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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: FGR3-C-U and FGR3-T-U

ISED CERTIFICATION #: 23293-FGR3
FCC ID: KNYFGR3

APPLICANT: FreeWave
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Boulder, CO 80301

TEST SITE(S): National Technical Systems
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SCOPE

An electromagnetic emissions test has been performed on the FreeWave model FGR3-C-U and FGR3-T-U, 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

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 FGR3-C-U. This model was considered representative of the FGR3-T-U model.

STATEMENT OF COMPLIANCE

The tested sample of FreeWave model FGR3-C-U 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 (DTSS), 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 model FGR3-C-U and therefore apply only to the tested sample. The sample was selected and prepared by Riaz Momand of FreeWave.

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	192 kHz	<= 500 kHz	Complies
15.247 (a) (1)	RSS 247 5.1 (2)	Channel Separation	228 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	10.44ms	<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	30.0 dBm (1.0 W) EIRP = 3.85 W Note 1	1Watt, EIRP <= 4 Watts	Complies
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	45.6 dBμV/m @ 967.63 MHz (Margin: -8.4 dB)	Refer to the limits section (p21) for restricted bands, all others < -20dBc	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 8.15 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	Custom RF connector	Unique or integral antenna required	Complies
15.407 (b) (6)	RSS-Gen Table 4	AC Conducted Emissions Kuantech MN: KSAS0121200080HU Power Supply	51.0dB μ V @ 0.191MHz (-13.0dB)	Refer to page 20	Complies
		AC Conducted Emissions Shenzhen Mingxin MN: MX15W-1200800UX Power Supply	56.2dB μ V @ 0.151MHz (-9.7dB)		
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 User Manual statement	Statement for products with detachable antenna	Complies
-	RSS-Gen 8.4	User Manual	Refer to separate exhibit	Statement for all products	Complies
-	RSP-100 RSS-Gen 6.7	Necessary Bandwidth	224.1 kHz 235.2 kHz	Information only	N/A

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 models FGR3-C-U and FGR3-T-U are 902-928 MHz, ISM band frequency hopping radios that are designed to Transmit and Receive data at 115.2Kbps and 153.6kbps rates. 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 +6 to +30 DC Volts, 644-125 milli-Amps.

The sample was received on November 29, 2018 and tested on November 29 through December 3, 2018. The EUT consisted of the following component(s):

Company	Model	Description	Serial Number	FCC ID
FreeWave Technologies, Inc.	FGR3-C-U	RS232, 902-928 MHz, ISM band radio	965-3691	KNYFGR3

OTHER EUT DETAILS

The following EUT details should be noted: There is no difference between FGR3, RS232 and TTL radios. Radio is the same. They just use different protocols to communicate with the host product.

ANTENNA SYSTEM

The antenna system consists of either an Omni (3 or 8.15 dBi) or Yagi (8.6 dBi) antenna.

ENCLOSURE

The EUT doesn't have enclosure. It measures approximately 6.1 cm wide by 12.8 cm length by 1.4 cm high.

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 local support equipment for testing:

Company	Model	Description	Serial Number	FCC ID
Toshiba	Satellite L645-S4102	Laptop	1B250508W	
KUANTECH	KSAS0121200080HU	AC/ DC Adaptor 1		
Shenzhen Mingxin Power Technologies Co Ltd	MX15W-1200800UX	AC/ DC Adaptor 2		
LAIRD Technologies	FG9026	8.15 dBi Omni Antenna		
WaveLink Antenna Systems, Inc.	MFR Part# PRO890-8-40F02N4 Freewave M# EAN0906YC	8.6 dBi Yagi Antenna		

Note: Worst case AC/ DC Adaptor adaptor will be tested for above 1GHz un-intentional testing. Both AC/ DC Adaptors tested for Un-intentional Radiated Emissions (30MHz to 1GHz) and Line Conducted Emissions

No remote support equipment was used during testing.

EUT INTERFACE PORTS

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

EUT

Port		Cable(s)		
From	To	Description	Shielded/Unshielded	Length(m)
10 pin (IO and Power port)	Power/ Laptop & Reset	10 pin Cable harness	Unshielded	1

Additional on Support Equipment

Port		Cable(s)		
From	To	Description	Shielded/Unshielded	Length(m)
RS232	Laptop	RS232 to USB	Shielded	1.5

EUT OPERATION

During emissions testing the EUT was continuously transmitting in the 902-928 MHz band (Hopping and single channel mode) at the selected power and data rate indicated.

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

Site	Designation / Registration Numbers		Location
	FCC	Canada	
Chamber 3	US0027	2845B-3	41039 Boyce Road Fremont, CA 94538-2435
Chamber 5	US0027	2845B-5	
Chamber 7	US0027	2845B-7	

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.

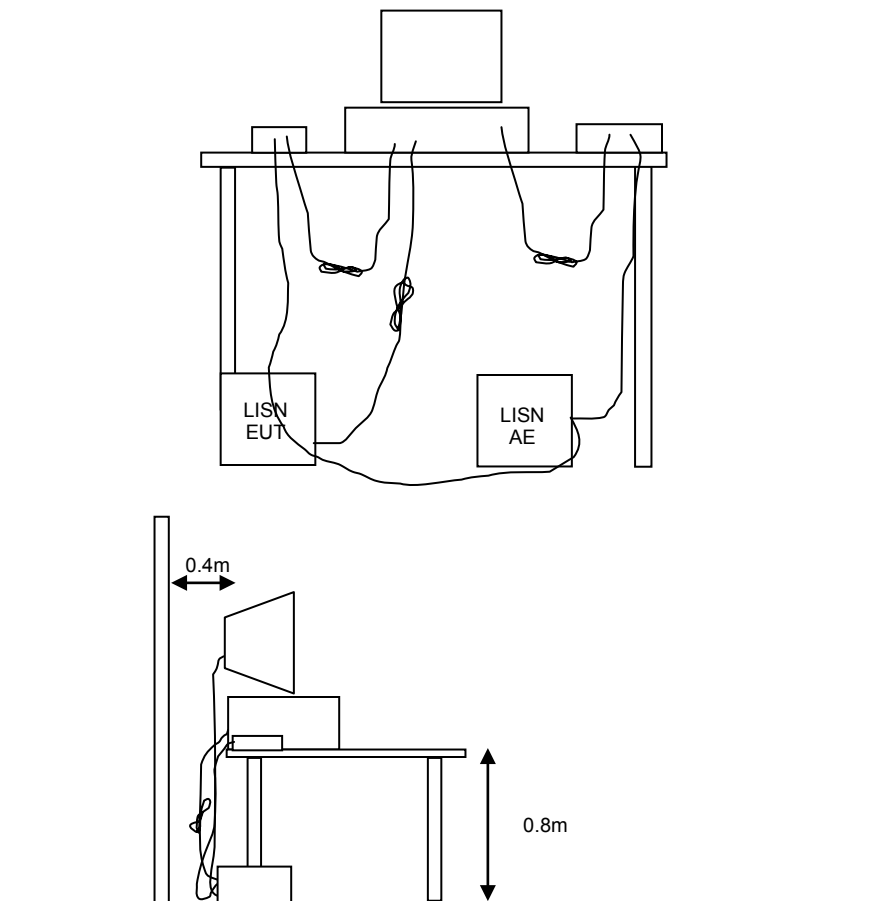


Figure 1 Typical Conducted Emissions Test Configuration

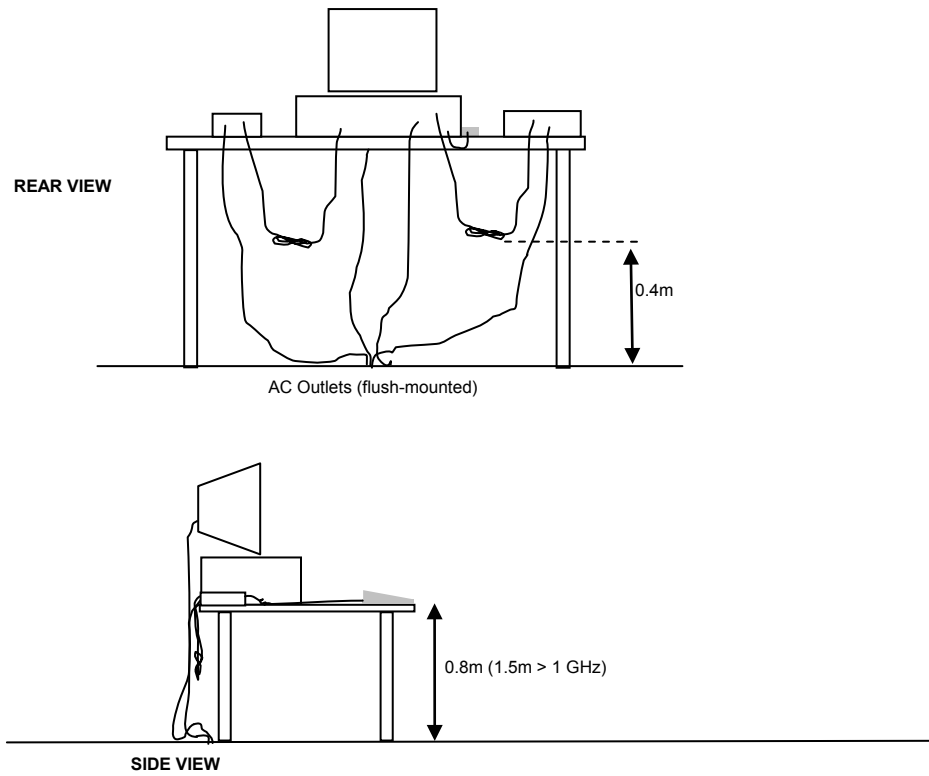
RADIATED EMISSIONS

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.

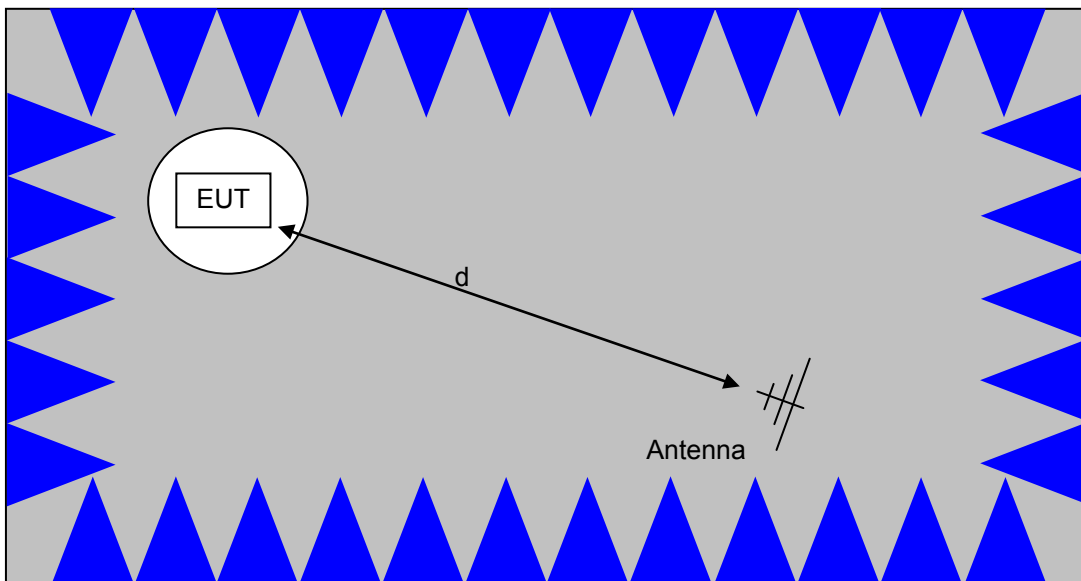
A speaker is provided in the receiver to aid in discriminating between EUT and ambient emissions. Other methods used during the preliminary scan for EUT emissions involve scanning with near field magnetic loops, monitoring I/O cables with RF current clamps, and cycling power to the EUT.

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

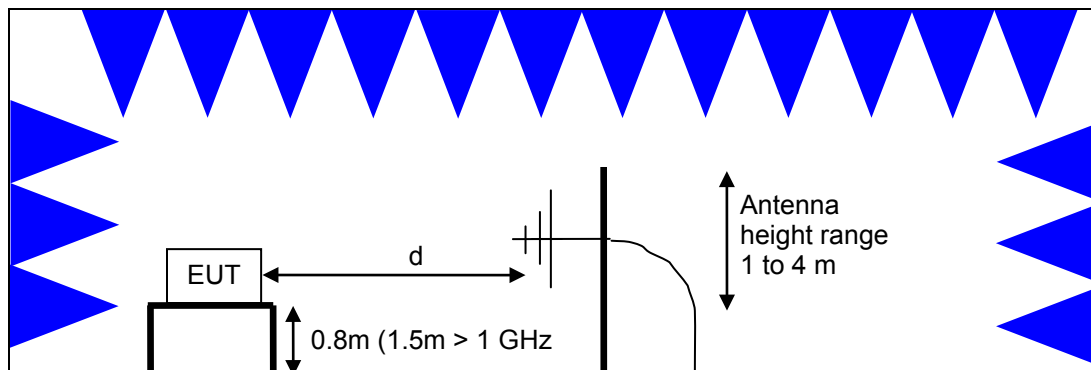


Typical Test Configuration for Radiated Field Strength Measurements



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.

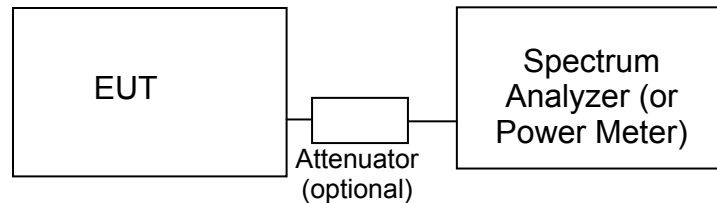
Floor-standing equipment is placed on the floor with insulating supports between the unit and the ground plane.



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 bands¹.

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

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).

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

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

Radiated Emissions, 30 - 10,000 MHz, 29-Nov-18 thorough 3-Dec-18

<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	785	9/5/2018	9/5/2019
EMCO	Antenna, Horn, 1-18 GHz (SA40-Red)	3115	1142	9/18/2018	9/18/2020
Hewlett Packard	Spectrum Analyzer (SA40) Red 30 Hz -40 GHz	8564E (84125C)	1148	9/27/2018	9/27/2019
Sunol Sciences	Biconilog, 30-3000 MHz	JB3	2237	7/3/2018	7/3/2020
Rohde & Schwarz	EMI Test Receiver, 20 Hz-40 GHz	ESI 40	2493	3/22/2018	3/22/2019
Hewlett Packard	9KHz-1300MHz pre-amp	8447F	2777	12/27/2017	12/27/2018
A. H. Systems	Spare System Horn, 18-40GHz	SAS-574, p/n: 2581	2162	8/4/2017	8/4/2019

Radiated Emissions, 30 - 10,000 MHz, 30-Nov-18

<u>Manufacturer</u>	<u>Description</u>	<u>Model</u>	<u>Asset #</u>	<u>Calibrated</u>	<u>Cal Due</u>
Sunol Sciences	Biconilog, 30-3000 MHz	JB3	1549	5/30/2017	5/30/2019
Com-Power	Preamplifier, 1-1000 MHz	PAM-103	2885	8/21/2018	8/21/2019
Rohde & Schwarz	EMI Test Receiver, 20 Hz-7 GHz	ESIB 7	9482	10/13/2018	10/13/2019

Conducted Emissions - AC Power Ports, 30-Nov-18

<u>Manufacturer</u>	<u>Description</u>	<u>Model</u>	<u>Asset #</u>	<u>Calibrated</u>	<u>Cal Due</u>
EMCO	LISN, 10 kHz-100 MHz	3825/2	1292	8/16/2018	8/16/2019
Rohde & Schwarz	Pulse Limiter	ESH3 Z2	1401	1/8/2018	1/8/2019
Rohde & Schwarz	EMI Test Receiver, 20 Hz-7 GHz	ESIB 7	9482	10/13/2018	10/13/2019

Radio Antenna Port (Power and Spurious Emissions), 04-Dec-18

<u>Manufacturer</u>	<u>Description</u>	<u>Model</u>	<u>Asset #</u>	<u>Calibrated</u>	<u>Cal Due</u>
Rohde & Schwarz	Power Meter, Dual Channel	NRVD	1071	4/4/2018	4/4/2019
Rohde & Schwarz	Peak Power Sensor 100 uW - 2 Watts (w/ 20 dB pad, SN BJ5155)	NRV-Z32	1536	6/21/2018	6/21/2019
Agilent Technologies	3Hz -44GHz PSA Spectrum Analyzer	E4446A	2796	5/31/2018	5/31/2019



Appendix B Test Data

TL091113-RA Pages 26 – 72



EMC Test Data

Client:	Freewave	PR Number:	PR091113
Product	FGR3-C-U and FGR3-T-U	T-Log Number:	TL091113-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

Product

FGR3-C-U and FGR3-T-U

Date of Last Test: 12/17/2018



EMC Test Data

Client:	Freewave	Job Number:	PR091113
Model:	FGR3-C-U and FGR3-T-U	T-Log Number:	TL091113-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15.247, RSS-247	Project Coordinator:	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: 42-44 %

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	45.6 dBμV/m @ 967.63 MHz (Margin: -8.4 dB)
3	30 - 10000 MHz - Transmitter Conducted Spurious Emissions	FCC Part 15.247(c)	Pass	All emission were more than 20dB below the limit
4	Output Power	15.247(b)	Pass	27.1 dBm (0.513 W)
5	20dB Bandwidth	15.247(a)	Pass	192 kHz
5	Channel Occupancy	15.247(a)	Pass	10.44ms
5	Channel Spacing	15.247(a)	Pass	228 kHz
5	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.

Use ANSI C63.10 section 7.8 for test methods



EMC Test Data

Client:	Freewave	Job Number:	PR091113
Model:	FGR3-C-U and FGR3-T-U	T-Log Number:	TL091113-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15.247, RSS-247	Project Coordinator:	David Bare
		Class:	N/A

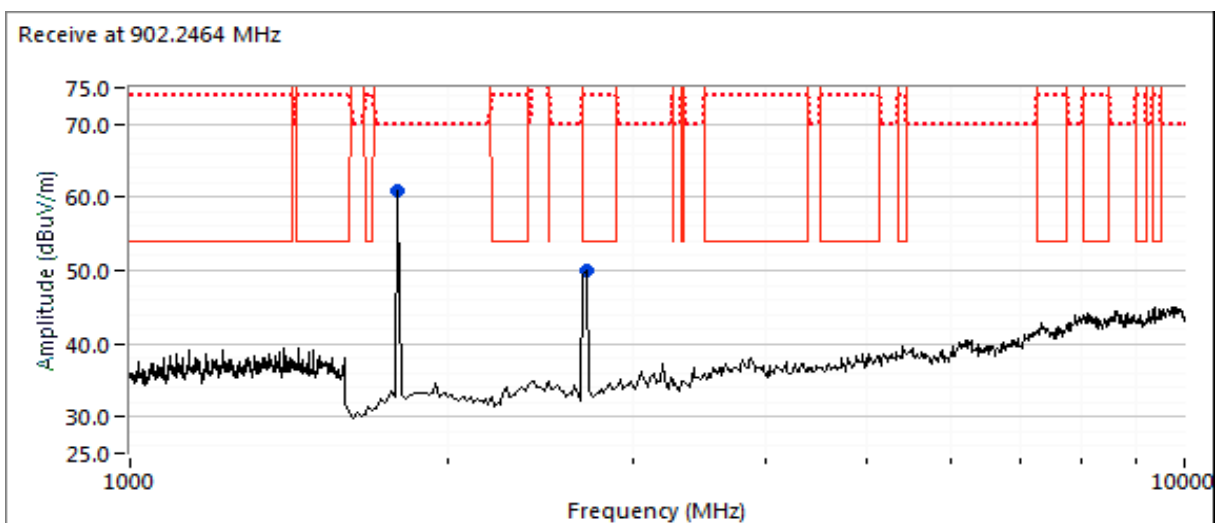
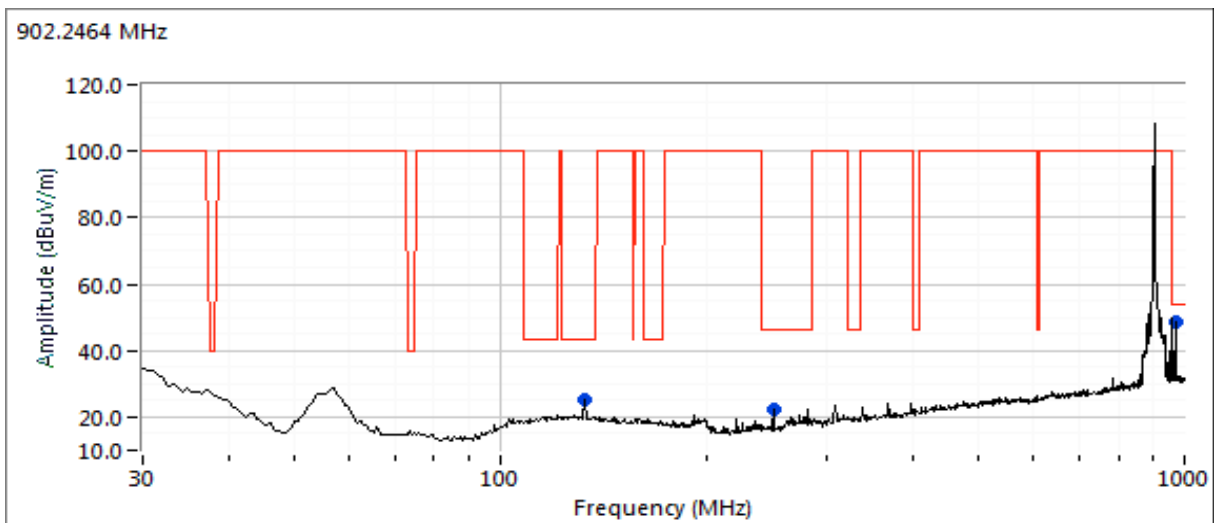
Run #1: Radiated Spurious Emissions, 30 - 10000 MHz.

Run #1a: Radiated Spurious Emissions, 30 - 10,000 MHz. Low Channel @ 902.2464 MHz

Fundamental Signal Field Strength: 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
902.247	132.0	H	-	-	PK	354	1.6

Fundamental emission level @ 3m in 100kHz RBW:	132.0	-
Limit for emissions outside of restricted bands:	112.0 dB μ V/m	Limit is -20dBc





EMC Test Data

Client:	Freewave	Job Number:	PR091113
Model:	FGR3-C-U and FGR3-T-U	T-Log Number:	TL091113-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15.247, RSS-247	Project Coordinator:	David Bare
		Class:	N/A

Band Edge Signal Field Strength

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBm	RF	Limit	Margin	PK/QP/Avg	degrees	meters	
902.000	-4.0	-	9.9	-13.9	PK	354	1.6	

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	
250.655	24.0	H	46.0	-22.0	QP	250	1.0	QP (1.00s)
132.708	28.8	H	43.5	-14.7	QP	226	2.0	QP (1.00s)
969.197	45.5	H	54.0	-8.5	QP	341	1.0	QP (1.00s)
1804.440	60.5	V	112.0	-51.5	PK	116	1.2	RB 1 MHz;VB 3 MHz;Peak
2706.770	37.9	V	54.0	-16.1	AVG	289	1.0	RB 1 MHz;VB 10 Hz;Peak
2706.720	45.4	V	74.0	-28.6	PK	289	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.



EMC Test Data

Client:	Freewave	Job Number:	PR091113
Model:	FGR3-C-U and FGR3-T-U	T-Log Number:	TL091113-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15.247, RSS-247	Project Coordinator:	David Bare
		Class:	N/A

Run #1b: Radiated Spurious Emissions, 30 - 10,000 MHz. Center Channel @ 914.9184 MHz

Fundamental Signal Field Strength: 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	
914.919	131.9	H	-	-	PK	354	1.6	100 kHz; VB: 300 kHz

Fundamental emission level @ 3m in 100kHz RBW:	131.9	-
Limit for emissions outside of restricted bands:	111.9 dB μ V/m	Limit is -20dBc

Spurious Emissions

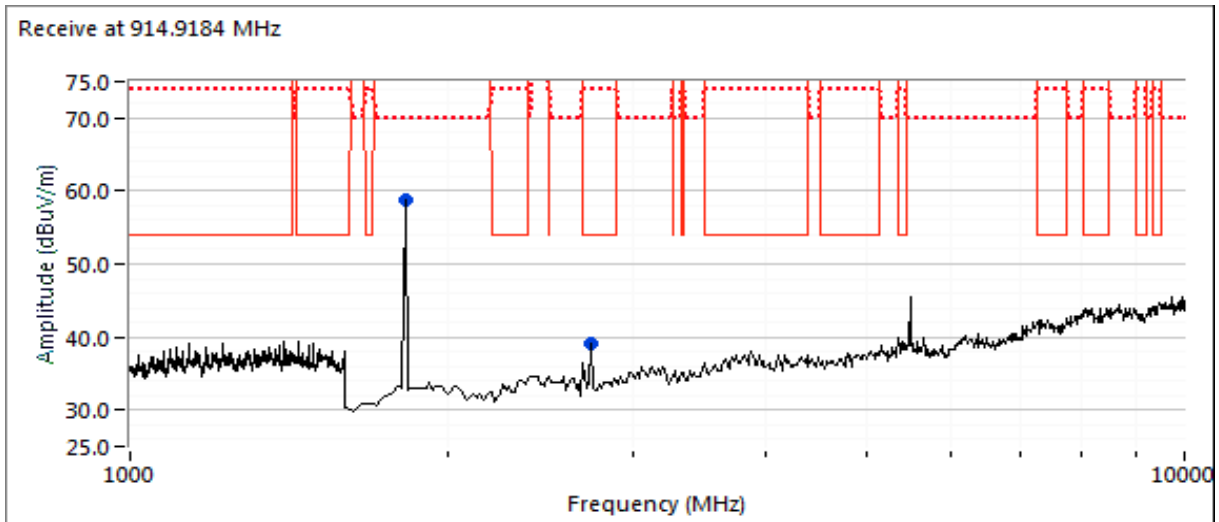
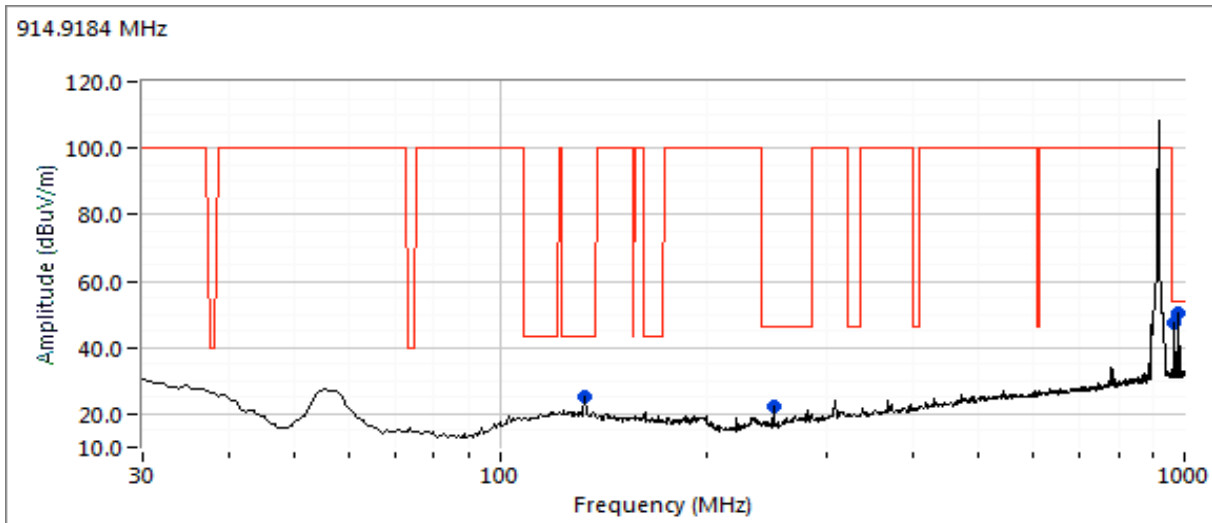
Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dB μ V/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
967.626	45.6	H	54.0	-8.4	QP	360	1.0	QP (1.00s)
980.897	45.5	H	54.0	-8.5	QP	355	1.0	QP (1.00s)
132.718	28.6	H	43.5	-14.9	QP	224	2.0	QP (1.00s)
2744.800	37.8	V	54.0	-16.2	AVG	286	1.1	RB 1 MHz;VB 10 Hz;Peak
249.356	21.7	H	46.0	-24.3	QP	252	1.0	QP (1.00s)
2744.680	45.5	V	74.0	-28.5	PK	286	1.1	RB 1 MHz;VB 3 MHz;Peak
1829.830	59.3	V	111.9	-52.6	PK	287	1.6	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.



EMC Test Data

Client:	Freewave	Job Number:	PR091113
Model:	FGR3-C-U and FGR3-T-U	T-Log Number:	TL091113-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15.247, RSS-247	Project Coordinator:	David Bare
		Class:	N/A





EMC Test Data

Client:	Freewave	Job Number:	PR091113
Model:	FGR3-C-U and FGR3-T-U	T-Log Number:	TL091113-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15.247, RSS-247	Project Coordinator:	David Bare
		Class:	N/A

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

Date of Test: 11/20/2018

EUT Setting/ Data Rate: 7, 153.6kbps

Test Engineer: M. Birgani

EUT Power: 26.5 dBm

Test Location: Chamber 3

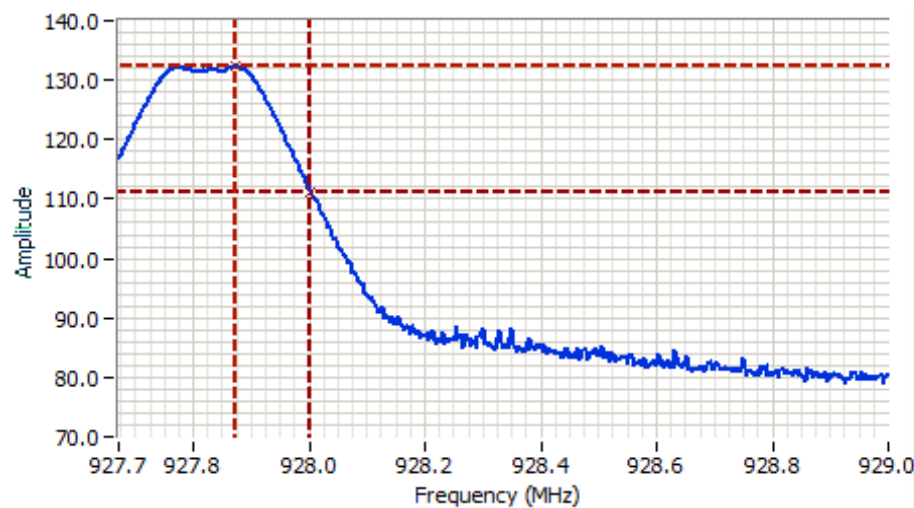
Antenna Gain: Yagi, 8.6dBi

Fundamental Signal Field Strength: Peak value measured in 100kHz

Frequency	Level	Pol	15.2		Detector	Azimuth	Height	Comments
MHz	dBμV/m	v/h	Limit	Margin	PK/QP/Avg	degrees	meters	
927.790	120.2	V	-	-	PK	43	1.7	100 kHz; VB: 300 kHz
927.875	132.2	H	-	-	PK	354	1.6	100 kHz; VB: 300 kHz

Fundamental emission level @ 3m in 100kHz RBW:	132.2	120.2
Limit for emissions outside of restricted bands:	112.2	dBμV/m

Limit is -20dBc



Analyzer Settings

Rohde&Schwarz,ESI
CF: 928.336 MHz
SPAN: 1.329 MHz
RB: 100 kHz
VB: 300 kHz
Detector: POS
Attn: 50 DB
RL Offset: 29.2 DB
Sweep Time: 5.0ms
Ref Lvl: 141.2 DBUV

Comments

Bandedge Measurement

Cursor 1	927.8734	132.2	
Cursor 2	928.0000	111.1	

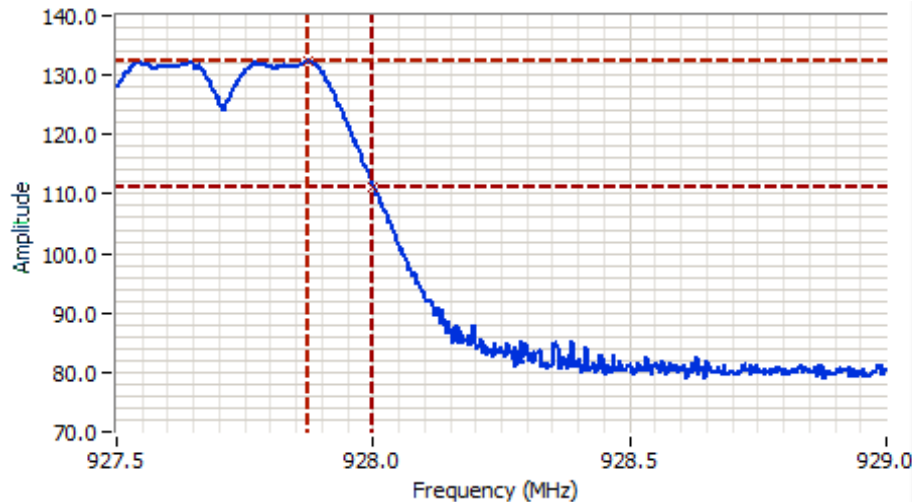
Delta Freq. 127 kHz
Delta Amplitude 21.1





EMC Test Data

Client:	Freewave	Job Number:	PR091113
Model:	FGR3-C-U and FGR3-T-U	T-Log Number:	TL091113-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15.247, RSS-247	Project Coordinator:	David Bare
		Class:	N/A



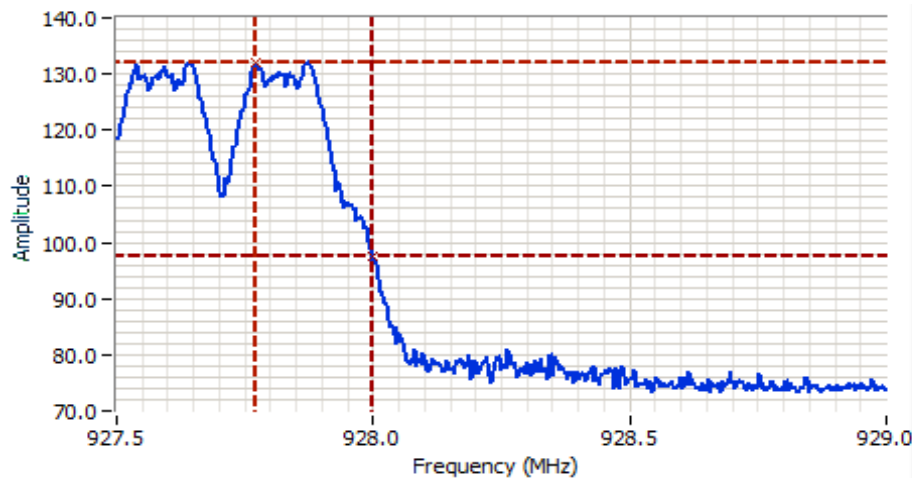
Analyzer Settings

Rohde&Schwarz,ESI
CF: 928.250 MHz
SPAN: 1.500 MHz
RB: 100 kHz
VB: 300 kHz
Detector: POS
Attn: 50 DB
RL Offset: 29.2 DB
Sweep Time: 5.0ms
Ref Lvl: 141.2 DBUV

Comments

Cursor 1 927.8727 132.2
Cursor 2 928.0000 111.1

Delta Freq. 127 kHz
Delta Amplitude 21.1



Analyzer Settings

Rohde&Schwarz,ESI
CF: 928.250 MHz
SPAN: 1.500 MHz
RB: 30.0 kHz
VB: 100 kHz
Detector: POS
Attn: 50 DB
RL Offset: 29.2 DB
Sweep Time: 5.0ms
Ref Lvl: 141.2 DBUV

Comments

Cursor 1 927.7709 132.2
Cursor 2 928.0000 97.5

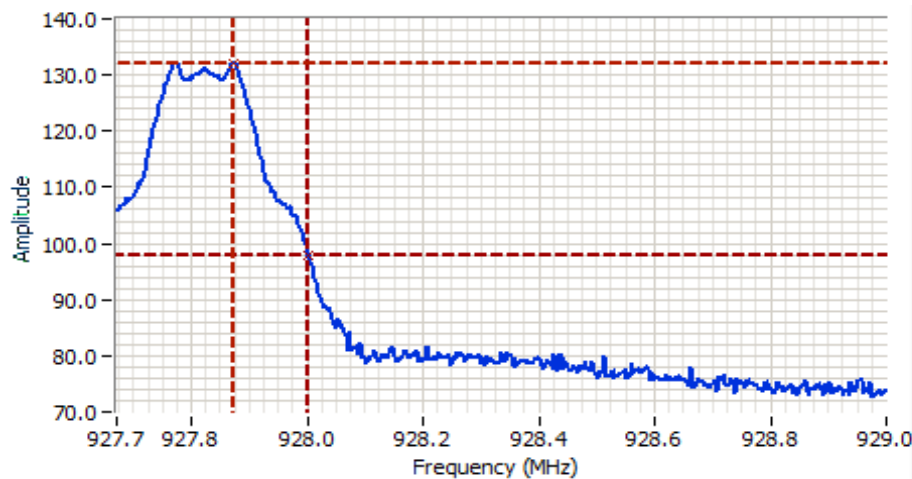
Delta Freq. 229 kHz
Delta Amplitude 34.6





EMC Test Data

Client:	Freewave	Job Number:	PR091113
Model:	FGR3-C-U and FGR3-T-U	T-Log Number:	TL091113-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15.247, RSS-247	Project Coordinator:	David Bare
		Class:	N/A



Analyzer Settings

Rohde&Schwarz,ESI
 CF: 928.336 MHz
 SPAN: 1.329 MHz
 RB: 30.0 kHz
 VB: 100 kHz
 Detector: POS
 Attn: 50 DB
 RL Offset: 29.2 DB
 Sweep Time: 5.0ms
 Ref Lvl: 141.2 DBUV

Comments

Delta Measurement

Cursor 1	927.8734	132.2	
Cursor 2	928.0000	97.9	

Delta Freq. 127 kHz
 Delta Amplitude 34.3



Delta Marker - Peak 34.3 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	97.9	H	112.2	-14.3	PK	354	1.6



EMC Test Data

Client:	Freewave	Job Number:	PR091113
Model:	FGR3-C-U and FGR3-T-U	T-Log Number:	TL091113-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15.247, RSS-247	Project Coordinator:	David Bare
		Class:	N/A

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

Date of Test: 11/20/2018

EUT Setting/ Data Rate: 7, 115.2kbps

Test Engineer: M. Birgani

EUT Power: 26.5 dBm

Test Location: Chamber 3

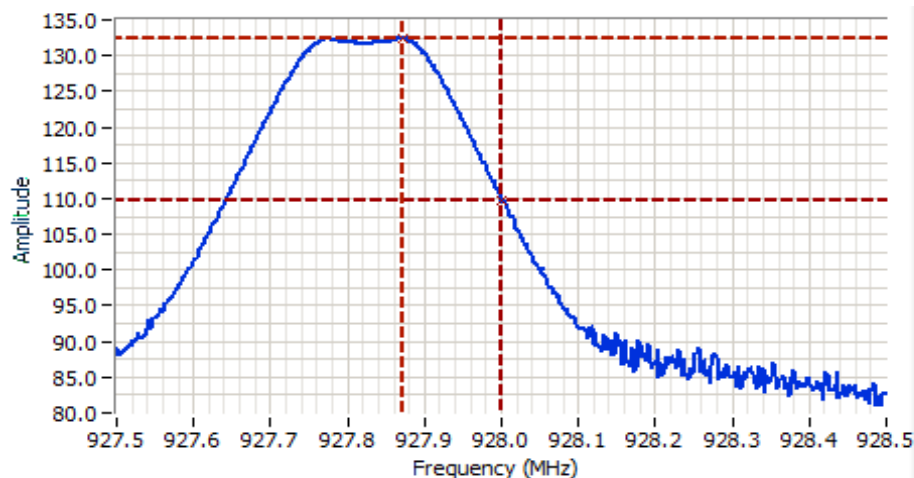
Antenna Gain: Yagi, 8.6dBi

Fundamental Signal Field Strength: Peak value measured in 100kHz

Frequency	Level	Pol	15.2		Detector	Azimuth	Height	Comments
MHz	dB μ V/m	v/h	Limit	Margin	PK/QP/Avg	degrees	meters	
927.869	116.6	V	-	-	PK	59	1.1	100 kHz; VB: 300 kHz
927.871	132.4	H	-	-	PK	0	1.6	100 kHz; VB: 300 kHz

Fundamental emission level @ 3m in 100kHz RBW:	132.4	116.6
Limit for emissions outside of restricted bands:	112.4	dB μ V/m

Limit is -20dBc



Analyzer Settings

Rohde&Schwarz,ESI
CF: 928.000 MHz
SPAN: 1.000 MHz
RB: 100 kHz
VB: 300 kHz
Detector: POS
Attn: 40 DB
RL Offset: 29.2 DB
Sweep Time: 5.0ms
Ref Lvl: 140.2 DBUV

Comments

Bandedge Measurement

Cursor 1	927.8707	132.4
Cursor 2	928.0000	109.7

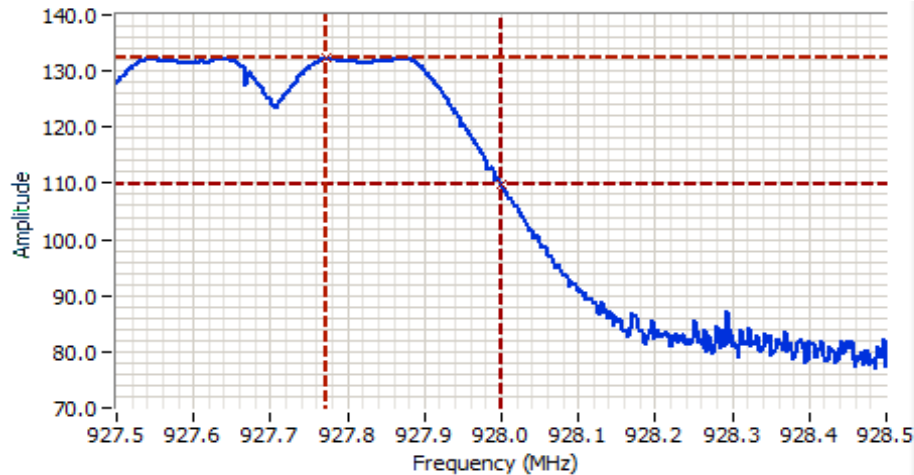
Delta Freq. 129 kHz
Delta Amplitude 22.7





EMC Test Data

Client:	Freewave	Job Number:	PR091113
Model:	FGR3-C-U and FGR3-T-U	T-Log Number:	TL091113-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15.247, RSS-247	Project Coordinator:	David Bare
		Class:	N/A



Analyzer Settings

Rohde&Schwarz,ESI
CF: 928.000 MHz
SPAN: 1.000 MHz
RB: 100 kHz
VB: 300 kHz
Detector: POS
Attn: 40 DB
RL Offset: 29.2 DB
Sweep Time: 5.0ms
Ref Lvl: 140.2 DBUV

Comments

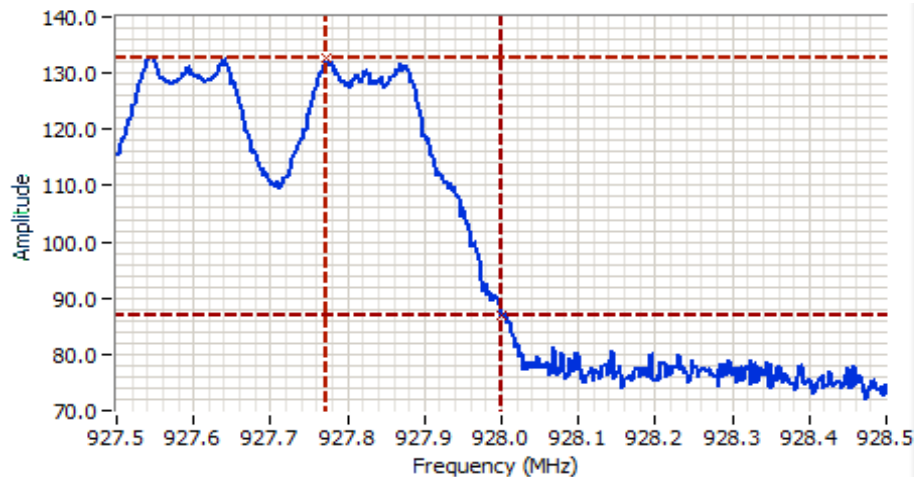
Bandedge Measurement
Hopping

Cursor 1 927.7723 132.2

Cursor 2 928.0000 109.7

Delta Freq. 228 kHz

Delta Amplitude 22.6



Analyzer Settings

Rohde&Schwarz,ESI
CF: 928.000 MHz
SPAN: 1.000 MHz
RB: 30.0 kHz
VB: 100 kHz
Detector: POS
Attn: 40 DB
RL Offset: 29.2 DB
Sweep Time: 5.0ms
Ref Lvl: 140.2 DBUV

Comments

Bandedge Measurement
Hopping

Cursor 1 927.7723 132.8

Cursor 2 928.0000 87.0

Delta Freq. 228 kHz

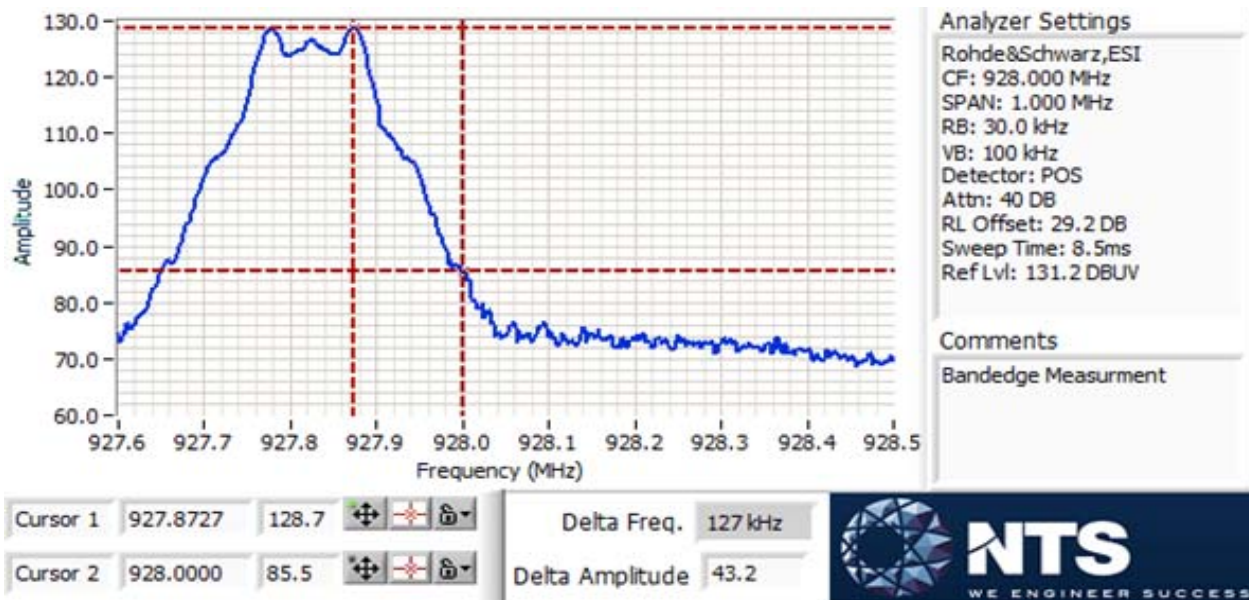
Delta Amplitude 45.7





EMC Test Data

Client:	Freewave	Job Number:	PR091113
Model:	FGR3-C-U and FGR3-T-U	T-Log Number:	TL091113-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15.247, RSS-247	Project Coordinator:	David Bare
		Class:	N/A



Delta Marker - Peak 43.2 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	
928.000	89.2	H	112.4	-23.2	PK	354	1.6	

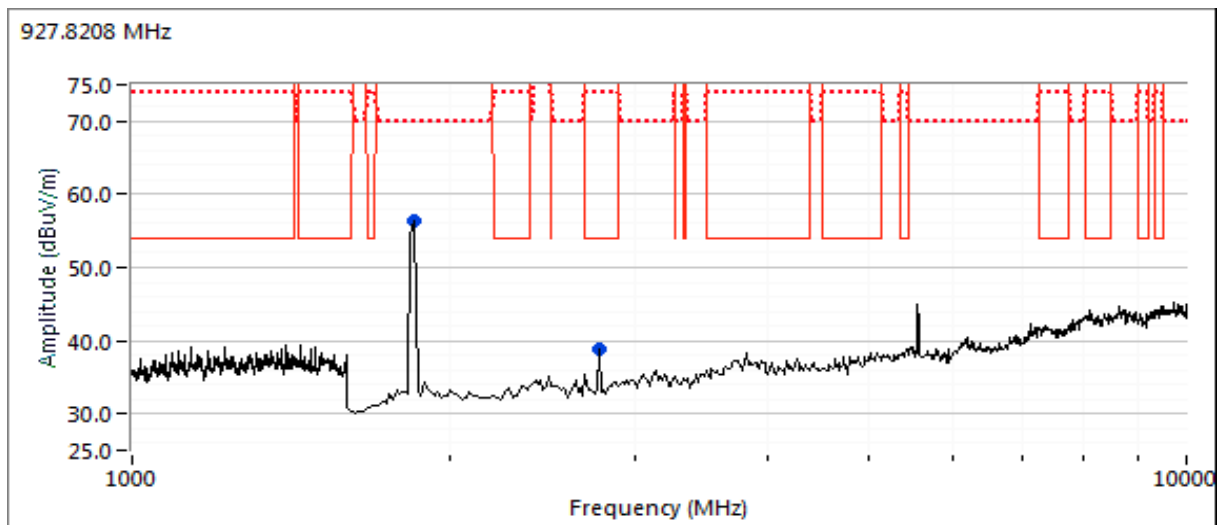
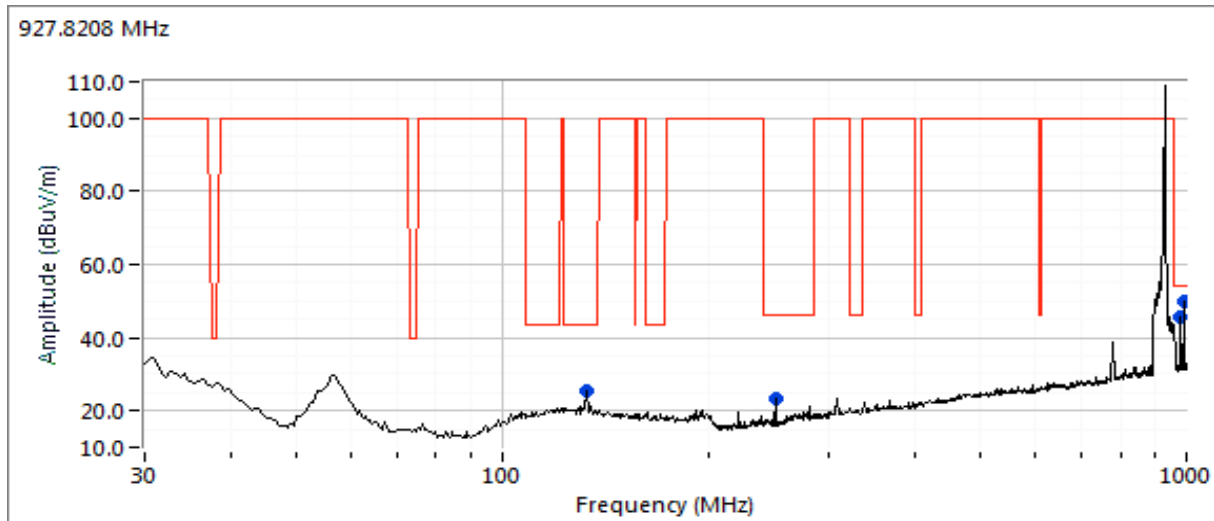
Spurious Emissions

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBμV/m	v/h	Limit	Margin	PK/QP/Avg	degrees	meters	
993.791	36.5	H	54.0	-17.5	QP	353	1.0	QP (1.00s)
250.665	25.2	H	46.0	-20.8	QP	285	1.0	QP (1.00s)
132.744	27.7	H	43.5	-15.8	QP	241	2.5	QP (1.00s)
980.611	45.5	H	54.0	-8.5	QP	0	1.0	QP (1.00s)
2783.480	37.0	H	54.0	-17.0	AVG	360	1.6	RB 1 MHz;VB 10 Hz;Peak
2783.620	44.8	H	74.0	-29.2	PK	360	1.6	RB 1 MHz;VB 3 MHz;Peak
1855.650	57.1	V	112.4	-55.3	PK	278	1.4	RB 1 MHz;VB 3 MHz;Peak



EMC Test Data

Client:	Freewave	Job Number:	PR091113
Model:	FGR3-C-U and FGR3-T-U	T-Log Number:	TL091113-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15.247, RSS-247	Project Coordinator:	David Bare
		Class:	N/A



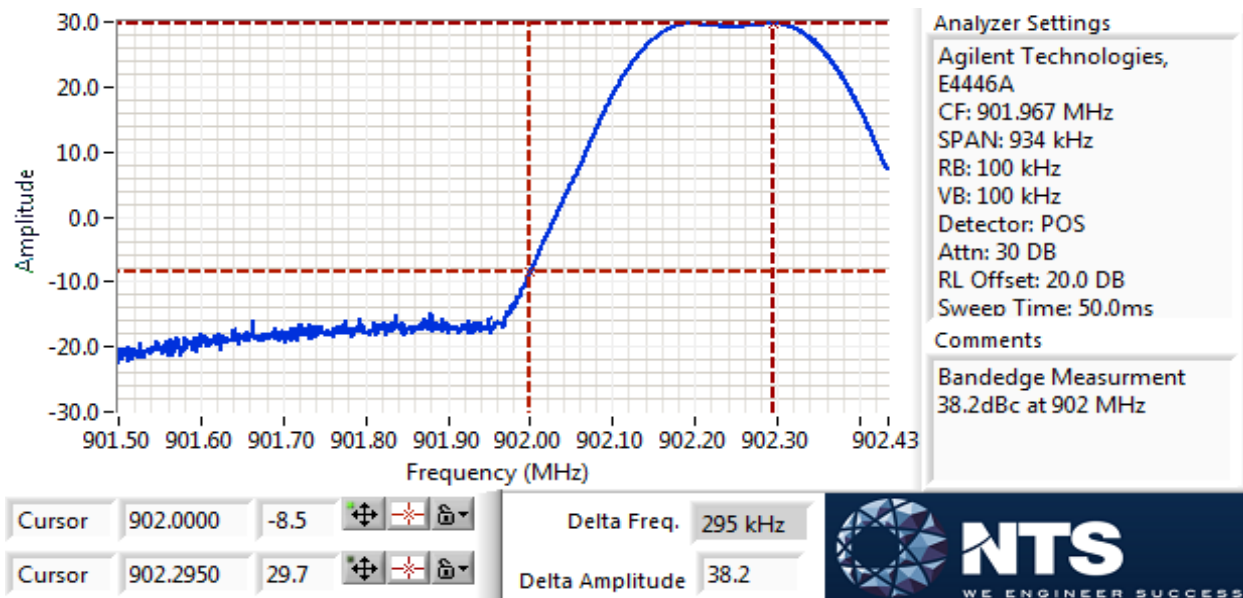


EMC Test Data

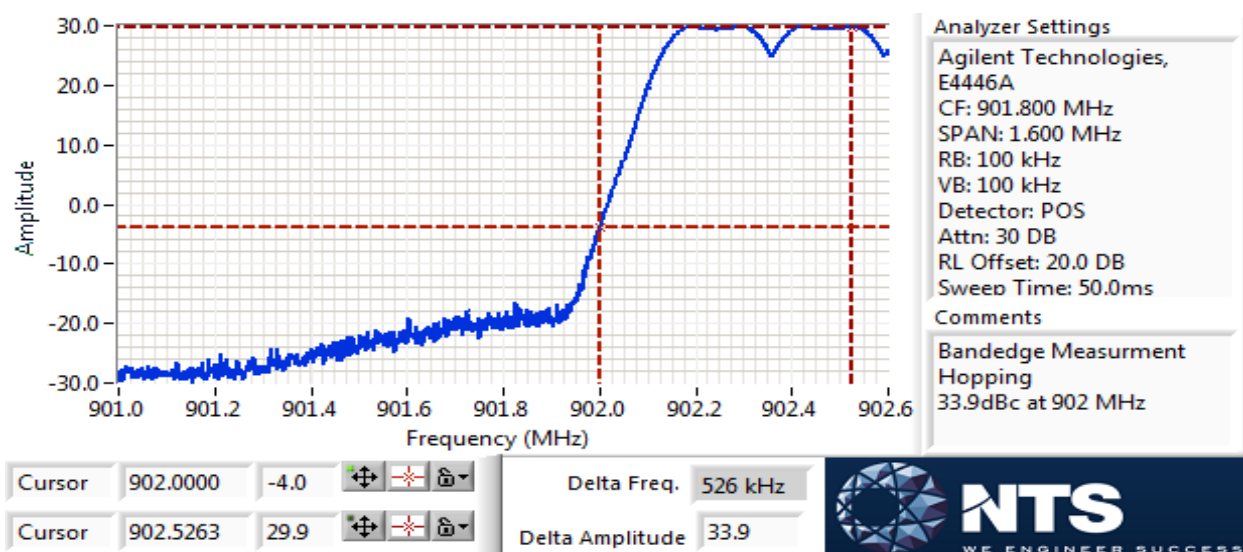
Client:	Freewave	Job Number:	PR091113
Model:	FGR3-C-U and FGR3-T-U	T-Log Number:	TL091113-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15.247, RSS-247	Project Coordinator:	David Bare
		Class:	N/A

Run #3: Antenna Conducted Spurious Emissions, 902 MHz 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.
hopping disabled (115.2 kbps)



hopping enabled (115.2 kbps)

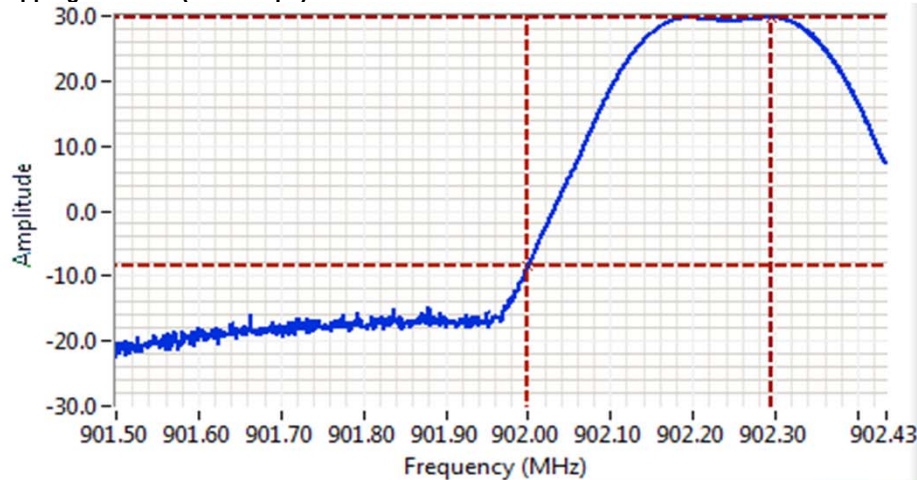




EMC Test Data

Client:	Freewave	Job Number:	PR091113
Model:	FGR3-C-U and FGR3-T-U	T-Log Number:	TL091113-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15.247, RSS-247	Project Coordinator:	David Bare
		Class:	N/A

hopping disabled (153.6 kbps)



Analyzer Settings

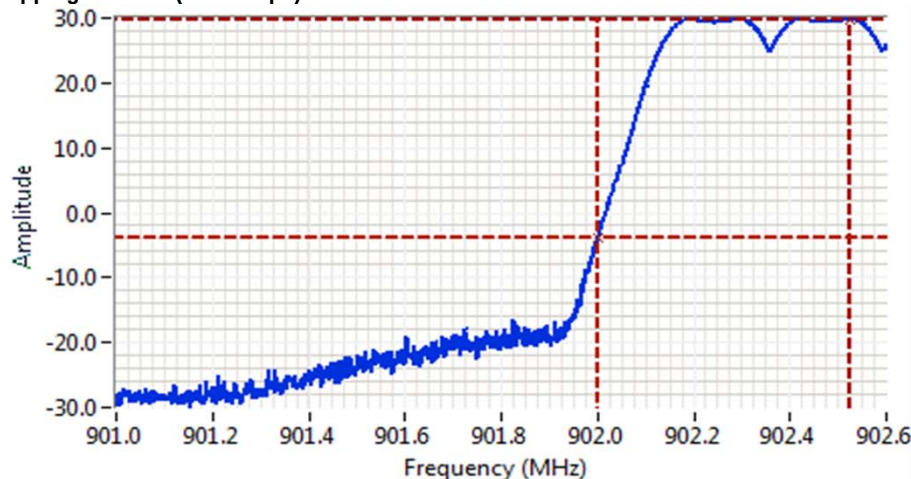
Agilent Technologies,
E4446A
CF: 901.967 MHz
SPAN: 934 kHz
RB: 100 kHz
VB: 100 kHz
Detector: POS
Attn: 30 DB
RL Offset: 20.0 DB
Sweep Time: 50.0ms
Comments
Bandedge Measurement
38.2dBc at 902 MHz
Data Rate: 153.6 kbps

Cursor 902.0000 -8.5
Cursor 902.2950 29.7

Delta Freq. 295 kHz
Delta Amplitude 38.2



hopping enabled (156.3 kbps)



Analyzer Settings

Agilent Technologies,
E4446A
CF: 901.800 MHz
SPAN: 1.600 MHz
RB: 100 kHz
VB: 100 kHz
Detector: POS
Attn: 30 DB
RL Offset: 20.0 DB
Sweep Time: 50.0ms
Comments
Bandedge Measurement
Hopping
33.9dBc at 902 MHz
Data Rate: 153.6 kbps

Cursor 902.0000 -4.0
Cursor 902.5263 29.9

Delta Freq. 526 kHz
Delta Amplitude 33.9





EMC Test Data

Client:	Freewave	Job Number:	PR091113
Model:	FGR3-C-U and FGR3-T-U	T-Log Number:	TL091113-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15.247, RSS-247	Project Coordinator:	David Bare
		Class:	N/A

Run #4: Output Power

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
7	902.2464	26.8	478.6	8.60	Pass	35.4	3.467
7	914.9184	26.7	467.7	8.60	Pass	35.3	3.388
7	927.8208	25.9	389.0	8.60	Pass	34.5	2.818

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
7	902.2464	27.1	512.9	8.60	Pass	35.7	3.715
7	914.9184	26.6	457.1	8.60	Pass	35.2	3.311
7	927.8208	25.9	389.0	8.60	Pass	34.5	2.818

Note 1: Output power measured using a peak power meter



EMC Test Data

Client:	Freewave	Job Number:	PR091113
Model:	FGR3-C-U and FGR3-T-U	T-Log Number:	TL091113-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15.247, RSS-247	Project Coordinator:	David Bare
		Class:	N/A

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

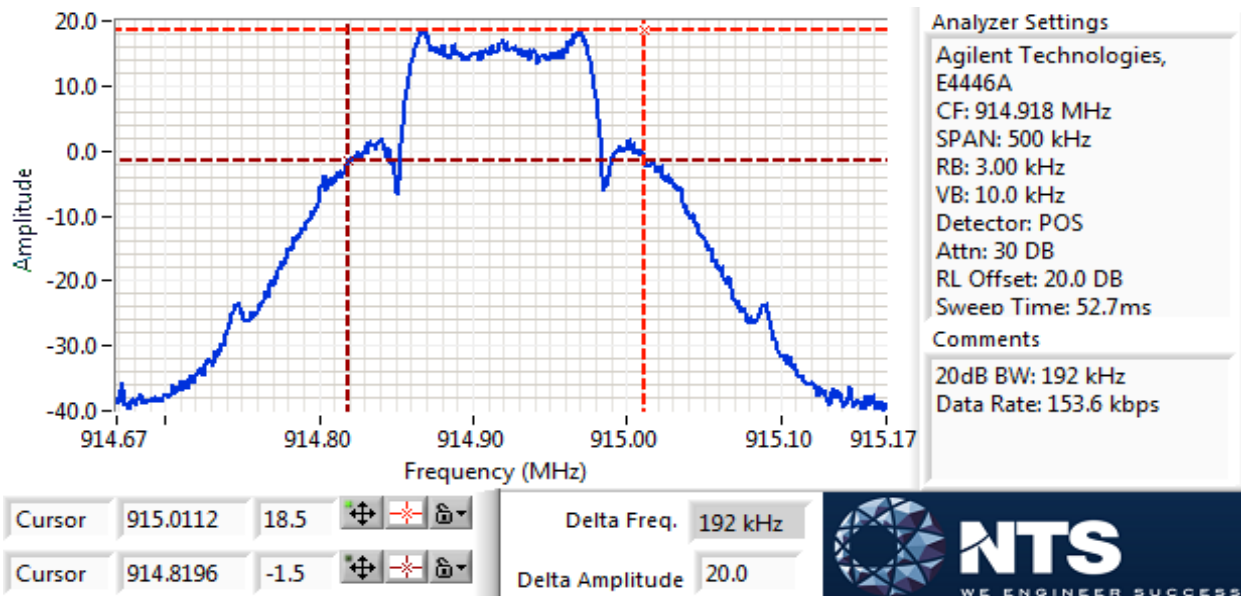
Data Rate: 115.2 kbps

Channel	Frequency (MHz)	Resolution Bandwidth	20dB Bandwidth (kHz)
Low	902.2464	3	185
Mid	914.9184	3	191
High	927.8208	3	185

Data Rate: 153.6 kbps

Channel	Frequency (MHz)	Resolution Bandwidth	20dB Bandwidth (kHz)
Low	902.2464	3	187
Mid	914.9184	3	192
High	927.8208	3	186

Note 1: 20dB bandwidth measured using RB = 3 kHz, VB = 10 kHz (VB > RB)



Note: Necessary Bandwidth calculated using $2.4 * D + R$ from NTIA guidance for FSK modulation where D = Deviation (50 kHz) and R = bitrate. $\therefore$ 224.1 kHz for 115.2 kbps and 235.2 kHz for 156.3 kbps.



EMC Test Data

Client:	Freewave	Job Number:	PR091113
Model:	FGR3-C-U and FGR3-T-U	T-Log Number:	TL091113-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15.247, RSS-247	Project Coordinator:	David Bare
		Class:	N/A

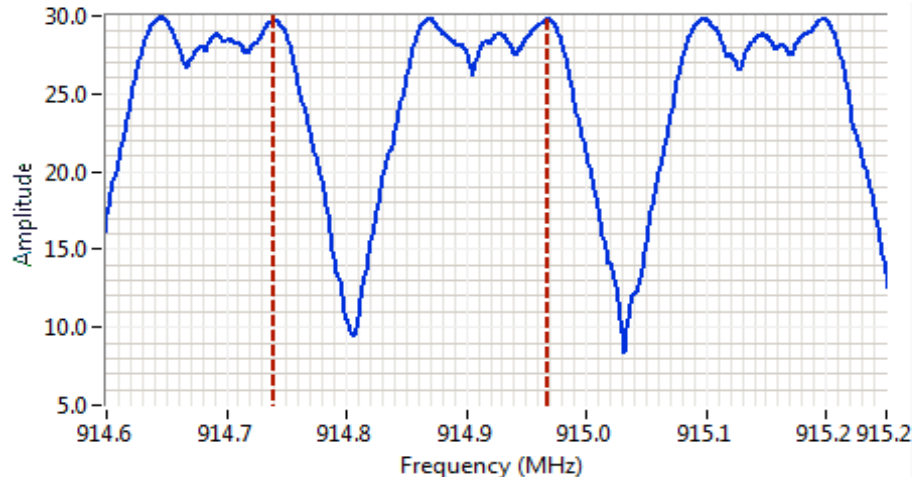
For frequency hopping systems operating in the **902-928 MHz** band:

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:	192 kHz	Pass	
Channel spacing:	228 kHz	Pass	Note 1
Transmission time per hop:	10.44 ms		
The time between successive hops on a channel:	1869 ms		
Number of channels (N):	110	Pass	
Channel dwell time in 20 seconds:	114.84 ms	Pass	

Note 1: Channel spacing was measured at both rates and showed both have same channel spacing.



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: 20.0 DB
Sweep Time: 1.1ms
Comments
Channel Spacing: 228 kHz

Cursor	914.7394	35.0	↕	↔	⏏
Cursor	914.9678	0.0	↕	↔	⏏

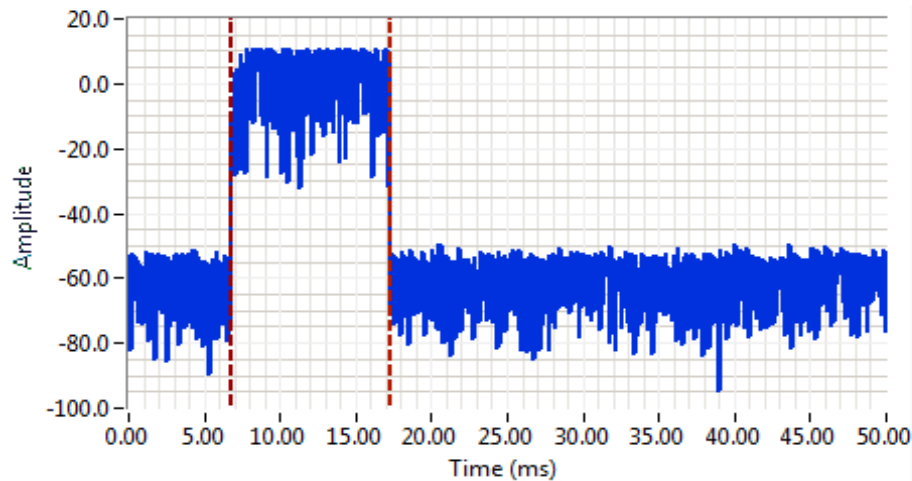
Delta Freq. 228 kHz
Delta Amplitude 35.0





EMC Test Data

Client:	Freewave	Job Number:	PR091113
Model:	FGR3-C-U and FGR3-T-U	T-Log Number:	TL091113-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15.247, RSS-247	Project Coordinator:	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: Normal

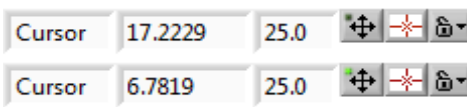
Attn: 30 DB

RL Offset: 20.0 DB

Sweep Time: 100.0ms

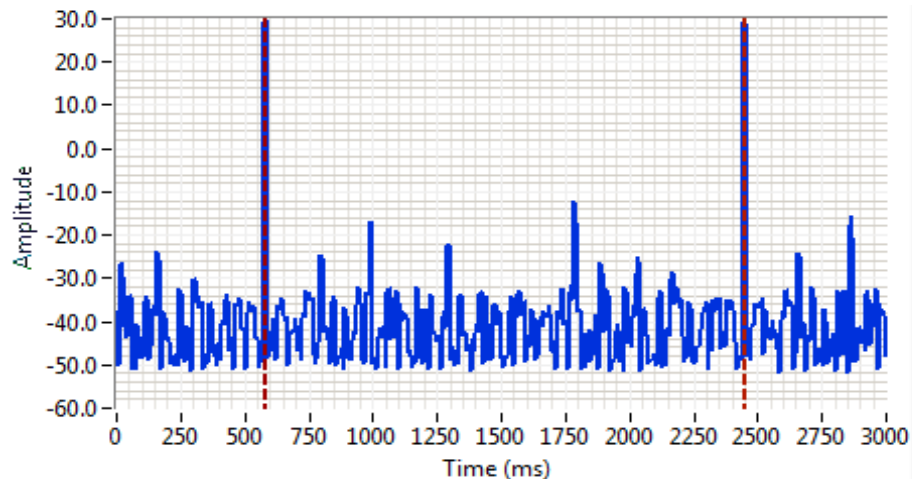
Comments

Transmission time/hop
10.44ms



Delta Time (ms) 10.44

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

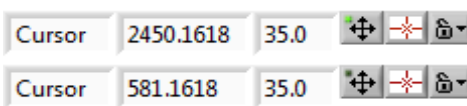
Attn: 30 DB

RL Offset: 20.0 DB

Sweep Time: 5.0s

Comments

Time between successive
hops on a channel:
1869.0ms



Delta Time (ms) 1869.0

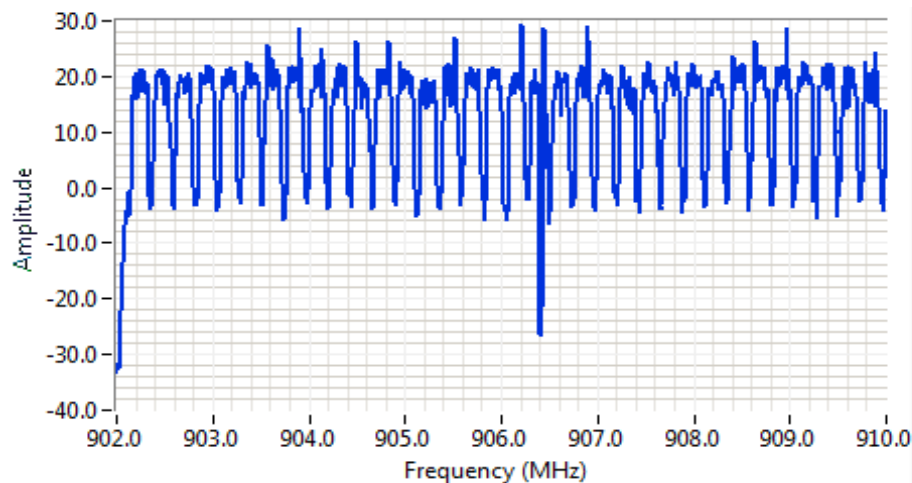
Delta Amplitude 0.0





EMC Test Data

Client:	Freewave	Job Number:	PR091113
Model:	FGR3-C-U and FGR3-T-U	T-Log Number:	TL091113-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15.247, RSS-247	Project Coordinator:	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

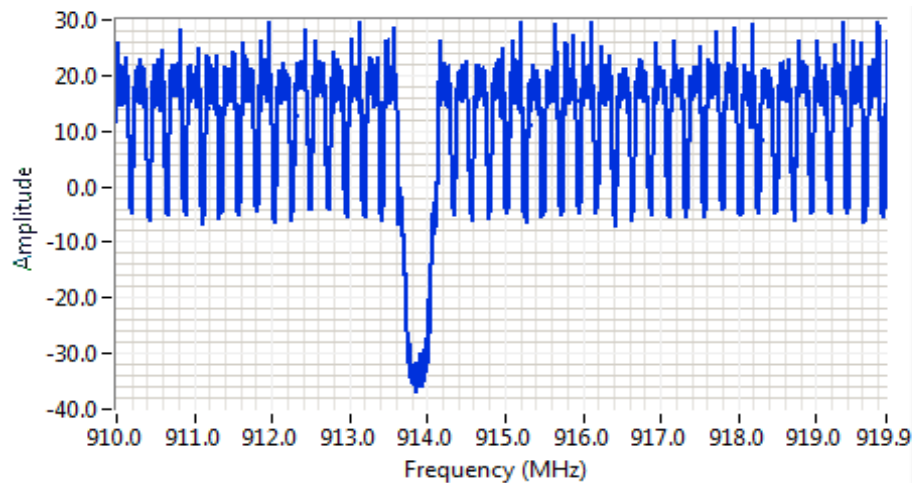
Attn: 30 DB

RL Offset: 20.0 DB

Sweep Time: 0.8s

Comments

Number of Channels
902-910MHz = 34



Analyzer Settings

Agilent Technologies,
E4446A

CF: 915.000 MHz

SPAN: 10.000 MHz

RB: 3.00 kHz

VB: 10.0 kHz

Detector: POS

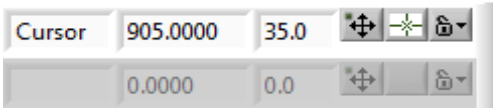
Attn: 30 DB

RL Offset: 20.0 DB

Sweep Time: 1.1s

Comments

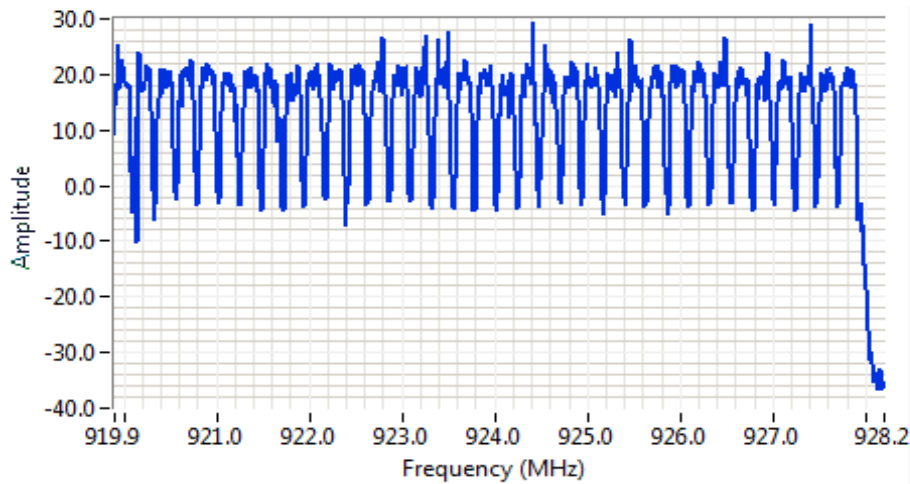
Number of Channels
910-919.9MHz = 41





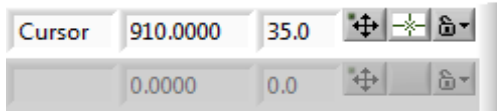
EMC Test Data

Client:	Freewave	Job Number:	PR091113
Model:	FGR3-C-U and FGR3-T-U	T-Log Number:	TL091113-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15.247, RSS-247	Project Coordinator:	David Bare
		Class:	N/A



Analyzer Settings
Agilent Technologies,
E4446A
CF: 924.050 MHz
SPAN: 8.300 MHz
RB: 3.00 kHz
VB: 10.0 kHz
Detector: POS
Attn: 30 DB
RL Offset: 20.0 DB
Sweep Time: 0.9s

Comments
Number of Channels
919.9-928.2MHz = 35





EMC Test Data

Client:	Freewave	Job Number:	PR091113
Model:	FGR3-C-U and FGR3-T-U	T-Log Number:	TL091113-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15.247, RSS-247	Project Coordinator:	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: 42-44 %

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	87.1 dBμV/m @ 928.00 MHz (Margin: -21.0 dB)
4	Output Power	15.247(b)	Pass	30.0 dBm (1 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.

Use ANSI C63.10 section 7.8 for test methods



EMC Test Data

Client:	Freewave	Job Number:	PR091113
Model:	FGR3-C-U and FGR3-T-U	T-Log Number:	TL091113-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15.247, RSS-247	Project Coordinator:	David Bare
		Class:	N/A

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

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

Date of Test: 11/20/2018

EUT Setting/ Data Rate: 10, 153.6kbps

Test Engineer: M. Birgani

EUT Power: 29.9 dBm

Test Location: Chamber 3

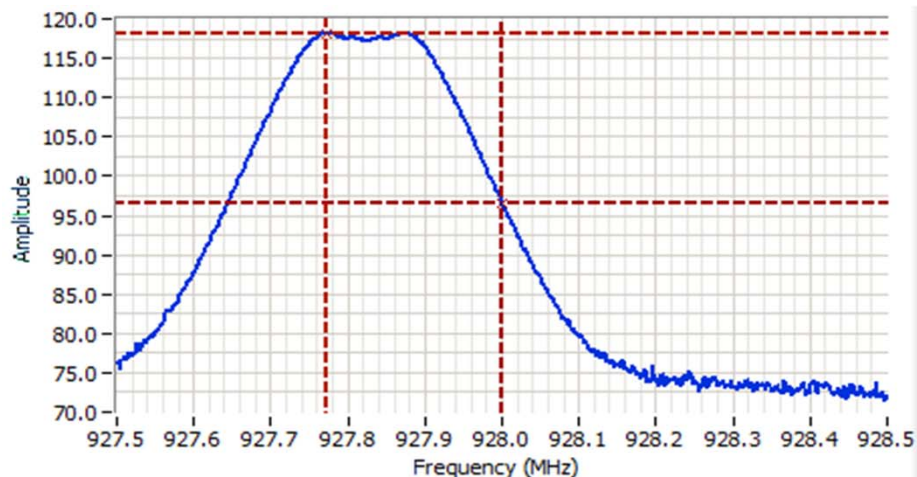
Antenna Gain: Omni 3dBi

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	
927.773	128.1	V	-	-	PK	240	1.0	100 kHz; VB: 300 kHz
927.773	117.2	H	-	-	PK	62	1.7	100 kHz; VB: 300 kHz

Fundamental emission level @ 3m in 100kHz RBW: 117.2 128.1

Limit for emissions outside of restricted bands: 108.1 dB μ V/m **Limit is -20dBc**



Analyzer Settings

Rohde&Schwarz,ESI
CF: 928.000 MHz
SPAN: 1.000 MHz
RB: 100 kHz
VB: 300 kHz
Detector: POS
Attn: 50 DB
RL Offset: 29.2 DB
Ref Lvl: 130.2 DBUV

Comments

Bandedge Measurement

Cursor 1	927.7725	128.1	+	-	↺
Cursor 2	928.0000	106.7	+	-	↺

Delta Freq. 227 kHz

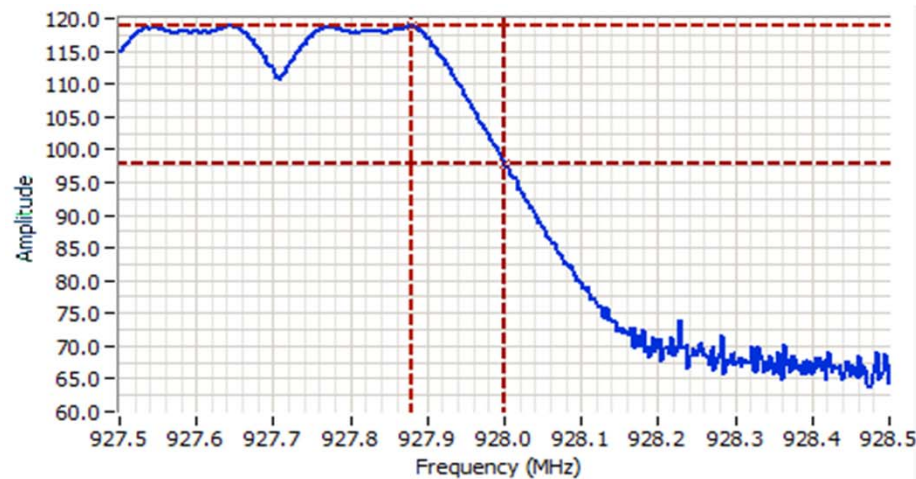
Delta Amplitude 21.5





EMC Test Data

Client:	Freewave	Job Number:	PR091113
Model:	FGR3-C-U and FGR3-T-U	T-Log Number:	TL091113-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15.247, RSS-247	Project Coordinator:	David Bare
		Class:	N/A



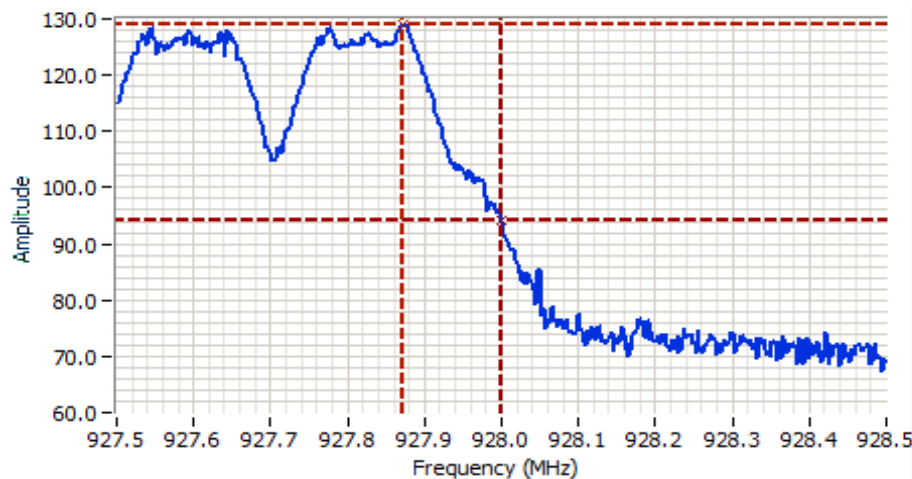
Analyzer Settings

Rohde&Schwarz,ESI
CF: 928.000 MHz
SPAN: 1.000 MHz
RB: 100 kHz
VB: 300 kHz
Detector: POS
Attn: 40 DB
RL Offset: 29.2 DB
Sweep Time: 5.0ms
Ref Lvl: 130.2 DBUV

Comments

Bandedge Measurement
Hopping

Cursor 927.8796 128.9
Cursor 928.0000 108.0
Delta Freq. 120 kHz
Delta Amplitude 20.9



Analyzer Settings

Rohde&Schwarz,ESI
CF: 928.000 MHz
SPAN: 1.000 MHz
RB: 30.0 kHz
VB: 100 kHz
Detector: POS
Attn: 40 DB
RL Offset: 29.2 DB
Sweep Time: 5.0ms
Ref Lvl: 131.2 DBUV

Comments

Bandedge Measurement
Hopping

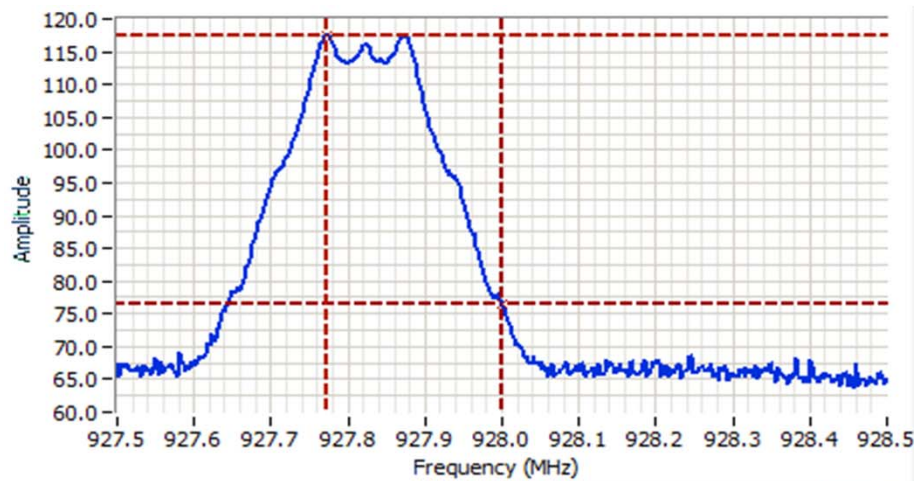
Cursor 1 927.8727 128.9
Cursor 2 928.0010 94.1
Delta Freq. 128 kHz
Delta Amplitude 34.8





EMC Test Data

Client:	Freewave	Job Number:	PR091113
Model:	FGR3-C-U and FGR3-T-U	T-Log Number:	TL091113-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15.247, RSS-247	Project Coordinator:	David Bare
		Class:	N/A



Analyzer Settings

Rohde&Schwarz, ESI
 CF: 928.000 MHz
 SPAN: 1.000 MHz
 RB: 30.0 kHz
 VB: 100 kHz
 Detector: POS
 Attn: 50 DB
 RL Offset: 29.2 DB
 Sweep Time: 5.0ms
 Ref Lvl: 130.2 DBUV

Comments

Bandedge Measurement

Cursor	927.7725	127.5	
Cursor	928.0000	86.5	

Delta Freq. 227 kHz

Delta Amplitude 41.0



Delta Marker - Peak 41.0 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	87.1	H	108.1	-21.0	PK	354	1.6



EMC Test Data

Client:	Freewave	Job Number:	PR091113
Model:	FGR3-C-U and FGR3-T-U	T-Log Number:	TL091113-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15.247, RSS-247	Project Coordinator:	David Bare
		Class:	N/A

Run #1b: Radiated Spurious Emissions, 30 - 1000 MHz. High Channel @ 927.8208 MHz

Date of Test: 11/20/2018

EUT Setting/ Data Rate: 10, 115.2kbps

Test Engineer: M. Birgani

EUT Power: 29.9 dBm

Test Location: Chamber 3

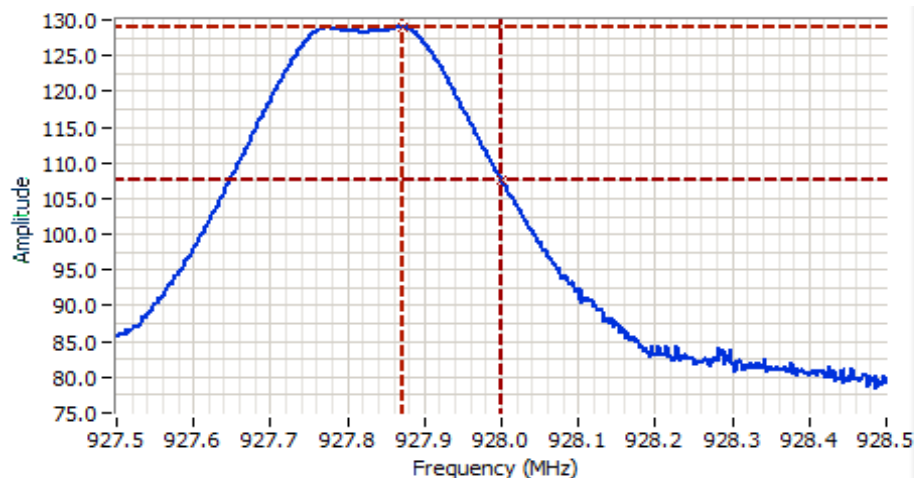
Antenna Gain: Omni 3dBi

Fundamental Signal Field Strength: Peak value measured in 100kHz

Frequency	Level	Pol	15.2		Detector	Azimuth	Height	Comments
MHz	dB μ V/m	v/h	Limit	Margin	PK/QP/Avg	degrees	meters	
927.865	129.1	V	-	-	PK	254	1.0	100 kHz; VB: 300 kHz
927.776	115.6	H	-	-	PK	62	1.7	100 kHz; VB: 300 kHz

Fundamental emission level @ 3m in 100kHz RBW:	129.1	115.6
Limit for emissions outside of restricted bands:	109.1	dB μ V/m

Limit is -20dBc



Analyzer Settings

Rohde&Schwarz,ESI
 CF: 928.000 MHz
 SPAN: 1.000 MHz
 RB: 100 kHz
 VB: 300 kHz
 Detector: POS
 Attn: 40 DB
 RL Offset: 29.2 DB
 Sweep Time: 5.0ms
 Ref Lvl: 131.2 DBUV

Comments

Bandedge Measurement

Cursor 1	927.8707	129.1	
Cursor 2	928.0000	107.5	

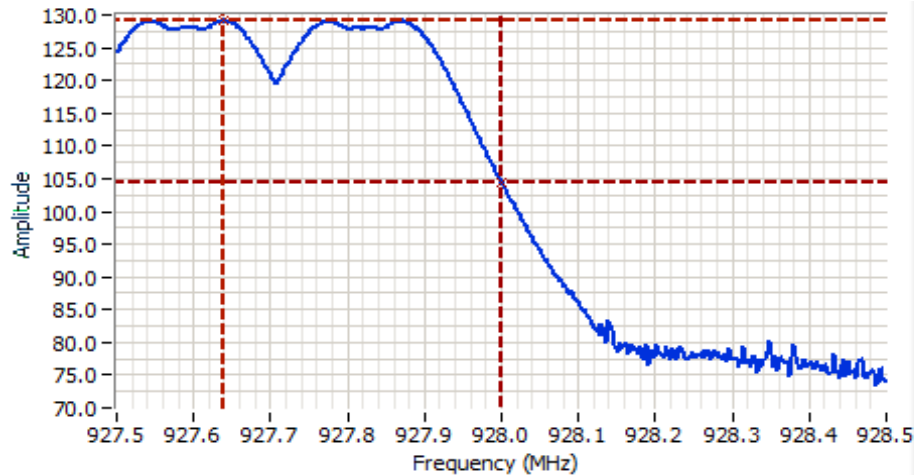
Delta Freq. 129 kHz
 Delta Amplitude 21.6





EMC Test Data

Client:	Freewave	Job Number:	PR091113
Model:	FGR3-C-U and FGR3-T-U	T-Log Number:	TL091113-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15.247, RSS-247	Project Coordinator:	David Bare
		Class:	N/A



Analyzer Settings

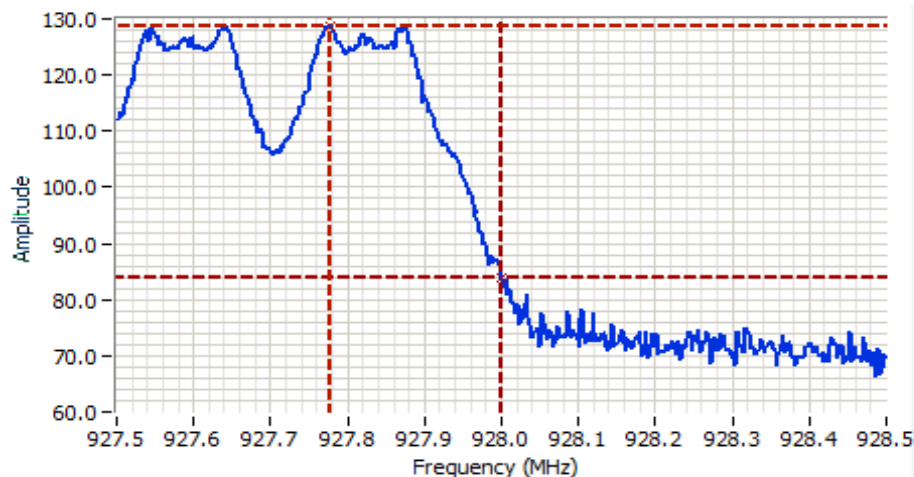
Rohde&Schwarz,ESI
CF: 928.000 MHz
SPAN: 1.000 MHz
RB: 100 kHz
VB: 300 kHz
Detector: POS
Attn: 40 DB
RL Offset: 29.2 DB
Sweep Time: 5.0ms
Ref Lvl: 131.2 DBUV

Comments

Bandedge Measurement
Hopping

Cursor 1 927.6383 129.0
Cursor 2 928.0010 104.3

Delta Freq. 363 kHz
Delta Amplitude 24.7



Analyzer Settings

Rohde&Schwarz,ESI
CF: 928.000 MHz
SPAN: 1.000 MHz
RB: 30.0 kHz
VB: 100 kHz
Detector: POS
Attn: 40 DB
RL Offset: 29.2 DB
Sweep Time: 5.0ms
Ref Lvl: 131.2 DBUV

Comments

Bandedge Measurement
Hopping

Cursor 1 927.7766 128.8
Cursor 2 928.0000 83.9

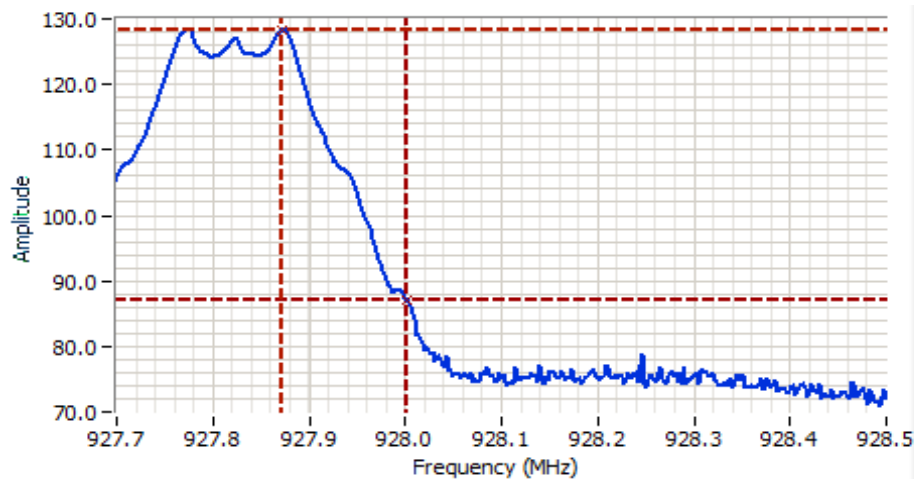
Delta Freq. 223 kHz
Delta Amplitude 44.9





EMC Test Data

Client:	Freewave	Job Number:	PR091113
Model:	FGR3-C-U and FGR3-T-U	T-Log Number:	TL091113-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15.247, RSS-247	Project Coordinator:	David Bare
		Class:	N/A



Analyzer Settings

Rohde&Schwarz,ESI
 CF: 928.000 MHz
 SPAN: 1.000 MHz
 RB: 30.0 kHz
 VB: 100 kHz
 Detector: POS
 Attn: 40 DB
 RL Offset: 29.2 DB
 Sweep Time: 5.0ms
 Ref Lvl: 131.2 DBUV

Comments

Bandedge Measurement

Cursor 1	927.8727	128.4	
Cursor 2	928.0010	87.2	

Delta Freq. 128 kHz
 Delta Amplitude 41.2



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	
928.000	87.9	H	109.1	-21.2	PK	354	1.6	



EMC Test Data

Client:	Freewave	Job Number:	PR091113
Model:	FGR3-C-U and FGR3-T-U	T-Log Number:	TL091113-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15.247, RSS-247	Project Coordinator:	David Bare
		Class:	N/A

Run #4: Output Power

Date of Test: 12/4/2018

Test Engineer: M. Birgani

Test Location: Chamber 2

Config. Used: 1

Config Change: -

EUT Voltage: 120V/ 60Hz

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

Modulation: 115.2 kbps

Power Setting	Frequency (MHz)	Output Power		Antenna Gain (dBi)	Result	EIRP	
		(dBm) ¹	mW			dBm	W
10	902.2464	30.0	1000.0	3.00	Pass	33.0	1.995
10	914.9184	30.0	1000.0	3.00	Pass	33.0	1.995
10	927.8208	29.6	912.0	3.00	Pass	32.6	1.820

Note 1: Output power measured using a peak power meter

Modulation: 153.6 kbps

Power Setting	Frequency (MHz)	Output Power		Antenna Gain (dBi)	Result	EIRP	
		(dBm) ¹	mW			dBm	W
10	902.2464	30.0	1000.0	3.00	Pass	33.0	1.995
10	914.9184	30.0	1000.0	3.00	Pass	33.0	1.995
10	927.8208	29.6	912.0	3.00	Pass	32.6	1.820

Note 1: Output power measured using a peak power meter



EMC Test Data

Client:	Freewave	Job Number:	PR091113
Model:	FGR3-C-U and FGR3-T-U	T-Log Number:	TL091113-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15.247, RSS-247	Project Coordinator:	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: 42-44 %

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	95.2 dBμV/m @ 928.00 MHz (Margin: -14.6 dB)
4	Output Power	15.247(b)	Pass	27.7 dBm (0.589 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.

Use ANSI C63.10 section 7.8 for test methods



EMC Test Data

Client:	Freewave	Job Number:	PR091113
Model:	FGR3-C-U and FGR3-T-U	T-Log Number:	TL091113-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15.247, RSS-247	Project Coordinator:	David Bare
		Class:	N/A

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

Date of Test: 11/28/18 to 12/3/2018
 Test Engineer: M. Birgani
 Test Location: Chamber 5

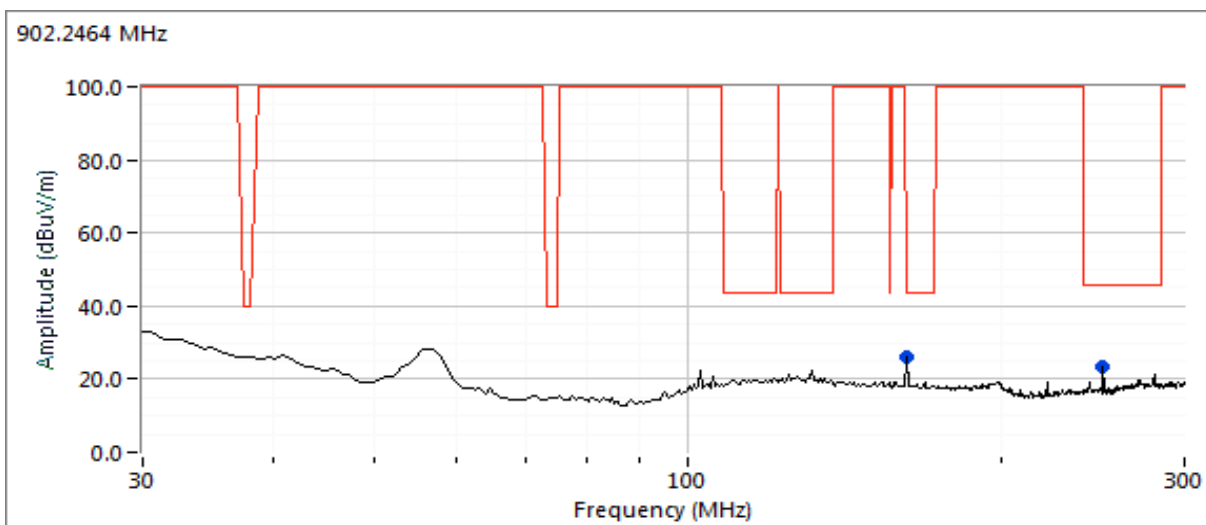
Config. Used: 1
 Config Change: -
 EUT Voltage: 120V/ 60Hz

Run #1a: Radiated Spurious Emissions, 30 - 10,000 MHz. Low Channel @ 902.2464 MHz

Fundamental Signal Field Strength: 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
902.247	130.0	V	-	-	PK	248	1.0
POS; RB 100 kHz; VB: 300 kHz							

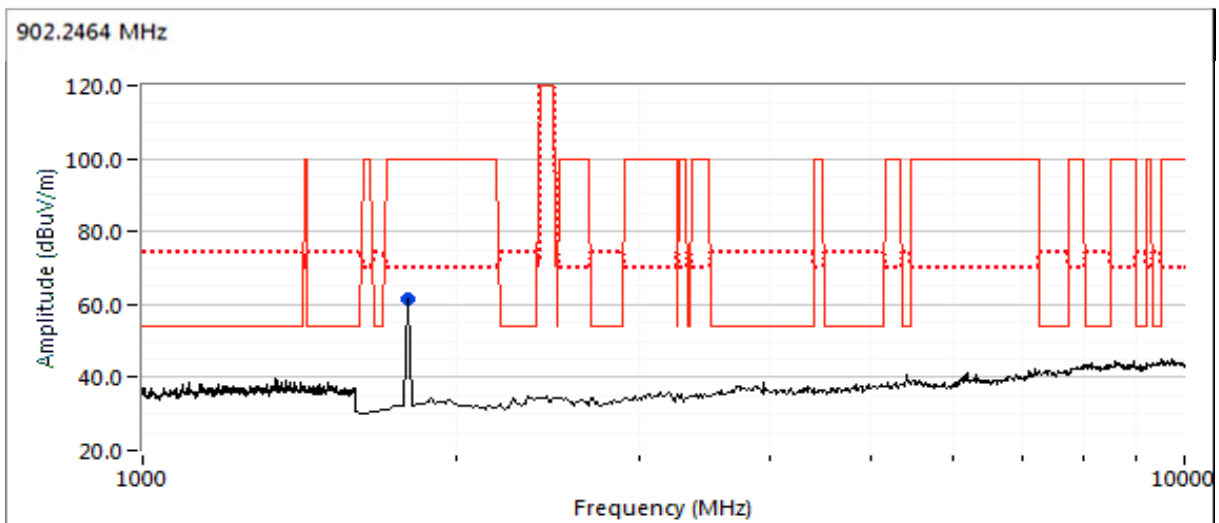
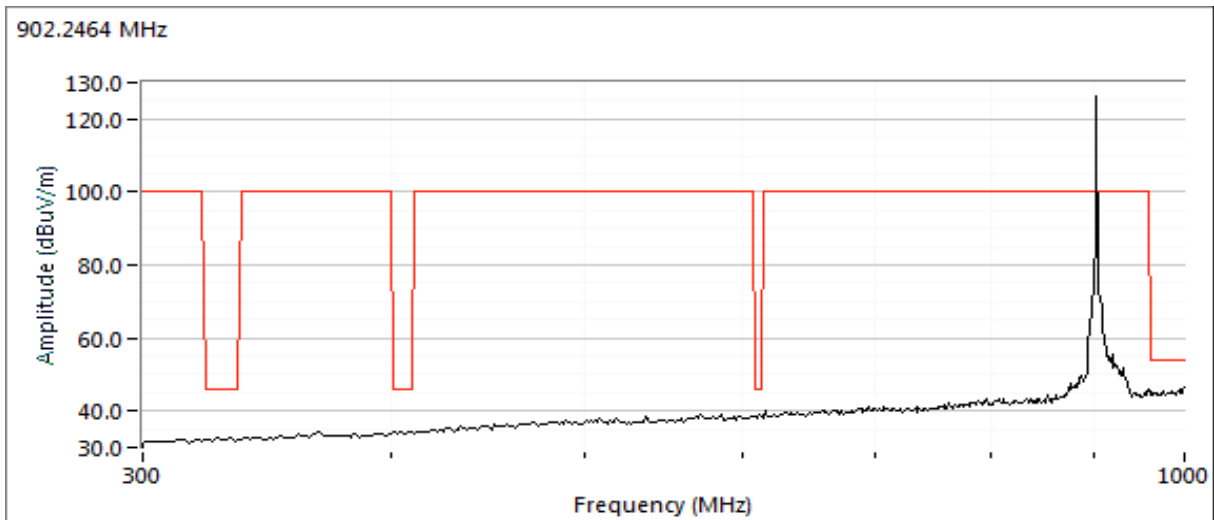
	H	V
Fundamental emission level @ 3m in 100kHz RBW:		130.0
Limit for emissions outside of restricted bands:	110.0 dB μ V/m	Limit is -20dBc





EMC Test Data

Client:	Freewave	Job Number:	PR091113
Model:	FGR3-C-U and FGR3-T-U	T-Log Number:	TL091113-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15.247, RSS-247	Project Coordinator:	David Bare
		Class:	N/A



Spurious Emissions

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBuV/m	v/h	Limit	Margin	PK/QP/Avg	degrees	meters	
162.276	24.9	H	43.5	-18.6	QP	151	1.5	QP (1.00s)
250.843	21.7	H	46.0	-24.3	QP	251	1.0	QP (1.00s)
1804.440	62.1	V	110.0	-47.9	PK	197	2.5	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.



EMC Test Data

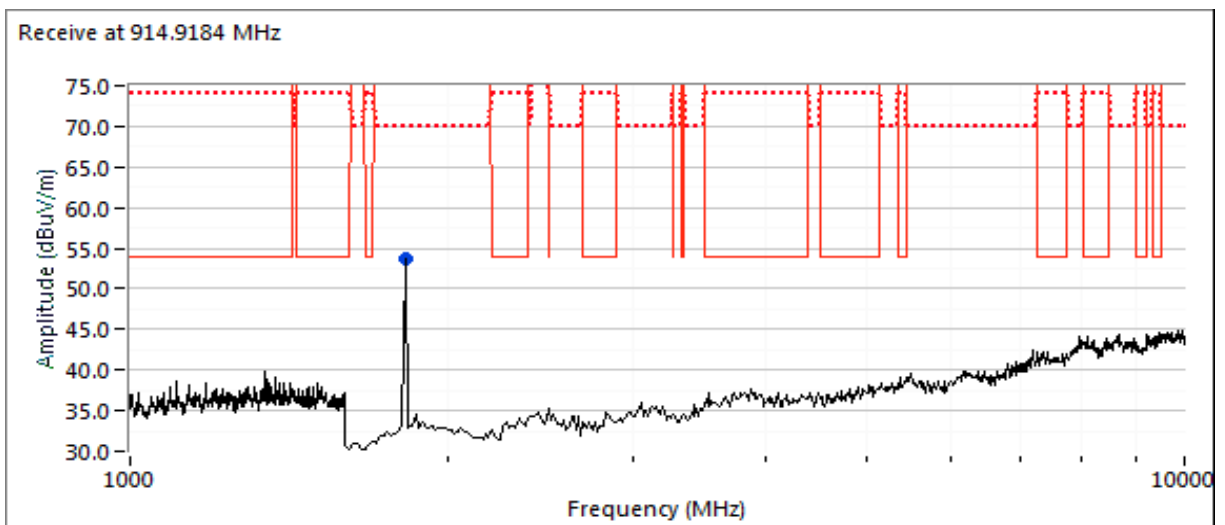
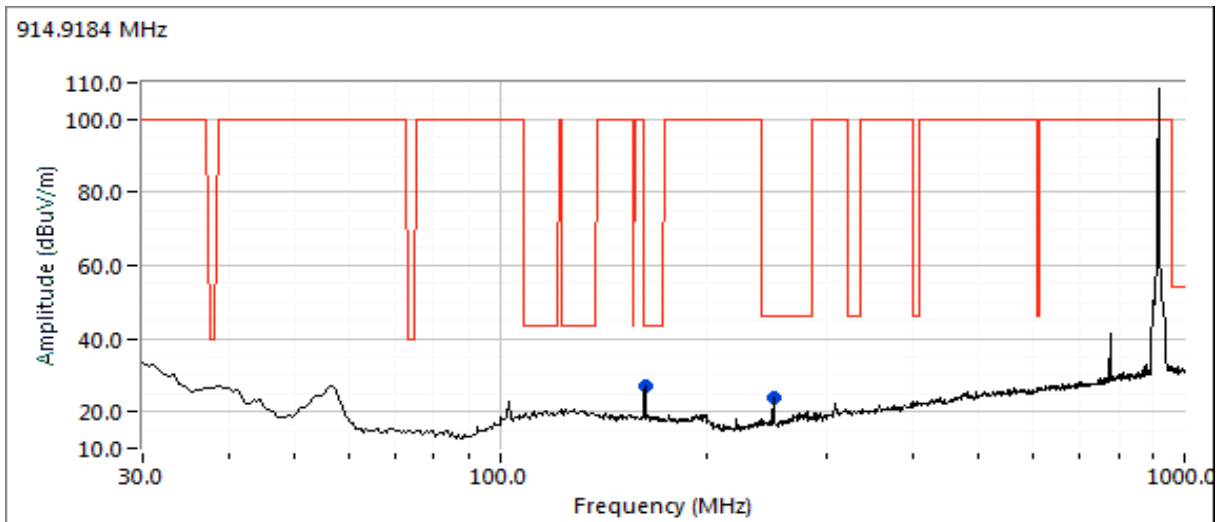
Client:	Freewave	Job Number:	PR091113
Model:	FGR3-C-U and FGR3-T-U	T-Log Number:	TL091113-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15.247, RSS-247	Project Coordinator:	David Bare
		Class:	N/A

Run #1b: Radiated Spurious Emissions, 30 - 10,000 MHz. Center Channel @ 914.9184 MHz

Fundamental Signal Field Strength: 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
914.918	130.0	V	-	-	PK	248	1.0

Fundamental emission level @ 3m in 100kHz RBW:	130.0
Limit for emissions outside of restricted bands:	110.0 dB μ V/m





EMC Test Data

Client:	Freewave	Job Number:	PR091113
Model:	FGR3-C-U and FGR3-T-U	T-Log Number:	TL091113-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15.247, RSS-247	Project Coordinator:	David Bare
		Class:	N/A

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	
162.224	27.6	H	43.5	-15.9	QP	139	1.5	QP (1.00s)
250.681	26.4	H	46.0	-19.6	QP	71	1.5	QP (1.00s)
1829.770	56.0	V	110.0	-54.0	PK	215	2.5	RB 1 MHz;VB 3 MHz;Peak



EMC Test Data

Client:	Freewave	Job Number:	PR091113
Model:	FGR3-C-U and FGR3-T-U	T-Log Number:	TL091113-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15.247, RSS-247	Project Coordinator:	David Bare
		Class:	N/A

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

Date of Test: 11/20/2018

EUT Setting/ Data Rate: 8, 153.6kbps

Test Engineer: M. Birgani

EUT Power: 27.7 dBm

Test Location: Chamber 3

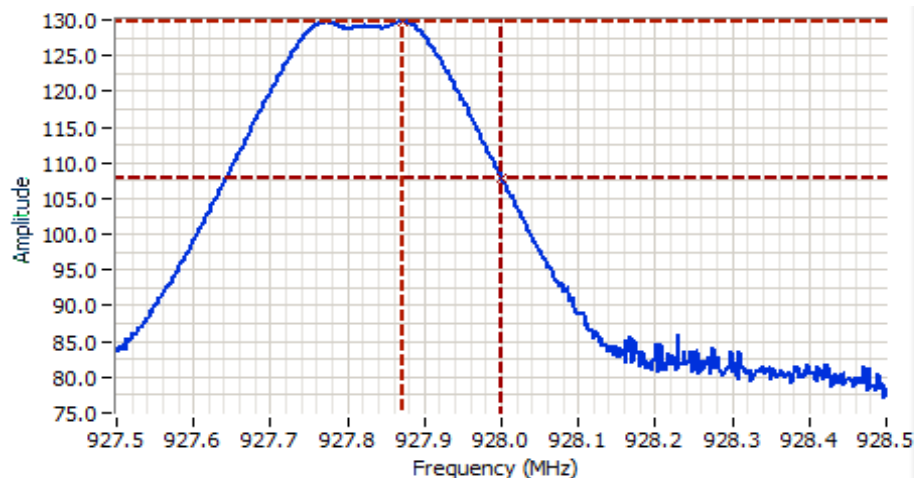
Antenna Gain: Omni 8.15dBi

Fundamental Signal Field Strength: Peak value measured in 100kHz

Frequency	Level	Pol	15.2		Detector	Azimuth	Height	Comments
MHz	dBμV/m	v/h	Limit	Margin	PK/QP/Avg	degrees	meters	
927.767	129.8	V	-	-	PK	248	1.0	POS; RB 100 kHz; VB: 300 kHz
927.777	114.4	H	-	-	PK	138	1.1	POS; RB 100 kHz; VB: 300 kHz

Fundamental emission level @ 3m in 100kHz RBW:	129.8	114.4
Limit for emissions outside of restricted bands:	109.8	dBμV/m

Limit is -20dBc



Analyzer Settings

Rohde&Schwarz,ESI
CF: 928.000 MHz
SPAN: 1.000 MHz
RB: 100 kHz
VB: 100 kHz
Detector: POS
Attn: 40 DB
RL Offset: 29.2 DB
Sweep Time: 5.0ms
Ref Lvl: 131.2 DBUV

Comments

Bandedge Measurement

Cursor 1	927.8707	129.8
Cursor 2	928.0000	107.9

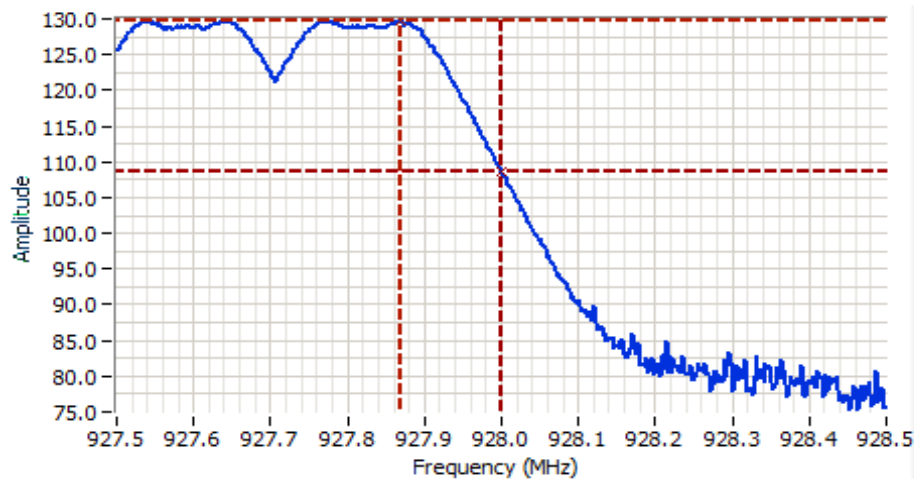
Delta Freq. 129 kHz
Delta Amplitude 21.9





EMC Test Data

Client:	Freewave	Job Number:	PR091113
Model:	FGR3-C-U and FGR3-T-U	T-Log Number:	TL091113-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15.247, RSS-247	Project Coordinator:	David Bare
		Class:	N/A



Analyzer Settings

Rohde&Schwarz,ESI
CF: 928.000 MHz
SPAN: 1.000 MHz
RB: 100 kHz
VB: 300 kHz
Detector: POS
Attn: 40 DB
RL Offset: 29.2 DB
Sweep Time: 5.0ms
Ref Lvl: 131.2 DBUV

Comments

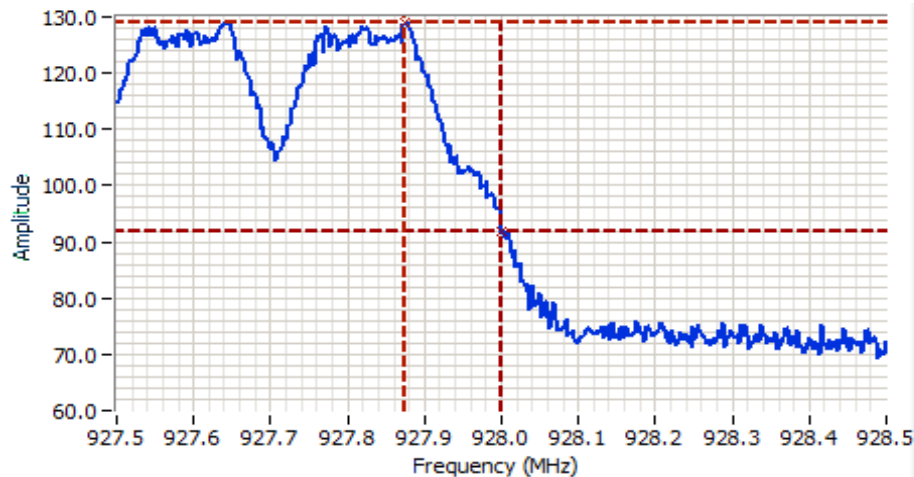
Bandedge Measurement
Hopping

Cursor 1 927.8687 129.6

Cursor 2 928.0000 108.7

Delta Freq. 131 kHz

Delta Amplitude 20.9



Analyzer Settings

Rohde&Schwarz,ESI
CF: 928.000 MHz
SPAN: 1.000 MHz
RB: 30.0 kHz
VB: 100 kHz
Detector: POS
Attn: 40 DB
RL Offset: 29.2 DB
Sweep Time: 5.0ms
Ref Lvl: 131.2 DBUV

Comments

Bandedge Measurement
Hopping

Cursor 1 927.8743 129.1

Cursor 2 928.0000 91.9

Delta Freq. 126 kHz

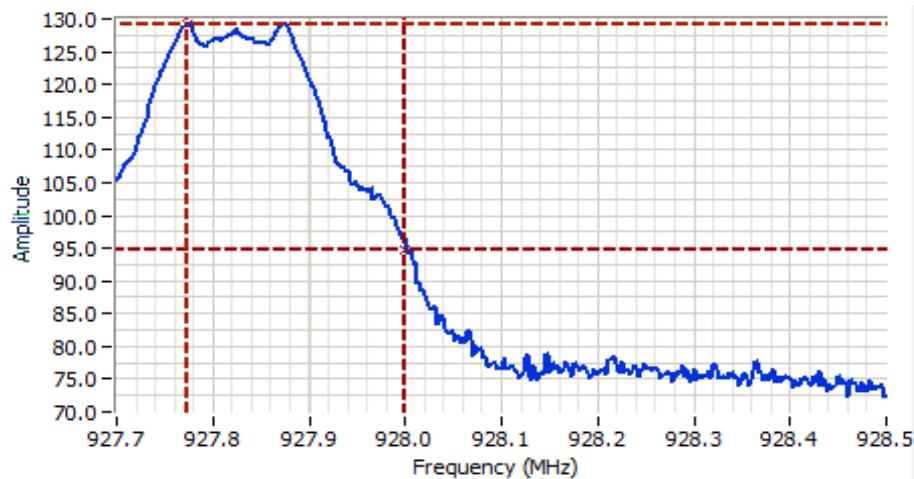
Delta Amplitude 37.2





EMC Test Data

Client:	Freewave	Job Number:	PR091113
Model:	FGR3-C-U and FGR3-T-U	T-Log Number:	TL091113-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15.247, RSS-247	Project Coordinator:	David Bare
		Class:	N/A



Analyzer Settings

Rohde&Schwarz, ESI
 CF: 928.000 MHz
 SPAN: 1.000 MHz
 RB: 30.0 kHz
 VB: 100 kHz
 Detector: POS
 Attn: 40 DB
 RL Offset: 29.2 DB
 Sweep Time: 5.0ms
 Ref Lvl: 131.2 DBUV

Comments

Bandedge Measurement

Cursor 1	927.7725	129.3	
Cursor 2	928.0000	94.7	

Delta Freq. 227 kHz
 Delta Amplitude 34.6



Delta Marker - Peak 34.6 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	95.2	V	109.8	-14.6	PK	248	1.0



EMC Test Data

Client:	Freewave	Job Number:	PR091113
Model:	FGR3-C-U and FGR3-T-U	T-Log Number:	TL091113-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15.247, RSS-247	Project Coordinator:	David Bare
		Class:	N/A

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

Date of Test: 11/20/2018

EUT Setting/ Data Rate: 8, 115.2 kbps

Test Engineer: M. Birgani

EUT Power: 27.7 dBm

Test Location: Chamber 3

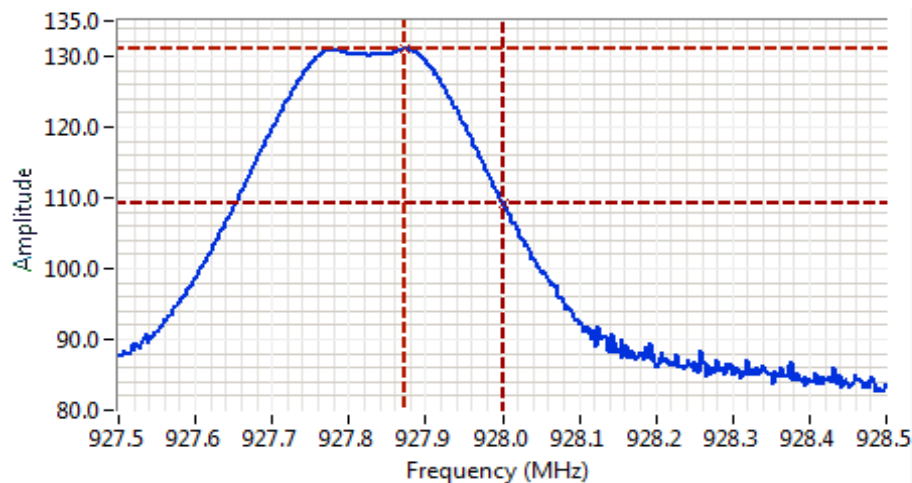
Antenna Gain: Omni 8.15dBi

Fundamental Signal Field Strength: Peak value measured in 100kHz

Frequency	Level	Pol	15.2		Detector	Azimuth	Height	Comments
MHz	dBμV/m	v/h	Limit	Margin	PK/QP/Avg	degrees	meters	
927.873	131.0	V	-	-	PK	187	1.1	POS; RB 100 kHz; VB: 300 kHz
927.777	114.2	H	-	-	PK	138	1.1	POS; RB 100 kHz; VB: 300 kHz

Fundamental emission level @ 3m in 100kHz RBW:	131.0	114.2
Limit for emissions outside of restricted bands:	111.0	dBμV/m

Limit is -20dBc



Analyzer Settings

Rohde&Schwarz, ESI
 CF: 928.000 MHz
 SPAN: 1.000 MHz
 RB: 100 kHz
 VB: 300 kHz
 Detector: POS
 Attn: 50 DB
 RL Offset: 28.6 DB
 Sweep Time: 5.0ms
 Ref Lvl: 143.6 DBUV

Comments

bandedge Measurement

Cursor	927.8727	131.0	↕	↔	↻
Cursor	928.0000	109.2	↕	↔	↻

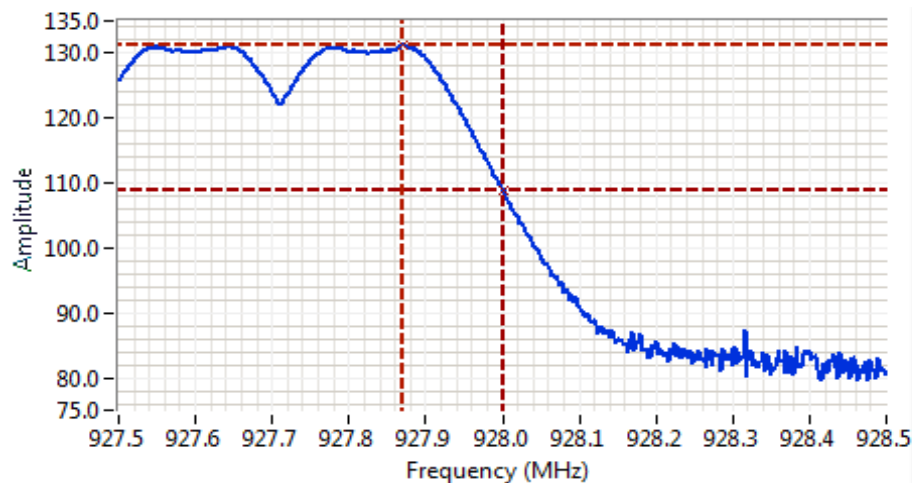
Delta Freq. 127 kHz
 Delta Amplitude 21.7





EMC Test Data

Client:	Freewave	Job Number:	PR091113
Model:	FGR3-C-U and FGR3-T-U	T-Log Number:	TL091113-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15.247, RSS-247	Project Coordinator:	David Bare
		Class:	N/A



Analyzer Settings

Rohde&Schwarz,ESI
CF: 928.000 MHz
SPAN: 1.000 MHz
RB: 100 kHz
VB: 300 kHz
Detector: POS
Attn: 50 DB
RL Offset: 28.6 DB
Sweep Time: 5.0ms
Ref Lvl: 143.6 DBUV

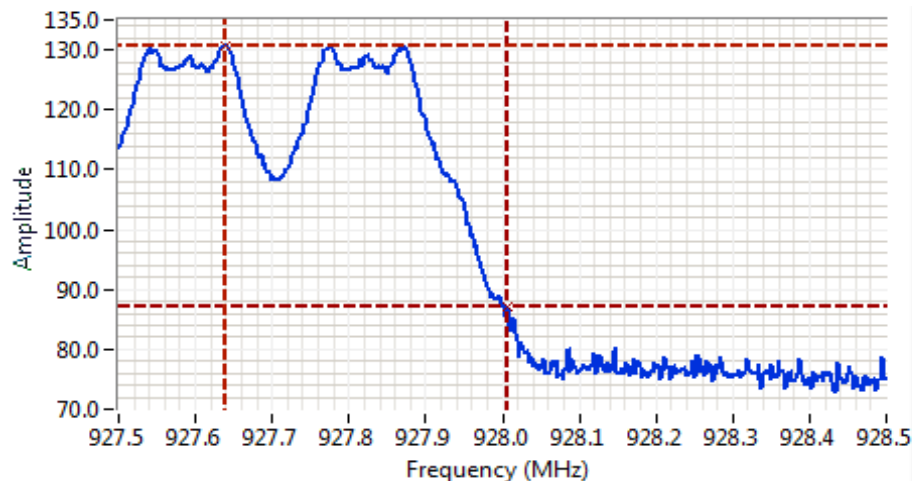
Comments

Bandedge Measurement
Hopping

Cursor 927.8707 131.3
Cursor 928.0010 108.8

Delta Freq. 130 kHz

Delta Amplitude 22.5



Analyzer Settings

Rohde&Schwarz,ESI
CF: 928.000 MHz
SPAN: 1.000 MHz
RB: 30.0 kHz
VB: 100 kHz
Detector: POS
Attn: 50 DB
RL Offset: 28.6 DB
Sweep Time: 5.0ms
Ref Lvl: 143.6 DBUV

Comments

Bandedge Measurement
Hopping

Cursor 927.6383 130.8
Cursor 928.0070 87.0

Delta Freq. 369 kHz

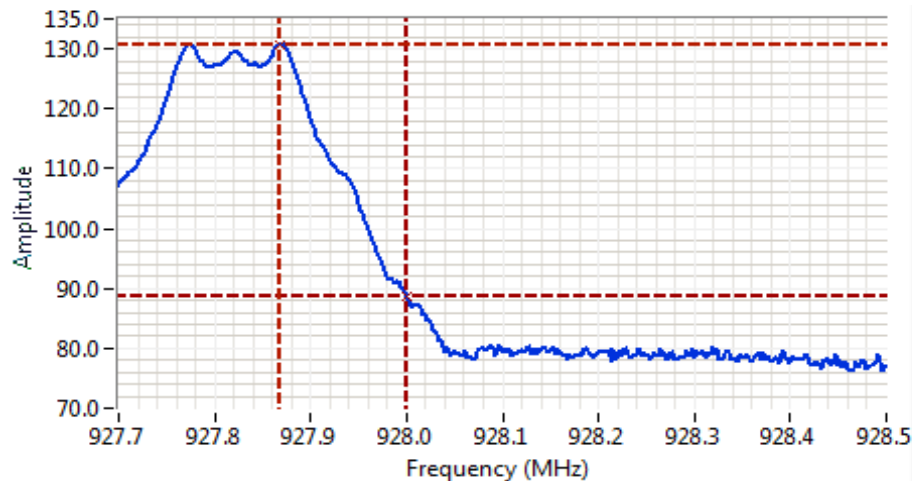
Delta Amplitude 43.7





EMC Test Data

Client:	Freewave	Job Number:	PR091113
Model:	FGR3-C-U and FGR3-T-U	T-Log Number:	TL091113-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15.247, RSS-247	Project Coordinator:	David Bare
		Class:	N/A



Analyzer Settings

Rohde&Schwarz,ESI
 CF: 928.000 MHz
 SPAN: 1.000 MHz
 RB: 30.0 kHz
 VB: 100 kHz
 Detector: POS
 Attn: 50 DB
 RL Offset: 28.6 DB
 Sweep Time: 5.0ms
 Ref Lvl: 143.6 DBUV

Comments

Bandedge Measurement

Cursor	927.8687	130.8	
Cursor	928.0000	88.7	

Delta Freq. 131 kHz
 Delta Amplitude 42.1



Delta Marker - Peak 34.6 dB

Delta between highest in-band and highest

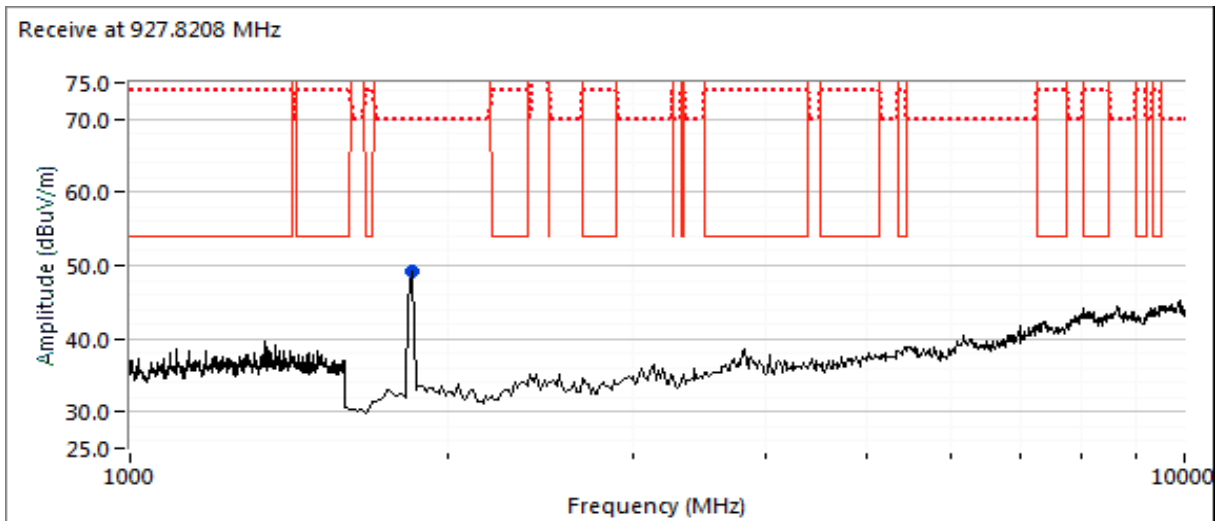
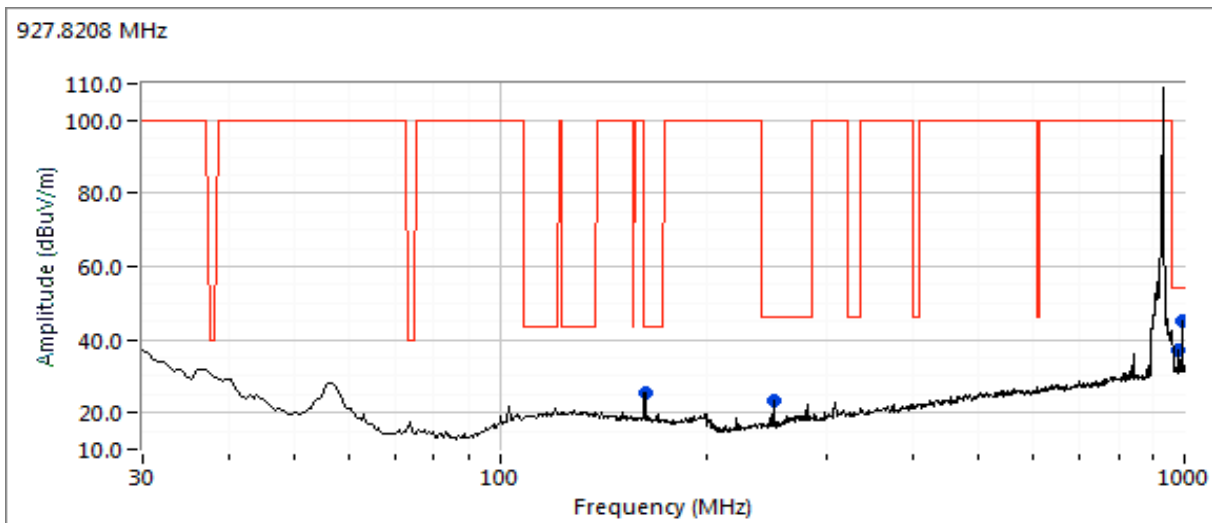
Band Edge Signal Field Strength

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	88.9	V	111.0	-22.1	PK	187	1.1



EMC Test Data

Client:	Freewave	Job Number:	PR091113
Model:	FGR3-C-U and FGR3-T-U	T-Log Number:	TL091113-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15.247, RSS-247	Project Coordinator:	David Bare
		Class:	N/A



Spurious Emissions

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBuV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
162.198	27.9	H	43.5	-15.6	QP	155	1.5	QP (1.00s)
993.791	36.0	V	54.0	-18.0	QP	199	1.0	QP (1.00s)
980.510	35.6	V	54.0	-18.4	QP	152	1.0	QP (1.00s)
250.687	26.2	H	46.0	-19.8	QP	243	1.0	QP (1.00s)
1855.660	52.3	V	111.0	-58.7	PK	232	2.5	RB 1 MHz;VB 3 MHz;Peak



EMC Test Data

Client:	Freewave	Job Number:	PR091113
Model:	FGR3-C-U and FGR3-T-U	T-Log Number:	TL091113-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15.247, RSS-247	Project Coordinator:	David Bare
		Class:	N/A

Run #4: Output Power

Date of Test: 12/4/2018

Test Engineer: M. Birgani

Test Location: Chamber 2

Config. Used: 1

Config Change: -

EUT Voltage: 120V/ 60Hz

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

Modulation: 115.2 kbps

Power Setting	Frequency (MHz)	Output Power		Antenna Gain (dBi)	Result	EIRP	
		(dBm) ¹	mW			dBm	W
8	902.2464	27.5	562.3	8.15	Pass	35.7	3.673
8	914.9184	27.7	588.8	8.15	Pass	35.9	3.846
8	927.8208	26.5	446.7	8.15	Pass	34.7	2.917

Note 1: Output power measured using a peak power meter

Modulation: 153.6 kbps

Power Setting	Frequency (MHz)	Output Power		Antenna Gain (dBi)	Result	EIRP	
		(dBm) ¹	mW			dBm	W
8	902.2464	27.4	549.5	8.15	Pass	35.6	3.589
8	914.9184	27.5	562.3	8.15	Pass	35.7	3.673
8	927.8208	26.5	446.7	8.15	Pass	34.7	2.917

Note 1: Output power measured using a peak power meter



EMC Test Data

Client:	Freewave	PR Number:	PR091113
Model:	FGR3-C-U and FGR3-T-U	T-Log Number:	TL091113-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: 11/30/2018
Test Engineer: M. Birgani
Test Location: Chamber #5

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: 20-22 °C
Rel. Humidity: 38-40 %

Summary of Results

Run #	Test Performed	Limit	Result	Margin
1 (Note 1)	CE, AC Power, 120V/60Hz	FCC 15.107(a)	PASS	51.0dBμV @ 0.191MHz (-13.0dB)
2 (Note 2)	CE, AC Power, 120V/60Hz	FCC 15.107(a)	PASS	56.2dBμV @ 0.151MHz (-9.7dB)

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: Power Supply used during testing: Kuantech MN: KSAS0121200080HU

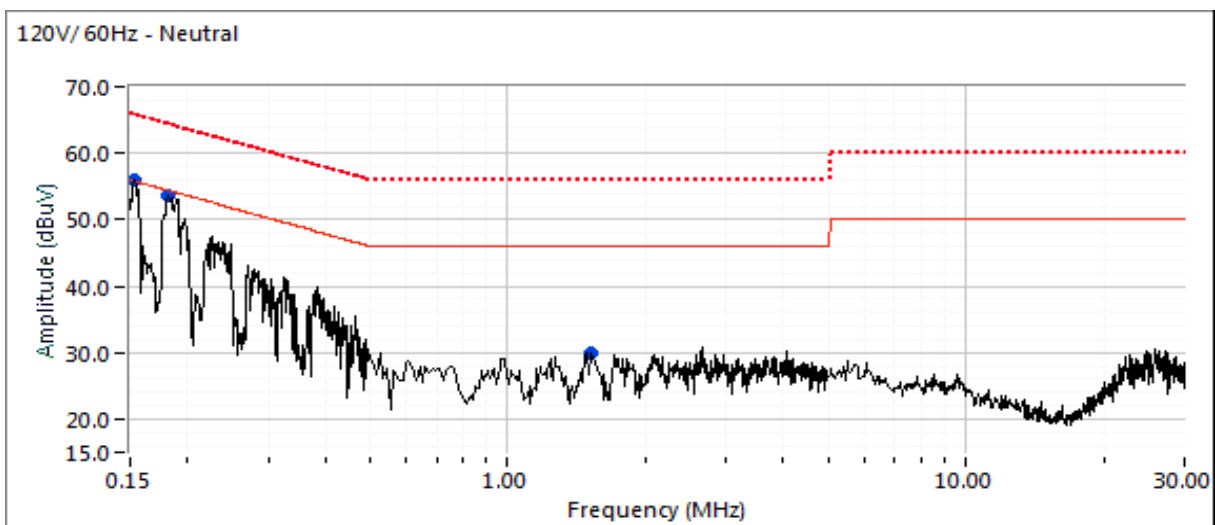
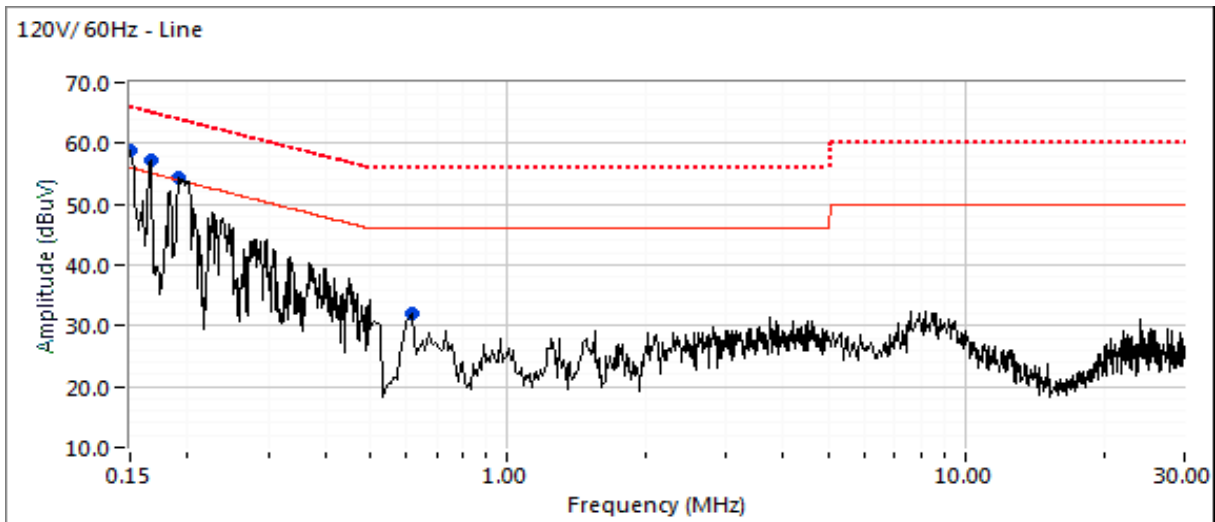
Note 2: Power Supply used during testing: Shenzhen Mingxin MN: MX15W-1200800UX



EMC Test Data

Client:	Freewave	PR Number:	PR091113
Model:	FGR3-C-U and FGR3-T-U	T-Log Number:	TL091113-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	PR Number:	PR091113
Model:	FGR3-C-U and FGR3-T-U	T-Log Number:	TL091113-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	Class B		Detector QP/Ave	Comments
			Limit	Margin		
0.151	58.7	Line	56.0	2.7	Peak	
0.165	57.1	Line	55.2	1.9	Peak	
0.191	54.5	Line	53.9	0.6	Peak	
0.191	54.5	Line	53.9	0.6	Peak	
0.153	55.9	Neutral	55.8	0.1	Peak	
0.180	53.7	Neutral	54.4	-0.7	Peak	
0.590	32.0	Line	46.0	-14.0	Peak	
1.538	29.8	Neutral	46.0	-16.2	Peak	

Final quasi-peak and average readings

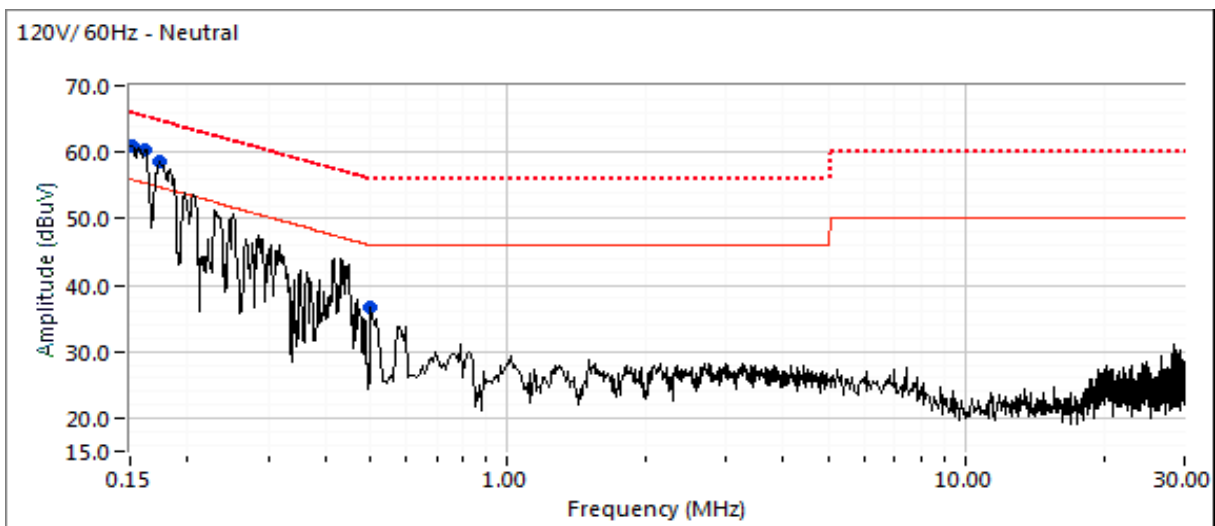
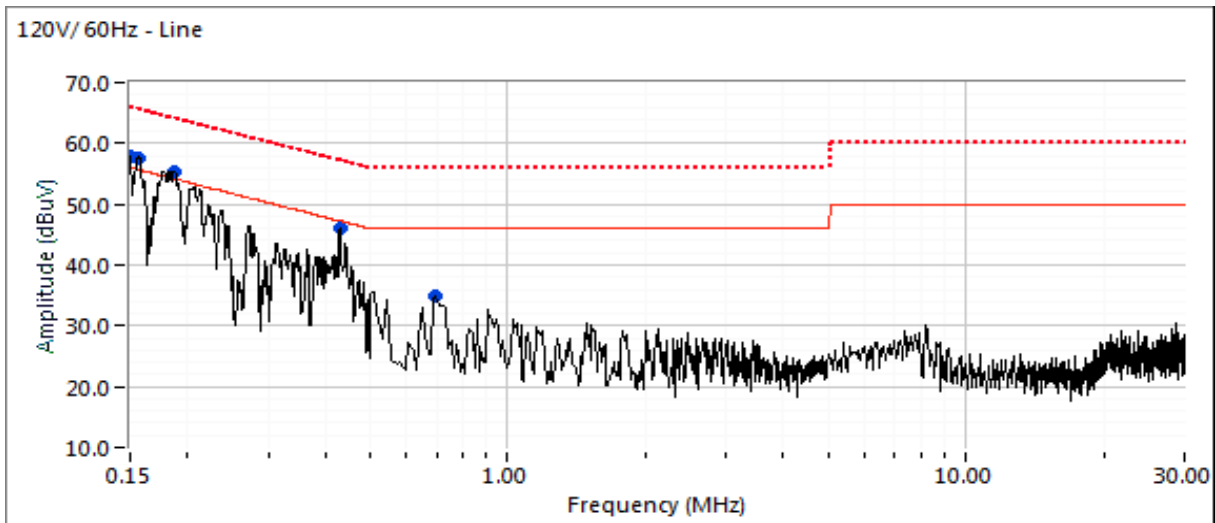
Frequency MHz	Level dB μ V	AC Line	Class B		Detector QP/Ave	Comments
			Limit	Margin		
0.191	51.0	Line	64.0	-13.0	QP	QP (1.00s)
0.151	52.8	Line	66.0	-13.2	QP	QP (1.00s)
0.191	50.8	Line	64.0	-13.2	QP	QP (1.00s)
0.180	49.0	Neutral	64.5	-15.5	QP	QP (1.00s)
0.153	48.7	Neutral	65.9	-17.2	QP	QP (1.00s)
0.191	34.8	Line	54.0	-19.2	AVG	AVG (0.10s)
0.191	33.5	Line	54.0	-20.5	AVG	AVG (0.10s)
0.165	42.7	Line	65.2	-22.5	QP	QP (1.00s)
0.151	32.9	Line	56.0	-23.1	AVG	AVG (0.10s)
0.180	25.0	Neutral	54.5	-29.5	AVG	AVG (0.10s)
0.165	25.6	Line	55.2	-29.6	AVG	AVG (0.10s)
1.538	25.3	Neutral	56.0	-30.7	QP	QP (1.00s)
0.153	24.0	Neutral	55.9	-31.9	AVG	AVG (0.10s)
1.538	14.1	Neutral	46.0	-31.9	AVG	AVG (0.10s)
0.590	24.0	Line	56.0	-32.0	QP	QP (1.00s)
0.590	11.3	Line	46.0	-34.7	AVG	AVG (0.10s)



EMC Test Data

Client:	Freewave	PR Number:	PR091113
Model:	FGR3-C-U and FGR3-T-U	T-Log Number:	TL091113-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15.247, RSS-247	Project Engineer:	David Bare
		Class:	-

Run #2: AC Power Port Conducted Emissions, 0.15 - 30MHz, 120V/60Hz





EMC Test Data

Client:	Freewave	PR Number:	PR091113
Model:	FGR3-C-U and FGR3-T-U	T-Log Number:	TL091113-RA
Contact:	Riaz Momand	Project Manager:	Deepa Shetty
Standard:	FCC Part 15.247, RSS-247	Project Engineer:	David Bare
		Class:	-

Run #2: 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	Class B		Detector QP/Ave	Comments
			Limit	Margin		
0.151	60.9	Neutral	55.9	5.0	Peak	
0.161	60.3	Neutral	55.4	4.9	Peak	
0.174	58.5	Neutral	54.7	3.8	Peak	
0.156	57.7	Line	55.7	2.0	Peak	
0.151	57.9	Line	56.0	1.9	Peak	
0.185	55.3	Line	54.2	1.1	Peak	
0.430	46.0	Line	47.3	-1.3	Peak	
0.499	36.7	Neutral	46.0	-9.3	Peak	
0.705	35.0	Line	46.0	-11.0	Peak	

Final quasi-peak and average readings

Frequency MHz	Level dB μ V	AC Line	Class B		Detector QP/Ave	Comments
			Limit	Margin		
0.151	56.2	Neutral	65.9	-9.7	QP	QP (1.00s)
0.156	54.3	Line	65.7	-11.4	QP	QP (1.00s)
0.174	53.3	Neutral	64.8	-11.5	QP	QP (1.00s)
0.151	53.9	Line	65.9	-12.0	QP	QP (1.00s)
0.161	52.5	Neutral	65.4	-12.9	QP	QP (1.00s)
0.185	51.0	Line	64.3	-13.3	QP	QP (1.00s)
0.430	39.7	Line	57.3	-17.6	QP	QP (1.00s)
0.151	36.7	Line	55.9	-19.2	AVG	AVG (0.10s)
0.430	26.5	Line	47.3	-20.8	AVG	AVG (0.10s)
0.185	32.4	Line	54.3	-21.9	AVG	AVG (0.10s)
0.156	32.4	Line	55.7	-23.3	AVG	AVG (0.10s)
0.151	32.5	Neutral	55.9	-23.4	AVG	AVG (0.10s)
0.499	31.9	Neutral	56.0	-24.1	QP	QP (1.00s)
0.174	30.3	Neutral	54.8	-24.5	AVG	AVG (0.10s)
0.161	28.8	Neutral	55.4	-26.6	AVG	AVG (0.10s)
0.705	29.3	Line	56.0	-26.7	QP	QP (1.00s)
0.499	16.3	Neutral	46.0	-29.7	AVG	AVG (0.10s)
0.705	14.3	Line	46.0	-31.7	AVG	AVG (0.10s)

End of Report

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