

MM2 Wireless Data Transceivers

MM2-T
MM2-LV-T
MM2-MR-R
MM2-MR-T

Integration Guide



Safety Information



Warning! Do not remove or insert diagnostics cable while circuit is live.

Mise en garde ! Ne pas enlever ou insérer le câble de diagnostic alors que le circuit est sous tension..

Warranty

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

In no event will FreeWave Technologies, Inc., its suppliers, or its licensors be liable for any damages arising from the use of or inability to use this Product. This includes business interruption, loss of business information, or other loss which may arise from the use of this Product. OEM customer's warranty periods can vary.

Warranty Policy will **not apply** in the following circumstances:

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

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 products are designed and manufactured in the United States of America.

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UL Notifications



Models MM2-T-U, MM2-LV-T-U, MM2-MR-R-U, and MM2-MR-T-U are suitable for use in Class 1, Division 2, Groups A, B, C, and D or non-hazardous locations only. Do not connect or disconnect any connectors while the circuit is live unless the area is known to be non-hazardous.



Warning! EXPLOSION HAZARD - SUBSTITUTION OF COMPONENTS MAY IMPAIR SUITABILITY FOR CLASS 1, DIVISION 2.

Mise en garde ! RISQUE D'EXPLOSION - LA SUBSTITUTION DE COMPOSANTS PEUT ALTÉRER LES QUALITÉS POUR LA CLASSE 1, DIVISION 2.

Warning! DO NOT REMOVE OR INSERT THE DIAGNOSTICS CABLE WHILE THE CIRCUIT IS LIVE.

Mise en garde ! Ne pas enlever ou insérer le câble de diagnostic alors que le circuit est sous tension.

Input voltage for the MM2-T-U models is +5.0 VDC. Input voltage for the MM2-LV-T-U models is +3.5 VDC ($\pm 5\%$). Input voltage for the MM2-MR-R-U and MM2-MR-T-U models is +6.5 VDC to +30.0 VDC.

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

FCC Notifications

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

This installation guide covers all models of the FreeWave Technologies 900 MHz spread spectrum transceiver sold under FCC ID KNYAMM0921TT.

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



Warning! The transceivers covered in this guide have a maximum transmitted output power of 1 W. The antennas used must provide a separation distance of at least 23 cm from all persons and must not be co-located or operate in conjunction with any other antenna or transmitter.

Mise en garde ! Les émetteurs-récepteurs abordés dans ce guide ont une puissance de sortie maximale de 1 w. Les antennes doivent fournir une distance d'au moins 23 cm de toute personne et ne doit pas être co-implanté ou fonctionner en conjonction avec toute autre antenne ou émetteur.

The models described in this guide must be installed in a NEMA enclosure. When any FreeWave Technologies, Inc. module is placed inside an enclosure, a label must be placed on the outside of the enclosure. The label must include the text "Contains Transmitter Module with FCC ID: KNYAMM0921TT."

IC Notifications

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

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

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Preface



Thank you for integrating the FreeWave MM2 series radio into your OEM product. The MM2 radios are full featured radios in a small form factor ideal for OEM use. This document helps guide you through the necessary parameters for embedding the MM2 into your OEM device and includes the following information:

- An introduction to the models covered in this document and the methods that are available for integrating the radio into your OEM device.
- Product specifications including connector pin outs and layout information.
- Mechanical drawings, including dimensions of each radio and connectors.
- Details regarding power and other information you need when integrating the radio.
- Details about programming the radio and best practices regarding a network design.
- Troubleshooting and diagnostics information.

The content of this document is designed for electronic hardware engineers that have a strong knowledge of digital electronics. The MM2 family consists of the following modules: MM2-T, MM2-T-LF, MM2-T-U, MM2-LT, MM2-LV-T, MM2-LV-T-LF, MM2-LV-T-U, MM2-MR-R, MM2-MR-R-U, MM2-MR-T, MM2-MR-T-U.

Notational Conventions

This document uses the following notational conventions:

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

Printing This Document

This document is set to print double-sided with a front cover and a back cover. If you are viewing this document online with a PDF viewer, you may see pages that are intentionally left blank to accommodate the double-sided printing.

Contacting FreeWave Technical Support

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

FreeWave provides technical support Monday through Friday, 7:30 AM to 5:30 PM Mountain Time (GMT -7). Call toll-free at 1.866.923.6168, within Colorado call 303.381.9200, or contact us through email at moreinfo@freewave.com.

FreeWave can offer engineering and network support, and assist you in integrating your radio into your OEM product. They can perform the integration for you, if required.

Documentation Feedback

Send comments or questions about this document's content to techpubs@freewave.com. Include the title of the document or the document's part number and revision letter (found in the footer) in your email.

Chapter 1: Introduction

This guide provides the integration details for the following radio models:

- MM2-LV-T
- MM2-T
- MM2-MR-R
- MM2-MR-T

Any integration differences between the models are indicated throughout this guide. The model number is printed on the label on the radio.

Model	Interface	Dimensions	Connector
MM2-LV-T	TTL	2.75 in L x 2.4 in W x 0.40 in H (70 mm L x 62 mm W x 9.6 mm H)	Dual row 14 pin
MM2-T	TTL	2 in L x 1.4 in W x 0.38 in H (50.8mm L x 36mm W x 9.6mm H)	Dual row 14 pin
MM2-MR-R	RS232	2.75 in L x 2.4 in W x 0.40 in H 70 mm L x 62 mm W x 9.6 mm H	Straight 10 pin
MM2-MR-T	TTL	2.75 in L x 2.4 in W x 0.40 in H (70 mm L x 62 mm W x 9.6 mm H)	Straight 10 pin

Additional Information

The MM2 embedded radios are discussed in detail, including information about each configuration parameter in the *MM2 Wireless Data Transceivers User Manual and Reference Guide* available on the *User Manual and System Tools* CD or from www.FreeWave.com.

Chapter 2: Hardware and Pinouts

This chapter provides information about the following:

- Connectors and cable recommendations.
- Connector pin details.
- Antenna selection, location, and installation considerations.
- Specifications for each embedded radio model, including operating temperature thresholds and voltage requirements.
- Mechanical drawings of each embedded radio model.

Embedded Radio Connector Pinouts

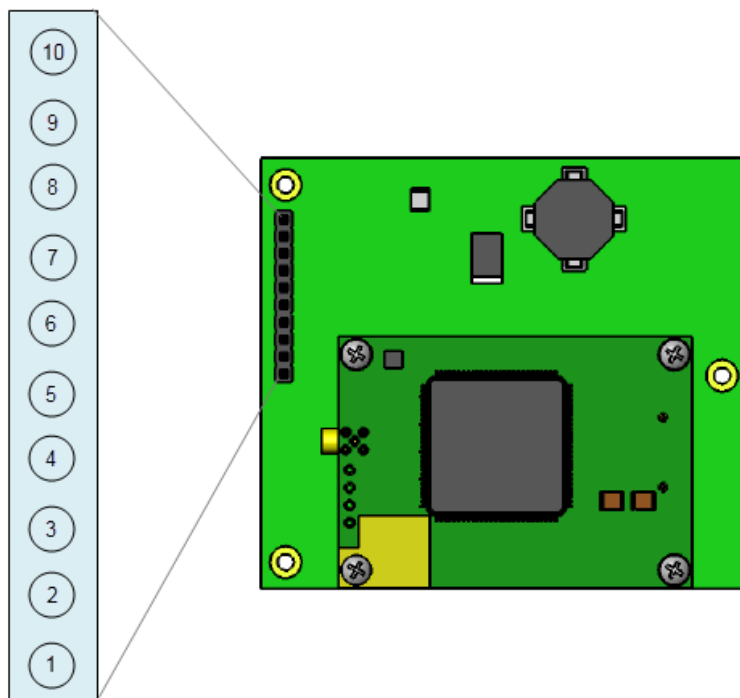
Each embedded transceiver model has a 10 or 14 pin connector. The following sections provide information about the function of each pin in the connector, and what to do if you do not use the pin.

10-Pin Connector

The following pin information applies to the straight 10-pin connector on the MM2-MR-T and MM2-MR-R models:

Pin	Input/ Output	Description	Label	If Not Used
1	Input	Power	B+	
2	Input	Reset	Interrupt	Pull High
3	Input	Data Terminal Ready	DTR	Pull to Ground

Pin	Input/Output	Description	Label	If Not Used
4	Ground	Ground	GND	
5	Output	Transmitted Data	TXD	
6	Ground	Ground	GND	
7	Input	Received Data	RXD	
8	Output	Carrier Detect	CD	
9	Input	Request to Send	RTS	Pull to Ground
10	Output	Clear to Send	CTS	



14-Pin Connector

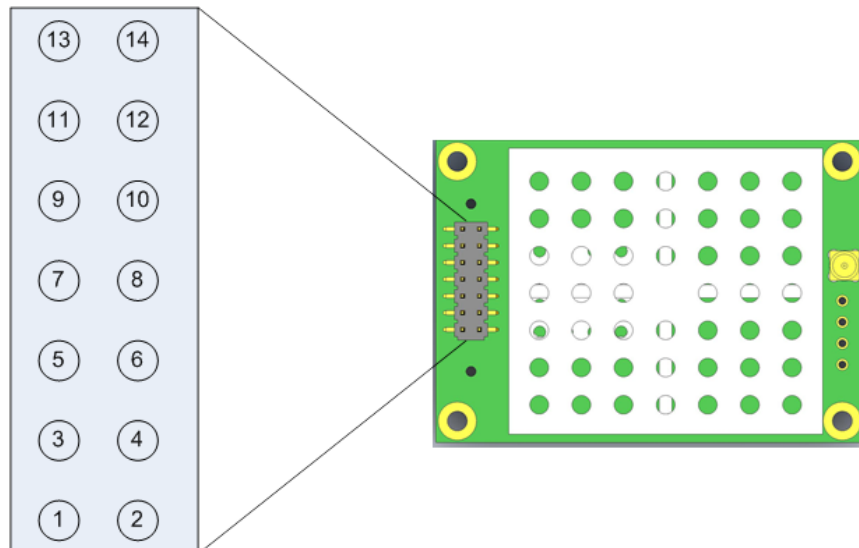
The following pin information applies to the dual row, 14-pin connector on the MM2-T and MM2-LV-T models:

Pin	Input/Output	Description	Label	Notes	If Not Used
1	Input	Power	B+	MM2-LV-T models: +3.5 VDC \pm 5% MM2-T models: +5.0 VDC \pm 5%	
2	Input	Reset	Interrupt	Active low, 100 μ s pulse	Pull High

Pin	Input/Output	Description	Label	Notes	If Not Used
3	Input	Data Terminal Ready	DTR	TTL **	Pull to Ground
4	Ground	Ground	GND		
5	Output	Transmitted Data	TXD	0 - 3.3 V TTL *	
6	Ground	Ground	GND		
7	Input	Received Data	RXD	TTL **	
8	Output	Carrier Detect	CD	0 - 3.3 V TTL *	
9	Input	Request to Send	RTS	TTL **	Pull to Ground
10	Output	Clear to Send	CTS	0 - 3.3 V TTL *	
11	Input	Diagnostic Received Data	Diag RX	TTL **	
12	Output	Diagnostic Transmitted Data	Diag TX	0 - 3.3 V TTL *	
13	Ground	Ground	GND		
14	Output	Baud Clock	Baud Clock	16 x serial port Baud Rate	

* 3.3 V output assumes greater than 3.3 V input voltage.

** 0-5 V TTL



Connectors and Cables

Use Samtec connectors for all embedded radios. The Samtec connectors and their interfaces are listed below.

Model Number	Uses Samtec Connector	Mating Samtec Connector Types
MM2-MR-T MM2-MR-R	MTSW-110-08-G-S-000	SSW, SSQ, ESW, ESW, BCS, BSW, IDSS, IDSD, CES, SLW, HLE
MM2-LV-T MM2-T	TMM-107-01-G-D-SM-A-P-TR	CLT, SMM, MMS, SQT, ESQT, SQW, TLE, TCSD, TLSD

About Antennas

FreeWave offers many antenna options. To improve the data link, FreeWave offers various antennas with cable lengths ranging from 13 inches up to 200 feet.

Consider the following antenna characteristics when choosing an antenna for your application:

- Antenna radiation patterns / antenna type
- Power gain
- Cable loss
- Directionality
- Polarization

When using antennas, follow the guidelines for selection, location, and installation provided in the sections below.

Antenna Location

When using an external antenna, placement of the FreeWave transceiver's antenna is likely to have a significant impact on the transceiver's 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 have a better communication link. However, a higher antenna may pick up more RF noise in the area, and other antennas in close proximity could cause interference. An adjustment as little as 2 feet in antenna placement can resolve some noise problems. In extreme cases, such as when interference is due to a pager or cellular tower, the band pass filters that FreeWave offers, may reduce this out-of-band noise.

Note: Use the Radio Statistics, available in option 4 in the main Setup menu of the radio to help identify problems.

Also consider the following points when locating antennas for your application:

- Identify sites with "Line of Sight". If you cannot see it you cannot talk to it.
- Long cable runs decrease signal and increase the amount of picked up noise. For example, if you use LMR 400 cable on a 200 foot tower, loss in the cable run alone is 8 dB over the 200 foot distance.

To help optimize your antenna location, have FreeWave complete a site study for you, free of charge. To initiate the request, complete and submit the Path Study form available from your sales representative. Email the completed form to pathstudy@freewave.com.

Approved Antennas for the 900 MHz MM2 Radio Family

Any antenna used with FreeWave transceivers must have the following characteristics to remain in compliance with FCC requirements and regulations.

- Antenna gain does not exceed 12 dBi for Yagi antennas and 8.15 dBi for Omni antennas.
- Overall system Equivalent Isotropically Radiated Power (EIRP) does not exceed 36 dBm.

The complete list of antennas available from FreeWave including antenna gains is shown below:

900 MHz Antennas				
Gain (dBd/dBi)	Manufacturer	Antenna Type	FreeWave Part Number for Ordering	Manufacturer Model Number
12 dBi	Wavelink	Yagi	EAN0906F	PRO890-12
6 dBd / 8.15 dBi	Antenex	Omni	EAN0906NF	FG9026
3 dBd/ 5.15 dBi	Maxrad	Omni	EAN0900WC	MAX-9053
2.85 dBd / 5.0 dBi	Antenex Maxrad	Omni	EAN0905WC	EB8965C BMEFC8985HD
-0.15 dBd / 2.0 dBi	Mobile Mark	Omni	EAN0900SR	PSKN3-925S
-2.15 dBd/ 0 dBi	Mobile Mark	Omni	EAN0900SQ	PSTG0-915SE

Antenna Installation

Antennas must be professionally installed on a fixed, mounted, and permanent structure to satisfy RF exposure requirements.



Warning! Any antenna placed outdoors must be properly grounded. Use extreme caution when installing antennas and follow *all* manufacturer instructions included with the antenna.

Mise en garde ! Toute antenne placée à l'extérieur doit être correctement mise à la terre. Soyez très prudent lors de l'installation d'antennes et suivre toutes les instructions du fabricant fournies avec l'antenne.

Per FCC regulations, any antenna used with FreeWave transceivers must be an approved antenna that has comparable performance parameters. For more information about approved antennas, see ["Approved Antennas for the 900 MHz MM2 Radio Family" on page 7](#).

Cable Loss and Transmit Power Settings

The **Transmit Power** parameter is the output power of the transceiver. The transceiver output power level must be set to satisfy maximum Equivalent Isotropically Radiated Power (EIRP) requirements in the country in which the installation exists.

When setting up the network, consider the power gain that an antenna may add, and the power loss through cabling. Adjust the **Transmit Power** on the transceiver to ensure that you do not exceed the maximum EIRP for the regulating body where the installation exists. Use the tables below to determine the correct **Transmit Power** parameter setting for each transceiver in the network.

Important: The information in this section discusses FCC and ETSI maximum EIRP regulations. Ensure your installation meets the maximum EIRP requirements for the country in which you are installing transceivers. It remains the installer's responsibility to ensure that an installation is within EIRP emission limits.

The FCC permits 1 Watt output power at the transceiver and 36 dBm (4 Watts) at the antenna. When calculating the power gain, use the following equation to determine the total output power at the antenna. Loss calculations should include cable, connectors, surge protectors, etc.

$$\text{Transceiver Output} - \text{Losses} + \text{Antenna Gain} = \text{Output Antenna Power}$$

For example, 30 dBm – 2 dB + 6 dBi = 34 dBm (or 2.5 Watts). 34 dBm is within the FCC limits. However, 30 dBm – 2 dB + 10 dBi = 38 dBm (or 6.3 Watts) **exceeds** the FCC limits.

Cable Type	Attenuation (db/100 ft)	Run Length (ft)	Total Run Attenuation (dB)
LMR400	3.93	25	1.0
LMR500	3.154	25	0.8
LMR600	2.518	25	0.6
LMR900	1.709	25	0.4

Shielding

FreeWave OEM transceivers are shielded to prevent any unintended emission. Additional shielding may be required to prevent the OEM equipment from interfering with the FreeWave transceiver. This is unlikely but it depends on the equipment and components in the OEM application.

Specifications

Use the information listed in this section to determine the requirements for specifications such as temperature and voltage within your OEM design.

MM2-T Specifications

The following specifications apply to MM2-T.

Specifications may change at any time without notice. For the most up-to-date specifications information, see the product's data sheet available at www.FreeWave.com.

Specification	
Frequency	902 to 928 MHz (FHSS) (DTS)
Transmitter	
Output power	10 mW to 1 W
Range	20 to 25 miles (using Omni to Omni antenna, with clear line of sight and no diffraction loss)
Modulation	2 level GFSK
RF Data Rate	Selectable speeds, 115.2 or 153.6 kbps
Occupied bandwidth	142 kHz
Hopping Patterns	15 per band, 105 total, user selectable
Hopping Channels	50 to 111, user selectable
Frequency Zones	16 zones
RF Connector	MMCX (Straight)
Receiver	
Sensitivity	-108 dBm at 115.2 kbps for 10^{-4} bit error rate -103 dBm at 153.6 kbps for 10^{-4} bit error rate
IF Selectivity	40 dB at $f_c \pm 230$ kHz
Dynamic Range	+10 dBm 3 rd Order Intercept Point at Input Connector
Data Transmission	
Error Detection	32 Bit CRC, retransmit on error
Data Encryption	AES 128/192/256 Bit Encryption* and Proprietary Spread Spectrum Technology
Data Interface	1200 bps to 230.4 kbps
Data Connector	Straight 14-pin dual row header 2.0 mm spacing
Data Throughput	115.2 kbps
Power Requirements	

Specification											
Operating Voltage	(± 5%) 5.0 VDC										
Typical Current (mA)	<table> <thead> <tr> <th>Mode</th> <th>+5 VDC</th> </tr> </thead> <tbody> <tr> <td>Transmit</td> <td>635</td> </tr> <tr> <td>Receive</td> <td>135</td> </tr> <tr> <td>Idle</td> <td>19</td> </tr> <tr> <td>Sleep</td> <td>6</td> </tr> </tbody> </table>	Mode	+5 VDC	Transmit	635	Receive	135	Idle	19	Sleep	6
Mode	+5 VDC										
Transmit	635										
Receive	135										
Idle	19										
Sleep	6										
General Information											
Operating Temperature Range	-40° C to +85° C (-40° F to 185° F)										
Dimensions	50.8 mm L x 36 mm W x 9.6 mm H (2" L x 1.4" W x 0.38" H)										
Weight	14 g (0.49 oz)										
Humidity	0 to 95% non-condensing										

* Contact your FreeWave reseller or sales representative for implementation details.

MM2-LV-T Specifications

The following specifications apply to the MM2-LV-T and MM2-LV-T-U models.

Specifications may change at any time without notice. For the most up-to-date specifications information, see the product's data sheet available at www.FreeWave.com.

Specification	
Frequency	902 to 928 MHz (FHSS) (DTS)
Transmitter	
Output power	10 mW to 1 W
Range	20 to 25 miles (using Omni to Omni antenna, with clear line of sight and no diffraction loss)
Modulation	2 level GFSK
RF Data Rate	Selectable speeds, 115.2 or 153.6 kbps
Occupied bandwidth	142 kHz
Hopping Patterns	15 per band, 105 total, user selectable
Hopping Channels	50 to 111, user selectable
Frequency Zones	16 zones
RF Connector	MMCX (Straight)
Receiver	
Sensitivity	-108 dBm at 115.2 kbps for 10 ⁻⁴ bit error rate -103 dBm at 153.6 kbps for 10 ⁻⁴ bit error rate

Specification											
IF Selectivity	40 dB at $f_c \pm 230$ kHz										
RF Selectivity	50 dB at 896 MHz, 935 MHz										
Dynamic Range	+10 dBm 3 rd Order Intercept Point at Input Connector										
Data Transmission											
Error Detection	32 Bit CRC, retransmit on error										
Data Encryption	AES 128/192/256 Bit Encryption* and Proprietary Spread Spectrum Technology										
Data Interface	1200 bps to 230.4 Kbps										
Data Connector	Straight 14-pin dual row header 2.0 mm spacing										
Data Throughput	115.2 kbps										
Power Requirements											
Operating Voltage	($\pm 5\%$) 3.5 VDC										
Typical Current (mA)	<table> <tr> <td>Mode</td> <td>+3.5 VDC</td> </tr> <tr> <td>Transmit</td> <td>760</td> </tr> <tr> <td>Receive</td> <td>125</td> </tr> <tr> <td>Idle</td> <td>38</td> </tr> <tr> <td>Sleep</td> <td>8</td> </tr> </table>	Mode	+3.5 VDC	Transmit	760	Receive	125	Idle	38	Sleep	8
Mode	+3.5 VDC										
Transmit	760										
Receive	125										
Idle	38										
Sleep	8										
General Information											
Operating Temperature Range	-40° C to +85° C (-40° F to 185° F)										
Dimensions	50.8 mm L x 36 mm W x 9.6 mm H (2" L x 1.4" W x 0.38" H)										
Weight	14 g (0.49 oz)										
Humidity	0 to 95% non-condensing										

* Contact your FreeWave reseller or sales representative for implementation details.

MM2-MR-T, MM2-MR-R Specifications

Specifications may change at any time without notice. For the most up-to-date specifications information, see the product's data sheet available at www.FreeWave.com.

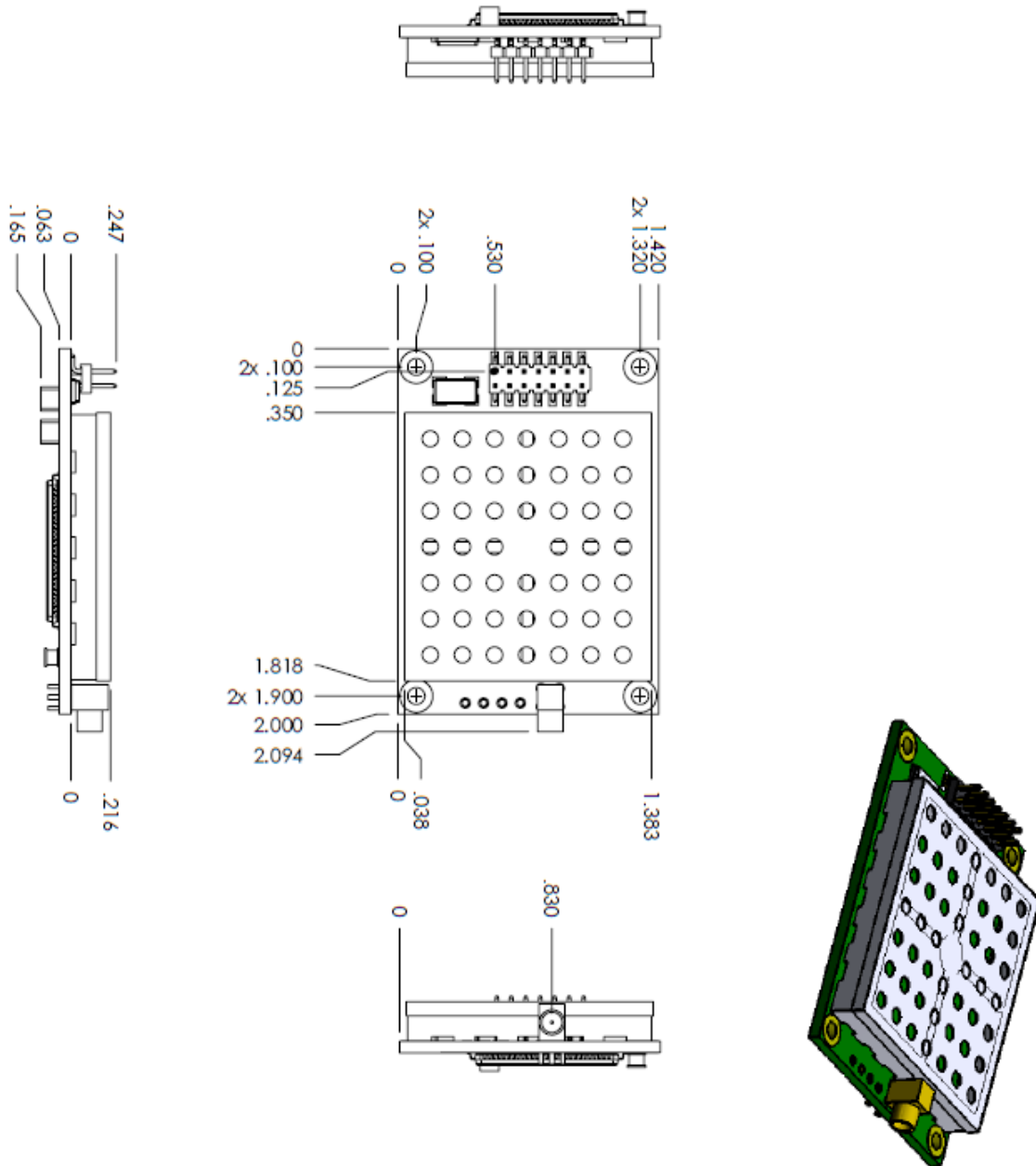
Specification									
Frequency	902-928 MHz (FHSS) (DTS)								
Transmitter									
Output Power	10 mW to 1 W								
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Occupied Bandwidth	142 kHz								
Hopping Patterns	15 per band, 105 total, user selectable								
Hopping Channels	50 to 111, user selectable								
Hopping Bands	7, user selectable								
Frequency Zones	16 zones								
RF Connector	MMCX (Straight)								
Receiver									
Sensitivity	-107 dBm at 115.2 Kbps for 10^{-4} bit error rate -102 dBm at 153.6 Kbps for 10^{-4} bit error rate								
IF Selectivity	40 dB at $f_c \pm 230$ kHz								
RF Selectivity	50 dB at 896 MHz, 935 MHz								
Dynamic Range	+10 dBm 3 rd Order Intercept Point at Input Connector								
Data Transmission									
Error Detection	32 Bit CRC, retransmit on error								
Data Encryption	Proprietary Spread Spectrum Technology								
Data Interface	1200 bps to 230.4 Kbps								
Data Connector	Board Level: 10-pin header, 0.1 inch spacing, power/data connector								
Data Throughput	115.2 Kbps								
Power Requirements									
Operating Voltage	+6.5 VDC to +30.0 VDC								
Typical Current	<table border="1"> <thead> <tr> <th>Mode</th> <th>+6.5 VDC</th> <th>+12.0 VDC</th> <th>+30.0 VDC</th> </tr> </thead> <tbody> <tr> <td>Transmit</td> <td>1 A</td> <td>500 mA</td> <td>200 mA</td> </tr> </tbody> </table>	Mode	+6.5 VDC	+12.0 VDC	+30.0 VDC	Transmit	1 A	500 mA	200 mA
Mode	+6.5 VDC	+12.0 VDC	+30.0 VDC						
Transmit	1 A	500 mA	200 mA						

Specification													
	<table><tr><td>Receive</td><td>152 mA</td><td>86 mA</td><td>43 mA</td></tr><tr><td>Idle</td><td>40 mA</td><td>21 mA</td><td>12 mA</td></tr><tr><td>Sleep</td><td>8 mA</td><td>6 mA</td><td>3 mA</td></tr></table>	Receive	152 mA	86 mA	43 mA	Idle	40 mA	21 mA	12 mA	Sleep	8 mA	6 mA	3 mA
Receive	152 mA	86 mA	43 mA										
Idle	40 mA	21 mA	12 mA										
Sleep	8 mA	6 mA	3 mA										
General Information													
Operating Temperature Range	-40° C to +85° C (-40° F to +185° F)												
Dimensions	70 mm L x 62 mm W x 9.6 mm H (2.75" L x 2.4" W x 0.40" H)												
Weight	38 g												
Humidity	0% to 95% non-condensing												

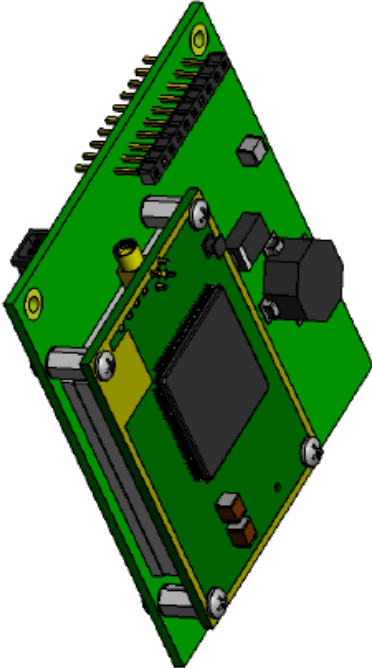
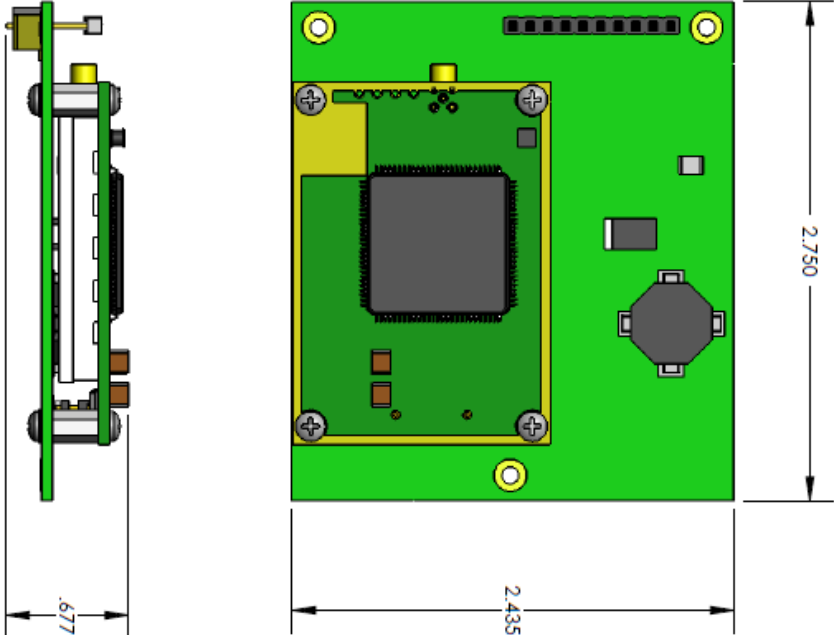
Mechanical Drawings

This section provides mechanical drawings of each model number that include overall radio dimensions, connector measurements, and so on.

MM2-LV-T, MM2-T Mechanical Drawing



MM2-MR-R, MM2-MR-T Mechanical Drawing



Chapter 3: Integration

Keep the following integration points in mind, when embedding a FreeWave radio into your OEM equipment:

- RS232 signals range from -15.0 to +15.0 and TTL signals range from 0 to +5 V.
- FreeWave radios are shielded to prevent any unintended emission. Depending on the OEM equipment design, additional shielding may be required to prevent the OEM equipment from interfacing with the FreeWave device.
- To connect the radio to the OEM device without modifying the OEM circuit board, see the cable options and connector pinouts in this guide. The OEM equipment needs to support TTL signals for the MM2-T.

In addition, this chapter provides information about the following elements to consider:

- Current Measurements
- TTL Signals and Timing
- PCB Board Design Guidelines

Current Measurements

The embedded radios discussed in this manual have the following current measurements.

MM2-T				
Supply: +5 V ($\pm 5\%$); Method 4T				
Xmit Power (mA)	TX Current (mA)		Xmit Power (mA)	TX Current (mA)
10	794		4	334
9	676		3	280
8	584		2	266
7	510		1	240
6	429		0	180
5	383			

MM2-LV-T				
Supply: +3.5 V ($\pm 5\%$); Method: 4T				
Xmit Power (mA)	TX Current (mA)		Xmit Power (mA)	TX Current (mA)
10	830		4	478
9	750		3	435
8	691		2	407
7	633		1	373
6	569		0	244
5	525			

TTL Signals and Timing

Timing	Measurement	Notes
Output Low Level Voltage (V_{OL})	0.0 to 0.35 VDC	The positive voltage from an output which the device considers will be accepted as a logic low.
Input Low Level Voltage (V_{IL})	0.0 to 0.8 VDC	The positive voltage applied to the input which will be accepted by the device as a logic low.
Input High Level Voltage (V_{IH})	2.0 to 5.0 VDC	The positive voltage applied to the input which will be accepted by the device as a logic high.
Output High Level Voltage (V_{OH})	2.0 to 3.3 VDC	The positive voltage from an output which the device considers will be accepted as a logic high.
Data Format	Mark = 3.3 V Space = 0 V	RS232 formatted data, inverted.

Chapter 4: Networks and Programming

This chapter provides information about setting up your network and how to program the transceiver configuration settings. For detailed information about each setting, see the user guide for the transceiver you are integrating.

Setting Up the Network

When designing and setting up a Point-to-Multipoint network, FreeWave recommends using Network IDs and Subnet IDs to route communications back to the Master. Only use the Call Book for small networks that contain under 10 Slaves, as it is limited to 10 Slaves with or without Repeaters in Point-to-Point networks. Repeaters are limited to 2 per Slave for 10 Slaves maximum, or 4 per Slave for 5 Slaves maximum. For more information about setting up networks, see the user guide for the transceiver you are integrating.

As you design and deploy your network, document your design including all the items listed below. This information can help you troubleshoot your network, and also help you as you expand your network.

- All radio settings.
- Radio serial numbers.
- Model numbers.
- Tower heights.
- Exact geographic locations.
- Any other parameters that can affect radio communication.

Programming Methods

Each FreeWave radio has a series of commands and settings that you can define that determine how the radio functions. You can access these commands in the following ways:

- **Tool Suite** - Most, but not all OEM radios are available for configuration using the FreeWave Tool Suite application. Tool Suite provides a group of tools for configuring the devices in your network and for monitoring your network's performance. Using the Configuration application within Tool Suite, you can program changes to your transceiver's settings.

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

- **Terminal Emulator** - A terminal emulator program, such as HyperTerminal or Tera Term, offers many of the same configuration options that are available in the Configuration application in Tool Suite. Terminal emulators vary in cost, and several are downloadable free of charge. If you run versions of the Windows operating system prior to Windows 7, HyperTerminal is included in the operating system installation. However, if you are running Windows 7 or newer, HyperTerminal is no longer available.



You can use the terminal emulator program of your choice to program the transceiver. The Setup Terminal application within Tool Suite provides the same interface that is available using a terminal emulator.

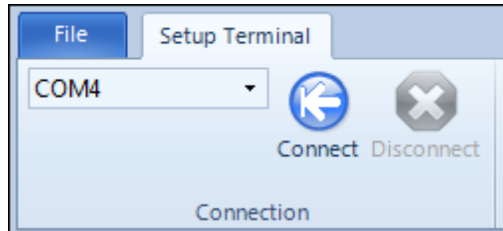
Accessing the Setup Menu Using a Terminal Emulator

Use a terminal emulator of your choice to access the Setup menu. For any terminal emulator application, plug the serial cable into a COM port on the transceiver, open a session, and ensure that the port settings are set to the following for a proper connection to the transceiver:

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

The following instructions describe how to access the transceiver's Setup menu using the Setup Terminal application within Tool Suite. Setup Terminal contains the port settings above, by default. For more information about using Tool Suite, see the *Tool Suite User Manual* available on the *User Manual and System Tools* CD or by selecting **File > Help** in the Tool Suite software

1. Plug a serial cable into the COM 1 port on the transceiver, connect the cable to a COM port on the computer running Tool Suite, and connect the transceiver to a power source.
2. Open Tool Suite and select Setup Terminal in the Applications pane.
3. From the drop-down list at the top left of the window, select the COM port on the computer to which the transceiver is connected.



4. Click **Connect**.
5. Place the transceiver in Setup Mode.
 - Short Pin 2 to ground. For pin location, see ["Embedded Radio Connector Pinouts" on page 3](#).
 - If using a data cable (FreeWave part number: ASC3610DB or ASC3610DJ), press the Setup button on the data cable.

If you are using the gray ribbon diagnostic cable (part number: AC2009DC), or the black diagnostic cable (part number: ASC0409DC), the transceiver changes to Setup mode automatically when you click Read Radio in Tool Suite.

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

```
(0)  Set Operation Mode
(1)  Set Baud Rate
(2)  Edit Call Book
(3)  Edit Radio Transmission Characteristics
(4)  Show Radio Statistics
(5)  Edit MultiPoint Parameters
(6)  TDMA Menu
(8)  Chg Password
(Esc) Exit Setup
```

Enter Choice _

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

Using Tool Suite to Connect to and Program Transceivers

1. Connect a serial or diagnostic cable between the computer or laptop and the radio.
2. Connect the power supply to the transceiver and the power source and turn on the radio.
3. With the radio connected to the computer in Tool Suite, click Configuration in the Application pane to display the Configuration application.
4. Ensure the correct port is selected in the **Com Port** field in the Configuration ribbon.
5. To place the transceiver in Setup mode, short pins 2 & 4 (Brown to Black) on the 10 pin header next to the LEDs.

If using a Data Cable (FreeWave part number: ASC3610DB or ASC3610DJ), press the Setup button on the data cable. If using a Data Cable (P/N ASC3610DB or ASC3610DJ), press the Setup button. If using the gray ribbon Diagnostic Cable (P/N AC2009DC), or the black Diagnostic Cable (P/N ASC0409DC), press **Shift-U** (capital **U**) to invoke the Setup menu.

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

6. Click **Read Radio** in the Configuration ribbon to read the transceiver's current settings.
7. Make the necessary parameter changes and do one of the following to send the changes to the transceiver.
 - To send only the parameters you have changed , within the Configuration application, in the Network Title ribbon, click **Quick**.
 - To send all the settings for all parameters, within the Configuration application, in the Network Title ribbon, click **All**.
 - To set a device back to its factory default settings, within the Configuration application, in the Network Title ribbon, click **Default**.

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

Settings to Note

Each of the parameters available to set on each model is described in detail in the user manual for that model. However, when setting up your network and defining parameters, especially note the following parameter settings for your OEM setup.

Low Power Mode

Note: This setting applies only to Multipoint Slave transceivers using the RS232 protocol. Low Power Mode does not work with MultiPoint Repeaters because they are constantly transmitting. RS232 protocol is available in the MM2-MR-R models.

FreeWave transceivers can be programmed to a low power state for battery/solar operation. There are several settings to the **Low Power Mode**, the higher the setting the lower the power. The transceiver can operate as low as 6 mA in the lowest power mode compared to 25 mA in idle mode. The transceiver also dims its LEDs to save power in this mode.

A Slave in a Multipoint network set to use **Low Power Mode** takes slightly longer to communicate with the Master.

For more information about **Low Power Mode**, see the user guide for the transceiver you are integrating.

Diagnostics

The **Diagnostics** setting allows diagnostics data to be viewed at the Master in parallel with application data. The setting in this parameter determines how many slots out of 128 are dedicated to diagnostics. For example, if you set to 10, 1 out of every 10 data slots is for diagnostics data; if you set to 100, 1 out of every 100 data slots is for diagnostics data. The diagnostic program must be run from the Master transceiver.

Note: Diagnostics is always secondary to actual transmitted data.

Diagnostics requires the following:

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

Chapter 5: Troubleshooting

The main areas to address when initially troubleshooting a radio network are as follows:
















- LEDs on the radio
- Radio Settings
- RF Quality

If you are experiencing trouble with a radio in you network, use the troubleshooting information available in this chapter to help determine the issue. If you continue to have issues, contact FreeWave Technical Support.

Troubleshooting

My radio does not stay in Setup mode and I am not able to program it through the diagnostics port. when I try to place the radio into Setup mode, all three LEDs flash green, and then go back to their previous state.

Additional symptoms of this problem include:

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

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

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

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

If there is a data source (PLC, RTU, PC, or Terminal Server) connected to the data port data is coming into the data port while you are trying to access Setup through the diagnostics port.

1. Disconnect the data source and place the radio into Setup.
2. Change **Setup Port** parameter in the Baud Rate tab to **Diagnostic Only**.

My transceivers are linked, but I cannot pass data.

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

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

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

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

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

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

Repeater 2 is experiencing high noise.

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

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

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

There is a "chatty" Slave in the network. The Slave is not getting acknowledgement of data it sends to the Master and it keeps trying to resend data to the Master locking out all other communications to the Master.

This is typically caused by a bad signal from the Slave to the Master. Verify line of sight, antenna direction, and noise levels at the Slave.

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

LOS (Line of Sight) issue or settings issue.

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

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

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

Baud rate above 38,400 may need flow control line connected.

Troubleshooting Flowchart

