Spread Spectrum Wireless Data Transceiver

FGR2 Series and I2 Series

User Manual and Reference Guide

Part Number: LUM0002AI
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Safety Information

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

Warning! DO NOT REMOVE OR INSERT DIAGNOSTICS CABLE WHILE CIRCUIT IS LIVE UNLESS THE AREA IS KNOWN TO BE FREE OF IGNITION CONCENTRATIONS OF FLAMMABLE GASES OR VAPORS.

Warranty

FreeWave Technologies warrants your FreeWave® Wireless Data Transceiver against defects in materials and manufacturing for a period of two years from the date of shipment. In the event of a Product failure due to materials or workmanship, FreeWave will, at its option, repair or replace the Product. The Product must be returned to FreeWave upon receiving a Return Material Authorization (RMA) for evaluation of Warranty Coverage.

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

Special Rate Replacement Option

A special rate replacement option is offered to non-warranty returns or upgrades. The option to purchase the replacement unit at this special rate is only valid for that RMA. The special replacement rate option expires if not exercised within 30 days of final disposition of RMA.

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FreeWave's Spread Spectrum Wireless Data Transceivers are designed and manufactured in the United States of America.

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UL Specifications

Models FGR2-C-U, FGR2-CE-U, FGR2-IOS-C-U, FGR2-IOS-CE-U, I2-C-U, I2-T-U, I2-IOS-C-U, and I2-IOS-T-U are suitable for use in Class 1, Division 2, Groups A, B, C, and D or non-hazardous locations only. Input voltage for the above models is +6 to +30 VDC.

Warning! Explosion Hazard – Substitution of components may impair suitability for Class 1, Division 2.

FCC Notifications

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

This device must be operated as supplied by FreeWave Technologies, Inc. Any changes or modifications made to the device without the express written approval of FreeWave Technologies may void the user's authority to operate the device.

Warning! The FGR2 series transceivers have a maximum transmitted output power of 1000 mW. It is recommended that the transmit antenna be kept at least 23 cm away from nearby persons to satisfy FCC exposure requirements.

The IM, I2 series transceivers have a maximum transmitted output power of 500 mW. It is recommended that the transmit antenna be kept at least 23 cm away from nearby persons to satisfy FCC exposure requirements.

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

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

Note: Whenever any FreeWave Technologies module is placed inside an enclosure a label **must** be placed on the outside of that enclosure which includes the module's FCC ID.

IC Notifications

This device complies with Industry Canada licence-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.

Document Revision History

Date	Rev Letter	Updates Made
09/27/2011	A	Added Tool Suite procedures. Updated document's organization. Updates included but are not limited to the following: • Document is now broken into chapters to help make information easier to find. See the table of contents. • All parameters that you can set on the transceiver are now listed in alphabetical order in the Parameter Reference chapter. • Firmware revision information is available in Appendix A.

Table Of Contents

Preface

This document includes the following regarding the FreeWave FGR2 Series and I2 Series transceivers:

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

For information about the firmware releases that apply to the transceiver, see Appendix A.

Notational Conventions

This guide uses the following notational conventions:

- **Bold** - Indicates items that you select, parameter settings, and parameter names.
-  **Warning!** - Indicates a situation that might cause damage to your radio, your data, or your network.
-  - Provides time saving or informative suggestions about using the product.

Contacting FreeWave Technical Support

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

FreeWave provides technical support Monday through Friday, 7:30 AM to 5:30 PM Mountain Time (GMT -7). Call toll-free at 1.800.548.5616, factory direct after hours at 303.381.9200, or contact us through email at moreinfo@FreeWave.com.

Documentation Feedback

Your feedback is important to us! FreeWave Technologies, Inc. is committed to continually improving the quality of our documentation. If you have any comments or suggestions about this document, send them to us at techpubs@freewave.com. Please include the name of the manual or the manual's part number in your email.

Additional Information

This guide covers settings and configurations that apply to FreeWave spread spectrum transceivers. Some transceiver 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 in your network, see the addendums and application notes listed below.

- *Cathodic Protection User Manual Addendum*
- *FGR Radio Modem in Mirrored Bit Mode Addendum*
- *FGR2-HS Series High Throughput 900 MHz Radio Addendum*
- *Application note #5412: Synchronizing Collocated Masters (Multi-Master Sync Mode)*
- Application note #5476: *Mode 6*
- Application note #5424: *Using the FGR-115MB Radio with Schweitzer Engineering Labs Mirrored Bits Communications*
- Application note: #5437: *DTR to CTS Line Alarm Feature*
- Application note #5457: *Local Mode*

For information about installing your transceivers, see the following guides:

- *900 MHz Wireless Modem Installation Guide*
- *2.4 GHz Wireless Modem Installation Guide*

All FreeWave documentation is available on the *User Manual and System Tools CD* and at www.FreeWave.com.

Chapter 1: Introduction

FreeWave transceivers operate in virtually any environment where data communications occur. A pair of transceivers functions as a 9-pin null modem cable. If the FreeWave transceivers are to be used in an application where a null modem cable is used, such as communication between two computers, then the FreeWave transceivers can be connected directly. If FreeWave transceivers are to be used to replace a straight-through RS232 cable, then a null modem cable must be placed between the transceiver and the Data Terminal Equipment (DTE) instrument to which it is connected.

Choosing a Location for the Transceivers

Placement of the FreeWave transceiver is likely to have a significant impact on its performance. The key to the overall robustness of the radio link is the height of the antenna. In general, FreeWave units with a higher antenna placement will have a better communication link. In practice, the transceiver should be placed away from computers, telephones, answering machines and other similar equipment. The RS232 cable included with the transceiver usually provides ample distance for placement away from other equipment. FreeWave

Technologies, Inc. offers directional and Omni directional antennas with cable lengths ranging from 3 to 200 feet. When using an external antenna, placement of that antenna is critical to a solid data link. Other antennas in close proximity are a potential source of interference; use the Radio Statistics to help identify potential problems.

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

FreeWave also offers a waterproof version of the 900 MHz transceivers. This model can be placed outdoors without additional weather protection. The waterproof enclosure requires an external antenna and includes a 6-foot data and power pigtail cable.

Choosing Point-to-Point or Point-to-MultiPoint Operation

A Point-to-Point network is best suited when your network consists of one Master and one Slave transceiver. You can add Repeaters to extend the reach of the network, but no other Master or Slave may be added.

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

It is important to note the differences between Point-to-Point and MultiPoint networks. In a Point-to-Point network all packets are acknowledged, whether sent from the Master to the Slave or from the Slave to the Master. In a MultiPoint network, you determine the set number of times outbound packets from the Master or Repeater to Slaves or other Repeaters are sent. The receiving transceiver, 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. As such, the architecture of such a network is different from Point-to-Point applications. The following parameters influence the number of radios in a MultiPoint network:

1. Size of the blocks of data. The longer the data blocks, the fewer number of deployed slaves can exist in the network.
2. Baud rate. The data rate between the radio and the device to which it is connected could limit the amount of data and the number of radios that can exist in a network
3. The amount of contention between Slaves. Polled Slaves vs. timed Slaves.
4. Use of Repeaters. Using the Repeater setting in a MultiPoint network decreases overall network capacity by 50%.

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

For examples and additional information on data communication links, see the section Examples of Data Communication Links later in this document.

Point-to-MultiPoint Network Quick Start

The following is a quick start guide for setting up two transceivers 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):

1. Connect the transceiver to the serial port of a computer either through a serial cable or via the diagnostics cable. Make sure to connect the radio to a power source. (Typically +6 to +30 VDC, but can vary depending on the radio. Verify the specifications for the model you are using.)
2. Open a Tool Suite session, select the **Configuration** application, and ensure the correct port is selected in the **Com Port** field in the Configuration ribbon.
3. From the Networks section of the Configuration ribbon, select the network in which the radio resides.
4. Click **Read Radio** in the Configuration ribbon to read the radio's current settings.
   - If you are using a diagnostics cable to connect to the radio, the radio automatically goes into Setup mode.
   - If you are using a data cable to connect to the radio, you are prompted to press the radio's Setup button to put the radio in Setup mode.
   - When in Setup mode, all three LEDs on the radio display solid green.
5. Select the Operation Mode tab.

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

   Note: A network can have only one Master.
6. Select the Baud Rate tab.

   Change the **Baud Rate**, **Data Parity**, and **Modbus RTU** to match the device that the radio is to be attached to.
7. Select the Transmission Characteristics tab.

   Set the following 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 MultiPoint 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** settings.

   Changing these settings from the factory defaults may help to eliminate interference from other FreeWave networks.
8. Select the MultiPoint Parameters tab.

In the **Network ID** field, set the value to any value between **1** and **4095**, except **255**. FreeWave recommends setting the **Network ID** to the last three or four digits of the radio's serial number.

Point-to-MultiPoint Network Quick Start (HyperTerminal):

1. Connect the transceiver to the serial port of a computer either through a serial cable or via the diagnostics cable. Make sure to connect the radio to a power source (typically, +6 to +30 VDC).
2. Open a HyperTerminal session and use the following settings when connecting the radio:
   - Connect to COMx (where 'x' is the number of the Com port being connected).
   - Set the following:
     - **Data Rate** - 19,200
     - **Data Bits** - 8
     - **Parity** - none
     - **Stop bits** – 1
     - **Flow control** – none
3. Press the **Setup** button on the radio. If using the diagnostics cable, press **Shift-U** (capital U).
   - The three LEDs on the radio should all turn green, indicating Setup mode.
   - The Main menu displays on the screen.
4. Press **0** to access the Operation Mode menu.
   - 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.
   - Press **Esc** to return to the Main menu.

   Note: A network can have only one Master.
5. Press **1** in the Main menu.
   - Change the **Baud Rate**, **Data Parity**, and **Modbus RTU** to match the device that the radio is to be attached to.
   - Press **Esc** to return to the Main menu.
6. Press **3** in the Main menu.
   - Set the following parameters so they are the same on all radios in the network:
     - **FreqKey**
     - **Max Packet Size**
     - **Min Packet Size**
     - **RF Data Rate**

   The Frequency Key options is located in the F submenu after you press **0** to access the Frequency Key menu in Main menu **3**.

   Changing these values may help to eliminate interference from other FreeWave networks.
   - Press **Esc** to return to the Main menu.

7. Press **5** in the Main menu.
   - Set the **Network ID** value to any value between **1** and **4095**, except **255**. FreeWave recommends setting the **Network ID** to the last three or 4 digits of the radio's serial number.
   - Ensure this value is the same on every radio in the network.
8. Press **Esc** to exit the Setup menu and resume normal radio operation.

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 red bright	Off	Blinking red	Solid red bright	Off	Blinking red
Repeater and Slave linked to Master, no data	Solid red bright	Solid red dim	Off	Solid green	Off	Solid red bright	Solid green	Solid red dim	Solid red bright
Repeater and Slave linked to Master, Master sending data to Slave	Solid red bright	Solid red dim	Off	Solid green	Off	Solid red bright	Solid green	Solid red dim	Solid red bright
Repeater and Slave linked to Master, Slave sending data to Master	Solid green RCV data or Solid red bright	Solid red dim	Intermittent flash red	Solid green	Intermittent flash red	Solid red bright	Solid green	Solid red bright	Solid red bright
Master with diagnostics program running	Solid red bright	Solid red dim	Intermittent flash red	Solid green	Intermittent flash red	Solid red bright	Solid green	Solid red bright	Solid red bright

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

Overlapping MultiPoint Networks

Overlapping MultiPoint networks may be set up effectively with FreeWave transceivers when several key parameters are set correctly. Overlapping MultiPoint networks are defined as networks using different Masters, which share or overlap in a specific geographic area. It may also include co-located transceivers configured into different networks. For more information, see application note #5412, *Synchronizing Collocated Masters (Multi-Master Sync Mode)*.

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

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

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

Point-to-Point Network Quick Start

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

Point-to-Point Network Quick Start (Tool Suite):

1. Connect antennas to the transceivers.
2. Connect the transceiver to the serial port of a computer either through a serial cable or using the diagnostics cable. Make sure to connect the radio to a power source. (Typically +6 to +30 VDC, but can vary depending on the radio. Verify the specifications for the model you are using.)
3. Open a Tool Suite session, select the **Configuration** application, and ensure the correct port is selected in the **Com Port** field in the Configuration ribbon.
4. From the Networks section of the Configuration ribbon, select the network in which the radio resides.
5. Click **Read Radio** in the Configuration ribbon to read the radio's current settings.
   - If you are using a diagnostics cable to connect to the radio, the radio automatically goes into Setup mode.
   - If you are using a data cable to connect to the radio, you are prompted to press the radio's Setup button to put the radio in Setup mode.
   - When in Setup mode, all three LEDs on the radio display solid green.
6. Select the Operation Mode tab.

   In the **Modem Mode** field, select to set the radio in Point-to-Point mode. For example, set one radio as a Point-to-Point Master (Mode 0) and the other as a Point-to-Point Slave (Mode 1). For more information about modem modes, see "Modem Mode" on page 47.

   Note: A network can have only one Master.
7. Select the Baud Rate tab.

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

   When setting the transceiver's baud rate, its RS232 data rate is set. The baud rate does not have to be the same setting for the two transceivers in the Point-to-Point network.
8. Select the Transmission Characteristics tab.

   Set the following 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 MultiPoint 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** settings.

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

9. Select the Call Book tab.

   Enter the Slave serial number in the Master's Call Book. Enter the Master's Serial number in the Slave's Call Book, or disable Slave Security (in the Slave). For more information about setting up the Call Book see "About the Call Book" on page 19.

   Shortly after both transceivers are plugged in, they should establish a communications link with each other and the connection is complete. Using the table below, verify that the radios are operating as expected.

Point-to-Point Network Quick Start (HyperTerminal):

1. Connect antennas to the transceivers.
2. Connect the transceiver to the serial port of a computer either through a serial cable or using the diagnostics cable. Make sure to connect the radio to a power source (typically, +6 to +30 VDC).
3. Open a HyperTerminal session and use the following settings in connecting the radio:
   - Connect to COMx (where 'x' is the number of the port being connected).
   - Set the following:
     - **Data Rate** - 19,200
     - **Data Bits** - 8
     - **Parity** - none
     - **Stop bits** – 1
     - **Flow control** – none
4. Press the **Setup** button on the radio. If using the diagnostics cable, press **Shift-U** (capital U).
   - The three LEDs on the radio should all turn green, indicating Setup mode.
   - The Main menu displays on the screen.
5. Press **0** to access the Operation Mode menu.
   - Press **0** to set the radio as a Point-to-Point Master or press **1** to set the radio as Point-to-Point slave. For more information about operation modes, see "Modem Mode" on page 47.
   - Press **Esc** to return to the Main menu.
6. Press **1** in the Main menu.
   - Change the **Baud Rate**, **Data Parity**, and **Modbus RTU** to match the device that the radio is to be attached to.

     When setting the transceiver's baud rate, its RS232 data rate is set. The baud rate does not have to be the same setting for the two transceivers in the Point-to-Point network.
   - Press **Esc** to return to the Main menu.
7. Press **2** in the Main menu to update the Call Book.

Enter the Slave serial number in the Master's Call Book. Enter the Master's Serial number in the Slave's Call Book, or disable Slave Security (in the Slave). For more information about setting up the Call Book see "About the Call Book" on page 19.

8. Press **3** in the Main menu.
   - Set the following parameters so they are the same on all radios in the network:
     - **FreqKey**
     - **Max Packet Size**
     - **Min Packet Size**
     - **RF Data Rate**

   The Frequency Key options is located in the F submenu after you press **0** to access the Frequency Key menu in Main menu **3**.

   Changing these values may help to eliminate interference from other FreeWave networks.

   - Press **Esc** to return to the Main menu.

   Shortly after both transceivers are plugged in, they should establish a communications link with each other and the connection is complete. Using the table below, verify that the radios are operating as expected.
9. Press **Esc** to exit the Setup menu and resume normal radio operation.

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

Chapter 2: Setting Up and Programming Transceivers

This chapter provides details about setting up and programming your transceiver using the setup tools available.

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

After the transceiver is powered and connected with a cable to the programming computer, you can use Tool Suite or HyperTerminal to access and program the device.

Warning! Do not “hot plug” transceivers to cycle power as this may cause damage to the circuitry, render the radio unusable and void your warranty.

You can use the following setup tools to configure the settings on your transceiver:

- **Tool Suite** - Tool Suite is the newest configuration software and replaces EZConfig, and is the recommended method for programming your transceivers.

  It provides a group of tools for configuring the devices in your network and for monitoring your network's performance. Using the Configuration application within Tool Suite, you can program changes to your transceiver's settings. Tool Suite is available on the *User Manual and System Tools* CD and is also available for download from www.FreeWave.com.

  For more information about the general use of Tool Suite, see the *Tool Suite User Manual* available on the *User Manual and System Tools* CD or by selecting **File > Help** in the Tool Suite software.

- **HyperTerminal** - HyperTerminal is an emulation program that offers many of the same configuration options that are available in the Configuration application in Tool Suite.

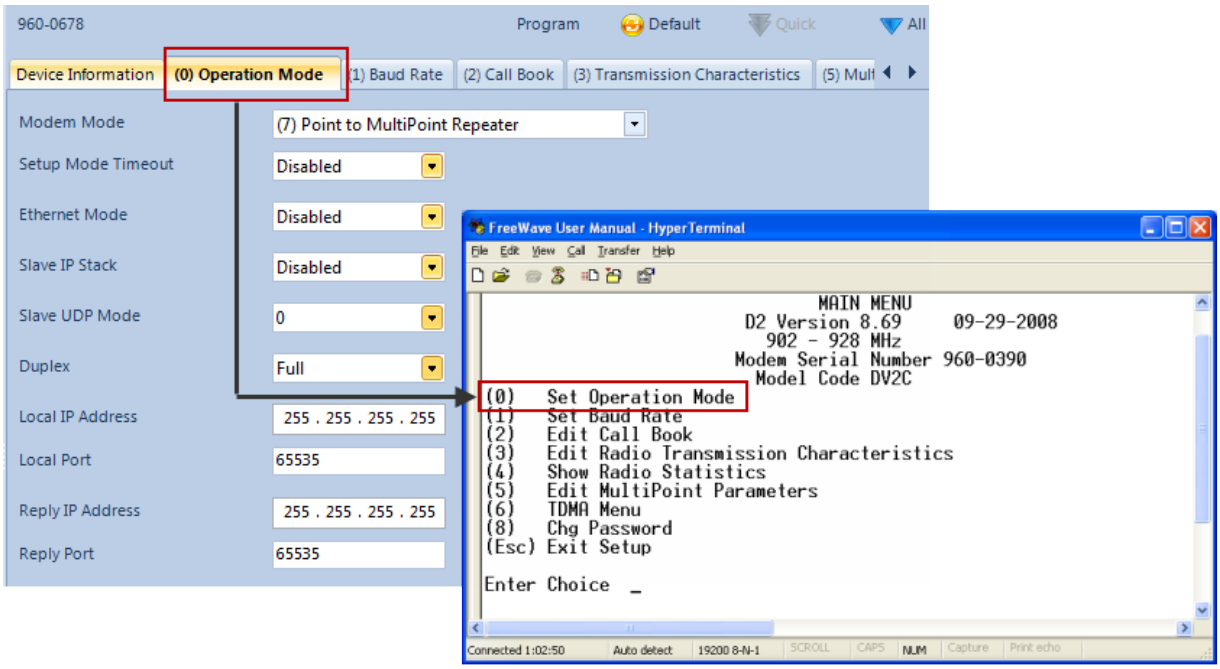
If you run versions of the Windows operating system prior to Windows 7, HyperTerminal is included in the operating system installation. However, if you are running Windows 7 or newer, HyperTerminal is no longer available. If you prefer the HyperTerminal interface, the Setup Terminal application within Tool Suite provides the same interface that is available using HyperTerminal.

For more information about using HyperTerminal, seeSee "Connecting and Disconnecting from HyperTerminal" on page 16.

You can also still use EZConfig to program your transceivers, however, Tool Suite is the recommended programming option. Newer transceiver releases are not available in EZConfig. For more information about using EZConfig, see the EZConfig manual available on the *User Manual and System Tools* CD.

Tool Suite and HyperTerminal

If you are using HyperTerminal, the tabs for a device in Tool Suite mirror the Setup main menu selections. For example, option **0** from the Setup main menu in HyperTerminal is **Set Operation Mode**. The corresponding configuration tab for the device in Tool Suite is **(0) Operation Mode.**



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

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

Using Tool Suite to Connect to and Program Transceivers

To read and program a transceiver using Tool Suite, you need to connect the radio to a desktop computer or a laptop that runs the Tool Suite software. You can also use Tool Suite to set up a template version of a transceiver. Templates include settings that apply to more than one transceiver in your network. For more information about using templates, see the *Tool Suite User Manual* available from the **File > Help** menu within the application.

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

   Using a diagnostic cable is recommended.

2. Connect the power supply to the transceiver and the power source and turn on the transceiver.
3. With the radio connected to the computer in Tool Suite, click **Configuration** in the Application pane to display the Configuration application.
4. Ensure the correct port is selected in the **Com Port** field in the Configuration ribbon.
5. Place the transceiver in Setup mode by pressing the Setup button on the back of the FreeWave transceiver.

   If you are using Setup Terminal or HyperTerminal and are connected to the diagnostics port, type **Shift-U** (Capital 'U') to invoke the Setup menu.

   To place the transceiver in Setup mode in board-level transceivers:

   - Short pins 2 & 4 (Brown to Black) on the white 10 pin header next to the LEDs.
   - If using a programming cable (FreeWave part number: ASC3610DB or ASC3610DJ), press the Setup button on the programming cable.

     If you are using Setup Terminal or HyperTerminal and using the gray ribbon Diagnostic Cable (part number: AC2009DC), or the black Diagnostic Cable (part number: ASC0409DC), press **Shift-U** (capital **U**).

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

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

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

For more information about using Tool Suite, see the *Tool Suite User Manual* available on the *User Manual and System Tools* CD or by selecting **File > Help** in the Tool Suite software.

Accessing the Setup Menu Using HyperTerminal

Note: The screen shots in the following sections represent HyperTerminal in Windows XP. The display may vary slightly if you are using a different operating system.

1. Click the Windows Start button and select **Programs > Accessories > Communications**, and then **HyperTerminal**.

   A window similar to the following displays:

2. Double-click the **Hypertrm.exe** icon.

   The following window displays:

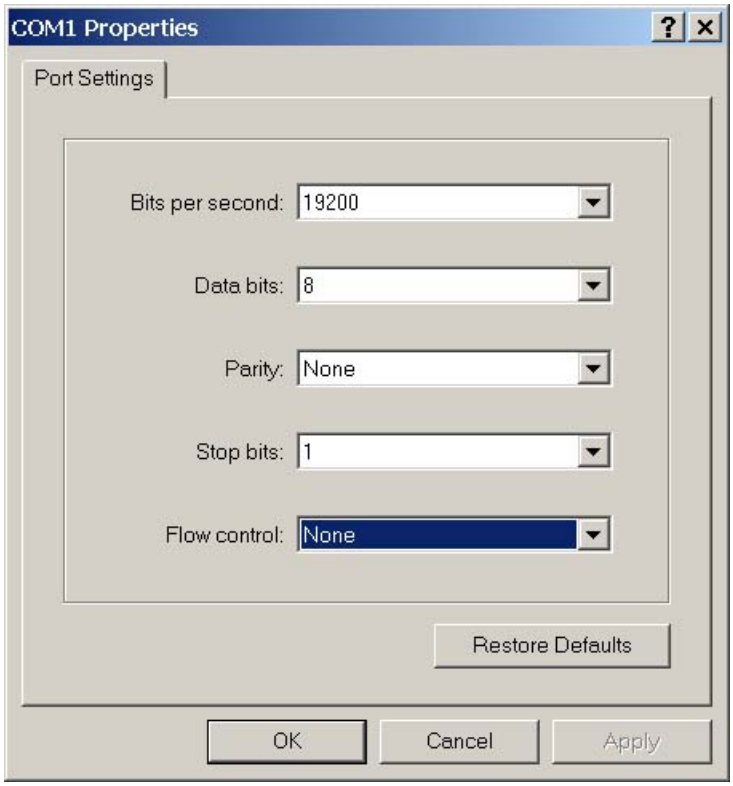
3. In the **Name** field, enter a descriptive name for the radio and select an icon from the Icon selection box.
4. Click **OK**.

   The Connect To dialog box displays.

5. In the **Connect Using** field, select the connection type to use.

   Select the active Com Port to which the radio is connected. In most cases the connection type will either **Direct to Com1** or **Direct to COM2**.
6. Click **OK**.

   The Properties dialog box displays for the selected connection type.

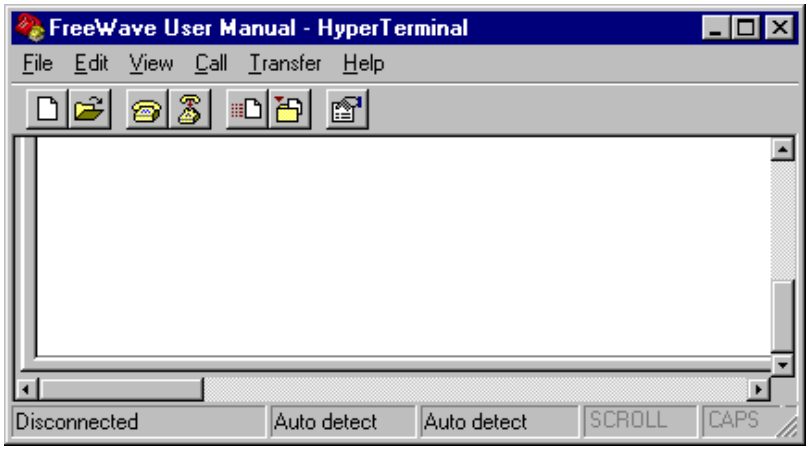


Enter the following port settings for a proper connection:

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

7. After selecting the option for each setting, click **OK**.

   The following HyperTerminal dialog box displays:



8. From the **File** menu, select **Save** to save the HyperTerminal connection settings

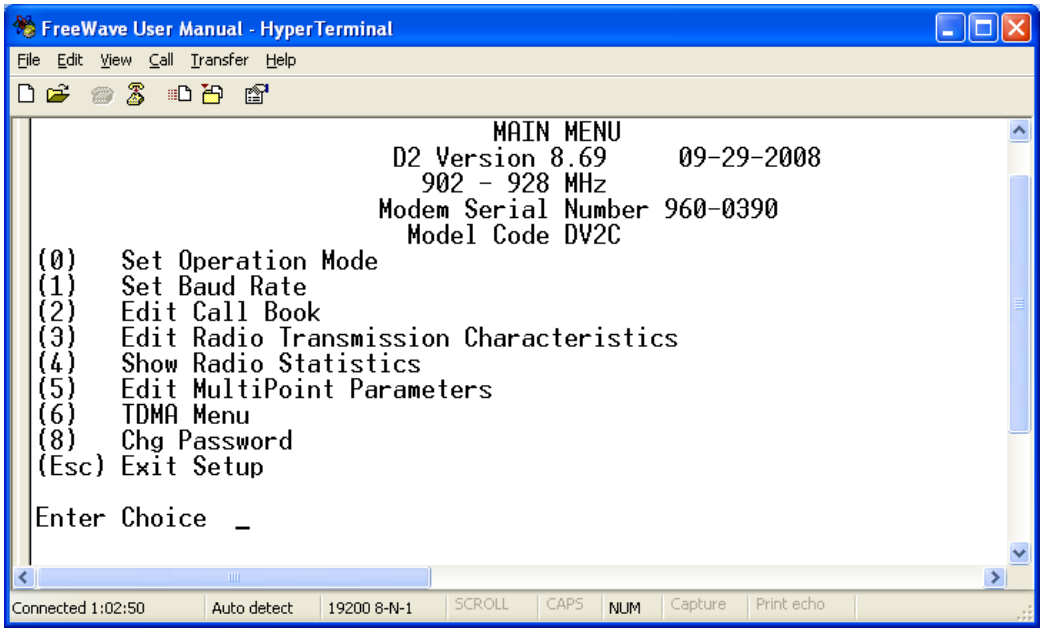
Important: Whenever a change is made to the HyperTerminal settings in an open terminal session, the HyperTerminal connection must be disconnected then reconnected before the settings take effect.

9. To connect HyperTerminal to the transceiver, press the Setup button on the back of the FreeWave transceiver. If connected to the diagnostics port, type **U** (Capital 'U') to invoke the Setup menu.

To display the Setup menu in board level radios:

- Short pins 2 & 4 (Brown to Black) on the white 10 pin header next to the LEDs.
- If using a Programming Cable (P/N ASC3610DB or ASC3610DJ), press the Setup button. If using the gray ribbon Diagnostic Cable (P/N AC2009DC), or the black Diagnostic Cable (P/N ASC0409DC), press Shift-U (capital U) to invoke the Setup menu.

When Setup is invoked, the FreeWave Setup Main Menu displays in the HyperTerminal dialog box. All three LEDs on the transceiver light green and stay green as long as the transceiver is in Setup mode.



As you navigate through the Setup menu and made changes to the parameters, the parameters are sent to the transceiver ***immediately***.

Connecting and Disconnecting from HyperTerminal

The HyperTerminal dialog box displays several icons in the toolbar. To reconnect to HyperTerminal, click the Disconnect  icon, and then click the Call  icon to reconnect. If the settings have not been saved they must be re-selected when HyperTerminal reconnects to the transceiver.

Troubleshooting HyperTerminal

The following are some common issues encountered while using HyperTerminal.

Important: When a change is made to the HyperTerminal settings in an open terminal sessions, the connection must be disconnected then reconnected before the settings will take effect.

Nothing displays on the screen after pressing the Setup button on the transceiver.

This usually indicates one of two things; either the wrong COM port is selected or a null modem cable is being used. Follow the steps below to change the COM ports.

1. Click the **Disconnect** icon.
2. From the **File** menu, select **Properties**.
3. Click the **Connect To** tab and verify that the correct COM port is selected.
4. Click **OK** to close the Properties dialog box.

5. Click the **Call** icon.
6. Return the transceiver to Setup mode. The Setup menu screen displays.

Gibberish displays on the screen after pressing the Setup button.

This usually indicates a Baud Rate problem. Follow the steps below to change the Baud Rate. The problem may also be that the transceiver under test is a TTL version and not RS232. Ensure the TTL from the radios is being converted to RS232. Gibberish before the Setup button is pressed indicates Diagnostics is enabled in a Master.

1. Click the **Disconnect** icon.
2. From the **File** Tmenu, select **Properties**.
3. Click **Configure**, change the **Baud Rate** to **19200**, and click **OK**.
4. Click **OK** to close the Properties dialog box.
5. Click the **Call** icon.
6. Return the transceiver to Setup mode. The Setup menu screen displays.

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

This usually indicates flow control is turned on in a three-wire connection (Rx, Tx, and Gnd). Follow the steps below if the connection uses a three-wire connection.

1. Click the **Disconnect** icon.
2. From the **File** menu, select **Properties**.
3. Click **Configure**, change the **Flow Control** to **None**, and click **OK**.
4. Click **OK** to close the Properties dialog box.
5. Click the **Call** icon.
6. Return the transceiver to Setup mode. The Setup menu screen displays.

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

This usually indicates a parity mismatch. To resolve this issue, ensure that the parity of the transceiver and the parity of HyperTerminal are set the same. HyperTerminal's parity settings are under Properties and the FreeWave parity is found under the Baud Rate in the Setup menu.

1. Click the **Disconnect** icon.
2. From the **File** menu, select **Properties**.
3. Click **Configure**, change the **Parity** to **None**, and click **OK**.
4. Click **OK** button to close the Properties dialog box.
5. Click the **Call** icon.
6. Return the transceiver to Setup mode. The Setup menu screen displays.

Basic Steps to Programming Transceivers

Use the following basic steps to program any FreeWave transceiver.

1. Be familiar with your network and know if you have a Point-to-Point or Point-to-MultiPoint configuration.

   Most FreeWave networks are Point-to-MultiPoint.

2. Connect the transceiver to the configuration tool, such as Tool Suite or HyperTerminal of your choice.
3. Set the transceiver's operation mode, whether it is a Slave, Repeater, Master, and so on and the network type it is in.
4. Program the receiver, ensuring that all devices in a MultiPoint network have the same settings for the following parameters:
   - Frequency Key
   - Max Packet Size
   - Min Packet Size
   - RF Data Rate
   - Network ID
5. Establish the Call Book settings if the transceiver is in a network not using Network IDs.

   If you are using a Network ID, see "Network ID" on page 49

MultiPoint Network Considerations

When installing MultiPoint networks it is important to do some up front planning. Unlike Point-to-Point networks, a Point-to-MultiPoint network requires several parameters are set consistently on all transceivers in the network. This includes **RF Data Rate** and **Min and Max Packet Size**.

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

Upgrading Transceivers to the Latest Firmware

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

For more information about viewing the latest firmware versions available, see the *Tool Suite User Manual* available from the **File > Help** menu within Tool Suite.

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

1. With the transceiver connected to Tool Suite and in Setup mode, in Tool Suite click **Configuration** in the Applications pane to display the Configuration application.
2. Click **Upgrade Radio** in the Firmware section of the Configuration ribbon.
3. Click **Yes** at the prompt to proceed or **No** to cancel without installing the new firmware.

   Tool Suite identifies and displays the firmware version that is loaded on the connected device and displays the latest version of firmware available for that model.

4. Click **Yes** to proceed with the upgrade, or **No** to exit.

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

About the Call Book

The Call Book is required in Point-to-Point networks. While the call book is an option in Point-to-MultiPoint networks, the **Network ID** feature is strongly recommended in most applications. The instructions provided in this section are for Point-to-Point mode only. Use of the Call Book for MultiPoint networks is explained later in this chapter.

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

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

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

The Call Book allows you to incorporate up to 10 FreeWave transceivers, designate 1 to 4 Repeaters to use with each transceiver, and designate which Slave the Master calls. To set the **Entry to Call** option, select the number in the **Entry to Call** field, select **All** to direct the Master to call all Slaves.

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

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

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

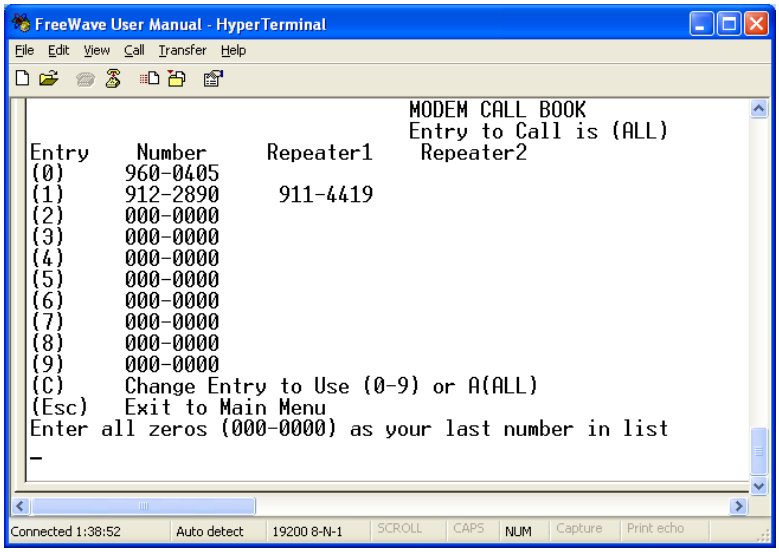
To set the call book in Tool Suite:

1. In the Tool Suite Configuration application, select the device to program and click the **(2) Call Book** tab.
2. In the **Number** column in **Row 0**, enter the seven-digit serial number of the transceiver being called.
3. In the **Repeater 1** column, enter Repeater 1's seven-digit number. If no Repeaters are being used, leave the column empty.
4. In the **Repeater 2** column, enter the second Repeater's seven-digit number. If only one Repeater is being used, leave the column empty.
5. If Repeaters are being used, select the appropriate **Entry to Call** option in the Master's Call Book.

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

To set the Call Book in HyperTerminal:

1. Select **(2) Call Book** from the main Setup menu to display the following window:



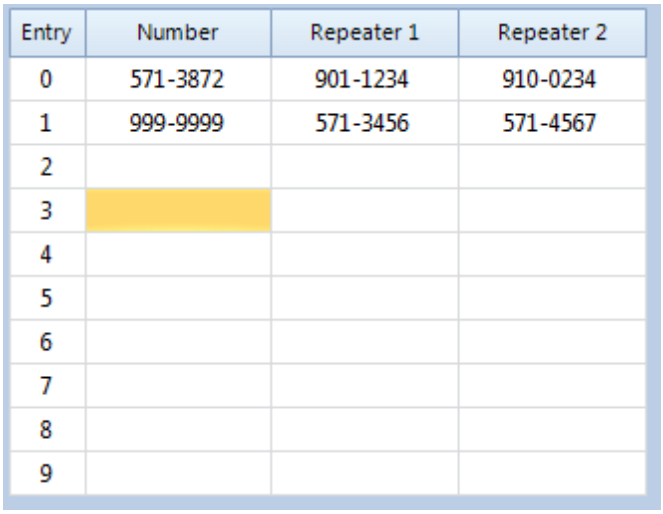
2. Enter the number or letter associated with the option you want to select.
3. Enter the seven-digit serial number of the transceiver being called.
4. The system prompts for Repeater 1's serial number. If no Repeaters are being used, press **Esc** and continue with step 6. Otherwise, enter the 7-digit serial number of the Repeater.
5. The system prompts for Repeater 2's serial number. Enter the 7-digit serial number of the second Repeater. If only one Repeater is being used, press **Esc**.

   The system refreshes the transceiver's Call Book menu with the new changes.
6. Press **Esc** to return to the Main menu.

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

In a Point-to-Point configuration FreeWave transceivers can use up to four Repeaters. To use three or four Repeaters, program the Call Book with the Slave's serial number, followed by the first two Repeaters. On the next line enter 999-9999 as the transceiver to call. When prompted for the Repeaters enter the third and fourth Repeaters in the link.

The illustration below 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			

To call a Slave through one or more Repeaters, that Slave must be called individually. With **Call All** selected, the Master will not connect with any Slaves 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 communication link with it prior to making contact with the Slave.

Programming Point-to-MultiPoint Call Book

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

Note: If the **Network ID** feature is used in a MultiPoint network, no entries are needed in the Call Book of any of the transceivers.

The following example shows the Call Books of a MultiPoint network comprised of a Master, Repeater, and Slave in which the Slave can communicate either through the Repeater or directly to the Master:

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

Entry	Number	Repeater 1	Repeater 2
(0)	000-0000		
(1)	000-0000		

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

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

Entry	Number	Repeater 1	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

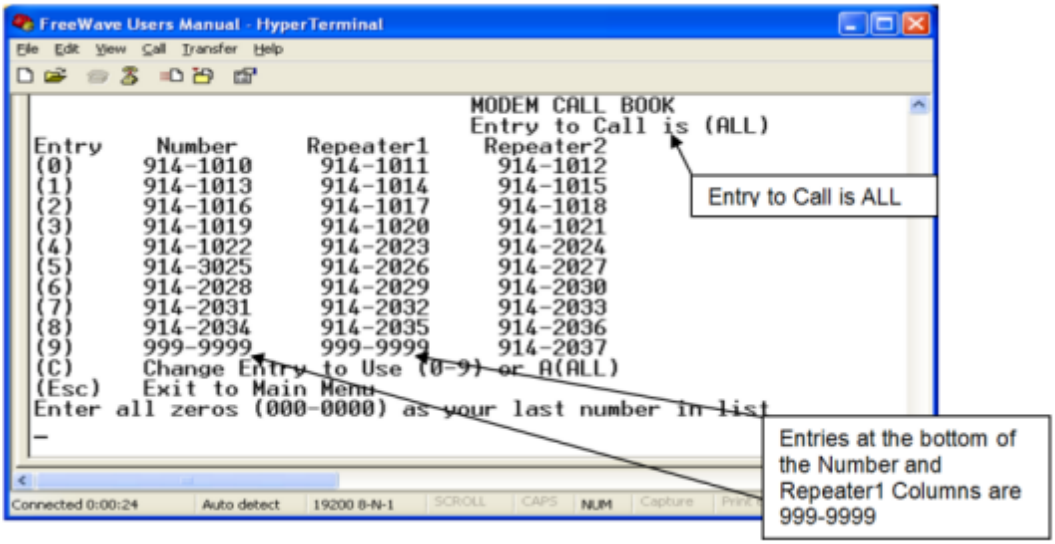
(2) 000-0000

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

Programming Point-to-MultiPoint Extended Call Book

In a MultiPoint network, a Slave can be programmed to roam between Masters and Repeaters using the MultiPoint Extended Call Book function. A Slave with its Call Book configured as below communicates with any transceiver whose serial number appears in any of the three columns. Do the following to enable this functionality:

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**.



Setting Transceiver Passwords

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

Note: You can only set, change, or delete a password using the Setup Terminal application in Tool Suite or through HyperTerminal.

If the **Setup Port** option in the Baud Rate tab is set to **(1) Main Only** or **(3) Both**, the password is only accepted if the option is accessed from the main data port. To use the Password function via 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, you need to return the transceiver to FreeWave to have the password disabled.

To set a password:

1. From the Setup main menu in Setup Terminal or in HyperTerminal, select **(8) Chg Password** to display the following prompt:

   New PW? (<esc> to exit)

2. To back out of the process and not enable the password press **Esc**. To set a password, type exactly four characters. Passwords are case sensitive.

   Press **Esc** to cancel the process at any point.

3. After you enter the four characters the following prompt displays:

   <Enter> to accept,<esc> to quit.

4. To accept the password as entered and enable the feature, press **Enter**. To quit the process and not enable the password, press **Esc**.

   If you press **Enter**, the password displays on the line above. The password is case sensitive and every keystroke is a character.

To change a password:

After the password feature has been enabled, it is possible to change to a new password.

1. From the Setup main menu in Setup Terminal or in HyperTerminal, select **(8) Chg Password**.
2. At the Enter Security Code prompt enter the current four character, case sensitive password.

   After entering the password correctly, the prompt to enter the new password displays. Enter the new four character, case sensitive password.

   Press **Esc** to cancel this process at any point.

3. To accept the password as entered and enable the feature, press **Enter**. To quit the process and not enable the password, press **Esc**.

   If you press Enter, the password displays on the line above. The password is case sensitive and every keystroke is a character.

To disable a password:

After the password features has been enabled, it is possible to disable the password if you know the current password.

1. From the Setup main menu in Setup Terminal or in HyperTerminal, select **(8) Chg Password**.
2. At the Enter Security Code prompt enter the current four character, case sensitive password.
3. Hold down the **Alt** key and type **0255** using the number pad on your keyboard and release the **Alt** key.
4. Repeat this step three more times (hold **Alt** and type **0255** a total of 4 times).

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

Chapter 3: Parameter Reference

This chapter contains the following information as it applies to each parameter that you can set for the transceivers described in this manual

parameter name (as you see it in Tool Suite or HyperTerminal)

Tool Suite Tab:	The name of the tab the parameter is grouped under within Tool Suite.
Setup Terminal Menu:	The name of the menu and the submenu the parameter is grouped under within Tool Suite's Setup Terminal and within HyperTerminal.
Network Type:	Point-to-Point, Point-To-Multipoint, or Both
Default Setting:	The factory default setting for the parameter.
Options:	The options to which the parameter can be set.
Description:	A description of what the parameter is and how it applies to the transceiver in your network.

The available parameters are listed below in alphabetical order.

Important: Parameters in the Transmission Characteristics tab in Tool Suite (the Edit Radio Characteristics menu in Setup Terminal and HyperTerminal) are for users with advanced knowledge of FreeWave transceivers and radio communication networks.

1 PPS Enable/Delay

Tool Suite Tab:	MultiPoint Parameters
Setup Terminal Menu:	(5) Edit MultiPoint Parameters > (9) 1 PPS Enable/Delay
Network Type:	Point-to-MultiPoint
Default Setting:	255
Options:	255 to disable 1 PPS 0 to 254 to enter the delay.
Description:	The **1 PPS Enable/Delay** setting allows the radio network to propagate a one pulse per second (1PPS) signal from the Master to all Slaves in a MultiPoint network. When this parameter is enabled a properly generated pulse applied on the Data Terminal Ready (DTR) line of the Master provides a 1PPS pulse on the CD line of any Slave in the network. **Note:** PPS is an electric signal that signifies the precise beginning of a second.

Follow the steps below to use the **1 PPS Enable/Delay** feature.

To setup 1PPS Enable/Delay:

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

   The Master must have a 1 PPS pulse on the DTR pin.
2. Enable the **1 PPS Enable/Delay** parameter on the Slaves. Slaves are calibrated at the factory.

To calibrate a Slave in 1PPS Enable/Delay mode:

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

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

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

Baud Rate

Tool Suite Tab:	Baud Rate
Setup Terminal Menu:	(1) Set Baud Rate
Network Type:	All
Default Setting:	115200
Options:	600, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 76800, 115200, 230400
Description:	The actual baud rate for the transceiver's *data* port. Set the baud rate to the highest level supported by the device to which it is connected. With a poor radio link, however, this may actually result in slower data communications. With a **Baud Rate** setting of 38,400 or higher, it is recommended that you use the Flow Control lines. **Note:** 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*.

This setting is the communication rate between the transceiver and the instrument to which it is connected, and is independent of the baud rate for the other transceivers in the network. For example, a pair of transceivers may be used in an application to send data from remote process instrumentation to the engineer's computer. In this application, the baud rate for the transceiver on the instrumentation might be set to 9600, and the transceiver on the engineer's computer might be set to 57,600.

Data Parity

Tool Suite Tab:	Baud Rate
Setup Terminal Menu:	(1) Set Baud Rate > (A) Data Parity
Network Type:	Both
Default Setting:	0 (8, N, 1)
Options:	See table below.
Description:	Six data word length and parity configurations are available for use with FreeWave transceivers. The default setting is **8-None-1** and is the most commonly used serial communications protocol.

The following table describes each option:

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

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

Diagnostics

Tool Suite Tab:	MultiPoint Parameters
Setup Terminal Menu:	(5) Edit MultiPoint Parameters > (B) Diagnostics
Network Type:	Point-to-MultiPoint
Default Setting:	0 (Disabled)
Options:	Any number between 0 and 128
Description:	Allows diagnostics data in the Network Diagnostics application within Tool Suite to be viewed at the Master in parallel with application data. The setting in this parameter determines how many slots out of 128 are dedicated to diagnostics. For example, if you set to 10, 1 out of every 10 data slots is for diagnostics data; if you set to 100, 1 out of every 100 data slots is for diagnostics data. Diagnostics is always secondary to actual transmitted data.

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

- A setting of this parameter on the Master between 1 and 128.
- A second computer or serial connection to run the diagnostics software.
- A diagnostics cable. (Available from FreeWave.)
- Diagnostics software. (Available on the *User Manual and System Tools CD*.)

For more information about Diagnostics, contact FreeWave Technical Support.

DTR Connect

Tool Suite Tab:	MultiPoint Parameters
Setup Terminal Menu:	(5) MultiPoint parameters > (4) DTR Connect
Network Type:	Point-to-MultiPoint
Default Setting:	(0) Off
Options:	(0) Off - When set to off in the Slave, the transceiver transmits when the data is received. (1) DTR Sensing - Forms a Point-to-Point link with the Master when the DTR line is high to send data. (2) Burst Mode - The transceiver transmits data in bursts.
Description:	Determines how the transceiver sends its data. This mode is valuable when a network has many low data rate devices and you want to increase overall network capacity.

If **DTR Connect** is set to **1** and the **RTS to CTS** function is enabled on the radio, then **RTS to CTS** takes precedence over **DTR Connect**.

If **DTR Connect** is set to **2** and **RTS to CTS** is enabled, then **RTS to CTS** is ignored. The transceiver has two separate transmit and receive user data buffers. For the FGR2 series radios, these buffers are 2 Kbytes each. In case of a buffer overflow, the transceiver outputs unpredictable data.

Flow Control

Tool Suite Tab:	Baud Rate
Setup Terminal Menu:	(2) Set Baud Rate > (F) FlowControl
Network Type:	Both
Default Setting:	(0) None
Options:	(0) None - No flow control CTS is active and de-asserts when buffering in 98% full. Can pass XON/XOFF data but does not use it in any way. (1) RTS - Uses standard RTS/CTS control lines. (2) DTR
Description:	Specifies the hardware flow control for the data port on the transceiver.

Frequency Key in 900 MHz Transceivers

Tool Suite Tab:	Transmission Characteristics
Setup Terminal Menu:	(3) Edit Radio Transmission Characteristics > (0) FreqKey
Network Type:	Both
Default Setting:	5
Options:	0 to 9 and A to E **Note:** Do not use Frequency Key **E** with the Australia (915-928 MHz), Taiwan (916-920 MHz), and New Zealand (921-928 MHz) hop tables.
Description:	Fifteen choices are available for the Frequency Key (0-9 and A-E) setting, representing 15 different pseudo-random hop patterns. Hopping patterns minimize the interference with other FreeWave transceivers operating in the area.

Important: In MultiPoint networks, the **Frequency Key** must be set identically in all transceivers. Any transceiver with a **Frequency Key** different from the Master will not establish a link.

In Point-to-Point networks the Master's settings take precedence over the Slave.

For example, if 10 pairs of FreeWave transceivers are operating on different networks in close proximity, setting a different **Frequency Key** value reduces the chance that transceivers 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.

You can gain additional network separation by adjusting the **Max Packet Size** and **Minimum Packet Size**.

Use the **Hop Table Version**, **Hop Table Size**, and **Frequency Zone** fields to define more network differentiation by way of limiting the number and location of frequencies the transceivers may hop on in the 902-928 MHz band

Note: 900 MHz transceivers do not use the **Hop Frequency Offset** setting.

Frequency Key in 2.4 GHz Transceivers

Tool Suite Tab:	Transmission Characteristics
Setup Terminal Menu:	(3) Edit Radio Transmission Characteristics > (0) FreqKey
Network Type:	Both
Default Setting:	5
Options:	0 to 9 and A to E
Description:	Fifteen choices are available for the Frequency Key (0-9 and A-E) setting, representing 15 different pseudo-random hop patterns. Hopping patterns minimize the interference with other FreeWave transceivers operating in the area.

Important: In MultiPoint networks, the **Frequency Key** must be set identically in all transceivers. Any transceiver with a **Frequency Key** different from the Master will not establish a link.

In Point-to-Point networks the Master's settings take precedence over the Slave.

The **Frequency Key** for the 2.4 GHz transceivers behaves identically to that of the 900 MHz transceivers. The selection of 15 Frequency Keys (0-9 and A-E) is the same as the 900 MHz, allowing for 15 different pseudo-random patterns. The difference comes in the Hop Table information.

For example, if 10 pairs of FreeWave transceivers are operating on different networks in close proximity, setting a different **Frequency Key** value reduces the chance that transceivers 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.

You can gain additional network separation by adjusting the **Max Packet Size** and **Minimum Packet Size**.

Use the **Hop Table Version**, **Hop Table Size**, and **Frequency Zone** fields to define more network differentiation by way of limiting the number and location of frequencies the transceivers may hop on in the 2.400 to 2.4835 GHz band.

Frequency Zones in 900 MHz Transceivers

Note: You only need to set Frequency Zones on the Master radio.

Tool Suite Tab:	Transmission Characteristics
Setup Terminal Menu:	(3) Edit Radio Transmission Characteristics > (0) FreqKey > F > (3) Frequency Zone
Network Type:	Both
Default Setting:	All selected
Options:	See below
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 Word, which is made up of 16 bits numbered 0 to 15. These bits when displayed LSB to MSB 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. Likewise, a value of **0** instructs the radio to bypass the represented band. This feature should only be used with the standard hop table.

Note: You must set the **Hop Table Version** to **902-928 MHz** when using Frequency Zones. If you select another **Hop Table Version**, the limitations of that selection would be applied to the hopping pattern as well. For example, you select **916-920** as the **Hop Table Version**, only the middle of the band would be available in the pattern. Then, if Frequency Zones 5, 6, 7, 8, and 9 were set to **0** no allowable frequencies would be available for the radio to use.

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

Warning! FCC regulations require a minimum of 50 separate channels be used within a hop pattern. Use the above table to determine the number of frequency zones required for legal communication.

EXAMPLE:

1. Using zones 1-7 is equal to 49 channels; this is not legal according to the FCC.

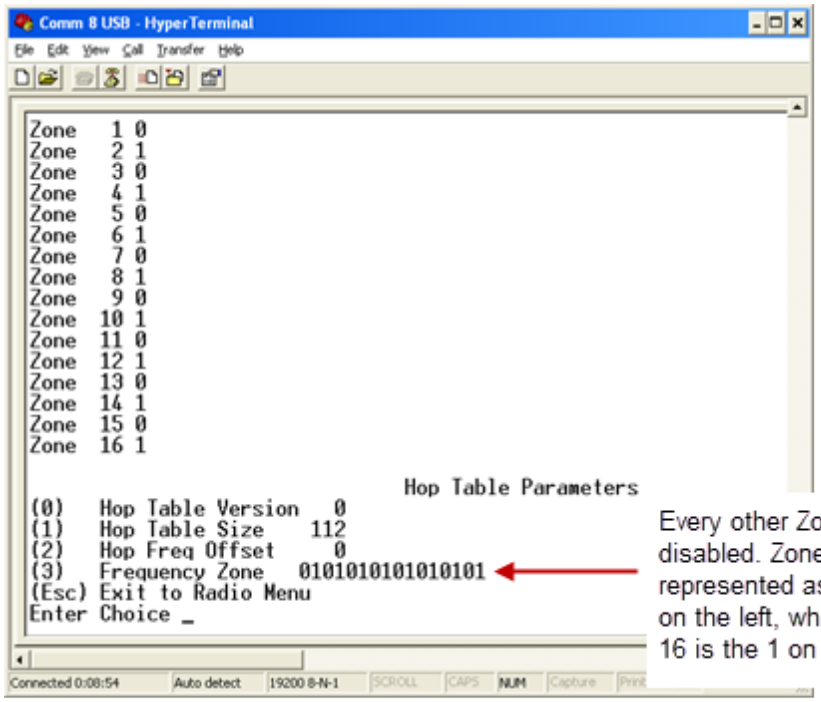
2. Using Zones 0-6 is equal to 50 channels; this is legal according to the FCC.

To enable Frequency Zones in Tool Suite:

1. In the Tool Suite Configuration application, select the device to program and click the **(3) Transmission Characteristics** tab.
2. Click **Frequency Zones** in the Transmission Characteristics tab to display the frequency zones available.
3. Select the check boxes next to the Frequency Zones to enable.

To enable Frequency Zones in HyperTerminal:

1. From 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 and **0** to disable a frequency zone. Frequency Zone entries begin with 1 (LSB) and continue through 16 (MSB).



Frequency Zones in 2.4 GHz Transceivers

Tool Suite Tab:	Transmission Characteristics
Setup Terminal Menu:	(3) Edit Radio Transmission Characteristics > (0) FreqKey > F > (3) Frequency Zone
Network Type:	Both
Default Setting:	All selected
Options:	See below
Description:	Use **Frequency Zones** to select which portions of the band the network uses. Setting a zone to **1** includes it in the hopping pattern, while setting the zone to **0** excludes that zone. Below is the frequency zone table displaying the beginning frequency and ending frequency in each of the 16 zones. The following tables reflects the usage of **Frequency Offset 0**. Using Frequency Offset **1** or **2** shifts all frequencies by 11.2 or 230.4 kHz respectively.

In MultiPoint networks, this setting only needs to be set on the Master radio. In a Point-to-Point network, the Master and the Slave must have matching **Frequency Zone** settings. By default, all Frequency Zones are enabled.

Note: The **Hop Table Version** must be set to **0** when using Frequency Zones. If another **Hop Table Version** were to be selected, the limitations of that selection would be applied to the hopping pattern as well. For example, if the **Hop Table Version** is set to **3**, only the middle of the band would be available in the pattern. Then, if Frequency Zones 5, 6, 7, 8, and 9 were set to 0, no allowable frequencies would be available for the radio to use.

Binary Zone Number (LSB First)	Beginning Freq. (MHz)	Ending Freq. (MHz)
0	2400.3072	2405.4912
1	2405.8368	2410.6752
2	2411.0208	2415.8592
3	2416.2048	2421.0432
4	2421.3888	2426.2272
5	2426.5728	2431.4112
6	2431.7568	2436.5952
7	2436.9408	2441.7792
8	2442.1248	2446.9632
9	2447.3088	2452.1472
10	2452.4928	2457.3312
11	2457.6768	2462.5152

Binary Zone Number (LSB First)	Beginning Freq. (MHz)	Ending Freq. (MHz)
12	2462.8608	2467.6992
13	2468.0448	2472.8832
14	2473.2288	2478.0672
15	2478.4128	2483.2512

Warning! To adhere to the EU specifications, it is necessary to use the proper frequency zone combination based on the frequency offset. While using a frequency offset of zero, the first zone (0) needs to be removed. Using frequency offsets of one or two, the last zone (15) needs to be removed. See table below.

Frequency Offset	Frequency Zone Requirements
0	0xxxxxxxxxxxxxx
1	xxxxxxxxxxxxxx0
2	xxxxxxxxxxxxxx0

To enable Frequency Zones in Tool Suite:

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

To enable Frequency Zones in HyperTerminal:

1. From 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 and **0** to disable a frequency zone. Frequency Zone entries begin with 0 (LSB) and continue through 15 (MSB).

Government Rules for 2.4 GHz Transceivers

Tool Suite Tab:	None
Setup Terminal Menu:	(3) Edit Radio Transmission Characteristics > (0) FreqKey > F > (4) Government Rules
Network Type:	Both
Default Setting:	The government rule is set at the factory to comply with the rules of the country to which the radio ships.
Options:	0 - FCC rules - Radio power output can be set to a maximum of 27 dBm (500 mW) 1 - ETSI 328 - Radio power output can be set to a maximum of 20 dBm (100 mW)
Description:	Sets the transceiver to comply with the government standards for the country to which it ships. The radio always uses the factory setting.

High Noise

Tool Suite Tab:	Transmission Characteristics
Setup Terminal Menu:	(3) Edit Radio Transmission Characteristics > (A) High Noise
Network Type:	Both
Default Setting:	(0) Disabled
Options:	(0) Disabled, (1) Enabled
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. When a noise problem is shown to be helped using the **High Noise** option, chances are that the noise may be further decreased using a bandpass filter available from FreeWave.

Hop Frequency Offset in 2.4 GHz Transceivers

Tool Suite Tab:	Transmission Characteristics
Setup Terminal Menu:	(3) Edit Radio Transmission Characteristics > (0) FreqKey > F > (2) Hop Frequency Offset
Network Type:	Both
Default Setting:	0
Options:	(0) - No Offset (1) - 115.2 KHz offset (2) - 230.4 KHz
Description:	In the 2.4 GHz transceivers, this setting allows you to select an offset of 115.2 KHz, or 230.4 KHz higher than the standard frequency selection. For example, if two networks are operating side by side, with one set to **Hop Freq Offset** of **0** and the other to **Frequency Offset** of **1**, the frequencies used in the different hopping patterns are offset by 115.2 KHz.

Hop Table Size in 900 MHz Transceivers

Tool Suite Tab:	Transmission Characteristics
Setup Terminal Menu:	(3) Edit Radio Transmission Characteristics > (0) FreqKey > F > (1) Hop Table Size
Network Type:	Both
Default Setting:	112
Options:	50 to 112
Description:	Defines how many separate channels a given network uses.

Important: All transceivers in a network must have identical **Hop Table** settings to function properly.

Hop Table Size in 2.4 GHz Transceivers

Note: FreeWave recommends using **Frequency Zones** instead of the Hop Table Size setting.

Tool Suite Tab:	Transmission Characteristics
Setup Terminal Menu:	(3) Edit Radio Transmission Characteristics > (0) FreqKey > F > (1) Hop Table Size
Network Type:	Both
Default Setting:	80
Options:	75 to 80
Description:	Defines how many separate channels a given network uses.

Important: All transceivers in a network must have identical **Hop Table** settings to function properly.

Warning! FCC regulations require a minimum of 50 separate frequency channels be used within a hop pattern. Using the Standard hop table, a minimum of 5 frequency zones are required for legal communication.

Hop Table Version in 900 MHz Transceivers

Tool Suite Tab:	Transmission Characteristics
Setup Terminal Menu:	(3) Edit Radio Transmission Characteristics > (0) FreqKey > F > (0) Hop Table Version
Network Type:	Both
Default Setting:	902-928 MHz
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 Do not use **Frequency Key E** (916-920 MHz) with the 915-928 MHz, 916-920 MHz, and 921-928 MHz hop tables.
Description:	Determines the section of the 900 MHz band the transceiver uses.

Important: All transceivers in a network must have identical **Hop Table** settings to function properly.

In Setup Terminal or HyperTerminal, enter the number that corresponds to the frequency band:

Number to Enter	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

Hop Table Version in 2.4 GHz Transceivers

Note: FreeWave recommends using **Frequency Zones** instead of the Hop Table Size setting.

Tool Suite Tab: Transmission Characteristics

Setup Terminal Menu: (3) Edit Radio Transmission Characteristics > (0) FreqKey > F > (0) Hop Table Version

Network Type: Both

Default Setting: 2400 - 2483 MHz

Options:

- 2400 – 2483 MHz (2.4 – 2.4835 GHz)
- 2400(46) – 2483(54) MHz, entire band, but offset frequencies
- 2400(46) – 2427(27) MHz, lower 1/3 of the band
- 2428(49) – 2455(51) MHz, middle of the band
- 2456(51) – 2483(54) MHz, upper 1/3 of the band
- 2428(49) – 2455(51) MHz, 2 outer 1/3rds of band, avoids the middle

Description: Determines the section of the 2.4 GHz band the transceiver uses.

Important: All transceivers in a network must have identical **Hop Table** settings to function properly.

In Setup Terminal or HyperTerminal, enter the number that corresponds to the frequency band:

Number to Enter	Frequency Band
0	2400 – 2483 MHz (2.4 – 2.4835 GHz)
1	2400(46) – 2483(54) MHz, entire band, but offset frequencies
2	2400(46) – 2427(27) MHz, lower 1/3 of the band
3	2428(49) – 2455(51) MHz, middle of the band

Number to Enter	Frequency Band
4	2456(51) – 2483(54) MHz, upper 1/3 of the band
5	2428(49) – 2455(51) MHz, 2 outer 1/3rds of band, avoids the middle

Local Mode

Tool Suite Tab:	MultiPoint Parameters
Setup Terminal Menu:	(5) Edit MultiPoint Parameters > (E) Local Access
Network Type:	Point-to-MultiPoint
Default Setting:	(0) Disabled
Options:	(0) Disabled, (1) Enabled
Description:	Enable **Local Mode** to access a MultiPoint slave with a local master. This Master is not the network master. For more information, see application note #5457, *Local Mode*.

Low Baud Rates

The transceiver's baud rate may be set to 300, 600, or 900 baud. For more information about using a low baud rate, contact FreeWave technical support.

Low Power Mode

Note: This setting applies to only Multipoint Slaves using a RS232 protocol.

Tool Suite Tab:	Transmission Characteristics
Setup Terminal Menu:	(3) Edit Radio Transmission Characteristics > (9) Low Power Mode
Network Type:	Point-to-MultiPoint
Default Setting:	0
Options:	Any number between 0 and 31. The higher the number, the greater the decrease in power consumption.
Description:	Allows a MultiPoint Slave to consume less power, primarily by dimming the transceiver's LEDs. When set to **2** through **31**, the transceiver sleeps between slots. For example, at a setting of **2** the transceiver sleeps 1 out of 2 slots; at a setting of **3** the transceiver sleeps 2 out of 3 slots, and so on.

The following table shows the changes at different **Low Power Mode** settings. The actual current draw depends on many factors. The table below gives only a qualitative indication of supply current savings. A low number reduces latency and a high number reduces current consumption.

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

Note the following about the **Low Power Mode** parameter:

- Power savings occur only when the Slave is linked. No power savings occur when the Slave is transmitting data. **Low Power Mode** is of little value when a Slave has a constant, high throughput. **MCU Speed** must be set to **0** and **RF Data Rate** must be set to **3** for **Low Power Mode** to operate properly.
- To communicate to an RS232 port of a transceiver that is in **Low Power Mode**, the RTS line must be held high to wake it up. The transceiver wakes up within approximately 20 milliseconds of when RTS goes high.
- If the Request to Send (RTS) line on the Slave is held high, the transceiver remains in normal operation regardless of the **Low Power Mode** setting. After RTS is dropped the transceiver reverts to the **Low Power Mode**.
- If the transceiver has the **DTR Connect** option In the MultiPoint Parameters tab set to **1** or **2** and if the **Low Power Mode** is enabled (set to **1-31**), the RTS line on the transceiver 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, ensure the following are set:
  - In the Baud Rate tab, the **Setup Port** parameter is set to **1 (Main Only)**.
  - In the MultiPoint Parameters tab, the **Diagnostics** parameter is set to **0** (Off)
- To realize full power savings in **Low Power Mode**, the serial port must be deactivated between operation. To do that the RTS line must be asserted. However, because RS485/422 operation uses the RTS line as part of the data bus, it cannot be asserted to wake-up the radio. Therefore, FreeWave recommends that all radios set to RS485 or RS422, use a **Low Power Mode** setting of **0**.

Master Packet Repeat

Tool Suite Tab:	MultiPoint Parameters
Setup Terminal Menu:	(5) Edit Multipoint Parameters > (1) Master Packet Repeat
Network Type:	Point-to-MultiPoint
Default Setting:	3
Options:	Any number between 0 and 9.
Description:	In a Point-to-MultiPoint network, Slaves do not acknowledge transmissions from the Master. If Slaves did acknowledge all data transmissions, in a large network, the Master would soon become overwhelmed with acknowledgments from the Slaves. Without acknowledgements, 100% confidence every Slave has received every packet cannot be met. To address this issue, you can modify the **Master Packet Repeat** parameter, assigning a value between **0** (the packet is transmitted once) to **9** (the packet is transmitted 10 times).

For networks with solid RF links, this parameter should be set to a low value such as **1** or **2**. If a network has some weak or marginal links it should be set with higher values. If a Slave receives a good packet from a Master more than once it discards the repeated packets. Similarly, after a MultiPoint Repeater receives a good packet from the Master, it discards any further repeated packets. In turn, the Repeater sends the packet out to 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. 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.

Note: The **Master Packet Repeat** may be set to **0** if the user software is capable of, or requires acknowledgment. In this case, if the Master sends a packet that the Slave does not receive, the user software controls the retries as needed.

Master Packet Repeat in MultiPoint Networks with Repeaters

The **Master Packet Repeat** parameter must also be set in MultiPoint Repeaters because a Repeater appears as a Master to a Slave. Therefore, the Repeater sends the packet out the number of times corresponding to its own **Master Packet Repeat** parameter. If this parameter is set improperly the reliability of the overall network may be diminished.

For example, if a Master's **Master Packet Repeat** setting is **3**, the link between the Master and Repeater should be robust. If the Repeater's **Master Packet Repeat** is set to **0**, this could cause marginal communications 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 does not respond as expected.

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

Max Packet Size and Min Packet Size

Tool Suite Tab:	Transmission Characteristics
Setup Terminal Menu:	(3) Edit Transmission Characteristics > (1) Max Packet Size and (2) Min Packet Size
Network Type:	Both
Default Setting:	Max Packet Size = 8 Min Packet Size = 9
Options:	Any number between 0 and 9.
Description:	The **Max** and **Min Packet Size** settings and the **RF Data Rate** 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 KBaud is desired. However, this may have an impact on latency. For 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.

Important: In MultiPoint networks, the **Max Packet Size** and **Min Packet Size** must be set identically in all transceivers.

In Point-to-Point networks the Master's settings take precedence over the Slave.

The following table defines the minimum packet size in bytes by charting the **Min Packet Size** setting versus the **RF Data Rate** setting. Using the default settings, the actual minimum packet size, in bytes, is 44.

Minimum Packet Size Definition		
Min Setting	**Min Packet Size RF Data Rate = 2**	**Min Packet Size RF Data Rate = 3**
0	15	8
1	21	12
2	26	16
3	31	20
4	37	24
5	42	28
6	47	32
7	53	36
8	58	40
9	63	44

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

Maximum Packet Size Definition with RF Data Rate of 2										
	Max 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

The following table defines the maximum packet size in bytes by charting the **Min Packet Size** setting versus the **Max Packet Size** setting where the **RF Data Rate** is set to **3** (Normal). Using the default settings, the actual maximum packet size, in bytes, is 172.

Maximum Packet Size Definition with RF Data Rate of 3										
	Max Setting									
Min 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's transmission, plus the quantity in the **Min Packet Size** setting

For example, if a Master transmits 100 bytes, the Slave then has a total of 116 bytes available:

(72 (“leftover bytes”) + 44 (Min packet size))

Max Slave Retry

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

MCU Speed

Tool Suite Tab:	Transmission Characteristics
Setup Terminal Menu:	(3) Edit Radio Transmission Characteristics > (B) MCU Speed
Network Type:	Both
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.
Description:	Controls the speed of the Micro Controller Unit (MCU) in the transceiver.

Modbus RTU

Tool Suite Tab:	Baud Rate
Setup Terminal Menu:	(1) Set Baud Rate > (B) Modbus RTU
Network Type:	Both
Default Setting:	0 (Disabled)
Options:	0 to 9
Description:	Support for **Modbus RTU** protocol is available. A setting other than **0** in this field causes the radio to wait for an amount of time "gathering" data before sending out the radio link.

- When **Modbus RTU** is set to **0** (Disabled), the radio sends data out through its radio link as soon as the data is received into the serial port.
- When **Modbus RTU** is set to **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 radio link. For example, if the **Master Packet Repeat** parameter is set to **3**, the transceiver waits for 6 slots, gathering data up the whole time. At the end of the 6 slots, the radio sends all received data in one "burst." This is the appropriate setting for most Modbus RTU devices.
- When **Modbus RTU** set to **2** and higher, the radio waits for a number of slots calculated using the following formula:

  (Modbus RTU setting + Master Packet Repeat setting + 1) x 2

  For 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.

Note: When using the transceiver 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. The **Modbus RTU** mode must be set to **1** when transceivers are configured in RS485 or RS422 mode.

Modem Mode

Tool Suite Tab: Operation Mode

Setup Terminal Menu: (0) Set Operation Mode

Network Type: Both

Default Setting: Point-to-Point Slave

Options: See below.

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

In a Point-to-Point configuration, Master or Slave mode may be used on either end of the communication link without performance degradation. When setting up the transceiver, remember that the Master's settings control a number of parameters. Therefore, deploying the Master on the communications end where it is easier to access is advised, but not necessary.

Note: To set a transceiver as a Point-to-MultiPoint Slave/Repeater, enable the Slave/Repeater parameter in the MultiPoint Parameters tab. For more information, see "Slave/Repeater" on page 57.

Operation Mode	Description
Point-to-Point Master (0)	This mode designates the transceiver as the Master in Point-to-Point mode. The Master may call any or all Slaves designated in its Call Book. In Point-to-Point mode the Master determines the setting used for most of the radio transmission characteristics, regardless of the settings in the Slave and/or Repeaters. The settings not determined by the Master are: • RF Xmit Power • Slave Security • Retry Time Out • Hop Table settings A quick method of identifying a Master is to power the transceiver. Prior to establishing a communication link with a Slave, all three of the Master's LEDs are solid red.
Point-to-Point Slave (1)	This mode designates the transceiver as a Slave in Point-to-Point mode. The Slave communicates with any Master in its Call Book—either directly or through up to four Repeaters. When functioning as a Slave, the Entry to Call feature in the transceiver's Call Book is not operational. Set **Slave Security** to **1** to bypass the Call Book in the Slave. For more information, see "Slave Security" on page 57.

Operation Mode	Description
Point–to-MultiPoint Master (2)	This mode designates the transceiver as a Master in MultiPoint mode. This mode allows one Master transceiver to communicate simultaneously with numerous Slaves and Repeaters. A Point-to-MultiPoint Master communicates only with other transceivers designated as Point-to-MultiPoint Slaves or Point-to-MultiPoint Repeaters.
Point-to- MultiPoint Slave (3)	This mode designates the transceiver 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 transceiver to act as *either* a Slave or Repeater—depending on the instructions from the Master. The transceiver cannot act as both a Slave and a Repeater at the same time. True Slave/Repeater functionality is only available in a MultiPoint mode. **Note:** Point-to-Point Slave/Repeaters have no security features. When a transceiver is designated a Point-to-Point Slave/Repeater, it allows any Master to use it as a Repeater.
Point-to-Point Repeater (5)	FreeWave allows the use of up to four Repeaters in a Point-to-Point communications link, significantly extending the operating range. When designated as a Repeater, a transceiver behaves as a pass-through link. All settings for the Call Book, baud rates, and radio transmission characteristics are disabled. A Repeater connects with any Master that calls it. The Repeater must be set up properly in the Master's Call Book.
Point-to-Point Slave/Master Switchable (6)	Mode 6 allows the transceiver to be controlled entirely through software commands. A number of key parameters in the FreeWave user interface may be changed either directly with a program such as Windows Terminal or through the use of script files. Additionally, when the **Point-to-Point Slave/Master Switchable** option is selected and the transceiver is not calling a Slave, it functions as a Slave and accepts any appropriate calls from other transceivers. For more information, see application note #5476, *Mode 6*.
Point-to-MultiPoint Repeater (7)	This option allows the transceiver to operate as a Repeater in a MultiPoint network.
Mirrorbit Master (A)	For information about Mirrored Bit Communication, see FreeWave application note #5424, *Using the FGR-115MB Radio with Schweitzer Engineering Labs Mirrored Bits Communications* and the *FGR Radio Modem in Mirrored Bit Mode Addendum*. Mirrored Bit Communication is supported in firmware version 8.77 and later.
Mirrorbit Slave (B)	
Ethernet Options (F)	This menu is needed for Ethernet transceivers only. Although the menu is included here, it is unrelated to this transceiver.

Multi-Master Synch

The **Multi-Master Synch** 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 Masters. For more information, see application note #5412, *Synchronizing Collocated Masters*, or contact FreeWave Technical Support.

Operation Mode

See "Modem Mode" on page 47.

Network ID

Tool Suite Tab:	MultiPoint Parameters
Setup Terminal Menu:	(5) Edit MultiPoint Parameters > (6) Network ID
Network Type:	Point-to-MultiPoint
Default Setting:	255, which enables the Call Book
Options:	Any value between 0 and 4095 (excluding 255)
Description:	Use the **Network ID** to establish MultiPoint networks without using the Call Book. To enable the **Network ID**, the value must be set between **0** and **4095** (excluding 255). Since **Network ID** does not use serial numbers, MultiPoint Masters and Repeaters may be replaced without reprogramming all of the Slaves in the network. Slaves link with the first Master or Repeater that it hears that has a matching the **Network ID**. The **Network ID** function should be used in conjunction with the **SubNet ID** feature (if necessary). Without having the serial numbers in the Call Book, a Slave may establish communications with different Masters, though not at the same time. This is very useful in mobile MultiPoint applications. A network ID of four characters is recommended. For example, the last four digits of the Master's serial number.

Number Repeaters

See "Repeaters" on page 51.

Radio ID

Tool Suite Tab:	MultiPoint Parameters
Setup Terminal Menu:	(5) Edit MultiPoint Parameters > (D) Radio ID
Network Type:	Point-to-MultiPoint
Default Setting:	Blank
Options:	Any 4 digit, user-defined number.
Description:	Use this option to designate a transceiver with an arbitrary, user-defined, 4-digit number that identifies the transceiver in Diagnostics mode.

Radio Name

Tool Suite Tab:	Device Information or MultiPoint Parameters
Setup Terminal Menu:	(5) Edit MultiPoint Parameters > (G) Radio Name
Network Type:	Both
Default Setting:	Blank
Options:	Any combination of letters or numbers up to 20 characters
Description:	Use this parameter to give a transceiver a name, such as its location. Naming transceivers can be helpful to identify a device when running network diagnostics.

Remote LED

Note: This feature is available in firmware versions 2.64 (900 MHz) and 3.64 (2.4 GHz) or higher.

Tool Suite Tab:	Transmission Characteristics
Setup Terminal Menu:	(3) Edit Radio Transmission Characteristics > (C) Remote LED
Network Type:	Both
Default Setting:	(0) Local Only
Options:	(0) Local Only - Only the LEDs on the radio board are enabled. (1) Remote and Local - LEDs on the radio board and remote LEDs through the diagnostic port are enabled. (2) Remote Only - LEDs on the radio board are disabled. Remote LEDs through the diagnostic port are enabled.
Description:	If you are using a transceiver with the optional 24-pin connector, you can use this option to connect Remote LEDs through the diagnostics port.

This feature may be used to save power in MultiPoint Repeaters. By turning off the on board LEDs (setting = **2**) the current consumption is reduced. To reduce current consumption in Slaves, use the **Low Power** (setting = **1**). Low Power does not work with MultiPoint Repeaters because they are constantly transmitting. **Remote LED** drives the Diagnostic port, which has a small amount of current draw.

Note: 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.

Repeater Frequency

Tool Suite Tab:	MultiPoint Parameters
Setup Terminal Menu:	(5) Edit MultiPoint Parameters > (5) Repeater Frequency
Network Type:	Point-to-MultiPoint
Default Setting:	(0) Disabled
Options:	(0) Disabled, (1) Enabled
Description:	Enable this parameter when you need a Frequency Key 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 Frequency Key set in the **Frequency Key** field in the Operation Mode tab. **Note:** When **Repeater Frequency** is disabled and **Subnets** are not configured, the **Frequency Key** setting in each Slave must match the Master or Repeater acting as the Master for the transceiver.

Repeaters

Tool Suite Tab:	MultiPoint Parameters
Setup Terminal Menu:	(5) Edit MultiPoint Parameters > (0) Number Repeaters
Network Type:	Point-to-MultiPoint
Default Setting:	(1) Enabled
Options:	(0) Disabled, (1) Enabled
Description:	Indicates if any number of Repeaters exist in the network. This parameter is used only in the MultiPoint Master radio.

Retry Odds

Tool Suite Tab:	MultiPoint Parameters
Setup Terminal Menu:	(5) Edit MultiPoint Parameters > (3) Retry Odds
Network Type:	Point-to-MultiPoint
Default Setting:	9
Options:	Any number between 0 and 9.
Description:	While packets transmitted from the Master to the Slaves in a MultiPoint network are not acknowledged, packets transmitted from Slaves to the Master are. It is possible, that more than one Slave attempts to transmit to the Master at the same time. Therefore, it is important that a protocol exists to resolve contention for the Master between Slaves. This is addressed through the **Max Slave Retry** and **Retry Odds** parameters. After the Slave has unsuccessfully attempted to transmit the packet the number of times specified in the **Max Slave Retry** parameter, it attempts to transmit to the Master on a random basis. The **Retry Odds** parameter determines the probability that the Slave attempts to retransmit the packet to the Master; a low setting assigns low odds to the Slave attempting to transmit. Conversely, a high setting assigns higher odds.

An example of how this parameter might be used would be when considering two different Slaves in a MultiPoint network, one with a strong RF link and the other with a weak RF link to the Master. You may want to assign higher **Retry Odds** to the Slave with the weaker link to give it a better chance of competing with the closer Slave(s) for the Master's attention.

When **Retry Odds** is set to **0**, after the Slave has exhausted the number of retries set in the **Max Slave Retry** parameter and still not gained the Master's attention, the Slave's data buffer is purged. A **Retry Odds** set to **0** is recommended for most networks.

Retry Time Out

Tool Suite Tab:	Transmission Characteristics
Setup Terminal Menu:	(3) Edit Transmission Characteristics > (8) Retry Time Out
Network Type:	Both
Default Setting:	255
Options:	Any number between 0 and 255 in MultiPoint networks. Any number between 151 and 255 in Point-to-Point networks.
Description:	The **Retry Time Out** parameter in a Slave or Repeater sets the delay the unit waits before dropping the connection to a Master or Repeater. The factory default is set at the maximum of **255**. The maximum setting means that if 1 packet in 255 is sent successfully from the Master to the Slave or Repeater, the link is maintained. The minimum setting is **8**. This allows a Slave or Repeater to drop a connection if less than 1 in 8 consecutive packets is successfully received from the Master. The function in the Master is effectively the same. With a setting of **255**, the Master allows a Slave or Repeater to stay connected as long as 1 packet in 255 is successfully received at the Master.

The **Retry Time Out** parameter is useful when a MultiPoint network has a roving Master or Slave(s). As the link gets weaker, a lower setting allows a poor link to break in search of a stronger one.

Note: Setting **Retry Time Out** 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.

While intended primarily for MultiPoint networks, the **Retry Time Out** parameter may also be modified in Point-to-Point networks. However, the value in Point-to-Point mode should not be set to less than 151.

RF Data Rate

Tool Suite Tab:	Transmission Characteristics
Setup Terminal Menu:	(3) Edit Transmission Characteristics > (4) RF Data Rate
Network Type:	Both
Default Setting:	(3) Normal
Options:	(2) High (3) Normal
Description:	FreeWave transceivers have two **RF Data Rate** settings; **2** (High) and **3** (Normal). **RF Data Rate** should not be confused with the serial port **Baud Rate**. Use setting **2** (RF Speed of 153.6 kbps) when the transceivers are close together and you need to optimize data throughput. Use setting **3** (RF Speed of 115.2 kbps) when the transceivers are farther away and a solid data link is preferred over data throughput.

Important: In MultiPoint networks, the **RF Data Rate** must be set identically in all transceivers. Any transceiver with an **RF Data Rate** different from the Master will not establish a link.

In Point-to-Point networks the Master's settings take precedence over the Slave.

RF Xmit Power

See "Transmit Power" on page 60.

RS232/RS485

See "Serial Interface" on page 55.

RTS to CTS

Note: The RTS to CTS option is only available in RS232 mode.

Tool Suite Tab:	Transmission Characteristics
Setup Terminal Menu:	(3) Edit Transmission Characteristics > (7) RTS to CTS
Network Type:	Both
Default Setting:	(0) Disabled
Options:	(0) Disabled, (1) Enabled, (2) Line Alarm Setting **2** is described in detail in the application note *#5437, DTR to CTS Line Alarm Feature*
Description:	Use this option to set the RTS line on the Master transceiver to control the CTS line of the Slave. In MultiPoint networks, the Master RTS line controls all Slaves' CTS lines. When enabled, the CTS line ceases to function as flow control. It is not recommended to enable this feature when operating at baud rates above 38.4 kB.

With **RTS to CTS** enabled, 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 21 ms, given no Repeaters in the network. At the minimum settings for **Max** and **Min Packet Size (0)**, the time is approximately 5.9 ms. 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.

For example, if the latency between the Master and the first Repeater is 15 ms, and two serial Repeaters are present, the total latency is 45 ms. (M—R1 (15 ms) + R1—R2 (15 ms) + R2—S (15 ms) = 45 ms)

Note: 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** in the MultiPoint Parameters tab is enabled and set to **2**, the RTS to CTS feature does not work. 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.

Serial Interface

Tool Suite Tab:	Baud Rate
Setup Terminal Menu:	(1) Set Baud Rate > (C) RS232/485
Network Type:	Both
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. See below.
	If set to anything other than **0**, the **Setup Port** must be set to **Diagnostics Only**.
Description:	Use this option to set the protocol of the data port. In TTL RF board products (FGR09Tx) this setting must be **0**.

DOT causes the CD line to indicate when data is transmitted on the serial port from the radio. When the radio is not sending data to the serial port, CD is de-asserted. When the radio is sending data to the serial port, CD is asserted. The CD line no longer has any radio link state functionality. **Turn Off Delay** works as described in all radios. **Turn On Delay** works as described on any Slave or Slave/Repeater - it has no functionality on the Master radio.

Setup Port

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

Tool Suite Tab:	Baud Rate
Setup Terminal Menu:	(1) Set Baud Rate > (D) Setup Port
Network Type:	Both

Default Setting:	(3) Both The factory setting is based on the transceiver type. A setting of **2** is used with Ethernet products and Mirrored Bit products, a setting of **3** is used otherwise.
Options:	(1) Main Only - Programming and reading a transceivers setup information is done through the data port pins. (2) Diagnostics Only - Programming and reading a transceivers setup information is done through the diagnostic port pins. 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 transceivers setup information is done through either the data port pins or the diagnostic port pins.
Description:	Determines which port on the radio, Main or Diagnostics, is used to access the parameter settings in Tool Suite or enter the Setup main menu in Setup Terminal or HyperTerminal.

Setup mode is invoked by sending a "U" (**Shift-U**) to the Diagnostics port or by pressing/toggling the Setup button/switch, if available.

Note: OEM boards may also enter Setup when Pin 2 on a 10-point connector or Pin 8 on a 24-pin connector is grounded.

The main data port is the RS232 port. The Diagnostics port is a 3-pin connector on the rear panel of the OEM “Mini” series transceivers. 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.

Setup Mode Timeout

Tool Suite Tab:	Operation Mode
Setup Terminal Menu:	(1) Set Baud Rate > (D) Setup Port
Network Type:	Both
Default Setting:	(0) Disabled
Options:	(0) Disabled, (1) Enabled
Description:	When enabled, this option adds a timeout feature to the radio being in Setup mode. If the transceiver goes into Setup mode and does not receive legitimate menu selections or programming information within 3 to 5 seconds, it exits Setup and resumes its previous mode.

Slave/Repeater

Tool Suite Tab:	MultiPoint Parameters
Setup Terminal Menu:	(5) MultiPoint Parameters > (A) Slave/Repeater
Network Type:	Point-to-MultiPoint
Default Setting:	(0) Disabled
Options:	(0) Disabled, (1) Enabled
Description:	The **Slave/Repeater** mode allows a transceiver in a MultiPoint network to switch between Slave and Repeater functions. When in this mode, a transceiver 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 transceiver. To operate a transceiver as a MultiPoint Slave/Repeater, the **Modem Mode** in the Operation Mode tab must be set to **MultiPoint Repeater** and the **Slave/Repeater** parameter set enabled.

Slave Security

Tool Suite Tab:	Transmission Characteristics
Setup Terminal Menu:	(3) Edit Transmission Characteristics > (6) Slave Security
Network Type:	Both
Default Setting:	(0) On
Options:	(0) On, (1) Off
Description:	Slave security allows Slave transceivers to accept transmissions from a Master not included in the Call Book. The default setting of **0** (On), means only Masters in the Slaves' Call Book may link to that Slave. **Slave Security** may be disabled (setting of **1**) allowing any Master to call the Slave. **Slave Security** has no effect in Point-to-MultiPoint networks where the **Network ID** is not set to **255**.

Slave Security must be set to **1** when the unit is operating in Mode 6, Slave/Master Switchable or a Point-to-Point network where the Slave may need to accept calls from more than 10 different Masters. When **Slave Security** is set to **1**, the transceiver accepts calls from any other FreeWave transceiver. Additional network security measures may be taken to prevent unauthorized access, such as changing default settings for **Frequency Key**, **Hop Table**, or **Frequency Zones**.

Subnet ID

Tool Suite Tab:	MultiPoint Parameters
Setup Terminal Menu:	(5) Edit MultiPoint Parameters > (C) Subnet ID
Network Type:	Point-to-MultiPoint using a Network ID
Default Setting:	F, F
Options:	Any number between 0 and 9 or any letter between A and F.
Description:	In a MultiPoint Network, a Slave or Repeater connects with the first Repeater or Master that it hears with the same Network ID. However, where communications need to be forced to follow a specific path, use the **Subnet ID**. Subnet ID is particularly helpful to force two Repeaters in the same network to operate in series rather than in parallel, or if desired, to force Slaves to communicate to a specific Repeater for load balancing purposes.

Two components exist with regard to the Subnet ID:

- **Rx** - This setting identifies which transceiver a Repeater or Slave listens to. In Setup Terminal, this is the **Rcv Subnet ID**.
- **Tx** - This setting identifies the ID on which this device transmits, and in turn which devices listen to it. The **Xmt Subnet ID** parameter is relevant for MultiPoint Masters and Repeaters ***only***. In Setup Terminal, this is the **Xmt Subnet ID**.

The default (disable) setting for both **Rx** and **Tx** is **F**, which is a good visual way to indicate that the device is the final in the line 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** of **0** or an **F**,**F Subnet ID**.

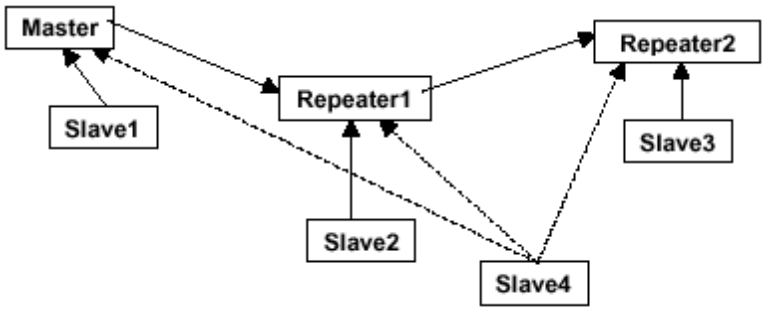
Note: A Master with firmware before x.40 always transmits and receives on **0**. With firmware of 2.40 and greater (900 MHz) or 3.40 and greater (2.4 GHz) the Master may be set to use alternate **Subnet ID** values. Changing these settings on the Master is not recommended under normal circumstances.

In some MultiPoint networks, the Frequency Key is the same setting for all transceivers. In other networks, where parallel Repeaters are introduced, the Frequency Key value needs to change. For more information, see the Frequency Key and Repeater Frequency sections earlier in this manual.

Setting both **Rx** and **Tx Subnet ID** to **0** allows a mobile Slave to roam from subnet to subnet.

The following drawing depicts a network in which Subnet IDs are used to force communications. In this example, Repeater1 must talk directly to the Master; Repeater2 must talk directly to Repeater1. Slaves 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.

The respective Subnet ID diagram and settings are shown below.



Subnet ID Settings

Transceiver	Rx	Tx	Other Information
Master	F	F	In firmware levels v2.34 and below, the Master uses 0, 0.
Master	0-F	0-F	In firmware levels v2.40 and above, the **Tx Subnet** value may be set in the Master. The default settings (F, F) actually use 0, 0. The **Rx Subnet** on the Master has no effect on the network.
Repeater1	0	1	A 0 forces the transceiver to link only to the Master.
Repeater2	1	2	**Rx Subnet** = 1 forces communication through Repeater1. Repeater1 transmits on SubnetID 1.
Slave1	0	0 or F	**Rx Subnet** = 0 forces communication through Master.
Slave2	1	0 or F	**Rx Subnet** = 1 forces communication through Repeater1.
Slave3	2	0 or F	**Rx SubnetID** = 2 forces communication through Repeater2.
Slave4	0	0	The 0, 0 setting allows the Slave to link with the first Master or Repeater it hears with the correct Network ID.

Note: With firmware 2.40 3.40 and above, the **Subnet ID** default is **F**,**F**. A Multipoint Master with an **F**,**F Subnet ID** behaves the same as if the **Subnet ID** was set to **0**,**0**. 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** of **0** or an **F**,**F Subnet ID**.

Time Divisible Multiple Access (TDMA)

Time Divisible Multiple Access (TDMA) allows radios to do various operations on specific time slots. This option is only used for peer-to-peer communications or when applications are very time specific.

For additional information about TDMA, contact FreeWave Technical Support.

Transmit Power

Tool Suite Tab: Transmission Characteristics

Setup Terminal Menu: (3) Edit Transmission Characteristics > (5) RF Xmit Power

Network Type: Both

Default Setting: 10 dBm

Options: Any number between 0 and 10

Description: Sets the output power of the radio. In FGR2 radios, a setting of **10** is approximately 1 W of output power. In the I2 series radios, a setting of 10 is approximately 500 mW of output power.

Setting	Power (in mW) for FGR2 radios	Power (in mW) for I2 radios
0	5	0
1	10	22
2	35	80
3	80	158
4	140	251
5	230	316
6	330	372
7	480	398
8	600	427
9	800	447
10	1000	500

Transmit Rate

Tool Suite Tab:	Transmission Characteristics
Setup Terminal Menu:	(3) Edit Transmission Characteristics > (3) Xmit Rate
Network Type:	Both
Default Setting:	(1) Normal
Options:	(0) Diagnostics (1) Normal
Description:	FreeWave transceivers have two available **Transmit Rate** settings. The setting for normal operation of the transceiver is **1**. **0** is useful to qualitatively gauge signal strength in Point-to-Point mode. When set to **0**, the transceivers 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.

Turn Off Delay

Tool Suite Tab:	Baud Rate
Setup Terminal Menu:	(1) Edit Baud Rate > Turn Off Delay
Network Type:	Both
Default Setting:	0
Options:	Any number between 0 and 9 mS.
Description:	Specifies the time after the end of transmission of a character to the RS485 bus that the transceiver 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 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. **Note: Turn Off Delay** must be set to a value of at least **4** for RS422 and RS485 operation.

Turn On Delay

Tool Suite Tab:	Baud Rate
Setup Terminal Menu:	(1) Set Baud Rate > (E) Turn On Delay
Network Type:	Both
Default Setting:	0 mS
Options:	Any number between 1 and 9 mS
Description:	Sets the delay between when the line drivers are turned on and when the data leaves the data port.

Xmit Rate

See "Transmit Rate" on page 61.

Factory Default Settings

FreeWave serial transceivers are shipped from the factory with the following default settings:

Operation Mode	Default
Point-to-Point Slave	1
Set Baud Rate	**Default**
Baud Rate	115200
(A) Data Parity	0
(B) Modbus RTU	0
(C) RS232/485	0
(D) Setup Port	3
(E) TurnOffDelay/OnDelay	0/0
(F) Flow Control	0
Radio Parameters	**Default**
(0) FREQ KEY	5
(0) HOP TABLE VERSION	0
(1) HOP TABLE SIZE	112
(2) HOP FREQ OFFSET	0
(3) Frequency Zone	All 1s (Enabled)
(4) Government Rules	0
(1) MAX PACKET SIZE	8
(2) MIN PACKET SIZE	9
(3) XMT RATE	1
(4) RF DATA RATE	3
(5) RF XMT POWER	20
(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

MultiPoint Parameters	Default
(0) NUMBER OF REPEATERS	1
(1) MASTER PACKET REPEAT	2
(2) MAX SLAVE RETRY	9
(3) RETRY ODDS	9
(4) DTR CONNECT	0
(5) REPEATER FREQUENCY	0
(6) NETWORK ID	255
(7) RESERVED	-
(8) MULTI MASTER SYNC	0
(9) 1 PPS ENABLE DELAY	255
(A) SLAVE/REPEATER	0
(B) DIAGNOSTICS	0
(C) SUBNET ID	“Disabled”
Rx ID	F
Tx ID	F
(D) RADIO ID	Not Set
(E) Local Access	0
(G) Radio Name	"blank"

Chapter 4: Viewing Radio Statistics

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

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

To display the radio statistics in Tool Suite:

1. In the Tool Suite Configuration application, select the device to program and click the Device Information tab.
2. Review the radio characteristics. Each characteristic is described in detail in the sections below.

To display the Radio Transmission Characteristics in HyperTerminal:

1. Select **(4) Show Radio Statistics** from the Setup main menu to display the following window:

   Review the radio characteristics. Each characteristic is described in detail in the sections below.

Master-Slave Distance

The physical distance between the slave radio and the master radio in your network.

Number of Disconnects

Anytime the link between the Master and the Slave is broken and the radios lose Carrier Detect.

The value indicates the total number of disconnects that have occurred from the time the transceiver 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 in the Network Diagnostics application.

Radio Temperature

The **Radio Temperature** value is the current operating temperature of the transceiver in degrees Celsius. For proper operation, a FreeWave transceiver must be in the temperature range of -40° to +75° C. Some of the transceivers are only tested to 0° C. See the transceiver specifications later in this document for details.

Antenna Reflected Power

This is a measurement of the transmitted power that is reflected back into the transceiver from mismatched antennas or cables, or loose connections between the transceiver 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. A reading of 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.

Noise Level

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

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

Ideally, noise levels should be below 70 J units and the difference between the average signal level and average noise level should be 26or more. Noise levels significantly higher than this are an indication of a high level of interference that may degrade the performance of the link. High noise levels can often be mitigated with band pass filters, antenna placement or antenna polarization.

Signal Level

The **Signal Level** indicates the level of received signal at this transceiver and at each of the Repeaters in the link. For each of these, the signal source is the transceiver that transmits to it. The number is an average of the received signal levels measured at each frequency in the transceiver's frequency hop table.

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

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

Note: See the installation manual for antenna and FCC requirements.

Rate %

The **Rate %** measures the percentage of data packets that were successfully transmitted from the Master to the Slave on the first attempt. 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. A **Rate %** of **100%** provides approximately 100 KBaud of bandwidth with an **RF Data Rate** setting of **3** and approximately 150 KBaud of bandwidth with an **RF Data Rate** of **2**. These numbers are reduced approximately 50% if one or more Repeaters are in the network.

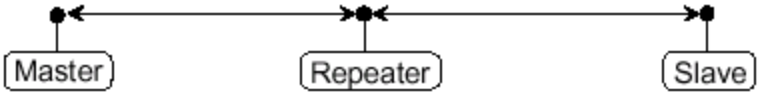
Chapter 5: Data Communication Link Examples

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

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

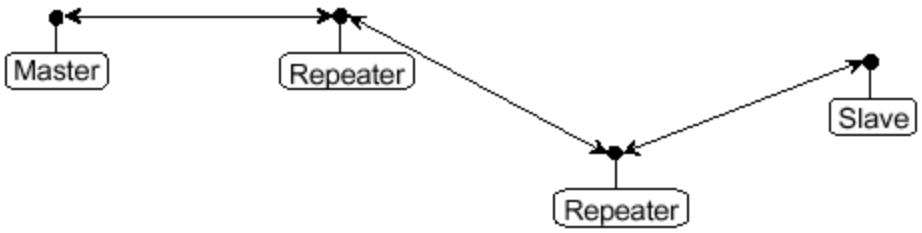
The example below shows how a link might be set up using a Repeater. The Repeater may be located on a hilltop or other elevated structure enhancing the link from the Master to the Slave. In this configuration, it may be desirable to use an external Omni directional antenna at the Repeater. Yagi antennas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

When a Repeaters is used, the RF throughput is cut in half.

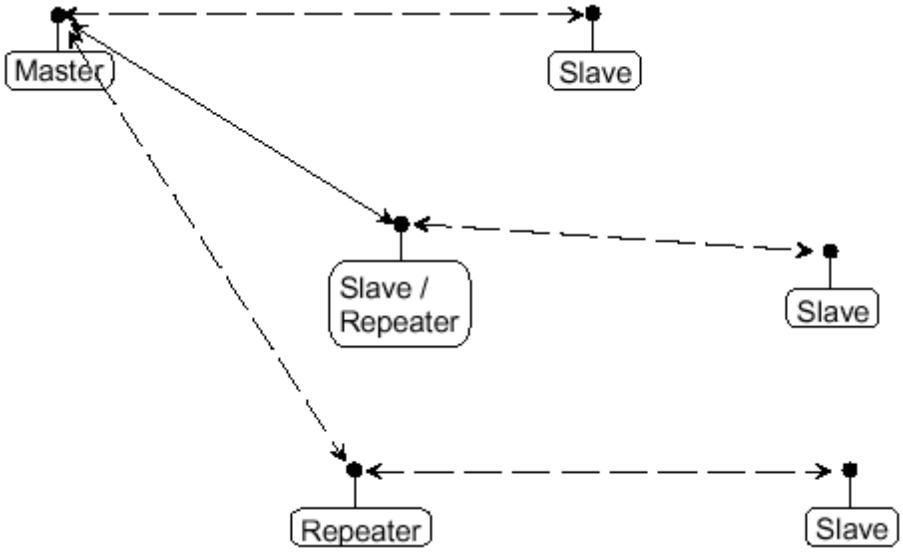


The example below shows a link with two Repeaters between the Master and Slave. With two Repeaters more flexibility in getting around obstacles and greater total range is possible. Once again, it would be desirable to use external Omni directional antennas with the Repeaters, and attaching a Yagi to the Master and Slave to increase the range of the link.

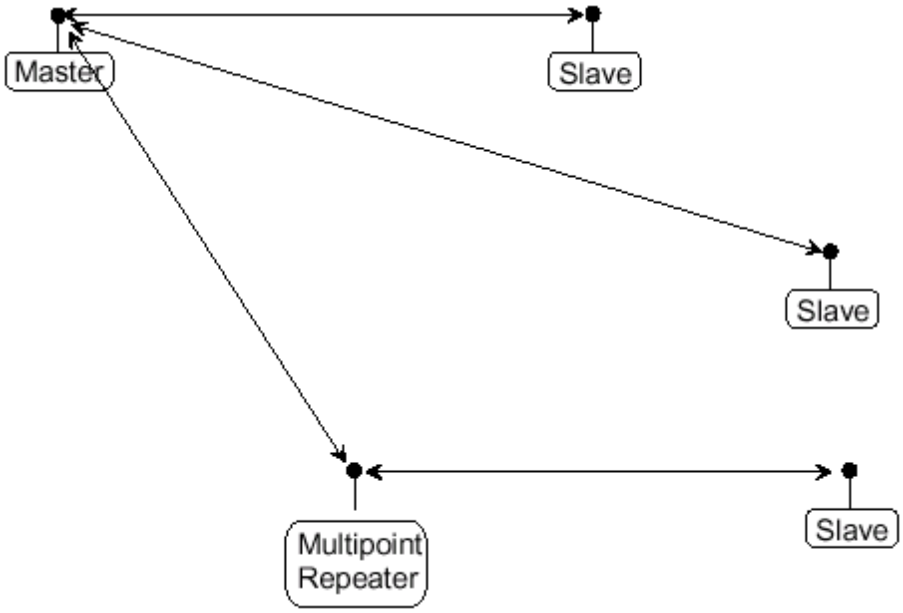
When two Repeaters are used no further degradation in the RF throughput of the link is experienced.



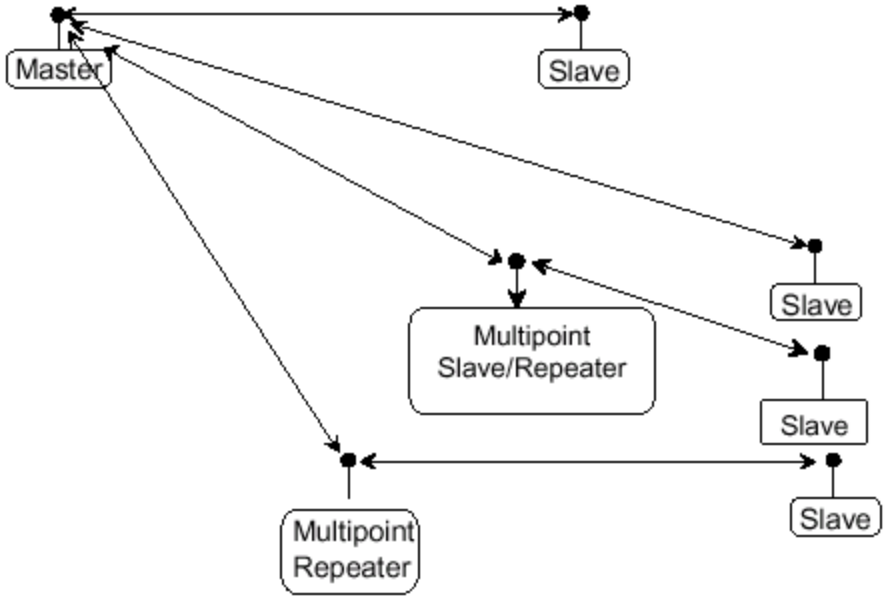
The example below shows a configuration where a Master routinely calls a number of Slaves at different times. The Master is communicating with a transceiver designated as a Slave/Repeater that is connected to a remote device. Since this device is placed in an elevated location, the transceiver may also be used as a Repeater when it is not used as a Slave. At any time the Master may call any of the Slaves, establish a connection, and send and receive data.



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



The last example is a Point-to-MultiPoint network which 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.



Chapter 6: Additional Transceiver Information

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

- Operational RS422 and RS485 information
- Connector pin assignments
- Specifications
- Mechanical drawings

Operational RS422 and RS485 Information

For RS422 and RS485, the FreeWave transceiver can drive 32 standard unit loads and loads the bus with only 1/8 unit load. This means you can tie up to 256 devices on the bus if all of the line receivers have 1/8 unit load.

RS422 is used for 4-wire or full duplex communication with one Master and multiple Slaves. The FreeWave Master transceiver keeps the line driver asserted at all times. The maximum line length is 4,000 feet using 2, 120 ohm twisted pair cables with a 5th wire for data common.

RS485 full duplex using 4 wire plus common is the same as RS422, except the system can have multiple Masters on the bus.

When setting the transceiver to RS485, enable Modbus and set **Master Packet Repeat** to **3** in the transceiver(s) that will use RS485. Also set **Turn Off Delay** to **4**.

RS422 and RS485 Full Duplex Pin-Outs

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

RS485 Half Duplex Pin-Outs

Function	Bare Board Pin Number	DB-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

RS232 Pin Assignments (DB-9)

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

RF Board Level Pinout

The RF board-Level transceivers are available in both TTL and RS232 versions.

The TTL versions use reverse polarity from standard RS232 at 0 to 5 Volt levels. All pin descriptions and pin numbering are the same as the RS232 version. The RS232 versions use standard RS232 polarity and voltage levels for all of the RS232 signal lines (DTR, Transmit Data, Receive Data, Carrier Detect, RTS, and Clear to Send) and TTL standard polarity and voltage level for the Interrupt pin.

Pin 1: B+ Power input.

Pin 2: Interrupt (INT) – Input – A 0 volt level on this pin will switch the radio into Setup mode.

Pin	Assignment	Color on ACS3610xx cable
1	B+ input	Red
2	Interrupt (temporarily ground to invoke menu)	Brown

Pin	Assignment	Color on ACS3610xx cable
3	Data Terminal Ready (DTR)	Orange
4	Ground	Black
5	Transmit Data (TXD)	Yellow
6	Ground	Black
7	Receive Data (RXD)	Green
8	Carrier Detect (DCD)	Blue
9	Request to Send (RTS)	Violet (purple)
10	Clear to Send (CTS)	Gray

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

900 MHz Transceiver Specifications (FGR2 Series)

Specification	
Frequency	902 to 928 MHz
Transmitter	
Output Power	5 mW to 1 W (+30 dBm) See RF transmit power settings, p. See "Transmit Power" on page 60.
Range	60 miles Line Of Sight, 0 dB antenna gain
Modulation	Spread spectrum GFSK, 120 or 170 Kbps
Spreading Method	Frequency hopping
Occupied bandwidth @ 60dB	230 kHz
Channel Spacing	230 kHz
Receiver	
Sensitivity	-109 dBm at 10^{-4} bit error rate -107 dBm at 10^{-6} bit error rate
Selectivity	-20 dB at f_c ± 115 kHz -60 dB at f_c ± 145 kHz
System gain	140 dB
Data Transmission	
Data rate	115.2 kbps sustained throughput* 57.6 kbps sustained throughput* with Repeaters.
Error detection	32 Bit CRC, retransmit on error
Data encryption	Substitution, dynamic key
Max link throughput	115.2 KBaud
Data interface	RS232/RS485 1200 Baud to 230.4 KBaud, async, full duplex TTL (RF board level only)
Power Requirements	
Supply voltage	+6.0 to +30 VDC
Transmit current, for 1 W power at 100% duty cycle	6 VDC: 1 A 12 VDC: 500mA 30 VDC: 200mA

Specification	
Receive current	6 VDC: 140mA 12 VDC: 75mA 30 VDC: 55mA
Idle current	6 VDC: 37mA 12 VDC: 21mA 30 VDC: 16mA
Sleep current	6 VDC: 12mA 12 VDC: 6mA 30 VDC: 5mA
Operating modes	Point-to-Point Point-to-MultiPoint
Operating environment	-40° C- +75° C, 0 to 95% humidity non-condensing

* At 100% receive success rate. RF data rate setting of 2.

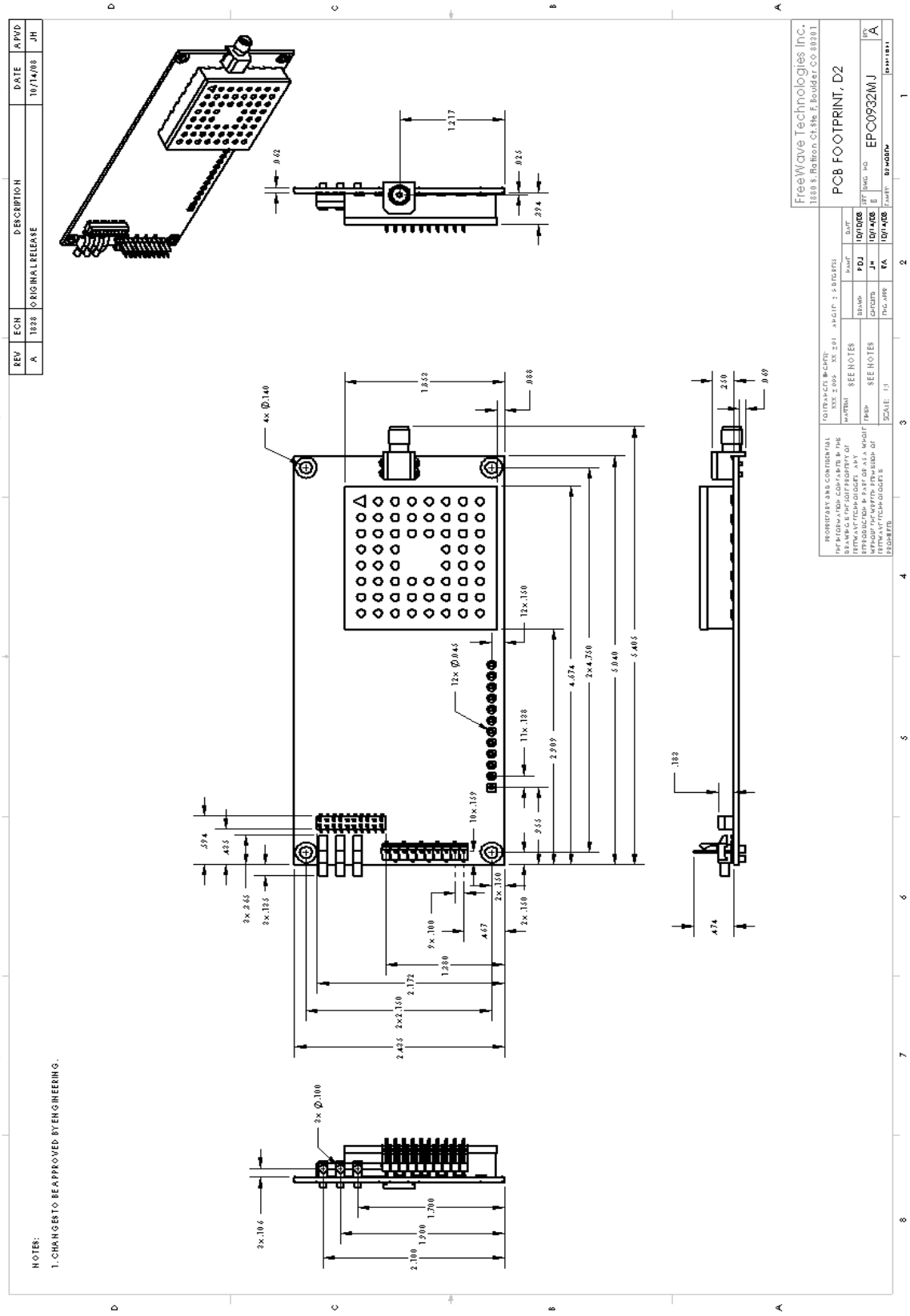
	FGR2-C	FGR2-CE
Data Port	10-pin PCB connector	RS232, DB-9
Enclosure	Bare board	Extruded aluminum
Dimensions	16 mm H x 62 mm W x 123 mm L	57 mm H x 74 mm W x 165 mm L
Weight	90 grams	441 grams
Power requirements	• 6-30 VDC	• 6-30 VDC • AC wall adapter provided • May be powered through pin 6 of DB9 connector.
Antenna	SMA female connector. External antenna required.	N type female connector. External antenna required.
FCC Identifier: FGR2	KNY-42182112519	KNY-42182112519
IC Identifier: FGR2	2329B-FGR2	2329B-FGR2

2.4 GHz Transceiver Specifications (I2 Series)

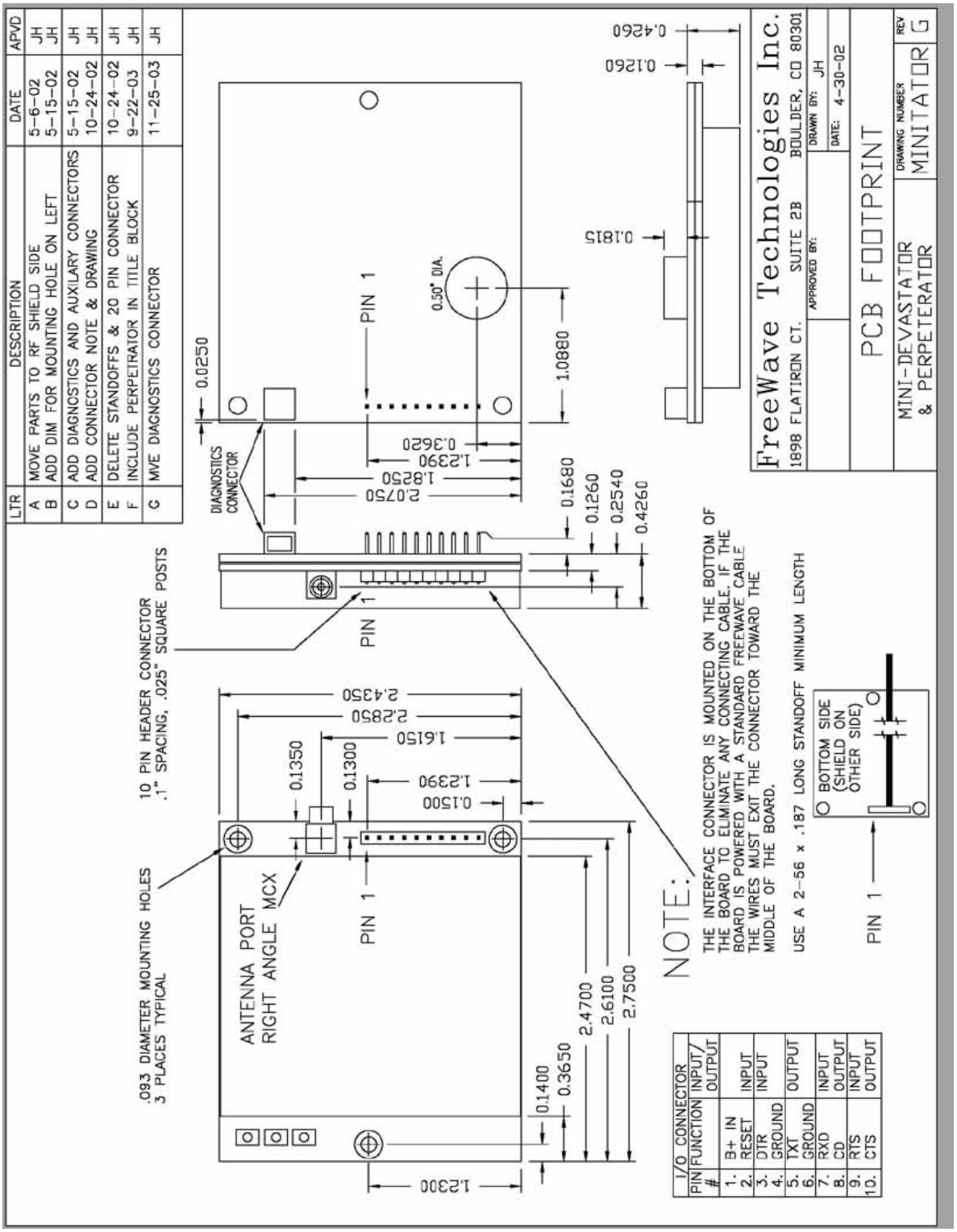
Specification	
Frequency	2.4 - 2.483 GHz (FHSS)
Transmitter	
Output power	5 mW to 500 mW
Range	20 miles (32 km) with clear line of sight
Modulation	2 level GFSK, 115.2 Kbps or 153.6 Kbps
Hopping Patterns	15 per band, 105 total, user selectable
Hopping Channels	75 to 80, user selectable
Frequency Zones	16 Zones, 5 Channels per zone
Occupied Bandwidth	230 kHz
RF Connector	SMA straight, or reversed SMA, or none
Receiver	
Sensitivity	-105 dBm for BER of 10^{-4}; -103 dBm for BER of 10^{-6}
Selectivity	20 dB at fx +/- 230 kHz 60 dB at fc +/- 290 kiHz
System Gain	132 dB
Data Transmission	
Error Detection	32 bit CRC, Retransmit on Error
Data Encryption	Dynamic Key Substitution
Link Throughput	115.2 Kbps standard speed, 80 Kbps low speed Uncompressed; measured assuming 75% frequency availability
Data Interface	RS232/485/422
Data Connector	10-pin header with locking ramp, 0.1 inch spacing power/data connector; separate diagnostics connector
Power Requirements	
Supply Voltage	+6.0 to +30 VDC
Current (mA)	**Mode** / **+6.0 VDC** / **+12 VDC** / **+30 VDC** **Transmit** 375 295 140 **Receive** 120 80 51 **Sleep** 9 5 3

Specification	
General Information	
Operating Temperature Range	-40° C to +75° C
Dimensions	I2-C: 127 L x 61 W x 11 H (mm)
Weight	53 g
Humidity	0 to 95% non-condensing

FGR2 OEM Full Size Board Level Mechanical Drawing



OEM Mini-Board Level Mechanical Drawing



Appendix A: Firmware Updates

As of this manual's release, the following firmware has been released for the model numbers to which this manual applies. The latest firmware versions are available on the FreeWave Web site at www.freewave.com. You can also view the latest firmware available for most radio models in Tool Suite.

The sections below describe the updates in each firmware revision. The most recent version is listed first.

Version 8.77

Release Date: 05/19/2011

Additions/Updates: Added support for mirror bits and multi-band master sync.

Notes: You can now select Mirrored Bit Master or Mirrored Bit Slave as a operation mode.

Version 8.73

Release Date: 10/23/2009

Additions/Updates:

- RS-485 Protocol fixed.
- Use Break Command to Enter Setup function fixed.
- Grand Master mode (for Multi-Master Sync) feature fixed.

Notes: No visual impact or settings changes.

Version 8.71

Release Date: 08/20/2009

Additions/Updates:

- Improved efficiency and reliability of writing TDMA settings to memory.
- Improved efficiency and reliability of writing Diagnostics settings to memory.

Version 8.70

Release Date: 03/09/2009

Additions/Updates: Mirror back-end changes.

Version 8.69

Release Date: 10/02/2008

Additions/Updates: Link acquisition issue corrected.

Version 8.68

Release Date: 06/27/2008

Additions/Updates: Initial release.


FreeWave®