# PRODUCT MANUAL

**Data Logger**

# CRVW3
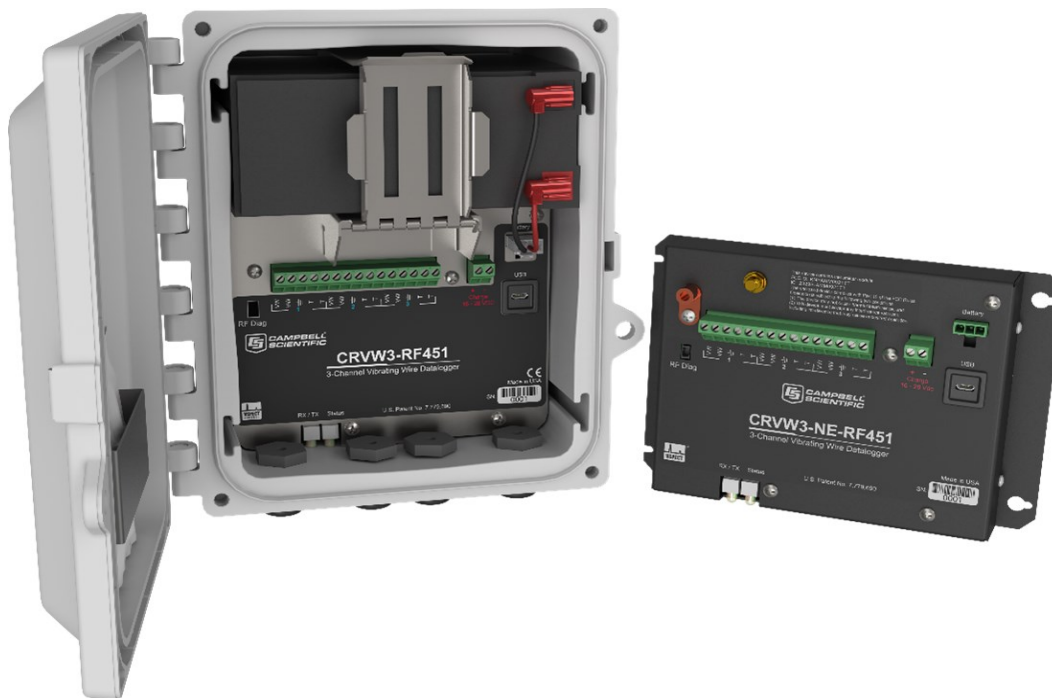
## 3-Channel Vibrating Wire Data Logger

RELIABLE MONITORING SINCE 1974

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# 1. Introduction

The CRVW3 is a data logger that measures and stores readings from up to three vibrating-wire sensors. A temperature measurement, usually obtained from a thermistor built into the sensor, is also available for each of these three channels. Separately purchased, single-coil-circuit vibrating-wire sensors are also supported. Common vibrating-wire measurements include water depth (pressure or column height), strain of structural members, loading, crack/gap extension, earth pressure, and tilt.

The use of patented VSPECT® technology helps to eliminate unwanted noise interference and results in high-resolution output. Learn about the patented Campbell Scientific VSPECT spectral-analysis technology at:

www.campbellsci.com/vspect ↗

Measurements may be taken as often as once every one to three seconds (one second per active channel) and as infrequently as once per day. Measurement history is preserved on the device, which enables data collection at anticipated intervals and protects against data loss during periods of intermittent radio connectivity.
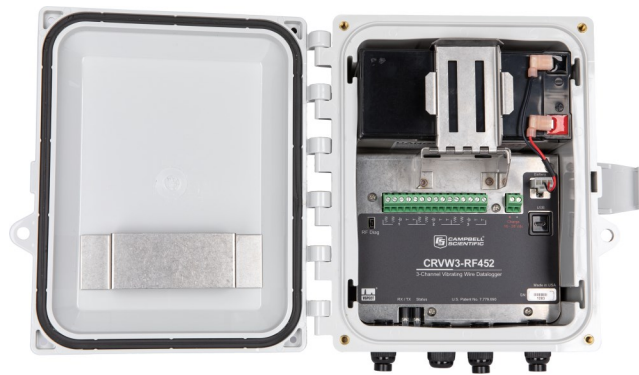


*Figure 1-1. CRVW3–RF451/RF452*

*Figure 1-2. CRVW3–NE*

The CRVW3 is available in both enclosure and non-enclosure versions. The standard CRVW3 is packaged inside a protective enclosure. On-board power support for a rechargeable battery (including a built-in charge regulator) or non-rechargeable D cells is included. The non-enclosure version (CRVW3–NE) comes without the enclosure and battery. While this manual refers mainly to the enclosure version, the configuration is identical for both models.

Multiple built-in CRVW3 radio options (–RF407, –RF412, –RF422, –RF427, –RF451, and –RF452) are available to enable the creation of wireless networks. All radio options except the CRVW3–RF427 are available in both enclosure and non-enclosure versions; CRVW3–RF427 is only available in the non-enclosure version.

- RF407 has a 902 to 928 MHz operating-frequency range appropriate for use in the United States and Canada. (FCC / IC / IFT compliant)

- RF412 has a 915 to 928 MHz operating-frequency range appropriate for use in Australia and New Zealand. (ACMA compliant)

- RF422 has an 863 to 870 MHz operating-frequency range appropriate for use in most of Europe and some of Asia. (ETSI compliant)

- RF427 has a 902 to 907 and 916 to 928 MHz operating-frequency range appropriate for use in Brazil. (ANATEL compliant)

- RF451/RF452 has a 902 to 928 MHz operating-frequency range appropriate for use in the United States and Canada. (FCC / IC / IFT compliant) RF451/RF452 can also be used in Australia and New Zealand but must be purchased directly from Campbell Scientific Australia to ensure that it is properly configured and labeled for ACMA compliance.

See Specifications (p. 10) for more information on the differences between the radio options.

> **NOTE:**
> RF451/RF452 has the same operating-frequency range as RF407; however, it has a higher output power. This allows for greater communications distance but also requires more power. To preserve battery power, it may be necessary to only turn on the radio during certain periods of time. See Validating CRVW3 radio operation (p. 51).

> **NOTE:**
> The CRVW3 –RF407, –RF412, –RF422, and –RF427 options are all versions of the same radio series. This manual will refer to a CRVW3 with any of these options as "CRVW3–RF407." The standalone radios will be referred to collectively as "RF407." Throughout this manual, RF407 can be replaced with RF412, RF422, or RF427, unless otherwise noted.

> **NOTE:**
> This manual refers to using RF451/RF452 standalone radio(s) in a CRVW3–RF451/RF452 network. The RF450, can also be used with CRVW3–RF451/RF452s. The configuration settings are the same for RF450s and RF451/RF452s. See the RF450 manual for more information on configuring the RF450. Note that RF450 uses a different antenna connector than RF451/RF452 (SMA instead of RPSMA), so antennas are not interchangeable between the two devices.

CRVW3 operation is controlled by software-configured settings made on the device. No CRBasic programming is required. Frequency and temperature measurements are obtained at the specified measurement interval. Optional engineering output can be calculated using advanced settings.

Before using the CRVW3, refer to the following:

- Quick deploy guide
    - a folded card stored within the CRVW3 that contains summarized deployment and use instructions
- Precautions (p. 4)
- Initial inspection (p. 5)

# 2. Precautions

- READ AND UNDERSTAND the Safety section at the back of this manual.

- DANGER:
  As with all electrical devices, ensure proper grounding using the ground lug of this device. Observe polarity (+/–) markings on the charge connector, and only apply voltage of 28 VDC or less.



- Carefully install any solar panels, other power supply devices, antennas, and cabling according to manufacturer recommendations. Use surge suppression where possible. Consider using the **Basic Grounding Kit**, the **Bulkhead Surge Protection Installed in Enclosure**, and **Black Cold Shrink Tape**, purchased separately. Find more information in the following application note:

  https://s.campbellsci.com/documents/us/technical-papers/surge-protector-kits.pdf⬈

- WARNING:
  Do not connect the CRVW3-RF451/RF452 to power without terminating the antenna port to a suitable load, such as a 50 ohm antenna, or an attenuator with a power rating greater than or equal to 2 W. Turning on the CRVW3-RF451/RF452 without a load attached may cause damage and void the warranty.

- WARNING:
  Close the lid of the enclosure and secure the latch when the CRVW3 is deployed to avoid unwanted water entry and provide isolation from other environmental factors. IP66 protection is available when using the four screws provided by the enclosure manufacturer to seal the lid properly. Wipe off any water on the outside of the

> enclosure before opening the lid.

- IMPORTANT — RF451/RF452s must be configured to use the proper hop table version to comply with local laws and to avoid interference with other radio frequency (RF) installations such as cellular services. Available hop table versions are listed in the *Device Configuration Utility* **Settings Editor** for the RF451/RF452. Hop table versions include North America (default), Australia, New Zealand, Taiwan, Brazil, International, and Notch (custom). For more information, see RF451/452 manual ☐.

> **NOTE:**
> When using multiple CRVW3 devices in an RF451/RF452 or RF407 radio network, it may be necessary to deploy an RF451/RF452 or RF407 device, in addition to those built into the CRVW3, to operate as the **radio base station** in the network. Please consult the radio-specific manuals for more information relating to the design and configuration of radio networks.

# 3. Initial inspection

Upon receipt of the CRVW3, inspect the packaging and contents for damage. File any damage claims with the shipping company.

Examine the outside label on the device to ensure that the correct communications option is provided (for example, –RF451/RF452 radio, –RF407 radio, or no radio).

Confirm that the appropriate battery option is installed in the CRVW3 enclosure. The –ALK option includes an 8-cell battery pack for eight D cell alkaline batteries. The –RC option includes a single rechargeable lead acid 7 Ah battery. For the –RC option, start charging the rechargeable battery as soon as possible after the shipment is received. See Providing temporary power to the CRVW3 (p. 18) for details.

Using the packing list included with each shipment, ensure that all related accessories included in your order are present and in good condition. Typical accessories include solar panels, other power equipment, antennas, cabling, grounding kits, and related items. Thoroughly check packaging materials for items that may be trapped inside.

# 4. Overview

The CRVW3 is a rugged, field-ready data logger for measuring vibrating-wire sensors. It provides built-in power options, including a charge regulator that enables direct solar panel connections. Built-in radio options are available to enable wireless communications, and the system comes inside an environmentally protective enclosure as a standard option. The basic parts of the CRVW3 are shown in Figure 4-1 (p. 6).
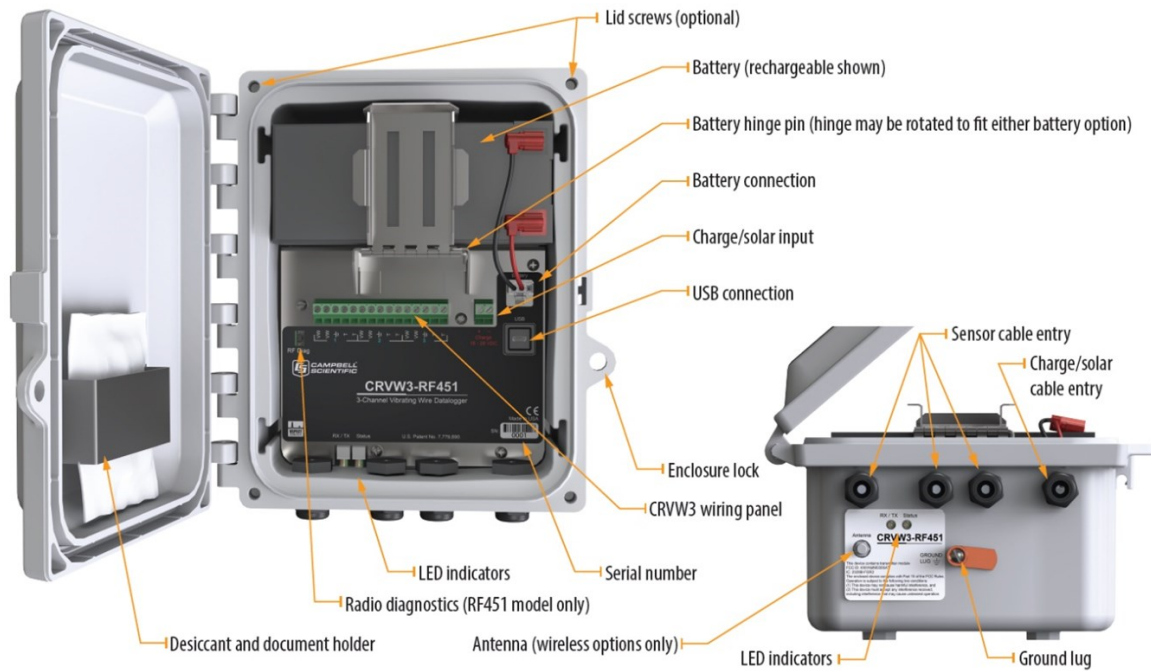


*Figure 4-1. Basic CRVW3 parts*

## 4.1 Measurement theory

A vibrating-wire sensor is designed so that its output corresponds to changes of the phenomenon in the environment that is being measured. This is done by converting environmental changes into changes of the tension on a suspended metal wire, which is located inside the sensor. The natural frequency of the wire changes as the tension changes; therefore, a change in frequency may be detected as changes in the measured phenomenon. A magnetic coil circuit is placed near the suspended wire and senses the motion of the wire by picking up the changes in the magnetic field caused by wire vibrations.

To measure a vibrating-wire sensor, three main steps are taken by the measurement system:

1.  Electrical energy is inserted into the coil circuit, creating a changing magnetic field that excites (plucks, or inserts energy into) the wire.

2.  The excitation terminates so that the wire is left to vibrate at its characteristic resonant, or natural, frequency. The coil circuit is used to electrically capture the motion of the wire vibrations during this stage.

3.  The measurement system processes the time-series waveform captured from the coil to assess the frequency of the wire vibrations. The basic output of a vibrating-wire sensor is frequency in Hz. Conversion from frequency to engineering units is possible based on a knowledge of how the sensor operates, and that is provided by the sensor manufacturer.



*Cutaway of Vibrating Wire Sensor*
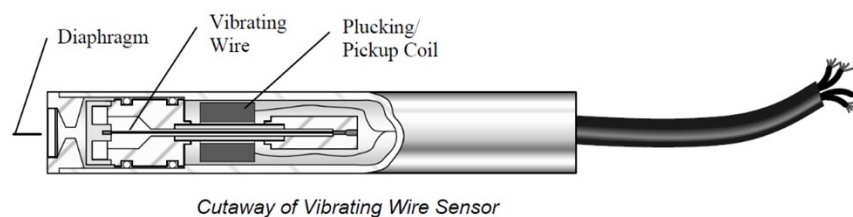
*Figure 4-2. Internal view of a typical vibrating-wire piezometer sensor*

The CRVW3 excites vibrating-wire sensors with a swept excitation (frequency-rich) waveform. The lowest frequency and highest frequency used in that excitation are customizable by the user. This lowest-to-highest frequency range represents all expected natural frequencies that the sensor should produce, including during the most extreme conditions in the environment. By exciting the sensor in only a certain range, interference from unwanted signals on the wire is reduced. The level of excitation (12, 5, and 2 VDC) can also be controlled by the user.

The main measurement output from a vibrating-wire sensor is a frequency (in Hz or digits) that corresponds to the natural resonance vibrations of the wire element embedded within the sensor. This frequency changes as the phenomenon being measured changes. It is important to consult the manual of your vibrating-wire sensor to document the highest and lowest frequencies that are expected as output. Consider the most extreme conditions of the phenomenon you are measuring. Then consider the highest and lowest frequencies that can be expected under both of those conditions. Using this information, you will formulate both a low frequency value and high frequency value to be configured into the CRVW3. This frequency range is used during excitation and during the read-back of the sensor: only energies within the specified frequency range are used for excitation, and only frequencies within the window are processed during sensor response read-out. Frequencies outside the specified range are

ignored. This is one of the ways that the VSPECT technology filters unwanted noise out of your vibrating-wire measurements.

# 4.2 VSPECT®

The CRVW3 uses Campbell Scientific VSPECT technology (U.S. Patent No. 7,779,690) to measure standard, single-coil-circuit vibrating-wire sensors. Learn about the patented Campbell Scientific VSPECT spectral-analysis technology at:

www.campbellsci.com/vspect ↗

The patented VSPECT process uses frequency-domain analysis (including the use of Fourier transforms), interpolation, and digital signal processing (DSP) to identify and eliminate unwanted noise from the measurement. The process produces a very high-resolution frequency output.
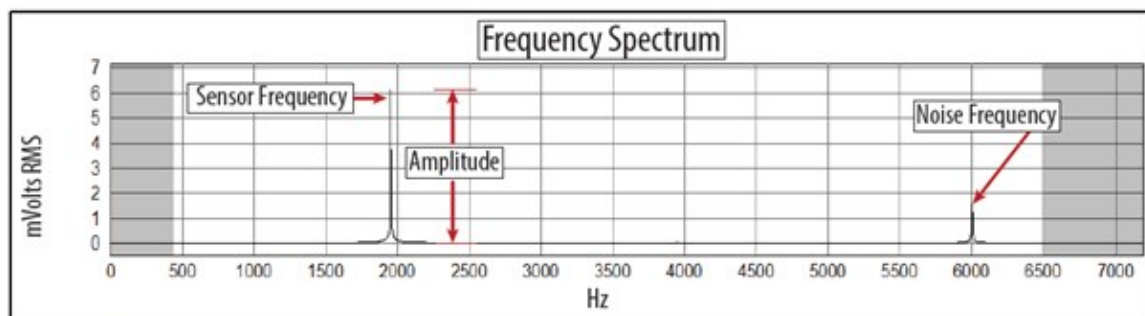


VSPECT technology determines the sensor frequency from the Frequency Spectrum while ignoring noise signals.
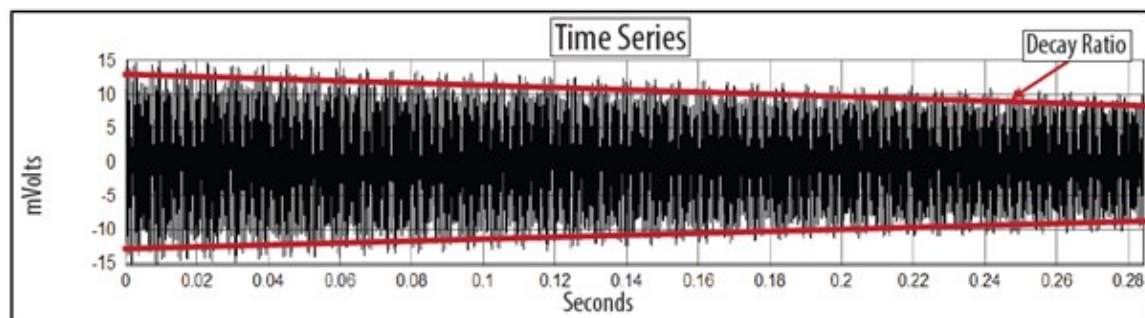


Traditional vibrating wire readers determine the sensor frequency from the Time Series where signal and noise can't be distinguished.

*Figure 4-3. Time series and frequency response of a vibrating-wire sensor*

Since changes in temperature can impact the density of the vibrating-wire element of the sensor, a slight change in frequency is expected on the sensor as temperature changes occur. To compensate for this effect, many vibrating-wire sensors contain a built-in thermistor or other resistive temperature device. The resistance of the device is measured and converted to

temperature. The temperature at the time of measurement is recorded and can then be used together with the frequency reading to calculate the value of the output phenomenon in engineering units (for example, measured value given with its dimensions or units of measure).

The following two sets of graphs illustrate the use of VSPECT to identify a sensor signal in a quiet and noisy environment. Both graphs were created from the same sensor using the Vibrating Wire Report created using a VWAnalyzer. The graphs on the left were was generated from a sensor measured in an electrically quiet environment. While the graphs on the right show an electrically noisy environment (AC power) similar to what can be seen in a field environment (power lines, motors, radio signals, etc.).
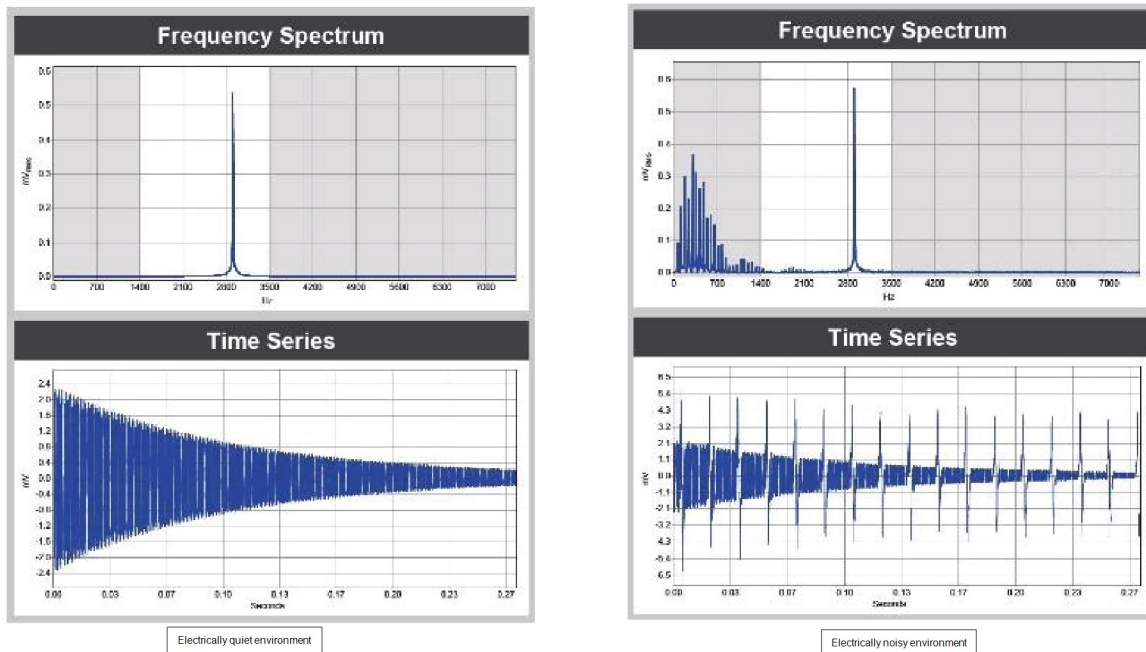


Vibrating wire signals

Vibrating wire readers that only use the time series to determine the frequency may report an incorrect frequency as a result of noise. The frequency spectrum (VSPECT) filters the noise and easily identifies the sensor signal. VSPECT provides noise immunity by correctly identifying the sensor signal and ignoring the influence of electrical noise that plagues time-domain-based vibrating wire readers.

# 5. Specifications

All CRVW3 data loggers are tested and guaranteed to meet the following electrical specifications in a –40 to 70 °C non-condensing environment:

## 5.1 Data logger

**Data logger**

| | |
|---|---|
| Processor: | ST ARM Cortex-M4 (32-bit with hardware FPU, running at 144 MHz) |
| Data storage: | 16 MB serial flash, up to 420,000 records (single channel), up to 160,000 records (three channels) |
| Clock accuracy: | ±3 minutes per year |
| Measurement interval range: | 1 s to 1 day |
| USB Micro-B: | Direct connect to computer (supplies power for configuration and data collection), 2.0 full speed, 12 Mbps |
| Configuration: | Software configurable, no programming required |

**Measurements**

| | |
|---|---|
| Channel count: | Three vibrating-wire (VW) and three thermistor/RTD (temperature) measurements |
| Measurement speed: | 1 s per sensor (VW and temperature) |

**Vibrating wire**

| | |
|---|---|
| Measurement excitation options: | 2 VDC (±1 VDC), 5 VDC (±2.5 VDC), 12 VDC (±6 VDC) |
| Measurement (frequency) resolution: | 0.001 Hz RMS (–40 to 70 °C) |
| Time series basic resolution: | 24-bit ADC |
| Measurement accuracy: | ±0.005% of reading (–40 to 70 °C) |
| Measurement method: | VSPECT (spectral analysis), U.S. Patent No. 7,779,690, includes diagnostic data |

Temperature (resistance)*

| | |
|---|---|
| Measurement method: | Half-bridge ratiometric, 24-bit ADC, built-in completion resistor 4.99 kΩ 0.1% |
| Thermistor precision: | 0.020 Ω RMS @ 3000 Ω (approximately 0.00015 °C RMS for most vibrating wire thermistors) |
| Accuracy: | ±0.15% of reading (–40 to 70 °C) |

Power

| | |
|---|---|
| Charge terminal: | 16 to 28 VDC from solar panel or DC power converter |
| Battery options: | Rechargeable 7 Ah or 8 D cell alkaline |

Physical

| | |
|---|---|
| Weight: | 4.2 kg (9.2 lb) with rechargeable battery or 3.0 kg (6.6 lb) with alkaline batteries |
| Operating temperature range: | –40 to 70 °C |
| Compliance: | CE, RoHS |
| Enclosure dimensions: | 24.1 × 22.9 × 14.0 cm (9.5 × 9.0 × 5.5 in) |
| Weatherproof enclosure rating: | NEMA 4X (IP66) with proper use of cable entry points |
| Enclosure mounting: | Stainless steel universal mount for pole/wall mount (optional) or plastic mounting tabs |

# 5.2 Radio option

**Antenna terminal**: Reverse Polarity SMA (RPSMA)

Radio type

- **RF407, RF412, RF427**, and **RF451/RF452**: Frequency-Hopping Spread-Spectrum (FHSS)
- **RF407, RF412**, and **RF427**: Frequency-Hopping Spread-Spectrum (FHSS)
- **RF422**: SRD860 Radio with Listen Before Talk (LBT) and Automatic Frequency Agility (AFA)

Frequency

- **RF407**: 902 to 928 MHz (US, Canada)
- **RF412**: 915 to 928 MHz (Australia, New Zealand)

- **RF422**: 863 to 870 MHz (Europe, Middle East, and Africa)
- **RF427**: 902 to 907.5 MHz/915 to 928 MHz (Brazil)
- **RF451/RF452**: 902 to 928 MHz

Transmit power output (software selectable)

- **RF407** and **RF412**: 5 to 250 mW
- **RF422**: 2 to 25 mW
- **RF427**: 5 to 250 mW
- **RF451/RF452**: 10 mW to 1,000 mW

Channel capacity

- **RF407**: Eight 25-channel hop sequences sharing 64 available channels.
- **RF412**: Eight 25-channel hop sequences sharing 31 available channels.
- **RF422**: Ten 30-channel hop sequences (default), software configurable to meet local regulations; 10 sequences for reducing interference through channel hop.
- **RF427**: Eight 25-channel hop sequences sharing 43 available channels.
- **RF451/RF452**: 50 to 112 user-selectable channels for a given network.

Receive sensitivity

- **RF407**, **RF412**, and **RF427**: –101 dBm
- **RF422**: –106 dBm
- **RF451/RF452**:
    - –108 dBm at 115.2 kbps for $10^{-4}$ BER
    - –103 dBm at 153.6 kbps for $10^{-4}$ BER

RF data rate

- **RF407**, **RF412**, and **RF427**: 200 kbps
- **RF422**: 10 kbps
- **RF451/RF452**: 115.2 or 153.6 kbps

Maximum nodes in network

- **RF407**, **RF412**, and **RF427**: 50
- **RF422**: 20

- **RF451/RF452**: 4 repeaters

# 6. Installation considerations

For summarized installation information, refer to the *Quick deploy guide* included with each CRVW3 inside the enclosure. You can view and download it from:

s.campbellsci.com/documents/us/manuals/crvw3-quick-deploy-guide.pdf ⬀

Preconfigure and test your measurement system before deployment in the field. Issues that are unresolved before deployment are often more difficult to resolve.

## 6.1 Individual devices and radio considerations

Each CRVW3 device can be deployed to the field as an independent data collection station. Additionally, radio communications options are provided to allow CRVW3 devices to communicate with each other, with repeater stations, and with a radio base station. This enables CRVW3 devices to interact from the field with *LoggerNet* software running in the lab, office, or other IT-hosted location. Automatic data collection, performed without technician field visits, is one of the most useful benefits provided by a radio network configuration of multiple CRVW3 devices.

When installing multiple CRVW3 devices, consider deployment issues for each individual station.

## 6.2 Radio networks

When creating CRVW3 radio networks, a radio base station is always required. The base station enables non-radio communications, such as data collection requests, to enter or exit the radio network. The communications pathway provided by the base radio is critical for *LoggerNet* or other software or hardware to communicate with a network of CRVW3 devices.

For many deployments, a simple radio network design will satisfy system requirements. This manual provides basic instructions for implementation and operation of simple networks. For complex or large radio networks see the specific radio manual: RF407-Series manual ⬀ or RF451/452 manual ⬀.

## 6.2.1 Simple radio networks

The simplest network has one base station and one remote CRVW3 station. While the number of remote stations in a network can vary, each network can only contain one base station. All remote stations will communicate with the same base station.

To determine whether your needs can be met with a simple radio network, consider the following requirements:

- The CRVW3 stations in the network should all have single-hop radio links to the base station:
  - No repeater stations should be required.
  - A line-of-sight radio transmission path should exist between each CRVW3 and the base station.
  - The distances between each CRVW3 and the base station should be conservative for the radio option being used.
- The base station location should have TCP/IP or internet connectivity sufficient to communicate with the computer running *LoggerNet*.
- No measurements should be required at the base station location.

The term "single-hop" refers to the ability of a CRVW3 station to make a radio connection directly with the base station without the need to route its radio communications through another radio-enabled station (in other words, no repeating is required). Generally, simple radio networks consist of 10 or fewer stations within distances that do not require repeaters.

> **NOTE:**
> If Ethernet TCP/IP connectivity (wired) is available at the base station location, a network link interfacing device, such as the Campbell Scientific NL201, is recommended (see www.campbellsci.com/nl201 ). In this manual, we provide instructions for using the NL201 device to connect the base radio to a TCP/IP network.

## 6.3 Software requirements

Periodically, check the Campbell Scientific website for software and CRVW3 operating system (OS) updates: www.campbellsci.com/downloads 

See Updating the operating system (p. 72) for more information.

# 7. Preconfiguring CRVW3 stations

Preconfigure and test your measurement system before deployment in the field. Issues that are unresolved before deployment are often more difficult to resolve.

## 7.1 Lab software configuration

For CRVW3 lab operations, you will need a Windows computer with administrative privileges. The following steps only need to be done once.

1. Install the latest version of *LoggerNet* or *PC400*.

   > **NOTE:**
   > *PC400* does not support combined communication options (for example, phone-to-RF, advanced PakBus routing, or scheduled data collection. *LoggerNet* software is recommended for applications that require those capabilities.

2. Open *Device Configuration Utility* and select **CRVW Series**.

3. Click **Install USB Driver**.
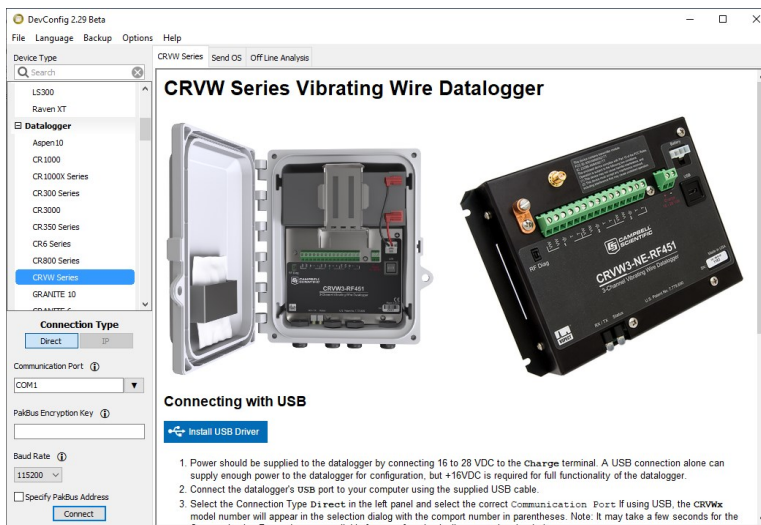
## 7.1.1 *Network Planner*

*Network Planner* ⬚, installed with *LoggerNet*, aids with radio network design and device configuration. *Network Planner* is found in the **Tools** section of the *LoggerNet* toolbar.

*Network Planner* allows you to plan which measurement stations, repeater stations, and base station will be used in your network. You can place hardware device icons onto a canvas (with an optional background graphic in place, such as a map) and explore how connections are made between each station. Many of the settings, such as unique PakBus addresses, are automatically set by the software as each device is added to the canvas. Additionally, the **Setup** details for the associated devices in your network are saved to *LoggerNet*.

See Key settings (p. 21) for an explanation of the required communications and vibrating wire settings.

After a design is complete, *Network Planner* can be used to automatically configure each device that is part of the system.
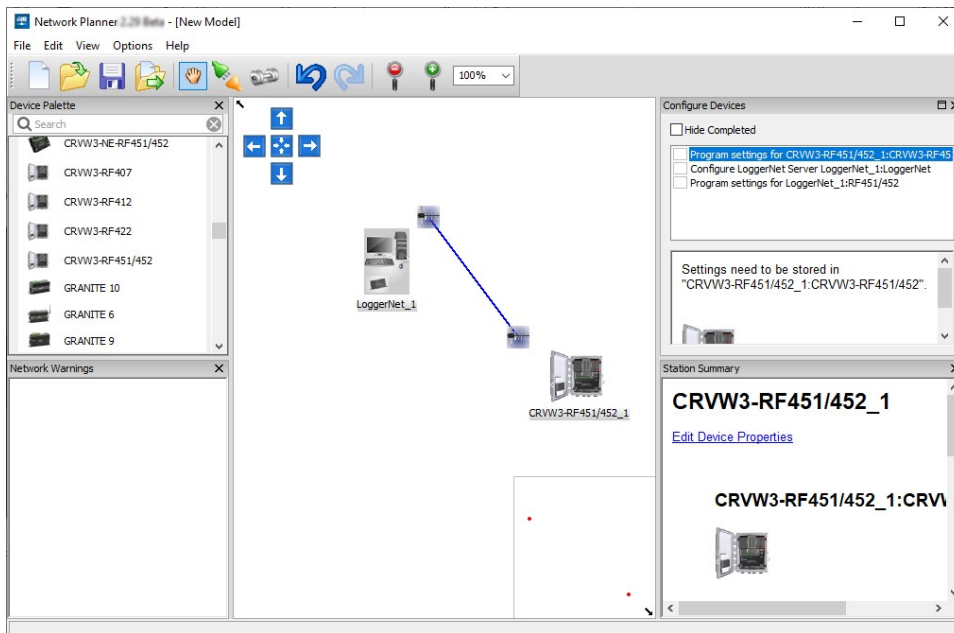


For more information about *Network Planner*, refer to the *LoggerNet Manual*, and related video:

https://s.campbellsci.com/documents/us/manuals/loggernet.pdf ⬚

https://www.campbellsci.com/videos/loggernet-software-network-planner ▶

# 7.2 Wiring temporary sensors to the CRVW3

Wire your sensors temporarily to the CRVW3 while in the lab to validate measurement operation. You can use the actual sensors (or similar) that will be used when the device is deployed to the field. Consider that any sensors connected in the lab may need to be disconnected from the CRVW3 when the system is transported to the field location.

Turn off the CRVW3 before wiring sensors to it. This includes removing the USB cable, if connected.

> **NOTE:**
> The USB connection supplies 5 VDC power as well as a direct communications link, which is adequate for setup. 12 VDC power will be needed for field deployment and radio communications. Measurements made while powered only with USB will result in **NAN** (not a number) for measurement output.

A vibrating-wire sensor may contain a built-in thermistor or other resistive temperature measurement device. If so, it will have five wires. Sensors without built-in temperature monitoring have only three wires. Refer to the manufacturer documentation to determine what sensor type you have.

Two of the sensor wires are for the main vibrating-wire measurement, and they are wired internally to the coil-circuit of the sensor. This connection is used for both sensor excitation (energy input) and for reading out the current measurement (measurement output). Use the **VW** terminals as shown in the following figure.
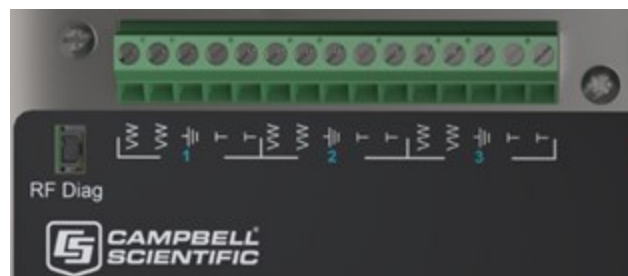


*Figure 7-1. CRVW3 wiring panel*

Sensor manufacturers often color-code wires so you can easily identify which wires are for the coil-circuit and which are for the temperature device. Polarity is not a consideration for wiring to the two **VW** terminals or the two **T** terminals. The following table and figure show typical sensor wire colors and connections.

| Table 7-1: Sensor wire color, function, and CRVW3 connection | | | |
|---|---|---|---|
| Label | Description | Common color schemes | |
| VW | First vibrating wire | Red | Orange |
| VW | Second vibrating wire | Black | Orange/White |
| ⏚ | Ground | Shield | Shield |
| T | First thermistor | Green | Blue |
| T | Second thermistor | White | Blue/White |



*Figure 7-2. Typical vibrating-wire sensor wire colors and connections*

Ensure that there is good contact between the wire metal and the inside of the terminal.

> **NOTE:**
> If the built-in temperature device is not a thermistor, measure only the resistance of the device in ohms. If it is a thermistor that follows the Steinhart-Hart conversion formula, you have the option to convert the thermistor resistance output into degrees Celsius. Refer to the sensor manual to know which kind of temperature device you have.

# 7.3 Providing temporary power to the CRVW3

> **WARNING:**
> Do not connect the CRVW3-RF451/RF452 to power without terminating the antenna port to a suitable load, such as a 50 ohm antenna, or an attenuator with a power rating greater than or equal to 2 W. Turning on the CRVW3-RF451/RF452 without a load attached may cause damage and void the warranty.

1.  Connect an antenna or power regulating attenuator to the CRVW3-RF451/RF452.

2.  To provide temporary power to the CRVW3 while in the lab, it is recommended that you use a 16 to 28 VDC power supply. Connect the power wires to the **Charge** terminals.
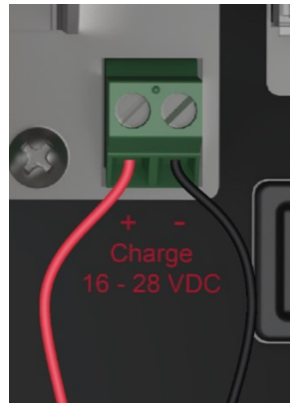


*Figure 7-3. Power source connection*

If your CRVW3 uses the –ALK option, you can disconnect that power source to preserve battery life while power is applied to the charge terminals. When using the –RC option, you can leave the rechargeable battery connected, and the charge circuit will charge the battery while the device is powered. You can also power the device through the terminals when no battery is present.

The USB connection supplies 5 VDC power as well as a direct communications link, which is adequate for setup. 12 VDC power will be needed for field deployment and radio communications. Measurements made while powered only with USB will result in **NAN** (not a number) for measurement output.

See Table 8-1 (p. 40) for LED behavior.

# 7.4 Connecting to the CRVW3

Before connecting to the CRVW3 via USB, ensure that the USB driver is installed as described in Lab software configuration (p. 15). After the driver is installed on a particular computer, it should be available for all future connections. Use a USB cable to connect the computer to the CRVW3.

*Figure 7-4. CRVW3 USB connection location*

1. Open *Device Configuration Utility* and select **CRVW Series**.

2. Select the communications port used to communicate with the data logger. It will be shown as **CRVWx**.

3. Click **OK** then **Connect**.

4. Click **OK** to avoid conflicts.

5. Select **Logger Control** tab. The **Station Time** should update once every second.

6. Click **Set Clock** to update the CRVW3 clock to match the computer clock.

7. Select **Settings Editor** > **Main**.

8. (Optional) Enter a **Station Name**.

9. Select a **Measurement Interval**.
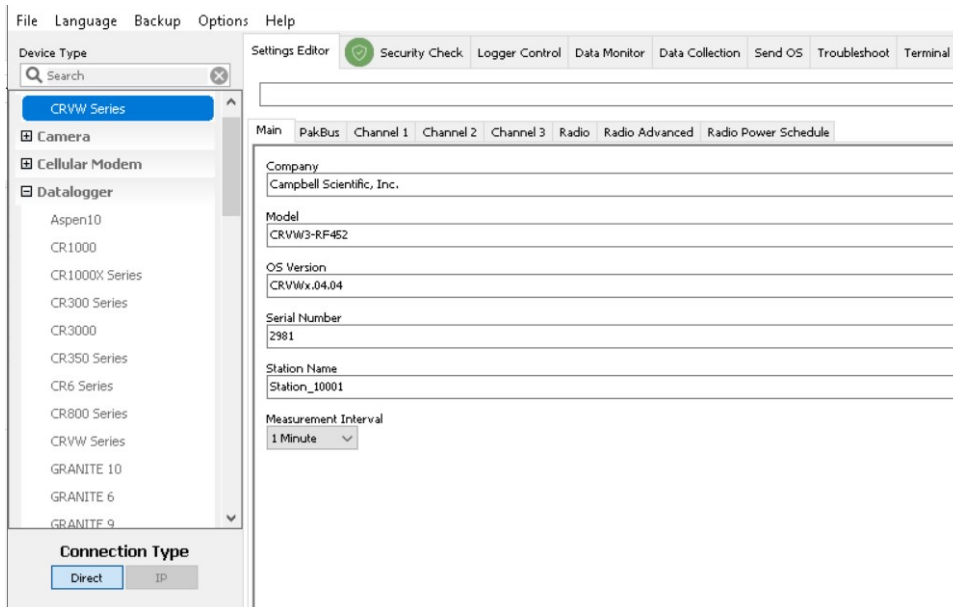
> **NOTE:**
> CRVW3s with embedded radios will have **Radio** and **Radio Power Schedule** tabs. The RF451/RF452 option will also have a **Radio Advanced** tab.

# 7.5 Configuring the CRVW3

While connected to the CRVW3, select the **Settings Editor** tab.

Key settings with values that should be reviewed and set are detailed in the following section. Place the cursor in the box for each setting to show help that describes the setting and how it is used.

> **TIP:**
> The *Network Planner* determines and sets the appropriate settings. If you use *Network Planner* you will not need to make changes to any key settings.

> **WARNING:**
> Collect all data from the CRVW3 before changing any settings. Applying changes to certain CRVW3 settings may cause the CRVW3 to reset its operating mode or change its table structure and **can result in data being erased**.

## 7.5.1 Key settings

*[TabName > SettingName]*

**Main** > **Station Name**

(Optional) Enter a unique name for each CRVW3. This can be beneficial in networks with multiple devices.

**Main** > **Measurement Interval**

Specifies how often the CRVW3 should measure the sensors connected to its active channels. The CRVW3 will automatically make measurements at this interval and store the results until it is turned off or reconfigured.

For one active channel, the smallest (fastest) measurement interval is **1 Second**. For two channels, **2 Seconds** is required, and for three channels, **3 Seconds** is the smallest interval. The longest allowable interval between measurements is **24 Hours**.

**PakBus** > **PakBus Address**

Give each CRVW3 a unique PakBus address.

Valid PakBus addresses are 1 to 4094. Generally, addresses between 4000 and 4094 are reserved for use by software such as *LoggerNet*, *PC400*, or *Device Configuration Utility*. Therefore, it is recommended that addresses 1 to 3999 be used for the CRVW3.

When deploying multiple devices to the field, plan carefully so that no two devices share the same address.

> **NOTE:**
> *Network Planner* can be used to manage PakBus addresses and ensure that each device has a unique value for this setting.

**PakBus** > **Is Router**

Sometimes, a CRVW3 is not only used to make measurements, but it is also used as a communications relay device in a radio network. This can extend the spatial range of the network by allowing distant stations to communicate back to a base station via multiple radio links or "hops." When a CRVW3 station performs these relay functions, it is known as a radio repeater and functions as a PakBus router. Set the **Is Router** setting to **True** when the CRVW3 will be used in this way.

> **NOTE:**
> Since a station configured as a router must communicate with multiple remote stations, an omnidirectional antenna is usually required instead of a directional antenna. For more information about repeater stations and routing, refer to the specific radio manual: RF407-Series manual ⧉ or RF451/452 manual ⧉.

**Channel 1, Channel 2, Channel 3** > **Name**

Give each measurement channel (sensor) a unique name. This helps to distinguish data from multiple sensors as it is stored in the final storage table and eventually collected into data files by *LoggerNet* or *PC400*.

**Channel 1, Channel 2, Channel 3** > **Enabled**

This setting is used to specify whether the channel will be actively measured or not. When set to **False**, any sensor connected to the channel will be ignored.

**Channel 1, Channel 2, Channel 3** > **Excitation Voltage**

This setting controls how much electrical excitation is applied to the vibrating-wire sensor just before being measured for its natural frequency. The excitation waveform is a frequency-rich sweep, containing frequencies from the lowest to the highest desired frequencies required for the sensor being measured. The amplitude of the input sweep waveform is controlled by this setting. Amplitudes of 2 VDC, 5 VDC, and 12 VDC can be selected. Longer sensor cable lengths

may require a higher voltage setting. Sensors measured on intervals three seconds or shorter may require the lowest (2 VDC) voltage setting to avoid loss of resolution.

### Channel 1, Channel 2, Channel 3 > Begin Frequency

This setting controls the lower frequency boundary that is used for the excitation sweep waveform. It also controls the high-pass digital filtering that is used on the measurement of the sensor. Any frequency detected on the sensor lower than this value will be ignored during processing.

Refer to your sensor documentation for guidance on what frequencies can be expected from your sensor during both usual and extreme environmental conditions. Sensors measured on intervals three seconds or shorter should use as narrow a window as possible to minimize the range between Begin Frequency and End Frequency and avoid a loss of resolution.

### Channel 1, Channel 2, Channel 3 > End Frequency

This setting controls the higher frequency boundary that is used for the excitation sweep waveform. It also controls the low-pass digital filtering that is used on the measurement of the sensor. Any frequency detected on the sensor higher than this value will be ignored during processing.

### Channel 1, Channel 2, Channel 3 > Thermistor Enabled

Set this setting to **True** if you have connected a built-in resistive temperature device from your sensor. If the temperature sensor is a thermistor that follows the Steinhart-Hart scaling equation, you can also specify the proper coefficients A, B, and C (given as the three settings following the **Thermistor Enabled** setting). This will result in a temperature output in units of degrees Celsius. Setting the three coefficient values to **0** will result in only the resistance in ohms as an output from the temperature sensor. Refer to your sensor documentation to confirm whether the temperature sensor follows the Steinhart-Hart equation and to obtain the three coefficients to be used (A, B, and C).

### Channel 1, Channel 2, Channel 3 > Calculate Engineering Output

Set this to **True** to output engineering units for sensor frequency and sensor temperature (if a thermistor is used). The CRVW3 applies a polynomial that works with most vibrating-wire sensors. For details about the polynomial-based calculation process, refer to Engineering output and calibration (p. 81).

> **NOTE:**
> To use a current barometric pressure reading as part of the calculation of water height, pressure, or related measurements, refer to Engineering output and calibration (p. 81).

**Radio, Radio Power Schedule** and **Radio Advanced**

When using a radio option, some key settings on the **Radio, Radio Power Schedule** and **Radio Advanced** tabs should be set. See Validating radio connectivity in the lab (p. 27) and Validating CRVW3 radio operation (p. 51) for more details about these settings.

## 7.5.2 Managing changes to settings

Once you have made changes to the CRVW3 settings, click **Apply** at the bottom of the *Device Configuration Utility* screen to save the settings. The CRVW3 will be busy for up to 20 seconds while applying the changes. During this time, you will be unable to connect to the CRVW3. Watch the LEDs on the device to determine when the device has completed its reconfiguration and has resumed making measurements. See LED indicators (p. 39) for more information.

(Optional) Save the configuration to a file on the computer. Click **Summary** to display a summary of the current settings. Click **Save** to save these settings to the computer as an XML file. The default filename includes the device type and date. If needed, these settings can be reapplied at a later time by clicking **Read File** then **Apply**.

The setting changes have been saved

### Configuration of CRVW Series

Configured on: Thursday, February 9, 2023 11:48:04 AM

| Setting Name | Setting Value |
|---|---|
| Company | Campbell Scientific, Inc. |
| Model | CRVW3 |
| OS Version | CRVWx.03.00 |
| Serial Number | 1,000 |
| Station Name | Station_1000 |
| Measurement Interval | 1 Minute |

Ok    Save    Print    Compare

# 7.6 Testing CRVW3 measurements

Once configured, the CRVW3 will restart and automatically begin measuring sensors at the interval specified. The data is stored as each measurement is made.

Use *Device Configuration Utility* in the lab to confirm measurements are being made by the CRVW3.

1. Select **Logger Control** tab. The **Station Time** should update once every second.

2. Select **Data Monitor** to view data being stored in the final storage and utility tables of the device. Click on a table name in the left pane to see its latest stored record in the right pane. The **Status** table shows general information about the CRVW3 and its operation. The **Public** table shows information about specific variables in use by the current program configuration. The **VW_Data** table is the main storage table. This is where a permanent history of sensor readings is stored. The **DataTableInfo** table gives details about final storage tables in use by the device. If calibration settings are used (baseline values), a **CalHist** table will also appear that shows calibration values captured during the latest calibration event.

3. Confirm that the **RecordNo** field of the **VW_Data** table is incrementing at the proper measurement interval, and that the measurement data (frequency, temperature) is correct. The **Time Stamp** field should also update as each measurement is made.

4. Use the **Troubleshoot** tab to see detailed information about the vibrating-wire sensor measurements made by the CRVW3. Manually trigger a measurement test and see diagnostic results within a few seconds. Select your **Channel** and click **Options** to set a test sweep excitation and frequency filtering window, and the excitation voltage level. Click **Poll** to initiate the test. Results will be displayed on the screen within a few seconds. For more information, see Confirm CRVW3 sensor measurements (p. 50).

5. View the frequency domain response of the vibrating-wire sensor in the **Spectrum** window. Peaks in the spectrum indicate the main frequencies at which the sensor wire vibrated during the measurement. The strength of the peaks is shown in the millivolt (mV) scale. Drag a rectangle on the viewing area to zoom in, then click **Undo Zoom** to return to the initial scale.

6. Use the **Time Series** window to see the motion of the sensor wire in millivolts (mV) during the measurement period as given by the changing magnetic field sensed by the coil circuitry. Drag a rectangle on the viewing area to zoom in, then click **Undo Zoom** to return to the initial scale.

7. The main frequency reading is given in the **Peak Frequency** box in units of Hertz (Hz).

8. The following diagnostic readings help assess the quality of the reading:

- **Signal-to-noise ratio:** Amplitude (mV) of the strongest frequency peak in the spectrum divided by the amplitude (mV) of the second strongest frequency peak.

- **Decay ratio:** Amplitude (mV) of the time-series motion of the wire at the beginning of the measurement divided by the amplitude (mV) of the wire motion at the end of the measurement. This can also be approximated by a study of the results in the **Time Series** window.

- **Peak amplitude:** Amplitude (mV) of the strongest frequency peak in the spectrum.

- **Noise frequency:** Frequency (Hz) of the second strongest frequency peak in the spectrum.

- **Thermistor:** Measurement of the thermistor electrical resistance in ohms (Ω).
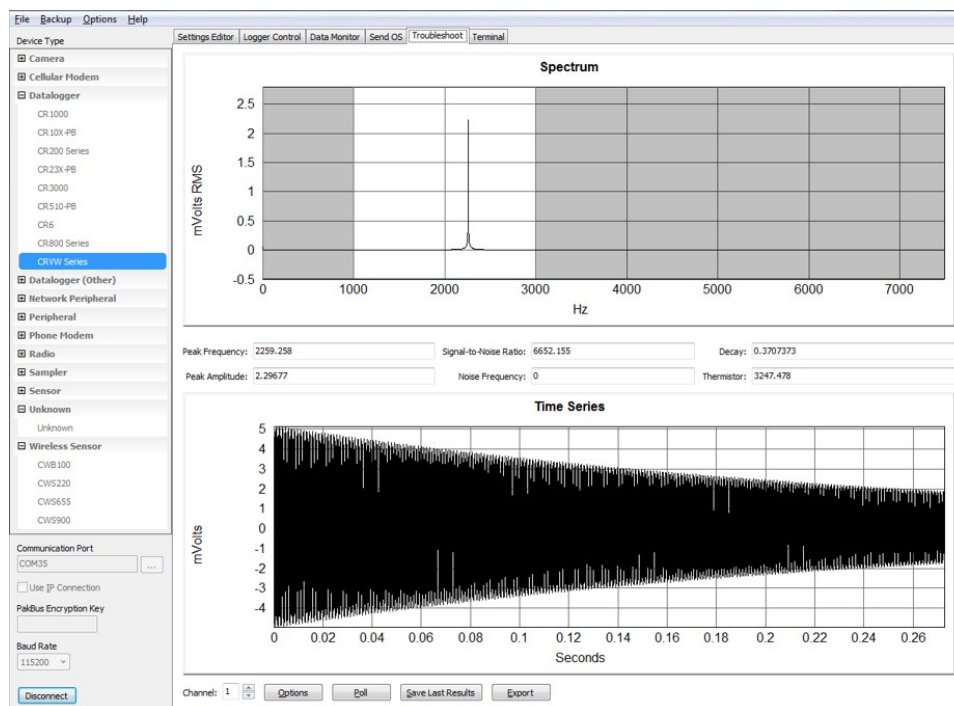


Click **Save Last Results** to save the results of the test to a binary file (*.bin). This file can be sent to Campbell Scientific support personnel (or to others) and then opened in *Device Configuration Utility* using the **Offline Analysis** tab that is shown when not connected to the CRVW3. This will allow others to assess the condition of your sensor measurement in detail. Click **Export** to save the results of the test into a text file.

9. Use the **Terminal tab** to make a terminal mode connection to the CRVW3. This is typically used under the direction of Campbell Scientific support personnel. See Terminal mode (p. 75) for more information.

# 7.7 Validating radio connectivity in the lab

For CRVW3 devices with the –RF451/RF452 or –RF407 option, verify that the radio is working and has been configured for field operation.

## 7.7.1 Validating CRVW3–RF451/RF452 radio connectivity

When using CRVW3–RF451/RF452 devices, the simplest way to confirm radio connectivity is to use an RF451/RF452 radio connected to your lab computer. The RF451/RF452 operates as the gateway (master) radio device and the base station. The CRVW3–RF451/RF452 device is configured as an endpoint (slave) device. See the RF451/452 manual ⬚ for more details about gateway/endpoint radio configurations and base station considerations.

> **WARNING:**
> Do not connect the CRVW3-RF451/RF452 to power without terminating the antenna port to a suitable load, such as a 50 ohm antenna, or an attenuator with a power rating greater than or equal to 2 W. Turning on the CRVW3-RF451/RF452 without a load attached may cause damage and void the warranty.

Use *Device Configuration Utility* or *LoggerNet* to test radio connectivity. For details about using *LoggerNet* to test the radio connectivity, see LoggerNet configuration (p. 54).

> **NOTE:**
> Different versions of *Device Configuration Utility* may use different RF451/RF452 terminology. Screen shots throughout this manual use the new terms.

Table 7-2: RF451/RF452 terminology

| New term | Old term |
|----------|----------|
| gateway | master or multi-point master |
| endpoint | slave or multi-point slave |

> **NOTE:**
> If testing the radio connectivity of multiple CRVW3–RF451/RF452 devices, only turn on one CRVW3–RF451/RF452 at a time when using this test method.

# 7.7.1.1 Configuring the base RF451/RF452

Radios are configured using *Device Configuration Utility*. See Figure 7-5 (p. 28). The following general procedure is used to configure an RF451/RF452 radio via *Device Configuration Utility*:

1. Connect the antenna. Do not connect the CRVW3-RF451/RF452 to power without terminating the antenna port to a suitable load, such as a 50 ohm antenna, or an attenuator with a power rating greater than or equal to 2 W. Turning on the CRVW3-RF451/RF452 without a load attached may cause damage and void the warranty.

2. Start *Device Configuration Utility* from the *LoggerNet* toolbar **Utilities** category.

3. From the **Device Type** list, select the **RF451/RF452**. Information, instruction, and help are provided on each screen.
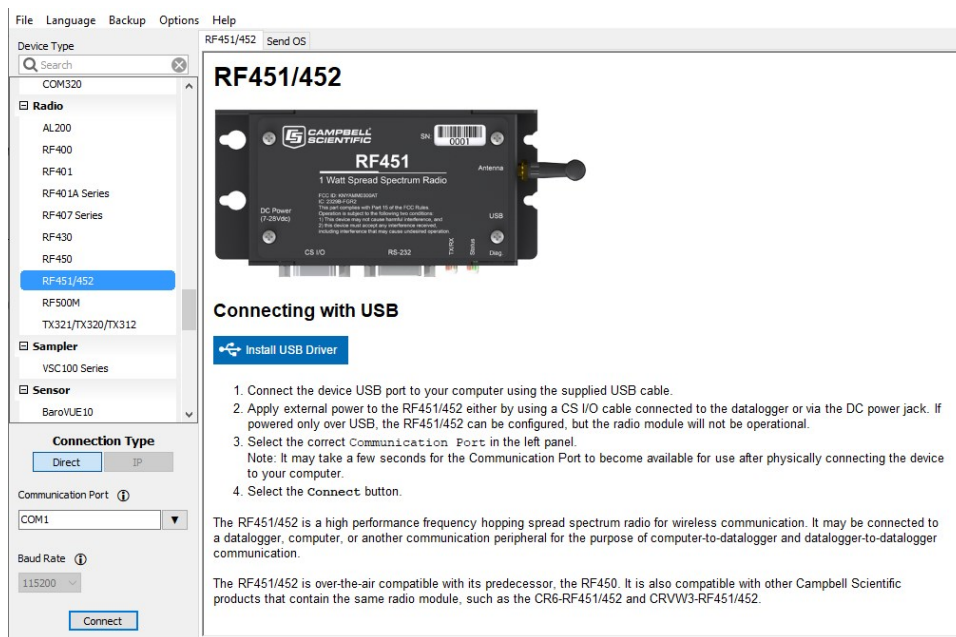


*Figure 7-5.* **Device Configuration Utility**

4. Click the **Install USB Driver** button. Carefully review the text on the right side of the screen. Installing the driver only needs to be done the first time the computer is connected to an RF451/RF452.

   > **NOTE:**
   > Install the device driver before plugging a radio into your computer for the first time. You will need to have the device driver properly installed before you can connect to the

| | radio via USB. |

5. With the USB device driver installation complete, connect a USB cable between the USB port on your computer and the USB port on the radio.

6. Select the COM port. It should be listed in the dialog as **RF451/RF452 (COM#)** where # is the COM port number.

   | | |
   |---|---|
   | | **NOTE:**<br>It may take a few seconds for the **Communication Port** to become available for use after physically connecting the RF451/RF452 to your computer. |

7. Click **Connect**. The radio **Status** LED will turn yellow. After several seconds, a screen similar to will appear:



*Figure 7-6. RF451/RF452 settings*
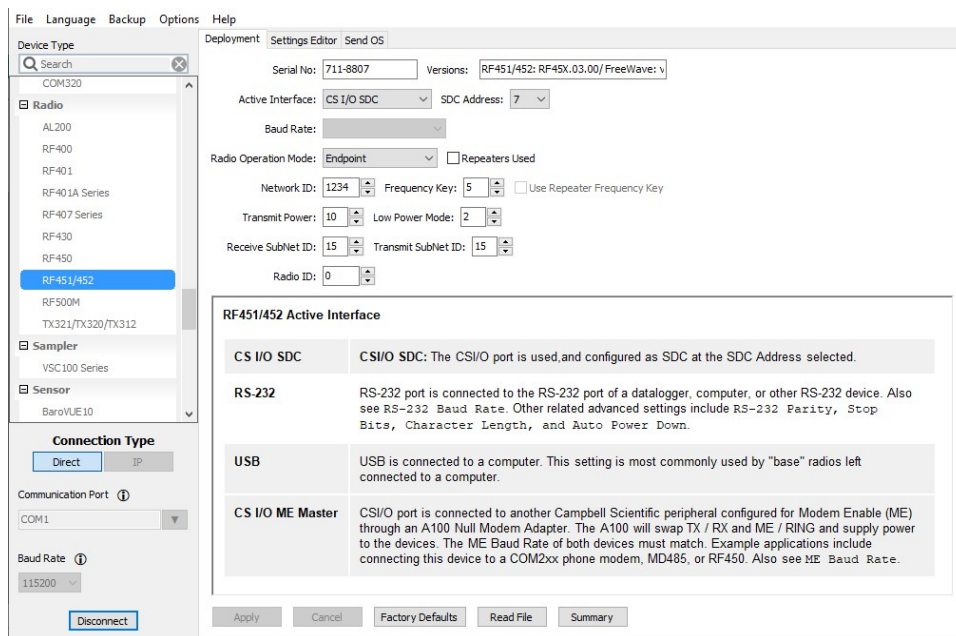
8. Set the following settings:

| Table 7-3: Base radio settings | |
|---|---|
| **Name** | **Setting** |
| Active Interface | USB |
| Radio Operation Mode | Gateway (Multi-point master) |

| Table 7-3: Base radio settings | |
|---|---|
| Name | Setting |
| Repeaters Used | Leave checkbox cleared |
| Network ID | Value should match the CRVW3 ID exactly (0 to 4095) |
| Frequency Key | Leave at 5 |
| Transmit Power | Leave at 10 |
| Receive SubNet ID | Leave at 15 |
| Transmit SubNet ID | Leave at 15 |
| Radio ID | Must be unique for each radio device; use 1 (CRVW3 will use 0) |

9. Click **Apply**.

10. Leave the USB cable connected to the USB port of the RF451/RF452 and the computer.

**Deployment**, **Settings Editor**, and **Send OS** tabs are available. The **Deployment** tab contains all the standard parameters that need to be set for a PakBus® network. The **Settings Editor** tab may be used to access all of the FreeWave® Radio settings. It should be used by experienced FreeWave Radio users only. New operating systems for the Campbell Scientific board are loaded through the **Send OS** tab.

*Device Configuration Utility* makes applying the same settings to multiple devices easy. Once settings are configured for one device, click **Apply** to save your changes; a summary screen similar to Figure 7-7 (p. 31) will be shown. Click **Save** to save a configuration file. This file can then be used to load the settings into another radio. Click **Read File** to load the settings in *Device Configuration Utility*. Then click **Apply** to save your changes to load the settings into the radio.
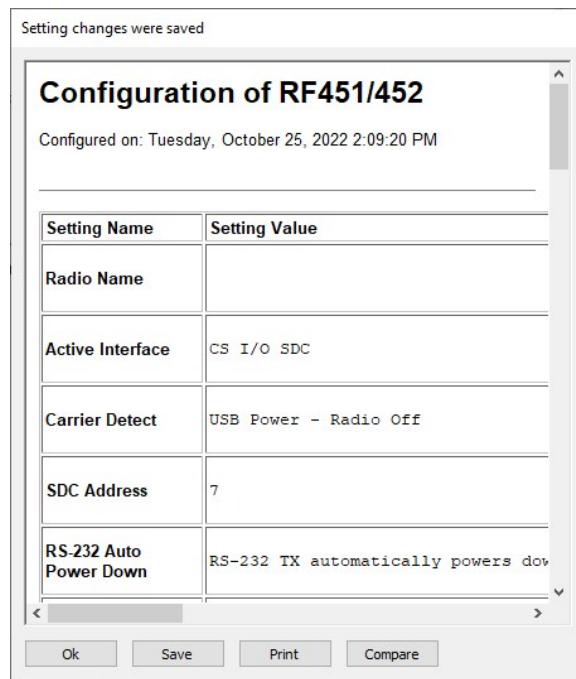
*Figure 7-7. **Device Configuration Utility** RF451/RF452 summary screen*

## 7.7.1.2 Configuring the CRVW3–RF451/RF452

1. Provide power to the CRVW3 as described in Providing temporary power to the CRVW3 (p. 18).

2. Connect the CRVW3 and computer using a USB cable.

3. In **Device Configuration Utility**, choose **CRVW Series**, select the **CRVWx** Communication Port. **Connect**.

4. In the **Settings Editor** tab, select the **Radio** sub-tab.

5. Set the following settings:

| Table 7-4: Base radio settings | |
|---|---|
| Name | Setting |
| Radio Enabled | True |
| Radio Operation Mode | Endpoint (Multi-point slave) |
| Frequency Key | Leave at 5 (matches RF451/RF452) |
| RF Transmit Power | Leave at 8 |

| Table 7-4: Base radio settings | |
|---|---|
| Name | Setting |
| Low Power Mode | Leave at 2 |
| Repeater Frequency | Leave at Use Gateway (Master) Frequency Key |
| Receive SubNet ID | Leave at 15 (matches RF451/RF452) |
| Transmit SubNet ID | Leave at 15 (matches RF451/RF452) |
| Network ID | Must match value given for RF451/RF452 (0 to 4095) |
| Radio ID | Leave at 0 (must be unique/different from RF451/RF452 radio ID, which should be 1) |

6. Click **Apply**.

7. Disconnect the USB cable from the CRVW3.

> **NOTE:**
> If devices have been previously tested or deployed, they may be assigned **Network ID** and **Frequency Key** values that do not match the current network settings. Make sure the **Network ID** and **Frequency Key** values match in all devices in the network and that the **Radio ID** is unique for each device.

## 7.7.1.3 Using *Device Configuration Utility* to connect to the CRVW3–RF451/RF452 over the radio

If no other CRVW3–RF451/RF452 devices are on the radio network (powered or in range), *Device Configuration Utility* connects to the CRVW3 device that is powered and available using the RF451/RF452/COM port on the computer as a transparent link. The *Device Configuration Utility* screens should behave the same as when there is a wired connection between the computer and CRVW3. You should be able to view and set all the settings of the CRVW3 over the radio connection.

1. Position the RF451/RF452 and computer at least 25 feet away from the CRVW3. The CRVW3 should no longer be wired to any device.

2. In *Device Configuration Utility* select **CRVW Series**.

3. Select the communications port on the computer that is connected to the RF451/RF452 radio.

4. Click **Connect**.

5. Confirm that the **RX/TX** LED flashes red and green on both the CRVW3 and RF451/RF452.

6. On the **Main** tab confirm that the **Serial Number** and **Station Name** correspond to the CRVW3 station being tested.

7. Use the **Data Monitor** tab to confirm proper CRVW3 operation.

> **NOTE:**
> If multiple CRVW3 devices need to be powered and located within radio range of the RF451/RF452 base station computer, you must use **LoggerNet** to test their radio connectivity. **LoggerNet** can distinguish between CRVW3 devices based on PakBus address. Each CRVW3 should have a unique Radio ID setting and a unique PakBus address. Follow the steps outlined in LoggerNet configuration (p. 54) to perform multiple CRVW3 radio tests using **LoggerNet**.

# 7.7.2 Validating CRVW3–RF407 radio connectivity

When using CRVW3–RF407 devices, the simplest way to confirm connectivity is to use an RF407 radio connected to your lab computer. The RF407 operates as the base station. See the RF407-Series manual⬈ or more details about radio configurations and base station considerations.

The RF407 and CRVW3–RF407 usually communicate easily in lab conditions if they are within about 100 feet of each other and if the RF407 is using a small 1/2 wave omnidirectional antenna. The CRVW3–RF407 typically does not need an antenna.

Use **Device Configuration Utility** or **LoggerNet** to test radio connectivity. For details about using **LoggerNet** to test the radio connectivity, see LoggerNet configuration (p. 54).

> **NOTE:**
> If testing the radio connectivity of multiple CRVW3–RF407s, only turn on one CRVW3–RF407 at a time when using this test method.

## 7.7.2.1 Configuring the baseRF407

Radios are configured using **Device Configuration Utility**. See Figure 7-8 (p. 34). The following general procedure is used to configure an RF407 radio via **Device Configuration Utility**:

1. Start *Device Configuration Utility* from the *LoggerNet* toolbar **Utilities** category.

2. From the **Device Type** list, select the **RF407**. Information, instruction, and help are provided on each screen.



*Figure 7-8. **Device Configuration Utility** startup screen*

3. Click the **Install USB Driver** button. Carefully review the text on the right side of the screen. Installing the driver only needs to be done the first time the computer is connected to an RF407.

    > **NOTE:**
    > Install the device driver before plugging a radio into your computer for the first time. You will need to have the device driver properly installed before you can connect to the radio via USB.

4. With the USB device driver installation complete, connect a USB cable between the USB port on your computer and the USB port on the radio.

5. Select the correct COM port for USB communications with the radio. It should be listed in the dialog as **RF407 (COM#)** where # is the COM port number.

    > **NOTE:**
    > It may take a few seconds for the **Communication Port** to become available for use after physically connecting the RF407 to your computer.

6.  Click **Connect**. The radio **Status** LED will turn yellow. After several seconds, a screen similar to Figure 7-9 (p. 35) will appear:
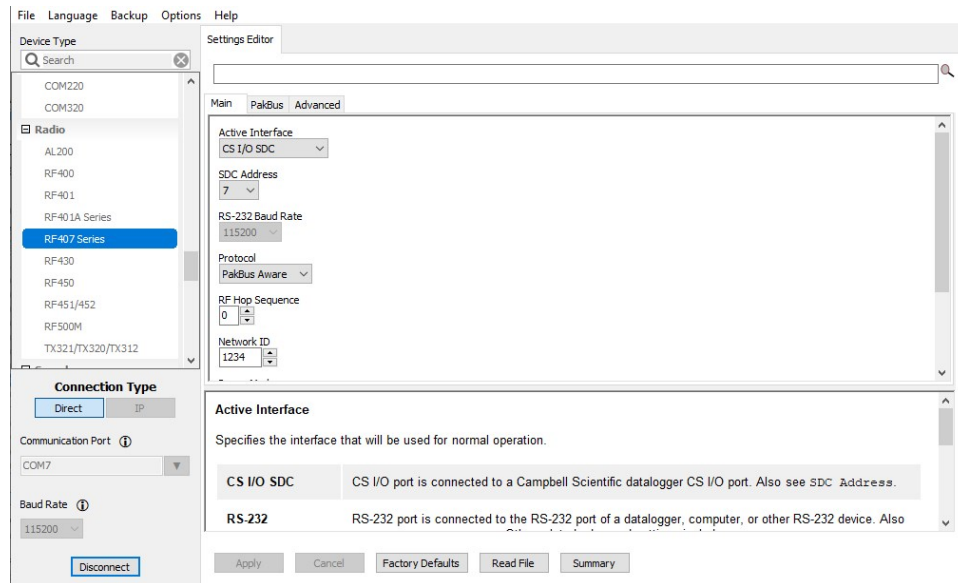


*Figure 7-9. RF407 settings*

7.  Click **Factory Defaults** to return the RF407 settings to the factory defaults.

8.  Set the **Active Interface** to **USB**.

9.  Click **Apply**.

10. Leave the USB cable connected to the **USB** port of the RF407 and the computer.

*Device Configuration Utility* makes applying the same settings to multiple devices easy. Once settings are configured for one device, click **Apply** to save your changes; a summary screen similar to Figure 7-10 (p. 36) will be shown. Click **Save** to save a configuration file. This file can then be used to load the settings into another radio. Click **Read File** to load the settings in *Device Configuration Utility*. Then click **Apply** to save your changes to load the settings into the radio.
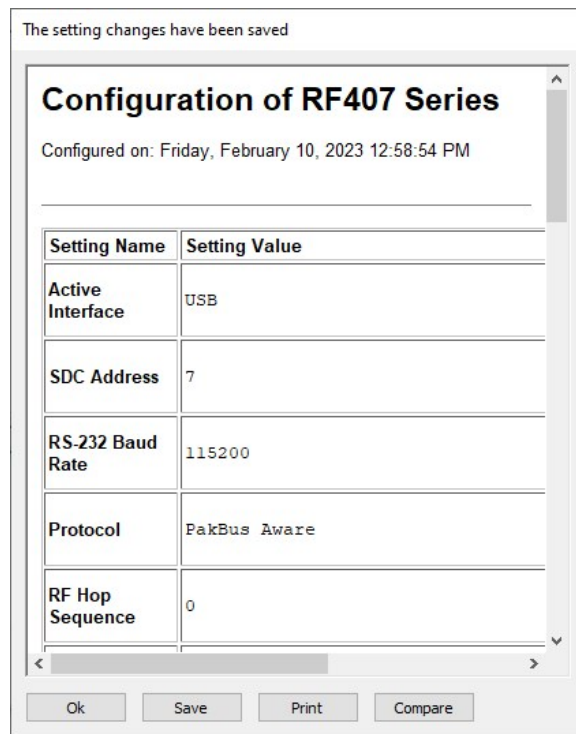
*Figure 7-10.* **Device Configuration Utility** *RF407 summary screen*

## 7.7.2.2 Configuring the CRVW3–RF407

1. Provide power to the CRVW3 as described in Providing temporary power to the CRVW3 (p. 18).

2. Connect the CRVW3 and computer using a USB cable.

3. In *Device Configuration Utility*, choose **CRVW Series**, select the **CRVWx** Communication Port. **Connect**.

4. In the **Settings Editor** tab, select the **Radio** sub-tab.

5.  Set the following settings:

| Table 7-5: Base radio settings | |
|---|---|
| Name | Setting |
| Radio Enabled | True |
| RF Hop Sequence | 0 (matches RF407) |
| Network ID | 1234 (matches RF407) |
| Power Mode | 0.5 Sec |
| Retry Level | Low |
| Radio TX Power Level | +24.0 dBm (250 mW) |

6.  Click **Apply**.

7.  Disconnect the USB cable from the CRVW3.

> **NOTE:**
> When testing deployed devices in the field, you may have already assigned different **RF Hop Sequence** and **Network ID** values than those shown previously. Make sure the **RF Hop Sequence** and **Network ID** values match in all devices in the network.

## 7.7.2.3 Using *Device Configuration Utility* to connect to the CRVW3–RF407 over the radio

If no other CRVW3–RF407s are on the radio network (powered or in range), *Device Configuration Utility* connects only to the CRVW3 device that is powered and available by using the RF451/RF452/COM port on the computer as a transparent link. The *Device Configuration Utility* screens should act just as they do when the computer has a wired connection to the CRVW3. You should be able to view and set all the settings of the CRVW3 over the radio connection.

1.  Position the RF407 and computer at least 25 feet away from the CRVW3. The CRVW3 should no longer be wired to any device.

2.  In *Device Configuration Utility* select **CRVW Series**.

3.  Select the communications port on the computer that is connected to the RF407 radio.

4.  Click **Connect**.

5.  Confirm that the **RX/TX** LED flashes red and green on both the CRVW3 and RF407.

6. On the **Main** tab confirm that the **Serial Number** and **Station Name** correspond to the CRVW3 station being tested.

7. Use the **Data Monitor** tab to confirm proper CRVW3 operation.

> **NOTE:**
> If multiple CRVW3 devices need to be powered and located within radio range of the RF407 base station computer, you must use *LoggerNet* to test their radio connectivity. *LoggerNet* can distinguish between CRVW3 devices based on PakBus address. Each CRVW3 should have a unique PakBus address. Follow the steps outlined in LoggerNet configuration (p. 54) to perform multiple CRVW3 radio tests using *LoggerNet*.

# 8. CRVW3 field deployment

When a CRVW3 is deployed to its permanent location in the field, several key considerations help to ensure that it works properly. This section discusses how to successfully install get each device at its planned location.

> **NOTE:**
> When using a CRVW3 with a radio option (–RF451/RF452 or –RF407), designing the radio network ahead of time is recommended to help ensure there is sufficient signal strength and connectivity between the CRVW3 and other devices in the network. It is important to determine how radio connectivity is impacted by the geographic location of each CRVW3 station.
>
> Preconfigure and test your measurement system before deployment in the field. Issues that are unresolved before deployment are often more difficult to resolve.

When installing devices with a radio option, bring a radio device into the field that can operate as a radio base station. For the CRVW3–RF451/RF452, the base station is an RF451/RF452 configured as the gateway (master) radio and *LoggerNet* software running on a computer. For the CRVW3–RF407, the base station is an RF407 and *LoggerNet* software running on a computer.

> **WARNING:**
> Do not connect the CRVW3-RF451/RF452 to power without terminating the antenna port to a suitable load, such as a 50 ohm antenna, or an attenuator with a power rating greater than or equal to 2 W. Turning on the CRVW3-RF451/RF452 without a load attached may cause damage and void the warranty.

# 8.1 LED indicators

The CRVW3 LEDs give an indication of its state. See the following figure for LED locations inside and outside of the enclosure. Table 8-1 (p. 40) summarizes LED operation.



*Figure 8-1. CRVW3 LEDs*

| Table 8-1: CRVW3 LED behavior | | | |
|---|---|---|---|
| RX/TX LED (left side)[1] | | Status LED (right side) | |
| Solid red | Radio error | Solid red | Measurement or program error |
| | | Solid green | Measuring sensor(s) |
| Solid orange | Radio configuration, system is busy and no communications will occur. Allow up to 20 seconds before attempting to connect. | Solid orange | Device or OS configuration, system is busy and no communications will occur. |
| Flashing red | Radio transmit (TX) | Flashing red | No measurements possible with only USB power. (For –RF451/RF452 option, radio is not powered. No communications possible.) |
| Flashing green | Radio receive (RX) | Flashing green | Awake (heartbeat) |
| Flashing orange | No carrier detect (RF451/RF452 radio only) | Flashing orange | Awake (heartbeat); in repeater mode for –RF451/RF452 option |
| Off | Connected to gateway (master), but not currently transmitting or receiving. | Off | Device idle or turned off |
| [1] Only applicable to CRVW3-RF models | | | |

# 8.2 Connecting sensors to the CRVW3

Install the vibrating-wire sensors according to manufacturer supplied instructions. A 5-wire or 3-wire cable will connect between each sensor and the CRVW3. Vibrating-wire sensors containing a built-in thermistor will have five wires. Sensors without a built-in thermistor will have three wires. A sensor with five wires will have two wires for the coil circuit, two wires for the thermistor, and a shield wire. A 3-wire sensor has two wires for the coil circuit and a shield wire.

Cable distances more than 500 m (1500 ft) may require the use of 12 VDC excitation instead of 5 VDC excitation. See Excitation voltage in Configuring the CRVW3 (p. 21). 12 VDC excitation uses more power which will reduce battery power more quickly than 5 VDC. Vibrating-wire sensor connections can provide reliable readings using cable distances up to 1500 m (4500 ft) in some circumstances. However, cable distances less than 500 m (1500 ft) are recommended. Up to three vibrating-wire sensors can be connected to each CRVW3.

1. Determine which channel on the CRVW3 will be used for each sensor.
2. Unscrew and remove the connector on the outside of the enclosure that corresponds to the channel currently being installed.
3. Remove the capping pin.
4. Feed the removed connector over the bare wires on the end of the sensor cable, and position the connector a few inches down the cable.
5. Feed the wires and cable through the connector hole.



*Figure 8-2. CRVW3 cable connection and entry points*

6. Secure the connector to the enclosure.
7. Wire the sensor using a procedure similar to the one you followed in Wiring temporary sensors to the CRVW3 (p. 17)

| Table 8-2: Sensor wire color, function, and CRVW3 connection | | | |
|---|---|---|---|
| Label | Description | Common color schemes | |
| VW | First vibrating wire | Red | Orange |
| VW | Second vibrating wire | Black | Orange/White |
| ⏚ | Ground | Shield | Shield |

| Table 8-2: Sensor wire color, function, and CRVW3 connection | | | |
|---|---|---|---|
| Label | Description | Common color schemes | |
| T | First thermistor | Green | Blue |
| T | Second thermistor | White | Blue/White |

8. Verify sensors are being measured correctly. See Testing CRVW3 measurements (p. 25).

9. Further secure the connector for field use. To do this, leave a slight amount of slack in the cable between the terminals and the connector, reconnect the connector cap (which was previously threaded onto the cable) on the outside of the enclosure. Tighten it by hand or with a wrench. Ensure that the seal contacts the cable evenly to avoid water ingress. Pull gently on the cable to ensure that it does not slide or move.

10. Repeat the sensor connection process for up to two additional sensors, using the terminals provided for those channels.

# 8.3 Providing power to the CRVW3

Although it is possible to operate the CRVW3 from a fully charged 7 Ah rechargeable battery without using a charge mechanism or solar panel, it is anticipated that longer discharge times will be obtained from the –ALK option rather than the –RC option. The –ALK option is recommended for non-charging battery-only power scenarios.

A CRVW3 with a radio option requires more power. See Validating CRVW3 radio operation (p. 51) for information on using the *Device Configuration Utility* **Radio Power Schedule** tab to reduce the amount of power consumed by the radio.

As a power-saving feature, the CRVW3 remains awake between measurements only for a limited time. If the CRVW3 is turned on without a USB cable connected to it, it will remain awake between measurements for five minutes. After five minutes, it will go into a low-power mode between measurements. While in low-power mode, the CRVW3 will wake up only long enough to measure its sensors and store the results

The CRVW3 will wake up (if not already awake) and remain awake as long as the USB cable is connected to the device. After the USB cable has been disconnected, the device will remain awake for five minutes, then sleep between measurements.

Radio transmissions received by the device will wake the CRVW3. The device will remain awake for as long as radio activity is in process, plus an additional 20 seconds in case additional radio transmissions are received.

How much power the CRVW3 uses, and how long batteries last depends on several factors, including:

- Which radio option is used
- How often measurements are made
- How often the radio communicates
- Whether the site experiences cold temperatures or extreme changes in temperature

# 8.3.1 Alkaline D cell option (–ALK)

CRVW3–ALK uses eight alkaline D-cell batteries for power. When using this option, no solar panel or charge mechanism is required. However, visits to the site will be required to replace old batteries with new ones.

Turn on the CRVW3 by connecting the battery connector to the CRVW3 as shown in the following figure:



*Figure 8-3. –ALK battery pack connection*

You should immediately see LED activity on the CRVW3. If no LED activity is observed, then check and replace the batteries if necessary. See LED indicators (p. 39) for more information.

When replacing batteries, disconnect the power connector and remove the CRVW3 battery pack. Disengage the securing latch by pushing on the metal backing; the hinge should snap out. Once the battery pack is removed from the enclosure, you can replace the batteries. Replace the battery pack in the enclosure. Secure the latch, ensuring that the bumpers on the pack contact the latch and that the battery pack does not move when pressed.
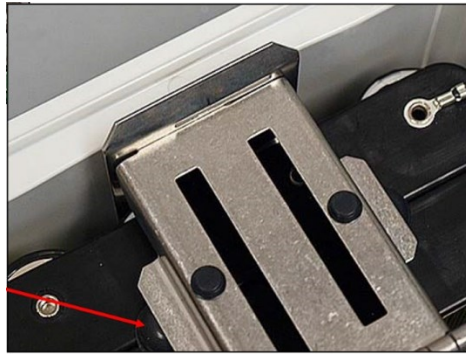
*Figure 8-4. Bumpers used to secure the –ALK battery pack*

# 8.3.2 Rechargeable battery option (–RC)

CRVW-RC uses a 7 Ah rechargeable battery for power. You will need a solar panel or some other DC voltage source (16 to 28 VDC) to recharge the battery. Due to the power requirements of the –RF451/RF452 radio option, most CRVW3–RF451/RF452 networks will use the –RC option.

The CRVW3 includes a built-in charge regulator to simplify the deployment and use of a solar panel. The output from the solar panel connects directly to this regulator via the CRVW3 charge terminals.

The charge regulator senses the voltage provided by the solar panel and either charges the battery or simply draws power from it. This ensures constant CRVW3 operation during changes from periods of full solar panel power production to periods of little or no panel output. When the battery is charged to its full state, the charge regulator applies just enough power to keep the battery fully charged.

Install the solar panel with the visibility and orientation to optimize the capture of solar energy. See your solar panel manual for more information.

> **NOTE:**
> A spreadsheet is available from Campbell Scientific to help you determine which solar panel to use based on the frequency of your measurements, radio communications activity, and estimated solar exposure. For more information, see
> www.campbellsci.com/downloads/power-budget-spreadsheet ⬀ and
> www.campbellsci.com/videos/power-budgeting ▶.

When connecting the solar panel output cable to the CRVW3, feed the cable through the corresponding gland and secure the seal using a similar process to that described in Connecting sensors to the CRVW3 (p. 40). Connect the solar panel cable to the **Charge +** and **–** terminals. The polarity of the wires from the solar panel must be observed, so check the cabling carefully.

Connect the 7 Ah rechargeable battery to the power/charge circuit by plugging the provided connector into the **Battery** connector on the panel.

You should see LED activity on the CRVW3 when either a charged battery is connected to the CRVW3 or sufficient voltage is applied to the charge terminals. See LED indicators (p. 39) for more information.

### 8.3.3 AC line power

The CRVW3 device can operate using AC line power as the main power source. However, it is still recommended to have a rechargeable battery (with the –RC option) as a backup source in case of power outages. This helps ensure measurement continuity and prevent data loss.

When voltage is applied to the charge terminals, the battery will be charged (or maintained at full charge) during times when AC line power is available. This helps ensure that the battery is always ready to provide backup power in case of power outages.

Additionally, the –ALK option provides backup power using a D cell alkaline battery pack. However, the –ALK option does not include any charging functionality, and the alkaline batteries will only be used when the voltage on the charge terminals is low or zero.

## 8.4 Humidity monitoring and control

Control moisture and humidity inside the enclosure to protect the CRVW3 electronics.

1. Install a humidity indicator card on the inside of the enclosure lid above the desiccant holder.

2. Review the status of the indicator card during maintenance visits.

3. Replace the desiccant, and card when one or more circles on the card change from blue to pink.

> **NOTE:**
> The humidity indicator card is a single-use card and should be replaced after one or more of its colored circles turn pink.

## 8.5 Mounting the CRVW3 enclosure

The CRVW3 enclosure can be securely attached to a pole or other surface. Figure 8-5 (p. 46) shows the CRVW3 with the –UM option installed.

*Figure 8-5. –UM mounting option*

Also consider the location of the solar panel and antenna and how all cabling will connect to enclosure.

Mount the enclosure with the sensor connectors, antenna connector, and ground lug facing downward. This minimizes water intrusion from precipitation and helps keep the inside of the enclosure dry.

# 8.6 Installing the CRVW3 antenna

When using a radio option on the CRVW3 (CRVW3–RF451/RF452 or CRVW3–RF407), carefully consider the kind of antenna to use with the device. Ensure that it can communicate properly with the applicable remote CRVW3s, radio repeater stations, and the radio base station. See Radio networks (p. 13) and the specific radio manual: RF407-Series manual☑ or RF451/452 manual☑ for more information about the configuration of radio networks.

A small whip or dipole antenna may be connected directly to the enclosure bottom. These are used for testing or for short distance communications links. For longer distances, a higher gain, externally cabled antenna is usually necessary. These antennas require mounting hardware (such as a pole) separate from the CRVW3.

If the CRVW3 communicates with only one other radio station or device, use a directional Yagi antenna, and position it to point directly at the remote station. If the CRVW3 communicates with more than one radio station or device (for example, when it is configured to operate as a repeater station), an omnidirectional antenna should be used. Raising the antenna higher may improve the signal reception and transmission.

It is important that there is an unobstructed line-of-sight (LOS) between the transmitting and receiving antennas. For more information, see https://www.campbellsci.com/blog/line-of-sight-more-than-meets-eye ⬈.

Antenna connections that are exposed to the environment should be protected with self-vulcanizing cold shrink tape. A surge suppressor kit is also recommended when using cabled antennas. This will protect against lightning strikes or other electrical hazards. An example of a weatherproofed surge suppressor is shown in the following figure.



*Figure 8-6. Properly weatherproofed antenna cable connection with surge protection*

# 8.7 Connecting the CRVW3 to earth ground

Electrical grounding of the CRVW3 station helps protect the hardware by mitigating against the risk of nearby lightning strikes, static discharges, or other unexpected electrical conditions. Connect the ground lug to an adequate earth/soil connection using a low-gauge wire (8 to 12 AWG) that accommodates high current flows.



*Figure 8-7. CRVW3 ground lug location*

A Basic Grounding Kit for Small Enclosures from Campbell Scientific can be used to make this connection.

## 8.7.1 Electrostatic discharge protection

Electrostatic discharge (ESD) can originate from several sources, the most common and destructive being lightning strikes. Primary lightning strikes are those that hit the CRVW3 or sensors directly; secondary strikes induce a high voltage in power lines or sensor wires.

The CRVW3 must be properly earth grounded to take advantage of its built-in protection to prevent damage from ESD. A good earth ground will minimize damage to the data logger and sensors by providing a low-resistance path around the system to a point of low potential. All components of the system (such as data loggers, sensors, external power supplies, mounts, and housings) should be referenced to one common earth ground.

In the field, at a minimum, a proper earth ground will consist of a 5-ft copper-sheathed grounding rod driven into the earth and connected to the large brass ground lug with a low-gauge wire (8 to 12 AWG). In low-conductive substrates (such as sand, very dry soil, ice, or rock), a single ground rod will probably not provide an adequate earth ground. For these situations, search for published literature on lightning protection or contact a qualified lightning protection consultant.

For information on the CRVW3 ESD testing, see ESD testing (p. 85).

## 8.7.1.1 Lightning protection

A simple, effective lightning protection system uses a lightning rod, metal mast, heavy- gauge ground wire, and ground rod to direct damaging current away from the data logger. See Figure 8-8 (p. 49).
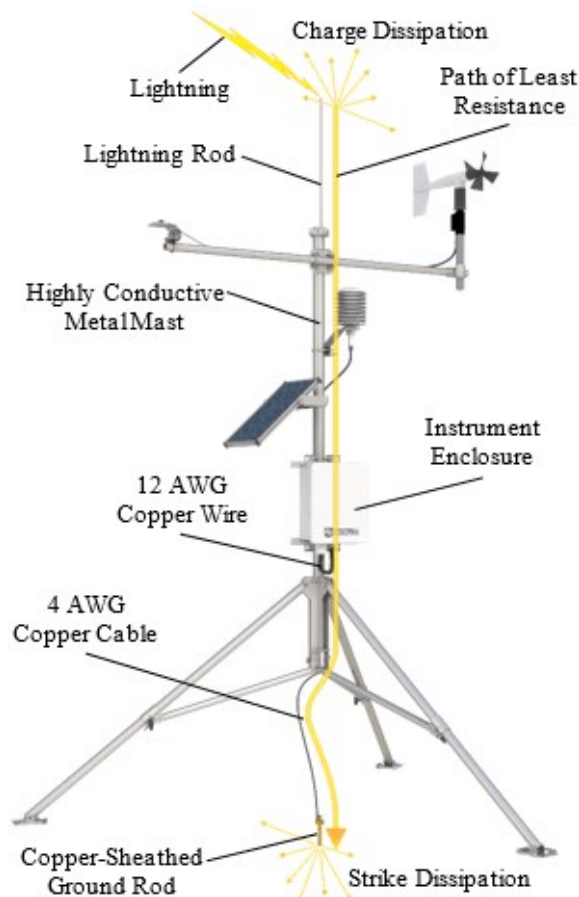
*Figure 8-8. Lightning protection scheme*

# 8.8 Validating and fine-tuning CRVW3 settings

Before completing the deployment of your CRVW3, confirm it is operating in the way you expect. Bring a computer running *Device Configuration Utility* with you in the field so you can connect to and adjust device settings.

> **TIP:**
> Remember to bring the USB cable.

Using *Device Configuration Utility*, confirm the following settings:

- Station Name
- Measurement interval
- PakBus Address

- Is Router (should be set to True when CRVW3 is also a radio repeater)
- Radio settings

Refer to Configuring the CRVW3 (p. 21) if any settings need to be adjusted. If you previously saved the configuration summary through *Device Configuration Utility*, you can restore them by clicking **Read File** then **Apply**.

## 8.8.1 Confirm CRVW3 sensor measurements

Use *Device Configuration Utility* to validate CRVW3 measurements.

1. Connect to the CRVW3 (see Connecting to the CRVW3 (p. 19) for more information).
2. Use the **Troubleshoot** tab screen to test the sensor response for each channel. The diagnostic information provided helps to determine whether the connected sensor is operating correctly.
3. Click **Poll** to perform the test. The results will appear after a few seconds.
4. Use the **Channel** selection box to select each active channel in turn for individual testing.
5. The following screenshot shows a high-quality sensor response.
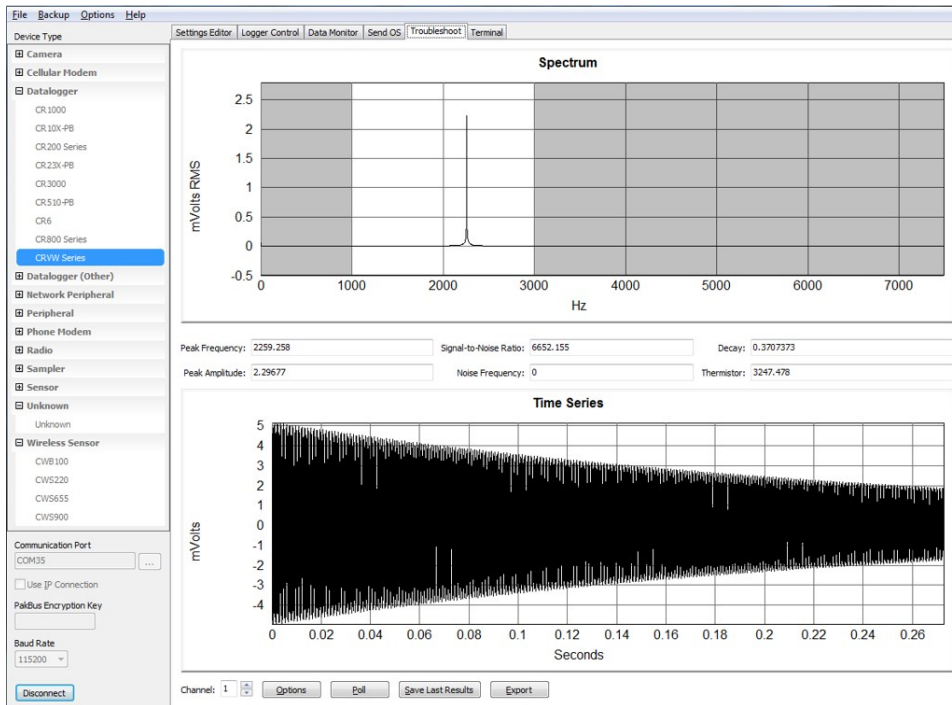


6. Check **Peak Frequency** to ensure that the main sensor reading is in the expected range.
7. A **Signal-to-Noise Ratio** of six or greater is preferred.

8. Check the **Thermistor** value (in ohms, Ω), if used.

9. If multiple peaks occur in the response **Spectrum**, choose a different **Begin Frequency** and **End Frequency** to eliminate unwanted signals yet still allow for variation of the sensor output frequency due to changes in the measured phenomenon.

   The grey shading in the Spectrum display indicates the set beginning and ending frequencies. Click **Options** to temporarily experiment with different frequency window ranges. Use the **Settings Editor** > **Channel 1**, **Channel 2**, and **Channel 3** to make permanent changes to the **Begin Frequency** and **End Frequency** settings.

10. Click **Save Last Results** or **Export** to save the test information to a file. These saved results can be stored and used as a historical reference (baseline or datum point) for comparison with future behavior of the same sensor.

11. Use the **Off Line Analysis** tab when disconnected from the CRVW3 to open and view a file saved previously. See Testing CRVW3 measurements (p. 25) for more information.

12. Use the **Data Monitor** tab to view frequency and temperature data in both the **Public** and **VW_Data** tables. The **VW_Data** table stores measurements made by the CRVW3. Confirm that the data in the **VW_Data** table updates immediately after each measurement. See Testing CRVW3 measurements (p. 25) for more information about using the **Data Monitor** tab.
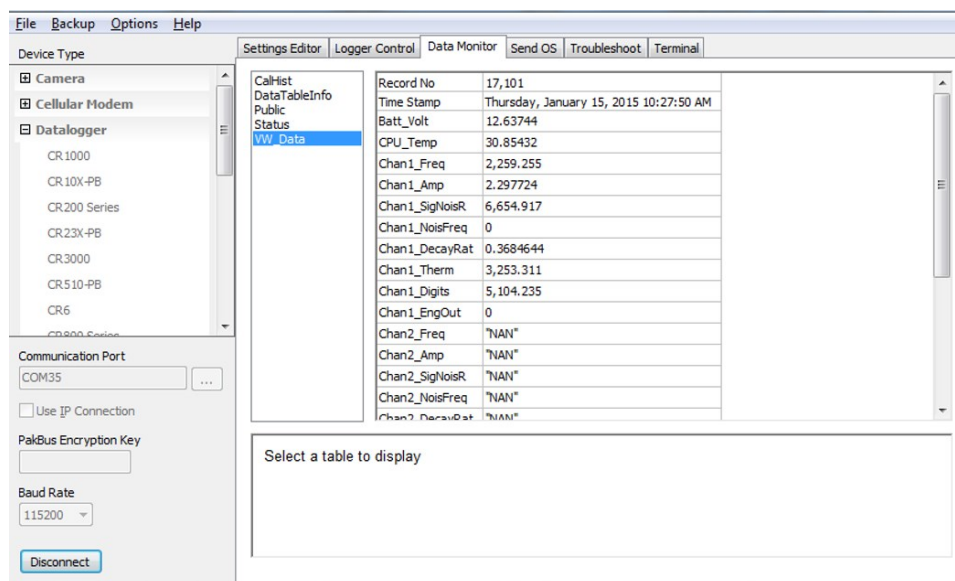


# 8.9 Validating CRVW3 radio operation

If you have a CRVW3 with a radio option (–RF451/RF452 or –RF407), validate that the radio is working properly before leaving the site. Follow the process described in Validating radio

connectivity in the lab (p. 27) using the antenna installed for the CRVW3 and a small omnidirectional whip antenna on the portable base radio.

For devices with the –RF451/RF452 option, use an RF451/RF452 configured as the gateway (master) radio and connected to the computer. For devices with the –RF407 option, use an RF407 connected to the computer. Position the computer and radio at least 25 feet away from the antenna installed on the CRVW3 to avoid radio frequency (RF) interference that can impede communications.

## | 8.9.1 Radio power schedule

A CRVW3 with a radio option can be configured to turn on and off at certain times during the day. This is done using the **Radio Power Schedule** tab in *Device Configuration Utility*. For example, use the following settings to turn the radio on for 15 minutes at midnight, 6:00 AM, noon, and 6:00 PM.

| | |
|---|---|
| **Radio start (power-on) time** | 00:00 |
| **Radio-on duration** | 15 minutes |
| **Repeat radio-on cycle** | Every 6 hours |

When the shut-off time is reached, the radio will stay on long enough to complete any current transactions, then turn off.

A USB cable connected to the CRVW3 device will override the **Radio Power Schedule** by turning on the radio and keeping it on for as long as the cable is connected.

When the radio has been off for long periods of time, issues such as PakBus discovery time should be considered before making a radio connection to the device, such as automatic/scheduled collection from within *LoggerNet*.

Using the **Radio Power Schedule** tab is especially important for a CRVW3–RF451/RF452, as the RF451/RF452 radio requires much more power than the RF407 option.

For the CRVW3–RF451/RF452, the **RF Transmit Power** setting should be chosen to provide for stable communications at the lowest possible level that works properly to conserve power. See the RF451/RF452 manual for more information https://s.campbellsci.com/documents/us/manuals/rf451.pdf ☐.

Similarly, the **Radio TX Power Level** setting on the CRVW3–RF407 should be strategically chosen to conserve power while still allowing robust communications. See the RF407 manual for more information https://s.campbellsci.com/documents/us/manuals/rf407-series.pdf ☐.

# 8.10 Sealing the CRVW3 enclosure

Once you have completed the installation of the CRVW3 and confirmed proper measurement and communications functionality, seal the enclosure. Proper enclosure sealing helps to avoid unwanted entry of water or humid air and provides isolation from other environmental factors.

1. Ensure the enclosure is mounted to minimize water exposure to the sensor cable entries, antenna connector, and ground lug. Typically, these items should face downward.

2. Ensure that the cable entry points are tightened properly.

3. Ensure that the humidity monitoring card and desiccant are in place. The CRVW3 enclosure includes a small vent to allow for changes in pressure. A patch prevents water from entering the enclosure through the vent.

4. Ensure that the lid closes properly and secure the latch. A padlock can be used to secure the enclosure.



*Figure 8-9. CRVW3 latch closure and lock location*

5. Install the Enclosure Lid Securing Screws into the four corners to ensure the maximum protective seal between the lid and the main section of the enclosure.

> **TIP:**
> During future site maintenance, wipe off any water from the outside of the enclosure before opening the enclosure lid.

# 9. *LoggerNet* configuration

Use *LoggerNet* for testing and validating deployed stations in your CRVW3 network. For *LoggerNet* to work properly, the computer running *LoggerNet* must first be physically connected to the base radio station or configured with a telemetry link to the base station. *LoggerNet* is then configured with details about the CRVW3 devices on your network, enabling connectivity. Once you can connect to and collect data manually from each CRVW3 station on your network, configure *LoggerNet* to collect data automatically, also known as scheduled data collection.

## 9.1 Physical connection to the base station

For wired connections between the *LoggerNet* computer and the base station, use a serial or USB cable. For USB, a USB driver is active and will indicate the specific port number being used when the device is plugged in. Otherwise, take note of which COM port is being used by your serial cable.

## 9.2 *LoggerNet* network map configuration

Once a serial or telemetry link between *LoggerNet* and the base station is physically established, *LoggerNet* needs to be configured to enable communications to occur through the base station and outward to the remote CRVW3 stations. The **Setup Screen** ⚒ in *LoggerNet* is used to create a tree-list of CRVW3 stations and their connectivity settings, as well as details for related hardware. This list of devices shows in multiple locations throughout the software and is called the network map.

> **NOTE:**
> If *Network Planner* was used to configure your network of CRVW3 devices, you can use a function in that software to configure the network map of *LoggerNet* so that it can communicate with the base station and the CRVW3 devices. Note the checkbox for configuring *LoggerNet* located in the Configure Devices checklist on the main screen. Once that task is executed, you will see the results of this configuration show up automatically in the Setup Screen of *LoggerNet*. This enables you to bypass the manual steps shown in this section. Refer to: s.campbellsci.com/documents/us/manuals/loggernet.pdf ↗.

1. From the **Main** category of the *LoggerNet* toolbar click **Setup** ⚒.

2. If the **Setup Screen** comes up in the *EZSetup* mode, click the **Std View** button to put it into the standard view mode.
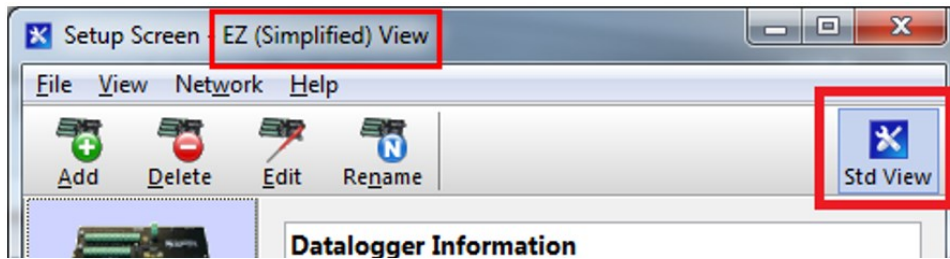


3. Click **Add Root**. When using a USB or serial cable connection to the base station, select **ComPort** for the type of root device. If you have a telemetry connection between *LoggerNet* and the base station, you will usually choose **IPPort** as the root device.
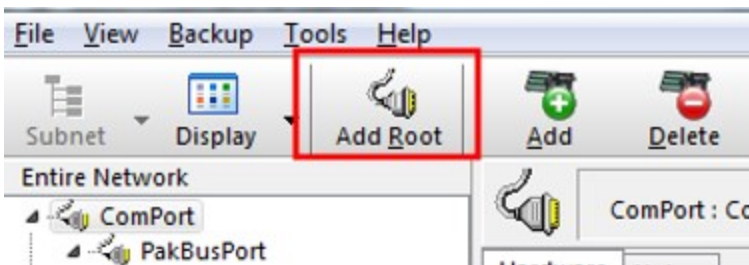


4. Select **PakBusPort (PakBus Loggers)**.
5. Select **CRVWSeries**.
6. Click **Close**.

If you started with an empty network map, your **Entire Network** should look similar to the following image.
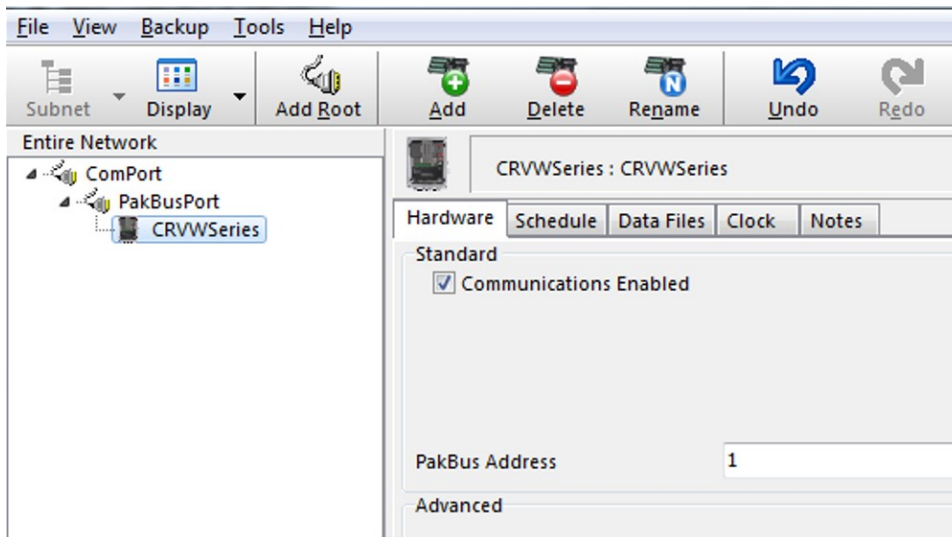


7. Click **ComPort** in the **Entire Network** pane.

8. On the **Hardware** tab, use the **ComPort Connection** drop-down selection box select the serial port to which the base radio is connected on your *LoggerNet* computer.
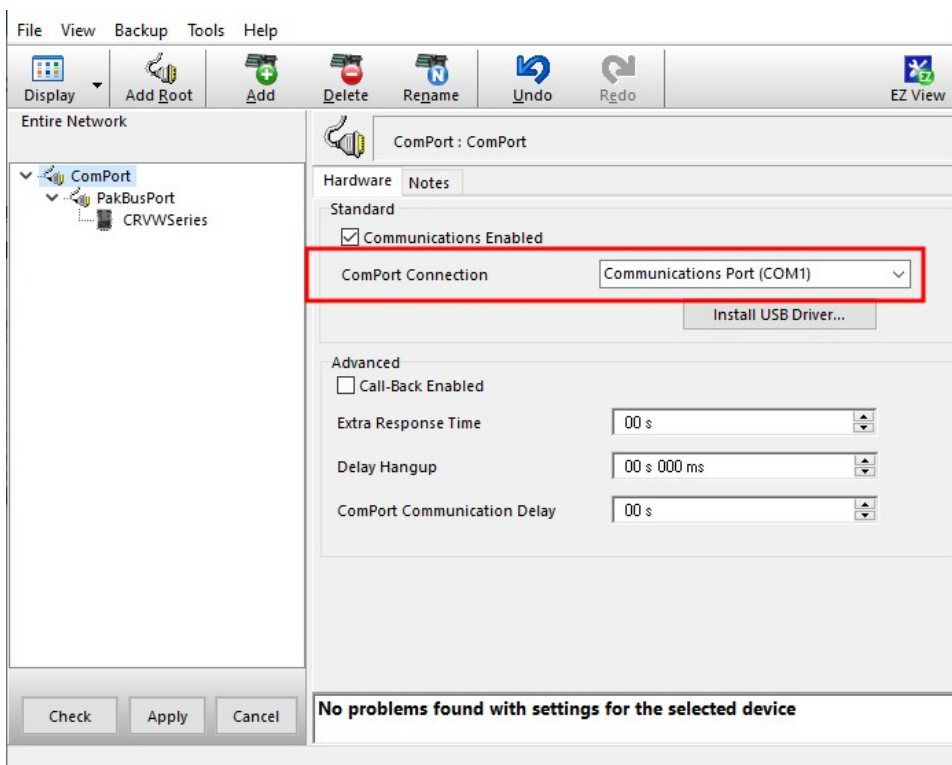


9. Click **Apply** to save your changes.

10. (IP option) Click **IPPort** device in the **Entire Network** pane.

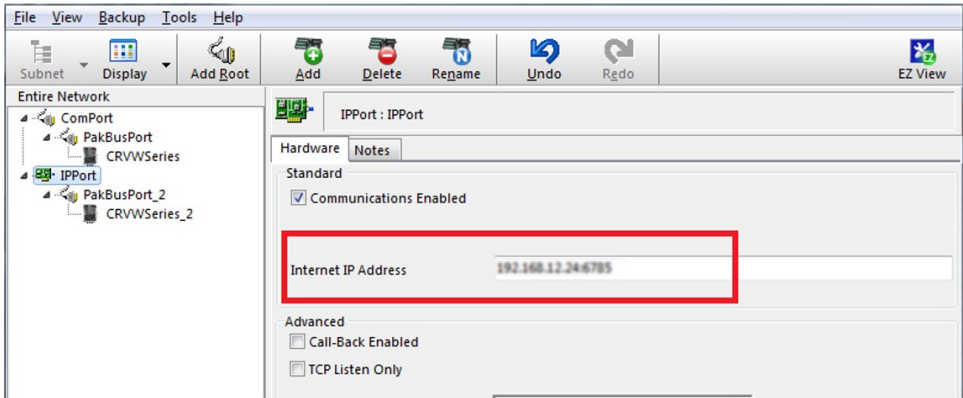11. On the **Hardware** tab, in the **Internet IP Address** box, enter the TCP/IP address and port number used to connect to your telemetry device at the base station location.



12. Click **Apply**.

13. Click **CRVWSeries** in the network map.Click **Rename** and enter a device name.
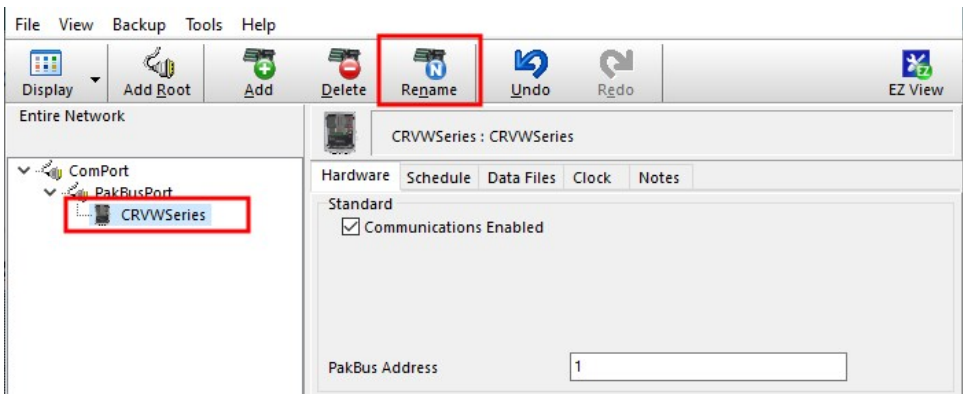


14. On the **Hardware** tab, set the **PakBus Address** value to match the value that was configured into the CRVW3 device with *Device Configuration Utility* or with the *Network Planner*.

15. Click **Apply**.

> **NOTE:**
> For more information about security codes, refer to your data logger manual or *Device Configuration Utility* help.

16. Select the **Clock** tab.

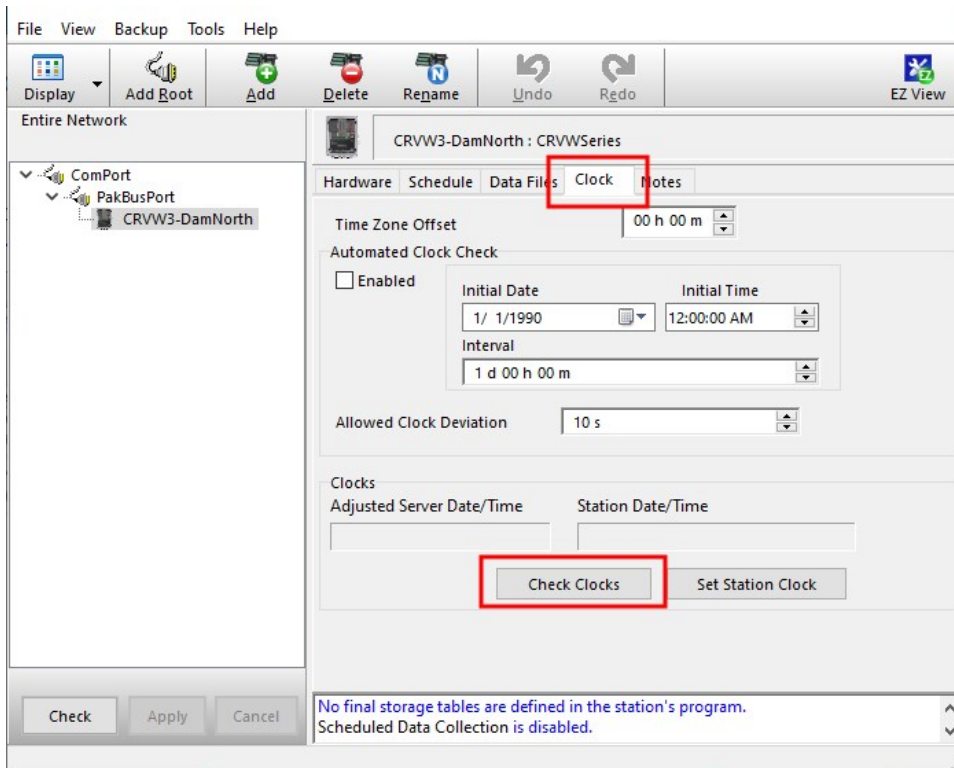17. Click **Check Clocks** button to instruct *LoggerNet* to send a clock check command through the base station to the destination CRVW3 station. If the radio link is working, the current date and time should show up in the **Adjusted Server Date/Time** and **Station Date/Time** boxes within a few seconds.



If *LoggerNet* returns an error after the clock check attempt, something is wrong with the radio link or the configuration of *LoggerNet*. Investigate at both the radio level and at the *LoggerNet* level. In-field validation with a temporary laptop computer running *LoggerNet* helps to validate radio links while still in the field and reduces the need to return to the CRVW3 sites to investigate radio problems.

If the clock check was successful, and you want the station time to be synchronized with the *LoggerNet* computer station time, click **Set Station Clock**.

18. Adding additional CRVW3 devices to your network map does not require re-entering **ComPort**, **IPPort**, or **PakBusPort**. Simply click on the existing **PakBusPort** device and click **Add**. Choose **CRVWSeries** from the list of data loggers and click **Close**. You will now have another CRVW3 device on the network map. It is recommended that you rename devices as you add them to avoid any confusion.

19. Click on the new CRVW3 device and repeat the configuration process described earlier in this section. You will enter a unique **PakBus Address** for each device added. Repeat this

process for every single-hop CRVW3 device in your network. Perform a clock check on each station as it is added. Click **Apply** in each case.

20. To add CRVW3 devices that are reached through a CRVW3 repeater station, click on the CRVW3 device that has been configured as a repeater station and click **Add**. Choose **CRVWSeries** from the data logger list and click **Close**. Now the CRVW3 device appears as a child device of the CRVW3 repeater. This will instruct *LoggerNet* to route through the CRVW3 repeater to communicate with the CRVW3 child device. Rename the device, configure it and click **Apply**. Multiple CRVW3 child devices can be added to any CRVW3 repeater/parent. Using the tab screens, configure these devices in the same way as the other CRVW3 devices.

# 9.3 Connecting to CRVW3 stations

Use the **Connect Screen** to connect to each CRVW3 station and confirm that it is communicating and operating correctly.

For more information, see: www.campbellsci.com/videos/connect-window-tutorial ▶.

1. From the **Main** category of the *LoggerNet* toolbar click **Connect** . The **Stations** list shows all CRVW3 devices that have been defined on your network map.

2. Select a station from the list on the left and click **Connect** .

3. The **Stations** list shows all CRVW3 devices that have been defined on your network map.

4. Select a station from the list on the left and click **Connect** .
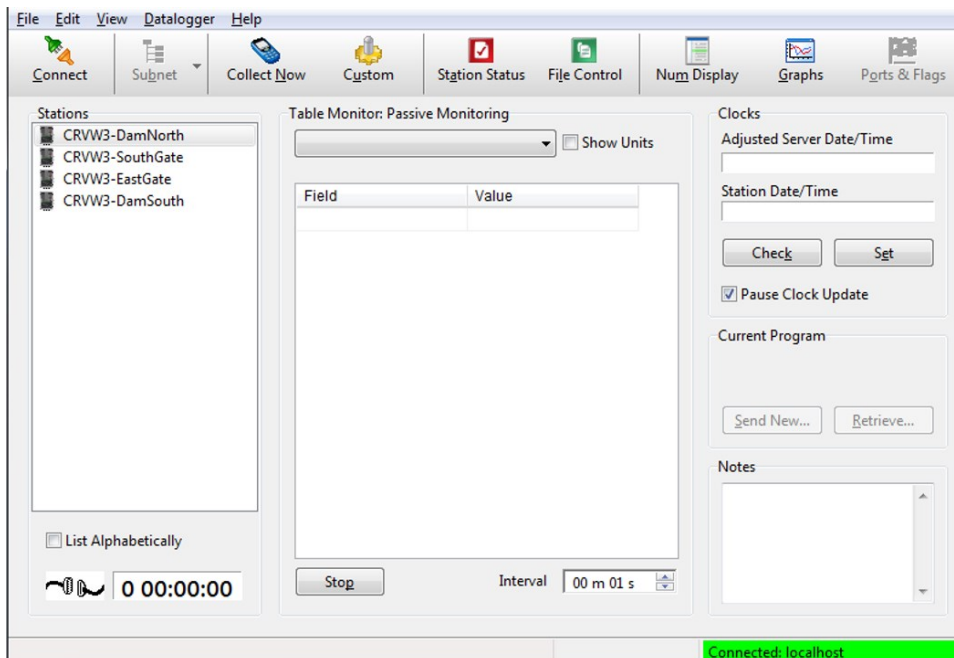
5.  If the radio link is healthy and *LoggerNet* is configured correctly, a successful connection to the device will be evidenced by the elapsed time display in the lower left corner incrementing. If errors occur, troubleshooting is needed. Data can be monitored from the station, once connected, using the **Table Monitor**. Select the **Public** table or **VW_Data** table from the **Table Monitor** dropdown and click **Start** to show current data from the station. The **Connect Screen** will continually poll for new data and display it.

6.  Click **Station Status** ☑ to display the **Status Summary**, **Table Fill** information, and the complete **Status** table of the device.

7.  Click **Collect Now** 📱 to confirm that data can be collected from each CRVW3 station.

8.  Use the **Connect Screen** to validate that every CRVW3 station is fully functional and communicating.

# 9.4 Setting up automatic data collection

When *LoggerNet* is running and scheduled collection is enabled, *LoggerNet* will automatically connect to a specified station at a designated time and collect data from it. This occurs behind the scenes, without any prompting from the *LoggerNet* user.

> **NOTE:**
> For automatic data collection to occur, the *LoggerNet* toolbar must be running; or, in the case of *LoggerNet Admin* installations, the *LoggerNet Service* must be started.

In addition to the *LoggerNet* manual, see www.campbellsci.com/videos/collect-data-tutorial▶ and www.campbellsci.com/videos/scheduled-automatic-data-collection▶ for more information.

1.  From the **Main** category of the *LoggerNet* toolbar click **Setup** ✖.

2.  Select a **CRVW3** from the **Entire Network** on the left.

3.  On the **Schedule** tab, select the **Scheduled Collection Enabled** checkbox.

4.  Set a **Collection Interval**.

5.  Click **Apply to Other Stations...** to have *LoggerNet* manage scheduled collection for other stations in your network.

6.  Use **Status Monitor** ♥, from the **Main** category of the *LoggerNet* toolbar, to ensure that *LoggerNet* is connecting with each station and that its data is being collected. For more information, see Status monitor (p. 69).

# 10. Maintenance

After your CRVW3 stations have been operating for some time, periodic maintenance tasks may need to be performed. Routine maintenance is a key activity that helps ensure the healthy and ongoing operation of your system.

Some of these maintenance tasks can be performed remotely using *LoggerNet* and related software tools. For other tasks, a visit to the CRVW3 field site is necessary.

## 10.1 CRVW3 maintenance with *LoggerNet*

From time to time, Campbell Scientific will release updates to the CRVW3 firmware, and make these available for download from the Campbell Scientific website. See Updating the operating system (p. 72) for details about how to update the CRVW3 firmware, including remote updates made from within *LoggerNet*.

If the measurement output of the CRVW3 has been configured for engineering output and baseline readings are used as part of that calculation, the sensors may need to be periodically calibrated using the *Calibration Wizard*. See Engineering output and calibration (p. 81) for details about calibration and using the *Calibration Wizard*.

## 10.1.1 Battery monitoring

The status of the battery on the CRVW3 should be monitored using the **Battery** field in the **Status** table. Voltage levels greater than 12 VDC indicate that the charge circuit is active and charging the battery. Levels of 12 VDC or less indicate no active charging. Once battery voltage drops to 10.5 VDC, functionality on the device begins to be restricted, and the **Low10_5_Count** value will be incremented. Full shutdown of the device occurs at 9.5 VDC.

When using the –ALK option, the D cells on the device should be replaced about once every 12 months. This may be needed more frequently if the –RF451/RF452 or –RF407 radio is used, or if measurements are made more frequently than once every 15 minutes. When using the –RC option, consider replacing the rechargeable battery after several years of use.

> **NOTE:**
> It is possible to convert a CRVW3 from the –RC option to the –ALK option and vice versa. This involves obtaining the desired battery or battery pack from Campbell Scientific and reversing the latch that secures the battery within the enclosure. Remove the battery hinge pin and rotate the hinge bracket to accommodate the desired battery option. Reinsert the hinge pin.

# 10.1.2 Sensor spectrum checks

Periodic verification that the CRVW3 is making proper readings from its sensors is recommended. During installation or during on-site maintenance, this can be done using the **Troubleshoot** tab in *Device Configuration Utility*. Making a similar spectrum check on a CRVW3 using *LoggerNet* and a remote connection if the device has a radio option is also possible. The creation of a binary file can be triggered, and then that file can be retrieved to the *LoggerNet* computer station using **File Control**. *Device Configuration Utility* can then be used to view the spectrum and diagnostic contents associated with that file. In this way, you can see the spectrum information on a remote CRVW3 without making a field visit.

Follow this process to check the spectrum on a remote CRVW3 station:

1. Use **Connect Screen** to establish a connection with the CRVW3 station of interest.

2. Open the **Status** table in the **Table Monitor** dropdown.

3. Set the **Channel_Diag** value to match the channel to be tested (1, 2, or 3).

4. Set the desired low frequency and high frequency (in Hz) for the measurement using the **Begin_Freq_Diag** and **End_Freq_Diag** fields.

5. Set the excitation level for the measurement using **Excitation_Opt_Diag**. Use 120 for 12 VDC, 50 for 5 VDC, and 20 for 2 VDC excitation.

6. Set the **Run_Diag** value to 1 to trigger the measurement. Watch and wait for the value to be set back to 0 to indicate that the test measurement is complete. Ensure that the **Diag_Result_Code** is 0.
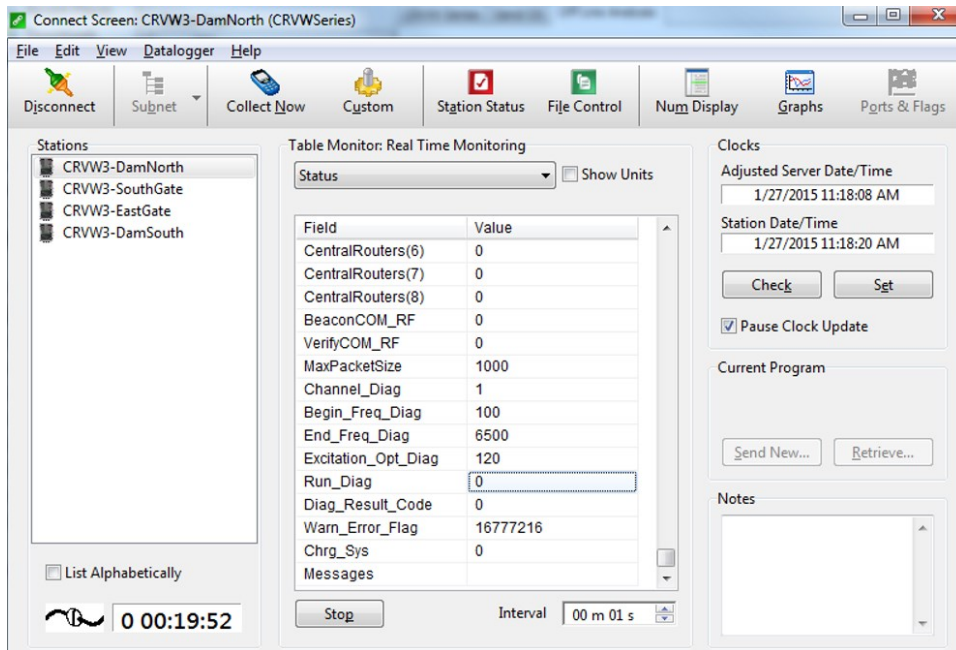


7. Open **File Control**.

8. Note the **Spectrum.bin** and **TimeSeries.bin** files located on the CPU drive. The date and time on these files should match the time of the test measurement. A timestamp of 0 on the files indicates that they do not yet exist, that the test has not yet been performed.

9. Select only the file **TimeSeries.bin** and click **Retrieve...**.
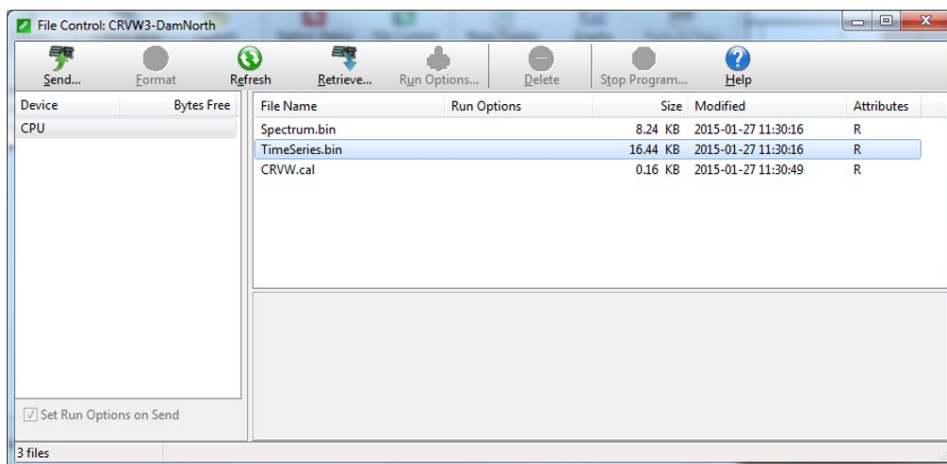


10. Save the file.

11. Open *Device Configuration Utility*, choose **CRVW Series** for the device, and select the **Off Line Analysis** tab. Click **Read File** and browse to the **TimeSeries.bin** file.

12. The contents of the file will be processed, and *Device Configuration Utility* will display the spectrum and time-series information as recorded by your remote CRVW3 station. Interpret the information shown in this screen in the same way as when using the **Troubleshoot** tab.
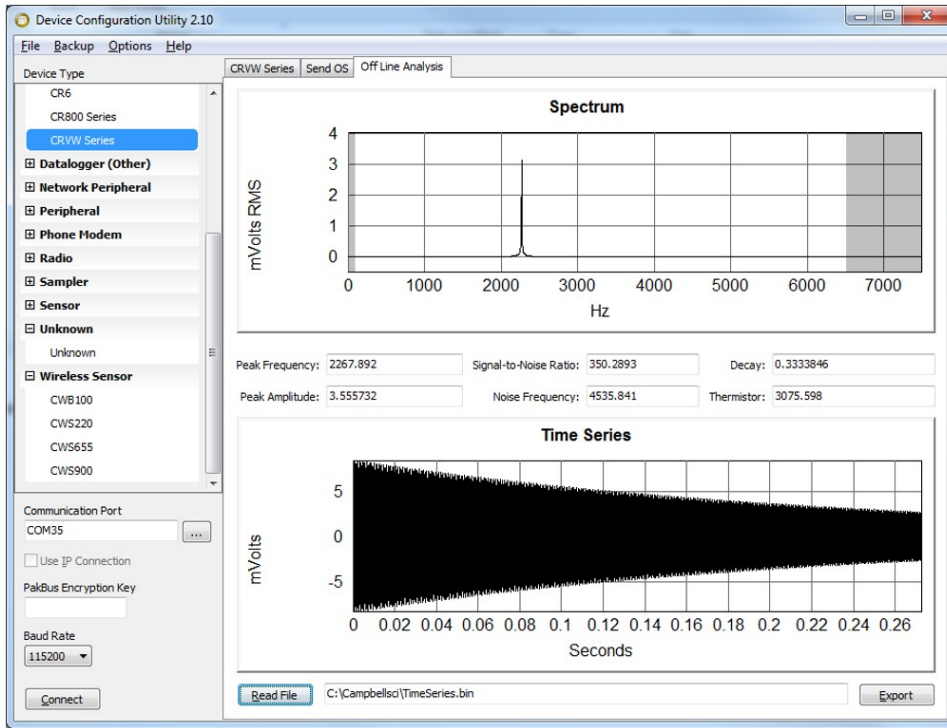


> **NOTE:**
> The **Off Line Analysis** tab is only available in *Device Configuration Utility* when disconnected from the CRVW3.

Repeat this process for channels 2 and 3 individually, if applicable. Rename the various files as needed to indicate the station and channel that they represent. It is recommended that some **TimeSeries.bin** files be captured soon after the installation of a CRVW3 station so they can be kept as baseline references that document how the sensor was operating at the time of deployment.

# 10.1.3 Device settings adjustments

You can view and change the current settings on each CRVW3 device using **Connect Screen**. This is possible even when connections are made remotely to the CRVW3 over radio links.

> **NOTE:**
> If a table, such as **VW_Data**, will be impacted by the change to the settings, pause the monitoring of that table in the **Table Monitor** tab of **Connect Screen**. Click **Stop** to do this. It is also recommended that you edit settings when *LoggerNet* is not automatically collecting or scheduled to collect data from other CRVW3 devices on the same radio network or communicating in other ways with those devices.

1. From the **Main** category of the *LoggerNet* toolbar click **Setup** .

2. Collect data.

3. Choose the **Settings Editor...** option from the **Datalogger** menu. A **Settings** screen will appear that works much like *Device Configuration Utility*. You can view settings for the device and change them if necessary; review the caution statement before changing any settings.

4. (Optionally) Use **PakBusGraph** to view and edit changes to device settings. Highlight the device in the main PakBus screen and right-click on the device, then choose **Edit Settings...** Make sure you have selected the correct **PakBusPort** in the **PakBusNetwork** dropdown (as defined in **Setup Screen**) to view your CRVW3 devices.

5. Click **Apply**. After you apply changes to a CRVW3 device settings, the CRVW3 will reset itself to begin measuring with the new settings.

6. Close the **Settings** screen, since it is no longer connected to the CRVW3. Allow up to 20 seconds to elapse before you can expect to communicate with the CRVW3 again. You may need to reconnect to the device in **Connect Screen**.

> **CAUTION:**
> Risks are associated with changing the settings of a remote CRVW3 using the **Settings** screen. It is possible to change the settings on the device in a way that causes it to stop communicating with *LoggerNet*. At that point, a field visit is required to restore communications between the device and *LoggerNet*. Consider each change carefully and only apply it once you understand what impact it will have. Settings that relate to the measurement process are usually safer to change than settings that relate to radio communications.

# 10.2 CRVW3 on-site maintenance visits

It is a good idea to make periodic visits to deployed CRVW3 stations. Consider making a visit to inspect each CRVW3 station after the winter season, particularly in climates where heavy cold-

weather precipitation occurs or where extreme temperatures occur. Heavy-rain events can also affect the operation of a station in some cases.

The following maintenance operations can be performed on-site:

- Check and change the battery or batteries if needed
- Check cable entry points for a good seal
- Wipe moisture off the lid gasket prior to opening to reduce water ingress
- Minimize moisture intrusion through cabling or connectors to the inside of the enclosure
- Check grounding rod, grounding cable, and connections
- Inspect for loose connections
- Remove any solar barriers, such as fallen debris, overhead branches, and leaves
- Clean solar panel with mild detergent and a clean cloth
- Replace desiccant bag and humidity indicator card as needed
- Install newer firmware/OS (*Device Configuration Utility*); see Updating the operating system (p. 72)
- Look at sensor spectra using the *Device Configuration Utility* **Troubleshoot** tab; see Testing CRVW3 measurements (p. 25) and Confirm CRVW3 sensor measurements (p. 50).
- Watch the LED activity as the device operates to ensure proper function; see LED indicators (p. 39)

Be aware of the siting and installation issues discussed in CRVW3 field deployment (p. 38) and check for any discrepancies. Observe the solar panel operation (–RC option) to ensure it is charging the battery properly. You can also double-check antenna operation using a temporary base station radio and a computer running *LoggerNet*. The **Terminal** mode of the CRVW3 from *Device Configuration Utility* can also be used to perform maintenance. For more information, see Terminal mode (p. 75).

# 10.3 Internal battery

The lithium battery powers the internal clock and SRAM when the CRVW3 is not powered. This voltage is displayed in the **Status** table `RTC_Battery` field. Replace the battery when voltage is approximately 2.7 VDC. The internal lithium battery life is extended when the CRVW3 is installed with an external power source. If it is used in a high-temperature application, the battery life is shortened.

To prevent clock and memory issues, it is recommended you have Campbell Scientific proactively replace the battery every 2 to 3 years, or more frequently when operating continuously in high temperatures.

> **WARNING:**
> Any damage made to the CRVW3 during user replacement of the internal battery is not covered under warranty.

> **NOTE:**
> The battery is replaced during regular factory recalibration, which is recommended every 3 years.

When the lithium battery is removed (or is depleted and primary power to the data logger is removed), the CRBasic program and most settings are maintained, but the following are lost:

- Run-now and run-on power-up settings.
- Routing and communications logs (relearned without user intervention).
- Time. Clock will need resetting when the battery is replaced.
- Final-memory data tables.

A replacement lithium battery can be purchased from Campbell Scientific or another supplier.

- 3 V coin cell CR2025 for battery-backed clock. 5-year life with no external power source.

> **WARNING:**
> Misuse or improper installation of the internal lithium battery can cause severe injury. Fire, explosion, and severe burns can result. Do not recharge, disassemble, heat above 100 °C (212 °F), solder directly to the cell, incinerate, or expose contents to water. Dispose of spent lithium batteries properly.

> **NOTE:**
> The **Status** field **Battery** value and the destination variable from the `Battery()` instruction (often called `Batt_Volt`) in the **Public** table reference the external battery voltage.

For additional information on the internal battery, see:

- Get to Know Your Data Logger's Spare Tire: The Lithium Battery ⬏
- https://www.campbellsci.com/videos/crvw3-battery ▶

# 11. Troubleshooting

By regularly reviewing collected data, you can identify problems with the system. Troubleshoot problems as soon as possible after they arise. Some clues relating to the source of the problem can change, even becoming more obscure, over time. Small problems can often escalate into larger ones due to cascading consequences.

**Status Monitor** is a key tool for identifying that a problem in the system exists (see Status monitor (p. 69) for guidance about using **Status Monitor**). Some common indicators that something is wrong with a station are:

- Scheduled (automatic) collection is not working as shown by the **Status Monitor** or **Table Monitor**
- Connection to the station does not work in the *LoggerNet* **Connect Screen**
- Clock checks (**Setup Screen**) are not working
- Manual collection via **Collect Now** or **Custom Collect** does not work
- **Station Status** (such as **Summary** and **Status** tables) are unviewable
- Station can communicate but collected data from that station has problems

Troubleshooting a part of the system that has never worked as desired is typically related to the installation process.

When a problem arises in a system area that used to work but has recently stopped working, the main question to ask is, "What changed?" What changed in the system to cause the station to stop operating? When did the failure begin? Examine key aspects of the system and its recent maintenance history to obtain clues about changes to the system. Sometimes a change to the system that seems harmless or unrelated turns out to be the cause of the trouble.

Problems may be caused by acts of nature, such as lightning strikes, storms, animal intrusion or by operational features of the station that worsened gradually and remained undetected until they finally ceased to function, such as a bad battery. An on-site camera can be helpful if physical problems occur with on-site equipment on a regular basis.

# 11.1 Using *LoggerNet* to remotely troubleshoot problems

Sometimes you can still communicate with the CRVW3 station, but its measurements make little or no sense or work only intermittently. In those cases, you can connect to the station and check the spectrum to see if a sensor problem exists with sensor cabling, connectivity, operation, or noise/interference to name a few examples. See Sensor spectrum checks (p. 62) for details about how this is done. Compare the current spectrum with a baseline spectrum saved during maintenance or installation. A visit to the site may still be required; however, the spectral information may give a clue about what has gone wrong.

*LoggerNet* has several tools for troubleshooting communications issues:

- PakBusGraph
- LogTool
- TroubleShooter

See the *LoggerNet* manual for more information s.campbellsci.com/documents/us/manuals/LoggerNet.pdf ⬏.

In an RF451/RF452 network of CRVW3 stations, you can perform radio diagnostics at the base station and using the **RF DIAG** connector of the base/gateway radio and a Diagnostics and Programming cable, purchased separately. For more information, see https://s.campbellsci.com/documents/us/manuals/rf451.pdf ⬏.

If there is trouble making a connection between *LoggerNet* and the RF451/RF452 or RF407 base station, use *Device Configuration Utility* to ensure that the baud rate setting of the RF451/RF452 or RF407 matches the PakBusPort baud rate setting in the *LoggerNet* **Setup Screen**.

By default, PakBus beaconing is set to occur at a 1-minute interval on the PakBusPort. This is configured in the **Setup Screen**. CRVW3 devices are not set up to use beaconing by default, since it makes more sense for *LoggerNet* to do that through the PakBusPort. When troubleshooting your network, consider using a more frequent beaconing interval. However, once the network is operating properly, the **Beacon Interval** setting should be set back to 1 minute or a slower interval to avoid unnecessary radio traffic.

## 11.1.1 Status monitor

Most CRVW3 devices that have been configured to be part of a radio network will also be part of an automatic collection schedule. For automatic data collection to occur, the *LoggerNet* toolbar
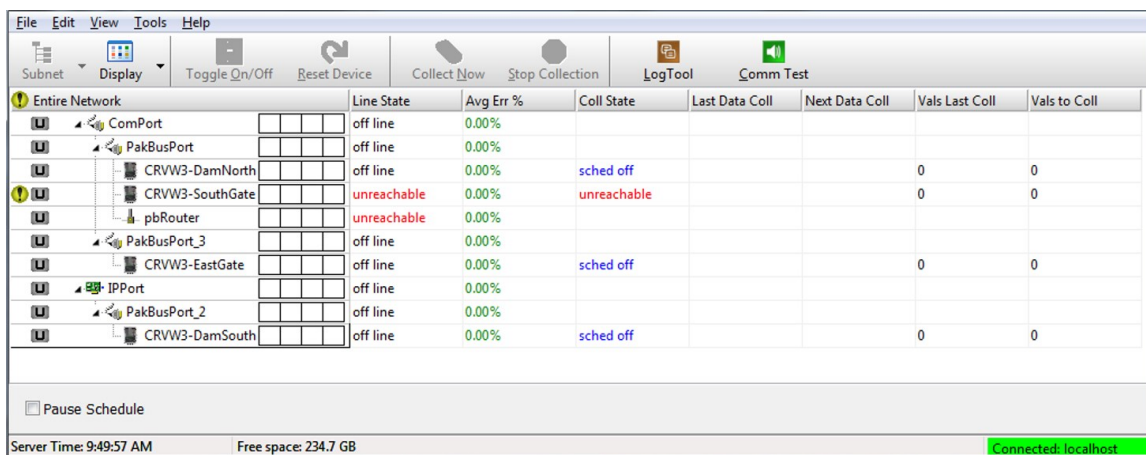
must be running; or, in the case of *LoggerNet Admin* installations, the *LoggerNet Service* must be started. See Setting up automatic data collection (p. 60).

Use *LoggerNet* Status Monitor 🤍 to assess the connectivity and collection status for all CRVW3 devices on your network. Status Monitor shows whether *LoggerNet* is connecting with each station and whether the data from that station is being collected properly. For more information see www.campbellsci.com/videos/status-monitor ▶.

Check **Status Monitor** on a regular basis, daily or weekly, to ensure that the expected data is being collected from each CRVW3 station at the expected time.

1. From the Main category of the *LoggerNet* toolbar click **Status Monitor**:

    The **Status Monitor** screen should look something like this:



    When the time for scheduled collection is reached on the *LoggerNet* computer clock, *LoggerNet* will connect to the station automatically and collect data from it.

2. For each station, observe the collection state (**Coll State**), the time that data was last collected (**Last Data Coll**), the time that data will be collected next (**Next Data Coll**), and the number of values collected (**Vals Last Coll**).

3. By highlighting a station, you can also force a data collection to occur immediately by clicking **Collect Now**.

# 11.2 CRVW3 site visits to troubleshoot problems

Be as prepared as possible when you travel to the field for troubleshooting. Gather as much information about the problem as possible before arriving. Bring the same configuration hardware with you to the field as was used during installation.

Once you arrive at the site, review physical installation and hardware configuration issues that are detailed in CRVW3 field deployment (p. 38). Refer to the maintenance items listed in CRVW3 on-

site maintenance visits (p. 65). Connect to the CRVW3 with a USB cable and *Device Configuration Utility*. Use the **DataMonitor** tab and **Troubleshoot** tab to investigate how the measurements of the sensors are working or not (see Confirm CRVW3 sensor measurements (p. 50) for more information). Compare the current spectrum with a baseline spectrum saved during maintenance (see Sensor spectrum checks (p. 62) for more information).

Use a portable base station (RF451/RF452 or RF407 depending on the network, and computer) to ensure you can communicate with the CRVW3 over its radio. It may be necessary to visit the base station or a repeater station to fully investigate radio network problems. Check the **CompileResults** field of the **Status** table to see if radio-related errors have been reported by the device firmware.

For complex or large radio networks see the specific radio manual: RF407-Series manual ⬈ or RF451/452 manual ⬈.

# Appendix A. Updating the operating system

Campbell Scientific posts operating system (OS) updates at www.campbellsci.com/downloads⬀ when they become available. It is recommended that before deploying instruments, you check operating system versions and update them as needed. The data logger operating system version is shown in the **Status** table, **Station Status Summary**, and *Device Configuration Utility* **Deployment** > **Datalogger**. An operating system may be sent through *Device Configuration Utility* or through program-send procedures.

> **WARNING:**
> Because sending an OS resets data logger memory and resets all settings on the data logger to factory defaults, data loss will certainly occur. Depending on several factors, the data logger may also become incapacitated until the new OS is programmed into memory.

> **TIP:**
> It is recommended that you retrieve data from the data logger and back up your programs and settings before updating your OS. To collect data using *LoggerNet*, connect to your data logger and click **Collect Now** . To backup your data logger, connect to it in *Device Configuration Utility*, click the **Backup** menu and select **Backup Datalogger**.

## A.1 Sending an operating system to a local data logger

Send an OS using *Device Configuration Utility*. This method requires a direct connection between your data logger and computer.

1. Download the latest Operating System at www.campbellsci.com/downloads⬀.

2. Locate the .exe download and double-click to run the file. This will extract the .obj OS file to the **C:\Campbellsci\Lib\OperatingSystems** folder.

3. Supply power to the data logger. If connecting via USB for the first time, you must first install USB drivers by using *Device Configuration Utility* (select your data logger, then on

the main page, click **Install USB Driver**). Alternately, you can install the USB drivers using EZ Setup. A USB connection supplies 5 V power (as well as a communications link), which is adequate for setup, but a 12 V battery will be needed for field deployment.

4. Physically connect your data logger to your computer using a USB cable, then open *Device Configuration Utility* and select your data logger.

5. Select the communications port used to communicate with the data logger from the **COM Port** list (you do not need to click **Connect**).

6. Click the **Send OS** tab. At the bottom of the window, click **Start**.

7. On the **Avoid Conflicts with the Local Server** window, click **OK**.

8. Navigate to the **C:\Campbellsci\Lib\OperatingSystems** folder.

9. Ensure **Datalogger Operating System Files (*.obj)** is selected in the **Files of type** list, select the new OS .obj file, and click **Open** to update the OS on the data logger.

Watch a video: Sending an OS to a Local Datalogger ▶.

# A.2 Sending an operating system to a remote data logger

If you have a data logger that is already deployed, you can update the OS over a telecommunications link by sending the OS to the data logger as a program. In most instances, sending an OS as a program preserves settings. This allows for sending supported operating systems remotely (check the release notes). However, this should be done with great caution as updating the OS may reset the data logger settings, even settings critical to supporting the telecommunication link.

The `default.CR1X` program can be edited to preserve critical data logger settings such as communications settings.

1. Download the latest Operating System at www.campbellsci.com/downloads ⬏.

2. Locate the .exe download and double-click to run the file. This will extract the .obj OS file to the **C:\Campbellsci\Lib\OperatingSystems** folder.

3. Using data logger support software, connect to your data logger.

   - *LoggerNet* users, select **Main** and click **Connect** 🔗 on the *LoggerNet* toolbar, select the data logger from the **Stations** list, then click **Connect** ◣.

- **PC400** users, select the data logger from the list and click **Connect** .

4. Select **File Control** at the top of the Connect window.

5. Click **Send** at the top of the File Control window.

6. Navigate to the **C:\Campbellsci\Lib\OperatingSystems** folder.

7. Ensure **Datalogger Operating System Files (\*.obj)** is selected in the files of type list, select the new OS .obj file, and click **Open** to update the OS on the data logger.
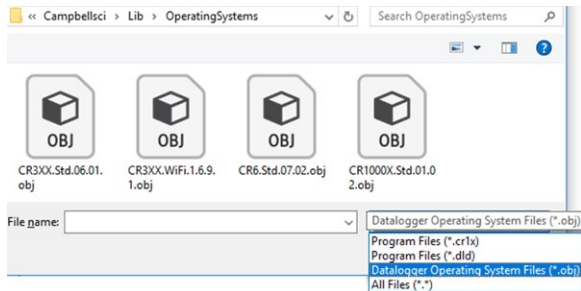


Note the following precautions when sending as a program:

- Any peripherals being powered through the **SW12** terminals will be turned off until the program logic turns them on again.

- Operating systems are very large files. Be cautious of data charges. Sending over a direct serial or USB connection is recommended, when possible.

# A.3 CRVW3 maintenance with *LoggerNet*

From time to time, Campbell Scientific will release updates to the CRVW3 firmware, and make these available for download from the Campbell Scientific website. See Updating the operating system (p. 72) for details about how to update the CRVW3 firmware, including remote updates made from within **LoggerNet**.

If the measurement output of the CRVW3 has been configured for engineering output and baseline readings are used as part of that calculation, the sensors may need to be periodically calibrated using the **Calibration Wizard**. See Engineering output and calibration (p. 81) for details about calibration and using the **Calibration Wizard**.

# Appendix B. Terminal mode

You can use the CRVW3 terminal mode for troubleshooting and configuration. Contact with Campbell Scientific support personnel is recommended before using this feature. The two most common ways to access the terminal mode are within **Device Configuration Utility** and using the **Connect Screen** of *LoggerNet*. When using the terminal mode in *LoggerNet*, you can make the connection to a remote station over a radio link without having to travel to the CRVW3 site.
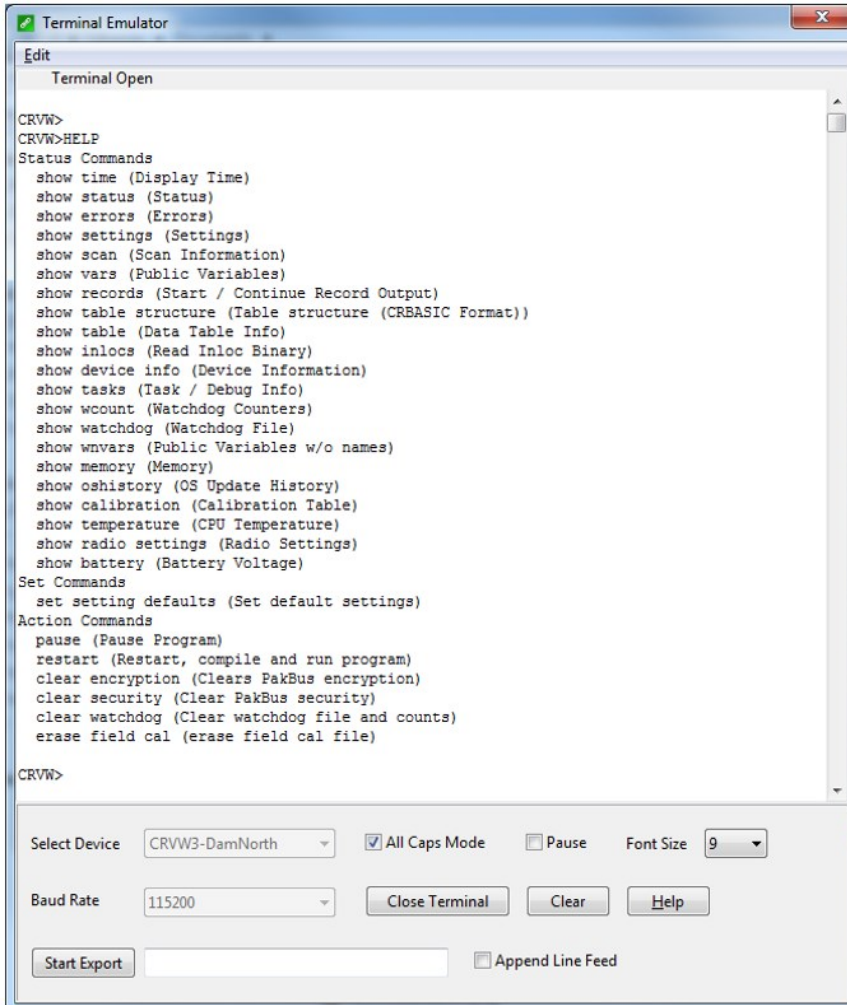


> **NOTE:**
> The **pause** instruction temporarily stops the program. However, after 2 hours, the program automatically resumes and a **watchdog.txt** file is written, containing the following text:
>
> "Watchdog timer Run Program Service triggered."

This **watchdog.txt** file need not cause concern; it simply indicates that the program automatically resumed.

# B.1 Using *Device Configuration Utility*

1. In *Device Configuration Utility*, connect to the CRVW3 and choose the **Terminal** tab.

2. Click in the screen and press **Enter** several times. You should get the **CRVW>** terminal prompt.

3. Type **help** and press **Enter**. A list of possible terminal commands will be given.

4. Type a command name, along with any required arguments, and press **Enter**.

   > **NOTE:**
   > If you wait too long between entering commands, you will need to press **Enter** several times again to restore the terminal session.

5. When finished with the terminal session, click **Close Terminal**.

# B.2 Using *LoggerNet*

1. In the *LoggerNet* **Connect Screen**, connect to the CRVW3.

2. Select **Datalogger** menu > Terminal **Emulator....**

3. Click **Open Terminal**.

4. Click in the screen and press **Enter** several times. You should get the **CRVW>** terminal prompt.

5. Type **help** and press **Enter**. A list of possible terminal commands will be given.

6. Type a command name, along with any required arguments, and press **Enter**.

   > **NOTE:**
   > If you wait too long between entering commands, you will need to press **Enter** several times again to restore the terminal session.

7. When finished with the terminal session, click **Close Terminal**.

# Appendix C. Aggregating data loggers

When you deploy a network of CRVW3 devices using radio telemetry, you have the option of placing an aggregating data logger into that network. An aggregating data logger is a Campbell Scientific data logger that connects to CRVW3 devices over a radio link and collects data from them. That data, aggregated, is stored on the data logger for later retrieval by *LoggerNet* software or other means. For simple radio networks as well as for many other radio network configurations, an aggregating data logger may not be necessary.

An aggregating data logger can also be configured as the base radio station, but that is not required.

To be a part of the radio network, a radio that is compatible with the CRVW3 radio network must be integrated to the data logger.

Reasons for using an aggregating data logger include the following:

- A system other than *LoggerNet* (such as Modbus) is used to communicate with the aggregating data logger, but not the CRVW3s
- Sensors other than vibrating-wire sensors need to be measured as part of the system
- Aggregation of the CRVW3 data is desired for backup or redundancy purposes
- Only one point of contact for data within *LoggerNet* is desired (in this case, the aggregator is the base station)

If you choose to use an aggregating data logger, you must include specific kinds of CRBasic declarations and instructions in the data logger program that instruct it to contact the CRVW3s and collect their data. This includes the use of the `GetDataRecord()` instruction.

## C.1 Aggregator station configuration

If the aggregator station communicates with more than one remote station (whether CRVW3 stations, base station, or other repeaters), it should be configured with an omnidirectional antenna. If it communicates with only one other station, a directional/Yagi antenna should be used. If the aggregator station is also the base radio station, some other medium of communications must be used between the data logger and *LoggerNet* (such as a serial cable,

TCP/IP, or cell modem). If no connection to *LoggerNet* is configured, regular visits to the data logger to collect the aggregated data must be made.

Since the aggregating data logger station uses PakBus to communicate with the CRVW3 stations, you must set beaconing and verify intervals on the data logger to ensure that PakBus discovery occurs on the network.

When the aggregator station is to be the base station on an RF451/RF452 radio network, the RF450 or RF451/RF452 radio connected or built into the data logger should be configured as the gateway (master) radio. Otherwise, it should be configured as an endpoint (slave) or endpoint/repeater (slave/repeater) radio. Use a portable base station or portable *LoggerNet* laptop to confirm the operation of the aggregator before leaving the site. For complex or large radio networks see the specific radio manual: RF407-Series manual ⬈ or RF451/452 manual ⬈.

# C.2 Programming the aggregator

In the CRBasic program running on the aggregating data logger, you must define a separate table for each CRVW3 from which data will be collected. Also, define appropriate variables for those stored values. The data logger will collect the **VW_Data** table from each CRVW3. For this to work properly, the definition of the table in the CRVW3 and in the data logger program must match. To obtain this table definition (a `DataTable`/`EndTable` structure), the **show table structure** terminal mode command must be executed on each CRVW3 whose data will be collected. Once the table information is captured from the CRVW3, it should be integrated into the CRBasic program. For information about using the terminal mode on the CRVW3, see Terminal mode (p. 75).

> **NOTE:**
> If you change the configuration of the CRVW3, the table definitions given by the **show table structure** terminal command will change, thus requiring the command to be executed again and your CRBasic program to be updated. Whenever possible, finalize the settings of the CRVW3 before retrieving its structure for use in the data logger program.

Once the tables have been set up in the program properly, use the `GetDataRecord()` instruction in your CRBasic program to get data from the CRVW3 and have it updated into the proper final storage table of the data logger. Within the `GetDataRecord()` instruction, you must use the PakBus address of the CRVW3 and any PakBus router/neighbor address needed to make the connection to that device. See GetDataRecord() sample program (p. 79).

> **NOTE:**
> Beginning with CR6 OS 7 and OS 32 for CR1000X, CR800-series, and CR300 data loggers, the `DataInterval()` for a `GetDataRecord()` table is not required to be integrally divisible by the program main scan interval. This allows the scan rate of the aggregator data logger to be independent of the `GetDataRecord()` interval and allows correct timestamps in the case that the CRVW3 is storing data faster than the local `GetDataRecord()` program. For example, if an aggregator data logger is running a main scan of one minute, and a CRVW3 is storing measurements every 10 seconds, then in order to get all of the most recent records from the CRVW3, the `MaxRecords` parameter of `GetDataRecord()` would be set to **6**:
>
> ```
> GetDataRecord (Result,ComSDC7,2,4,0000,200,2,&H8000 + 1,VW_Data_
> 1,6)
> ```

# C.3 `GetDataRecord()` sample program

```
CRBasic Example 1: Using GetDataRecord() to extract data from a CRVW3
```

```
'GetDataRecord FromCRVW3

'Campbell Scientific CR1000X
'This program demonstrates how to use
'the GetDataRecord instruction to extract
'data from the CRVW3 final storage tables

'Result codes for GetDataRecord instructions
Public GDRResult1, GDRResult2

'The following declarations and table definitions were extracted
'from the CRVW3 terminal mode "show table structure" command.
'Note that if you change settings on the CRVW3, these definitions
'could also change, and so they would need to be re-extracted
'from the terminal mode again and reinserted into the program
'in that case

Public Batt_Volt
Public CPU_Temp
Public Chan1_Freq
Public Chan1_Amp
Public Chan1_SigNoisR
Public Chan1_NoisFreq
Public Chan1_DecayRat
Public Chan1_Therm
Public Chan1_Temp
Public Chan1_Digits
Public Chan1_EngOut
```

```
DataTable (VW_Data,1,-1)
  DataInterval (0,5,Sec,10)
  Sample (1,Batt_Volt,IEEE4)
  Sample (1,CPU_Temp,IEEE4)
  Sample (1,Chan1_Freq,IEEE4)
  Sample (1,Chan1_Amp,IEEE4)
  Sample (1,Chan1_SigNoisR,IEEE4)
  Sample (1,Chan1_NoisFreq,IEEE4)
  Sample (1,Chan1_DecayRat,IEEE4)
  Sample (1,Chan1_Therm,IEEE4)
  Sample (1,Chan1_Temp,IEEE4)
  Sample (1,Chan1_Digits,IEEE4)
  Sample (1,Chan1_EngOut,IEEE4)
EndTable

Public CalTime(2) As Long
Public FreqBL_Chan1
Public TempBL_Chan1
Public PressureBL_Chan1

DataTable (CalHist,1,-1)
  Sample (1,CalTime,Nsec)
  Sample (1,FreqBL_Chan1,IEEE4)
  Sample (1,TempBL_Chan1,IEEE4)
  Sample (1,PressureBL_Chan1,IEEE4)
EndTable
'End of declarations extracted from the CRVW3 terminal mode

'Main Program running GetDataRecord instructions every 5 seconds
BeginProg
  Scan (5,Sec,0,0)
    'adding &H8000 to the remote table number is required
    'to avoid a -7 table signature mismatch code (returned to GDRResult1/2)
    'See the GetDataRecord CRBasic help topic for more details.
    'The PakBus address of the CRVW3 is "4", the PakBus neighbor to route
    'through is "2"
    'The radio is connected to the CS I/O SDC7 port+channel
    'Only the most recent record is retrieved and placed into the table
    '(MaxRecords=1)
    ' Use MaxRecords > N to get the most recent N records.For example,
    to get the 5 most recent records, set MaxRecords to 5.
    GetDataRecord(GDRResult1,ComSDC7,2,4,0000,0,2,1+&H8000,VW_Data,1)
    GetDataRecord(GDRResult2,ComSDC7,2,4,0000,0,2,2+&H8000,CalHist,1)
  NextScan
EndProg
```

# Appendix D. Engineering output and calibration

The basic measurement outputs given by the CRVW3 are sensor frequency and, if a thermistor is used, sensor temperature. These values can be used both to calculate an output value in engineering units, as well as to form the basis for calibration adjustments that are stored and applied to the outputs.

## D.1 Engineering output

The frequency reading on the CRVW3 is expressed both in units of Hertz (Hz) and in units of digits ($Hz^2$/1000). The CRVW3 can be configured to calculate an output value that is specified in engineering units of measure or dimensions. Examples of units are kPa, millibar, mmHg, $mmH_2O$, in., ft, or m for piezometers, με (microstrain) or ε (strain) for strain gages, kg, ton, or lb for load cells, and mm or in. for crackmeters. The CRVW3 implements a polynomial that works with most vibrating-wire sensors, and it uses frequency and temperature as inputs.

> **NOTE:**
> Some sensor calibration sheets report data in units of **digits** or **B units**. The relationship between Hertz and digits or B units is shown in the following formula:
>
> **digits** or **B units** = $Hz^2$ / 1000

The sensor manual should include information that describes the process of converting a frequency and temperature value pair into engineering output. Sometimes the temperature value is not used. Constants involved in the calculation are often slightly different for each manufactured sensor, in which case a calibration sheet or calibration record will be provided with each individual sensor. This information will be necessary in configuring the settings of the CRVW3 to obtain the desired result. Determine most of the details for calculating engineering output by using typical sensors in the lab or office before field deployment.

The settings used on the CRVW3 to configure engineering output are found in *Device Configuration Utility* > **Settings Editor** > **Channel 1**, **Channel 2**, and **Channel 3**. See Configuring the CRVW3 (p. 21) for more information.

A temperature reading cannot be used as part of the calculation unless it is expressed in units of degrees Celsius; raw resistance in ohms will not work. To use temperature as part of the output

calculation, set **Thermistor Enabled** to **True** and enter the thermistor coefficient A, B, and C values for Steinhart-Hart conversion. The CRVW3 uses the following equation to convert from resistance to temperature:

Tc = (1 / (A + B × ln (Rs) + C × (ln (Rs))$^3$)) – 273.15

Enable the calculation by setting **Calculate Engineering Output** to **True**. Enter a label for the desired output units in the **Engineering Units** box. This is a string label for the units of the calculated output values (for example, mm, ft, kg, kPa, or με); it does not affect the calculations.

If your sensor manual uses digits as the frequency input for calculating engineering units, set **UseDigits** to **True**. The polynomial used for calculation will be based on digits and temperature; frequency in Hz will not be used. Conversely, when **UseDigits** is **False**, the polynomial used will be based on frequency (Hz) and temperature; digits are not used.

The following table shows the engineering units polynomial constants and the related terms used in *Device Configuration Utility*.

| Table D-1: *Device Configuration Utility* settings used to set coefficients | |
|---|---|
| Use this *Device Configuration Utility* setting | To set this coefficient |
| Frequency/Digits squared (second-degree) coefficient | A (first polynomial constant) |
| Frequency/Digits linear (first-degree) coefficient | B |
| Constant term | C |
| Temperature squared (second-degree) coefficient | D |
| Temperature linear (first-degree) coefficient | E |
| Hybrid temperature coefficient (Temp × Freq or Temp × Digits) | F |

When **UseDigits** is **True**, the form of the calculation polynomial is:

**A** × $d^2$ + **B** × $d$ + **C** + **D** × $t^2$ + **E** × $t$ + **F** × $d$ × $t$

Where:

$d$ = digits

$t$ = temperature

**A**, **B**, **C**, **D**, **E**, **F** = user-specified coefficients (constants)

When **UseDigits** is **False**, the form of the polynomial is:

**A** × $f^2$ + **B** × $f$ + **C** + **D** × $t^2$ + **E** × $t$ + **F** × $f$ × $t$

Where:

$f$ = frequency (Hz)

$t$ = temperature (°C)

**A**, **B**, **C**, **D**, **E**, **F** = user-specified coefficients (constants)

For correct calculations, sensor documentation must provide data to discern which coefficients of the polynomial are relevant (**A**, **B**, **C**, **D**, **E**, or **F**); all other coefficients must be set to **0** so that they have no impact on the output calculation. Do this by comparing the calculation equations of your sensor manual to the polynomials previously shown. Contact your Campbell Scientific support representative if you require assistance for this step. The polynomial coefficient schemes have already been determined for the most common sensor types, and these can be shared.

Enter your sensor-specific coefficients in *Device Configuration Utility*. See *Device Configuration Utility* help for more information.

Once the settings have been applied and the CRVW3 restarts, the calculated output in engineering units will be given in the **ChanX_EngOut** value of the **VW_Data** output table, where *X* represents the channel number, unless "ChanX" is the name you gave to the sensor/channel.

# D.2 Sensor calibration

To enable in-field CRVW3 calibration, set **Use Baseline Offsets** to **True**, or set **Use Ambient Pressure Correction** to **True**.

Once these settings have been applied, the CRVW3 will restart, and the calibration functionality will be operational. To perform a calibration, use the **Calibration Wizard**, which is found using *LoggerNet* **Connect Screen Datalogger** menu.

For more information about the calibration process and using the **Calibration Wizard**, see the *RTDAQ* or *LoggerNet* manual:

[s.campbellsci.com/documents/us/manuals/rtdaq.pdf](s.campbellsci.com/documents/us/manuals/rtdaq.pdf)↗

[s.campbellsci.com/documents/us/manuals/loggernet.pdf](s.campbellsci.com/documents/us/manuals/loggernet.pdf)↗

Disregard the discussion of the `FieldCal` CRBasic instruction in this documentation. However, the process of manual calibration described in those sections can be performed using the **Public** table of the CRVW3.

The **Use Baseline Offsets** setting enables engineering output to be adjusted using stored baseline values, such as datum or zero-condition readings. Baseline values for frequency, temperature, and pressure will be stored via the **Calibration Wizard**, where applicable, and used for output calculations. The offset value is subtracted from the calculated value to obtain the final output.

The **Use Ambient Pressure Correction** setting controls whether engineering output will be adjusted using the current atmospheric pressure value that is stored in certain variables in the

CRVW3 **Public** table. The **Public** variable value will be subtracted from the calculated engineering result to give the final engineering output.

The **Public** variables used are shown in the following table:

| Table D-2: Public variables and channel numbers | |
|---|---|
| Public variable | Channel number |
| Pressure_Chan1_FC | 1 |
| Pressure_Chan2_FC | 2 |
| Pressure_Chan3_FC | 3 |
| Pressure_All | All |

When the `Pressure_All` variable is used, or when it is set to a non-0 value, all enabled channels will use that value. If `Pressure_All` is left at 0, the values given for individual channels will be used.

> **NOTE:**
> It will be necessary to set the values of these variables from an external Campbell Scientific data logger that has measured the current atmospheric pressure. Use `SendVariables()`, or similar, in its CRBasic program.

# Appendix E. ESD testing

The CRVW3 has been subjected to the Class Level 4 of two tests that are based upon the criteria of standards set by the International Electrotechnical Commission. The CRVW3 maintained its full functionality after being subjected to these tests. The tests are known as the electrical fast transient/burst immunity test (IEC 61000-4-4) and the surge immunity test (IEC 61000-4-5).

The electrical fast transient/burst immunity test is intended to demonstrate the immunity of electrical and electronic equipment when subjected to types of transient disturbances such as those originating from switching transients. At the Class Level 4, the power and earth terminals of the CRVW3 are subjected to 4000-volt bursts and the signal and control terminals are subjected to 2000 volt bursts.

The object of the surge immunity test is to evaluate the immunity of electrical and electronic equipment to unidirectional surges caused by over-voltages from switching and lightning transients. At the Class Level 4 of the test, the CRVW3 is subjected to line-to-line open circuit test voltages up to 2000 volts and line-to-ground open circuit test voltages up to 4000 volts.

> **NOTE:**
> These tests are not intended to test the capability of the CRVW3 or any other electronic devices to withstand primary lightning strikes.

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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. 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.
- 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.

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.

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.

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.

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