



**FreeWave Technologies**

**LRS-455**

**Data Transceiver**

**Version 1.0, Revision D**

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**LICENSED BAND WIRELESS DATA TRANSCEIVER USER MANUAL**

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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.

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Printed in the United States of America.

**UL NOTIFICATION**

Models LRS455-C-U, LRS455-CE-U, LRS455-T-U, LRS455-TE-U are suitable for use in Class 1, Division 2, Groups A, B, C, and D or non-hazardous locations only. Input voltage for the above models is 6 to 30 volts DC.

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

**FCC NOTIFICATIONS**

The transceiver is approved under 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. Any unauthorized modification or changes to this device without the express approval of FreeWave Technologies may void the user's authority to operate this device. Furthermore, this device is intended to be used only when installed in accordance with the instructions outlined in this manual. Failure to comply with these instructions may void the user's authority to operate this device.

**Note:** The LRS-455 transceivers are approved for use in Canada within the 450MHz to 470MHz band.

**CAUTION:** The LRS-455 series transceiver have maximum transmitted output power of 2W. It is recommended that the transmit antenna be kept at least 71 cm away from nearby persons to satisfy FCC RF exposure requirements.

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## 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.

**WARNING:** Do not connect the LRS455 series radio to power without terminating the antenna port to a load.

## 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.

**Note:** In licensed band operation it is suggested to set the repeated master packets at 0 due to the spectrum being quiet. This will maximize throughput and leverage the advantages of licensed band operation.

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 antenna port to a load and the radio to a power source (typically, 6 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.

Condition	Master			Slave		
	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:

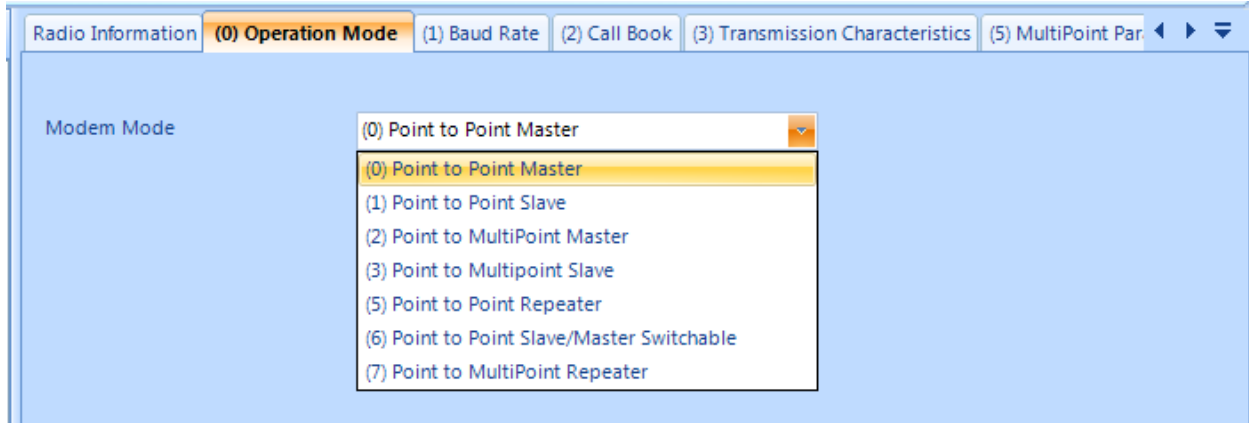
1. Connect antennas to the transceivers. Freewave Technologies recommends that the antenna port be loaded at all times to prevent damage to the LRS-455 radios. Noise potential may be reduced on the bench by lowering the Xmit power.
2. Connect the transceiver to the instrument with the RS232 cable, connect the antenna port to a load, 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).
3. 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).
4. 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.
5. 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).
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

Condition	Master			Slave		
	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.

Operation Mode	Description
Point-to-Point Master (0)	<p>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.</p> <p>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.</p> <p>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.</p>
Point-to-Point Slave (1)	<p>This mode designates the transceiver as a Slave in Point-to-Point mode. The Slave communicates with any Master in its Call Book.</p> <p>When functioning as a Slave, the <b>Entry to Call</b> 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.</p>
Point-to-MultiPoint Master (2)	<p>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.</p> <p>A Point-to-MultiPoint Master communicates only with other transceivers designated as Point-to-MultiPoint Slaves.</p>
Point-to-MultiPoint	<p>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</p>

Slave (3)	communicate with its Master.
Point-to-Point Repeater (5)	FreeWave allows the use of one repeater in a Point-to-Point communications link, significantly extending the operating range. When designated as a Repeater, a transceiver behaves as a pass-through link. All settings for the call book, baud rates and radio transmission characteristics are disabled. A Repeater will connect with any Master that calls it. The Repeater must be set up properly in the Master's call book.
Point-to-Point Slave/Master Switchable (6)	Mode 6 allows the transceiver to be controlled entirely through software commands. A number of key parameters in FreeWave's user interface may be changed either directly with a program such as Windows Terminal or through the use of script files. Additionally, when the Point-to-Point Slave/Master Switchable option is selected and the transceiver is not calling a Slave, it will function as a Slave and accept any appropriate calls from other transceivers.
Point-to-MultiPoint Repeater (7)	This option allows the transceiver to operate as a Repeater in a MultiPoint network. See the MultiPoint parameters section for details on enabling MultiPoint Slave/Repeater mode.

## 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

The screenshot shows a software interface with a tabbed menu at the top. The tabs are: Radio Information, (0) Operation Mode, (1) Baud Rate (which is highlighted with a yellow border), (2) Call Book, (3) Transmission Characteristics, and (5) MultiPoint Parameters. Below the tabs, there are several configuration fields:

Baud Rate	1200	Data Parity	8 - None - 1
Modbus RTU	0	Serial Interface	RS232
Setup Port	Diagnostics only	Turn On Delay	0
Turn Off Delay	0	Flow Control	None
Use Break to Access Setup	Off		

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

Baud Rate	Description																					
<b>Actual Baud Rate (selections 0-9)</b>	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.																					
<b>Data, Parity</b>	There are six data word length and parity configurations available to be used with FreeWave transceivers. The default setting is <b>0</b> (8, N, 1) and is the most commonly used serial communications protocol. Select the appropriate option to communicate with the end device.  <table border="1"> <thead> <tr> <th>Data Bits</th> <th>Parity</th> <th>Stop Bits</th> </tr> </thead> <tbody> <tr> <td>8</td> <td>None</td> <td>1</td> </tr> <tr> <td>7</td> <td>Even</td> <td>1</td> </tr> <tr> <td>7</td> <td>Odd</td> <td>1</td> </tr> <tr> <td>8</td> <td>None</td> <td>2</td> </tr> <tr> <td>8</td> <td>Even</td> <td>1</td> </tr> <tr> <td>8</td> <td>Odd</td> <td>1</td> </tr> </tbody> </table>	Data Bits	Parity	Stop Bits	8	None	1	7	Even	1	7	Odd	1	8	None	2	8	Even	1	8	Odd	1
Data Bits	Parity	Stop Bits																				
8	None	1																				
7	Even	1																				
7	Odd	1																				
8	None	2																				
8	Even	1																				
8	Odd	1																				
<b>Modbus RTU</b>	Support for <b>Modbus RTU</b> protocol is available. The default setting for <b>Modbus RTU</b> is <b>0</b> (Not Enabled).  To enable Modbus capability, set <b>Modbus RTU</b> to 1.  <b>Note:</b> When using the transceiver in <b>Modbus RTU</b> mode, the Master Packet Repeat must match in every radio with <b>Modbus RTU</b> enabled, regardless of whether the network is in Point-to-Point or MultiPoint mode. The <b>Modbus RTU</b> mode must be selected when transceivers are configured in RS485 or RS422 mode.																					
<b>Serial Interface</b>	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".  <table border="1"> <thead> <tr> <th>Protocol</th> <th>Additional Information</th> </tr> </thead> <tbody> <tr> <td>RS232</td> <td>Also used for TTL transceivers.</td> </tr> <tr> <td>RS422</td> <td>Modbus RTU mode must be enabled. See above.</td> </tr> <tr> <td>RS485</td> <td>Modbus RTU mode must be enabled. See above.</td> </tr> <tr> <td>DOT</td> <td>Special for the Department of Transportation.</td> </tr> </tbody> </table> <b>Note:</b> When DOT mode is enabled, the TimeDelay settings operate the same as in the RS485/422 mode.  <b>Note:</b> RS4xx mode must have Modbus RTU enabled, and TurnoffDelay set to at least 4.	Protocol	Additional Information	RS232	Also used for TTL transceivers.	RS422	Modbus RTU mode must be enabled. See above.	RS485	Modbus RTU mode must be enabled. See above.	DOT	Special for the Department of Transportation.											
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RS485	Modbus RTU mode must be enabled. See above.																					
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<b>Setup Port</b>	<b>Note: DO NOT change this setting unless the correct programming cable is available for the new setting.</b>  This setting determines which port, Main or Diagnostics, is used to enter the Setup Main Menu.  <table border="1"> <thead> <tr> <th>Port</th> <th>Additional Information</th> </tr> </thead> <tbody> <tr> <td>Main Only</td> <td>The terminal is connected to the Main Data Port.</td> </tr> <tr> <td>Diagnostics Only</td> <td>The terminal is connected to the Diagnostic Port.</td> </tr> </tbody> </table>	Port	Additional Information	Main Only	The terminal is connected to the Main Data Port.	Diagnostics Only	The terminal is connected to the Diagnostic Port.															
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	<p>Both Ports      The terminal may be connected to either port.</p> <p>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.</p> <p>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.</p>										
<b>TurnOn/OffDelay</b>	<p><b>TurnOnDelay-</b> 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.</p> <p><b>TurnOffDelay-</b> 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 <math>\frac{1}{4}</math> 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.</p> <p>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.</p> <p><b>Note:</b> TurnOffDelay must be set to a value of at least 4 for RS4xx operation.</p>										
<b>FlowControl</b>	<p>This menu specifies the hardware flow control for the Data port. The options for 0-3 are described below.</p> <table border="0"> <thead> <tr> <th data-bbox="461 1094 521 1121"><b>Port</b></th> <th data-bbox="643 1094 924 1121"><b>Additional Information</b></th> </tr> </thead> <tbody> <tr> <td data-bbox="461 1136 521 1163">None</td> <td data-bbox="643 1136 1167 1163">Default - Uses software control (XON XOFF)</td> </tr> <tr> <td data-bbox="461 1178 521 1205">RTS</td> <td></td> </tr> <tr> <td data-bbox="461 1220 521 1247">DTR</td> <td></td> </tr> <tr> <td data-bbox="461 1262 521 1289">DOT</td> <td></td> </tr> </tbody> </table>	<b>Port</b>	<b>Additional Information</b>	None	Default - Uses software control (XON XOFF)	RTS		DTR		DOT	
<b>Port</b>	<b>Additional Information</b>										
None	Default - Uses software control (XON XOFF)										
RTS											
DTR											
DOT											

## Modbus RTU Timing

The Modbus RTU setting causes the radio to wait for an amount of time, “gathering” data before sending out the radio link.

With a setting of **0** (Disabled), the radio will send data out its radio link as soon as the data is received into the serial port.

With a setting of **1**, the radio will wait for a number of slots equal to 2 times the Master Packet Repeat setting before sending the received data out the radio link. For example, if **Master Packet Repeat = 3**, the radio will wait for 6 slots, gathering data up the whole time. At the end of the 6 slots, the radio will send all received data in one “burst”. This is the appropriate setting for most Modbus RTU devices.

With a setting of **2** and higher, the radio will wait for a number of slots calculated by the following formula:

$$(\text{Modbus RTU Setting} + \text{Master Packet Repeat Setting} + 1) \times 2$$

For example, in a radio where the Modbus RTU setting = **2** and the Master Packet Repeat setting = **3**, the radio will wait for  $(2+3+1) \times 2$ , or 12 slots.

## Call Book

Entry	Number	Repeater 1	Repeater 2
0	455-0084	455-0072	
1			
2			
3			
4			
5			
6			
7			
8			
9			

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, select the appropriate option in the drop down.



## 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.

Radio Information	(0) Operation Mode	(1) Baud Rate	(2) Call Book	(3) Transmission Characteristics	(5) MultiPoint Pa
Tx Frequency (MHz)	440.3125				
Rx Frequency (MHz)	440.3125				
Max Packet Size	6				
Min Packet Size	3				
Transmit Rate	1				
RF Data Rate (GFSK Type)	(3) 25 kHz 2 Level				
Transmit Power	0				
Slave Security	Off				
RTS to CTS	0				
Retry Timeout	80				
Low Power Mode	0				
Remote LED	Local Only				

## Edit Radio Transmission Characteristics

### SETTING XMIT AND RCV FREQUENCIES

The 400MHz Data Transceiver has the option to operate in a Frequency Division Duplex mode by transmitting on one frequency and receiving on another.

The LRS-455 transceivers must be programmed to operate on the appropriate frequency. To program the transceiver for single channel operation, enter the frequency, in Megahertz, into the TX and RX Frequency slots.

If the transceivers are to operate in Frequency Division Duplex, the TX and RX Frequency slots will have different frequencies assigned.

**(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.

The following 3 tables provide the information to determine optimum setting values.

Minimum Packet Size Definition	
Min Setting	Min Packet Size
0	0
1	16
2	32
3	48
4	64
5	80
6	96
7	112
8	128
9	144

Maximum Packet Size (2 level FSK)	
Max Setting	Max Packet Size
0	32
1	48
2	64
3	80
4	96
5	112
6	128
7	135
8	135
9	135

Maximum Packet Size (4 level FSK)	
Max Setting	Max Packet Size
0	32
1	48
2	64
3	80
4	96
5	112
6	128
7	144
8	160
9	176

**(3) XMIT RATE**

FreeWave transceivers utilize a Master Transmit Beacon to provide low current consumption in the slave radios. The slave radios will turn their receiver off when no data is being passed.

The Xmit Rate setting allows the duty cycle of the Master Transmit Beacon to be changed. A setting of 0 is the highest duty cycle and a setting of 9 is the lowest duty cycle.

**(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
1	50kHz	2-level GFSK
2	25kHz	4-level GFSK
3	25kHz	2-level GFSK
4	12.5kHz	4-level GFSK
5	12.5kHz	2-level GFSK

**Note: \*ONLY\* RF Data Rates 4 and 5 are currently FCC Approved.**

**(5) RF XMIT POWER**

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

**Note:** For use in applications requiring greater than 70% transmit duty cycle, the LRS-760 series of radios must be attached to an appropriate heat sink.

The following table shows RF TX output versus the RF Xmit Power setting.

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

## (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. 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.

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.

Current Draw



#### 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.

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

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.

## 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 and Min and Max Packet Size.

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

## Edit MultiPoint Parameters

formation	(0) Operation Mode	(1) Baud Rate	(2) Call Book	(3) Transmission Characteristics	(5) MultiPoint Parameters
Repeaters	On	Master Packet Repeat	1		
Max Slave Retry	9	Retry Odds	0		
DTR Connect	0 - Off	Network ID	1234		
Multi-Master Sync	Off	1 PPS Enable Delay	255		
Slave/Repeater	Off	Diagnostics	0		
Radio ID	0	Radio Name	Mark		
	Rx	Tx			
Subnet	0	1			

### (0) REPEATERS

The Repeaters selection must be set to On if a repeater is to be used in the network. However, if the network will not utilize a repeater, FreeWave recommends setting Repeaters to Off to provide higher throughput.

### (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 0 or 1. 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 0 to 1 will work well for most well designed licensed band 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.

**(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 SYNC**

MultiMaster Sync 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 sync 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**

Normally a repeater does not have the ability to provide data on the data port. When this capability is necessary Slave/Repeater should be set to On. When using Slave/Repeater, the baud rate and communication protocol must match the end device.

**(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.)

**NOTE:** When collecting diagnostics from an LRS455 network, FreeWave recommends setting the diagnostics polling rate to 400 ms or higher.

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

**(C) SUBNET ID**

The Subnet ID function only works in MultiPoint Networks utilizing the Network ID option. In a MultiPoint Network, a Slave or Repeater will connect with the first Repeater or Master that it hears with the same Network ID. However, where communications need to be forced to follow a specific path the Subnet ID is

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

1. Rcv Subnet ID. This setting identifies which transceiver a Repeater or Slave will listen to.
2. Xmit Subnet ID. This setting identifies the ID on which this device transmits, and in turn which devices will listen to it. *The Xmit Subnet ID parameter is relevant for MultiPoint Repeaters only.*

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

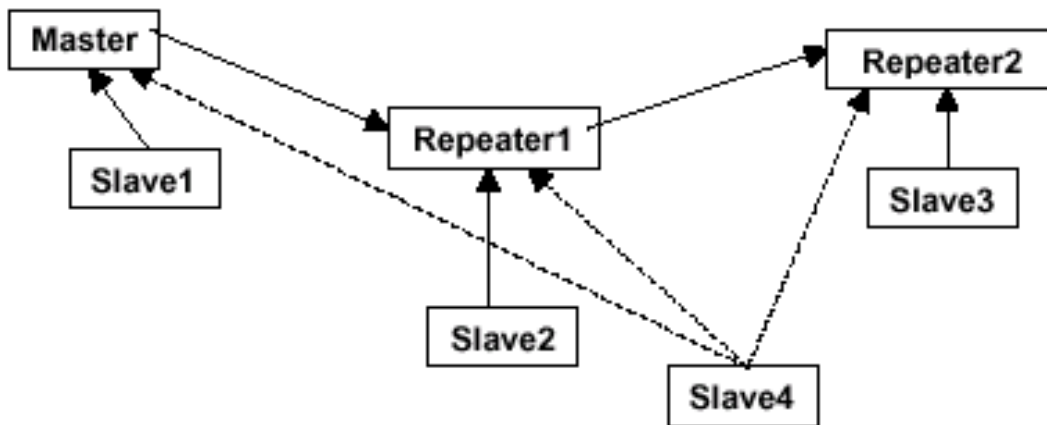
**Notes:** A Master will always transmit and receive on 0. With firmware of 2.40 and greater (900MHz) or 3.40 and greater (2.4GHz) the Master may be set to use alternate Subnet ID values. Changing these settings on the Master is not recommended, under normal circumstances.

In some MultiPoint Networks, the FreqKey will be at the same setting for all transceivers. In other networks, where parallel Repeaters are introduced, the FreqKey value will need to change. See FreqKey and Repeater Frequency sections earlier in this manual for more information.

If both Rcv Subnet ID and Xmit Subnet ID are set to 0 the Subnet ID will show **Roaming** in the menu. This setting will allow a mobile Slave to roam from subnet to subnet and possibly from network to network.

This drawing depicts a Network in which Subnet IDs are used to force communications. In this example, Repeater1 *must* talk directly to the Master; Repeater2 *must* talk directly to Repeater1. Slaves 1, 2, and 3 are forced along the direction of the solid lines. Slave4 may link to the first Master or Repeater it hears.

The respective Subnet ID diagram and settings are shown below.



#### (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.

**Radio Information**

Radio Information		(0) Operation Mode	(1) Baud Rate	(2) Call Book	(3) Transmission Characteristics	(5) M
Model	LRS 455 MHz Series	Date Created	3/19/2009 11:31 AM			
Serial Number	455-0085	Date Modified	3/31/2009 8:08 AM			
Firmware Version	1.66w1					
<b>User Data</b>						
Radio Name	455-0085 - LRS 455 MHz Series					
Radio Notes	<div style="border: 1px solid gray; height: 100px;"></div>					
User created information pertaining to the radio.						
<b>Diagnostics</b>						
Master-Slave Distance (m)	0	Noise (dBm)	-134			
Number of Disconnects	1	Signal (dBm)	-86			
Radio Temperature (C)	22	Rate %	0			
Antenna Reflected Power	0					
Transmit Current (mA)	0					
These are the saved values the radio reported the last time it was read.						

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.

#### **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 -120 dBm units and the difference between the average signal level and average noise level should be 26 dB 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 dB. 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.

#### **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 -30° to +60° C.



## 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, set Modbus RTU to 1 and make Master Packet Repeat match 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 above 9600 bps in RF Data Rate = 5 and above 19200 bps in RF Date Rate = 4 are not recommended without a protocol that can handle error detection properly.

**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. <b>Note:</b> 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 400 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](http://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](mailto:moreinfo@FreeWave.com)



## Frequency List

The LRS-455 transceivers tune from 435MHz to 470MHz with a tuning resolution of 6.25KHz. This gives a total of 5600 available channels. Using the license allowed frequency, the channel number can be determined using the following formula.

$$\text{Channel number} = F^{\text{MHz}} (160) - 69600$$

Note: This is a partial list. If the required frequency is not listed use the  $F^{\text{MHz}}$  formula to obtain the appropriate channel number.

Channel#	Frequency	Channel #	Frequency	Channel #	Frequency
0	435.000	2060	447.875	4120	460.750
20	435.125	2080	448.000	4140	460.875
40	435.250	2100	448.125	4160	461.000
60	435.375	2120	448.250	4180	461.125
80	435.500	2140	448.375	4200	461.250
100	435.625	2160	448.500	4220	461.375
120	435.750	2180	448.625	4240	461.500
140	435.875	2200	448.750	4260	461.625
160	436.000	2220	448.875	4280	461.750
180	436.125	2240	449.000	4300	461.875
200	436.250	2260	449.125	4320	462.000
220	436.375	2280	449.250	4340	462.125
240	436.500	2300	449.375	4360	462.250
260	436.625	2320	449.500	4380	462.375
280	436.750	2340	449.625	4400	462.500
300	436.875	2360	449.750	4420	462.625
320	437.000	2380	449.875	4440	462.750
340	437.125	2400	450.000	4460	462.875
360	437.250	2420	450.125	4480	463.000
380	437.375	2440	450.250	4500	463.125
400	437.500	2460	450.375	4520	463.250

Channel#	Frequency	Channel#	Frequency	Channel#	Frequency
420	437.625	2480	450.500	4540	463.375
440	437.750	2500	450.625	4560	463.500
460	437.875	2520	450.750	4580	463.625
480	438.000	2540	450.875	4600	463.750
500	438.125	2560	451.000	4620	463.875
520	438.250	2580	451.125	4640	464.000
540	438.375	2600	451.250	4660	464.125
560	438.500	2620	451.375	4680	464.250
580	438.625	2640	451.500	4700	464.375
600	438.750	2660	451.625	4720	464.500
620	438.875	2680	451.750	4740	464.625
640	439.000	2700	451.875	4760	464.750
660	439.125	2720	452.000	4780	464.875
680	439.250	2740	452.125	4800	465.000
700	439.375	2760	452.250	4820	465.125
720	439.500	2780	452.375	4840	465.250
740	439.625	2800	452.500	4860	465.375
760	439.750	2820	452.625	4880	465.500
780	439.875	2840	452.750	4900	465.625
800	440.000	2860	452.875	4920	465.750
820	440.125	2880	453.000	4940	465.875
840	440.250	2900	453.125	4960	466.000
860	440.375	2920	453.250	4980	466.125
880	440.500	2940	453.375	5000	466.250
900	440.625	2960	453.500	5020	466.375
920	440.750	2980	453.625	5040	466.500
940	440.875	3000	453.750	5060	466.625
960	441.000	3020	453.875	5080	466.750

Channel#	Frequency	Channel#	Frequency	Channel#	Frequency
980	441.125	3040	454.000	5100	466.875
1000	441.250	3060	454.125	5120	467.000
1020	441.375	3080	454.250	5140	467.125
1040	441.500	3100	454.375	5160	467.250
1060	441.625	3120	454.500	5180	467.375
1080	441.750	3140	454.625	5200	467.500
1100	441.875	3160	454.750	5220	467.625
1120	442.000	3180	454.875	5240	467.750
1140	442.125	3200	455.000	5260	467.875
1160	442.250	3220	455.125	5280	468.000
1180	442.375	3240	455.250	5300	468.125
1200	442.500	3260	455.375	5320	468.250
1220	442.625	3280	455.500	5340	468.375
1240	442.750	3300	455.625	5360	468.500
1260	442.875	3320	455.750	5380	468.625
1280	443.000	3340	455.875	5400	468.750
1300	443.125	3360	456.000	5420	468.875
1320	443.250	3380	456.125	5440	469.000
1340	443.375	3400	456.250	5460	469.125
1360	443.500	3420	456.375	5480	469.250
1380	443.625	3440	456.500	5500	469.375
1400	443.750	3460	456.625	5520	469.500
1420	443.875	3480	456.750	5540	469.625
1440	444.000	3500	456.875	5560	469.750
1460	444.125	3520	457.000	5580	469.875
1480	444.250	3540	457.125	5600	470.000
1500	444.375	3560	457.250		
1520	444.500	3580	457.375		

Channel#	Frequency	Channel#	Frequency		
1540	444.625	3600	457.500		
1560	444.750	3620	457.625		
1580	444.875	3640	457.750		
1600	445.000	3660	457.875		
1620	445.125	3680	458.000		
1640	445.250	3700	458.125		
1660	445.375	3720	458.250		
1680	445.500	3740	458.375		
1700	445.625	3760	458.500		
1720	445.750	3780	458.625		
1740	445.875	3800	458.750		
1760	446.000	3820	458.875		
1780	446.125	3840	459.000		
1800	446.250	3860	459.125		
1820	446.375	3880	459.250		
1840	446.500	3900	459.375		
1860	446.625	3920	459.500		
1880	446.750	3940	459.625		
1900	446.875	3960	459.750		
1920	447.000	3980	459.875		
1940	447.125	4000	460.000		
1960	447.250	4020	460.125		
1980	447.375	4040	460.250		
2000	447.500	4060	460.375		
2020	447.625	4080	460.500		
2040	447.750	4100	460.625		

## Errata

### Firmware versions 1.67o and lower

- Setting **Master Packet Repeat** to **0** and **Modbus RTU** to **1** results in a large data transmission delay. **Master Packet Repeat** should be set to **1** or higher if the **Modbus RTU** setting is enabled.