INSTRUCTION MANUAL

RF450 Spread Spectrum Radio

Revision: 8/11

®

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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 module number FGR09 has a maximum transmitted output power of 955mW.   It is recommended that the transmit antenna be kept at least 23cm (approximately 10 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

RF450 Spread Spectrum Radio

1. General Description

The RF450 Spread Spectrum Radio is a 900 MHz license-free radio specifically designed to work with Campbell Scientific dataloggers. RF450 radios consist of a FreeWave DGR09 radio module and an interface board.

This manual addresses the RF450's interface with CR3000, CR1000, and CR800-series dataloggers and a PC running LoggerNet. Though the radios may be setup 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 Slave radios at the datalogger site. This reduces the required power at remote sites from about 75 mA to less than 10 mA in most applications.

NOTE
to International users
Radios deployed outside of the United States must use a ***Hop Table Version*** other than zero (the default). See Appendix B for details on changing the Hop Table Version.

2. Specifications

Frequency:	902 to 928 Mhz

Transmit:

Output Power	5 mW to 1 W, user selectable
Range	60 miles maximum assuming ideal conditions, line-of-sight, and appropriate antenna. Note that line-of-sight obstructions, RF interference, and antenna type will affect transmission distance. Realistic, reliable distances are approximately 13 miles.
Modulation	Spread spectrum GFSK, 120 or 170 kbps
Spreading Method	Frequency hopping
Occupied Bandwidth	230 kHz, at 60 dB
Channel Spacing	230 kHz
Hopping Patterns	15 per band, 105 total, user selectable
Hopping Channels	50 to 112, user selectable
Hopping Bands	7, user selectable
Frequency Zones	16 Zones, 7 Channels per zone

Receive:

Sensitivity	-108 dBm for 10-6 bit error rate
	-110 dBm for 10-4 bit error rate
Selectivity	-20 dB at Fc +/- 115 kHz
	-60 dB at Fc +/- 145 kHz
System Gain	140 dB

Data Transmission:

Error Detection	32 bit CRC, retransmit on error
Data Encryption	Substitution, dynamic key
Link Throughput	115.2 kbps, max

Data Interface:

Protocol	RS-232, DCE, CS I/O, ME, and SDC; 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
Antenna	SMA female connector
	External antenna required

Power Requirements:

Voltage	7 to 28 Vdc	
Current	Transmit	500 mA
	Receive	76 mA*
	Idle	22 mA*
	Sleep	7 mA*

Environmental:

Operating Temperature	-40° to +75°C
Dimensions	1.44" x 3.17" x 5.70" (3.66 x 8.05 x 14.48 cm)
	1.44" x 3.17" x 7.5" (3.66 x 8.05 x 19.05 cm) with mounting plate
Weight	0.7 lbs (0.3 kg)
Humidity	0 to 95% non-condensing

FCC ID:	KNY-6231812519
Canada:	2329B-DGR09RAS

3. Configuration

3.1 Theory of Radio Operation

In a point-to-multi-point network (multi-point network) the transceiver designated as a Master, is able to simultaneously communicate with numerous Slaves. In its simplest form, a multi-point network functions with the Master broadcasting its messages to all Slaves and the Slaves responding to the Master when given data by the datalogger connected to the data port (see Figure 3.1-1).
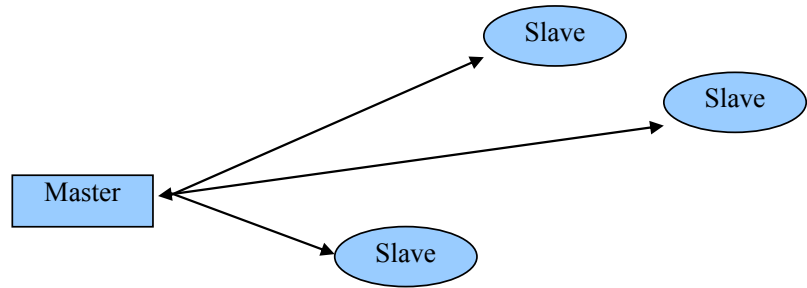
NOTE   There may be only one RF450 Master in a network and it must be connected to a PakBus router. A PakBus router may be software such as LoggerNet or PC400 or a datalogger configured as a router.

FIGURE 3.1-1. Simplest Form of a Multi-Point Network

In a multi-point network, outbound packets from the Master or repeater to Slaves or other repeaters are sent a set number of times determined by the user. The receiving transceiver, Slave 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 Master, all packets sent are acknowledged or retransmitted until they are acknowledged. Therefore, the return link in a multi-point network is generally very robust.

Traditionally, a multi-point network is used in applications where data is collected from one to many dataloggers and reported back to one central site. The central site is typically a PC running LoggerNet, but could be a datalogger. Refer to Appendix A for different installation scenarios.

Though the radios may be setup 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 Slave radios at the datalogger site. This reduces the required power at remote sites from about 75mA to less than 10mA in most applications.

3.2 PakBus Graph

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

Because RF450 networking protocols are used to direct packets, not PakBus protocols, the network's representation in PakBus Graph may be significantly different than one would expect. Figure 3.2-1 depicts the physical network of six dataloggers and one LoggerNet server. Dataloggers numbered 1 and 2 route packets to other dataloggers from the LoggerNet server.
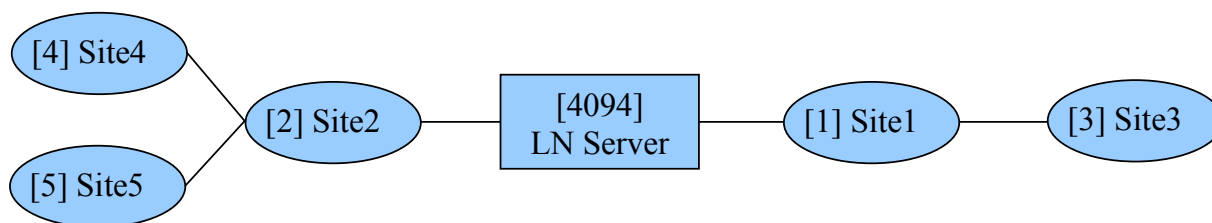
FIGURE 3.2-1. Point to Multi-Point Network with Two Routers

This same network will be depicted in PakBus Graph as shown in Figure 3.2-2. Dataloggers numbered 1 and 2 have RF450 radios configured as Slave/Repeaters. The RF450 radios are doing the networking, not the PakBus dataloggers.
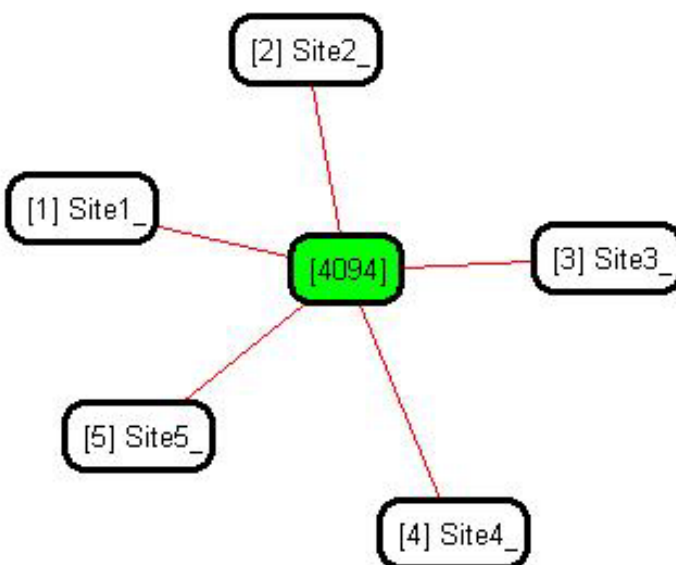
FIGURE 3.2-2. RF450 Point to Multi-Point Network with Two Routers as Displayed in PakBus Graph

3.3 Location of the Transceivers

Placement of the radio 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 antenna.

3.4 Using the Device Configuration Utility

Radios are configured using the CSI Device Configuration Utility (DevConfig) software tool that comes with LoggerNet (see Figure 3.4-1). To avoid COM port conflict, DevConfig is usually run when LoggerNet is shut down, and vice versa. The following general procedure is used to configure the RF450 radios via DevConfig:

1. Launch DevConfig by double clicking the icon on the Windows Desktop or through the Windows Start Menu | Start | All Programs | LoggerNet | Device Configuration Utility.

2. From the Device Type list, select the RF450. Information, instruction and help are provided on each screen.
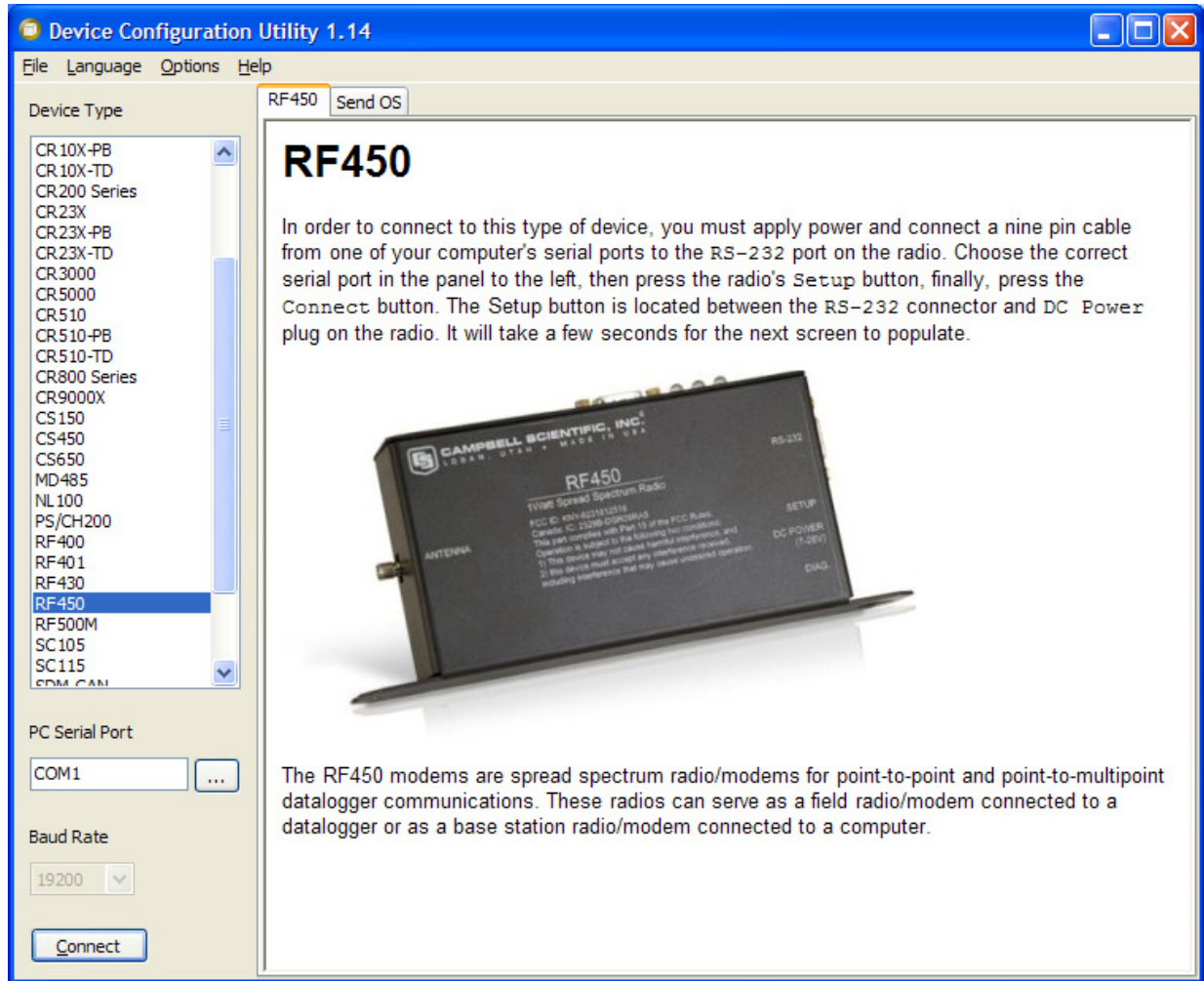
FIGURE 3.4-1. Start-up DevConfig Screen for Configuring the RF450

3. Select the correct COM port for serial communications with the radio.

4. Power the RF450 radio by using the power plug or by using the SC12 cable to connect the radio's CS I/O port to the datalogger's CS I/O port.

5. Connect an RS-232 or USB-to-RS-232 cable between the RF450 and PC.

6. Click Connect then press the green "setup" button located on the side of the RF450 between the RS-232 and power ports. The radio CD and CTS LEDs should turn green. After several seconds, a screen similar to Figure 3.4-2 will appear:
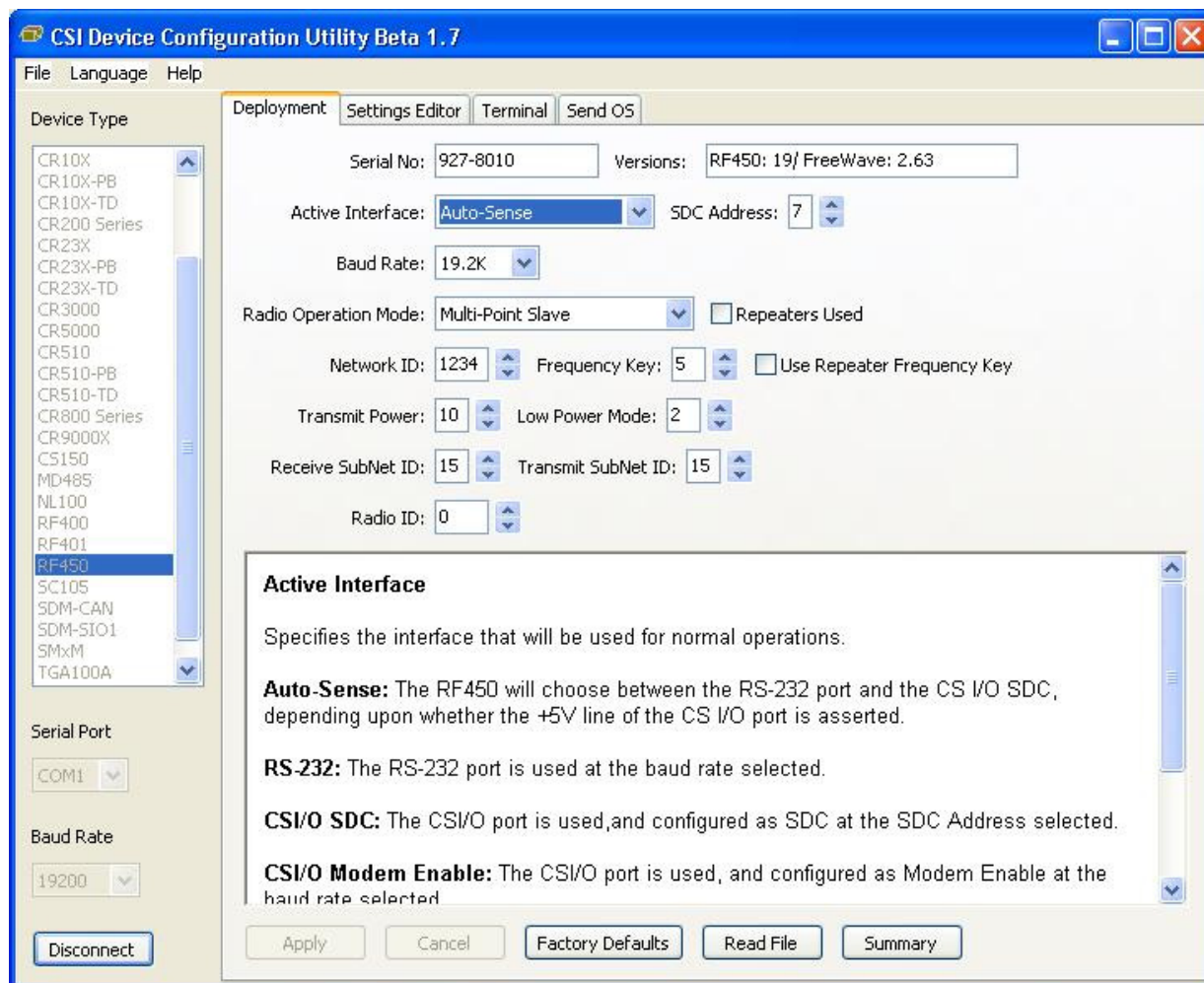
FIGURE 3.4-2. DevConfig Screen Showing the RF450 Settings

Deployment, Settings Editor, Terminal, 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 or Terminal tabs may be used to access all of the FreeWave Radio settings. They should be used by experienced FreeWave Radio users only. New operating systems for the CSI board are loaded through the Send OS tab.

The Device Configuration Utility makes applying the same settings to multiple devices easy. Once settings are configured for one device, click the Apply button; a summary screen similar to Figure 3.4-3 will show. Click the Save button to save a configuration file. This file can then be used to load the settings into another RF450. Click the Read File button to load the settings in DevConfig then the Apply button to load the settings into the RF450.
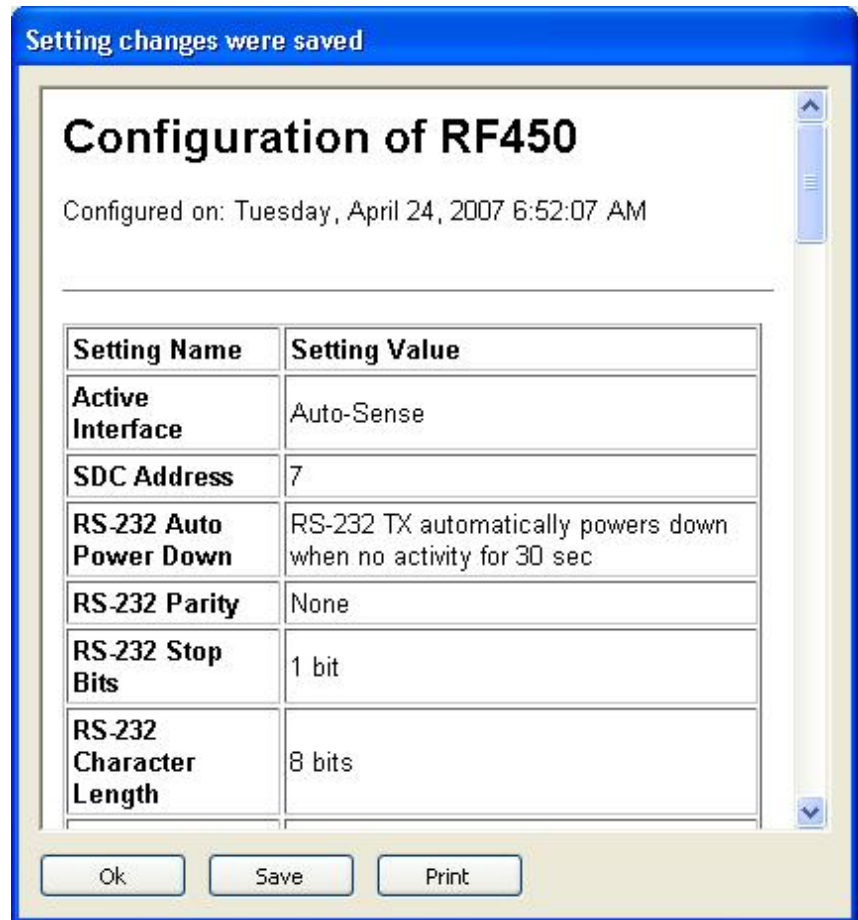
FIGURE 3.4-3. DevConfig RF450 Summary Screen

3.5 Quick Start

1. Using DevConfig, set a unique PakBus Address for each datalogger in the network. Keep the other settings as their default.

2. Decide on a unique Network Identification Number between 0 and 4095, excluding 255. All radios in the network will have the same Network ID.

3. Select a Frequency Key Number between 0 and 14. It is recommended that you change this from 5 which is the default. Generally all radios in the network will have the same Frequency Key.

4. Select one radio to be the Master; the others will be designated as Slaves.

5. Slave Radios: Using DevConfig, set the "Radio Operation Mode" to Multi-Point Slave. Set the Network ID to the number decided upon in step 2 above. Set the Frequency Key to the number decided upon in step 3 above. Set the Radio ID to the PakBus Address assigned in step 1 above. Keep the remaining settings as their defaults. (See note below regarding repeaters.)

6. Master Radio: Using DevConfig, set the "Radio Operation Mode" to Multi-Point Master. Set the Network ID to the number decided upon in step 2 above. Set the Frequency Key to the number decided upon in step 3 above. Set the Radio ID to the PakBus Address assigned in step 1 above. Keep the remaining settings as their defaults. (See note below regarding repeaters.)

7. Select a datalogger, or PC running LoggerNet, to be a router. Using DevConfig, set this node to beacon. Attach the Master Radio to this node.

NOTE   If RF450 repeaters will be used, select Multi-Point Slave/Repeater as the Radio Operation Mode.   Check the "Repeaters Used" box for all radios in the Network.

3.6 Deployment Settings

NOTE   See Appendix A for example radio settings in different network configurations.

3.6.1 Active Interface

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

*   Auto-Sense: The RF450 will choose between the RS-232 port and the CS I/O SDC, depending upon whether the +5 V line of the CS I/O port is present.

*   RS-232: The RS-232 port is used at the baud rate selected.

*   CS I/O SDC: The CS I/O port is used, and configured as SDC at the SDC Address selected.

*   CS I/O Modem Enable: The CS I/O port is used, and configured as Modem Enable at the baud rate selected.

*   ME Master: The CS I/O port is used, and configured for direct connection to a CSI COM200, COM210, COM220, or other ME configured device (MD485, RF416, etc). The connection is a type of "null modem" that crosses TX & RX, and ME & RING; this line swapping is done by using an A100. The baud rates of both the COM2xx (or other device) and RF450 must be the same.

3.6.2 SDC Address

Specifies the SDC address that will be used on the RF450 CS I/O port when CS I/O SDC or Auto-Sense is selected as the active interface.

3.6.3 Baud Rate

Specifies the baud rate that will be used on the RS-232 port or CS I/O ME port.

3.6.4 RF450 Operation Mode Setting

The Operation Mode option designates the method FreeWave transceivers use to communicate with each other. FreeWave transceivers operate in a Master-to-Slave configuration. Before the transceivers can operate together, they must be set up to properly communicate.

In a point-to-point configuration, Master or Slave mode may be used on either end of the communication link without performance degradation. When setting up the transceiver, remember that a number of parameters are controlled by the settings in the Master. Also, radio network diagnostics can only be accessed at the Master radio. Therefore, we suggest you deploy the Master on the communications end where it will be easier to access.

For a datalogger PakBus network, the multi-point radio modes should be used. For other configurations, the Operation Mode will need to be set through the Settings Editor tab.

3.6.4.1 Operation Mode Description Point-to-MultiPoint Master

This mode designates the transceiver as a Master in multi-point mode. This mode allows one Master transceiver to simultaneously be in communication with numerous Slaves and repeaters. A point-to-multi-point Master communicates only with other transceivers designated as point-to-multipoint Slaves or point-to-multipoint repeaters.

Point-to-MultiPoint Slave

This mode designates the transceiver as a Slave in multi-point mode. This mode allows the Slave to communicate with a multi-point Master. The Slave may communicate with its Master through one or more repeaters.

Point-to-MultiPoint Repeater

This option allows the transceiver to operate as a repeater in a multi-point network.

Point-to-MultiPoint Slave/Repeater

This option allows the transceiver to operate as a repeater and a Slave in a multi-point network. The radio will repeat packets sent across the network as well as use the active interface. Choosing this setting effectively sets the operation mode to multi-point repeater and sets the Slave/repeater mode.

Repeaters Used Setting

In a multi-point network, it is critical to transmission timing to configure this parameter correctly. This box should be checked (set to 1 in Settings Editor) if there are **any** repeaters in the network. It should be left unchecked (set to 0 in Settings Editor) if there are no repeaters present.

This parameter should be set to the same value in all transceivers in a multi-point network.

NOTE	This box should be checked (set to 1 in Settings Editor) when running diagnostics from the Master.

3.6.5 Network ID

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

Slaves will link with the first Master or repeater that 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.

3.6.6 Frequency Key Setting

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 Repeaters' Frequency Key would be different from the Master radio, and downstream radios intended to connect to the repeater would have the same Frequency Key setting (as the repeater).

3.6.7 Repeater Frequency Key Setting

This is a setting that is only used by repeaters. The Repeater Frequency Key must be checked when you want a repeater to use a Frequency Key other than that of the Master.

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

The default setting of box not checked (Use Master Frequency) causes the repeater to transmit on the Master's Frequency Key.

NOTE	When this setting is not used, the Frequency Key setting should match that of the Master or of the repeater acting as the Master for that transceiver.

3.6.8 Transmit Power Setting

This setting specifies the RF transmit power.   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]

The RF450 maximum power is 30.5 dBm; therefore, a 6 dB (or lower) gain antenna can be used with any Transmit Power setting. If higher gain antennas are 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 that lower transmit power can be used (to conserve battery power) if the required range allows it.

Table 3.6-1 shows the RF450 RF transmit power versus the setting.

TABLE 3.6-1. Transmit Power Settings		
RF Transmit Power Setting	**RF Power (dBm)**	**RF Power (mW)**
10	30.5	1122
9	30.0	1000
8	29.5	891
7	28.8	759
6	27.4	550
5	26.4	437
4	24.4	275
3	21.5	141
2	18.2	66
1	12.3	17
0	7.5	6

3.6.9 Low Power Mode Setting

This setting allows a multi-point Slave to consume less power. This is achieved primarily by dimming the transceiver's 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 3.6-2 shows the changes at different low power mode settings. The actual current draw depends on many factors. The table below 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 3.6-2. Low Power Mode Settings	
Setting	Description
0	Low Power, disabled
1	LEDs dimmed, transceiver remains awake, transceiver is listening to the Master's transmissions on every slot.
2	LEDs dimmed, transceiver sleeps every other slot
3	LEDs dimmed, transceiver sleeps 2 of 3 slots
4-31	LEDs dimmed, transceiver sleeps the number of slots corresponding to the setting. For example, with a setting of 31 the transceiver sleeps 30 of 31 slots.

NOTE   Low power mode is used only in multi-point Slaves. Power savings occur only when the Slave is linked. There are no power savings when the Slave is transmitting data. Low power mode is of little value when a Slave has a constant, high throughput.

3.6.10 Transmit Subnet ID Setting

In a multi-point network, a Slave or repeater will connect with the first repeater or Master 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, if desired, to force Slaves 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 Slave will listen to.

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 relevant to repeaters in multi-point networks.

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

NOTES   Changing these settings on the Master is not recommended, under normal circumstances. The Receive Subnet ID on the Master has no effect on the network. If both Receive Subnet ID and Transmit Subnet ID are set to 0, a mobile Slave can roam from subnet to subnet and possibly from network to network.

3.6.11 Radio ID Setting

This setting allows a transceiver to be designated with an arbitrary, user-selectable, 4-digit number which identifies the transceiver in diagnostics mode. When used in conjunction with PakBus dataloggers, it is recommended that this value be assigned the PakBus address of the station. This is because the radio ID appears in the FreeWave diagnostics program, and allows the user to associate a particular datalogger with its attached radio.

To further this association of the RF450 RF network with the PakBus network, the dataloggers (CR1000, CR800, etc) read the serial number of the attached radio and include this in the datalogger settings when the CS I/O SDC interface is used. This serial number is the main radio identifier used by the FreeWave Diagnostics program.

3.7 Master Radio

A multi-point network may only contain a single Master radio. Slave radios communicate from and to the Master radio.

NOTE   The Master RF450 must be connected to a PakBus router. A PakBus router may be software such as LoggerNet or PC400 or a datalogger configured as a router.

Selecting "Multi-Point Master" in the Radio Operation Mode designates the transceiver as a Master in multi-point mode. This mode allows one Master transceiver to simultaneously be in communication with numerous Slaves and repeaters. A point-to-multipoint Master communicates only with other transceivers designated as point-to-multipoint Slaves or point-to-multipoint repeaters.

One setting, Low Power Mode, is not applicable to Master radios, thus is greyed out in the Device Configuration Utility (see Figure 3.7-1).

FIGURE 3.7-1. DevConfig Screen Showing Settings for Multi-Point Master

3.8 Slave

Radios configured as Slaves in a multi-point network are allowed to communicate with a multi-point Master (see Figure 3.8-1). The Slave may communicate with its Master through one or more repeaters.

FIGURE 3.8-1. DevConfig Screen Showing Settings for a Slave in a Multi-Point Network

3.9 Repeater

Setting the Radio Operation Mode to "Multi-Point Repeater" allows the transceiver to operate as a repeater in a multi-pPoint network. The "Repeaters Used" box should be checked if there are **any** repeaters in the network; it should be set the same for all transceivers in a multi-point network (see Figure 3.9-1).

FIGURE 3.9-1. DevConfig Screen Showing Settings for Repeater in a Multi-Point Network

3.10 Power Considerations

The RF450 radio requires 6 to 30 VDC power. This may be supplied through either a wall charger (CSI part number 15966) connected to the DC power jack on the side of the radio or through the datalogger via the CS I/O port.

Networks configured in multi-point mode take advantage of the low power mode of the *Slave radios* at the datalogger site. This reduces the required power at remote sites from about 75mA to less than 10 mA in most applications. Power savings occur only when the Slave is not transmitting data. Also, low power mode is of little value when a Slave has a constant, high throughput. Master and repeater radios do not go into a low power mode. RF450 power requirements in the various states of operation are listed in Table 3.10-1.

For help with determining a power budget and solar panel sizes for remote sites, see the Campbell Scientific Application Note titled "Power Supplies" available from our web site: http://www.campbellsci.com/documents/apnotes/pow-sup.pdf.

TABLE 3.10-1. Power Requirements at 12 VDC	
Transmit current, for 1 W power at 100% duty cycle	500 mA
Receive current	75 mA
Idle current	21 mA
Sleep current	6 mA

4. Antennas

4.1 Antennas for the RF450 Series

Several antennas are offered to satisfy the needs for various Master and Slave 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. You must pick one of the antennas listed below.

Omnidirectional antennas are normally used at the base station and nearby stations. Yagi antennas are needed at distant stations or other special cases. Call one of our Applications Engineers for help in choosing an antenna. Only the following FCC approved antennas can be used.

Indoor, Omnidirectional	
19512	0 dBd, ½ wave whip. SMA connector attaches directly to the radio; no antenna cable is needed.
20644	1 dBd, dipole, with window/wall mount. The antenna is shipped with a 79 in. cable that has an SMA male connector that attaches to the radio.
Outdoor, Omindirectional	
14221	3 dBd with rugged FM2 antenna mounts and a Type N female connector. It requires an antenna cable to connect to the radio.
Outdoor, Yagi	
14201	9 dBd, with mounts and a Type N female connector. It requires an antenna cable to connect to the radio. Please note that because the FCC limits EIRP to36 dBm, use of this antenna may require a reduction of the RF450's transmit power.
Antenna Cables and Surge Protectors for Outdoor Antennas	
Recommended for cable lengths less than 10 ft.	
COAXSMA-L	LMR195 antenna cable with type SMA to type N Male Connector
Recommended for cable lengths greater than 10 ft and/or use with lightning protection	
COAXNTN-L	Low-loss (4.1 dB/100 ft) RG8 antenna cable with type N male to type N male connectors (requires 19533 surge protector). Specify length, in feet, after the L.
19533	Surge Suppressor that is recommended when the length of the antenna cable is greater than 10 feet. The surge suppressor helps protect the radio from electrical discharge being conducted down the antenna cable. It includes a COAXSMA-L1.5 cable and requires the COAXNTN-L antenna cable.
Additional Accessories	
15966	AC Wall charger for base station radio
14291	Optional DC power cable
18663	Null modem cable used to connect the radio to the RS-232 port on the datalogger.
CM230	Adjustable Angle Mounting Kit for attaching an outdoor antenna to a tripod or tower.
20625	FreeWave Diagnostics cable and Software CD

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.

CAUTION	In order to comply with the FCC RF exposure requirements, the RF450 series may be used only with **approved antennas** that have been tested with this radio and a minimum separation distance of 20 cm must be maintained from the antenna to any nearby persons.

4.2 Antenna Cables and Surge Protection

4.2.1 Antenna Cables

The 14201, 14221, 19512, and 20XXX antennas require an antenna cable; either (1) the COAXSMA-L cable or (2) the COAXNTN-L cable with surge protector. Indoor omnidirectional antennas are either supplied with an appropriate cable or connect directly to the radio.

4.2.2 Electrostatic Issues

Many RF450 series installations are out of doors and therefore susceptible to lightning damage, especially via the antenna system. Also, depending on climate and location, electro-statically 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 the Item # 19533 Antenna Surge Protection Kit.

Antenna surge protection is recommended in the following applications:

- When the antenna cable length exceeds 10 feet

- When use of COAXSMA cable would result in too much signal loss

- When the radio will be used in an environment susceptible to lightning or electro-static buildup

4.2.3 Antenna Surge Protector Kit

The Surge Protector Kit includes the following:

- Polyphaser protector

- COAXSMA-L cable with 1.5 ft length (its type N male connector fastens to the polyphaser's equipment connector; its SMA connector fastens to the radio's antenna connector)

- Screw (pn 505) and grommet (pn 6044) to secure the polyphaser protector to the backplate of an enclosure

- 1.5 ft, 10 AWG ground wire (insert one end of the wire between the #505 screw and the polyphaser, then secure the other end to a ground lug)

5. LoggerNet Software Setup

The Device Map is configured from the "Setup" button on the LoggerNet or PC400 toolbar. Configure the Device Map as described below (see Figure 5.1-1).

1. Select Add Root | COM Port.

2. Add a PakBusPort, set the Maximum Baud Rate to 115200, set the beacon interval to 60 seconds if the Master radio will be at the PC.

3. Add datalogger, set the PakBus address to match that of the datalogger.
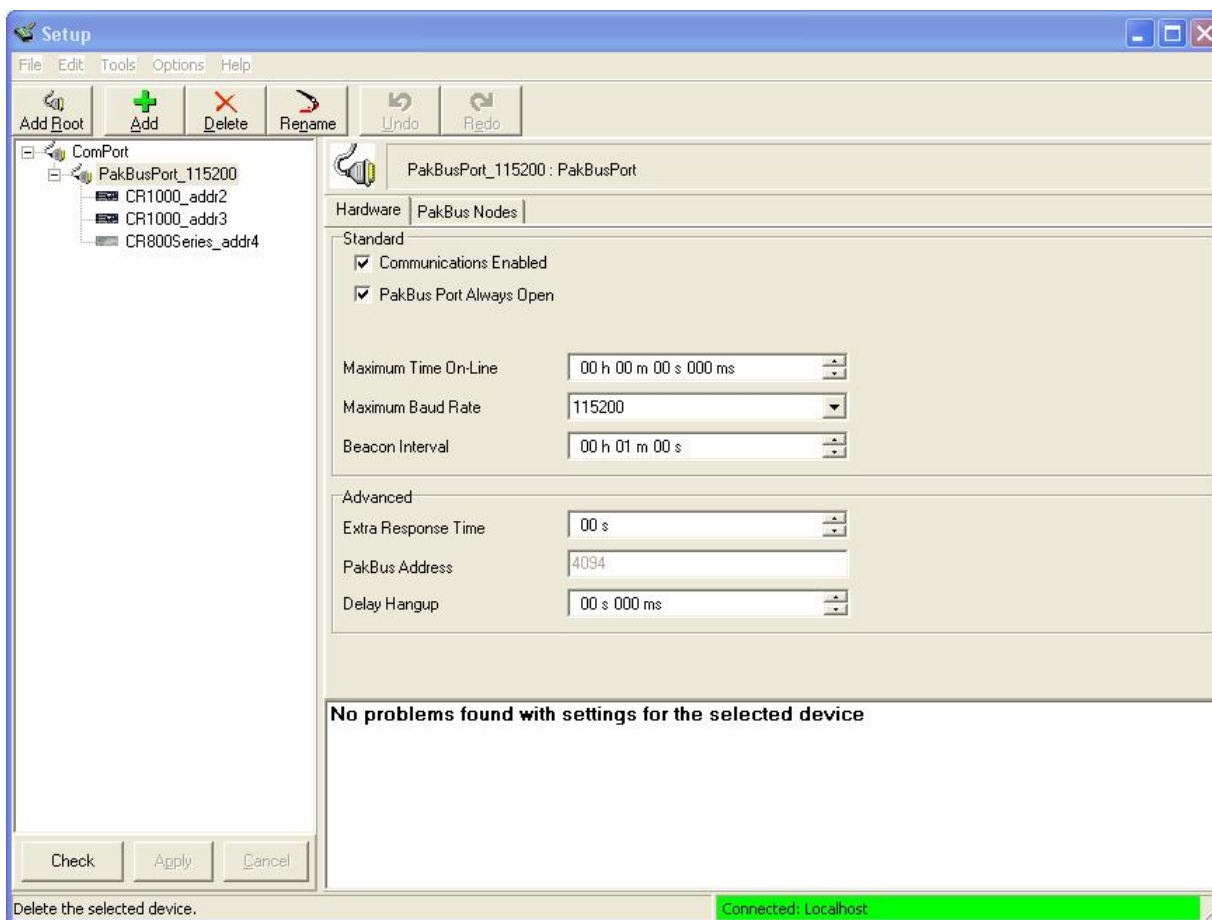
4. Apply Settings.

FIGURE 5.1-1. LoggerNet Setup Screen for an RF450 Multi-Point Network

6. RF450s with RF401 or CR206(X) in the Same Network

Using RF450s in the same network as Campbell Scientific's RF401 radios or CR206(X) dataloggers is not recommended. RF450s will not communicate directly with RF401s and CR206(X)s. The RF450s will interfere with the RF401s' and CR206(X)s' transmissions. If RF450s and RF401/CR206(X)s must be in the same network, there are some things you can do to get better performance out of the RF401 portion of your network:

1. Use Yagi antennas and separate them.

2. Disable Frequency Zones 4 through 11 on the RF450. This is done through the Settings Editor Tab of the Device Configuration Utility.

7. Troubleshooting

LED Status

The RF450 has three red/green LED status indicator lights. Table 7-1 shows the status of each light when the RF450 is in various states of communication.
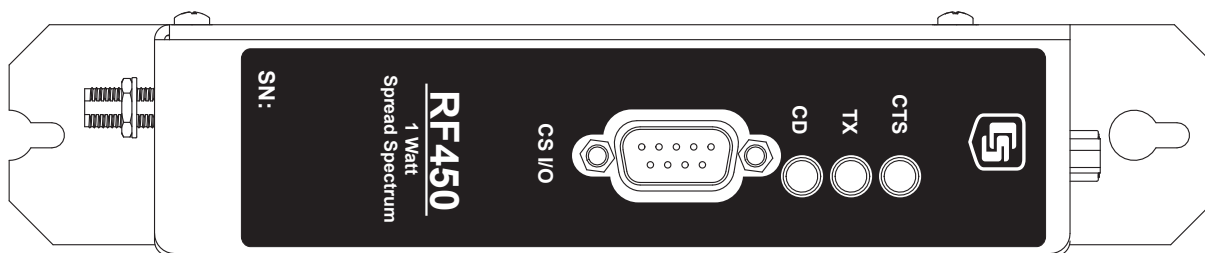

FIGURE 7-1. RF450 Front Side View

TABLE 7-1. Multi-Point Network LED Status								
	Master			**Slave**			**Repeater**		
Condition	Carrier Detect (CD)	Transmit (TX)	Clear to Send (CTS)	Carrier Detect (CD)	Transmit (TX)	Clear to Send (CTS)	Carrier Detect (CD)	Transmit (TX)	Clear to Send (CTS)
Powered, not linked	Solid bright red	Solid dim red	Off	Solid bright red	Off	Blinking red	Solid bright red	Off	Blinking red (a)
Repeater and Slave linked to Master, no data	Solid bright red	Solid dim red	Off	Solid green	Off	Solid bright red (a)	Solid green	Solid dim red	Solid bright red (a)

	Master			Slave			Repeater		
Repeater and Slave linked to Master, Master sending data to Slave	Solid bright red	Solid dim red	Off	Solid green	Off	Solid bright red (a)	Solid green	Solid dim red	Solid bright red (a)
Repeater and Slave linked to Master, Slave sending data to Master	Solid bright red OR Solid green RCV data	Solid dim red	Intermittent flashing red	Solid green	Intermittent flashing red	Solid bright red (a)	Solid green	Solid bright red	Solid bright red (a)
Master with diagnostics program running	Solid bright red	Solid dim red	Intermittent flashing red	Solid green	Intermittent flashing red	Solid bright red (a)	Solid green	Solid bright red	Solid bright red (a)
(a) Clear to Send will be solid red with a solid link, as the link weakens the CTS on the Repeater and Slave will begin to flash.									

If DevConfig is unable to establish a connection with the RF450:

1.   Check that other Campbell Scientific software is closed.

2.   Check power to the radio. The Carrier Detect (CD) light should be flashing red.

3.   Check serial cable connections.

4.   Check serial port assignment for DevConfig.

5.   Press green Setup button on the RF450 and wait several seconds. CD and Clear to Send (CTS) lights should be solid green.

Radios not networked together, not communicating:

1.   Check the baud rate of all RF450s; they should be the same.

2.   Check Network IDs of all RF450s; they should be the same.

3.   Check Frequency Key Number of all RF450s; they should be the same unless two branches of the network are operating in a parallel manner. See Appendix A, Example 3 for settings used in a parallel network.

4.   Check the "Repeaters Used" box for all RF450s.

5.   Check the PakBus address of dataloggers connected to RF450s and in LoggerNet.

6.   Check that antenna and antenna cables are SMA (SubMiniature version A). They will have a yellow heat shrink label to distinguish them from RPSMA (Reverse Polarity SubMiniature version A) devices. RPSMA antennas and cables are not compatible with the RF450.

LEDs flash when LoggerNet command transmitted but no response from datalogger:

1. Check SC12 cable on the datalogger's CS I/O port.

2. Check SDC address in RF450.

3. Check SDC address in datalogger.

4. Check the baud rate of all RF450s; they should be the same.

5. Check the baud rate of LoggerNet; it should match the baud rate of the RF450s.

Using the diagnostics port.

A special FreeWave Diagnostics cable and software (CSI part number 20625) can be useful in troubleshooting radio problems. Contact FreeWave Inc. for more information on using the Diagnostics cable.

Appendix A. Installation Scenarios

A.1 Example 1: PC-to-RF Network

In this example, the Master radio is connected to a PC running LoggerNet (see Figure A.1-1). Slave radios are connected to CR1000s in the field. LoggerNet may be used to view real-time values from the dataloggers, collect data, set datalogger clocks, and send programs.

Remember, each datalogger must have a unique PakBus Address.
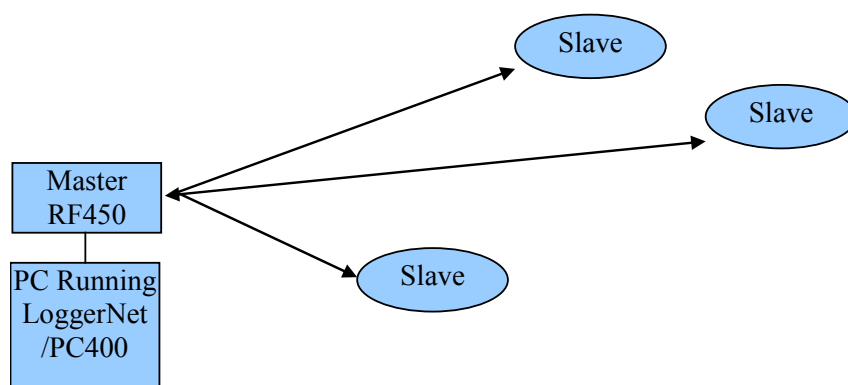
FIGURE A.1-1. Schematic of PC-to-RF450 Network

Using the Device Configuration Utility setup the Master and Slave RF450 radios according to Table A.1-1 below. The Deployment tab of DevConfig should look similar to Figure A.1-2.

FIGURE A.1-2. DevConfig Screen Showing Master Radio Settings for Example 1

TABLE A.1-1. RF450 Settings for Example 1		
	Master	**Slave(s)**
Hardware	RF450 connected to PC running LoggerNet	RF450 connected to CR1000's CS I/O port
Keep all factory default settings except:		
Radio Operation Mode	Multi-Point Master	Multi-Point Slave
Network ID	1726 (yours may be different)	1726 (yours may be different)
Frequency Key	1 (yours may be different)	1 (yours may be different)
Radio ID	4094 (to match LoggerNet's PakBus Address)	2 (to match CR1000's PakBus Address) (a)
(a) All Slave Radios in the network will have these same settings except for the Radio ID. The Radio ID should match the PakBus Address of the datalogger it is connected to.		

The Device Map in LoggerNet's Setup screen will look something like this:
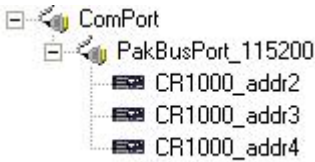
A.2 Example 2: PC-to-RF Network with Repeater

In this example, the Master radio is connected to a PC running LoggerNet (see Figure A.2-1). Slave radios are connected to CR1000s in the field. One Slave radio, also connected to a CR1000, is used as a repeater to go around an obstacle such as a hill. To take advantage of the low power mode, those devices that are NOT repeaters should be configured as multi-point Slaves and not as mult-point Slave/repeaters. In this configuration, it may be desirable to use an external omni directional antenna at the repeater.

When a repeater is used, the RF throughput is cut in half. When more than one repeater is used there is no further degradation in the RF throughput of the link. 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.

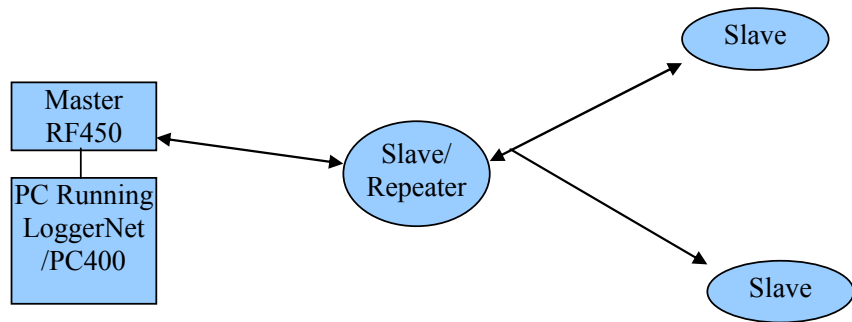Remember, each datalogger must have a unique PakBus Address.

FIGURE A.2-1. Schematic of PC-to-RF450 Network with Repeater

TABLE A.2-1. RF450 Settings for Example 2			
	Master	**Slave/Repeater**	**Slave(s)**
Hardware	RF450 connected to PC running LoggerNet	RF450 connected to CR1000's CS I/O port	RF450 connected to CR1000's CS I/O port
PakBus Address	4094	2	3
Keep all factory default settings except:			
Radio Operation Mode	Multi-Point Master	Multi-Point Slave/Repeater	Multi-Point Slave
Repeaters Used	Yes, check box	Yes, check box	Yes, check 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's PakBus Address)	2 (to match CR1000's PakBus Address) (a)	3 (to match CR1000's PakBus Address) (a)

Master Radio Settings:

FIGURE A.2-2. DevConfig Screen Showing Master Radio Settings for Example 2

Slave/Repeater Radio Settings:

FIGURE A.2-3. DevConfig Screen Showing Slave/Repeater Radio Settings for Example 2

Slave Radio Settings:

FIGURE A.2-4. DevConfig Screen Showing Slave Radio Settings for Example 2

The Device Map in LoggerNet's Setup screen will look something like this:
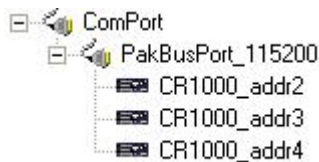
A.3 Example 3: PC-to-RF Network with Parallel Repeaters (using the SubNet ID)

In this example, the Master radio is connected to a PC running LoggerNet (see Figure A.3-1 and Table A.3-1). One stand-alone repeater (Repeater 1) is used to access several Slave radios connected to CR1000s in the field. The stand-alone repeater consists of an RF450, power supply, and antenna. Another repeater (Slave/Repeater 2) connected to a CR1000 is used to access several other Slave radios on CR1000s.

To take advantage of the low power mode, those devices that are NOT repeaters should be configured as multi-point Slaves and not as multi-point Slave/repeaters. In this configuration, it may be desirable to use an external omni directional antenna at the repeaters.

When a repeater is used, the RF throughput is cut in half. When more than one repeater is used there is no further degradation in the RF throughput of the link. 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.

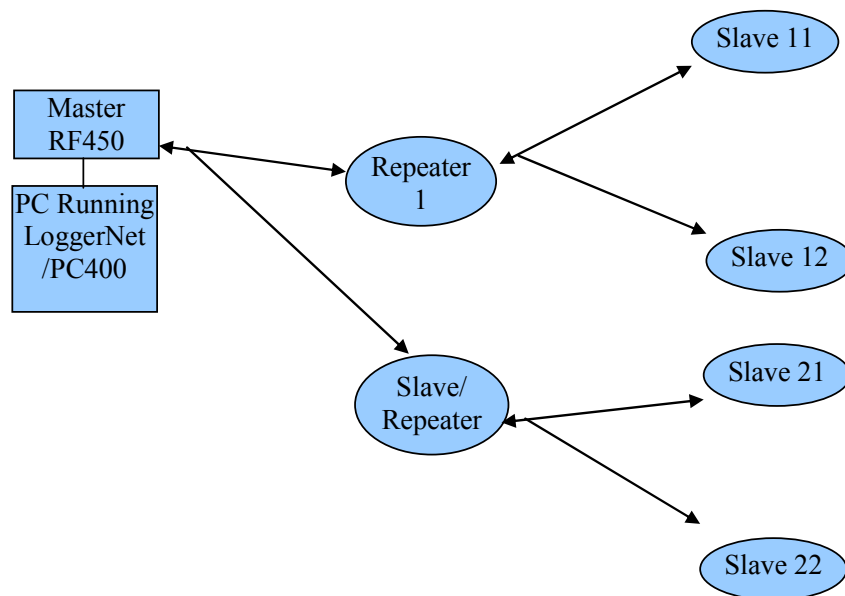Remember, each datalogger must have a unique PakBus Address.

FIGURE A.3-1. Schematic of PC-to-RF Network with Parallel Repeaters (using the SubNet ID)

TABLE A.3-1. RF450 Settings for Example 3					
	Master	**Repeater**	**Slave/Repeater**	**Slave 11, 12 etc.**	**Slave 21, 22 etc.**
Hardware(d)	PC running LoggerNet, RF450	RF450	CR1000, RF450	CR1000, RF450	CR1000, RF450
Baud Rate	115.2K	115.2K	115.2K	115.2K	115.2K
Radio Operation Mode	Multi-Point Master	Multi-Point Repeater	Multi-Point Slave/Repeater	Multi-Point Slave	Multi-Point Slave
Repeaters Used	Yes; check box	Yes; check box	Yes; check box	Yes; check box	Yes; check box
Network ID (a)	1726	1726	1726	1726	1726
Frequency Key (a)	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(b)	2	3 (c)	11, 12 etc. (c)	21, 22, etc (c)

Notes:

(a) your Network ID and Frequency Key may be different

(b) to match LoggerNet's PakBus Address

(c) to match CR1000's PakBus Address

(d) not inclusive; other typical hardware items may include power supply, antenna, enclosure, etc.

NA = not applicable

A.4 Example 4: Phone-to-RF Base

In this example, a COM220 phone modem and Master radio are connected without a datalogger to a network of CR1000s in the field (see Figure A.4-1 and Table A.4-1). The computer running LoggerNet uses a phone modem to call into the Master site and connect to the rest of the network. The rest of the network can be configured as in other examples. In this configuration, datalogger-to-datalogger communications and datalogger call-back is NOT supported; see Example 5.
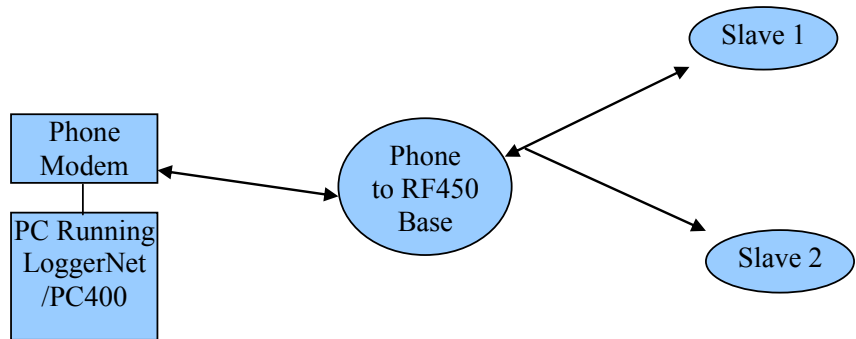

FIGURE A.4-1. Schematic of Phone-to-RF Base

TABLE A.4-1. RF450 Settings for Example 4			
		Phone to RF450 Base	**Slaves**
Hardware(d)	PC running LoggerNet, Phone Modem	COM220, RF450, A100	CR1000, RF450
Active Interface		ME Master	Auto-Sense
Baud Rate		115.2K	115.2K
Radio Operation Mode		Multi-Point Master	Multi-Point Slave
Network ID (a)		1726	1726
Frequency Key (a)		1	1
Radio ID		2	3 (c)
Notes: (a) your Network ID and Frequency Key may be different (b) to match LoggerNet's PakBus Address (c) to match CR1000's PakBus Address (d) not inclusive; other typical hardware items may include power supply, antenna, enclosure, etc. NA = not applicable			

A.5 Example 5: 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 RF450s as the single communications device as in Examples 1, 2, and 3. Example configurations where call-back is supported:

LN-RF450 Master ~~~~~RF450 Slave -DL

LN-RF450 Master ~~~~~~RF450 Slave/Repeater-DL~~~~~~RF450 Slave-DL

LN-RF450 Master ~~~~~~~~RF450 Repeater ~~~~~~~~RF450 Slave -DL

LN-Phone Modem -----COM220-DL-RF450 Master ~~~~~~RF450 Slave -DL

NOTE: LN=LoggerNet; DL=Datalogger

In a mixed-communication devices network, e.g. phone to RF450, the *base* site makes the transition between communication types. Call-back is NOT supported when the base RF450's Active Interface is configured as Modem Enable (ME) Master. The RF450's Active Interface is configured as ME Master when the CS I/O port is used for direct connection to a ME device (COM200, COM210, COM220, MD485, etc). The connection is done by using an A100. Example configurations where call-back is NOT supported:

LN-Phone Modem -----COM220-CSI null modem-RF450 Master~~~~~RF450 Slave -DL(1)

LN--Ethernet--RavenXT-rs232nullmodem-RF450 Master~~RF450 Slave -DL

NOTE: LN=LoggerNet; DL=Datalogger

In this example the RF450s are set-up as described in Example 1. In the following program the datalogger 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 datalogger and store it into a file based on the data collection settings in LoggerNet's Setup window. Note that the PakBus Port setting in LoggerNet's Setup window must be set to Always Open.

```
'CR1000 Series Datalogger
'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 (Test,true,-1)
    DataInterval (0,15,Sec,10)
    Sample (1,counter,FP2)
EndTable
```

```
'Main Program
BeginProg
'Configure the CR1000's CS I/O port to match the SDC address and baud rate
'set in the RF450
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 Test
    NextScan
EndProg
```

Appendix B. Settings Editor

The Settings Editor of the Device Configuration Utility provides access to additional settings not shown on the Deployment Tab. Most RF450 networks do not need to make changes through the Settings Editor.
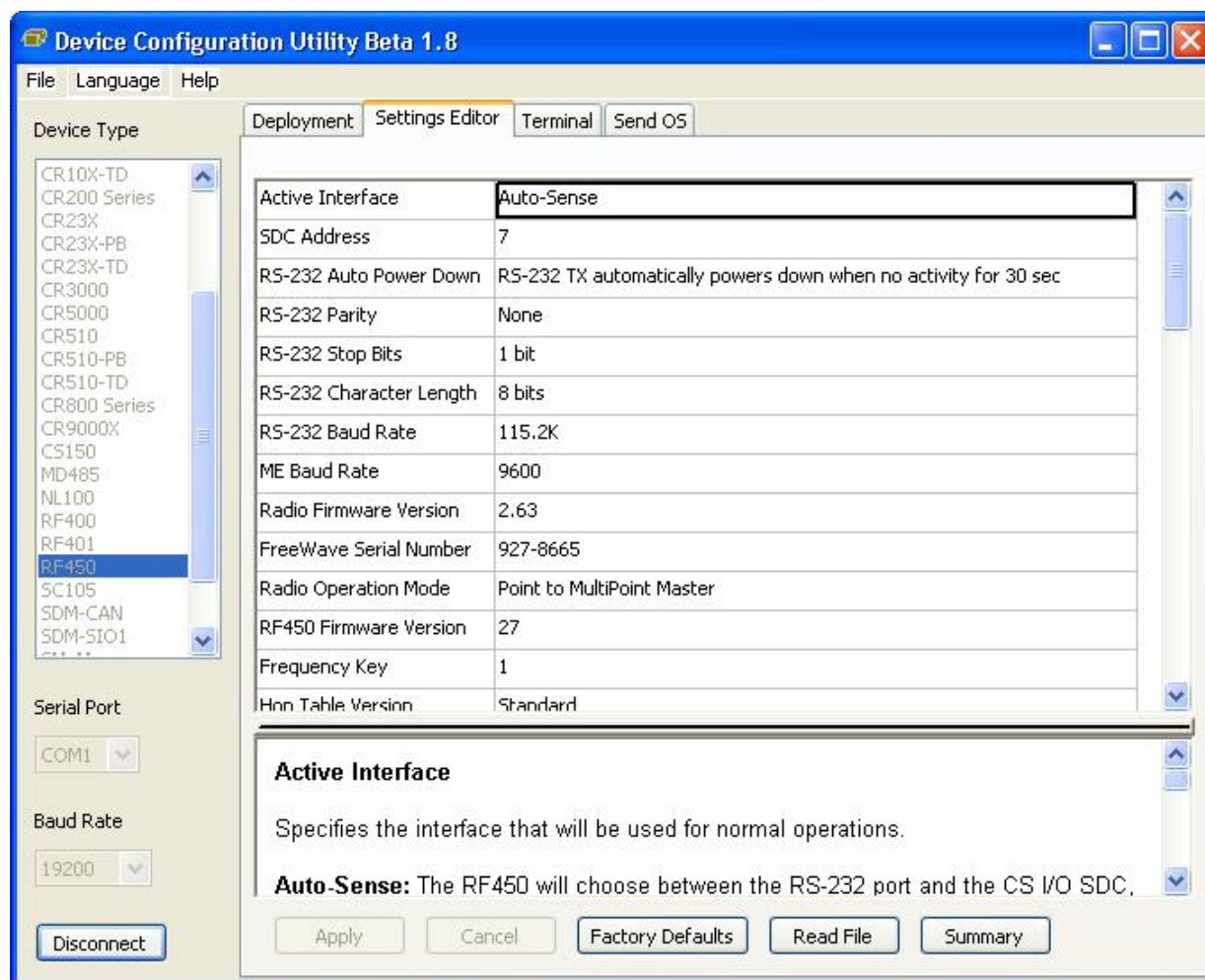
Radios deployed outside of the United States must use a *Hop Table Version* other than zero (the default). This setting can be changed through the Settings Editor tab.
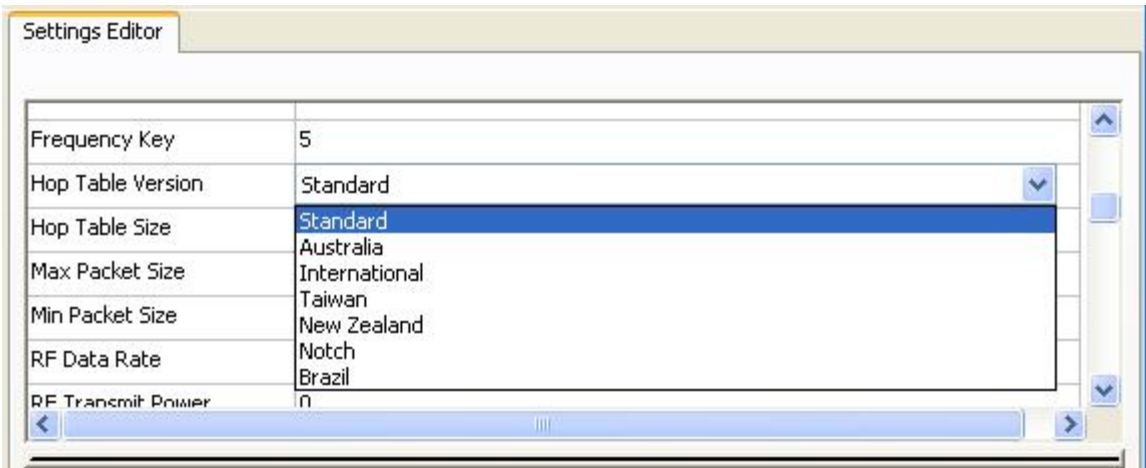
The Hop Table Version setting allows the user to choose the portion of the band in which the transceiver will operate.

0	Standard	Full 902-928 MHz
1	Australia	915-928 MHz
2	International	902-928 MHz, 16 fewer frequencies than full U.S. set
3	Taiwan	916-920 MHz
4	New Zealand	921-928 MHz
5	Notch	Uses 902-928 MHz with center frequencies of 911-919 MHz notched out
6	Brazil	902-915 MHz

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