PRODUCT MANUAL

Communications Device

RF451/RF452

Spread Spectrum Radios

Revision: 03/2026

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RELIABLE MONITORING SINCE 1974

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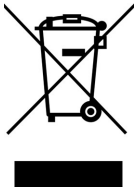
About this manual

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

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

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



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

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1. Introduction

The RF451/RF452 Spread Spectrum Radio is a 900 MHz license-free radio specifically designed to work with Campbell Scientific data loggers and existing RF450/RF451/RF452 networks. RF452 radios consist of a FreeWave® MM3 LV-T radio module and an interface board. RF451s and RF450s contain the MM2 LV-T and DGR09 radio models, respectively.

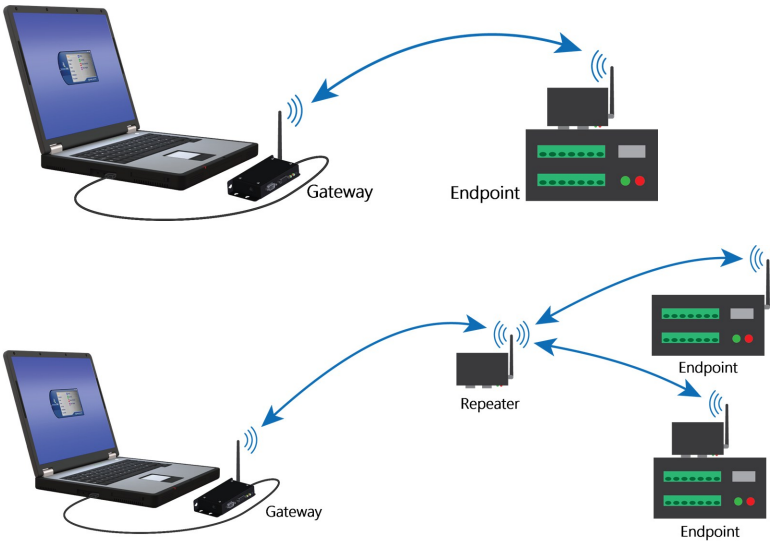
This manual addresses the RF451/RF452 interface with CR6, CR1000X, CR800-series, CR350-series, CR300-series, CR3000, and CR1000 data loggers and a computer running ***LoggerNet***. Additionally the CR6 and CR350-series data loggers have an integrated RF451/RF452 option.

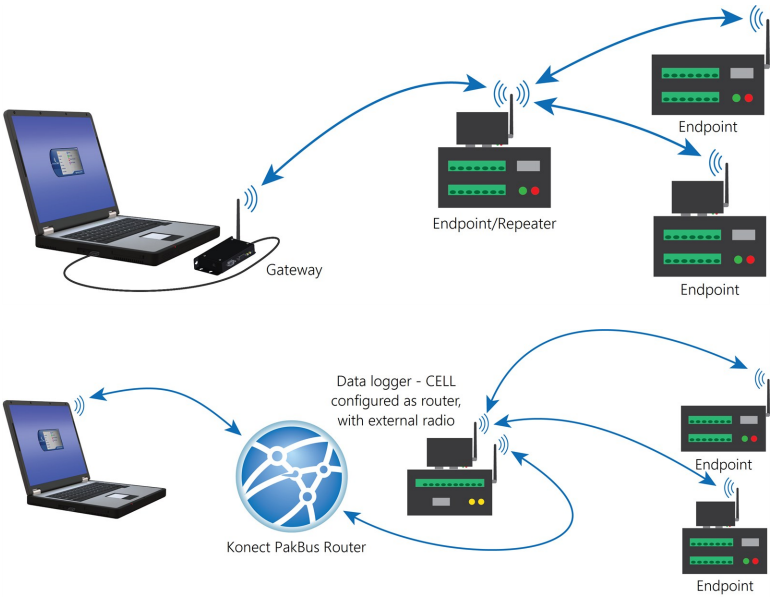
Though the radios may be set up in a point-to-point mode, this manual will only address multi-point applications, as this is the only way to take advantage of the low-power mode of the endpoint radios at the data logger site. This reduces the required power at remote sites from about 75 mA to less than 10 mA in most applications.

> NOTE:
> This manual replaces the terms Master with *Gateway* and Slave with *Endpoint*.

1.1 Configuration options

The following images show the most frequently used configurations with the RF-series data logger and RF-series radio:





2. Precautions

- IMPORTANT — Radios must be configured to use the proper hop table version to comply with local laws and to avoid interference with other RF installations such as cellular services. The **Hop Table Version** setting allows the user to choose the portion of the band in which the transceiver will operate. Radios purchased through Campbell Scientific for use outside of the United States and Canada will have the country-specific **Hop Table Version** set.
- READ AND UNDERSTAND the Safety section at the back of this manual.
- This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. See FCC notifications (p. 26) for more information.
- Line-of-sight obstructions and RF interference will affect the transmission distance. See Line of Sight Technical Paper and Link Budget Technical Paper for a discussion of antenna gain and other factors affecting distance.
- **WARNING:**
  Connect a suitable load to the antenna port before applying DC power to the RF451/RF452. This load should be either a 50-ohm antenna or an attenuator with a power rating of 2 watts or higher. Failure to follow this procedure may damage the radio voiding the warranty.

3. Initial inspection

- Upon receipt of the RF451/RF452, inspect the packaging and contents for damage. File damage claims with the shipping company. Contact Campbell Scientific to facilitate repair or replacement.
- Immediately check package contents against shipping documentation. Thoroughly check all packaging material for product that may be trapped inside it. Contact Campbell Scientific immediately about any discrepancies. Model numbers are found on each product. On cables, the model number is often found at the connection end of the cable.

4. QuickStart

WARNING:
Connect a suitable load to the antenna port before applying DC power to the RF451/RF452. This load should be either a 50-ohm antenna or an attenuator with a power rating of 2 watts or higher. Failure to follow this procedure may damage the radio voiding the warranty.

1. Using *Device Configuration Utility* set a unique **PakBus™ Address** for each data logger in the network. Keep the other settings at their default. See Configuring the RF451/RF452 (p. 7).
2. Decide on a unique **Network ID** between 0 and 4095, excluding 255. All radios in the network will use the same **Network ID**.
3. Select a **Frequency Key** between 0 and 14. It is recommended that you change this from the default value of 5. Generally, all radios in the network will have the same Frequency Key.
4. Select one radio to be the gateway; the others will be designated as endpoints. The radio designated as a gateway is able to simultaneously communicate with numerous endpoints.
5. Endpoint radios: Using *Device Configuration Utility*, set the **Radio Operation Mode** to **Endpoint**. Set the **Network ID** to the number decided upon in step 2. Set the **Frequency Key** to the number decided upon in step 3. Set the **Radio ID** to the **PakBus Address** assigned in step 1. Keep the remaining settings at their defaults.

> **TIP:**
> The **Radio ID** setting allows a transceiver to be designated an arbitrary, user-selectable, 4-digit number which identifies the transceiver in diagnostics mode. When used in conjunction with PakBus data loggers, we recommend this setting be assigned the PakBus address of the station. This is because the Radio ID appears in the Network Diagnostics application within the FreeWave Tool Suite software, and it allows the user to associate a particular data logger with its attached radio.

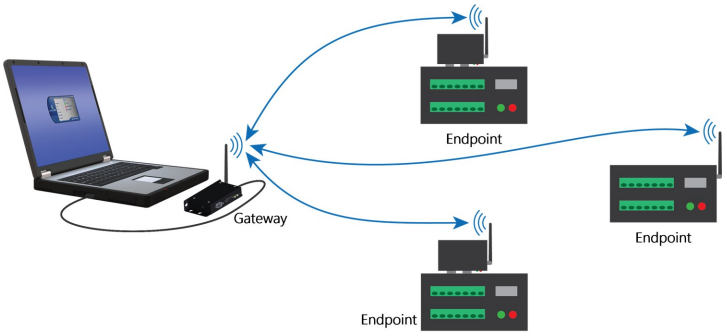
> **NOTE:**
> If RF450/RF451/RF452 repeaters will be used, select **Endpoint/Repeater** as the **Radio Operation Mode** for all endpoint/repeaters in the network (that is, radios that are being used as a repeater but also have a data logger attached). Select **Repeater** as the **Radio Operation Mode** for all standalone repeaters in the network (that is, radios that are being used only as a repeater without a data logger attached). Select the **Repeaters Used** box for all radios in the network.

6. Gateway radio: Using ***Device Configuration Utility***, set the **Radio Operation Mode** to **Gateway**. Set the **Network ID** to the number decided upon in step 2. Set the **Frequency Key** to the number decided upon in step 3. Set the **Radio ID** to the **PakBus Address** assigned in step 1. If the gateway radio will be at computer running ***LoggerNet***, set the **Active Interface** to **USB** or **RS-232** depending on how ***LoggerNet*** will be communicating with the RF451/RF452. Keep the remaining settings at their defaults. (See previous note regarding repeaters.)
7. Select a data logger or a computer running ***LoggerNet*** to be a router. Using ***Device Configuration Utility***, set this node to beacon. See LoggerNet setup (p. 19). Attach the gateway radio to this node.

5. Overview

The transceiver (radio) designated as a gateway is able to simultaneously communicate with numerous endpoints. In its simplest form, the network functions with the gateway broadcasting its messages to all endpoints, and the endpoints responding to the gateway when given data by the data logger connected to its data port.

NOTE:
There may be only one RF451/RF452 or RF450 gateway in a network, and it must be connected to a PakBus™ router. The PakBus router may be software, such as ***LoggerNet*** or ***PC400***, or a data logger configured as a router.



Outbound packets from the gateway or repeater to the endpoints or other repeaters are sent a set number of times determined by the user. The receiving transceiver, endpoint or repeater, will accept the first packet received with the correct signature (32-bit CRC). However, the packet is not acknowledged. On the return trip to the gateway, all packets sent are acknowledged or retransmitted until they are acknowledged. Therefore, the return link is generally very robust.

Traditionally, a network is used in applications where data is collected from one to many data loggers and reported back to one central site. The central site is typically a computer running ***LoggerNet***, but could be a data logger. Refer to Installation examples (p. 27) for different installation scenarios.

6. Specifications

Frequency:	902 to 928 MHz
Transmit	
Output power:	10 mW to 1 W, user selectable
Range:	20 to 95 km (13 to 60 miles) assuming ideal conditions, line-of-sight, and appropriate antenna Note that line-of-sight obstructions, RF interference, and antenna type will affect transmission distance. Maximum distances can be greatly reduced by vegetation, line-of-sight obstacles, humidity levels, and other environmental and physical factors.

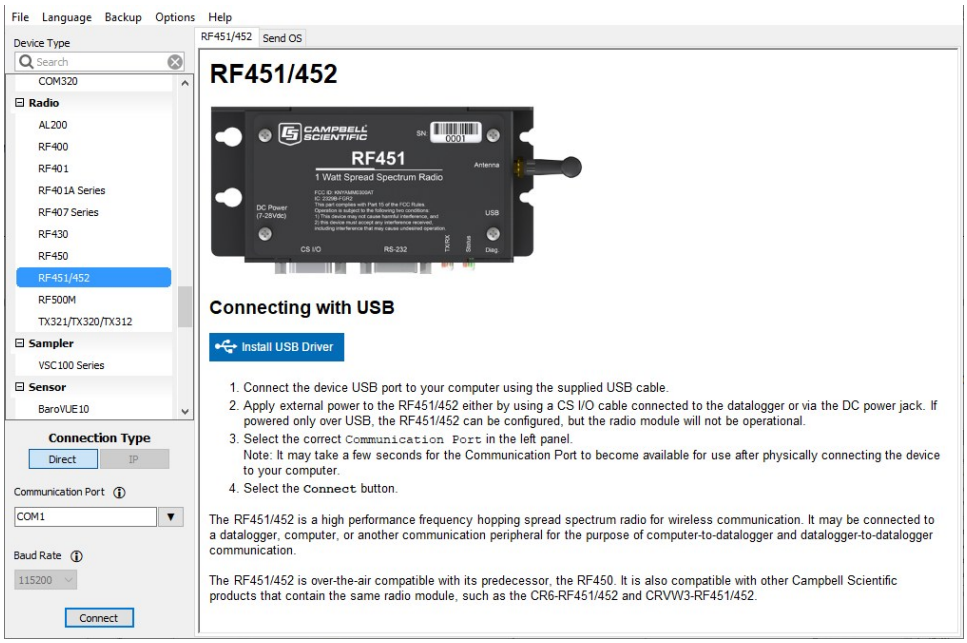
Modulation:	2 level GFSK
Spreading method:	Frequency hopping
Occupied bandwidth:	142 kHz (applicable to FCC ID KNYAMM0921TT)
Hopping patterns:	15 per band, 105 total, user selectable
Hopping channels:	50 to 111, user selectable
Hopping bands:	7, user selectable
Frequency zones:	16 zones
Maximum number of repeaters in a network:	4
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 fc ± 230 kHz
RF selectivity:	60 dB at 896 MHz, 935 MHz
Dynamic range:	+10 dBm 3rd 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
Data interface	
Protocol:	RS-232, USB, CS I/O SDC, and CS I/O ME Gateway; user selectable
RS-232 baud rate:	1200 bps, 4800 bps, 9600 bps, 19.2 kbps, 38.4 kbps, 57.6 kbps, 115.2 kbps; user selectable
Connectors:	DB9, USB Type B
Antenna:	Reverse Polarity SMA (RPSMA) jack (female). External antenna required.
Power requirements	
Voltage:	7 to 28 VDC

Current	
Transmit:	650 mA
Receive:	40 mA
Idle:	15 mA
Sleep:	6 mA
Environmental	
Operating temperature:	–40 to 85 °C
Dimensions:	2.74 x 7.01 x 13.61 cm (1.08 x 2.76 x 5.36 in)
Weight:	0.18 kg (0.4 lb)
Humidity:	0 to 95% non-condensing
Compliance	
FCC ID:	RF452: KNYMM3
	RF451: KNYAMM0921TT
Industry Canada (IC):	RF452: 2329B-MM3
	RF451: 2329B-AMM0921TT
Documents:	View at: www.campbellsci.com/rf451 and www.campbellsci.com/rf452

7. Configuring the RF451/RF452

Radios are configured using the Campbell Scientific ***Device Configuration Utility*** software tool that comes with ***LoggerNet***. ***Device Configuration Utility*** is also available for free from the Campbell Scientific website. The following general procedure is used to configure an RF451/RF452 radio via ***Device Configuration Utility***:

1. Launch *Device Configuration Utility* from the *LoggerNet* toolbar **Utilities** category.
2. From the **Device Type** list, select the **RF451/RF452**. Information, instruction, and help are provided on each screen.



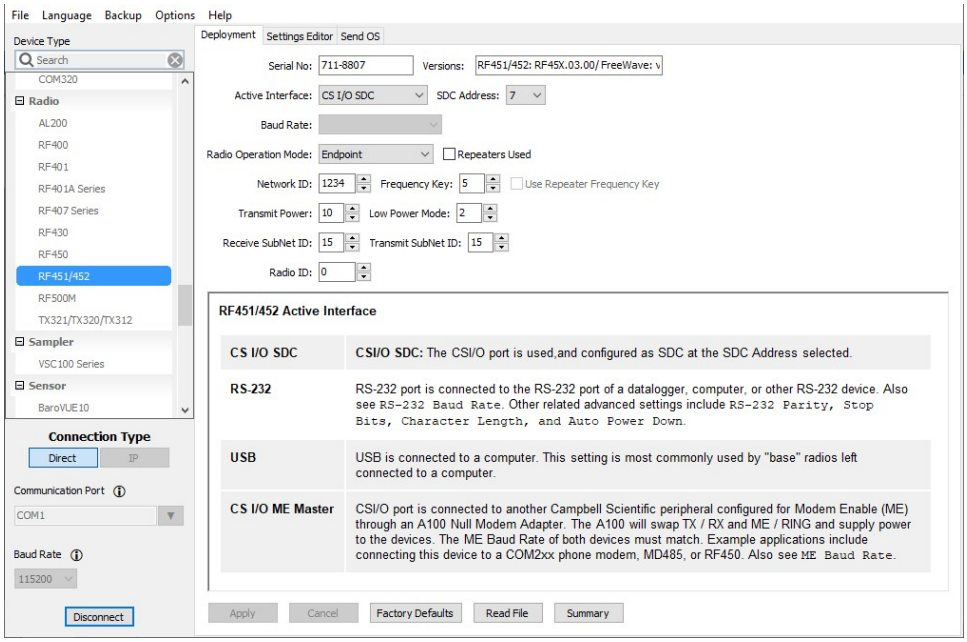
3. Click the **Install USB Driver** button. Carefully review the text on the right side of the screen. Installing the driver only needs to be done the first time the computer is connected to an RF451/RF452.

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

4. With the USB device driver installation complete, connect the supplied USB cable between the USB port on your computer and the USB port on the radio.
5. Select the correct COM port for USB communications with the radio. It should be listed in the dialog as **RF451/RF452 (COM#)** where # is the COM port number.

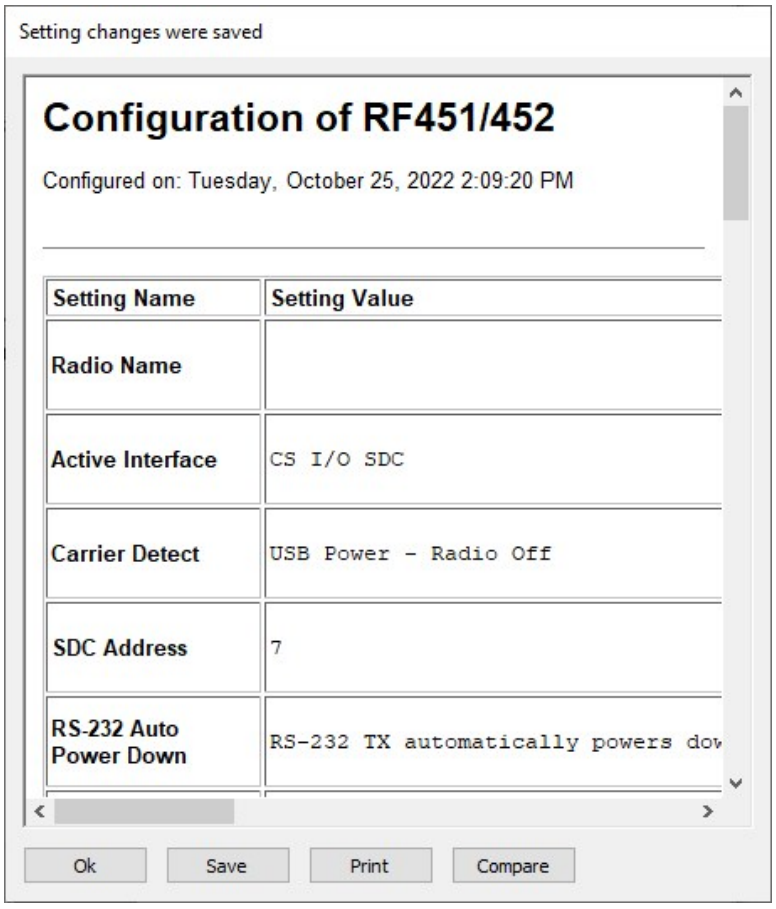
> **NOTE:**
> It may take a few seconds for the **Communication Port** to become available for use after physically connecting the RF451/RF452 to your computer.

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



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

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



7.1 Deployment settings

This section describes the RF451/RF452 **Deployment** tab settings used in Configuring the RF451/RF452 (p. 7).

> NOTE:
> See Installation examples (p. 27) for example radio settings in different network configurations.

7.1.1 Active Interface

Specify the interface that will be used for normal operations. The following active interfaces are available:

- **RS-232:** The RS-232 port is used with the selected **Baud Rate**.
- **CS I/O SDC:** The CS I/O port is used and configured as SDC with the selected **SDC Address**.

- **CS I/O ME Master:** The CS I/O port is used and configured for direct connection to a CSI COM220 or other modem enabled (ME) device such as an MD485. The connection is a type of "null modem" that crosses TX and RX, and ME and RING; this line swapping is done by using an A100. The baud rates of both the COM220 (or other device) and the RF451/RF452 must be the same.
- **USB:** The USB port is used when connected to a computer.

7.1.2 SDC Address

Specifies the SDC address that will be used on the RF451/RF452 CS I/O port when **CS I/O SDC** is selected as the **Active Interface**.

7.1.3 Baud Rate

Specifies the baud rate that will be used on the RS-232 port.

7.1.4 Radio Operation Mode

The **Radio Operation Mode** option designates the method RF451/RF452 transceivers use to communicate with each other. RF451/RF452 transceivers operate in a gateway-to-endpoint configuration. Before the transceivers can operate together, they must be properly set up to communicate.

When setting up the transceiver, remember that a number of parameters are controlled by the settings in the gateway. Also, radio network diagnostics can only be accessed at the gateway radio. Therefore, it is recommended that you deploy the gateway on the communications end where it will be easier to access.

- **Gateway**: This operation mode designates the radio as the gateway. This mode allows the gateway to communicate simultaneously with numerous endpoints, repeaters, and endpoint/repeaters. There can be only one gateway radio in the radio network.
- **Endpoint**: This operation mode designates the radio as an endpoint. This mode allows the endpoint to communicate with the gateway. The endpoint will send packets received from the gateway to the device attached to the active interface (CS I/O or RS-232) and send data received from the device attached to the active interface to the gateway. Endpoints may communicate with the gateway through one or more repeaters and/or endpoint/repeaters.

- **Repeater**: This operation mode designates the radio as a repeater. This mode allows the repeater to repeat packets sent across the radio network to the gateway, endpoints, other repeaters, and endpoint/repeaters. Repeaters may communicate with the gateway through one or more other repeaters and/or endpoint/repeaters.
- **Endpoint/Repeater**: This operation mode designates the radio as an endpoint/repeater. This mode allows the endpoint/repeater to operate as both an endpoint and a repeater. The endpoint/repeater will repeat packets sent across the radio network to the gateway, endpoints, repeaters, and other endpoint/repeaters. In addition, the endpoint/repeater will send packets received from the gateway to the device attached to the active interface (CS I/O or RS-232) and send data received from the device attached to the active interface to the gateway. Endpoint/repeaters may communicate with the gateway through one or more repeaters and/or other endpoint/repeaters.

7.1.5 Network ID

All radios in a network need to have the same **Network ID**. The value must be between 0 and 4095 (excluding 255). The ID of 255 is reserved.

An endpoint will link with the first gateway or repeater it hears with a matching **Network ID**. Assigning a unique **Network ID** will reduce the chance a radio in your network links with another, unrelated network in the same RF area.

If necessary, the **Network ID** function can be used in conjunction with the **SubNet ID** feature. See Subnet ID (p. 15) for more information.

7.1.6 Frequency Key

The **Frequency Key** determines the frequency hopping sequence of the transceiver. There are 15 choices available (0–14) which represent 15 unique pseudo-random hop patterns. This setting allows you to minimize RF interference with other FreeWave transceivers operating in the same RF area.

> NOTE:
> The **Frequency Key** setting should be the same for all radios in the entire network. The exception to this is if the **Repeater Frequency Key** setting is used. If this is used, the repeater's **Frequency Key** would be different from the gateway radio, and downstream radios intended to connect to the repeater would have the same **Frequency Key** setting as the repeater.

7.1.7 Repeater Frequency Key

This is a setting that is only used by repeaters. The **Use Repeater Frequency Key** checkbox must be selected when you want a repeater to use a **Frequency Key** other than that of the gateway.

This is useful when there are parallel repeaters in a network, and you want to force communications through a particular repeater. When this setting is used, the repeater will receive on the **Frequency Key** of the upstream gateway (or repeater), and transmit on its **Frequency Key** setting (which typically is set to a different value than the gateway).

By default, the **Use Repeater Frequency Key** checkbox is left cleared, which causes the repeater to transmit on the gateway **Frequency Key**.

> **NOTE:**
> When the **Repeater Frequency Key** checkbox is left cleared, the **Frequency Key** setting should match that of the gateway or of the repeater acting as the gateway for that transceiver.

7.1.8 Transmit Power

This setting specifies the RF transmit power.

> **TIP:**
> Use a transmit power of 0 when bench testing to reduce RF exposure.

The FCC specifies a maximum EIRP (Effective Isotropic Radiated Power) of 36 dBm.

EIRP = (Transmitter Power) + (Antenna Gain) - (Cable Losses) [all in dB or dBm]

Radio installations should be performed by a professional. It is very important that the transmit power level selected and the gain of the attached antenna do not exceed the maximum allowed EIRP permitted by local regulations. Regulations vary by country and region. As the equipment owner, you are responsible for making sure that your installation and maintenance of the radio equipment ensure local regulations are met. For example, in much of the United States, FCC part 15 rules limit the 900 MHz, ISM band transmission from the RF451/RF452 to a maximum effective radiated power of +36 dBm.

The RF451/RF452 maximum power is 30.0 dBm; therefore, a 6 dB (or lower) gain antenna can be used with any **Transmit Power** setting. If a higher gain antenna is used, the cable loss will need to be determined, and the **Transmit Power** adjusted so as not to exceed the FCC limit of +36 dBm.

NOTE:
A lower **Transmit Power** can be used (to conserve battery power) if the required range allows it.

Table 7-1 (p. 14) shows the RF451/RF452 RF transmit power versus the setting.

Table 7-1: Transmit power settings

RF transmit power setting	RF power (dBm)	RF power (mW)
10	30.0	1000
9	29.0	800
8	27.8	600
7	26.8	480
6	25.2	330
5	23.6	230
4	21.5	140
3	19.0	80
2	15.4	35
1	10.0	10
0	7.0	5

7.1.9 Low Power Mode

This setting allows an endpoint to consume less power. This is achieved primarily by dimming the transceiver LEDs. When set to **2** through **31**, the transceiver will sleep between slots. For example, at a setting of **2**, the transceiver sleeps 1 out of 2 slots; at a setting of **3**, the transceiver sleeps 2 out of 3 slots, and so on.

Table 7-2 (p. 15) shows the changes at different **Low Power Mode** settings. The actual current draw depends on many factors. The following table gives only a qualitative indication of supply current savings. A low number reduces latency and a high number reduces current consumption. An optimum setting (balancing latency and power savings) is **2** or **3**.

Table 7-2: Low power mode settings	
Setting	Description
0	Disabled
1	Transceiver remains awake, listening for the gateway radio transmission on every slot.
2	Transceiver sleeps every other slot
3	Transceiver sleeps 2 of 3 slots
4–31	Transceiver sleeps the number of slots corresponding to one less than the setting. For example, with a setting of 31, the transceiver sleeps 30 of 31 slots.

Low Power Mode is used only in endpoints. Power savings occur only when the endpoint is linked. There are no power savings when the endpoint is transmitting data. Low power mode is of little value when an endpoint has a constant, high throughput.

7.1.10 Subnet ID

An endpoint or repeater will connect with the first repeater or gateway that it hears with the same **Network ID**. There are scenarios, however, where communications need to be forced to follow a specific path. For instance, the **SubNet ID** is particularly helpful to force two repeaters in the same network to operate in series rather than in parallel; or, to force endpoints to communicate to a specific repeater for load-balancing purposes.

There are two components to the **SubNet ID**:

1. **Receive SubNet ID:** This setting identifies which transceiver a repeater or endpoint will listen to. This setting has no effect on gateway radios; leave it at the default value of 15.
2. **Transmit SubNet ID:** This setting identifies the Network ID on which this device transmits, and, in turn, which devices will listen to it. This setting is only used with gateways and repeaters.

The default setting for both receive and transmit is 15 which disables SubNetwork functions. For the gateway, this setting (15) causes the gateway to actually use 0. So, if the SubNet ID is to be used, the downstream radios that need to connect to the gateway will need their **Receive SubNet ID** set to **0**.

NOTE:
Changing these settings on the gateway is not recommended; under normal circumstances, they should be left at 15, 15. The **Receive SubNet ID** on the gateway has no effect on the network. If both **Receive SubNet ID** and **Transmit SubNet ID** are set to **0**, a mobile endpoint can roam from subnet to subnet and possibly from network to network.

The following figure shows an example of a network built using SubNet IDs.

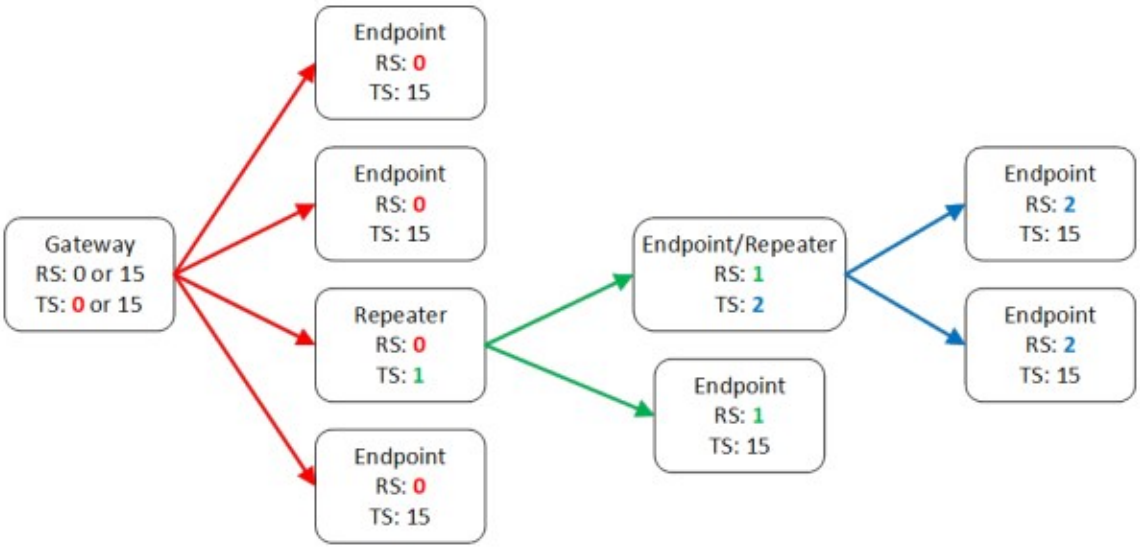


Figure 7-1. Example of network using SubNet IDs

7.1.11 Radio ID

The **Radio ID** setting allows a transceiver to be designated an arbitrary, user-selectable, 4-digit number which identifies the transceiver in diagnostics mode. When used in conjunction with PakBus data loggers, we recommend this setting be assigned the PakBus address of the station. This is because the Radio ID appears in the Network Diagnostics application within the FreeWave Tool Suite software, and it allows the user to associate a particular data logger with its attached radio.

To further this association of the RF451/RF452 RF network with the PakBus network, the data logger reads the serial number of the attached radio and includes this in the data logger settings when the CS I/O SDC interface is used. This serial number is the main radio identifier used by the Network Diagnostics application within the FreeWave Tool Suite software. See https://support.freewave.com/ for more information.

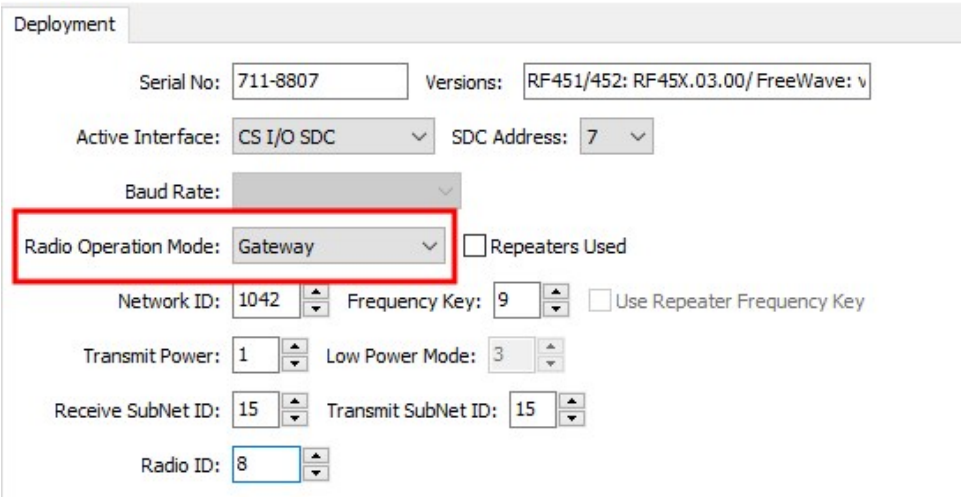
8. Gateway radio

A network can only contain a single gateway radio, either an RF450 or RF451/RF452. Endpoint radios communicate from and to the gateway radio.

> NOTE:
> The gateway RF450/RF451/RF452 must be connected to a PakBus router. The PakBus router may be software, such as LoggerNet or PC400, or a data logger configured as a router.

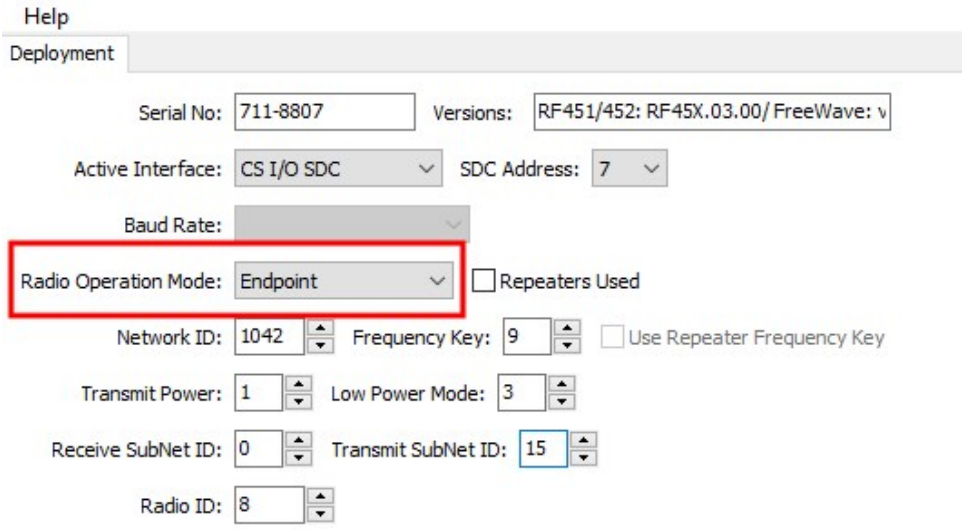
Selecting **Gateway** in the **Radio Operation Mode** designates the transceiver as a gateway. This allows one gateway transceiver to simultaneously be in communications with numerous endpoints and repeaters. A gateway communicates only with other transceivers designated as endpoints, repeaters and endpoint/repeaters.

One setting, **Low Power Mode**, is not applicable to gateway radios, and thus is grayed out in *Device Configuration Utility*.



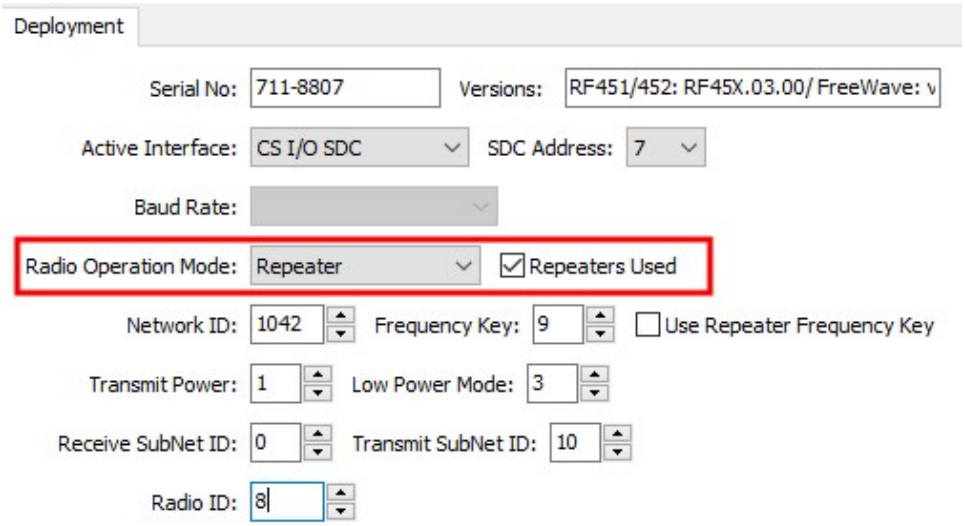
9. Endpoint

Radios configured as endpoints are allowed to communicate with a gateway. The endpoint may communicate with its gateway directly, or through one or more repeaters.



10. Repeater

Setting the **Radio Operation Mode** to **Repeater** allows the transceiver to operate as a repeater. The **Repeaters Used** checkbox should be selected if there are any repeaters in the network; it should be set the same for all transceivers.

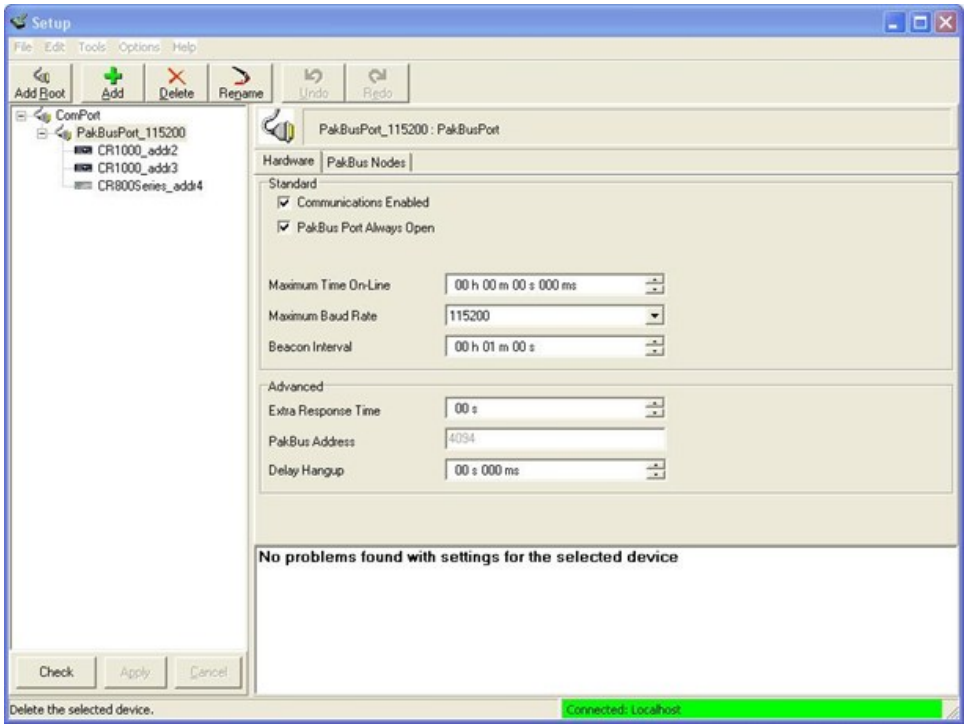


> **NOTE:**
> A maximum of four repeaters are allowed in a network. When a repeater is used, the RF throughput is cut in half. Throughput is the rate at which data is sent or received. Reducing throughput means less data can be transmitted in a specified amount of time.

11. *LoggerNet* setup

The **Network Map** is configured from the ***LoggerNet* Setup** screen. Use the following steps to configure the **Network Map**.

1. Select **Add Root** > **COM Port**.
2. Add a **PakBusPort**. Set the **Maximum Baud Rate** to **115200**. For gateway radios at a computer, set the **Beacon Interval** to **1 minute**.
3. Add data logger. Set the **PakBus Address** to match that of the data logger.
4. **Apply** to save your changes.

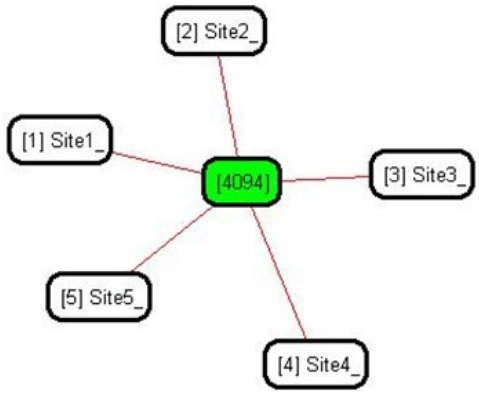


12. PakBus Graph

PakBus Graph is a ***LoggerNet*** utility that graphically depicts the devices and connections in a PakBus data logger network. In ***PakBus Graph***, the ***LoggerNet*** server is typically represented by PakBus address 4094, and each of the PakBus data loggers that have been configured in Setup will be shown by its PakBus address in brackets followed by its name assigned through ***LoggerNet*** Setup.

Because RF451/RF452 networking protocols, not PakBus protocols, are used to direct packets, the network representation in ***PakBus Graph*** may be significantly different than one would expect. The following figure depicts the physical network of five data loggers and one ***LoggerNet*** server. Data loggers numbered 1 and 2 route packets to other data loggers from the ***LoggerNet*** server.

This same network will be depicted in ***PakBus Graph*** as shown in the following figure. Data loggers numbered 1 and 2 have RF451/RF452 radios configured as endpoint/repeaters. The RF451/RF452 radios are doing the networking, not the PakBus data loggers.



13. Transceiver location

Placement of the transceivers is likely to have a significant impact on its performance. The key to the overall robustness of the radio link is the height of the antennas and the line-of-sight between antennas. Additionally, longer cable lengths have higher losses. See Transmit Power (p. 13) for more information.

Line-of-sight obstructions and RF interference will affect the transmission distance. See Line of Sight Technical Paper and Link Budget Technical Paper for a discussion of antenna gain and other factors affecting distance.

14. Power considerations

The RF451/RF452 radio requires 7 to 28 VDC power. This may be supplied through one of the following:

- a wall charger connected to the DC power jack on the side of the radio
- the data logger via the **CS I/O** port
- a field power cable connected to the data logger **12V** and **G** and the DC power jack on the side of the radio

NOTE:
The RF451/RF452 can be powered by USB for configuration only. When power is being supplied by USB, the internal radio is not operational.

WARNING:
Connect a suitable load to the antenna port before applying DC power to the RF451/RF452. This load should be either a 50-ohm antenna or an attenuator with a power rating of 2 watts or higher. Failure to follow this procedure may damage the radio voiding the warranty.

Power savings occur only when the endpoint is not transmitting data. Also, **Low Power Mode** is of little value when an endpoint has a constant, high throughput. Gateway and repeater radios do not go into a low power mode. See Low Power Mode (p. 14) for more information. RF451/RF452 power requirements in the various states of operation are listed in Table 14-1 (p. 21).

For help with determining a power budget and solar panel sizes for remote sites, see www.campbellsci.com/videos/power-budgeting.

Table 14-1: Power requirements at 12 VDC

Transmit current, for 1 W power at 100% duty cycle	650 mA
Receive current	40 mA
Idle current	15 mA
Sleep current	6 mA

15. RF451/RF452 antennas

Several antennas are offered to satisfy the needs for various gateway, endpoint, and endpoint/repeater requirements. These antennas have been tested at an authorized FCC open-field test site and are certified to be in compliance with FCC emissions limits. The use of an unauthorized antenna could cause transmitted field strengths in excess of FCC rules, interfere with licensed services, and result in FCC sanctions against user.

> NOTE:
> An FCC authorized antenna is a REQUIRED component.

Omnidirectional antennas are normally used at the base station and nearby stations. Yagi antennas are needed at distant stations or other special cases.

FCC OET Bulletin No. 63 (October 1993):

> "Changing the antenna on a transmitter can significantly increase, or decrease, the strength of the signal that is ultimately transmitted. Except for cable locating equipment, the standards in Part 15 are not based solely on output power but also take into account the antenna characteristics. Thus, a low power transmitter that complies with the technical standards in Part 15 with a particular antenna attached can exceed the Part 15 standards if a different antenna is attached. Should this happen it could pose a serious interference problem to authorized radio communications such as emergency, broadcast, and air-traffic control communications."

In order to comply with the FCC RF exposure requirements, the RF451/RF452 may be used only with approved antennas that have been tested with this radio and a minimum separation distance of 23 cm (9 inches) must be maintained from the antenna to any nearby persons.

16. Electrostatic issues

Many RF451/RF452 installations are outdoors and, therefore, susceptible to lightning damage, especially via the antenna system. Also, depending on climate and location, electrostatic-charged wind can damage sensitive electronics, if sufficient electric charge is allowed to accumulate on the antenna and cable. To protect against this, Campbell Scientific offers Antenna Surge Protection Kits.

Antenna surge protection is recommended in the following applications:

- When the antenna cable length exceeds 10 feet
- When use of COAXRPSMA cable would result in too much signal loss
- When the radio will be used in an environment susceptible to lightning or electrostatic buildup

17. Troubleshooting

The following sections provide troubleshooting guidelines.

17.1 LED status 23
17.2 Troubleshooting scenarios 24

17.1 LED status

The RF451/RF452 has two red/green/orange LED status indicator lights on the front. Table 17-1 (p. 23) and Table 17-2 (p. 24) show the status of each light when the RF451/RF452 is in various states of communications.

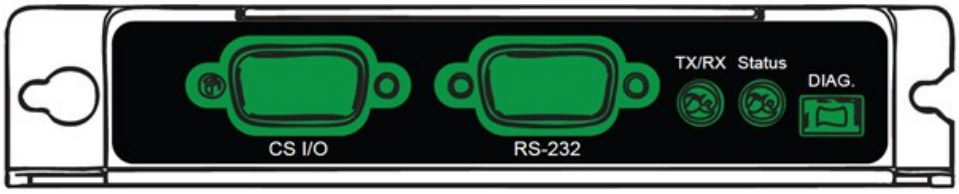


Table 17-1: Status LED

LED state	Description
Red (solid)	Not used
Green (solid)	Not used
Orange (solid)	Configuration of processor or radio (OS or settings)
Red (flash)	RF451/RF452 powered by USB – radio not operational

Table 17-1: Status LED	
LED state	Description
Green (flash)	Device powered – configured in gateway or endpoint mode
Orange (flash)	Device powered – configured in repeater mode
OFF	No power

Table 17-2: TX/RX LED	
LED state	Description
Red (solid)	Not used
Green (solid)	Not used
Orange (solid)	Not used
Red (flash)	Transmit
Green (flash)	Receive
Orange (flash)	No gateway detected (applies only to endpoints and repeaters)
OFF	No activity / No power

17.2 Troubleshooting scenarios

Device Configuration Utility is unable to establish a connection with the RF451/RF452:

1. Check that all other Campbell Scientific software is closed.
2. Check power to the radio. The Status LED should be flashing green if 12 volt power is supplied or red if only USB power is applied.
3. Check USB cable connections.
4. Check serial port assignment for *Device Configuration Utility*.

Radios not networked together, not communicating:

1. Check the baud rate of all RF450s/RF451/RF452s; they should be the same.
2. Check Network IDs of all RF450s/RF451/RF452s; they should be the same.

3. Check Frequency Key Number of all RF45s/RF451/RF452s; they should be the same, unless two branches of the network are operating in a parallel manner. See Computer-to-RF network with parallel repeaters (using SubNet ID) (p. 35) for settings used in a parallel network.
4. If one or more radios are configured as repeaters, check the **Repeaters Used** box for all RF450s/RF451/RF452s.
5. Check the PakBus™ address of data loggers connected to RF450s/RF451/RF452s and in ***LoggerNet***.
6. Check that antenna and antenna cables are correct for each radio type. RF451/RF452 radios use RPSMA (Reverse Polarity SubMiniature version A). RF450 radios use SMA (SubMiniature Version A). SMA antennas will have a yellow heat shrink label to distinguish them from RPSMA. See www.campbellsci.com/blog/ins-outs-rf-connectors for more information.

LEDs flash when ***LoggerNet*** command transmitted but no response from data logger:

1. Check SC12 cable on the data logger CS I/O port.
2. Check SDC address in RF450/RF451/RF452.
3. Check SDC address in data logger.
4. Check the baud rate of all RF450s/RF451/RF452s; they should be the same.
5. Check the baud rate of ***LoggerNet***; it should match the baud rate of the RF450s/RF451/RF452s.

See also: Troubleshooting large networks paper.

Appendix A. FCC notifications

This device complies with part 15 of the FCC rules. Operation is subject to the following two conditions: 1) This device may not cause harmful interference and 2) This device must accept any interference received, including interference that may cause undesired operation. This device must be operated as supplied by Campbell Scientific, Inc. Any changes or modifications made to the device without the express written approval of Campbell Scientific, Inc. may void the user's authority to operate the device.

> CAUTION:
> The MM2 transceiver has a maximum transmitted output power of 1 watt. It is recommended that the transmit antenna be kept at least 23 cm (approximately 9 inches) away from nearby persons to satisfy FCC RF exposure requirements.

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna
- Increase the separation between the equipment and receiver
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected
- Consult an experienced radio/TV technician for help
- Consult Campbell Scientific

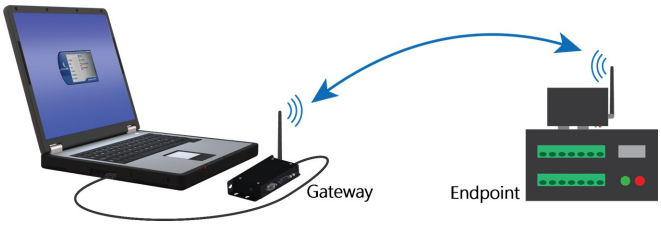
Appendix B. Installation examples

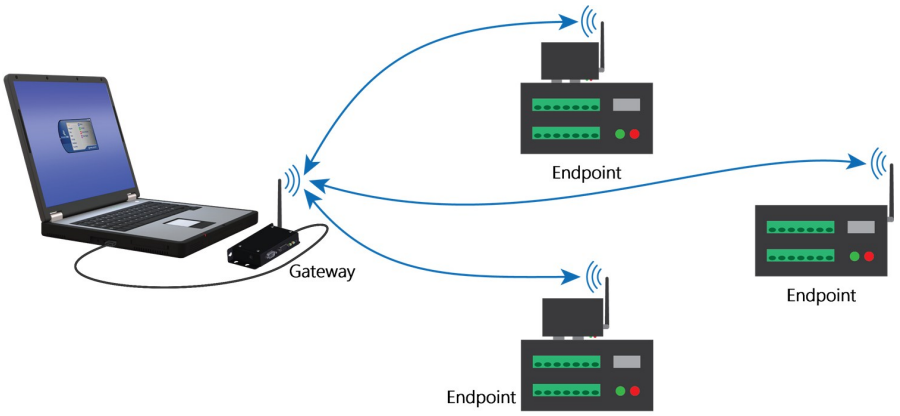
WARNING:
Connect a suitable load to the antenna port before applying DC power to the RF451/RF452. This load should be either a 50-ohm antenna or an attenuator with a power rating of 2 watts or higher. Failure to follow this procedure may damage the radio voiding the warranty.

The following sections describe frequently used configurations with the RF451/RF452.

B.1 RF451/RF452 radio communications with one or more data loggers 27
B.2 RF451/RF452 communications with multiple data loggers using one repeater 31
B.3 Using additional communications methods 35
B.4 Computer-to-RF network with parallel repeaters (using SubNet ID) 35
B.5 Data logger call-back 38
B.6 CELL200-series to RF 39
B.7 NL241 with radio network 43

B.1 RF451/RF452 radio communications with one or more data loggers





NOTE:
This procedure assumes the RF451/RF452 radios are using factory default settings.

The following table summarizes the hardware settings for this type of network. For detailed instructions on setting up the hardware and data logger support software see:

B.1.1 Configuring the RF451/RF452 radio connected to the computer 29
B.1.2 Configuring endpoint RF451/RF452 data loggers 30
B.1.3 Setting up communications between the RF451/RF452 data logger and the computer 30

Table B-1: Settings for RF451/RF452 radio communications with one or more data loggers

	Gateway	Endpoint(s)
Hardware	RF451/RF452 connected to computer running ***LoggerNet***	RF451/RF452 connected to data logger CS I/O port
Keep all factory default settings except:		
Active Interface	USB or RS-232 (to match how ***LoggerNet*** will be communicating with the radio)	CS I/O SDC (with SDC Address set to an unused SDC address on the data logger)
Radio Operation Mode	Gateway	Endpoint
Network ID	1726 (yours may be different)	1726 (yours may be different)

Table B-1: Settings for RF451/RF452 radio communications with one or more data loggers		
	Gateway	Endpoint(s)
Frequency Key	1 (yours may be different)	1 (yours may be different)
Radio ID	4094 (to match *LoggerNet* PakBus address)	2 (to match data logger PakBus address)[1]
[1]All endpoint radios in the network will have these same settings except for the **Radio ID**. The **Radio ID** setting allows a transceiver to be designated an arbitrary, user-selectable, 4-digit number which identifies the transceiver in diagnostics mode. When used in conjunction with PakBus data loggers, we recommend this setting be assigned the PakBus address of the station. This is because the Radio ID appears in the Network Diagnostics application within the FreeWave Tool Suite software, and it allows the user to associate a particular data logger with its attached radio.		

B.1.1 Configuring the RF451/RF452 radio connected to the computer

Configure the RF451/RF452 radio connected to the computer.

1. Ensure your RF451/RF452 radio is connected to an antenna before applying power.
2. If connecting via USB for the first time, you must first install USB drivers using *Device Configuration Utility* (select your radio, then on the main page, click **Install USB Driver**). Plug the RF451/RF452 radio to your computer using a USB cable.
3. Using *Device Configuration Utility*, connect to the RF451/RF452 radio.
4. On the **Deployment** tab, set the **Active Interface** to **USB** or **RS-232** (depending on how your computer will be connected to the radio).
5. Set the **Radio Operation Mode** to **Gateway**.
6. In the **Network ID** field, type a unique number between 0 and 4095 (excluding 255). This is used to communicate with RF451/RF452 devices in the network. Make note of this number. All radios in the network require the same Network ID.
7. Select a **Frequency Key** between 0 and 14 and make note of this number. Generally all radios in the network will have the same Frequency Key.
8. **Apply** to save your changes.
9. Connect the RF451/RF452 radio to the computer communications port selected in the previous step.

B.1.2 Configuring endpoint RF451/RF452 data loggers

Follow these instructions multiple times to set up multiple data loggers. In this case, each must be given a unique name and PakBus address. For more complicated networks, it is recommended that you use Network Planner.

1. Ensure your RF451/RF452 radio is connected to an antenna before applying power.
2. Using *Device Configuration Utility*, connect to the RF451/RF452 data logger.
3. On the **Deployment > Datalogger** tab, assign a unique PakBus address.
4. On the **Deployment > Radio** tab, set the **Radio Operation Mode** to **Endpoint**.
5. In the **Network ID** field, type the same number set in the previous section: Configuring the RF451/RF452 radio connected to the computer (p. 29).
6. Select the same **Frequency Key** set in the previous section.
7. **Apply** to save your changes.

B.1.3 Setting up communications between the RF451/RF452 data logger and the computer

These instructions provide an easy way to set up communications between the RF451/RF452 data logger and the computer with an RF451/RF452 radio. Follow these instructions multiple times to set up multiple data loggers. For more complicated networks, it is recommended that you use Network Planner.

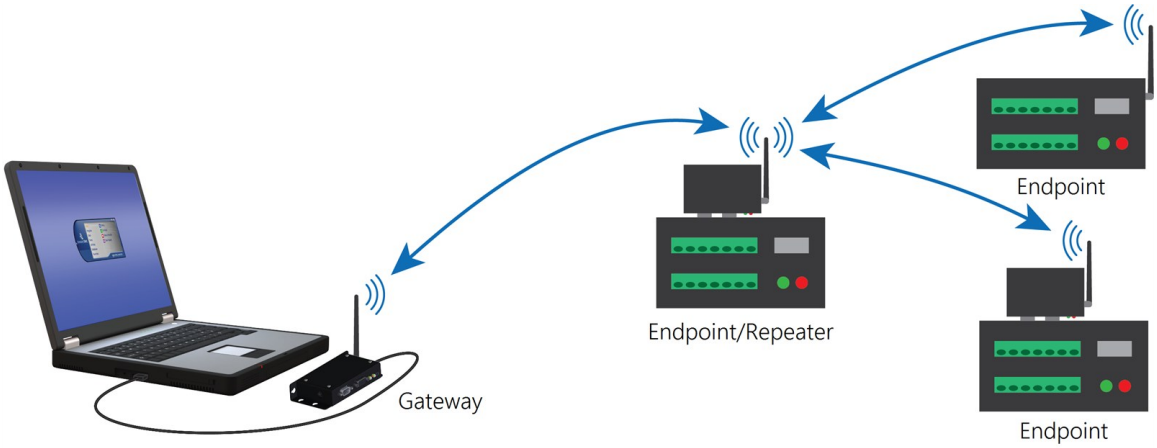
1. Ensure your RF451/RF452 radio is connected to an antenna before applying power.
2. Connect the RF451/RF452 data logger to the computer communications port that was selected as the active interface in *Device Configuration Utility*.
3. Using data logger support software, launch the EZSetup Wizard.
   - *LoggerNet* users, from the *Main* category click **Setup** and select the **View** menu to ensure you are in the **EZ (Simplified)** view, then click **Add**.
   - *PC400* users, click **Add Datalogger**.
4. Click **Next**.
5. Select your data logger from the list, type a meaningful name for your data logger (for example, a site identifier or project name), and click **Next**.
6. If prompted, select the **Direct Connect** connection type and click **Next**.

7. Select the communications port used to communicate with the RF451/RF452 from the **COM Port** list.
8. Accept the default value of **00 seconds** in the **COM Port Communication Delay** - this box is used to allow time for hardware devices to "wake up" and negotiate a communications link. Click **Next**.
9. You do not need to select a baud rate. The PakBus address must match the hardware settings for your data logger.
10. Click **Next**.
11. By default, the data logger does not use a security code or a PakBus encryption key. Therefore, the **Security Code** can be set to **0**, and the **PakBus Encryption Key** can be left blank. If either setting has been changed, enter the new code or key.
12. Click **Next**.
13. Review the **Communication Setup Summary**. If you need to make changes, click the **Previous** button to return to a previous window and change the settings.

Setup is now complete. The EZSetup Wizard allows you to **Finish**, or you may click **Next** to test communications, set the data logger clock, and send a program to the data logger.

B.2 RF451/RF452 communications with multiple data loggers using one repeater

This type of network configuration is useful for communicating around an obstacle, such as a hill or building, or to reach longer distances.



The following table summarizes the hardware settings for this type of network. For detailed instructions on setting up the hardware and data logger support software see:

B.2.1 Configuring the RF451/RF452 radio connected to the computer 33
B.2.2 Configuring the data logger acting as a repeater 33
B.2.3 Adding the endpoint/repeater data logger to the LoggerNet network 34
B.2.4 Adding endpoint data loggers to the network 34

Table B-2: RF451/RF452 settings for RF451/RF452 communications with multiple data loggers using one repeater

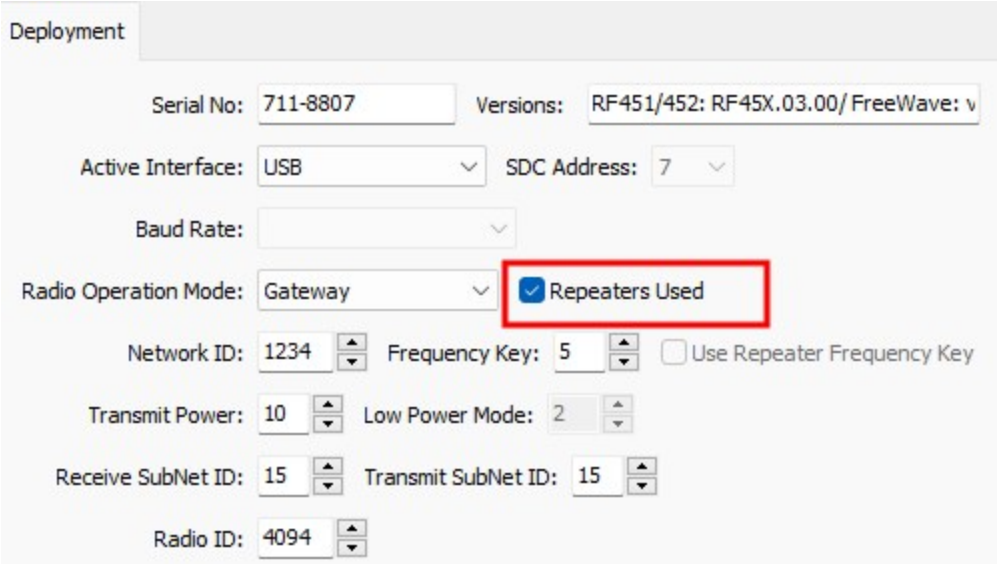
	Gateway	Endpoint/repeater	Endpoint(s)
Hardware	RF451/RF452 connected to computer running *LoggerNet*	RF451/RF452 connected to data logger CS I/O port	RF451/RF452 connected to data logger CS I/O port
PakBus Address	4094	2	3
Keep all factory default settings except:			
Active Interface	USB or RS-232 (to match how *LoggerNet* will be communicating with the radio)	CS I/O SDC (with SDC Address set to an unused SDC address on the data logger)	CS I/O SDC (with SDC Address set to an unused SDC address on the data logger)
Radio Operation Mode	Gateway	Endpoint/Repeater	Endpoint
Repeaters Used	Yes, select box	Yes, select box	Yes, select box
Network ID	1726 (yours may be different)	1726 (yours may be different)	1726 (yours may be different)
Frequency Key	1 (yours may be different)	1 (yours may be different)	1 (yours may be different)
Radio ID	4094 (to match LoggerNet PakBus address)	2 (to match data logger PakBus address)[1]	3 (to match data logger PakBus address)[1]

[1]All endpoint radios in the network will have these same settings except for the **Radio ID**. The **Radio ID** should match the PakBus address of the data logger it is connected to.

B.2.1 Configuring the RF451/RF452 radio connected to the computer

Configure the RF451/RF452 radio connected to the computer (see previous image for reference).

1. Ensure your RF451/RF452 radio is connected to an antenna before applying power.
2. Using ***Device Configuration Utility***, connect to the RF451/RF452 radio.
3. On the **Deployment** tab, set the **Active Interface** to **USB** or **RS-232** (depending on how your computer will be connected to the radio).
4. Set the **Radio Operation Mode** to **Gateway**. In the **Network ID** box, type a unique number between 0 and 4095 (excluding 255). This is used to communicate with RF451/RF452 devices in the network. Make note of this number. All radios in the network require the same Network ID.
5. In the **Frequency Key** box, type a number between 0 and 14, and make note of this number. Generally, all radios in the nework will have the same Frequency Key.
6. Select the **Repeaters Used** box.



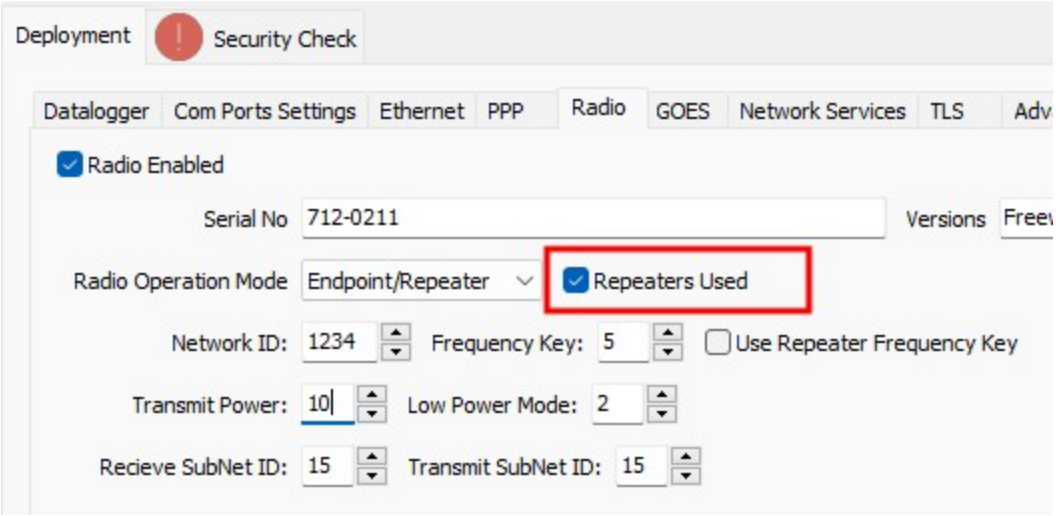
7. **Apply** to save your changes.

B.2.2 Configuring the data logger acting as a repeater

1. Ensure your RF451/RF452 radio is connected to an antenna before applying power.
2. Supply power to the data logger. If connecting via USB for the first time, you must first install USB drivers by using ***Device Configuration Utility*** (select your data logger, then on

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

3. Using ***Device Configuration Utility***, connect to the RF451/RF452 data logger.
4. Click the **Radio** sub-tab and select the **Repeaters Used** box.



5. Also on the **Radio** sub-tab, set the **Radio Operation Mode** to **Endpoint/Repeater**. In the **Network ID** box, type the same number set in the previous instruction Configuring the RF451/RF452 radio connected to the computer (p. 33).
6. In the **Frequency Key** box, type the same number set in the previous instruction.
7. **Apply** to save your changes.

B.2.3 Adding the endpoint/repeater data logger to the *LoggerNet* network

To add the repeater data logger to the ***LoggerNet*** network, follow the instructions found in Setting up communications between the RF451/RF452 data logger and the computer (p. 30).

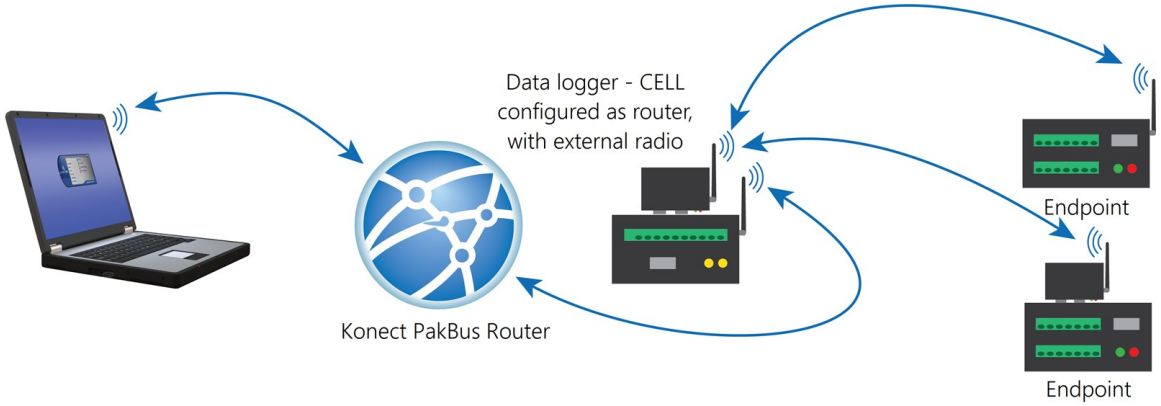
B.2.4 Adding endpoint data loggers to the network

1. In the ***LoggerNet*** **Standard Setup** view (click **Setup** and then the **View** menu to ensure you are in the **Standard** view), right-click on the repeater data logger in the Entire Network pane on the left side of the window and select your data logger model such as **CR6Series**.

2. With the newly added data logger selected in the **Entire Network** pane, set the **PakBus Address** to the address that was assigned to the endpoint data logger in ***Device Configuration Utility***.
3. Click **Rename** to provide the data logger a descriptive name.
4. **Apply** to save your changes.
5. Repeat these steps for each endpoint data logger in the network.

B.3 Using additional communications methods

Using similar instructions, an RF451/RF452 data logger can be used in a system with additional communications methods. For example, in the following image, the router RF451/RF452 data logger communicates with ***LoggerNet*** through Konect PakBus Router. The router RF451/RF452 data logger communicates with the endpoint RF451/RF452 data loggers over RF.



The RF portion of this network requires no changes to the hardware settings described in the previous procedure.

See the Konect Pakbus Router Getting Started Guide for more information on setting up that part of the network.

B.4 Computer-to-RF network with parallel repeaters (using SubNet ID)

In this example, the gateway radio is connected to a computer running ***LoggerNet***. One stand-alone repeater (Repeater 1) is used to access several endpoint radios connected to data loggers in the field. The stand-alone repeater consists of an RF451/RF452, power supply, and antenna. Another repeater (endpoint/repeater) connected to a data logger is used to access several other endpoint radios on data loggers.

To take advantage of the low power mode, those devices that are NOT repeaters should be configured as endpoints and not as endpoint/repeaters. In this configuration, it may be desirable to use an external omnidirectional antenna at the repeaters.

A maximum of four repeaters are allowed in a network. When a repeater is used, the RF throughput is cut in half. Throughput is the rate at which data is sent or received. Reducing throughput means less data can be transmitted in a specified amount of time.

Remember, each data logger must have a unique PakBus address.

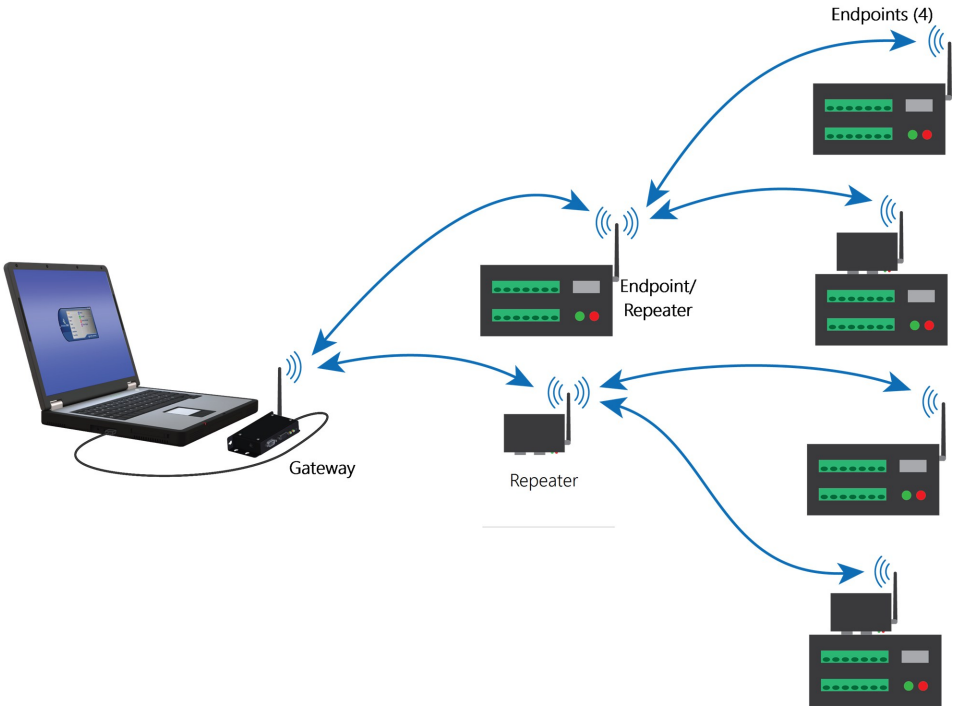


Table B-3: RF451/RF452 settings for Computer-to-RF network with parallel repeaters (using SubNet ID)

	Gateway	Repeater	Endpoint/repeater	Endpoint 11, 12 etc.	Endpoint 21, 22 etc.
Hardware[4]	computer running ***LoggerNet***, RF451/RF452	RF451/RF452	data logger, RF451/RF452	data logger, RF451/RF452	data logger, RF451/RF452
Baud Rate	115.2K	115.2K	115.2K	115.2K	115.2K

Table B-3: RF451/RF452 settings for Computer-to-RF network with parallel repeaters (using SubNet ID)

	Gateway	Repeater	Endpoint/repeater	Endpoint 11, 12 etc.	Endpoint 21, 22 etc.
Active Interface	USB or RS-232 (to match how *LoggerNet* will be communicating with the radio)	NA	CS I/O SDC (with SDC Address set to an unused SDC address on the data logger)	CS I/O SDC (with SDC Address set to an unused SDC address on the data logger)	CS I/O SDC (with SDC Address set to an unused SDC address on the data logger)
Radio Operation Mode	Gateway	Repeater	Endpoint/Repeater	Endpoint	Endpoint
Repeaters Used	Yes; select box	Yes; select box	Yes; select box	Yes; select box	Yes; select box
Network ID[1]	1726	1726	1726	1726	1726
Frequency Key[1]	1	1	1	1	1
Receive SubNet ID	NA	0	0	1	2
Transmit SubNet ID	15 (default)	1	2	0	0
Radio ID	4094[2]	2	33	11, 12 etc.[3]	21, 22, etc.[3]

[1]Your **Network ID** and **Frequency Key** may be different

[2]To match ***LoggerNet*** PakBus address

[3]To match data logger PakBus address

[4]Not inclusive; other typical hardware items may include power supply, antenna, enclosure, etc.

NA = not applicable

TIP:
The **Radio ID** setting allows a transceiver to be designated an arbitrary, user-selectable, 4-digit number which identifies the transceiver in diagnostics mode. When used in conjunction

with PakBus data loggers, we recommend this setting be assigned the PakBus address of the station. This is because the Radio ID appears in the Network Diagnostics application within the FreeWave Tool Suite software, and it allows the user to associate a particular data logger with its attached radio.

B.5 Data logger call-back

Call-back is the ability of a remote site to initiate a call to ***LoggerNet*** and have ***LoggerNet*** call back to collect data. Call-back is supported in networks consisting of RF451/RF452s as the single communications device.

In a mixed-communications devices network, for example, phone to RF451/RF452, the base site makes the transition between communications types. Call-back is NOT supported when the base RF451/RF452s **Active Interface** is configured as **CS I/O ME Master**. The RF451/RF452 **Active Interface** is configured as **CS I/O ME Master** when the CS I/O port is used for direct connection to an ME device such as a COM220 or MD485). The connection is done by using an A100.

In this example, the RF451/RF452s are set up as described in RF451/RF452 radio communications with one or more data loggers (p. 27). In the following program the data logger will send a variable named `Callback` to ***LoggerNet*** (PakBus address 4094) when the `CallbackFlag` variable is true. After ***LoggerNet*** receives the variable `Callback` it will begin collecting data from the data logger and store it into a file based on the data collection settings in the ***LoggerNet*** **Setup** screen. Note that the **PakBus Port** in the ***LoggerNet*** **Setup** screen must have **PakBus Port Always Open** selected.

CRBasic Example 1: CRBasic call-back program

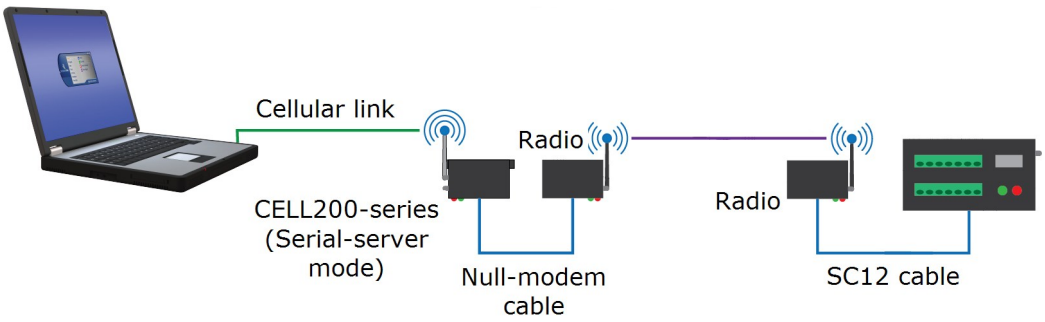
```
'Declare Public Variables
Public counter, Result
Public CallbackFlag As Boolean
Dim scratch  'this variable is a place-holder it is not used

'Define Data Tables
DataTable (OneMin,true,-1)
  DataInterval (0,1,Min,10)
  Sample (1,counter,FP2)
EndTable

'Main Program
BeginProg
  'Configure the data logger CS I/O port to match the SDC address and baud rate
  'set in the RF451/RF452
  SerialOpen (ComSDC7,-115200,0,0,10000)
  Scan (1,Sec,0,0)
    counter = counter + 1
    If CallbackFlag = true Then
      SendVariables (Result,ComSDC7,0,4094,0000,0,"Public","Callback",Scratch,1)
      CallbackFlag = false
    EndIf
    'Call Output Tables
    CallTable OneMin
  NextScan
EndProg
```

B.6 CELL200-series to RF

This type of network is useful when a single data logger is not located close enough to a reliable cellular signal. To overcome this distance, use radios to establish connectivity with the cellular network.



B.6.1 CELL200-series physical setup

1. Connect the CELL200-series and radio RS-232 ports using an RS-232 pin-to-pin null-modem cable.
2. Connect the cellular and radio antennas, if they are not already connected.
3. Apply DC power to the CELL200-series and radio.

B.6.2 Configure the CELL200-series as a serial server

1. Connect a USB cable between a USB port on your computer and the **USB** port on the CELL200 series.
2. Starting with the default settings, open a web browser and go to: **cell.linktodevice.com**.

   > NOTE:
   > Cellular service must be setup before configuring the CELL200-series. See Pre-installation for more information.

3. If the data logger has been assigned a **public static IP address**, on the **Settings** > **General** tab:
   a. Enter the **APN** as assigned by your service provider.
   b. Change **Mode** from PPP to **Serial Server**.
   c. Click **Apply** to save the changes and then close the browser tab.
4. If the data logger has been assigned a **private dynamic IP address** and you are using the **Konect PakBus Router** service, on the **Settings** tab:
   a. **General** tab > Enter the **APN** as assigned by your service provider.
   b. **General** tab > Change **Mode** from PPP to **Serial Server/Client**.
   c. **Serial Mode Setup** > **URL** > Enter the Konect PakBus Router address.
   d. **Serial Mode Setup** > **Port Number** > Enter the Konect PakBus Router port number.

      > NOTE:
      > *Konect PakBus Route*r connections through a CELL200 series modem do not support a TCP Password. Contact Campbell Scientific support for more information.

B.6.3 Configure radio connected to the CELL200-series

Connect a USB cable between a USB port on your computer and the **USB** port on the radio that will be connected to the CELL200 series. Either RF407-series or RF451/452 radios can be used. See those product manuals for additional details.

B.6.3.1 RF451/452

1. Connect to the radio in ***Device Configuration Utility***.
2. Click the **Factory Defaults** button at the bottom of the Deployment window.
3. On the **Deployment** tab set:
    a. **Active Interface** to **RS-232**
    b. **Radio Operation Mode** to **Gateway** (previously called Master)

    > NOTE:
    > There can only be one Gateway in an RF451/452 network.

4. Click **Apply** to save the changes.

B.6.4 Configure radio connected to the data logger

1. Using an SC12 cable connect the data logger **CS I/O** port to the radio **CS I/O** port.
2. Connect a USB cable between a USB port on your computer and the radio **USB** port.

B.6.4.1 RF451/452

1. Connect to the radio in ***Device Configuration Utility***.
2. Click the **Factory Defaults** button at the bottom of the Deployment window.
3. On the **Deployment** tab keep the defaults and confirm:
    a. **Active Interface** is **CS I/O SDC**
    b. **SDC Addres** is **7**
    c. **Radio Operation Mode** is **Endpoint** (previously called Slave)
4. Click **Apply** to save the changes.

B.6.5 Configure the data logger

1. Connect a USB cable between a USB port on your computer and the data logger **USB** port.
2. Connect to the data logger in ***Device Configuration Utility***.
3. Click the **Factory Defaults** button at the bottom of the Deployment window.
4. On the **Datalogger** tab verify or change the PakBus address.
    - Default address is **1**.
    - If using ***Konect PakBus Router***, verify the address assigned here matches the address you setup for the data logger in **Konect PakBus Router**.
5. On the **Com Ports Settings** tab set:
    a. **ComPort** to **CS I/O SDC7**
    b. **Beacon Interval** to **60** (seconds)
6. Click **Apply** to save the changes and then close ***Device Configuration Utility***.

B.6.6 Setup *LoggerNet*

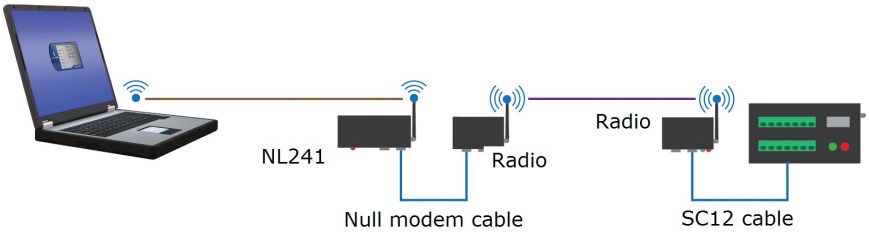
1. In the ***LoggerNet*** Setup screen, click **Add Root** and select **IPPort**. Enter the CELL200-series IP address and port number. The IP address and port number are input on the same line separated by a colon. IPv6 addresses will need to be enclosed in square brackets when specifying a port number. An IPv4 address may look like 192.168.1.100:3001. An IPv6 address may look like [2001:db8::1234:5678]:3001. A fully qualified host name entry may look like yourlogger.com:3001. In serial server mode, the default port number is **3001**.

    If you are using a ***Konect PakBus Router*** use the address of the ***Konect PakBus Router*** followed by a colon and the port number of the PakBus router.
2. Add **PakBusPort (PakBus Loggers)**.
3. Add a PakBus Router (**pbRouter**). The default PakBus address for the ***Konect PakBus Router*** is **4070**. Click **Close**.
4. Add the data logger and enter its PakBus address. If using a ***Konect PakBus Router*** ensure that the PakBus address matches both that of the data logger and the configuration you setup with your ***Konect PakBus Router***.
5. Click **Apply** to save the changes.
6. You are now ready to connect to your data logger using ***LoggerNet***. Select **Main** and

Connect on the ***LoggerNet*** toolbar, select the data logger from the **Stations** list, then **Connect**. From there, you can view and collect data, or manage data logger settings.

B.7 NL241 with radio network

This type of network is useful when the data logger is not located close enough to a Wi-Fi network. To overcome this distance, use spread-spectrum radios to establish connectivity with the Wi-Fi network.



B.7.1 Configure the NL241 as a PakBus router

Out of the box, the NL241 is configured for operation as a PakBus router. You may not need to make any changes. The following steps provide information about these default settings.

1. Connect to the NL241 in ***Device Configuration Utility***.
2. On the **NL241** tab, set **Bridge Mode** to **disable**.
3. If a dynamic address is to be used, the network information acquired via DHCP can be seen on the NL241 tab under **Status**. The **Status** box also displays the MAC address of the NL241.
4. To enter a static IP address, select **disable** in the **Use DHCP** field. Then input the **IP Address**, **Network Mask**, and **Default Gateway**. These values can be provided by your network administrator.
5. On the **RS-232** tab:
    a. Set **Configuration** to **PakBus**.
    b. Set **Baud Rate** to baud rate of attached radio. Generally this is **115200** (default).
    c. Set **Beacon Interval** to **60** (seconds) and **Verify Interval** to **0**. If you want to restrict communications paths, use the **PakBus Neighbors Allowed** setting to specify allowed neighbor addresses.
6. On the **Network Services** tab, make note of the **PakBus/TCP Service Port**. The default **PakBus/TCP Service Port** is **6785**. Unless firewall issues exist, it is not necessary to change the port from its default value. This port number must match the port number entered in LoggerNet Setup after the IP address. See Setup LoggerNet (p. 45).

B.7.2 Configure radio connected to the NL241

Using a USB cable, connect to the radio that will be connected to the NL241. Either an RF407-series or RF451/452 can be used. See those product manuals for additional details.

B.7.2.1 RF451/452

1. Connect to the radio in ***Device Configuration Utility***.
2. Click the **Factory Defaults** button at the bottom of the Deployment window.
3. On the **Deployment** tab set:
    a. **Active Interface** to **RS-232**
    b. **Radio Operation Mode** to **Gateway** (previously called Master)

    > **NOTE:**
    > There can only be one Gateway in an RF451/452 network.

4. Click **Apply** to save the changes.

B.7.3 Configure radio connected to the data logger

1. Using an SC12 cable, connect the data logger **CS I/O** port to the radio **CS I/O** port.
2. Connect a USB cable between a USB port on your computer and the radio **USB** port.

B.7.3.1 RF451/452

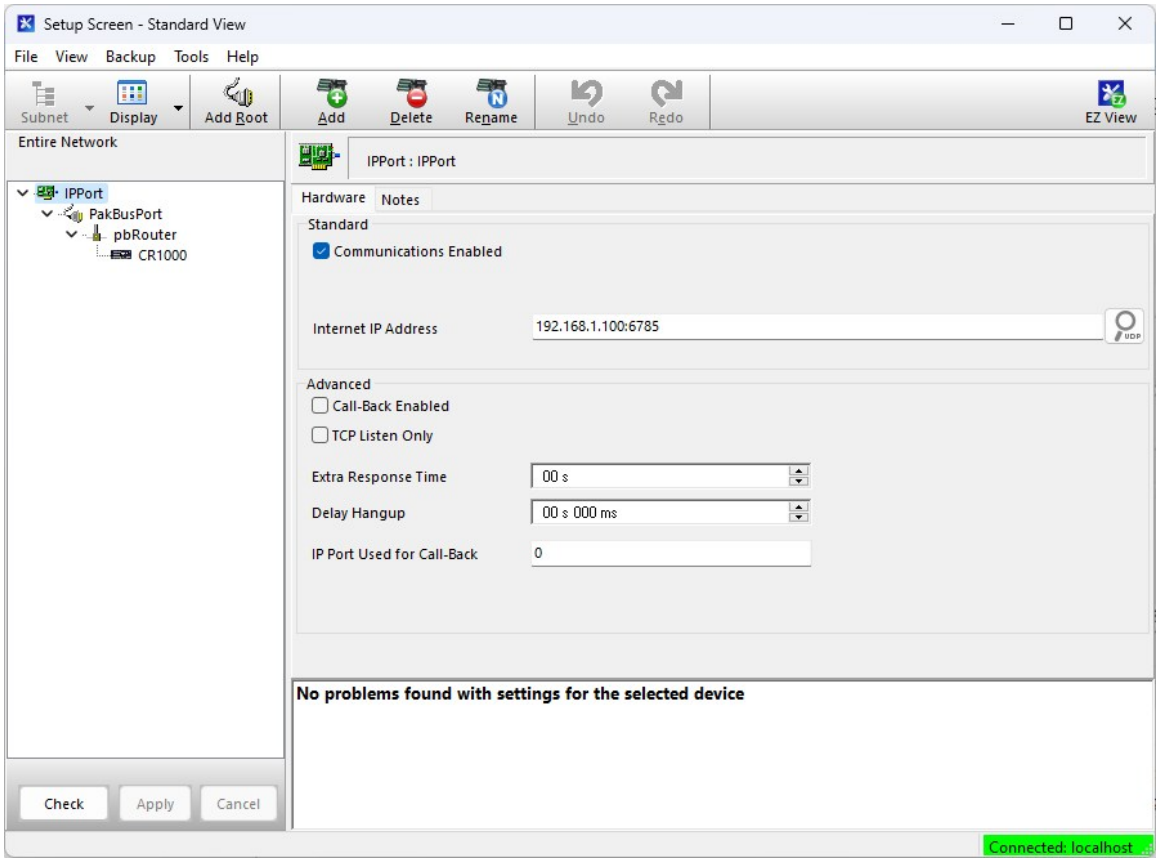
1. Connect to the radio in ***Device Configuration Utility***.
2. Click the **Factory Defaults** button at the bottom of the Deployment window.
3. On the **Deployment** tab, keep the defaults and confirm:
    a. **Active Interface** is **CS I/O SDC**
    b. **SDC Addres** is **7**
    c. **Radio Operation Mode** is **Endpoint** (previously called Slave)
4. Click **Apply** to save the changes.

B.7.4 Configure the data logger

1. Connect to the data logger in ***Device Configuration Utility***.
2. Click the **Factory Defaults** button at the bottom of the Deployment window.
3. On the **Com Ports Settings** tab set:
    a. **ComPort** to **CS I/O SDC7**
    b. **Beacon Interval** to **60** (seconds)
4. Click **Apply** to save the changes and then close ***Device Configuration Utility***.

B.7.5 Setup *LoggerNet*

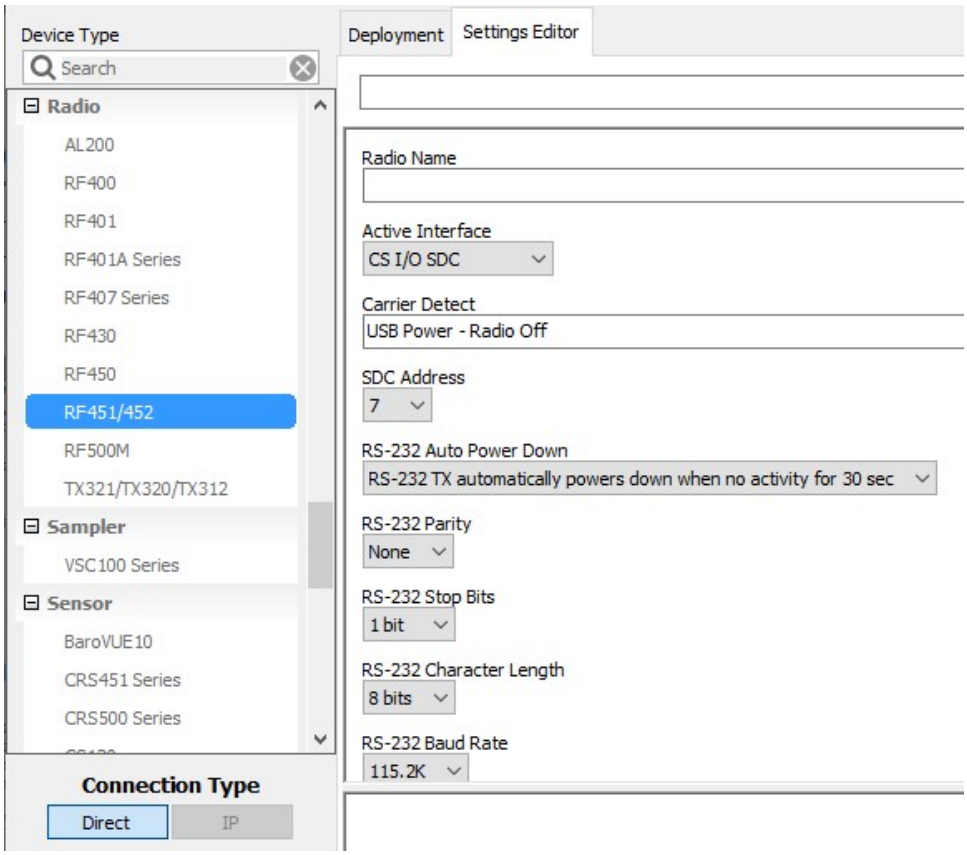
1. In the ***LoggerNet*** Setup screen, click **Add Root** and select **IPPort**. Enter the NL241 IP address and port number. The IP address and port number are input on the same line separated by a colon. IPv6 addresses will need to be enclosed in square brackets when specifying a port number. An IPv4 address may look like 192.168.1.100:6785. An IPv6 address may look like [2001:db8::1234:5678]:6785. A fully qualified host name entry may look like yourlogger.com:6785.
2. Add **PakBusPort (PakBus Loggers)**.
3. Add a PakBus Router (**pbRouter**). Enter the PakBus address of the NL241. The NL241 default PakBus address is **678**. Click **Close**.
4. Add the data logger and enter its PakBus address.
5. Click **Apply** to save the changes.



6. You are now ready to connect to your data logger using ***LoggerNet***. Select **Main** and **Connect** on the ***LoggerNet*** toolbar, select the data logger from the **Stations** list, then **Connect**. From there, you can view and collect data, or manage data logger settings.

Appendix C. Settings Editor

The **Settings Editor** of *Device Configuration Utility* provides access to additional settings not shown on the Deployment tab. Most RF451/RF452 networks do not need to make changes through the **Settings Editor**.



The **Hop Table Version** setting allows the user to choose the portion of the band in which the transceiver will operate. Radios purchased through Campbell Scientific for use outside of the United States and Canada will have the country-specific **Hop Table Version** set.

> NOTE:
> Do not use a **Frequency Key Setting** of **14** with a **Hop Table Version** of **1**, **2**, or **4**.

Limited warranty

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

1. There must be a defect in materials or workmanship that affects form, fit, or function of the device.

2. The defect cannot be the result of misuse.

3. The defect must have occurred within a specified period of time; and

4. The determination must be made by a qualified technician at a Campbell Scientific Service Center/ repair facility.

The following is not covered:

1. Equipment which has been modified or altered in any way without the written permission of Campbell Scientific.

2. Batteries; and

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

Campbell Scientific regional offices handle repairs for customers within their territories. Please see the back page of the manual for a list of regional offices or visit www.campbellsci.com/contact to determine which Campbell Scientific office serves your country. For directions on how to return equipment, see Assistance.

Other manufacturer's products, that are resold by Campbell Scientific, are warranted only to the limits extended by the original manufacturer.

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MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. Campbell Scientific hereby disclaims, to the fullest extent allowed by applicable law, any and all warranties and conditions with respect to the products, whether express, implied, or statutory, other than those expressly provided herein.

Campbell Scientific will, as a default, return warranted equipment by surface carrier prepaid. However, the method of return shipment is at Campbell Scientific's sole discretion. Campbell Scientific will not reimburse the claimant for costs incurred in removing and/or reinstalling equipment. This warranty and the Company's obligation thereunder is in lieu of all other

warranties, expressed or implied, including those of suitability and fitness for a particular purpose. Campbell Scientific is not liable for consequential damage.

In the event of any conflict or inconsistency between the provisions of this Warranty and the provisions of Campbell Scientific's Terms, the provisions of Campbell Scientific's Terms shall prevail. Furthermore, Campbell Scientific's Terms are hereby incorporated by reference into this Warranty. To view Terms and conditions that apply to Campbell Scientific, Logan, UT, USA, see Terms and Conditions. To view terms and conditions that apply to Campbell Scientific offices outside of the United States, contact the regional office that serves your country.

Assistance

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

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

When returning equipment, a RMA number must be clearly marked on the outside of the package. Please state the faults as clearly as possible. Quotations for repairs can be given on request.

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

> NOTE:
> All goods that cross trade boundaries may be subject to some form of fee (customs clearance, duties or import tax). Also, some regional offices require a purchase order upfront if a product is out of the warranty period. Please contact your regional Campbell Scientific office for details.

Safety

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

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

General

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

Utility and Electrical

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

Elevated Work and Weather

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

Internal Battery

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

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

Use and disposal of batteries

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

Avoiding unnecessary exposure to radio transmitter radiation

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

Maintenance

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

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

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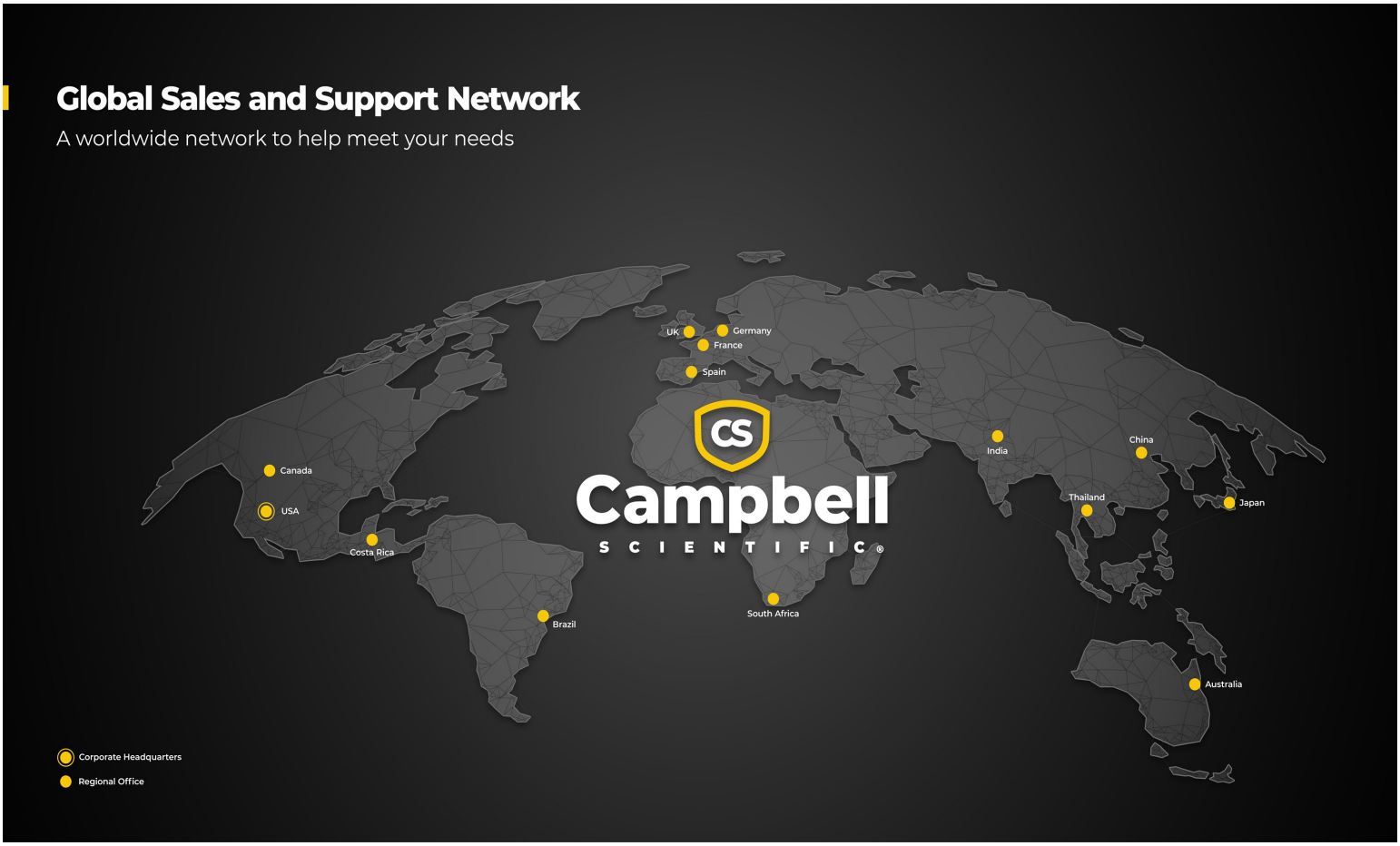

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