FCC PART 15, SUBPART C

TEST AND MEASUREMENT REPORT

For

NUIO, LLC

PO Box 1327, Los Gatos, CA 95031

FCC ID: 2BEQU-FLOW-KB-L-001

Report Type: Original Report		**Product Type:** Keyboard
Prepared By	Will Hu Test Engineer	
Report Number	R2311032-249-L	
Report Date	2024-06-04	
Reviewed By	Christian McCaig RF Lead Engineer	
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ACCREDITED
CERTIFICATE #3297.02

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DOCUMENT REVISION HISTORY

Revision Number	Report Number	Description of Revision	Date of Revision
0	R2311032-249-L	Original Report	2024-06-04

1 General Description

1.1 Product Description for Equipment Under Test (EUT)

This test and measurement report was prepared on behalf of *NUIO, LLC,* and their product model: FLOWKB001, FCC ID: 2BEQU-FLOW-KB-L-001, or the "EUT" as referred to in this report. It is a left part of a wireless keyboard with ISM wireless function operating in the 2.4 GHz band. The EUT can transmit with the right side device (Bluetooth and ISM) at the same time.

1.2 Mechanical Description of EUT

The EUT measures approximately 17 cm (L) x 13 cm (W) x 1 cm (H) and weighs approximately 0.26 kg.

The test data gathered are from typical production sample, serial number: R2311032-01 assigned by BACL.

1.3 Objective

This report is prepared on behalf of *NUIO, LLC.* in accordance with Part 2, Subpart J, and Part 15, Subparts C of the Federal Communication Commission's rules.

The objective is to determine compliance with FCC Part 15.249 rules for Antenna Requirements, RF Exposure, AC Line Conducted Emissions, Occupied Bandwidth, and Radiated Spurious Emissions.

1.4 Related Submittal(s)/Grant(s)

FCC Part 15.249, Equipment Class: DXX, FCC ID: 2BEQU-FLOW-KB-R-001.
FCC Part 15.247, Equipment Class: DTS, FCC ID: 2BEQU-FLOW-KB-R-001.

1.5 Test Methodology

All measurements contained in this report were conducted in accordance with ANSI C63.10-2013, American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices.

1.6 Measurement Uncertainty

All measurements involve certain levels of uncertainties, especially in the field of EMC. The factors contributing to uncertainties are spectrum analyzer, cable loss, antenna factor calibration, antenna directivity, antenna factor variation with height, antenna phase center variation, antenna factor frequency interpolation, measurement distance variation, site imperfections, mismatch (average), and system repeatability.

Parameter	Measurement uncertainty
Occupied Channel Bandwidth	±5 %
RF output power, conducted	±0.57 dB
Power Spectral Density, conducted	±1.48dB
Unwanted Emissions, conducted	±1.57dB
All emissions, radiated	±4.0 dB
AC power line Conducted Emission	±2.0 dB
Temperature	±2 ºC
Humidity	±5 %
DC and low frequency voltages	±1.0 %
Time	±2 %
Duty Cycle	±3 %

1.7 Test Facility Registrations

BACLs test facilities that are used to perform Radiated and Conducted Emissions tests are currently recognized by the Federal Communications Commission as Accredited with NIST Designation Number US1129.

BACL's test facilities that are used to perform Radiated and Conducted Emissions tests are currently registered with Industry Canada under Registration Numbers: 3062A-1, 3062A-2, and 3062A-3.

BACL is a Chinese Taipei Bureau of Standards Metrology and Inspection (BSMI) validated Conformity Assessment Body (CAB), under Appendix B, Phase I Procedures of the APEC Mutual Recognition Arrangement (MRA). BACL's BSMI Lab Code Number is: SL2-IN-E-1002R

BACL's test facilities that are used to perform AC Line Conducted Emissions, Telecommunications Line Conducted Emissions, Radiated Emissions from 30 MHz to 1 GHz, and Radiated Emissions from 1 GHz to 6 GHz are currently recognized as Accredited in accordance with the Voluntary Control Council for Interference [VCCI] Article 15 procedures under Registration Number A-0027.

1.8 Test Facility Accreditations

Bay Area Compliance Laboratories Corp. (BACL) is:

A- ***An independent, 3rd-Party, Commercial Test Laboratory accredited to ISO/IEC 17025:2017 by A2LA (Test Laboratory Accreditation Certificate Number 3297.02),*** in the fields of: Electromagnetic Compatibility and Telecommunications. Unless noted by an Asterisk (*) in the Compliance Matrix (See Section 3 of this Test Report), BACL's ISO/IEC 17025:2005 Scope of Accreditation includes all of the Test Method Standards and/or the Product Family Standards detailed in this Test Report..

BACL's ISO/IEC 17025:2005 Scope of Accreditation includes a comprehensive suite of EMC Emissions, EMC Immunity, Radio, RF Exposure, Safety and wireline Telecommunications test methods applicable to a wide

range of product categories. These product categories include Central Office Telecommunications Equipment [including NEBS - Network Equipment Building Systems], Unlicensed and Licensed Wireless and RF devices, Information Technology Equipment (ITE); Telecommunications Terminal Equipment (TTE); Medical Electrical Equipment; Industrial, Scientific and Medical Test Equipment; Professional Audio and Video Equipment; Industrial and Scientific Instruments and Laboratory Apparatus; Cable Distribution Systems, and Energy Efficient Lighting.

B- ***A Product Certification Body accredited to ISO/IEC 17065:2012 by A2LA (Product Certification Body Accreditation Certificate Number 3297.03)*** to certify

- For the USA (Federal Communications Commission):
  - 1- All Unlicensed radio frequency devices within FCC Scopes A1, A2, A3, and A4;
  - 2- All Licensed radio frequency devices within FCC Scopes B1, B2, B3, and B4;
  - 3- All Telephone Terminal Equipment within FCC Scope C.
- For the Canada (Industry Canada):
  - 1 All Scope 1-Licence-Exempt Radio Frequency Devices;
  - 2 All Scope 2-Licensed Personal Mobile Radio Services;
  - 3 All Scope 3-Licensed General Mobile and Fixed Radio Services;
  - 4 All Scope 4-Licensed Maritime and Aviation Radio Services;
  - 5 All Scope 5-Licensed Fixed Microwave Radio Services
  - 6 All Broadcasting Technical Standards (BETS) in the Category I Equipment Standards List.
- For Singapore (Info-Communications Development Authority (IDA)):
  - 1 All Line Terminal Equipment: All Technical Specifications for Line Terminal Equipment – Table 1 of IDA MRA Recognition Scheme: 2011, Annex 2
  - 2. All Radio-Communication Equipment: All Technical Specifications for Radio-Communication Equipment – Table 2 of IDA MRA Recognition Scheme: 2011, Annex 2
- For the Hong Kong Special Administrative Region:
  - 1 All Radio Equipment, per KHCA 10XX-series Specifications;
  - 2 All GMDSS Marine Radio Equipment, per HKCA 12XX-series Specifications;
  - 3 All Fixed Network Equipment, per HKCA 20XX-series Specifications.
- For Japan:
  - 1 MIC Telecommunication Business Law (Terminal Equipment):
    - All Scope A1 - Terminal Equipment for the Purpose of Calls;
    - All Scope A2 - Other Terminal Equipment
  - 2 Radio Law (Radio Equipment):
    - All Scope B1 - Specified Radio Equipment specified in Article 38-2-2, paragraph 1, item 1 of the Radio Law
    - All Scope B2 - Specified Radio Equipment specified in Article 38-2-2, paragraph 1, item 2 of the Radio Law
    - All Scope B3 - Specified Radio Equipment specified in Article 38-2-2, paragraph 1, item 3 of the Radio Law

C- ***A Product Certification Body accredited to ISO/IEC 17065:2012 by A2LA (Product Certification Body Accreditation Certificate Number 3297.01)*** to certify Products to USA's Environmental Protection Agency (EPA) ENERGY STAR Product Specifications for:

- 1 Electronics and Office Equipment:
  - for Telephony (ver. 3.0)
  - for Audio/Video (ver. 3.0)
  - for Battery Charging Systems (ver. 1.1)
  - for Set-top Boxes and Cable Boxes (ver. 4.1)
  - for Televisions (ver. 6.1)
  - for Computers (ver. 6.0)
  - for Displays (ver. 6.0)

- for Imaging Equipment (ver. 2.0)
- for Computer Servers (ver. 2.0)

2 Commercial Food Service Equipment
- for Commercial Dishwashers (ver. 2.0)
- for Commercial Ice Machines (ver. 2.0)
- for Commercial Ovens (ver. 2.1)
- for Commercial Refrigerators and Freezers

3 Lighting Products
- For Decorative Light Strings (ver. 1.5)
- For Luminaires (including sub-components) and Lamps (ver. 1.2)
- For Compact Fluorescent Lamps (CFLs) (ver. 4.3)
- For Integral LED Lamps (ver. 1.4)

4 Heating, Ventilation, and AC Products
- for Residential Ceiling Fans (ver. 3.0)
- for Residential Ventilating Fans (ver. 3.2)

5 Other
- For Water Coolers (ver. 3.0)

D- ***A NIST Designated Phase-I and Phase-II Conformity Assessment Body (CAB) for the following economies and regulatory authorities under the terms of the stated MRAs/Treaties:***

- Australia: ACMA (Australian Communication and Media Authority) – APEC Tel MRA -Phase I;
- Canada: (Industry Canada - IC) Foreign Certification Body – FCB – APEC Tel MRA -Phase I & Phase II;
- Chinese Taipei (Republic of China – Taiwan):
  - BSMI (Bureau of Standards, Metrology and Inspection) APEC Tel MRA -Phase I;
  - NCC (National Communications Commission) APEC Tel MRA -Phase I;
- European Union:
  - Radio & Teleterminal Equipment (R&TTE) Directive 1995/5/EC
    US -EU EMC & Telecom MRA CAB
- Hong Kong Special Administrative Region: (Office of the Telecommunications Authority – OFTA)
  APEC Tel MRA -Phase I & Phase II
- Israel – US-Israel MRA Phase I
- Republic of Korea (Ministry of Communications - Radio Research Laboratory) APEC Tel MRA -Phase I
- Singapore: (Infocomm Development Authority - IDA) APEC Tel MRA -Phase I & Phase II;
- Japan: VCCI - Voluntary Control Council for Interference US-Japan Telecom Treaty VCCI Side Letter-
- USA:
  - ENERGY STAR Recognized Test Laboratory – US EPA
  - Telecommunications Certification Body (TCB) – US FCC;
- Vietnam: APEC Tel MRA -Phase I;

2 System Test Configuration

2.1 Justification

The EUT was configured for testing according to ANSI C63.10-2013.

The EUT was tested in a testing mode to represent worst-case results during the final qualification test.

2.2 EUT Exercise Software

The EUT was transmit using key binding functions provided by *NUIO, LLC.*

Modulation	Frequency (MHz)	Power Setting
GFSK	2405	default
	2442	default
	2475	default

Note: Colocation test was configured with both devices (left and right) transmitting in ISM middle channel, 2442 MHz, and right side device transmitting in BLE middle channel, 2456 MHz at the same time.

2.3 Equipment Modifications

None

2.4 Local Support Equipment

N/A

2.5 Support Equipment

N/A

2.6 Interface Ports and Cabling

Cable Description	Length (m)	To	From
Power Cable	< 1 m	AC Power Source	EUT

3 Summary of Test Results

Results reported relate only to the product tested.

FCC Rules	Description of Test	Results
FCC §2.1093	RF Exposure	Compliant
FCC §15.203	Antenna Requirement	Compliant
FCC §15.207	AC Line Conducted Emissions	Compliant
FCC §2.1053, §15.205, §15.209, §15.249 (a)	Radiated Spurious Emissions	Compliant
FCC §15.215	Emission Bandwidth	Compliant

BACL is responsible for all the information provided in this report, except when information is provided by the customer as identified in this report. Information provided by the customer, e.g., antenna gain, can affect the validity of results.

4 FCC §2.1093 - RF Exposure

4.1 Applicable Standards

According to FCC KDB 447498 D01 General RF Exposure Guidance v06 Section 4.3.1, Unless specifically required by the published RF exposure KDB procedures, standalone 1-g head or body and 10-g extremity SAR evaluation for general population exposure conditions, by measurement or numerical simulation, is not required when the corresponding SAR Test Exclusion Threshold condition, listed below, is satisfied. These test exclusion conditions are based on source-based time-averaged maximum conducted output power of the RF channel requiring evaluation, adjusted for tune-up tolerance, and the minimum test separation distance required for the exposure conditions. The minimum test separation distance is determined by the smallest distance from the antenna and radiating structures or outer surface of the device, according to the host form factor, exposure conditions and platform requirements, to any part of the body or extremity of a user or bystander (see 5) of section 4.1). To qualify for SAR test exclusion, the test separation distances applied must be fully explained and justified by the operating configurations and exposure conditions of the transmitter and applicable host platform requirements, typically in the SAR measurement or SAR analysis report, according to the required published RF exposure KDB procedures. When no other RF exposure testing or reporting is required, a statement of justification and compliance must be included in the equipment approval, in lieu of the SAR report, to qualify for the SAR test exclusion. When required, the device specific conditions described in the other published RF exposure KDB procedures must be satisfied before applying these SAR test exclusion provisions; for example, handheld PTT two-way radios, handsets, laptops & tablets etc.

1) The 1-g and 10-g SAR test exclusion thresholds for 100 MHz to 6 GHz at test separation distances ≤ 50 mm are determined by:

   [(max. power of channel, including tune-up tolerance, mW)/(min. test separation distance, mm)] · [√f(GHz)] ≤ 3.0 for 1-g SAR and ≤ 7.5 for 10-g extremity SAR, where

   • f (GHz) is the RF channel transmit frequency in GHz
   • Power and distance are rounded to the nearest mW and mm before calculation
   • The result is rounded to one decimal place for comparison
   • 3.0 and 7.5 are referred to as the numeric thresholds in the step 2 below

   The test exclusions are applicable only when the minimum test separation distance is ≤ 50 mm and for transmission frequencies between 100 MHz and 6 GHz. When the minimum test separation distance is < 5 mm, a distance of 5 mm according to 5) in section 4.1 is applied to determine SAR test exclusion.

2) At 100 MHz to 6 GHz and for test separation distances > 50 mm, the SAR test exclusion threshold is determined according to the following, and as illustrated in Appendix B:

   a) [Power allowed at numeric threshold for 50 mm in step 1) + (test separation distance - 50 mm) (f(MHz)/150)] mW, at 100 MHz to 1500 MHz
   b) [Power allowed at numeric threshold for 50 mm in step 1) + (test separation distance - 50 mm) ·10] mW at > 1500 MHz and ≤ 6 GHz

3) At frequencies below 100 MHz, the following may be considered for SAR test exclusion, and as illustrated in Appendix C:

   a) The power threshold at the corresponding test separation distance at 100 MHz in step 2) is multiplied by [1 + log(100/f(MHz))] for test separation distances > 50 mm and < 200 mm
   b) The power threshold determined by the equation in a) for 50 mm and 100 MHz is multiplied by ½ for test separation distances ≤ 50 mm

c) SAR measurement procedures are not established below 100 MHz. When SAR test exclusion cannot be applied, a KDB inquiry is required to determine SAR evaluation requirements for any test results to be acceptable.

4.2 RF exposure evaluation exemption for FCC

The maximum power of channel, including tune-up tolerance is -13.013dBm(0.05mW). According to FCC KDB 447498,

[(max. power of channel, including tune-up tolerance, mW)/(min. test separation distance, mm)] [√f(GHz)] = (0.05 mW/5mm)* √2.4 = 0.02, which is less than 7.5. Therefore, FCC SAR testing is excluded.

Colocation Evaluation:

Left ISM ratio + Right ISM ratio + BLE ratio = 0.03/7.5 + +0.02/7.5 + 0.89/7.5 = 0.13 < 1.0

NOTE: EIRP used is determined by 82.287 dBuV/m @3m – 95.3dB = -13.013 dBm.

5 FCC §15.203 - Antenna Requirements

5.1 Applicable Standards

According to FCC §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.

The applicant for equipment certification, as per RSP-100, must provide a list of all antenna types that may be used with the license-exempt transmitter, indicating the maximum permissible antenna gain (in dBi) and the required impedance for each antenna.

License-exempt transmitters that have received equipment certification may operate with different types of antennas. However, it is not permissible to exceed the maximum equivalent isotropically radiated power (e.i.r.p.) limits specified in the applicable standard (RSS) for the license-exempt apparatus.

Testing shall be performed using the highest gain antenna of each combination of license-exempt transmitter and antenna type, with the transmitter output power set at the maximum level. 9 When a measurement at the antenna connector is used to determine RF output power, the effective gain of the device's antenna shall be stated, based on a measurement or on data from the antenna manufacturer.

User manuals for transmitters equipped with detachable antennas shall also contain the following notice in a conspicuous location:

This radio transmitter (identify the device by certification number) has been approved by Industry Canada to operate with the antenna types listed below with the maximum permissible gain indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Immediately following the above notice, the manufacturer shall provide a list of all antenna types approved for use with the transmitter, indicating the maximum permissible antenna gain (in dBi).

5.2 Antenna Description

Internal/Integral/ External	Frequency Range (MHz)	Antenna Type	Maximum Antenna Gain (dBi)
Integral	2400-2500	PCB	2.7

6 FCC §15.207 - AC Line Conducted Emissions

6.1 Applicable Standards

As per FCC §15.207 Conducted limits:

For 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 frequencies ranges.

Frequency of Emission (MHz)	Conducted Limit (dBuV)	
	Quasi-Peak	Average
0.15-0.5	66 to 56 Note1	56 to 46 Note2
0.5-5	56	46
5-30	60	50

Note1: Decreases with the logarithm of the frequency.
Note2: A linear average detector is required

6.2 Test Setup

The measurement was performed at shield room, using the setup per ANSI C63.10-2013 measurement procedure. The specification used were FCC §15.207 limits.

External I/O cables were draped along the edge of the test table and bundle when necessary.

The AC/DC power adapter of the EUT was connected with LISN-1 which provided 120 V / 60 Hz AC power.

6.3 Test Procedure

During the conducted emissions test, the power cord of the EUT host system was connected to the mains outlet of the LISN-1 and the power cords of support equipment were connected to LISN-2.

Maximizing procedure was performed on the six (6) highest emissions of the EUT.

All data were recorded in the peak, quasi-peak, and average detection mode. Quasi-Peak readings are distinguished with a "QP." Average readings are distinguished with an "Ave".

6.4 Corrected Amplitude & Margin Calculation

The Corrected Amplitude (CA) is calculated by adding the Correction Factor (CF) to indicated Amplitude (Ai) reading. The basic equation is as follows:

$$CA = Ai + CF$$

For example, a corrected amplitude of 46.2 dBuV = Indicated Reading (32.5 dBuV) + Correction Factor (13.7 dB)

The Correction Factor is calculated by adding Cable loss (CL) and attenuation of the impulse limiter and the high pass filter. The basic equation is as follows:

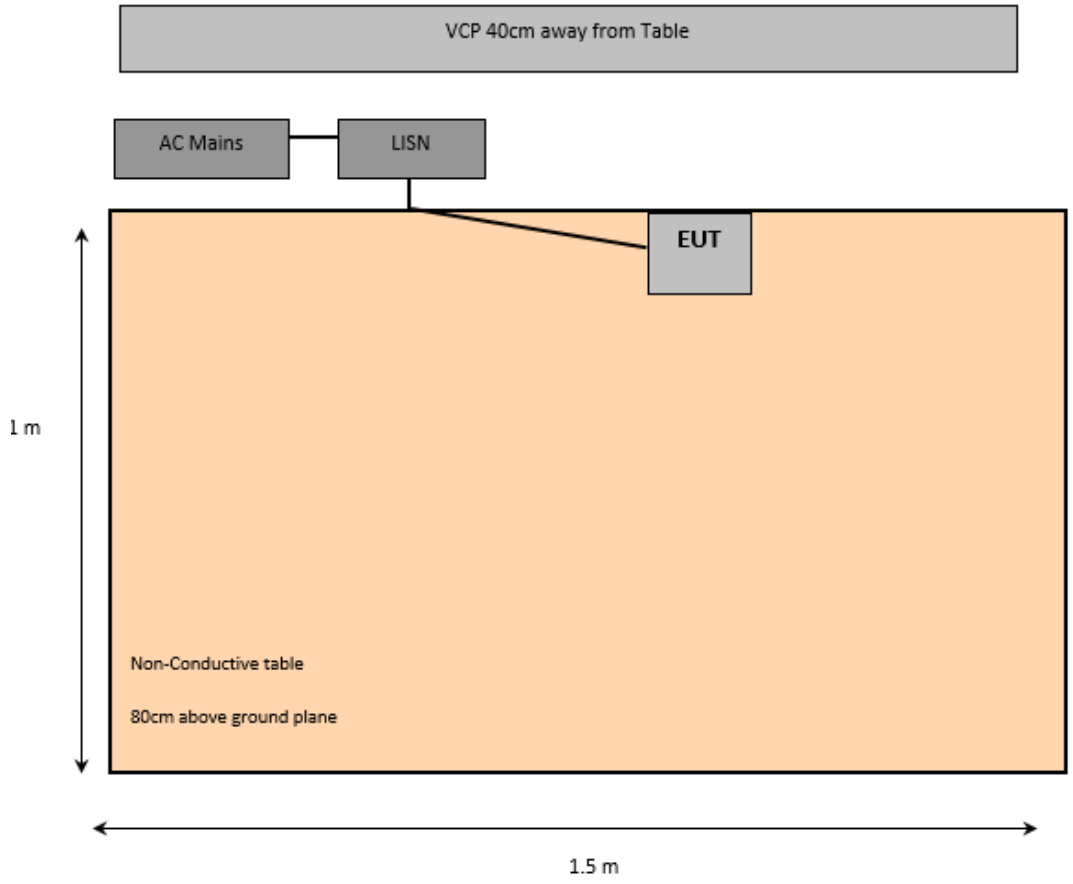
$$CF= CL + Attenuator$$

For example, a corrected amplitude of 13.7 dB = Cable Loss (3.7 dB) + Attenuation (10 dB)

The "**Margin**" column of the following data tables indicates the degree of compliance within the applicable limit. For example, a margin of -7 dB means the emission is 7 dB below the maximum limit. The equation for margin calculation is as follows:

$$Margin = Corrected\ Amplitude – Limit$$

6.5 Test Setup Block Diagram



6.6 Test Equipment List and Details

BACL No.	Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
124	Rohde & Schwarz	EMI Test Receiver	ESCI 1166.5950K03	100044	2023-06-16	1 year
681	Rohde & Schwarz	Impulse Limiter	ESH3-Z2	101962	2024-01-04	6 months
726	Solar Electronics Company	High Pass Filter	Type 7930-100	7930150204	2024-01-08	6 months
732	FCC	LISN	FCC-LISN-50-25-2-10-CISPR16	160129	2023-09-12	1 year
1241	Pasternack	RG223 Coaxial cable 1500cm	PE3447-1500cm	N/A	2024-01-02	6 months

Statement of Traceability: BACL Corp. *attests that all of the calibrations on the equipment items listed above were traceable to NIST or to another internationally recognized National Metrology Institute (NMI), and were compliant with the latest version of A2LA policy P102 "A2LA Policy on Metrological Traceability".*

6.7 Test Environmental Conditions

Temperature:	22 ℃
Relative Humidity:	49%
ATM Pressure:	102.6 kPa

The testing was performed by Will Hu on 2024-01-16 in the 5 meter chamber 3.

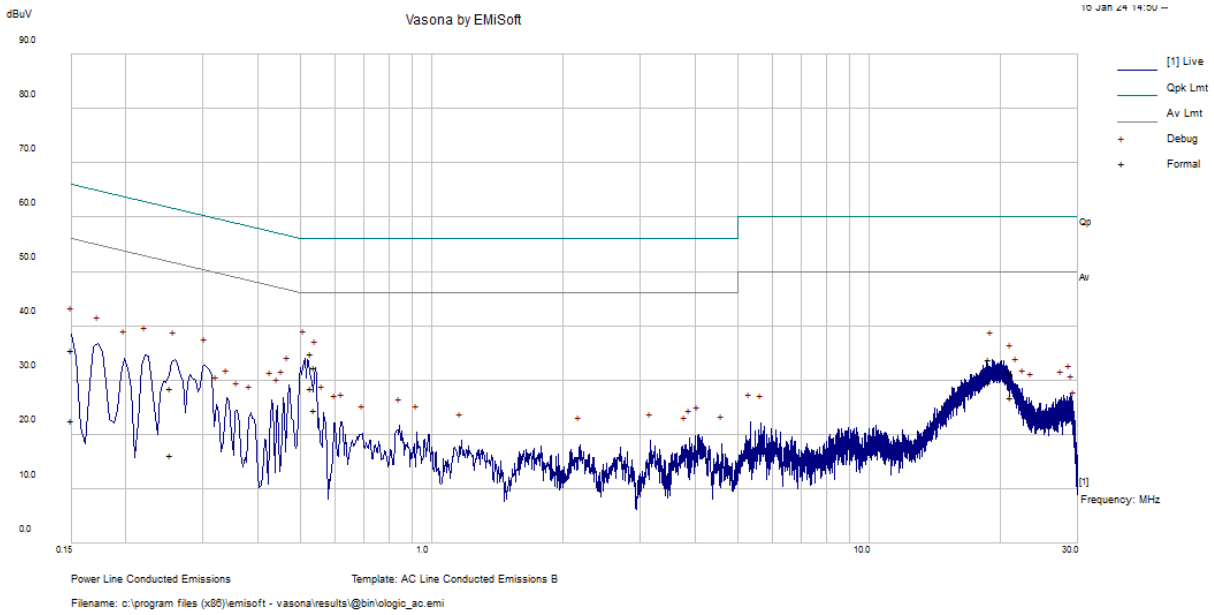
6.8 Summary of Test Results

According to the recorded data in following table, the EUT complied with the FCC 15C standard conducted emissions limits, with the margin reading of:

Worst Case – AC Line: 120V, 60Hz			
Margin (dB)	**Frequency (MHz)**	**Conductor Mode (Hot/Neutral)**	**Range (MHz)**
-17.43	0.529108	Neutral	0.15 to 30

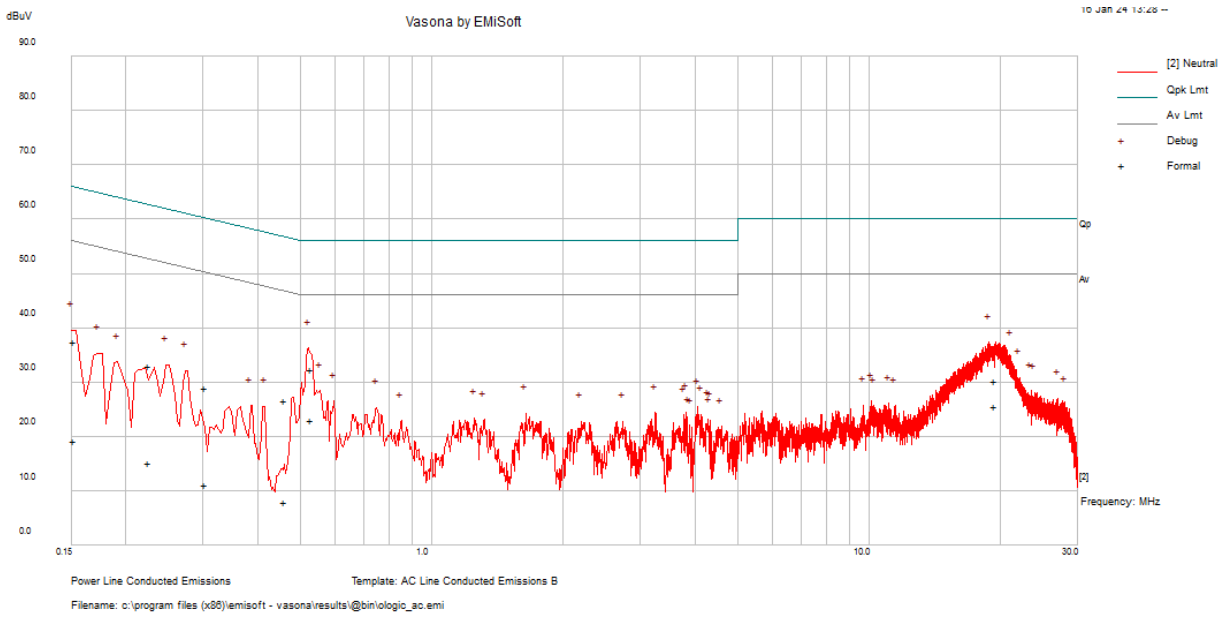
6.9 Conducted Emissions Test Plots and Data

AC Line: 120V, 60Hz – Hot Conductor



Frequency (MHz)	Ai. Reading (dBuV)	Correction Factor (dB)	Corrected Amplitude (dBµV)	Limit (dBµV)	Margin (dB)	Detector
0.520812	21.46	9.82	31.28	56	-24.72	QP
0.52433	21.71	9.82	31.53	56	-24.47	QP
19.056389	19.81	10.24	30.05	60	-29.95	QP
0.484679	17.4	9.82	27.22	56.26	-29.04	QP
0.287566	19.25	9.83	29.08	60.59	-31.52	QP
0.150186	26.62	9.7	36.32	65.99	-29.67	QP
0.520812	11.48	9.82	21.3	46	-24.7	Ave
0.52433	12.65	9.82	22.47	46	-23.53	Ave
19.056389	15.26	10.24	25.5	50	-24.5	Ave
0.484679	1.4	9.82	11.21	46.26	-35.05	Ave
0.287566	1.67	9.83	11.49	50.59	-39.1	Ave
0.150186	9.13	9.7	18.82	55.99	-37.17	Ave

AC Line: 120V, 60Hz – Neutral Conductor



Frequency (MHz)	Ai. Reading (dBuV)	Correction Factor (dB)	Corrected Amplitude (dBµV)	Limit (dBµV)	Margin (dB)	Detector
0.529108	25.14	9.82	34.96	56	-21.04	QP
18.76653	23.65	10.27	33.92	60	-26.08	QP
21.10794	20.94	10.3	31.24	60	-28.76	QP
0.150095	25.84	9.7	35.53	65.99	-30.46	QP
0.540012	22.53	9.82	32.35	56	-23.65	QP
0.252383	18.78	9.81	28.59	61.68	-33.09	QP
0.529108	**18.75**	**9.82**	**28.57**	**46**	**-17.43**	**Ave**
18.76653	19.34	10.27	29.61	50	-20.39	Ave
21.10794	16.61	10.3	26.9	50	-23.1	Ave
0.150095	12.76	9.7	22.45	55.99	-33.54	Ave
0.540012	14.64	9.82	24.47	46	-21.53	Ave
0.252383	6.44	9.81	16.25	51.68	-35.43	Ave

7 FCC §15.209, §15.249(a) - Spurious Radiated Emissions

7.1 Applicable Standards

As per FCC §15.35(b): Unless otherwise specified, on any frequency or frequencies above 1000 MHz, the radiated emission limits are based on the use of measurement instrumentation employing an average detector function. Unless otherwise specified, measurements above 1000 MHz shall be performed using a minimum resolution bandwidth of 1 MHz.

As Per FCC §15.205(a) except as show in paragraph (d) of this section, only spurious emissions are permitted in any of the frequency bands listed below:

MHz	MHz	MHz	GHz
0.090 – 0.110	16.42 – 16.423	960 – 1240	4. 5 – 5. 15
0.495 – 0.505	16.69475 – 16.69525	1300 – 1427	5. 35 – 5. 46
2.1735 – 2.1905	25.5 – 25.67	1435 – 1626.5	7.25 – 7.75
4.125 – 4.128	37.5 – 38.25	1645.5 – 1646.5	8.025 – 8.5
4.17725 – 4.17775	73 – 74.6	1660 – 1710	9.0 – 9.2
4.20725 – 4.20775	74.8 – 75.2	1718.8 – 1722.2	9.3 – 9.5
6.215 – 6.218	108 – 121.94	2200 – 2300	10.6 – 12.7
6.26775 – 6.26825	123 – 138	2310 – 2390	13.25 – 13.4
6.31175 – 6.31225	149.9 – 150.05	2483.5 – 2500	14.47 – 14.5
8.291 – 8.294	156.52475 – 156.52525	2690 – 2900	15.35 – 16.2
8.362 – 8.366	156.7 – 156.9	3260 – 3267	17.7 – 21.4
8.37625 – 8.38675	162.0125 –167.17	3.332 – 3.339	22.01 – 23.12
8.41425 – 8.41475	167.72 – 173.2	3 3458 – 3 358	23.6 – 24.0
12.29 – 12.293	240 – 285	3.600 – 4.400	31.2 – 31.8
12.51975 – 12.52025	322 – 335.4		36.43 – 36.5
12.57675 – 12.57725	399.9 – 410		Above 38.6
13.36 – 13.41	608 – 614		

As per FCC §15.209(a): Except as provided elsewhere in this Subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table

Frequency (MHz)	Field Strength (micro volts/meter)	Measurement Distance (meters)
0.009 - 0.490	2400/F(kHz)	300
0.490 - 1.705	24000/F(kHz)	30
1.705 - 30.0	30	30
30 - 88	100**	3
88 - 216	150**	3
216 - 960	200**	3
Above 960	500	3

** Except as provided in paragraph (g), fundamental emissions from intentional radiators operating under this Section shall not be located in the frequency bands 54-72 MHz, 76-88 MHz, 174-216 MHz or 470-806 MHz. However, operation within these frequency bands is permitted under other sections of this Part, e.g., Sections 15.231 and 15.241.

As per FCC §15.249(a) Annex 2 section A2.9: 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:

Frequency (MHz)	Field Strength of Fundamental (millivolts/meter)	Field Strength of Harmonics (microvolts/meter)
902-928	50	500
2400-2483.5	50	500
5725-5875	50	500
24000-24250	250	2500

As per FCC §15.249(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.

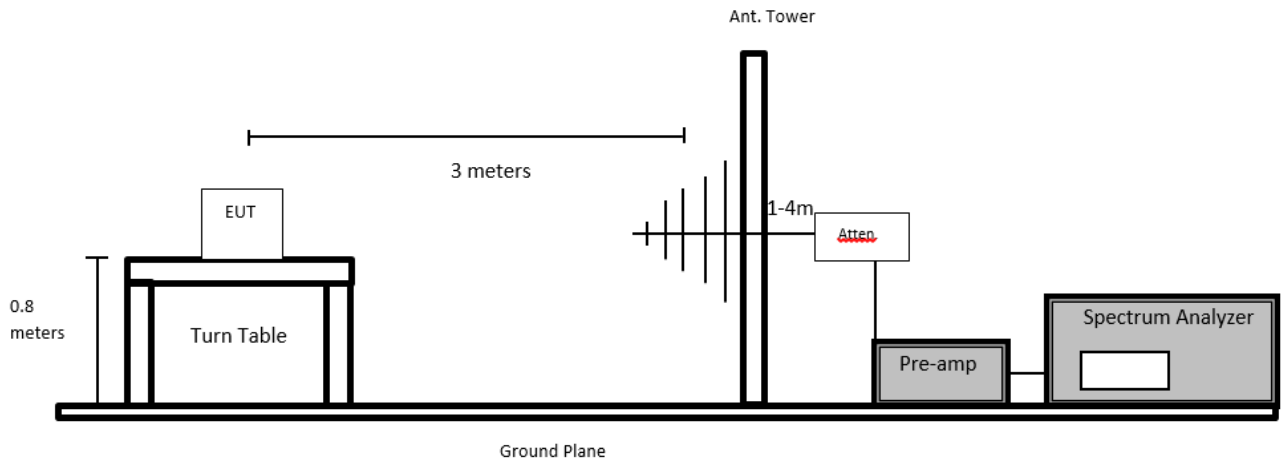
7.2 Test Setup

The radiated emissions tests were performed in the 5-meter chamber and 10-meter chamber, using the setup in accordance with ANSI C63.10-2013. The specification used was the FCC 15 Subpart C.
The spacing between the peripherals was 10 centimeters.

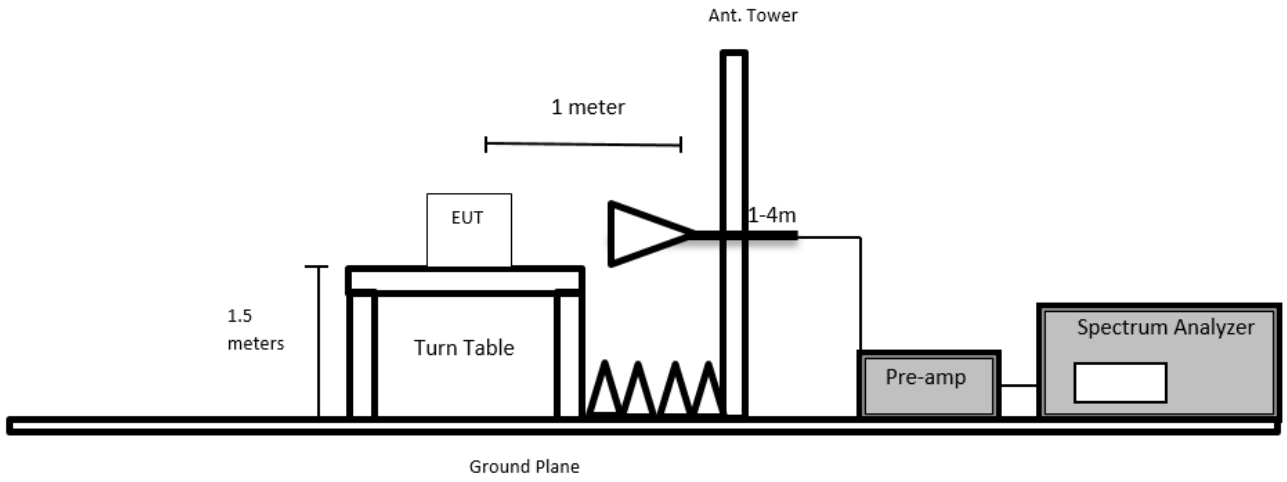
External I/O cables were draped along the edge of the test table and bundled when necessary.

7.3 Test Setup diagrams

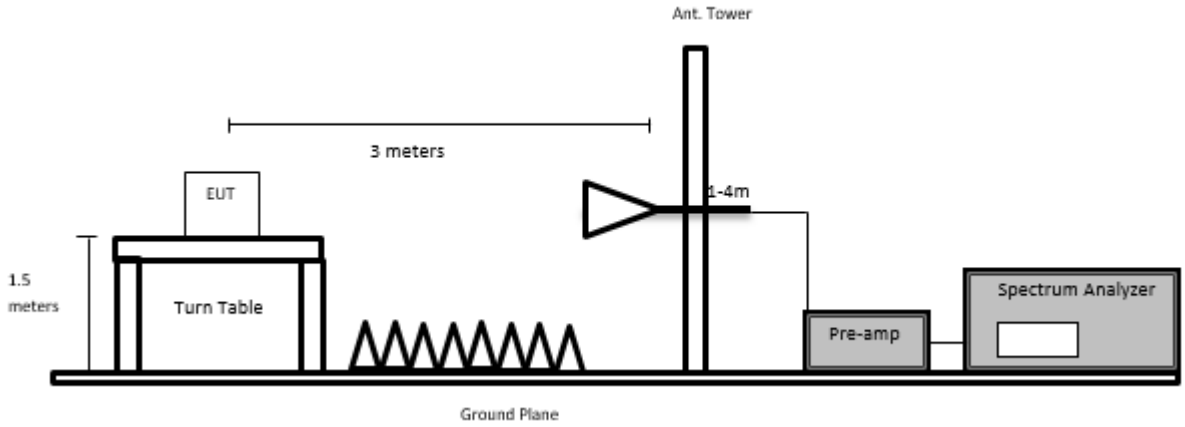
Radiated Spurious Test Below 1 GHz



Radiated Spurious Test Above 1 GHz



Fundamental Emission Test



7.4 Test Procedure

For the radiated emissions test, the EUT host, and all support equipment power cords were connected to the AC floor outlet.

Maximizing procedure was performed on the highest emissions to ensure that the EUT complied with all installation combinations.

The EUT was set 3 meter away from the testing antenna, which was varied from 1-4 meter, and the EUT was placed on a turntable, which was 0.8 meter and 1.5 meter above the ground plane for below and above 1000 MHz measurements, the table shall be rotated for 360 degrees to find out the highest emission. The receiving antenna's polarity should be changed between horizontal and vertical.

The spectrum analyzer or receiver was set as:

Below 1000 MHz:

RBW = 100 kHz / VBW = 300 kHz / Sweep = Auto

Above 1000 MHz:

(1) Peak: RBW = 1MHz / VBW = 1MHz / Sweep = Auto
(2) Average: RBW = 1MHz / VBW = 10Hz / Sweep = Auto

7.5 Corrected Amplitude & Margin Calculation

The Corrected Amplitude (CA) is calculated by adding the Antenna Factor (AF), the Cable Loss (CL), the Attenuator Factor (Atten) and subtracting the Amplifier Gain (Ga) to indicated Amplitude (Ai) reading. The basic equation is as follows:

CA = Ai + AF + CL + Atten – Ga

For example, a corrected amplitude of 40.3 dBuV/m = Indicated Reading (32.5 dBuV) + Antenna Factor (+23.5dB) + Cable Loss (3.7 dB) + Attenuator (10 dB) - Amplifier Gain (29.4 dB)

The "**Margin**" column of the following data tables indicates the degree of compliance within the applicable limit. For example, a margin of -7 dB means the emission is 7 dB below the maximum limit. The equation for margin calculation is as follows:

Margin = Corrected Amplitude – Limit

7.6 Test Equipment List and Details

BACL No.	Manufacturer	Description	Model	Serial Number	Calibration Date	Calibration Interval
310	Rohde & Schwarz	EMI test receiver 9 kHz to 3 GHZ	ESCI 1166.5950.03	100338	2023-05-11	1 year
624	Agilent	Spectrum Analyzer	E4446A	MY48250238	2023-05-12	1 year
124	Rhode & Schwarz	EMI Test Receiver	ESCI	100044	2023-06-16	1 year
327	Sunol Sciences	System Controller	SC110V	122303-1	N/R	N/R
1075	Sunol Sciences	Boresight Tower	TLT3	050119-7	N/R	N/R
1388	Sunol Sciences	Flush Mount Turntable	FM	112005-2	N/R	N/R
316	Sonoma Instruments	Preamplifier 10 kHz - 2.5 GHz	317	260406	2023-09-26	6 months
658	HP/ Agilant	Pre Amplifier	8449B OPT HO2	3008A01103	2023-12-01	6 months[1]
1247	Uti flex	Micro - Coax	N/A	N/A	2023-12-01	6 months[1]
827	AH Systems	Preamplifier	PAM 1840 VH	170	2023-11-08	6 months
321	Sunol Sciences	Biconilog Antenna	JB3	A020106-2; 1504	2023-12-18	2 years [2]
1246	HEWLET PACKARD	RF Limiter	11867A	01734	2023-04-13	1 year
1245	-	6dB Attenuator	PE7390-6	01182018A	2023-12-18	2 years[2]
1192	ETS Lindgren	Horn Antenna	3117	00218973	2022-09-29	2 years
90	Wisewave	Antenna, Horn	ARH-4223-02	10555-01	2023-05-02	2 years
1186	Pasternack	Coaxial Cable, RG214	PE3062-1050CM	N/A	2023-10-03	6 months
1248	Pasternack	RG214 COAX Cable	PE3062	N/A	2023-10-04	6 months
1249	Time Microwave	LMR-400 Cable Dc-3 GHz	AE13684	2k80612-5 6fts	2023-10-09	6 months
1346	RFMW	2.92mm 10ft RF cable	KMSE-160SAW-240.0-KSME	N/A	2023-11-03	6 months
1354	RFMW	2.92mm 10ft RF Cable DC to 40 GHz	P1CA-29M29M-F150-120	N/A	2023-02-24	1 year
1295	Carlisle	10m Ultra Low Loss Coaxial Cable	UFB142A-1-3937-200200	64639890912-001	2023-10-31	6 months
1334	Micro-Tronics	2400-2500 MHz Notch Filter	BRM50702	G361	2023-01-12	1 year

Note[1]: Test equipment is used on test dates: 2023-12-07 and 2023-12-21
Note[2]: Test equipment is used on test dates: 2024-01-04 and 2023-12-21

Statement of Traceability: BACL Corp. *attests that all of the calibrations on the equipment items listed above were traceable to NIST or to another internationally recognized National Metrology Institute (NMI), and were compliant with the latest version of A2LA policy P102 "A2LA Policy on Metrological Traceability".*

7.7 Test Environmental Conditions

Temperature:	21-23 ℃
Relative Humidity:	38-44.5 %
ATM Pressure:	101.8 kPa

The testing was performed by Will Hu on 2023-12-07, 2023-12-21 and 2024-01-04 in 5m chamber 3.

7.8 Summary of Test Results

According to the data hereinafter, the EUT complied with FCC Title 47, Part 15C standard radiated emissions limits, and had the worst spurious emission margin of:

Mode: Transmitting			
Margin (dB)	**Frequency (MHz)**	**Polarization (Horizontal/Vertical)**	**Configuration**
-6	116.859	Vertical	Colocation, Low Channel, 2405 MHz

Please refer to the following table and plots for specific test result details

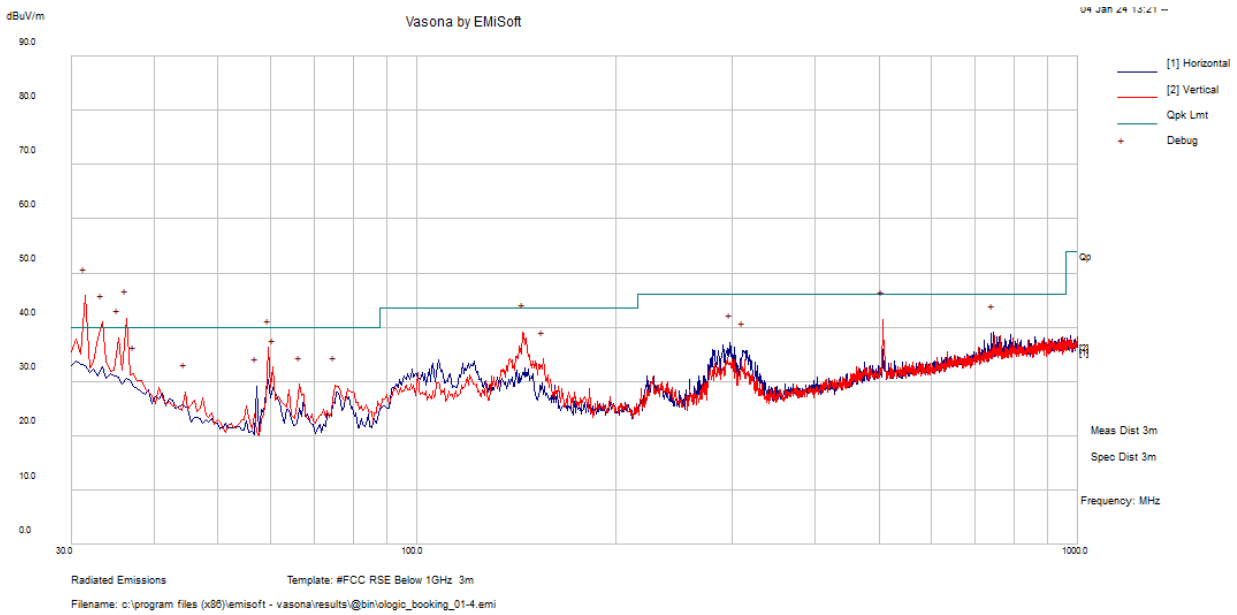
7.9 Radiated Emissions Test Results

Note: Except fundamental field strength and band-edge emissions, testing was performed with band-reject filter.
Note: The tested position is verified as the worst case in comparison to different orientations.

Part 1: Radiated test data for ISM radio

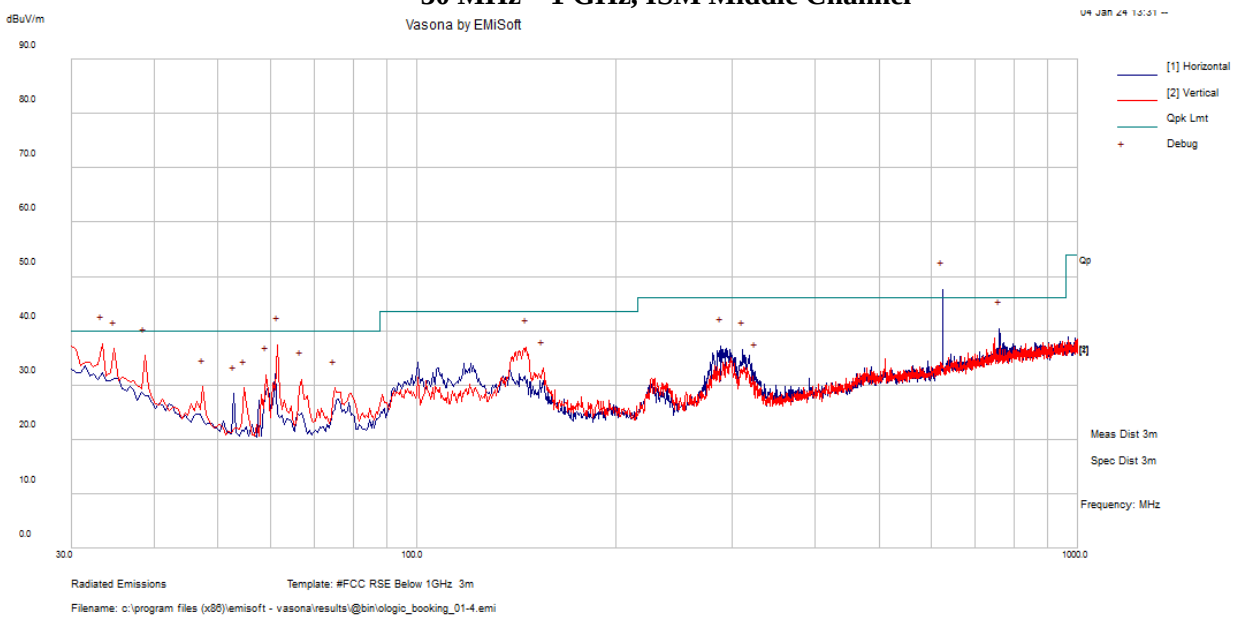
1) 30 MHz – 1 GHz, Measured at 3 meters

Worst Case, ISM Low Channel, 2405 MHz



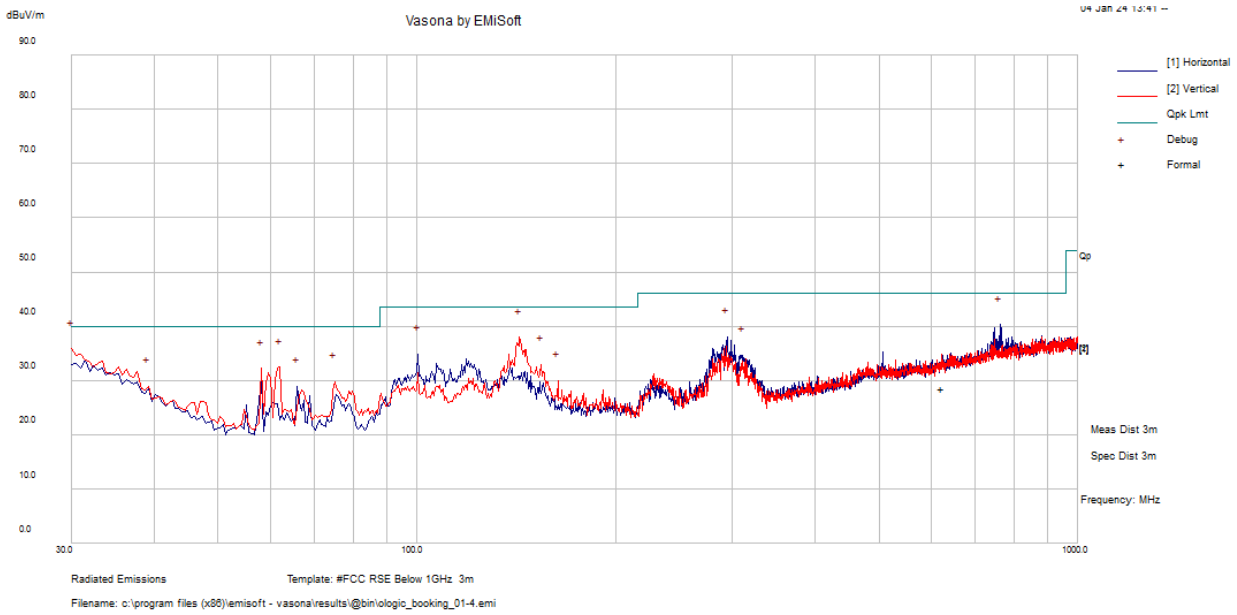
Frequency (MHz)	S.A. Reading (dBuV)	Correction Factor (dB/m)	Corrected Amplitude (dBµV/m)	Antenna Height (cm)	Antenna Polarity (H/V)	Turntable Azimuth (degrees)	Limit (dBµV/m)	Margin (dB)	Comment
31.4455	29.88	-2.05	27.82	225	V	292	40	-12.18	QP/Pass
36.08625	30.39	-5.11	25.28	179	V	192	40	-14.72	QP/Pass
33.4835	31.24	-3.29	27.95	137	V	344	40	-12.05	QP/Pass
35.121	30.89	-4.44	26.44	112	V	56	40	-13.56	QP/Pass
59.78025	32.65	-13.7	18.95	200	V	222	40	-21.05	QP/Pass
144.5968	36.83	-7.99	28.84	145	V	99	43.5	-14.66	QP/Pass

30 MHz – 1 GHz, ISM Middle Channel



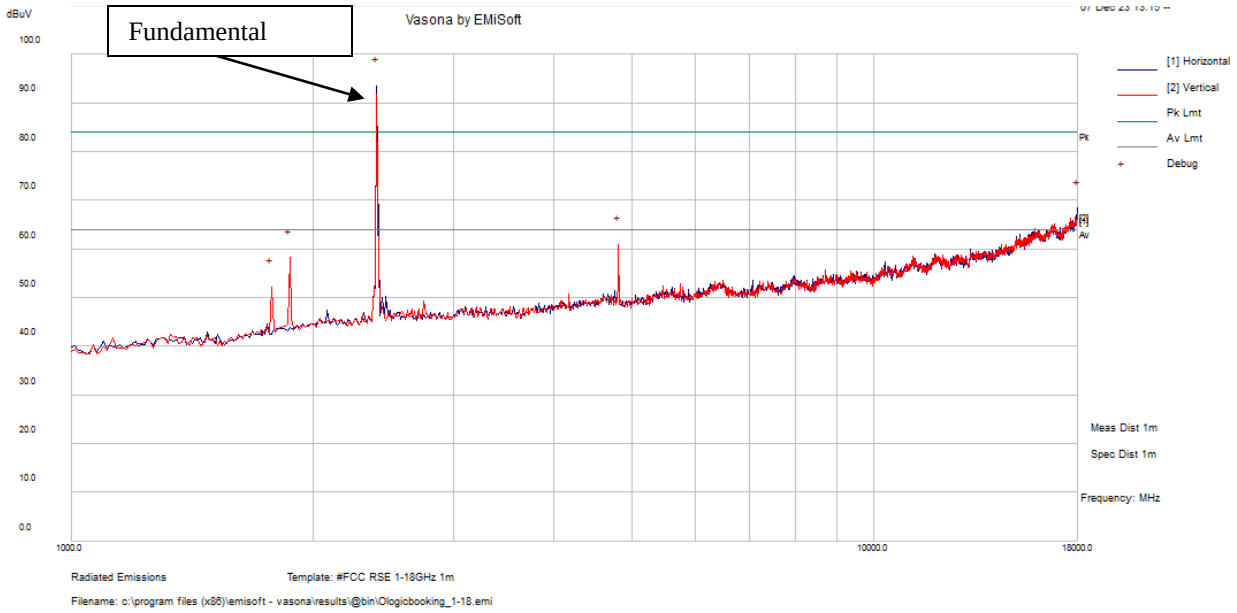
Frequency (MHz)	S.A. Reading (dBuV)	Correction Factor (dB/m)	Corrected Amplitude (dBµV/m)	Antenna Height (cm)	Antenna Polarity (H/V)	Turntable Azimuth (degrees)	Limit (dBµV/m)	Margin (dB)	Comment
623.9855	28.61	-0.02	28.58	137	H	312	46	-17.42	QP/Pass

30 MHz – 1 GHz, ISM High Channel



2) 1–18 GHz, Measured at 1 meter

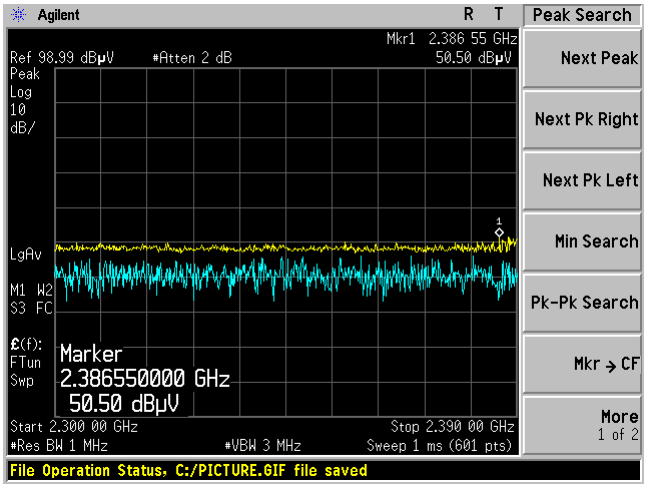
ISM low channel, 2405 MHz



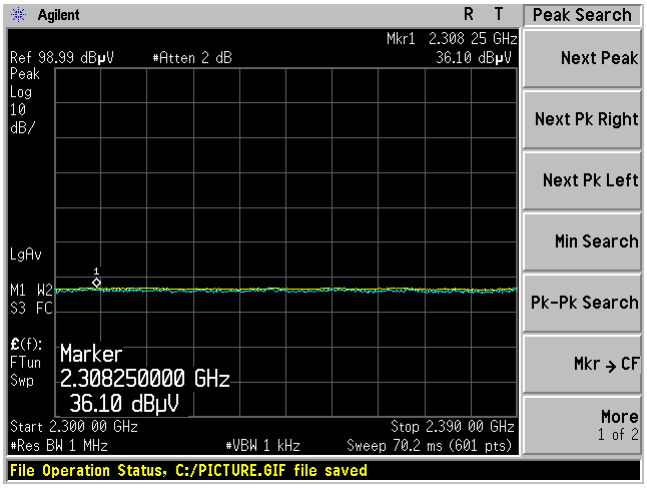
Frequency (MHz)	S.A. Reading (dBuV)	Correction Factor (dB/m)	Corrected Amplitude (dBµV/m)	Antenna Height (cm)	Antenna Polarity (H/V)	Turntable Azimuth (degrees)	Limit (dBµV/m)	Margin (dB)	Comment
4814.375	57.88	3	60.89	100	V	0	64	-3.11	Pass
1871.25	62.27	-4.06	58.21	300	V	0	64	-5.79	Pass
1775.625	57.47	-5.21	52.26	300	V	0	64	-11.74	Pass

Low Band edge

Peak



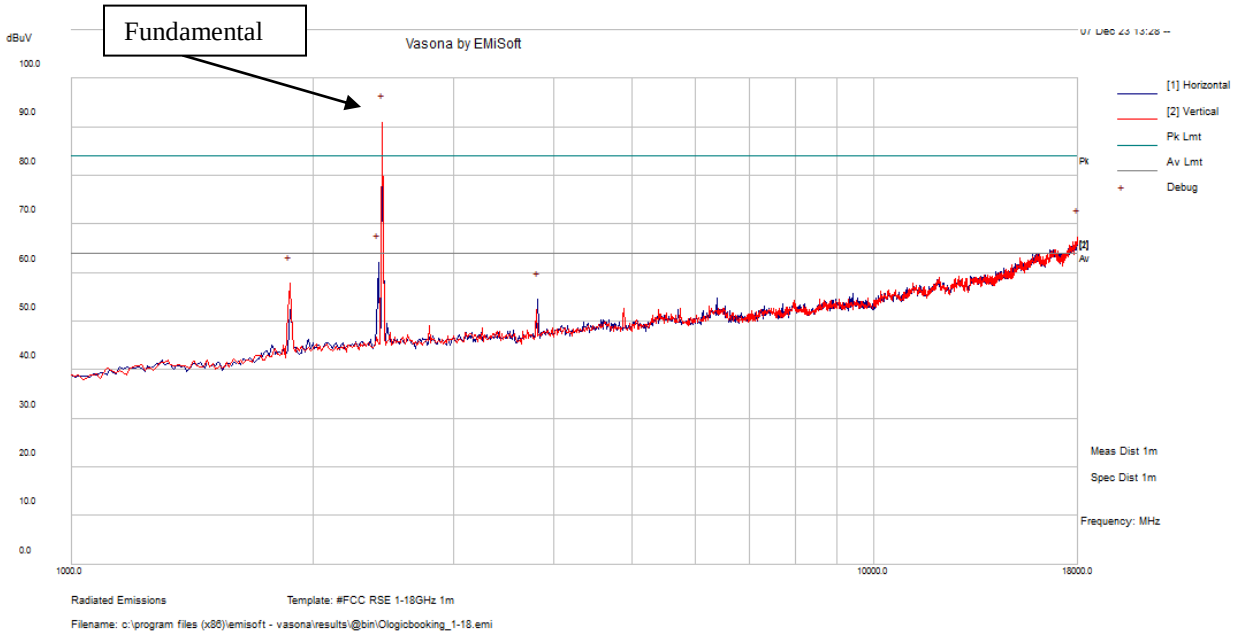
Average



Frequency (MHz)	S.A. Reading (dBuV)	Turntable Azimuth (degrees)	Test Antenna Height (cm)	Correction Factor (dB/m)	Corrected Amplitude (dBµV/m at 3m)	Limit (dBuV/m at 3m)	Margin (dB)
2310-2390	50.50	326	156	-1.103	49.397	74	-24.603
2310-2390	36.10	326	156	-1.103	34.997	54	-19.003

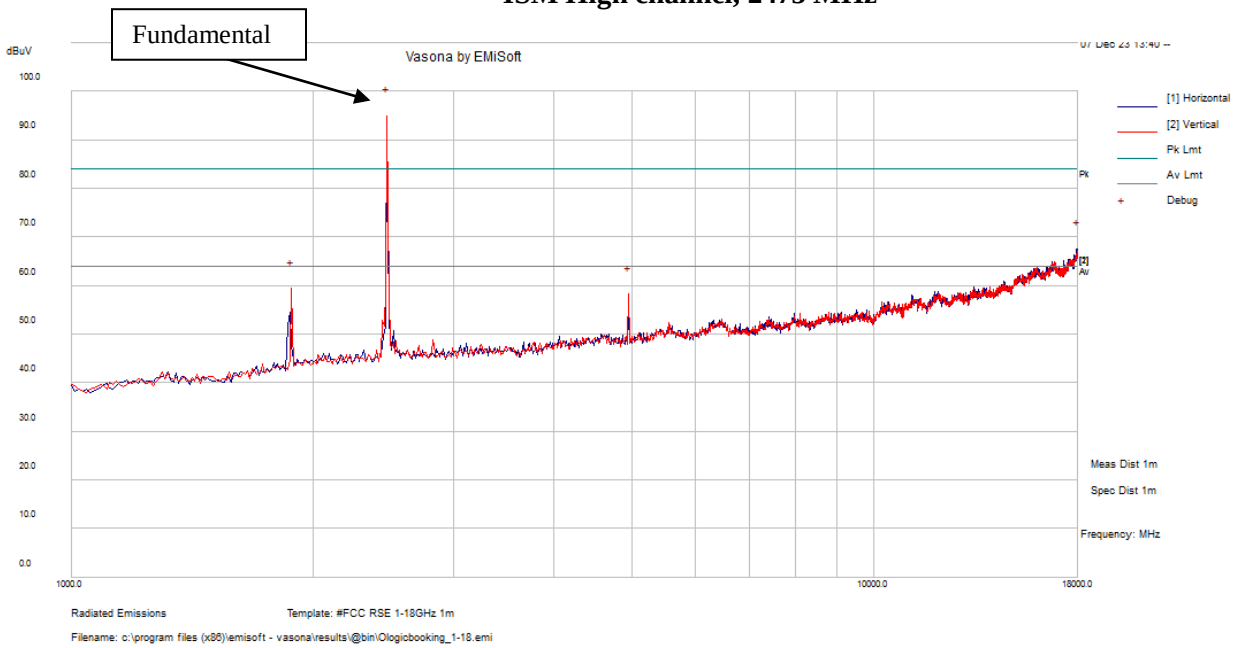
Note: The Vertical polarization is determined to be the worst case.

ISM Middle channel, 2442 MHz



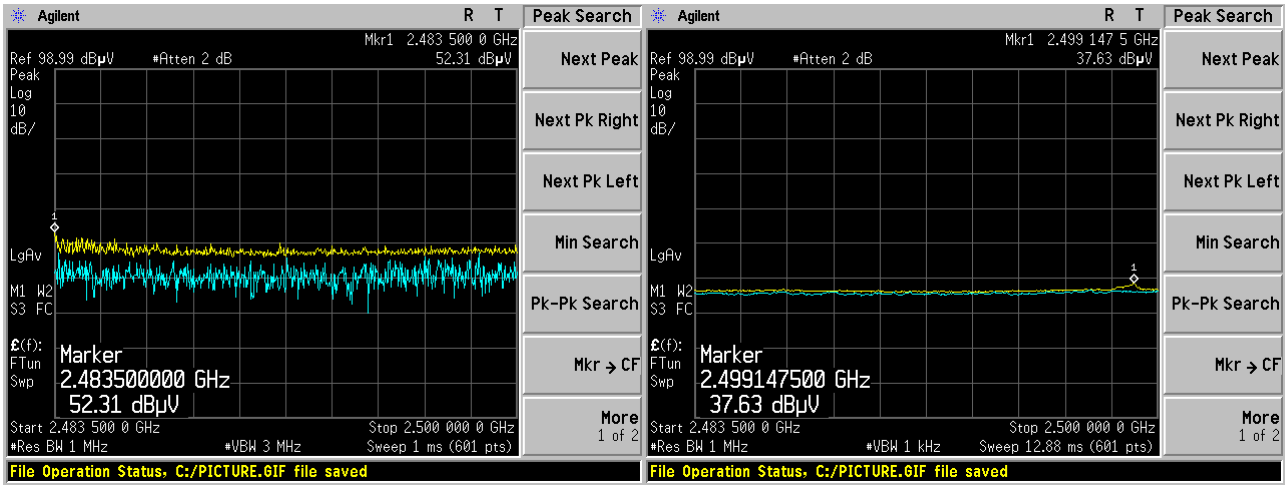
Frequency (MHz)	S.A. Reading (dBuV)	Correction Factor (dB/m)	Corrected Amplitude (dBµV/m)	Antenna Height (cm)	Antenna Polarity (H/V)	Turntable Azimuth (degrees)	Limit (dBµV/m)	Margin (dB)	Comment
1871.25	61.76	-4.06	57.7	200	V	0	64	-6.3	Pass
3815.625	53.01	1.44	54.45	300	H	0	64	-9.56	Pass

ISM High channel, 2475 MHz



High Band edge

Peak **Average**

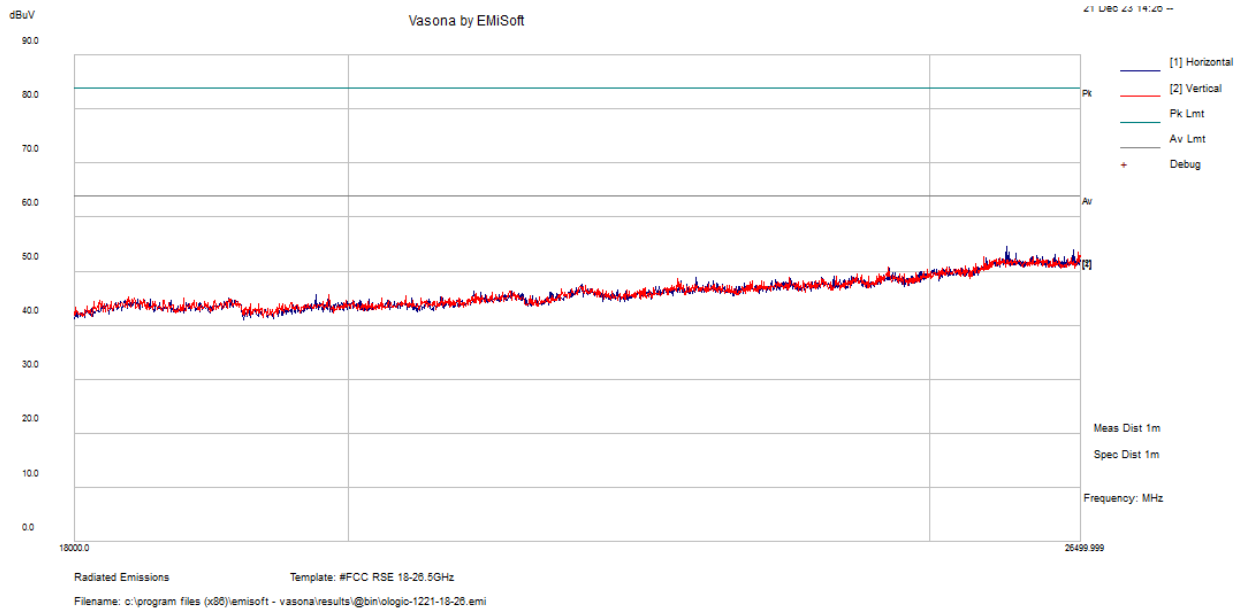


Frequency (MHz)	S.A. Reading (dBuV)	Turntable Azimuth (degrees)	Test Antenna Height (cm)	Correction Factor (dB/m)	Corrected Amplitude (dBµV/m at 3m)	Limit (dBuV/m at 3m)	Margin (dB)
2483.5-2500	52.31	334	245	-0.89	51.42	74	-22.58
2483.5-2500	37.63	334	245	-0.89	36.74	54	-17.26

Note: The Vertical polarization is determined to be the worst case.

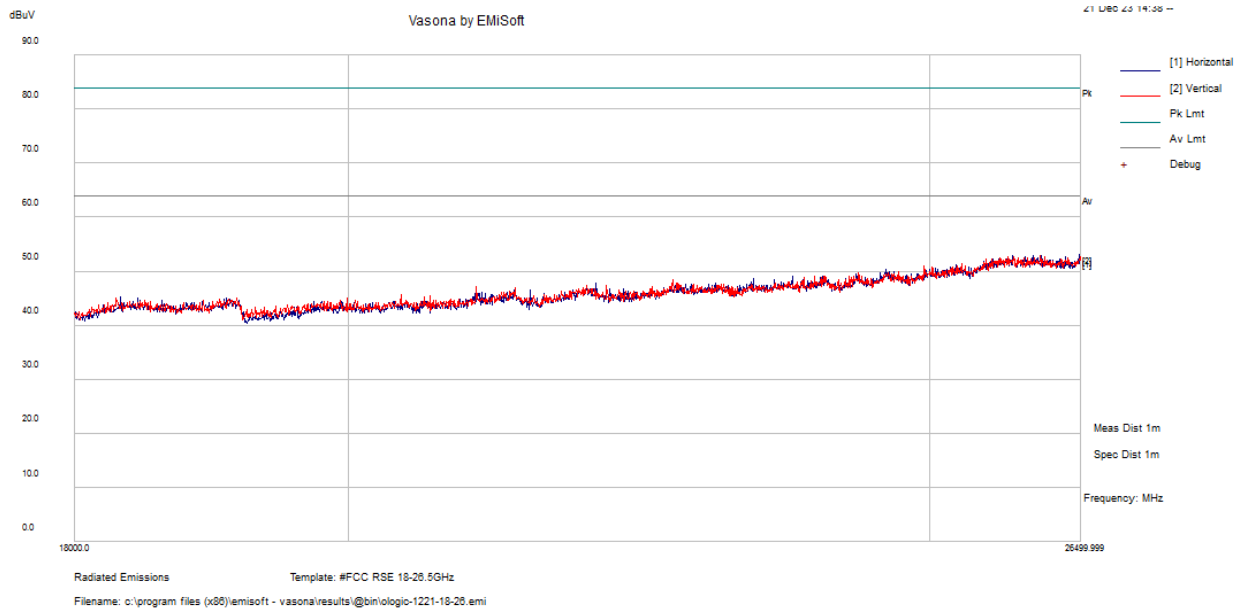
3) 18-26.5 GHz, Measured at 1 meter

ISM low channel, 2405 MHz



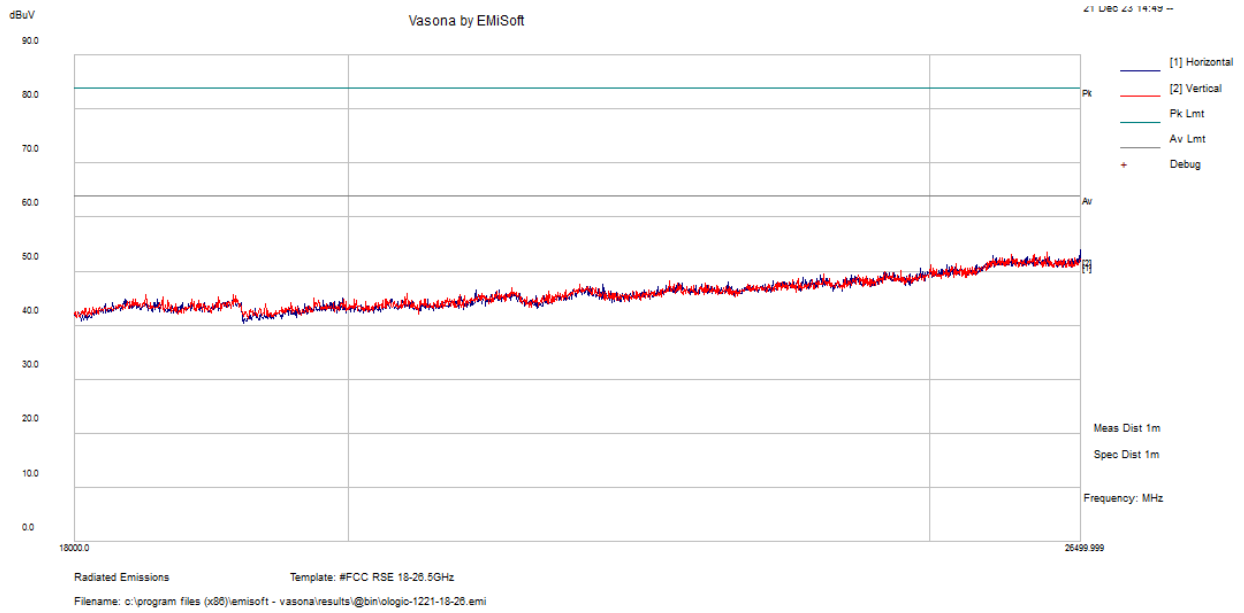
Frequency (MHz)	S.A. Reading (dBuV)	Correction Factor (dB/m)	Corrected Amplitude (dBµV/m)	Ant. Polarity (H/V)	Ant. Height (cm)	Turntable Azimuth (degrees)	Limit (dBµV/m)	Margin (dB)	Detector (Peak /Ave.)
26499	43.68	7.79	51.47	H	150	0	63.54	-12.07	Peak compared to Average Limit

ISM Middle channel, 2442 MHz



Frequency (MHz)	S.A. Reading (dBuV)	Correction Factor (dB/m)	Corrected Amplitude (dBµV/m)	Ant. Polarity (H/V)	Ant. Height (cm)	Turntable Azimuth (degrees)	Limit (dBµV/m)	Margin (dB)	Detector (Peak /Ave.)
26499	43.55	7.79	51.34	H	150	0	63.54	-12.2	Peak compared to Average Limit

ISM High channel, 2475 MHz

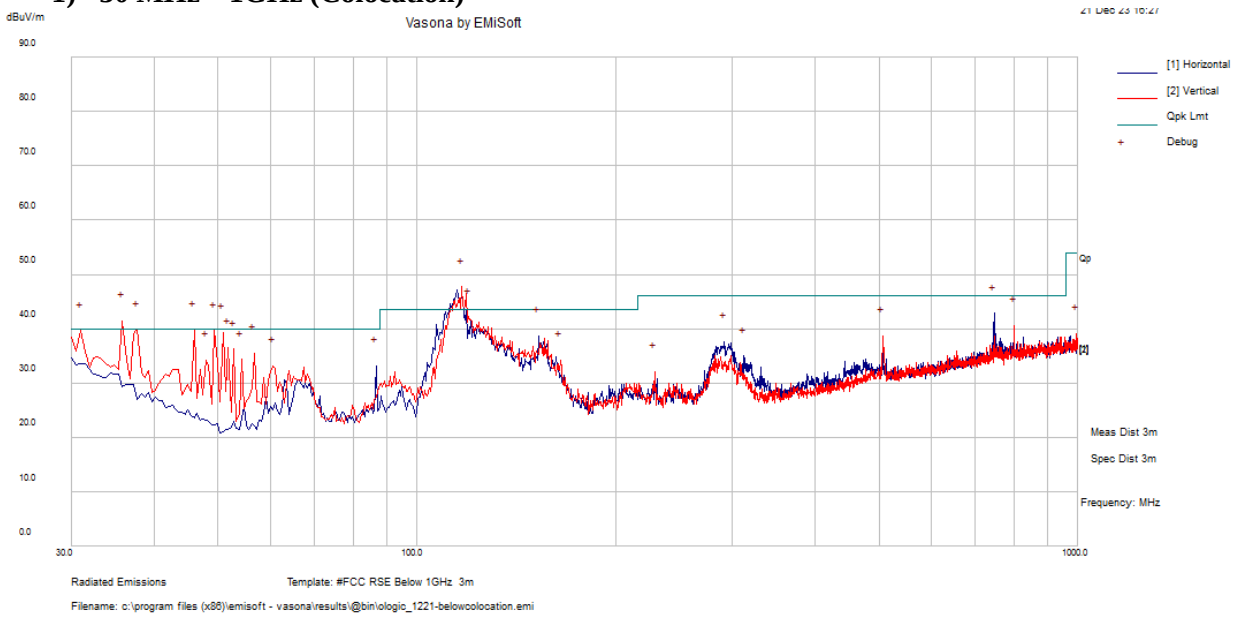


Frequency (MHz)	S.A. Reading (dBuV)	Correction Factor (dB/m)	Corrected Amplitude (dBµV/m)	Ant. Polarity (H/V)	Ant. Height (cm)	Turntable Azimuth (degrees)	Limit (dBµV/m)	Margin (dB)	Detector (Peak /Ave.)
26499	43.76	7.79	51.55	H	150	0	63.54	-11.99	Peak compared to Average Limit

Part 2: Colocation Test Result:

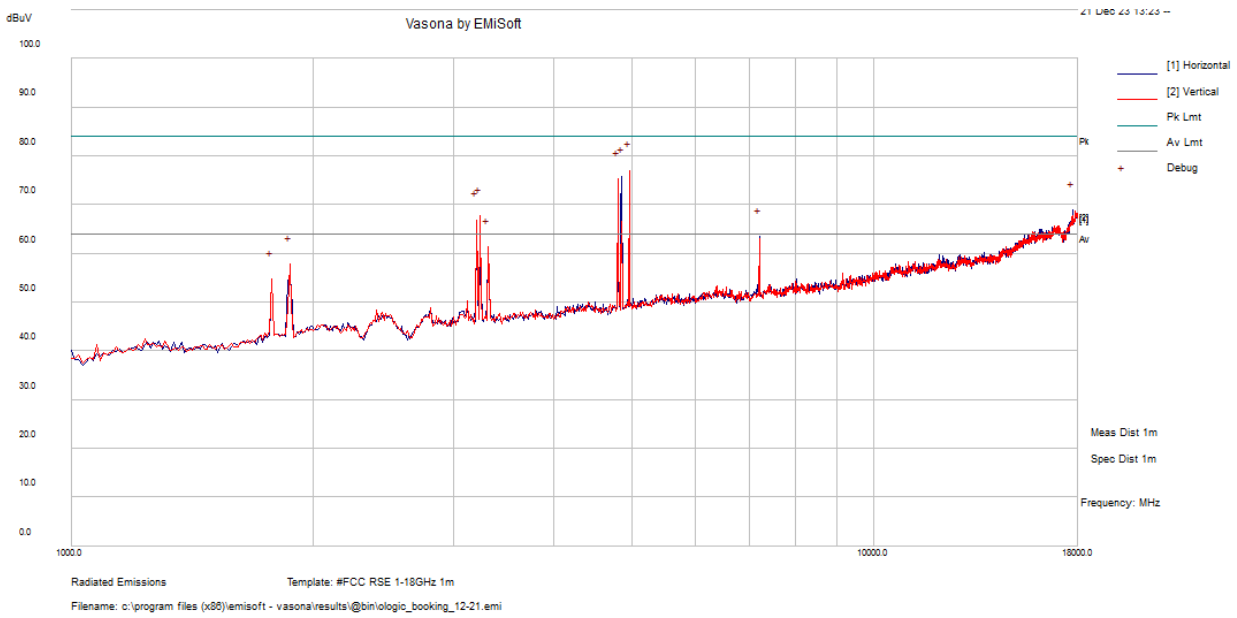
Note: All three radios (Left side device: ISM, Right side device: ISM+ BLE) are transmitted at the same time for colocation test

1) 30 MHz – 1GHz (Colocation)



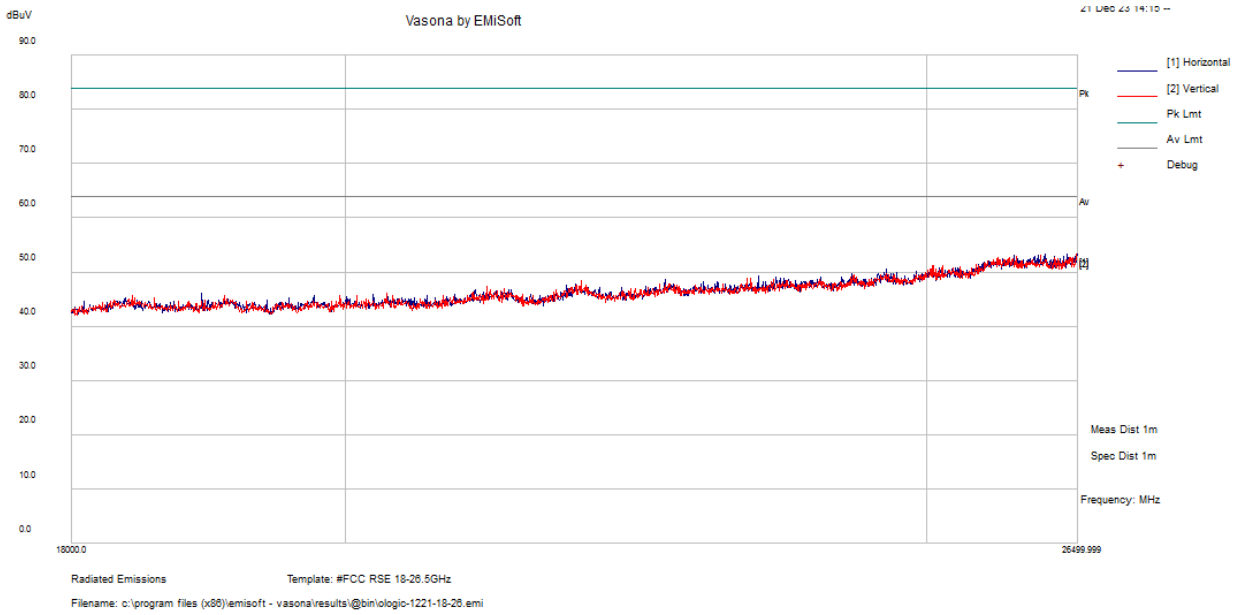
Frequency (MHz)	S.A. Reading (dBuV)	Correction Factor (dB/m)	Corrected Amplitude (dBµV/m)	Antenna Height (cm)	Antenna Polarity (H/V)	Turntable Azimuth (degrees)	Limit (dBµV/m)	Margin (dB)	Comment
116.859	44.62	-7.11	37.5	192	V	192	43.5	-6	QP/Pass
35.6625	31.1	-4.82	26.28	120	V	120	40	-13.72	QP/Pass
37.76	31.02	-6.27	24.75	121	V	121	40	-15.25	QP/Pass
46.005	37.95	-11.26	26.69	250	V	250	40	-13.31	QP/Pass
30.97	27.35	-1.72	25.63	213	V	213	40	-14.37	QP/Pass
49.4	25.26	-12.61	12.65	108	V	108	40	-27.35	QP/Pass

2) 1 GHz – 18 GHz (Colocation)



Frequency (MHz)	S.A. Reading (dBuV)	Correction Factor (dB/m)	Corrected Amplitude (dBµV/m)	Antenna Height (cm)	Antenna Polarity (H/V)	Turntable Azimuth (degrees)	Limit (dBµV/m)	Margin (dB)	Comment
4961.143	60.87	3.33	64.2	127	V	335	84	-19.8	Peak/Pass
4858.26	45.46	3.09	48.56	177	H	118	84	-35.44	Peak/Pass
4804.47	53.83	2.97	56.8	241	V	352	84	-27.2	Peak/Pass
3231.8	46.19	-0.6	45.59	193	V	116	84	-38.41	Peak/Pass
3198.668	50.32	-0.62	49.71	192	V	119	84	-34.29	Peak/Pass
4961.143	39.48	3.33	42.81	127	V	335	64	-21.19	Avg/Pass
4858.26	34.35	3.09	37.45	177	H	118	64	-26.55	Avg/Pass
4804.47	35.68	2.97	38.65	241	V	352	64	-25.35	Avg/Pass
3231.8	35.46	-0.6	34.85	193	V	116	64	-29.15	Avg/Pass
3198.668	35.65	-0.62	35.03	192	V	119	64	-28.97	Avg/Pass

3) 18 GHz – 26.5 GHz (Colocation)



Frequency (MHz)	S.A. Reading (dBuV)	Correction Factor (dB/m)	Corrected Amplitude (dBµV/m)	Ant. Polarity (H/V)	Ant. Height (cm)	Turntable Azimuth (degrees)	Limit (dBµV/m)	Margin (dB)	Detector (Peak /Ave.)
26499	43.59	7.79	51.38	H	150	0	63.54	-12.16	Peak compared to Average Limit

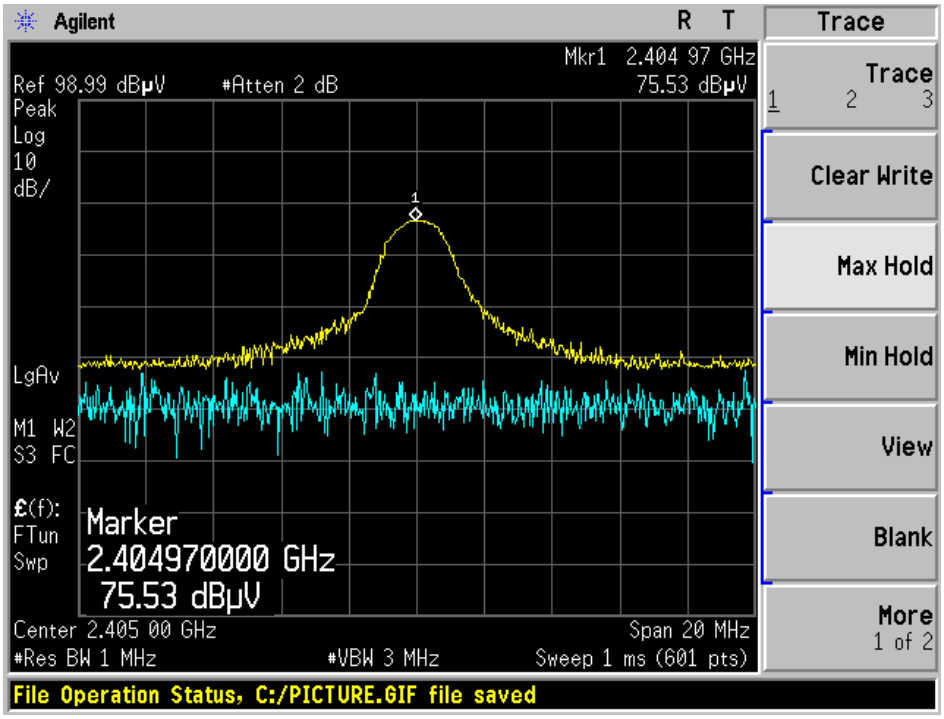
Part 3: Fundamental Emissions Test Result

Frequency (MHz)	S.A. Reading (dBuV)	Turntable Azimuth (degrees)	Test Antenna Height (cm)	Correction Factor (dB/m)	Corrected Amplitude (dBµV/m at 3m)	Limit (dBuV/m at 3m)	Margin (dB)
2405	75.53	326	156	-1.1	74.427	94	-19.57
2442	81.89	257	232	-1.1	80.787		-13.213
2475	83.39	334	245	-1.1	82.287		-11.71

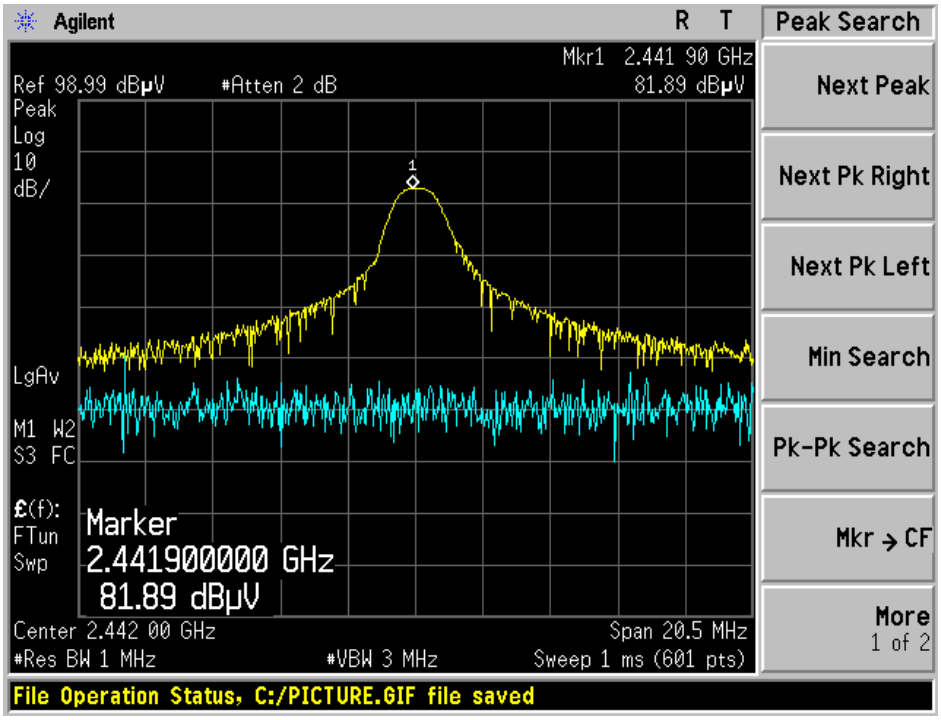
Note: 94 dBuV/m at 3meters is a conversion of 50mV/m at 3meters
Note: The Vertical polarization is determined to be the worst case.

Please see below plots as reference:

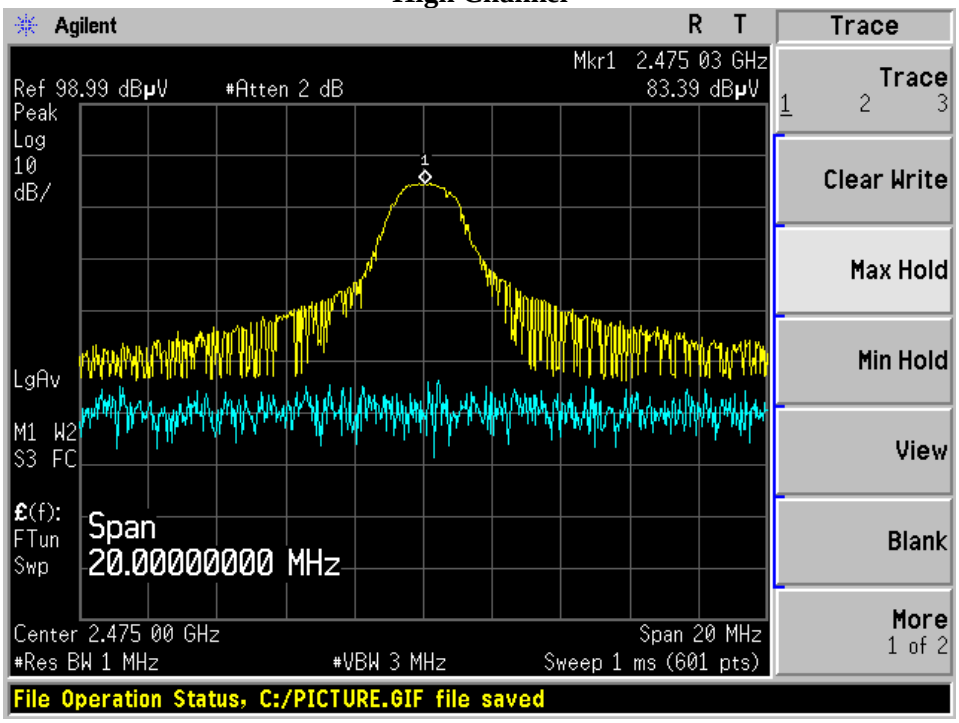
Low Channel



Middle Channel



High Channel



8 FCC §15.215 (c) - Emission Bandwidth

8.1 Applicable Standards

As per FCC §15.215 (c),

Intentional radiators operating under the alternative provisions to the general emission limits, as contained in §§15.217 through 15.257 and in subpart E of this part, must be designed to ensure that the 20 dB bandwidth of the emission, or whatever bandwidth may otherwise be specified in the specific rule section under which the equipment operates, is contained within the frequency band designated in the rule section under which the equipment is operated. In the case of intentional radiators operating under the provisions of subpart E, the emission bandwidth may span across multiple contiguous frequency bands identified in that subpart. The requirement to contain the designated bandwidth of the emission within the specified frequency band includes the effects from frequency sweeping, frequency hopping and other modulation techniques that may be employed as well as the frequency stability of the transmitter over expected variations in temperature and supply voltage. If a frequency stability is not specified in the regulations, it is recommended that the fundamental emission be kept within at least the central 80% of the permitted band in order to minimize the possibility of out-of-band operation.

The emission bandwidth (×dB) is defined as the frequency range between two points, one above and one below the carrier frequency, at which the spectral density of the emission is attenuated × dB below the maximum in-band spectral density of the modulated signal. Spectral density (power per unit bandwidth) is to be measured with a detector of resolution bandwidth in the range of 1% to 5% of the anticipated emission bandwidth, and a video bandwidth at least 3 × the resolution bandwidth.
When the occupied bandwidth limit is not stated in the applicable RSS or reference measurement method, the transmitted signal bandwidth shall be reported as the 99% emission bandwidth, as calculated or measured.

8.2 Measurement Procedure

The transmitter shall be operated at its maximum carrier power measured under normal test conditions.

The span of the analyzer shall be set to capture all products of the modulation process, including the emission skirts.

The resolution bandwidth (RBW) shall be in the range of 1% to 5% of the occupied bandwidth (OBW) and video bandwidth (VBW) shall be approximately 3 ×RBW.

Note: Video averaging is not permitted.

A peak, or peak hold, may be used in place of the sampling detector as this may produce a wider bandwidth than the actual bandwidth (worst-case measurement). Use of a peak hold may be necessary to determine the occupied bandwidth if the device is not transmitting continuously.

The trace data points are recovered and are directly summed in linear power level terms. The recovered amplitude data points, beginning at the lowest frequency, are placed in a running sum until 0.5% of the total is reached and that frequency recorded. The process is repeated for the highest frequency data points (starting at the highest frequency, at the right side of the span, and going down in frequency). This frequency is then recorded.

The difference between the two recorded frequencies is the 99% occupied bandwidth.

8.3 Test Equipment List and Details

BACL No.	Manufacturer	Description	Model	Serial Number	Calibration Date	Calibration Interval
624	Agilent	Spectrum Analyzer	E4446A	MY48250238	2023-05-12	1 year
658	HP/ Agilant	Pre Amplifier	8449B OPT HO2	3008A01103	2023-12-01	6 months
1247	Uti flex	Micro - Coax	N/A	N/A	2023-12-01	6 months
1192	ETS Lindgren	Horn Antenna	3117	00218973	2022-09-29	2 years
1295	Carlisle	10m Ultra Low Loss Coaxial Cable	UFB142A-1-3937-200200	64639890912-001	2023-10-31	6 months

Statement of Traceability: BACL Corp. *attests that all of the calibrations on the equipment items listed above were traceable to NIST or to another internationally recognized National Metrology Institute (NMI), and were compliant with the latest version of A2LA policy P102 "A2LA Policy on Metrological Traceability".*

8.4 Test Environmental Conditions

Temperature:	23 ºC
Relative Humidity:	39 %
ATM Pressure:	101.7 KPa

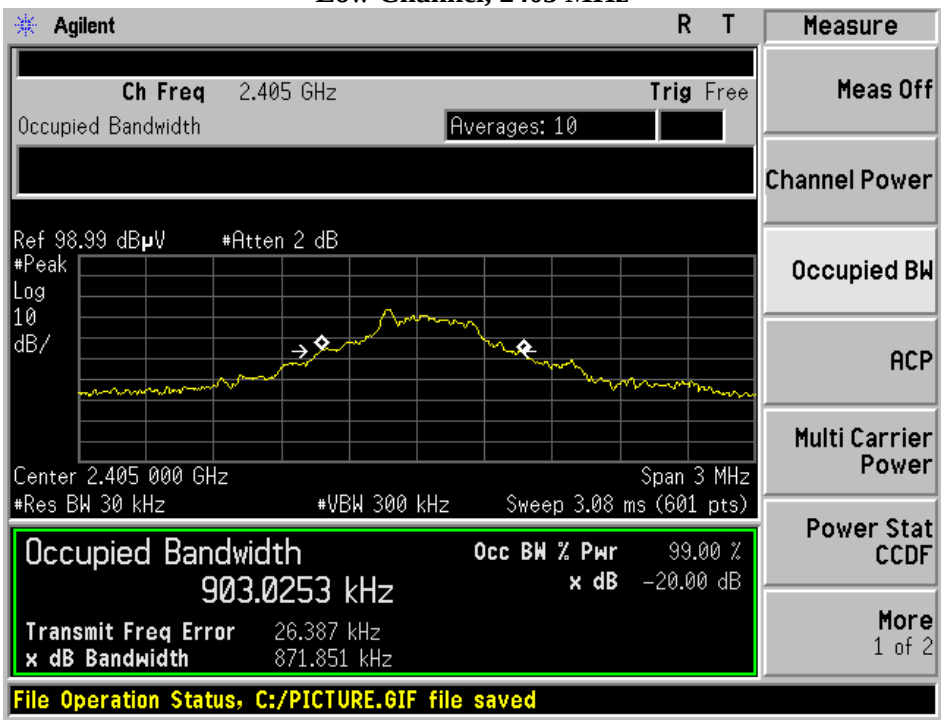
The testing was performed by Will Hu on 2023-12-07 in 5m3 chamber.

8.5 Test Results

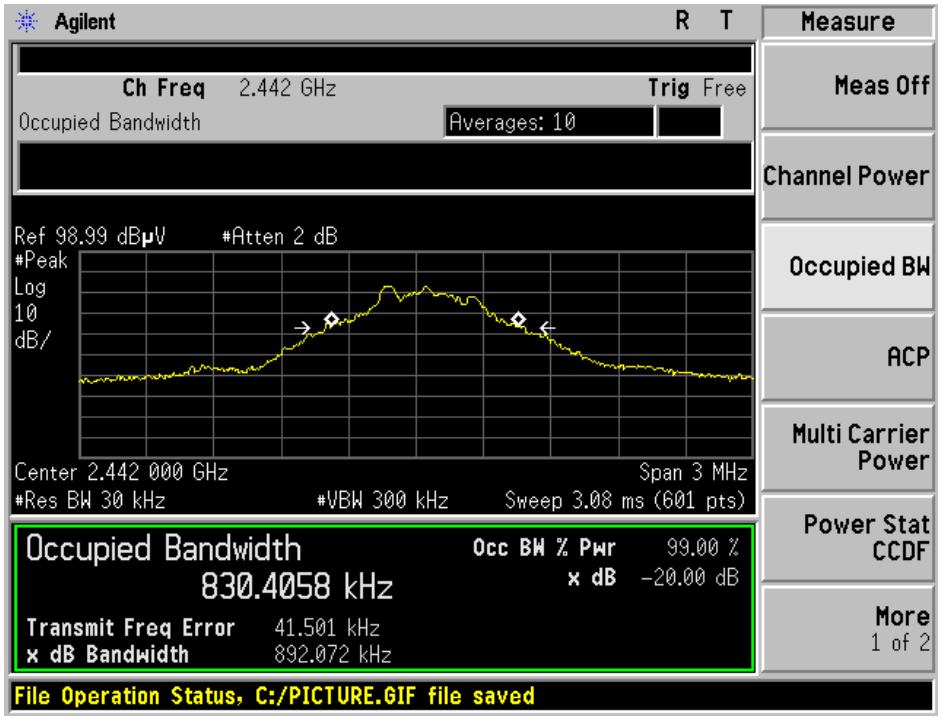
Frequency (MHz)	99% OBW (kHz)	20 dB Bandwidth (kHz)
2405	903.02	871.85
2442	830.40	892.07
2475	926.55	902.43

Please refer to the following plots for detailed test results.

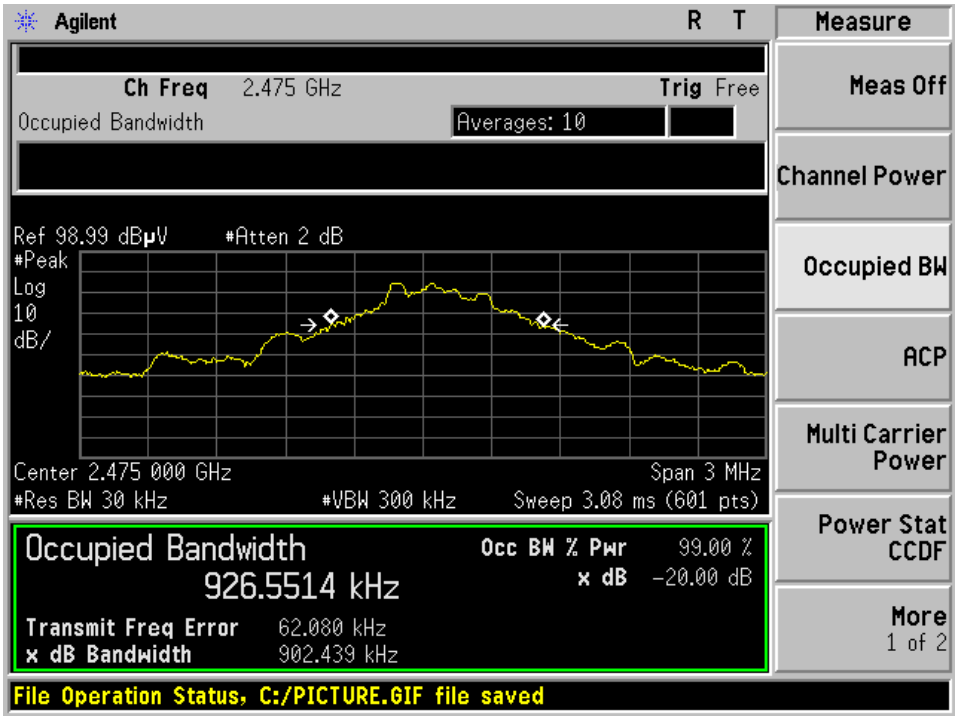
Low Channel, 2405 MHz



Middle Channel, 2442 MHz



High Channel, 2475 MHz



8 Annex A (Normative) – EUT Test Setup Photographs

Please refer to the attachment.

9 Annex B (Normative) – EUT External Photographs

Please refer to the attachment.

10 Annex C (Normative) – EUT Internal Photographs

Please refer to the attachment.

11 Annex D (Normative) – A2LA Electrical Testing Certificate

Accredited Laboratory

A2LA has accredited

BAY AREA COMPLIACE LABORATORIES CORP.

Sunnyvale, CA

for technical competence in the field of

Electrical Testing

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2017 *General requirements for the competence of testing and calibration laboratories*. This laboratory also meets A2LA R222 - Specific Requirements EPA ENERGY STAR Accreditation Program. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (*refer to joint ISO-ILAC-IAF Communiqué dated April 2017*).

Presented this 21st day of December 2022.

Mr. Trace McInturff, Vice President, Accreditation Services
For the Accreditation Council
Certificate Number 3297.02
Valid to September 30, 2024

For the tests to which this accreditation applies, please refer to the laboratory's Electrical Scope of Accreditation.

Please follow the web link below for a full ISO 17025 scope

https://www.a2la.org/scopepdf/3297-02.pdf

--- END OF REPORT ---