Product Manual

Sensor

# RainVUE-Series

## SDI-12 Precipitation Sensors


Revision: 11/2022



CSL I.D - 1359

RELIABLE SINCE 1974 MONITORING

CAMPBELL® SCIENTIFIC

# Guarantee

This equipment is guaranteed against defects in materials and workmanship. We will repair or replace products which prove to be defective during the guarantee period as detailed on your invoice, provided they are returned to us prepaid. The guarantee will not apply to:

- Equipment which has been modified or altered in any way without the written permission of Campbell Scientific
- Batteries
- Any product which has been subjected to misuse, neglect, acts of God or damage in transit.

Campbell Scientific will return guaranteed equipment by surface carrier prepaid. Campbell Scientific will not reimburse the claimant for costs incurred in removing and/or reinstalling equipment. This guarantee and the Company's obligation thereunder is in lieu of all other guarantees, expressed or implied, including those of suitability and fitness for a particular purpose. Campbell Scientific is not liable for consequential damage.

Please inform us before returning equipment and obtain a Repair Reference Number whether the repair is under guarantee or not. Please state the faults as clearly as possible, and if the product is out of the guarantee period it should be accompanied by a purchase order. Quotations for repairs can be given on request. 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 a "Declaration of Hazardous Material and Decontamination" form will be issued for completion.

When returning equipment, the Repair Reference Number must be clearly marked on the outside of the package. Complete the "Declaration of Hazardous Material and Decontamination" form and ensure a completed copy is returned with your goods. Please note your Repair may not be processed if you do not include a copy of this form and Campbell Scientific Ltd reserves the right to return goods at the customers' expense.

Note that goods sent air freight are subject to Customs clearance fees which Campbell Scientific will charge to customers. In many cases, these charges are greater than the cost of the repair.

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# About this manual

Please note that this manual was originally produced by Campbell Scientific Inc. primarily for the North American market. Some spellings, weights and measures may reflect this origin.

Some useful conversion factors:

| | | | |
|---|---|---|---|
| **Area:** | 1 $in^2$ (square inch) = 645 $mm^2$ | **Mass:** | 1 oz. (ounce) = 28.35 g<br>1 lb (pound weight) = 0.454 kg |
| **Length:** | 1 in. (inch) = 25.4 mm<br>1 ft (foot) = 304.8 mm<br>1 yard = 0.914 m<br>1 mile = 1.609 km | **Pressure:** | 1 psi ($lb/in^2$) = 68.95 mb |
| | | **Volume:** | 1 UK pint = 568.3 ml<br>1 UK gallon = 4.546 litres<br>1 US gallon = 3.785 litres |

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 European 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 British/European use. *Please note, however, that when a power supply adapter is ordered it will be suitable for use in your country.*

Reference to some radio transmitters, digital cell phones and aerials 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 European market; in some cases alternatives are offered. Details of the alternatives will be covered in separate manuals.

Part numbers prefixed with a "#" symbol are special order parts for use with non-EU variants or for special installations. Please quote the full part number with the # when ordering.

## Recycling information

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 products life should be removed from the product and also be sent to an appropriate recycling facility.

Campbell Scientific Ltd 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 advice or support, please contact Campbell Scientific Ltd, or your local agent.

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# Safety

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.eu or by telephoning +44(0) 1509 828 888 (UK). 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**

- 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, or 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.

**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.

**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.

WHILE EVERY ATTEMPT IS MADE TO EMBODY THE HIGHEST DEGREE OF SAFETY IN ALL CAMPBELL SCIENTIFIC PRODUCTS, THE CUSTOMER ASSUMES ALL RISK FROM ANY INJURY RESULTING FROM IMPROPER INSTALLATION, USE, OR MAINTENANCE OF TRIPODS, TOWERS, OR ATTACHMENTS TO TRIPODS AND TOWERS SUCH AS SENSORS, CROSSARMS, ENCLOSURES, ANTENNAS, ETC.

# Table of contents

# 1. Introduction

The RainVUE-series rain sensors are an ideal solution for many hydrological or meteorological applications such as weather stations and flood warning systems. The models differ in their body material; the RainVUE™10 has a moulded UV-stabilized plastic body, and the RainVUE™20 has a rugged aluminium body. In both models, a microprocessor corrects for rainfall intensity and outputs an SDI-12 signal to communicate with any SDI-12 recorder, including Campbell Scientific data loggers.

> NOTE:
> The RainVUE-series rain sensors are compatible with all data loggers that support SDI-12 communications. This manual focuses on Campbell Scientific CRBasic data loggers.

# 2. Precautions

- READ AND UNDERSTAND the Safety section at the front of this manual.
- RainVUE-series is a precision instrument that must be handled with care.
- During installation, remove the piece of foam from under the tipping mechanism. This foam should be saved and used whenever the sensor is transported.
- Pull and remove the insulator tab used to prevent draining of the backup coin cell battery during shipping and storage. The tab extends from the bottom of the RainVUE-series interface to inside the RainVUE-series.

# 3. Initial inspection

- Check the packaging and contents of the shipment. If damage occurred during transport, immediately file a claim with the carrier. Contact Campbell Scientific to facilitate repair or replacement.
- Check model information against the shipping documents to ensure the expected products and the correct lengths of cable are received. Model numbers are found on each product.

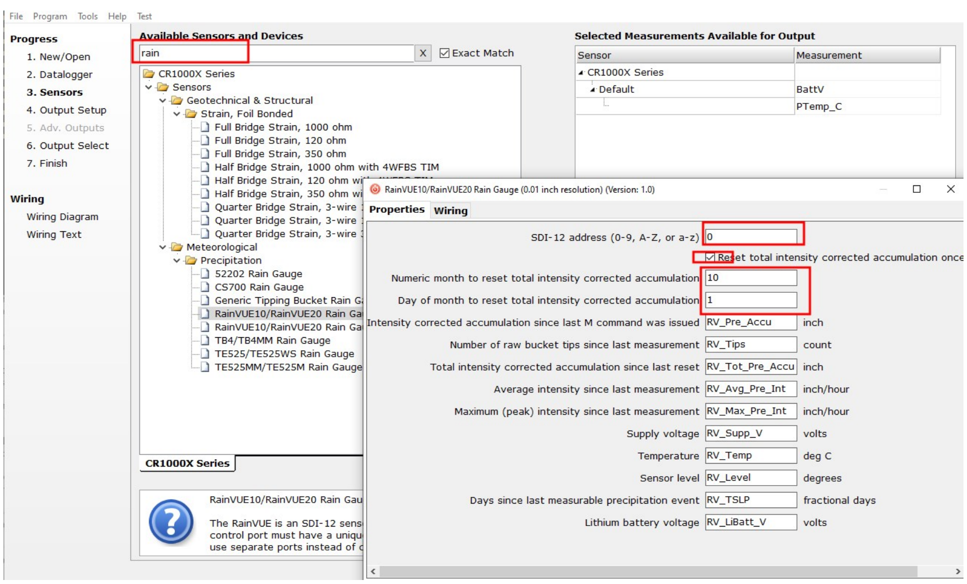
On cables and cabled items, the model number is usually found at the connection end of the cable. Report any discrepancies immediately to Campbell Scientific.

# 4. QuickStart

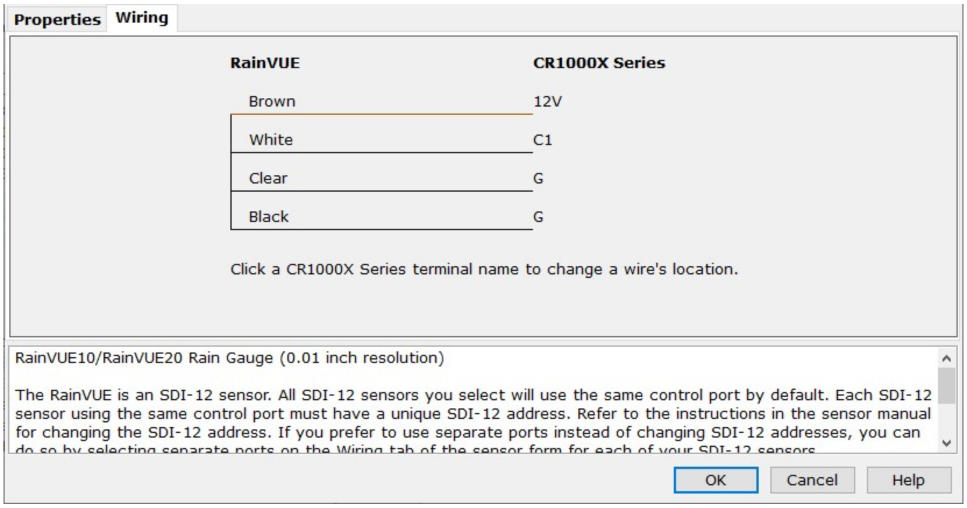
A video that describes data logger programming using ***Short Cut*** is available at: www.campbellsci.eu/videos/cr1000x-data logger-getting-started-program-part-3. ***Short Cut*** is an easy way to program your data logger to measure the sensor and assign data logger wiring terminals. ***Short Cut*** is available as a download on www.campbellsci.eu. It is included in installations of ***LoggerNet***, ***RTDAQ***, and ***PC400***.

The following procedure shows how to use ***Short Cut*** to program the RainVUE-series:

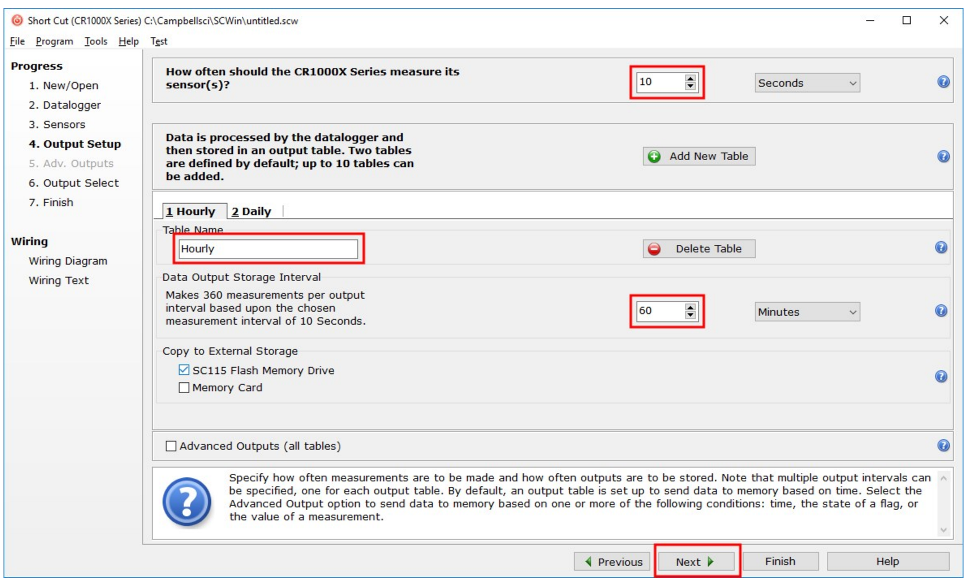
1. Open ***Short Cut*** and click **Create New Program**.
2. Double-click the data logger model.
3. In the **Available Sensors and Devices** box, type RainVUE or find it in the **Sensors** > **Meteorological** > **Precipitation** folder, and double-click **RainVUE10/RainVUE20 Rain Gauge**. Enter the correct **SDI-12 address** for the sensor if it has been changed from the factory-set default value. Type the numeric month and day for resetting the total accumulation, if you want to do this. Otherwise, uncheck the **Reset total intensity corrected accumulation once a year** box.



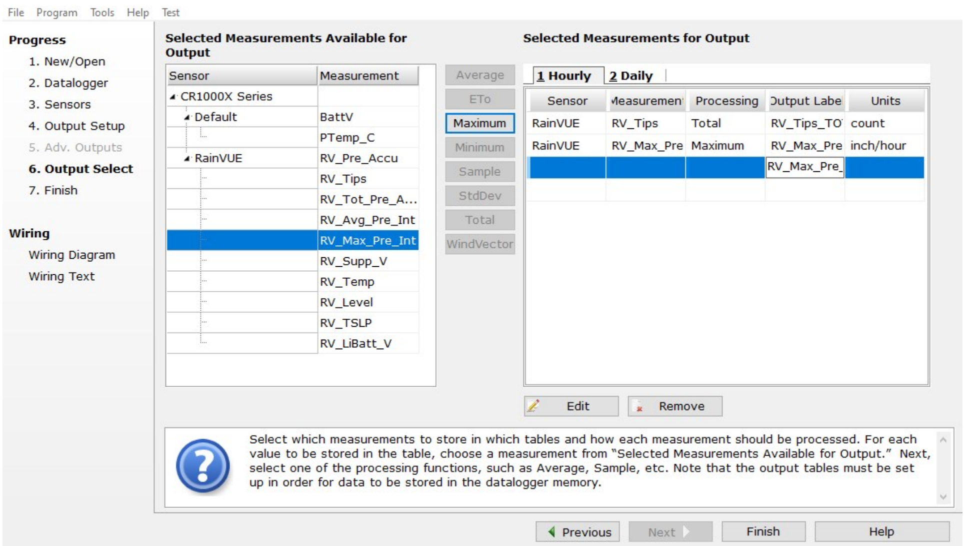
4. Click the **Wiring** tab, wire the sensor, then click **OK**.




5. Repeat steps three and four for other sensors you want to measure. Click **Next**.
6. In **Output Setup**, type the scan rate, a **Table Name**, and **Data Output Storage Interval**. Click **Next**.



7. Select the output options.




8. Click **Finish** and save the program. Send the program to the data logger if the data logger is connected to the computer.

9. If the sensor is connected to the data logger, check the output of the sensor in the data display in ***LoggerNet***, ***RTDAQ***, or ***PC400*** to make sure it is making reasonable measurements.

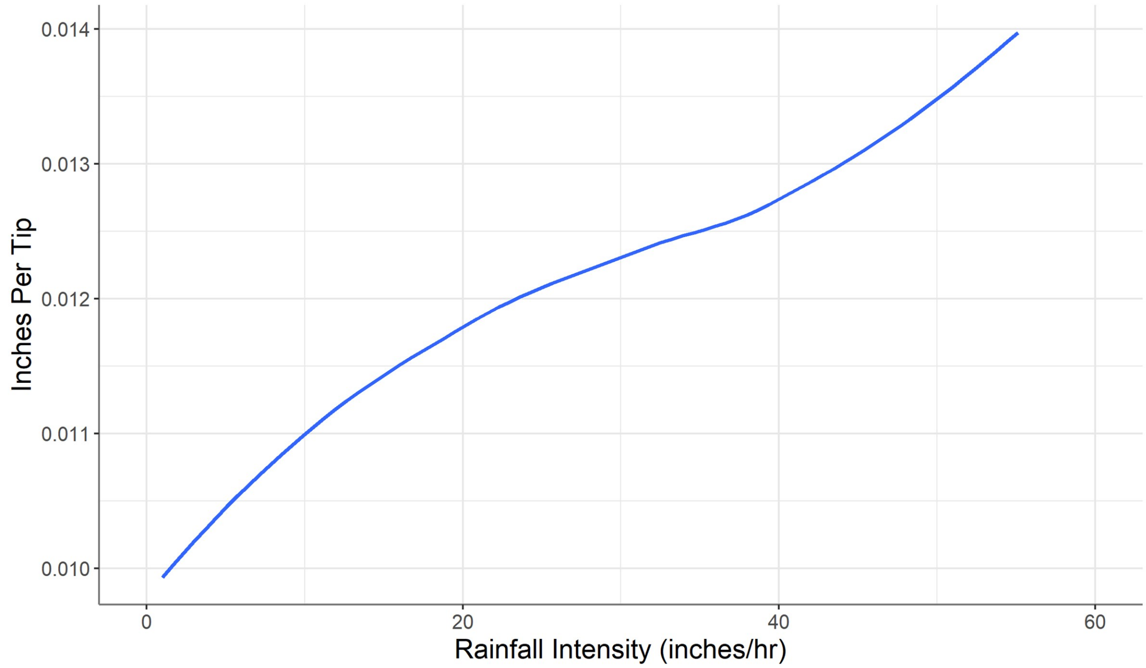
# 5. Overview

The RainVUE-series funnels rainfall through a stainless-steel screen that traps debris, preventing it from impeding the flow of precipitation. Rainfall flows through a nozzle into one of two bucket halves. The internal tipping mechanism assembly rotates around a pivot point. The tipping mechanism tips when the first bucket fills to a fixed calibrated level, then the tipping mechanism moves the second bucket under the funnel. A magnet attached to the tipping mechanism actuates a reed switch as the bucket tips. The outgoing water drains through outlets.

The aerodynamic design of the RainVUE-series reduces the amount of rain that wind carries away from the collecting vessel. With traditional cylindrical tipping bucket rain sensors, wind can reduce the rainfall catch by up to 20 percent. The RainVUE-series also includes a microprocessor that corrects for rainfall intensity and outputs an SDI-12 signal.

During intense rainfall, extra water can accumulate in the bucket before the tipping mechanism tips. The following graph shows the relationship between bucket volume and rainfall rate. The RainVUE-series microprocessor corrects for the intensity sensitivity of the bucket mechanism.

This correction adjusts the rainfall rate based on the time between bucket tips. An electronic timer precisely measures the time between tips.




**Features:**

- Suitable for non-freezing precipitation and high intensity rain events
- Digital processing to correct for high intensity precipitation errors (see Specifications [p. 5])
- Unique aerodynamic shape increases measurement accuracy in windy conditions
- Compliance with WMO recommendations for accuracy and funnel area
- Adjustable mounting feet to simplify levelling
- Tilt, internal temperature, and voltage measurements for remote diagnostics on the sensor
- Compatible with CRBasic data loggers: GRANITE-series, CR6, CR1000X, CR800-series, CR350-series, CR300-series, CR3000, CR1000

# 6. Specifications

| | |
|---|---|
| **Sensor type:** | Tipping bucket with magnetic reed switch |
| **Output:** | SDI-12 version 1.4 |
| **Response time:** | 0 s for `M0!` command and 1 s for `M1!` command |
| **Tilt uncertainty:** | ±1 ° |

| | |
|---|---|
| **Temperature uncertainty:** | ±0.25 °C (±0.45 °F) |
| **Supply voltage uncertainty:** | ±0.5 V |
| **Operating temperature:** | 1 to 70 °C (34 to 158 °F); –40 to 70 °C (–40 to 158 °F) including melting snow |
| **Funnel diameter:** | 20.0 cm (7.87 in) |
| **Height:** | 43.5 to 46.5 cm (17.1 to 18.3 in) with feet adjustment |
| **Power:** | 6 to 18 VDC |
| **Compliance:** | WMO compliant: 0.1 mm option only<br>View compliance documents at:<br>www.campbellsci.eu/rainvue10<br>www.campbellsci.eu/rainvue20 |

Table 6-1: RainVUE-series comparison

| Specification | RainVUE 10 | RainVUE 20 |
|---|---|---|
| **Measurement range** | 0.01 inch option: 0 to 1200 mm/hr (0 to 48 in/hr)<br>0.1 mm option: 0 to 500 mm/hr (0 to 19.7 in/hr)<br>0.2 mm option: 0 to 1000 mm/hr (0 to 39.4 in/hr) | 0.01 inch option: 0 to 1200 mm/hr (0 to 48 in/hr)<br>0.1 mm option: 0 to 600 mm/hr (0 to 23.6 in/hr |
| **Precipitation amount resolution** | 0.01 inch option: 0.254 mm (0.01 in)<br>0.1 mm option: 0.1 mm (0.004 in)<br>0.2 mm option: 0.2 mm (0.008 in) | 0.01 inch option: 0.254 mm (0.01 in)<br>0.1 mm option: 0.1 mm (0.004 in) |

Table 6-1: RainVUE-series comparison

| Specification | RainVUE 10 | RainVUE 20 |
|---|---|---|
| **Precipitation amount measurement uncertainty (mm/tip or in/tip)** | 0.01 inch option: ±1% at 0 to 1200 mm/hr (0 to 48 in/hr) intensity<br>0.1 mm option: The larger of 0.1 mm or 4% error at 0 to 500 mm/h intensity (0 to 19.7 in/h intensity)<br>0.2 mm option: < 4% at 0 to 1000 mm/h intensity (0 to 39.4 in/h intensity) | 0.01 inch option: ±1% at 0 to 500 mm/hr (0 to 20 in/hr) intensity<br>0.1 mm option: ±3.08% at 0 to 20 mm/hr (0 to 0.8 in/hr); ±3.6% at 20 to 600 mm/hr (0.8 to 24 in/hr) intensity |
| **Precipitation intensity measurement uncertainty (mm/hr or in/hr)**[1] | 0.1 mm option: ≤ 3.5% at 0 to 300 mm/h (7.9 to 11.8 in/hr); ≤ 5% at 0 to 500 mm/h (11.8 to 19.7 in/hr)<br>0.2 mm option: ±4% at 200 to 1,000 mm/hr (7.9 to 39.4 in/hr) intensity | 0.01 inch option: ±1% at 0 to 500 mm/hr (0 to 19.7 in/hr) intensity<br>0.1 mm option: ±3.58% at 20 to 600 mm/hr (0.8 to 23.6 in/hr) intensity |
| **Material** | White, ASA LI-911 plastic | Main collector body: 2 mm thick, powder-coated aluminium<br>Base: LM6 marine-grade aluminium |
| **Weight** | 2 kg (4.5 lb) | 6 kg (13 lb) |

[1]Accuracy over the rain intensity range requires a mechanical calibration that is within 1 percent at a 1 in/hr intensity. RainVUE-series sensors are calibrated at the factory to meet this specification but should be verified prior to deployment; see Calibration validation.

# 7. Installation

If you are programming your data logger with ***Short Cut***, skip Wiring (p. 8) and Data logger programming (p. 8), as ***Short Cut*** does this work for you. See QuickStart (p. 2) for a ***Short Cut*** tutorial.

# 7.1 Wiring

Connect the wires in the order shown in the following table.

Table 7-1: Wire colour and function and data logger connection

| Wire colour | Wire function | Data logger connection |
|---|---|---|
| White | SDI-12 signal | **C** or **U** configured for SDI-12[1] |
| Clear | Shield | **G** |
| Brown | Power | **12V** |
| Black | Power ground | **G** |

[1]**U** and **C** terminals are automatically configured by the `SDI12Recorder()` instruction.

If multiple SDI-12 sensors are connected to a data logger, Campbell Scientific recommends using separate terminals when possible. However, multiple SDI-12 sensors can connect to the same data logger control or **U** terminal. Each must have a unique SDI-12 address. Valid addresses are 0 through 9, a through z, and A through Z.

For the CR6 and CR1000X data loggers, triggering conflicts may occur when a companion terminal is used for a triggering instruction such as `TimerInput()`, `PulseCount()`, or `WaitDigTrig()`. For example, if the RainVUE-series is connected to **C3** on a CR1000X, then **C4** cannot be used in the `TimerInput()`, `PulseCount()`, or `WaitDigTrig()` instructions.

# 7.2 Data logger programming

***Short Cut*** is the best source for up-to-date programming code for Campbell Scientific data loggers. If your data acquisition requirements are simple, you can probably create and maintain a data logger program exclusively with ***Short Cut***. If your data acquisition needs are more complex, the files that ***Short Cut*** creates are a great source for programming code to start a new program or add to an existing custom program.

> NOTE:
> ***Short Cut*** cannot edit programs after they are imported and edited in ***CRBasic Editor***.

A ***Short Cut*** tutorial is available in QuickStart (p. 2). If you wish to import ***Short Cut*** code into ***CRBasic Editor*** to create or add to a customized program, follow the procedure in Importing Short Cut code into CRBasic Editor (p. 34). Programming basics for CRBasic data loggers are provided in the following section.

## 7.2.1 CRBasic programming

The SDI12Recorder() instruction is used to measure a RainVUE-series. This instruction sends a request to the sensor to make a measurement and then retrieves the measurement from the sensor. See SDI-12 measurements (p. 15) for more information.

For most data loggers, the SDI12Recorder() instruction has the following syntax:

```
SDI12Recorder(Destination, SDIPort, SDIAddress, “SDICommand”, Multiplier, Offset,
FillNAN, WaitonTimeout)
```

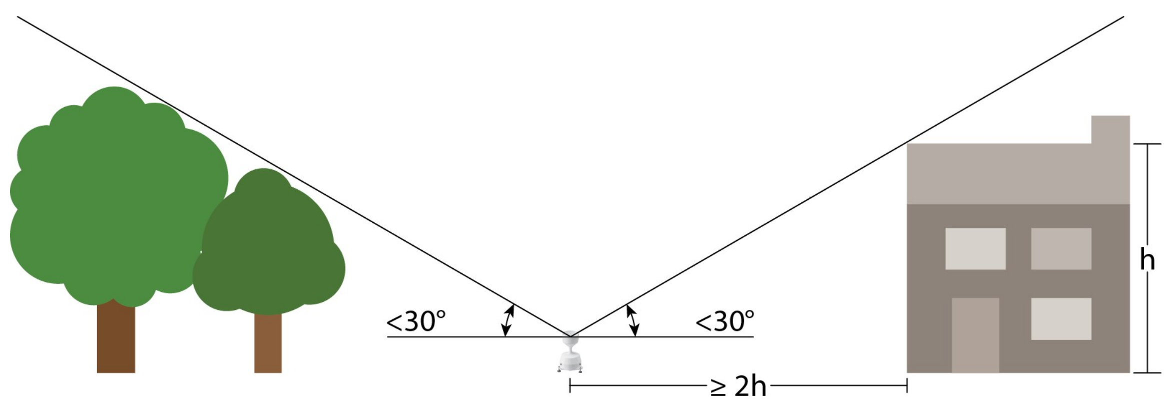
For the SDIAddress, alphabetical characters need to be enclosed in quotation marks (for example, “A”). Also enclose the SDICommand in quotation marks as shown. The Destination parameter must be an array. The required number of values in the array depends on the command (see Table 8-1 [p. 16]).

FillNAN and WaitonTimeout are optional parameters (refer to CRBasic Help for more information).

A downloadable example program is available at www.campbellsci.eu/downloads/rainvue-example-program.

# 7.3 Siting

Mount the RainVUE-series in a relatively level location representative of the surrounding area. Ensure that the funnel is horizontal. Place the sensor away from objects that obstruct the wind at a distance of at least two times the height of the obstruction. A concrete pad is recommended, but the RainVUE-series should not be installed over a large paved or concrete surface.




# 7.4 Mounting

The RainVUE-series has three equally spaced levelling feet. Next to each levelling foot is a hole for securing the sensor to a flat surface. The CM241 mounting bracket offered by Campbell Scientific allows the RainVUE-series to be mounted on a CM300-series mounting pole or to a user-supplied 1.5-inch IPS (1.9-inch OD) unthreaded pipe.

Mounting poles may be placed directly into a concrete foundation, attached to a concrete foundation with J-bolts, or self supported with three legs (see Figure 7-1 [p. 10]).

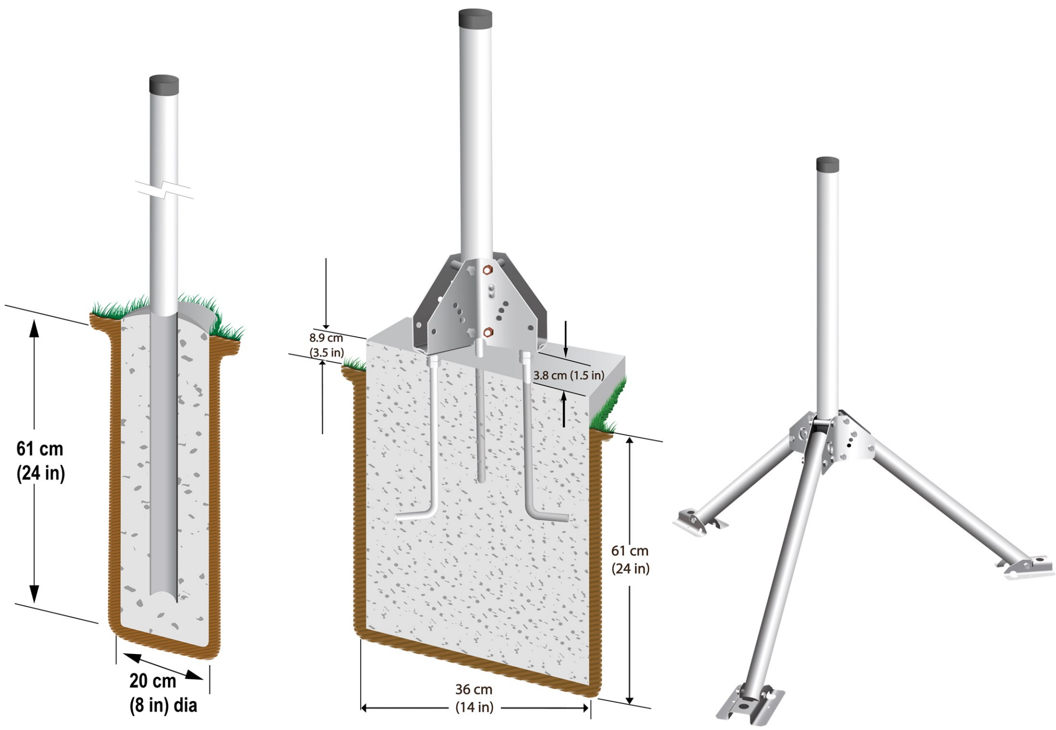



*Figure 7-1. CM300-series mounting options*

The procedure for mounting to a CM241 bracket and levelling the sensor is as follows:

1. Attach the feet to the sensor using the nuts and washers provided. The hardware used to mount the feet are shipped in a bag with the feet.

*Figure 7-2. RainVUE-series feet*

2. Loosen and remove the three base thumb screws, then lift the funnel upward.


*Figure 7-3. Thumb screw on RainVUE 20*

3. Remove the wing nuts and washers from the CM241 mounting bracket.

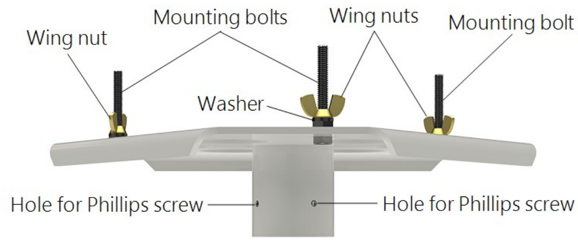



*Figure 7-4. CM241 mounting bracket*

4. Line up the RainVUE-series mounting holes over the CM241 mounting bolts and place the sensor on the bracket.

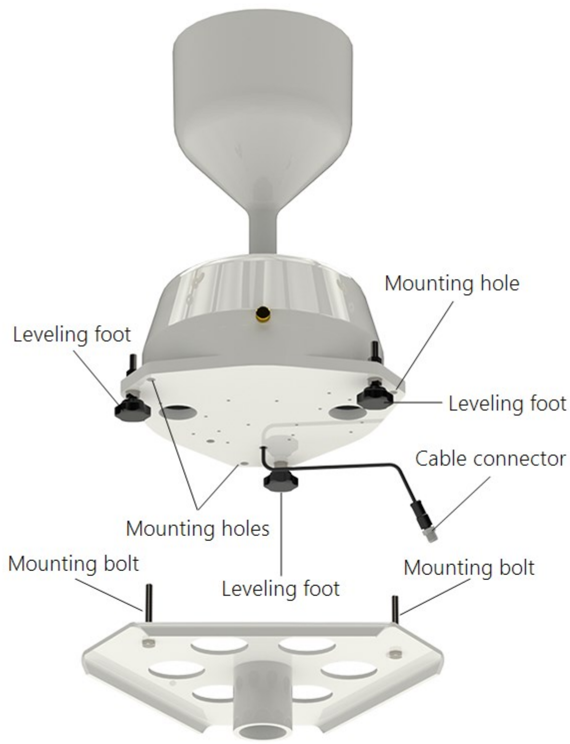



*Figure 7-5. Exploded view of RainVUE-series and CM241 bracket; wing nuts and pole not shown*

5. Loosely secure the RainVUE-series to the CM241 using the washers and wing nuts.
6. Place the CM241 on the pole or pipe and secure it to the pole or pipe by tightening the screws with a Phillips screwdriver (see Figure 7-4 [p. 12] and Figure 7-8 [p. 14]).

7. Adjust the three levelling feet to level the RainVUE-series. The RainVUE 10 has a bubble level next to a levelling foot; the RainVUE 20 bubble level is visible after removing the funnel. See Figure 7-6 (p. 13).


*Figure 7-6. Bubble level locations on the RainVUE-series*

8. Once the RainVUE-series is level, tighten the wing nuts by hand and recheck the level.
9. During installation, remove the piece of foam from under the tipping mechanism. This foam should be saved and used whenever the sensor is transported.
10. Tip the tipping assembly several times to ensure the tipping mechanism can move freely.

11. Pull and remove the insulator tab used to prevent draining of the backup coin cell battery during shipping and storage. The tab extends from the bottom of the RainVUE-series interface to inside the RainVUE-series.


*Figure 7-7. RainVUE-series interface and insulator tab*

12. Replace the funnel and tighten the three base thumb screws to secure the funnel to the base.

*Figure 7-8. RainVUE-series mounted on a pole*

13. Join the extension cable connector to the cable connector. Only hand tighten the connectors.

# 8. Operation

This section discusses the following:



## 8.1 SDI-12 measurements

The RainVUE-series responds to the SDI-12 measurement commands shown in Table 8-1 (p. 16). When the data logger issues an `M!` command, the sensor should respond immediately indicating how long it will take to perform the measurement. The data logger then waits that amount of time or, if the sensor finishes sooner, the sensor will send a service request to the data logger indicating data can be collected. After receiving the service request or waiting the indicated time, the data logger will send the `D!` command to collect the data.

The `C!` command follows the same pattern as an `M!` command, except it does not require the data logger to pause its operation until the values are ready. Rather, the data logger retrieves the data with the `D!` command on the next scan through the program. Another measurement request is then sent so that data is ready on the next scan.

> **NOTE:**
> SDI-12 sensor support (p. 37) describes the SDI-12 commands. Additional SDI-12 information is available at www.sdi-12.org.

| Table 8-1: SDI-12 measurement commands | | | |
|---|---|---|---|
| **SDI-12 command[1]** | **Values returned** | **Units** | **Comments** |
| *a*`M!`, *a*`MC!`, *a*`C!`, *a*`CC!`, *a*`R0!`, *a*`RC0!` | 1. Intensity corrected accumulation (ICA) since last measurement accumulator reset[2]<br>2. Number of raw bucket tips since last measurement accumulator reset[2]<br>3. Total intensity corrected accumulation since total intensity accumulator reset[3]<br>4. Average precipitation intensity since last measurement accumulator reset[2]<br>5. Maximum (peak) intensity since last measurement accumulator reset[2] | 1. mm or inch<br>2. Count<br>3. mm or inch<br>4. mm/hr or in/hr<br>5. mm/hr or in/hr | Each tip event adds to the tip counter (#2) and computes the values described in Calculations (p. 21).<br>Commands reset measurement accumulator |
| *a*`M1!` | 1. Supply voltage<br>2. Temperature<br>3. Sensor level<br>4. Time since last measurable precipitation event<br>5. Lithium battery voltage | 1. VDC<br>2. °C<br>3. Degrees from normal, flat<br>4. Days<br>5. VDC | |
| *a*`MC1!`, *a*`C1!`, *a*`CC1!`, *a*`RC1!` | 1. Supply voltage<br>2. Temperature<br>3. Sensor level<br>4. Time since last measurable precipitation event<br>5. Lithium battery voltage | 1. VDC<br>2. °C<br>3. Degrees from normal, flat<br>4. Days<br>5. VDC | Commands reset measurement accumulator |

| Table 8-1: SDI-12 measurement commands | | | |
|---|---|---|---|
| **SDI-12 command[1]** | **Values returned** | **Units** | **Comments** |
| *a*`R9!` | 1. Intensity corrected accumulation since last measurement accumulator reset[2]<br>2. Number of raw bucket tips since last measurement accumulator reset[2]<br>3. Total intensity corrected accumulation since total intensity accumulator reset[3]<br>4. Average precipitation intensity since last measurement accumulator reset[2]<br>5. Maximum (peak) intensity since last measurement accumulator reset[2] | 1. mm or inch<br>2. Count<br>3. mm or inch<br>4. mm/hr or in/hr<br>5. mm/hr or in/hr | Each tip event adds to the tip counter (#2) and computes the values described in Calculations (p. 21).<br>Command does not reset accumulators |
| *a*`I!` | *a*14CampbellRainVU *vvv*SN=*xxxxxxx*<br>SDI-12 address: *a*<br>SDI-12 version: 14<br>Vendor: Campbell<br>Model: RainVU<br>Model version: *vvv*<br>RainVUE 10 (0.01 in) = 10i<br>RainVUE 10 (0.1 mm) = 10m<br>RainVUE 10 (0.2 mm) = 10n<br>RainVUE 20 (0.01 in) = 20i<br>RainVUE 20 (0.1 mm) = 20m<br>Serial number: SN=*xxxxxxx* | Not applicable (NA) | |

| Table 8-1: SDI-12 measurement commands | | | |
|---|---|---|---|
| **SDI-12 command[1]** | **Values returned** | **Units** | **Comments** |
| *a*`V!` | 1. Operating system (OS) version<br>2. Hardware revision starting at 1<br>3. Reset code<br>2 = Power on<br>11 = OS update<br>12 = Watchdog timeout | NA | |

[1]*a* is the sensor address. In the `SDI12Recorder()` CRBasic instruction, the command parameter does not include the SDI-12 address because the address is a separate parameter.

[2]The *a*`M!`, *a*`MC!`, *a*`MC1!`, *a*`C!`, *a*`C1!`, *a*`CC!`, *a*`CC1!`, *a*`RC0!`, and *a*`RC1!` commands reset the measurement accumulator.

[3]The total intensity accumulator is reset using the *a*`XWARA!`, *a*`XWA+`*xx.xx*`!`, or *a*`XWRESET!` commands. Refer to SDI-12 extended commands for more information.

# 8.2 SDI-12 extended commands

Enter the SDI-12 extended commands in Table 8-2 (p. 18) using the transparent mode while the computer is communicating with the data logger through a terminal emulator program. It is accessed through Campbell Scientific ***Device Configuration Utility*** software or other terminal emulator programs. Data logger keyboards and displays cannot be used. Refer to SDI-12 transparent mode (p. 44) for more information.

| Table 8-2: SDI-12 extended commands | | |
|---|---|---|
| **SDI-12 command[1]** | **Values returned or function** | **Comments** |
| `XRDT!` | Reads sensor date and time. | |
| *a*`XWDT+`*MM/DD/YYYY hh:mm:ss*`!` | Writes date and time. | |
| *a*`XWARA!` | Extended write adjusted rainfall accumulator command; resets the total adjusted rain accumulator to 0.00. | Typically this command is issued on the start of the water year, often October 1 or January 1. |

Table 8-2: SDI-12 extended commands

| SDI-12 command[1] | Values returned or function | Comments |
|---|---|---|
| *a*XWA+*xx.xx*!<br>(where *xx.xx* = current rain value) | Resets the total adjusted rain to a current value and returns the number of values.<br>Follow this command with the *a*D0! command to get the new adjusted rain. | Used when replacing the RainVUE-series midway through a water year. |
| *a*XWRESET! | Resets all accumulators. | |
| *a*XWD! | Resets RTC or 24 hour tick counter to midnight. | This command is a simple way for data loggers to sync the time clock without having to format the SDI-12 command. |
| *a*XWTILT! | Zero tilt sensor (XWTILT) status; returns a status flag indicating the success of the levelling process.<br>s = 0 Success<br>s = 1 Error (cannot zero the sensor) | Mechanically balance the sensor, then issue this command. |
| *a*XRTILT! | Reads the tilt angle (degrees) of the tilt sensor. | When this command is issued right after the sensor is zeroed, it should return 0.00 degrees, verifying the RainVUE-series is level. |
| *a*XTEST! | Returns two lines of header information, then returns updated data at every tip and every 2 seconds or until a break is detected with each line terminated with a <CR><LF>. | Command is only intended for testing and debugging the sensor; refer to Calibration validation (p. 35) for detailed information about using this command. |
| *a*XHELP! | Lists the standard measurement and extended commands supported by the RainVUE-series. | Command is only intended for testing and debugging the sensor. |

| Table 8-2: SDI-12 extended commands | | |
|---|---|---|
| SDI-12 command[1] | Values returned or function | Comments |
| *a*XRCAL! | Returns bucket calibration setting. | |
| *a*XWCAL+*x.xxxx*! (where *x.xxxx* = calibration factor) | Writes bucket calibration setting; returns 01 if it worked correctly. | |
| [1]*a* is the sensor address. | | |

# 8.3 SDI-12 version 1.4 identify measurement commands and responses

Version 1.4 compliant sensors must respond to identify commands for each type of measurement command and each parameter with a command. The broad identify commands return how many variables will be returned with a given measurement command and the time it will take the sensor to respond. The specific identify parameter commands will return a SHEF code, the measurement units, and the type of measurement (sample, count, or average). For more information, see the SDI-12 version 1.4 specification: http://sdi-12.org/current_specification/SDI-12_version-1_4-Jan-10-2019.pdf.

| Table 8-3: Identify commands for the RainVUE-series | | | |
|---|---|---|---|
| Type of command | Command | Sensor response | Comment |
| Identify measurement for M commands | *a*IM!, *a*IMC!, *a*IM1!, *a*IMC1! | atttn | ttt: response time (seconds)<br>n: # of values returned |
| Identify measurement for C commands | *a*IC!, *a*ICC!, *a*IC1!, *a*ICC1! | atttnn | ttt: response time (seconds)<br>nn: # of values returned |
| Identify measurement for the V command | *a*IV! | atttn | ttt: response time (seconds)<br>n: # of values returned |

| Table 8-3: Identify commands for the RainVUE-series | | | |
|---|---|---|---|
| **Type of command** | **Command** | **Sensor response** | **Comment** |
| Identify measurement parameter 001 of M command | *a*IM_001! | aAdjRain,Inches or aAdjRain,mm | AdjRain: adjusted or intensity-corrected precipitation since last measurement<br>Units: inches or mm |
| Identify measurement parameter 002 of M command | *a*IM_002! | aRawTips,Tips | RawTips: number of raw bucket tips since last measurement (counts)<br>Units: counts |
| Identify measurement parameter 003 of M command | *a*IM_003! | aTotAdjRain,Inches or aTotAdjRain,mm | TotAdjRain: total adjusted or total intensity-corrected precipitation since last reset<br>Units: inches or mm |
| Identify measurement parameter 004 of M command | *a*IM_004! | aAvgInt,Inches/Hour or aAvgInt,mm/Hour | AvgInt: average precipitation intensity since last measurement<br>Units: inches/hour or mm/hour |
| Identify measurement parameter 005 of M command | *a*IM_005! | aMaxInt,Inches/Hour or aMaxInt,mm/Hour | MaxInt: maximum peak precipitation intensity since last measurement<br>Units: inches/hour or mm/hour |

# 8.4 Calculations

Reported measurement values in the measurement commands (M, MC, C, CC, R0, RC0, or R9) are as follows:

1. Intensity Correct Accumulation (ICA) since last measurement accumulator reset[1] (inches)
2. Number of tips since last measurement accumulator reset[1]

3. Total accumulation since last reset (inches)[2]
4. Average precipitation intensity since last measurement accumulator reset[1] (in/hr)
5. Max intensity since last measurement accumulator reset[1] (in/hr)

[1]The *a*`M!`, *a*`MC!`, *a*`MC1!`, *a*`C!`, *a*`C1!`, *a*`CC!`, *a*`CC1!`, and *a*`RC1!` commands reset the measurement accumulator.

[2]The total intensity accumulator is reset using the *a*`XWARA!`, *a*`XWA+`*xx.xx*`!`, or *a*`XWRESET!` commands. Refer to Table 8-2 (p. 18) for more information.

1. Intensity Corrected Accumulation (ICA) calculation:

   ICA is the amount of water in HEIGHT for the tip based on the time interval between tips. An algorithm generates a compensated value to account for flow rates above the mechanical calibrated flow rate. Without correction, intensity rates higher than the mechanical calibrated flow rate will under-count the rainfall amount. The intensity is determined by time between tips, and each tip is adjusted giving the best performance possible. For example, when the RainVUE-series has the 0.01-inch tip option, instead of applying 0.01 inch for each tip, the algorithm generates a compensated value to account for flow rates >1 in/hr.

2. Number of tips calculation:

   Each tip event adds to the tip counter.

3. Total accumulation calculation:

   New total accumulation = total accumulation + ICA

4. Average precipitation intensity calculation:

   For each tip, the following equation is used to calculate intensity:

   Intensity (over tip interval) = h/tbt * sec_per_hr = height [in or mm]/hour **Eq. 1**

   Where:

   h = height [in or mm] or ICA

   tbt = time between tips [sec]

   sec_per_hr = 3600 sec/hr

   Each intensity value is added to an accumulator.

   The accumulator is divided by the number of samples (tips) since the last measurement request (*a*`M!`, *a*`MC!`, *a*`MC1!`, *a*`C!`, *a*`C1!`, *a*`CC!`, *a*`CC1!`, or *a*`RC1!` command).

   Avg_Intensity = accum_intensity_values / num_samples since last measurement request (*a*`M!`, *a*`MC!`, *a*`MC1!`, *a*`C!`, *a*`C1!`, *a*`CC!`, *a*`CC1!`, or *a*`RC1!` command).

5. Max intensity calculation:

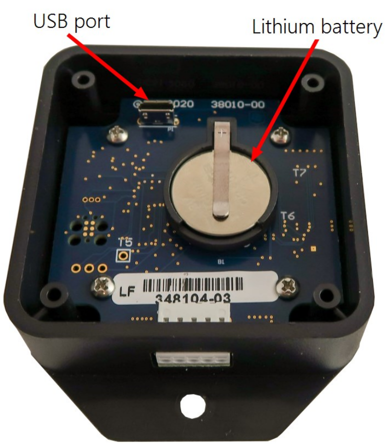
   This is the largest of the calculated intensity values observed since last measurement request (*a*`M!`, *a*`MC!`, *a*`MC1!`, *a*`C!`, *a*`C1!`, *a*`CC!`, *a*`CC1!`, or *a*`RC1!` command).

## 8.5 *Device Configuration Utility*

Use ***Device Configuration Utility*** to change the SDI-12 address, view sensor measurements, collect data, and update an operating system (see Updating the operating system [p. 31]).

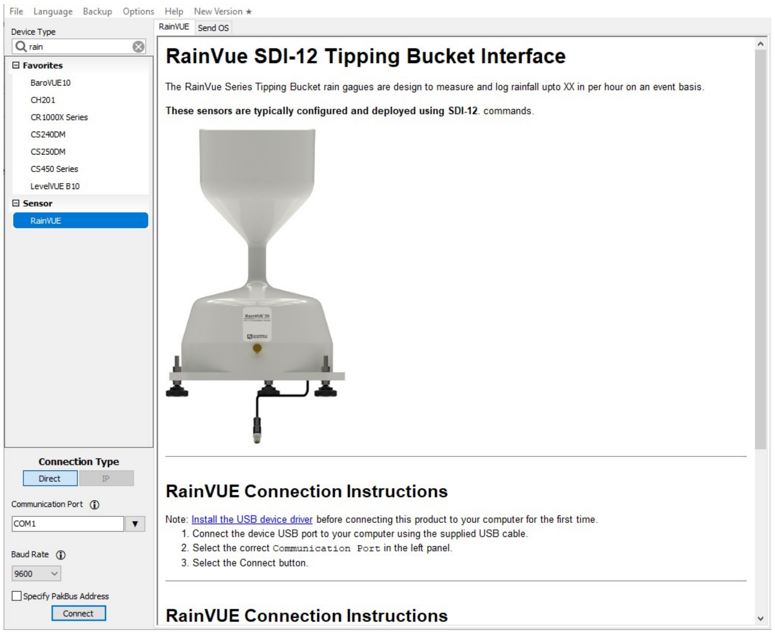
1. Loosen and remove the three base thumb screws, then lift the funnel upward.
2. Use a Phillips screwdriver to remove the four screws on the RainVUE-series interface.


3. Remove the interface cover to access the USB port.




4. Open ***Device Configuration Utility***.

5. Type RainVUE in the **Device Type** box and click RainVUE. The model and tip option is selected in step 10.

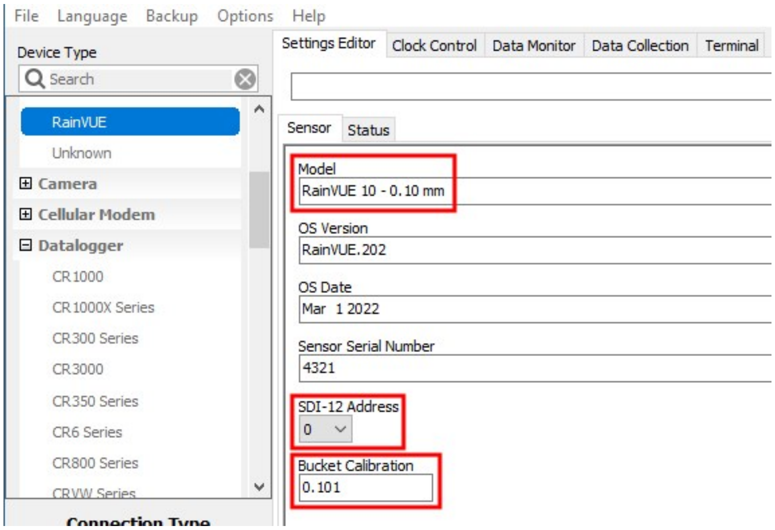



6. If this is the first time connecting the RainVUE-series to the computer, click **install the USB device driver** before connecting the cable to the computer.
7. Use the supplied USB cable to connect the RainVUE-series USB port to the computer USB port.
8. Select the **Communication Port** in the left panel. **RAINVUE** will appear in the selection dialog.

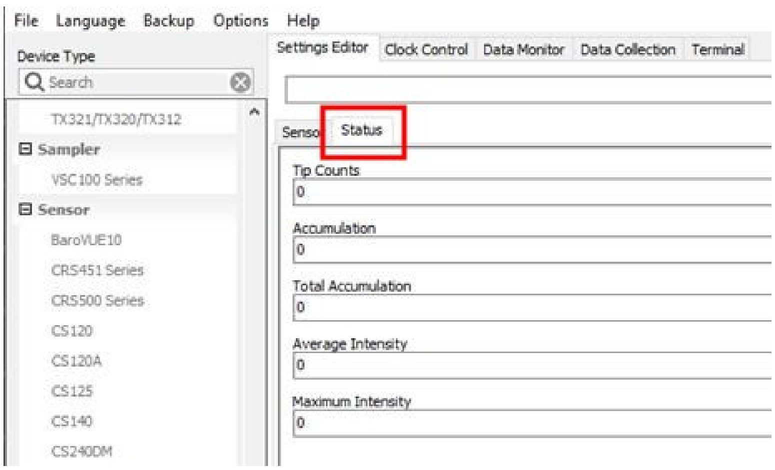
> **NOTE:**
> It may take a few seconds for the **Communication Port** to become available for use after physically connecting the RainVUE-series to the computer.

9. Click **Connect**.

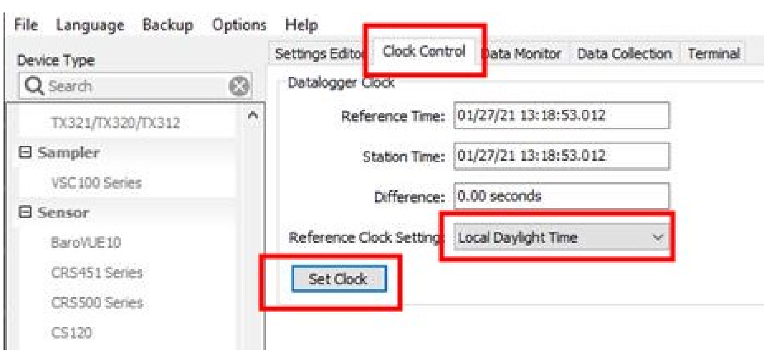
10. Select the **Model**. To change the SDI-12 address, click the **SDI-12 Address** box and select a different value. Type the calibration in the **Bucket Calibration** box.



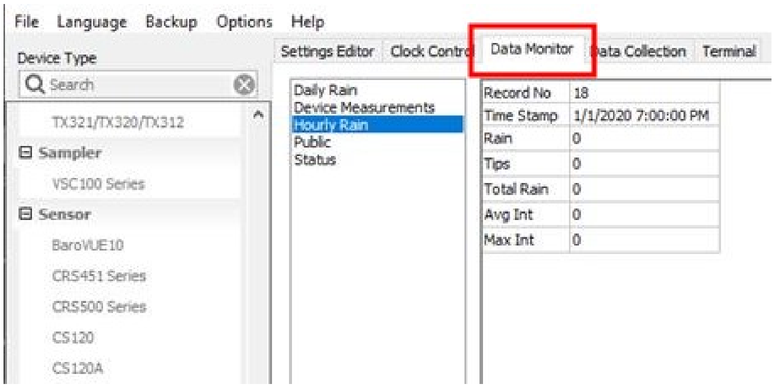

11. Click the **Status** tab to view tip counts, accumulation, and intensity information.



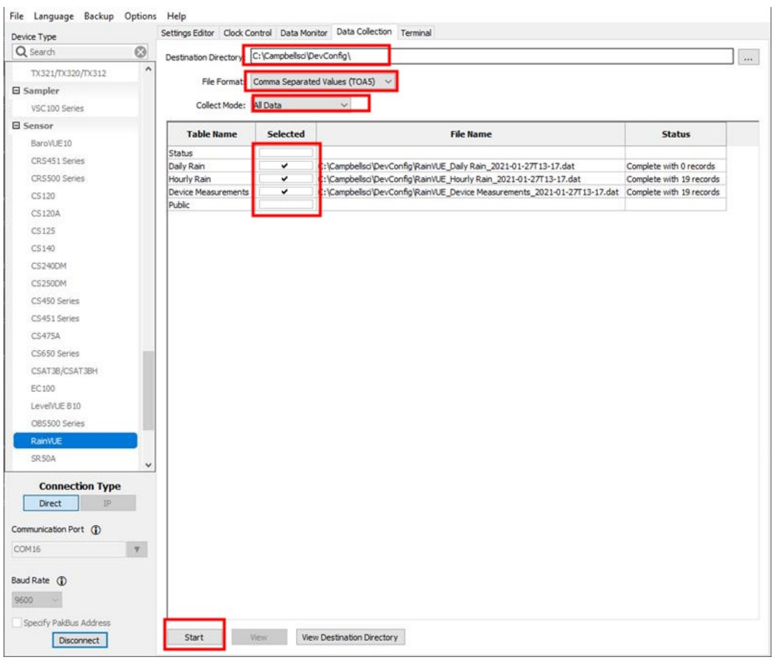

12. Click the **Clock Control** tab to change the **Reference Clock Setting**. Click **Set Clock** to manually initiate a clock check of the reference time and station time.



13. Click the **Data Monitor** tab to view real-time data. From the list, select the table you want to display.




14. Click the **Data Collection** tab to manually collect data. Check the **Destination Directory** and **File Format** to make sure the files are where you want them and in the right format. Select **Collect Mode**, tables, then click **Start**.



The following shows data collected from an hourly rain table:

RainVUE_Hourly Rain_2021-02-17.dat - Notepad

File Edit Format View Help

```
"TOA5","RainVUE","201","200","RainVUE.201","RainVUE","58570","Hourly Rain"
"TIMESTAMP","RECORD","Rain","Tips","Total Rain","Avg Int","Max Int"
"TS","RN","Inches","Tips","Inches","In/Hr","In/Hr"
"","","Smp","Smp","Smp","Smp","Smp"
"2021-02-16 13:00:00",194,0.08018232,8,0.08018232,0.9281653,2.487704
"2021-02-16 14:00:00",195,1.405512,140,1.485694,1.436232,2.492251
"2021-02-16 15:00:00",196,1.199677,119,2.685371,1.779221,2.219253
"2021-02-16 16:00:00",197,0.6451383,64,3.330509,1.661599,4.781378
"2021-02-16 17:00:00",198,1.538052,153,4.868562,1.563827,2.793025
"2021-02-16 18:00:00",199,0.4801372,48,5.348699,1.203217,1.375089
"2021-02-16 19:00:00",200,0,0,5.348699,0,0
"2021-02-16 20:00:00",201,0,0,5.348699,0,0
"2021-02-16 21:00:00",202,0,0,5.348699,0,0
"2021-02-16 22:00:00",203,0,0,5.348699,0,0
"2021-02-16 23:00:00",204,0,0,5.348699,0,0
"2021-02-17 00:00:00",205,0,0,5.348699,0,0
"2021-02-17 01:00:00",206,0,0,5.348699,0,0
"2021-02-17 02:00:00",207,0,0,5.348699,0,0
"2021-02-17 03:00:00",208,0,0,5.348699,0,0
"2021-02-17 04:00:00",209,0,0,5.348699,0,0
"2021-02-17 05:00:00",210,0,0,5.348699,0,0
"2021-02-17 06:00:00",211,0,0,5.348699,0,0
"2021-02-17 07:00:00",212,0,0,5.348699,0,0
"2021-02-17 08:00:00",213,0,0,5.348699,0,0
"2021-02-17 09:00:00",214,0,0,5.348699,0,0
"2021-02-17 10:00:00",215,0,0,5.348699,0,0
"2021-02-17 11:00:00",216,0,0,5.348699,0,0
"2021-02-17 12:00:00",217,0.3263632,31,5.675062,5.540471,20.95949
"2021-02-17 13:00:00",218,0.2610095,26,5.936072,1.257819,2.204605
```

# 9. Maintenance and troubleshooting

**NOTE:**
All factory repairs and recalibrations require a returned material authorization (RMA) and completion of the “Statement of Product Cleanliness and Decontamination” form. Refer to the About this manual page at the front of this manual for more information.

This section discusses the following:

# 9.1 Maintenance

To ensure reliable and accurate measurements, Campbell Scientific recommends doing the following every month:

1. Check the integrity of the cable and data logger connections. Replace cable if damaged.
2. Inspect the funnel for any damage or blockage. To clear a blockage, detach the funnel from the base, remove debris, then reattach the funnel.
3. Check and clean the filters (see the following section).
4. Level the RainVUE-series if necessary (see `aXWTILT!` and `aXRTILT!` commands in Table 8-2 [p. 18]). The RainVUE 10 has a bubble level next to a levelling foot; the RainVUE 20 bubble level is visible after removing the funnel.
5. Clean dirt from the tipping bucket. Avoid tipping the bucket if the RainVUE-series is still connected to the data logger.
6. If the data logger is disconnected, check the tipping mechanism for stiffness.
   a. Try to balance the bucket in its centre position. It should be extremely difficult or impossible to balance.
   b. If the bucket balances easily, closely examine the tipping bucket assembly for dirt or wear on the pivot pin and bucket tubs.

## 9.1.1 Cleaning and replacing filters

The RainVUE-series has both a funnel filter and a stainless-steel, mesh screen filter (see the following figures). The mesh screen should be regularly cleaned. Both filters can be replaced if damaged or lost.

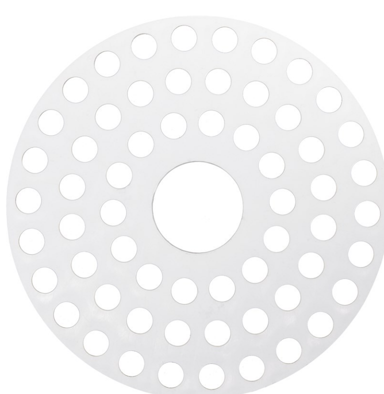


*Figure 9-1. Funnel filter*

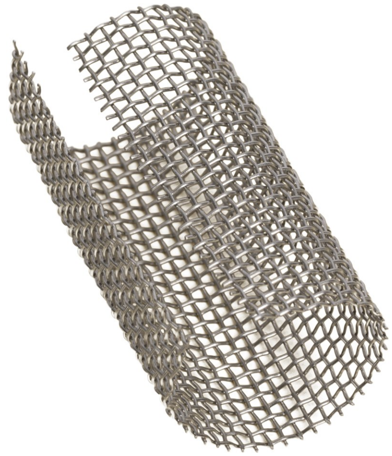
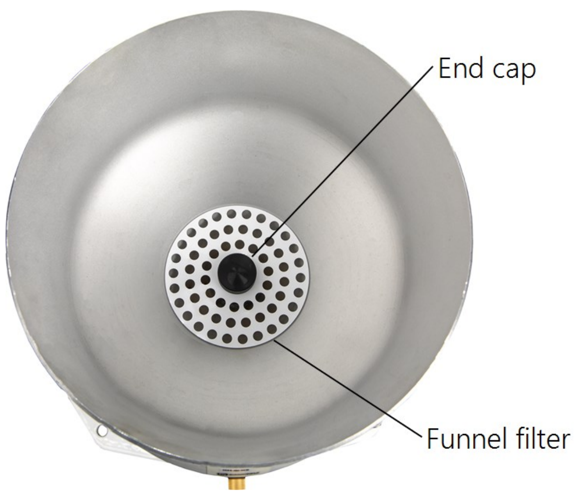


*Figure 9-2. Stainless-steel mesh screen filter*

#### Filter cleaning and replacement procedure:

1. Unscrew the end cap from the filter tube.




2. Remove the funnel filter.

3. Carefully remove the stainless-steel mesh screen from the filter tube.


4. Gently clean mesh screen.
5. Place mesh screen back in filter tube.
6. Place funnel filter in the funnel.
7. Screw on the end cap.

## 9.1.2 Internal lithium battery

An internal lithium coin cell battery powers the RainVUE-series during power loss of the main 12 V power source. The battery allows the RainVUE-series to capture rain events for 12 to 15 days depending on battery age, temperature, and frequency of rain detections and SDI-12 measurement request.

The `M1!` and `IM1_005!` SDI-12 commands report the lithium battery voltage (see Table 8-1 [p. 16] and Table 8-3 [p. 20]). Replace the battery when voltage is approximately 2.7 VDC.

Campbell Scientific recommends replacing the battery every two to three years and after each loss of power event. High temperatures can reduce the battery life, and low temperatures can decrease battery capacity, lowering available power and sensor runtime.

Remove the backup battery when the sensor is removed from service. Replace the battery when the RainVUE-series is placed back in service.

**Battery replacement procedure:**

1. Loosen and remove the three base thumb screws, then lift the funnel upward.
2. Use a Phillips screwdriver to remove the four screws on the RainVUE-series interface.

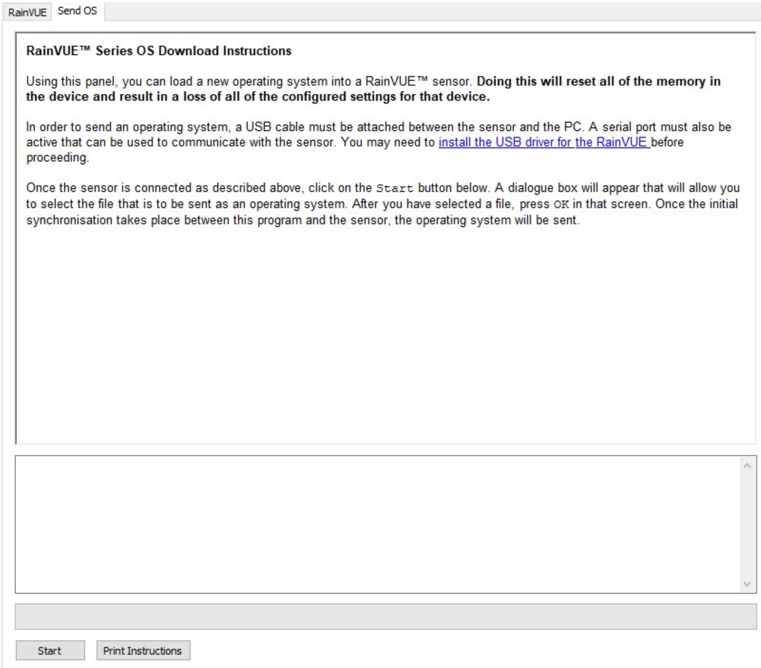

3. Remove the interface cover.
4. Replace the old lithium battery with the new battery (3 V coin cell CR2032).


5. Place the interface cover on the interface and secure with the four screws.
6. Replace the funnel and tighten the three base thumb screws by hand to secure the funnel to the base.

## 9.1.3 Updating the operating system

1. Go to www.campbellsci.eu/downloads/rainvue-os, click **Download Now**, and click **Save File**. This will download an .exe file onto your computer.
2. Double-click the .exe file. This will save the operating system file in C:/Campbellsci/Lib/OperatingSystems.
3. Access ***Device Configuration Utility*** (see Device Configuration Utility [p. 23]).

4. Click the **Send OS** tab.




5. Click **Start**.
6. Select the file. It will have an .a43 extension.
7. Click **OK**.

# 9.2 Troubleshooting

**Symptom:**

On a CRBasic data logger, data values report **NAN**, or on a non-Campbell Scientific data logger, data values do not change when the tipping mechanism is activated and new measurement commands are issued.

**Solution:**

1. Verify that the RainVUE-series is wired correctly (Table 7-1 [p. 8]).

> **NOTE:**
> Connect the power wire to the data logger **12V** terminal and not the **SW12** terminal.

2. Verify that power to the RainVUE-series is in the appropriate range (6 to 18 VDC).
3. Verify that the correct SDI-12 address is being used when communicating with the RainVUE-series. Use the transparent mode to verify that the data logger can communicate with the sensor. For additional information, refer to SDI-12 transparent mode (p. 44).

**Symptom:**

Reported data values are lower than expected.

**Solution:**

1. Ensure that the filter is clean and allows water to flow through it.
2. Check that the tipping mechanism can move freely.
3. Use a voltmeter on the switch to verify that the switch is activated as expected while transitioning from one side to the other. While the tipping mechanism is in its resting positions, the voltmeter should read 3 to 5 V. When at the mid-point as it transitions from one side to the other side, the voltmeter should read 0 V.
4. Ensure that the RainVUE-series is level. The RainVUE 10 has a bubble level next to a levelling foot; the RainVUE 20 bubble level is visible after removing the funnel.
5. Check that the wires and connections between the switch and the interface are secure.
6. Verify that no obstacles are preventing rain from entering the funnel.

**Symptom:**

Reported data values are higher than expected.

**Solution:**

1. Verify that the tipping mechanism is not stuck near the centre of its movement from one side to the other.
2. Verify that the wires and connections between the switch and the interface are secure.
3. Verify that the RainVUE-series is not under a structure that will drip into it.

For more information, refer to:

www.campbellsci.eu/videos/sdi12-sensors-transparent-mode ▶

www.campbellsci.eu/videos/sdi12-sensors-watch-or-sniffer-mode ▶

# Appendix A. Importing *Short Cut* code into *CRBasic Editor*

***Short Cut*** creates a .DEF file that contains wiring information and a program file that can be imported into ***CRBasic Editor***. By default, these files reside in the C:\campbellsci\SCWin folder.

Import ***Short Cut*** program file and wiring information into ***CRBasic Editor***:

1. Create the ***Short Cut*** program, then save it. Click the **Advanced** tab then the **CRBasic Editor** button. Your program file will open in CRBasic with a generic name. Provide a meaningful name and save the CRBasic program. This program can now be edited for additional refinement.

   > **NOTE:**
   > Once the file is edited with ***CRBasic Editor***, ***Short Cut*** can no longer be used to edit the program.

2. To add the ***Short Cut*** wiring information into the new CRBasic program, open the .DEF file located in the C:\campbellsci\SCWin folder. Copy the wiring information, which is at the beginning of the .DEF file.
3. Go into the CRBasic program and paste the wiring information at the beginning of the program.
4. In the CRBasic program, highlight the wiring information, right-click, and select **Comment Block**. This adds an apostrophe (') to the beginning of each of the highlighted lines, which instructs the data logger compiler to ignore those lines when compiling. The **Comment Block** feature is demonstrated at about 5:10 in the CRBasic | Features video ▶.

# Appendix B. Calibration validation

Use the XTEST! SDI-12 command to validate the calibration. Enter this command in the transparent mode while the computer is communicating with the data logger through a terminal emulator program.

This command displays simulated rain fall data that does not affect rain accumulators used for the normal operation. It runs for 60 minutes then returns to normal operation. The XTEST! command can also be aborted by a break on the SDI-12 data line. Therefore, suspend the data logger program before you begin field calibration.

To validate the calibration, first run a fixed amount of water through the RainVUE-series, then use the XTEST! command and compare the results. A common amount of simulated rain is 946 ml, which equates to 115 tips on the 0.01-inch rain gage at a rate of 2 inches of rain per hour or slower.

Initially, the command sends the following header information:

| Raw Tip | Corrected Rain Fall | Total Rain Fall | Balance |
|---|---|---|---|

For each second or each tip detected, the command displays a new line of data, such as the following:

| Raw Tip | Corrected Rain Fall | Total Rain Fall | Balance |
|---|---|---|---|
| 0 | 0.000 | 0.000 | 0 |
| 0 | 0.000 | 0.000 | 0 |

Eventually, the numbers should start changing, and the latest data should give an indication of how close the gage is to calibration.

| Raw Tip | Corrected Rain Fall | Total Rain Fall | Balance |
|---|---|---|---|
| 0 | 0.000 | 0.000 | 0 |
| 0 | 0.000 | 0.000 | 0 |
| 1 | 0.010 | 0.010 | 33 |
| 2 | 0.011 | 0.021 | 68 |
| 3 | 0.011 | 0.032 | 51 |
| 4 | 0.012 | 0.044 | 50 |
| 5 | 0.010 | 0.054 | 51 |
| 6 | 0.011 | 0.065 | 49 |
| 8 | 0.023 | 0.088 | 51 |
| \| | | | |
| \| | | | |
| 110 | 0.011 | 1.180 | 51 |
| 111 | 0.011 | 1.191 | 50 |
| 112 | 0.011 | 1.202 | 51 |
| 113 | 0.012 | 1.214 | 51 |
| 114 | 0.010 | 1.224 | 51 |
| 114 | 0.000 | 1.224 | 51 |
| 114 | 0.000 | 1.224 | 51 |

The corrected rain fall and total rain fall values include intensity correction. When the simulated rain is run through the gage at a fast rate, the number of tips may be lower than expected, but the corrected rain fall should be close to the actual amount of simulated rain.

The balance value represents how balanced the tipping mechanism is as it tips from one side to the other. If the gage needs to be adjusted, it is best to try to keep the balance as close to 50 percent as possible. The balance value is only valid if the simulated rain is being applied at a constant rate. It is best to look at this value after the test has been running consistently for a few tips.

# Appendix C. SDI-12 sensor support

Serial Data Interface at 1200 baud (SDI-12) is a protocol developed to simplify sensor and data logger compatibility. Only three wires are necessary—serial data, ground, and 12 V. With unique addresses, multiple SDI-12 sensors can connect to a single SDI-12 terminal on a Campbell Scientific data logger.

This appendix discusses the structure of SDI-12 commands and the process of querying SDI-12 sensors. For more detailed information, refer to version 1.4 of the SDI-12 protocol, available at www.sdi-12.org.

For additional information, refer to the SDI-12 Sensors | Transparent Mode and SDI-12 Sensors | Watch or Sniffer Mode videos.

## C.1 SDI-12 command basics

SDI-12 commands have three components:

- **Sensor address (a)** – a single character and the first character of the command. Use the default address of zero (0) unless multiple sensors are connected to the same port.
- **Command body** – an uppercase letter (the "command"), optionally followed by one or more alphanumeric qualifiers.
- **Command termination (!)** – an exclamation mark.

An active sensor responds to each command. Responses have several standard forms and always terminate with <CR><LF> (carriage return and line feed). Standard SDI-12 commands are listed in Table C-1 (p. 37).

**Table C-1: Campbell Scientific sensor SDI-12 command and response set**

| Name | Command[1] | Response |
|---|---|---|
| Acknowledge active | `a!` | a<CR><LF> |
| Send identification | `aI!` | allccccccccmmmmmmvvvxxx...xx <CR><LF> |
| Start verification | `aV!` | atttn<CR><LF> |

| Table C-1: Campbell Scientific sensor SDI-12 command and response set | | |
|---|---|---|
| Name | Command[1] | Response |
| Address query | `?!` | a<CR><LF> |
| Change address | `aAb!` | b<CR><LF> |
| Start measurement | `aM!`<br>`aM1!...aM9!` | atttn<CR><LF> |
| Start measurement and request CRC | `aMC!`<br>`aMC1!...aMC9!` | atttn<CR><LF> |
| Start concurrent measurement | `aC!`<br>`aC1!...aC9!` | atttnn<CR><LF> |
| Start doncurrent measurement and request CRC | `aCC!`<br>`aCC1!...aCC9!` | atttnn<CR><LF> |
| Send data | `aD0!...aD9!` | a<values><CR><LF> or<br>a<values><CRC><CR><LF> |
| Continuous measurement | `aR0!...aR9!` | a<values><CR><LF> |
| Continuous measurement and request CRC | `aRC0!...aRC9!` | a<values><CRC><CR><LF> |
| Extended commands | `aXNNN!` | a<values><CR><LF> |

[1] Information on each of these commands is given in the following sections.

## C.1.1 Acknowledge active command (a!)

The acknowledge active command (`a!`) is used to test a sensor on the SDI-12 bus. An active sensor responds with its address.

## C.1.2 Send identification command (aI!)

Sensor identifiers are requested by issuing command `aI!`. The reply is defined by the sensor manufacturer but usually includes the sensor address, SDI-12 version, manufacturer name, and sensor model information. Serial number or other sensor-specific information may also be included. Source: SDI-12: A Serial-Digital Interface Standard for Microprocessor-Based Sensors (see References [p. 46]).

Command: `aI!`

Response: *allccccccccmmmmmmvvvxxx...xx*<CR><LF>

Where

*a* = sensor address

*ll* = SDI-12 version number (indicates compatibility)

*cccccccc* = eight-character vendor identification

*mmmmmm* = six characters specifying the sensor model

*vvv* = three characters specifying the sensor version (operating system)

*xxx…xx* = up to 13 optional characters used for a serial number or other specific sensor information that is not relevant for operation of the data logger

<CR><LF> = terminates the response

## C.1.3 Start verification command (aV!)

The response to a start verification command can include hardware diagnostics, but like the `aI!` command, the response is not standardized.

Command: `aV!`

Response: *atttfffhhhn<CR><LF>*

Where

*a* = sensor address

*ttt* = time, in seconds, until verification information is available

*fff* = firmware (OS) version

*hhh* = hardware version

*n* = number of values to be returned when one or more subsequent `D!` commands are issued

## C.1.4 Address query command (?!)

Command `?!` requests the address of the connected sensor. The sensor replies to the query with the address(*a*). This command should only be used with one sensor on the SDI-12 bus at a time.

## C.1.5 Change address command (aAb!)

Multiple SDI-12 sensors can connect to a single SDI-12 terminal on a data logger. Each device on a single terminal must have a unique address.

A sensor address is changed with command `aAb!`, where *a* is the current address and *b* is the new address. For example, to change an address from *0* to *2*, the command is `0A2!`. The sensor responds with the new address *b*, which in this case is 2.

**NOTE:**
Only one sensor should be connected to a particular terminal at a time when changing addresses.

## C.1.6 Start measurement commands (aM!)

A measurement is initiated with the `M!` command. The response to each command has the form *atttn<CR><LF>*, where

*a* = sensor address

*ttt* = time, in seconds, until measurement data is available; when the data is ready, the sensor notifies the data logger, and the data logger begins issuing **D** commands

*n* = number of values returned when one or more subsequent **D** commands are issued; for the **`aM!`** command, *n* is an integer from 0 to 9

When **`aM!`** is issued, the data logger pauses its operation and waits until either it receives the data from the sensor or the time (*ttt*) expires. Depending on the scan interval of the data logger program and the response time of the sensor, this may cause skipped scans to occur. To avoid this, make sure your scan interval is longer than the longest measurement time (*ttt*).

| Table C-2: Example aM! sequence | |
|---|---|
| `0M!` | The data logger makes a request to sensor 0 to start a measurement. |
| 00352<CR><LF> | Sensor 0 immediately indicates that it will return two values within the next 35 seconds. |
| 0<CR><LF> | Within 35 seconds, sensor 0 indicates that it has completed the measurement by sending a service request to the data logger. |
| **`0D0!`** | The data logger immediately issues the first **D** command to collect data from the sensor. |
| 0+.859+3.54<CR><LF> | The sensor immediately responds with the sensor address and the two values. |

## C.1.7 Start concurrent measurement commands (aC!)

A concurrent measurement (**`aC!`**) command follows the same pattern as the **`aM!`** command, with the exception that it does not require the data logger to pause its operation, and other SDI-12 sensors may take measurements at the same time. The sensor will not issue a service request to notify the data logger that the measurement is complete. The data logger will issue the **`aD0!`** command during the next scan after the measurement time reported by the sensor has expired.

To use this command, the scan interval should be 10 seconds or less. The response to each command has the form *atttn<CR><LF>*, where

*a* = sensor address

*ttt* = time, in seconds, until measurement data is available

*nn* = number of values to be returned when one or more subsequent **D** commands are issued

See the example in Table C-3 (p. 41). A data logger has three sensors wired into terminal **C1**. The sensors are addresses X, Y, and Z. The data logger will issue the following commands and receive the following responses:

| Table C-3: Example aC! sequence | |
|---|---|
| XC! | The data logger makes a request to sensor X to start a concurrent measurement. |
| X03005<CR><LF> | Sensor X immediately indicates that it will have five (05) values ready for collection within the next 30 (030) seconds. |
| YC! | The data logger makes a request to sensor Y to start a concurrent measurement. |
| Y04006<CR><LF> | Sensor Y immediately indicates that it will have six (06) values ready for collection within the next 40 (040) seconds. |
| ZC! | The data logger makes a request to sensor Z to start a concurrent measurement. |
| Z02010<CR><LF> | Sensor Z immediately indicates that it will have ten (10) values ready for collection within the next 20 (020) seconds. |
| ZD0! | After 20 seconds have passed, the data logger starts the process of collecting the data by issuing the first **D** command to sensor Z. |
| Z+1+2+3+4+5+6+7+8+9+10<CR><LF> | Sensor Z immediately responds with the sensor address and the ten values. |
| XD0! | 10 seconds later, after a total of 30 seconds has passed, the data logger starts the process of collecting data from sensor X by issuing the first **D** command. |

| Table C-3: Example aC! sequence | |
|---|---|
| X+1+2+3+4+5<CR><LF> | The sensor immediately responds with the sensor address and the five values. |
| **YD0!** | 10 seconds later, after a total of 40 seconds has passed, the data logger starts the process of collecting data from sensor Y by issuing the first **D** command. |
| Y+1+2+3+4+5+6<CR><LF> | The sensor immediately responds with the sensor address and the six values. |

## C.1.8 Start measurement commands with cyclic redundancy check (aMC! and aCC!)

Error checking is done by using measurement commands with cyclic redundancy checks (**aMC!** or **aCC!**). This is most commonly implemented when long cable lengths or electronic noise may impact measurement transmission to the data logger. When these commands are used, the data returned in response to **D** or **R** commands must have a cyclic redundancy check (CRC) code appended to it. The CRC code is a 16-bit value encoded within three characters appended before the <CR><LF>. This code is not returned in the data table but checked by the data logger as it comes. The code returned is based on the SDI-12 protocol. See the SDI-12 communication specification for version 1.4, available at www.sdi-12.org, to learn more about how the CRC code is developed.

## C.1.9 Stopping a measurement command

A measurement command (M!) is stopped if it detects a break signal before the measurement is complete. A break signal is sent by the data logger before most commands.

A concurrent measurement command (**C!**) is aborted when another valid command is sent to the sensor before the measurement time has elapsed.

## C.1.10 Send data command (aD0! ... aD9!)

The send data command requests data from the sensor. It is issued automatically with every type of measurement command (**aM!**, **aMC!**, **aC!**, **aCC!**). When the measurement command is **aM!** or **aMC!**, the data logger issues the **aD0!** command once a service request has been received from the sensor or the reported time has expired. When the data logger is issuing concurrent commands (**aC!** or **aCC!**), the send data command is issued after the required time has elapsed (no service request will be sent by the sensor). In transparent mode (see SDI-12 transparent mode [p. 44]), the user asserts this command to obtain data.

Depending on the type of data returned and the number of values a sensor returns, the data logger may need to issue `aD0!` up to `aD9!` to retrieve all data. A sensor may return up to 35 characters of data in response to a `D` command that follows an `M!` or `MC!` command. A sensor may return up to 75 characters of data in response to a `D` command that follows a `C!` or `CC!` command. Data values are separated by plus or minus signs.

Command: `aD0!` (`aD1!` … `aD9!`)

Response: *a<values><CR><LF>* or *a<values><CRC><CR><LF>*

where

*a* = sensor address

*<values>* = values returned with a polarity sign (+ or –)

*<CR><LF>* = terminates the response

*<CRC>* = 16-bit CRC code appended if data was requested with `aMC!` or `aCC!`

## C.1.11 Continuous measurement command (aR0! … aR9!)

Sensors that are able to continuously monitor the phenomena to be measured can be read directly with the `R` commands (`R0!` … `R9!`). The response to `R` commands mirrors the send data command (`aD0!`). A maximum of 75 characters can be returned in the *<values>* part of the response to the `R` command.

## C.1.12 Extended commands

Many sensors support extended SDI-12 commands. An extended command is specific to a make of sensor and tells the sensor to perform a specific task. They have the following structure. Responses vary from unit to unit. See the sensor manual for specifics.

Command: `aXNNNN!`

The command will start with the sensor address (*a*), followed by an `X` then a set of optional letters, and terminate with an exclamation point.

Response: *a<optional values><CR><LF>*

The response will start with the sensor address and end with a carriage return/line feed.

# C.2 SDI-12 transparent mode

System operators can manually interrogate and enter settings in probes using transparent mode. Transparent mode is useful in troubleshooting SDI-12 systems because it allows direct communication with probes. Data logger security may need to be unlocked before activating the transparent mode.

Transparent mode is entered while the computer is communicating with the data logger through a terminal emulator program. It is accessed through Campbell Scientific data logger support software or other terminal emulator programs. Data logger keyboards and displays cannot be used.

The terminal emulator is accessed through Campbell Scientific ***Device Configuration Utility*** software.

Watch videos/sdi12-sensors-transparent-mode from the Campbell Scientific website.

Data loggers from other manufacturers will also have a transparent mode. Refer to those manuals for information on how to use their transparent mode.

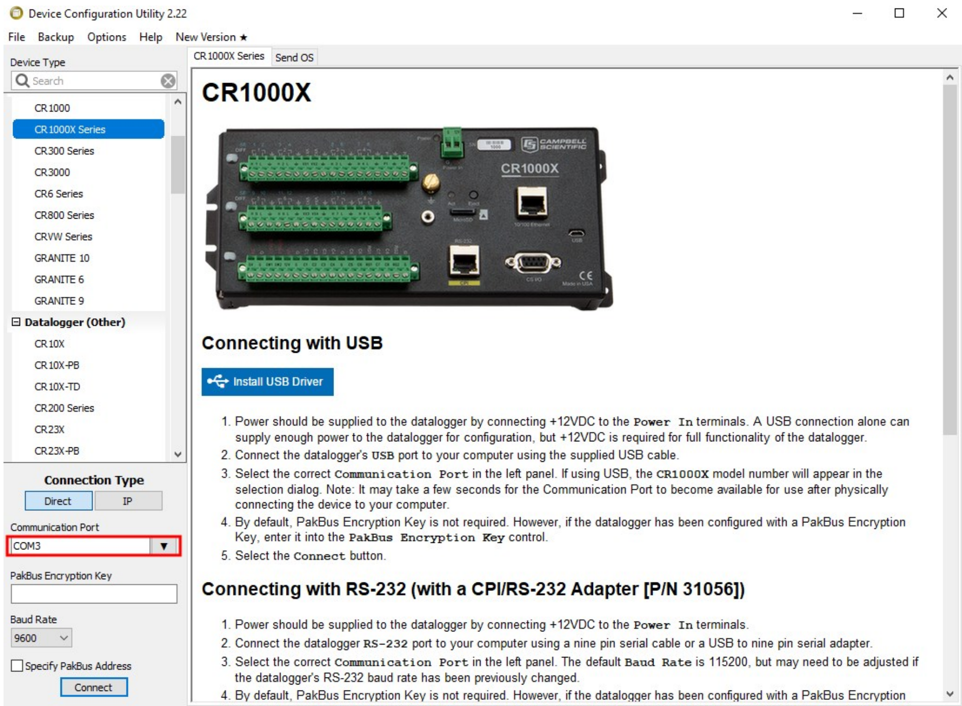
The following examples show how to enter transparent mode and change the SDI-12 address of an SDI-12 sensor. The steps shown in Changing an SDI-12 address (p. 44) are used with most Campbell Scientific data loggers.

## C.2.1 Changing an SDI-12 address

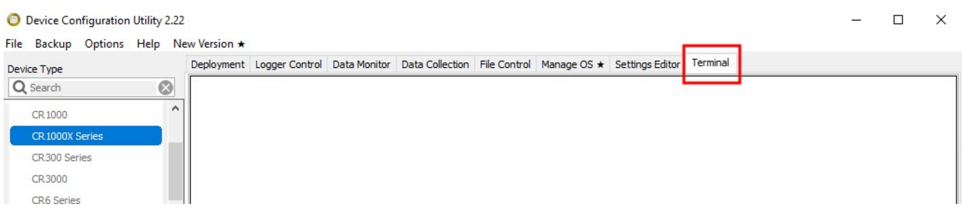
This example was done with a CR1000X, but the steps are only slightly different for Granite-series, CR6, CR800-series, CR300-series data loggers.

1. Connect an SDI-12 sensor to the CR1000X.
2. Open ***Device Configuration Utility***.
3. Under **Device Type**, type the data logger model and double-click on the model type. This example uses a CR1000X directly connected to the computer USB port.

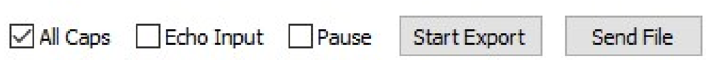
4. Select the correct **Communication Port** and click **Connect**.



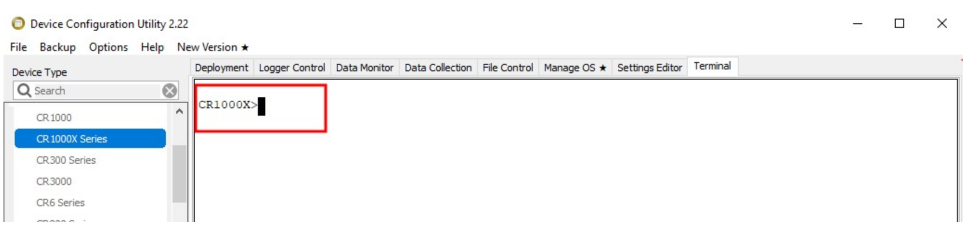

5. Click the **Terminal** tab.




6. Select **All Caps Mode**.




7. Press **Enter** until the data logger responds with the data logger (**CR1000X>**) prompt.




8. Type **SDI12** and press Enter.
9. At the **Select SDI12 Port** prompt, type the number corresponding to the control port where the sensor is connected and press **Enter**. In this example the sensor is connected to C3. The

response **Entering SDI12 Terminal** indicates that the sensor is ready to accept SDI-12 commands.

```
CR1000X>
CR1000X>SDI12
1: C1
2: C3
3: C5
4: C7
Select SDI12 Port: 2
```

10. To query the sensor for its current SDI-12 address, type **?!** and press **Enter**. The sensor responds with its SDI-12 address. If no characters are typed within 60 seconds, the mode is exited. In that case, simply type **SDI12** again, press **Enter**, and type the correct control port number when prompted.

```
?!
0
```

11. To change the SDI-12 address, type **aAb!**, where **a** is the current address from the previous step and **b** is the new address. Press **Enter**. The sensor changes its address and responds with the new address. In the following example, the sensor address is changed from 0 to B.

```
SDI12
SDI12>0AB!B
```

12. To exit SDI-12 transparent mode, click **Close Terminal**.

> **NOTE:**
> The transparent mode for the Granite-series, CR6, CR3000, CR800-series, CR300-series data loggers is similar to that shown for the CR1000X.

# C.3 References

SDI-12 Support Group. 2017. *SDI-12: A Serial-Digital Interface Standard for Microprocessor-Based Sensors – Version 1.4*. River Heights, UT: SDI-12 Support Group. http://www.sdi-12.org/current_specification/SDI-12_version-1_4-Dec-1-2017.pdf.

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