

INSTRUCTION MANUAL



CRVW3 3-Channel **Vibrating-Wire Datalogger**

Revision: 1/18



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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.

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General

- Prior to performing site or installation work, obtain required approvals and permits.
- 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.

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.

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PLEASE READ FIRST

About this manual

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

Some useful conversion factors:

Area:	1 in ² (square inch) = 645 mm ²
Length:	1 in. (inch) = 25.4 mm
	1 ft (foot) = 304.8 mm
	1 yard = 0.914 m
	1 mile = 1.609 km
Mass:	1 oz. (ounce) = 28.35 g
	1 lb (pound weight) = 0.454 kg
Pressure:	1 psi (lb/in ²) = 68.95 mb
Volume:	1 US gallon = 3.785 litres

In addition, part ordering numbers may vary. For example, the CABLE5CBL is a CSI part number and known as a FIN5COND at Campbell Scientific Canada (CSC). CSC Technical Support will be pleased to assist with any questions.

About sensor wiring

Please note that certain sensor configurations may require a user supplied jumper wire. It is recommended to review the sensor configuration requirements for your application and supply the jumper wire is necessary.

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CRVW3 3-Channel Vibrating-Wire Datalogger

1. Introduction

The CRVW3 is a datalogger (Campbell recorder) that measures and stores readings from up to three vibrating-wire sensors. A temperature measurement (usually obtained from a thermistor built-in to the sensor) is also available for each of these three channels. Standard, single-coil-circuit vibrating-wire sensors are supported (purchased separately). 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. Measurements may be taken as often as once every 1 to 3 seconds (1 second per active channel) and as infrequently as once per day. Measurement history is preserved on the device enabling data collection at reasonable intervals, and protecting against data loss due to periods of intermittent radio connectivity.



FIGURE 1-1. The CRVW3 3-Channel Vibrating-Wire Datalogger



FIGURE 1-2. The CRVW3-NE 3-Channel Vibrating-Wire Datalogger

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, the CRW3-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 radio options (–RF407, –RF412, –RF422, –RF427, and –RF451) are available to enable the creation of wireless networks. All radio options except the –RF427 are available in both enclosure and non-enclosure versions. The –RF427 is only available in the non-enclosure version.

- The RF407 has a 902 to 928 MHz operating-frequency range appropriate for use in the United States and Canada. (FCC / IC / IFT compliant)
- The RF412 has a 915 to 928 MHz operating-frequency range appropriate for use in Australia and New Zealand. (ACMA compliant)
- The RF422 has an 863 to 870 MHz operating-frequency range appropriate for use in most of Europe and some of Asia. (ETSI compliant)
- The RF427 has a 902 to 907 and 916 to 928 MHz operating-frequency range appropriate for use in Brazil. (ANATEL compliant)
- The RF451 has a 902 to 928 MHz operating-frequency range appropriate for use in the United States and Canada. (FCC / IC / IFT compliant) The RF451 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 badged for ACMA compliance.

See Section 6, *Specifications* (p. 10), for more information on the differences between the radio options.

NOTE

The RF451 has the same operating frequency range as the RF407. However, it has a higher output power. This provides a longer communication distance, but also requires more power. To preserve battery power, it may be necessary to only turn the radio during certain periods of time. See Section 8.2.9, *Validating CRVW3 Radio Operation* (p. 49).

NOTE

The RF407, RF412, RF422, and RF427 options are all versions of the same series of radios. This manual will refer to a CRVW3 with any of these options as the “CRVW3-RF407.” The standalone radios will be referred to collectively as “RF407.” Throughout the manual, RF407 can be replaced with RF412, RF422, or RF427, unless otherwise noted.

NOTE

This manual refers to using RF451 standalone radio(s) in a CRVW3-RF451 network. Our older radio model, the RF450, can also be used with CRVW3-RF451s. The configuration settings are the same for RF450s and RF451s. See the RF450 manual for more information on configuring the RF450. Note that the RF450 uses a different antenna connector than the RF451 (SMA instead of RPSMA), so antennas are not interchangeable between the two devices.

Configuration of devices and automated data collection can be performed remotely using the wireless options.

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.

Additional information about the CRVW3 can be found on the Campbell Scientific website:

www.campbellsci.com/crvw3

Before using the CRVW3, please refer to the following:

- *Quick Deploy Guide*
 - a folded card stored within the CRVW3 that contains summarized deployment and use instructions
- Section 2, *Precautions* (p. 4)
- Section 3, *Initial Inspection* (p. 5)

2. Precautions

- READ AND UNDERSTAND the [Safety](#) section at the front of this manual.
- DANGER: As with all electrical devices, ensure proper grounding using the ground lug of the device. Observe polarity (+/-) markings on the charge connector, and do not apply voltages over 28 V.



- Carefully install any solar panels, other power supply devices, antennae, and cabling according to manufacturer recommendations. Use surge suppression where possible. Consider the use of the Basic Grounding Kit (pn 31163), the Bulkhead Surge Suppressor Kit (pn 31312), and Self-Vulcanizing Shrink Tape (pn 21212). See this application note for more information on using self-vulcanizing shrink tape:

s.campbellsci.com/documents/us/technical-papers/weatherproofing-exterior-antenna-connections.pdf

- WARNING: Close the lid of the enclosure and secure the latch when the CRVW3 is deployed. This will help avoid unwanted entry of water, 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 from the outside of the enclosure before opening the enclosure lid.

NOTE

When using multiple CRVW3 devices in an RF451 (or RF407) radio network, it may be necessary to deploy an RF451 (or RF407) device (in addition to those built-in to the CRVW3) to operate as the **base radio station** in the network. Please consult with your local Campbell Scientific support representative regarding the use of radio options. Also refer to Section 9, *Radio Networks* (p. 51), and Section 10, *Complex (Large) Radio Networks* (p. 58), for more information relating to the design and configuration of radio networks.

3. Initial Inspection

Ensure that the following standard items were included with your shipment of the CRVW3:

- USB 2.0 Cable Type A Male to Micro B Male (pn 27555)
- Flat-bladed Screwdriver (pn 1113)
- *Quick Deploy Guide* (folded card, pn 31174)
- Desiccant Bag (pn 4905)
- Humidity Indicator Card w/ Mounting Tape (pn 28878)
- Original Enclosure Manufacturer Parts bag including (4) Lid-securing Screws

NOTE

Most of these items are shipped from the factory inside a bag stored within the enclosure.

The contents of the enclosure manufacturer parts bag are shown in [FIGURE 3-1](#).



FIGURE 3-1. Contents of the enclosure manufacturer parts bag

Examine the outside label on the device to ensure that the correct communication option was provided (–RF451 radio, –RF407 radio, No radio).

Confirm that the appropriate battery option is installed within the CRVW3 enclosure. For the –ALK option, this is an 8-cell battery pack along with 8 D-cell alkaline batteries. For the –RC option, this is a single rechargeable lead-acid 7 Ahr battery. If you received a CRVW3 with the –RC option, you should begin charging your rechargeable battery as soon as possible after receiving your shipment. See [Section 8.1.3, Providing Temporary Power to the CRVW3 \(p. 20\)](#), for details about how this is done.

If the –UM mounting option was selected, ensure that the corresponding mounting hardware was included with your shipment:

- Mounting Bracket (2)
- U-bolt (2)
- Screws (4)
- Washers (4)
- Lock Washers (4)
- Nuts (4)

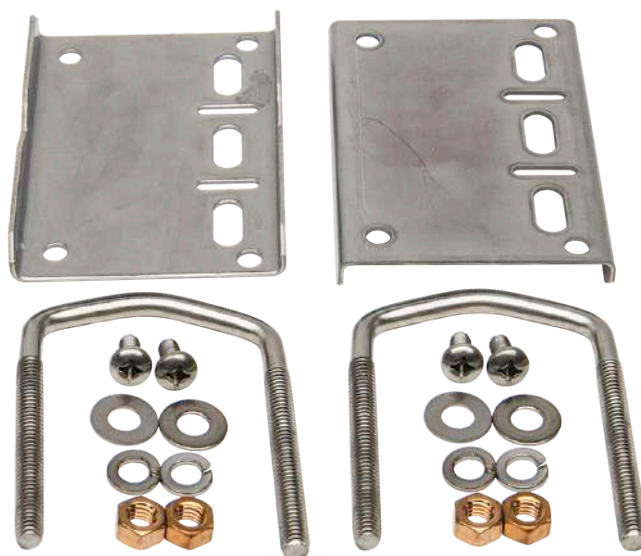


FIGURE 3-2. Contents of the –UM mounting option



FIGURE 3-3. CRVW3 with the –UM mounting option

Find the packing list that came with your shipment and ensure that all other related accessories included in your order are present and in good condition. Typical accessories include solar panels, other power equipment, antennae, cabling, grounding kits, and related items. Thoroughly check the packaging material for items that may be trapped inside. In case of damage, file claims with the shipping company. Contact Campbell Scientific to facilitate repair or replacement of damaged items.

4. QuickStart

For Quickstart information, refer to the *Quick Deploy Guide* included with each CRVW3 as a folded card inside the enclosure (pn 31174). You can also view and download the *Quick Deploy Guide* from the Campbell Scientific website:

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

5. Overview

The CRVW3 is a rugged, field-ready datalogger 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 5-1.

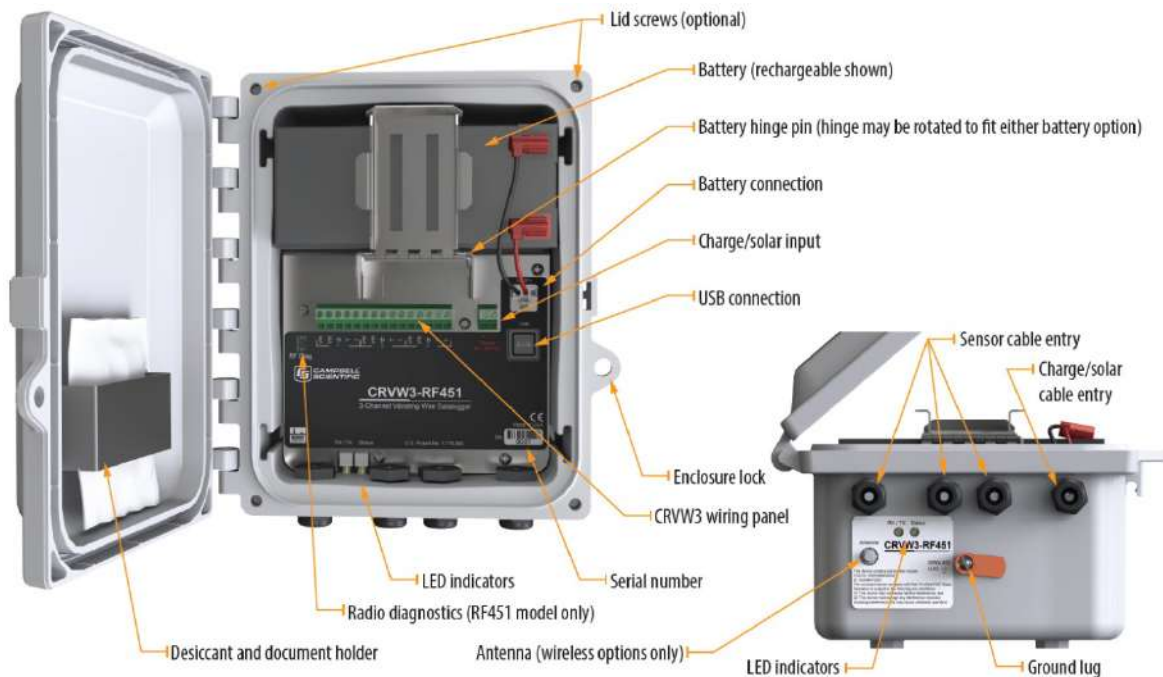


FIGURE 5-1. Basic Parts of the CRVW3

5.1 Measurement Theory

The CRVW3 uses Campbell Scientific VSPECT™ technology (U.S. Patent No. 7,779,690) to measure standard, single-coil-circuit vibrating-wire sensors.



FIGURE 5-2. CRVW3 Cable Connection and Entry Points

A vibrating-wire sensor is designed by its manufacturer so that its output corresponds to changes of the phenomenon in the environment 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 wire's natural frequency 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 frequency (natural frequency). The coil circuit is used to electrically capture the motion of the wire's vibrations during this stage. 3) The measurement system processes the time-series waveform captured from the coil to assess the frequency of the wire's vibration. 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.

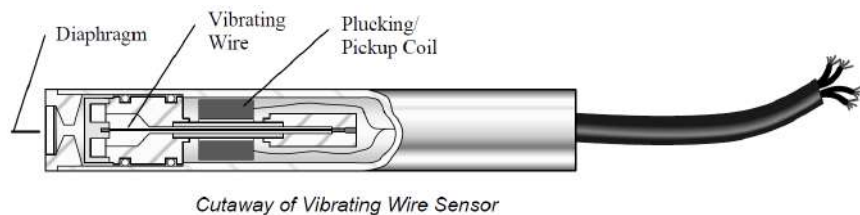
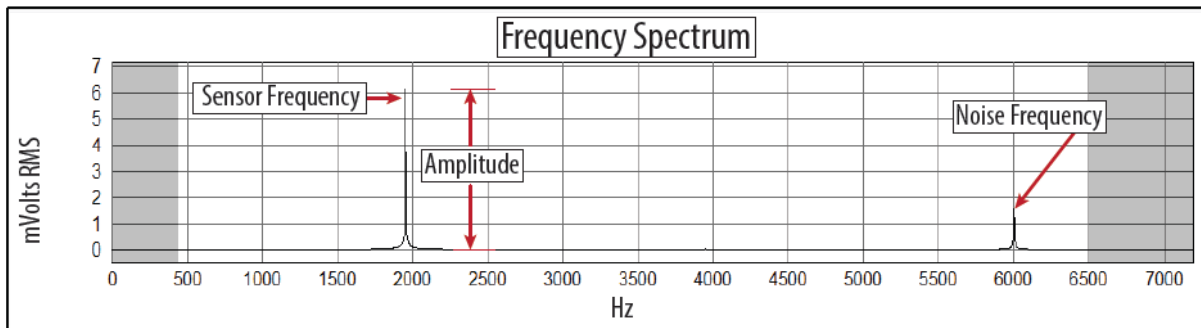


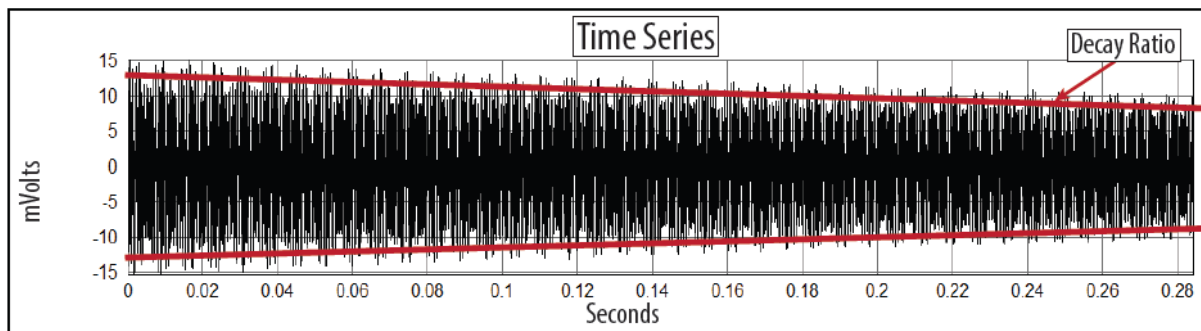
FIGURE 5-3. Internal View of a Typical Vibrating-Wire Piezometer Sensor

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 frequency range represents all expected natural frequencies that the sensor should produce, including those expected when it measures the most extreme conditions in the environment (highest and lowest frequencies). By exciting the sensor in only a certain range, interference from unwanted signals on the wire is reduced. The level of the excitation (12 V, 5 V, 2 V) can also be controlled by the user.

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, and 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 5-4. 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 (i.e., measured value given with its dimensions or units of measure).

5.2 About This Manual

Please study the remaining sections of this manual to obtain maximum benefit from your CRVW3 dataloggers.

Section 6, *Specifications* (p. 10), contains key specifications relevant to the measurement and use of the CRVW3.

Section 7, *Installation* (p. 14), introduces the main installation issues applicable to the CRVW3.

Section 8, *Installation of Individual CRVW3 Stations* (p. 15), focuses on the installation of individual CRVW3 stations.

Section 9, *Radio Networks* (p. 51), and Section 10, *Complex (Large) Radio Networks* (p. 58), discuss the planning and implementation of networks containing multiple CRVW3 stations that communicate with each other using radio telemetry.

Section 11, *Operation of CRVW3 Networks* (p. 88), Section 12, *Maintenance of CRVW3 Networks* (p. 96), and Section 13, *Troubleshooting CRVW3 Networks* (p. 101), provide guidance for the operation, maintenance, and troubleshooting required when administering CRVW3 measurement systems.

Appendices are also provided containing supplemental information.

6. Specifications

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

Datalogger

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 (3 channels)
Clock Accuracy:	±3 minutes per year
Measurement	
Interval Range:	1 s to 1 day
USB Micro B:	Direct connect to PC (supplies power for configuration and data collection), 2.0 full speed, 12 Mbps
Configuration:	Software configurable, no programming required

Measurements

Channel Count:	3 vibrating wire (VW) and 3 thermistor/RTD (temperature) measurements
Measurement Speed:	1 s per sensor (VW and temperature)

Vibrating Wire**Measurement****Excitation Options:** 2 V (± 1 V), 5 V (± 2.5 V), 12 V (± 6 V)**Measurement****(Frequency) Resolution:** 0.001 Hz RMS (-40 to 70 °C)**Time-series****Basic Resolution:** 24-bit ADC**Measurement Accuracy:** $\pm 0.005\%$ 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 $4.99\text{ k}\Omega$ 0.1%**Thermistor Precision:** $0.020\text{ }\Omega$ RMS @ $3000\text{ }\Omega$ (approximately 0.00015 °C RMS for most vibrating wire thermistors)**Accuracy:** $\pm 0.15\%$ of reading (-40 to $+70$ °C)**Wireless Communications**

RF451 Option	
Radio Type:	900 MHz Frequency Hopping Spread Spectrum (FHSS)
Frequency:	902 to 928 MHz
Transmit	
Power Output:	5 mW to 1 W, user selectable
Range:	20 to 25 miles assuming ideal conditions, line-of-sight, and appropriate antenna
Modulation:	2 level GFSK
Spreading Method:	Frequency hopping
Occupied Bandwidth:	142 kHz (applicable to FCC ID KNYAMM0921TT)
Hopping Patterns:	15 per band, 105 total, user selectable
Hopping Channels:	50 to 111, user selectable
Hopping Bands:	7, user selectable
Frequency Zones:	16 zones
Receive	
Sensitivity:	-108 dBm at 115.2 kbps for 10^{-4} bit error rate -103 dBm at 153.6 kbps for 10^{-4} bit error rate
IF Selectivity:	40 dB at $f_c \pm 230\text{ kHz}$
RF Selectivity:	60 dB at 896 MHz, 935 MHz
Dynamic Range:	+10 dBm 3 rd order intercept point at input connector

Data Transmission	
Error Detection:	32-bit CRC, retransmit on error
Data Encryption:	Proprietary spread spectrum technology
Link Throughput:	115.2 kbps, max
Average Additional Current	
Transmit:	650 mA (@12 Vdc)
Receive:	40 mA (@12 Vdc)
Idle:	15 mA (@12 Vdc)
Sleep:	6 mA (@12 Vdc)
Radio Repeater:	Devices with the –RF451 option can be setup as a radio repeater
Antenna Connector:	Reverse Polarity SMA (RPSMA)

RF407, RF412, RF427, and RF422 Radio Options				
	RF407	RF412	RF427	RF422
Radio Type	Frequency Hopping Spread Spectrum (FHSS)			SRD860, LBT + AFA
Frequency	902 to 928 MHz	915 to 928 MHz	902-907 MHz, 916-928 MHz	863 to 870 MHz
Transmit Power Output ¹	5 to 250 mW			2 to 25 mW
Channel Capacity	Eight 25-channel hop sequences sharing 64 available channels	Eight 25-channel hop sequences sharing 31 available channels	Eight 25-channel hop sequences sharing 43 available channels	Ten 30-channel hop sequences ²
Receiver Sensitivity	−101 dBm			−106 dBm
RF Data Rate	200 kbps			10 kbps
Average Additional Current Contribution at 12 Vdc				
Transmit	45 mA			20 mA
Idle On	12 mA			9.5 mA
Idle 0.5 sec Power Mode	4 mA			3.5 mA
Idle 1 sec Power Mode	3 mA			2.5 mA
Idle 4 sec Power Mode	1.5 mA			1.5 mA
Antenna Connector:	Reverse Polarity SMA (RPSMA)			
¹ Software selectable				
² 30 channels (default), software configurable to meet local regulations; 10 sequences for reducing interference through channel hop				

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, 3.0 kg (6.6 lb) with alkaline batteries
Operating Temperature Range:	–40 to 70 °C
Compliance:	CE, RoHS
Enclosure Dimensions:	24.1 x 22.9 x 14.0 cm (9.5 x 9.0 x 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 (included)

Compliance

RF451 Option:	United States FCC ID: KNYAMM0921TT Canada (IC): 2329B-AMM0921TT
RF407 Option:	United States FCC Part 15.247: MCQ-XB900HP Industry Canada (IC): 1846A-XB900HP Mexico IF: RCPDIXB15-0672-A2
RF412 Option:	ACMA RCM United States FCC Part 15.247: MCQ-XB900HP Industry Canada (IC): 1846A-XB900HP
RF422 Option:	View the CRVW3-RF422 radio option EU Declaration of Conformity at www.campbellsci.com/crvw3
RF427 Option:	This device complies with Brazil ANATEL standards in Resolution No. 506. The operating frequencies are 902 MHz to 907 MHz and 915 MHz to 928 MHz



* Thermistor or RTD resistance can be scaled to Temperature (°C) per manufacturer specifications. The resulting temperature can be used as a correction factor for the sensor's output.

7. Installation

For summarized installation information, refer to the *Quick Deploy Guide* (pn 31174) included with each CRVW3 as a folded card inside the enclosure. You can also view and download the *Quick Deploy Guide* from the Campbell Scientific website:

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

Campbell Scientific Field-Deployment Philosophy

Pre-configure and test your measurement system before taking it to the field. Issues that are unresolved before placing instrumentation in the field will usually be more difficult to resolve once in-field. Campbell Scientific equipment and software are among the best available, but the integration process can be demanding and involves trial and error; contingencies should be developed to address possible problems. Perform the bulk of the integration work in a comfortable and dry location that has a communications link with Campbell Scientific during regular business hours. If you are experienced with field deployments, set aside at least a full day for pre-configuration work. Otherwise, set aside three to seven days for system development before traveling to the field.

7.1 Individual Devices and Radio Considerations

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

When installing CRVW3 devices, consider the deployment issues for both individual stations (Section 8, *Installation of Individual CRVW3 Stations* (p. 15)) and also the planning and configuration of radio communications within a multi-CRVW3 network (Section 9, *Radio Networks* (p. 51), and Section 10, *Complex (Large) Radio Networks* (p. 58)).

7.2 Software Requirements

To use the computer software described in this manual, you must have a version that includes CRVW3 support. These software versions are:

- *LoggerNet* version 4.3 or higher (MS-Windows or Linux platforms)
- *PC400* version 4.3 or higher (MS-Windows only)
- *PC200W* version 4.3 or higher (MS-Windows only)
- *Device Configuration Utility* version 2.10 or higher (MS-Windows only)

You should periodically check the Campbell Scientific website for updates to these software packages, and also for updates to the firmware/OS of the CRVW3:

www.campbellsci.com/downloads

8. Installation of Individual CRVW3 Stations

The installation of an individual CRVW3 station includes two critical steps:

1. Connecting with and configuring the CRVW3 device in the lab or office (Section 8.1, *Lab Connection and Configuration* (p. 15))
2. Deployment of the CRVW3 device to a permanent location in the field (Section 8.2, *Field Deployment of the CRVW3* (p. 33))

Both steps are usually performed on each device. In unusual situations, or when installation personnel have sufficient deployment experience, it is conceivable that step 1 could be omitted. When that step is bypassed, some of its elements will still need to be performed at the field location. If a station is deployed as an independent collection station (i.e., with no radio links), its data can be manually collected using a USB cable connection from the CRVW3 to a laptop or similar computer.

NOTE

When deploying a system of multiple CRVW3 devices using radio-based communication options (such as the CRVW3-RF451 or CRVW3-RF407), also refer to Section 9, *Radio Networks* (p. 51).

8.1 Lab Connection and Configuration

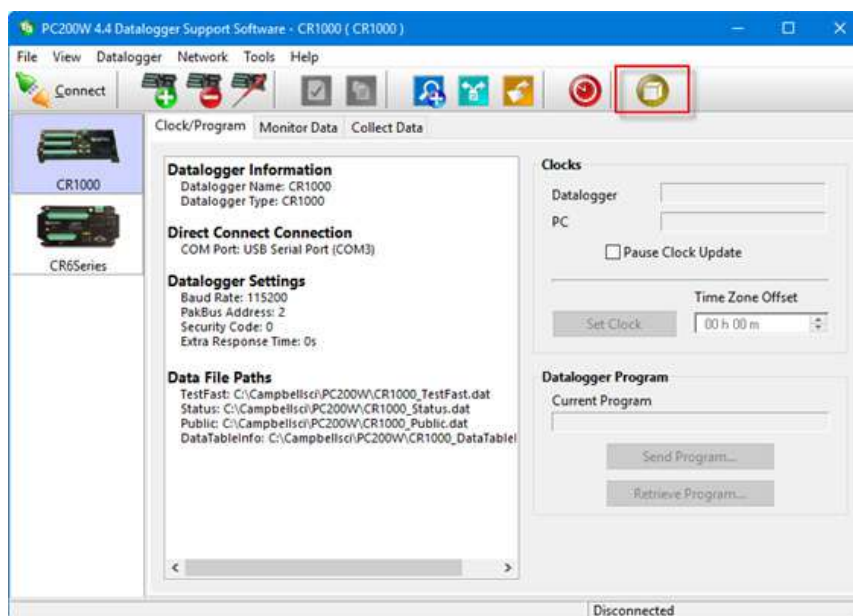
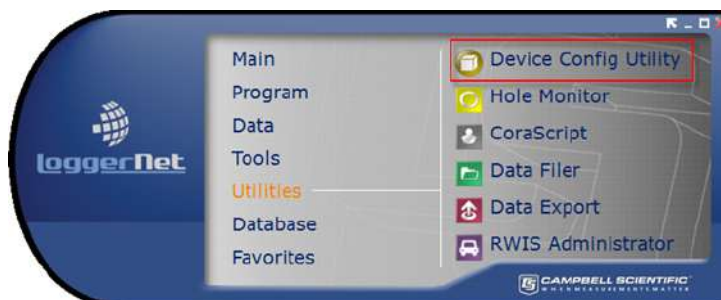
When using a CRVW3 device in the lab or office, there are several key tasks to perform. A Microsoft Windows-based laptop or desktop computer (Personal Computer, i.e., PC) should be available. Electrical outlets or other power options, as well as vibrating-wire sensors for testing the device should also be on-hand. During this process, the proper software and drivers will be installed on the PC, the device will be wired to one or more sensors, and then it will be powered. A connection between the device and the PC will be established, the device will be configured, and the device's measurement operation will be validated.

8.1.1 Preparing the Windows Computer (PC)

For CRVW3 lab operations, you will need a desktop or laptop computer running Microsoft Windows. This document also refers to that computer as a PC (Personal Computer). When installing software, you should have administrative privileges on the account used to log in to the computer at startup. Consider the benefits of configuring and using a laptop in the lab — once it is configured, it can then be taken into the field to facilitate efficient deployment of CRVW3 devices (see Section 8.2, *Field Deployment of the CRVW3* (p. 33)).

8.1.1.1 Device Configuration Utility (DevConfig)

You should first install the *Device Configuration Utility* (a.k.a., *DevConfig*). The CRVW3 requires version 2.10 or later of this software. If you have installed *LoggerNet* 4.3, *PC400* 4.3, or *PC200W* 4.3 on your computer, this software is already available.



This software is also available as a free download from the Campbell scientific website (www.campbellsci.com/downloads, www.campbellsci.com/19_1_9999_83). Check the version of any previously installed *DevConfig* software to ensure it is version 2.10 or later. If it is an earlier version, it will need to be upgraded using a newer installation program. The installation program can also be found on the *ResourceDVD* which is included with most hardware orders shipped from Campbell Scientific.



NOTE

If you upgrade your *LoggerNet*, *PC400*, or *PC200W* software from an earlier version to version 4.3, version 2.10 of *DevConfig* should automatically be installed during that process.

8.1.1.2 Install the CRVW3 USB Driver

In order to make a wired communications connection between the CRVW3 and the PC, it is necessary to use a USB cable. This requires a driver to be installed on Windows in order to operate correctly.

Start *DevConfig*, and then scroll down and highlight the *CRVW Series* device and you will see a screen like this:



Install the USB driver by clicking on the link entitled “install the USB driver onto your computer”.

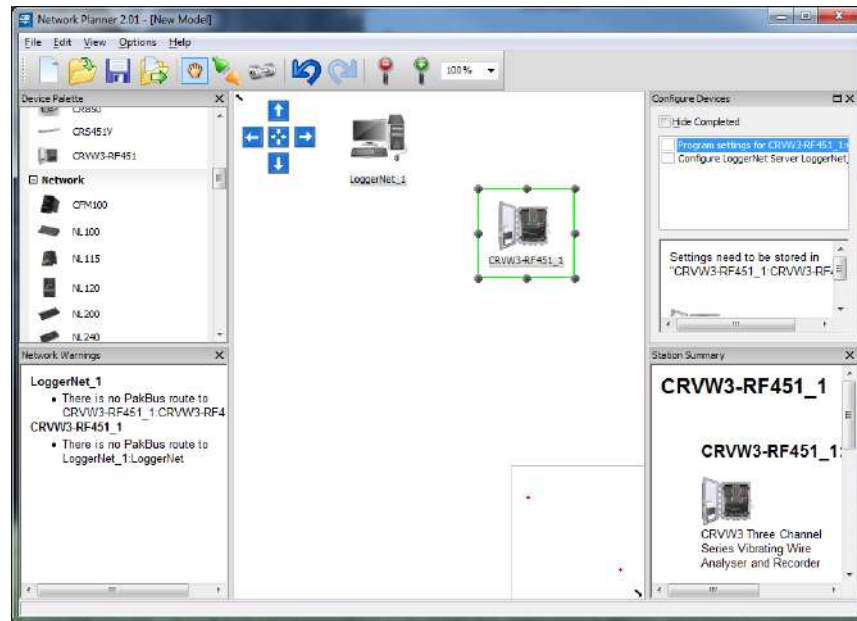
8.1.1.3 Network Planner

If you have installed the *LoggerNet* software, you can use the *Network Planner* tool to make network design decisions and configure devices before they are deployed to the field. The *Network Planner* is found in the Tools section of the *LoggerNet* toolbar.



The *Network Planner* allows you to plan out which measurement stations, repeater stations, and base station will be used in your deployed system. You can place hardware device icons onto a canvas (with an optional background graphic in place, such as map), and explore how connections are made between each station. Many of the settings are automatically set by the software as each device is added to the canvas (such as unique PakBus addresses). Details about the computer running *LoggerNet* are also worked out. After a design is complete, the *Network Planner* can be used to automatically configure each

device that is a part of the system. Using a checklist showing each device that requires configuration (**Configure Devices**), screens similar to those found in *DevConfig* are used to prepare each device for field use.



For more information about the *Network Planner*, refer to the *LoggerNet Manual*, Section 4.3.

For more information about the design of radio telemetry networks, see Section 9, *Radio Networks* (p. 51), and Section 10, *Complex (Large) Radio Networks* (p. 58).

8.1.2 Wiring Temporary Sensors to the CRVW3

Wiring sensors temporarily to the CRVW3 is necessary 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.

When wiring sensors to the CRVW3, it is recommended that the device be powered down. Note that this includes removing any USB cable that may be connected, since a USB cable provides enough power for the device to operate (for configuration or data collection purposes).

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



FIGURE 8-1. Wiring Panel of the CRVW3

Two of the sensor leads 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). These two leads should be connected to the two **VW** terminals on the CRVW3 corresponding to the desired measurement channel. The shield wire should be connected to the ground associated with that channel (located in between the **VW** terminals and the **T** terminals). If the sensor has a built-in temperature measurement device, those two leads should be connected to the two **T** terminals.

Sensor manufacturers often color-code the leads so you can easily identify which leads are for the coil-circuit and which are for the temperature device. Polarity does not need to be considered when wiring the two leads for the **VW** terminals and the two leads for the **T** terminals.



FIGURE 8-2. Typical Vibrating-Wire Sensor Lead Colors and Connections

Use the provided screwdriver (pn 1113) to wire the leads securely into the terminal blocks. Ensure a good connection between the metal lead and the inside of the terminal.

NOTE

If the built-in temperature device isn't 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.

8.1.3 Providing Temporary Power to the CRVW3

To provide temporary power to the CRVW3 while in the lab, it is recommended that you use pn 29796 (Power Supply 24 Vdc, 5 ft Cable). You can also use any power supply with a 16 to 28 volt DC output. Connect the power leads to the charge terminals located on the CRVW3.



FIGURE 8-3. Power Source Connection to the CRVW3 Charge Terminals

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.

A USB cable will also provide power to the CRVW3. However, the USB connection alone does not provide enough power to operate the radio or make measurements. USB power should only be used to configure the device or to collect data. A power source other than USB should be provided for the CRVW3 to make measurements properly and to enable radio communications. For CRVW3 devices with the radio option, the **RX/TX** LED is solid red when only USB power is provided to remind the user that the radio is not operating. The **Status** LED shows a red flash when no radio is used and only USB power is provided to the device. Measurements made while powered only with USB will result in NAN (invalid) for measurement output.

8.1.4 Connecting to the CRVW3

Before connecting to the CRVW3 via USB, you must ensure that the USB driver is installed as described above. After the driver is installed on a particular PC, it should be in-place for all future connections. Connect pn 27555 USB cable (included with the CRVW3 shipment) between the PC and the powered CRVW3.



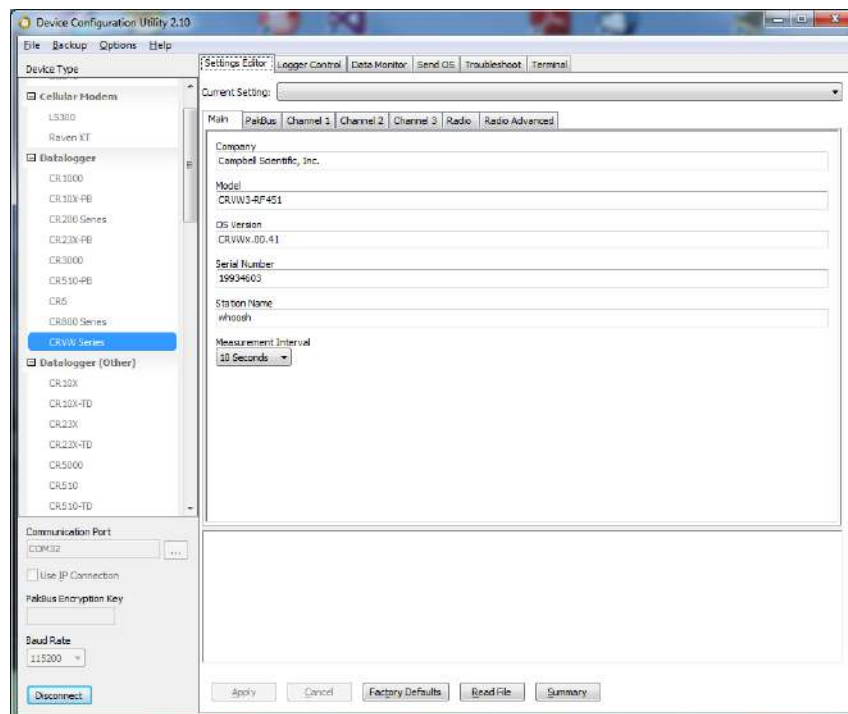
FIGURE 8-4. CRVW3 USB Connection Location

Start the *Device Configuration Utility* software (*DevConfig*). Find the **CRVW Series** device item in the **Datalogger** category (subtree) and select it. If the **Show Device Type Categories** item in the **Options** menu is not selected, the devices will be listed alphabetically. Once selected, you should see a picture of the CRVW3 and connection instructions as shown below:



Press the ellipsis button (...) next to the **Communication Port** box. This will list available COM ports on your system. With the USB driver properly installed, one of these items should include **CRVWx** in the name. Choose that COM port and press **OK**. Now press the **Connect** button in the lower left corner of the *DevConfig* window. A window may appear warning of potential conflicts with COM ports on the local server. In most cases, selecting **OK** will be sufficient to proceed.

After a few moments, you should see the **Settings Editor** and **Main** tabs for the CRVW3 device, as shown here:



If you are having trouble when pressing **Connect**, refer to Section 13, *Troubleshooting CRVW3 Networks* (p. 101).

The top set of tabs should include: **Settings Editor**, **Logger Control**, **Data Monitor**, **Send OS**, **Troubleshoot**, and **Terminal**. With the **Settings Editor** tab selected, the tabs should include: **Main**, **PakBus**, **Channel 1**, **Channel 2**, and **Channel 3**. CRVW3 devices with embedded radios will have **Radio**, and **Radio Power Schedule** tabs. The –RF451 option will also have a **Radio Advanced** tab.

Ensure you have selected the **Settings Editor** and **Main** tabs. The **Model** setting for your CRVW3 should be shown. This should show **CRVW3–RF451** if you have the –RF451 communications option. If you have the –RF407 communications option, you should see the value **CRVW3–RF407**. For the model without a radio, you should simply see **CRVW3** for the model.

You can use the **OS Version** box to determine which version of the device’s firmware (operating system) is currently loaded in the device. For details on how to update the firmware of the device, see Appendix A, *Updating CRVW3 Firmware* (p. A-1).

The **Serial Number** box shows the factory serial number of your device. The Company box should read as **Campbell Scientific, Inc.**

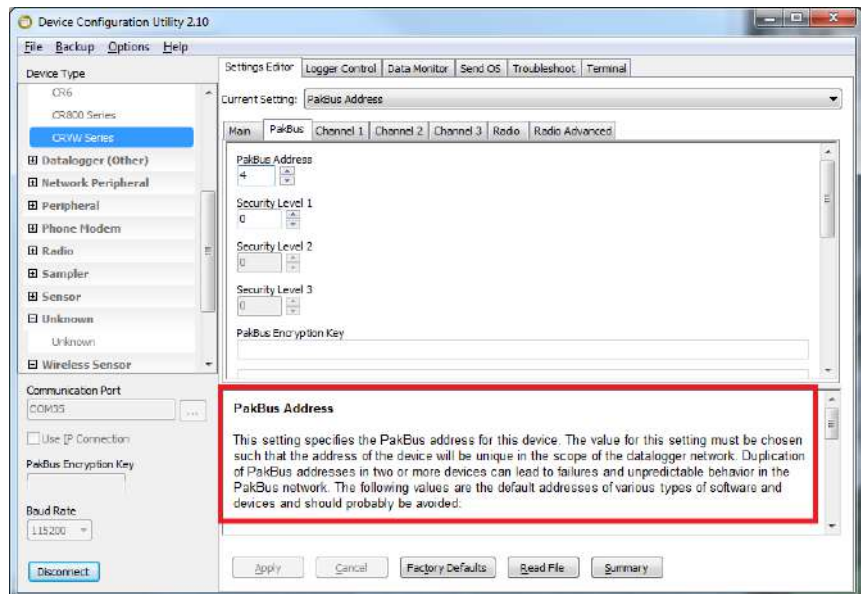
Choose the **Logger Control** tab. You should see the **Station Time** update once every second. This behavior confirms that you have a good connection with the CRVW3 device. You may update the device’s clock to match the clock on the computer by using the **Set Clock** button.

8.1.5 Configuring the CRVW3

Once you have successfully connected to the CRVW3 using *DevConfig* (see above), you can configure the device. This is an important installation activity that cannot be overlooked. Key settings must be configured before (or when) a device is deployed to the field.

Use the **Settings Editor** tab that is available when *DevConfig* is connected to make configurations to the CRVW3. The following sub-tabs will appear: **Main**, **PakBus**, **Channel 1**, **Channel 2**, and **Channel 3**. CRVW3 devices with embedded radios will have **Radio**, and **Radio Power Schedule** tabs. The –RF451 option will also have a **Radio Advanced** tab.

Key settings whose values you should review and set are listed below. As you place the cursor in the box for each setting, the frame in the lower right corner of the *DevConfig* screen shows text that describes the setting and how it is used (online help).



8.1.5.1 Key Settings

[TabName – SettingName]

Main – Station Name

You can give a name to each CRVW3 station and store it in the device. When planning a network of multiple devices, station naming can assist you in the organization of your system. (See **Planning your Network** in Section 10.2, *Planning the Radio Network* (p. 62).)

Main – Measurement Interval

This setting specifies how often the CRVW3 should measure the sensors connected to its active channels. The CRVW3 will repeatedly and automatically make these measurements at this interval and store the results until powered down, or re-configured.

For 1 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 interval between measurements that can be used is 24 hours.

PakBus – PakBus Address

If multiple CRVW3 devices will communicate with each other in the field or communicate to *LoggerNet* from the field, each CRVW3 station requires a unique **PakBus address**. You may wish to give a unique address to each CRVW3 even if it currently won't be deployed as part of a radio network in case your communications usage on the device changes in the future. Valid PakBus address range is 1 to 4094. Generally, addresses between 4000 and 4094 are reserved for use by specialized PakBus server tools such as *LoggerNet* or *DevConfig*. Therefore, it is recommended that addresses between 4000 and 4094 be used only by experienced PakBus network engineers.

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

NOTE

The *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 also functions as a PakBus router. Set the **Is Router** setting to true when the CRVW3 station 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 Section 10, *Complex (Large) Radio Networks* (p. 58).

Channel 1, Channel 2, Channel 3 – Name

Each measurement channel (sensor) can be given a 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 other means. Sometimes a name more descriptive than just the channel number is helpful.

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 energy is inserted into 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 V, 5 V, and 12 V can be selected. Longer cable lengths between a sensor and the CRVW3 may require a higher voltage setting. Sensors measured on a 3 second or shorter interval may require the lowest (2 V) 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 a 3 second or shorter interval should use as narrow of a window as possible (i.e., minimize the range between Begin Frequency and End Frequency) to 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 zero will result in only the resistance in Ohms being given as an output from the temperature sensor. Refer to your sensor documentation to confirm whether the temperature sensor follows the Steinhart-Hart equation, and also to obtain the three coefficients to be used (A,B,C).

Channel 1, Channel 2, Channel 3 – Calculate Engineering Output

Use this setting if output in engineering units is desired. The basic measurement outputs given by the CRVW3 are sensor frequency (including digits) and sensor temperature (if a thermistor is used). It is possible to calculate a reading or output that is specified in engineering units (units of measure or dimensions) using frequency/digits and temperature as the inputs. The CRVW3 implements a polynomial that works with most vibrating-wire sensors. Configuration of the polynomial can be an involved process and requires knowledge of the sensor's measurement factors, as well as an

understanding of the multiple settings that are set within *DevConfig*. For details about this polynomial-based calculation process, refer to Appendix E, *Engineering Output and Calibration* (p. E-1).

NOTE

If you wish to use a current barometric pressure reading as part of the calculation of water height, pressure, or related measurements, refer to Appendix E, *Engineering Output and Calibration* (p. E-1).

Radio, Radio Power Schedule, Radio Advanced

When using a radio option, there are some key settings on the **Radio**, **Radio Power Schedule**, and **Radio Advanced** tabs that should be set. See Section 8.1.7, *Validating Radio Connectivity in the Lab* (p. 29), and Section 8.2.9, *Validating CRVW3 Radio Operation* (p. 49), for more details about these settings.

8.1.5.2 Managing Changes to Settings

Once you have made changes to the CRVW3's settings, the **Apply** button at the bottom of the *DevConfig* screen becomes active. Press **Apply** to execute the changes on the device. The CRVW3 will be busy for up to 20 seconds to complete the changes. During that time, you will not be able to connect to the CRVW3. Watch the LEDs on the device to determine when the device has completed its reconfiguration and has begun making measurements again.

NOTE

Applying changes to certain CRVW3 settings may cause the CRVW3 to reset its operating mode, change its table structure, and **can result in data being erased**. Please be certain that you have collected all required data from the CRVW3 before making changes to its settings. Changes to the following settings will reset the final storage data on the CRVW3:

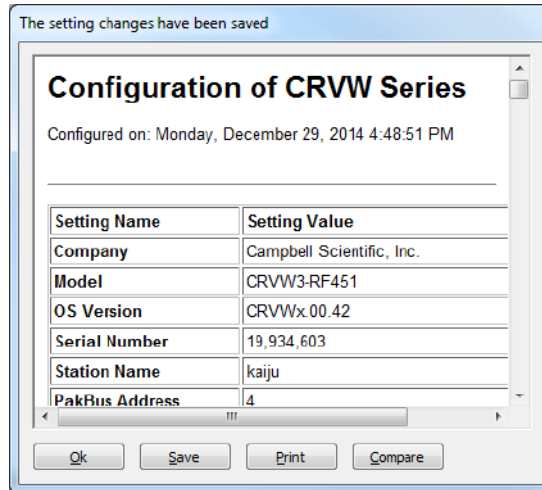
- Measurement Interval
- Channel Enabled
- Channel Name (when channel is enabled)
- Thermistor Enabled
- Thermistor Coefficients ABC (when changed from all zeroes or changed to all zeroes)
- Calculate Engineering Output
- Use Baseline Offsets
- Use Ambient Pressure Correction
- Engineering Units (string setting)
- Use Digits

If you want to abandon the changes that have been made since connecting to the CRVW3, use the **Cancel** button.

Press the **Factory Defaults** button to set all settings to their default values. It is necessary to press **Apply** to execute these settings and place them into the device.

Once you have used the **Settings Editor** tab to configure a device with certain settings, the current state can be saved to a file on the PC. You can use the **Summary** button to display a summary of the current settings. Press the **Save**

button to save these settings onto the computer as an xml file (*.xml). A filename is suggested which includes the device type and the date. You can change the name of the file to something different if you wish. Later on, you can use the **Read File** button to retrieve the device settings that were saved to an xml file, and re-apply them to the device with the **Apply** button.



When applying settings to a device using the **Apply** button, the **Save** screen appears, allowing you to review and save the settings. Use the **Save** button to save the *.xml file at that time, if desired.

8.1.6 Testing the Measurement Operation of the CRVW3

You can use the *Device Configuration Utility* in the lab to confirm the measurement operations of the CRVW3. Once you have configured the CRVW3 as desired, the CRVW3 will restart itself and automatically begin measuring its sensors at the interval you have specified. The data is stored immediately as each measurement is made.

When you first connect to the CRVW3, the following tabs are available: **Settings Editor**, **Logger Control**, **Data Monitor**, **Send OS**, **Troubleshoot**, and **Terminal**. If any changes are made to settings within the **Settings Editor** tab and its sub-tabs, all of these tabs except **Settings Editor** will disappear until those changes are either applied or canceled.

Use the **LoggerControl** tab to check the real-time clock of the device. The CRVW3's clock can be synchronized with the PC clock using the **Set Clock** button. If the **LoggerControl** tab is unable to obtain the time from the CRVW3, there are connectivity problems that need to be resolved (see Section 13, *Troubleshooting CRVW3 Networks* (p. 101)).

Use the **Data Monitor** tab to examine the data being stored in the final storage tables and utility tables of the device. Click on a table's name in the left pane, and its latest stored record will be displayed 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 showing calibration values captured during the latest calibration event.

To ensure proper operation of the CRVW3, you should 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 get updated as each measurement is made. By confirming this operation in the lab, you have the opportunity to resolve any problems as early as possible and in an environment more favorable for troubleshooting.

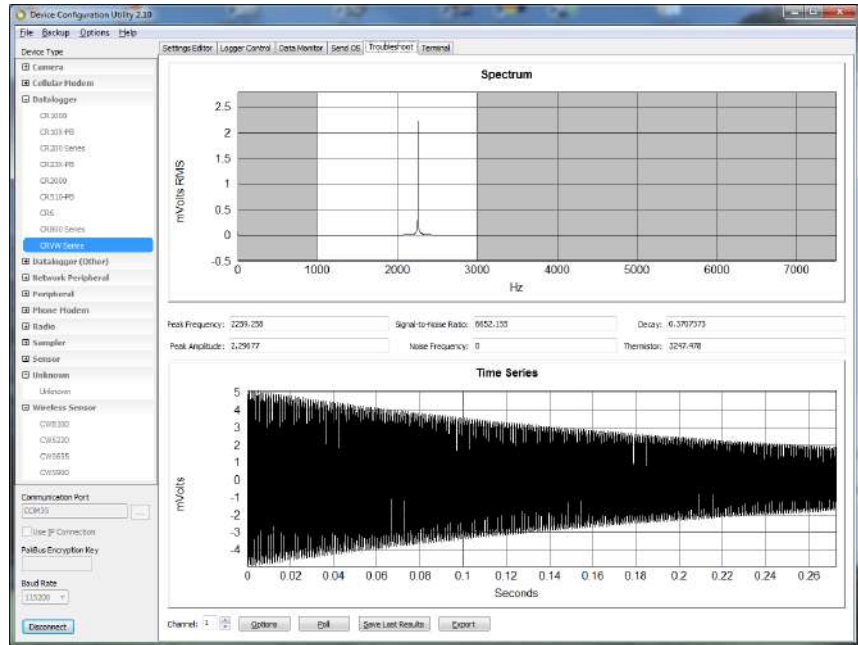
The **Troubleshoot** tab is provided so you can see detailed information about the vibrating-wire sensor measurements made by the CRVW3. You can manually trigger a measurement test and see diagnostic results within a few seconds. Select your channel of interest in the **Channel** selection box. Use the **Options** button to set the sweep excitation and frequency filtering window, and also to set the excitation voltage level to be used during the test. Press the **Poll** button to initiate the test. Within a few seconds the results will be displayed on the screen.

The **Spectrum** window shows the frequency domain response of the vibrating-wire sensor. Peaks in the spectrum indicate the main frequencies at which the sensor's wire vibrated during the measurement. The strength of the peaks are shown in the millivolt scale. Drag a rectangle on the viewing area to zoom in. Press the **Undo Zoom** button to return to the initial scale.

The **Time Series** window shows the motion of the sensor's wire (in millivolts) 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. Press the **Undo Zoom** button to return to the initial scale.

The main frequency reading is given in the **Peak Frequency** box in units of Hertz (Hz). Other diagnostic readings are given to help assess the quality of the reading:

- **Signal-to-Noise Ratio:** The amplitude (mV) of the strongest frequency peak in the spectrum divided by the amplitude (mV) of the 2nd strongest frequency peak.
- **Decay (Decay Ratio):** The 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 approximately discerned by a study of the results in the **Time Series** window.
- **Peak Amplitude:** The amplitude in millivolts (mV) of the strongest frequency peak in the spectrum.
- **Noise Frequency:** The frequency (Hz) of the 2nd strongest frequency peak in the spectrum.
- **Thermistor:** The measurement of the thermistor's electrical resistance in units of Ohms.



Use the **Save Last Results** button 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 within *DevConfig* 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. Use the **Export** button to save the results of the test into a text file that is readable using standard text editor programs.

The **Send OS** tab is used when updated firmware (an operating system) is installed into the CRVW3. Campbell Scientific will periodically provide firmware updates for the CRVW3 on its website. (see www.campbellsci.com/downloads). Once a newer firmware file is obtained from the website, follow the installation instructions that are displayed when this tab is selected.

You can 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 or by advanced users. See Appendix B, *Terminal Mode from Connect Screen or DevConfig (p. B-1)*, for more information.

8.1.7 Validating Radio Connectivity in the Lab

For CRVW3 devices with the –RF451 or –RF407 communications option, you should verify while still in the lab that the radio is working and has been configured to be reasonably ready for field operation.

8.1.7.1 Validating CRVW3-RF451 Radio Connectivity

When using CRVW3-RF451 devices, the simplest way to confirm this is to use an RF451 radio (www.campbellsci.com/rf451) connected to your lab computer. The RF451 operates as the master radio device and the base station. The CRVW3-RF451 device is configured as a slave device. (See Section 10.2.6, *Planning RF451 Radio Networks (p. 68)*, for more details about master/slave radio configurations and base station considerations.)

The RF451 and CRVW3-RF451 usually communicate easily in lab conditions, if within about 100 feet of each other, and if the RF451 is using a small 1/2 wave antenna (pn 14204). Typically in this situation, no antenna is required on the CRVW3-RF451.

Use the *Device Configuration Utility (DevConfig)* or *LoggerNet* to test radio connectivity. For details about using *LoggerNet* to test the radio connectivity, see Section 10.7, *LoggerNet Configuration (p. 80)*.

NOTE

If testing the radio connectivity of multiple CRVW3-RF451 devices, only power one CRVW3-RF451 at a time when using this test method.

8.1.7.1.1 Configuring the RF451 Radio

From *DevConfig*, install the USB device driver by selecting RF451 for the Device Type (in the Radio section) and pressing the **Install the USB device driver** link. This only needs to be done the first time the computer is connected to an RF451.

Connect the **USB** port of the RF451 to a USB port on your *DevConfig* computer. Select **RF451** for the Device Type (in the radio section) of *DevConfig*. Select the COM port labeled RF451 (COM#) where # is the COM port number. Press the **Connect** button. The radio **Status** LED will turn yellow

Set these settings with *DevConfig*:

- Active Interface: USB
- Baud Rate: 115.2K
- Radio Operation Mode: Multi-Point Master
- Repeaters Used: leave unchecked
- Network ID: This 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: This must be unique for each radio device: Use "1" (CRVW3 will use 0)

Press **Apply**. Leave the RF451 powered during the test. Leave the USB cable on the **USB** port of the RF451 connected to the computer.

8.1.7.1.2 Configuring the CRVW3-RF451

Provide power to the CRVW3 per Section 8.1.3, *Providing Temporary Power to the CRVW3 (p. 20)*. Connect the USB cable between the CRVW3 and the computer. In *DevConfig*, choose **CRVW Series**, select the port that was created when the USB driver was activated, and press **Connect**. In the **Settings Editor** tab, choose the **Radio** sub-tab.

Set the following settings:

- Radio Enabled: True
- Radio Operation Mode: Point to MultiPoint Slave

- Frequency Key: 5 (matches RF451)
- RF Transmit Power: Leave at 8
- Low Power Mode: Leave at 2
- Repeater Frequency: Leave at “Use Master Frequency Key”
- Receive SubNet ID: 15 (matches RF451)
- Transmit SubNet ID: 15 (matches RF451)
- Network ID: Same value as given for RF451 – must match (0 to 4095)
- Radio ID: Leave at zero (must be unique/different from RF451 radio ID, which should be 1).

Press **Apply**. Disconnect the USB cable from the CRVW3.

NOTE

When testing deployed devices in the field, you may have already assigned different **Radio ID**, **Network ID**, and **Frequency Key** values than those shown above. Make sure the **Network ID** and **Frequency Key** values match between both (all) devices and that the **Radio ID** is unique for each device.

8.1.7.1.3 Using *DevConfig* to Connect to the CRVW3-RF451 Over the Radio

Position the RF451 and computer to be at least 25 feet away from the CRVW3. The CRVW3 should no longer be wired to any device. Highlight **CRVW Series** in *DevConfig* (not **RF451**). Choose the port on the computer that is connected to the RF451 radio. Now Press **Connect**. Confirm red and green flashes on the **RX/TX** LED of the CRVW3 and on the RF451 as radio communications now occur.

If no other CRVW3-RF451 devices are on the radio network (i.e., powered or in range), *DevConfig* connects only to the CRVW3 device that is powered and available, using the RF451/COM port on the computer as a transparent link. The *DevConfig* 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. Confirm that the **Serial Number** and **Station Name** in the **Main** tab are correct and correspond to the CRVW3 station being tested. 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 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 Section 10.7, *LoggerNet Configuration* (p. 80), to perform multiple CRVW3 radio testing using *LoggerNet*.

8.1.7.2 Validating CRVW3-RF407 Radio Connectivity

When using CRVW3-RF407 devices, the simplest way to confirm connectivity is to use an RF407 radio (www.campbellsci.com/rf407) connected to your lab computer. The RF407 operates as the base station. (See Section 10.2.7, *Planning RF407 Radio Networks* (p. 69), for more details about base station considerations.)

The RF407 and CRVW3-RF407 usually communicate easily in lab conditions, if within about 100 feet of each other, and if the RF407 is using a small 1/2 wave antenna (pn 14204). Typically in this situation, no antenna is required on the CRVW3-RF407.

Use the *Device Configuration Utility (DevConfig)* or *LoggerNet* to test radio connectivity. For details about using *LoggerNet* to test the radio connectivity, see Section 10.7, *LoggerNet Configuration (p. 80)*.

NOTE

If testing the radio connectivity of multiple CRVW3-RF407 devices, only power one CRVW3-RF407 at a time when using this test method.

8.1.7.2.1 Configuring the RF407 Radio

From *DevConfig*, install the USB device driver by selecting RF407 for the Device Type (in the Radio section) and pressing the **Install the USB device driver** link. This only needs to be done the first time the computer is connected to an RF407.

Connect the **USB** port of the RF407 to a USB port on your *DevConfig* computer. Select **RF407 Series** for the Device Type (in the radio section) of *DevConfig*. Select the COM port labeled RF407 (COM#) where # is the COM port number. Press the **Connect** button.

Press **Factory Defaults** to return the RF407 settings to the factory defaults. Set the **Active Interface** to **USB**. Press **Apply**.

Leave the RF407 powered during the test. Leave the USB cable on the **USB** port of the RF407 connected to the computer.

8.1.7.2.2 Configuring the CRVW3-RF407

Provide power to the CRVW3 per Section 8.1.3, *Providing Temporary Power to the CRVW3 (p. 20)*. Connect the USB cable between the CRVW3 and the computer. In *DevConfig*, choose **CRVW Series**, select the port that was created when the USB driver was activated, and press **Connect**. In the **Settings Editor** tab, choose the **Radio** sub-tab.

Set the following settings:

- 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)

Do not change other settings. Press **Apply**. 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 above. Make sure the **RF Hop Sequence** and **Network ID** match between both (all) devices.

8.1.7.2.3 Using DevConfig to Connect to the CRVW3-RF407 Over the Radio

Position the RF407 and computer to be at least 25 feet away from the CRVW3. The CRVW3 should no longer be wired to any device. Highlight **CRVW Series** in *DevConfig* (not **RF07**). Choose the port on the computer that is connected to the RF407 radio. Now Press **Connect**. Confirm red and green flashes on the **RX/TX** LED of the CRVW3 and on the RF407 as radio communications now occur.

If no other CRVW3-RF407 devices are on the radio network (i.e., powered or in range), *DevConfig* connects only to the CRVW3 device that is powered and available, using the RF407 COM port on the computer as a transparent link. The *DevConfig* 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. Confirm that the **Serial Number** and **Station Name** in the **Main** tab are correct and correspond to the CRVW3 station being tested. 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 Section 10.7, *LoggerNet Configuration* (p. 80), to perform multiple CRVW3 radio testing using *LoggerNet*.

8.2 Field Deployment of the CRVW3

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

NOTE

When using a CRVW3 with a radio option (–RF451 or –RF407), it is recommended that you design the radio network before deploying any device to the field. Radio connectivity is a factor that can impact the geographic location of a CRVW3 site. See Section 9, *Radio Networks* (p. 51), and Section 10, *Complex (Large) Radio Networks* (p. 58), for more information about the use of radios. It is also recommended that at least some of the configuration of the CRVW3 be done in the office or lab (Section 8.1, *Lab Connection and Configuration* (p. 15)) before deploying it into the field.

Bring a laptop with *DevConfig* installed when you travel to the installation site (see Section 8.1.1, *Preparing the Windows Computer (PC)* (p. 15), and Section

8.1.4, Connecting to the CRVW3 (p. 20)). Consider the following tasks when installing a CRVW3 station:

- Connecting Sensors to the CRVW3
- Providing Power to the CRVW3
- Monitoring and Controlling Humidity Within the CRVW3 Enclosure
- Mounting the CRVW3 Enclosure
- Installing the CRVW3 Antenna (for devices with a radio option)
- Connecting the CRVW3 Electrical System to Earth Ground, Surge Protection
- Validating and Fine-Tuning CRVW3 Settings
- Confirming CRVW3 Sensor Measurement Operation
- Validating Radio communications (when applicable)
- Sealing the CRVW3 Enclosure

Details about these tasks are provided in this section.

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 this is the RF451 device configured as the master radio and *LoggerNet* software running on a laptop computer. For the CRVW3-RF407 this is the RF407 device and *LoggerNet* software running on a laptop computer.

8.2.1 Connecting Sensors to the CRVW3

Selection of the proper vibrating-wire sensors to meet your data acquisition needs is a process that is beyond the scope of this document. Contact an application engineer at your local Campbell Scientific support office for guidance regarding sensor selection and purchase. Campbell Scientific, Inc. also provides training related to the measurement of several kinds of vibrating-wire sensors.

The vibrating-wire sensors to be measured should be located within a reasonable distance of the CRVW3. Install the sensors according to manufacturer supplied instructions. A 5-wire or 3-wire cable will connect between each sensor and the CRVW3. Longer cable distances (more than 500 m or 1500 feet) may require the use of 12 volt excitation instead of 5 volt excitation (see Excitation Voltage in Section 8.1.5, *Configuring the CRVW3* (p. 23)). Since 12 volt excitation uses more power, consider how that excitation level may impact your power storage. Vibrating-wire sensor connections can provide reliable readings using cable distances up to 1500 m/5000 feet in some circumstances. Cable distances less than 500 m/1500 ft. are recommended. Up to three vibrating-wire sensors can be connected to each CRVW3.

Vibrating-wire sensors containing a built in thermistor will have five wire leads. Sensors that do not contain a built-in thermistor will have three leads. A sensor with five wire leads will have two leads for the coil circuit, two leads for the thermistor, and a shield lead. A 3-wire sensor has two leads for the coil circuit and a shield lead.

Color coding of wire leads for some of the more prevalent vibrating-wire sensors is shown in FIGURE 8-5.

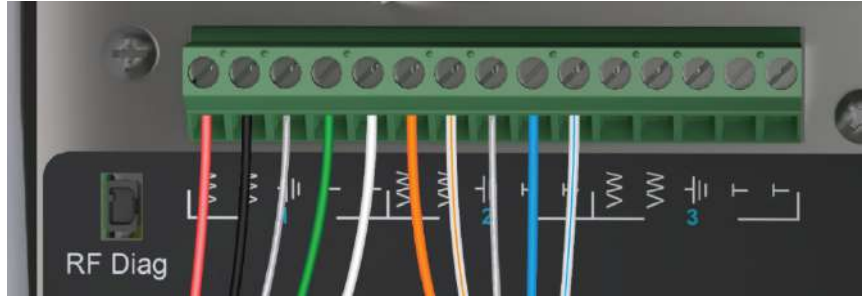


FIGURE 8-5. Typical Vibrating-Wire Sensor Lead Colors and Connections

Scheme 1: Red-coil-VW, Black-coil-VW, Clear-shield-ground, Green-thermistor-T, White-thermistor-T

Scheme 2: Orange-coil-VW, Orange-White-coil-VW, Clear-shield-ground, Blue-thermistor-T, Blue-White-thermistor-T

Determine which channel on the CRVW3 will be used for each sensor. Unscrew and remove the gland connector on the outside of the enclosure that corresponds to the channel currently being installed. Remove the gland capping pin, and feed the removed gland connector over the bare leads on the end of the sensor cable and position it a few inches down the cable. Now feed the cable through the gland hole. Before securing the gland, first connect the leads to the proper terminals on the CRVW3.



FIGURE 8-6. CRVW3 Cable Connection and Entry Points

Connect the two leads of the coil circuit to the two VW terminals on the face of the CRVW3 inside the enclosure. Choose the terminals that correspond to the desired channel (1, 2, or 3). Since the polarity of the coil circuit for sensor excitation and read-back makes no difference in the final measurement result, it doesn't matter which coil wire is connected to which VW terminal. If the sensor has a thermistor, connect the two thermistor leads to the T and T terminals. Similarly, it doesn't matter which thermistor lead is wired to which T terminal. Connect the shield wire to the ground connector.

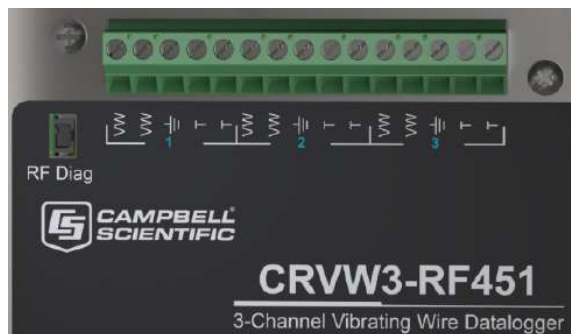


FIGURE 8-7. Wiring Panel of the CRVW3

After performing some of the validation steps shown later in this section, you will become confident that the sensor is being measured properly by the CRVW3. Once that occurs, you can secure the gland into its permanent field state. To do this, leave a slight amount of slack in the cable between the terminals and the gland and reconnect the gland cap (which was previously threaded onto the cable) on the outside of the enclosure and tighten it by hand or with a wrench. Ensure that the seal of the gland contacts the cable evenly around its circular connection to avoid any water ingress. Pull gently on the cable to ensure that it does not slide or move through the gland.

Repeat the sensor connection process for up to two additional sensors, using the terminals provided for those channels. After the device is powered (Section 8.2.2, *Providing Power to the CRVW3* (p. 36)), tests can be performed to validate that the CRVW3 is measuring the frequency and thermistor of the connected vibrating-wire sensor properly (Section 8.2.8, *Confirming CRVW3 Sensor Measurement Operation* (p. 45)).

8.2.2 Providing Power to the CRVW3

Consider carefully how power will be provided to your CRVW3 station to ensure reliable field operation.

If there is no electrical distribution grid power available at your CRVW3 site, you must use a battery option to provide power to the device. Two main battery options are available: –ALK and –RC.

NOTE

A CRVW3 with a radio option requires more power. See Section 8.2.9, *Validating CRVW3 Radio Operation* (p. 49), for information on using the *DevConfig* **Radio Power Schedule** tab to reduce the amount of power consumed by the radio.

8.2.2.1 Alkaline D-Cell Option (–ALK)

If you selected the –ALK option when ordering your CRVW3, it uses alkaline D-cell batteries for power. Eight cells are installed into the provided battery pack. When using this option, no solar panel or charge mechanism is required. However, visits to the site will be required on a regular basis to remove old batteries and insert new ones. The length of time that the CRVW3 can operate with one set of eight batteries depends on a number of factors. These factors include which radio option is used (the –RF451 option requires more power than the –RF407 option), how often measurements are made, how often radio

contact is made with other devices, and whether the site experiences cold temperatures or extreme changes in temperature. Alkaline battery discharge periods from several months up to one year are anticipated. Spend some time observing the CRVW3 in operation to formulate and refine the optimal battery maintenance schedule for your stations.

The –ALK battery pack should have arrived from the factory with the D-cell batteries already installed and the battery pack secured inside the enclosure. To power-up the CRVW3 using this pack, connect the battery connector to the CRVW3 panel as shown here:



FIGURE 8-8. –ALK Battery Pack Connector Cable and CRVW3 Battery Connection

LED activity should immediately occur on the CRVW3 indicating startup and operation. If no LED activity is observed, the batteries may be discharged and should be checked and replaced if necessary.

When changing out the batteries, disconnect the power connector, and remove the battery pack from the CRVW3 by disengaging the securing latch (push on the metal backing for the hinge to snap out). Once the battery pack is removed from the enclosure, you can remove the old D-cells, and insert the new D-cells. The battery pack can then be placed back into the CRVW3 enclosure and the latch secured. Ensure that the bumpers on the pack contact the latch and that the battery pack does not wiggle when pressed.

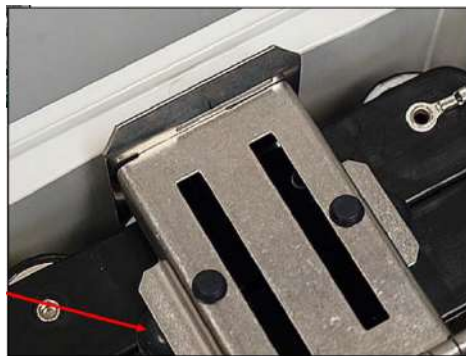


FIGURE 8-9. Bumpers Used to Secure the –ALK Battery Pack

8.2.2.2 Rechargeable Battery Option (–RC)

If you selected the –RC option when ordering your CRVW3, a 7 Ahr rechargeable battery is used to power the device. You will need a solar panel or some other DC voltage source (16 V to 28 V) to recharge the battery. Due to

the power requirements of the –RF451 radio option, it is anticipated that most deployments of the CRVW3-RF451 will use the –RC option.

NOTE

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.

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 into this regulator via the charge terminals of the CRVW3.

The charge regulator can sense the voltage provided by the solar panel and decide whether to charge the battery or simply draw power from the battery. This ensures constant device operation during changes between periods of full panel power production to periods of little or no panel output. This includes changes from day to night or changes from clear weather to heavy cloud cover. When sufficient power has been provided to charge the battery to its full state, the charge regulator also applies just enough power to keep the battery in the fully-charged state.

A 10 watt solar panel (SP10) is commonly used with the CRVW3. However, 5 watt or 20 watt panels (SP5, SP20) may also be used depending on site-specific power needs. Procure the hardware needed to mount the panel for optimal output. Installation instructions are provided with that hardware. The solar panel should be installed with the visibility and orientation that optimizes the capture of solar energy.

NOTE

A spreadsheet is available from Campbell Scientific to help you determine which solar panel you should use based on the frequency of your measurements, radio communication activity, and estimated solar exposure. Contact your local support office for more information.

When connecting the solar panel output cable to the CRVW3, feed the cable through the corresponding gland and secure the gland seal using a similar process to that described in Section 8.2.1, *Connecting Sensors to the CRVW3* (p. 34). Connect the solar panel cable to the Charge “+” and “–” terminals. The polarity of the leads from the solar panel must be observed, so check the cabling carefully.



FIGURE 8-10. Power Source Connection to the CRVW3 Charge Terminals

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

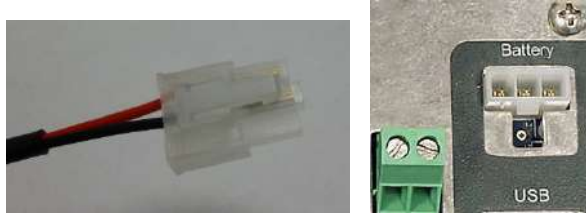


FIGURE 8-11. -RC Battery Connector Cable and CRVW3 Battery Connection

When either a charged battery is connected to the CRVW3 or sufficient voltage is applied to the charge terminals of the CRVW3, LED activity should be observed on the device to indicate startup and operation.

NOTE

It is possible to convert a CRVW3 device 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. This is done by removing the battery hinge pin, rotating the hinge bracket to accommodate the desired battery option, and re-inserting the hinge pin. Contact your local support representative if further details about this process are required.

8.2.2.3 Grid Power

If grid power is available at the CRVW3 site, that can be used as the main power source. Although the CRVW3 can operate exclusively from a proper voltage applied to its charge terminals, a battery option is still recommended for backup purposes and measurement continuity in case of power outages. Use pn 29796 as the main power source and connect it through the appropriate gland to the charge terminals. Any charge source with a level of 16 V to 28 V may be used. A rechargeable battery is recommended (-RC option) as a backup source in this scenario. When the device is powered by applying voltage to the charge terminals, the battery will be charged (or kept fully

charged) during those times when grid power is available. It is also possible to use the –ALK option for backup power. In that case, the D-cell alkaline battery pack will be drawn upon for power only when the voltage on the charge terminals is low or zero. No charging of the batteries occurs with the –ALK option.

8.2.3 Humidity Monitoring and Control

To ensure proper operation of the CRVW3, steps can be taken to control moisture and humidity conditions inside of the enclosure. Approximate humidity history can be tracked for analysis during maintenance visits to the site.

Install the humidity indicator card (pn 28878 included with CRVW3 shipment) by attaching it using the included backing tape. Place it on the inside of the enclosure lid above the desiccant holder. Review the status of the indicator card when maintenance visits are made to the CRVW3 site.

Ensure a fresh desiccant package (pn 4905 included with CRVW3 shipment) is inserted into the desiccant holder. Note that the *Quick Deploy Guide* is also kept in the desiccant holder. Additional desiccant packs can be ordered from Campbell Scientific when needed.

Humidity conditions can vary widely among CRVW3 deployment locations and associated weather conditions. Monitor the state of the humidity indicator card in order to determine when a replacement desiccant pack is needed. Humidity history from a weather station near the CRVW3 may also be helpful in predicting desiccant maintenance schedules.

8.2.4 Mounting the CRVW3 Enclosure

The enclosure of the CRVW3 can be securely attached to a pole or other applicable mounting hardware. Use the supplied mounting kit (option –SM, included with CRVW3 shipment) or the Universal Mounting Bracket (pn 30840, –UM option, shown in FIGURE 8-12) to secure the CRVW3 enclosure at its permanent location.



FIGURE 8-12. CRVW3 with the –UM mounting option

Also consider the location of the solar panel and antenna and how the cabling of those two items will connect into the CRVW3 enclosure.

Mount the enclosure with the sensor glands, antenna connector, and ground lug facing downward. This minimizes water exposure (rain, snow, etc.) to those locations, and helps ensure that the inside of the enclosure remains dry.



FIGURE 8-13. Proper Field-Installed Orientation of the CRVW3

8.2.5 Installing the CRVW3 Antenna

When using a radio option on the CRVW3 (CRVW3-RF451 or CRVW3-RF407), you should carefully consider the kind of antenna to use with the device. You should ensure that it can communicate properly with the applicable remote CRVW3 devices, radio repeater stations, and the radio base station. (See Section 9, *Radio Networks* (p. 51), and Section 10, *Complex (Large) Radio Networks* (p. 58), for more information about the configuration of radio networks.)

A small “whip” or “dipole” antenna may be connected directly to the enclosure bottom (pn 14204). These are used for testing or for short distance communication links. For longer distances, a higher gain, externally cabled antenna is usually necessary. These antennae require mounting hardware (a pole, etc.) separate from the CRVW3. Be sure to order an antenna cable long enough to connect between the antenna mount and the mounted location of the CRVW3.

If the CRVW3 communicates with only one other radio station or device, use a directional antenna (such as a Yagi, pn 14205 for the -RF451 option, pn 14201 for the -RF407 option), and position the antenna so it points directly at the remote station. If the CRVW3 communicates with more than one radio station or device (i.e., when it is configured to operate as a repeater station), an omnidirectional antenna (aka “omni”) should be used (pn 14221). Raising the antenna to a higher elevation may improve the signal reception and transmission.

Antenna connections that are exposed to the environment should be protected with self-vulcanizing tape (pn 21212). A surge suppressor kit (pn 31314) is also recommended when using cabled antennas. This will protect against

lightning strikes or other electrical hazards. An example of weatherproofing installed on a surge suppressor connection is shown in FIGURE 8-14.



FIGURE 8-14. Properly Weather-proofed Antenna Cable Connection with Surge Protection

8.2.6 Connecting the CRVW3 Electrical System to Earth Ground

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



FIGURE 8-15. CRVW3 Ground Lug Location

The Campbell Scientific small enclosure grounding kit (pn 31163) can be used to make this connection.

8.2.6.1 Electrostatic Discharge Protection

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

The CRVW3 has built-in protection to prevent damage from Electrostatic Discharge (ESD). It is important to understand that the built-in ESD protection will be completely ineffective unless the CRVW3 is properly earth grounded at the installation site.

A good earth (chassis) ground will minimize damage to the datalogger and sensors by providing a low-resistance path around the system to a point of low potential. Campbell Scientific recommends that all dataloggers be earth

(chassis) grounded. All components of the system (dataloggers, sensors, external power supplies, mounts, housings, etc.) should be referenced to one common earth (chassis) ground.

In the field, at a minimum, a proper earth ground will consist of a five-foot copper-sheathed grounding rod driven into the earth and connected to the large brass ground lug with a low gage wire (8-12 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.

NOTE

For information on the ESD testing of the CRVW3, see Appendix [F](#), *ESD Testing* (p. F-1).

8.2.6.1.1 Lightning Protection

Elaborate, expensive and nearly infallible lightning protection systems are on the market. Campbell Scientific, for many years, has employed a simple and inexpensive design that protects most systems in most circumstances. The system employs a lightning rod, metal mast, heavy-gage ground wire, and ground rod to direct damaging current away from the datalogger. This system, however, is not infallible. FIGURE 8-16 is a drawing of a typical application of this simple design.

NOTE

Lightning strikes may damage or destroy the CRVW3 and associated sensors and power supplies.

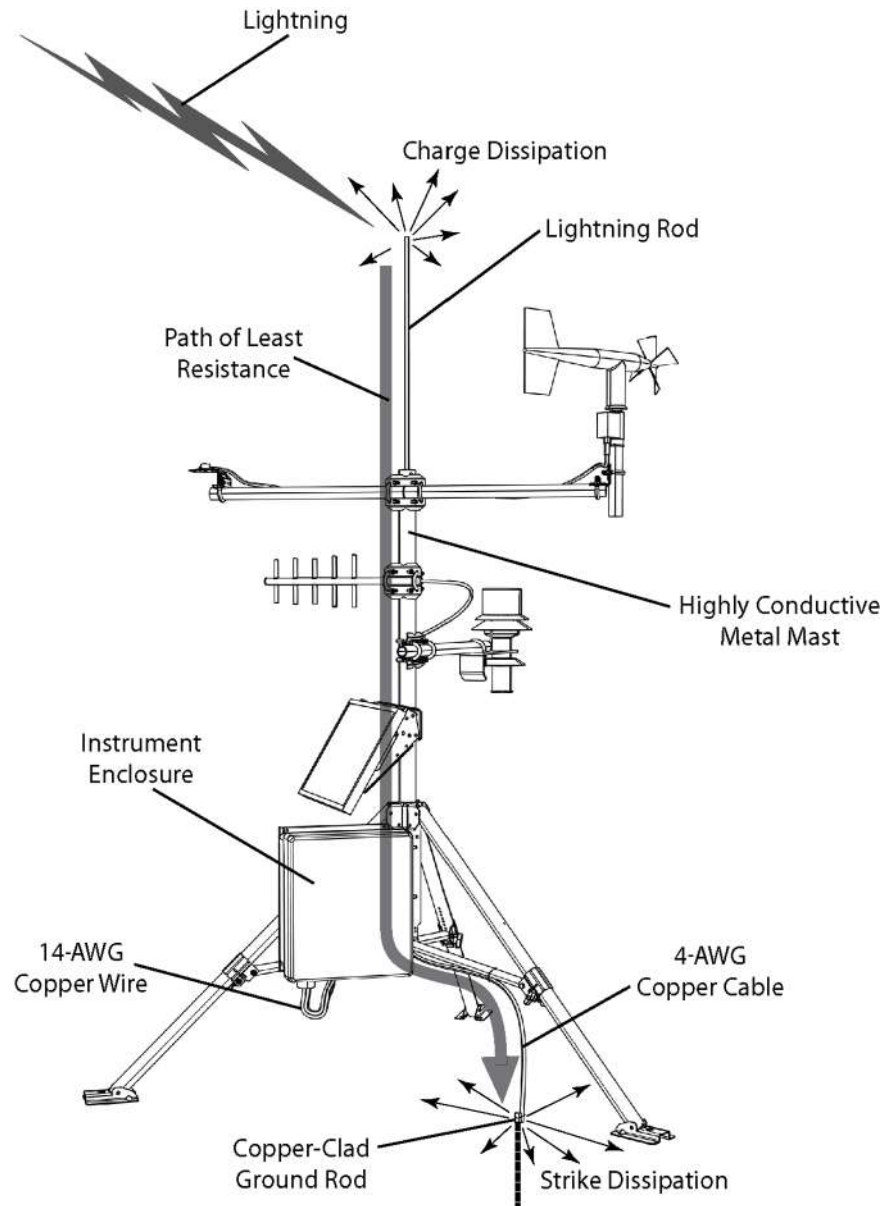


FIGURE 8-16. Lightning Protection Scheme

8.2.7 Validating and Fine-Tuning CRVW3 Settings

Before completing the deployment of your CRVW3, you should confirm that it is configured to operate in the way you expect. Plan to have a laptop or other Windows computer running *DevConfig* with you in the field so you can connect to and configure the device. Be sure to bring the USB cable (pn 27555) that was included in your CRVW3 shipment. Section 8.1.5, *Configuring the CRVW3* (p. 23), discusses the basic configuration of a CRVW3 device. If no configuration of the CRVW3 for the current sensors has been previously performed, first follow the steps outlined in that section to configure the CRVW3.

The main measurement output from a vibrating-wire sensor is a frequency (in units of 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 that you 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 frequency that can be expected under both of those conditions. Using this information, you will formulate both a low frequency value and high frequency value that is configured into the CRVW3. This frequency range is used during excitation and also during the read-back of the sensor. When exciting the sensor, only energies within the specified frequency range are used for excitation. When reading out the sensor's response, only frequencies within the window are processed, and 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.

Using *DevConfig*, make sure the following settings are properly configured:

- Station Name
- Measurement interval
- PakBus Address
- Is Router (should be set to “true” when the CRVW3 is also a radio repeater device).

Then make sure that the following settings are properly set for each sensor channel:

- Channel Enabled
- Channel Name
- Excitation Voltage
- Begin Frequency, End Frequency
- Thermistor Enabled
- Calculate Engineering Output

Refer to Section 8.1.5, *Configuring the CRVW3* (p. 23), for more details about configuring and applying these settings. Consider saving the XML (*.xml) configuration file on your laptop to store the settings as they were applied to your device in the field.

NOTE

When using the –RF451 radio option, there are some key settings on the **Radio** and **Radio Advanced** tabs of *DevConfig* that should be confirmed. See Section 8.1.7, *Validating Radio Connectivity in the Lab* (p. 29), and Section 8.2.9, *Validating CRVW3 Radio Operation* (p. 49).

8.2.8 Confirming CRVW3 Sensor Measurement Operation

Once the CRVW3 is properly installed at its permanent deployment site and configured for operation, you should confirm (before leaving the site) that it is measuring its sensors properly. This validation includes the use of a laptop running *DevConfig* connected via USB cable.

8.2.8.1 LED Operation

You can observe the LED behavior of the CRVW3 to assess its condition. The LED lights can be observed from both the inside and the outside of the enclosure.



FIGURE 8-17. LED Viewing Locations on the CRVW3

TABLE 8-1 summarizes LED operation on the CRVW3.

TABLE 8-1. CRVW3 LED Behavior			
RX/TX LED (left side)		Status LED (right side)	
Solid Red	Radio Error	Solid Red	Measurement or Program Error
		Solid Green	Measuring Sensor(s)
Solid Orange	Configuration of Radio, Busy, No communications will occur	Solid Orange	Configuration of Device Settings or OS, Busy, No communications will occur
Blinking Red	Radio Transmit (TX)	Blinking Red	No measurements possible with only USB power Also, for –RF451 option, communication is not possible with only USB power. (The radio is not powered.)
Blinking Green	Radio Receive (RX)	Blinking Green	Awake (heartbeat)
Blinking Orange	No Carrier Detect (RF451 Radio Only)	Blinking Orange	Awake (heartbeat) – in Repeater mode for –RF451 option
Off	No Radio Activity	Off	Device asleep or powered down

NOTE

For CRVW3 devices without a communications option (no radio), only the **Status** LED behavior shown above (right-side) is applicable.

When the CRVW3 is powered up or has a change of settings applied, it executes its startup sequence. During the final stage of the startup sequence, you will see both LEDs in a solid orange state. Allow time for the startup sequence to complete (up to 20 seconds) before attempting to connect to the

CRVW3. Once the startup sequence is finished, the two LEDs will stop showing solid orange, and begin to indicate the regular measurement and communications status of the device.

When the CRVW3 begins operating you will see a green flash on the **Status** LED every few seconds to indicate that the device is awake. If the CRVW3-RF451 is configured as a radio repeater (see Section 10.1, *Radio Network Station Types (p. 58)*), the **Status** LED will flash orange instead of green while it is awake. While the device is measuring its sensors, the **Status** LED will show as solid green. This lasts about 1-3 seconds and then the solid green condition ends. You should observe this LED behavior to confirm that the CRVW3 is measuring its channels at the desired interval (which was set previously using *DevConfig*).

As a power-saving feature, the CRVW3 remains awake between measurements only for a limited time. If the device is powered up without a USB cable connected to it, it will remain awake between measurements (indicated by the green or orange “awake” flash on the **Status** LED) for five minutes. After five minutes, the device will sleep between measurements. While in sleep mode, the CRVW3 will wake up only long enough to measure its sensors and store the results, and the **Status** LED will light up as solid green during that time. The device then immediately returns to sleep, and therefore no “awake” indicator flashes (green or orange) will be observed between measurements.

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, and then sleep between measurements.

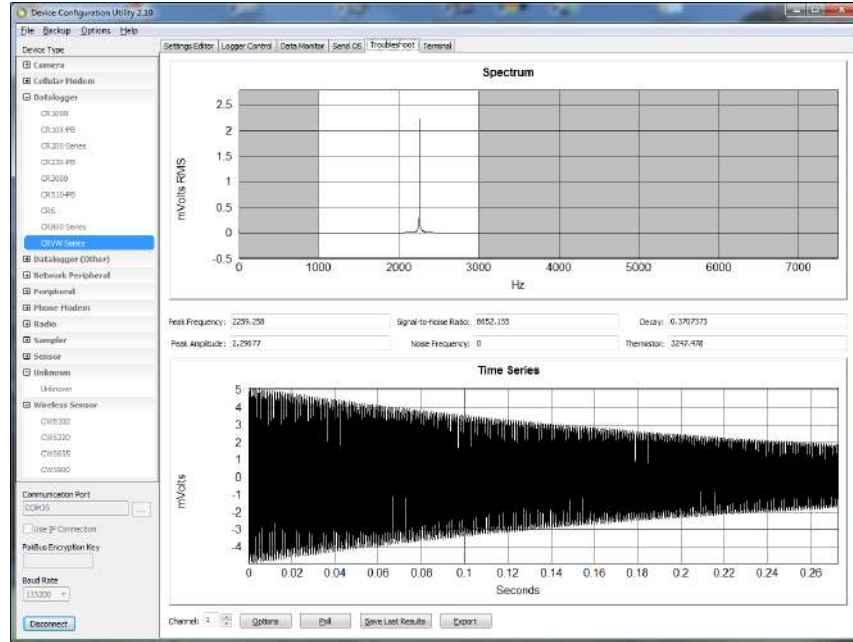
On devices with the –RF451 and –RF407 options, the **RX/TX** LED flashes red when transmitting data over the radio and green when receiving data over the radio. A solid red condition indicates a radio error.

Radio transmissions received by the device will wake it up if needed. The device will remain awake for as long as radio activity is in process plus an additional 20 seconds (just in case additional radio transmissions are received). After that the device will return to sleep (if it was asleep before the radio transmissions were first received).

8.2.8.2 Validation with DevConfig

To perform measurement validation with the laptop, connect the USB cable, run *DevConfig*, and connect to the CRVW3 (see Section 8.1.4, *Connecting to the CRVW3 (p. 20)*, for more information). The top set of tabs displayed after connecting includes the **Troubleshoot** tab. Use the **Troubleshoot** tab screen to test and examine the sensor response for each channel. The diagnostic information provided helps you determine whether the connected sensor is operating correctly and is providing proper measurement readings. Press the **Poll** button to perform the test and wait a few seconds for the results to appear on the screen. Use the **Channel** selection box to select each active channel in turn for individual testing.

A high-quality sensor response (spectrum and time-series waveform in the **Troubleshoot** screen) is shown here:

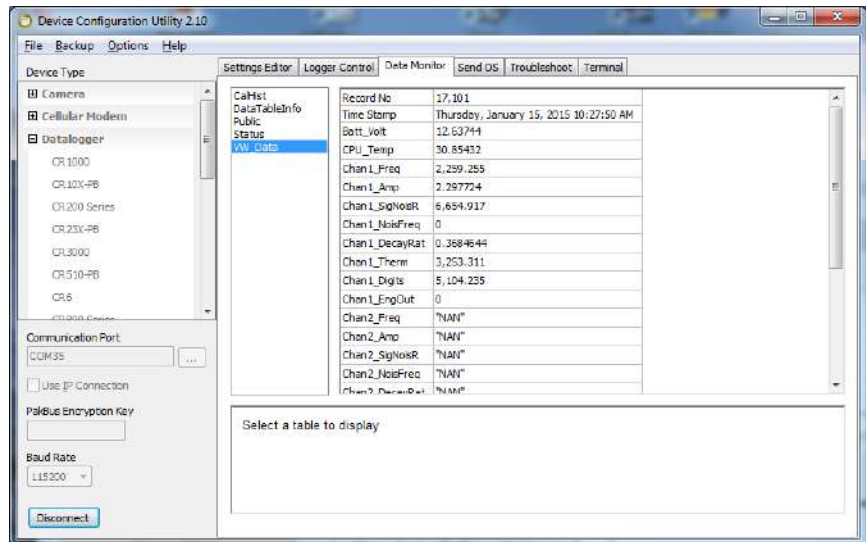


Check the **Peak Frequency** to ensure that the main sensor reading is in the expected range. A **Signal-to-Noise Ratio** of 6 or greater is preferred. Check the **Thermistor** value (in units of Ohms) if used.

If multiple peaks occur in the response spectrum of the sensor, be sure to choose the **Begin Frequency** and **End Frequency** carefully 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 how the beginning and ending frequencies are set. Use the **Options** button to temporarily experiment with different frequency window ranges. Use the **Channel1**, **Channel2**, and **Channel3** tabs (under the **Settings Editor** tab) to make permanent changes to the **Begin Frequency** and **End Frequency** settings.

You can use the **Save Last Results** or **Export** buttons to save the test information shown on the screen into a file. These saved results can be stored and used as a historical reference (baseline or datum point) for comparison with the same sensor's behavior in the future. The saved results can also be sent to others (including Campbell Scientific support personnel) for evaluation and troubleshooting purposes. Use the **Off Line Analysis** tab of *DevConfig* (shown when disconnected from the CRVW3) to open and view a file saved previously with the **Save Last Results** button. Refer to Section 8.1.6, *Testing the Measurement Operation of the CRVW3* (p. 27), for more information about the operation of the **Troubleshoot** tab screen.

Use the **Data Monitor** tab in *DevConfig* to view frequency and temperature data in both the **Public** table and the **VW_Data** table. The **VW_Data** table is the final storage table used to persist measurements made by the CRVW3. You should confirm that the data in the **VW_Data** table is updating immediately after each measurement is made by the device. Refer to Section 8.1.6, *Testing the Measurement Operation of the CRVW3* (p. 27), for more information about using the **Data Monitor** tab.



8.2.9 Validating CRVW3 Radio Operation

If you have a CRVW3 with a radio option (–RF451 or –RF407), you should validate that the radio on the device is working properly before leaving the site. Use a laptop computer running *DevConfig* and *LoggerNet* with a USB connection to do this. Follow the process described in Section 8.1.7, *Validating Radio Connectivity in the Lab* (p. 29), using the antenna just installed for the CRVW3, and a “whip” antenna on the portable base radio.

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

A CRVW3 with a radio option can be configured to cause the radio to be powered only at certain times during the day. This is done using the **Radio Power Schedule** tab in *DevConfig*. In the **Radio start (power-on) time**, specify the time of day for the radio to be initially powered. Set the **Radio-on duration** to the amount of time for the radio to be powered. Use the **Repeat radio-on cycle** to cause the radio to be powered on (for the **Radio-on duration**) periodically throughout the day. For example:

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

In this example, the radio would be powered on for 15 minutes at midnight, 6:00 AM., noon, and 6:00 PM.

When the radio powers on, the **RX/TX** LED shows solid orange for 1 to 2 seconds. When the radio powers off, a short orange flash is seen on the **RX/TX** LED. When the shut-off time is reached, the radio will stay on long enough to complete any current transactions and then switch off.

A USB cable connected to the CRVW3 device will override the power-off condition (powering up the radio if necessary) and keep the radio on/active 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 with automatic/scheduled collection from within *LoggerNet*.

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

NOTE

For the CRVW3-RF451, the **RF Transmit Power** setting should be chosen to provide for stable communications at the lowest possible level that works properly in order to conserve power. This will allow for the longest possible operation time under adverse weather conditions. An unnecessarily high value for this setting could waste energy and shorten the length of time that communications are possible, when the device experiences adverse weather conditions or when snow is present on the solar panel.

Similarly, the **Radio TX Power Level** setting on the CRVW3-RF407 should be strategically chosen to conserve power, yet still allow robust communications.

8.2.10 Sealing the CRVW3 Enclosure

Once you have completed the installation of the CRVW3 and confirmed proper measurement and communication functionality, you should seal the enclosure. This will ensure optimal protection and maximize operational up-time. Proper enclosure sealing helps to avoid unwanted entry of water or humid air, and provides isolation from other environmental factors.

Ensure that the enclosure is mounted so as to minimize water exposure to the sensor glands, antenna connector, and ground lug (typically these items should face downward).

Ensure that the cable entry points are installed and tightened properly. Ensure that the humidity monitoring card and desiccant are in place (Section 8.2.3, *Humidity Monitoring and Control* (p. 40)). The CRVW3 enclosure includes a small vent to allow for changes in pressure. A gore patch prevents water from entering the enclosure through the vent.

Ensure that nothing impedes the lid from closing properly (USB cable removed, RF diagnostic cable removed), then close the lid of the enclosure and secure the latch. A padlock can be used to protect the closed lid from unauthorized access, if desired.



FIGURE 8-18. CRVW3 Latch Closure and Lock Location

Screws are provided by the enclosure manufacturer to maximize water protection. Install these screws into each of the four corners of the enclosure to ensure the maximum protective seal between the lid and the main section of the enclosure.

During maintenance, you should wipe off any water from the outside of the enclosure before opening the enclosure lid.

8.3 On-site Manual Data Collection

A technician located at a deployment site can use a USB cable to manually collect measured data from a CRVW3 using a Windows computer (laptop PC) and *LoggerNet*, *PC400*, or *PC200W* software.

See Section 11.2.2, *Manual Data Collection at the CRVW3 Site* (p. 92), for details about this data collection process.

9. Radio Networks

Any deployment of radio-based CRVW3 devices involves the installation and operation of a *radio network*. That radio network can be simple or complex, depending on how it is designed and implemented. Implementation decisions are driven by the measurement requirements and geographic constraints of the desired data collection system.

When creating CRVW3 radio networks, a *base radio station* is always required. The base station functions as a gateway device enabling non-radio communications 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.

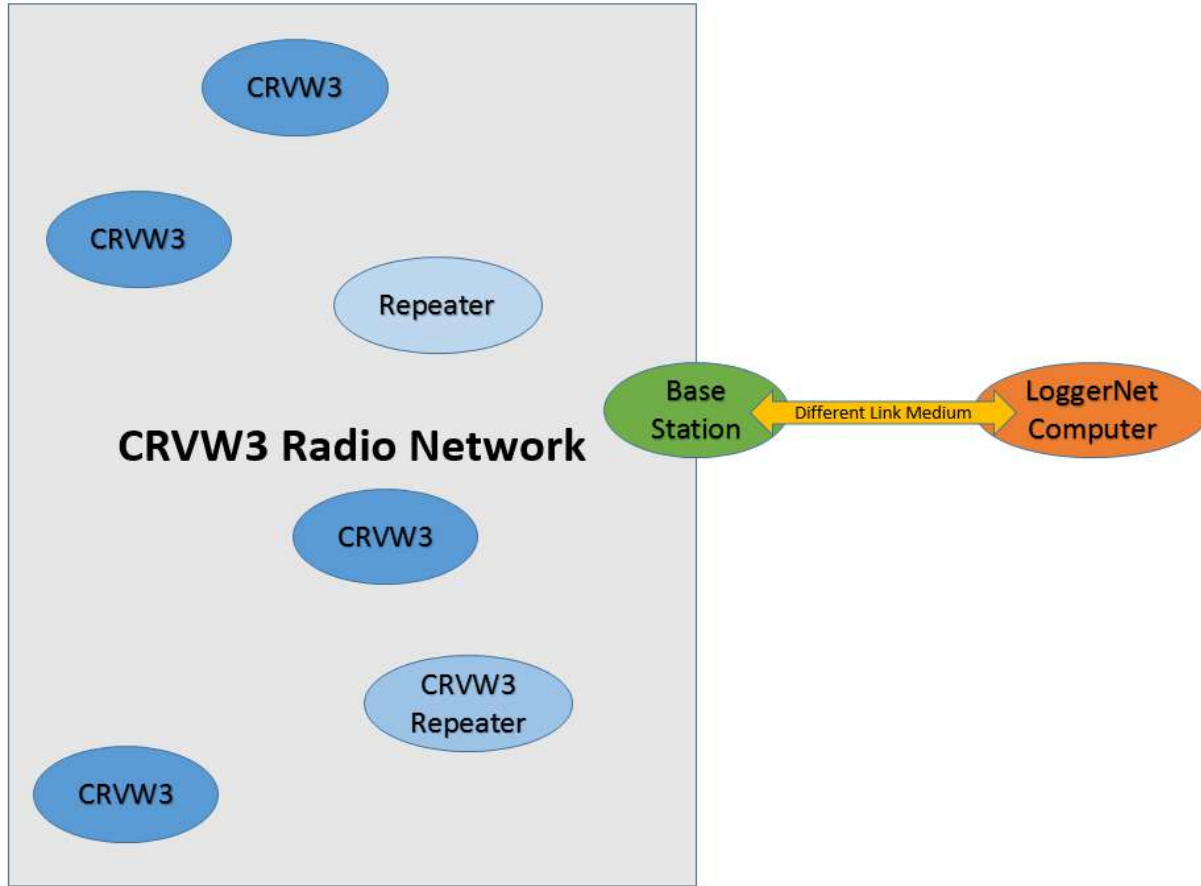


FIGURE 9-1. CRVW3 Radio Network

For many deployments, a simple radio network design will adequately satisfy the system's requirements. Basic instructions are provided in this section to facilitate timely field implementation and operation of simple networks. More detailed guidance is provided in Section 10, *Complex (Large) Radio Networks* (p. 58), for planning and configuring networks with greater complexity.

9.1 Simple Radio Network Definition

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 the base station and each CRVW3 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 Windows computer station that runs the *LoggerNet* software.

- No measurements should be required to be made at the base station's location

The term “single-hop” refers to a CRVW3 station's ability to make a radio connection directly with the base station without the need to route its radio communications through another radio-enabled station (i.e., no repeating is required). When fewer stations are used (10 or less) or shorter distances are used, the complexity of the network can be reduced significantly.

NOTE

If Ethernet TCP/IP connectivity (wired) is available at the base station location, a Campbell Scientific NL201 device is recommended – pn 26245 www.campbellsci.com/nl201 . Note that the TCP/IP requirement can be met in some cases by using a cell phone modem such as the RV50 (pn 31886, www.campbellsci.com/rv50). If WiFi connectivity is available at the base station location, the NL240 device may be used – pn 28714 www.campbellsci.com/nl240 . In this section we provide instructions for using the NL201 device to connect the base radio to a TCP/IP network.

If your system does not meet the above criteria, refer to Section 10, *Complex (Large) Radio Networks* (p. 58).

9.2 Simple Network Installation Overview

The high-level process for setting up a simple network includes:

- Deploying and Configuring individual CRVW3 measurement stations
- Enabling and confirming radio connectivity on each CRVW3 station
- Installing the base station and confirming radio connectivity between it and the CRVW3 stations
- Using *LoggerNet* to connect to the base station and then to the CRVW3 stations
- Setting up automatic collection within *LoggerNet* for each CRVW3 station

In the simplest network, you have one base station and one remote station. No matter how many stations are in the network, there is always only one base station. All remote stations will communicate with the same base station.

If a CRVW3 station cannot make a radio communications link directly with the base station, a radio repeater station must be inserted between those two locations. The design and use of repeater stations is discussed in Section 10, *Complex (Large) Radio Networks* (p. 58). This section assumes that no repeater stations will be required.

9.3 CRVW3-RF451 Simple Network Installation

In a simple network installation for CRVW3-RF451 devices, an RF451 will be used as the main component of the base station. The RF451 is configured as the master radio. Please refer to the RF451 manual for more information about the use of the RF451: s.campbellsci.com/documents/us/manuals/rf451.pdf.

The RF451 will be coupled with an NL201 device to enable the TCP/IP or internet connection. This allows the *LoggerNet* software to remotely drive the RF451 base radio over the TCP/IP connection. In this way, *LoggerNet* can be far away and out of radio range (at any location where reliable connectivity to the internet is available), and still use the base station RF451 to communicate with the CRVW3 devices on the radio network.



FIGURE 9-2. RF451 Network Base Station Configured for Remote LoggerNet Connectivity

9.3.1 Deploying CRVW3 End-node Stations, Confirming Radio Connectivity (CRVW3-RF451)

You should install individual radio-enabled CRVW3 devices at their field locations by following the instructions in Section 8.2, *Field Deployment of the CRVW3* (p. 33). Ensure that the CRVW3-RF451 is configured as a Slave device using *DevConfig*. Do this from the **Settings Editor** tab in *DevConfig*. Choose the **Radio** tab. Now ensure that the **Radio Operation Mode** is set to **Point to Multipoint Slave**. Ensure that the **Radio Enabled** setting is set to **True**. The **Radio ID** setting should be a unique number for every CRVW3-RF451 being deployed. Every CRVW3 should use the same **Frequency Key** and the same **Network ID**. Press **Apply** if necessary.

After the CRVW3 has been installed, powered, and configured, you should confirm that it can communicate over its radio (as described in Section 8.2.9, *Validating CRVW3 Radio Operation* (p. 49), and Section 8.1.7.1, *Validating CRVW3-RF451 Radio Connectivity* (p. 29)). Use a laptop running *DevConfig* and a portable RF451 device configured as the master radio to complete this step.

From the CRVW3 location, confirm the line-of-sight path to the base station site. Install a directional/Yagi antenna unless the distance to the base station is very short. Orient the Yagi antenna so that it points directly at the base station.

9.3.2 Base Station Installation and Validation (CRVW3-RF451)

Select a location for the base radio station that has good radio connectivity with all the CRVW3-RF451 stations, as well as TCP/IP Ethernet access.

If the *LoggerNet* computer station will be co-located at the base station site, it will connect directly to the RF451 with a USB or serial cable.

Refer to the RF451 manual for details regarding the setup and configuration of the RF451 radio portion of the master/base station.

s.campbellsci.com/documents/us/manuals/rf451.pdf

Ensure that proper power, enclosure, grounding, and mounting options are available for permanently siting the base station. An omnidirectional antenna

should be used, since the base station will communicate with more than one CRVW3 station.

A serial cable should be connected from the RS-232 port of the RF451 radio to the RS-232 port of the NL201 device. Refer to the NL201 manual for details on how to configure it as a serial server:

s.campbellsci.com/documents/us/manuals/nl200.pdf. Once the base station is enabled via the NL201, *LoggerNet* will use TCP/IP to communicate with the base station.

Once the base station is installed and configured, you will use a laptop computer running *LoggerNet* at the site to perform a validation. Configure *LoggerNet* to use the base station according to the instructions in Section 9.3.3, *Configuring LoggerNet for Connectivity and Scheduled Collection* (p. 55), and confirm that it can connect to and collect from the remote CRVW3 devices. This should be done *before* leaving the base station site and travelling to the remote *LoggerNet* location.

If your *LoggerNet* computer station is co-located at the base station location, configure the permanent computer station's instance of *LoggerNet* per Section 9.3.3, *Configuring LoggerNet for Connectivity and Scheduled Collection* (p. 55), instead of the laptop's *LoggerNet* instance.

9.3.3 Configuring *LoggerNet* for Connectivity and Scheduled Collection (CRVW3-RF451)

LoggerNet will first be used to confirm connectivity to each CRVW3 remote station through the base station. After connectivity to each station is in place, *LoggerNet* can be configured to perform automatic (scheduled) data collection.

In Section 9.3.2, *Base Station Installation and Validation* (p. 54), the *LoggerNet* computer station was configured with a physical-layer telemetry link to the base station (or it was directly connected with a serial cable). The *LoggerNet* software now needs to be configured with details about the CRVW3 devices on your network and how it should connect to the base station. After that is complete, the connectivity to individual CRVW3 stations can be confirmed.

Follow the configuration instructions given in Section 10.7.2, *Configuring the Network Map of LoggerNet* (p. 80), using the **IPPort** root device case (i.e., the telemetry connection).

If *LoggerNet* connects to the base radio via serial cable, use the **ComPort** root device case. Refer to Section 10.7.1, *Physical Connection to the Base Station* (p. 80), if a USB-to-serial cable is used between the *LoggerNet* computer and the RF451 radio.

Skip the instructions at the end of Section 10.7.2, *Configuring the Network Map of LoggerNet* (p. 80), regarding repeater stations. You can optionally follow the instructions in Section 10.7.3, *Connecting to CRVW3 Stations* (p. 86), to confirm connections to each CRVW3 station, though it probably isn't necessary once you can check the clock on each device. Next, you should follow the instructions in Section 10.7.4, *Setting up Automatic Data Collection* (p. 87), to set up automatic data collection.

For details about the design and implementation of large or complex CRVW3 radio networks, see Section 10, *Complex (Large) Radio Networks* (p. 58). Refer

to Section 11, *Operation of CRVW3 Networks* (p. 88), Section 12, *Maintenance of CRVW3 Networks* (p. 96), and Section 13, *Troubleshooting CRVW3 Networks* (p. 101), for information on how to operate, maintain, and troubleshoot CRVW3 radio networks, such as those created using the process described in this section.

9.4 CRVW3-RF407 Simple Network Installation

In a simple network installation for CRVW3-RF407 devices, an RF407 will be used as the main component of the base station. Please refer to the RF407 manual for more information about the use of the RF407: s.campbellsci.com/documents/us/manuals/rf407-series.pdf.

The RF407 will be coupled with an NL201 device to enable the TCP/IP or internet connection. This allows the *LoggerNet* software to remotely drive the RF407 base radio over the TCP/IP connection. In this way, *LoggerNet* can be far away and out of radio range (at any location where reliable connectivity to the internet is available), and still use the base station RF407 to communicate with the CRVW3 devices on the radio network.



FIGURE 9-3. RF451 Network Base Station Configured for Remote LoggerNet Connectivity

9.4.1 Deploying CRVW3 End-node Stations, Confirming Radio Connectivity (CRVW3-RF407)

You should install individual radio-enabled CRVW3 devices at their field locations by following the instructions in Section 8.2, *Field Deployment of the CRVW3* (p. 33). Ensure that the CRVW3-RF407 is configured correctly using *DevConfig*. Do this from the **Settings Editor** tab in *DevConfig*. Choose the **Radio** tab. Ensure that the **Radio Enabled** setting is set to **True**. Every CRVW3 should use the same **RF Hop Sequence** and the same **Network ID**. Press **Apply** if necessary.

After the CRVW3 has been installed, powered, and configured, you should confirm that it can communicate over its radio (as described in Section 8.2.9, *Validating CRVW3 Radio Operation* (p. 49), and Section 8.1.7.2, *Validating CRVW3-RF407 Radio Connectivity* (p. 31)). Use a laptop running *DevConfig* and a portable RF407 to complete this step.

From the CRVW3 location, confirm the line-of-sight path to the base station site. Install a directional/Yagi unless the distance to the base station is very short. Orient the Yagi antenna so that it points directly at the base station.

9.4.2 Base Station Installation and Validation (CRVW3-RF407)

Select a location for the base radio station that has good radio connectivity with all the CRVW3-RF407 stations, as well as TCP/IP Ethernet access.

If the LoggerNet computer station will be co-located at the base station site, it will connect directly to the RF407 with a USB or serial cable.

Refer to the RF407 manual for details regarding the setup and configuration of the RF407 radio portion of the base station.

s.campbellsci.com/documents/us/manuals/rf407-series.pdf

Ensure that proper power, enclosure, grounding, and mounting options are available for permanently siting the base station. An omnidirectional antenna should be used, since the base station will communicate with more than one CRVW3 station.

A serial cable should be connected from the RS-232 port of the RF407 radio to the RS-232 port of the NL201 device. Refer to the NL201 manual for details on how to configure it as a serial server:

s.campbellsci.com/documents/us/manuals/nl200.pdf. Once the base station is enabled via the NL201, *LoggerNet* will use TCP/IP to communicate with the base station.

Once the base station is installed and configured, you will use a laptop computer running *LoggerNet* at the site to perform a validation. Configure *LoggerNet* to use the base station according to the instructions in Section 9.3.3, *Configuring LoggerNet for Connectivity and Scheduled Collection* (p. 55), and confirm that it can connect to and collect from the remote CRVW3 devices. This should be done *before* leaving the base station site and travelling to the remote *LoggerNet* location.

If your *LoggerNet* computer station is co-located at the base station location, configure the permanent computer station's instance of *LoggerNet* per Section 9.3.3, *Configuring LoggerNet for Connectivity and Scheduled Collection* (p. 55), instead of the laptop's *LoggerNet* instance.

9.4.3 Configuring *LoggerNet* for Connectivity and Scheduled Collection (CRVW3-RF407)

LoggerNet will first be used to confirm connectivity to each CRVW3 remote station through the base station. After connectivity to each station is in place, *LoggerNet* can be configured to perform automatic (scheduled) data collection.

In Section 9.3.2, *Base Station Installation and Validation* (p. 54), the *LoggerNet* computer station was configured with a physical-layer telemetry link to the base station (or it was directly connected with a serial cable). The *LoggerNet* software now needs to be configured with details about the CRVW3 devices on your network and how it should connect to the base station. After that is complete, the connectivity to individual CRVW3 stations can be confirmed.

Follow the configuration instructions given in Section 10.7.2, *Configuring the Network Map of LoggerNet* (p. 80), using the **IPPort** root device case (i.e., the telemetry connection).

If *LoggerNet* connects to the base radio via serial cable, use the **ComPort** root device case. Refer to Section 10.7.1, *Physical Connection to the Base Station* (p. 80), if a USB-to-serial cable is used between the *LoggerNet* computer and the RF407 radio.

Skip the instructions at the end of Section 10.7.2, *Configuring the Network Map of LoggerNet* (p. 80), regarding repeater stations. You can optionally follow the instructions in Section 10.7.3, *Connecting to CRVW3 Stations* (p. 86), to confirm connections to each CRVW3 station, though it probably isn't necessary once you can check the clock on each device. Next, you should follow the instructions in Section 10.7.4, *Setting up Automatic Data Collection* (p. 87), to set up automatic data collection.

For details about the design and implementation of large or complex CRVW3 radio networks, see Section 10, *Complex (Large) Radio Networks* (p. 58). Refer to Section 11, *Operation of CRVW3 Networks* (p. 88), Section 12, *Maintenance of CRVW3 Networks* (p. 96), and Section 13, *Troubleshooting CRVW3 Networks* (p. 101), for information on how to operate, maintain, and troubleshoot CRVW3 radio networks, such as those created using the process described in this section.

10. Complex (Large) Radio Networks

As the number of radio-enabled CRVW3 devices increases, or as more complex terrain or other geographical constraints emerge within your system, additional consideration must be given to radio network design and operation. Refer to Section 9, *Radio Networks* (p. 51), for a basic definition of a radio network. Refer to Section 9.1, *Simple Radio Network Definition* (p. 52), to see if your system requirements can be satisfied using a simple network design.

To implement a large radio network, it is important to understand in detail the types of stations that can form the nodes of the network. Planning the network layout (before hardware is purchased) becomes a necessity. Each station needs to be deployed to its site properly followed by the validation of radio communications. Station operation is confirmed using *LoggerNet*. Proper deployment and configuration of the network ensures that the data collection process operates smoothly.

10.1 Radio Network Station Types

Consider the six most common station types (network nodes) that are the building blocks of a CRVW3 radio network:

1. *LoggerNet* computer station
2. Base radio station
3. CRVW3 end-node station
4. CRVW3 repeater station
5. Dedicated repeater station (repeater-only station)
6. Aggregating datalogger station

As you design the network, you must determine which station types are required to measure all of your deployed sensors, and then you must ensure that each station can adequately communicate with one or more adjacent stations. Definitions and connectivity information are provided here for each station type.

10.1.1 *LoggerNet* Computer Station

The costs associated with implementing and maintaining a radio network are usually justified by the ability to automatically collect data from sensors in a way that minimizes on-site technician visits. This automatic collection is

typically accomplished using *LoggerNet* software. To ensure the smooth operation of your automatic collection process, you should plan to use a computer that operates 24 hours per day and 7 days per week, is readily available for establishing remote connections, and whose main purpose is to constantly run *LoggerNet*. This is recommended even if you have other copies of *LoggerNet* running on desktop computers in your office or on portable computers (laptops). To manage CRVW3 stations with *LoggerNet*, you must have version 4.3 or later.

www.campbellsci.com/LoggerNet

The computer running *LoggerNet* can be a Windows PC/server or it can be a Linux server (Debian, RedHat, SuSE, CentOS, and related distributions). The machine can be located in your office, or it can be maintained elsewhere in your organization by IT personnel. It can run on the internet cloud (hosted or virtual), or it can be located adjacent to your field deployment site. To facilitate the hosted operation of *LoggerNet*, consider the use of *LoggerNet Admin* and *LoggerNet Remote* (see the **LoggerNet Packages** section of this brochure: s.campbellsci.com/documents/us/product-brochures/b_LoggerNet4.pdf).

Because data collected from sensors is a key deliverable, you should plan carefully so that a computer running *LoggerNet* with the above capabilities is available for use. For most automatic data collection scenarios, only one instance of *LoggerNet* is required. If the number of stations in your network exceeds 85, deploying multiple *LoggerNet* instances may improve data collection performance.

10.1.2 Base Radio Station

The purpose of a base radio station (also called a “base station”) is to be a gateway for communications between the radio network (which is your group of multiple CRVW3 stations) and other devices that communicate with them through some other communications medium. The *LoggerNet* computer is typically the most important device that communicates with your radio network via the base station.

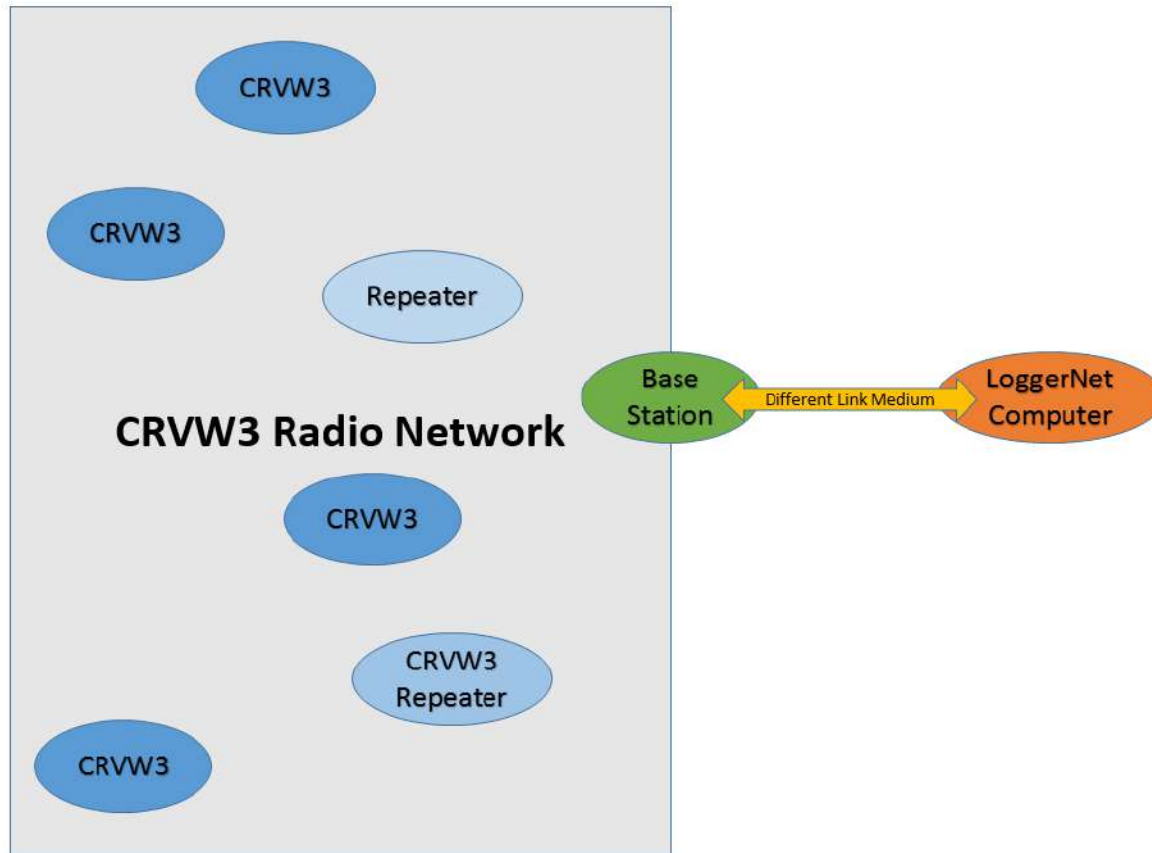


FIGURE 10-1. CRVW3 Radio Network and Base Station Operation

Only one base station is configured and used per radio network. It forms the link between all devices on the network and any involved devices situated outside the network.

The fundamental parts of a base station are a radio that can communicate with the CRVW3 stations (RF450, RF451, or RF407) and the means to communicate outward to other devices. A base station can use a variety of communications media for its outward facing connection — wired connections (serial cable, phone modem, TCP/IP, RS-485), or another radio connection that is different from the kind used by the CRVW3 stations (cell modem, WiFi, VHF narrow-band, satellite, Bluetooth).

Plan carefully how the base station will communicate with the *LoggerNet* computer. Sometimes the *LoggerNet* computer and the base station can be at the same location (forming a single station), and only a serial cable is used to establish the connection between them. In other scenarios, a communication device (such as an NL201 with a TCP/IP link) enables communications to travel from the base radio outward to the *LoggerNet* computer at a remote location.

10.1.3 CRVW3 End-node Station

A CRVW3 end-node station is a radio-enabled CRVW3 (i.e., with the –RF407 or –RF451 option) that communicates with only one other station. The single remote (neighboring) station can be either a repeater station or the base station.

10.1.4 CRVW3 Repeater Station

A CRVW3 repeater station is a radio-enabled CRVW3 that communicates with two or more other stations. The purpose of a repeater station is to relay radio communications between other stations that cannot communicate with each other directly. Stations can sometimes be out of range from each other or are impeded by interfering geographic features.

It takes a little more time for communications to occur between the two stations that use a repeater, although that delay usually doesn't cause any problems. To operate as a repeater station, the **Is Router** setting of the CRVW3 (found on the **PakBus** tab in *DevConfig*) should be set to **True** (see Section 8.1.5, *Configuring the CRVW3* (p. 23), for how to configure the **Is Router** setting). For a CRVW3-RF451 repeater station, the radio of the CRVW3 must also be configured as a repeater. (This is not necessary for a CRVW3-RF407 station.)

A CRVW3 repeater station can measure its own sensors (up to 3), store that data, and communicate it back to the base station. It does this in addition to passing radio messages between any of the remote stations with which it can communicate.

10.1.5 Dedicated Repeater Station

A dedicated repeater station (also called a repeater-only station) is a radio station whose only purpose is to relay radio communications between two or more remote stations. It does not make measurements of its own. Because no sensor measurements are required at the repeater location, this kind of station provides a lower-cost connectivity option. All of its communications are triggered by requests from remote stations to forward data to another station with which that remote station cannot communicate directly. The main component of this station is a radio that can communicate on the radio network with other CRVW3 stations and usually the base station. For a CRVW3-RF407 network, the repeating component is an RF407. For a CRVW3-RF451 network, the repeating component is an RF450 or RF451. See Section 10.2.6, *Planning RF451 Radio Networks* (p. 68), or Section 10.2.7, *Planning RF407 Radio Networks* (p. 69).

10.1.6 Aggregating Datalogger Station

An aggregating datalogger station is a CR6-series, CR3000, CR1000, CR800-series, or CR300-series datalogger (www.campbellsci.com/dataloggers) whose purpose is to communicate with multiple CRVW3 stations and collect data from them. A radio that is compatible with the network must be integrated to this datalogger (using an RF407, RF451, or RF450). Once data is collected from the remote CRVW3 stations, it is stored on the datalogger (aggregated) so it can be retrieved later by *LoggerNet* or other data collection agents. It is possible for an aggregating datalogger station to also function as the base station of the network, but it is not required.

NOTE

An aggregating datalogger must use special instructions in its CRBasic program to communicate with CRVW3 devices. For more information about aggregating dataloggers, see Appendix C, *Aggregating Dataloggers* (p. C-1).

10.2 Planning the Radio Network

When automatic collection is used on a radio network, the data flows from the sensors (which are the initial source of the data) all the way to the *LoggerNet* computer station. You should determine what kind of station you need at every step along that communications pathway. It is recommended that you plan your network (at least with a preliminary analysis) before making your initial hardware purchase.

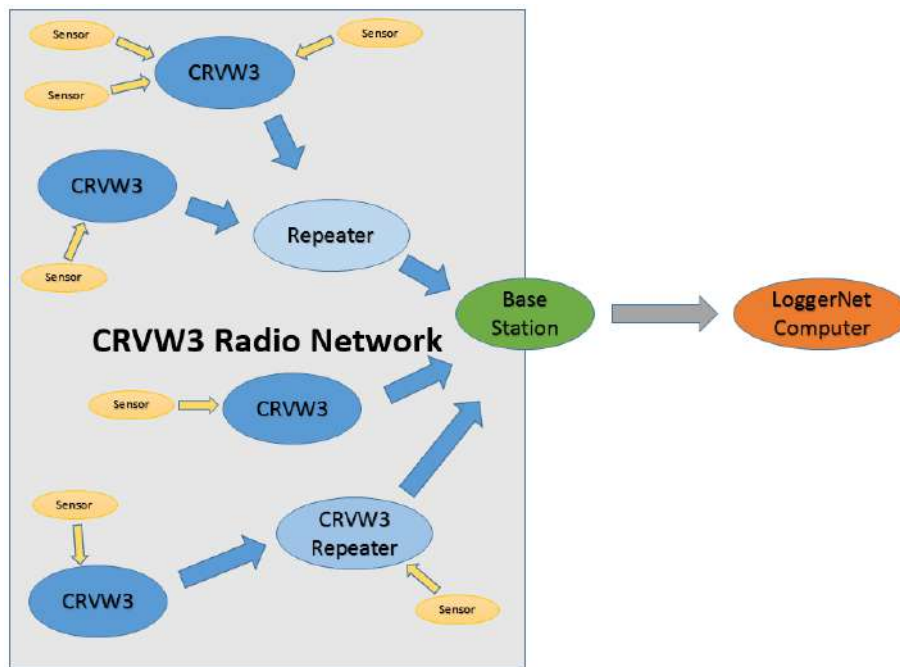


FIGURE 10-2. CRVW3 Collected Data Flow

You can divide your network up conceptually into two sides and a center area. On one side the sensors are measured and on the other side *LoggerNet* collects the data. On the sensor side, you will start by identifying where sensors will be located and where you will place CRVW3 stations to measure those sensors. On the *LoggerNet* side, you should decide where the *LoggerNet* computer station will be located and how it will communicate with the base radio station. The location of the base station should also be determined. To bridge the two sides of the network, you should determine where you need to set up CRVW3 devices as repeater stations, and where you should introduce dedicated repeater stations.

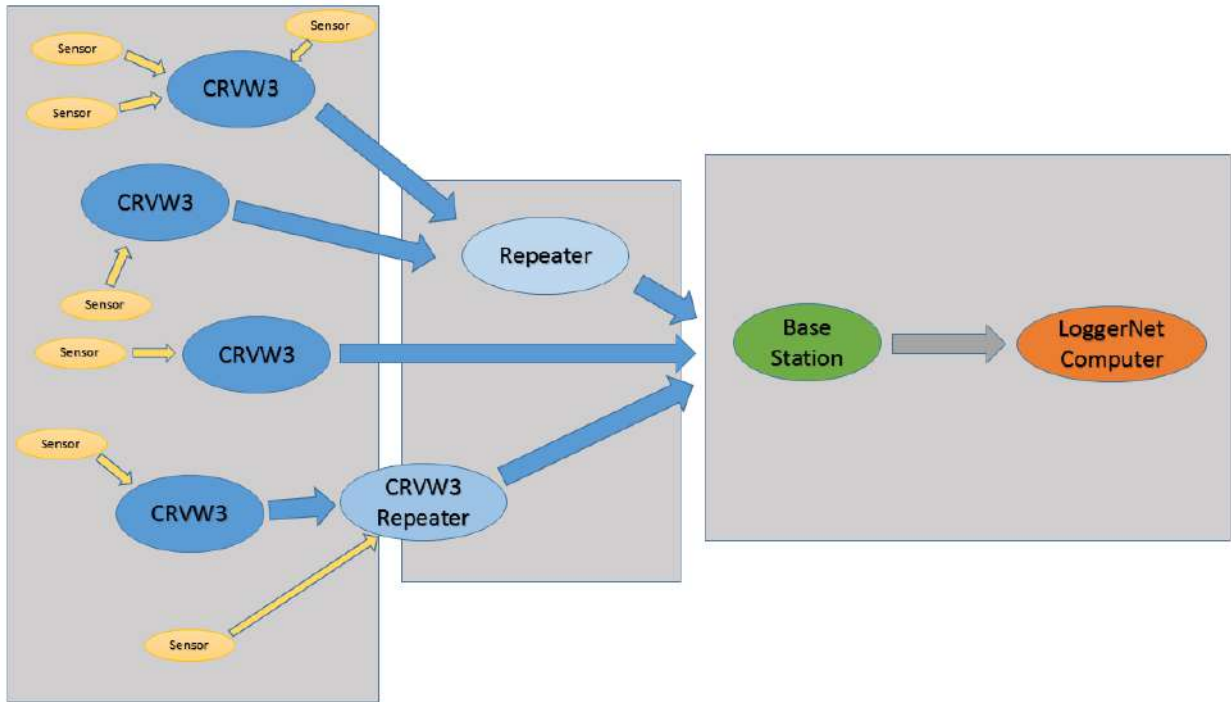


FIGURE 10-3. Sensor Side and LoggerNet Side of a CRVW3 Network

The plan for your network should include an itemized list of:

- Sensors to be measured (Section 10.2.1, *Sensor Planning* (p. 64))
- The CRVW3 devices required to measure all the sensors (Section 10.2.2, *Planning for CRVW3 End-node Stations* (p. 65))
- The CRVW3 devices that will be used as repeater stations (Section 10.2.3, *Repeater Planning* (p. 66))
- The dedicated repeater stations that are needed (Section 10.2.3, *Repeater Planning* (p. 66))
- The location of the *LoggerNet* computer station (Section 10.2.4, *LoggerNet Station Planning* (p. 66))
- The location of the base station (Section 10.2.5, *Planning the Base Station* (p. 67))
- Aggregating dataloggers, if needed (see Appendix C, *Aggregating Dataloggers* (p. C-1))

Since the planning of a radio network involves geographic decision making, it is recommended that maps be created which indicate the geographic location of each of these items.

NOTE Consider using the *Network Planner* tool as part of the development of your network plan. The *Network Planner* is part of the *LoggerNet* software package. With this tool, you can import a graphical map (JPG or PNG format) of the area and use that as a background for the designer canvas. Then you can place CRVW3 devices and other hardware onto the map/canvas at the desired locations. After that you can plan out how connectivity will occur between the CRVW3 devices, repeaters, the base station and the *LoggerNet* computer. Once a plan is created it can be saved to a computer file and retrieved later on when it is time to configure your hardware. The tool can be used as a replacement for *DevConfig* for configuring the device settings of multiple hardware devices in a coordinated way. Please refer to the *LoggerNet* manual Section 4.3 for more information about the *Network Planner*.

s.campbellsci.com/documents/us/manuals/logger-net.pdf

NOTE It is possible to design a network inside of *LoggerNet* that includes many other data acquisition devices (other dataloggers, communications peripherals, non-vibrating-wire sensors, etc.) mingled together with CRVW3 devices and related hardware. Within *LoggerNet*, the CRVW3 has functionality typical of other mainstream dataloggers, and it will act as expected for those familiar with datalogger behavior inside that software. Although mixed networks like this can operate properly, and it is expected that many users will use networks with this kind of heterogeneous design, this manual will focus only on the details of setting up CRVW3-based data collection networks.

10.2.1 Sensor Planning

The ultimate objective of a CRVW3 network is to measure vibrating-wire sensors and relay that data back to *LoggerNet*. You should plan out, preferably using maps or other location-based diagrams, where each vibrating-wire sensor will be located. You should finalize how many sensors will be measured. You should know which sensors are already deployed into the field, and which sensors will need to be procured and installed. You should document the make and model of each sensor, and what output units are desired for its measurement. You should know whether each sensor has a built-in thermistor or not. You should ensure that manufacturer documentation for each sensor type is available. Any cabling that is already connected to the sensor should be documented (type and length). Implementing a naming convention for sensors is often helpful. Installation of sensors should be planned out in accordance with the installation guidelines specified by the sensor manufacturers.

The CRVW3 measures mainstream, single-coil circuit vibrating-wire sensors. These sensors are readily available from multiple well-known vendors within the industry. Campbell Scientific support personnel can give brief guidance, if needed, on what measurements can be made with vibrating-wire sensors and what sources can be used to procure them. A Geotechnical Instrumentation class is available from Campbell Scientific's world headquarters in the United States that discusses vibrating-wire measurement sensors and systems.

www.campbellsci.com/training

10.2.2 Planning for CRVW3 End-node Stations

Using the locations mapped in Section 10.2.1, *Sensor Planning* (p. 64), plan out how each sensor will connect with a CRVW3 device. To minimize the required number of stations, plan for three sensors to connect to each CRVW3 whenever possible. Indicate on a map where the CRVW3 stations will be located.

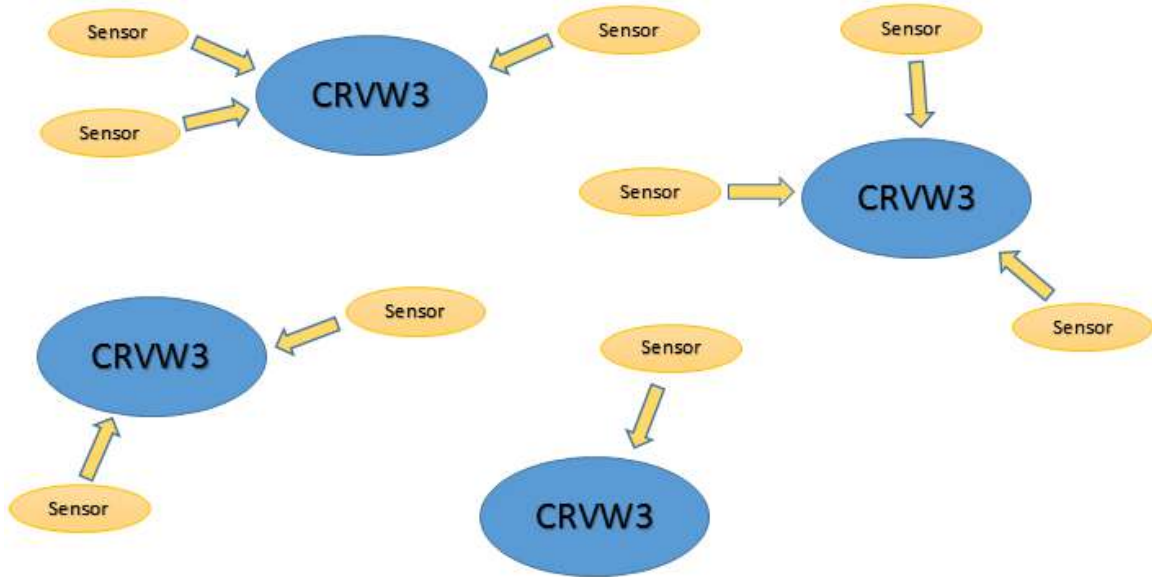


FIGURE 10-4. Each Sensor Connects to a CRVW3

The length of cable between the sensor and the CRVW3 is a factor to consider. The distance between the CRVW3 and the measured sensor can be up to 1600 m in many instances. Long cable distances (> 500 m) should be validated for proper operation using careful field experimentation. Cabling distances shorter than 500 m can usually work well with lower excitation levels (5 V instead of 12 V) which saves on power consumed during the measurement cycle. Document the length of cabling that will enable each sensor to connect with a CRVW3.

Plan for each CRVW3 to have a line-of-sight radio connection with a repeater station (which can be another CRVW3) or with the base station. A CRVW3 end-node station will communicate with only one remote radio station. The location of a CRVW3 may need to be adjusted to allow for a satisfactory radio communications link. Some field-based groundwork may be necessary to determine radio strength capabilities between potential station sites (see Section 10.2.8.1, *Pre-procurement Field Visits* (p. 71)).

If the remote station is within a close enough distance to the CRVW3, a whip antenna can be used. However, for longer distances a high-gain antenna will be needed. A Yagi antenna is recommended for a CRVW3 end-node station because of its high gain and directional beaming capability.

For specific information relating to CRVW3 end-node stations, see Section 10.2.6, *Planning RF451 Radio Networks* (p. 68), or Section 10.2.7, *Planning RF407 Radio Networks* (p. 69).

10.2.3 Repeater Planning

A repeater station can be implemented using a CRVW3 station or it can be a dedicated repeater station (repeater-only station). If it makes sense to measure one or more vibrating-wire sensors near the proposed repeater site, deploy a CRVW3 repeater, otherwise plan for a dedicated repeater station.

Design your network with repeater stations in strategic locations to overcome line-of-sight problems or signal strength difficulties in the network. A CRVW3 end-node station may be too far away from the base station to communicate properly, or blocked from the base station by interfering geographic features. In those cases, the CRVW3 end-node should route its radio communications through a repeater station to reach the base station. In a few cases, multiple repeaters may be needed to establish a route from a CRVW3 end-node to the base station.

You should make a field visit to validate your planned repeater site locations (see Section 10.2.8.1, *Pre-procurement Field Visits* (p. 71)).

Each conveyance of data from one station to another is called a “radio hop” or simply a “hop”. A CRVW3 end-node that communicates directly with the base station is said to have a “single-hop” link. When a CRVW3 end-node communicates with the base station via one repeater station it is said to have a “dual-hop” or “2-hop” link. When an end-node routes through two or more repeaters, it is referred to as a “multi-hop” link.

A repeater station is always required to communicate with multiple remote stations, therefore an omnidirectional antenna should be used on the station (often called an “omni” antenna).

You should designate on the map of your network plan which CRVW3 devices will act as repeater stations. You should also identify the locations of any dedicated repeater stations.

For specific information relating to CRVW3-RF451 repeaters and RF451-based dedicated repeaters, see Section 10.2.6, *Planning RF451 Radio Networks* (p. 68). For specific information relating to CRVW3-RF407 repeaters and RF407-based dedicated repeaters, see Section 10.2.7, *Planning RF407 Radio Networks* (p. 69).

10.2.4 LoggerNet Station Planning

When planning your network, you need to finalize the location of the computer that will permanently run the *LoggerNet* software and which will operate as the first-stage permanent data repository (see Section 10.1.1, *LoggerNet Computer Station* (p. 58)). One of the key factors to consider when making this decision is how the base station will communicate with the *LoggerNet* computer.

If you choose to deploy the *LoggerNet* computer in the field, within radio range of some or all of the CRVW3 stations, the *LoggerNet* computer will be co-located with the radio base station. In that case, only a serial cable is needed to connect between the computer and the base station’s radio device. *LoggerNet* controls the base radio via the serial cable to make connections with all CRVW3 devices. Consider that a protective location must be procured for the *LoggerNet* computer, power provided, and that some sort of network connectivity between *LoggerNet* and your office location must be established.

Sometimes an office building is within radio distance of some of the CRVW3 devices and some of the repeaters. In that case, *LoggerNet* can run in the office, and steps are taken to mount an antenna for use by the base radio somewhere on the exterior of the office building. The antenna cable is fed through to the base radio, which is located inside the building near the *LoggerNet* computer and connected via a serial cable.

Another option is to use a TCP/IP, Wi-Fi, Cell Modem, RS-485 or other kind of communications link (different from the radio links) in the field location that will connect between the base station radio and *LoggerNet* at a remote location. In these scenarios, *LoggerNet* is located at the office or at a hosted site and uses TCP/IP (or another data protocol) to make a remote connection to the base radio station. The base station is located somewhere within range of the CRVW3 devices and the repeaters. The base station in this instance contains its main radio but also hosts another device. This can be an NL201 (or similar serial-to-Ethernet bridge), an NL240 (or other serial-to-Wi-Fi bridge), an RV50 (or similar cell modem to TCP/IP gateway), or an MD485 for enabling RS-485 wired communications. The base radio and the bridging device are linked together. When installed in this way, *LoggerNet* can control the base radio via TCP/IP (or other data protocol) even though the two stations are located at a significant distance from each other.

If multiple people need to interact with the same *LoggerNet* computer in your office, you should strongly consider the use of *LoggerNet Admin* (installed on the *LoggerNet* computer or server), and *LoggerNet Remote* (which is installed on an individual's workstation PC in the office and connects as a client to *LoggerNet Admin*). See Section 10.1.1, *LoggerNet Computer Station* (p. 58), or www.campbellsci.com/LoggerNet for more information.

Once the location of the *LoggerNet* computer station is known, indicate it on the map of your network plan, and begin making arrangements for the other items necessary for it to connect with the base station.

10.2.5 Planning the Base Station

The location of the base radio station should be selected carefully. The base station must have good radio connectivity with all repeater stations and with as many CRVW3 end-node stations as possible. In addition, it must be able to communicate with the *LoggerNet* computer station. The main purpose of the base station is to be a bridge or gateway between your CRVW3 radio network and the rest of the world (any other remote devices that need to communicate with your CRVW3 devices). Please refer to the diagram in Section 10.1.2, *Base Radio Station* (p. 59).

Usually a base station requires an omnidirectional antenna since it communicates with multiple remote stations. In the less-common case where the base station communicates with only one remote repeater (through which all other stations route), a directional antenna (Yagi) can be used.

LoggerNet is usually the main device outside the radio network that communicates with the base station. Choose a location that allows the base station to establish a link to the *LoggerNet* computer station. Sometimes the *LoggerNet* computer and the base station are at the same location. In other deployments, they are remotely located and communicate via a TCP/IP telemetry device, or similar. For more information about making connections

between *LoggerNet* and the base station, see Section 10.2.4, *LoggerNet Station Planning* (p. 66).

NOTE

When planning for an aggregating datalogger (Section 10.1.6, *Aggregating Datalogger Station* (p. 61)) to be part of your network, including an aggregator that can operate as the base station, see Appendix C, *Aggregating Dataloggers* (p. C-1).

Once the location of the base radio station is determined, indicate it on the map in your network plan.

10.2.6 Planning RF451 Radio Networks

The CRVW3 can be purchased with the –RF451 communications option (i.e., as a CRVW3-RF451). This manual refers to the radio networks used by CRVW3-RF451 devices as *RF451 radio networks*. The following devices can be used to create a functioning station within an RF451 radio network:

- CRVW3-RF451
- RF450 radio+modem (pn 18326, www.campbellsci.com/rf450)
- RF451 radio+modem (pn 31412, www.campbellsci.com/rf451)
- CR6-RF451 (CR6 datalogger with built-in RF451 radio, pn 31697 www.campbellsci.com/cr6)

NOTE

Certain compatible radio devices available from Freewave (www.freewave.com) can also be configured to operate in an RF451 radio network. Call your Campbell Scientific support representative for more details.

Every RF451 network requires one radio to be defined as the *master radio*. This master radio is the main component of the base station, i.e., the base station is defined as the station that controls the master radio. Communications entering or exiting the RF451 network are routed through the master radio station. Usually the RF451 will be used as the master radio in the base station of an RF451 radio network. The RF451 can also be used to create dedicated repeater stations in an RF451 network. CRVW3-RF451 end-node stations are defined and configured as Slave stations. CRVW3-RF451 repeater stations are defined and configured as Slave/Repeater stations.

You should rent the Radio Test Kit (pn 21107) to perform in-field site exploration and radio link strength testing when designing an RF451 radio network.

Please refer to the RF451 manual for more information about the use of the RF451:

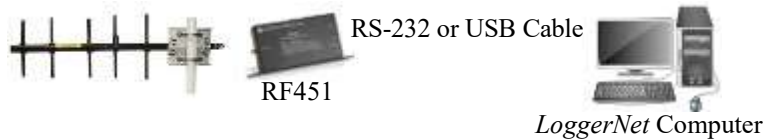
s.campbellsci.com/documents/us/manuals/rf451.pdf

10.2.6.1 Base Station Design for RF451 Radio Networks

For most base station designs on an RF451 radio network, the RF451 radio+modem device should be used. It is configured as the master radio when implemented as the main component of base station.

When *LoggerNet* is co-located with the base station, a USB or serial cable makes the connection between the RF451 radio and the *LoggerNet* computer. The physical configuration of the base station has this form:

Antenna <--> RF451 <--> RS-232 or USB cable <--> *LoggerNet* computer



When a telemetry device is used to make a remote connection between the RF451 base station and the *LoggerNet* computer, the serial communications between them are transmitted over a different medium. The following physical configurations illustrate the use of TCP/IP connections made through wired Ethernet, Wi-Fi, or Cell-modem media:

Antenna <--> RF451 <--> NL201 <--> InternetCloud <--> *LoggerNet* computer



Antenna <--> RF451 <--> NL240 <--> WiFi Router <--> InternetCloud <--> *LoggerNet* computer

Antenna <--> RF451 <--> RV50 <--> Cell Tower <--> InternetCloud <--> *LoggerNet* computer

Other cell modems could be substituted for the RV50, other Wi-Fi-to-serial devices for the NL240, and other serial-to-TCP/IP devices for the NL201. Phone modems could also be used or other telemetry options.

Antenna <--> RF451 <--> Any RS-232-based telemetry option <--> *LoggerNet* computer

s.campbellsci.com/documents/us/category-brochures/b_telecommunications.pdf

It is possible to designate the CRVW3 as the master radio of an RF451 radio network, and use it as the base station. This should only be done if a permanent USB cable connection can be maintained between the base CRVW3 and the *LoggerNet* computer. It is expected that this configuration will be used only rarely. The physical configuration of the base station will have this form:

Antenna <--> CRVW3-RF451 set as Master <--> USB cable connection <--> *LoggerNet* computer

10.2.7 Planning RF407 Radio Networks

The CRVW3 can be purchased with the –RF407 communications option (i.e., as a CRVW3-RF407). This manual refers to the radio networks used by CRVW3-RF407 devices as *RF407 radio networks*. The following devices can be used to create a functioning station within an RF407 radio network:

- CRVW3-RF407
- RF407 (pn 31412, www.campbellsci.com/rf451)
- CR6-RF407 (CR6 datalogger with built-in RF407 radio, pn 31697, www.campbellsci.com/cr6)
- CR300-RF407 (CR300 datalogger with built-in RF407 radio, pn 32407, www.campbellsci.com/cr300)
- CR310-RF407 (CR310 datalogger with built-in RF407 radio, pn 32411, www.campbellsci.com/cr310)

Usually an RF407 will be used at the base station of an RF407 radio network. RF407s can also be used to create dedicated repeater stations in an RF407 network.

You should rent the Radio Test Kit (pn 21107) to perform in-field site exploration and radio link strength testing when designing an RF407 radio network.

Please refer to the RF407 manual for more information about the use of the RF407:

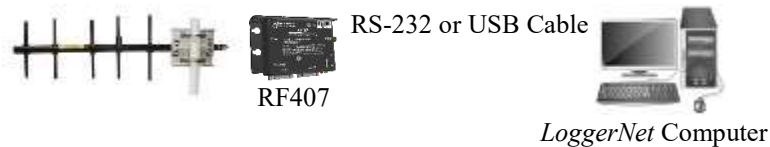
s.campbellsci.com/documents/us/manuals/rf407-series.pdf

10.2.7.1 Base Station Design for RF407 Radio Networks

For most base station designs on an RF407 radio network, an RF407 should be used.

When *LoggerNet* is co-located with the base station, a USB or serial cable makes the connection between the RF407 and the *LoggerNet* computer. The physical configuration of the base station has this form:

Antenna <--> RF407 <--> RS-232 or USB cable <--> *LoggerNet* computer



When a telemetry device is used to make a remote connection between the RF407 base station and the *LoggerNet* computer, the serial communications between them are transmitted over a different medium. The following physical configurations illustrate the use of TCP/IP connections made through wired Ethernet, Wi-Fi, or Cell-modem media:

Antenna <--> RF407 <--> NL201 <--> Internet Cloud <--> *LoggerNet* computer



Antenna <--> RF407 <--> NL240 <--> Wi-Fi Router <--> Internet Cloud <--> *LoggerNet* computer

Antenna <--> RF407 <--> RV50 <--> Cell Tower <--> Internet Cloud <--> *LoggerNet* computer

Other cell modems could be substituted for the RV50, other Wi-Fi-to-serial devices for the NL240, and other serial-to-TCP/IP devices for the NL201. Phone modems could also be used or other telemetry options.

Antenna <--> RF407 <--> Any RS-232-based telemetry option <--> *LoggerNet* computer

s.campbellsci.com/documents/us/category-brochures/b_telecommunications.pdf

It is possible to use CRVW3-RF407 at the base station of an RF407 radio network. This should only be done if a permanent USB cable connection can be maintained between the base CRVW3 and the *LoggerNet* computer. It is expected that this configuration will be used only rarely. The physical configuration of the base station will have this form:

Antenna <--> CRVW3-RF407 <--> USB cable connection <--> *LoggerNet* computer

10.2.8 Plan Validation and Hardware Procurement

Once you have documented your implementation plan for sensors, and planned out your CRVW3 station sites, repeaters, base station, and *LoggerNet* computer station, you should make a field visit to validate radio link feasibility. You should also get feedback about your plan from others. Slight modifications to your plan may be necessary. After these activities are complete you should be ready to place an order to procure your hardware.

10.2.8.1 Pre-procurement Field Visits

It is best to confirm your radio network plan with a visit to the field. One of your main tasks is to confirm line-of-sight visibility between proposed radio station locations. Consider using a Radio Test Kit (for example, pn 21107). This will allow you to work out radio connectivity issues and the types of antennae needed before procuring hardware. Using the kit, you set up a temporary radio station at two different sites and measure the connectivity strength between them. End-node stations use Yagi antennae and repeater stations (and usually the base station) use Omni antennae. These are also used as part of the test.

There are several key factors that can influence the quality of a radio communications link. Some are mentioned here:

Radio Power: Different radio types have different broadcast power options. The RF451 radio and the CRVW3-RF451 can broadcast at power ratings configurable up to 1 watt. Practical links can be established at distances of 21 km (13 miles). The RF407 and CRVW3-RF407 operate at a maximum power of 250 milliwatts, and have a practical range of several miles. In conditions that are closer to the ideal, longer distance links can be achieved. However, in certain conditions, much shorter maximum distances occur.

Seasonal Vegetation Changes: Sometimes seasonal changes to the environment can impact the quality of a radio communications link. For example, if a radio link is tested in the winter when trees have no leaves, it may

not operate as well in the summer when leaves are on the trees. When choosing a site for a station, consider any factors in the environment that may change seasonally.

Reflective Interference and Fresnel Zones: Because transmissions from an antenna radiate outward in multiple directions, radio wave pathways sometimes get reflected in a way that causes destructive interference at the receiving location. Water surfaces, some kinds of flat landscape/ground, or other flat features can reflect radio waves and cause this type of signal degradation. A Fresnel zone helps to identify the height at which an antenna should be placed to maximize signal strength between two stations. In the field, you can experiment by raising (or sometimes lowering) the antenna to maximize the radio link strength. For more information, see en.wikipedia.org/wiki/Fresnel_zone.

10.2.8.2 Plan Validation with Others

It can be helpful to share your radio network plan with others. This process may uncover items that require additional planning. There may be others in your organization that have experience deploying and operating radio networks. Contact your local Campbell Scientific support representative to discuss your plan and any questions or concerns you may have with it. When using the *Network Planner* software, a saved *.NWP file can be provided to Campbell Scientific or others for review.

Ensure that you have the right antenna types selected for each station. Mounting hardware may be needed for repeater stations and the base station. Review the items discussed in Section 8.2, *Field Deployment of the CRVW3* (p. 33).

10.2.8.3 Hardware Procurement

Using your network plan as a resource, contact your local Campbell Scientific representative to place an order for the required hardware. The ordering process brings a number of items into the discussion that are usually needed for typical deployments.

10.3 Deployment Strategy

Once the hardware for your CRVW3 radio network arrives, it needs to be configured, validated, and deployed to the field.

10.3.1 Radio Network Lab Validation

You should connect to each CRVW3 individually in the office or lab and configure it (See Section 8.1, *Lab Connection and Configuration* (p. 15)). However, you should also set up at least part of your radio network and validate it in the lab, if possible. Install and configure *LoggerNet* on a temporary or portable computer. Set up a base station, and confirm that it can communicate with a few CRVW3 stations. Set up a repeater station and ensure it works. Refer to Sections 10.4 through 10.7 for details about how this is done.

NOTE

Consider the use of the *Network Planner* when configuring your devices in the lab. After the devices are placed onto the canvas of the *Network Planner* and settings are specified, the software provides a way to connect to each device individually (in turn) and configure it. It operates in a similar manner to *DevConfig*, except that the settings are pushed into the device in a more automated manner. A checklist guides you through the process of isolating each device one at a time and connecting it to your computer to be configured. See Section 10.2, Planning the Radio Network (p. 62), for more information about the *Network Planner*.

10.3.2 Field Deployment Considerations

For larger networks, you should develop a strategy specifying the order of operations for deploying your stations. Each CRVW3 radio network consists of: one *LoggerNet* station, one base station, one or more CRVW3 end-nodes, and one or more repeater stations. Some CRVW3 end-nodes require repeaters to communicate, while others communicate directly with the base station (single-hop).

In most cases it is helpful to install repeater stations and the CRVW3 devices that require them at the end of your deployment cycle. By ensuring during the first part of your deployment that single-hop CRVW3 devices are operating properly with the base station and with *LoggerNet*, the level of complexity is reduced for the repeater station validation process.

One common approach would be to first install the CRVW3 end-nodes that connect directly with the base station, followed by the installation of the base station itself and then the installation of the permanent *LoggerNet* station. With those items in place and functioning, attention can be given to installation of the CRVW3 devices that require repeaters and the actual repeater sites.

Another approach would be to install the base station first, followed by the CRVW3 end-nodes that connect directly to the base station. After that the *LoggerNet* station can be configured and validated. Installation of CRVW3 stations requiring repeaters and the actual repeater sites would be last.

Single-hop CRVW3 End-node-first approach

1. CRVW3 end-nodes that connect directly to base station (single hop)
2. Base Station
3. *LoggerNet*
4. CRVW3 end-nodes that connect via repeaters
5. Repeaters

Base Station-first approach

1. Base Station
2. CRVW3 end-nodes that connect directly to base station (single hop)
3. *LoggerNet*
4. CRVW3 end-nodes that connect via repeaters
5. Repeaters

After the physical installation of the hardware at a site location, the configuration of each station requires validation. You want to make sure that

radio communications and related functions are working properly before leaving the site.

To confirm that a station is working properly, you need to control elements of the CRVW3 configuration, elements of the base station configuration, and elements of the *LoggerNet* configuration all at the same time. Sometimes this is coordinated through the use of multiple technicians at different stations that communicate using voice cell phones or voice radios. However, another option is to employ temporary versions of system components that are brought with you to the station installation site.

For instance, when installing a CRVW3 station, bring a laptop running *LoggerNet* with a serial cable that connects to a base radio. This will be the temporary “*LoggerNet* and base radio” station, and it will help to confirm proper CRVW3 operation. When installing a base radio site, bring a laptop running *LoggerNet* that can make a wired serial connection to the base radio being deployed, and also bring a temporary CRVW3 device which will communicate with the base radio and validate it. The amount of time saved by having these temporary devices available can be substantial.

10.4 Deployment of CRVW3 Radio Stations

You should install individual radio-enabled CRVW3 devices at their field locations by following the instructions in Section 8.2, *Field Deployment of the CRVW3* (p. 33). After a device has been installed and powered, you should confirm that it can communicate over its radio (Section 8.2.9, *Validating CRVW3 Radio Operation* (p. 49), and Section 8.1.7, *Validating Radio Connectivity in the Lab* (p. 29)).

Using a temporary base station radio and laptop running *LoggerNet*, you should confirm that *LoggerNet* can connect to the station and collect data from it. See Section 10.7, *LoggerNet Configuration* (p. 80), for details about how to configure and use *LoggerNet* to do this. Be sure to place the base radio more than 25 feet away from the CRVW3 antenna to avoid interference.

Confirm the line-of-sight path to the permanent base station site (or repeater station site). A CRVW3 end-node station will communicate with only one remote radio station. If that station is distant, use a Directional/Yagi antenna. Orient the antenna so that it points directly at the remote station. You may need to experiment with antenna height to get the best link strength possible (see Section 10.2.8.1, *Pre-procurement Field Visits* (p. 71)).

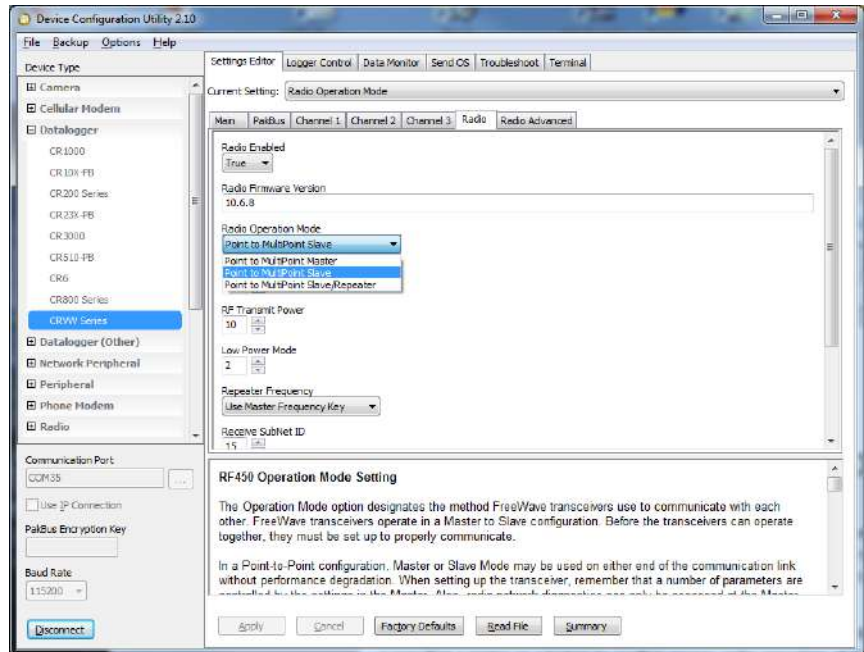
If the CRVW3 station will operate as a repeater station, see instructions in Section 10.6, *Repeater Station Deployment* (p. 79).

When several or all of the CRVW3 end-node stations have been installed and confirmed as working, connectivity with the permanent base station should be validated at the base station location. (See Section 10.5, *Base Station Deployment* (p. 76).)

10.4.1 CRVW3-RF451 Deployment

When the CRVW3-RF451 is deployed as an end-node in the network, ensure that it is configured as a Slave device using *DevConfig*. (See Section 10.2.6, *Planning RF451 Radio Networks* (p. 68).) From the **Settings Editor** tab in *DevConfig*, choose the **Radio** tab. Now ensure that the **Radio Operation**

Mode is set to **Point to Multipoint Slave**. Press **Apply** if necessary. See Section 10.6, *Repeater Station Deployment* (p. 79), if the station is a repeater.

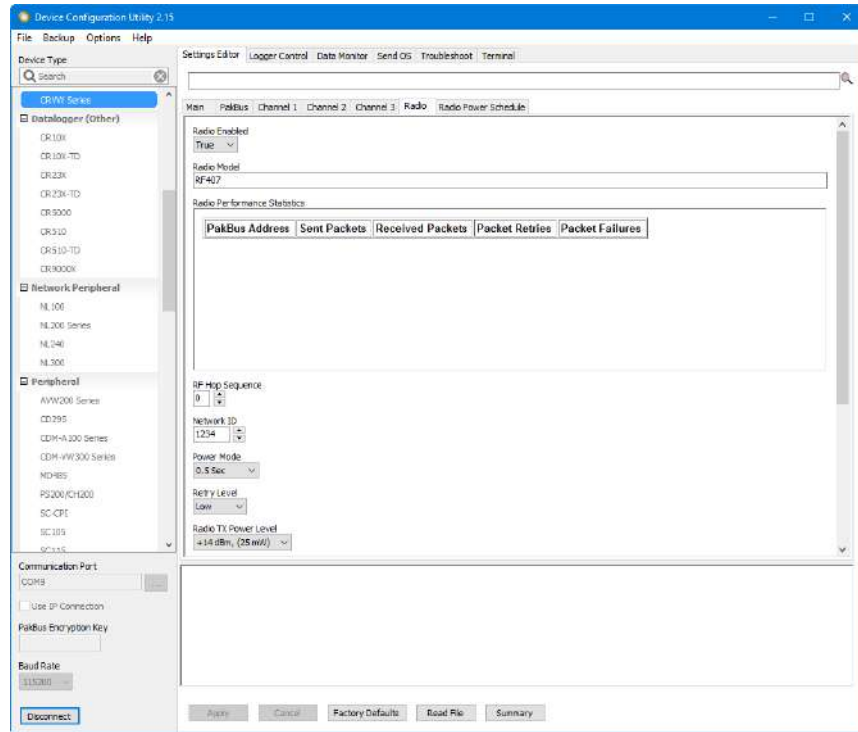


Ensure that the **Radio Enabled** setting is set to **True**. The **Radio ID** setting should be a unique number for every device on the RF451 network (end-node, repeater, and base station). Often it is convenient to set it to the same number as the PakBus Address, though that is not required. Every device on the network should use the same **Frequency Key** and the same **Network ID**. To understand how to use the other settings on the **Radio** and **Radio Advanced** tabs, refer to the topical help in *DevConfig*, or to the RF451 manual (s.campbellsci.com/documents/us/manuals/rf451.pdf).

While on-site, use a portable (temporary) RF451 device configured as the master radio and connected to *LoggerNet* running on a laptop to confirm proper radio operation of the station. (See Section 10.4, *Deployment of CRVW3 Radio Stations* (p. 74), and Section 10.7, *LoggerNet Configuration* (p. 80).) Connect to the station and collect data.

10.4.2 CRVW3-RF407 Deployment

When the CRVW3-RF407 is deployed as an end-node in the network, ensure that it is configured correctly using *DevConfig*. (See Section 10.2.7, *Planning RF407 Radio Networks* (p. 69).) From the **Settings Editor** tab in *DevConfig*, choose the **Radio** tab.



Ensure that the **Radio Enabled** setting is set to **True**. Every device on the network should use the same **RF Hop Sequence** and the same **Network ID**. To understand how to use the other settings on the **Radio** tab, refer to the topical help in *DevConfig*, or to the RF407 manual (s.campbellsci.com/documents/us/manuals/rf407-series.pdf).

Press **Apply** if necessary, if settings were changed.

See Section 10.6, *Repeater Station Deployment* (p. 79), if the station is a repeater.

While on-site, use a portable (temporary) RF407 device connected to *LoggerNet* running on a laptop to confirm proper radio operation of the station. (See Section 10.4, *Deployment of CRVW3 Radio Stations* (p. 74), and Section 10.7, *LoggerNet Configuration* (p. 80).) Connect to the station and collect data.

10.5 Base Station Deployment

The base radio station used in a CRVW3 network has two communications pathways. One is the radio pathway that is used to communicate with CRVW3 end-node stations and repeater stations. The other is the pathway to *LoggerNet* and other remote devices that may require connectivity with the radio network. Local *LoggerNet* computer stations connect to the base station using a serial cable. Details for making a telemetry communications link between the base station and *LoggerNet* are specific to the kind of radio device used on the base station. See Section 10.5.1, *Base Station on the RF451 Network* (p. 77), or Section 10.5.2, *Base Station on the RF407 Network* (p. 78), for more information.

A typical base station consists of a radio device that is compatible with the CRVW3 devices on the network (RF407, RF450, or RF451). For stations that

make a remote connection to *LoggerNet*, a telemetry device for that purpose is also part of the station. You should ensure that proper power, enclosure, grounding, and mounting options are available for the station. An Omnidirectional antenna should be used, since the base station usually communicates with more than one remote radio station. Consult the manual for the applicable radio device to obtain detailed instructions for setting up the radio portion of the base station.

A CRVW3 device itself is not usually used as the base station in a CRVW3 network. This should only be done if a permanent USB cable connection can be maintained between the base CRVW3 and the *LoggerNet* computer. It is expected that this configuration will be used only rarely.

Once the base station is set up and configured, you can use a temporary CRVW3 station located with you at the site to confirm operation of the base. You will also need to configure the *LoggerNet* station if it is co-located with the base station, or use a portable/laptop computer running *LoggerNet* to perform the validation. Configure *LoggerNet* to use the base station (see Section 10.7, *LoggerNet Configuration* (p. 80)), and confirm that you can connect to the temporary CRVW3 station and collect data from it. If CRVW3 end-node stations have already been deployed, *LoggerNet* can be configured to connect to and collect from those devices as well. Be sure to place the temporary CRVW3 more than 25 feet away from the base station antenna to avoid interference.

10.5.1 Base Station on the RF451 Network

The RF451 radio should typically be used as the main component of the base station in an RF451 network. The RF451 will be configured as the master radio. Refer to the RF451 manual for details regarding the setup and configuration of the RF451 radio portion of the master/base station.
s.campbellsci.com/documents/us/manuals/rf451.pdf.

The base radio should connect to *LoggerNet* either through a USB cable or via a telemetry device such as the NL201, NL240, or RV50. When using telemetry options, a serial cable is typically connected from the RS-232 port of the RF451 radio to the RS-232 port of the telemetry device. The telemetry device should usually be configured as a serial server. When using Campbell Scientific telemetry devices, the device can be configured as a PakBus router instead. Consult both the RF451 manual and the manual for your specific telemetry device for details about how to connect and configure these devices to work together. Once the base station is enabled via telemetry, *LoggerNet* will usually use TCP/IP to communicate with the base station.

s.campbellsci.com/documents/us/manuals/nl200.pdf



s.campbellsci.com/documents/us/manuals/nl240.pdf

s.campbellsci.com/documents/us/manuals/rv50.pdf

When connecting the RF451 base radio directly to the *LoggerNet* computer, connect the USB cable to the **USB** port of the RF451, and configure it with *DevConfig* as instructed in the RF451 manual. See Section 10.7.1, *Physical Connection to the Base Station* (p. 80), for more information.

As indicated in Section 10.2.6.1, *Base Station Design for RF451 Radio Networks* (p. 68), the CRVW3 itself is rarely used as the base radio station in an RF451 Network. However, to use that configuration, ensure that the **Radio Operation Mode** setting in the **Radio** tab of *DevConfig* is set to **Point to MultiPoint Master**. Also set the **Is Router** setting located on the **PakBus** tab of the **Settings Editor** tab in *DevConfig* to **True**.

Use a temporary CRVW3 station and *LoggerNet* to validate the operation of your deployed RF451 base station before leaving the site (see Section 10.5, *Base Station Deployment* (p. 76), above).

10.5.2 Base Station on the RF407 Network

The RF407 radio should typically be used as the main component of the base station in an RF407 network. Refer to the RF407 manual for details regarding the setup and configuration of the RF407 radio portion of the base station. s.campbellsci.com/documents/us/manuals/rf407-series.pdf.

The base radio should connect to *LoggerNet* either through a USB cable or via a telemetry device such as the NL201, NL240, or RV50. When using telemetry options, a serial cable is typically connected from the RS-232 port of the RF407 radio to the RS-232 port of the telemetry device. The telemetry device should usually be configured as a serial server. When using Campbell Scientific telemetry devices, the device can be configured as a PakBus router instead. Consult both the RF407 manual and the manual for your specific telemetry device for details about how to connect and configure these devices to work together. Once the base station is enabled via telemetry, *LoggerNet* will usually use TCP/IP to communicate with the base station.

s.campbellsci.com/documents/us/manuals/nl200.pdf



s.campbellsci.com/documents/us/manuals/nl240.pdf

s.campbellsci.com/documents/us/manuals/rv50.pdf

When connecting the RF407 base radio directly to the *LoggerNet* computer, connect the USB cable to the **USB** port of the RF407, and configure it with *DevConfig* as instructed in the RF407 manual. See Section 10.7.1, *Physical Connection to the Base Station* (p. 80), for more information.

As indicated in Section 10.2.7.1, *Base Station Design for RF407 Radio Networks* (p. 70), the CRVW3 itself is rarely used as the base radio station in an RF407 Network. However, to use that configuration, ensure that the **Is Router** setting located on the **PakBus** tab of the **Settings Editor** tab in *DevConfig* is set to **True**.

Use a temporary CRVW3 station and *LoggerNet* to validate the operation of your deployed RF407 base station before leaving the site (see Section 10.5, *Base Station Deployment* (p. 76), above).

10.6 Repeater Station Deployment

A repeater station in a CRVW3 radio network can be either a CRVW3 station configured as a repeater, or a dedicated repeater station.

To configure a CRVW3 station as a repeater station, follow the steps outlined in Section 10.4, *Deployment of CRVW3 Radio Stations* (p. 74), but use an omnidirectional antenna instead of a directional/Yagi antenna. Additionally, set the **Is Router** setting located on the **PakBus** tab of the **Settings Editor** tab in *DevConfig* to **True**. See Section 10.6.1, *Repeaters on RF451 Networks* (p. 79), for additional configuration steps required when using the CRVW3-RF451 as a repeater.

For dedicated repeater stations, the stand-alone radio that matches the radio type of your CRVW3 stations should be used (RF407, RF450, RF451). Consult the manual for that radio device for instructions on setting up and configuring a repeater station. You should ensure that proper power, enclosure, grounding, and mounting options are available for the station.

If CRVW3 end-nodes have already been deployed that rely on this repeater site being installed and configured, you can test it before leaving the site (see Section 10.3.2, *Field Deployment Considerations* (p. 73)). Use a temporary base station and laptop running *LoggerNet* to connect to one or more of the remote CRVW3 sites through the repeater. (See Section 10.7, *LoggerNet Configuration* (p. 80), for *LoggerNet* configuration details). Be sure to place the base radio more than 25 feet away from the repeater antenna to avoid interference. Validation of the repeater station by performing a test at the permanent base station location is also recommended. Travel to the base station location, and use the process outlined in Section 10.5, *Base Station Deployment* (p. 76), but use the remote CRVW3 (routed through the repeater) as the test device instead of the local/temporary CRVW3.

10.6.1 Repeaters on RF451 Networks

When using a CRVW3-RF451 as a repeater station, ensure that the **Radio Operation Mode** setting on the **Radio** tab on the **Settings Editor** tab in *DevConfig* is set to **Point to MultiPoint Slave/Repeater**. When using slave/repeater devices in lab conditions, ensure each device is using an antenna such as a ½ wave whip. Also see instructions in Section 10.6, *Repeater Station Deployment* (p. 79).

When using a dedicated repeater station on an RF451 Network, use the RF451 radio as the main component of the station. Consult the RF451 manual for details about the configuration of the radio as a repeater device (s.campbellsci.com/documents/us/manuals/rf451.pdf). See also Section 10.6, *Repeater Station Deployment* (p. 79).

10.6.2 Repeaters on RF407 Networks

When using a CRVW3-RF407 as a repeater station, the instructions in Section 10.6, *Repeater Station Deployment* (p. 79), cover all of the necessary configuration steps.

When using a dedicated repeater station on an RF407 Network, use the RF407 radio as the main component of the station. You must use *DevConfig* to set the **Active Interface** to **PakBus Router** and the **Protocol** to **PakBus Node**. The RF407 must also be assigned a **PakBus Address** different from all other devices in the network. Consult the RF407 manual for details about the configuration of the radio as a repeater device (s.campbellsci.com/documents/us/manuals/rf407-series.pdf). See also Section 10.6, *Repeater Station Deployment* (p. 79).

10.7 LoggerNet Configuration

The use of *LoggerNet* for testing and validating deployed stations in your CRVW3 network is critical. 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. The *LoggerNet* software 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, you should configure *LoggerNet* to execute data collection automatically (often called scheduled data collection.)

10.7.1 Physical Connection to the Base Station

For wired connections between the *LoggerNet* computer and the base station, use a serial cable. If the computer running *LoggerNet* has a dedicated RS-232 COM port, you can use a standard DB9 serial cable to make the connection (pn 10873). If your *LoggerNet* computer does not have a dedicated RS-232 port, you can use a USB-to-Serial conversion cable (pn 17394) utilizing a USB port on the computer. Connect the serial cable to the RS-232 port of the radio used at the base station. You should note which COM port is being used by your serial cable. For USB-to-serial converter scenarios, a USB driver is active which will indicate the specific port number being used when the device is plugged in.

For details about establishing a telemetry link between *LoggerNet* and the base station see Section 10.5.1, *Base Station on the RF451 Network* (p. 77), or Section 10.5.2, *Base Station on the RF407 Network* (p. 78). Once configured, most telemetry links will use a TCP/IP connection to send data between *LoggerNet* and the base station.

10.7.2 Configuring the Network Map of *LoggerNet*

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

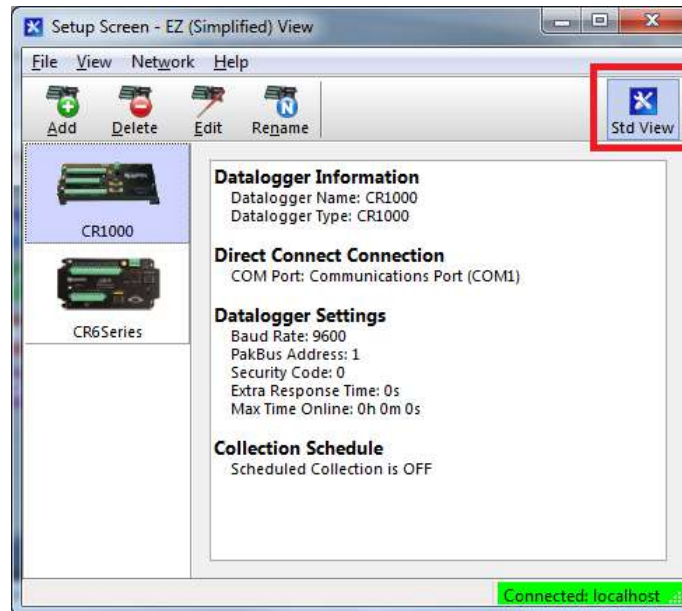
If the *Network Planner* was used to configure your network of CRVW3 devices, there is also a function in that software to configure the network map of *LoggerNet* so that it can communicate with the base station and the CRVW3 devices. Note the checkbox for configuring *LoggerNet* located in the **Configure 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 the *LoggerNet* manual Section 4.3 for more information about the *Network Planner*.

s.campbellsci.com/documents/us/manuals/logger-net.pdf

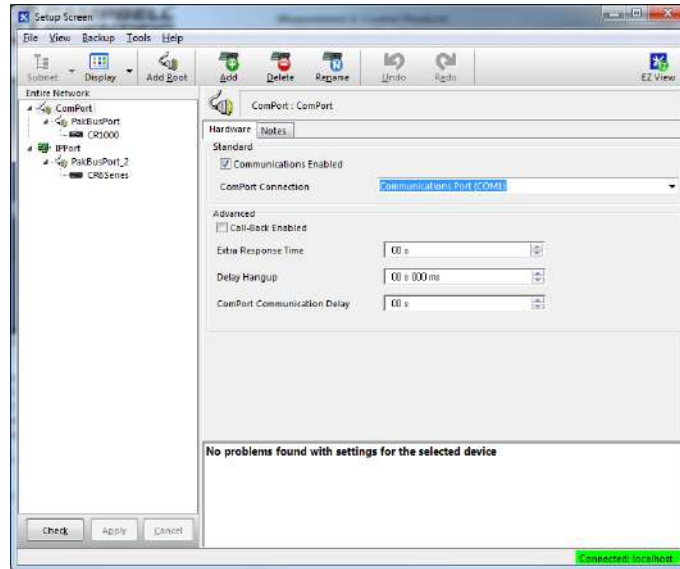
The *Setup Screen* is found on the **Main** category of the toolbar which appears when *LoggerNet* is first started. Click the blue “wrench and screwdriver” icon to start the application:



If the *Setup Screen* comes up in the EZSetup Mode,



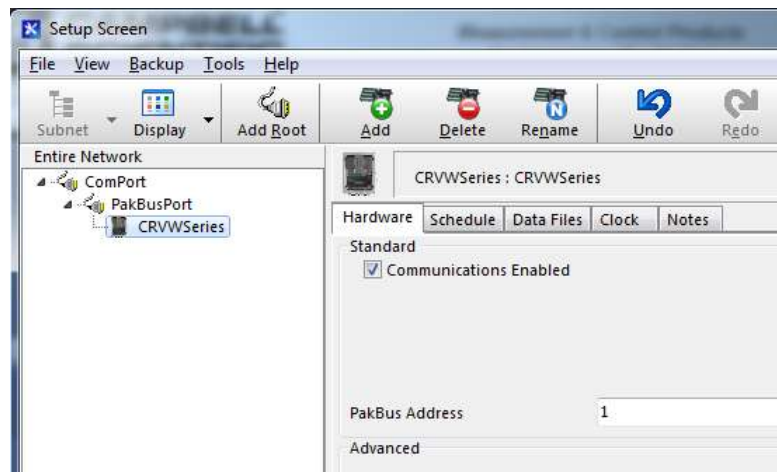
click the **Std View** button to put it into the Standard View Mode:



First, add a root device to the network map by pressing the **Add Root** button. When using a serial cable (local) connection to the base station, you should 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. From the next list that is presented, choose **PakBusPort (PakBus Loggers)**.

You will be presented with a list of dataloggers. Choose **CRVWSeries**, and press **Close**.

Assuming you started with an empty network map, you should now see something like this on the left side of the screen (**Entire Network**):



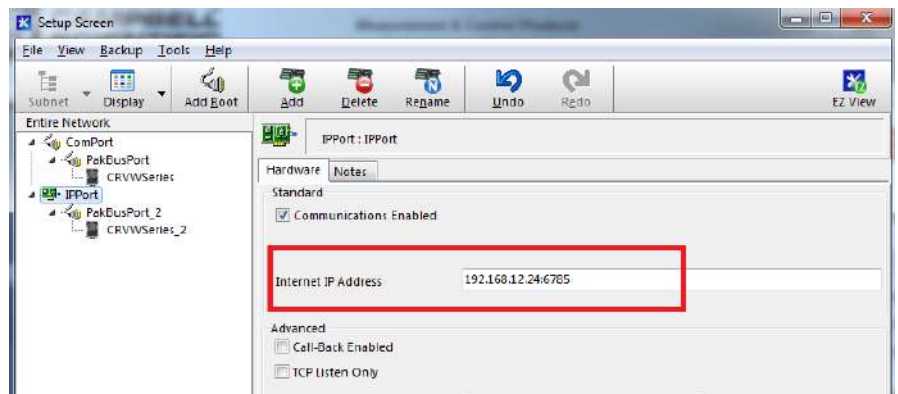
The **ComPort** or **IPPort** root device is the object used to establish a link with your base station.

Click on the **ComPort** device in the network map (**Entire Network**) pane, and note the **Hardware** tab in the right hand pane. Use the drop-down selection box called **ComPort Connection** to choose the serial port to which the base

radio is connected on your *LoggerNet* computer. Press **Apply** in the bottom left part of the screen to save the changes you have made so far.



If you are using telemetry to connect to the base station, click on the **IPPort** device. In the **Hardware** tab note 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. Press **Apply**. The particular TCP/IP address and port number to be used is determined as part of the configuration and deployment of the telemetry device used together with the base radio. See Section 10.5, *Base Station Deployment* (p. 76), and Section 10.5.1, *Base Station on the RF451 Network* (p. 77), or Section 10.5.2, *Base Station on the RF407 Network* (p. 78).

Now click on the **CRVWSeries** device in the network map. Note that the following tabs appear: **Hardware**, **Schedule**, **Data Files**, **Clock**, **Notes**.



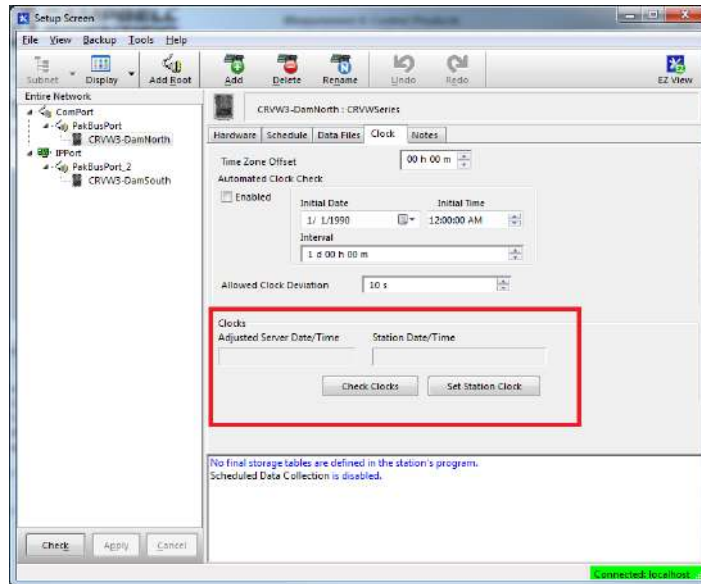
Choose one of your deployed CRVW3 devices that has a single-hop connection to the base station. Click on the **CRVWSeries** item in the network map and press the **Rename** button. Rename the device with the name of that station which you designated in your radio network planning documents (see Section 10.2, *Planning the Radio Network* (p. 62)).

In the **Hardware** tab, set the **PakBus Address** value to match up with the value that was configured into the CRVW3 device with *DevConfig* or with the *Network Planner*. Press **Apply**.

NOTE

If you are using PakBus encryption, the proper key should be entered in this screen. This key should match the value that was previously set in the CRVW3 using the **PakBus** tab in the **Settings Editor** tab of *DevConfig*. Refer to the online help system of *DevConfig*, **PakBus Encryption Key** field topic for more information. Also, if a Security Level 1, Security Level 2, or Security Level 3 code was set for the CRVW3 in *DevConfig*'s **PakBus** tab, put the proper code in the **Security Code** box of this screen. For more information about security codes, refer to your datalogger manual or the *DevConfig* help.

Now switch to the **Clock** tab. The **Check Clocks** and **Set Station Clock** buttons should be active. If they are not, press the **Apply** button.



Press the **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* and troubleshooting needs to occur. 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. See Section 13, *Troubleshooting CRVW3 Networks* (p. 101), for additional troubleshooting procedures, or contact your local Campbell Scientific support representative.

If the clock check was successful, and you want the station time to be synchronized with the *LoggerNet* computer station time, press **Set Station Clock**. If the clock check executed successfully, the set clock operation should also work, otherwise troubleshooting may be needed.

To add additional CRVW3 devices to your network map, you don't need to add a **ComPort**, **IPPort** or **PakBusPort** again. Simply click on the existing **PakBusPort** device and press **Add**. Choose **CRVWSeries** from the list of dataloggers and press **Close**. You will now have another CRVW3 device on the network map. Rename it to avoid any confusion. *LoggerNet* will automatically add numbers to the device names as they are added to make sure they are unique (until you get a chance to rename them).

Now you can click on the new CRVW3 device, and repeat the configuration process described earlier in this section. You will put in a unique **PakBus Address** for each device added. You should repeat this process for every single-hop CRVW3 device on your network (which may include CRVW3 repeater stations). Perform a clock check on each station as it is added. Don't forget to press **Apply**.

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 press **Add**. Choose **CRVWSeries** from the datalogger list and press **Close**. Now you have a CRVW3 device showing up as a child device of the CRVW3 repeater. This will instruct *LoggerNet* to route through the CRVW3 repeater to get to the CRVW3 child device. Rename the device, configure it and press **Apply**. Multiple CRVW3 child devices can be added to any CRVW3 repeater/parent. Configure these devices using the tab screens in the same way as the other CRVW3 devices were configured.

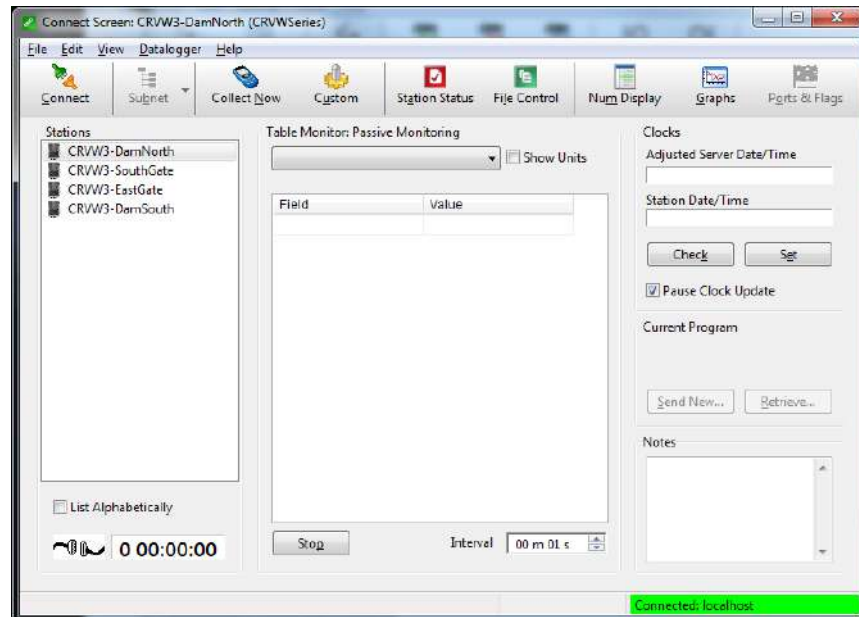
If you have a dedicated repeater station that is configured as a PakBus router station, you should click on the **PakBusPort** device, and press **Add**. Select **pbRouter** and press **Close**. Enter the **PakBus Address** of the PakBus router/repeater and press **Apply**. Now you can click on the **pbRouter** device and press **Add** to add stations that route through this repeater. Choose **CRVWSeries** from the datalogger list and press **Close**. Rename the device, configure it, and press **Apply**.

If a dedicated repeater station is not configured as a PakBus router, you should add the CRVW3 devices reached through that repeater to the **PakBusPort** as described above.

Once you can successfully check the clock on all of your CRVW3 devices, you should proceed to Section 10.7.3, *Connecting to CRVW3 Stations* (p. 86).

10.7.3 Connecting to CRVW3 Stations

Use the *Connect Screen* to connect to each CRVW3 station and confirm that it is communicating and operating correctly. Click on the green chain-link icon from the **Main** category of the *LoggerNet* toolbar to open the *Connect Screen*.



The **Stations** list shows all CRVW3 devices that have been defined on your network map. Click on a station and press **Connect** in the upper left corner to establish a communications session to the station. If the radio link is healthy and *LoggerNet* is configured correctly, you will see a successful connection to the device and the button's icon will change to show a connected state (the green and orange connector plugs will show as connected to each other). 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 press **Start** to show current data from the station. The *Connect Screen* will continually poll for new data and display it.

Use the **Station Status** button to display the Status Summary, Table Fill information, and the complete **Status** table of the device.

Use the **Collect Now** button to confirm that data can be collected from each CRVW3 station.

Use the *Connect Screen* to validate that the CRVW3 station is fully functional and fully communicating. Once each station has been validated, see Section 10.7.4, *Setting up Automatic Data Collection* (p. 87).

You can use the *PakBusGraph* application to troubleshoot your network. This is launched from the **Tools** category of the *LoggerNet* toolbar. You can also use *LogTool* to monitor how communication links are working. For more information, see Section 13, *Troubleshooting CRVW3 Networks* (p. 101), or refer to the *LoggerNet* manual.

s.campbellsci.com/documents/us/manuals/LoggerNet.pdf

NOTE

By default, PakBus beaconing is set to occur at an interval of 1 minute on the PakBusPort 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 some other slower interval to avoid unnecessary radio traffic. It may be necessary in some circumstances to set the beacon interval on a CRVW3 repeater station.

10.7.4 Setting up Automatic Data Collection

With a good connection working to every CRVW3, you can now set up automatic data collection (also called scheduled data collection) in *LoggerNet* for each station/device. To do this, use the *Setup Screen* (see Section 10.7.2, *Configuring the Network Map of LoggerNet* (p. 80)). You will use the **Schedule** and **Data Files** tabs for each CRVW3 device that is already defined on your network map. Remember to press **Apply** after making changes.

When *LoggerNet* is running and scheduled collection is enabled, it 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.

Details for using the **Schedule** and **Data Files** tabs of a datalogger to set up scheduled collection is documented in Section 4.2 and 4.2.5 of the *LoggerNet* manual. Please refer to that document for guidance in accomplishing this task.

s.campbellsci.com/documents/us/manuals/LoggerNet.pdf

Once scheduled collection has been configured and activated, you can open the *Status Monitor* application in *LoggerNet* to ensure that *LoggerNet* is connecting with each station and that its data is being collected properly. To open *Status Monitor*, choose the heartbeat icon from the Main category of the *LoggerNet* toolbar:



Please refer to Section 6 of the *LoggerNet* manual for more details about using the *Status Monitor*.

Refer to Section 11, *Operation of CRVW3 Networks* (p. 88), Section 12, *Maintenance of CRVW3 Networks* (p. 96), and Section 13, *Troubleshooting CRVW3 Networks* (p. 101), of this manual for information regarding how to operate, maintain, and troubleshoot CRVW3 networks.

11. Operation of CRVW3 Networks

Once your CRVW3 stations, repeaters, and base station are deployed and operating, and *LoggerNet* can connect with and collect from each station, your attention should turn to the operation of your CRVW3 network. Most of this work is done using *LoggerNet* and related tools. The data collection process is one of the most important operational activities that occurs on your network.

Refer to the *LoggerNet* manual for detailed instructions about any use of that software:

s.campbellsci.com/documents/us/manuals/loggernet.pdf

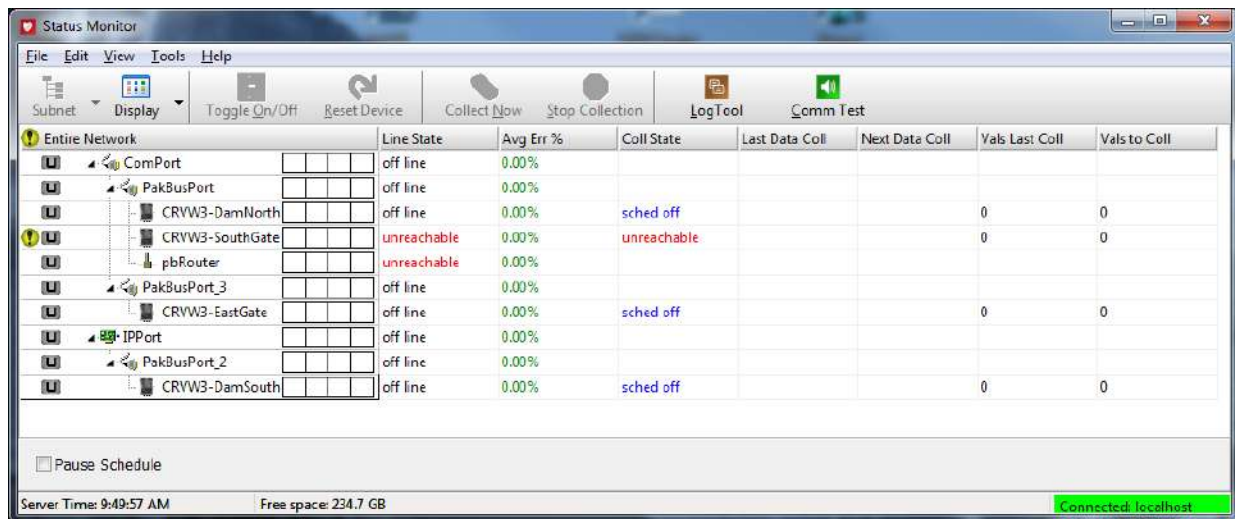
11.1 Monitoring Automatic Data Collection

Most CRVW3 devices that have been configured to be part of a radio network will also be part of an automatic collection schedule that is executed by *LoggerNet*. For more information about configuring *LoggerNet* to use automatic data collection, see Section 10.7.4, *Setting up Automatic Data Collection* (p. 87).

In order for automatic data collection to occur, the *LoggerNet* toolbar must be running (or the *LoggerNet Service* must be started in the case of *LoggerNet Admin* installations). Use the *LoggerNet Status Monitor* to assess the connectivity and collection status for all of the CRVW3 devices on your network. The *Status Monitor* shows whether *LoggerNet* is connecting with each station and whether that station's data is being collected properly. To open *Status Monitor*, choose the heartbeat icon from the **Main** category of the *LoggerNet* toolbar:



You should see the *Status Monitor* main screen like this:



Whenever the time for collection (specified for each individual CRVW3 in the **Schedule** tab of *Setup Screen*, see Section 10.7.4, *Setting up Automatic Data Collection* (p. 87)) is reached on the *LoggerNet* computer's clock, *LoggerNet* will connect to the station automatically and collect data from it. You can observe *LoggerNet* performing these tasks using the *Status Monitor*.

For each station, focus on the collection State (**Coll State** column), the time that data was last collected from the station (**Last Data Coll** column), the time that data will be collected next (**Next Data Coll** column) and the number of values collected (these will be non-zero when actual records get collected). By highlighting a particular station, you can also force a data collection to occur immediately using the **Collect Now** button. For more information about using the *Status Monitor*, refer to Section 6 of the *LoggerNet* manual.

Check the *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. The *Status Monitor* is a key application for ensuring the regular flow of data on your network, so you should invest effort to be familiar with how it operates.

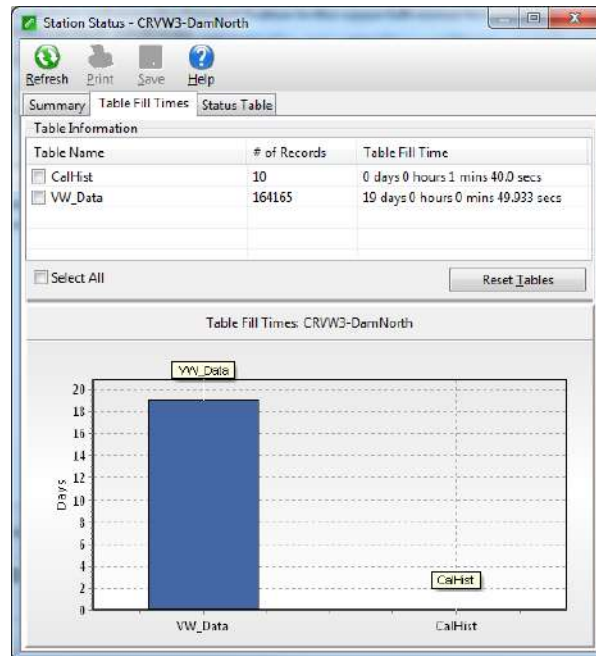
When *LoggerNet* succeeds in collecting data from a station, it places that new data into a file (which usually has a .DAT extension in the filename). This file is specified in the **Data Files** tab for that station in the *Setup Screen*. See Section 10.7.4, *Setting up Automatic Data Collection* (p. 87), and Sections 4.2 and 4.2.5 of the *LoggerNet* manual for more details. You can observe the file modification date to ensure that data was written to the file at the expected time. These files can also be opened and examined using the **View Pro** utility (see Section 11.4.2, *Analyzing and Publishing Historical Data* (p. 94)). Recent collected data is also cached into a *LoggerNet* memory location for easy sharing with *LoggerNet* client applications, such as the **Numeric Display** or **Graph** used in *Connect Screen*. The *LogTool* application can also be used to confirm that table collection is working. See Section 6.2 of the *LoggerNet* manual for more information.

The CRVW3 uses tables that operate like those found in programmable dataloggers (CR6, CR1000, CR3000, etc.). The CRVW3 communicates these

table definitions to *LoggerNet*, enabling you to work with the tables in the standard way. The main three tables of interest on the CRVW3 are the **VW_Data** table, the **Public** table, and the **Status** table. There is a separate .DAT file defined in *LoggerNet (Setup Screen)* for each table that is enabled for automatic collection. There is also a table called **CalHist** that stores calibration information, if that is used on the device.

The **VW_Data** table is the final storage table used by the CRVW3. It is the permanent repository of measurements made, and includes frequency data and temperature data (when applicable). If conversion to engineering units is used, that data is also included. This table should be enabled for automatic collection, and the data collected from it into a .DAT file should be viewed periodically to ensure that the collection is working.

You need to collect all the data successfully from a CRVW3 before the memory space on the CRVW3 becomes full. The CRVW3 uses “ring memory” which means that the oldest records begin to get overwritten with new records as soon as the memory storage is filled. The factors that affect the table fill time are the number of channels being measured, how often measurements are made, and whether engineering output calculations are used. To check how long it takes from the time the program starts until the memory fills up as well as to see how many records it can store, use the *Connect Screen* application’s **Station Status** screen. A tab called **Table Fill Times** will show both the amount of time it takes (from the time the program started) for the table to fill up and also how many records can be stored during that time.



Plan the collection interval in your scheduled collection scenario to collect data from your CRVW3 devices well before any data loss can occur.

The **Reset Tables** button can be used to clear all the records out of a specified table. If you choose to reset the **VW_Data** table or one of the other tables, do so only with extreme caution (after having collected and confirmed receipt of all needed data) to ensure that no data loss occurs.

11.2 Manual Data Collection

Although automatic data collection regularly retrieves the data from a CRVW3 station and stores it on the *LoggerNet* computer, there may be times when data needs to be retrieved without having to wait for the next scheduled poll (data collection) event to occur. For example, if data is collected automatically only once per hour or once every four hours, manual collection can be used to ensure data collection is working properly without having to wait for an hour or more to confirm operation. For those cases, manual data collection can be used. It is also possible to retrieve data from a CRVW3 using manual collection when a technician visits the CRVW3 field site.

11.2.1 Manual Data Collection from the *LoggerNet* Station

Use the *Connect Screen* to collect data manually from a station using *LoggerNet*. Establish a preferred connection to a specific CRVW3 device from which data is to be collected by highlighting the station in the **Stations** list and pressing the **Connect** button.

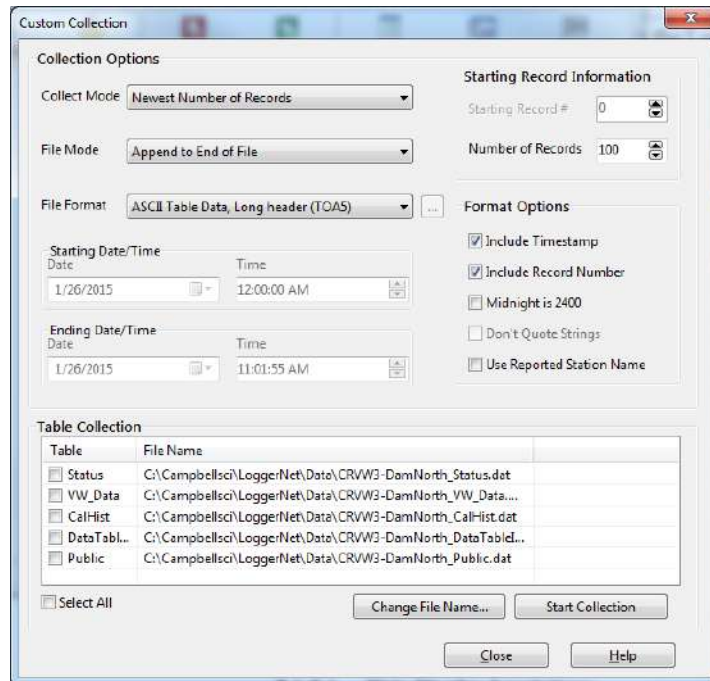
There are two kinds of manual collection methods available: **Custom Collection** and **Collect Now**.

Use **Collect Now** when you want the collection of data to operate just as it does when automatic/scheduled collection occurs, except that the collect operation will occur immediately and not wait for the next automatic event. With **Collect Now**, data that is collected is placed into the same .DAT file used when automatic collection occurs (defined in the *Setup Screen*). Only those records are collected from the device that have not been collected already during previous scheduled collections or previous **Collect Now** events. The records collected are placed into *LoggerNet*'s cached memory location so that **Numeric Displays** and **Graphs**, and other client applications (such as *RTMC* and *LNDB*, see Section 11.4.2, *Analyzing and Publishing Historical Data* (p. 94)) will see the data and process/display it.

To use the **Collect Now** feature, simply ensure you are connected to the station, and press the **Collect Now** button. **Collect Now** can also be used from the *Status Monitor*.

Use **Custom Collect** when you want to retrieve data from a station in a manner that is completely independent from the scheduled collection process. Different .DAT files are created and will be placed into a separate folder. A custom collection has no impact on the execution of the automatic collection schedule. Any records stored on the device may be collected. The cached memory location of *LoggerNet* is not updated, so there is no impact on **Numeric Displays** or **Graphs** or other client applications.

To use the **Custom Collect** feature, press the **Custom** button while connected to the station of interest in the *Connect Screen*. For more information about custom data collection, see Section 5.1.2.2 of the *LoggerNet* manual.



11.2.2 Manual Data Collection at the CRVW3 Site

A technician located at a CRVW3 deployment site can use a USB cable to manually collect data from a CRVW3 using a Windows computer (laptop PC) running *LoggerNet*, *PC400*, or *PC200W* software.

If you are using *LoggerNet* on a laptop in the field, make sure that the particular CRVW3 device has been added to the network map of the laptop's instance of *LoggerNet* (using *Setup Screen* or *EZSetup*, see Section 10.7.2, *Configuring the Network Map of LoggerNet* (p. 80)) and that the connection is set up as a **ComPort** that references your USB cable connection. To do so, make sure the USB driver is installed (see Section 8.1.4, *Connecting to the CRVW3* (p. 20)). Once you have *LoggerNet* setup correctly, open the *Connect Screen* and connect to the device.

Once you are directly connected to the device in the field via USB, follow the process outlined in Section 11.2.1, *Manual Data Collection from the LoggerNet Station* (p. 91), above to collect data from the CRVW3.

When using *PC400* and *PC200W*, you will need to add the device in the *EZSetup* wizard. Ensure that the USB driver creates a **ComPort** that references your USB cable connection, and which is specified in *EZSetup*. Once you can connect to the CRVW3, choose the **Collect Data** tab from the main screen of *PC400* or *PC200W*. Refer to the *PC400* documentation (Section 4.4) or *PC200W* on-line help for details about using the **Collect Data** tab.

s.campbellsci.com/documents/us/manuals/pc400.pdf

NOTE

If your CRVW3 device does not have a radio option, you should make a plan for visiting the site on a regular basis to collect its data as described in this section. Plan to make a collection visit before the newly collected data begins overwriting the older data that needs to be collected (see explanation in Section 11.1, *Monitoring Automatic Data Collection* (p. 88)).

11.3 Station Health Monitoring

You should periodically check the health of each CRVW3 station on your network using *LoggerNet*.

In the *Connect Screen*, you can monitor the **Public** and **Status** tables with the **Table Monitor** (see Section 10.7.3, *Connecting to CRVW3 Stations* (p. 86)). Use the **Station Status** button to bring up the **Station Status** screen. The **Summary** tab will show items in red or blue that may require your attention.

You can view the current settings on each CRVW3 device using the *Connect Screen*. Choose the **Settings Editor...** option from the **Datalogger** menu. A **Settings** screen will appear that works much like *DevConfig*. You can view settings for the device.

CAUTION

Before making changes to a remote device with the **Settings** screen, review Section 12.1.3, *Adjusting Device Settings* (p. 99).

In order to keep the clocks of your CRVW3 stations synchronized with the *LoggerNet* computer station's clock, consider the use of the *Automatic Clock Set* functionality. Use the **Clock** tab in the *Setup Screen* to enable a periodic and automated clock check for each device. Once enabled for a station, if the clock of the device has deviated more than a specified interval, the clock will automatically be set back to (synchronized with) the *LoggerNet* computer's clock value. 24-hour or 7-day clock check intervals are typical. In some cases, it makes sense to perform automated clock checks at a time different from a scheduled collection event to avoid radio traffic congestion issues. A clock synchronization is recommended (manually or automatically) at least once per month.

You can use the *PakBusGraph* application to periodically ping all of the stations and make sure PakBus discovery and beaconing is working properly. For a healthy, operating network, you should see an active link to each device defined in your network map. Make sure you have selected the correct **PakBusPort** in the **PakBusNetwork** dropdown (as defined in *Setup Screen*) to view your CRVW3 devices.

For CRVW3-RF451 devices and RF451 radio networks, you can use the RF450 diagnostic cable (pn 20625) on the master radio (base station) to assess radio link strength as it changes over time. Install and use the software provided with the cable to do this. Each CRVW3-RF451 can connect directly to a computer using this cable and the **RF DIAG** port located on the wiring panel of the CRVW3-RF451.

CAUTION

It is possible to use the software to change settings on a device which are not available within *DevConfig*. Configuring a setting incorrectly can cause a device to stop communicating on the network. Only use this feature with proper training and appropriate care.

NOTE

If you use the diagnostic cable (pn 20625) to update the radio firmware of an RF450 or CRVW3-RF451 device, it must be configured as a Slave, not the Master. When updating a Master radio, change it to be a Slave first, load the firmware, and then change it back to be the Master after the new firmware is working.

11.4 Processing Collected Data

Once you have data flowing into the *LoggerNet* station on a regular basis, you need to evaluate the quality of the data, analyze the data, and then publish and deliver it to the appropriate data consumers.

11.4.1 Monitoring Data Influx Using Real-time Displays

You can use the **Table Monitor**, **Numeric Displays**, and **Graphs** of the *Connect Screen* in *LoggerNet* to monitor data as it is collected by *LoggerNet*. This works for data collected via automatic collection or via *Collect Now*. Once connected, use the **Table Monitor** dropdown to select one of the CRVW3 tables for display. Use the **Num Display** button to open and configure a **Numeric Display** monitor. This allows data from more than one table to be displayed. Use the **Graphs** button to display data graphically with some time history over the width of the display. For more information about using the **Numeric Displays** and **Graphs** in the *Connect Screen*, refer to the *LoggerNet* manual Section 5.1.

You can also use the **RTMC** (included with *LoggerNet*) and **RTMC Pro** (purchased separately) products to create customized screens for monitoring data as it is collected. See Section 5.2 of the *LoggerNet* manual for more details.

11.4.2 Analyzing and Publishing Historical Data

Once data has been collected by *LoggerNet* into .DAT files, it is referred to as *historical* data. You will want to review, analyze, examine, and publish data that has been collected from your CRVW3 stations.

TIMESTAMP	RECORD	Batt_Volt	CPU_Temp	Chan1_Freq	Chan1_Amp	Chan1_SigNoise	Chan1_NoiseFreq	Chan1_DecayRate	Chan1_Therm
2015-01-23 08:31:40	0	11.72219	29.14245	2256.847	2.208836	6397.411	0	0.369091	3304.571
2015-01-23 08:31:40	1	11.79484	29.43050	2256.863	2.205655	6388.257	0	0.3704297	3304.176
2015-01-23 08:31:50	2	11.79526	29.34594	2256.879	2.204785	6385.738	0	0.3705422	3303.751
2015-01-23 08:32:00	3	11.79237	29.295	2256.895	2.202706	6379.715	0	0.3668925	3303.387
2015-01-23 08:32:10	4	11.79309	29.27805	2256.912	2.201339	6375.796	0	0.3702147	3303.025
2015-01-23 08:32:20	5	11.79671	29.2272	2256.928	2.199455	6370.301	0	0.3694435	3302.63
2015-01-23 08:32:30	6	11.79588	29.1933	2256.944	2.198041	6366.205	0	0.3718268	3302.283
2015-01-23 08:32:40	7	11.79092	29.17635	2256.961	2.196023	6360.358	0	0.3686745	3301.918
2015-01-23 08:32:50	8	11.79598	29.10855	2256.977	2.194257	6355.274	0	0.3683266	3301.543
2015-01-23 08:33:00	9	11.79671	29.32889	2256.993	2.192682	6350.682	0	0.3679253	3301.197
2015-01-23 08:33:10	10	11.79598	29.1933	2257.009	2.188857	6342.501	0	0.3678869	3300.824
2015-01-23 08:33:20	11	11.79092	29.34594	2257.026	2.188963	6339.913	0	0.3694649	3300.499
2015-01-23 08:33:30	12	11.79671	29.32889	2257.041	2.185285	6332.135	0	0.3684443	3300.078
2015-01-23 08:33:40	13	11.79671	29.1933	2257.058	2.185718	6330.513	0	0.3707288	3299.711
2015-01-23 08:33:50	14	11.79598	29.32889	2257.074	2.183136	6323.037	0	0.3703777	3299.338
2015-01-23 08:34:00	15	11.78803	29.2611	2257.091	2.182849	6322.205	0	0.3694232	3299.005
2015-01-23 08:34:10	16	11.79815	29.24414	2257.104	2.152049	6232.998	0	0.3707439	3298.599
2015-01-23 08:34:20	17	11.79743	29.43059	2257.123	2.178632	6309.589	0	0.3637963	3298.281
2015-01-23 08:34:30	18	11.79598	29.37974	2257.139	2.176632	6304.799	0	0.3693119	3297.9
2015-01-23 08:34:40	19	11.7973	29.34594	2257.155	2.175131	6299.851	0	0.366787	3297.535
2015-01-23 08:34:50	20	11.79671	29.36279	2257.171	2.174621	6298.375	0	0.3707992	3297.183
2015-01-23 08:35:00	21	11.79815	29.44794	2257.188	2.171574	6289.548	0	0.3669266	3296.806
2015-01-23 08:35:10	22	11.79526	29.39669	2257.204	2.1713	6288.755	0	0.3693648	3296.469
2015-01-23 08:35:20	23	11.78947	29.37974	2257.22	2.168584	6280.887	0	0.3689132	3296.096
2015-01-23 08:35:30	24	11.79671	29.34594	2257.236	2.188921	6280.999	0	0.3689469	3295.711
2015-01-23 08:35:40	25	11.79743	29.48144	2257.252	2.166705	6275.446	0	0.3694028	3295.336
2015-01-23 08:35:50	26	11.79381	29.43059	2257.269	2.16481	6269.339	0	0.3688558	3294.994
2015-01-23 08:36:00	27	11.78803	29.46449	2257.285	2.163168	6265.202	0	0.3707428	3294.629
2015-01-23 08:36:10	28	11.79671	29.43059	2257.301	2.162218	6262.449	0	0.3661414	3294.277
2015-01-23 08:36:20	29	11.79671	29.43059	2257.318	2.180694	6258.037	0	0.3704332	3293.906
2015-01-23 08:36:30	30	11.79598	29.53225	2257.351	2.111504	6173.449	0	0.3694608	3293.551
2015-01-23 08:36:40	31	11.7973	29.37974	2257.36	2.158635	6252.074	0	0.3668704	3293.229
2015-01-23 08:36:50	32	11.79743	29.60008	2257.366	2.157889	6249.513	0	0.3703473	3292.851

The *View Pro* application is provided within *LoggerNet* for viewing and graphing historical data stored in .DAT files. When you perform a **Collect Now** or **Custom Collect** operation, a screen appears which allows you to open and display the affected .DAT file within the *View Pro* application. Press the **View File** button in the **Data Collection Results** Screen. It is also possible to start the *View Pro* application from the *LoggerNet* toolbar and then browse to and open any .DAT file available on the computer. You can look up the location of various .DAT files by looking at the **Data Files** tab for each CRVW3 in the *Setup Screen*. For more information about using *View Pro*, refer to Section 8.1 of the *LoggerNet* manual.

Table	Output File Name	File Output Mode	Output Format
CalHist	The file is remote/inaccessible or does not exist. (C:\Campbellsc...	Append to End of File	ASCII Table Data, Long Header (T...
VW_Data	C:\Campbellsci\LoggerNet\CRVW3-DamNorth_VW_Data.dat	Append to End of File	ASCII Table Data, Long Header (T...

Total number of values collected: 10560

OK View File Help

Another option available for storing data as it is collected from devices is *LNDB* (*LoggerNet* Database software). *LNDB* is purchased separately from *LoggerNet*, but it does require a *LoggerNet* installation to operate. Once installed and running, *LNDB* monitors the data that is collected within *LoggerNet* and stores it into a MySQL or SQLServer database that has been configured by the user. This database can be on the same computer that runs

LoggerNet or on a different computer accessible from the *LoggerNet* computer via TCP/IP.

For more information, refer to the *LNDB* product website:

www.campbellsci.com/lndb

RTMC and *RTMC Pro* can be used to create screens for viewing real-time data as it is collected by *LoggerNet*. *RTMC Pro* can also be used to create customized screens for viewing historical data that resides in .DAT files or in an *LNDB* database. Once screens have been created with this product, they can be viewed using the *RTMC Runtime* viewer, or they can be published out as web-enabled sites using the *CSI Web Server* product. Refer to these product websites for more information:

www.campbellsci.com/rtrmcpro

www.campbellsci.com/csiwebs

12. Maintenance of CRVW3 Networks

After your CRVW3 stations have been operating for some time, there may be periodic maintenance tasks that 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 deployment site is necessary.

12.1 CRVW3 Maintenance with *LoggerNet*

See Section 11.3, *Station Health Monitoring (p. 93)*, for details about how to use *LoggerNet* to periodically check the health of a CRVW3 station.

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 Appendix A, *Updating CRVW3 Firmware (p. A-1)*, 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 Appendix E, *Engineering Output and Calibration (p. E-1)*, for details about calibration and using the Calibration Wizard.

12.1.1 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 V indicate that the charge circuit is active and charging the battery. Levels of 12 V or less indicate no charging is active. Once battery voltage reaches 10.5 V, 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 V.

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 or –RF407 radio is used, or if measurements are made more frequently than once every 15 minutes. When using the –RC option, consider replacement of the rechargeable battery after several years of use.

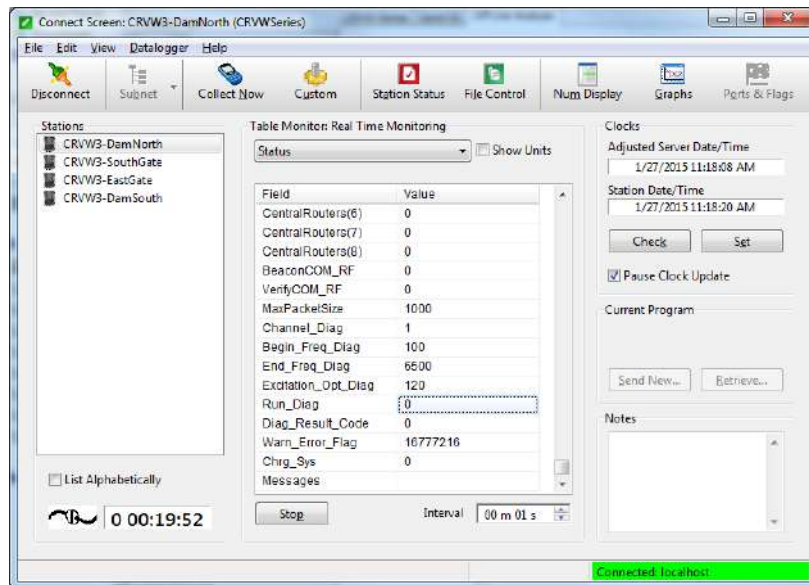
12.1.2 Sensor Spectrum Checks

You should periodically verify that the CRVW3 is making proper readings from its sensors. During installation or during on-site maintenance, this can be done using the **Troubleshoot** tab in *DevConfig* (see Section 8.1.6, *Testing the Measurement Operation of the CRVW3* (p. 27), and Section 8.2.8.2, *Validation with DevConfig* (p. 47). There is a way to make a similar spectrum check on a CRVW3 using *LoggerNet* and a remote connection (i.e., if the device has a radio option). The creation of a binary file can be triggered, and then that file can be retrieved to the *LoggerNet* computer station using **File Control**. *DevConfig* 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.

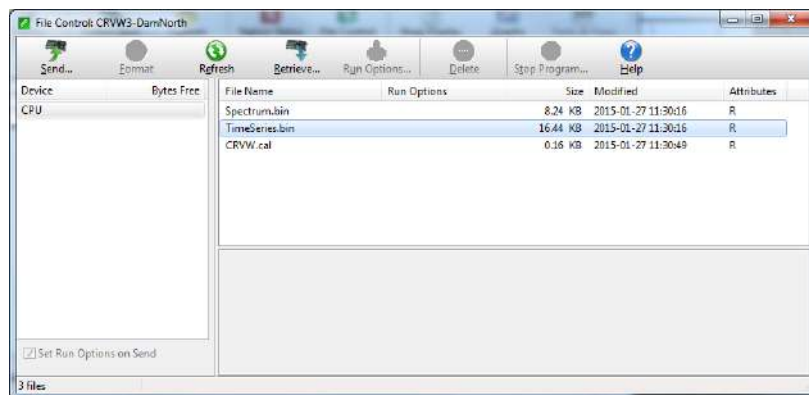
Follow this process to check the spectrum on a remote CRVW3 station:

1. Use *Connect Screen* to establish a connection to 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 Low Frequency and High Frequency desired (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 V, 50 for 5 V and 20 for 2 V excitation.

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

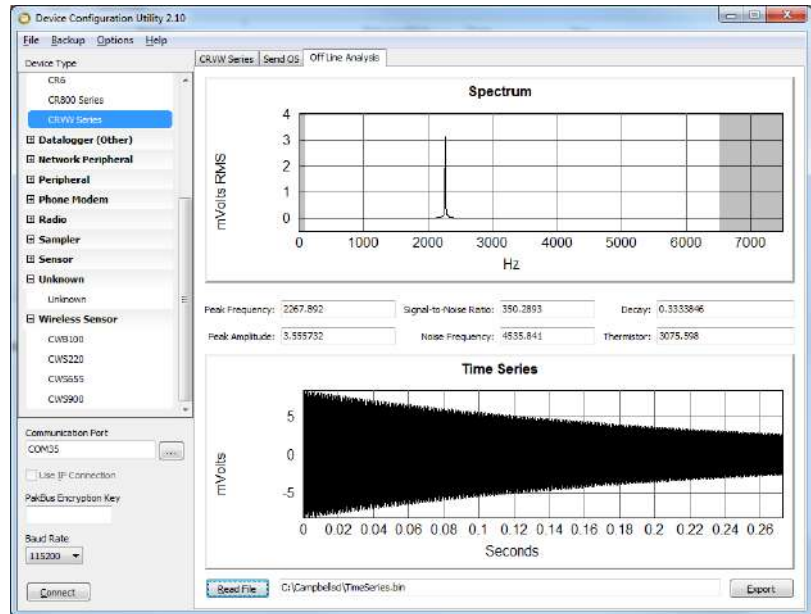


7. Open the **File Control** screen using the **File Control** button.
8. Note the *Spectrum.bin* and *TimeSeries.bin* files located on the CPU drive. The date and time on these files should match the time of the test measurement. (A timestamp of zero on the files indicates that they do not yet exist, the test has not yet been performed).
9. Select only the file *TimeSeries.bin* and press the **Retrieve...** button.



10. Save the file to a known folder location on your *LoggerNet* computer station.
11. Open *DevConfig*, choose **CRVW Series** for the device, select the **Off Line Analysis** tab. Press the **Read File** button, and browse to the **TimeSeries.bin** file.
12. The contents of the file will be processed, and *DevConfig* will display the spectrum and time-series information as recorded by your remote CRVW3

station. Interpret the information shown in this screen the same way as when using the **Troubleshoot** tab.



NOTE

The **Off Line Analysis** tab is only available in *DevConfig* when **not** connected to a CRVW3.

Repeat the above 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 that they can be kept as baseline references that document how the sensor was operating at the time of deployment.

12.1.3 Adjusting Device Settings

You can view and change the current settings on each CRVW3 device using the *Connect Screen*. This is possible even when connections are made remotely to the CRVW3 over radio links, including repeater links. Choose the **Settings Editor...** option from the **Datalogger** menu. A **Settings** screen will appear that works much like *DevConfig*. You can view settings for the device and change them if necessary. Review the warning below before changing any settings.

You can also use *PakBusGraph* to view and edit changes to the device's 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.

Make sure you have collected all required data before making a change to the settings. After you apply changes to a CRVW3's device settings, the CRVW3 will reset itself to begin measuring with the new settings. Close the **Settings** screen since it is no longer connected to the CRVW3. You will need to allow up to 20 seconds to elapse after pressing **Apply** before you can expect to

communicate with the CRVW3 again. You may need to re-connect to the device in *Connect Screen*.

CAUTION

There are risks 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.

You should pause the monitoring of a table (such as *VW_Data*) in the *Connect Screen Table Monitor*, if it will be impacted by the change to the settings. (Use the **Stop** button). It is also recommended that you edit settings when *LoggerNet* is not automatically collecting data from other CRVW3 devices on the same radio network (that is, a scheduled collection) or communicating in other ways with those devices.

12.2 CRVW3 On-site Maintenance Visits

It is wise to schedule periodic visits to the deployment site of a CRVW3 station. Consider making a visit to inspect each CRVW3 station after the winter season (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 after arriving at the site:

- Check and change the battery or batteries if needed
- Check cable entry points for a good seal
- Wipe moisture off of the lid gasket prior to opening (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
- Clean solar panel with mild detergent and a clean cloth
- Replace desiccant (pn 4905) and humidity indicator card (pn 28878) as needed
- Remove any solar barriers (fallen debris, overhead branches, leaves, etc.)
- Install newer firmware/OS (*DevConfig*) — Refer to Appendix [A](#), *Updating CRVW3 Firmware (p. A-1)*

- Look at Sensor spectra using the *DevConfig* **Troubleshoot** tab (refer to Section 8.1.6, *Testing the Measurement Operation of the CRVW3* (p. 27), and Section 8.2.8.2, *Validation with DevConfig* (p. 47))
- Watch the LED activity as the device operates to ensure proper function (see Section 8, *Installation of Individual CRVW3 Stations* (p. 15))

You should be aware of the siting and installation issues discussed in Section 8.2, *Field Deployment of the CRVW3* (p. 33), and check them for any discrepancies. You should 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 laptop running *LoggerNet* (see Section 10, *Complex (Large) Radio Networks* (p. 58)). Using the Terminal mode of the CRVW3 from *DevConfig* can also be used to perform maintenance (see Appendix B, *Terminal Mode from Connect Screen or DevConfig* (p. B-1)).

13. Troubleshooting CRVW3 Networks

By following the tasks outlined in Section 11, *Operation of CRVW3 Networks* (p. 88), and Section 12, *Maintenance of CRVW3 Networks* (p. 96), for operating and maintaining your network of CRVW3 stations, you can identify problems with the system when they emerge or very soon after they occur.

The *Status Monitor* is a key tool for identifying that a problem in the system exists (see Section 11.1, *Monitoring Automatic Data Collection* (p. 88), for guidance about using *Status Monitor*). Some common indicators that something is wrong with a station are:

- Automatic (scheduled) collection is not working as shown by the *Status Monitor* or **Table Monitor**
- You can't connect to the station in the *LoggerNet Connect Screen*
- Clock checks (*Setup Screen*) are not working
- Manual collection doesn't work (*Custom Collect* and *Collect Now*)
- You can't view the **Station Status (Summary and Status Table)**
- The station is able to communicate, but the data that is collected from that station has problems

You should troubleshoot problems as soon as possible after they arise. Some clues relating to the source of the problem can change (become more obscure) over time. Small problems can often escalate into larger ones, due to cascading consequences.

Troubleshooting a part of the system that has never worked is strongly related to the installation process. Review Sections 7 through 10 as a first step of investigation in such cases.

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 made to the system. Sometimes a change to the system that seems harmless or unrelated turns out to be the cause of the trouble.

When you begin troubleshooting a system, you do not yet know the source of the problem. You should suspect all parts of the system (communications, power, repeaters, base station, software, *LoggerNet* computer station issues) until you determine what went wrong. Use the clues given by the problem to narrow your focus. However, you may need to broaden your focus from time to time if causes of the problem fail to emerge.

Sometimes the problem is caused by intentional changes to the system, sometimes it is caused by unintentional changes to the system. Sometimes problems are caused by acts of nature (lightning strikes, storms, animal intrusion), and sometimes operational features of the station had problems that changed gradually and remained undetected until they finally ceased to function (bad battery, etc.). An on-site camera can be helpful if physical problems occur with on-site equipment on a regular basis.

It can be helpful to review the key installation sections of this manual (Section 8, *Installation of Individual CRVW3 Stations* (p. 15), and Section 10, *Complex (Large) Radio Networks* (p. 58)) with a “problem identification” perspective. This can trigger ideas about things that can be investigated.

You should perform whatever troubleshooting work is possible from the lab/office before travelling to the field. Once all remote *LoggerNet* options have been tried, plan a visit to the field to investigate the station or problem area directly.

13.1 Troubleshooting Problems Remotely Using *LoggerNet*

Sometimes you can still communicate with the CRVW3 station, but its measurements don’t seem to make sense or work only intermittently. In those cases, you can connect to the station and check the spectrum to see if there is a sensor problem (sensor cabling, connectivity, operation, noise/interference). See Section 12.1.2, *Sensor Spectrum Checks* (p. 97), 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.

PakBusGraph is an excellent tool for troubleshooting stations and how they communicate with each other. Refer to Section 11.3, *Station Health Monitoring* (p. 93), or Section 6.4 of the *LoggerNet* manual for more information.

LoggerNet also has a *LogTool* utility that shows low-level text messages about how *LoggerNet* is operating and attempting to connect and interact with CRVW3 stations. These logs can be captured and sent to your support representative for evaluation. *LoggerNet* also has a *TroubleShooter* utility that helps to identify communication problems. For more information about using these tools, refer to Section 6 of the *LoggerNet* manual.

s.campbellsci.com/documents/us/manuals/LoggerNet.pdf

In an RF451 network of CRVW3 stations, you can perform radio diagnostics by visiting the base station and using the **RF DIAG** connector of the base/master radio. Use the appropriate cable (pn 20625) and run the included software.

If there is trouble making a connection between *LoggerNet* and the RF451 or RF407 base station, you should use *DevConfig* to ensure that the baud rate setting of the RF451 or RF407 matches the **PakBusPort** baud rate setting in the *LoggerNet Setup Screen*. If these do not match, connectivity will not occur.

13.2 Troubleshooting Problems by Visiting the CRVW3 Site

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 have arrived at the site, review physical installation and hardware configuration issues that are detailed in Section 8.2, *Field Deployment of the CRVW3* (p. 33). Refer to the maintenance items listed in Section 12.2, *CRVW3 On-site Maintenance Visits* (p. 100). Connect to the CRVW3 with a USB cable and *DevConfig*. Use the **DataMonitor** tab and **Troubleshoot** tab to investigate how the measurements of the sensors are working or not (see Section 8.2.8.2, *Validation with DevConfig* (p. 47)). Compare the current spectrum with a baseline spectrum saved during maintenance (see Section 12.1.2, *Sensor Spectrum Checks* (p. 97)).

Refer to Section 10, *Complex (Large) Radio Networks* (p. 58), for details that will help troubleshoot radio connectivity problems. Use a portable base station (RF451 or RF407 depending on the network, and laptop) 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.

Contact your local Campbell Scientific support representative for additional help when troubleshooting problems with CRVW3 operation or radio connectivity.

13.2.1 RF451 Network Troubleshooting Summary

Step 1

Using *DevConfig*, ensure the **Radio Operation Mode** setting is configured properly for each device on the network:

- **Point to MultiPoint Master:** Only one of these is used/configured per network (stand-alone RF451 or CRVW3-RF451 with USB connection to *LoggerNet*).
- **Point to MultiPoint Slave/Repeater:** Used when radio repeating/relay is required at a location as well as measurements needing to be made (CRVW3-RF451 acting as repeater).

NOTE

If repeaters are used anywhere in the network, the **Repeaters Used** setting must be set on all devices in the network (masters, repeaters, and slaves).

- **Point to MultiPoint Slave:** End points, CRVW3-RF451 devices

- **Point to MultiPoint Repeater:** Repeater only stations, stand-alone RF451s

Step 2

Ensure the following settings are identical for every device in the network:

Under **Radio** tab:

- **Frequency Key**
- **Network ID**

Under **Radio Advanced** tab:

- **Hop Table Version**
- **Hop Table Size**
- **RF Max Packet Size**
- **RF Min Packet Size**
- **RF Data Rate**

Step 3

For RF451 stand-alone radios, check the **Baud Rate** and **Active Interface** setting and verify that they are correct for your network.

13.2.2 RF407 Network Troubleshooting Summary

Step 1

Using *DevConfig*, ensure the **Radio Enabled** setting is set to **True** for each CRVW3-RF407 in the network. If the CRVW3-RF407 is to be used as a repeater, verify the **Is Router** setting is set to **True**. (See Section 8.1.5, *Configuring the CRVW3* (p. 23), for information on how to configure the **Is Router** setting.)

Step 2

Ensure the following settings found on the **Radio** tab are identical for every device in the network:

- **RF Hop Sequence**
- **Network ID**

Step 3

For RF407 stand-alone radios, check the **Baud Rate** and **Active Interface** setting and verify that they are correct for your network.

Appendix A. Updating CRVW3 Firmware

From time to time, Campbell Scientific will release updates to the CRVW3 firmware (also known as the *Operating System* or *OS*) which will improve the operating stability of the product and may introduce minor feature enhancements. Once published, these are available for download from the Campbell Scientific website:

www.campbellsci.com/downloads

The version of the OS currently active in the CRVW3 is shown in the **Status** table (as **OSVersion**) which can be viewed in the **Data Monitor** tab of *DevConfig* or in the **Table Monitor** in the *Connect Screen* of *LoggerNet*. The version of the OS is also shown in the **Main** tab on the **Settings Editor** tab of *DevConfig*. A date (**OSDate**) and signature (**OSSignature**) are also shown to help ensure proper installation. Compare your current OS version to that available on the website to determine whether an update is required. Campbell support personnel may also provide you with a CRVW3 OS under certain circumstances.

The OS is packaged as an *.obj file. This file can be sent to the CRVW3 using *DevConfig* or *LoggerNet*. When the CRVW3 receives an *.obj file, the update of the firmware is triggered automatically.

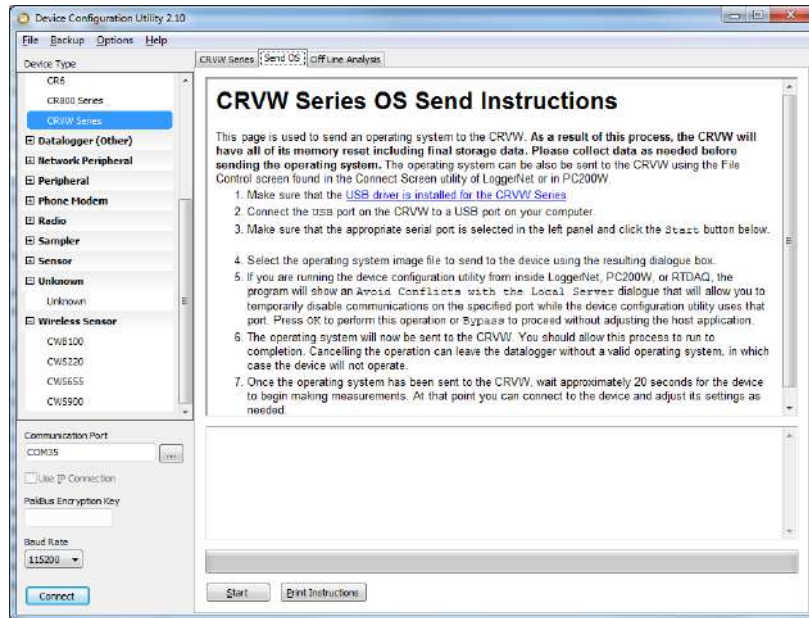
NOTE

Any attempt to send a new OS to the CRVW3 will reset the final storage on the device. You should collect any data needed from the CRVW3 before making any attempt to update its OS. The settings of the device will remain intact.

To install the OS with *DevConfig*:

1. Open *DevConfig* and choose the **CRVW Series** for the device.
2. Choose the **Send OS** tab.

3. Follow the instructions shown in this screen, including using the **Start** button to browse to the *.obj file.



4. The OS file will be read, sent to the CRVW3, and the operating system will be loaded. A progress bar will be shown during the send process. Do not remove power from the device during this time.
5. After the OS is sent, a period of about 25 seconds is required to fully load the OS and restart the device. Watch for both LEDs to flash together rapidly just before the completion of the update. Do not attempt to connect to the device during this time.
6. After the load process is complete, connect to the device and confirm in the **Main** tab or in the **Data Monitor** tab that the correct OS was loaded.

To install the OS to a remote CRVW3 using *LoggerNet*:

1. Ensure all data is collected from the CRVW3. Consider saving the settings of the device to an *.xml file using the **Settings** screen (**Settings Editor...** from the **Datalogger** menu of *Connect Screen*).
2. Open the *Connect Screen* of *LoggerNet* and connect to the CRVW3 station that will receive the update.
3. Open the **File Control** screen, press the **Send...** button.
4. Browse to the *.obj file, select it and press **Open**.
5. Carefully review the warning, press **OK** if no further preparation is needed, otherwise **Cancel**.
6. The file is sent over the radio link to the remote CRVW3 and the OS update occurs automatically.

7. After the OS is sent, a period of about 25 seconds is required for the CRVW3 to fully load the OS and restart itself. Do not attempt to connect to the device during this time.
8. When the load is complete, connect to the device and confirm in the **Status** table with the **Table Monitor** that the proper OS was loaded.

CAUTION

There is a risk that communications may be lost from *LoggerNet* to the remote CRVW3 if something goes wrong during *LoggerNet* OS load process. Ensure you have a solid radio communications channel with the device before sending the OS update using *LoggerNet* and **File Control**.

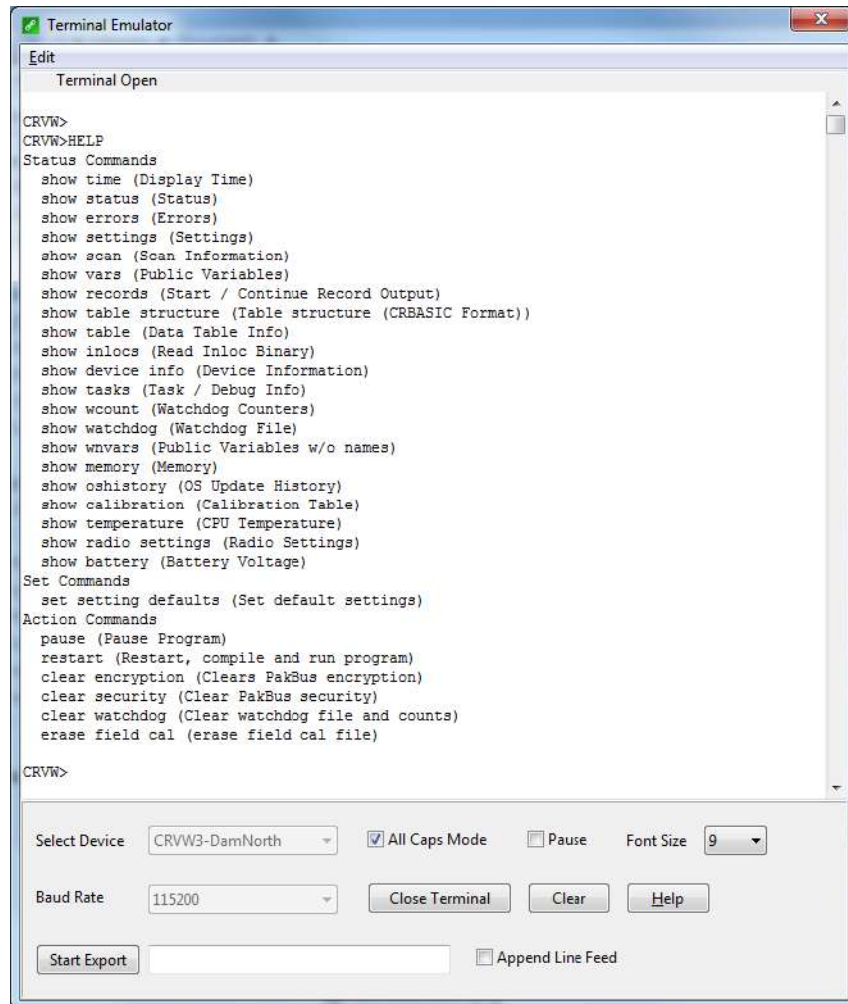
You can use **File Control** in *PC400* or *PC200W* in a similar way to that described above to send an OS to the CRVW3.

Appendix B. Terminal Mode from Connect Screen or DevConfig

You can use the terminal mode of a CRVW3 datalogger to perform troubleshooting and configuration of the device. You should usually have contact with Campbell Scientific support personnel before using this feature. The two most common ways to access the terminal mode are within *DevConfig* 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 (i.e., without having to travel to the CRVW3 site).

In *DevConfig*, connect to the CRVW3 and choose the **Terminal** tab. Click in the screen and press <Enter> several times. You should get the **CRVW>** terminal prompt. Type “help” and press <Enter>. A list of possible terminal commands will be given. Choose a command, type its name, along with any required arguments, and press <Enter>. If you wait too long between entering commands, you will need to press <Enter> several times again to restore the terminal session.

In the *Connect Screen* of *LoggerNet*, connect to the CRVW3 of interest. From the **Datalogger** menu, choose the **Terminal Emulator...** item. The **Terminal Emulator** screen will appear. Click the **Open Terminal** button. Click in the box and press <Enter> several times. You should get the **CRVW>** terminal prompt. Type “help” and press <Enter>. A list of possible terminal commands will be given. Choose a command, type its name, along with any required arguments, and press <Enter>. If you wait too long between entering commands, you will need to press <Enter> several times again to restore the terminal session. When finished with the terminal session, press the **Close Terminal** button.



NOTE

When you use the **pause** instruction from the CRVW3 terminal, the program is temporarily stopped. However, after 2 hours, the program will automatically resume. When the program resumes, a watchdog.txt file is written which contains the following text:

“Watchdog timer Run Program Service triggered.”

When you see this watchdog.txt file show up, there is no need for concern. It just indicates that the program automatically resumed.

Appendix C. Aggregating Dataloggers

When you deploy a network of CRVW3 devices using radio telemetry, you have the option of placing an aggregating datalogger into that network. An aggregating datalogger is a Campbell Scientific CR300-series, CR6-series, CR1000, CR3000, or CR800-series datalogger that connects to CRVW3 devices over a radio link and collects data from them. That data is stored on the datalogger (i.e., aggregated) for later retrieval by *LoggerNet* software or other means. For simple radio networks as well as for many other radio network configurations, an aggregating datalogger may not be necessary.

An aggregating datalogger 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 datalogger. This will be an RF450 device, an RF451 device, or an RF407 device. The CR6 is available with the –RF451 or –RF407 option which will provide a built-in radio option for connecting to the CRVW3 network. CR300-series dataloggers are also available with the built-in –RF407 option.

Some of the reasons why you would use an aggregating datalogger are:

- You use a system other than *LoggerNet* that can communicate with the CR300, CR6, CR1000, CR3000, or CR800 devices (ModBus, etc.) but not the CRVW3 devices
- Sensors other than vibrating-wire sensors need to be measured as part of the system
- You want to aggregate the CRVW3 data for backup or redundancy purposes
- You want to have only one point of contact for data within *LoggerNet* (in this case the aggregator is the base station)

If you choose to use an aggregating datalogger, you must include specific kinds of *CRBasic* declarations and instructions in the datalogger program that instruct it to contact the CRVW3 devices and collect their data. This includes the use of the **GetDataRecord()** instruction. You should also consider the cost of purchasing and deploying an additional station.

C.1 Aggregator Station Configuration

You should ensure that proper power, enclosure, grounding, and mounting options are available for the aggregating datalogger station. If the aggregator station communicates with more than one remote station (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 communication must be used between the datalogger and *LoggerNet* (serial cable, TCP/IP, cell modem, etc.). If no connection to *LoggerNet* is configured, regular visits to the datalogger to collect the aggregated data must be made.

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

When the aggregator station is to be the base station on an RF451 radio network, the RF450 or RF451 radio connected or built-in to the datalogger should be configured as the master radio. Otherwise, it should be configured as a Slave or Slave/Repeater radio. Use a portable base station or portable *LoggerNet* laptop to confirm the operation of the aggregator before leaving the site. Review Section 10, *Complex (Large) Radio Networks (p. 58)*, for more details about deploying radio stations.

C.2 Programming the Aggregator

In the *CRBasic* program running on the aggregating datalogger, you must define a separate table for each CRVW3 station from which data will be collected, and declare appropriate variables for those stored values. The datalogger will collect the **VW_Data** table from each CRVW3. In order for this to work properly, the definition of the table in the CRVW3 and in the datalogger program must match each other. To obtain this table definition (a *DataTable/EndTable* structure) you must execute the “show table structure” terminal mode command 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 Appendix B, *Terminal Mode from Connect Screen or DevConfig (p. B-1)*.

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 again. Whenever possible, finalize the settings of the CRVW3 before retrieving its structure for use in the datalogger program.

Once the tables have been set up in the program properly, you 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 datalogger. 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. A sample program is given in Appendix D, *GetDataRecord Sample Program (p. D-1)*.

Appendix D. GetDataRecord Sample Program

CRBasic Example D-1. Using GetDataRecord to Extract Data From a CRVW3

```
GetDataRecordFromCRVW3.CR1

'Campbell Scientific CR1000
'This program demonstrates how to use
'the GetDataRecord instruction to extract
'data from the CRVW3's final storage tables

'Result codes for GetDataRecord instructions
Public GDRResult1, GDRResult2

'The following declarations and table definitions were extracted
'from the CRVW3 terminal mode's "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 re-inserted 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)
    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 CRW3 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 = -100 to get the 100 most recent records in timestamped order
  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 E. Engineering Output and Calibration

The basic measurement outputs given by the CRVW3 are sensor frequency and sensor temperature (if a thermistor is used). 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.

E.1 Engineering Output

The frequency reading on the CRVW3 is expressed both in units of Hertz (Hz) and in units of digits (Hz²/1000). The CRVW3 can be configured to calculate an output value that is specified in engineering units (in units of measure or dimensions). Examples of units are kPa, millibar, mmHg, mmH₂O, inches, feet, or meters for piezometers, $\mu\epsilon$ (microstrain) or ϵ (strain) for strain gages, kilograms, tons, or pounds for load cells, mm or inches for crackmeters, and so forth. The CRVW3 implements a polynomial that works with most vibrating-wire sensors, and uses frequency and temperature as inputs.

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. You should study the manual carefully to understand what factors are used to make these calculations. 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. You will need this information when configuring the settings of the CRVW3 to obtain the desired result. You should work out most of the details for calculating engineering output by using typical sensors in the lab or office. This will help ensure that the field deployment process will proceed as smoothly as possible.

The settings used on the CRVW3 to configure engineering output are found on the **Channel1**, **Channel2**, and **Channel3** tabs of the **Settings Editor** tab in *DevConfig*. Section 8.1.5, *Configuring the CRVW3* (p. 23), discusses basic information for using *DevConfig* to configure the CRVW3.

If you will use a temperature reading as part of the output calculation, you should set **Thermistor Enabled** to **True**, and enter the thermistor coefficient A, B, and C values for Steinhart-Hart conversion. You can't use a temperature reading as part of the calculation unless it is expressed in units of Degrees Celsius (raw resistance in Ohms will not work).

Enable the calculation to occur by setting **Calculate Engineering Output** to **True**. Enter the desired output units in the **Engineering Units** box. This is a string representing the units of measure for the calculated output values (mm, feet, kilograms, kPa, $\mu\epsilon$, etc.).

If your sensor manual uses digits as the frequency input for calculating engineering units, set the **UseDigits** setting to **True**. At that point, the polynomial used for calculation will be based on digits and temperature, and frequency in Hz will *not* be used. When **UseDigits** is **False**, the polynomial

used will be based on frequency (Hz) and temperature and digits will *not* be used.

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* represents digits, *t* represents temperature, and the upper-case letters are 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* represents the frequency in Hz, *t* represents temperature, and the upper-case letters are user-specified coefficients (constants).

For the proper calculation to occur, you must discern from your sensor documentation which coefficients of the polynomial are relevant (**A,B,C,D,E** and **F**), and set all other coefficients to zero, so that they have no impact on the output calculation. Do this by comparing your sensor manual's calculation equations to the polynomials listed above. 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.

Once you know which coefficients to use, enter their values using *DevConfig*. To specify the coefficients/constants of either polynomial shown above, use the following CRVW3 settings:

Use this <i>DevConfig</i> 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

Please refer to the *DevConfig* online help topics for the **UseDigits** and **Calculate Engineering Output** settings for more information. Relevant help information is also found in the *DevConfig* help topics for each coefficient setting listed in the above table.

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 or ChanX is the name you gave to the sensor/channel.

E.2 Calibration of Sensors

To enable in-field calibration on the CRVW3, set the **Use Baseline Offsets** setting to **True**, or set the **Use Ambient Pressure Correction** setting 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. This is found in the **Datalogger** menu of the *Connect Screen* application in *LoggerNet*.

For more information about the calibration process and using the Calibration Wizard, see Section 9 of the *RTDAQ* manual:

s.campbellsci.com/documents/us/manuals/rtdaq.pdf

You can also refer to Section 5.1.12 and Appendix F of the *LoggerNet* manual:

s.campbellsci.com/documents/us/manuals/loggernet.pdf

You may 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 (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 **Public** table of the CRVW3. The public variable's value will be subtracted from the calculated engineering result to give the final engineering output.

The public variables used are shown in this table:

Public Variable	Channel Number
Pressure_Chanel_FC	1
Pressure_Chanel2_FC	2
Pressure_Chanel3_FC	3
Pressure_All	All

When the **Pressure_All** variable is used (i.e. set to a non-zero value), all enabled channels will use that value. If **Pressure_All** is left at zero, the values given for individual channels will be used.

NOTE

It will be necessary to set the values of these variables from an external datalogger (such as a CR1000) that has measured the current atmospheric pressure. The datalogger should use the **SendVariables** PakBus instruction or similar in its *CRBasic* program to accomplish this.

Appendix F. 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 was able to maintain 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 (IEC61000-4-5).

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 ports of the CRVW3 are subjected to 4000 volt bursts and the signal and control ports 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.

Please note that these tests are not intended to test the capability of the CRVW3 or any other electronic devices to withstand primary lightning strikes.

Campbell Scientific Companies

Campbell Scientific, Inc.

815 West 1800 North
Logan, Utah 84321
UNITED STATES

www.campbellsci.com • info@campbellsci.com

Campbell Scientific Canada Corp.

14532 – 131 Avenue NW
Edmonton AB T5L 4X4
CANADA

www.campbellsci.ca • dataloggers@campbellsci.ca

Campbell Scientific Africa Pty. Ltd.

PO Box 2450
Somerset West 7129
SOUTH AFRICA

www.campbellsci.co.za • cleroux@csafrica.co.za

Campbell Scientific Centro Caribe S.A.

300 N Cementerio, Edificio Breller
Santo Domingo, Heredia 40305
COSTA RICA

www.campbellsci.cc • info@campbellsci.cc

Campbell Scientific Southeast Asia Co., Ltd.

877/22 Nirvana@Work, Rama 9 Road
Suan Luang Subdistrict, Suan Luang District
Bangkok 10250
THAILAND

www.campbellsci.asia • info@campbellsci.asia

Campbell Scientific Ltd.

Campbell Park
80 Hathern Road
Shepshed, Loughborough LE12 9GX
UNITED KINGDOM

www.campbellsci.co.uk • sales@campbellsci.co.uk

Campbell Scientific Australia Pty. Ltd.

PO Box 8108
Garbutt Post Shop QLD 4814
AUSTRALIA

www.campbellsci.com.au • info@campbellsci.com.au

Campbell Scientific Ltd.

3 Avenue de la Division Leclerc
92160 ANTONY
FRANCE

www.campbellsci.fr • info@campbellsci.fr

Campbell Scientific (Beijing) Co., Ltd.

8B16, Floor 8 Tower B, Hanwei Plaza
7 Guanghua Road
Chaoyang, Beijing 100004
P.R. CHINA

www.campbellsci.com • info@campbellsci.com.cn

Campbell Scientific Ltd.

Fahrenheitstraße 13
28359 Bremen
GERMANY

www.campbellsci.de • info@campbellsci.de

Campbell Scientific do Brasil Ltda.

Rua Apinagés, n.br. 2018 — Perdizes
CEP: 01258-00 — São Paulo — SP
BRASIL

www.campbellsci.com.br • vendas@campbellsci.com.br

Campbell Scientific Spain, S. L.

Avda. Pompeu Fabra 7-9, local 1
08024 Barcelona
SPAIN

www.campbellsci.es • info@campbellsci.es

Please visit www.campbellsci.com to obtain contact information for your local US or international representative.