

Nemko Korea Co., Ltd.

165-51, Yurim-ro, Cheoin-gu, Yongin-si, Gyeonggi-do, 17042, Republic of Korea
TEL: +82 31 330-1700 FAX: +82 31 322 2332

FCC EVALUATION REPORT FOR CERTIFICATION

Applicant :**Olive Union inc**

5F, 24, Banpo-daero 28-gil, Seocho-gu,
Seoul, Republic of Korea

Dates of Issue :

January 17, 2023

Test Site :

Nemko Korea Co., Ltd.

FCC ID:**2AOLH-OU1P0102****Applicant :****Olive Union inc****Brand Name :****Model:**

OU1P0102

Additional Model(s):

-

EUT Type:

Olive Max Earbuds

Classification:

Digital Transmission System (DTS)

Date of Test:

November 02, 2022 ~ December 26, 2022

Applied Standard:

FCC 47 CFR Part 15.247

The device bearing the brand name and model specified above has been shown to comply with the applicable technical standards as indicated in the measurement report and was tested in accordance with the measurement procedures specified in ANSI C63.10-2013. The client should not use it to claim product endorsement by TAF or any government agencies. The test results in the report only apply to the tested sample.

I attest to the accuracy of data and all measurements reported herein were performed by me or were made under my supervision and are correct to the best of my knowledge and belief. I assume full responsibility for the completeness of these measurements and vouch for the qualifications of all persons taking them.



Tested By : Jaehyong Lee
Test Engineer



Reviewed By : Hoonpyo Lee
Technical Manager

Revision History

Rev.	Issue Date	Revisions	Revised By
00	December 27, 2022	Initial issue	Jaehyong Lee
01	January 17, 2023	Updated to address TCB's question	Jaehyong Lee

TABLE OF CONTENTS

1. INTRODUCTION.....	5
1.1 Test facility	5
2.2 Accreditation and listing	5
2. EUT INFORMATION & TEST CONDITIONS.....	6
2.1 EUT Information	6
2.2 Operation During Test.....	7
2.3 Support Equipment.....	9
2.4 Setup Drawing	9
3. ANTENNA REQUIREMENTS.....	10
4. SUMMARY OF TEST RESULTS	11
5. TEST METHODOLOGY.....	11
6. DESCRIPTION OF TESTS	12
6.1 Duty Cycle	12
6.2 6 dB Bandwidth	13
6.3 Peak Output Power	14
6.4 Peak Power Spectral Density	15
6.5 Conducted Spurious Emissions.....	16
6.6 Radiated Emissions	17
6.7 Conducted Emissions.....	18
7. TEST DATA	19
7.1 Duty Cycle	19
7.2 6 dB Bandwidth	22
7.3 Peak Output Power	27
7.4 Peak Power Spectral Density	32
7.5 Conducted Spurious Emissions.....	37
7.6 Radiated Spurious Emissions.....	46
7.7 Radiated Band Edge	54
7.8 Radiated Emissions_Below 1GHz.....	57
7.9 Conducted	59

8. TEST EQUIPMENT.....	60
9. ACCURACY OF MEASUREMENT & DECISION RULE.....	61
9.1 Uncertainty Calculation.....	61
9.2 Decision rule.....	61

1. INTRODUCTION







1.1 Test facility

The measurement procedure described in American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz (ANSI C63.4-2014), the American National Standard for Testing Unlicensed Wireless Devices (ANSI C63.10-2013) was used in determining radiated and conducted emissions emanating.

These measurement tests were conducted at **Nemko Korea Co., Ltd.**

The site address 165-51, Yurim-ro, Cheoin-gu, Yongin-si, Gyeonggi-do, 17042, Rep. of Korea and 155, Osan-ro, Mohyeon-eup, Cheoin-gu, Yongin-si, Gyeonggi-do 16885 Rep. of Korea.

2.2 Accreditation and listing

Accreditation type		Accreditation number
	CAB Accreditation for DOC	Designation No. KR0026
	KOLAS Accredited Lab. (Korea Laboratory Accreditation Scheme)	Registration No. KT155
	Canada IC Registered site	Site No. 29506 Site No. 2040E
	VCCI registration site(RE/CE/Telecom CE)	Member No. 2118
	EMC CBTL	TL124
	KCC(RRL)Designated Lab.	Registration No. KR0026

2. EUT INFORMATION & TEST CONDITIONS

2.1 EUT Information

Specifications:

EUT Type	Olive Max Earbuds
Model Name	OU1P0102
Brand Name	Olive Union
Frequency of Operation	2 402 MHz ~ 2 480 MHz
Peak Output Power (Conducted)	Left : 8.77 dBm Right : 8.34 dBm
Number of Channels	40 CH
Modulations	GFSK (BLE)
Antenna Gain (peak)	Left : 2.23 dBi Right : 2.21 dBi
Antenna Setup	1TX / 1RX
EUT Rated Voltage	3.7 Vdc
EUT Test Voltage	3.7 Vdc
Temperature Range	0 °C ~ +50 °C
Remarks	-

2.2 Operation During Test

The EUT is the transceiver which is Bluetooth v5.1 supporting BDR/EDR/LE mode.

The Laptop was used to control the EUT to transmit the wanted TX channel continuously (duty cycle< 98%) by the testing program (RTLBTAPP) supported by manufacturer.

The operating voltage of EUT was 3.7 Vdc supplied from jig board connected to USB port on Laptop PC.

The EUT was tested at the lowest, middle and the highest channels with the maximum output power in accordance with the manufacturer's specifications. The worst data were recorded in the report.

2.2.1 Table of Test power setting

Frequency	Mode	Power setting Level
2 402 MHz ~ 2 480 MHz	Bluetooth LE (1Mbps/2Mbps)	Default

2.2.2 Table of Test frequency

Frequency Band	Mode	Test Channel (CH)	Frequency (MHz)
2.4 GHz	Bluetooth LE (1Mbps/2Mbps)	0	2 402
		19	2 440
		39	2 480

2.2.3 Antenna Information

Frequency Band	Mode	Antenna TX mode	Support CDD	Support MIMO
2.4 GHz	Bluetooth LE (1Mbps/2Mbps)	<input checked="" type="checkbox"/> 1TX, <input type="checkbox"/> 2TX	<input type="checkbox"/> Yes, <input checked="" type="checkbox"/> No	<input type="checkbox"/> Yes, <input checked="" type="checkbox"/> No

2.2.4 Additional Information Related to Testing

The cable and attenuator loss from 30 MHz to 26.5 GHz was reflected in spectrum analyzer with correction factor for all conducted testing.

2.2.5 Worst-case Configuration and Mode

Radiated emission below was performed with the EUT set to transmit at the channel with highest output power as worst-case scenario.

Radiated emission above 1GHz was performed with the EUT set to transmit low/mid/high channels.

The emissions (Band-edge & spurious emissions) were investigated in three orthogonal orientations X, Y and Z.

Accordingly, the orientation was determined and tested as shown in the table below:

- Left

Test Items	X	Y	Z
Band-edge	O	-	-
Spurious emissions	O	-	-

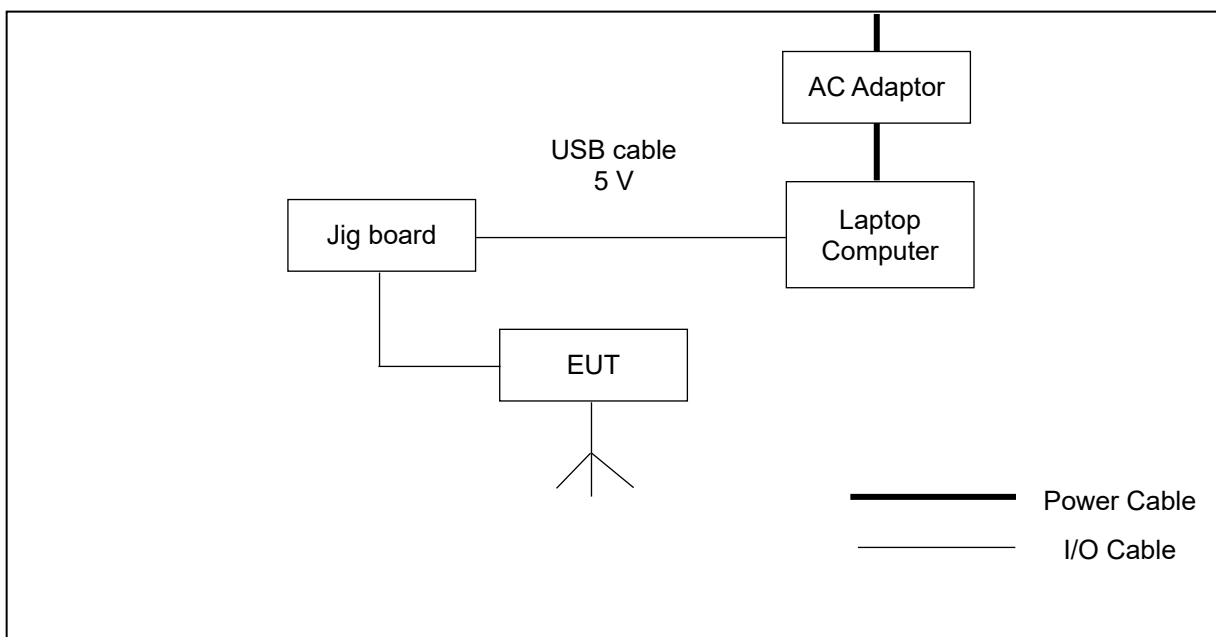
- Right

Test Items	X	Y	Z
Band-edge	-	O	-
Spurious emissions	-	O	-

2.3 Support Equipment

EUT	Olive Union inc Model : OU1P0102	S/N: N/A Identical Proto-type
Laptop Computer	LG Model : 14Z970	FCC DOC S/N : 701NZRP065862
AC/DC Adapter	LG Model : LCAP48-WK	FCC DOC S/N : EGDNV634687019352

2.4 Setup Drawing



3. ANTENNA REQUIREMENTS

Measurement and determination of electromagnetic emissions (EME) of radio frequency devices including intentional and/or unintentional radiators for compliance with the technical rules and regulations of the Federal Communications Commission under FCC part 15 and IC RSS-247 Issue 2.

§15.203 of the FCC Rules part 15 Subpart C

: 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 antenna of the EUT and there are no provisions for connection to an external antenna. It complies with the requirement of §15.203.

Used Antenna	
Model name	2 402 MHz ~ 2 480 MHz
	Max. peak gain (dBi)
Olive Max Earbuds FPCB Antenna Left	2.23
Olive Max Earbuds FPCB Antenna Right	2.21

4. SUMMARY OF TEST RESULTS

The EUT has been tested according to the following specification:

Name of Test	FCC Paragraph No.	Result	Remark
Conducted Emission	15.207	N/P	
Radiated Emission	15.209	Complies	
6 dB Bandwidth	15.247(a)(2)	Complies	
Peak Output Power and E.I.R.P	15.247(b)(3)	Complies	
Power Spectral Density	15.247(e)	Complies	
Conducted Spurious Emission	15.247(d)	Complies	
Radiated Spurious Emission	15.247(d)	Complies	
Maximum Permissible Exposure	1.1307(b)	Complies	

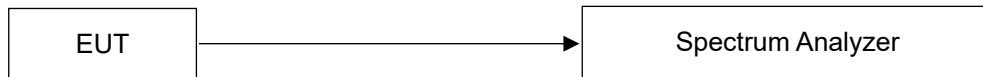
5. TEST METHODOLOGY

1. FCC CFR 47 Part 2.
2. FCC CFR 47 Part 15.
3. KDB 558074 D01 DTS Meas Guidance v05r02.
4. ANSI C63.10-2013.

6. DESCRIPTION OF TESTS

6.1 Duty Cycle

Test Setup



Test Procedure

EUTs Duty Cycle is measured at middle channel with a spectrum analyzer connected to the antenna terminal while the EUTs operating at its maximum power control level.

The spectrum analyzer setting is as follows.

RBW \geq OBW

RBW \geq VBW

Span = zero span

Detector = Peak

The zero-span measurement method shall not be used unless both RBW and VBW are $> 50/T$ and the number of sweep points across duration T exceeds 100.

6.2 6 dB Bandwidth

Test Setup



Test Procedure

EUTs 6 dB bandwidth is measured at low, middle, high channels with a spectrum analyzer connected to the antenna terminal while the EUTs operating at its maximum power control level.

The spectrum analyzer setting is as follows.

RBW = 100 kHz

VBW > 3 x RBW

Detector = Peak

Trace mode = max hold

Sweep = auto couple

The bandwidth measurement function on the spectrum analyzer is used to measure the 6 dB bandwidth.

6.3 Peak Output Power

Test Setup



Test Procedure

EUTs Maximum Peak Conducted Output Power is measured at low, middle, high channels with a spectrum analyzer connected to the antenna terminal while the EUTs operating at its maximum power control level.

The spectrum analyzer setting is as follows.

RBW \geq DTS bandwidth

VBW $\geq 3 \times$ RBW

Span $\geq 3 \times$ RBW

Sweep time = auto couple

Detector = peak

Trace mode = max hold

Allow trace to fully stabilize.

Use peak marker function to determine the peak amplitude level.

6.4 Peak Power Spectral Density

Test Setup



Test Procedure

EUTs Peak Power Spectral Density is measured at low, middle, high channels with a spectrum analyzer connected to the antenna terminal while the EUTs operating at its maximum power control level.

The spectrum analyzer setting is as follows.

Center frequency = DTS channel center frequency

Span = 1.5 times the DTS channel bandwidth

RBW \geq 3kHz

VBW \geq 3 x RBW

Detector = peak

Sweep time = auto couple

Trace mode = max hold

Allow the trace to stabilize.

The peak search function on the spectrum analyzer is used to determine the maximum amplitude level within the RBW.

6.5 Conducted Spurious Emissions

Test Setup



Test Procedure

EUTs Conducted spurious emissions are measured at low, middle, high channels with a spectrum analyzer connected to the antenna terminal while the EUTs operating at its maximum power control level. The spectrum analyzer setting is as follows.

1) Reference Level

Center frequency = DTS channel center frequency

Span $\geq 1.5 \times$ DTS bandwidth

RBW = 100 kHz

VBW $\geq 3 \times$ RBW

Detector = peak

Sweep time = auto couple

Trace mode = max hold

Allow trace to fully stabilize.

Use the peak marker function to determine the maximum PSD level.

Note that the channel found to contain the maximum PSD level can be used to establish the reference level.

2) Unwanted Emissions

Set the center frequency and span to encompass frequency range to be measured.

RBW = 100 kHz

VBW $\geq 3 \times$ RBW

Detector = peak

Sweep time = auto couple

Trace mode = max hold

Allow trace to fully stabilize.

Use the peak marker function to determine the maximum amplitude level.

6.6 Radiated Emissions

The measurement was performed at the test site that is specified in accordance with ANSI C63.10-2013.

The spurious emission was scanned from 9 kHz to 30 MHz using Loop Antenna and 30 to 1000 MHz using Trilog broadband test antenna. Above 1 GHz, Horn antenna was used.

For emissions testing at below 1GHz, The test equipment was placed on turntable with 0.8 m above ground. For emission measurements above 1 GHz, The test equipment was placed on turntable with 1.5 m above ground. Sufficient time for the EUT, support equipment, and test equipment was allowed in order for them to warm up to their normal operating condition. The EUT, cable, wire arrangement and mode of operation that has the highest amplitude relative to the limit was selected. Then, the turn table was rotated from 0° to 360° and an antenna mast was moved from 1 m to 4 m height to maximize the suspected highest amplitude signal. The final maximized level was recorded.

At frequencies below 1000 MHz, measurements performed using the CISPR quasi-peak detection. At frequencies above 1000 MHz, measurements performed using the peak and average measurement procedures described in ANSI 63.10-2013 section 11.12. Peak emission levels were measured by setting the analyzer RBW = 1 MHz, VBW = 3 MHz, Detector = Peak, Trace mode = max hold. Average emission levels were measured by setting the analyzer RBW = 1 MHz, VBW = 10 kHz, Detector = Peak, Trace mode = max hold. Allow max hold to run for at least 50 times (1/duty cycle) traces.

Frequency (MHz)	Field strength (microvolts/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

Radiated Emissions Limits per 47 CFR 15.209(a) and RSS-GEN Issue 5 8.9

6.7 Conducted Emissions

The Line conducted emission test facility is located inside a 4 x 7 x 2.5 meter shielded enclosure.

It is manufactured by EM engineering. The shielding effectiveness of the shielded room is in accordance with MIL-STD-285 or NSA 65-6. A 1 m x 1.5 m wooden table 0.8 m height is placed 0.4 m away from the vertical wall and 1.5 m away from the side of wall of the shielded room. Rohde & Schwarz (ENV216) of the 50 ohm/50 μ H Line Impedance Stabilization Network (LISN) are bonded to the shielded room. The EUT is powered from the Rohde & Schwarz LISN. Power to the LISNs are filtered by high-current high insertion loss Power line filters. The purpose of filter is to attenuate ambient signal interference and this filter is also bonded to shielded enclosure. All electrical cables are shielded by tinned copper zipper tubing with inner diameter of 1 / 2 ". If DC power device, power will be derived from the source power supply it normally will be powered from and this supply lines will be connected to the LISNs, All interconnecting cables more than 1 meter were shortened by non-inductive bundling (serpentine fashion) to a 1 meter length. Sufficient time for EUT, support equipment, and test equipment was allowed in order for them to warm up to their normal operating condition. The RF output of the LISN was connected to the spectrum analyzer to determine the frequency producing the maximum EME from the EUT. The spectrum was scanned from 150 kHz to 30 MHz with 200 msec sweep time. The frequency producing the maximum level was re-examined using the EMI test receiver. (Rohde & Schwarz ESCI). The detector functions were set to CISPR quasi-peak mode & average mode. The bandwidth of receiver was set to 9 kHz. The EUT, support equipment, and interconnecting cables were arranged and manipulated to maximize each EME emission. Each emission was maximized by; switching power lines; varying the mode of operation or resolution; clock or data exchange speed; scrolling H pattern to the EUT and of support equipment, and powering the monitor from the floor mounted outlet box and computer aux AC outlet, if applicable; whichever determined the worst case emission.

Each EME reported was calibrated using the R&S signal generator.

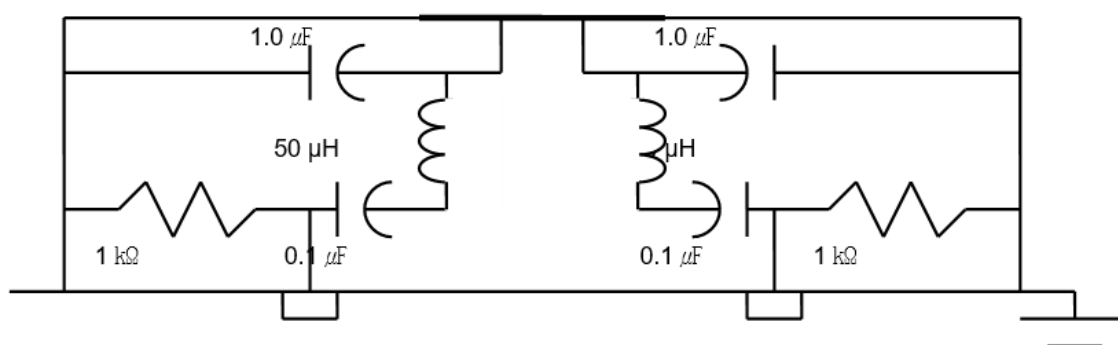


Fig. 2. LISN Schematic Diagram

7. TEST DATA

7.1 Duty Cycle

For reporting purposes only.

Result

- Left

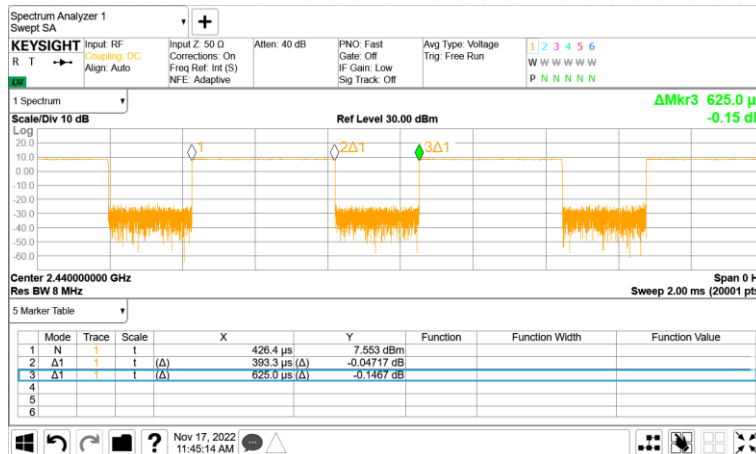
Mode	On time [msec]	Period [msec]	Duty cycle x [Linear]	Duty Cycle [%]	Duty Cycle Correction Factor [dB]	1/T Minimum CBW [kHz]
BLE (1 Mbps)	0.393	0.625	0.629	62.93	2.01	2.54
BLE (2 Mbps)	0.208	0.625	0.333	33.25	4.78	4.81

- Right

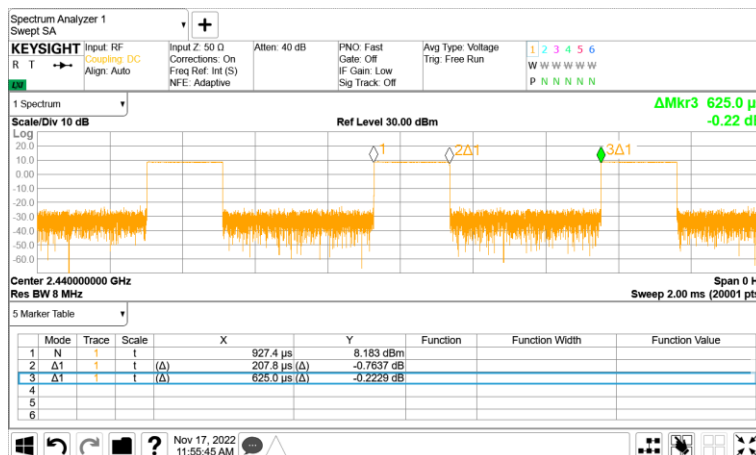
Mode	On time [msec]	Period [msec]	Duty cycle x [Linear]	Duty Cycle [%]	Duty Cycle Correction Factor [dB]	1/T Minimum CBW [kHz]
BLE (1 Mbps)	0.394	0.625	0.630	62.95	2.01	2.54
BLE (2 Mbps)	0.208	0.625	0.333	33.24	4.78	4.81

PLOTS OF EMISSIONS

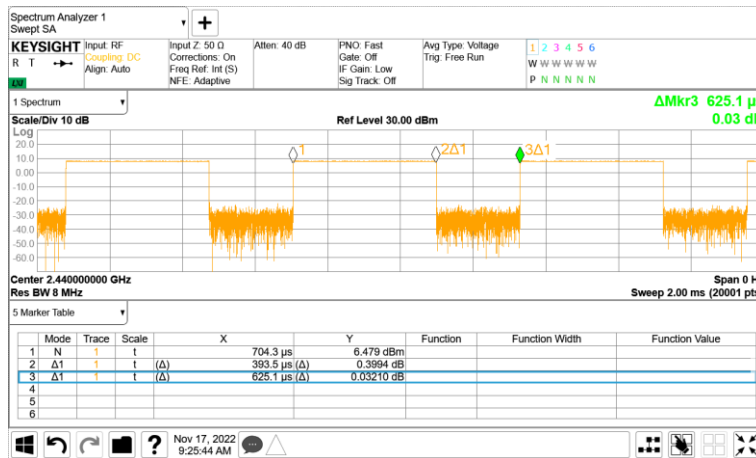
Left, Duty Cycle, BLE 1Mbps, Middle Channel (2 440 MHz)



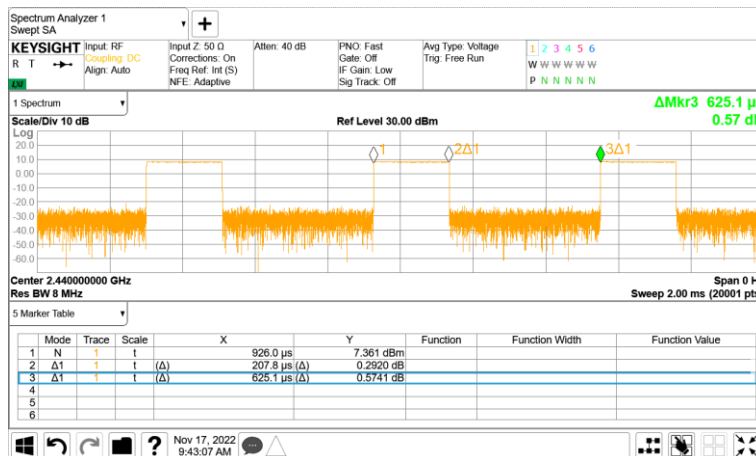
Left, Duty Cycle, BLE 2Mbps, Middle Channel (2 440 MHz)



Right, Duty Cycle, BLE 1Mbps, Middle Channel (2 440 MHz)



Right, Duty Cycle, BLE 2Mbps, Middle Channel (2 440 MHz)



7.2 6 dB Bandwidth

FCC §15.247(a)(2)

Test Mode : Set to Lowest channel, Middle channel and Highest channel

Result

- Left

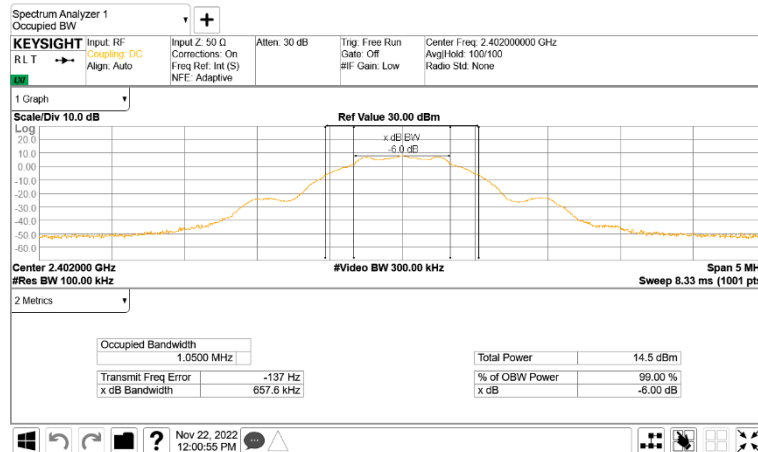
Mode	Channel	Frequency (MHz)	6 dB modulated bandwidth (MHz)	Limit (MHz)	Margin (MHz)
BLE 1Mbps	Lowest	2 402	0.66	0.50	0.16
	Middle	2 440	0.66	0.50	0.16
	Highest	2 480	0.66	0.50	0.16
BLE 2Mbps	Lowest	2 402	1.13	0.50	0.63
	Middle	2 440	1.13	0.50	0.63
	Highest	2 480	0.96	0.50	0.46

- Right

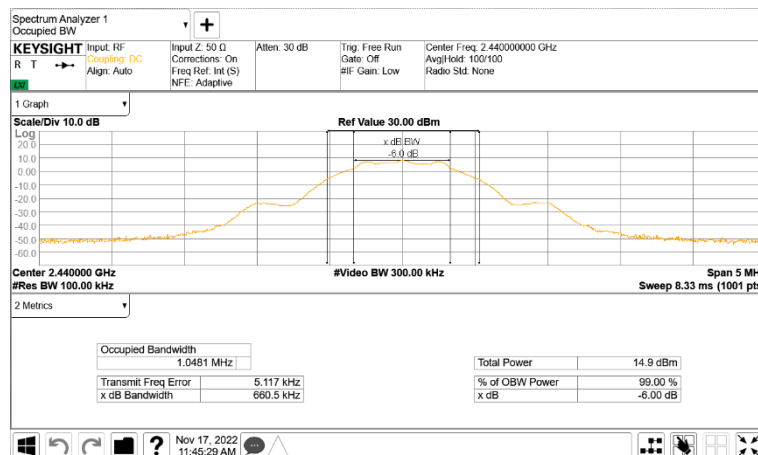
Mode	Channel	Frequency (MHz)	6 dB modulated bandwidth (MHz)	Limit (MHz)	Margin (MHz)
BLE 1Mbps	Lowest	2 402	0.66	0.50	0.16
	Middle	2 440	0.66	0.50	0.16
	Highest	2 480	0.67	0.50	0.16
BLE 2Mbps	Lowest	2 402	1.11	0.50	0.61
	Middle	2 440	0.96	0.50	0.46
	Highest	2 480	1.11	0.50	0.61

PLOTS OF EMISSIONS

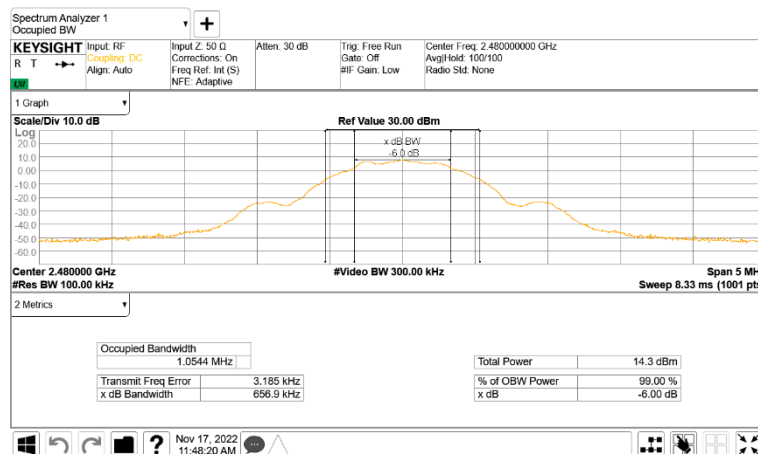
Left, BLE 1Mbps, 6 dB Bandwidth, Lowest Channel (2 402 MHz)



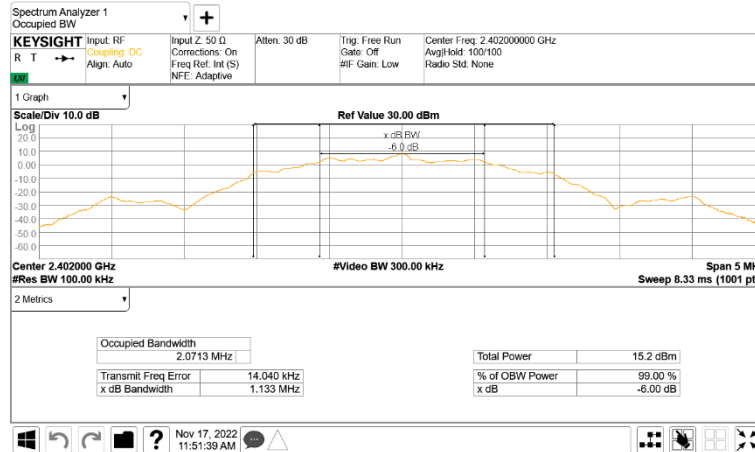
Left, BLE 1Mbps, 6 dB Bandwidth, Middle Channel (2 440 MHz)



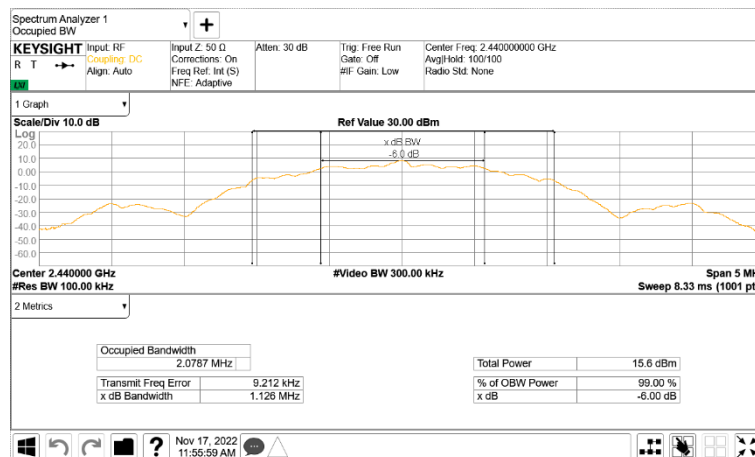
Left, BLE 1Mbps, 6 dB Bandwidth, Highest Channel (2 480 MHz)



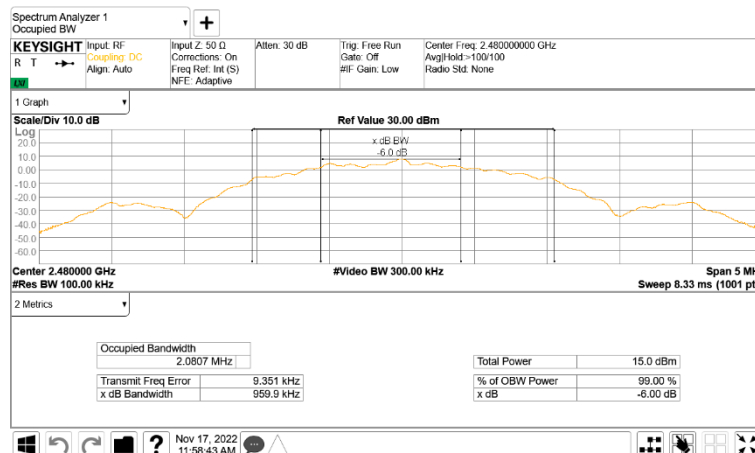
Left, BLE 2Mbps, 6 dB Bandwidth, Lowest Channel (2 402 MHz)



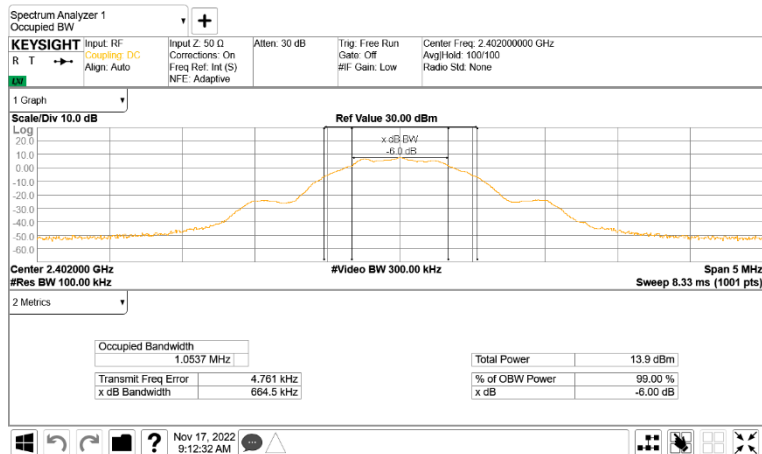
Left, BLE 2Mbps, 6 dB Bandwidth, Middle Channel (2 440 MHz)



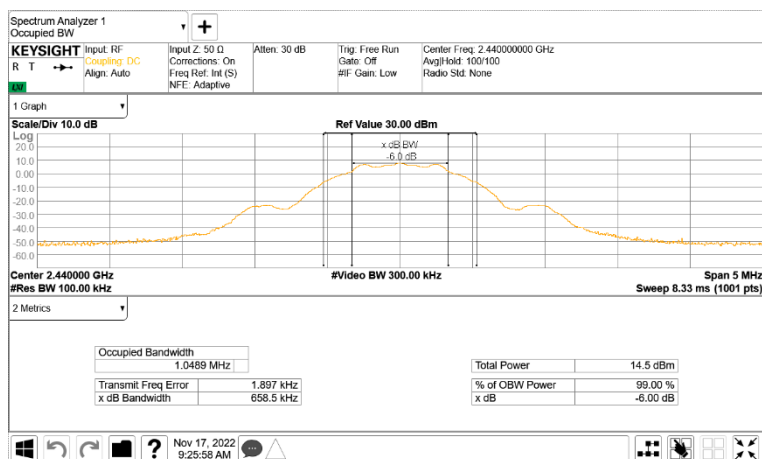
Left, BLE 2Mbps, 6 dB Bandwidth, Highest Channel (2 480 MHz)



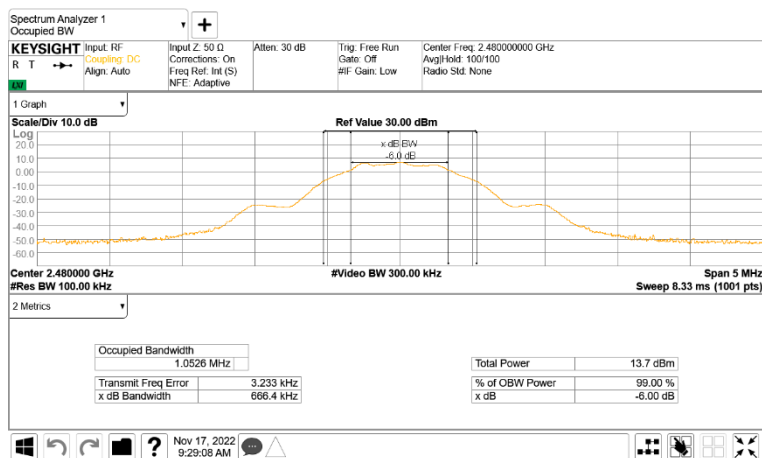
Right, BLE 1Mbps, 6 dB Bandwidth, Lowest Channel (2 402 MHz)



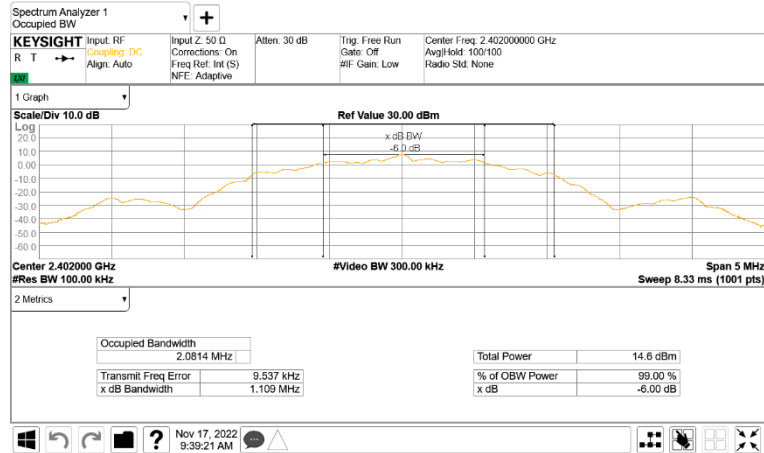
Right, BLE 1Mbps, 6 dB Bandwidth, Middle Channel (2 440 MHz)



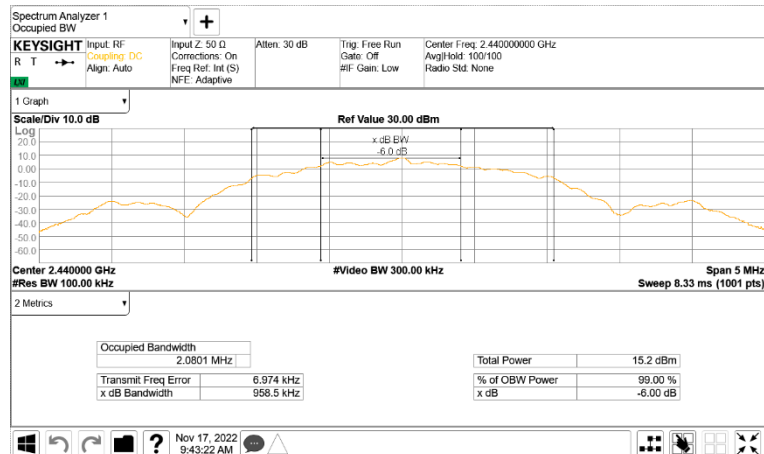
Right, BLE 1Mbps, 6 dB Bandwidth, Highest Channel (2 480 MHz)



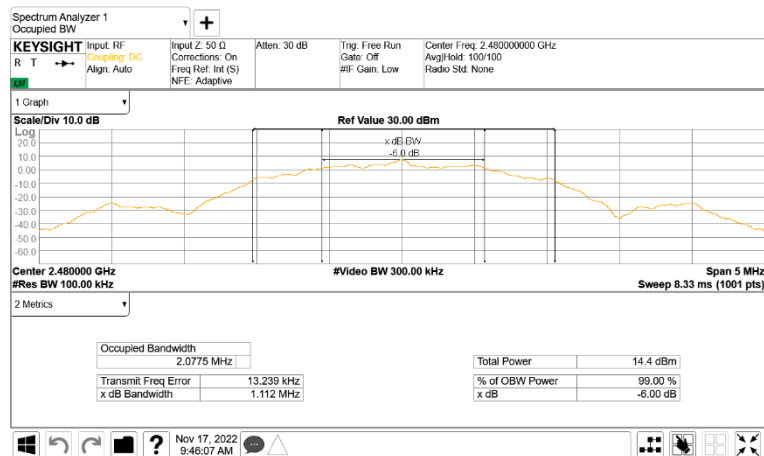
Right, BLE 2Mbps, 6 dB Bandwidth, Lowest Channel (2 402 MHz)



Right, BLE 2Mbps, 6 dB Bandwidth, Middle Channel (2 440 MHz)



Right, BLE 2Mbps, 6 dB Bandwidth, Highest Channel (2 480 MHz)



7.3 Peak Output Power

FCC §15.247(b)(3)

Test Mode : Set to Lowest channel, Middle channel and Highest channel

Result

- Left

Mode	Channel	Frequency (MHz)	Peak Output Power (dBm)	Limit (dBm)
BLE 1Mbps	Lowest	2 402	8.25	30.00
	Middle	2 440	8.39	30.00
	Highest	2 480	7.94	30.00
BLE 2Mbps	Lowest	2 402	8.36	30.00
	Middle	2 440	8.77	30.00
	Highest	2 480	8.21	30.00

- Right

Mode	Channel	Frequency (MHz)	Peak Output Power (dBm)	Limit (dBm)
BLE 1Mbps	Lowest	2 402	7.61	30.00
	Middle	2 440	8.05	30.00
	Highest	2 480	7.39	30.00
BLE 2Mbps	Lowest	2 402	7.81	30.00
	Middle	2 440	8.34	30.00
	Highest	2 480	7.58	30.00

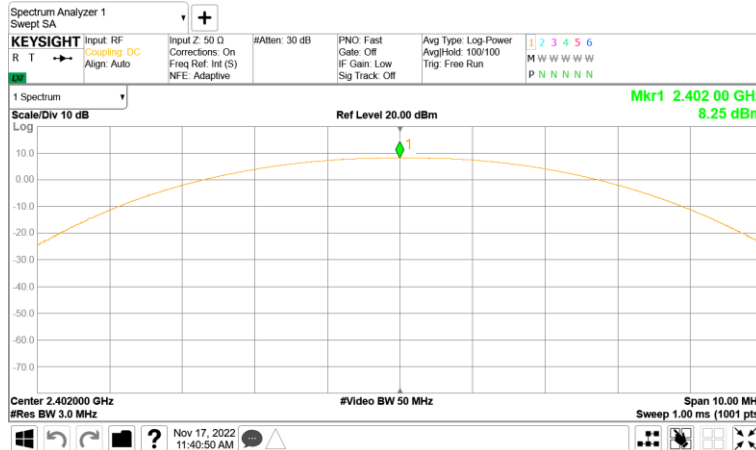
Notes:

1. The following equation was used for spectrum offset:

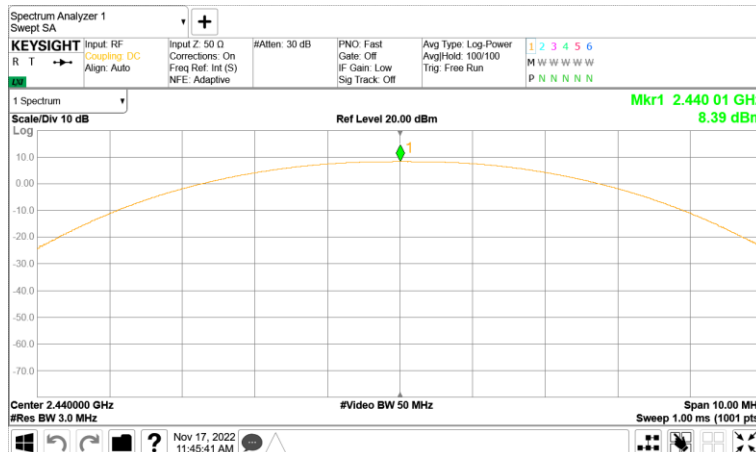
$$\text{Spectrum offset (dB)} = \text{Attenuator (dB)} + \text{Cable Loss (dB)} + \text{SMA Type Connector Loss (dB)}$$

PLOTS OF EMISSIONS

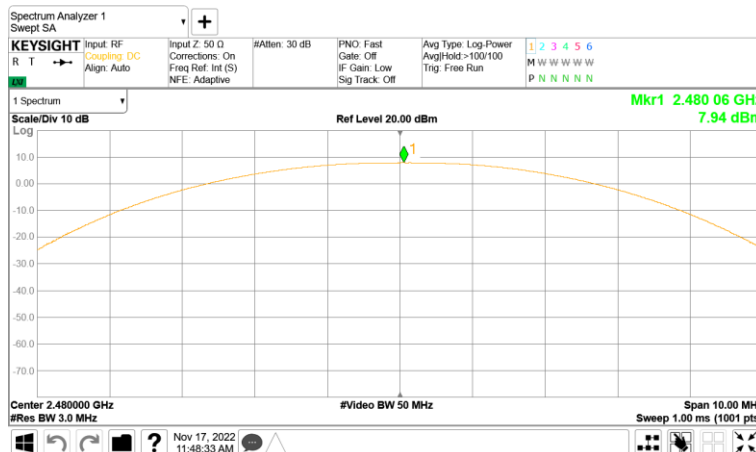
Left, BLE 1Mbps, Maximum Peak Output Power, Lowest Channel (2 402 MHz)



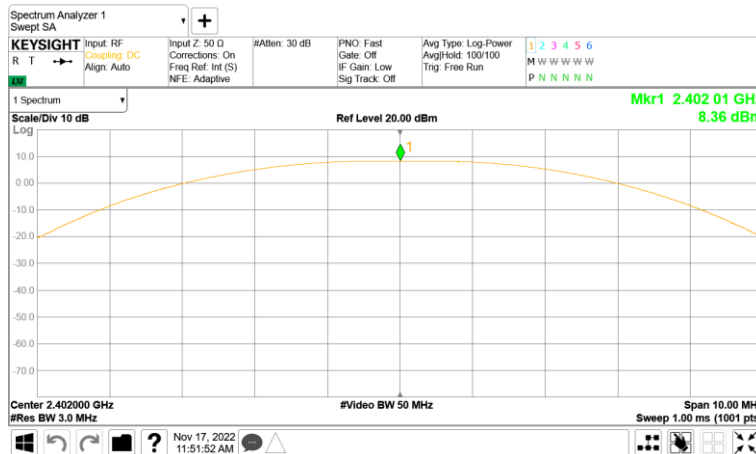
Left, BLE 1Mbps, Maximum Peak Output Power, Middle Channel (2 440 MHz)



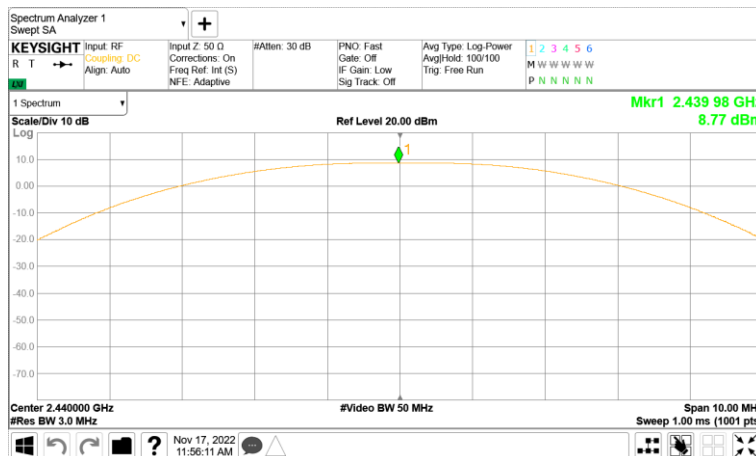
Left, BLE 1Mbps, Maximum Peak Output Power, Highest Channel (2 480 MHz)



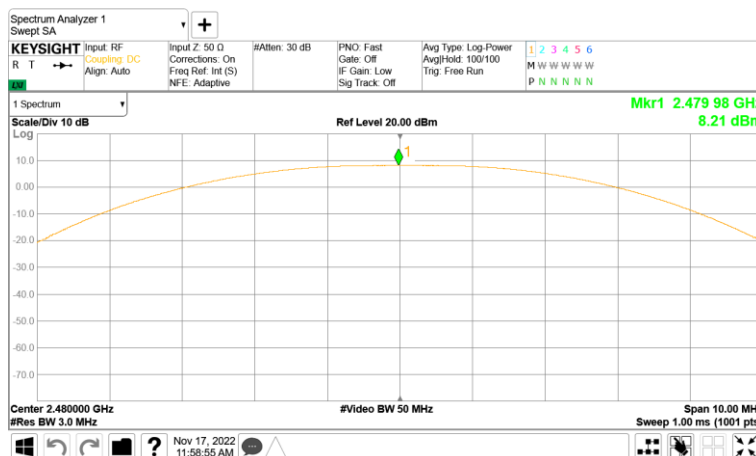
Left, BLE 2Mbps, Maximum Peak Output Power, Lowest Channel (2 402 MHz)



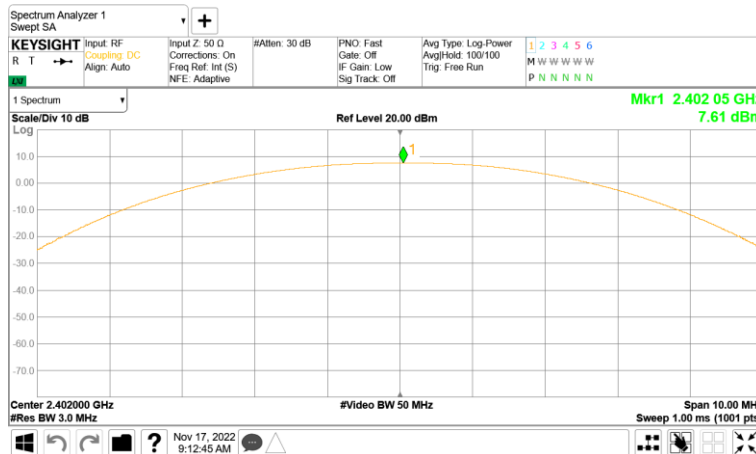
Left, BLE 2Mbps, Maximum Peak Output Power, Middle Channel (2 440 MHz)



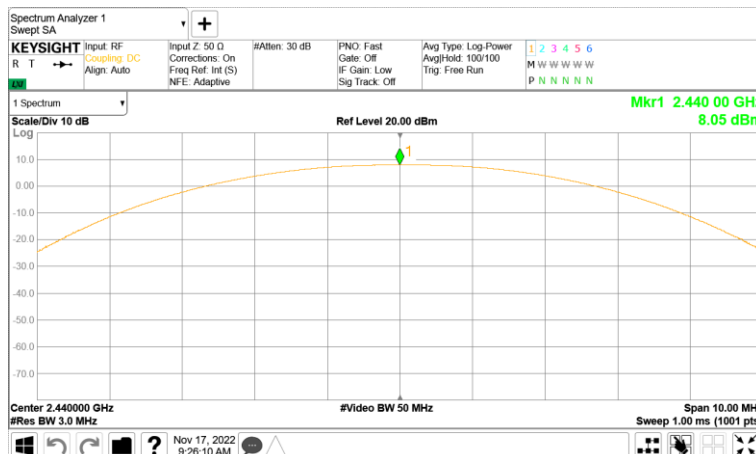
Left, BLE 2Mbps, Maximum Peak Output Power, Highest Channel (2 480 MHz)



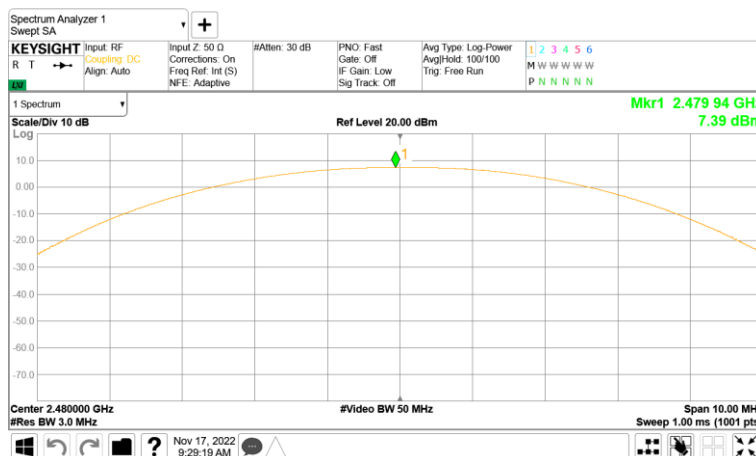
Right, BLE 1Mbps, Maximum Peak Output Power, Lowest Channel (2 402 MHz)



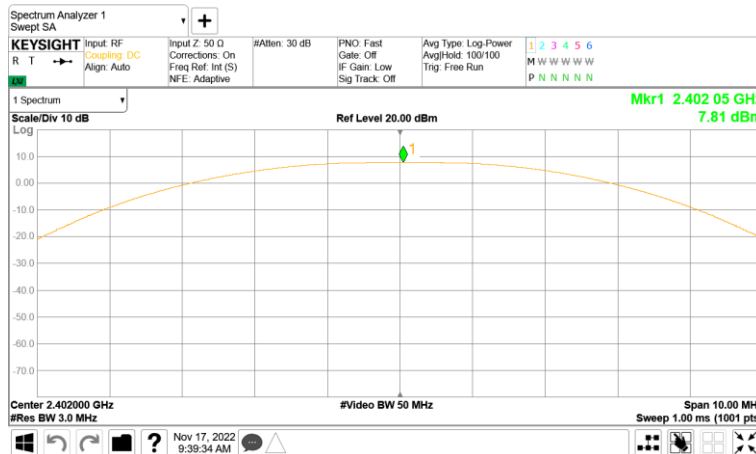
Right, BLE 1Mbps, Maximum Peak Output Power, Middle Channel (2 440 MHz)



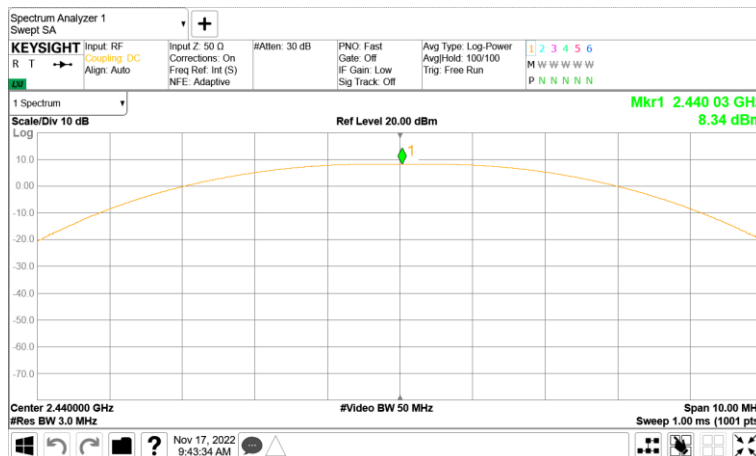
Right, BLE 1Mbps, Maximum Peak Output Power, Highest Channel (2 480 MHz)



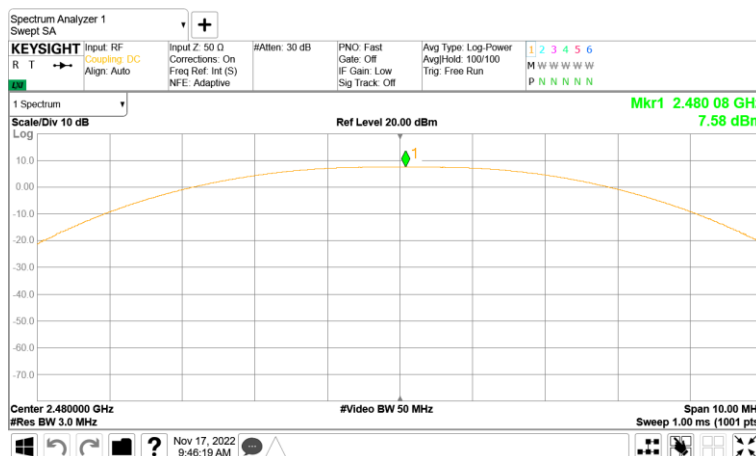
Right, BLE 2Mbps, Maximum Peak Output Power, Lowest Channel (2 402 MHz)



Right, BLE 2Mbps, Maximum Peak Output Power, Middle Channel (2 440 MHz)



Right, BLE 2Mbps, Maximum Peak Output Power, Highest Channel (2 480 MHz)



7.4 Peak Power Spectral Density

FCC §15.247(e)

Test Mode : Set to Lowest channel, Middle channel and Highest channel,

Result

- Left

Mode	Channel	Frequency (MHz)	Peak Power Spectral Density (dBm/3 kHz)	Limit (dBm/3 kHz)
BLE 1Mbps	Lowest	2 402	-6.74	8.00
	Middle	2 440	-8.27	8.00
	Highest	2 480	-7.98	8.00
BLE 2Mbps	Lowest	2 402	-9.00	8.00
	Middle	2 440	-8.77	8.00
	Highest	2 480	-8.86	8.00

- Right

Mode	Channel	Frequency (MHz)	Peak Power Spectral Density (dBm/3 kHz)	Limit (dBm/3 kHz)
BLE 1Mbps	Lowest	2 402	-7.82	8.00
	Middle	2 440	-7.55	8.00
	Highest	2 480	-8.71	8.00
BLE 2Mbps	Lowest	2 402	-10.30	8.00
	Middle	2 440	-8.12	8.00
	Highest	2 480	-9.91	8.00

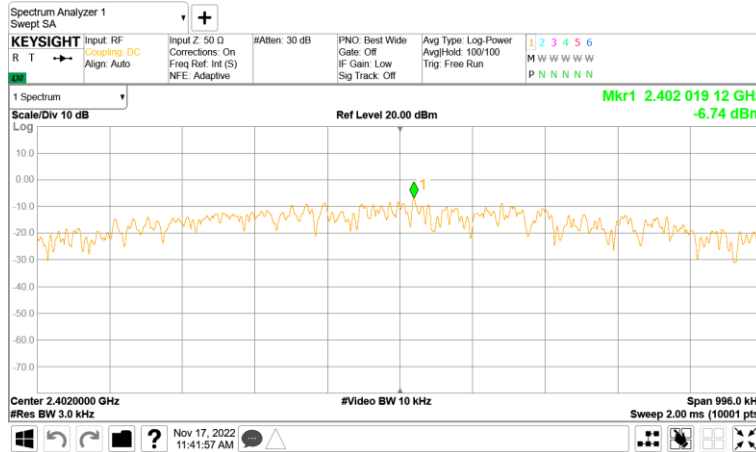
Notes:

1. The following equation was used for spectrum offset:

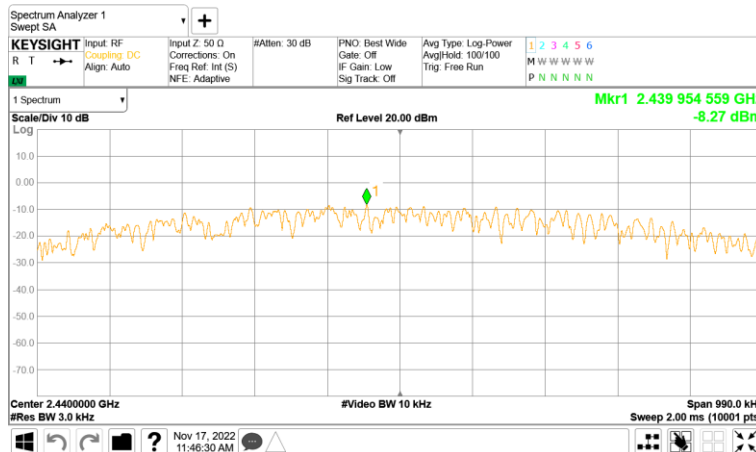
$$\text{Spectrum offset (dB)} = \text{Attenuator (dB)} + \text{Cable Loss (dB)} + \text{SMA Type Connector Loss (dB)}$$

PLOTS OF EMISSIONS

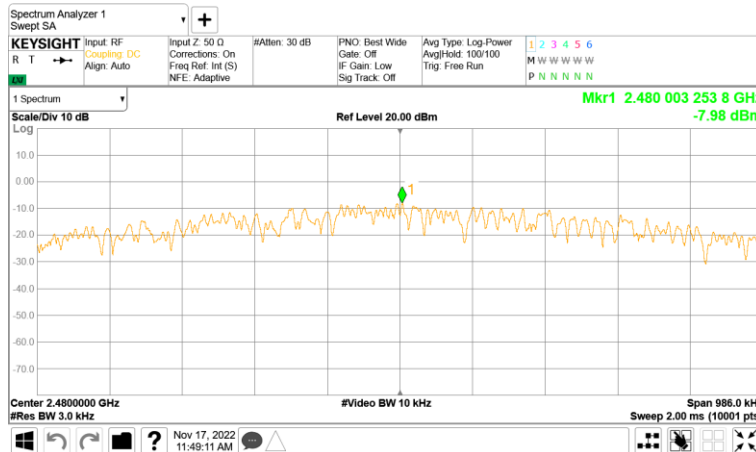
Left, BLE 1Mbps, Peak Power Spectral Density, Lowest Channel (2 402 MHz)



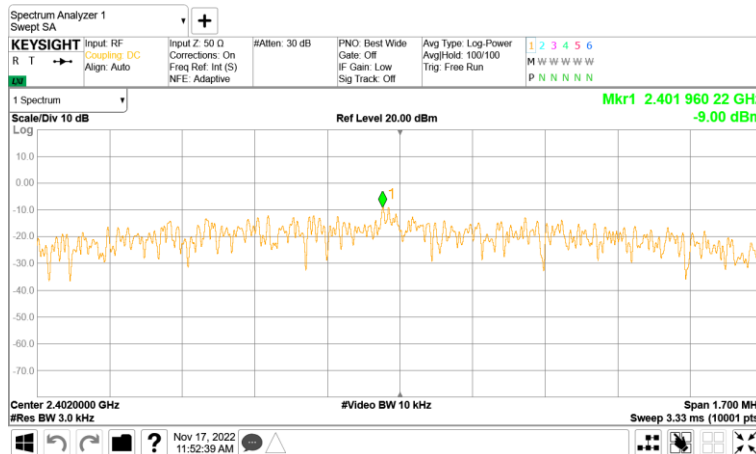
Left, BLE 1Mbps, Peak Power Spectral Density, Middle Channel (2 440 MHz)



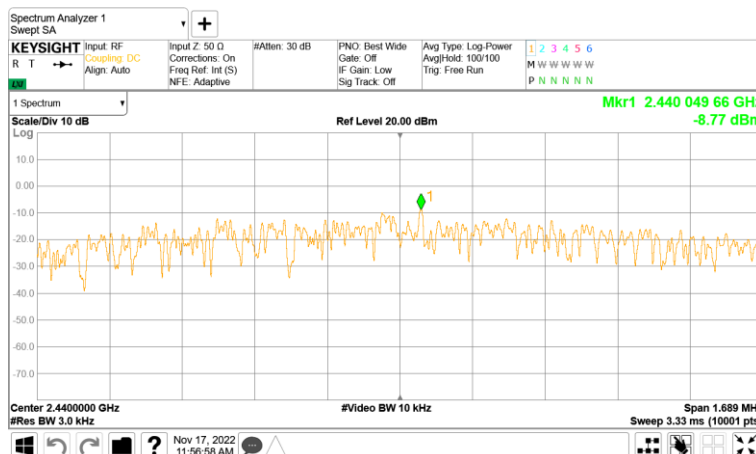
Left, BLE 1Mbps, Peak Power Spectral Density, Highest Channel (2 480 MHz)



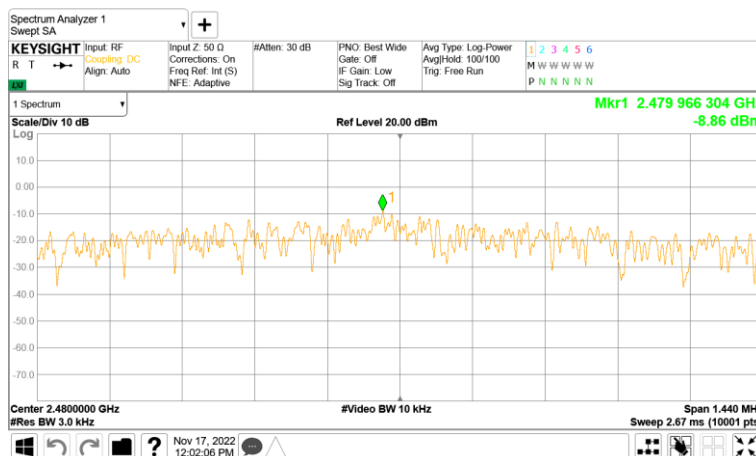
Left, BLE 2Mbps, Peak Power Spectral Density, Lowest Channel (2 402 MHz)



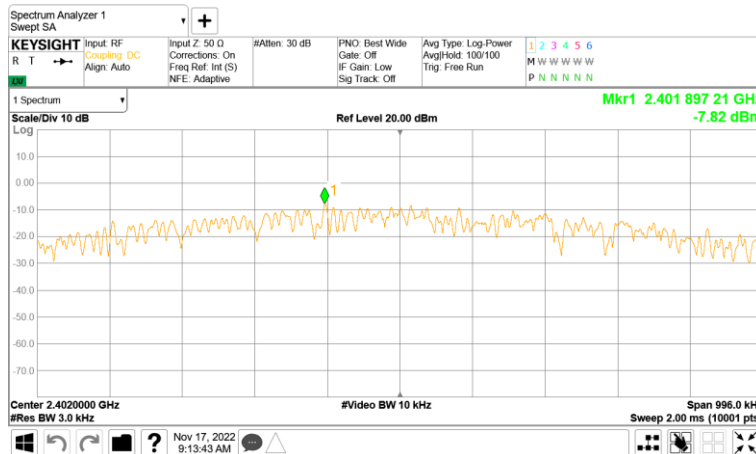
Left, BLE 2Mbps, Peak Power Spectral Density, Middle Channel (2 440 MHz)



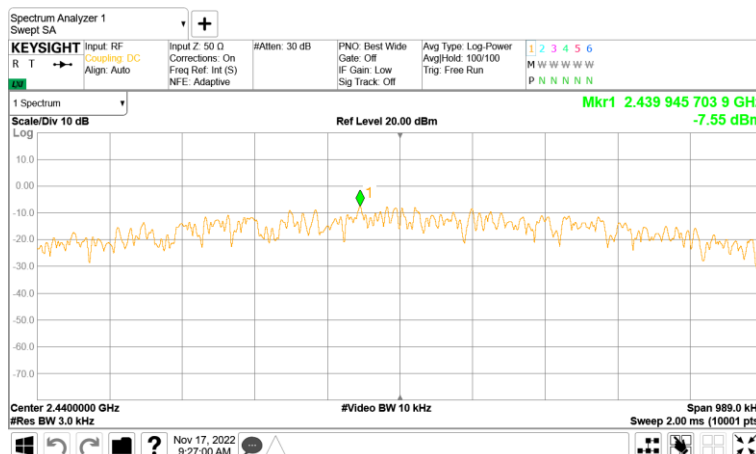
Left, BLE 2Mbps, Peak Power Spectral Density, Highest Channel (2 480 MHz)



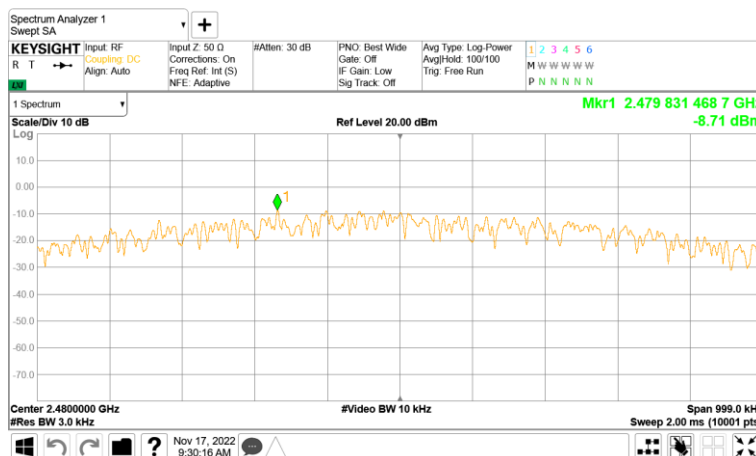
Right, BLE 1Mbps, Peak Power Spectral Density, Lowest Channel (2 402 MHz)



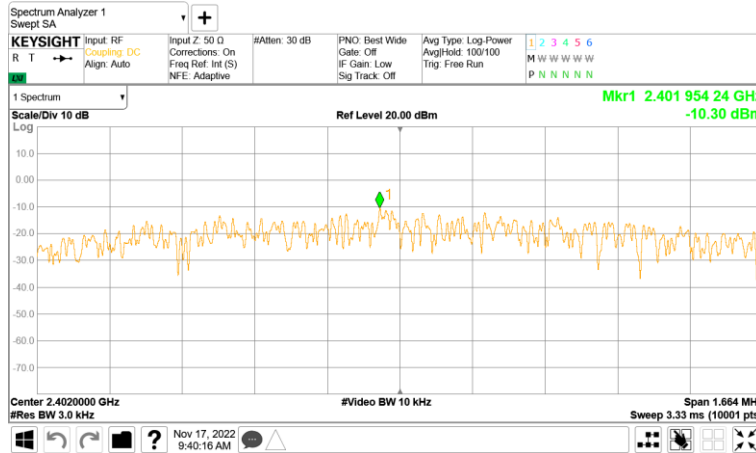
Right, BLE 1Mbps, Peak Power Spectral Density, Middle Channel (2 440 MHz)



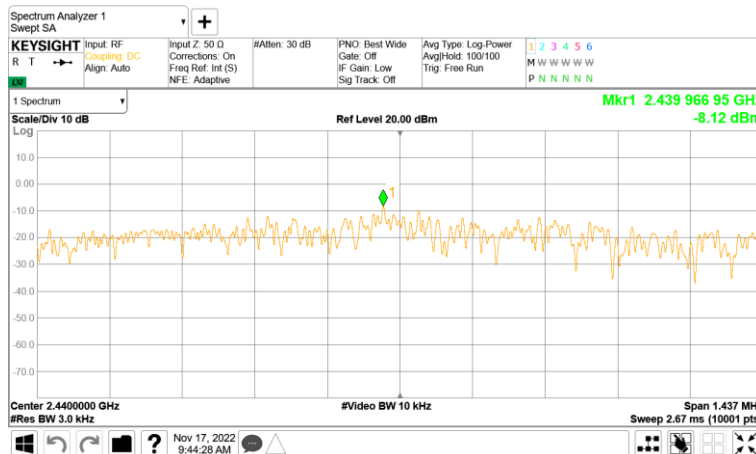
Right, BLE 1Mbps, Peak Power Spectral Density, Highest Channel (2 480 MHz)



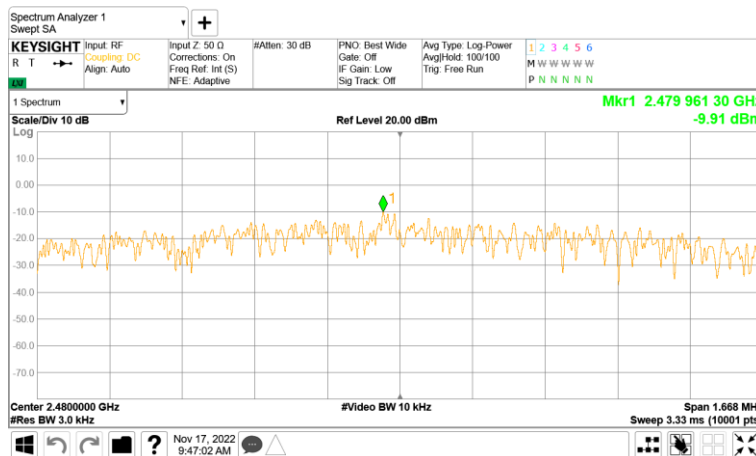
Right, BLE 2Mbps, Peak Power Spectral Density, Lowest Channel (2 402 MHz)



Right, BLE 2Mbps, Peak Power Spectral Density, Middle Channel (2 440 MHz)



Right, BLE 2Mbps, Peak Power Spectral Density, Highest Channel (2 480 MHz)



7.5 Conducted Spurious Emissions

FCC §15.247(e)

Test Mode : Set to Lowest channel, Middle channel and Highest channel

Result

- Left

Mode	Channel	Frequency (MHz)	Reference Level (dBm/100kHz)	Conducted Spurious Emissions (dBc)	Limit (dBc)
BLE 1Mbps	Lowest	2 402	7.99	More than 20 dBc	20
	Middle	2 440	8.28	More than 20 dBc	20
	Highest	2 480	7.78	More than 20 dBc	20
BLE 2Mbps	Lowest	2 402	8.19	More than 20 dBc	20
	Middle	2 440	8.62	More than 20 dBc	20
	Highest	2 480	8.01	More than 20 dBc	20

- Right

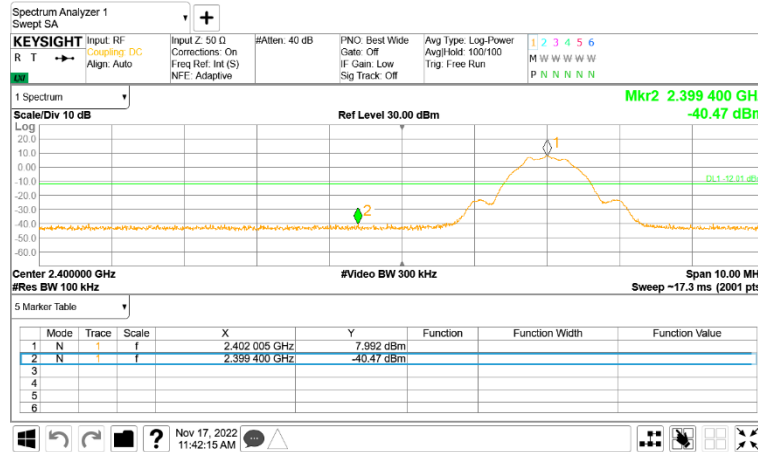
Mode	Channel	Frequency (MHz)	Reference Level (dBm/100kHz)	Conducted Spurious Emissions (dBc)	Limit (dBc)
BLE 1Mbps	Lowest	2 402	7.46	More than 20 dBc	20
	Middle	2 440	7.96	More than 20 dBc	20
	Highest	2 480	7.30	More than 20 dBc	20
BLE 2Mbps	Lowest	2 402	7.60	More than 20 dBc	20
	Middle	2 440	8.19	More than 20 dBc	20
	Highest	2 480	7.39	More than 20 dBc	20

Notes:

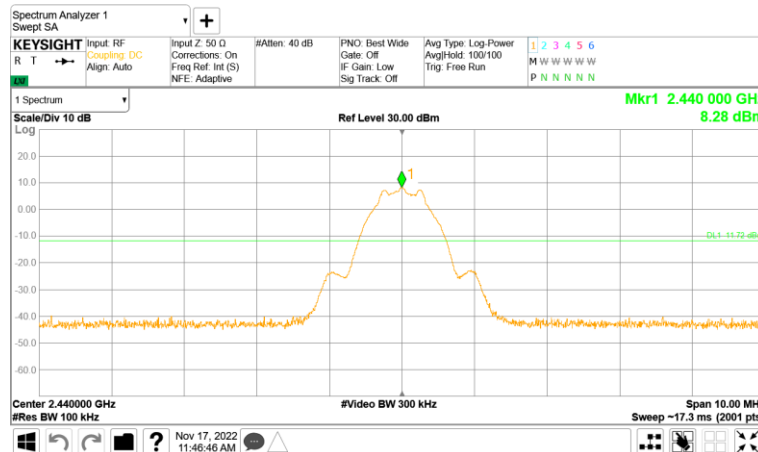
The cable and attenuator loss from 30 MHz to 26.5 GHz was reflected in spectrum analyzer with correction factor for the spurious emissions test.

PLOTS OF EMISSIONS

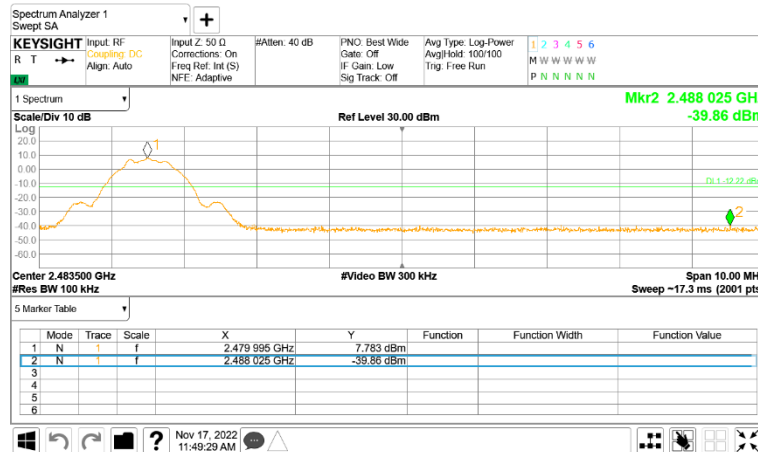
Left, BLE 1Mbps, Band Edge, Lowest Channel (2 402 MHz)



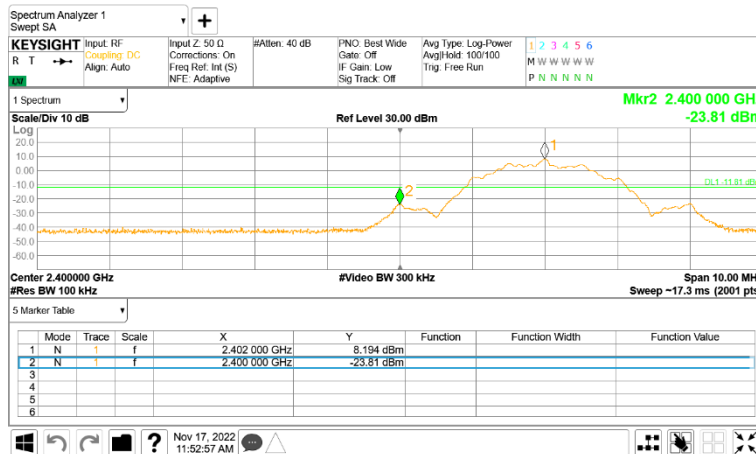
Left, BLE 1Mbps, Reference Power Spectral Density, Middle Channel (2 440 MHz)



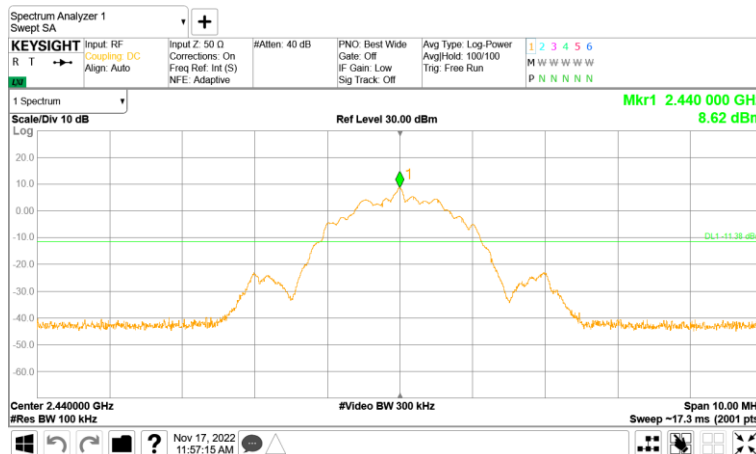
Left, BLE 1Mbps, Band Edge, Highest Channel (2 480 MHz)



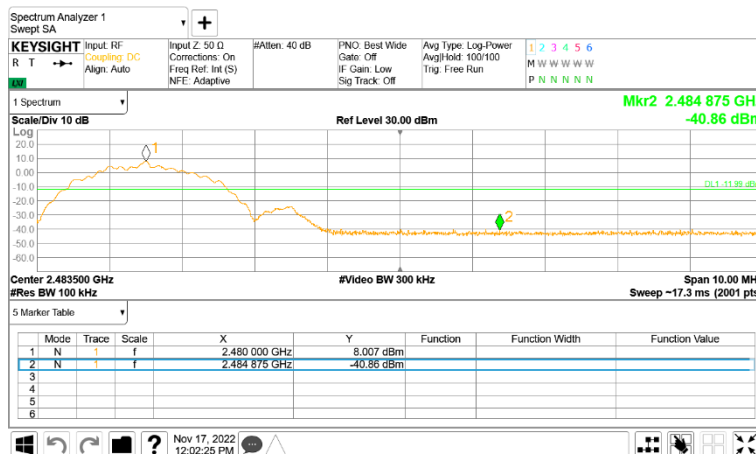
Left, BLE 2Mbps, Band Edge, Lowest Channel (2 402 MHz)



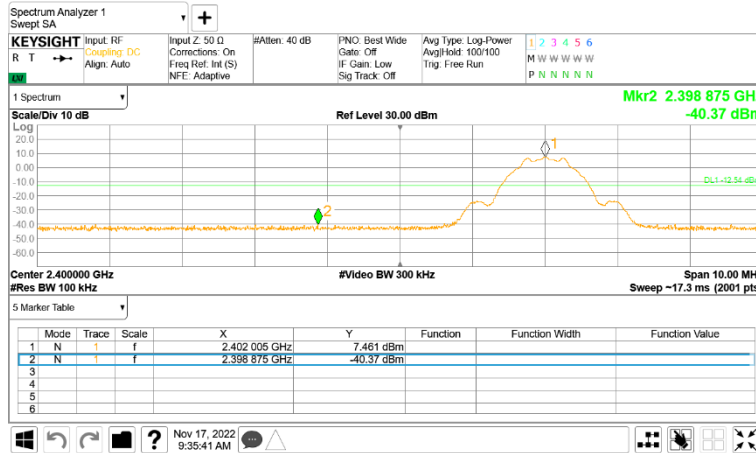
Left, BLE 2Mbps, Reference Power Spectral Density, Middle Channel (2 440 MHz)



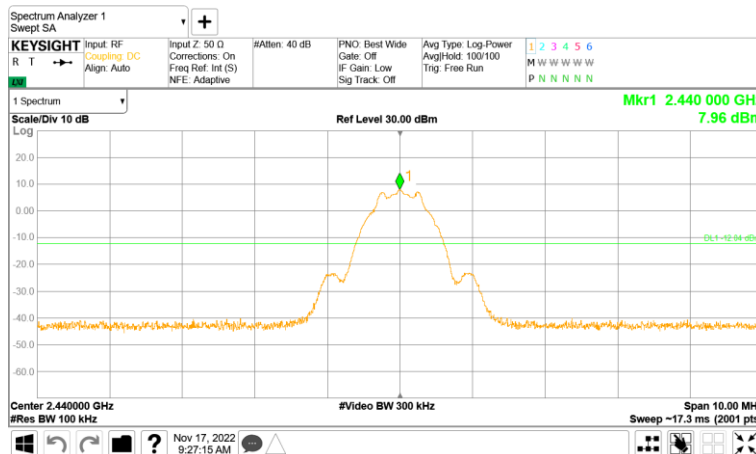
Left, BLE 2Mbps, Band Edge, Highest Channel (2 480 MHz)



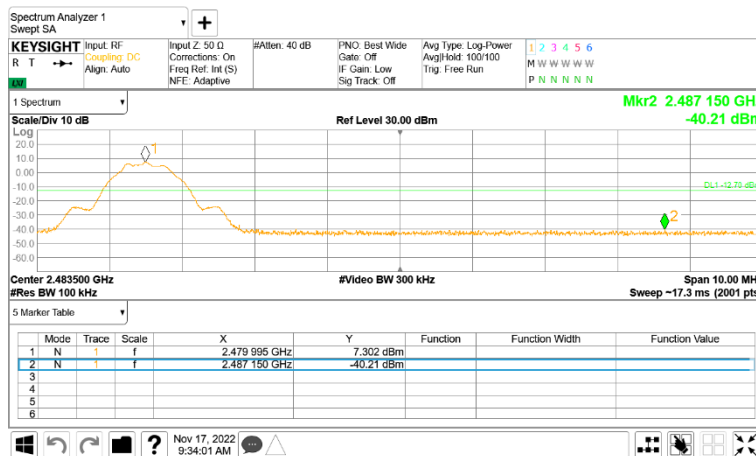
Right, BLE 1Mbps, Band Edge, Lowest Channel (2 402 MHz)



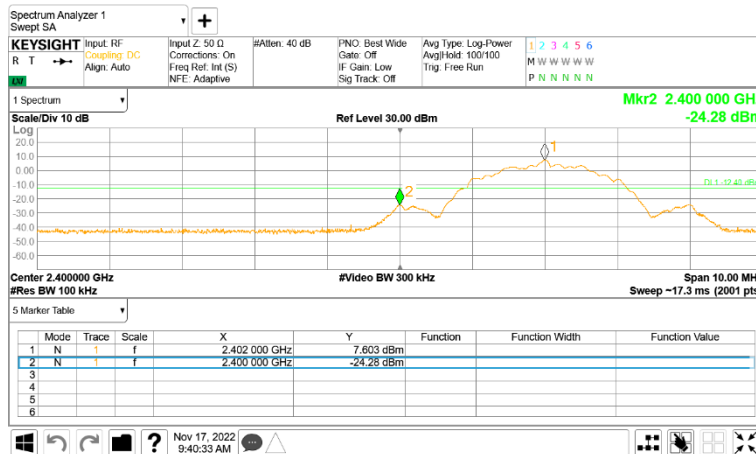
Right, BLE 1Mbps, Reference Spectral Density, Middle Channel (2 440 MHz)



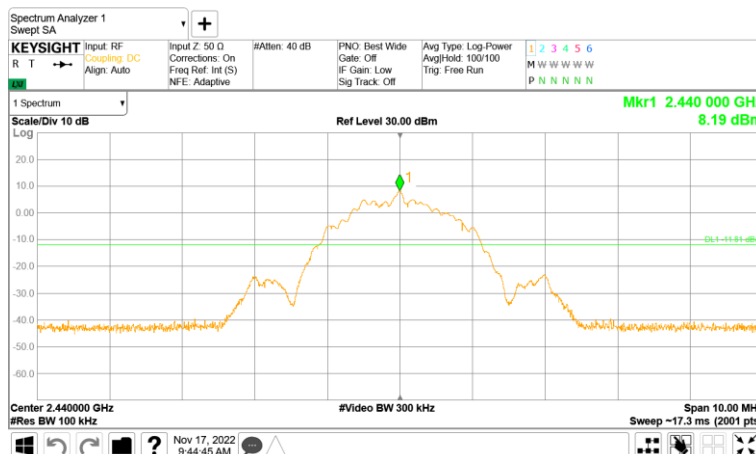
Right, BLE 1Mbps, Band Edge, Highest Channel (2 480 MHz)



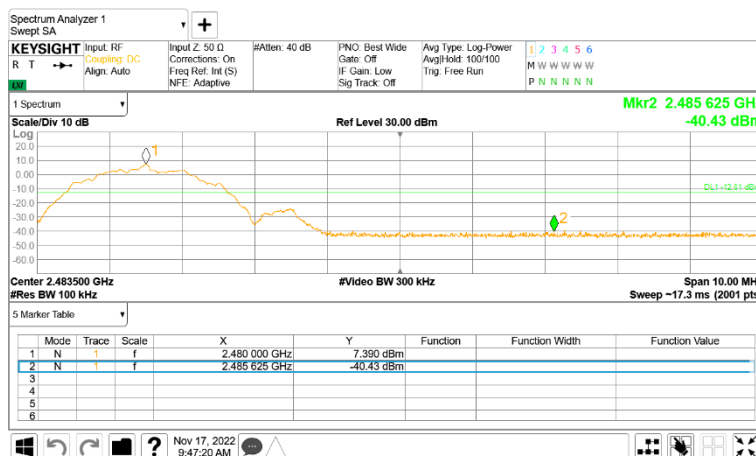
Right, BLE 2Mbps, Band Edge, Lowest Channel (2 402 MHz)



Right, BLE 2Mbps, Reference Power Spectral Density, Middle Channel (2 440 MHz)

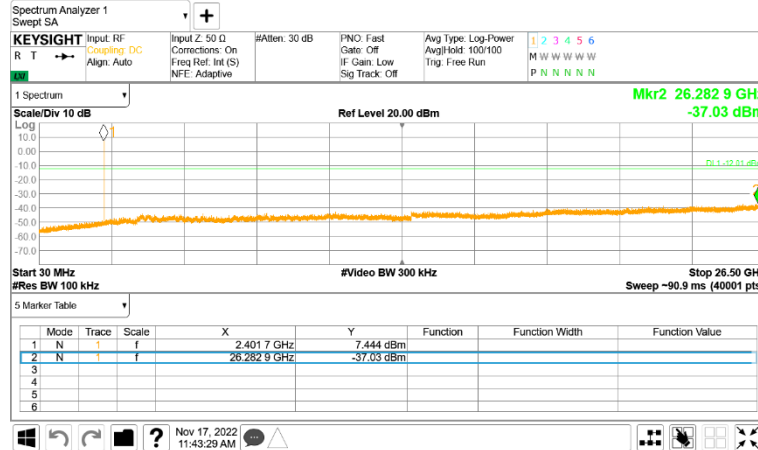


Right, BLE 2Mbps, Band Edge, Highest Channel (2 480 MHz)

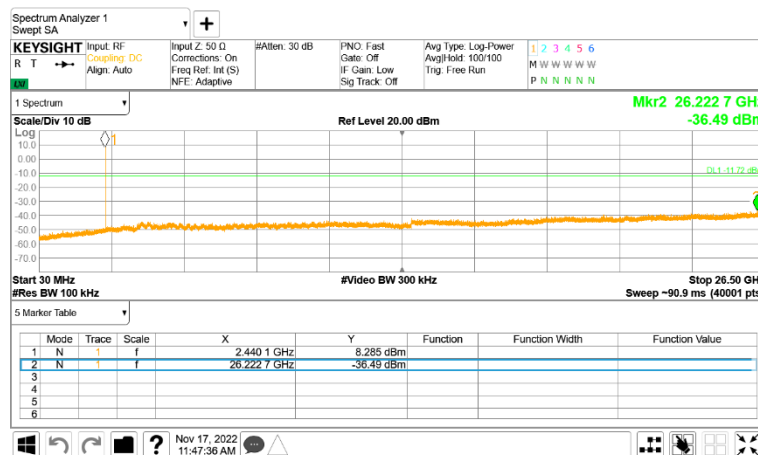


PLOTS OF EMISSIONS

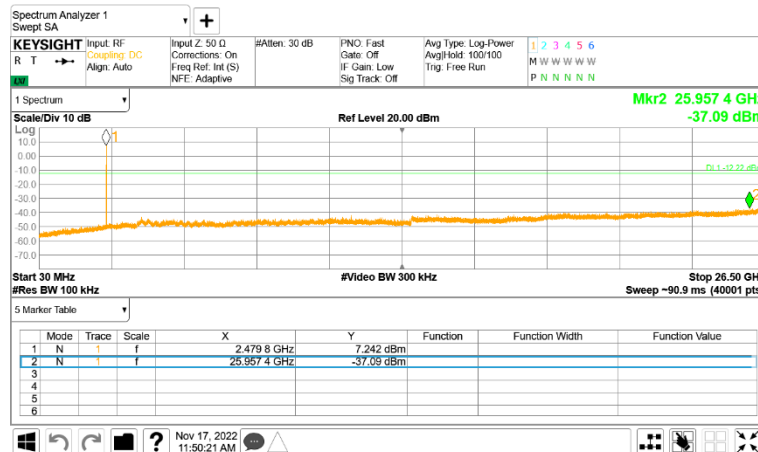
Left, BLE 1Mbps, Conducted Spurious Emissions, Lowest Channel (2 402 MHz)



Left, BLE 1Mbps, Conducted Spurious Emissions, Middle Channel (2 440 MHz)



Left, BLE 1Mbps, Conducted Spurious Emissions, Highest Channel (2 480 MHz)



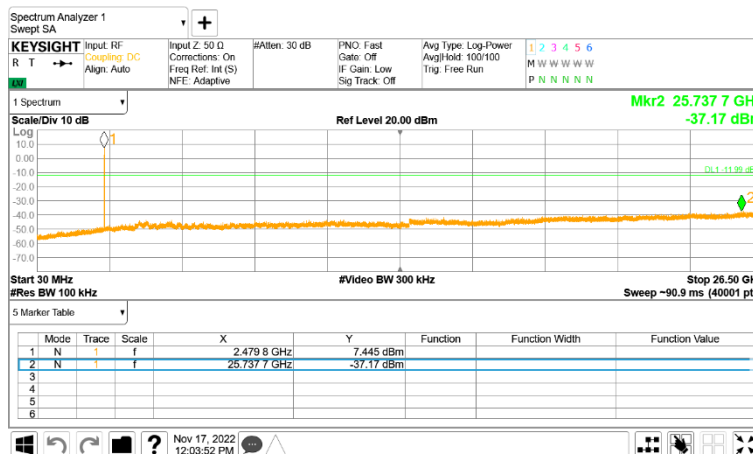
Left, BLE 2Mbps, Conducted Spurious Emissions, Lowest Channel (2 402 MHz)



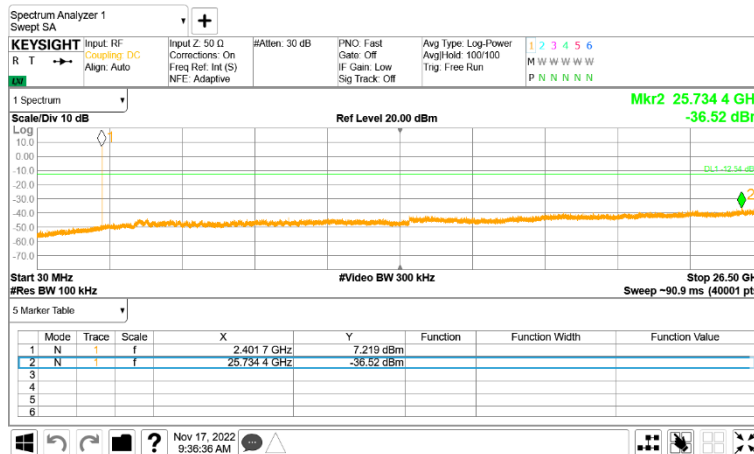
Left, BLE 2Mbps, Conducted Spurious Emissions, Middle Channel (2 440 MHz)



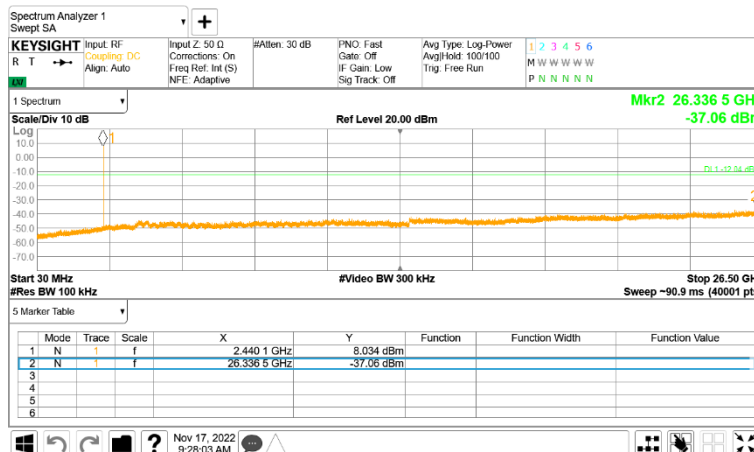
Left, BLE 2Mbps, Conducted Spurious Emissions, Highest Channel (2 480 MHz)



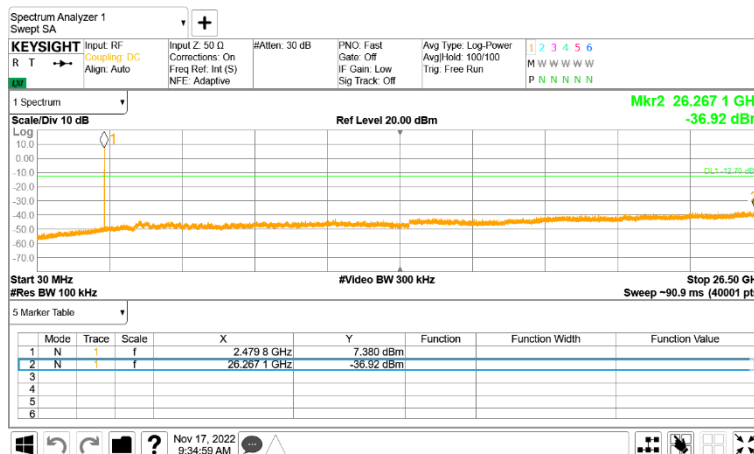
Right, BLE 1Mbps, Conducted Spurious Emissions, Lowest Channel (2 402 MHz)



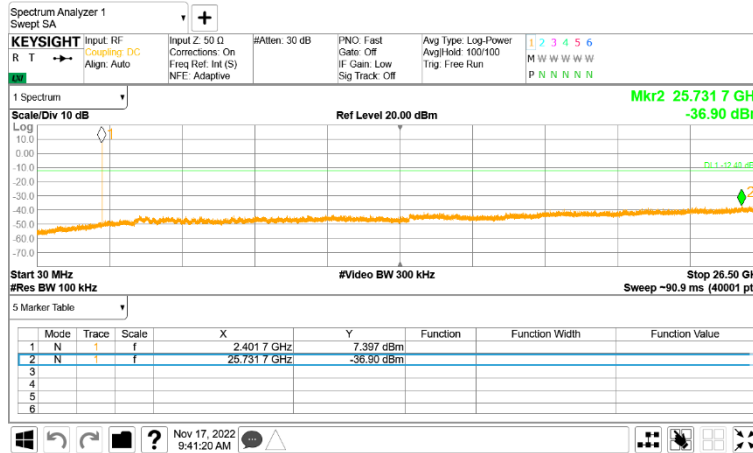
Right, BLE 1Mbps, Conducted Spurious Emissions, Middle Channel (2 440 MHz)



Right, BLE 1Mbps, Conducted Spurious Emissions, Highest Channel (2 480 MHz)



Right, BLE 2Mbps, Conducted Spurious Emissions, Lowest Channel (2 402 MHz)



Right, BLE 2Mbps, Conducted Spurious Emissions, Middle Channel (2 440 MHz)



Right, BLE 2Mbps, Conducted Spurious Emissions, Highest Channel (2 480 MHz)



7.6 Radiated Spurious Emissions

FCC §15.247(d)

Test Mode : Set to Lowest channel, Middle channel and Highest channel

Result

- Left

BLE 1Mbps, Lowest channel

Frequency (MHz)	Reading (dBμV)	Pol* (H/V)	Mode	AF+CL+Amp (dB)**	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)
4 805.00	43.33	H	Peak	3.4	46.73	74.00	27.27
7 208.13	40.57	V	Peak	7.7	48.27	74.00	25.73

BLE 1Mbps, Middle channel

Frequency (MHz)	Reading (dBμV)	Pol* (H/V)	Mode	AF+CL+Amp (dB)**	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)
4 885.63	45.14	H	Peak	3.9	49.04	74.00	24.96
7 325.00	41.26	H	Peak	7.9	49.16	74.00	24.84

BLE 1Mbps, Highest channel

Frequency (MHz)	Reading (dBμV)	Pol* (H/V)	Mode	AF+CL+Amp (dB)**	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)
4 968.75	44.36	V	Peak	4.0	48.36	74.00	25.64
7 441.88	40.22	H	Peak	8.4	48.62	74.00	25.38

BLE 2Mbps, Lowest channel

Frequency (MHz)	Reading (dBμV)	Pol* (H/V)	Mode	AF+CL+Amp (dB)**	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)
4 805.63	43.63	H	Peak	3.4	47.03	74.00	26.97
7 206.25	38.70	V	Peak	7.7	46.40	74.00	27.60

BLE 2Mbps, Middle channel

Frequency (MHz)	Reading (dBμV)	Pol* (H/V)	Mode	AF+CL+Amp (dB)**	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)
4 883.75	43.80	V	Peak	3.9	47.70	74.00	26.30
7 320.63	39.42	H	Peak	7.8	47.22	74.00	26.78

BLE 2Mbps, Highest channel

Frequency (MHz)	Reading (dBμV)	Pol* (H/V)	Mode	AF+CL+Amp (dB)**	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)
4 968.13	44.28	V	Peak	4.0	48.28	74.00	25.72
7 440.00	39.94	H	Peak	8.4	48.34	74.00	25.66

Notes:

- *Pol. H = Horizontal V = Vertical
- **AF + CL + Amp. = Antenna Factor + Cable Loss + Amplifier.
- Average measurement was not performed when peak-detected emission complies with the average limit.
- Other spurious was under 20 dB below Fundamental.
- BLE 1Mbps, Middle channel (2 440 MHz) was the worst condition.
- The radiated emissions testing were made by rotating EUT through three orthogonal axes and rotating the receive antenna with horizontal, Vertical polarization.
- Peak emissions were measured using RBW = 1 MHz, VBW = 3 MHz, Detector = Peak.
- Average emissions were measured using RBW = 1 MHz, VBW = 3 kHz, Detector = Peak.
- The spectrum was measured from 1 GHz to 10th harmonic and the worst-case emissions were reported. No significant emissions were found beyond the 3rd harmonic for this device.

- Right

BLE 1Mbps, Lowest channel

Frequency (MHz)	Reading (dBμV)	Pol* (H/V)	Mode	AF+CL+Amp (dB)**	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)
4 804.38	42.60	V	Peak	3.4	46.00	74.00	28.00
7 206.25	40.15	H	Peak	7.7	47.85	74.00	26.15

BLE 1Mbps, Middle channel

Frequency (MHz)	Reading (dBμV)	Pol* (H/V)	Mode	AF+CL+Amp (dB)**	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)
4 880.00	43.21	V	Peak	3.9	47.11	74.00	26.89
7 320.00	38.24	H	Peak	7.8	46.04	74.00	27.96

BLE 1Mbps, Highest channel

Frequency (MHz)	Reading (dBμV)	Pol* (H/V)	Mode	AF+CL+Amp (dB)**	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)
4 960.00	42.93	H	Peak	4.0	46.93	74.00	27.07
7 440.63	39.71	V	Peak	8.4	48.11	74.00	25.89

BLE 2Mbps, Lowest channel

Frequency (MHz)	Reading (dBμV)	Pol* (H/V)	Mode	AF+CL+Amp (dB)**	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)
4 804.38	43.37	V	Peak	3.4	46.77	74.00	27.23
7 206.25	40.85	H	Peak	7.7	48.55	74.00	25.45

BLE 2Mbps, Middle channel

Frequency (MHz)	Reading (dBμV)	Pol* (H/V)	Mode	AF+CL+Amp (dB)**	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)
4 880.00	42.63	V	Peak	3.9	46.53	74.00	27.47
7 320.00	40.00	H	Peak	7.8	47.80	74.00	26.20

BLE 2Mbps, Highest channel

Frequency (MHz)	Reading (dBμV)	Pol* (H/V)	Mode	AF+CL+Amp (dB)**	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)
4 960.63	42.75	H	Peak	4.0	46.75	74.00	27.25
7 440.63	38.52	H	Peak	8.4	46.92	74.00	27.08

Notes:

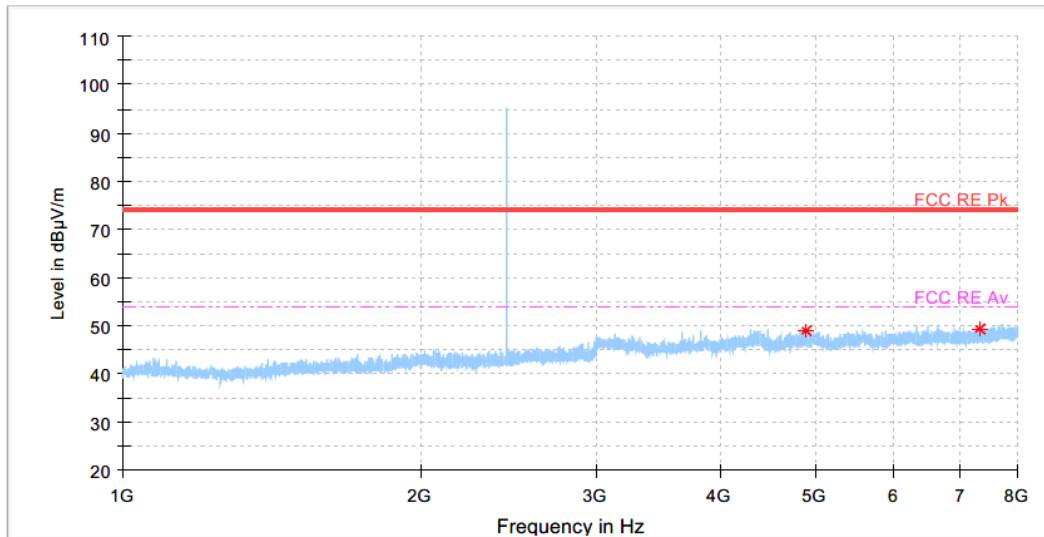
1. *Pol. H = Horizontal V = Vertical
2. **AF + CL + Amp. = Antenna Factor + Cable Loss + Amplifier.
3. Average measurement was not performed when peak-detected emission complies with the average limit.
4. Other spurious was under 20 dB below Fundamental.
5. BLE 2Mbps, Lowest channel (2 402 MHz) was the worst condition.
6. The radiated emissions testing were made by rotating EUT through three orthogonal axes and rotating the receive antenna with horizontal, Vertical polarization.
7. Peak emissions were measured using RBW = 1 MHz, VBW = 3 MHz, Detector = Peak.
8. Average emissions were measured using RBW = 1 MHz, VBW = 3 kHz, Detector = Peak.
9. The spectrum was measured from 1 GHz to 10th harmonic and the worst-case emissions were reported. No significant emissions were found beyond the 3rd harmonic for this device.

PLOTS OF EMISSIONS

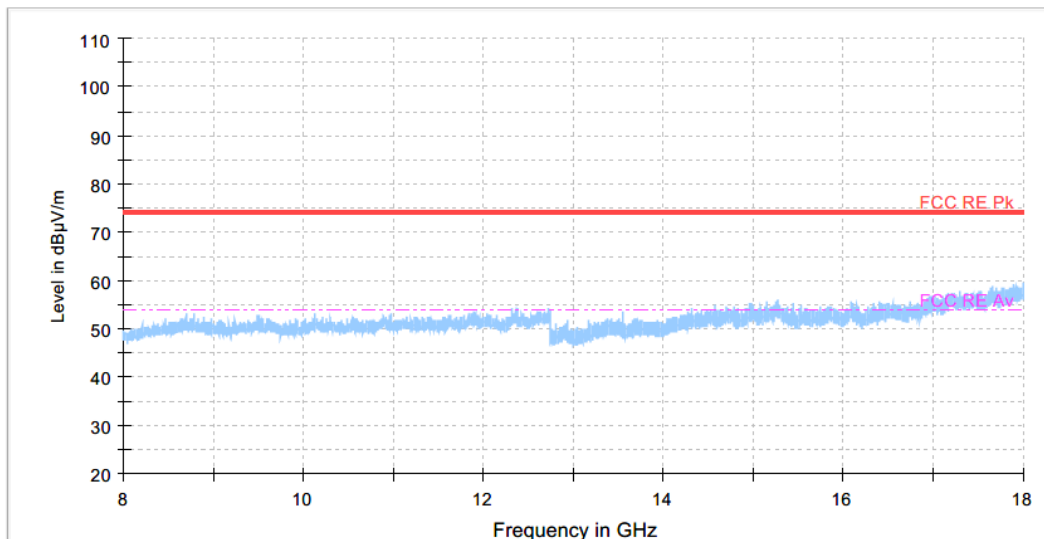
Worst Case

- Left

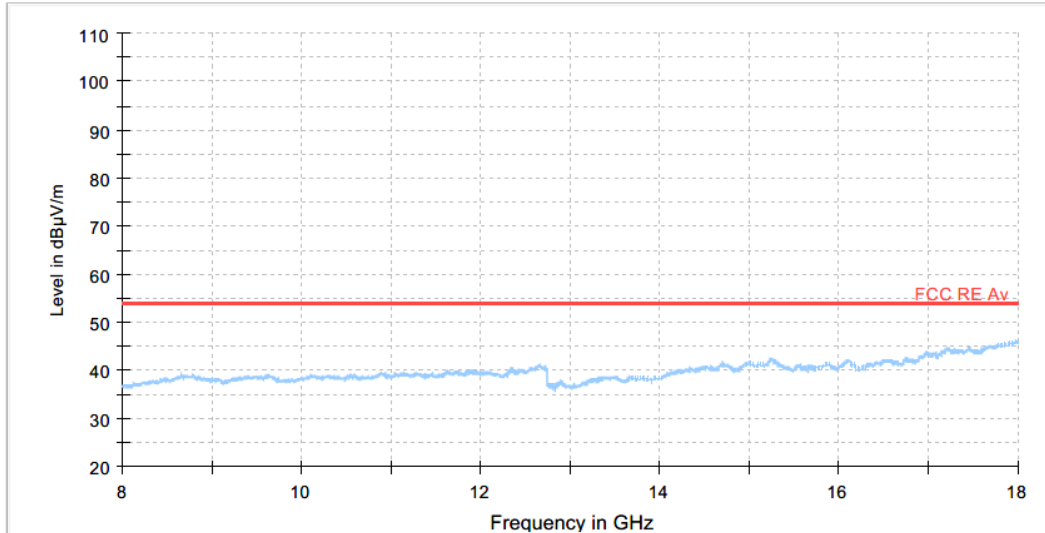
BLE 1Mbps, Middle Channel : 1 GHz to 8 GHz_Peak



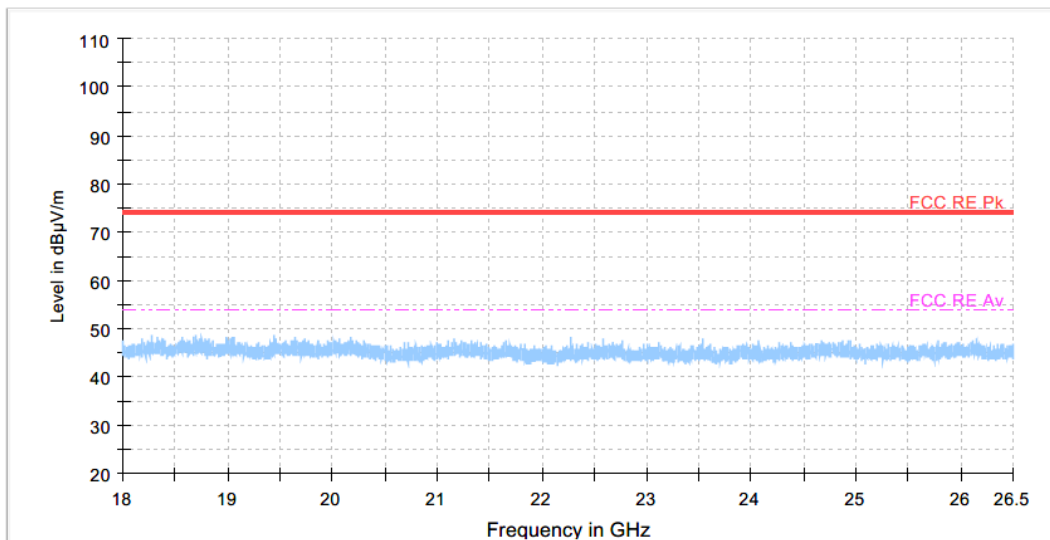
BLE 1Mbps, Middle Channel : 8 GHz to 18 GHz_Peak



BLE 1Mbps, Middle Channel : 8 GHz to 18 GHz_Average

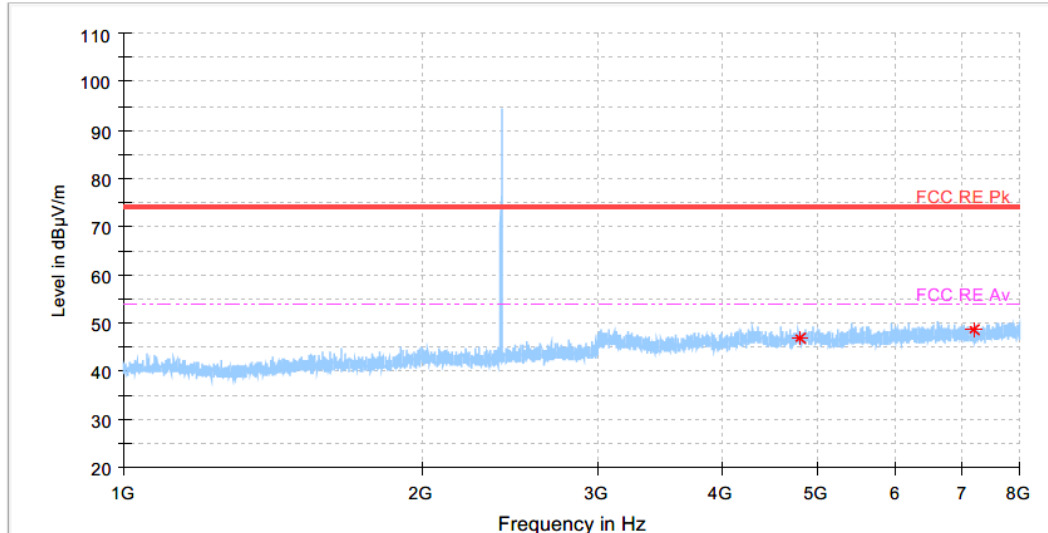


BLE 1Mbps, Middle Channel : 18 GHz to 26.5 GHz_Peak

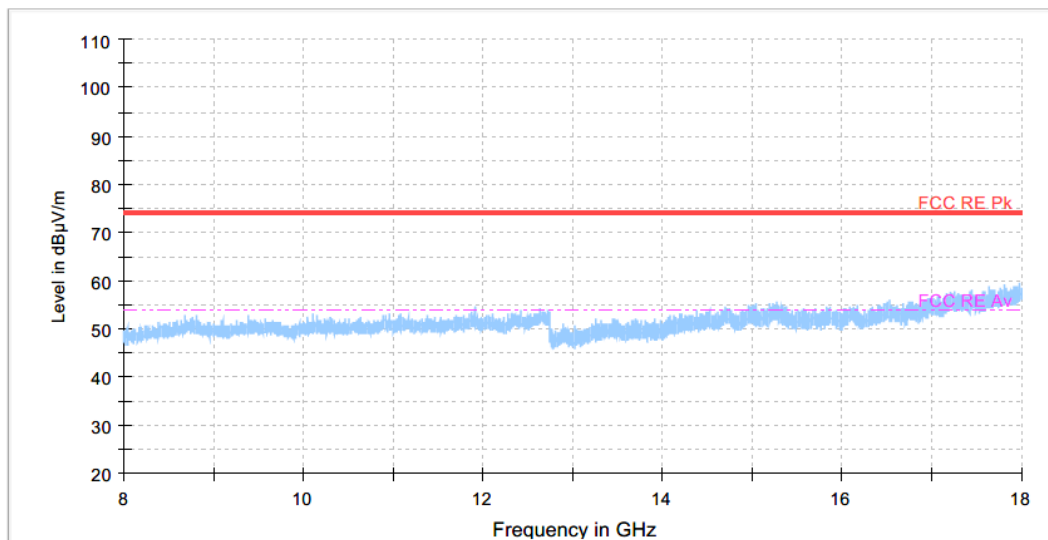


- Right

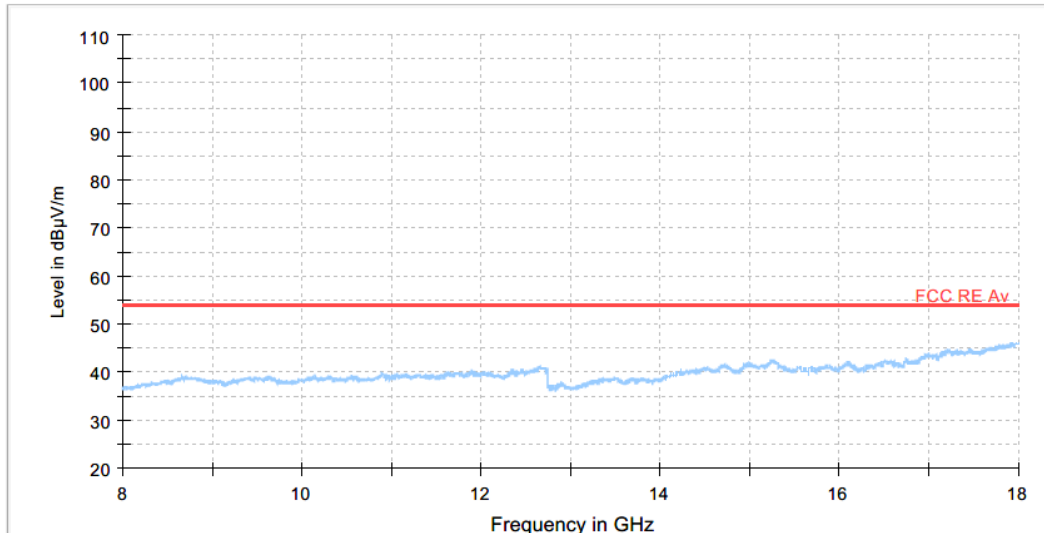
BLE 2Mbps, Lowest Channel : 1 GHz to 8 GHz_Peak



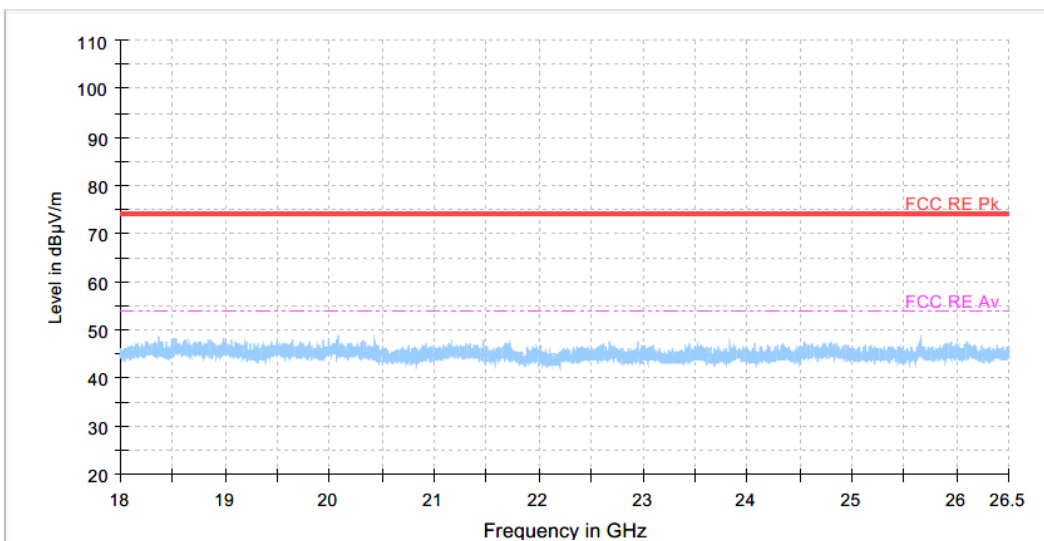
BLE 2Mbps, Lowest Channel : 8 GHz to 18 GHz_Peak



BLE 2Mbps, Lowest Channel : 8 GHz to 18 GHz_Average



BLE 2Mbps, Lowest Channel : 18 GHz to 26.5 GHz_Peak



7.7 Radiated Band Edge

FCC §15.247(d)

Test Mode : Set to Lowest channel and Highest channel

Result

- Left

BLE 1Mbps, Lowest channel

Frequency (MHz)	Reading (dBμV)	Pol* (H/V)	Mode	AF+CL+Amp (dB)**	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)
2 380.40	51.49	H	Peak	-6.1	45.39	74.00	28.61

BLE 1Mbps, Highest channel

Frequency (MHz)	Reading (dBμV)	Pol* (H/V)	Mode	AF+CL+Amp (dB)**	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)
2 498.49	50.27	V	Peak	-5.5	44.77	74.00	29.23

BLE 2Mbps, Lowest channel

Frequency (MHz)	Reading (dBμV)	Pol* (H/V)	Mode	AF+CL+Amp (dB)**	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)
2 335.34	52.35	V	Peak	-6.4	45.95	74.00	28.05

BLE 2Mbps, Highest channel

Frequency (MHz)	Reading (dBμV)	Pol* (H/V)	Mode	AF+CL+Amp (dB)**	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)
2 495.49	49.33	V	Peak	-5.5	43.83	74.00	30.17

Notes:

- *Pol. H = Horizontal V = Vertical
- **AF + CL + Amp. = Antenna Factor + Cable Loss + Amplifier.
- Average measurement was not performed when peak-detected emission complies with the average limit.
- Other spurious was under 20 dB below Fundamental.
- BLE 2Mbps, Lowest channel (2 402 MHz) was the worst condition.
- The radiated emissions testing were made by rotating EUT through three orthogonal axes and rotating the receive antenna with horizontal, Vertical polarization.
- Peak emissions were measured using RBW = 1 MHz, VBW = 3 MHz, Detector = Peak.

- Right

BLE 1Mbps, Lowest channel

Frequency (MHz)	Reading (dBμV)	Pol* (H/V)	Mode	AF+CL+Amp (dB)**	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)
2 386.01	51.50	H	Peak	-6.1	45.40	74.00	28.60

BLE 1Mbps, Highest channel

Frequency (MHz)	Reading (dBμV)	Pol* (H/V)	Mode	AF+CL+Amp (dB)**	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)
2 485.80	49.81	H	Peak	-5.5	44.31	74.00	29.69

BLE 2Mbps, Lowest channel

Frequency (MHz)	Reading (dBμV)	Pol* (H/V)	Mode	AF+CL+Amp (dB)**	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)
2 330.69	52.57	H	Peak	-6.4	46.17	74.00	27.83

BLE 2Mbps, Highest channel

Frequency (MHz)	Reading (dBμV)	Pol* (H/V)	Mode	AF+CL+Amp (dB)**	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)
2 486.34	50.13	H	Peak	-5.5	44.63	74.00	29.37

Notes:

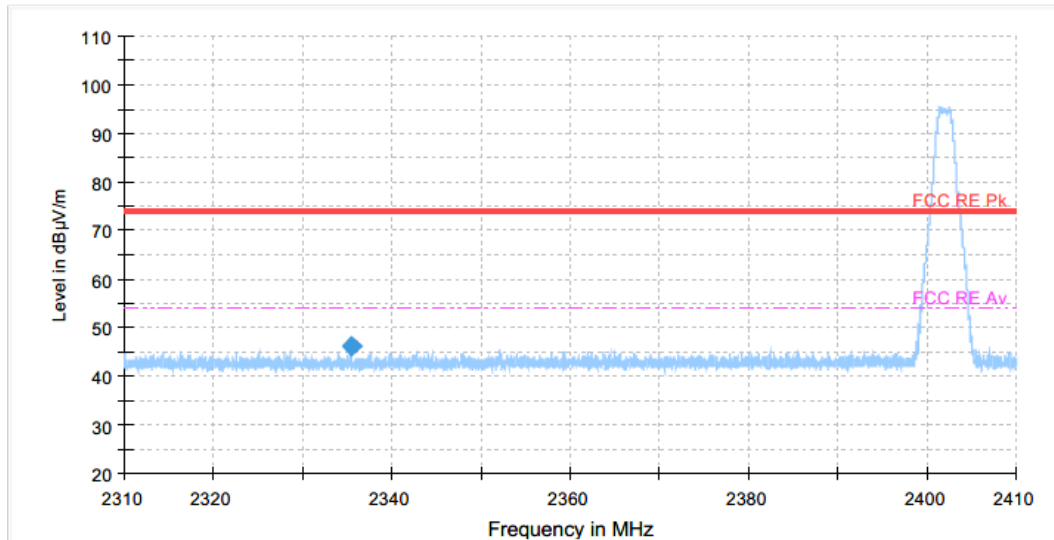
- *Pol. H = Horizontal V = Vertical
- **AF + CL + Amp. = Antenna Factor + Cable Loss + Amplifier.
- Average measurement was not performed when peak-detected emission complies with the average limit.
- Other spurious was under 20 dB below Fundamental.
- BLE 2Mbps, Lowest channel (2 402 MHz) was the worst condition.
- The radiated emissions testing were made by rotating EUT through three orthogonal axes and rotating the receive antenna with horizontal, Vertical polarization.
- Peak emissions were measured using RBW = 1 MHz, VBW = 3 MHz, Detector = Peak.

PLOTS OF EMISSIONS

Worst Case

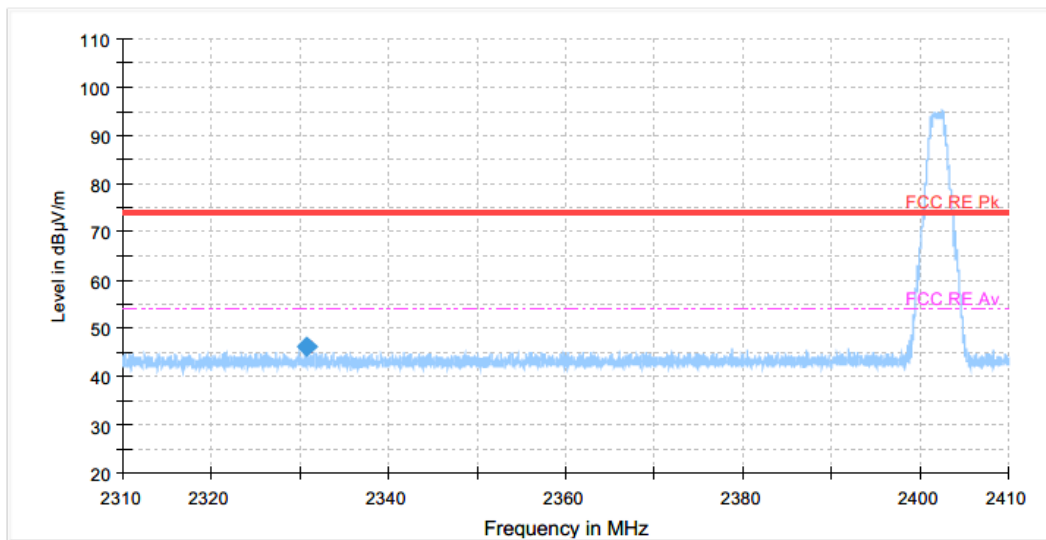
- Left

BLE 2Mbps, Lowest Channel_Peak



- Right

BLE 2Mbps, Lowest Channel_Peak



7.8 Radiated Emissions_Below 1GHz

FCC §15.209

Result

- Left

BLE 2Mbps, Middle channel

Frequency (MHz)	Reading (dBμV)	Pol* (H/V)	Mode	AF+CL+Amp (dB)**	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)
34.69	54.57	V	QP	-26.0	28.57	40.00	11.43
35.98	51.49	V	QP	-25.7	25.79	40.00	14.21
59.59	51.08	V	QP	-23.5	27.58	40.00	12.42
60.88	50.18	V	QP	-23.8	26.38	40.00	13.62
101.46	41.09	V	QP	-24.1	16.99	43.50	26.51
196.36	44.43	V	QP	-23.9	20.53	43.50	22.97

Radiated Measurements at 3meters

- Right

BLE 2Mbps, Middle channel

Frequency (MHz)	Reading (dBμV)	Pol* (H/V)	Mode	AF+CL+Amp (dB)**	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)
35.28	58.02	V	QP	-25.8	32.22	40.00	7.78
60.12	51.99	V	QP	-23.6	28.39	40.00	11.61
98.06	48.56	V	QP	-24.6	23.96	43.50	19.54
102.64	49.23	V	QP	-24.1	25.13	43.50	18.37
158.09	50.65	H	QP	-27.2	23.45	43.50	20.05
193.01	50.36	H	QP	-24.6	25.76	43.50	17.74

Radiated Measurements at 3meters

Notes:

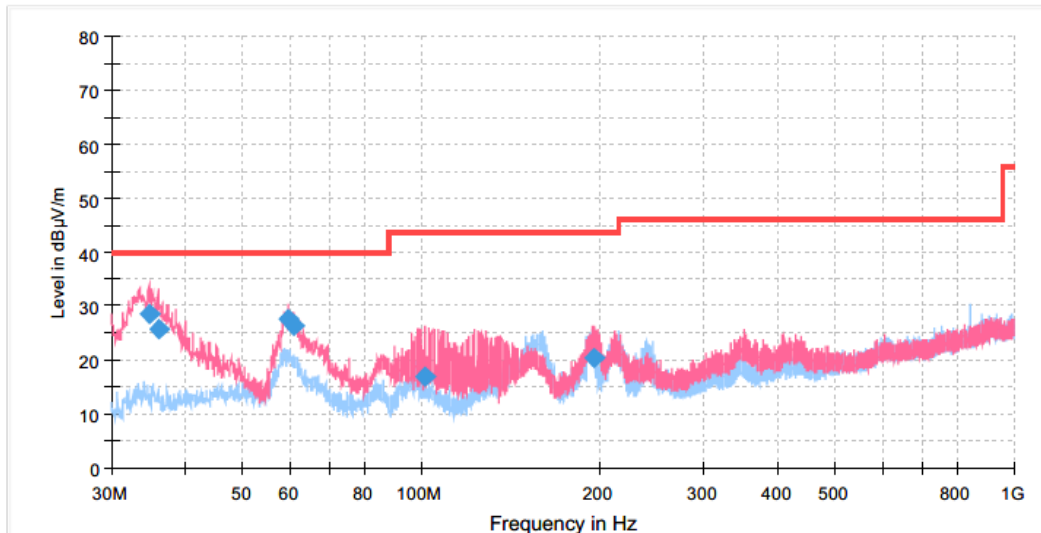
1. The worst-case emission was reported.
2. *Pol. H = Horizontal, V = Vertical
3. **AF + CL + Amp. = Antenna Factor + Cable Loss + Amplifier.
4. Measurements using CISPR quasi-peak mode below 1 GHz.
5. The radiated emissions testing were made by rotating EUT through three orthogonal axes and rotating the receive antenna with horizontal, Vertical polarization. The worst data was recorded.
6. No emission found between lowest internal used/generated frequency to 30MHz (9kHz~30MHz).
Per FCC part 15.31(o), test results were not reported.
Although these tests were performed other than open field test site, adequate comparison measurements were confirmed against 30 m open are test site.
Therefore, sufficient tests were made to demonstrate that the alternative site produces results that correlate with the one of tests made in an open field based on KDB 414788.
7. The limit is on the FCC §15.209.
8. Emission was pre-scanned from 9kHz to 30MHz; No emissions were detected which was at least 20dB below the specification limit (consider distance correction factor).

PLOTS OF EMISSIONS

Worst Case

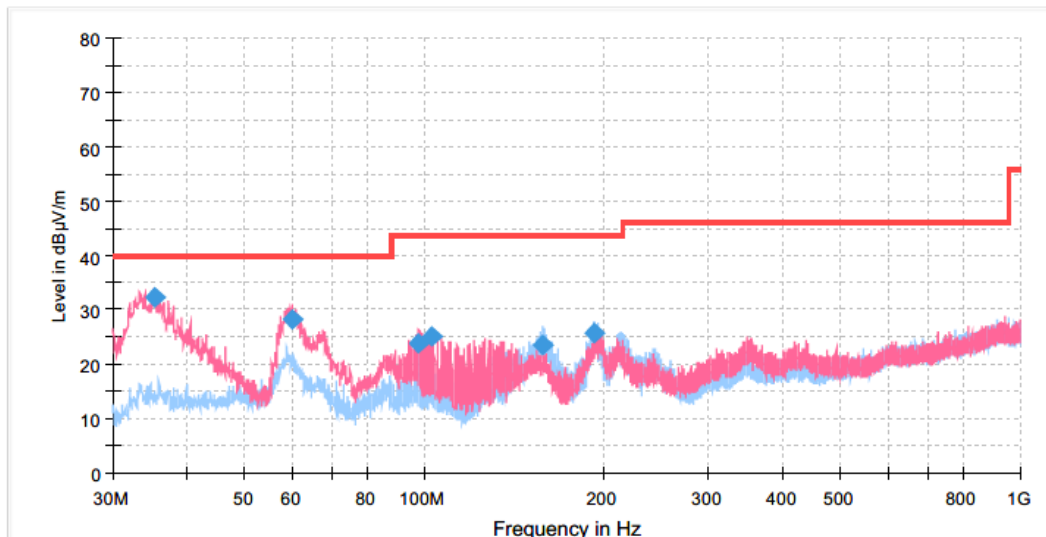
- Left

Radiated emission below 1GHz, BLE 2Mbps, Middle Channel



- Right

Radiated emission below 1GHz, BLE 2Mbps, Middle Channel



TEST DATA

7.9 Conducted

FCC §15.207,

Result : N/P

Note : The AC power line test was not performed because the EUT does not operate Bluetooth mode while charging.

8. TEST EQUIPMENT

No.	Instrument	Manufacture	Model	Serial No.	Calibration Data	Calibration Interval
1	Double Ridged Broadband Horn Antenna	Schwarzbeck	BBHA 9120 D	01615	2022-09-13	2023-09-13
2	SWITCH AND EXTENSION UNIT CAN-BUS	R&S	OSP150	100929	N/A	N/A
3	WiFi Filter Bank	R&S	U082	N/A	N/A	N/A
4	TRILOG Broadband Test Antenna	Schwarzbeck	VULB 9163	01431	2022-11-16	2024-11-16
5	Signal Conditioning Unit	ROHDE & SCHWARZ	SCU 01	10029	2022-04-05	2023-04-05
6	DOUBLE RIDGED HORN ANTENNA	ROHDE & SCHWARZ	HF907	100197	2022-01-28	2023-01-28
7	Signal Conditioning Unit	ROHDE & SCHWARZ	SCU 18	10065	2022-04-05	2023-04-05
8	Horn Antenna	Q-par Angus	QMS-00225	17637	2022-09-13	2023-09-13
9	Signal Conditioning Unit	R&S	SCU-26D	1984522	2022-04-06	2023-04-06
10	LOOP ANTENNA	R&S	HFH2-Z2	100279	2021-03-14	2023-03-14
11	EMI TEST RECEIVER	R&S	ESW44	103091	2022-05-16	2023-05-16
12	DIGITAL MULTIMETER	EZ DIGITAL	DM-334	2111395	2022-10-13	2023-10-13
13	DC POWER SUPPLY	KEYSIGHT	N6953A	MY59130146	2022-07-07	2023-07-07
14	Vector Signal Generator	R&S	SMW200A	105755	2022-04-06	2023-04-06
15	Signal & Spectrum Analyzer	KEYSIGHT	N9030B	MY57144327	2022-04-06	2023-04-06
16	10 dB Attenuator	API technologies corp	40A2W-10	1914	2022-07-06	2023-07-06

*) Test equipment used during the test

9. ACCURACY OF MEASUREMENT & DECISION RULE

9.1 Uncertainty Calculation

The Measurement Uncertainties stated were calculated in accordance with the requirements of measurement uncertainty contained in CISPR 16-4-2 with the confidence level of 95%

PARAMETER	UNCERTAINTY
Conducted Disturbance, 0.15 to 30 MHz	2.44 dB
Radiated Disturbance, 30 MHz to 1 GHz	5.68 dB
Radiated Disturbance, Above 1 GHz	5.06 dB

9.2 Decision rule

Decision rule for statement(s) of conformity is based on Procedure 2, Clause 4.4.3 in IEC Guide 115:2021.

- END REPORT -