FCC Part 15.247 RF TEST REPORT

Test Report Number……	**IVE-18102201-FCC-RF Rev1.1**
Applicant……	**INNOVIVE LLC**
Applicant Address……	**10019 Waples Ct, San Diego, CA 92121**
Product Name……	Sub-GHz Radio Module
Model Number……	CC1312R1_RevB
FCC ID……	2ARO6INV-CC1312R1
Date of EUT received……	10/29/2018
Date of Test……	10/29/2018-11/14/2018
Report Issue Date……	11/23/2018
Test Standards……	**47CFR Part 15.247: 2018**

Issued By:

Vista Laboratories

1261 Puerta Del Sol, San Clemente, CA 92673 USA

www.vista-compliance.com

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Tested by:	**Approved By:**
David Zhang/Test Engineer	**Jerry Bai/Quality Manager**

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VISTA LABORATORIES, INC.

San Clemente, CA

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Presented this 21st day of June 2018.

President and CEO
For the Accreditation Council
Certificate Number 4848.01
Valid to July 31, 2020

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17025 Product Testing Accreditation Certificate

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REVISION HISTORY

Revision	Issue Date	Description	Note
Original	11/14/2018	Original release	N/A
Rev1.0	11/15/2018	Update antenna information	N/A
Rev1.1	11/23/2018	Add evaluation for hopping protocol	N/A

1 General Information

1.1 Applicant

Applicant:	INNOVIVE LLC
Applicant address:	10019 Waples Ct, San Diego, CA 92121
Manufacturer:	INNOVIVE LLC
Manufacturer Address:	10019 Waples Ct, San Diego, CA 92121

1.2 Product information

Product Name	Sub-GHz Radio Module
Model Number	CC1312R1_RevB
Serial Number	N/A
Frequency Band	902.4 – 927.6 MHz
Type of modulation	FHSS
Equipment Class/ Category	DSS
Maximum output power	13.907 dBm
Antenna Information	Internal PCB antenna: 3.03 dBi External Dipole antenna: 2 dBi
Clock Frequencies	32.768 KHz, 48 MHz
Port/Connectors	RP-SMA (for external antenna)
Input Power	5 VDC (micro-USB)
Power Adapter Manu/Model	N/A
Power Adapter SN	N/A
Hardware version	RevB
Software version	N/A
Simultaneous Transmission	N/A
Additional Info	This radio module has two hardware version, one with on-board PCB trace antenna and the other one with off-board external antennas. Both the internal and the external dipole antennas was tested. For on-board antenna version, the C36 is populated to choose right RF path; while for off-board antenna version, the C31 is populated to choose another RF path. No other change on the hardware. The unique RP-SMA connector is used for the external antenna coupling.

1.3 Test standard and method

Test standard	47CFR Part 15.247: 2018
Test method	ANSI C63.10: 2013

1.4 Test purpose and statement

The purpose of this test report is intended to demonstrate the compliance of product listed in section 1.2, received from company listed in section 1.1, to the requirements of standard and method listed in section 1.3. Based on our test results, we conclude that the product tested complies with the requirements of the standards indicated.

2 Test site information

Lab performing tests	**Vista Laboratories**
Lab Address	1261 Puerta Del Sol, San Clemente, CA 92673 USA
Phone Number	+1 (949) 393-1123
Website	www.vista-compliance.com

Test condition	Test Engineer	Test Environment	Test Date
RF conducted	David Zhang	22.1°C / 53.5%/996 mbar	10/29/2018 – 11/14/2018
Radiated	David Zhang	22.2°C / 54.1%/997 mbar	10/29/2018 – 11/14/2018

3 Modification of EUT

For RF conducted measurement purposes, the internal antenna port of the test sample was removed and replaced with an external SMA connector; the external antenna port was unmodified because it has a direct port to connect to. A short serial wire cable was soldered onto the PCB for sending commands from the laptop to the EUT to enable RF testing mode; the special test firmware is used for testing purpose.

For radiated measurement, a short serial wire cable was soldered onto the PCB for sending commands from the laptop to EUT to enable RF test mode; the special test firmware is used for testing purpose. No other physical modification was made.

4 Test configuration and operation

4.1 EUT test configuration

The EUT is powered by a 5 VDC power supply. It is loaded with test firmware for RF measurement. Radio test software is used to load test firmware to EUT to enable the RF test mode.

4.2 EUT test mode

Radio	Channel	Frequency (MHz)
Sub-GHz Transceiver	1 (Low)	902.4
Sub-GHz Transceiver	64 (Mid)	915.0
Sub-GHz Transceiver	127 (High)	927.6

4.3 Supporting Equipment

Index	Description	Model	S/N	Brand	Remark
1	Laptop	P29G003	G1H5102	Dell	N/A
2	AC/DC power supply	PSM06A-050Q	520	ASUS	5VDC micro USB
3	TI development board	Cc1312R1	L10CO00	TI	N/A

4.4 EUT setup diagram

4.5 EUT operation

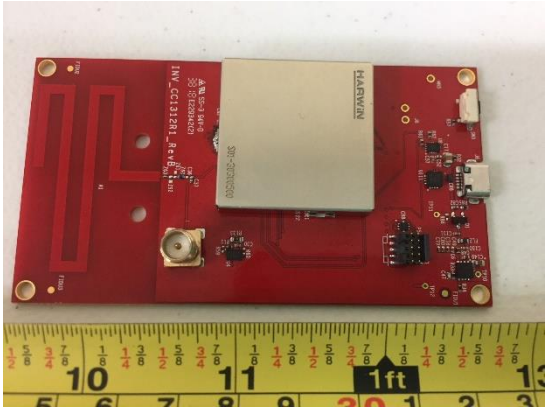
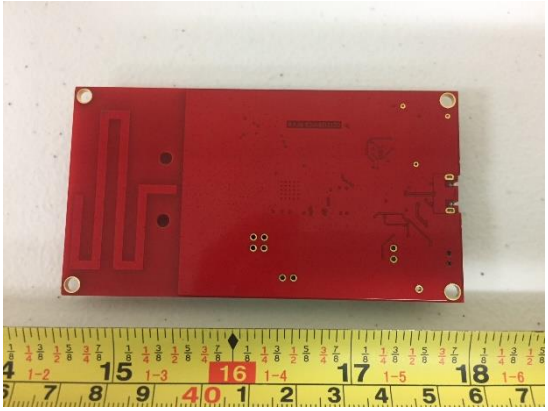
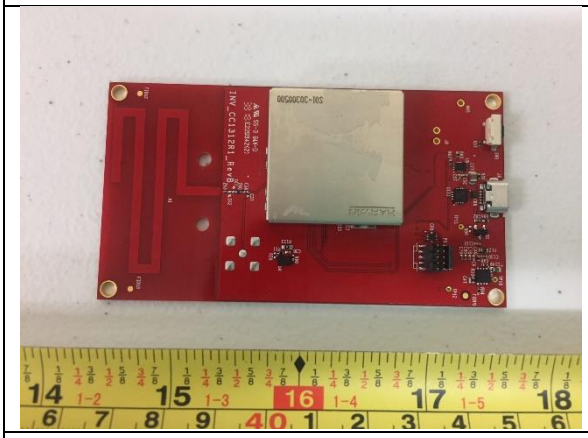
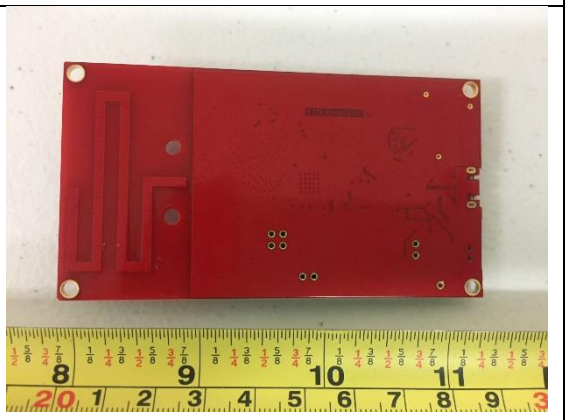
Radio test software is used to send command to EUT to enable the RF test mode.

4.6 Test software

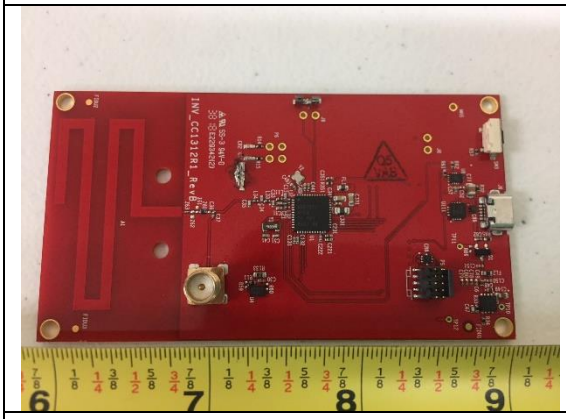
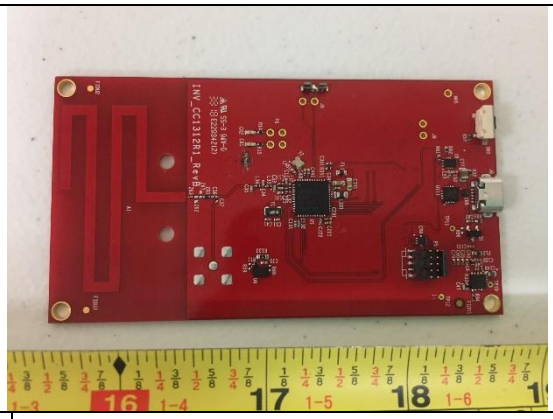
Index	Description	Remark
1	UniFlash	Programming software to load test firmware to device for running RF test mode.
2	EMISoft Vasona 6.0049	EMC/Spurious emission test software used during testing

5 EUT and test setup pictures

5.1 EUT external pictures

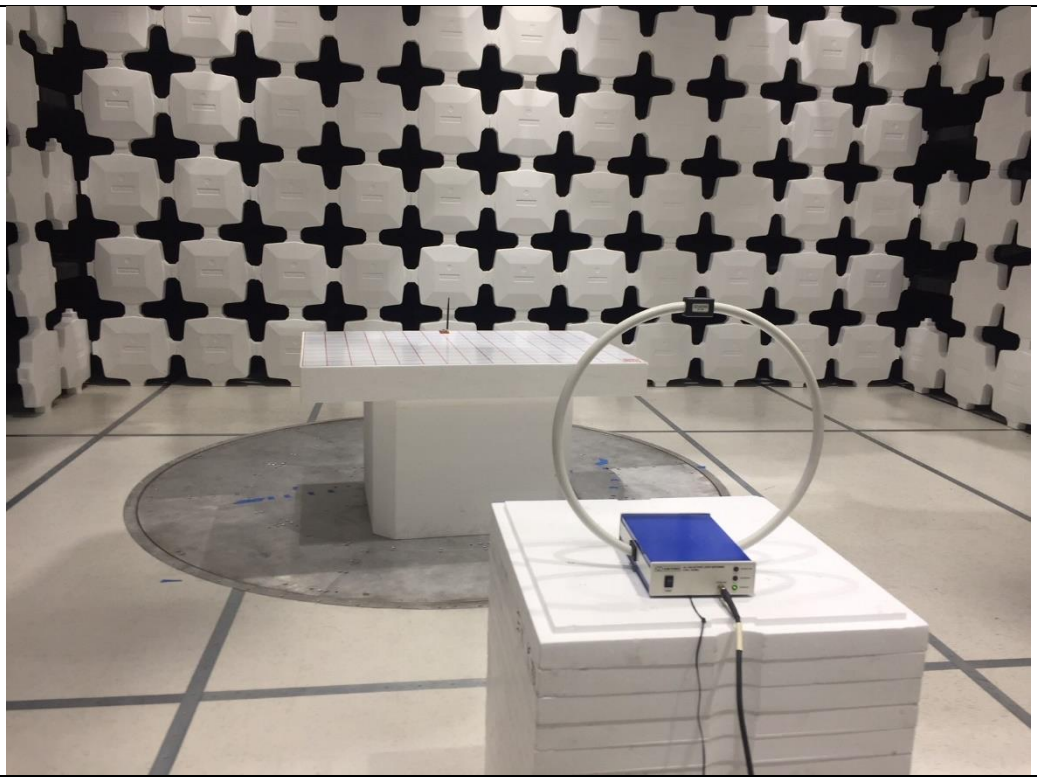
EUT External Pictures	
	
EUT Top View – External antenna version	**EUT Bottom View – External antenna version**
	
EUT Top View – Internal antenna version	**EUT Bottom View – Internal antenna version**
External antenna Top View	**External antenna Front View**

5.2 EUT internal pictures

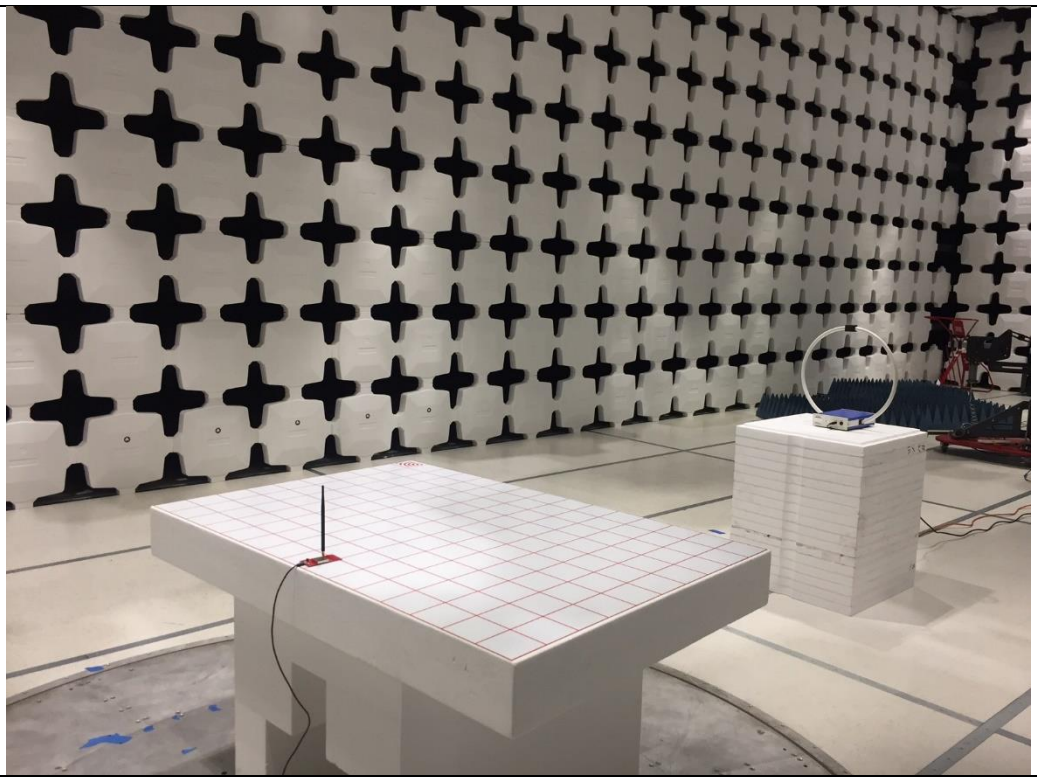
EUT Internal Pictures	
	
EUT Internal View – External antenna version	**EUT Internal View – Internal antenna version**

5.3 EUT test setup pictures

Radiated Emissions Below 30MHz setup



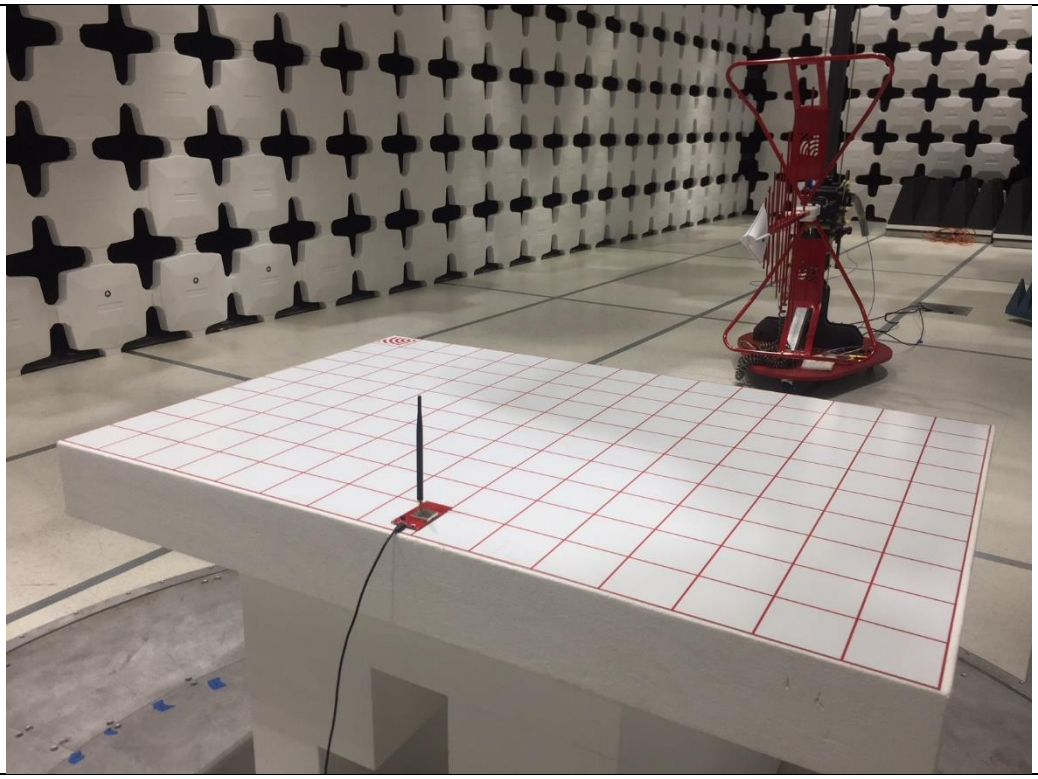
External antenna version - Front



External antenna version - Rear

Radiated Emissions Below 1GHz setup

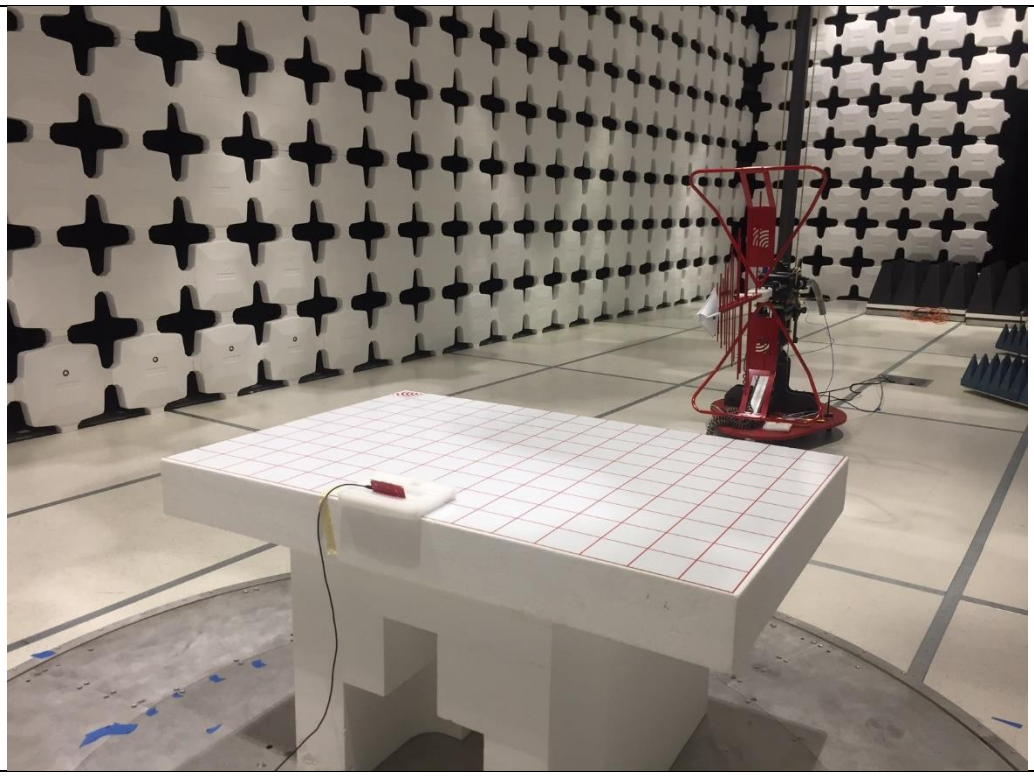
External antenna version - Front



External antenna version - Rear

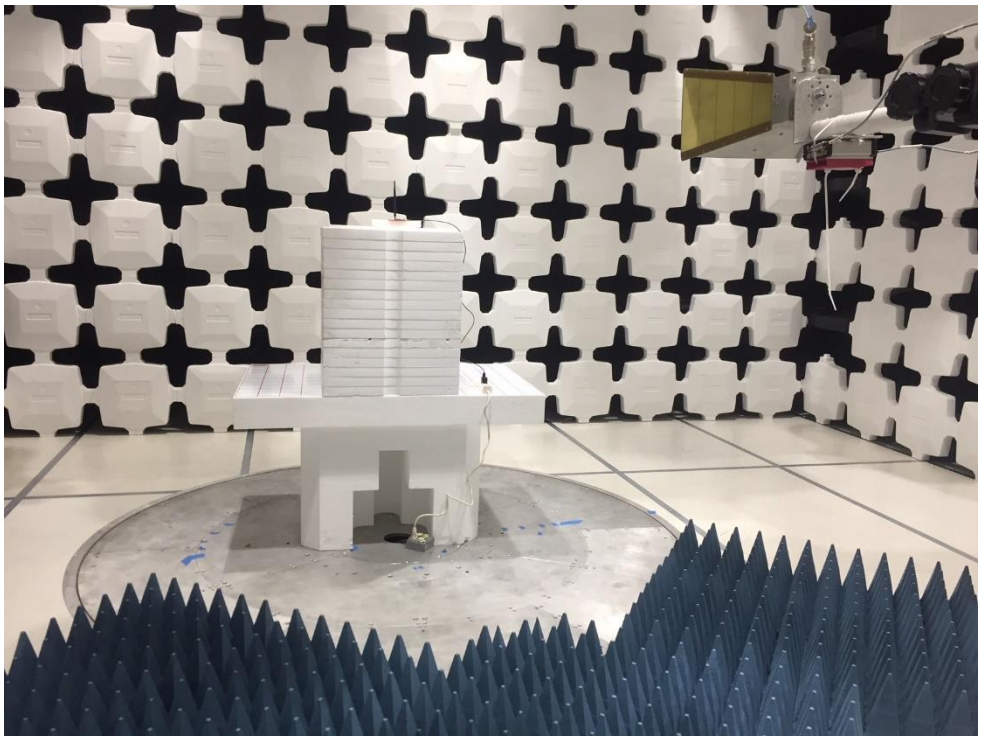
Radiated Emissions Below 1GHz setup

Internal antenna version - Front

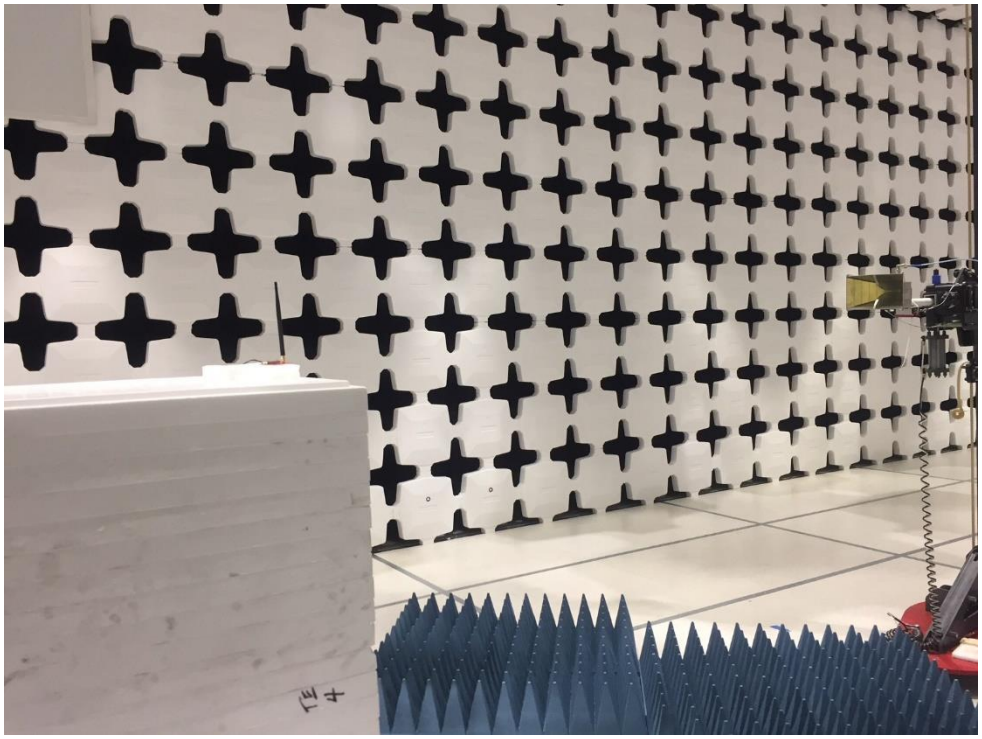


Internal antenna version - Front

Radiated Emissions Above 1GHz setup

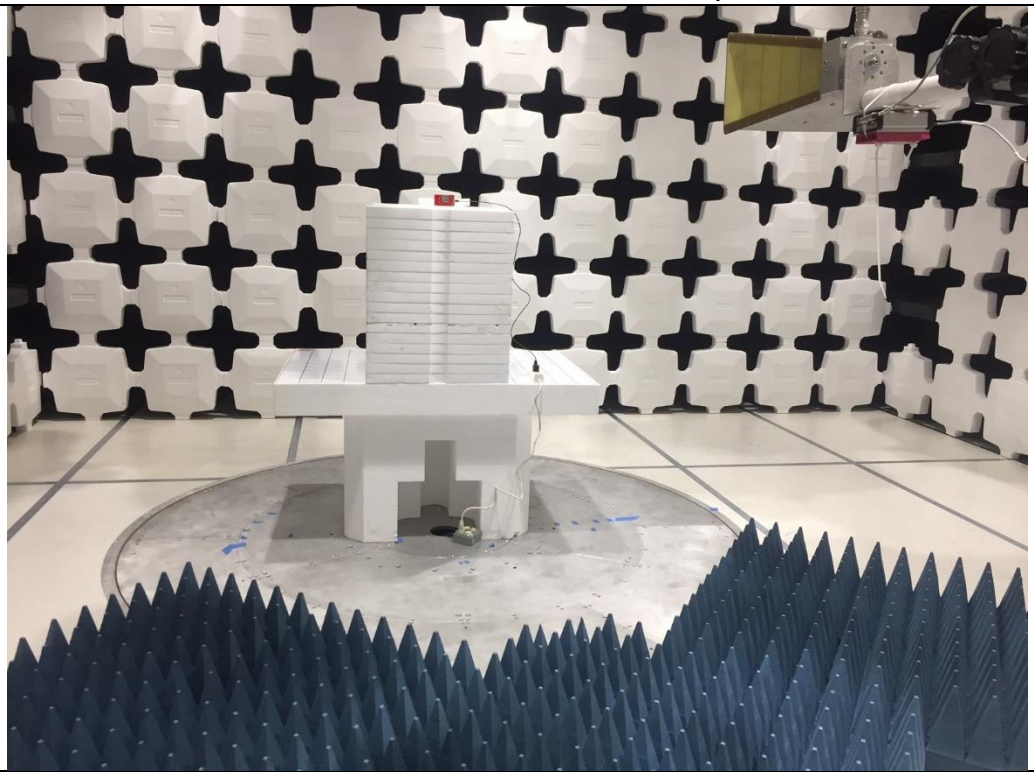


External antenna version - Front

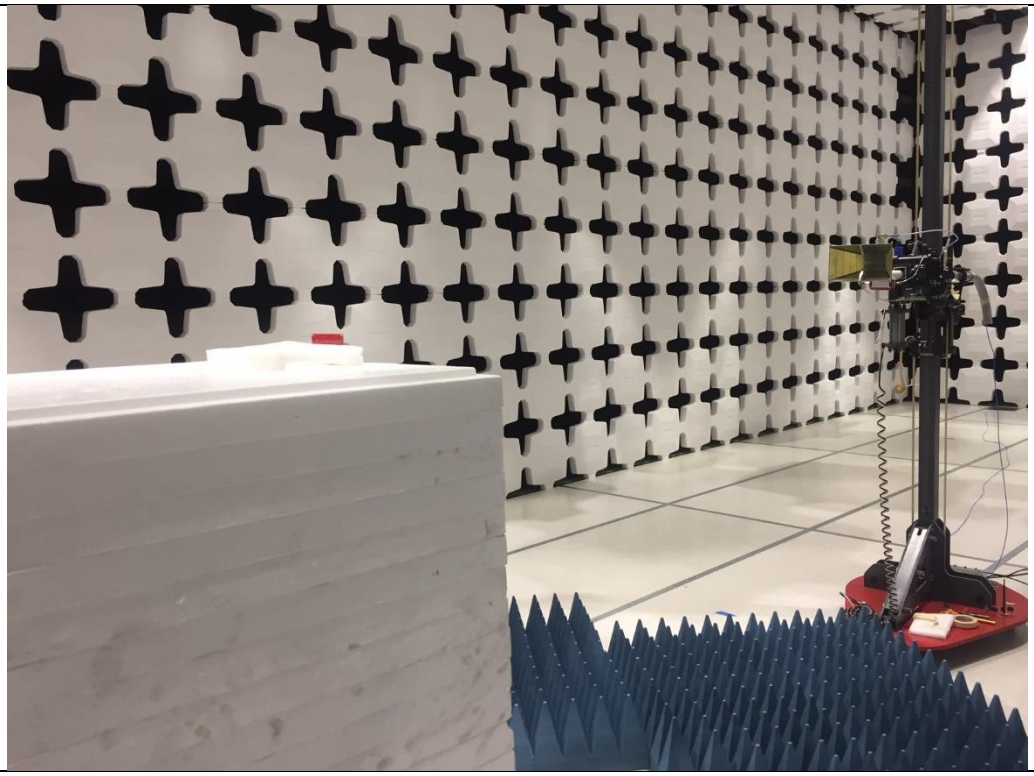


External antenna version - Rear

Radiated Emissions Above 1GHz setup

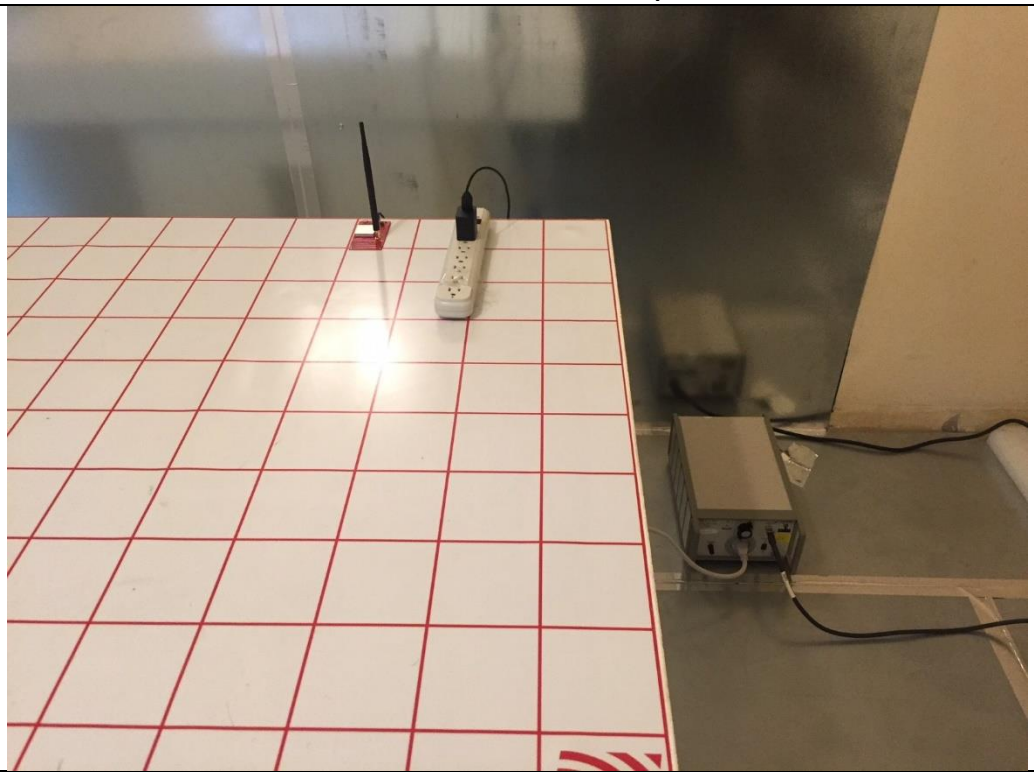


Internal antenna version - Front

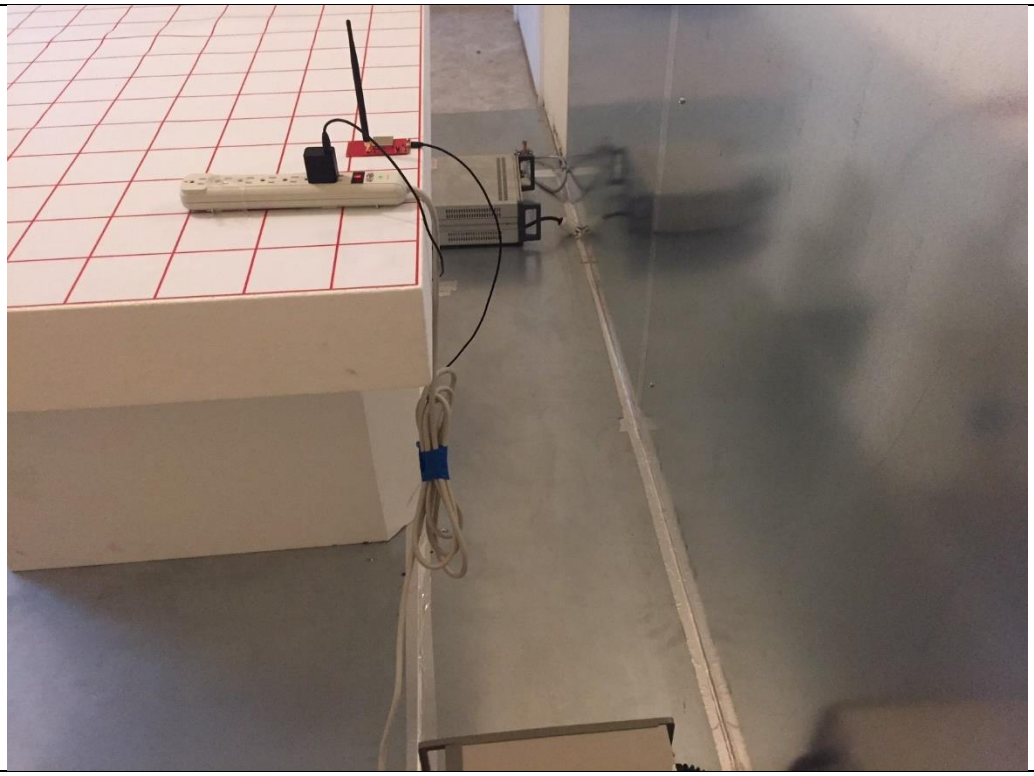


Internal antenna version - Front

Conducted Emissions setup



External antenna version - Front



External antenna version - Rear

6 Test Summary

FCC Rules	Test Item	Test standard	Section in report	Verdict
§15.203	Antenna Requirement	47CFR Part 15.247	8.1	Pass
§15.207 (a)	AC Power Line Conducted Emissions	47CFR Part 15.207	8.2	Pass
§15.247 (a)(1)	20 dB Bandwidth	47CFR Part 15.247	8.3	Pass
§15.247 (a)(1)	Number of Hopping Channel	47CFR Part 15.247	8.4	Pass
§15.247(b)(2)	Conducted Maximum Output Power	47CFR Part 15.247	8.5	Pass
§15.247 (a)(1)	Chanel Separation	47CFR Part 15.247	8.6	Pass
§15.247 (a)(1)	Time of Occupancy	47CFR Part 15.247	8.7	Pass
§15.247(d)	Conducted Unwanted Emissions	47CFR Part 15.247	8.8	Pass
§15.205, §15.209, §15.247(d)	Radiated Emissions & Unwanted Emissions into Restricted Frequency Bands	47CFR Part 15.247	8.9	Pass
§15.247 (a)(1), §15.247 (g), §15.247 (h)	Frequency Hopping System Requirement	47CFR Part 15.247	8.10	Pass

Note: N/A

7 Uncertainty of Measurement

Test item	Measurement Uncertainty (dB)
RF Output Power (Conducted)	±1.2 dB
Power Spectral Density	±0.9 dB
Unwanted Emission (Conducted)	±2.6 dB
Occupied Channel Bandwidth	±5 %
Radiated Emission (9KHz-30MHz)	±3.5 dB
Radiated Emission (30MHz-1GHz)	±4.6 dB
Radiated Emission (1-18GHz)	±4.9 dB
Radiated Emission (18-40GHz)	±3.5 dB
Conducted Emissions (150KHz-30MHz)	±3.6 dB

8 Test summary and result

8.1 Antenna Requirement

8.1.1 Requirement

Per § 15.203, an intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited.

8.1.2 Result

Analysis:

The EUT has an option of using the internal antenna, or an external antenna.

- For the internal antenna version, the EUT uses an on board PCB trace antenna that is permanently attached.
- For the external antenna version, the EUT has a provision for connection to an external dipole antenna, using a unique RP-SMA connector. No other external antennas are to be used with the EUT. The external antenna will be directly coupled to the board through RP-SMA connector. No RF extension cable will be used.

Conclusion:

EUT complies with antenna requirement in § 15.203.

8.2 Conducted Emissions

8.2.1 Requirement

Per § 15.207 (a), an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50 µH/50 ohms line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

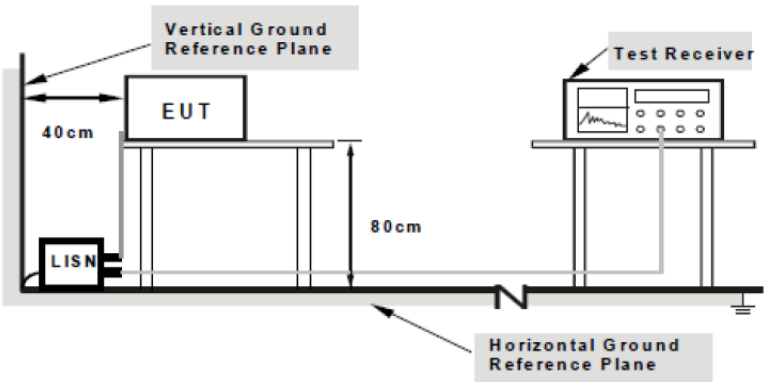
Limits for Conducted Emissions at the Mains Ports

Section	Frequency ranges (MHz)	Limit (dBuV)	
		QP	Average
Class B devices	0.15 – 0.5	66 – 56	56 – 46
	0.5 – 5	56	46
	5 - 30	60	50
NOTE 1 The lower limit shall apply at the transition frequencies.			

Limits for Conducted Emissions at the Telecommunication Ports

Section	Frequency ranges (MHz)	Limit (dBuV)	
		QP	Average
Class B devices	0.15 – 0.5	85 – 74	74 – 64
	0.5 – 5	74	64
NOTE 1 The limits decrease linearly with the logarithm of the frequency in the range 0.15 MHz to 0.5 MHz NOTE 2 The voltage disturbance limits are derived for use with an impedance stabilization network (ISN) which presents a common mode (asymmetric mode) impedance of 150 Ω to the telecommunication port under test (conversion factor is 20 log10 150 / I = 44 dB).			

8.2.2 Test setup



Note: 1.Support units were connected to second LISN.
2.Both of LISNs (AMN) are 80cm from EUT and at least 80cm from other units and other metal planes support units.

8.2.3 Test Procedure

1. The EUT and supporting equipment were set up in accordance with the requirements of the standard on top of a 1.5m x 1m x 0.8m high, non-metallic table.
2. The power supply for the EUT was fed through a 50Ω/50µH EUT LISN, connected to filtered mains.
3. The RF OUT of the EUT LISN was connected to the EMI test receiver via a low-loss coaxial cable.
4. All other supporting equipment was powered separately from another main supply.
5. The EUT was switched on and allowed to warm up to its normal operating condition.
6. A scan was made on the NEUTRAL line (for AC mains) or Earth line (for DC power) over the required frequency range using an EMI test receiver.
7. High peaks, relative to the limit line, were then selected.
8. The EMI test receiver was then tuned to the selected frequencies and the necessary measurements made with a receiver bandwidth setting of 10 kHz. For FCC tests, only Quasi-peak measurements were made; while for CISPR/EN tests, both Quasi-peak and Average measurements were made
9. All possible modes of operation were investigated. Only the worst case emissions were measured and reported. All other emissions were relatively insignificant.

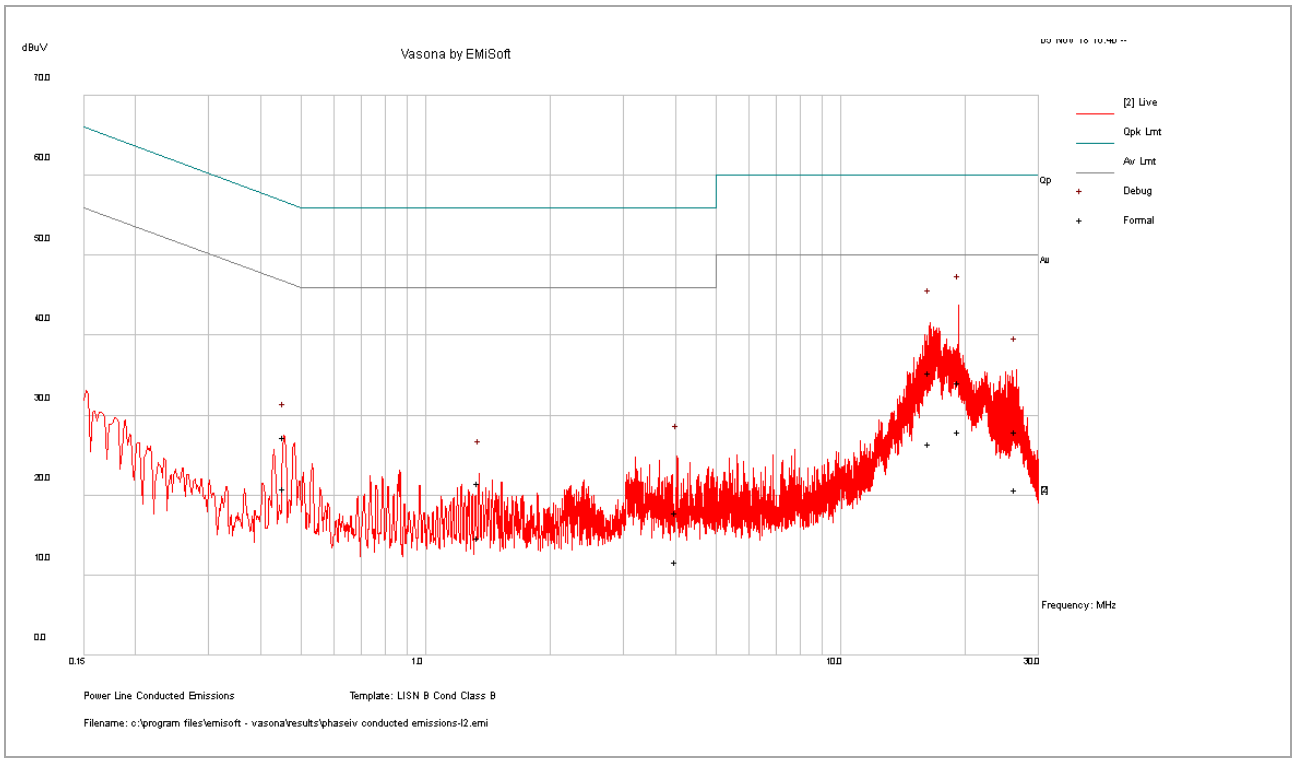
Note:

1) The AC line conducted emission was verified on both version boards and the worst case result tested with external antenna version is presented here.

8.2.4 Test Result

Live Line

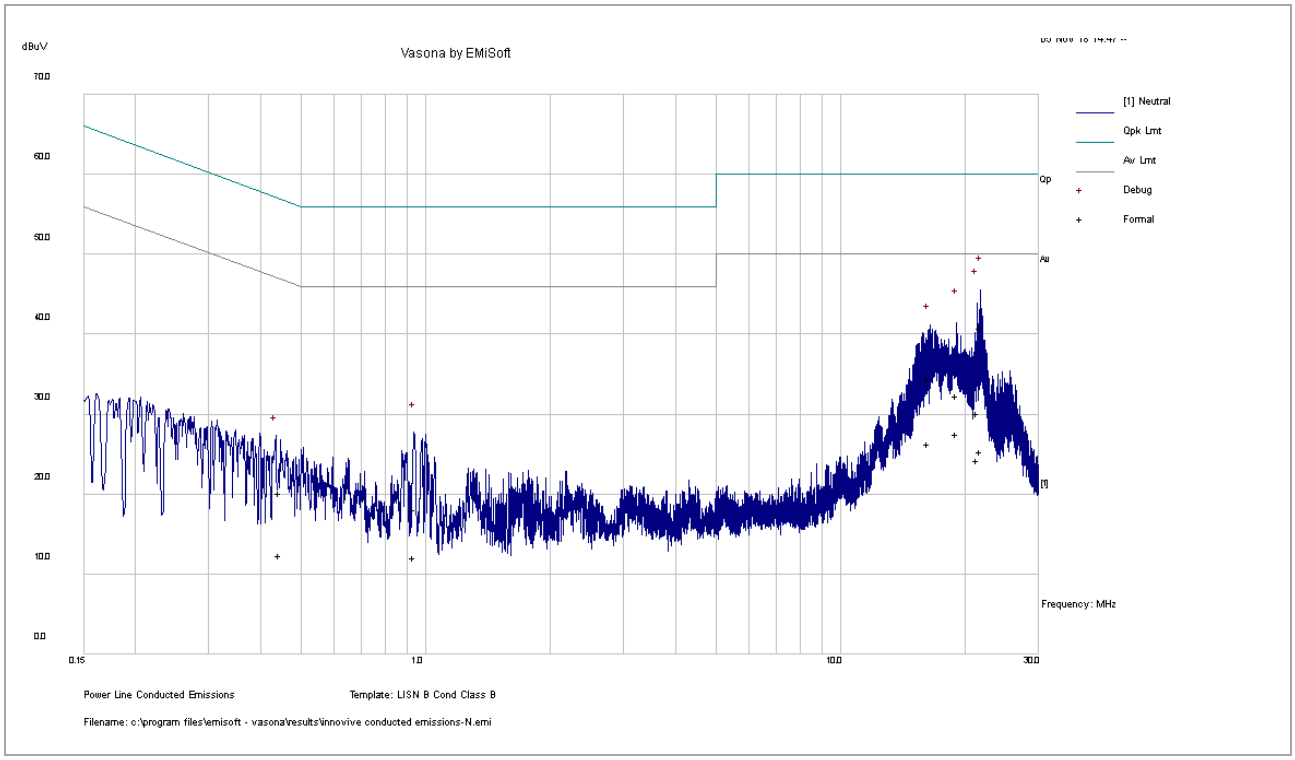
Test Standard:	**47CFR 15.207**	**Mode:**	**Line**
Frequency Range:	**0.15-30MHz**	**Test Date:**	**11/05/2018**
Antenna Type/Polarity:	**N/A**	**Test Personnel:**	**David Zhang**
Remark:	**External antenna version**	**Test Result:**	**Pass**



Frequency (MHz)	Raw (dBuV)	Cable Loss (dB)	Factors (dB)	Level (dBuV/m)	Meas. Type	Line	Limit (dBuV/m)	Margin (dB)	Pass /Fail
0.46	16.91	10.11	0.28	27.29	QP	Live	56.77	-29.48	Pass
1.34	10.84	10.18	0.53	21.56	QP	Live	56.00	-34.44	Pass
4.02	5.17	10.34	2.35	17.85	QP	Live	56.00	-38.15	Pass
16.39	10.78	10.69	13.87	35.33	QP	Live	60.00	-24.67	Pass
19.26	7.49	10.76	15.81	34.06	QP	Live	60.00	-25.94	Pass
26.46	2.71	10.87	14.33	27.91	QP	Live	60.00	-32.09	Pass
0.46	10.45	10.11	0.28	20.84	AV	Live	46.77	-25.93	Pass
1.34	4.03	10.18	0.53	14.74	AV	Live	46.00	-31.26	Pass
4.02	-1.02	10.34	2.35	11.67	AV	Live	46.00	-34.33	Pass
16.39	1.83	10.69	13.87	26.39	AV	Live	50.00	-23.61	Pass
19.26	1.33	10.76	15.81	27.90	AV	Live	50.00	-22.10	Pass
26.46	-4.56	10.87	14.33	20.64	AV	Live	50.00	-29.36	Pass

Neutral Line

Test Standard:	47CFR 15.207	Mode:	Neutral
Frequency Range:	0.15-30MHz	Test Date:	11/05/2018
Antenna Type/Polarity:	N/A	Test Personnel:	David Zhang
Remark:	External antenna version	Test Result:	Pass



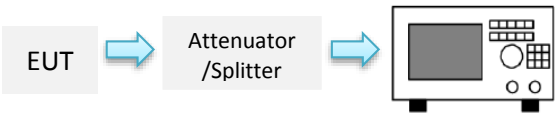
Frequency (MHz)	Raw (dBuV)	Cable Loss (dB)	Factors (dB)	Level (dBuV/m)	Meas. Type	Line	Limit (dBuV/m)	Margin (dB)	Pass /Fail
0.44	9.74	10.11	0.28	20.13	QP	Neutral	57.00	-36.87	Pass
0.93	7.59	10.15	0.39	18.13	QP	Neutral	56.00	-37.87	Pass
16.31	9.91	10.69	13.82	34.41	QP	Neutral	60.00	-25.59	Pass
19.04	5.85	10.76	15.74	32.35	QP	Neutral	60.00	-27.65	Pass
21.30	3.57	10.79	15.82	30.18	QP	Neutral	60.00	-29.82	Pass
21.75	14.18	10.79	15.91	40.88	QP	Neutral	60.00	-19.12	Pass
0.44	1.97	10.11	0.28	12.36	AV	Neutral	47.00	-34.64	Pass
0.93	1.53	10.15	0.39	12.06	AV	Neutral	46.00	-33.94	Pass
16.31	1.78	10.69	13.82	26.28	AV	Neutral	50.00	-23.72	Pass
19.04	1.03	10.76	15.74	27.53	AV	Neutral	50.00	-22.47	Pass

8.3 20 dB Bandwidth

8.3.1 Requirement

Per § 15.247 (a) (1) (i), 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; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

8.3.2 Test setup



8.3.3 Test Procedure

According to section 6.9.2, in ANSI C63.10-2013:

Measurement is made with the occupied bandwidth measurement function incorporated in spectrum analyzer. The following setting are used per ANSI C63.10-2013.

1. Set Center Frequency = Nominal EUT channel center frequency.
2. Set Span to be between two times and five times of the OBW.
3. RBW shall be in the range of 1% to 5% of the OBW, and VBW shall be approximately three times RBW.
4. Set detection mode to peak and trace mode to max hold.
5. Use the occupied bandwidth measurement function to place two markers, one at the lowest frequency and the other at the highest frequency of the envelope of the spectral display, such that each marker is at or slightly below the “-xx dB down amplitude” determined.
6. The occupied bandwidth shall be reported by providing plot(s) of the measuring instrument display; the plot axes and the scale units per division shall be clearly labelled. Tabular data may be reported in addition to the plot(s).

8.3.4 Test Result

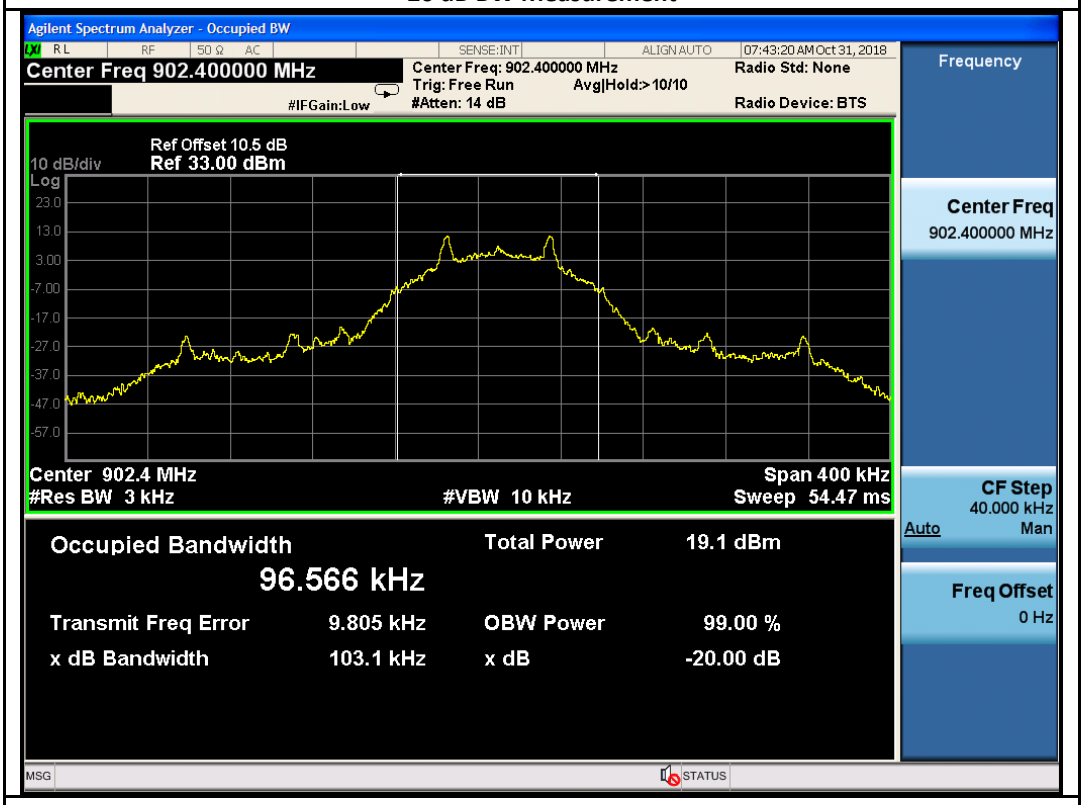
Radio	Test Frequency (MHz)	Measured Bandwidth (KHz)	Maximum Bandwidth (KHz)	Result
Sub-GHz radio	902.4	103.1	500	Pass
	915.0	101.5	500	Pass
	927.6	103.0	500	Pass

Note: both RF paths are verified and the results were found identical.

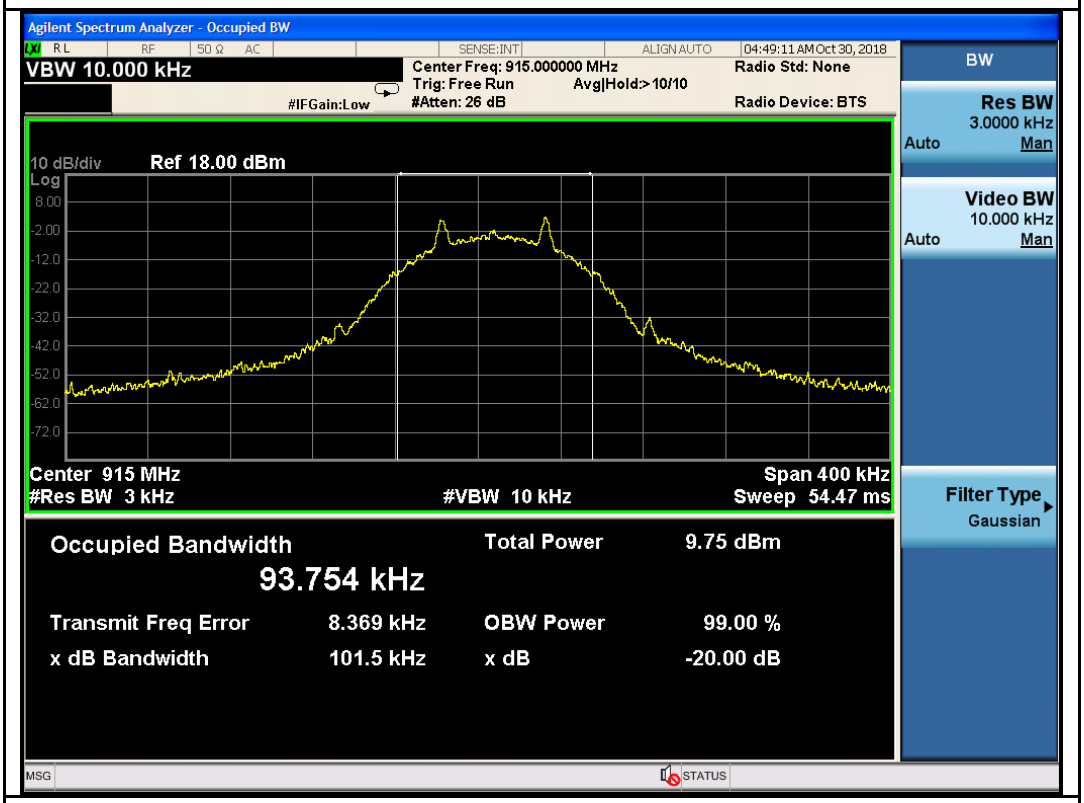
Only one set of data is presented here.

8.3.5 Test Plots

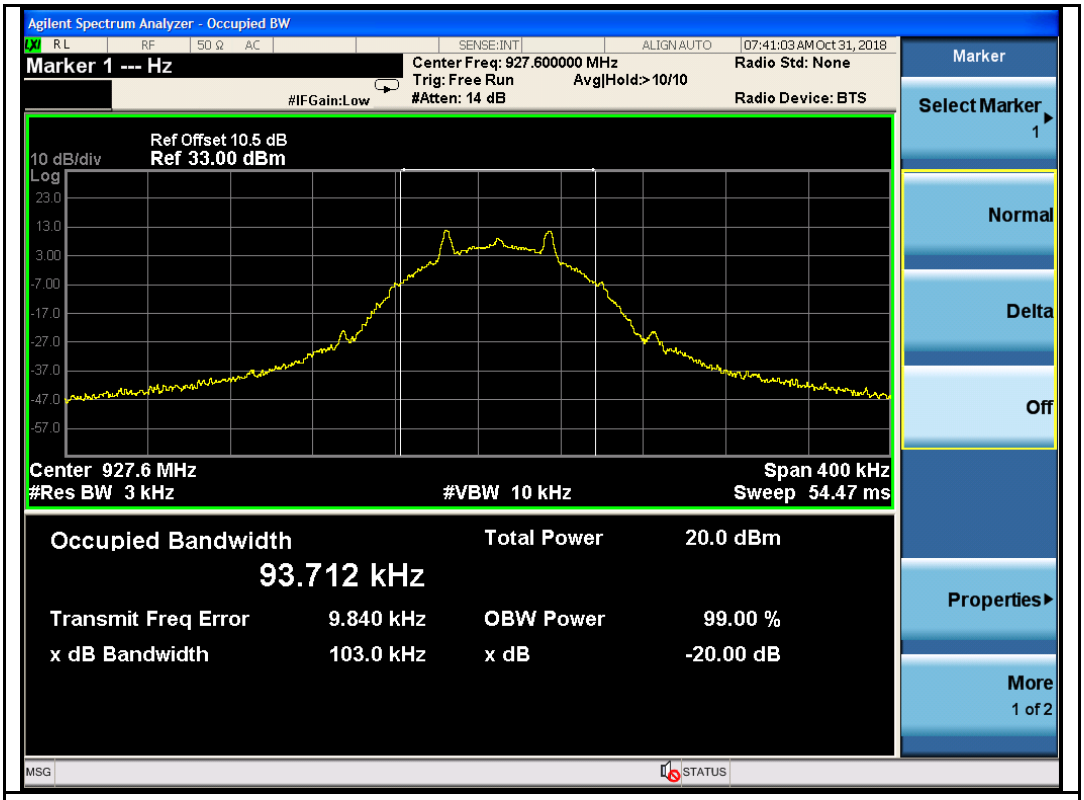
20 dB BW Measurement



20 dB Bandwidth – 902.4MHz



20 dB Bandwidth – 915MHz



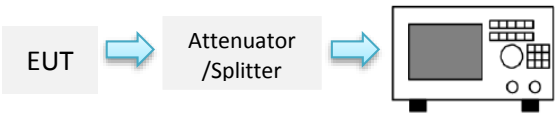
20 dB Bandwidth – 927.6MHz

8.4 Number of Hopping Channel

8.4.1 Requirement

Per § 15.247 (a) (1) (i), 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; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

8.4.2 Test setup



8.4.3 Test Procedure

According to section 7.8.3, in ANSI C63.10-2013:

Measurement is made with spectrum analyzer. The following setting is used.

1. Set Span to be the frequency band of operation.
2. Set RBW to less 30% of the channel spacing or the 20 dB bandwidth, whichever is smaller.
3. VBW ≥ RBW.
4. Sweep: Auto.
5. Detector function: Peak.
6. Trace: Max hold.
7. Allow the trace to stabilize.

8.4.4 Test Result

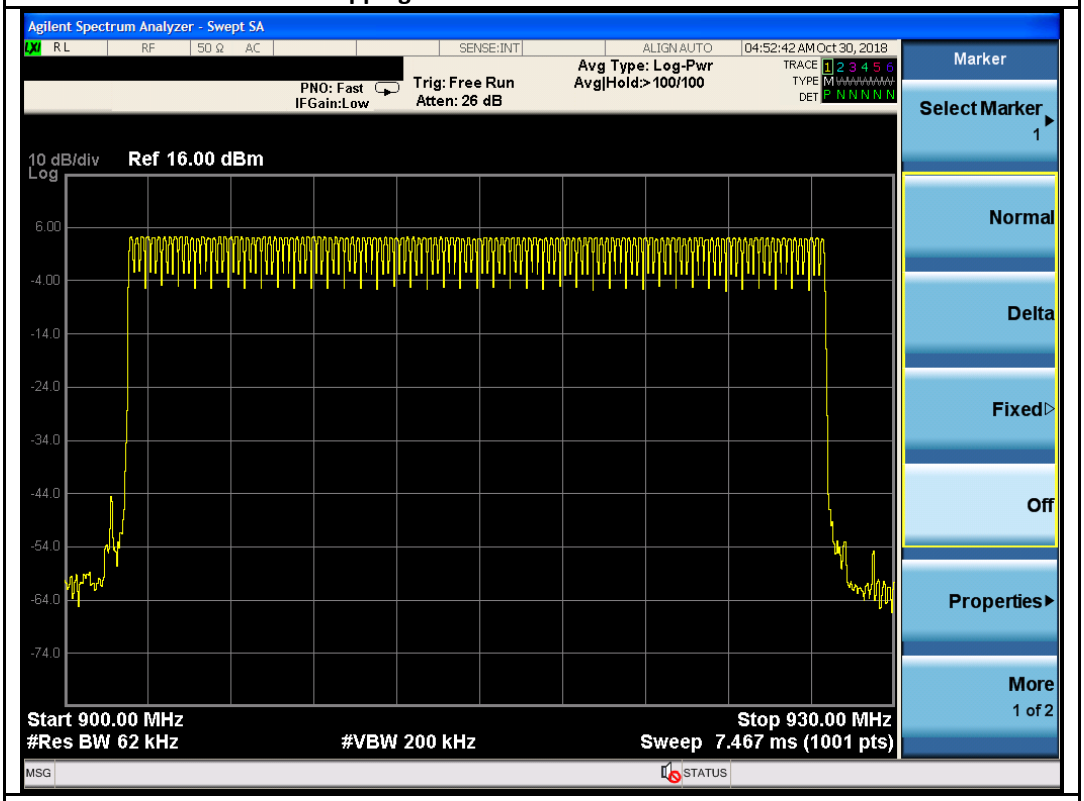
Radio	Test Frequency (MHz)	Channel Number	Limit	Result
Sub-GHz radio	902-928MHz	127	50	Pass

Note: both RF paths are verified and the results were found identical.

Only one set of data is presented here.

8.4.5 Test Plots

Hopping Channel Number Measurement



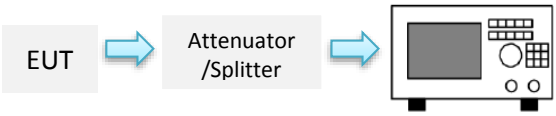
Hopping Channel Number

8.5 Maximum Output Power

8.5.1 Requirement

Per § 15.247 (b)(2), 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, as permitted under paragraph (a)(1)(i) of this section.

8.5.2 Test setup



8.5.3 Test Procedure

According to section 7.8.5 of ANSI C63.10-2013. The measurement was made with EUT directly connected to spectrum analyzer. The following setting is used.

1. Set the RBW > 20 dB BW
2. Set VBW ≥ RBW.
3. Set span to approximately five times the 20 dB bandwidth, centered on a hopping channel.
4. Sweep time = auto couple.
5. Detector = peak.
6. Trace mode = max hold.
7. Allow trace to fully stabilize.
8. Use peak marker function to determine the peak amplitude level.

8.5.4 Test Result

External Dipole Antennas path

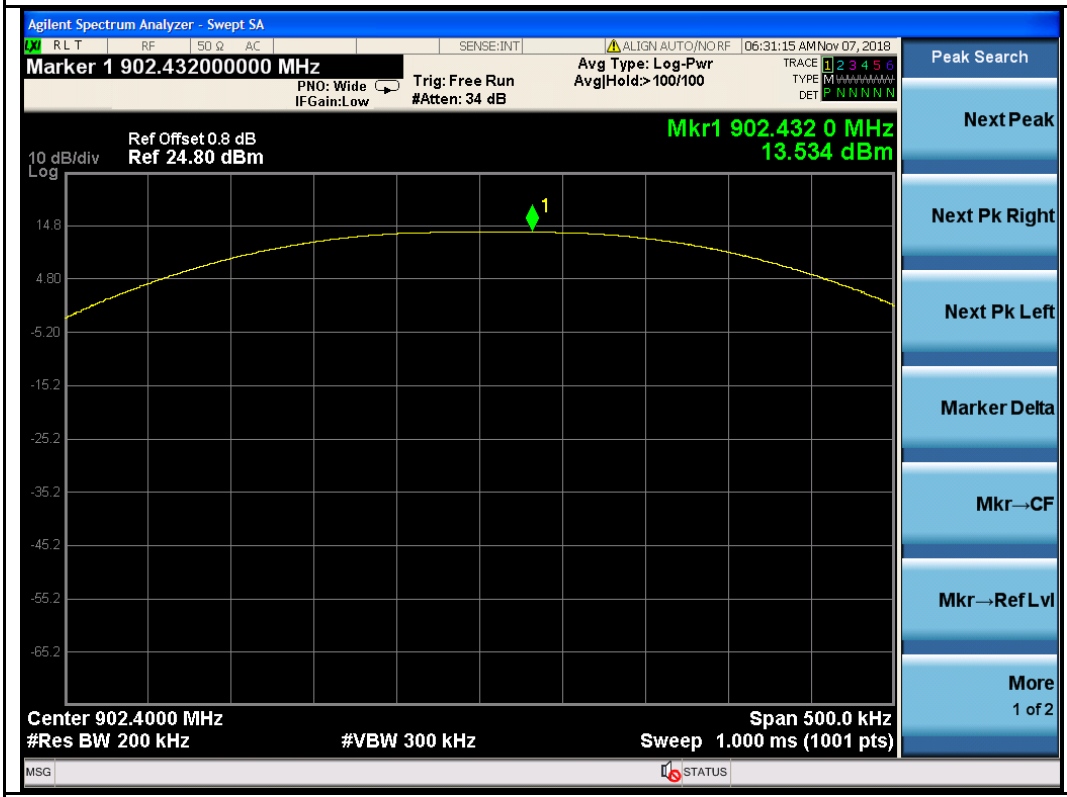
Radio	Test Frequency (MHz)	Measured Output Power (dBm)	Maximum Output Power (dBm)	Result
Sub-GHz radio	902.4	13.534	30	Pass
	915.0	13.591	30	Pass
	927.6	13.578	30	Pass

Internal PCB trace Antenna path

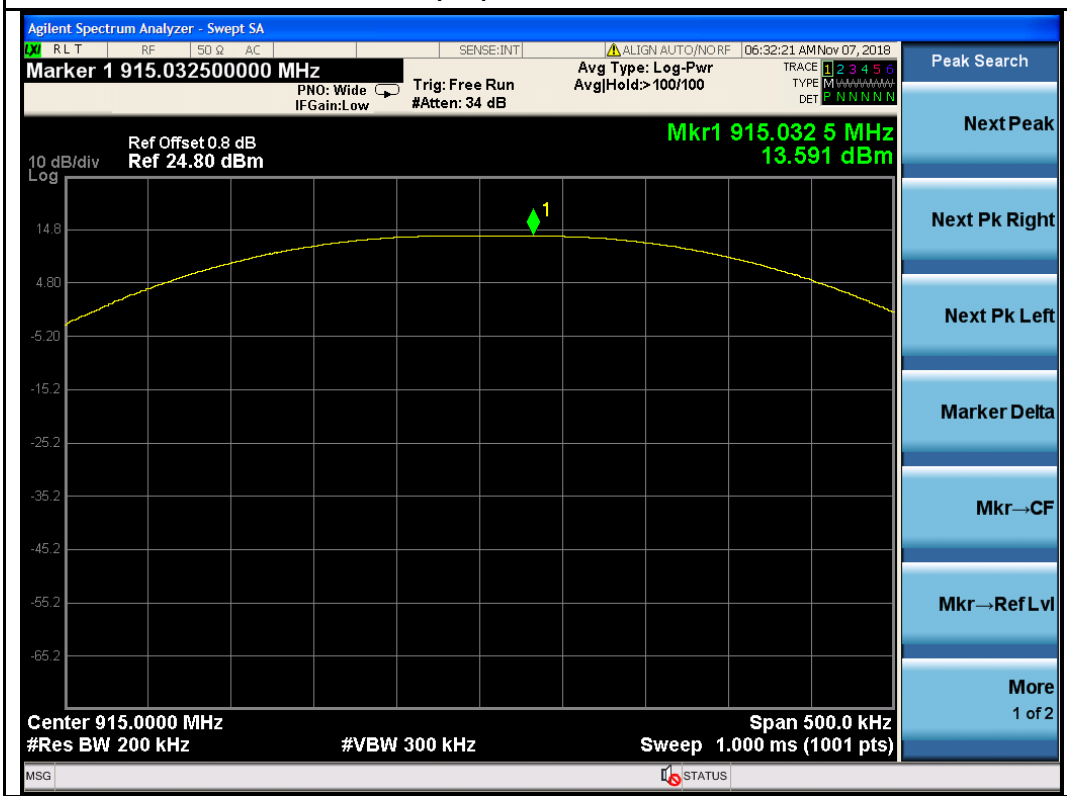
Radio	Test Frequency (MHz)	Measured Output Power (dBm)	Maximum Output Power (dBm)	Result
2.4 GHz Module	902.4	13.907	30	Pass
	915.0	13.746	30	Pass
	927.6	13.439	30	Pass

8.5.5 Test Plots

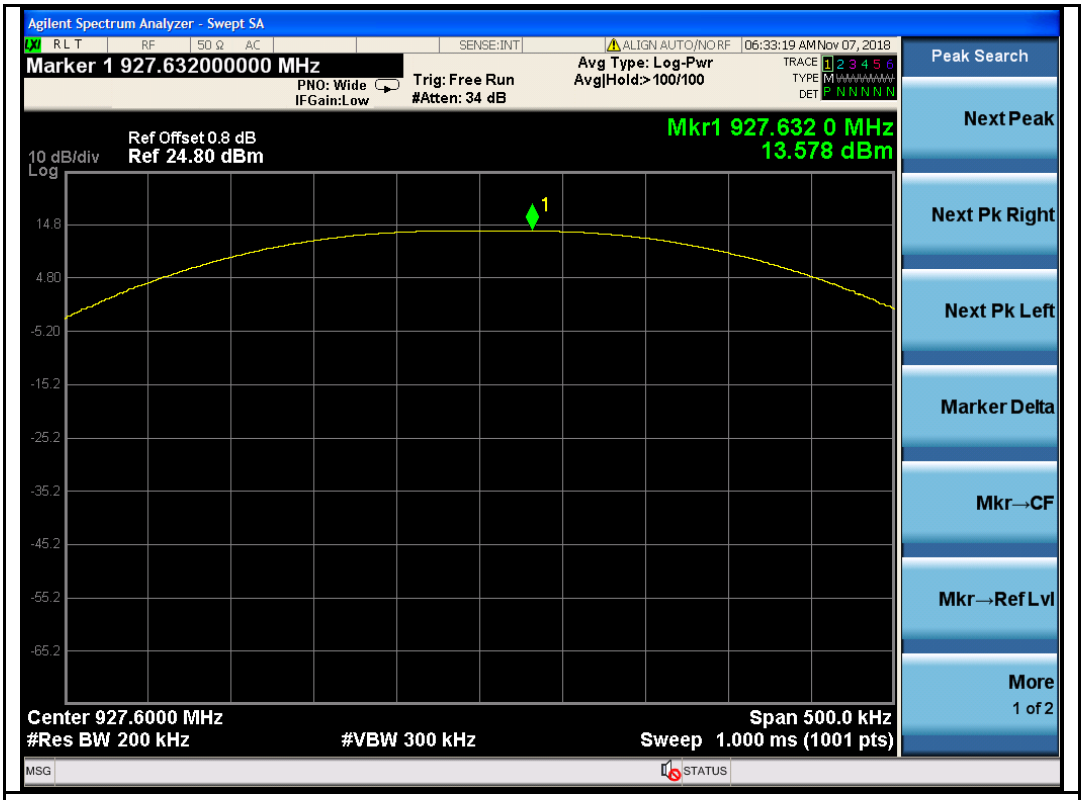
External Antenna Port Measurement



Output power – 902.4MHz

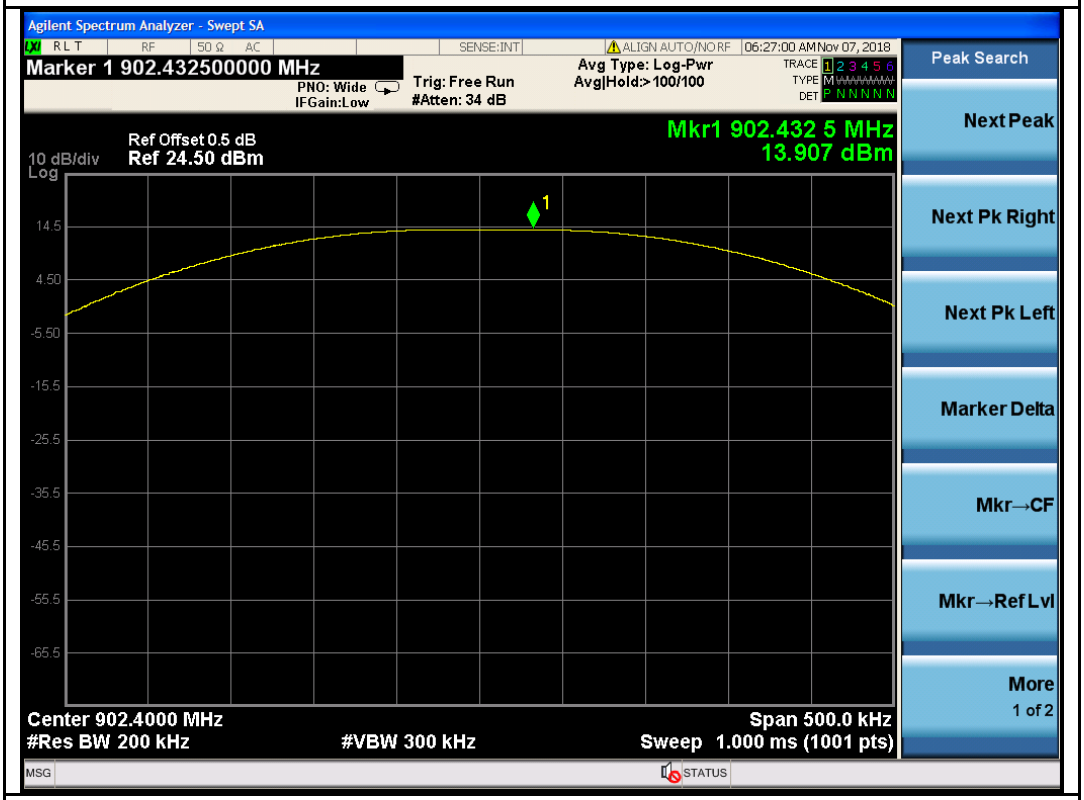


Output power – 915MHz

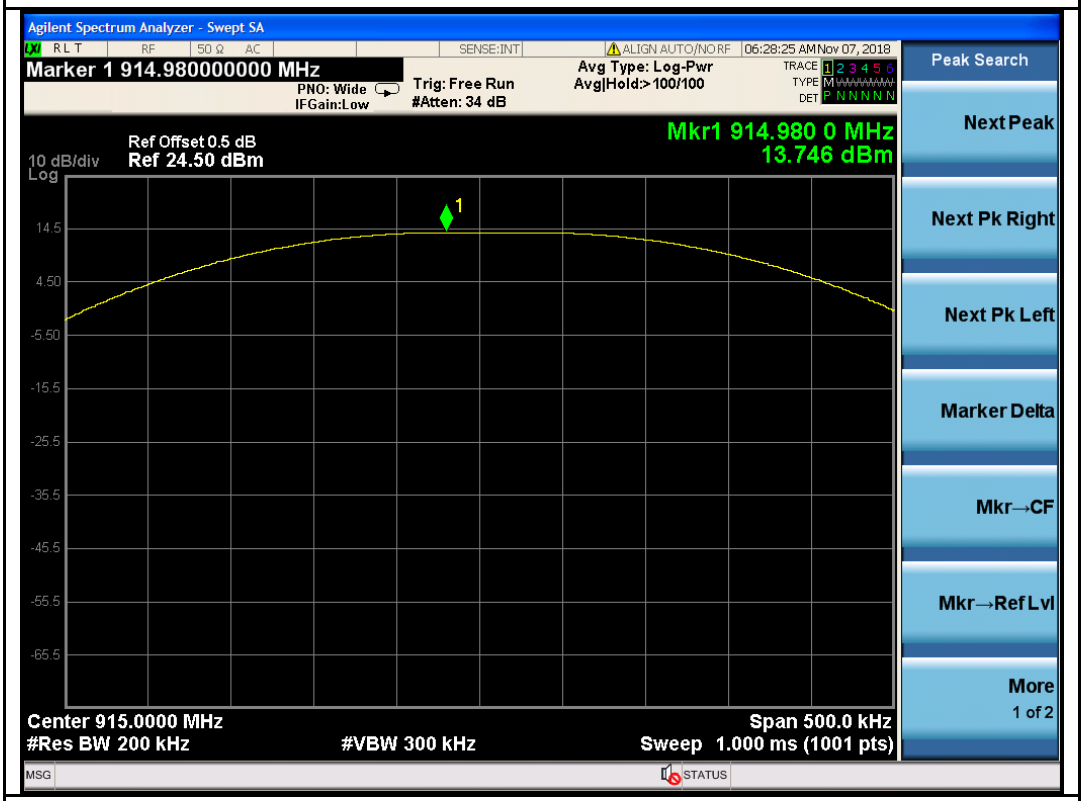


Output power – 927.6MHz

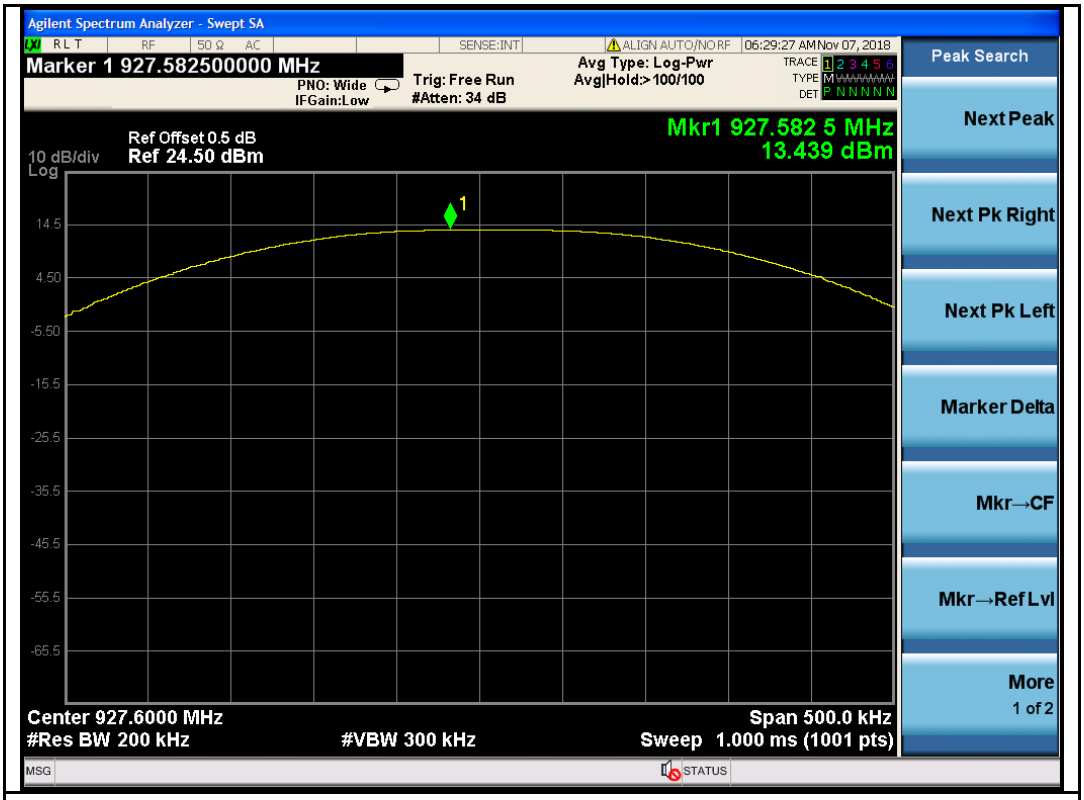
Internal Antenna Port Measurement



Output power – 902.4MHz



Output power – 915MHz



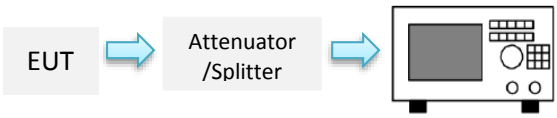
Output power – 927.6MHz

8.6 Channel Separation

8.6.1 Requirement

Per § 15.247 (a) (1), frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater.

8.6.2 Test setup



8.6.3 Test Procedure

According to section 7.8.2 of ANSI C63.10-2013. The measurement was made with spectrum analyzer. The following setting is used.

1. Set Span to wide enough to capture the peaks of two adjacent channels.
2. RBW: Start with the RBW set to approximately 30% of the channel spacing
3. VBW ≥ RBW.
5. Detector = peak.
6. Sweep time = auto couple.
7. Trace mode = max hold.
8. Allow trace to fully stabilize.
9. Use the peak marker function to determine separation between the peaks of adjacent channels.

8.6.4 Test Result

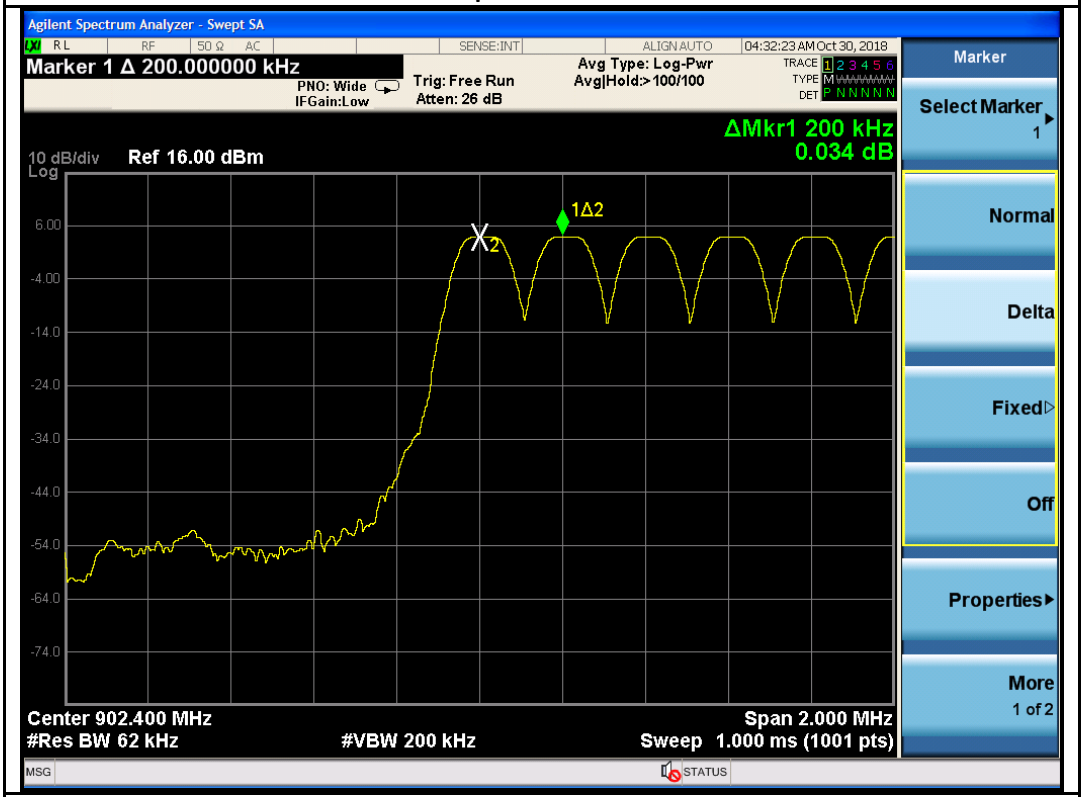
Radio	Test Frequency (MHz)	Channel Separation (KHz)	20 dB Bandwidth (KHz)	Result
Sub-GHz radio	902.4	200	103.1	Pass
	915.0	204	101.5	Pass
	927.6	204	103.0	Pass

Note: both RF paths are verified and the results were found identical.

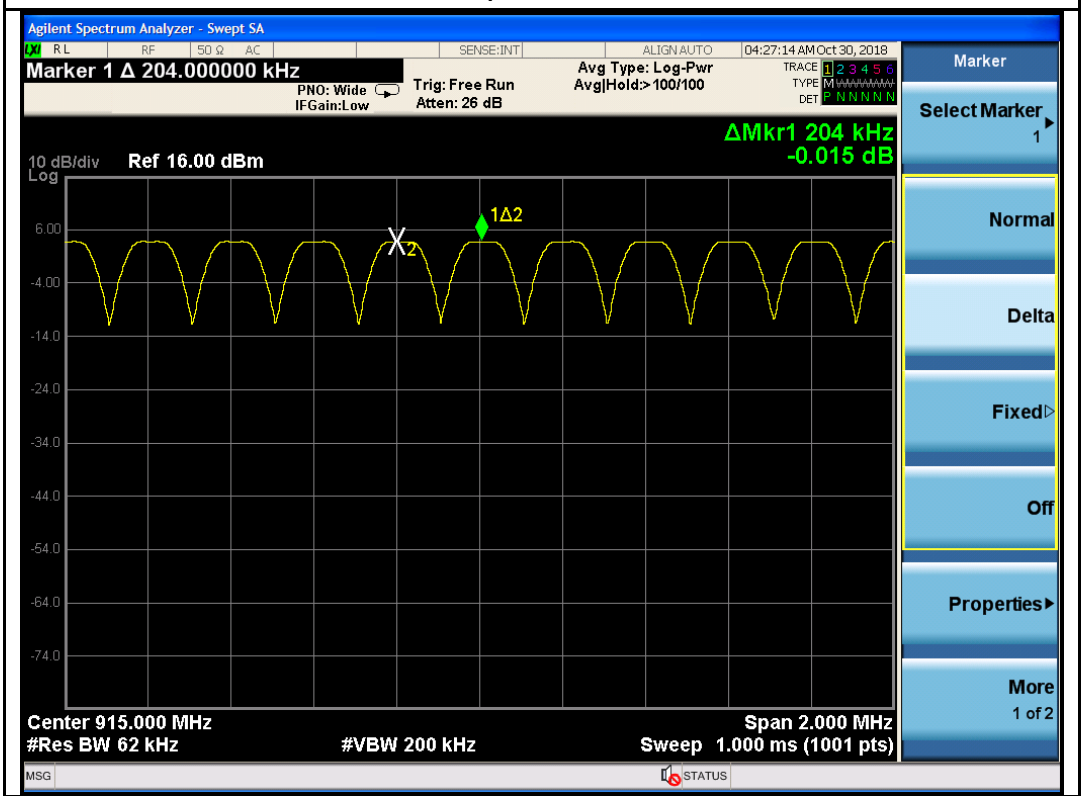
Only one set of data is presented here.

8.6.5 Test Plots

Channel Separation Measurement



Channel Separation – 902.4MHz



Channel Separation – 915.0MHz

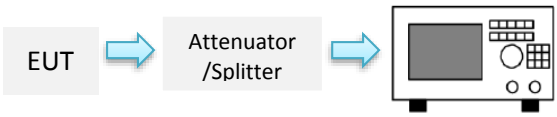
Channel Separation – 927.6MHz

8.7 Time of Occupancy

8.7.1 Requirement

Per § 15.247 (a) (1) (i), 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; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

8.7.2 Test setup



8.7.3 Test Procedure

According to section 7.8.4 of ANSI C63.10-2013. The measurement was made with spectrum analyzer. The following setting is used.

1. Set Span to zero, centered on a hopping channel.
2. RBW shall be ≤ channel spacing.
3. VBW ≥ RBW.
5. Detector = peak.
6. Sweep time = auto couple. As necessary to capture the entire dwell time per hopping channel; where possible use a video trigger and trigger delay so that the transmitted signal starts a little to the right of the start of the plot. The trigger level might need slight adjustment to prevent triggering when the system hops on an adjacent channel; a second plot might be needed with a longer sweep time to show two successive hops on a channel.
7. Trace mode = max hold.
8. Allow trace to fully stabilize.
9. Use the marker-delta function to determine the transmit time per hop.

8.7.4 Test Result

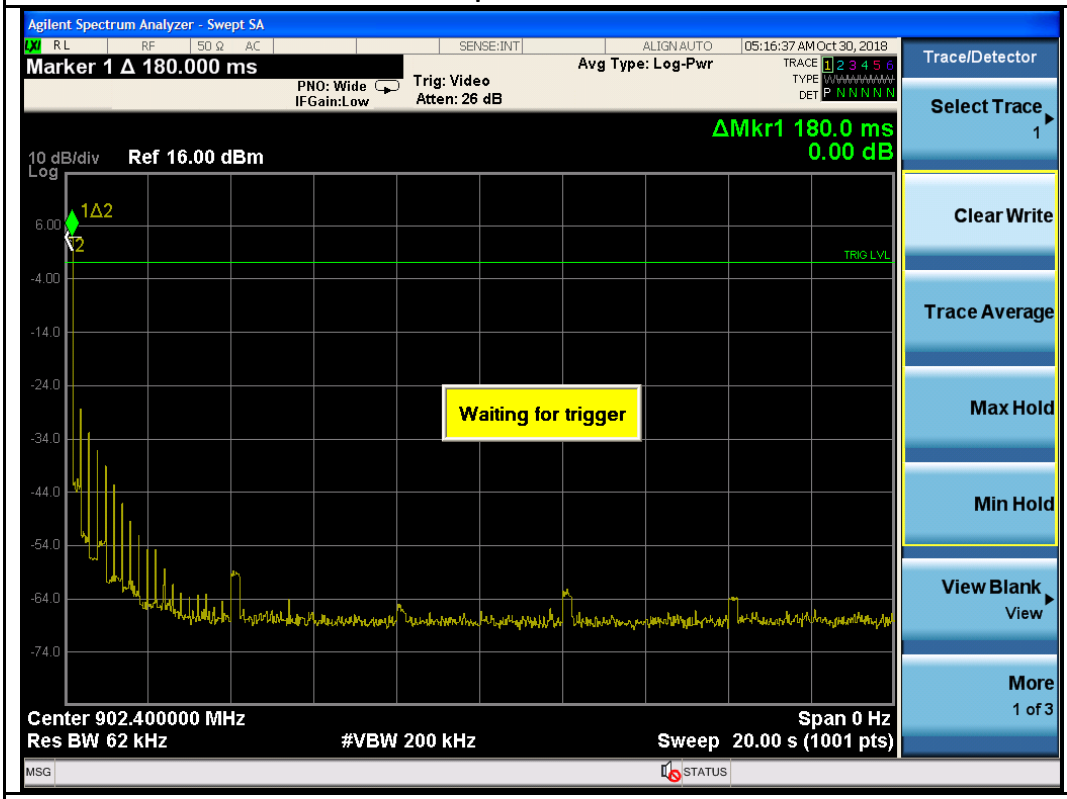
Radio	Test Frequency (MHz)	Pulse time (ms)	Repetition (times)	Total Dwell time (sec)	Limit (sec)	Result
Sub-GHz radio	902.4	197	1	0.197	0.4	Pass
	915.0	197	1	0.197	0.4	Pass
	927.6	195	1	0.195	0.4	Pass

Note: both RF paths are verified and the results were found identical.

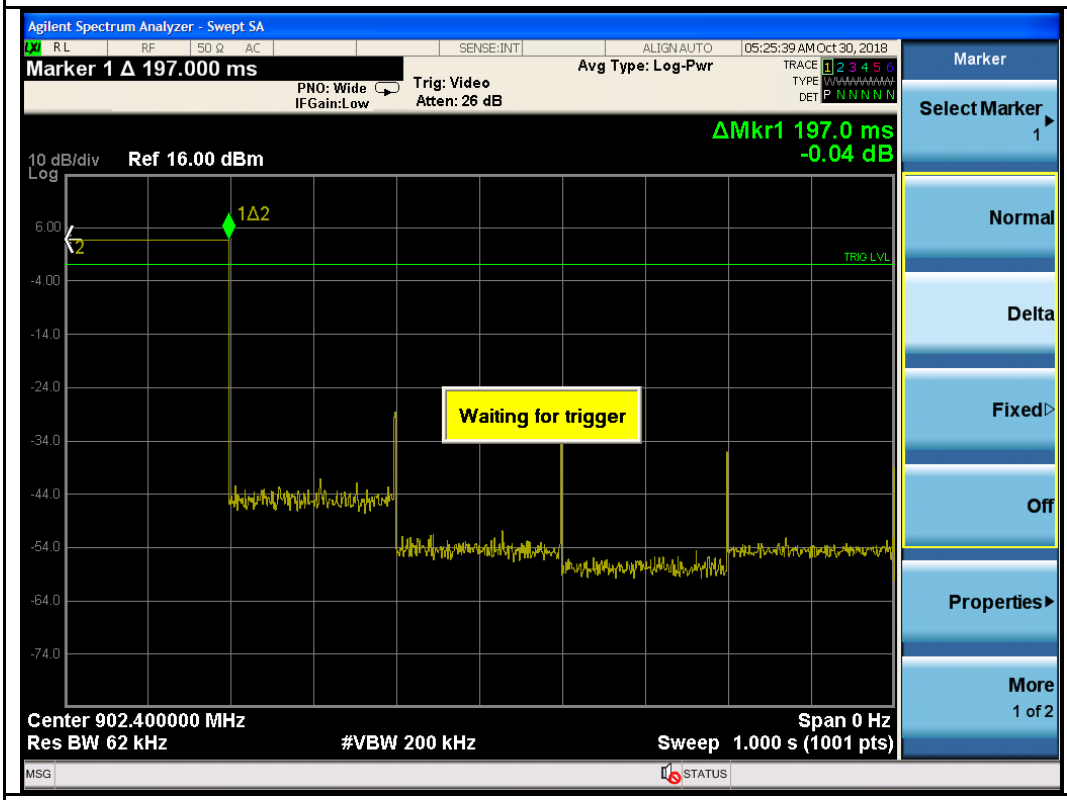
Only one set of data is presented here.

8.7.5 Test Plots

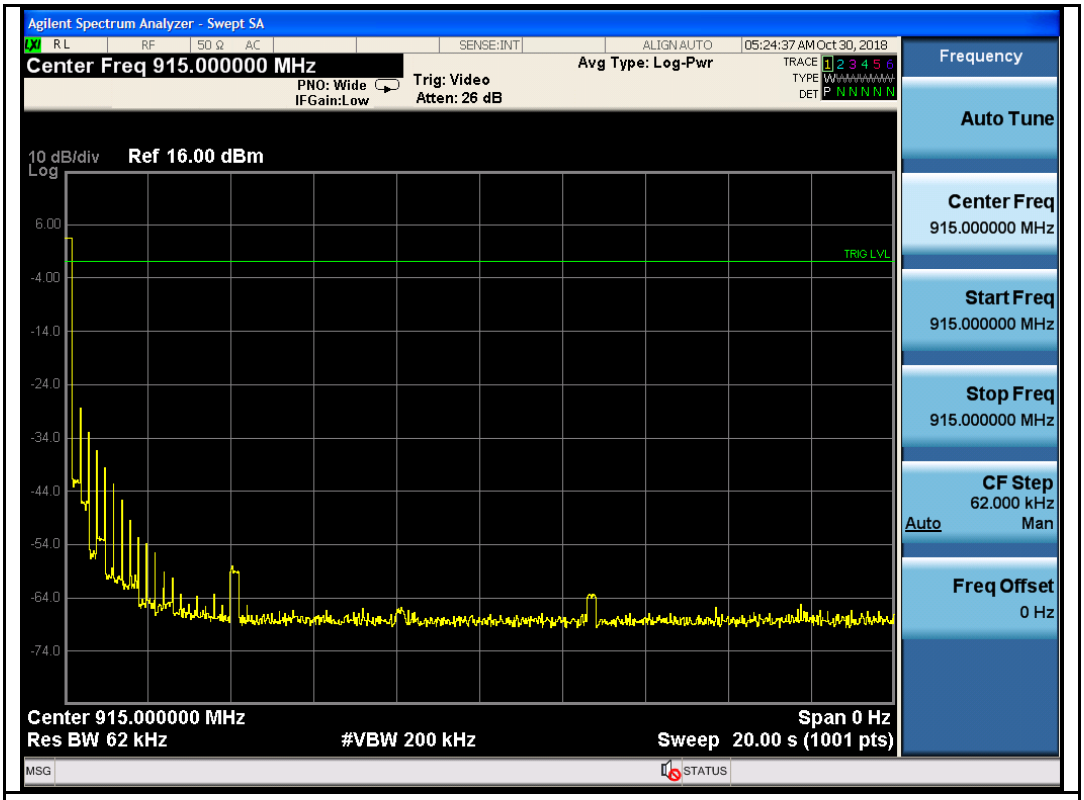
Channel Separation Measurement



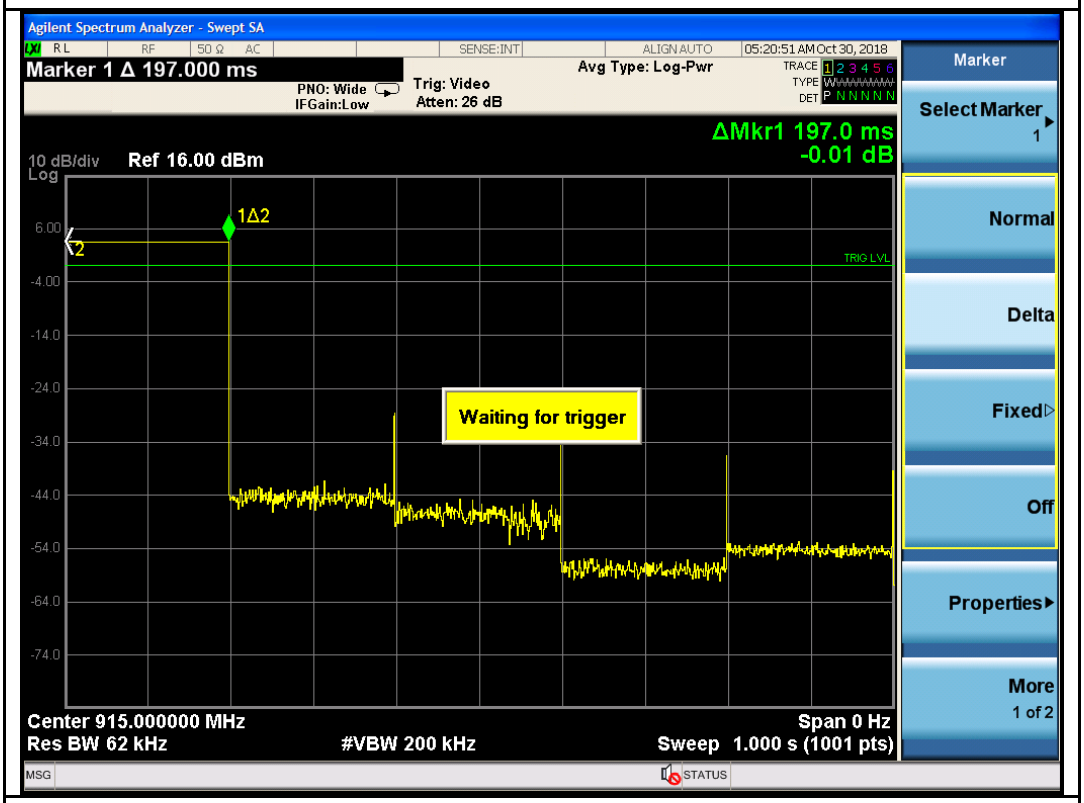
Dwell time – 902.4MHz - Repetition



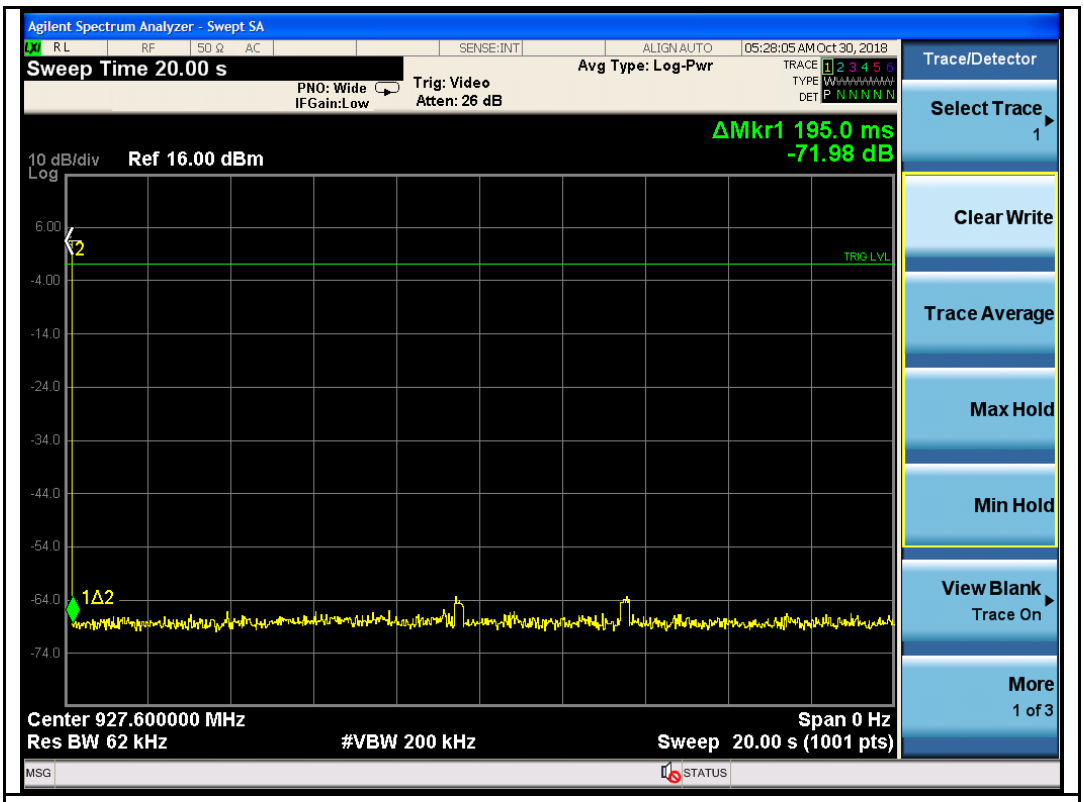
Dwell time – 902.4MHz – Pulse width



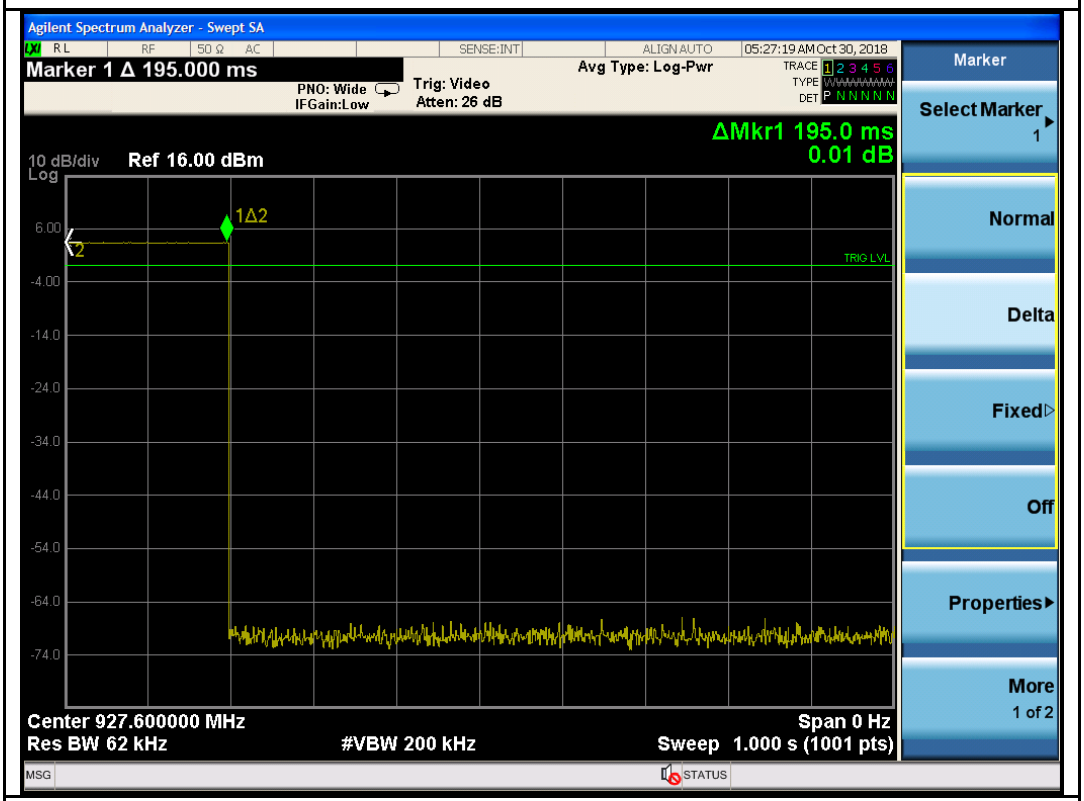
Dwell time – 915.0MHz - Repetition



Dwell time – 915.0MHz – Pulse width



Dwell time – 927.6MHz - Repetition



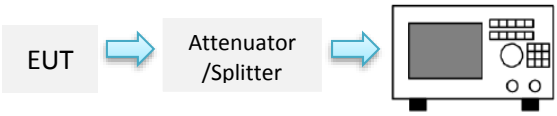
Dwell time – 927.6MHz – Pulse width

8.8 Conducted Unwanted Emissions Measurement

8.8.1 Requirement

Per § 15.247 (d), in any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits.

8.8.2 Test setup



8.8.3 Test Procedure

According to section 7.8.8 of ANSI C63.10-2013.

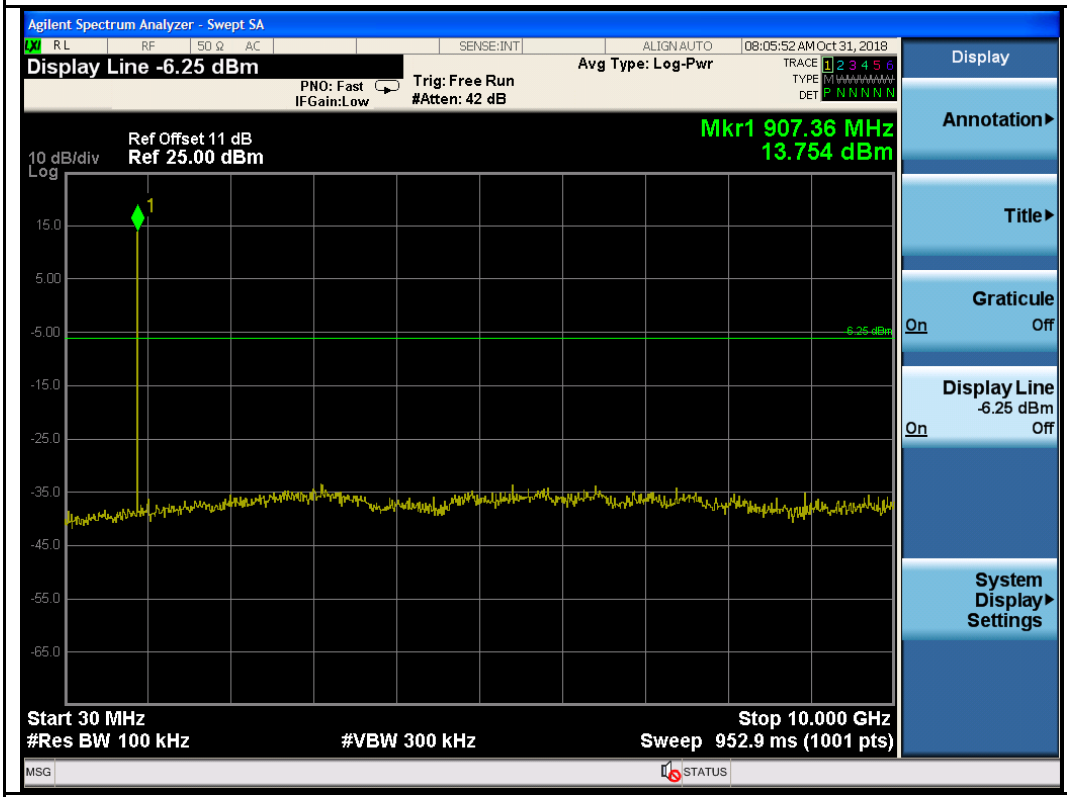
Connect the primary antenna port through an attenuator to the spectrum analyzer input; in the results, account for all losses between the unlicensed wireless device output and the spectrum analyzer. The instrument shall span 30 MHz to 10 times the operating frequency in GHz, with a resolution bandwidth of 100 kHz, video bandwidth of 300 kHz, and a coupled sweep time with a peak detector. The band 30 MHz to the highest frequency may be split into smaller spans, as long as the entire spectrum is covered. The following setting is used.

8.8.4 Test Result

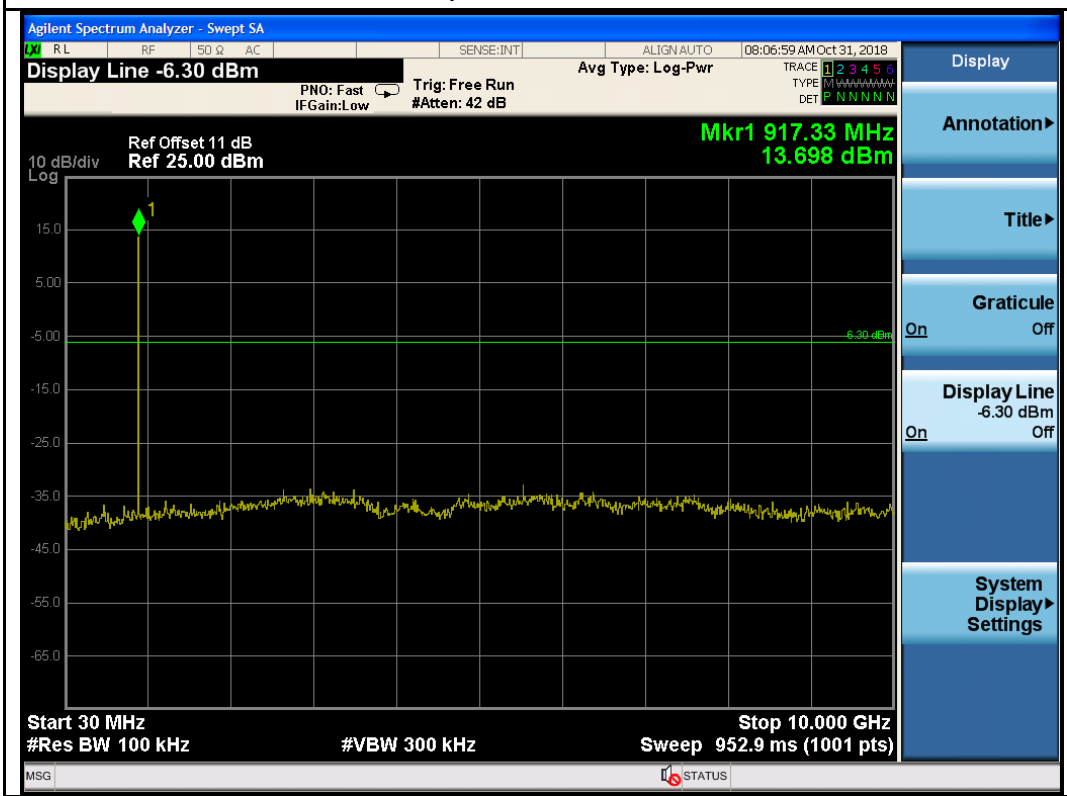
See test plots

8.8.5 Test Plots

External Antenna Port Measurement

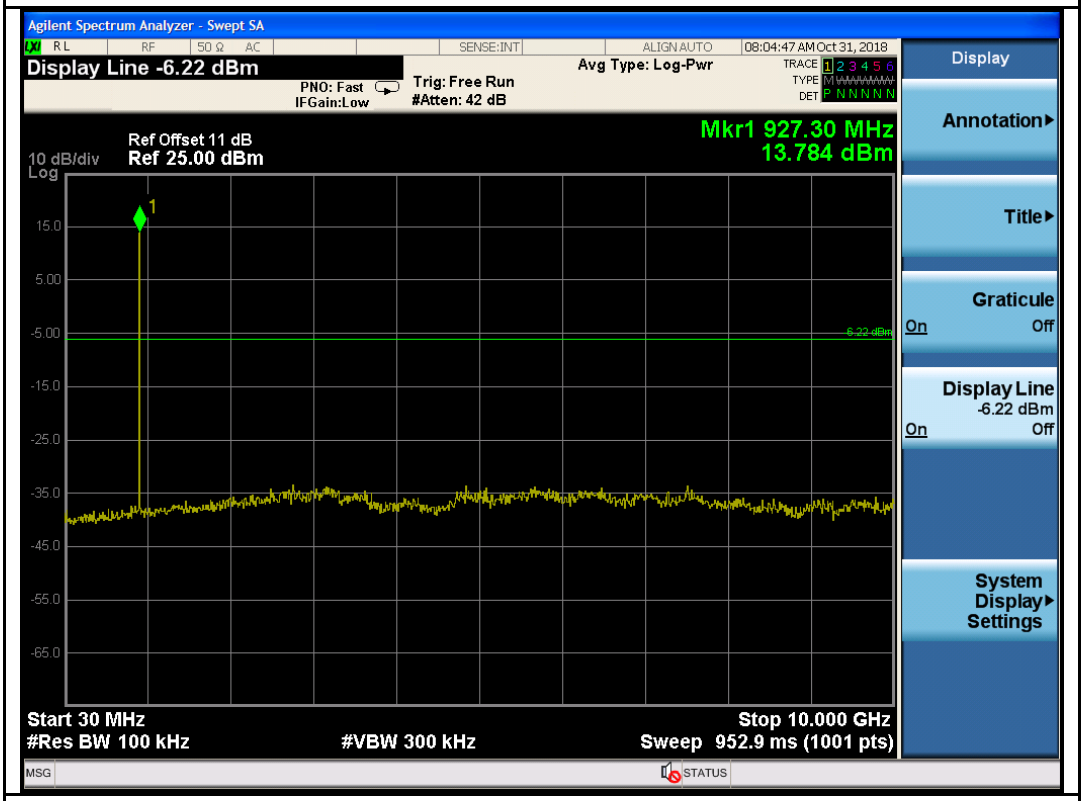


Conducted Spurious Emission – 902.4MHz



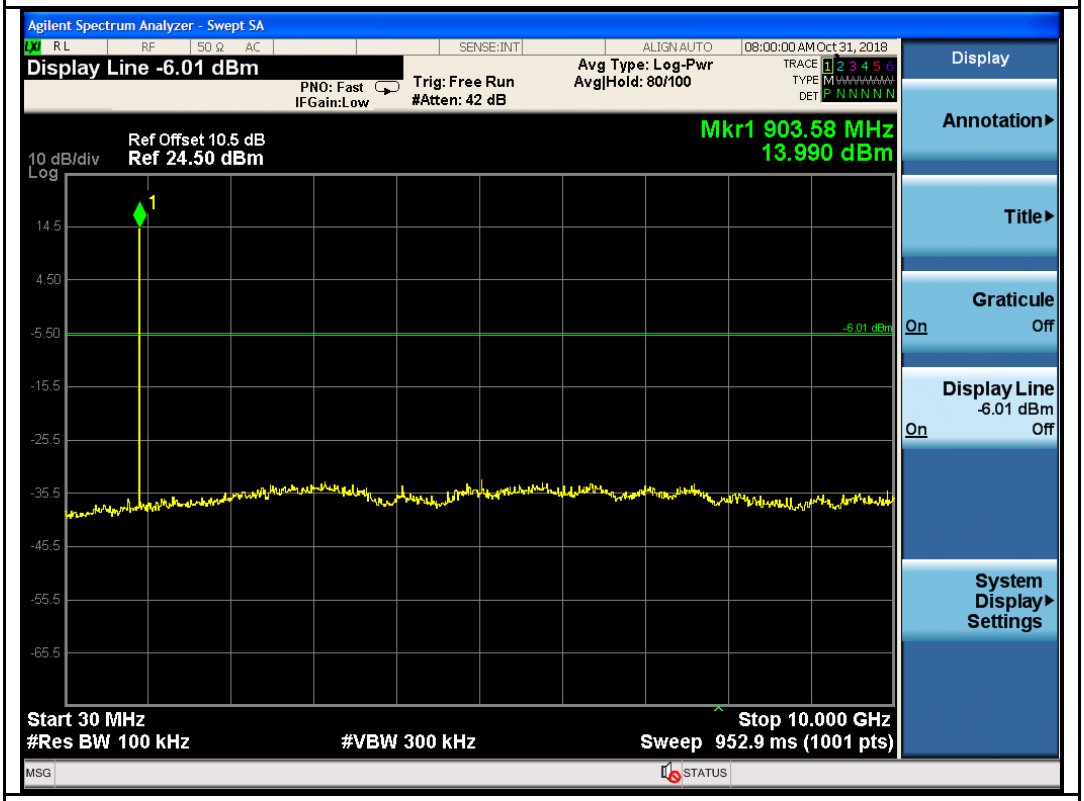
Conducted Spurious Emission – 915.0MHz

External Antenna Port Measurement

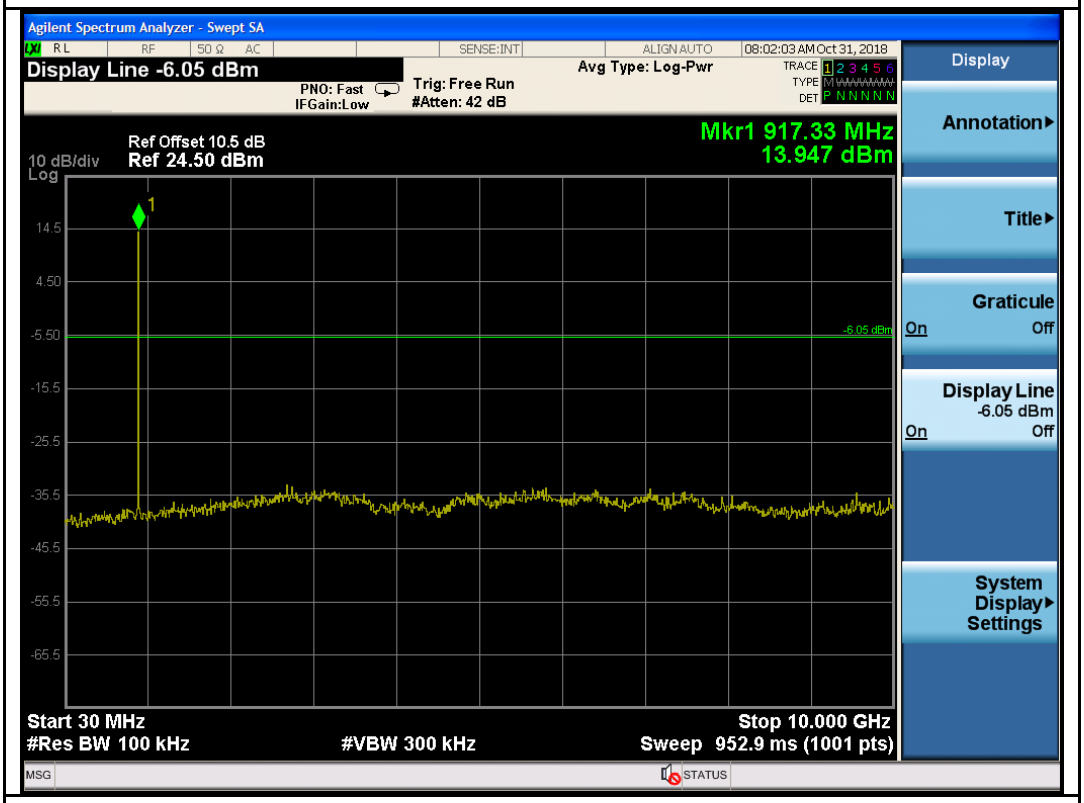


Conducted Spurious Emission – 927.6MHz

Internal Antenna Port Measurement

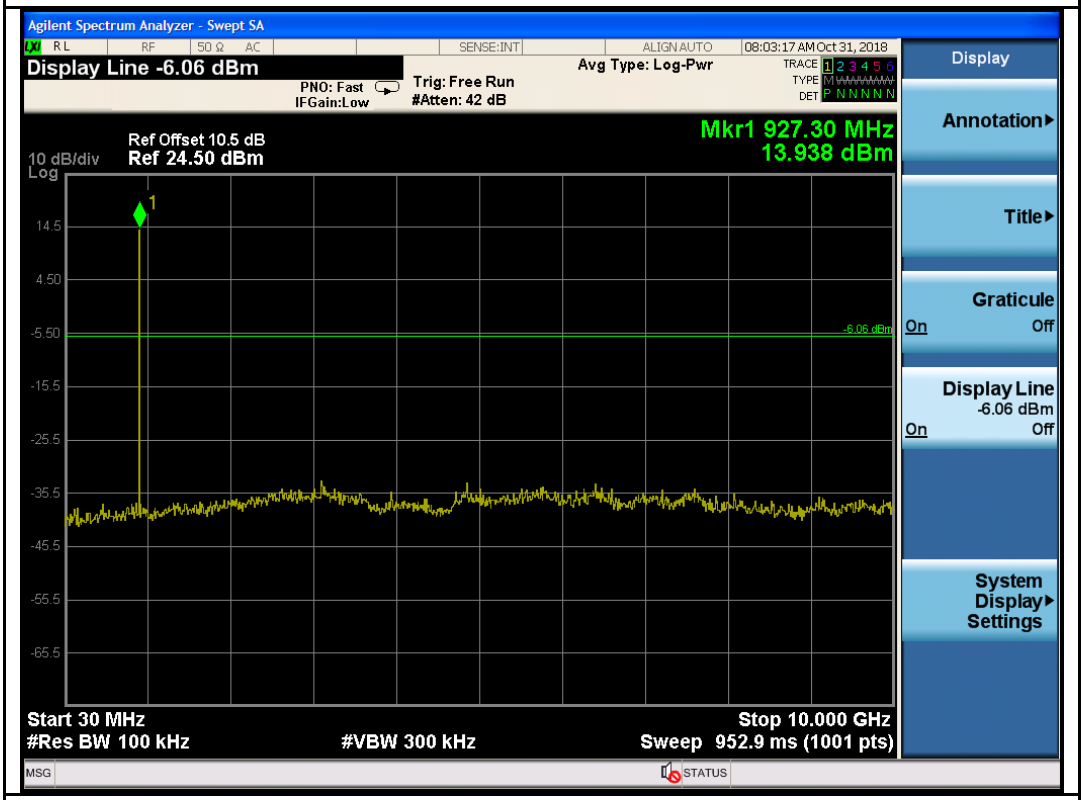


Conducted Spurious Emission – 902.4MHz



Conducted Spurious Emission – 915.0MHz

Internal Antenna Port Measurement



Conducted Spurious Emission – 927.6MHz

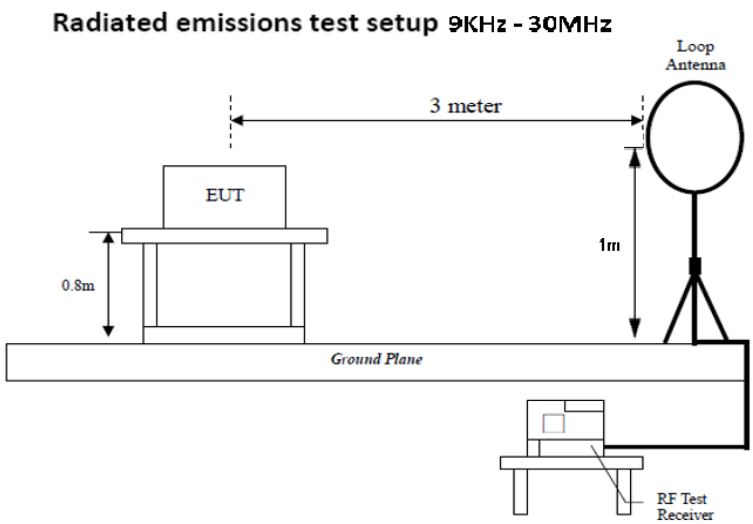
8.9 Radiated Band-Edge & Spurious Emissions into Restricted Frequency Bands

8.9.1 Requirement

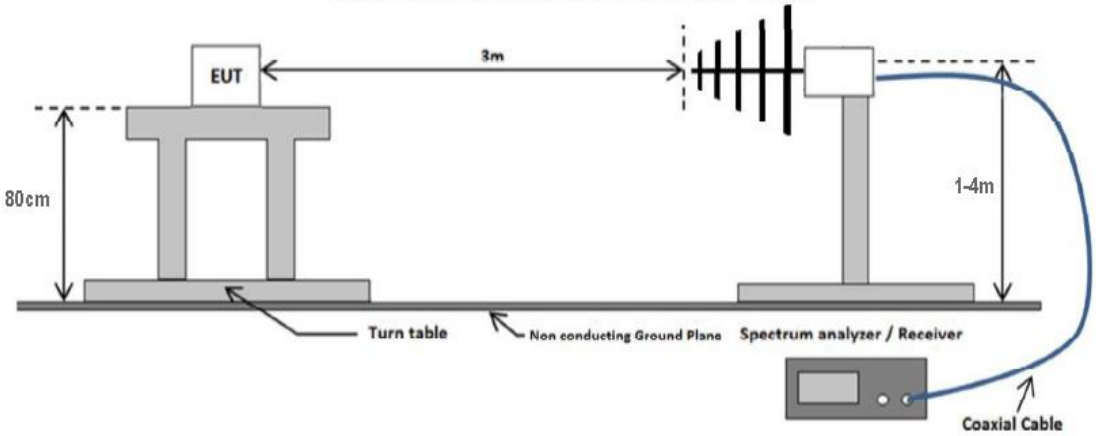
Per § 15.247 (d), in any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

Frequency range (MHz)	Field Strength (µV/m)
0.009~0.490	2400/F(KHz)
0.490~1.705	24000/F(KHz)
1.705~30.0	30
30 – 88	100
88 – 216	150
216 960	200
Above 960	500

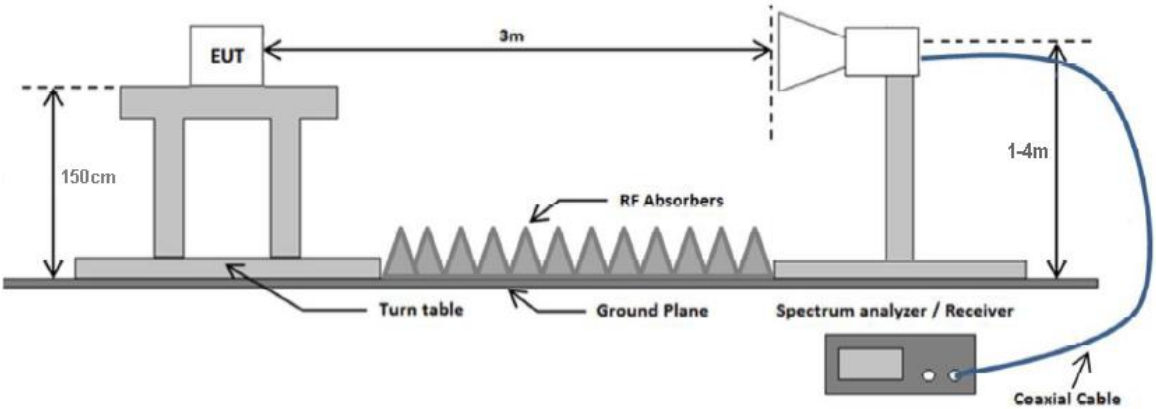
8.9.2 Test setup



Radiated emissions test setup 30 MHz - 1 GHz



Radiated emissions test setup above 1 GHz



8.9.3 Test Procedure

According to section 6 .5 and 6.6 Radiated spurious emission measurements in ANSI C63.10-2013 as well as the procedures for maximizing and measuring radiated emissions that are described in ANSI C63.10 was followed. Boresight antenna mast was used during the scanning to point to EUT to maximize the emission. The process will be repeated in three EUT orientations.

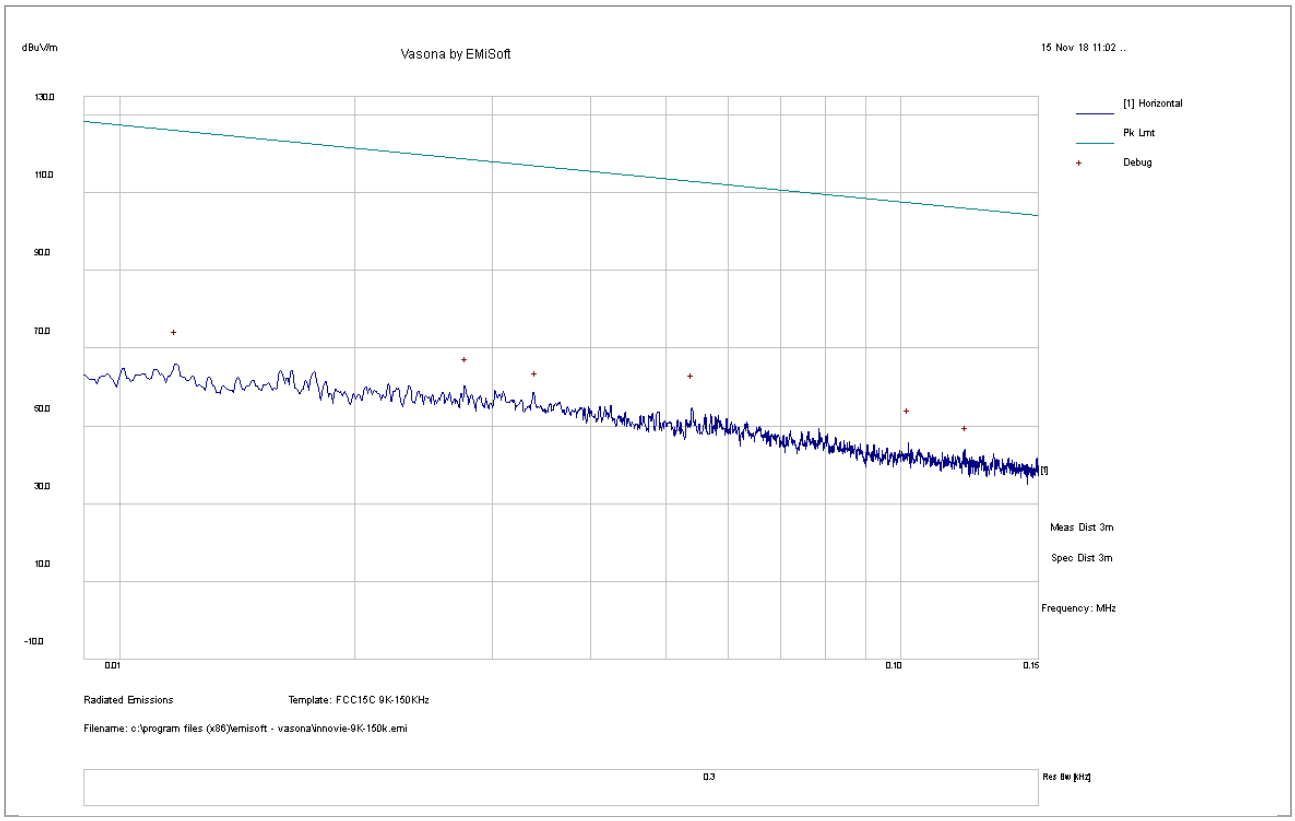
1. The EUT was switched on and allowed to warm up to its normal operating condition.
2. The test was carried out at the selected frequency points obtained from the EUT characterization. Maximization of the emissions, was carried out by rotating the EUT, changing the antenna polarization, and adjusting the antenna height in the following manner:
   a. Vertical or horizontal polarization (whichever gave the higher emission level over a full rotation of the EUT) was chosen.
   b. The EUT was then rotated to the direction that gave the maximum emission.
   c. Finally, the antenna height was adjusted to the height that gave the maximum emission.
3. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 120 kHz for Quasi-Peak detection at frequency below 1GHz.
4. The resolution bandwidth of test receiver/spectrum analyzer is 1MHz and video bandwidth is 3MHz with Peak detection for Peak measurement at frequency above 1GHz.

   The resolution bandwidth of test receiver/spectrum analyzer is 1MHz and the video bandwidth is 10Hz with Peak detection for Average Measurement as below at frequency above 1GHz.
5. Steps 2 and 3 were repeated for the next frequency point, until all selected frequency points were measured.

8.9.4 Test Result

9KHz – 150KHz test result

Test Standard:	**47CFR 15.209**	**Mode:**	**915MHz**
Frequency Range:	**Below 150KHz**	**Test Date:**	**11/14/2018**
Antenna Type/Polarity:	**Loop / 0 deg & 90 deg**	**Test Personnel:**	**David Zhang**
Remark:	**External antenna**	**Test Result:**	**Pass**



Frequency MHz	Raw dB	Cable dB	AF dB	Level dBuV/m	Det	Pol deg	Height cm	Table cm	Limit dBuV/m	Margin dB
0.012	55.15	0.33	10.44	65.92	PK	0	100	65	126.15	-60.23
0.028	44.91	0.41	13.49	58.81	PK	0	100	220	118.73	-59.92
0.034	40.92	0.43	13.73	55.09	PK	0	100	109	116.95	-61.86
0.054	41.57	0.48	12.57	54.62	PK	0	100	21	112.95	-58.33
0.102	34.07	0.54	11.00	45.61	PK	0	100	98	107.42	-61.81
0.121	29.49	0.56	11.00	41.05	PK	0	100	11	105.92	-64.87

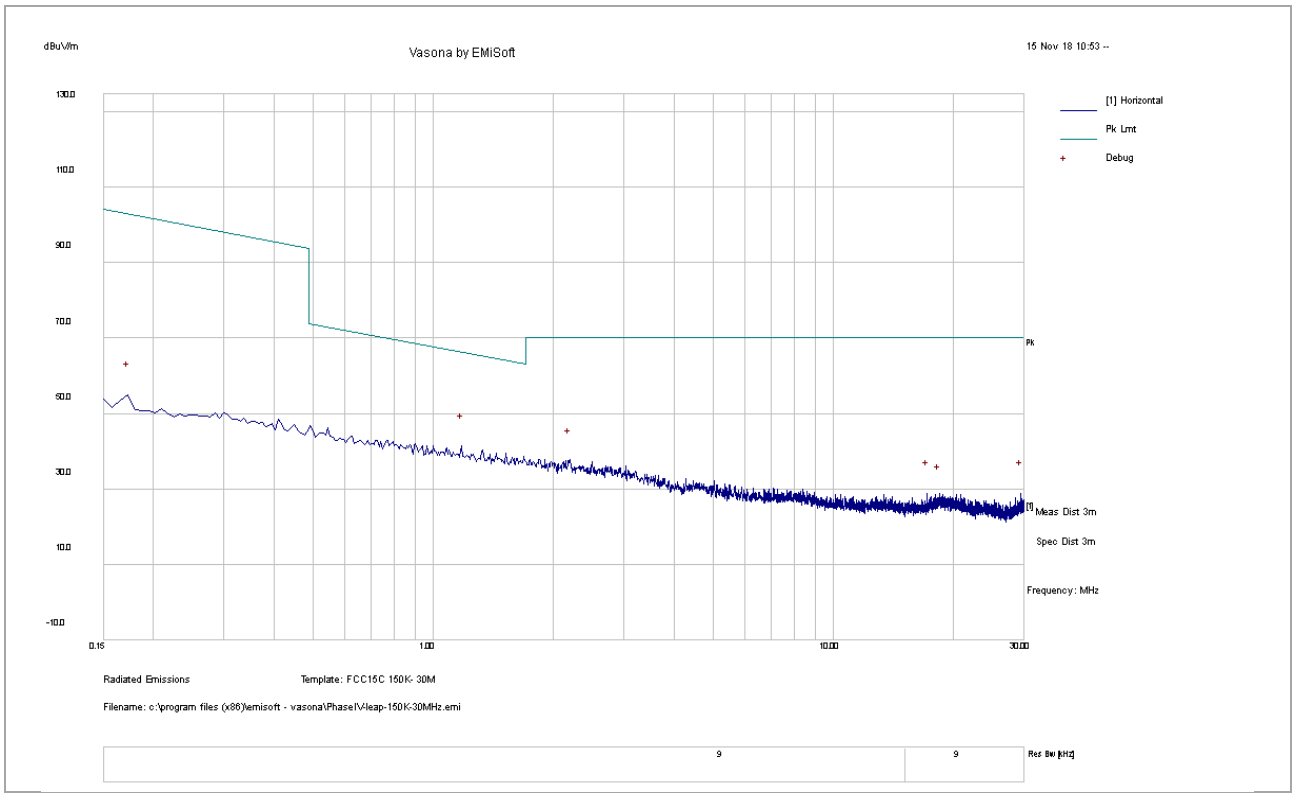
Note: 1) Both 0 deg and 90 deg setup of the loop antenna have been verified and the worst case result is presented here.

2) All different antenna versions have been verified and the worst case result is presented here.

3) All three EUT orientations have been tested.

150KHz – 30MHz test result

Test Standard:	**47CFR 15.209**	**Mode:**	**915MHz**
Frequency Range:	**150KHz – 30MHz**	**Test Date:**	**11/14/2018**
Antenna Type/Polarity:	**Loop / 0 deg & 90 deg**	**Test Personnel:**	**David Zhang**
Remark:	**External antenna**	**Test Result:**	**Pass**



Frequency MHz	Raw dB	Cable dB	AF dB	Level dBuV/m	Det	Pol deg	Height cm	Table cm	Limit dBuV/m	Margin dB
0.223	39.78	0.62	11.32	51.72	PK	0	100	59	100.64	-48.92
0.958	26.67	0.77	12.86	40.30	PK	0	100	108	67.97	-27.67
2.082	22.69	0.84	13.19	36.72	PK	0	100	72	70.00	-33.28
3.632	17.41	0.90	13.03	31.34	PK	0	100	162	70.00	-38.66
8.763	13.69	0.99	13.38	28.05	PK	0	100	331	70.00	-41.95
16.122	11.87	1.53	13.33	26.73	PK	0	100	12	70.00	-43.27
22.156	13.25	1.89	13.34	28.47	PK	0	100	99	70.00	-41.53

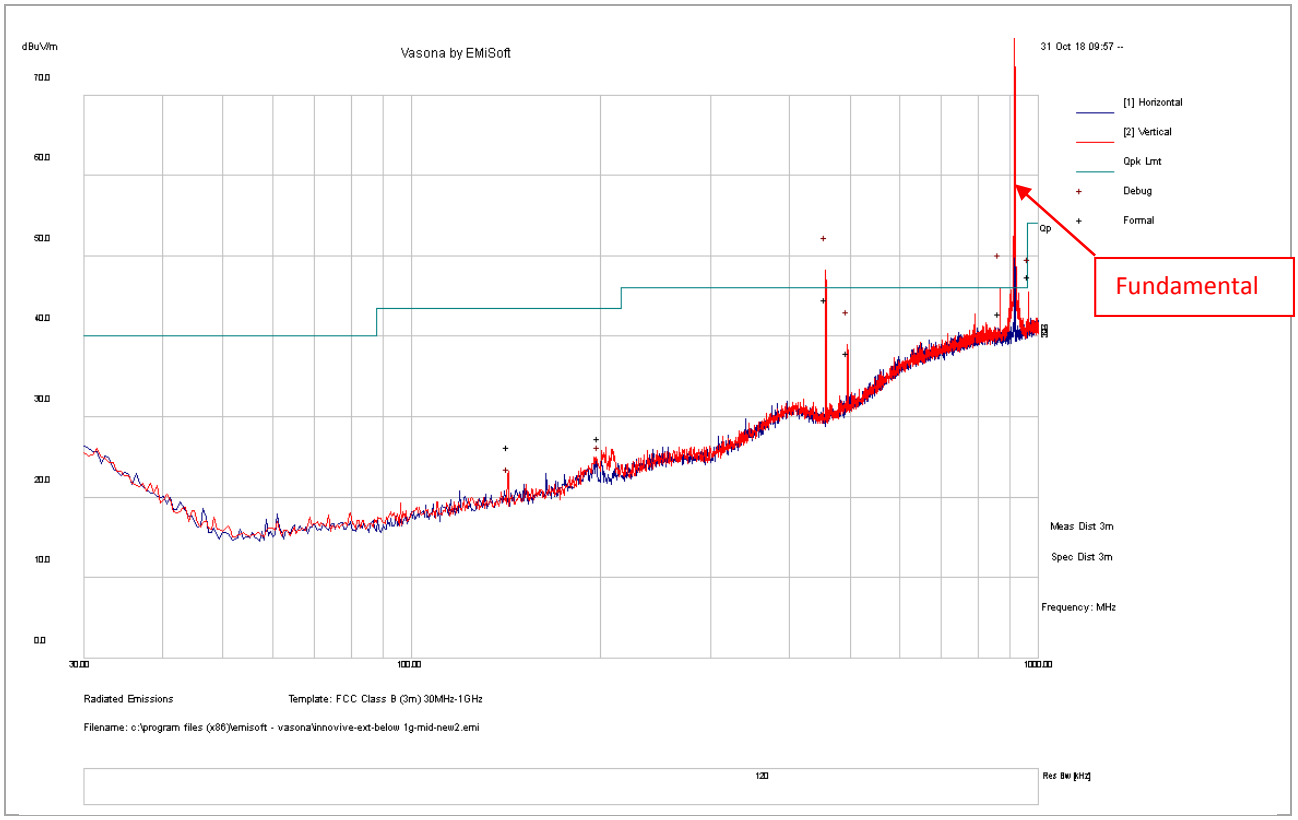
Note: 1) Both 0 deg and 90 deg setup of the loop antenna have been verified and the worst case result is presented here.

2) All different antenna versions have been verified and the worst case result is presented here.

3) All three EUT orientations have been tested.

30-1000MHz test result for external antenna version

Test Standard:	**47CFR 15.209**	**Mode:**	**902.4MHz**
Frequency Range:	**30-1000MHz**	**Test Date:**	**10/31/2018**
Antenna Type/Polarity:	**Bi-Log/Hor & Ver**	**Test Personnel:**	**David Zhang**
Remark:	**N/A**	**Test Result:**	**Pass**

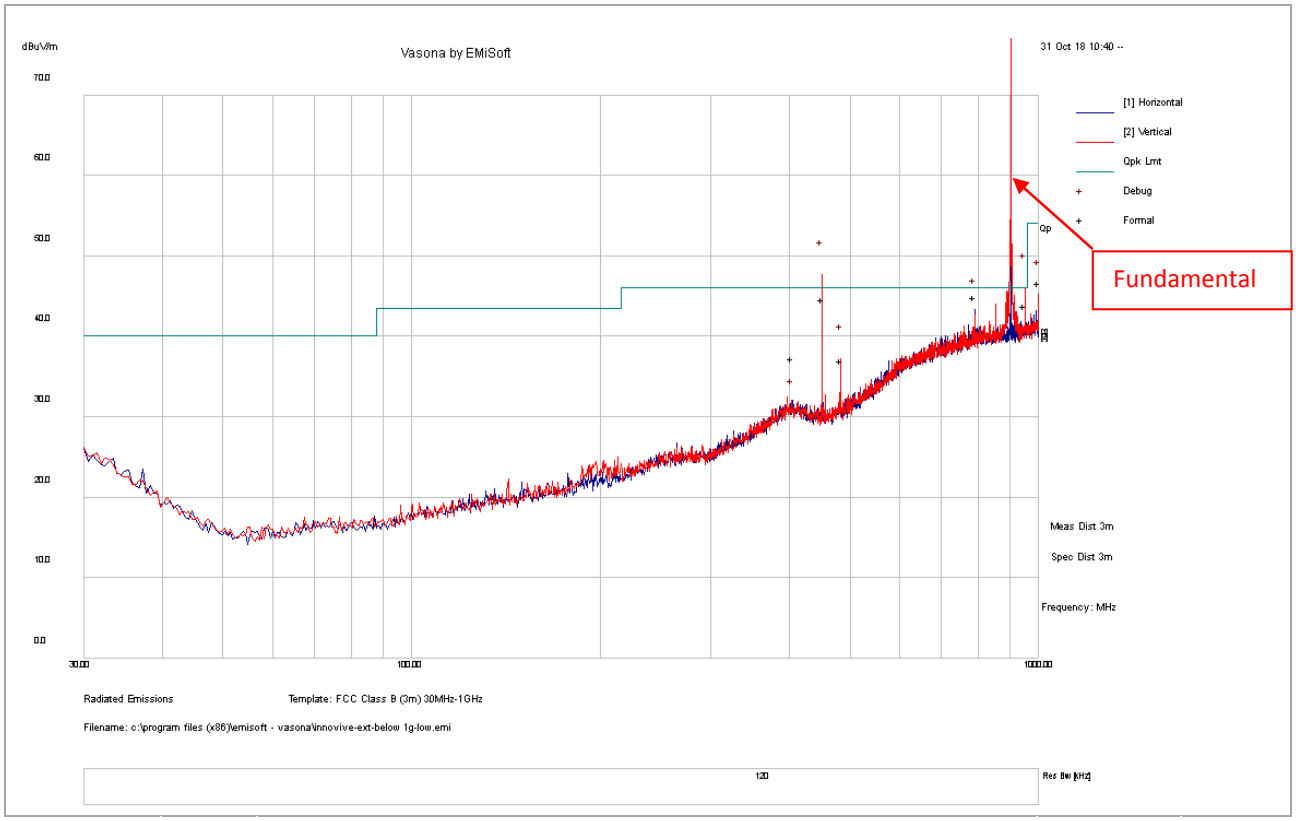


Frequency MHz	Raw dB	Cable dB	AF dB	Level dBuV/m	Det	Pol deg	Height cm	Table deg	Limit dBuV/m	Margin dB
142.53	13.05	4.16	9.04	26.25	QP	V	122	339	43.50	-17.25
198.39	12.65	4.72	9.98	27.35	QP	H	288	320	43.50	-16.15
457.51	21.00	6.20	17.50	44.70	QP	V	100	351	46.00	-1.30
495.84	13.37	6.09	18.50	37.96	QP	V	100	48	46.00	-8.04
866.97	11.90	7.50	23.50	42.90	QP	V	200	328	46.00	-3.10
962.99	15.74	7.85	23.94	47.54	QP	V	100	196	54.00	-6.46

Note: For below 1GHz, all different channel and modes were verified but only the worst case result is shown here. All three EUT orientations have been tested.

30-1000MHz test result for external antenna version

Test Standard:	**47CFR 15.209**	**Mode:**	**915MHz**
Frequency Range:	**30-1000MHz**	**Test Date:**	**10/31/2018**
Antenna Type/Polarity:	**Bi-Log/Hor & Ver**	**Test Personnel:**	**David Zhang**
Remark:	**N/A**	**Test Result:**	**Pass**

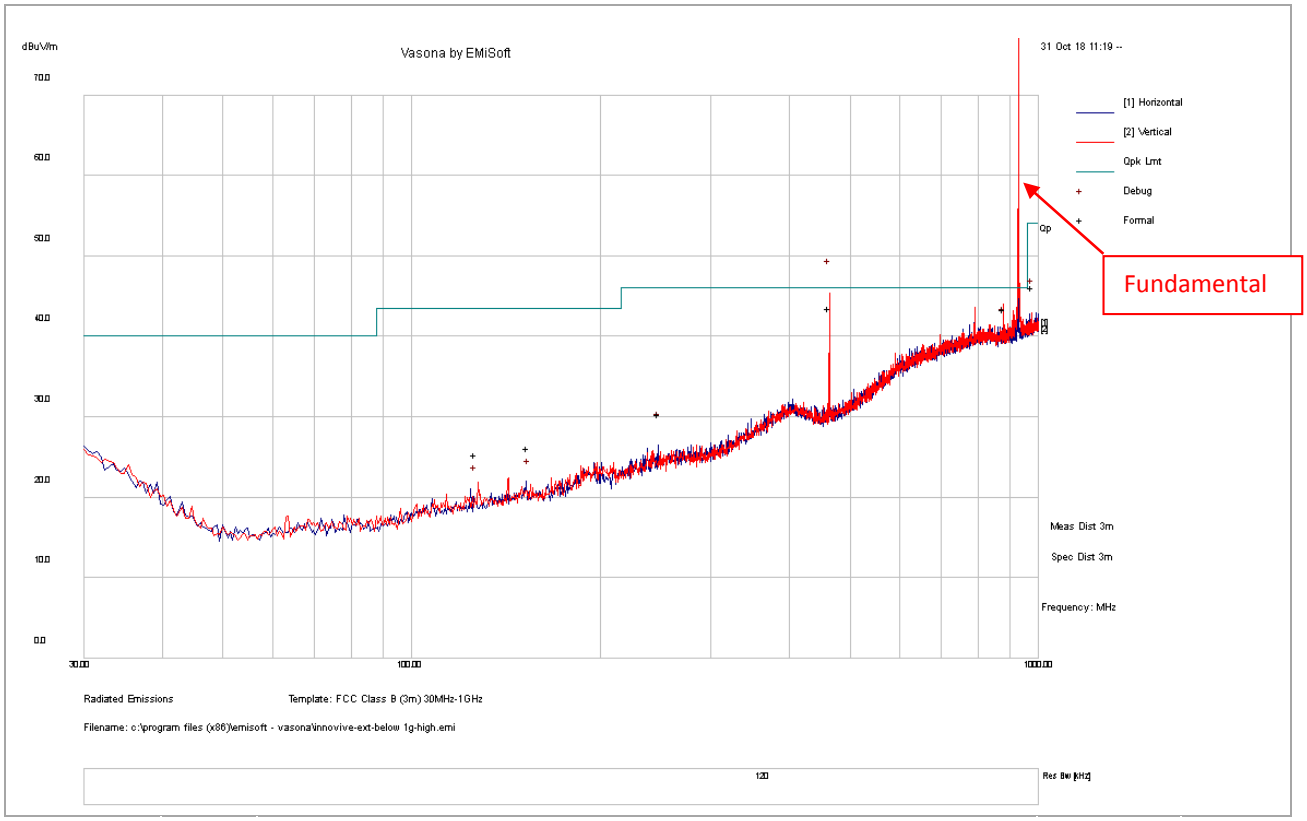


Frequency MHz	Raw dB	Cable dB	AF dB	Level dBuV/m	Det	Pol deg	Height cm	Table deg	Limit dBuV/m	Margin dB
403.22	12.96	6.36	18.05	37.37	QP	H	170	50	46.00	-8.63
451.21	21.10	6.20	17.30	44.60	QP	V	101	0	46.00	-1.40
483.25	12.70	6.12	18.18	37.00	QP	V	400	218	46.00	-9.00
789.85	13.97	7.25	23.69	44.91	QP	H	172	209	46.00	-1.09
950.40	12.20	7.80	23.80	43.80	QP	V	132	0	46.00	-2.20
998.37	14.46	7.98	24.28	46.72	QP	V	144	297	54.00	-7.28

Note: For below 1GHz, all different channel and modes were verified but only the worst case result is shown here. All three EUT orientations have been tested.

30-1000MHz test result for external antenna version

Test Standard:	**47CFR 15.209**	**Mode:**	**927.4MHz**
Frequency Range:	**30-1000MHz**	**Test Date:**	**10/31/2018**
Antenna Type/Polarity:	**Bi-Log/Hor & Ver**	**Test Personnel:**	**David Zhang**
Remark:	**N/A**	**Test Result:**	**Pass**

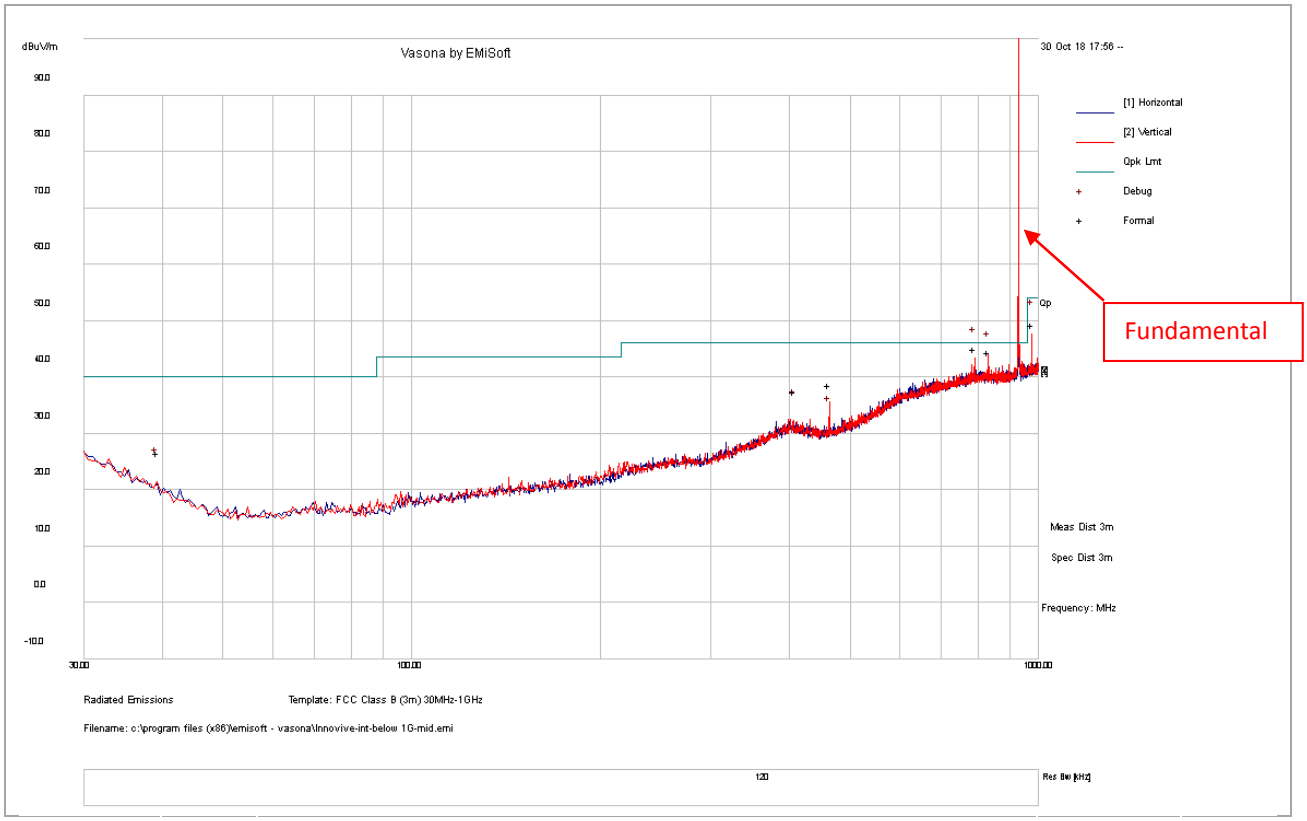


Frequency MHz	Raw dB	Cable dB	AF dB	Level dBuV/m	Det	Pol deg	Height cm	Table deg	Limit dBuV/m	Margin dB
126.10	12.74	3.95	8.64	25.34	QP	H	319	266	43.50	-18.16
153.30	12.65	4.28	9.26	26.20	QP	H	292	292	43.50	-17.30
247.38	12.89	5.23	12.29	30.40	QP	H	320	14	46.00	-15.60
463.81	19.80	6.20	17.70	43.60	QP	V	100	361	46.00	-2.40
879.67	12.50	7.50	23.40	43.40	QP	V	162	321	46.00	-2.60
975.65	14.24	7.90	24.07	46.21	QP	V	400	191	54.00	-7.79

Note: For below 1GHz, all different channel and modes were verified but only the worst case result is shown here. All three EUT orientations have been tested.

30-1000MHz test result for internal antenna version

Test Standard:	**47CFR 15.209**	**Mode:**	**902.4MHz**
Frequency Range:	**30-1000MHz**	**Test Date:**	**10/30/2018**
Antenna Type/Polarity:	**Bi-Log/Hor & Ver**	**Test Personnel:**	**David Zhang**
Remark:	**N/A**	**Test Result:**	**Pass**

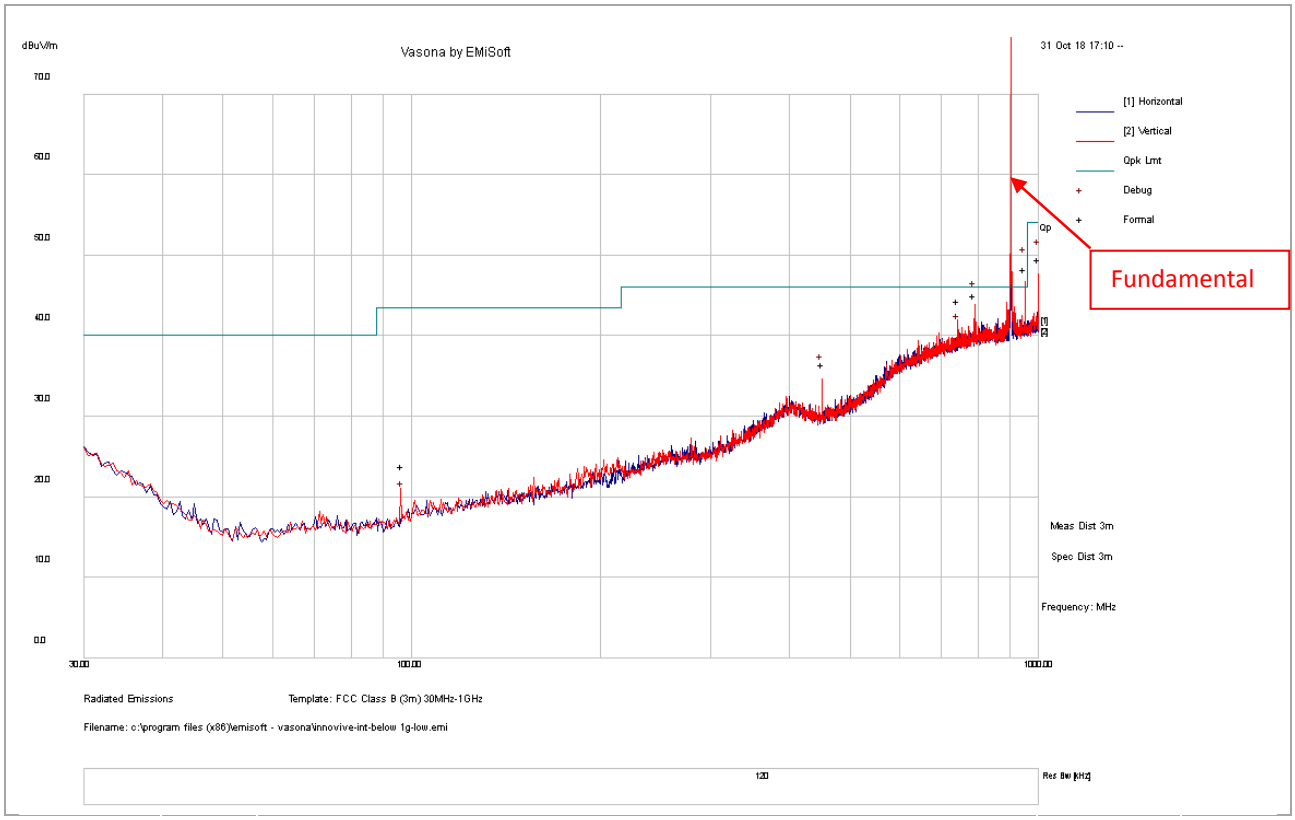


Frequency MHz	Raw dB	Cable dB	AF dB	Level dBuV/m	Det	Pol deg	Height cm	Table deg	Limit dBuV/m	Margin dB
39.36	13.43	2.53	10.73	26.69	QP	V	188	71	40.00	-13.31
406.67	13.05	6.35	17.99	37.39	QP	H	345	268	46.00	-8.61
463.81	14.81	6.17	17.67	38.66	QP	V	100	305	46.00	-7.34
790.11	14.01	7.25	23.69	44.95	QP	H	353	49	46.00	-1.05
831.62	13.50	7.40	23.60	44.50	QP	H	100	224	46.00	-1.50
975.64	17.31	7.90	24.07	49.28	QP	V	130	206	54.00	-4.72

Note: For below 1GHz, all different channel and modes were verified but only the worst case result is shown here. All three EUT orientations have been tested.

30-1000MHz test result for internal antenna version

Test Standard:	**47CFR 15.209**	**Mode:**	**915MHz**
Frequency Range:	**30-1000MHz**	**Test Date:**	**10/31/2018**
Antenna Type/Polarity:	**Bi-Log/Hor & Ver**	**Test Personnel:**	**David Zhang**
Remark:	**N/A**	**Test Result:**	**Pass**

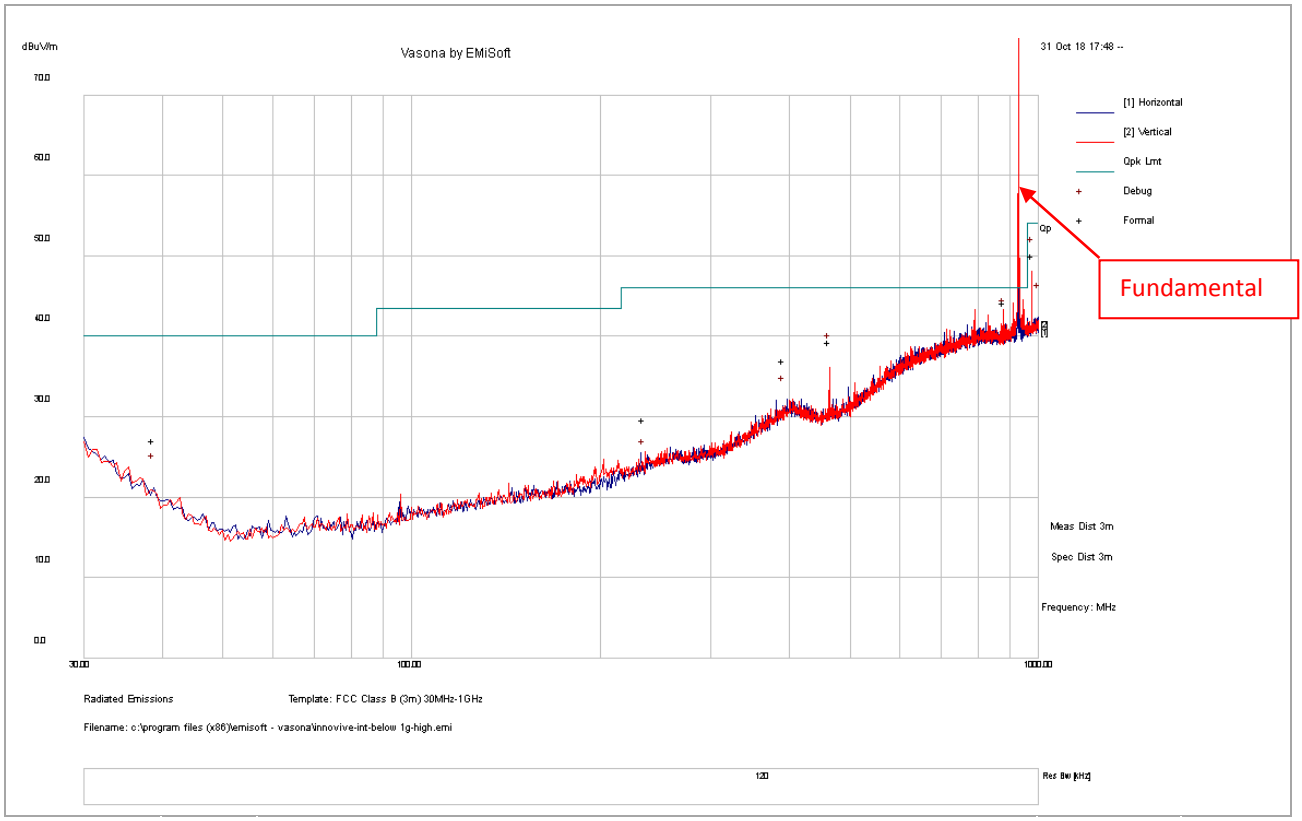


Frequency MHz	Raw dB	Cable dB	AF dB	Level dBuV/m	Det	Pol deg	Height cm	Table cm	Limit dBuV/m	Margin dB
96.50	12.78	3.52	7.56	23.87	QP	V	170	360	43.50	-19.63
451.13	13.02	6.21	17.33	36.56	QP	H	160	290	46.00	-9.44
743.68	13.90	7.28	23.14	44.32	QP	V	260	64	46.00	-1.68
790.15	14.06	7.25	23.69	45.00	QP	H	299	353	46.00	-1.00
950.43	12.70	7.80	23.80	44.30	QP	V	144	184	46.00	-1.70
998.40	17.30	7.98	24.28	49.56	QP	V	100	174	54.00	-4.44

Note: For below 1GHz, all different channel and modes were verified but only the worst case result is shown here. All three EUT orientations have been tested.

30-1000MHz test result for internal antenna version

Test Standard:	**47CFR 15.209**	**Mode:**	**927.4MHz**
Frequency Range:	**30-1000MHz**	**Test Date:**	**10/31/2018**
Antenna Type/Polarity:	**Bi-Log/Hor & Ver**	**Test Personnel:**	**David Zhang**
Remark:	**N/A**	**Test Result:**	**Pass**



Frequency MHz	Raw dB	Cable dB	AF dB	Level dBuV/m	Det	Pol deg	Height cm	Table cm	Limit dBuV/m	Margin dB
38.63	13.55	2.50	11.11	27.17	QP	H	399	97	40.00	-12.83
234.39	12.95	5.10	11.71	29.76	QP	H	278	138	46.00	-16.24
390.57	13.06	6.31	17.62	36.99	QP	H	351	160	46.00	-9.01
463.80	15.52	6.17	17.67	39.37	QP	V	100	252	46.00	-6.63
879.68	13.40	7.50	23.40	44.30	QP	V	310	324	46.00	-1.70
975.64	18.17	7.90	24.07	50.13	QP	V	100	78	54.00	-3.87

Note: For below 1GHz, all different channel and modes were verified but only the worst case result is shown here. All three EUT orientations have been tested.

1GHz – 10GHz Test Result for External Antenna version

Test Mode: 902.4MHz

Freq. MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Meas. Type	Pol	Hgt cm	Deg	Limit dBuV/m	Margin dB	Pass /Fail
2707.26	49.12	15.11	-9.20	55.04	PK	H	197	360	74	-18.96	Pass
6316.69	41.76	17.87	-2.72	56.91	PK	V	195	266	74	-17.10	Pass
7409.73	35.60	19.61	-1.13	54.08	PK	H	161	72	74	-19.92	Pass
7783.26	34.78	19.78	-1.17	53.39	PK	H	237	71	74	-20.61	Pass
2707.26	45.33	15.11	-9.20	51.24	AV	H	197	360	54	-2.76	Pass
6316.69	34.34	17.87	-2.72	49.48	AV	V	195	266	54	-4.52	Pass
7409.73	24.01	19.61	-1.13	42.49	AV	H	161	72	54	-11.51	Pass
7783.26	22.88	19.78	-1.17	41.49	AV	H	237	71	54	-12.51	Pass

Test Mode: 915MHz

Freq. MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Meas. Type	Pol	Hgt cm	Deg	Limit dBuV/m	Margin dB	Pass /Fail
2744.92	48.79	15.15	-9.15	54.79	PK	H	170	250	74	-19.21	Pass
6405.20	42.35	17.86	-2.79	57.42	PK	V	173	92	74	-16.58	Pass
7564.86	34.50	19.79	-1.28	53.01	PK	H	237	251	74	-20.99	Pass
10731.34	29.45	22.20	1.74	53.38	PK	H	329	95	74	-20.62	Pass
2744.92	44.99	15.15	-9.15	50.99	AV	H	170	250	54	-3.01	Pass
6405.20	34.77	17.86	-2.79	49.85	AV	V	173	92	54	-4.15	Pass
7564.86	23.15	19.79	-1.28	41.67	AV	H	237	251	54	-12.33	Pass
10731.34	17.96	22.20	1.74	41.89	AV	H	329	95	54	-12.11	Pass

Test Mode: 927.6MHz

Freq. MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Meas. Type	Pol	Hgt cm	Deg	Limit dBuV/m	Margin dB	Pass /Fail
2782.78	46.14	15.18	-9.07	52.25	PK	V	136	238	74	-21.75	Pass
6493.11	41.44	17.86	-2.66	56.64	PK	H	133	310	74	-17.36	Pass
7485.95	35.97	19.76	-1.16	54.57	PK	H	385	315	74	-19.43	Pass
2782.78	40.24	15.18	-9.07	46.35	AV	V	136	238	54	-7.65	Pass
6493.11	33.50	17.86	-2.66	48.70	AV	H	133	310	54	-5.30	Pass
7485.95	24.11	19.76	-1.16	42.71	AV	H	385	315	54	-11.29	Pass

Note: All three EUT orientations have been tested.

1GHz – 10GHz Test Result for Internal Antenna version

Test Mode: 902.4MHz

Freq. MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Meas. Type	Pol	Hgt cm	Deg	Limit dBuV/m	Margin dB	Pass /Fail
2707.45	48.74	15.11	-9.20	54.65	PK	H	160	175	74	-19.35	Pass
4512.23	46.34	16.80	-6.33	56.82	PK	H	232	110	74	-17.18	Pass
6667.83	37.83	18.16	-2.42	53.58	PK	V	311	84	74	-20.42	Pass
7356.03	35.96	19.50	-1.12	54.34	PK	H	174	176	74	-19.66	Pass
2707.45	43.89	15.11	-9.20	49.80	AV	H	160	175	54	-4.20	Pass
4512.23	41.45	16.80	-6.33	51.93	AV	H	232	110	54	-2.07	Pass
6667.83	25.51	18.16	-2.42	41.26	AV	V	311	84	54	-12.74	Pass
7356.03	24.19	19.50	-1.12	42.57	AV	H	174	176	54	-11.43	Pass

Test Mode: 915MHz

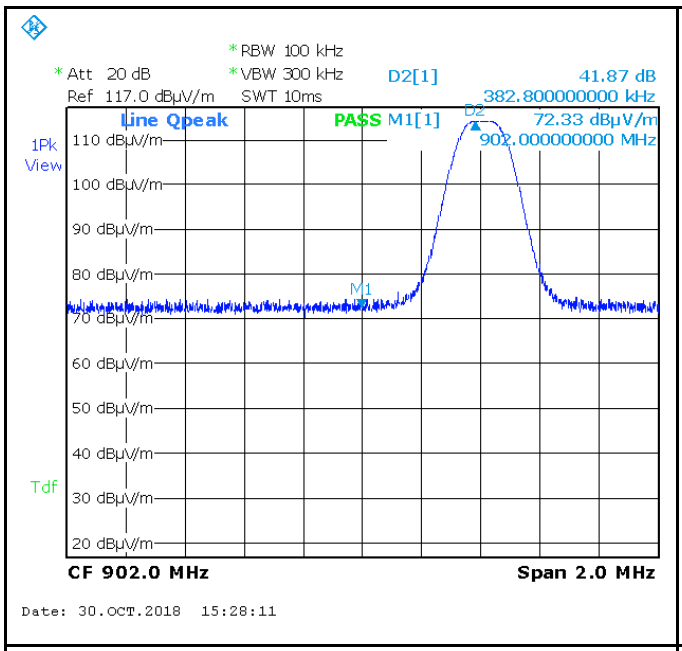
Freq. MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Meas. Type	Pol	Hgt cm	Deg	Limit dBuV/m	Margin dB	Pass /Fail
2744.78	46.09	15.15	-9.15	52.09	PK	H	173	181	74	-21.91	Pass
4575.04	47.01	16.81	-6.08	57.74	PK	V	189	181	74	-16.26	Pass
6345.63	38.21	17.87	-2.80	53.28	PK	H	400	300	74	-20.72	Pass
7389.24	35.78	19.57	-1.12	54.22	PK	H	244	340	74	-19.78	Pass
2744.78	39.28	15.15	-9.15	45.28	AV	H	173	181	54	-8.72	Pass
4575.04	41.60	16.80	-6.10	52.30	AV	V	189	181	54	-1.70	Pass
6345.63	26.15	17.87	-2.80	41.21	AV	H	400	300	54	-12.79	Pass
7389.24	24.07	19.57	-1.12	42.51	AV	H	244	340	54	-11.49	Pass

Test Mode: 927.6MHz

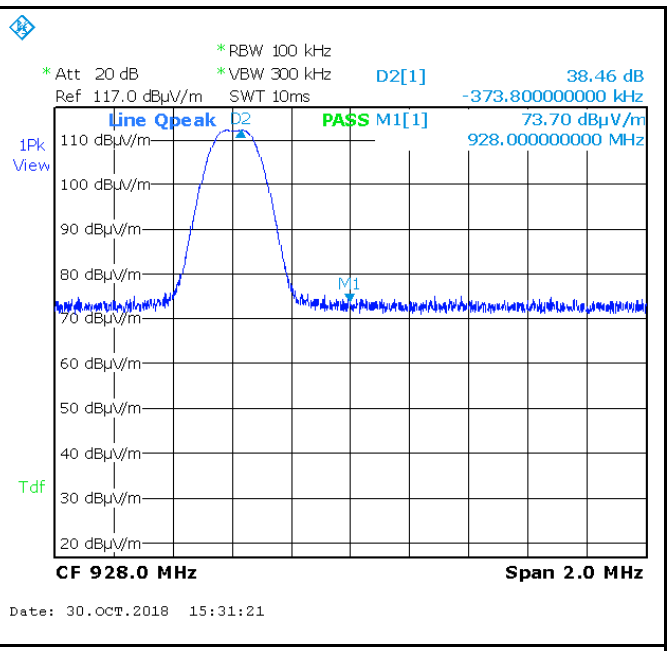
Freq. MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Meas. Type	Pol	Hgt cm	Deg	Limit dBuV/m	Margin dB	Pass /Fail
4638.14	48.70	16.83	-5.90	59.63	PK	V	153	192	74	-14.37	Pass
7735.45	35.24	19.79	-1.21	53.82	PK	H	138	134	74	-20.18	Pass
7467.09	35.80	19.73	-1.15	54.37	PK	H	206	361	74	-19.63	Pass
2783.08	49.64	15.18	-9.07	55.76	PK	H	139	184	74	-18.25	Pass
4638.14	41.30	16.80	-5.90	52.20	AV	V	153	192	54	-1.80	Pass
7735.45	23.30	19.79	-1.21	41.87	AV	H	138	134	54	-12.13	Pass
7467.09	23.98	19.73	-1.15	42.56	AV	H	206	361	54	-11.45	Pass
2783.08	44.82	15.18	-9.07	50.93	AV	H	139	184	54	-3.07	Pass

Note: All three EUT orientations have been tested.

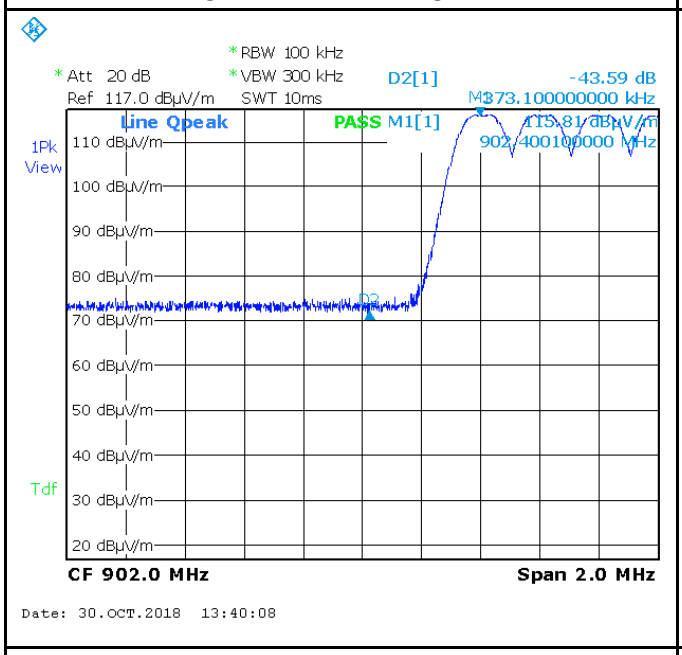
Radiated Band Edge Measurement Result for External Antenna



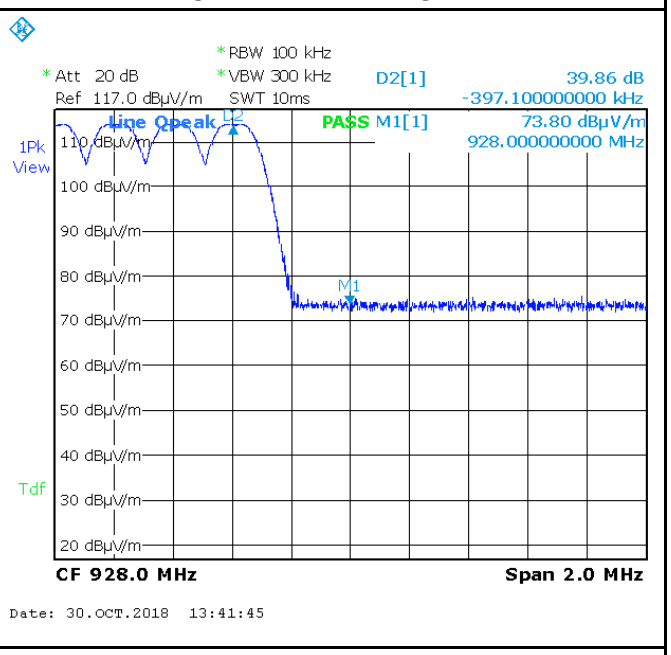
Band Edge – 902.4MHz (single channel)



Band Edge – 927.6MHz (single channel)



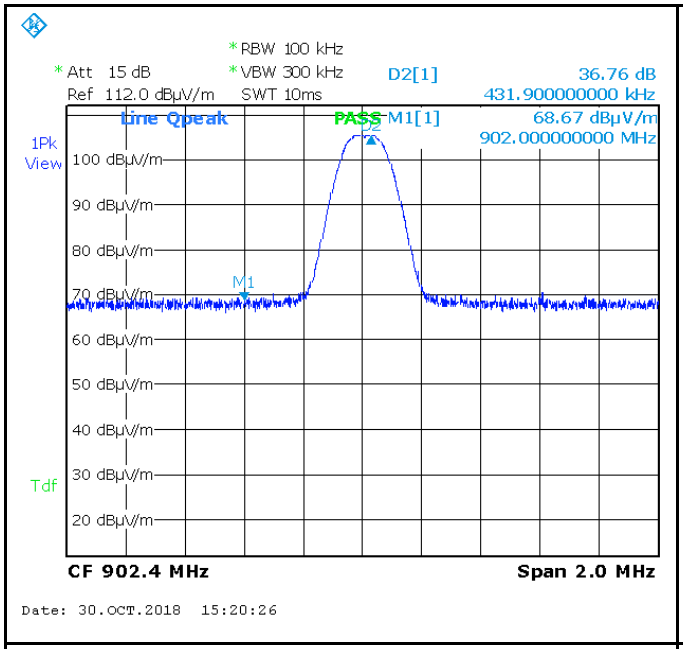
Band Edge – 902.4MHz (hopping mode)



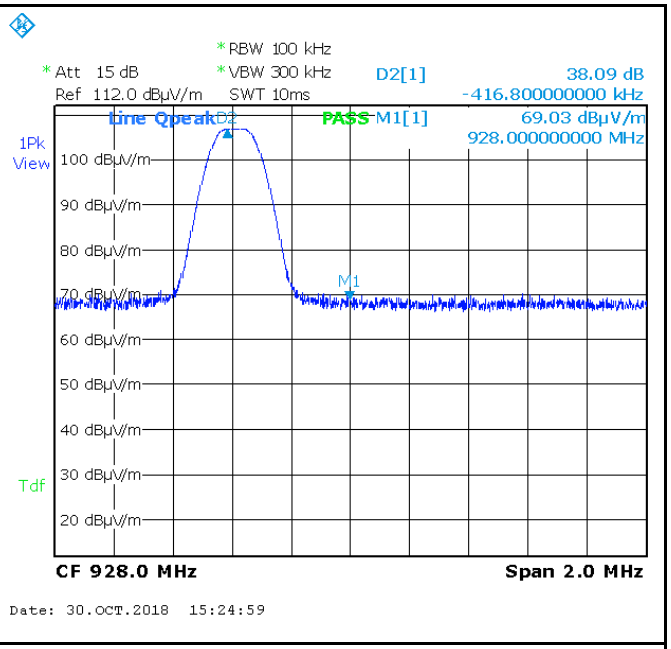
Band Edge – 927.6MHz (hopping mode)

Note: Both Horizontal and vertical polarities were investigated.

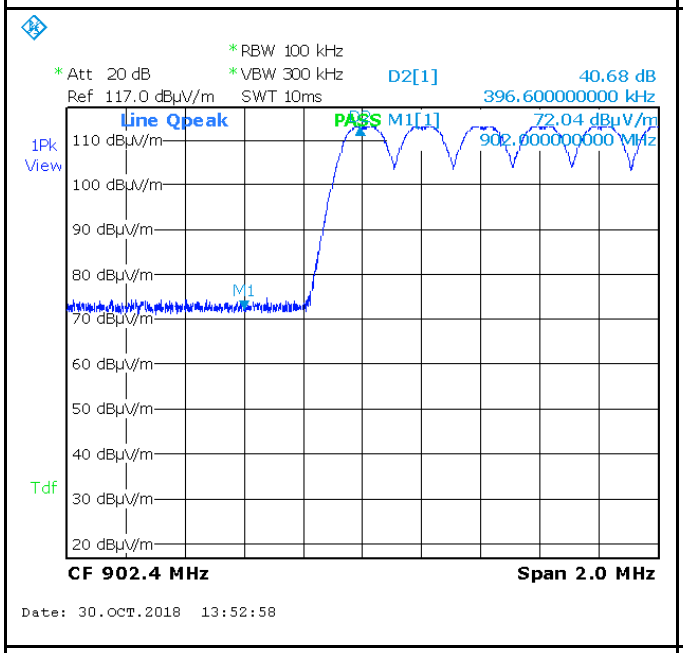
Radiated Band Edge Measurement Result for Internal Antenna



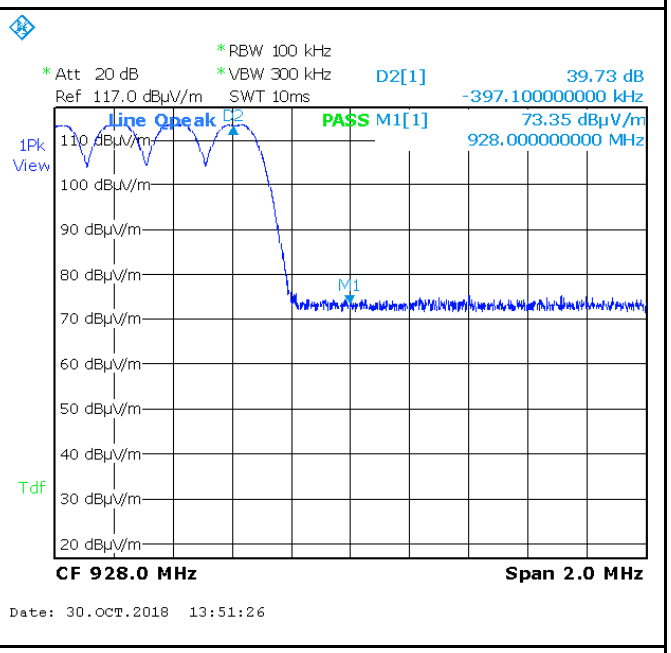
Band Edge – 902.4MHz (single channel)



Band Edge – 927.6MHz (single channel)



Band Edge – 902.4MHz (hopping mode)



Band Edge – 927.6MHz (hopping mode)

Note: Both Horizontal and vertical polarities were investigated.

8.10 Frequency Hopping System Requirement

8.10.1 Requirement

Per § 15.247 (a) (1), the system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

Per § 15.247 (g), frequency hopping spread spectrum systems are not required to employ all available hopping channels during each transmission. However, the system, consisting of both the transmitter and the receiver, must be designed to comply with all of the regulations in this section should the transmitter be presented with a continuous data (or information) stream. In addition, a system employing short transmission bursts must comply with the definition of a frequency hopping system and must distribute its transmissions over the minimum number of hopping channels specified in this section.

Per § 15.247 (h), the incorporation of intelligence within a frequency hopping spread spectrum system that permits the system to recognize other users within the spectrum band so that it individually and independently chooses and adapts its hopsets to avoid hopping on occupied channels is permitted. The coordination of frequency hopping systems in any other manner for the express purpose of avoiding the simultaneous occupancy of individual hopping frequencies by multiple transmitters is not permitted.

8.10.2 Result

Analysis:

This system, consisting of both the transmitter and the receiver, is designed to comply with all of the regulations defined per § 15.247, and the transmitter is presented with a continuous data stream. This system also complies with the definition of a frequency hopping system and distribute its transmissions over the 127 channels which meets § 15.247 requirement.

The hopping sequence for the channel is based on direct hash channel function (DH1CF) as defined in the Wi-SUN FAN specification. DH1CF generates a pseudo random sequence of channels based on the extended address of the node and thus is unique to each node. The pseudorandom sequence is always followed and no other effort for adaptation or coordination is used.

An example of Pseudorandom Frequency Hopping Sequence Table as below:

8, 111, 118, 81, 79, 113, 124, 94, 103, 55, 23, 87, 44, 114, 78, 31, 60, 34, 16, 42, 35, 52, 67, 4, 112, 109, 85, 48, 92, 25, 119, 41, 15, 104, 22, 98, 61, 10, 86, 91, 102, 107, 45, 38, 120, 36, 115, 121, 108, 63, 127, 76, 2, 9, 18, 106, 37, 11, 116, 126, 46, 95, 88, 89, 17, 33, 32, 14, 84, 47, 101, 83, 6, 64, 39, 12, 20, 68, 125, 51, 58, 122, 43, 1, 54, 80, 123, 74, 73, 90, 3, 26, 110, 70, 53, 82, 5, 56, 117, 13, 27, 69, 19, 105, 99, 57, 50, 24, 29, 72, 28, 93, 100, 75, 65, 97, 62, 30, 77, 59, 71, 21, 7, 40, 66, 49, 96, etc.

The pseudorandom sequence of frequencies is followed by each receiver and each channel frequency within the sequence is listened to for a uniform dwell period. The transmitter syncs to a receiver's sequence and transmits on each channel within the sequence for dwell time. The device continues to cycle through each frequency and repeats the sequence in a regular period. This ensures that a constant transmitter uniformly spreads transmission equally across its frequency set. The system uses a uniformly distributed transmission scheme so the transmissions will on average occupy each transmission equally.

The system transmitters match the hopping channel sequence of the receiver. The input bandwidth matches the channel hopping and shift frequencies in synchronization with the transmitted signals.

The system receiver's listen on channels according to their pseudorandom channel sequence and dwell period. The input bandwidth is determined by this sequence and the system transmitters shift frequencies in synchronization with the receivers.

Conclusion:

EUT complies with frequency hopping system requirement in § 15.247.

9 Test instrument list

Equipment	Manufacturer	Model	Serial Number	Cal. Date	Cal. Due
Semi-Anechoic Chamber	ETS-Lindgren	10M	VL001	5/11/2018	5/11/2019
Shielding Control Room	ETS-Lindgren	Series 81	VL006	N/A	N/A
Spectrum Analyzer	Keysight	N9020A	MY50110074	5/4/2018	5/4/2019
EMC Test Receiver	R&S	ESL6	100230	5/7/2018	5/7/2019
LISN (9KHz – 30MHz)	EMCO	3816/2	9705-1066	5/4/2018	5/4/2019
Bi-Log Antenna	ETS-Lindgren	3142E	217921	11/15/2017	11/15/2018
Horn Antenna (1-18GHz)	Electro-Metrics	EM-6961	6292	5/2/2018	5/2/2019
Horn Antenna (18-40GHz)	Com-Power	AH-840	101109	5/2/2018	5/2/2019
Preamplifier	RF Bay, Inc.	LPA-10-20	11180621	5/10/2018	5/10/2019
True RMS Multi-meter	UNI-T	UT181A	C173014829	5/10/2018	5/10/2019
Temp / Humidity / Pressure Meter	PCE Instruments	PCE-THB 40	R062028	5/9/2018	5/9/2019
RF Attenuator	Pasternack	PE7005-3	VL061	5/10/2018	5/10/2019
Preamplifier 100KHz - 40GHz	Aeroflex	33711-392-77150-11	064	5/10/2018	5/10/2019
EM Center Control	ETS-Lindgren	7006-001	160136	N/A	N/A
Turn Table	ETS-Lindgren	2181-3.03	VL002	N/A	N/A
Boresight Antenna Tower	ETS-Lindgren	2171B	VL003	N/A	N/A
Loop Antenna (9k-30MHz)	Com-Power	AL-130	121012	5/9/2018	5/9/2019
RE test cable(below 6GHz)	Vista	RE-6GHz-01	RE-6GHz-01	5/10/2018	5/10/2019
RE test cable (1-18GHz)	PhaseTrack	II-240	RE-18GHz-01	5/10/2018	5/10/2019
RE test cable (>18GHz)	Sucoflex	104	344903/4	5/10/2018	5/10/2019
Pulse limiter	Com-Power	LIT-930A	531727	5/15/2018	5/15/2019
CE test cable #1	FIRST RF	FRF-C-1002-001	CE-6GHz-01	5/10/2018	5/10/2019
CE test cable#2	FIRST RF	FRF-C-1002-001	CE-6GHz-02	5/9/2018	5/9/2019