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FCC CERTIFICATION TEST REPORT

Manufacturer:	**Avuity, LLC** **302 West Third** **Suite 810** **Cincinnati, Ohio 45208 USA**
Applicant:	**Same as Above**
Product Name:	Wireless Module
Product Description:	A high integrated wireless module, which works in 2.4 GHz of ISM band. VuAi V1 adopts Nordic's RF chip nRF24L01+ and high efficiency RF amplifier.
Operating Voltage/Frequency:	Battery-Powered
Model(s):	**VuAi V1**
FCC ID:	**2AUPP-VUAI01**
Testing Commenced:	2019-09-18
Testing Ended:	2021-01-19
Summary of Test Results:	In Compliance The EUT complies with the EMC requirements when manufactured identically as the unit tested in this report, including any required modifications and/or manufacturer's statement. Any changes to the design or build of this unit subsequent to this testing may deem it non-compliant.

Standards:

- **FCC Part 15 Subpart C, Section 15.249**
- **FCC Part 15, Subpart C, Section 15.209**

Evaluation Conducted by:

Julius Chiller, EMC/Wireless Engineer

Report Reviewed by:

Ken Littell, Vice President of EMC

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1 ADMINISTRATIVE INFORMATION

1.1 Measurement Location:

F2 Labs in Middlefield, Ohio. Site description and attenuation data are on file with the FCC's Sampling and Measurement Branch at the FCC Laboratory in Columbia, MD.

1.2 Measurement Procedure:

All measurements were performed according to the 2013 version of ANSI C63.10 and recommended FCC procedure of measurement of DXT operating under Section 15.249. A list of the measurement equipment can be found in Section 6.

1.3 Uncertainty Budget:

The uncertainty in EMC measurements arises from several factors which affect the results, some associated with environmental conditions in the measurement room, the test equipment being used, and the measurement techniques adopted.

The measurement uncertainty budgets detailed below are calculated from the test and calibration data and are expressed with a 95% confidence factor. Note: Only measurements listed below which relate to tests included in this Test Report are applicable to it.

Measurement Range	Expanded Uncertainty	Combined Uncertainly
Radiated Emissions <1 GHz @ 3m	±5.07dB	±2.54
Radiated Emissions <1 GHz @10m	±5.09dB	±2.55
Radiated Emissions 1 GHz to 2.7 GHz	±3.62dB	±1.81
Radiated Emissions 2.7 GHz to 18 GHz	±3.10dB	±1.55
AC Power Line Conducted Emissions, 150kHz to 30 MHz	±2.76dB	±1.38

This Uncertainty represents an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2.

1.4 Document History:

Document Number	Description	Issue Date	Approved By
F2P21720-01E	First Issue	2020-06-09	K. Littell
F2P21720-01E Rev. 1	Freq. Range Correction and Band edge data replacement.	2021-01-14	K. Littell
F2P21720-01E Rev. 2	Various revisions, including model.	2021-01-20	K. Littell

2 SUMMARY OF TEST RESULTS/MODIFICATIONS

Test Name	Standard(s)	Results
Field Strength of Emissions from Intentional Radiators	FCC PART 15.249(a)(d)	Complies
Radiated Spurious Emission	CFR 47 Part 15.249(d) / Part 15.209	Complies

Modifications Made to the Equipment
None

3 ENGINEERING STATEMENT

This report has been prepared on behalf of Avuity, LLC to provide documentation for the testing described herein to be used as evidence that the Class II change, due to the addition of an antenna, has not increased the spurious emissions level of the original Grant and that the combined RF Exposures are within the MPE limits. This equipment has been tested and found to comply with parts 15.249 and 15.209 of the FCC Rules and using ANSI C63.4 standards. The test results found in this test report relate only to the items tested.

4 EUT INFORMATION

4.1 Equipment Under Test:

Device	Manufacturer	Model Number	Serial Number	FCC ID
Wireless Module	Avuity, LLC	VuAi V1	None Specified	2AUPP-VUAI01
2.5dBi gain Chip Antenna	Johnson Technology	p/n 2500AT44M0400	None Specified	N/A

4.2 Trade Name:
Avuity, LLC

4.3 Power Supply:
Battery-powered

4.4 Applicable Rules:
CFR 47, Part 15.249, subpart C
CFR 47, Part 15.209

4.5 Equipment Category:
Radio Transmitter-DXT

4.6 Accessories: None

4.7 Test Item Condition:
The equipment to be tested was received in good condition.

4.8 Testing Algorithm:
EUT was set to transmit continuously. Readings were taken at low, mid and high channels to determine worst case spurious emissions. Low channel (2402 MHz) was determined to be worst case. Measurement table includes results for all channels.

5.0 TEST EQUIPMENT USED

Equipment Type	Asset Number	Manufacturer	Model	Serial Number	Calibration Due Date
Shielded Chamber 2014	CL166-E	AlbatrossProjects	B83117-DF435-T261	US140023	Oct. 31, 2019
Shield Room	0175-3V	Ray Proof	N/A	11645	June 23, 2020
Temp./Hum. Recorder	CL261	Extech	445814	04	Feb. 12, 2021
Receiver	CL151	Rohde & Schwarz	ESU40	100319	Oct. 21, 2020
Antenna, JB3 Combination	CL175	Sunol Sciences	JB3	A030315	Oct. 11, 2019
Low Loss Cable Set	--	Pasternack	PE3C0666-252 / PE3C066-50CM	None Spec.	July 16, 2020
Horn Antenna	CL098	Emco	3115	9809-5580	Jan. 31, 2021
Pre-amplifier	CL153	Agilent	83006-69007	MY39500791	Aug. 5, 2020
Amplifier w/Monopole & 18” Loop	CL163-Loop	A.H. Systems, Inc.	EHA-52B	100	July 24, 2020
Antenna, Horn	CL114	A.H. Systems, Inc.	SAS-572	237	Feb. 4, 2021
Software:	Tile Version 3.4.B.3.		Software Verified: Sept. 18, 2019		
Software	EMC 32, Version 8.53.0		Software Verified: Sept. 18, 2019, Jan. 12, 2021		

6 FIELD STRENGTH OF EMISSIONS FROM INTENTIONAL RADIATORS

(a) Except as provided in paragraph (b) of this section, the field strength of emissions from intentional radiators operated within these frequency bands shall comply with the following:

Fundamental frequency	Field strength of fundamental (millivolts/meter)	Field strength of harmonics (microvolts/meter)
902-928 MHz	50	500
2400-2483.5 MHz	50	500
5725-5875 MHz	50	500
24.0-24.25 GHz	250	2500

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

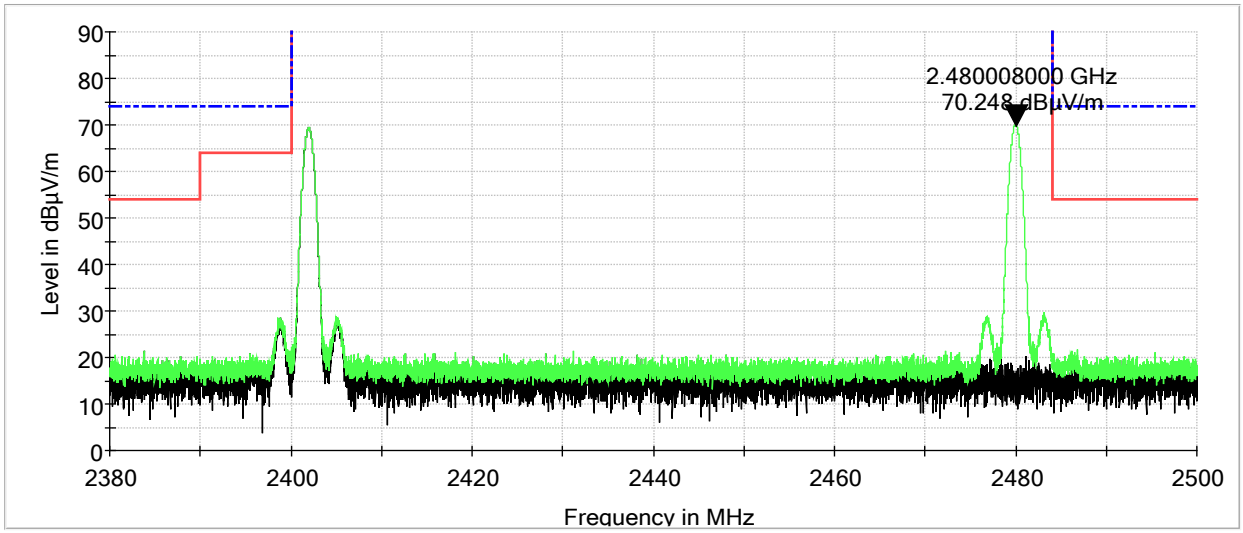
NOTE: During the pre-scan evaluation, the EUT was rotated in all possible directions to find the maximum emissions. The orthogonal position that showed the highest emissions was used. The antenna was raised between 1 and 4 meters and the EUT turntable was rotated 360 degrees to maximize the emissions.

6.1 Test Data - Field Strength of Emissions from Intentional Radiators

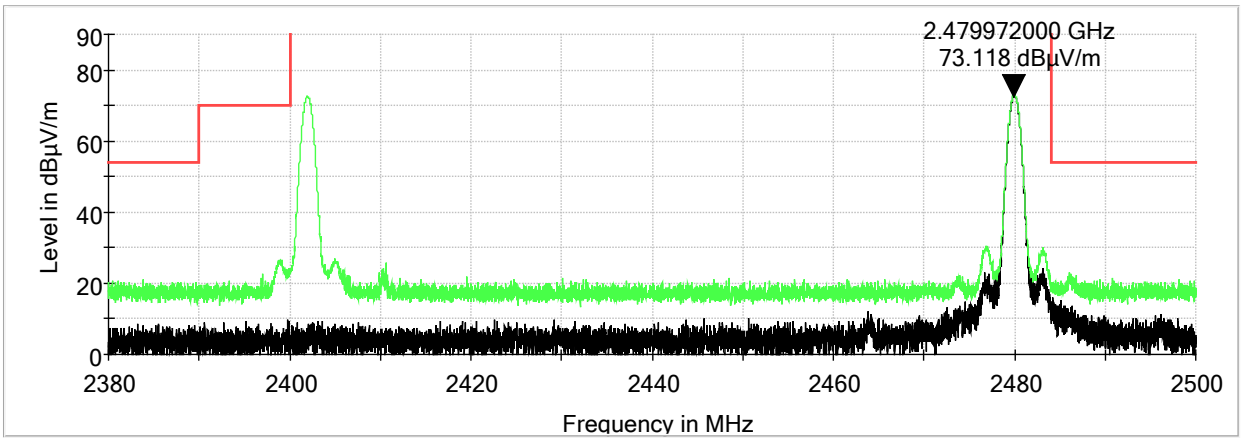
Test Date(s):	Jan. 19, 2021	**Test Engineer(s):**	J. Chiller
Standards:	CFR 47 Part 15.249(a)	**Air Temperature:**	21.3ºC
		Relative Humidity:	38%

Test	Low Channel (2402 MHz)	Mid Channel (2440 MHz)	High Channel (2480 MHz)
Peak Field Strength of Fundamental	72.90 dBµV/m, 4.42 mV/m	73.10 dBµV/m, 4.52 mV/m	73.30 dBµV/m, 4.63 mV/m
Peak Limit for Fundamental	114 dBµV/m, 501 mV/m	114 dBµV/m, 501 mV/m	114 dBµV/m, 501 mV/m
Average Field Strength of Fundamental	72.90 dBµV/m, 4.42 mV/m	73.10 dBµV/m, 4.52 mV/m	73.30 dBµV/m, 4.63 mV/m
Average Limit for Fundamental	94 dBµV/m, 50 mV/m	94 dBµV/m, 50 mV/m	94 dBµV/m, 50 mV/m

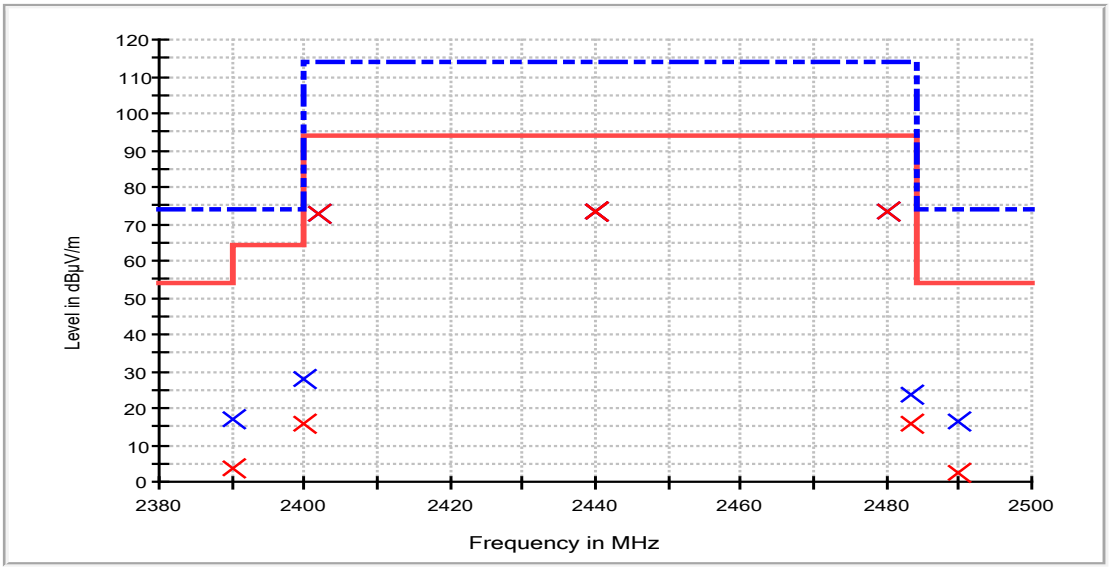
Band Edge, Vertical



Band Edge, Horizontal



Band Edge, Measurements



MaxPeak

Frequency (MHz)	Antenna Polarization	Antenna Height (cm)	Azimuth (deg)	Reading (dBµV)	Cable Loss & Antenna Factor (dB)	Emission (dBµV/m)	Limit (dBµV/m)	Margin (dB)
2400.00	H	100.00	0.00	29.7	-2.1	27.60	74.0	-46.4
2402.00	H	100.00	0.00	74.7	-1.9	72.80	114.0	-41.2
2440.00	H	150.00	0.00	75.2	-2.1	73.10	114.0	-40.9
2480.00	H	275.00	0.00	75.0	-1.7	73.30	114.0	-40.7
2483.50	H	275.00	0.00	25.5	-1.6	23.90	74.0	-50.1

AVG

Frequency (MHz)	Antenna Polarization	Antenna Height (cm)	Azimuth (deg)	Reading (dBµV)	Cable Loss & Antenna Factor (dB)	Emission (dBµV/m)	Limit (dBµV/m)	Margin (dB)
2400.00	H	100.00	0.00	18.0	-2.1	15.90	54.0	-38.1
2402.00	H	100.00	0.00	74.8	-1.9	72.90	94.0	-21.1
2440.00	H	150.00	0.00	75.2	-2.1	73.10	94.0	-20.9
2480.00	H	275.00	0.00	75.0	-1.7	73.30	94.0	-20.7
2483.50	H	275.00	0.00	17.1	-1.6	15.50	54.0	-38.5

7 RADIATED SPURIOUS EMISSION

Notes: Plots are peak, max hold pre-scan data included only to determine what frequencies to investigate and measure. During the pre-scan evaluation, the EUT was rotated in all possible directions to find the maximum emissions. All three orthogonal positions were checked and the orthogonal position that showed the highest emissions was used. At some frequencies, no emissions from the EUT were measurable over the ambient noise floor. The readings did not change with EUT on and EUT off.

At least 6 of the highest frequencies were measured per ANSI 63.10 semi-anechoic chamber. From 9 kHz to 30 MHz the EUT was scanned with a loop antenna in all 3 orthogonal positions and there were no emissions above the ambient noise floor. Frequencies below 1 GHz were measured using a quasi-peak detector. The antenna was raised between 1 and 4 meters and the EUT turntable was rotated 360 degrees to maximize the emissions. Some of the frequencies did not change with the EUT on or off. At those frequencies, the test distance was shortened to 1 meter and still no emissions from the EUT were visible or over the ambient or limit.

Note: The following tables include the significant emissions from the EUT. No other significant emissions were within 20dB of the limit.

7.1 Requirements:

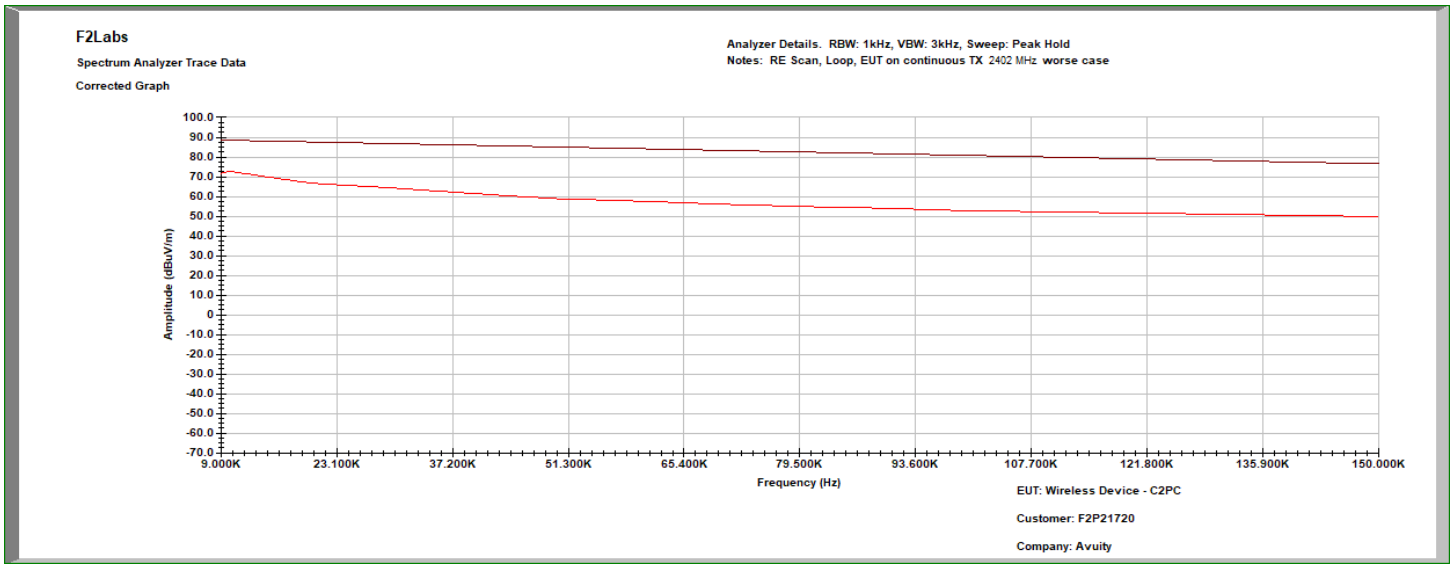
Emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 50 dB below the level of the fundamental or to the general radiated emission limits in §15.209, whichever is the lesser attenuation.

7.2 Radiated Spurious Emission Test Data

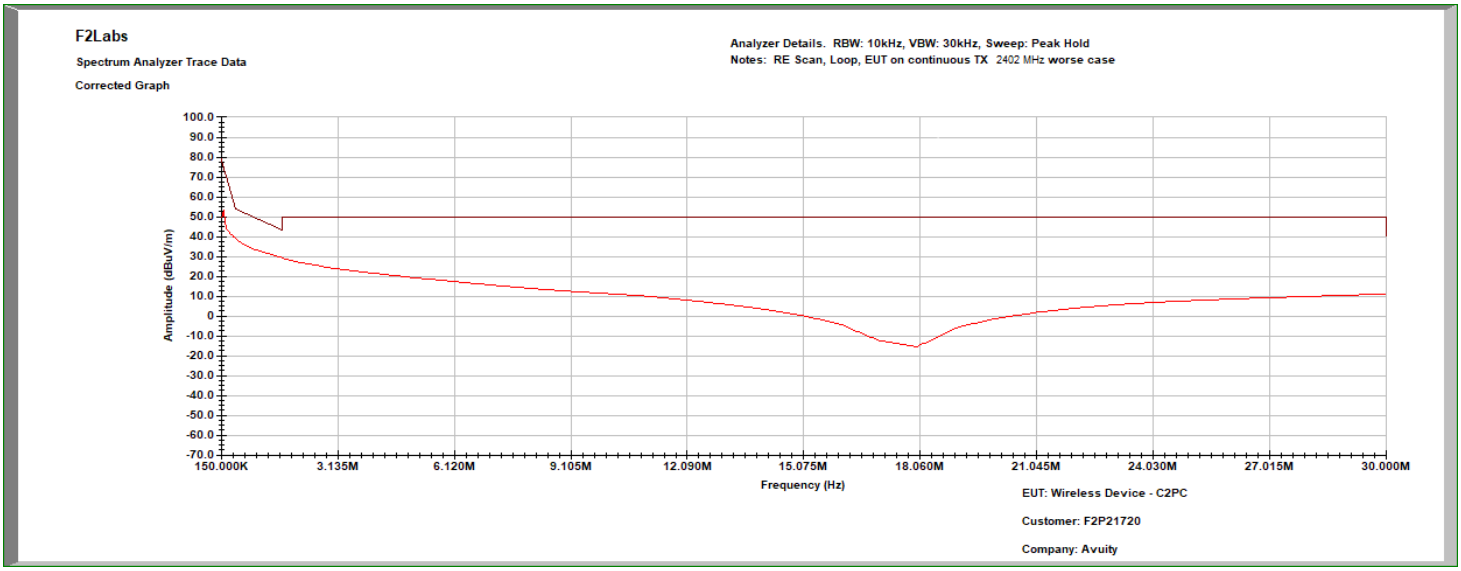
Test Dates:	Sept. 18, 2019	**Test Engineers:**	J. Chiller
Standards:	CFR 47 Part 15.249(d); Part 15.209 / KDB558074	**Air Temperature:**	21.6°C
		Relative Humidity:	47%

Notes: Plots are peak, max hold data. During the evaluation, the EUT was rotated in all possible directions to find the maximum emissions. The orthogonal position that showed the highest emissions was used. The antenna was raised between 1 and 4 meters and the EUT turntable was rotated 360 degrees to maximize the emissions. Measurements were taken on High, Mid, and Low channels were tested and graphs of results are shown below. From 9kHz to 30 MHz, the worse-case channel was used for the graphs. The measurement table includes data from all three channels.

Loop Antenna, 0.009 MHz to 0.15 MHz

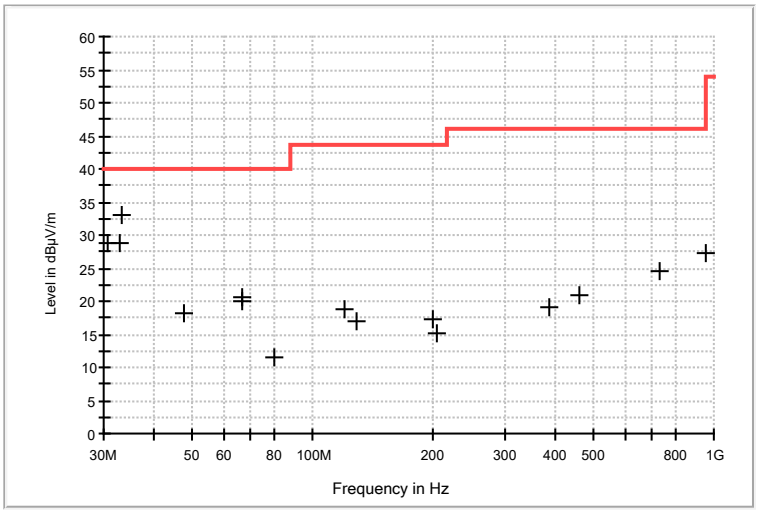


Loop Antenna, 0.15 MHz to 30 MHz



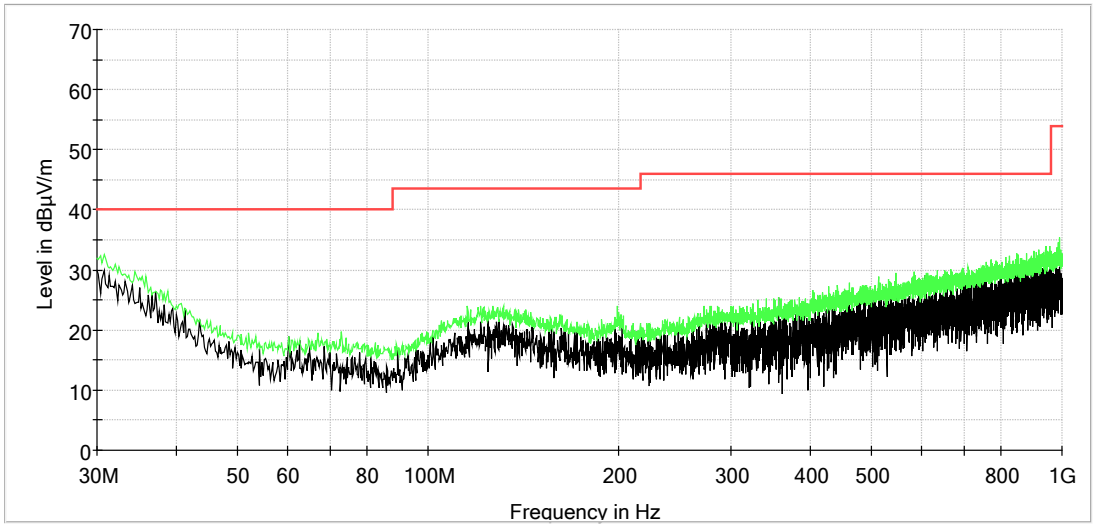
Measurements: 30 MHz to 1000 MHz

Frequency (MHz)	Antenna Polarization	Antenna Height (em)	Azimuth (deg)	Reading (dBµV)	Correction Factors (dB)	Emission (dBµV/m)	Limit (dBµV/m)	Margin (dB)
30.76	V	100.00	0.00	22.50	6.4	28.90	40.0	-11.1
32.92	H	100.00	0.00	24.00	4.7	28.70	40.0	-11.3
33.28	V	100.00	0.00	28.50	4.4	32.90	40.0	-7.1
47.48	H	100.00	0.00	23.80	-5.5	18.30	40.0	-21.7
66.48	V	100.00	0.00	27.80	-7.2	20.60	40.0	-19.4
66.68	H	100.00	0.00	27.10	-7.2	19.90	40.0	-20.1
79.84	H	100.00	0.00	19.20	-7.6	11.60	40.0	-28.4
120	V	100.00	0.00	20.70	-1.8	18.90	43.5	-24.6
128.76	H	100.00	0.00	18.70	-1.7	17.00	43.5	-26.5
199.96	V	100.00	0.00	19.80	-2.5	17.30	43.5	-26.2
204.6	H	100.00	0.00	18.90	-3.9	15.00	43.5	-28.5
390.08	H	100.00	0.00	18.80	0.2	19.00	46.0	-27.0
462.24	V	100.00	0.00	18.90	2.1	21.00	46.0	-25.0
733.44	H	100.00	0.00	19.00	5.5	24.50	46.0	-21.5
952.68	V	100.00	0.00	19.50	7.8	27.30	46.0	-18.7

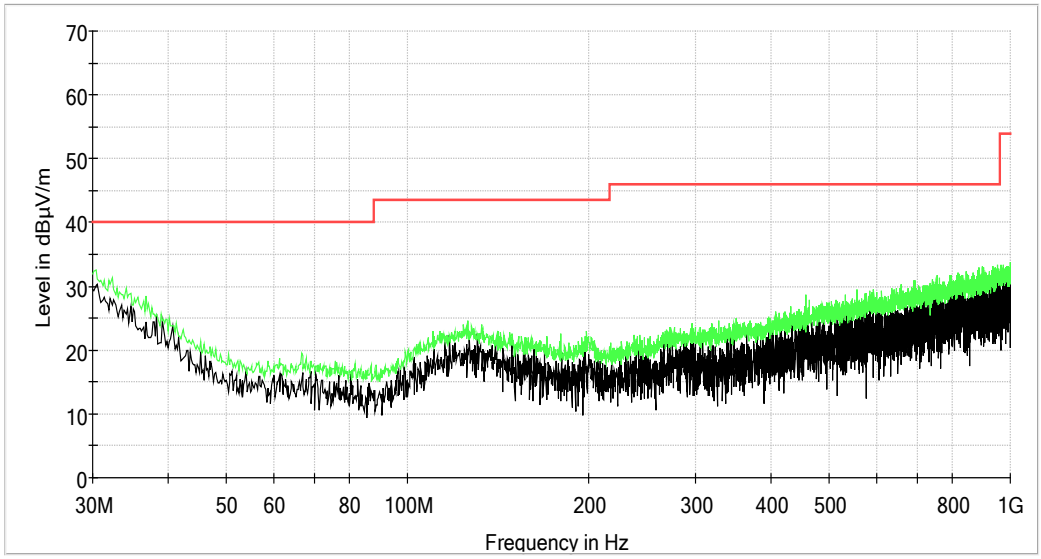


Note: In plots that follow, black waveform represents the active scan, green waveform represents MaxPk emissions readings with EUT on, red line is the limit line.

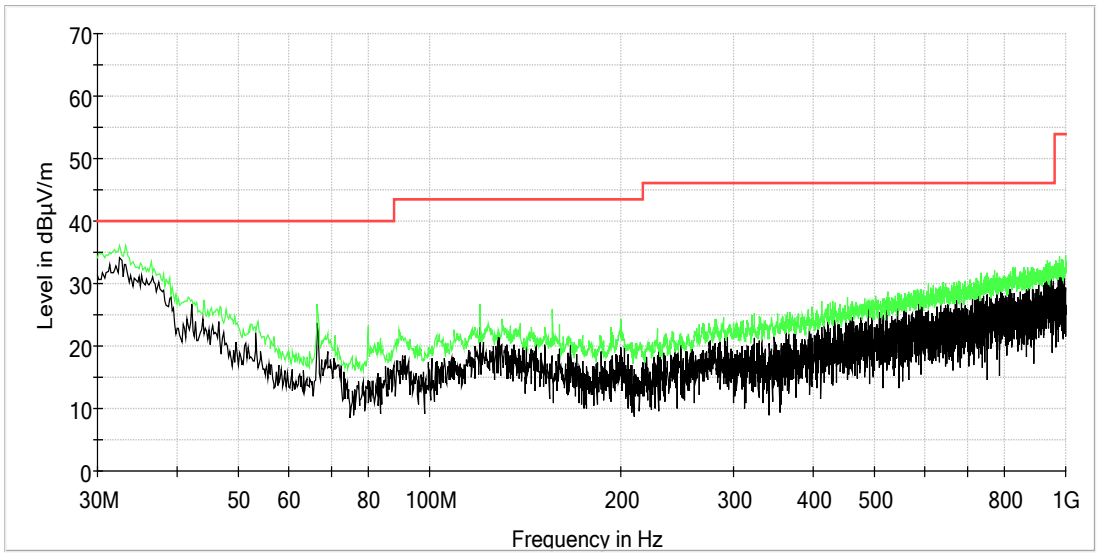
Low Channel: Characterization Scan, 30 MHz to 1000 MHz, Vertical



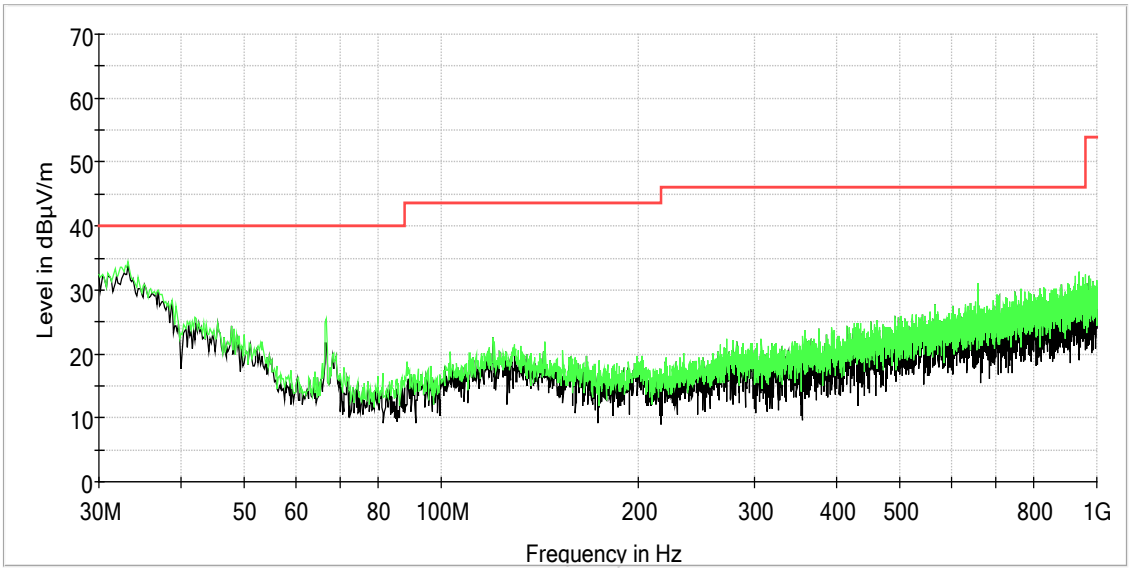
Low Channel: Characterization Scan, 30 MHz to 1000 MHz, Horizontal



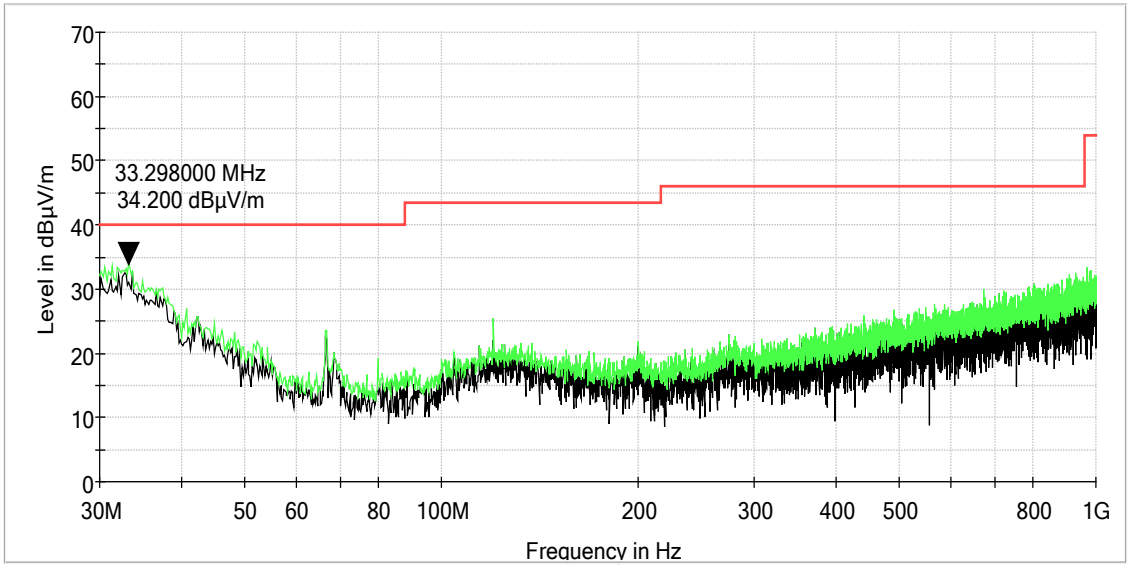
Mid Channel: Characterization Scan, 30 MHz to 1000 MHz, Vertical



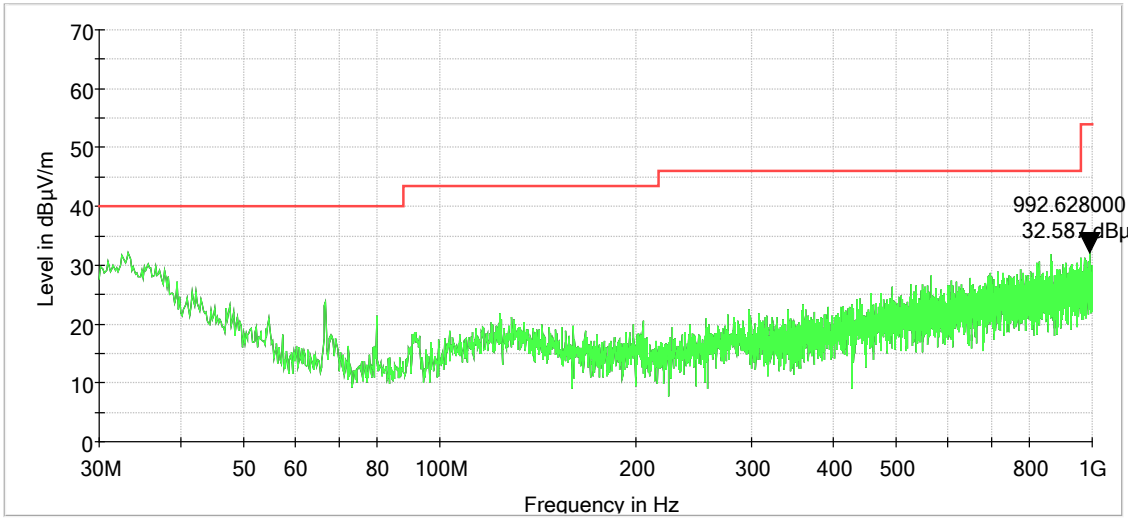
Mid Channel: Characterization Scan, 30 MHz to 1000 MHz, Horizontal



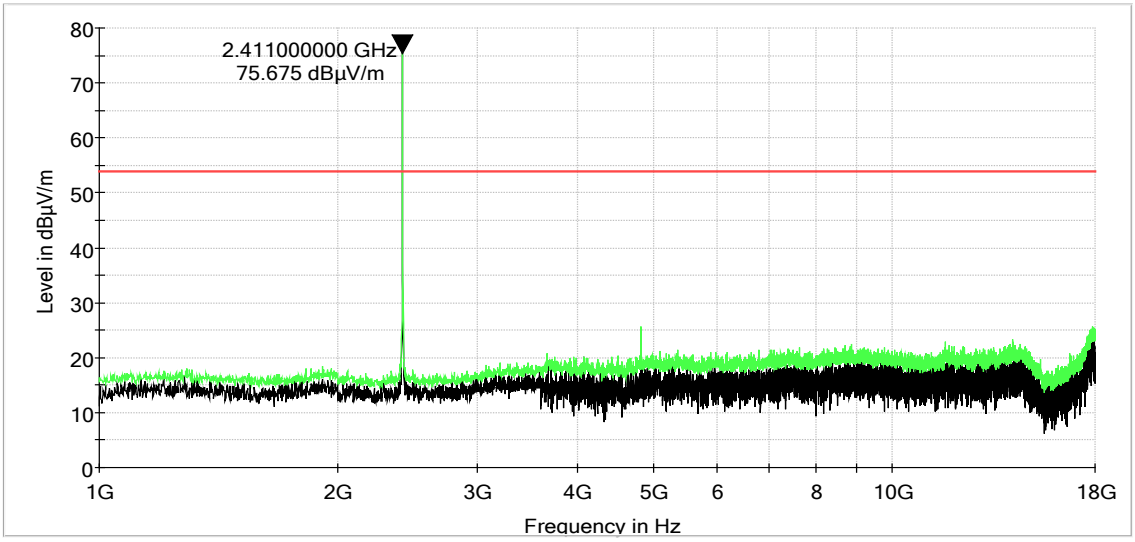
High Channel: Characterization Scan, 30 MHz to 1000 MHz, Vertical



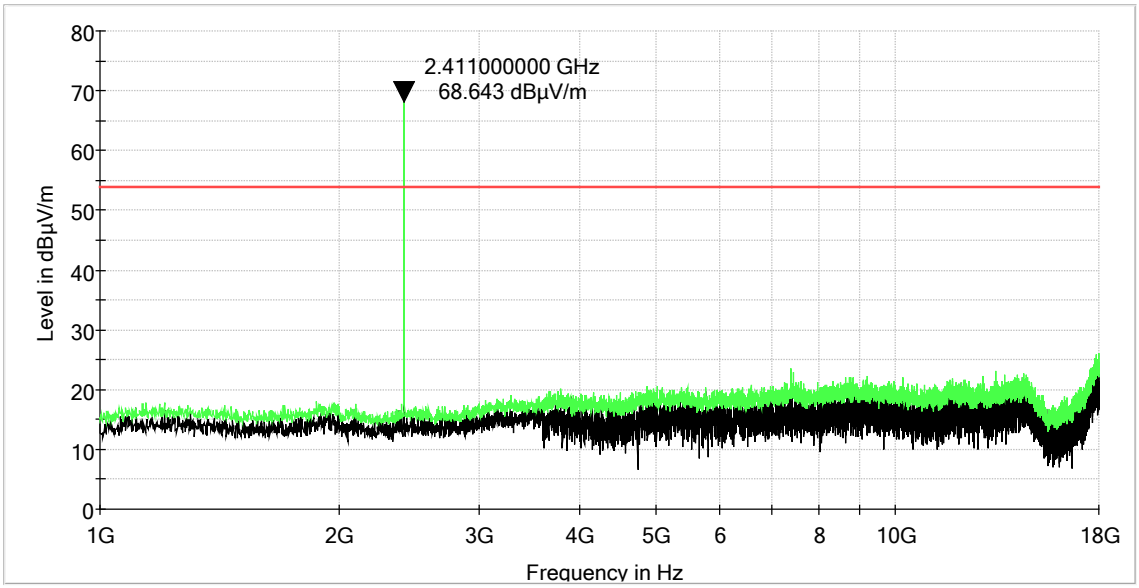
High Channel: Characterization Scan, 30 MHz to 1000 MHz, Horizontal



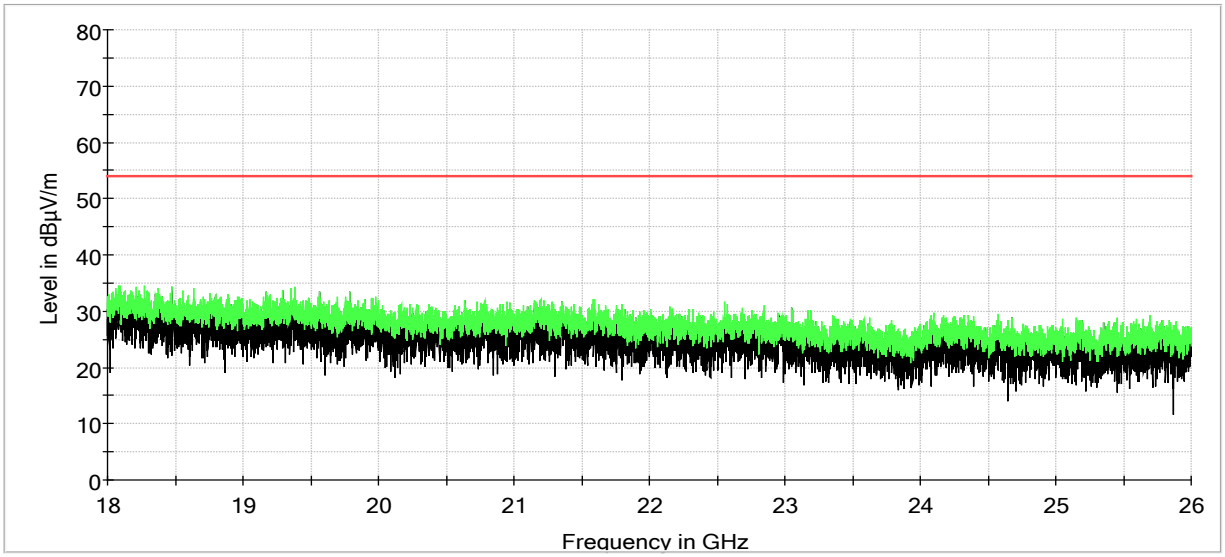
Low Channel: 1 GHz to 18 GHz, Vertical



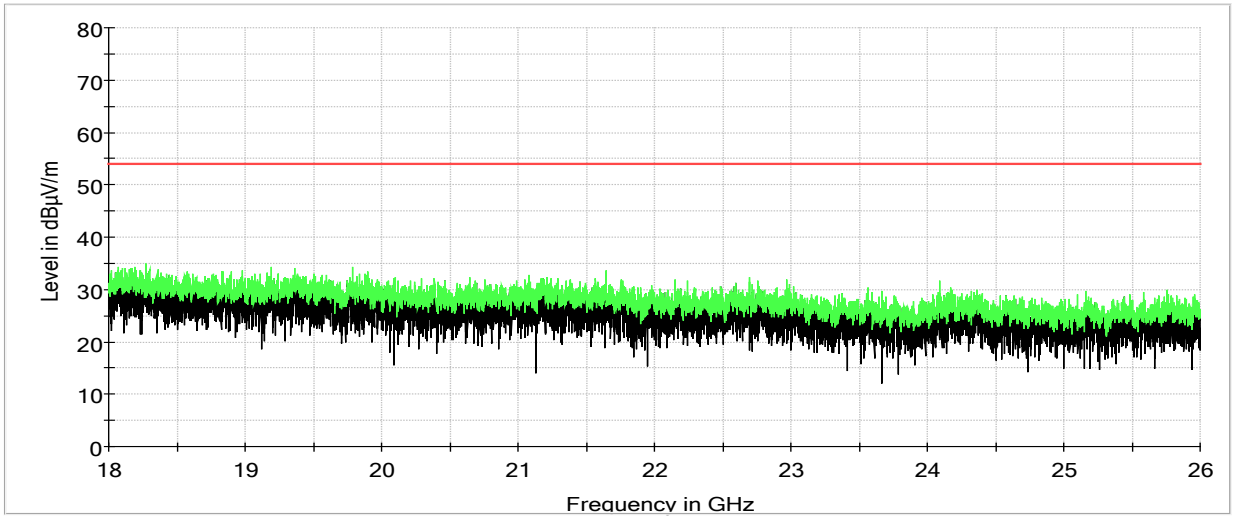
Low Channel: 1 GHz to 18 GHz, Horizontal



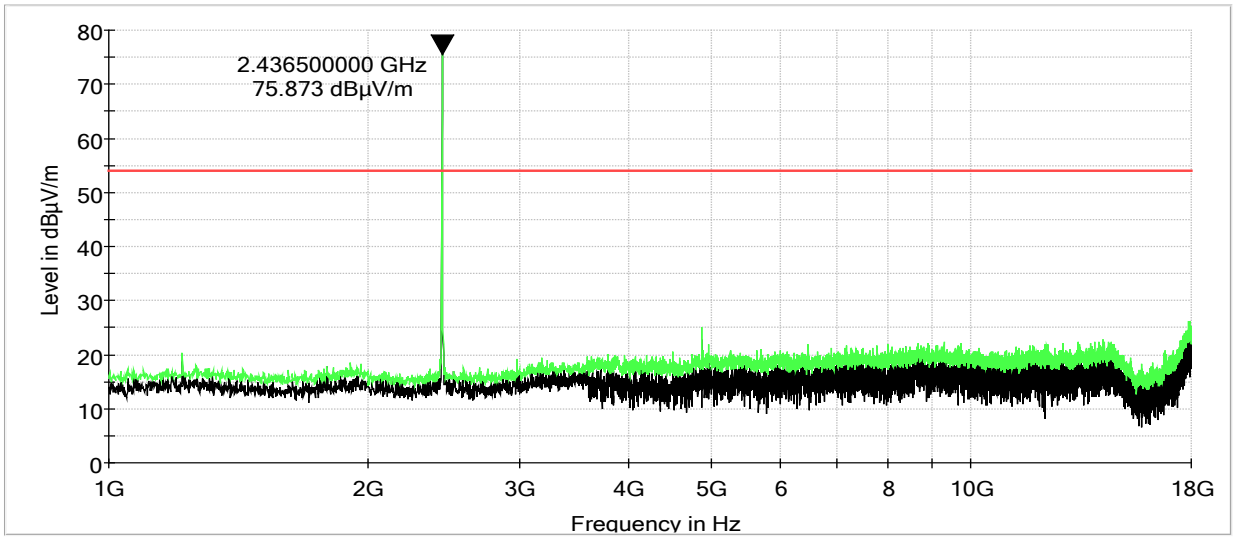
Low Channel: 18 GHz to 26 GHz, Vertical



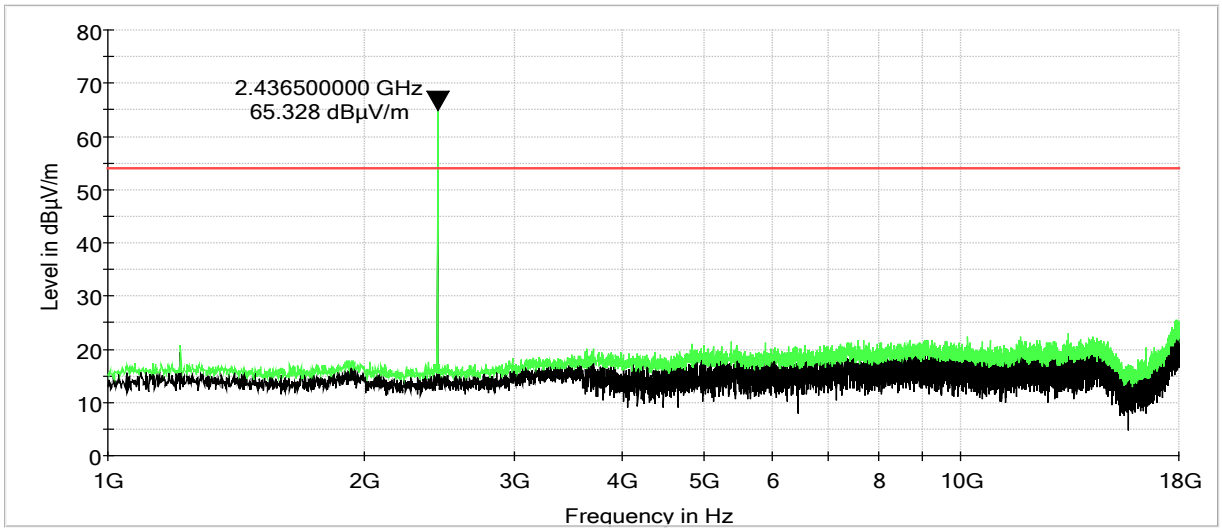
Low Channel: 18 GHz to 26 GHz, Horizontal



Mid Channel: 1 GHz to 18 GHz, Vertical

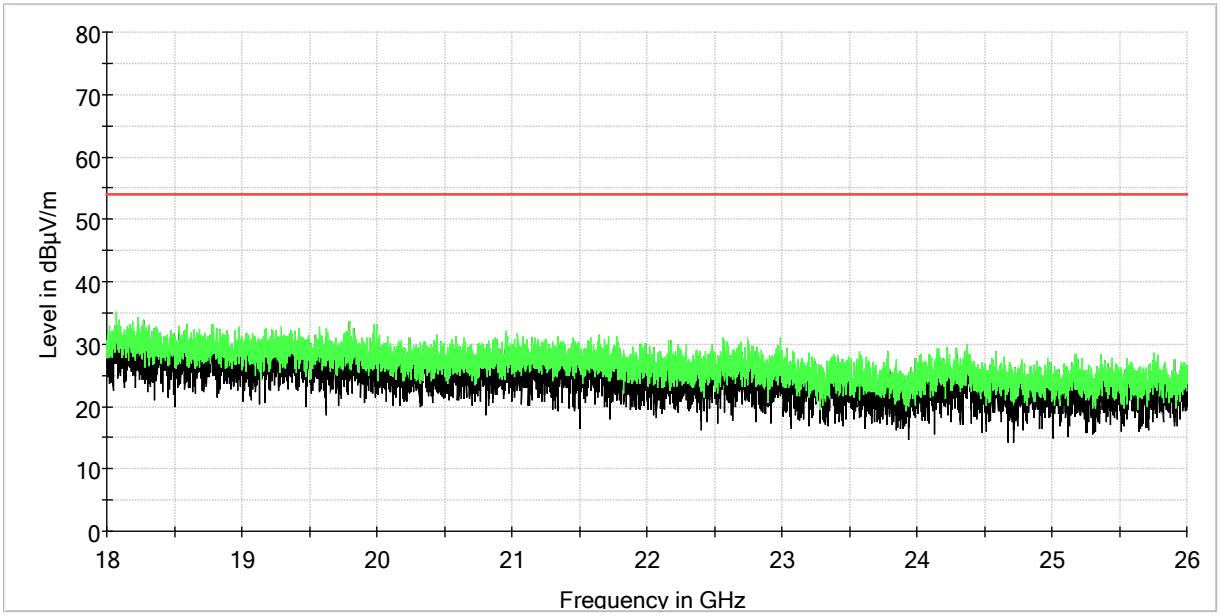


Mid Channel: 1 GHz to 18 GHz, Horizontal

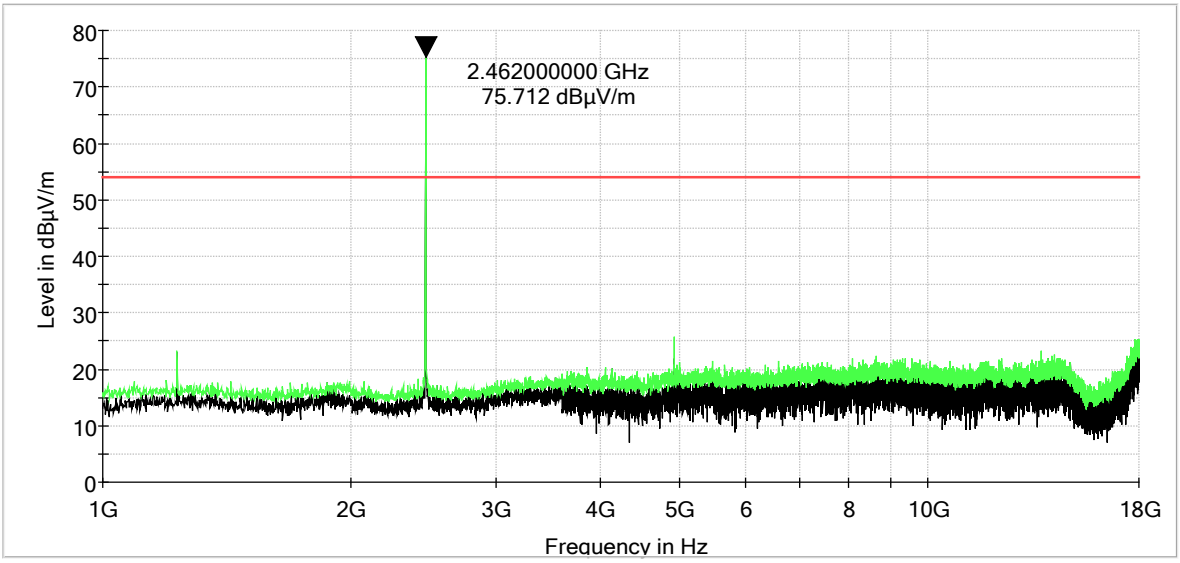


Mid Channel: 18 GHz to 26 GHz, Vertical

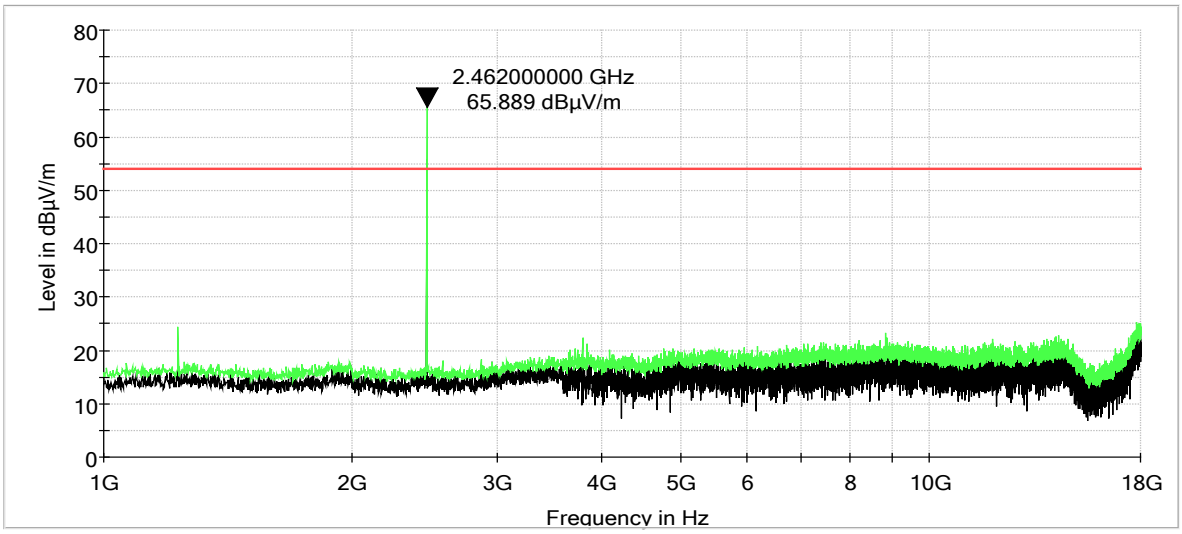
Mid Channel: 18 GHz to 26 GHz, Horizontal



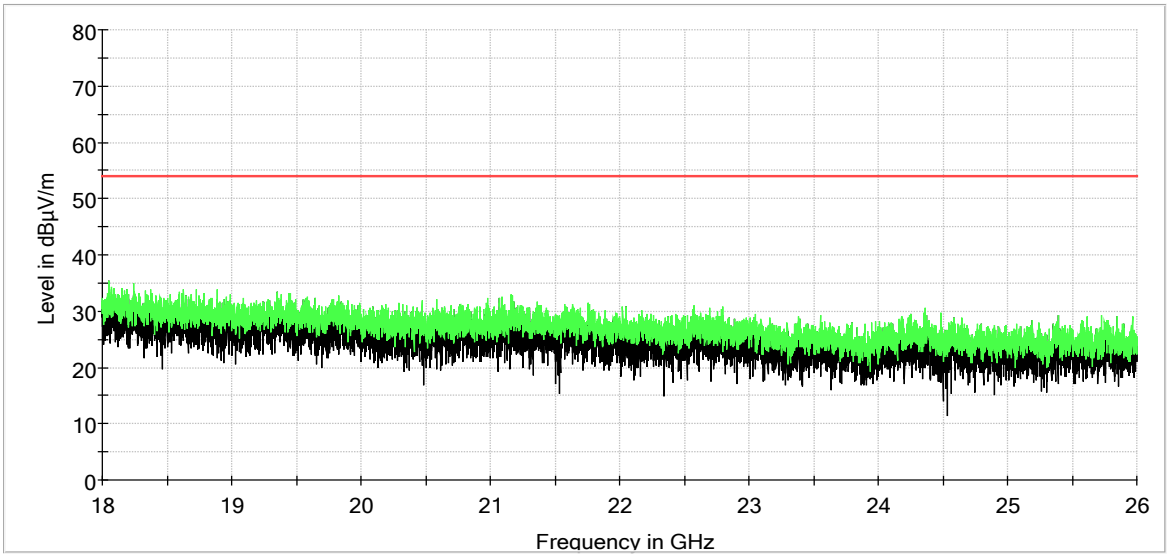
High Channel: 1 GHz to 18 GHz, Vertical



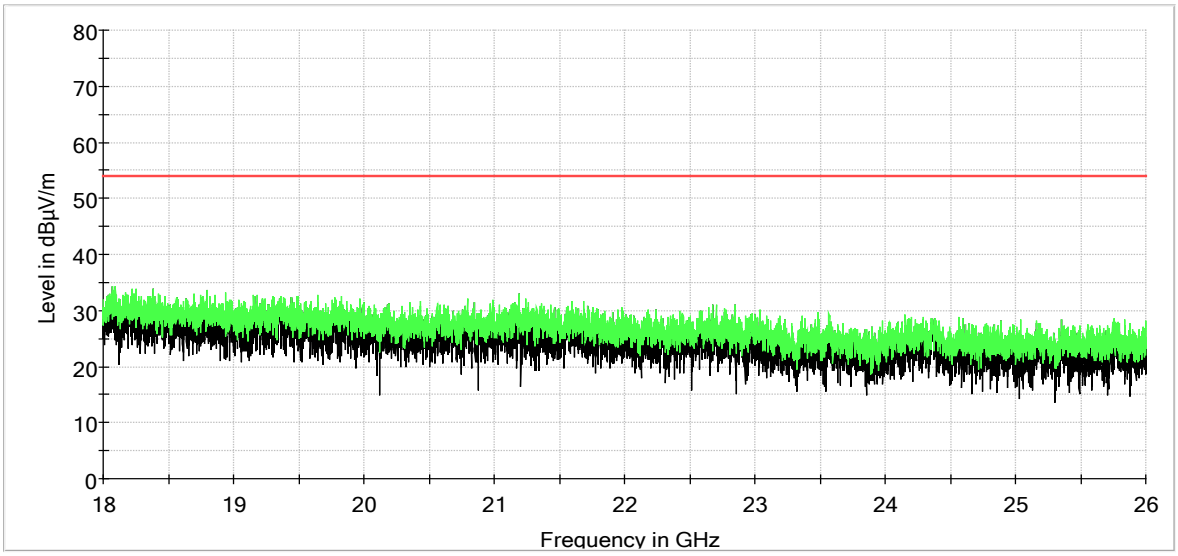
High Channel: 1 GHz to 18 GHz, Horizontal



High Channel: 18 GHz to 26 GHz, Vertical



High Channel: 18 GHz to 26 GHz, Horizontal



8 MPE CALCULATION

The MPE calculation below uses the output power of this module with max power of a Wi-Fi module and 6dBi gain of antenna as worse case.

MPE RF EXPOSURE FOR DEVICE

Distance Used:	**20cm**
Limit:	1mW/cm^2
Formula Used for Result:	$\frac{\text{E.I.R.P.}}{4 \pi R^2}$
Results:	E.I.R.P = 4000.0046mW with worse case Wi-Fi

E.I.R.P of 0.0046mW was determined by using the worst case E.I.R.P., 73.3 dBuV/m @ 3m, which equals 0.0046V/m. Using C63.10 Annex G2, then:

73.3 dBuV/m = 0.0046V/m

E.I.R.P. = (0.0046v/m x 3) ^2 / 30 = 0.0000046W =0.0046mW

Wi-Fi: Max E.I.R.P. = 4000mW

Combined E.I.R.P. (Wi-Fi + Module) = 4000mW+ 0.0046mW= 4000.0046mW

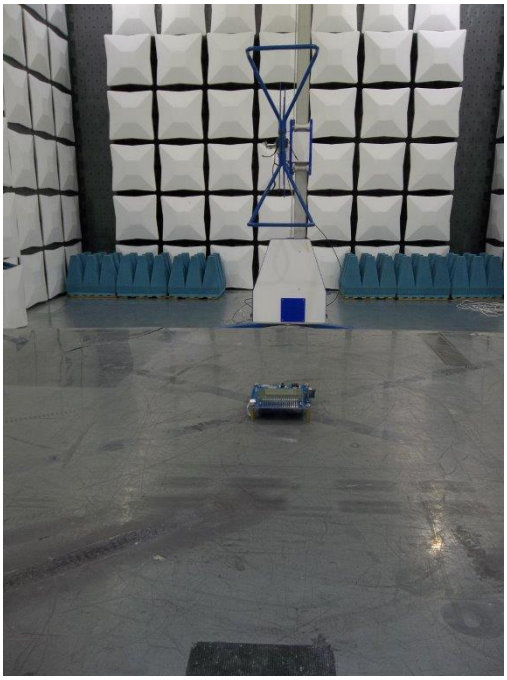
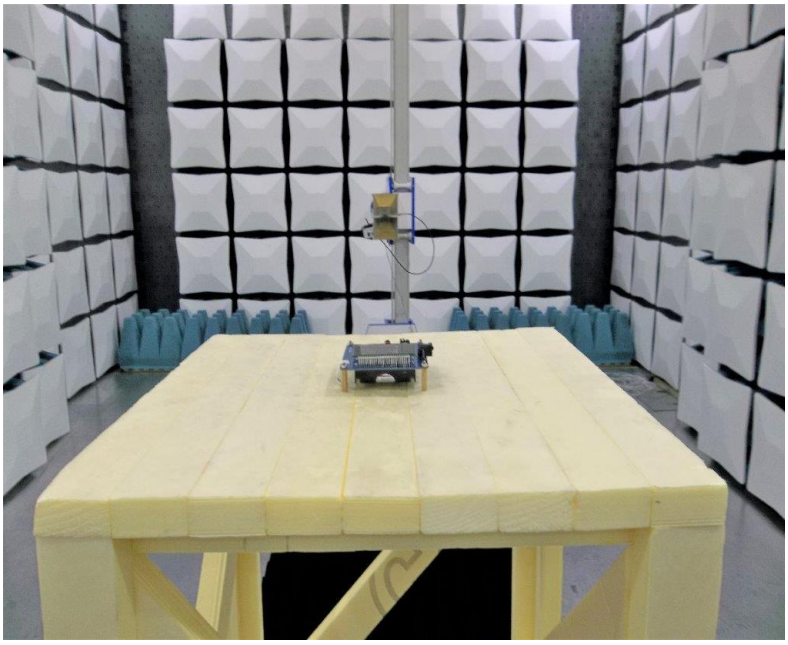
Combined MPE (Maximum allowed Wi-Fi + Module) =
4000.0046mW / (4 (3.1416)(20 x 20)) =
4000.0046/5026 =0.7958 mW/cm2.

The calculated combined MPE is below the MPE limit when the Limited Modular Approved module is co-located with a Wi-Fi device operating in Maximum allowed E.I.R.P.

9 PHOTOGRAPHS – TEST SETUP

Loop Antenna

Less Than 1 GHz



Above 1 GHz