LRS455A Wireless Data Radio

LRS455A-C

LRS455A-CE

LRS455A-T

Covering Firmware 1.79

User-Reference Manual

Safety Information

The products described in this manual can fail in a variety of modes due to misuse, age, or malfunction and is not designed or intended for used in systems requiring fail-safe performance, including life safety systems. Systems with the products must be designed to prevent personal injury and property damage during product operation and in the event of product failure.

FreeWave Technologies, Inc. warrants the FreeWave® LRS455 Wireless Data Radio (Product) that you have purchased 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). The replacement product will remain under warranty for 90 days or the remainder of the original product warranty period, whichever is longer.

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, INABILITY TO ACCESS OR SEND COMMUNICATION OR DATA, PERSONAL INJURY OR DAMAGE, OR OTHER LOSS WHICH MAY ARISE FROM THE USE OF THIS PRODUCT. THE WARRANTY IS EXCLUSIVE AND ALL OTHER WARRANTIES EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR USE ARE EXPRESSLY DISCLAIMED.

FreeWave's Warranty does **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. Where applicable, this includes the addition of conformal coating.

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Preface

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 support@freewave.com.

Additional Information

> **Note**: Use the support.freewave.com website to download the latest documentation for the **LRS455A-C, LRS455A-CE, LRS455-T**.
> Registration is required to use this website.

Document Styles

This document uses these styles:

- Products and applications appear as: **FreeWave**.
- 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**.

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.

Provides time saving or informative suggestions about using the product.

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

Parameter Preference

The **Parameter Preference** table describes the available parameters.

<Parameter Name>	
Setting	**Description**
Default Setting	The factory default setting for the parameter.
Options	The options the parameter can be set to.
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. Overview

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 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 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 **LRS455A-C, LRS455A-CE, LRS455-T** 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 LRS455A-C, LRS455A-CE, LRS455-T 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 **LRS455A-C, LRS455A-CE, LRS455-T** radios are narrowband radios and have a limited channel size based on the license obtained from the regulating body. Therefore, the radios can experience a dramatic impact in throughput if a Repeater is implemented in the network.
If large amounts of data are transferred and a Repeater is added to the network, the polling host / RTU settings must be optimized 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. Examples of Data Communication Links

1.3.1. Example 1 - Point-to-Point Link

Figure 2 shows the most common and straightforward link, a Master communicating to a Slave in a Point-to-Point link.
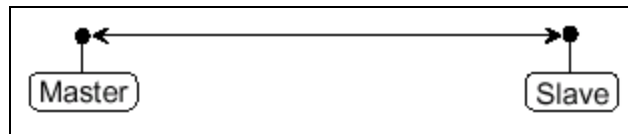
Figure 2: Point-to-Point Link

1.3.2. Example 2 - Point-to-Point Link with Repeater

Figure 3 shows a link using a Repeater.

- If a Repeater is located on a hilltop or other elevated structure, it can enhance the link from the Master to the Slave.
- In this configuration, it is desirable to use an Omni-directional antenna at the Repeater.
- Yagi antennas may be used at both the Master and Slave radios to increase the range of the link.

Note: Adding Repeaters to a network cuts the data throughput by 50% and **decreases** overall network capacity by 50%.
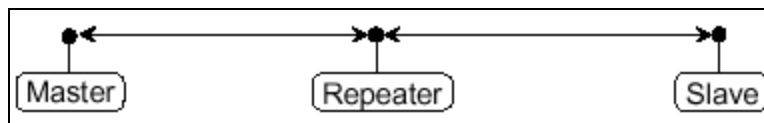
Figure 3: Point-to-Point Link with a Repeater

Important!: In **LRS455A-C, LRS455A-CE, LRS455-T** radio networks, only one Repeater is allowed. 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 **LRS455A-C, LRS455A-CE, LRS455-T** radios are narrowband radios and have a limited channel size based on the license obtained from the regulating body. Therefore, the radios can experience a dramatic impact in throughput if a Repeater is implemented in the network.
If large amounts of data are transferred and a Repeater is added to the network, the polling host / RTU settings must be optimized 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. Example 3 - Standard Point-to-Multipoint Network

Figure 4 shows a standard Point-to-MultiPoint network.

- From the Master, any data is broadcast to all three Slave radios, one of which receives it through a Multipoint Repeater.
- The data is sent out of the serial port of each of the three Slave radios.
- The end device should be configured to interpret the serial message and act on it if necessary.

> **Important!**: The end device should be configured to interpret the serial message and act on it if necessary.
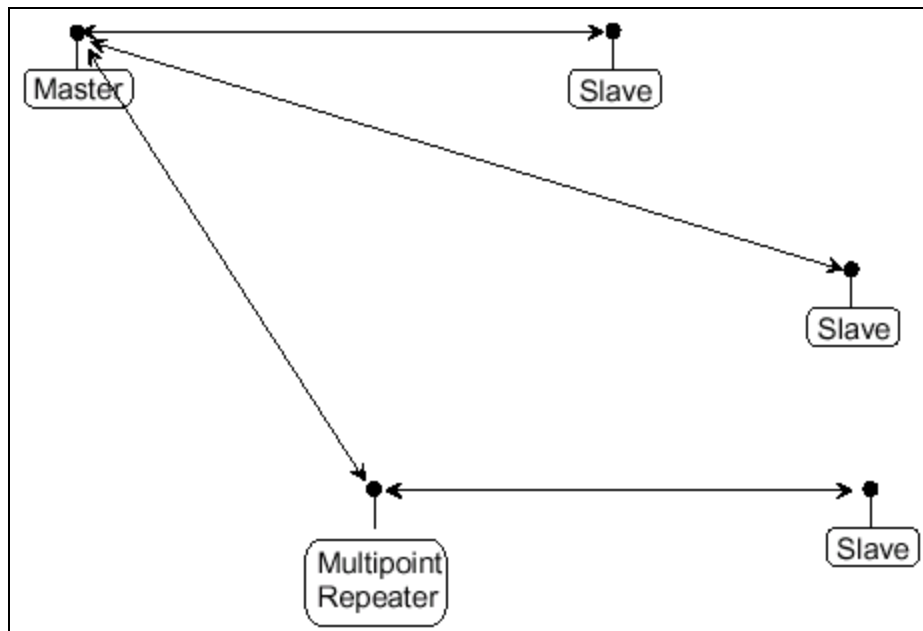
Figure 4: Standard Point-to-Multipoint Network

2. Equipment

2.1. Included Equipment

Included Equipment	
Qty	**Description**
1	**LRS455A-C, LRS455A-CE, LRS455-T** radio
1	FreeWave Part Number: ECD2409DM (6ft DE-9 extension cable) **Note**: LRS455-CE-U only.
1	FreeWave Part Number: EMD1230UX (power supply) **Note**: LRS455-CE-U only.

2.1.1. User-supplied Equipment

- DC power source
- Interface / Power Cables
- FCC approved antenna
- Data cable (FreeWave Part Number: ASC3610DB or ASC3610DJ)
- Black diagnostic cable (FreeWave Part Number: ASC0409DC)

2.2. Finding the Product Serial Number

Each FreeWave radio is assigned a unique serial number.

The serial number is three digits, followed by a hyphen, then four digits (e.g., 111-1111), and is printed on the FreeWave label on the radio.

> **Important!**: This number is needed when contacting FreeWave Technical Support.

3. Installation

3.1. Power the Radio

Connect the radio to a positive power supply with +6.0 to +27.0 VDC, (typically, +12 VDC).

> **Warning!** **Do not** connect the **LRS455A-C, LRS455A-CE, LRS455-T** 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.

3.2. 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 show Solid Green ▪ .

> **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 35).

The Setup Port (on page 33) 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.

3.2.1. Use Tool Suite to Connect to and Program Radios

To read and program a radio using **Tool Suite**, connect the radio to a computer that runs the **Tool Suite** software.

> **Note**: Use **Tool Suite** to set up a template version of a radio. Templates include settings that apply to more than one radio in the network.
> For more information about using templates, see the **Tool Suite User Manual** in the **Tool Suite** software.

Procedure

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 view the **Setup** menu in the Enclosed radio:
   - Press the Setup button on the FreeWave radio. Figure 5
   - If connected to the diagnostics port, type <Shift+U> to activate the **Setup** menu.

Figure 5: Setup Button

4. To view the **Setup** menu in board level radios:
   - Short pins 2 & 4 (Brown to Black) on the white 10 pin header next to the LEDs. Figure 6
   - If using a data cable, press the Setup button.
   - If using the gray ribbon diagnostic cable or the black diagnostic cable, type <Shift+U>.

   > **Note**: See User-supplied Equipment (on page 15) for FreeWave-specific equipment.
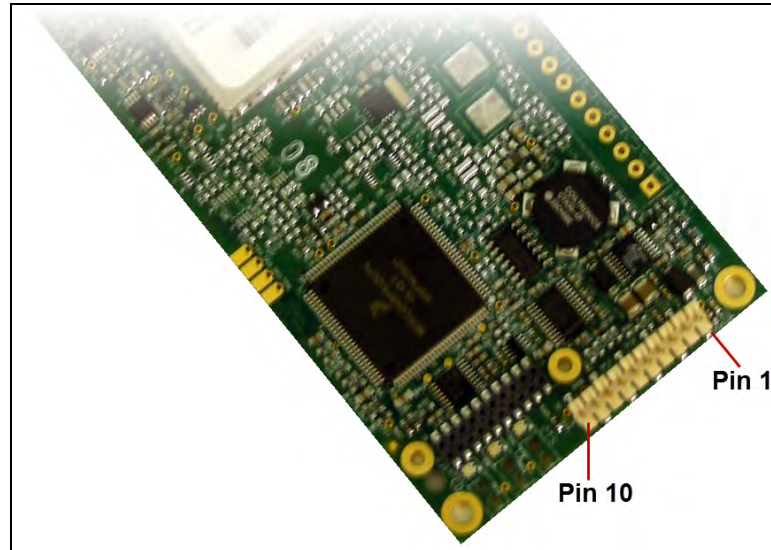
Figure 6: Pins 1 and 10

All three LEDs on the radio light Solid Green ■ and stay green as long as the radio is in **Setup** mode.

5. Click **Configuration** in the **Application** pane to open the **Configuration** application.

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

7. Make the necessary parameter changes.

8. Send the changes to the radio using one of these procedures:

   - To send only the changed parameters, in the **Configuration** application, in the **Network Title** ribbon, click **Quick**.

     - This option is only available if **Read Radio** is selected and parameter settings are NOT sent from a template to the radio.

   - To send all the settings for all parameters, in the **Configuration** application, in the **Network Title** ribbon, click **All**.

   - To set a device back to its factory default settings, in the **Configuration** application, in the **Network Title** ribbon, click **Default**.

3.2.2. Access the Setup Menu using a Terminal Emulator in Tool Suite

This procedure describes how to access the radio's **Setup** menu using the **Setup Terminal** application in **Tool Suite**.

By default, the **Setup Terminal** contains these port settings.

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

Procedure

1. Plug a serial cable into Com 1 and connect it to the computer running **Tool Suite** .
2. Connect the radio to power.
3. Open **Tool Suite**.
4. In the **Applications** pane, select **Setup Terminal**.
5. In the top left of the window, click the drop-down list and select the Com port on the computer to which the radio is connected. Figure 7

Figure 7: Tool Suite Connect button

6. Click **Connect**.
7. To view the **Setup** menu in the Enclosed radio:
   - Press the Setup button on the FreeWave radio. Figure 5
   - If connected to the diagnostics port, type <Shift+U> to activate the **Setup** menu.
8. To view the **Setup** menu in board level radios:
   - Short pins 2 & 4 (Brown to Black) on the white 10 pin header next to the LEDs. Figure 6
   - If using a data cable, press the Setup button.
   - If using the gray ribbon diagnostic cable or the black diagnostic cable, type <Shift+U>.

> **Note**: See User-supplied Equipment (on page 15) for FreeWave-specific equipment.

When Setup is activated, the **Main** menu appears in the terminal emulator window.

All three LEDs on the radio light Solid Green ● and stay green as long as the radio is in **Setup** mode.

> **Important!**: When changes are made to the parameters through the **Setup** menu, the changes are sent to the radio immediately.

3.2.3. 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 33).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.

3.3. 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, use either of these 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 the network's performance. Use the **Configuration** application in **Tool Suite** to program changes to the radio's settings.
- **Terminal Emulator** - A terminal emulator program, e.g., **Tera Term**, offers many of the same configuration options that are available in the **Configuration** application in **Tool Suite**.

3.3.1. 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**.
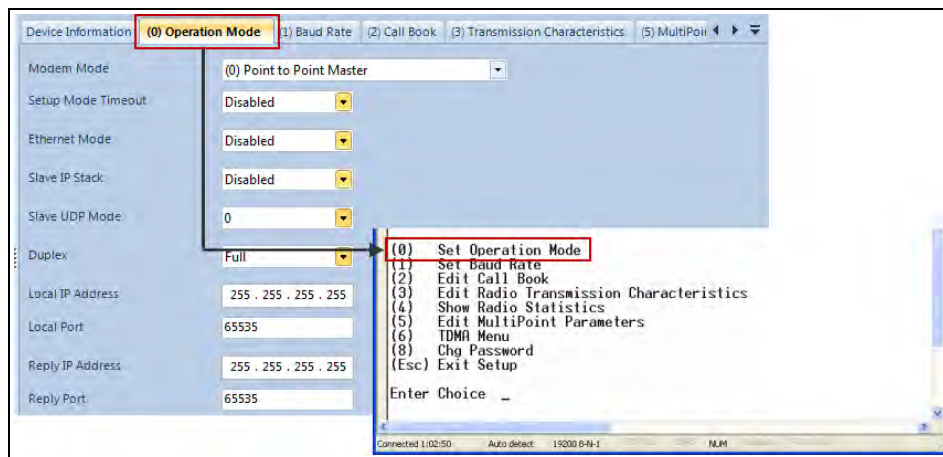
Figure 8: Tool Suite menu Matched to Terminal menu

> **Note**: In this document, if the setup procedure in the terminal emulator is different than the procedure in **Tool Suite**, the terminal instructions are also included.

3.4. Upgrade the Radios to the Latest Firmware Version

If **Tool Suite** is connected to a radio, and a new version of the firmware is available for that radio model, an indication appears in the **Configuration** application's **Device Information** tab.

Use **Tool Suite** to upgrade the firmware on a serial radio connected directly to the computer using the diagnostic cable.

> **Important!**: An over-the-air upgrade using **Tool Suite** is not allowed.

> **FREEWAVE Recommends**: If using a USB-to-serial converter cable, a software upgrade can take a long time to complete.
> Use USB-to-serial cables that include the FTDI Chip Set to shorten the upgrade time.
> This inclusion is listed on the cable's packaging.
> See the **Application Note #5471 Optimizing Firmware Upgrade Speed While Using a USB-Serial Adaptor** for additional information (available at support.freewave.com).
> Registration is required to use this website.

> **Note**: For more information about using **Tool Suite**, see the **Tool Suite User Manual** in the **Tool Suite** software.

Procedure

1. With the radio connected to the computer through the COM port, open **Tool Suite**.

2. In the **Applications** pane, click **Configuration** to open the **Configuration** application.

3. In the **Firmware** area of the **Configuration** application, click **Upgrade Radio**.

4. Click **Yes** at the prompt to proceed.
   Tool Suite identifies the software version loaded on the connected device and shows the latest version of software available for that model.

5. Click **Yes** to continue with the upgrade.
   The system shows the progress of the software upgrade.
   After the firmware upgrade is complete, a message appears confirming that the software upgrade was successful.

4. 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.

4.1. Define the Network Type and the Radio's Role in that Network

Networks consist of a Master radio and any number of other components including Repeaters, Slave radios, and radios that act as both a Slave and a Repeater. The first parameter to set in a radio is its **Operation** 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.

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

In a Point-to-Point configuration, Master or Slave mode may be used on either end of the communication link without performance degradation.

On the **Operation Mode** menu, use the **Modem Mode** field to set the **Modem Mode**.

> **Note**: These settings are available in the **Operation Mode** menu in the terminal interface.

> **Important!**: The network type must match for all radios in a network.

> 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.

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 transmission characteristics, regardless of the settings in the Slaves and/or Repeaters. The settings NOT determined by the Master are: • Hop Table settings • Retry Time Out • Slave Security • Transmit Power A quick method of identifying a Master is to power the radio. Prior to establishing a link with a Slave, all three of the LEDs on the Master are Solid Red (Bright) ▬ .

Operation Mode	Description
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 a maximum of four Repeaters. • When functioning as a Slave, the **Entry to Call** feature in the radio's **Call Book** is NOT operational. • Set the **Slave Security** parameter to 1 to bypass the **Call Book** in the Slave. **Note**: For more information, see the **Slave Security** parameter.
Point–to-MultiPoint Master (2)	This mode designates the radio as a Master in MultiPoint mode. • This mode allows one Master radio to communicate simultaneously with numerous Slaves and Repeaters. • 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 or more Repeaters.
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)	FreeWave allows the use of a maximum of four Repeaters in a Point-to-Point communications link, significantly extending 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 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**. **Note**: Adding Repeaters to a network cuts the data throughput by 50% and **decreases** overall network capacity by 50%.

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 using 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. **Note**: For more information, see **Application Note #5476, Mode 6** (available at support.freewave.com). Registration is required to use this website.
Point-to-MultiPoint Repeater (7)	This option allows the radio to operate as a Repeater in a MultiPoint network. • As many Repeaters as necessary are allowed in a MultiPoint network. • If the Repeater is to act as a Slave / Repeater, set the **Slave Repeater** parameter in the **MultiPoint Parameters** menu to `Enabled`.
Ethernet Options (F)	**Note**: This menu is only used for Ethernet radios. Although this menu may be visible, it is not used in the **LRS455A-C, LRS455A-CE, LRS455-T**.

4.2. Establish Communication with Instrumentation and Computers

The settings on the **Baud Rate** tab are the communications settings between the radio and the instrument or computer it is connected to (radio serial port to the device).

Important!: These settings are unique to each radio, and do not need to match across the network.

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.

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.

Note: See the Parameter Preference (on page 8) for a description of the parameter table's content.

4.2.1. 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
Description	• This is the communication rate between the radio's data port and the instrument it is connected to. • This parameter is independent from the Baud Rate for the other radios in the network. **Important!**: The **Setup Port** Baud Rate always defaults to **19,200** no matter how the **Data Port** Baud Rate is set. The only exception is Mode 6. For more information, see **Application Note #5476, Mode 6** (available at support.freewave.com). Registration is required to use this website. **FREEWAVE Recommends**: Use Flow Control (on page 31) if the **Baud Rate** higher than 9,600 in a narrow-band licensed network.

4.2.2. Data Parity

When **Data Parity** is selected from the **Baud Rate** menu, a prompt to enter a value appears.

Data Parity	
Setting	**Description**
Default Setting	0 (8, N, 1)
Options	See Description.
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. This table describes each option: _See table below_

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

4.2.3. Flow Control

Flow Control	
Setting	**Description**
Default Setting	(0) None

Options	• **(0) None** - No flow control CTS is active and de-asserts when buffering is 98% full.
	   • Can pass XON/XOFF data but does not use it in any way.
	• **(1) RTS** - Uses RTS/CTS (Request to Send/Clear to Send) for flow control.
	   • CTS performs the same way as in option **(0) None**.
	   • RTS must be activated for the radio to output data over the serial port.
	• **(2) DTR** - Uses DTR/DSR (Data Terminal Ready/Data Set Ready) for flow control.

Setup Terminal Menu	(2) Set Baud Rate > (F) FlowControl
Description	• Specifies the hardware flow control for the data port on the radio. • Flow control is the process of managing the speed data is transmitted to not overwhelm the device receiving the transmission. **FREEWAVE Recommends**: Use **Flow Control** if the **Baud Rate** is higher than 9,600 in a narrow-band licensed network.

4.2.4. Modbus RTU

> **Important!**: When using the radio in **Modbus RTU** mode, the Master Packet Repeat (on page 66) 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)
Options	Any number between 0 to 9
Setup Terminal Menu	(1) Set Baud Rate > (B) Modbus RTU

Description	A setting other than 0 in this parameter causes the radio to wait for an amount of time gathering data before sending out the RF link (e.g., a port delay).
	
	• **0 (Disabled)** - The radio sends data out through its RF link as soon as the data is received into the serial port. This is the default setting.
	
	• **1** - The radio waits for a number of slots equal to two times the **Master Packet Repeat** setting before sending the received data out the RF link.
	
	   • With a setting of 1, the radio waits for a number of slots equal to two times the **Master Packet Repeat** setting before sending the received data out the RF link.
	
	      Example: If the **Master Packet Repeat** parameter is set to 3, the radio 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.
	
	• **2 or higher** - The radio waits for a number of slots calculated using this 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.

4.2.5. 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** - 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 link state functionality. - Turn Off Delay (on page 34) works as described in all radios. - Turn On Delay (on page 35) 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 for connection to an external device. **Important!**: This setting must be 0 in TTL RF board products. If set to anything other than 0, the Setup Port (on page 33) must be set to `Diagnostics Only`.

4.2.6. 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

Setup Port	
Setting	**Description**
Options	• **(1) Main Only** - Programming and reading a radio's setup information is done through the Data port. • **(2) Diagnostics Only** - Programming and reading a radio's setup information is done through the Diagnostic port. > **Important!**: If the Serial Interface (on page 32) 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 data port or the diagnostic port .
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 the **Setup** main menu in the terminal interface. • The main Data port is the RS232 / RS485 port. • The Diagnostics port is a 3-pin connector. • The Diagnostic cable for this port is FreeWave Part Number: ASC0409DC.

4.2.7. Turn Off Delay

NAME	
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 0-9. • A setting of 4 means a delay equivalent to the duration of a full character. • The default is 0 (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.

4.2.8. Turn On Delay

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

4.2.9. Use Break to Access Setup

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

Use Break to Access Setup	
Setting	**Description**
Default Setting	(0) Disabled
Options	**(0) - Disabled** - The break command is disabled. **(1) - Enabled** - The **Setup** menu is sent at `19,200` bps. **(2) - Enabled** - The **Setup** menu is sent at the radio's current Baud Rate (on page 30). - 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	- This parameter 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. **Example**: If a character is defined as having 1 start bit, 8 data bits, and 1 stop bit, the character time is 10 bits. The transmit data line must be held in the space voltage level for a period of time longer than 10 bits.

4.3. Establishing Communication with Other Radios in the Network

For the radios in the network to communicate successfully, the radios need to be told what other devices are available for them to communicate with. Use one of these options:

- **Network ID** - Used in MultiPoint Networks, the **Network ID** parameter is available on the **MultiPoint Parameters** tab.
  - Each radio in a single network should be assigned the same 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.
    - Without having the serial numbers in the Call Book, Slaves may establish communications with different Masters that match the radio's Golden Settings (on page 36), 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 59).
- Call Book - The Call Book is **required** in Point-to-Point networks.
  - The Call Book stores serial numbers of other 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.
    - For more information about defining the Call Book in a Point-to-Point network, see Using Call Book in Point-to-Point Networks (on page 79).
    - For more information about defining the Call Book in a Point-to-MultiPoint network, see Using the Call Book in MultiPoint Networks (on page 59).

> **FREEWAVE Recommends**: 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 a radio needs to be added to or replaced in the network, each radio in the network must be physically reprogrammed and the new serial number entered in the radio's Call Book.
>
> This can be a time consuming process and can cause a delay in getting the network back up and running.
>
> Because the **Network ID** does not use serial numbers, MultiPoint Master radios and Repeaters may be added or replaced without reprogramming each Slave radio in the network.

4.3.1. Golden Settings

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

- Max Packet Size and Min Packet Size (on page 40)
- Network ID (on page 43)
- RF Data Rate (on page 45)
- Rx Frequency (on page 46)
- Tx Frequency (on page 50)

Radios that contain the same settings in all these parameters can communicate with each other.

> **Important!**: If using 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.
> If working with parallel Repeaters, the **Frequency Key** setting may differ.

4.4. Set the Data Transmission Characteristics

The **Transmission Characteristics** parameters are used to change settings that determine how data is sent between radios in the network. Many of these parameters must be maintained throughout the network for proper functionality.

These parameters 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 the description.

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

> **FREEWAVE Recommends**: Most parameters in the **Edit Radio Transmission Characteristics** menu can be left to their default settings when completing basic setup.

- Several settings on a Slave or Repeater radio come from the Master and are set ONLY at the Master.
  - These settings MUST be set on **every** Slave or Repeater:
    - Hop Table Size (on page 38)
    - Retry Timeout (on page 44)
    - Slave Security (on page 47)
    - Transmit Power (on page 48)

> ⚠ **Caution**: These parameters **must be set** and they **must be the same** for all radios in the network:

- Max Packet Size and Min Packet Size (on page 40)
- RF Data Rate (on page 45)
- Rx Frequency (on page 46)
- Tx Frequency (on page 50)

4.4.1. High Noise

> **Note**: This parameter does not apply to the **LRS455A-C, LRS455A-CE, LRS455-T** radios.

4.4.2. Hop Table Size

> **Important!**: All radios in a network must have identical **Hop Table** settings.

🛑 **Warning!** FCC and ISED regulations require a minimum of separate frequency channels be used within a hop pattern.

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) More > (1) Hop Table Size
Description	The **Hop Table Size** defines how many separate channels are used by a given network. **FREEWAVE Recommends**: Use the **Frequency Zones** instead of the **Hop Table Size** setting.

4.4.3. Low Power Mode

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

> **Important!**: The **Low Power Mode** parameter applies only to MultiPoint Slave radios.
> **Low Power Mode** does NOT work with MultiPoint Repeaters because they are constantly transmitting.

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

Low Power Mode	
Setting	**Description**
Description	The **Low Power Mode** parameter allows a Multipoint Slave to consume less power by dimming the radio's LEDs. ● When set to 2 through 31, the radio sleeps between slots. > **Example**: Using a setting of 2 the radio sleeps 1 out of 2 slots. Using a setting of 3 the radio sleeps 2 out of 3 slots, etc. ● When the radio is asleep, it hears nothing from the Master.

This table shows the changes at different **Low Power Mode** settings.

- The actual current draw depends on many factors.
- The table gives only a qualitative indication of supply current savings.
  - A low number reduces latency and a high number reduces current consumption.

> **Important!**: The actual current draw depends on many factors.
> The table provides only a qualitative indication of supply current savings.

Current Draw	Setting	Description
More	0	Low power, disabled.
	1	● LEDs are dimmed. ● Radio remains awake, listening to the Master's transmissions on every slot. ● The 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 can send data to the Master.
	2	LEDs dimmed, radio sleeps every other slot.
	3	LEDs dimmed, radio sleeps 2 of 3 slots.
Less	4-31	LEDs dimmed, radio sleeps the number of slots corresponding to the setting. > **Example**: When using a setting of 31, the radio sleeps 30 of 31 slots.

Notes

- **Low Power Mode** is used only in a Multipoint Slave using serial protocol.
  - 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.

- For **Low Power Mode** to operate properly, the RF Data Rate (on page 45) must be set to `3`.
- To communicate to a TTL or 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.
- 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 the **Low Power Mode**.
- If the radio has the DTR Connect (on page 65) parameter set to `1` or `2` and if the **Low Power Mode** is enabled (set to `1 to 31`), the RTS line on the radio must be asserted for the **DTR Connect** to operate properly.
- Disable or terminate the Diagnostic pins to a cable for the **Sleep** current in **Low Power Mode** to match the specifications.
  - To disable the Diagnostics pins, verify the:
    - On the **Baud Rate** tab, the Setup Port (on page 33) parameter is set to `1 (Main Only)`.
    - On the **MultiPoint Parameters** tab, the Diagnostics (on page 64) parameter is set to `0 (Off)`.

Conserve Power

> (Tip) Use Remote LED to conserve power by turning off the Diagnostic LEDs.

- If the radio has the optional 20-in connector, use **Remote LED** to connect remote LEDs through the Diagnostics port.
- If the radio has the optional connector, use **Remote LED** to connect remote LEDs through the Diagnostics port.
- To realize full power savings in **Low Power Mode** MUST have the serial port deactivated between operation by asserting the RTS line.
  - Conserves power primarily by dimming the radio's LEDs.
  - However, because RS422 / RS485 operation uses the RTS line as part of the data bus, it cannot be asserted to wake-up the radio.

> **FREEWAVE Recommends**: Have all radios set to RS422 or RS485 use a **Low Power Mode** setting of `0 (Off)`.

4.4.4. 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** and **Min Packet Size** parameter settings and the **RF Data Rate** parameter determine the number of bytes in the packets. • Throughput can be enhanced when packet sizes are optimized. • In Point-to-Point mode, the **Max** and **Min Packet Size** settings do not have material impact on throughput unless 115.2 kbps is desired. • However, this may have an impact on latency. **Example**: If small amounts of data are sent and large packet sizes are selected, a certain amount of time wasted between each packet would be seen. • In each over-the-air frame, both the Master and Slave are guaranteed the number of bytes specified in the **Minimum Packet Size** parameter. • In the Master, this is used for maintaining the RF link whether the Gateway has data to transmit or not. • The **Maximum Packet Size** parameter is used to allocate the maximum number of bytes for each Master transmission. • The **Minimum Packet Size** parameter is used to allocate the minimum number of bytes for each Slave transmission. • If the Master does not use all the bytes allocated in the **Maximum Packet Size** setting minus the **Minimum Packet Size** setting, then the remaining bytes are available for the Slave.

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

Minimum Packet Size Definition	
Min Setting	Min Packet Size
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

4.4.5. Network ID

Network ID	
Setting	**Description**
Default Setting	0255
Options	0-4095 (excluding 255)
Setup Terminal Menu	(5) Edit Multipoint Parameters > (6) Network ID
Description	**Network ID** is used to establish Multipoint networks without using the **Call Book**. Set the value between 0 and 4095 (excluding 0255) to enable **Network ID**. **Important!**: The default setting of 0255 enables the **Call Book**. • Since **Network ID** does NOT use serial numbers, Multipoint Masters and Repeaters can be replaced without reprogramming all of the Slaves in the network. • A Slave links with the first Master or Repeater that it hears that has a matching **Network ID**. • Use the **Network ID** function in conjunction with the Subnet ID (on page 70) setting. • Without having the serial numbers in the **Call Book**, a Slave establishes communications with different Masters, though not at the same time. Tip: This is very useful in mobile Multipoint applications.

4.4.6. Remote LED

Remote LED	
Setting	**Description**
Default Setting	(0) Local Only
Options	• **(0) Local Only** - Only the LEDs on the board are enabled. • **(1) Remote and Local** - LEDs on the board and remote LEDs through the diagnostic port are enabled. • **(2) Remote Only** - LEDs on the board are disabled. • Remote LEDs through the Diagnostic port are enabled.
Setup Terminal Menu	(3) Edit Radio Transmission Characteristics > (C) Remote LED

Remote LED	
Setting	**Description**
Description	• If using an enclosed radio, set the **Remote LED** parameter to either `Remote Only` or `Remote and Local`. • If the **Remote LED** parameter is set to `Local Only`, the LEDs are not visible. **Note**: If using a radio with the optional 24-pin connector, use this option to connect remote LEDs through the Diagnostics port.

4.4.7. 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 Timeout** parameter in a Slave or Repeater sets the delay the unit waits before dropping the connection to a Master or Repeater.
	
	● The factory default is set at the maximum of **255**.
	   ● 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 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 **Retry Timeout** parameter is useful when a MultiPoint network has a roving Master or Slave.
	   ● As the link gets weaker, a lower setting allows a poor link to break in search of a stronger one.
	
	FREEWAVE Recommends: Setting the **Retry Timeout** parameter to 20 in the MultiPoint Master 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.
	
	Note: While intended primarily for MultiPoint networks, the **Retry Timeout** parameter may be changed in Point-to-Point networks.
	However, the value in Point-to-Point mode should NOT be set to less than 151.

4.4.8. 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	(5) 12.5 kHz 2 level

RF Data Rate	
Setting	**Description**

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.

Setup Terminal Menu	(3) Edit Transmission Characteristics > (4) RF Data Rate
Description	**Important!**: Do NOT confuse the **RF Data Rate** with the serial port **Baud Rate**. The **RF Data Rate** is the over-the-air data rate between radios in the network. The **LRS455A-C, LRS455A-CE, LRS455-T** radios have two settings for the RF Data Rate (4, 5). • 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. **Note**: Although additional **RF Data Rates** are available, only rates and 5 4 are FCC approved for **LRS455A-C, LRS455A-CE, LRS455-T**.

4.4.9. RTS to CTS

Note: This parameter does not apply to the **LRS455A-C, LRS455A-CE, LRS455-T** radios.

4.4.10. Rx Frequency

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

Rx Frequency	
Setting	**Description**
Default Setting	435
Options	Any frequency between 435 and 470 MHz. **Note**: For more information, see LRS455 Frequency Table (on page 100)
Setup Terminal Menu	(3) Edit Transmission Characteristics > (0) Frequency Key
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 **Rx Frequency** and **Tx Frequency** fields. • By default, the radio is set for single-channel operation. • If the radios are to operate in **Frequency Division Duplex**, the **Rx Frequency** and **Tx Frequency** fields have different frequencies assigned.

See:

- Set the Radio to a Single Channel in a Terminal Emulator (on page 53)
- Set the Radio to Hop Channels (on page 53)
- Edit Frequencies for Multiple Channels (on page 54)

4.4.11. Slave Security

Important!: **Slave Security** has no effect in Point-to-MultiPoint networks where the Network ID (on page 43) 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

Slave Security	
Setting	**Description**

Description	**Slave Security** allows Slave radios to accept transmissions from a Master not included in the **Call Book**.
	
	• The default setting is **0 - Enabled**.
	   • This allows only a Master listed in the Slave's **Call Book** to link to that Slave.
	• Set this parameter to **1** to disable **Slave Security**.
	   • This allows any Master to call the Slave.
	• **Slave Security** has no effect in Point-to-Multipoint networks where the **Network ID** is not set to **255**.
	• **Slave Security must be** set to **1** when the **LRS455A-C, LRS455A-CE, LRS455-T** is operating in:
	   • **Mode 6 Slave/Master Switchable**.
	   • a Point-to-Point network where the Slave needs to accept calls from more than 10 different Masters.
	      • For more information, see **Application Note #5476, Mode 6** (available at support.freewave.com).
	       Registration is required to use this website.
	• When **Slave Security** is set to **1**, the radio accepts calls from any other FreeWave radio.
	   • Additional network security measures can be taken to prevent unauthorized access (e.g., changing default settings for **FreqKey**, **Hop Table**, or **Frequency Zones**).

4.4.12. Transmit Power

Transmit Power	
Setting	**Description**
Default Setting	10
Options	Any number between 0 (zero) and 10
Setup Terminal Menu	(3) Edit Transmission Characteristics > (5) RF Xmit Power

Transmit Power	
Setting	**Description**
Description	The **RF Xmit Power** option sets the RF output transmit power of the **LRS455A-C, LRS455A-CE, LRS455-T.** • The output transmit power can be controlled 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, and they are in close proximity to one another, set the **Transmit Power** parameter to a low number. When deploying 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.

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

4.4.13. 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

Transmit Rate	
Setting	**Description**
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. 💡 If not frequently polling for data or installing new devices, lower the duty cycle (i.e., set this field to 9).

4.4.14. Tx Frequency

> **Important!**: In the Master, this setting must be the same as the Rx Frequency (on page 46) in the Slaves.

Tx Frequency	
Setting	**Description**
Default Setting	435
Options	Any frequency between 435 and 470 MHz. **Note**: See LRS455 Frequency Table (on page 100) for more information.
Setup Terminal Menu	(3) Edit Transmission Characteristics > (0) Frequency Key
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 **Rx Frequency** and **Tx Frequency** fields. • By default, the radio is set for single-channel operation. • If the radios are to operate in **Frequency Division Duplex**, the **Rx Frequency** and **Tx Frequency** fields have different frequencies assigned.

4.5. Set Radio Passwords

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

- If the Setup Port (on page 33) 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 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, the radio must be returned to FreeWave to have the password disabled.

- Set a Password (on page 51)
- Change the Password (on page 52)
- Disable the Password (on page 52)

4.5.1. Set a Password

1. On 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>.

   > **Tip** Press <Enter> to view the password on the line above.

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

4.5.2. 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>.

   > **Tip** Press <Enter> to view the password on the line above.

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

4.5.3. Disable the Password

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

> **Important!**: The password can only be disabled when using the prompt when reading the radio in **Tool Suite** or through a terminal emulator.
> The password **cannot** be disabled using the **Setup Terminal** application in **Tool Suite**.

1. On 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.

   > ⚠ **Caution**: After the fourth entry, the password is disabled.

4.6. Set the Hop Table Size in the Terminal Interface

1. Connect the **LRS455A-C, LRS455A-CE, LRS455-T** to a terminal emulator.
2. Place the radio in **Setup** mode.
3. On the main **Setup** menu, select **(3) Transmission Characteristics > (0) Freq Key**
4. At the **Enter New Frequency Key Prompt**, enter **F** to view more options.
5. At the **Number of Hopping Channels** prompt, enter **2**.
6. At the **Num Channels (1-16)** prompt, enter the number of channels for the hop table and press <Enter>.
7. Press <Esc> to return to the **Radio Parameters** menu.
8. Press <Esc> again to return to the main **Setup** menu.

4.7. Set the Radio to a Single Channel in a Terminal Emulator

1. Connect the **LRS455A-C, LRS455A-CE, LRS455-T** to a terminal emulator.
2. Place the radio in **Setup** mode.
3. On the main **Setup** menu, select **(3) Edit Transmission Characteristics > (0) FreqKey**.
4. At the **Enter New Frequency Key Prompt**, enter **F** to view more options.
   The 16 channels and their transmit and receive frequencies appear.
5. At the prompt, enter **1** for Single Frequency.
6. 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.
7. Press <Esc> to return to the **Radio Parameters** menu.
8. Press <Esc> again to return to the main **Setup** menu.

4.8. Set the Radio to Hop Channels

STOP **Warning!** The regulating body in the country where the **LRS455A-C, LRS455A-CE, LRS455-T** radio is used determines whether the radio can be operated in multichannel mode.

1. Connect the **LRS455A-C, LRS455A-CE, LRS455-T** to a terminal emulator.
2. Place the radio in **Setup** mode.
3. On the main **Setup** menu, select **(3) Edit Transmission Characteristics > (0) FreqKey**.
4. At the **Enter New Frequency Key Prompt**, enter **0**.
5. Press <Esc> to return to the **Radio Parameters** menu.
6. Press <Esc> again to return to the main **Setup** menu.

4.9. Edit Frequencies for Multiple Channels

Warning! The regulating body in the country where the **LRS455A-C, LRS455A-CE, LRS455-T** radio is used determines whether the radio can be operated in multichannel mode.

1. Connect the **LRS455A-C, LRS455A-CE, LRS455-T** to a terminal emulator.

2. Place the radio in **Setup** mode.

3. On the main **Setup** menu, select **(3) Edit Transmission Characteristics > (0) FreqKey**.

4. At the **Enter New Frequency Key Prompt**, enter **F** to view more options.
   The 16 channels and their transmit and receive frequencies appear.

5. At the prompt, enter **0** to edit the hop table.

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

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

8. 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.

9. Press <Esc> to return to the **Radio Parameters** menu.

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

5. Configure Point-to-MultiPoint Networks

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

- Only one Master.
  - All communications are from and to the Master.
- An unlimited number of Slave radios (remote sites).
- An unlimited number of Repeaters between any Slave and the Master.
- Serial Repeaters can be Slave radios and Repeaters at the same time.

This section provides details specifically to a Multipoint network:

- Point to MultiPoint network characteristics.
- Use the Network ID (on page 43) or the **Call Book** to establish which radios in the network can communicate with each other.
- Use Subnet ID (on page 70) to route traffic through the network and back to the Master.
- Settings and recommendations for additional parameters that apply to a MultiPoint network.
- Conserve power in devices in the network.
- Running network diagnostics.

5.1. Point to MultiPoint Network Characteristics

A Point to MultiPoint network has these unique characteristics:

- Golden Settings (on page 56).
- Master to Slave Communications (on page 56).
- Slave to Master Communications (on page 56).

5.1.1. Golden Settings

A Point-to-MultiPoint network requires that the Golden Settings (on page 36) are set the same on **ALL** radios in the network.

> **Note**: If several independent MultiPoint networks are located in close proximity, the planning becomes more critical.
> It is very important to include as much frequency and time diversity as possible using different **Min and Max Packet Size**.
> In some instances the use of the **MultiMaster Sync** option may be required.

- For more information, see **Application Note #5412, Synchronizing Collocated Masters (Multi-Master Sync Mode)** (available at support.freewave.com). Registration is required to use this website.
  - Or Contact FreeWave Technical Support (on page 7).

5.1.2. Master to Slave Communications

Master - to - Slave communications in a MultiPoint network have these characteristics:

- Data packets sent from the Master include a 32-bit CRC.
- The Master repeats its data broadcast between 0 to 9 times, depending on the Master Packet Repeat (on page 66) setting.
- A Slave or Repeater does not send acknowledgments to the Master when it receives data.
  - When any Slave in the network receives the data packet from the Master with the 32-bit CRC, that Slave ignores any additional repeats of the data, and passes the data to its data port.
- Repeaters in the network send data to Slave radios and other Repeaters.

5.1.3. Slave to Master Communications

Slave - to - Master communications in a MultiPoint network have these characteristics:

- Data packets sent from the Slave to the Master include a 32-bit CRC.
- When the Master successfully receives data, it sends an acknowledgment to the Slave and passes the data out its data port.

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

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

2. Connect the radio to a power source.

> **Warning! Do not** connect the **LRS455A-C, LRS455A-CE, LRS455-T** 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.

> **Tip** Use the **Tool Suite Setup Terminal** application if a terminal emulator is not available.

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

5. Set these options:
   a. Data Rate: `19,200`
   b. Data Bits: `8`
   c. Parity: `None`
   d. Stop Bits: `1`
   e. Flow Control: `None`

6. If 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>.
   - The three LEDs on the radio should all turn Solid Green ▪, indicating **Setup** mode.
   - The **Main** menu appears on the screen.

7. Type `0` and press <Enter> to access the **Operation Mode** menu.

8. Type `2` and press <Enter> to set the radio as a Point-to-MultiPoint Master OR
   Type `3` and press <Enter> 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. On the **Main Menu**, type `1` and press <Enter>.

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. On the **Main Menu**, type `3` and press <Enter>.

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

a. Max Packet Size and Min Packet Size (on page 40)
b. RF Data Rate (on page 45)
c. Rx Frequency (on page 46)
d. Tx Frequency (on page 50)

> **Note**: The **Frequency Key** option is located in the **F** submenu after 0 is typed to access the **Frequency Key** menu in **Main Menu 3**.
> Changing these values may help to eliminate interference from other FreeWave networks.

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

16. On the **Main Menu**, type 5 and press <Enter>.

17. In the **Network ID** field, type any value between 1 and 4095 (except **255**).

> **FREEWAVE Recommends**: Set the **Network ID** field to the last three or four digits of the Master radio's serial number if it is below 4095.
> This value must be the same in all radios in the network.

> **Important!**: 255 disables the Network ID (on page 43) and enables the **Call Book**.

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

5.3. Overlapping MultiPoint Networks

Overlapping MultiPoint networks may be set up effectively when several key parameters are set correctly. Overlapping MultiPoint networks are defined as networks using different Master radios, which share or overlap in a specific geographic area. It may also include collocated radios configured into different networks.

> **Note**: For more information, see **Application Note #5412, Synchronizing Collocated Masters (Multi-Master Sync Mode)** (available at support.freewave.com).
> Registration is required to use this website.

Co-located MultiPoint networks require that these parameters be unique for each network:

- Network ID (on page 43) (unless using the **Call Book**)
- Max Packet Size and Min Packet Size (on page 40)

> **Note**: For more information about the installation of Point-to-MultiPoint networks, Contact FreeWave Technical Support on page 7

5.4. Establishing Communication with Other Radios in a MultiPoint Network

- For the radios in the network to communicate successfully, the radio needs to know what other devices are available for them to communicate with. Use the Network ID (on page 43) or the **Call Book**.

> **FREEWAVE Recommends**: 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 a radio needs to be added to or replaced in the network, each radio in the network must be physically reprogrammed and the new serial number entered in the radio's **Call Book**.
> This can be a time consuming process and can cause a delay in getting the network back up and running.
> Because the **Network ID** does not use serial numbers, MultiPoint Master radios and Repeaters may be added or replaced without reprogramming each Slave radio in the network.

- Using the Network ID in MultiPoint Networks (on page 59)
- Using the Call Book in MultiPoint Networks (on page 59)

5.4.1. Using the Network ID in MultiPoint Networks

The Network ID (on page 43) parameter is located on the **MultiPoint Parameters** tab.

In a single network, assign each radio the same **Network ID**. Slave radios link with the first Master or Repeater it hears that has a matching **Network ID**.

When setting the **Network ID**:

- The value can be any value between **1** and **4095**, except **255**.
  - **255** enables the **Call Book**.
- To help ensure the ID is unique to the network, avoid using numbers that coincide with nearby landmarks or highways.

> **Example**: Use the last four digits of the Master serial number if it is below 4095.
> This is ensured to be unique and does not overlap with other nearby FreeWave networks.

- Use the **Network ID** in conjunction with the Subnet ID (on page 70) (if necessary) to route data through the radio network.

5.4.2. Using the Call Book in MultiPoint Networks

Although NOT recommended, the **Call Book** is an option in MultiPoint networks.

If the Network ID (on page 43) parameter is used in a MultiPoint network, no entries are needed in the **Call Book** of any of the radios.

FREEWAVE Recommends: 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 a radio needs to be added to or replaced in the network, each radio in the network must be physically reprogrammed and the new serial number entered in the radio's **Call Book**.

This can be a time consuming process and can cause a delay in getting the network back up and running.

Because the **Network ID** does not use serial numbers, MultiPoint Master radios and Repeaters may be added or replaced without reprogramming each Slave radio in the network.

Important!: Using the **Call Book** in a MultiPoint network can cause delay in resuming communications if a Master is damaged.

Note: For information about setting the Call Book, see Using Call Book in Point-to-Point Networks (on page 79).

In a MultiPoint network, the Slave radios and Repeaters are not listed in the Master radio's **Call Book**. Slave radios must have the Master and any Repeater it is going to use in its **Call Book**.

These examples show the **Call Book** 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	Repeater 2
(0)	000-0000		
(1)	000-0000		

Note: 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	Repeater 2
(0)	900-0001		
(1)	000-0000		

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

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

> At times, the Slave radios need to be forced to go through a specific MultiPoint Repeater. In this scenario, the Slave radio's **Call Book** should contain only the serial number for that Repeater as the entry on line **0**.

5.5. Routing Communication Through the Network

When using the Network ID (on page 43), a Repeater or Slave links to the first Repeater or Master it hears with the same ID.

- Use Subnet ID (on page 70) to determine the path a Repeater or Slave uses to communicate back to the Master.
- **Subnet IDs** are particularly helpful to force:
  - Two Repeaters in the same network to operate in series rather than in parallel.
  - Slave radios to communicate to a specific Repeater for load balancing purposes.

> **Note**: Forcing the communications path optimizes the performance of the network by ensuring the Repeater or Slave links to a Repeater or Master with robust RF communications. **Subnet IDs** can help minimize latency.

- Assigning Subnet ID Values (on page 61)

5.5.1. Assigning Subnet ID Values

Subnet IDs consist of two parts, both available on 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 this device transmits on and 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, F**.
  - This 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 **Transmit Subnet** 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.

This example shows:

- Repeater 1 must talk directly to the Master.
- Repeater 2 must talk directly to Repeater 1.
- Slave 1, 2, and 3 are forced along the direction of the solid lines.
- Slave 4 may link to the first Master or Repeater it hears in the network.
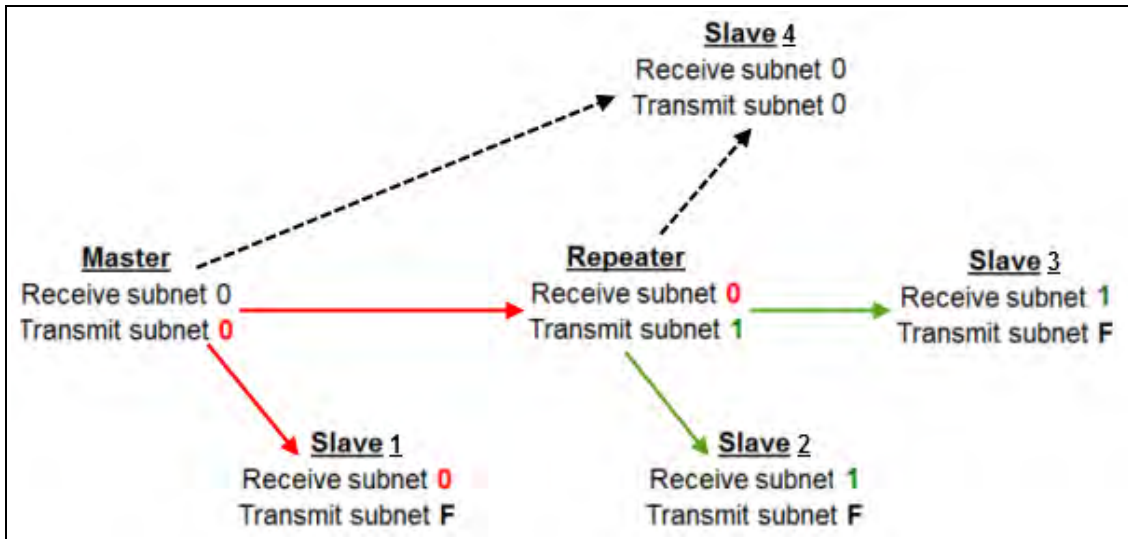
Figure 9: Subnet and Optional Slave Communication

Subnet and Optional Slave Communication			
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 communication through the Master. Transmits on **Subnet ID 1**.
Slave 2	1	F	**Rx Subnet** = 1 forces communication through the Repeater.
Slave 3	1	F	**Rx Subnet** = 1 forces communication through 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 the Slave hears first.

5.6. Setting Other MultiPoint Parameters

The other MultiPoint Parameters options are used to change several different parameters in the radio that determine the characteristics of a MultiPoint network.

- In **Tool Suite**, set these parameters in the **MultiPoint Parameters** tab.
- These settings are available in the **MultiPoint Parameters menu** in the terminal interface.

> **Note**: See the Parameter Preference (on page 8) for a description of the parameter table's content.

5.6.1. 1 PPS Enable Delay

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

1 PPS Enable Delay	
Setting	**Description**
Default Setting	255
Options	0 to 255 **Note**: Pulse-per-second 255 is **Off**.
Setup Terminal Menu	(5) Edit MultiPoint Parameters > (9) 1 PPS Enable/Delay
Description	The **1 PPS Enable/Delay** parameter allows a 1PPS signal to propagate from the Master to all Slave 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. On the Master radio, set the **1 PPS Enable/Delay** parameter to 0.

> **Note**: The Master **must have** a 1 PPS pulse on the DTR pin, otherwise the RF network will not function.

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

Calibrate a Slave Radio in 1PPS Enable / Delay Mode

1. On the Master radio, trigger an oscilloscope on the 1 PPS pulse on the DTR line.
2. Monitor the CD line of the Slave radio.
3. Optional: If the timing on the Slave radio differs from the Master, it may be adjusted via the value in the Slave radio's **1 PPS Enable/Delay** parameter.

Notes

- The difference in time between each incremental integer value is 542.534 nanoseconds (ns).
- Changing the parameter to higher values decreases the Slave radio time delay and changing the parameter to lower values increases the time delay.
- When properly calibrated, the CD line Slave radio outputs a pulse that goes high for about 2 ms in sync with the 1 PPS pulse on the Master radio.
- The output on the Slave radio occurs within 20 microseconds of the input to the Master.

5.6.2. Diagnostics

> **Important!**: The diagnostic program **must** be run from the Master radio.

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	The **Diagnostics** parameter determines how many slots out of 128 are dedicated to diagnostics.

The **Diagnostics** parameter determines how many slots out of 128 are dedicated to diagnostics.

- Setting this parameter allows diagnostics data in the **Network Diagnostics** in **Tool Suite** to be viewed at the Master radio in parallel with application data.
- Diagnostics is **always** secondary to actual transmitted data.

> **Example**: If set to 10, 1 out of every 10 data slots is for diagnostics data. If set to 100, 1 out of every 100 data slots is for diagnostics data.

> **Note**: For more information, see Reading Diagnostics in Tool Suite on page 72.

Diagnostics require:

- 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 **LRS455A-C, LRS455A-CE, LRS455-T** network, set the diagnostics polling rate to 400 ms or higher.

> **Note**: For more information about **Diagnostics**, Contact FreeWave Technical Support (on page 7).

5.6.3. DTR Connect

> **Note**: This parameter does not apply to the **LRS455A-C, LRS455A-CE, LRS455-T** radios.

5.6.4. Local Mode

> **Note**: This parameter does not apply to the **LRS455A-C, LRS455A-CE, LRS455-T** radios.

5.6.5. 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

Description	In a Point-to-MultiPoint network, Slave radios do not acknowledge transmissions from the Master.
	
	• If Slave radios 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 radio has received every packet cannot be met.
	• To address this issue, change 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 (e.g., 1 or 2).
	• If a network has some weak or marginal links it should be set with higher values.
	• If a Slave radio 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 the next Repeater or Slaves the number of times corresponding to its own **Master Packet Repeat** setting.
	
	Notes
	• 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 2 to 3 works well for most well designed networks.
	• The **Master Packet Repeat** parameter 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 radio does not receive, the user software controls the retries as needed.

5.6.6. 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	• The **Max Slave Retry** defines how many times (`0 to 9`) the Slave attempts to retransmit a packet to the Master before beginning to use a back-off algorithm, which is defined by the Retry Odds (on page 68) parameter. • Slave retries stop when an acknowledgment is received from the Master.

5.6.7. Multi-Master Sync

> **Note**: This parameter does not apply to the **LRS455A-C, LRS455A-CE, LRS455-T** radios.

5.6.8. Radio ID

Radio ID	
Setting	**Description**
Default Setting	Blank
Options	0-4095
Setup Terminal Menu	(5) Edit MultiPoint Parameters > (D) Radio ID
Description	Use the Radio ID parameter to designate a radio with an arbitrary, user-defined number that identifies the radio in **Diagnostics** mode.

5.6.9. Repeaters

> **Important!**: This parameter is **only** set on the MultiPoint Master.
> The setting has no effect if set in a MultiPoint Slave.
> When this parameter is enabled, network throughput is reduced to 50%.

Repeaters	
Setting	**Description**
Default Setting	(1) Enabled

Repeaters	
Setting	**Description**
Options	• **(0) Disabled** - There is **no 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.

5.6.10. Repeater Frequency

Note: This parameter does not apply to the **LRS455A-C, LRS455A-CE, LRS455-T** radios.

5.6.11. Retry Odds

Retry Odds	
Setting	**Description**
Default Setting	0
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 Slave radios in a MultiPoint network are not acknowledged, packets transmitted from Slaves to the Master are acknowledged.
	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 in the network.
	This is addressed through the Max Slave Retry (on page 67) 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.
	Example: Use two different Slave radios 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 weak or poor link, set the **Retry Odds** parameter to 0 as it may become a chatty Slave and lockup the network, causing a loss of communication.
	• When the **Retry Odds** parameter 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.
	FREEWAVE Recommends: A **Retry Odds** parameter set to 0 is recommended for most networks.

5.6.12. Slave / Repeater

Slave / Repeater	
Setting	**Description**
Default Setting	(0) Disabled
Options	(0) Disabled (1) Enabled
Setup Terminal Menu	(5) MultiPoint Parameters > (A) Slave/Repeater

Slave / Repeater	
Setting	**Description**
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. This allows one radio at one site. • Thus, where one Repeater and one Slave may be required in another vendor's network, FreeWave networks require only one radio. **Note**: To operate a radio as a MultiPoint **Slave/Repeater**, use the **Multipoint Parameters** menu and set the operation mode to `Multipoint Repeater (7)` and `Slave/Repeater (1)`.

5.6.13. Subnet ID

In a Multipoint network, a Slave or Repeater connects with the first Repeater or Master it hears with the same Network ID (on page 43).

Note: **Subnet ID** only works in Multipoint networks using the **Network ID** option.

Subnet ID is particularly helpful to force two Repeaters in the same network to operate in series rather than in parallel or to force Slaves to communicate to a specific Repeater for load balancing purposes. Two components exist with regard to the **Subnet ID**:

• **Rx Subnet ID** - This setting identifies the radio a Repeater or Slave listens to.
• **Xmit Subnet ID** - This setting identifies the ID the device transmits on and the devices listening to it. The **Xmit Subnet ID** parameter is relevant for Multipoint masters and repeaters only.

The default (disable) setting for both **Rx** and **Xmit** is **F**.

Important!: Changing these settings on the Master is NOT recommended under normal circumstances.

In some Multipoint networks, the **Frequency Key** is at the same setting for all radios. In other networks, where parallel Repeaters are used, the **Frequency Key** value needs to change.

• If both **Rx Subnet ID** and **Xmit Subnet ID** are set to 0 (zero), the **Subnet ID** shows **Roaming** in the menu.
  • This setting allows a mobile slave to roam from subnet to subnet and possibly from network to network.

Figure 10 shows a network where **Subnet IDs** are used to force communications. In this example:

• Repeater 1 must talk directly to the Master.
• Repeater 2 must talk directly to Repeater 1.

- Slaves 1, 2, and 3 are forced along the direction of the solid lines.
- Slave 4 links to the first Master or Repeater it hears.
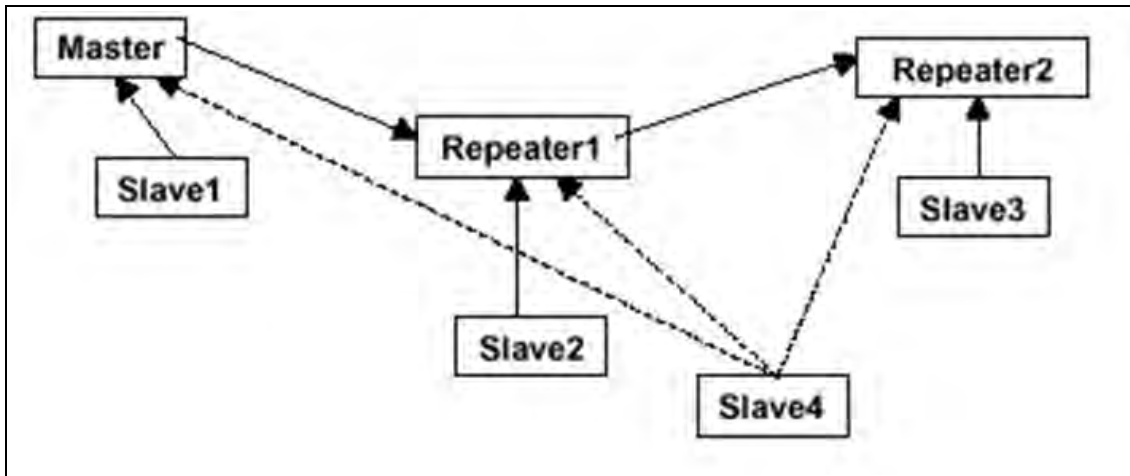
Figure 10: Subnet IDs Forcing Communication

Subnet ID Settings			
Radio	**Rx Subnet ID**	**Xmit Subnet ID**	**Other Information**
Master	F	F	The Master uses 0,0.
Master	0	0	• The **Xmit Subnet ID** value may be set in the Master. • The default settings (**F,F**) actually use **0,0**. • The **Rx Subnet** on the Master has no effect on the network.
Repeater1	0	1	**Rx Subnet** = 0 forces communication through the Master.
Repeater2	1	2	• **Rx Subnet** = 1 forces communication through Repeater 1. • Repeater 1 transmits on SubnetID 1.
Slave1	0	0 or F	**Rx Subnet** = 0 forces communication through the Master.
Slave2	1	0 or F	**Rx Subnet** = 1 forces communication through Repeater 1.
Slave3	2	0 or F	**Rx Subnet** = 2 forces communication through Repeater 2.
Slave4	0	0	The 0,0 setting allows the Slave to link with the first Master or Repeater it hears with the correct **Network ID**.

5.7. 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 the network in real time.

> **Important!**: The **Network Diagnostics** application is NOT meant to replicate the functionality of a Network Management System.
> It is a tool intended for occasional network monitoring or troubleshooting in the field, not for continuous, long-term collection of diagnostic data.

This topic provides basic steps for reading diagnostics using **Tool Suite**. **Tool Suite** stores the diagnostic data in the database for import from or export to a diagnostic file.

> **Note**: For information about the available data, recommended best practices, and importing and exporting files using the **Network Diagnostics** application, see the **Tool Suite** User Manual.

> **Tip**: To help identify the radios in the network when running **Network Diagnostics**, set the **Radio Name** and **Radio ID** settings on the **MultiPoint Parameters** tab.

> **Important!**: Network Diagnostics **must** be run from the Master radio.

Diagnostics require:

- 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 user-supplied diagnostics cable (available from FreeWave).
- **Tool Suite** - Available from support.freewave.com.
  - Registration is required to use this website.

> **Note**: For more diagnostics information, Contact FreeWave Technical Support (on page 7).

Procedure

1. Connect the Master to the computer running **Tool Suite**.

2. Open **Tool Suite**.

3. On the **Applications** tab, click **Network Diagnostics**.

4. In the **Networks** section of the ribbon, use the list box to select the serial network to run diagnostics on.

> **Note**: If there is no network defined, click **Add** and follow the instructions in the wizard.

5. On the ribbon, click **Start**.

6. To stop running diagnostics, click **Stop**.

> **Note**: The **Network Diagnostics** application continues to poll for diagnostic data until it is stopped.

> **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.

6. Configure
Point-to-Point Networks

Point-to-Point networks are the most basic type of network and do not require much more than the setup described in the Basic Radio Programming and Setup (on page 26) section.

This section includes:

- Point-to-Point Network Quick Start (Terminal Interface) (on page 77)
- Point-to-Point Network Quick Start (Tool Suite) (on page 75)
- Using Call Book in Point-to-Point Networks (on page 79)

6.1. 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 via the diagnostics cable.

2. Connect the radio to a power source.

> **Warning!** **Do not** connect the **LRS455A-C, LRS455A-CE, LRS455-T** 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.

4. Click the **Configuration** application.

5. Verify the correct port is selected in the **Com Port** field in the **Configuration** ribbon.

6. On the **Configuration** ribbon, in the **Networks** section, select the network the radio resides in or click **Add Network** to create a new network in **Tool Suite**.

7. Click **Read Radio** on 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, a prompt appears to press the radio's **Setup** button to enter **Setup** mode.
   - When in **Setup** mode, all three LEDs on the radio display Solid Green ▪.

8. Click the **Operation Mode** tab.

9. In the **Modem Mode** field, select to set the radio to Point-to-Point mode.

> **Example**: Set one radio as a Point-to-Point Master (Mode 0) and the other as a Point-to-Point Slave (Mode 1).

> **Note**: A Point-to-Point network can have only one Master.
> For more information about modem modes, see Define the Network Type and the Radio's Role in that Network (on page 27).

10. Click the **Baud Rate** tab.

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

12. Click the **Transmission Characteristics** tab.

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

    - Max Packet Size and Min Packet Size (on page 40)
    - RF Data Rate (on page 45)
    - Rx Frequency (on page 46)
    - Tx Frequency (on page 50)

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

14. Click the **Call Book** tab.
15. Enter the Slave serial number in the Master's **Call Book**.
16. Enter the Master's Serial number in the Slave's **Call Book**, or disable the **Slave Security** parameter in the Slave.

> **Note**: For more information about setting up the **Call Book** see Using Call Book in Point-to-Point Networks (on page 79).

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

17. Using the Point-to-Point Operation LEDs (on page 107), verify that the radios are operating as expected.
18. On the **Configuration** application in the **Network Title** ribbon:
    - Click **All** to send all the settings for all parameters.
    - Click **Quick** to send only the changed parameters.

    > **Note**: **Quick** is only available if **Read Radio** is selected and parameter settings are NOT sent from a template to the radio.

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

When purchased as a pair, the FreeWave radios are shipped from the factory pre-configured with most of the settings to operate in Point-to-Point applications.

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

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

2. Connect the radio to a power source.

> **Warning!** **Do not** connect the **LRS455A-C, LRS455A-CE, LRS455-T** 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.

> **Note**: Use the **Setup Terminal** application in **Tool Suite** if a terminal emulator is unavailable.

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

5. Set these parameters to:
   a. Data Rate = `19,200`
   b. Data Bits = `8`
   c. Parity = `none`
   d. Stop bits = `1`
   e. Flow Control = `none`

6. Press the **Setup** button on the radio.
   If using the diagnostics cable, press <Shift+U>.
   - When in **Setup** mode, all three LEDs on the radio show Solid Green ●.
   - The **Main Menu** appears in the window.

7. Type `0` and press <Enter> to access the **Operation Mode** menu.

8. Type `0` and press <Enter> to set the radio as a Point-to-Point Master or
   Type `1` and press <Enter> to set the radio as Point-to-Point Slave.

> **Note**: For more information about modem modes, see Define the Network Type and the Radio's Role in that Network (on page 27).

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

10. On the **Main Menu**, type `1` and press <Enter>.

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. On the **Main Menu**, type `2` and press <Enter> 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 the Slave Security (on page 47) parameter in the Slave.

> **Note**: For more information about setting up the **Call Book** see Using in Point-to-Point Networks.

16. On the **Main Menu**, type 3 and press <Enter>.

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

    a. Max Packet Size and Min Packet Size (on page 40)

    b. RF Data Rate (on page 45)

    c. Rx Frequency (on page 46)

    d. Tx Frequency (on page 50)

> **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.

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

18. Press <Esc> to return to the **Main** menu.

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

19. Using the Point-to-Point Operation LEDs (on page 107), verify that the radios are operating as expected.

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

6.3. Using Call Book in Point-to-Point Networks

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

> **Important!**: The Call Book is required in Point-to-Point networks.

> **FREEWAVE Recommends**: 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 a radio needs to be added to or replaced in the network, each radio in the network must be physically reprogrammed and the new serial number entered in the radio's Call Book.
> This can be a time consuming process and can cause a delay in getting the network back up and running.
> Because the **Network ID** does not use serial numbers, MultiPoint Master radios and Repeaters may be added or replaced without reprogramming each Slave radio in the network.

- The Call Book allows a maximum of 10 FreeWave radios.
  - Designate 1 to 4 Repeaters to use with each radio.
  - Designate which Slave the Master calls.

These settings are required for two FreeWave radios to communicate in Point-to-Point mode:

1. The Master radio serial number must be listed in the Slave radio's Call Book or **Slave Security** is turned off in the Slave.
2. The Slave serial number must be listed in the Master Call Book .
3. The Master must be programmed to call the Slave (**Entry to Call** option).
   a. Select the number in the **Entry to Call** field, select **All** to direct the Master to call all Slave radios.

> **Note**: To set the **Entry to Call** option in the terminal interface, press <C> at the Call Book menu, followed by the menu number corresponding to that Slave.
> To call any available Slave in the list, press <C> then press <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 Slave radios 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, define only the Repeaters in the Master's Call Book.
> The Slave's Call Book only requires the Master serial number.
> A Repeater need not have anything listed in its Call Book.

6.3.1. Set the Call Book in Tool Suite

1. In the **Tool Suite Configuration** application, select the device to program.

2. Click the **(2) Call Book** tab.

3. In the **Number** column in **Row 0**, enter the seven-digit serial number of the radio being called.

4. In the **Repeater 1** column, enter the first Repeater's seven-digit number.
   If no Repeaters are being used, leave the column empty.

5. In the **Repeater 2** column, enter the second Repeater's 7-digit number.
   If only one Repeater is being used, leave the column empty.

6. If Repeaters are used, select the appropriate **Entry to Call** option in the Master **Call Book**.

7. To apply the changes, click either the **Quick** or **All** icon.
   Tool Suite applies the changes to the radio.

6.3.2. Set the Call Book in the Terminal Interface

1. On the **Setup** menu, click **C (2) Edit all Book**.
   The **Modem Call Book** window opens.
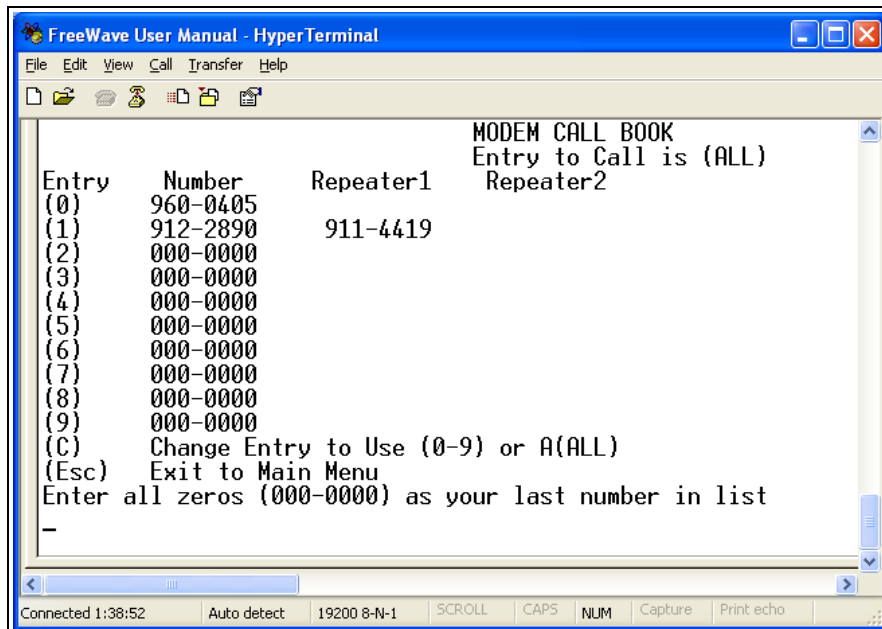
Figure 11: Modem Call Book window

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

3. In the **Enter New Number prompt**, enter the seven-digit serial number of the radio being called.
   The system prompts for the first Repeater's serial number.

4. If no Repeaters are being used, press <Esc> and continue.
   Otherwise, enter the 7-digit serial number of the Repeater.
   The system prompts for the second Repeater's serial number.
   The **LRS455A-C, LRS455A-CE, LRS455-T** network supports only one
   Repeater.

5. Press <Esc> to continue without entering a second Repeater.
   The system refreshes the radio's **Call Book** menu with the new changes.

6. Repeat steps 2 to 5 for additional radios in the network.

7. Press <Esc> to return to the **Main** menu.

7. View Radio Statistics

When a radio is read, the system shows data transmission statistics the radio has gathered during the most recent session. This information is valuable 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.

> **Note**: More data transmission characteristics are available in the **Network Diagnostics** application. For information about running network diagnostics, see the **Tool Suite** User Manual.

- View Statistics in Tool Suite (on page 83)
- View the Radio Transmission Characteristics in the Terminal Interface (on page 83)
- Antenna Fwd (on page 83)
- Antenna Reflected Power (on page 83)
- Antenna Rev (on page 83)
- Master-Slave Distance (on page 84)
- Noise Level (on page 84)
- Number of Disconnects (on page 84)
- Radio Temperature (on page 85)
- Rate % (on page 85)
- Signal Level (on page 85)

7.1. View Statistics in Tool Suite

> 💡 **Tip** View the same statistics using the **Setup Terminal** option in Tool Suite.

1. In Tool Suite, click **Configuration > Read Radio**.
2. Click the **Device Information** tab.

7.2. View the Radio Transmission Characteristics in the Terminal Interface

On the **Setup** main menu, click **(4) Show Radio Statistics**.

7.3. Antenna Fwd

> **Note**: This statistic is available only in the terminal interface.

- **Antenna Fwd** 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.

7.4. Antenna Reflected Power

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

7.5. Antenna Rev

> **Note**: This statistic is available only in the terminal interface.

Antenna Rev 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.
    - 30 or higher indicates a definite problem in the system.
        - The most likely cause is a cable issue between the radio and the antenna.

7.6. Master-Slave Distance

This is the physical distance between the Slave radio and the Master radio in the network.

> **Note**: This distance is most accurate at a distance greater than 2.5 miles (4.0234 km).

7.7. Noise Level

The **Noise Level** indicates the level of background noise and interference at this radio and at each of the Repeaters in the link.

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 viewing statistics in the terminal interface, press <Enter> when the **Radio Statistics** menu appears.
> See LRS455 Frequency Table (on page 100).

- Ideally, noise levels should be below -112 dBm.
- The difference between the average signal level and average noise level should be 26 or more.
- Margins significantly higher than this are an indication of a high level of interference that may degrade the performance of the link.

> Use band pass filters, adjust the antenna placement, or use antenna polarization to mitigate high noise levels.

7.8. Number of Disconnects

The value in the **Number of Disconnects** statistic indicates the total number of times the link between the Master and the Slave has been lost and the radios lose **Carrier Detect** 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 (zero).
- One or more disconnects may indicate:
  - a weak link,
  - the presence of severe interference problems, or
  - loss of power to any of the radios in the link.

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

7.9. Radio Temperature

The **Radio Temperature** value is the current operating temperature of the radio in degrees Celsius.

> **FREEWAVE Recommends**: For proper operation, a FreeWave radio must be in the temperature range of -30° to +60° C.

7.10. Rate %

The **Rate %** measures the percentage of data packets that were successfully transmitted from the Master and received by the upstream radio on the first attempt.

> **Important!**: The rate percentage represents only what the upstream radio received.

- A number of 75 or higher indicates a robust link that provides very good performance even at high data transmission rates.
- A number of 15 or lower indicates a weak or marginal link that provides lower data throughput.

> **Note**: Many settings can impact actual throughput, including **Master Packet Repeat** and **Max Slave Retry**.
> If the link is asymmetrical, the percentage reported in this statistic can be very high, and the uplink can still be poor.

7.11. Signal Level

The **Signal Level** indicates the level of received signal at the radio and at each of the Repeaters in the link.

- The source of the signal is the radio that transmits to the radio reading this statistic.
- The number is an average of the received signal levels measured at each frequency in the radio's frequency hop 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, better antenna placement and / or additional Repeaters.

> The individual measurement values at each frequency hop channel are shown in the frequency table.
> If viewing statistics in the terminal interface, press <Enter> when the **Radio Statistics** menu appears.
> See LRS455 Frequency Table (on page 100).

8. Release Notes

These sections describe the additions, changes, and known limitations in each software version for the LRS455 Wireless Data Radio. The most recent version is listed first.

> 💡 **Tip** The latest firmware and software versions and the most recent list of known limitations and workarounds are available on support.freewave.com.

8.1. Version 1.79

Release Date: July 2018

Additions and Changes

- Fixed TX waveform for 2GFSK mode to have more margin with the mask.
- Fixed TX waveform for 4GFSK mode to have more margin with the mask.
- Adjusted 4GFSK RX thresholds with new waveform to improve sensitivity.

Known Limitations and Workarounds

- 4GFSK (data rate setting of 4) data rate **is not OTA backwards compatible** with all prior firmware versions.
  - 2GFSK (data rate setting of 5) data rate **is backwards** compatible with prior firmware versions.
- OTA does not pass through Repeaters nor does it update the Repeater.
  - In networks with a Repeater, for an OTA upgrade, the Endpoints should be updated from the Repeater and then the remaining network from there.
  - Repeater and Gateways should be updated locally when updating Endpoints OTA.

- Upgrade methods **not** available: Tool Suite or Data port.
  - Users **must use** the **.exe** and the Diagnostic port for upgrades.

8.2. Version 1.77

Release Date: January 2015

Additions and Changes

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

Known Limitations and Workarounds

- No known additional limitations.

8.3. 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.
    No hardware or other functionality changes is 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.
- The Tx remote LED output is currently unavailable.
- Over the air firmware updates via the data port are NOT recommended at this time.
- Network diagnostics data is not reliably reported at polling intervals shorter than 400 ms.

> **FREEWAVE Recommends**: Use polling intervals of 400 ms or longer.

- Local Diagnostics in **Tool Suite** is NOT supported.
- Radios can potentially stop responding to the Ctrl+Break command to enter Startup mode.
- In some cases, a Slave does not re-link to the Master immediately if the Master is momentarily powered off.
- Automatic Frequency Adjustment can cause a delay in modems linking.

8.4. Version 1.72

Release Date: November 2011

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.

8.5. Version 1.71

Release Date: May 2011

Additions and Changes

- Fixes to support VCO Range testing.

8.6. 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

8.7. Version 1.69d9

Release Date: October 2010

Additions and Changes

- Transmitter response fixed.

8.8. 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.

9. 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

9.1. 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 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.

9.1.1. RS422 and RS485 Full Duplex Pinouts

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

9.1.2. RS485 Half Duplex Pinout

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

9.2. Attenuator for Testing

Attenuation for Testing

DIRECT CONNECTION
OR
SPLITTER BOX

5 WATT / 50 dB
ATTENUATOR

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.
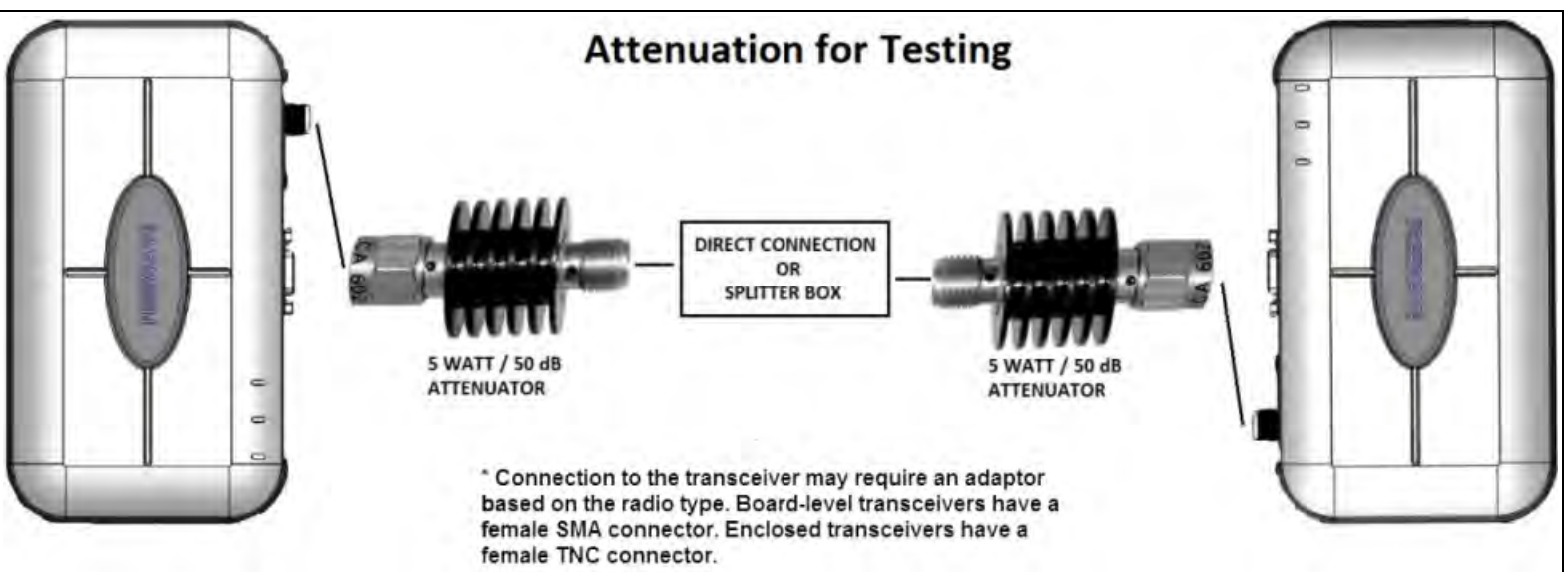
Appendix A: Technical Specifications

> **Note**: Specifications are subject to change without notice. For the most up-to-date specifications information, see the product's data sheet available at www.freewave.com.

Data Transmission

Data Transmission	
Specification	**Description**
Modulation	• 2 level GFSK • 4 level GFSK
Link Throughput	• 8.3125 kbps, standard speed • 16.875 kbps, high speed
Error Detection	32-bit CRC, retransmit on error
Hopping Channels	5,601 channels @ 6.25 kHz

Protocol	• Board Level Unit:
	  • RS232 / RS485 / RS422 (-C)
	  • TTL (-T)
	• Enclosed Unit: RS232 / RS422 / RS485

General Information

General Information	
Specification	**Description**
Operating Temperature	• -30°C to +60°C • -22°F to +140°F
Humidity	0 to 95% non-condensing

Dimensions	• Board Level Unit
	  • 137.29 L x 61.85 W x 21.49 H (mm)
	  • 5.40 L x 2.44 W x 0.85 (in.)
	• Enclosed Unit
	  • 172.71 L x 111.43 W x 34.19 H (mm)
	  • 6.80 L x 4.39 W x 1.35 H (in.)

Weight	• Board Level Unit: 74.4g (0.16 lbs.) • Enclosed Unit: 605g (1.33 lbs.)

Interfaces

Interfaces	
Specification	**Description**
Data Interface	Serial, 1200 bps to 230.4 kbps

Interfaces	
Specification	**Description**
Data Connectors	- Board Level Unit: 10-pin header with locking ramp 0.1 inch spacing, power / data connector - Enclosed Unit: DB9 female, DCE
Diagnostics Interface	Serial, RS232, or TTL
RF Connector	- Board Level Unit: SMA Female - Enclosed Unit: TNC Female

Power Requirements

Power Requirements				
Specification	**Description**			
Operating Voltage	+6 to +27 VDC			
Current Consumption	**Voltage**	**Transmit Current**	**Receive Current**	**Idle Current**
	+6 VDC	1.5 A	200 mA	76 mA
	+12 VDC	750 mA	100 mA	44 mA
	+27 VDC	340 mA	53 mA	24 mA

Receiver

Receiver	
Specification	**Description**
System Gain	145 dB at 9,600 bps 133 dB at 19,200 bps
Sensitivity	2 level GFSK: -112 dBm, standard speed, BER 10^{-4} 4 level GFSK: -100 dBm, high speed, BER 10^{-4}

Transmitter

Transmitter	
Specification	**Description**
Frequency Range	435 to 470 MHz
Output Power	- Up to 2 W - user selectable

Transmitter	
Specification	**Description**
Range	113 km (70 miles), clear line of sight
Channel Spacing	12.5 kHz
RF Data Rate	• 9,600 bps, standard speed • 19,200 bps, high speed

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 - DB9

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: LRS455 Frequency Table

The **LRS455A-C, LRS455A-CE, LRS455-T** 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.

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

LRS455 Frequency List							
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

LRS455 Frequency List							
Channel#	Frequency		Channel#	Frequency		Channel#	Frequency
220	436.375		2280	449.250		4340	462.125
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

LRS455 Frequency List					
Channel#	Frequency	Channel#	Frequency	Channel#	Frequency
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
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

LRS455 Frequency List							
Channel#	Frequency		Channel#	Frequency		Channel#	Frequency
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			
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 **LRS455A-C, LRS455A-CE, LRS455-T** 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: 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 Black	Solid Red (Bright)	Off Solid Black	Blinking Red	Solid Red (Bright)	Off Solid Black	Blinking Red
Repeater and Slave linked to Master. No data.	Solid Red (Bright)	Solid Red (Dim)	Off Solid Black	Solid Green	Off Solid Black	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 Black	Solid Green	Off Solid Black	Solid Red (Bright)	Solid Green	Solid Red (Dim)	Solid Red (Bright)
Repeater and Slave linked to Master. Slave sending data to Master.	RCV data - Solid Green or Solid Red (Bright)	Solid Red (Dim)	Intermittent Red Flash	Solid Green	Intermittent Red Flash	Solid Red (Bright)	Solid Green	Solid Red (Bright)	Solid Red (Bright)
Master with diagnostics program running.	Solid Red (Bright)	Solid Red (Dim)	Intermittent Red Flash	Solid Green	Intermittent Red Flash	Solid Red (Bright)	Solid Green	Solid Red (Bright)	Solid Red (Bright)

Note: *In an idle condition, the CTS LED is Solid Red (Bright) with a solid link.
As the link weakens, the CTS LED on the Repeater and Slave begins Blinking Red .

Appendix G: 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 Solid Black	Blinking Red	Solid Red (Bright)	Off Solid Black	Blinking Red
Linked. No Repeater Sending sparse data	Solid Green	Intermittent Red Flash	Intermittent Red Flash	Solid Green	Intermittent Red Flash	Intermittent Red Flash	N/A	N/A	N/A
Master calling Slave through Repeater	Solid Red (Bright)	Solid Red (Dim)	Solid Red (Bright)	Solid Red (Bright)	Off Solid Black	Blinking Red	Solid Red (Bright)	Off Solid Black	Blinking Red
Master linked to Repeater, not to Slave	Blinking Orange	Solid Red (Dim)	Solid Red (Bright)	Solid Red (Bright)	Off Solid Black	Blinking Red	Solid Red (Bright)	Solid Red (Dim)	Solid Red (Bright)
Repeater linked to Slave	Solid Green	Intermittent Red Flash	Intermittent Red Flash	Solid Green	Intermittent Red Flash	Intermittent Red Flash	Solid Green	Intermittent Red Flash	Intermittent Red Flash
Mode 6 Waiting for ATD command	Solid Red (Bright)	Off Solid Black	Blinking Red	Solid Red (Bright)	Off Solid Black	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

Appendix H: Continuous Transmit Operating Instructions

In order to test a host OEM product with the LRS455A module installed, the host product will need to be tested for complete product compliance. This sections describes how to enable the LRS455A for continuous transmit mode in order to test the host product.

Hardware Setup:

Utilizing the same HW power up procedures defined in the Section 3, make sure the Serial communication is set at:

a.   Appropriate com port (COM1, for example)
b.   19200 baud
c.   8 bit
d.   Parity: none
e.   Stop: 1-bit
f.   Flow Control: none

Pushing the reset button at any time will put the radio in idle mode (3 green LEDs) and will bring up the Main Menu on the screen:

(0)   Set Operation Mode
(1)   Set Baud Rate
(2)   Edit Call Book
(3)   Edit Radio Transmission Characteristics
(4)   Show Radio Statistics
(5)   Edit MultiPoint Parameters
(6)   TDMA Menu
(8)   Chg Password
(Esc) Exit Setup
Enter Choice`

Radio Setup: (The DUT was shipped configured in Receive mode, on the mid channel, in 2-GSFK mode.)

To set Transmit Channel:

To create channel at 435 MHz channel (channel 0):
From Main Menu, press 3, 0, F, 0, 0, Enter, 0000, Enter, 0000, Enter, Esc, Esc.
To select channel 0 (435 MHz):
From Main Menu, press 3, 0, F, 1, 0, Enter, Esc, Esc.

To create channel at 450 MHz channel (channel 7):
From Main Menu, press 3, 0, F, 0, 7, Enter, 2400, Enter, 2400, Enter, Esc, Esc.
To select channel 7 (450 MHz):
From Main Menu, press 3, 0, F, 1, 7, Enter, Esc, Esc.

To create channel at 460 MHz channel (channel 9):
From Main Menu, press 3, 0, F, 0, 9, Enter, 4000, Enter, 4000, Enter, Esc, Esc.
To select channel 9 (460 MHz):
From Main Menu, press 3, 0, F, 1, 9, Enter, Esc, Esc.

To create channel at 470 MHz channel (channel 15):
From Main Menu, press 3, 0, F, 0, 15, Enter, 5600, Enter, 5600, Enter, Esc, Esc.
To select channel 15 (470 MHz):
From Main Menu, press 3, 0, F, 1, 15, Enter, Esc, Esc.

To Set 2-GFSK Mode:
From Main Menu, Press 3, press 4, press 5, press Esc.

To Set 4-GFSK Mode:
From Main Menu, Press 3, press 4, press 4, press Esc.

To set radio to Continuous Transmit Mode modulated :
From Main Menu, press 5, C, 0, 0, esc
press 4, press T (uppercase).
Push Reset button to stop.

To set radio to Continuous Transmit Mode unmodulated :
From Main Menu, press 5, C, 1, 0, esc
press 4, press T (uppercase).
Push Reset button to stop.

Appendix I: FreeWave Legal Information

Export Notification

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.

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FreeWave products are designed and manufactured in the United States of America.

DO NOT OPEN THE LRS455A Wireless Data Radio WHEN AN EXPLOSIVE ATMOSPHERE IS PRESENT.

GNU License Notification

Some of the software in the firmware is licensed under the GNU General Public License and other Open Source and Free Software licenses. Contact FreeWave to obtain the corresponding source on CD.

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 document covers FreeWave Technologies, Inc. models sold under FCC ID: KNYLRS455A.

All models sold under the listed FCC ID(s) 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.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

The modular transmitter is only FCC authorized for the specific rule parts (i.e., FCC transmitter rules) listed on the grant, and that the host product manufacturer is responsible for compliance to any other FCC rules that apply to the host not covered by the modular transmitter grant of certification

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 FCC ID: KNYLRS455A.**"

FCC Radiation Exposure Statement

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance 95 cm between the radiator and your body.

FCC Notification of Power Warning

The LRS455A Wireless Data Radio covered in this document has a maximum transmitted output power of 2 W.

The antennas used MUST provide a separation distance of at least 95 cm from all persons and MUST NOT be co-located or operate in conjunction with any other antenna or transmitter.

ISEDC Notifications

This device complies with Industry Canada license-exempt 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 content of this documentation covers FreeWave Technologies, Inc. models sold under IC: 2329B-LRS455A.

ISEDC Host Installation and Label

When any FreeWave Technologies, Inc. module is placed inside a Host, a label must be placed on the outside of the Host. The label must include the text "**Contains IC**: 2329B-LRS455A.

IC Radiation Exposure Statement

This system has been evaluated for RF Exposure per RSS-102 and is in compliance with the limits specified by Health Canada Safety Code 6. The system must be installed at a minimum separation distance from the antenna to a general bystander of 37.4 inches (95 cm) to maintain compliance with the General Population limits.

L'exposition aux radiofréquences de ce système a été évaluée selon la norme RSS-102 et est jugée conforme aux limites établies par le Code de sécurité 6 de Santé Canada. Le système doit être installé à une distance minimale de 37.4 pouces (95 cm) séparant l'antenne d'une personne présente en conformité avec les limites permises d'exposition du grand public.

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

Models LRS455A-C-U, LRS455A-CE-U, LRS455A-T-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.

Type	Maximum Gain (dBi)	Impedance (Ohms)
Yagi	9.25dBi	50
Omni	5.15dBi	50

UL Notifications / Warnings - Class I, Division 2

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

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

UL Power Source

Input voltage for the listed models is +6.0 to +27.0 VDC.

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

FREEWAVE