1   |
| 40283    | F32       | R          | Internal RH              | Internal Relative Humidity             | %                | 0    | 100 |
| 40285    | F32       | R          | Temp - Clean Reference   | Temperature of the clean reference     | °C               |      |     |
| 40287    | F32       | R          | Temp - Soiled            | Temperature of the soiled module       | °C               |      |     |
| 40289    | F32       | R          | Temp - Rear Soiled       | Temperature of the rear soiled module  | °C               |      |     |
| 40291    | F32       | R          | Irradiance Clean         | Irradiance of up-facing clean cell     | W/m <sup>2</sup> |      |     |
| 40293    | F32       | R          | Irradiance Clean Rear    | Irradiance of rear-facing clean cell   | W/m <sup>2</sup> |      |     |
| 40295    | F32       | R          | Pmax                     | Maximum power of solar module          | W                |      |     |
| 40297    | F32       | R          | Pmax expected            | Expected maximum power of solar module | W                |      |     |

**Table 7-6: Modbus timestamps registers**

| Register | Data type | Read/ Write | Measurement                             | Description                                                   | Units | Min. | Max |
|----------|-----------|-------------|-----------------------------------------|---------------------------------------------------------------|-------|------|-----|
| 40301    | F32       | R           | Timestamp – Soiling Ratio Sample - Year | Time of the most recent last soiling ratio calculation - Year | year  |      |     |
| 40303    | F32       | R           | Timestamp – Soiling Ratio - Month       | Time of the most recent soiling ratio calculation - Month     | month |      |     |
| 40305    | F32       | R           | Timestamp – Soiling Ratio - Day         | Time of the most recent soiling ratio calculation - Day       | day   |      |     |
| 40307    | F32       | R           | Timestamp – Soiling Ratio – Hour        | Time of the most recent soiling ratio calculation - Hour      | hr    |      |     |
| 40309    | F32       | R           | Timestamp – Soiling Ratio – Minute      | Time of the most recent soiling ratio calculation - Minute    | min   |      |     |
| 40311    | F32       | R           | Timestamp - Washed Clean - Year         | Date of the most recent clean cell wash - Year                | year  |      |     |
| 40313    | F32       | R           | Timestamp - Washed Clean - Month        | Date of the most recent clean cell wash - Month               | month | 1    | 12  |
| 40315    | F32       | R           | Timestamp - Washed Clean - Day          | Date of the most recent clean cell wash - Day                 | day   | 1    | 31  |
| 40317    | F32       | R           | Timestamp - Washed Soiled – Year        | Date of the most recent soiled cell wash - Year               | year  |      |     |
| 40319    | F32       | R           | Timestamp - Washed Soiled - Month       | Date of the most recent soiled cell wash - Month              | month | 1    | 12  |

| Table 7-6: Modbus timestamps registers |           |            |                                   |                                                |       |      |     |
|----------------------------------------|-----------|------------|-----------------------------------|------------------------------------------------|-------|------|-----|
| Register                               | Data type | Read/Write | Measurement                       | Description                                    | Units | Min. | Max |
| 40321                                  | F32       | R          | Timestamp - Washed Soiled - Day   | Date of the most recent soiled cell wash - Day | day   | 1    | 31  |
| 40323                                  | F32       | R          | Timestamp - Offset Update - Year  | Date of the most recent offset update - Year   | year  |      |     |
| 40325                                  | F32       | R          | Timestamp - Offset Update - Month | Date of the most recent offset update - Month  | month | 1    | 12  |
| 40327                                  | F32       | R          | Timestamp - Offset Update - Day   | Date of the most recent offset update - Day    | day   | 1    | 31  |

**Table 7-7: Modbus soiling data registers**

| Register | Data type | Read/Write | Measurement                     | Description                                                                                                                                                                                                                                                                                                                                         | Units | Min. | Max |
|----------|-----------|------------|---------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|------|-----|
| 40357    | F32       | R          | Daily Soiling Ratio - Isc       | Use this value to assess site soiling conditions. It represents the average of all individual Isc soiling ratio samples collected during the sampling window. This value will be updated once per day at the end of the sampling window. If no samples were collected that day (due to cloudiness or low irradiance), this register will read NAN.  | ratio | 0    | 1   |
| 40359    | F32       | R          | Daily Soiling Ratio – Pmax      | Use this value to assess site soiling conditions. It represents the average of all individual Pmax soiling ratio samples collected during the sampling window. This value will be updated once per day at the end of the sampling window. If no samples were collected that day (due to cloudiness or low irradiance), this register will read NAN. | ratio | 0    | 1   |
| 40361    | F32       | R          | Daily Soiling Ratio - Rear      | This value is the rear-facing daily soiling ratio average.                                                                                                                                                                                                                                                                                          | ratio | 0    | 1   |
| 40363    | F32       | R          | Daily Soiling Ratio Num Samples | Number of samples used to calculate the daily soiling ratio                                                                                                                                                                                                                                                                                         |       | 0    |     |

Table 7-7: Modbus soiling data registers

| Register | Data type | Read/Write | Measurement                | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Units | Min. | Max |
|----------|-----------|------------|----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|------|-----|
| 40365    | F32       | R          | Soiling Ratio Sample – Isc | <p>This value represents the most recent individual Isc soiling ratio sample and is updated each time a new sample is taken. This measurement is provided for monitoring individual readings. (The associated timestamp registers indicate when the most recent individual sample was taken.)</p> <p>For assessing soiling conditions, use the Daily Soiling Ratio. The Daily Soiling Ratio is recommended because it is calculated from the average of all individual samples collected during the day's sampling window and provides the better representative indication of soiling.</p> |       |      |     |

Table 7-7: Modbus soiling data registers

| Register | Data type | Read/Write | Measurement                 | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Units | Min. | Max |
|----------|-----------|------------|-----------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|------|-----|
| 40367    | F32       | R          | Soiling Ratio Sample – Pmax | <p>This value represents the most recent individual Pmax soiling ratio sample and is updated each time a new sample is taken. This measurement is provided for monitoring individual readings. (The associated timestamp registers indicate when the most recent individual sample was taken.)</p> <p>For assessing soiling conditions, use the Daily Soiling Ratio. The Daily Soiling Ratio is recommended because it is calculated from the average of all individual samples collected during the day's sampling window and provides the better representative indication of soiling.</p> |       |      |     |
| 40369    | F32       | R          | Soiling Ratio Sample - Rear | <p>This value represents the most recent individual rear-facing soiling ratio sample and is provided for monitoring individual readings. Use the daily ratio register for the average of all the individual samples during the day's sampling window.</p>                                                                                                                                                                                                                                                                                                                                    |       |      |     |
| 40401    | F32       | R          | IV Curve (Voltage)          | Starting register for IV Curve Voltages (79 values)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | V     |      |     |

| Table 7-7: Modbus soiling data registers |           |            |                       |                                                                                                                                                                                                                                                                                                                 |       |      |     |
|------------------------------------------|-----------|------------|-----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|------|-----|
| Register                                 | Data type | Read/Write | Measurement           | Description                                                                                                                                                                                                                                                                                                     | Units | Min. | Max |
| 40559                                    | F32       | R          | IV Curve (Current)    | Starting register for IV Curve Currents (79 values)                                                                                                                                                                                                                                                             | A     |      |     |
| 40717                                    | F32       | R          | IV Curve Sample Count | <p>This register increments throughout the day every time a soiling ratio sample is taken. The register will be updated after all the IV Curve Voltage and Current registers have been updated.</p> <p>Once this value updates, the IV curve registers will not change again for sampling interval minutes.</p> |       |      |     |

## 8. Maintenance and troubleshooting

|                                         |    |
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### 8.1 Updating firmware

#### CAUTION:

Updating the firmware may result in loss of historic data and settings from the sensor.

1. Find the DustVue 20 operating system at [www.campbellsci.com/downloads](http://www.campbellsci.com/downloads), click **Download Now**, and click **Save File**. This will download a .web.obj.gz file on your computer.
2. Use a USB C cable to connect the DustVue 20 USB port to a computer USB port.
3. Access the web UI (see [QuickStart](#) [p. 3]).
4. Click the **Diagnostics** tab.
5. Click **Updates**.

## Diagnostics

The screenshot shows the 'Diagnostics' section with two tabs: 'Watch' and 'Updates'. The 'Updates' tab is selected. Below the tabs is a header 'Update'. The main content area shows 'Installed Version: dustvue20 1.04 Beta 08' and a link 'Change Log'. A yellow warning box contains the text: 'A device update will take several minutes. The device will be unresponsive while the update is performed.' At the bottom of the section is an orange button labeled 'Update from File'.

6. Click **Update from File**.

The screenshot shows a 'Device Update' dialog box. It contains the text: 'The device update will take several minutes. The device will be unresponsive while the update is performed.' Below this is a yellow warning box with the text: 'Warning: The update process may result in lost data. You may wish to first collect the data from the device by visiting the **Monitor Data** page, selecting the tables you wish to save, and clicking the **Collect Data** button.' At the bottom, it asks 'Are you sure you wish to perform the device update?' and has two buttons: 'Begin' (orange) and 'Cancel' (gray).

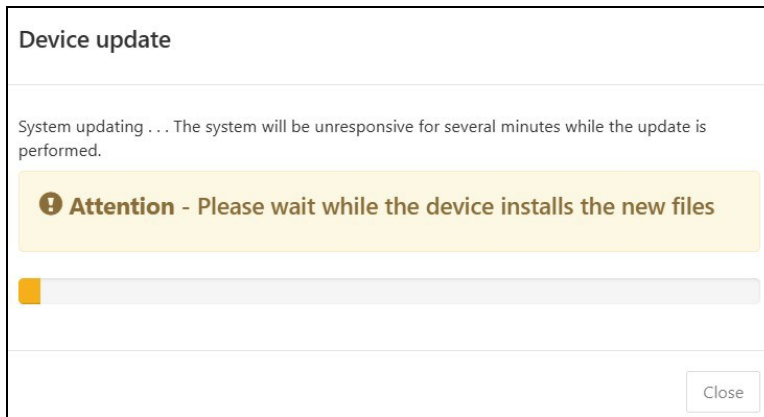
7. Click **Begin**.

8. Select the file. The file will end in a .web.obj.gz extension (for example, dustvue20\_1.00.web.obj.gz). The operating system will start downloading.

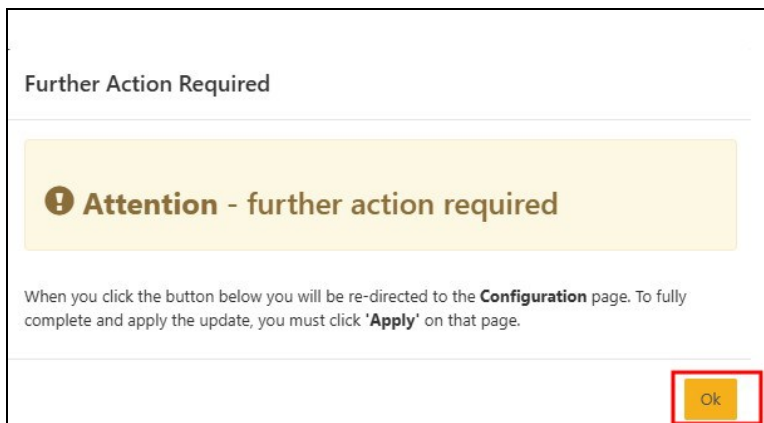
**CAUTION:**

Do not remove power or disconnect the device during the operating system download.

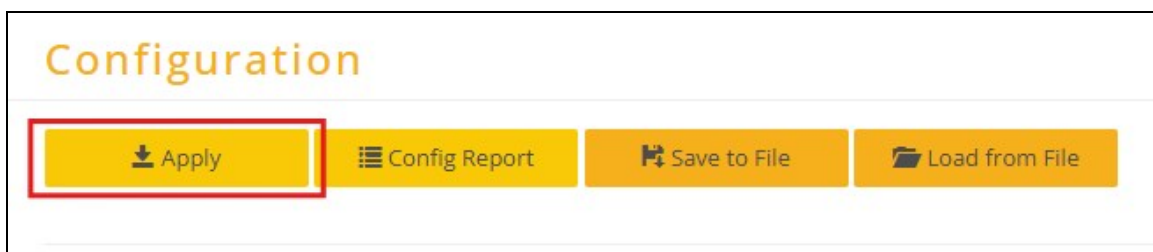
9. The device will take a few minutes to update its files. Wait until the device finishes completely before navigating away from this page.



10. Click **Ok** to navigate to the **Configuration** page.



11. On the **Configuration** page, click **Apply** to finish and complete the update.



12. Remove the USB cable.

## 8.2 Downloading data tables

The DustVue 20 is a Modbus RTU on RS-485. It can connect directly to a SCADA system or be integrated with any device capable of reading Modbus on RS-485, such as Campbell Scientific data loggers. A list of our compatible data loggers is available on the product web page.

The DustVue 20 can also store a local copy of historic data that can be downloaded using the web UI if needed.

## 8.3 Calibration and recalibration

The DustVue 20 provides a soiling ratio, which is a relative measurement between collocated sensors. As such, it does not require radiometric calibration of the sensors. A relative calibration between clean and soiled cells is all that is needed, and it should be performed in the field after installation.

## 8.4 Maintenance

The sensor measures soiling ratio by comparing outputs from two collocated PV reference cells. To get a good representative measurement, periodically check the clean reference cells and clean them when needed. Typically, the cleaning schedule can be every 6 to 12 months.

However, Campbell Scientific suggests cleaning both the soiled and reference cells whenever the solar plant is cleaned. This resets the soiling ratio.

It is best practice to also perform an Offsets Update every time the sensor is cleaned.

The DustVue 20 has a clock that should be set on every site visit or at least once every six months. The **Dashboard** page displays the current time and the clock can be set on this page. The clock can also be set using Modbus. It is a good practice to program the SCADA system to set the clock at a fixed interval.

## 8.5 Troubleshooting

The following is a list of some common problems and their suggested solutions.

| Table 8-1: Problems and suggested solutions                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|---------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Problems                                                                                                                  | Suggested solutions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| No measurement shown on <b>Dashboard</b>                                                                                  | <ul style="list-style-type: none"> <li>• Check for the configuration for all location and timing settings</li> <li>• Ensure that sensor clock displaying correct time</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| Some of the <b>Device Status</b> fields are empty.                                                                        | Navigate to the <b>Configuration</b> page, verify the settings, and click <b>Apply to Station</b> .                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| NAN (not a number) reported for the <b>Soiling Ratio</b>                                                                  | <ul style="list-style-type: none"> <li>• NAN are reported before a soiling ratio measurement has been taken after initial setup.</li> <li>• Check the <b>Sampling Window</b>, <b>Sampling Interval</b> and <b>Sample Status</b> to see when the next sample is expected to be taken. Make any adjustments to the <b>Sampling Window</b> or <b>Sampling Interval</b> via the <b>Configuration</b> page.</li> <li>• Try manually triggering a soiling ratio measurement by clicking <b>Trigger Soiling Ratio</b>. At the top of the next minute, a soiling ratio measurement should begin. The cover will open, a measurement will be taken, the cover will close, and the soiling ratio values should update.</li> <li>• If the above steps do not work, check the cover for problems. Check the <b>Motor Status</b> value. Try clicking <b>Open Cover</b>. The cover should open and the <b>Motor Status</b> should say <b>OK</b>. Close the cover by clicking the button again. If the cover will not open and close without error, maintenance is required.</li> </ul> |
| Missing or unexpected information is displayed on the <b>Dashboard</b> , <b>Monitor Data</b> , or <b>Diagnostics</b> page | <ul style="list-style-type: none"> <li>• Your browser may be loading some old files from cache which could be causing problems. Try forcing the browser to retrieve a fresh copy of the page thus ignoring cached content. The method for doing this varies across browsers but is typically performed by holding <b>Shift</b> or <b>Ctrl</b> while clicking the refresh button. Another common way is by pressing <b>Shift+F5</b>, or <b>Ctrl+F5</b>.</li> <li>• Or you can try clearing your browsers history and cache.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |

| Table 8-1: Problems and suggested solutions                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|----------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Problems                                                                   | Suggested solutions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| The motor is making a clicking sound and a motor jammed error is displayed | The voltage might be too low. Increase the source voltage or shorten the connecting cable length.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| The sensor is getting unreasonable values for irradiance                   | <ul style="list-style-type: none"> <li>• Check that the solar module is connected securely to the DustVue 20. Check the MC4 connectors. If it feels warm, there might be loose contact.</li> <li>• The offsets might be bad. Check the offsets by navigating to the <b>Monitor Data</b> page. If the Offset_Applied values are not close to 1, do another offset update or try a factory reset. A factory reset will reset the offsets to 1 and will bring the values back within reason.</li> </ul> <p><b>NOTE:</b><br/>A factory reset will also reset all settings and clear data tables.</p> <p>Following a factory reset, an offset should be performed in the field after the unit has been installed to calibrate the soiling ratio measurement.</p> |
| The device solar noon is not correct                                       | The device measures the soiling ratio during a prescribed period centered around solar noon called the <b>Sampling Window</b> . An accurate solar noon calculation is necessary for proper device operation. If the solar noon calculation is not correct, check the <b>Latitude</b> , <b>Longitude</b> , <b>Altitude</b> , and <b>UTC Offset</b> settings. These settings can be set via the <b>Configuration</b> page, or via Modbus. Also check that the sensor time has been set correctly. The time can be set via the <b>Dashboard</b> or via Modbus.                                                                                                                                                                                                 |

# Appendix A. Example program

A downloadable example program is available at:

[www.campbellsci.com/resources/software/dustvue-20-example-program](http://www.campbellsci.com/resources/software/dustvue-20-example-program) .

## CRBasic Example 1: CR1000X-series program that measures the DustVue 20

```
'CR1000X Series Data Logger
'
' -----
' | Title: DustVue20 Example Program (CR1000Xe) |
' | Notes: Use this program as a template to create your |
' | program to read and write to the registers on |
' | your new DustVue 20 Sensor. |
' | -----
'
' Wiring Diagram
' |-----|-----|
' |Function | Pin | Color*| Wire Termination |
' |-----|-----|
' | Power + 1 | Red | Power Supply + |
' |-----|-----|
' | Power - | 4 | Black | Power Supply - |
' |-----|-----|
' | RS-485 (A-) 5 | Blue | C Odd |
' |-----|-----|
' | RS-485 (B+) 2 | White | C Even |
' |-----|-----|
' | RS-485 Common 3 | Green | G |
' |-----|-----|
' (*) = With current RS485CBL cables
'
' -----
' Public Variables
' -----
Public SoilingData(7)
Public MBRes(6)
Public OpenCover As Boolean
Public System_Status As String * 250
Public Measurement_Status As String * 250
Public Measurement_Flags As String * 250
Public Debug_Test_Set_Time As Boolean = False
Public DV_Time(6)
' -----
' Private Variables
' -----
Dim Bits(4) = {1, 2, 4, 8} ' define Bits(4) to use in bitwise compare
Dim BitwiseFlags(3) = {NAN, NAN, NAN} ' define BitwiseFlags(3) to store bitwise flags
Dim rTime(9) ' define rTime(9) to store real time values
' -----
' Aliases
```

## CRBasic Example 1: CR1000X-series program that measures the DustVue 20

```

' -----
Alias SoilingData(1) = Daily_Soiling_Ratio_Isc
Alias SoilingData(2) = Daily_Soiling_Ratio_Pmax
Alias SoilingData(3) = Daily_Soiling_Ratio_Rear
Alias SoilingData(4) = Daily_Soiling_Num_Samples
Alias SoilingData(5) = Soiling_Ratio_Sample_Isc
Alias SoilingData(6) = Soiling_Ratio_Sample_Pmax
Alias SoilingData(7) = Soiling_Ratio_Sample_Rear

Alias MBRes(1) = MBRes_DailySoiling
Alias MBRes(2) = MBRes_StatusCode
Alias MBRes(3) = MBRes_WriteMotorReg
Alias MBRes(4) = MBRes_WriteClockRegs
Alias MBRes(5) = MBRes_WriteClock
Alias MBRes(6) = MBRes_ReadClock

Alias rTime(1) = Year ' assign the alias Year to rTime(1)
Alias rTime(2) = Month ' assign the alias Month to rTime(2)
Alias rTime(3) = DOM ' assign the alias DOM to rTime(3)
Alias rTime(4) = Hour ' assign the alias Hour to rTime(4)
Alias rTime(5) = Minute ' assign the alias Minute to rTime(5)
Alias rTime(6) = Second ' assign the alias Second to rTime(6)
Alias rTime(7) = uSecond ' assign the alias uSecond to rTime(7)
Alias rTime(8) = WeekDay ' assign the alias WeekDay to rTime(8)
Alias rTime(9) = Day_of_Year ' assign the alias Day_of_Year to rTime(9)
' -----
' Tables
' -----
' Const table to allow user to edit settings
ConstTable(UserVars,0)
  Const MAddr = 1
  Const BaudRate = 19200
  Const Format = 2
  Const TXDelay = 0
  Const BufferSize = 0
EndConstTable

' Daily Soiling Information
DataTable(DataSet_Soiling,1,-1)
  DataInterval(0,1,Min,10)
  Sample(7,SoilingData,Float)
  Sample(3,BitwiseFlags(),Float)
EndTable

' -----
' Functions
' -----
Function DecodeStatCode(number)
  If number = NAN Then
    System_Status = "Error: No status received from DV Unit. Check Communication"
  ElseIf number = 0 Then
    System_Status = "OK"
  Else
    ' Compile status string

```

## CRBasic Example 1: CR1000X-series program that measures the DustVue 20

```

System_Status = ""
If((number AND Bits(1)) > 0) Then System_Status += "Cover Error, "
If((number AND Bits(2)) > 0) Then System_Status += "Motor lockout (low voltage), "
If((number AND Bits(3)) > 0) Then System_Status += "Backup battery voltage is low, "
If((number AND &HFF0000) Then System_Status += "IV curve error, "

' Trim off last comma/space
System_Status = Left(System_Status, Len(System_Status)-2)
EndIf
EndFunction

Function DecodeMeasStatCode(number)
If number = NAN Then
Measurement_Status = "Error: No status recieved from DV Unit. Check Communication"
ElseIf number = 0 Then
Measurement_Status = "OK"
Else
' Compile Meas Status String
Measurement_Status = ""
If((number AND Bits(1)) > 0) Then Measurement_Status += "Irradiance is below opening threshold, "
If((number AND Bits(2)) > 0) Then Measurement_Status += "Irradiance is not stable enough to open, "
If((number AND Bits(3)) > 0) Then Measurement_Status += "Open cover triggered by user (will not sample), "
If((number AND Bits(4)) > 0) Then Measurement_Status += "Prevent open triggered by user (will not sample), "

' Trim off last comma/space
Measurement_Status = Left(Measurement_Status, Len(Measurement_Status)-2)
EndIf
EndFunction

Function DecodeMeasCode(number)
If number = NAN Then
Measurement_Flags = "Error: No status recieved from DV Unit. Check Communication"
ElseIf number = 0 Then
Measurement_Flags = "OK"
Else
' Compile status string
Measurement_Flags = ""
If((number AND Bits(1)) > 0) Then Measurement_Flags += "Soiling ratio measurement is outside normal range, "
If((number AND Bits(2)) > 0) Then Measurement_Flags += "Soiling ratio rear measurement is outside normal range, "

' Trim off last comma/space
Measurement_Flags = Left(Measurement_Flags, Len(Measurement_Flags)-2)
EndIf
EndFunction

' -----
' Sub Routines
' -----

Sub CoverOpen()
Dim OpenCoverRegValue
If OpenCover = True Then OpenCoverRegValue = 1 Else OpenCoverRegValue = 0
'If OpenCoverRegValue is non-zero, this commands the DustVue to open.
'If OpenCoverRegValue is zero, the cover will operate normally
ModbusClient(MBRes_WriteMotorReg, ComC1, BaudRate, MBAddr, 16, OpenCoverRegValue, 203, 1, 3, 50, 2)
EndSub

```

## CRBasic Example 1: CR1000X-series program that measures the DustVue 20

```
Sub SetTime()  
  ' Set time once an hour  
  If (IfTime (0,24,Hr) OR Debug_Test_Set_Time) Then  
    RealTime (rTime()) ' Get the current time  
    Dim TIMESET = 1 ' The value to set the TimeSet register (register 113) to  
  
    ' Write the Time year, month, day, hour, minute, and second to their respective registers  
    ModbusClient(MBRes_WriteClockRegs,ComC1,BaudRate,MBAAddr,16,rTime(),101,6,3,50,2)  
  
    ' If we successfully wrote to each register set the time  
    If MBRes_WriteClockRegs = 0 Then  
      ModbusClient(MBRes_WriteClock,ComC1,BaudRate,MBAAddr,16,TIMESET,113,1,3,50,2)  
    EndIf  
  
    ' Set Debug_Test_Set_Time to False to avoid repeating the routine if it was manually triggered  
    Debug_Test_Set_Time = False  
  EndIf  
EndSub  
  
' -----  
'Main Program  
' -----  
BeginProg  
  ' Open ComC1 for Modbus Communications  
  SerialOpen (ComC1,BaudRate,Format,TXDelay,BufferSize,4)  
  
  Scan (1,Sec,0,0)  
    ' get daily soiling ratio data  
    ModbusClient(MBRes_DailySoiling,ComC1,BaudRate,MBAAddr,3,SoilingData(),357,7,3,50,2)  
  
    ' get the status codes  
    ModbusClient(MBRes_StatusCode,ComC1,BaudRate,MBAAddr,3,BitwiseFlags(),251,3,3,50,2)  
    If MBRes_StatusCode <> 0 Then BitWiseFlags() = NAN  
  
    ' get the current time from the DustVue  
    ModbusClient(MBRes_ReadClock,ComC1,BaudRate,MBAAddr,3,DV_Time(),257,6,3,50,2)  
  
    ' Call Sub Routines to open the cover and set the time if conditions are met  
    Call CoverOpen()  
    Call SetTime()  
  
    ' Decode the bitwise status code returned via Modbus  
    DecodeStatCode(BitwiseFlags(1))  
    DecodeMeasStatCode(BitwiseFlags(2))  
    DecodeMeasCode(BitwiseFlags(3))  
  
    ' Populate tables  
    CallTable(DataSet_Soiling)  
  NextScan  
EndProg
```

# Limited warranty

---

Covered equipment is warranted/guaranteed against defects in materials and workmanship under normal use and service for the period listed on your sales invoice or the product order information web page. The covered period begins on the date of shipment unless otherwise specified. For a repair to be covered under warranty, the following criteria must be met:

1. There must be a defect in materials or workmanship that affects form, fit, or function of the device.
2. The defect cannot be the result of misuse.
3. The defect must have occurred within a specified period of time; and
4. The determination must be made by a qualified technician at a Campbell Scientific Service Center/ repair facility.

The following is not covered:

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2. Batteries; and
3. Any equipment which has been subjected to misuse, neglect, acts of God or damage in transit.

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# Assistance

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Products may not be returned without prior authorization. Please inform us before returning equipment and obtain a **return material authorization (RMA) number** whether the repair is under warranty/guarantee or not. See [Limited warranty](#) for information on covered equipment.

Campbell Scientific regional offices handle repairs for customers within their territories. Please see the back page of the manual for a list of [regional offices](#) or visit [www.campbellsci.com/contact](http://www.campbellsci.com/contact)  to determine which Campbell Scientific office serves your country.

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It is the policy of Campbell Scientific to protect the health of its employees and provide a safe working environment. In support of this policy, when equipment is returned to Campbell Scientific, Logan, UT, USA, it is mandatory that a “[Declaration of Hazardous Material and Decontamination](#)” form be received before the return can be processed. If the form is not received within 5 working days of product receipt or is incomplete, the product will be returned to the customer at the customer’s expense. For details on decontamination standards specific to your country, please reach out to your [regional Campbell Scientific](#) office.

## NOTE:

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# Safety

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DANGER — MANY HAZARDS ARE ASSOCIATED WITH INSTALLING, USING, MAINTAINING, AND WORKING ON OR AROUND TRIPODS, TOWERS, AND ANY ATTACHMENTS TO TRIPODS AND TOWERS SUCH AS SENSORS, CROSSARMS, ENCLOSURES, ANTENNAS, ETC. FAILURE TO PROPERLY AND COMPLETELY ASSEMBLE, INSTALL, OPERATE, USE, AND MAINTAIN TRIPODS, TOWERS, AND ATTACHMENTS, AND FAILURE TO HEED WARNINGS, INCREASES THE RISK OF DEATH, ACCIDENT, SERIOUS INJURY, PROPERTY DAMAGE, AND PRODUCT FAILURE. TAKE ALL REASONABLE PRECAUTIONS TO AVOID THESE HAZARDS. CHECK WITH YOUR ORGANIZATION'S SAFETY COORDINATOR (OR POLICY) FOR PROCEDURES AND REQUIRED PROTECTIVE EQUIPMENT PRIOR TO PERFORMING ANY WORK.

Use tripods, towers, and attachments to tripods and towers only for purposes for which they are designed. Do not exceed design limits. Be familiar and comply with all instructions provided in product manuals. Manuals are available at [www.campbellsci.com](http://www.campbellsci.com) You are responsible for conformance with governing codes and regulations, including safety regulations, and the integrity and location of structures or land to which towers, tripods, and any attachments are attached. Installation sites should be evaluated and approved by a qualified engineer. If questions or concerns arise regarding installation, use, or maintenance of tripods, towers, attachments, or electrical connections, consult with a licensed and qualified engineer or electrician.

## General

- Protect from over-voltage.
- Protect electrical equipment from water.
- Protect from electrostatic discharge (ESD).
- Protect from lightning.
- Prior to performing site or installation work, obtain required approvals and permits. Comply with all governing structure-height regulations, such as those of the FAA in the USA.
- Use only qualified personnel for installation, use, and maintenance of tripods and towers, and any attachments to tripods and towers. The use of licensed and qualified contractors is highly recommended.
- Read all applicable instructions carefully and understand procedures thoroughly before beginning work.
- Wear a hardhat and eye protection, and take other appropriate safety precautions while working on or around tripods and towers.
- Do not climb tripods or towers at any time, and prohibit climbing by other persons. Take reasonable precautions to secure tripod and tower sites from trespassers.
- Use only manufacturer recommended parts, materials, and tools.

## Utility and Electrical

- You can be killed or sustain serious bodily injury if the tripod, tower, or attachments you are installing, constructing, using, or maintaining, or a tool, stake, or anchor, come in contact with overhead or underground utility lines.
- Maintain a distance of at least one-and-one-half times structure height, 6 meters (20 feet), or the distance required by applicable law, whichever is greater, between overhead utility lines and the structure (tripod, tower, attachments, or tools).
- Prior to performing site or installation work, inform all utility companies and have all underground utilities marked.
- Comply with all electrical codes. Electrical equipment and related grounding devices should be installed by a licensed and qualified electrician.
- Only use power sources approved for use in the country of installation to power Campbell Scientific devices.

## Elevated Work and Weather

- Exercise extreme caution when performing elevated work.
- Use appropriate equipment and safety practices.
- During installation and maintenance, keep tower and tripod sites clear of un-trained or non-essential personnel. Take precautions to prevent elevated tools and objects from dropping.
- Do not perform any work in inclement weather, including wind, rain, snow, lightning, etc.

## Internal Battery

- Be aware of fire, explosion, and severe-burn hazards.
- Misuse or improper installation of the internal lithium battery can cause severe injury.

- Do not recharge, disassemble, heat above 100 °C (212 °F), solder directly to the cell, incinerate, or expose contents to water. Dispose of spent batteries properly.

#### Use and disposal of batteries

- Where batteries need to be transported to the installation site, ensure they are packed to prevent the battery terminals shorting which could cause a fire or explosion. Especially in the case of lithium batteries, ensure they are packed and transported in a way that complies with local shipping regulations and the safety requirements of the carriers involved.
- When installing the batteries follow the installation instructions very carefully. This is to avoid risk of damage to the equipment caused by installing the wrong type of battery or reverse connections.
- When disposing of used batteries, it is still important to avoid the risk of shorting. Do not dispose of the batteries in a fire as there is risk of explosion and leakage of harmful chemicals into the environment. Batteries should be disposed of at registered recycling facilities.

#### Avoiding unnecessary exposure to radio transmitter radiation

- Where the equipment includes a radio transmitter, precautions should be taken to avoid unnecessary exposure to radiation from the antenna. The degree of caution required varies with the power of the transmitter, but as a rule it is best to avoid getting closer to the antenna than 20 cm (8 inches) when the antenna is active. In particular keep your head away from the antenna. For higher power radios (in excess of 1 W ERP) turn the radio off when servicing the system, unless the antenna is installed away from the station, e.g. it is mounted above the system on an arm or pole.

#### Maintenance

- Periodically (at least yearly) check for wear and damage, including corrosion, stress cracks, frayed cables, loose cable clamps, cable tightness, etc. and take necessary corrective actions.
- Periodically (at least yearly) check electrical ground connections.

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