FREEWAVE

GX Serial Wireless Data Radios

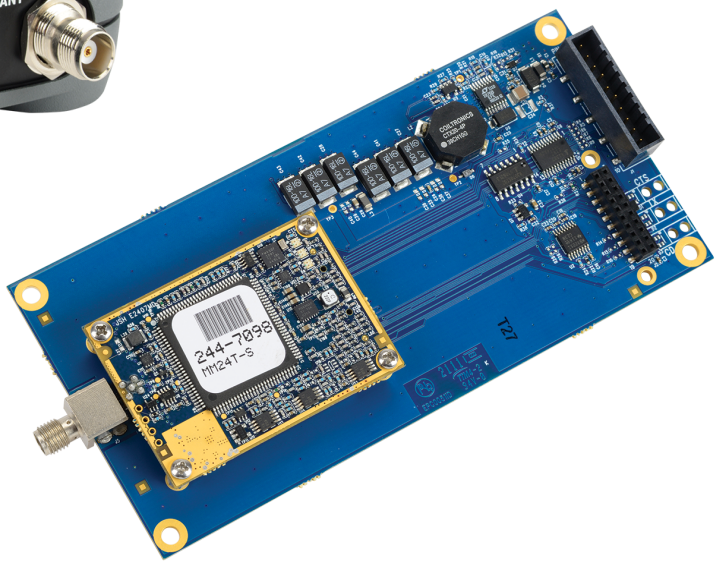
GX-C

GX-CE

GX-T

Covering Firmware v9.7.9

User & Reference Manual



Part Number: LUM0034AA
Revision: May-2018

Warranty Information

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

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

Safety Information

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

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

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

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Preface

Thank you for purchasing the FreeWave GX Serial Wireless Data Radios radio.

This document includes information about the FreeWave GX-C, GX-CE, GX-T serial radio:

- A basic introduction to the radio and how to determine the mode to run it in.
- Examples of how FreeWave radios can exist in a network with other radios.
- How to access the setup parameters available on the radio.
- Basic radio programming and setup information that applies to all network types.
- Considerations and quick starts for the network design, including charts of LED meanings.
- Details about defining a MultiPoint network including the use of Subnet IDs to route information through the network.
- Steps to view statistics about a radio's performance.
- Pinouts and mechanical drawings.

Additional Information

This User Manual covers settings and configurations that apply to GX-C FreeWave radios.

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

- Cathodic Protection User Manual Addendum
- Application Note #5412: Synchronizing Collocated Masters (Multi-Master Sync Mode)
- Application Note #5476: Mode 6
  - Mode 6 is designed to give control of which Slave a Master links to in a Point-to-Point configuration.

- Application Note : #5437: DTR to CTS Line Alarm Feature
- Application Note #5457: Local Mode

For information about installing radios, see the **2.4 GHz Wireless Radios Installation Guide**.

Note: FreeWave documentation is available at www.freewave.com.

Contact FreeWave Technical Support

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

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

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

Document Styles

This document uses these styles:

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

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

Example: Provides example information of the related text.

FREEWAVE Recommends: Identifies FreeWave recommendation information.

Important!: Provides semi-cautionary information relevant to the text or procedure.

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

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

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

Parameter Preference

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

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

1. Overview

FreeWave radios operate in virtually any environment where data communications occur. The radios act as data transmission devices, duplicating data in Point-to-Point, Point-to-MultiPoint, or TDMA mode.

The GX includes:

- **GX-C** - Provides performance, reliability, and quality in a globally available spectrum and is backward compatible with the I2 and IM radios.
- **GX-CE** - Provides the same performance and features as the **GX-C**, but in a ruggedized enclosure.
- **GX-CP** - Cathodic Protection remote monitoring radio is a multipurpose, spread spectrum, board-level product.
  - The **GX-CP** has specific inputs and outputs for monitoring and reporting operational values on pipelines, tanks, structures, and other facilities or structures and any other metallic subject to environmental corrosion.

1.1. Choose a Radio Location

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

When using an external antenna, placement of that antenna is critical to a solid data link. Other antennas in close proximity are a potential source of interference.

Use the **Radio Statistics** to help identify potential problems. In general, FreeWave units with a higher antenna placement will have a better communication link.

In practice, the radio should be placed away from computers, telephones, answering machines, and other similar devices. The cable included with the radio provides ample distance for placement away from other equipment.

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

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

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

Important!: For either a PTP or PTMP network, adding a Repeater cuts the network throughput by 50%.

1.2.1. Point-to-Point (PTP) Network

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

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

1.2.2. Point-to-MultiPoint (PTMP) Network

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

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

Differences between PTP and PTMP

- In a Point-to-Point network all packets are acknowledged, whether sent from the Master to the Slave or from the Slave to the Master.
- In a MultiPoint network, the user determines the number of times outbound packets from the Master or Repeater to the Slave or other Repeaters are sent.
  - The receiving radio, Slave or Repeater, accepts the first packet received that passes the 32 bit CRC. However, the packet is NOT acknowledged.
  - On the return trip to the Master, all packets sent are acknowledged or retransmitted until they are acknowledged.
  - Therefore, the return link in a MultiPoint network is generally very robust.

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

- Data block size.
  - The longer the data blocks, the fewer number of deployed Slave radios can exist in the network.
- Baud rate.
  - The data rate between the radio and the device it is connected to could limit the amount of data and the number of radios that can exist in a network
- The amount of contention between Slave radios.
- Polled Slave radios versus timed Slave radios.
- Repeater Use.
  - Using the **Repeater** setting in a Point-to-Point or MultiPoint network decreases overall network capacity by 50%.

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

1.3. Data Communication Link Examples

- Example 1 - Point-to-Point Gateway to Endpoint (on page 13)
- Example 2 - Gateway Repeater Endpoint (on page 14)
- Example 3 - Two Repeaters (on page 14)
- Example 4 - Multiple Radios (on page 15)
- Example 5 - Point-to-MultiPoint (on page 16)
- Example 6 - Point-to-MultiPoint with a Repeater Site (on page 17)

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

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

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

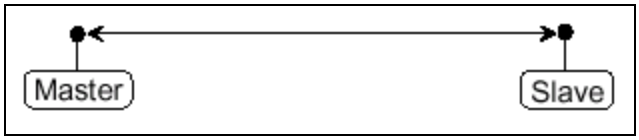


Figure 1: Master Communicating to a Slave in a Point-to-Point Link

1.3.2. Example 2 - Gateway Repeater Endpoint

This example shows a link using a Repeater.

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

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

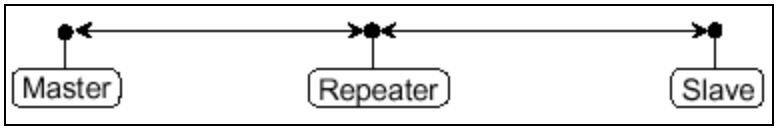


Figure 2: Master Communicating to a Slave in a Point-to-Point Link with a Repeater

1.3.3. Example 3 - Two Repeaters

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

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

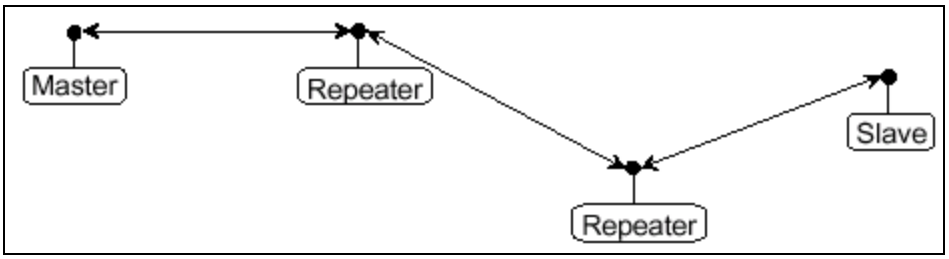


Figure 3: Master Communicating to a Slave in a Point-to-Point Link with Two Repeaters

1.3.4. Example 4 - Multiple Radios

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

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

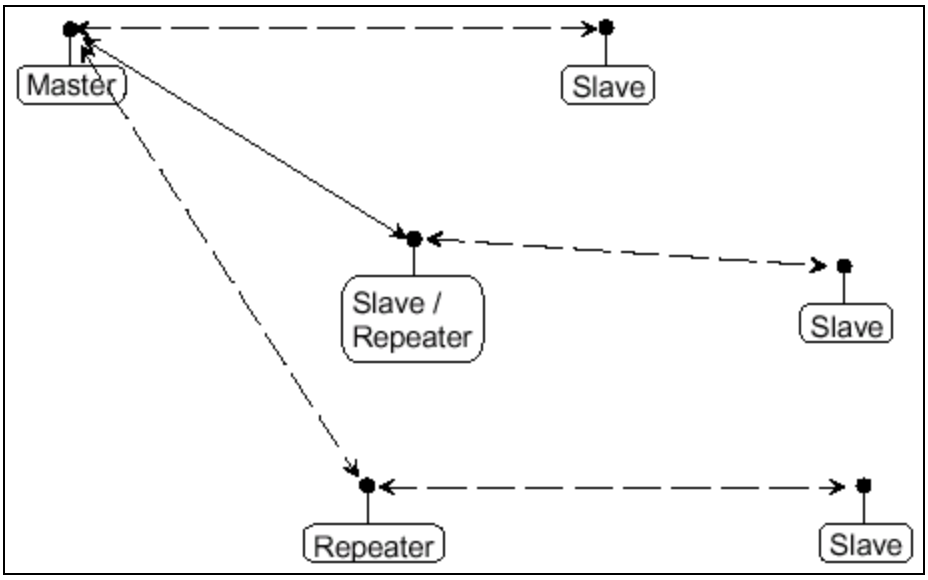


Figure 4: Master Communicating to Multiple Slave Radios at Different Times

1.3.5. Example 5 - Point-to-MultiPoint

This example illustrates a standard Point-to-MultiPoint network.

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

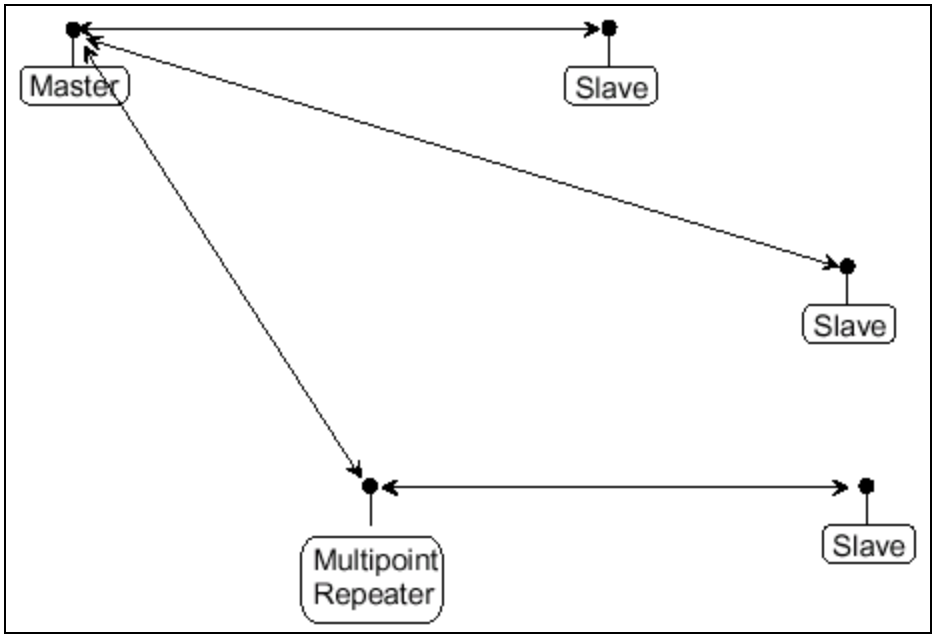


Figure 5: Master Communicating in a Point-to-MultiPoint Network

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

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

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

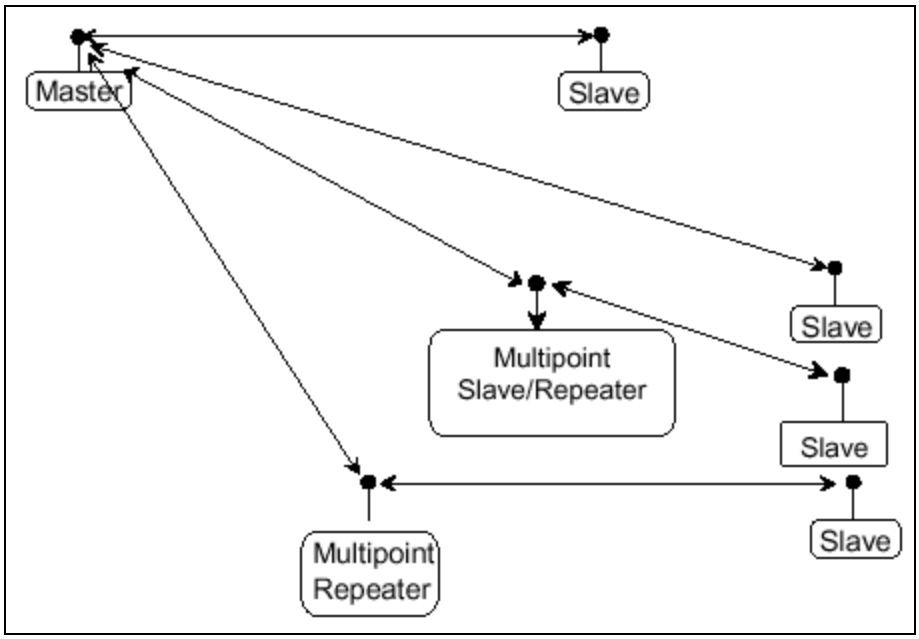


Figure 6: Master Communicating in a Point-to-MultiPoint Network using a Slave/Repeater

1.4. Finding the Product Serial Number

Each FreeWave radio is assigned a unique serial number.

Important!: This number is needed to contact FreeWave Technical Support.

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

Note: The example in this section is an image is of a GXM model.
The serial number information is in the same location on different models.

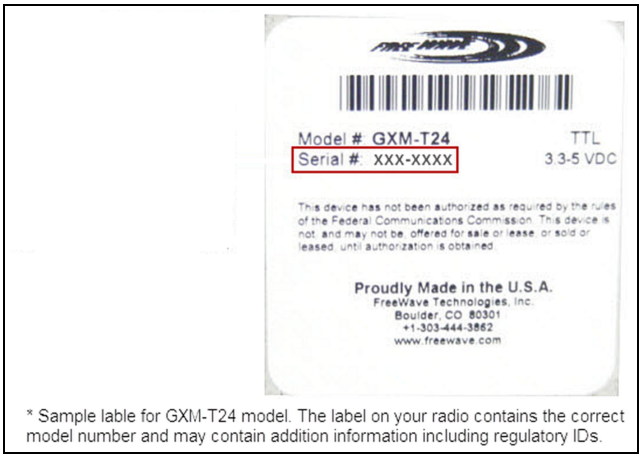


Figure 7: Example of the Serial Number for a GXM model

On radios that are not in an enclosure, the serial number is printed on a label on the back (the flat, smooth side) of the radio.

This label is in larger print.

Figure 8: Example of the label and Serial Number of a non-enclosed radio

1.5. Powering the Radio

Connect the radio to a positive power supply with +6.0 to +27.0 VDC, typically +12.0 VDC.

Important!: **GX-C**, **GX-CE**, and **GX-T** radios are UL approved for voltage use between +6.0 to +27.0 VDC.

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

Warning! If the power supply is above approximately +18.0 to +20.0 VDC, use a 1-ohm resistor inline with B+ input to the radio.

Note: For more information about pinouts, see RF Board Level Pinout (on page 104).

If the power supply line runs outside the enclosure, use:

- electrostatic discharge (ESD) protectors to protect the radio from electric shock.
- transient voltage suppressors (TVS) to protect from an over-voltage situation.

Using both helps enhances reliable operation.

1.6. Configuration Tool Options

When the radio is in **Setup** mode, use these setup tools to configure the settings on the radio:

- Tool Suite- Tool Suite is the recommended method for programming the radios.
  - It provides a group of tools for configuring the devices in the network and for monitoring the network's performance.
  - Use the **Configuration** application in Tool Suite to program changes to the radio's settings.
  - Tool Suite is available for download from www.freewave.com.

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

Use the **Setup Terminal** application in Tool Suite to use and view the terminal menus. It shows the same menus and provides the same programming settings as you see using a terminal emulator.

FREEWAVE Recommends: Tool Suite is the recommended programming option. EZConfig can still be used to program older radio models. However, newer radio models and newer firmware versions are not available in EZConfig.

1.6.1. Tool Suite and Terminal Emulators

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

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

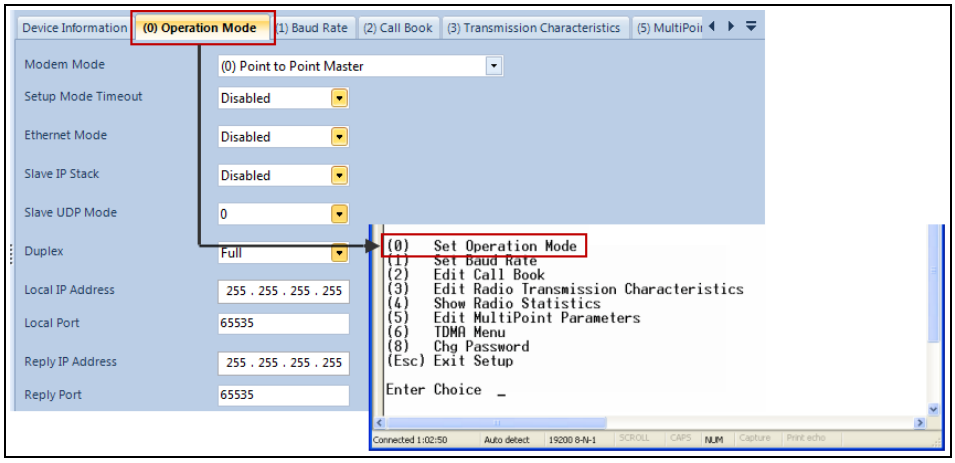


Figure 9: Tool Suite menu Matched to Terminal menu

Use the **Setup Terminal** application in Tool Suite to use and view the terminal menus. It shows the same menus and provides the same programming settings as you see using a terminal emulator.

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

1.7. Radio Setup Mode

To read the current settings from or to program a radio, the radio must be in **Setup** mode. When a radio is in **Setup** mode, all three LEDs appear solid green . These sections provide details about how to access the radio's **Setup** mode using Tool Suite or the terminal interface.

Note: OEM boards may also enter **Setup** when Pin 2 on a 10- or 14-pin connector or Pin 8 on a 24-pin connector is grounded, or using a break command.
For information about the break command, see Use Break to Access Setup (on page 38).

- The **Setup Port** parameter on the **Baud Rate** tab determines whether the main data port or the diagnostics port is used to access the setup parameters for the radio. For more information, see Setup Port (on page 37).
- Use the **Setup Mode Timeout** parameter on the **Operation Mode** tab to set the radio to exit **Setup Mode** automatically. When the setting is enabled, if the radio has not received any menu selections or programming information within 5 seconds, it exits **Setup** and resumes its previous mode.

Note: For **Setup** mode troubleshooting information, see Troubleshooting (on page 107).

1.7.1. Using Tool Suite to Connect to and Program Radios

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

Use Tool Suite to set up a template version of a radio. Templates include settings that apply to more than one radio in the network.

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

Procedure

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

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

2. Connect the power supply to the radio and the power source and turn on the radio.
3. Open Tool Suite.
4. In the **Applications** window, click **Configuration** to open the **Configuration** application.
5. Verify the correct port is selected in the **Com Port** field on the **Configuration** ribbon.
6. Press the **Setup** button on the back of the FreeWave radio.
   The radio is changed to **Setup** mode.

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

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

   > **Note**: If using the **Setup Terminal** application or a terminal emulator and using the gray ribbon diagnostic cable (part number **ASC2009DC**), or the black diagnostic cable (part number **ASC0409DC**), the radio changes to **Setup mode** automatically when **Read Radio** is clicked in Tool Suite.

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

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

    - Click **All** to send all the settings for all parameters.
    - Click **Default** to set a device back to its factory default settings.

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

1.7.2. Access the Setup Menu Using a Terminal Emulator

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

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

Procedure

1. Plug a serial cable into the COM 1 port on the radio.
2. Connect the cable to a COM port on the computer running Tool Suite.
3. Connect the radio to a power source.
4. Open Tool Suite.
5. On the **Applications** window, click **Setup Terminal**.

6. Click the **Connection** list box arrow in the top left of the window and select the COM port on the computer the radio is connected to.

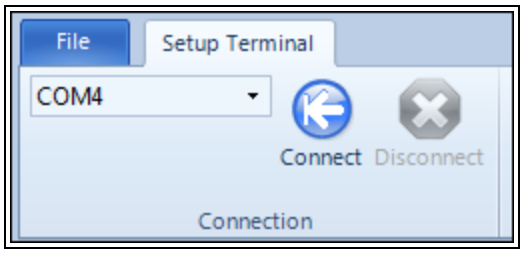


Figure 10: Connection list box

7. Click **Connect**.
8. To connect **Setup Terminal** to the radio, press the **Setup** button on the back of the FreeWave radio.
   If connected to the diagnostics port, press <Shift+U> to view the **Setup** menu.
9. To view the **Setup** menu in board-level radios:
   - Short pins 2 & 4 (Brown to Black) on the 10 pin header next to the LEDs.

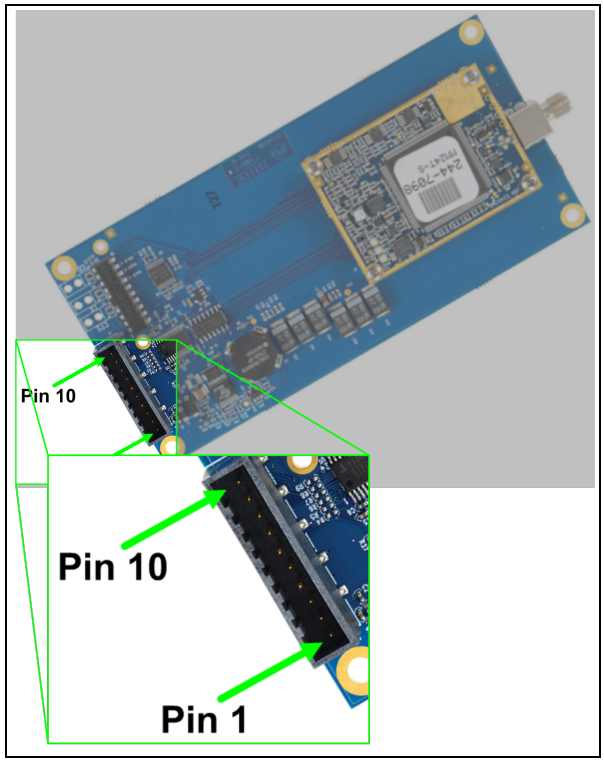


Figure 11: GX-C Pin Layout

   - If using a data cable (FreeWave part number: **ASC3610DB** or **ASC3610DJ**), press the **Setup** button on the data cable.
   - If using the gray ribbon diagnostic cable (P/N **ASC2009DC**), or the black diagnostic cable (P/N **ASC0409DC**), press <Shift+U> to view the **Setup** menu.

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

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

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

1.7.3. Connecting and Disconnecting from HyperTerminal

The HyperTerminal dialog box has several toolbar buttons.

To reconnect to HyperTerminal, disconnect from the current session.

1. Click the **Disconnect**  .
2. Click the **Call**  to reconnect.

Note: If the settings have not been saved they must be re-selected when HyperTerminal reconnects to the radio.

1.7.4. Troubleshooting HyperTerminal

These are some common issues encountered while using HyperTerminal as the terminal emulator.

- The steps to resolve the issue are specific to the HyperTerminal interface.
- Similar steps can be used when troubleshooting other terminal emulators.

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

- Change the COM Port (on page 24).
- Change the Baud Rate (on page 26).
- Change the Flow Control (on page 27).
- Change the Parity (on page 28).

Change the COM Port

Important!: Nothing appears on the screen after placing the radio into Setup mode.

This error usually indicates one of two things:

- The wrong COM port is selected.
- A null modem cable is being used.

1. Click  .
2. On the **File** menu, click **Properties**.
3. Click the **Connect To** tab.
4. Verify the correct COM port is selected.
5. Click **OK** to close the **Properties** dialog box.
6. Click  .
7. Return the radio to **Setup** mode.
   The Setup menu screen appears.

If the radio has been previously configured, the wrong port could be used to access the **Setup** menu.

Note: For more information, see Setup Port (on page 37). Try connecting to the other port.

Change the Baud Rate

Important!: Unrecognizable characters appear on the screen after placing the radio into Setup mode.

- Unrecognizable characters usually indicate a **Baud Rate** problem.
- The problem may also be that the radio under test is a TTL version or has been set to RS485 and not RS232. If the radio is TTL or in RS485 mode, verify connection through the Diagnostic port. Gibberish before the **Setup** button is pressed indicates Diagnostics is enabled in a Master.

1. Click  .
2. On the **File** menu, click **Properties**.
3. Click **Configure**.
4. Change these settings and click **OK**:
   - **Baud Rate** to **19200**
   - **Data Bits** to **8**
   - **Parity** to **None**
   - **Stop Bits** to **1**
   - **Flow Control** to **1**
5. Click **OK** to close the **Properties** dialog box.
6. Click  .
7. Return the radio to **Setup** mode.
   The **Setup** menu screen appears.

Change the Flow Control

Important!: The Setup menu appears on the screen, but nothing happens when keys on the keyboard are pressed.

- This error usually indicates flow control is turned on in a three-wire connection (Rx, Tx, and Gnd).

Follow these steps if the connection uses a three-wire connection.

1. Click  .
2. On the **File** menu, click **Properties**.
3. Click **Configure**.
4. Change the **Flow Control** to **None**, and click **OK**.
5. Click **OK** to close the **Properties** dialog box.
6. Click  .
7. Return the radio to **Setup** mode.
   The **Setup** menu screen appears.

Change the Parity

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

- This error usually indicates a parity mismatch.
  - To resolve this issue, verify the parity of the radio and the parity of HyperTerminal are set the same.
- HyperTerminal's parity settings are under the **Properties** menu.
- The FreeWave radio parity is found under the **Baud Rate menu** in the **Setup** menu.

1. In HyperTerminal, click  .
2. On the **File** menu, click **Properties**.
3. Click **Configure**.
4. Change the **Parity** to **None**, and click **OK**.
5. Click **OK** button to close the **Properties** dialog box.
6. Click  .
7. Return the radio to **Setup** mode.
   The **Setup** menu screen appears.

1.8. Upgrade the Radios to the Latest Software Version

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

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

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

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

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

Procedure

1. With the radio connected to the computer through the COM port, open Tool Suite.
2. In the **Applications** window, click **Configuration** to open the **Configuration** application.
3. In the **Firmware** area of the **Configuration** application, click **Upgrade Radio**.
4. Click **Yes** at the prompt to proceed.
   Tool Suite identifies the software version loaded on the connected device and shows the latest version of software available for that model.
5. Click **Yes** to continue with the upgrade.
   The system shows the progress of the software upgrade.
   After the firmware upgrade is complete, a message appears confirming that the software upgrade was successful.

2. Basic Radio Programming and Setup

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

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

- Setting the Radio's Role in the Network and the Network Type (on page 31).
- Establishing Communication with Instrumentation and Computers (on page 34).
- Establishing Communication with Other Radios in the Network (on page 40).
- Designate the RF Transmission Characteristics (on page 41).

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

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

The mode tells the radio what network type it is in (Point-to-Point or Point-to-MultiPoint) and what role it plays (Master, Slave, or Repeater) in that network.

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

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

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

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

Operation Mode	Description
Point-to-Point Master (0)	This mode designates the radio as the Master in Point-to-Point mode. The Master may call any or all Slaves designated in its Call Book. In Point-to-Point mode the Master determines the setting used for most of the transmission characteristics, regardless of the settings in the Slave and/or Repeaters. The settings NOT determined by the Master are: • Hop Table settings • Retry Time Out • Slave Security • Transmit Power A quick method of identifying a Master is to power the radio. Prior to establishing a link with a Slave, all three of the LEDs on the Master are solid red.

Operation Mode	Description
Point-to-Point Slave (1)	This mode designates the radio as a Slave in Point-to-Point mode. • The Slave communicates with any Master in its Call Book - either directly or through a maximum of four Repeaters. • When functioning as a Slave, the **Entry to Call** feature in the radio's Call Book is NOT operational. • Set the **Slave Security** parameter to **1** to bypass the Call Book in the Slave. **Note**: For more information, see Slave Security on page 51.
Point–to-MultiPoint Master (2)	This mode designates the radio as a Master in MultiPoint mode. • This mode allows one Master radio to communicate simultaneously with numerous Slaves and Repeaters. • A Point-to-MultiPoint Master communicates only with other radios designated as Point-to-MultiPoint Slaves or Point-to-MultiPoint Repeaters.
Point-to-MultiPoint Slave (3)	This mode designates the radio as a Slave in MultiPoint mode. • This mode allows the Slave to communicate with a MultiPoint Master. • The Slave may communicate with its Master through one or more Repeaters.
Point-to-Point Slave / Repeater (4)	This mode designates the radio to act as **either** a Slave or Repeater, depending on the instructions from the Master. • The radio cannot act as both a Slave and a Repeater at the same time. • True Slave/Repeater functionality is only available in a MultiPoint mode. • Point-to-Point Slave/Repeaters have no security features. • When a radio is designated a Point-to-Point Slave/Repeater, it allows any Master to use it as a Repeater. **Note**: Adding Repeaters to a network cuts the network throughput by 50%.

Operation Mode	Description
Point-to-Point Repeater (5)	FreeWave allows the use of a maximum of four Repeaters in a Point-to-Point communications link, significantly extending the operating range. • When designated as a Repeater, a radio behaves as a pass-through link. • All settings for the Call Book, baud rates, and transmission characteristics are disabled. • A Repeater connects with any Master that calls it. • The Repeater must be set up properly in the Master's Call Book. **Note**: Adding Repeaters to a network cuts the network throughput by 50%.
Point-to-Point Slave / Master Switchable (6)	Mode 6 allows the radio to be controlled entirely through software commands. • A number of key parameters in the FreeWave user interface may be changed either directly using a terminal emulator or using script files. • When the **Point-to-Point Slave/Master Switchable** option is selected and the radio is not calling a Slave, it functions as a Slave and accepts any appropriate calls from other radios. **Note**: For more information, see **Application Note #5476, Mode 6**.
Point-to-MultiPoint Repeater (7)	This option allows the radio to operate as a Repeater in a MultiPoint network. • A MultiPoint network can have as many Repeaters as necessary. • If the Repeater is to act as a Slave/Repeater, set the **Slave Repeater** parameter in the MultiPoint Parameters tab to **Enabled**. **Note**: Adding Repeaters to a network cuts the network throughput by 50%.
Mirrorbit Master (A) Mirrorbit Slave (B)	As of May-2018, Mirrorbit Master and Mirrorbit Slave mode are not supported.
Ethernet Options (F)	This menu is used for Ethernet radios only.

2.2. Establishing Communication with Instrumentation and Computers

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

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

Example: A pair of radios may be used in an application to send data from remote process instrumentation to an engineer's computer.
In this application, the **Baud Rate** for the radio on the instrumentation might be set to 9600 and the radio on the polling host might be set to 57,600.

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

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

2.2.1. Baud Rate

Baud Rate	
Setting	**Description**
Default Setting	115200
Options	600, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 76800, 115200, 230400
Terminal Menu	(1) Set Baud Rate

Description:	• This is the communication rate between the radio's data port and the instrument it is connected to.
	• This setting is independent from the baud rate for the other radios in the network.
	Note: With a poor RF link, this may actually result in slower data communications.
	• The **Setup Port** Baud Rate always defaults to **19,200** no matter how the **Data Port** Baud Rate is set.
	  • The only exception is Mode 6.
	  • For more information, see **Application Note #5476, Mode 6**.
	FREEWAVE Recommends: With a **Baud Rate** setting of 38,400 or higher, FreeWave recommends using the lines of the Flow Control (on page 35).

2.2.2. Data Parity

Data Parity	
Setting	**Description**
Default Setting	0 (8, N, 1)
Options	See Description.
Terminal Menu	(1) Set Baud Rate > (A) Data Parity
Description:	• Six data word length and parity configurations are available for use with FreeWave radios. • The default setting is **8-None-1** and is the most commonly used serial communications protocol. This table describes each option:

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

2.2.3. Flow Control

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

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

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

Flow Control	
Setting	**Description**
Description:	Specifies the hardware flow control for the data port on the radio. Flow control is the process of managing the speed data is transmitted to not overwhelm the device receiving the transmission. **FREEWAVE Recommends**: Use **Flow Control** if the **Baud Rate** is higher than 38,400.

2.2.4. Modbus RTU

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

Modbus RTU	
Setting	**Description**
Default Setting	0 (Disabled)
Options	0 to 9
Terminal Menu	(1) Set Baud Rate > (B) Modbus RTU
Description:	A setting other than **0** in this parameter causes the radio to wait for an amount of time gathering data before sending out the RF link. • **0 (Disabled)** - The radio sends data out through its RF link as soon as the data is received into the serial port. This is the default setting. • **1** - The radio waits for a number of slots equal to two times the **Master Packet Repeat** setting before sending the received data out the RF link. **Example**: If the **Master Packet Repeat** parameter is set to **3**, the radio waits for 6 slots, gathering data up the whole time. At the end of the 6 slots, the radio sends all received data in one "burst." This is the appropriate setting for most Modbus RTU devices. • **2 or higher** - The radio waits for a number of slots calculated using this formula: (Modbus RTU setting + Master Packet Repeat setting + 1) x 2 **Example**: In a radio where the **Modbus RTU** setting is **2** and the **Master Packet Repeat** setting is **3**, the radio waits for (2 + 3 + 1) x 2, or 12 slots.

2.2.5. Serial Interface

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

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

Terminal Menu	(1) Set Baud Rate > (C) RS232/485
Description:	Use this option to set the protocol of the data port for connection to an external device. **Note**: This setting must be **0** in TTL RF board products.

2.2.6. Setup Port

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

Setup Port	
Setting	**Description**
Default Setting	(3) Both

Setup Port	
Setting	**Description**
Options	• **(1) Main Only** - Programming and reading a radio's setup information is done through the data port. • **(2) Diagnostics Only** - Programming and reading a radio's setup information is done through the diagnostic port. • If the **Serial interface** is set to anything other than RS232, then the **Setup Port** must be set to **Diagnostics Only**. • **(3) Both** - Programming and reading a radio's setup information is done through either the data port or the diagnostic port .
Terminal Menu	(1) Set Baud Rate > (D) Setup Port

Description:	Determines which port on the radio, Main or Diagnostics, is used to access the parameter settings in Tool Suite or enter the **Setup** main menu in the terminal interface.
	• The main data port is the RS232 port.
	• The diagnostics port is a 3-pin connector on the rear panel of the OEM Mini series radios.
	  • The diagnostic cable for this port (**ASC0409DC**) is available from FreeWave.
	• The OEM modules use a 2-row, 2 mm female connector.
	  • The diagnostic cable for this port (**ASC2009DC**) is available from FreeWave.

2.2.7. Turn Off Delay

Note: This setting is not supported in the GX-C, GX-CE, GX-T radios.

2.2.8. Turn On Delay

Note: This setting is not supported in the GX-C, GX-CE, GX-T radios.

2.2.9. Use Break to Access Setup

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

Use Break to Access Setup	
Setting	**Description**
Default Setting	Disabled

Use Break to Access Setup	
Setting	**Description**
Options	• **(0) - Disabled** - The break command is disabled. • **(1) - Enabled** - The Setup menu is sent at 19,200 bps. • **(2) - Enabled** - The Setup menu is sent at the radio's current baud rate.
Terminal Menu	(1) Set Baud Rate > (G) Use break to access setup
Description:	Enables a break command to put the radio into Setup mode over the data port. To send a break character, the end device must hold the Tx data line in the space voltage level for longer than 1 character time. **Example**: If a character is defined as having 1 start bit, 8 data bits, and 1 stop bit, the character time is 10 bits. Thus, the transmit data line must be held in the space voltage level for a period of time longer than 10 bits.

2.3. Establishing Communication with Other Radios in the Network

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

- **Network ID** - Used in MultiPoint Networks, the **Network ID** parameter is available on the **MultiPoint Parameters** tab.
  - Each radio in a single network should be assigned the same ID.
  - A Slave links with the first Master or Repeater that it hears that has a matching **Network ID**.
    - Because the **Network ID** does not use serial numbers, MultiPoint Masters and Repeaters may be replaced without reprogramming all of the Slaves in the network. The **Network ID** function should be used in conjunction with the **Subnet ID** feature (if necessary) to route data through the radio network.
    - Without having the serial numbers in the Call Book, Slaves may establish communications with different Masters that match the radio's golden settings described below, though not at the same time. This is very useful in mobile MultiPoint applications.
    - For information about setting the **Network ID** parameter in a MultiPoint Network, see Using the Network ID in MultiPoint Networks (on page 60).
- Call Book - The Call Book is **required** in Point-to-Point networks.
  - The Call Book stores serial numbers of other radios in the network that are allowed to talk to a radio.
  - Using the Call Book offers both security and flexibility in determining how FreeWave radios communicate with each other.

FREEWAVE Recommends: While the Call Book is an option in Point-to-MultiPoint networks, FreeWave **strongly recommends** using the **Network ID** feature in most applications.
If a large MultiPoint network is implemented using the Call Book and a radio needs to be added to or replaced in the network, each radio in the network must be physically reprogrammed and the new serial number entered in the radio's Call Book.
This can be a time consuming process and can cause a delay in getting the network back up and running.
Because the **Network ID** does not use serial numbers, MultiPoint Master radios and Repeaters may be added or replaced without reprogramming each Slave radio in the network.

Note: For more information about defining the Call Book in a Point-to-Point network, see Using the Call Book in Point-to-Point Networks (on page 80).

2.3.1. Golden Settings

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

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

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

- If using the Call Book instead of the **Network ID**, or are running a Point-to-Point network, the appropriate serial numbers must be listed in the Call Book for each radio.
- If working with parallel Repeaters, the **Frequency Key** setting may differ.

2.4. Designate the RF Transmission Characteristics

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

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

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

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

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

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

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

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

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

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

2.4.1. 2.4GHz Frequency Key (Golden Setting)

Note: In MultiPoint networks, the **Frequency Key** must be set identically in all radios.
Any radio with a **Frequency Key** different from the Master radio will NOT establish a link.
In Point-to-Point networks the Master radio's settings take precedence over the Slave radio.

2.4GHz Frequency Key (Golden Setting)	
Setting	**Description**
Default Setting	5
Options	0 to 9 A to E
Terminal Menu	(3) Edit Radio Transmission Characteristics > (0) FreqKey
Description:	• Fifteen choices are available for the **Frequency Key** (0 to 9 and A to E) setting, representing 15 different pseudo-random hop patterns. • Hopping patterns minimize the interference with other FreeWave radios operating in the area. **Example**: If 10 pairs of FreeWave radios are operating on different networks in close proximity, setting a different **Frequency Key** value reduces the chance that radios hop to the same frequency at the same time. If two networks were to hop to the same frequency, the next hop would be to a different frequency for both networks.  Gain additional network separation by adjusting the **Max Packet Size** and **Min Packet Size** parameters. **Note**: Use the **Hop Table Version**, **Hop Table Size**, and **Frequency Zone** parameters to define more network differentiation by limiting the number and location of frequencies the radios may hop in the 2.400 to 2.4835 GHz band.

2.4.2. 2.4GHz Frequency Zones

2.4GHz Frequency Zones	
Setting	**Description**
Default Setting	All zones selected
Options	See Description.
Terminal Menu	(3) Edit Radio Transmission Characteristics > (0) FreqKey > F > (3) Frequency Zone
Description:	Use **Frequency Zones** to select which portions of the band the network uses. • Setting a zone to **1** includes it in the hopping pattern. • Setting the zone to **0** excludes that zone. • In MultiPoint networks, this setting only needs to be set in the Master radio. • In a Point-to-Point network, the Master radio and the Slave radios must have matching **Frequency Zone** settings. • By default, all **Frequency Zones** are enabled. **Caution**: The **Hop Table Version** must be set to **0** when using **Frequency Zones**. If another **Hop Table Version** is selected, the limitations of that selection are also applied to the hopping pattern. **Example**: If the **Hop Table Version** is set to **3**, only the middle of the band is available in the pattern. Then, if **Frequency Zones** 5, 6, 7, 8, and 9 are set to **0**, no allowable frequencies are available for the radio to use.

2.4GHz Frequency Zones Table

This 2.4GHz **Frequency Zone** table shows the beginning frequency and ending frequency in each of the 16 zones.

Note: The table reflects the usage of **Frequency Offset 0**.
Using **Frequency Offset 1** or **2** shifts all frequencies by 115.2 or 230.4 kHz respectively.

2.4GHz Frequency Zones (using Frequency Offset 0)		
Binary Zone Number (LSB First)	**Beginning Freq. (MHz)**	**Ending Freq. (MHz)**
0	2400.6528	2405.4912
1	2405.8368	2410.6752

2.4GHz Frequency Zones (using Frequency Offset 0)		
Binary Zone Number (LSB First)	**Beginning Freq. (MHz)**	**Ending Freq. (MHz)**
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
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 European Union specifications, it is necessary to use the proper frequency zone combination based on the frequency offset.
Using a frequency offset of **0**, the first zone (0) needs to be removed.
Using frequency offsets of **1** or **2** , the last zone (15) needs to be removed.
See ETSI TDMA Compliance (on page 112).

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

Enable Frequency Zones in Tool Suite

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

Enable Frequency Zones using the Terminal Interface

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

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

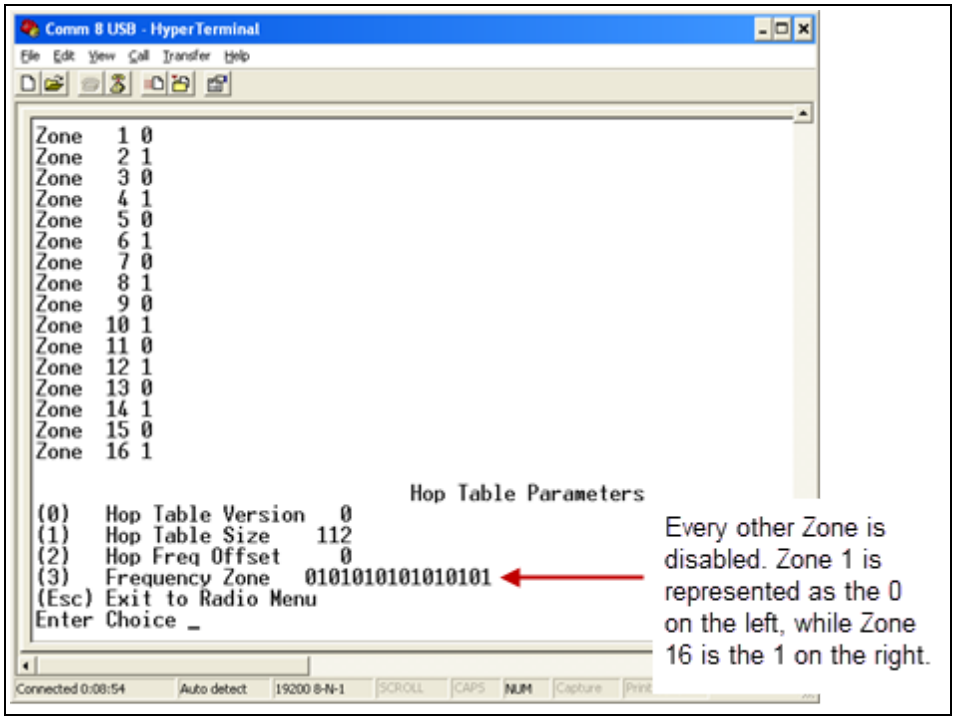


Figure 12: HyperTerminal window with Frequency Zones

2.4.3. 2.4GHzGovernment Rules

2.4GHz Government Rules	
Setting	**Description**
Default Setting	The government rule is set at the factory to comply with the rules of the country the radio is shipped to.

2.4GHz Government Rules	
Setting	**Description**
Options	• **(0) FCC rules** - Power output can be set to a maximum of 27 dBm (500 mW) • **(1) ETSI 328** - Power output can be set to a maximum of 20 dBm (100 mW) • See ETSI TDMA Compliance (on page 112) for additional information.
Terminal Menu	(3) Edit Radio Transmission Characteristics > (0) FreqKey > F > (4) Government Rules
Description:	Sets the radio to comply with the government standards of the country the radio is shipped to. **Note**: The radio always uses the factory setting.

2.4.4. High Noise

Note: This setting is not supported in the GX-C, GX-CE, GX-T radios.

2.4.5. 2.4GHz Hop Frequency Offset

Important!: FreeWave internal use only.

2.4.6. 2.4GHz Hop Table Size

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

2.4GHz Hop Table Size	
Setting	**Description**
Default Setting	80
Options	75 to 80
Terminal Menu	(3) Edit Radio Transmission Characteristics > (0) FreqKey > F > (1) Hop Table Size
Description:	Defines how many separate channels a given network uses. **FREEWAVE Recommends**: Use the **Frequency Zones** instead of the **Hop Table Size** setting.

Warning! FCC regulations require a minimum of 75 separate frequency channels be used within a hop pattern.

2.4.7. 2.4GHz Hop Table Version

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

2.4GHz Hop Table Version	
Setting	**Description**
Default Setting	2400 - 2483 MHz
Options	• 2400 – 2483 MHz • (2.4 - 2.4835 GHz)
Terminal Menu	(3) Edit Radio Transmission Characteristics > (0) FreqKey > F > (0) Hop Table Version
Description:	Determines the section of the 2.4 GHz band the radio uses. In the terminal interface, enter the number that corresponds to the frequency band:

Number to Enter	Frequency Band	Description
0	2400 – 2483 MHz (2.4 – 2.4835 GHz)	Entire band except for offset frequencies.
1	2400(46) – 2483 (54)MHz	Entire band except for offset frequencies.
2	2400(46) – 2427 (27)MHz	Lower 1/3 of the band.
3	2428(49) – 2455 (51)MHz	Middle of the band.
4	2456(51) – 2483 (54)MHz	Upper 1/3 of the band.
5	2428(49) – 2455 (51)MHz	2 outer 1/3 of band, avoids the middle

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

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

Max Packet Size and Min Packet Size (Golden Setting)	
Setting	**Description**
Default Setting	• Max Packet Size = 8 • Min Packet Size = 9
Options	Any number between 0 and 9.
Terminal Menu	(3) Edit Transmission Characteristics > (1) Max Packet Size and (2) Min Packet Size
Description:	The **Max** and **Min Packet Size** parameter settings and the **RF Data Rate** parameter determine the number of bytes in the packets. • Throughput can be enhanced when packet sizes are optimized. • In Point-to-Point mode, the **Max** and **Min Packet Size** settings do not have material impact on throughput unless 115.2 kbps is desired. • However, this may have an impact on latency. **Example**: If small amounts of data are sent and large packet sizes are selected, a certain amount of time wasted between each packet would be seen. • In each over-the-air frame, both the Master and Slave are guaranteed the number of bytes specified in the **Minimum Packet Size** parameter. • In the Master, this is used for maintaining the RF link whether the Gateway has data to transmit or not. • The **Maximum Packet Size** parameter is used to allocate the maximum number of bytes for each Master transmission. • The **Minimum Packet Size** parameter is used to allocate the minimum number of bytes for each Slave transmission. • If the Master does not use all the bytes allocated in the **Maximum Packet Size** setting minus the **Minimum Packet Size** setting, then the remaining bytes are available for the Slave.

2.4.9. MCU Speed

MCU Speed	
Setting	**Description**
Default Setting	(0) Normal

MCU Speed	
Setting	**Description**
Options	• (0) Normal (low speed) - Reduces current consumption. • (1) Fast (high speed) - Required for 230 KBaud and greater data port rate. **Note**: If the radio is AES enabled and using the encryption functionality, set this parameter to **3** using the terminal interface. The value is accepted even though it is not viewable as an option and applies only when using AES encryption. For more information about setting up AES encryption, see Enable and Set Up AES Encryption (on page 88).
Terminal Menu	(3) Edit Radio Transmission Characteristics > (B) MCU Speed
Description:	Controls the speed of the Micro Controller Unit (MCU) in the radio.

2.4.10. Remote LED

Remote LED	
Setting	**Description**
Default Setting	(0) Local Only
Options	• **(0) Local Only** - Only the LEDs on the board are enabled. • **(1) Remote and Local** - LEDs on the board and remote LEDs through the diagnostic port are enabled. • **(2) Remote Only** - LEDs on the board are disabled. Remote LEDs through the diagnostic port are enabled.
Terminal Menu	(3) Edit Radio Transmission Characteristics > (C) Remote LED
Description:	**Note**: If using a GX radio with the optional 24-pin connector, 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 Slave radios, use **Low Power Mode** (setting = **1**). • **Low Power Mode** does NOT work with MultiPoint Repeaters because Repeaters are constantly transmitting. • **Remote LED** drives the Diagnostic port, which has a small amount of current draw. • When using remote LEDs, the center (TX) LED does NOT output a signal for a green LED when in Setup mode. • The Green TX LED has no remote pinout.

2.4.11. Retry Time Out

Retry Time Out	
Setting	**Description**
Default Setting	255
Options	Any number between 0 and 255 in MultiPoint networks. **Note**: The minimum in 900MHz radios is 8 seconds. Any number between 151 and 255 in Point-to-Point networks.
Terminal Menu	(3) Edit Transmission Characteristics > (8) Retry Time Out
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**. • With a setting of **255**, the Master allows a Slave or Repeater to stay connected as long as 1 packet in 255 is successfully received at the Master. • The maximum setting means that if 1 packet in 255 is sent successfully from the Master to the Slave or Repeater, the link is maintained. • This allows a Slave or Repeater to drop a connection if less than 1 in 8 consecutive packets is successfully received from the Master. The **Retry Time Out** parameter is useful when a MultiPoint network has a roving Master or Slave. As the link gets weaker, a lower setting allows a poor link to break in search of a stronger one. **FREEWAVE Recommends**: Setting the **Retry Time Out** parameter to **20** in the MultiPoint Master is recommended in areas where several FreeWave networks exist. This recommended setting allows Slaves and Repeaters to drop the connection if the link becomes too weak, while at the same time prevent errant disconnects due to interference from neighboring networks. **Note**: While intended primarily for MultiPoint networks, the **Retry Time Out** parameter may be changed in Point-to-Point networks. However, the value in Point-to-Point mode should NOT be set to less than 151.

2.4.12. RF Data Rate (Golden Setting)

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

RF Data Rate (Golden Setting)	
Setting	**Description**
Default Setting	(3) Normal
Options	• (2) High - 153.6 kbps • (3) Normal - 115.2 kbps
Terminal Menu	(3) Edit Transmission Characteristics > (4) RF Data Rate

Description:	**Important!**: Do NOT confuse the **RF Data Rate** with the serial port **Baud Rate**.
	FreeWave radios have these **RF Data Rate** settings:
	• **2** (High).
	  • Use setting **2** (RF Speed of 153.6 kbps) when the radios are close together and need to optimize data throughput.
	• **3** (Normal).
	  • Use setting **3** (RF Speed of 115.2 kbps) when the radios are farther away and a solid data link is preferred over data throughput.

2.4.13. Slave Security

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

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

Slave Security	
Setting	**Description**

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

2.4.14. Transmit Power

Transmit Power	
Setting	**Description**
Default Setting	20
Options	Any number between 0 and 27
Terminal Menu	(3) Edit Transmission Characteristics > (5) RF Xmit Power
Description:	Sets the output power of the radio in dBm. Settings range from 0dBm (1mW) to 27dBm (500mW). The maximum value may be capped at 20 dBm at the factory to comply with ETSI regulations, or capped at other values to comply with country-specific requirements. **Note**: See ETSI TDMA Compliance (on page 112) for more information.  When testing radios, and they are in close proximity to one another, set the **Transmit Power** parameter to a low number. When deploying radios to the field, raise the **Transmit Power** number accordingly.

Important!: This table is for reference only. All Transmit Power settings below 9 are approximate.

2.4.15. Transmit Rate

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

3. Configuring Point-to-MultiPoint Networks

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

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

This section provides details about the setup that applies specifically to a MultiPoint network:

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

Note: See Routing Communications through the Network (on page 98) and Assigning Subnet ID Values (on page 98) for additional information.

3.1. Point to MultiPoint Network Characteristics

A Point to MultiPoint network has these unique characteristics:

- Golden Settings (on page 55).
- Master to Slave Communications (on page 55).
- Slave to Master Communications (on page 55).

3.1.1. Golden Settings

A Point-to-MultiPoint network requires that the Golden Settings (described in Golden Settings (on page 41)) are set the same on **ALL** radios in the network.

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

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

3.1.2. Master to Slave Communications

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

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

3.1.3. Slave to Master Communications

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

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

3.2. Point-to-MultiPoint Network Quick Start

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

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

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

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

3. Open a Tool Suite session.
4. Click the **Configuration** application.
5. Verify the correct port is selected in the **Com Port** field in the upper left of the **Configuration** ribbon.
6. On the **Configuration** ribbon, in the **Network** section, click the network the radio resides in
   or
   Click **Add Network** to create a new network in Tool Suite.
7. Click **Read Radio** on the **Configuration** ribbon to read the radio's current settings.
   - If using a diagnostics cable to connect to the radio, the radio automatically goes into **Setup** mode.
   - When in **Setup** mode, all three LEDs on the radio are solid green.
   - If using a data cable to connect to the radio, follow the prompt to press the radio's **Setup** button to put it in **Setup** mode.
8. Click the **Operation Mode** tab.
9. In the **Modem Mode** field:
   Select **2** to set the radio as a Point-to-MultiPoint Master.
   Select **3** to set the radio as a Point-to-MultiPoint Slave.

   > **Note**: A MultiPoint network can have only one Master, unless running in **Multi-Master Sync** mode.
   > For more information, see Multi-Master Sync (on page 93).

10. Click the **Baud Rate** tab.
11. Change the **Baud Rate**, **Data Parity**, and **Modbus RTU** to match the device that the radio is to be connected to.
12. Click the **Transmission Characteristics** tab.
13. Set these parameters so they are identical on all radios in the network:
    - Frequency Key
    - Max Packet Size

- Min Packet Size
- RF Data Rate

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

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

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

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

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

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

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

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

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

3. Open a terminal emulator session.

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

4. Connect to COMx (where 'x' is the number of the COM connected port).
5. Set these options:
    - Data Rate: **19,200**
    - Data Bits: **8**
    - Parity: **None**

- Stop Bits: **1**
- Flow Control: **None**

6. Press the **Setup** button on the radio.
   If using the diagnostics cable, press <Shift+U>.
   - The three LEDs on the radio should all turn green , indicating **Setup** mode.
   - The **Main** menu appears on the screen.
7. Press <**0**> to access the **Operation Mode** menu.
8. Press <**2**> to set the radio as a Point-to-MultiPoint Master or
   Press <**3**> to set the radio as a Point-to-MultiPoint Slave.
9. Press <**Esc**> to return to the **Main** menu.

> **Note**: A MultiPoint network can have only one Master, unless running in **Multi-Master Sync** mode.
> For more information, see Multi-Master Sync (on page 93).

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

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

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

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

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

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

3.3. 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

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

3.4. Overlapping MultiPoint Networks

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

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

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

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

Note: For more information about the installation of Point-to-MultiPoint networks, contact FreeWave Technical Support.
See Contact FreeWave Technical Support on page 9

3.5. Establishing Communication with Other Radios in a MultiPoint Network

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

FREEWAVE Recommends: While the Call Book is an option in Point-to-MultiPoint networks, FreeWave **strongly recommends** using the **Network ID** feature in most applications.
If a large MultiPoint network is implemented using the Call Book and a radio needs to be added to or replaced in the network, each radio in the network must be physically reprogrammed and the new serial number entered in the radio's Call Book.
This can be a time consuming process and can cause a delay in getting the network back up and running.
Because the **Network ID** does not use serial numbers, MultiPoint Master radios and Repeaters may be added or replaced without reprogramming each Slave radio in the network.

3.5.1. Using the Network ID in MultiPoint Networks

The **Network ID** parameter is located on the **MultiPoint Parameters** tab. In a single network, assign each radio the same **Network ID**. Slave radios link with the first Master or Repeater it hears that has a matching **Network ID**.

When setting the **Network ID**:

- The value can be any value between 1 and 4095, except 255.
  - 255 enables the Call Book.

- To help ensure the ID is unique to the network, avoid using numbers that coincide with nearby landmarks or highways.

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

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

3.5.2. Using the Call Book in MultiPoint Networks

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

FREEWAVE Recommends: While the Call Book is an option in Point-to-MultiPoint networks, FreeWave **strongly recommends** using the **Network ID** feature in most applications.
If a large MultiPoint network is implemented using the Call Book and a radio needs to be added to or replaced in the network, each radio in the network must be physically reprogrammed and the new serial number entered in the radio's Call Book.
This can be a time consuming process and can cause a delay in getting the network back up and running.
Because the **Network ID** does not use serial numbers, MultiPoint Master radios and Repeaters may be added or replaced without reprogramming each Slave radio in the network.

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

Note: For information about setting the Call Book, see Using the Call Book in Point-to-Point Networks on page 80.

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

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

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

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

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

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

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

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

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

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

3.5.3. Programming Point-to-MultiPoint Extended Call Book

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

Procedure

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

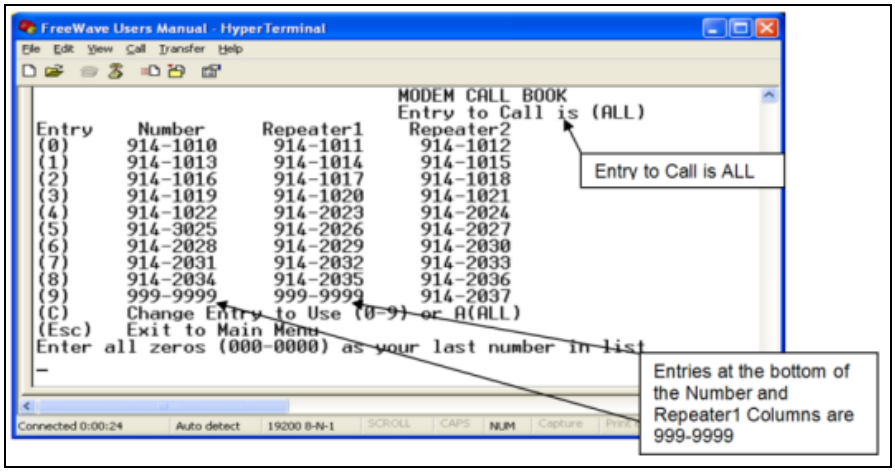


Figure 13: HyperTerminal PTMP Extended Call Book

3.6. Setting Other MultiPoint Parameters

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

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

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

3.6.1. 1 PPS Enable Delay

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

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

Setup 1PPS Enable/Delay

1. On the Master radio, set the **1 PPS Enable/Delay** parameter to **0**.

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

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

Calibrate a Slave Radio in 1PPS Enable/Delay Mode

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

The difference in time between each incremental integer value is 542.534 nanoseconds (ns). Changing the parameter to higher values decreases the Slave radio time delay and changing the parameter to lower values increases the time delay.

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

3.6.2. Diagnostics

Diagnostics	
Setting	**Description**
Default Setting	0 (Disabled)
Options	Any number between 0 and 128
Terminal Menu	(5) Edit MultiPoint Parameters > (B) Diagnostics
Description:	Allows diagnostics data in the **Network Diagnostics** in Tool Suite to be viewed at the Master radio in parallel with application data. • The setting in this parameter determines how many slots out of 128 are dedicated to diagnostics. • Diagnostics is always secondary to actual transmitted data. **Example**: If set to **10**, 1 out of every 10 data slots is for diagnostics data. If set to **100**, 1 out of every 100 data slots is for diagnostics data. **Note**: For more information, see Reading Diagnostics in Tool Suite on page 73.

3.6.3. DTR Connect

DTR Connect	
Setting	**Description**
Default Setting	(0) Off

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

3.6.4. Local Mode

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

3.6.5. Master Packet Repeat

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

Master Packet Repeat	
Setting	**Description**
Default Setting	3
Options	Any number between 0 and 9.
Terminal Menu	(5) Edit MultiPoint Parameters > (1) Master Packet Repeat
Description:	In a Point-to-MultiPoint network, Slave radios do not acknowledge transmissions from the Master. • If Slave radios did acknowledge all data transmissions, in a large network, the Master would soon become overwhelmed with acknowledgments from the Slaves. • Without acknowledgments, 100% confidence every Slave radio has received every packet cannot be met. • To address this issue, change the **Master Packet Repeat** parameter, assigning a value between **0** (the packet is transmitted once) to **9** (the packet is transmitted 10 times). For networks with solid RF links, this parameter should be set to a low value (e.g., **1** or **2**). • If a network has some weak or marginal links it should be set with higher values. • If a Slave radio receives a good packet from a Master more than once it discards the repeated packets. • Similarly, after a MultiPoint Repeater receives a good packet from the Master, it discards any further repeated packets. • In turn, the Repeater sends the packet out to the next Repeater or Slaves the number of times corresponding to its own **Master Packet Repeat** setting. Increasing the **Master Packet Repeat** setting increases the probability of a packet getting through, but also increases latency in the network because each packet from the Master or Repeater is being sent multiple times. **Note**: Therefore, it is important to find the optimal mix between network robustness, throughput, and latency. In general, a setting of **2** to **3** works well for most well designed networks. The **Master Packet Repeat** parameter may be set to **0** if the user software is capable of, or requires acknowledgment. In this case, if the Master sends a packet that the Slave radio does not receive, the user software controls the retries as needed.

3.6.6. Master Packet Repeat in MultiPoint Networks with Repeaters

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

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

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

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

3.6.7. Max Slave Retry

Max Slave Retry	
Setting	**Description**
Default Setting	9
Options	Any number between 1 and 9.
Terminal Menu	(5) Edit MultiPoint Parameters > (2) Max Slave Retry
Description:	• Defines how many times the Slave radio attempts to retransmit a packet to the Master before beginning to use a back-off algorithm as defined by the Retry Odds on page 69 setting. • The Slave radio retries stop when the Slave receives an acknowledgment from the Master.

3.6.8. Radio ID

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

3.6.9. Radio Name

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

3.6.10. Repeater Frequency

Repeater Frequency	
Setting	**Description**
Default Setting	(0) Disabled
Options	(0) Disabled (1) Enabled
Terminal Menu	(5) Edit MultiPoint Parameters > (5) Repeater Frequency
Description:	Enable this parameter when a **Frequency Key** is needed other than that of the Master. • This condition occurs when parallel Repeaters in a network may have overlapping areas of responsibility. • The default setting of **0** (Disabled) causes the Repeater to use the key set in the **Frequency Key** parameter on the Tool Suite **Transmission Characteristics** tab. **Note**: When the **Repeater Frequency** parameter is disabled and **Subnets** are NOT configured, the **Frequency Key** parameter setting in each Slave radio MUST match the Master or Repeater acting as the Master for the radio.

3.6.11. Repeaters

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

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

3.6.12. Retry Odds

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

Retry Odds	
Setting	**Description**
Description:	While packets transmitted from the Master to the Slave radios in a MultiPoint network are not acknowledged, packets transmitted from Slaves to the Master are acknowledged. It is possible that more than one Slave attempts to transmit to the Master at the same time. Therefore, it is important that a protocol exists to resolve contention for the Master between Slaves in the network. This is addressed through the Max Slave Retry (on page 67) and **Retry Odds** parameters. • After the Slave has unsuccessfully attempted to transmit the packet the number of times specified in the **Max Slave Retry** parameter, it attempts to transmit to the Master on a random basis. • The **Retry Odds** parameter determines the probability that the Slave attempts to retransmit the packet to the Master; a low setting assigns low odds to the Slave attempting to transmit. • Conversely, a high setting assigns higher odds. **Example**: Consider two different Slave radios in a MultiPoint network, one with a strong RF link and the other with a weak RF link to the Master. If a Slave has a weak or poor link, set the **Retry Odds** parameter to **0** as it may become a chatty Slave and lockup the network, causing a loss of communication. • When the **Retry Odds** parameter is set to **0**, after the Slave has exhausted the number of retries set in the **Max Slave Retry** parameter and still not gained the Master's attention, the Slave's data buffer is purged. **FREEWAVE Recommends**: A **Retry Odds** parameter set to **0** is recommended for most networks.

3.6.13. Slave / Repeater

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

Slave / Repeater	
Setting	**Description**
Description:	The **Slave/Repeater** mode allows a radio in a MultiPoint network to switch between Slave and Repeater functions. • When in this mode, a radio repeats any packets sent across the network as well as uses the data port. • Thus, where one Repeater and one Slave may be required in another vendor's network, FreeWave networks require only one radio. To operate a radio as a MultiPoint **Slave/Repeater**, these parameters must be set: • The **Modem Mode** parameter in the **Operation Mode** tab must be set to **MultiPoint Repeater**. • The **Slave/Repeater** parameter in the **MultiPoint Parameters** tab must be enabled.

3.7. Conserving Power

Power consumption can be essential, especially for remote sites that are difficult to access. Use these options on the **Transmission Characteristics** tab to conserve power.

These settings are available in the **Radio Transmission Characteristics** menu in the terminal interface.

- **Low Power Mode** - Available in MultiPoint Slaves.
  - Conserves power primarily by dimming the radio's LEDs.

  Note: For more information, see Low Power Mode (on page 71).
- **Remote LEDs** - If the radio has the optional connector, use this option to connect remote LEDs through the diagnostics port.

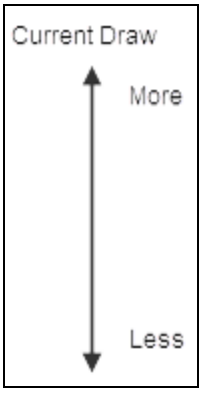
  

  This feature may be used to save power in MultiPoint Repeaters where the other options are not available.

  Note: For more information, see Remote LED (on page 49).

3.7.1. Low Power Mode

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

<table>
<tr><th colspan="2">Low Power Mode</th></tr>
<tr><th>Setting</th><th>Description</th></tr>
<tr><td>Default Setting</td><td>0</td></tr>
<tr><td>Options</td><td>• Any number between 0 and 31.
• The higher the number, the greater the power consumption decrease.</td></tr>
<tr><td>Terminal Menu</td><td>(3) Edit Radio Transmission Characteristics > (9) Low Power Mode</td></tr>
<tr><td>Description:</td><td>Allows a MultiPoint Slave radio to consume less power, primarily by dimming the radio's LEDs.
When set to 2 through 31, the radio sleeps between slots.
Example: Using a setting of 2 the radio sleeps 1 out of 2 slots.
Using a setting of 3 the radio sleeps 2 out of 3 slots, etc.
When the radio is asleep, it hears nothing from the Master.
This table shows the changes at different Low Power Mode settings.
• The actual current draw depends on many factors.
• The table gives only a qualitative indication of supply current savings.
• A low number reduces latency and a high number reduces current consumption.
<table>
<tr><th></th><th>Setting</th><th>Description</th></tr>
<tr><td rowspan="6"> 
</td><td>0</td><td>Low power, disabled.</td></tr>
<tr><td>1</td><td>• LEDs dimmed, radio remains awake.
• Radio is listening to the Master’s transmissions on every slot.
• Radio’s data port is shut down if the RTS line is de-asserted (low).
• In this case, the radio needs to be awakened before it is able to send data to the Master.</td></tr>
<tr><td>2</td><td>LEDs dimmed, radio sleeps every other slot.</td></tr>
<tr><td>3</td><td>LEDs dimmed, radio sleeps 2 of 3 slots.</td></tr>
<tr><td>4-31</td><td>LEDs dimmed, radio sleeps the number of slots corresponding to the setting.
Example: With a setting of 31 the radio sleeps 30 of 31 slots.</td></tr>
</table></td></tr>
</table>

Low Power Mode	
Setting	**Description**

	Notes
	• Power savings occur only when the Slave radio is linked.
	  • No power savings occur when the Slave radio is transmitting data.
	  • **Low Power Mode** is of little value when a Slave has a constant, high throughput.
	  • The **MCU Speed** parameter MUST be set to **0** and the **RF Data Rate** parameter MUST be set to **3** for **Low Power Mode** to operate properly.
	• To communicate to an RS-232 port of a radio that is in **Low Power Mode**, the RTS line MUST be held high to wake it up.
	  • The radio wakes up within approximately 20 milliseconds of when RTS goes high.
	  • If the Request to Send (RTS) line on the Slave radio is held high, the radio remains in normal operation regardless of the **Low Power Mode** setting.
	  • After RTS is dropped the radio reverts to the **Low Power Mode**.
	• If the radio has the DTR Connect (on page 64) parameter in the **MultiPoint Parameters tab** set to **1** or **2** and if the **Low Power Mode** is enabled (set to **1 to 31**), the RTS line on the radio MUST be asserted for the **DTR Connect** feature to operate properly.
	• The diagnostic pins MUST be disabled or terminated to a cable for the sleep current in **Lower Power Mode** to match the specifications.
	  • To disable the diagnostic pins, set these options:
	  • In the **Baud Rate tab**, the Setup Port (on page 37) parameter is set to **1 (Main Only)**.
	  • In the **MultiPoint Parameters tab**, the Diagnostics (on page 64) parameter is set to **0 (Off)**.

3.8. Reading Diagnostics in Tool Suite

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

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

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

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

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

The diagnostic program **must** be run from the Master radio. Diagnostics require:

- A setting between 1 and 128 in the **Diagnostics** parameter available in the MultiPoint Parameters menu on the Master.
- A second computer or serial connection to run the diagnostics software.
- A diagnostics cable. (Available from FreeWave.)
- Diagnostics software. (Available from www.freewave.com).

Note: For more information about diagnostics, contact FreeWave Technical Support.
Contact FreeWave Technical Support (on page 9) for assistance.

Procedure

1. Connect the Master to the computer running Tool Suite.
2. Open Tool Suite.
3. On the Applications tab, click **Network Diagnostics**.
4. In the **Networks** section of the ribbon, use the list box to select the serial network to run diagnostics on.

   If there is no network defined, click **Add** and follow the instructions in the wizard.
5. On the ribbon, click **Start**.
6. To stop running diagnostics, click **Stop**.

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

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

4. Configuring Point-to-Point Networks

Point-to-Point networks are the most basic type of network and do not require much more than the setup described in the basic programming and setup section.

This section provides:

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

4.1. Point-to-Point Network Quick Start

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

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

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

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

3. Open a Tool Suite session.
4. Click the **Configuration** application.
5. Verify the correct port is selected in the **Com Port** field in the **Configuration** ribbon.
6. On the **Configuration** ribbon, in the **Networks** section, select the network the radio resides in or click **Add Network** to create a new network in Tool Suite.

7. Click **Read Radio** on the **Configuration** ribbon to read the radio's current settings.
   - If using a diagnostics cable to connect to the radio, the radio automatically goes into **Setup** mode.
   - If using a data cable to connect to the radio, a prompt appears to press the radio's **Setup** button to enter **Setup** mode.
   - When in **Setup** mode, all three LEDs on the radio display solid green .
8. Click the **Operation Mode** tab.
9. In the **Modem Mode** field, select to set the radio to Point-to-Point mode.

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

   Note: A Point-to-Point network can have only one Master.
   For more information about modem modes, see Setting the Radio's Role in the Network and the Network Type (on page 31).
10. Click the **Baud Rate** tab.
11. Change the **Baud Rate**, **Data Parity**, and **Modbus RTU** to match the device that the radio is to be attached to.
12. Click the **Transmission Characteristics** tab.
13. Set these parameters so they are identical on all radios in the network:
    - Frequency Key
    - Max Packet Size
    - Min Packet Size
    - RF Data Rate

    If several independent networks are located in close proximity, it becomes very important to include as much frequency and time diversity as possible through use of different **Frequency Key**, **Min and Max Packet Size**, and **Hop Table** parameter settings.
14. Click the Call Book tab.
15. Enter the Slave serial number in the Master's Call Book.
16. Enter the Master's Serial number in the Slave's Call Book, or disable the **Slave Security** parameter in the Slave.

    Note: For more information about setting up the Call Book see Using the Call Book in Point-to-Point Networks (on page 80).

    Shortly after both radios are plugged in, they should establish a link with each other and the connection is complete.
17. Using the Point-to-Point Operation LEDs (on page 79), verify that the radios are operating as expected.
18. On the **Configuration** application in the **Network Title** ribbon:

- Click **All** to send all the settings for all parameters.
- Click **Quick** to send only the changed parameters.

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

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

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

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

3. Open a terminal emulator session.

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

4. Connect to COMx (where 'x' is the number of the COM port being connected).
5. Set these parameters to:
   - Data Rate - **19,200**
   - Data Bits - **8**
   - Parity - **none**
   - Stop bits - **1**
   - Flow Control - **none**
6. Press the **Setup** button on the radio.
   If using the diagnostics cable, press <Shift+U>.
   - When in **Setup** mode, all three LEDs on the radio display solid green.
   - The **Main Menu** appears in the window.
7. Type **0** and press <Enter> to access the **Operation Mode** menu.
8. Type **0** and press <Enter> to set the radio as a Point-to-Point Masteror
   Type **1** and press <Enter> to set the radio as Point-to-Point Slave.

   > **Note**: For more information about modem modes, see Setting the Radio's Role in the Network and the Network Type (on page 31).

9. Press <**Esc**> to return to the **Main** menu.
10. On the **Main Menu**, type **1** and press <Enter>.
11. Change the **Baud Rate**, **Data Parity**, and **Modbus RTU** to match the device that the radio is to be attached to.
12. Press <**Esc**> to return to the **Main** menu.
13. On the **Main Menu**, type **2** and press <Enter> to update the Call Book.

14. Enter the Slave serial number in the Master's Call Book.
15. Enter the Master's Serial number in the Slave's Call Book or disable the Slave Security (on page 51) parameter in the Slave.

    Note: For more information about setting up the Call Book see Using the Call Book in Point-to-Point Networks (on page 80).

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

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

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

    Shortly after both radios are plugged in, they should establish a link with each other and the connection is complete.
21. Using the Point-to-Point Operation LEDs (on page 79), verify that the radios are operating as expected.
22. Press <**Esc**> to exit the **Setup** menu and resume normal radio operation.

4.2. 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

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

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

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

FREEWAVE Recommends: While the Call Book is an option in Point-to-MultiPoint networks, FreeWave **strongly recommends** using the **Network ID** feature in most applications.
If a large MultiPoint network is implemented using the Call Book and a radio needs to be added to or replaced in the network, each radio in the network must be physically reprogrammed and the new serial number entered in the radio's Call Book.
This can be a time consuming process and can cause a delay in getting the network back up and running.
Because the **Network ID** does not use serial numbers, MultiPoint Master radios and Repeaters may be added or replaced without reprogramming each Slave radio in the network.

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

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

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

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

It is important that the Call Book slots (0-9) are filled sequentially starting with slot 0.

- When a Master is instructed to **Call All**, it calls all Slave radios listed until it reaches the first serial number of 000-0000 (or a blank slot).
- If a serial number is entered after the all zero number or as a Repeater, the Master does not recognize it as a valid number.

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

4.3.1. Setting the Call Book in Tool Suite

1. In the Tool Suite **Configuration** application, select the device to program.
2. Click the **(2) Call Book** tab.
3. In the **Number** column in **Row 0**, enter the seven-digit serial number of the radio being called.
4. In the **Repeater 1** column, enter the first Repeater's seven-digit number.
   If no Repeaters are being used, leave the column empty.
5. In the **Repeater 2** column, enter the second Repeater's 7-digit number.
   If only one Repeater is being used, leave the column empty.
6. If Repeaters are being used, select the appropriate **Entry to Call** option in the Master Call Book.
7. To apply the changes, click either the **Quick** or **All** icon.
   Tool Suite applies the changes to the radio.

4.3.2. Setting the Call Book in the Terminal Interface

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

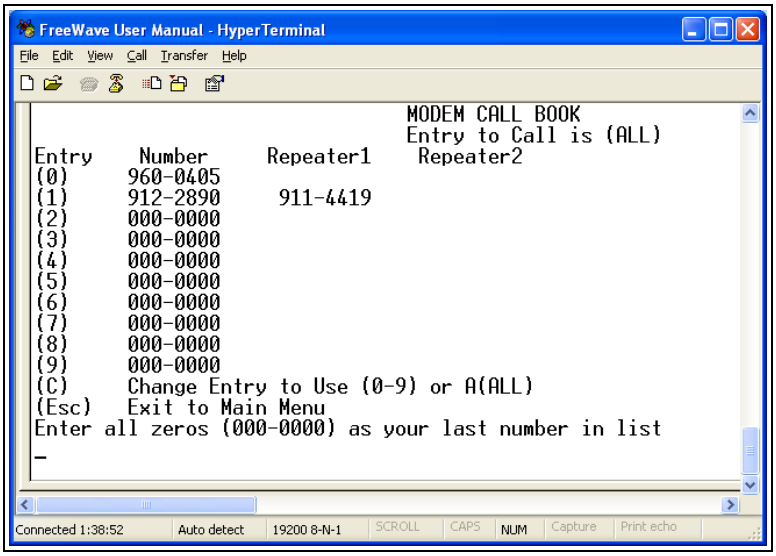


Figure 14: Modem Call Book window

2. Enter the number or letter associated with the option to select.
3. In the **Enter New Number prompt**, enter the seven-digit serial number of the radio being called.
   The system prompts for the first Repeater's serial number.
4. If no Repeaters are being used, press <Esc> and continue.
   Otherwise, enter the 7-digit serial number of the Repeater.
   The system prompts for the second Repeater's serial number.

5. Enter the 7-digit serial number of the second Repeater.
   If only one Repeater is being used, press <Esc>.
   The system refreshes the radio's **Call Book** menu with the new changes.
6. Repeat steps 2 to 5 for additional radios in the network.
7. Press <Esc> to return to the Main menu.

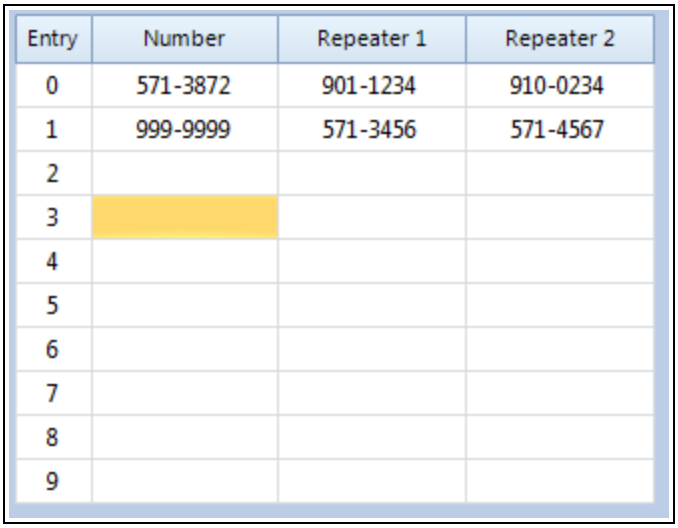
4.3.3. Programming Point-To-Point Extended Call Book to Use Three or Four Repeaters

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

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

Figure 15 shows a Point-to-Point link where a Slave is called through four Repeaters. In this example:

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



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

Figure 15: Point-to-Point link where a Slave is called through four Repeaters

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

5. Advanced Programming

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

- Working with Parallel Repeaters (on page 85)
- Setting and Changing Radio Passwords (on page 87)
- Enable and Set Up AES Encryption (on page 88)
  - Encryption Channel Key (on page 91)
  - Encryption Key (on page 90)
  - Encryption (Strength) (on page 89)
  - Troubleshooting AES Setup (on page 92)
- Low Baud Rates (on page 93)
- Multi-Master Sync (on page 93)
- Time Divisible Multiple Access (TDMA) (on page 93)

5.1. Working with Parallel Repeaters

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

- Repeaters Data Transmitted on the Same Frequency Key (on page 85)
- Adding a Repeater to the Network (on page 86)

5.1.1. Repeaters Data Transmitted on the Same Frequency Key

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

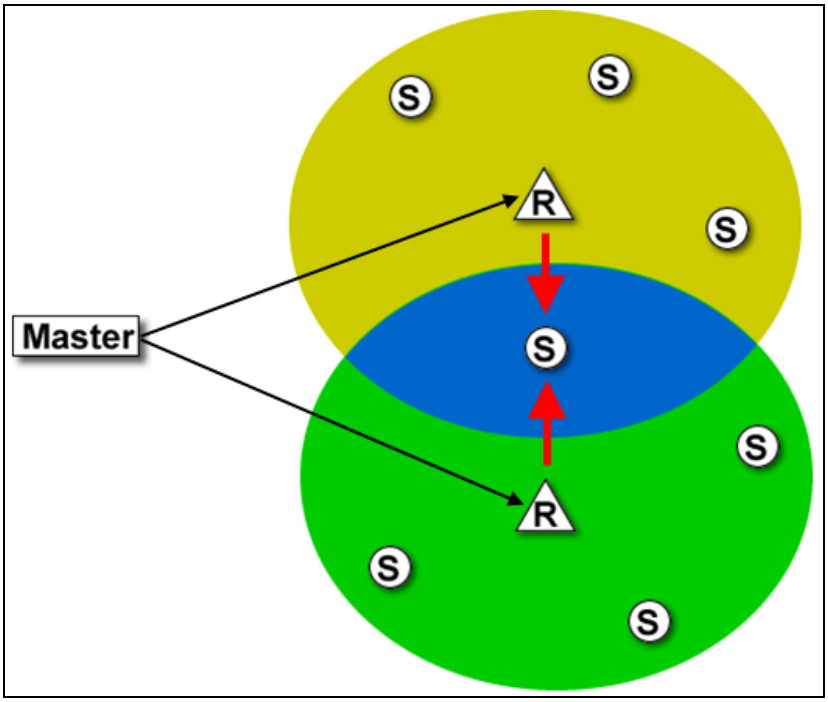


Figure 16: Slave Radio with Overlapping Coverage

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

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

Settings to Change on Repeaters in Conflict	
Setting	**Description**
Frequency Key	Set the **Frequency Key** parameter in the **Transmission Characteristics** tab to a key other than that of the conflicting Repeater.

5.1.2. Adding a Repeater to the Network

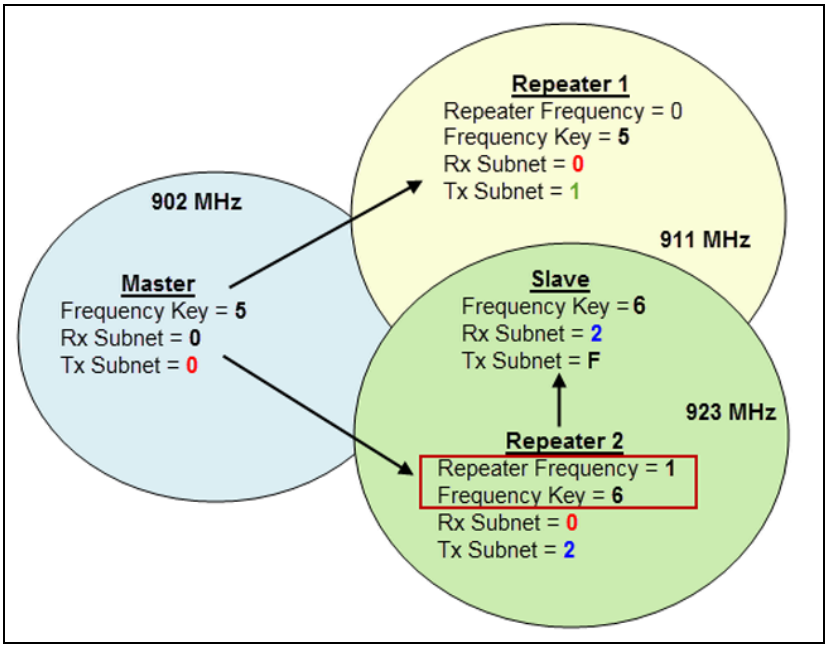


Figure 17: Repeater Added to Network

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

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

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

2. Review the network diagnostics file.
   Pay special attention to these settings on each Repeater and the Master:
   - Frequency Key
   - Repeater Frequency
   - Rx and Tx Subnet IDs
3. On a piece of paper, draw the network.
4. Note the above settings for each Repeater.
   Verify there are no duplicates.
5. If there are duplicates, change the **Repeater Frequency** and the **Frequency Key** parameters described in the table.

6. If the Repeater being adding is the only Repeater in the network, set the:
   a. **Frequency Key** parameter to match the Master.
   b. **Rx Subnet ID** parameter to match the Master's **Tx Subnet ID** parameter setting
   c. **Tx Subnet ID** parameter to **1**.
   d. In the Master, set the **Repeaters** parameter to **Enabled**.

5.2. Setting and Changing Radio Passwords

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

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

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

5.2.1. Setting the Password

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

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

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

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

5.2.2. Changing a Password

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

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

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

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

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

5.2.3. Disable a Password

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

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

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

   > **Important!**: Type the **0255** using the NUM Pad on the keyboard, NOT the top row of numerals.

5. After the fourth entry, the password is disabled.

5.3. Enable and Set Up AES Encryption

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

> **Note**: AES encryption is available as an option set at the FreeWave factory.
> If AES encryption is running, Tool Suite cannot be used to upgrade or downgrade the radio.

When using AES encryption, these settings are required:

- Encryption Channel Key (on page 91).
- Encryption Key (on page 90).
- Encryption (Strength) (on page 89).

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

Note: For information about accessing the **Setup** menu using the terminal interface, see Access the Setup Menu Using a Terminal Emulator (on page 22).

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

5.3.1. Encryption (Strength)

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

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

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

Encryption (Strength)	
Setting	**Description**
Description:	AES encryption is available in various strengths. • The network and the data being sent determine the encryption strength used. • The higher the encryption strength, the stronger the encryption although it can also take longer for the encryption and un-encryption to take place.

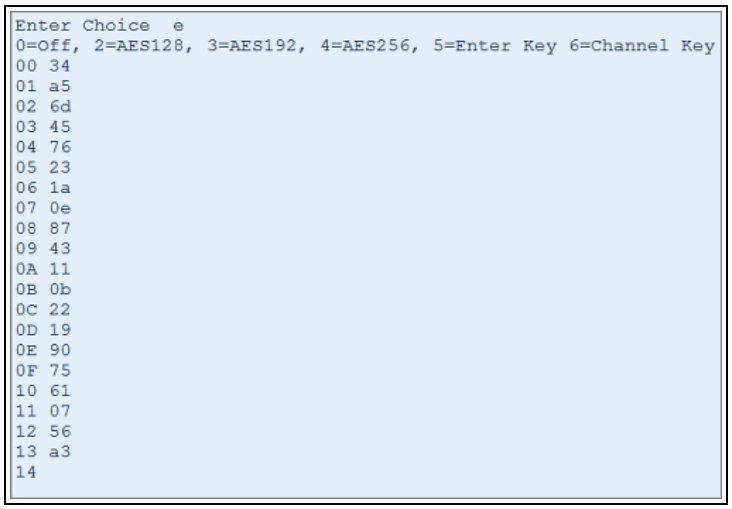
5.3.2. Encryption Key

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

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

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

Encryption Key	
Setting	**Description**

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

5.3.3. Encryption Channel Key

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

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

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

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

5.3.4. Troubleshooting AES Setup

The radios link, transmit data, and then unlink.

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

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

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

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

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

5.4. Low Baud Rates

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

Note: For more information about using a low baud rate, Contact FreeWave Technical Support (on page 9).

5.5. Multi-Master Sync

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

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

Note: For more information about using **Multi-Master Sync** while in TDMA mode, contact FreeWave Technical Support.
See Contact FreeWave Technical Support (on page 9).

5.6. Time Divisible Multiple Access (TDMA)

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

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

Note: For additional information about TDMA, contact FreeWave Technical Support.
See Contact FreeWave Technical Support (on page 9).

6. Viewing Radio Statistics

When reading a radio, the system shows data transmission statistics the radio has gathered during the most recent session. This information is valuable to know the signal strength and noise levels of the link. Statistics are gathered during each time the Master and Slave link and are reset when the next link begins.

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

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

- Antenna Reflected Power (on page 94)
- Noise Level (on page 95)
- Number of Disconnects (on page 95)
- Radio Temperature (on page 96)
- Rate % (Receive Percentage Rate) (on page 96)
- Signal Level (on page 96)
- Transmit Current (on page 97)

6.1. Antenna Reflected Power

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

A reading of:

- 0 to 5 is good.
- 5 to 20 is marginal.

- 20 or higher indicates that the connections should be inspected for loose connections and cable quality.
- 30 or higher indicates a definite problem in the system.

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

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

6.2. Master-Slave Distance

The physical distance between the Slave radio and the Master radio in the network.

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

6.3. Noise Level

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

The individual measurement values at each frequency hop channel are shown in the Frequency Zones Table or the 2.4GHz Frequency Zones Table (on page 43).
If viewing statistics in the terminal interface, press <Enter> when the **Radio Statistics** menu appears.

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

6.4. Number of Disconnects

The value in this statistic indicates the total number of times the link between the Master and the Slave has been lost and the radios lose **Carrier Detect** from the time the radio is powered on until the radio is put into **Setup** mode.

- Under ideal operating conditions, the number of disconnects should be **0**.
- One or more disconnects may indicate a weak link, the presence of severe interference problems, or loss of power to any of the radios in the link.

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

6.5. Radio Temperature

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

FREEWAVE Recommends: For proper operation, a FreeWave radio must be in the temperature range of -40° to +85 °C.

6.6. Rate % (Receive Percentage Rate)

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

- A number of 75 or higher indicates a robust link that provides very good performance even at high data transmission rates.
- A number of 15 or lower indicates a weak or marginal link that provides lower data throughput.
- Throughput is reduced by 50 percent if the network contains a Repeater.

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

6.7. Signal Level

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

- The source of the signal is the radio that transmits to the radio reading this statistic.
- The number is an average of the received signal levels measured at each frequency in the radio's frequency hop table.
- For a reliable link, the margin should be at least 15 dB.
- Low average signal levels can often be corrected with higher gain antennas, better antenna placement and/or additional Repeaters.

The individual measurement values at each frequency hop channel are shown in the Frequency Zones Table or the 2.4GHz Frequency Zones Table (on page 43).
If viewing statistics in the terminal interface, press <Enter> when the **Radio Statistics** menu appears.

6.8. Transmit Current

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

7. Routing Communications through the Network

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

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

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

7.1. Assigning Subnet ID Values

Subnet IDs consist of two parts, both available on the **MultiPoint Parameters** tab:

- **Rx** - This setting identifies which radio a Repeater or Slave listens to.
  - In the terminal interface, this is the **Rcv Subnet ID**.
- **Tx** - This setting identifies the ID this device transmits on and which devices listen to it.
  - The **Tx Subnet ID** parameter is relevant for MultiPoint Master radios and Repeaters **only**.
  - In the terminal interface, this is the **Xmt Subnet ID**.
- The default (disable) setting for both **Rx** and **Tx** is **F, F**.
  - This is a visual way to indicate that the device is the final in the line of communication and does not use a subnet ID.

- A MultiPoint Slave with a **Subnet ID** of **F, F** does not roam from one Repeater or network to the next.
  - It only links to a Master or Repeater that has either a **Transmit Subnet** setting of **0** or an **F, F Subnet ID**.
- Setting both **Rx** and **Tx Subnet ID** to **0** allows a mobile Slave to roam from subnet to subnet, and possibly from network to network, provided the **Network ID**, **Max and Min Packet Size**, and **RF Data Rates** are the same between networks.

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

7.1.1. Example 1: Subnet and Specific Path Communication

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

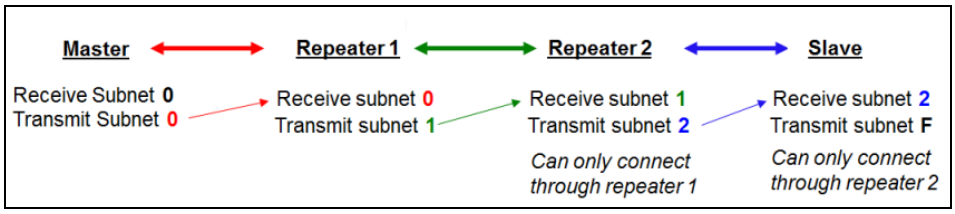


Figure 18: Subnet and Specific Path Communication

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

7.1.2. Example 2: Subnet and Communication Required through Repeaters

This example shows:

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

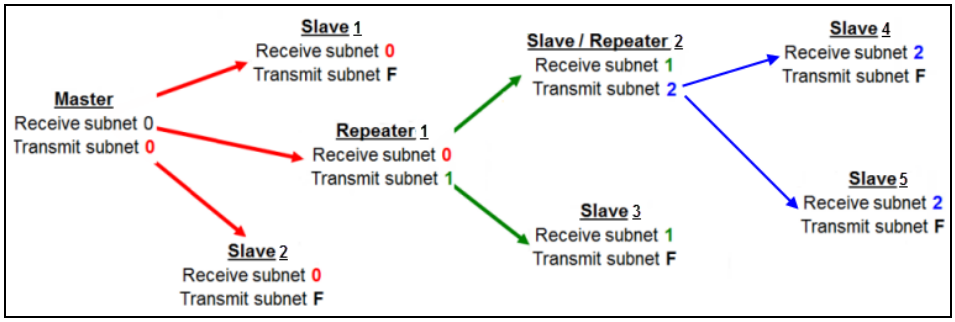


Figure 19: Subnet and Communication Required through Repeaters

Subnet and Communication Required through Repeaters			
Radio	**Rx**	**Tx**	**Additional Information**
Master	0	0	The default settings (**F, F**) actually use **0, 0**. The **Rx Subnet** on the Master has no effect on the network.
Slave 1	0	F	**Rx Subnet** = **0** forces the radio to link only to the Master. The Slave does not transmit to any device except the Master, so its **Tx Subnet** is **F**.
Repeater 1	0	1	**Rx Subnet** = **0** forces the radio to link only to the Master. Transmits on subnet **1**.
Slave 2	0	F	**Rx Subnet** = **0** forces the radio to link only to the Master.
Slave/Repeater 2	1	2	**Rx Subnet** = **1** forces the radio to link only to Repeater 1. It transmits on **Tx Subnet 2** to Slave 4 and 5.
Slave 3	1	F	**Rx Subnet** = **1** forces the radio to link only to Repeater 1. The Slave does not transmit to any device except Repeater 1, so its **Tx Subnet** is **F**.
Slave 4	2	F	**Rx Subnet** = **2** forces the radio to link with Slave/Repeater 2.
Slave 5	2	F	**Rx Subnet** = **2** forces the radio to link with Slave/Repeater 2.

7.1.3. Example 3: Subnet and Optional Slave Communication

This example shows:

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

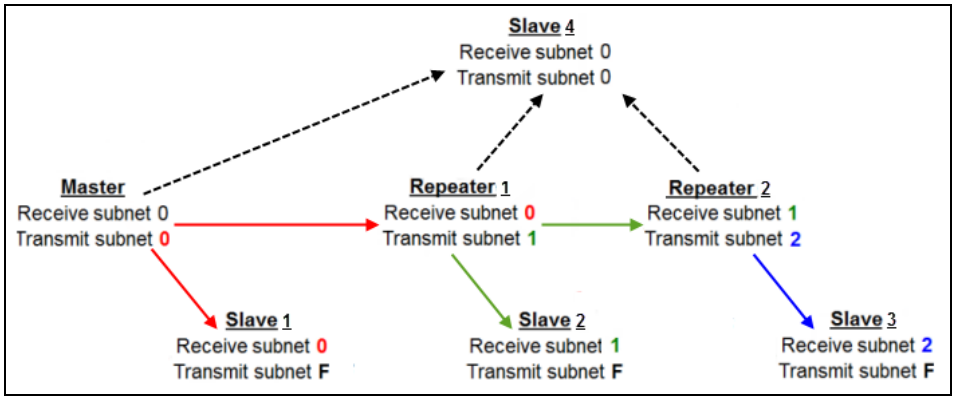


Figure 20: Subnet and Optional Slave Communication

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

8. GX Serial Wireless Data Radios Pinouts

8.1. Operational RS422 and RS485 Information

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

- RS-422 is used for 4-wire or full duplex communications with one Master radio and multiple Slave radios.
- The Master radio keeps the line driver asserted at all times.
- The maximum line length is 4,000 feet using two, 120 ohm twisted pair cables with a 5th wire for data common.

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

- The most common operation of RS485 is a two-wire comprised of a 120 ohm impedance single twisted pair.
- In this system the loading of the FreeWave radio allows a maximum of 256 1/8 unit load units on the bus.
- Maximum line length is also 4,000 feet with a third wire required for data common.
- The radio checks the line to be certain no other device is transmitting before enabling the line driver for data transmission.

When setting the radio to RS-485:

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

- The **Turn Off Delay** parameter is used to control the length of time the transmitter driver stays asserted after data transmission has finished.
- This is needed to allow the last transmitted character to reach the end of a long line and is normally set to one character length of time.
- This setting also allows three complete reflections to the end of the line to ensure the ringing on the line has fully dampened before releasing the bus to another device.
- Shorter line lengths may use shorter delays, but four ¼-character delay times are recommended.
- In Modbus, a **Turn Off Delay** -parameter setting of **0**causes internal timing errors.

Important!: No provision for handshaking is made in any of these modes of operation.
Data rates of 57.6 KBaud and above are **not recommended** without a protocol that can handle error detection properly.

8.2. Pinout Assignments and Descriptions

- RF Board Level Pinout (on page 104)
- RS-232 Pin Assignments (DB-9) (on page 105)
- RS422 and RS485 Full Duplex Pinouts (on page 106)
- RS485 Half Duplex Pinouts (on page 106)

8.3. RF Board Level Pinout

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

- Pin 1: B+ Power input.
- Pin 2: Interrupt (INT) – Input – A 0 Volt level on this pin switches the radio into Setup mode.
- Pin 1 on the board-level radio is the pin farthest from the three LEDs and pin 10 is closest to the LEDs.

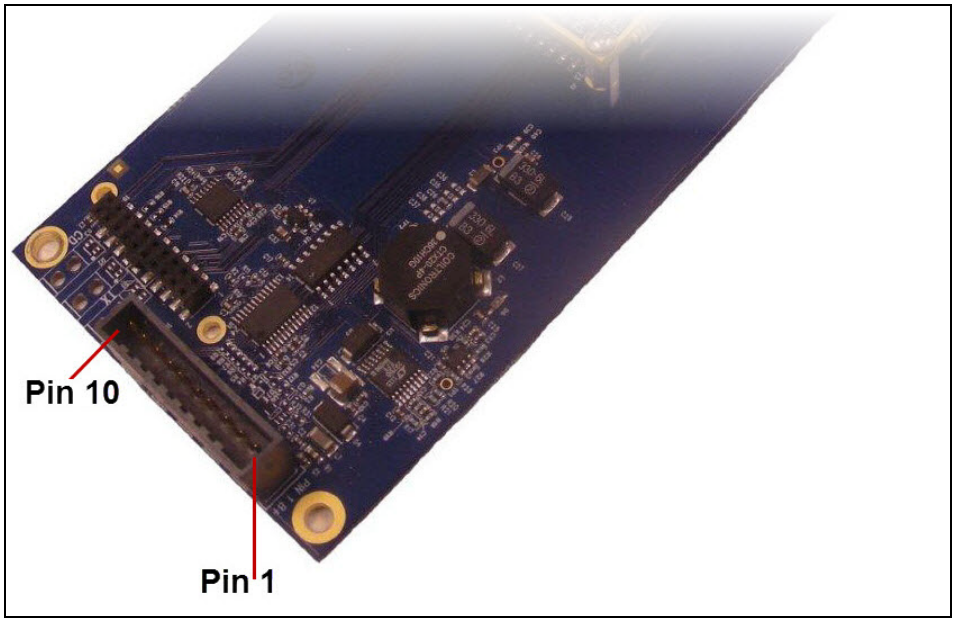


Figure 21: GX-C Pin Layout

RF Board Level Pinout			
Pin	**Assignment**	**Signal**	**ACS3610xx Cable Color**
1	B+ input	Power	Red
2	Interrupt (temporarily ground to invoke menu)	Input	Brown
3	Data Terminal Ready (DTR)	Input	Orange
4	Ground		Black
5	Transmit Data (TXD)	Output	Yellow
6	Ground		Black
7	Receive Data (RXD)	Input	Green

RF Board Level Pinout			
Pin	**Assignment**	**Signal**	**ACS3610xx Cable Color**
8	Carrier Detect (DCD)	Output	Blue
9	Request to Send (RTS)	Input	Violet (purple)
10	Clear to Send (CTS)	Output	Gray

8.4. RS-232 Pin Assignments (DB-9)

RS232 Pin Assignments (DB-9)			
Pin	**Assignment**	**Signal**	**Description**
1	CD - Carrier Detect	Output	Used to show an RF connection between radios.
2	TX - Transmit Data	Output	Used to transmit data bits serially from the radios to the system device.
3	RX - Receive Data	Input	Used to receive data bits serially from the system device connected to the radios.
4	DTR - Data Terminal Ready	Input	Used only in radios in Point-to-Point Slave/Master switchable mode or for DTR Connect.
5	GND - Ground		Signal return for all signal lines shared with Pin 9.
6	DSR - Data Set Ready	Output	Always high when the radio is powered from the 2.5 mm power connector. Indicates power is on to the radio. Also, this pin can be used for +12.0 Volts when powering the radios directly through the RS232 port. **Important!**: This is not used on the OEM module.
7	RTS - Request to Send	Input	The radio does not recognize RTS for flow control. RTS is used as a control line in RTS/CTS mode.
8	CTS - Clear to Send	Output	This signal is used to tell the system device connected to the radio that the radio is ready to receive data. • When asserted, the radio accepts data, when de-asserted the radio does not accept data. • This should always be used for data rates above 38.4 KB or a risk of lost data may occur if an RF link is not very robust.
9	GND - Ground		Signal return for all signal lines shared with Pin 5.

8.5. RS422 and RS485 Full Duplex Pinouts

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

8.6. RS485 Half Duplex Pinouts

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

9. Troubleshooting

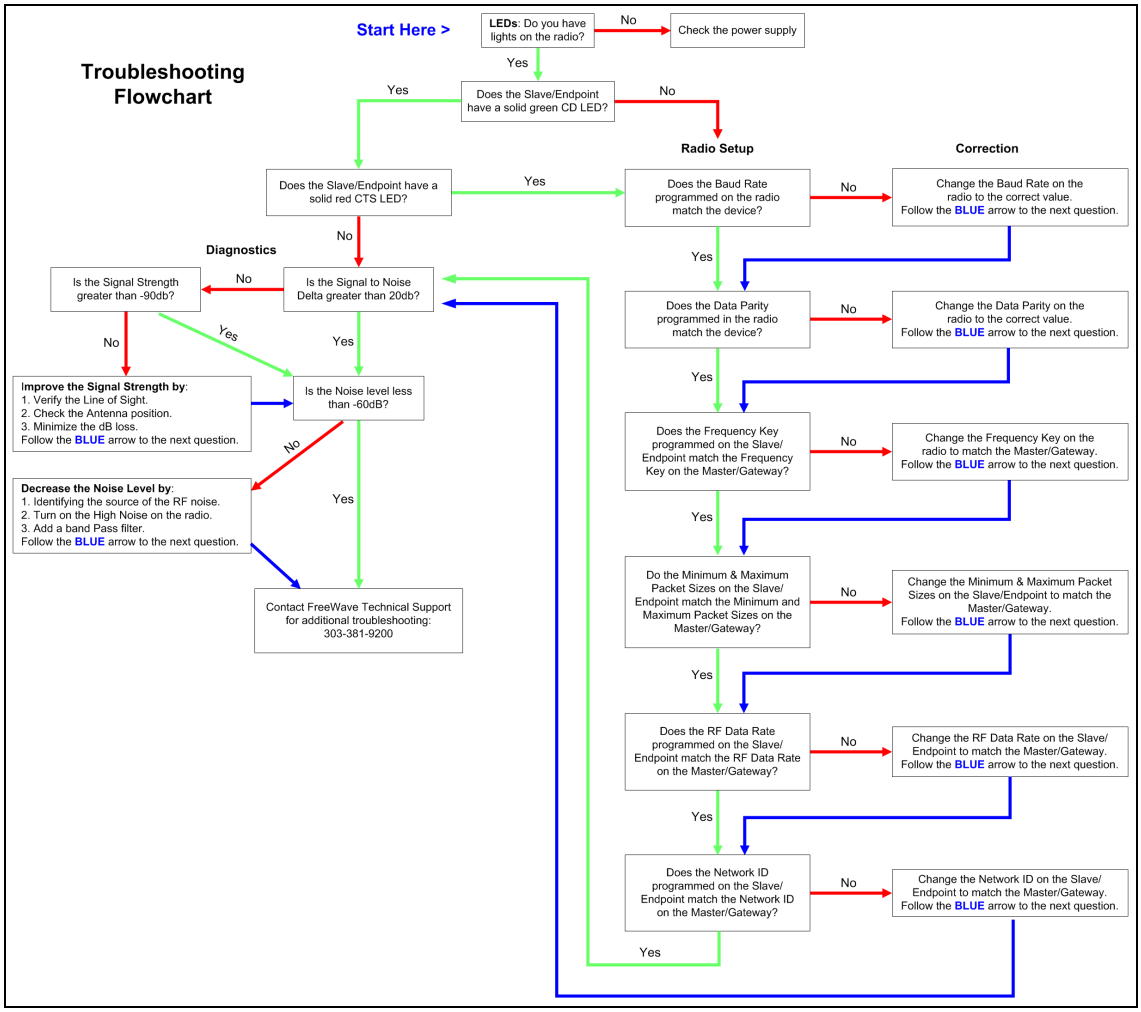
If experiencing trouble with the network, see these sections to initially troubleshoot and help identify the problem with the network or a radio within it:

- LEDs on the radio.
  - Point-to-MultiPoint Operation LEDs (on page 59).
  - Point-to-Point Operation LEDs (on page 79).
- Settings
- RF Quality

Use the Troubleshooting Flowchart (on page 108) for basic checks to help diagnose the issue.

Note: Contact FreeWave Technical Support (on page 9) for assistance.

9.1. Troubleshooting Flowchart



9.2. Unlicensed Serial Radio - Specific Troubleshooting

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

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

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

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

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

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

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

9.3. General Troubleshooting

Note: For AES encryption troubleshooting tips, see Troubleshooting AES Setup on page 92.

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

Additional symptoms of this problem include:

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

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

The radio is wired for RS485 and Pins 5 and 7 on a board-level radio, or Pins 2 and 3 on an enclosed radio(or one with a DB9 connector) are shorted together.

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

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

My radios are linked, but I cannot pass data.

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

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

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

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

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

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

Repeater 2 is experiencing high noise.

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

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

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

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

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

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

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

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

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

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

10. GX-C, GX-CE, GX-T Release Notes

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

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

10.1. ETSI TDMA Compliance

The FreeWave GXM series of radios in TDMA and Standard mode complies with the new ETSI rules for non-adaptive equipment.

There are certain data rate and output power restrictions in both modes that are required to be followed to stay compliant with the new ETSI regulations. This document details those settings.

Important!: As of January 1, 2015, these settings are required for the radio to be in compliance for the new ETSI regulations.
Per ETSI EN 300 328 v1.8.1, if the EIRP is set to **≤10mW**, the GXM radios have **no** restrictions or restricted settings.

Caution: These settings will result in decreased data throughput.

This information is available:

- TDMA Settings (on page 113).
- Standard Mode Settings (on page 114).
- Calculations (on page 114).
- Standard and Editions (on page 115).

10.1.1. TDMA Settings

RF Data Rate Setting of 3 - Normal

> **Important!**: In TDMA mode, full power is available using the **Setting** information in the TDMA table.
> The allowable maximum EIRP is 100mW / 20dBm.
> The TDMA settings that are critical are (1) through (5).

Procedure

1. On the **Main Menu**, enter **6** to open the **TDMA Menu** options.
2. Change these parameters, (1) to (5), to the **Setting** specified in the table:
   a. RF Data Rate Setting of 3 - Normal (on page 113).
   b. RF Data Rate Setting of 2 - High (on page 113).

TDMA Settings - RF Data Rate Setting of 3 - Normal		
TDMA Parameters	**Description**	**Setting**
(1)	Slave Data Packet Size (8-240)	Maximum is **38**
(2)	MasterData Packet Size (8-240)	Maximum is **38**
(3)	Number of SubMasters (0-15)	0 **Important!**: The sum of **Settings** for TDMA Commands (3), (4), and (5) MUST equal, at a minimum, 4 to maintain the transmit power of 100mW / 20dBm.
(4)	Slave Frames per Master Frame (1-15)	1
(5)	Slave Repeaters per Frame (0-15)	**3**

RF Data Rate Setting of 2 - High

TDMA Settings - RF Data Rate Setting of 2 - High		
TDMA Parameters	**Description**	**Setting**
(1)	Slave Data Packet Size (8-240)	Maximum is 60
(2)	MasterData Packet Size (8-240)	Maximum is 60

TDMA Settings - RF Data Rate Setting of 2 - High		
TDMA Parameters	**Description**	**Setting**
(3)	Number of SubMasters (0-15)	0 **Important!**: The sum of **Settings** for TDMA Commands (3), (4), and (5) MUST equal, at a minimum, 4 to maintain the transmit power of 100mW / 20dBm.
(4)	Slave Frames per Master Frame (1-15)	1
(5)	Slave Repeaters per Frame (0-15)	3

10.1.2. Standard Mode Settings

Point-to-Point and MultiPoint Mode

Important!: In either a Point-to-Point or MultiPoint mode, full power is **not** available. Using the **Setting** identified in the Standard Mode table for both data rates, the maximum power available is 39mW / 16dBm.

Procedure

1. On the **Main Menu**, enter **3** to open the **Radio Parameters** options.
2. Change these parameters to the **Setting** specified in the table:

Standard Mode		
Command	**Description**	**Setting**
(1)	Max Packet Size	1
(2)	Min Packet Size **Note**: Repeater mode reduces the duty cycle.	6

Note: Variations from the specified **Setting** makes the radio non-compliant with the ETSI standards.

10.1.3. Calculations

These calculations show the average data rate returned using the settings identified in TDMA Settings on page 113.

TDMA Mode

- ≈ 12 Kbps where the RF Data Rate =3.
- ≈ 19 Kbps where the RF Data Rate =2.

Point-to-Point and MultiPoint Mode

- ≈ 36 Kbps where the RF Data Rate = 3.
- ≈ 52 Kbps where the RF Data Rate = 2.

10.1.4. Standards and Editions

The GXM series radios have been tested and comply to these standards:

- EN 55022:2010
- EN 55024: 2010
- ETSI EN 300-328 v1.8.1
- ETSI EN 301 489-1:2008
- IEC 60950-1 (2005) Second Edition
- IEC 61000-4-2:1995 with A1:1998 and A2:2001
- IEC 61000-4-3:2006
- IEC 61000-4-4:2004
- IEC 61000-4-6:2003 with A1:2004 and A2:2006

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

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

For more information about the additions and updates in each release, see the **GX Serial Wireless Data Radios User Manual and Reference Guide**.

10.2. Version v9.7.9

Release Date: October 2012

Additions and Changes

- Updated firmware versioning to use the vX.X.X format.
- Added Low power mode (0x04 entry) to TDMA tables.
- Removed Ultra Low Power Mode feature.
- (TDMA mode only) A 0x40 in the frame table, which was being used to designate a low power frame, was also used by several packet data commands to reserve a frame to transmit data. The usage of bit 6 (0x40) for the affected packet data commands has moved to bit 7, which is used only for sending a diagnostic poll response. The packet data commands and the diagnostic poll responses can share the usage of bit 7, leaving bit 6 to

define a frame that is in power save mode.

- Resolved the data sizes over 160 bytes in TDMA mode issue seen in version 8.78.

Known Limitations and Workarounds

- In Point-to-MultiPoint mode with the **Diagnostics** parameter set to **Enabled**, the radio drops its link when a continuous data transfer is stopped at an **RF Data Rate** setting of **2**. If you experience this behavior, either update the **RF Data Rate** setting to **3** (115.2 kbps) or set the **Diagnostics** parameter to **Disabled**.
- In the **Edit Radio Transmission Characteristics > FreqKey menu**, the **Hop Table Size** option allows entries outside the acceptable range. Only use a **Hop Table Size** between **75** and **80**.
- Modem statistics currently reports incorrect receive signal strength when the receive signal is greater than -60 dBm.
- In the Modem Mode menu, **Ethernet Options** displays under entry **F**. These options do not apply to this radio.

Version 8.78 (Initial Release)

Release Date: December 2011

- If you are using the Time Divisible Multiple Access (TDMA) mode available on some GX models, and you are using data sizes over 160 bytes, FreeWave recommends that you *do not* upgrade to 8.78 and continue to use version 8.77.

FreeWave is working on a resolution for this issue in a future firmware version.

- Mirrored Bit settings are currently not supported.

Appendix A: GX-C, GX-CE, GX-T Technical Specifications

GX-C, GX-CE, GX-T Technical Specifications	
Specification	**Description**
Transmitter	
Frequency Range	2.4 to 2.483 GHz
Output Power	Up to 500 mW with option to limit to 100 mW
Range	Up to 32 km (20 mi.), clear line of sight
Channel Spacing	230 kHz
RF Data Rate	115.2 or 153.6 kbps, User selectable
Receiver	
Sensitivity	• -105 dBm @ 115.2 kbps for BER 10^{-4} • -103 dBm @ 153.6 kbps for BER 10^{-6}
Selectivity	20 dB at fc +/- 230 kHz 60 dB at fc +/- 290 kHz
System Gain	132 dB
Data Transmission	
Type	Frequency Hopping Spread Spectrum
Modulation	2 level GFSK

<table>
<tr><th colspan="2">GX-C, GX-CE, GX-T Technical Specifications</th></tr>
<tr><th>Specification</th><th>Description</th></tr>
<tr><td>Data Throughput</td><td>• 80 kbps slow speed
• 115.2 kbps standard speed**
• Uncompressed, measured assuming 75% frequency availability</td></tr>
<tr><td>Error Detection</td><td>32-bit CRC, retransmit on error</td></tr>
<tr><td>Data Encryption</td><td>Options AES 128, 256-bit encryption</td></tr>
<tr><td>Hopping Zones</td><td>• 16 zones
• 5 channels per zone
• User selectable</td></tr>
<tr><td>Hopping Bands</td><td>7 bands, User selectable</td></tr>
<tr><td>Hopping Channels</td><td>• 3 groups of 80
• User selectable</td></tr>
<tr><td>Hopping Patterns</td><td>• 15 per band
• 105 total
• User selectable</td></tr>
<tr><td>Protocol</td><td>RS232 / RS422 / RS485</td></tr>
<tr><td>Power Requirements</td><td></td></tr>
<tr><td>Operating Voltage</td><td>+6.0 to +27.0 VDC</td></tr>
<tr><td>Current Consumption</td><td>
<table>
<tr><th>Voltage</th><th>Transmit</th><th>Receive</th><th>Idle</th></tr>
<tr><td>6 VDC</td><td>375 mA</td><td>120 mA</td><td>9 mA</td></tr>
<tr><td>12 VDC</td><td>295 mA</td><td>80 mA</td><td>5 mA</td></tr>
<tr><td>30 VDC</td><td>140 mA</td><td>51 mA</td><td>3 mA</td></tr>
</table>
</td></tr>
<tr><td>Interfaces</td><td></td></tr>
<tr><td>Data Interface</td><td>• 10-pin header with locking clamp
• 2.5mm (0.1in) spacing power / data connector</td></tr>
<tr><td>Diagnostics Interface</td><td>• Separate diagnostic connector
  • Board level: Separate 20-pin PCB header
  • Enclosed: 3-pin PCB header</td></tr>
<tr><td>RF Connector</td><td>• Board level: Right-angle female SMA
• Enclosed: Female TNC</td></tr>
<tr><td>General Information</td><td></td></tr>
<tr><td>Operating Temperature</td><td>• -40°C to +85°C
• -40°F to 185°F</td></tr>
<tr><td>Humidity</td><td>0 to 95% non-condensing</td></tr>
</table>

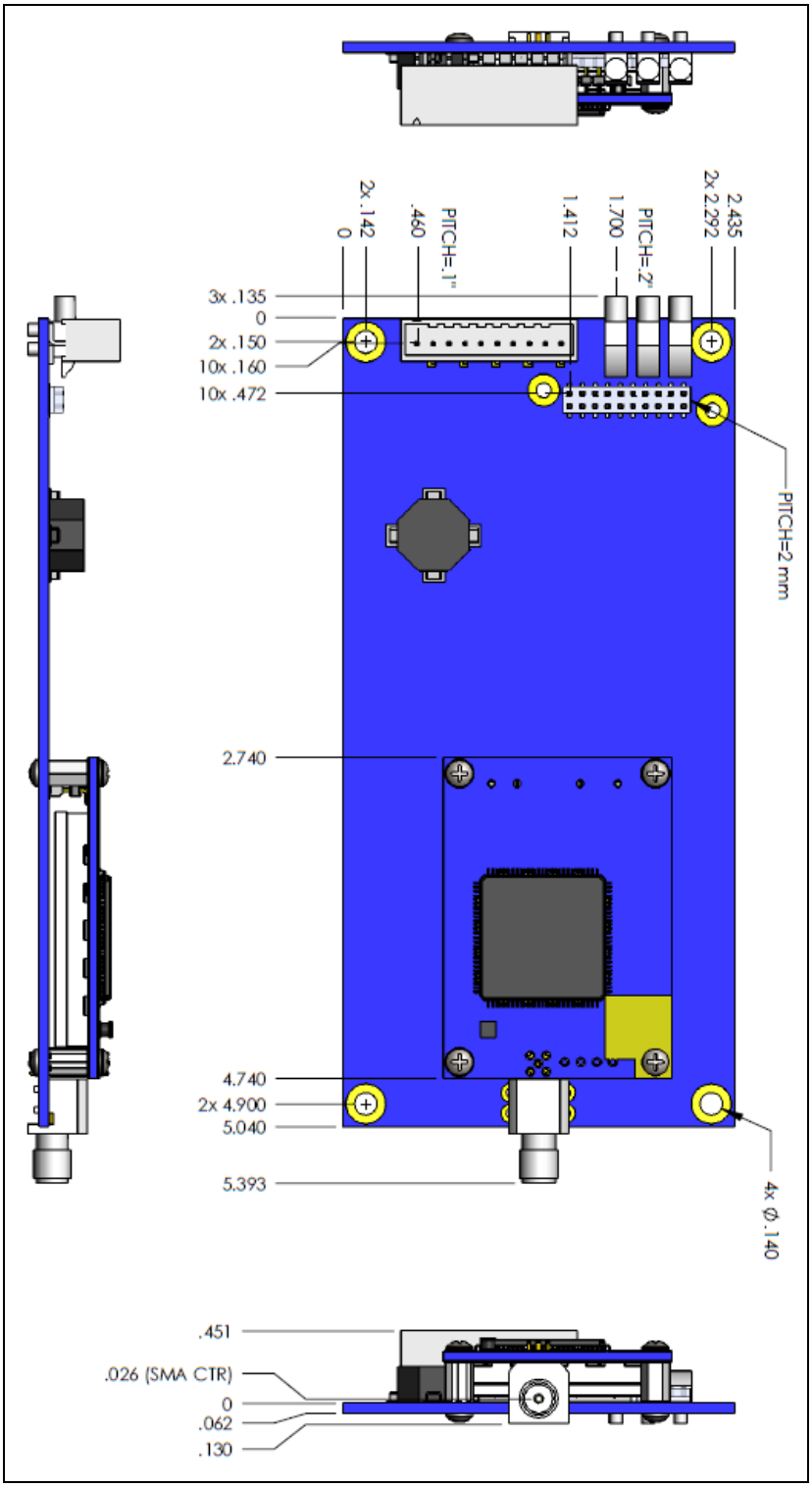
GX-C, GX-CE, GX-T Technical Specifications	
Specification	**Description**

Dimensions	• Board level:
	  • 127 L x 61 W x 11 H (mm)
	  • 5.0 L x 2.4 W x 0.43 H (in.)
	• Enclosed
	  • 173 L x 107 W x 35 H (mm)
	  • 6.81 L x 4.21 W x 1.38 H (in.)

Weight	• Board level: 53g (0.12 lbs.) • Enclosed: 504g (1.11 lbs.)

FREEWAVE Recommends: **GX-C, GX-CE, and GX-T radios are UL approved between +6.0 to +27.0 VDC.
However, for guaranteed performance, FreeWave recommends using a power supply between +7.5 to +27.0 VDC.

Appendix B: GX-C Mechanical Drawing



Appendix C: 2.4GHz Factory Default Settings

2.4GHz Factory Default Settings			
Operation Mode	**Default**	**MultiPoint Parameters**	**Default**
Point-to-Point Slave	1	(0) Number of Repeaters	1
Set Baud Rate	**Default**	(1) Master Packet Repeat	3
Baud Rate	115200	(2) Max Slave Retry	9
(A) Data Parity	0	(3) Retry Odds	0
(B) Modbus RTU	0	(4) DTR Connect	0
(C) RS232/485	0	(5) Repeater Frequency	0
(D) Setup Port	3	(6) Network ID	255
Setup Mode Timeout	0	(7) Reserved	-
(E) TurnOffDelay/OnDelay	N/A	(8) MultiMaster Sync	0
(F) Flow Control	0	(9) 1 PPS Enable Delay	255
Radio Parameters	**Default**	(A) Slave/Repeater	0
(0) Freq Key	5	(B) Diagnostics	0
(0) Hop Table Version	0	(C) Subnet ID	“Disabled”
(1) Hop Table Size	80	Rx ID	F
(2) Hop Freq Offset	0	Tx ID	F
(3) Frequency Zone	All 1s (Enabled)	(D) Radio ID	Not Set
(4) Government Rules	0	(E) Local Access	0
(1) Max Packet Size	8	(G) Radio Name	"blank"

2.4GHz Factory Default Settings			
Operation Mode	**Default**	**MultiPoint Parameters**	**Default**
(2) Min Packet Size	9		
(3) Xmit Rate	1		
(4) RF Data Rate	3		
(5) RF Xmit Power	20		
(6) Slave Security	0		
(7) RTS to CTS	0		
(8) Retry Timeout	255		
(9) Low Power Mode	0		
(B) MCU Speed	0		
(C) Remote LED	0		
(E) Encryption			
Strength	0 (Off)		
Enter Key	Blank		
Channel Key	Blank		

Appendix D: FreeWave Legal Information

Restricted Rights

Any product names mentioned in this manual may be trademarks or registered trademarks of their respective companies and are hereby acknowledged.

This manual is for use by purchasers and other authorized users of FreeWave products.

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Export Notification

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

FCC Notifications

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

The content of this guide covers FreeWave Technologies, Inc. models sold under FCC ID: KNYAMI0032AT.

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

The antennas used MUST have a separation distance of at least 20 cm from all persons and MUST NOT be co-located or operate in conjunction with any other antenna or transmitter.

FCC NEMA Installation and Label

Where applicable, the models described in this guide must be installed in a NEMA enclosure. When any FreeWave Technologies, Inc. module is placed inside an enclosure, a label must be placed on the outside of the enclosure. The label must include the text "**Contains Transmitter Module with FCC ID: KNYAMI0032AT.**"

FCC Notification of Power Warning

The GX Serial Wireless Data Radios covered in this document have a maximum transmitted output power of 500 mW.

The antennas used MUST have a separation distance of at least 20 cm from all persons and MUST NOT be co-located or operate in conjunction with any other antenna or transmitter.

IC Notifications

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

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

UL Notifications / Warnings - Class1 Div2

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

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

UL Power Source

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

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

Do not connect or disconnect any connectors while the circuit is live unless the area is known to be non-hazardous.

- Models GX-C, GX-CE, and GX-T are suitable for use in Class 1, Division 2, Groups A, B, C, and D or non-hazardous locations only.
- Input voltage for the GX-C, GX-CE, and GX-T models is +6.0 to +27.0 VDC.

Declaration of Conformity

We, FreeWave Technologies, Inc. declare under our sole responsibility that the following product:

Name: GXM

Models: GXM-T14, GXM-T24, GX-C, GX-T, GXM-MR-R, GXM-MR-T, GX-CE

to which this declaration relates is in conformity with the essential requirements and other relevant requirements of the following standards:

LVD: (Art. 3.1a)

EN 60950-1: 2006+A11: 2009, IEC 60950-1: 2005 (2nd Edition)

Report Number: UL E327789-A2-CB-1

EMC: (Art. 3.1b)

EN 301 489-1 V2.2.0 Report Number: SGS 4152605EMC02

EN 301 489-17 V3.2.0 Report Number: SGS 4152605EMC02

RED: (Art. 3.2)

EN 300 328 V2.1.1 Report Number: SGS 4152605EMC01

Supplementary Information

Notified body involved:

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FREEWAVE