FCC Part 15.247

TEST REPORT

For

Leadtek Research Inc

18F, No. 166, Jian-Yi Rd., Chung Ho Dist.,New Taipei City Taiwan, R.O.C.

FCC ID: I2ILRBT01

Report Type:	**Product Type:**
Original Report	BT module

Report Producer : Coco Lin Coco Lin

Report Number : RXZ210924005RF02

Report Date : 2021-11-17

Reviewed By: Andy Shih Andy Shih

Prepared By: Bay Area Compliance Laboratories Corp.
70, Lane 169, Sec. 2, Datong Road, Xizhi Dist.,
New Taipei City 22183, Taiwan, R.O.C.
Tel: +886 (2) 2647 6898
Fax: +886 (2) 2647 6895
www.bacl.com.tw

Revision History

Revision	No.	Report Number	Issue Date	Description	Author/ Revised by
0.0	RXZ210924005	RXZ210924005RF02	2021-11-17	Original Report	Coco Lin

TABLE OF CONTENTS

1 General Information

1.1 Product Description for Equipment under Test (EUT)

Applicant	Leadtek Research Inc
	18F, No. 166, Jian-Yi Rd., Chung Ho Dist.,New Taipei City Taiwan, R.O.C
Manufacturer	Leadtek Research Inc
	18F, No. 166, Jian-Yi Rd., Chung Ho Dist.,New Taipei City Taiwan, R.O.C
Brand(Trade) Name	LEADTEK
Product (Equipment)	BT module
Main Model Name	LRBT01
Frequency Range	BLE(1M) / BLE(2M) : 2402 ~ 2480 MHz
Transmit Power	BLE(1M) Mode : 0.19 dBm BLE(2M) Mode : 0.13 dBm
Modulation Technique	BLE(1M) / BLE(2M) : GFSK
Channel Separation	BLE(1M) / BLE(2M) : 2 MHz
Power Operation (Voltage Range)	☐ AC 120V/60Hz ☐ Adapter I/P: 100-240Vac,1.2A ; O/P: 12Vdc, 3A ☐ By AC Power Cord ☐ PoE
	☒ DC Type ☐ Battery ☒ DC Power Supply: 3.3Vdc ☐ External from USB Cable ☐ External DC Adapter
	☐ Host System
Received Date	Sep. 27, 2021
Date of Test	Oct 05, 2021 ~ Oct. 19, 20211

*All measurement and test data in this report was gathered from production sample serial number: RXZ210924005-01 (Assigned by BACL.)

1.2 Objective

This report is prepared on behalf of Leadtek Research Inc in accordance with Part 2, Subpart J, Part 15, Subparts A and C of the Federal Communication Commission's rules.

The objective is to determine compliance with FCC Part 15.247 rules for Output Power, Antenna Requirements, 6 dB Bandwidth, Power Spectral Density, 100 kHz Bandwidth of Band Edges Measurement, Conducted and Radiated Spurious Emissions.

1.3 Related Submittal(s)/Grant(s)

N/A.

1.4 Test Methodology

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

KDB 558074 D01 15.247 Meas Guidance v05r02

1.5 Statement of Compliance

Decision Rule: No, (The test results do not include MU judgment)

Unless otherwise stated the results shown in this test report refer only to the sample(s) tested.

The determination of the test results does not require consideration of the uncertainty of the measurement, unless the assessment is required by customer agreement, regulation or standard document specification.

Bay Area Compliance Laboratories Corp. is not responsible for the authenticity of the information provided by the applicant that affects the test results.

1.6 Measurement Uncertainty

Parameter		Uncertainty
AC Mains		+/- 2.36 dB
RF output power, conducted		+/- 0.93 dB
Occupied Bandwidth		+/- 0.35 MHz
Power Spectral Density, conducted		+/- 0.93 dBm
Unwanted Emissions, conducted		+/- 1.69 dBm
Emissions, radiated	30 MHz~1GHz	+/- 5.22 dB
	1 GHz~18 GHz	+/- 6.12 dB
	18 GHz~40 GHz	+/- 4.99 dB
Temperature		+/- 1.27 °C
Humidity		+/- 3 %

1.7 Environmental Conditions

Test Site	Test Data	Temperature (℃)	Relative Humidity (%)	ATM Pressure (hPa)	Test Engineer
AC Line Conducted Emissions	2021/10/19	26	44	1010	David Lee
Radiation Spurious Emissions	2021/10/05	24.4	51	1010	David Lee
Conducted Spurious Emissions	2021/10/06	24.8	42	1010	Boris Kao
6 dB Emission Bandwidth	2021/10/06	24.8	42	1010	Boris Kao
Maximum Output Power	2021/10/06	24.8	42	1010	Boris Kao
100 kHz Bandwidth of Frequency Band Edge	2021/10/06	24.8	42	1010	Boris Kao
Power Spectral Density	2021/10/06	24.8	42	1010	Boris Kao

1.8 Test Facility

The Test site used by Bay Area Compliance Laboratories Corp. to collect test data is located on ☒70, Lane 169, Sec. 2, Datong Road, Xizhi Dist., New Taipei City 22183, Taiwan, R.O.C.

Bay Area Compliance Laboratories Corp. is accredited to ISO 17025 by Taiwan Accreditation Foundation (TAF code: 3732) and the FCC designation No.TW3732 under the Mutual Recognition Agreement (MRA) in FCC Test. The facility also complies with the radiated and AC line conducted test site criteria set forth in ANSI C63.10.

2 System Test Configuration

2.1 Description of Test Configuration

For BLE mode, there are totally 40 channels.

Channel	Frequency (MHz)	Channel	Frequency (MHz)
0	2402	20	2442
1	2404	--	--
2	2406	--	--
3	2408	37	2476
--	--	38	2478
19	2440	39	2480

For BLE Modes were tested with channel 0, 19 and 39.

The system was configured for testing in engineering mode, which was provided by manufacturer.

2.2 Equipment Modifications

No modification was made to the EUT.

2.3 EUT Exercise Software

EUT Exercise Software : nrfconnect-3.7.1

Test Frequency		Low	Mid	High
Power Level Setting	BLE 1M	8	8	8
	BLE 2M	8	8	8

The worst-case data rates are determined to be as follows for each mode based upon investigations by measuring the average power and PSD across all data rates bandwidths, and modulations.

BLE 1M : 1 Mbps

BLE 2M : 2 Mbps

2.4 Support Equipment List and Details

No.	Equipment	Trade Name	Model	Serial No.
1	NB	DELL	E6410	8N7PXN1
2	Test fixture	N/A	N/A	N/A

2.5 External Cable List and Details

N/A

2.6 Test Mode

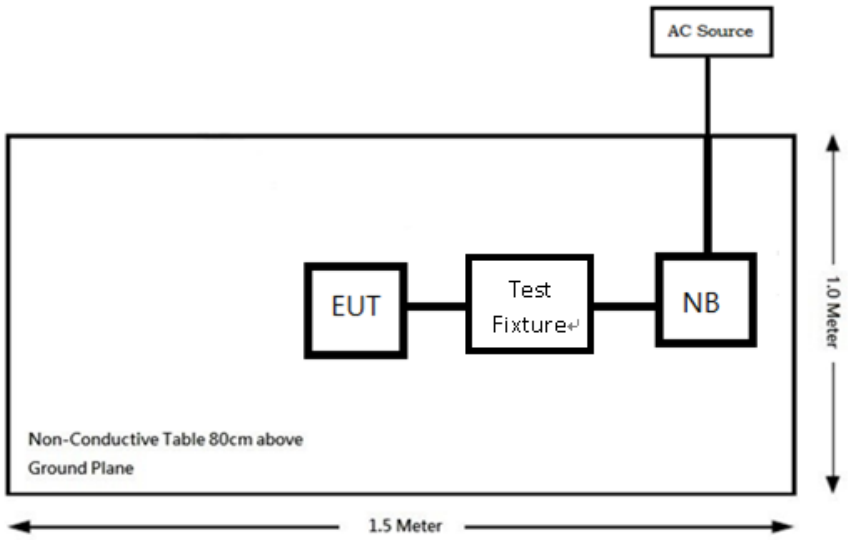
Full System (model: LRBT01) for all test item.

2.7 Block Diagram of Test Setup

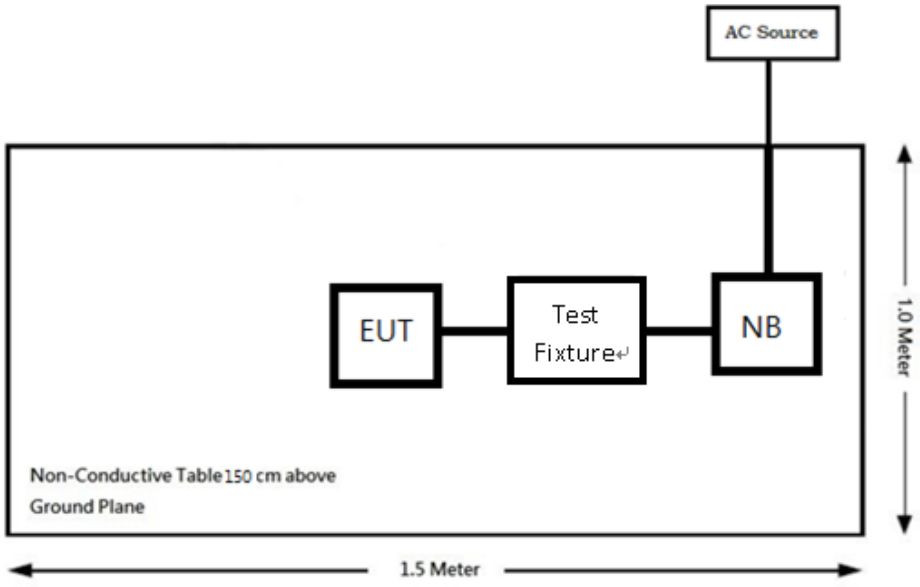
See test photographs attached in setup photos for the actual connections between EUT and support equipment.

Radiation:

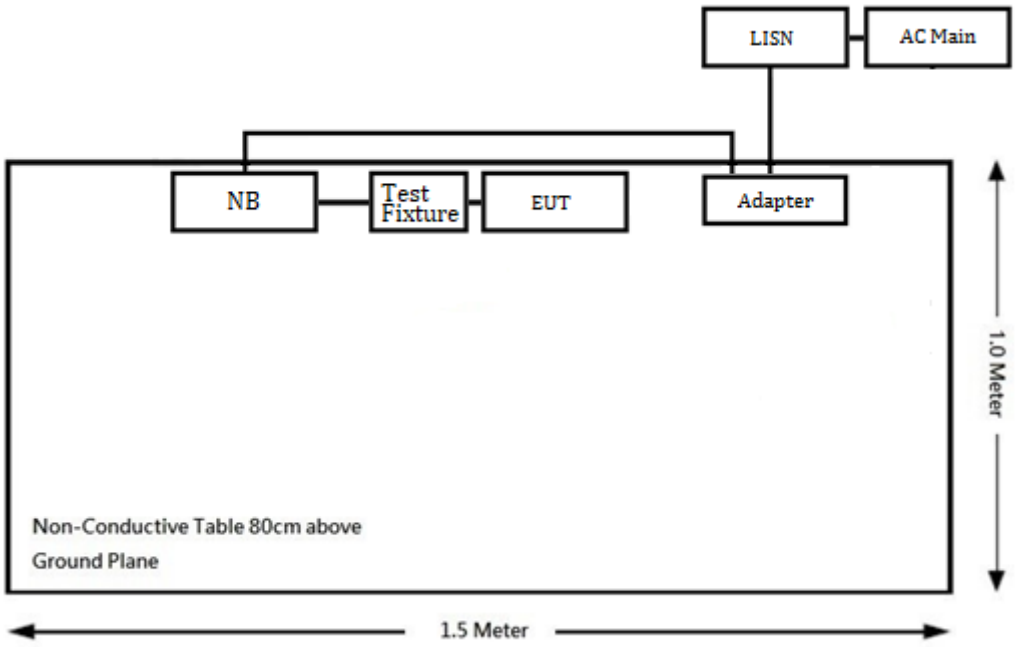
Below 1GHz:



Above 1GHz:



Conduction:



2.8 Duty Cycle

According to KDB 558074 D01 15.247 Meas Guidance v05r02 section 6.0:

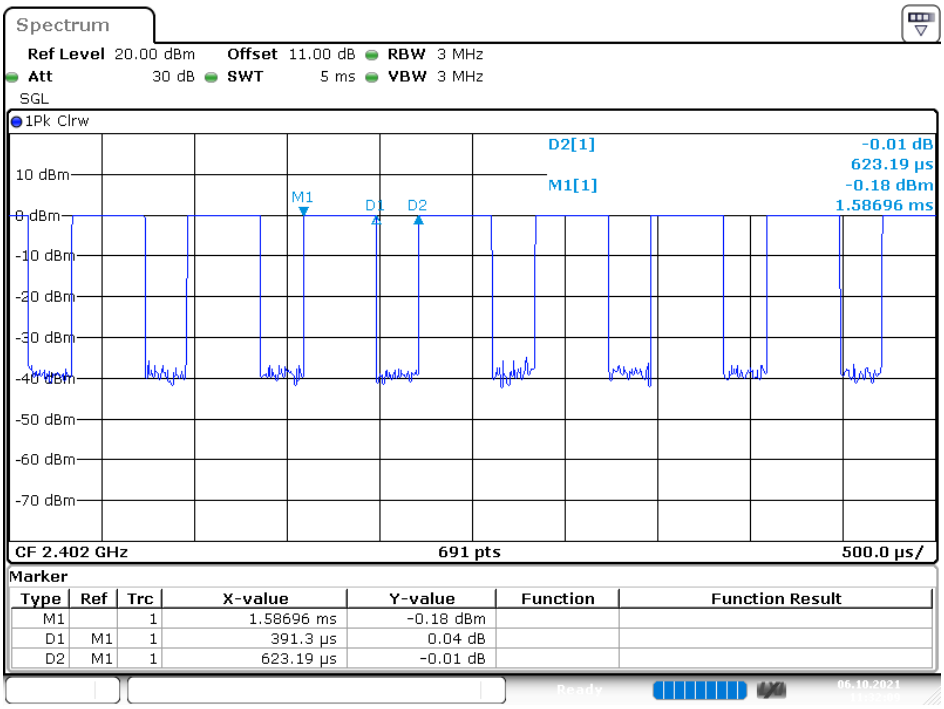
All measurements are to be performed with the EUT transmitting at 100% duty cycle at its maximum power control level; however, if 100% duty cycle cannot be achieved, measurements of duty cycle, x, and maximumpower transmission duration, T, are required for each tested mode of operation.

Radio Mode	On Time (ms)	Period (ms)	Duty Cycle (%)	Duty Cycle Correction Factor (dB)
BLE(1M)	0.391	0.623	62	2.08
BLE(2M)	0.311	0.623	49	3.10

Note: Duty Cycle Correction Factor = 10*log(1/duty cycle)

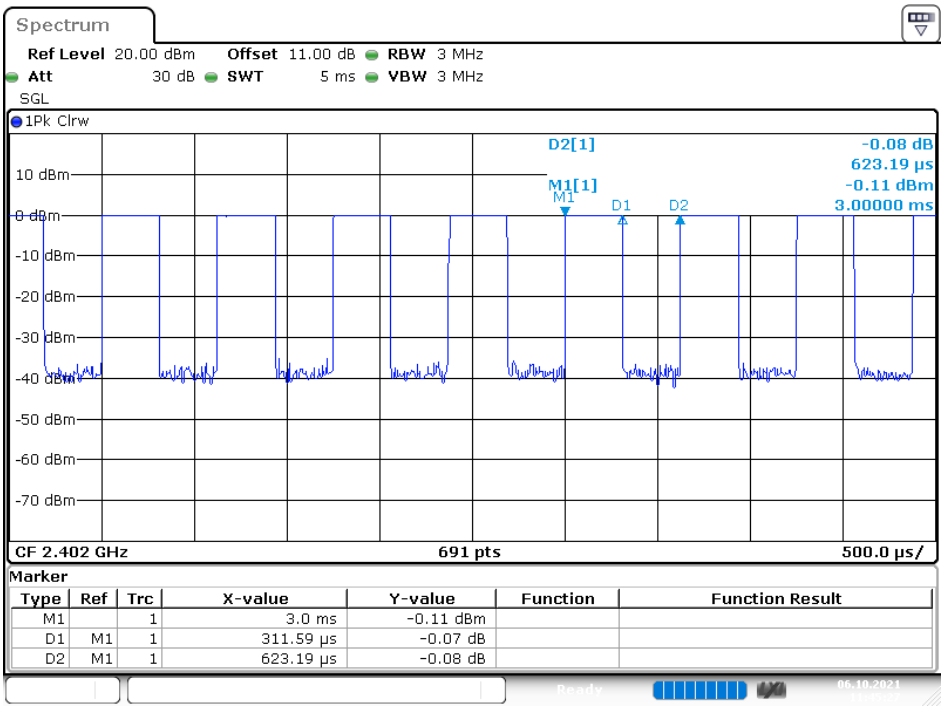
Please refer to the following plots.

BLE(1M) Mode



Date: 6.OCT.2021 11:32:10

BLE(2M) Mode



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3 Summary of Test Results

FCC Rules	Description of Test	Results
§15.247(i), §1.1310, §2.1091	Maximum Permissible Exposure (MPE)	Compliance
§15.203	Antenna Requirement	Compliance
§15.207(a)	AC Line Conducted Emissions	Compliance
§15.205, §15.209, §15.247(d)	Spurious Emissions	Compliance
§15.247(a)(2)	6 dB Emission Bandwidth	Compliance
§15.247(b)(3)	Maximum Peak Output Power	Compliance
§15.247(d)	100 kHz Bandwidth of Frequency Band Edge	Compliance
§15.247(e)	Power Spectral Density	Compliance

4 Test Equipment List and Details

Description	Manufacturer	Model	Serial Number	Calibration Date	Calibration Due Date
AC Line Conduction Room (CON-A)					
LISN	Rohde & Schwarz	ENV216	101612	2020/12/30	2021/12/29
LISN	COM-POWER	LI-550A	211726	2020/12/30	2021/12/29
EMI Test Receiver	Rohde & Schwarz	ESR3	102099	2021/6/2	2022/6/1
Pulse Limiter	Rohde & Schwarz	ESH3Z2	TXZEM104	2021/7/29	2022/7/29
RF Cable	EMEC	EM-CB5D	1	2021/6/11	2022/6/11
Software	AUDIX	E3	V9.150826k	N.C.R	N.C.R
Radiation 3M Room (966-A)					
Bilog Antenna with 6 dB Attenuator	SUNOL SCIENCES & MINI-CIRCUITS	JB6/UNAT-6+	A050115/15542_01	2021/1/19	2022/1/18
EMI Test Receiver	Rohde & Schwarz	ESR7	101419	2020/11/12	2021/11/11
Horn Antenna	EMCO	SAS-571	1020	2021/4/23	2022/4/22
Horn Antenna	ETS-Lindgren	3116	62638	2021/8/11	2022/8/10
Preamplifier	Sonoma	310N	130602	2021/6/8	2022/6/7
Preamplifier	A.H. system Inc.	PAM-0118P	466	2020/11/5	2021/11/4
Microware Preamplifier	EM Electronics Corporation	EM18G40G	60656	2020/12/30	2021/12/29
Spectrum Analyzer	Rohde & Schwarz	FSV40	101435	2021/1/7	2022/1/6
Micro flex Cable	UTIFLEX	UFB197C-1-2362-70U-70U	225757-001	2021/2/1	2022/1/31
Coaxial Cable	COMMATE	PEWC	8Dr	2020/12/25	2021/12/24
Coaxial Cable	UTIFLEX	UFB311A-Q-1440-300300	220490-006	2021/2/1	2022/1/31
Coaxial Cable	JUNFLON	J12J102248-00-B-5	AUG-07-15-044	2020/12/25	2021/12/24
Cable	EMC	EMC105-SM-SM-10000	201003	2021/2/3	2022/2/2
Software	Farad	EZ_EMC	BACL-03A1	N.C.R	N.C.R
Conducted Room					
Spectrum Analyzer	Rohde & Schwarz	FSV40	101140	2021/1/7	2022/1/6
Cable	UTIFLEX	UFA210A	9435	2021/10/5	2022/10/4

Power Sensor	KEYSIGHT	U2021XA	MY54080018	2021/1/28	2022/1/28
Attenuator	MINI-CIRCUITS	BW-S10W5+	1419	2021/1/28	2022/1/27

***Statement of Traceability:** BACL Corp. attests that all of the calibrations on the equipment items listed above were traceable to the SI System of Units via the R.O.C. Center for Measurement Standards of the Electronics Testing Center, Taiwan (ETC) or to another internationally recognized National Metrology Institute (NMI), and were compliant with the current Taiwan Accreditation Foundation (TAF) requirements

5 FCC §15.247(i), §1.1310, § 2.1091 - Maximum Permissible Exposure (MPE)

5.1 Applicable Standard

According to subpart 15.247(i)and subpart §1.1310, systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy level in excess of the Commission's guidelines.

Limits for Maximum Permissible Exposure (MPE) (§1.1310, §2.1091)

(B) Limits for General Population/Uncontrolled Exposure				
Frequency Range (MHz)	**Electric Field Strength (V/m)**	**Magnetic Field Strength (A/m)**	**Power Density (mW/cm^2)**	**Averaging Time (minutes)**
0.3–1.34	614	1.63	*(100)	30
1.34–30	824/f	2.19/f	*($180/f^2$)	30
30–300	27.5	0.073	0.2	30
300–1500	/	/	f/1500	30
1500–100,000	/	/	1.0	30

f = frequency in MHz; * = Plane-wave equivalent power density;

According to §1.1310 and §2.1091 RF exposure is calculated.

Calculated Formulary:

Predication of MPE limit at a given distance

$S = PG/4\pi R^2$ = power density (in appropriate units, e.g. mW/cm^2);

P = power input to the antenna (in appropriate units, e.g., mW);

G = power gain of the antenna in the direction of interest relative to an isotropic radiator, the power gain factor, is normally numeric gain;

R = distance to the center of radiation of the antenna (appropriate units, e.g., cm);

5.2 RF Exposure Evaluation Result

MPE evaluation:

Mode	Frequency Range (MHz)	Antenna Gain		Target Power		Evaluation Distance (cm)	Power Density (mW/cm^2)	MPE Limit (mW/cm^2)
		(dBi)	(numeric)	(dBm)	(mW)			
BLE(1Mbps)	2402-2480	0.83	1.211	0.5	1.122	20	0.0003	1
BLE(2Mbps)	2402-2480	0.83	1.211	0.5	1.122	20	0.0003	1

Conclusion: The EUT meets exemption requirement- RF exposure evaluation greater than 20cm distance specified in § 2.1091. If the device built into a host as a portable usage, the additional RF exposure evaluation may be required as specified by§ 2.1093.

6 FCC §15.203 – Antenna Requirements

6.1 Applicable Standard

According to § 15.203,

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the user of a standard antenna jack or electrical connector is prohibited.

And according to FCC 47 CFR section 15.247 (b), if the transmitting antennas of directional gain greater than 6dBi are used, the power shall be reduced by the amount in dB that the directional gain of the antenna does not exceed 6dBi.

6.2 Antenna Information

Manufacturer	Model	Type	Antenna Gain
LEADTEK	LRBT01	PCB Antenna	0.83 dBi

Result: Compliance

7 FCC §15.207(a) – AC Line Conducted Emissions

7.1 Applicable Standard

According to §15.207

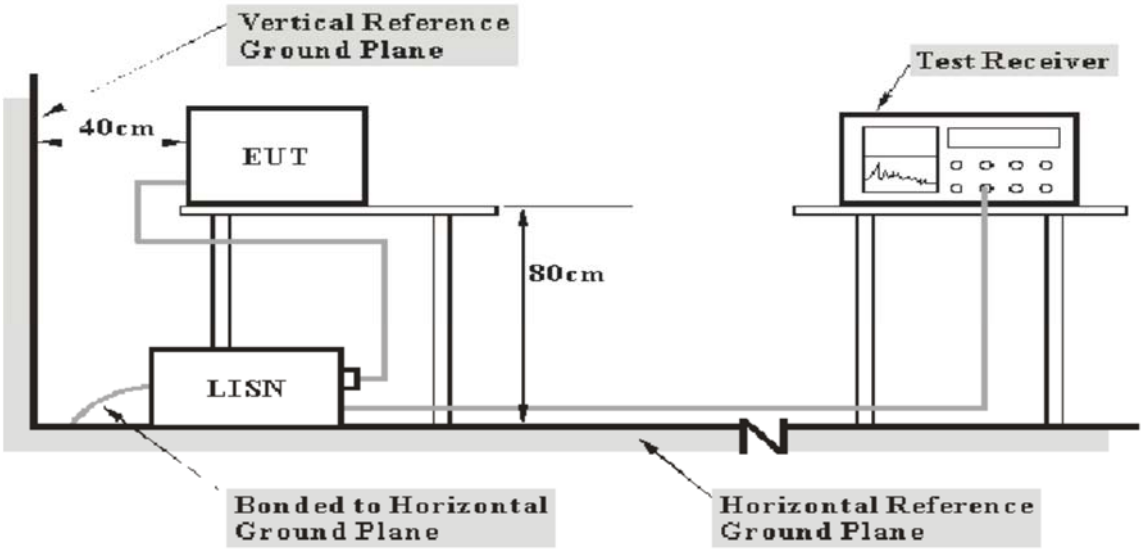
For an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies within the band 150 kHz to 30 MHz shall not exceed the limits in the following table, as measured using a 50 μH/50 ohms line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequencies ranges.

Frequency of Emission (MHz)	Conducted Limit (dBuV)	
	Quasi-Peak	Average
0.15-0.5	66 to 56 Note 1	56 to 46 Note 2
0.5-5	56	46
5-30	60	50

Note 1: Decreases with the logarithm of the frequency.

Note 2: A linear average detector is required

7.2 EUT Setup



Note: 1. Support units were connected to second LISN.
2. Both of LISNs (AMN) 80 cm from EUT and at the least 80 cm from other units and other metal planes support units.

The setup of EUT is according with per ANSI C63.10-2013 measurement procedure. The specification used was with the FCC Part 15.207 limits.

7.3 EMI Test Receiver Setup

The EMI test receiver was set to investigate the spectrum from 150kHz to 30MHz.

During the conducted emission test, the EMI test receiver was set with the following configurations

Frequency Range	IF B/W
150kHz – 30MHz	9kHz

7.4 Test Procedure

During the conducted emission test, the adapter was connected to the outlet of the LISN.

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

All data was recorded in the Quasi-peak and average detection mode.

7.5 Corrected Factor & Margin Calculation

The factor is calculated by adding LISN/ISN VDF (Voltage Division Factor), Cable Loss and Transient Limiter Attenuation. The basic equation is as follows:

Factor = LISN VDF + Cable Loss + Transient Limiter Attenuation

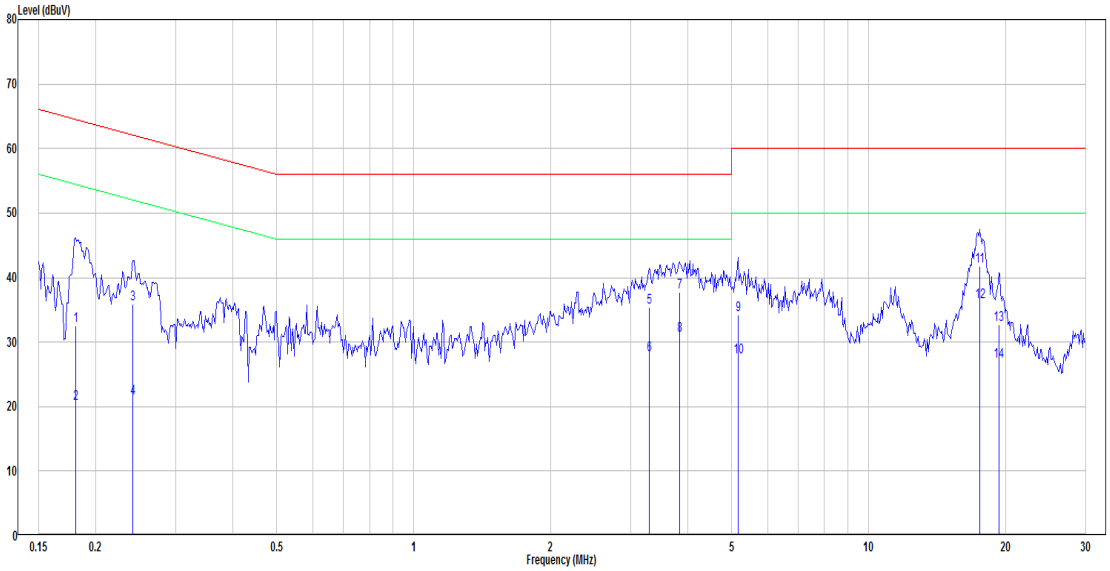
The “Over Limit” column of the following data tables indicates the degree of compliance with the applicable limit. For example, an over limit of -7 dB means the emission is 7 dB below the limit. The equation for Over Limit calculation is as follows:

Over Limit = Level – Limit Line

7.6 Test Results

Test Mode: Transmitting

Main: AC120 V, 60 Hz, Line



No.	Frequency	Reading	Correct	Result	Limit	Over limit	Remark
	(MHz)	(dBµV)	Factor(dB)	(dBµV)	(dBµV)	(dB)	
1	0.181	12.88	19.59	32.47	64.46	-31.99	QP
2	0.181	0.85	19.59	20.44	54.46	-34.02	Average
3	0.242	16.33	19.58	35.91	62.04	-26.13	QP
4	0.242	1.78	19.58	21.36	52.04	-30.68	Average
5	3.293	15.67	19.67	35.34	56.00	-20.66	QP
6	3.293	8.38	19.67	28.05	46.00	-17.95	Average
7	3.840	17.97	19.69	37.66	56.00	-18.34	QP
8	3.840	11.31	19.69	31.00	46.00	-15.00	Average
9	5.166	14.48	19.72	34.20	60.00	-25.80	QP
10	5.166	8.02	19.72	27.74	50.00	-22.26	Average
11	17.568	21.87	19.87	41.74	60.00	-18.26	QP
12	17.568	16.30	19.87	36.17	50.00	-13.83	Average
13	19.326	12.80	19.88	32.68	60.00	-27.32	QP
14	19.326	7.09	19.88	26.97	50.00	-23.03	Average

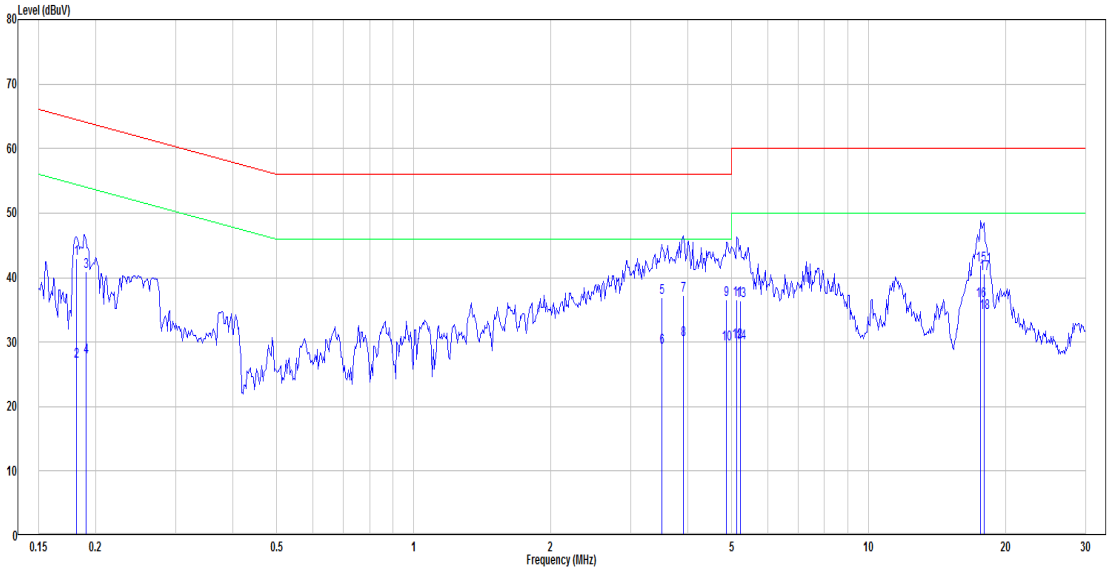
Note:

Level = Read Level + Factor

Over Limit = Level – Limit Line

Factor = (LISN, ISN, PLC or current probe) Factor + Cable Loss + Attenuator

Main: AC120 V, 60 Hz, Neutral



No.	Frequency	Reading	Correct	Result	Limit	Over limit	Remark
	(MHz)	(dBµV)	Factor(dB)	(dBµV)	(dBµV)	(dB)	
1	0.182	23.36	19.59	42.95	64.42	-21.47	QP
2	0.182	7.45	19.59	27.04	54.42	-27.38	Average
3	0.190	21.34	19.58	40.92	64.02	-23.10	QP
4	0.190	8.02	19.58	27.60	54.02	-26.42	Average
5	3.509	17.16	19.68	36.84	56.00	-19.16	QP
6	3.509	9.59	19.68	29.27	46.00	-16.73	Average
7	3.922	17.60	19.69	37.29	56.00	-18.71	QP
8	3.922	10.66	19.69	30.35	46.00	-15.65	Average
9	4.874	16.76	19.72	36.48	56.00	-19.52	QP
10	4.874	10.00	19.72	29.72	46.00	-16.28	Average
11	5.139	16.85	19.72	36.57	60.00	-23.43	QP
12	5.139	10.37	19.72	30.09	50.00	-19.91	Average
13	5.221	16.62	19.72	36.34	60.00	-23.66	QP
14	5.221	10.08	19.72	29.80	50.00	-20.20	Average
15	17.661	22.12	19.89	42.01	60.00	-17.99	QP
16	17.661	16.45	19.89	36.34	50.00	-13.66	Average
17	17.944	20.63	19.89	40.52	60.00	-19.48	QP
18	17.944	14.73	19.89	34.62	50.00	-15.38	Average

Note:

Level = Read Level + Factor

Over Limit = Level – Limit Line

Factor = (LISN, ISN, PLC or current probe) Factor + Cable Loss + Attenuator

8 FCC §15.209, §15.205 , §15.247(d) – Spurious Emissions

8.1 Applicable Standard

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

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

MHz	MHz	MHz	GHz
0.090 – 0.110	16.42 – 16.423	608 – 614	4. 5 – 5. 15
0.495 – 0.505	16.69475 – 16.69525	960 – 1240	5. 35 – 5. 46
2.1735 – 2.1905	16.80425 – 16.80475	1300 – 1427	7.25 – 7.75
4.125 – 4.128	25.5 – 25.67	1435 – 1626.5	8.025 – 8.5
4.17725 – 4.17775	37.5 – 38.25	1645.5 – 1646.5	9.0 – 9.2
4.20725 – 4.20775	73 – 74.6	1660 – 1710	9.3 – 9.5
6.215 – 6.218	74.8 – 75.2	1718.8 – 1722.2	10.6 – 12.7
6.26775 – 6.26825	108 – 121.94	2200 – 2300	13.25 – 13.4
6.31175 – 6.31225	123 – 138	2310 – 2390	14.47 – 14.5
8.291 – 8.294	149.9 – 150.05	2483.5 – 2500	15.35 – 16.2
8.362 – 8.366	156.52475 – 156.52525	2690 – 2900	17.7 – 21.4
8.37625 – 8.38675	156.7 – 156.9	3260 – 3267	22.01 – 23.12
8.41425 – 8.41475	162.0125 –167.17	3.332 – 3.339	23.6 – 24.0
12.29 – 12.293	167.72 – 173.2	3 3458 – 3 358	31.2 – 31.8
12.51975 – 12.52025	240 – 285	3.600 – 4.400	36.43 – 36.5
12.57675 – 12.57725	322 – 335.4		Above 38.6
13.36 – 13.41	399.9 – 410		

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

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

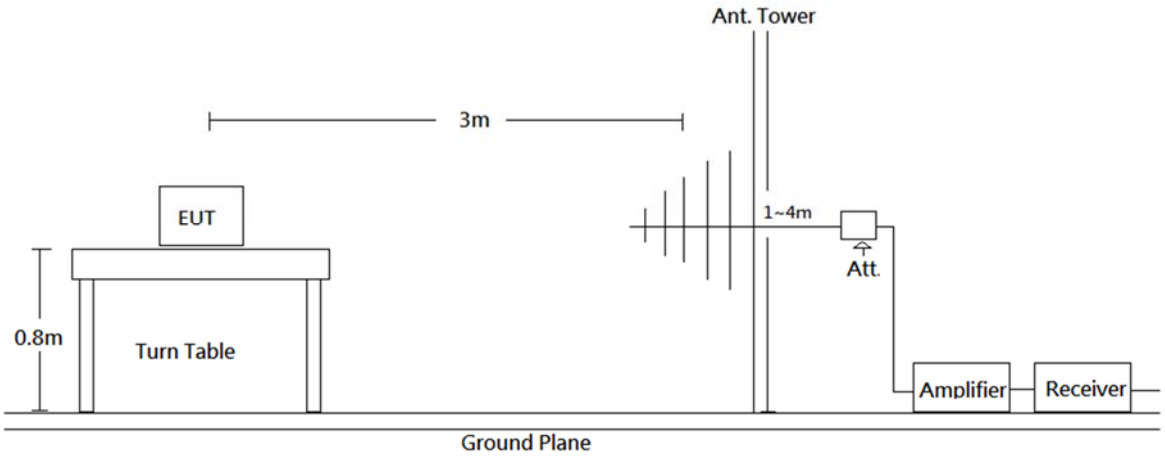
** Except as provided in paragraph (g), fundamental emissions from intentional radiators operating under this Section shall not be located in the frequency bands 54-72 MHz, 76-88 MHz, 174-216 MHz or 470-806 MHz. However, operation within these frequency bands is permitted under other sections of this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

As per FCC §15.247 (d) In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the

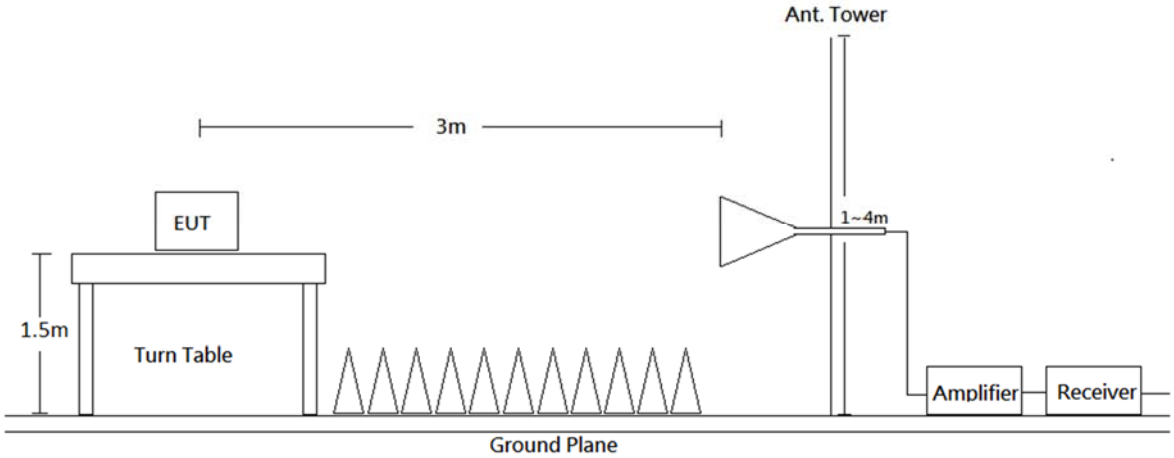
intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c).

8.2 EUT Setup

Below 1 GHz:



Above 1 GHz:



Radiated emission tests were performed in the 3 meters chamber test site, using the setup accordance with the ANSI C63.10-2013. The specification used was the FCC Part 15.209 and FCC 15.247 Limits.

8.3 EMI Test Receiver & Spectrum Analyzer Setup

The system was investigated from 30 MHz to 26.5 GHz. During the radiated emission test, the EMI test receiver was set with the following configurations measurement method 6.3 in ANSI C63.10.

Frequency Range	RBW	VBW	Detector	Duty cycle	Measurement method
30-1000 MHz	120 kHz	/	QP		QP
Above 1 GHz	1 MHz	3 MHz	PK		PK
	1 MHz	3 MHz	RMS	>98%	Ave
	1 MHz	1/T	PK	<98%	Ave

8.4 Test Procedure

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

All data was recorded in the Quasi-peak detector mode from 30 MHz to 1 GHz and PK and average detector modes for frequencies above 1 GHz.

8.5 Corrected Factor & Margin Calculation

The Correct Factor is calculated by adding the Antenna Factor and Cable Loss, and subtracting the Amplifier Gain from the Meter Reading. The basic equation is as follows:

Correct Factor = Antenna Factor + Cable Loss – Amplifier Gain

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

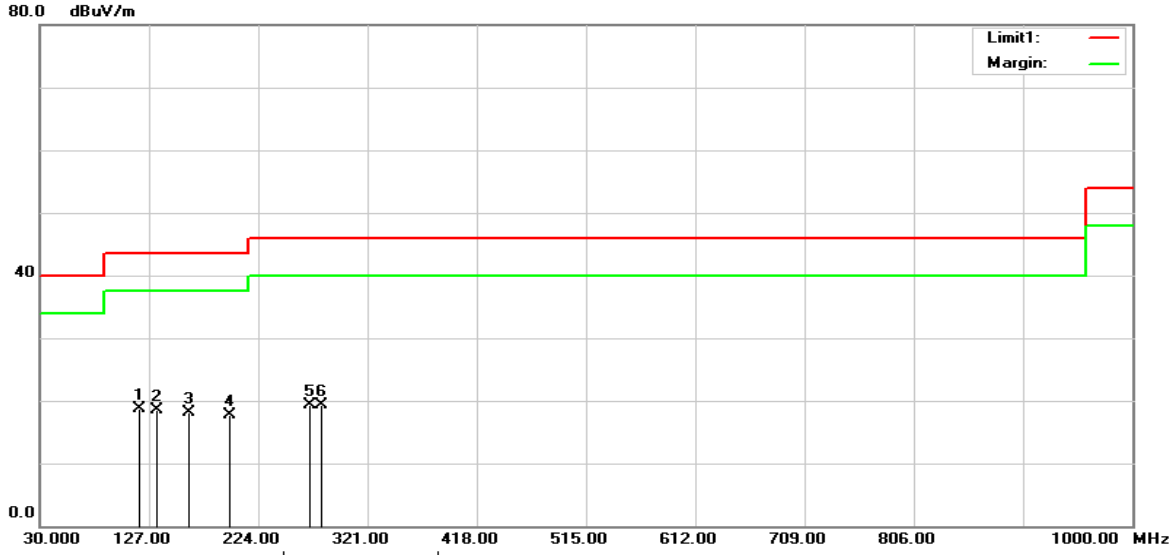
Margin = Result – Limit

8.6 Test Results

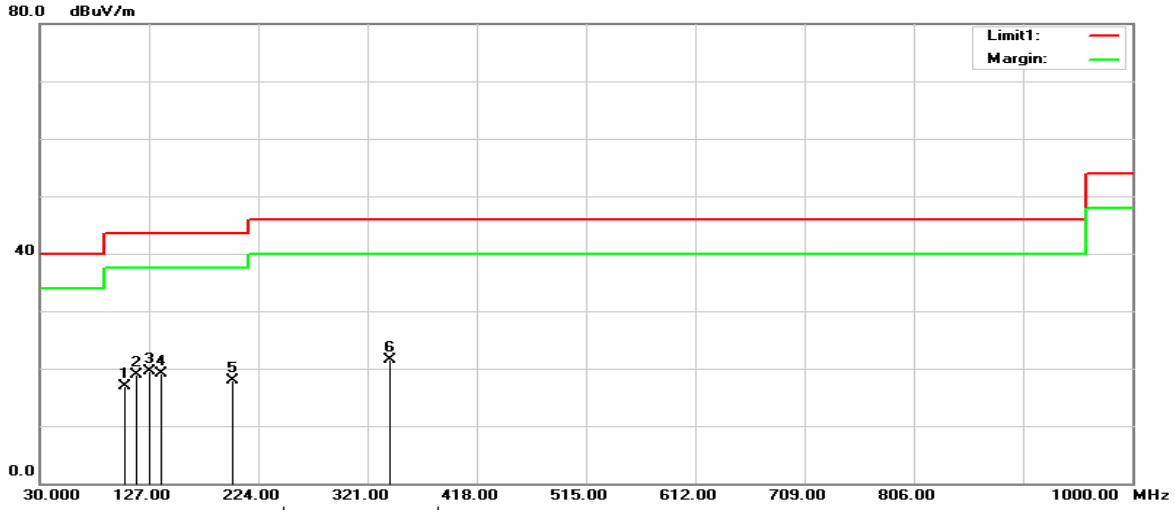
Test Mode: Transmitting (Pre-scan with three orthogonal axis, and worse case as X axis.)

30MHz-1GHz: (worst case is BLE 1M mode high channel)

Horizontal



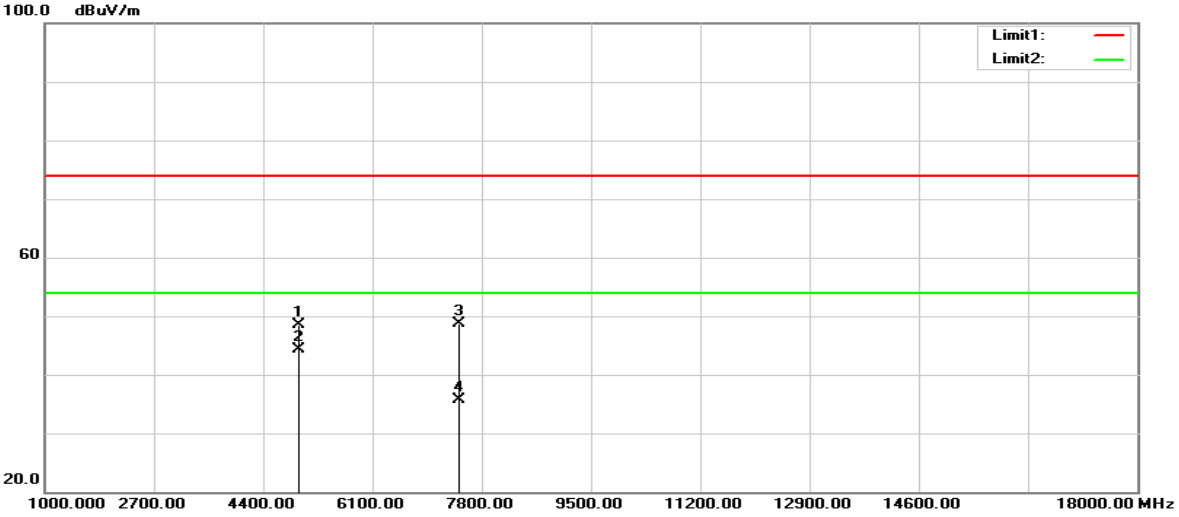
Vertical



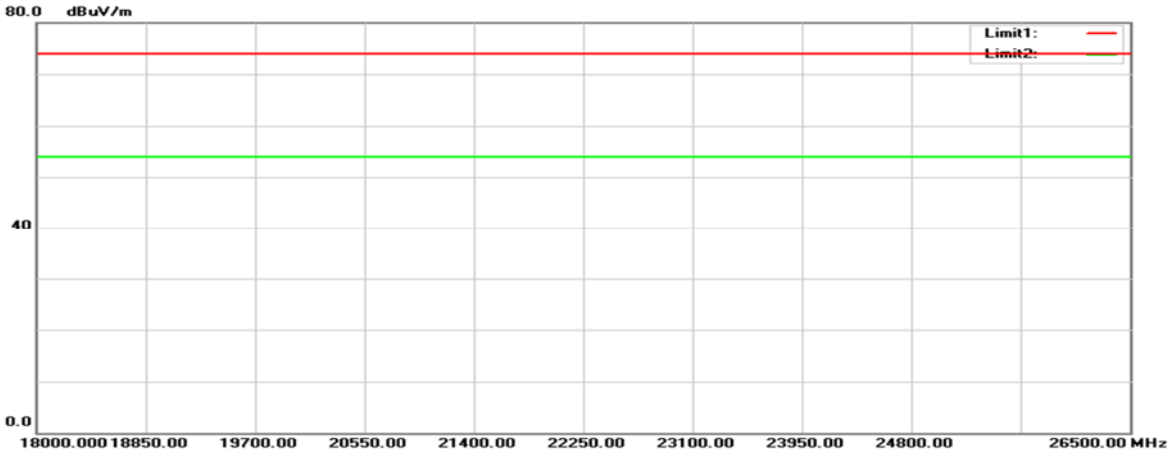
BLE(1M) Mode (Pre-scan with three orthogonal axis, and worse case as X axis.)

Horizontal (worst case is high channel)

1GHz-18GHz:

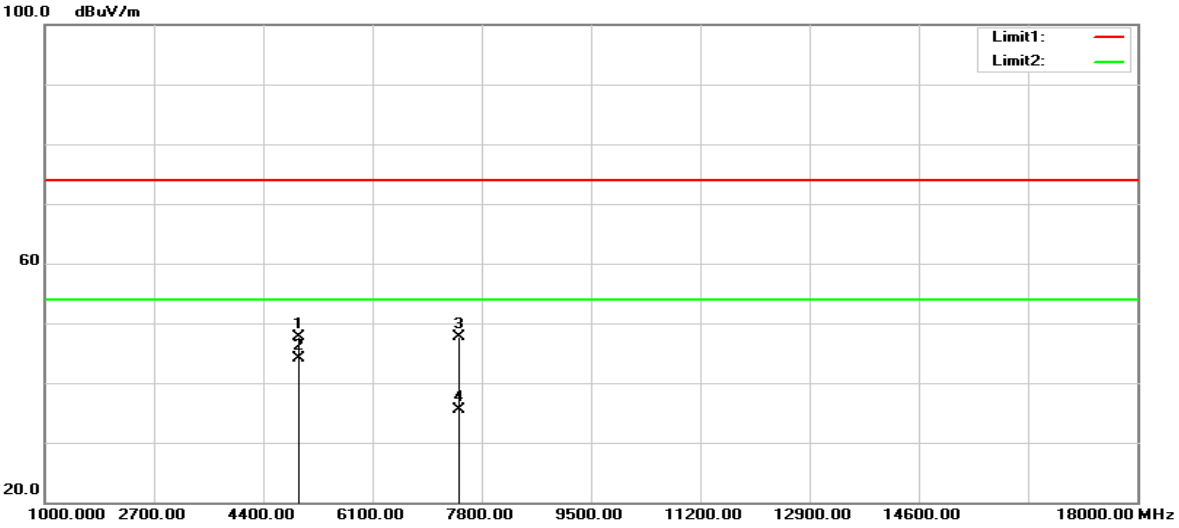


18GHz-26.5GHz:

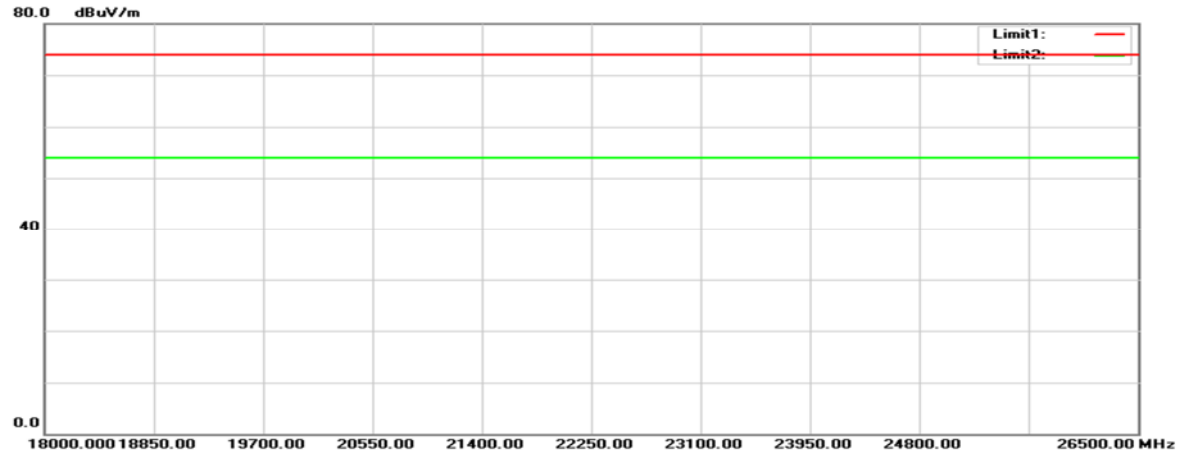


Vertical (worst case is high channel)

1GHz-18GHz:



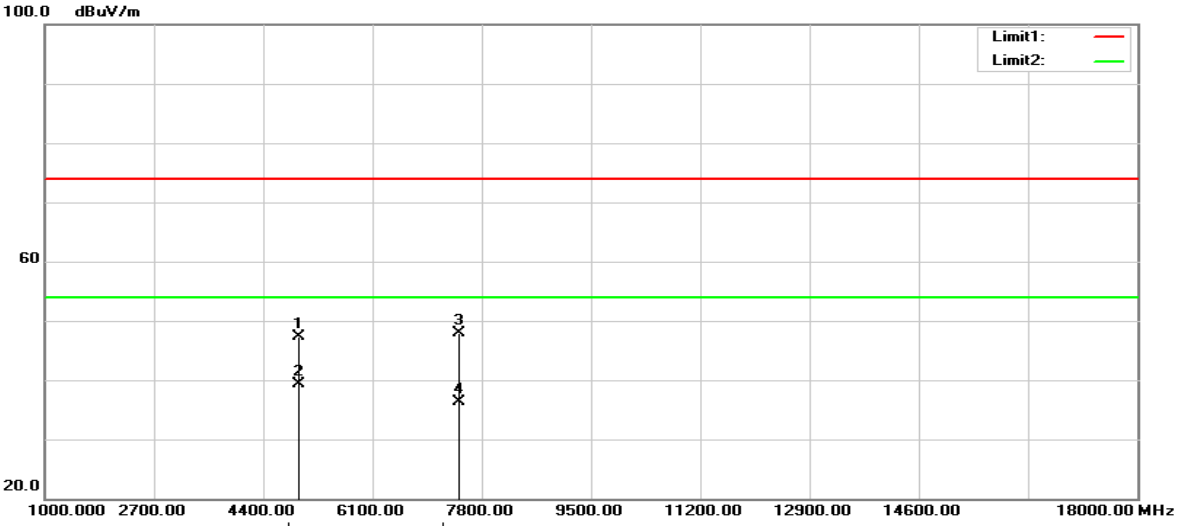
18GHz-26.5GHz:



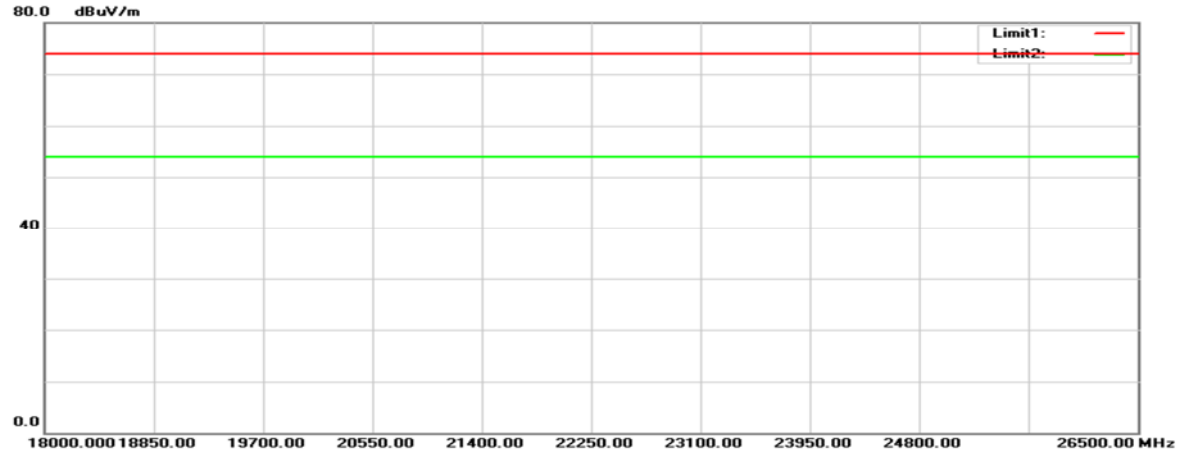
BLE(2M) Mode (Pre-scan with three orthogonal axis, and worse case as X axis.)

Horizontal (worst case is high channel)

1GHz-18GHz:

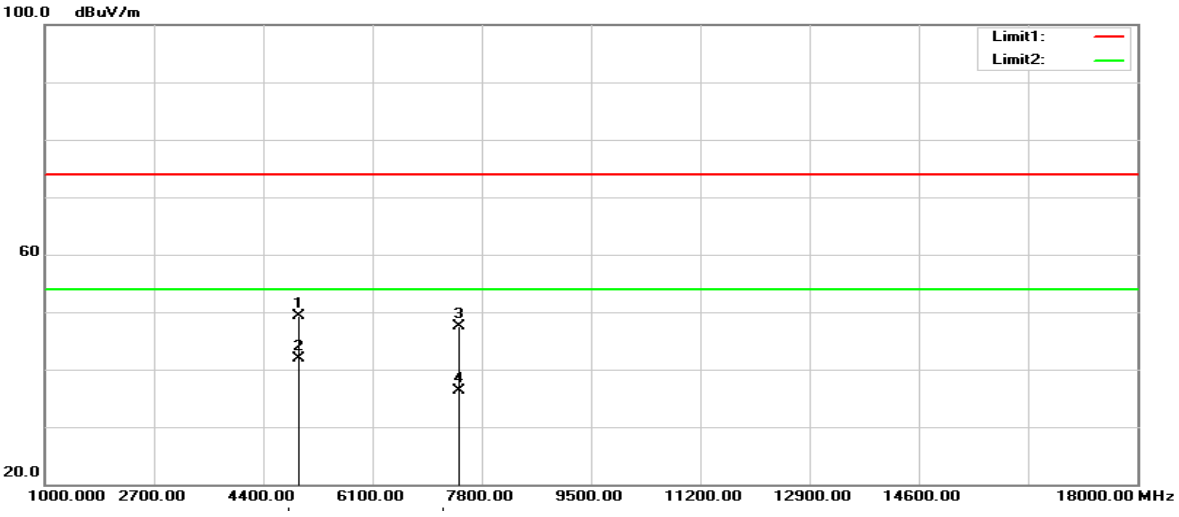


18GHz-26.5GHz:

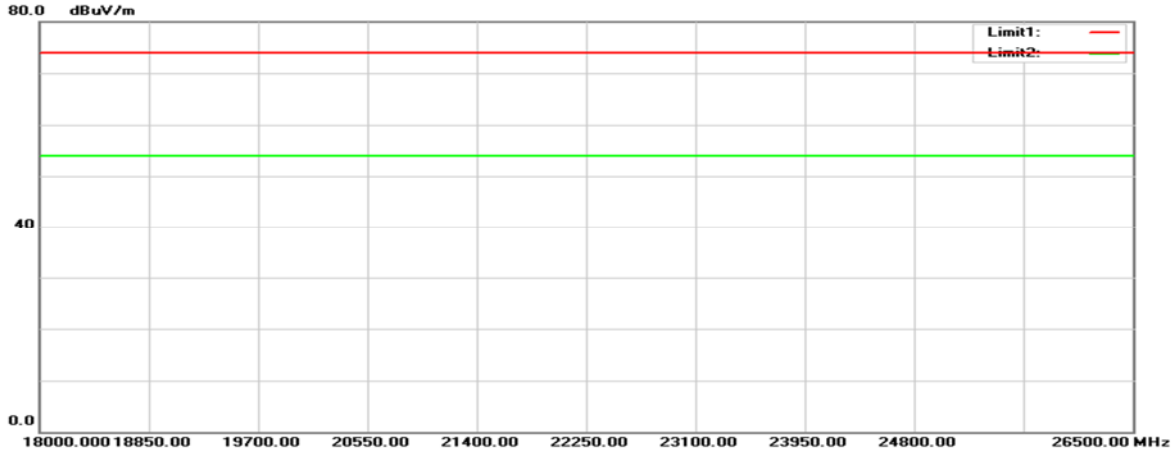


Vertical (worst case is high channel)

1GHz-18GHz:



18GHz-26.5GHz:



Below 1GHz

Horizontal

Frequency (MHz)	Reading (dBµV)	Correct Factor(dB/m)	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Height (cm)	Degree (°)	Remark
118.2700	29.39	-10.69	18.70	43.50	-24.80	100	148	peak
133.7900	29.07	-10.50	18.57	43.50	-24.93	100	315	peak
161.9200	29.55	-11.43	18.12	43.50	-25.38	100	337	peak
198.7800	28.79	-11.09	17.70	43.50	-25.80	100	17	peak
269.5900	29.68	-10.46	19.22	46.00	-26.78	100	91	peak
280.2600	29.62	-10.25	19.37	46.00	-26.63	100	251	peak

Vertical

Frequency (MHz)	Reading (dBµV)	Correct Factor(dB/m)	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Height (cm)	Degree (°)	Remark
105.6600	29.51	-12.56	16.95	43.50	-26.55	100	178	peak
116.3300	29.84	-10.92	18.92	43.50	-24.58	100	95	peak
127.0000	29.73	-10.14	19.59	43.50	-23.91	100	307	peak
137.6700	29.83	-10.66	19.17	43.50	-24.33	100	357	peak
200.7200	29.14	-11.23	17.91	43.50	-25.59	100	115	peak
341.3700	31.05	-9.45	21.60	46.00	-24.40	100	19	peak

Result = Reading + Correct Factor
Margin = Result – Limit
Correct Factor = Antenna Factor + Cable Loss – Amplifier Gain
Spurious emissions more than 20 dB below the limit were not reported.

BLE(1M) Mode

Above 1GHz

Horizontal

Frequency	Reading	Correct	Result	Limit	Margin	Height	Degree	Remark
(MHz)	(dBμV)	Factor(dB/m)	(dBμV/m)	(dBμV/m)	(dB)	(cm)	(°)	
Low channel								
2337.200	57.28	-10.55	46.73	74.00	-27.27	163	206	peak
2337.200	44.72	-10.55	34.17	54.00	-19.83	163	206	AVG
2402.000	100.20	-10.14	90.06	N/A	N/A	163	206	peak
2402.000	99.60	-10.14	89.46	N/A	N/A	163	206	AVG
4804.000	47.37	-3.28	44.09	74.00	-29.91	137	132	peak
4804.000	42.72	-3.28	39.44	54.00	-14.56	137	132	AVG
7206.000	42.66	3.10	45.76	74.00	-28.24	149	273	peak
7206.000	32.99	3.10	36.09	54.00	-17.91	149	273	AVG
Middle channel								
2440.000	101.00	-9.82	91.18	N/A	N/A	158	200	peak
2440.000	100.41	-9.82	90.59	N/A	N/A	158	200	AVG
4880.000	45.13	-3.03	42.10	74.00	-31.90	152	313	peak
4880.000	40.16	-3.03	37.13	54.00	-16.87	152	313	AVG
7320.000	43.19	4.07	47.26	74.00	-26.74	150	281	peak
7320.000	31.30	4.07	35.37	54.00	-18.63	150	281	AVG
High channel								
2480.000	100.98	-9.31	91.67	N/A	N/A	166	208	peak
2480.000	100.36	-9.31	91.05	N/A	N/A	166	208	AVG
2483.500	67.59	-9.26	58.33	74.00	-15.67	166	208	peak
2483.500	44.84	-9.26	35.58	54.00	-18.42	166	208	AVG
4960.000	51.28	-2.69	48.59	74.00	-25.41	150	22	peak
4960.000	47.03	-2.69	44.34	54.00	-9.66	150	22	AVG
7440.000	44.54	4.25	48.79	74.00	-25.21	150	263	peak
7440.000	31.39	4.25	35.64	54.00	-18.36	150	263	AVG

Result = Reading + Correct Factor
Margin = Result – Limit
Correct Factor = Antenna Factor + Cable Loss – Amplifier Gain
Spurious emissions more than 20 dB below the limit were not reported.

Vertical

Frequency (MHz)	Reading (dBµV)	Correct Factor(dB/m)	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Height (cm)	Degree (°)	Remark
Low channel								
2382.200	58.55	-10.29	48.26	74.00	-25.74	128	121	peak
2382.200	45.23	-10.29	34.94	54.00	-19.06	128	121	AVG
2402.000	104.87	-10.14	94.73	N/A	N/A	128	121	peak
2402.000	104.27	-10.14	94.13	N/A	N/A	128	121	AVG
4804.000	50.74	-3.28	47.46	74.00	-26.54	158	356	peak
4804.000	47.35	-3.28	44.07	54.00	-9.93	158	356	AVG
7206.000	43.26	3.10	46.36	74.00	-27.64	103	105	peak
7206.000	38.15	3.10	41.25	54.00	-12.75	103	105	AVG
Middle channel								
2440.000	105.70	-9.82	95.88	N/A	N/A	125	118	peak
2440.000	105.08	-9.82	95.26	N/A	N/A	125	118	AVG
4880.000	45.68	-3.03	42.65	74.00	-31.35	127	17	peak
4880.000	40.18	-3.03	37.15	54.00	-16.85	127	17	AVG
7320.000	42.79	4.07	46.86	74.00	-27.14	150	2	peak
7320.000	32.28	4.07	36.35	54.00	-17.65	150	2	AVG
High channel								
2480.000	106.16	-9.31	96.85	N/A	N/A	123	121	peak
2480.000	105.58	-9.31	96.27	N/A	N/A	123	121	AVG
2483.500	72.76	-9.26	63.50	74.00	-10.50	123	121	peak
2483.500	46.67	-9.26	37.41	54.00	-16.59	123	121	AVG
4960.000	50.36	-2.69	47.67	74.00	-26.33	141	31	peak
4960.000	46.76	-2.69	44.07	54.00	-9.93	141	31	AVG
7440.000	43.45	4.25	47.70	74.00	-26.30	150	0	peak
7440.000	31.29	4.25	35.54	54.00	-18.46	150	0	AVG

Result = Reading + Correct Factor
Margin = Result – Limit
Correct Factor = Antenna Factor + Cable Loss – Amplifier Gain
Spurious emissions more than 20 dB below the limit were not reported.

BLE(2M) Mode

Above 1GHz

Horizontal

Frequency	Reading	Correct	Result	Limit	Margin	Height	Degree	Remark
(MHz)	(dBµV)	Factor(dB/m)	(dBµV/m)	(dBµV/m)	(dB)	(cm)	(°)	
Low channel								
2375.600	56.84	-10.35	46.49	74.00	-27.51	136	204	peak
2375.600	45.17	-10.35	34.82	54.00	-19.18	136	204	AVG
2402.000	100.09	-10.14	89.95	N/A	N/A	136	204	peak
2402.000	98.52	-10.14	88.38	N/A	N/A	136	204	AVG
4804.000	46.90	-3.28	43.62	74.00	-30.38	146	350	peak
4804.000	39.12	-3.28	35.84	54.00	-18.16	146	350	AVG
7206.000	43.59	3.10	46.69	74.00	-27.31	155	2	peak
7206.000	31.53	3.10	34.63	54.00	-19.37	155	2	AVG
Middle channel								
2440.000	101.25	-9.82	91.43	N/A	N/A	184	208	peak
2440.000	99.70	-9.82	89.88	N/A	N/A	184	208	AVG
4880.000	45.86	-3.03	42.83	74.00	-31.17	150	41	peak
4880.000	41.96	-3.03	38.93	54.00	-15.07	150	41	AVG
7320.000	42.66	4.07	46.73	74.00	-27.27	150	297	peak
7320.000	31.48	4.07	35.55	54.00	-18.45	150	297	AVG
High channel								
2480.000	102.11	-9.31	92.80	N/A	N/A	151	205	peak
2480.000	100.06	-9.31	90.75	N/A	N/A	151	205	AVG
2483.500	68.85	-9.26	59.59	74.00	-14.41	151	205	peak
2483.500	48.35	-9.26	39.09	54.00	-14.91	151	205	AVG
4960.000	50.02	-2.69	47.33	74.00	-26.67	150	1	peak
4960.000	42.04	-2.69	39.35	54.00	-14.65	150	1	AVG
7440.000	43.69	4.25	47.94	74.00	-26.06	150	63	peak
7440.000	31.97	4.25	36.22	54.00	-17.78	150	63	AVG

Result = Reading + Correct Factor
Margin = Result – Limit
Correct Factor = Antenna Factor + Cable Loss – Amplifier Gain
Spurious emissions more than 20 dB below the limit were not reported.

Vertical

Frequency (MHz)	Reading (dBµV)	Correct Factor(dB/m)	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Height (cm)	Degree (°)	Remark
Low channel								
2382.700	58.58	-10.29	48.29	74.00	-25.71	112	117	peak
2382.700	45.57	-10.29	35.28	54.00	-18.72	112	117	AVG
2402.000	105.58	-10.14	95.44	N/A	N/A	112	117	peak
2402.000	103.99	-10.14	93.85	N/A	N/A	112	117	AVG
4804.000	50.15	-3.28	46.87	74.00	-27.13	139	349	peak
4804.000	42.32	-3.28	39.04	54.00	-14.96	139	349	AVG
7206.000	43.01	3.10	46.11	74.00	-27.89	150	320	peak
7206.000	31.99	3.10	35.09	54.00	-18.91	150	320	AVG
Middle channel								
2440.000	106.03	-9.82	96.21	N/A	N/A	144	119	peak
2440.000	104.46	-9.82	94.64	N/A	N/A	144	119	AVG
4880.000	47.83	-3.03	44.80	74.00	-29.20	153	19	peak
4880.000	41.30	-3.03	38.27	54.00	-15.73	153	19	AVG
7320.000	42.73	4.07	46.80	74.00	-27.20	150	244	peak
7320.000	31.95	4.07	36.02	54.00	-17.98	150	244	AVG
High channel								
2480.000	106.16	-9.31	96.85	N/A	N/A	124	135	peak
2480.000	104.16	-9.31	94.85	N/A	N/A	124	135	AVG
2483.500	72.61	-9.26	63.35	74.00	-10.65	124	135	peak
2483.500	51.02	-9.26	41.76	54.00	-12.24	124	135	AVG
4960.000	51.92	-2.69	49.23	74.00	-24.77	150	36	peak
4960.000	44.57	-2.69	41.88	54.00	-12.12	150	36	AVG
7440.000	43.33	4.25	47.58	74.00	-26.42	150	257	peak
7440.000	32.07	4.25	36.32	54.00	-17.68	150	257	AVG

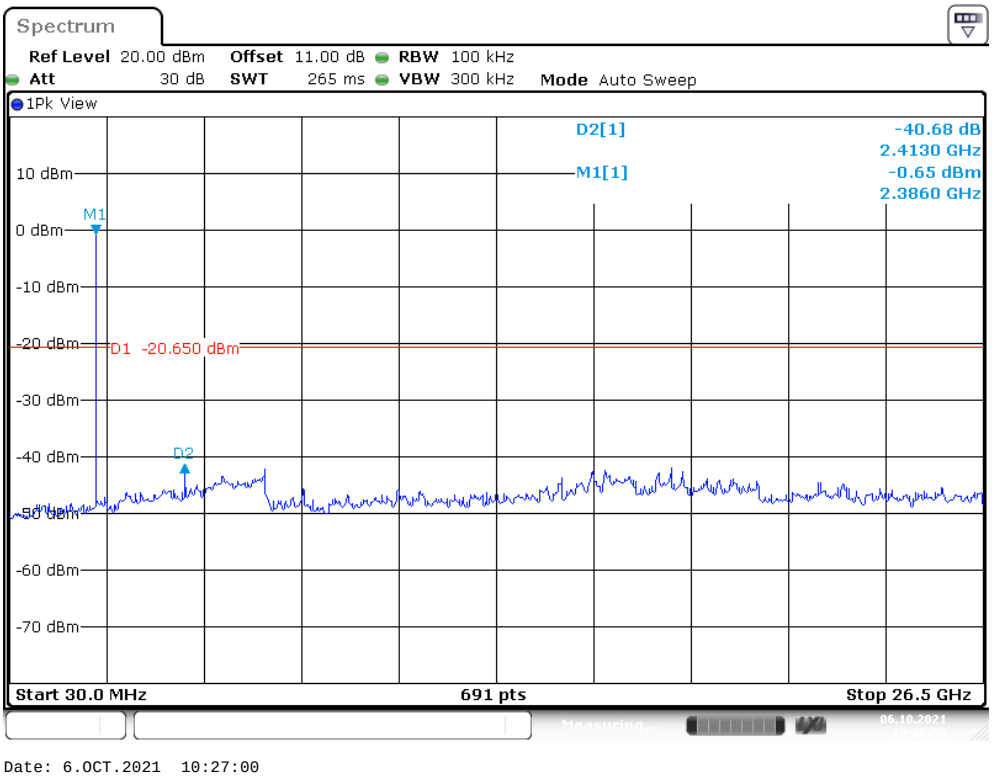
Result = Reading + Correct Factor
Margin = Result – Limit
Correct Factor = Antenna Factor + Cable Loss – Amplifier Gain
Spurious emissions more than 20 dB below the limit were not reported.

Conducted Spurious Emissions:

Channel	Frequency (MHz)	Delta Peak to Band Emission (dBc)	Limit (dBc)	Result
BLE(1M) Mode				
Low	2402	40.68	≥ 20	PASS
Mid	2441	40.41	≥ 20	PASS
High	2480	41.52	≥ 20	PASS
BLE(2M) Mode				
Low	2402	38.05	≥ 20	PASS
Mid	2441	40.30	≥ 20	PASS
High	2480	42.28	≥ 20	PASS

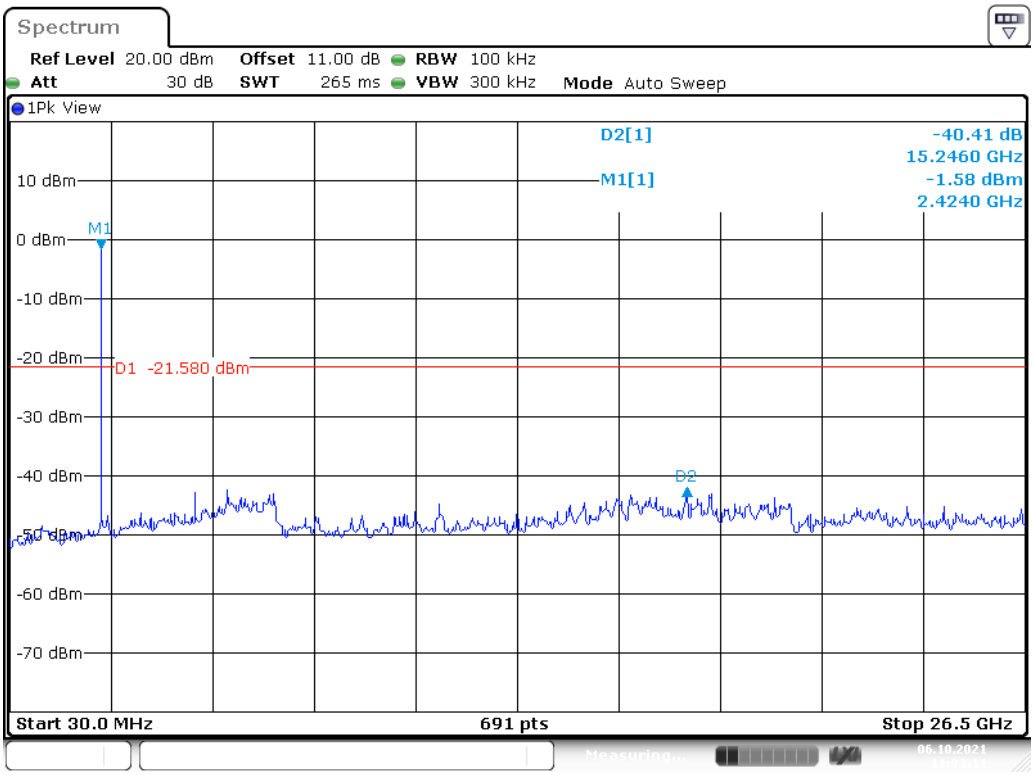
Please refer to the following plots

BLE(1M) Mode
Low Channel



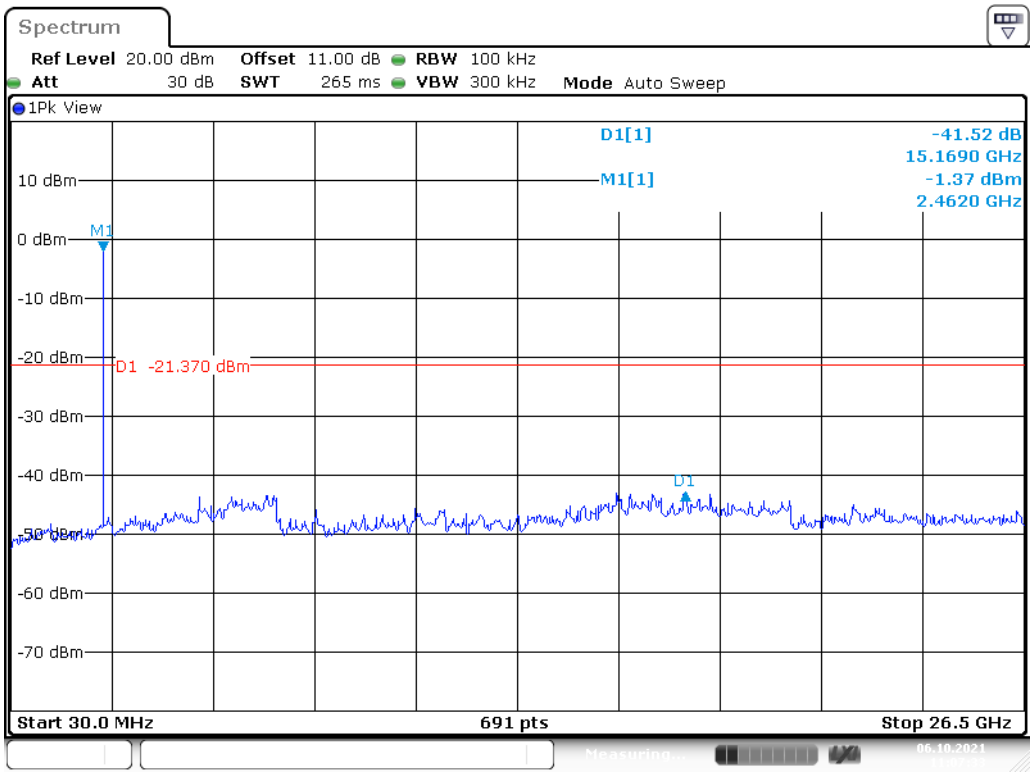
Date: 6.OCT.2021 10:27:00

Middle Channel



Date: 6.OCT.2021 11:03:11

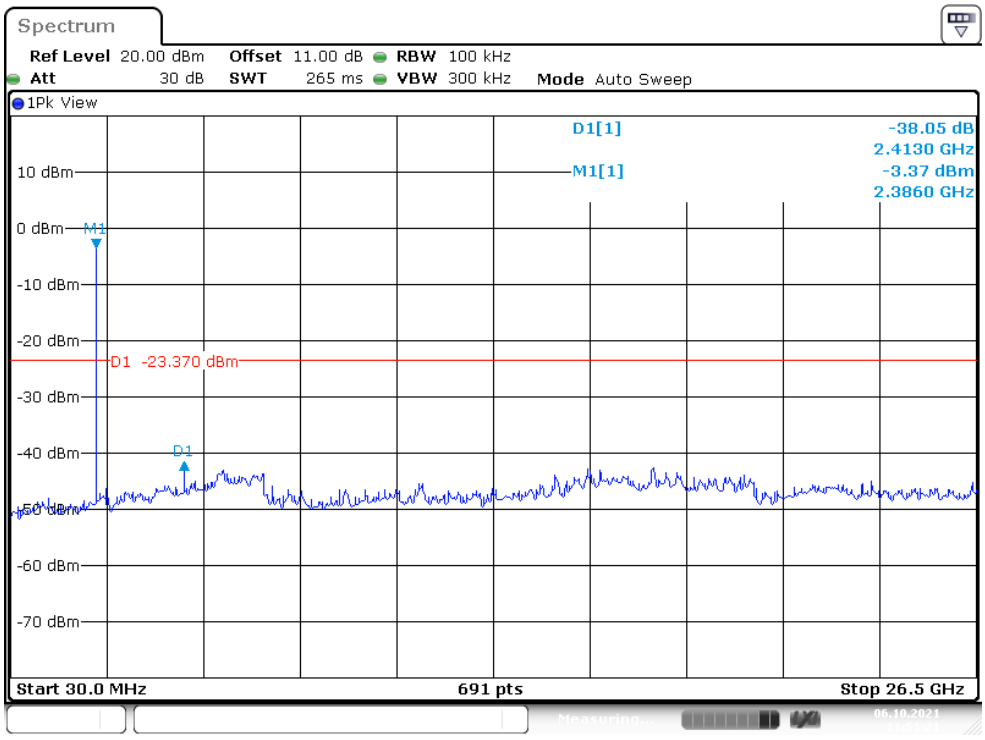
High Channel



Date: 6.OCT.2021 11:07:33

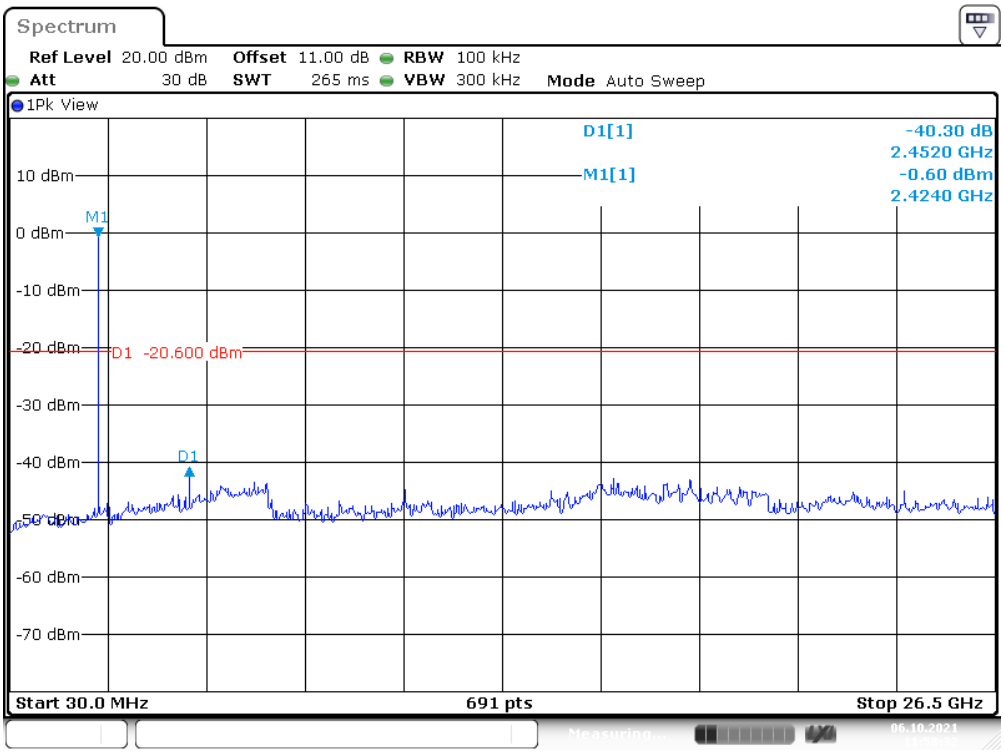
BLE(2M) Mode

Low Channel



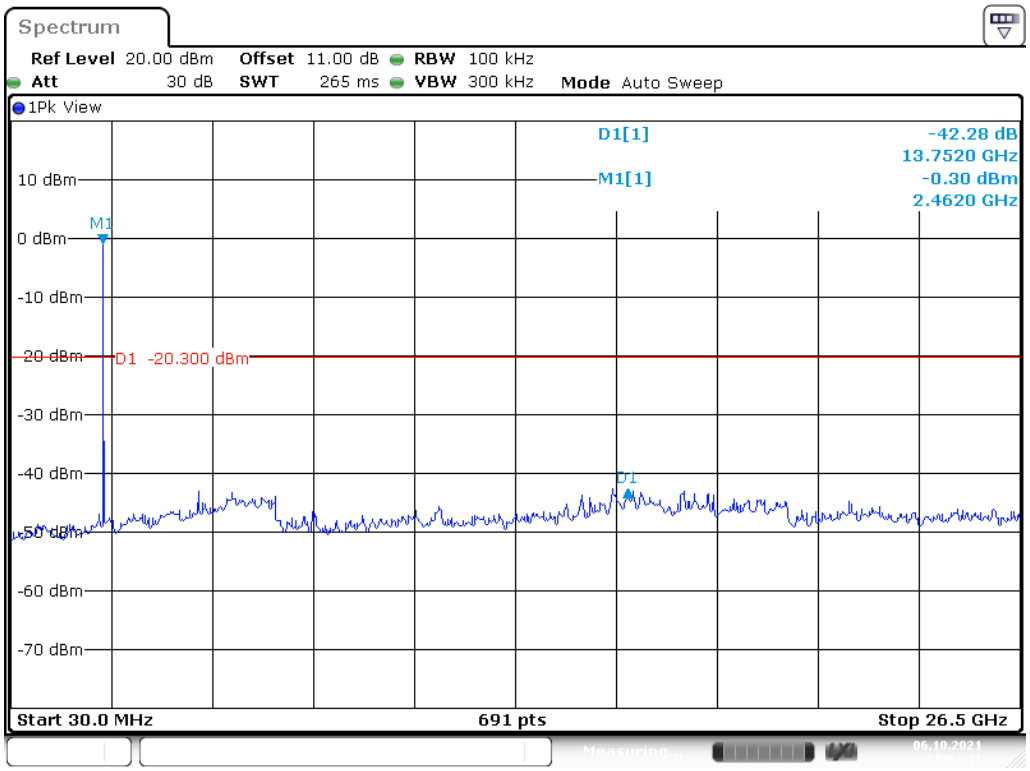
Date: 6.OCT.2021 11:51:21

Middle Channel



Date: 6.OCT.2021 11:58:32

High Channel



Date: 6.OCT.2021 12:04:41

9 FCC §15.247(a)(2) – 6 dB Emission Bandwidth

9.1 Applicable Standard

According to FCC §15.247(a)(2).

Systems using digital modulation techniques may operate in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz.

9.2 Test Procedure

The steps for the first option are as follows:

a) Set RBW = 100 kHz.

b) Set the VBW ≥ [3 × RBW].

c) Detector = peak.

d) Trace mode = max hold.

e) Sweep = auto couple.

f) Allow the trace to stabilize.

g) Measure the maximum width of the emission that is constrained by the frequencies associated with the two outermost amplitude points (upper and lower frequencies) that are attenuated by 6 dB relative to the maximum level measured in the fundamental emission.

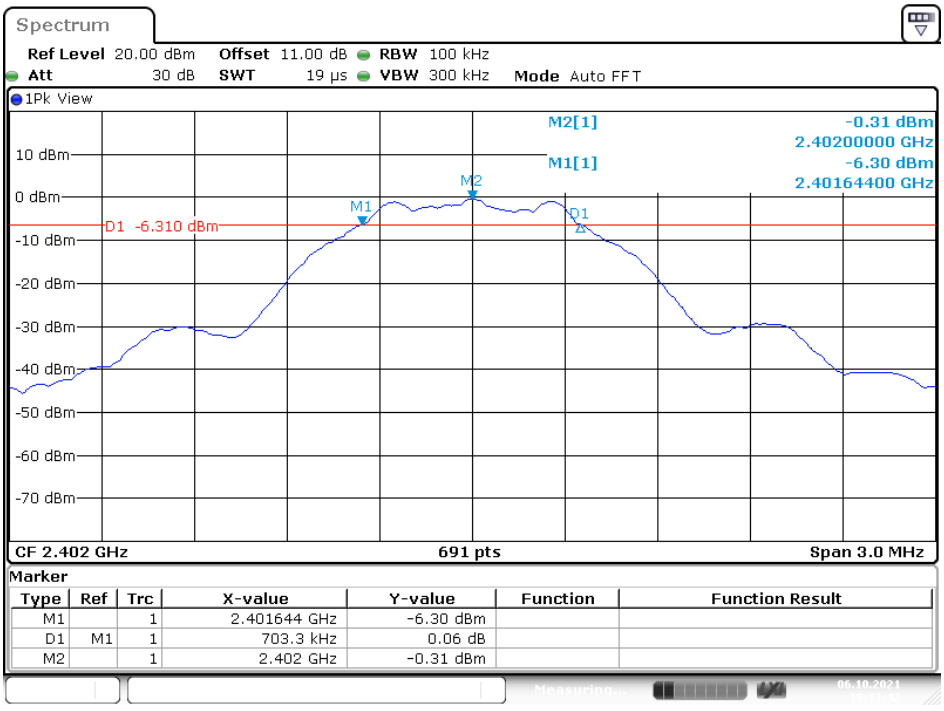
9.3 Test Results

Channel	Frequency (MHz)	6 dB Emission Bandwidth (kHz)	Limit (kHz)	Result
BLE(1M) Mode				
Low	2402	703	> 500	Compliance
Middle	2440	703	> 500	Compliance
High	2480	703	> 500	Compliance
BLE(2M) Mode				
Low	2402	1133	> 500	Compliance
Middle	2440	1133	> 500	Compliance
High	2480	1133	> 500	Compliance

Please refer to the following plots

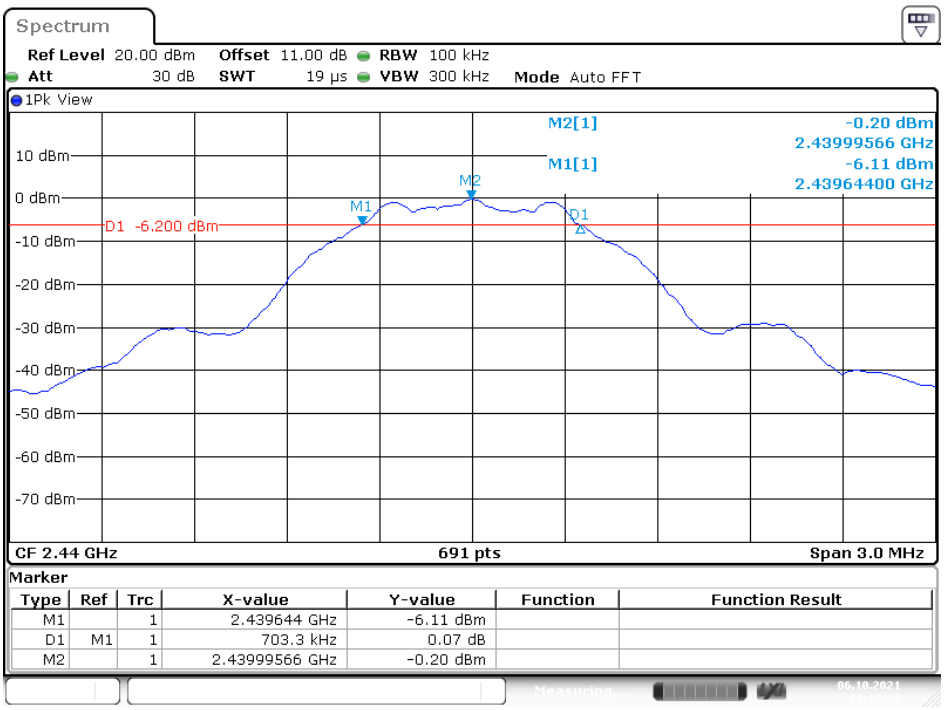
BLE(1M) Mode

Low Channel



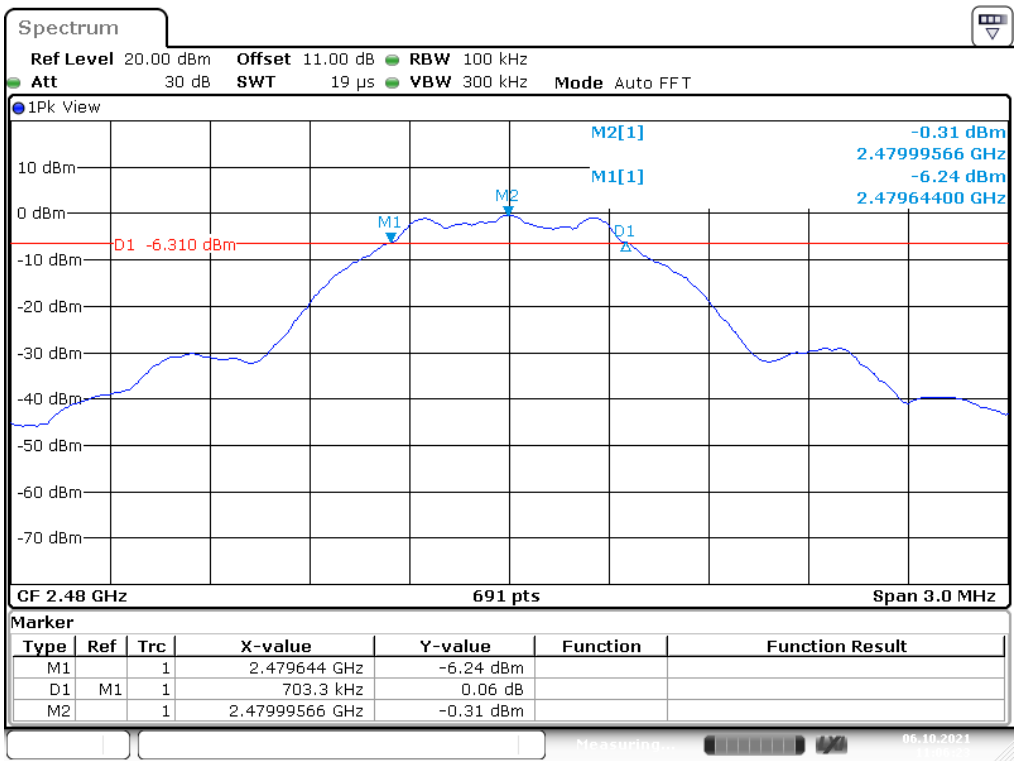
Date: 6.OCT.2021 10:11:42

Middle Channel



Date: 6.OCT.2021 11:18:32

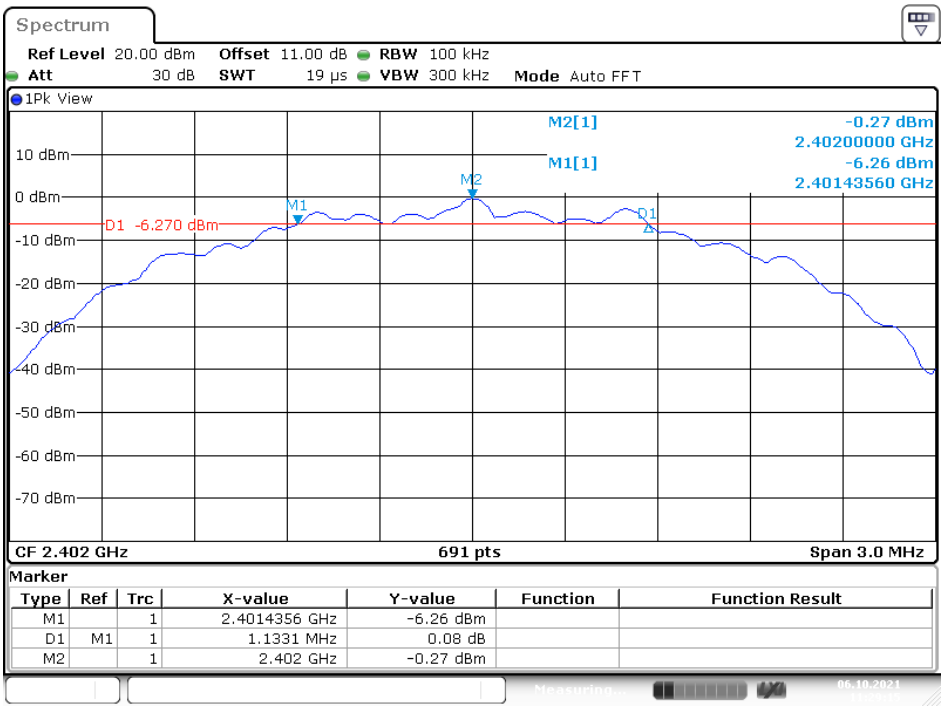
High Channel



Date: 6.OCT.2021 11:06:23

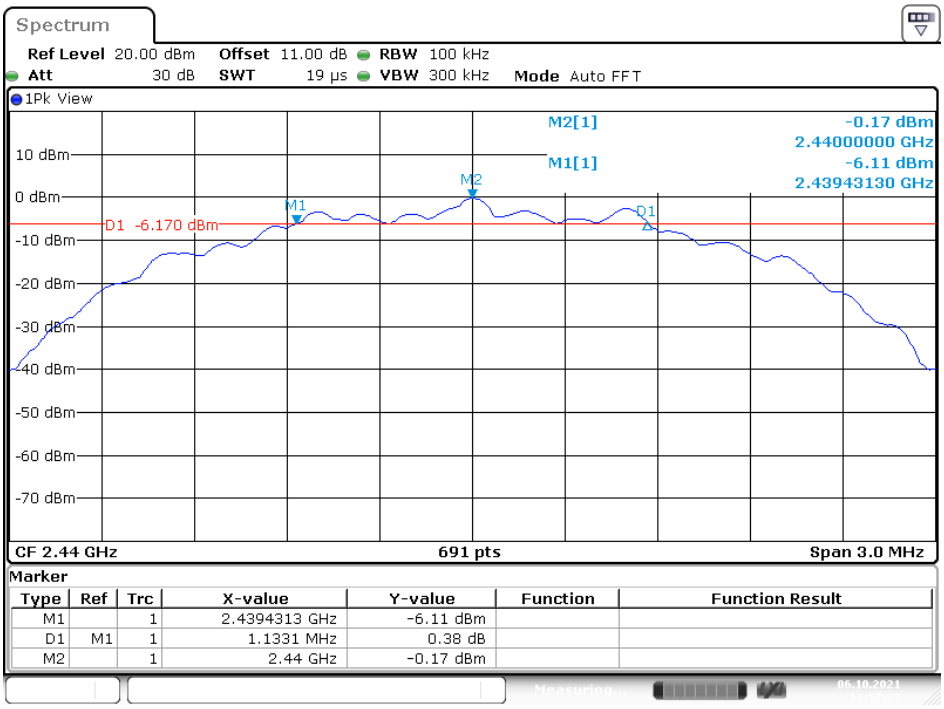
BLE(2M) Mode

Low Channel



Date: 6.OCT.2021 11:29:15

Middle Channel



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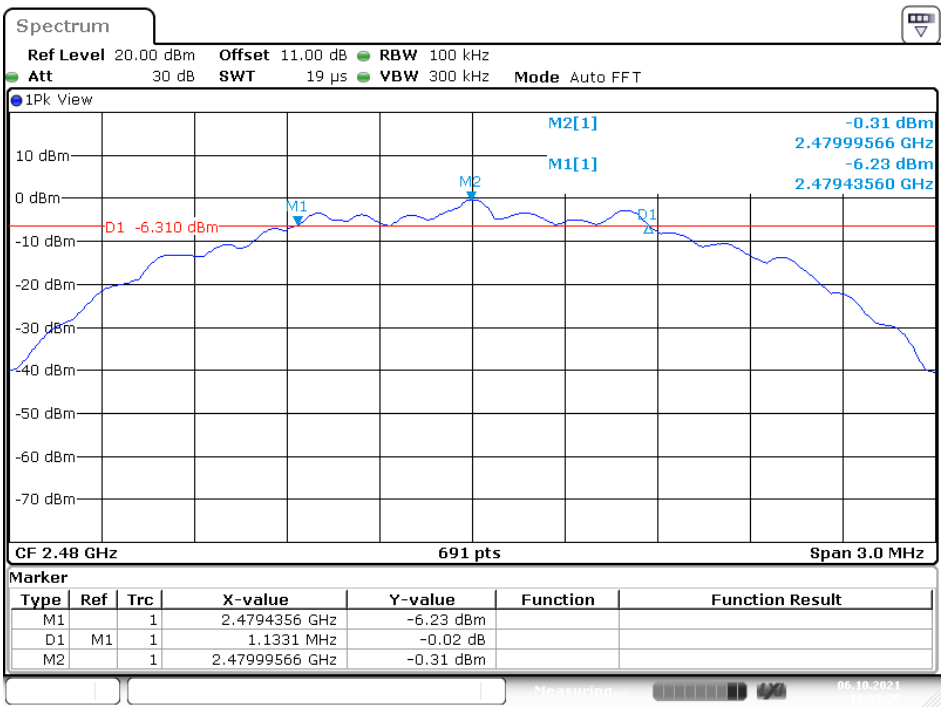
High Channel



Date: 6.OCT.2021 12:08:27

10 FCC §15.247(b)(3) – Maximum Output Power

10.1 Applicable Standard

According to FCC §15.247(b) (3).

Systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt. As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the maximum conducted output power is the highest total transmit power occurring in any mode.

10.2 Test Procedure

1. Place the EUT on a bench and set it in transmitting mode.
2. Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to measuring equipment.

10.3 Test Results

Channel	Frequency	Maximum peak Conducted Output Power		Limit	Result
	(MHz)	(dBm)	(W)	(W)	
BLE(1M) Mode					
Low	2402	0.03	0.001	1	PASS
Middle	2440	0.19	0.001	1	PASS
High	2480	0.16	0.001	1	PASS
BLE(2M) Mode					
Low	2402	-0.05	0.001	1	PASS
Middle	2440	0.09	0.001	1	PASS
High	2480	0.13	0.001	1	PASS

11 FCC§15.247(d) – 100 kHz Bandwidth of Frequency Band Edge

11.1 Applicable Standard

According to FCC §15.247(d).

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

11.2 Test Procedure

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.

2. Position the EUT without connection to measurement instrument. Turn on the EUT and connect its antenna terminal to measurement instrument via a low loss cable. Then set it to any one measured frequency within its operating range, and make sure the instrument is operated in its linear range.

3. Set RBW to 100 kHz and VBW of spectrum analyzer to 300 kHz with a convenient frequency span including 100 kHz bandwidth from band edge.

4. Measure the highest amplitude appearing on spectral display and set it as a reference level. Plot the graph with marking the highest point and edge frequency.

5. Repeat above procedures until all measured frequencies were complete.

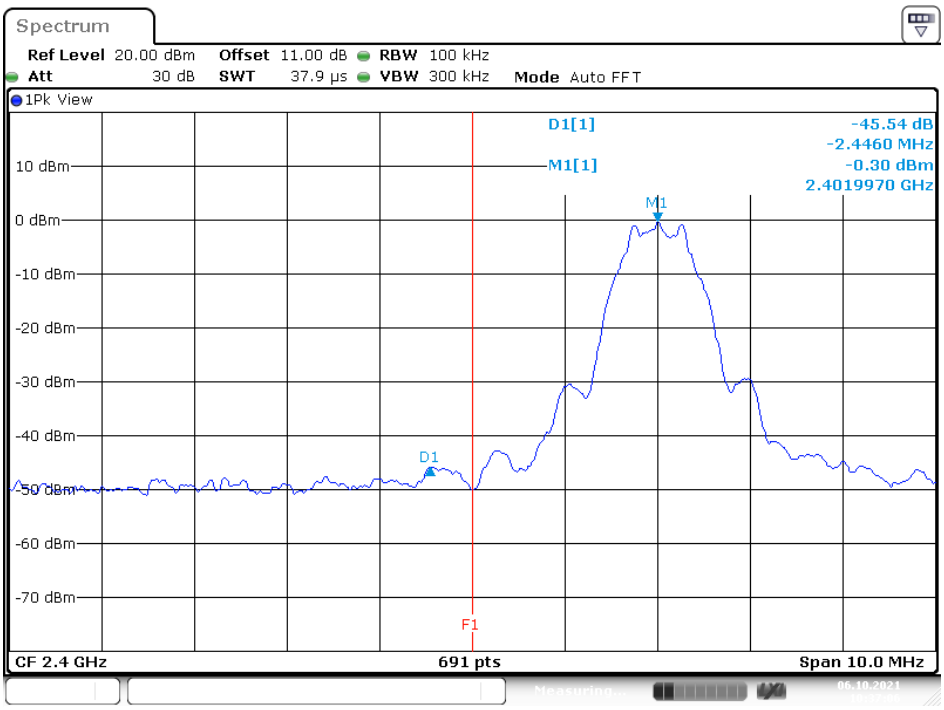
11.3 Test Results

Channel	Frequency (MHz)	Delta Peak to Band Emission (dBc)	Limit (dBc)	Result
BLE(1M) Mode				
Low	2402	45.54	≥ 20	PASS
High	2480	46.83	≥ 20	PASS
BLE(2M) Mode				
Low	2402	33.91	≥ 20	PASS
High	2480	45.55	≥ 20	PASS

Please refer to the following plots

BLE(1M) Mode

Band Edge, Left Side



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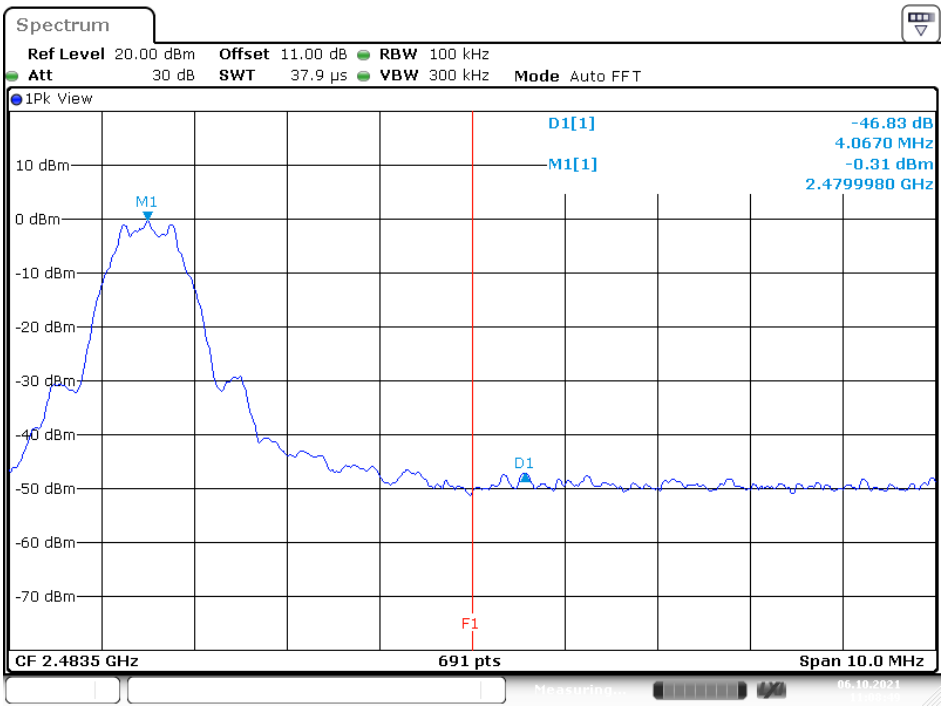
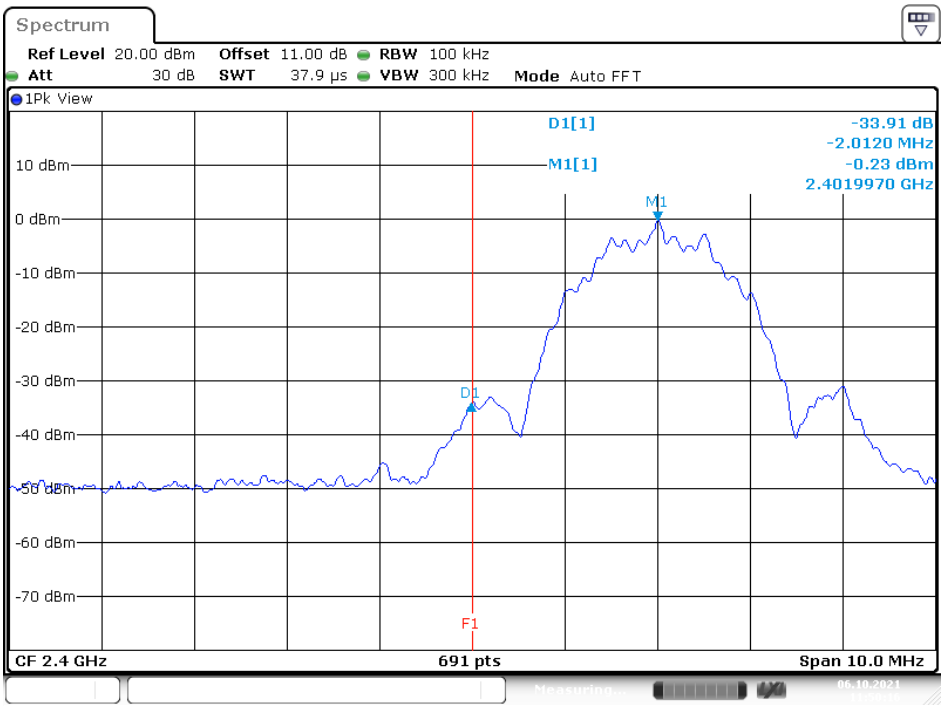
Band Edge, Right Side



Date: 6.OCT.2021 11:08:49

BLE(2M) Mode

Band Edge, Left Side



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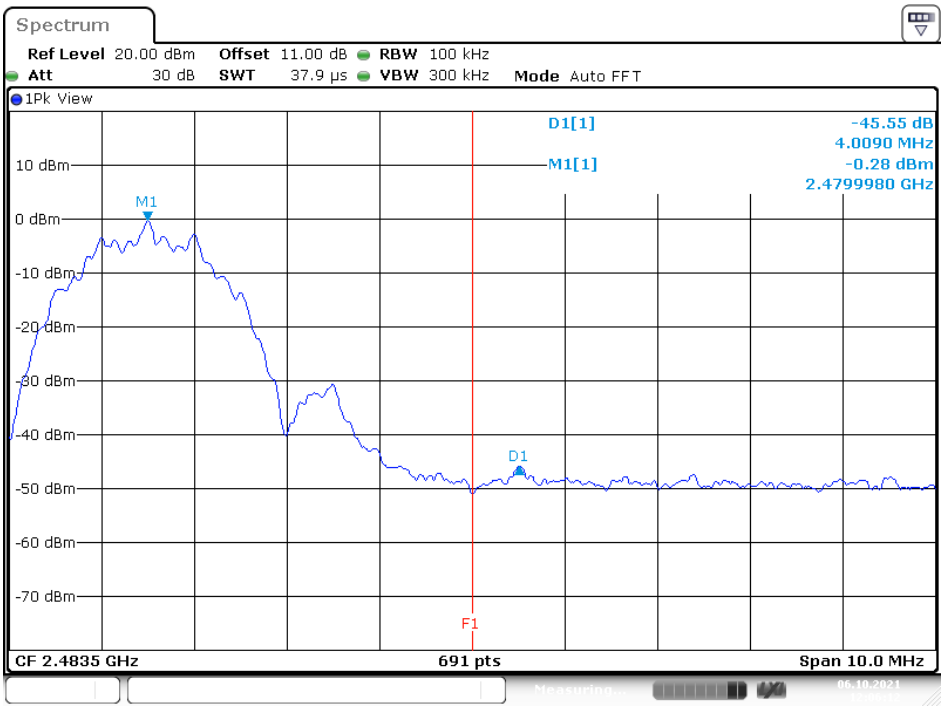
Band Edge, Right Side



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12 FCC §15.247(e) – Power Spectral Density

12.1 Applicable Standard

According to FCC §15.247(e).

For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. This power spectral density shall be determined in accordance with the provisions of paragraph (b) of this section. The same method of determining the conducted output power shall be used to determine the power spectral density.

12.2 Test Procedure

According to ANSI C63.10-2013

a) Set analyzer center frequency to DTS channel center frequency.

b) Set the span to 1.5 times the DTS bandwidth.

c) Set the RBW to 3 kHz ≤ RBW ≤ 100 kHz.

d) Set the VBW ≥ [3 × RBW].

e) Detector = peak.

f) Sweep time = auto couple.

g) Trace mode = max hold.

h) Allow trace to fully stabilize.

i) Use the peak marker function to determine the maximum amplitude level within the RBW.

j) If measured value exceeds requirement, then reduce RBW (but no less than 3 kHz) and repeat

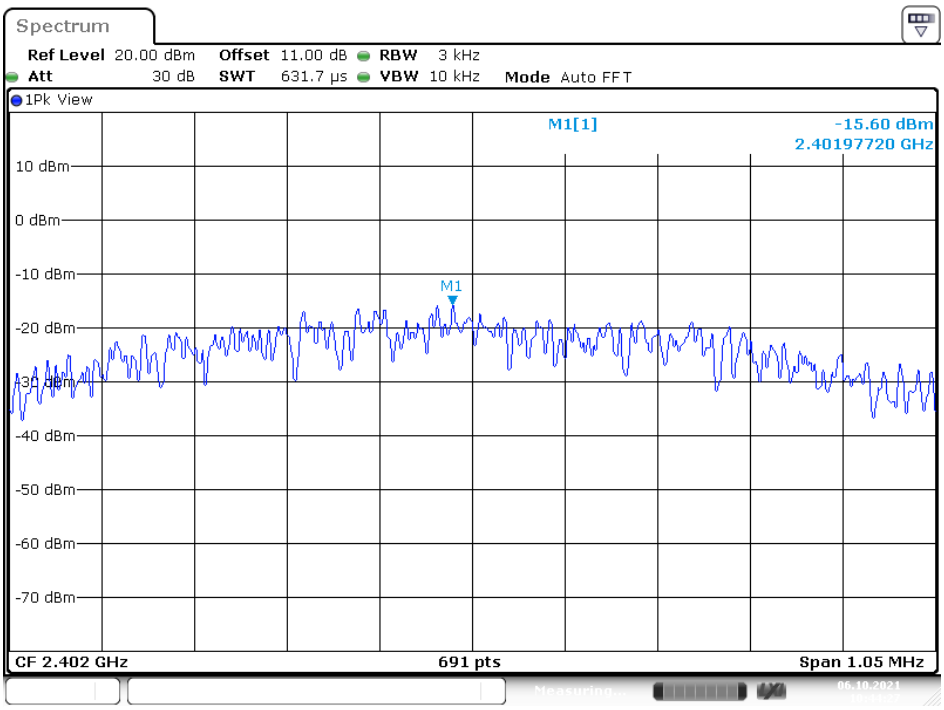
12.3 Test Results

Channel	Frequency (MHz)	Power Spectral Density (dBm/3 kHz)	Limit (dBm/3 kHz)	Result
BLE(1M) Mode				
Low	2402	-15.60	8	Compliance
Middle	2440	-15.53	8	Compliance
High	2480	-15.65	8	Compliance
BLE(2M) Mode				
Low	2402	-18.46	8	Compliance
Middle	2440	-18.42	8	Compliance
High	2480	-18.53	8	Compliance

Please refer to the following plots

BLE(1M) Mode

Low Channel



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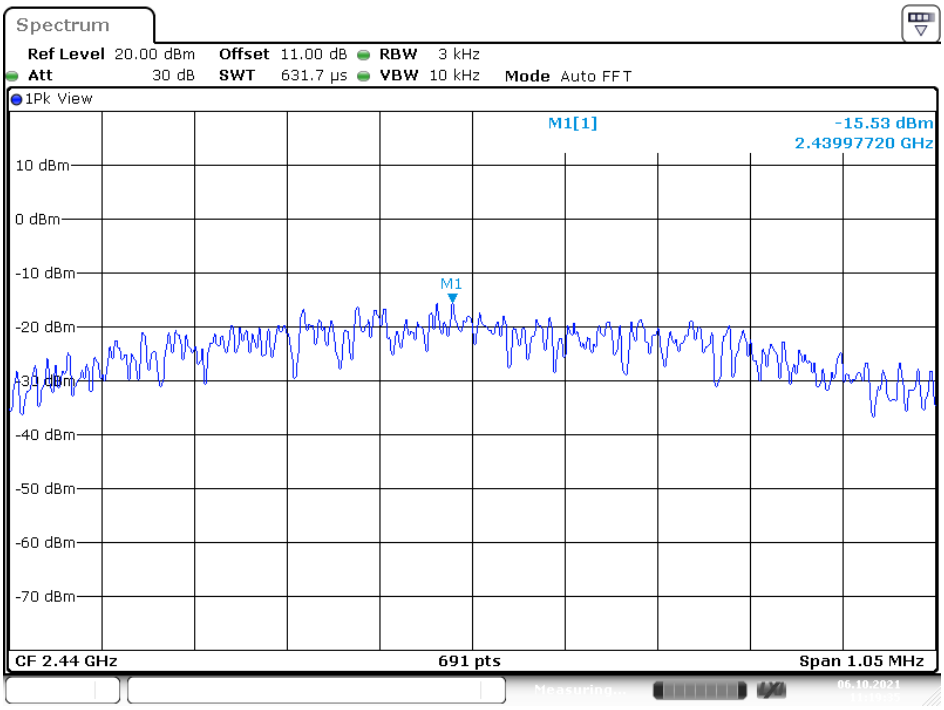
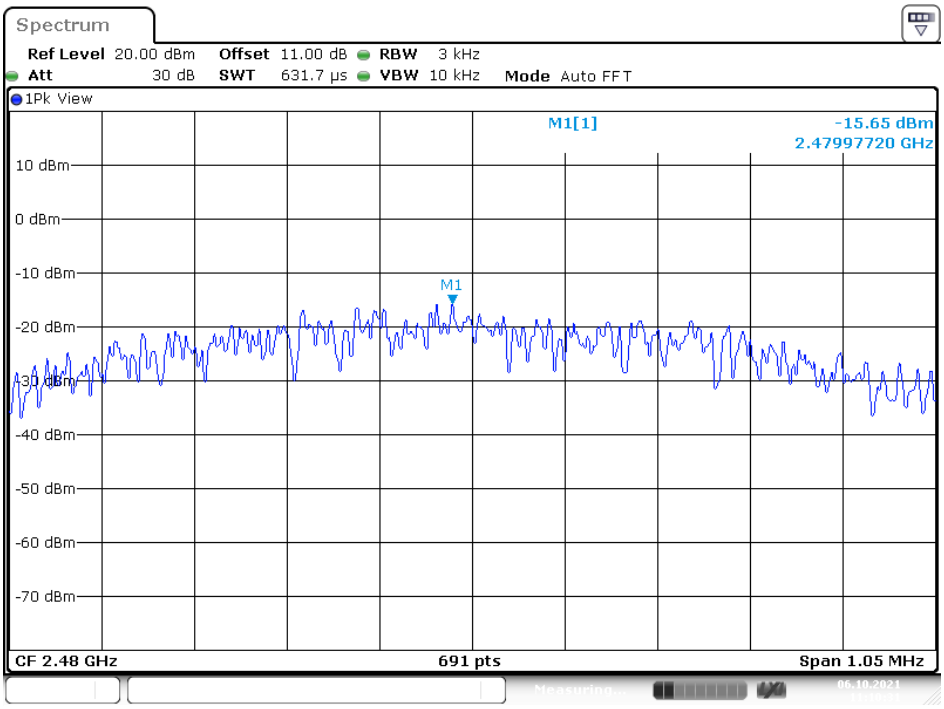
Middle Channel



Date: 6.OCT.2021 11:19:35

High Channel



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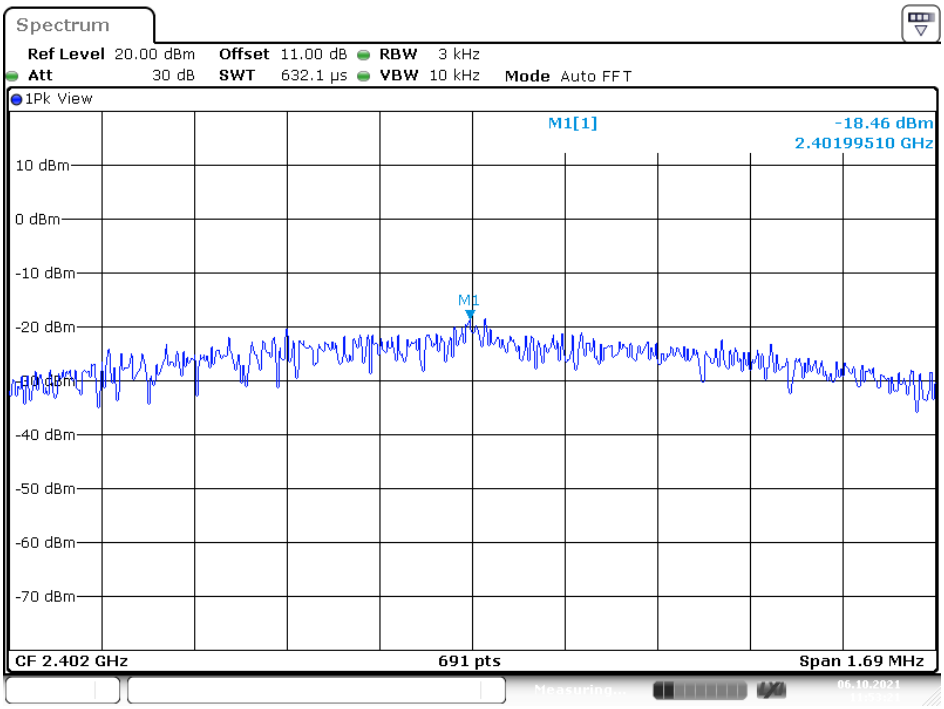
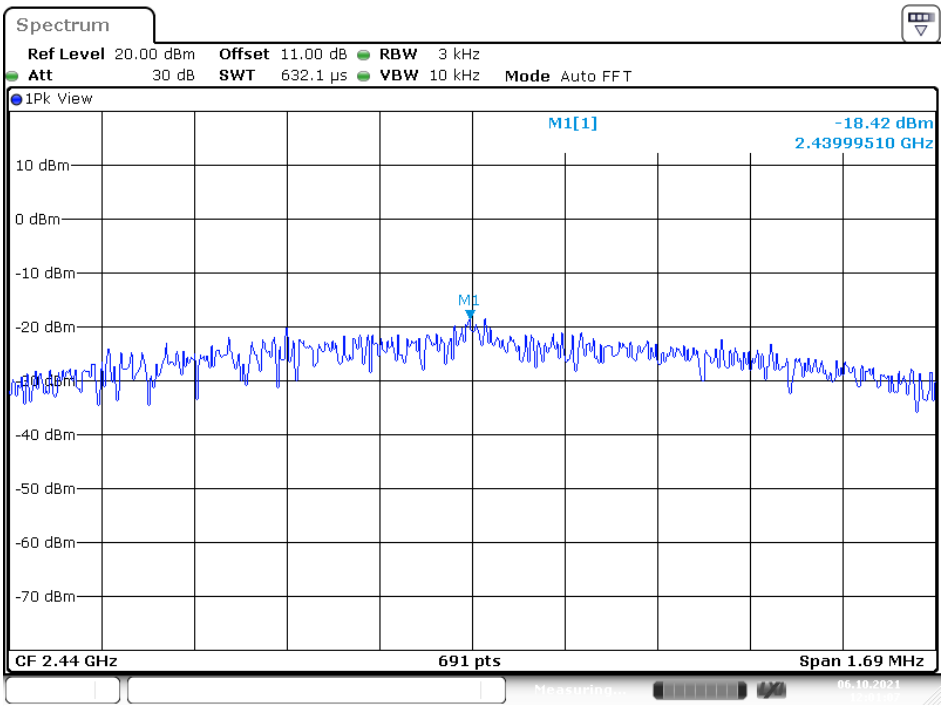
BLE(2M) Mode

Low Channel



Date: 6.OCT.2021 11:53:21

Middle Channel



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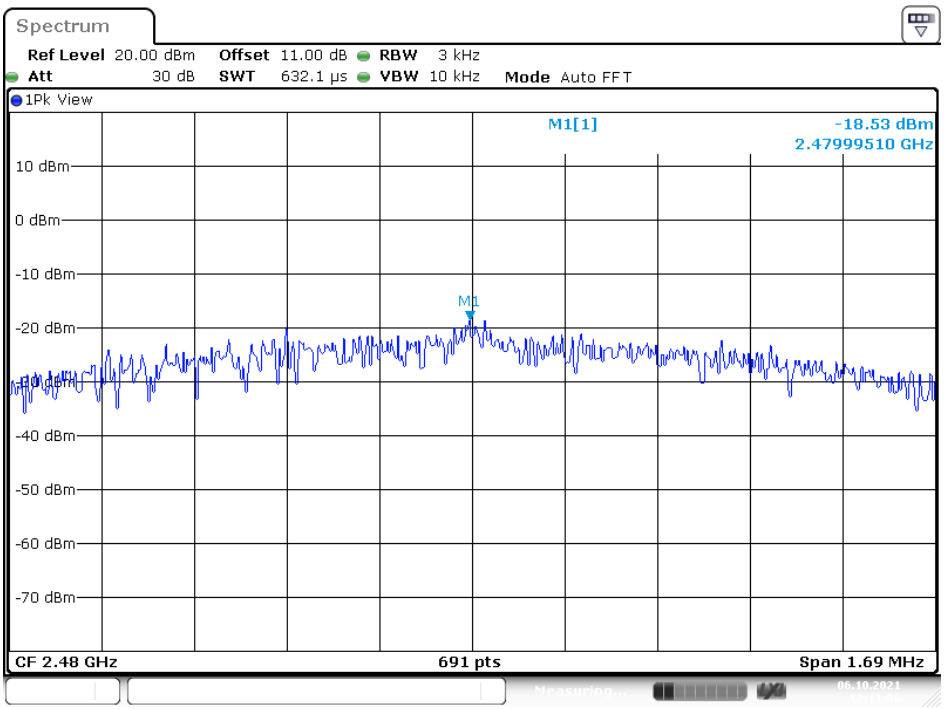
High Channel



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