FREEWAVE

LRS455 Wireless Data Radio

LRS455-C-U

LRS455-CE-U

LRS455-T-U

Covering Firmware 1.77

User & Reference Manual

Warranty

FreeWave Technologies, Inc. warrants your FreeWave® Wireless Data radio against defects in materials and manufacturing for a period of three years from the date of shipment, depending on model number. In the event of a Product failure due to materials or workmanship, FreeWave will, at its discretion, repair or replace the Product. For evaluation of Warranty coverage, return the Product to FreeWave upon receiving a Return Material Authorization (RMA).

In no event will FreeWave Technologies, Inc., its suppliers, or its licensors be liable for any damages arising from the use of or inability to use this Product. This includes business interruption, loss of business information, or other loss which may arise from the use of this Product. OEM customer's warranty periods can vary.

Warranty Policy will **not apply** in the following circumstances:

1. If Product repair, adjustments, or parts replacements are required due to accident, neglect, or undue physical, electrical, or electromagnetic stress.
2. If Product is used outside of FreeWave specifications as stated in the Product's data sheet.
3. If Product has been modified, repaired, or altered by Customer unless FreeWave specifically authorized such alterations in each instance in writing. This includes the addition of conformal coating.

Safety Information

The products described in this manual can fail in a variety of modes due to misuse, age, or malfunction. Systems with these products must be designed to prevent personal injury and property damage during product operation and in the event of product failure.

Warning! **Do not** remove or insert the Ethernet or diagnostics cable while circuit is live unless the area is known to be free of ignition concentrations of flammable gasses or vapors.

Warning! Do not connect the LRS455-C-U, CE-U, -T-U series radios to DC power without terminating the antenna port to a suitable load, such as a 50 ohm antenna, or an attenuator with a power rating greater than or equal to 2 W. Powering up without a load attached will damage the radio and void the warranty.

Table of Contents

Preface

This document includes this information about the FreeWave LRS455-C-U, CE-U, -T-U radios:

- A basic introduction to the radio and how to determine the mode you want to run it in.
- Considerations and quick starts for your network design, including charts of LED displays.
- Steps to setting up and programming the radio using Tool Suite and through a terminal emulator.
- A reference section that details each parameter that you can set on the radio.
- Steps to view statistics about a radio's performance.
- Examples of how FreeWave radios can exist in a network with other radios.
- Pin out and mechanical drawings.

Contact FreeWave Technical Support

For up-to-date troubleshooting information, check the **Support** page at www.freewave.com.

FreeWave provides technical support Monday through Friday, 8:00 AM to 5:00 PM Mountain Time (GMT -7).

- Call toll-free at 1.866.923.6168.
- In Colorado, call 303.381.9200.
- Contact us through e-mail at moreinfo@freewave.com.

Document Styles

This document uses these styles:

- Parameter setting text appears as: **[Page=radioSettings]**
- File names appear as: **configuration.cfg**.

- File paths appear as: **C:\Program Files (x86)\FreeWave Technologies**.
- User-entered text appears as: **xxxxxxxxx**.
- 3rd-party names appear as: **Notepad**®.

⚠ **Caution**: Indicates a situation that **may** cause damage to personnel, the radio, data, or network.

Example: Provides example information of the related text.

FREEWAVE Recommends: Identifies FreeWave recommendation information.

Important!: Provides crucial information relevant to the text or procedure.

Note: Emphasis of specific information relevant to the text or procedure.

(Tip) Provides time saving or informative suggestions about using the product.

STOP **Warning!** Indicates a situation that **will** cause damage to personnel, the radio, data, or network.

Parameter Preference Table

The **Parameter Preference** table describes the parameter, its options, and usage.

<Parameter Name>	
Setting	**Description**
Default Setting	The factory default setting for the parameter.
Options	The options the parameter can be set to.
Setup Terminal Menu	The menu path and field name to access the parameter using the terminal menus available through the serial port.
Description	A description of what the parameter is and how it applies to the radio in the network.

1. Introduction

FreeWave radios operate in virtually any environment where serial data communications occur. A pair of radios functions as a 9-pin null modem cable.

- If the FreeWave radios are to be used in an application where a null modem cable is used, such as communication between two computers, then the FreeWave radios can be connected directly.
- If FreeWave radios are to be used to replace a straight-through RS232 cable, then a null modem cable must be placed between the radio (DCE) and the DTE instrument to which it is connected.

Figure 1: LRS455 Wireless Data Radio

Warning! Do not connect the LRS455-C-U, CE-U, -T-U series radios to DC power without terminating the antenna port to a suitable load, such as a 50 ohm antenna, or an attenuator with a power rating greater than or equal to 2 W. Powering up without a load attached will damage the radio and void the warranty.

1.1. Choosing a Location for the Radios

Placement of the FreeWave 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. In general, FreeWave units with a higher antenna placement will have a better communication link. In practice, the radio should be placed away from computers, telephones, answering machines, and other similar equipment. The cable included with the radio usually provides ample distance for placement away from other equipment. FreeWave offers directional and Omni-directional antennas with cable lengths ranging from 3 to 200 feet. When using an external antenna, placement of that antenna is critical to a solid data link. Other antennas in close proximity are a potential source of interference. Use the Radio Statistics to help identify potential problems.

The Show Radio Statistics page is found in option 4 in the main Setup menu or in the Diagnostic information in Tool Suite. An adjustment as little as 2 feet in antenna placement can resolve some noise problems. In extreme cases, such as when interference is due to a Pager or Cellular Telephone tower, the band pass filters that FreeWave offers may reduce this out-of-band noise.

1.2. Choosing Point-to-Point or Point-to-MultiPoint Operation

Note: In an LRS455-C-U, CE-U, -T-U radio network, you can use only one Repeater.

A Point-to-Point network is best suited when your network consists of one Master and one Slave radio.

Important!: Adding a Repeater to a network reduces the throughput by 50%. For example, over-the-air throughput in a network running at 2-Level GFSK and with the Repeaters parameter disabled is 9600 bps. With the Repeaters parameter enabled, the over-the-air throughput drops to 4800 bps.

The LRS455-C-U, CE-U, -T-U radios are narrowband radios and have a limited channel size based on the license obtained from the FCC. Therefore, the radios can experience a dramatic impact in throughput if a Repeater is implemented in the network. If you have large amounts of data to transfer and choose to add a Repeater in your network, you must optimize polling host / RTU settings to accommodate for the lower throughput. Polling host / RTU optimization settings include reducing block/packet sizes and increasing overall time-out parameters.

In a Point-to-MultiPoint network (also referred to as MultiPoint network), the Master radio is able to simultaneously communicate with numerous Slave radios. In its simplest form, a MultiPoint network functions with the Master broadcasting its messages to all Slaves. If requested by the Master, the Slaves respond to the Master when given data by the device connected to the data port. This response depends on your setup. You can extend the reach of a licensed network with

one Repeater. As with a Repeater in a Point-to-Point network, adding a Repeater to a network cuts the data throughput by half.

It is important to note the differences between Point-to-Point and MultiPoint networks. In a Point-to-Point network all packets are acknowledged, whether sent from the Master to the Slave or from the Slave to the Master. In a MultiPoint network, you determine the number of times outbound packets from the Master or Repeater to Slaves are sent. The receiving radio, Slave or Repeater, accepts the first packet received that passes the 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 MultiPoint network is very robust.

Traditionally, a MultiPoint network is used in applications where data is collected from many instruments and reported back to one central site. The architecture of such a network is different from Point-to-Point applications. The following parameters influence the number of radios that can exist in a MultiPoint network:

1. Size of the blocks of data. The longer the data blocks, the fewer number of deployed Slaves can exist in the network.

2. Baud rate. The data rate between the radio and the device to which it is connected could limit the amount of data and the number of radios that can exist in a network

3. The amount of contention between Slaves. Polled Slaves vs. timed Slaves.

4. Use of a Repeater. Using the Repeaters setting in a MultiPoint network decreases overall network capacity by 50%.

> **Example**: If the network polls Slaves once a day to retrieve sparse data, several hundred Slaves could be configured to a single Master. However, if each Slave transmits larger amounts of data or data more frequently, then fewer Slaves can link to the Master while receiving the same network performance. When larger amounts of data are sent more frequently, the overall network bandwidth is closer to capacity with fewer Slaves.

For examples and additional information about data communication links, see the Data Communication Links section.

1.3. Data Communication Link Examples

FreeWave radios' versatility allows data communication links to be established using a variety of different configurations.

1.3.1. Point to Point Link

The example below shows the most common and straight forward link; a Master communicating to a Slave in a Point-to-Point link.
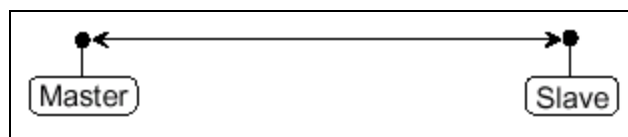
Figure 2: Point to Point Link

1.3.2. Repeater Link

The example below shows how a link might be set up using a Repeater. The Repeater may be located on a hilltop or other elevated structure enhancing the link from the Master to the Slave. In this configuration, it may be desirable to use an external Omni directional antenna at the Repeater. Yagi antennas may be used at both the Master and Slave radios.

In an LRS455-C-U, CE-U, -T-U radio network, you can use only one Repeater.
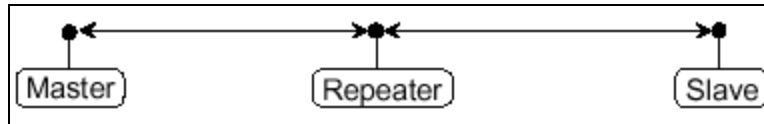
Figure 3: Repeater Link

Important!: Adding a Repeater to a network reduces the throughput by 50%. For example, over-the-air throughput in a network running at 2-Level GFSK and with the Repeaters parameter disabled is 9600 bps. With the Repeaters parameter enabled, the over-the-air throughput drops to 4800 bps.

The LRS455-C-U, CE-U, -T-U radios are narrowband radios and have a limited channel size based on the license obtained from the FCC. Therefore, the radios can experience a dramatic impact in throughput if a Repeater is implemented in the network. If you have large amounts of data to transfer and choose to add a Repeater in your network, you must optimize polling host / RTU settings to accommodate for the lower throughput. Polling host / RTU optimization settings include reducing block/packet sizes and increasing overall time-out parameters.

1.3.3. Point to Multipoint Network

The next example depicts a standard Point-to-MultiPoint network. From the Master, any data is broadcast to all three Slaves, one of which receives it through a MultiPoint Repeater. The data is in turn sent out of the serial port of each of the three Slaves. The end device should be configured to interpret the serial message and act on it if necessary.
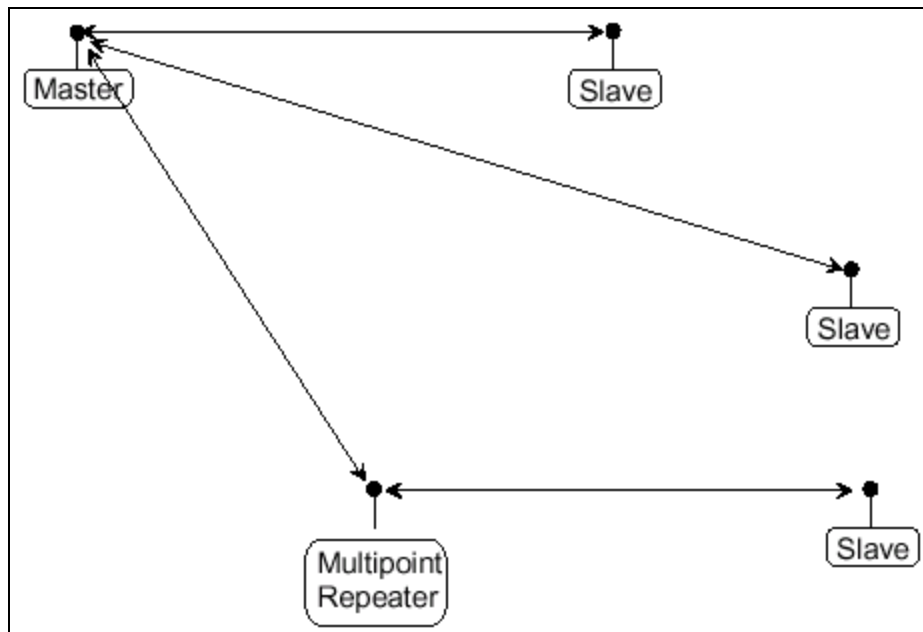
Figure 4: Point to Multipoint Link

1.4. Finding the Product Serial Number

Each FreeWave radio is assigned a unique serial number. If you need to contact FreeWave Technical Support, you will be asked for the serial number on the radio you are calling about.

The serial number is three digits, followed by a hyphen and four digits, for example 111-1111, and is printed on the FreeWave label on the radio. The example below is for a GXM model; however, the serial number information will be in the same location on different models.
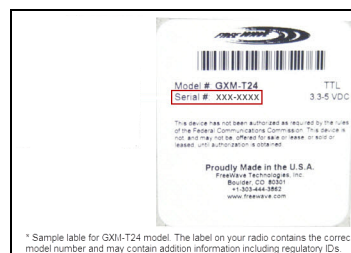
Figure 5: Serial Number Location for Enclosed Model

On radios that are not in an enclosure, you can also find the serial number printed on a label on the back (the flat, smooth side) of the radio. This label is in larger print.
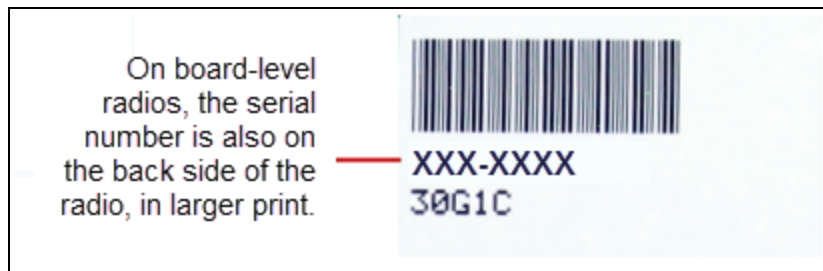
Figure 6: Serial Number Location for Non-Enclosed Model

1.5. Powering the Radio

To provide power to the radio, connect it to a positive supply with +6.0 to +27.0 VDC (typically, +12 VDC).

Using a dedicated power supply line is preferred. The power supply you use must provide more current than the amount of current drain listed in the product specifications listed in the product's data sheet available on www.FreeWave.com for the voltage you are using. For example, if you are using +12.0 VDC, the power supply must provide above the drain that is required for transmit using +12 VDC.

Warning! Do not connect the LRS455-C-U, CE-U, -T-U series radios to DC power without terminating the antenna port to a suitable load, such as a 50 ohm antenna, or an attenuator with a power rating greater than or equal to 2 W. Powering up without a load attached will damage the radio and void the warranty.

If the power supply line runs outside the radio enclosure, use electrostatic discharge (ESD) protectors to protect the radio from electric shock, and transient voltage suppressors (TVS) to protect from an over-voltage situation. Using both helps to ensure long-term, reliable operation. FreeWave does not supply or sell these items; however, they can be purchased at most electronic supply stores.

1.6. Configuration Tool Options

Note: The terms modem and radio are used interchangeably in this document and in the text within the setup tools. While the words have different meanings, the two terms should be treated as one and the same when referring to FreeWave products.

When the radio is in Setup mode, you can use the following setup tools to configure the settings on the radio:

- **Tool Suite** - provides a group of tools for configuring the devices in your network and for monitoring your network's performance. Using the Configuration application within Tool Suite, you can program changes to your radio's settings.
- **Terminal Emulator** - A terminal emulator program, e.g., TeraTerm, offers many of the same configuration options that are available in the Configuration application in Tool Suite.

- You can use the terminal emulator program of your choice to program the radio. The Setup Terminal application in Tool Suite provides the same interface that is available using a terminal emulator.

1.6.1. Tool Suite and Terminal Emulators

If using a terminal emulator, the tabs for a device in Tool Suite mirror the Setup main menu selections.

Example: Option 0 from the Setup main menu in the terminal menu setup is **Set Operation Mode**. The corresponding configuration tab for the device in Tool Suite is **(0) Operation Mode**.
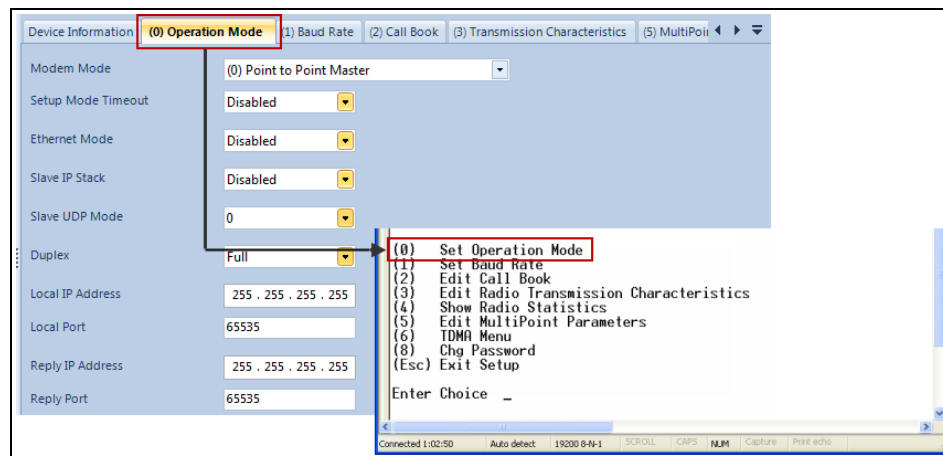
Figure 7: Tool Suite and Setup Menu

You can also use the Setup Terminal application within Tool Suite to use and view the terminal menus. It displays the same menus and provides the same programming settings as you see using a terminal emulator.

Throughout this document, if the setup procedure in the terminal emulator is different than the procedure in Tool Suite, the terminal instructions are also included.

1.7. Radio Setup Mode

To read the current settings from or to program a radio, the radio must be in Setup mode. When a radio is in Setup mode, all three LEDs display solid green ● ● ●. See the sections below for details about how to access the radio's Setup mode using Tool Suite or a terminal emulator.

Note: OEM boards may also enter Setup when Pin 2 on a 10-point connector or Pin 8 on a 24-pin connector is grounded, or using a break command. For more information about the break command, see Use Break to Access Setup (on page 28).

The Setup Port (on page 26) parameter in the Baud Rate tab determines whether the main data port or the diagnostics port is used to access the setup parameters for the radio.

Using the **Setup Mode Timeout** parameter in the **Operation Mode** tab, you can set the radio to exit Setup Mode automatically. When the setting is enabled, if the radio has not received any menu selections or programming information within 5 seconds, it exits Setup and resumes its previous mode.

1.7.1. Using Tool Suite to Connect to and Program Radios

To read and program a radio using Tool Suite, you need to connect the radio to a desktop computer or a laptop that runs the Tool Suite software.

1. Connect a serial or diagnostic cable between the computer or laptop and the radio.

> **FREEWAVE Recommends**: Using a diagnostic cable is recommended.

2. Connect the power supply to the radio and the power source and turn on the radio.

3. To place the radio in Setup mode, press the Setup button on the back of the FreeWave radio. If connected to the diagnostics port, type <Shift+U> to activate the Setup menu.

Figure 8: Setup Button

To place the radio in Setup mode in board-level radios:

- Short pins 2 & 4 (Brown to Black) on the white 10 pin header next to the LEDs.

4.
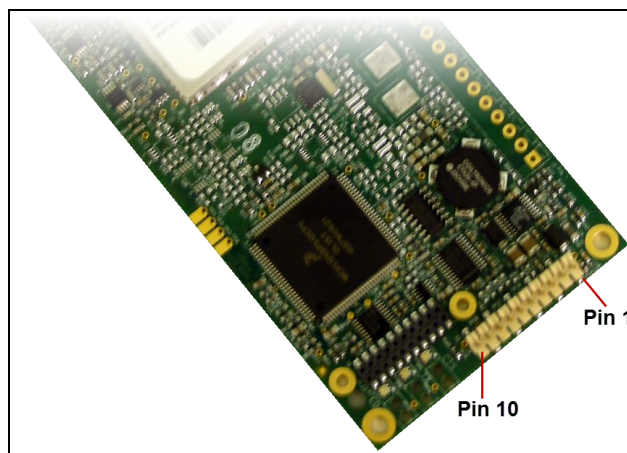
Figure 9: Pins 1 and 10

- If using a Data Cable (FreeWave Part Number: ASC3610DB or ASC3610DJ), press the Setup button.
- If using the gray ribbon Diagnostic Cable (FreeWave Part Number: AC2009DC), or the black Diagnostic Cable (FreeWave Part Number: ASC0409DC), type <Shift+U>.

All three LEDs on the radio light green ▬ ▬ ▬ and stay green as long as the radio is in Setup mode.

5. With the radio connected to the computer and in Setup mode, in Tool Suite, click Configuration in the Application pane to display the Configuration application.

6. Click Read Radio in the Configuration ribbon to read the radio's current settings.

7. Make the necessary parameter changes and do one of the following to send the changes to the radio:

- To send only the parameters you have changed, within the Configuration application, in the Network Title ribbon, click **Quick**. This option is only available if you clicked Read Radio and are not sending parameter settings from a template to the radio.
- To send all the settings for all parameters, within the Configuration application, in the Network Title ribbon, click **All**.
- To set a device back to its factory default settings, within the Configuration application, in the Network Title ribbon, click **Default**.

1.7.2. Accessing the Setup Menu using a Terminal Emulator

Use a terminal emulator of your choice to access the Setup menu. For any terminal emulator application, plug the serial cable into a com port on the radio, open a session and ensure that the port settings are set to the following for a proper connection to the radio:

Port Setting	Select
Bits per second	19200
Data Bits	8
Parity	None
Stop Bits	1
Flow Control	None

The instructions describe how to access the radio's Setup menu using the Setup Terminal application in Tool Suite. Setup Terminal contains the port settings above, by default.

1. Plug a serial cable into Com 1 and connect it to the computer running Tool Suite and connect the radio to power.

2. Open Tool Suite.

3. Select Setup Terminal in the Applications pane.

4. From the drop-down list at the top left of the window, select the Com port on the computer to which the radio is connected.
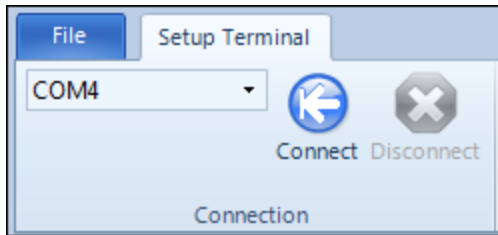
Figure 10: Tool Suite Connect button

5. Click **Connect**.

6. To connect to the radio, in enclosed radios, press the Setup button on the back of the FreeWave radio. If connected to the diagnostics port, type **U** (Capital 'U') to invoke the Setup menu.

    To display the Setup menu in board level radios:

    - Short pins 2 & 4 (Brown to Black) on the 10 pin header next to the LEDs.
    - If using a data cable (FreeWave Part Number: ASC3610DB or ASC3610DJ), press the Setup button.
    - If using the gray ribbon diagnostic cable (FreeWave Part Number: AC2009DC) or the black diagnostic cable (P/N ASC0409DC), type <Shift+U> to activate the Setup menu.

When Setup is activated, the FreeWave Setup Main Menu shows in the terminal emulator window. All three LEDs on the radio light green ▪ ▪ ▪ and stay green as long as the radio is in Setup mode. The main setup menu appears.

> **Important!**: As you navigate through the Setup menu and make changes to the parameters, the parameters are sent to the radio immediately.

1.7.3. Troubleshooting Terminal Emulators

These are some common issues encountered while using terminal emulators:

Nothing displays on the screen after placing the radio into Setup mode.

This usually indicates one of two things; either the wrong Com port is selected or a null modem cable is being used. Change the Com port, verify the cable, and attempt to connect again.

In addition, if the radio has been previously configured, you could be using the wrong port to access the Setup menu. For more information, see Setup Port (on page 26).Try connecting to the other port.

Unreadable characters display on the screen after placing the radio into Setup mode.

This typically indicates a baud rate mismatch. Unreadable characters before grounding the pin indicates Diagnostics is enabled and the terminal emulator is connected to the Diagnostics pins. Update the terminal emulator's baud rate to 19200 and reconnect to the radio.

The Setup menu displays on the screen, but nothing happens when keys on the keyboard are pressed.

This usually indicates flow control is turned on in a three-wire connection (Rx, Tx, and Gnd). Update the terminal emulator's flow control setting to None and reconnect to the radio.

A connection exists, the terminal emulator is receiving data, and some data is correct, but the remaining data is in unrecognizable characters.

This usually indicates a parity mismatch. Ensure that the parity of the radio and the parity of emulator are are set the same.

1.8. Upgrading Radios to the Latest Firmware

If Tool Suite is connected to a radio, and a new version of the firmware is available for that radio model, an indication displays within the Configuration application's Device Information tab. You can use Tool Suite to upgrade firmware on a serial radio that is connected directly to the computer using the diagnostic cable. You cannot complete an over-the-air upgrade using Tool Suite.

> **Note**: If you are using a USB-to-serial converter cable, a firmware upgrade can take a long time to complete. FreeWave recommends using only USB-to-serial cables that include the FTDI Chip Set. This inclusion is listed on the cable's packaging.

Use the steps below to upgrade a radio to the latest firmware:

1. With the radio connected to your computer through the Com port, open Tool Suite and click **Configuration** in the Applications pane to display the Configuration application.
2. Click **Upgrade Radio** in the Firmware section of the Configuration ribbon.
3. Click **Yes** at the prompt to proceed or **No** to cancel without installing the new firmware.

   Tool Suite identifies and displays the firmware version that is loaded on the connected device and displays the latest version of firmware available for that model.
4. Click **Yes** to proceed with the upgrade, or **No** to exit.

The system displays the progress of the firmware upgrade. After the firmware upgrade is complete, a message displays that the firmware upgrade was successful.

2. Basic Radio Programming and Setup

As you set up your network, whether it be a Point-to-MultiPoint network or a Point-to-Point network, the process for setting up and programming a radio is the same. This chapter describes the following aspects of programming and setting up a radio, regardless of the network type:

- Setting the radio's role in the network, and the network type.
- Entering parameters that establish communication with the instrument or computer to which the radio is connected.
- Establishing communication with other radios in the network.
- Setting data transmission characteristics.

2.1. Setting the Radio's Role in the Network and the Network Type

Radio networks consist of a Master and any number of other components including Repeaters, Slave radios, and radio's that act as both Slave and a Repeater radio. The first parameter to set in a radio is to select its Operation Mode or Modem Mode. The mode tells the radio what network type it is in (Point-to-Point or Point-to-MultiPoint) and what role it plays, Master, Slave, or Repeater, in that network.

> **Note**: The network type must match for all radios in a network. For example, if you are configuring a Point-to-MultiPoint network, ensure the Modem Mode selection for radios in the network starts with Point-to-MultiPoint.

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 radio, remember that the settings on the Master control a number of parameters. Therefore, deploying the Master on the communications end where it is easier to access is advised, but not necessary.

Set the Modem Mode in the Operation Mode tab, using the **Modem Mode** field. These settings are available in the **Operation Mode** menu in the terminal interface. Select from these options:

Operation Mode	Description
Point-to-Point Master (0)	This mode designates the radio as the Master in Point-to-Point mode. The Master may call any or all Slaves designated in its Call Book.
	In Point-to-Point mode the Master determines the setting used for most of the radio transmission characteristics, regardless of the settings in the Slave and/or Repeater. The settings not determined by the Master are:
	- Transmit Power
	- Slave Security
	- Retry Time Out
	- Hop Table settings
	To identify a Master, power the radio. Prior to establishing a communication link with a Slave, all three of the Master's LEDs are solid red.
Point-to-Point Slave (1)	This mode designates the radio as a Slave in Point-to-Point mode. The Slave communicates with any Master in its Call Book—either directly or through one Repeater.
	When functioning as a Slave, the Entry to Call feature in the radio's Call Book is not operational.
	Set **Slave Security** to 1 to bypass the Call Book in the Slave. For more information, see Slave Security (on page 37).
Point–to-MultiPoint Master (2)	This mode designates the radio as a Master in MultiPoint mode. This mode allows one Master to communicate simultaneously with numerous Slaves.
	A Point-to-MultiPoint Master communicates only with other radios designated as Point-to-MultiPoint Slaves or Point-to-MultiPoint Repeaters.
Point-to- MultiPoint Slave (3)	This mode designates the radio as a Slave in MultiPoint mode. This mode allows the Slave to communicate with a MultiPoint Master. The Slave may communicate with its Master through one Repeater.
Point-to-Point Slave/Repeater (4)	This mode designates the radio to act as either a Slave or Repeater—depending on the instructions from the Master. The radio cannot act as both a Slave and a Repeater at the same time. True Slave/Repeater functionality is only available in a MultiPoint mode.
	Point-to-Point Slave/Repeaters have no security features. When a radio is designated a Point-to-Point Slave/Repeater, it allows any Master to use it as a Repeater.
Point-to-Point Repeater (5)	A network using LRS455-C-U, CE-U, -T-U radios can have one Repeater in a Point-to-Point communications link, to extend the operating range. When designated as a Repeater, a radio behaves as a pass-through link. All settings for the Call Book, baud rates, and radio transmission characteristics are disabled. A Repeater connects with any Master that calls it. The Repeater must be set up properly in the Master's Call Book.

Operation Mode	Description
Point-to-Point Slave/Master Switchable (6)	Mode 6 allows the radio to be controlled entirely through software commands. A number of key parameters in the FreeWave user interface may be changed either directly with a program such as Windows Terminal or through the use of script files. Additionally, when the Point-to-Point Slave/Master Switchable option is selected and the radio is not calling a Slave, it functions as a Slave and accepts any appropriate calls from other radios.
	For more information, see Application Note #5476, Mode 6.
Point-to-MultiPoint Repeater (7)	This mode allows the radio to operate as a Repeater in a MultiPoint network. You can have one Repeater in an LRS455-C-U, CE-U, -T-U network.
Ethernet Options (F)	This menu applies to Ethernet radios only. Although the menu is included here, it is unrelated to this radio.

2.2. Establishing Communication with Instrumentation and Computers

The settings in the Baud Rate tab are the communication settings between the radio and the instrument or computer to which it is connected (radio serial port to the device). These settings are unique to each radio, and do not need to match across the network.

For example, a pair of radios may be used in an application to send data from remote process instrumentation to an engineer's computer. In this application, the baud rate for the radio on the instrumentation might be set to 9600, and the radio on the polling host might be set to 57,600.

Set the following parameters in the Baud Rate tab. These settings are available in the Baud Rate menu in the terminal interface, and apply to both Point-to-Point and Point-to-MultiPoint networks.

2.2.1. Baud Rate

Baud Rate	
Setting	**Description**
Default Setting	115200
Options	1200, 2400, 4800, 9600, 19200, 38400, 57600, 76800, 115200, 230400
Setup Terminal Menu	(1) Set Baud Rate

Baud Rate	
Setting	**Description**
Description	This is the actual baud rate for the radio's data port. • This setting is the communication rate between the radio and the instrument to which it is connected, and is independent of the baud rate for the other radios in the network. • Set the baud rate to the highest level supported by the device to which it is connected. • With a poor radio link, however, this may actually result in slower data communications. **Example**: A pair of radios may be used in an application to send data from remote process instrumentation to the engineer's computer. In this application, the baud rate for the radio on the instrumentation might be set to 9600, and the radio on the engineer's computer might be set to 57,600. **FREEWAVE Recommends**: With a Baud Rate setting of 9600 or higher, FreeWave recommends using the Flow Control lines. For more information, see Flow Control (on page 24). **Note**: The **setup port** Baud Rate always defaults to 19,200 regardless of how the **data port** Baud Rate is set. The only exception is Mode 6. For more information, see application note #5476, Mode 6.

2.2.2. Data Parity

Data Parity	
Setting	**Description**
Default Setting	0 (8, N, 1)
Options	See table below
Setup Terminal Menu	(1) Set Baud Rate > (A) Data Parity

Data Parity	
Setting	**Description**
Description	Six data word length and parity configurations are available for use with FreeWave radios. The default setting is 8-None-1 and is the most commonly used serial communications protocol. The following table describes each option:

Option	Data Bits	Parity	Stop Bits
0	8	None	1
1	7	Even	1
2	7	Odd	1
3	8	None	2
4	8	Even	1
5	8	Odd	1

2.2.3. Flow Control

Flow Control	
Setting	**Description**
Default Setting	(0) None
Options	• **(0) None** - No flow control CTS is active and de-asserts when buffering in 98% full. Can pass XON/XOFF data but does not use it in any way. • **(1) RTS** - Uses standard RTS/CTS control lines. • **(2) DTR**
Setup Terminal Menu	(2) Set Baud Rate > (F) FlowControl
Description	Specifies the hardware flow control for the data port on the radio. FreeWave recommends using **Flow Control** if you are using a baud rate higher than 9600 bps in a narrow-band licensed network.

2.2.4. Modbus RTU

Note: When using the radio in Modbus RTU mode, the Master Packet Repeat setting must match in every radio, regardless of whether the network is in Point-to-Point or MultiPoint mode.

Modbus RTU	
Setting	**Description**
Default Setting	0 (Disabled)

Modbus RTU	
Setting	**Description**
Options	Any number between 0 to 9
Setup Terminal Menu	(1) Set Baud Rate > (B) Modbus RTU
Description	The **Modbus RTU** setting is a port delay. This setting can be used with several different timing sensitive protocols, such as Modbus RTU and DNP3. A setting other than **0** causes the radio to wait for an amount of time "gathering" data before sending out the radio link. • When set to 0 (Disabled), the radio sends data out through its radio link as soon as the data is received into the serial port. • When set to 1, the radio waits for a number of slots equal to two times the **Master Packet Repeat** setting before waits for 6 slots, gathering data up the whole time. At the end of the 6 slots, the radio sends all received data in one "burst." This is the appropriate setting for most Modbus RTU devices. • When set to 2 and higher, the radio waits for a number of slots calculated using the following formula: (Modbus RTU setting + Master Packet Repeat setting + 1) x 2 **Example**: In a radio where the **Modbus RTU** setting is 2 and the Master Packet Repeat setting is 3, the radio waits for (2 + 3 + 1) x 2, or 12 slots.

2.2.5. Serial Interface

Serial Interface	
Setting	**Description**
Default Setting	(0) RS232

Serial Interface	
Setting	**Description**

Options	• **(0) RS232** - Also used for TTL.
	• **(1) RS422/Full Duplex RS485** - **Modbus RTU** mode must be enabled and **Turn Off Delay** set to at least 4.
	• **(2) Half Duplex RS485** - **Modbus RTU** mode must be enabled and **Turn Off Delay** set to at least 4
	• **(3) DOT**- DOT causes the CD line to indicate when data is transmitted on the serial port from the radio.
	   • When the radio is not sending data to the serial port, CD is de-asserted.
	   • When the radio is sending data to the serial port, CD is asserted.
	   • The CD line no longer has any radio link state functionality.
	   • **Turn Off Delay** works as described in all radios.
	   • **Turn On Delay** works as described on any Slave or Slave/Repeater - it has no functionality on the Master.

Setup Terminal Menu	(1) Set Baud Rate > (C) RS232/485
Description	Use this option to set the protocol of the data port. **Note**: In TTL RF board products this setting must be 0. If set to anything other than 0, the **Setup Port** must be set to `Diagnostics Only`.

2.2.6. Setup Port

⚠️ **Caution**: Do not change this setting unless the correct programming cable is available for the new setting.

Setup Port	
Setting	**Description**
Default Setting	3
Options	• **(1) Main Only** - Programming and reading a radio's setup information is done through the data port pins only. • **(2) Diagnostics Only** - Programming and reading a radio's setup information is done through the diagnostic port only. • If the **Serial interface** is set to anything other than RS232, then the **Setup Port** must be set to `Diagnostics Only`. • **(3) Both** - Programming and reading a radio's setup information is done through either the main data port or the diagnostics port.

Setup Port	
Setting	**Description**
Setup Terminal Menu	(1) Set Baud Rate > (D) Setup Port
Description	Determines which port on the radio, Main or Diagnostics, is used to access the parameter settings in Tool Suite or enter the Setup main menu in Setup Terminal or a terminal emulator. Setup mode is invoked by sending a <Shift+U> to the Diagnostics port or by pressing/toggling the Setup button/switch, if available. • OEM boards may also enter Setup mode when Pin 2 is grounded. • The data port on OEM models uses a 2-row, 2 mm female connector. • The diagnostic cable for this port is FreeWave Part Number: ASC2009DC.

2.2.7. Turn Off Delay

Turn Off Delay	
Setting	**Description**
Default Setting	0
Options	Any number between 0 and 9
Setup Terminal Menu	(1) Edit Baud Rate > Turn Off Delay

Description	Specifies the time after the end of transmission of a character to the RS485 bus that the radio stops driving the bus and releases the bus to other devices.
	
	• The units are ¼ of a character with a range of 0 to 9.
	  • An entry of 4 means a delay equivalent to the duration of a full character. The default is zero delay.
	• For data rates of 1200 bits/S or slower, avoid setting the **Turn Off Delay** parameter higher than 4.
	  • At those rates the functionality of the microprocessor changes so that a **Turn Off Delay** of 5 has the same effect as if set to 1, and a setting of 6 has the same effect as 2, and so on.
	• **Turn Off Delay** must be set to a value of at least 4 for RS422 and RS485 operation.

2.2.8. Turn On Delay

Turn On Delay	
Setting	**Description**
Default Setting	0 ms

Turn On Delay	
Setting	**Description**
Options	Any number between 1 and 9
Setup Terminal Menu	(1) Set Baud rate > (E) Turn On Delay
Description	Sets the delay between when the line drivers are turned on and when the data leaves the data port.

2.2.9. Use Break to Access Setup

> **Note**: This setting is typically only used in OEM scenarios.

Use Break to Access Setup	
Setting	**Description**
Default Setting	(0) Disabled
Options	• **(0) Disabled** • **(1) Enabled** - The Setup menu is set at 19200 bps. • **(2) Enabled** - The setup menu is set at the radio's current baud rate. • This setting is only available through the terminal interface using Setup Terminal or another terminal emulator.
Setup Terminal Menu	(2) Set Baud Rate > (G) Use break to access setup
Description	Enables a break command to put the radio into Setup mode over the data port. • To send a break character the end device must hold the Tx data line in the space voltage level for longer than 1 character time. • If a character is defined as having 1 start bit, 8 data bits, and 1 stop bit, the character time is 10 bits, thus the Tx data line must be held in the space voltage level for a period of time longer than 10 bits.

2.3. Establishing Communication with Other Radios in the Network

For the radios in your network to communicate successfully, you need to tell the radios what other devices are available for them to communicate. Use one of the following options:

- **Network ID** - Used in MultiPoint Networks, the **Network ID** parameter is available in the MultiPoint Parameters tab. Each radio in a single network should be assigned the same network ID. A Slave links with the first Master or Repeater that it hears that has a matching **Network ID**.

Because the **Network ID** does not use serial numbers, MultiPoint Masters and Repeaters may be replaced without reprogramming all of the Slaves in the network. The **Network ID** function

should be used in conjunction with the **Subnet ID** feature (if necessary) to route data through the radio network.

Without having the serial numbers in the Call Book, Slaves can establish communications with different Masters that match the radio's golden settings described below, though not at the same time. This is very useful in mobile MultiPoint applications.

For information about setting the Network ID parameter in a MultiPoint Network, see Using the Network ID in MultiPoint Networks (on page 47).

- **Call Book** - The Call Book is required in Point-to-Point networks.
  - The Call Book stores serial numbers of radios in the network that are allowed to talk to a radio.
  - Using the Call Book offers both security and flexibility in determining how FreeWave radios communicate with each other.

> **Important!**: While the Call Book is an option in Point-to-MultiPoint networks, FreeWave strongly recommends using the Network ID feature in most applications. If a large MultiPoint network is implemented using the Call Book and you want to add a radio to the network, or need to replace a radio, you must physically reprogram each radio in the network and enter the new serial number in the radio's Call Book. This can be a time consuming process and can cause a delay in getting your network back up and running.

For more information about defining the Call Book in a Point-to-Point network, see Using the Call Book in Point-to-Point Networks (on page 66). For more information about defining the Call Book in a Point-to-MultiPoint network, see Using the Call Book in MultiPoint Networks (on page 47).

2.3.1. Golden Settings

A standard network requires that the following parameters are set the same on all radios in the network. FreeWave refers to these as the **Golden Settings**.

- Rx Frequency
- Tx Frequency
- Min Packet Size
- Max Packet Size
- Network ID
- RF Data Rate

Radios that contain the same settings in all these parameters can communicate with each other. If you choose to use the Call Book instead of the **Network ID**, or are running a Point-to-Point network, the appropriate serial numbers must be listed in the Call Book for each radio.

2.4. Setting RF Transmission Characteristics

The Transmission Characteristics parameters allow you to modify settings that determine how data is sent between radios in your network. Many of these parameters must be maintained throughout the network for proper functionality.

Important!: The parameters in the Transmission Characteristics tab are only for the advanced user who has a good understanding of the principles of RF transmission.

Several settings on a Slave or Repeater radio come from the Master, and are therefore set only at the Master. Settings that you must set on each Slave or Repeater include:

- Transmit Power
- Slave Security
- Retry Time Out
- Hop Table Size

You can leave most parameters in the Transmission Characteristics tab set to their default settings when completing basic setup. However, you must set the following parameters, and they must be the same for all radios in your network:

- Rx Frequency and Tx Frequency
- Max Packet Size
- Min Packet Size
- RF Data Rate

Set the following parameters in the Transmission Characteristics tab. These settings are available in the Edit Radio Transmission Characteristics menu in the terminal interface, and apply to both Point-to-Point and Point-to-MultiPoint networks, unless indicated otherwise in their description.

2.4.1. High Noise

Note: This parameter does not apply to the LRS455-C-U, CE-U, -T-U radios.

2.4.2. Hop Table Size

Important!: This setting must be the same on all radios in the network.

Hop Table Size	
Setting	**Description**
Default Setting	16
Options	Any number between 1 and 16
Setup Terminal Menu	(3) Edit Radio Transmission Characteristics > (0) FreqKey > F > 2
Description	Defines how many separate channels a given network uses.

Set the Hop Table Size in the Terminal Interface

1. Place the radio in Setup mode and connect to it using a terminal emulator.
2. From the main Setup menu, select **(3) Transmission Characteristics > (0) Freq Key**.
3. At the Enter New Frequency Key Prompt, enter F to display more options.

4. At the prompt, enter 2 for Number of Hopping Channels.

5. At the Num Channels (1-16) prompt, enter the number of channels for the hop table and press <Enter>.

6. Press <Esc> to return to the Radio Parameters menu.

7. Press <Esc> again to return to the main Setup menu.

2.4.3. Max Packet Size and Min Packet Size

> **Note**: In MultiPoint networks, the **Max Packet Size** and **Min Packet Size** must be set identically in all radios. In Point-to-Point networks the Master's setting takes precedence over the Slave.

Max Packet Size and Min Packet Size	
Setting	**Description**
Default Setting	Max Packet Size = 8 Min Packet Size = 9
Options	Any number between 0 and 9
Setup Terminal Menu	(3) Edit Transmission Characteristics > (1) Max Packet Size and (2) Min Packet Size
Description	The **Max Packet Size** and **Min Packet Size** settings and the **RF Data Rate** determine the number of bytes in the packets. > **Note**: Throughput can be enhanced when packet sizes are optimized.

These tables provide the information to determine optimum setting values:

Minimum Packet Size Definition	
Min Setting	**Min Packet Size**
1	16
2	32
3	48
4	64
5	80
6	96
7	112
8	128
9	144

| Maximum Packet Size (2 Level FSK) ||
Max Setting	Max Packet Size
0	32
1	48
2	64
3	80
4	96
5	112
6	128
7	135
8	135
9	135

| Maximum Packet Size (4 Level FSK) ||
Max Setting	Max Packet Size
0	32
1	48
2	64
3	80
4	96
5	112
6	128
7	144
8	160
9	176

2.4.4. Remote LED

Remote LED	
Setting	Description
Default Setting	(0) Local Only
Options	(3) Edit Radio Transmission Characteristics > (C) Remote LED

Remote LED	
Setting	**Description**
Setup Terminal Menu	If using a radio with the optional 24-pin connector, use this option to connect Remote LEDs through the diagnostics port.
	When using Remote LEDs, the center (Tx) LED does not turn Green when in Setup mode. This line is not pinned out.
	• If using an enclosed radio, set the Remote LED parameter to either `Remote Only` or `Remote and Local`.
	• If you leave the setting at `Local Only`, you will not be able to see the LEDs.
Description	• **(0) Local Only** - Only the LEDs on the radio board are enabled.
	• **(1) Remote and Local** - LEDs on the radio board and remote LEDs through the diagnostic port are enabled.
	• **(2) Remote Only** - LEDs on the radio board are disabled. Remote LEDs through the diagnostic port are enabled.

2.4.5. Retry Timeout

Retry Timeout	
Setting	**Description**
Default Setting	255
Options	Any number between 0 and 255 in MultiPoint networks.
	Any number between 151 and 255 in Point-to-Point networks.
Setup Terminal Menu	(3) Edit Transmission Characteristics > (8) Retry Time Out

Retry Timeout	
Setting	**Description**
Description	The **Retry Time Out** parameter in a Slave or Repeater sets the delay the unit waits before dropping the connection to a Master or Repeater. ● The maximum setting means that if 1 packet in 255 is sent successfully from the Master to the Slave or Repeater, the link is maintained. ● The minimum setting is 8. ● This allows a Slave or Repeater to drop a connection if less than 1 in 8 consecutive packets is successfully received from the Master. ● The function in the Master is effectively the same. With a setting of 255, the Master allows a Slave or Repeater to stay connected as long as 1 packet in 255 is successfully received at the Master. The **Retry Time Out** parameter is useful when a MultiPoint network has a roving Master or Slave(s). As the link gets weaker, a lower setting allows a poor link to break in search of a stronger one. Setting **Retry Time Out** to 20 is recommended in areas where several FreeWave networks exist. This recommended setting allows Slaves and Repeaters to drop the connection if the link becomes too weak, while at the same time prevent errant disconnects due to interference from neighboring networks. While intended primarily for MultiPoint networks, the **Retry Time Out** parameter may also be modified in Point-to-Point networks. However, the value in Point-to-Point mode should not be set to less than 151.

2.4.6. RF Data Rate

Note: In MultiPoint networks, the **RF Data Rate** must be identical in all radios. Any radio with an **RF Data Rate** different from the Master will not establish a link. In Point-to-Point networks the Master's settings take precedence over the Slave.

RF Data Rate	
Setting	**Description**
Default Setting	(4) 12.5 kHz 4 level
Options	● **(4)** - With an occupied bandwidth of 12.5 kHz and modulation level of 4-level GFSK. With an **RF Data Rate** of 4, the maximum over-the-air operating speed is 19,200 bps. **Important!**: **RF Data Rate 4** is not compatible with firmware versions 1.69 and older. ● **(5)** - With an occupied bandwidth of 12.5 kHz and a modulation level of 2-level GFSK. With an **RF Data Rate** of 5, the maximum over-the-air operating speed is 9600 bps.

RF Data Rate	
Setting	**Description**
Setup Terminal Menu	(3) Edit Transmission Characteristics > (4) RF Data Rate
Description	The LRS455-C-U, CE-U, -T-ULRS-400S radios have two settings for the RF Data Rate (4, 5). **Important!**: The **RF Data Rate** is the over-the-air data rate between radios in the network, and should not be confused with the serial port baud rate. **Note**: Although additional **RF Data Rates** are available, only rates 4 and 5 are FCC approved. • Use setting 4 when the radios are close together and data throughput needs to be optimized. • Use setting 5 when the radios are farther away and a solid data link is preferred over data throughput.

2.4.7. RTS to CTS

Note: This parameter does not apply to the LRS455-C-U, CE-U, -T-U radios.

2.4.8. Rx Frequency

Note: In the Master, this setting must be the same as the Tx Frequency setting in the Slaves.

Rx Frequency	
Setting	**Description**
Default Setting	435
Options	Any frequency between 435 and 470 MHz. **Note**: See Frequency List (on page 82)
Setup Terminal Menu	(3) Edit Transmission Characteristics > (0) Frequency Key > F > 0

Rx Frequency	
Setting	**Description**
Description	The radios must be programmed to operate on the appropriate frequency.
	To program the radio for single-channel operation, enter the frequency, in Megahertz, in the **Tx Frequency** and **Rx Frequency** fields. By default, the radio is set for single-channel operation.
	If the radios are to operate in Frequency Division Duplex, the **Tx Frequency** and **Rx Frequency** fields have different frequencies assigned.
	Define the **Tx Frequency** and **Rx Frequency** for multiple channels through the terminal interface using Setup Terminal or another terminal emulator.

Set the Radio to a Single Channel in a Terminal Emulator

1. Place the radio in Setup Mode and connect to it in Setup Terminal or a terminal emulator.
2. On the main Setup menu, select **(3) Edit Transmission Characteristics > (0) FreqKey**.
3. At the Enter New Frequency Key Prompt, enter F to view more options.
   The 16 channels and their transmit and receive frequencies appear.
4. At the prompt, enter 1 for Single Frequency.
5. At the Enter Frequency Channel to Use prompt, enter the frequency channel to use between
   0 and 15 and press <Enter>.
   The entered number corresponds with the channel number as listed in the channel table.
6. Press <Esc> to return to the Radio Parameters menu.
7. Press <Esc> again to return to the main Setup menu.

Set the Radio to Hop Channels

1. Place the radio in Setup Mode and connect to it in Setup Terminal or a terminal emulator.
2. From the main Setup menu, select **(3) Edit Transmission Characteristics > (0) FreqKey**.
3. At the Enter New Frequency Key Prompt, enter 0.
4. Press <Esc> to return to the Radio Parameters menu.
5. Press <Esc> again to return to the main Setup menu.

Edit Frequencies for Multiple Channels

Important!: The regulating body in the country where you are using the LRS455-C-U, CE-U, -T-U radio determines if you can run the radio in multichannel mode.

1. Place the radio in Setup Mode and connect to it in Setup Terminal or a terminal emulator.
2. From the main Setup menu, select **(3) Edit Transmission Characteristics > (0) FreqKey**.
3. At the Enter New Frequency Key Prompt, enter F to display more options.

The 16 channels and their transmit and receive frequencies display.

4. At the prompt, enter 0 for to edit the hop table.

5. At the Channel Number (0-15) prompt, enter the channel number you want to change and press <Enter>.

6. At the Xmit Chan (0-5600) prompt, enter a transmit channel number between 0 and 5600 and press <Enter>.

7. At the Rcv Chan (0-5600) prompt, enter a transmit channel number between 0 and 5600 and press <Enter>.

The channel table updates to reflect the changes.

8. Press <Esc> to return to the Radio Parameters menu.

9. Press <Esc> again to return to the main Setup menu.

2.4.9. Slave Security

Important!: **Slave Security** has no effect in Point-to-MultiPoint networks where the **Network ID** is used instead of the Call Book.

Slave Security	
Setting	**Description**
Default Setting	(0) On
Options	(0) On, (1) Off
Setup Terminal Menu	(3) Edit Transmission Characteristics > (6) Slave Security
Description	**Slave Security** allows Slave radios to accept transmissions from a Master not included in the Call Book. The default setting of 0 (On), means only Masters in the Slaves' Call Book may link to that Slave. • **Slave Security** may be disabled (setting of 1) allowing any Master to call the Slave. • **Slave Security** must be set to 1 when the unit is operating in Mode 6 Slave/Master Switchable or a Point-to-Point network where the Slave may need to accept calls from more than 10 different Masters. • When **Slave Security** is set to 1, the radio accepts calls from any other FreeWave radio. • Additional network security measures may be taken to prevent unauthorized access, such as changing default settings for **Frequency** and **Hop Table**.

2.4.10. Transmit Power

Transmit Power	
Setting	**Description**
Default Setting	10
Options	Any number between 0 and 10
Setup Terminal Menu	(3) Edit Transmission Characteristics > (5) RF Xmit Power
Description	Sets the output power of the radio. You can control the output transmit power up to 2 W (+33 dBm).
	For use in applications requiring greater than 70% transmit duty cycle, the radios must be attached to an appropriate heat sink.
	When testing radios at your facility and they are in close proximity to one another, set the **Transmit Power** parameter to a low number. When you deploy radios to the field, raise the **Transmit Power** number accordingly.

Important!: This table is for reference only.
All **Transmit Power** settings below 9 are approximate.
A **Transmit Power** setting of 10 is +33 dBm.

Transmit Power Setting	RF Transmit Power (dBm)
10	+33
9	+32
8	+31
7	+30
6	+29
5	+28
4	+27
3	+26
2	+25
1	+24
0	+23

2.4.11. Transmit Rate

Important!: This setting must be the same on radios in the network.

Transmit Rate	
Setting	**Description**
Default Setting	(1) Normal
Options	Any number between 0 to 9
Setup Terminal Menu	(3) Edit Transmission Characteristics > (3) Xmit Rate
Description	FreeWave radios use a Master Transmit Beacon to provide low current consumption in the Slave radios. • The Slaves turn their receiver off when no data is being passed. • This setting allows the duty cycle of the Master Transmit Beacon to be changed. • A setting of 0 is the highest duty cycle and 9 is the lowest duty cycle. Tip: If not frequently polling for data or installing new devices, lower the duty cycle (i.e., set this field to 9).

2.4.12. Tx Frequency

Important!: In the Master, this setting must be the same as the **Rx Frequency** setting in the Slaves.

Tx Frequency	
Setting	**Description**
Default Setting	435
Options	Any frequency between 435 and 470 MHz. **Note**: See Frequency List (on page 82) for more information.
Setup Terminal Menu	(3) Edit Transmission Characteristics > (0) FreqKey
Description	The radios must be programmed to operate on the appropriate frequency. To program the radio for single channel operation, enter the frequency, in Megahertz, into the **Tx Frequency** and **Rx Frequency** fields. If the radios are to operate in Frequency Division Duplex, the **Tx Frequency** and **Rx Frequency** fields have different frequencies assigned. The **Tx Frequency** field in the Tool Suite Configuration application handles only a single channel. To set multiple channels, use the terminal interface. For information, see the instructions in Rx Frequency (on page 35).

2.5. Setting Radio Passwords

Use passwords to prevent access to or changing of any of the radio's parameters. This option is useful if you want to prevent unauthorized personnel from gaining access to the radio settings.

If the **Setup Port** option in the Baud Rate tab is set to `(1) Main Only` or `(3) Both`, the password is only accepted if the option is accessed from the main data port. To use the Password function using the diagnostics port, the **Setup Port** option must be set to `(2) Diagnostics Only`.

STOP **Warning!** If the password feature is enabled and the password is forgotten, you need to return the radio to FreeWave to have the password disabled.

2.5.1. Set a Password

1. From the Setup main menu in the terminal interface, select `(8) Chg Password` to show this prompt: **New PW? (<esc> to exit)**.
2. To back out of the process and not enable the password press <Esc>.
   To set a password, type exactly four characters.
   Passwords are case sensitive.

   Note: Press <Esc> to cancel the process at any point.

   After the four characters are entered, this prompt appears: **<Enter> to accept,<esc> to quit**.
3. To accept the password as entered and enable the feature, press <Enter>.
   To quit the process and not enable the password, press <Esc>.

   If you press <Enter>, the password appears on the line above.

   Important!: The password is case sensitive and every keystroke is a character.

2.5.2. Change the Password

1. On the Setup main menu in the terminal interface, select `(8) Chg Password`.
2. At the **Enter Security Code** prompt enter the current four character, case sensitive password.

   After entering the password correctly, the prompt to enter the new password appears.
3. Enter the new four character, case sensitive password.
4. To accept the password as entered and enable the feature, press <Enter>.
   To quit the process and not enable the password, press <Esc>.

   If you press <Enter>, the password appears on the line above.

   Important!: The password is case sensitive and every keystroke is a character.

2.5.3. Disable the Password

The password can be disables if the current password is known.

> **Important!**: You can only disable a password using the prompt when you read the radio in Tool Suite, or through a terminal emulator. You cannot disable the password using Setup Terminal application in Tool Suite.

1. From the Setup main menu in the terminal interface, select **(8) Chg Password**.
2. Hold down the <Alt> key and type `0255` using the number pad on the keyboard and release the <Alt> key.
3. Repeat this step three more times (hold the <Alt> key and type `0255` a total of 4 times).

> **Important!**: You must type the `0255` using the NUM Pad on your computer, NOT the top row of numerals.

After the fourth entry, the password is disabled.

3. Configuring Point-to-MultiPoint Networks

When installing MultiPoint networks it is important to do some up front planning around the devices you are going to implement and the route your data is going to take back to the Master. A MultiPoint network can contain the following devices:

- Only one Master. All communications are from and to the Master.
- An unlimited number of Slaves (remote sites).
- An LRS455-C-U, CE-U, -T-U MultiPoint network can have only one Repeater.
- A Serial Repeater can be a Slave and a Repeater at the same time.

This chapter builds on the settings described in the previous chapters and provides details about the following setup that applies specifically to a MultiPoint network:

- Point-to-MultiPoint network characteristics.
- Using the Network ID or the Call Book to establish which radios in the network can communicate with each other.
- Using subnet IDs to route communication through the network, back to the Master.
- Settings and recommendations for additional parameters that apply to a MultiPoint network.
- Conserving power in devices within the network.
- Running network diagnostics.

3.1. Point-to-MultiPoint Network Quick Start

This is a quick start guide for setting up two radios in Point-to-MultiPoint mode. This mode allows for a Master to communicate with several Slaves simultaneously.

3.1.1. Point-to-MultiPoint Network Quick Start (Tool Suite)

1. Connect the radio to the serial port of a computer either through a serial cable or using the diagnostics cable.

2. Connect the radio to a power source (+6.0 to +27.0 VDC).

> **Warning!** Do not connect the LRS455-C-U, CE-U, -T-U series radios to DC power without terminating the antenna port to a suitable load, such as a 50 ohm antenna, or an attenuator with a power rating greater than or equal to 2 W. Powering up without a load attached will damage the radio and void the warranty.

3. Open a Tool Suite session, select the **Configuration** application, and ensure the correct port is selected in the **Com Port** field in the upper left of the Configuration ribbon.

4. From the **Networks** section of the Configuration ribbon, select the network in which the radio resides or click **Add Network** to create a new network in Tool Suite.

5. Click **Read Radio** in the Configuration ribbon to read the radio's current settings.

   - If using a diagnostics cable to connect to the radio, the radio automatically goes into Setup mode.

   - If using a data cable to connect to the radio, you are prompted to press the radio's Setup button to put the radio in Setup mode. If you are using a board-level radio, use the interrupt line to short pin 2 and 4.

   - When in Setup mode, all three LEDs on the radio display solid green (▪ ▪ ▪).

6. Click the **Operation Mode** tab.

7. In the **Modem Mode** field, select 2 to set the radio as a Point-to-MultiPoint Master or select 3 to set the radio as a Point-to-MultiPoint Slave.

   > **Important!**: A network can have only one Master.

8. Click the **Baud Rate** tab.

9. Change the **Baud Rate**, **Data Parity**, and **Modbus RTU** to match the device that the radio is to be attached to.

10. Click the **Transmission Characteristics** tab.

11. Set these parameters so they are identical on all radios in the network:

    - Tx Frequency
    - Rx Frequency
    - Max Packet Size
    - Min Packet Size
    - RF Data Rate (Only 4 and 5 are approved by the FCC for use in the United States).

> **Note**: Changing these settings from the factory defaults may help to eliminate interference from other FreeWave networks.

12. Click the **MultiPoint Parameters** tab.
13. In the **Network ID** field, set the value to any value between 1 and 4095, except **255**.

> **FREEWAVE Recommends**: FreeWave recommends setting the **Network ID** to the last three or four digits of the Master radio's serial number, as this is a number you can look up if necessary.

> **Important!**: This value must be the same in all radios in the network.

3.1.2. Point-to-MultiPoint Network Quick Start (Terminal Interface)

1. Connect the radio to the serial port of a computer either through a serial cable or using the diagnostics cable.
2. Connect the radio to a power source (+6.0 to +27.0 VDC).

> **Warning!** Do not connect the LRS455-C-U, CE-U, -T-U series radios to DC power without terminating the antenna port to a suitable load, such as a 50 ohm antenna, or an attenuator with a power rating greater than or equal to 2 W. Powering up without a load attached will damage the radio and void the warranty.

3. Open a terminal emulator session.
4. Connect to COMx (where 'x' is the number of the Com port being connected).
5. Define these settings as:
   - Data Rate = 19,200
   - Data Bits = 8
   - Parity = None
   - Stop Bits = 1
   - Flow Control = None
6. If you are using the data cable, press the **Setup** button on the radio or use the interrupt line to short pin 2 and 4.
   If using the diagnostics cable, press <Shift+U>.
   - When in Setup mode, all three LEDs on the radio display solid green (🟩 🟩 🟩).
   - The Main menu appears on the screen.
7. Press 0 to open the **Operation Mode** menu.
8. Press 2 to set the radio as a Point-to-MultiPoint Master or press 3 to set the radio as a Point-to-MultiPoint Slave.
9. Press <Esc> to return to the Main menu.

> **Important!**: A network can have only one Master.

10. Press 1 in the Main menu.

11. Change the **Baud Rate**, **Data Parity**, and **Modbus RTU** to match the device that the radio is to be attached to.

12. Press <Esc> to return to the Main menu.

13. Press 3 in the Main menu.

14. Set these parameters so they are identical on all radios in the network:

- Tx Frequency
- Rx Frequency
- Max Packet Size
- Min Packet Size
- RF Data Rate (Only 4 and 5 are approved by the FCC for use in the United States).

> **Note**: The **Tx Frequency** and **Rx Frequency** options, or **Frequency Key**, are located in the F submenu after you press 0 to access the Frequency Key menu in Main menu 3.

> **Note**: Changing these settings from the factory defaults may help to eliminate interference from other FreeWave networks.

15. Press <Esc> to return to the Main menu.

16. Press 5 in the Main menu.

17. In the **Network ID** field, set the value to any value between 1 and 4095, except **255**.

> **FREEWAVE Recommends**: FreeWave recommends setting the **Network ID** to the last three or four digits of the Master radio's serial number, as this is a number you can look up if necessary.

> **Important!**: This value must be the same in all radios in the network.

18. Press <Esc> to exit the Setup menu and resume normal radio operation.

3.2. Point-to-MultiPoint Operation LEDs

Condition	Master			Slave			Repeater		
	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 red bright 🟥	Solid red dim 🟥	Off ⬛	Solid red bright 🟥	Off ⬛	Blinking red ⊖	Solid red bright 🟥	Off ⬛	Blinking red ⊖
Repeater and Slave linked to Master, no data	Solid red bright 🟥	Solid red dim 🟥	Off ⬛	Solid green 🟩	Off ⬛	Solid red bright 🟥	Solid green 🟩	Solid red dim 🟥	Solid red bright 🟥
Repeater and Slave linked to Master, Master sending data to Slave.	Solid red bright 🟥	Solid red dim 🟥	Off ⬛	Solid green 🟩	Off ⬛	Solid red bright 🟥	Solid green 🟩	Solid red dim 🟥	Solid red bright 🟥
Repeater and Slave linked to Master, Slave sending data to Master.	Solid green 🟩 RCV data or Solid red bright 🟥	Solid red dim 🟥	Intermittent flashing red ⬡	Solid green 🟩	Intermittent flash red ⬡	Solid red bright 🟥	Solid green 🟩	Solid red bright 🟥	Solid red bright 🟥
Master with diagnostics program running	Solid red bright 🟥	Solid red dim 🟥	Intermittent flashing red ⬡	Solid green 🟩	Intermittent flash red ⬡	Solid red bright 🟥	Solid green 🟩	Solid red bright 🟥	Solid red bright 🟥

* In an idle condition, the CTS LED is solid red 🟥 with a solid link, as the link weakens the CTS LED on the Repeater and Slave begins to blink ⊖.

3.3. Overlapping MultiPoint Networks

Overlapping MultiPoint networks may be set up effectively with FreeWave radios when several key parameters are set correctly. Overlapping MultiPoint networks are defined as networks using different Master, which share or overlap in a specific geographic area.

Co-located MultiPoint networks require the following parameters be unique for each network:

- Network ID, unless using the Call Book
- Max Packet Size
- Min Packet Size

Note: For more information about the installation of Point-to-MultiPoint networks, contact FreeWave Technical Support.

3.4. Establishing Communication with Other Radios in a MultiPoint Network

For the radios in the network to communicate successfully, tell the radio what other devices are available for them to communicate with. You can use the **Network ID** or the Call Book.

FREEWAVE Recommends: Use the **Network ID** option instead of the Call Book in MultiPoint networks. Because the **Network ID** does not use serial numbers, MultiPoint Master and Repeaters may be added or replaced without reprogramming all of the Slave in the network.

3.4.1. Using the Network ID in MultiPoint Networks

The **Network ID** parameter is located in the **MultiPoint Parameters** tab. A radio from the factory has a **Network ID** setting of 255, which enables the Call Book. Assign each radio in a single network the same **Network ID**. The Slave links with the first Master or Repeater it hears that has a matching **Network ID**.

Keep the following in mind when setting the **Network ID**:

- The value can be any value between 0 and 4095, NOT 255.
- To help ensure your ID is unique to your network, avoid using numbers that coincide with nearby landmarks or highways.
- FreeWave recommends a **Network ID** of four characters.
    - For example, the last four digits of the Master's serial number, which is ensured to be unique and does not overlap with other nearby FreeWave networks.
- Use the **Network ID** function in conjunction with the **Subnet ID** feature (if necessary) to route data through the radio network.

3.4.2. Using the Call Book in MultiPoint Networks

Although not recommended, the Call Book is an option in MultiPoint networks. If the **Network ID** feature is used in a MultiPoint network, no entries are needed in the Call Book of any of the radios.

> **FREEWAVE Recommends**: Use the **Network ID** feature in a MultiPoint network. Using the Call Book in a MultiPoint network can cause delay in resuming communication if a Master is damaged.

> **Note**: For information about setting the Call Book, see Using the Call Book in Point-to-Point Networks (on page 66).

In a MultiPoint network, the Slaves and Repeater are not listed in the Master's Call Book. A Slave must have the Master and the Repeater it is going to use in its Call Book.

These examples show the Call Books of a MultiPoint network comprised of a Master, Repeater, and Slave in which the Slave can communicate either through the Repeater or directly to the Master:

MultiPoint Master Call Book (Unit Serial Number 900-0001)

Entry	Number	Repeater 1
(0)	000-0000	
(1)	000-0000	

No serial number entries are necessary in the Master's Call Book.

MultiPoint Repeater Call Book (Unit Serial Number 900-0002)

Entry	Number	Repeater 1
(0)	900-0001	
(1)	000-0000	

MultiPoint Slave Call Book (Unit Serial Number 900-0003)

Entry	Number	Repeater 1
(0)	900-0001	
(1)	900-0002	
(2)	000-0000	

At times, you may want to force a Slave to go through a specific MultiPoint Repeater. In this scenario, the Slave's Call Book should contain only the serial number for that Repeater as the entry on line 0.

3.5. Routing Communication Through the Network

When using the **Network ID** feature, a Repeater or Slave links to the first Repeater or Master is hears with the same ID. Using subnet IDs, you can determine the path a Repeater or Slave uses to communicate back to the Master.

By forcing the communication path, you can optimize performance of the network by ensuring the Repeater or Slave links to a Repeater or Master with robust RF communications. Subnet IDs can help to minimize latency. By designing paths in a network, you can create the most efficient communication paths.

3.5.1. Assigning Subnet ID Values

Subnet IDs consist of two parts, both available in the Multipoint Parameters tab:

- Rx - This setting identifies which radio a Repeater or Slave listens to. In the terminal interface, this is the Rcv Subnet ID.
- Tx - This setting identifies the ID on which this device transmits, and in turn which devices listen to it. The Tx Subnet ID parameter is relevant for Multipoint Master radios and Repeaters *only*. In the terminal interface, this is the Xmt Subnet ID.

The default (disable) setting for both Rx and Tx is F, which is a visual way to indicate that the device is the final in the line of communication and does not use a subnet ID. A Multipoint Slave with a Subnet ID of F,F does not roam from one Repeater or network to the next, it only links to a Master or Repeater that has either a Tx setting of 0 or an F,F Subnet ID.

Setting both Rx and Tx Subnet ID to 0 allows a mobile Slave to roam from subnet to subnet, and possibly from network to network, provided the Network ID, Max and Min Packet Size, and RF Data Rates are the same between networks.

The examples in this section show the subnet definitions from the Master radio through the network to the Slave radios. When the subnet path is defined, the Slave radios can follow the route back to the Master.

In the following example, the Repeater and Slave 1 must talk directly to the Master. Slave 2 and Slave 3 must talk directly to the Repeater. Slave 4 may link to the Master or Repeater, whichever it hears first in the network.
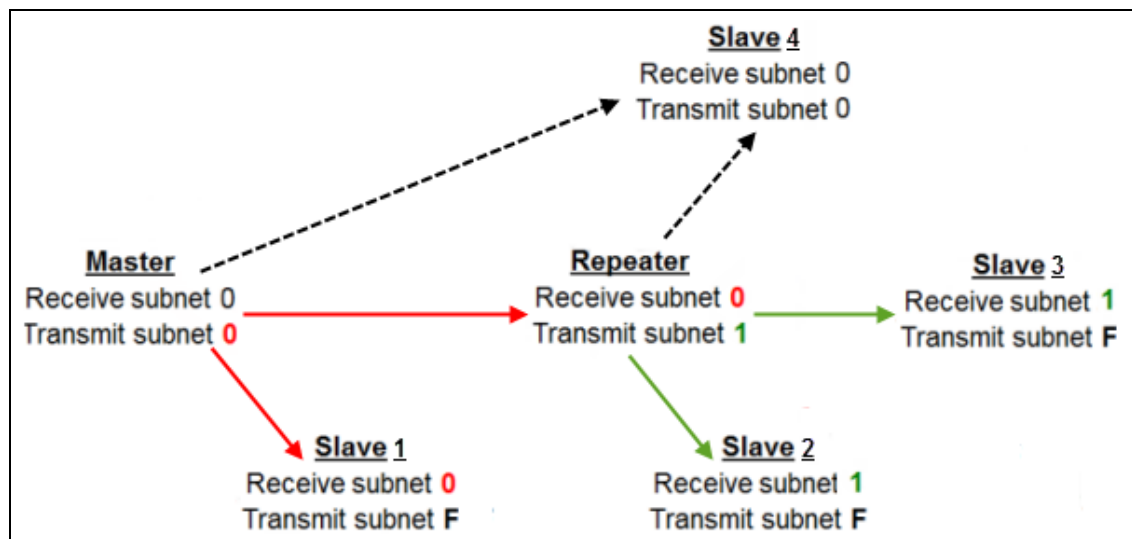
Figure 11: Repeater and Slave 1 Must Talk Directly to the Master

Subnet ID Settings for This Example

Radio	Rx	Tx	Description
Master	0	0	The default settings (F, F) actually use 0, 0. The **Rx Subnet** on the Master has no effect on the network.
Slave 1	0	F	**Rx Subnet** = 0 forces the radio to link only to the Master. The Slave does not transmit to any device except the Master, so its **Tx Subnet** is F.
Repeater	0	1	**Rx Subnet** = 0 forces the radio to link only to the Master. Transmits on subnet **1**.
Slave 2	1	F	**Rx Subnet** = 1 forces the radio to link only the Repeater.
Slave 3	1	F	**Rx Subnet** = 1 forces the radio to link only to the Repeater.
Slave 4	0	0	The 0,0 setting allows the Slave to link with the Master or Repeater with the same Network ID, whichever it hears first.

3.6. Setting Other MultiPoint Parameters

The other MultiPoint Parameters options allow you to modify several different parameters in the radio that determine the characteristics of a MultiPoint network.

Set the following parameters in the **MultiPoint Parameters** tab. These settings are available in the **MultiPoint Parameters** menu in the terminal interface.

3.6.1. 1 PPS Enable Delay

1 PPS Enable Delay	
Setting	**Description**
Default Setting	255
Options	255 to disable 1 PPS 0 to 254 to enter the delay
Setup Terminal Menu	(5) Edit MultiPoint Parameters > (9) 1 PPS Enable/Delay
Description	The **1 PPS Enable/Delay** setting allows the radio network to propagate a 1PPS signal from the Master to all Slaves in a MultiPoint network. When this parameter is enabled a properly generated pulse applied on the DTR line of the Master provides a 1 PPS pulse on the CD line of any Slave in the network

Setup 1PPS Enable/Delay

1. Set the **1 PPS Enable/Delay** parameter to 0 in the Master.

    The Master must have a 1 PPS pulse on the DTR pin.

2. Enable the **1 PPS Enable/Delay** parameter on the Slaves.
    Slaves are calibrated at the factory.

Calibrate a Slave in 1PPS Enable/Delay Mode

1. Trigger an oscilloscope on the 1 PPS pulse on the DTR line of the Master.
2. Monitor the CD line of the Slave.
3. If the timing on the Slave differs from the Master it may be adjusted via the value in the Slave's **1 PPS Enable/Delay** parameter. The difference in time between each incremental integer value is 542.534 nS. Changing the parameter to higher values decreases the Slave time delay and changing the parameter to lower values increases the time delay.

When properly calibrated the CD line of a Slave radio outputs a pulse that goes high for about 2 ms in synch with the 1 PPS pulse on the Master radio. The output on the Slave occurs within 20 microseconds of the input to the Master.

> **Important!**: When **1 PPS Enable/Delay** is enabled, the Master must have a 1 PPS pulse on its DTR pin, otherwise the RF network does not function.

3.6.2. Diagnostics

Diagnostics	
Setting	**Description**
Default Setting	1
Options	Any number between 0 and 128
Setup Terminal Menu	(5) Edit MultiPoint Parameters > (B) Diagnostics

Diagnostics	
Setting	**Description**
Description	Allows diagnostics data in the Network Diagnostics application within Tool Suite to be viewed at the Master in parallel with application data. The setting in this parameter determines how many slots out of 128 are dedicated to diagnostics. **Example**: If you set to 10, 1 out of every 10 data slots is for diagnostics data; if you set to 100, 1 out of every 100 data slots is for diagnostics data. Diagnostics is always secondary to actual transmitted data. The diagnostic program **must** be run from the Master radio. Diagnostics requires the following: • A setting of this parameter on the Master between 1 and 128. • A second computer or serial connection to run the diagnostics software. • A diagnostics cable. (Available from FreeWave.) • Diagnostics software. **FREEWAVE Recommends**: When collecting diagnostics from an LRS455-C-U, CE-U, -T-U network, FreeWave recommends setting the diagnostics polling rate to 400 ms or higher. **Note**: For more information about Diagnostics, contact FreeWave Technical Support.

3.6.3. DTR Connect

Note: This parameter does not apply to the LRS455-C-U, CE-U, -T-U radios.

3.6.4. Local Mode

Note: This parameter does not apply to the LRS455-C-U, CE-U, -T-U radios.

3.6.5. Master Packet Repeat

Master Packet Repeat	
Setting	**Description**
Default Setting	2
Options	Any number between 0 and 9
Setup Terminal Menu	(5) Edit Multipoint Parameters > (1) Master Packet Repeat

Master Packet Repeat	
Setting	**Description**
Description	In a Point-to-MultiPoint network, Slaves do not acknowledge transmissions from the Master. If Slaves did acknowledge all data transmissions, in a large network, the Master would soon become overwhelmed with acknowledgments from the Slaves. Without acknowledgments, 100% confidence every Slave has received every packet cannot be met. To address this issue, you can modify the **Master Packet Repeat** parameter, assigning a value between 0 (the packet is transmitted once) to 9 (the packet is transmitted 10 times). **FREEWAVE Recommends**: Use a setting of 1 or 2 in a licensed network. For networks with solid RF links, this parameter should be set to a low value such as 0 or 1. If a network has some weak or marginal links it should be set with higher values. If a Slave receives a good packet from a Master more than once it discards the repeated packets. Similarly, after a MultiPoint Repeater receives a good packet from the Master, it discards any further repeated packets. In turn, the Repeater sends the packet out to Slaves the number of times corresponding to its own **Master Packet Repeat** setting. Increasing the **Master Packet Repeat** setting increases the probability of a packet getting through, but also increases latency in the network because each packet from the Master or Repeater is being sent multiple times. Therefore, it is important to find the optimal mix between network robustness, throughput, and latency. In general, a setting of 0 to 1 works well for most well designed networks. The **Master Packet Repeat** may be set to 0 if the user software is capable of, or requires acknowledgment. In this case, if the Master sends a packet that the Slave does not receive, the user software controls the retries as needed.

3.6.6. Max Slave Retry

Max Slave Retry	
Setting	**Description**
Default Setting	9
Options	Any number between 0 and 9
Setup Terminal Menu	(5) Edit MultiPoint Parameters > (2) Max Slave Retry
Description	Defines how many times the Slave attempts to retransmit a packet to the Master before beginning to use a back-off algorithm (defined by the **Retry Odds** parameter). Slave retries stop when the slave receives an acknowledgment from the Master.

3.6.7. Multi-Master Sync

Note: This parameter does not apply to the LRS455-C-U, CE-U, -T-U radios.

3.6.8. Radio ID

Radio ID	
Setting	**Description**
Default Setting	Blank
Options	Any 4 digit, user-defined number
Setup Terminal Menu	(5) Edit MultiPoint Parameters > (D) Radio ID
Description	Use this option to designate a radio with an arbitrary, user-defined, 4-digit number that identifies the radio in Diagnostics mode.
	This setting does not change the communication of the radio.

3.6.9. Radio Name

Radio Name	
Setting	**Description**
Default Setting	Blank
Options	Any combination of letters and numbers up to 20 characters
Setup Terminal Menu	(5) Edit MultiPoint Parameters > (G) Radio Name
Description	Use this parameter to give a radio a name, such as its location. Naming radios can be helpful to identify a device when running network diagnostics.
	This setting does not change the communication of the radio.

3.6.10. Repeater Frequency

Note: This parameter does not apply to the LRS455-C-U, CE-U, -T-U radios.

3.6.11. Repeaters

Important!: Adding a Repeater to a network reduces the throughput by 50%. For example, over-the-air throughput in a network running at 2-Level GFSK and with the Repeaters parameter disabled is 9600 bps. With the Repeaters parameter enabled, the over-the-air throughput drops to 4800 bps.

The LRS455-C-U, CE-U, -T-U radios are narrowband radios and have a limited channel size based on the license obtained from the FCC. Therefore, the radios can experience a dramatic impact in throughput if a Repeater is implemented in the network. If you have large amounts of data to transfer and choose to add a Repeater in your network, you must optimize polling host / RTU settings to accommodate for the lower throughput. Polling host / RTU optimization settings include reducing block/packet sizes and increasing overall time-out parameters.

Important!: This parameter needs to be set in the MultiPoint Master only. The setting has no effect if set on a Slave.

Repeaters	
Setting	**Description**
Default Setting	(1) Enabled
Options	• **(0) Disabled** - There is not a Repeater in the network. • **(1) Enabled** - There is a Repeater in the network.
Setup Terminal Menu	(5) Edit MultiPoint Parameters > (0) Number Repeaters
Description	Indicates if there is a Repeater in the network.

3.6.12. Retry Odds

Retry Odds	
Setting	**Description**
Default Setting	9
Options	Any number between 0 and 9
Setup Terminal Menu	(5) Edit MultiPoint Parameters > (3) Retry Odds

Retry Odds	
Setting	**Description**
Description	While packets transmitted from the Master to the Slaves in a MultiPoint network are not acknowledged, packets transmitted from Slaves to the Master are. It is possible, that more than one Slave attempts to transmit to the Master at the same time. Therefore, it is important that a protocol exists to resolve contention for the Master between Slaves. This is addressed through the **Max Slave Retry** and **Retry Odds** parameters.
	After the Slave has unsuccessfully attempted to transmit the packet the number of times specified in the **Max Slave Retry** parameter, it attempts to transmit to the Master on a random basis. The **Retry Odds** parameter determines the probability that the Slave attempts to retransmit the packet to the Master; a low setting assigns low odds to the Slave attempting to transmit. Conversely, a high setting assigns higher odds.
	An example of how this parameter might be used would be when considering two different Slaves in a MultiPoint network, one with a strong RF link and the other with a weak RF link to the Master. If a Slave has a week or poor link, set **Retry Odds** to 0, as it may become a "chatty" Slave and lockup your network, causing a loss of communication.
	When **Retry Odds** is set to 0, after the Slave has exhausted the number of retries set in the **Max Slave Retry** parameter and still not gained the Master's attention, the Slave's data buffer is purged. A **Retry Odds** set to 0 is recommended for most networks.

3.6.13. Slave/Repeater

Slave/Repeater	
Setting	**Description**
Default Setting	(0) Disabled
Options	(0) Disabled, (1) Enabled
Setup Terminal Menu	(5) MultiPoint Parameters > (A) Slave/Repeater
Description	The **Slave/Repeater** mode allows a radio in a MultiPoint network to switch between Slave and Repeater functions. When in this mode, a radio repeats any packets sent across the network as well as uses the data port. Thus, where one Repeater and one Slave may be required in another vendor's network, FreeWave networks require only one radio.
	To operate a radio as a MultiPoint Slave/Repeater, the **Modem Mode** in the Operation Mode tab must be set to **Point to MultiPoint Repeater** and the **Slave/Repeater** parameter enabled.

3.7. Conserving Power

Power consumption can be essential, especially for remote sites that are difficult to access.

You can conserve power using the following options available in the Transmission Characteristics tab. These settings are available in the Radio Transmission Characteristics menu in the terminal interface.

- **Low Power Mode** - Available in MultiPoint Slaves using RS232. Conserves power primarily by dimming the radio's LEDs. For more information, see Low Power Mode (on page 57).
- **Remote LEDs** - If the radio has the optional connector, you can use this option to connect remote LEDs through the diagnostics port. This feature may be used to save power in MultiPoint Repeaters where the other options are not available. For more information, see Remote LED (on page 32).

3.7.1. Low Power Mode

> **Note**: This setting applies to only Multipoint Slaves using a serial protocol.

Low Power Mode	
Setting	**Description**
Default Setting	0
Options	Any number between 0 and 31. > **Note**: The higher the number, the greater the decrease in power consumption.
Setup Terminal Menu	(3) Edit Radio Transmission Characteristics > (9) Low Power Mode

Low Power Mode	
Setting	**Description**
Description	Allows a MultiPoint Slave to consume less power, primarily by dimming the radio's LEDs.

> **Note**: When set to 2 through 31, the radio sleeps between slots.
> When the radio is asleep, it hears nothing from the Master.

> **Example**: Using a setting of 2 the radio sleeps 1 out of 2 slots; a setting of 3 the radio sleeps 2 out of 3 slots, and so on.

This table 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.

	Setting	**Description**
	0	Low power, disabled
Current Draw ↑ More ↓ Less	1	LEDs dimmed, radio remains awake, radio is listening to the Master's transmissions on every slot, and radio's data port is shut down if the RTS line is de-asserted (low). In this case, the radio needs to be awakened before it is able to send data to the Master.
	2	LEDs dimmed, radio sleeps every other slot.
	3	LEDs dimmed, radio sleeps 2 of 3 slots.
	4-31	LEDs dimmed, radio sleeps the number of slots corresponding to the setting. **Example**: With a setting of 31 the radio sleeps 30 of 31 slots.

Notes

- Power savings occur only when the Slave is linked. No power savings occur when the Slave is transmitting data. **Low Power Mode** is of little value when a Slave has a constant, high throughput.
  - **MCU Speed** must be set to 0 and **RF Data Rate** must be set to 3 for **Low Power Mode** to operate properly.
- To communicate to an RS232 port of a radio that is in **Low Power Mode**, the RTS line must be held high to wake it up. The radio wakes up within approximately 20 milliseconds of when RTS goes high.

Low Power Mode	
Setting	**Description**
	• If the RTS line on the Slave is held high, the radio remains in normal operation regardless of the **Low Power Mode** setting. After RTS is dropped the radio reverts to Low Power Mode.
	• If the radio has the **DTR Connect** option in the MultiPoint Parameters tab set to 1 or 2 and if the **Low Power Mode** is enabled (set to 1–31), the RTS line on the radio must be asserted for the **DTR Connect** feature to operate properly.
	• To realize full power savings in **Low Power Mode**, the serial port must be deactivated between operation.
	• To do that the RTS line must be asserted.
	• However, since RS485 and RS422 operation uses the RTS line as part of the data bus, it cannot be asserted to wake-up the radio.
	• Therefore, FreeWave recommends that all radios set to RS485 or RS422, use a **Low Power Mode** setting of 0.
	• The diagnostic pins must be disabled or terminated to a cable for the Sleep current in Lower Power Mode to match the specifications.
	• To disable the diagnostic pins, verify the **Baud Rate** tab, the **Setup Port** parameter is set to `1 (Main Only)`.

3.8. Reading Diagnostics in Tool Suite

The Network Diagnostics application provides a place to view diagnostic data for all the devices connected to the Master in your network in real time. This application is not meant to replicate the functionality of a Network Management System, but rather it is a tool that can be used for diagnostics and troubleshooting in the field.

> **Important!**: The Network Diagnostics application is intended for occasional network monitoring or troubleshooting, not for continuous, long-term collection of diagnostic data.

This section provides basic steps for reading diagnostics using Tool Suite. Tool Suite stores the diagnostic data in the database and you can import or export a diagnostic file. For information regarding the data available, recommended best practices, and importing and exporting files using the Network Diagnostics application, see the Tool Suite User Manual.

> **Note**: To help identify the radios in your network when running Network Diagnostics, set the **Radio Name** and **Radio ID** fields in the **Multipoint Parameters** tab.

The diagnostic program must be run from the Master radio. Diagnostics requires the following:

- A setting between 1 and 128 in the **Diagnostics** parameter available in the MultiPoint Parameters menu on the Master.
- A second computer or serial connection to run the diagnostics software.

- A diagnostics cable. (Available from FreeWave.)
- Diagnostics software.

> **Note**: For more information about Diagnostics, contact FreeWave Technical Support.

3.8.1. Run Diagnostics using Tool Suite

1. Connect the Master to the computer running Tool Suite.
2. Open Tool Suite and click **Network Diagnostics** in the Applications window.
3. From the drop-down menu in the **Networks** section of the ribbon, select the serial network for which you want to run diagnostics.

> **Note**: If you do not have a network defined, click **Add** and follow the instructions in the wizard. For more information, see the Tool Suite User's Manual.

4. From the ribbon, click **Start**.
5. To stop running diagnostics, click **Stop**.

> **Note**: If you move away from the Network Diagnostics application without selecting **Stop**, the program continues to poll for diagnostic data.

> **Important!**: Tool Suite is not optimized for the collection and management of large amounts of diagnostic data from continuous polling. Collection of excessive amounts of data results in overall performance degradation in Tool Suite and network throughput degradation.

4. Configuring Point-to-Point Networks

Point-to-Point networks are the most basic type of network, and do not require much more than setting up the basic network, as described in the basic programming and setup chapter.

This section includes:

- A brief quick start to setup a Point-to-Point network.
- An LED chart for LED function within a Point-to-Point network.
- Information about programming the Call Book.

4.1. Point-to-Point Network Quick Start

To establish communications between a pair of FreeWave radios just received from the factory, complete the steps described below for each radio.

4.1.1. Point-to-Point Network Quick Start (Tool Suite)

1. Connect the radio to the serial port of a computer either through a serial cable or using the diagnostics cable.
2. Connect the radio to a power source (+6.0 to +27.0 VDC).

   Warning! Do not connect the LRS455-C-U, CE-U, -T-U series radios to DC power without terminating the antenna port to a suitable load, such as a 50 ohm antenna, or an attenuator with a power rating greater than or equal to 2 W. Powering up without a load attached will damage the radio and void the warranty.

3. Open a Tool Suite session, select the **Configuration** application, and ensure the correct port is selected in the **Com Port** field in the upper left of the Configuration ribbon.
4. From the **Networks** section of the Configuration ribbon, select the network in which the radio resides or click **Add Network** to create a new network in Tool Suite.

5. Click **Read Radio** in the Configuration ribbon to read the radio's current settings.
   - If using a diagnostics cable to connect to the radio, the radio automatically goes into Setup mode.
   - If using a data cable to connect to the radio, you are prompted to press the radio's Setup button to put the radio in Setup mode. If you are using a board-level radio, use the interrupt line to short pin 2 and 4.
   - When in Setup mode, all three LEDs on the radio display solid green (■ ■ ■).
6. Click the **Operation Mode** tab.
7. In the **Modem Mode** field, select to set the radio in Point-to-Point mode. For example, set one radio as a Point-to-Point Master (Mode 0) and the other as a Point-to-Point Slave (Mode 1)

> **Important!**: A network can have only one Master.

8. Click the **Baud Rate** tab.
9. Change the **Baud Rate**, **Data Parity**, and **Modbus RTU** to match the device that the radio is to be attached to.
10. Click the **Transmission Characteristics** tab.
11. Set these parameters so they are identical on all radios in the network:
    - Tx Frequency
    - Rx Frequency
    - Max Packet Size
    - Min Packet Size
    - RF Data Rate (Only 4 and 5 are approved by the FCC for use in the United States).

> **Note**: Changing these settings from the factory defaults may help to eliminate interference from other FreeWave networks.

12. Click the **Call Book** tab.
13. Enter the Slave serial number in the Master's Call Book. Enter the Master's Serial number in the Slave's Call Book, or disable Slave Security (in the Slave).

    Shortly after both radios are plugged in, they should establish a communications link with each other and the connection is complete.

4.1.2. Point-to-Point Network Quick Start (Terminal Interface)

1. Connect the radio to the serial port of a computer either through a serial cable or using the diagnostics cable.

2. Connect the radio to a power source (+6.0 to +27.0 VDC).

> **Warning!** Do not connect the LRS455-C-U, CE-U, -T-U series radios to DC power without terminating the antenna port to a suitable load, such as a 50 ohm antenna, or an attenuator with a power rating greater than or equal to 2 W. Powering up without a load attached will damage the radio and void the warranty.

3. Open a terminal emulator session.

4. Connect to COMx (where 'x' is the number of the Com port being connected).

5. Define these settings as:
   - Data Rate = 19,200
   - Data Bits = 8
   - Parity = None
   - Stop Bits = 1
   - Flow Control = None

6. If you are using the data cable, press the **Setup** button on the radio or use the interrupt line to short pin 2 and 4.
   If using the diagnostics cable, press <Shift+U>.
   - When in Setup mode, all three LEDs on the radio display solid green (▪ ▪ ▪).
   - The Main menu appears on the screen.

7. Press 0 to open the **Operation Mode** menu.

8. Press 0 to set the radio as a Point-to-Point Master or press 1 to set the radio as Point-to-Point slave.

9. Press <Esc> to return to the Main menu.

> **Important!**: A network can have only one Master.

10. Press 1 in the Main menu.

11. Change the **Baud Rate**, **Data Parity**, and **Modbus RTU** to match the device that the radio is to be attached to.

> **Important!**: When setting the radio's baud rate, its RS232 data rate is set. The baud rate does not have to be the same setting for the two radios in the Point-to-Point network.

12. Press <Esc> to return to the Main menu.

13. Press 2 in the Main menu to update the Call Book.

14. Enter the Slave serial number in the Master's Call Book.

15. Enter the Master's Serial number in the Slave's Call Book, or disable Slave Security (in the Slave).

16. Press 3 in the Main menu.

17. Set these parameters so they are identical on all radios in the network:
  - Tx Frequency
  - Rx Frequency
  - Max Packet Size
  - Min Packet Size
  - RF Data Rate (Only 4 and 5 are approved by the FCC for use in the United States).

> **Note**: The **Tx Frequency** and **Rx Frequency** options, or **Frequency Key**, are located in the F submenu after you press 0 to access the Frequency Key menu in Main menu 3.

> **Note**: Changing these settings from the factory defaults may help to eliminate interference from other FreeWave networks.

Shortly after both radios are plugged in, they should establish a communications link with each other and the connection is complete.

18. Press <Esc> to exit the Setup menu and resume normal radio operation.

4.2. Point-to-Point Operation LEDs

Condition	Master			Slave			Repeater		
	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, no link	Solid red bright	Solid red bright	Solid red bright	Solid red bright	Off	Blinking red	Solid red bright	Off	Blinking red
Linked, no Repeater, sending sparse data	Solid green	Intermittent flashing red	Intermittent flashing red	Solid green	Intermittent flashing red	Intermittent flashing red	N/A	N/A	N/A
Master calling Slave through Repeater	Solid red bright	Solid red dim	Solid red bright	Solid red bright	Off	Blinking red	Solid red bright	Off	Blinking red
Master linked to Repeater, not to Slave	Flashing orange	Solid red dim	Solid red bright	Solid red bright	Off	Blinking red	Solid red bright	Solid red dim	Solid red bright
Repeater linked to Slave	Solid green	Intermittent flashing red	Intermittent flashing red	Solid green	Intermittent flash red	Intermittent flash red	Solid green	Intermittent flashing red	Intermittent flashing red
Mode 6 - waiting for ATD command	Solid red bright	Off	Blinking red	Solid red bright	Off	Blinking red	N/A	N/A	N/A
Setup Mode	Solid green	Solid green	Solid green	Solid green	Solid green	Solid green	Solid green	Solid green	Solid green

4.3. Using the Call Book in Point-to-Point Networks

The Call Book is required in Point-to-Point networks. While the Call Book is an option in Point-to-MultiPoint networks, FreeWave strongly recommends using the **Network ID** feature in most applications. If a large MultiPoint network is implemented using the Call Book and you want to add a radio to the network, or need to replace a radio, you must physically travel to all radios in the network and enter the new serial number in the radio's Call Book.

Using the Call Book offers both security and flexibility in determining how FreeWave radios communicate with each other.

You must set the following for two FreeWave radios to communicate in Point-to-Point mode:

1. The Master's serial number must be listed in the Slave's Call Book or Slave Security is turned off in the Slave .
2. The Slave's serial number must be listed in the Master's Call Book.
3. The Master must be programmed to call the Slave.

The Call Book allows you to incorporate up to 10 FreeWave radios, designate one Repeater, and designate which Slave the Master calls. To set the Entry to Call option, select the number in the Entry to Call field, select **All** to direct the Master to call all Slaves.

> **Note**: To set the Entry to Call option in the terminal interface, enter C at the Call Book menu, followed by the menu number corresponding to that Slave. To call any available Slave in the list, enter C then enter A to direct the Master to Call All.

It is important that the Call Book slots (0-9) are filled sequentially starting with slot 0. When a Master is instructed to Call All, it calls all Slaves listed until it reaches the first serial number of 000-0000 (or a blank slot). If a serial number is entered after the all zero number or as a Repeater, the Master does not recognize it as a valid number.

> **Note**: When entering numbers into the Call Book, you need only define the Repeater in the Master's Call Book. The Slave Call Book only requires the Master's serial number. A Repeater need not have anything listed in its Call Book.

4.4. Set Call Book in Tool Suite

1. In the Tool Suite Configuration application, select the device to program and click the **(2) Call Book** tab.
2. In the **Number** column in **Row 0**, enter the seven-digit serial number of the radio being called.
3. In the **Repeater 1** column, enter the Repeater's seven-digit number. If you are not using a Repeater, leave the column empty.
4. If a Repeater is being used, select the appropriate **Entry to Call** option in the Master's Call Book.
5. To apply the changes, select either the **Quick** or **All** icon. Tool Suite applies the changes to the radio.

4.5. Set the Call Book in the Terminal Interface

1. Select **(2) Edit Call Book** from the main Setup menu to open this window:


```
MODEM CALL BOOK
Entry to Call is (ALL)
Entry     Number      Repeater1    Repeater2
(0)       960-0405
(1)       912-2890    911-4419
(2)       000-0000
(3)       000-0000
(4)       000-0000
(5)       000-0000
(6)       000-0000
(7)       000-0000
(8)       000-0000
(9)       000-0000
(C)       Change Entry to Use (0-9) or A(ALL)
(Esc)     Exit to Main Menu
Enter all zeros (000-0000) as your last number in list
—
```
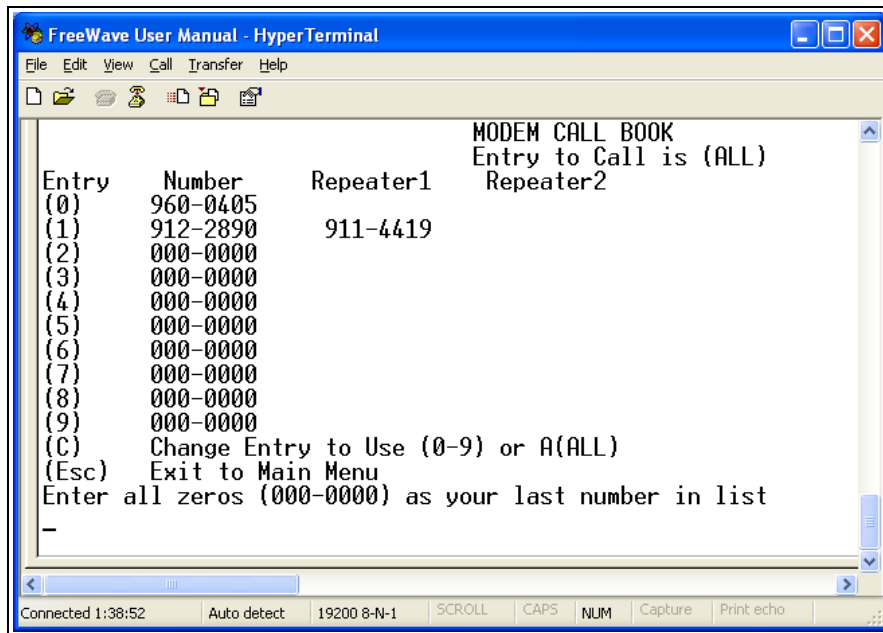
Figure 12: HyperTerminal window

2. Enter the number or letter associated with the option you want to select.

3. At the Enter New Number prompt, enter the seven-digit serial number of the radio being called.

4. The system prompts for Repeater 1's serial number.
   If a Repeater is not being used, press <Esc> and continue with Step 6.
   Otherwise, enter the 7-digit serial number of the Repeater.

5. The system prompts for Repeater 2's serial number.
   The LRS455-C-U, CE-U, -T-U network supports only one Repeater.

6. Press <Esc> to continue without entering a second Repeater.

   The system refreshes the radio's Call Book menu with the new changes.

7. Repeat Steps 2 to 5 for additional radios in the network.

8. Press <Esc> to return to the Main menu.

5. Viewing Radio Statistics

When you read a radio the system displays data transmission statistics the radio has gathered during the most recent session. This information is valuable when you need to know the signal strength and noise levels of the link. Statistics are gathered during each data link and are reset when the next link begins.

In addition, you can view more data transmission characteristics in the Network Diagnostics application. For information about running network diagnostics using Tool Suite, see the Tool Suite User Manual.

5.0.1. View Statistics in Tool Suite

1. In the Tool Suite Configuration application, click Read Radio, and then click the Device Information tab.
2. Review the statistics. Each statistic is described in detail in the sections below.

> **Note**: You can also view the same statistics using the **Setup Terminal** option in Tool Suite.

5.0.2. View Radio Transmission Characteristics in the Terminal Interface

1. Select `(4) Show Radio Statistics` from the Setup main menu.
2. Review the radio statistics. Each statistic is described in detail in the sections below.

5.1. Antenna Reflected Power

> **Note**: Displayed in Tool Suite. Not currently supported.

5.2. Antenna Rev

This statistic is available only in the terminal interface and measures the antenna power when data is received from the perspective of the local device.

- A reading of 0 to 5 is good; 5 to 20 is marginal;
- 20 or higher indicates that the connections should be inspected for loose connections and cable quality.
- A reading of 30 or higher indicates a definite problem in the system.
  - The most likely cause is a cable issue between the radio and the antenna.

5.3. Antenna Fwd

This statistic is available only in the terminal interface and measures the antenna power when data is transmitted from the perspective of the local device. A reading of 0 to 5 is good; 5 to 20 is marginal; 20 or higher indicates that the connections should be inspected for loose connections and cable quality. A reading of 30 or higher indicates a definite problem in the system. The most likely cause is a cable issue between the radio and the antenna.

5.4. Master-Slave Distance

The physical distance between the slave radio and the master radio in your network. This number is measured in meters and is more accurate at distances over 2.5 miles.

5.5. Number of Disconnects

The number of times the link between the Master and the Slave is broken and the radios lose Carrier Detect.

The value indicates the total number of disconnects that have occurred from the time the radio is powered on until the radio is put into Setup mode. Under ideal operating conditions, the number of disconnects should be **0**. One or more disconnects may indicate a weak link, the presence of severe interference problems on any of the radios in the link.

> **Note**: In Tool Suite, the disconnect information is available in the Summary View in the Network Diagnostics application.

5.6. Noise Level

The **Noise Level** indicates the level of background noise and interference at this radio. The number is an average of the noise levels measured at each frequency in the radio's frequency hop table.

> The individual measurement values at each frequency hop channel are shown in the frequency table. If you are viewing statistics in Setup Terminal or another terminal emulator, press <Enter> when the Radio Statistics menu displays to view the frequency table.

- Ideally, noise levels should be below -112 dBm and the difference between the average signal level and average noise level should be 26 or more.
- Noise levels significantly higher than this are an indication of a high level of interference that may degrade the performance of the link.
- High noise levels can often be mitigated with band pass filters, antenna placement or antenna polarization.

5.7. Signal Level

The level of received signal at this radio. For each of these, the signal source is the radio that transmits to it. The number is an average of the received signal levels measured at each frequency in the radio's frequency hop table.

> **Tip** The individual measurement values at each frequency hop channel are shown in the frequency table. If you are viewing statistics in the Setup Terminal application or another terminal emulator, press <Enter> when the Radio Statistics menu displays to view the frequency table.

- For a reliable link, the margin should be at least 26 dB.
- Low average signal levels can often be corrected with higher gain antennas or better antenna placement.

> **Note**: See the installation manual for antenna and regulating requirements.

5.8. Rate %

Measures the percentage of data packets that were successfully transmitted from the Master to the Slave.

- A number of 75 or higher indicates a robust link that provides very good performance even at high data transmission rates.
- A number of 74 lower indicates a weak or marginal link that provides lower data throughput.

5.9. Radio Temperature

The current operating temperature of the radio in degrees Celsius. For proper operation, a FreeWave radio must be in the temperature range of -30° to +60° C.

6. Release Notes

These sections describe the updates and known limitations in each firmware version for the identified model numbers, as of this document's release. The latest documentation and firmware versions are available on the FreeWave Web site at www.freewave.com.

Version 1.77

Release Date: January 2015

Additions and Changes

- Setting to RS485 is now stable.
  - This was a software-only fix and no hardware or other functionality changes were required.

Known Limitations and Workarounds

- No known additional limitations.

Version 1.74

Release Date: April 2013

Additions and Changes

- Use of frequency 452.25 MHz (CH 2760) now functions correctly.
  - This was a software only fix, and no hardware or other functionality changes were required.

Known Limitations and Workarounds

- The **RF Data Rate** parameter displays **0 to 5** as valid entries.
  - In LRS455-C and LRS455-T models, only **RF Data Rates 4 and 5** are valid and accepted.
- Setting 2 in the **Use Break to Access Setup** parameter is NOT supported.
  - Use option 1 to use the Break to Access Setup functionality.
- Operation Mode 6 is NOT supported.
- In some cases, if the Slave is powered up before the Master, the Slave may not maintain its link to the Master.
  - To ensure the Slave maintains its link, power up the Master prior to powering up a connecting Slave.
  - A Slave doe NOT re-link to the Master immediately if the Master is momentarily powered off.
- If a Slave is communicating through a Repeater, the Slave is unavailable in Network Diagnostics within Tool Suite.
- Local Diagnostics in Tool Suite is NOT supported.
- The Tx remote LED output is currently unavailable.
- Over the air firmware updates via the data port are NOT recommended at this time.

Version 1.72

Additions and Changes

- Crystal drift firmware fix. No visual changes or updates to functionality.

Known Limitations and Workarounds

- The **RF Data Rate** parameter shows **0 to 5** as valid entries.
  - In LRS455-C models, only **RF Data Rates 4 and 5** are valid and accepted.
- Setting 2 in the **Use Break to Access Setup** parameter is NOT supported.
  - Use option 1 to use the Break to Access Setup functionality.
- Operation Mode 6 is NOT supported.
- In some cases, if the Slave is powered up before the Master, the Slave may not maintain its link to the Master.
  - To ensure the Slave maintains its link, power up the Master prior to powering up a connecting Slave.
- If a Slave is communicating through a Repeater, the Slave is unavailable in Network Diagnostics in Tool Suite.
- Local Diagnostics in Tool Suite is NOT supported.
- The Tx remote LED output is currently unavailable.

Version 1.71

Release Date: May 2011

Additions and Changes

- Fixes to support VCO Range testing.

Version 1.70

Release Date: February 2011

Additions and Changes

- Miscellaneous fixes. No details provided.

Known Limitations and Workarounds

- Point-to-Point Repeaters are NOT supported

Version 1.69d9

Release Date: October 2010

Additions and Changes

- Transmitter response fixed.

Version 1.67o

Release Date: August 2010

Known Limitations and Workarounds

- Setting **Master Packet Repeat** to **0** and **Modbus RTU** to **1** results in a large data transmission delay.
  - **Master Packet Repeat** should be set to **1** or higher if the **Modbus RTU** setting is enabled.

7. Additional Radio Information

This section contains additional important information about the FreeWave radios described in this manual.

- Operational RS422 and RS485 Information
- RS422 and RS485 full duplex pin-outs
- RS485 half duplex pin-outs

7.1. Operational RS422 and RS485 Information

For RS422 and RS485, the FreeWave radio can drive 32 standard unit loads and loads the bus with only 1/8 unit load. This allows a maximum of 256 devices on the bus if all of the line receivers have 1/8 unit load.

RS422 is used for 4-wire or full duplex communication with one Master and multiple Slave radios.

- The Master radio keeps the line driver asserted at all times.
- The maximum line length is 4,000 feet using two, 120 ohm twisted pair cables with a fifth wire for data common.
- RS485 full duplex using 4-wire plus common is the same as RS422, except the system can have multiple Masters on the bus.

The most common operation of RS485 is a two-wire comprised of a 120 ohm impedance single twisted pair.

In this system the loading of the FreeWave radio is as described above, which allows up to 256 1/8 unit load units on the bus.

Maximum line length is also 4,000 feet with a third wire required for data common.

The FreeWave radio checks the line to be certain no other device is transmitting before enabling the line driver for data transmission.

When setting the radio to RS485:

1. Enable **Modbus**.
2. Set **Master Packet Repeat** to 3 in the radios that use RS485.
3. Set **Turn Off Delay** to 4.

The **Turn Off Delay** setting in the menu is used to control the length of time the transmitter driver stays asserted after data transmission has finished.

- This is needed to allow the last transmitted character to reach the end of a long line and is normally set to one character length of time.
- This setting also allows three complete reflections to the end of the line to ensure the ringing on the line has fully dampened before releasing the bus to another device.

> **FREEWAVE Recommends**: Shorter line lengths may use shorter delays, but four one-quarter-character delay times are recommended.

> **Note**: In Modbus, a **Turn Off Delay** setting of 0 causes internal timing errors.

> **Important!**: There is no provision for hand shaking in any of the above modes of operation.
> Data rates above 9600 bps in **RF Data Rate = 5** and above 19200 bps in **RF Date Rate = 4** are NOT recommended without a protocol that can handle error detection properly.

7.1.1. RS422 and RS485 Full Duplex Pin-Outs

Function	Bare Board Pin Number	DB-9 Pin Number
RX+	7	3
RX-	9	7
TX+	5	2
TX-	10	8
Signal Ground	4 or 6	5

7.1.2. RS485 Half Duplex Pin-Out

Function	Bare Board Pin Number	DB-9 Pin Number
Wire to both bins for Bus +	Short 5 and 7	Short 2 and 3
Wire to both pins for Bus -	Short 9 and 10	Short 7 and 8
Signal Ground	4 or 6	5

7.2. Attenuator for Testing

Attenuation for Testing

5 WATT / 50 dB ATTENUATOR

DIRECT CONNECTION OR SPLITTER BOX

5 WATT / 50 dB ATTENUATOR

* Connection to the transceiver may require an adaptor based on the radio type. Board-level transceivers have a female SMA connector. Enclosed transceivers have a female TNC connector.
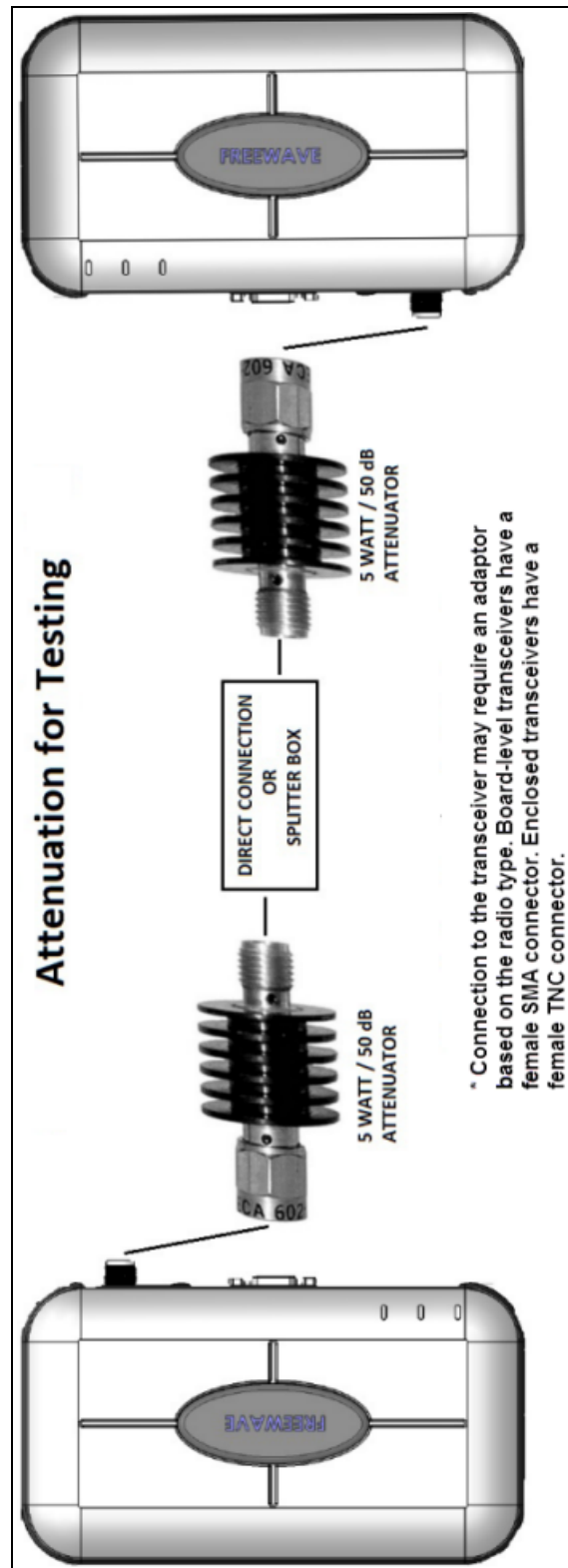
Appendix A: LRS455 Technical Specifications

Specifications may change at any time without notice. For the most up-to-date specifications information, see the product's data sheet available at www.FreeWave.com.

LRS455 Technical Specifications	
Specification	**Description**
Transmitter	
Frequency	435-470 MHz
Output Power	Programmable up to 2 W
Range	70 miles with clear line of sight
Modulation	2 and 4 level GFSK
Occupied Bandwidth	12.5 kHz
Frequency Channels	5600 Channels @ 6.25 kHz
Receiver	
Sensitivity	(2 level) -112 dBm at 9,600 bps and BER 10^{-6}
	(4 level) -100 dBm at 19,200 bps BER 10^{-6}
Data Transmission	
Error Detection	32 bit CRC, Retransmit on error
Link Throughput	9.6 Kbps at 2 level GFSK
	19.2 Kbps at 4 level GFSK
Data Interface	RS232 / RS422 / RS485 or TTL

LRS455 Technical Specifications	
Specification	**Description**
Data Connector	Board Level: 10 pin header with locking ramp, 0.1 inch spacing power / data connector. Enclosed: DB9
Diagnostics	
Connector	Board Level: Separate 20-pin connector Enclosed: 3-pin PCB header
Power Requirement	
Operating Voltage	+6.0 to +27.0 VDC
Current Drain	

Mode	+6 VDC	+12 VDC	+27 VDC
Transmit	1.5 A	0.75 A	0.34 A
Receive	200 mA	100 mA	45 mA
Idle	50 mA	25 mA	12 mA

General Information	
Operating Temperature	-30 °C to + 60 °C
Dimensions	128 L x 61.8 W x 19.7 H (mm) Enclosed: 173 L x 112 W x 35 H (mm)
Weight	74.4 g Enclosed: 605 g
External Antenna Connector	SMA (board level), TNC (enclosure)
Humidity	0 to 95% non-condensing

Appendix B: RF Board Pin-Out

The LRS455 Wireless Data Radio series radios are available in both TTL and RS232 versions.

- The TTL versions use reverse polarity from standard RS232 at 0 to 5 Volt levels.
- All pin descriptions and pin numbering are the same as the RS232 version.
- The RS232 versions use standard RS232 polarity and voltage levels for all of the RS232 signal lines (DTR, Transmit Data, Receive Data, Carrier Detect, RTS, and Clear to Send) and TTL standard polarity and voltage level for the Interrupt pin.
  - Pin 1 - B+ Power input.
  - Pin 2 - Interrupt (INT) – Input – A 0 volt level on this pin switches the radio into Setup mode.

Note: Pin 1 on the board-level radios is the pin farthest from the three LEDs and pin 10 is the closest to the LEDs.

Pin	Assignment	Color on ACS3610xx Cable
1	B+ input	Red
2	Interrupt (temporarily ground to invoke menu)	Brown
3	Data Terminal Ready (DTR)	Orange
4	Ground	Black
5	Transmit Data (TXD)	Yellow
6	Ground	Black
7	Receive Data (RXD)	Green
8	Carrier Detect (DCD)	Blue

Pin	Assignment	Color on ACS3610xx Cable
9	Request to Send (RTS)	Violet (purple)
10	Clear to Send (CTS)	Gray

Appendix C: RS232 Pin Assignments

Pin		Assignment	Signal	Definition
1	CD	Carrier Detect	Output	Used to show an RF connection between radios.
2	TX	Transmit Data	Output	Used to transmit data bits serially from the radios to the system device.
3	RX	Receive Data	Input	Used to receive data bits serially from the system device connected to the radios.
4	DTR	Data Terminal Ready	Input	Used only in radios in Point-to-Point Slave/Master switchable mode or for DTR Connect.
5	GND	Ground		Signal return for all signal lines shared with Pin 9.
6	DSR	Data Set Ready	Output	Always high when the radio is powered from the 2.5 mm power connector. Indicated power is on to the radio. Also, this pin can be used for +12 Volts when powering the radios directly through the RS232 port. This is not used on the OEM module.
7	RTS	Request to Send	Input	The radio does not recognize RTS for flow control. RTS is used as a control line in RTS/CTS mode.
8	CTS	Clear to Send	Output	This signal is used to tell the system device connected to the radio that the radio is ready to receive data. When asserted, the radio accepts data, when de-asserted, the radio does not accept data. This should always be used for data rates above 38.4 KB or there is a risk of lost data if an RF link is not very robust.
9	GND	Ground		Signal return for all signal lines shared with Pin 5.

Appendix D: Frequency List

The LRS455-C-U, CE-U, -T-U radios tune from 435 MHz to 470 MHz with a tuning resolution of 6.25 KHz. This gives a total of 5600 available channels. Using the license allowed frequency, the channel number can be determined using this formula.

Channel number = $F^{MHz} (160) - 69600$

Note: This is a partial list. If the required frequency is not listed use the F^{MHz} formula to obtain the appropriate channel number.

Channel#	Frequency		Channel #	Frequency		Channel #	Frequency
0	435.000		2060	447.875		4120	460.750
20	435.125		2080	448.000		4140	460.875
40	435.250		2100	448.125		4160	461.000
60	435.375		2120	448.250		4180	461.125
80	435.500		2140	448.375		4200	461.250
100	435.625		2160	448.500		4220	461.375
120	435.750		2180	448.625		4240	461.500
140	435.875		2200	448.750		4260	461.625
160	436.000		2220	448.875		4280	461.750
180	436.125		2240	449.000		4300	461.875
200	436.250		2260	449.125		4320	462.000
220	436.375		2280	449.250		4340	462.125

Channel#	Frequency	Channel #	Frequency	Channel #	Frequency
240	436.500	2300	449.375	4360	462.250
260	436.625	2320	449.500	4380	462.375
280	436.750	2340	449.625	4400	462.500
300	436.875	2360	449.750	4420	462.625
320	437.000	2380	449.875	4440	462.750
340	437.125	2400	450.000	4460	462.875
360	437.250	2420	450.125	4480	463.000
380	437.375	2440	450.250	4500	463.125
400	437.500	2460	450.375	4520	463.250
420	437.625	2480	450.500	4540	463.375
440	437.750	2500	450.625	4560	463.500
460	437.875	2520	450.750	4580	463.625
480	438.000	2540	450.875	4600	463.750
500	438.125	2560	451.000	4620	463.875
520	438.250	2580	451.125	4640	464.000
540	438.375	2600	451.250	4660	464.125
560	438.500	2620	451.375	4680	464.250
580	438.625	2640	451.500	4700	464.375
600	438.750	2660	451.625	4720	464.500
620	438.875	2680	451.750	4740	464.625
640	439.000	2700	451.875	4760	464.750
660	439.125	2720	452.000	4780	464.875
680	439.250	2740	452.125	4800	465.000
700	439.375	2760	452.250	4820	465.125
720	439.500	2780	452.375	4840	465.250
740	439.625	2800	452.500	4860	465.375
760	439.750	2820	452.625	4880	465.500
780	439.875	2840	452.750	4900	465.625
800	440.000	2860	452.875	4920	465.750
820	440.125	2880	453.000	4940	465.875
840	440.250	2900	453.125	4960	466.000
860	440.375	2920	453.250	4980	466.125
880	440.500	2940	453.375	5000	466.250

Channel#	Frequency	Channel #	Frequency	Channel #	Frequency
900	440.625	2960	453.500	5020	466.375
920	440.750	2980	453.625	5040	466.500
940	440.875	3000	453.750	5060	466.625
960	441.000	3020	453.875	5080	466.750
980	441.125	3040	454.000	5100	466.875
1000	441.250	3060	454.125	5120	467.000
1020	441.375	3080	454.250	5140	467.125
1040	441.500	3100	454.375	5160	467.250
1060	441.625	3120	454.500	5180	467.375
1080	441.750	3140	454.625	5200	467.500
1100	441.875	3160	454.750	5220	467.625
1120	442.000	3180	454.875	5240	467.750
1140	442.125	3200	455.000	5260	467.875
1160	442.250	3220	455.125	5280	468.000
1180	442.375	3240	455.250	5300	468.125
1200	442.500	3260	455.375	5320	468.250
1220	442.625	3280	455.500	5340	468.375
1240	442.750	3300	455.625	5360	468.500
1260	442.875	3320	455.750	5380	468.625
1280	443.000	3340	455.875	5400	468.750
1300	443.125	3360	456.000	5420	468.875
1320	443.250	3380	456.125	5440	469.000
1340	443.375	3400	456.250	5460	469.125
1360	443.500	3420	456.375	5480	469.250
1380	443.625	3440	456.500	5500	469.375
1400	443.750	3460	456.625	5520	469.500
1420	443.875	3480	456.750	5540	469.625
1440	444.000	3500	456.875	5560	469.750
1460	444.125	3520	457.000	5580	469.875
1480	444.250	3540	457.125	5600	470.000
1500	444.375	3560	457.250		
1520	444.500	3580	457.375		
1540	444.625	3600	457.500		

Channel#	Frequency	Channel #	Frequency	Channel #	Frequency
1560	444.750	3620	457.625		
1580	444.875	3640	457.750		
1600	445.000	3660	457.875		
1620	445.125	3680	458.000		
1640	445.250	3700	458.125		
1660	445.375	3720	458.250		
1680	445.500	3740	458.375		
1700	445.625	3760	458.500		
1720	445.750	3780	458.625		
1740	445.875	3800	458.750		
1760	446.000	3820	458.875		
1780	446.125	3840	459.000		
1800	446.250	3860	459.125		
1820	446.375	3880	459.250		
1840	446.500	3900	459.375		
1860	446.625	3920	459.500		
1880	446.750	3940	459.625		
1900	446.875	3960	459.750		
1920	447.000	3980	459.875		
1940	447.125	4000	460.000		
1960	447.250	4020	460.125		
1980	447.375	4040	460.250		
2000	447.500	4060	460.375		
2020	447.625	4080	460.500		
2040	447.750	4100	460.625		

Appendix E: Factory Default Settings

FreeWave LRS455-C-U, CE-U, -T-U radios ship from the factory with these default settings:

Operation Mode	Default		MultiPoint Parameters	Default
Point-to-Point Slave	1		(1) MASTER PACKET REPEAT	0
Set Baud Rate	Default		(2) MAX SLAVE RETRY	9
Baud Rate	19200		(3) RETRY ODDS	0
(A) Data Parity	0		(4) DTR CONNECT	0
(B) Modbus RTU	0		(6) NETWORK ID	255
(C) RS232/485	0		(7) RESERVED	-
(D) Setup Port	3		(8) MULTI MASTER SYNC	0
(E) TurnOffDelay/OnDelay	0/0		(9) 1 PPS ENABLE DELAY	255
(F) Flow Control	0		(A) SLAVE/REPEATER	0
Radio Parameters	**Default**		(B) DIAGNOSTICS	0
(1) MAX PACKET SIZE	9		(C) SUBNET ID	Disabled
(2) MIN PACKET SIZE	1		Rx ID	F
(3) XMT RATE	1		Tx ID	F
(4) RF DATA RATE	5		(D) RADIO ID	Not Set
(5) RF XMT POWER	10		(E) Local Mode	0
(6) SLAVE SECURITY	0		(F) Radio Name	blank
(7) RTS TO CTS	0			
(8) RETRY TIMEOUT	255			

Operation Mode	Default		MultiPoint Parameters	Default
(9) LOW POWER MODE	0			
(A) High Noise	0			
(B) MCU Speed	0			
(C) Remote LED	0			

Appendix F: FreeWave Legal Information

FreeWave Technologies, Inc. products may be subject to control by the Export Administration Regulations (EAR) and/or the International Traffic in Arms Regulations (ITAR). Export, re-export, or transfer of these products without required authorization from the U.S. Department of Commerce, Bureau of Industry and Security, or the U.S. Department of State, Directorate of Defense Trade Controls, as applicable, is prohibited. Any party exporting, re-exporting, or transferring FreeWave products is responsible for obtaining all necessary U.S. government authorizations required to ensure compliance with these and other applicable U.S. laws. Consult with your legal counsel for further guidance.

Input voltage for these models is +6.0 to +27.0 VDC.

Models LRS455-C-U, LRS455-CE-U, LRS455-T-U, LRS455-TE-U are suitable for use in Class 1, Division 2, Groups A, B, C, and D or non-hazardous locations only. Do not connect or disconnect any connectors while the circuit is live unless the area is known to be non-hazardous.

UL Notifications / Warnings - Class1 Div2

 Warning! EXPLOSION HAZARD! - Substitution of components may impair suitability for Class 1, Division 2.

 Warning! DO NOT REMOVE or insert the diagnostics cable while the circuit is live!

UL Power Source

Important!: Input power shall be derived from a single Class 2 power source.

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.

The content of this guide covers FreeWave Technologies, Inc. models sold under FCC ID: KNY821191151819.

All models sold under the FCC ID(s) listed above must be installed professionally and are only approved for use when installed in devices produced by FreeWave Technologies or third party OEMs with the express written approval of FreeWave Technologies, Inc. Changes or modifications should not be made to the device.

FCC NEMA Installation and Label

Where applicable, the models described in this guide must be installed in a NEMA enclosure. When any FreeWave Technologies, Inc. module is placed inside an enclosure, a label must be placed on the outside of the enclosure. The label must include the text "**Contains Transmitter Module with FCC ID: KNY821191151819.**"

FCC Notification of Power Warning

The covered in this document have a maximum transmitted output power of 2 W.

The antennas used MUST have a separation distance of at least 71 cm from all persons and MUST NOT be co-located or operate in conjunction with any other antenna or transmitter.

Antennas used with the radio must not exceed 9.25dBi.

IC Notifications

This device complies with Industry Canada licensed RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Ce dispositif est conforme aux normes permis-exemptes du Canada RSS d'industrie. L'opération est sujette aux deux conditions suivantes : (1) ce dispositif peut ne pas causer l'interférence, et (2) ce dispositif doit accepter n'importe quelle interférence, y compris l'interférence qui peut causer le fonctionnement peu désiré du dispositif.

The LRS455 radios are approved for use in Canada within the 450 MHz to 470 MHz band.

FREEWAVE