FreeWave Technologies

760 MHz

Data Transceiver

Version 1.0

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SPREAD SPECTRUM WIRELESS DATA TRANSCEIVER USER MANUAL

WARRANTY

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

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2. If Product is used outside of FreeWave specifications.
3. If Product has been modified, repaired or altered by Customer unless FreeWave specifically authorized such alterations in each instance in writing. This includes the addition of conformal coating.

[dupe of above]Special Rate Replacement Option

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

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

Printed in the United States of America.

FCC NOTIFICATIONS

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

CAUTION: The LRS-760 series transceiver have maximum transmitted output power of 2W. It is recommended that the transmit antenna be kept at least 37 cm away from nearby persons to satisfy FCC RF exposure requirements.

Table of Contents

About FreeWave Transceivers

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

Choosing a Location for the Transceivers

Placement of the FreeWave transceiver is likely to have a significant impact on its performance. The key to the overall robustness of the radio link is the height of the antenna. In general, FreeWave units with a higher antenna placement will have a better communication link. In practice, the transceiver should be placed away from computers, telephones, answering machines and other similar equipment. The RS232 cable included with the transceiver usually provides ample distance for placement away from other equipment. To improve the data link, FreeWave Technologies offers directional antennas with cable lengths ranging from 3 to 200 feet. When using an external antenna, placement of that antenna is critical to a solid data link. Other antennas in close proximity are a potential source of interference; use the Radio Statistics to help identify potential problems. The Show Radio Statistics page is found in option 4 in the Main Menu. An adjustment as little as 2 feet in antenna placement can resolve some noise problems. In extreme cases, band pass filter may reduce the out-of-band noise.

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

A Point-to-Point network is limited to one Master and one Slave transceiver.

In a Point-to-MultiPoint network (also referred to as MultiPoint network) the transceiver, designated as a Master, is able to simultaneously communicate with numerous Slaves. In its simplest form, a MultiPoint network functions with the Master broadcasting its messages to all Slaves and the Slaves responding to the Master when given data by the device connected to the data port.

It is important to note the differences between Point-to-Point and MultiPoint networks. In a Point-to-Point network all packets are acknowledged, whether sent from the Master to the Slave or from the Slave to the Master. In a MultiPoint network, outbound packets from the Master to Slaves are sent a set number of times determined by the user. The receiving transceiver will accept 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 by the Slave are acknowledged or retransmitted until they are acknowledged. Therefore, the return link in a MultiPoint network is generally very robust.

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

1. Size of the blocks of data. The longer the data blocks, the smaller the network capacity.
2. Baud rate.
3. The amount of contention between Slaves. Polled Slaves vs. timed Slaves.

For example, if the network will be polling Slaves once a day to retrieve sparse data, several hundred Slaves could be configured to a single Master. However, if each Slave will be transmitting data at greater levels, then fewer Slaves should be linked to the Master. The overall network will be closer to capacity with fewer Slaves.

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

Quick Start on a Point-to-MultiPoint Network

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

1. Connect the transceiver to the serial port of a computer either through a serial cable or via the diagnostics cable. Make sure to connect the radio to a power source (typically, 9 to 30 VDC).

2. Open up a HyperTerminal session.
   - Use the following settings in connecting with HyperTerminal
   - Connect to COMx (where 'x' is the number of the com port being connected to)
   - Set data rate to **19,200**, data bits - **8,** Parity- **none**, Stop bits – **1**, Flow control – **none**.

3. Press the **Setup** button on the radio. If using the diagnostics cable, press *Shift-U* (capital U).
   - The three lights on the board should all turn green, indicating Setup mode.
   - The main menu will appear on the screen.

4. Press **0** to get into the Operation Mode menu.
   - Press **2** to set the radio as a point to ***MultiPoint Master*.**
   - OR, Press **3** to set the radio as a point to ***MultiPoint Slave.***
   - Press **Esc** to get back to Main menu.

5. Press **1** in the main menu to change the Baud Rate.
   - The baud rate must be changed to match the baud rate of the device that the radio is to be attached to.
   - Press **Esc** to get back to Main menu.

6. At the Main Menu, press **3.**
   - Set FreqKey, Max Packet Size, Min Packet Size, RF Data rate identical on all radios in the network.

Note: Changing these values may help to eliminate interference from other FreeWave networks.
   - Press **Esc** to get back to Main menu.

7. At the Main Menu, press **5**.
   - Set the Network ID value to any value between 1 and 4095, except 255.
   - Make sure this value is the same on every radio in the network.

Point-to-MultiPoint Operation LEDs.

	Master			Slave		
Condition	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
Slave linked to Master, no data	Solid red bright	Solid red dim	Off	Solid green	Off	* Solid red bright
Slave linked to Master, Master sending data to Slave	Solid red bright	Solid red dim	Off	Solid green	Off	* Solid red bright
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
Master with diagnostics program running	Solid red bright	Solid red dim	Intermittent flash red	Solid green	Intermittent flash red	* Solid red bright

* Clear to Send LED will be solid red with a solid link, as the link weakens the Clear to Send LED light on the Slave will begin to flash.

Quick Start on a Point-to-Point Network

When purchased as a pair, the FreeWave® Wireless Data Transceivers are shipped from the factory pre-configured to operate in Point-to-Point applications. To establish communications between a pair of FreeWave Wireless Data Transceivers just received from the factory:

1. Connect the transceiver to the instrument with the RS232 cable and also attach power. The cable supplied with enclosed transceivers (except Waterproof) is a 9-pin male serial; professional board level transceivers will need a separate programming cable (sold separately).

2. Set the Modem mode in each transceiver. One should be set as a Point-to-Point Master (Mode 0) and the other set as a Point-to-Point Slave (Mode 1).

3. Set the baud rate on each transceiver to match the baud rate of the instrument to which it is attached. Please note, when setting the transceiver's baud rate, its RS232 data rate is set. The baud rate does not have to be on the same setting for the two transceivers.

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

5. Connect antennas to the transceiver. Any FreeWave transceiver may be operated without an antenna for bench-top testing without concern for damaging the product. Noise potential may be reduced on the bench by lowering the Xmit power.

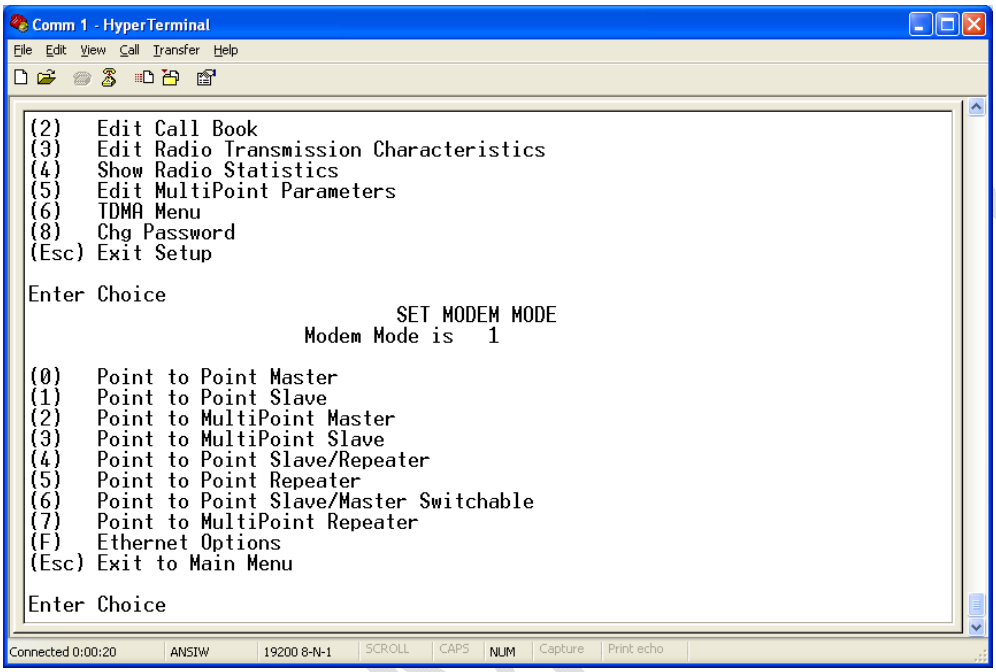
6. Shortly after both transceivers are plugged in, they should establish a communications link with each other and the connection is complete. Using the table below, verify that the radios are operating as expected.

Point-to-Point Operation LEDs

	Master			Slave		
Condition	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
Linked, sending sparse data	Solid green	Intermittent flash red	Intermittent flash red	Solid green	Intermittent flash red	Intermittent flash red
Master calling Slave	Solid red bright	Solid red dim	Solid red bright	Solid red bright	Off	Blinking red
Mode 6 - waiting for ATD command	Solid red bright	Off	Blinking red	Solid red bright	Off	Blinking red
Setup Mode	Solid green	Solid green	Solid green	Solid green	Solid green	Solid green

Setting up a Transceiver

Operation Mode



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

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

Note: Operation Modes not described below are not to be used in the FreeWave 760 MHz Data Transceiver.

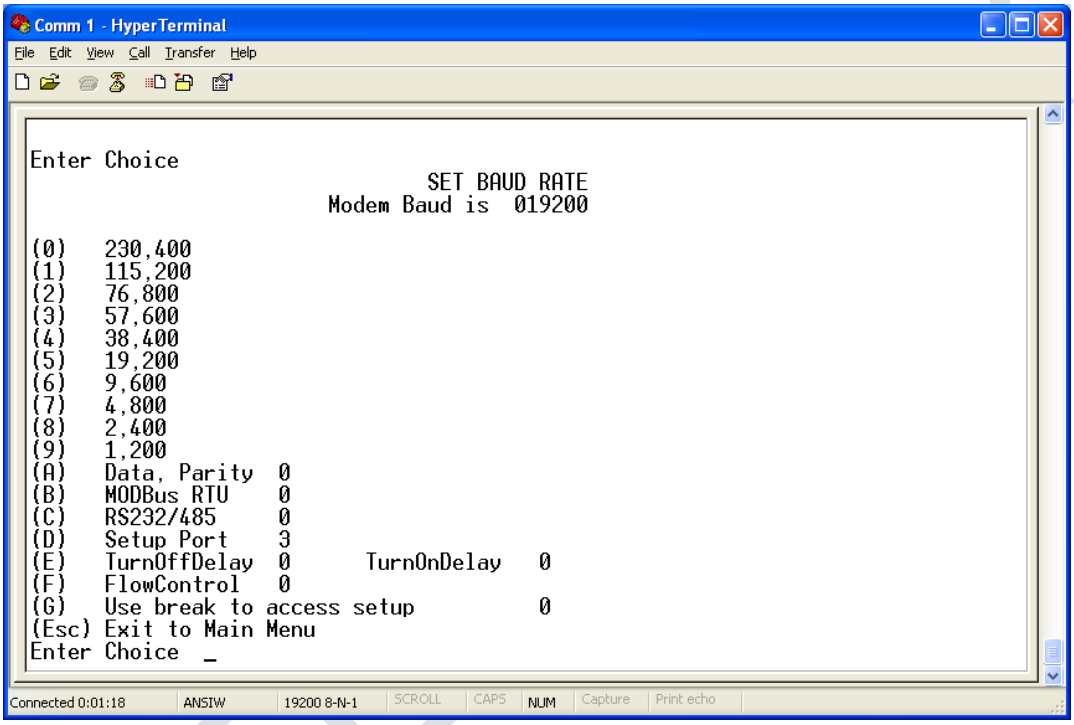
Operation Mode	Description
Point-to-Point Master (0)	This mode designates the transceiver as the Master in Point-to-Point mode. The Master may call any or all Slaves designated in its Call Book. In Point-to-Point mode the Master determines the setting used for most of the radio transmission characteristics,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

Point-to-Point Slave (1)	This mode designates the transceiver as a Slave in Point-to-Point mode. The Slave communicates with any Master in its Call Book. When functioning as a Slave, the **Entry to Call** feature in the transceiver's Call Book is not operational. The Call Book may be bypassed in the Slave by setting Slave Security to 1. See the Slave Security section later in this manual.
Point–to-MultiPoint Master (2)	This mode designates the transceiver as a Master in MultiPoint mode. This mode allows one Master transceiver to simultaneously be in communication with numerous Slaves. A Point-to-MultiPoint Master communicates only with other transceivers designated as Point-to-MultiPoint Slaves.
Point-to-MultiPoint Slave (3)	This mode designates the transceiver as a Slave in MultiPoint mode. This mode allows the Slave to communicate with a MultiPoint Master. The Slave may communicate with its Master.

Baud Rate

This setting is the communication rate between the transceiver and the instrument to which it is connected. It is important to note that this is independent of the baud rate for the other transceiver(s) in the network. For example, a pair of transceivers 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 transceiver on the instrumentation might be set to 9600, and the transceiver on the engineer's computer might be set to 57,600.

Set Baud Rate



1. Select the appropriate baud rate to match the attached device.

<table>
<tr><th>Baud Rate</th><th>Description</th></tr>
<tr><td>Actual Baud Rate (selections 0-9)</td><td>The actual baud rate for the transceiver's data port.
It is desirable to set the baud rate to the highest level supported by the device to which it is connected. In certain circumstances, however, this may actually result in slower data communications.</td></tr>
<tr><td>Data, Parity</td><td>There are six data word length and parity configurations available to be used with FreeWave transceivers. The default setting is 0 (8, N, 1) and is the most commonly used serial communications protocol. When Data, Parity are selected from the Baud Rate menu, a prompt to enter a value for Data, Parity displays. The following describes each option:

<table>
<tr><th>Menu</th><th>Setting</th><th>Data Bits Parity</th><th>Stop Bits</th></tr>
<tr><td>0</td><td>8</td><td>None</td><td>1</td></tr>
<tr><td>1</td><td>7</td><td>Even</td><td>1</td></tr>
<tr><td>2</td><td>7</td><td>Odd</td><td>1</td></tr>
<tr><td>3</td><td>8</td><td>None</td><td>2</td></tr>
<tr><td>4</td><td>8</td><td>Even</td><td>1</td></tr>
<tr><td>5</td><td>8</td><td>Odd</td><td>1</td></tr>
</table></td></tr>
<tr><td>FlowControl</td><td>This menu specifies the hardware flow control for the Data port. The options for 0-3 are described below.
<table>
<tr><th>Menu</th><th>Port</th><th>Additional Information</th></tr>
<tr><td>0</td><td>None</td><td>Default - Uses software control (XON XOFF)</td></tr>
<tr><td>1</td><td>RTS</td><td></td></tr>
<tr><td>2</td><td>DTR</td><td></td></tr>
<tr><td>3</td><td>DOT</td><td></td></tr>
</table></td></tr>
<tr><td>Modbus RTU</td><td>Support for Modbus RTU protocol is available. The default setting for Modbus RTU is 0 (Not Enabled).

To enable the Modbus RTU mode:

1. In the Set Baud Rate menu enter (B) and then select 1

2. In the Set MultiPoint Parameters menu, set Master Packet Repeat to 3.

Note: When using the transceiver in Modbus RTU mode, the Master Packet Repeat must be set to 3 regardless of whether the network is in Point-to-Point or MultiPoint mode. The Modbus RTU mode must be selected when transceivers are configured in RS485 or RS422 mode.</td></tr>
</table>

<table>
<tr><td>Serial Interface</td><td>In products for which the protocol of the data port is software selectable, use this menu to set the protocol of the data port. In the TTL RF board product this setting must be "0".
Menu Protocol Additional Information
0 RS232 Also used for TTL transceivers.
1 RS422 Modbus RTU mode must be enabled. See above.
2 RS485 Modbus RTU mode must be enabled. See above.
3 DOT Special for the Department of Transportation.
Note: When DOT mode is enabled, the TimeDelay settings operate the same as in the RS485/422 mode.

Note: RS4xx mode must have Modbus RTU enabled, and TurnoffDelay set to at least 4.</td></tr>
<tr><td>Setup Port</td><td>Note: DO NOT change this setting unless the correct programming cable is available for the new setting.

This setting determines which port, Main or Diagnostics, is used to enter the Setup Main Menu.

Menu Port Additional Information
1 Main Only The terminal is connected to the Main Data Port.
2 Diagnostics Only The terminal is connected to the Diagnostic Port.
3 Both Ports The terminal may be connected to either port.

Setup mode is invoked by sending a "U" (capital) to the Diagnostics port or by pressing/toggling the Set-up button/switch, if available. OEM boards may also enter Setup when Pin 2 is grounded.

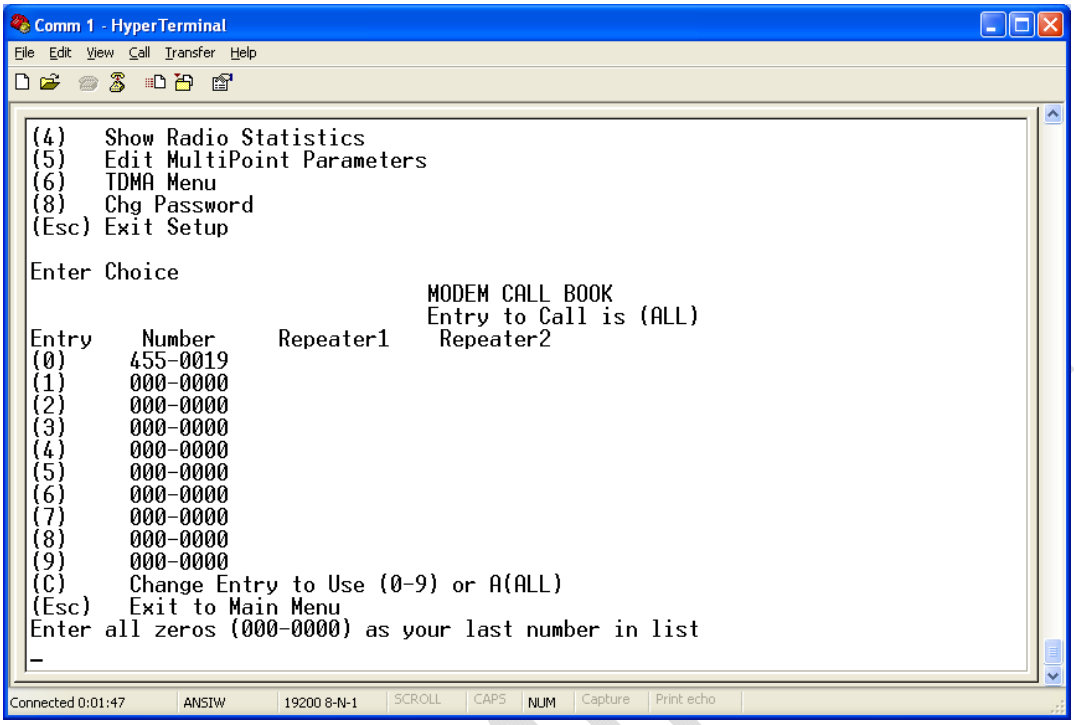
The Main Data Port is the RS232 port. The OEM modules use a 2-row, 2 mm female connector. The diagnostic cable for this port (ASC2009DC) is available from FreeWave.</td></tr>
<tr><td>TurnOn/OffDelay</td><td>TurnOnDelay- Sets the delay between when the line drivers are turned on and when the data leaves the data port. This setting can be adjusted for a 1-9 mS delay.

TurnOffDelay- This setting specifies the time after the end of transmission of a character to the RS485 bus that the transceiver stops driving the bus and releases the bus to other devices. The units are ¼ of a character with a range of 0-9. An entry of 4 means a delay equivalent to the duration of a full character. Default is zero delay.

For data rates of 1200 bits/S or slower, avoid setting the TurnoffDelay parameter higher than 4. At those rates the functionality of the microprocessor changes so that a TurnoffDelay of 5 will have the same effect as if set to 1, and a setting of 6 will have the same effect as 2, and so on.

Note: TurnOffDelay must be set to a value of at least 4 for RS4xx operation.</td></tr>
</table>

Call Book



The Call Book is required to be used in Point-to-Point networks. The instructions provided in this section are for Point-to-Point mode only.

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

Three settings must be made for two FreeWave transceivers to communicate in Point-to-Point mode:

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

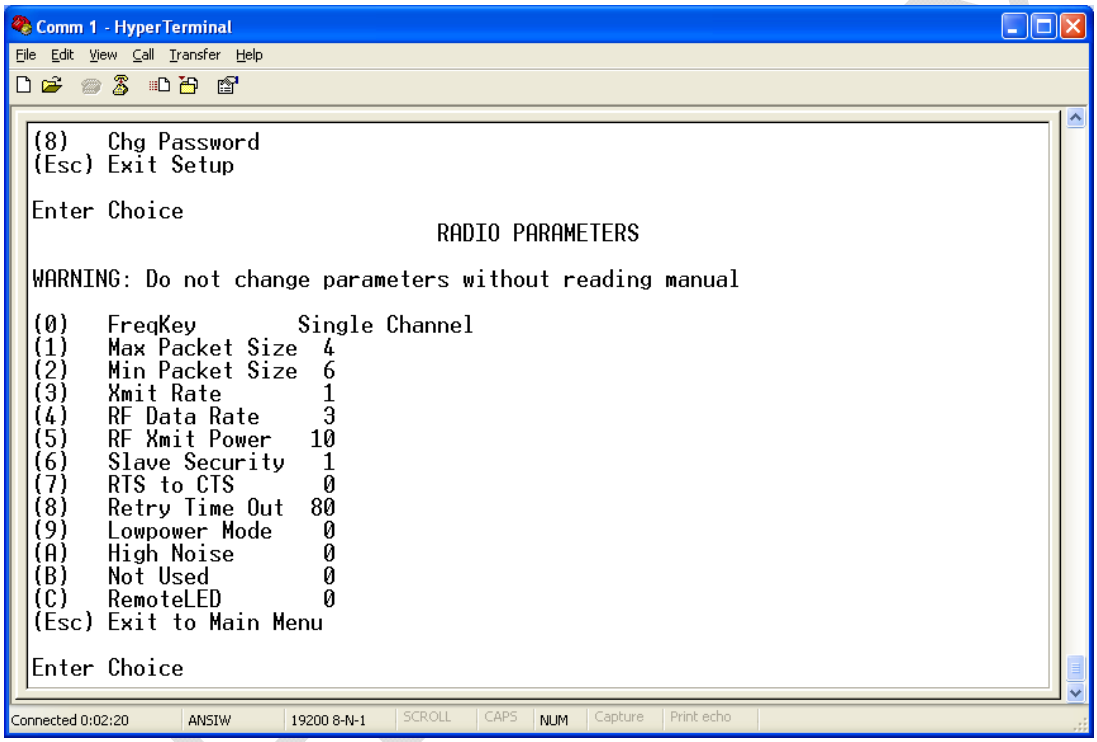
The Call Book allows users to incorporate up to 10 FreeWave transceivers, and designate which Slave the Master will call. To set the **Entry to Call** option, enter **C** at the prompt, followed by the menu number corresponding to that Slave. To call any available Slave in the list, enter **C** then enter **A** to direct the Master to Call All.

Radio Transmission Characteristics

The Edit Radio Transmission Characteristics option allows the user to modify several different parameters in the transceiver. Many of these parameters must be maintained throughout the network for proper functionality.

Note: This menu is **only** for the sophisticated user who has a good understanding of the principles of radio data transmission.

The settings for the Slave(s) not determined by the Master are RF Xmit Power, Slave Security, Retry Time Out and Hop Table Size, Hop Table Version, and Hop Table Offset.

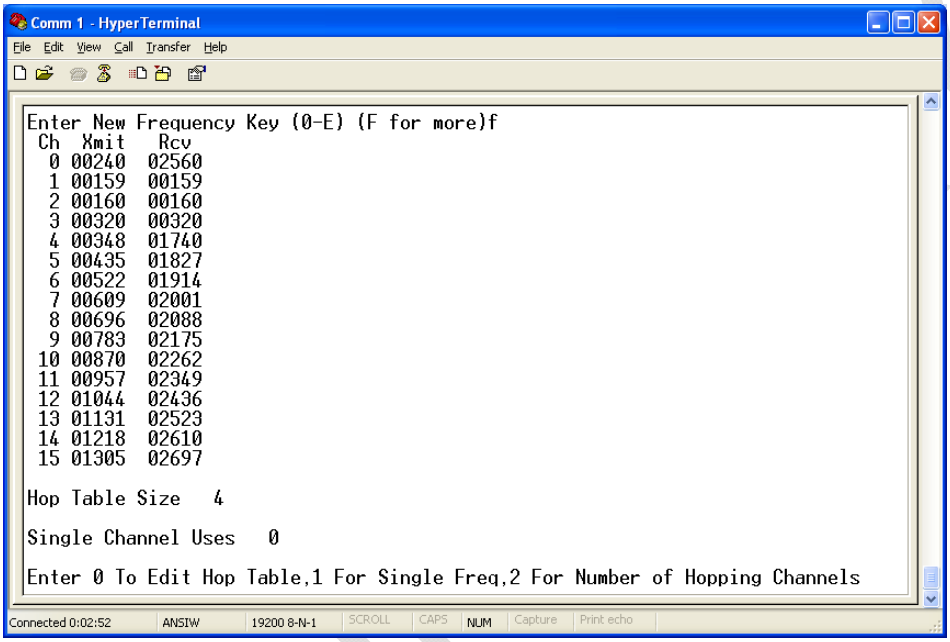


Edit Radio Transmission Characteristics

(0) FREQKEY

The FreqKey parameter should always be set to operate in single channel mode.

To set FreqKey for Single Channel, select option 0 “FreqKey”, then select option F for more options. Select option 1 for Single Channel, then select the appropriate Frequency Channel.



SETTING XMIT AND RCV FREQUENCIES

The 760MHz Data Transceiver operates by transmitting on one frequency and receiving on a second unique frequency.

In order to program these channels, please refer to the Channel and Frequency lists at the end of this document.

Select option 0 Edit Hop Table, and then select the appropriate Channel Number to edit. Enter the appropriate Xmit channel number, from the Channel List, and press enter, and then enter the appropriate Rcv channel number, from the Channel List.

Select option 1 For Single Channel, then select the appropriate Channel number to use the frequencies just programmed.

(1) AND (2) MAX PACKET SIZE AND MIN PACKET SIZE

The Max and Min Packet Size settings and the RF Data Rate determine the number of bytes in the packets. Throughput can be enhanced when packet sizes are optimized. In Point-to-Point mode, the Max and Min Packet Settings will not have material impact on throughput unless 115.2 KBaud is desired. However, this may have an impact on latency. For example, if small amounts of data are sent and large packet sizes are selected, there would be a certain amount of time “wasted” between each packet.

The following 6 tables provide the information to determine optimum setting values.

The default settings for Max and Min packet size and RF Data Rate are 8, 9, and 3, respectively.

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

Minimum Packet Size Definition

Min Setting	Min Packet Size RF Data Rate = 1	Min Packet Size RF Data Rate = 2	Min Packet Size RF Data Rate = 3	Min Packet Size RF Data Rate = 4	Min Packet Size RF Data Rate = 5
0					
1					
2					
3					
4					
5					
6					
7					
8					
9					

The following table defines the Maximum packet size in bytes by way of charting the Min Packet Size setting versus the Max Packet Size setting where the RF Data Rate is set to 1.

Using the default settings, the actual maximum packet size, in bytes, is x.

Maximum Packet Size Definition with RF Date Rate of 1

	Max Setting												
Min Setting	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**A**	**B**	**C**
0													
1													
2													
3													
4													
5													
6													
7													
8													
9													

The following table defines the Maximum packet size in bytes by way of charting the Min Packet Size setting versus the Max Packet Size setting where the RF Data Rate is set to 2.

Maximum Packet Size Definition with RF Date Rate of 2													
	Max Setting												
Min Setting	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**A**	**B**	**C**
0													
1													
2													
3													
4													
5													
6													
7													
8													
9													

The following table defines the Maximum packet size in bytes by way of charting the Min Packet Size setting versus the Max Packet Size setting where the RF Data Rate is set to 3.

Maximum Packet Size Definition with RF Date Rate of 3													
	Max Setting												
Min Setting	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**A**	**B**	**C**
0													
1													
2													
3													
4													
5													
6													
7													
8													
9													

The following table defines the Maximum packet size in bytes by way of charting the Min Packet Size setting versus the Max Packet Size setting where the RF Data Rate is set to 4.

Maximum Packet Size Definition with RF Date Rate of 4													
	Max Setting												
Min Setting	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**A**	**B**	**C**
0													
1													
2													
3													
4													
5													
6													
7													
8													
9													

The following table defines the Maximum packet size in bytes by way of charting the Min Packet Size setting versus the Max Packet Size setting where the RF Data Rate is set to 5.

Maximum Packet Size Definition with RF Date Rate of 5													
	Max Setting												
Min Setting	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**A**	**B**	**C**
0													
1													
2													
3													
4													
5													
6													
7													
8													
9													

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

For example, if a Master transmits 100 bytes, the Slave will then have a total of 116 bytes available (72("leftover bytes") + 44 (Min packet size))

(3) XMIT RATE

There are two settings for the Transmit Rate parameter. The setting for normal operation of the transceiver is a Transmit Rate 1. Transmit Rate 0 is useful to qualitatively gauge signal strength in Point to Point mode. When set to Transmit Rate 0, the transceivers will transmit back and forth continuously regardless if they have any actual data. In Point-to-Point operation, Transmit Rate 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 LED. A solid red CTS LED indicates a strong signal; a blinking CTS LED indicates a weaker signal.

(4) RF DATA RATE

FreeWave transceivers have five settings for the RF Data Rate (1, 2, 3, 4, 5). RF Data Rate should not be confused with the serial port Baud Rate.

Setting 2 should be used when the transceivers are close together and data throughput needs to be optimized. Setting 3 should be used when the transceivers are farther away and a solid data link is preferred over data throughput.

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

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

RF Data Rate Setting	Occupied Bandwidth	Modulation Level	Throughput
1	50kHz	GFSK	
2	25kHz	4-level GFSK	
3	25kHz	GFSK	
4	12.5kHz	4-level GFSK	
5	12.5kHz	GFSK	

(5)RF XMIT POWER

The RF Xmit Power parameter allows the user to control the output transmit power up to two watts (+33dBm).

(6) SLAVE SECURITY

Slave security is a feature which allows Slave transceivers to accept transmissions from a Master not included in the Call Book. The default setting is 0 (Slave Security enabled) which means, only Masters in the Slaves' Call Book may link to that Slave.

Slave Security may be disabled (setting of 1) allowing any Master to call the Slave. Slave Security has no effect in Point-to-MultiPoint networks where the Network ID is not set to 255.

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

(7) RTS TO CTS

Menu selection RTS to CTS in the Radio Parameters menu provides the option of allowing the RTS line on the Master transceiver to control the CTS line of the Slave. This pass-through control can be enabled in both Point-to-Point and Point-to-MultiPoint. In MultiPoint networks, the Master RTS line will control all Slaves' CTS lines. When enabled, the CTS line ceases to function as flow control. It is not recommended to enable this feature when operating at RS-232 speeds above 38.4kB.

The default setting of 0 disables this function, where as a setting of 1 enables RTS-CTS control.

RTS-CTS setting 2 is described in detail in the application note #5437 DTR to CTS Line Alarm Feature.

With an RTS to CTS setting of 1, the Master senses the RTS line prior to all scheduled packet transmissions. If the state has changed, the Master will then transmit a message to the Slave with the new status. This transmission will occur regardless of data being sent. If data is ready to be sent, the RTS status message will be sent in addition to the data. In Point-to-Point mode, the Master will continue sending the new status message until it receives an acknowledgment from the Slave. In MultiPoint mode, the Master will repeat the message the number of times equal to the Master Packet Repeat value in the MultiPoint Parameters menu.

Master transmit times are completely asynchronous to the occurrence of any change of the RTS line; the latency time from RTS to CTS is variable. The Max and Min Packet Size parameters in the Radio Parameter menu determine this duration. Setting both parameters to their maximum value of 9 will produce a maximum latency time of approximately 21 ms. At the minimum settings for Max and Min Packet Size (0), the time will be approximately 5.9 ms. Please note that this latency can increase significantly if packets are lost between the Master and Slave. In Point-to-MultiPoint mode, there is no absolute guarantee that the state change will be communicated to all Slaves in the unlikely event that all repeated packets from the Master do not get through to all Slaves.

Note: If DTRConnect is enabled and set to 2, the RTS to CTS feature will not work.

Note: If the DTRConnect is enabled and set to 1, RTS to CTS mode takes precedence over the functionality of the CTS line on the Slave relating to the DTRConnect feature.

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

(8) Retry Time Out

The Retry Time Out parameter in a Slave sets the delay the unit will wait before dropping the connection to a Master in MultiPoint mode. The factory default is set at the maximum of 255. The maximum setting means that if 1 packet in 255 is sent successfully from the Master to the Slave, the link will be maintained. The minimum setting is 8. This allows a Slave to drop a connection if less than 1 in 8 consecutive packets is successfully received from the Master.

On the other hand, the function in the Master is effectively the same. With a setting of 255, the Master will allow a Slave to stay connected as long as 1 packet in 255 is successfully received at the Master.

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

Note: Setting Retry Time Out to 20 is recommended in areas where several FreeWave networks exist. This setting will allow Slaves to drop the connection if the link becomes too weak, while at the same time prevent errant disconnects due to interference from neighboring networks.

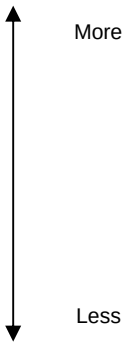
While intended primarily for MultiPoint networks, the Retry Time Out parameter may also be modified in Point-to-Point networks. However, the value in Point-to-Point mode should not be set to less than 151.

(9) Lowpower Mode

The Lowpower Mode feature allows a MultiPoint Slave to consume less power. This is achieved primarily by dimming the transceiver's LEDs. When set to 2 through 31, the transceiver will sleep between slots. For example, at a setting of 2 the transceiver sleeps 1 out of 2 slots; at a setting of 3 the transceiver sleeps 2 out of 3 slots, and so on.

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

Current Draw



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

IMPORTANT NOTES

1. Lowpower Mode is used only in MultiPoint Slaves using serial protocol. Power savings occur only when the Slave is linked. There are no power savings when the Slave is transmitting data. Lowpower Mode is of little value when a Slave has a constant, high throughput. MCUSpeed must be set to '0' and RF Data Rate must be set to '3' for Lowpower Mode to operate properly.

2. To communicate to an RS232 port of a transceiver that is in Lowpower Mode, the RTS line must be held high to wake it up. The transceiver will wake up within approximately 20 milliseconds of when RTS goes high.

3. If the RTS line on the Slave is held high, the transceiver will remain in normal operation regardless of the Lowpower Mode setting. Once RTS is dropped the transceiver reverts to the Lowpower Mode.

If the transceiver has the DTRConnect option set to 1 or 2 and if the Lowpower Mode enabled (set to 1-31), the RTS line on the transceiver must be asserted for the 'DTRConnect' feature to operate properly.

(A) HIGH NOISE

The High Noise Option is useful in determining if out of band interference is affecting a radio link. A setting of 1 will provide a reduction of gain in the front end circuit thereby decreasing the affect of any out of band noise. The results will be seen as a lower signal value and a much lower noise value (as found in Radio Statistics or Diagnostics). If the noise is not reduced by a greater amount than the signal, the interference is most likely an in band issue.

When a noise problem is shown to be helped by way of the High Noise option, chances are that the noise may be further squelched by use of a band pass filter available for sale from FreeWave Technologies.

(C) REMOTE LED

This setting enables the user to connect Remote LED's through the diagnostics port.

Setting	Description	Notes
0	Board LED's	Default. Only on board LEDs are enabled.
1	Board and Remote LED's	Onboard LED's are enabled as well as Remote LED's through the Diagnostic port.
2	Remote LED's	On board LED's are disabled. Remote LED's are enabled through the Diagnostic port.

Note: When using Remote LED's the center (TX) LED will not turn Green when in Setup mode. This line is not pinned out.

Show Radio Statistics

Radio Statistics in the Main Menu allows the user to view data transmission statistics gathered by the transceiver during the most recent session. This is valuable when the user needs to know the signal strength and noise levels of the link. Statistics are gathered during each data link and are reset when the next link begins. See display below.

Number of Disconnects

Any time the link between the Master and the Slave is broken and the radios lose Carrier Detect, it is recorded in the Number of Disconnects value. The value indicates the total number of disconnects that have occurred from the time the transceiver is powered on until the radio is put into Setup mode. Under ideal operating conditions, the number of disconnects should be 0. One or more disconnects may indicate a weak link, the presence of severe interference problems or loss of power to any of the radios in the link.

Antenna Reflected Power

This is a measurement of the transmitted power that is reflected back into the transceiver from mismatched antennas or cables, or loose connections between the transceiver and antenna. A reading of 0-5 is good; 5-30 is acceptable; 30+ indicates that the connections should be inspected for loose connections and cable quality.

Transmit Current (mA)

This measures the current draw of the transmitter in milliamps. Refer to Transceiver specs for typical values.

Average Noise Level

The average noise level indicates the level of background noise and interference at this transceiver. The number is an average of the noise levels measured at each frequency in the transceiver's frequency hop table. The individual measurement values at each frequency hop channel are shown in the frequency table. Pressing the **Enter** key when the Radio Statistics menu is displayed, accesses the frequency table.

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

Average Signal Level

The average signal level indicates the level of received signal at this transceiver. For each of these, the signal source is the transceiver that transmits to it. The number is an average of the received signal levels measured at each frequency in the transceiver's frequency hop table. The individual measurement values at each frequency hop channel are shown in the frequency table. Pressing the **Enter** key when the Radio Statistics menu is displayed accesses the frequency table. For a reliable link, the margin should be at least 26 J units. Low Average Signal Levels can often be corrected with higher gain antennas and better antenna placement.

Note: Please consult the install manual for antenna and FCC requirements.

Overall Rcv Rate (%)

The Overall Receive Rate measures the percentage of data packets that were successfully transmitted from the Master to the Slave on the first attempt. A number of 75 or higher indicates a robust link that will provide very good performance even at high data transmission rates. A number of 15 or lower indicates a weak or marginal link that will provide lower data throughput. An Overall Receive Rate of 100% will

provide approximately 100 KBaud of bandwidth with an RF Data Rate setting of 3 and approximately 150 KBaud of bandwidth with an RF Data Rate of 2.

RADIO TEMPERATURE

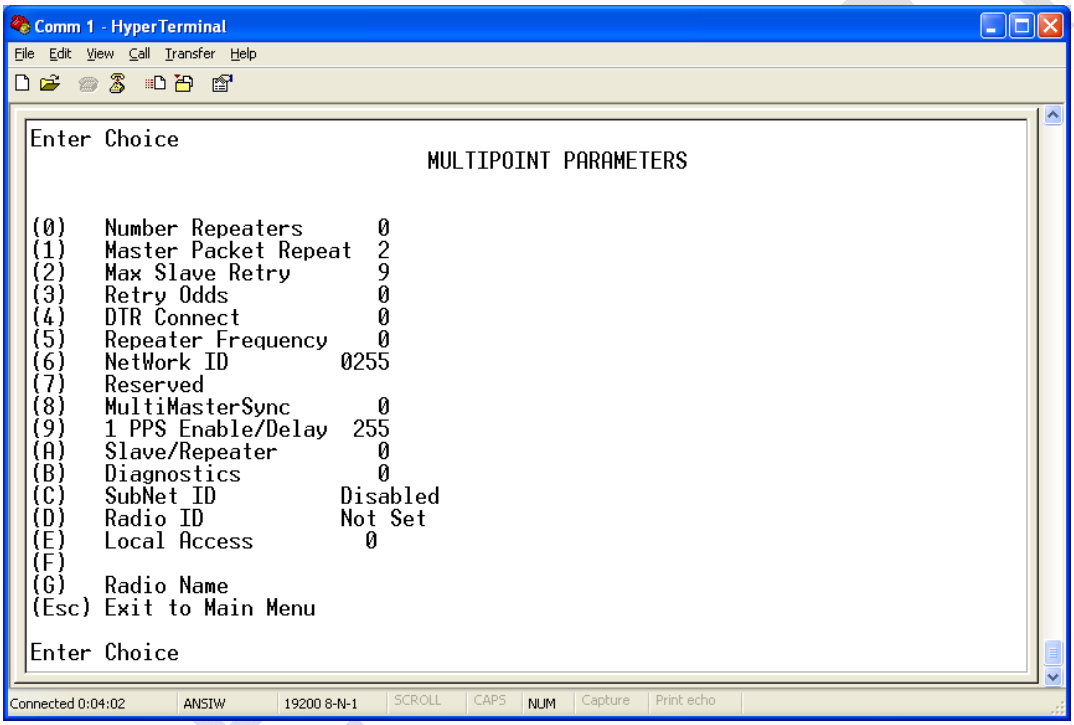
The Radio Temperature value is the current operating temperature of the transceiver in degrees Celsius. For proper operation, a FreeWave transceiver must be in the temperature range of -40° to +75° C. Some of the transceivers are only tested to 0° C. See transceiver specification papers for details.

MultiPoint Parameters

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

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

Edit MultiPoint Parameters



Selecting (5) Edit MultiPoint Parameters from the main menu displays the following window:

(0) Number Repeaters

Repeaters are not available in the FreeWave LRS-760 Data Transceivers.

(1) Master Packet Repeat

In a Point-to-MultiPoint network, Slaves do not acknowledge transmissions from the Master. If Slaves did acknowledge all data transmissions, in a large network, the Master would soon become overwhelmed with acknowledgments from the Slaves. Without acknowledgements, 100% confidence every Slave has received every packet cannot be met. To address this issue, the user may modify the Master Packet Repeat setting, assigning a value between 0 (the packet is transmitted once) to 9 (the packet is transmitted 10 times). For networks with solid RF links, this parameter should be set to a low value such as 1 or 2. If a network has some weak or marginal links it should be set with higher values. If a Slave receives a good packet from a Master more than once it will discard the repeated packets

Increasing the Master Packet Repeat setting will increase the probability of a packet getting through, but will also increase latency in the network because each packet from the Master is being sent multiple

times. Therefore, it is important to find the optimal mix between network robustness, throughput, and latency. In general, a setting of 2 to 3 will work well for most well designed networks.

Note: The Master Packet Repeat may be set to 0 if the user software is capable of, or requires acknowledgment. In this case if a packet sent by the Master and not received by the Slave, the user software will control the retries as needed.

(2) MAX SLAVE RETRY

The Max Slave Retry setting defines how many times (0 to 9) the Slave will attempt to retransmit a packet to the Master before beginning to use a back-off algorithm (defined by the Retry Odds setting). Slave retries will stop when an acknowledgement is received from the Master.

(3) RETRY ODDS

While packets transmitted from the Master to the Slaves in a MultiPoint network are not acknowledged, packets transmitted from Slaves to the Master are. It is possible, that more than one Slave will attempt to transmit to the Master at the same time. Therefore, it is important that a protocol exists to resolve contention for the Master between Slaves. This is addressed through parameters (2) Max Slave Retry and (3) Retry Odds. Once the Slave has unsuccessfully attempted to transmit the packet the number of times specified in Max Slave Retry, it will attempt to transmit to the Master on a random basis. The Retry Odds parameter determines the probability that the Slave will attempt to retransmit the packet to the Master; a low setting will assign low odds to the Slave attempting to transmit. Conversely, a high setting will assign higher odds. An example of how this parameter might be used would be when considering two different Slaves in a MultiPoint network, one with a strong RF link and the other with a weak RF link to the Master. It may be desirable to assign higher Retry Odds to the Slave with the weaker link to give it a better chance of competing with the closer Slave(s) for the Master's attention.

When Retry Odds = 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 will be purged.

(4) DTR CONNECT

With the setting of 0 in the Slave, the transceiver will transmit when RS232 data is received. A setting of 1 will form a Point-to-Point link with the Master when the DTR line is high. With a setting of 2, the transceiver will transmit in bursts. This mode is valuable when a network has many low data rate devices and it is desirable to increase overall network capacity.

Note: If 'DTRConnect' is set to 1 and the 'RTS to CTS' function is enabled on the radio, then 'RTS to CTS' takes precedence over 'DTRConnect'.

Note: If 'DTRConnect' is set to '2' and 'RTS to CTS' is enabled, then 'RTS to CTS' is ignored. The transceiver has two separate transmit and receive user data buffers. These buffers are 2 Kbytes each. In case of a buffer overflow, the transceiver will output unpredictable data.

(5) REPEATER FREQUENCY

Repeaters are not available in the FreeWave 760 MHz Data Transceivers.

(6) NETWORK ID

Network ID allows MultiPoint networks to be established without using the Call Book. The default setting of 255 enables the Call Book. To enable Network ID the value must be set between 0 and 4095 (excluding 255). Since Network ID does not use serial numbers, MultiPoint Masters may be replaced without reprogramming all of the Slaves in the network. Slaves will link with the first Master that it hears that has a matching Network ID. The Network ID function should be used in conjunction with the Subnet ID feature (If necessary).

Without having the serial numbers in the Call Book, a Slave may establish communications with different Masters, though not at the same time. This is very useful in mobile MultiPoint applications.

(8) MULTIMASTER SYNCH

MultiMaster Synch is reserved for applications, in both Point-to-Point and MultiPoint modes, with concentrations of Master units where it is necessary to reduce interference between the Masters. Please contact FreeWave Technologies for more information.

(9) 1 PPS ENABLE/DELAY

The 1 PPS Enable/Delay option allows the radio network to propagate a 1PPS signal from the Master to all Slaves in a MultiPoint network. When this parameter is enabled a properly generated pulse applied on the DTR line of the Master will provide a 1 PPS pulse on the CD line of any Slave in the network. To use the 1 PPS Enable/Delay feature the steps outlined below must be followed:

1PPS Enable/Delay Setup:

1. The 1 PPS Enable/Delay parameter must be set to 0 in the Master.
2. The Master must have a 1 PPS pulse on the DTR pin.
3. The 1 PPS Enable/Delay parameter on the Slaves must be enabled. Slaves are calibrated at the factory.

Calibrating a Slave in 1PPS Enable/Delay mode

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

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

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

(A) SLAVE/REPEATER

Repeaters are not available in the FreeWave 760 MHz Data Transceivers.

(B) DIAGNOSTICS

This option provides diagnostics data to be viewed at the Master in parallel with application data. The diagnostic program MUST be run from the Master transceiver. Diagnostics requires the following:

1. Diagnostics set to (1 to 128) in the Master.
2. A second computer or serial connection to run the diagnostics software.
3. A diagnostics cable. (Available from FreeWave Technologies.)
4. Diagnostics software. (Available on the User Manual and System Tools CD.)

For more information on Diagnostics, please contact FreeWave Technical Support at (303) 381-9200.

(C) SUBNET ID

Subnet ID is not to be used in the FreeWave LRS-760 Data Transceivers.

(D) RADIO ID

Option (D) allows a transceiver to be designated with an arbitrary, user selectable, 4 digit number which identifies the transceiver in diagnostics mode.

(E) LOCAL ACCESS

Local Access is not to be used at this time.

(G) RADIO NAME

Option (G) allows the user to set a unique 20 character Radio name.

Overlapping MultiPoint Networks

Overlapping MultiPoint networks may be set up effectively with FreeWave transceivers when several key parameters are set correctly. Overlapping MultiPoint networks are defined as networks using different Masters which share or overlap in a specific geographic area. It may also include co-located transceivers configured into different networks.

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

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

For more questions about the installation of Point-to-MultiPoint networks, please contact FreeWave Technical Support at (303) 444-3862.

Factory Default Settings

FreeWave serial transceivers are shipped from the factory with the following Default Settings:

Operation Mode	Default
Point to Point Slave	1
Set Baud Rate	**Default**
Baud Rate	115200
(A) Data Parity	0
(B) Modbus RTU	0
(C) RS232/485	0
(D) Setup Port	3
(E) TurnOffDelay/OnDelay	0/0
(F) Flow Control	0
Radio Parameters	**Default**
(1) MAX PACKET SIZE	8
(2) MIN PACKET SIZE	9
(3) XMT RATE	1
(4) RF DATA RATE	3
(5) RF XMT POWER	10
(6) SLAVE SECURITY	0
(7) RTS TO CTS	0
(8) RETRY TIMEOUT	255
(9) LOW POWER MODE	0
(A) High Noise	0
(B) MCU Speed	0
(C) Remote LED	0

MultiPoint Parameters	Default
(1) MASTER PACKET REPEAT	2
(2) MAX SLAVE RETRY	9
(3) RETRY ODDS	9
(4) DTR CONNECT	0
(6) NETWORK ID	255
(7) RESERVED	-
(8) MULTI MASTER SYNC	0
(9) 1 PPS ENABLE DELAY	255
(B) DIAGNOSTICS	0
(D) RADIO ID	Not Set

Additional Transceiver information

This section contains additional important information about FreeWave transceivers. The following topics are included in this section:

- Operational RS422 and RS-485 Information
- RS232 Pin Assignments
- OEM Board Pin Assignments

Operational RS-422 and RS-485 Information

For both RS-422 and RS-485, the FreeWave transceiver can drive 32 standard unit loads and loads the bus with only 1/8 unit load. This means the user can tie up to 256 devices on the bus if all of the line receivers have 1/8 unit load.

RS-422 is used for 4-wire or full duplex communication with one Master and multiple Slaves. The FreeWave Master transceiver keeps the line driver asserted at all times. The maximum line length is 4,000 feet using 2, 120 ohm twisted pair cables with a 5th wire for data common.

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 RS-485 is a two-wire comprised of a 120 ohm impedance single twisted pair. In this system the loading of the FreeWave transceiver is as described above which allows up to 256 1/8 unit load units on the bus. Maximum line length is also 4,000 feet with a third wire required for data common. The FreeWave transceiver will check the line to be certain no other device is transmitting before enabling the line driver for data transmission.

When setting the transceiver to RS-485, enable Modbus and set Master Packet Repeat to 3 in the transceiver(s) that will use RS-485. Also set TurnOff Delay to 4.

The TurnOffDelay setting in the menu is used to control the length of time the transmitter driver stays asserted after data transmission has finished. This is needed to allow the last transmitted character to reach the end of a long line and is normally set to one character length of time. This setting also allows 3 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 one-quarter-character delay times are recommended. In Modbus, a TurnOffDelay setting of 0 will cause internal timing errors.

There is no provision for hand shaking in any of the above modes of operation, so data rates of 57.6 KBaud and above are not recommended without a protocol that can handle error detection properly.

RS-422 and RS-485 Full Duplex Pin-Outs

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

RS-485 Half Duplex Pin-Outs

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

RS232 Pin Assignments

Pin		Assignment	Signal	Definition
1	CD	Carrier Detect	Output	Used to show an RF connection between transceivers.
2	TX	Transmit Data	Output	Used to transmit data bits serially from the transceivers to the system device.
3	RX	Receive Data	Input	Used to receive data bits serially from the system device connected to the transceivers.
4	DTR	Data Terminal Ready	Input	Used only in transceivers in Point-to-Point Slave/Master switchable mode or for DTR Connect.
5	GND	Ground		Signal return for all signal lines shared with Pin 9.
6	DSR	Data Set Ready	Output	Always high when the radio is powered from the 2.5mm power connector. Indicated power is on to the radio. Also, this pin can be used for +12Volts when powering the transceivers directly through the RS-232 port. **Note:** This is not used on the OEM module.
7	RTS	Request to Send	Input	The transceiver does not recognize RTS for flow control. RTS is used as a control line in RTS/CTS mode.
8	CTS	Clear to Send	Output	This signal is used to tell the system device connected to the transceiver that the transceiver is ready to receive data. When asserted, the transceiver will accept data, when deasserted the transceiver will not accept data. This should always be used for data rates above 38.4KB or there will be a risk of lost data if an RF link is not very robust.
9	GND	Ground		Signal return for all signal lines shared with Pin 5.

RF Board Pinout

The 760 MHZ Series transceivers are available in both TTL and RS232 versions.

The TTL versions use reverse polarity from standard RS-232 at 0 to 5 Volt levels. All pin descriptions and pin numbering are the same as the RS232 version. The RS232 versions use standard RS232 polarity and voltage levels for all of the RS232 signal lines (DTR, Transmit Data, Receive Data, Carrier Detect, RTS, and Clear to Send) and TTL standard polarity and voltage level for the Interrupt pin.

Pin 1: B+ Power input.

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

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

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

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 us toll-free at **1-800-548-5616 or factory direct after hours at 303-444-3862** or email us at moreinfo@FreeWave.com

CHANNEL LISTS

Channel#	Freq	Channel#	Freq	Channel#	Freq	Channel#	Freq
0	757	46	757.2875	92	757.575	138	757.8625
1	757.00625	47	757.29375	93	757.58125	139	757.86875
2	757.0125	48	757.3	94	757.5875	140	757.875
3	757.01875	49	757.30625	95	757.59375	141	757.88125
4	757.025	50	757.3125	96	757.6	142	757.8875
5	757.03125	51	757.31875	97	757.60625	143	757.89375
6	757.0375	52	757.325	98	757.6125	144	757.9
7	757.04375	53	757.33125	99	757.61875	145	757.90625
8	757.05	54	757.3375	100	757.625	146	757.9125
9	757.05625	55	757.34375	101	757.63125	147	757.91875
10	757.0625	56	757.35	102	757.6375	148	757.925
11	757.06875	57	757.35625	103	757.64375	149	757.93125
12	757.075	58	757.3625	104	757.65	150	757.9375
13	757.08125	59	757.36875	105	757.65625	151	757.94375
14	757.0875	60	757.375	106	757.6625	152	757.95
15	757.09375	61	757.38125	107	757.66875	153	757.95625
16	757.1	62	757.3875	108	757.675	154	757.9625
17	757.10625	63	757.39375	109	757.68125	155	757.96875
18	757.1125	64	757.4	110	757.6875	156	757.975
19	757.11875	65	757.40625	111	757.69375	157	757.98125
20	757.125	66	757.4125	112	757.7	158	757.9875
21	757.13125	67	757.41875	113	757.70625	159	757.99375
22	757.1375	68	757.425	114	757.7125		
23	757.14375	69	757.43125	115	757.71875		
24	757.15	70	757.4375	116	757.725		
25	757.15625	71	757.44375	117	757.73125		
26	757.1625	72	757.45	118	757.7375		
27	757.16875	73	757.45625	119	757.74375		
28	757.175	74	757.4625	120	757.75		
29	757.18125	75	757.46875	121	757.75625		
30	757.1875	76	757.475	122	757.7625		
31	757.19375	77	757.48125	123	757.76875		
32	757.2	78	757.4875	124	757.775		
33	757.20625	79	757.49375	125	757.78125		
34	757.2125	80	757.5	126	757.7875		
35	757.21875	81	757.50625	127	757.79375		
36	757.225	82	757.5125	128	757.8		
37	757.23125	83	757.51875	129	757.80625		
38	757.2375	84	757.525	130	757.8125		
39	757.24375	85	757.53125	131	757.81875		
40	757.25	86	757.5375	132	757.825		
41	757.25625	87	757.54375	133	757.83125		
42	757.2625	88	757.55	134	757.8375		
43	757.26875	89	757.55625	135	757.84375		
44	757.275	90	757.5625	136	757.85		
45	757.28125	91	757.56875	137	757.85625		

Channel#	Freq	Channel#	Freq	Channel#	Freq	Channel#	Freq
160	787	206	787.2875	252	787.575	298	787.8625
161	787.00625	207	787.29375	253	787.58125	299	787.86875
162	787.0125	208	787.3	254	787.5875	300	787.875
163	787.01875	209	787.30625	255	787.59375	301	787.88125
164	787.025	210	787.3125	256	787.6	302	787.8875
165	787.03125	211	787.31875	257	787.60625	303	787.89375
166	787.0375	212	787.325	258	787.6125	304	787.9
167	787.04375	213	787.33125	259	787.61875	305	787.90625
168	787.05	214	787.3375	260	787.625	306	787.9125
169	787.05625	215	787.34375	261	787.63125	307	787.91875
170	787.0625	216	787.35	262	787.6375	308	787.925
171	787.06875	217	787.35625	263	787.64375	309	787.93125
172	787.075	218	787.3625	264	787.65	310	787.9375
173	787.08125	219	787.36875	265	787.65625	311	787.94375
174	787.0875	220	787.375	266	787.6625	312	787.95
175	787.09375	221	787.38125	267	787.66875	313	787.95625
176	787.1	222	787.3875	268	787.675	314	787.9625
177	787.10625	223	787.39375	269	787.68125	315	787.96875
178	787.1125	224	787.4	270	787.6875	316	787.975
179	787.11875	225	787.40625	271	787.69375	317	787.98125
180	787.125	226	787.4125	272	787.7	318	787.9875
181	787.13125	227	787.41875	273	787.70625	319	787.99375
182	787.1375	228	787.425	274	787.7125	320	788
183	787.14375	229	787.43125	275	787.71875		
184	787.15	230	787.4375	276	787.725		
185	787.15625	231	787.44375	277	787.73125		
186	787.1625	232	787.45	278	787.7375		
187	787.16875	233	787.45625	279	787.74375		
188	787.175	234	787.4625	280	787.75		
189	787.18125	235	787.46875	281	787.75625		
190	787.1875	236	787.475	282	787.7625		
191	787.19375	237	787.48125	283	787.76875		
192	787.2	238	787.4875	284	787.775		
193	787.20625	239	787.49375	285	787.78125		
194	787.2125	240	787.5	286	787.7875		
195	787.21875	241	787.50625	287	787.79375		
196	787.225	242	787.5125	288	787.8		
197	787.23125	243	787.51875	289	787.80625		
198	787.2375	244	787.525	290	787.8125		
199	787.24375	245	787.53125	291	787.81875		
200	787.25	246	787.5375	292	787.825		
201	787.25625	247	787.54375	293	787.83125		
202	787.2625	248	787.55	294	787.8375		
203	787.26875	249	787.55625	295	787.84375		
204	787.275	250	787.5625	296	787.85		
205	787.28125	251	787.56875	297	787.85625		