



41039 Boyce Road
Fremont, CA. 94538

510-578-3500 Phone
510-440-9525 Fax

EMC Test Report

Application for FCC Grant of Equipment Authorization Canada Certification

Innovation, Science and Economic Development Canada RSS-Gen Issue 5 / RSS-247 Issue 2 FCC Part 15 Subpart C

Models: MM3-T and MM3-T-U

FCC ID: KNYMM3
ISED CERTIFICATION #: 2392B-MM3

APPLICANT: FreeWave Technologies, Inc.
32605 Endeavour Way
Union City, CA 94587

TEST SITE(S): National Technical Systems
41039 Boyce Road.
Fremont, CA. 94538-2435

IC SITE REGISTRATION #: 2845B-7

PROJECT NUMBER: PR117299

REPORT DATE: July 10, 2020

RE_ISSUED DATE: August 24, 2020

FINAL TEST DATES: May 11, 12, 13, 14 and 15, 2020

TOTAL NUMBER OF PAGES: 94



This report and the information contained herein represent the results of testing of only those articles / products identified in this document and selected by the client. The tests were performed to specifications and/or procedures selected by the client. National Technical Systems (NTS) makes no representations expressed or implied that such testing fully demonstrates efficiency, performance, reliability, or any other characteristic of the articles being tested, or similar products. This report should not be relied upon as an endorsement or certification by NTS of the equipment tested, nor does it present any statement whatsoever as to its merchantability or fitness of the test article or similar products, for a particular purpose. This report shall not be reproduced except in full without written approval from NTS.



VALIDATING SIGNATORIES

PROGRAM MGR

A handwritten signature in black ink that reads "David W. Bare".

David W. Bare
Chief Engineer

TECHNICAL REVIEWER:

A handwritten signature in black ink that reads "David W. Bare".

David W. Bare
Chief Engineer

FINAL REPORT PREPARER:

A handwritten signature in blue ink that reads "David Guidotti".

David Guidotti
Senior Technical Writer

QUALITY ASSURANCE DELEGATE

A handwritten signature in black ink that reads "Gary Izard".

Gary Izard
Quality Assurance Representative



REVISION HISTORY

Rev#	Date	Comments	Modified By
-	July 10, 2020	First release	
1	August 24, 2020	Added test results below 30 MHz	dwb

TABLE OF CONTENTS

COVER PAGE.....	1
VALIDATING SIGNATORIES	2
REVISION HISTORY	3
TABLE OF CONTENTS	4
SCOPE.....	5
OBJECTIVE	5
STATEMENT OF COMPLIANCE.....	6
DEVIATIONS FROM THE STANDARDS.....	6
TEST RESULTS SUMMARY	7
FREQUENCY HOPPING SPREAD SPECTRUM (902 – 928 MHZ, 50 CHANNELS OR MORE)	7
MEASUREMENT UNCERTAINTIES.....	9
EQUIPMENT UNDER TEST (EUT) DETAILS.....	10
GENERAL.....	10
OTHER EUT DETAILS.....	10
ANTENNA SYSTEM	10
ENCLOSURE.....	10
MODIFICATIONS.....	10
SUPPORT EQUIPMENT.....	10
EUT INTERFACE PORTS	11
EUT OPERATION	11
TEST SITE.....	12
GENERAL INFORMATION	12
CONDUCTED EMISSIONS CONSIDERATIONS	12
RADIATED EMISSIONS CONSIDERATIONS	12
MEASUREMENT INSTRUMENTATION	13
RECEIVER SYSTEM	13
INSTRUMENT CONTROL COMPUTER	13
LINE IMPEDANCE STABILIZATION NETWORK (LISN).....	13
FILTERS/ATTENUATORS	14
ANTENNAS.....	14
ANTENNA MAST AND EQUIPMENT TURNTABLE	14
INSTRUMENT CALIBRATION.....	14
TEST PROCEDURES	15
EUT AND CABLE PLACEMENT	15
CONDUCTED EMISSIONS.....	15
RADIATED EMISSIONS	15
CONDUCTED EMISSIONS FROM ANTENNA PORT	19
BANDWIDTH MEASUREMENTS	19
SPECIFICATION LIMITS AND SAMPLE CALCULATIONS.....	20
CONDUCTED EMISSIONS SPECIFICATION LIMITS: FCC 15.207; RSS GEN.....	20
GENERAL TRANSMITTER RADIATED EMISSIONS SPECIFICATION LIMITS	20
OUTPUT POWER LIMITS – FHSS SYSTEMS	21
TRANSMIT MODE SPURIOUS RADIATED EMISSIONS LIMITS – FHSS AND DTS SYSTEMS.....	21
SAMPLE CALCULATIONS - CONDUCTED EMISSIONS	22
SAMPLE CALCULATIONS - RADIATED EMISSIONS.....	22
SAMPLE CALCULATIONS - FIELD STRENGTH TO EIRP CONVERSION.....	23
APPENDIX A TEST EQUIPMENT CALIBRATION DATA	24
APPENDIX B TEST DATA	26
END OF REPORT	94

SCOPE

An electromagnetic emissions test has been performed on the FreeWave Technologies, Inc. model MM3-T, pursuant to the following rules:

RSS-GEN Issue 5 “General Requirements for Compliance of Radio Apparatus”

RSS 247 Issue 2 “Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSS) and Licence-Exempt Local Area Network (LE-LAN) Devices”

FCC Part 15 Subpart C

Conducted and radiated emissions data has been collected, reduced, and analyzed within this report in accordance with measurement guidelines set forth in the following reference standards and as outlined in National Technical Systems test procedures:

ANSI C63.10-2013

The intentional radiator above has been tested in a simulated typical installation to demonstrate compliance with the relevant Industry Canada performance and procedural standards.

Final system data was gathered in a mode that tended to maximize emissions by varying orientation of EUT, orientation of power and I/O cabling, antenna search height, and antenna polarization.

Every practical effort was made to perform an impartial test using appropriate test equipment of known calibration. All pertinent factors have been applied to reach the determination of compliance.

National Technical Systems is accredited by the A2LA, certificate number 0214.26, to perform the test(s) listed in this report, except where noted otherwise.

OBJECTIVE

The primary objective of the manufacturer is compliance with the regulations outlined in the previous section.

Prior to marketing in the USA, all unlicensed transmitters and transceivers require certification. Receive-only devices operating between 30 MHz and 960 MHz are subject to either certification or a manufacturer’s declaration of conformity, with all other receive-only devices exempt from the technical requirements.

Prior to marketing in Canada, Class I transmitters, receivers and transceivers require certification. Class II devices are required to meet the appropriate technical requirements but are exempt from certification requirements.

Certification is a procedure where the manufacturer submits test data and technical information to a certification body and receives a certificate or grant of equipment authorization upon successful completion of the certification body's review of the submitted documents. Once the equipment authorization has been obtained, the label indicating compliance must be attached to all identical units, which are subsequently manufactured.

Maintenance of compliance is the responsibility of the manufacturer. Any modification of the product which may result in increased emissions should be checked to ensure compliance has been maintained (i.e., printed circuit board layout changes, different line filter, different power supply, harnessing or I/O cable changes, etc.).

Testing was performed only on model MM3-T. This model was considered representative of the MM3-T and MM3-T-U. Refer to the product description section starting on page 10 for full details.

STATEMENT OF COMPLIANCE

The tested sample of FreeWave Technologies, Inc. model MM3-T complied with the requirements of the following regulations:

RSS-GEN Issue 5 "General Requirements for Compliance of Radio Apparatus"
RSS 247 Issue 2 "Digital Transmission Systems (DTSSs), Frequency Hopping Systems (FHSS) and Licence-Exempt Local Area Network (LE-LAN) Devices"
FCC Part 15 Subpart C

Maintenance of compliance is the responsibility of the manufacturer. Any modifications to the product should be assessed to determine their potential impact on the compliance status of the device with respect to the standards detailed in this test report.

The test results recorded herein are based on a single type test of FreeWave Technologies, Inc. model MM3-T and therefore apply only to the tested sample. The sample was selected and prepared by Riaz Momand of FreeWave Technologies, Inc.

DEVIATIONS FROM THE STANDARDS

No deviations were made from the published requirements listed in the scope of this report.

TEST RESULTS SUMMARY

FREQUENCY HOPPING SPREAD SPECTRUM (902 – 928 MHz, 50 channels or more)

FCC Rule Part	RSS Rule Part	Description	Measured Value / Comments	Limit / Requirement	Result
15.247 (a) (1) (i)	RSS 247 5.1 (1) & (3)	20dB Bandwidth	194 kHz	≤ 500 kHz	Complies
15.247 (a) (1)	RSS 247 5.1 (2)	Channel Separation	230 kHz	Channel spacing > 20dB bandwidth (minimum 25kHz)	Complies
15.247 (a) (1) (i)	RSS 247 5.1 (3)	Number of Channels	50-110	50 or more	Complies
15.247 (a) (1) (i)	RSS 247 5.1 (3)	Channel Dwell Time	116.4ms	<0.4 second within a 20 second period	Complies
15.247 (a) (1)	RSS 247 5.1 (1)	Channel Utilization	All channels are used equally - refer to the operational description for full explanation	All channels shall, on average, be used equally	Complies
15.247 (b) (3)	RSS 247 5.4 (1)	Output Power 5dBi Omni	29.9 dBm (0.9772 W) EIRP = 3.09 W ^{Note 1}	1Watt, EIRP ≤ 4 Watts	Complies
		Output Power 8.15dBi Omni	27.4 dBm (0.5494 W) EIRP = 3.59 W ^{Note 1}		
		Output Power 12dBi Yagi	23.8 dBm (0.2399 W) EIRP = 3.80 W ^{Note 1}		
15.247 (d)	RSS 247 5.5	Antenna Port Spurious Emissions 30MHz – 9.28 GHz	All spurious emissions < -20dBc	< -20dBc	Complies
15.247 (d) / 15.209	RSS 247 5.5	Radiated Spurious Emissions 30MHz – 9.28 GHz	5dBi Omni: 105.6 dB μ V/m @ 928.00 MHz (-2.3 dB)	Refer to the limits section (p20) for restricted bands, all others < -20dBc	Complies
			8.15dBi Omni: 108.3 dB μ V/m @ 928.00 MHz (-1.4 dB)		
			12dBi Yagi: 110.2 dB μ V/m @ 927.76 MHz (Margin: -2.1 dB)		
15.247 (d) / 15.209	RSS 247 5.5	Radiated Spurious Emissions 400kHz - 30MHz	No emissions observed above the noise floor	Refer to the limits section (p20) for restricted bands	Complies
15.247 (a) (1)	RSS 247 5.1(2)	Receiver bandwidth	Refer to operational description	Shall match the channel bandwidth	Complies

Note 1: EIRP calculated using antenna gain of 5, 8.15 or 12 dBi .

GENERAL REQUIREMENTS APPLICABLE TO ALL BANDS

FCC Rule Part	RSS Rule part	Description	Measured Value / Comments	Limit / Requirement	Result (margin)
15.203	-	RF Connector	Custom RF connector	Unique or integral antenna required	Complies
15.407 (b) (6)	RSS-Gen Table 4	AC Conducted Emissions	38.8 dB μ V @ 0.17 MHz (-16.2 dB)	Refer to page 20	Complies
15.247 (i) 15.407 (f)	RSS 102	RF Exposure Requirements	Refer to MPE calculations in separate exhibit, RSS 102 declaration and User Manual statements.	Refer to OET 65, FCC Part 1 and RSS 102	Complies
-	RSS-Gen 6.8	User Manual	Refer to separate exhibit	Statement for products with detachable antenna	Complies
-	RSS-Gen 8.4	User Manual	Refer to separate exhibit	Statement for all products	Complies

MEASUREMENT UNCERTAINTIES

ISO/IEC 17025 requires that an estimate of the measurement uncertainties associated with the emissions test results be included in the report. The measurement uncertainties given below are based on a 95% confidence level and were calculated in accordance with UKAS document LAB 34.

Measurement Type	Measurement Unit	Frequency Range	Expanded Uncertainty
RF power, conducted (power meter)	dBm	25 to 7000 MHz	± 0.52 dB
RF power, conducted (Spectrum analyzer)	dBm	25 to 7000 MHz	± 0.7 dB
Conducted emission of transmitter	dBm	25 to 26500 MHz	± 0.7 dB
Conducted emission of receiver	dBm	25 to 26500 MHz	± 0.7 dB
Radiated emission (substitution method)	dBm	25 to 26500 MHz	± 2.5 dB
Radiated emission (field strength)	dB μ V/m	25 to 1000 MHz	± 3.6 dB
		1000 to 40000 MHz	± 6.0 dB
Conducted Emissions (AC Power)	dB μ V	0.15 to 30 MHz	± 2.4 dB

EQUIPMENT UNDER TEST (EUT) DETAILS**GENERAL**

The FreeWave Technologies, Inc. model MM3-T is a 900MHz frequency hopping transceiver module that is designed to be installed in host equipment. Since the EUT could be placed in any position during operation, the EUT was treated as tabletop equipment during testing to simulate the end-user environment. The electrical rating of the EUT is 5 VDC, 0.86 Amps. The electrical rating of the AC adapter supplied for testing is 100-240 Volts, 50/60 Hz and 0.4 Amps

The sample was received on May 11, 2020 and tested on May 11, 12, 13, 14 and 15, 2020. The EUT consisted of the following component(s):

Company	Model	Description	Serial Number	FCC ID
FreeWave Technologies, Inc.	MM3-T	Frequency Hopping Transceiver	9712854	KNYMM3

OTHER EUT DETAILS

The following EUT details should be noted: The MM3-T and MM3-T-U are identical except use different model numbers for marketing purposes.

ANTENNA SYSTEM

The antennas tested with the system were a 5dBi Omni, a 8.15dBi Omni and a 12dBi Yagi.

ENCLOSURE

The EUT does not have an enclosure as it is intended to be installed in host equipment.

MODIFICATIONS

No modifications were made to the EUT during the time the product was at NTS Silicon Valley.

SUPPORT EQUIPMENT

The following equipment was used as support equipment for testing:

Company	Model	Description	Serial Number	FCC ID
Shenzhen Mingxin Power Technologies	KSAS0121200080HU	AC Adapter	-	-
FreeWave	-	MM2 Serial Interface	402-6602-2777	-

The following equipment was used as remote support equipment for emissions testing:

Company	Model	Description	Serial Number	FCC ID
Toshiba	PSK0GU-0CT002	Laptop	1B250508W	-

EUT INTERFACE PORTS

The I/O cabling configuration during testing was as follows:

EUT

Port	Connected To	Cable(s)		
		Description	Shielded or Unshielded	Length(m)
RF	Antenna	Coax	Shielded	0.4

Additional on Support Equipment

Port	Connected To	Cable(s)		
		Description	Shielded or Unshielded	Length(m)
Laptop USB	MM2 Serial Interface	Multiwire	Shielded	1.6
MM2 Serial Interface	AC Adapter	Two wire	Unshielded	1.6
Laptop Power	AC Adapter	Two wire	Unshielded	1.5

EUT OPERATION

During emissions testing the EUT was set to transmit at the specified power setting continuously in either CW or hopping mode depending on the test and in receive mode for receiver tests using test software on the Laptop.

TEST SITE**GENERAL INFORMATION**

Final test measurements were taken at the test sites listed below. Pursuant to section 2.948 of the FCC's Rules and section 6.2 of RSS-GEN, NTS has been recognized as an accredited test laboratory by the Commission and Innovation, Science and Economic Development Canada. A description of the facilities employed for testing is maintained by NTS.

Site	Company / Registration Numbers		Location
	FCC	Canada	
Chamber 7	US1031	2845B (Wireless Test Lab #US0027)	41039 Boyce Road Fremont, CA 94538-2435

ANSI C63.4 recommends that ambient noise at the test site be at least 6 dB below the allowable limits. Ambient levels are below this requirement. The test site(s) contain separate areas for radiated and conducted emissions testing. Results from testing performed in this chamber have been correlated with results from an open area test site. Considerable engineering effort has been expended to ensure that the facilities conform to all pertinent requirements of ANSI C63.4.

CONDUCTED EMISSIONS CONSIDERATIONS

Conducted emissions testing is performed in conformance with ANSI C63.10. Measurements are made with the EUT connected to the public power network through a nominal, standardized RF impedance, which is provided by a line impedance stabilization network, known as a LISN. A LISN is inserted in series with each current-carrying conductor in the EUT power cord.

RADIATED EMISSIONS CONSIDERATIONS

The FCC has determined that radiation measurements made in a shielded enclosure are not suitable for determining levels of radiated emissions. Radiated measurements are performed in an open field environment or in a semi-anechoic chamber. The test sites are maintained free of conductive objects within the CISPR defined elliptical area incorporated in ANSI C63.4 guidelines and meet the Normalized Site Attenuation (NSA) requirements of ANSI C63.4.

MEASUREMENT INSTRUMENTATION

RECEIVER SYSTEM

An EMI receiver as specified in CISPR 16-1-1 is used for emissions measurements. The receivers used can measure over the frequency range of 9 kHz up to 2000 MHz. These receivers allow both ease of measurement and high accuracy to be achieved. The receivers have Peak, Average, and CISPR (Quasi-peak) detectors built into their design so no external adapters are necessary. The receiver automatically sets the required bandwidth for the CISPR detector used during measurements. If the repetition frequency of the signal being measured is below 20Hz, peak measurements are made in lieu of Quasi-Peak measurements.

For measurements above the frequency range of the receivers, a spectrum analyzer is utilized because it provides visibility of the entire spectrum along with the precision and versatility required to support engineering analysis. Average measurements above 1000MHz are performed on the spectrum analyzer using the linear-average method with a resolution bandwidth of 1 MHz and a video bandwidth of 10 Hz, unless the signal is pulsed in which case the average (or video) bandwidth of the measuring instrument is reduced to onset of pulse desensitization and then increased.

INSTRUMENT CONTROL COMPUTER

Software is used to view and convert receiver measurements to the field strength at an antenna or voltage developed at the LISN measurement port, which is then compared directly with the appropriate specification limit. This provides faster, more accurate readings by performing the conversions described under Sample Calculations within the Test Procedures section of this report. Results are printed in a graphic and/or tabular format, as appropriate. A personal computer is used to record all measurements made with the receivers. The software used for radiated and conducted emissions measurements is NTS EMI Test Software (rev 2.10)

LINE IMPEDANCE STABILIZATION NETWORK (LISN)

Line conducted measurements utilize a fifty microhenry Line Impedance Stabilization Network as the monitoring point. The LISN used also contains a 250 uH CISPR adapter. This network provides for calibrated radio frequency noise measurements by the design of the internal low pass and high pass filters on the EUT and measurement ports, respectively.

FILTERS/ATTENUATORS

External filters and precision attenuators are often connected between the receiving antenna or LISN and the receiver. This eliminates saturation effects and non-linear operation due to high amplitude transient events.

ANTENNAS

A loop antenna is used below 30 MHz. For the measurement range 30 MHz to 1000 MHz either a combination of a biconical antenna and a log periodic or a bi-log antenna is used. Above 1000 MHz, horn antennas are used. The antenna calibration factors to convert the received voltage to an electric field strength are included with appropriate cable loss and amplifier gain factors to determine an overall site factor, which is then programmed into the test receivers or incorporated into the test software.

ANTENNA MAST AND EQUIPMENT TURNTABLE

The antennas used to measure the radiated electric field strength are mounted on a non-conductive antenna mast equipped with a motor-drive to vary the antenna height. Measurements below 30 MHz are made with the loop antenna at a fixed height of 1m above the ground plane.

ANSI C63.10 specifies that the test height above ground for table mounted devices shall be 80 centimeters for testing below 1 GHz and 1.5m for testing above 1 GHz. Floor mounted equipment shall be placed on the ground plane if the device is normally used on a conductive floor or separated from the ground plane by insulating material from 3 to 12 mm if the device is normally used on a non-conductive floor as specified in ANSI C63.4. During radiated measurements, the EUT is positioned on a motorized turntable in conformance with this requirement.

INSTRUMENT CALIBRATION

All test equipment is regularly checked to ensure that performance is maintained in accordance with the manufacturer's specifications. All antennas are calibrated at regular intervals with respect to tuned half-wave dipoles. An exhibit of this report contains the list of test equipment used and calibration information.

TEST PROCEDURES

EUT AND CABLE PLACEMENT

The regulations require that interconnecting cables be connected to the available ports of the unit and that the placement of the unit and the attached cables simulate the worst case orientation that can be expected from a typical installation, so far as practicable. To this end, the position of the unit and associated cabling is varied within the guidelines of ANSI C63.10, and the worst-case orientation is used for final measurements.

CONDUCTED EMISSIONS

Conducted emissions are measured at the plug end of the power cord supplied with the EUT. Excess power cord length is wrapped in a bundle between 30 and 40 centimeters in length near the center of the cord. Preliminary measurements are made to determine the highest amplitude emission relative to the specification limit for all the modes of operation. Placement of system components and varying of cable positions are performed in each mode. A final peak mode scan is then performed in the position and mode for which the highest emission was noted on all current carrying conductors of the power cord.

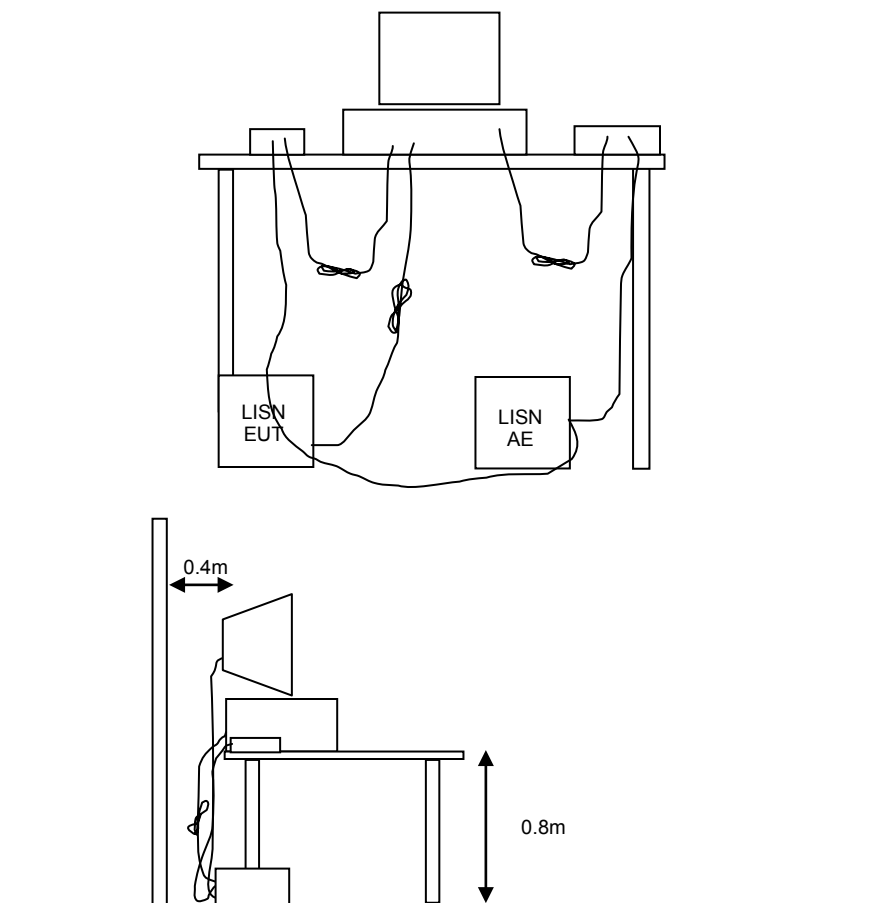


Figure 1 Typical Conducted Emissions Test Configuration

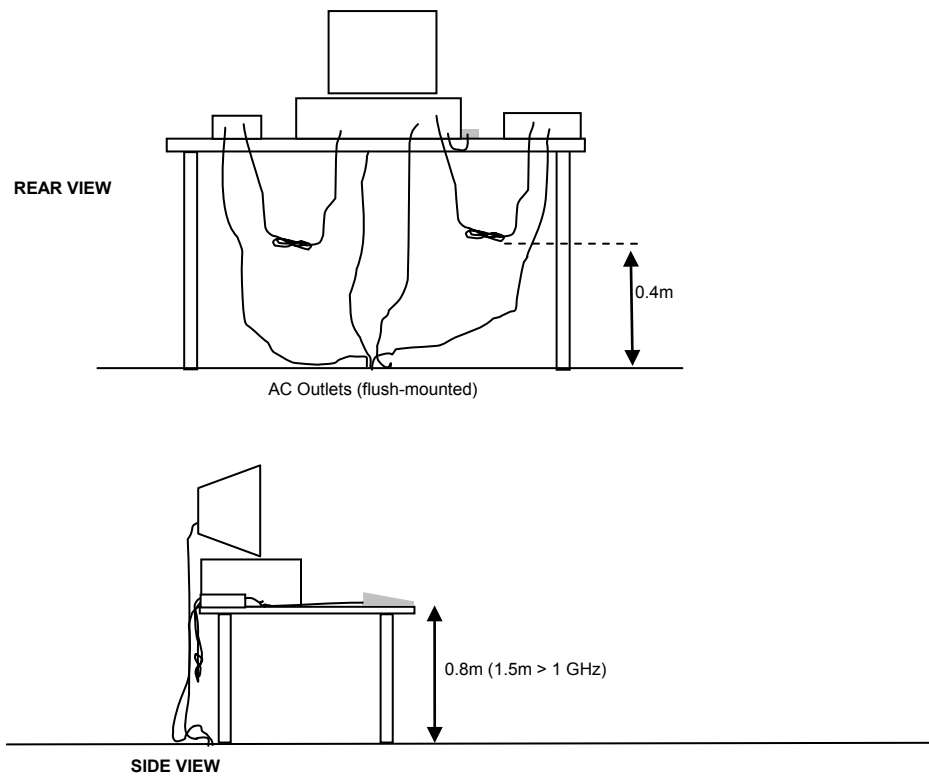
RADIATED EMISSIONS

A preliminary scan of the radiated emissions is performed in which all significant EUT frequencies are identified with the system in a nominal configuration. At least two scans are performed, one scan for each antenna polarization (horizontal and vertical; loop parallel and perpendicular to the EUT). During the preliminary scans, the EUT is rotated through 360°, the antenna height is varied (for measurements above 30 MHz) and cable positions are varied to determine the highest emission relative to the limit. Preliminary scans may be performed in a fully anechoic chamber for the purposes of identifying the frequencies of the highest emissions from the EUT.

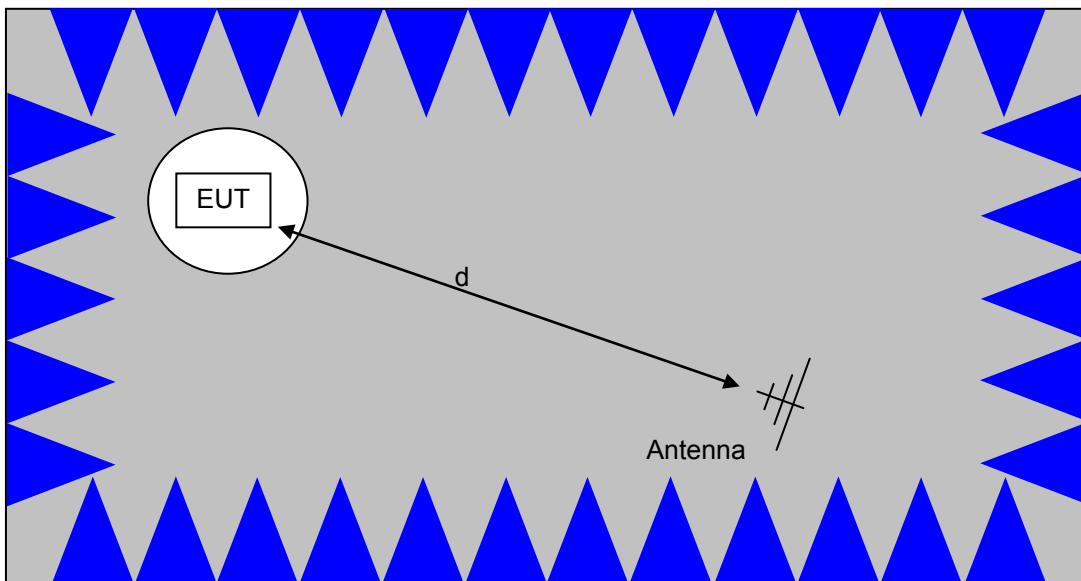
A speaker is provided in the receiver to aid in discriminating between EUT and ambient emissions. Other methods used during the preliminary scan for EUT emissions involve scanning with near field magnetic loops, monitoring I/O cables with RF current clamps, and cycling power to the EUT.

Final maximization is a phase in which the highest amplitude emissions identified in the spectral search are viewed while the EUT azimuth angle is varied from 0 to 360 degrees relative to the receiving antenna. The azimuth, which results in the highest emission is then maintained while varying the antenna height from one to four meters (for measurements above 30 MHz, measurements below 30 MHz are made with the loop antenna at a fixed height of 1m). The result is the identification of the highest amplitude for each of the highest peaks. Each recorded level is corrected in the receiver using appropriate factors for cables, connectors, antennas, and preamplifier gain.

When testing above 18 GHz, the receive antenna is located at 1 meter from the EUT and the antenna height is restricted to a maximum of 2.5 meters.

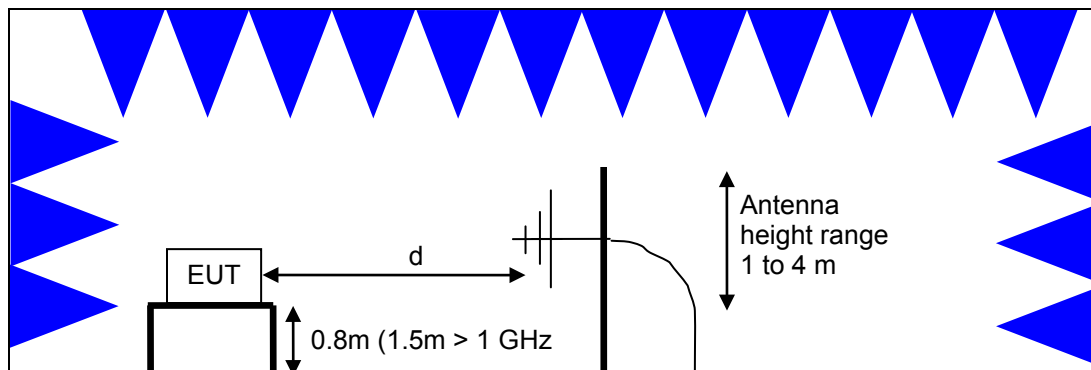


Typical Test Configuration for Radiated Field Strength Measurements



The anechoic materials on the walls and ceiling ensure compliance with the normalized site attenuation requirements of CISPR 16 / CISPR 22 / ANSI C63.4 for an alternate test site at the measurement distances used.

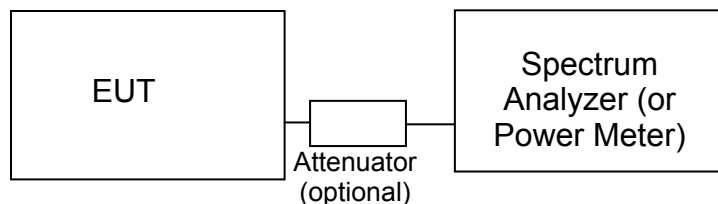
Floor-standing equipment is placed on the floor with insulating supports between the unit and the ground plane.



Test Configuration for Radiated Field Strength Measurements
Semi-Anechoic Chamber, Plan and Side Views

CONDUCTED EMISSIONS FROM ANTENNA PORT

Direct measurements of power, bandwidth and power spectral density are performed, where possible, with the antenna port of the EUT connected to either the power meter or spectrum analyzer via a suitable attenuator and/or filter. These are used to ensure that the front end of the measurement instrument is not overloaded by the fundamental transmission.

**Test Configuration for Antenna Port Measurements**

Measurement bandwidths (video and resolution) are set in accordance with the relevant standards and NTS Silicon Valley's test procedures for the type of radio being tested. When power measurements are made using a resolution bandwidth less than the signal bandwidth the power is calculated by summing the power across the signal bandwidth using either the analyzer channel power function or by capturing the trace data and calculating the power using software. In both cases the summed power is corrected to account for the equivalent noise bandwidth (ENBW) of the resolution bandwidth used.

If power averaging is used (typically for certain digital modulation techniques), the EUT is configured to transmit continuously. Power averaging is performed using either the built-in function of the analyzer or, if the analyzer does not feature power averaging, using external software. In both cases the average power is calculated over a number of sweeps (typically 100). When the EUT cannot be configured to continuously transmit then either the analyzer is configured to perform a gated sweep to ensure that the power is averaged over periods that the device is transmitting or power averaging is disabled and a max-hold feature is used.

If a power meter is used to make output power measurements the sensor head type (peak or average) is stated in the test data table.

BANDWIDTH MEASUREMENTS

The 6dB, 20dB, 26dB and/or 99% signal bandwidth are measured using the bandwidths recommended by ANSI C63.10 and RSS GEN.

SPECIFICATION LIMITS AND SAMPLE CALCULATIONS

The limits for conducted emissions are given in units of microvolts, and the limits for radiated emissions are given in units of microvolts per meter at a specified test distance. Data is measured in the logarithmic form of decibels relative to one microvolt, or dB microvolts (dBuV). For radiated emissions, the measured data is converted to the field strength at the antenna in dB microvolts per meter (dBuV/m). The results are then converted to the linear forms of uV and uV/m for comparison to published specifications.

For reference, converting the specification limits from linear to decibel form is accomplished by taking the base ten logarithm, then multiplying by 20. These limits in both linear and logarithmic form are as follows:

CONDUCTED EMISSIONS SPECIFICATION LIMITS: FCC 15.207; RSS GEN

The table below shows the limits for the emissions on the AC power line from an intentional radiator and a receiver.

Frequency (MHz)	Average Limit (dBuV)	Quasi Peak Limit (dBuV)
0.150 to 0.500	Linear decrease on logarithmic frequency axis between 56.0 and 46.0	Linear decrease on logarithmic frequency axis between 66.0 and 56.0
0.500 to 5.000	46.0	56.0
5.000 to 30.000	50.0	60.0

GENERAL TRANSMITTER RADIATED EMISSIONS SPECIFICATION LIMITS

The table below shows the limits for the spurious emissions from transmitters that fall in restricted bands¹.

Frequency Range (MHz)	Limit (uV/m)	Limit (dBuV/m @ 3m)
0.009-0.490	$2400/F_{\text{KHz}} @ 300\text{m}$	$67.6-20*\log_{10}(F_{\text{KHz}}) @ 300\text{m}$
0.490-1.705	$24000/F_{\text{KHz}} @ 30\text{m}$	$87.6-20*\log_{10}(F_{\text{KHz}}) @ 30\text{m}$
1.705 to 30	30 @ 30m	29.5 @ 30m
30 to 88	100 @ 3m	40 @ 3m
88 to 216	150 @ 3m	43.5 @ 3m
216 to 960	200 @ 3m	46.0 @ 3m
Above 960	500 @ 3m	54.0 @ 3m

¹ The restricted bands are detailed in FCC 15.205 and RSS-Gen Table 7

OUTPUT POWER LIMITS – FHSS SYSTEMS

The table below shows the limits for output power based on the number of channels available for the hopping system.

Operating Frequency (MHz)	Number of Channels	Output Power
902 – 928	≥ 50	1 Watt (30 dBm)
902 – 928	25 to 49	0.25 Watts (24 dBm)
2400 – 2483.5	≥ 75	1 Watt (30 dBm)
2400 – 2483.5	< 75	0.125 Watts (21 dBm)
5725 – 5850	75	1 Watt (30 dBm)

The maximum permitted output power is reduced by 1dB for every dB the antenna gain exceeds 6dBi. Fixed point-to-point applications using the 5725 – 5850 MHz band are not subject to this restriction.

TRANSMIT MODE SPURIOUS RADIATED EMISSIONS LIMITS – FHSS and DTS SYSTEMS

The limits for unwanted (spurious) emissions from the transmitter falling in the restricted bands are those specified in the general limits sections of FCC Part 15 and RSS GEN. All other unwanted (spurious) emissions shall be at least 20dB below the level of the highest in-band signal level (30dB if the power is measured using the sample detector/power averaging method).

SAMPLE CALCULATIONS - CONDUCTED EMISSIONS

Receiver readings are compared directly to the conducted emissions specification limit (decibel form) as follows:

$$R_r - S = M$$

where:

R_r = Receiver Reading in dBuV

S = Specification Limit in dBuV

M = Margin to Specification in +/- dB

SAMPLE CALCULATIONS - RADIATED EMISSIONS

Receiver readings are compared directly to the specification limit (decibel form). The receiver internally corrects for cable loss, preamplifier gain, and antenna factor. The calculations are in the reverse direction of the actual signal flow, thus cable loss is added and the amplifier gain is subtracted. The Antenna Factor converts the voltage at the antenna coaxial connector to the field strength at the antenna elements.

A distance factor, when used for electric field measurements above 30MHz, is calculated by using the following formula:

$$F_d = 20 * \log_{10} (D_m/D_s)$$

where:

F_d = Distance Factor in dB

D_m = Measurement Distance in meters

D_s = Specification Distance in meters

For electric field measurements below 30MHz the extrapolation factor is either determined by making measurements at multiple distances or a theoretical value is calculated using the formula:

$$F_d = 40 * \log_{10} (D_m/D_s)$$

Measurement Distance is the distance at which the measurements were taken and Specification Distance is the distance at which the specification limits are based. The antenna factor converts the voltage at the antenna coaxial connector to the field strength at the antenna elements.

The margin of a given emission peak relative to the limit is calculated as follows:

$$R_c = R_r + F_d$$

and

$$M = R_c - L_s$$

where:

R_r = Receiver Reading in dBuV/m

F_d = Distance Factor in dB

R_c = Corrected Reading in dBuV/m

L_s = Specification Limit in dBuV/m

M = Margin in dB Relative to Spec

SAMPLE CALCULATIONS - FIELD STRENGTH TO EIRP CONVERSION

Where the radiated electric field strength is expressed in terms of the equivalent isotropic radiated power (eirp), or where a field strength measurement of output power is made in lieu of a direct measurement, the following formula is used to convert between eirp and field strength at a distance of d (meters) from the equipment under test:

$$E = \frac{1000000 \sqrt{30 P}}{d} \quad \text{microvolts per meter}$$

where P is the eirp (Watts)

For a measurement at 3m the conversion from a logarithmic value for field strength (dBuV/m) to an eirp power (dBm) is -95.3dB.

Appendix A Test Equipment Calibration Data

<u>Manufacturer</u>	<u>Description</u>	<u>Model</u>	<u>Asset #</u>	<u>Calibrated</u>	<u>Cal Due</u>
Radiated Emissions, 30 - 1,000 MHz, 11-May-20					
National Technical Systems	NTS EMI Software (rev 2.10)	N/A	WC022452	N/A	
Rohde & Schwarz	EMI Test Receiver, 20 Hz-7 GHz	ESIB 7	WC064492	6/22/2019	6/22/2020
Sunol Sciences	Biconilog, 30-3000 MHz	JB3	WC064582	7/3/2018	7/3/2020
Band edge Measurement, 12-May-20					
National Technical Systems	NTS EMI Software (rev 2.10)	N/A	WC022452	N/A	
National Technical Systems	NTS Capture Analyzer Software (rev 4.0)	N/A	WC022706	N/A	
Rohde & Schwarz	EMI Test Receiver, 20 Hz-7 GHz	ESIB 7	WC064492	6/22/2019	6/22/2020
Sunol Sciences	Biconilog, 30-3000 MHz	JB3	WC064582	7/3/2018	7/3/2020
Radiated Emissions, 30 - 10,000 MHz, 13-May-20					
National Technical Systems	NTS EMI Software (rev 2.10)	N/A	WC022452	N/A	
EMCO	Horn Antenna	3115	WC062583	7/9/2018	7/9/2020
Rohde & Schwarz	EMI Test Receiver, 20 Hz-7 GHz	ESIB 7	WC064492	6/22/2019	6/22/2020
Hewlett Packard	Spectrum Analyzer 9kHz-40GHz non-radio 3dB BW	8564E	WC064572	8/1/2019	8/1/2020
Sunol Sciences	Biconilog, 30-3000 MHz	JB3	WC064582	7/3/2018	7/3/2020
Hewlett Packard	Microwave Preamplifier, 1-26.5GHz	8449B	WC068124	12/10/2019	12/10/2020
Conducted Emissions - AC Power Ports, 14-May-20					
National Technical Systems	NTS EMI Software (rev 2.10)	N/A	WC022452	N/A	
Rohde & Schwarz	EMI Test Receiver, 20 Hz-7 GHz	ESIB 7	WC064492	6/22/2019	6/22/2020
Com-Power	9KHz-30MHz, 50uH, 15Aac, 10Adc, max CISPR 15	LI-215A	WC064688	8/1/2019	8/1/2020
Rohde & Schwarz	Pulse Limiter	ESH3-Z2	WC072357	6/24/2019	6/24/2020
Radiated Emissions, 30 - 26,000 MHz, 14-May-20					
National Technical Systems	NTS EMI Software (rev 2.10)	N/A	WC022452	N/A	
EMCO	Horn Antenna	3115	WC062583	7/9/2018	7/9/2020
Rohde & Schwarz	EMI Test Receiver, 20 Hz-7 GHz	ESIB 7	WC064492	6/22/2019	6/22/2020
A. H. Systems	Antenna, Horn, 18-40GHz	SAS-574	WC064553	9/5/2017	8/8/2020
Hewlett Packard	Microwave Preamplifier Head, 18-40 GHz (Blue)	84125C EMI Test Head (Blue)	WC055663	12/3/2019	12/3/2020
Hewlett Packard	Spectrum Analyzer 9kHz-40GHz non-radio 3dB BW	8564E	WC064572	8/1/2019	8/1/2020
Sunol Sciences	Biconilog, 30-3000 MHz	JB3	WC064582	7/3/2018	7/3/2020



<u>Manufacturer</u>	<u>Description</u>	<u>Model</u>	<u>Asset #</u>	<u>Calibrated</u>	<u>Cal Due</u>
Hewlett Packard	Microwave Preamplifier, 1-26.5GHz	8449B	WC068124	12/10/2019	12/10/2020

Radio Antenna Port (Hopping Parameters and Spurious Emissions), 15-May-20

National Technical Systems	NTS EMI Software (rev 2.10)	N/A	WC022452	N/A	
National Technical Systems	NTS Capture Analyzer Software (rev 4.0)	N/A	WC022706	N/A	
Agilent Technologies	PSA Spectrum Analyzer	E4446A	WC055650	7/18/2019	7/18/2020

Radiated Emissions, 0.4 - 30 MHz, 24-Aug-20

National Technical Systems	NTS EMI Software (rev 2.10)	N/A	WC022452	N/A	
Rhode & Schwarz	Loop Antenna	HFH2-Z2	WC062457	1/23/2020	1/23/2022
Rhode & Schwarz	EMI Test Receiver 20Hz-26.5GHz	ESI	WC071498	5/4/2020	5/4/2021

Appendix B Test Data

TL117299-RA Pages 27 – 93



EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Product	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
System Configuration:	-	Project Manager:	Deepa Shetty
Contact:	Riaz Momand	Project Engineer:	David Bare
Emissions Standard(s):	FCC Part 15. 247, RSS-247	Class:	-
Immunity Standard(s):	-	Environment:	Radio

EMC Test Data

For The

FreeWave Technologies, Inc.

Product

MM3-T, MM3-T-U

Date of Last Test: 8/24/2020



EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	-

Radiated Emissions

Test Specific Details

Objective: The objective of this test session is to perform final qualification testing of the EUT with respect to the specification listed above.

Date of Test: 8/24/2020
Test Engineer: David Bare
Test Location: Fremont Chamber #4

Config. Used: 1
Config Change: None
EUT Voltage: 120V/60Hz

General Test Configuration

The EUT and any local support equipment were located on the turntable for radiated emissions testing.

The test distance and extrapolation factor (if used) are detailed under each run description.

Note, preliminary testing indicates that the emissions were maximized by orientation of the EUT and elevation of the measurement antenna. Maximized testing indicated that the emissions were maximized by orientation of the EUT, elevation of the measurement antenna, and manipulation of the EUT's interface cables.

Ambient Conditions:
Temperature: 24 °C
Rel. Humidity: 45 %

Summary of Results

Run #	Test Performed	Limit	Result	Margin
1	0.4 - 30 MHz	FCC 15.209	Pass	Refer to individual runs

Modifications Made During Testing

No modifications were made to the EUT during testing

Deviations From The Standard

No deviations were made from the requirements of the standard.



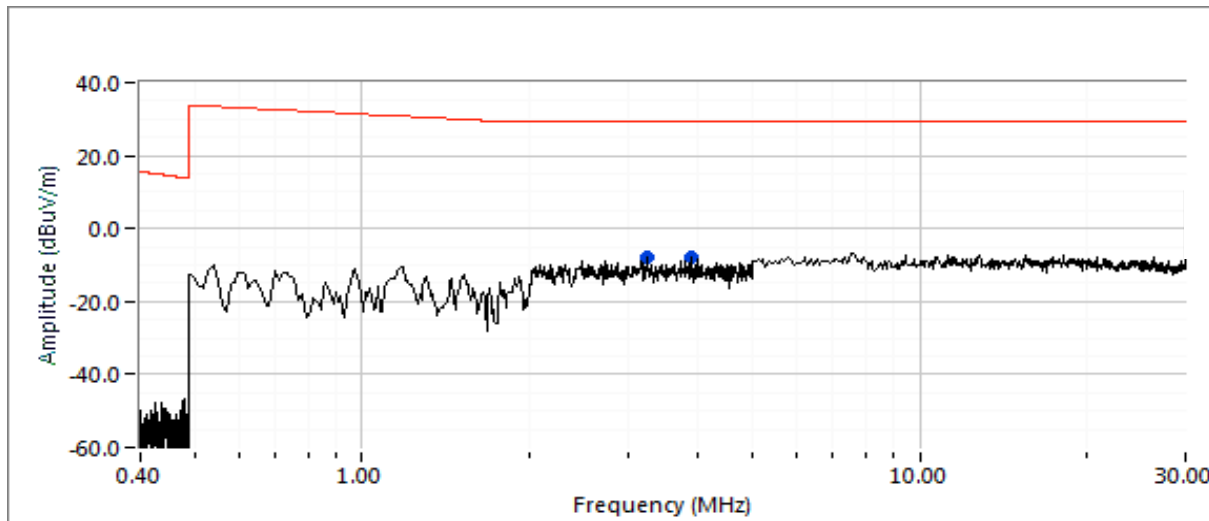
EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	-

Run #1: Radiated Emissions, 0.4 - 30 MHz, FCC 15.209

Frequency Range	Test Distance	Limit Distance	Extrapolation Factor
0.400 - 0.490 MHz	3	300	-80.0
0.490 - 1.705 MHz	3	30	-40.0
1.705 - 30.0 MHz	3	30	-40.0

Note - the extrapolation factor is based on $40\log(\text{test distance}/\text{limit distance})$ as permitted by FCC 15.31



Preliminary readings

Frequency	Level	Pol	FCC 15.209		Detector	Azimuth	Height	Comments
MHz	dBuV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
3.238	-7.7	H	29.5	-37.2	Peak	1	1.3	Noise Floor, Note 2
3.906	-8.1	H	29.5	-37.6	Peak	1	1.3	Noise Floor, Note 2

Note 1:	The emission limits shown in the above table are based on measurements employing a CISPR quasi-peak detector except for the frequency bands 9-90 kHz, 110-490 kHz and above 1000 MHz. Radiated emission limits in these three bands are based on measurements employing an average detector, with a peak limit 20dB above the average limit.
Note 2:	Value calculated from measured value at 3m extrapolated to 30m using $40\log(d2/d1)$.



EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A

RSS-247 and FCC 15.247 (FHSS) Measurements Power, Bandwidth and Spurious Emissions

Test Specific Details

Objective: The objective of this test session is to perform final qualification testing of the EUT with respect to the specification listed above.

General Test Configuration

The EUT and all local support equipment were located on the turntable for radiated spurious emissions testing.

For radiated emissions testing the measurement antenna was located 3 meters from the EUT.

When measuring the conducted emissions from the EUT's antenna port, the antenna port of the EUT was connected to the spectrum analyzer or power meter via a suitable attenuator to prevent overloading the measurement system. All measurements are corrected to allow for the external attenuators used.

Unless stated otherwise the EUT was operating such that it constantly hopped on either the low, center or high channels.

Ambient Conditions:

Temperature: 21-23 °C

Rel. Humidity: 39-43 %

Summary of Results

Run #	Test Performed	Limit	Pass / Fail	Result / Margin
1-3	30 - 10000 MHz - Transmitter Radiated Spurious Emissions	FCC Part 15.209 / 15.247(c)	Pass	105.6 dBμV/m @ 928.00 MHz (-2.3 dB)
4	30 - 10000 MHz - Transmitter Conducted Spurious Emissions	FCC Part 15.247(c)	Pass	-24.8 dBm @ 1855.72 MHz (-33.1 dB)
5	Output Power	15.247(b)	Pass	29.9 dBm (0.9772 W)
6	20dB Bandwidth	15.247(a)	Pass	194 kHz
6	Channel Occupancy	15.247(a)	Pass	116.4ms
6	Number of Channels	15.247(a)	Pass	110

Modifications Made During Testing:

No modifications were made to the EUT during testing

Deviations From The Standard

No deviations were made from the requirements of the standard.



EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A

Run #1: Radiated Spurious Emissions, 30 - 10000 MHz.

Run #1a: Radiated Spurious Emissions, 30 - 10000 MHz. Low Channel @ 902.2464 MHz

Date of Test: 5/11/2020

EUT Setting/ Data Rate: 10, 115.2kbps

Test Engineer: Rafael Varelas

EUT Power: 29.6 dBm

Test Location: Fremont Chamber #7

Antenna Gain: Omni, 5dBi

Fundamental Signal Field Strength: Peak and average values measured in 1 MHz, and peak value measured in 100kHz

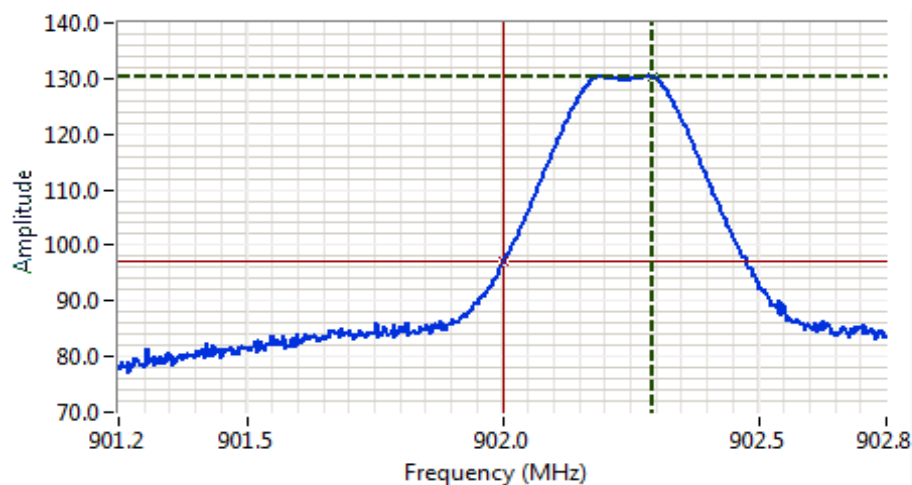
Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dB μ V/m	V/H	Limit	Margin	PK/QP/Avg	degrees	meters	
902.191	120.3	H	-	-	PK	282	1.0	100 kHz; VB: 300 kHz
902.284	130.1	V	-	-	PK	252	1.0	100 kHz; VB: 300 kHz

Fundamental emission level @ 3m in 100kHz RBW:	130.1	
Limit for emissions outside of restricted bands:	110.1 dB μ V/m	Limit is -20dBc

Band Edge Signal Field Strength

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBμV/m	V/H	Limit	Margin	PK/QP/Avg	degrees	meters	
902.284	96.9	V	110.1	-13.2	PK	252	1.0	

Note 1: Calculated by subtracting the marker delta values from the fundamental field strength measurements.



Analyzer Settings
 Rohde&Schwarz,ESI
 CF: 902.000 MHz
 SPAN: 1.500 MHz
 RB: 100 kHz
 VB: 300 kHz
 Detector: POS
 Attn: 30 DB
 RL Offset: 28.8 DB
 Sweep Time: 5.0ms
 Ref Lvl: 142.0 DBUV
 Comments

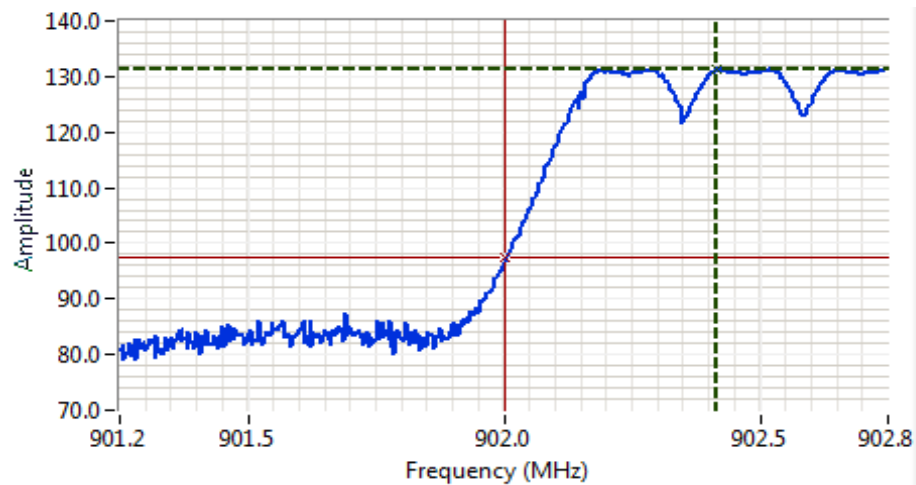
Cursor	902.293307	130.3		Delta Freq.	293 kHz
Cursor	902.000000	97.1		Delta Amplitude	33.2





EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A



Analyzer Settings

Rohde&Schwarz, ESI
CF: 902.000 MHz
SPAN: 1.500 MHz
RB: 100 kHz
VB: 300 kHz
Detector: POS
Attn: 30 DB
RL Offset: 28.8 DB
Sweep Time: 5.0ms
Ref Lvl: 142.0 DBUV

Comments

Cursor	902.415354	131.3	
Cursor	902.000000	97.5	

Delta Freq. 415 kHz
Delta Amplitude 33.8





EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A

Run #1b: Radiated Spurious Emissions, 30 - 10000 MHz. Low Channel @ 902.2464 MHz

Date of Test: 5/11/2020

EUT Setting/ Data Rate: 10, 153.6kbps

Test Engineer: M. Birgani

EUT Power: 29.9 dBm

Test Location: Fremont Chamber #7

Antenna Gain: Omni, 5dBi

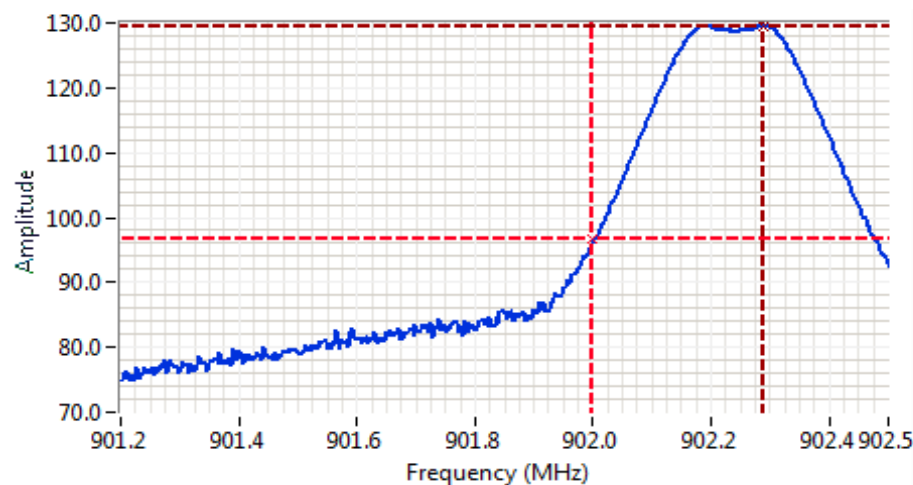
Fundamental Signal Field Strength: Peak and average values measured in 1 MHz, and peak value measured in 100kHz

Frequency	Level	Pol	15.209 / 15.247	Detector	Azimuth	Height	Comments
MHz	dB μ V/m	V/H	Limit	Margin	PK/QP/Avg	degrees	meters
902.291	129.5	V	-	-	PK	239	1.0
902.289	119.6	H	-	-	PK	283	1.0

Fundamental emission level @ 3m in 100kHz RBW:	129.5	119.6
Limit for emissions outside of restricted bands:	109.5 dB μ V/m	Limit is -20dBc

Band Edge Signal Field Strength

Frequency	Level	Pol	15.209 / 15.247	Detector	Azimuth	Height	Comments
MHz	dB μ V/m	V/H	Limit	Margin	PK/QP/Avg	degrees	meters
902.000	96.7	V	109.5	-12.8	PK	239	1.0



Analyzer Settings

Rohde&Schwarz, ESI
CF: 901.900 MHz
SPAN: 1.400 MHz
RB: 100 kHz
VB: 300 kHz
Detector: POS
Attn: 40 DB
RL Offset: 28.6 DB
Sweep Time: 5.0ms
Ref Lvl: 135.6 DBUV

Comments

Bandedge Measurement
Date Rate: 153.6kbps
EUT Setting: 10

Cursor	902.000000	96.7	
Cursor	902.288574	129.5	

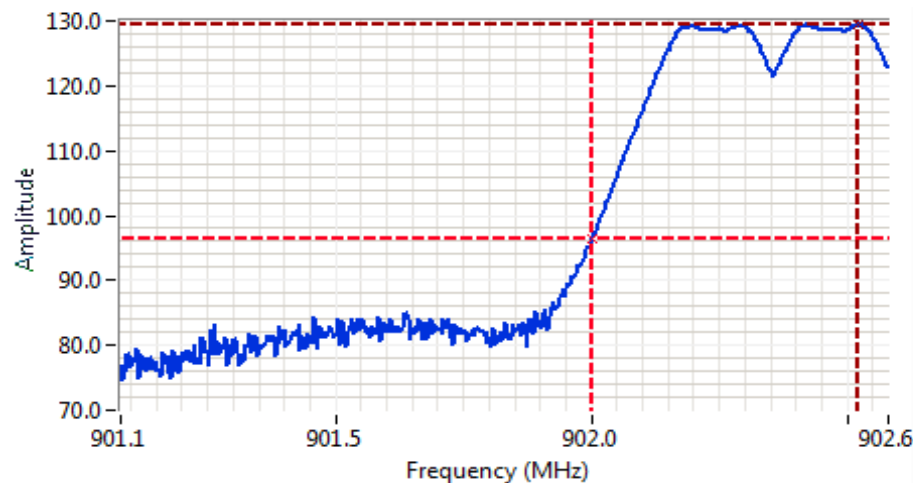
Delta Freq. 289 kHz
Delta Amplitude 32.8





EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A



Analyzer Settings

Rohde&Schwarz, ESI
CF: 901.830 MHz
SPAN: 1.500 MHz
RB: 100 kHz
VB: 300 kHz
Detector: POS
Attn: 40 DB
RL Offset: 28.8 DB
Sweep Time: 5.0ms
Ref Lvl: 131.8 DBUV

Comments

Bandedge Measurement
Date Rate: 153.6kbps
EUT Setting: 10
Hopping

Cursor	902.002869	96.5	
Cursor	902.519897	129.4	

Delta Freq. 517 kHz
Delta Amplitude 32.9





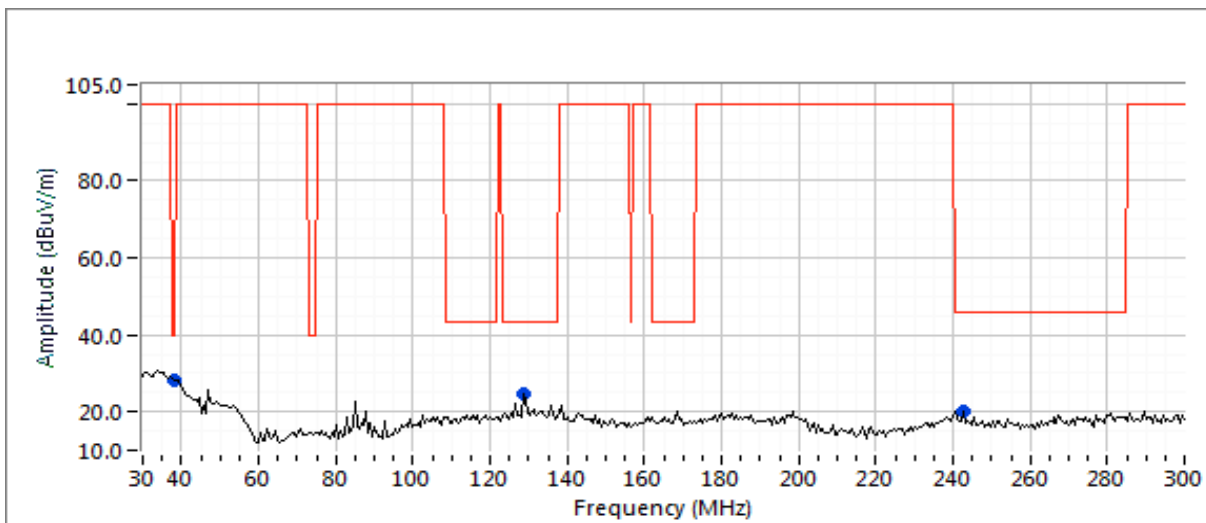
EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A

Other Spurious Emissions

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dB μ V/m	V/H	Limit	Margin	Pk/QP/Avg	degrees	meters	
242.645	22.6	V	46.0	-23.4	QP	317	1.0	QP (1.00s)
128.477	24.4	V	43.5	-19.1	QP	320	1.0	QP (1.00s)
38.116	27.9	V	40.0	-12.1	QP	347	1.0	QP (1.00s)
1804.490	60.9	V	109.5	-48.6	PK	174	2.2	RB 1 MHz;VB 3 MHz;Peak

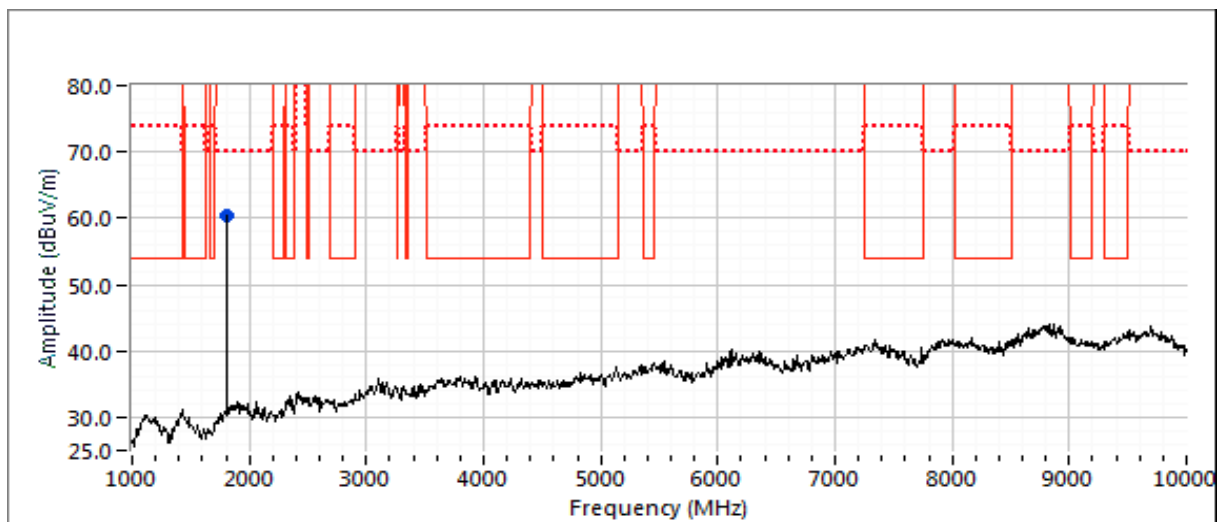
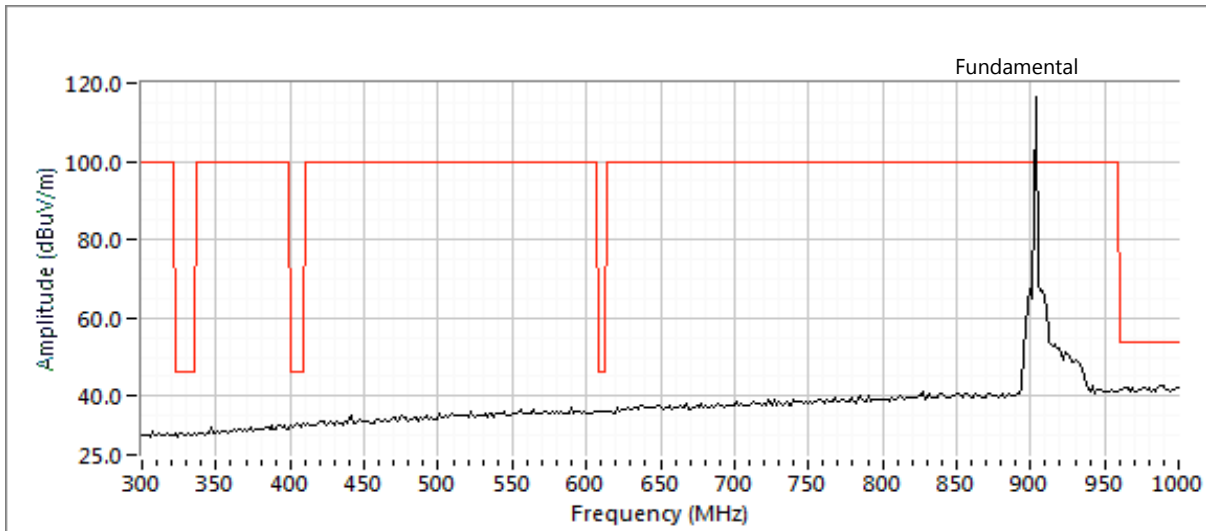
Note 1:	For emissions in restricted bands, the limit of 15.209 was used. For all other emissions, the limit was set 20dB below the level of the fundamental.
Note 2:	As the bandwidth and thus power spectral density are the same for both data rates, spurious emissions were performed only at the lowest data rate.





EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A





EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A

Date of Test: 5/13/2020
 Test Engineer: David Bare
 Test Location: Fremont Chamber #7

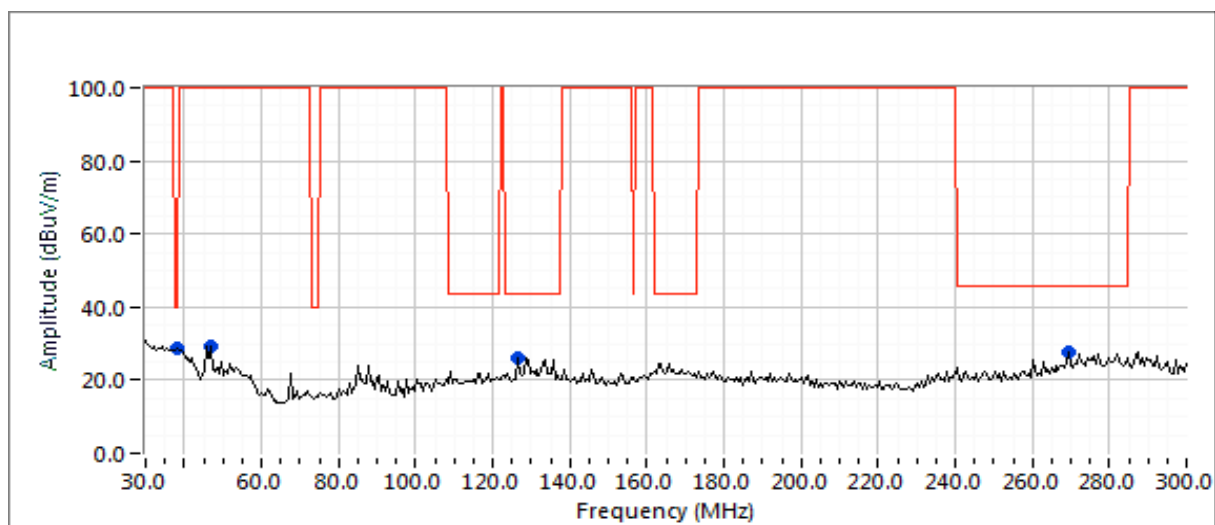
EUT Setting/ Data Rate: 10, 115.2kbps
 EUT Power: 29.1 dBm
 Antenna Gain: Omni 5dBi

Run #2: Radiated Spurious Emissions, 30 - 10000 MHz. Center Channel @ 914.9184 MHz

	H	V
Fundamental emission level @ 3m in 100kHz RBW:		129.8
Limit for emissions outside of restricted bands:	109.8 dB μ V/m	

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dB μ V/m	V/H	Limit	Margin	Pk/QP/Avg	degrees	meters	
38.116	26.8	V	40.0	-13.2	QP	9	1.0	QP (1.00s)
126.313	24.5	V	43.5	-19.0	QP	145	2.0	QP (1.00s)
269.699	26.7	H	46.0	-19.3	QP	258	1.0	QP (1.00s)
1829.990	56.9	V	109.8	-52.9	PK	127	1.0	RB 1 MHz;VB 3 MHz;Peak

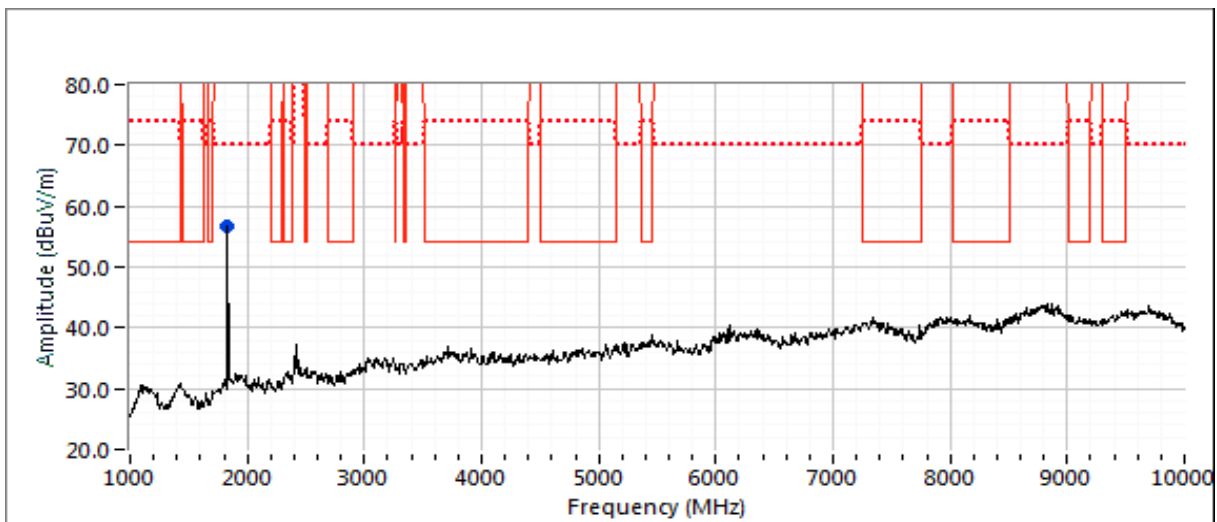
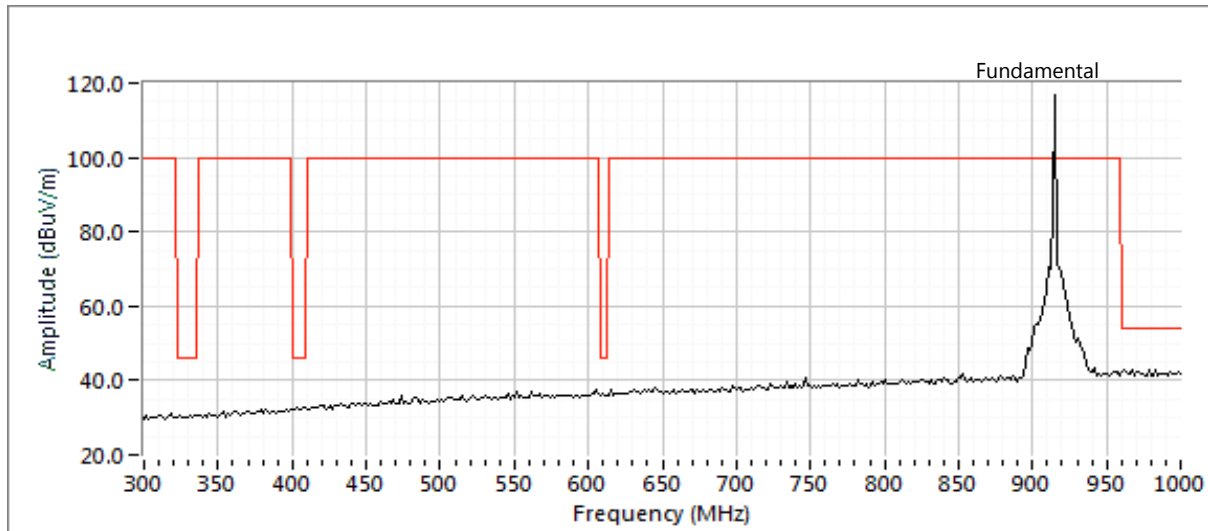
Note 1:	For emissions in restricted bands, the limit of 15.209 was used. For all other emissions, the limit was set 20dB below the level of the fundamental.
Note 2:	As the bandwidth and thus power spectral density are the same for both data rates, spurious emisissions were performed only at the lowest data rate.





EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A





EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A

Run #3a: Radiated Spurious Emissions, 30 - 10000 MHz. High Channel @ 927.8208 MHz

Date of Test: 5/12-13/2020

EUT Setting/ Data Rate: 10, 115.2kbps

Test Engineer: M. Birgani & David Bare

EUT Power: 29.6 dBm

Test Location: Fremont Chamber #7

Antenna Gain: Omni, 5dBi

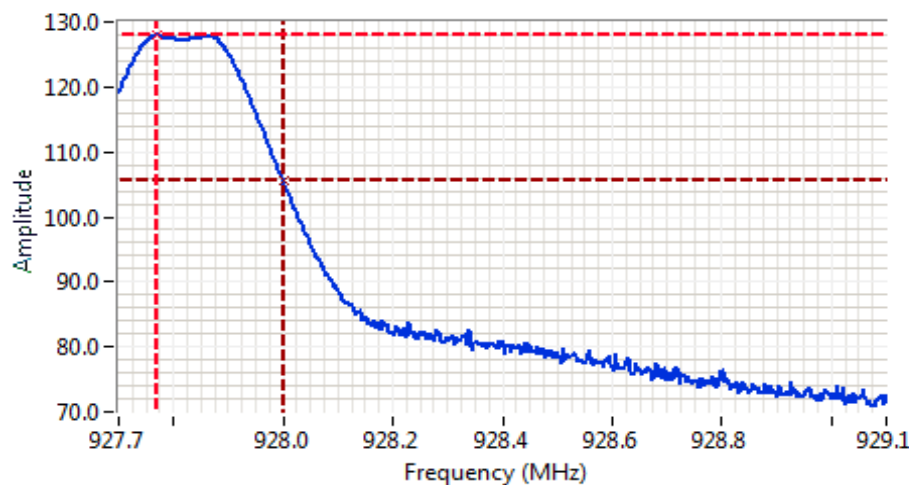
Fundamental Signal Field Strength: Peak and average values measured in 1 MHz, and peak value measured in 100kHz

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBμV/m	V/H	Limit	Margin	Pk/QP/Avg	degrees	meters	
927.767	127.9	V	-	-	PK	252	1.0	100 kHz; VB: 300 kHz
927.770	117.3	H	-	-	PK	236	1.0	100 kHz; VB: 300 kHz

Fundamental emission level @ 3m in 100kHz RBW:	127.9	117.3
Limit for emissions outside of restricted bands:	107.9 dBμV/m	Limit is -20dBc

Band Edge Signal Field Strength

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBμV/m	V/H	Limit	Margin	Pk/QP/Avg	degrees	meters	
928.000	105.6	V	107.9	-2.3	PK	252	1.0	100 kHz; VB: 300 kHz



Analyzer Settings

Rohde&Schwarz, ESI
 CF: 928.400 MHz
 SPAN: 1.400 MHz
 RB: 100 kHz
 VB: 300 kHz
 Detector: POS
 Attn: 40 DB
 RL Offset: 28.8 DB
 Sweep Time: 5.0ms
 Ref Lvl: 130.8 DBUV
 Comments

Bandedge Measurement
 Date Rate: 115.2kbps
 EUT Setting: 10

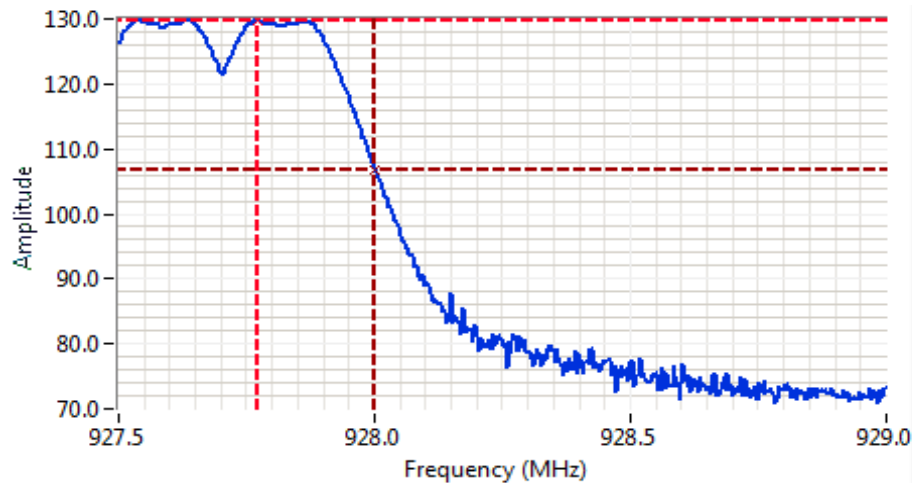
Cursor	927.770142	127.9	Delta Freq.	230 kHz
Cursor	928.000000	105.6	Delta Amplitude	22.3





EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A



Analyzer Settings

Rohde&Schwarz,ESI
CF: 928.250 MHz
SPAN: 1.500 MHz
RB: 100 kHz
VB: 300 kHz
Detector: POS
Attn: 40 DB
RL Offset: 28.8 DB
Sweep Time: 5.0ms
Ref Lvl: 130.8 DBUV

Comments

Bandedge Measurement
Date Rate: 115.2kbps
EUT Setting: 10
Hopping

Cursor	927.770569	129.8	+	-	+	-
Cursor	928.000000	106.8	+	-	+	-
Delta Freq.		229 kHz		Delta Amplitude		23.0





EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A

Run #3b: Radiated Spurious Emissions, 30 - 10000 MHz. High Channel @ 927.8208 MHz

Date of Test: 5/11 & 13/2020

EUT Setting/ Data Rate: 10, 153.6kbps

Test Engineer: M. Birgani & David Bare

EUT Power: 28.4 dBm

Test Location: Fremont Chamber #7

Antenna Gain: Omni 5.0dBi

Fundamental Signal Field Strength: Peak value measured in 100kHz

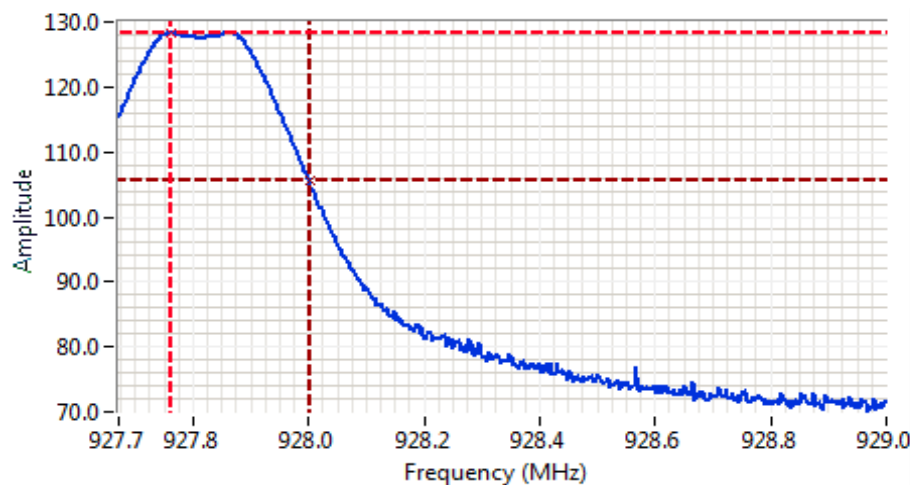
Frequency	Level	Pol	15.247		Detector	Azimuth	Height	Comments
MHz	dB μ V/m	v/h	Limit	Margin	PK/QP/Avg	degrees	meters	
927.762	128.3	V	-	-	PK	274	1.5	100 kHz; VB: 300 kHz
927.875	118.1	H	-	-	PK	300	1.0	100 kHz; VB: 300 kHz

Fundamental emission level @ 3m in 100kHz RBW:	128.3	120.2
Limit for emissions outside of restricted bands:	108.3	dB μ V/m

Limit is -20dBc

Band Edge Signal Field Strength

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dB μ V/m	v/h	Limit	Margin	PK/QP/Avg	degrees	meters	
928.000	105.9	V	108.3	-2.4	PK	274	1.5	100 kHz; VB: 300 kHz



Analyzer Settings

Rohde&Schwarz, ESI

CF: 928.336 MHz

SPAN: 1.329 MHz

RB: 100 kHz

VB: 300 kHz

Detector: POS

Attn: 40 DB

RL Offset: 28.8 DB

Sweep Time: 5.0ms

Ref Lvl: 131.8 DBUV

Comments

Bandedge Measurement

Date Rate: 153.6kbps

EUT Setting: 10

Cursor	927.761536	128.3	↔	↗	↘
Cursor	928.001282	105.5	↔	↗	↘

Delta Freq. 240 kHz

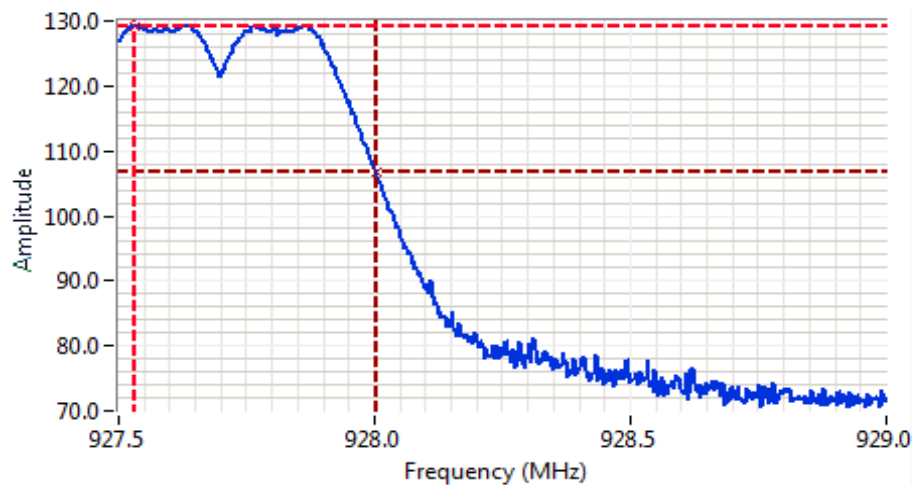
Delta Amplitude 22.9





EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A



Analyzer Settings

Rohde&Schwarz, ESI
CF: 928.250 MHz
SPAN: 1.500 MHz
RB: 100 kHz
VB: 300 kHz
Detector: POS
Attn: 40 DB
RL Offset: 28.8 DB
Sweep Time: 5.0ms
Ref Lvl: 131.8 DBUV

Comments

Bandedge Measurement
Date Rate: 153.6kbps
EUT Setting: 10
Hopping

Cursor	927.533081	129.2	
Cursor	928.002014	106.8	

Delta Freq. 469 kHz
Delta Amplitude 22.4





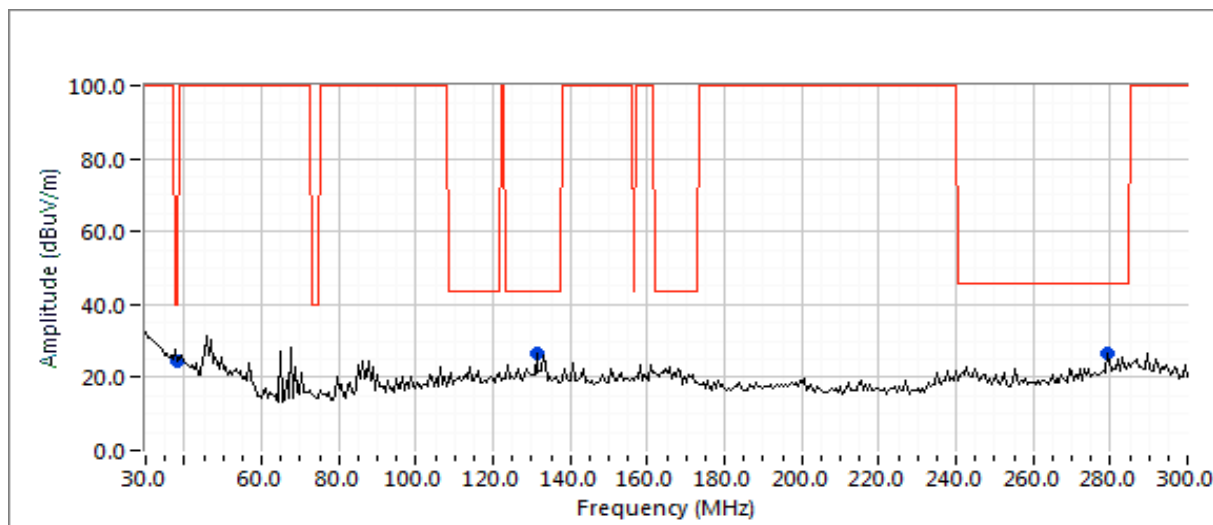
EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A

Other Spurious Emissions

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dB μ V/m	V/H	Limit	Margin	Pk/QP/Avg	degrees	meters	
38.116	26.1	V	40.0	-13.9	QP	335	1.0	QP (1.00s)
131.182	24.9	V	43.5	-18.6	QP	123	1.0	QP (1.00s)
279.439	26.9	V	46.0	-19.1	QP	93	1.0	QP (1.00s)
1855.570	61.4	V	108.3	-46.9	PK	171	1.0	RB 1 MHz;VB 3 MHz;Peak

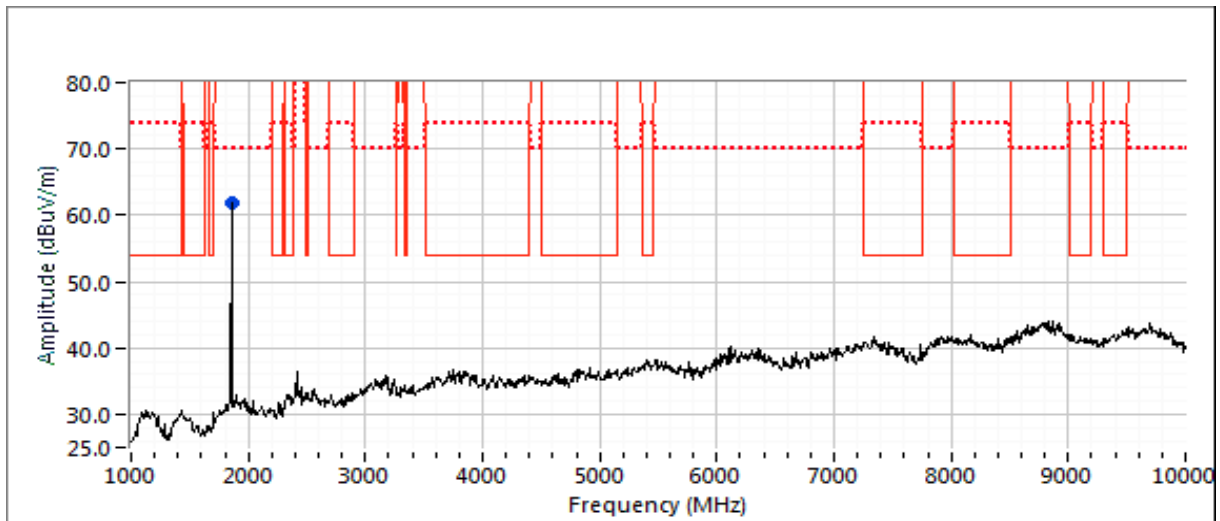
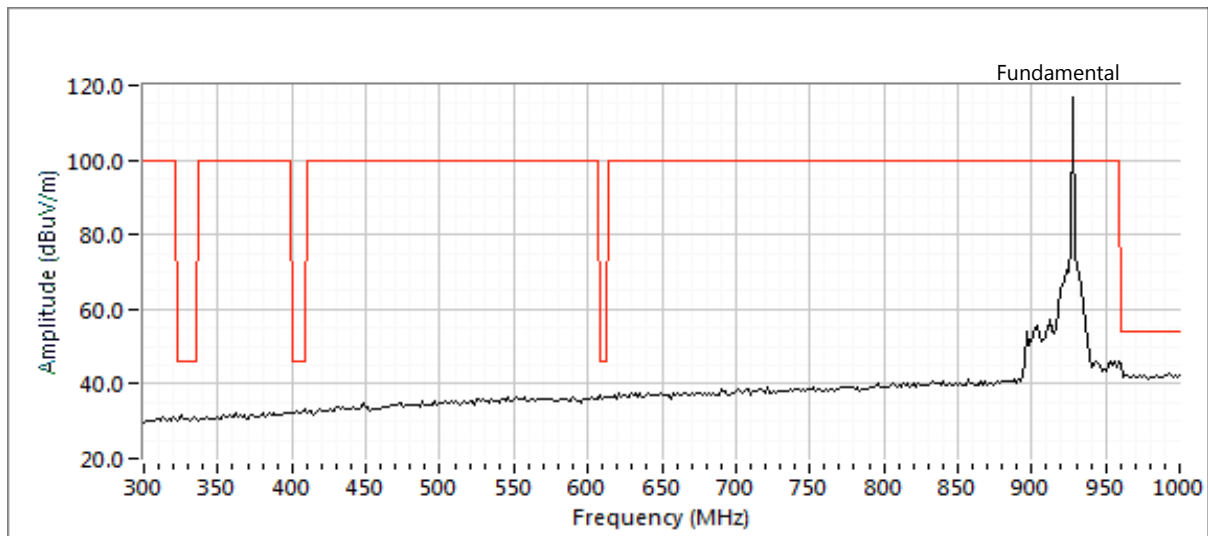
Note 1:	For emissions in restricted bands, the limit of 15.209 was used. For all other emissions, the limit was set 20dB below the level of the fundamental.
Note 2:	As the bandwidth and thus power spectral density are the same for both data rates, spurious emissions were performed only at the lowest data rate.





EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A





EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A

Run #4: Antenna Conducted Spurious Emissions, 30 - 10,000 MHz.

Date of Test: 5/15/2020

Test Engineer: David Bare

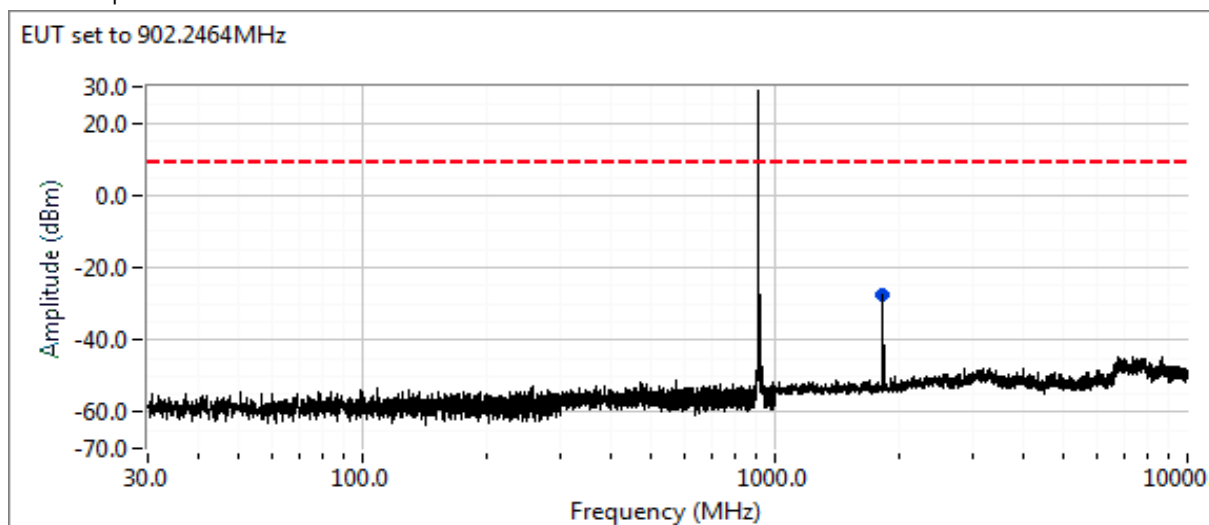
Test Location: Fremont Chamber #2

Refer to plots below. Scans made using RBW=100 KHz, VBW=300kHz with the limit line set at 20dB below the highest in-band signal level with the **hopping feature disabled**.

Frequency MHz	Level dBμV	Port	FCC 15.247		Detector QP/Ave	Comments
			Limit	Margin		
1823.470	-25.3	RF Port	9.6	-34.9	Peak	RB 100 kHz; VB: 300 kHz
1829.930	-24.9	RF Port	9.1	-34.0	Peak	RB 100 kHz; VB: 300 kHz
1855.720	-24.8	RF Port	8.3	-33.1	Peak	RB 100 kHz; VB: 300 kHz

Low channel

Broadband plot



Plot showing -20dBc at the lower band edge performed using radiated method w/ hopping both disabled and enabled per ANSI C63.10

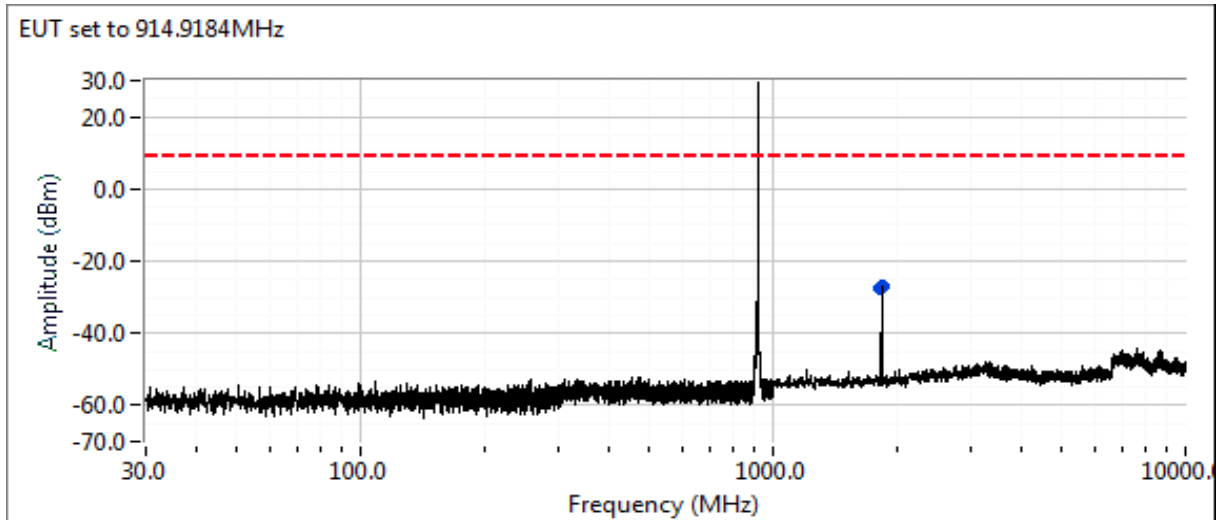


EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A

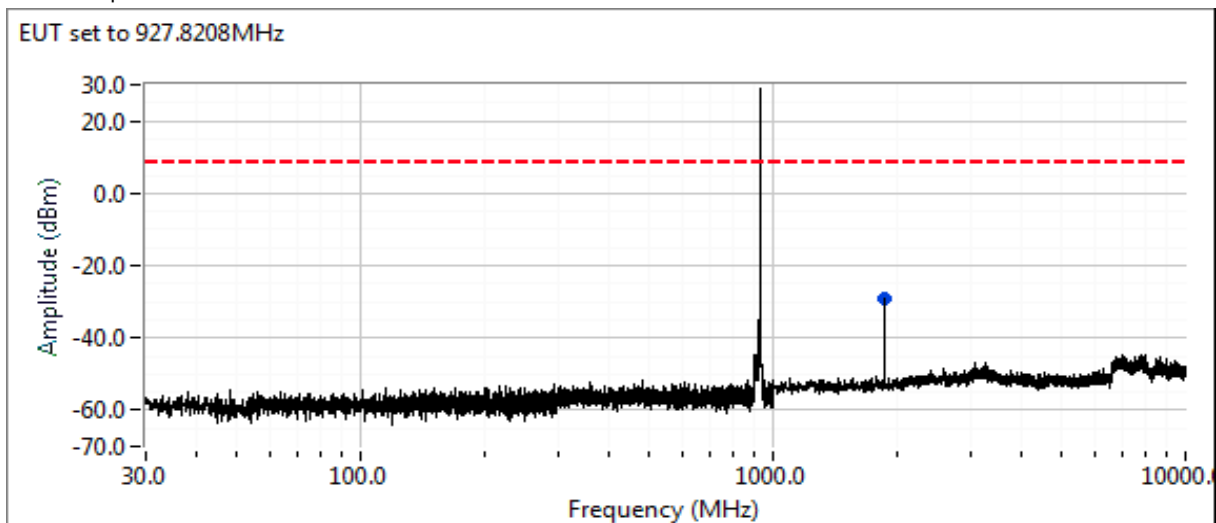
Center channel

Broadband plot



High channel

Broadband plot



Plot showing -20dBc at the upper band edge performed using radiated method w/ hopping both disabled and enabled per ANSI C63.10



EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A

Run #4: Output Power

Date of Test: 5/11/2020

Test Engineer: Rafael Varelas

Test Location: Fremont Chamber #7

For frequency hopping systems operating in the 902-928 MHz band: 1 watt for systems employing at least 50 hopping channels.

Data Rate: 115.2 kbps

Power Setting	Frequency (MHz)	Output Power		Antenna Gain (dBi)	Result	EIRP	
		(dBm) ¹	mW			dBm	W
10	902.2464	29.6	912.0	5.00	Pass	34.6	2.884
10	914.9184	29.1	812.8	5.00	Pass	34.1	2.570
10	927.8208	28.3	676.1	5.00	Pass	33.3	2.138

Note 1: Output power measured using a peak power meter

Data Rate: 153.6 kbps

Power Setting	Frequency (MHz)	Output Power		Antenna Gain (dBi)	Result	EIRP	
		(dBm) ¹	mW			dBm	W
10	902.2464	29.9	977.2	5.00	Pass	34.9	3.090
10	914.9184	28.4	691.8	5.00	Pass	33.4	2.188
10	927.8208	29.0	794.3	5.00	Pass	34.0	2.512

Note 1: Output power measured using a peak power meter



EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A

Run #5: Bandwidth, Channel Occupancy, Spacing and Number of Channels

Date of Test: 5/13/2020

Test Engineer: David Bare

Test Location: Fremont Chamber #7

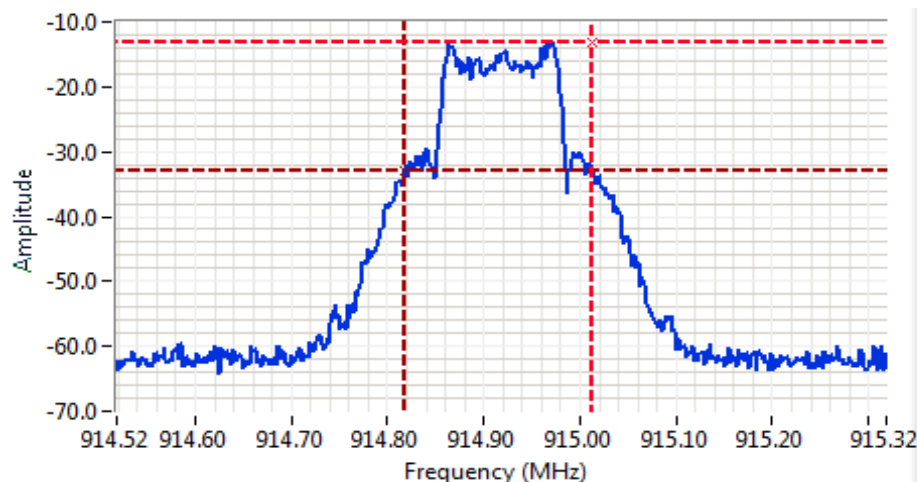
Data Rate: 115.2 kbps

Channel	Frequency (MHz)	Resolution Bandwidth	20dB Bandwidth (kHz)
Low	902.2464	5 kHz	191
Mid	914.9184	5 kHz	194
High	927.8208	5 kHz	189

Data Rate: 153.6 kbps

Channel	Frequency (MHz)	Resolution Bandwidth	20dB Bandwidth (kHz)
Low	902.2464	5 kHz	192
Mid	914.9184	5 kHz	194
High	927.8208	5 kHz	188

Note 1: 20dB bandwidth measured using RB = 5 kHz, VB = 50 kHz (VB > RB), Span = 800 kHz



Analyzer Settings

Rohde&Schwarz, ESI
CF: 914.918 MHz
SPAN: 800 kHz
RB: 5.00 kHz
VB: 50.0 kHz
Detector: POS
Attn: 60 DB
RL Offset: 0.0 DB
Sweep Time: 80.0ms
Ref Lvl: 6.0 DBM

Comments

Date Rate: 115.2kbps
EUT Setting: 10
20dB BW: 194 kHz
CF: 914.9184 MHz

Cursor	915.01288	-13.1	
Cursor	914.818200	-33.1	

Delta Freq. 194 kHz
Delta Amplitude 20.0





EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A

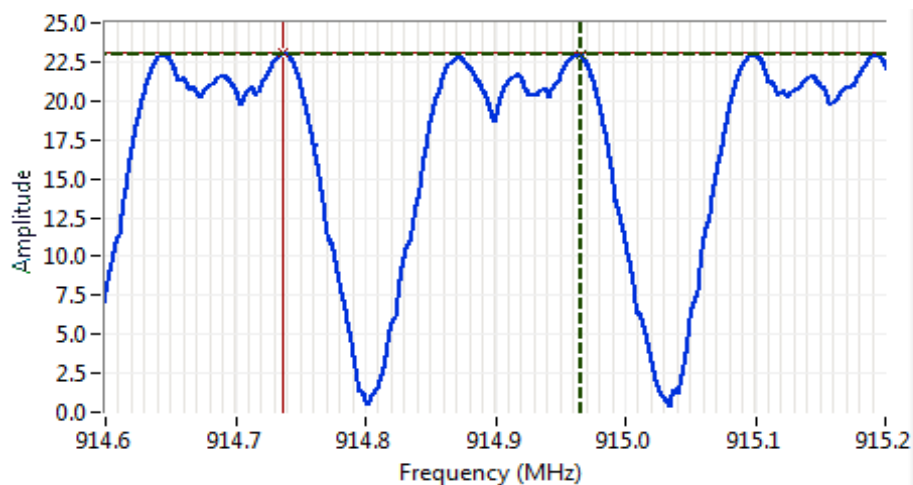
Date of Test: 5/15/2020
Test Engineer: David Bare
Test Location: Fremont Chamber #2

For frequency hopping systems operating in the **902-928 MHz** band:

If the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period.

The channel dwell time is calculated from the transmit time on a channel multiplied by the number of times a channel could be used in the 20 second period (i.e. 20s divided by the time between successive hops, rounded up to the closest integer), unless the time between successive hops exceeds 20s in which case the channel dwell time is the transmit time on a channel.

Maximum 20dB bandwidth:	194 kHz	Pass
Channel spacing:	230 kHz	Pass
Transmission time per hop:	10.58 ms	
The time between successive hops on a channel:	1861.3 ms	
Maximum Number of channels (N):	110	Pass
Channel dwell time in 20 seconds:	116.38 ms	Pass



Analyzer Settings
Agilent Technologies, E4446A
CF: 914.918 MHz
SPAN: 1.000 MHz
RB: 30.0 kHz
VB: 300 kHz
Detector: POS
Attn: 30 DB
RL Offset: 10.0 DB
Sweep Time: 1.2ms
Comments
Channel Spacing: 230 kHz

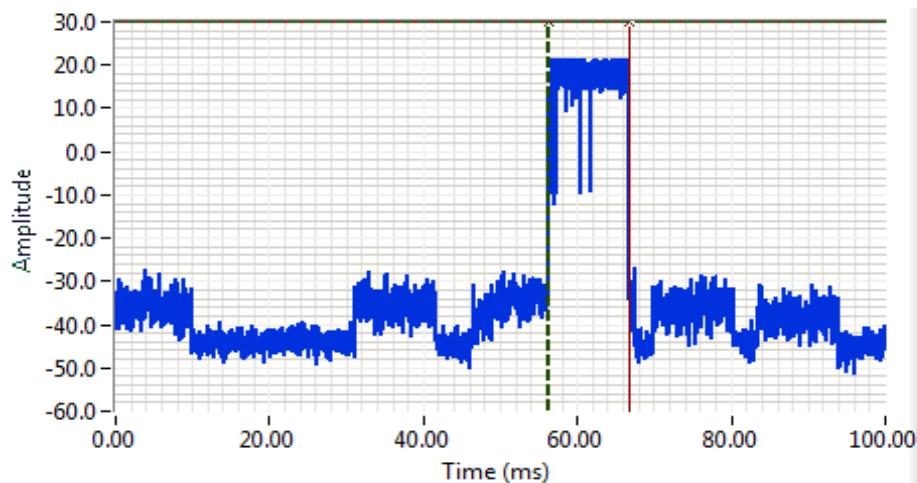
Cursor	914.965891	23.0	Delta Freq.	230 kHz
Cursor	914.735829	23.1	Delta Amplitude	0.1





EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A



Analyzer Settings

Agilent Technologies,
E4446A
CF: 914.918 MHz
SPAN: 0.000 MHz
RB: 30.0 kHz
VB: 300 kHz
Detector: POS
Attn: 30 DB
RL Offset: 10.0 DB
Sweep Time: 100.0ms

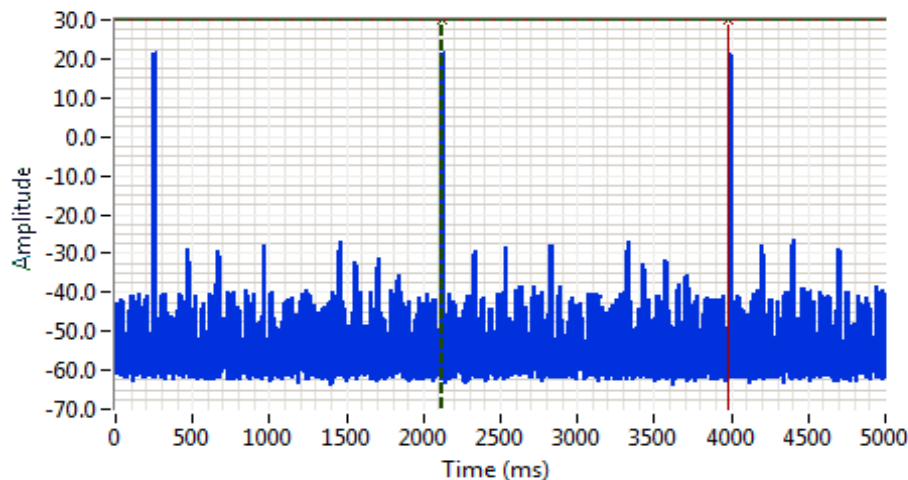
Comments

Trasnmission time:/hop
10.58ms

Cursor 56.178010 30.0
Cursor 66.753927 30.0

Delta Time (ms) 10.58

Delta Amplitude 0.0



Analyzer Settings

Agilent Technologies,
E4446A
CF: 914.918 MHz
SPAN: 0.000 MHz
RB: 30.0 kHz
VB: 300 kHz
Detector: POS
Attn: 30 DB
RL Offset: 10.0 DB
Sweep Time: 5.0s

Comments

Time between successive
hops on channel:
1861.3ms

Cursor 2117.801047 30.0
Cursor 3979.057592 30.0

Delta Time (ms) 1861.3

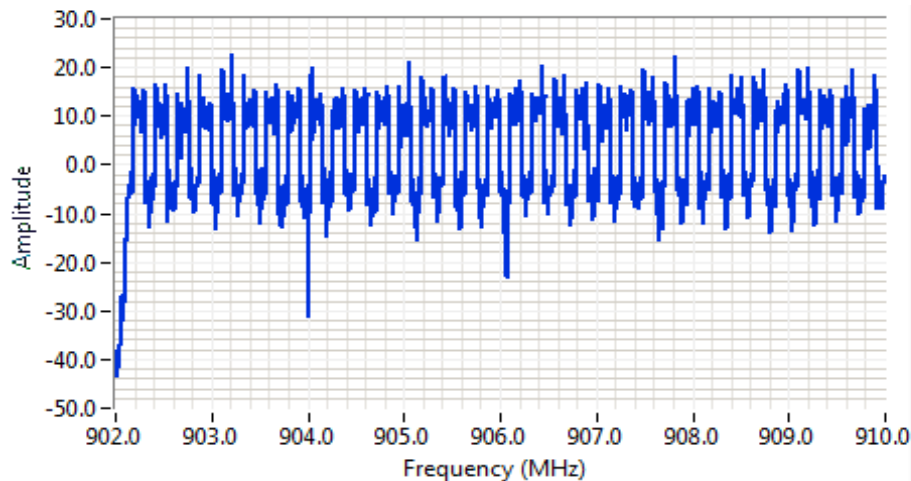
Delta Amplitude 0.0





EMC Test Data

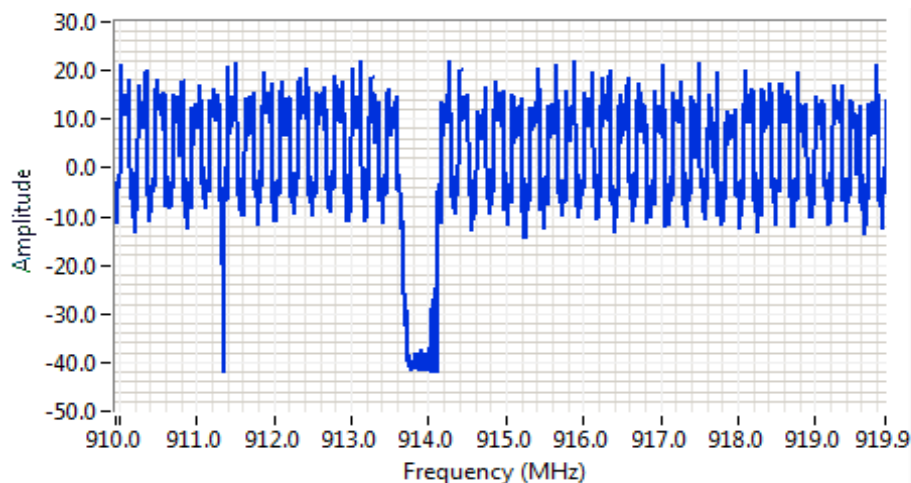
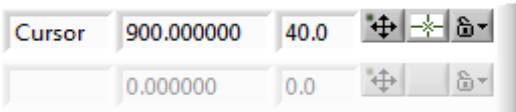
Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A



Analyzer Settings

Agilent Technologies,
E4446A
CF: 906.000 MHz
SPAN: 8.000 MHz
RB: 3.00 kHz
VB: 10.0 kHz
Detector: POS
Attn: 30 DB
RL Offset: 10.0 DB
Sweep Time: 0.8s
Comments

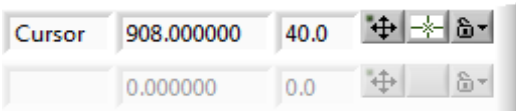
Number of channels
902-910MHz = 34



Analyzer Settings

Agilent Technologies,
E4446A
CF: 914.950 MHz
SPAN: 10.000 MHz
RB: 3.00 kHz
VB: 10.0 kHz
Detector: POS
Attn: 30 DB
RL Offset: 10.0 DB
Sweep Time: 1.1s
Comments

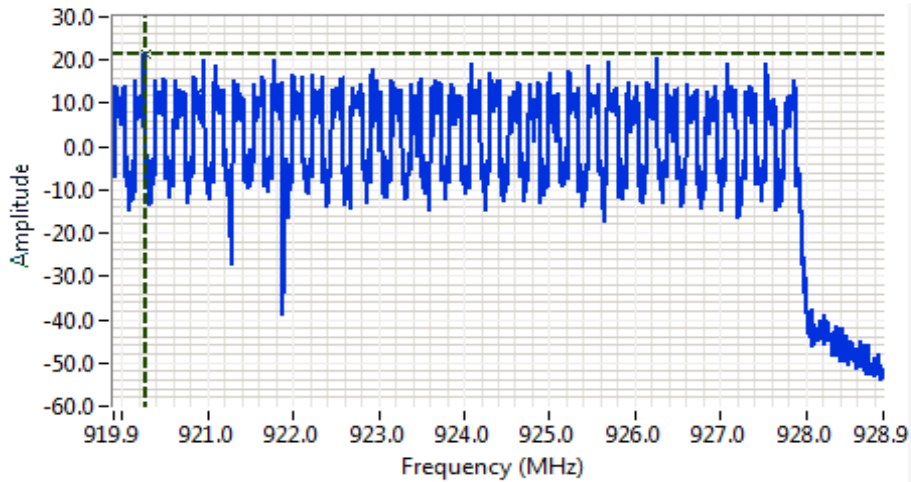
Number of channels
910-919.9MHz = 41





EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A



Analyzer Settings

Agilent Technologies,
E4446A
CF: 924.400 MHz
SPAN: 9.000 MHz
RB: 3.00 kHz
VB: 10.0 kHz
Detector: POS
Attn: 30 DB
RL Offset: 10.0 DB
Sweep Time: 0.9s

Comments

Number of channels
919.9-928MHz = 35

Cursor 920.266000 21.3

0.000000 0.0





EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A

RSS-247 and FCC 15.247 (FHSS) Measurements Power, Bandwidth and Spurious Emissions

Test Specific Details

Objective: The objective of this test session is to perform final qualification testing of the EUT with respect to the specification listed above.

General Test Configuration

The EUT and all local support equipment were located on the turntable for radiated spurious emissions testing.

For radiated emissions testing the measurement antenna was located 3 meters from the EUT.

When measuring the conducted emissions from the EUT's antenna port, the antenna port of the EUT was connected to the spectrum analyzer or power meter via a suitable attenuator to prevent overloading the measurement system. All measurements are corrected to allow for the external attenuators used.

Unless stated otherwise the EUT was operating such that it constantly hopped on either the low, center or high channels.

Ambient Conditions:

Temperature: 21-23 °C

Rel. Humidity: 39-43 %

Summary of Results

Run #	Test Performed	Limit	Pass / Fail	Result / Margin
1-3	30 - 10000 MHz - Transmitter Radiated Spurious Emissions	FCC Part 15.209 / 15.247(c)	Pass	108.3 dBµV/m @ 928.00 MHz (-1.4 dB)
4	Output Power	15.247(b)	Pass	27.4 dBm (0.5494 W)

Modifications Made During Testing:

No modifications were made to the EUT during testing

Deviations From The Standard

No deviations were made from the requirements of the standard.



EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A

Radiated Spurious Emissions, 30 - 10000 MHz.

Date of Test: 5/12/2020

Test Engineer: M. Birgani

Test Location: Fremont Chamber #7

EUT Setting/ Data Rate: 8, 115.2kbps

EUT Power: 26.3 dBm

Antenna Gain: Omni, 8.15dBi

Run #1a: Radiated Spurious Emissions, Low Channel @ 902.2464 MHz

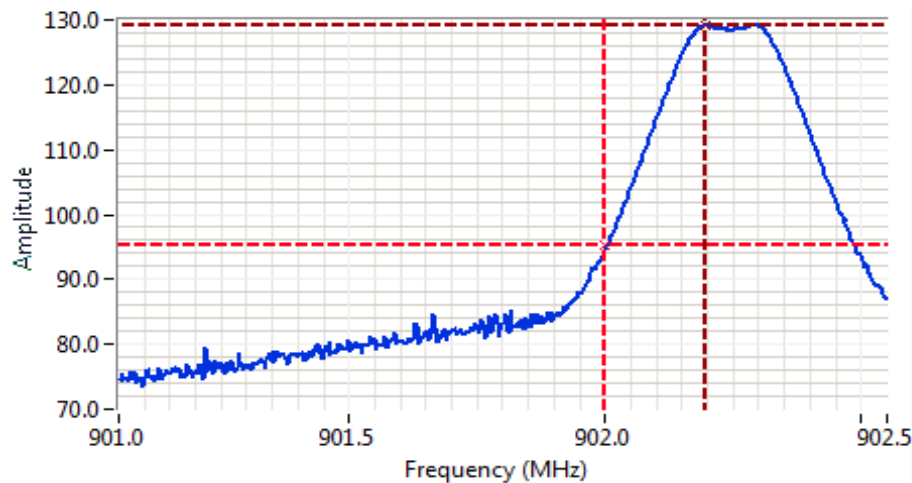
Fundamental Signal Field Strength: Peak and average values measured in 1 MHz, and peak value measured in 100kHz

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBμV/m	V/H	Limit	Margin	Pk/QP/Avg	degrees	meters	
902.195	129.2	V	-	-	PK	218	1.0	100 kHz; VB: 300 kHz
902.193	114.9	H	-	-	PK	240	1.1	100 kHz; VB: 300 kHz

Fundamental emission level @ 3m in 100kHz RBW:	129.2	114.9
Limit for emissions outside of restricted bands:	109.2 dBμV/m	Limit is -20dBc

Band Edge Signal Field Strength

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBμV/m	V/H	Limit	Margin	PK/QP/Avg	degrees	meters	
902.000	95.3	V	109.2	-13.9	PK	218	1.0	100 kHz; VB: 300 kHz



Analyzer Settings

Rohde&Schwarz, ESI
CF: 901.800 MHz
SPAN: 1.500 MHz
RB: 100 kHz
VB: 300 kHz
Detector: POS
Attn: 40 DB
RL Offset: 28.6 DB
Sweep Time: 5.0ms
Ref Lvl: 130.6 DBUV

Comments

Bandedge Measurement
Date Rate: 115.2kbps
EUT Setting: 8

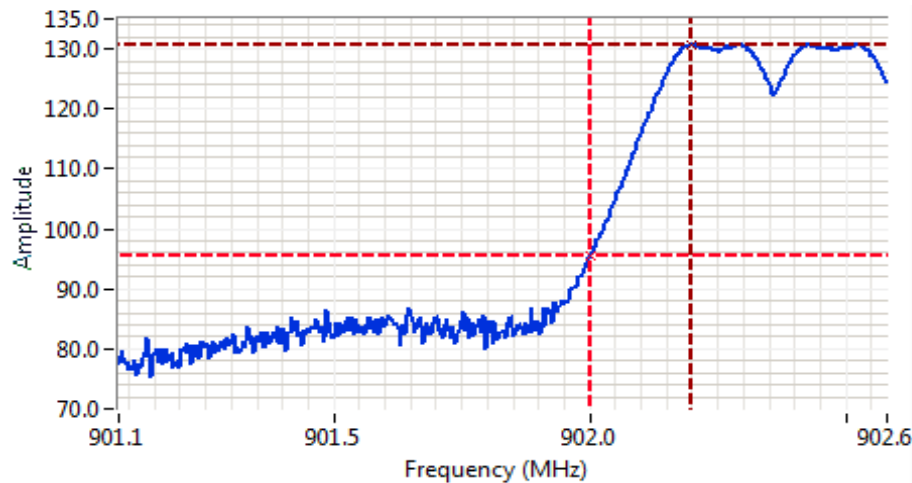
Cursor	902.000000	95.3	Delta Freq.	195 kHz
Cursor	902.195312	129.1	Delta Amplitude	33.9





EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A



Analyzer Settings

Rohde&Schwarz, ESI
CF: 901.830 MHz
SPAN: 1.500 MHz
RB: 100 kHz
VB: 300 kHz
Detector: POS
Attn: 40 DB
RL Offset: 28.6 DB
Sweep Time: 5.0ms
Ref Lvl: 138.6 DBUV

Comments

Bandedge Measurment
Date Rate: 115.2kbps
EUT Setting: 8
Hopping

Cursor	902.000000	95.6	
Cursor	902.198242	130.6	

Delta Freq. 198 kHz
Delta Amplitude 35.1





EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A

Date of Test: 5/12/2020

Test Engineer: M. Birgani

Test Location: Fremont Chamber #7

EUT Setting/ Data Rate: 8, 153.6kbps

EUT Power: 26.3 dBm

Antenna Gain: Omni, 8.15dBi

Run #1a: Radiated Spurious Emissions, Low Channel @ 902.2464 MHz

Fundamental Signal Field Strength: Peak and average values measured in 1 MHz, and peak value measured in 100kHz

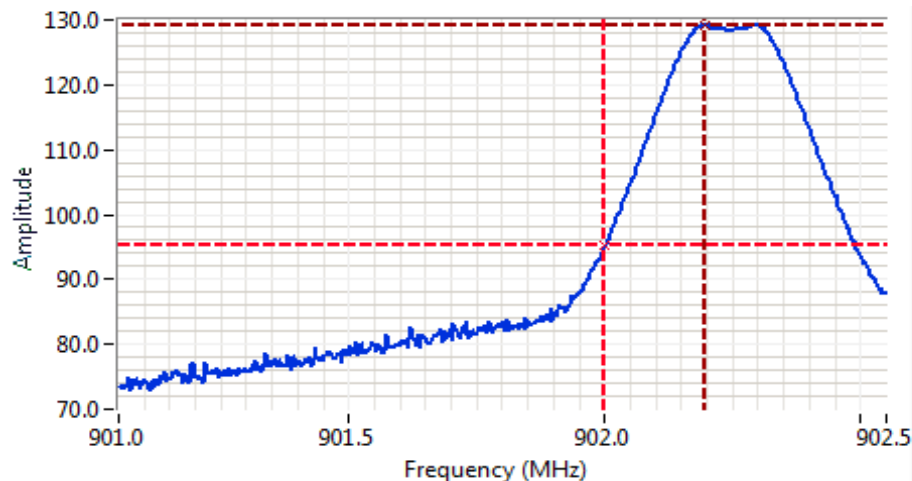
Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dB μ V/m	V/H	Limit	Margin	PK/QP/Avg	degrees	meters	
902.292	129.2	V	-	-	PK	178	1.0	100 kHz; VB: 300 kHz

Fundamental emission level @ 3m in 100kHz RBW: 129.2

Limit for emissions outside of restricted bands: 109.2 dB μ V/m **Limit is -20dBc**

Band Edge Signal Field Strength

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dB μ V/m	V/H	Limit	Margin	PK/QP/Avg	degrees	meters	
902.000	96.4	V	109.2	-12.8	PK	218	1.0	100 kHz; VB: 300 kHz



Analyzer Settings

Rohde&Schwarz,ESI
CF: 901.800 MHz
SPAN: 1.500 MHz
RB: 100 kHz
VB: 300 kHz
Detector: POS
Attn: 40 DB
RL Offset: 28.6 DB
Sweep Time: 5.0ms
Ref Lvl: 133.6 DBUV

Comments

Bandedge Measurement
Date Rate: 153.6kbps
EUT Setting: 8

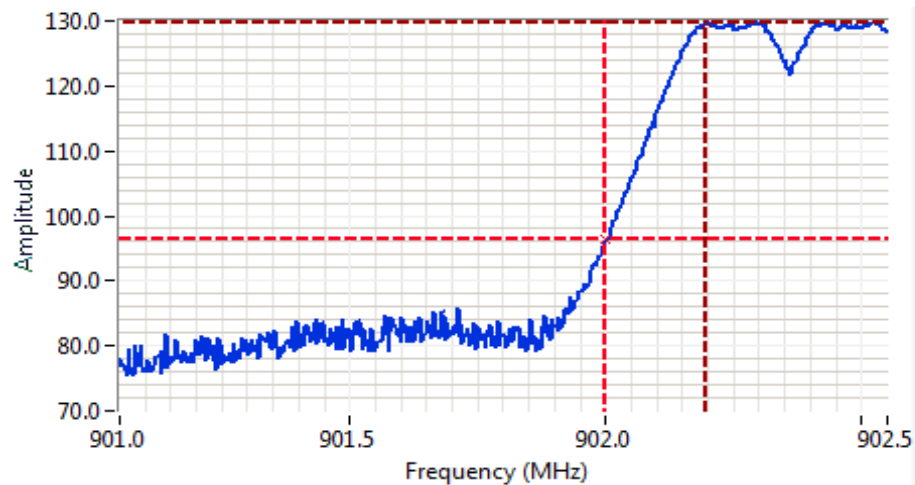
Cursor	902.000000	95.3		Delta Freq.	195 kHz
Cursor	902.195312	129.1		Delta Amplitude	33.7





EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A



Analyzer Settings
Rohde&Schwarz, ESI
CF: 901.800 MHz
SPAN: 1.500 MHz
RB: 100 kHz
VB: 300 kHz
Detector: POS
Attn: 40 DB
RL Offset: 28.6 DB
Sweep Time: 5.0ms
Ref Lvl: 133.6 DBUV
Comments
Bandedge Measurement
Date Rate: 153.6kbps
EUT Setting: 8
Hopping

Cursor	902.000000	96.4		Delta Freq.	195 kHz
Cursor	902.195312	129.7		Delta Amplitude	33.3





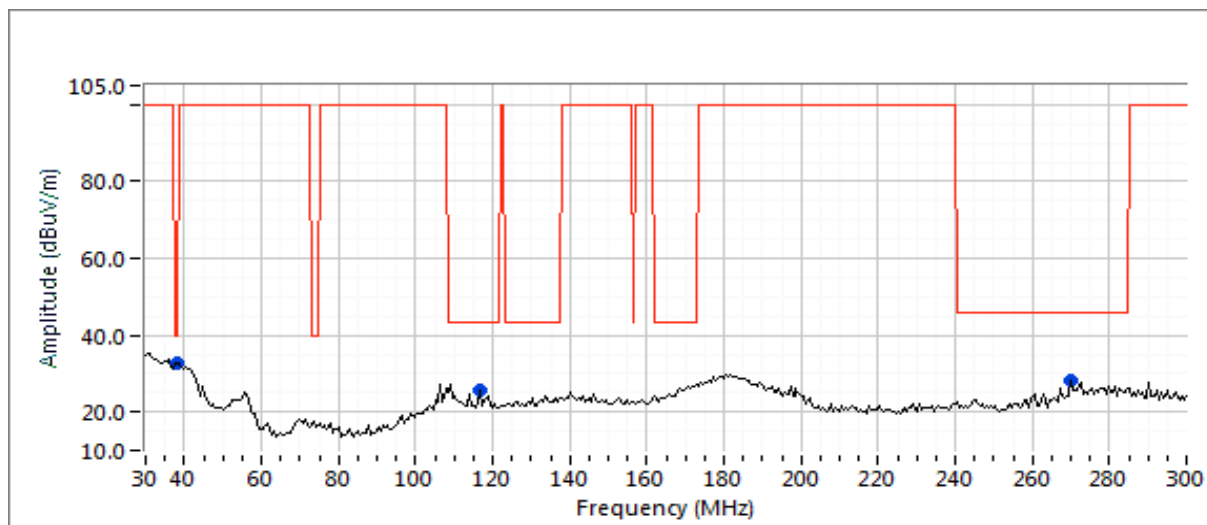
EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A

Other Spurious Emissions

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dB μ V/m	V/H	Limit	Margin	Pk/QP/Avg	degrees	meters	
270.240	25.7	H	46.0	-20.3	QP	307	1.5	QP (1.00s)
116.573	24.4	H	43.5	-19.1	QP	284	1.5	QP (1.00s)
38.116	28.6	V	40.0	-11.4	QP	175	1.0	QP (1.00s)
1804.410	68.8	V	109.2	-40.4	PK	320	2.2	RB 1 MHz;VB 3 MHz;Peak

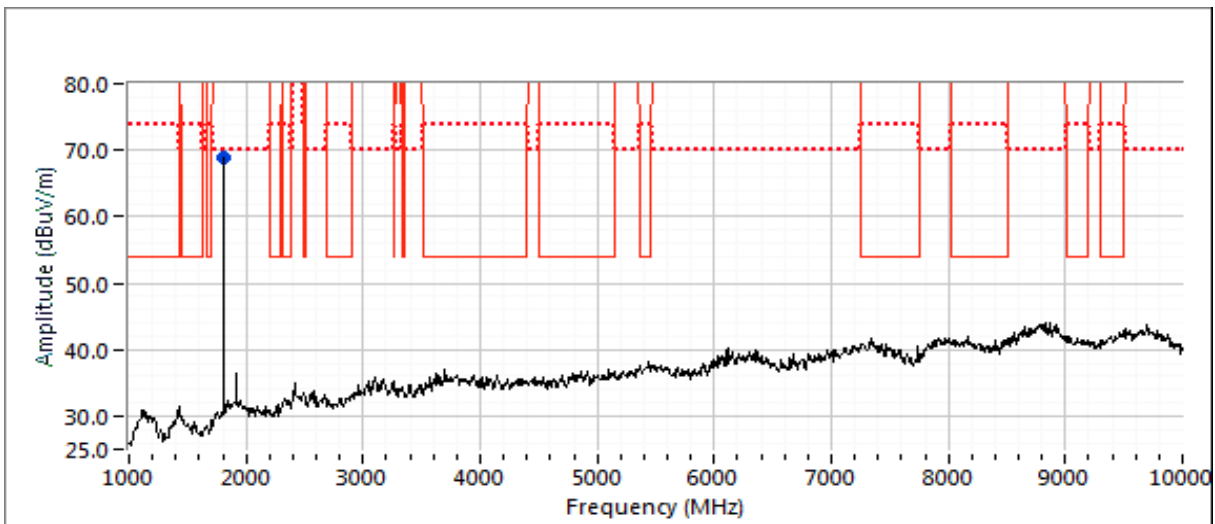
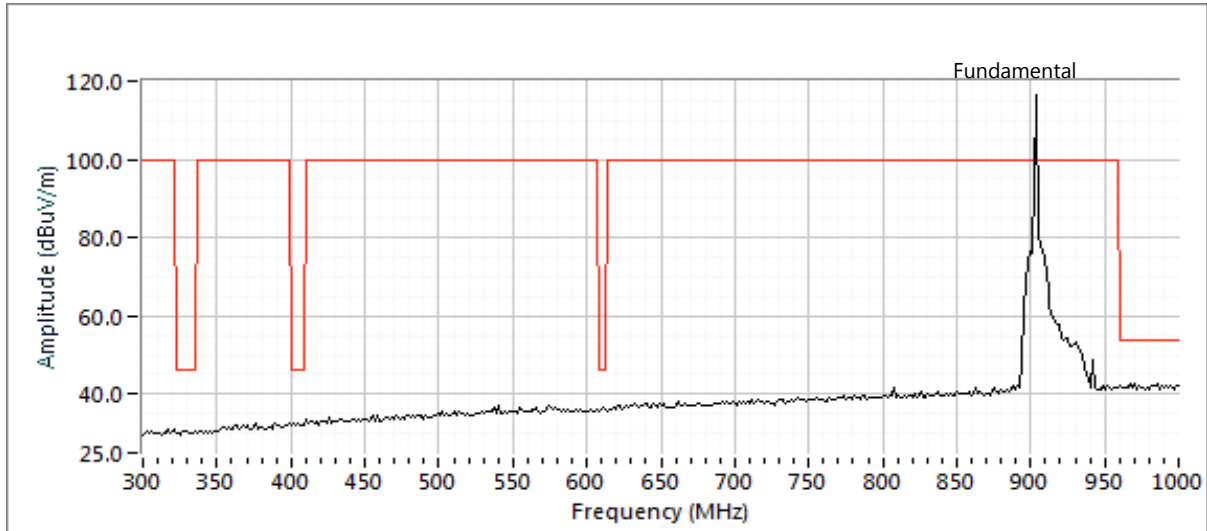
Note 1:	For emissions in restricted bands, the limit of 15.209 was used. For all other emissions, the limit was set 20dB below the level of the fundamental.
Note 2:	As the bandwidth and thus power spectral density are the same for both data rates, spurious emissions were performed only at the lowest data rate.





EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A





EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A

Date of Test: 5/12/2020

Test Engineer: M. Birgani

Test Location: Fremont Chamber #7

EUT Setting/ Data Rate: 8, 153.6kbps

EUT Power: 26.3 dBm

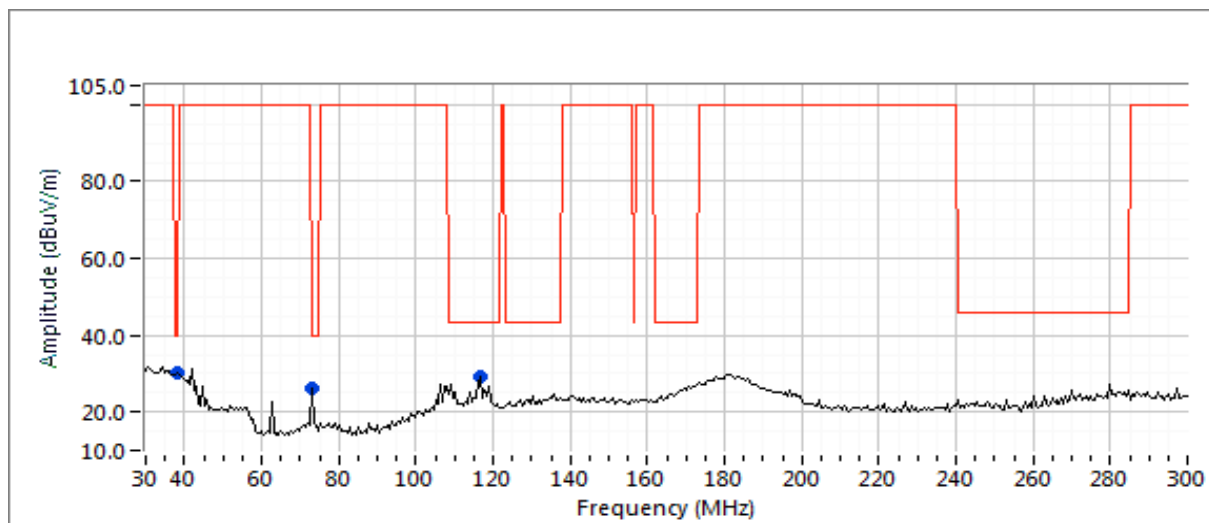
Antenna Gain: Omni, 8.15dBi

Run #1b: Radiated Spurious Emissions, Center Channel @ 914.9184 MHz

	H	V
Fundamental emission level @ 3m in 100kHz RBW:		129.2
Limit for emissions outside of restricted bands:	109.2 dB μ V/m	

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dB μ V/m	V/H	Limit	Margin	PK/QP/Avg	degrees	meters	
116.573	24.7	H	43.5	-18.8	QP	275	2.5	QP (1.00s)
38.116	28.5	V	40.0	-11.5	QP	132	1.0	QP (1.00s)
73.287	18.6	V	40.0	-21.4	QP	10	2.0	QP (1.00s)
1829.770	66.3	V	109.2	-42.9	PK	201	2.2	RB 1 MHz;VB 3 MHz;Peak

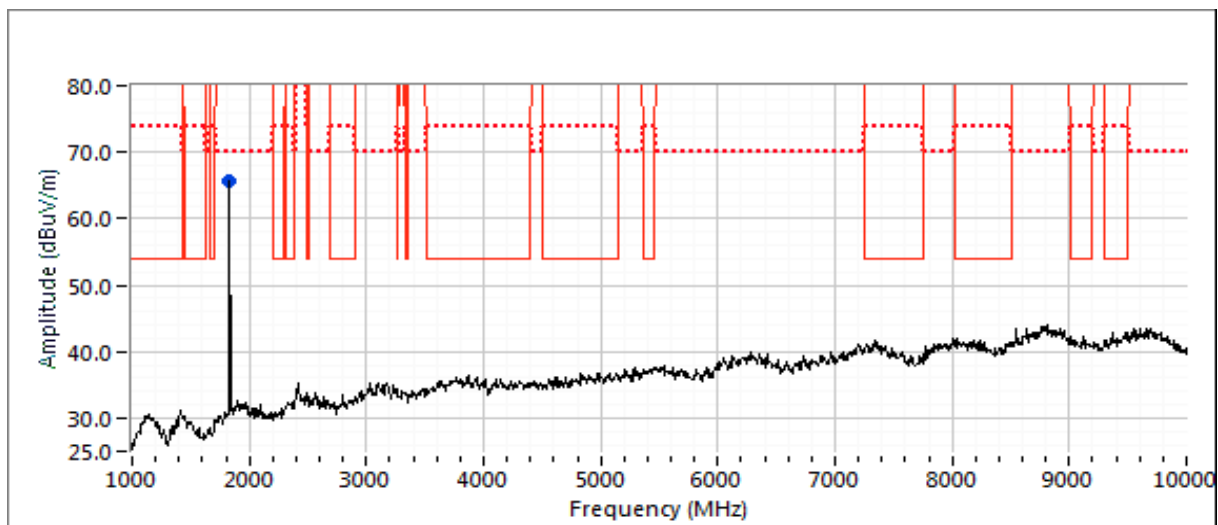
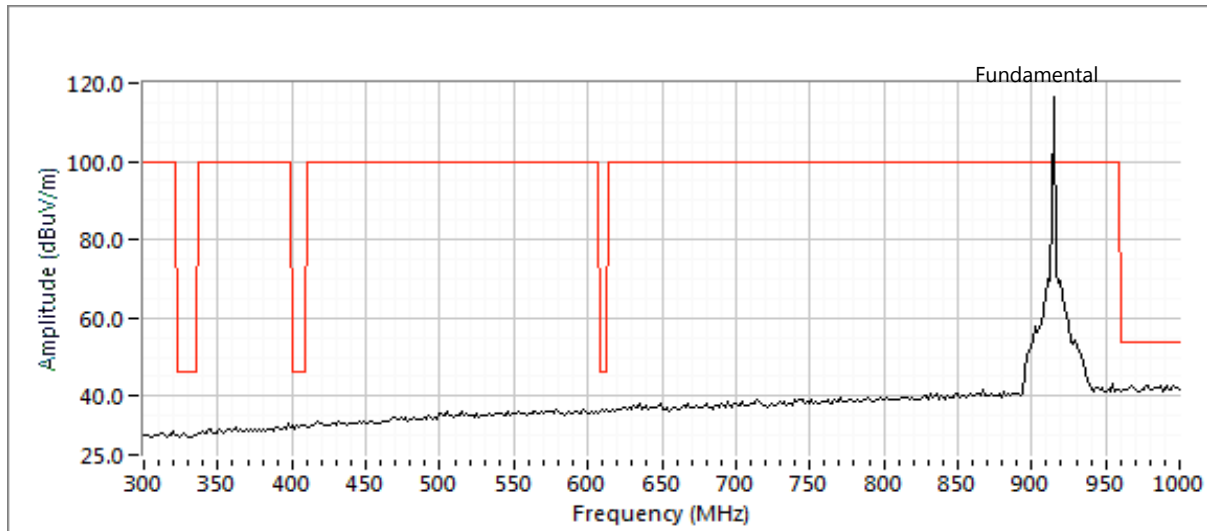
Note 1:	For emissions in restricted bands, the limit of 15.209 was used. For all other emissions, the limit was set 20dB below the level of the fundamental.
Note 2:	As the bandwidth and thus power spectral density are the same for both data rates, spurious emissions were performed only at the lowest data rate.





EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A





EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A

Date of Test: 5/11-12/2020

Test Engineer: M. Birgani

Test Location: Fremont Chamber #7

EUT Setting/ Data Rate: 9, 115.2kbps

EUT Power: 27.4 dBm

Antenna Gain: Omni, 8.15dBi

Run #3a: Radiated Spurious Emissions, High Channel @ 927.8208 MHz

Fundamental Signal Field Strength: Peak and average values measured in 1 MHz, and peak value measured in 100kHz

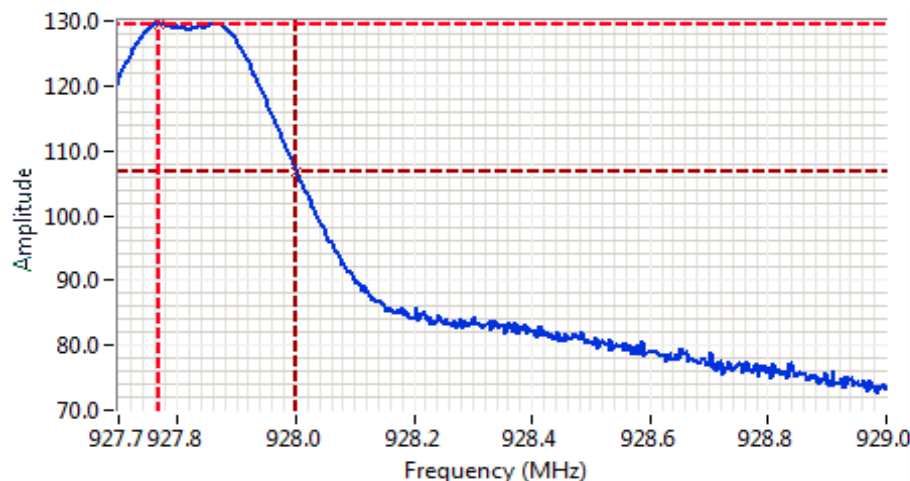
Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dB μ V/m	V/H	Limit	Margin	PK/QP/Avg	degrees	meters	
927.770	129.7	V	-	-	PK	149	1.3	100 kHz; VB: 300 kHz
927.770	111.8	H	-	-	PK	241	1.0	100 kHz; VB: 300 kHz

Fundamental emission level @ 3m in 100kHz RBW: 129.7 111.8

Limit for emissions outside of restricted bands: 109.7 dB μ V/m **Limit is -20dBc**

Band Edge Signal Field Strength

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dB μ V/m	V/H	Limit	Margin	PK/QP/Avg	degrees	meters	
928.000	108.3	V	109.7	-1.4	PK	149	1.3	100 kHz; VB: 300 kHz



Analyzer Settings

Rohde&Schwarz, ESI
CF: 928.250 MHz
SPAN: 1.500 MHz
RB: 100 kHz
VB: 300 kHz
Detector: POS
Attn: 40 DB
RL Offset: 28.8 DB
Sweep Time: 5.0ms
Ref Lvl: 133.8 DBUV
Comments

Bandedge Measurement

Date Rate: 115.2kbps
EUT Setting: 8

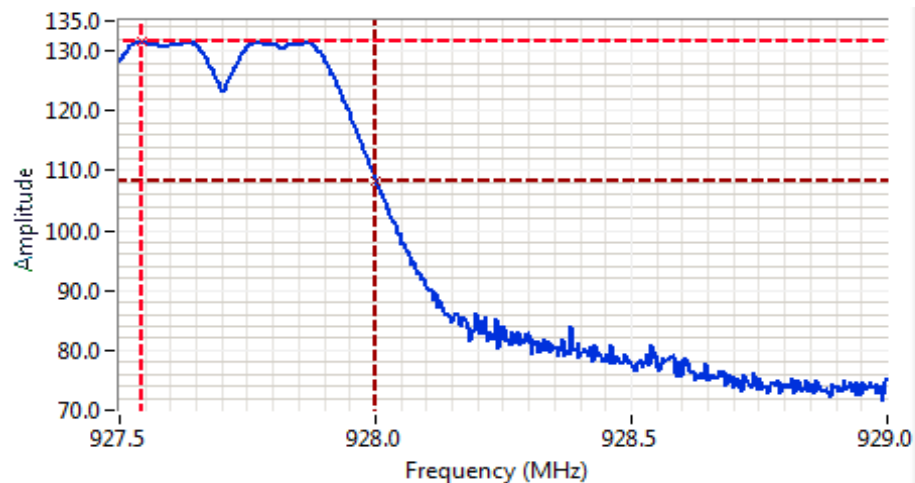
Cursor	927.767517	129.5			Delta Freq.	232 kHz
Cursor	928.000000	106.6			Delta Amplitude	22.9





EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A



Analyzer Settings

Rohde&Schwarz, ESI
CF: 928.250 MHz
SPAN: 1.500 MHz
RB: 100 kHz
VB: 300 kHz
Detector: POS
Attn: 40 DB
RL Offset: 28.8 DB
Sweep Time: 5.0ms
Ref Lvl: 133.8 DBUV

Comments

Bandedge Measurement
Date Rate: 115.2kbps
EUT Setting: 8
Hopping

Cursor	927.542114	131.5	
Cursor	928.000000	108.3	

Delta Freq. 458 kHz
Delta Amplitude 23.2





EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A

Date of Test: 5/11-12/2020

Test Engineer: M. Birgani

Test Location: Fremont Chamber #7

EUT Setting/ Data Rate: 9, 153.6kbps

EUT Power: 27.3 dBm

Antenna Gain: Omni, 8.15dBi

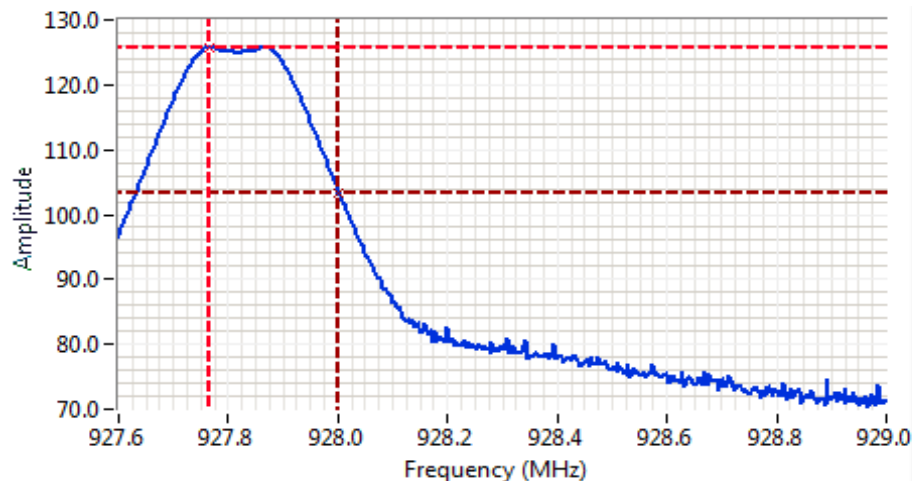
Run #3b: Radiated Spurious Emissions, High Channel @ 927.8208 MHz

Fundamental Signal Field Strength: Peak and average values measured in 1 MHz, and peak value measured in 100kHz

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dB μ V/m	V/H	Limit	Margin	PK/QP/Avg	degrees	meters	
927.764	125.7	V	-	-	PK	149	1.2	100 kHz; VB: 300 kHz

Fundamental emission level @ 3m in 100kHz RBW: 125.7

Limit for emissions outside of restricted bands: 105.7 dB μ V/m Limit is -20dBc



Analyzer Settings

Rohde&Schwarz,ESI

CF: 928.250 MHz

SPAN: 1.500 MHz

RB: 100 kHz

VB: 300 kHz

Detector: POS

Attn: 40 DB

RL Offset: 28.8 DB

Sweep Time: 5.0ms

Ref Lvl: 130.8 DBUV

Comments

Bandedge Measurement

Date Rate: 153.6kbps

EUT Setting: 8

Cursor 927.764526 125.8

Delta Freq. 235 kHz

Cursor 928.000000 103.4

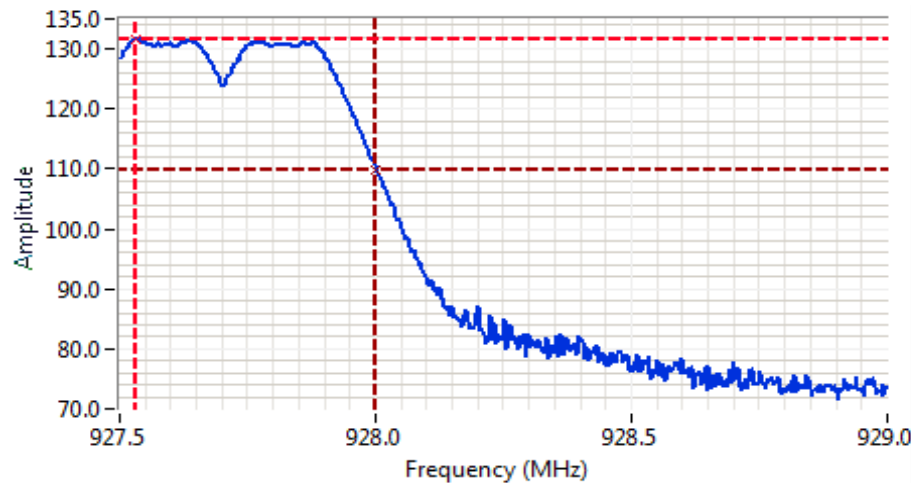
Delta Amplitude 22.3





EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A

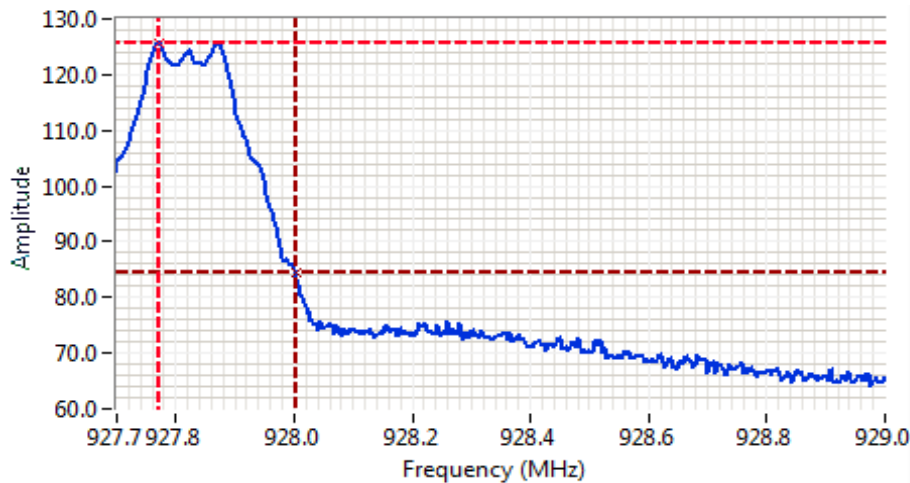


Analyzer Settings

Rohde&Schwarz, ESI
CF: 928.250 MHz
SPAN: 1.500 MHz
RB: 100 kHz
VB: 300 kHz
Detector: POS
Attn: 40 DB
RL Offset: 28.8 DB
Sweep Time: 5.0ms
Ref Lvl: 137.8 DBUV

Comments

Bandedge Measurement
Date Rate: 153.6kbps
EUT Setting: 8
Hopping



Analyzer Settings

Rohde&Schwarz, ESI
CF: 928.250 MHz
SPAN: 1.500 MHz
RB: 30.0 kHz
VB: 100 kHz
Detector: POS
Attn: 40 DB
RL Offset: 28.8 DB
Sweep Time: 5.0ms
Ref Lvl: 130.8 DBUV

Comments

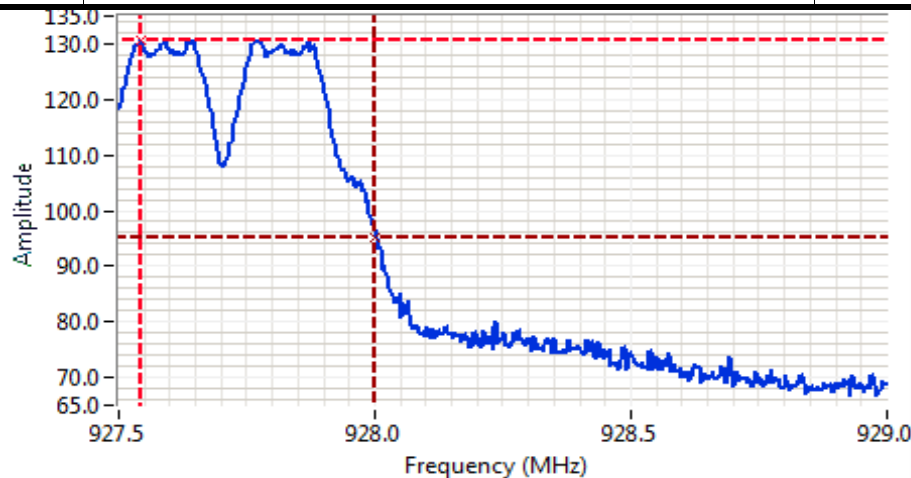
Bandedge Measurement
Date Rate: 153.6kbps
EUT Setting: 8





EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A



Analyzer Settings

Rohde&Schwarz, ESI
CF: 928.250 MHz
SPAN: 1.500 MHz
RB: 30.0 kHz
VB: 100 kHz
Detector: POS
Attn: 40 DB
RL Offset: 28.8 DB
Sweep Time: 5.0ms
Ref Lvl: 130.8 DBUV

Comments

Bandedge Measurement
Date Rate: 153.6kbps
EUT Setting: 8
Hopping

Cursor	927.542114	130.8	↕	↔	↖	↗
Cursor	928.000000	95.3	↕	↔	↖	↗
Delta Freq.		458 kHz				
Delta Amplitude		35.5				



Delta Marker - Peak 35.5 dB Delta between highest in-band and highest

Band Edge Signal Field Strength

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBμV/m	V/H	Limit	Margin	PK/QP/Avg	degrees	meters	
928.000	103.4	V	105.7	-2.3	PK	149	1.2	100 kHz; VB: 300 kHz



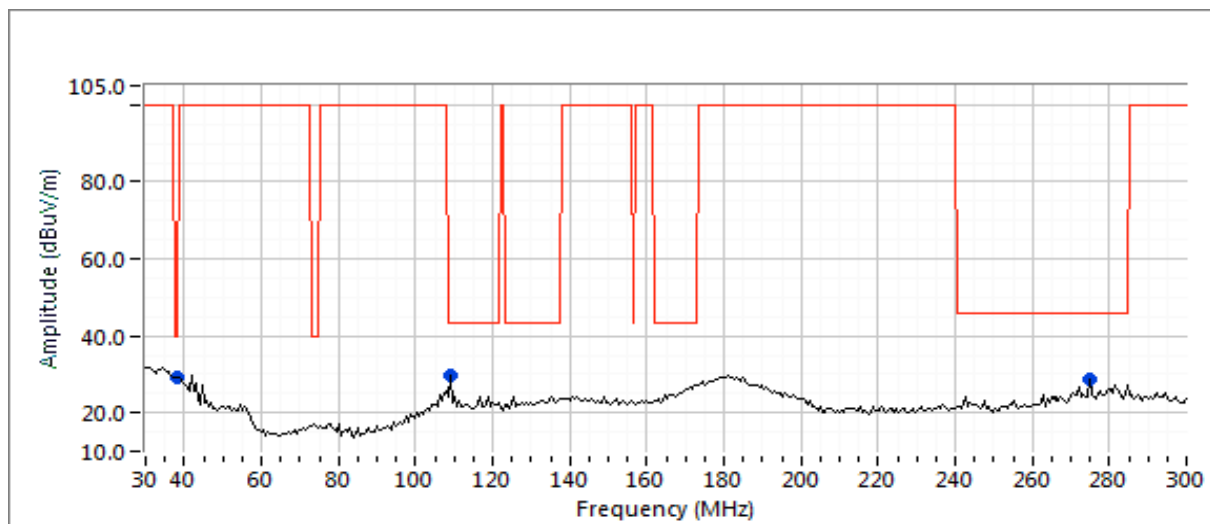
EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A

Other Spurious Emissions

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dB μ V/m	V/H	Limit	Margin	Pk/QP/Avg	degrees	meters	
38.116	28.0	V	40.0	-12.0	QP	106	1.0	QP (1.00s)
108.998	24.7	H	43.5	-18.8	QP	221	3.0	QP (1.00s)
275.110	26.4	H	46.0	-19.6	QP	307	1.0	QP (1.00s)
1855.560	69.5	V	105.7	-36.2	PK	190	2.2	RB 1 MHz;VB 3 MHz;Peak

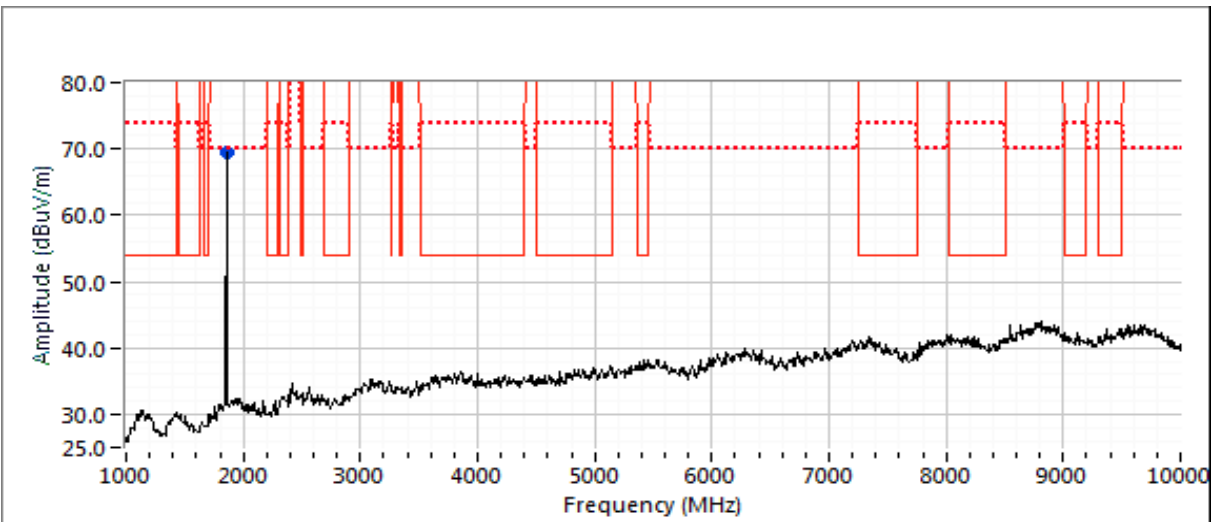
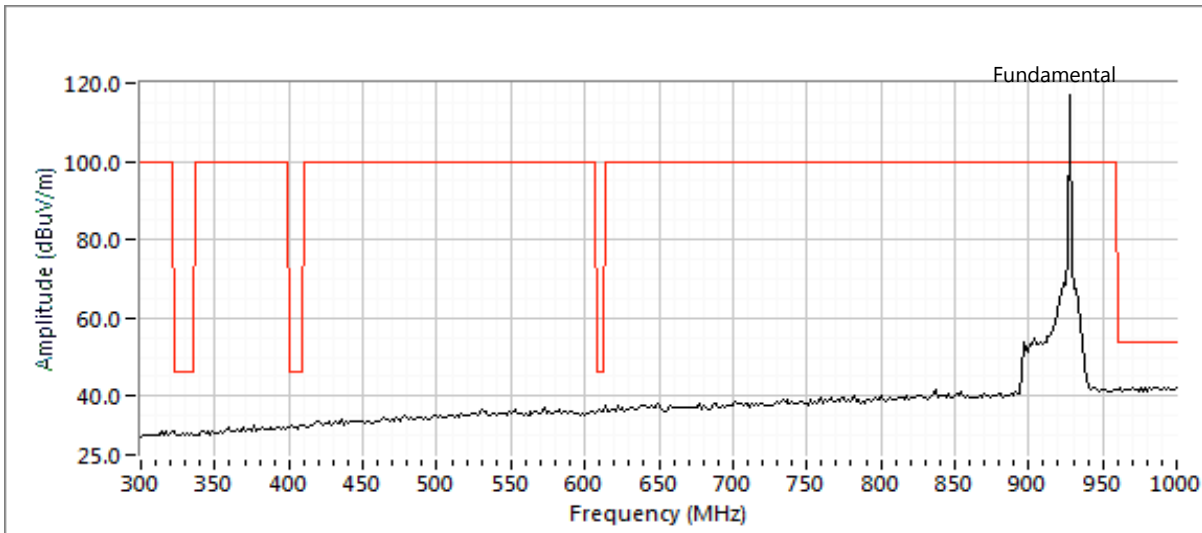
Note 1:	For emissions in restricted bands, the limit of 15.209 was used. For all other emissions, the limit was set 20dB below the level of the fundamental.
Note 2:	As the bandwidth and thus power spectral density are the same for both data rates, spurious emisisions were performed only at the lowest data rate.





EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A





EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A

Run #4: Output Power

Date of Test: 5/11/2020

Test Engineer: M. Birgani

Test Location: Fremont Chamber #7

For frequency hopping systems operating in the 902-928 MHz band: 1 watt for systems employing at least 50 hopping channels.

Data Rate: 115.2 kbps

Power Setting	Frequency (MHz)	Output Power		Antenna Gain (dBi)	Result	EIRP	
		(dBm) ¹	mW			dBm	W
8	902.2464	26.3	426.6	8.15	Pass	34.5	2.786
8	914.9184	26.2	416.9	8.15	Pass	34.4	2.723
9	927.8208	27.4	549.5	8.15	Pass	35.6	3.589

Note 1: Output power measured using a peak power meter

Data Rate: 153.6 kbps

Power Setting	Frequency (MHz)	Output Power		Antenna Gain (dBi)	Result	EIRP	
		(dBm) ¹	mW			dBm	W
8	902.2464	26.3	426.6	8.15	Pass	34.5	2.786
8	914.9184	26.2	416.9	8.15	Pass	34.4	2.723
9	927.8208	27.3	537.0	8.15	Pass	35.5	3.508

Note 1: Output power measured using a peak power meter



EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A

RSS-247 and FCC 15.247 (FHSS) Measurements Power, Bandwidth and Spurious Emissions

Test Specific Details

Objective: The objective of this test session is to perform final qualification testing of the EUT with respect to the specification listed above.

General Test Configuration

The EUT and all local support equipment were located on the turntable for radiated spurious emissions testing.

For radiated emissions testing the measurement antenna was located 3 meters from the EUT.

When measuring the conducted emissions from the EUT's antenna port, the antenna port of the EUT was connected to the spectrum analyzer or power meter via a suitable attenuator to prevent overloading the measurement system. All measurements are corrected to allow for the external attenuators used.

Unless stated otherwise the EUT was operating such that it constantly hopped on either the low, center or high channels.

Ambient Conditions:

Temperature: 21-23 °C

Rel. Humidity: 40-43 %

Summary of Results

Run #	Test Performed	Limit	Pass / Fail	Result / Margin
1	30 - 10000 MHz - Transmitter Radiated Spurious Emissions	FCC Part 15.209 / 15.247(c)	Pass	110.2 dBµV/m @ 927.76 MHz (Margin: -2.1 dB)
2	Output Power	15.247(b)	Pass	23.8 dBm (0.2399 W)

Modifications Made During Testing:

No modifications were made to the EUT during testing

Deviations From The Standard

No deviations were made from the requirements of the standard.



EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A

Run #1: Radiated Spurious Emissions, 30 - 10000 MHz.

Run #1a: Radiated Spurious Emissions, 30 - 10000 MHz. Low Channel @ 902.2464 MHz

Date of Test: 5/11/2020

EUT Setting/ Data Rate: 5, 115.2kbps

Test Engineer: Rafael Varelas

EUT Power: 23.8 dBm

Test Location: Fremont Chamber #7

Antenna Gain: Yagi, 12dBi

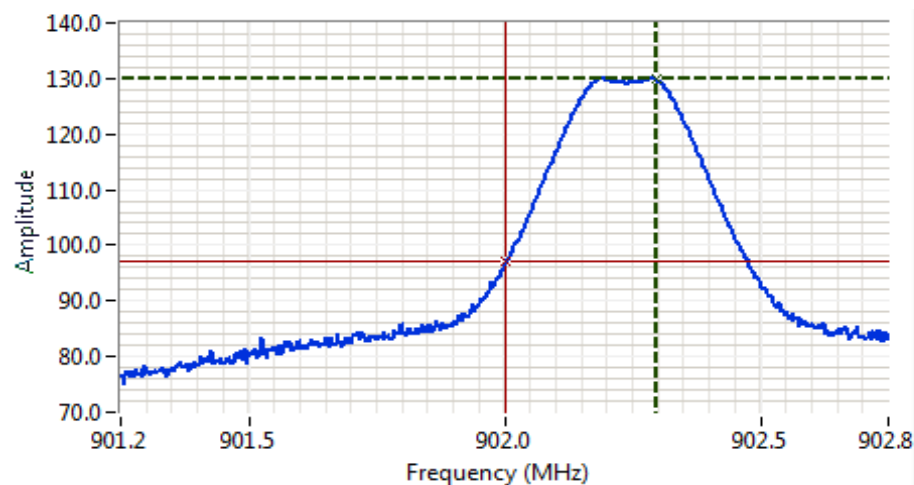
Fundamental Signal Field Strength: Peak and average values measured in 1 MHz, and peak value measured in 100kHz

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dB μ V/m	V/H	Limit	Margin	PK/QP/Avg	degrees	meters	
902.286	114.9	V	-	-	PK	92	1.0	100 kHz; VB: 300 kHz
902.186	130.1	H	-	-	PK	164	1.0	100 kHz; VB: 300 kHz

Fundamental emission level @ 3m in 100kHz RBW:	130.1	
Limit for emissions outside of restricted bands:	110.1 dB μ V/m	Limit is -20dBc

Band Edge Signal Field Strength

Frequency	Level	Pol	15.209 / 15.247	Detector	Azimuth	Height	Comments
MHz	dB μ V/m	V/H	Limit	Margin	PK/QP/Avg	degrees	meters
902.186	97.3	H	110.1	-12.8	PK	164	1.0



Analyzer Settings

Rohde&Schwarz,ESI
CF: 902.000 MHz
SPAN: 1.500 MHz
RB: 100 kHz
VB: 300 kHz
Detector: POS
Attn: 30 DB
RL Offset: 28.6 DB
Sweep Time: 5.0ms
Ref Lvl: 142.0 DBUV
Comments

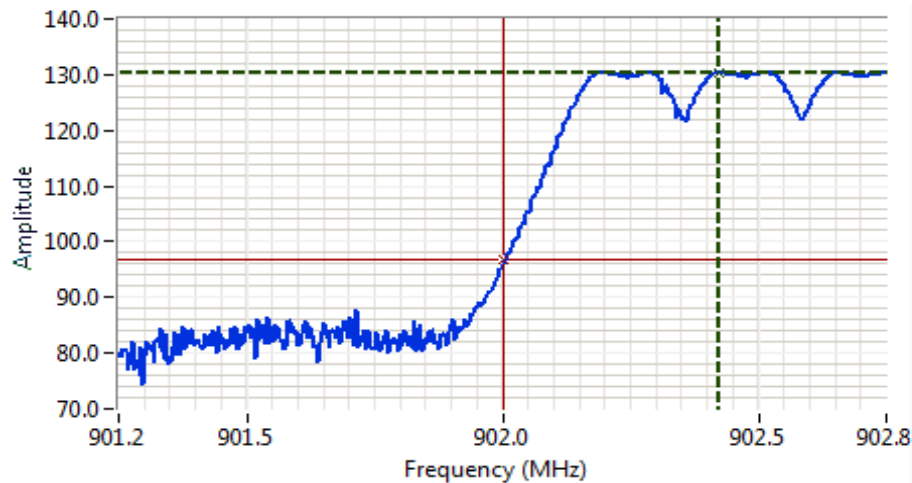
Cursor	902.297244	129.9		Delta Freq.	297 kHz
Cursor	902.000000	97.1		Delta Amplitude	32.8





EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A



Analyzer Settings

Rohde&Schwarz, ESI
CF: 902.000 MHz
SPAN: 1.500 MHz
RB: 100 kHz
VB: 300 kHz
Detector: POS
Attn: 30 DB
RL Offset: 28.6 DB
Sweep Time: 5.0ms
Ref Lvl: 140.6 DBUV

Comments

Cursor	902.423228	130.4	
Cursor	902.000000	96.8	

Delta Freq. 423 kHz
Delta Amplitude 33.6





EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A

Run #1a: Radiated Spurious Emissions, 30 - 10000 MHz. Low Channel @ 902.2464 MHz

Date of Test: 5/11/2020

EUT Setting/ Data Rate: 5, 153.6kbps

Test Engineer: Rafael Varelas

EUT Power: 23.7 dBm

Test Location: Fremont Chamber #7

Antenna Gain: Yagi, 12dBi

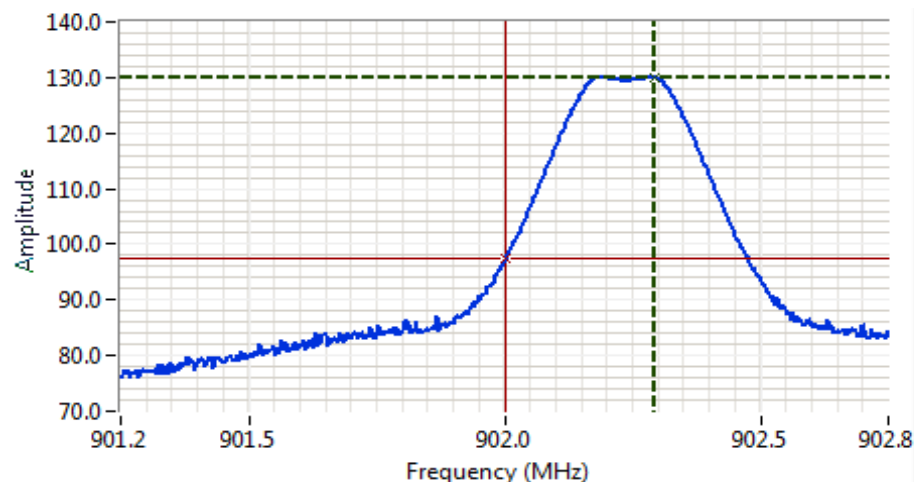
Fundamental Signal Field Strength: Peak and average values measured in 1 MHz, and peak value measured in 100kHz

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dB μ V/m	V/H	Limit	Margin	PK/QP/Avg	degrees	meters	
902.184	130.1	H	-	-	PK	166	1.0	100 kHz; VB: 300 kHz

Fundamental emission level @ 3m in 100kHz RBW:	130.1	
Limit for emissions outside of restricted bands:	110.1 dB μ V/m	Limit is -20dBc

Band Edge Signal Field Strength

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dB μ V/m	V/H	Limit	Margin	PK/QP/Avg	degrees	meters	
902.184	97.6	H	110.1	-12.5	PK	166	1.0	



Analyzer Settings
Rohde&Schwarz, ESI
CF: 902.000 MHz
SPAN: 1.500 MHz
RB: 100 kHz
VB: 300 kHz
Detector: POS
Attn: 30 DB
RL Offset: 28.6 DB
Sweep Time: 5.0ms
Ref Lvl: 140.0 DBUV
Comments

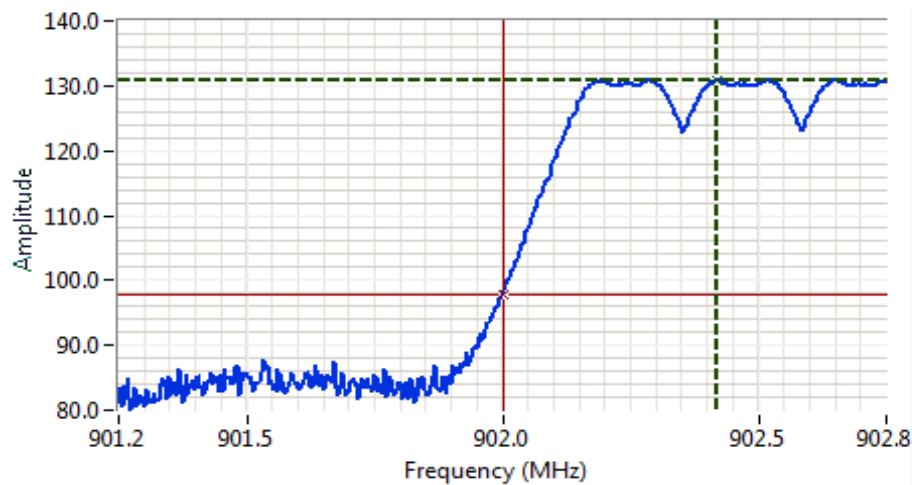
Cursor	902.293307	130.0		Delta Freq.	293 kHz
Cursor	902.000000	97.5		Delta Amplitude	32.5





EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A



Analyzer Settings
Rohde&Schwarz,ESI
CF: 902.000 MHz
SPAN: 1.500 MHz
RB: 100 kHz
VB: 300 kHz
Detector: POS
Attn: 30 DB
RL Offset: 28.6 DB
Sweep Time: 5.0ms
Ref Lvl: 140.0 DBUV
Comments

Cursor	902.419291	130.8	
Cursor	902.000000	97.8	

Delta Freq. 419 kHz
Delta Amplitude 33.0





EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A

Other Spurious Emissions

Date of Test: 5/13/2020

Test Engineer: David Bare

Test Location: Fremont Chamber #7

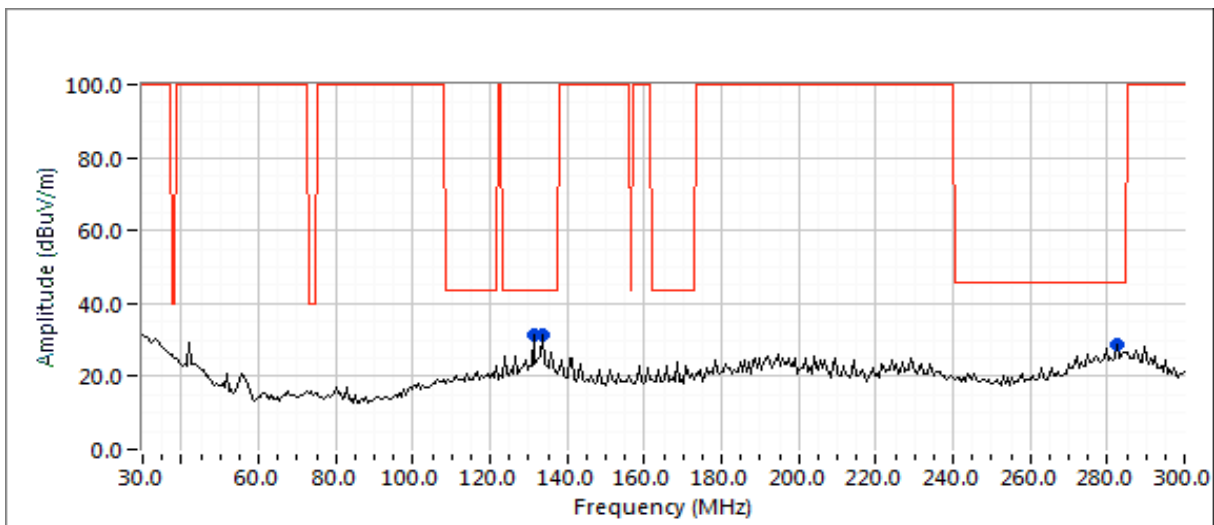
EUT Setting/ Data Rate: 5, 115.2kbps

EUT Power: 23.8 dBm

Antenna Gain: Yagi, 12dBi

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBuV/m	V/H	Limit	Margin	PK/QP/Avg	degrees	meters	
131.182	31.3	H	43.5	-12.2	QP	280	3.0	QP (1.00s)
133.888	25.4	H	43.5	-18.1	QP	294	3.5	QP (1.00s)
282.685	26.2	H	46.0	-19.8	QP	0	2.5	QP (1.00s)
1804.500	62.0	V	110.1	-48.1	PK	134	1.0	RB 1 MHz;VB 3 MHz

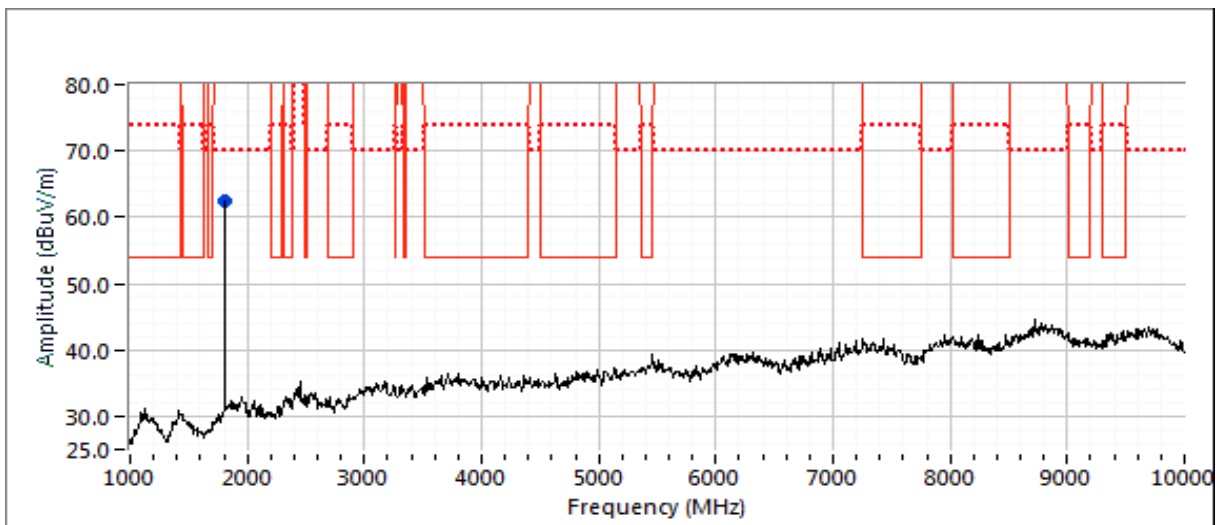
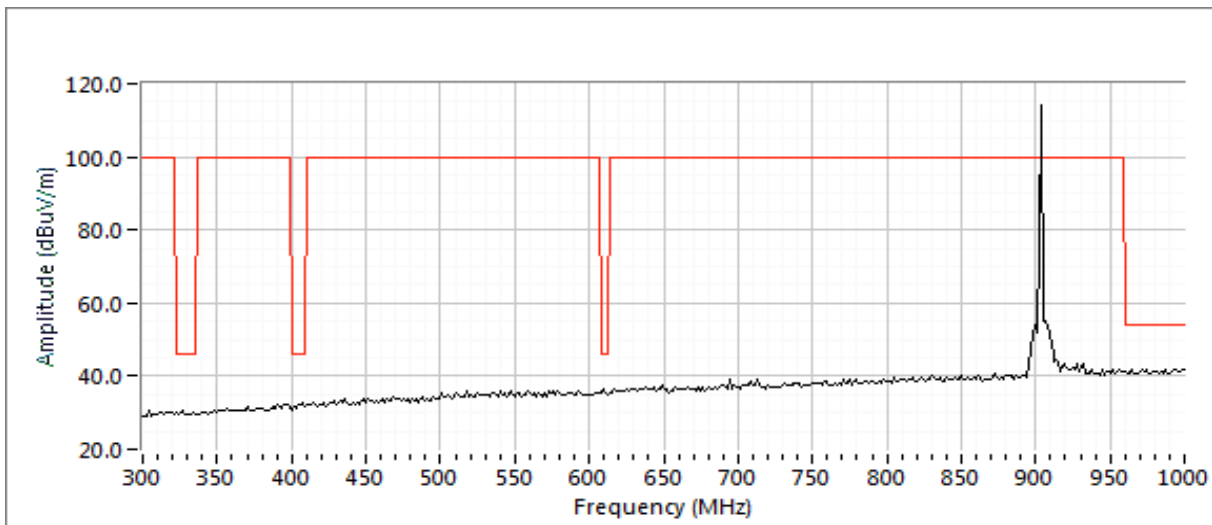
Note 1:	For emissions in restricted bands, the limit of 15.209 was used. For all other emissions, the limit was set 20dB below the level of the fundamental.
Note 2:	As the bandwidth and thus power spectral density are the same for both data rates, spurious emissions were performed only at the lowest data rate.





EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A





EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A

Run #1b: Radiated Spurious Emissions, 30 - 10000 MHz. Center Channel @ 914.9184 MHz

Date of Test: 5/13/2020

EUT Setting/ Data Rate: 5, 115.2kbps

Test Engineer: David Bare

EUT Power: 23.8 dBm

Test Location: Fremont Chamber #7

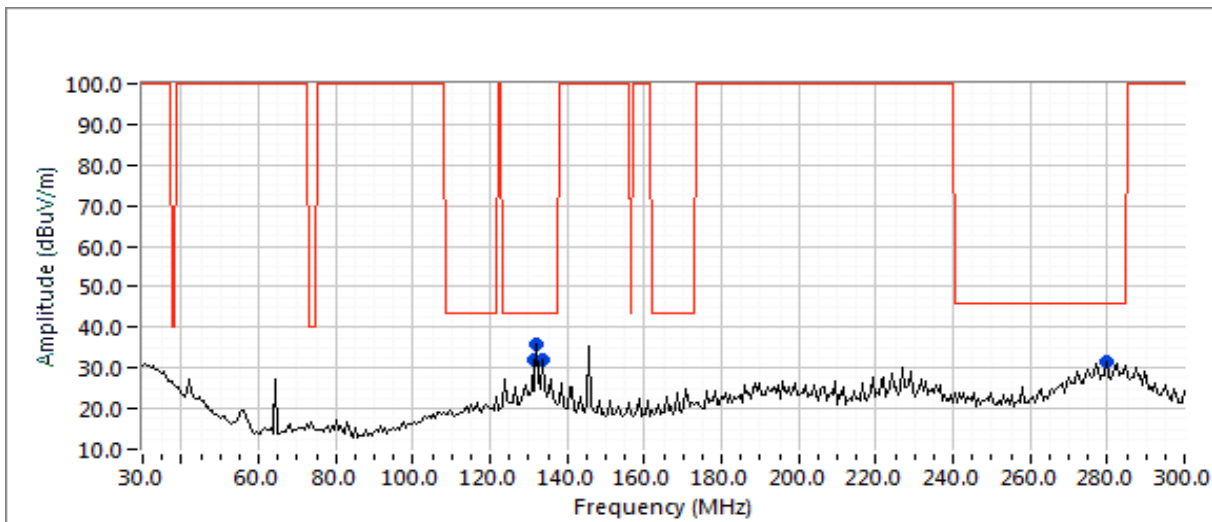
Antenna Gain: Yagi, 12dBi

	H	V
Fundamental emission level @ 3m in 100kHz RBW:		129.2
Limit for emissions outside of restricted bands:	109.2 dB μ V/m	

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dB μ V/m	V/H	Limit	Margin	Pk/QP/Avg	degrees	meters	
131.182	31.4	H	43.5	-12.1	QP	116	2.5	QP (1.00s)
132.265	24.7	H	43.5	-18.8	QP	324	3.0	QP (1.00s)
133.888	25.7	H	43.5	-17.8	QP	297	2.0	QP (1.00s)
279.980	27.6	H	46.0	-18.4	QP	202	1.5	QP (1.00s)
1829.950	60.9	V	109.2	-48.3	PK	316	1.0	RB 1 MHz;VB 3 MHz;Peak

Note 1: For emissions in restricted bands, the limit of 15.209 was used. For all other emissions, the limit was set 20dB below the level of the fundamental.

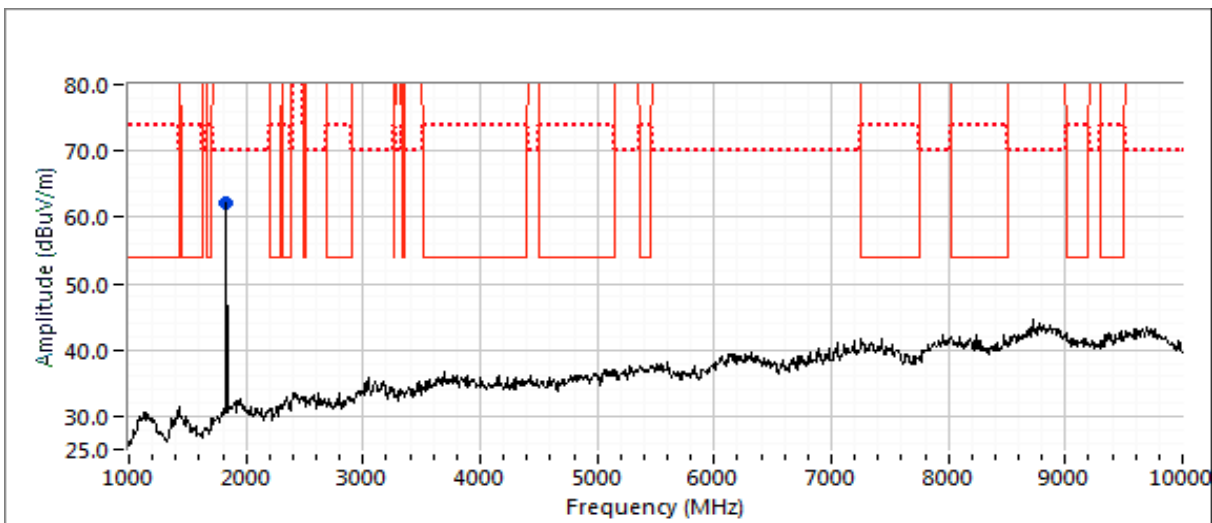
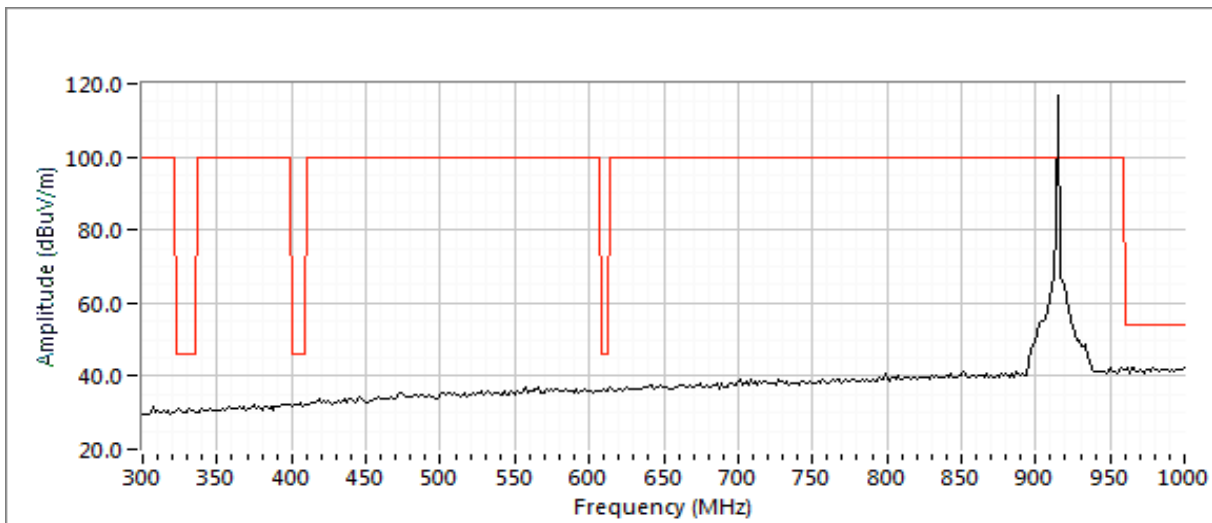
Note 2: As the bandwidth and thus power spectral density are the same for both data rates, spurious emissions were performed only at the lowest data rate.





EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A





EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A

Run #1c: Radiated Spurious Emissions, 30 - 10000 MHz. High Channel @ 927.8208 MHz

Date of Test: 5/11/2020

EUT Setting/ Data Rate: 6, 115.2kbps

Test Engineer: R. Varelas; M. Birgani

EUT Power: 23.6 dBm

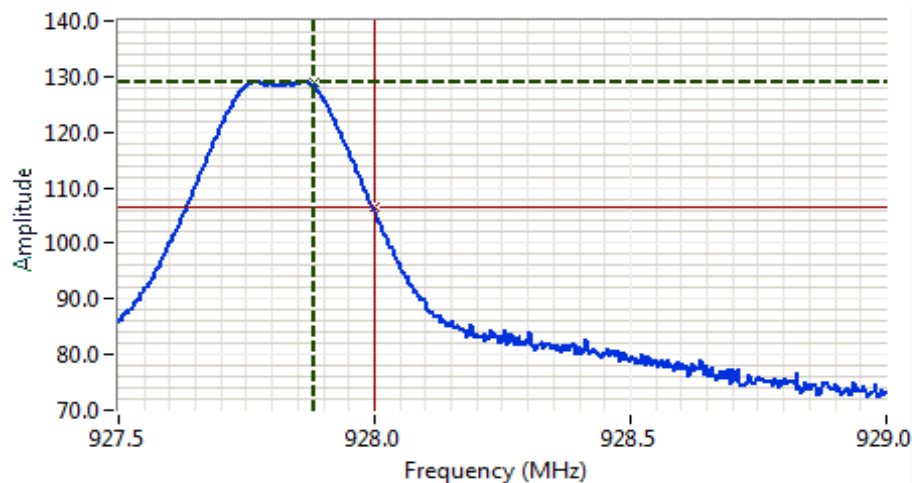
Test Location: Fremont Chamber #7

Antenna Gain: Yagi, 12dBi

Fundamental Signal Field Strength: Peak and average values measured in 1 MHz, and peak value measured in 100kHz

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dB μ V/m	V/H	Limit	Margin	PK/QP/Avg	degrees	meters	
927.768	115.0	V	-	-	PK	192	1.7	100 kHz; VB: 300 kHz
927.765	129.1	H	-	-	PK	207	1.0	100 kHz; VB: 300 kHz

Fundamental emission level @ 3m in 100kHz RBW:	129.1	
Limit for emissions outside of restricted bands:	109.1 dB μ V/m	Limit is -20dBc



Analyzer Settings

Rohde&Schwarz, ESI
CF: 928.250 MHz
SPAN: 1.500 MHz
RB: 100 kHz
VB: 300 kHz
Detector: POS
Attn: 30 DB
RL Offset: 28.8 DB
Sweep Time: 5.0ms
Ref Lvl: 142.8 DBUV
Comments

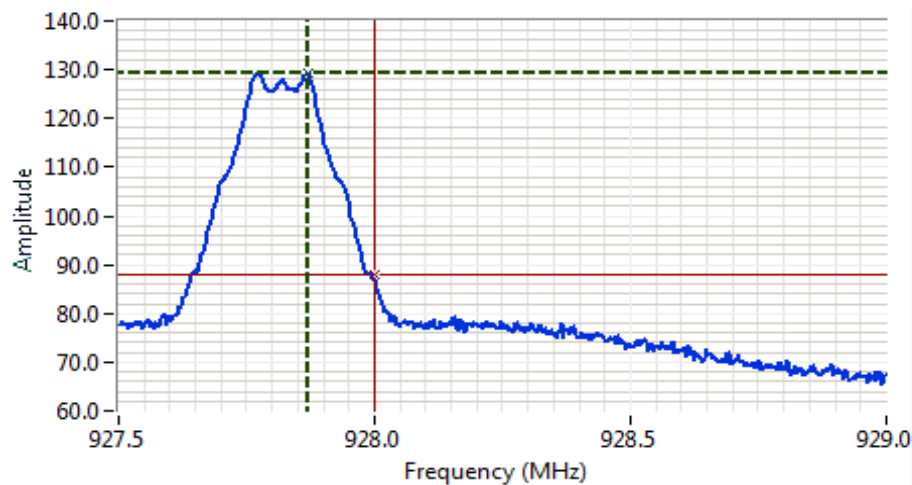
Cursor	927.881890	129.0		Delta Freq.	118 kHz
Cursor	928.000000	106.5		Delta Amplitude	22.5





EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A

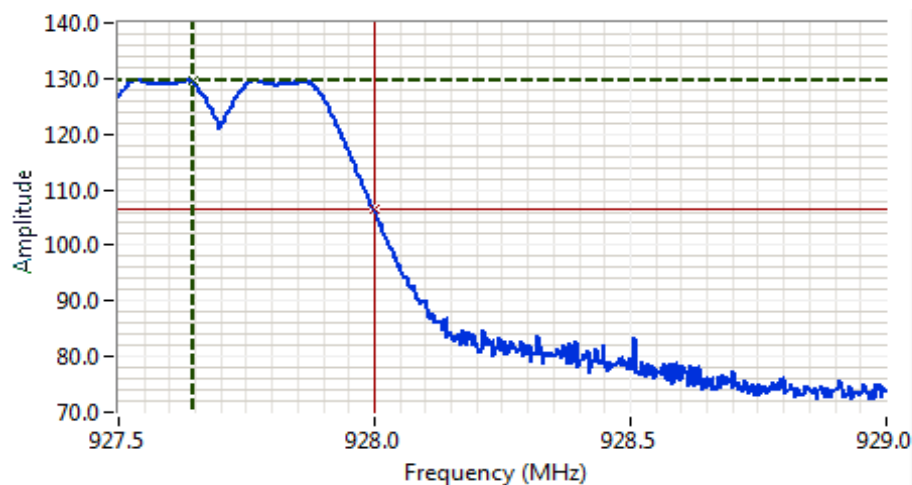


Analyzer Settings

Rohde&Schwarz,ESI
CF: 928.250 MHz
SPAN: 1.500 MHz
RB: 30.0 kHz
VB: 100 kHz
Detector: POS
Attn: 30 DB
RL Offset: 28.8 DB
Sweep Time: 5.0ms
Ref Lvl: 142.8 DBUV

Comments

Cursor	927.870079	129.1		Delta Freq.	130 kHz
Cursor	928.000000	87.9		Delta Amplitude	41.2



Analyzer Settings

Rohde&Schwarz,ESI
CF: 928.250 MHz
SPAN: 1.500 MHz
RB: 100 kHz
VB: 300 kHz
Detector: POS
Attn: 30 DB
RL Offset: 28.8 DB
Sweep Time: 5.0ms
Ref Lvl: 142.8 DBUV

Comments

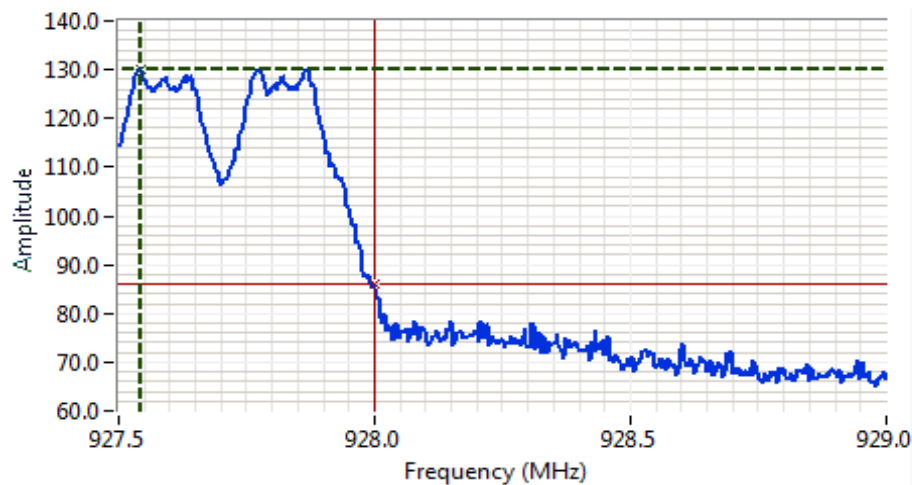
Cursor	927.645669	129.7		Delta Freq.	354 kHz
Cursor	928.000000	106.5		Delta Amplitude	23.2





EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A



Analyzer Settings
Rohde&Schwarz, ESI
CF: 928.250 MHz
SPAN: 1.500 MHz
RB: 30.0 kHz
VB: 100 kHz
Detector: POS
Attn: 30 DB
RL Offset: 28.8 DB
Sweep Time: 5.0ms
Ref Lvl: 142.8 DBUV
Comments

Cursor	927.543307	130.0	Delta Freq.	457 kHz
Cursor	928.000000	86.0	Delta Amplitude	44.0



Delta Marker - Peak 41.2 dB Delta between highest in-band and highest

Band Edge Signal Field Strength

Frequency	Level	Pol	15.209 / 15.247	Detector	Azimuth	Height	Comments
MHz	dBμV/m	V/H	Limit	Margin	Pk/QP/Avg	degrees	meters
927.765	106.6	H	109.1	-2.5	PK	207	1.0

Note 1: Calculated by subtracting the marker delta values from the fundamental field strength measurement.



EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A

Run #1c: Radiated Spurious Emissions, 30 - 10000 MHz. High Channel @ 927.8208 MHz

Date of Test: 5/11/2020

EUT Setting/ Data Rate: 6, 153.6kbps

Test Engineer: R. Varelas; M. Birgani

EUT Power: 23.7 dBm

Test Location: Fremont Chamber #7

Antenna Gain: Yagi, 12dBi

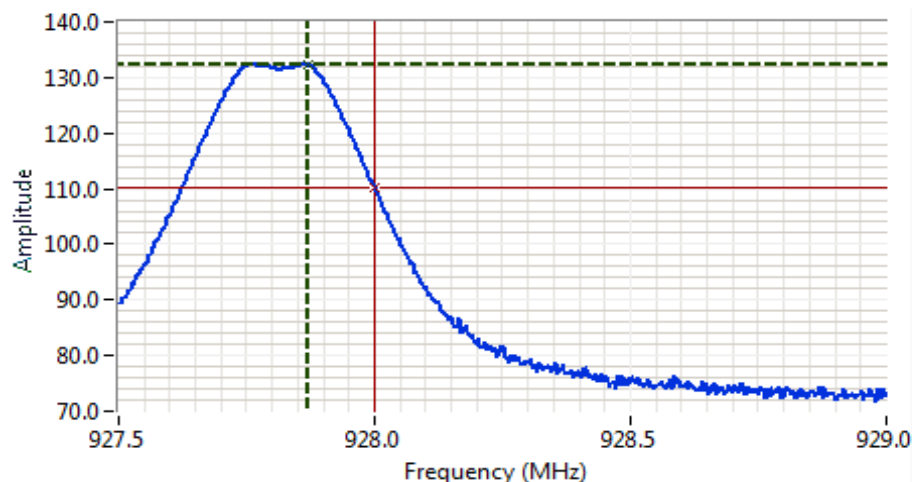
Fundamental Signal Field Strength: Peak and average values measured in 1 MHz, and peak value measured in 100kHz

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dB μ V/m	V/H	Limit	Margin	Pk/QP/Avg	degrees	meters	
927.758	132.3	H	-	-	PK	182	1.0	100 kHz; VB: 300 kHz

Fundamental emission level @ 3m in 100kHz RBW:	132.3	
Limit for emissions outside of restricted bands:	112.3 dB μ V/m	Limit is -20dBc

Band Edge Signal Field Strength

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dB μ V/m	V/H	Limit	Margin	Pk/QP/Avg	degrees	meters	
927.758	110.2	H	112.3	-2.1	PK	182	1.0	100 kHz; VB: 300 kHz



Analyzer Settings

Rohde&Schwarz,ESI
CF: 928.250 MHz
SPAN: 1.500 MHz
RB: 100 kHz
VB: 300 kHz
Detector: POS
Attn: 30 DB
RL Offset: 28.8 DB
Sweep Time: 5.0ms
Ref Lvl: 142.0 DBUV
Comments

Cursor	927.870079	132.3	
Cursor	928.000000	110.2	

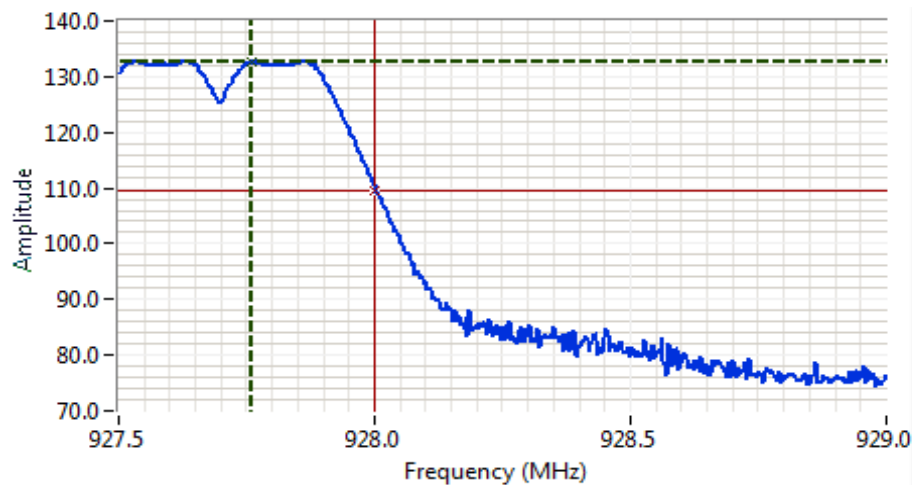
Delta Freq. 130 kHz
Delta Amplitude 22.1





EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A



Analyzer Settings

Rohde&Schwarz, ESI
CF: 928.250 MHz
SPAN: 1.500 MHz
RB: 100 kHz
VB: 300 kHz
Detector: POS
Attn: 30 DB
RL Offset: 28.8 DB
Sweep Time: 5.0ms
Ref Lvl: 142.0 DBUV

Comments

Cursor	927.759843	132.7	
Cursor	928.000000	109.5	

Delta Freq. 240 kHz
Delta Amplitude 23.2





EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A

Other Spurious Emissions

Date of Test: 5/13/2020

Test Engineer: David Bare

Test Location: Fremont Chamber #7

EUT Setting/ Data Rate: 6, 115.2kbps

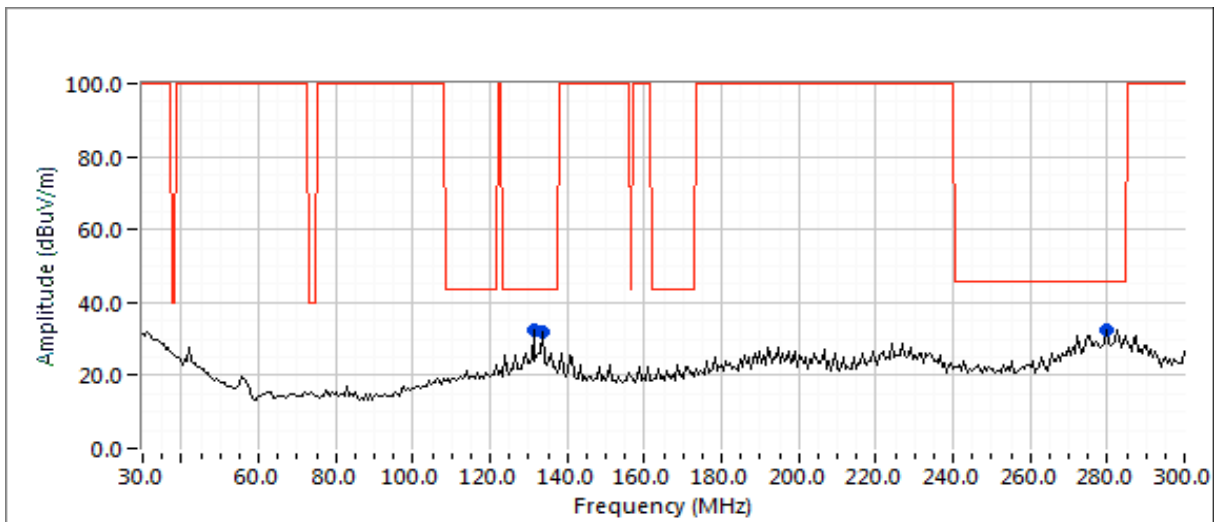
EUT Power: 23.6 dBm

Antenna Gain: Yagi, 12dBi

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dB μ V/m	V/H	Limit	Margin	PK/QP/Avg	degrees	meters	
131.182	31.6	H	43.5	-11.9	QP	294	2.5	QP (1.00s)
133.888	25.6	H	43.5	-17.9	QP	298	1.5	QP (1.00s)
279.980	27.7	H	46.0	-18.3	QP	205	1.5	QP (1.00s)
1855.650	60.0	V	112.3	-52.3	PK	314	1.0	RB 1 MHz;VB 3 MHz;Peak

Note 1: For emissions in restricted bands, the limit of 15.209 was used. For all other emissions, the limit was set 20dB below the level of the fundamental.

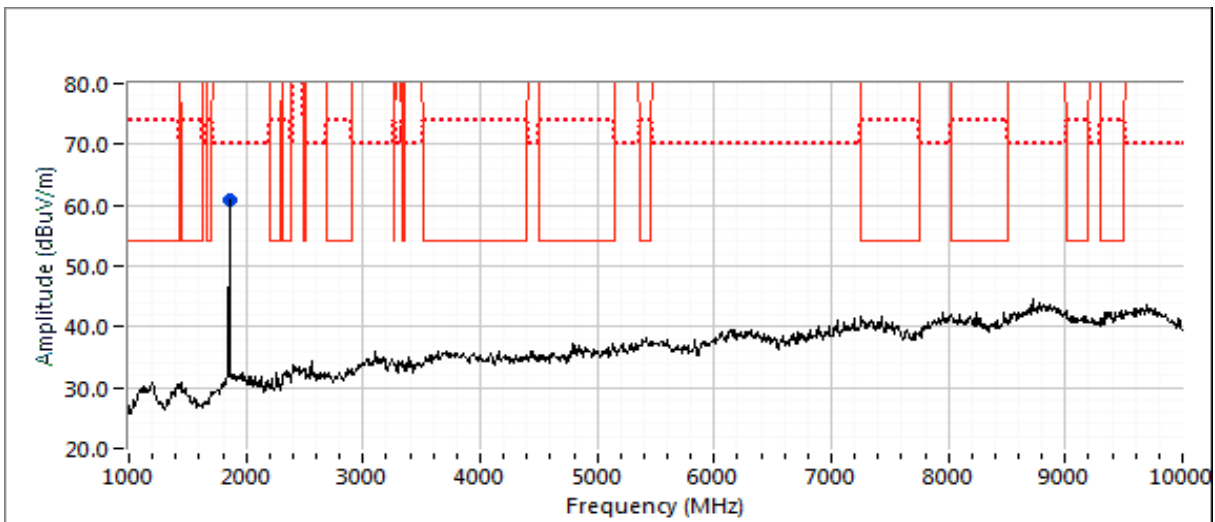
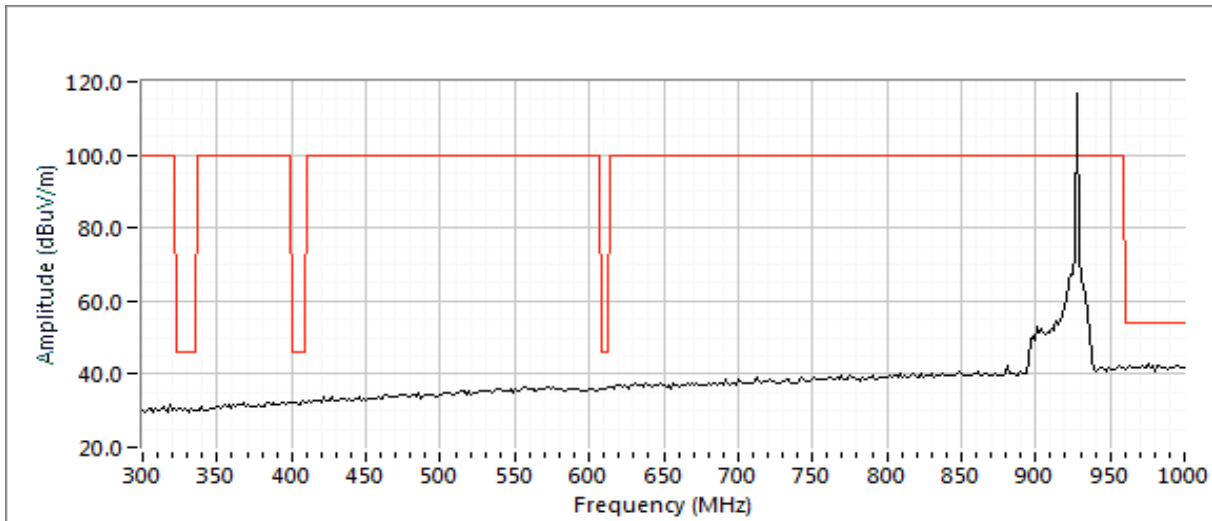
Note 2: As the bandwidth and thus power spectral density are the same for both data rates, spurious emissions were performed only at the lowest data rate.





EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A





EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	N/A

Run #3: Output Power

Date of Test: 5/11/2020

Test Engineer: M. Birgani

Test Location: Fremont Chamber #7

For frequency hopping systems operating in the 902-928 MHz band: 1 watt for systems employing at least 50 hopping channels.

Data Rate: 115.2 kbps

Power Setting	Frequency (MHz)	Output Power		Antenna Gain (dBi)	Result	EIRP	
		(dBm) ¹	mW			dBm	W
5	902.2464	23.8	239.9	12.00	Pass	35.8	3.802
4	914.9184	23.6	229.1	12.00	Pass	35.6	3.631
6	927.8208	23.6	229.1	12.00	Pass	35.6	3.631

Note 1: Output power measured using a peak power meter

Data Rate: 153.6 kbps

Power Setting	Frequency (MHz)	Output Power		Antenna Gain (dBi)	Result	EIRP	
		(dBm) ¹	mW			dBm	W
5	902.2464	23.7	234.4	12.00	Pass	35.7	3.715
5	914.9184	23.2	208.9	12.00	Pass	35.2	3.311
6	927.8208	23.7	234.4	12.00	Pass	35.7	3.715

Note 1: Output power measured using a peak power meter



EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	-

Conducted Emissions

(NTS Silicon Valley, Fremont Facility, Semi-Anechoic Chamber)

Test Specific Details

Objective: The objective of this test session is to perform final qualification testing of the EUT with respect to the specification listed above.

Date of Test: 5/14/2020
Test Engineer: M. Birgani
Test Location: Fremont Chamber # 7

Config. Used: 1
Config Change: -
EUT Voltage: 120V/ 60Hz

General Test Configuration

The EUT was located on a table inside the semi-anechoic chamber, 40 cm from a vertical coupling plane and 80cm from the LISN.

Ambient Conditions:
Temperature: 18-20 °C
Rel. Humidity: 40-42 %

Summary of Results

Run #	Test Performed	Limit	Result	Margin
1	CE, AC Power, 120V/60Hz	FCC 15.207	Pass	38.8 dBμV @ 0.17 MHz (-16.2 dB)

Modifications Made During Testing

No modifications were made to the EUT during testing

Deviations From The Standard

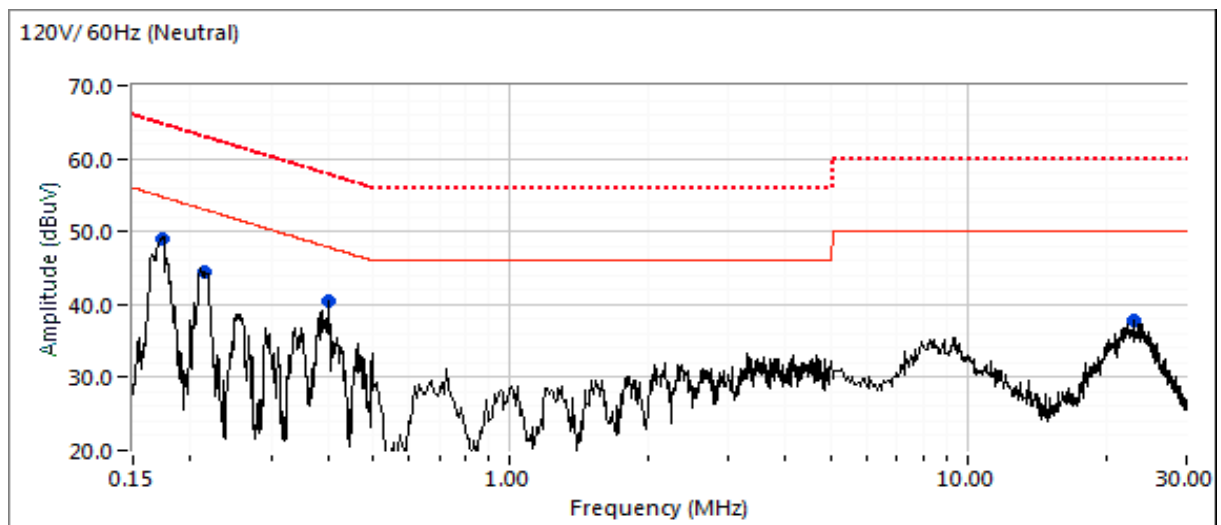
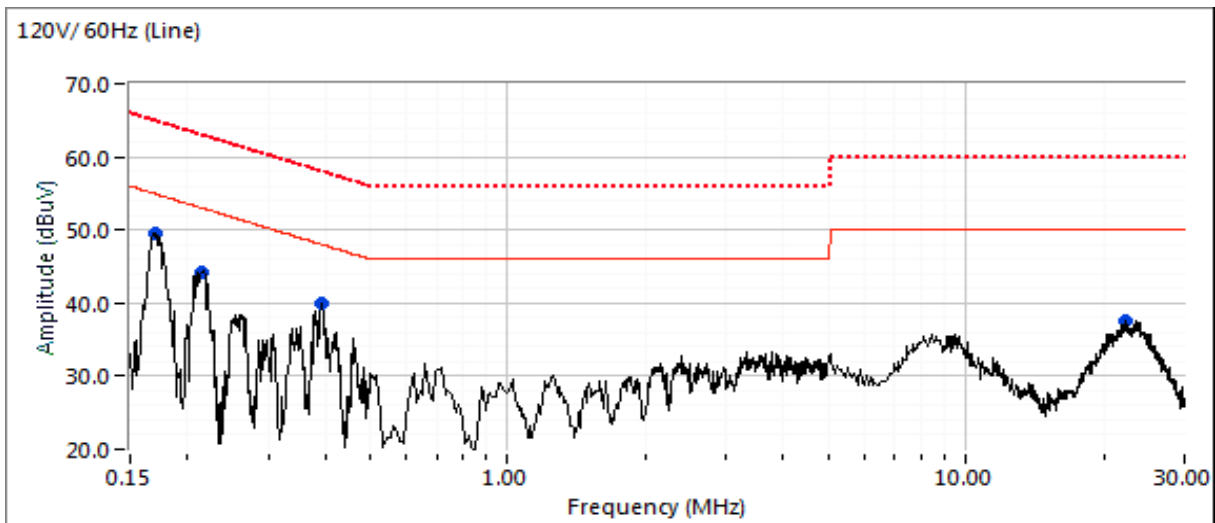
No deviations were made from the requirements of the standard.



EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	-

Run #1: AC Power Port Conducted Emissions, 0.15 - 30MHz, 120V/60Hz





EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	-

Run #1: AC Power Port Conducted Emissions, 0.15 - 30MHz, 120V/60Hz

Preliminary peak readings captured during pre-scan (peak readings vs. average limit)

Frequency MHz	Level dB μ V	AC Line	FCC 15.207		Detector QP/Ave	Comments
			Limit	Margin		
0.169	49.4	Line	55.0	-5.6	Peak	
0.176	49.1	Neutral	54.7	-5.6	Peak	
0.213	44.2	Line	53.0	-8.8	Peak	
0.214	44.5	Neutral	53.0	-8.5	Peak	
0.394	40.0	Line	48.0	-8.0	Peak	
0.399	40.4	Neutral	47.8	-7.4	Peak	
22.309	37.6	Line	50.0	-12.4	Peak	
22.991	37.9	Neutral	50.0	-12.1	Peak	

Final quasi-peak and average readings

Frequency MHz	Level dB μ V	AC Line	FCC 15.207		Detector QP/Ave	Comments
			Limit	Margin		
0.169	38.8	Line	55.0	-16.2	AVG	AVG (0.10s)
0.169	47.2	Line	65.0	-17.8	QP	QP (1.00s)
0.176	45.8	Neutral	64.7	-18.9	QP	QP (1.00s)
0.176	35.0	Neutral	54.7	-19.7	AVG	AVG (0.10s)
0.394	27.8	Line	48.0	-20.2	AVG	AVG (0.10s)
0.213	42.1	Line	63.1	-21.0	QP	QP (1.00s)
0.214	41.9	Neutral	63.0	-21.1	QP	QP (1.00s)
0.394	36.3	Line	58.0	-21.7	QP	QP (1.00s)
0.399	35.4	Neutral	57.9	-22.5	QP	QP (1.00s)
0.213	30.2	Line	53.1	-22.9	AVG	AVG (0.10s)
0.399	24.9	Neutral	47.9	-23.0	AVG	AVG (0.10s)
0.214	29.9	Neutral	53.0	-23.1	AVG	AVG (0.10s)
22.991	24.3	Neutral	50.0	-25.7	AVG	AVG (0.10s)
22.309	24.1	Line	50.0	-25.9	AVG	AVG (0.10s)
22.991	32.4	Neutral	60.0	-27.6	QP	QP (1.00s)
22.309	32.3	Line	60.0	-27.7	QP	QP (1.00s)



EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	-

Radiated Emissions

(NTS Silicon Valley, Fremont Facility, Semi-Anechoic Chamber)

Test Specific Details

Objective: The objective of this test session is to perform final qualification testing of the EUT with respect to the specification listed above.

Date of Test: 05/14/20
Test Engineer: M. Birgani
Test Location: Chamber #7

Config. Used: 1
Config Change: -
EUT Voltage: 120V/ 60Hz

General Test Configuration

The EUT and all local support equipment were located on the turntable for radiated spurious emissions testing.

For radiated emissions testing the measurement antenna was located 3 meters from the EUT.

Ambient Conditions: Temperature: 21-23 °C
Rel. Humidity: 42-44 %

Summary of Results

Run #	Test Performed	Limit	Pass / Fail	Result / Margin
1 (see note 1)	30 - 26,000 MHz Radiated Spurious Emissions	FCC Class B	Pass	34.3 dBμV/m @ 30.54 MHz (-5.7 dB)

Modifications Made During Testing:

No modifications were made to the EUT during testing

Deviations From The Standard

No deviations were made from the requirements of the standard.

Note 1: Unit set to receive at 914.9184 MHz



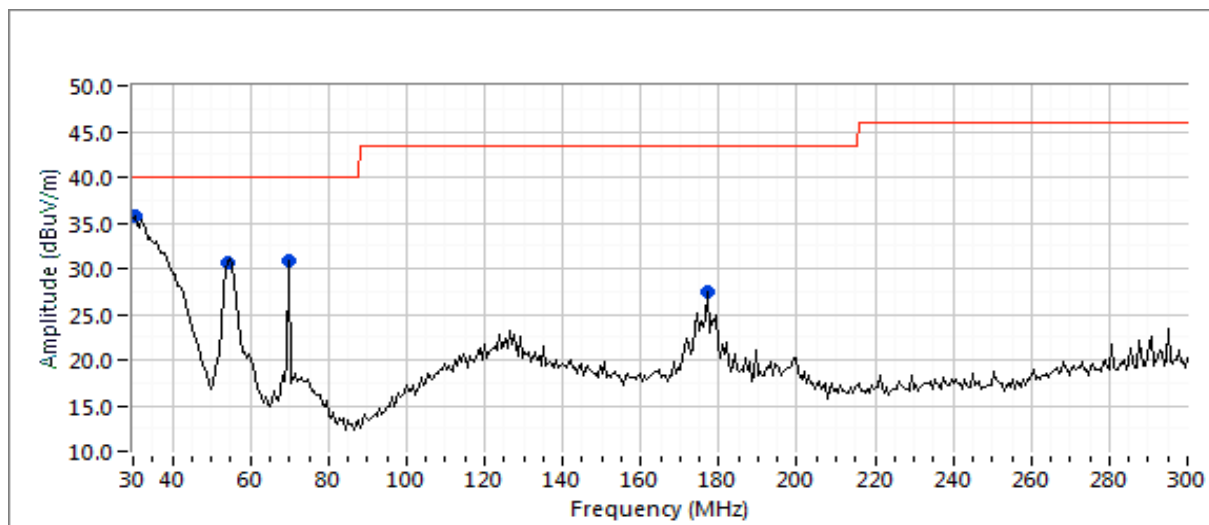
EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	-

Run #1: Radiated Spurious Emissions, 30 - 26,000 MHz.

Maximized quasi-peak readings (includes manipulation of EUT interface cables)

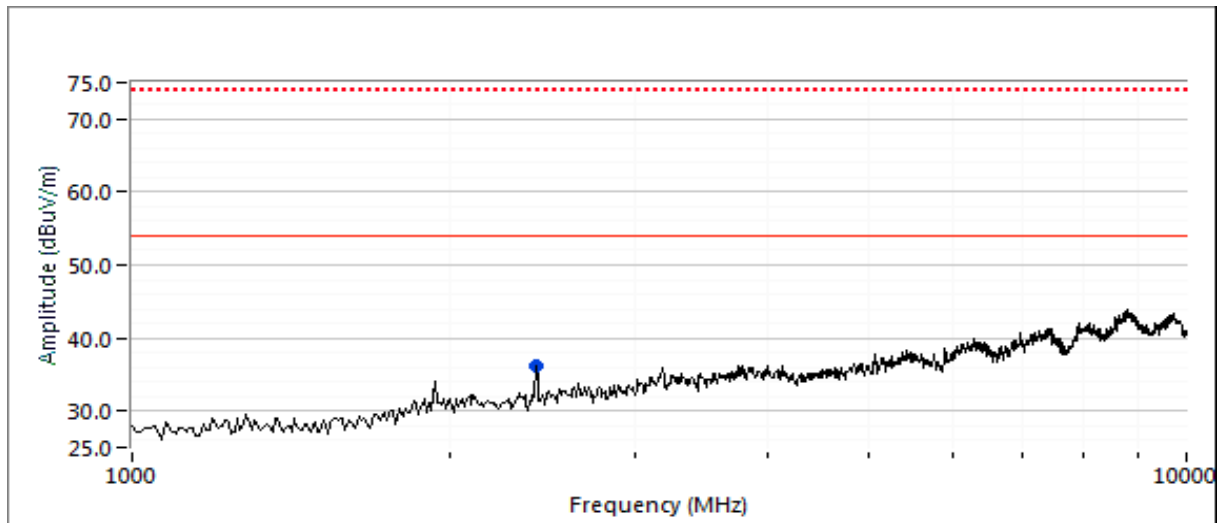
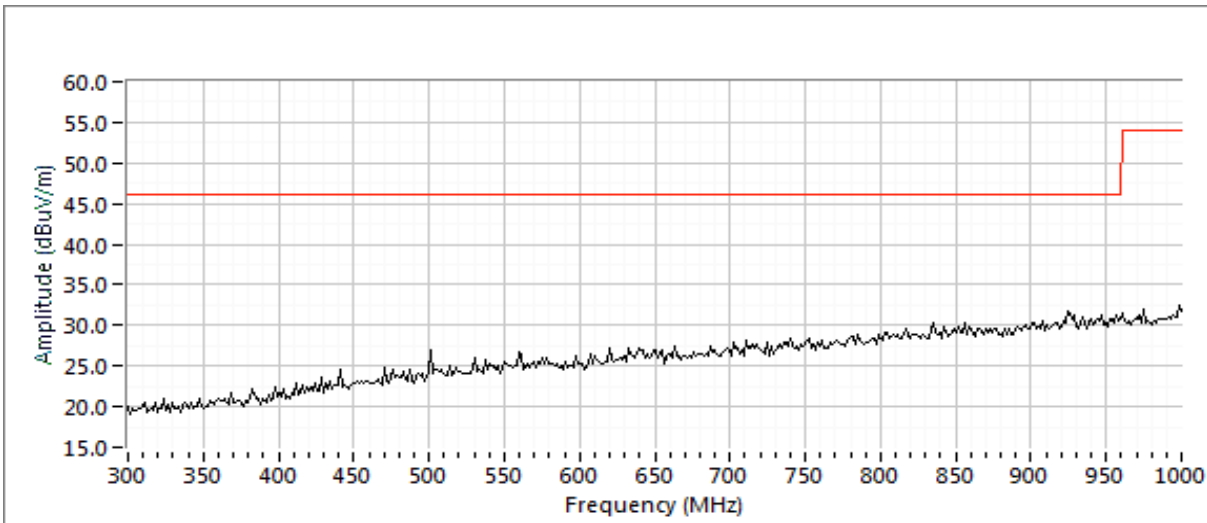
Frequency	Level	Pol	Class B		Detector	Azimuth	Height	Comments
MHz	dB μ V/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
30.541	34.3	V	40.0	-5.7	QP	346	1.0	QP (1.00s)
54.349	28.8	V	40.0	-11.2	QP	106	1.0	QP (1.00s)
177.174	23.3	H	43.5	-20.2	QP	228	2.0	QP (1.00s)
70.040	18.7	V	40.0	-21.3	QP	122	2.0	QP (1.00s)
2414.920	35.8	V	54.0	-18.2	AVG	268	1.0	RB 1 MHz;VB 10 Hz;Peak
2413.490	44.7	V	74.0	-29.3	PK	268	1.0	RB 1 MHz;VB 3 MHz;Peak





EMC Test Data

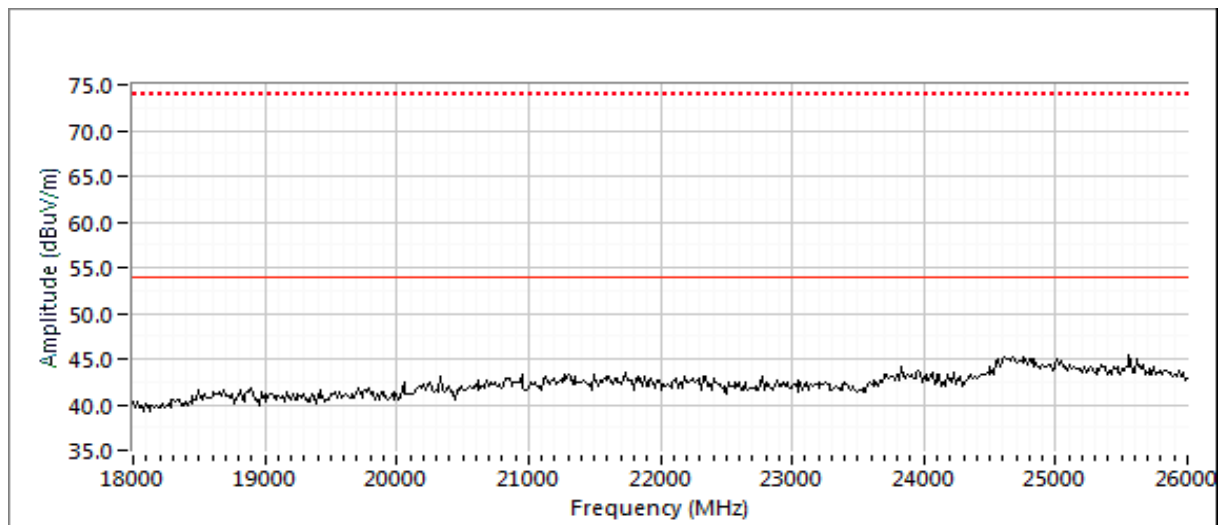
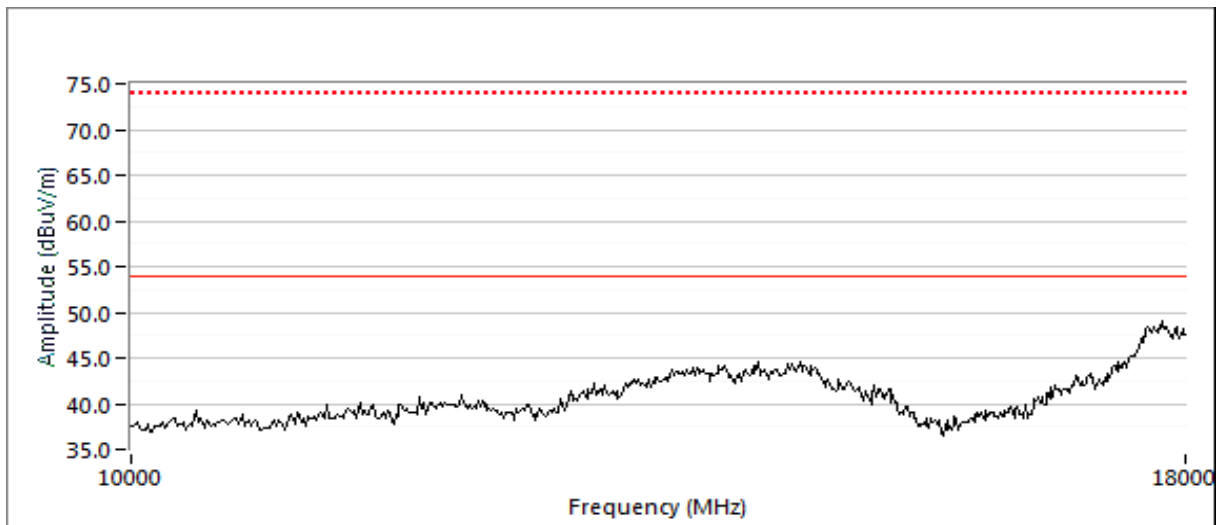
Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	-





EMC Test Data

Client:	FreeWave Technologies, Inc.	PR Number:	PR117299
Model:	MM3-T, MM3-T-U	T-Log Number:	TL117299-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15. 247, RSS-247	Project Engineer:	David Bare
		Class:	-



End of Report

This page is intentionally blank and marks the last page of this test report.