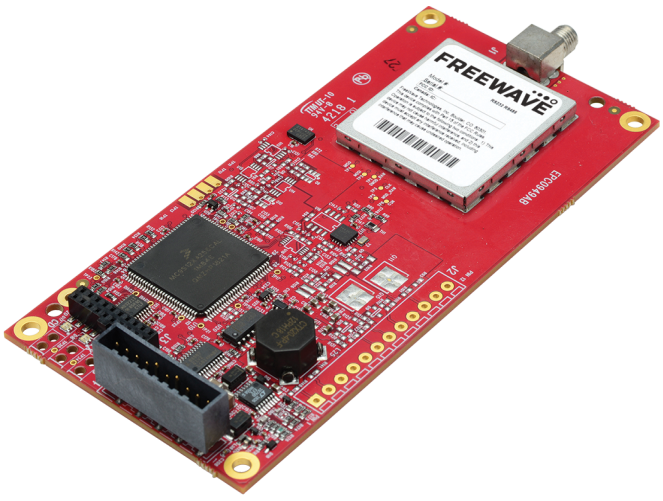
FGR3 Wireless Data Radios

FGR3-C-U

FGR3-CE-U

Covering Firmware v11.0.08

User-Reference Manual



Part Number: LUM0110AA
Revision: May-2019

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® FGR3 Wireless Data Radios (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.

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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.

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

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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

This User Manual covers settings and configurations that apply to FreeWave spread spectrum radios.

Some radio models have specific settings and configurations that apply to only that model. For information about a specific model or additional information about using the radios, see these Addendums and Application Notes:

- **Addendums**
  - Cathodic Protection User Manual Addendum (FreeWave Part Number: LAD0014AA)
  - FGR Radio Modem in Mirrored Bit Mode User Manual Addendum (FreeWave Part Number: LAD0006AB)
- **Application Notes**
  - Application Note : #5437: DTR to CTS Line Alarm Feature
  - Application Note #5457: Local Mode
  - Application Note #5476: Mode 6
    - Mode 6 is designed to give control of which Slave a Master links to in a Point-to-Point configuration.

Note: Use the http://support.freewave.com/ website to download the latest documentation for the FGR3-C-U or FGR3-CE-U.
Registration is required to use this website.

Document Styles

This document uses these styles:

- Parameter setting text appears as: **[Page=radioSettings]**
- File names appear as: **configuration.cfg**.
- File paths appear as: **C:\Program Files (x86)\FreeWave Technologies**.
- User-entered text appears as: **xxxxxxxxx**.

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.
Setup Terminal Menu:	The menu path and field name to access the parameter using the terminal menus available through the serial port.
Description:	A description of what the parameter is and how it applies to the radio in the network.

1. Introduction

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

- If the FreeWave radios are used in an application where a null modem cable is used, (e.g.,communications between two computers) 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 and the Data Communication Equipment (DCE) instrument it is connected to.

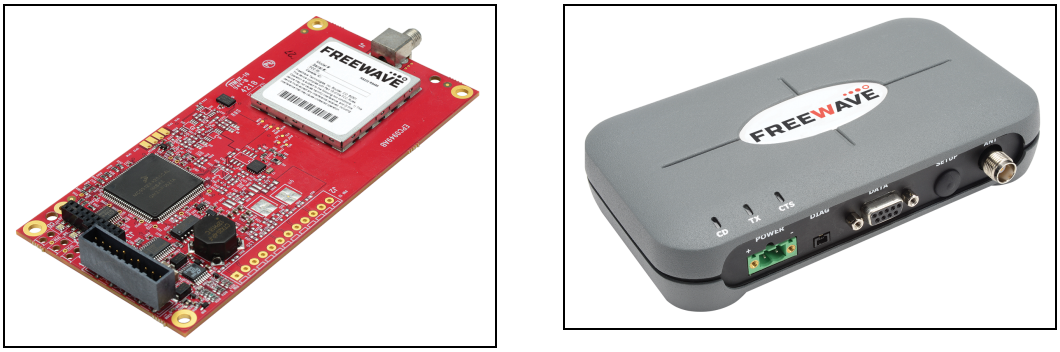


Figure 1: FGR3-C-U or FGR3-CE-U Wireless Data Radios

1.1. Choose a Radio Location

Placement of the FreeWave radio may have a significant impact on its performance. The key to the overall robustness of the radio link is the height of the antenna.

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. In general, FreeWave units with a higher antenna placement will have a better communication link.

Note: FreeWave offers directional and Omni-directional antennas with cable lengths ranging from 3 to 200 feet.

An adjustment as little as 2 feet in antenna placement may resolve noise issues.
In extreme cases, (e.g., Cellular Telephone tower interference) the band pass filters that FreeWave offers may reduce out-of-band noise.

In extreme cases, such as when interference is due to a cellular 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

Important!: Adding a Repeater cuts the network throughput by 50%.

1.2.1. Point-to-Point (PTP) Network

A PTP network work best when the network consists of one Master and one Slave radio.

Note: A maximum of four Repeaters can be added to extend the reach of the network.

1.2.2. Point-to-MultiPoint (PTMP) Network

In a PTMP network (also referred to as MultiPoint network) the Master radio is able to simultaneously communicate with numerous Slave radios.

- A MultiPoint network functions with the Master broadcasting its messages to all Slave radios.
- If requested by the Master, the Slave radios respond to the Master when given data by the device connected to the data port. The response depends on the setup.
- The network reach can be extended with as many Repeaters as is required.

Differences between PTP and PTMP

- 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, packets sent from the Master or Repeaters to Slaves are not acknowledged by the Slaves.

- Packets sent from a slave to the Master are acknowledged.
- Communication robustness is provided by repeating broadcast messages sent from the Master radio or Repeaters to Slaves.
- The user determines the number of times outbound packets from the Master or Repeater to the Slave or other Repeaters 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 generally 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.

These factors influence the number of radios that can exist in a MultiPoint network:

- Packet size
  - The longer the data blocks, the fewer number of deployed Slave radios can exist in the network.
  - See Max Packet Size and Min Packet Size (Golden Setting) (on page 48) or Min Packet Size vs. RF Data Rate (on page 49) for additional information.
- Baud Rate (on page 30)
  - The data rate between the radio and the device it is connected to could limit the amount of data and the number of radios that can exist in a network
- The amount of contention between Slave radios.
- Polled Slave radios versus timed Slave radios.
- Repeater Use
  - Using the **Repeater** setting in a Point-to-Point or MultiPoint network decreases overall network capacity by 50%.

Example: If the network polls once a day to retrieve sparse data, several hundred Slave radios could be configured to a single Master.
However, if each Slave transmits larger amounts of data or data more frequently, fewer Slave radios 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 Slave radios.

1.3. Data Communication Link Examples

1.3.1. Example 1 - Point-to-Point Gateway to Endpoint

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

This example shows the most common and straight-forward link; a Master communicating to a Slave in a Point-to-Point link.

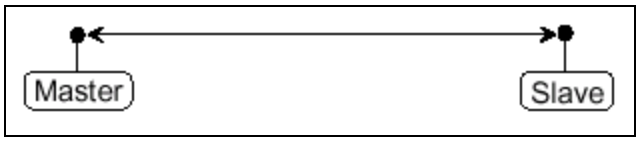


Figure 2: Master Communicating to a Slave in a Point-to-Point Link

1.3.2. Example 2 - Gateway Repeater Endpoint

This example shows a link using a Repeater.

- The Repeater may be located on a hilltop or other elevated structure enhancing the link from the Master to the Slave.
- In this configuration, it may be desirable to use an external Omni directional antenna at the Repeater.
- A Yagi antenna may be used at both the Master and Slave radios.

Note: Adding Repeaters to a network cuts the network throughput by 50%.

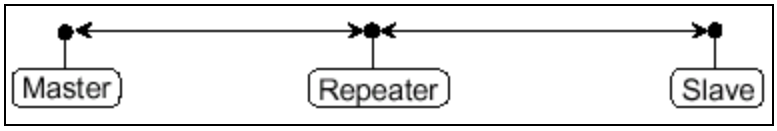


Figure 3: Master Communicating to a Slave in a Point-to-Point Link with a Repeater

1.3.3. Example 3 - Two Repeaters

This example shows a link with two Repeaters between the Master and Slave.

- With two Repeaters there is more flexibility in getting around obstacles and greater total range is possible.
- It may be desirable to use external Omni-directional antennas with the Repeaters, and attaching a Yagi antenna to the Master and Slave radio to increase the range of the link.
- When two Repeaters are used no further degradation in the RF throughput of the link is experienced.

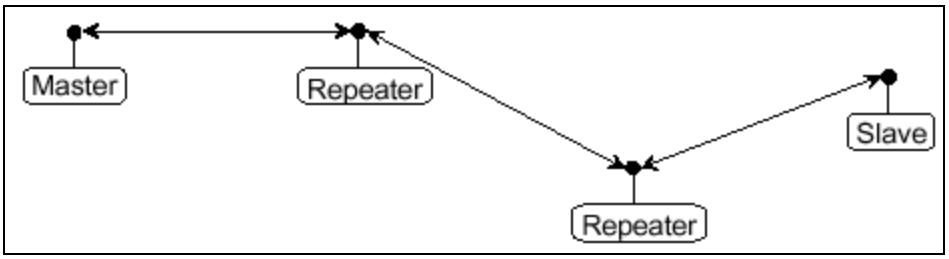


Figure 4: Master Communicating to a Slave in a Point-to-Point Link with Two Repeaters

1.3.4. Example 4 - Multiple Radios

This example shows a configuration where a Master radio routinely calls a number of Slave radios at different times.

- The Master radio is communicating with a radio designated as a Slave/Repeater that is connected to a remote device.
- Since this device is placed in an elevated location, the radio may also be used as a Repeater when it is not used as a Slave.
- At any time the Master may call any of the Slave radios, establish a connection, and send and receive data.

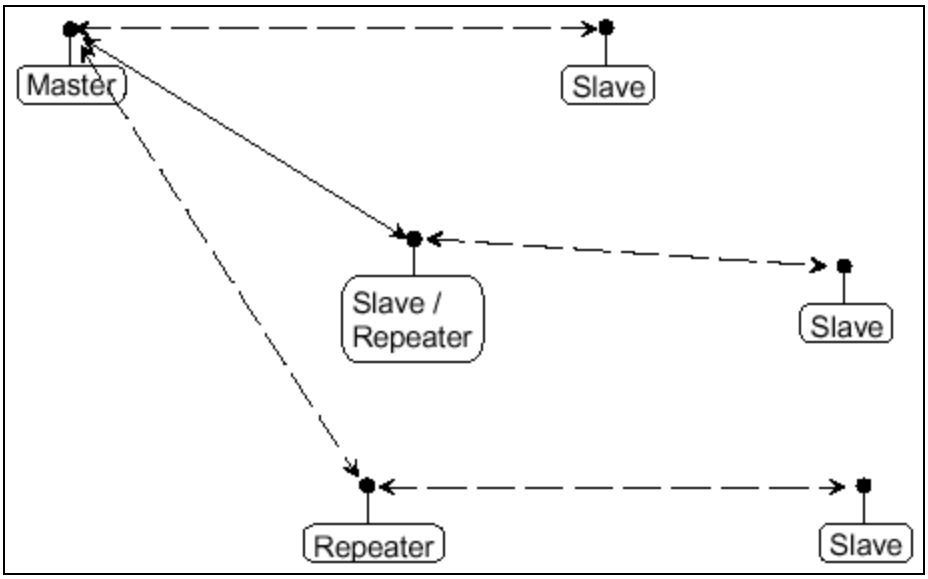


Figure 5: Master Communicating to Multiple Slave Radios at Different Times

1.3.5. Example 5 - Point-to-MultiPoint

This example illustrates 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.

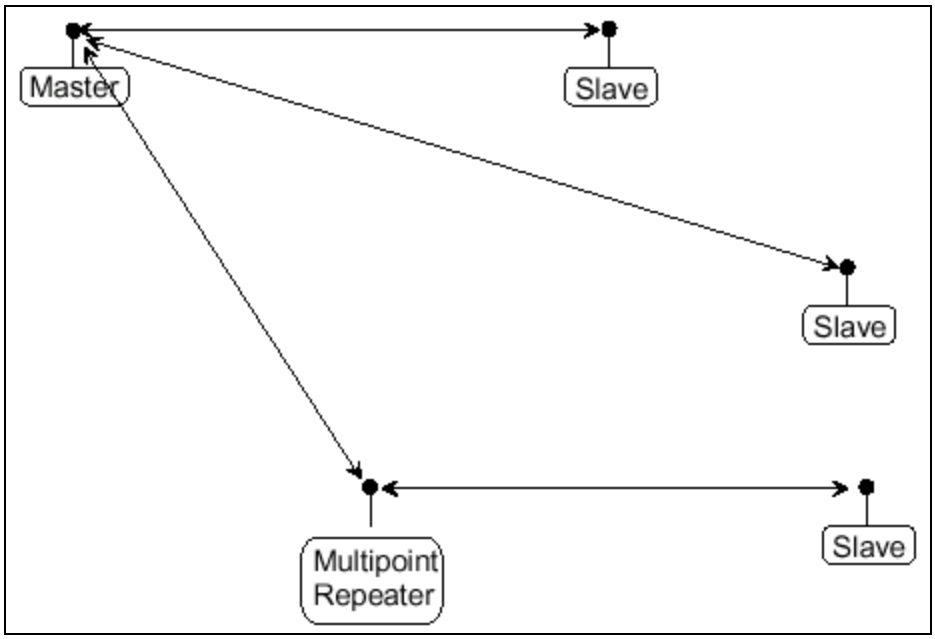


Figure 6: Master Communicating in a Point-to-MultiPoint Network

1.3.6. Example 6 - Point-to-MultiPoint with a Repeater Site

This example is a Point-to-MultiPoint network that uses one of the sites as a Slave/Repeater.

- This network functions in the same manner as a standard MultiPoint network with Repeaters.
- However, the number of radios may be reduced with the use of the MultiPoint Slave/Repeater feature.

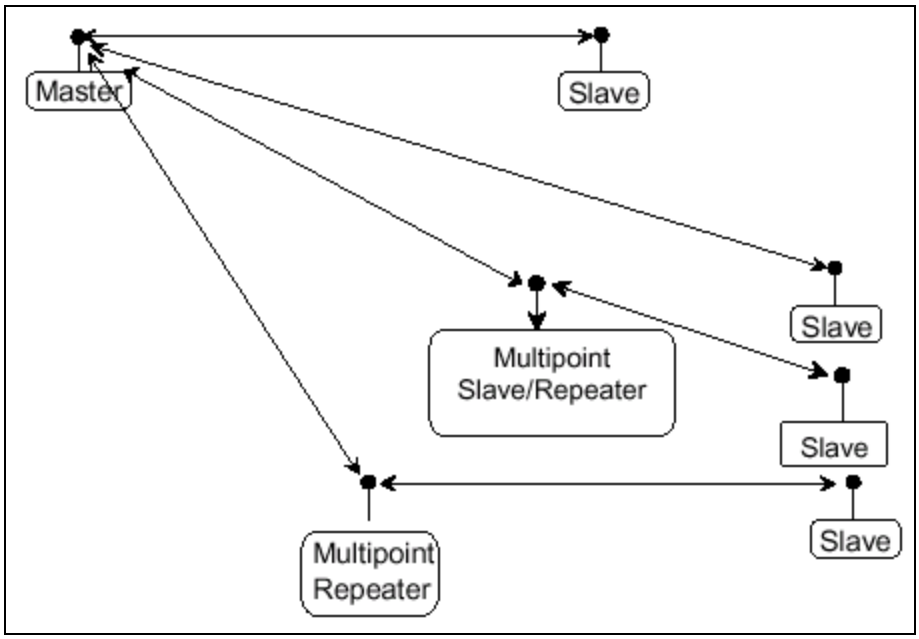


Figure 7: Master Communicating in a Point-to-MultiPoint Network using a Slave/Repeater

1.4. Powering the Radio

Connect the radio to a positive power supply with +6 to +30 VDC, typically +12.0 VDC.

FREEWAVE Recommends: For guaranteed performance, FreeWave recommends using between +7.5 to +30.0 VDC to power the radio.

Note: For more information about pinouts, see the RF Board Level Pinout (on page 111).

If the power supply line runs outside the enclosure, use a surge suppression device to protect the radio and all other equipment in the event of electrostatic discharge.

1.5. Configuration Tool Options

- **Tool Suite**- **Tool Suite** is the recommended method for programming the radios.
  - It provides a group of tools for configuring the devices in the network and for monitoring the network's performance.
  - Use the **Configuration** application in **Tool Suite** to program changes to the radio's settings.
  - Use the **Setup Terminal** in **Tool Suite** to perform radio configuration if a command line interface is preferred.
    - This functions the same as a third-party terminal emulator when programming FreeWave radios.
  - **Tool Suite** is available for download from www.freewave.com.

    Note: For more information about using **Tool Suite**, see the **Tool Suite User Manual** in the **Tool Suite** software.
- **Terminal Emulator** - A terminal emulator program (e.g., HyperTerminal or **Tera Term**) offers many of the same configuration options available in the **Configuration** application in **Tool Suite**.
  - If running versions of the **Windows®** operating system prior to **Windows®** 7, HyperTerminal is included in the operating system installation.

1.5.1. 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** on 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**.

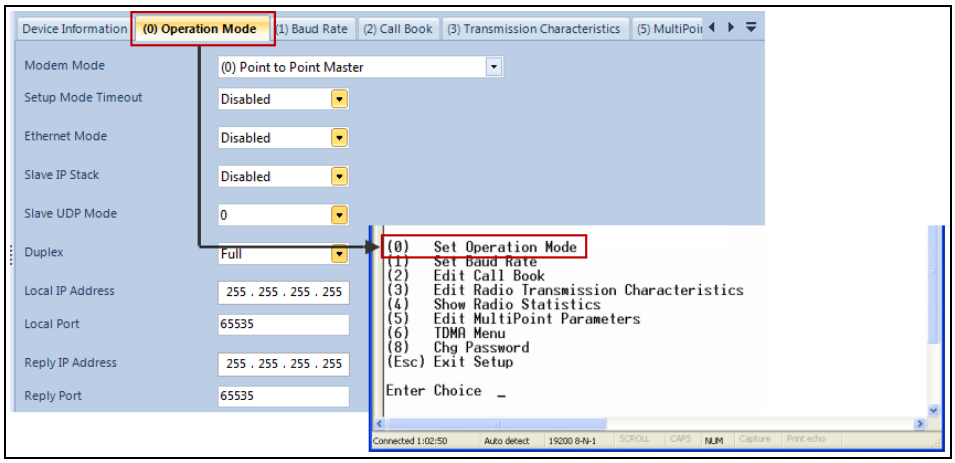


Figure 8: Tool Suite menu Matched to Terminal menu

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.

1.6. 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 appear solid green. These sections provide details about how to access the radio's **Setup** mode using **Tool Suite** or the terminal interface.

Note: OEM boards may also enter **Setup** when Pin 2 on a 10- or 14-pin connector or Pin 8 on a 24-pin connector is grounded, or using a break command.
For information about the break command, see Use Break to Access Setup (on page 35).

- The **Setup Port** parameter on the **Baud Rate** tab determines whether the main data port or the diagnostics port is used to access the setup parameters for the radio. For more information, see Setup Port (on page 33).
- Use the **Setup Mode Timeout** parameter on the **Operation Mode** tab to 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.

Note: For **Setup** mode troubleshooting information, see Troubleshooting (on page 114).

- Using Tool Suite to Connect to and Program Radios (on page 21)
- Access the Setup Menu Using a Setup Terminal (on page 23)

1.6.1. Using 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 and the radio.

   > **FREEWAVE Recommends**: Using a diagnostic cable and the diagnostic port.

2. Connect the power supply to the radio and the power source and turn on the radio.
3. Open **Tool Suite**.
4. In the **Applications** window, click **Configuration** to open the **Configuration** application.
5. Verify the correct port is selected in the **Com Port** field on the **Configuration** ribbon.
6. Place the FGR3-C-U or FGR3-CE-U in **Setup** mode using one of these options:
   - On an enclosed FreeWave radio, press the **Setup** button.

     > **Note**: If connected to the diagnostics port, the radio changes to **Setup mode** automatically when **Read Radio** is clicked in **Tool Suite**.

   - On a board-level radio, short Pins 2 and 4 (Brown to Black) on the 10-pin header next to the LEDs.
   - If using a data cable (FreeWave part number: **ASC3610DB** or **ASC3610DJ**), press the **Setup** button on the data cable.

     > **Note**: If using the **Setup Terminal** application or a terminal emulator and using the gray ribbon diagnostic cable (part number **AC2009DC**), or the black diagnostic cable (part number **ASC0409DC**), the radio changes to **Setup mode** automatically when **Read Radio** is clicked in **Tool Suite**.

   All three LEDs on the radio are green and stay green as long as the radio is in **Setup** mode.
7. On the **Configuration** ribbon, click **Read Radio** to read the radio's current settings.
8. Make the necessary parameter changes.
9. On the **Network Title ribbon**, use one of these options to send the changes to the radio:
   - Click **Quick** to send only the changed parameters.

     > **Note**: This option is only available if the **Read Radio** button is clicked and parameter settings are NOT sent from a template to the FGR3-C-U or FGR3-CE-U.

- Click **All** to send all the settings for all parameters whether they have been changed or not.
- Click **Default** to set a device back to its factory default settings.

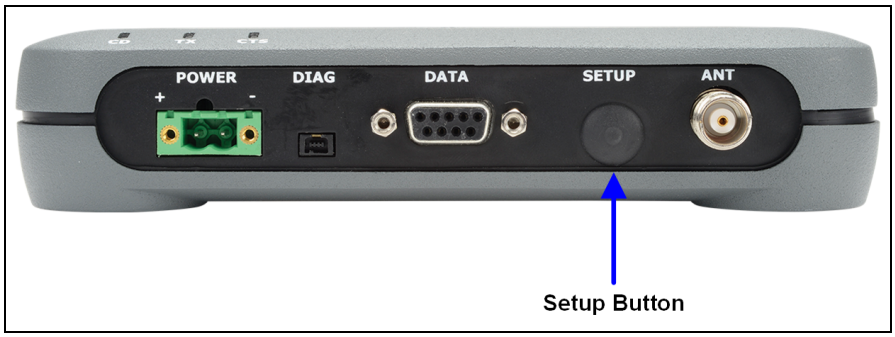


Figure 9: FGR3-C-U or FGR3-CE-U Setup Port

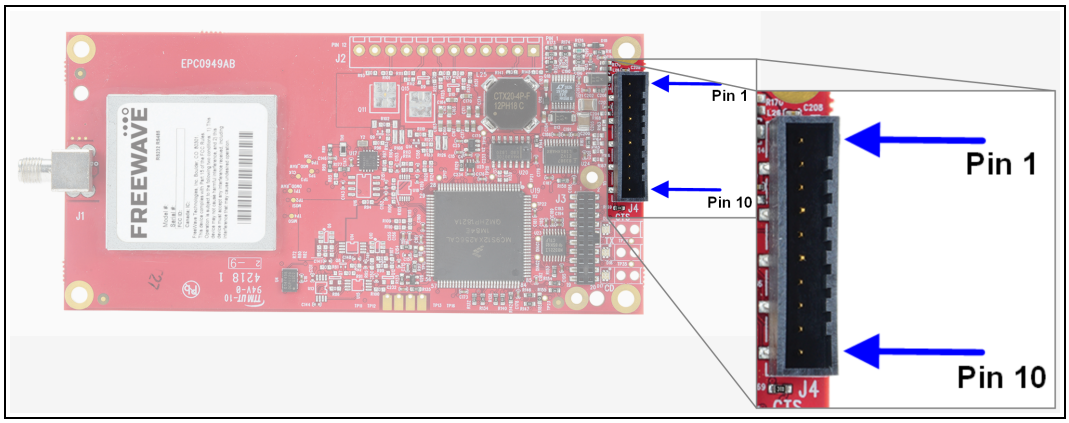


Figure 10: FGR3-C-U or FGR3-CE-U Pin Layout

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

1.6.2. Access the Setup Menu Using a Setup Terminal

This procedure accesses the radio's **Setup** menu using the **Setup Terminal** application in **Tool Suite**.

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

Procedure

1. Plug a serial cable into the COM 1 port on the radio.
2. Connect the cable to a COM port on the computer running **Tool Suite**.
3. Connect the radio to a power source.
4. Open **Tool Suite**.
5. On the **Applications** window, click **Setup Terminal**.
6. Click the **Connection** list box arrow in the top left of the window and select the COM port on the computer the radio is connected to.

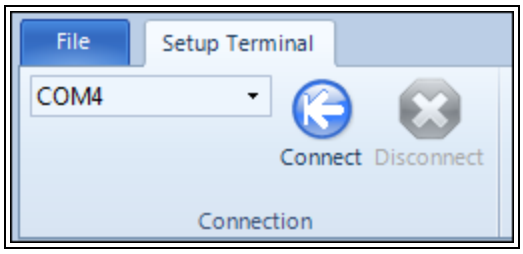


Figure 11: Connection list box

7. Click **Connect**.
8. To connect **Setup Terminal** to the radio, press the **Setup** button on the back of the FreeWave radio.
   If connected to the diagnostics port, press <Shift+U> to view the **Setup** menu.

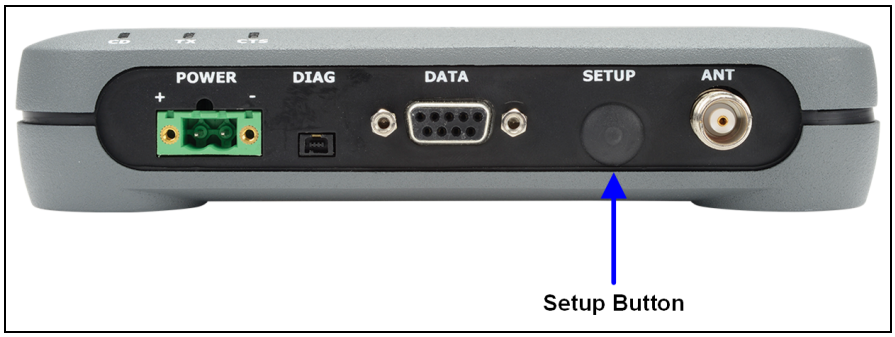


Figure 12: FGR3-C-U or FGR3-CE-U Setup Port

9. To view the **Setup** menu in board-level radios:
   - Short pins 2 & 4 (Brown to Black) on the 10 pin header next to the LEDs.

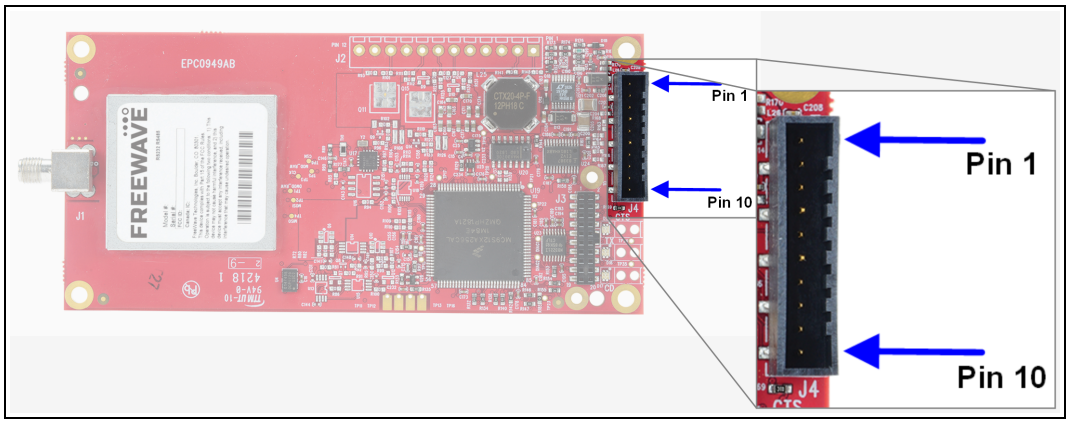


Figure 13: FGR3-C-U or FGR3-CE-U Pin Layout

- If using a data cable (FreeWave part number: **ASC3610DB** or **ASC3610DJ**), press the **Setup** button on the data cable.
- If using the gray ribbon diagnostic cable (P/N **AC2009DC**), or the black diagnostic cable (P/N **ASC0409DC**), press <Shift+U> to view the **Setup** menu.

When **Setup** is activated, the FreeWave **Setup Main Menu** appears in the HyperTerminal dialog box.

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

Important!: When navigating through the Setup menu and making changes to the parameters, the parameters are sent **immediately** to the radio.

1.7. Upgrade the Radios to the Latest Software Version

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

Use **Tool Suite** to upgrade the software 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 www.freewave.com).

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** window, 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.

2. Basic Radio Programming and Setup

When setting up either a Point-to-MultiPoint network or a Point-to-Point network, the process for setting up and programming a radio is the same.

This section describes these aspects of programming and setting up a radio:

- Setting the Radio's Role in the Network and the Network Type (on page 27).
- Establishing Communication with Instrumentation and Computers (on page 30).
- Establishing Communication with Other Radios in the Network (on page 36).
- Designate the RF Transmission Characteristics (on page 37).

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

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.

Note: The network type must match for all radios in a network.

If configuring a Point-to-MultiPoint network, verify the **Modem Mode** selection for radios in the network starts with Point-to-MultiPoint.

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

Set the **Modem** mode on the **Operation Mode** tab, using the **Modem Mode** field. These settings are available in the **Operation Mode** menu in the terminal interface.

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 Slave and/or Repeaters. The settings NOT determined by the Master are: • Hop Table settings • Retry Timeout • 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.

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 Slave Security on page 56.
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. Adding Repeaters to a network cuts the network throughput by 50%.
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**. Adding Repeaters to a network cuts the network throughput 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 terminal emulator or using script files. • When the **Point-to-Point Slave/Master Switchable** option is selected and the radio is not calling a Slave, it functions as a Slave and accepts any appropriate calls from other radios. For more information, see **Application Note #5476, Mode 6**.
Point-to-MultiPoint Repeater (7)	This option allows the radio to operate as a Repeater in a MultiPoint network. • A MultiPoint network can have as many Repeaters as necessary. • If the Repeater is to act as a Slave/Repeater, set the **Slave Repeater** parameter in the MultiPoint Parameters tab to **Enabled**. Adding Repeaters to a network cuts the network throughput by 50%.
Mirrorbit Master (A) Mirrorbit Slave (B)	Mirrored Bit Communication is supported in firmware version 8.77 and later. For information about **Mirrored Bit Communication**, see the FreeWave: • Application Note #5424, Using the FGR-115MB Radio with Schweitzer Engineering Labs Mirrored Bits Communications. • FGR Radio Modem in Mirrored Bit Mode Addendum.
Ethernet Options (F)	This menu is used for Ethernet radios only.

2.2. Establishing 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 10) for a description of the parameter table's content.

2.2.1. Baud Rate

Baud Rate	
Setting	**Description**
Default Setting	115200
Options	600, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 76800, 115200, 230400
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 setting is independent from the baud rate for the other radios in the network.
	• 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**.
	FREEWAVE Recommends: With a **Baud Rate** setting of 38,400 or higher, FreeWave recommends using the lines of the Flow Control (on page 31).

2.2.2. Data Parity

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

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

2.2.3. Flow Control

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

Options	• **(0) None** - No flow control CTS is active and de-asserts when buffering 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.
	• **(3) DOT** - Half Duplex.

Terminal Menu	(1) Set Baud Rate > (F) FlowControl

Flow Control	
Setting	**Description**
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 38,400.

2.2.4. Modbus RTU

Note: When using the radio in **Modbus RTU** mode, the **Master Packet Repeat** parameter setting on the **MultiPoint Parameters** tab MUST match in every radio.
The **Modbus RTU** mode must be set to **1** when radios are configured in RS422 or RS485 mode.

Modbus RTU	
Setting	**Description**
Default Setting	0 (Disabled)
Options	0 to 9
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. • **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. **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.

2.2.5. Serial Interface

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

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

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. **Note**: This setting must be 0 in TTL RF board products.

2.2.6. Setup Port

Important!: Do NOT change this setting unless the correct programming cable is available for the new setting.

Setup Port	
Setting	**Description**
Default Setting	(3) Both The factory setting is based on the radio type. • A setting of 2 is used with Ethernet products and Mirrored Bit products. • A setting of 3 is used in other products.

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. • If the **Serial interface** is set to anything other than RS232, then the **Setup Port** must be set to **Diagnostics Only**. • **(3) Both** - Programming and reading a radio's setup information is done through either the data port or the diagnostic port .
Terminal Menu	(1) Set Baud Rate > (D) Setup Port

Description:	Determines which port on the radio, Main or Diagnostics, is used to access the parameter settings in **Tool Suite** or enter the **Setup** main menu in the terminal interface.
	• The main data port is the RS232 / RS485 port.
	  • The diagnostic cable for this port (**ASC0409DC**) is available from FreeWave.
	• The OEM modules use a 2-row, 2 mm female connector.
	  • The diagnostic cable for this port (**ASC2009DC**) is available from FreeWave.

2.2.7. Turn Off Delay

Turn Off Delay	
Setting	**Description**
Default Setting	0
Options	Any number between 0 and 9 ms.
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. • An entry 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.

2.2.8. Turn On Delay

Turn On Delay	
Setting	**Description**
Default Setting	0 ms
Options	Any number between 0 and 9 ms
Terminal Menu	(1) Set Baud Rate > (E) Turn On Delay
Description:	Sets the delay between when the line drivers are turned on and when the data leaves the data port.

2.2.9. Use Break to Access Setup

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

Use Break to Access Setup	
Setting	**Description**
Default Setting	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.
Terminal Menu	(1) Set Baud Rate > (G) Use break to access setup
Description:	Enables a break command to put the radio into Setup mode over the data port. To send a break character, the end device must hold the Tx data line in the space voltage level for longer than 1 character time. **Example**: If a character is defined as having 1 start bit, 8 data bits, and 1 stop bit, the character time is 10 bits. Thus, the transmit data line must be held in the space voltage level for a period of time longer than 10 bits.

2.3. Establishing Communication with Other Radios in the Network

For the radios in 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. The **Network ID** function should be used in conjunction with the **Subnet ID** feature (if necessary) to route data through the radio network.
    - Without having the serial numbers in the **Call Book**, Slaves may establish communications with different Masters that match the radio's golden settings described below, though not at the same time. This is very useful in mobile MultiPoint applications.
    - For information about setting the **Network ID** parameter in a MultiPoint Network, see Using the Network ID in MultiPoint Networks (on page 65).
- **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.

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.

Note: For more information about defining the **Call Book** in a Point-to-Point network, see Using the Call Book in Point-to-Point Networks (on page 90).

2.3.1. 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**:

- Frequency Key
- Min Packet Size
- Max Packet Size
- Network ID
- RF Data Rate

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

- If 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.

2.4. Designate the RF 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.

> **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.

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

- Hop Table Offset
- Hop Table Size
- Hop Table Version
- Retry Timeout
- Slave Security
- Transmit Power

Accept the default settings on the **Transmission Characteristics** tab when completing basic setup.

However, these parameters must be set and they **must be the same** for all radios in the network:

- Frequency Key
- Hop Table properties (Size, Version, and Offset)
- Max Packet Size
- Min Packet Size
- RF Data Rate

Set these parameters on the **Transmission Characteristics** tab. These settings are available in the **Edit > Radio Transmission Characteristics** menu in the terminal interface and apply to

both Point-to-Point and Point-to-MultiPoint networks, unless indicated otherwise in the description.

Note: See the Parameter Preference (on page 10) for a description of the parameter table's content.

2.4.1. 900MHz Channel Select Parameters

- The Channel tables are used to enable / disable each channel within the range of channels available in the user's region.
  - The available frequencies are shown as either Enabled (**1**) or Disabled (**0** (zero)) in the CLI.
- Specific regional frequencies are set by FreeWave.
  - These frequencies are NOT available to customers.
  - They are represented in the CLI by a **.** (period).

900MHz Channel Select Parameters	
Setting	**Description**
Default Setting	(0) Mode Set = Zone
Options	(0) Mode Set (1) Set Single Channel Mask
Terminal Menu	(3) Edit Radio Transmission Characteristics > (0) FreqKey > F > (4) **Important!**: This command is NOT visible in the CLI menu and NOT accessible from **Tool Suite**. In the CLI, type **4** and press <Enter> to view the Channel Select Parameters. See Access to the Single Channel Mask (on page 40).

900MHz Channel Select Parameters	
Setting	**Description**
Description:	**(0) Mode Set options** • 0 - sets as Single mode • 1 - sets as Zone mode that allows the 900MHz Frequency Zones (on page 42) to be changed. **(1) Set Single Channel Mask** **Important!**: This option is ONLY available if `Single` is selected in the **Mode Set** command. 1. Enter `1` and press <Enter>. 2. Enter the **Channel ID** (from 0 to 111) and press <Enter>. 3. Enter `1` to set the channel **On** or Enter `0` (zero) to turn the channel **Off**. **Example**: See Example of Single Channel Mask (on page 41). **Note**: See or for the Channel IDs to use.

Access to the Single Channel Mask

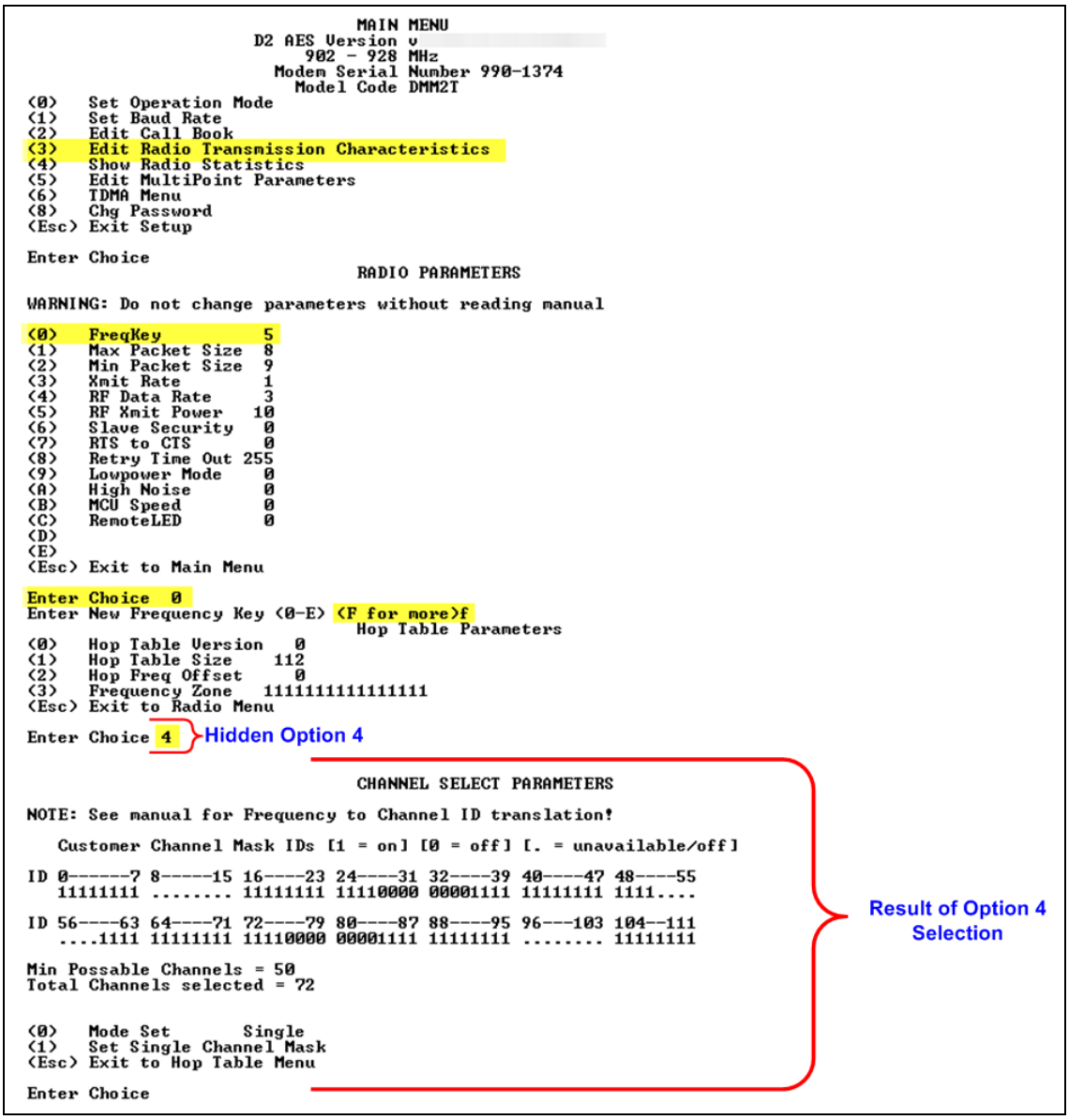


Figure 14: Access to Single Channel Mask

Example of Single Channel Mask

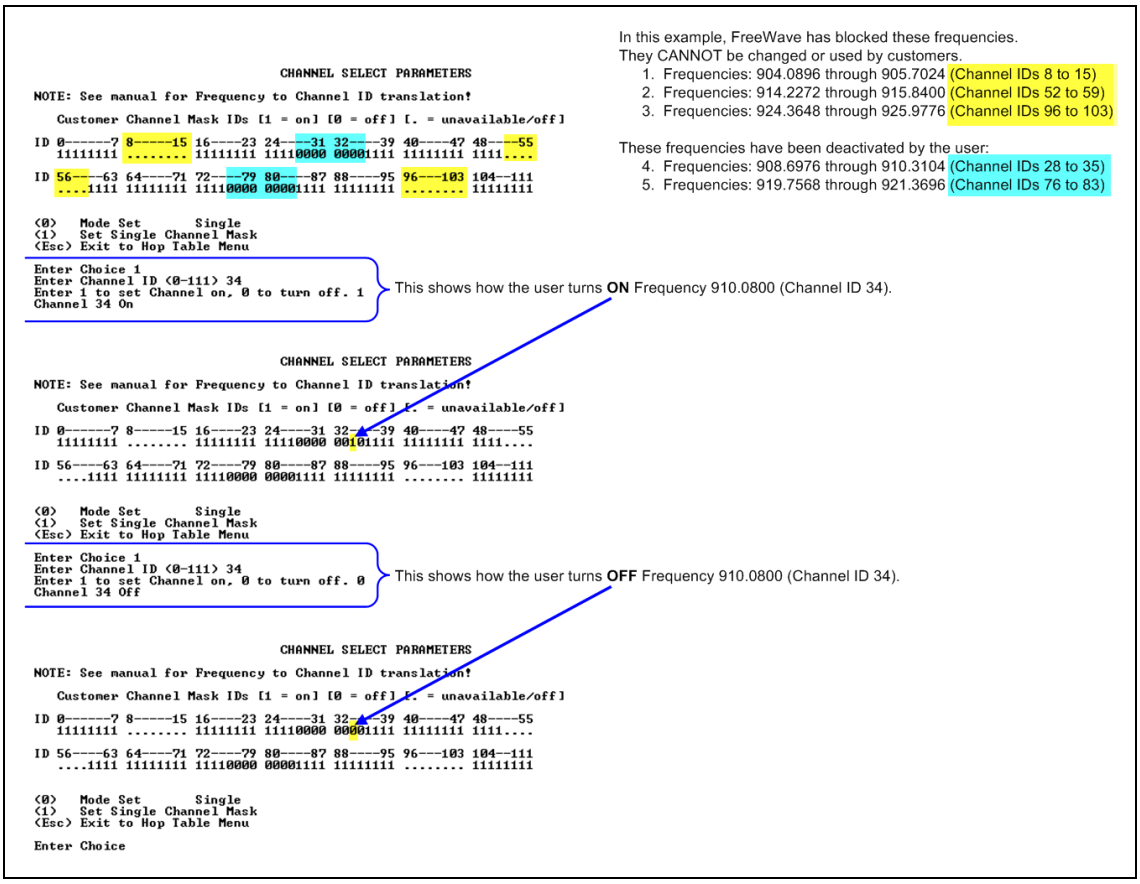


Figure 15: Example of Single Channel Mask

2.4.2. 900MHz Frequency Key (Golden Setting)

Note: In MultiPoint networks, the **Frequency Key** must be set identically in all radios. Any radio with a **Frequency Key** different from the Master radio will not establish a link. In Point-to-Point networks the Master radio's settings take precedence over the Slave radio. There are exceptions if the network contains parallel repeaters. For more information, see Working with Parallel Repeaters on page 94.

900MHz Frequency Key (Golden Setting)	
Setting	**Description**
Default Setting	5

900MHz Frequency Key (Golden Setting)	
Setting	**Description**
Options	0 to 9 A to E **Important!**: Do NOT use **Frequency Key E** with the 915 to 928 MHz, 916 to 920 MHz, and 921 to 928 MHz hop tables.
Terminal Menu	(3) Edit Radio Transmission Characteristics > (0) FreqKey
Description:	• Fifteen choices are available for the **Frequency Key** (0 to 9 and A to E) setting, representing 15 different pseudo-random hop patterns. • Hopping patterns minimize the interference with other FreeWave radios operating in the area. **Example**: If 10 pairs of FreeWave radios are operating on different networks in close proximity, setting a different **Frequency Key** value reduces the chance that radios hop to the same frequency at the same time. If two networks were to hop to the same frequency, the next hop would be to a different frequency for both networks. Tip Gain additional network separation by adjusting the **Max Packet Size** and **Min Packet Size** parameters. **Note**: Use the **Hop Table Version**, **Hop Table Size**, and **Frequency Zone** parameters to define more network differentiation by limiting the number and location of frequencies the radios may hop in the 902 to 928 MHz band. **Important!**: 900MHz radios do NOT use the **Hop Frequency Offset** setting.

2.4.3. 900MHz Frequency Zones

Note: In MultiPoint networks, this setting needs to only be set on the Master.
In a Point-to-Point network, the Master and the Slave must have matching **Frequency Zone** settings.

Important!: **Frequency Zones** are NOT valid if **Single** is selected in the 900MHz Channel Select Parameters (on page 38).

900MHz Frequency Zones	
Setting	**Description**
Default Setting	All zones selected
Options	See Description.
Terminal Menu	(3) Edit Radio Transmission Characteristics > (0) FreqKey > F > (3) Frequency Zone

Description:	Divides the available band (902 MHz to 928 MHz) into smaller bands.
	In this case 16 smaller bands each consisting of 5, 7, and 8 frequency channels depending on the frequency zone.
	• These 16 zones are stored in a binary word, which is made up of 16 bits numbered 0 to 15.
	• Displayed in LSB to MSB, these bits directly represent the zones that the radio operates on from lowest frequency to highest.
	  • A value of **1** in the bit sequence instructs the radio to operate within the represented band.
	  • A value of **0** bypasses the represented band. This feature should only be used with the standard hop table.
	Caution: Set the **Hop Table Version** to **902 to 928 MHz** when using **Frequency Zones**.
	If another **Hop Table Version** is selected, the limitations of that selection are also applied to the hopping pattern.
	Example: If **916 to 920** is used as the **Hop Table Version**, only the middle of the band is available in the pattern.
	Then, if **Frequency Zones** 5, 6, 7, 8, and 9 are set to **0**, no allowable frequencies are available for the radio to use.

900MHz Frequency Zones Table

Warning! FCC regulations require a minimum of 50 separate channels be used within a hop pattern.
Use the 900MHz **Frequency Zones Table** to determine the number of frequency zones required for legal FCC use.

Example: Using zones 1 to 7 is equal to 49 channels; this is NOT legal according to the FCC.
Using zones 0 to 6 is equal to 50 channels; this is legal according to the FCC.

900MHz Frequency Zones			
Binary Zone Number (LSB First)	**Beginning Freq. (MHz)**	**Ending Freq. (MHz)**	**Number Of Channels**
1	902.2464	903.8592	8
2	904.0896	905.4720	7
3	905.7024	907.0848	7
4	907.3152	908.6976	7
5	908.9280	910.3104	7
6	910.5408	911.9232	7
7	912.1536	913.5360	7
8	913.7664	915.1488	7
9	915.3792	916.7616	7
10	916.9920	918.6048	8
11	918.8352	920.2176	7
12	920.4480	921.8304	7
13	922.0608	923.4432	7
14	923.6736	925.0560	7
15	925.2864	926.6688	7
16	926.8992	927.8208	5

Enable Frequency Zones in Tool Suite

1. In the Tool Suite Configuration application, select the device to program.
2. Click the **(3) Transmission Characteristics** tab.
3. Click **Frequency Zones** to view the available frequency zones.
4. Select the **Frequency Zones** to enable.

Enable Frequency Zones using the Terminal Interface

1. On the main **Setup** menu, select **3 Edit Radio Transmission Characteristics**.
2. Select option **0 FreqKey**.
3. Select **F** for **More**.
4. Select option **3 Frequency Zone**.
5. Enter:
   1 to enable a frequency zone or
   0 to disable a frequency zone.

Note: **Frequency Zone** entries begin with **0** (LSB) and continue through **15** (MSB).

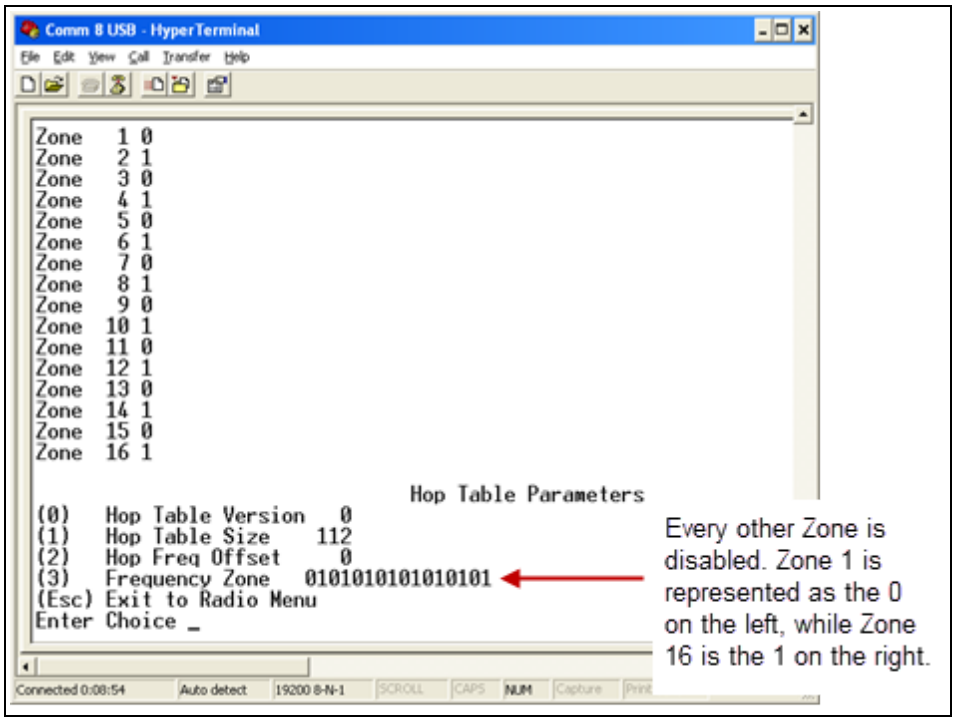


Figure 16: HyperTerminal window with Frequency Zones

2.4.4. High Noise

High Noise	
Setting	**Description**
Default Setting	(0) Disabled
Options	(0) Disabled (1) Enabled
Terminal Menu	(3) Edit Radio Transmission Characteristics > (A) High Noise
Description:	Use to determine if out-of-band interference is affecting a radio link. • A setting of **1** provides a reduction of gain in the front end circuit thereby decreasing the effect of any out-of- band noise. • The results are seen as a lower signal value and a much lower noise value (as found in Radio Statistics or Diagnostics). • If the noise is not reduced by a greater amount than the signal, the interference is most likely an in-band issue. **Note**: When a noise problem is shown to be helped using the **High Noise** option, the noise may be further decreased using a bandpass filter available from FreeWave.

2.4.5. 900MHz Hop Frequency Offset

Important!: FreeWave internal use only.

2.4.6. 900MHz Hop Table Size

Note: All radios in a network must have identical **Hop Table** settings.

Warning! FCC and ISED regulations require a minimum of 50 separate frequency channels be used within a hop pattern.

900MHz Hop Table Size	
Setting	**Description**
Default Setting	112
Options	50 to 112
Terminal Menu	(3) Edit Radio Transmission Characteristics > (0) FreqKey > F > (1) Hop Table Size
Description:	Defines how many separate channels a given network uses. **FREEWAVE Recommends**: Use the **Frequency Zones** instead of the **Hop Table Size** setting.

2.4.7. 900MHz Hop Table Version

Note: All radios in a network must have identical **Hop Table** settings.

900MHz Hop Table Version	
Setting	**Description**
Default Setting	902-928 MHz

900MHz Hop Table Version	
Setting	**Description**
Options	• 902-928 MHz, full band • 915-928 MHz • 903.744-926.3232 MHz • 916-920 MHz • 921-928 MHz • 902-911_919-928 MHz • Uses 902-928 MHz with center frequencies of 911-919 MHz notched out. • 902-915 MHz **Important!**: If using a **Hop Table Version** setting of 915-928 MHz, 916-920 MHz, or 921-928 MHz, do NOT set the **Frequency Key** parameter setting to **E** (916-920 MHz).
Terminal Menu	(3) Edit Radio Transmission Characteristics > (0) FreqKey > F > (0) Hop Table Version
Description:	Determines the section of the 900 MHz band the radio uses. In the terminal interface, enter the number that corresponds to the frequency band:

Terminal Interface Number	Frequency Band
0	902-928 MHz, uses the full band
1	915-928 MHz
2	903.744-926.3232 MHz
3	916-920 MHz
4	921-928 MHz
5	902-911_919.928 MHz Uses 902-928 MHz with center frequencies of 911-919 MHz notched out.
6	902-915 MHz

2.4.8. Max Packet Size and Min Packet Size (Golden Setting)

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 radio's settings take precedence over the Slave radio.

Max Packet Size and Min Packet Size (Golden Setting)	
Setting	**Description**
Default Setting	• Max Packet Size = 8 • Min Packet Size = 9
Options	Any number between 0 and 9.
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.

2.4.9. Min Packet Size vs. RF Data Rate

RF Data Rate of 2 (High)

This table defines the maximum packet size in bytes by charting the **Min Packet Size** parameter setting versus the **Max Packet Size** parameter setting where the **RF Data Rate** is set to **2** (High).

Maximum Packet Size Definition with RF Data Rate of 2 (High, 153.6 kbps)										
	Maximum Setting									
Minimum Setting	0	1	2	3	4	5	6	7	8	9
0	15	37	58	79	101	122	143	165	186	207
1	21	42	63	85	106	127	149	170	191	213
2	26	47	69	90	111	133	154	175	197	218
3	31	53	74	95	117	138	159	181	202	223
4	37	58	79	101	122	143	165	186	207	229
5	42	63	85	106	127	149	170	191	213	234
6	47	69	90	111	133	154	175	197	218	239
7	53	74	95	117	138	159	181	202	223	245
8	58	79	101	122	143	165	186	207	229	250
9	63	85	106	127	149	170	191	213	234	255

RF Data Rate of 3 (Normal)

This table defines the maximum packet size in bytes by charting the **Min Packet Size** parameter setting versus the **Max Packet Size** parameter setting where the **RF Data Rate** is set to **3** (Normal).

Note: Using the default settings, the actual maximum packet size, in bytes, is 172.

Maximum Packet Size Definition with RF Data Rate of 3 (Normal, 115.2 kbps)

	Maximum Setting									
Minimum Setting	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
0	8	24	40	56	72	88	104	120	136	152
1	12	28	44	60	76	92	108	124	140	156
2	16	32	48	64	80	96	112	128	144	160
3	20	36	52	68	84	100	116	132	148	164
4	24	40	56	72	88	104	120	136	152	168
5	28	44	60	76	92	108	124	140	156	172
6	32	48	64	80	96	112	128	144	160	176
7	36	52	68	84	100	116	132	148	164	180
8	40	56	72	88	104	120	136	152	168	184
9	44	60	76	92	108	124	140	156	172	188

Referencing the default settings, the Master transmits up to 172 bytes on every hop. If fewer than 172 bytes are transmitted, the balance is allocated to the Slave radio's transmission, plus the quantity in the **Min Packet Size** parameter setting.

Example: If a Master transmits 100 bytes, the Slave then has a total of 116 bytes available: (72 (leftover bytes) + 44 (Min packet size)).

2.4.10. MCU Speed

MCU Speed	
Setting	**Description**
Default Setting	(0) Normal
Options	• (0) Normal (low speed) - Reduces current consumption. • (1) Fast (high speed) - Required for 230 KBaud and greater data port rate. **Note**: If the radio is AES enabled and using the encryption functionality, set this parameter to **3** using the terminal interface. The value is accepted even though it is not viewable as an option and applies only when using AES encryption. For more information about setting up AES encryption, see Enable and Set Up AES Encryption (on page 97).
Terminal Menu	(3) Edit Radio Transmission Characteristics > (B) MCU Speed
Description:	Controls the speed of the Micro Controller Unit (MCU) in the radio.

2.4.11. Remote LED

This feature may be used to save power in MultiPoint Repeaters where the other options are not available.

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.
Terminal Menu	(3) Edit Radio Transmission Characteristics > (C) Remote LED

Remote LED	
Setting	**Description**
Description:	This feature may be used to save power in MultiPoint Repeaters. • By turning off the on-board LEDs (setting = 2) the current consumption is reduced. • To reduce current consumption in Slave radios, use **Low Power Mode** (setting = 1). • **Low Power Mode** does NOT work with MultiPoint Repeaters because Repeaters are constantly transmitting. • **Remote LED** drives the Diagnostic port, which has a small amount of current draw. • When using remote LEDs, the center (TX) LED does NOT output a signal for a green LED when in Setup mode. • The Green TX LED has no remote pinout. **Note**: If using a radio with the optional 20-pin connector, use this option to connect remote LEDs through the diagnostics port. **Important!**: For the FGR3-CE-U, option 1 or 2 must be selected for the external LED's to function.

2.4.12. Retry Timeout

Retry Timeout	
Setting	**Description**
Default Setting	255
Options	Any number between 0 and 255 in MultiPoint networks. **Note**: The minimum in 900MHz radios is 8 seconds. Any number between 151 and 255 in Point-to-Point networks.
Terminal Menu	(3) Edit Transmission Characteristics > (8) Retry Timeout

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. • 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.

2.4.13. RF Data Rate (Golden Setting)

Note: In MultiPoint networks, the **RF Data Rate** parameter must be set the same in all radios. Any radio with an **RF Data Rate** setting different from the Master will not establish a link. In Point-to-Point networks the Master setting takes precedence over the Slave.

RF Data Rate (Golden Setting)	
Setting	**Description**
Default Setting	(3) Normal
Options	• (2) High - 153.6 kbps • (3) Normal - 115.2 kbps
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**.
	FreeWave radios have these **RF Data Rate** settings:
	• **2** (High).
	  • Use setting **2** (RF Speed of 153.6 kbps) when the radios are close together and need to optimize data throughput.
	• **3** (Normal).
	  • Use setting **3** (RF Speed of 115.2 kbps) when the radios are farther away and a solid data link is preferred over data throughput.

2.4.14. RTS to CTS

Important!: The **RTS to CTS** option is only available in RS232 mode.
It is NOT recommended to enable this feature when operating at Baud Rates above 38,400.

RTS to CTS	
Setting	**Description**
Default Setting	(0) Disabled
Options	• (0) Disabled • (1) Enabled • (2) Line Alarm **Note**: Setting **2** is described in detail in the **Application Note #5437, DTR to CTS Line Alarm Feature**.
Terminal Menu	(3) Edit Transmission Characteristics > (7) RTS to CTS

RTS to CTS	
Setting	**Description**

Description:	Use this option to set the RTS line on the Master radio to control the CTS line of the Slave.
	With **RTS to CTS** enabled:
	• In MultiPoint networks, the Master RTS line controls all Slave's CTS lines.
	• The CTS line stops functioning as flow control.
	• The Master senses the RTS line prior to all scheduled packet transmissions.
	  • If the state has changed, the Master then transmits a message to the Slave with the new status. This transmission occurs regardless of data being sent.
	  • If data is ready to be sent, the RTS status message is sent in addition to the data.
	• In Point-to-Point mode, the Master continues sending the new status message until it receives an acknowledgment from the Slave.
	• In MultiPoint mode, the Master repeats the message the number of times equal to the **Master Packet Repeat** value in the MultiPoint Parameters tab.
	• Master transmit times are completely asynchronous to the occurrence of any change of the RTS line; the latency time from RTS to CTS is variable.
	• The **Max** and **Min Packet Size** parameters determine this duration.
	  • Setting both parameters to their maximum value of 9 produces a maximum latency time of approximately 21ms, given no Repeaters in the network.
	• At the minimum settings for **Max** and **Min Packet Size (0)**, the time is approximately 5.9ms.
	• This latency can increase significantly if packets are lost between the Master and Slave.
	• In Point-to-MultiPoint mode, no absolute guarantee is made that the state change is communicated to all Slaves.
	• In MultiPoint networks with Repeaters present, the latency is cumulative for each serial Repeater.
	Example: If the latency between the Master and the first Repeater is 15ms, and two serial Repeaters are present, the total latency is 45ms. (M—R1 (15ms) + R1—R2 (15ms) + R2—S (15ms) = 45ms).
	Important!: The **RTS to CTS** feature does NOT function in Point-to-Point networks that contain a Repeater.
	If this feature is needed in such network, the mode should be changed to Point-to-MultiPoint.
	• If **DTR Connect** on the **Tool Suite** **MultiPoint Parameters** tab is enabled and set to 2, the RTS to CTS feature does not work.

RTS to CTS	
Setting	**Description**
	• If **DTR Connect** is enabled and set to **1**, RTS to CTS mode takes precedence over the functionality of the CTS line on the Slave relating to the **DTR Connect** feature.

2.4.15. Slave Security

Note: The **Slave Security** parameter has no effect in Point-to-MultiPoint networks where the **Network ID** is used.

Slave Security	
Setting	**Description**
Default Setting	(0) On
Options	(0) On (1) Off
Terminal Menu	(3) Edit Transmission Characteristics > (6) Slave Security

Description:	• **Slave Security** allows Slave radios to accept transmissions from a Master not included in the **Call Book**.
	  • The default setting of **0** (On) means only Masters in the Slave radio's **Call Book** may link to that Slave.
	• The **Slave Security** parameter may be disabled (setting of **1**) allowing any Master to call the Slave.
	• The **Slave Security** parameter must be set to **1** when the unit is operating in Mode 6, Slave/Master Switchable or a Point-to-Point network where the Slave may need to accept calls from more than 10 different Masters.
	  • See **Application Note #5476: Mode 6** for additional information.
	• When the **Slave Security** parameter is set to **1**, the radio accepts calls from any other radio.
	• Additional network security measures may be taken to prevent unauthorized access (e.g.,changing default settings for **Frequency Key**, **Hop Table**, or **Frequency Zones**).

2.4.16. Transmit Power

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

Transmit Power	
Setting	**Description**
Description:	Sets the output power of the radio in dBm. • In FGR3-C-U or FGR3-CE-U radios, a setting of **10** is approximately 1 W of output power.  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	Power (in mW) for FGR3-C-U or FGR3-CE-U Radios
0	5
1	10
2	35
3	80
4	140
5	230
6	330
7	480
8	600
9	800
10	1000

Note: The output power setting must be set so the radiated power does NOT exceed 36dBm.

Example: When using the 8.6dBi Yagi antenna, the maximum power setting allowed is 7.
When using the 8.15dBi Omni antenna, the maximum power setting allowed is 8.

2.4.17. Transmit Rate

Transmit Rate	
Setting	**Description**
Default Setting	(1) Normal
Options	• 0 - Diagnostics • 1 - Normal
Terminal Menu	(3) Edit Transmission Characteristics > (3) Xmit Rate
Description:	FGR3-C-U or FGR3-CE-U radios have two available **Transmit Rate** settings. • The setting for normal operation of the radio is **1**. • When set to **0**, the radios transmit back and forth continuously regardless if they have any actual data. • **0** should be used only as a diagnostic tool and not for normal operation. • The strength of the signal may be gauged by the Clear to Send (CTS) LED. • A solid red ( ) CTS LED indicates a strong signal. • A blinking ( ) CTS LED indicates a weaker signal. **0** is useful to qualitatively gauge signal strength in Point-to-Point mode.

3. Configuring 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 the following 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 about the setup that applies specifically to a MultiPoint network:

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

Note: See Routing Communications through the Network (on page 68) and Assigning Subnet ID Values (on page 68) for additional information.

3.1. Point to MultiPoint Network Characteristics

A Point to MultiPoint network has these unique characteristics:

- Golden Settings (on page 60).
- Master to Slave Communications (on page 60).
- Slave to Master Communications (on page 60).

3.1.1. Golden Settings

A Point-to-MultiPoint network requires that the Golden Settings (described in Golden Settings (on page 37)) are set the same on **ALL** radios in the network.

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.

In almost all MultiPoint networks, the **Frequency Key** is the same for all radios. In other networks, where parallel Repeaters are introduced, the **Frequency Key** value needs to change.

3.1.2. Master to Slave Communications

Master - to - Slave communications within 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** setting. For more information, see Master Packet Repeat (on page 76).
- 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.

3.1.3. Slave to Master Communications

Slave - to - Master communications within 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.

3.2. Point-to-MultiPoint Network Quick Start

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

- Point-to-MultiPoint Network Quick Start (Tool Suite) (on page 61)
- Point-to-MultiPoint Network Quick Start (Terminal Interface) (on page 63)

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

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.

   > **Important!**: Power supply ranges and recommendations vary depending on model. Verify the specifications for the model prior to connecting power.

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 upper left of the **Configuration** ribbon.
6. On the **Configuration** ribbon, in the **Network** section, click 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.
   - When in **Setup** mode, all three LEDs on the radio are solid green.
   - If using a data cable to connect to the radio, follow the prompt to press the radio's **Setup** button to put it in **Setup** mode.
8. Click the **Operation Mode** tab.
9. In the **Modem Mode** field:
   Select **2** to set the radio as a Point-to-MultiPoint Master.
   Select **3** to set the radio as a Point-to-MultiPoint Slave.

   > **Note**: A MultiPoint network can have only one Master, unless running in **Multi-Master Sync** mode.
   > For more information, see Multi-Master Sync (on page 101).

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 connected to.
12. Click the **Transmission Characteristics** tab.
13. Set these parameters so they are identical on all radios in the network:
    - Frequency Key
    - Max Packet Size
    - Min Packet Size
    - RF Data Rate

> **Note**: If several independent MultiPoint networks are located in close proximity, it is very important to include as much frequency and time diversity as possible through use of different **Frequency Key**, **Min and Max Packet Size**, and **Hop Table** settings.

14. Click the **MultiPoint Parameters** tab.
15. In the **Network ID** field, set to any value between **1** and **4095**.

> **FREEWAVE Recommends**: Set the **Network ID** 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!**: A setting of **255** disables the **Network ID** feature and enables the **Call Book**.

16. Send the parameter settings by either:
    - Sending all the settings for all parameters:
      In the **Configuration** application, on the **Network Title** ribbon, click **All**.
    - Sending only the changed parameters:
      In the **Configuration** application, on the **Network Title** ribbon, click **Quick**.

      > **Note**: This option is only available if the **Read Radio** button is clicked and parameter settings are NOT sent from a template to the FGR3-C-U or FGR3-CE-U.

3.2.2. 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.

   Important!: Power supply ranges and recommendations vary depending on model. Verify the specifications for the model prior to connecting power.

3. Open a terminal emulator session.

   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:
   - Data Rate: **19,200**
   - Data Bits: **8**
   - Parity: **None**
   - Stop Bits: **1**
   - Flow Control: **None**
6. Press the **Setup** button on the radio.
   If using the diagnostics cable, press <Shift+U>.
   - The three LEDs on the radio should all turn green, indicating **Setup** mode.
   - The **Main** menu appears on the screen.
7. Press <**0**> to access the **Operation Mode** menu.
8. Press <**2**> to set the radio as a Point-to-MultiPoint Master or
   Press <**3**> to set the radio as a Point-to-MultiPoint Slave.
9. Press <**Esc**> to return to the **Main** menu.

   Note: A MultiPoint network can have only one Master, unless running in **Multi-Master Sync** mode.
   For more information, see Multi-Master Sync (on page 101).

10. Press <**1**> on the **Main** menu.
11. Change the **Baud Rate**, **Data Parity**, and **Modbus RTU** to match the device that the radio is to be attached to.
12. Press <**Esc**> to return to the **Main** menu.
13. Press <**3**> in the **Main** menu.
14. Set these parameters so they are the same on all radios in the network:
    - FreqKey
    - Max Packet Size
    - Min Packet Size
    - RF Data Rate

> **Note**: The **Frequency Key** option is located in the **F** submenu after pressing **0** to access the **Frequency Key** menu in **Main** menu **3**.

15. Press <**Esc**> to return to the **Main** menu.
16. Press <**5**> on the **Main** menu.
17. In the **Network ID** field, set the value to any value between **1** and **4095**.

> **Note**: A **255** setting disables the **Network ID** feature and enables the **Call Book**.

> **FREEWAVE Recommends**: Set the **Network ID** 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.

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

3.3. 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.

For more information, see Application Note #5412, **Synchronizing Collocated Masters (Multi-Master Sync Mode)** (available from www.freewave.com).

Collocated MultiPoint networks require these parameters be unique for each network:

- Network ID (unless using the **Call Book**)
- Frequency Key (with Repeater Frequency)
- Max Packet Size
- Min Packet Size

Note: For more information about the installation of Point-to-MultiPoint networks, contact FreeWave Technical Support.
See Contact FreeWave Technical Support on page 8

3.4. 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** 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 65)
- Using the Call Book in MultiPoint Networks (on page 66)
- Programming Point-to-MultiPoint Extended Call Book (on page 67)

3.4.1. Using the Network ID in MultiPoint Networks

The **Network ID** 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**.
- Use the **Network ID** function in conjunction with the **Subnet ID** feature (if necessary) to route data through the radio network.

3.4.2. Using the Call Book in MultiPoint Networks

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

FREEWAVE Recommends: 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 the Call Book in Point-to-Point Networks on page 90.

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**.

3.4.3. Programming Point-to-MultiPoint Extended Call Book

In a MultiPoint network, Slave radios can be programmed to roam between Master radios and Repeaters using the MultiPoint **Extended Call Book** function. Slave radios with **Call Book**, as configured in this procedure, communicate with any radio whose serial number appears in any of the three columns.

Procedure

1. Set the **Network ID** to **255**.
2. In the **Call Book**, enter **999-9999** as the last entry in the first and second columns.
3. In the **Call Book**, set **Entry to Call** to **All**.

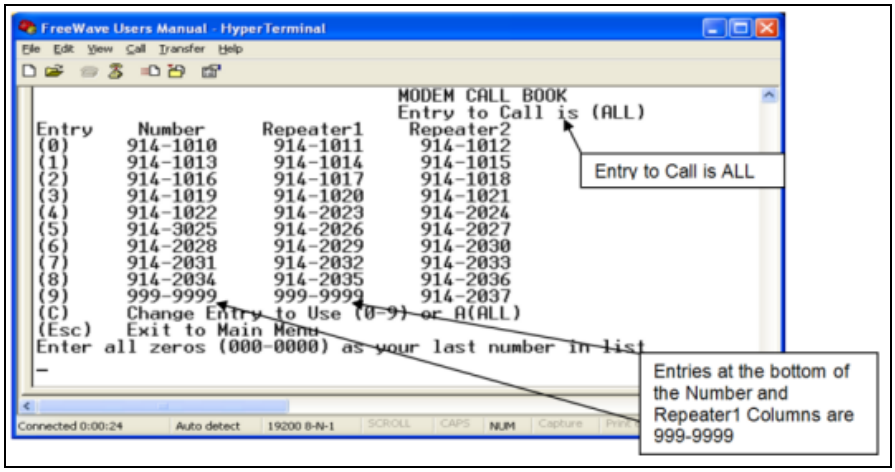


Figure 17: HyperTerminal PTMP Extended Call Book

3.5. Routing Communications through the Network

When using the **Network ID**, a Repeater or Slave links to the first Repeater or Master it hears with the same ID.

- Use Subnet IDs 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 to minimize latency.

3.5.1. 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.

Example 1: Subnet and Specific Path Communication

This example shows a network in which subnet IDs are used to force communications along a specific path.

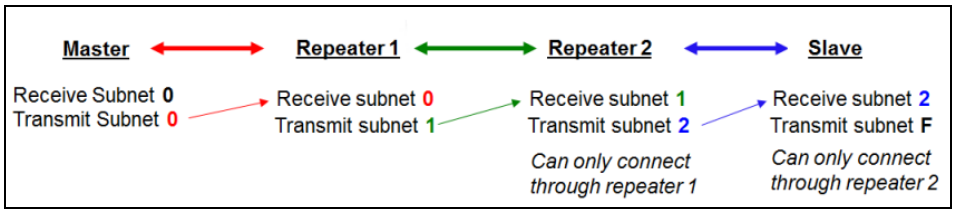


Figure 18: Subnet and Specific Path Communication

Subnet and Specific Path Communication			
Radio	**Rx**	**Tx**	**Additional Information**
Master	0	0	The default settings (**F, F**) actually use **0, 0**. The **Rx Subnet** on the Master has no effect on the network.
Repeater 1	0	1	**Rx Subnet** = **0** forces the radio to link only to the Master.
Repeater 2	1	2	**Rx Subnet** = **1** forces communication through Repeater 1. Repeater 1 transmits on subnet **2**.
Slave	2	F	**Rx Subnet** = **2** forces communication through Repeater 2. The Slave is the end of the network, so its **Tx Subnet** is **F**.

Example 2: Subnet and Communication Required through Repeaters

This example shows:

- Repeater 2 must communicate through Repeater 1.
- The Slave connected to Repeater 1 must route through Repeater 1.
- The other two Slave radios must route through Slave/Repeater 2.

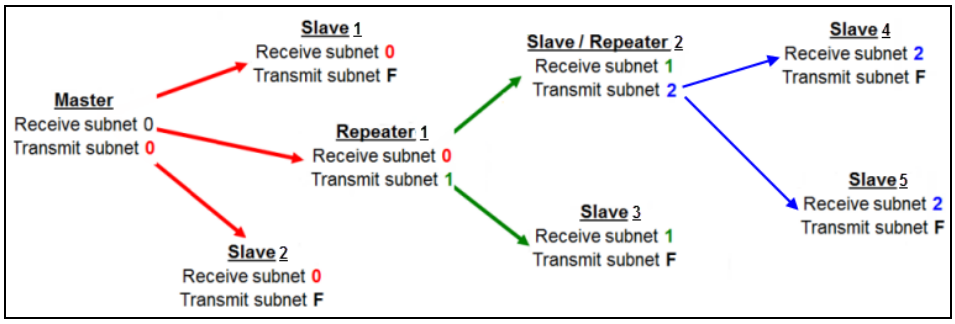


Figure 19: Subnet and Communication Required through Repeaters

Subnet and Communication Required through Repeaters			
Radio	**Rx**	**Tx**	**Additional Information**
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 1	0	1	**Rx Subnet** = **0** forces the radio to link only to the Master. Transmits on subnet **1**.
Slave 2	0	F	**Rx Subnet** = **0** forces the radio to link only to the Master.
Slave/Repeater 2	1	2	**Rx Subnet** = **1** forces the radio to link only to Repeater 1. It transmits on **Tx Subnet 2** to Slave 4 and 5.
Slave 3	1	F	**Rx Subnet** = **1** forces the radio to link only to Repeater 1. The Slave does not transmit to any device except Repeater 1, so its **Tx Subnet** is **F**.
Slave 4	2	F	**Rx Subnet** = **2** forces the radio to link with Slave/Repeater 2.
Slave 5	2	F	**Rx Subnet** = **2** forces the radio to link with Slave/Repeater 2.

Example 3: Subnet and Optional Slave Communication

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.

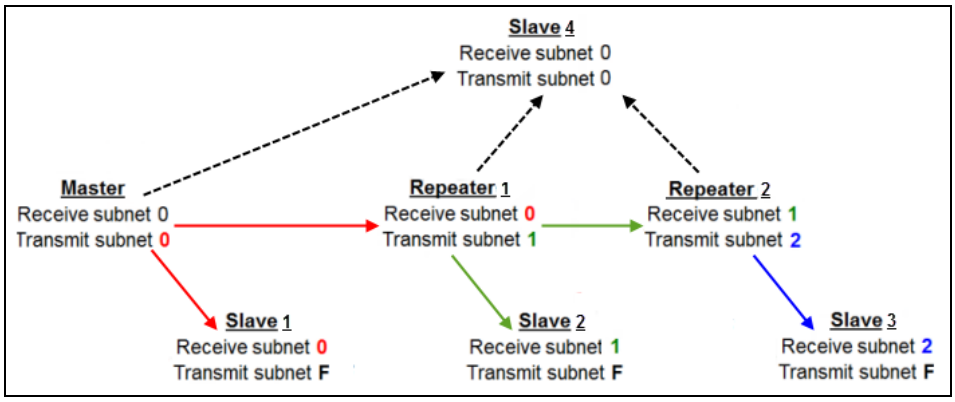


Figure 20: Subnet and Optional Slave Communication

Subnet and Optional Slave Communication			
Radio	**Rx**	**Tx**	**Additional Information**
Master	0 or F	0 or F	The default settings (**F, F**) actually use **0, 0**. The **Rx Subnet** on the Master has no effect on the network.
Repeater 1	0	1	**Rx Subnet** = **0** forces the radio to link only to the Master.
Repeater 2	1	2	**Rx Subnet** = **1** forces communication through Repeater 1. Repeater 1 transmits on SubnetID 1.
Slave 1	0	0 or F	**Rx Subnet** = **0** forces communication through the Master.
Slave 2	1	0 or F	**Rx Subnet** = **1** forces communication through Repeater 1.
Slave 3	2	0 or F	**Rx Subnet** = **2** forces communication through Repeater 2.
Slave 4	0	0	The **0, 0** setting allows the Slave to link with the: • first Master or • Repeater it hears with the same **Network ID**.

3.6. Setting Other MultiPoint Parameters

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

- 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 10) for a description of the parameter table's content.

3.6.1. 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	• 255 to disable 1 PPS • 0 to 254 to enter the delay
Terminal Menu	(5) Edit MultiPoint Parameters > (9) 1 PPS Enable/Delay
Description	The **1 PPS Enable/Delay** setting 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. 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.

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.

3.6.2. Diagnostics

Diagnostics	
Setting	**Description**
Default Setting	0 (Disabled)
Options	Any number between 0 and 128
Terminal Menu	(5) Edit MultiPoint Parameters > (B) Diagnostics
Description:	Allows diagnostics data in the **Network Diagnostics** in **Tool Suite** to be viewed at the Master radio in parallel with application data. • The setting in this parameter determines how many slots out of 128 are dedicated to diagnostics. • 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 83.

3.6.3. DTR Connect

DTR Connect	
Setting	**Description**
Default Setting	(0) Off
Options	• **(0) Off** - When set to off in the Slave radio, the radio transmits when the data is received. • **(1) DTR Sensing** - Forms a Point-to-Point link with the Master radio when the DTR line is high to send data. • **(2) Burst Mode** - The radio transmits data in bursts.
Terminal Menu	(5) MultiPoint parameters > (4) DTR Connect
Description:	Determines how the radio sends its data. **Note**: This mode is valuable when a network has many low data rate devices and to increase overall network capacity. The radio has two separate transmit and receive user data buffers of 2kb each. **Caution**: In case of a buffer overflow, the radio outputs unpredictable data.

3.6.4. Local Mode

Local Mode	
Setting	**Description**
Default Setting	(0) Disabled
Options	(0) Disabled, (1) Enabled
Terminal Menu	(5) Edit MultiPoint Parameters > (E) Local Access
Description:	Enable **Local Mode** to access a Slave radio with a local Master radio. **Important!**: This Master does NOT take the place of the network Master. **Note**: For more information, see **Application Note #5457, Local Mode** (available from www.freewave.com).

3.6.5. Master Packet Repeat

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

Master Packet Repeat	
Setting	**Description**
Default Setting	3
Options	Any number between 0 and 9.
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). 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. 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. **Note**: 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.

3.6.6. Master Packet Repeat in MultiPoint Networks with Repeaters

The **Master Packet Repeat** parameter must be set in MultiPoint Repeaters because a Repeater appears as a Master to a Slave radio.

Therefore, the Repeater sends the packet out the number of times corresponding to its own **Master Packet Repeat** parameter setting. If this parameter is set improperly the reliability of the overall network may be diminished.

Example: If a Master's **Master Packet Repeat** parameter setting is **3**, the link between the Master and Repeater should be robust.
If the Repeater's **Master Packet Repeat** parameter setting is **0**, this could cause marginal links between the Repeater and the Slaves.
The Slaves communicating through this Repeater only receive the initial packet from the Master with no repeats.
Therefore, if the packet is not received on the first try, the Slave radio does not respond as expected.

Note: The **Master Packet Repeat** parameter setting in any MultiPoint Repeater must be **less than or equal** to the Master's setting.

3.6.7. Max Slave Retry

Max Slave Retry	
Setting	**Description**
Default Setting	9
Options	Any number between 1 and 9.
Terminal Menu	(5) Edit MultiPoint Parameters > (2) Max Slave Retry
Description:	• Defines how many times the Slave radio attempts to retransmit a packet to the Master before beginning to use a back-off algorithm as defined by the Retry Odds on page 79 setting. • The Slave radio retries stop when the Slave receives an acknowledgment from the Master.

3.6.8. Radio ID

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

3.6.9. Radio Name

Radio Name	
Setting	**Description**
Default Setting	Blank
Options	A maximum of 20 characters in any combination of letters or numbers.
Terminal Menu	(5) Edit MultiPoint Parameters > (G) Radio Name
Description:	Use this parameter to give a radio a name, such as its location.  Naming radios can be helpful to identify a radio when in **Diagnostics** mode.

3.6.10. Repeaters

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

Important!: When this parameter is enabled, network throughput is reduced to 50%.

Repeaters	
Setting	**Description**
Default Setting	(1) Enabled
Options	• 0 - Disabled • 1 - Enabled
Terminal Menu	(5) Edit MultiPoint Parameters > (0) Number Repeaters
Description:	Indicates if any number of Repeaters exist in the network.

3.6.11. Repeater Frequency

Repeater Frequency	
Setting	**Description**
Default Setting	(0) Disabled
Options	(0) Disabled (1) Enabled
Terminal Menu	(5) Edit MultiPoint Parameters > (5) Repeater Frequency

Repeater Frequency	
Setting	**Description**
Description:	Enable this parameter when a **Frequency Key** is needed other than that of the Master. • This condition occurs when parallel Repeaters in a network may have overlapping areas of responsibility. • The default setting of **0** (Disabled) causes the Repeater to use the key set in the **Frequency Key** parameter on the **Tool Suite** **Transmission Characteristics** tab. **Note**: When the **Repeater Frequency** parameter is disabled and **Subnets** are NOT configured, the **Frequency Key** parameter setting in each Slave radio MUST match the Master or Repeater acting as the Master for the radio.

3.6.12. Retry Odds

Retry Odds	
Setting	**Description**
Default Setting	0
Options	Any number between 0 and 9.
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 77) 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**: Consider 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.

3.6.13. Slave / Repeater

Slave / Repeater	
Setting	**Description**
Default Setting	(0) Disabled
Options	(0) Disabled (1) Enabled
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. • Thus, where one Repeater and one Slave may be required in another vendor's network, FreeWave networks require only one radio. To operate a radio as a MultiPoint **Slave/Repeater**, these parameters must be set: • The **Modem Mode** parameter in the **Operation Mode** tab must be set to **MultiPoint Repeater**. • The **Slave/Repeater** parameter in the **MultiPoint Parameters** tab must be enabled.

3.7. Low Power Mode

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

Use these options on the **Transmission Characteristics** tab to conserve power.

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

Additionally, use **Remote LEDs** to conserve power by turning off the Diagnostic LEDs.

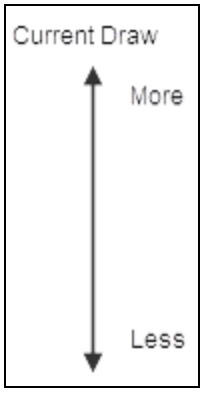
- If the radio has the optional 20-in connector, use this option to connect remote LEDs through the diagnostics port.

  > **Note**: For more information, see Remote LED (on page 51).

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

Low Power Mode

Setting	Description
Description:	Allows a MultiPoint Slave radio to consume less power, primarily 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.



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

Low Power Mode	
Setting	**Description**

	Notes
	• Power savings occur only when the Slave radio is linked.
	  • No power savings occur when the Slave radio is transmitting data.
	  • **Low Power Mode** is of little value when a Slave has a constant, high throughput.
	  • The **MCU Speed** parameter MUST be set to **0** and the **RF Data Rate** parameter MUST be set to **3** for **Low Power Mode** to operate properly.
	• To communicate to an RS-232 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 Request to Send (RTS) line on the Slave radio 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 75) parameter in the **MultiPoint Parameters tab** 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** feature to operate properly.
	• The diagnostic pins MUST be disabled or terminated to a cable for the sleep current in **Lower Power Mode** to match the specifications.
	  • To disable the diagnostic pins, set these options:
	  • In the **Baud Rate tab**, the Setup Port (on page 33) parameter is set to **1 (Main Only)**.
	  • In the **MultiPoint Parameters tab**, the Diagnostics (on page 74) parameter is set to **0 (Off)**.

3.8. Reading Diagnostics in Tool Suite

The **Network Diagnostics** application provides a place to view diagnostic data for all the devices connected to the Master in 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 section 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.

For information regarding the data available, recommended best practices, and importing and exporting files using the **Network Diagnostics** application, see the **Tool Suite User Manual** available in the **Tool Suite** software.

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

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 diagnostics cable. (Available from FreeWave.)
- **Tool Suite** - Available from www.freewave.com.

Note: For more information about diagnostics, contact FreeWave Technical Support.
Contact FreeWave Technical Support (on page 8) for assistance.

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.

   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.

4. Configuring 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 programming and setup section.

This section provides:

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

4.1. Point-to-Point Network Quick Start

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

- Point-to-Point Network Quick Start (Tool Suite) (on page 86)
- Point-to-Point Network Quick Start (Terminal Interface) (on page 88)

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

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

   Note: Power supply ranges and recommendations vary depending on model.
   Verify the specifications for the model you are using prior to connecting power.

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 Setting the Radio's Role in the Network and the Network Type (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:
    - Frequency Key
    - Max Packet Size
    - Min Packet Size
    - RF Data Rate

    If several independent networks are located in close proximity, it becomes very important to include as much frequency and time diversity as possible through use of different **Frequency Key**, **Min and Max Packet Size**, and **Hop Table** parameter settings.

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 the Call Book in Point-to-Point Networks (on page 90).

    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 132), 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.

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

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

   Note: Power supply ranges and recommendations vary depending on model.
   Verify the specifications for the model you are using prior to connecting power.

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:
   - Data Rate - **19,200**
   - Data Bits - **8**
   - Parity - **none**
   - Stop bits - **1**
   - 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 display 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 Masteror
   Type **1** and press <Enter> to set the radio as Point-to-Point Slave.

   Note: For more information about modem modes, see Setting the Radio's Role in the Network and the Network Type (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 56) parameter in the Slave.

    Note: For more information about setting up the **Call Book** see Using the Call Book in Point-to-Point Networks (on page 90).

16. On the **Main Menu**, type **3** and press <Enter>.
17.
18. Press <**3**> on the **Main** menu.
19. Set these parameters so they are identical on all radios in the network:
    - Frequency Key
    - Max Packet Size
    - Min Packet Size
    - RF Data Rate

    Note: The **Frequency Key** option is located in the **F** submenu after you press <**0**> to access the **Frequency Key** menu on **Main** menu <**3**>.
20. 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.
21. Using the Point-to-Point Operation LEDs (on page 132), verify that the radios are operating as expected.
22. Press <**Esc**> to exit the **Setup** menu and resume normal radio operation.

4.2. Using the 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.

- 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**.

4.2.1. Setting 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 being 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.

4.2.2. Setting the Call Book in the Terminal Interface

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

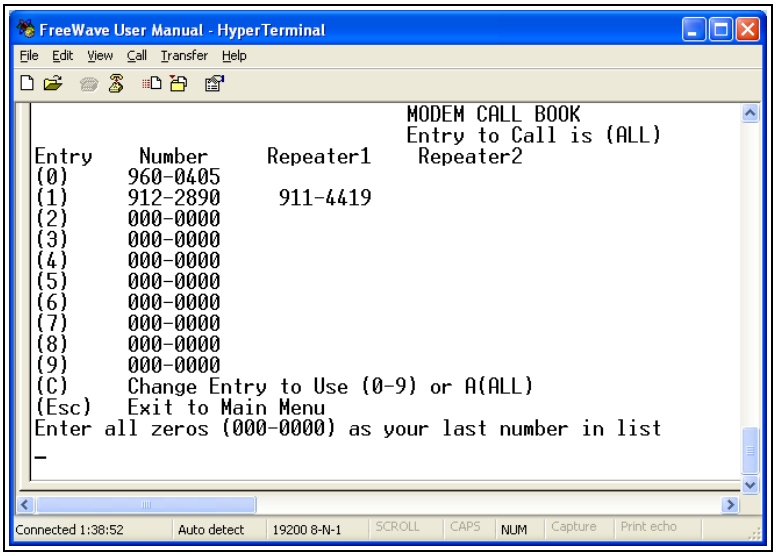


Figure 21: Modem Call Book window

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.
5. Enter the 7-digit serial number of the second Repeater.
   If only one Repeater is being used, press <Esc>.
   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.

4.2.3. Programming Point-To-Point Extended Call Book to Use Three or Four Repeaters

In a Point-to-Point configuration, FreeWave radios can use a maximum of four Repeaters.

1. To use three or four Repeaters, program the **Call Book** with the Slave serial number, followed by the first two Repeaters.
2. On the next line enter 999-9999 as the radio to call.
3. When prompted for the Repeaters enter the third and fourth Repeaters in the link.

Figure 22 shows a Point-to-Point link where a Slave is called through four Repeaters. In this example:

- the Master is calling the Slave, 571-3872, through Repeater 1, 901-1234,
  - then Repeater 2,910-0234,
  - then Repeater 3, 571-3456, and finally
  - Repeater 4, 571-4567.
- Entering the serial number 999-9999 in line 1 instructs the Master to continue calling through the Repeaters programmed on that line.

Entry	Number	Repeater 1	Repeater 2
0	571-3872	901-1234	910-0234
1	999-9999	571-3456	571-4567
2			
3			
4			
5			
6			
7			
8			
9			

Figure 22: Point-to-Point link where a Slave is called through four Repeaters

- To call a Slave radio through one or more Repeaters, that Slave must be called individually.
- With **Call All** selected, the Master will not connect with any Slave radios through Repeaters.
- The Master calls every Slave in the list and connects with the first Slave that responds.
- When calling through a Repeater, the Master must first call that Repeater and establish a communications link with it prior to making contact with the Slave.

5. Advanced Programming

The settings and scenarios covered in this section are considered advanced programming.

5.1. Working with Parallel Repeaters

When Repeaters are added to a network, plan accordingly to avoid creating a parallel Repeater scenario. A parallel Repeater is defined as two or more Repeaters linked to the same point in the network.

- Repeaters Data Transmitted on the Same Frequency Key (on page 94)
- Adding a Repeater to the Network (on page 95)

5.1.1. Repeaters Data Transmitted on the Same Frequency Key

In this diagram, the Slave radio in the middle has overlapping coverage from both the Repeaters (parallel Repeaters). Data from the Repeaters is transmitted on the same **Frequency Key** in the same time slot, which creates message collisions.

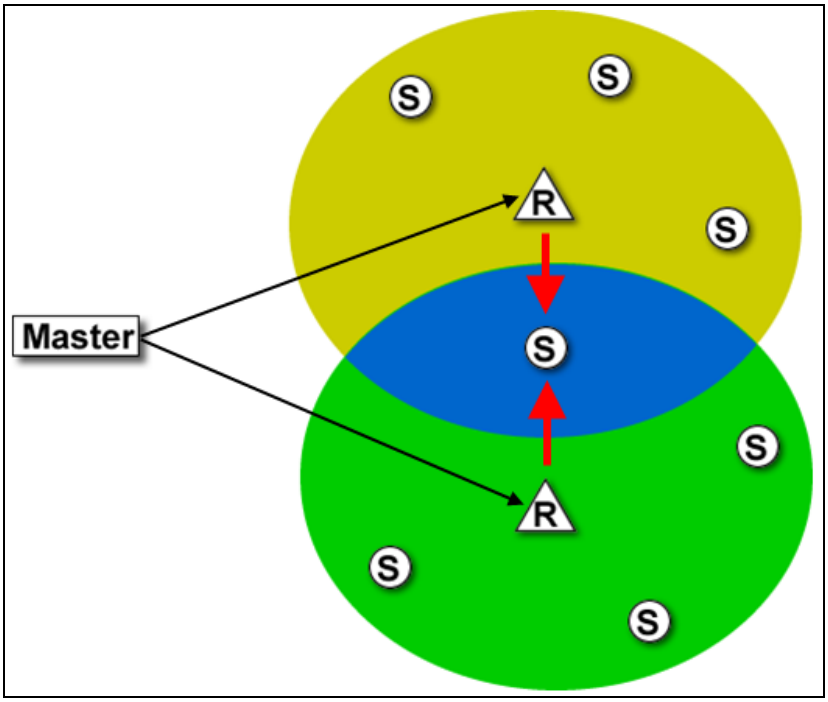


Figure 23: Slave Radio with Overlapping Coverage

To resolve this scenario, change these settings on one or more of the Repeaters in conflict:

Settings to Change on Repeaters in Conflict	
Setting	**Description**
Repeater Frequency	• Set the **Repeater Frequency** parameter in the **MultiPoint Parameters** tab to any number other than **0**. • If set to a number other than **0**, the radio uses the frequency key set in the **Frequency Key** parameter in the **Transmission Characteristics** tab, instead of the frequency key assigned to the Master.
Frequency Key	Set the **Frequency Key** parameter in the **Transmission Characteristics** tab to a key other than that of the conflicting Repeater.

5.1.2. Adding a Repeater to the Network

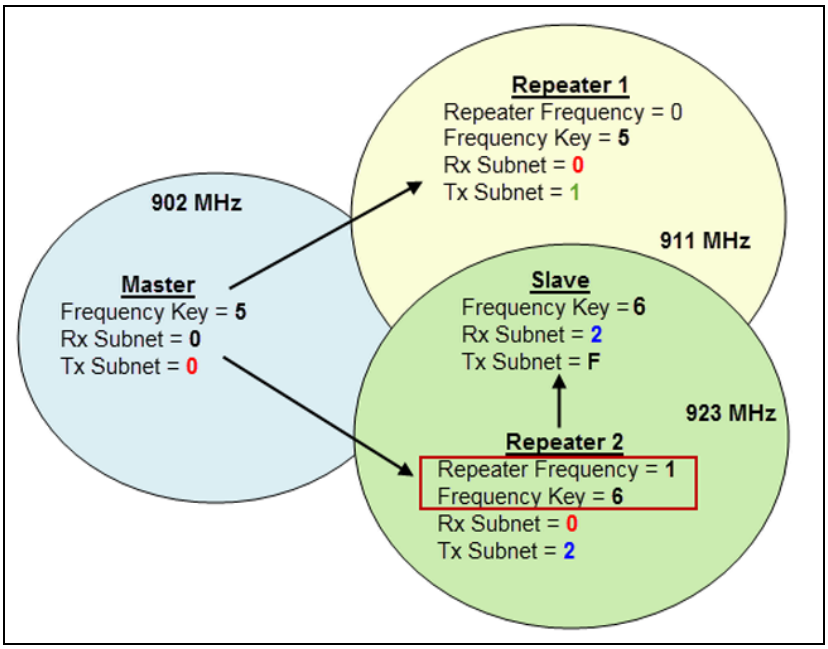


Figure 24: Repeater Added to Network

If a Repeater needs to be added to the network, use these steps to ensure any parallel Repeater issues are resolved before deploying the Repeater in the network.

1. In **Tool Suite**, run a network diagnostics file.

   Tip: Gather the settings from all the Repeaters that are currently in the network.

2. Review the network diagnostics file.
   Pay special attention to these settings on each Repeater and the Master:
   - Frequency Key
   - Repeater Frequency
   - Rx and Tx Subnet IDs
3. On a piece of paper, draw the network.
4. Note the above settings for each Repeater.
   Verify there are no duplicates.
5. If there are duplicates, change the **Repeater Frequency** and the **Frequency Key** parameters described in the table.
6. If the Repeater being adding is the only Repeater in the network, set the:
   a. **Frequency Key** parameter to match the Master.
   b. **Rx Subnet ID** parameter to match the Master's **Tx Subnet ID** parameter setting
   c. **Tx Subnet ID** parameter to **1**.
   d. In the Master, set the **Repeaters** parameter to **Enabled**.

5.2. Setting and Changing 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.

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

Warning! If the password feature is enabled and the password is forgotten, the radio MUST be returned to FreeWave to have the password disabled.

5.2.1. Setting the Password

1. On the **Setup** menu in the terminal interface, select **(8) Chg Password**.
   New PW? (<esc> to exit) appears.

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

2. Enter **exactly** four characters.
   Passwords are case sensitive.
   <Enter> to accept, <esc> to quit appears.
3. Press <Enter> to accept the password and enable the feature.
   Press <Esc> to quit the process and not enable the password.

Important!: Press <Enter> and the password appears on the line above.
The password is case sensitive and every keystroke is a character.

5.2.2. Changing a Password

1. On the **Setup** menu in the terminal interface, select **(8) Chg Password**.
   The **Enter Security Code** prompt appears.
2. Enter the current four character, case-sensitive password.
   The prompt to enter the new password appears.
3. Re-enter the new four character, case-sensitive password.

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

4. Press <Enter> to accept the password and enable the feature.
   Press <Esc> to quit the process and not enable the password.

Important!: Press <Enter> and the password appears on the line above.
The password is case sensitive and every keystroke is a character.

5.2.3. Disable a Password

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

1. On the **Setup** 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.
3. Release the <Alt> key.
4. Repeat this step three more times (hold <Alt> and type **0255** a total of 4 times).

   Important!: Type the **0255** using the NUM Pad on the keyboard, NOT the top row of numerals.
5. After the fourth entry, the password is disabled.

5.3. Enable and Set Up AES Encryption

Protecting the confidentiality, integrity, and authenticity of data communications is essential to maintaining a robust, reliable, and secure wireless infrastructure. FreeWave has incorporated a number of mechanisms to achieve these critical security objectives, including the use of AES encryption. When available and enabled, AES encryption adds a layer of 128-bit, 192-bit, or 256-bit encryption strength to the data before it is sent over the RF link.

When using AES encryption, these settings are required:

- Encryption Channel Key (on page 98).
- Encryption Key (on page 98).
- Encryption (Strength) (on page 100).

Important!: These settings are ONLY available in the **(3) Edit Radio Transmission Characteristics > (E) Encryption** menu in the terminal interface.
These settings are NOT available in **Tool Suite**.

Note: For information about accessing the **Setup** menu using the terminal interface, see Access the Setup Menu Using a Setup Terminal (on page 23).

Important!: When AES is enabled, every radio in the network must have matching encryption strengths, encryption keys, and encryption channel keys, and the **MCU Speed** parameter set to **3** for successful communication and data transmission.

5.3.1. Encryption Channel Key

Note: AES encryption settings are available only through the Setup menu in the terminal interface. If the radio does not have **Encryption** enabled, menu option **E** in the **(3) Edit Radio Transmission Characteristics** menu is blank and has no function.

Important!: This setting MUST match across all radios in the network.

Encryption Channel Key	
Setting	**Description**
Default Setting	Blank
Options	Any set of hexadecimal pairs identified in **Description**.
Terminal Menu	(3) Edit Radio Transmission Characteristics > (E) Encryption > (6) Channel Key

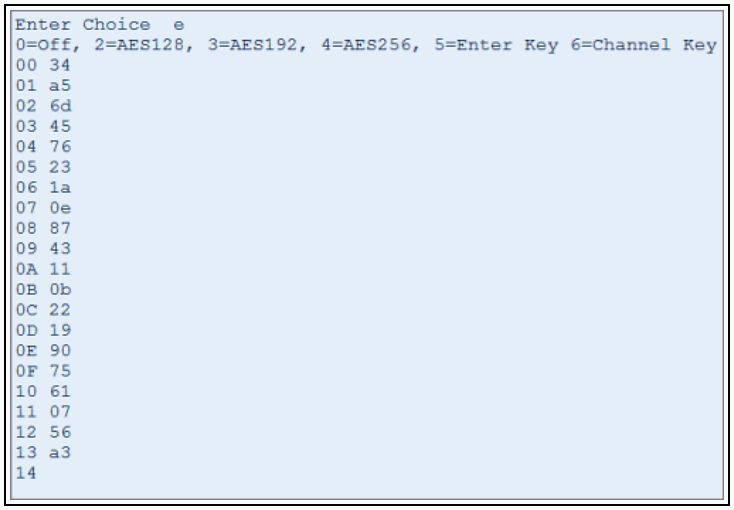
Description:	The channel key is required when AES encryption is enabled for radios in the network to link when AES encryption is enabled.
	This setting is different from the **Encryption Key** parameter because it does not encrypt the actual data but is required to match in all radios in a network for successful communication.
	Channel keys should be random and entered as hexadecimal values (e.g.,0 to F in two-character pairs). Any combination of characters can be used for the key.
	Example: A combination of numbers, or a sentence or phrase converted into hexadecimal format.
	Various string-to-hexadecimal converters are available on the Internet.
	Enter the encryption key in 2-character hexadecimal combinations in lines 00 to 07 in the lines provided.
	`Enter Choice e`
	`0=Off, 2=AES128, 3=AES192, 4=AES256, 5=Enter Key 6=Channel Key`
	`00 12`
	`01 af`
	`02 21`
	`03 43`
	`04 51`
	`05 ab`
	`06 Ac`
	`07 cD`

5.3.2. Encryption Key

Note: AES encryption settings are available only through the **Setup** menu in the terminal interface. If the radio does not have **Encryption** enabled, menu option **E** in the (3) Edit Radio Transmission Characteristics menu is blank and has no function.

Important!: This setting MUST match across all radios in the network.

Encryption Key	
Setting	**Description**
Default Setting	Blank
Options	Any set of hexadecimal pairs identified in **Description**.
Terminal Menu	(3) Edit Radio Transmission Characteristics > (E) Encryption > (5) Enter Key

Description:	The encryption key is the piece of information used to encrypt and decrypt the data sent through the network. Even with encryption, the data is only as secure as the strength of the encryption key used.
	Keys should be random and entered as hexadecimal values (i.e., 0 to F in two-character pairs). Any combination of characters can be used for the key.
	Example: A combination of numbers, or a sentence or phrase converted into hexadecimal format.
	Various string-to-hexadecimal converters are available on the Internet.
	Enter the encryption key in 2-character hexadecimal combinations in the lines provided:
	 
	The **Enter Key** option always asks for all 32 lines of the encryption key. However, the encryption strength you select determines how many of the lines are required:
	• **128-bit encryption** - Enter key information in rows 00 to 0F.
	  • The last 16 lines (10 to 1F) are ignored.
	• **192-bit encryption** - Enter key information in rows 00 to 17.
	  • The last 8 entries (18 to 1F) are ignored.
	• **256-bit encryption** - Enter key information in rows 00 to 1F.
	  • All lines are used.

5.3.3. Encryption (Strength)

Note: AES encryption settings are available only through the **Setup** menu in the terminal interface. If the radio does not have **Encryption** enabled, menu option **E** in the **(3) Edit Radio Transmission Characteristics** menu is blank and has no function.

Important!: This setting MUST match across all radios in the network.

Encryption (Strength)	
Setting	**Description**
Default Setting	(0) Off
Options	• **(0) Off** - Turns off AES encryption. • **(2) AES 128** - Enables AES encryption, 128-bit strength. • **(3) AES 192** - Enables AES encryption, 192-bit strength. • **(4) AES 256** - Enables AES encryption, 256-bit strength. The options available for selection are based on the encryption strength set at the factory, or within the upgrade to use AES completed with FreeWave technical support's assistance. **Example**: If the radio is factory set to include AES 256, then each strength option is available. However, if the radio is factory set to include AES 192, then only **Off**, **AES 128**, and **AES 192** are available. **Note**: Selecting any option other than `(0) Off` enables AES encryption. The encryption key and the channel key are required for successful communication.
Terminal Menu	(3) Edit Radio Transmission Characteristics > (E) Encryption
Description:	AES encryption is available in various strengths. • The network and the data being sent determine the encryption strength used. • The higher the encryption strength, the stronger the encryption although it can also take longer for the encryption and un-encryption to take place.

5.3.4. Troubleshooting AES Setup

The radios link, transmit data, and then unlink.

- Verify that the **MCU Speed** parameter is set to **3** in the terminal interface.

The radios link, transmit data, but the data is in unrecognizable characters.

- Verify that the **Encryption Key** on each radio is set exactly the same. If the keys do not match, the radios can still transmit data, but cannot decrypt the data.

The radios do not link and the golden settings are all set the same.

- Verify that the **Channel Key** in the Encryption menu is set the same across the radios in the network. If the keys do not match, the radios will not link when AES is enabled, even if the golden settings match.

5.4. Low Baud Rates

The radio's Baud Rate may be set to 300, 600, or 900.

> **Note**: For more information about using a low baud rate, Contact FreeWave Technical Support (on page 8).

5.5. Multi-Master Sync

The **Multi-Master Sync** setting is reserved for applications in both Point-to-Point and MultiPoint modes with concentrations of Master units where it is necessary to reduce interference between the Master radios.

- For more information about using **Multi-Master Sync** in non-TDMA mode, see **Application Note #5412, Synchronizing Collocated Masters**.

> **Note**: For more information about using **Multi-Master Sync** while in TDMA mode, contact FreeWave Technical Support.
> See Contact FreeWave Technical Support (on page 8).

5.6. Time Divisible Multiple Access (TDMA)

- Available as an optional, add-on feature, the FreeWave Time Division Multiple Access (TDMA) protocol is an enhanced and sophisticated version of Point-to-MultiPoint communications.
- The TDMA protocol provides timing and other parameters, which in turn allow large radio networks to work in a non-polled environment.

> **Important!**: This option is only used for peer-to-peer communications or when applications are very time specific. If you purchase TDMA as an option, additional information is provided to you about implementing and using the feature.

> **Note**: For additional information about TDMA, contact FreeWave Technical Support.
> See Contact FreeWave Technical Support (on page 8).

6. Viewing Radio Statistics

When reading a radio, 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 time the Master and Slave link and are reset when the next link begins.

More data transmission characteristics are available, including averages gathered over time, in the **Network Diagnostics** application.

Note: For information about running network diagnostics see the **Tool Suite** User Manual.

6.1. View Statistics in Tool Suite

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.

6.2. View the Radio Transmission Characteristics in the Terminal Interface

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

6.2.1. Antenna Reflected Power

This is a measurement of the transmitted power that is reflected back into the radio from mismatched antennas or cables, or loose connections between the radio and antenna.

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 reason for a higher **Antenna Reflected Power** reading is a cable issue between the radio and the antenna: loose connections, cable kinks, breaks in cable shielding, moisture in the fittings or connections, etc.

Less commonly, a high **Antenna Reflected Power** reading can indicate a hardware problem with the radio itself, such as a damaged RF connector. Lastly, a high reading may indicate a problem with the antenna itself, although antenna problems are the least likely indicator.

Note: See VSWR (on page 103) for additional information.

VSWR

This is a reference between the Antenna Reflected Power reading in Menu 4 of the FGR3-C-U or FGR3-CE-U and the VSWR ratio.

This table provides a reference between Antenna Reflected Power and a VSWR ratio.

Important!: Set the Transmit Power (on page 56) of the FGR3-C-U or FGR3-CE-U to `10` to get an accurate reading.

Antenna Reflected Power	VSWR
131	8.7
91	4.4
65	3.0
48	2.3
33	1.9
21	1.7
15	1.5
10	1.4
6	1.3
4	1.2

- VSWR ratios of 1.9:1 (1.9 to 1) and lower are considered marginal to good.
- Ratios higher than 1.9:1 are considered poor and problematic.
- If the ratio is greater than 1.9:1 this indicates an issue with the antenna cable or antenna.

6.2.2. Master-Slave Distance

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).

6.2.3. 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 900MHz Frequency Zones Table (on page 43).
If viewing statistics in the terminal interface, press <Enter> when the **Radio Statistics** menu appears.

- Ideally, the difference between the average signal level and average noise level should be **15** or more.
- Margins that are significantly lower than this are an indication of a high level of interference that may degrade the performance of the link.

6.2.4. Number of Disconnects

The value in this 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**.
- 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**.

6.2.5. 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 -40° to +75° C.

6.2.6. Rate % (Receive Percentage 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. 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.

6.2.7. 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 15 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 900MHz Frequency Zones Table (on page 43).
If viewing statistics in the terminal interface, press <Enter> when the **Radio Statistics** menu appears.

6.2.8. Transmit Current

The **Transmit Current** measures the current draw of the transmitter in milliamps (mA). See the radio specifications for typical values.

7. Approved Antennas

7.1. 900MHz Yagi Directional Antennas

Note: The FGR3-C-U or FGR3-CE-U is approved by the FCC for use with directional antennas with an 8.6 dBi gain or less.

900MHz Yagi Directional Antennas			
Gain (dBi)	**Manufacturer**	**Manufacturer Model Number**	**FreeWave Model Number**
8	Larsen	YA6-900	EAN0906YA
8.6	Bluewave	BMY890G5502N4	EAN0906YC
8.6	WaveLink	PRO890-8	EAN0906YC

7.2. 900MHz Omni-directional Antennas

Note: The FGR3-C-U or FGR3-CE-U is approved by the FCC for use with omni-directional antennas with a 8.15 dBi gain or less.

900MHz Omni-directional Antennas			
Gain (dBi)	**Manufacturer**	**Manufacturer Model Number**	**FreeWave Model Number**
3	Mobile Mark	PSKN3-925S	EAN0900SR
3	Maxrad	MAX-9053	EAN0900WC
5	Antennex	EB8965C	EAN0905WC
5	Maxrad	BMEFC8985HD	EAN0905WC
8.15	Antennex	FG9026	EAN0906NF

8. FGR3 Wireless Data Radios Pinouts

8.1. Operational RS422 and RS485 Information

For RS-422 and RS-485, the FreeWave radio can drive 32 standard unit loads and loads the bus with only 1/8 unit load. A maximum of 256 devices can be tied on the bus if all of the line receivers have 1/8 unit load.

- RS-422 is used for 4-wire or full duplex communications with one Master radio 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 5th wire for data common.

An RS-485 full duplex using 4 wire plus common is the same as RS-422, except the system can have multiple Masters on the bus.

When setting the radio to RS-485:

1. Enable Modbus.
2. Set the **Master Packet Repeat** parameter to **3** in the radios that will use RS-485.
3. Set the **Turn Off Delay** parameter to **4**.

8.2. Pinout Assignments and Descriptions

- 20-Pin Diagnostics Connector Pinout (on page 110)
- RF Board Level Pinout (on page 111)
- Waterproof Enclosure Pinout

8.3. 20-Pin Diagnostics Connector Pinout

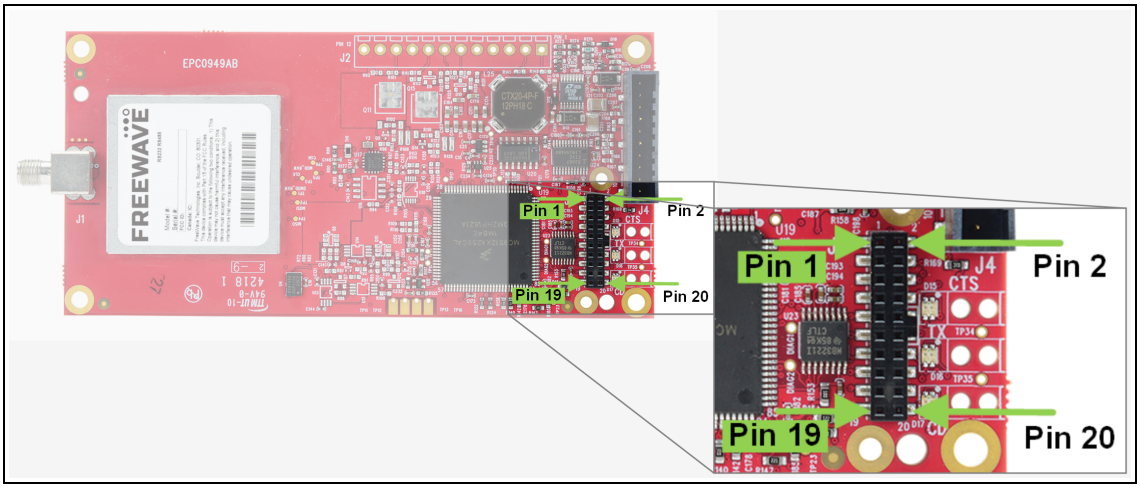


Figure 25: 20-Pin Diagnostics Connector Pinout

Note: Pins listed with no assignment are for internal FreeWave use only.

Pin	Assignment	Pin	Assignment
1	GND	11	—
2	GDN	12	Remote Tx
3	Diag Tx	13	—
4	Diag Rx	14	—
5	—	15	Remote CTS-a
6	—	16	Remote CTS-b
7	—	17	Remote CD-a
8	—	18	Remote CD-b
9	—	19	GND
10	—	20	—

8.4. RF Board Level Pinout

The board-level radios are available in both TTL and RS232 versions. The TTL version uses 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 version uses 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.
- Pin 1 on the board-level radio is the pin farthest from the three LEDs and pin 10 is closest to the LEDs.

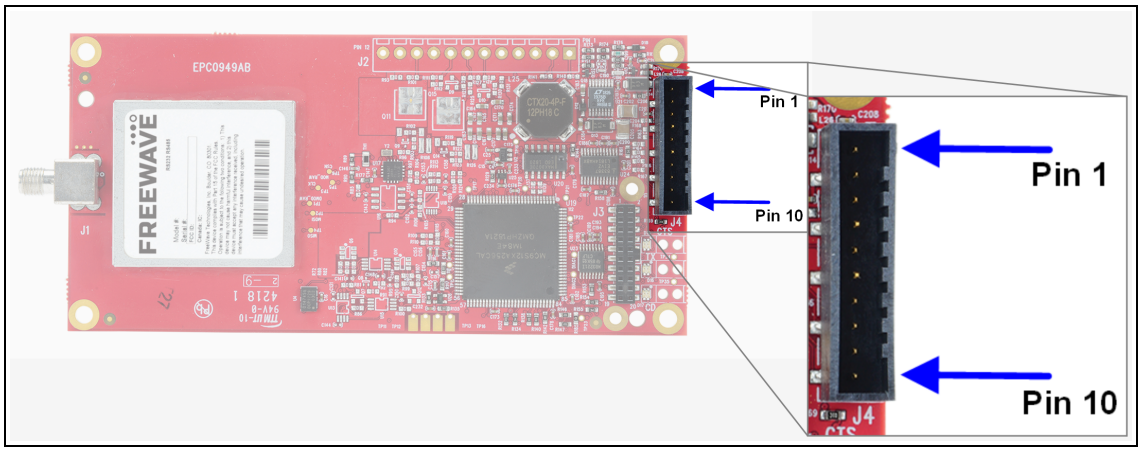


Figure 26: FGR3-C-U or FGR3-CE-U Pin Layout

RF Board Level Pinout

Pin	Assignment	Signal	ACS3610xx Cable Color
1	B+ input	Power	Red
2	Interrupt (temporarily ground to invoke menu)	Input	Brown
3	Data Terminal Ready (DTR)	Input	Orange
4	Ground		Black
5	Transmit Data (TXD)	Output	Yellow
6	Ground		Black
7	Receive Data (RXD)	Input	Green
8	Carrier Detect (DCD)	Output	Blue
9	Request to Send (RTS)	Input	Violet (purple)
10	Clear to Send (CTS)	Output	Gray

8.5. RS-232 Pin Assignments (DE-9)

RS232 Pin Assignments (DE-9)			
Pin	**Assignment**	**Signal**	**Description**
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. Indicates power is on to the radio. Also, this pin can be used for +12.0 Volts when powering the radios directly through the RS232 port. **Important!**: 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 a risk of lost data may occur if an RF link is not very robust.
9	GND - Ground		Signal return for all signal lines shared with Pin 5.

8.6. RS422 and RS485 Full Duplex Pinouts

RS422 and RS485 Full Duplex Pinouts		
Function	**Bare Board Pin Number**	**DE-9 Pin Number**
RX+	7	3
RX-	9	7
TX+	5	2
TX-	10	8
Signal Ground	4 or 6	5

8.7. RS485 Half Duplex Pinouts

RS485 Half Duplex Pin-Outs		
Function	**Bare Board Pin Number**	**DE-9 Pin Number**
Wire to both pins 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. Troubleshooting

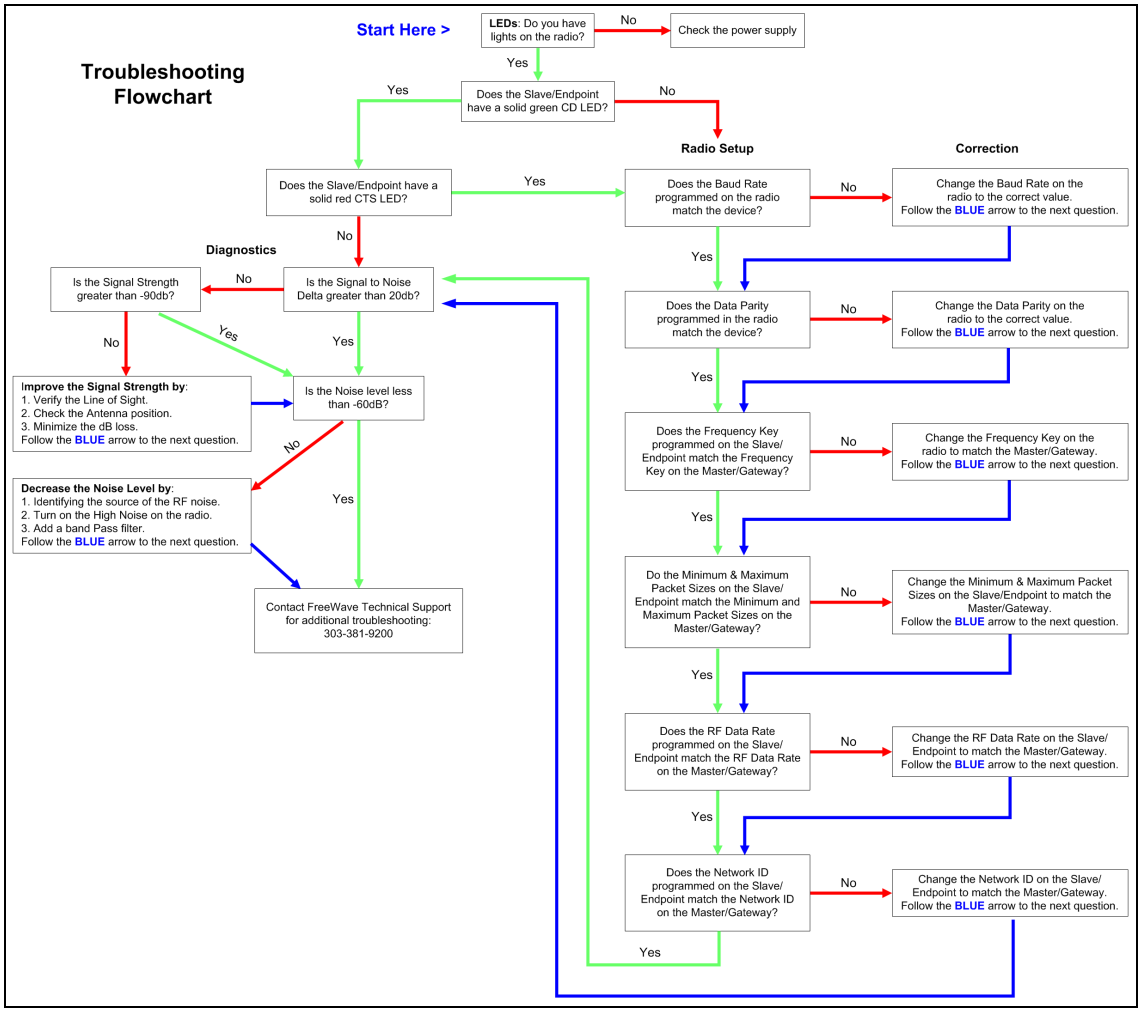
If experiencing trouble with the network, see these sections to initially troubleshoot and help identify the problem with the network or a radio within it:

- LEDs on the radio.
  - Point-to-MultiPoint Operation LEDs (on page 131).
  - Point-to-Point Operation LEDs (on page 132).
- Settings
- RF Quality

Use the Troubleshooting Flowchart (on page 115) for basic checks to help diagnose the issue.

Note: Contact FreeWave Technical Support (on page 8) for assistance.

9.1. Troubleshooting Flowchart



9.2. General Troubleshooting

Note: For AES encryption troubleshooting tips, see Troubleshooting AES Setup on page 100.

The radio does not stay in Setup mode and cannot be programmed through the diagnostics port.
When I try to place the radio into Setup mode, all three LEDs flash green, and then return to their previous state.

Additional symptoms of this problem include:

	Carrier Detect (CD)	Transmit (Tx)	Clear to Send (CTS)
MultiPoint Master	Solid red bright	Solid red dim	Off
MultiPoint Slave (unlinked)	Solid red bright	Off	Blinking red
MultiPoint Slave (linked)	Solid green	Off	Solid red bright
Point-to-Point Master (unlinked)	Solid red bright	Solid red dim	Solid red bright
Point-to-Point Master or Slave	Solid green	Intermittent flash red	Intermittent flash red

Two scenarios could be causing the radio to not enter **Setup** mode.

The radio is wired for RS485 and Pins 5 and 7 on a board-level radio, or Pins 2 and 3 on an enclosed radio(or one with a DE-9 connector) are shorted together.

1. Separate the wires and place the radio into **Setup**.
2. On the **Baud Rate** tab, change the **Setup Port** parameter to **Diagnostic Only**.

   If there is a data source (PLC, RTU, PC, or Terminal Server) connected to the data port, data is coming into the data port while trying to access **Setup** through the diagnostics port.
3. Disconnect the data source and place the radio into **Setup**.
4. On the **Baud Rate** tab, change the **Setup Port** parameter to **Diagnostic Only**.

My radios are linked, but I cannot pass data.

Verify that the **Baud Rate** and **Data Parity** settings match between devices.

We recently had a bad storm with lots of lightning and my radio has not worked since. I have replaced the radio but it still does not link.

Verify that the coax cable or antenna were not damaged in the storm.

I have a new network. My radios are linked but I am not able to pass data. Company X has had a FreeWave network out here in the same area for a long time and they are not having issues. What is wrong?

Your network is likely using the default settings for **Frequency Key**, **Network IDs**, **Minimum Packet Size**, and **Maximum Packet Size**. Refer to the user manual for the added radio and change the settings from the default settings.

Most of my sites report in and I can poll, but I cannot poll any of the Slaves that talk back to Repeater 2.

Repeater 2 is experiencing high noise.

My network has been running flawlessly for the last 2 years. Now, all of a sudden, I have a group of Slaves that I cannot poll.

A Parallel Repeater has likely been added or changed in the network and has the same frequency settings and is now interfering with the other Repeater. Program the new Repeater with a different set of parameters.

My network keeps locking up. If I cycle power on the Master, the network is restored and I can poll again until the next time the network locks up.

There is a chatty Slave in the network. The Slave is not getting acknowledgment of data it sends to the Master and keeps trying to resend data to the Master locking out all other communications to the Master. This is typically caused by a bad signal from the Slave to the Master. Verify line of sight, antenna direction, and noise levels at the Slave.

I installed a new Slave in my network, but I cannot get it to link. The CD light is solid red and the CTS light is blinking red.

This is either an LOS (Line of Sight) issue or settings issue.

I have a site that used to perform flawlessly. Now I cannot reliably get data from the RTU at this site.

Antenna reflected power is causing a problem. Reflected power may be caused by defects or damage in the antenna, cabling, connections, etc. Verify that the cabling, connectors, and the antenna are connected correctly and have not sustained any damage.

When I connect directly to my RTU I am able to poll data successfully. When I add in the radios, I cannot get any data from my poll.

A baud rate above 38,400 may need a flow control line connected.

9.3. Unlicensed Serial Radio - Specific Troubleshooting

My Master radio is receiving odd or incorrect data after a poll request.

Several scenarios can cause radios in the network to send odd or incorrect data back to the Master radio.

FGR2 radios running firmware versions prior to 8.74 have a known issue in RS485 mode that echoes data back to the Master radio.

1. In **Tool Suite**, save a network diagnostic file for the network.
2. Review the file to find any radios that are running firmware versions older than 8.74.
3. Upgrade those radios to the latest version of firmware available.

Note: For more information, see Upgrade the Radios to the Latest Software Version (on page 25).

There is a serial interface mismatch between the site, the device, or the radio.

1. In **Tool Suite**, save a network diagnostic file for the network.
2. Scan the file for serial radios with a **Serial Interface** parameter set to **RS232**.
3. For RS232 radios, look at the **Data TX** information in the summary view for any radio that has an excessively high Data TX.
4. Search for one or more sites that increase the data count by the number of bytes contained in the poll request.

   Example: If a poll is 64 bytes, the data poll increases by 64 bytes after the poll.

5. The identified sites may be configured as RS232, but wired as RS485. Send a technician to the site to verify the wiring.
6. If the site is wired for RS485 and the device connected to the radio is an RS485 device, correct these parameter settings on the **Baud Rate** tab. Send these new settings to the radio:

Parameter	New Setting
Serial Interface	RS485
Setup Port	Diagnostics Only
Modbus RTU	1
Turn Off Delay	4

7. If the site is wired for RS485 and device connected requires RS232, correct the wiring from the radio to the device.
   - Pin 5 on the FreeWave radio to device RX.
   - Pin 7 on the FreeWave radio to device TX.
   - Pin 6 on the FreeWave radio to device signal ground.

10. Release Notes

These sections describe the updates and known limitations in each software version for the FGR3 Wireless Data Radios. The most recent version is listed first.

The latest firmware and software versions and the most recent list of known limitations and workarounds are available on www.freewave.com.

10.1. Version 11.0.08 (Initial Release)

Release Date: April, 2019

Additions and Changes

- FGR3-C-U or FGR3-CE-U is designed to have identical operation to FGR2-C/CE-U v10.7.04
- Methods for determining power consumption have changed from prior product releases.
- Do not use the power consumption from the FGR2-C-U and FGR2-CE-U radios for comparison purposes to FGR3-C-U or FGR3-CE-U

Known Limitations and Workarounds

- Remote LED functionality on enclosed radios requires the Remote LED (on page 51) parameter to be enabled for enclosure LEDs to operate.
  - The LED behavior is not changed for board-level radios.
- In the **Operation Mode** tab in **Tool Suite** (**Modem Mode** menu in the terminal interface), Ethernet parameters are visible.
  - These options do NOT apply to the FGR3-C-U or FGR3-CE-U.

- TDMA functionality **MUST BE** programmed through a terminal and **cannot** be programmed correctly using **Tool Suite**.
- When using the terminal to program a device, entering invalid options can sometimes cause the radio to behave unpredictably.

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**
Type	Frequency Hopping Spread Spectrum
Modulation	2 level GFSK
Data Throughput	• 80 kbps, standard speed • 115.2 kbps, high speed
Error Detection	32-bit CRC, retransmit on error
Data Encryption	• Options: 128-, 192-, and 256-bit AES encryption • Proprietary Spread Spectrum Technology
Hopping Bands	7, user selectable
Hopping Channels	50 to 110, user selectable
Hopping Patterns	• 15 per band, 105 total • user selectable
Hopping Zones	16 zones, user selectable
Protocol	RS232 / RS422 / RS485

General Information

General Information	
Specification	**Description**
Operating Temperature	• -40°C to +75°C • -40°F to +167°F
Humidity	0 to 95% non-condensing
Dimensions	• **FGR3-C-U**: 127 L x 61 W x 12 H (mm) 5.0 L x 2.4 W x 0.47 H (in.) • **FGR3-CE-U**: 173 L x 107 W x 35 H (mm) 6.81 L x 4.21 W x 1.38 H (in.)
Weight	• **FGR3-C-U**: 58g (0.13 lbs) • **FGR3-CE-U**: 504g (1.1 lbs)
Enclosure	• FGR3-C-U: None. Board-level • FGR3-CE-U: Extruded aluminum
Reliability	MTBF: 200,000 hours
Safety	Class I, Division 2, Groups A-D
FCC	Part 15

Interfaces

Interfaces	
Specification	**Description**
Data Interface	• Serial, 1200 bps to 230.4 kbps, DCE • **FGR3-C-U**: 10-pin shrouded header for power and data, 2mm pin spacing • **FGR3-CE-U**: DE-9
Diagnostics Interface	Serial, RS232, or TTL • **FGR3-C-U**: 20-pin header • **FGR3-CE-U**: 3-pin plug
RF Connector	• **FGR3-C-U**: SMA Female • **FGR3-CE-U**: TNC Female

Power Requirements

Power Requirements	
Specification	**Description**
Operating Voltage	+6 to +30 VDC
Current Consumption, Typical	**Note**: All measurements at 25°C in Point-to-Multipoint mode with min packet size 0, max packet size 9.

Voltage	Transmit	Receive	Idle, Linked Slave	Idle, Linked Master
+6 VDC	192 mA	74 mA	73 mA	118 mA
+12 VDC	101 mA	42 mA	42 mA	63 mA
+30 VDC	47 mA	22 mA	22 mA	32 mA

Receiver

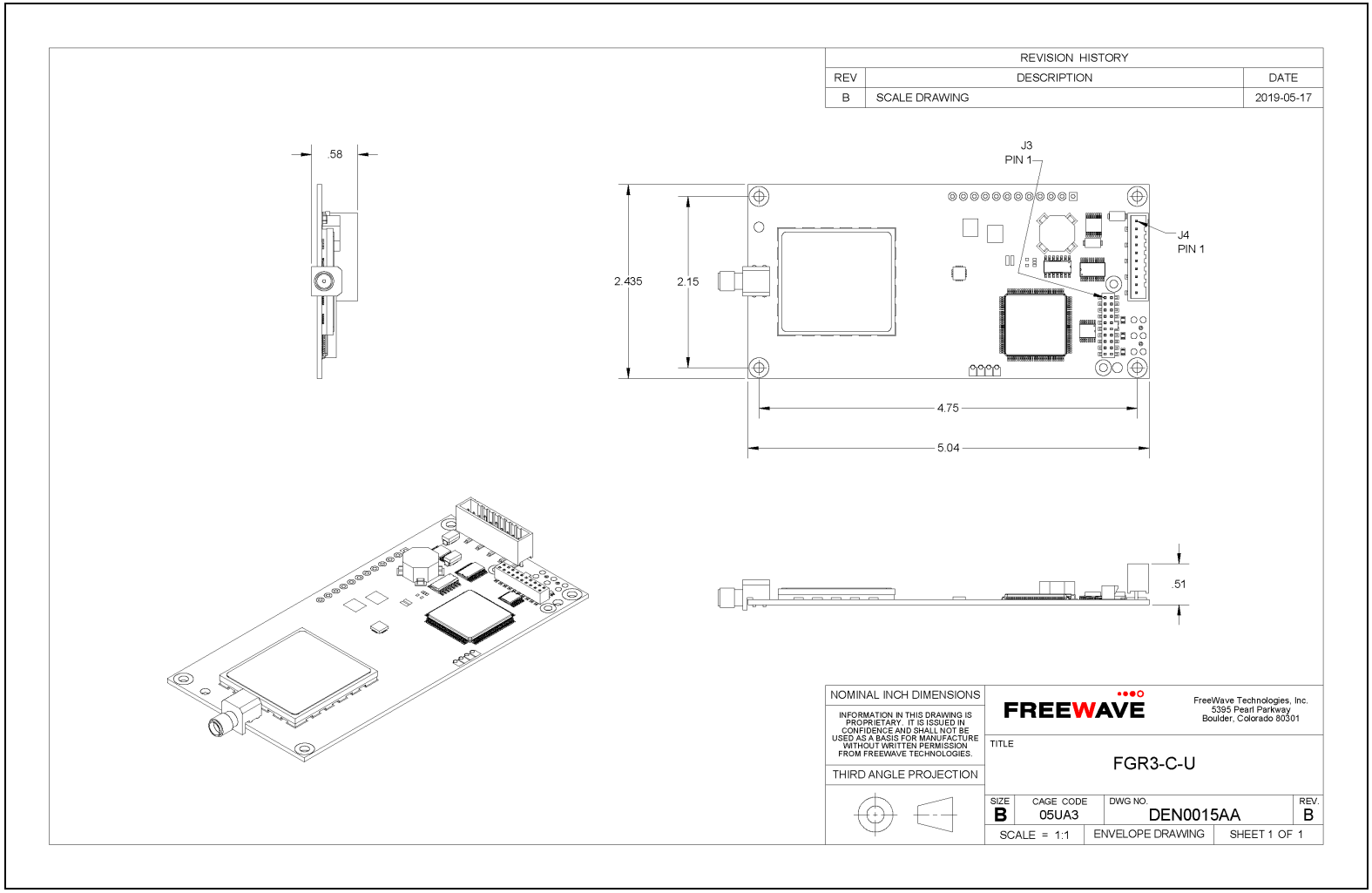
Receiver	
Specification	**Description**
Sensitivity	• -107 dBm @ 115.2 kbps for BER 10^{-4} • -104 dBm @ 153.6 kbps for BER 10^{-4}
IF Selectivity	40 dB at fc +/- 460 kHz
RF Selectivity	> 60 dB
Maximum Input Power	+10 dBm

Transmitter

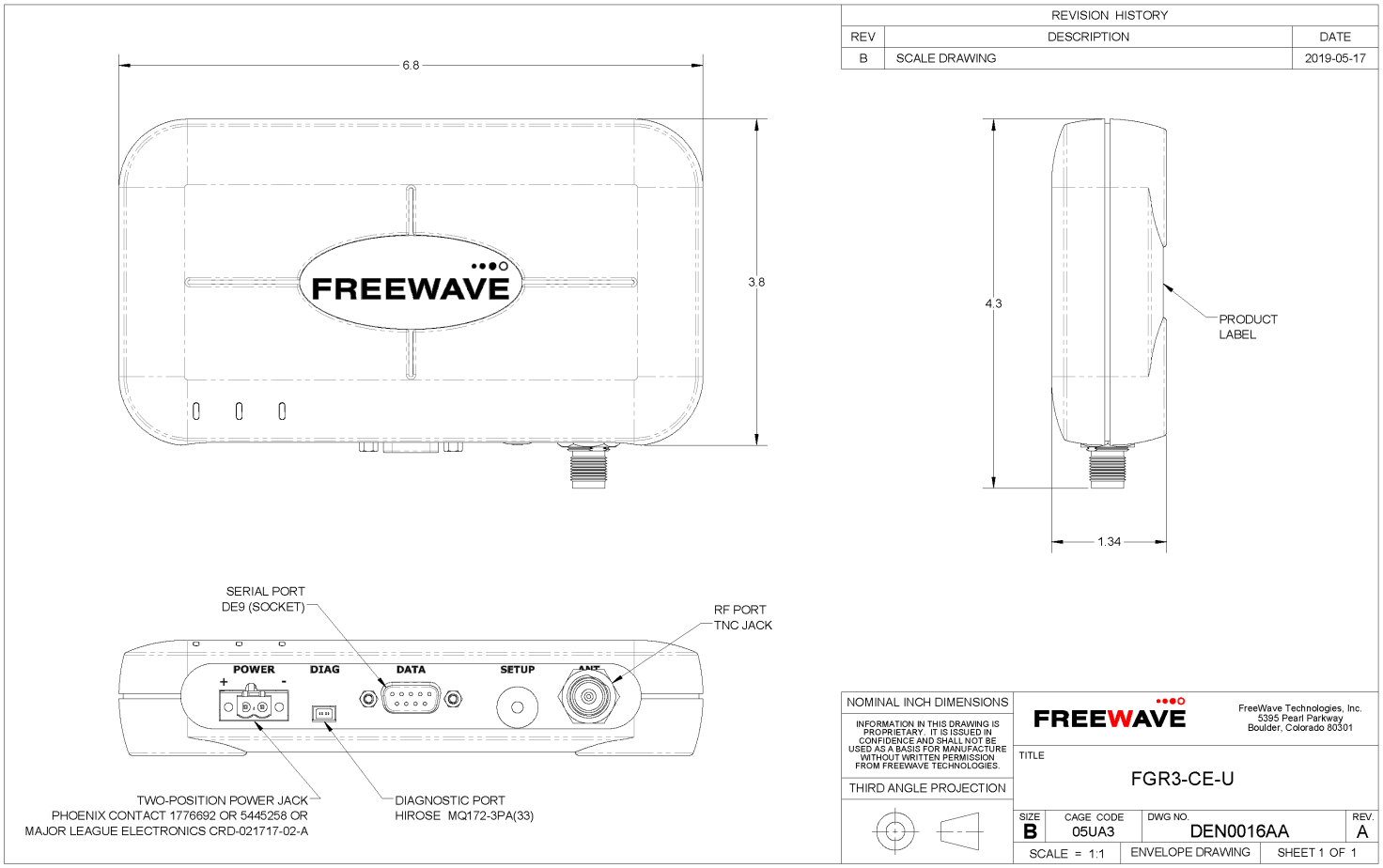
Transmitter	
Specification	**Description**
Frequency Range	902 to 928 MHz
Output Power	Up to 1 W
Range	97 km (60 miles), clear line of sight
Channel Spacing	230 kHz
RF Data Rate	• 115.2 kbps, standard speed • 153.6 kbps, high speed • user selectable

Appendix B: Mechanical Drawings

FGR3-C-U Mechanical Drawing



FGR3-CE-U Mechanical Drawing



Appendix C: 900MHz Factory Default Settings

900MHz Factory Default Settings			
Operation Mode	**Default**	**MultiPoint Parameters**	**Default**
Point-to-Point Slave	1	(0) Number of Repeaters	1
Set Baud Rate	Default	(1) Master Packet Repeat	2
Baud Rate	115200	(2) Max Slave Retry	9
(A) Data Parity	0	(3) Retry Odds	9
(B) Modbus RTU	0	(4) DTR Connect	0
(C) RS232/485	0	(5) Repeatr Frequency	0
(D) Setup Port	3	(6) Network ID	255
(E) Turn Off Delay / On Delay	0/0	(7) Reserved	-
(F) Flow Control	0	(8) MultiMaster Sync	0
Radio Parameters	Default	(9) 1 PPS Enable Delay	255
(0) Freq Key	5	(A) Slave/Repeater	0
(0) Hop Table Version	0	(B) Diagnostics	0
(1) Hop Table Size	112	(C) Subnext ID	“Disabled”
(2) Hop Freq Offset	0	Rx ID	F
(3) Frequency Zone	All 1s (Enabled)	Tx ID	F
(4) Government Rules	0	(D) Radio ID	Not Set
(1) Max Packet Size	8	(E) Local Access	0
(2) Min Packet Size	9	(G) Radio Name	"blank"

900MHz Factory Default Settings			
Operation Mode	**Default**	**MultiPoint Parameters**	**Default**
(3) Xmit rate	1		
(4) RF Data Rate	3		
(5) RF Xmit Power	10		
(6) Slave Security	0		
(7) RTS to CTS	0		
(8) Retry Timeout	255		
(9) Low Power Mode	0		
(A) High Noise	0		
(B) MCU Speed	0		
(C) Remote LED	0		
(E) Encryption			
Strength	(0) Off		
Enter Key	Blank		
Channel Key	Blank		

Appendix D: LEDs

Point-to-MultiPoint Operation LEDs

	Master			Slave			Repeater		
Condition	**Carrier Detect (CD)**	**Transmit (Tx)**	**Clear to Send (CTS)***	**Carrier Detect (CD)**	**Transmit (Tx)**	**Clear to Send (CTS)***	**Carrier Detect (CD)**	**Transmit (Tx)**	**Clear to Send (CTS)***
Powered, not linked	Solid 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.

Point-to-Point Operation LEDs

	Master			Slave			Repeater		
Condition	**Carrier Detect (CD)**	**Transmit (Tx)**	**Clear to Send (CTS)**	**Carrier Detect (CD)**	**Transmit (Tx)**	**Clear to Send (CTS)**	**Carrier Detect (CD)**	**Transmit (Tx)**	**Clear to Send (CTS)**
Powered, 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 E: 900MHz Channel Frequency IDs

Note: See 900MHz Channel Select Parameters (on page 38) for additional information.

900MHz Channel Frequency IDs

ID	Frequency		ID	Frequency		ID	Frequency
0	902.2464		40	911.4624		80	920.6784
1	902.4768		41	911.6928		81	920.9088
2	902.7072		42	911.9232		82	921.1392
3	902.9376		43	912.1536		83	921.3696
4	903.1680		44	912.3840		84	921.6000
5	903.3984		45	912.6144		85	921.8304
6	903.6288		46	912.8448		86	922.0608
7	903.8592		47	913.0752		87	922.2912
8	904.0896		48	913.3056		88	922.5216
9	904.3200		49	913.5360		89	922.7520
10	904.5504		50	913.7664		90	922.9824
11	904.7808		51	913.9968		91	923.2128
12	905.0112		52	914.2272		92	923.4432
13	905.2416		53	914.4576		93	923.6736
14	905.4720		54	914.6880		94	923.9040
15	905.7024		55	914.9184		95	924.1344

900MHz Channel Frequency IDs							
ID	**Frequency**		**ID**	**Frequency**		**ID**	**Frequency**
16	905.9328		56	915.1488		96	924.3648
17	906.1632		57	915.3792		97	924.5952
18	906.3936		58	915.6096		98	924.8256
19	906.6240		59	915.8400		99	925.0560
20	906.8544		60	916.0704		100	925.2864
21	907.0848		61	916.3008		101	925.5168
22	907.3152		62	916.5312		102	925.7472
23	907.5456		63	916.7616		103	925.9776
24	907.7760		64	916.9920		104	926.2080
25	908.0064		65	917.2224		105	926.4384
26	908.2368		66	917.4528		106	926.6688
27	908.4672		67	917.6832		107	926.8992
28	908.6976		68	917.9136		108	927.1296
29	908.9280		69	918.1440		109	927.3600
30	909.1584		70	918.3744		110	927.5904
31	909.3888		71	918.6048		111	927.8208
32	909.6192		72	918.8352			
33	909.8496		73	919.0656			
34	910.0800		74	919.2960			
35	910.3104		75	919.5264			
36	910.5408		76	919.7568			
37	910.7712		77	919.9872			
38	911.0016		78	920.2176			
39	911.2320		79	920.4480			

Appendix F: 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.

FCC Notifications

Supplier's Declaration of Conformity

Model numbers: FGR3-C-U, FGR3-CE-U

Company contact information: 5395 Pearl Parkway, Boulder, CO 80301

Phone number: 303.381.9200

Website: www.FreeWave.com

This device complies with Part 15 of the FCC rules. Operation is subject to the following two conditions: 1) This device may not cause harmful interference and 2) this device must accept any interference received, including interference that may cause undesired operation.

The content of this guide covers FreeWave Technologies, Inc. models sold under FCC ID: KNYFGR3.

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 antennas used MUST have a separation distance of at least 22.4 cm from all persons and MUST NOT be co-located or operate in conjunction with any other antenna or transmitter.

FCC 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 FCC: KNYFGR3**".

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 22.4 cm between the radiator and your body.

FCC Notification of Power Warning

The FGR3 Wireless Data Radios covered in this document has a maximum transmitted output power of 1000mW.

The antennas used MUST provide a separation distance of at least 22.4 cm from all persons and MUST NOT be co-located or operate in conjunction with any other antenna or transmitter.

ISED 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-FGR3.

ISED 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-FGR3**".

ISED 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 13.1 inches (33.3 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 13.1 pouces (33.3 cm) séparant l'antenne d'une personne présente en conformité avec les limites permises d'exposition du grand public.

Professional Installation

All models sold under the listed IC ID must be professionally installed.

Detachable Antenna Usage

This radio transmitter 2329B-FGR3 has been approved by ISED to operate with the antenna types listed in the Approved Antennas List (on page 137) with maximum permissible gain indicated.

Le présent émetteur radio 2329B-FGR3 a été approuvé par ISED pour fonctionner avec les types d'antenne énumérés dans le Approved Antennas List (on page 137) et ayant un gain admissible maximal.

Important!: Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.
Les types d'antenne non inclus dans cette liste, et dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.

Approved Antennas List

Approved Antennas List		
Antenna Type	**Maximum Gain (dBi)**	**Impedance (Ohms)**
Yagi Directional	8.6	50
Omni-directional	8.15	50

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.

Hazardous Locations and UL Notifications:

Electrical Rating: 6-30Vdc, 644-125 mA.

Ambient Temperature Rating: -40°C to 75°C

Temperature Code (T-Code): T5

- Suitable for use in Class I, Division 2, Groups A-D hazardous locations or non-hazardous locations only.
- These devices are open type devices that are intended to be installed in a tool-only accessible enclosure that is suitable for the environment.

Warning! EXPLOSION HAZARD! – DO NOT DISCONNECT EQUIPMENT WHILE THE CIRCUIT IS LIVE OR UNLESS THE AREA IS KNOWN TO BE FREE OF IGNITABLE CONCENTRATIONS.
AVERTISSEMENT - RISQUE D'EXPLOSION. NE PAS DÉBRANCHER PENDANT QUE LE CIRCUIT EST SOUS TENSION OU À MOINS QUE L'EMPLACEMENT NE SOIT EXEMPT DE CONCENTRATIONS INFLAMMABLES.

- Antennas intended for use in Class I, Division 2 hazardous locations must be installed within the end use enclosure for remote mounting in an unclassified location, routing and installation of the antennas shall be in accordance with National Electrical Code requirements (NEC/CEC).
- The “DIAG” port may only be accessed for equipment set-up, installation, and maintenance within non-hazardous location. This port and its associated interconnecting cable shall remain inaccessible within the hazardous location.
- Power Adapter (optionally provided with the product) shall not be used in the hazardous location. If a power adapter is provided with the equipment, the adapter and associated wiring harness may only be used in a non-hazardous (unclassified) location.
- The product is to be supplied by an adapter having output which is PS2/ES1 limited (LPS or NEC Class 2).
- When used with external power supply by Kuantech Co., Ltd. KSAS01212000080HU, the power supply shall be located within a maximum 50°C ambient.
  Lorsqu'il est utilisé avec une alimentation externe par Kuantech Co., Ltd KSAS01212000080HU, l'alimentation doit être située dans une temperature ambiante maximale de 50°C.

- When used with external power supply by Shenzhen Mingxin Power Technologies Co Ltd. MX15 series, the power supply shall be located within a maximum 40°C ambient.
  Lorsqu'elle est utilisée avec une source d'alimentation externe par la série MX15 de Shenzhen Mingxin Power Technologies Co., l'alimentation doit être située dans une plage de température ambiante maximale de 40 ° C.
- Antenna Terminal is not evaluated for connection to an external circuit.
  External circuit connection of antenna requires installation of a surge suppression at building entry points and that the outer conductor of the coaxial cable is grounded in accordance with NEC/CEC or local electrical code requirements.
- FGR3-C-U is a Recognized component under UL File Numbers: E484141.AZOW and E327789.AZOT
- FGR3-CE-U is a Listed component under UL File Numbers: E484141.AZOW and E327789.AZOT

FREEWAVE