TEST REPORT

Report Number: 103187255MPK-002
Project Number: G103187255
November 28, 2017

Testing performed on the
Z-Wave Automation Controller
Models: ISY994zw and ISY994i ZW
FCC ID: 2AOFQ-ISY994

to

FCC Part 15 Subpart C (15.249)
RSS-210 Issue 9
FCC Part 15, Subpart B
Industry Canada ICES-003

For

Universal Devices, Inc.

Test Performed by:	**Test Authorized by:**
Intertek	Universal Devices, Inc.
1365 Adams Court	5535 Balboa Blvd., Suite 113
Menlo Park, CA 94025 USA	Encino, CA 91316-3112 USA

Prepared by: _____ **Date:** November 28, 2017
Todd Moy

Reviewed by: _____ **Date:** November 28, 2017
Krishna K Vemuri

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VERIFICATION OF COMPLIANCE
Report No. 103187255MPK-002

Verification is hereby issued to the named APPLICANT and is VALID ONLY for the equipment identified hereon for use under the rules and regulations listed below.

Equipment Under Test:	Zwave Controller
Trade Name:	Universal Devices, Inc.
Model Numbers:	ISY994zw and ISY994i ZW
Serial Numbers:	57386003282 & 57386003138
Applicant:	Universal Devices, Inc.
Contact:	Michel Kohanim
Address:	Universal Devices, Inc. 5535 Balboa Blvd., Suite 113 Encino, CA 91316-3112
Country	USA
Tel. Number:	(818) 631-0333
Email:	michel@universal-devices.com
Applicable Regulation:	FCC Part 15 Subpart C (15.249) RSS-210 Issue 9 FCC Part 15, Subpart B Industry Canada ICES-003 Issue 6
Date of Test:	November 3 – November 21, 2017

We attest to the accuracy of this report:

Todd Moy Project Engineer	Krishna K Vemuri Engineering Team Lead

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1.0 Summary of Tests

TEST	REFERENCE FCC Part 15C	REFERENCE IC RSS-210/ RSS-Gen	RESULT
Field Strength of Fundamental	15.249(a)	B.10(a) RSS-210	Complies
Field Strength of Harmonics	15.249(a)	B.10(a) RSS-210	Complies
Radiated Emissions outside the band	15.249(d)	B.10(b) RSS-210	Complies
Occupied Bandwidth	15.215(c)	6.6.6 RSS-Gen	Complies
Line Conducted Emissions	15.207	8.8.8 RSS-Gen	Complies
Antenna requirement	15.203	8.8.3 RSS-Gen	Complies
Radiated Emissions	15.109	ICES-003	Complies
AC Line Conducted Emission	15.107	ICES-003	Complies

2.0 General Description

2.1 Product Description

The Equipment Under Test (EUT) is a module, model numbers ISY994zw and ISY994i ZW, that contains a Zwave radio.

Information about the Zwave radio is presented below:

Applicant name & address	Universal Devices, Inc. 5535 Balboa Blvd., Suite 113 Encino, CA 91316-3112
Manufacturer name & address	Universal Devices, Inc. 5535 Balboa Blvd., Suite 113 Encino, CA 91316-3112
Model Nos.	ISY994zw and ISY994i ZW
FCC Identifier	2AOFQ-ISY994
Frequency Range	908-916 MHz
Rated RF Output	93.90 dB(μV/m) at 3m
Number of Channel(s)	2
Type of Modulation	FSK
Data Rate	40Kbps for 908 MHz Channel, 10 Kbps for 916 MHz Channel
Antenna(s) & Gain	PCB antenna, Gain: 0 dBi

EUT receive date: October 24, 2017
EUT receive condition: The pre-production version of the EUT was received in good condition with no apparent damage. As declared by the Applicant, it is identical to the production units.
Test start date: November 3, 2017
Test completion date: November 21, 2017
The test results in this report pertain only to the item tested.

2.2 Related Submittal(s) Grants

None.

2.3 Test Methodology

Radiated emissions and AC mains conducted emissions measurements were performed according to the procedures in ANSI C63.10: 2013 and RSS-GEN Issue 4. Radiated tests were performed at an antenna to EUT distance of 3 meters, unless stated otherwise in the "Data Sheet" of this report. All other measurements were made in accordance with the procedures in part 2 of CFR 47.

2.4 Test Facility

The test site used to collect the radiated data is site 1 (10-m semi-anechoic chamber). This test facility and site measurement data have been fully placed on file with the FCC, IC and A2LA accredited.

2.5 Measurement Uncertainty

Compliance with the limits was based on the results of the measurements and doesn't take into account the measurement uncertainty.

Estimated Measurement Uncertainty

Measurement	Expanded Uncertainty (k=2)		
	0.15 MHz – 1 GHz	1 GHz – 2.5 GHz	> 2.5 GHz
RF Power and Power Density – antenna conducted	-	0.7 dB	-
Unwanted emissions - antenna conducted	1.1 dB	1.3 dB	1.9 dB
Bandwidth – antenna conducted	-	30 Hz	-
Radiated emissions	4.2 dB	3.4 dB	4.4 dB
AC mains conducted emissions	2.4 dB	-	-

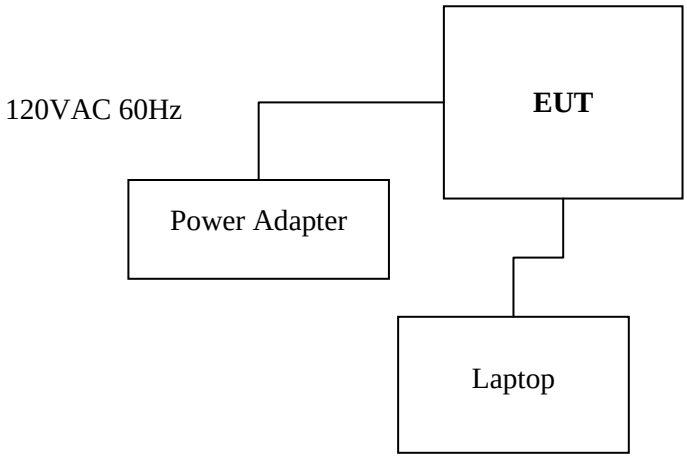
3.0 System Test Configuration

3.1 Support Equipment and description

Description	Model No./ Part No.	Serial No.
HP Laptop	Elitebook 840	Not Labeled
Zwave Controller	ISY994zw	57386003282

3.2 Block Diagram of Test Setup

Internal Radio Model: ISY994i ZW

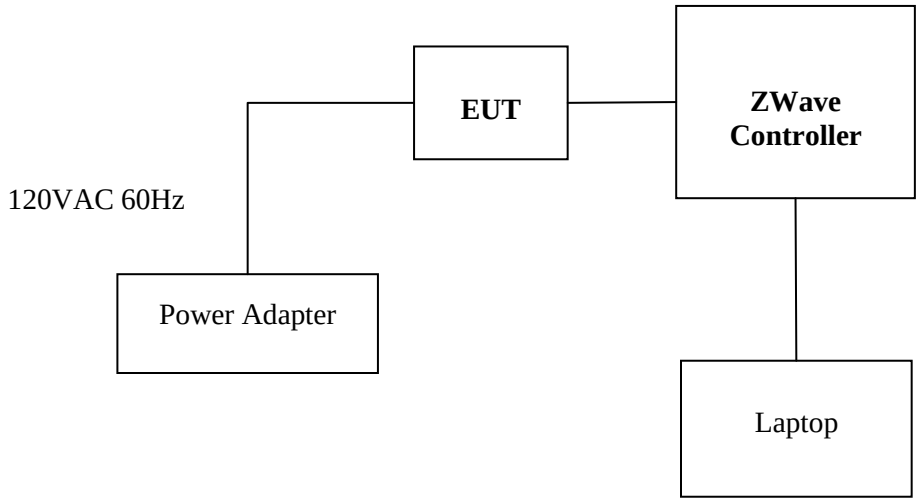


Note: Power Adapter model number is HRS050050.

S = Shielded **U** = Unshielded	**F** = With Ferrite **M** = Meter

3.2 Block Diagram of Test Setup (continued)

External Radio Model: ISY994zw



Note: Power Adapter model number is HRS050050.

S = Shielded **U** = Unshielded	**F** = With Ferrite **M** = Meter

3.3 Justification

For radiated emission measurements the EUT is placed on a non-conductive table. The EUT is attached to peripherals and they are connected and operational (as typical as possible). The EUT is wired to transmit full-power. During testing, all cables are manipulated to produce worst-case emissions.

3.4 Software Exercise Program

The EUT exercise program used during radiated and conducted testing was designed to exercise the various system components in a manner similar to a typical use.

The following table is the power setting for the EUT.

Model	Frequency	
	908 MHz	916 MHz
Internal	15	10
External	8	8

3.5 Mode of operation during test

During the test the EUT was set to transmit the modulated signal with 100% duty cycle.

3.6 Modifications required for Compliance

No modifications were installed by Intertek during compliance testing in order to bring the product into compliance.

3.7 Additions, deviations and exclusions from standards

No additions, deviations or exclusion have been made from standard.

4.0 Measurement Results

4.1 Transmitter Radiated Emissions
FCC Rules: 15.249, 15.209; IC Rules: RSS-210 (B.10), RSS-Gen

Requirements

The Field Strength of emissions at a distance of 3 meters shall not exceed the following levels:
94 dB(μV/m) for fundamental frequency,
54 dB(μV/m) for harmonics.

Emissions radiated outside of the specified frequency band, except for harmonics, shall be attenuated by at least 50 dB below the level of fundamental or to the general radiated emission limits in 15.209, whichever is the lesser attenuation.

Procedure

Radiated emission measurements were performed from 30 MHz to 10 GHz according to the procedure described in ANSI C64.10. Spectrum Analyzer Resolution Bandwidth is 100 kHz or greater for frequencies 30 MHz to 1000 MHz, 1 MHz for frequencies above 1000 MHz. Above 1000 MHz Peak measurements were performed.

Radiated emissions are taken at 10 meters for frequencies below 1 GHz and at 3 meters for frequencies above 1 GHz

The EUT is placed on a plastic turntable that is 80 cm in height. If the EUT attaches to peripherals, they are connected and operational (as typical as possible). During testing, all cables were manipulated to produce worst-case emissions. The signal is maximized through rotation. The antenna height and polarization are varied during the search for maximum signal level. The antenna height is varied from 1 to 4 meters.

Test was performed with the supply voltage varied between 85% and 115% of the nominal rated supply voltage as per FCC Rule 15.31(e).

Data is included of the worst case configuration (the configuration which resulted in the highest emission levels). A sample calculation, configuration photographs and data tables of the emissions are included.

Field Strength Calculation

The field strength is calculated by adding the Antenna Factor and Cable Factor, and subtracting the Amplifier Gain (if any) from the measured reading. The basic equation with a sample calculation is as follows:

FS = RA + AF + CF – AG; if measurement is performed at a distance other than specified in the rule, a Distance Correction Factor (DCF) shall be added.

Where FS = Field Strength in dB(μV/m)
RA = Receiver Amplitude (including preamplifier) in dB(μV); AF = Antenna Factor in dB(1/m)
CF = Cable Attenuation Factor in dB; AG = Amplifier Gain in dB

Assume a receiver reading of 52.0 dB(μV) is obtained. The antennas factor of 7.4 dB(1/m) and cable factor of 1.6 dB is added. The amplifier gain of 29 dB is subtracted, giving field strength of 32 dB(μV/m). This value in dB(μV/m) was converted to its corresponding level in μV/m.
RA = 52.0 dB(μV)
AF = 7.4 dB(1/m)
CF = 1.6 dB
AG = 29.0 dB
FS = 52.0+7.4+1.6-29.0 = 32 dB(μV/m).
Level in μV/m = Common Antilogarithm [(32 dBμV/m)/20] = 39.8 μV/m.

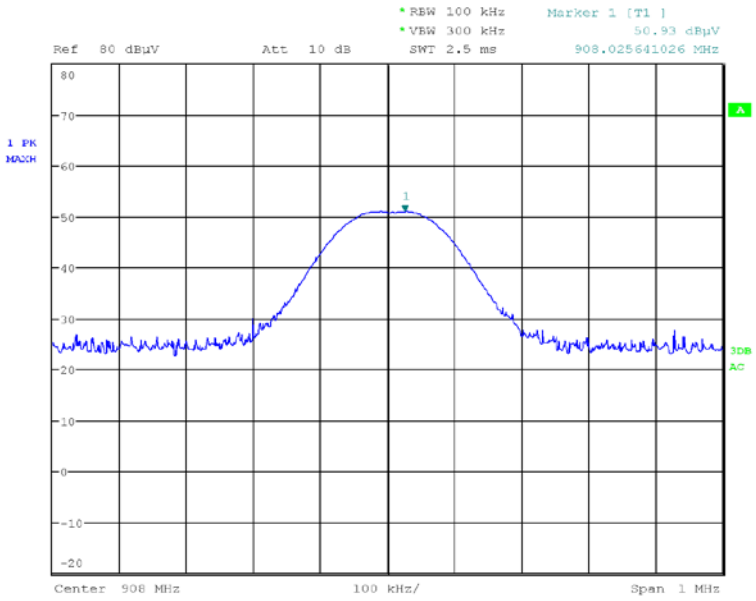
Test Result

The data below shows the significant emission frequencies, the limit and the margin of compliance.

The EUT passed 0.17dB.

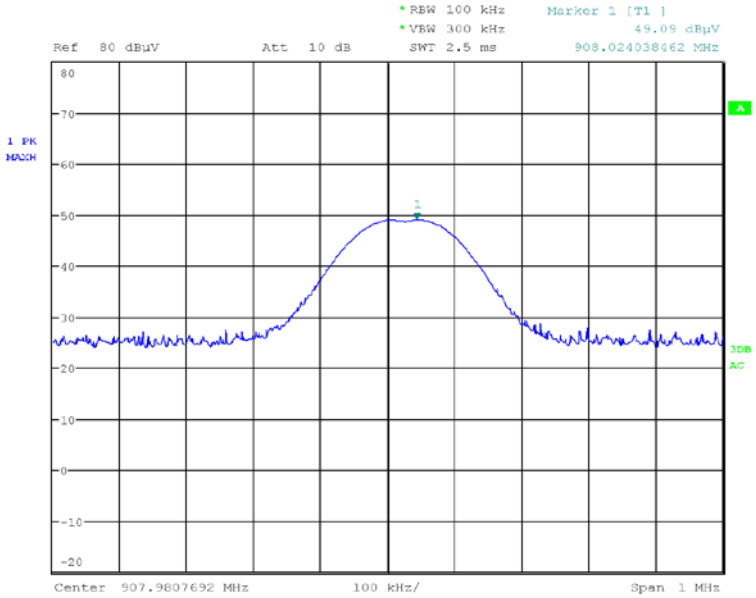
Internal Radio Model

Radiated emissions at 908 MHz, Horizontal Polarization



Date: 27.OCT.2017 09:54:55

Radiated emissions at 908 MHz, Vertical Polarization



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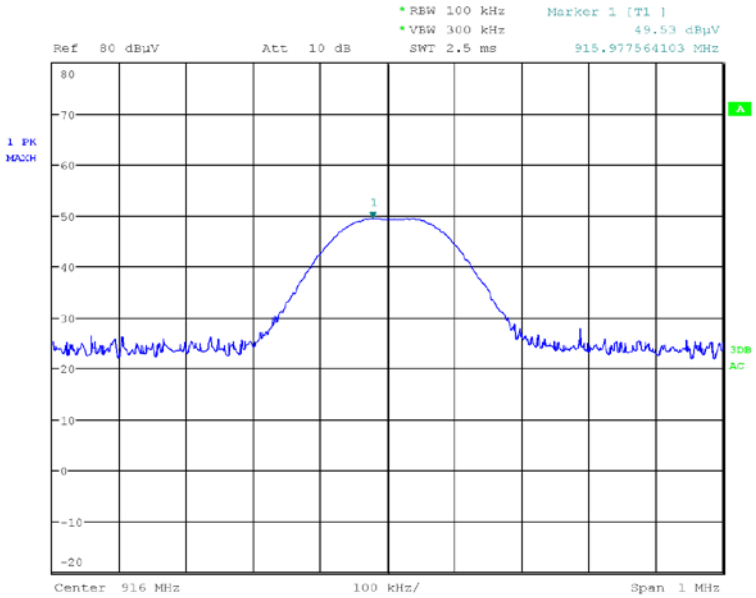
Radiated emissions at 916 MHz, Horizontal Polarization



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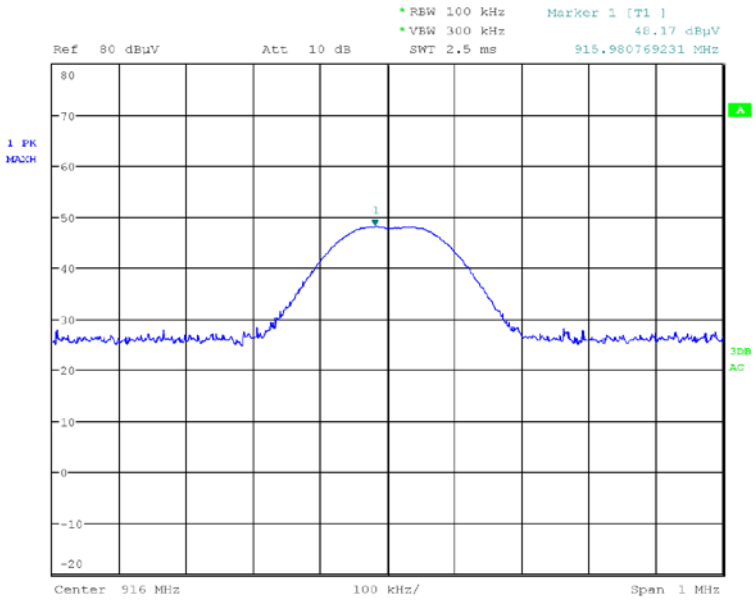
Radiated emissions at 916 MHz, Vertical Polarization



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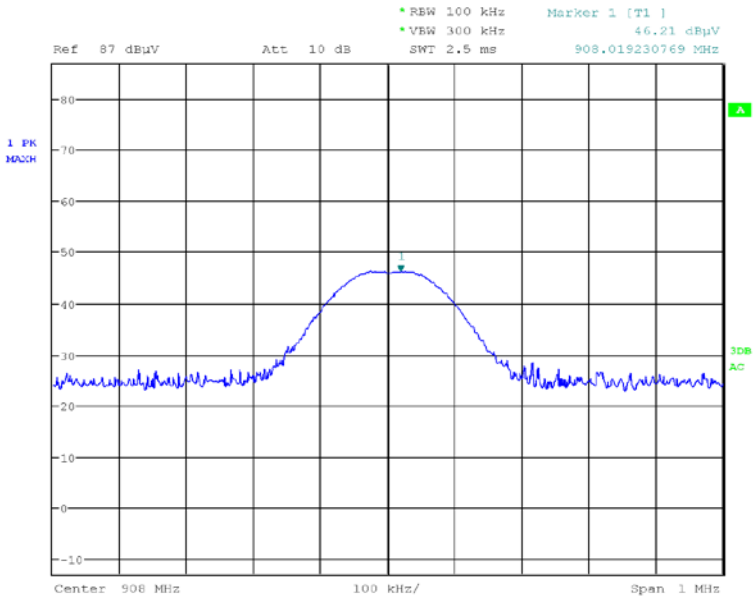
External Radio Model

Radiated emissions at 908 MHz, Horizontal Polarization



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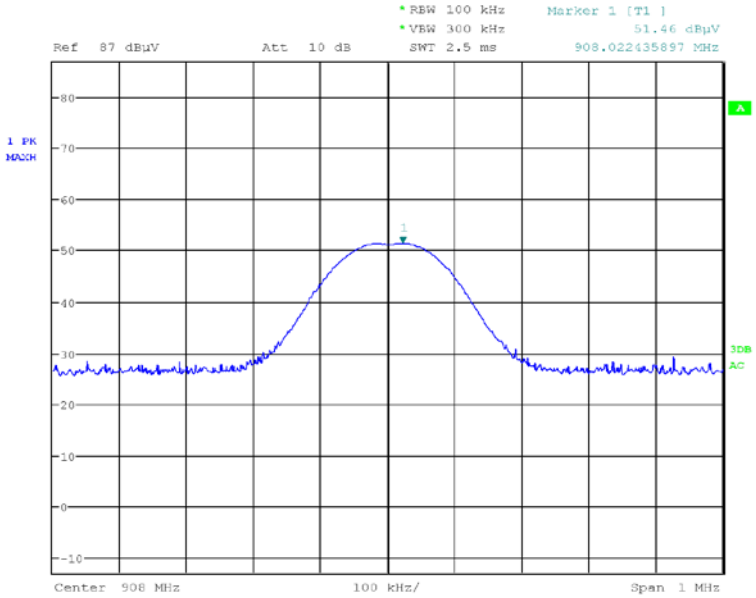
Radiated emissions at 908 MHz, Vertical Polarization



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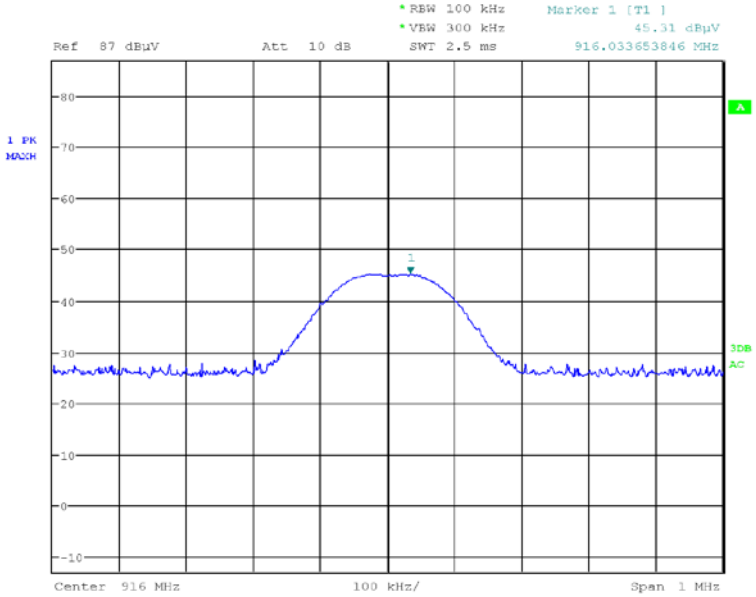
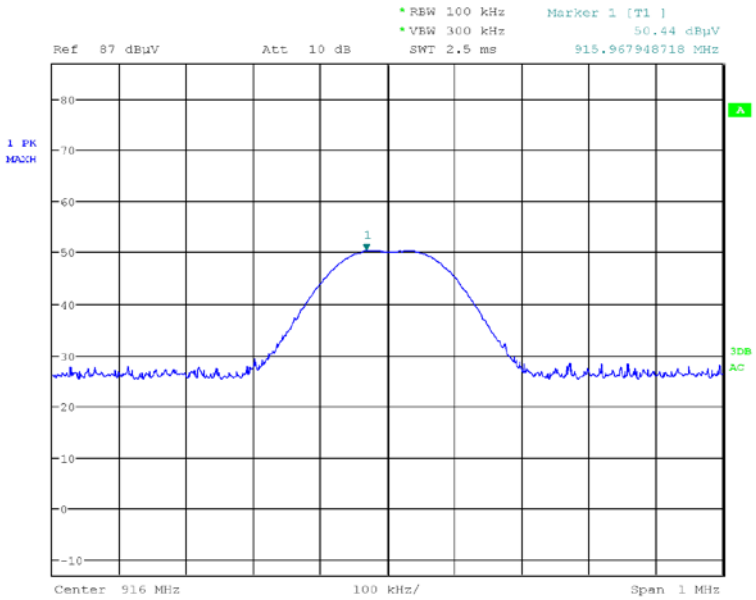
Radiated emissions at 916 MHz, Horizontal Polarization



Date: 26.OCT.2017 08:46:14

Radiated emissions at 916 MHz, Vertical Polarization



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Internal Model Field Strength

Frequency (MHz)	Polarity	RA @10m (dBuV)	FS @3m dBuV/m)	Height (m)	Angle (degree)	Limit @3m (dBuV/m)	Margin (dB)	Correction Factor (dB)
908	V	49.09	91.53	162.26	211.25	93.98	-2.45	42.44
	H	50.93	93.37	260	166	93.98	-0.61	42.44
916	V	48.17	91.02	161.25	195.25	93.98	-2.96	42.85
	H	49.53	92.38	115.64	299	93.98	-1.60	42.85

External Model Field Strength

Frequency (MHz)	Polarity	RA @10m (dBuV)	FS @3m dBuV/m)	Height (m)	Angle (degree)	Limit @3m (dBuV/m)	Margin (dB)	Correction Factor (dB)
908	V	51.46	93.90	195.22	298.75	93.98	-0.08	42.44
	H	46.21	88.65	100.35	72.75	93.98	-5.33	42.44
916	V	50.44	93.29	184.95	295.25	93.98	-0.69	42.85
	H	45.31	88.16	334.44	154.25	93.98	-5.82	42.85

Note: The supply voltage was varied between 85% and 115% of the nominal rated Voltage. No Fundamental frequency Field Strength variation was observed.

Transmitter Radiated Emissions below 1GHz for Internal Radio Model

Spurious Emissions Data, 30MHz to 1MHz, Low Channel

Final Measurements Quasi-Peak (QP)								
Frequency (MHz)	**FS@10m (dBµV/m)**	**Limit@10m (dB(uV/m))**	**Margin (dB)**	**Azimuth (deg)**	**Height (m)**	**Polarity**	**RA @10m (dBuV)**	**Correction (dB)**
36.01456	25.6	33.5*	-7.9	212.25	2	Vertical	35.64	-10.04
39.79832	32.07	33.5*	-1.43	200.5	1	Vertical	44.13	-12.06
48.042	28.68	33.5*	-4.82	83.5	3	Vertical	46.35	-17.67
72.03465	31.21	33.5*	-2.29	184.25	1.98	Vertical	50.04	-18.83
516.4227	34.42	35.5	-1.08	300.5	3	Vertical	41.05	-6.63
663.8627	35.33	35.5	-0.17	255.75	1.98	Horizontal	39.26	-3.93

* FCC 15.249 (d) limits were applied.

Spurious Emissions Data, 30MHz to 1MHz, High Channel

Final Measurements Quasi-Peak (QP)								
Frequency (MHz)	**FS@10m (dBµV/m)**	**Limit@10m (dB(uV/m))**	**Margin (dB)**	**Azimuth (deg)**	**Height (m)**	**Polarity**	**RA @10m (dBuV)**	**Correction (dB)**
38.05576	32.81	33.5*	-0.69	240.75	1	Vertical	45.14	-12.33
50.53167	29.33	33.5*	-4.17	64.75	4	Vertical	48.31	-18.98
54.347	27.37	33.5*	-6.13	182.75	3	Vertical	47.85	-20.48
59.84367	32.89	33.5*	-0.61	52.75	1	Vertical	54.04	-21.15
61.58967	27.2	33.5*	-6.3	77.75	2	Horizontal	48.3	-21.1
870.3433	33.37	35.5	-2.13	12.25	1	Horizontal	33.16	0.21

* FCC 15.249 (d) limits were applied.

Transmitter Radiated Emissions below 1GHz for External Radio Model

Spurious Emissions Data, 30MHz to 1MHz, Low Channel

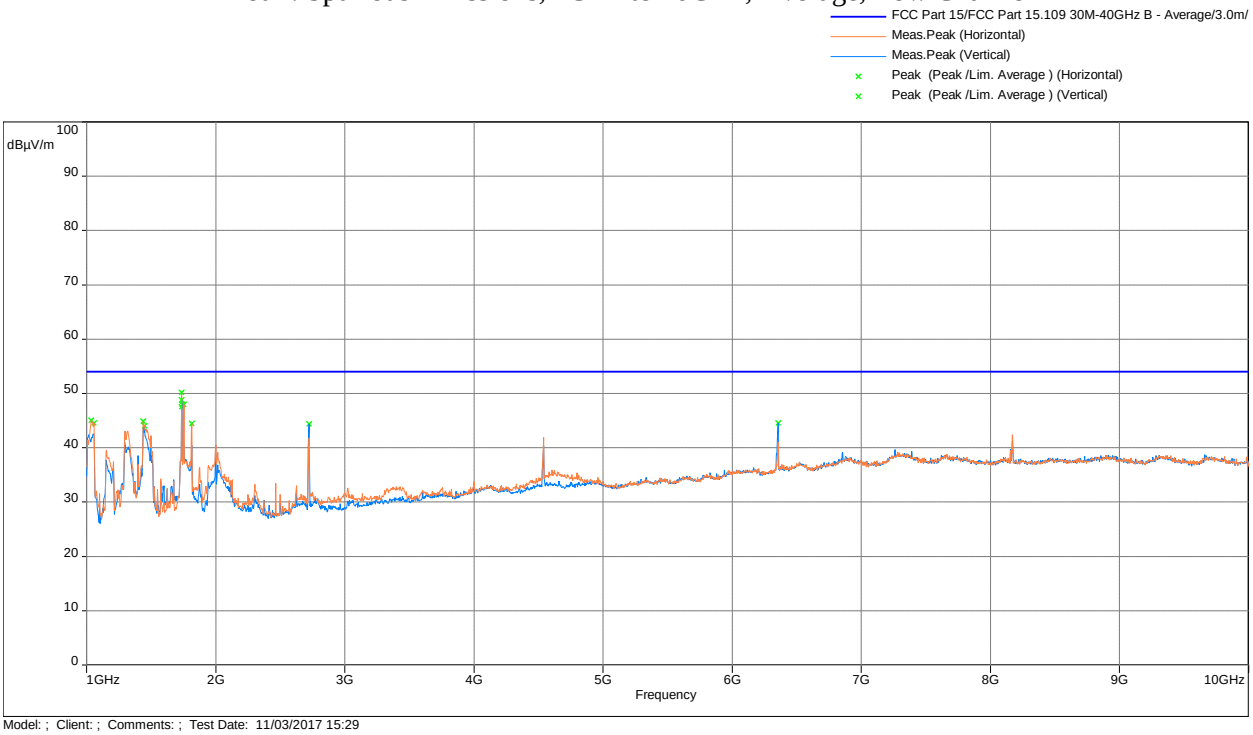
Final Measurements Quasi-Peak (QP)								
Frequency (MHz)	**FS@10m (dBµV/m)**	**Limit@10m (dB(uV/m))**	**Margin (dB)**	**Azimuth (deg)**	**Height (m)**	**Polarity**	**RA @10m (dBuV)**	**Correction (dB)**
299.9705	29.94	35.5	-5.56	6	1	Vertical	40.24	-10.3
524.9523	33.05	35.5	-2.45	344	1.85	Horizontal	38.27	-5.22
574.946	31.76	35.5	-3.74	280.75	1.73	Horizontal	35.48	-3.72
674.9354	30.86	35.5	-4.64	322.75	1.3	Horizontal	34.15	-3.28
868.1362	32.4	35.5	-3.1	350	1.24	Horizontal	32.88	-0.48
299.9705	29.94	35.5	-5.56	6	1	Vertical	40.24	-10.3

Spurious Emissions Data, 30MHz to 1MHz, High Channel

Final Measurements Quasi-Peak (QP)								
Frequency (MHz)	**FS@10m (dBµV/m)**	**Limit@10m (dB(uV/m))**	**Margin (dB)**	**Azimuth (deg)**	**Height (m)**	**Polarity**	**RA @10m (dBuV)**	**Correction (dB)**
324.9706	29.82	35.5	-5.68	317.5	1	Vertical	39.43	-9.61
474.9537	31.81	35.5	-3.69	343	1.66	Horizontal	37.28	-5.47
524.9523	31.34	35.5	-4.16	344.75	1.78	Horizontal	36.56	-5.22
574.9444	31.73	35.5	-3.77	253.5	1.75	Horizontal	35.45	-3.72
868.0925	31.99	35.5	-3.51	338.75	1.08	Horizontal	32.47	-0.48
324.9706	29.82	35.5	-5.68	317.5	1	Vertical	39.43	-9.61

Transmitter Radiated Emissions above 1GHz for Internal Radio Model

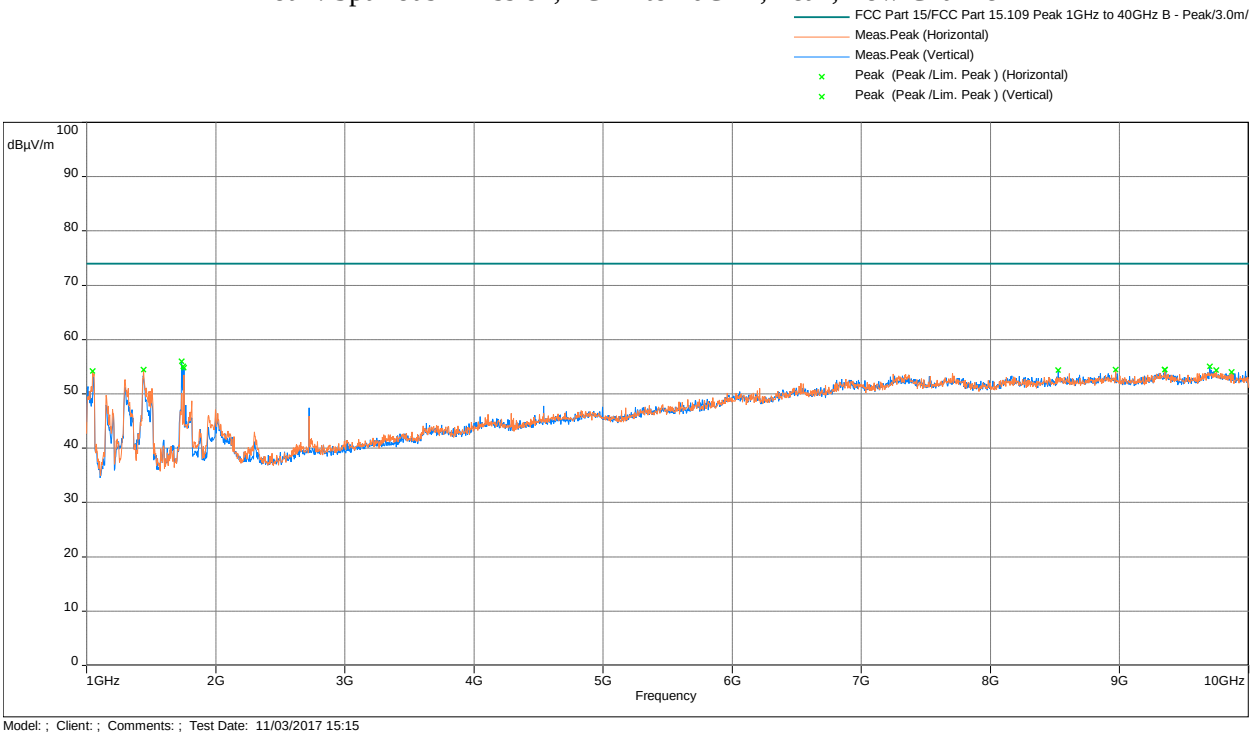
Plot 1: Spurious Emissions, 1GHz to 10GHz, Average, Low Channel



Model: ; Client: ; Comments: ; Test Date: 11/03/2017 15:29

Final Measurements								
Frequency (MHz)	**FS@3m (dBµV/m)**	**Limit@3m (dB(uV/m))**	**Margin (dB)**	**Azimuth (deg)**	**Height (m)**	**Polarity**	**RA@3m (dBuV)**	**Correction (dB)**
1034.8	45.02	54	-8.98	3.99	309.75	Horizontal	51.16	-6.14
1056.7	44.58	54	-9.42	3.99	309.75	Horizontal	50.53	-5.95
1439.2	44.87	54	-9.13	1.02	192.75	Horizontal	48.7	-3.83
1449.7	44.06	54	-9.94	1.01	94.5	Vertical	47.88	-3.82
1735.9	48.77	54	-5.23	3.99	0	Vertical	52.44	-3.67
1735.9	50.14	54	-3.86	3.99	252.75	Horizontal	53.81	-3.67

Plot 2: Spurious Emission, 1GHz to 10GHz, Peak, Low Channel



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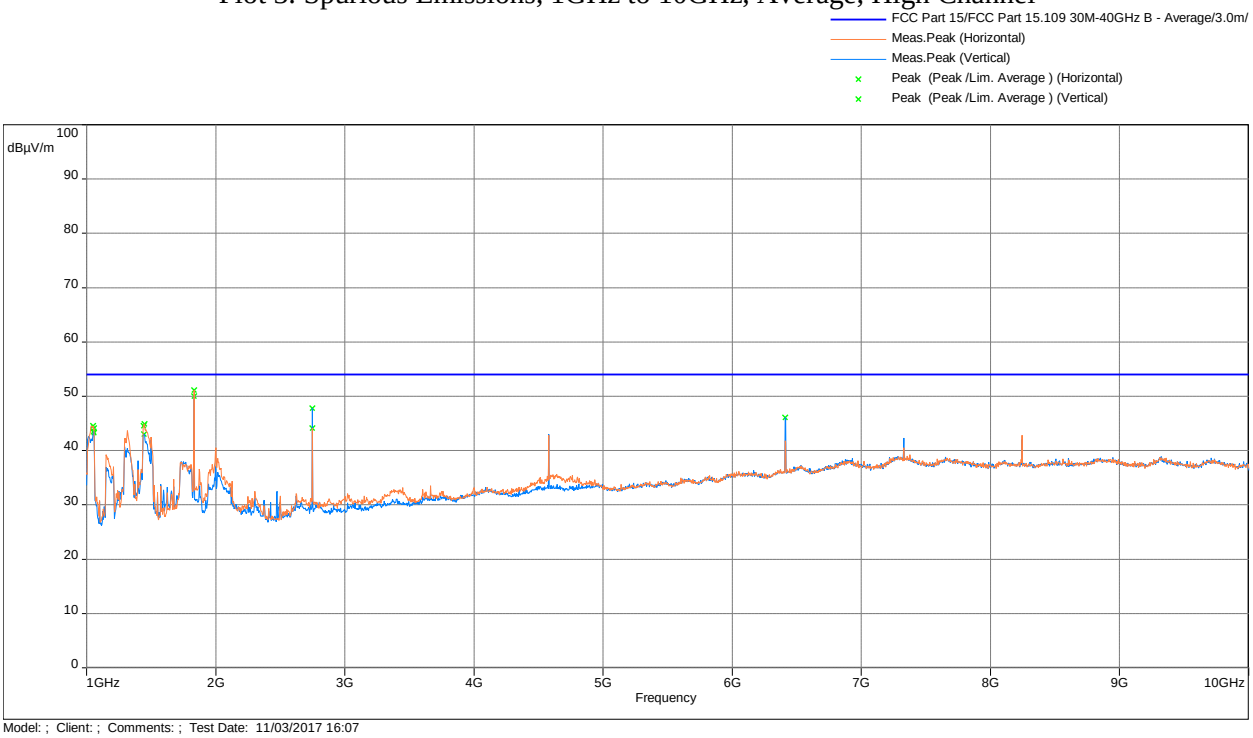
Final Measurements								
Frequency (MHz)	**FS@3m (dBµV/m)**	**Limit@3m (dB(uV/m))**	**Margin (dB)**	**Azimuth (deg)**	**Height (m)**	**Polarity**	**RA@3m (dBuV)**	**Correction (dB)**
1047.1	54.18	74	-19.82	3.98	325	Horizontal	60.21	-6.03
1440.7	54.41	74	-19.59	1.01	164.5	Horizontal	58.23	-3.82
1736.8	56	74	-18	3.99	340.75	Vertical	59.66	-3.66
8971	54.44	74	-19.56	1.01	328.75	Horizontal	40.07	14.37
9348.7	54.44	74	-19.56	1.98	349.75	Horizontal	39.72	14.72
9749.8	54.38	74	-19.62	2.98	3.5	Horizontal	39.44	14.94

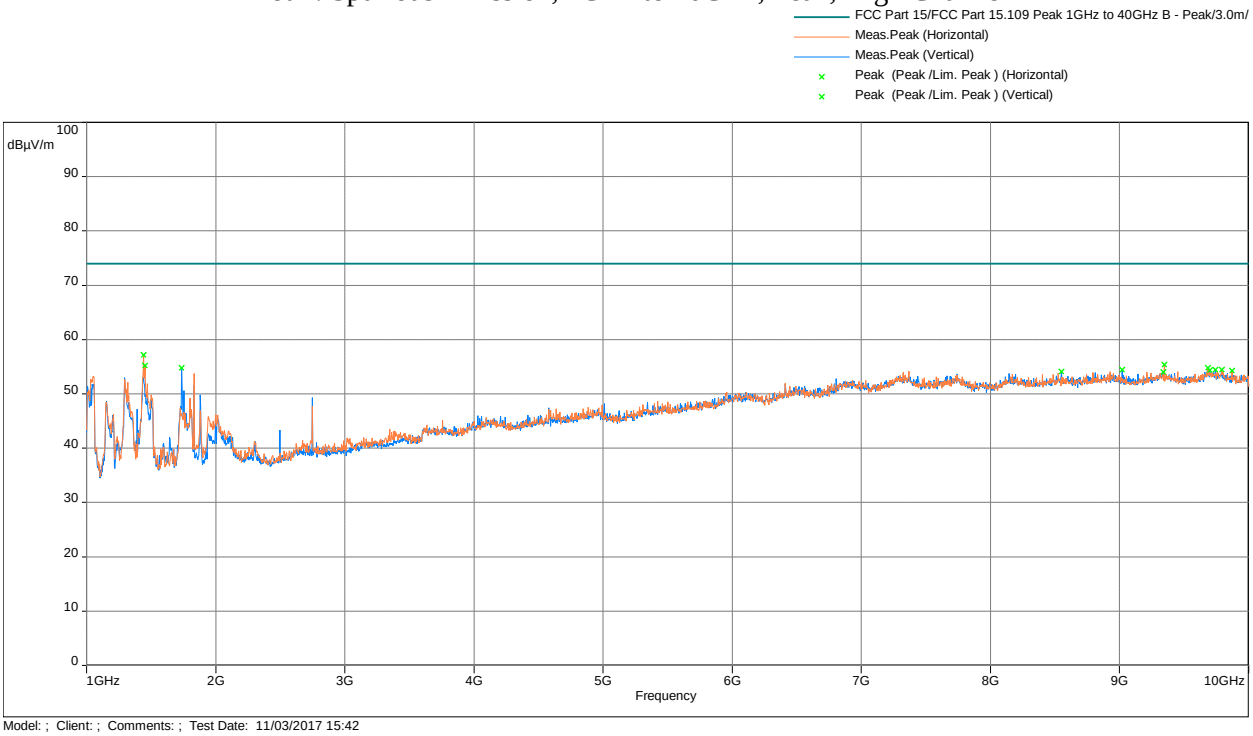
Plot 3: Spurious Emissions, 1GHz to 10GHz, Average, High Channel



Model: ; Client: ; Comments: ; Test Date: 11/03/2017 16:07

Final Measurements								
Frequency (MHz)	**FS@3m (dBµV/m)**	**Limit@3m (dB(uV/m))**	**Margin (dB)**	**Azimuth (deg)**	**Height (m)**	**Polarity**	**RA@3m (dBuV)**	**Correction (dB)**
1050.7	44.58	54	-9.42	3.98	306.75	Horizontal	50.58	-6.0
1450	44.9	54	-9.1	1.02	180.5	Horizontal	48.72	-3.82
1831.9	51.12	54	-2.88	1.02	95	Horizontal	54.33	-3.21
1831.9	50.01	54	-3.99	1.99	65.75	Vertical	53.22	-3.21
2748.1	47.83	54	-6.17	2.99	352	Vertical	47.8	0.03
6412	46.05	54	-7.95	1.99	322.75	Vertical	34.76	11.29

Plot 4: Spurious Emission, 1GHz to 10GHz, Peak, High Channel

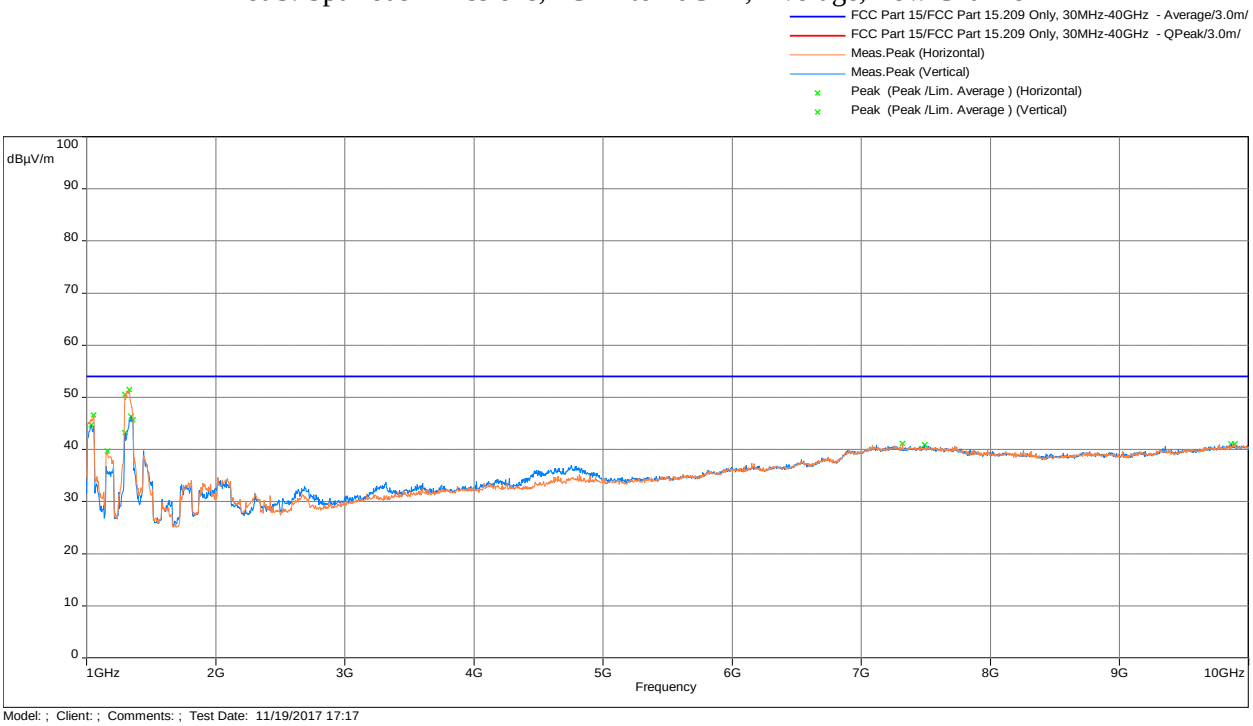


Model: ; Client: ; Comments: ; Test Date: 11/03/2017 15:42

Final Measurements								
Frequency (MHz)	**FS@3m (dBµV/m)**	**Limit@3m (dB(uV/m))**	**Margin (dB)**	**Azimuth (deg)**	**Height (m)**	**Polarity**	**RA@3m (dBuV)**	**Correction (dB)**
1440.7	57.21	74	-16.79	1.01	191	Horizontal	61.03	-3.82
1451.2	55.17	74	-18.83	1.01	191	Horizontal	58.99	-3.82
1736.5	54.78	74	-19.22	3.99	34	Vertical	58.44	-3.66
9346.3	55.42	74	-18.58	2.98	343.75	Horizontal	40.7	14.72
9685.3	54.77	74	-19.23	3.98	346	Horizontal	39.72	15.05
9793.3	54.47	74	-19.53	1.98	151.75	Horizontal	39.78	14.69

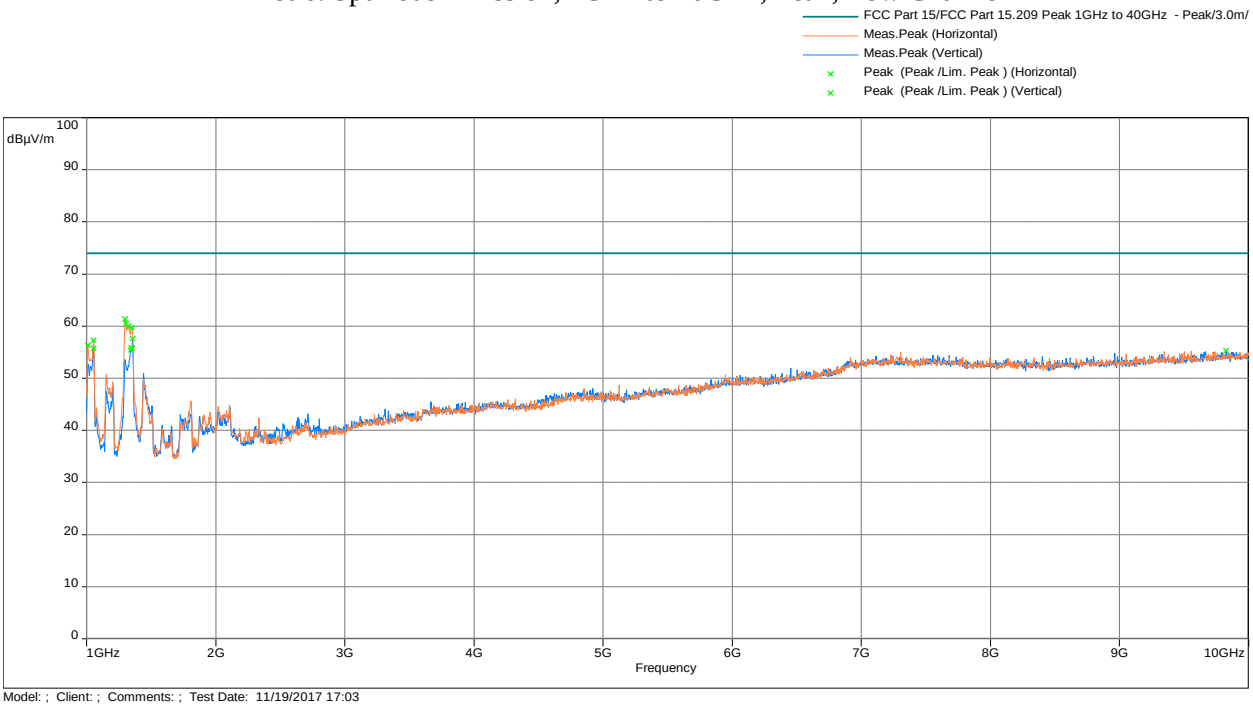
Transmitter Radiated Emissions above 1GHz for External Radio Model

Plot 5: Spurious Emissions, 1GHz to 10GHz, Average, Low Channel



Final Measurements								
Frequency (MHz)	**FS@3m (dBµV/m)**	**Limit@3m (dB(uV/m))**	**Margin (dB)**	**Azimuth (deg)**	**Height (m)**	**Polarity**	**RA@3m (dBuV)**	**Correction (dB)**
1035.1	44.73	54	-9.27	3.99	94	Vertical	50.92	-6.19
1055.5	46.61	54	-7.39	3.02	167.25	Horizontal	52.62	-6.01
1296.7	50.48	54	-3.52	1.02	309.25	Horizontal	54.77	-4.29
1331.2	51.42	54	-2.58	1.02	309.25	Horizontal	55.56	-4.14
1344.1	46.38	54	-7.62	3.99	208.25	Vertical	50.47	-4.09
1358.2	45.64	54	-8.36	3.99	208.25	Vertical	49.68	-4.04

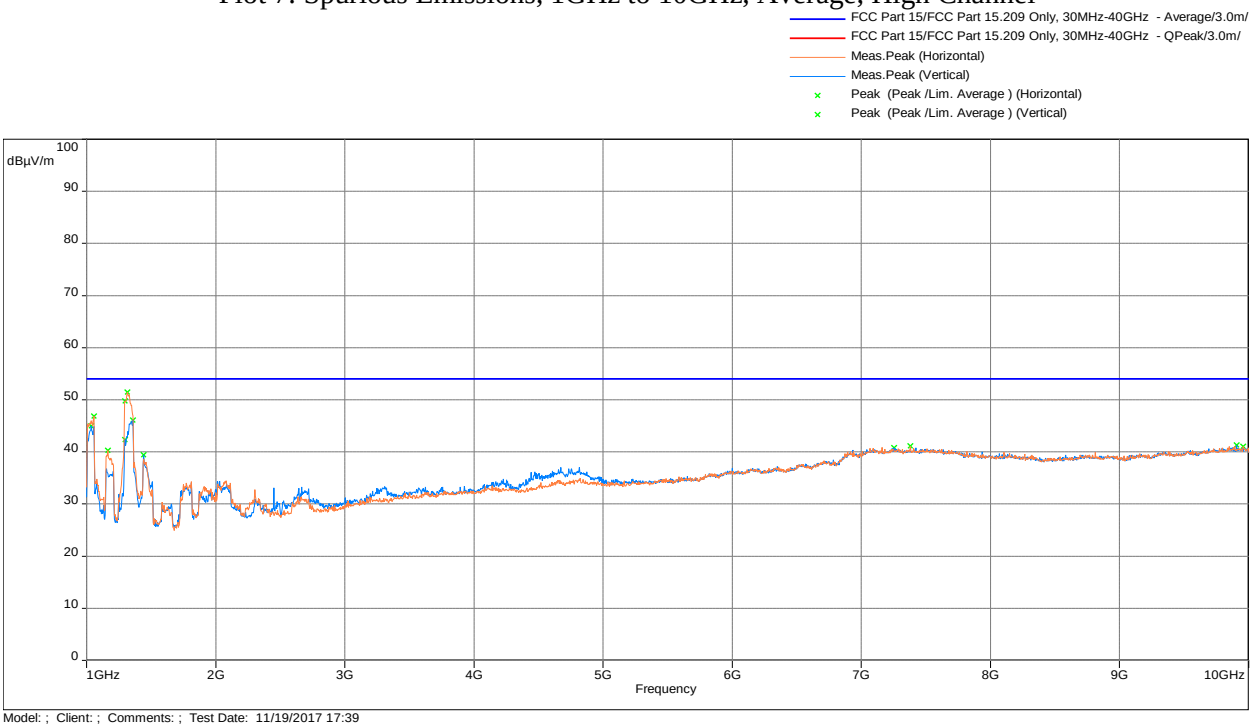
Plot 6: Spurious Emission, 1GHz to 10GHz, Peak, Low Channel



Model: ; Client: ; Comments: ; Test Date: 11/19/2017 17:03

Final Measurements								
Frequency (MHz)	**FS@3m (dBµV/m)**	**Limit@3m (dB(uV/m))**	**Margin (dB)**	**Azimuth (deg)**	**Height (m)**	**Polarity**	**RA@3m (dBuV)**	**Correction (dB)**
1054.9	57.27	74	-16.73	2.98	168.75	Horizontal	63.29	-6.02
1298.8	61.34	74	-12.66	1.02	303	Horizontal	65.62	-4.28
1304.5	60.5	74	-13.5	1.02	303	Horizontal	64.76	-4.26
1321.6	60	74	-14	1.02	303	Horizontal	64.18	-4.18
1353.1	59.67	74	-14.33	1.02	303	Horizontal	63.73	-4.06
1354.3	57.59	74	-16.41	3.99	217.5	Vertical	61.64	-4.05

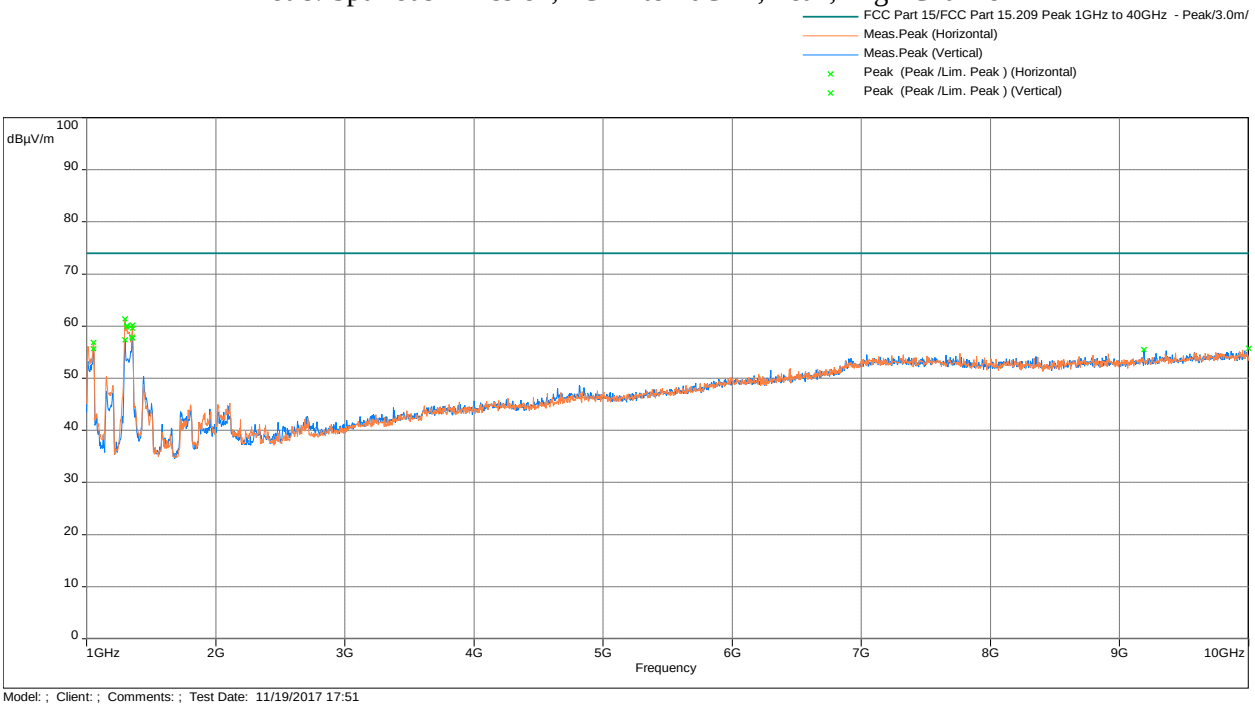
Plot 7: Spurious Emissions, 1GHz to 10GHz, Average, High Channel



Model: ; Client: ; Comments: ; Test Date: 11/19/2017 17:39

Final Measurements								
Frequency (MHz)	**FS@3m (dBµV/m)**	**Limit@3m (dB(uV/m))**	**Margin (dB)**	**Azimuth (deg)**	**Height (m)**	**Polarity**	**RA@3m (dBuV)**	**Correction (dB)**
1055.8	46.84	54	-7.16	2.98	167.5	Horizontal	52.85	-6.01
1163.5	40.29	54	-13.71	1.98	153	Horizontal	45.56	-5.27
1296.7	49.72	54	-4.28	1.02	307.75	Horizontal	54.01	-4.29
1316.5	51.5	54	-2.5	1.02	307.75	Horizontal	55.7	-4.2
7379.8	41.13	54	-12.87	2.98	96	Horizontal	27	14.13
9958.6	41.09	54	-12.91	3.98	39.5	Horizontal	26.18	14.91

Plot 8: Spurious Emission, 1GHz to 10GHz, Peak, High Channel

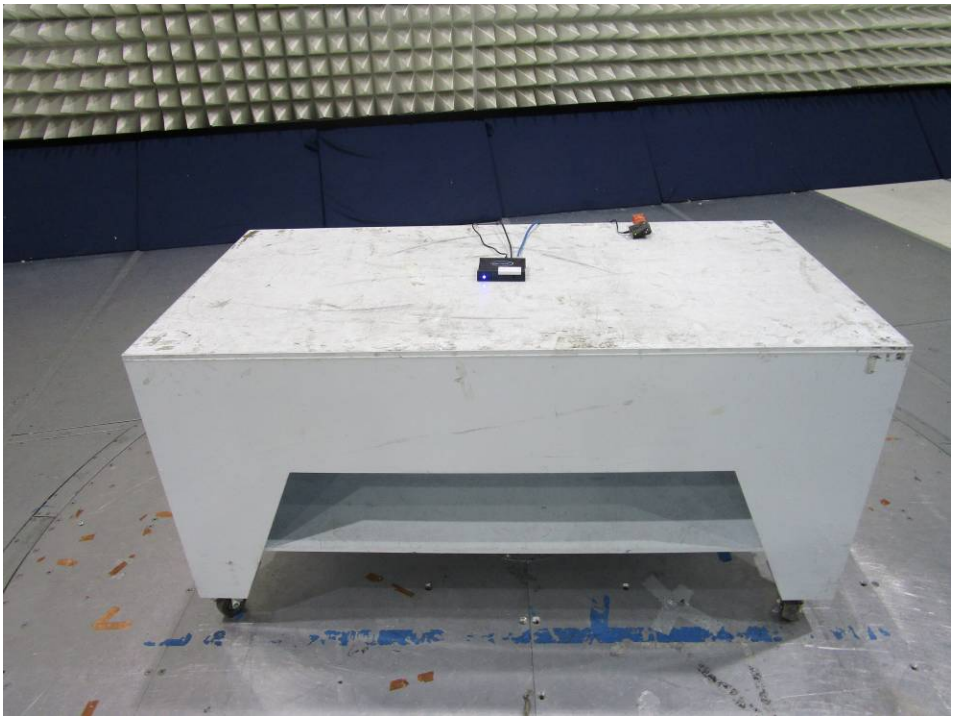


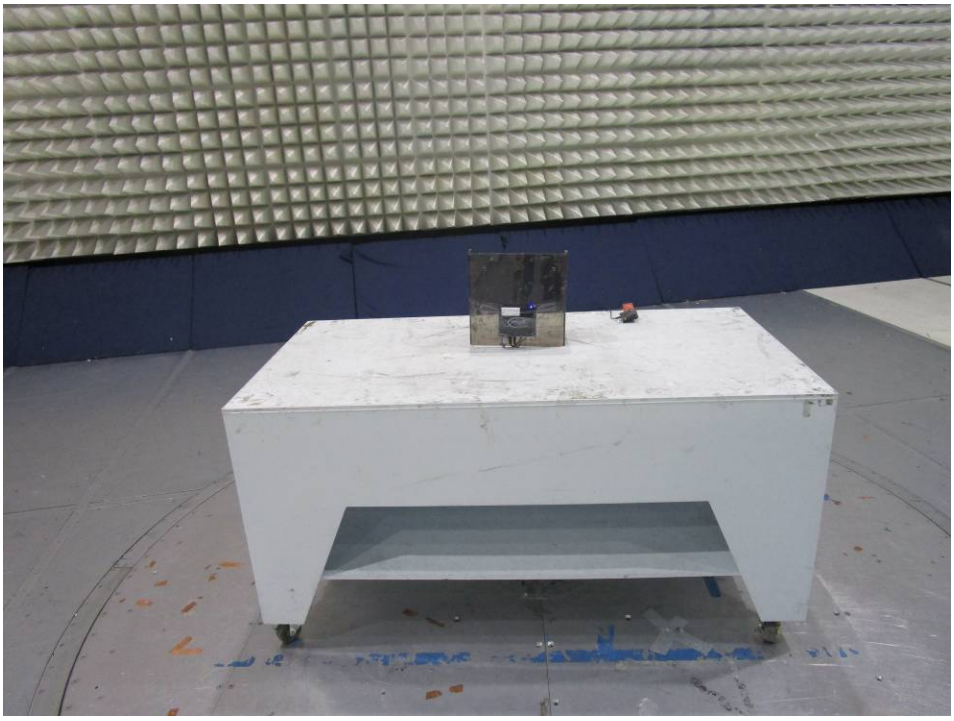
Model: ; Client: ; Comments: ; Test Date: 11/19/2017 17:51

Final Measurements								
Frequency (MHz)	**FS@3m (dBµV/m)**	**Limit@3m (dB(uV/m))**	**Margin (dB)**	**Azimuth (deg)**	**Height (m)**	**Polarity**	**RA@3m (dBuV)**	**Correction (dB)**
1299.4	61.34	74	-12.66	1.02	304	Horizontal	65.62	-4.28
1310.8	59.81	74	-14.19	1.02	304	Horizontal	64.04	-4.23
1314.1	60.06	74	-13.94	1.02	304	Horizontal	64.27	-4.21
1353.4	57.88	74	-16.12	3.99	229.5	Vertical	61.94	-4.06
1354.6	60.14	74	-13.86	1.02	304	Horizontal	64.19	-4.05
1355.2	59.58	74	-14.42	1.02	304	Horizontal	63.63	-4.05

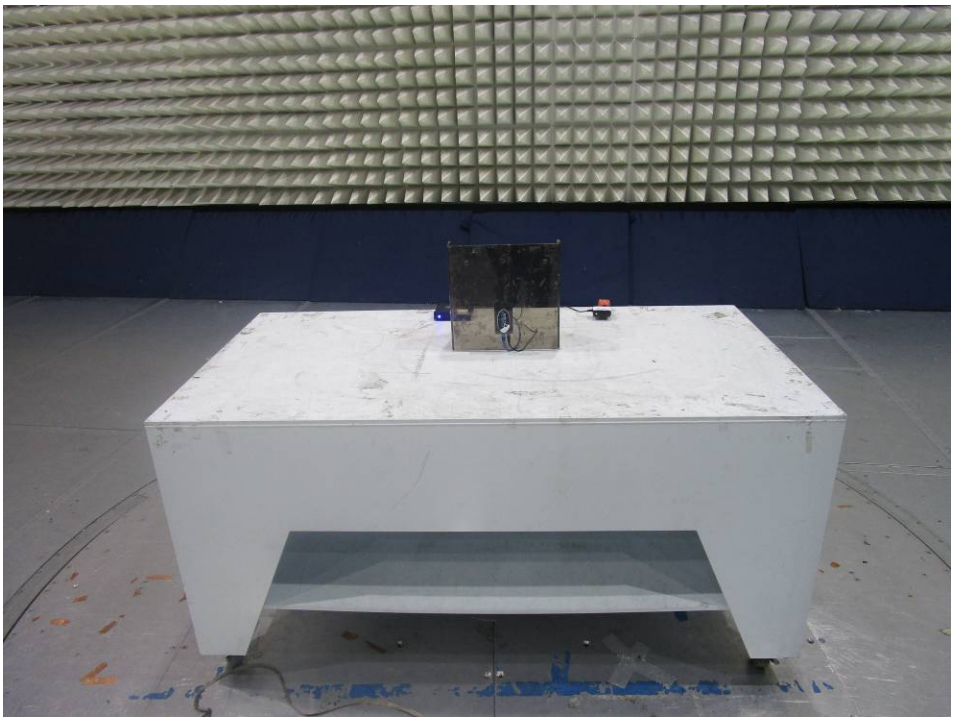
Test setup photographs

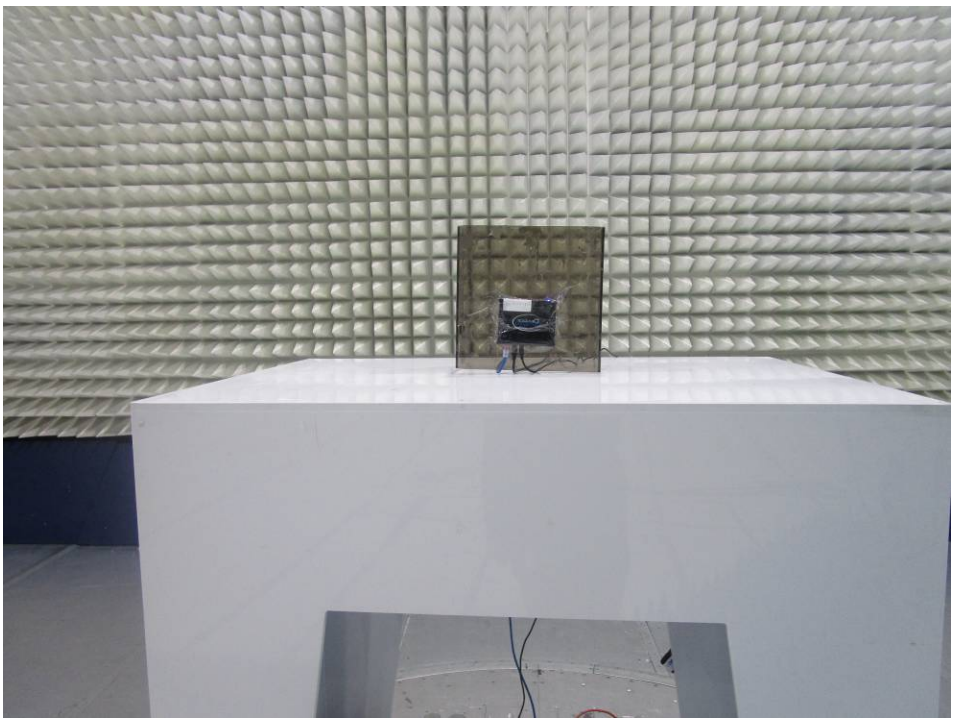
The following photographs show the testing configurations used.



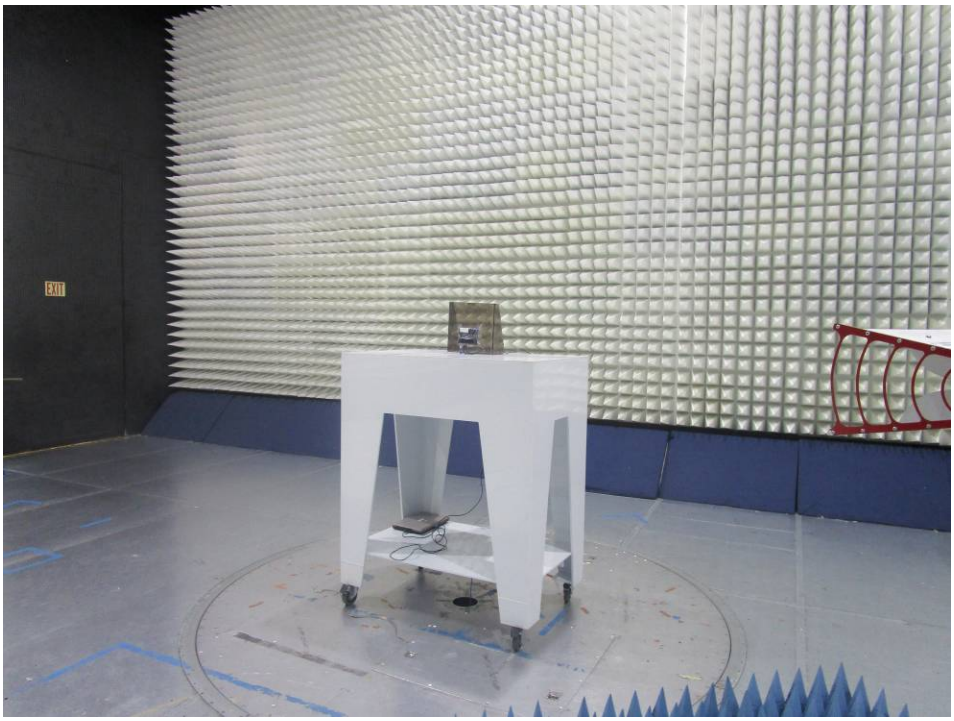


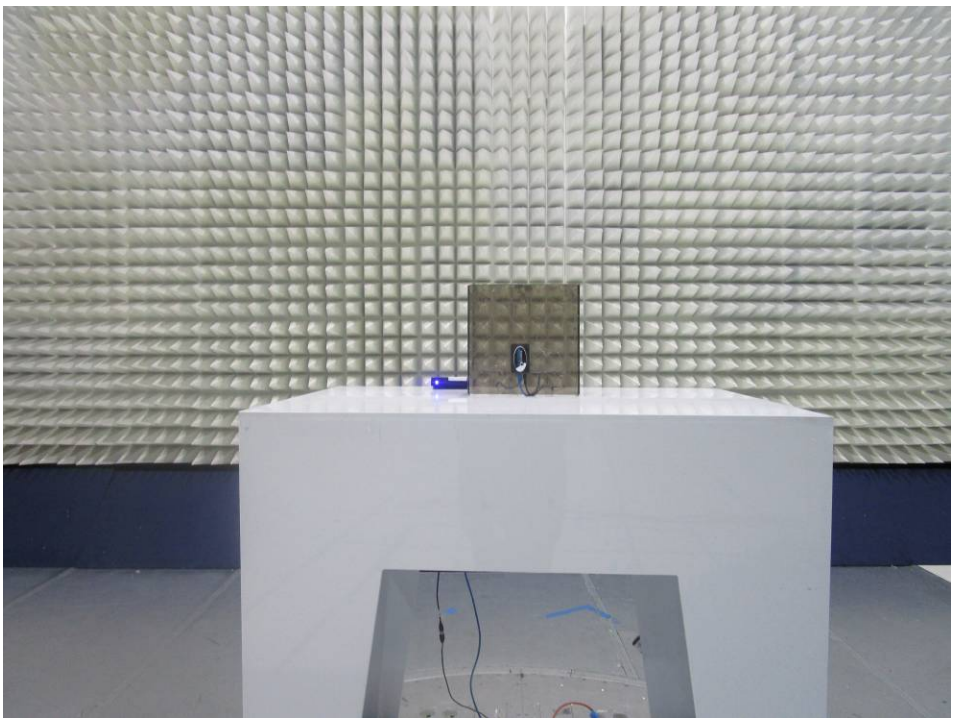
Test setup photographs (Continued)



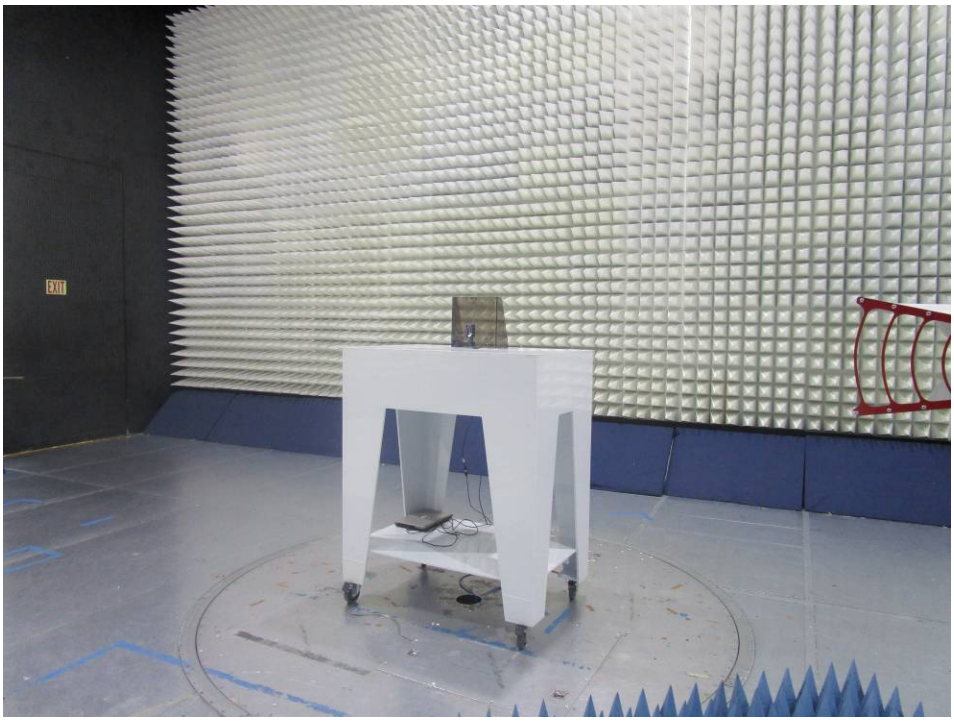


Test setup photographs (Continued)





Test setup photographs (Continued)



4.2 Occupied Bandwidth
FCC Rules: 15.215(c); IC Rules: RSS-Gen

Requirements

No limits for 20 dB Bandwidth and Occupied Bandwidths.

Procedure

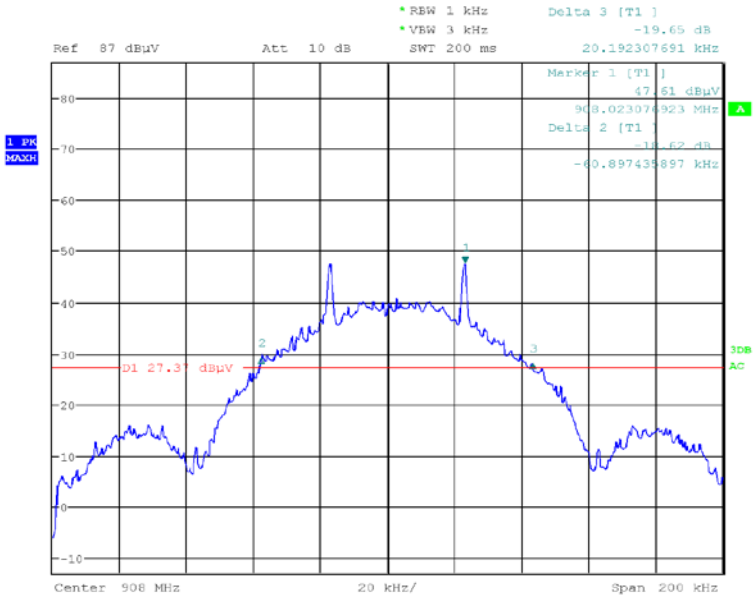
The antenna port of the EUT was connected to the input of a spectrum analyzer (SA). For each RF output channel investigated, the spectrum analyzer center frequency was set to the channel carrier. A PEAK output reading was taken, a DISPLAY line was drawn 20 dB lower than PEAK level. The 20 dB bandwidth was determined from where the channel output spectrum intersected the marker delta.

The occupied bandwidth was measured using the built-in spectrum analyzer function for 99% power bandwidth measurement.

Test Results

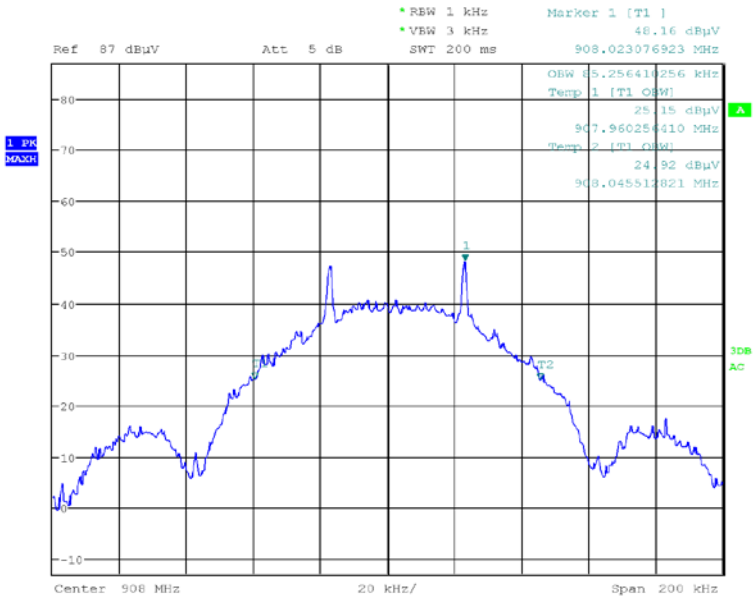
Frequency MHz	20-dB bandwidth kHz	Occupied bandwidth kHz
908	81.089	85.26
916	125	109.295

Plot 1: 908 MHz 20dB Bandwidth



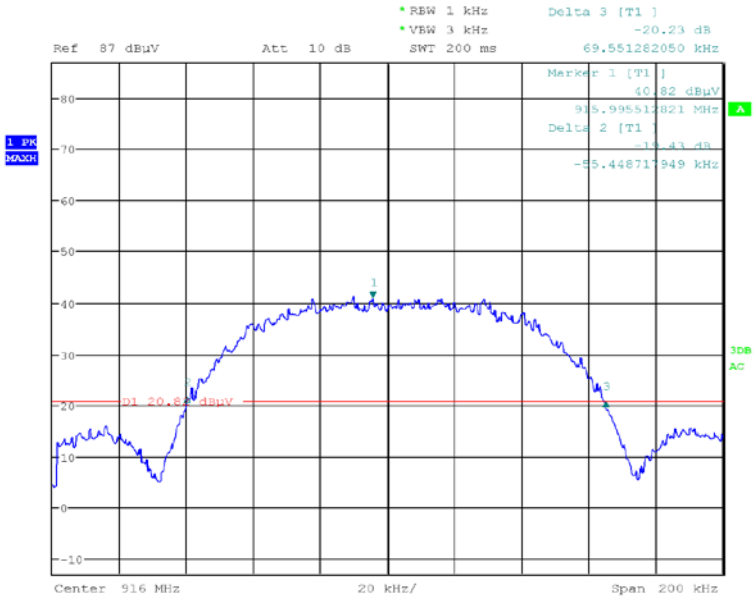
Date: 26.OCT.2017 08:14:26

Plot 2: 908 MHz 99% Bandwidth



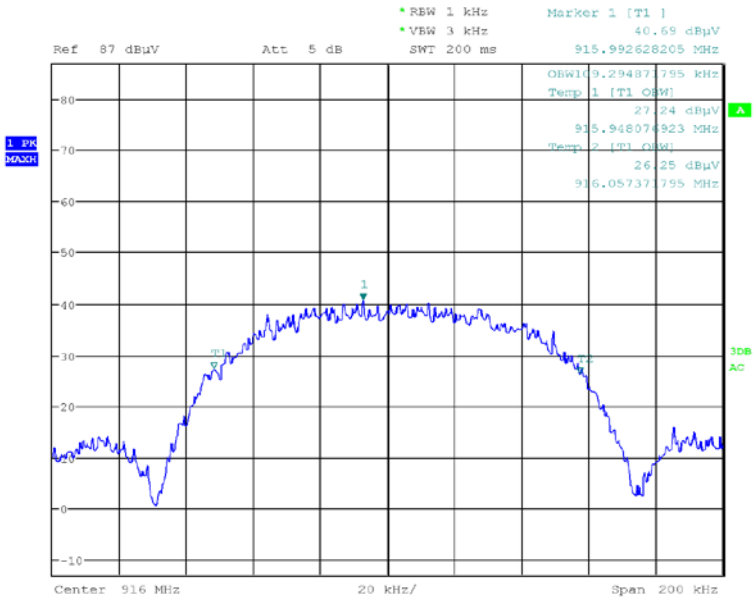
Date: 26.OCT.2017 08:15:57

Plot 3: 916 MHz 20dB Bandwidth



Date: 26.OCT.2017 07:59:00

Plot 4: 916 MHz 99% Bandwidth



Date: 26.OCT.2017 08:00:18

4.3 Radiated Emissions from Digital Parts
FCC Ref: 15.109

Requirements

Limits for Electromagnetic Radiated Emissions, FCC Section 15.109(b) and ICES 003*

Frequency (MHz)	Class A at 10m dB(μV/m)	Class B at 3m dB(μV/m)
30-88	39	40.0
88-216	43.5	43.5
216-960	46.4	46.0
Above 960	49.5	54.0

* According to FCC Part 15.109(g) an alternative to the radiated emission limits shown above, digital devices may be shown to comply with the limit of CISPR Pub. 22

Procedure

Measurements are conducted with a quasi-peak detector instrument in the frequency range of 30 MHz to 1000 MHz and with the average detector instrument in the frequency range above 1000 MHz. The measuring receiver meets the requirements of Section One of CISPR 16 and the measuring antenna correlates to a balanced dipole.

Measurements of the radiated field are made with the antenna located at a distance of 10 meters from the EUT. If the field-strength measurements at 10m cannot be made because of high ambient noise level or for other reasons, measurements of Class B equipment may be made at a closer distance, for example 3m. An inverse proportionality factor of 20 dB per decade should be used to normalize the measured data to the specified distance for determining compliance.

The antenna is adjusted between 1m and 4m in height above the ground plane for maximum meter reading at each test frequency.

The antenna-to-EUT azimuth is varied during the measurement to find the maximum field-strength readings.

The antenna-to-EUT polarization (horizontal and vertical) is varied during the measurements to find the maximum field-strength readings.

The EUT, where intended for tabletop use, is placed on a table whose top is 0.8m above the ground plane. The table is constructed of non-conductive materials. Its dimensions are 1m by 1.5m, but may be extended for a larger EUT.

Floor standing EUTs are placed on a horizontal metal ground plane and isolated from the ground plane by 3 to 12 mm of insulating material.

Equipment setup for radiated disturbance tests followed the guidelines of ANSI C63.4:2014.

Example Field Strength Calculation

The field strength is calculated by adding the Antenna Factor and Cable Factor to from the measured reading, followed by subtracting the Amplifier Gain (if any) and Distance Correction Factor (if any). The basic equation with a sample calculation is as follows:

FS = RA + AF + CF – PA – DCF

Where FS = Field Strength in dB (μV/m)
RA = Receiver Amplitude (including preamplifier) in dB (μV)
CF = Cable Attenuation Factor in dB
AF = Antenna Factor in dB (1/m)
AG = Amplifier Gain in dB
DCF=Distance Correction Factor in dB
(Formula: DCF = $20\log_{10}$ (measurement distance/specification distance)

Assume a receiver reading of 52.0 dB (μV) is obtained. The antenna factor of 7.4 dB and cable factor of 1.6 dB is added. The amplifier gain of 29 dB and DCF of 10.5 dB (DCF in this example: $20\log_{10}$ (10/3)) is subtracted, giving field strength of 21.5 dB (μV/m).

RA = 52.0 dB (μV)
AF = 7.4 dB (1/m)
CF = 1.6 dB
AG = 29.0 dB
DCF=10.5 dB
FS = RF + AF + CF – AG – DCF
FS = 52.0 + 7.4 + 1.6 – 29.0 – 10.5
FS = 21.5 dB (μV/m)

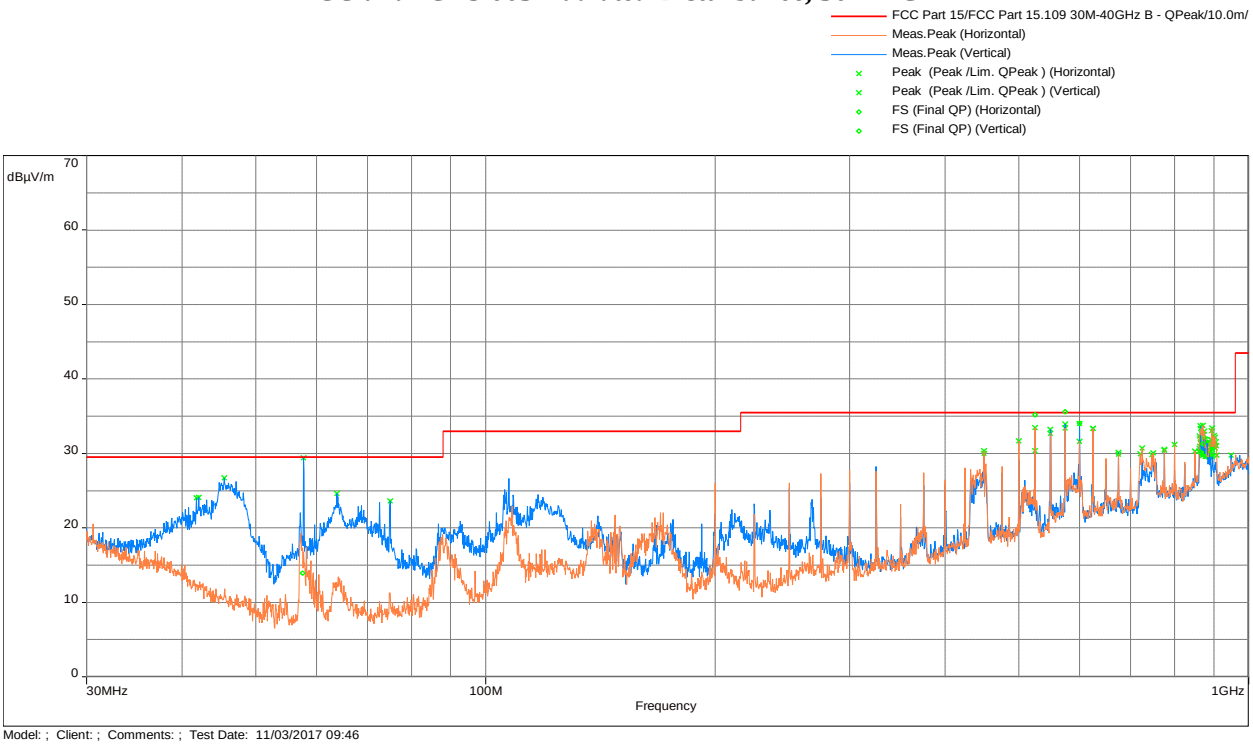
Test Results

Radiated emission measurements were performed from 30 MHz to 1000 MHz. Spectrum Analyzer RBW is 100 kHz or greater - below 1000 MHz and 1 MHz - above 1000 MHz.

The EUT passed 6.6dB for Class B.

Internal Radio Model

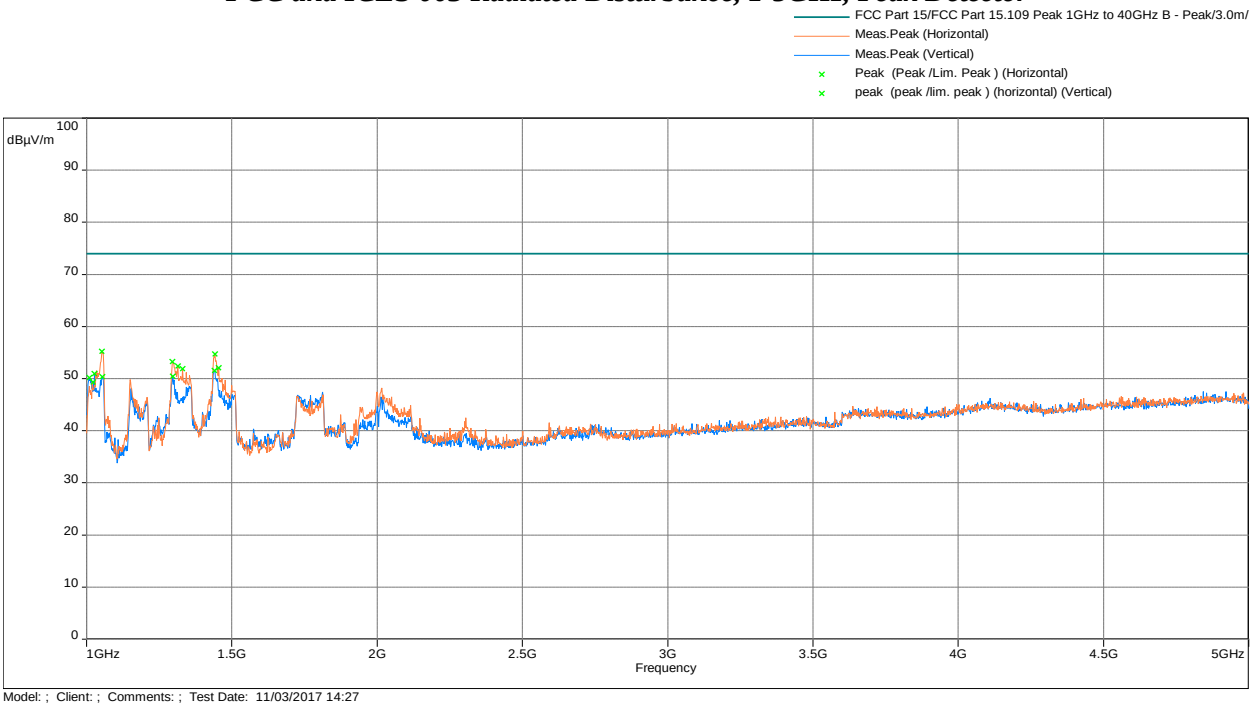
FCC and ICES 003 Radiated Disturbance, 30M-1GHz



Model: ; Client: ; Comments: ; Test Date: 11/03/2017 09:46

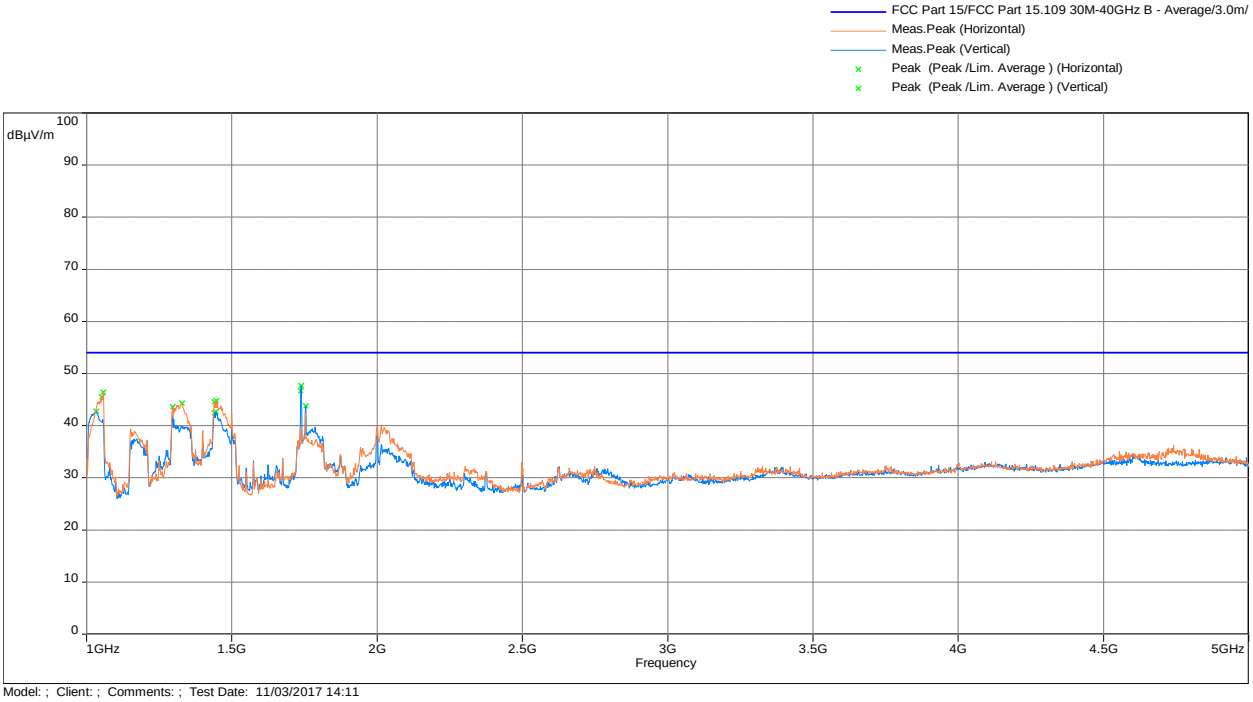
Final Measurements Quasi-Peak (QP)								
Frequency (MHz)	**FS@10m (dBµV/m)**	**Limit@10m (dB(uV/m))**	**Margin (dB)**	**Azimuth (deg)**	**Height (m)**	**Polarity**	**RA@10m (dBuV)**	**Correction (dB)**
57.54997	13.93	29.5	-15.57	312.5	2.17	Vertical	35.1	-21.11
524.9507	35.19	35.5	-0.31	256.5	1.58	Horizontal	41.8	-6.62
574.946	34.99	35.5	-0.51	0.99	144.75	Vertical	39.4	-4.42
599.9445	34.02	35.5	-1.48	124.75	2.99	Vertical	38.7	-4.62
864.4624	30.14	35.5	-5.36	263	1.89	Vertical	29.9	0.23
870.229	31.29	35.5	-4.21	37.25	1.12	Horizontal	31.1	0.21

FCC and ICES 003 Radiated Disturbance, 1-5GHz, Peak Detector



Model: ; Client: ; Comments: ; Test Date: 11/03/2017 14:27

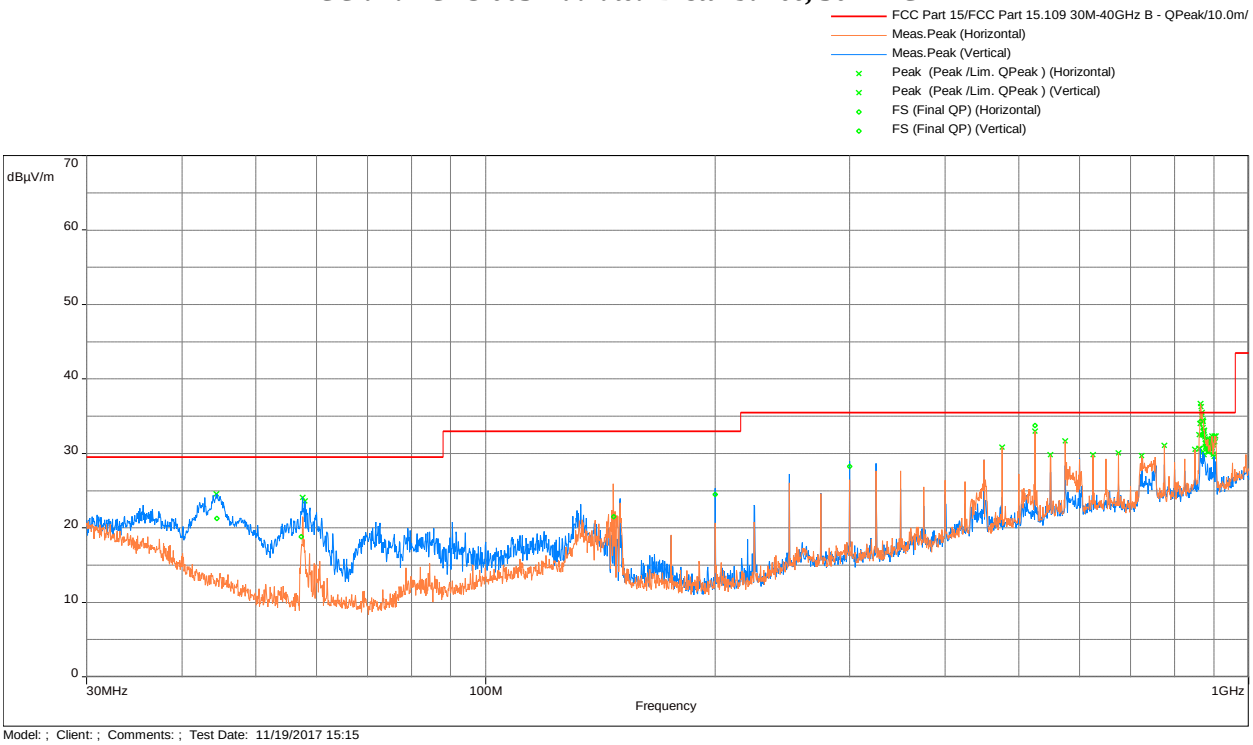
FCC and ICES 003 Radiated Disturbance, 1GHz-5GHz, Average Detector



Model: ; Client: ; Comments: ; Test Date: 11/03/2017 14:11

External Radio Model

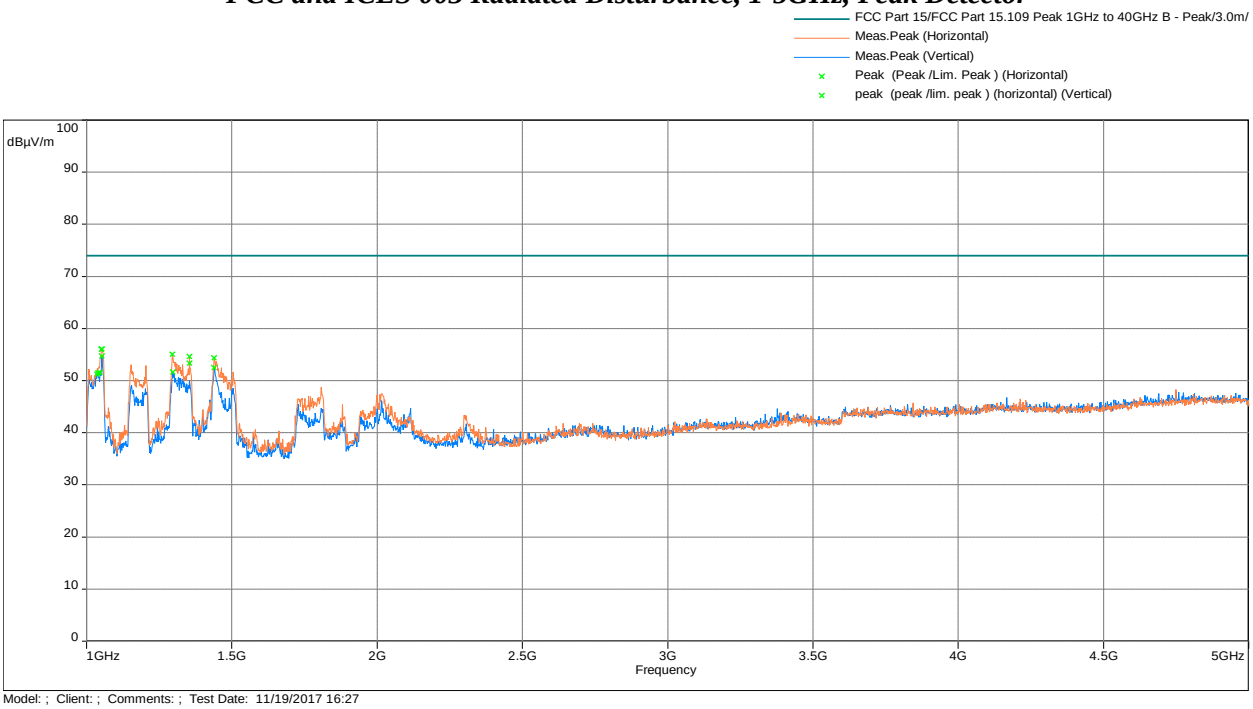
FCC and ICES 003 Radiated Disturbance, 30M-1GHz



Model: ; Client: ; Comments: ; Test Date: 11/19/2017 15:15

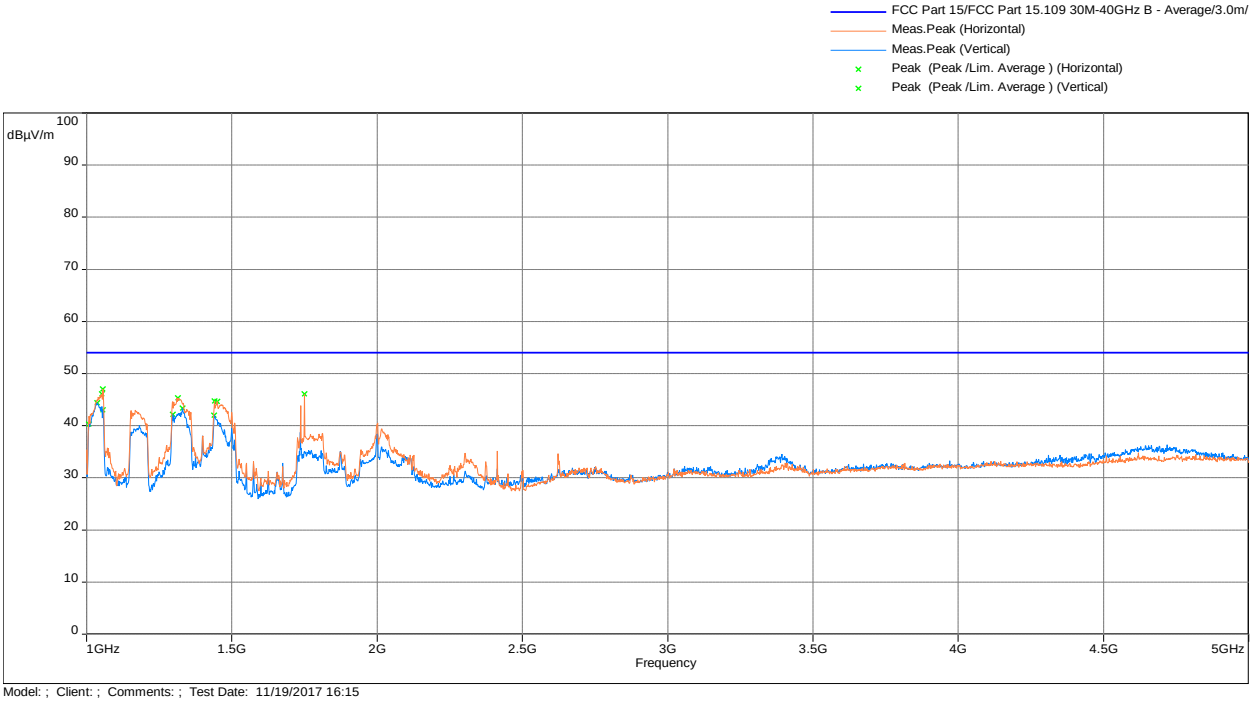
Final Measurements Quasi-Peak (QP)								
Frequency (MHz)	**FS@10m (dBµV/m)**	**Limit@10m (dB(uV/m))**	**Margin (dB)**	**Azimuth (deg)**	**Height (m)**	**Polarity**	**RA@10m (dBuV)**	**Correction (dB)**
44.42651	21.25	29.5	-8.25	304.25	1.82	Vertical	35.43	-14.21
57.35465	18.84	29.5	-10.66	272.5	3.38	Vertical	37.55	-18.69
147.1006	21.48	33	-11.52	291	3.58	Horizontal	35.11	-13.63
199.9795	24.47	33	-8.53	38	1	Vertical	39.08	-14.6
299.9737	28.25	35.5	-7.25	5	1	Vertical	38.55	-10.3
524.9491	33.77	35.5	-1.73	344.25	1.8	Horizontal	38.99	-5.22
864.8689	34.31	35.5	-1.19	351	1.24	Horizontal	34.78	-0.47

FCC and ICES 003 Radiated Disturbance, 1-5GHz, Peak Detector



Model: ; Client: ; Comments: ; Test Date: 11/19/2017 16:27

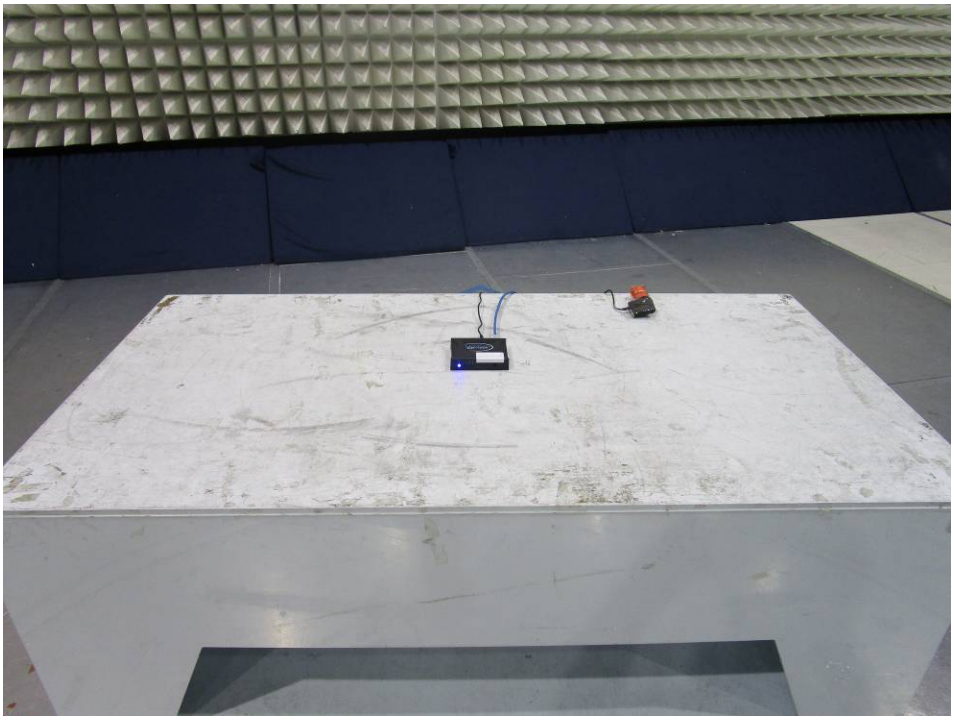
FCC and ICES 003 Radiated Disturbance, 1GHz-5GHz, Average Detector

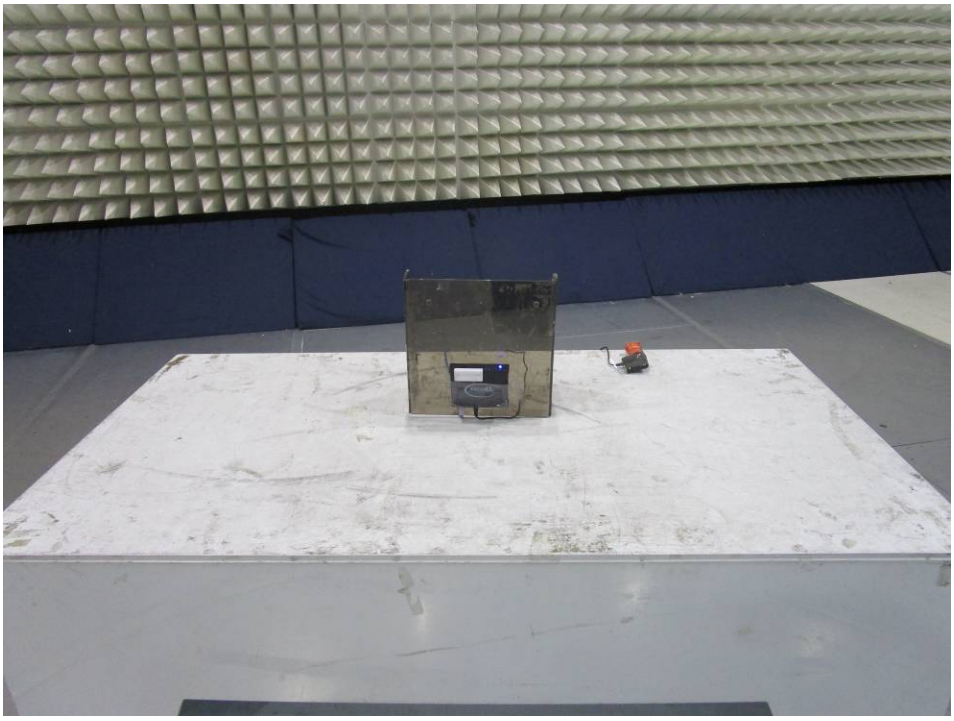


Model: ; Client: ; Comments: ; Test Date: 11/19/2017 16:15

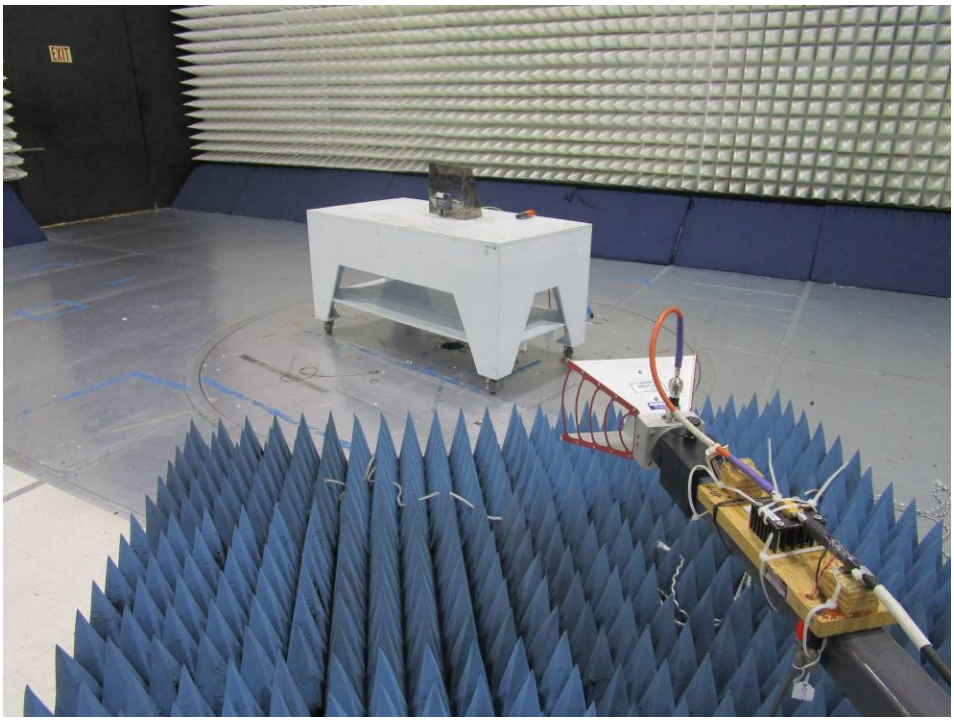
Test setup photographs

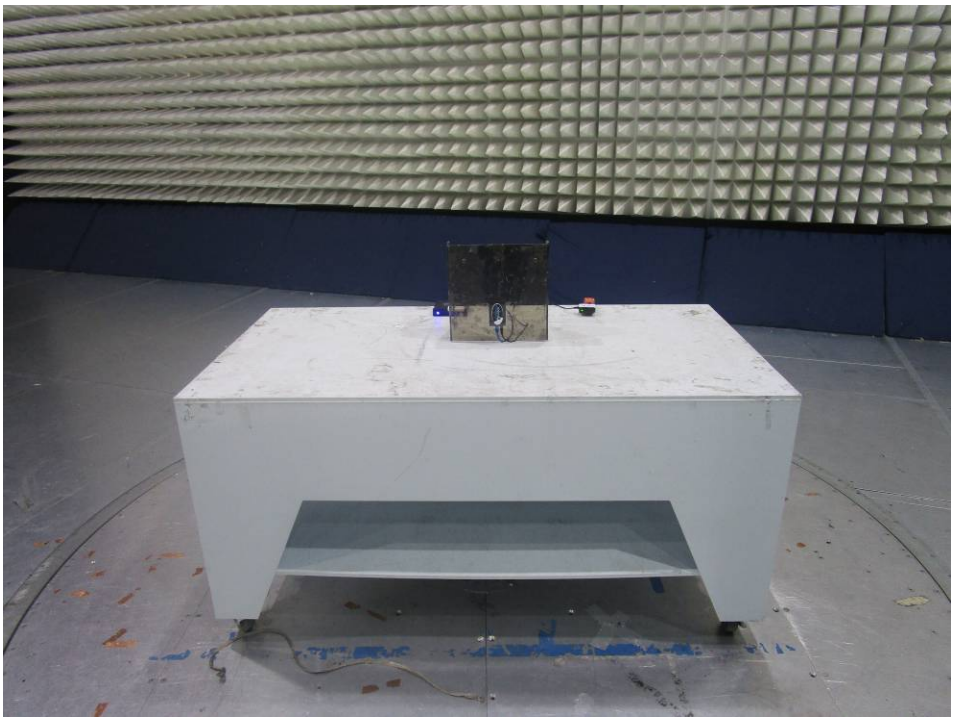
The following photographs show the testing configurations used.



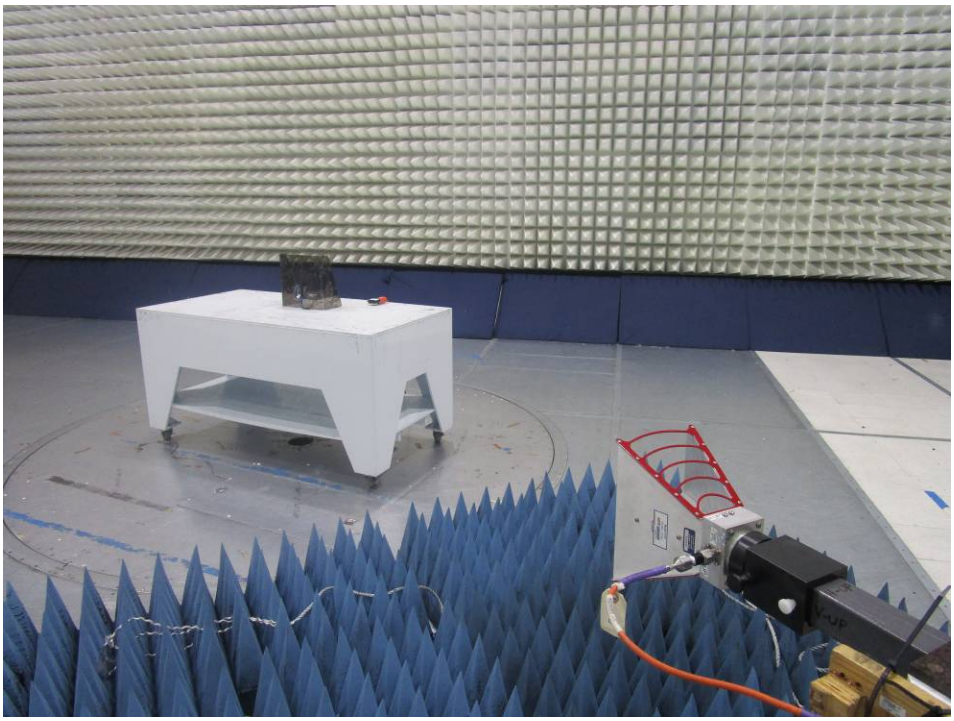


Test setup photographs (Continued)





Test setup photographs (Continued)



4.4 Line Conducted Emissions
FCC Rules: 15.207; IC Rules: RSS-Gen
FCC Rules: 15.107; IC Rules: ICES 003

Requirements

Frequency Band MHz	Class B Limit dB(μV)	
	Quasi-Peak	Average
0.15-0.50	66 to 56 *	56 to 46 *
0.50-5.00	56	46
5.00-30.00	60	50

*Note: *Decreases linearly with the logarithm of the frequency*
At the transition frequency the lower limit applies.

Procedure

Measurements are carried out using quasi-peak and average detector receivers in accordance with CISPR 16. An AMN is required to provide defined impedance at high frequencies across the power feed at the point of measurement of terminal voltage and also to provide isolation of the circuit under test from the ambient noise on the power lines. An AMN as defined in CISPR 16 shall be used.

The EUT is located so that the distance between the boundary of the EUT and the closest surface of the AMN is 0.8m.

Where a flexible mains cord is provided by the manufacturer, this shall be 1m long or if in excess of 1m, the excess cable is folded back and forth as far as possible so as to form a bundle not exceeding 0.4m in length.

The EUT is arranged and connected with cables terminated in accordance with the product specification.

Conducted disturbance is measured between the phase lead and the reference ground, and between the neutral lead and the reference ground. Both measured values are reported.

The EUT, where intended for tabletop use, is placed on a table whose top is 0.8m above the ground plane. A vertical, metal reference plane is placed 0.4m from the EUT. The vertical metal reference-plane is at least 2m by 2m. The EUT shall be kept at least 0.8m from any other metal surface or other ground plane not being part of the EUT. The table is constructed of non-conductive materials. Its dimensions are 1m by 1.5m, but may be extended for larger EUT.

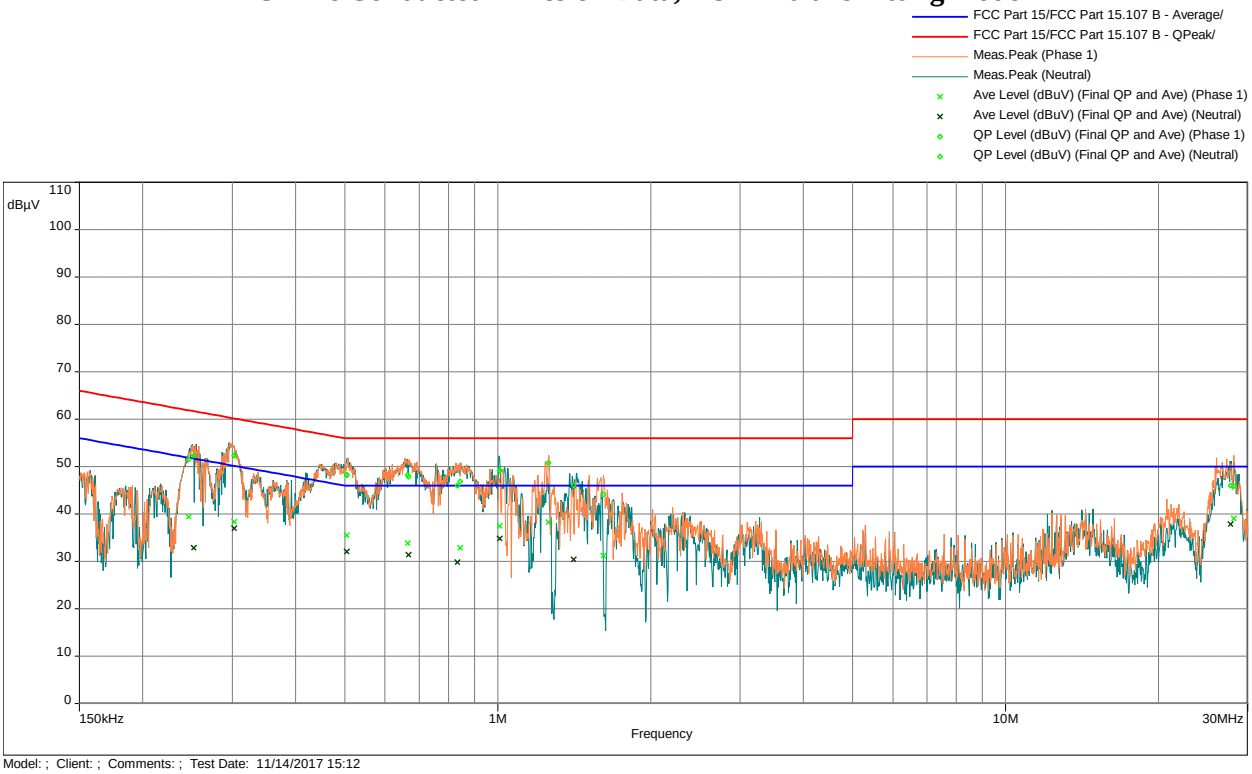
Floor standing EUT are placed on a horizontal metal ground plane and isolated from the ground plane by resting on an insulating material. The metal ground plane extends at least 0.5m beyond the boundaries of the EUT and has minimum dimensions of 2m by 2m.

Equipment setup for conducted disturbance tests followed the guidelines of ANSI C63.4:2014.

Test Result

Internal Radio Model

AC Line Conducted Emission Data, EUT in transmitting mode

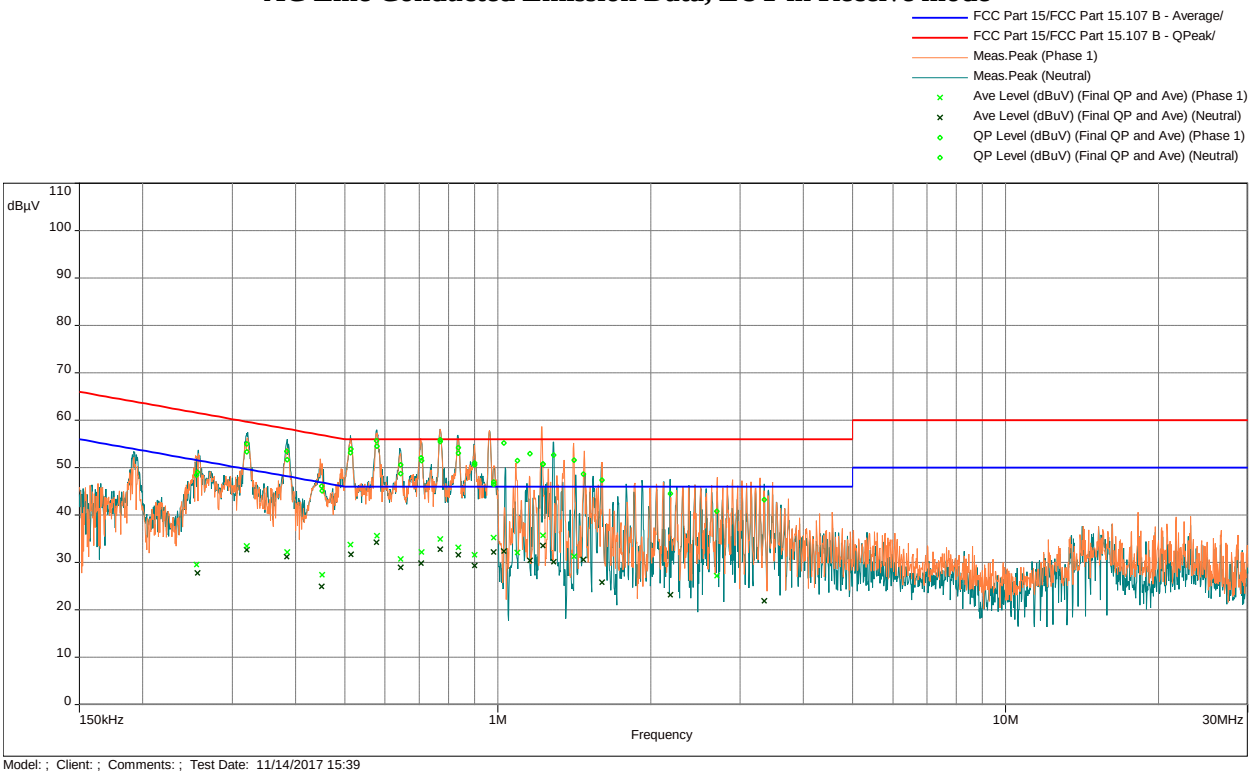


Model: ; Client: ; Comments: ; Test Date: 11/14/2017 15:12

All finals							
Freq (MHz)	**Ave Level (dBuV)**	**QP Level (dBuV)**	**Ave Limit (dBuV)**	**QP Limit (dBuV)**	**Ave Margin (dB)**	**QP Margin (dB)**	**Line**
0.246284	39.39	51.58	51.88	61.88	-12.49	-10.3	Phase 1
0.251997	32.9	52.31	51.69	61.69	-18.79	-9.38	Neutral
0.30288	38.33	52.37	50.16	60.16	-11.83	-7.79	Phase 1
0.30288	36.98	52.37	50.16	60.16	-13.18	-7.79	Neutral
0.503797	32.09	48.18	46	56	-13.91	-7.82	Neutral
0.50397	35.48	48.3	46	56	-10.52	-7.7	Phase 1
0.664909	33.82	48.25	46	56	-12.18	-7.75	Phase 1
0.666983	31.37	47.82	46	56	-14.63	-8.18	Neutral
0.83209	29.79	45.97	46	56	-16.21	-10.03	Neutral
0.84388	32.87	46.87	46	56	-13.13	-9.13	Phase 1
1.007662	34.85	49.17	46	56	-11.15	-6.83	Neutral
1.008015	37.45	49.23	46	56	-8.55	-6.77	Phase 1
1.25994	38.25	50.76	46	56	-7.75	-5.24	Phase 1
1.411271	30.36	46.09	46	56	-15.64	-9.91	Neutral
1.615261	31.23	44.09	46	56	-14.77	-11.91	Phase 1
27.72481	37.86	45.97	50	60	-12.14	-14.03	Neutral

Results	**Complies** by 5.24dB

AC Line Conducted Emission Data, EUT in Receive mode



Model: ; Client: ; Comments: ; Test Date: 11/14/2017 15:39

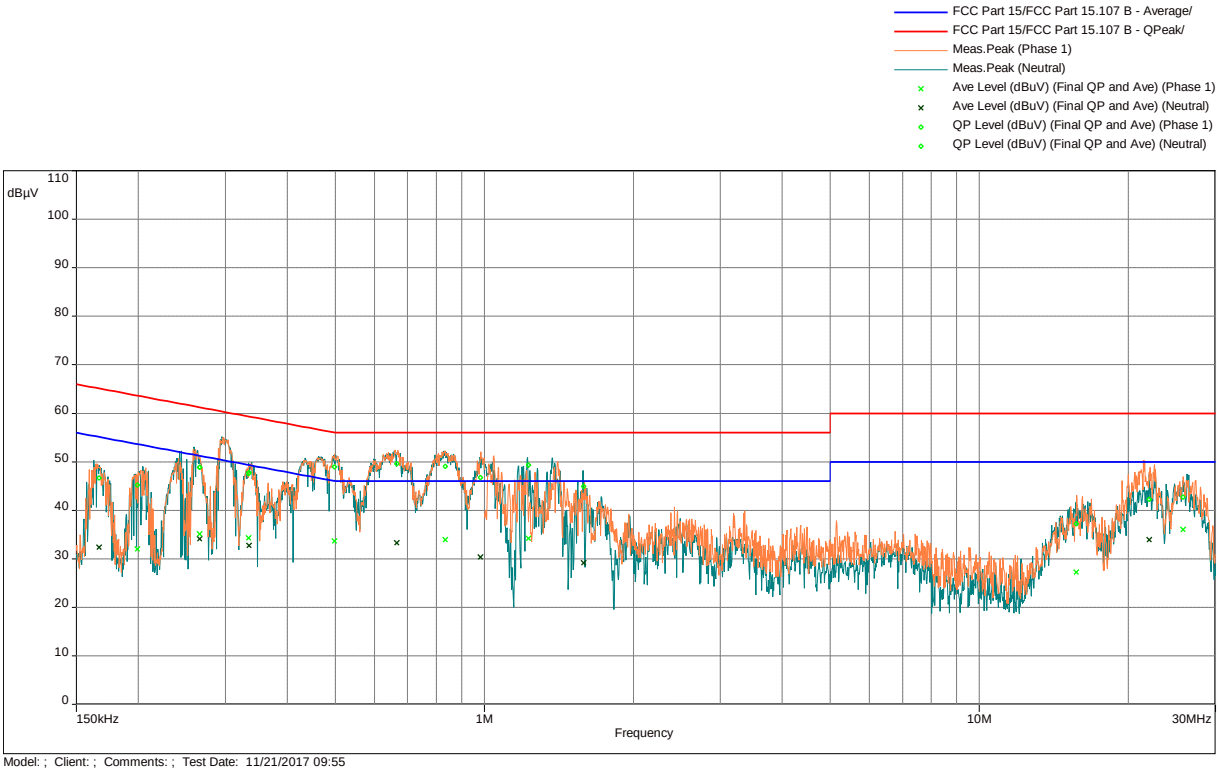
All finals							
Freq (MHz)	**Ave Level (dBuV)**	**QP Level (dBuV)**	**Ave Limit (dBuV)**	**QP Limit (dBuV)**	**Ave Margin (dB)**	**QP Margin (dB)**	**Line**
0.255262	29.5	48.47	51.59	61.59	-22.09	-13.12	Phase 1
0.256219	27.73	49	51.55	61.55	-23.82	-12.55	Neutral
0.320729	33.48	53.31	49.69	59.69	-16.2	-6.37	Phase 1
0.320753	32.68	54.98	49.69	59.69	-17.01	-4.71	Neutral
0.384454	31.21	53.43	48.18	58.18	-16.97	-4.75	Neutral
0.38469	32.21	51.68	48.18	58.18	-15.97	-6.5	Phase 1
0.450312	24.9	46.11	46.87	56.87	-21.97	-10.76	Neutral
0.450851	27.39	45.06	46.86	56.86	-19.47	-11.8	Phase 1
0.512367	33.71	53.18	46	56	-12.29	-2.82	Phase 1
0.513576	31.69	53.91	46	56	-14.31	-2.09	Neutral
0.577431	34.25	55.66	46	56	-11.75	-0.34	Neutral
0.578281	35.62	54.56	46	56	-10.38	-1.44	Phase 1
0.643891	30.71	48.73	46	56	-15.29	-7.27	Phase 1
0.644119	28.96	50.57	46	56	-17.04	-5.43	Neutral
0.705842	29.78	52.04	46	56	-16.22	-3.96	Neutral
0.707653	32.18	51.5	46	56	-13.82	-4.5	Phase 1
0.76991	34.91	55.49	46	56	-11.09	-0.51	Phase 1
0.770731	32.78	55.89	46	56	-13.22	-0.11	Neutral
0.835464	33.12	53.07	46	56	-12.88	-2.93	Phase 1
0.835506	31.55	54.2	46	56	-14.45	-1.8	Neutral
0.900853	31.57	50.62	46	56	-14.43	-5.38	Phase 1
0.900914	29.29	50.96	46	56	-16.71	-5.04	Neutral
0.982071	35.2	46.99	46	56	-10.8	-9.01	Phase 1
0.982195	32.12	46.51	46	56	-13.88	-9.49	Neutral
1.027888	32.33	55.18	46	56	-13.67	-0.82	Neutral
1.093451	32.04	51.51	46	56	-13.96	-4.49	Phase 1
1.156944	30.35	52.98	46	56	-15.65	-3.02	Neutral
1.22757	35.73	50.74	46	56	-10.27	-5.26	Phase 1
1.227576	33.51	50.81	46	56	-12.49	-5.19	Neutral
1.288	30.1	52.67	46	56	-15.9	-3.33	Neutral
1.413846	31.25	51.58	46	56	-14.75	-4.42	Phase 1
1.473161	30.61	48.68	46	56	-15.39	-7.32	Neutral

All finals							
Freq (MHz)	**Ave Level (dBuV)**	**QP Level (dBuV)**	**Ave Limit (dBuV)**	**QP Limit (dBuV)**	**Ave Margin (dB)**	**QP Margin (dB)**	**Line**
1.602864	25.77	47.32	46	56	-20.23	-8.68	Neutral
2.186742	23.1	44.49	46	56	-22.9	-11.51	Neutral
2.700594	27.21	40.76	46	56	-18.79	-15.24	Phase 1
3.348944	21.88	43.26	46	56	-24.12	-12.74	Neutral

Results	**Complies** by 0.11dB

External Radio Model

AC Line Conducted Emission Data, EUT in transmitting mode

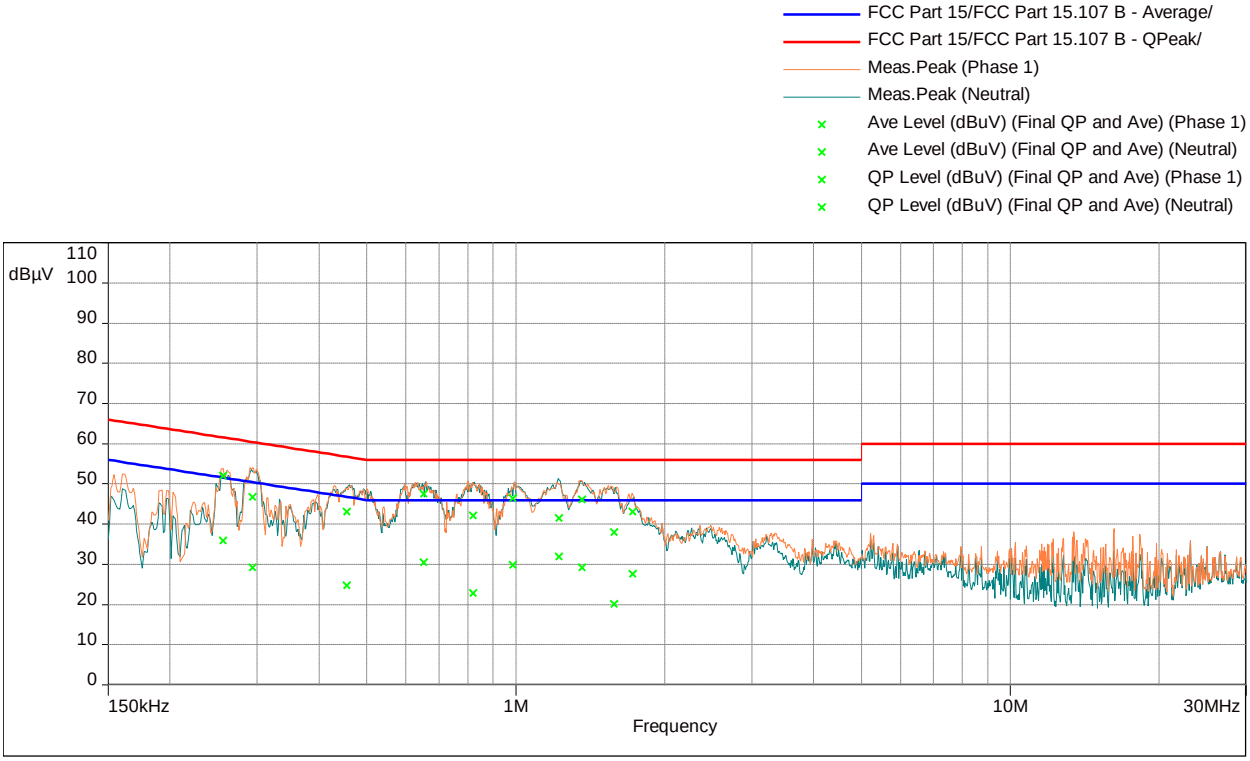


Model: ; Client: ; Comments: ; Test Date: 11/21/2017 09:55

All finals							
Freq (MHz)	**Ave Level (dBuV)**	**QP Level (dBuV)**	**Ave Limit (dBuV)**	**QP Limit (dBuV)**	**Ave Margin (dB)**	**QP Margin (dB)**	**Line**
0.166602	32.38	46.63	55.13	65.13	-22.75	-18.5	Neutral
0.199352	31.99	45.19	53.64	63.64	-21.65	-18.45	Phase 1
0.266072	35.14	48.89	51.24	61.24	-16.1	-12.35	Phase 1
0.26615	34.11	48.83	51.24	61.24	-17.13	-12.41	Neutral
0.334393	34.29	47.6	49.34	59.34	-15.05	-11.74	Phase 1
0.335184	32.72	47.79	49.32	59.32	-16.6	-11.53	Neutral
0.498175	33.67	48.93	46.03	56.03	-12.36	-7.1	Phase 1
0.665312	33.27	49.61	46	56	-12.73	-6.39	Neutral
0.833822	33.91	49.04	46	56	-12.09	-6.96	Phase 1
0.98325	30.33	46.73	46	56	-15.67	-9.27	Neutral
1.229338	34.19	49.28	46	56	-11.81	-6.72	Phase 1
1.588729	29.14	44.93	46	56	-16.86	-11.07	Neutral
15.71191	27.19	37.24	50	60	-22.81	-22.76	Phase 1
22.05176	33.89	42.3	50	60	-16.11	-17.7	Neutral
25.77464	36.02	42.69	50	60	-13.98	-17.31	Phase 1

Results	**Complies** by 6.39 dB

AC Line Conducted Emission Data, EUT in Receive mode



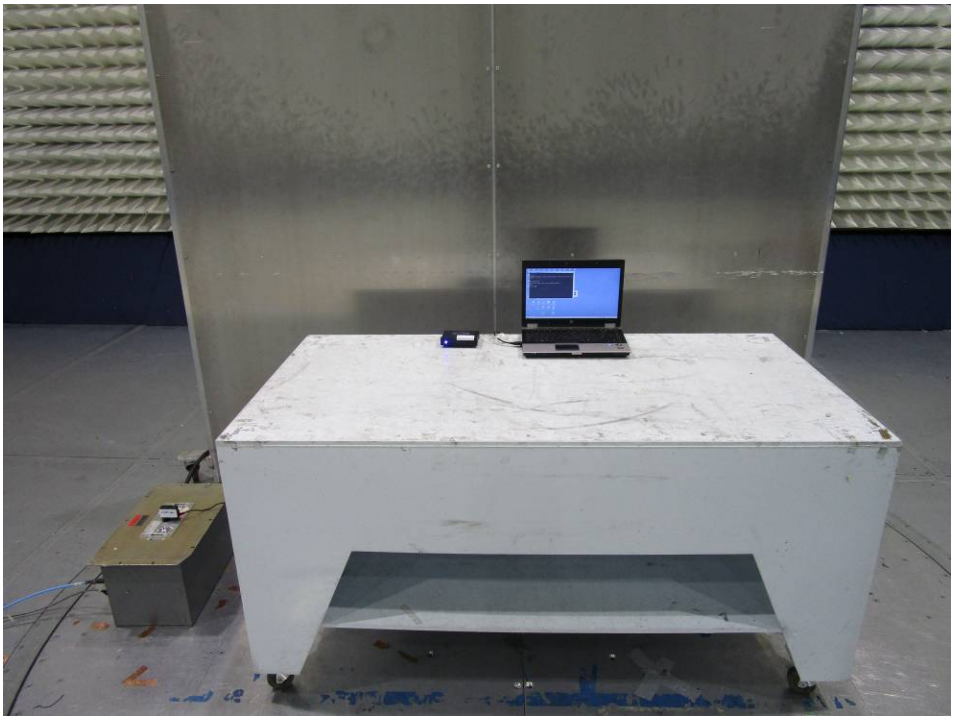
Model: ; Client: ; Comments: ; Test Date: 11/20/2017 15:45

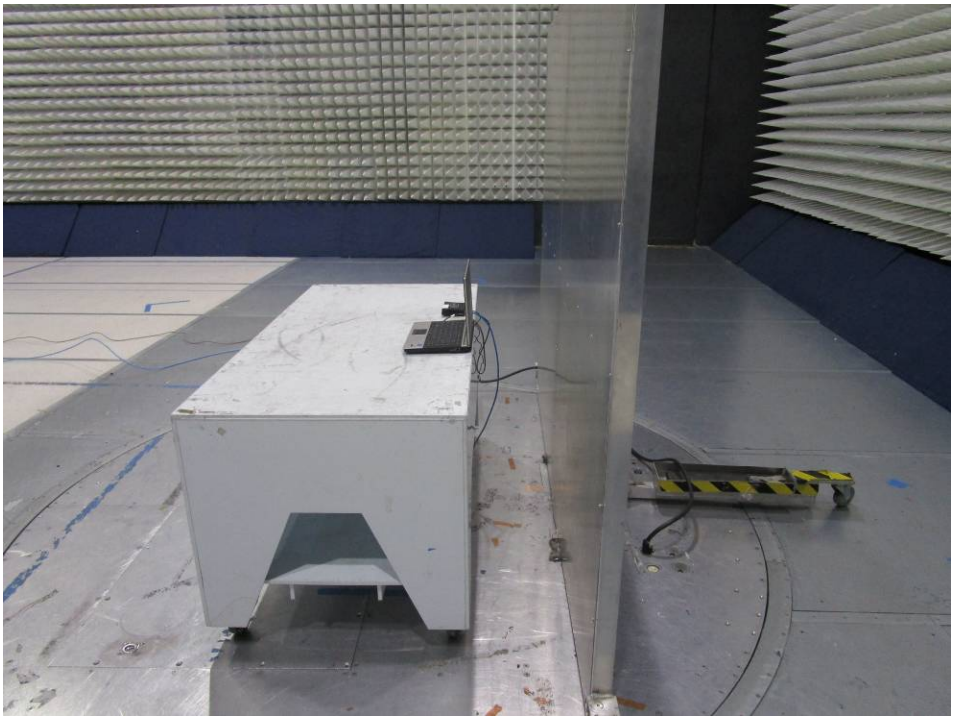
All finals							
Freq (MHz)	**Ave Level (dBuV)**	**QP Level (dBuV)**	**Ave Limit (dBuV)**	**QP Limit (dBuV)**	**Ave Margin (dB)**	**QP Margin (dB)**	**Line**
0.25625	35.81	51.93	51.55	61.55	-15.74	-9.62	Phase 1
0.29375	29.23	46.72	50.42	60.42	-21.2	-13.71	Neutral
0.45598	24.68	43.05	46.77	56.77	-22.09	-13.72	Neutral
0.6513	30.41	47.44	46	56	-15.59	-8.56	Phase 1
0.82034	22.87	42.1	46	56	-23.13	-13.9	Neutral
0.98726	29.79	46.45	46	56	-16.21	-9.55	Phase 1
1.22574	31.83	41.54	46	56	-14.17	-14.46	Neutral
1.35875	29.14	46.02	46	56	-16.86	-9.98	Phase 1
1.5798	20.12	38.02	46	56	-25.88	-17.98	Neutral
1.72293	27.65	43.02	46	56	-18.35	-12.98	Phase 1
0.25625	35.81	51.93	51.55	61.55	-15.74	-9.62	Phase 1
0.29375	29.23	46.72	50.42	60.42	-21.2	-13.71	Neutral
0.45598	24.68	43.05	46.77	56.77	-22.09	-13.72	Neutral
0.6513	30.41	47.44	46	56	-15.59	-8.56	Phase 1
0.82034	22.87	42.1	46	56	-23.13	-13.9	Neutral
0.98726	29.79	46.45	46	56	-16.21	-9.55	Phase 1
1.22574	31.83	41.54	46	56	-14.17	-14.46	Neutral
1.35875	29.14	46.02	46	56	-16.86	-9.98	Phase 1
1.5798	20.12	38.02	46	56	-25.88	-17.98	Neutral
1.72293	27.65	43.02	46	56	-18.35	-12.98	Phase 1

Results	**Complies** by 8.56 dB

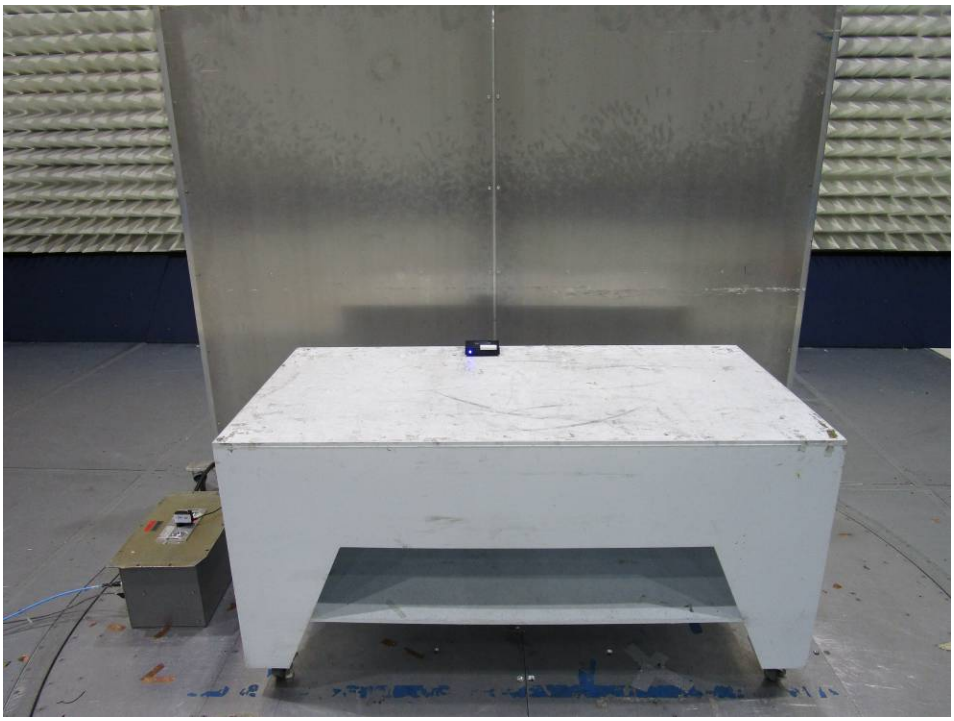
Test setup photographs

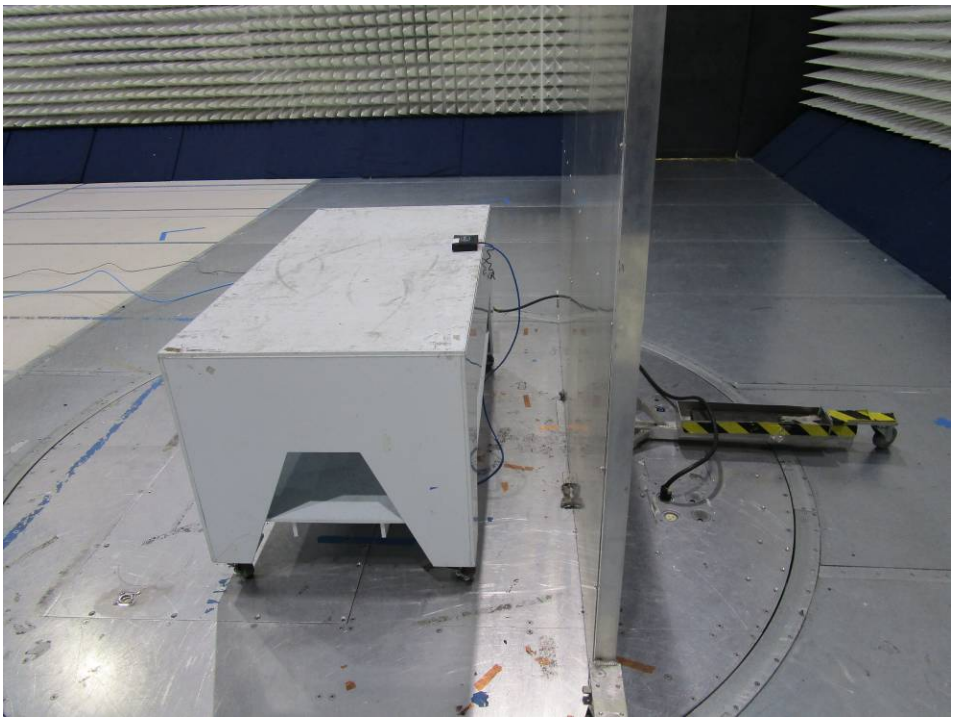
The following photographs show the testing configurations used.



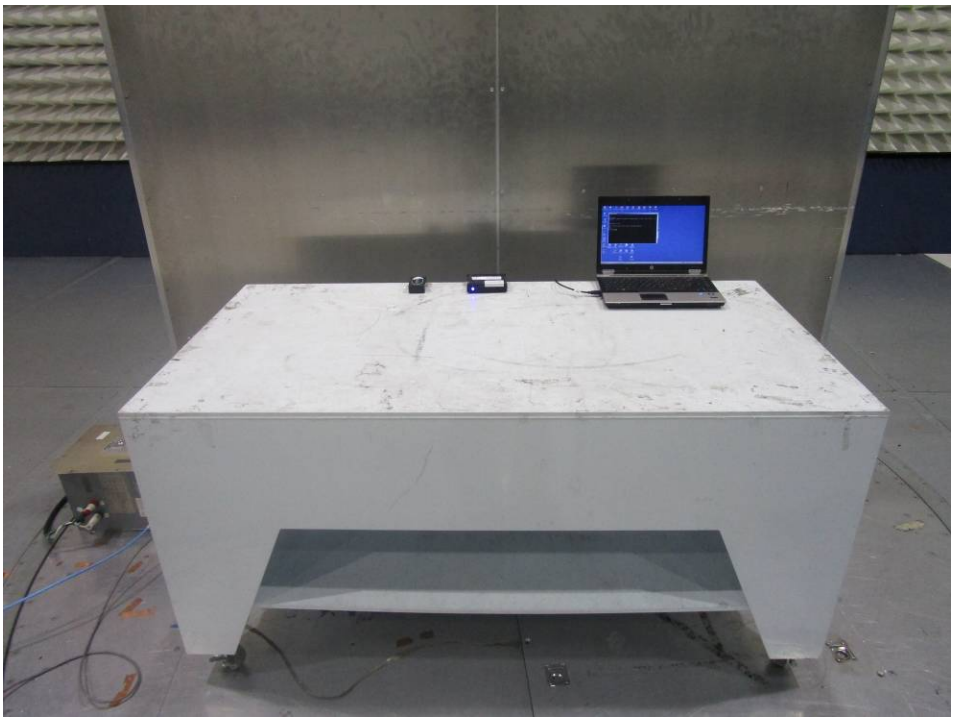


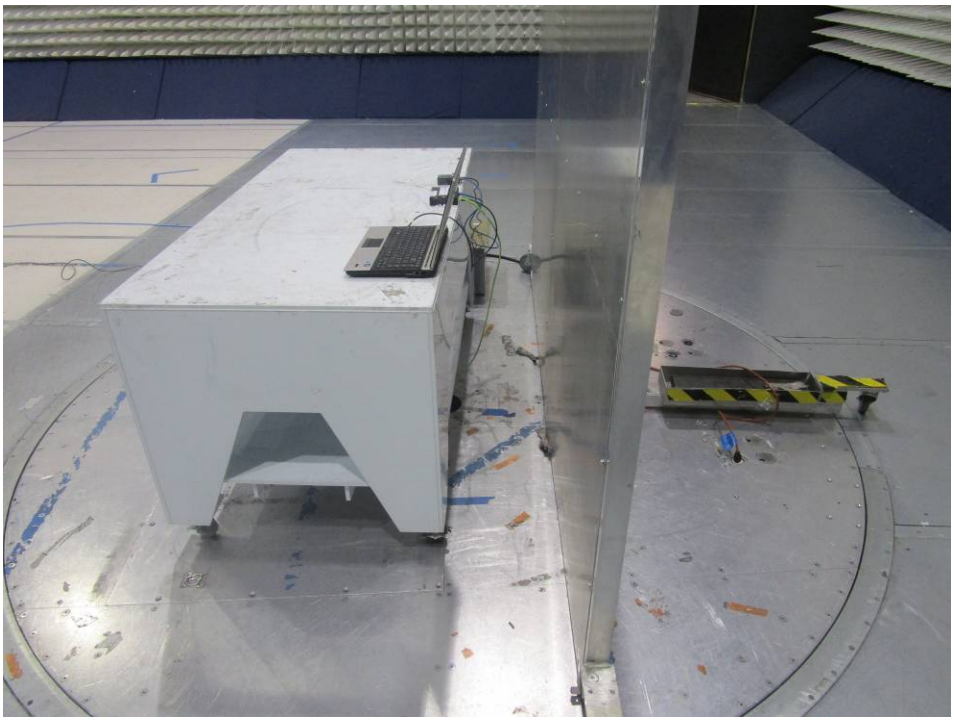
Test setup photographs (continued)



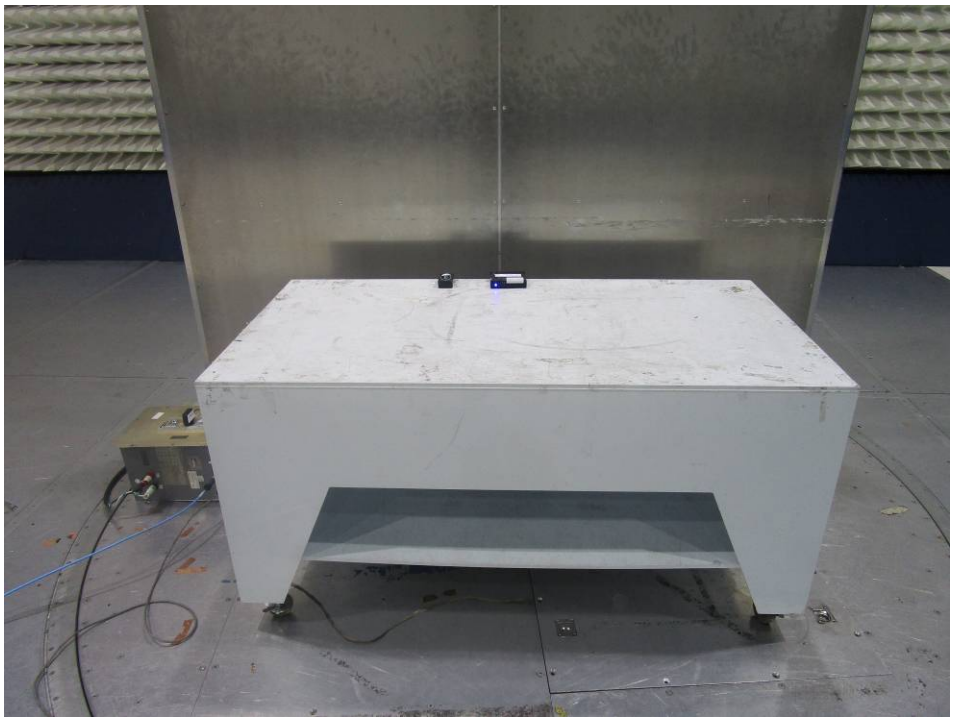


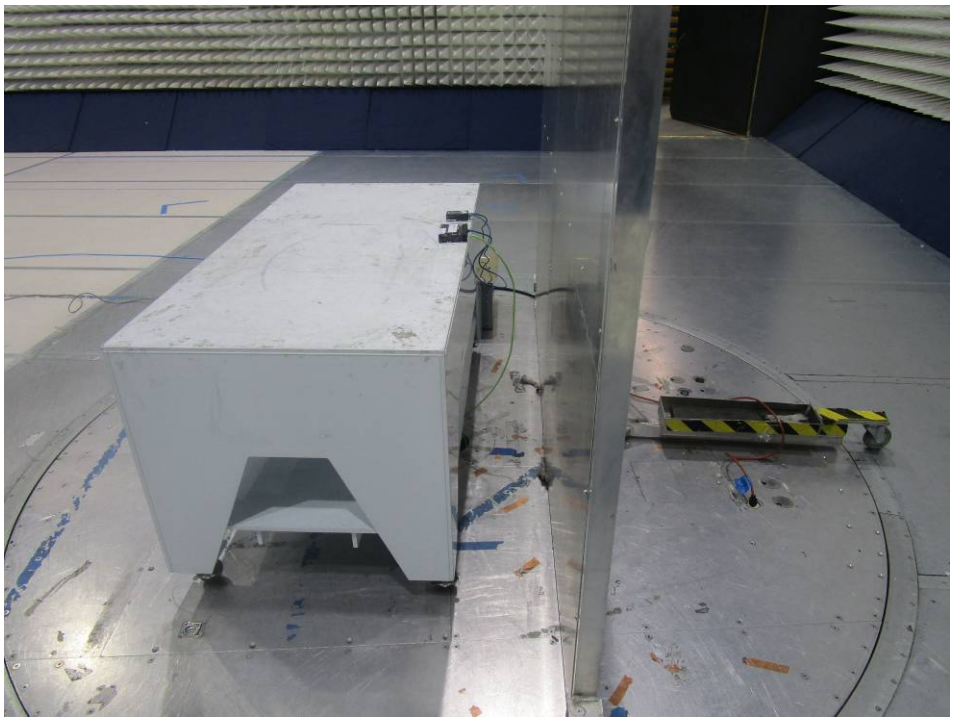
Test setup photographs (continued)





Test setup photographs (continued)





5.0 List of Test Equipment

Measurement equipment used for emission compliance testing utilized the equipment on the following list:

Equipment	Manufacturer	Model/Type	Asset #	Cal Int	Cal Due
EMI Receiver	Rohde and Schwarz	ESU40	ITS 01375	12	12/10/17
BI-Log Antenna	Teseq	CBL 6111D	ITS 01058	12	08/11/18
Horn Antenna	ETS-Lindgren	3115	ITS 00982	12	02/03/18
Pre-Amplifier (1-18 GHz)	Miteq	AMF 4D-001180-24-10P	ITS 00526	12	01/04/18
Pre-Amplifier	Sonoma Instrument	310	ITS 00942	12	01/19/18
RF Cable	TRU Corporation	TRU CORE 300	ITS 01462	12	08/19/18
RF Cable	TRU Corporation	TRU CORE 300	ITS 01465	12	08/19/18
RF Cable	TRU Corporation	TRU CORE 300	ITS 01470	12	08/19/18
Attenuator	Mini Circuits	BW-N3W5+	ITS 01345	12	05/05/18
RF Cable	Megaphase	EMC1-K1K1-236	ITS 01538	12	06/13/18
RF Cable	Megaphase	TM40-K1K1-19	ITS 01154	12	01/26/18
Transient Limiter	COM-POWER	LIT-153A	ITS 01452	12	06/19/18
RF Cable	Megaphase	TM40-K1K1-59 RF	ITS 01156	12	01/26/18
Notch Filter	Micro-tronics	RBRC50722	ITS 01170	12	01/19/18
LISN	FCC	FCC-LISN-50-50-M-H	ITS 00552	12	09/15/18

No Calibration required

6.0 Document History

Revision/ Job Number	Writer Initials	Reviewer Initials	Date	Change
1.0 / G103187255	TM	KV	November 28, 2017	Original document