

RADIO PERFORMANCE TEST REPORT

Test Report No. : OT-219-RWD-050
Reception No. : 2108003898
Applicant : LG Electronics USA, Inc.
Address : 111 Sylvan Ave, North Building, Englewood Cliffs, New Jersey, United States
Manufacturer : LG Electronics Inc.
Address : 222 LG-ro Jinwi-myeon, Pyeongtaek-si, Gyeonggi-do, Korea
Type of Equipment : Bluetooth Earbud
FCC ID. : ZNFTONEFP3
Model Name : TONE-FP3
Multiple Model Name : TONE-FP3W, TONE-TFP3, TONE-TFP3W, TONE-UFP3, TONE-UFP3W, TONE-DFP3, TONE-DFP3W
Serial number : N/A
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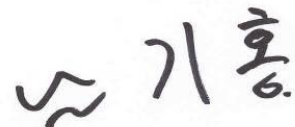
SUMMARY

The equipment complies with the regulation; **FCC PART 15 SUBPART C Section 15.247**

This test report only contains the result of a single test of the sample supplied for the examination.

It is not a generally valid assessment of the features of the respective products of the mass-production.





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Revision History

Rev. No.	Issue Report No.	Issued Date	Revisions	Section Affected
0	OT-219-RWD-050	September 28, 2021	Initial Release	All

1. VERIFICATION OF COMPLIANCE

Applicant : LG Electronics USA, Inc.

Address : 111 Sylvan Ave, North Building, Englewood Cliffs, New Jersey, United States

Contact Person : Dae Woong Kim / Director, Regulatory and Environmental Affairs

Telephone No. : 201-266-2215

FCC ID : ZNFTONEFP3

Model Name : TONE-FP3

Brand Name : LG

Serial Number : N/A

Date : September 28, 2021

EQUIPMENT CLASS	DTS – DIGITAL TRNSMISSION SYSTEM
E.U.T. DESCRIPTION	Bluetooth Earbud
THIS REPORT CONCERNS	Original Grant
MEASUREMENT PROCEDURES	ANSI C63.10: 2020
TYPE OF EQUIPMENT TESTED	Pre-Production
KIND OF EQUIPMENT AUTHORIZATION REQUESTED	Certification
EQUIPMENT WILL BE OPERATED UNDER FCC RULES PART(S)	FCC PART 15 SUBPART C Section 15.247 KDB 558074 D01 15.247 Meas Guidance v05r02
Modifications on the Equipment to Achieve Compliance	None
Final Test was Conducted On	3 m, Semi Anechoic Chamber

-. The above equipment was tested by ONETECH Corp. for compliance with the requirement set forth in the FCC Rules and Regulations. This said equipment in the configuration described in this report, shows the maximum emission levels emanating from equipment are within the compliance requirements.

2. TEST SUMMARY

2.1 Test items and results

SECTION	TEST ITEMS	RESULTS
15.247 (a) (2)	Minimum 6 dB Bandwidth	Met the Limit / PASS
15.247 (b) (3)	Maximum Peak Conducted Output Power	Met the Limit / PASS
15.247 (d)	100 kHz Bandwidth Outside the Frequency Band	Met the Limit / PASS
15.247 (d)	Radiated Emission which fall in the Restricted Band	Met the Limit / PASS
15.247 (e)	Peak Power Spectral Density	Met the Limit / PASS
15.209	Radiated Emission Limits	Met the Limit / PASS
15.207	Conducted Limits	N/A (See Note)
15.203	Antenna Requirement	Met requirement / PASS

Note. : This test is not performed because the EUT is operated by DC battery.

2.2 Additions, deviations, exclusions from standards

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

2.3 Related Submittal(s) / Grant(s)

Original submittal only

2.4 Purpose of the test

To determine whether the equipment under test fulfills the requirements of the regulation stated in FCC PART 15 SUBPART C Section 15.247.

2.5 Test Methodology

Both conducted and radiated testing was performed according to the procedures in ANSI C63.10: 2020. Radiated testing was performed at a distance of 3 m from EUT to the antenna.

2.6 Test Facility

The Onetech Corp. has been designated to perform equipment testing in compliance with ISO/IEC 17025.

The Electromagnetic compatibility measurement facilities are located at 43-14, Jinsaegol-gil, Chowol-eup, Gwangju-si, Gyeonggi-do, 12735, Korea.

-. Site Filing:

VCCI (Voluntary Control Council for Interference) – Registration No. R-20122/ C-14617/ G-10666/ T-11842

ISED (Innovation, Science and Economic Development Canada) – Registration No. Site# 3736A-3

KOLAS (Korea Laboratory Accreditation Scheme) - Accreditation NO. KT085

FCC (Federal Communications Commission) - Accreditation No. KR0013

RRA (Radio Research Agency) – Designation No. KR0013

3. GENERAL INFORMATION

3.1 Product Description

The LG Electronics USA, Inc., Model TONE-FP3 (referred to as the EUT in this report) is a Bluetooth Earbud. The product specification described herein was obtained from product data sheet or user's manual.

Device Type		Bluetooth Earbud		
Operating Frequency		Bluetooth	2 402 MHz ~ 2 480 MHz	
		Bluetooth LE		
RF Output Power	Left Earbud	Bluetooth	1 Mbps	11.46 dBm
			2 Mbps	11.40 dBm
			3 Mbps	11.58 dBm
		Bluetooth LE	1 Mbps	8.89 dBm
			2 Mbps	8.82 dBm
	Right Earbud	Bluetooth	1 Mbps	11.34 dBm
			2 Mbps	11.15 dBm
			3 Mbps	11.39 dBm
		Bluetooth LE	1 Mbps	9.44 dBm
2 Mbps	9.56 dBm			
Number of Channel		Bluetooth	79 Channels	
		Bluetooth LE	40 Channels	
Modulation Type		Bluetooth	GFSK for 1 Mbps, $\pi/4$ -DQPSK for 2 Mbps, 8-DPSK for 3 Mbps	
		Bluetooth LE	GFSK	
Antenna Type	Left Earbud	FPCB Antenna		
	Right Earbud			
Antenna Gain	Left Earbud	-0.5 dBi		
	Right Earbud	-0.5 dBi		
List of each Osc. or crystal Freq.(Freq. $\geq$ 1 MHz)		40 MHz		
Rated Supply Voltage		DC 3.7 V		

3.2 Alternative type(s)/model(s); also covered by this test report.

-. The following lists consist of the added model and their differences.

Model Name	Differences	Tested
TONE-FP3	Basic Model	☒
TONE-FP3W	This model is different from the basic model in color and country of sale. (Color: White / Country of sale: Global)	☐
TONE-TFP3	This model is different from the basic model in color and country of sale. (Color: Black / Country of sale: Korea)	☐
TONE-TFP3W	This model is different from the basic model in color and country of sale. (Color: White / Country of sale: Korea)	☐
TONE-UFP3	This model is different from the basic model in color and country of sale. (Color: Black / Country of sale: England)	☐
TONE-UFP3W	This model is different from the basic model in color and country of sale. (Color: White / Country of sale: England)	☐
TONE-DFP3	This model is different from the basic model in color and country of sale. (Color: Black / Country of sale: Germany)	☐
TONE-DFP3W	This model is different from the basic model in color and country of sale. (Color: White / Country of sale: Germany)	☐

Note: 1. Applicant consigns only basic model to test. Therefore, this test report just guarantees the units, which have been tested.

2. The Applicant/manufacturer is responsible for the compliance of all variants.

4. EUT MODIFICATIONS

-. None

5. SYSTEM TEST CONFIGURATION

5.1 Justification

This device was configured for testing in a typical way as a normal customer is supposed to be used. During the test, the following components were installed inside of the EUT.

DEVICE TYPE	MANUFACTURER	MODEL/PART NUMBER	FCC ID
Main Board	LG Electronics Inc.	N/A	N/A
Battery	LG Electronics Inc.	N/A	N/A

5.2 Peripheral equipment

Defined as equipment needed for correct operation of the EUT, but not considered as tested:

Model	Manufacturer	Description	Connected to
TONE-FP3	LG Electronics Inc.	Bluetooth Earbud (EUT)	
Ideapad 330-15IKB	Lenovo	Notebook PC	EUT
TC-3000C	TESCOM	BLUETOOTH TESTER	EUT

5.3 Mode of operation during the test

For the testing, software used to control the EUT for staying in continuous transmitting is programmed.

For final testing, the EUT was set at 2 402 MHz, 2 440 MHz, and 2 480 MHz to get a maximum emission levels from the EUT. The EUT was moved throughout the XY, XZ, and YZ planes and the worst case is “XY” axis, but the worst data was recorded in this report.

-. Frequency / Channel Operations

Channel	Frequency
0	2 402
19	2 440
39	2 480

Duty cycle for Bluetooth LE 1 Mbps

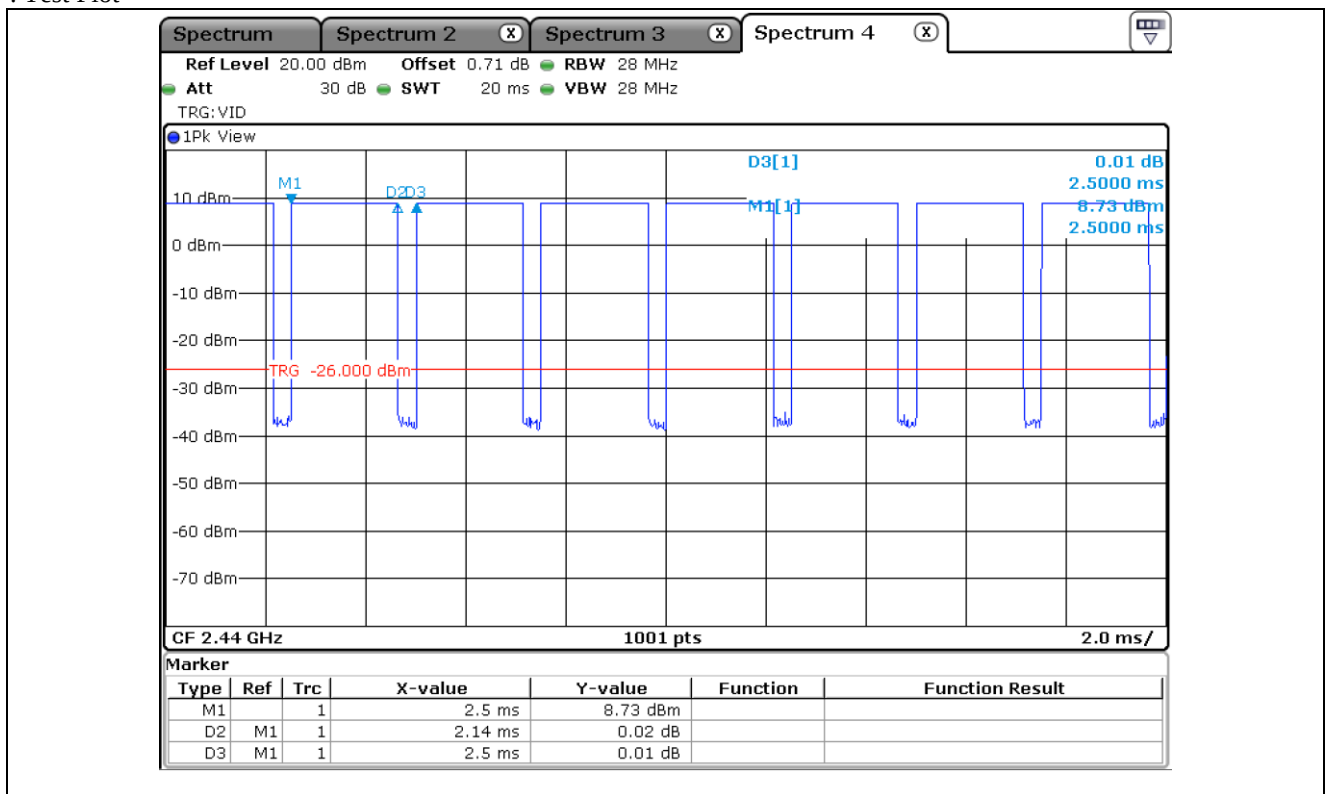
-. Left Earbud

Mode	Tx On Time [ms]	Tx Off Time [ms]	Duty Cycle [%]	Correction Factor [dB]
Bluetooth LE	2.14	0.36	85.60	0.68

Note – Duty Cycle : (Tx On Time / (Tx On Time + Tx Off Time)) * 100

Correction Factor : $10 * \log(1 / (\text{Duty Cycle} / 100))$

-. Test Plot



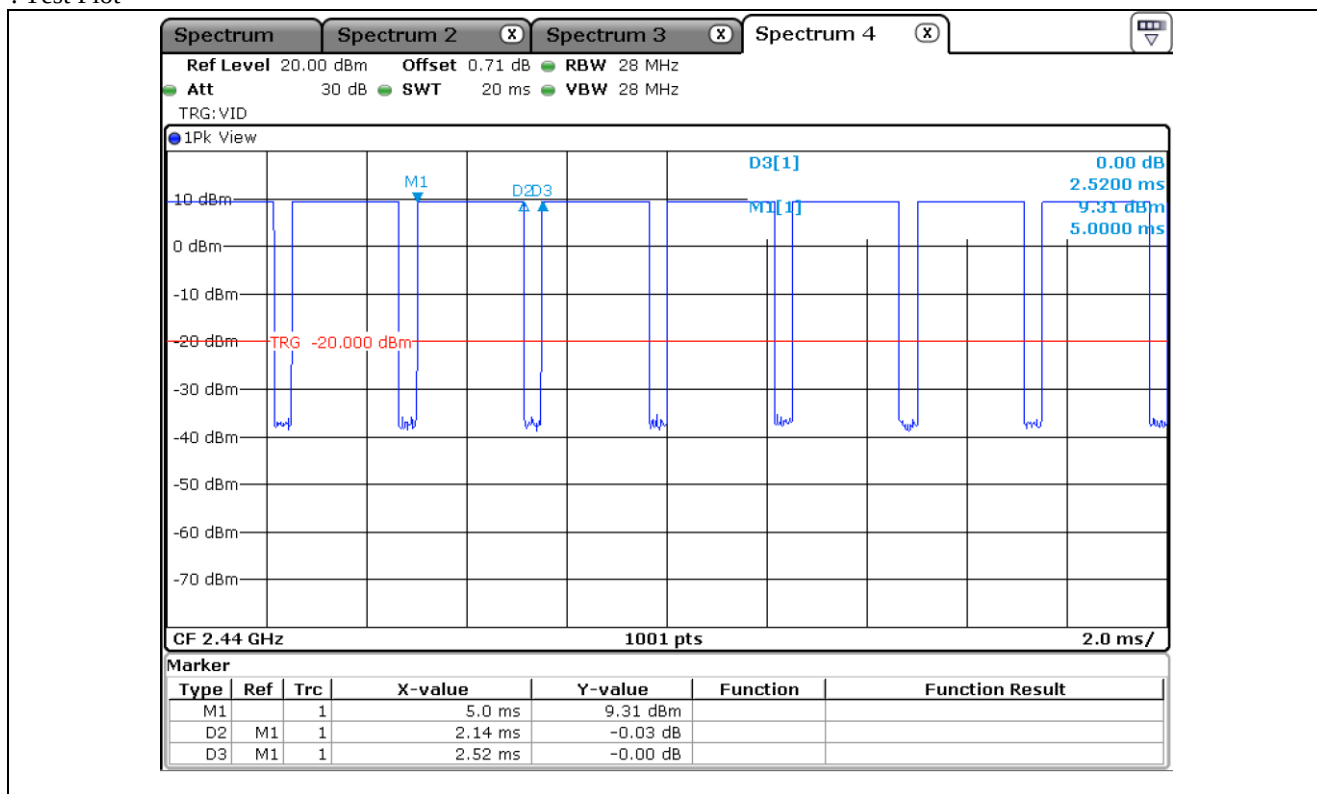
- Right Earbud

Mode	Tx On Time [ms]	Tx Off Time [ms]	Duty Cycle [%]	Correction Factor [dB]
Bluetooth LE	2.14	0.38	84.92	0.71

Note – Duty Cycle : (Tx On Time / (Tx On Time + Tx Off Time)) * 100

Correction Factor : 10 * Log(1 / (Duty Cycle / 100))

- Test Plot



Duty cycle for Bluetooth LE 2 Mbps

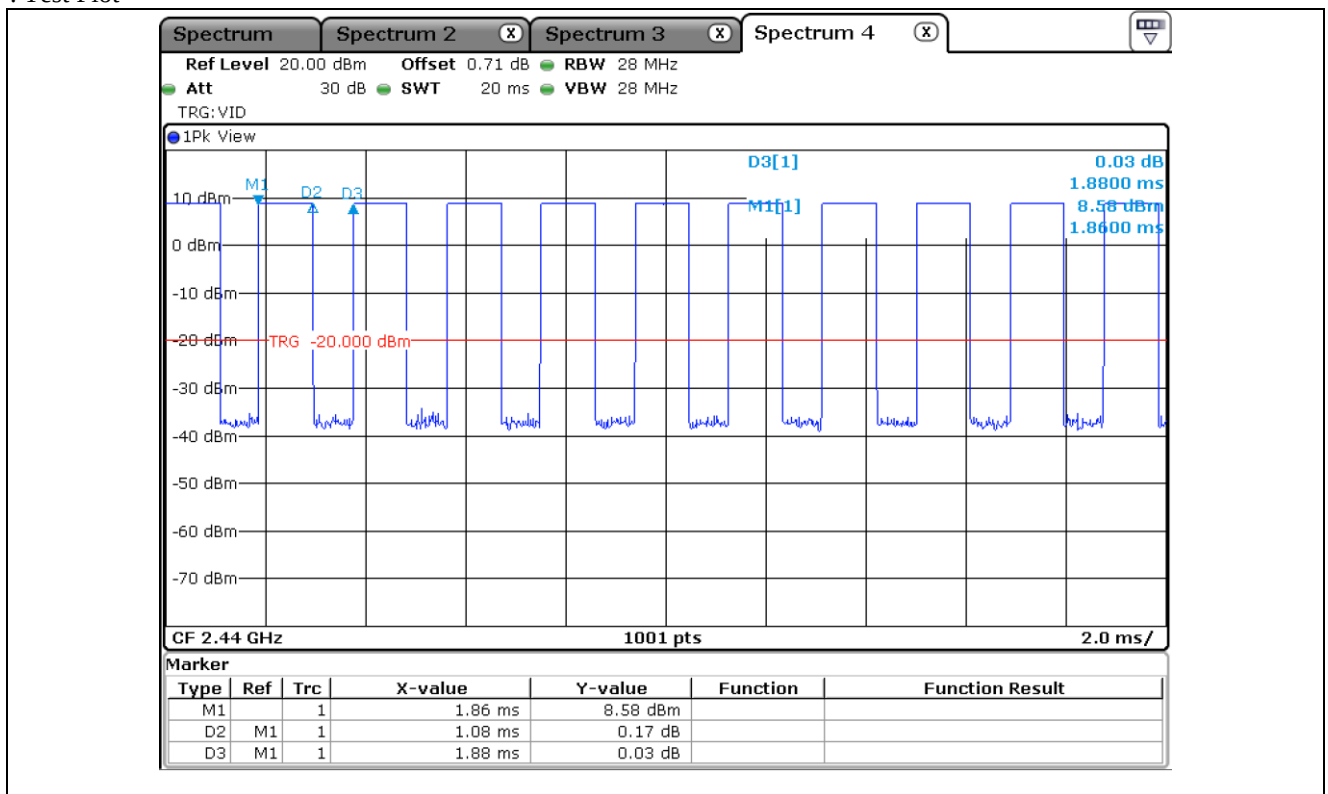
-. Left Earbud

Mode	Tx On Time [ms]	Tx Off Time [ms]	Duty Cycle [%]	Correction Factor [dB]
Bluetooth LE	1.08	0.80	57.45	2.41

Note – Duty Cycle : (Tx On Time / (Tx On Time + Tx Off Time)) * 100

Correction Factor : 10 * Log(1 / (Duty Cycle / 100))

-. Test Plot



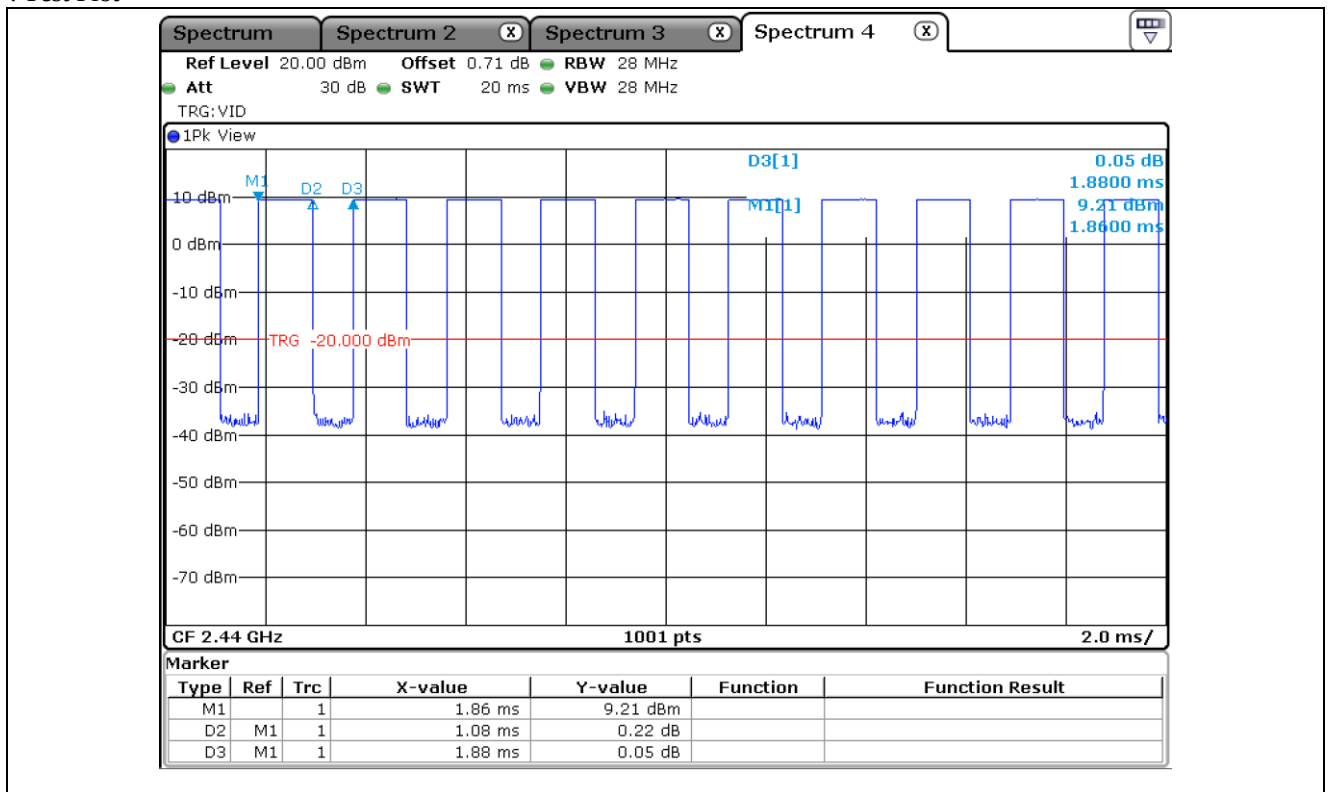
- Right Earbud

Mode	Tx On Time [ms]	Tx Off Time [ms]	Duty Cycle [%]	Correction Factor [dB]
Bluetooth LE	1.08	0.80	57.45	2.41

Note – Duty Cycle : (Tx On Time / (Tx On Time + Tx Off Time)) * 100

Correction Factor : 10 * Log(1 / (Duty Cycle / 100))

- Test Plot



5.4 Configuration of Test System

Line Conducted Test: As the EUT is operated by DC battery, this test item is not requirement to be performed.

Radiated Emission Test: Preliminary radiated emissions test were conducted using the procedure in ANSI C63.10: 2020 to determine the worse operating conditions. Final radiated emission tests were conducted at 3 meter Semi Anechoic Chamber.

The turntable was rotated through 360 degrees and the EUT was tested by positioned three orthogonal planes to obtain the highest reading on the field strength meter. Once maximum reading was determined, the search antenna was raised and lowered in both vertical and horizontal polarization.

5.5 Antenna Requirement

For intentional device, according to section 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.

Antenna Construction:

The antenna of the EUT is a FPCB Antenna on the main board in the EUT, so no consideration of replacement by the user.

6. PRELIMINARY TEST

6.1 AC Power line Conducted Emissions Tests

During Preliminary Test, the following operating mode was investigated.

Operation Mode	The Worse operating condition (Please check one only)
This test is not performed because the EUT is wireless function does not work while charging mode.	

6.2 General Radiated Emissions Tests

During Preliminary Test, the following operating mode was investigated.

Operation Mode	The Worse operating condition (Please check one only)
Transmitting Mode	X

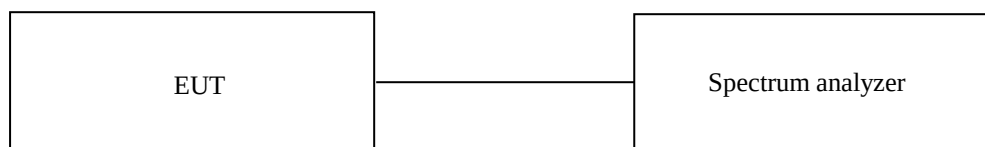
7. MINIMUM 6 dB BANDWIDTH

7.1 Operating environment

Temperature : 22 °C
Relative humidity : 46 % R.H.

7.2 Test set-up

The antenna output of the EUT was connected to the spectrum analyzer. The resolution bandwidth is set to 100 kHz, and peak detection was used. The 6 dB bandwidth is defined as the total spectrum over which the power is higher than the peak power minus 6 dB.



7.3 Test Date

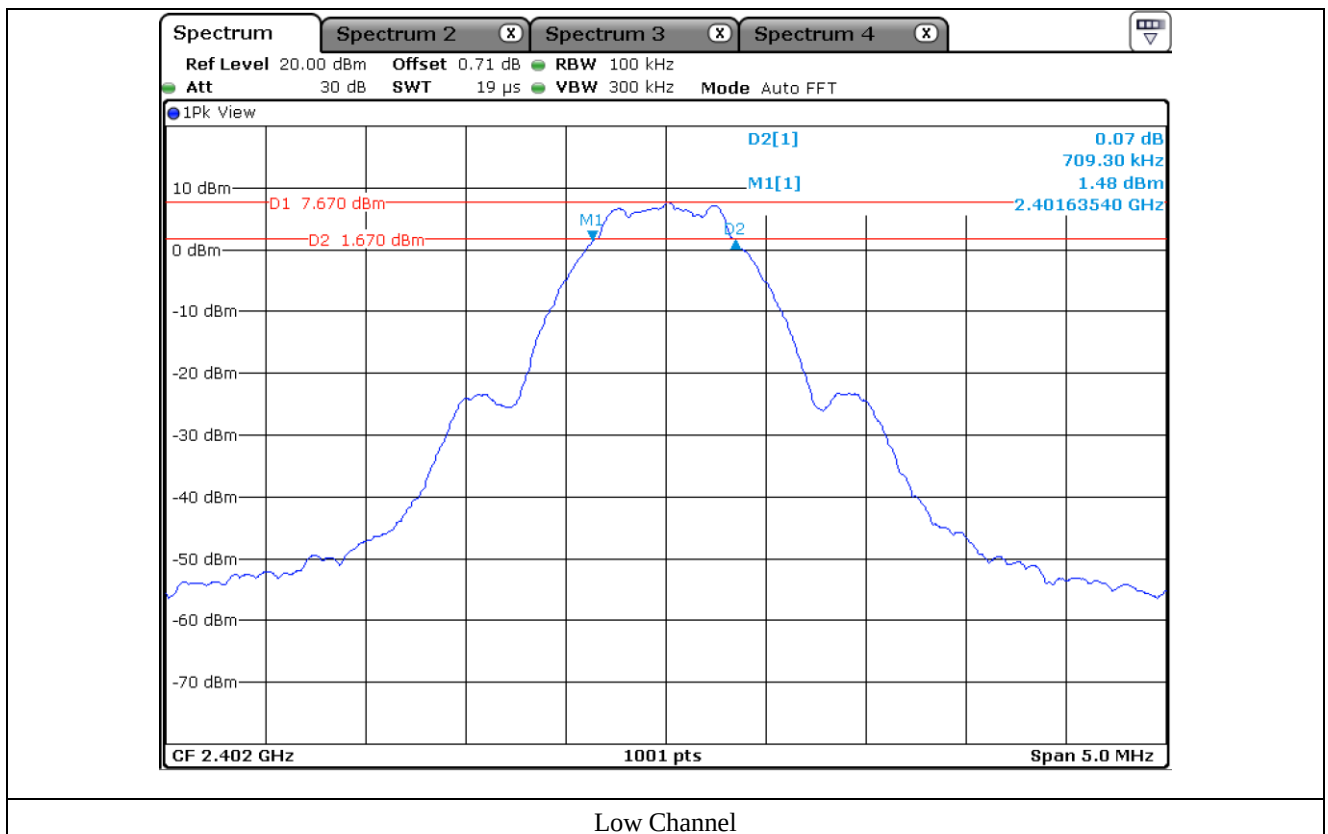
September 10, 2021 ~ September 15, 2021

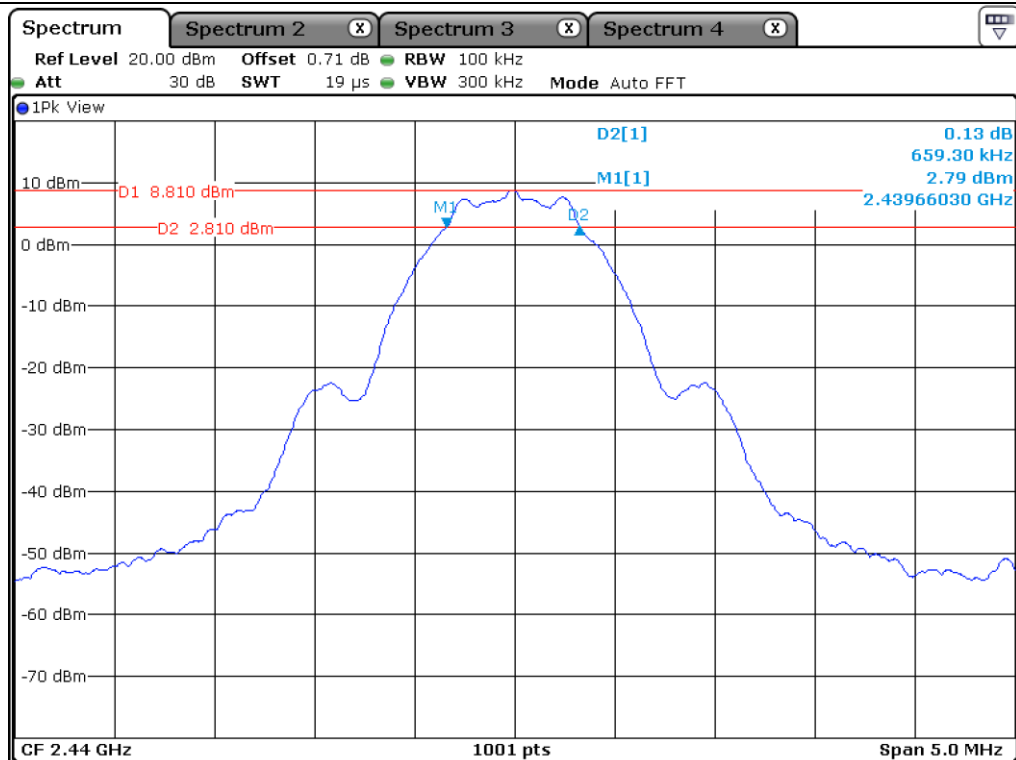
7.4 Test data for Bluetooth LE 1 Mbps

7.4.1 Test data for Left Earbud

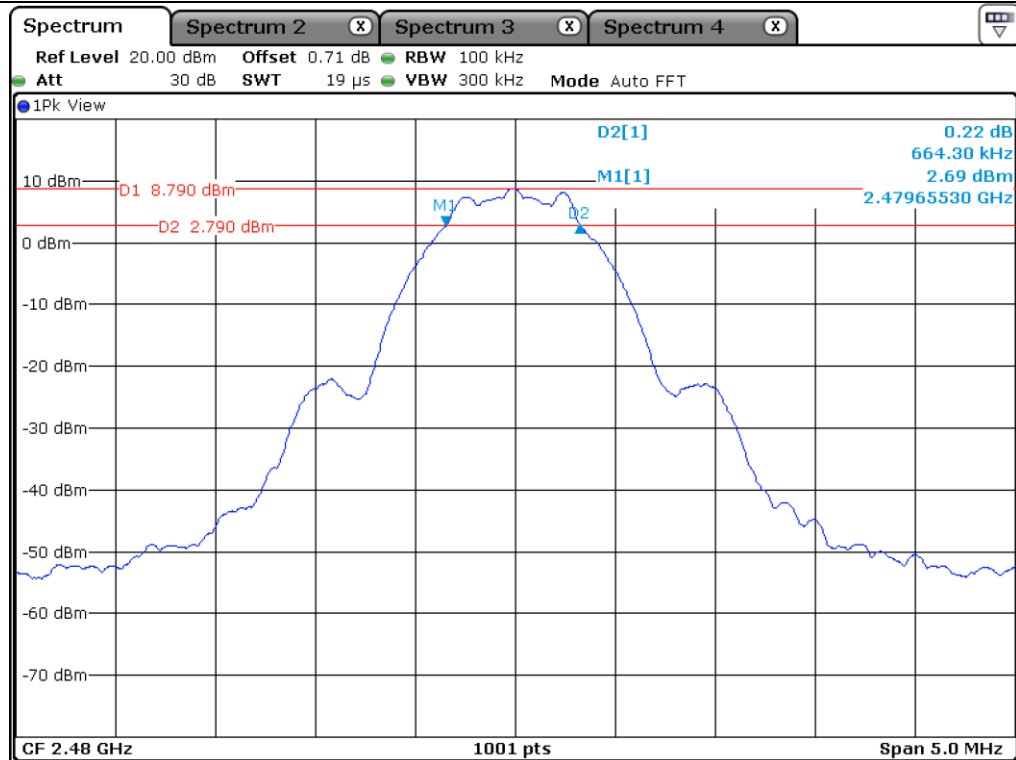
CHANNEL	FREQUENCY(MHz)	MEASURED VALUE (kHz)	LIMIT (kHz)	MARGIN (kHz)
Low	2 402.00	709.30	500.00	209.30
Middle	2 440.00	659.30	500.00	159.30
High	2 480.00	664.30	500.00	164.30

Remark. Margin = Measured Value - Limit





Middle Channel

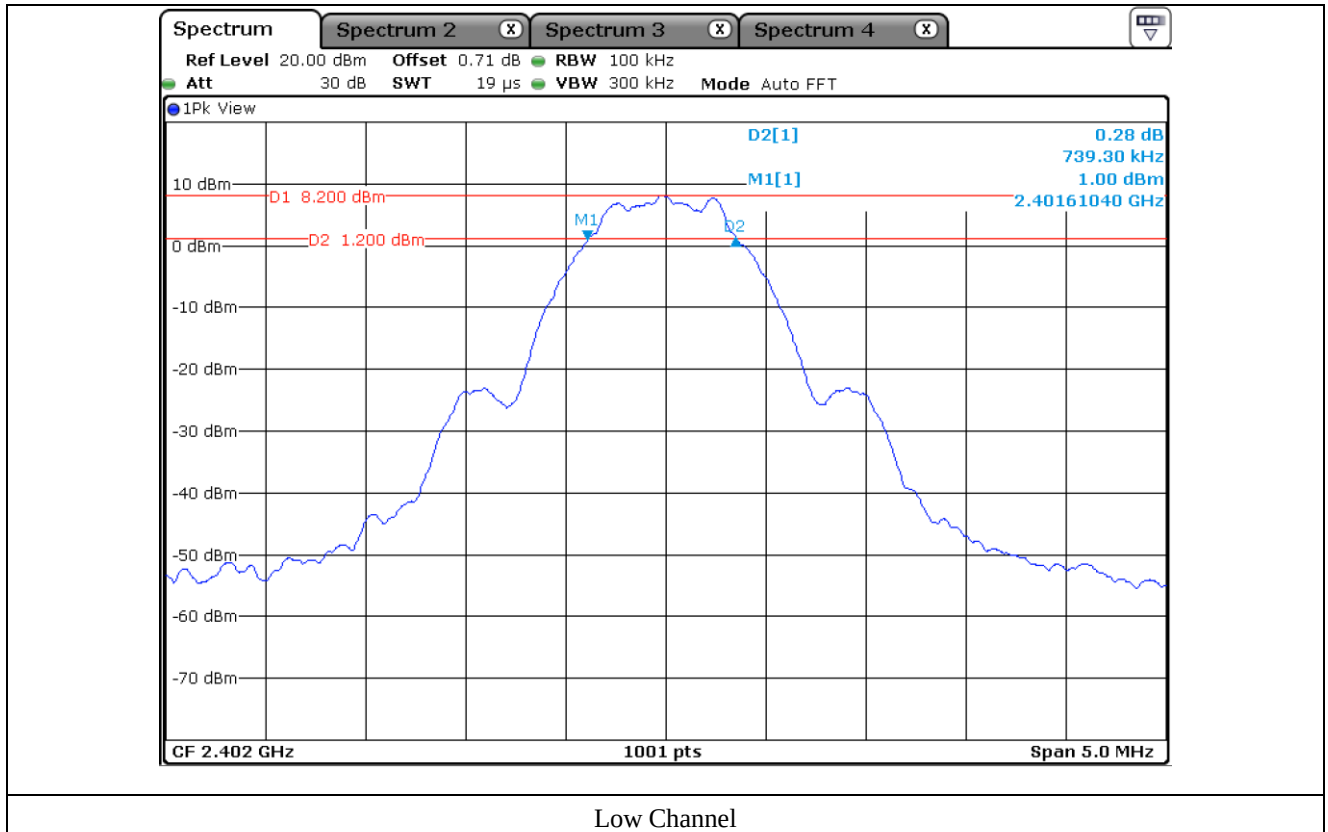


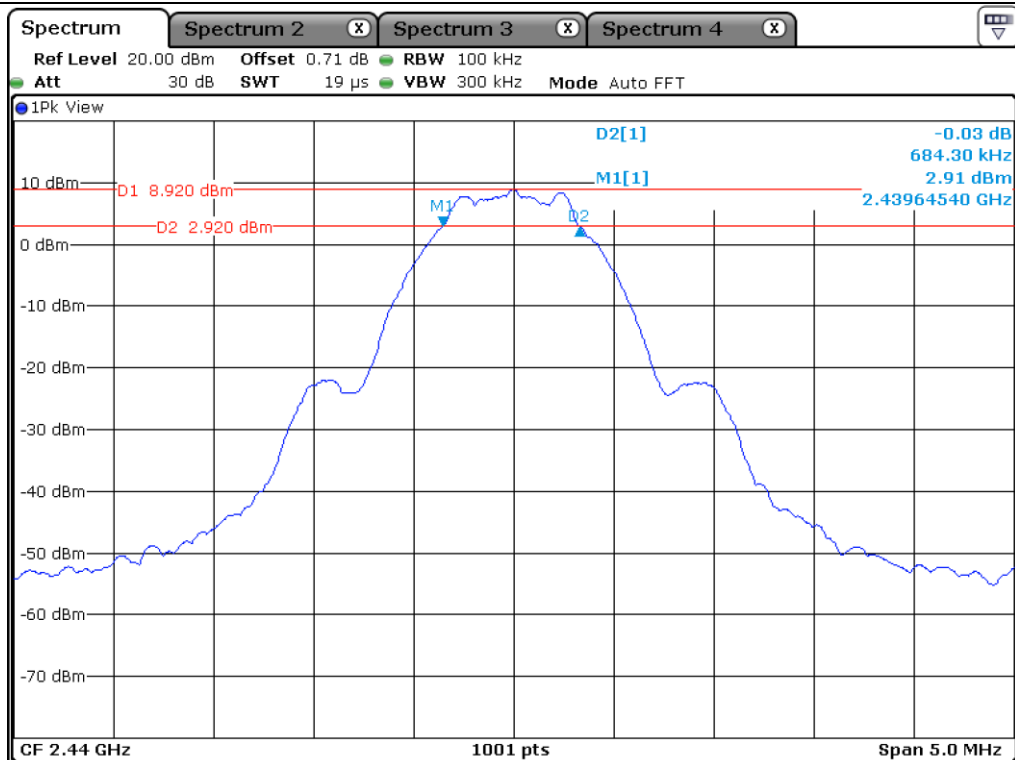
High Channel

7.4.2 Test data for Right Earbud

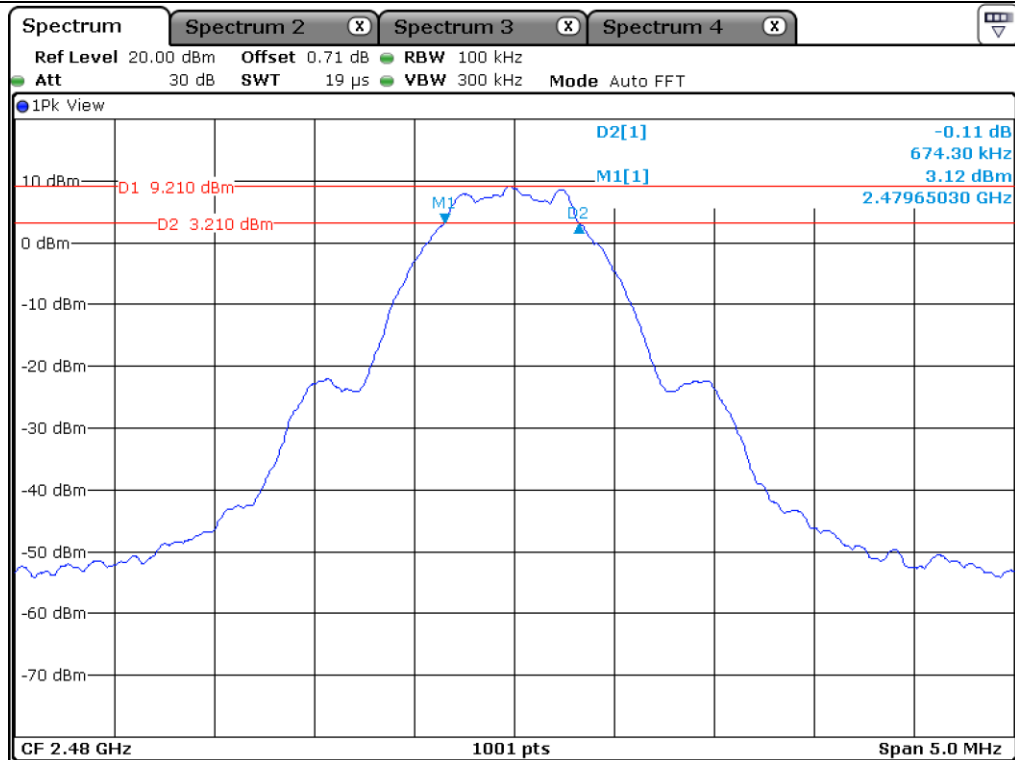
CHANNEL	FREQUENCY(MHz)	MEASURED VALUE (kHz)	LIMIT (kHz)	MARGIN (kHz)
Low	2 402.00	739.30	500.00	239.30
Middle	2 440.00	684.30	500.00	184.30
High	2 480.00	674.30	500.00	174.30

Remark. Margin = Measured Value - Limit





Middle Channel



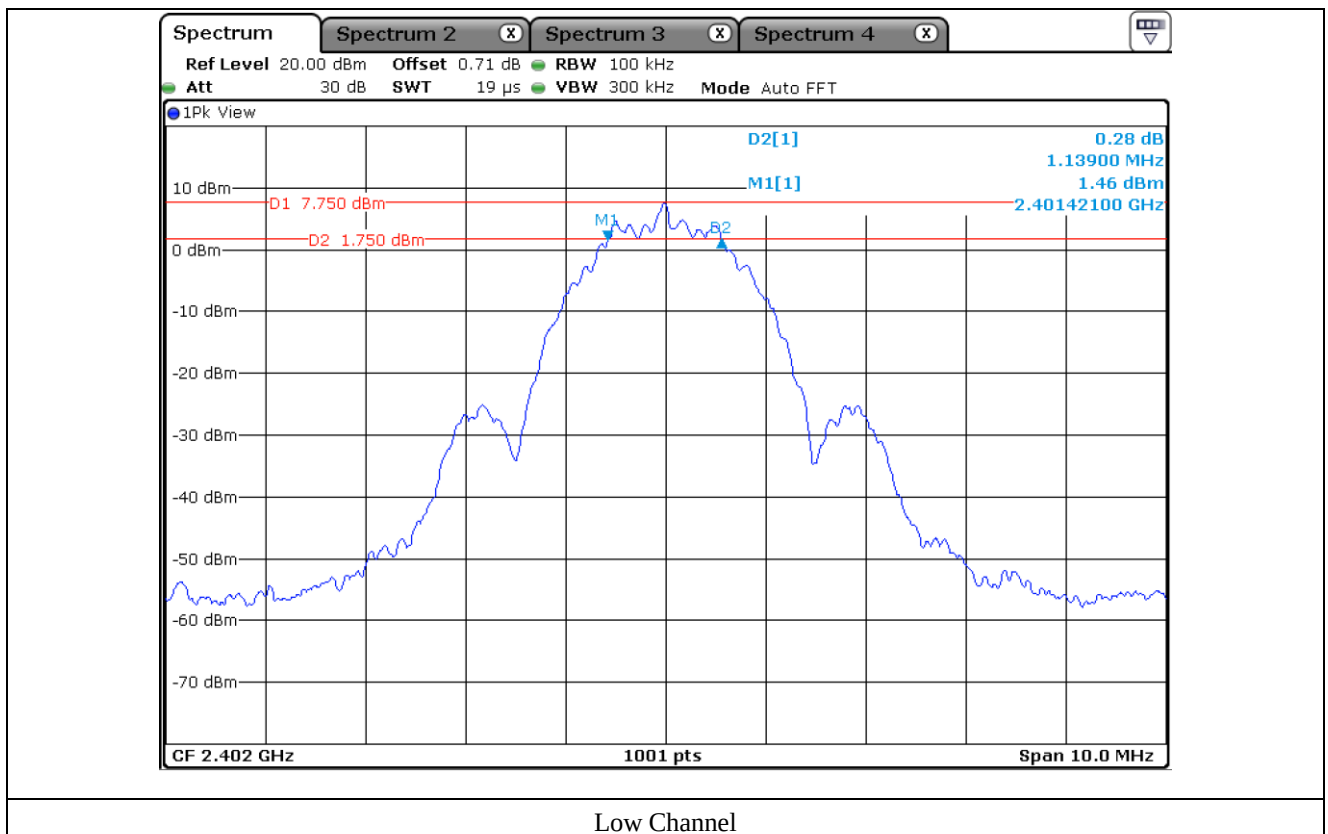
High Channel

7.5 Test data for Bluetooth LE 2 Mbps

7.5.1 Test data for Left Earbud

CHANNEL	FREQUENCY(MHz)	MEASURED VALUE (kHz)	LIMIT (kHz)	MARGIN (kHz)
Low	2 402.00	1 139.00	500.00	639.00
Middle	2 440.00	1 139.00	500.00	639.00
High	2 480.00	1 129.00	500.00	629.00

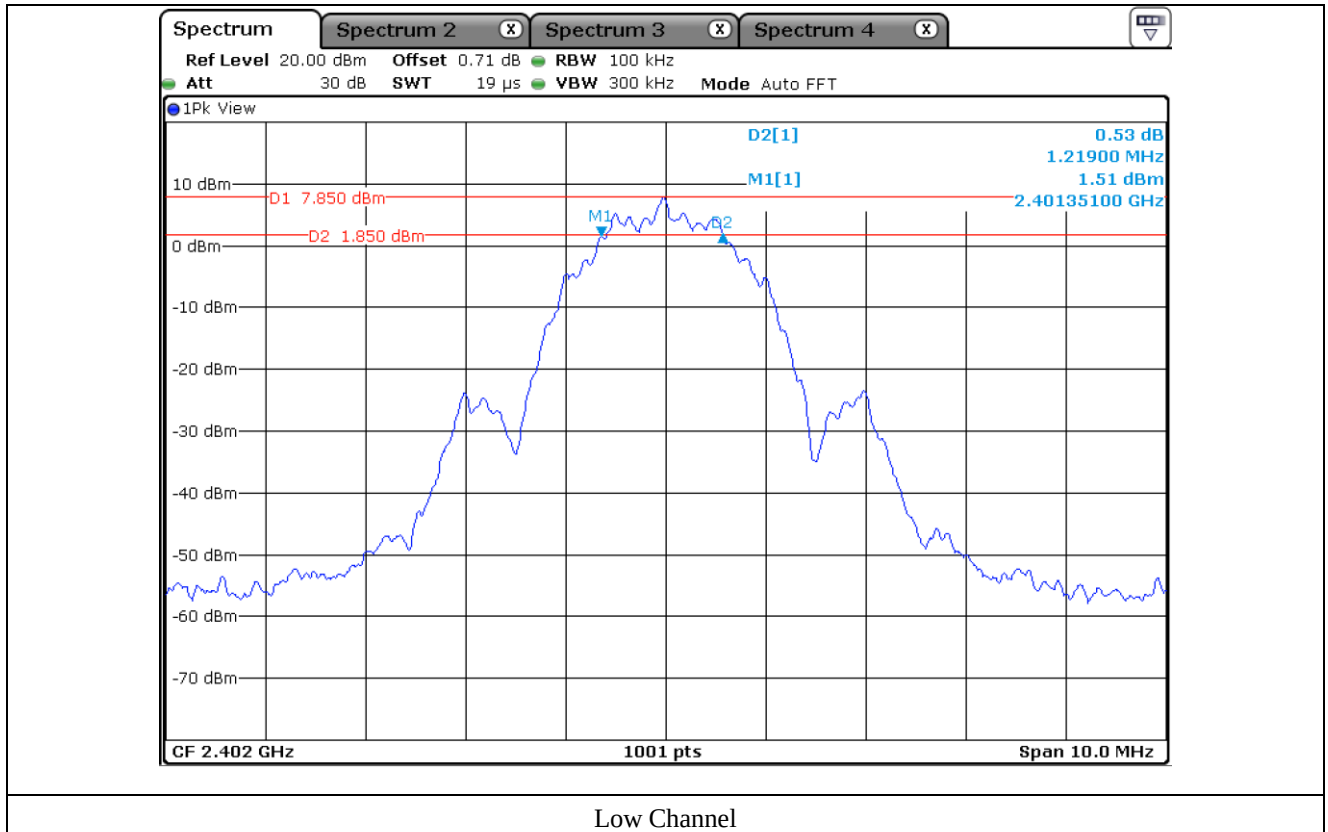
Remark. Margin = Measured Value - Limit

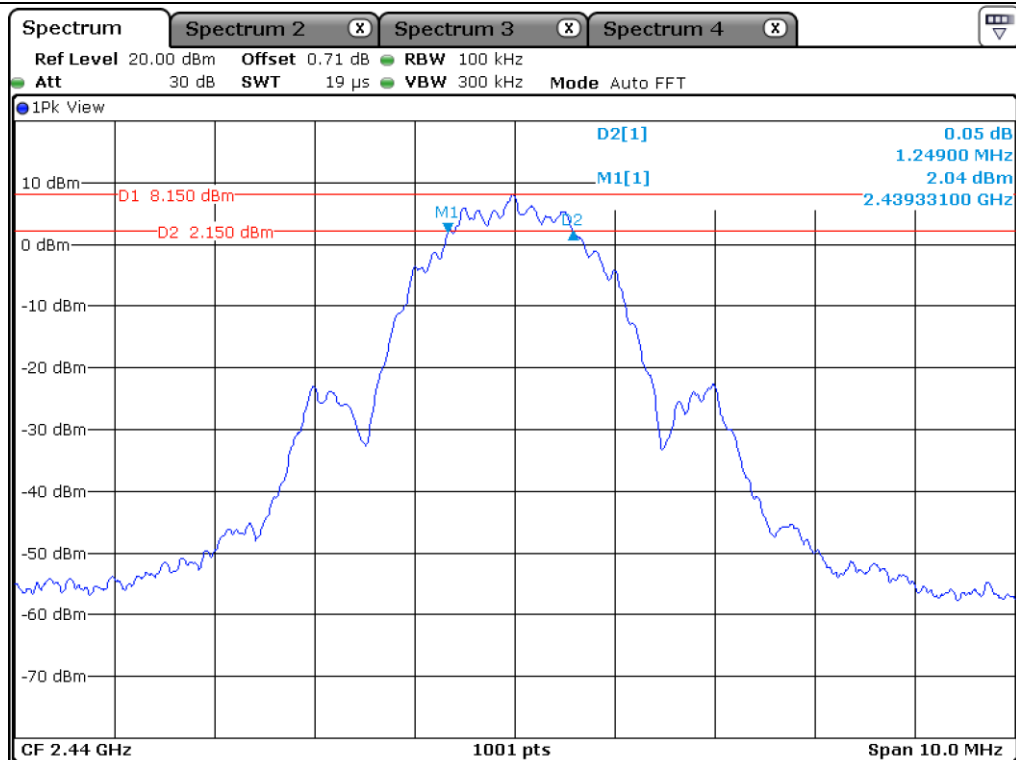


7.5.2 Test data for Right Earbud

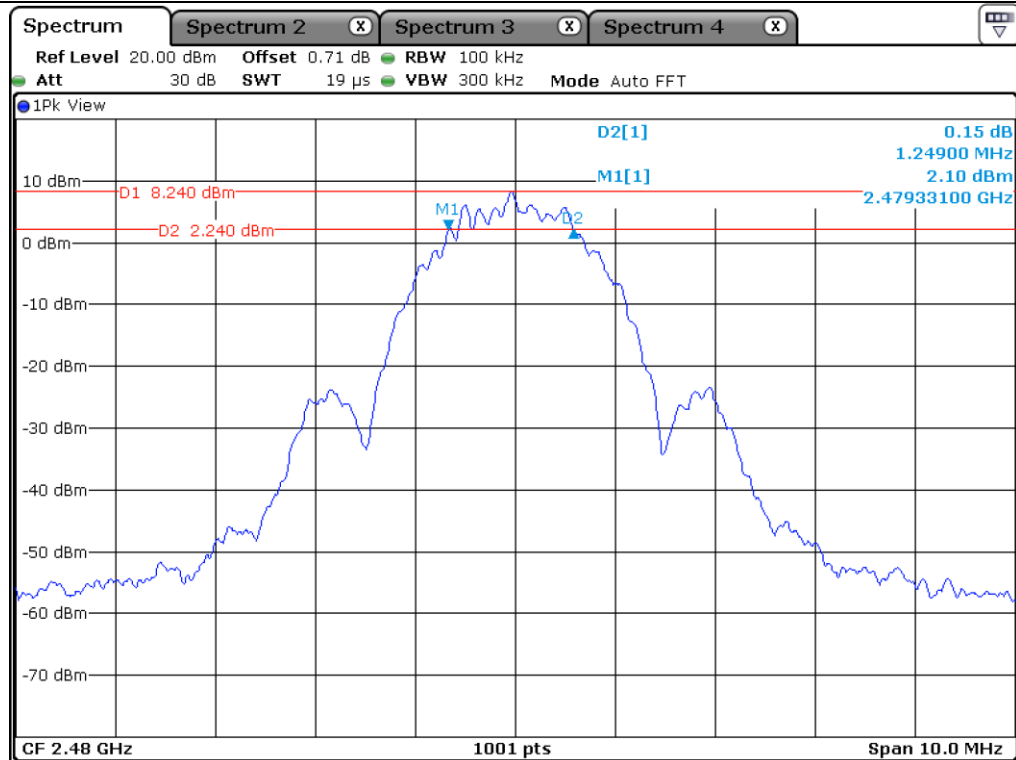
CHANNEL	FREQUENCY(MHz)	MEASURED VALUE (kHz)	LIMIT (kHz)	MARGIN (kHz)
Low	2 402.00	1 219.00	500.00	719.00
Middle	2 440.00	1 249.00	500.00	749.00
High	2 480.00	1 249.00	500.00	749.00

Remark. Margin = Measured Value - Limit





Middle Channel



High Channel

8. MAXIMUM PEAK OUTPUT POWER

8.1 Operating environment

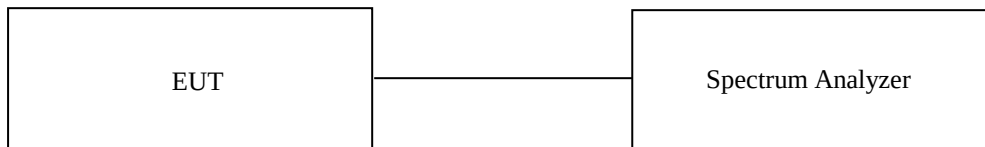
Temperature : 22 °C

Relative humidity : 46 % R.H.

8.2 Test set-up

The antenna output of the EUT was connected to the spectrum analyzer.

The resolution bandwidth is set to $\geq$ DTS Bandwidth, the video bandwidth is set to 3 times the resolution bandwidth.



8.3 Test Date

September 10, 2021 ~ September 15, 2021

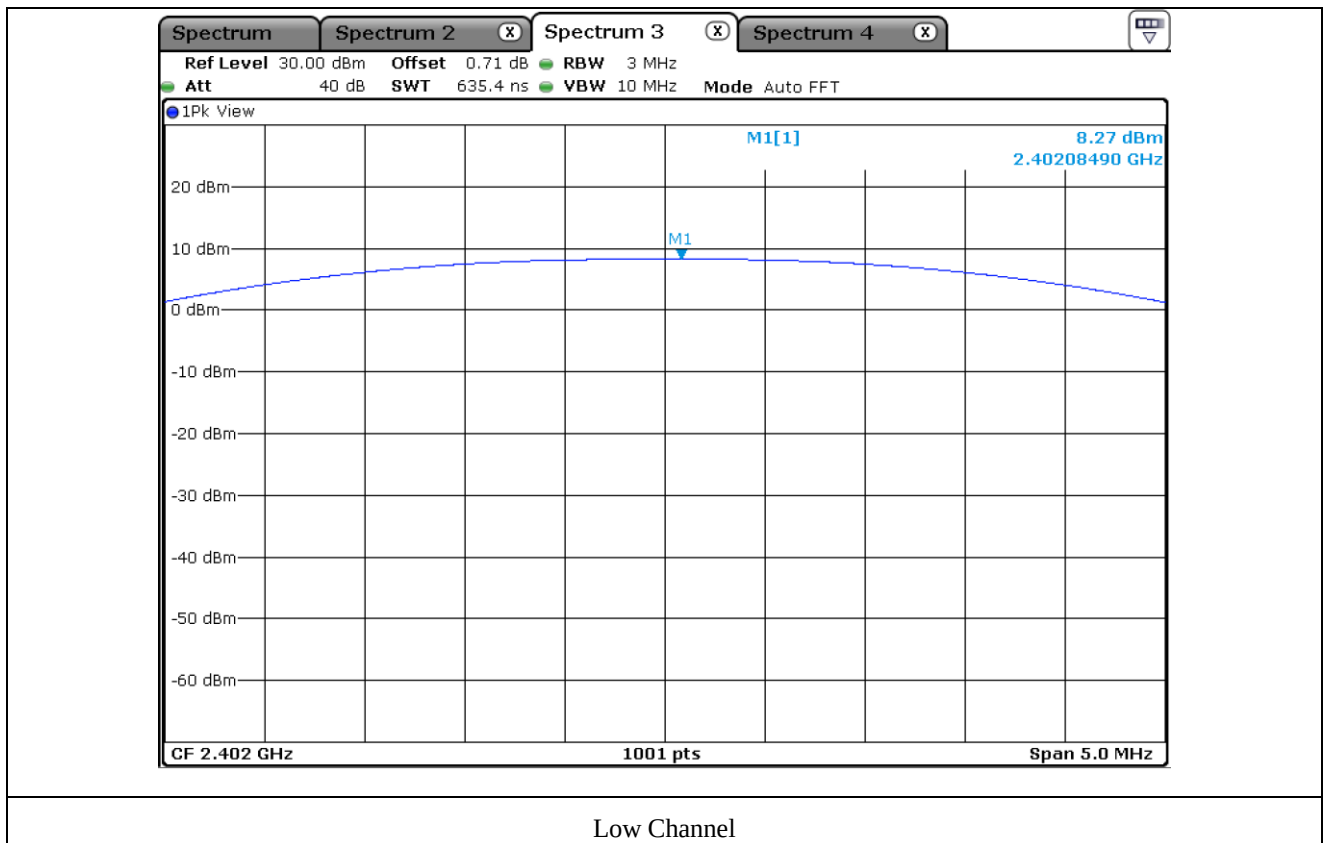
8.4 Test data for Bluetooth LE 1 Mbps

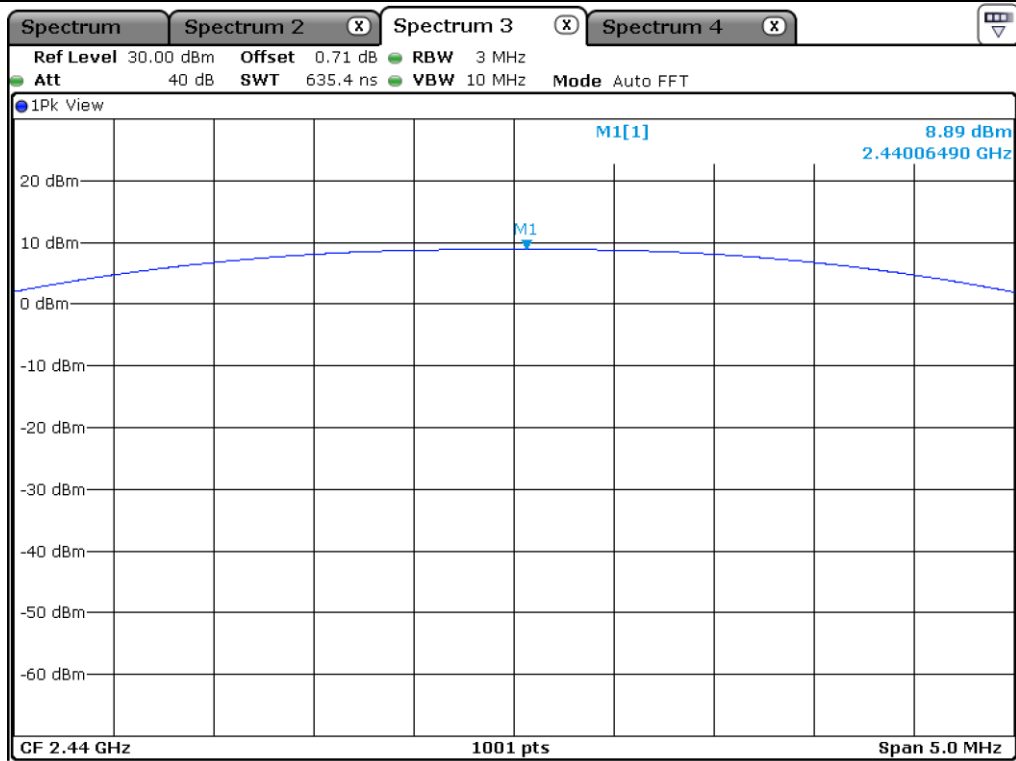
8.4.1 Test data for Left Earbud

-. Test Result : Pass

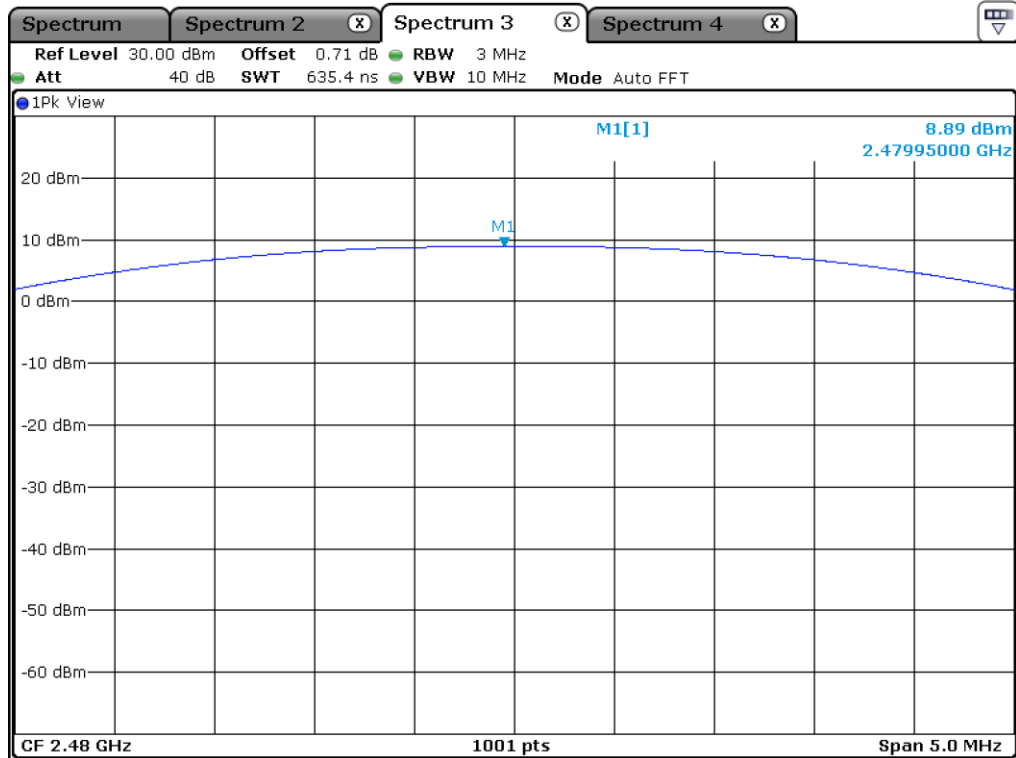
CHANNEL	FREQUENCY (MHz)	6 dB Bandwidth(kHz)	MEASURED VALUE (dBm)	LIMIT (dBm)	MARGIN (dB)
LOW	2 402.00	709.30	8.27	30.00	21.73
MIDDLE	2 440.00	659.30	8.89	30.00	21.11
HIGH	2 480.00	664.30	8.89	30.00	21.11

Remark. Margin = Limit – Measured Value (=Receiver Reading + Cable Loss)





Middle Channel



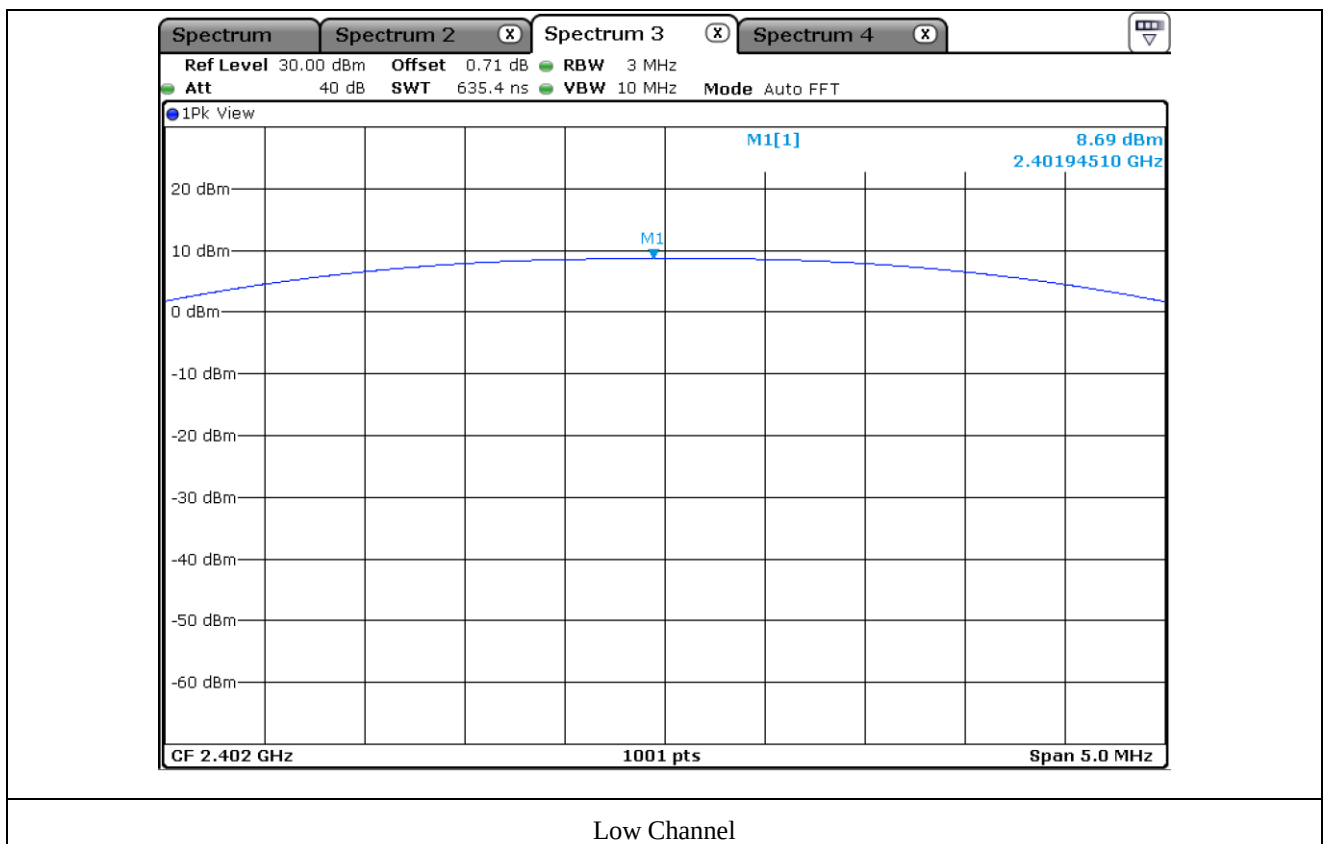
High Channel

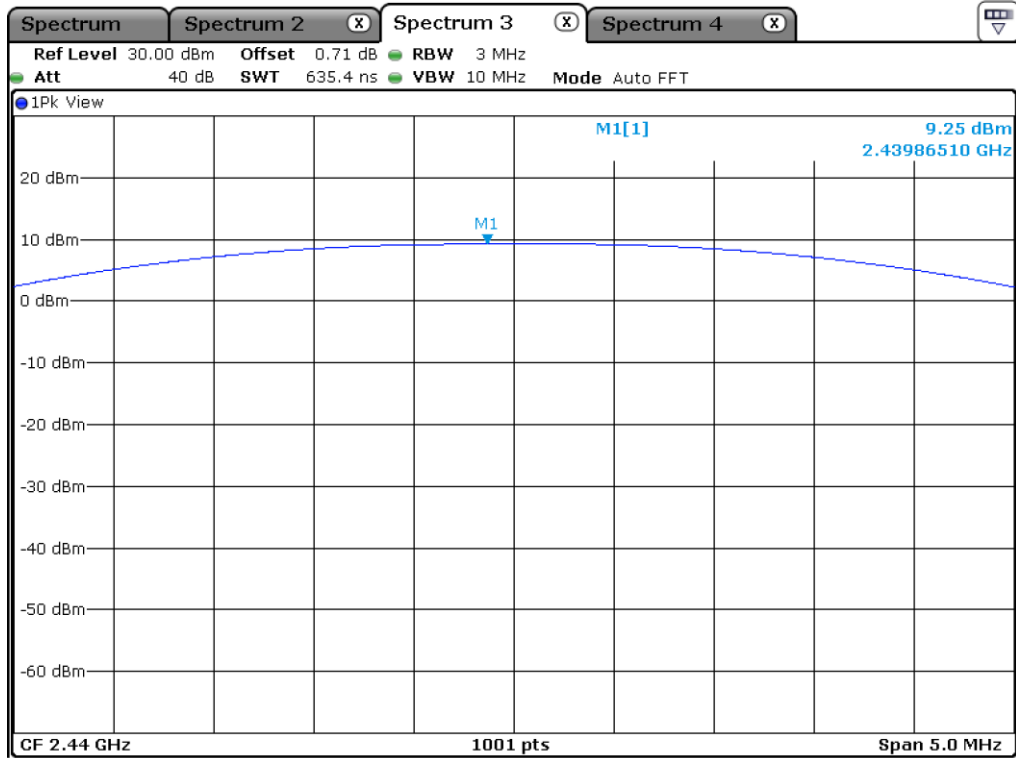
8.4.2 Test data for Right Earbud

-. Test Result : Pass

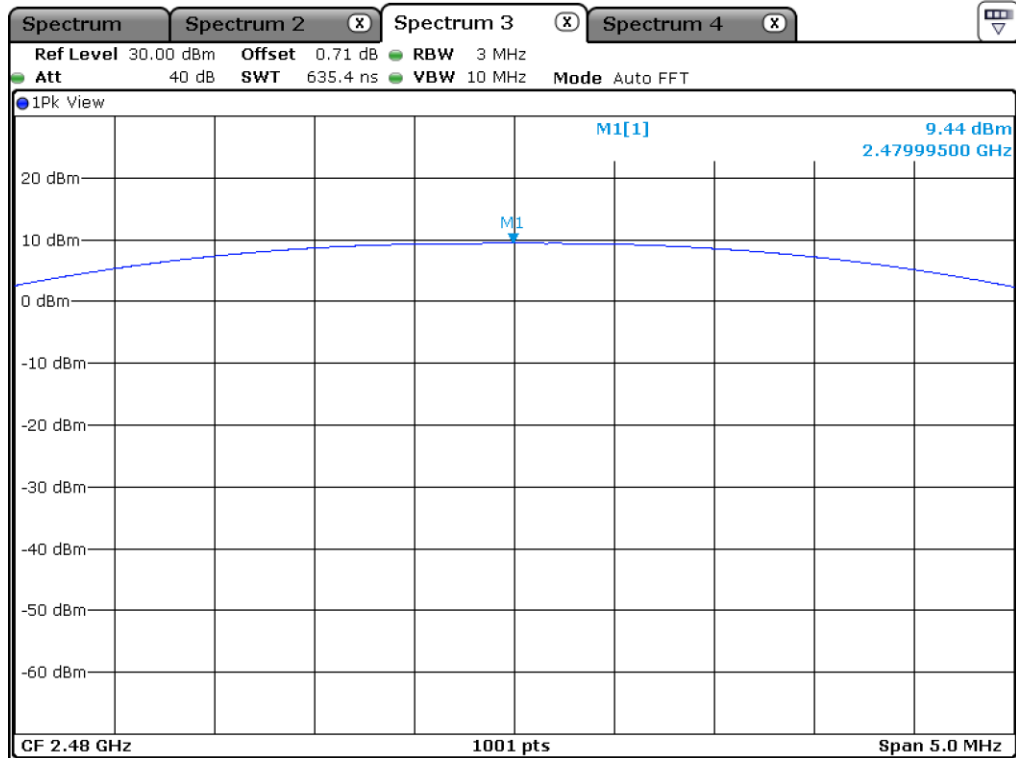
CHANNEL	FREQUENCY (MHz)	6 dB Bandwidth(kHz)	MEASURED VALUE (dBm)	LIMIT (dBm)	MARGIN (dB)
LOW	2 402.00	739.30	8.69	30.00	21.31
MIDDLE	2 440.00	684.30	9.25	30.00	20.75
HIGH	2 480.00	674.30	9.44	30.00	20.56

Remark. Margin = Limit – Measured Value (=Receiver Reading + Cable Loss)





Middle Channel



High Channel

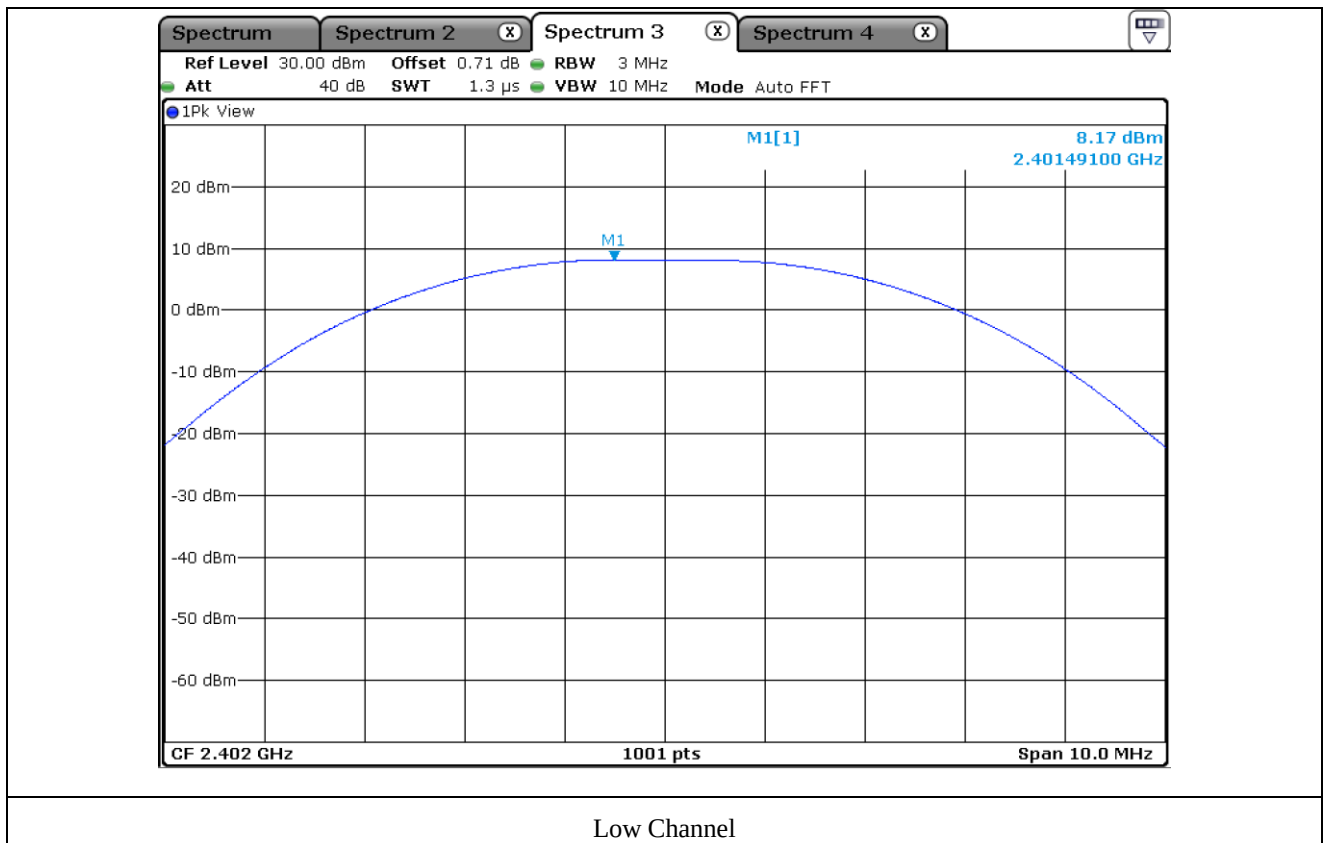
8.5 Test data for Bluetooth LE 2 Mbps

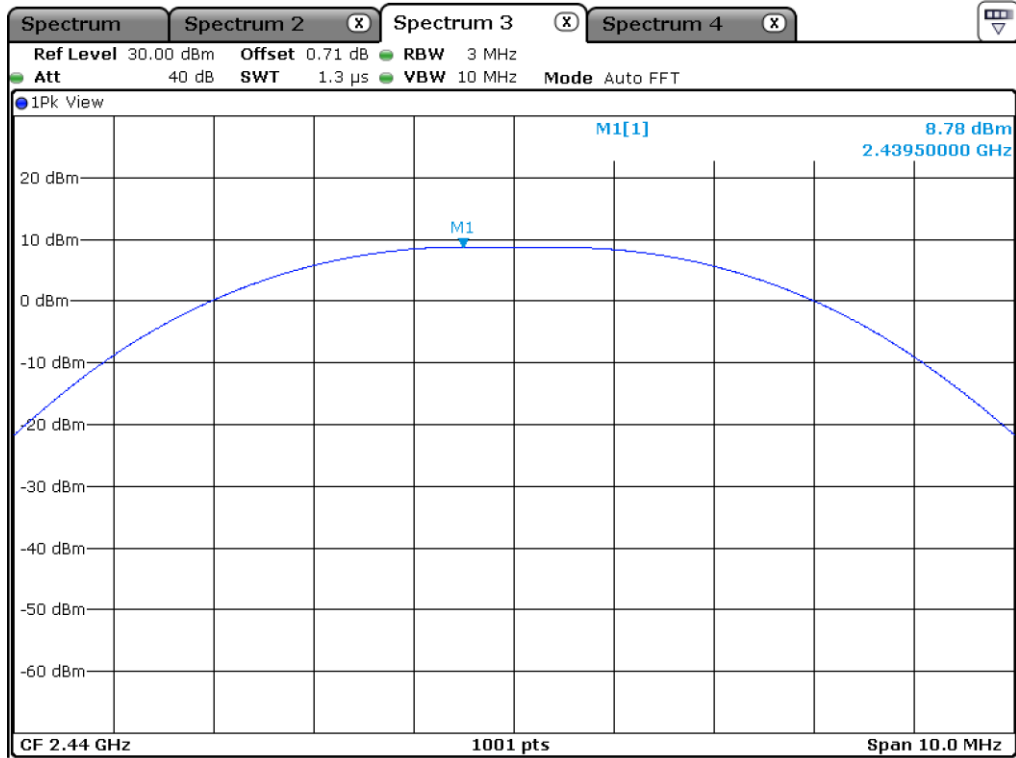
8.5.1 Test data for Left Earbud

-. Test Result : Pass

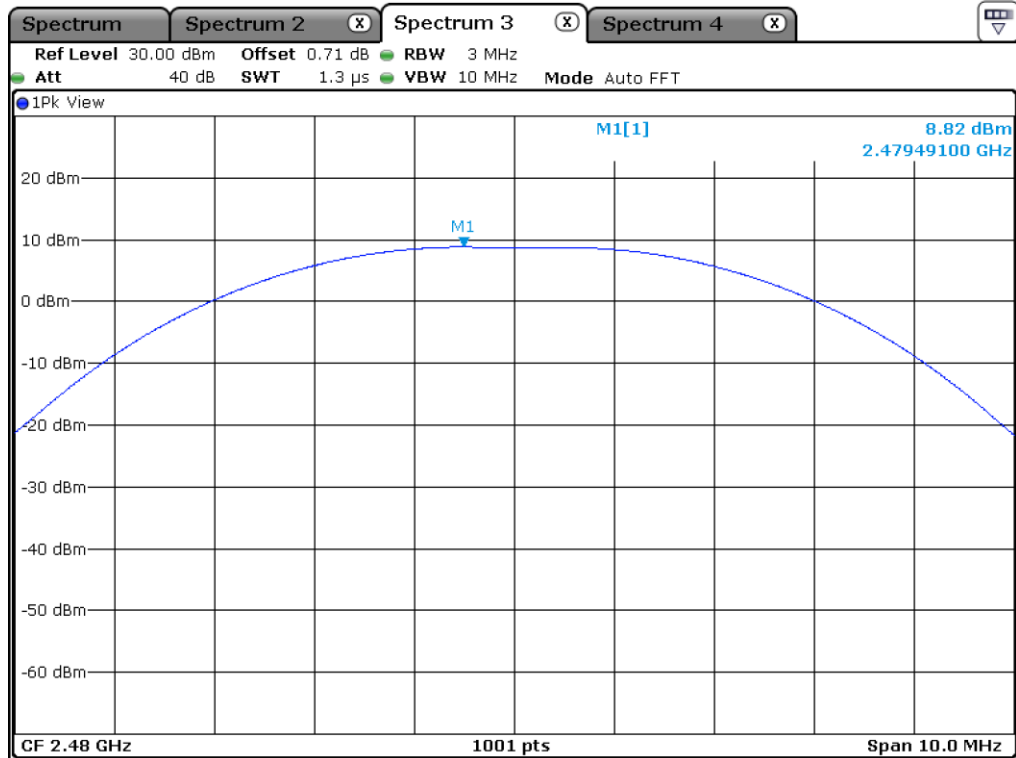
CHANNEL	FREQUENCY (MHz)	6 dB Bandwidth(kHz)	MEASURED VALUE (dBm)	LIMIT (dBm)	MARGIN (dB)
LOW	2 402.00	1 139.00	8.17	30.00	21.83
MIDDLE	2 440.00	1 139.00	8.78	30.00	21.22
HIGH	2 480.00	1 129.00	8.82	30.00	21.18

Remark. Margin = Limit – Measured Value (=Receiver Reading + Cable Loss)





Middle Channel



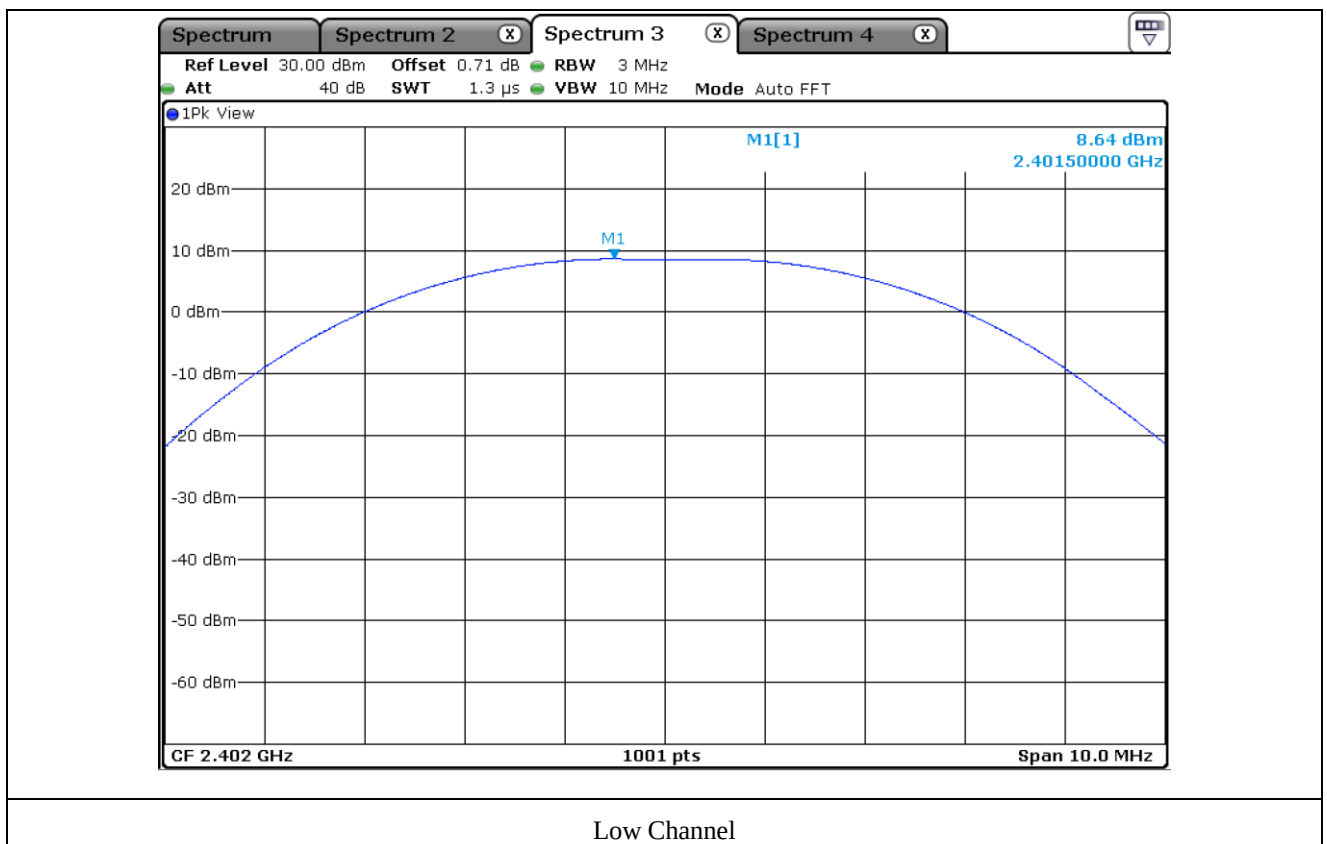
High Channel

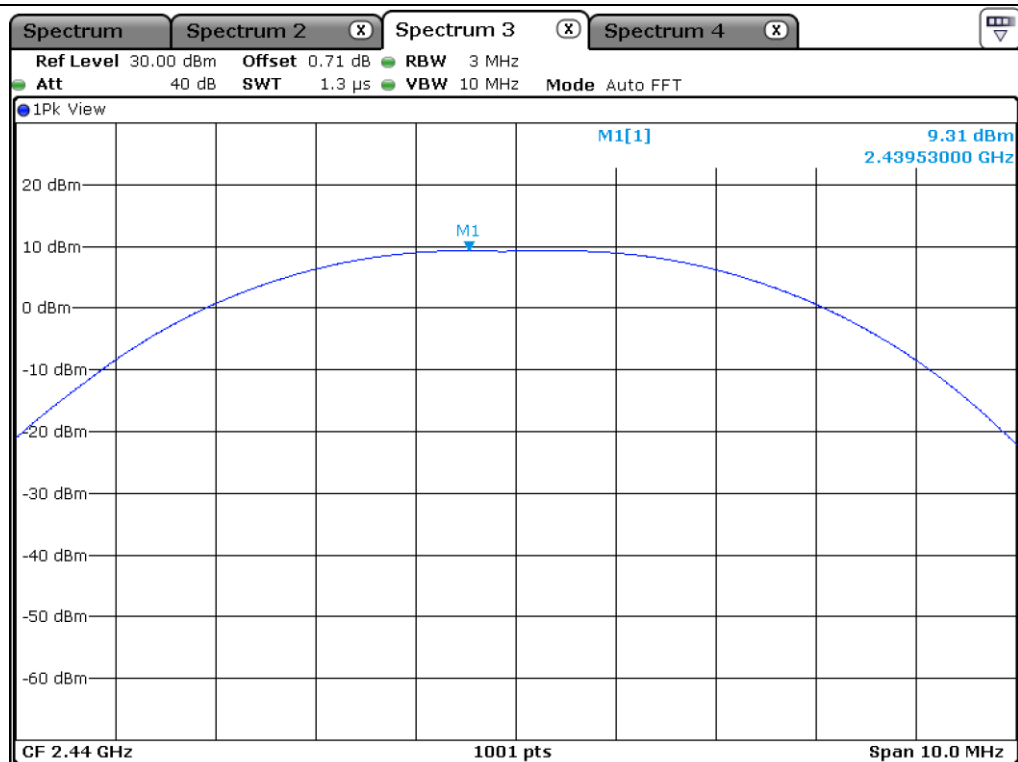
8.5.2 Test data for Right Earbud

-. Test Result : Pass

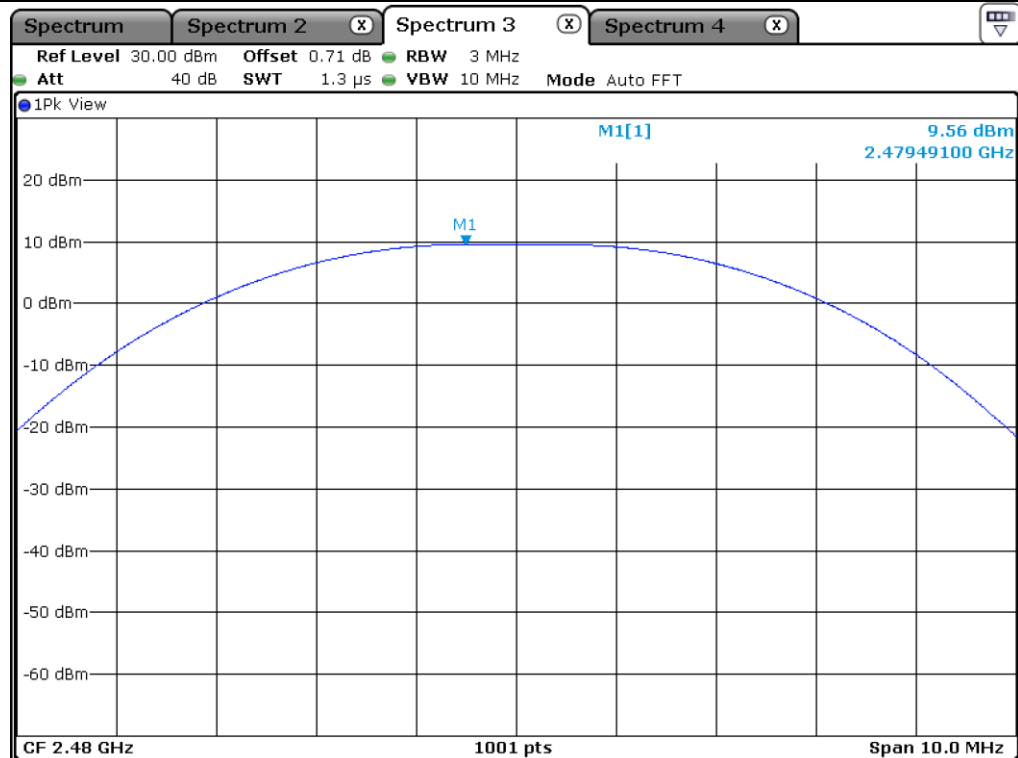
CHANNEL	FREQUENCY (MHz)	6 dB Bandwidth(kHz)	MEASURED VALUE (dBm)	LIMIT (dBm)	MARGIN (dB)
LOW	2 402.00	1 219.00	8.64	30.00	21.36
MIDDLE	2 440.00	1 249.00	9.31	30.00	20.69
HIGH	2 480.00	1 249.00	9.56	30.00	20.44

Remark. Margin = Limit – Measured Value (=Receiver Reading + Cable Loss)





Middle Channel



High Channel

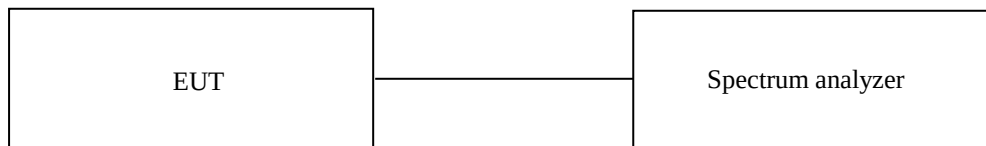
9. 100 kHz BANDWIDTH OUTSIDE THE FREQUENCY BAND

9.1 Operating environment

Temperature : 22 °C
Relative humidity : 46 % R.H.

9.2 Test set-up for conducted measurement

The antenna output of the EUT was connected to the spectrum analyzer. The resolution bandwidth is set to 100 kHz, the video bandwidth is set to 3 times the resolution bandwidth and peak detection was used.



9.3 Test set-up for radiated measurement

The radiated emissions measurements were performed on the 3 m semi anechoic chamber. The EUT was placed on turntable approximately 1.5 m above the ground plane.

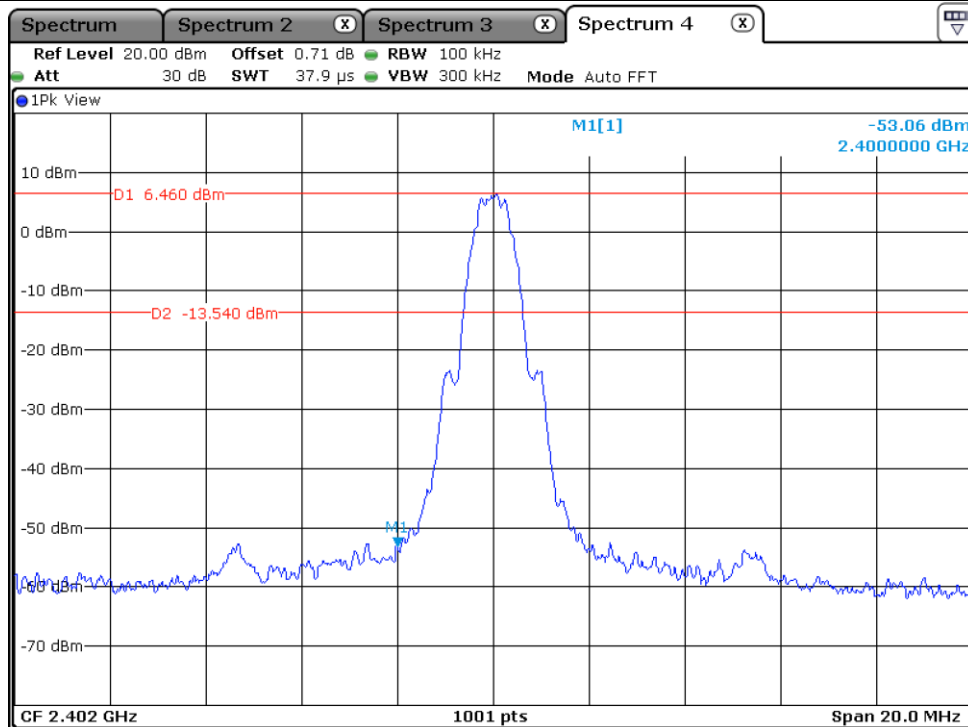
The frequency spectrum from 30 MHz to 26.5 GHz was scanned and maximum emission levels at each frequency recorded. The system was rotated 360°, and the antenna was varied in the height between 1.0 m and 4.0 m in order to determine the maximum emission levels. This procedure was performed for horizontal and vertical polarization of the receiving antenna.

9.4 Test Date

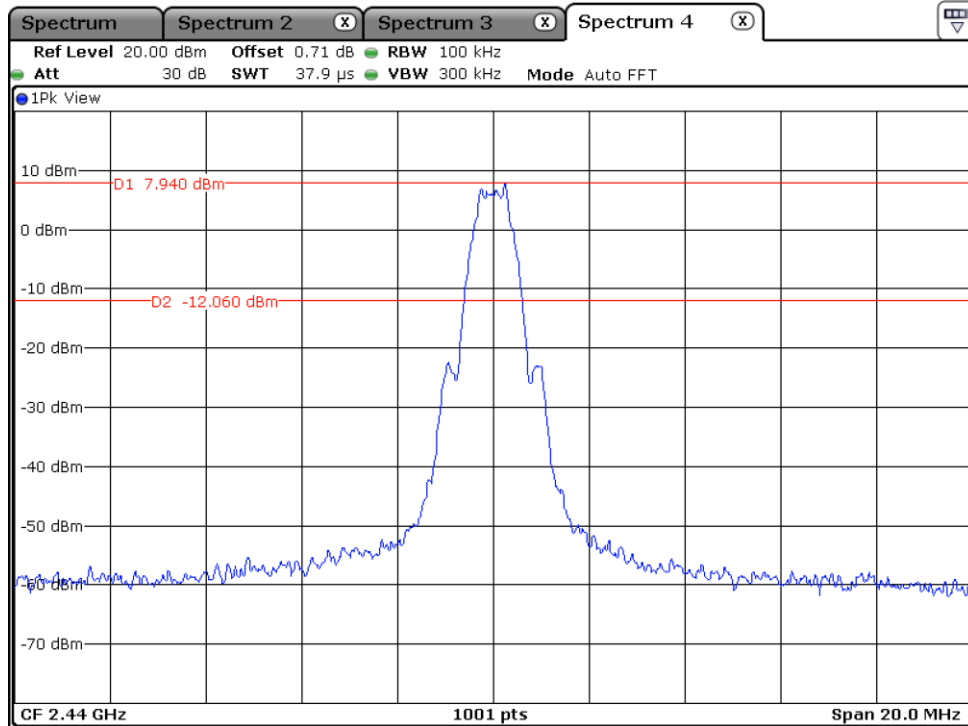
September 10, 2021 ~ September 15, 2021

9.5 Test data for conducted emission (Bluetooth LE 1Mbps)

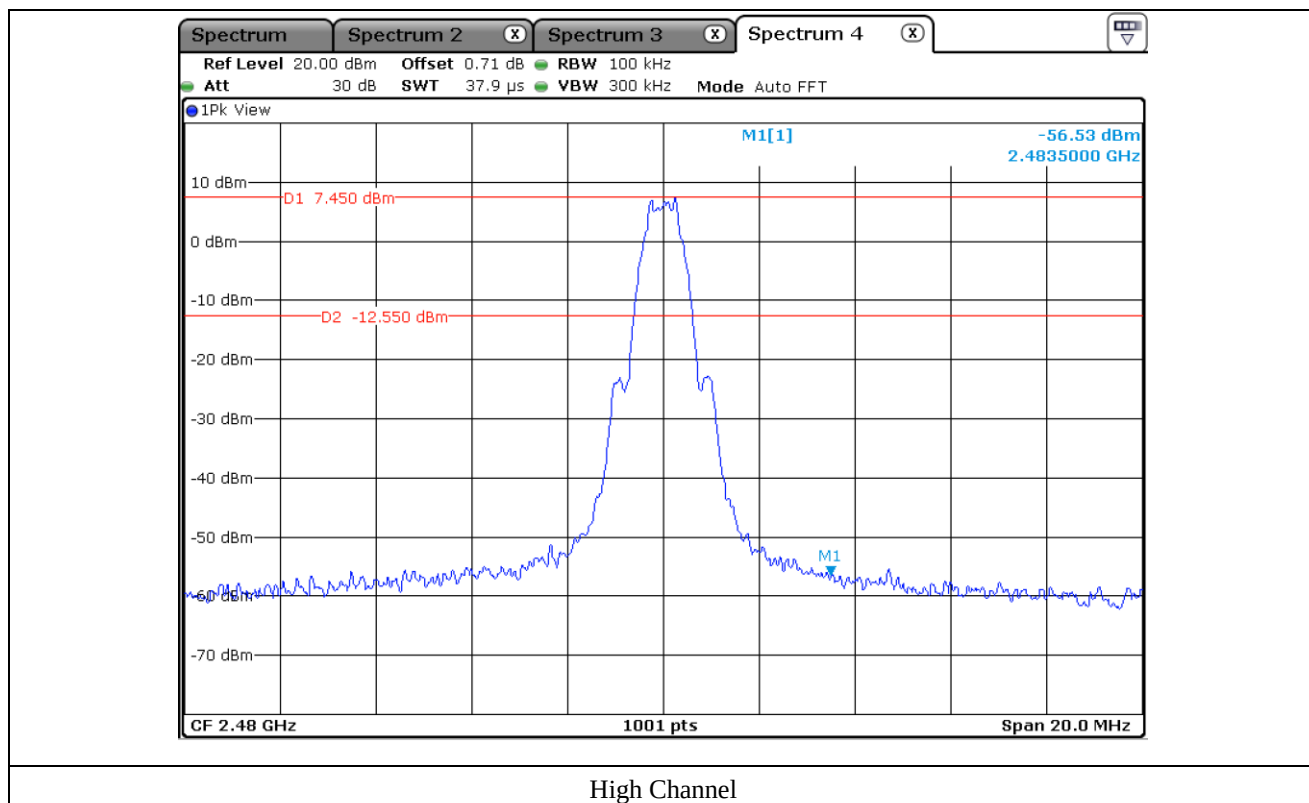
9.5.1 Test data for Left Earbud

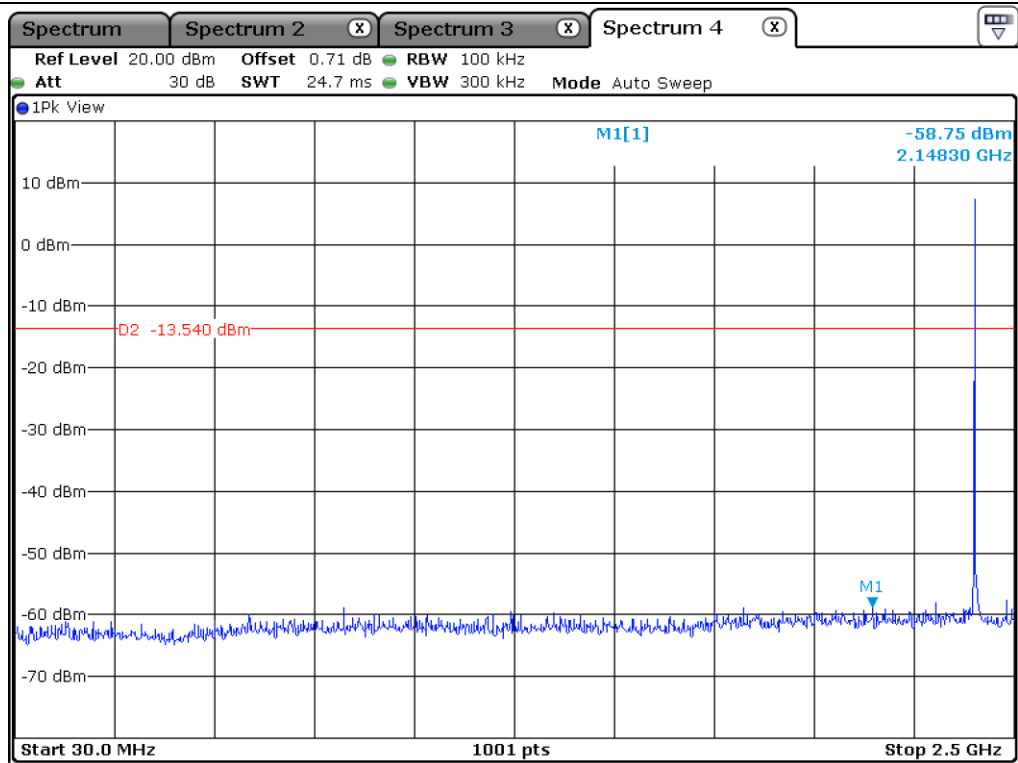


Low Channel

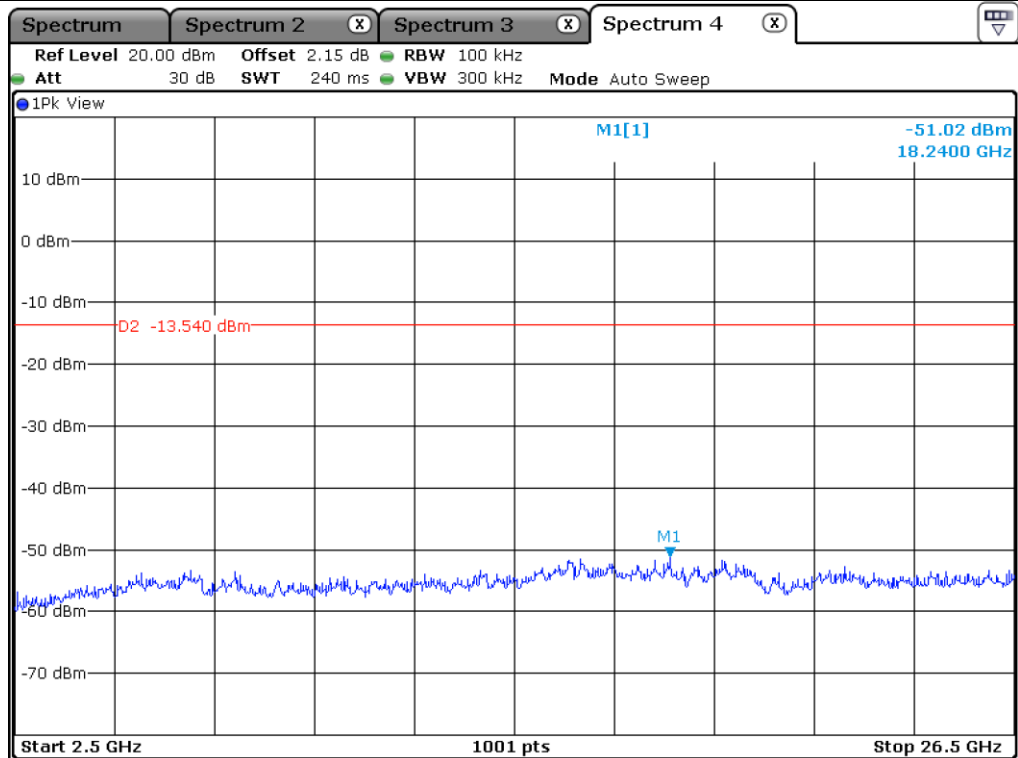


Middle Channel

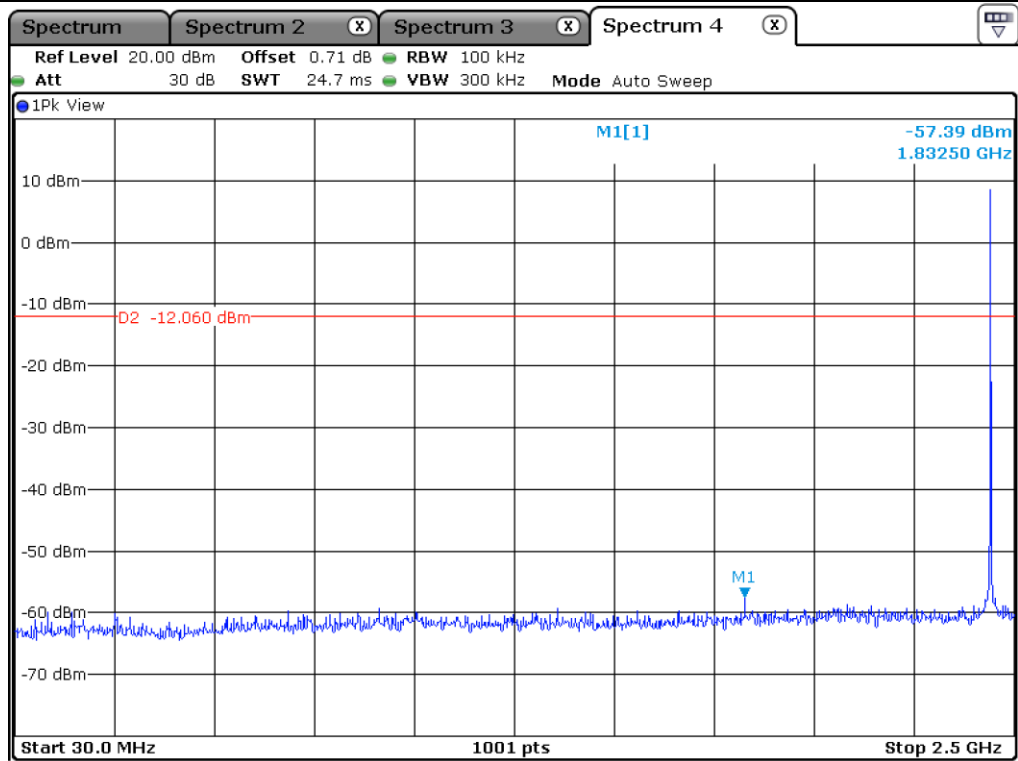




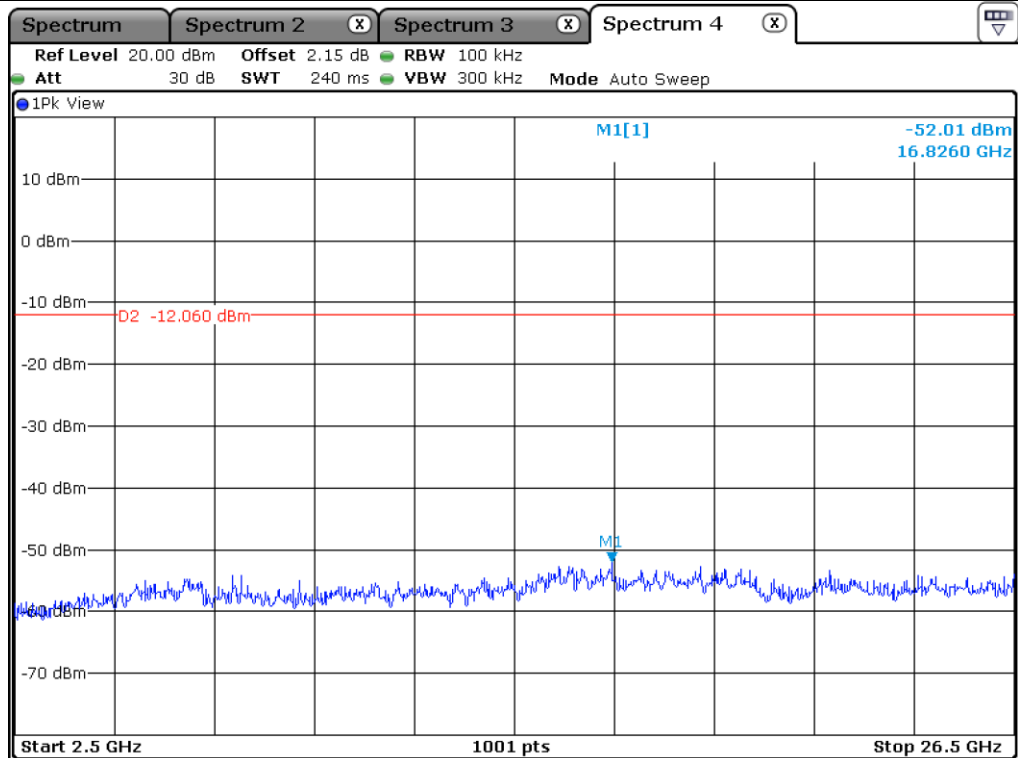
Low Channel



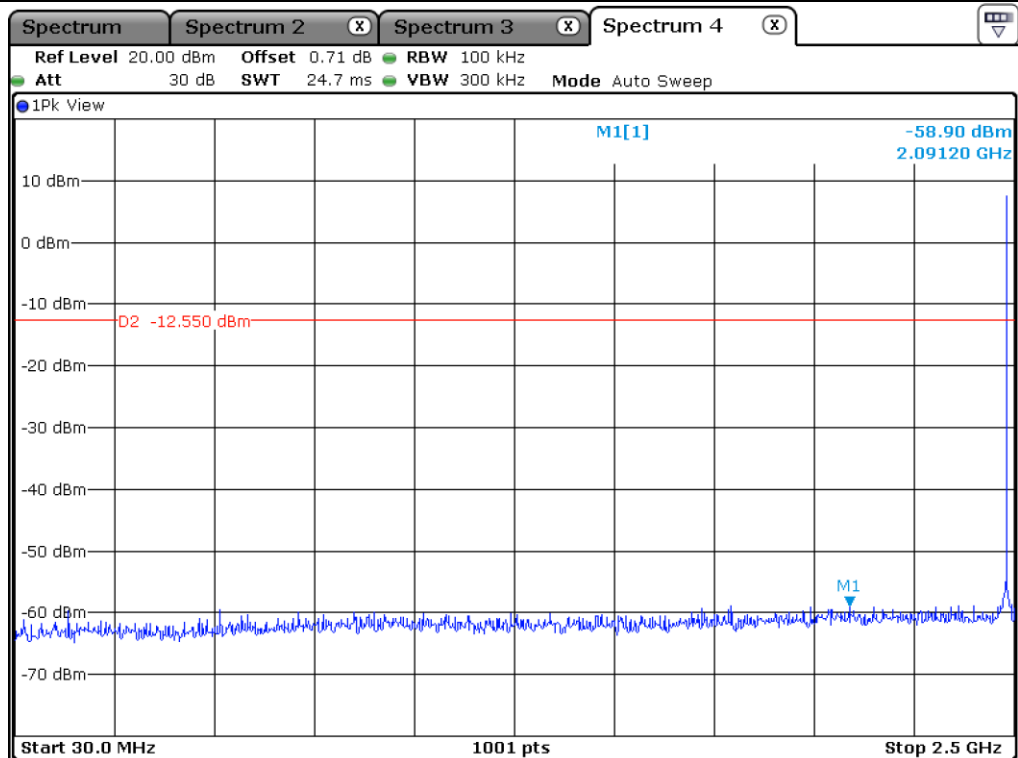
Low Channel



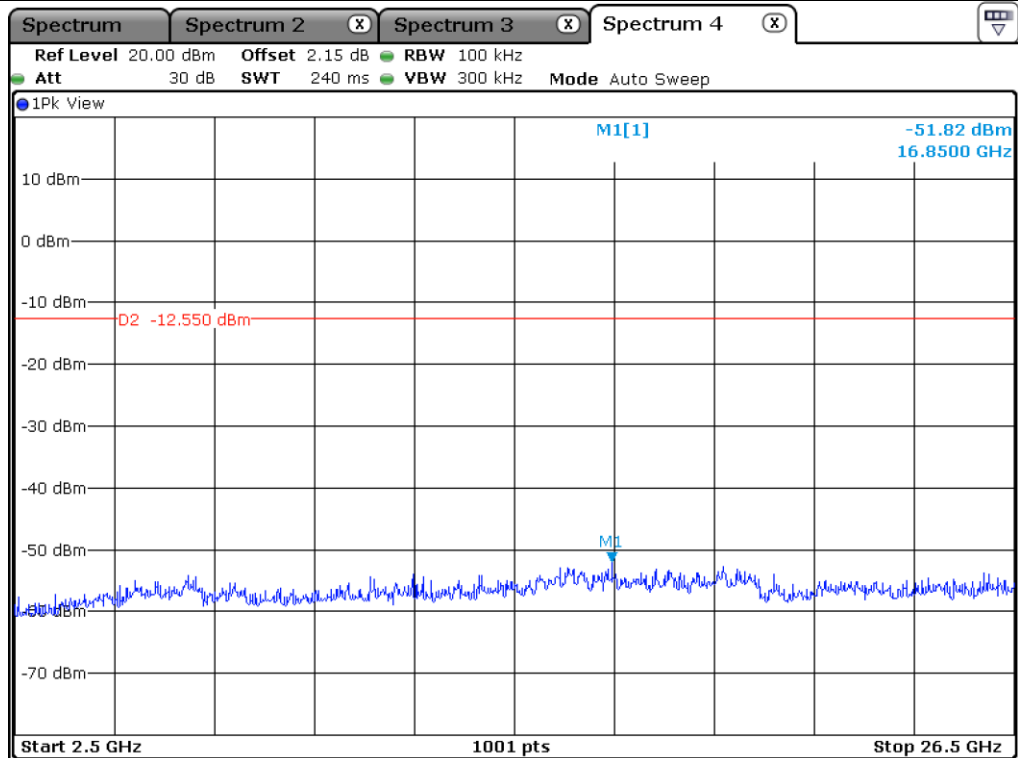
Middle Channel



Middle Channel

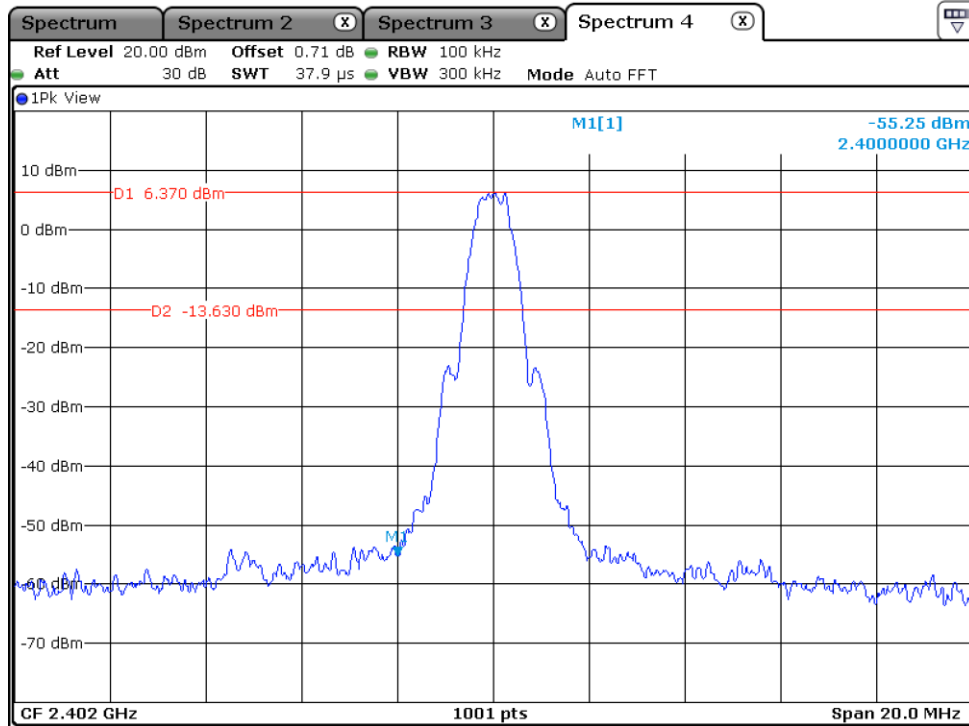


High Channel

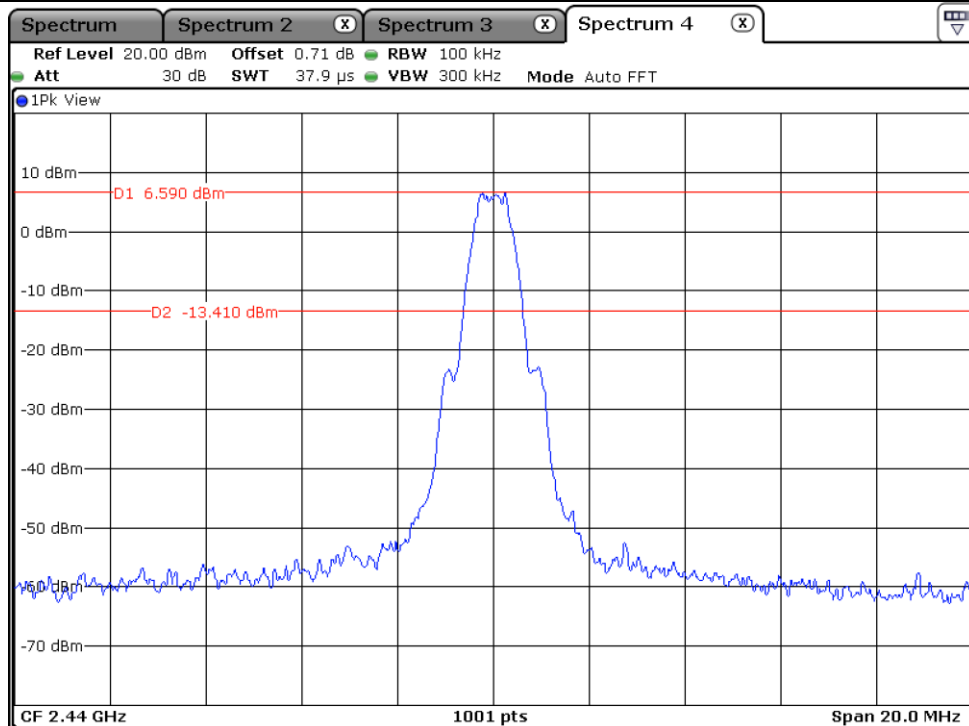


High Channel

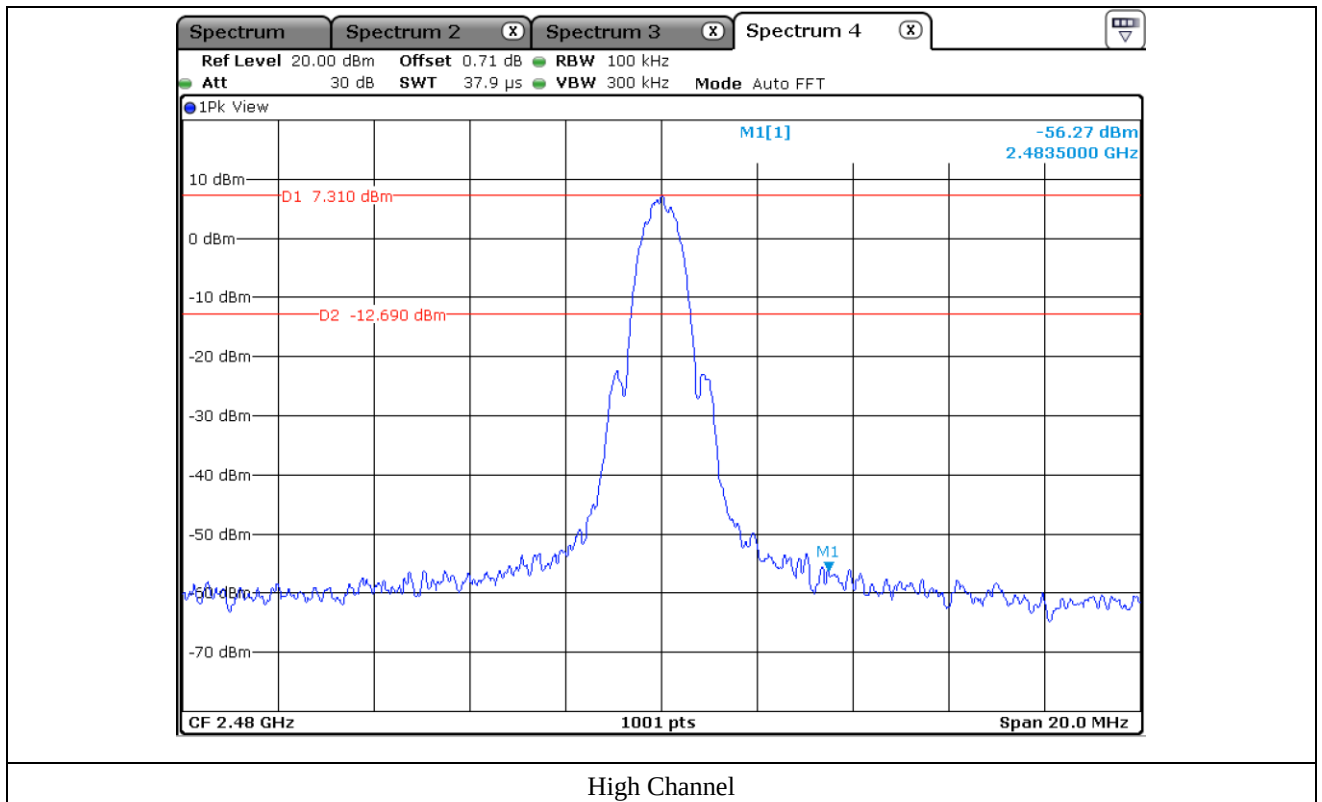
9.5.2 Test data for Right Earbud

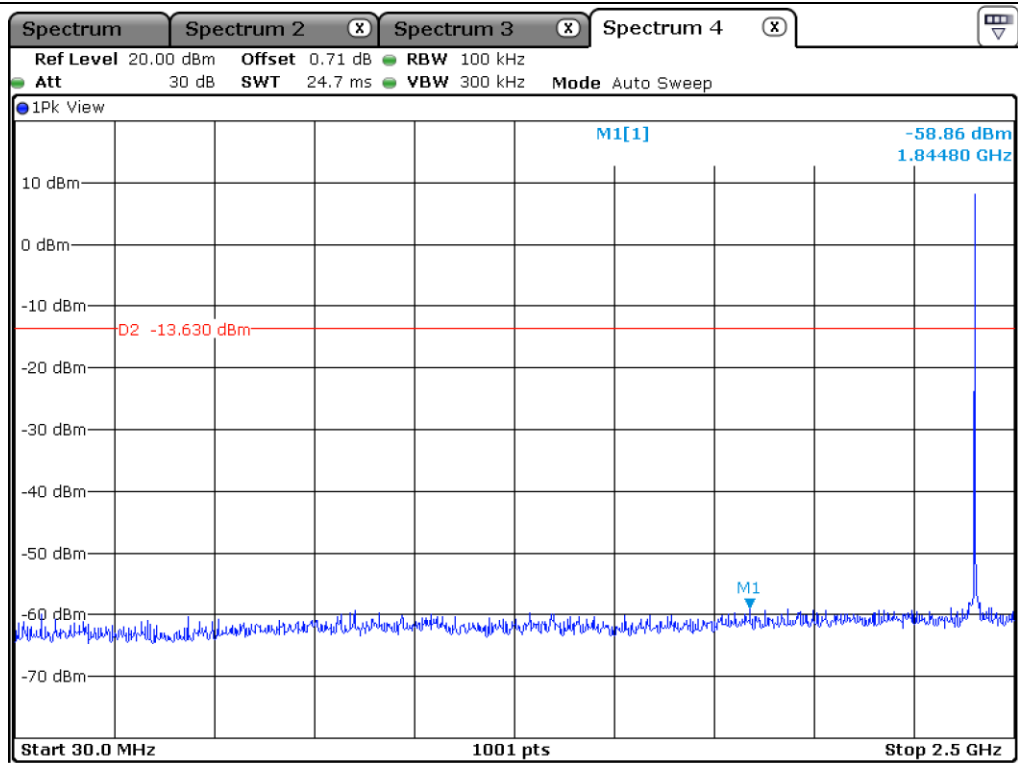


Low Channel

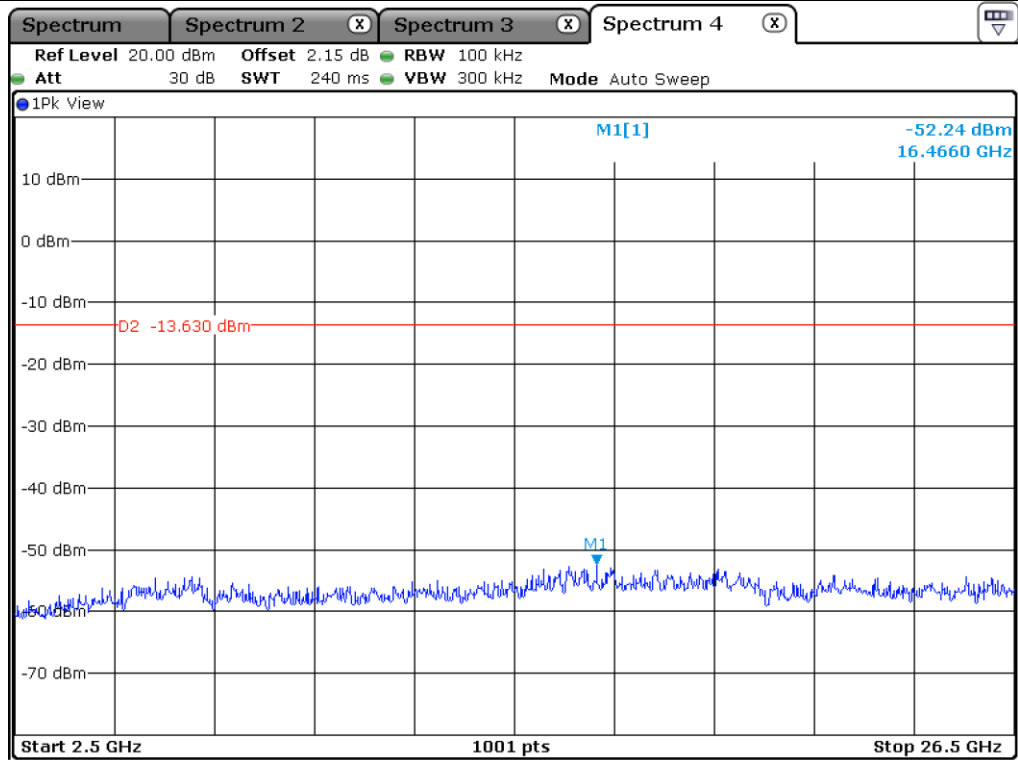


Middle Channel

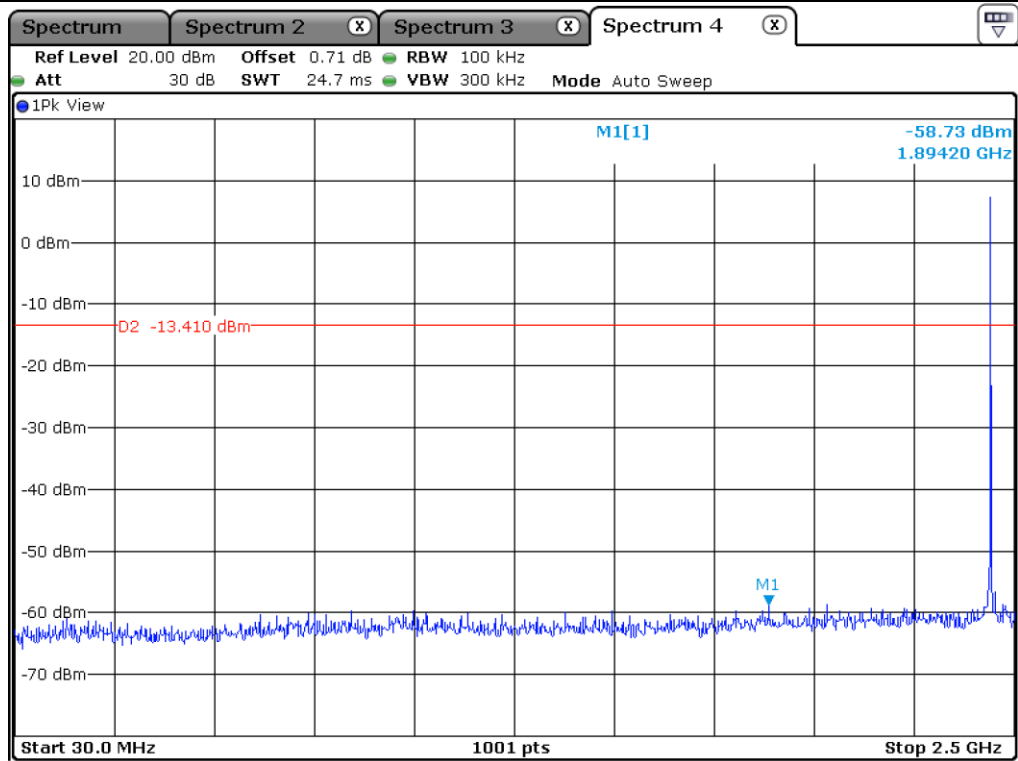




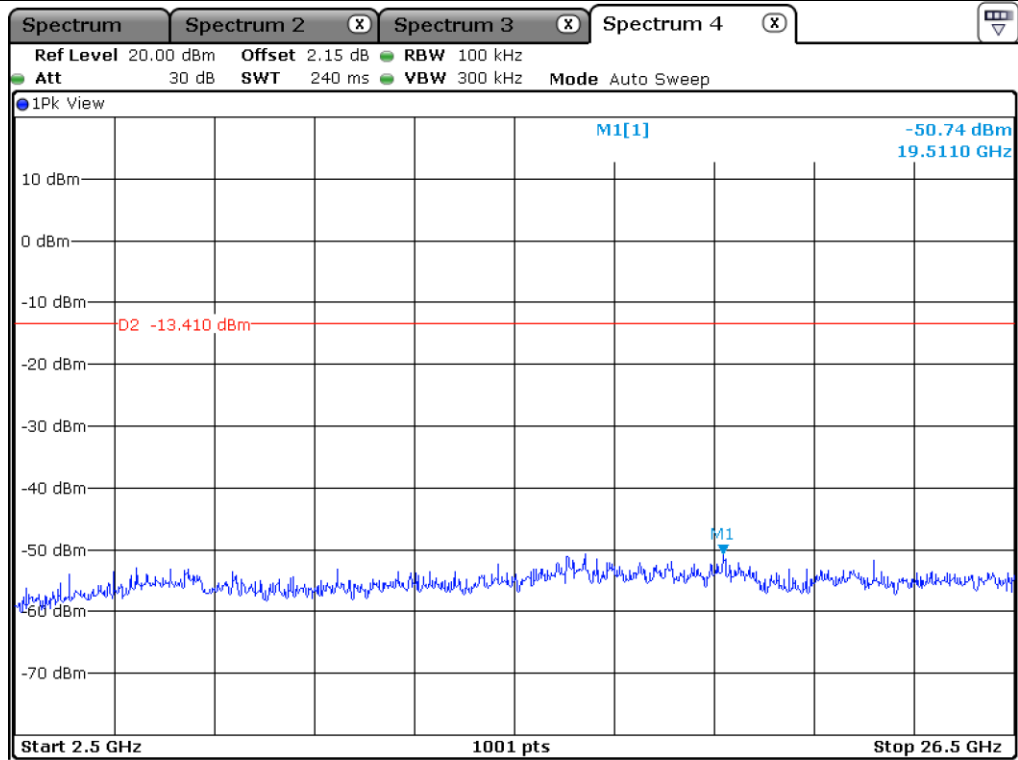
Low Channel



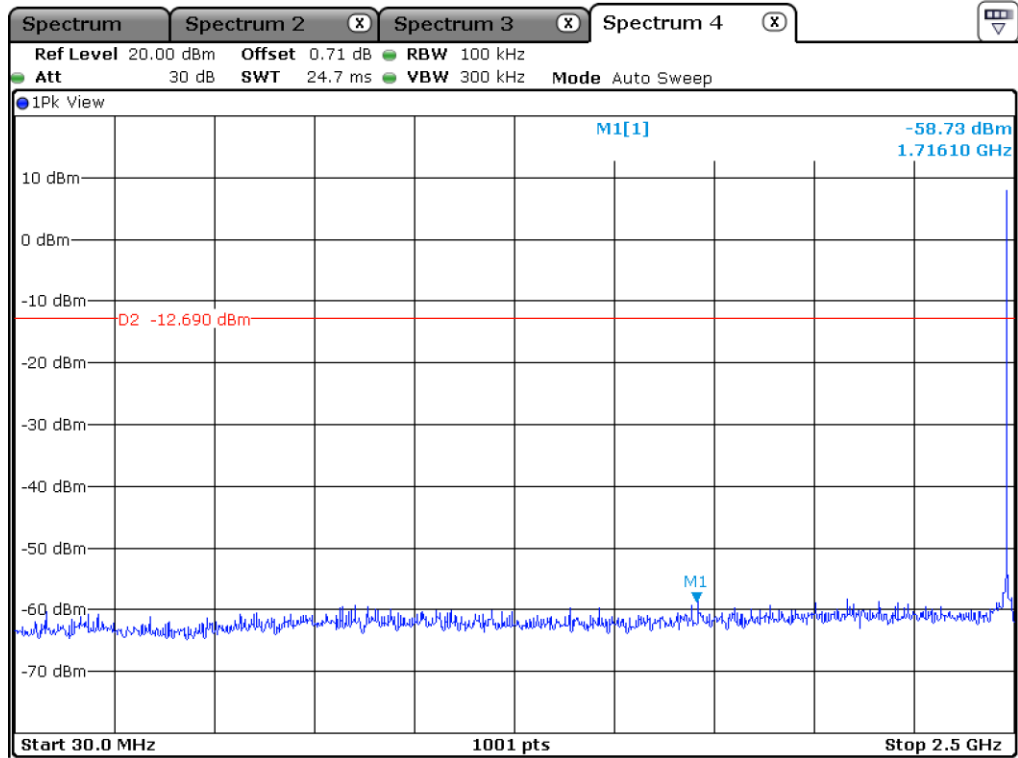
Low Channel



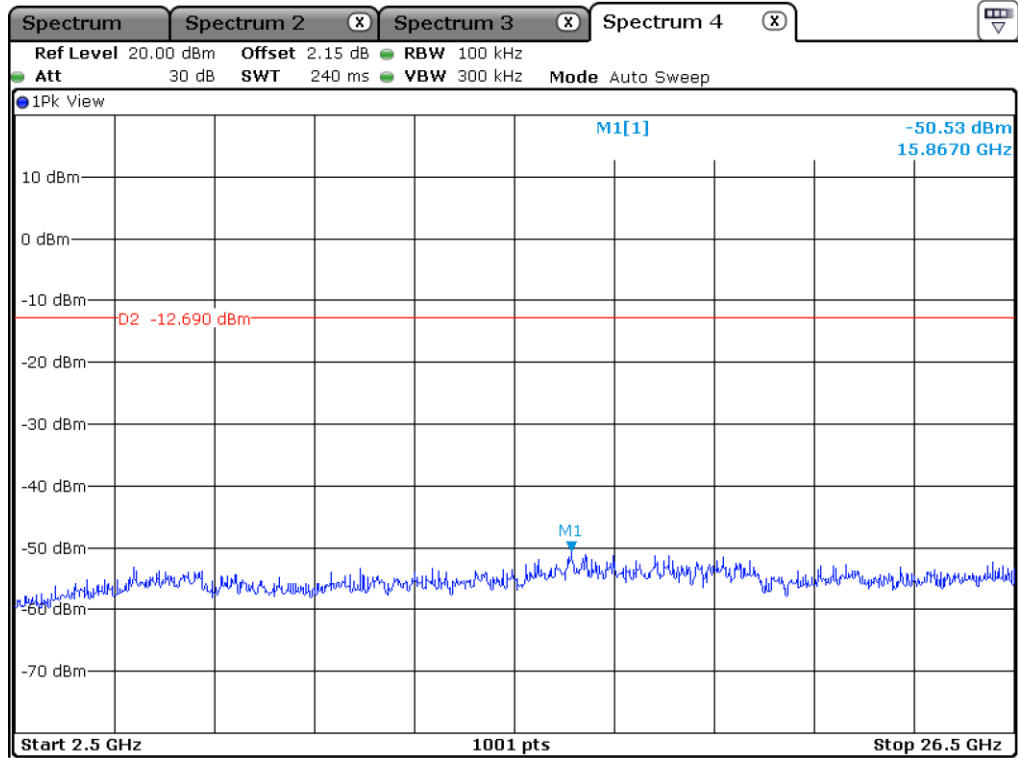
Middle Channel



Middle Channel



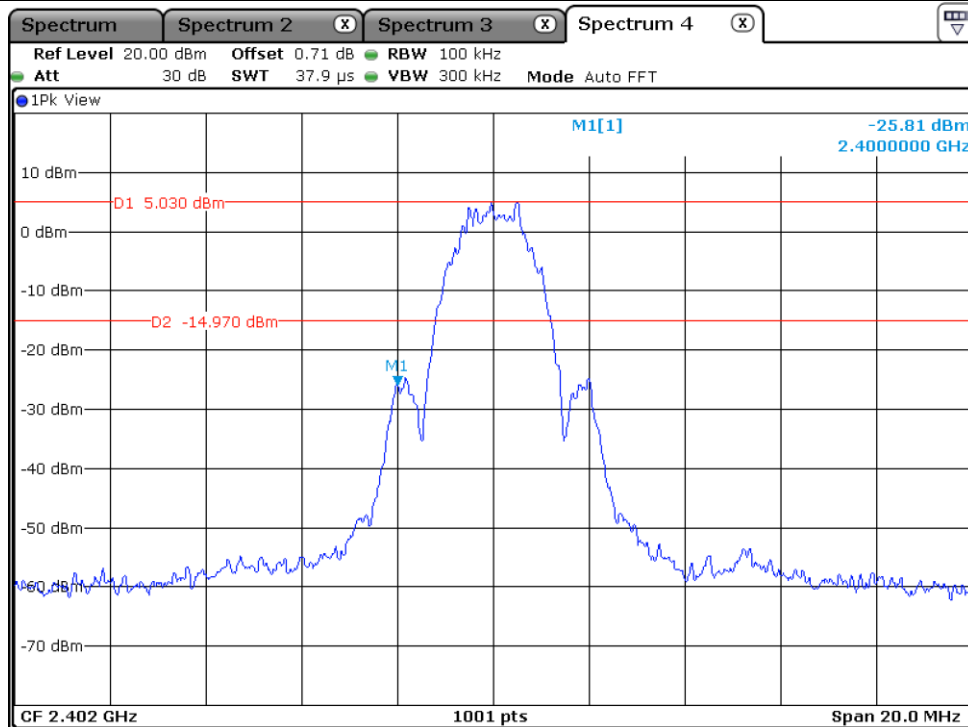
High Channel



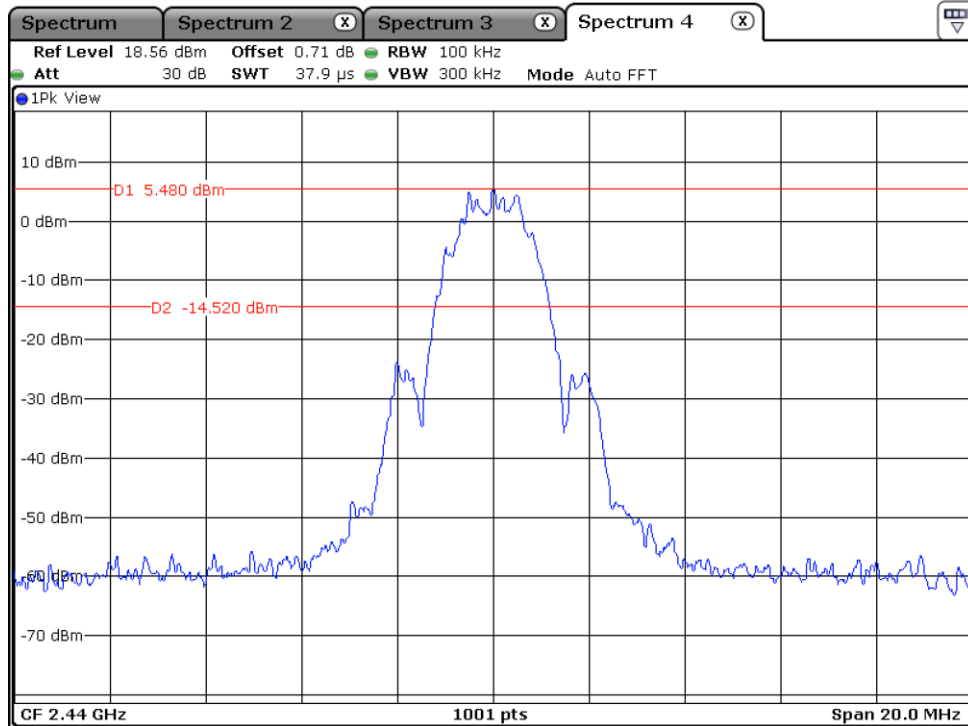
High Channel

9.6 Test data for conducted emission (Bluetooth LE 2Mbps)

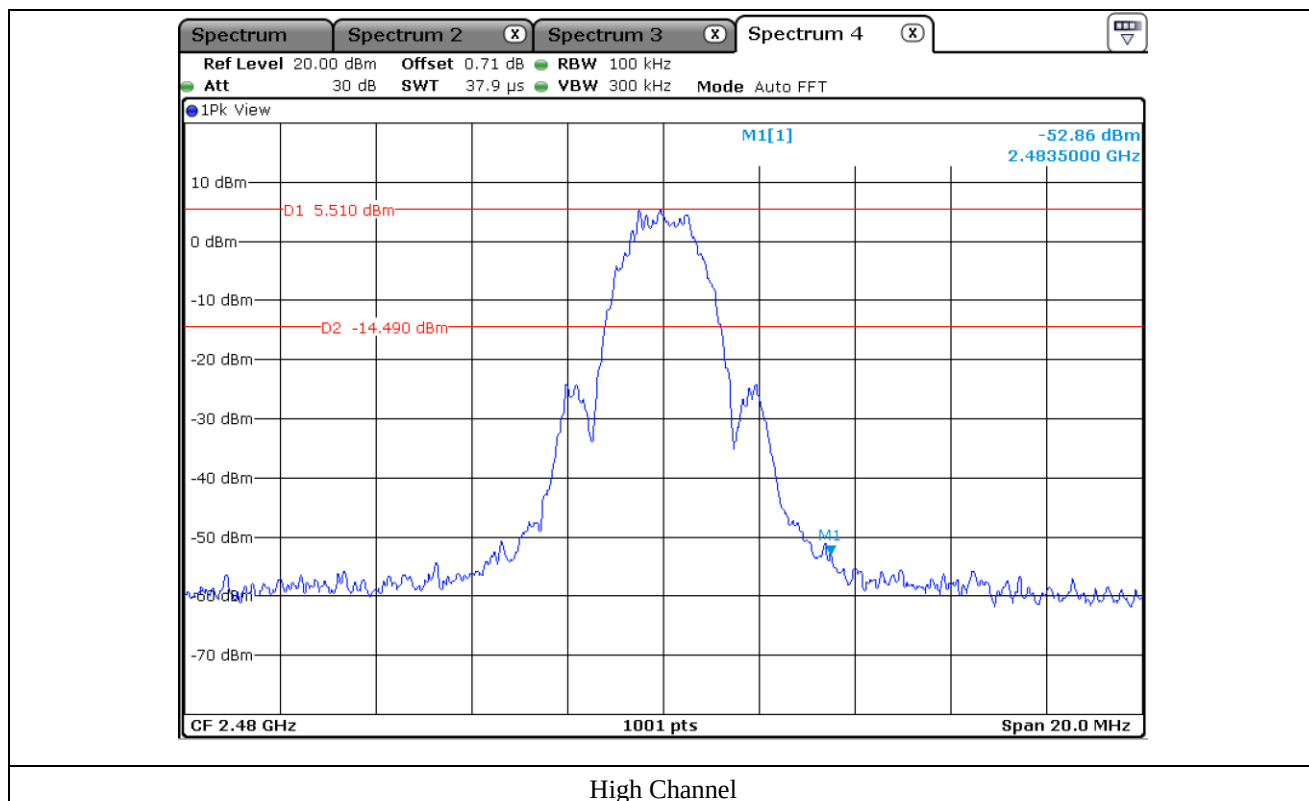
9.6.1 Test data for Left Earbud



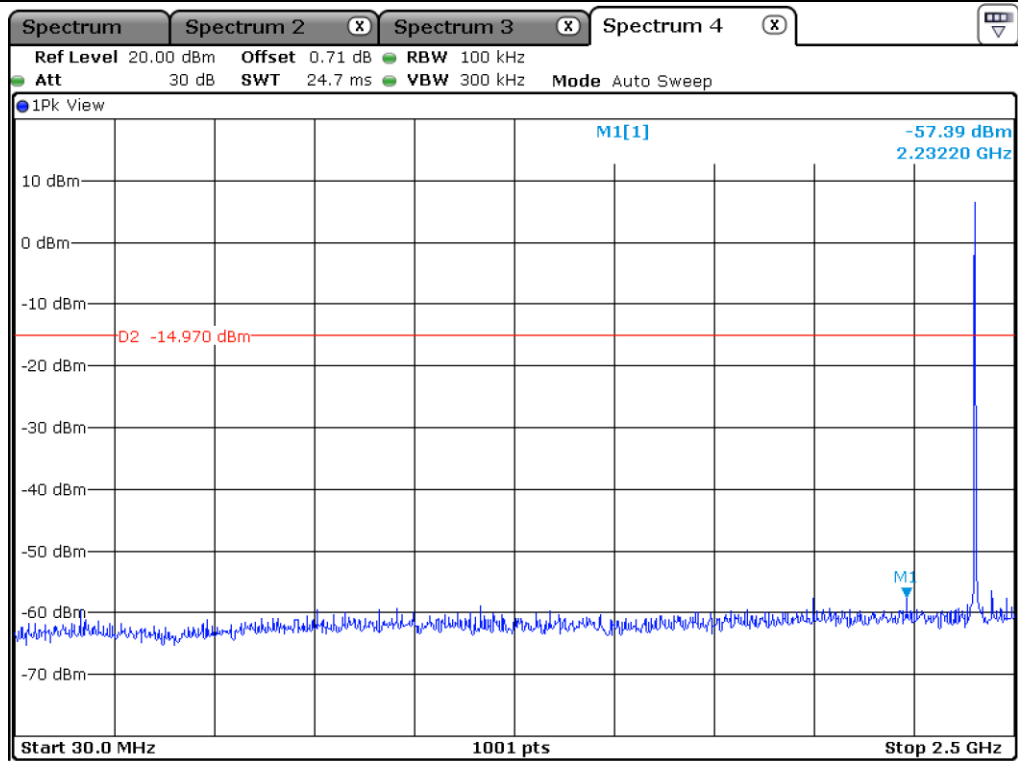
Low Channel



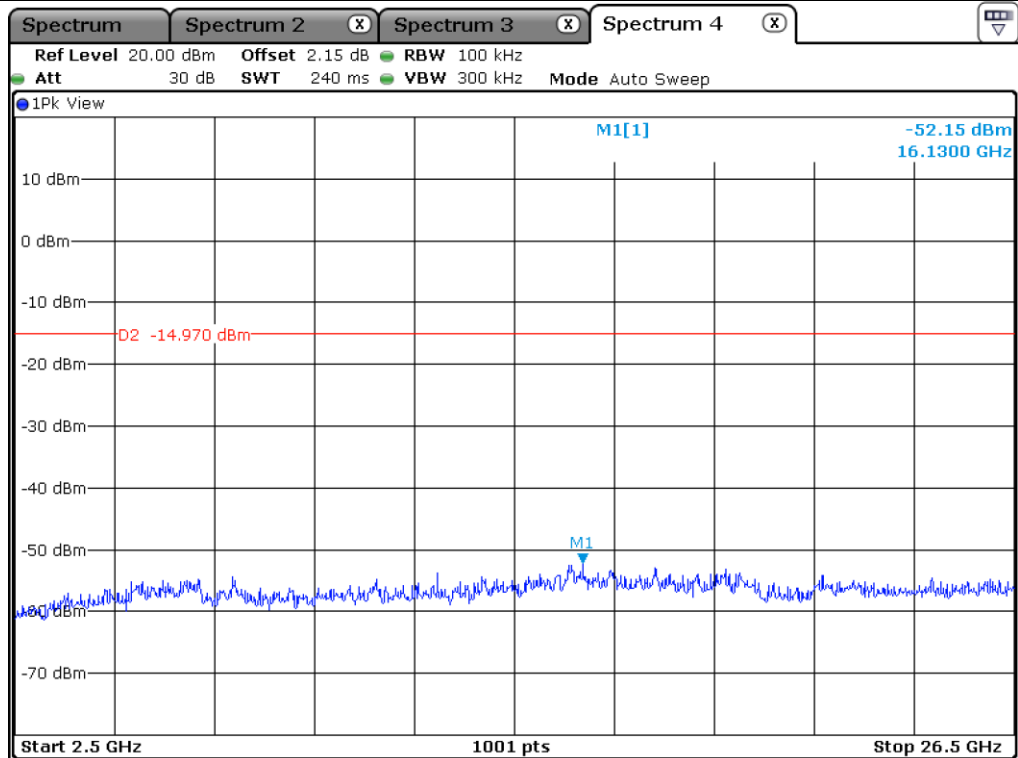
Middle Channel



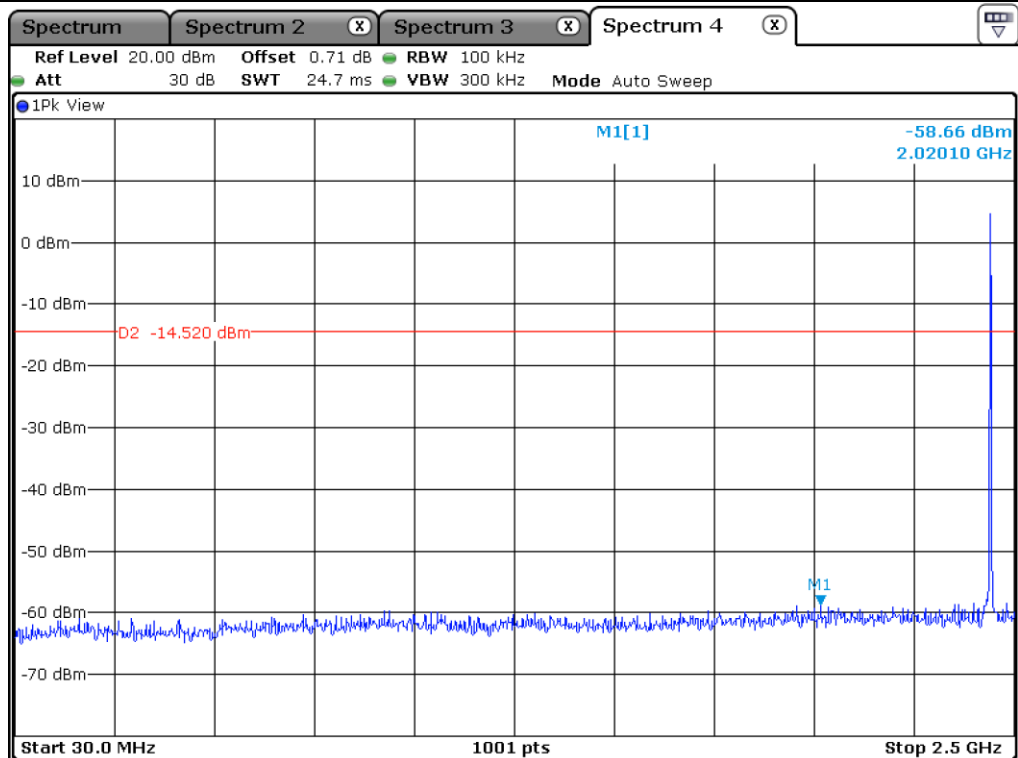
High Channel



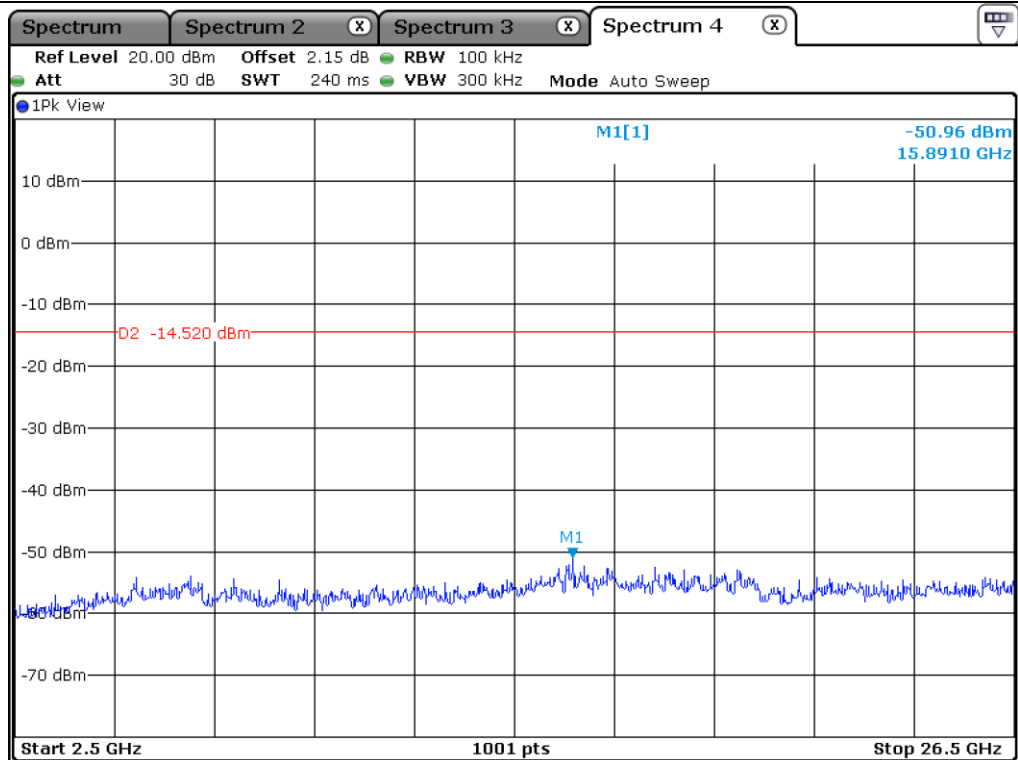
Low Channel



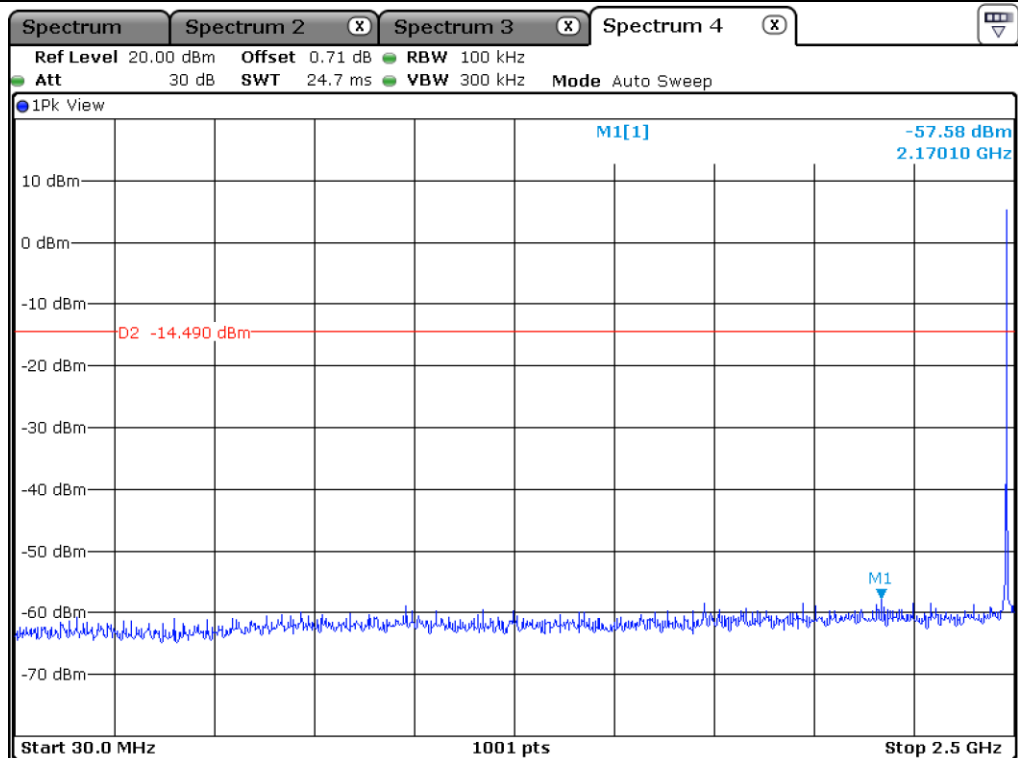
Low Channel



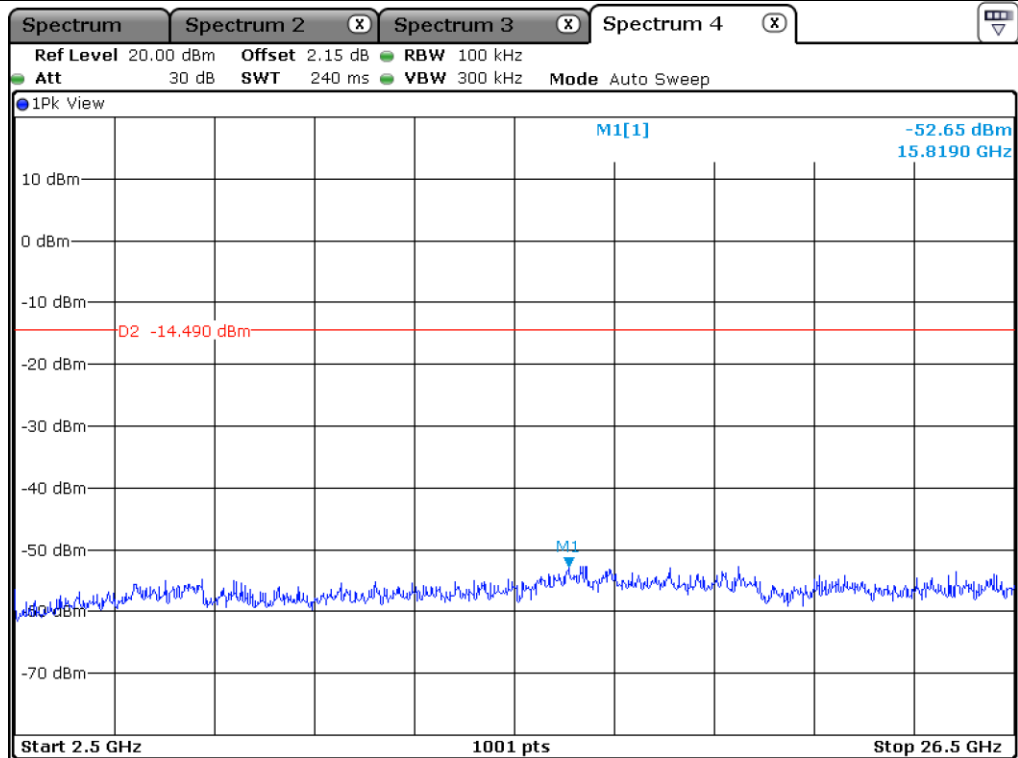
Middle Channel



Middle Channel

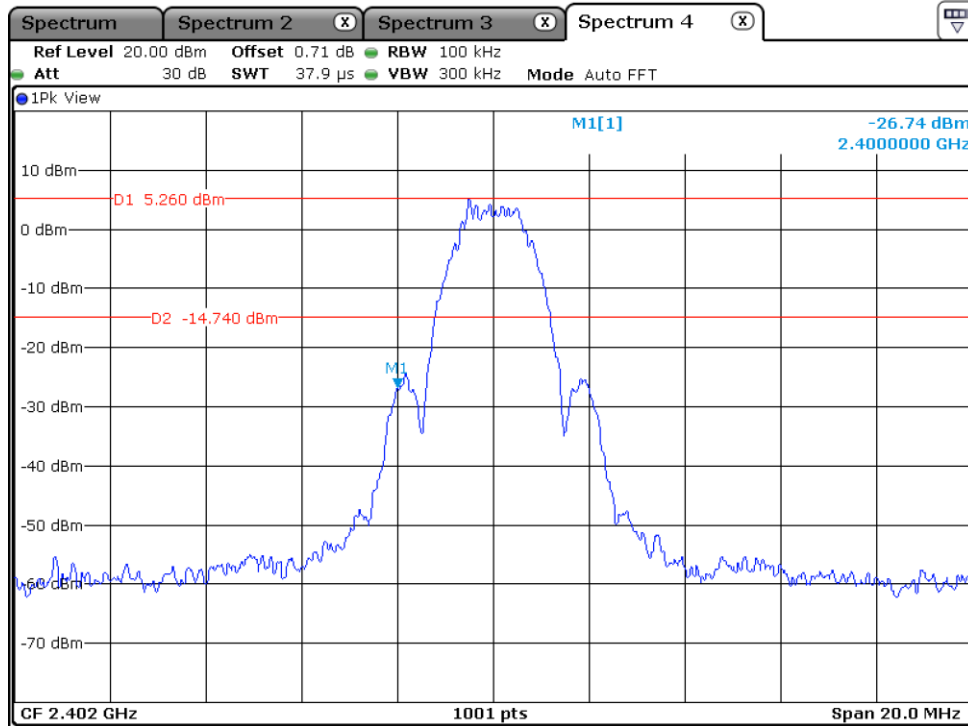


High Channel

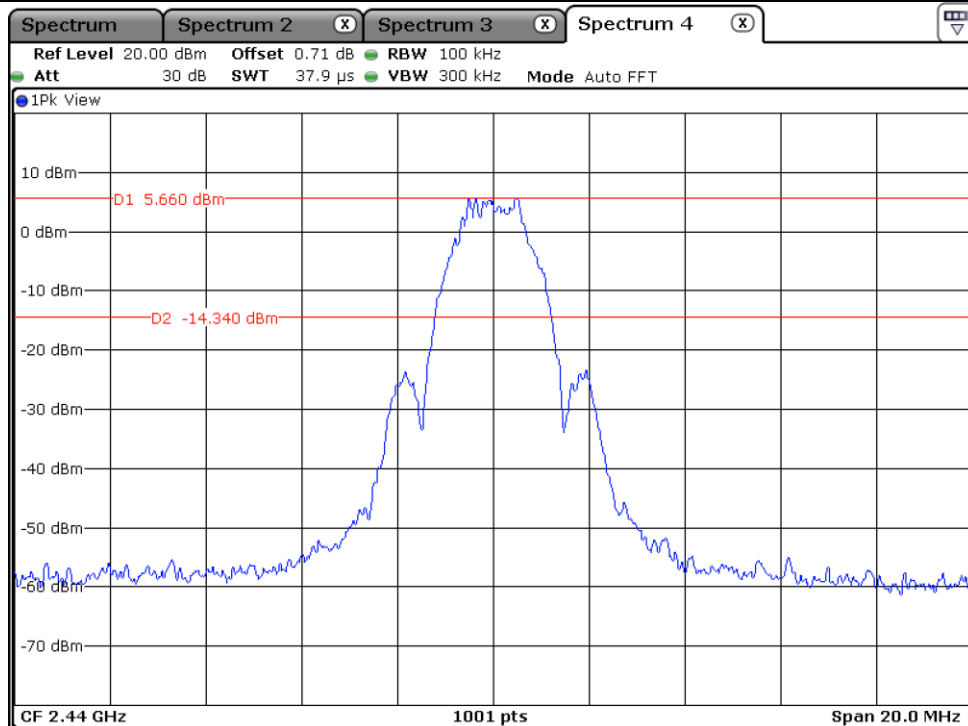


High Channel

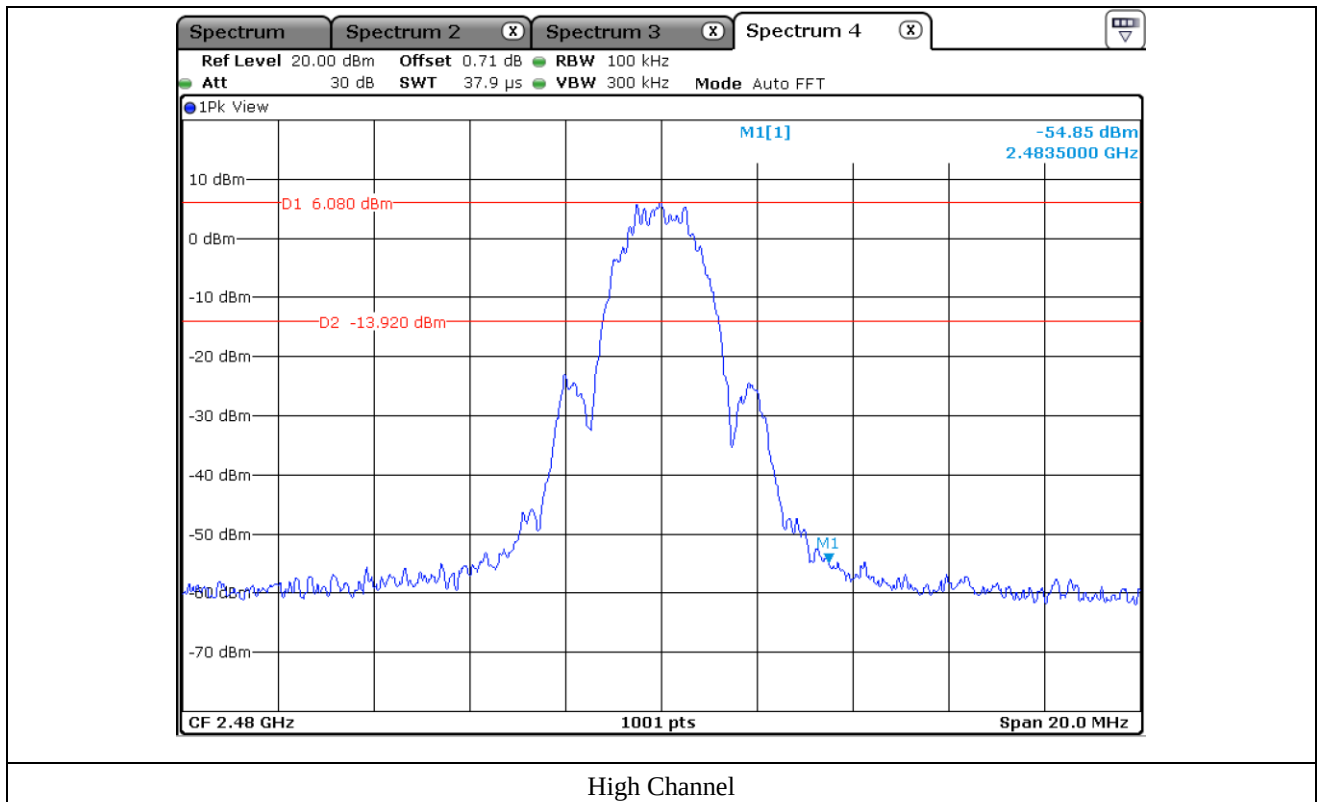
9.6.2 Test data for Right Earbud

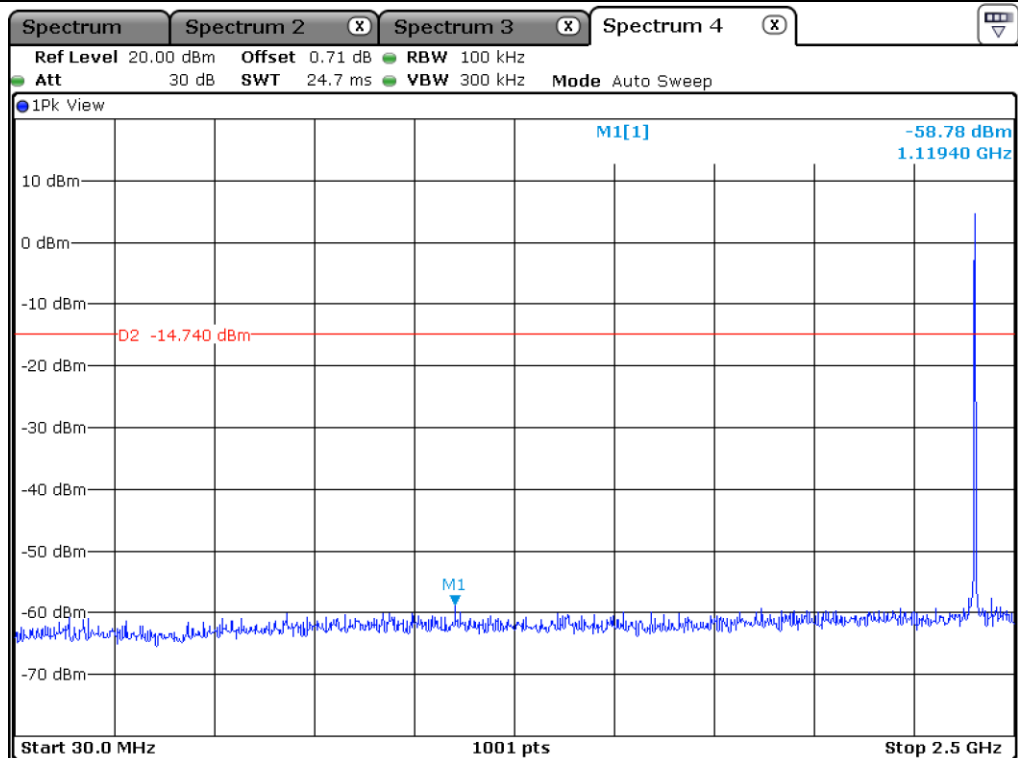


Low Channel

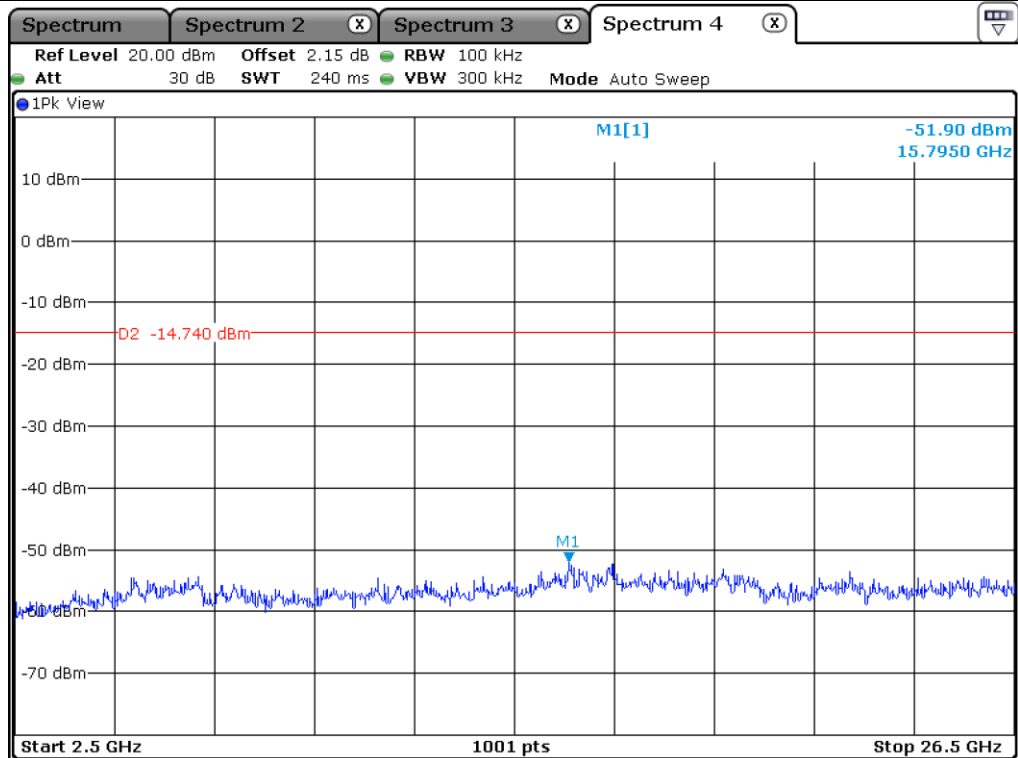


Middle Channel

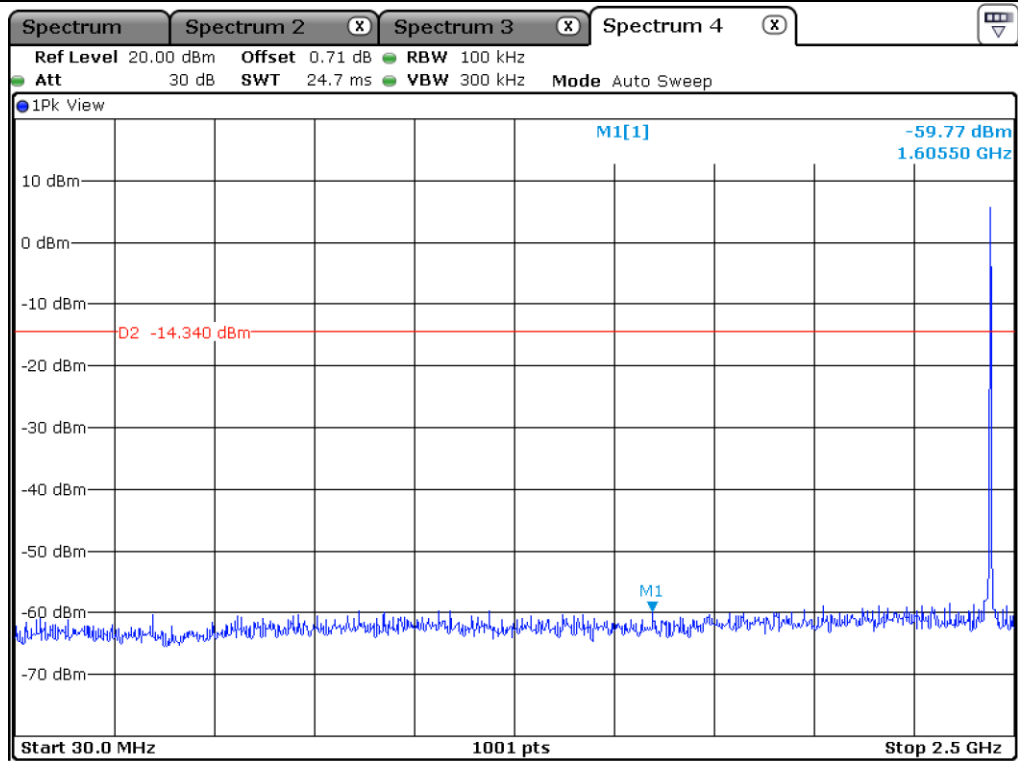




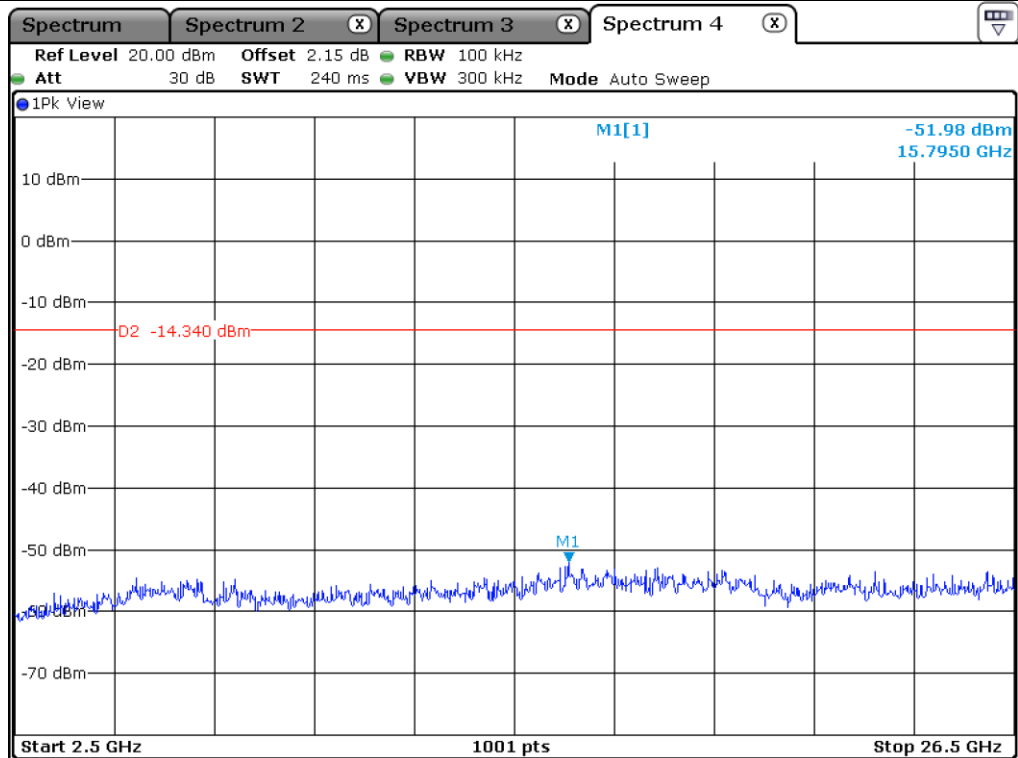
Low Channel



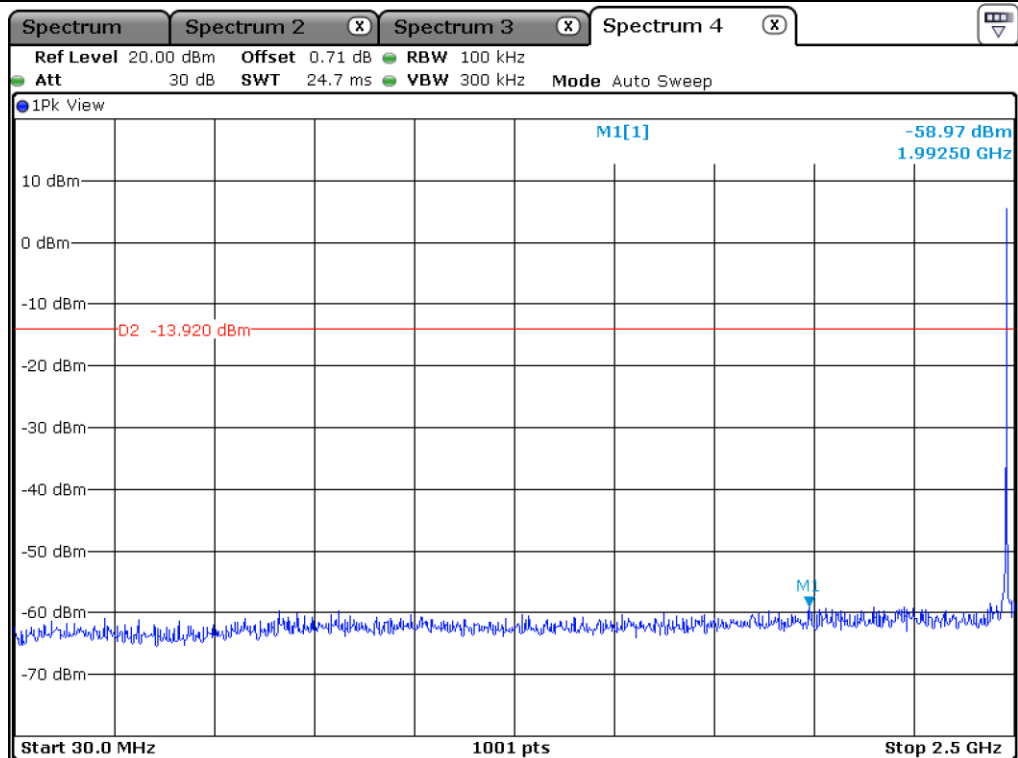
Low Channel



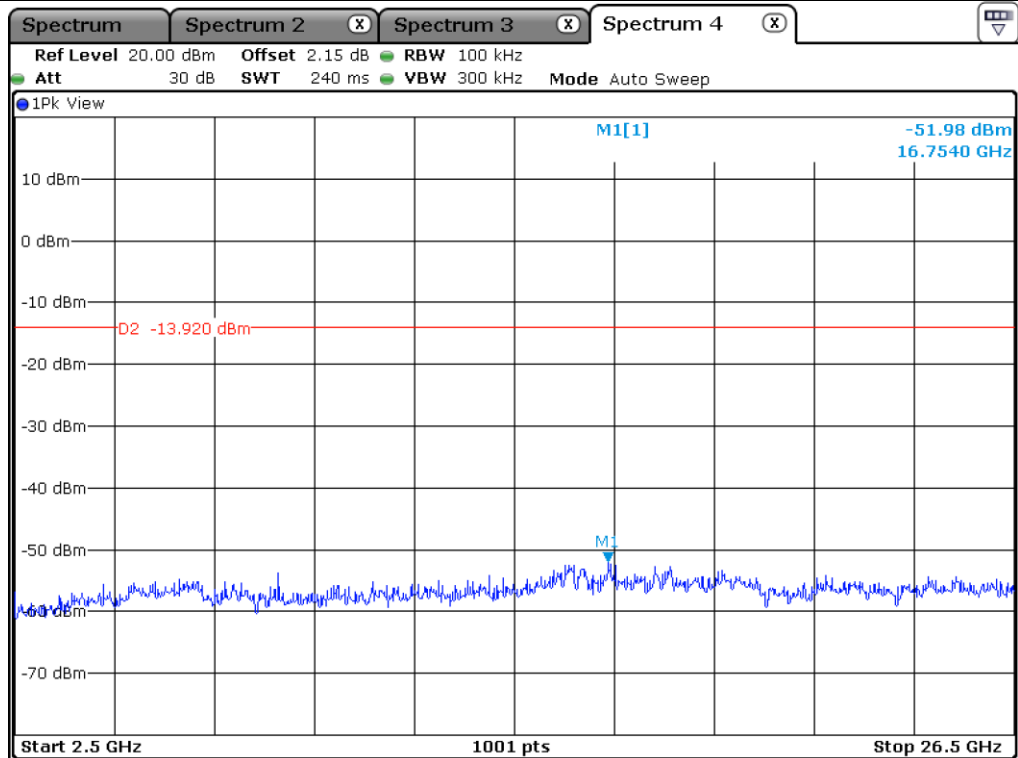
Middle Channel



Middle Channel



High Channel



High Channel

9.7 Test data for radiated emission

9.7.1 Radiated Emission which fall in the Restricted Band (Bluetooth LE 1 Mbps)

9.7.1.1 Test data for Left Earbud

- Resolution bandwidth : 1 MHz and Peak Detector for Peak Mode
1 MHz and RMS Detector for Average Mode
- Video bandwidth : 3 MHz for Peak and Average Mode
- Measurement distance : 3 m
- Duty Cycle : 85.60 %
- Result : PASSED

Frequency (MHz)	Reading (dBμV)	Detector Mode	Ant. Pol. (H/V)	Ant. Factor	Cable Loss	Amp Gain	Duty Factor (dB)	Total (dBμV/m)	Limits (dBμV/m)	Margin (dB)
Test Data for Low Channel										
2 385.59	53.42	Peak	H	28.30	8.12	46.15	-	43.69	74.00	30.31
2 321.99	44.48	Average	H	28.30	8.12	46.15	0.68	35.43	54.00	18.57
2 390.00	52.96	Peak	V	28.30	8.12	46.15	-	43.23	74.00	30.77
2 321.90	44.51	Average	V	28.30	8.12	46.15	0.68	35.46	54.00	18.54
Test Data for High Channel										
2 483.50	60.67	Peak	H	28.70	8.20	46.06	-	51.51	74.00	22.49
2 483.50	49.13	Average	H	28.70	8.20	46.06	0.68	40.65	54.00	13.35
2 483.50	59.67	Peak	V	28.70	8.20	46.06	-	50.51	74.00	23.49
2 483.50	49.29	Average	V	28.70	8.20	46.06	0.68	40.81	54.00	13.19

Tabulated test data for Restricted Band

Remark: "H": Horizontal, "V": Vertical

Margin (dB) = Limits (dBμV/m) - Total Level (dBμV/m)

Total Level = Reading + Antenna Factor + Cable Loss + Duty Factor - Amp Gain

9.7.1.2 Test data for Right Earbud

- . Resolution bandwidth : 1 MHz and Peak Detector for Peak Mode
1 MHz and RMS Detector for Average Mode
- . Video bandwidth : 3 MHz for Peak and Average Mode
- . Measurement distance : 3 m
- . Duty Cycle : 84.92 %
- . Result : PASSED

Frequency (MHz)	Reading (dBμV)	Detector Mode	Ant. Pol. (H/V)	Ant. Factor	Cable Loss	Amp Gain	Duty Factor (dB)	Total (dBμV/m)	Limits (dBμV/m)	Margin (dB)
Test Data for Low Channel										
2 327.04	52.14	Peak	H	28.30	8.12	46.15	-	42.41	74.00	31.59
2 321.90	43.62	Average	H	28.30	8.12	46.15	0.71	34.60	54.00	19.40
2 346.63	51.62	Peak	V	28.30	8.12	46.15	-	41.89	74.00	32.11
2 387.43	43.13	Average	V	28.30	8.12	46.15	0.71	34.11	54.00	19.89
Test Data for High Channel										
2 483.50	56.26	Peak	H	28.70	8.20	46.06	-	47.10	74.00	26.90
2 483.50	46.99	Average	H	28.70	8.20	46.06	0.71	38.54	54.00	15.46
2 484.32	56.34	Peak	V	28.70	8.20	46.06	-	47.18	74.00	26.82
2 483.50	47.13	Average	V	28.70	8.20	46.06	0.71	38.68	54.00	15.32

Tabulated test data for Restricted Band

Remark: "H": Horizontal, "V": Vertical

$$\text{Margin (dB)} = \text{Limits (dB}\mu\text{V/m)} - \text{Total Level (dB}\mu\text{V/m)}$$

$$\text{Total Level} = \text{Reading} + \text{Antenna Factor} + \text{Cable Loss} + \text{Duty Factor} - \text{Amp Gain}$$

9.7.2 Radiated Emission which fall in the Restricted Band (Bluetooth LE 2 Mbps)

9.7.2.1 Test data for Left Earbud

- Resolution bandwidth : 1 MHz and Peak Detector for Peak Mode
1 MHz and RMS Detector for Average Mode
- Video bandwidth : 3 MHz for Peak and Average Mode
- Measurement distance : 3 m
- Duty Cycle : 57.45 %
- Result : PASSED

Frequency (MHz)	Reading (dBμV)	Detector Mode	Ant. Pol. (H/V)	Ant. Factor	Cable Loss	Amp Gain	Duty Factor (dB)	Total (dBμV/m)	Limits (dBμV/m)	Margin (dB)
Test Data for Low Channel										
2 361.14	52.72	Peak	H	28.30	8.12	46.15	-	42.99	74.00	31.01
2 362.52	44.86	Average	H	28.30	8.12	46.15	2.41	37.54	54.00	16.46
2 366.75	52.19	Peak	V	28.30	8.12	46.15	-	42.46	74.00	31.54
2 388.90	44.01	Average	V	28.30	8.12	46.15	2.41	36.69	54.00	17.31
Test Data for High Channel										
2 483.50	63.27	Peak	H	28.70	8.20	46.06	-	54.11	74.00	19.89
2 483.50	51.66	Average	H	28.70	8.20	46.06	2.41	44.91	54.00	9.09
2 483.50	62.34	Peak	V	28.70	8.20	46.06	-	53.18	74.00	20.82
2 483.50	53.20	Average	V	28.70	8.20	46.06	2.41	46.45	54.00	7.55

Tabulated test data for Restricted Band

Remark: "H": Horizontal, "V": Vertical

$$\text{Margin (dB)} = \text{Limits (dB}\mu\text{V/m)} - \text{Total Level (dB}\mu\text{V/m)}$$

$$\text{Total Level} = \text{Reading} + \text{Antenna Factor} + \text{Cable Loss} + \text{Duty Factor} - \text{Amp Gain}$$

9.7.2.2 Test data for Right Earbud

- . Resolution bandwidth : 1 MHz and Peak Detector for Peak Mode
1 MHz and RMS Detector for Average Mode
- . Video bandwidth : 3 MHz for Peak and Average Mode
- . Measurement distance : 3 m
- . Duty Cycle : 57.45 %
- . Result : PASSED

Frequency (MHz)	Reading (dBμV)	Detector Mode	Ant. Pol. (H/V)	Ant. Factor	Cable Loss	Amp Gain	Duty Factor (dB)	Total (dBμV/m)	Limits (dBμV/m)	Margin (dB)
Test Data for Low Channel										
2 327.78	52.47	Peak	H	28.30	8.12	46.15	-	42.74	74.00	31.26
2 362.80	42.88	Average	H	28.30	8.12	46.15	2.41	35.56	54.00	18.44
2 384.58	51.89	Peak	V	28.30	8.12	46.15	-	42.16	74.00	31.84
2 362.61	43.03	Average	V	28.30	8.12	46.15	2.41	35.71	54.00	18.29
Test Data for High Channel										
2 483.50	59.62	Peak	H	28.70	8.20	46.06	-	50.46	74.00	23.54
2 483.50	51.40	Average	H	28.70	8.20	46.06	2.41	44.65	54.00	9.35
2 483.50	59.50	Peak	V	28.70	8.20	46.06	-	50.34	74.00	23.66
2 483.50	50.54	Average	V	28.70	8.20	46.06	2.41	43.79	54.00	10.21

Tabulated test data for Restricted Band

Remark: "H": Horizontal, "V": Vertical

$$\text{Margin (dB)} = \text{Limits (dB}\mu\text{V/m)} - \text{Total Level (dB}\mu\text{V/m)}$$

$$\text{Total Level} = \text{Reading} + \text{Antenna Factor} + \text{Cable Loss} + \text{Duty Factor} - \text{Amp Gain}$$

9.7.3 Spurious & Harmonic Radiated Emission (Bluetooth LE 1 Mbps)

9.7.3.1 Test data for Left Earbud

- Resolution bandwidth : 1 MHz for Peak and Average Mode for the emissions fall in restricted band,
1 MHz for Peak Mode for the emissions outside restricted band
- Video bandwidth : 3 MHz for Peak and Average Mode
- Frequency range : 1 GHz ~ 26.5 GHz
- Measurement distance : 3 m
- Duty Cycle : 85.60 %
- Result : PASSED

Frequency (MHz)	Reading (dBμV)	Detector Mode	Ant. Pol. (H/V)	Ant. Factor	Cable Loss	Amp Gain	Duty Factor (dB)	Total (dBμV/m)	Limits (dBμV/m)	Margin (dB)
Test Data for Low Channel										
4 804.00	49.40	Peak	H	33.40	11.19	45.73	-	48.26	74.00	25.74
4 804.00	41.30	Average	H	33.40	11.19	45.73	0.68	40.84	54.00	13.16
4 804.00	49.98	Peak	V	33.40	11.19	45.73	-	48.84	74.00	25.16
4 804.00	40.05	Average	V	33.40	11.19	45.73	0.68	39.59	54.00	14.41
Test Data for Middle Channel										
4 880.00	50.65	Peak	H	33.50	11.21	45.80	-	49.56	74.00	24.44
4 880.00	40.54	Average	H	33.50	11.21	45.80	0.68	40.13	54.00	13.87
4 880.00	49.22	Peak	V	33.50	11.21	45.80	-	48.13	74.00	25.87
4 880.00	40.26	Average	V	33.50	11.21	45.80	0.68	39.85	54.00	14.15
Test Data for High Channel										
4 960.00	49.42	Peak	H	33.40	11.28	45.89	-	48.21	74.00	25.79
4 960.00	40.27	Average	H	33.40	11.28	45.89	0.68	39.74	54.00	14.26
4 960.00	49.43	Peak	V	33.40	11.28	45.89	-	48.22	74.00	25.78
4 960.00	40.08	Average	V	33.40	11.28	45.89	0.68	39.55	54.00	14.45

Remark: "H": Horizontal, "V": Vertical

$$\text{Margin (dB)} = \text{Limits (dBμV/m)} - \text{Total Level (dBμV/m)}$$

$$\text{Total Level} = \text{Reading} + \text{Antenna Factor} + \text{Cable Loss} + \text{Duty Factor} - \text{Amp Gain}$$

9.7.2.2 Test data for Right Earbud

- Resolution bandwidth : 1 MHz for Peak and Average Mode for the emissions fall in restricted band,
1 MHz for Peak Mode for the emissions outside restricted band
- Video bandwidth : 3 MHz for Peak and Average Mode
- Frequency range : 1 GHz ~ 26.5 GHz
- Measurement distance : 3 m
- Duty Cycle : 84.92 %
- Result : PASSED

Frequency (MHz)	Reading (dBμV)	Detector Mode	Ant. Pol. (H/V)	Ant. Factor	Cable Loss	Amp Gain	Duty Factor (dB)	Total (dBμV/m)	Limits (dBμV/m)	Margin (dB)
Test Data for Low Channel										
4 804.00	50.37	Peak	H	33.40	11.19	45.73	-	49.23	74.00	24.77
4 804.00	40.57	Average	H	33.40	11.19	45.73	0.71	40.14	54.00	13.86
4 804.00	50.64	Peak	V	33.40	11.19	45.73	-	49.50	74.00	24.50
4 804.00	40.19	Average	V	33.40	11.19	45.73	0.71	39.76	54.00	14.24
Test Data for Middle Channel										
4 880.00	49.93	Peak	H	33.50	11.21	45.80	-	48.84	74.00	25.16
4 880.00	40.13	Average	H	33.50	11.21	45.80	0.71	39.75	54.00	14.25
4 880.00	49.96	Peak	V	33.50	11.21	45.80	-	48.87	74.00	25.13
4 880.00	40.29	Average	V	33.50	11.21	45.80	0.71	39.91	54.00	14.09
Test Data for High Channel										
4 960.00	49.71	Peak	H	33.40	11.28	45.89	-	48.50	74.00	25.50
4 960.00	40.16	Average	H	33.40	11.28	45.89	0.71	39.66	54.00	14.34
4 960.00	50.65	Peak	V	33.40	11.28	45.89	-	49.44	74.00	24.56
4 960.00	39.77	Average	V	33.40	11.28	45.89	0.71	39.27	54.00	14.73

Remark: "H": Horizontal, "V": Vertical

$$\text{Margin (dB)} = \text{Limits (dB}\mu\text{V/m)} - \text{Total Level (dB}\mu\text{V/m)}$$

$$\text{Total Level} = \text{Reading} + \text{Antenna Factor} + \text{Cable Loss} + \text{Duty Factor} - \text{Amp Gain}$$

9.7.4 Spurious & Harmonic Radiated Emission (Bluetooth LE 2 Mbps)

9.7.4.1 Test data for Left Earbud

- Resolution bandwidth : 1 MHz for Peak and Average Mode for the emissions fall in restricted band,
1 MHz for Peak Mode for the emissions outside restricted band
- Video bandwidth : 3 MHz for Peak and Average Mode
- Frequency range : 1 GHz ~ 26.5 GHz
- Measurement distance : 3 m
- Duty Cycle : 57.45 %
- Result : PASSED

Frequency (MHz)	Reading (dBμV)	Detector Mode	Ant. Pol. (H/V)	Ant. Factor	Cable Loss	Amp Gain	Duty Factor (dB)	Total (dBμV/m)	Limits (dBμV/m)	Margin (dB)
Test Data for Low Channel										
4 804.00	50.86	Peak	H	33.40	11.19	45.73	-	49.72	74.00	24.28
4 804.00	40.84	Average	H	33.40	11.19	45.73	2.41	42.11	54.00	11.89
4 804.00	51.71	Peak	V	33.40	11.19	45.73	-	50.57	74.00	23.43
4 804.00	40.39	Average	V	33.40	11.19	45.73	2.41	41.66	54.00	12.34
Test Data for Middle Channel										
4 880.00	50.46	Peak	H	33.50	11.21	45.80	-	49.37	74.00	24.63
4 880.00	40.06	Average	H	33.50	11.21	45.80	2.41	41.38	54.00	12.62
4 880.00	50.30	Peak	V	33.50	11.21	45.80	-	49.21	74.00	24.79
4 880.00	40.57	Average	V	33.50	11.21	45.80	2.41	41.89	54.00	12.11
Test Data for High Channel										
4 960.00	50.43	Peak	H	33.40	11.28	45.89	-	49.22	74.00	24.78
4 960.00	40.01	Average	H	33.40	11.28	45.89	2.41	41.21	54.00	12.79
4 960.00	49.13	Peak	V	33.40	11.28	45.89	-	47.92	74.00	26.08
4 960.00	40.26	Average	V	33.40	11.28	45.89	2.41	41.46	54.00	12.54

Remark: "H": Horizontal, "V": Vertical

$$\text{Margin (dB)} = \text{Limits (dB}\mu\text{V/m)} - \text{Total Level (dB}\mu\text{V/m)}$$

$$\text{Total Level} = \text{Reading} + \text{Antenna Factor} + \text{Cable Loss} + \text{Duty Factor} - \text{Amp Gain}$$

9.7.4.2 Test data for Right Earbud

- Resolution bandwidth : 1 MHz for Peak and Average Mode for the emissions fall in restricted band,
1 MHz for Peak Mode for the emissions outside restricted band
- Video bandwidth : 3 MHz for Peak and Average Mode
- Frequency range : 1 GHz ~ 26.5 GHz
- Measurement distance : 3 m
- Duty Cycle : 57.45 %
- Result : PASSED

Frequency (MHz)	Reading (dBμV)	Detector Mode	Ant. Pol. (H/V)	Ant. Factor	Cable Loss	Amp Gain	Duty Factor (dB)	Total (dBμV/m)	Limits (dBμV/m)	Margin (dB)
Test Data for Low Channel										
4 804.00	49.78	Peak	H	33.40	11.19	45.73	-	48.64	74.00	25.36
4 804.00	39.93	Average	H	33.40	11.19	45.73	2.41	41.20	54.00	12.80
4 804.00	48.6	Peak	V	33.40	11.19	45.73	-	47.46	74.00	26.54
4 804.00	40.24	Average	V	33.40	11.19	45.73	2.41	41.51	54.00	12.49
Test Data for Middle Channel										
4 880.00	50.64	Peak	H	33.50	11.21	45.80	-	49.55	74.00	24.45
4 880.00	40.18	Average	H	33.50	11.21	45.80	2.41	41.50	54.00	12.50
4 880.00	50.16	Peak	V	33.50	11.21	45.80	-	49.07	74.00	24.93
4 880.00	40.28	Average	V	33.50	11.21	45.80	2.41	41.60	54.00	12.40
Test Data for High Channel										
4 960.00	49.03	Peak	H	33.40	11.28	45.89	-	47.82	74.00	26.18
4 960.00	40.06	Average	H	33.40	11.28	45.89	2.41	41.26	54.00	12.74
4 960.00	49.74	Peak	V	33.40	11.28	45.89	-	48.53	74.00	25.47
4 960.00	39.74	Average	V	33.40	11.28	45.89	2.41	40.94	54.00	13.06

Remark: "H": Horizontal, "V": Vertical

$$\text{Margin (dB)} = \text{Limits (dBμV/m)} - \text{Total Level (dBμV/m)}$$

$$\text{Total Level} = \text{Reading} + \text{Antenna Factor} + \text{Cable Loss} + \text{Duty Factor} - \text{Amp Gain}$$

10. PEAK POWER SPECTRAL DENSITY

10.1 Operating environment

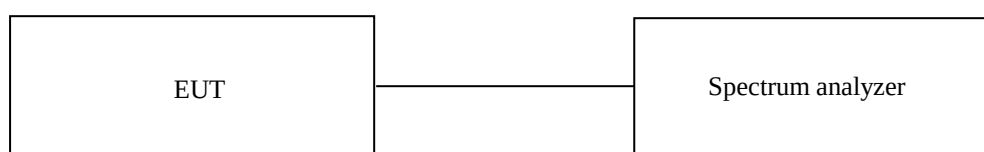
Temperature : 22 °C

Relative humidity : 46 % R.H.

10.2 Test set-up

The antenna output of the EUT was connected to the spectrum analyzer.

The resolution bandwidth is set to $3 \text{ kHz} \leq \text{RBW} \leq 100 \text{ kHz}$, the video bandwidth is set to 3 times the resolution bandwidth.



10.3 Test Date

September 10, 2021 ~ September 15, 2021

10.4 Test data for Bluetooth LE 1 Mbps

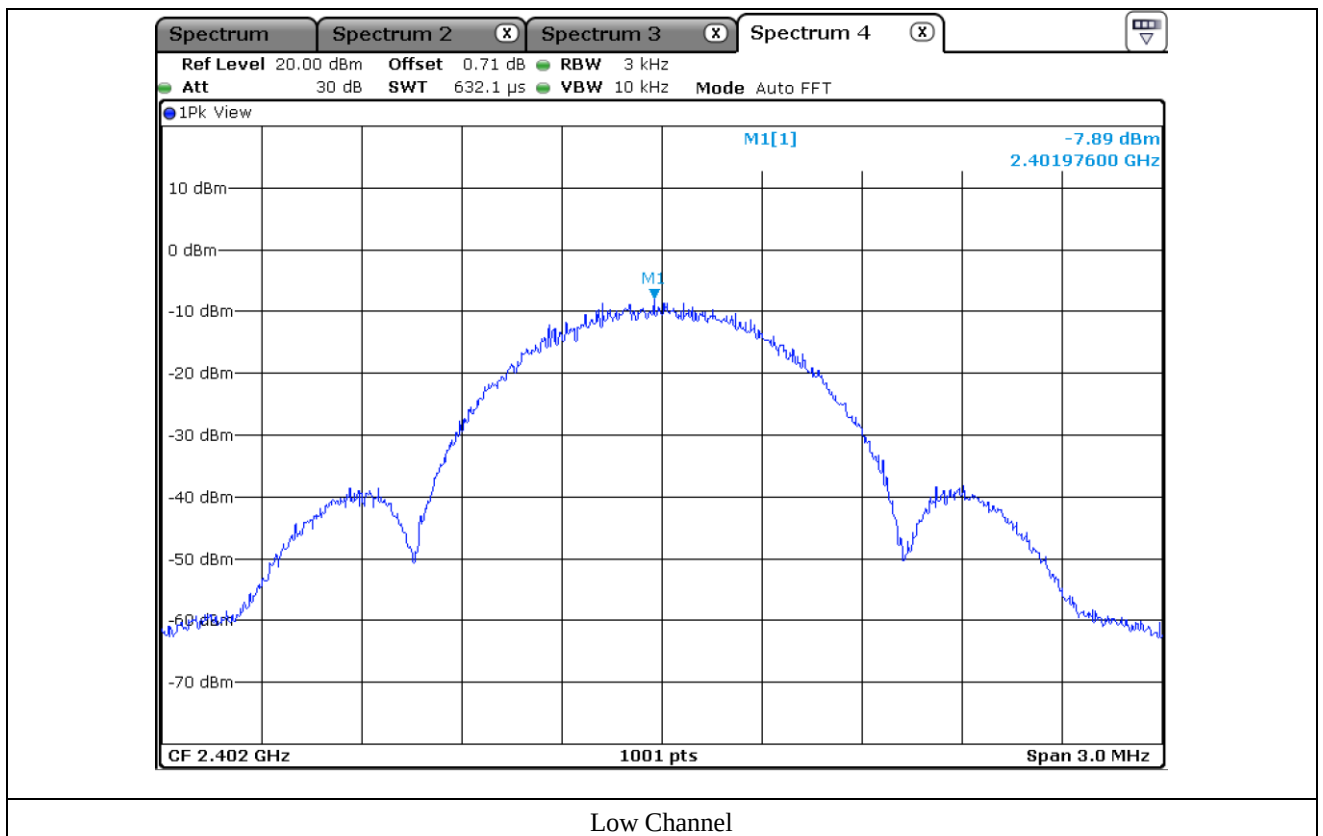
10.4.1 Test data for Left Earbud

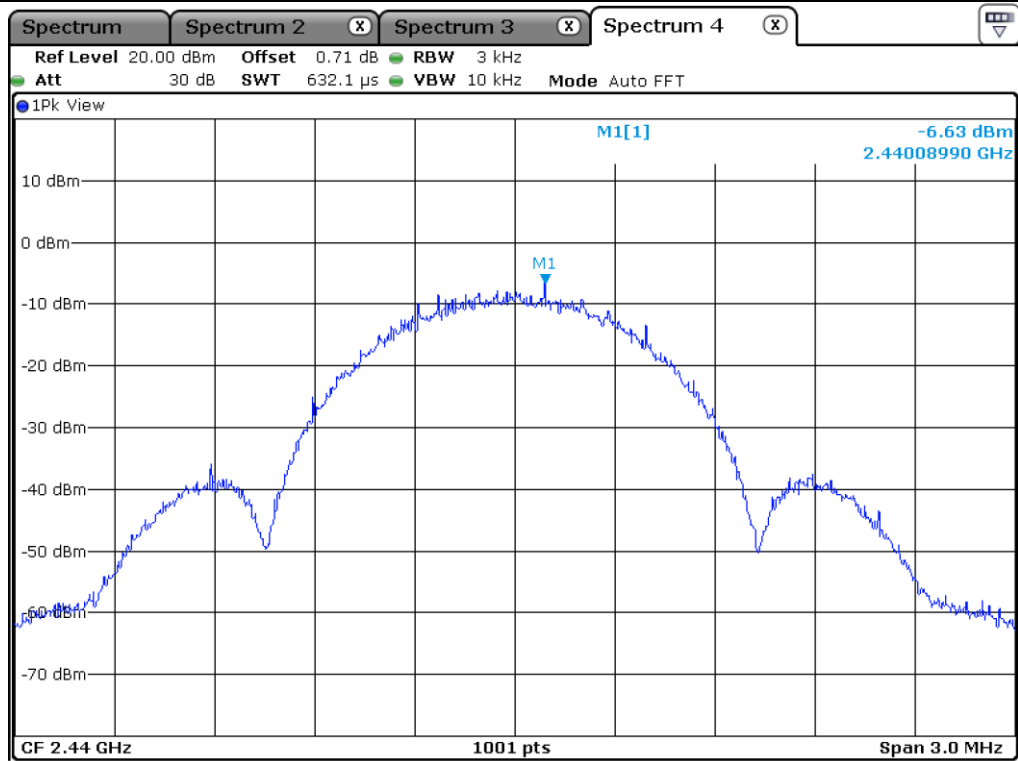
-. Test Result : Pass

-. Operating Condition : Continuous transmitting mode

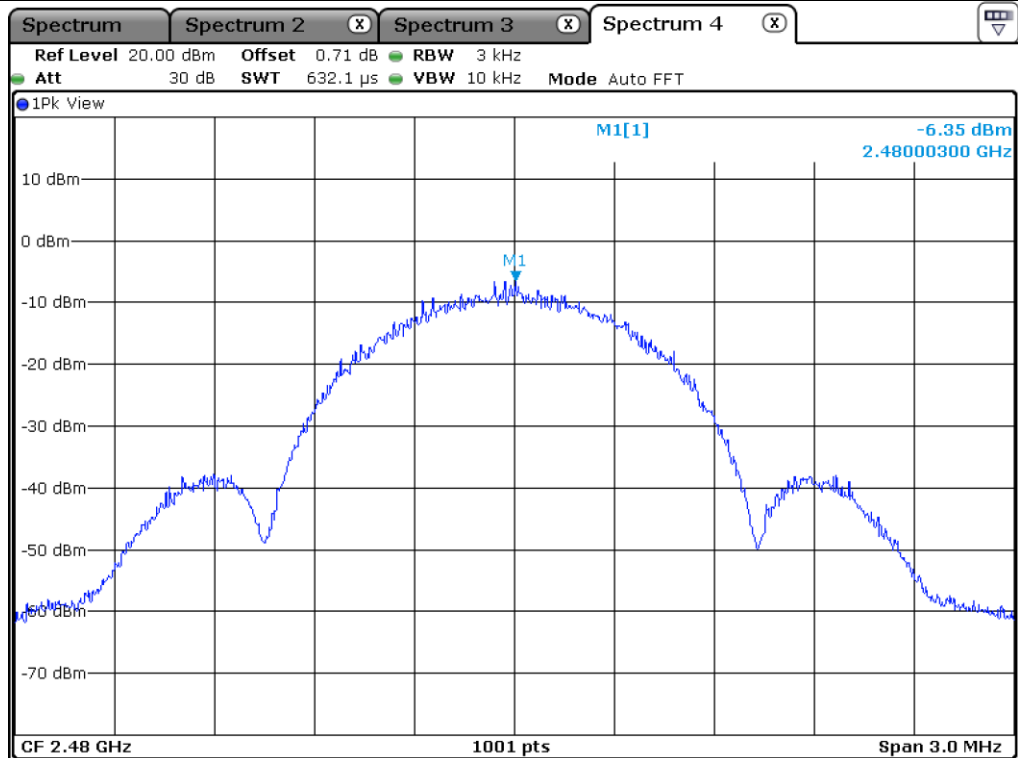
CHANNEL	FREQUENCY(MHz)	MEASURED VALUE (dBm)	LIMIT (dBm)	MARGIN (dB)
Low	2 402.00	-7.89	8.00	15.89
Middle	2 440.00	-6.63	8.00	14.63
High	2 480.00	-6.35	8.00	14.35

Remark. Margin = Limit – Measured value





Middle Channel



High Channel

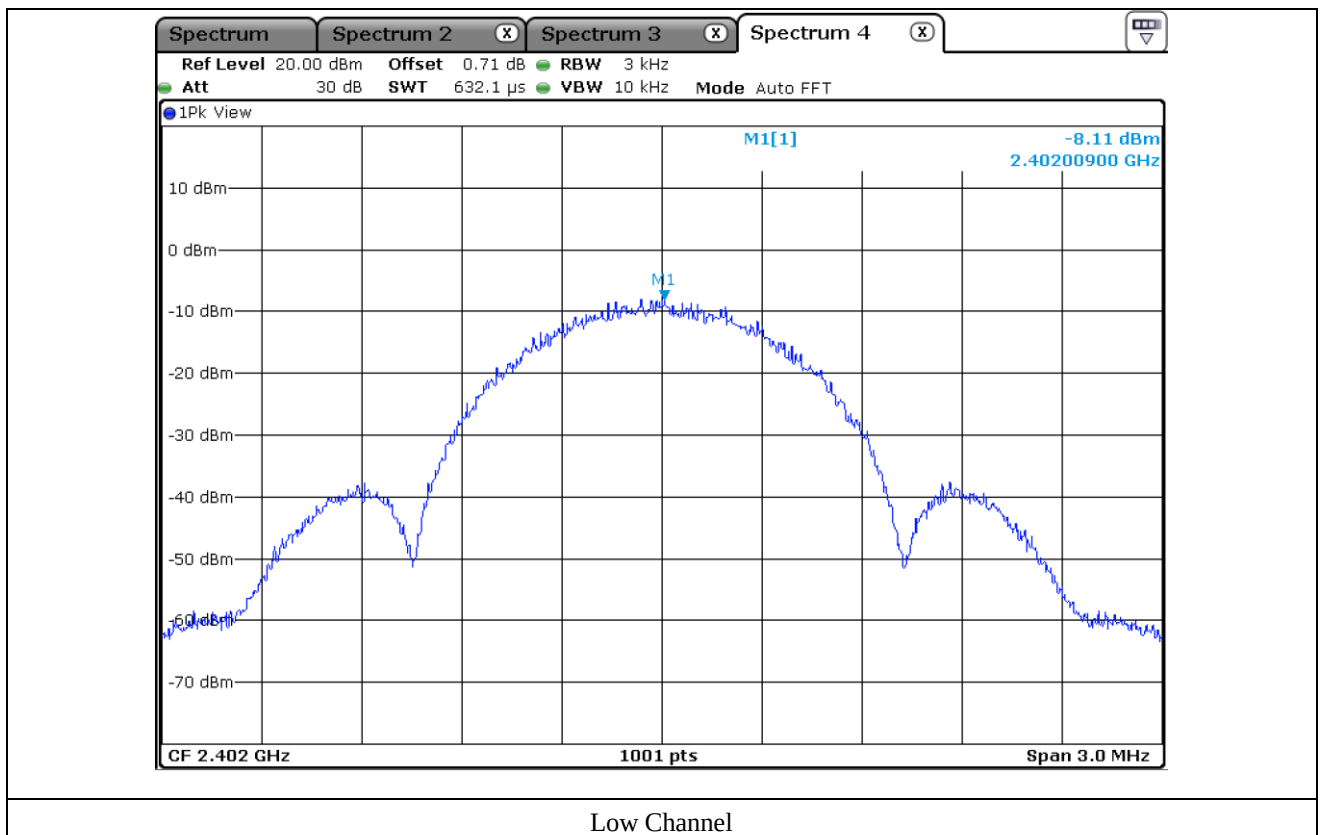
10.4.2 Test data for Right Earbud

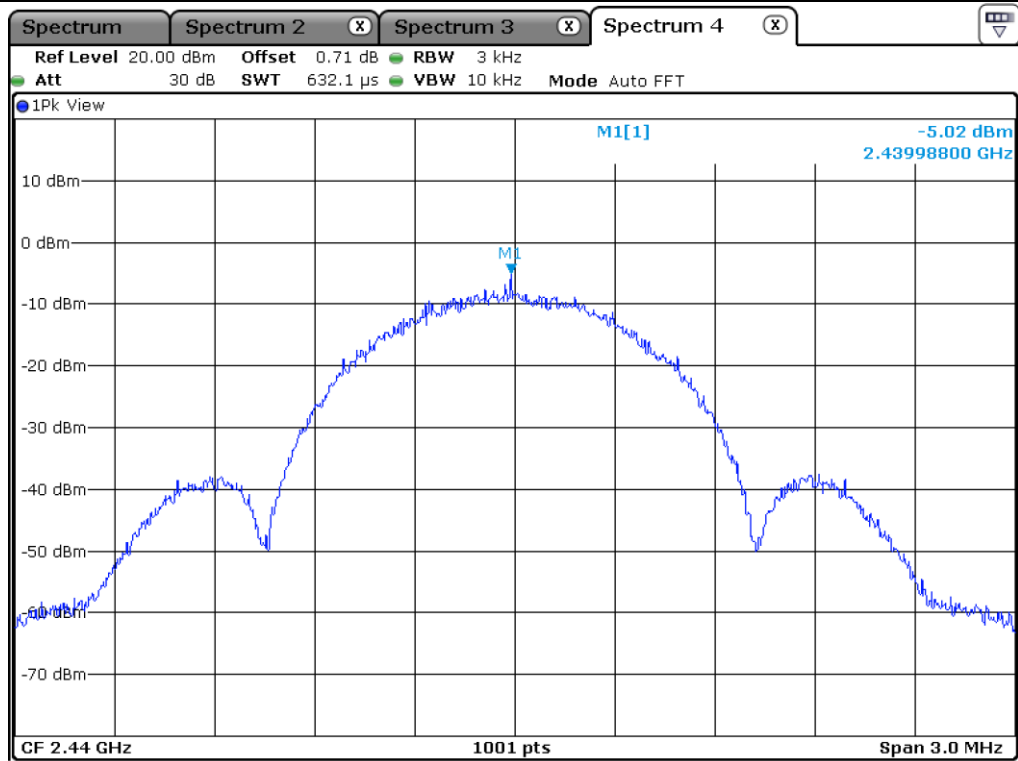
-. Test Result : Pass

-. Operating Condition : Continuous transmitting mode

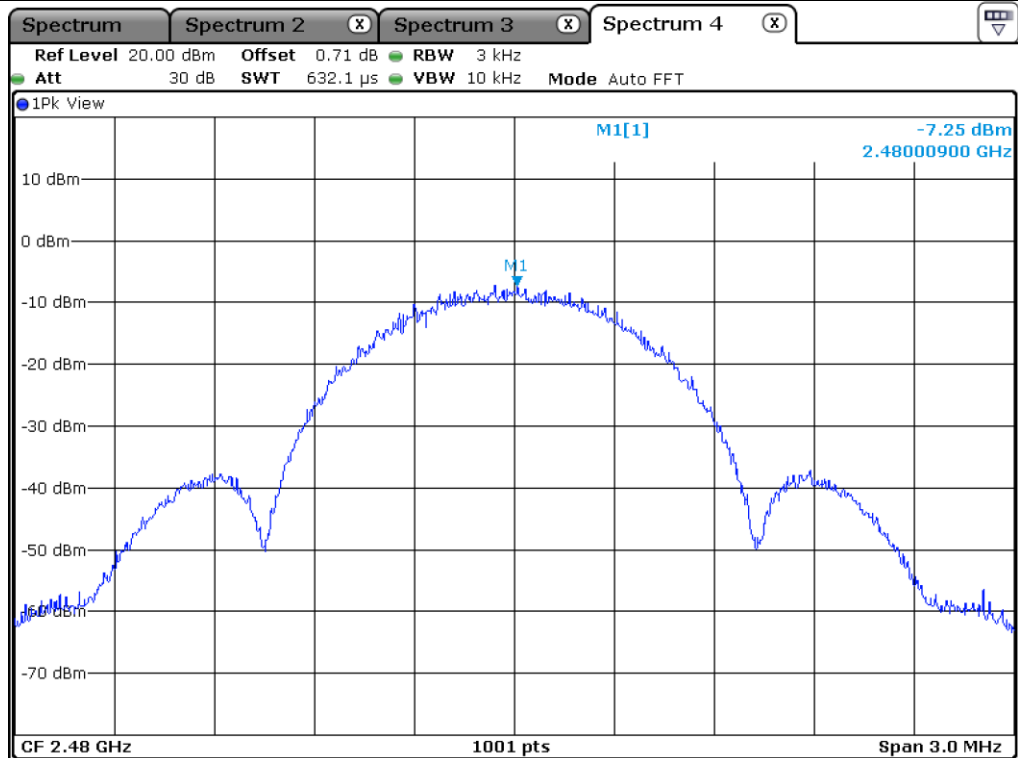
CHANNEL	FREQUENCY(MHz)	MEASURED VALUE (dBm)	LIMIT (dBm)	MARGIN (dB)
Low	2 402.00	-8.11	8.00	16.11
Middle	2 440.00	-5.02	8.00	13.02
High	2 480.00	-7.25	8.00	15.25

Remark. Margin = Limit – Measured value





Middle Channel



High Channel

10.5 Test data for Bluetooth LE 2 Mbps

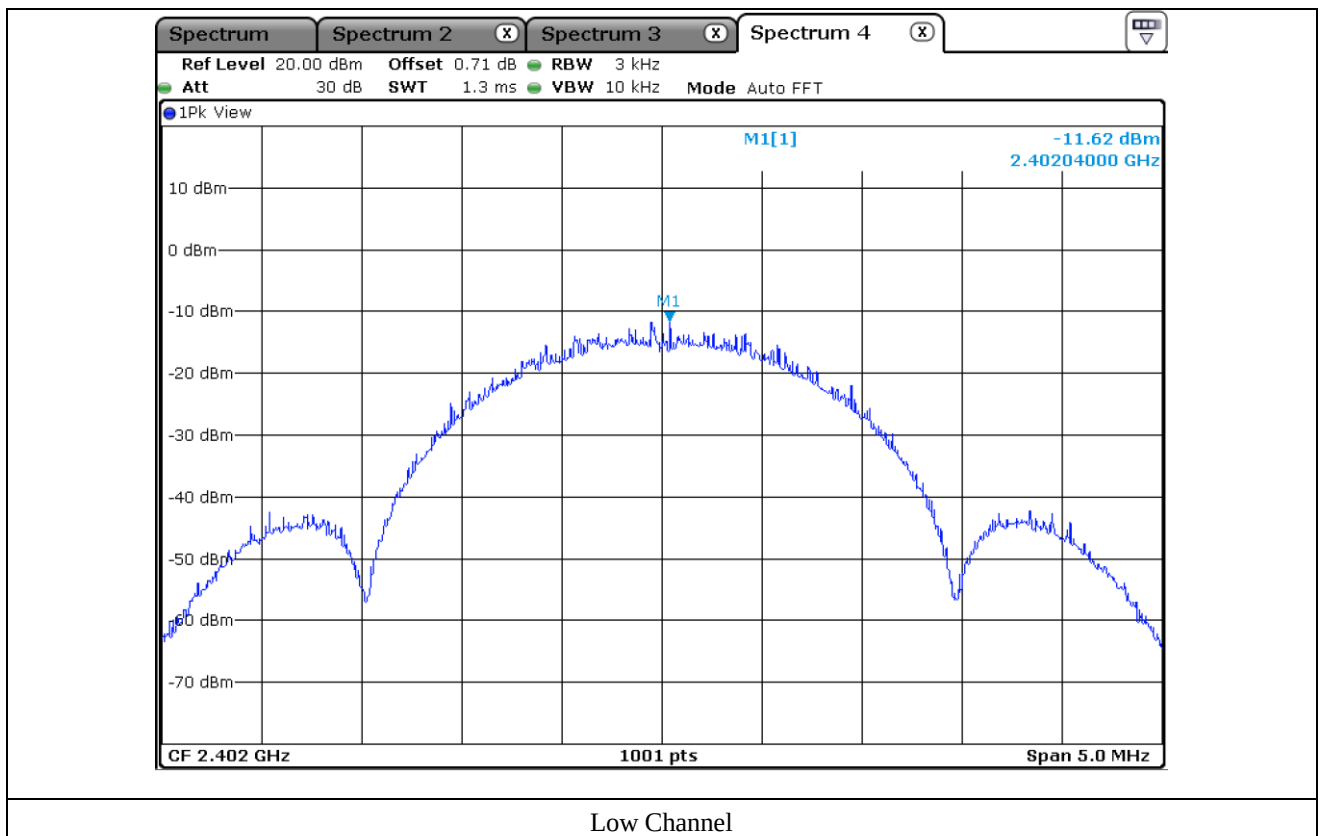
10.5.1 Test data for Left Earbud

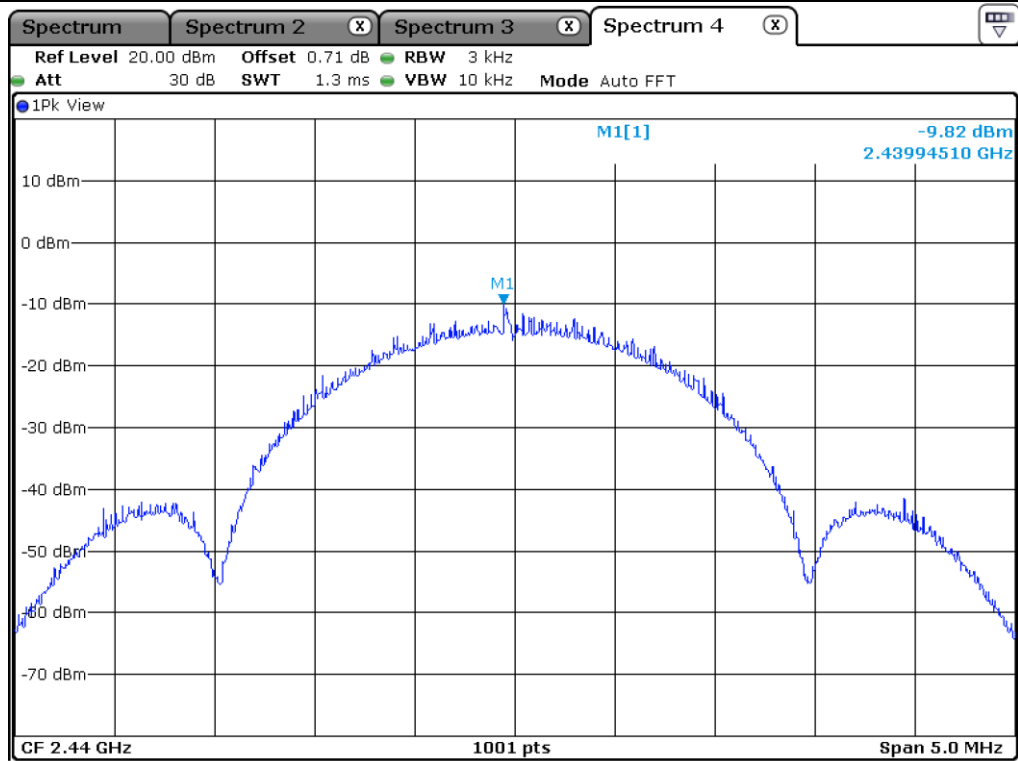
-. Test Result : Pass

-. Operating Condition : Continuous transmitting mode

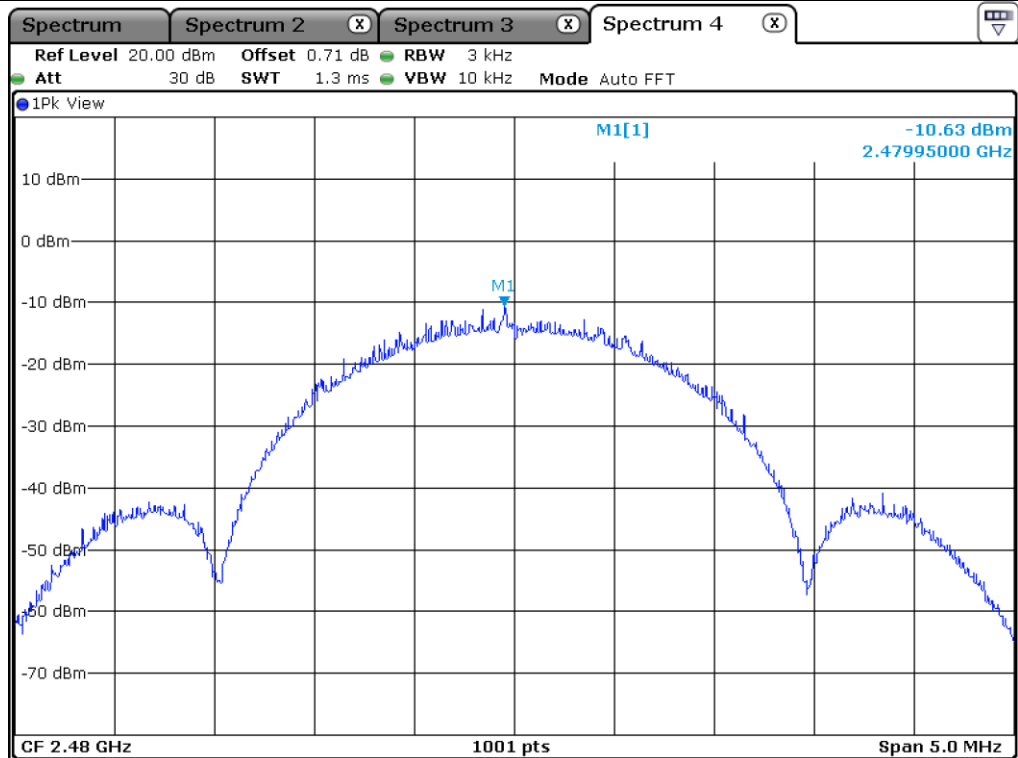
CHANNEL	FREQUENCY(MHz)	MEASURED VALUE (dBm)	LIMIT (dBm)	MARGIN (dB)
Low	2 402.00	-11.62	8.00	19.62
Middle	2 440.00	-9.82	8.00	17.82
High	2 480.00	-10.63	8.00	18.63

Remark. Margin = Limit – Measured value





Middle Channel



High Channel

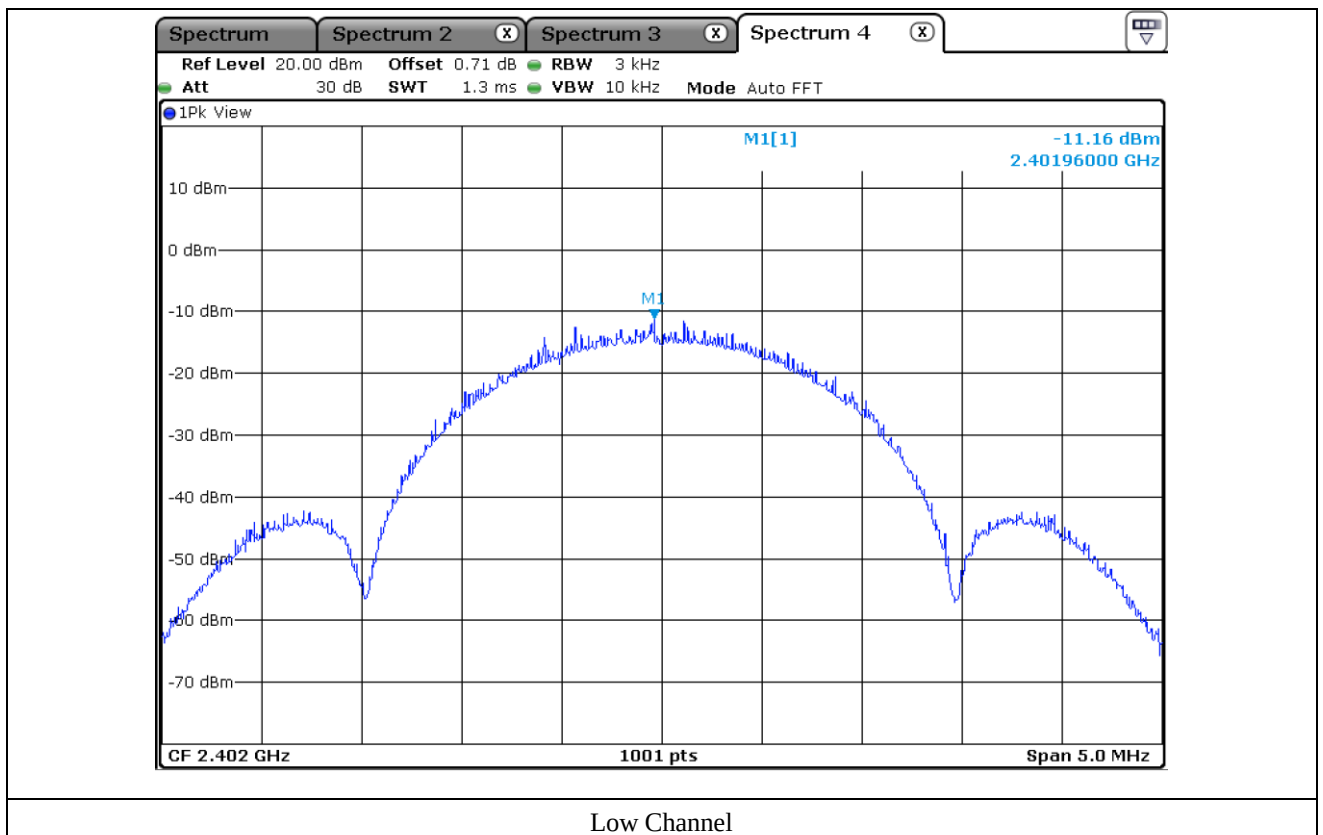
10.5.2 Test data for Right Earbud

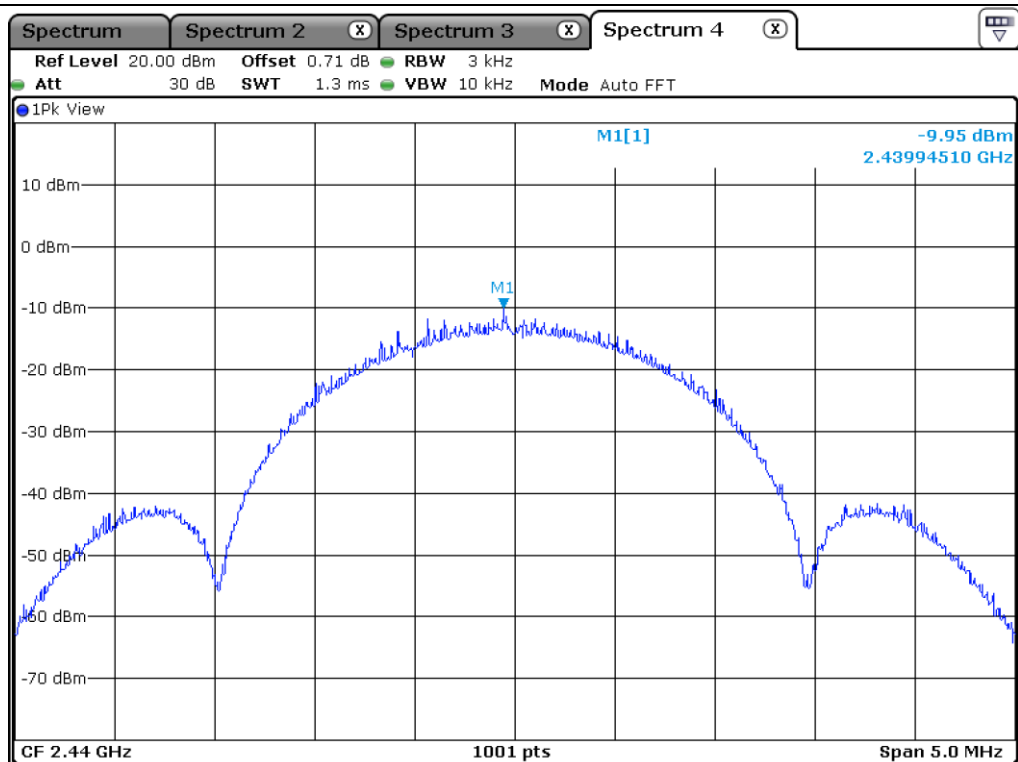
-. Test Result : Pass

-. Operating Condition : Continuous transmitting mode

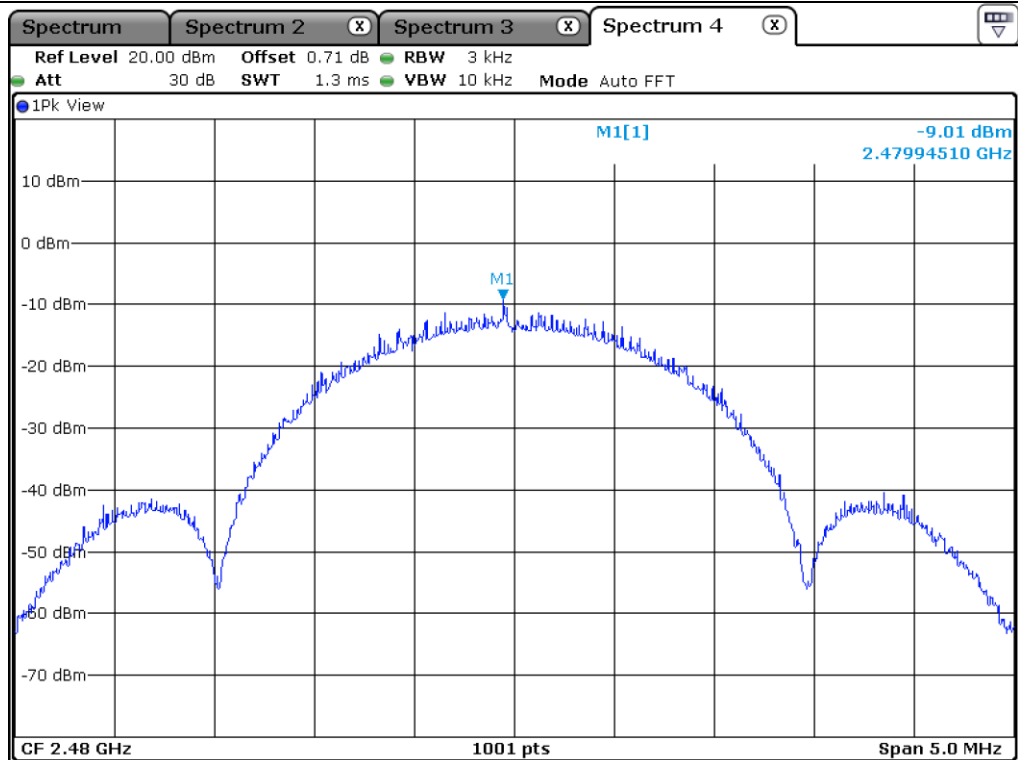
CHANNEL	FREQUENCY(MHz)	MEASURED VALUE (dBm)	LIMIT (dBm)	MARGIN (dB)
Low	2 402.00	-11.16	8.00	19.16
Middle	2 440.00	-9.95	8.00	17.95
High	2 480.00	-9.01	8.00	17.01

Remark. Margin = Limit – Measured value





Middle Channel



High Channel

11. RADIATED EMISSION TEST

11.1 Operating environment

Temperature : 22 °C
Relative humidity : 46 % R.H.

11.2 Test set-up

The radiated emissions measurements were on the 3 m semi anechoic chamber. The EUT and other support equipment were placed on a non-conductive turntable above the ground plane. The interconnecting cables from outside test site were inserted into ferrite clamps at the point where the cables reach the turntable.

The frequency spectrum from 30 MHz to 26.5 GHz was scanned and emission levels maximized at each frequency recorded. The system was rotated 360°, and the antenna was varied in height between 1.0 m and 4.0 m in order to determine the maximum emission levels. This procedure was performed for both horizontal and vertical polarization of the receiving antenna.

11.3 Test Date

September 10, 2021 ~ September 15, 2021

11.4 Test data for Left Earbud

11.4.1 Test data for 30 MHz ~ 1000 MHz

Humidity Level : 46 % R.H.

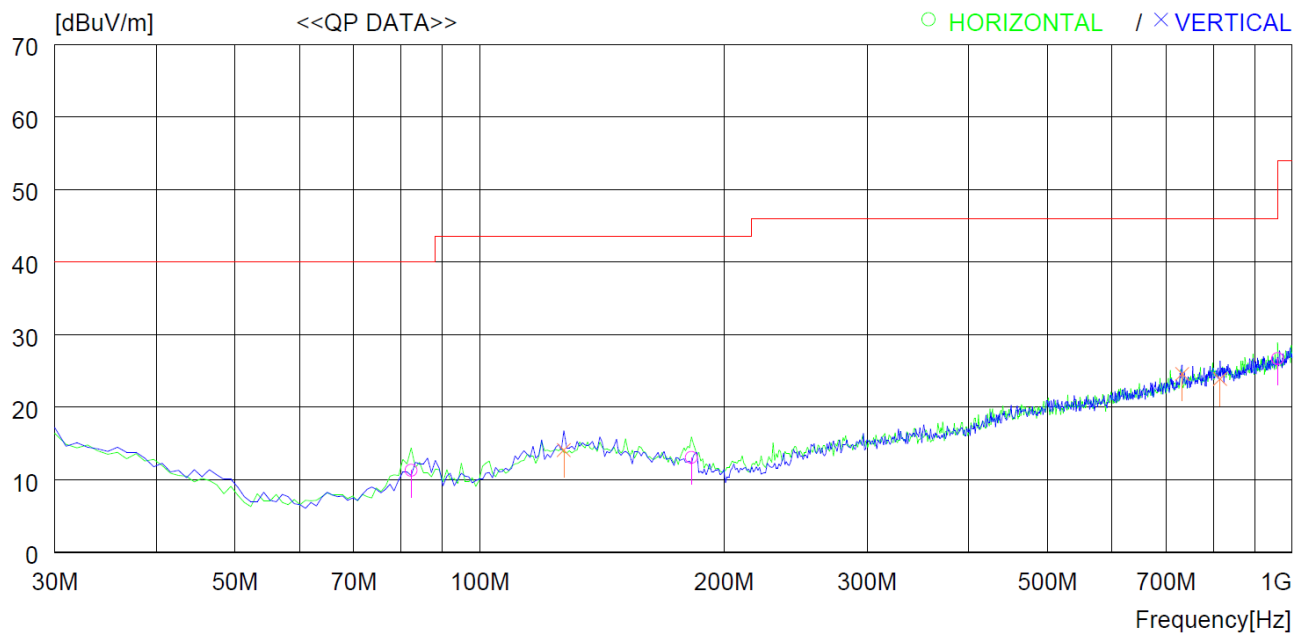
Temperature: 22 °C

Limits apply to : FCC CFR 47, PART 15, SUBPART C, SECTION 15.247

Result : PASSED

EUT : Bluetooth Earbud

Detector : CISPR Quasi-Peak (6 dB Bandwidth: 120 kHz)



No.	FREQ	READING	ANT	LOSS	GAIN	RESULT	LIMIT	MARGIN	ANTENNA	TABLE
	[MHz]	QP	FACTOR							
	[MHz]	[dBuV]	[dB]	[dB]	[dB]	[dBuV/m]	[dBuV/m]	[dB]	[cm]	[DEG]
----- Horizontal -----										
1	82.380	29.8	12.9	1.7	33.1	11.3	40.0	28.7	300	359
2	182.290	27.2	16.4	2.5	33.0	13.1	43.5	30.4	300	63
3	960.217	24.3	28.2	6.2	32.0	26.7	54.0	27.3	200	2
----- Vertical -----										
4	127.000	25.8	19.1	2.2	33.0	14.1	43.5	29.4	400	359
5	732.274	26.5	26.1	5.3	33.3	24.6	46.0	21.4	400	359
6	815.691	24.1	27.2	5.6	33.0	23.9	46.0	22.1	100	64

11.4.2 Test data for Below 30 MHz

- . Resolution bandwidth : 200 Hz (from 9 kHz to 0.15 MHz), 9 kHz (from 0.15 MHz to 30 MHz)
- . Frequency range : 9 kHz ~ 30 MHz
- . Measurement distance : 3 m
- . Operating mode : Transmitting mode

Frequency (MHz)	Reading (dBμV)	Ant. Pol. (H/V)	Ant. Height (m)	Angle (°)	Ant. Factor (dB/m)	Cable Loss	Emission Level(dBμV/m)	Limits (dBμV/m)	Margin (dB)
Emission from the EUT more than 20 dB below the limit in each frequency range.									

11.4.3 Test data for above 1 GHz

- . Resolution bandwidth : 1 MHz for Peak and Average Mode
- . Video bandwidth : 3 MHz for Peak and Average Mode
- . Frequency range : 1 GHz ~ 26.5 GHz
- . Measurement distance : 3 m
- . Operating mode : Transmitting mode

Frequency (MHz)	Reading (dBμV)	Ant. Pol. (H/V)	Ant. Height (m)	Angle (°)	Ant. Factor (dB/m)	Cable Loss	Emission Level(dBμV/m)	Limits (dBμV/m)	Margin (dB)
Emission from the EUT more than 20 dB below the limit in each frequency range.									

11.5 Test data for Right Earbud

11.5.1 Test data for 30 MHz ~ 1000 MHz

Humidity Level : 46 % R.H.

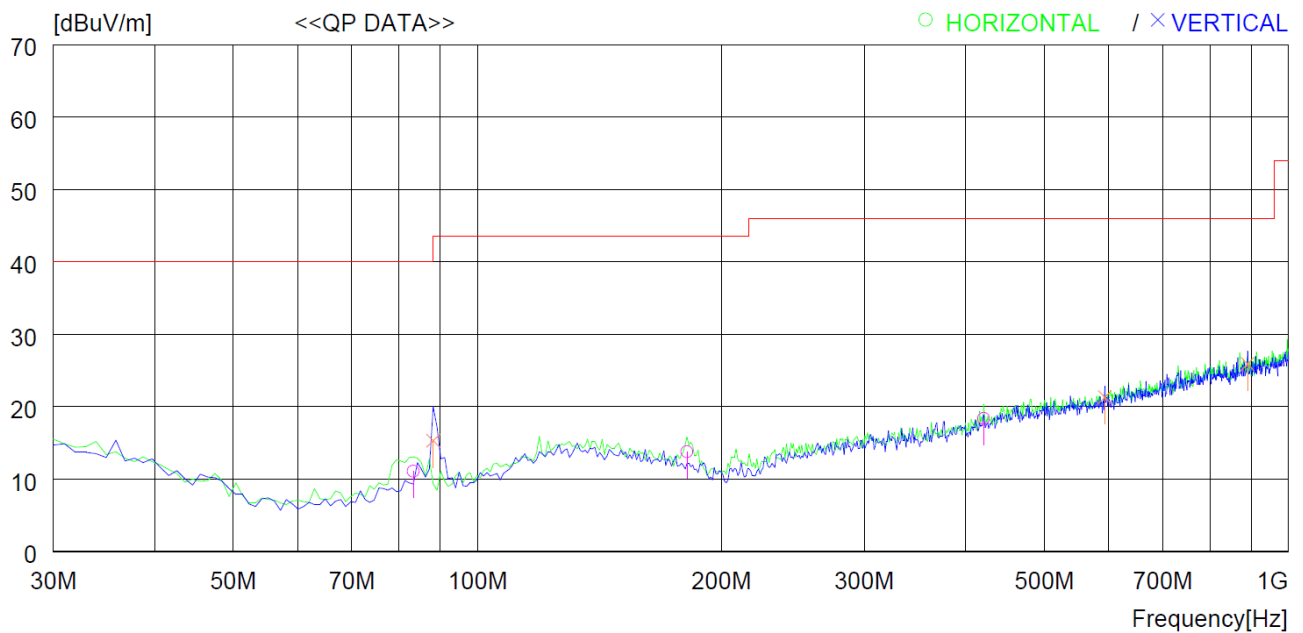
Temperature: 22 °C

Limits apply to : FCC CFR 47, PART 15, SUBPART C, SECTION 15.247

Result : PASSED

EUT : Bluetooth Earbud

Detector : CISPR Quasi-Peak (6 dB Bandwidth: 120 kHz)



No.	FREQ	READING	ANT	LOSS	GAIN	RESULT	LIMIT	MARGIN	ANTENNA	TABLE
	[MHz]	QP	FACTOR	[dB]	[dB]	[dBuV/m]	[dBuV/m]	[dB]	[cm]	[DEG]
----- Horizontal -----										
1	83.350	29.5	12.9	1.8	33.1	11.1	40.0	28.9	400	0
2	181.320	27.8	16.5	2.5	33.0	13.8	43.5	29.7	400	0
3	420.911	25.9	21.5	4.0	33.0	18.4	46.0	27.6	400	19
----- Vertical -----										
4	88.200	33.3	13.3	1.8	33.1	15.3	43.5	28.2	200	2
5	593.568	25.4	24.2	4.9	33.2	21.3	46.0	24.7	300	0
6	890.379	25.1	27.5	5.9	32.6	25.9	46.0	20.1	300	222

11.5.2 Test data for Below 30 MHz

- . Resolution bandwidth : 200 Hz (from 9 kHz to 0.15 MHz), 9 kHz (from 0.15 MHz to 30 MHz)
- . Frequency range : 9 kHz ~ 30 MHz
- . Measurement distance : 3 m
- . Operating mode : Transmitting mode

Frequency (MHz)	Reading (dBμV)	Ant. Pol. (H/V)	Ant. Height (m)	Angle (°)	Ant. Factor (dB/m)	Cable Loss	Emission Level(dBμV/m)	Limits (dBμV/m)	Margin (dB)
Emission from the EUT more than 20 dB below the limit in each frequency range.									

11.5.3 Test data for above 1 GHz

- . Resolution bandwidth : 1 MHz for Peak and Average Mode
- . Video bandwidth : 3 MHz for Peak and Average Mode
- . Frequency range : 1 GHz ~ 26.5 GHz
- . Measurement distance : 3 m
- . Operating mode : Transmitting mode

Frequency (MHz)	Reading (dBμV)	Ant. Pol. (H/V)	Ant. Height (m)	Angle (°)	Ant. Factor (dB/m)	Cable Loss	Emission Level(dBμV/m)	Limits (dBμV/m)	Margin (dB)
Emission from the EUT more than 20 dB below the limit in each frequency range.									

12. LIST OF TEST EQUIPMENT

Model Number	Manufacturer	Description	Serial Number	Last Cal.(Interval)
FSV40-N	Rohde & Schwarz	Signal Analyzer	101457	Apr. 16, 2021 (1Y)
ESW 44	Rohde & Schwarz	EMI Test Receiver	101851	Mar. 23, 2021 (1Y)
310N	Sonoma Instrument	Pre-Amplifier	392756	Oct. 16, 2020 (1Y)
PAM-840A	Com-Power	Pre-Amplifier	461339	Oct. 16, 2020 (1Y)
SCU18	Rohde & Schwarz	Pre-Amplifier	102266	Jul. 14, 2021 (1Y)
DT2000-2t	Innco Systems GmbH	Turn Table	N/A	N/A
CO3000	Innco Systems GmbH	Controller	1026/40960617/P	N/A
MA-4640-XPET	Innco Systems GmbH	Antenna Master	MA4640/652/ 43100318/P	N/A
HLP-2008	TDK RF Solutions	Hybrid Antenna	131316	Feb. 27, 2020 (2Y)
BBHA9170	Schwarzbeck	Horn Antenna	BBHA9170178	Jan. 07, 2021 (1Y)
AH-118	Com-Power	Horn Antenna	10050061	Oct. 15, 2020 (1Y)
FMZB 1513	Schwarzbeck	Loop Antenna	1513-235	Mar. 24, 2020 (2Y)
HPF 3GHz	Rohde & Schwarz	High Pass Filter (1-3 GHz)	N/A	Feb. 08, 2021 (1Y)