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EMC Test Report

Application for Grant of Equipment Authorization

FCC Part 15 Subpart C

Model: MM2-T

FCC ID:	KNYAMM0300AT
APPLICANT:	FreeWave Technologies, Inc. 5395 Pearl Parkway, Suite 100 Boulder, CO 80301
TEST SITE(S):	National Technical Systems - Silicon Valley 41039 Boyce Road. Fremont, CA. 94538-2435
REPORT DATE:	September 17, 2013
FINAL TEST DATES:	July 16, 18 and 24, 2013
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A2LA ACCREDITED
Testing Cert #0214.26

REVISION HISTORY

Rev#	Date	Comments	Modified By
	09-17-2013	First release	

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SCOPE

An electromagnetic emissions test has been performed on the FreeWave Technologies, Inc. model MM2-T, pursuant to the following rules:

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 - Silicon Valley test procedures:

ANSI C63.10-2009
FHSS test procedure DA 00-0705A1

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.

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.

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.).

STATEMENT OF COMPLIANCE

The tested sample of FreeWave Technologies, Inc. model MM2-T complied with the requirements of the following regulations:

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 MM2-T and therefore apply only to the tested sample. The sample was selected and prepared by Dean Busch 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)	RSS 210 A8.1 (1)	20dB Bandwidth	142 kHz	Channel spacing > 20dB bandwidth / 25kHz	Complies
		Channel Separation	230.4 kHz		Complies
15.247 (a) (1) (i)	RSS 210 A8.1 (3)	Number of Channels	50-111	50 or more	Complies
15.247 (a) (1) (i)	RSS 210 A8.1 (3)	Channel Dwell Time	202.8 ms per 20 seconds	<0.4 second within a 20 second period	Complies
15.247 (a) (1)	RSS 210 A8.1 (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 210 A8.4 (1)	Output Power	29.9 dBm (0.984 Watts) EIRP = 3.92 W Note 1	1Watt, EIRP < 4 Watts	Complies
15.247 (c)	RSS 210 A8.5	Antenna Port Spurious Emissions 30MHz – 9.28 GHz	All spurious emissions < -20dBc	< -20dBc	Complies
15.247 (c) 15.209	RSS 210 A8.5 Table 2, 3	Radiated Spurious Emissions 30MHz – 9.28 GHz	41.6 dBµV/m @ 162.44 MHz (Margin: -1.9 dB)	15.207 in restricted bands, all others < -20dBc	Complies
15.247 (a) (1)	RSS 210 A8.1(2)	Receiver bandwidth	Refer to operational description	Shall match the channel bandwidth	Complies
Note 1: EIRP calculated using antenna gain of 6 dBi for the highest EIRP system.					

GENERAL REQUIREMENTS APPLICABLE TO ALL BANDS

FCC Rule Part	RSS Rule part	Description	Measured Value / Comments	Limit / Requirement	Result (margin)
15.203	-	RF Connector	Unique connector	Unique or integral antenna required	Complies
15.207	RSS GEN Table 2	AC Conducted Emissions	46.9 dBµV @ 26.747 MHz (-13.1 dB)	Refer to page 17	Complies
15.109		Receiver spurious emissions	41.3 dBµV/m @ 162.44 MHz (Margin: -2.2 dB)	Refer to page 18	Complies
15.247 (b) (5) 15.407 (f)	RSS 102	RF Exposure Requirements	Refer to MPE calculations in separate Exhibit and User Manual statements.	Refer to OET 65, FCC Part 1 and RSS 102	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)	dBµV/m	25 to 1000 MHz	± 3.6 dB
		1000 to 40000 MHz	± 6.0 dB
Conducted Emissions (AC Power)	dBµV	0.15 to 30 MHz	± 2.4 dB

EQUIPMENT UNDER TEST (EUT) DETAILS

GENERAL

The FreeWave Technologies, Inc. model MM2-T is a modular frequency hopping spread spectrum radio which is designed to monitor industrial control systems. Normally, the EUT would be placed on a tabletop during operation. The EUT was, therefore, placed in this position during emissions testing to simulate the end user environment. The electrical rating of the EUT is 3.3/5 Vdc, 0.635 Amps.

The sample was received on July 16, 2013 and tested on July 16, 18 and 24, 2013. The EUT consisted of the following component(s):

Company	Model	Description	Serial Number	FCC ID
Freewave Technologies, Inc.	MM2-T	Modular Frequency Hopping Spread Spectrum Radio	-	KNYAMM0300AT

OTHER EUT DETAILS

The following EUT details should be noted:

Model	Description
MM2-LT	115.2K 5.0 VDC, OEM, not for resale IN THE USA
MM2-LV-T	115.2K , TTL, 3.3 VDC
MM2-LV-T-LF	153.6 Kbps, 3.5V, Lead Free
MM2-LV-T-U	115.2K, TTL, 3.3 VDC, Class I, Div II.
MM2-T	115.2K, TTL, 5.0 VDC, Class I, Div II.
MM2-T-LF	153.6 Kbps, Lead free
MM2-T-U	115.2K, TTL, 5.0 VDC

ANTENNA SYSTEM

The antenna system consists of a 6dBi monopole.

ENCLOSURE

The EUT does not have an enclosure as it is designed to be installed in final products.

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
Agilent	E3610A	DC Power Supply	-	-
Laird Technologies	FG9026	Omni Antenna	5091306	-

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

Company	Model	Description	Serial Number	FCC ID
Hewlett Packard	Pavilion DV6000	Laptop	CNF73411TQ	-

EUT INTERFACE PORTS

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

Port	Connected To	Cable(s)		
		Description	Shielded or Unshielded	Length(m)
EUT/Serial	Remote laptop / USB	Serial to USB	Shielded	5.0
EUT Antenna	Omni Antenna	Coax	Shielded	6.0
DC Power	Power Supply	2Wire	Unshielded	1.5

EUT OPERATION

During testing, the EUT was configured to transmit at maximum power (power setting 10) and 115k data rate for Low, Middle, and High Channels. Power was identical at 156k data rate. Some tests were performed with the EUT hopping as noted.

TEST SITE(S)

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 3.3 of RSP-100, construction, calibration, and equipment data has been filed with the Commission and with industry Canada.

Site	Registration Numbers		Location
	FCC	Canada	
Chamber 4	211948	2845B-4	41039 Boyce Road Fremont, CA 94538-2435
Chamber 5	211948	2845B-5	

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. 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

The receivers utilize either a Rohde & Schwarz EZM Spectrum Monitor/Controller or contain an internal Spectrum Monitor/Controller to view and convert the 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 Spectrum Monitor provides a visual display of the signal being measured. In addition, the controller or a personal computer run automated data collection programs which control the receivers. This provides added accuracy since all site correction factors, such as cable loss and antenna factors are added automatically.

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. 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.

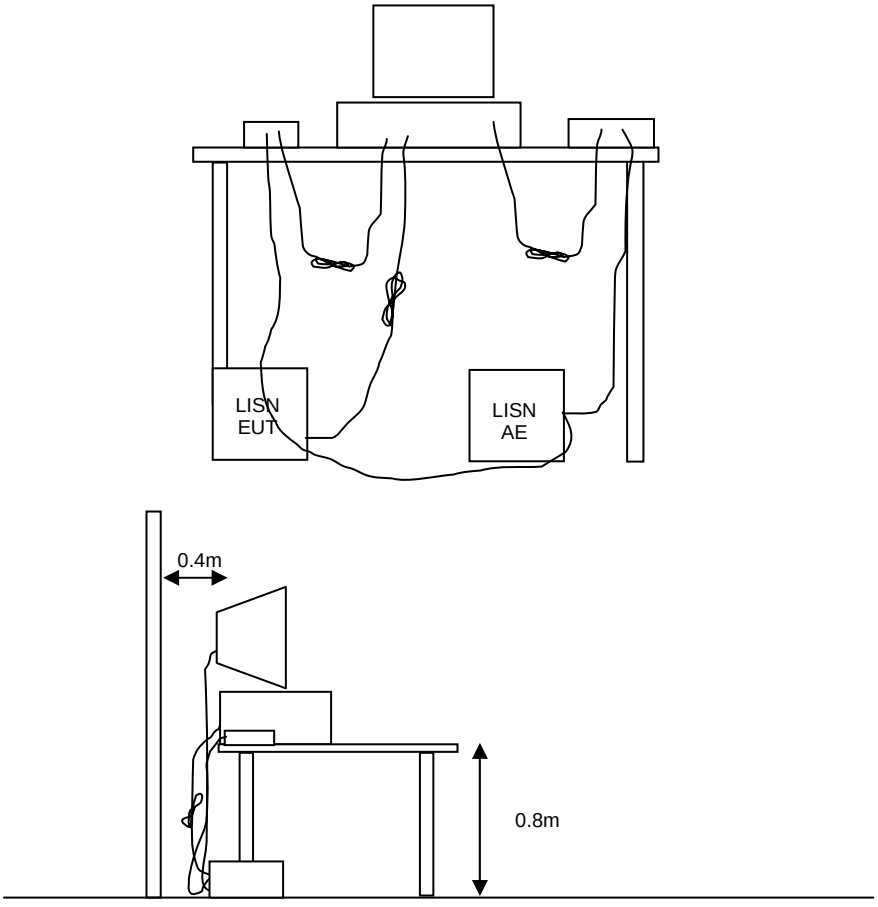


Figure 1 Typical Conducted Emissions Test Configuration

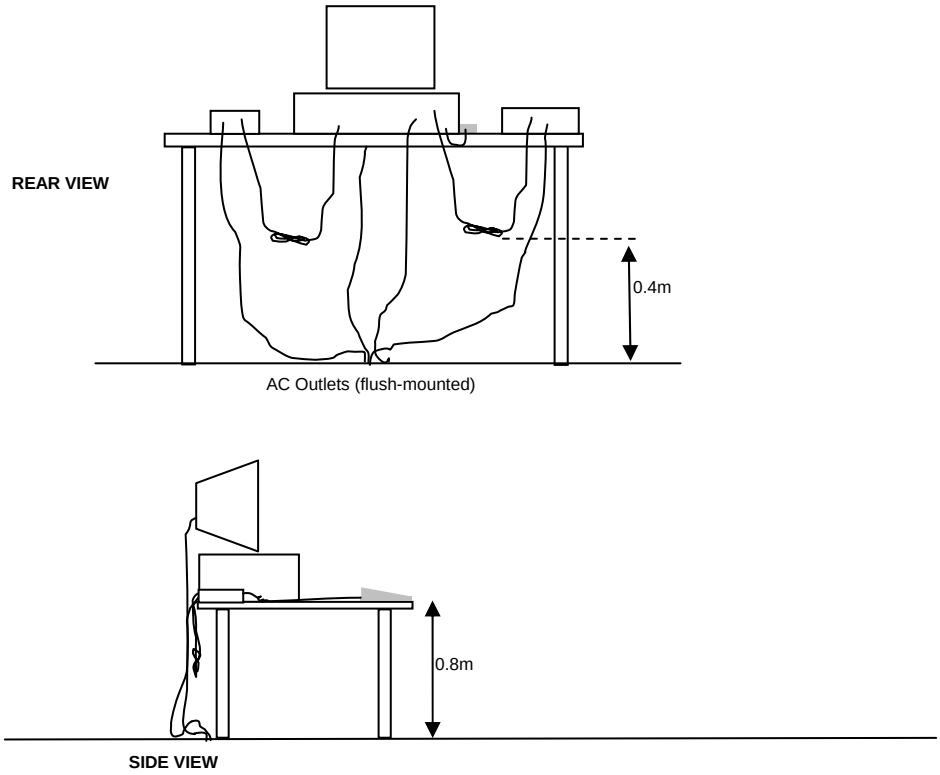
RADIATED EMISSIONS

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.

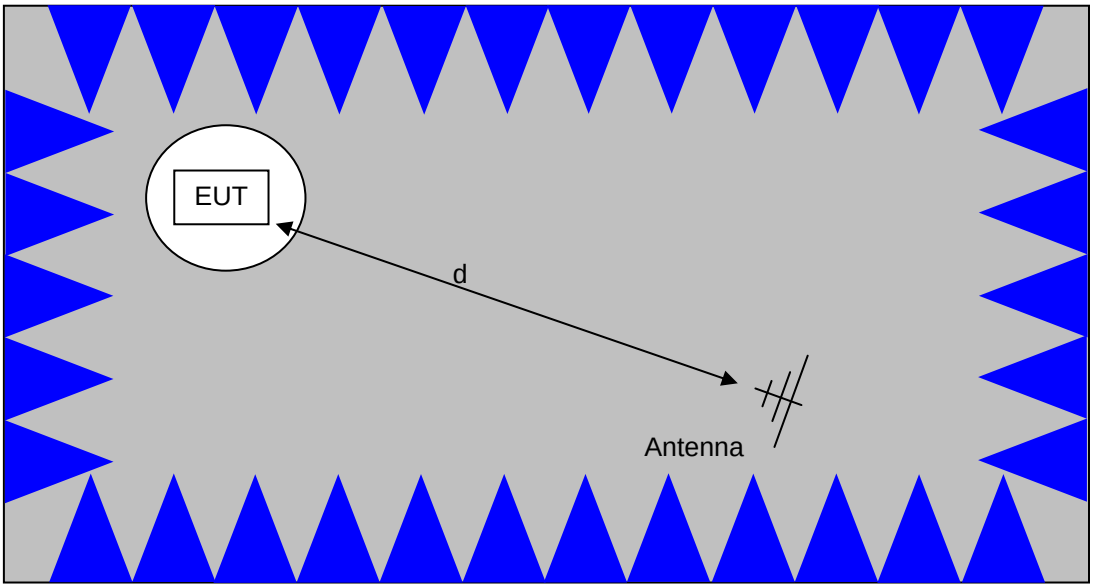
A speaker is provided in the receiver to aid in discriminating between EUT and ambient emissions. Other methods used during the preliminary scan for EUT emissions involve scanning with near field magnetic loops, monitoring I/O cables with RF current clamps, and cycling power to the EUT.

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 1meter from the EUT and the antenna height is restricted to a maximum of 2.5 meters.

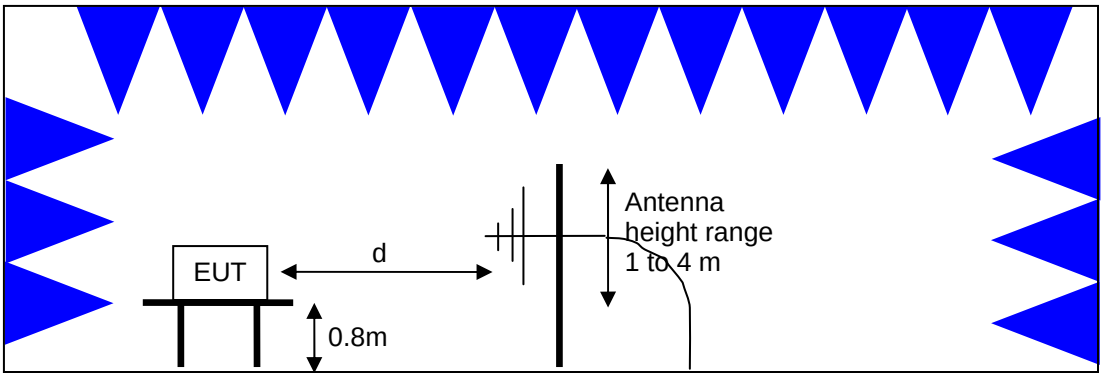


Typical Test Configuration for Radiated Field Strength Measurements



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.

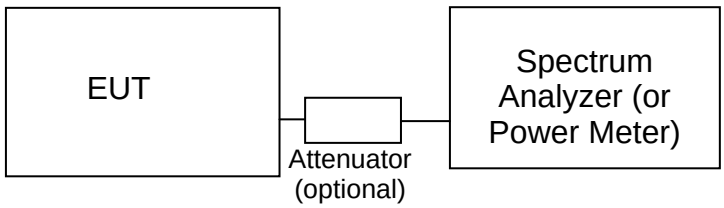
Floor-standing equipment is placed on the floor with insulating supports between the unit and the ground plane.



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; FCC 15.107(a), 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 bands[1] (with the exception of transmitters operating under FCC Part 15 Subpart D and RSS 210 Annex 9), the limits for all emissions from a low power device operating under the general rules of RSS 310 (tables 3 and 4), RSS 210 (table 2) and FCC Part 15 Subpart C section 15.209.

Frequency Range (MHz)	Limit (uV/m)	Limit (dBuV/m @ 3m)
0.009-0.490	$2400/F_{KHz}$ @ 300m	$67.6-20*\log_{10}(F_{KHz})$ @ 300m
0.490-1.705	$24000/F_{KHz}$ @ 30m	$87.6-20*\log_{10}(F_{KHz})$ @ 30m
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

RECEIVER RADIATED SPURIOUS EMISSIONS SPECIFICATION LIMITS

The table below shows the limits for the spurious emissions from receivers as detailed in FCC Part 15.109. Note that receivers operating outside of the frequency range 30 MHz – 960 MHz are exempt from the requirements of 15.109.

Frequency Range (MHz)	Limit (uV/m @ 3m)	Limit (dBuV/m @ 3m)
30 to 88	100	40
88 to 216	150	43.5
216 to 960	200	46.0
Above 960	500	54.0

[1] The restricted bands are detailed in FCC 15.203, RSS 210 Table 1 and RSS 310 Table 2

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 210. 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

T92989

Radio Antenna Port , 16-Jul-13

Manufacturer	Description	Model	Asset #	Cal Due
Agilent Technologies	PSA, Spectrum Analyzer	E4446A	2139	3/7/2014

Radio Antenna Port (Power and Spurious Emissions), 18-Jul-13

Manufacturer	Description	Model	Asset #	Cal Due
Agilent Technologies	3Hz -44GHz PSA Spectrum Analyzer	E4446A	2796	1/28/2014

Radiated Emissions, 30 - 1,000 MHz, 24-Jul-13

Manufacturer	Description	Model	Asset #	Cal Due
Sunol Sciences	Biconilog, 30-3000 MHz	JB3	2197	2/7/2014
Rohde & Schwarz	EMI Test Receiver, 20 Hz-40 GHz	ESIB40 (1088.7490.40)	2493	1/18/2014

Radiated Emissions, 1,000 - 10,000 MHz, 24-Jul-13

Manufacturer	Description	Model	Asset #	Cal Due
EMCO	Antenna, Horn, 1-18 GHz	3115	487	7/19/2014
Hewlett Packard	Microwave Preamplifier, 1-26.5GHz	8449B	2199	2/19/2014
Hewlett Packard	SpecAn 9 kHz - 40 GHz, (SA40) Purple	8564E (84125C)	2415	8/10/2013

Radiated Emissions, 1000 - 6,500 MHz, 01-Aug-13

Manufacturer	Description	Model	Asset #	Cal Due
EMCO	Antenna, Horn, 1-18GHz	3115	868	6/19/2014
Rohde & Schwarz	EMI Test Receiver, 20 Hz-7 GHz	ESIB7	1756	6/8/2014

Radiated Emissions, 30 - 1,000 MHz, 31-Aug-13

Manufacturer	Description	Model	Asset #	Cal Due
Sunol Sciences	Biconilog, 30-3000 MHz	JB3	1548	8/9/2014
Rohde & Schwarz	EMI Test Receiver, 20 Hz-7 GHz	ESIB7	1756	6/8/2014
Hewlett Packard	9KHz-1300MHz pre-amp	8447F	2777	3/5/2014

Radio Antenna Port (Spurious Emissions), 04-Sep-13

Manufacturer	Description	Model	Asset #	Cal Due
Agilent Technologies	3Hz -44GHz PSA Spectrum Analyzer	E4446A	2796	1/28/2014

T93004

Conducted Emissions - AC Power Ports, 18-Jul-13

Manufacturer	Description	Model	Asset #	Cal Due
Rohde & Schwarz	Pulse Limiter	ESH3 Z2	1594	5/15/2014
Rohde & Schwarz	EMI Test Receiver, 20 Hz-40 GHz	ESIB40 (1088.7490.40)	2493	1/18/2014
Com-Power	9KHz-30MHz, 50uH, 15Aac, 10Adc, max	LI-215A	2671	5/24/2014

Appendix B Test Data

T92989 Pages 24 – 47
T93004 Pages 48 – 51

Client:	Freewave Technologies, Inc.	Job Number:	J92945
Product	MM2-T	T-Log Number:	T92989
		Project Manager:	Sheareen Jacobs
Contact:	Dean Busch	Project Coordinator:	Irene Rademacher
Emissions Standard(s):	FCC Part 15.247	Class:	A
Immunity Standard(s):	-	Environment:	Radio

EMC Test Data

For The

Freewave Technologies, Inc.

Product

MM2-T

Date of Last Test: 9/13/2013

Client:	Freewave Technologies, Inc.	Job Number:	J92945
Model:	MM2-T	T-Log Number:	T92989
		Project Manager:	Sheareen Jacobs
Contact:	Dean Busch	Project Coordinator:	Irene Rademacher
Standard:	FCC Part 15.247	Class:	N/A

FCC 15.247 FHSS - 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. All remote support equipment was located outside the test chamber with the cabling running under the test chamber floor.
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: 25 °C
Rel. Humidity: 32 %

Summary of Results

Run #	Test Performed	Limit	Pass / Fail	Result / Margin
1	30 - 9280 MHz - Transmitter Radiated Spurious Emissions	FCC Part 15.209 / 15.247(c)	Pass	41.6 dBµV/m @ 162.44 MHz (Margin: -1.9 dB)
2	30 - 2800 MHz - Receiver Radiated Spurious Emissions	FCC Part 15.109	Pass	42.2 dBµV/m @ 105.76 MHz (-1.3 dB)
3	30 - 9280 MHz - Transmitter Conducted Spurious Emissions	FCC Part 15.247(c)	Pass	See data below
4	Output Power	15.247(b)	Pass	29.9 dBm (0.98 W)
5	20dB Bandwidth	15.247(a)	Pass	142kHz
5	99% bandwidth	15.247(a)	Pass	200kHz
5	Channel Occupancy	15.247(a)	Pass	See data below
5	Number of Channels	15.247(a)	Pass	See data below

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.

Client:	Freewave Technologies, Inc.	Job Number:	J92945
Model:	MM2-T	T-Log Number:	T92989
		Project Manager:	Shearen Jacobs
Contact:	Dean Busch	Project Coordinator:	Irene Rademacher
Standard:	FCC Part 15.247	Class:	N/A

Test using ANSI C63.4-2009 and C63.10-2009 and DA-00-705, floor absorbers for measurements above 1 GHz.

Procedure Comments:

Peak measurements performed with: RBW=1MHz, VBW=3MHz, peak detector, max hold, auto sweep time
Unless otherwise stated/noted, emission has duty cycle ≥ 98% and was measured using RBW=1MHz, VBW=10Hz, peak detector,

Mode	Data Rate	Duty Cycle (x)	Constant DC?	T (ms)	Pwr Cor Factor*	Lin Volt Cor Factor**	Min VBW for FS (Hz)
-	115k	55%	Yes	4.21	2.62	5.24	237.5

Measurement Specific Notes:

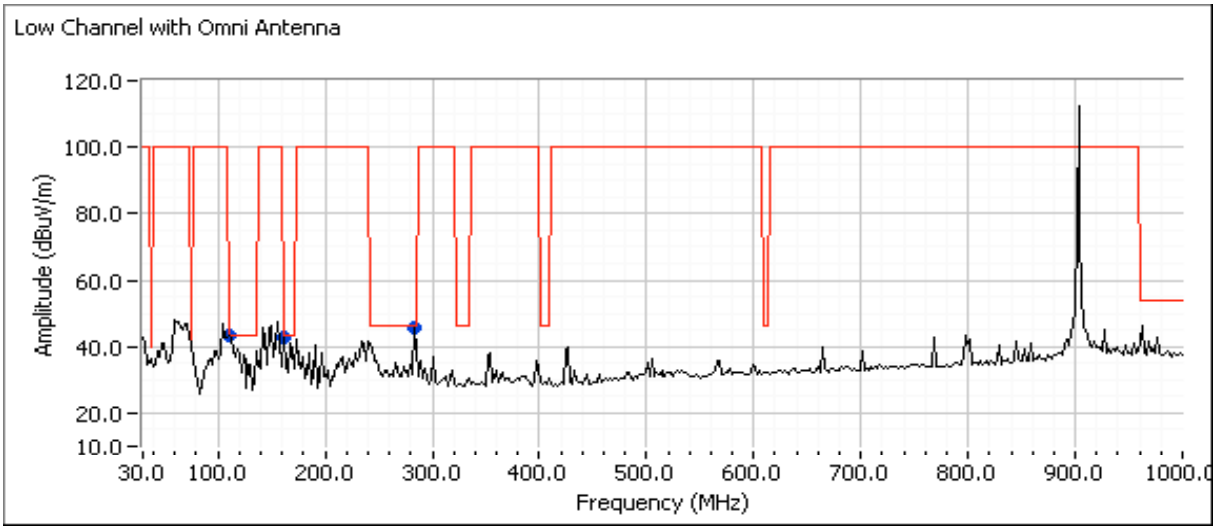
Note 1:	Emission in non-restricted band, but limit of 15.209 used.
Note 2:	Emission in non-restricted band, the limit was set 20dB below the level of the fundamental and measured in 100kHz.
Note 3:	Emission has duty cycle < 98%, but constant, average measurement performed: RBW=1MHz, VBW=10Hz, peak detector, linear averaging, auto sweep, trace average 100 traces, measurement corrected by Linear Voltage correction factor
Note 6:	Plots of the average and peak bandedge do not account for any duty cycle correction. Refer to the tabular results for final
Note 7:	Average measurement further corrected based on dwell time in any 100ms window (see below), per DA 00-705

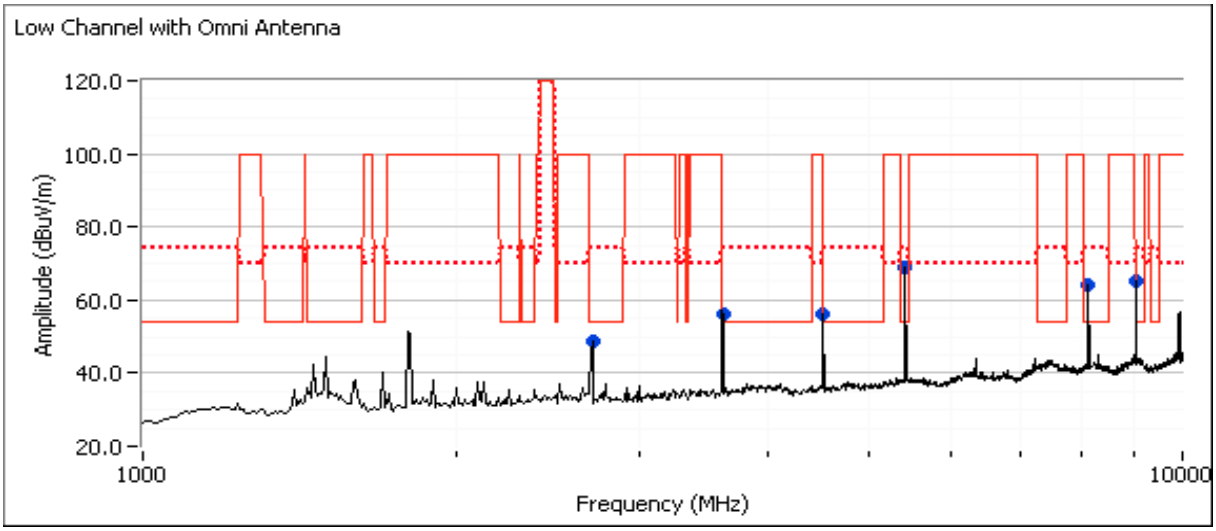
Test Mode Duty Cycle

The maximum dwell time in any 100 ms period is 3.9 ms.
The average correction factor is, therefore, 20log(3.9/100) or 28dB.
As this is a hopping radio the correction factor can be applied to the average value of the signal provided the average value was measured with the device continuously transmitting. DA 00-0705 permits the use of the average correction on the measured average value for frequency hopping radios.

Client:	Freewave Technologies, Inc.	Job Number:	J92945
Model:	MM2-T	T-Log Number:	T92989
		Project Manager:	Sheareen Jacobs
Contact:	Dean Busch	Project Coordinator:	Irene Rademacher
Standard:	FCC Part 15.247	Class:	N/A

Run #1: Radiated Spurious Emissions, 30 - 9280 MHz, Omni Antenna
Date of Test: 8/1/2013
Test Engineer: Joseph Cadigal
Test Location: FT Chamber#4
Run #1a: Radiated Spurious Emissions, 30 - 9280 MHz Low Channel
Power setting 10, Cable Loss 0.44dB





Client:	Freewave Technologies, Inc.	Job Number:	J92945
Model:	MM2-T	T-Log Number:	T92989
		Project Manager:	Sheareen Jacobs
Contact:	Dean Busch	Project Coordinator:	Irene Rademacher
Standard:	FCC Part 15.247	Class:	N/A

Spurious Emissions

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
4511.510	56.3	V	54.0	2.3	Peak	19	1.3	
9022.080	65.2	V	54.0	11.2	Peak	118	1.6	
8120.590	64.4	V	54.0	10.4	Peak	174	1.6	
5413.260	68.7	V	54.0	14.7	Peak	263	1.6	
3608.850	56.1	V	54.0	2.1	Peak	314	1.0	
2706.940	48.9	V	54.0	-5.1	Peak	356	1.9	
282.009	45.6	V	46.0	-0.4	Peak	8	1.0	
111.009	43.3	V	43.5	-0.2	Peak	193	1.0	
162.025	42.9	V	43.5	-0.6	Peak	291	1.0	

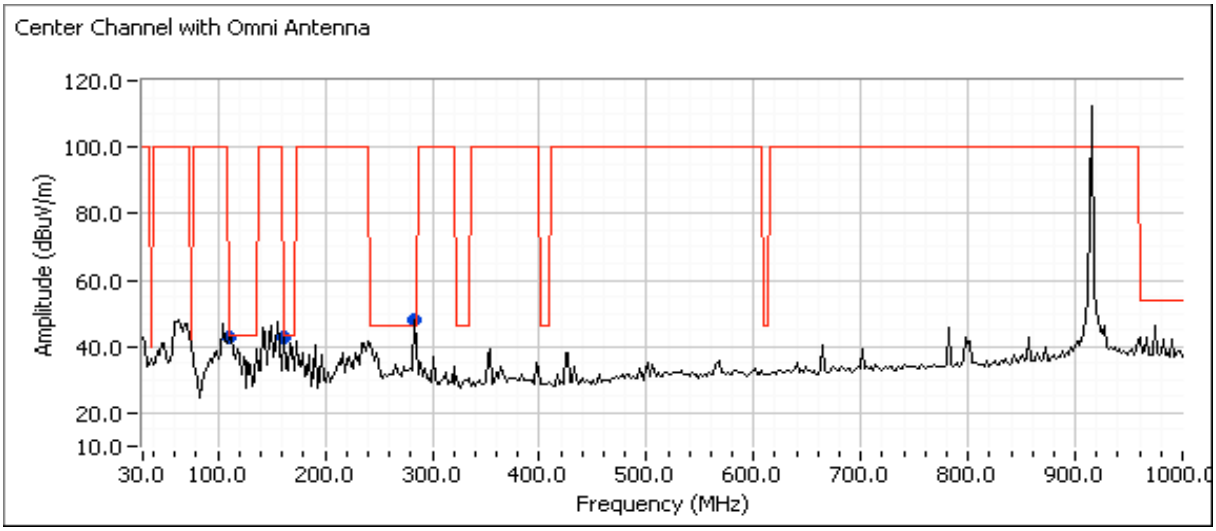
Spurious Emissions

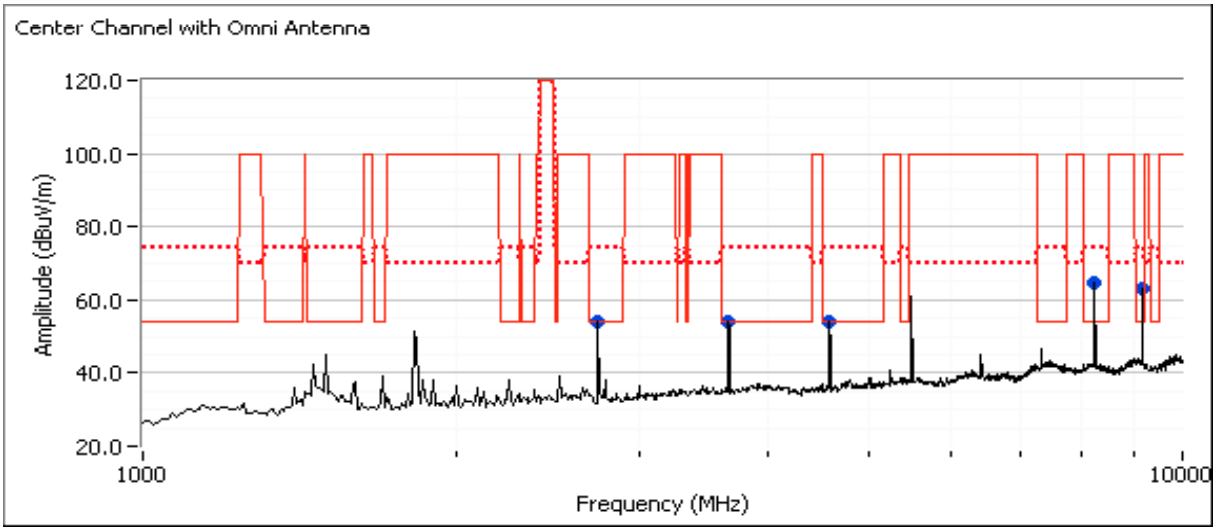
Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
111.009	43.3	V	43.5	-0.2	QP	194	1.0	QP (1.00s)
162.025	41.3	V	43.5	-2.2	QP	291	1.0	QP (1.00s)
9022.830	66.4	V	74.0	-7.6	PK	120	1.6	RB 1 MHz;VB 3 MHz;Peak
8120.120	64.5	V	74.0	-9.5	PK	175	1.6	RB 1 MHz;VB 3 MHz;Peak
5413.150	64.5	V	74.0	-9.5	PK	264	1.6	RB 1 MHz;VB 3 MHz;Peak
282.009	33.9	V	46.0	-12.1	QP	7	1.0	QP (1.00s)
5413.650	39.8	V	54.0	-14.2	AVG	264	1.6	RB 1 MHz;VB 10 Hz;Peak, Note 3
9022.150	39.6	V	54.0	-14.4	AVG	120	1.6	RB 1 MHz;VB 10 Hz;Peak, Note 3
8119.950	37.9	V	54.0	-16.1	AVG	175	1.6	RB 1 MHz;VB 10 Hz;Peak, Note 3
4510.970	55.8	V	74.0	-18.2	PK	17	1.3	RB 1 MHz;VB 3 MHz;Peak
3608.730	54.0	V	74.0	-20.0	PK	315	1.0	RB 1 MHz;VB 3 MHz;Peak
2707.030	50.9	V	74.0	-23.1	PK	356	1.9	RB 1 MHz;VB 3 MHz;Peak
4511.200	30.7	V	54.0	-23.3	AVG	17	1.3	RB 1 MHz;VB 10 Hz;Peak, Note 3
3608.920	28.7	V	54.0	-25.3	AVG	315	1.0	RB 1 MHz;VB 10 Hz;Peak, Note 3
2706.740	24.5	V	54.0	-29.5	AVG	356	1.9	RB 1 MHz;VB 10 Hz;Peak, Note 3

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:	Measurements of emissions not within a restricted band were performed on the RF port.
Note 3:	Average measurement was corrected by 22.76dB for duty cycle and hopping (=5.24-28)

Client:	Freewave Technologies, Inc.	Job Number:	J92945
Model:	MM2-T	T-Log Number:	T92989
		Project Manager:	Sheareen Jacobs
Contact:	Dean Busch	Project Coordinator:	Irene Rademacher
Standard:	FCC Part 15.247	Class:	N/A

Run #1b: Radiated Spurious Emissions, 30 - 9280 MHz Center Channel
Power setting 10, Cable Lost 0.44dB





Client:	Freewave Technologies, Inc.	Job Number:	J92945
Model:	MM2-T	T-Log Number:	T92989
		Project Manager:	Sheareen Jacobs
Contact:	Dean Busch	Project Coordinator:	Irene Rademacher
Standard:	FCC Part 15.247	Class:	N/A

Spurious Emissions

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
2745.080	54.2	V	54.0	0.2	Peak	23	2.5	
4574.830	54.3	V	54.0	0.3	Peak	33	1.3	
9149.620	62.9	V	54.0	8.9	Peak	106	1.6	
8233.920	64.6	V	54.0	10.6	Peak	172	1.6	
3659.490	53.8	V	54.0	-0.2	Peak	352	1.0	
162.009	42.9	V	43.5	-0.6	Peak	147	1.0	
111.025	42.9	V	43.5	-0.6	Peak	198	1.0	
281.978	48.0	V	46.0	2.0	Peak	310	1.0	

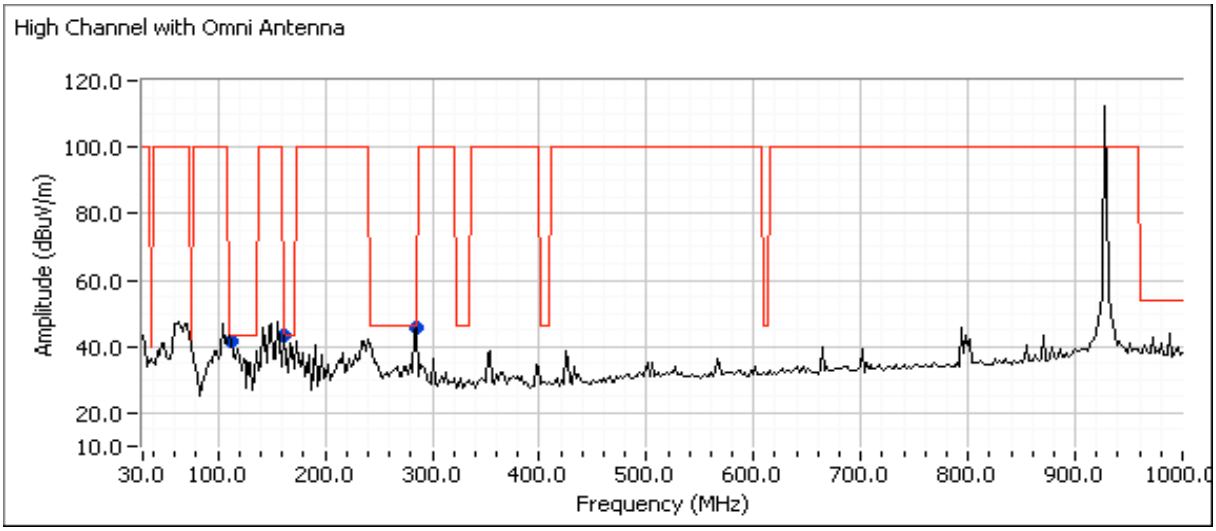
Spurious Emissions

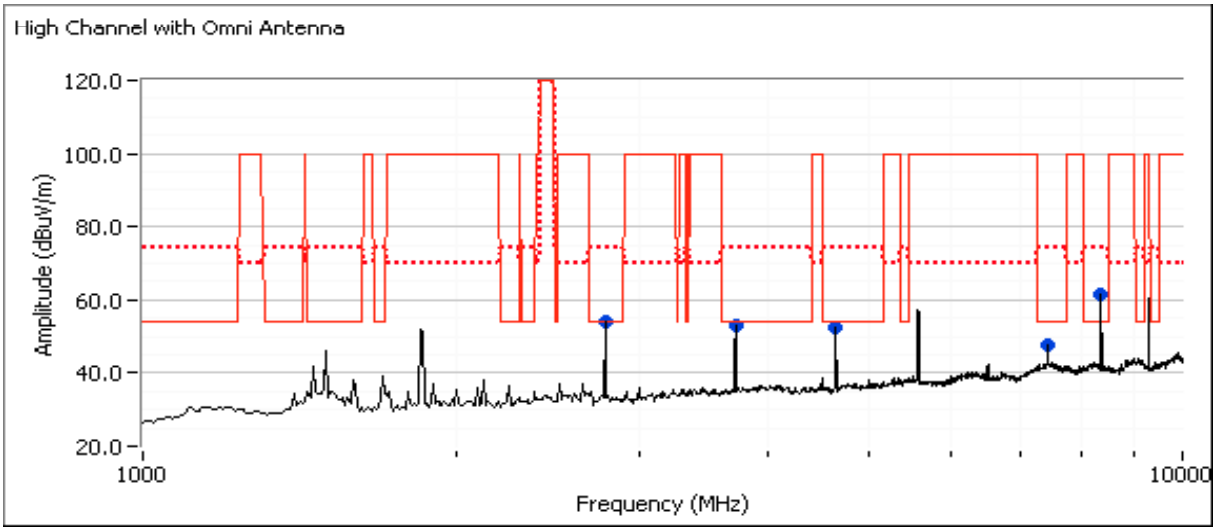
Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
111.025	43.3	V	43.5	-0.2	QP	199	1.0	QP (1.00s)
162.009	42.8	V	43.5	-0.7	QP	145	1.0	QP (1.00s)
281.978	31.8	V	46.0	-14.2	QP	312	1.0	QP (1.00s)
2744.790	30.8	V	54.0	-23.2	AVG	24	2.5	RB 1 MHz;VB 10 Hz;Peak, Note 3
2744.650	55.9	V	74.0	-18.1	PK	24	2.5	RB 1 MHz;VB 3 MHz;Peak
4574.500	28.1	V	54.0	-25.9	AVG	35	1.2	RB 1 MHz;VB 10 Hz;Peak, Note 3
4574.790	53.8	V	74.0	-20.2	PK	35	1.2	RB 1 MHz;VB 3 MHz;Peak
9148.830	37.0	V	54.0	-17.0	AVG	108	1.6	RB 1 MHz;VB 10 Hz;Peak, Note 3
9149.010	64.0	V	74.0	-10.0	PK	108	1.6	RB 1 MHz;VB 3 MHz;Peak
8234.580	38.5	V	54.0	-15.5	AVG	174	1.6	RB 1 MHz;VB 10 Hz;Peak, Note 3
8233.980	64.8	V	74.0	-9.2	PK	174	1.6	RB 1 MHz;VB 3 MHz;Peak
3659.620	31.3	V	54.0	-22.7	AVG	353	1.0	RB 1 MHz;VB 10 Hz;Peak, Note 3
3659.740	56.0	V	74.0	-18.0	PK	353	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:	Measurements of emissions not within a restricted band were performed on the RF port.
Note 3:	Average measurement was corrected by 22.76dB for duty cycle and hopping (=5.24-28)

Client:	Freewave Technologies, Inc.	Job Number:	J92945
Model:	MM2-T	T-Log Number:	T92989
		Project Manager:	Sheareen Jacobs
Contact:	Dean Busch	Project Coordinator:	Irene Rademacher
Standard:	FCC Part 15.247	Class:	N/A

Run #1c: Radiated Spurious Emissions, 30 - 9280 MHz High Channel
Power setting 10, Cable Lost 0.44dB





Client:	Freewave Technologies, Inc.	Job Number:	J92945
Model:	MM2-T	T-Log Number:	T92989
		Project Manager:	Sheareen Jacobs
Contact:	Dean Busch	Project Coordinator:	Irene Rademacher
Standard:	FCC Part 15.247	Class:	N/A

Other Spurious Emissions

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
8354.170	61.7	V	54.0	7.7	Peak	182	1.6	
7424.810	47.5	V	54.0	-6.5	Peak	223	1.6	
4638.920	52.7	V	54.0	-1.3	Peak	239	1.6	
3711.510	53.2	V	54.0	-0.8	Peak	303	1.0	
2783.720	54.2	V	54.0	0.2	Peak	344	2.5	
285.003	45.5	V	46.0	-0.5	Peak	30	1.0	
162.001	43.5	V	43.5	0.0	Peak	148	1.0	
111.002	41.5	V	43.5	-2.0	Peak	202	1.0	

Other Spurious Emissions

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
111.002	43.1	V	43.5	-0.4	QP	203	1.0	QP (1.00s)
8349.970	63.7	V	74.0	-10.3	PK	180	1.6	RB 1 MHz;VB 3 MHz;Peak
8350.170	37.5	V	54.0	-16.5	AVG	180	1.6	RB 1 MHz;VB 10 Hz;Peak, Note 3
3711.350	54.6	V	74.0	-19.4	PK	304	1.0	RB 1 MHz;VB 3 MHz;Peak
4639.380	31.4	V	74.0	-19.8	PK	240	1.6	RB 1 MHz;VB 3 MHz;Peak
2783.660	54.0	V	74.0	-20.0	PK	345	2.5	RB 1 MHz;VB 3 MHz;Peak
7418.480	51.4	V	74.0	-22.6	PK	224	1.6	RB 1 MHz;VB 3 MHz;Peak
2783.470	28.7	V	54.0	-25.3	AVG	345	2.5	RB 1 MHz;VB 10 Hz;Peak, Note 3
3711.340	28.4	V	54.0	-25.6	AVG	304	1.0	RB 1 MHz;VB 10 Hz;Peak, Note 3
4639.040	23.5	V	54.0	-30.5	AVG	240	1.6	RB 1 MHz;VB 10 Hz;Peak, Note 3
7422.480	20.4	V	54.0	-33.6	AVG	224	1.6	RB 1 MHz;VB 10 Hz;Peak, Note 3
285.003	33.1	V	N/A	N/A	QP	28	1.0	Note 2
162.001	43.4	V	N/A	N/A	QP	150	1.0	Note 2

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:	Measurements of emissions not within a restricted band were performed on the RF port.
Note 3:	Average measurement was corrected by 22.76dB for duty cycle and hopping (=5.24-28)

Client:	Freewave Technologies, Inc.	Job Number:	J92945
Model:	MM2-T	T-Log Number:	T92989
		Project Manager:	Sheareen Jacobs
Contact:	Dean Busch	Project Coordinator:	Irene Rademacher
Standard:	FCC Part 15.247	Class:	N/A

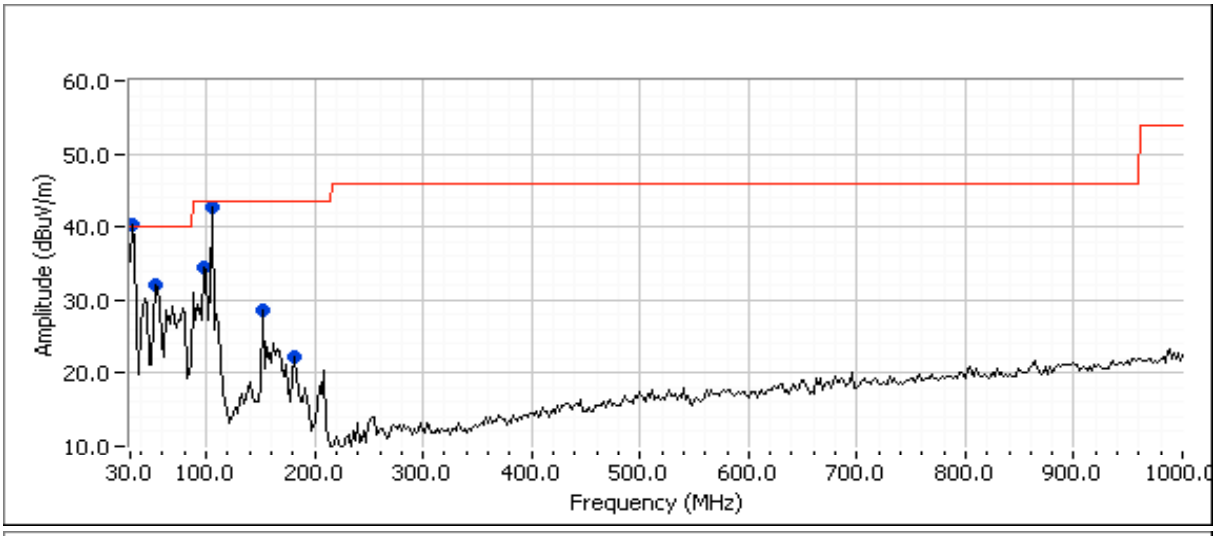
Run #2: Receiver Radiated Spurious Emissions, 30 - 2800 MHz

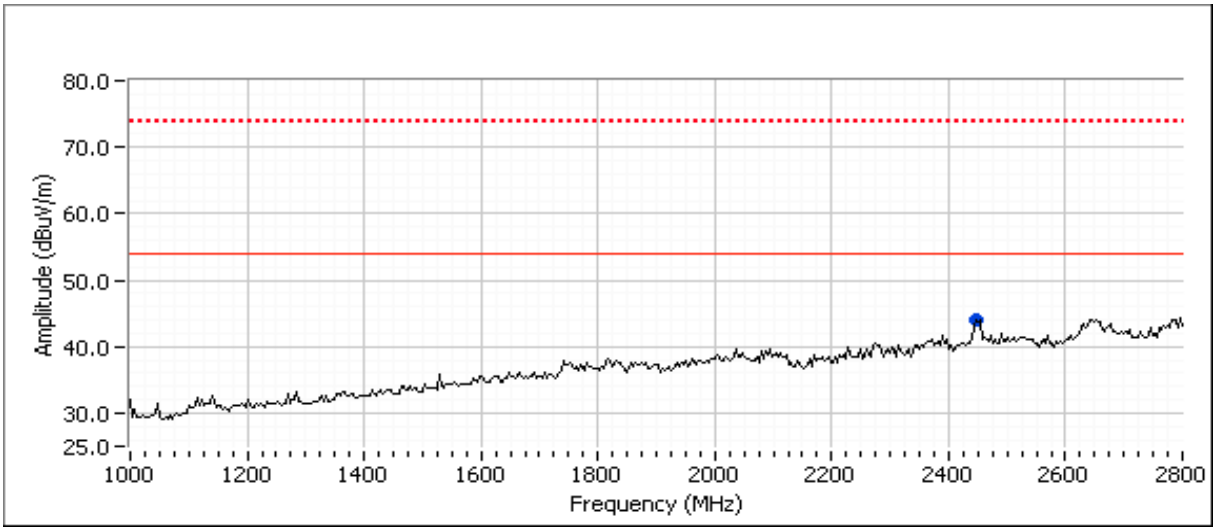
Date of Test: 8/30/2013

Test Engineer: Rafael Varelas

Test Location: FT Chamber #4

Run #2a: Receiver Radiated Spurious Emissions, 30 - 2800 MHz Low Channel @ 902.245 MHz



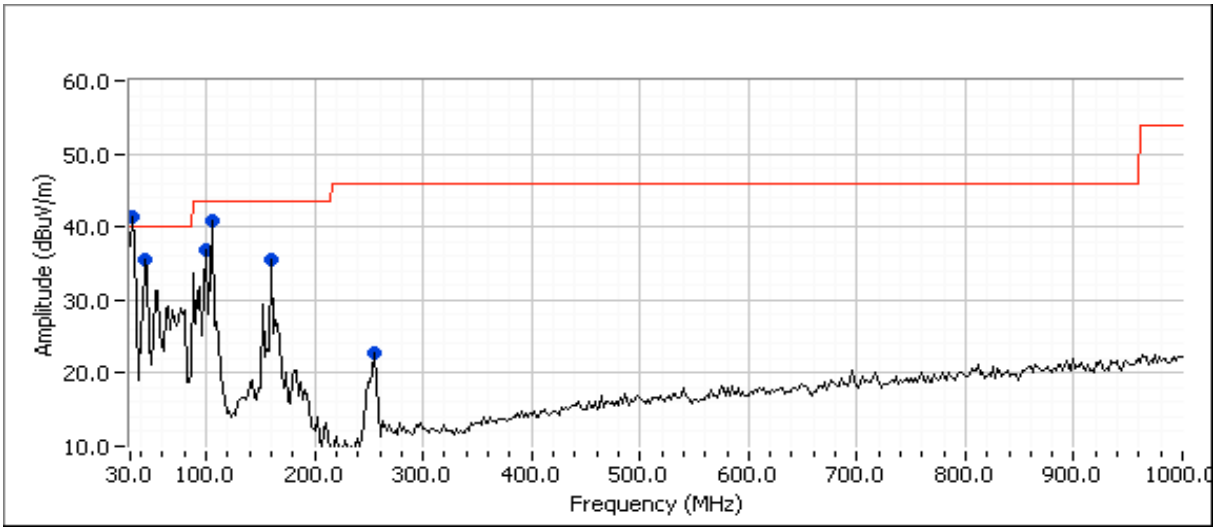


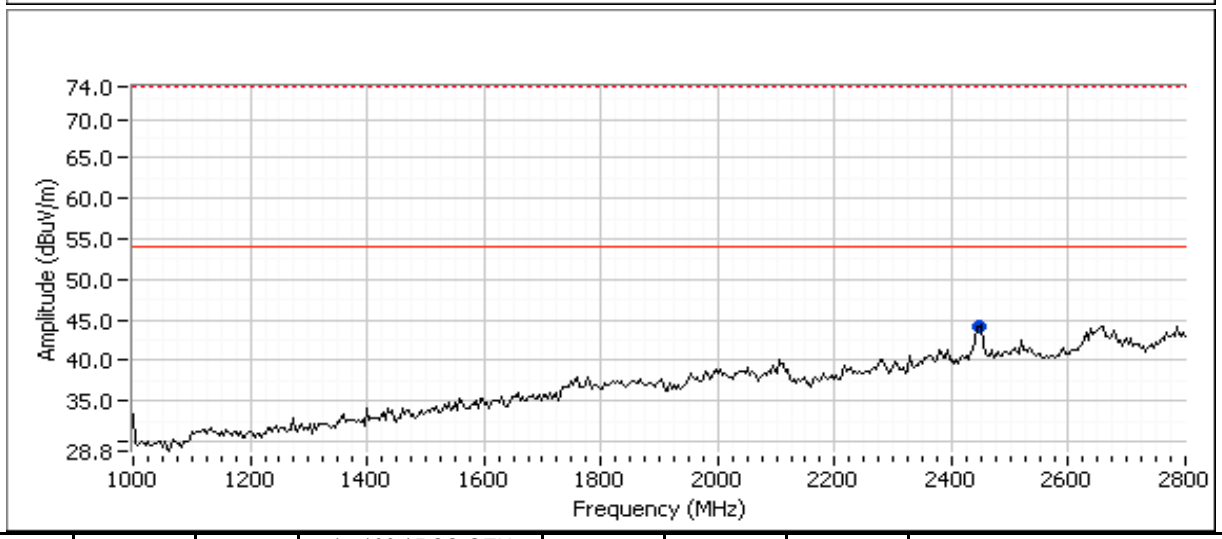
Client:	Freewave Technologies, Inc.	Job Number:	J92945
Model:	MM2-T	T-Log Number:	T92989
		Project Manager:	Sheareen Jacobs
Contact:	Dean Busch	Project Coordinator:	Irene Rademacher
Standard:	FCC Part 15.247	Class:	N/A

Frequency	Level	Pol	15.109 / RSS GEN		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
105.763	42.2	V	43.5	-1.3	QP	240	1.0	QP (1.00s)
33.569	35.8	V	40.0	-4.2	QP	117	0.9	QP (1.00s)
54.709	29.2	V	40.0	-10.8	QP	199	0.9	QP (1.00s)
98.487	32.0	V	43.5	-11.5	QP	221	1.4	QP (1.00s)
153.310	28.5	V	43.5	-15.0	Peak	356	1.0	
182.362	22.3	H	43.5	-21.2	Peak	332	1.5	
2446.490	43.9	H	54.0	-10.1	Peak	26	1.3	

Client:	Freewave Technologies, Inc.	Job Number:	J92945
Model:	MM2-T	T-Log Number:	T92989
		Project Manager:	Sheareen Jacobs
Contact:	Dean Busch	Project Coordinator:	Irene Rademacher
Standard:	FCC Part 15.247	Class:	N/A

Run #2b: Receiver Radiated Spurious Emissions, 30 - 2800 MHz Center Channel @ 915 MHz

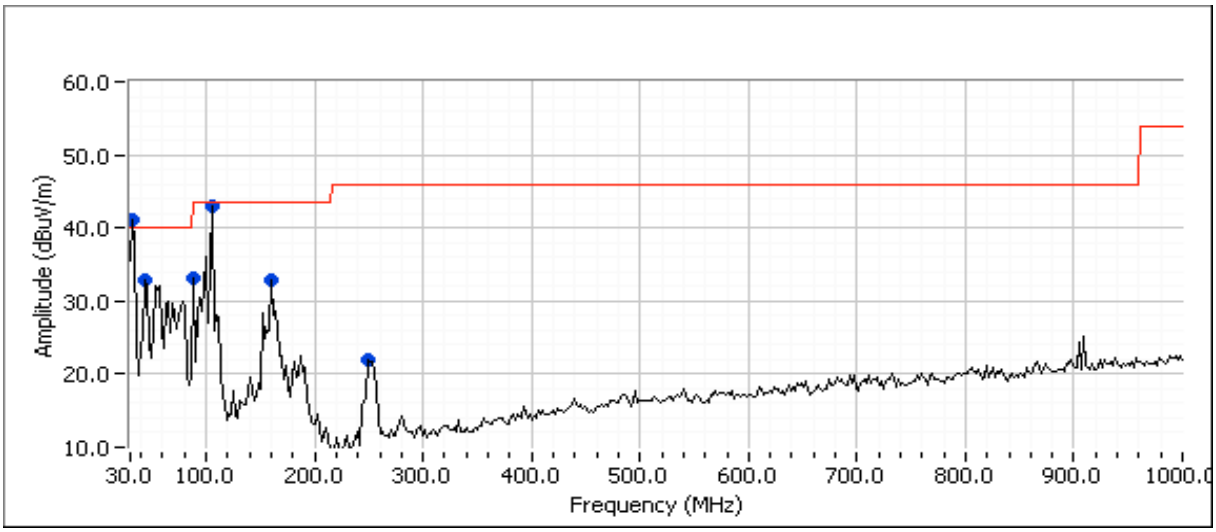


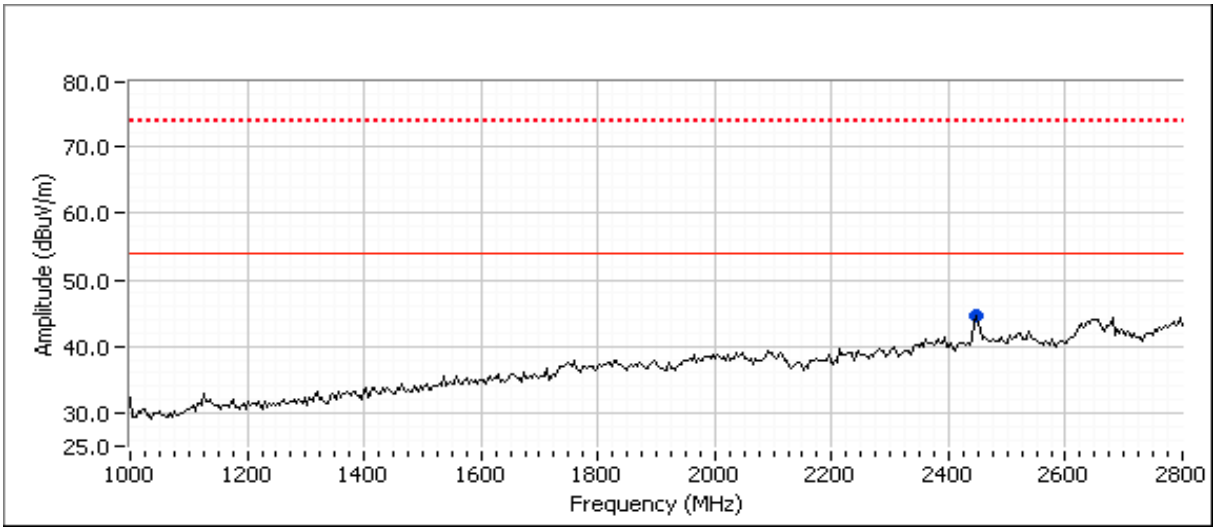


Frequency	Level	Pol	15.109 / RSS GEN		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
33.569	37.1	V	40.0	-2.9	QP	10	1.0	QP (1.00s)
106.111	40.2	V	43.5	-3.3	QP	254	1.0	QP (1.00s)
100.340	36.0	V	43.5	-7.5	QP	232	2.2	QP (1.00s)
2446.490	*44.2*	*H*	*54.0*	*-9.8*	*Peak*	*55*	*1.0*	
44.459	25.3	V	40.0	-14.7	QP	328	1.0	QP (1.00s)
256.707	22.7	V	46.0	-23.3	Peak	295	1.0	
160.782	13.4	V	43.5	-30.1	QP	269	2.0	QP (1.00s)

Client:	Freewave Technologies, Inc.	Job Number:	J92945
Model:	MM2-T	T-Log Number:	T92989
		Project Manager:	Sheareen Jacobs
Contact:	Dean Busch	Project Coordinator:	Irene Rademacher
Standard:	FCC Part 15.247	Class:	N/A

Run #2c: Receiver Radiated Spurious Emissions, 30 - 2800 MHz High Channel @ 927.82MHz





Client:	Freewave Technologies, Inc.	Job Number:	J92945
Model:	MM2-T	T-Log Number:	T92989
		Project Manager:	Sheareen Jacobs
Contact:	Dean Busch	Project Coordinator:	Irene Rademacher
Standard:	FCC Part 15.247	Class:	N/A

Frequency	Level	Pol	15.109 / RSS GEN		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
106.081	42.2	V	43.5	-1.3	QP	248	1.0	QP (1.00s)
33.569	37.1	V	40.0	-2.9	QP	352	1.0	QP (1.00s)
2446.490	44.7	V	54.0	-9.3	Peak	10	1.0	
160.009	32.8	H	43.5	-10.7	Peak	285	1.0	
44.952	28.3	V	40.0	-11.7	QP	231	0.9	QP (1.00s)
88.495	30.7	H	43.5	-12.8	QP	329	1.9	QP (1.00s)
251.034	22.0	H	46.0	-24.0	Peak	278	1.0	

Run #3: Antenna Conducted Spurious Emissions, 30 - 9280 MHz

Date of Test: 7/18/2013

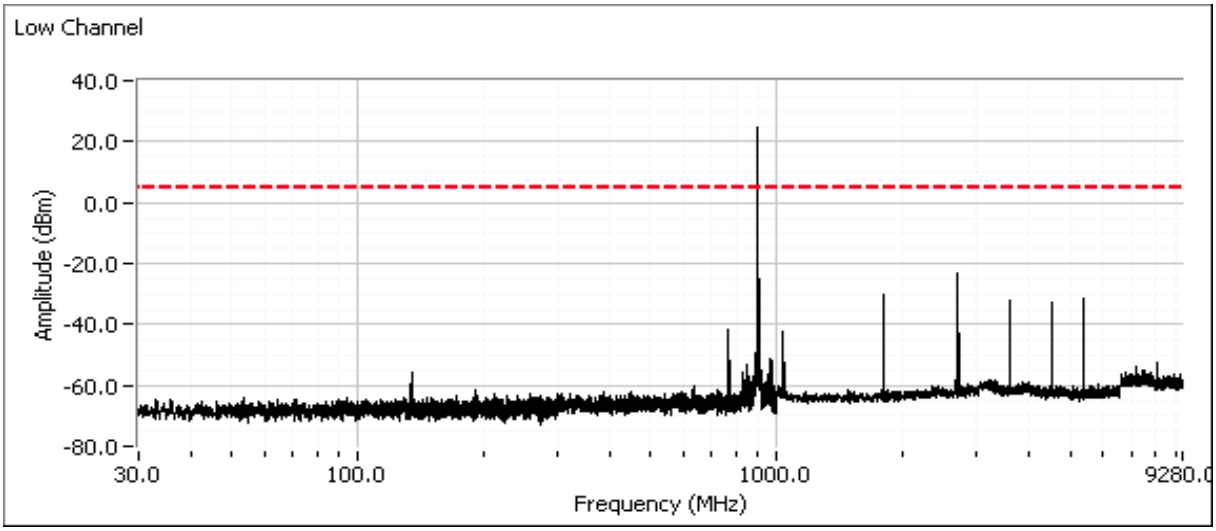
Test Engineer: Joseph Cadigal

Test Location: FT Lab#4b

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

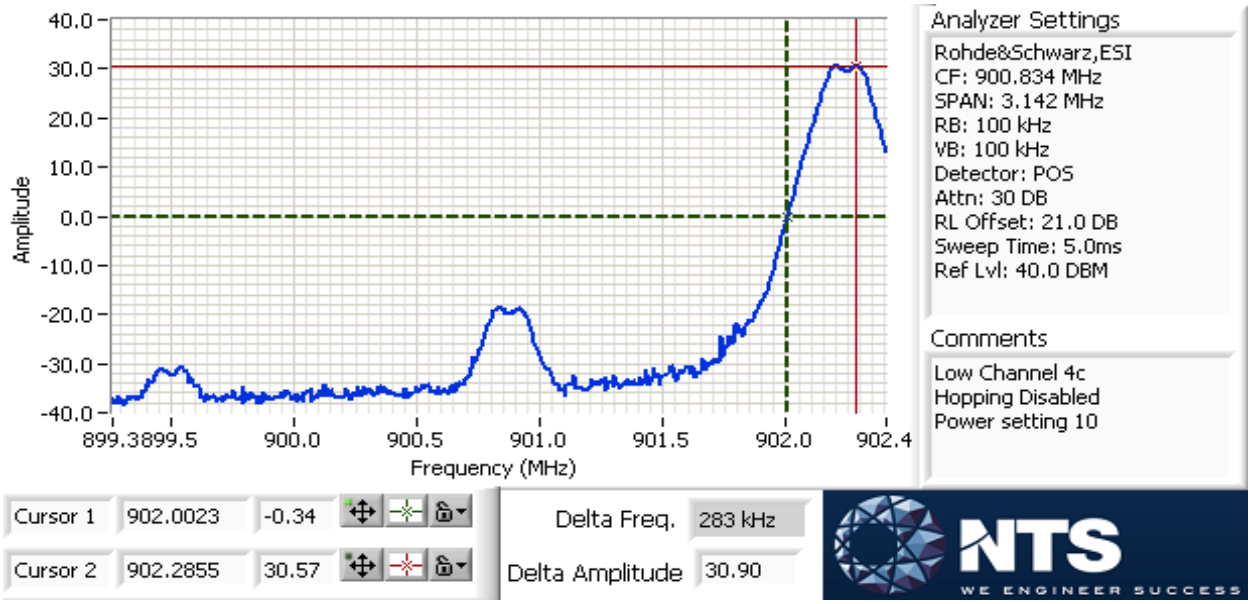
Low channel

Broadband plot



Client:	Freewave Technologies, Inc.	Job Number:	J92945
Model:	MM2-T	T-Log Number:	T92989
		Project Manager:	Sheareen Jacobs
Contact:	Dean Busch	Project Coordinator:	Irene Rademacher
Standard:	FCC Part 15.247	Class:	N/A

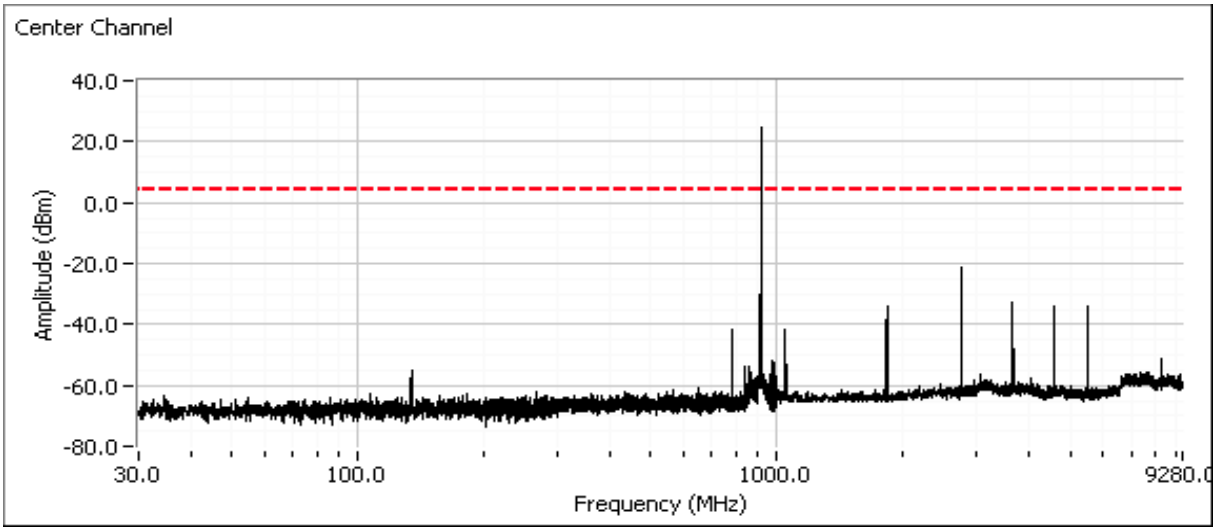
Plot showing -20dBc at the lower band edge, hopping disabled



Client:	Freewave Technologies, Inc.	Job Number:	J92945
Model:	MM2-T	T-Log Number:	T92989
		Project Manager:	Sheareen Jacobs
Contact:	Dean Busch	Project Coordinator:	Irene Rademacher
Standard:	FCC Part 15.247	Class:	N/A

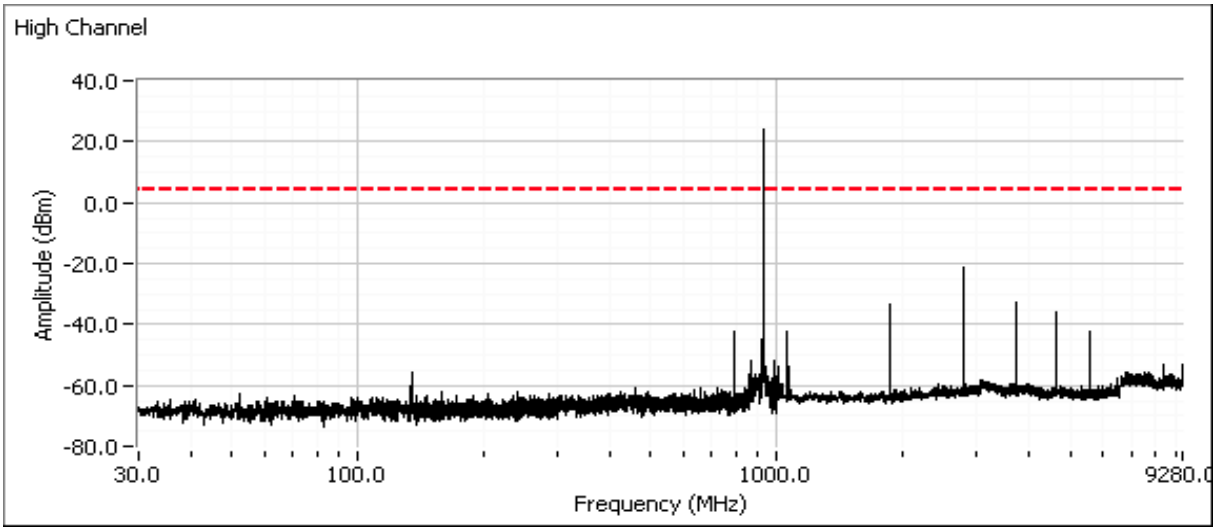
Center channel

Broadband plot



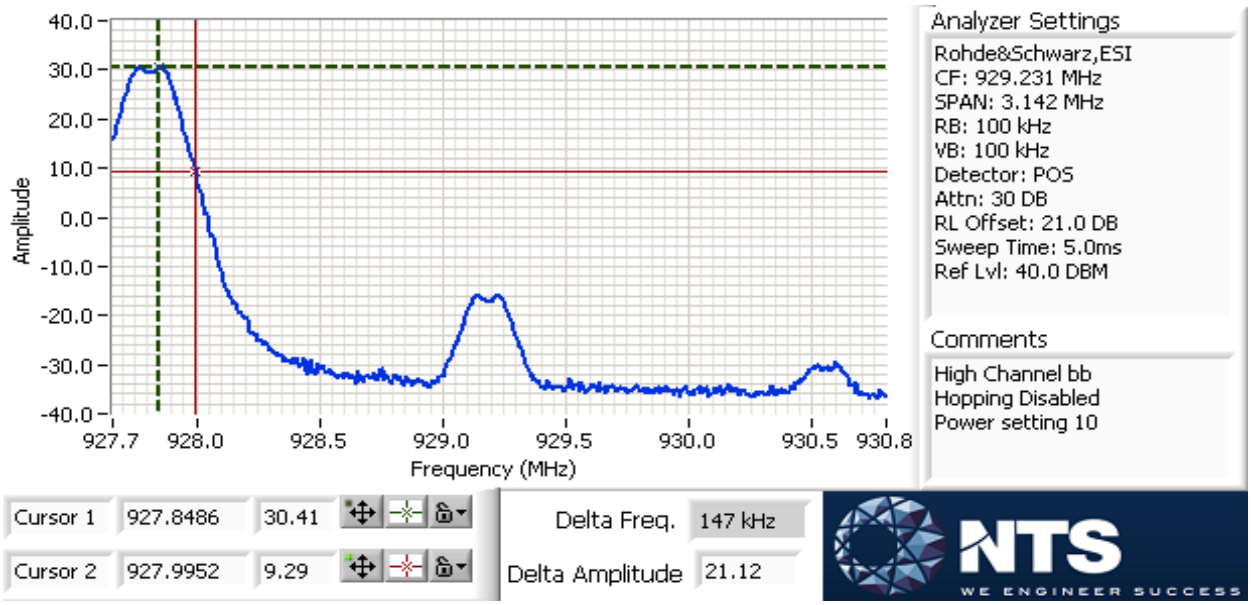
High channel

Broadband plot



Client:	Freewave Technologies, Inc.	Job Number:	J92945
Model:	MM2-T	T-Log Number:	T92989
		Project Manager:	Sheareen Jacobs
Contact:	Dean Busch	Project Coordinator:	Irene Rademacher
Standard:	FCC Part 15.247	Class:	N/A

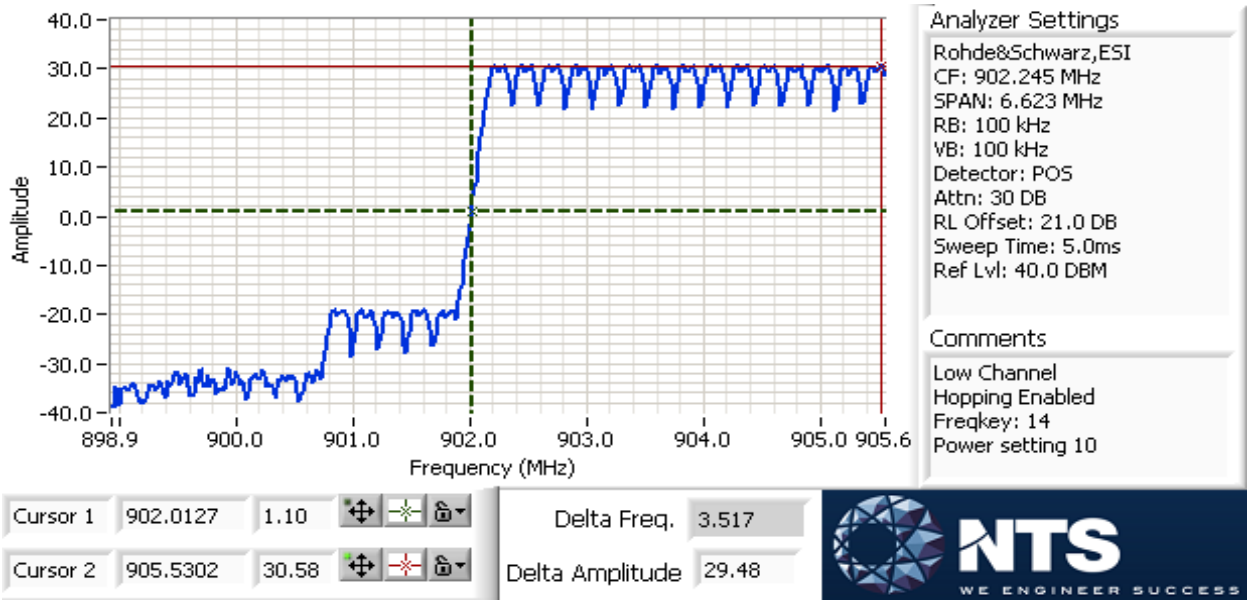
Plot showing -20dBc at the upper band edge, hopping disabled



Client:	Freewave Technologies, Inc.	Job Number:	J92945
Model:	MM2-T	T-Log Number:	T92989
		Project Manager:	Sheareen Jacobs
Contact:	Dean Busch	Project Coordinator:	Irene Rademacher
Standard:	FCC Part 15.247	Class:	N/A

Low channel, hopping enabled
Plot showing -20dBc at the lower band edge

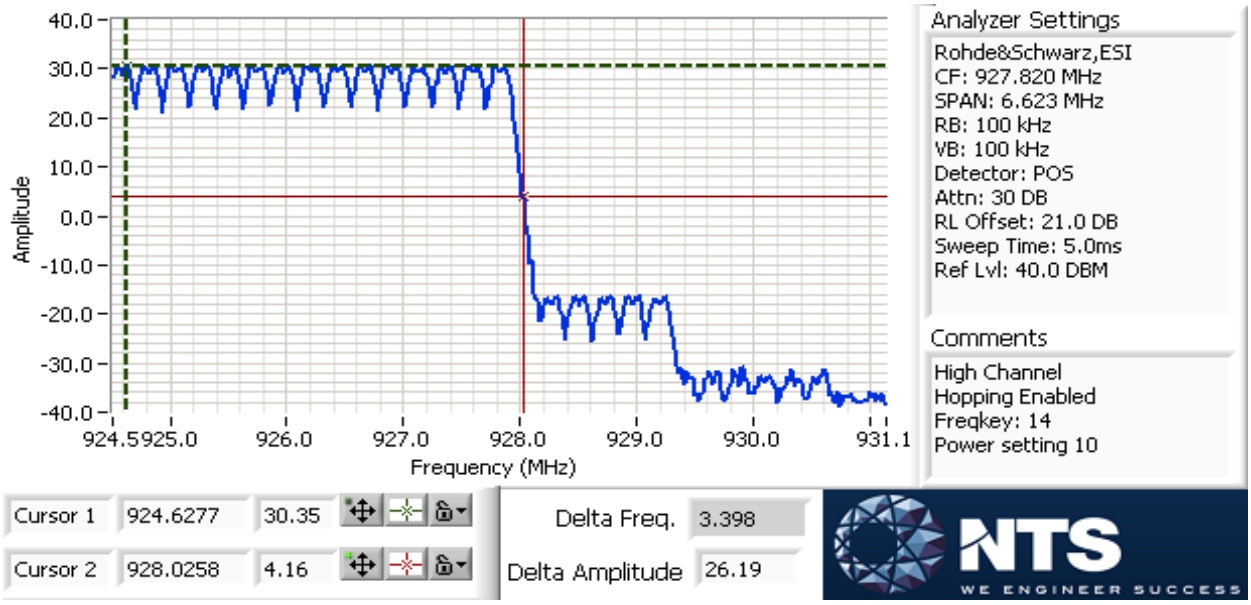
Refer to plots below. Scans made using RBW=VB=100 KHz with the limit line set at 20dB below the highest in-band signal level with the hopping feature enabled to show compliance with the -20dBc requirement at the allocated band edge. The spectrum analyzer is left in max hold mode until the trace stabilizes.



Client:	Freewave Technologies, Inc.	Job Number:	J92945
Model:	MM2-T	T-Log Number:	T92989
		Project Manager:	Sheareen Jacobs
Contact:	Dean Busch	Project Coordinator:	Irene Rademacher
Standard:	FCC Part 15.247	Class:	N/A

High channel, hopping enabled

Plot showing -20dBc at the upper band edge



Client:	Freewave Technologies, Inc.	Job Number:	J92945
Model:	MM2-T	T-Log Number:	T92989
		Project Manager:	Sheareen Jacobs
Contact:	Dean Busch	Project Coordinator:	Irene Rademacher
Standard:	FCC Part 15.247	Class:	N/A

Run #4: Output Power

Date of Test: 9/11/2013

Test Engineer: Mehran Birgani

Test Location: FT Lab#4b

For frequency hopping systems operating in the 902-928 MHz band: 1 watt for systems employing at least 50 hopping channels; and, 0.25 watts for systems employing less than 50 hopping channels, but at least 25 hopping channels.

Maximum effective antenna gain: 6 dBi Power reduction or feed line loss is used.

Channel	Frequency (MHz)	Res BW	Output Power (dBm)	Output Power (W)	EIRP (W)
Low	902.245	1 MHz	29.93	0.984	3.92
Mid	915.14	1 MHz	29.89	0.975	3.88
High	927.82	1 MHz	29.80	0.955	3.80

Note 1:	The power was identical for the 156 kbps data rate.

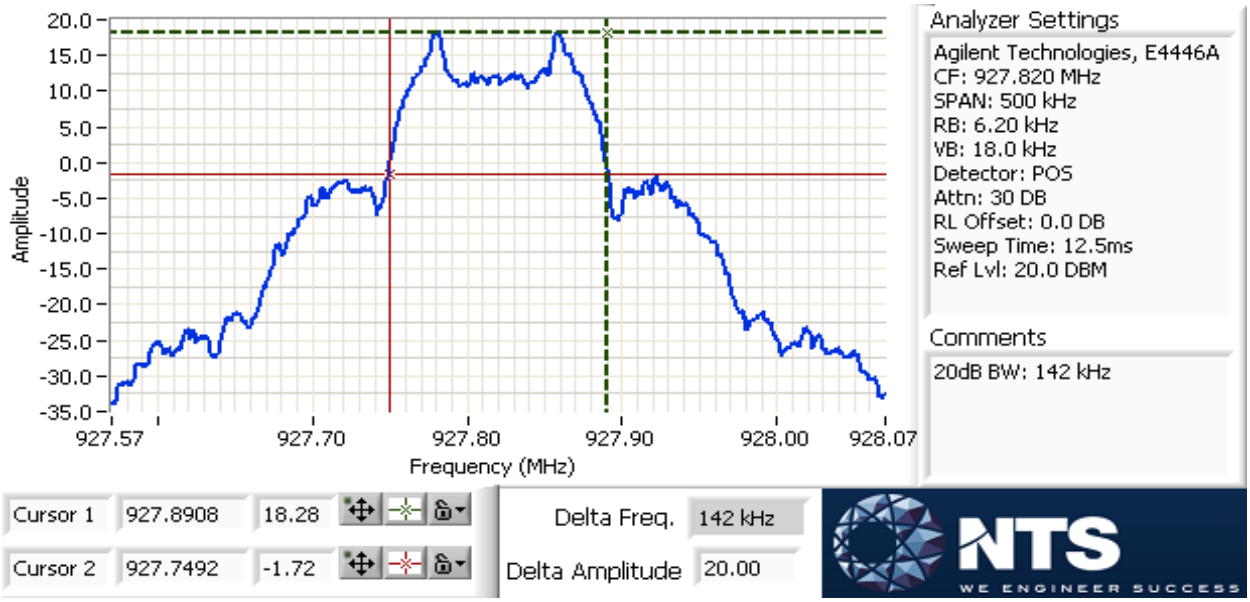
Client:	Freewave Technologies, Inc.	Job Number:	J92945
Model:	MM2-T	T-Log Number:	T92989
		Project Manager:	Sheareen Jacobs
Contact:	Dean Busch	Project Coordinator:	Irene Rademacher
Standard:	FCC Part 15.247	Class:	N/A

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

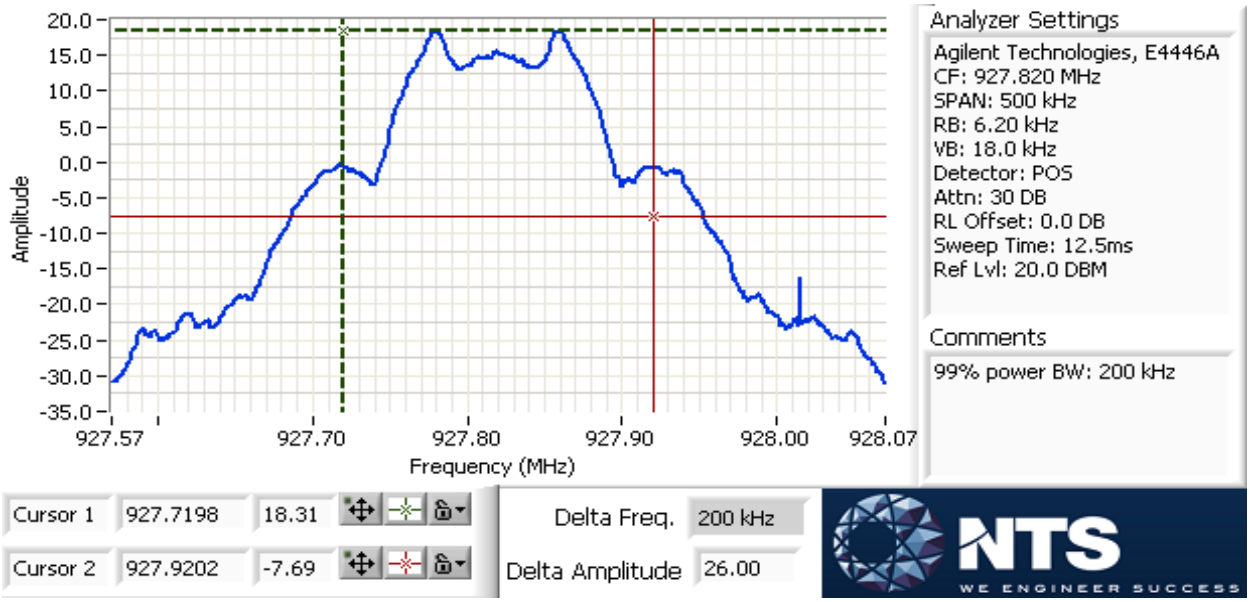
Date of Test: 7/16/2013
Test Engineer: David Bare
Test Location: Fremont Lab #4a

Frequency (MHz)	Resolution Bandwidth	20dB Bandwidth (kHz)	Resolution Bandwidth	99% Bandwidth (kHz)
927.82	6.2 kHz	142	6.2 kHz	200

Note 1:	20dB bandwidth measured using RB = 6.20kHz, VB = 18.0kHz (VB > RB)
Note 2:	99% bandwidth measured using RB = 6.20kHz, VB = 18.0kHz (VB >=3RB)



Client:	Freewave Technologies, Inc.	Job Number:	J92945
Model:	MM2-T	T-Log Number:	T92989
		Project Manager:	Sheareen Jacobs
Contact:	Dean Busch	Project Coordinator:	Irene Rademacher
Standard:	FCC Part 15.247	Class:	N/A

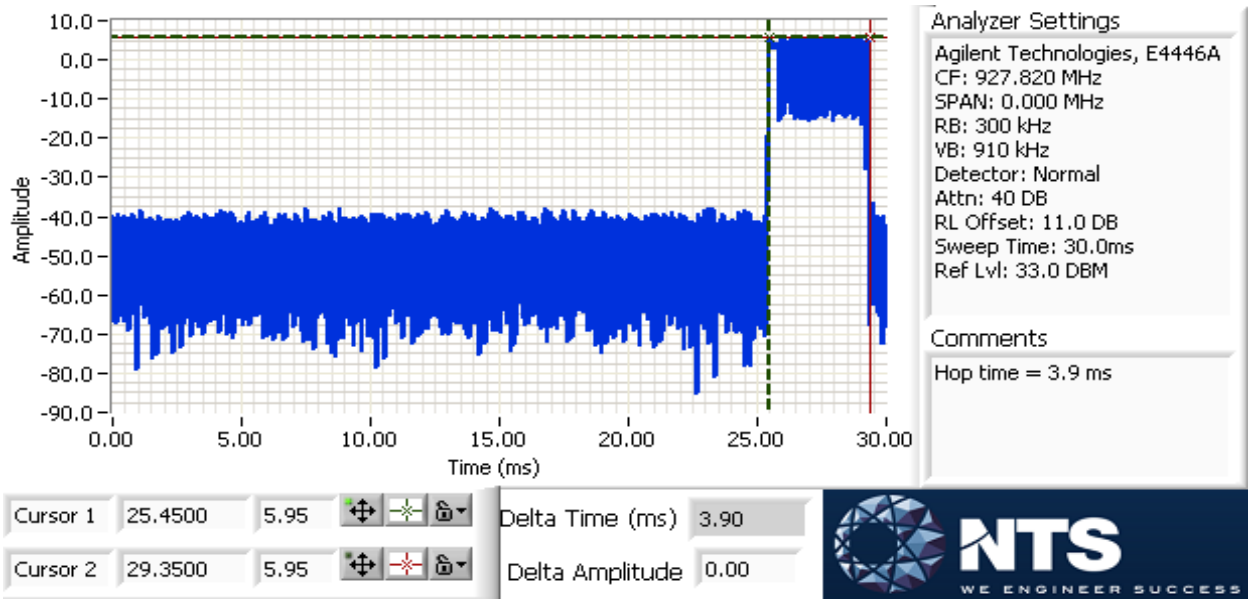


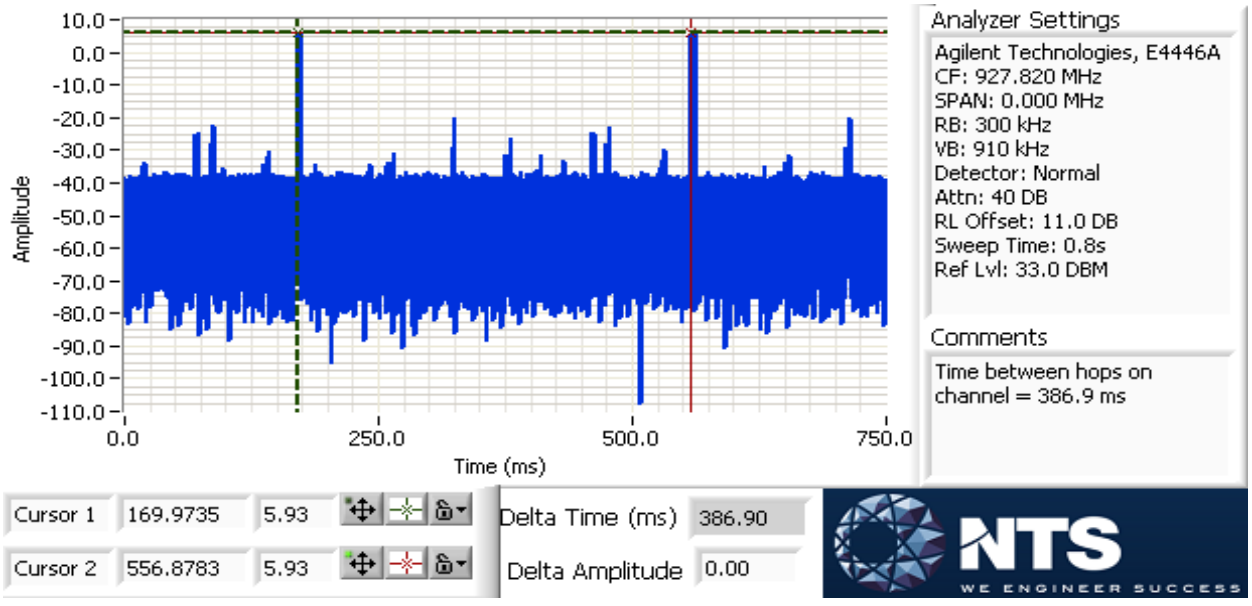
The minimum channel spacing is (927.82-902.245)/111 = 230.4 kHz

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

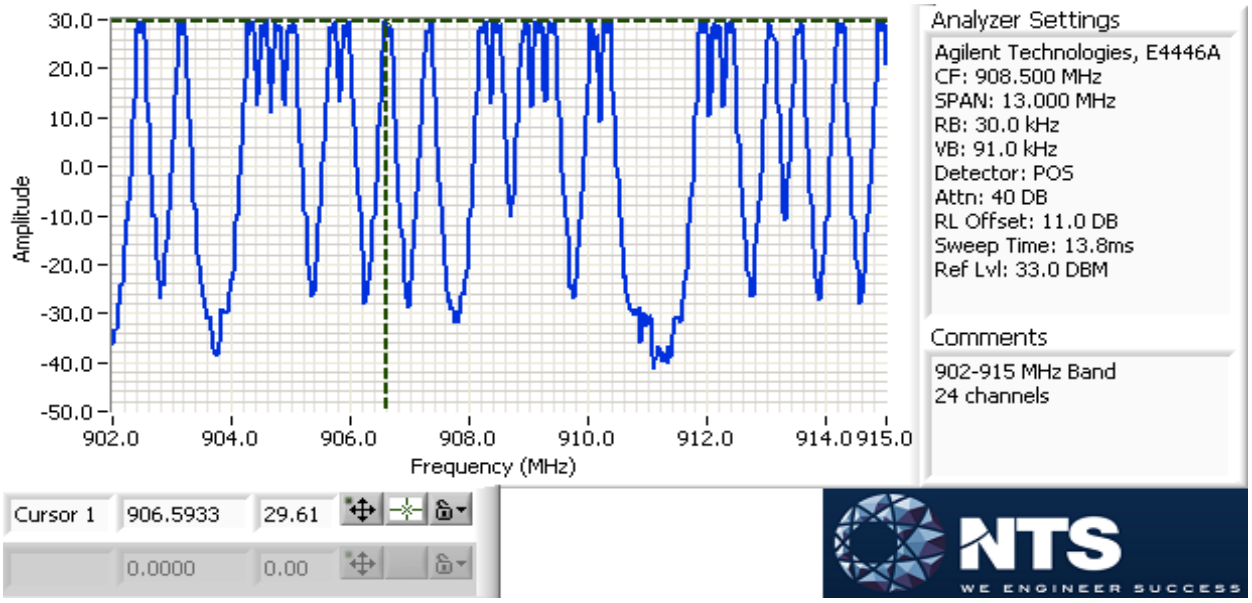
20dB bandwidth:	142	kHz	Pass	
Channel spacing:	230.4	kHz	Pass	
Transmission time per hop:	3.9	ms		
The time between successive hops on a channel:	386.9	ms		
Mininum number of channels (N):	50		Pass	
Channel dwell time in 20 seconds:	202.8	ms	Pass	See above note

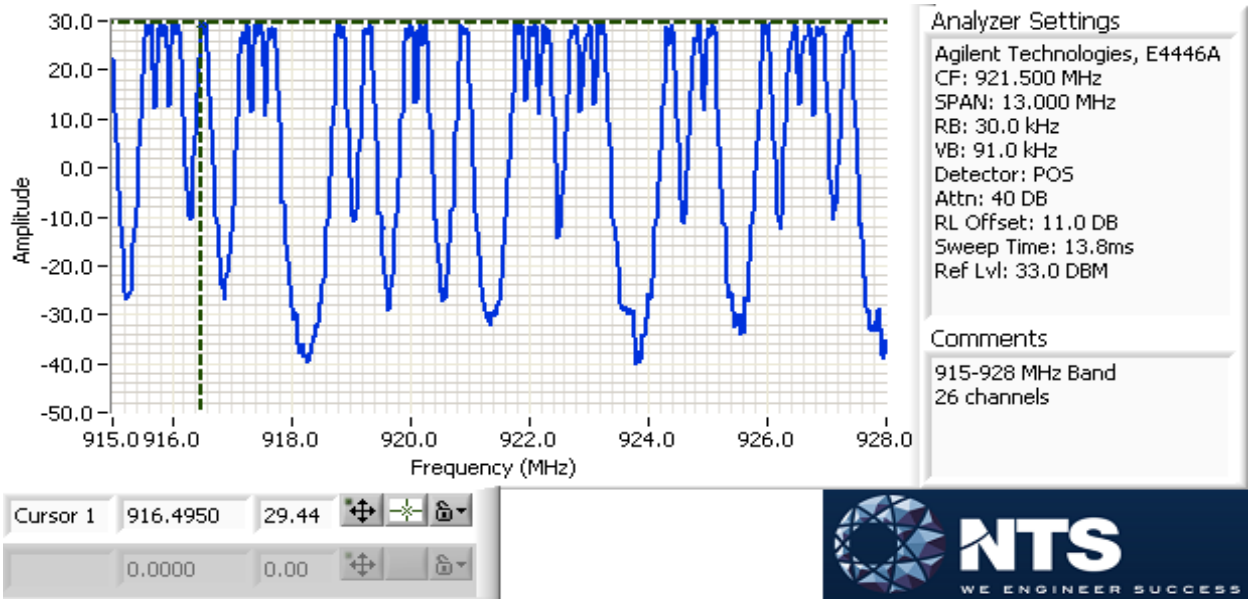
Client:	Freewave Technologies, Inc.	Job Number:	J92945
Model:	MM2-T	T-Log Number:	T92989
		Project Manager:	Sheareen Jacobs
Contact:	Dean Busch	Project Coordinator:	Irene Rademacher
Standard:	FCC Part 15.247	Class:	N/A





Client:	Freewave Technologies, Inc.	Job Number:	J92945
Model:	MM2-T	T-Log Number:	T92989
		Project Manager:	Sheareen Jacobs
Contact:	Dean Busch	Project Coordinator:	Irene Rademacher
Standard:	FCC Part 15.247	Class:	N/A





Client:	Freeware	Job Number:	J92945
Product	MM2-LT	T-Log Number:	T93004
		Project Manager:	Sheareen Jacobs
Contact:	Dean Busch	Project Coordinator:	Irene Rademacher
Emissions Standard(s):	FCC Part 15.247	Class:	A
Immunity Standard(s):	-	Environment:	Radio

EMC Test Data

For The

Freeware

Product

MM2-LT

Date of Last Test: 7/18/2013

Client:	Freeware	Job Number:	J92945
Model:	MM2-LT	T-Log Number:	T93004
		Project Manager:	Sheareen Jacobs
Contact:	Dean Busch	Project Coordinator:	Irene Rademacher
Standard:	FCC Part 15.247	Class:	A

Conducted Emissions

(Elliott Laboratories 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: 7/18/2013
Test Engineer: Alika Hirano
Test Location: Fremont Chamber #5

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

General Test Configuration

For tabletop equipment, the EUT was located on a wooden table inside the semi-anechoic chamber, 40 cm from a vertical coupling plane

Ambient Conditions:

Temperature: 20 °C
Rel. Humidity: 37 %

Summary of Results

Run #	Test Performed	Limit	Result	Margin
1	CE, AC Power,120V/60Hz	Class B	Pass	46.9 dBµV @ 26.747 MHz (-3.1 dB)

Modifications Made During Testing

No modifications were made to the EUT during testing

Deviations From The Standard

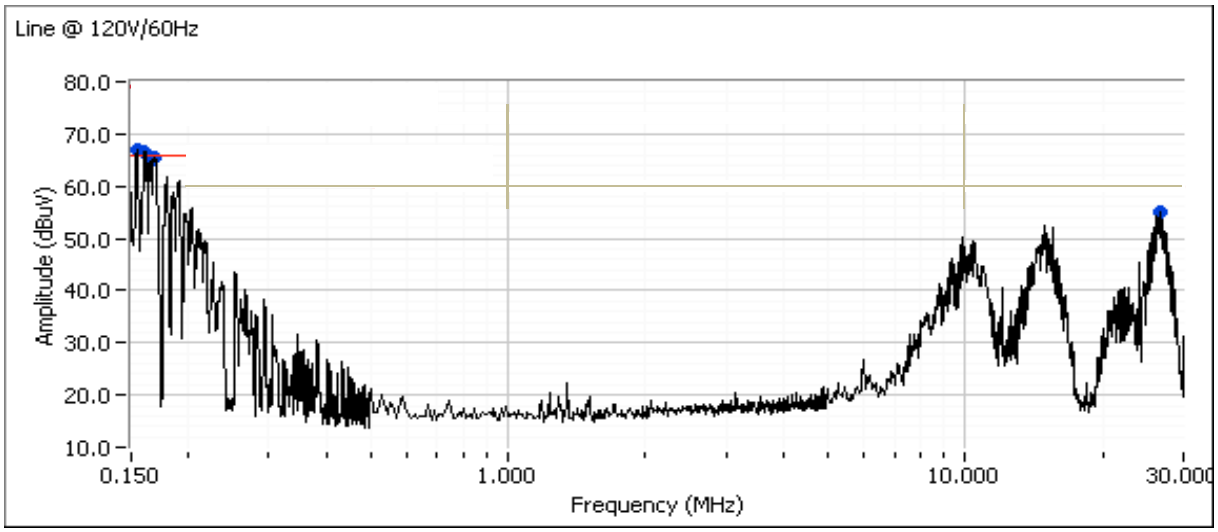
No deviations were made from the requirements of the standard.

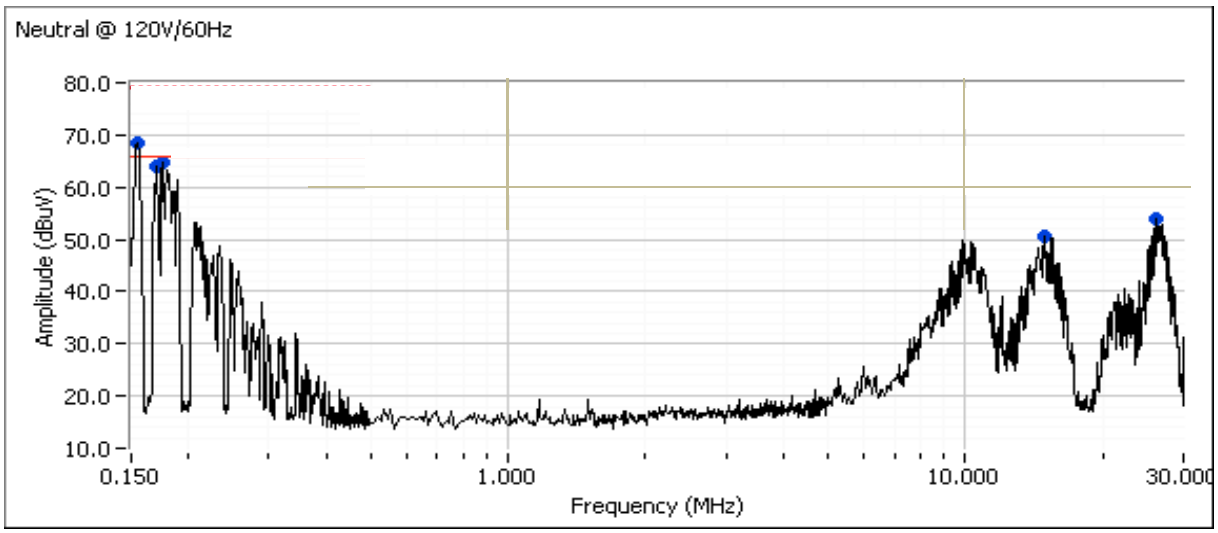
Notes

Testing was performed with a Yagi antenna connected to the EUT. This antenna was removed from consideration later by Freewave and only the Omni will be used.

Client:	Freeware	Job Number:	J92945
Model:	MM2-LT	T-Log Number:	T93004
		Project Manager:	Sheareen Jacobs
Contact:	Dean Busch	Project Coordinator:	Irene Rademacher
Standard:	FCC Part 15.247	Class:	A

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





Client:	Freeware	Job Number:	J92945
Model:	MM2-LT	T-Log Number:	T93004
		Project Manager:	Sheareen Jacobs
Contact:	Dean Busch	Project Coordinator:	Irene Rademacher
Standard:	FCC Part 15.247	Class:	A

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

Frequency	Level	AC	Class B		Detector	Comments
MHz	dBµV	Line	Limit	Margin	QP/Ave	
0.154	67.0	Line 1	65.8	1.2	Peak	Peak reading compared to the QP limit
0.161	66.5	Line 1	65.4	1.1	Peak	Peak reading compared to the QP limit
0.165	64.6	Line 1	65.2	-0.6	Peak	Peak reading compared to the QP limit
0.169	65.3	Line 1	65.0	0.3	Peak	Peak reading compared to the QP limit
26.747	54.9	Line 1	60.0	-5.1	Peak	Peak reading compared to the QP limit
0.155	68.5	Neutral	65.7	2.8	Peak	Peak reading compared to the QP limit
0.170	64.0	Neutral	65.0	-1.0	Peak	Peak reading compared to the QP limit
0.176	64.7	Neutral	64.7	0.0	Peak	Peak reading compared to the QP limit
14.946	50.4	Neutral	60.0	-9.6	Peak	Peak reading compared to the QP limit
26.235	54.0	Neutral	60.0	-6.0	Peak	Peak reading compared to the QP limit

Final quasi-peak and average readings

Frequency	Level	AC	Class B		Detector	Comments
MHz	dBµV	Line	Limit	Margin	QP/Ave	
26.747	46.9	Line 1	50.0	-3.1	AVG	AVG (0.10s)
26.235	46.5	Neutral	50.0	-3.5	AVG	AVG (0.10s)
14.946	43.9	Neutral	50.0	-6.1	AVG	AVG (0.10s)
0.154	61.5	Line 1	65.8	-4.3	QP	QP (1.00s)
0.161	60.6	Line 1	65.4	-4.8	QP	QP (1.00s)
0.155	60.4	Neutral	65.7	-5.3	QP	QP (1.00s)
0.165	59.9	Line 1	65.2	-5.3	QP	QP (1.00s)
0.169	59.1	Line 1	65.0	-5.9	QP	QP (1.00s)
26.747	52.8	Line 1	60.0	-7.2	QP	QP (1.00s)
26.235	52.7	Neutral	60.0	-7.3	QP	QP (1.00s)
0.170	58.1	Neutral	65.0	-6.9	QP	QP (1.00s)
0.176	56.8	Neutral	64.7	-7.9	QP	QP (1.00s)
14.946	49.9	Neutral	60.0	-10.1	QP	QP (1.00s)
0.154	30.9	Line 1	55.8	-24.9	AVG	AVG (0.10s)
0.161	30.2	Line 1	55.4	-25.2	AVG	AVG (0.10s)
0.155	29.9	Neutral	55.7	-25.8	AVG	AVG (0.10s)
0.165	29.4	Line 1	55.2	-25.8	AVG	AVG (0.10s)
0.169	28.5	Line 1	55.0	-26.5	AVG	AVG (0.10s)
0.170	27.4	Neutral	55.0	-27.6	AVG	AVG (0.10s)
0.176	26.5	Neutral	54.7	-28.2	AVG	AVG (0.10s)

End of Report

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