FCC Part 15.247

TEST REPORT

For

TIBBO TECHNOLOGY

9F-3, NO. 31, LANE 169, KANG-NING ST., HSI-CHIH,TAIPEI,Taiwan

FCC ID: XOJ-WS1102

Report Type: Original Report	**Product Type:** WS1102 Programmable Wireless RS232/422/485 Controller

Report Producer : Nana Hsu

Report Number : RXZ210830002RF01

Report Date : 2021-10-18

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Revision History

Revision	No.	Report Number	Issue Date	Description	Author/ Revised by
0.0	RXZ210830002	RXZ210830002RF01	2021-10-18	Original Report	Nana Hsu

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1 General Information

1.1 Product Description for Equipment under Test (EUT)

Applicant	TIBBO TECHNOLOGY
	9F-3,NO.31, LANE 169, KANG-NING ST., HSI-CHIH, TAIPEI, Taiwan
Manufacturer	TIBBO TECHNOLOGY
	9F-3,NO.31, LANE 169, KANG-NING ST., HSI-CHIH, TAIPEI, Taiwan
Brand(Trade) Name	Tibbo or Tibbo TECHNOLOGY
Product (Equipment)	WS1102 Programmable Wireless RS232/422/485 Controller
Main Model Name	WS1102
Frequency Range	IEEE 802.11b/g /IEEE 802.11n HT20 Mode: 2412 ~ 2462 MHz IEEE 802.11n HT40 Mode: 2422 ~ 2452 MHz BLE(1M): 2402 ~ 2480 MHz
Transmit Power	IEEE 802.11b Mode: 20.48 dBm IEEE 802.11g Mode: 23.28 dBm IEEE 802.11n HT20 Mode: 23.10 dBm IEEE 802.11n HT40 Mode: 21.96 dBm BLE(1M) Mode : 11.46 dBm
Modulation Technique	IEEE 802.11b Mode: DSSS IEEE 802.11g Mode: OFDM IEEE 802.11n HT20 Mode: OFDM IEEE 802.11n HT40 Mode: OFDM BLE(1M) Mode: GFSK
Power Operation (Voltage Range)	☒ AC 120V/60Hz ☒ Adapter Brand Name: Anthin Model:APS305-1205 I/P: AC 100~240V 50/60Hz 0.2A ; O/P: DC 12V 0.5A ☐ By AC Power Cord ☐ PoE
	☐ DC Type ☐ Battery ☐ DC Power Supply ☐ External from USB Cable ☐ External DC Adapter
	☐ Host System
Received Date	Aug 31, 2021
Date of Test	Sep 07, 2021 ~ Sep 23, 2021

*All measurement and test data in this report was gathered from production sample serial number: RXZ210830002-01-07 (Assigned by BACL (New Taipei Laboratory)).

1.2 Objective

This report is prepared on behalf of *TIBBO TECHNOLOGY* 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)

FCC Part 15.407 NII submissions with FCC ID: XOJ-WS1102

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. (New Taipei Laboratory) 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
Power Spectral Density, conducted		+/- 0.93 dBm
Occupied Bandwidth		+/- 0.35 MHz
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	2021/09/19	25.4	46	1010	Boris
Radiation Spurious Emissions	2021/09/07 ~ 2021/09/09	24.3 ~ 24.5	61 ~ 66	1010	Ken
Conducted Spurious Emissions	2021/09/22 ~ 2021/09/23	25.1 ~ 25.4	44 ~ 49	1010	David Lee
6 dB Emission Bandwidth	2021/09/22 ~ 2021/09/23	25.1 ~ 25.4	44 ~ 49	1010	David Lee
Maximum Output Power	2021/09/22 ~ 2021/09/23	25.1 ~ 25.4	44 ~ 49	1010	David Lee
100 kHz Bandwidth of Frequency Band Edge	2021/09/22 ~ 2021/09/23	25.1 ~ 25.4	44 ~ 49	1010	David Lee
Power Spectral Density	2021/09/22 ~ 2021/09/23	25.1 ~ 25.4	44 ~ 49	1010	David Lee

1.8 Test Facility

The Test site used by Bay Area Compliance Laboratories Corp. (New Taipei Laboratory) 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. (New Taipei Laboratory) 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.

2 System Test Configuration

2.1 Description of Test Configuration

For WIFI mode, there are totally 11 channels.

Channel	Frequency (MHz)	Channel	Frequency (MHz)
1	2412	7	2442
2	2417	8	2447
3	2422	9	2452
4	2427	10	2457
5	2432	11	2462
6	2437		

For 802.11 b/g/n20 Modes were tested with channel 1, 6 and 11.

For 802.11n40 Mode were tested with channel 3, 6 and 9.

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

The test software was used "QATol_Dbg v1.0"

Test Frequency		Low	Mid	High
Power Level Setting	B Mode	25	25	25
	G Mode	21	25	23
	N20 Mode	1F	25	20
	N40 Mode	1B	25	1E
	BLE 1M	7	7	7

The EUT was configured for testing in an engineering mode which was provided by the manufacturer.

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.

802.11b: 1Mbps

802.11g: 6Mbps

802.11n HT20: MCS0

802.11n HT40: MCS0

BLE 1M : 1 Mbps

2.4 Test Mode

Full System (model: WS1102) for all test item.

2.5 Support Equipment List and Details

Description	Manufacturer	Model Number	S/N
NB	DELL	E6410	8N7PXN1
Adapter	Anthin	APS305-1205	N/A
fixture	N/A	N/A	N/A

2.6 External Cable List and Details

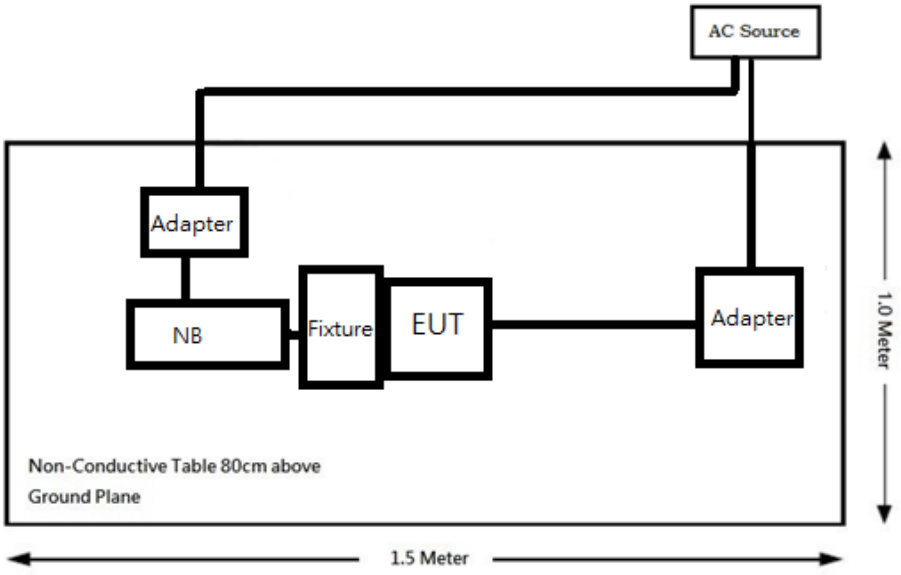
N/A

2.7 Block Diagram of Test Setup

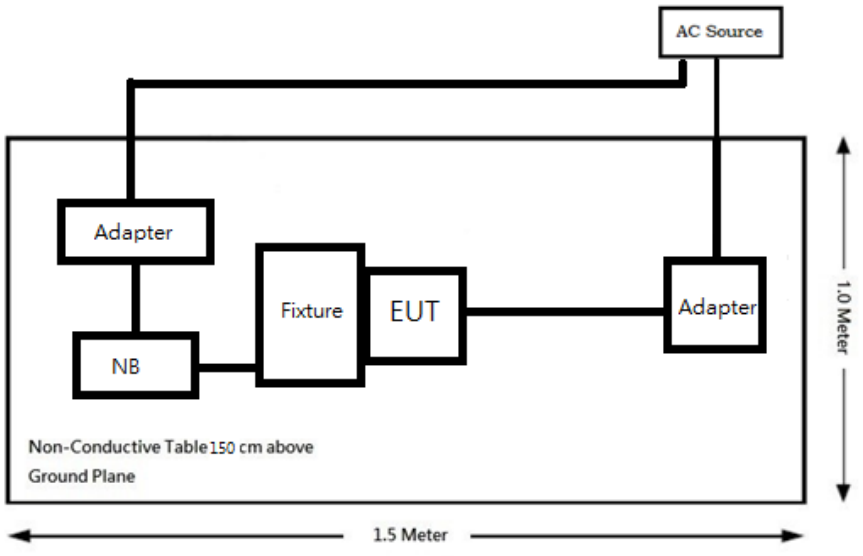
See test photographs attached in setup photos for the actual connections between EUT and support equipment.

Radiation:

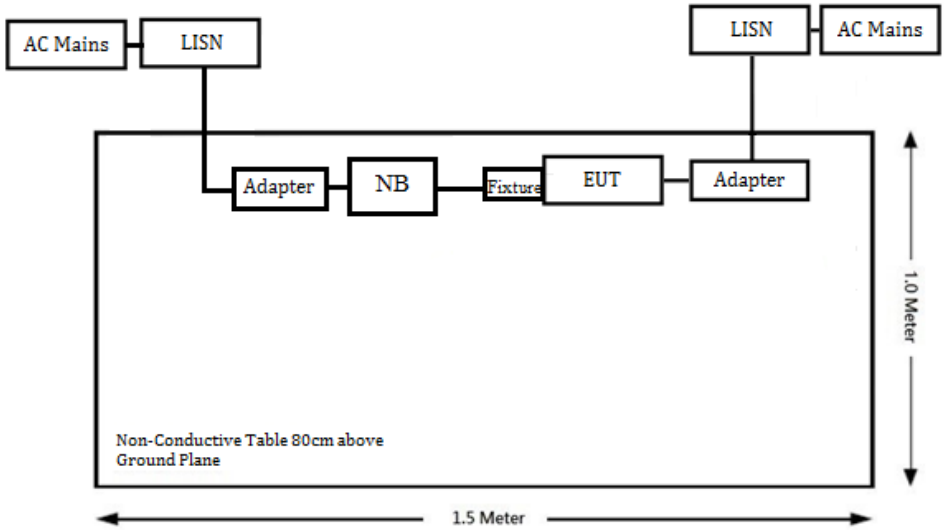
Below 1GHz:



Above 1GHz:



Conduction:



2.8 Duty Cycle

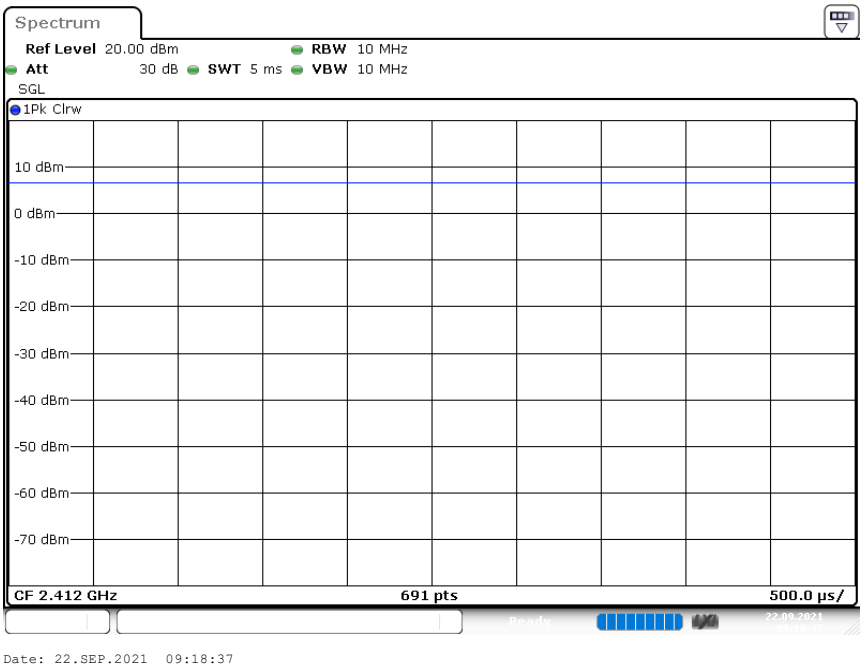
The duty cycle as below:

Radio Mode	On Time (ms)	Off Time (ms)	Duty Cycle (%)	Duty Cycle Correction Factor (dB)
802.11b	1	0	100	0
802.11g	1	0	100	0
802.11n20	1	0	100	0
802.11n40	1	0	100	0
BLE(1M)	0.362	0.261	58	2.37

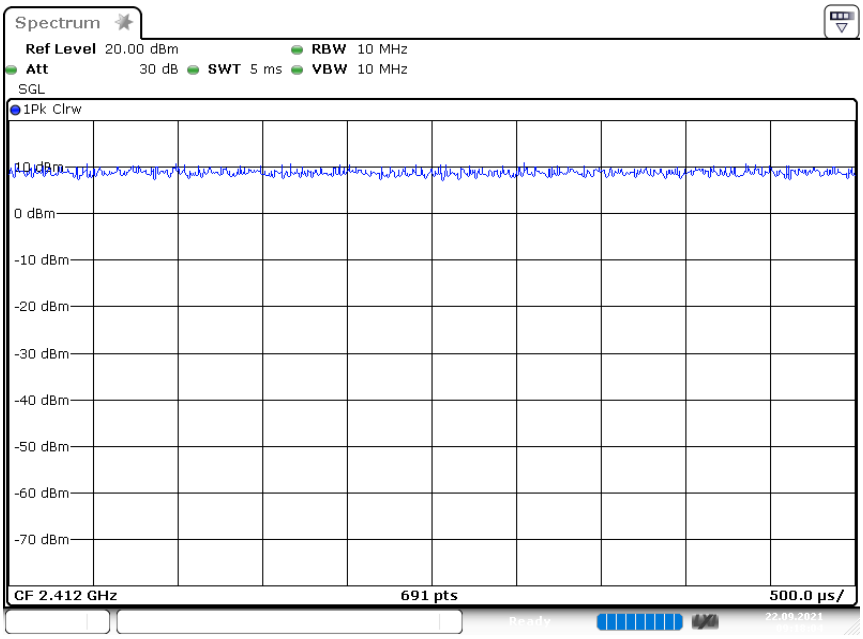
Note: Duty Cycle Correction Factor = 10*log(1/duty cycle)

Please refer to the following plots.

B Mode



G Mode



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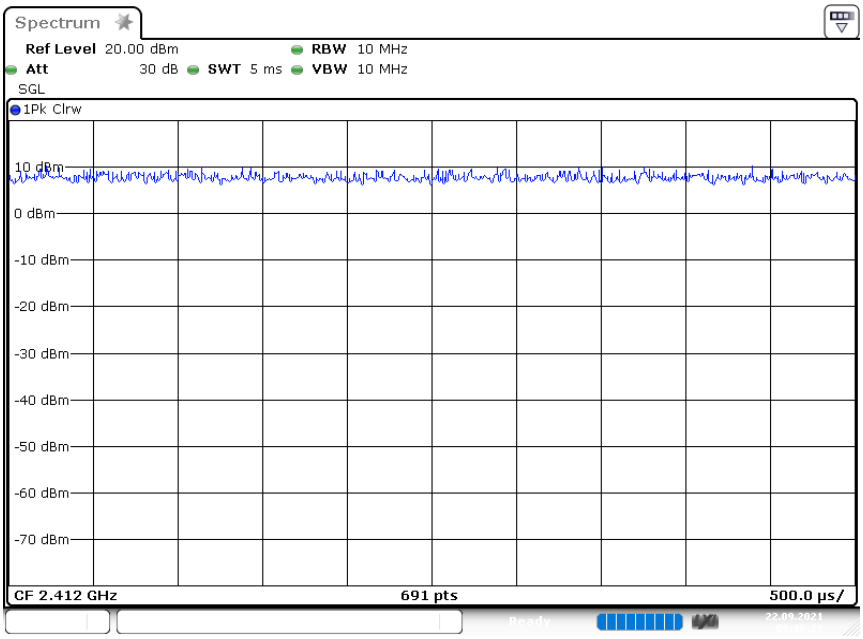
N20 Mode



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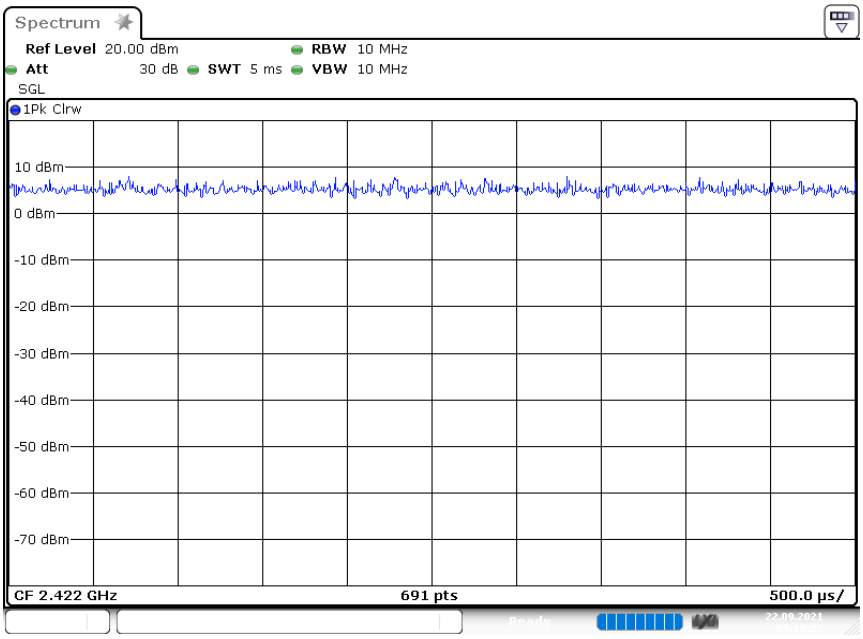
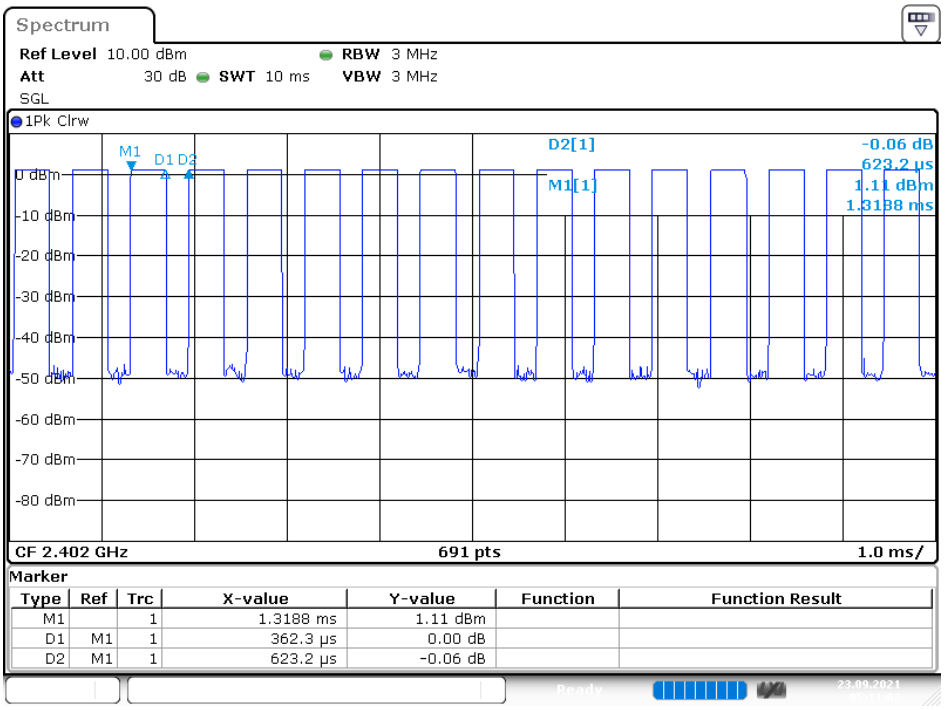
N40 Mode



Date: 22.SEP.2021 09:19:22

BLE(1M) Mode



Date: 23.SEP.2021 05:11:03

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	Rohde & Schwarz	ENV216	101248	2021/06/08	2022/06/07
EMI Test Receiver	Rohde & Schwarz	ESR7	101419	2020/11/12	2021/11/11
Pulse Limiter	Rohde & Schwarz	ESH3Z2	TXZEM104	2021/7/29	2022/7/29
RF Cable	EMEC	EM-CB5D	001	2021/6/11	2022/6/11
Software	AUDIX	E3	V9.150826k	N.C.R	N.C.R
Radiated Room (966-A)					
Bilog Antenna with 6 dB Attenuator	SUNOL SCIENCES & MINI-CIRCUITS	JB6/UNAT-6+	A050115/15542_01	2021/01/19	2022/01/18
Horn Antenna	EMCO	SAS-571	1020	2021/04/23	2022/04/22
Horn Antenna	ETS-Lindgren	3116	62638	2021/08/11	2022/08/10
Preamplifier	Sonoma	310N	130602	2021/06/08	2022/06/07
Preamplifier	A.H. system Inc.	PAM-0118P	470	2021/03/15	2022/13/14
Microware Preamplifier	EM Electronics Corporation	EM18G40G	060656	2020/12/30	2021/12/29
EMI Test Receiver	Rohde & Schwarz	ESR7	101419	2020/11/12	2021/11/11
Spectrum Analyzer	Rohde & Schwarz	FSV40	101435	2021/01/07	2022/01/06
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	WOKEN	N/A	S02-160323-025	2021/08/06	2022/08/05
Attenuator	MCL	BW-S10W5+	1419	2021/01/28	2022/01/27
Power Sensor	KEYSIGHT	U2021XA	MY54080018	2021/01/28	2022/01/27

***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	2402-2480	2.93	1.963	11.5	14.125	20	0.005	1
WI-FI	2412-2462	2.93	1.963	23.5	223.872	20	0.087	1
WI-FI	5150-5250	3.53	2.254	12.50	17.783	20	0.008	1
WI-FI	5725-5850	2.46	1.762	15.00	31.623	20	0.011	1

Note: Wi-Fi 2.4G, Wi-Fi 5G and BLE can't transmit simultaneously.

Result: MPE evaluation meets the requirements of the **20cm** standard.

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 List and Details

Model	Antenna Type	Antenna Gain
FDAH0I19	PCB	2.93 dBi

Result: Compliance

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

7.1 Applicable Standard

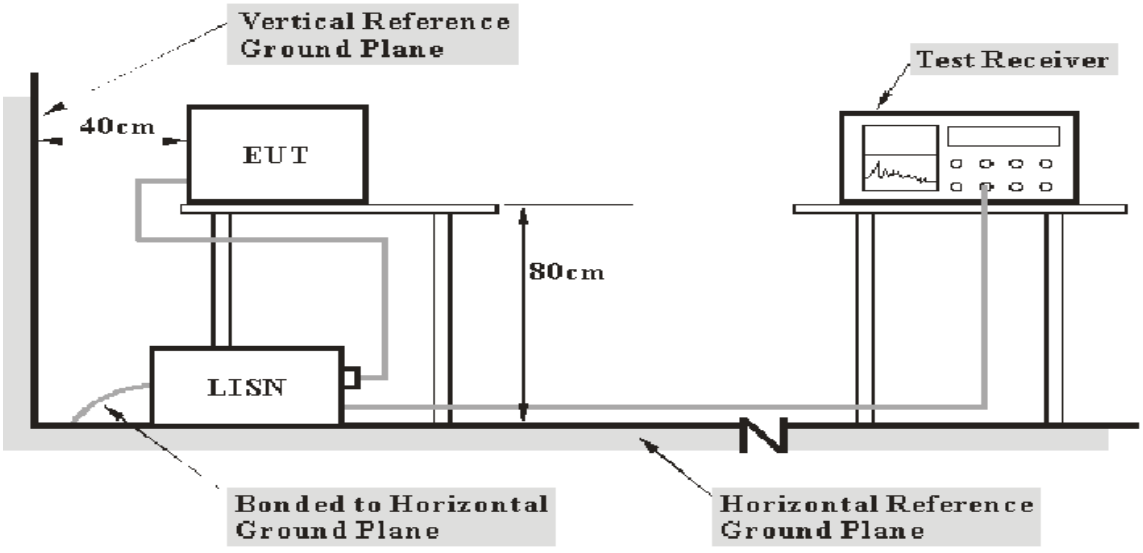
According to §15.207

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 1)
0.5-5	56	46
5-30	60	50

Note 1: Decreases with the logarithm of the frequency.

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:

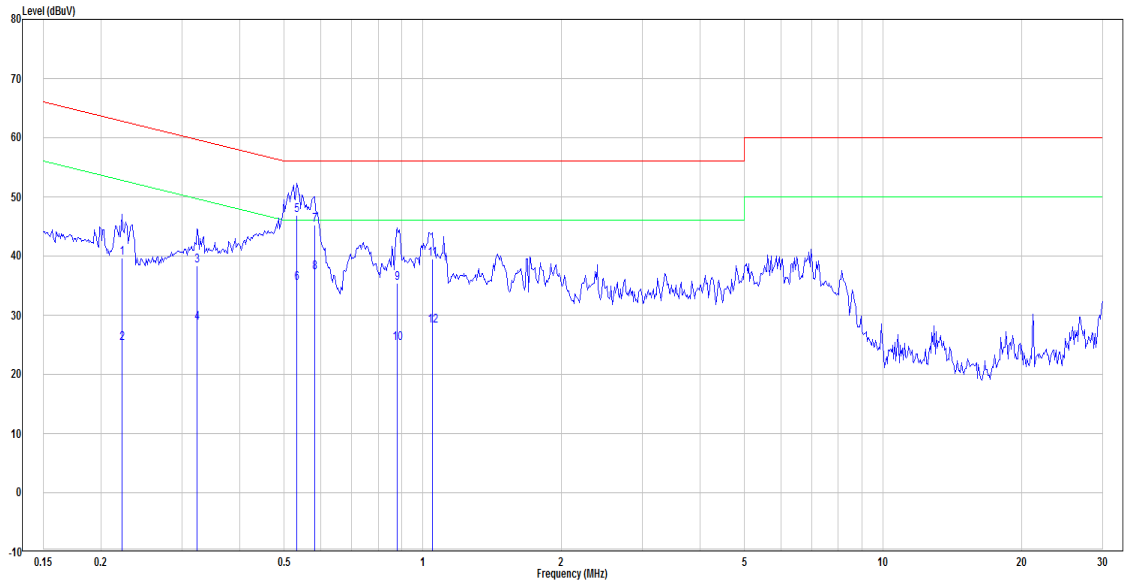
Over Limit = Level – Limit Line

7.6 Test Results

Test Mode: Transmitting

WIFI Mode

Main: AC120 V, 60 Hz, Line



No.	Frequency	Reading	Correct	Result	Limit	Over limit	Remark
	(MHz)	(dBµV)	Factor(dB)	(dBµV)	(dBµV)	(dB)	
1	0.222	20.13	19.58	39.71	62.74	-23.03	QP
2	0.222	5.64	19.58	25.22	52.74	-27.52	Average
3	0.323	18.76	19.58	38.34	59.62	-21.28	QP
4	0.323	9.05	19.58	28.63	49.62	-20.99	Average
5	0.532	27.37	19.59	46.96	56.00	-9.04	QP
6	0.532	15.87	19.59	35.46	46.00	-10.54	Average
7	0.582	25.69	19.59	45.28	56.00	-10.72	QP
8	0.582	17.56	19.59	37.15	46.00	-8.85	Average
9	0.880	15.85	19.61	35.46	56.00	-20.54	QP
10	0.880	5.65	19.61	25.26	46.00	-20.74	Average
11	1.049	19.97	19.61	39.58	56.00	-16.42	QP
12	1.049	8.61	19.61	28.22	46.00	-17.78	Average

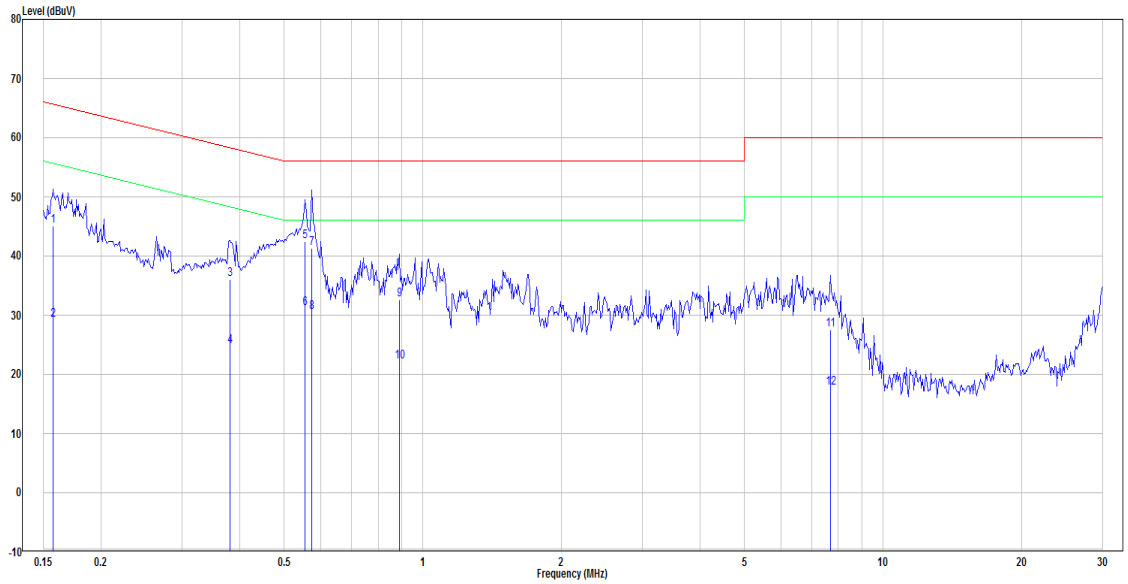
Note:

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	0.157	25.51	19.59	45.10	65.60	-20.50	QP
2	0.157	9.59	19.59	29.18	55.60	-26.42	Average
3	0.381	16.46	19.58	36.04	58.25	-22.21	QP
4	0.381	5.24	19.58	24.82	48.25	-23.43	Average
5	0.555	22.84	19.59	42.43	56.00	-13.57	QP
6	0.555	11.54	19.59	31.13	46.00	-14.87	Average
7	0.573	21.78	19.59	41.37	56.00	-14.63	QP
8	0.573	10.84	19.59	30.43	46.00	-15.57	Average
9	0.890	12.99	19.60	32.59	56.00	-23.41	QP
10	0.890	2.49	19.60	22.09	46.00	-23.91	Average
11	7.687	7.74	19.77	27.51	60.00	-32.49	QP
12	7.687	-2.07	19.77	17.70	50.00	-32.30	Average

Note:

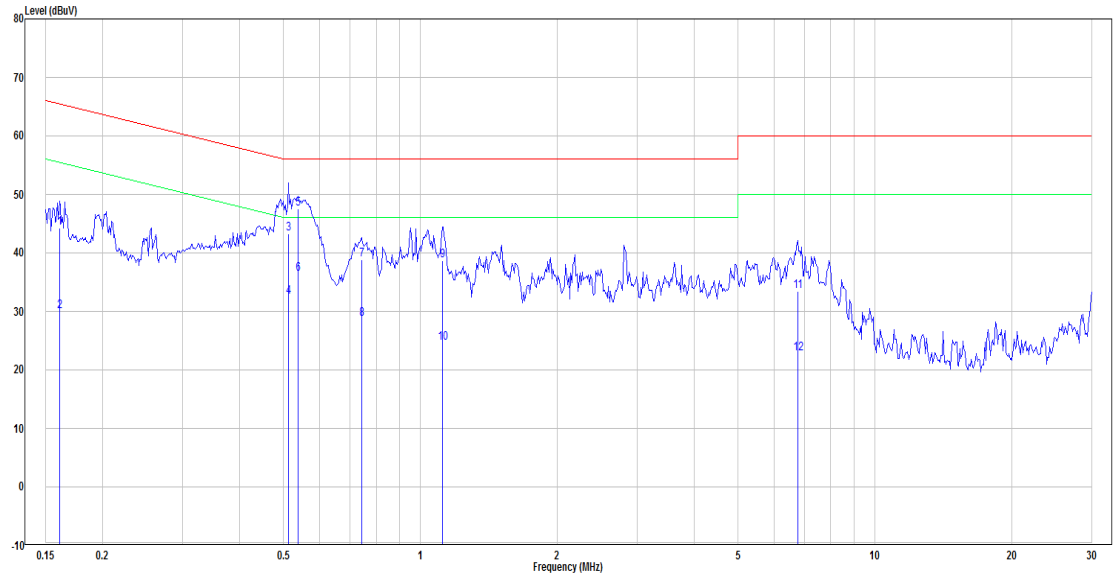
Level = Read Level + Factor

Over Limit = Level – Limit Line

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

BLE Mode

Main: AC120 V, 60 Hz, Line



No.	Frequency (MHz)	Reading (dBµV)	Correct Factor(dB)	Result (dBµV)	Limit (dBµV)	Over limit (dB)	Remark
1	0.161	24.64	19.59	44.23	65.43	-21.20	QP
2	0.161	10.33	19.59	29.92	55.43	-25.51	Average
3	0.513	23.65	19.59	43.24	56.00	-12.76	QP
4	0.513	12.83	19.59	32.42	46.00	-13.58	Average
5	0.538	27.89	19.59	47.48	56.00	-8.52	QP
6	0.538	16.86	19.59	36.45	46.00	-9.55	Average
7	0.743	19.32	19.60	38.92	56.00	-17.08	QP
8	0.743	9.07	19.60	28.67	46.00	-17.33	Average
9	1.117	19.04	19.61	38.65	56.00	-17.35	QP
10	1.117	4.94	19.61	24.55	46.00	-21.45	Average
11	6.769	13.67	19.75	33.42	60.00	-26.58	QP
12	6.769	3.11	19.75	22.86	50.00	-27.14	Average

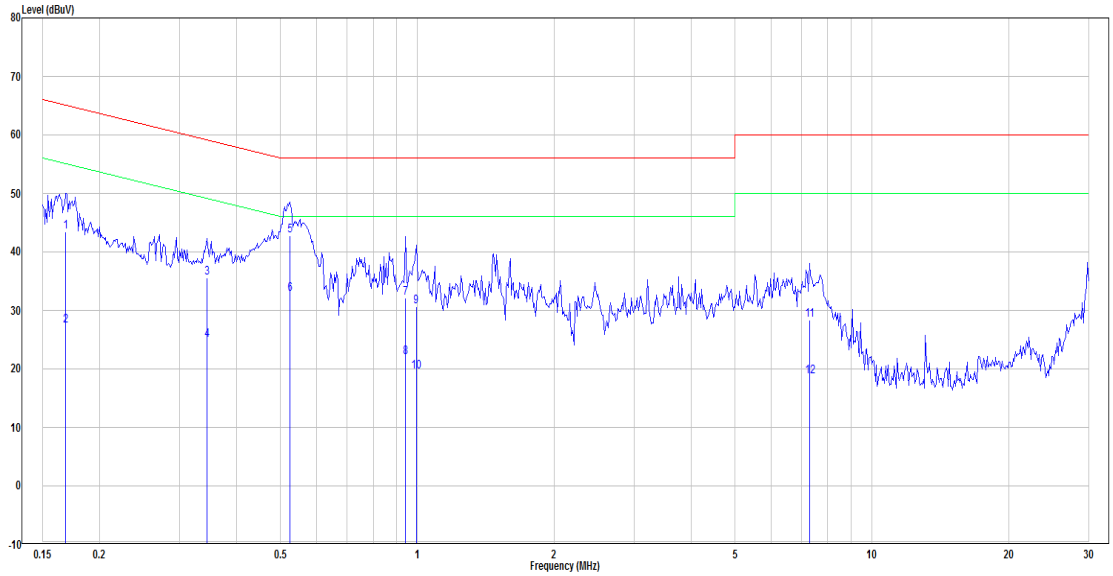
Note:

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	0.169	23.79	19.59	43.38	65.03	-21.65	QP
2	0.169	7.74	19.59	27.33	55.03	-27.70	Average
3	0.345	16.06	19.58	35.64	59.09	-23.45	QP
4	0.345	5.40	19.58	24.98	49.09	-24.11	Average
5	0.524	23.14	19.59	42.73	56.00	-13.27	QP
6	0.524	13.21	19.59	32.80	46.00	-13.20	Average
7	0.943	12.48	19.60	32.08	56.00	-23.92	QP
8	0.943	2.37	19.60	21.97	46.00	-24.03	Average
9	0.994	11.12	19.60	30.72	56.00	-25.28	QP
10	0.994	-0.03	19.60	19.57	46.00	-26.43	Average
11	7.290	8.63	19.76	28.38	60.00	-31.62	QP
12	7.290	-1.07	19.76	18.69	50.00	-31.31	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:

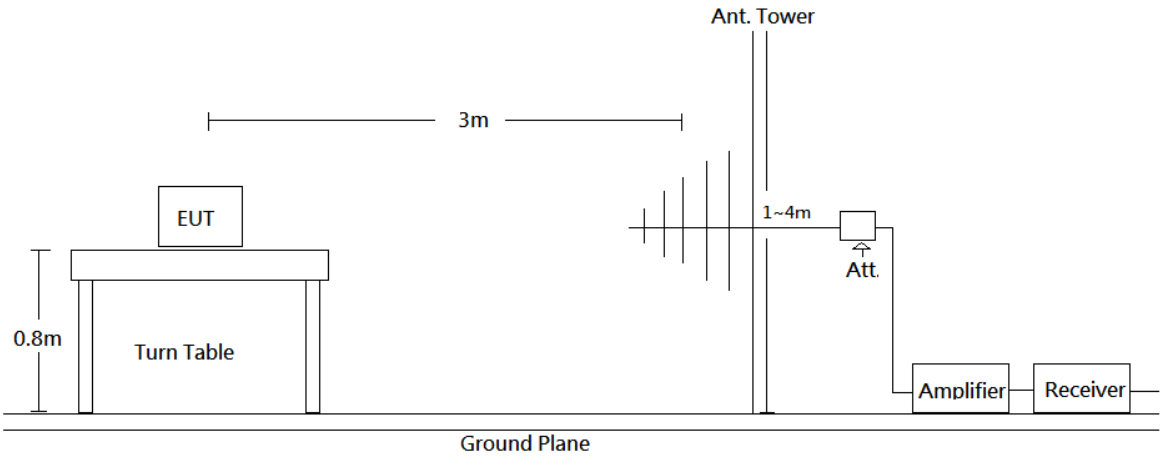
Frequency (MHz)	Field Strength (micro volts/meter)	Measurement Distance (meters)
0.009 - 0.490	2400/F(kHz)	300
0.490 - 1.705	24000/F(kHz)	30
1.705 - 30.0	30	30
30 - 88	100**	3
88 - 216	150**	3
216 - 960	200**	3
Above 960	500	3

** 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.

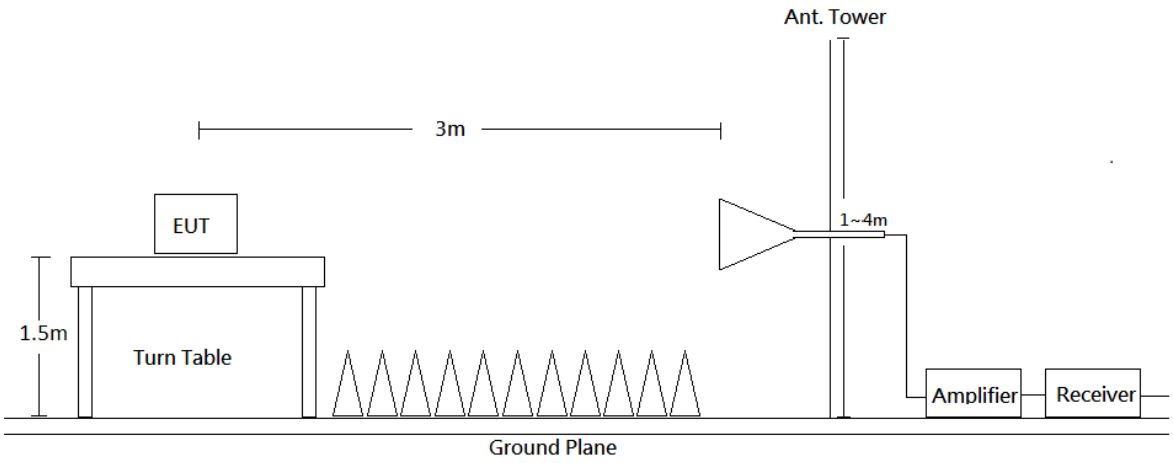
As per FCC §15.247 (d) In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the 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	Duty cycle	Measurement method
30-1000 MHz	120 kHz	/	/	QP
Above 1 GHz	1 MHz	3 MHz	/	PK
	1 MHz	3 MHz	>98%	Ave
	1 MHz	1/T	<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

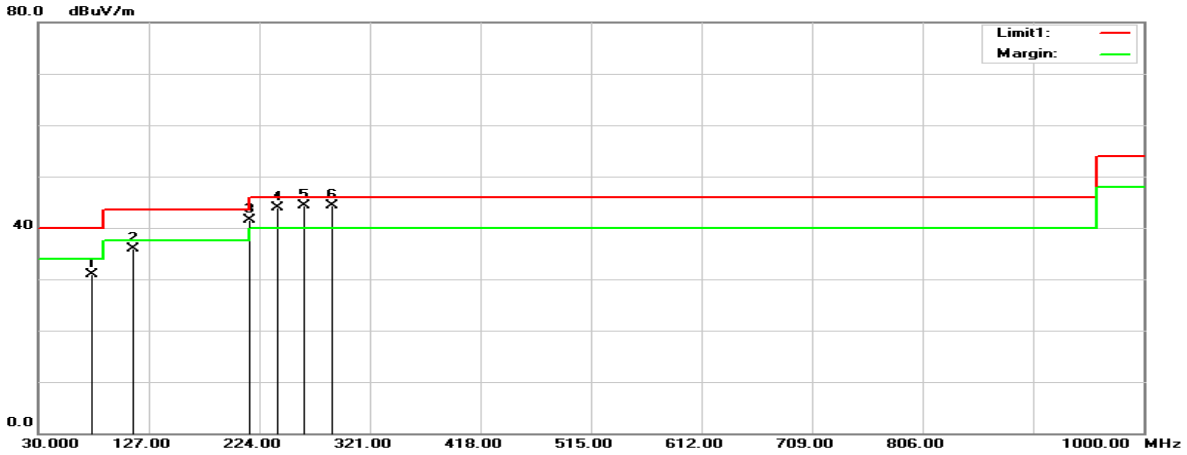
8.6 Test Results

Test Mode: Transmitting

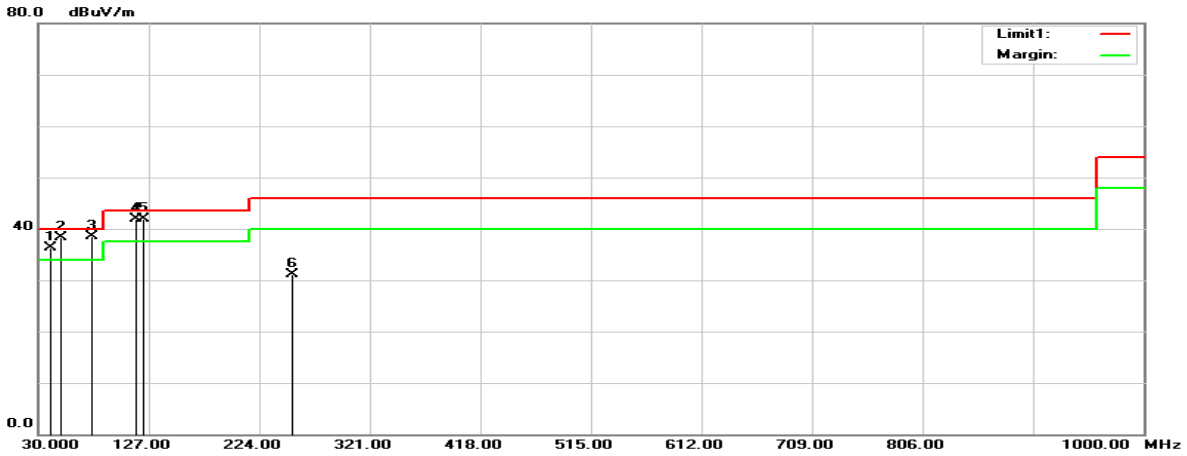
WIFI Mode (Pre-scan with three orthogonal axis, and worse case as X axis.)

30MHz-1GHz: (worst case is 802.11g mode Middle channel)

Horizontal

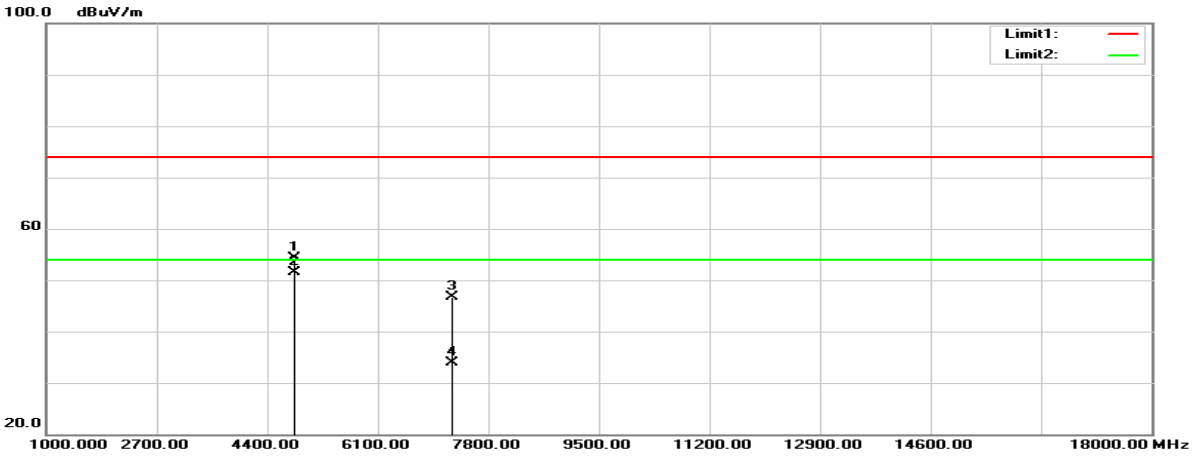


Vertical

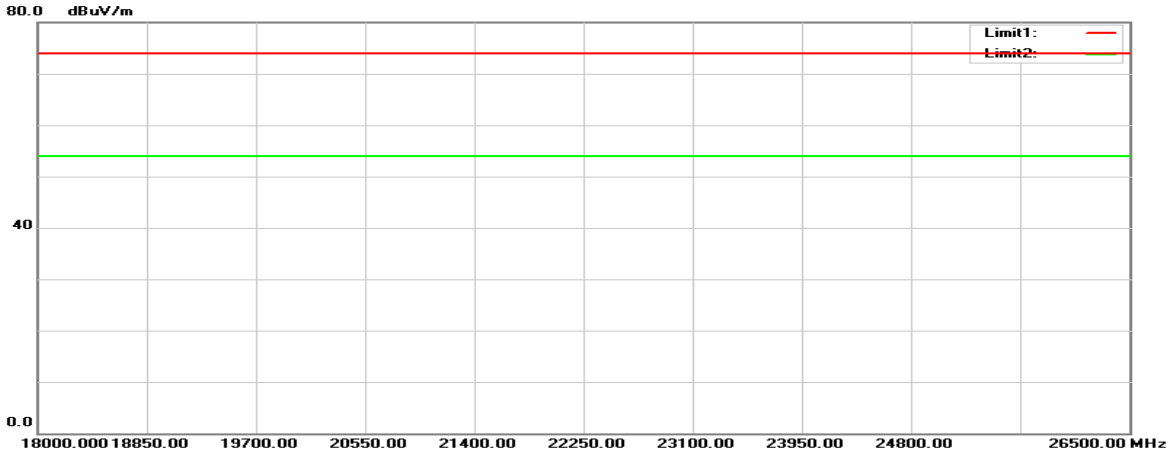


Horizontal (worst case is 802.11g mode Middle channel)

1GHz-18GHz:

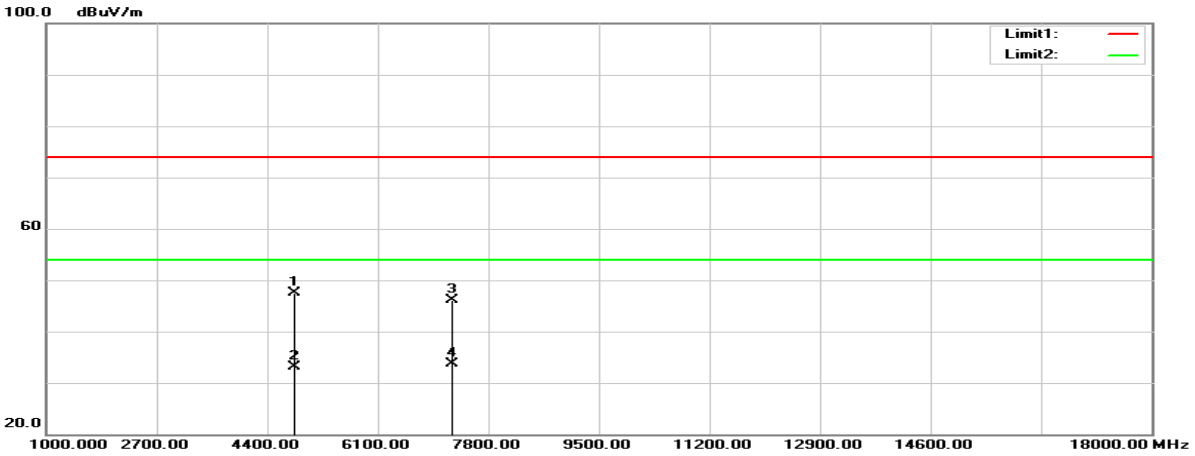


18GHz-26.5GHz:

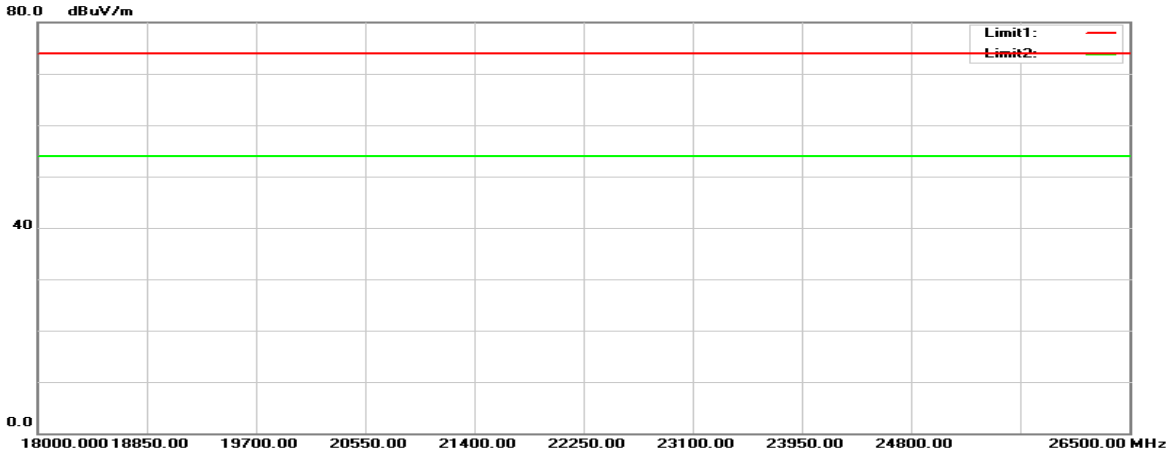


Vertical (worst case is 802.11g mode Middle channel)

1GHz-18GHz:



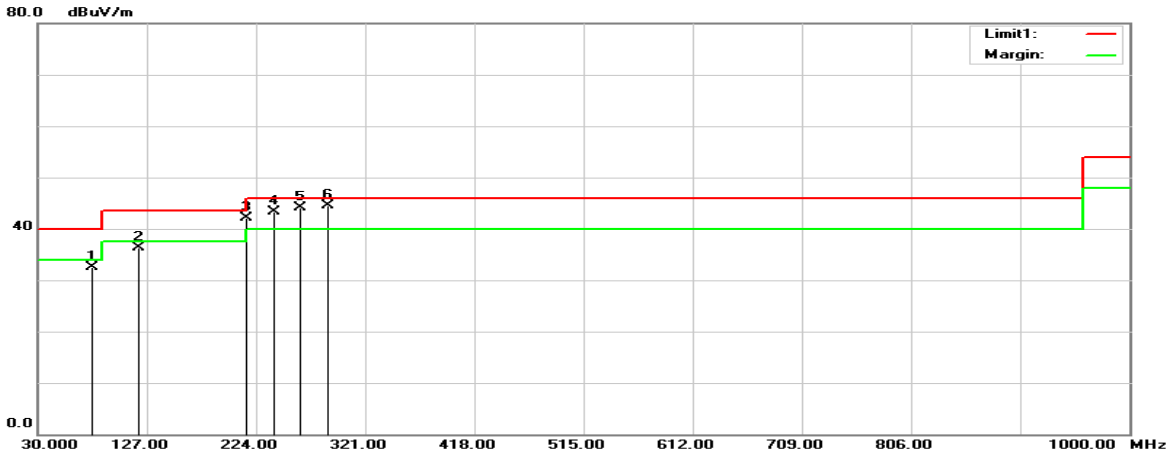
18GHz-26.5GHz:



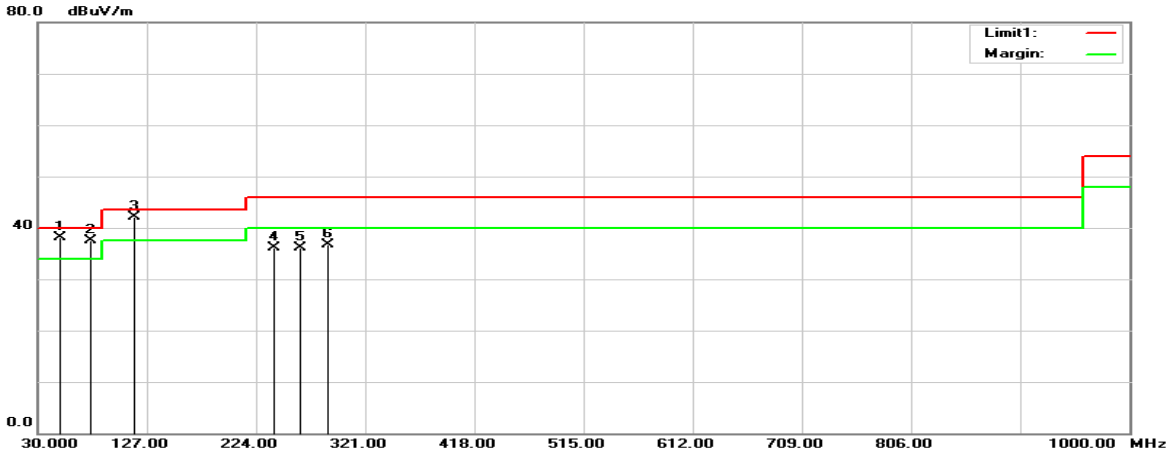
BLE(1M) Mode (Pre-scan with three orthogonal axis, and worse case as X axis.)

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

Horizontal

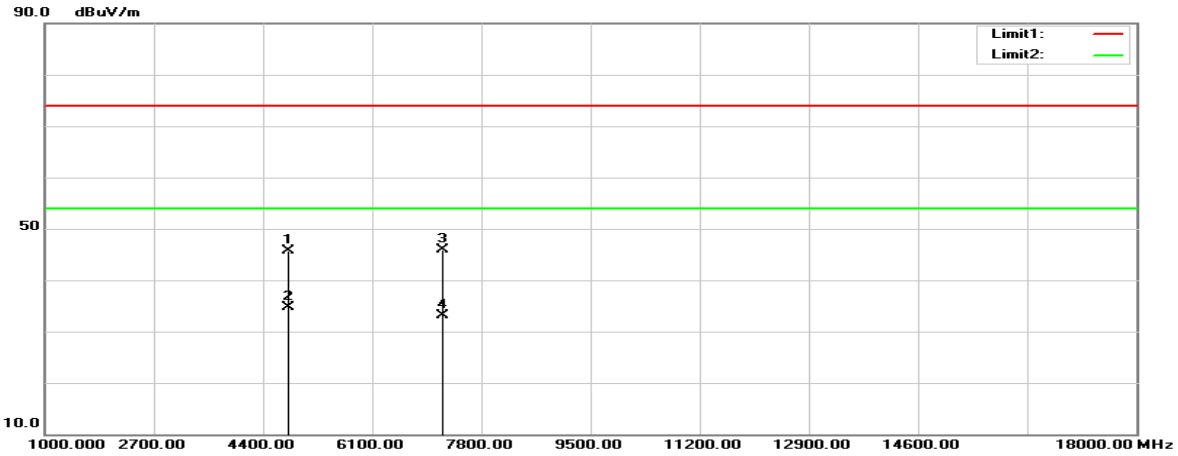


Vertical

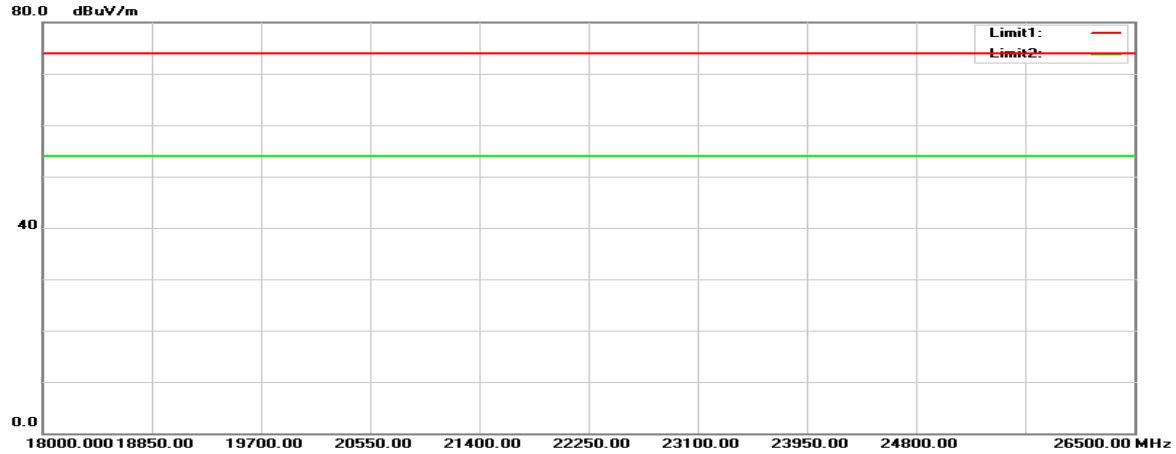


Horizontal (worst case is BLE 1M mode low channel)

1GHz-18GHz

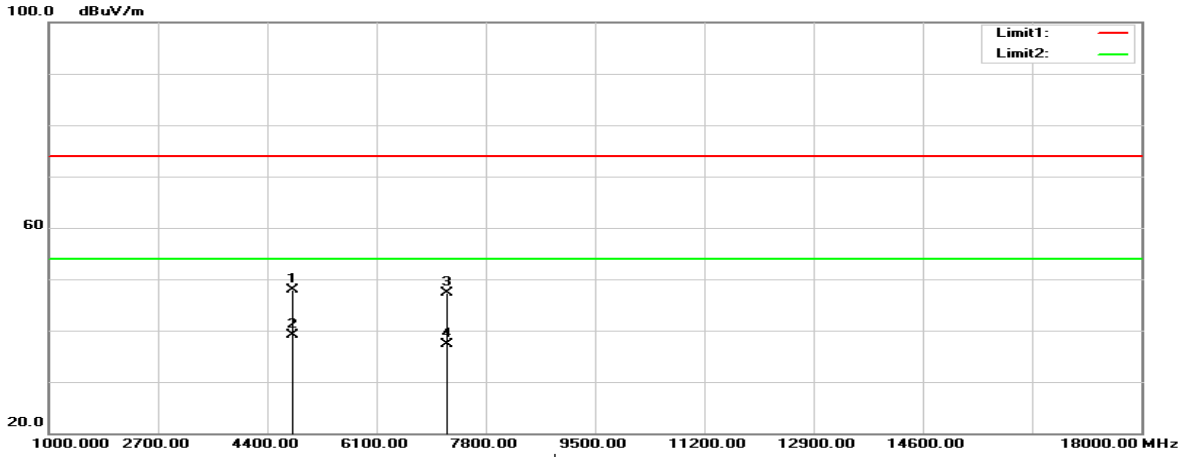


18GHz-26.5GHz:

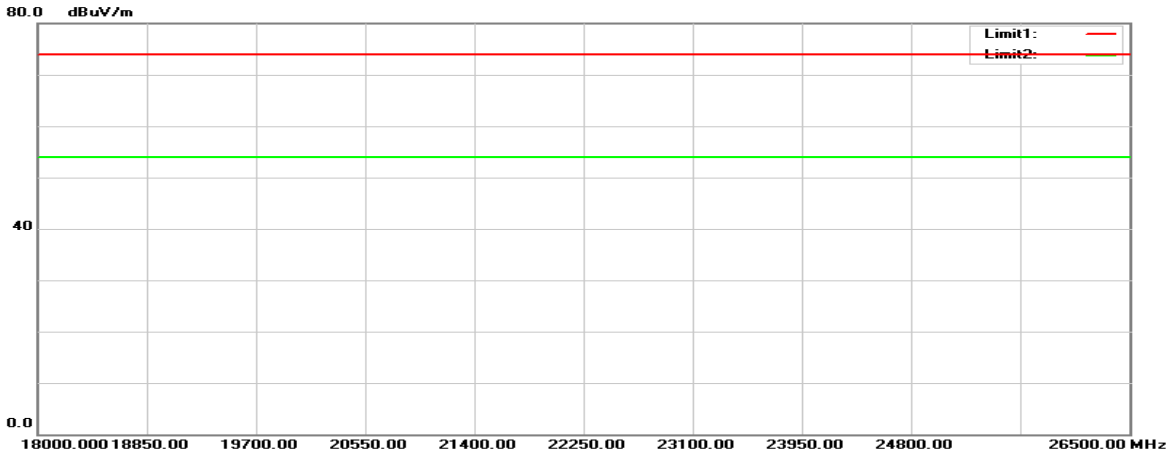


Vertical (worst case is BLE 1M mode low channel)

1GHz-18GHz



18GHz-26.5GHz:



Below 1GHz

WIFI Mode

Horizontal

Frequency (MHz)	Reading (dBµV)	Correct Factor(dB/m)	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Height (cm)	Degree (°)	Remark
77.5300	47.37	-16.37	31.00	40.00	-9.00	100	214	QP
113.4200	47.05	-11.20	35.85	43.50	-7.65	100	98	QP
215.2700	54.73	-13.18	41.55	43.50	-1.95	100	113	QP
239.5200	56.13	-12.25	43.88	46.00	-2.12	100	117	QP
263.7700	55.32	-11.06	44.26	46.00	-1.74	100	105	QP
288.0200	54.28	-10.05	44.23	46.00	-1.77	100	54	QP

Vertical

Frequency (MHz)	Reading (dBµV)	Correct Factor(dB/m)	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Height (cm)	Degree (°)	Remark
40.6700	47.39	-11.14	36.25	40.00	-3.75	100	124	peak
50.3700	54.57	-16.25	38.32	40.00	-1.68	100	182	peak
77.5300	54.79	-16.37	38.42	40.00	-1.58	100	120	peak
115.3600	52.78	-10.90	41.88	43.50	-1.62	100	346	QP
122.1500	52.70	-10.72	41.98	43.50	-1.52	100	15	peak
253.1000	43.38	-12.26	31.12	46.00	-14.88	100	38	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

Horizontal

Frequency (MHz)	Reading (dBµV)	Correct Factor(dB/m)	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Height (cm)	Degree (°)	Remark
78.5000	48.92	-16.42	32.50	40.00	-7.50	100	46	peak
119.2400	46.88	-10.54	36.34	43.50	-7.16	100	55	peak
215.2700	55.30	-13.18	42.12	43.50	-1.38	100	110	QP
239.5200	55.47	-12.25	43.22	46.00	-2.78	100	118	QP
263.7700	55.12	-11.06	44.06	46.00	-1.94	100	99	QP
288.0200	54.60	-10.05	44.55	46.00	-1.45	100	73	QP

Vertical

Frequency (MHz)	Reading (dBµV)	Correct Factor(dB/m)	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Height (cm)	Degree (°)	Remark
50.3700	54.36	-16.25	38.11	40.00	-1.89	100	324	QP
76.5600	53.75	-16.27	37.48	40.00	-2.52	100	360	QP
115.3600	53.07	-10.90	42.17	43.50	-1.33	100	328	QP
239.5200	48.34	-12.25	36.09	46.00	-9.91	100	3	peak
263.7700	47.26	-11.06	36.20	46.00	-9.80	100	142	peak
288.0200	46.75	-10.05	36.70	46.00	-9.30	100	155	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.

Above 1GHz

Horizontal

Frequency (MHz)	Reading (dBµV)	Correct Factor(dB/m)	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Height (cm)	Degree (°)	Remark
B Mode, Low channel								
2375.632	60.96	-10.34	50.62	74.00	-23.38	140	282	peak
2375.632	48.17	-10.34	37.83	54.00	-16.17	140	282	AVG
2412.000	112.65	-10.06	102.59	N/A	N/A	140	282	peak
2412.000	109.38	-10.06	99.32	N/A	N/A	140	282	AVG
4824.000	57.67	-3.27	54.40	74.00	-19.60	120	285	peak
4824.000	54.85	-3.27	51.58	54.00	-2.42	120	285	AVG
7236.000	43.28	3.48	46.76	74.00	-27.24	150	52	peak
7236.000	30.42	3.48	33.90	54.00	-20.10	150	52	AVG
B Mode, Middle channel								
2437.000	111.16	-9.85	101.31	N/A	N/A	135	288	peak
2437.000	106.68	-9.85	96.83	N/A	N/A	135	288	AVG
4874.000	57.66	-3.07	54.59	74.00	-19.41	124	282	peak
4874.000	54.73	-3.07	51.66	54.00	-2.34	124	282	AVG
7311.000	44.01	4.04	48.05	74.00	-25.95	150	226	peak
7311.000	30.53	4.04	34.57	54.00	-19.43	150	226	AVG
B Mode, High channel								
2462.000	113.69	-9.56	104.13	N/A	N/A	139	282	peak
2462.000	110.58	-9.56	101.02	N/A	N/A	139	282	AVG
2486.900	61.79	-9.21	52.58	74.00	-21.42	139	282	peak
2486.900	50.03	-9.21	40.82	54.00	-13.18	139	282	AVG
4924.000	52.95	-2.82	50.13	74.00	-23.87	139	238	peak
4924.000	51.94	-2.82	49.12	54.00	-4.88	139	238	AVG
7386.000	43.97	4.19	48.16	74.00	-25.84	150	224	peak
7386.000	30.81	4.19	35.00	54.00	-19.00	150	224	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
B Mode, Low channel								
2378.096	57.92	-10.33	47.59	74.00	-26.41	195	11	peak
2378.096	43.60	-10.33	33.27	54.00	-20.73	195	11	AVG
2412.000	100.54	-10.06	90.48	N/A	N/A	195	11	peak
2412.000	97.32	-10.06	87.26	N/A	N/A	195	11	AVG
4824.000	49.12	-3.27	45.85	74.00	-28.15	150	184	peak
4824.000	46.53	-3.27	43.26	54.00	-10.74	150	184	AVG
7236.000	43.10	3.48	46.58	74.00	-27.42	150	119	peak
7236.000	29.93	3.48	33.41	54.00	-20.59	150	119	AVG
B Mode, Middle channel								
2437.000	97.14	-9.85	87.29	N/A	N/A	186	13	peak
2437.000	92.40	-9.85	82.55	N/A	N/A	186	13	AVG
4874.000	49.86	-3.07	46.79	74.00	-27.21	139	78	peak
4874.000	44.17	-3.07	41.10	54.00	-12.90	139	78	AVG
7311.000	42.79	4.04	46.83	74.00	-27.17	150	99	peak
7311.000	30.48	4.04	34.52	54.00	-19.48	150	99	AVG
B Mode, High channel								
2462.000	97.53	-9.56	87.97	N/A	N/A	195	11	peak
2462.000	94.41	-9.56	84.85	N/A	N/A	195	11	AVG
2521.100	56.88	-8.87	48.01	74.00	-25.99	195	11	peak
2521.100	43.33	-8.87	34.46	54.00	-19.54	195	11	AVG
4924.000	48.51	-2.82	45.69	74.00	-28.31	150	4	peak
4924.000	38.54	-2.82	35.72	54.00	-18.28	150	4	AVG
7386.000	41.78	4.19	45.97	74.00	-28.03	150	25	peak
7386.000	30.80	4.19	34.99	54.00	-19.01	150	25	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.

Horizontal

Frequency (MHz)	Reading (dBµV)	Correct Factor(dB/m)	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Height (cm)	Degree (°)	Remark
G Mode, Low channel								
2390.000	84.07	-10.23	73.84	74.00	-0.16	137	284	peak
2390.000	61.43	-10.23	51.20	54.00	-2.80	137	284	AVG
2412.000	114.41	-10.06	104.35	N/A	N/A	137	284	peak
2412.000	105.30	-10.06	95.24	N/A	N/A	137	284	AVG
4824.000	58.03	-3.27	54.76	74.00	-19.24	136	282	peak
4824.000	45.57	-3.27	42.30	54.00	-11.70	136	282	AVG
7236.000	42.57	3.48	46.05	74.00	-27.95	150	130	peak
7236.000	30.28	3.48	33.76	54.00	-20.24	150	130	AVG
G Mode, Middle channel								
2437.000	115.55	-9.85	105.70	N/A	N/A	116	282	peak
2437.000	105.79	-9.85	95.94	N/A	N/A	116	282	AVG
4874.000	60.81	-3.07	57.74	74.00	-16.26	123	269	peak
4874.000	46.85	-3.07	43.78	54.00	-10.22	123	269	AVG
7311.000	42.44	4.04	46.48	74.00	-27.52	150	277	peak
7311.000	30.31	4.04	34.35	54.00	-19.65	150	277	AVG
G Mode, High channel								
2462.000	116.30	-9.56	106.74	N/A	N/A	138	284	peak
2462.000	105.71	-9.56	96.15	N/A	N/A	138	284	AVG
2483.500	82.33	-9.26	73.07	74.00	-0.93	138	284	peak
2483.500	61.06	-9.26	51.80	54.00	-2.20	138	284	AVG
4924.000	59.59	-2.82	56.77	74.00	-17.23	150	266	peak
4924.000	45.78	-2.82	42.96	54.00	-11.04	150	266	AVG
7386.000	43.18	4.19	47.37	74.00	-26.63	150	59	peak
7386.000	30.85	4.19	35.04	54.00	-18.96	150	59	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
G Mode, Low channel								
2390.000	67.34	-10.23	57.11	74.00	-16.89	194	14	peak
2390.000	47.24	-10.23	37.01	54.00	-16.99	194	14	AVG
2412.000	102.78	-10.06	92.72	N/A	N/A	194	14	peak
2412.000	92.69	-10.06	82.63	N/A	N/A	194	14	AVG
4824.000	50.85	-3.27	47.58	74.00	-26.42	127	63	peak
4824.000	36.31	-3.27	33.04	54.00	-20.96	127	63	AVG
7236.000	42.64	3.48	46.12	74.00	-27.88	150	271	peak
7236.000	30.15	3.48	33.63	54.00	-20.37	150	271	AVG
G Mode, Middle channel								
2437.000	100.56	-9.85	90.71	N/A	N/A	189	13	peak
2437.000	91.26	-9.85	81.41	N/A	N/A	189	13	AVG
4874.000	51.21	-3.07	48.14	74.00	-25.86	142	95	peak
4874.000	37.10	-3.07	34.03	54.00	-19.97	142	95	AVG
7311.000	43.39	4.04	47.43	74.00	-26.57	150	240	peak
7311.000	30.41	4.04	34.45	54.00	-19.55	150	240	AVG
G Mode, High channel								
2462.000	99.94	-9.56	90.38	N/A	N/A	193	13	peak
2462.000	89.59	-9.56	80.03	N/A	N/A	193	13	AVG
2483.500	64.79	-9.26	55.53	74.00	-18.47	193	13	peak
2483.500	46.93	-9.26	37.67	54.00	-16.33	193	13	AVG
4924.000	49.16	-2.82	46.34	74.00	-27.66	150	97	peak
4924.000	36.74	-2.82	33.92	54.00	-20.08	150	97	AVG
7386.000	43.10	4.19	47.29	74.00	-26.71	150	210	peak
7386.000	30.51	4.19	34.70	54.00	-19.30	150	210	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.

Horizontal

Frequency (MHz)	Reading (dBµV)	Correct Factor(dB/m)	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Height (cm)	Degree (°)	Remark
N20 Mode, Low channel								
2390.000	83.41	-10.23	73.18	74.00	-0.82	139	280	peak
2390.000	60.16	-10.23	49.93	54.00	-4.07	139	280	AVG
2412.000	114.37	-10.06	104.31	N/A	N/A	139	280	peak
2412.000	103.66	-10.06	93.60	N/A	N/A	139	280	AVG
4824.000	63.66	-3.27	60.39	74.00	-13.61	150	275	peak
4824.000	49.10	-3.27	45.83	54.00	-8.17	150	275	AVG
7236.000	43.16	3.48	46.64	74.00	-27.36	150	49	peak
7236.000	30.26	3.48	33.74	54.00	-20.26	150	49	AVG
N20 Mode, Middle channel								
2437.000	115.24	-9.85	105.39	N/A	N/A	136	281	peak
2437.000	105.19	-9.85	95.34	N/A	N/A	136	281	AVG
4874.000	61.47	-3.07	58.40	74.00	-15.60	123	264	peak
4874.000	47.84	-3.07	44.77	54.00	-9.23	123	264	AVG
7311.000	42.84	4.04	46.88	74.00	-27.12	150	333	peak
7311.000	30.65	4.04	34.69	54.00	-19.31	150	333	AVG
N20 Mode, High channel								
2462.200	114.34	-9.55	104.79	N/A	N/A	134	280	peak
2462.200	103.42	-9.55	93.87	N/A	N/A	134	280	AVG
2483.500	81.97	-9.26	72.71	74.00	-1.29	134	280	peak
2483.500	58.23	-9.26	48.97	54.00	-5.03	134	280	AVG
4924.000	59.98	-2.82	57.16	74.00	-16.84	148	278	peak
4924.000	46.47	-2.82	43.65	54.00	-10.35	148	278	AVG
7386.000	42.82	4.19	47.01	74.00	-26.99	150	165	peak
7386.000	30.62	4.19	34.81	54.00	-19.19	150	165	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
N20 Mode, Low channel								
2389.296	68.65	-10.24	58.41	74.00	-15.59	195	8	peak
2389.296	47.21	-10.24	36.97	54.00	-17.03	195	8	AVG
2412.000	99.69	-10.06	89.63	N/A	N/A	195	8	peak
2412.000	90.45	-10.06	80.39	N/A	N/A	195	8	AVG
4824.000	53.38	-3.27	50.11	74.00	-23.89	150	66	peak
4824.000	38.04	-3.27	34.77	54.00	-19.23	150	66	AVG
7236.000	43.03	3.48	46.51	74.00	-27.49	150	83	peak
7236.000	30.26	3.48	33.74	54.00	-20.26	150	83	AVG
N20 Mode, Middle channel								
2437.000	101.84	-9.85	91.99	N/A	N/A	188	30	peak
2437.000	91.05	-9.85	81.20	N/A	N/A	188	30	AVG
4874.000	51.79	-3.07	48.72	74.00	-25.28	150	73	peak
4874.000	36.79	-3.07	33.72	54.00	-20.28	150	73	AVG
7311.000	42.03	4.04	46.07	74.00	-27.93	150	178	peak
7311.000	30.14	4.04	34.18	54.00	-19.82	150	178	AVG
N20 Mode, High channel								
2462.000	101.44	-9.56	91.88	N/A	N/A	167	14	peak
2462.000	90.63	-9.56	81.07	N/A	N/A	167	14	AVG
2484.400	61.63	-9.25	52.38	74.00	-21.62	167	14	peak
2484.400	45.05	-9.25	35.80	54.00	-18.20	167	14	AVG
4924.000	51.14	-2.82	48.32	74.00	-25.68	150	95	peak
4924.000	38.47	-2.82	35.65	54.00	-18.35	150	95	AVG
7386.000	43.19	4.19	47.38	74.00	-26.62	150	124	peak
7386.000	30.85	4.19	35.04	54.00	-18.96	150	124	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.

Horizontal

Frequency (MHz)	Reading (dBµV)	Correct Factor(dB/m)	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Height (cm)	Degree (°)	Remark
N40 Mode, Low channel								
2385.372	81.41	-10.27	71.14	74.00	-2.86	136	273	peak
2385.372	61.54	-10.27	51.27	54.00	-2.73	136	273	AVG
2422.000	109.57	-9.97	99.60	N/A	N/A	136	273	peak
2422.000	98.70	-9.97	88.73	N/A	N/A	136	273	AVG
4844.000	60.24	-3.25	56.99	74.00	-17.01	137	271	peak
4844.000	45.80	-3.25	42.55	54.00	-11.45	137	271	AVG
7266.000	43.34	3.77	47.11	74.00	-26.89	150	202	peak
7266.000	30.13	3.77	33.90	54.00	-20.10	150	202	AVG
N40 Mode, Middle channel								
2437.000	112.71	-9.85	102.86	N/A	N/A	105	264	peak
2437.000	102.49	-9.85	92.64	N/A	N/A	105	264	AVG
4874.000	58.62	-3.07	55.55	74.00	-18.45	152	277	peak
4874.000	44.08	-3.07	41.01	54.00	-12.99	152	277	AVG
7311.000	42.72	4.04	46.76	74.00	-27.24	150	338	peak
7311.000	30.36	4.04	34.40	54.00	-19.60	150	338	AVG
N40 Mode, High channel								
2452.000	109.97	-9.71	100.26	N/A	N/A	138	279	peak
2452.000	98.95	-9.71	89.24	N/A	N/A	138	279	AVG
2483.500	80.94	-9.26	71.68	74.00	-2.32	138	279	peak
2483.500	60.22	-9.26	50.96	54.00	-3.04	138	279	AVG
4904.000	58.13	-2.88	55.25	74.00	-18.75	150	281	peak
4904.000	43.74	-2.88	40.86	54.00	-13.14	150	281	AVG
7356.000	43.18	4.16	47.34	74.00	-26.66	150	266	peak
7356.000	30.34	4.16	34.50	54.00	-19.50	150	266	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
N40 Mode, Low channel								
2385.900	66.19	-10.26	55.93	74.00	-18.07	195	13	peak
2385.900	47.76	-10.26	37.50	54.00	-16.50	195	13	AVG
2422.000	96.58	-9.97	86.61	N/A	N/A	195	13	peak
2422.000	84.75	-9.97	74.78	N/A	N/A	195	13	AVG
4844.000	49.03	-3.25	45.78	74.00	-28.22	150	158	peak
4844.000	33.33	-3.25	30.08	54.00	-23.92	150	158	AVG
7266.000	42.43	3.77	46.20	74.00	-27.80	150	1	peak
7266.000	29.92	3.77	33.69	54.00	-20.31	150	1	AVG
N40 Mode, Middle channel								
2437.000	98.88	-9.85	89.03	N/A	N/A	188	30	peak
2437.000	88.49	-9.85	78.64	N/A	N/A	188	30	AVG
4874.000	49.26	-3.07	46.19	74.00	-27.81	150	59	peak
4874.000	33.51	-3.07	30.44	54.00	-23.56	150	59	AVG
7311.000	43.02	4.04	47.06	74.00	-26.94	150	0	peak
7311.000	30.44	4.04	34.48	54.00	-19.52	150	0	AVG
N40 Mode, High channel								
2452.000	92.97	-9.71	83.26	N/A	N/A	195	14	peak
2452.000	81.15	-9.71	71.44	N/A	N/A	195	14	AVG
2483.500	66.22	-9.26	56.96	74.00	-17.04	195	14	peak
2483.500	45.94	-9.26	36.68	54.00	-17.32	195	14	AVG
4904.000	48.89	-2.88	46.01	74.00	-27.99	150	8	peak
4904.000	34.55	-2.88	31.67	54.00	-22.33	150	8	AVG
7356.000	42.97	4.16	47.13	74.00	-26.87	150	106	peak
7356.000	30.36	4.16	34.52	54.00	-19.48	150	106	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.

Horizontal

Frequency (MHz)	Reading (dBµV)	Correct Factor(dB/m)	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Height (cm)	Degree (°)	Remark
BLE(1M) Mode, Low channel								
2390.000	53.92	-10.23	43.69	74.00	-30.31	169	137	peak
2390.000	43.26	-10.23	33.03	54.00	-20.97	169	137	AVG
2402.000	101.77	-10.14	91.63	N/A	N/A	169	137	peak
2402.000	101.11	-10.14	90.97	N/A	N/A	169	137	AVG
4804.000	49.04	-3.28	45.76	74.00	-28.24	150	18	peak
4804.000	37.96	-3.28	34.68	54.00	-19.32	150	18	AVG
7206.000	42.88	3.10	45.98	74.00	-28.02	150	120	peak
7206.000	30.01	3.10	33.11	54.00	-20.89	150	120	AVG
BLE(1M) Mode, Middle channel								
2440.000	104.05	-9.82	94.23	N/A	N/A	158	144	peak
2440.000	103.43	-9.82	93.61	N/A	N/A	158	144	AVG
4880.000	48.11	-3.03	45.08	74.00	-28.92	150	111	peak
4880.000	34.03	-3.03	31.00	54.00	-23.00	150	111	AVG
7320.000	42.83	4.07	46.90	74.00	-27.10	150	288	peak
7320.000	30.23	4.07	34.30	54.00	-19.70	150	288	AVG
BLE(1M) Mode, High channel								
2480.000	103.94	-9.31	94.63	N/A	N/A	157	142	peak
2480.000	103.29	-9.31	93.98	N/A	N/A	157	142	AVG
2483.500	56.34	-9.26	47.08	74.00	-26.92	157	142	peak
2483.500	44.39	-9.26	35.13	54.00	-18.87	157	142	AVG
4960.000	48.37	-2.69	45.68	74.00	-28.32	150	263	peak
4960.000	34.26	-2.69	31.57	54.00	-22.43	150	263	AVG
7440.000	42.64	4.25	46.89	74.00	-27.11	150	145	peak
7440.000	30.51	4.25	34.76	54.00	-19.24	150	145	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
BLE(1M) Mode, Low channel								
2390.000	53.08	-10.23	42.85	74.00	-31.15	123	239	peak
2390.000	42.87	-10.23	32.64	54.00	-21.36	123	239	AVG
2402.000	108.89	-10.14	98.75	N/A	N/A	123	239	peak
2402.000	108.29	-10.14	98.15	N/A	N/A	123	239	AVG
4804.000	49.04	-3.28	45.76	74.00	-28.24	150	18	peak
4804.000	37.96	-3.28	34.68	54.00	-19.32	150	18	AVG
7206.000	42.88	3.10	45.98	74.00	-28.02	150	120	peak
7206.000	30.01	3.10	33.11	54.00	-20.89	150	120	AVG
BLE(1M) Mode, Middle channel								
2440.000	108.26	-9.82	98.44	N/A	N/A	135	238	peak
2440.000	107.61	-9.82	97.79	N/A	N/A	135	238	AVG
4880.000	47.12	-3.03	44.09	74.00	-29.91	150	359	peak
4880.000	35.68	-3.03	32.65	54.00	-21.35	150	359	AVG
7320.000	42.57	4.07	46.64	74.00	-27.36	150	107	peak
7320.000	30.19	4.07	34.26	54.00	-19.74	150	107	AVG
BLE(1M) Mode, High channel								
2480.000	109.56	-9.31	100.25	N/A	N/A	128	241	peak
2480.000	108.92	-9.31	99.61	N/A	N/A	128	241	AVG
2483.500	59.35	-9.26	50.09	74.00	-23.91	128	241	peak
2483.500	46.71	-9.26	37.45	54.00	-16.55	128	241	AVG
4960.000	46.43	-2.69	43.74	74.00	-30.26	150	214	peak
4960.000	35.84	-2.69	33.15	54.00	-20.85	150	214	AVG
7440.000	43.09	4.25	47.34	74.00	-26.66	150	92	peak
7440.000	30.37	4.25	34.62	54.00	-19.38	150	92	AVG

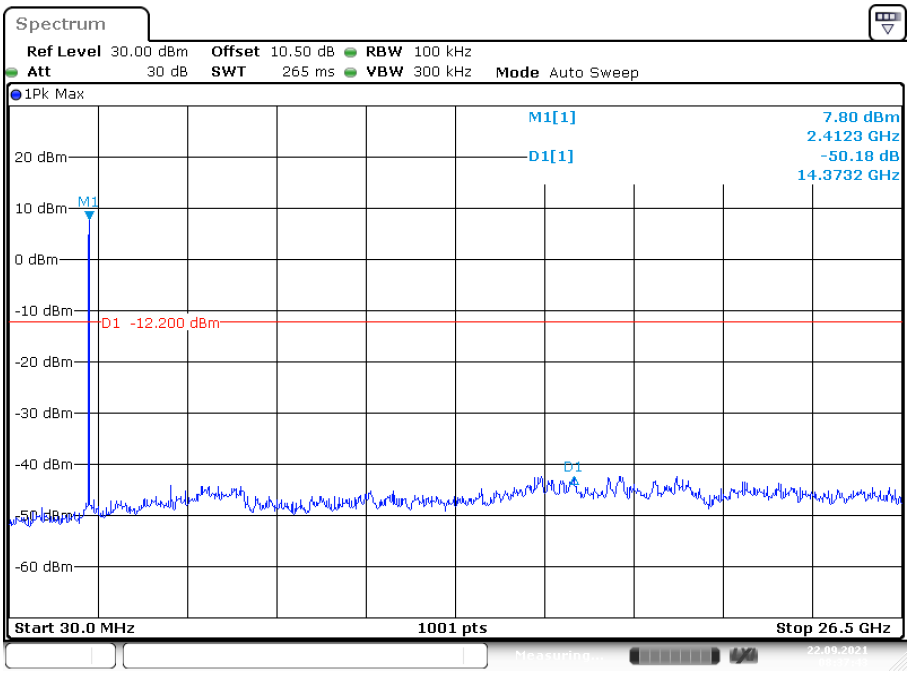
Result = Reading + Correct Factor
Margin = Result – Limit
Correct Factor = Antenna Factor + Cable Loss – Amplifier Gain
Spurious emissions more than 20 dB below the limit were not reported.

Conducted Spurious Emissions:

Channel	Frequency (MHz)	Delta Peak to Band Emission (dBc)	Limit (dBc)	Result
B Mode				
Low	2412	50.18	≥ 20	PASS
Mid	2437	49.05	≥ 20	PASS
High	2462	48.53	≥ 20	PASS
G Mode				
Low	2412	46.54	≥ 20	PASS
Mid	2437	46.84	≥ 20	PASS
High	2462	45.44	≥ 20	PASS
N20 Mode				
Low	2412	40.98	≥ 20	PASS
Mid	2437	45.41	≥ 20	PASS
High	2462	42.35	≥ 20	PASS
N40 Mode				
Low	2422	37.15	≥ 20	PASS
Mid	2437	41.79	≥ 20	PASS
High	2452	38.50	≥ 20	PASS
BLE(1M) Mode				
Low	2402	51.79	≥ 20	PASS
Mid	2440	49.63	≥ 20	PASS
High	2480	51.95	≥ 20	PASS

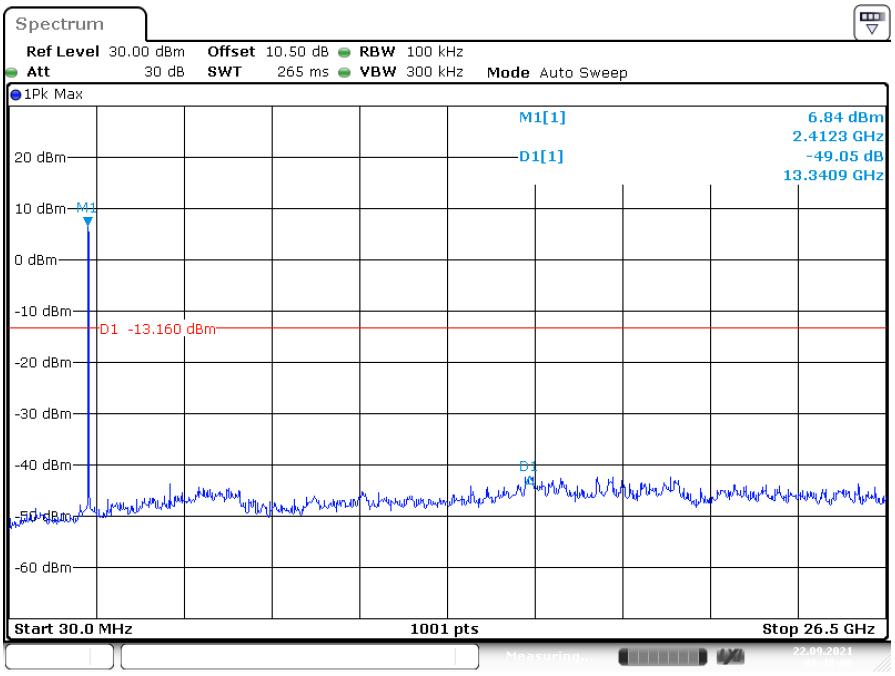
B Mode

Low Channel



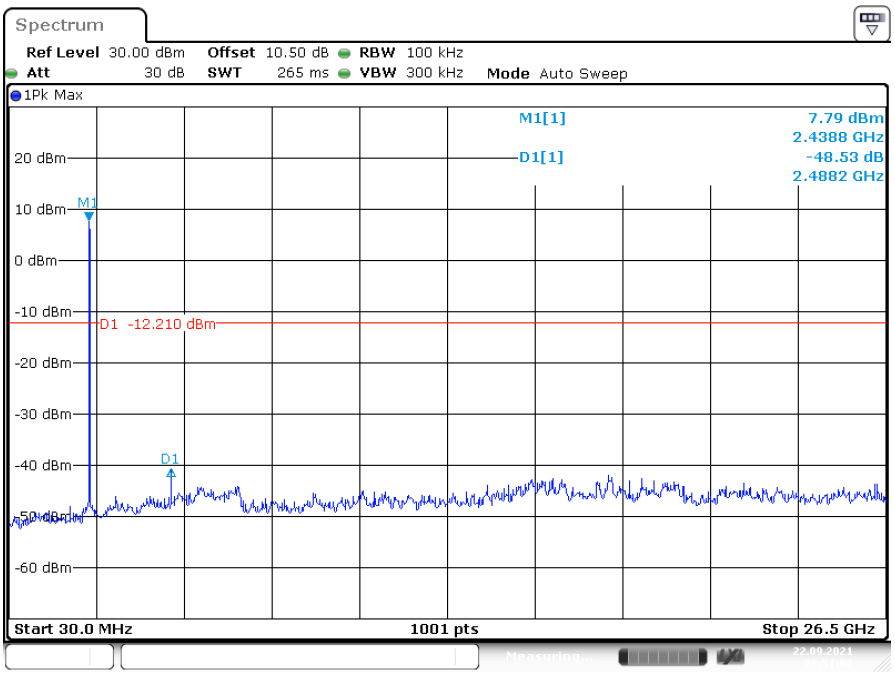
Date: 22.SEP.2021 08:37:43

Middle Channel



Date: 22.SEP.2021 08:48:01

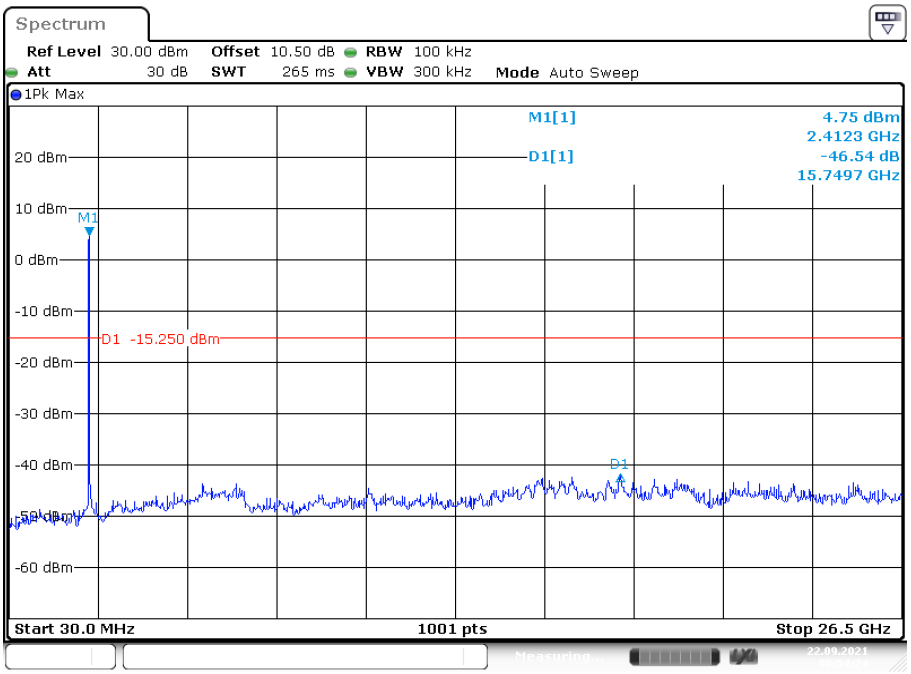
High Channel



Date: 22.SEP.2021 08:51:01

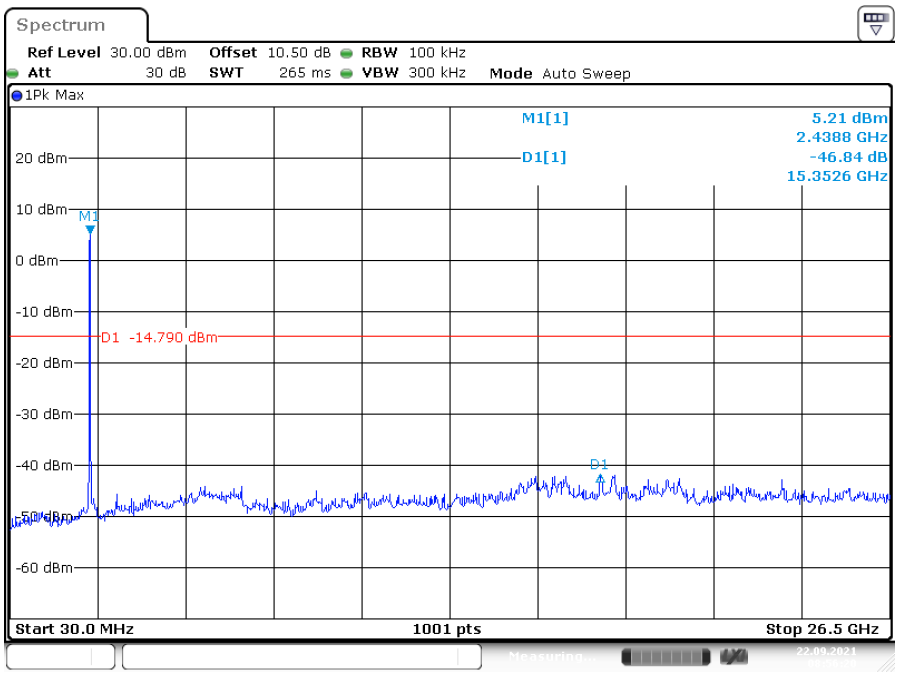
G Mode

Low Channel



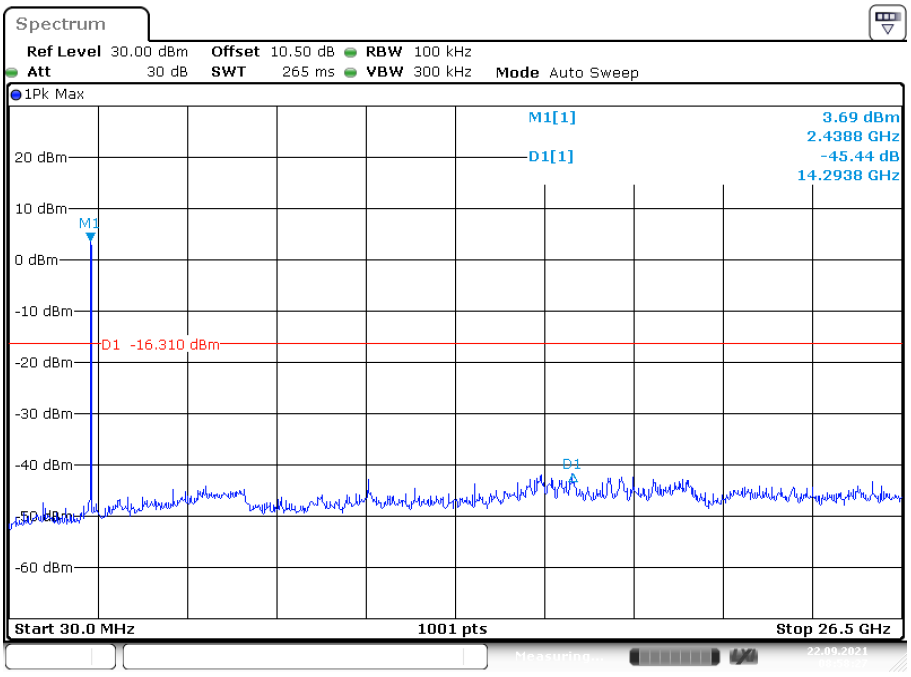
Date: 22.SEP.2021 08:54:25

Middle Channel



Date: 22.SEP.2021 08:56:21

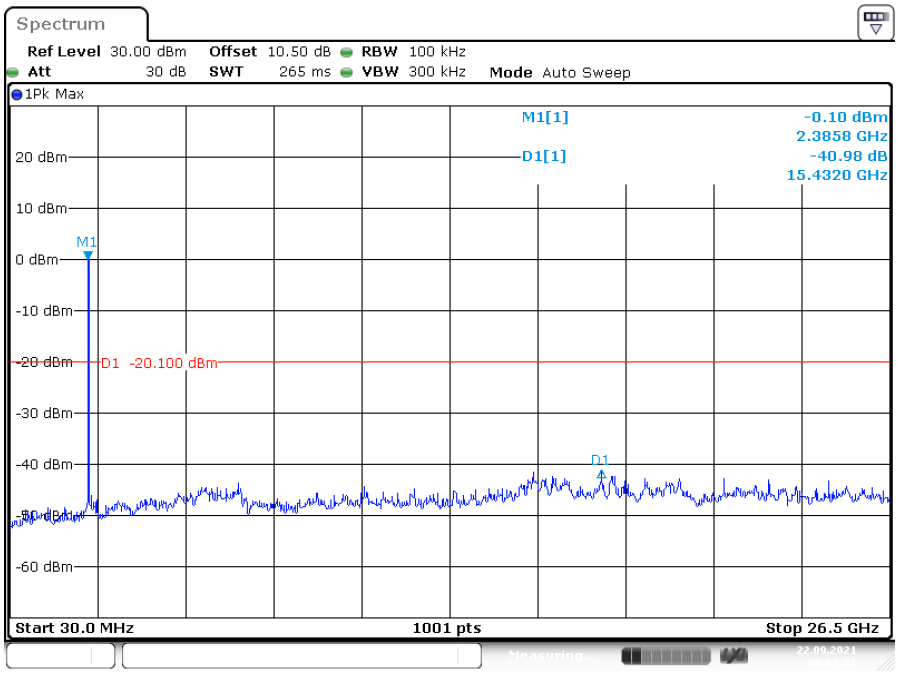
High Channel



Date: 22.SEP.2021 08:58:28

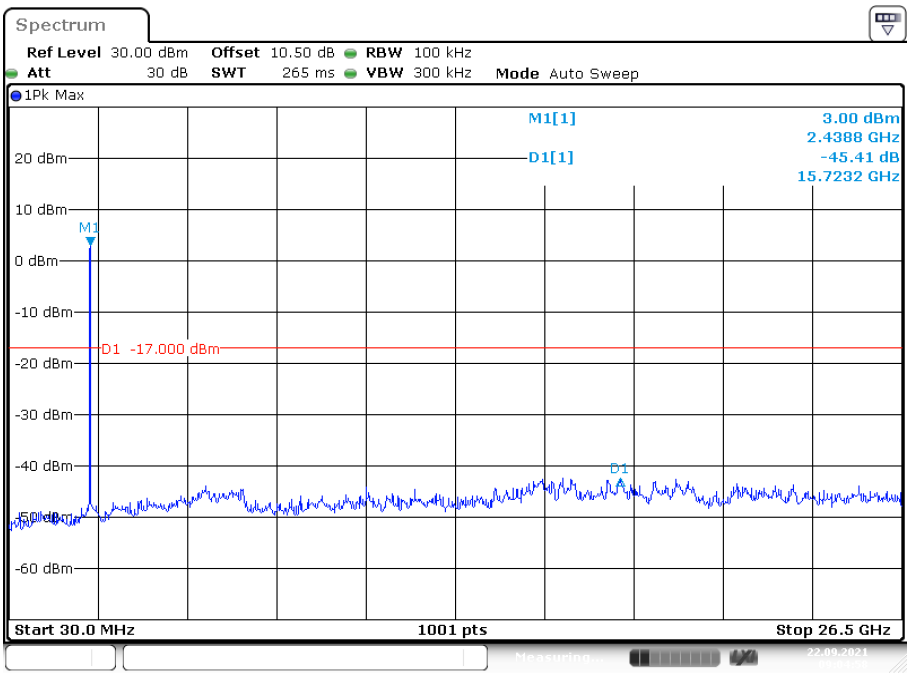
N20 Mode

Low Channel



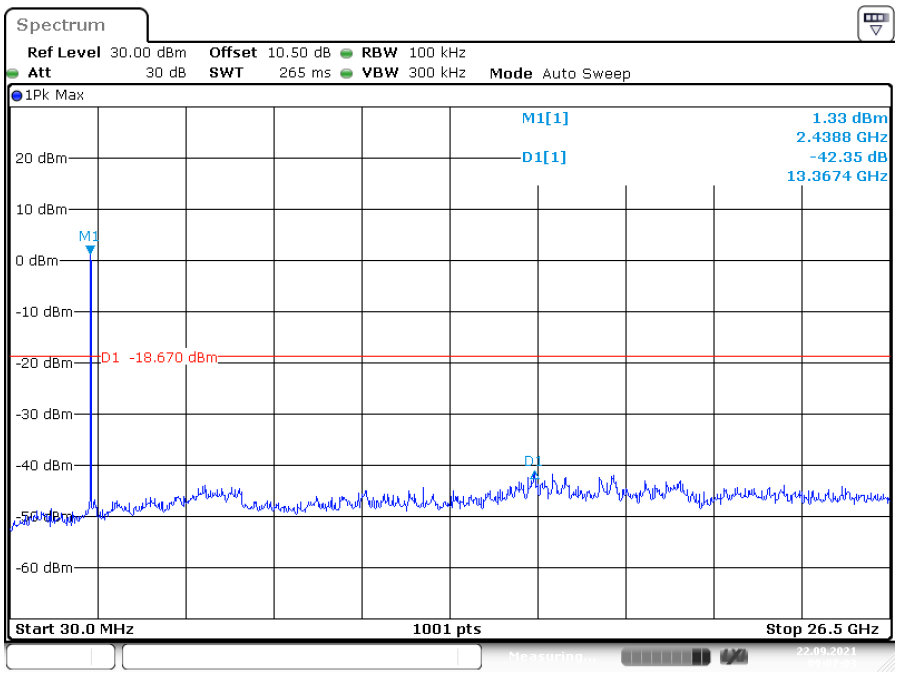
Date: 22.SEP.2021 09:02:51

Middle Channel



Date: 22.SEP.2021 09:04:59

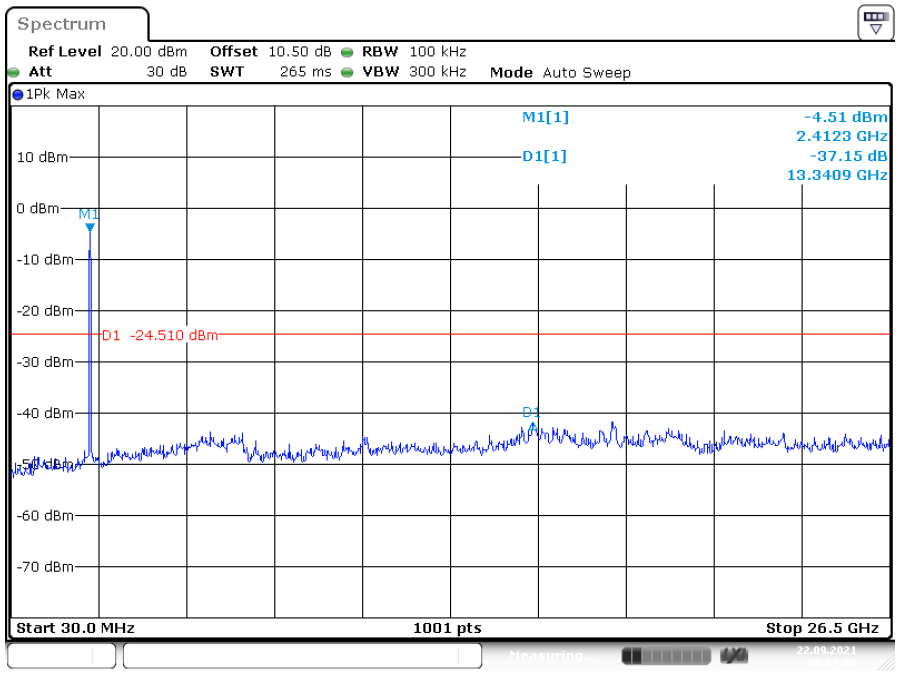
High Channel



Date: 22.SEP.2021 09:07:04

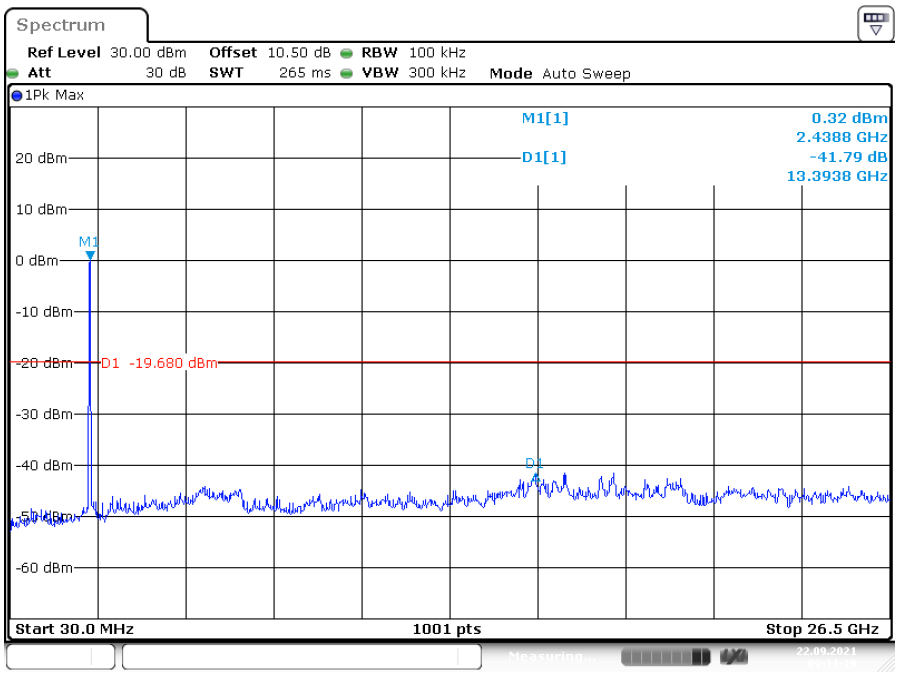
N40 Mode

Low Channel



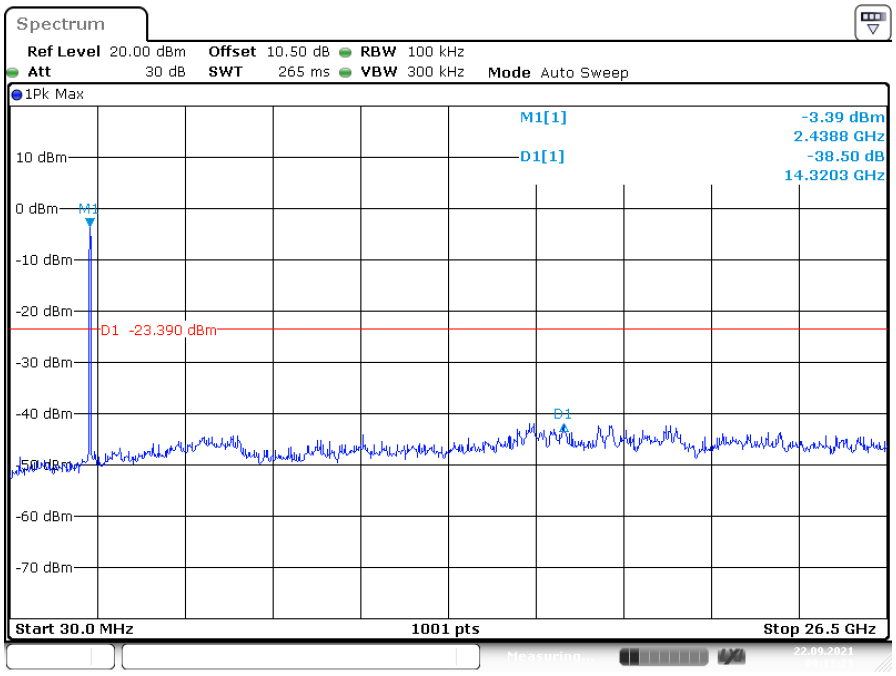
Date: 22.SEP.2021 09:09:26

Middle Channel



Date: 22.SEP.2021 09:11:20

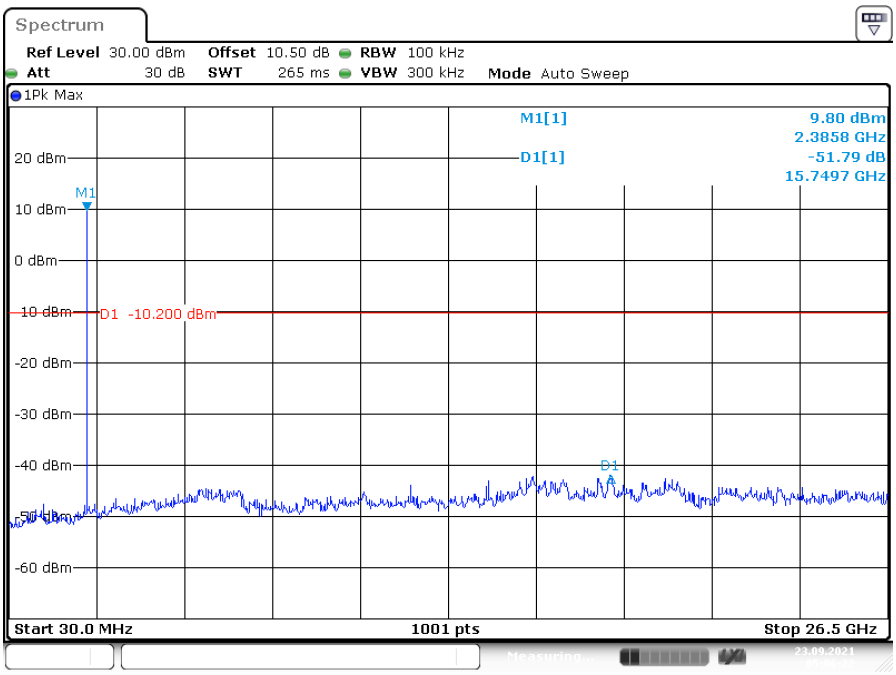
High Channel



Date: 22.SEP.2021 09:13:24

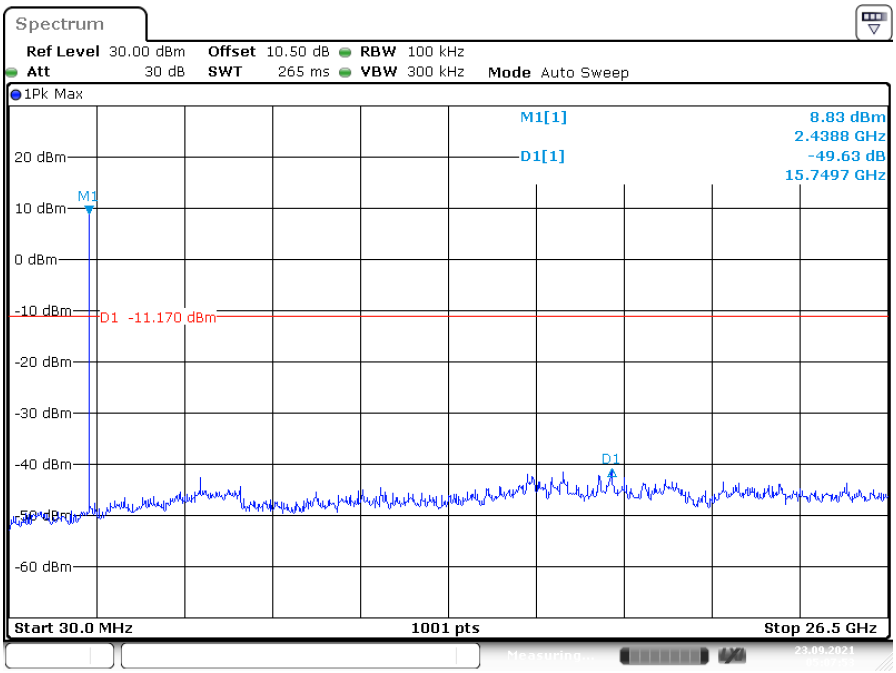
BLE(1M) Mode

Low Channel



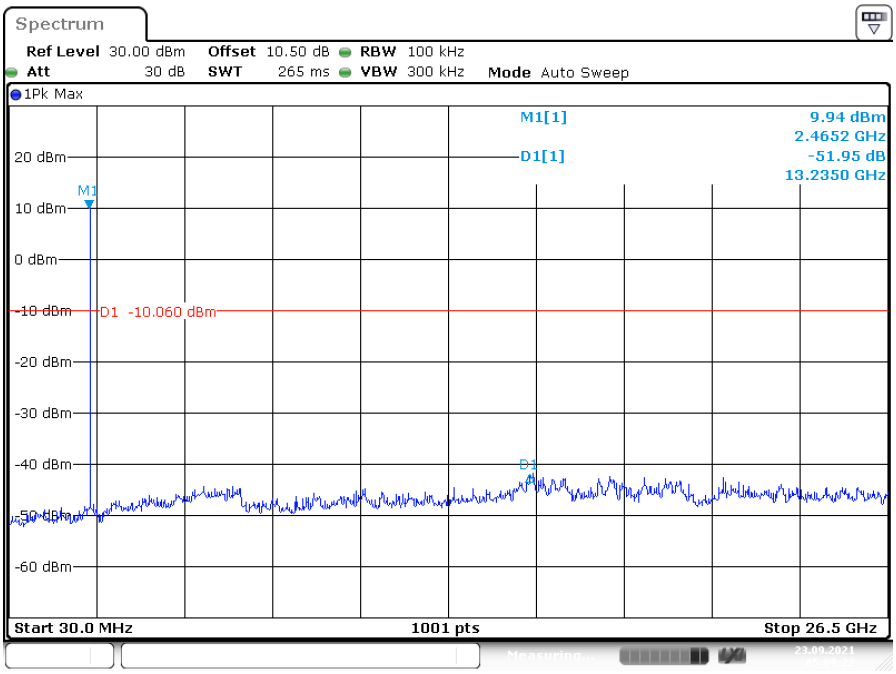
Date: 23.SEP.2021 05:06:23

Middle Channel



Date: 23.SEP.2021 05:07:53

High Channel



Date: 23.SEP.2021 05:09:22

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.

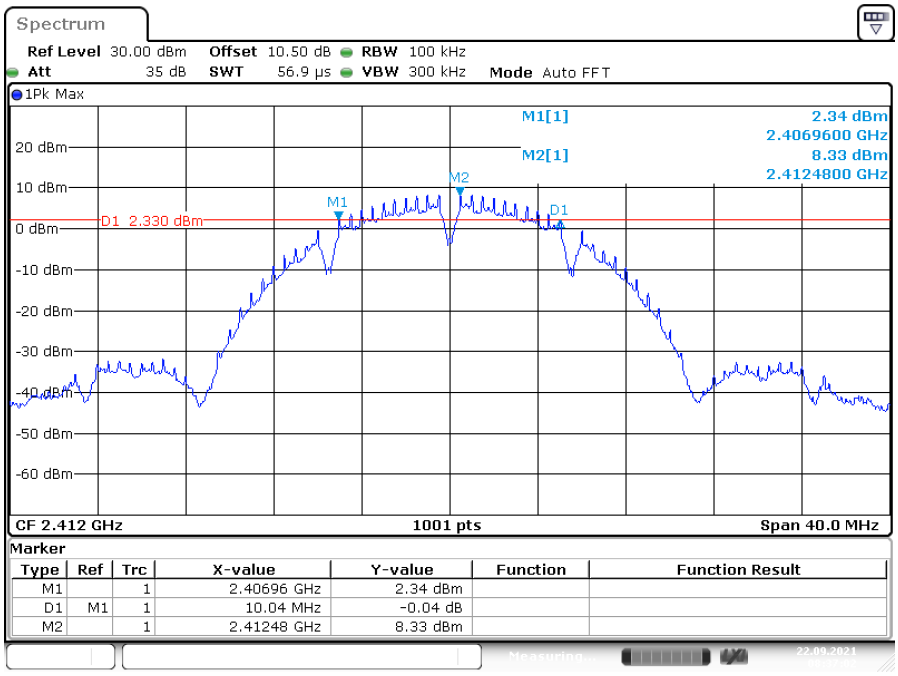
9.3 Test Results

Channel	Frequency (MHz)	6 dB Emission Bandwidth (MHz)	Limit (kHz)	Result
B Mode				
Low	2412	10.04	> 500	PASS
Middle	2437	10.04	> 500	PASS
High	2462	10.04	> 500	PASS
G Mode				
Low	2412	16.32	> 500	PASS
Middle	2437	16.36	> 500	PASS
High	2462	16.36	> 500	PASS
N20 Mode				
Low	2412	17.56	> 500	PASS
Middle	2437	17.56	> 500	PASS
High	2462	17.56	> 500	PASS
N40 Mode				
Low	2422	35.84	> 500	PASS
Middle	2437	36.32	> 500	PASS
High	2452	36.08	> 500	PASS
BLE(1M) Mode				
Low	2402	0.73	> 500	PASS
Middle	2440	0.73	> 500	PASS
High	2480	0.73	> 500	PASS

Please refer to the following plots

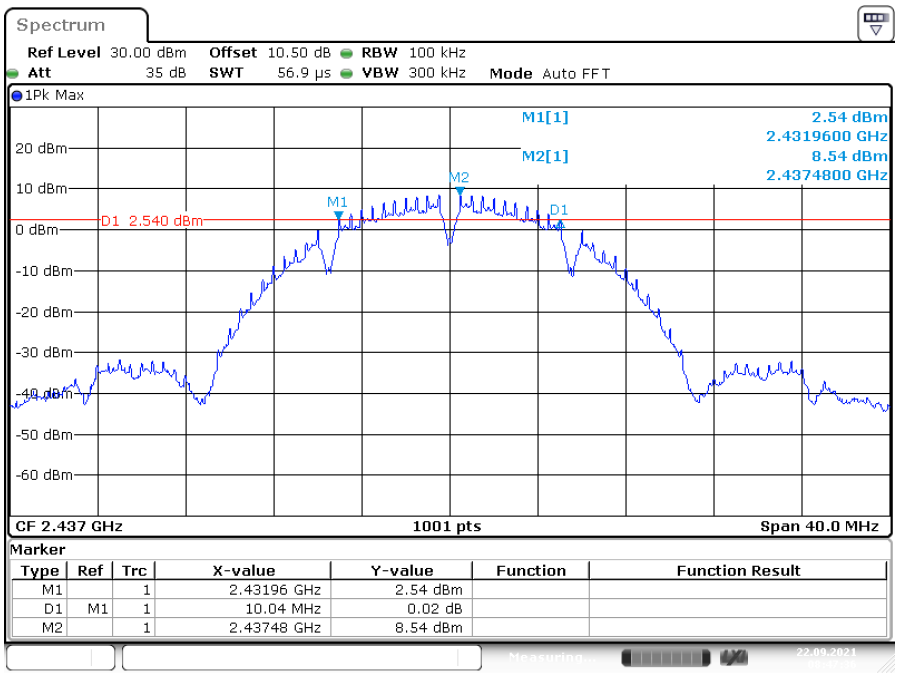
B Mode

Low Channel



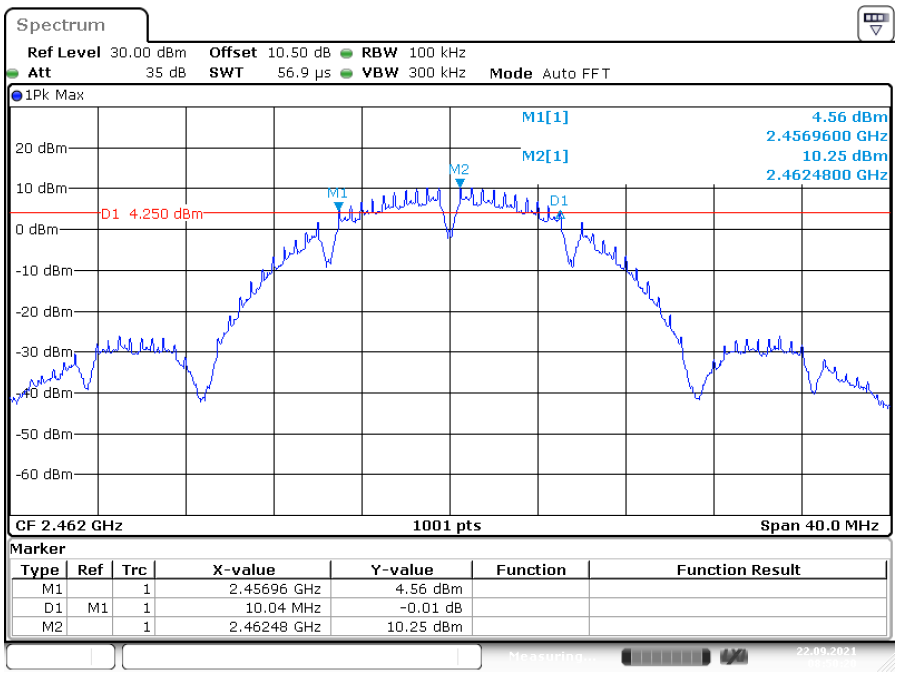
Date: 22.SEP.2021 08:37:03

Middle Channel



Date: 22.SEP.2021 08:47:36

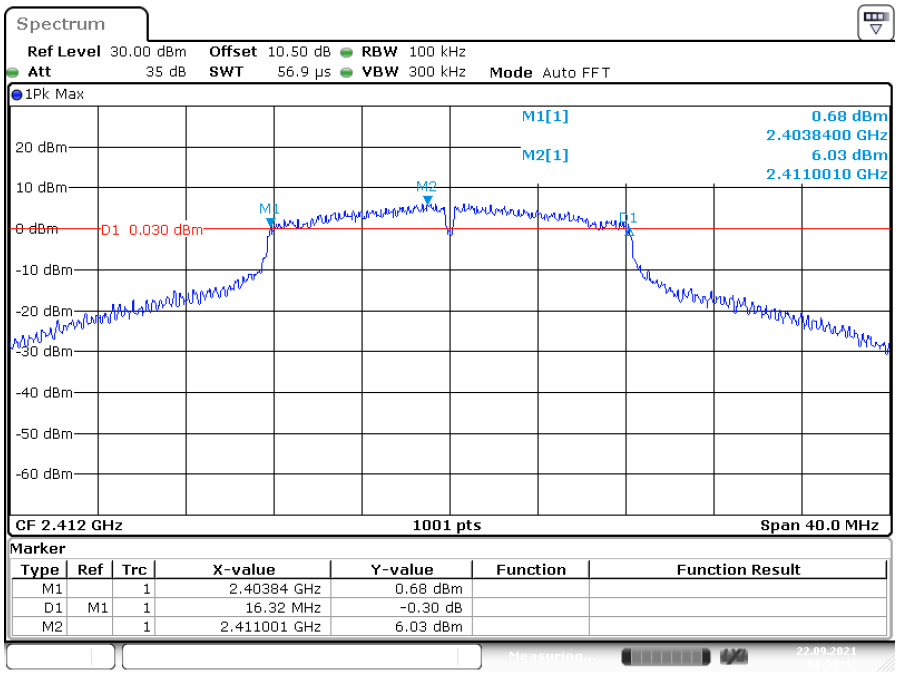
High Channel



Date: 22.SEP.2021 08:50:20

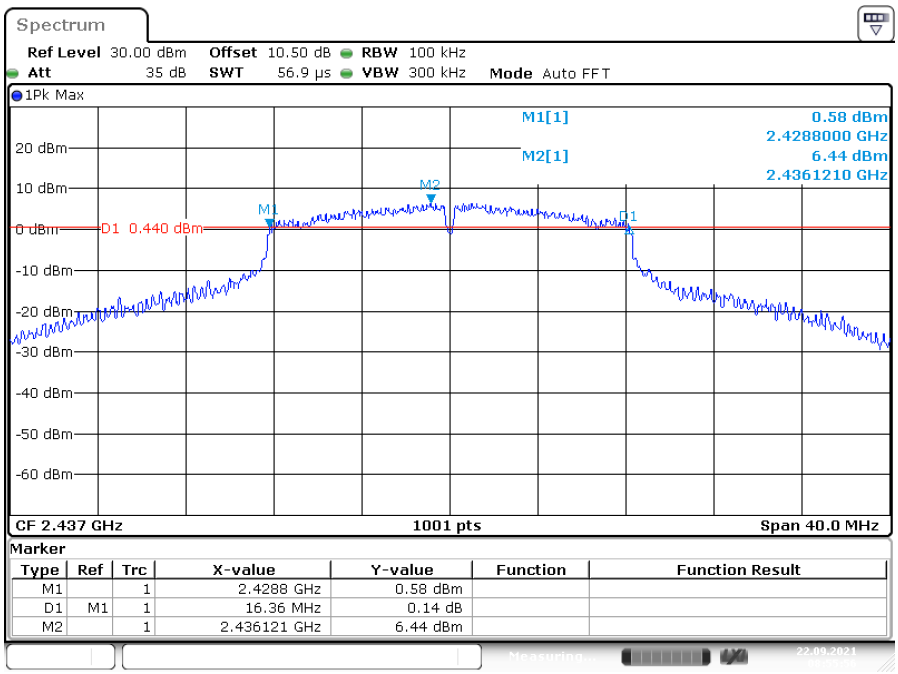
G Mode

Low Channel



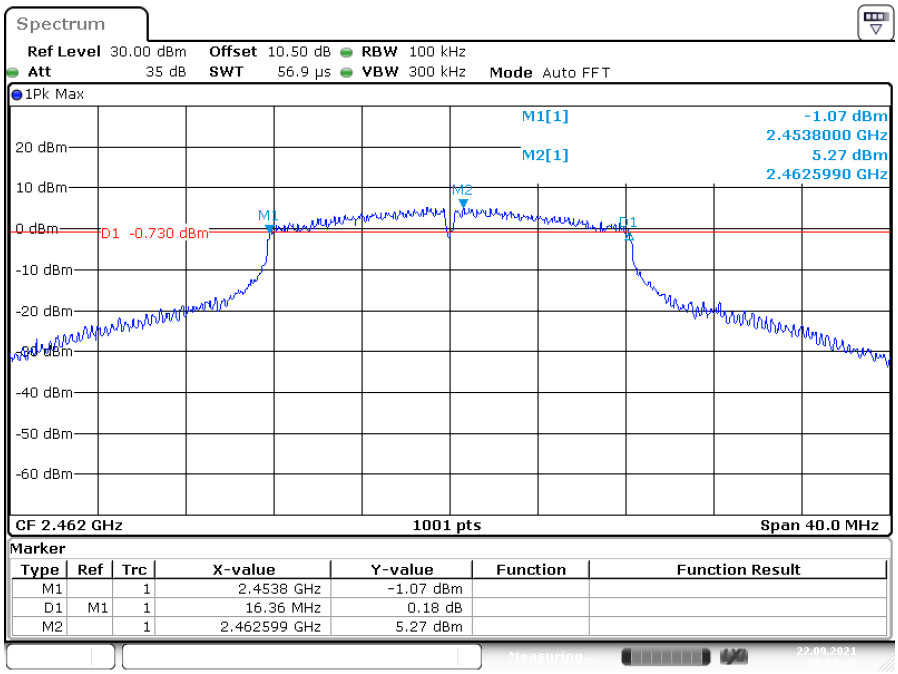
Date: 22.SEP.2021 08:53:43

Middle Channel



Date: 22.SEP.2021 08:55:56

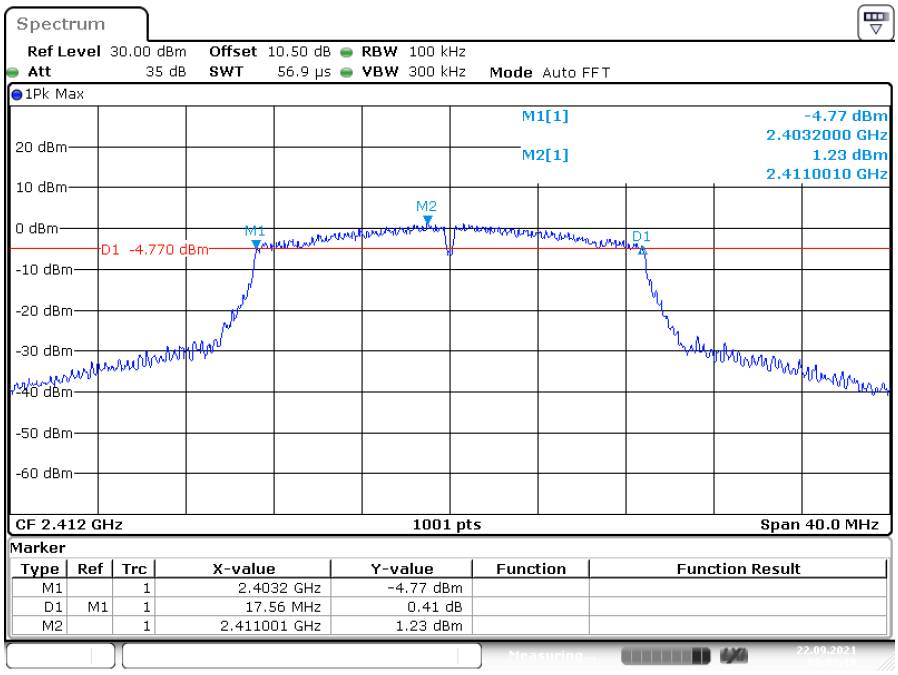
High Channel



Date: 22.SEP.2021 08:57:47

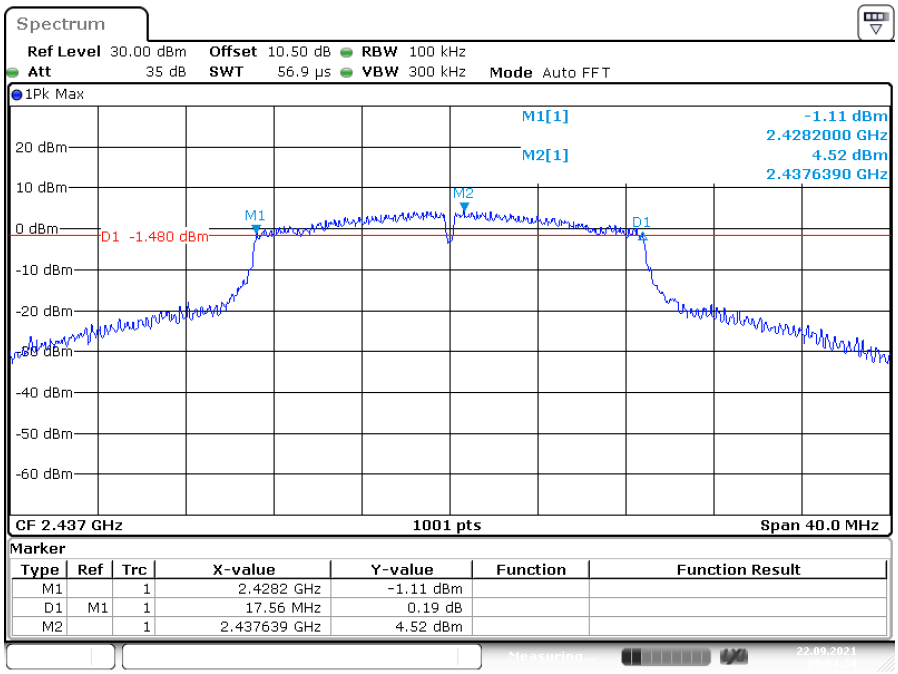
N20 Mode

Low Channel



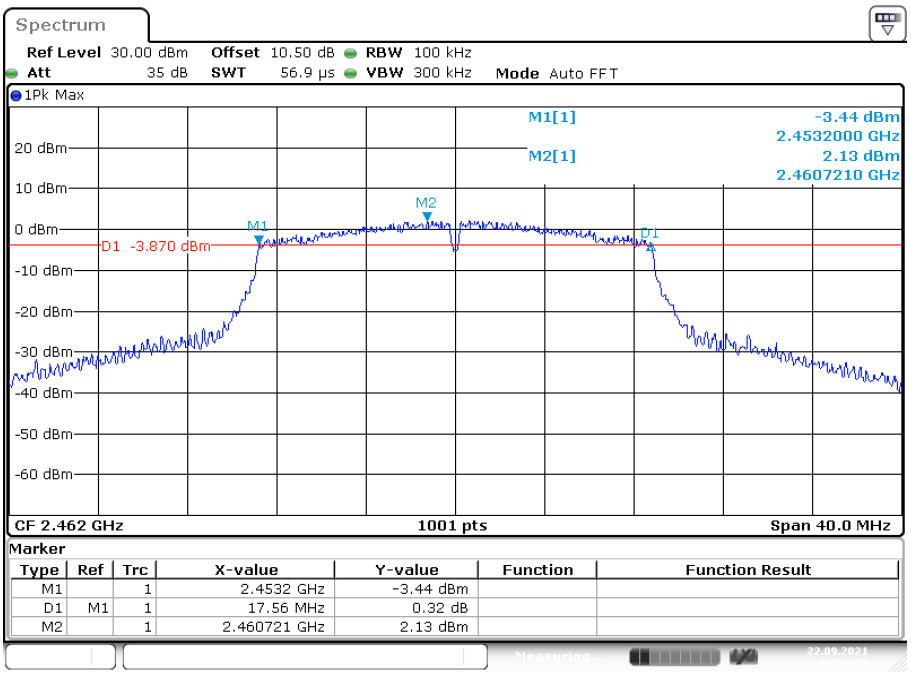
Date: 22.SEP.2021 09:02:11

Middle Channel



Date: 22.SEP.2021 09:04:34

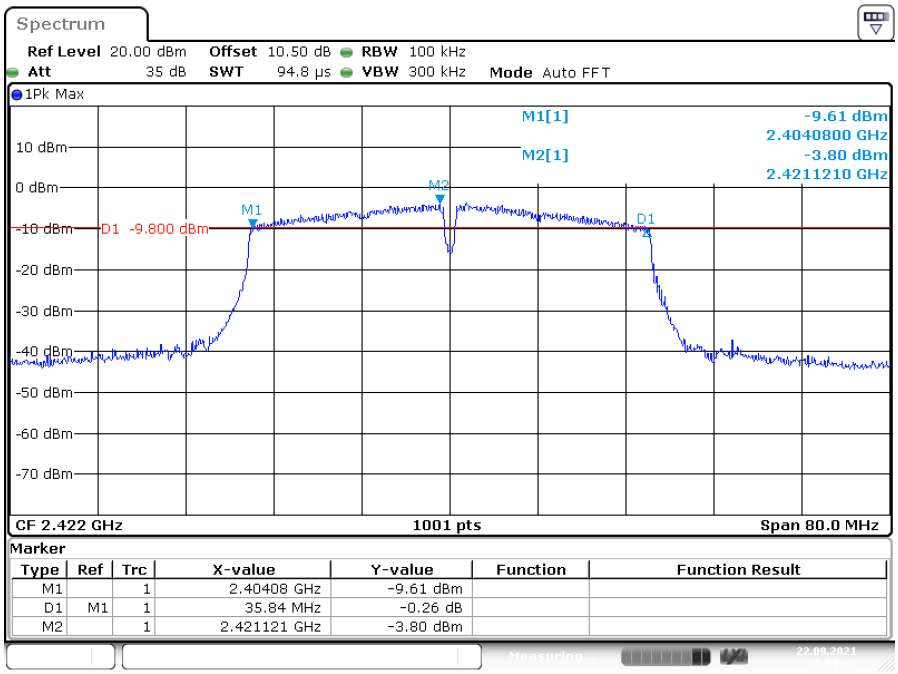
High Channel



Date: 22.SEP.2021 09:06:24

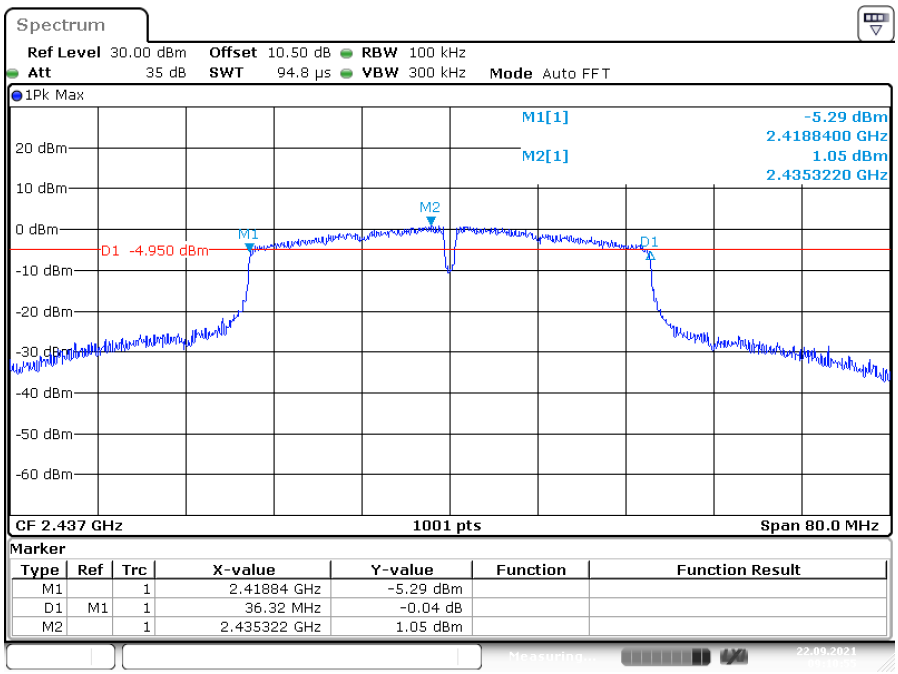
N40 Mode

Low Channel



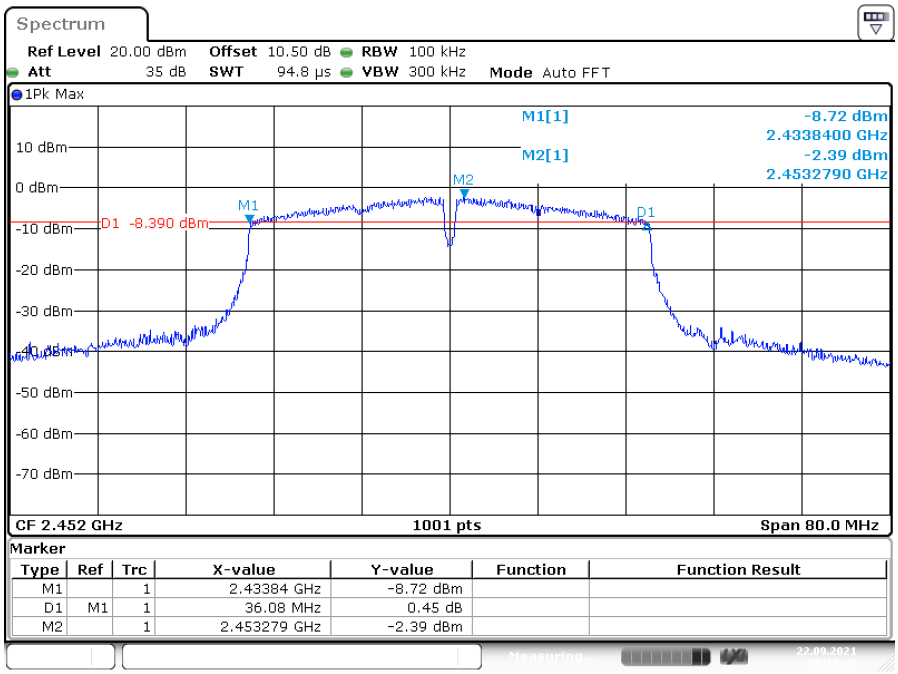
Date: 22.SEP.2021 09:08:46

Middle Channel



Date: 22.SEP.2021 09:10:55

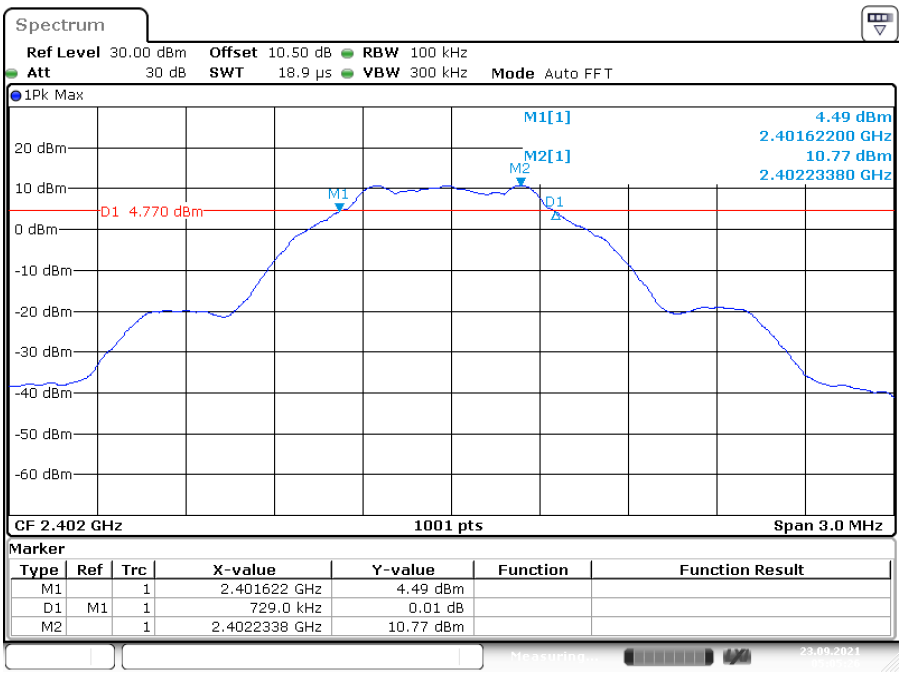
High Channel



Date: 22.SEP.2021 09:12:43

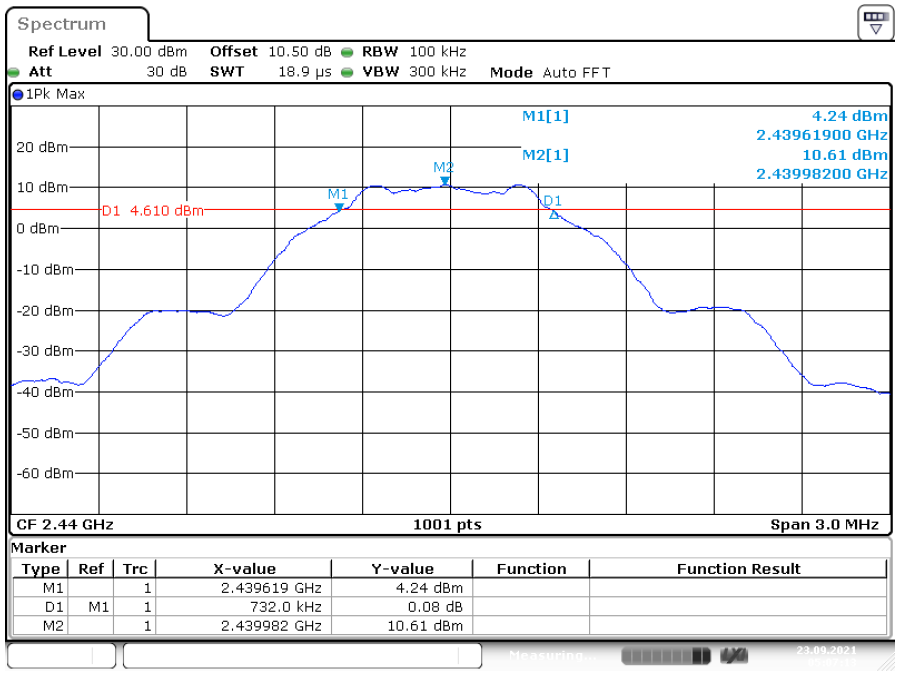
BLE(1M) Mode

Low Channel



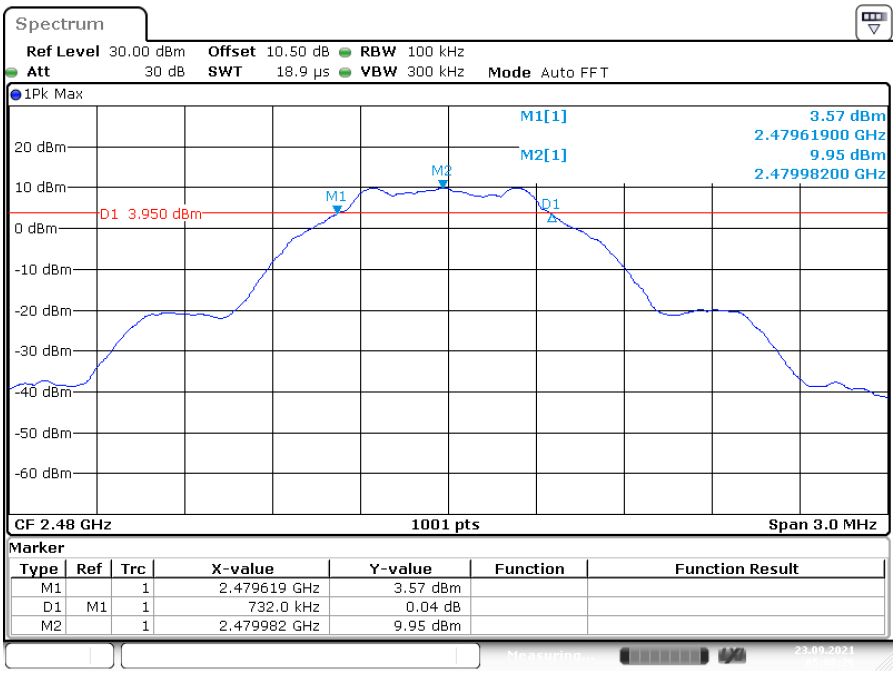
Date: 23.SEP.2021 05:05:27

Middle Channel



Date: 23.SEP.2021 05:07:13

High Channel



Date: 23.SEP.2021 05:08:27

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

Conducted Peak Output Power

Channel	Frequency (MHz)	Power (dBm)	Power (W)	Limit (W)	Result
802.11b Mode					
Low	2412	18.61	0.073	1	PASS
Middle	2437	18.77	0.075	1	PASS
High	2462	20.48	0.112	1	PASS
802.11g Mode					
Low	2412	22.92	0.196	1	PASS
Middle	2437	23.28	0.213	1	PASS
High	2462	23.15	0.207	1	PASS
802.11n HT20 Mode					
Low	2412	21.76	0.150	1	PASS
Middle	2437	23.10	0.204	1	PASS
High	2462	21.92	0.156	1	PASS
802.11n HT40 Mode					
Low	2422	19.15	0.082	1	PASS
Middle	2437	21.96	0.157	1	PASS
High	2452	20.21	0.105	1	PASS
BLE(1M) Mode					
Low	2402	11.46	0.014	1	PASS
Middle	2440	11.39	0.014	1	PASS
High	2480	10.71	0.012	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 100kHz 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 20dB below that in the 100kHz 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 30dB instead of 20dB. 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.

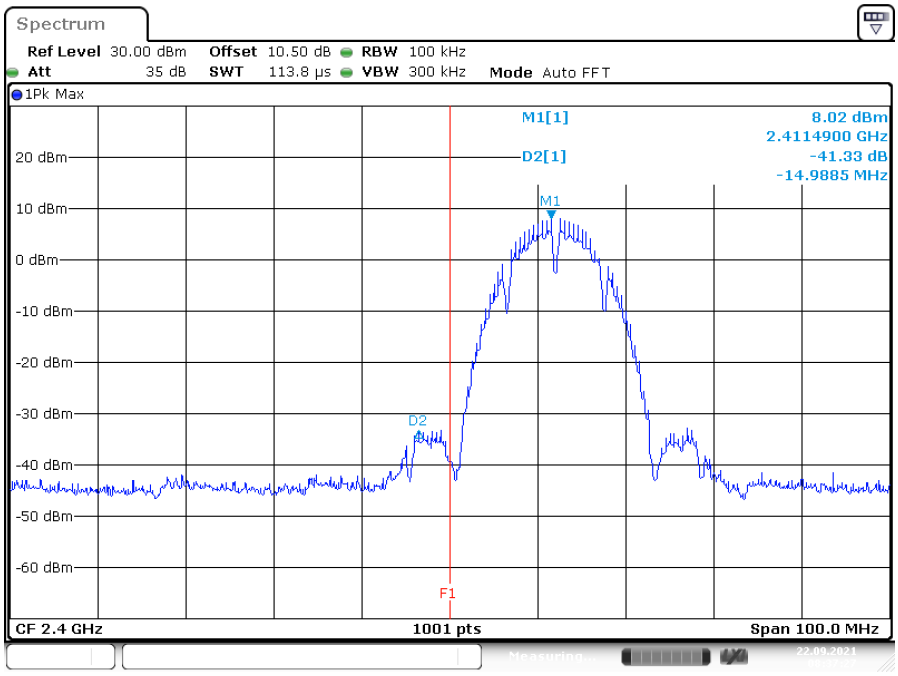
11.3 Test Results

Channel	Frequency (MHz)	Delta Peak to Band Emission (dBc)	Limit (dBc)	Result
B Mode				
Low	2412	41.33	≥ 20	PASS
High	2462	51.93	≥ 20	PASS
G Mode				
Low	2412	22.92	≥ 20	PASS
High	2462	42.39	≥ 20	PASS
N20 Mode				
Low	2412	31.37	≥ 20	PASS
High	2462	42.17	≥ 20	PASS
N40 Mode				
Low	2422	33.49	≥ 20	PASS
High	2452	36.54	≥ 20	PASS
BLE(1M) Mode				
Low	2402	56.02	≥ 20	PASS
High	2480	55.95	≥ 20	PASS

Please refer to the following plots.

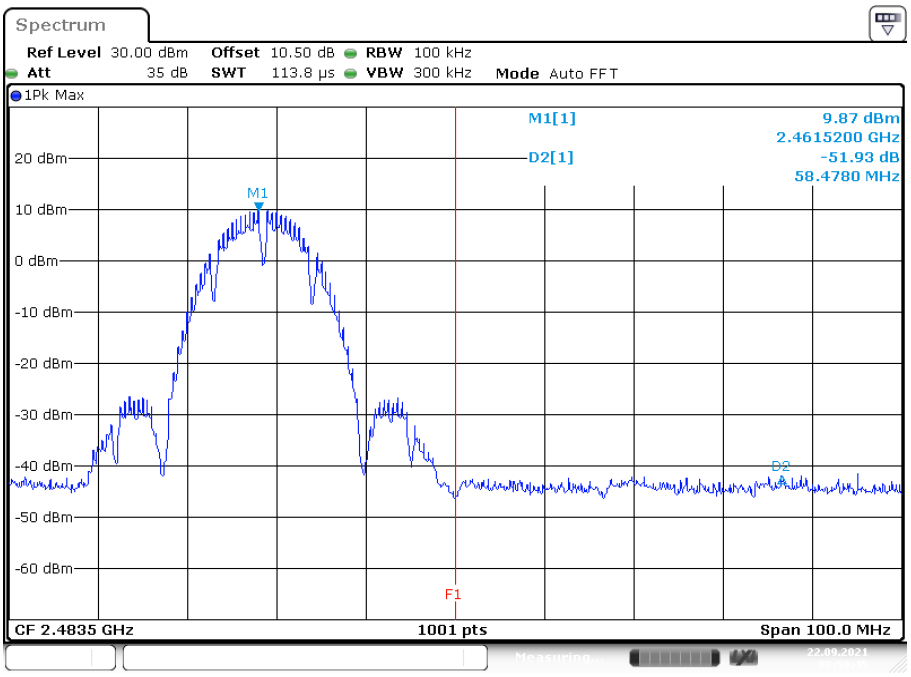
B Mode

Band Edge, Left Side



Date: 22.SEP.2021 08:37:28

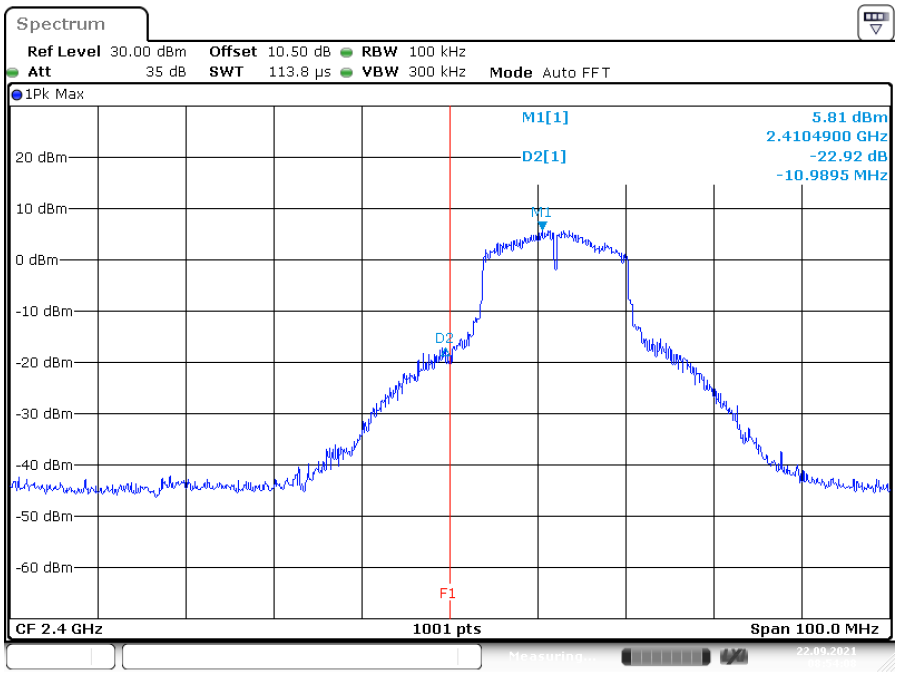
Band Edge, Right Side



Date: 22.SEP.2021 08:50:45

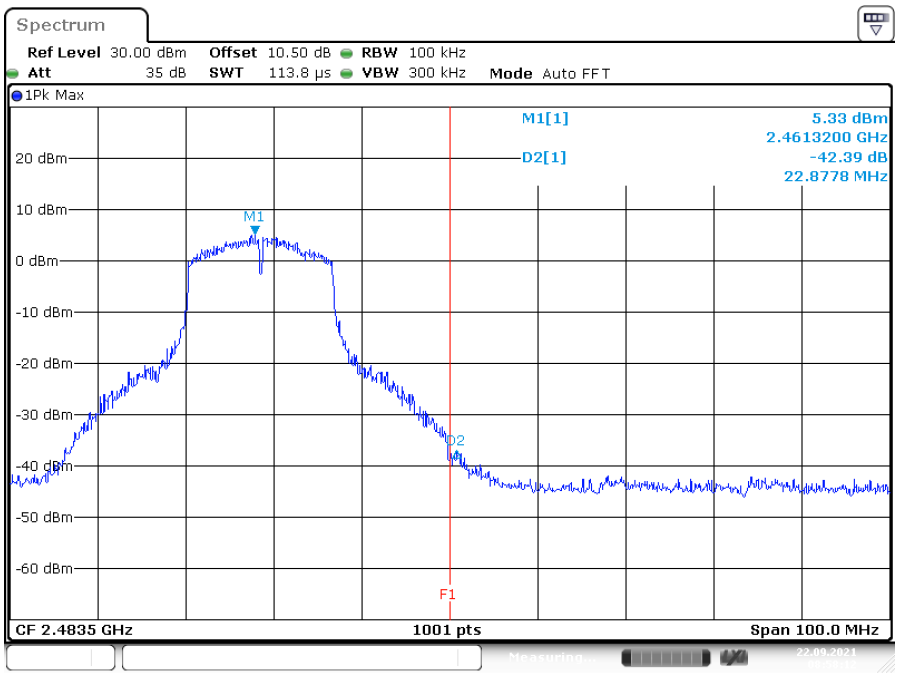
G Mode

Band Edge, Left Side



Date: 22.SEP.2021 08:54:09

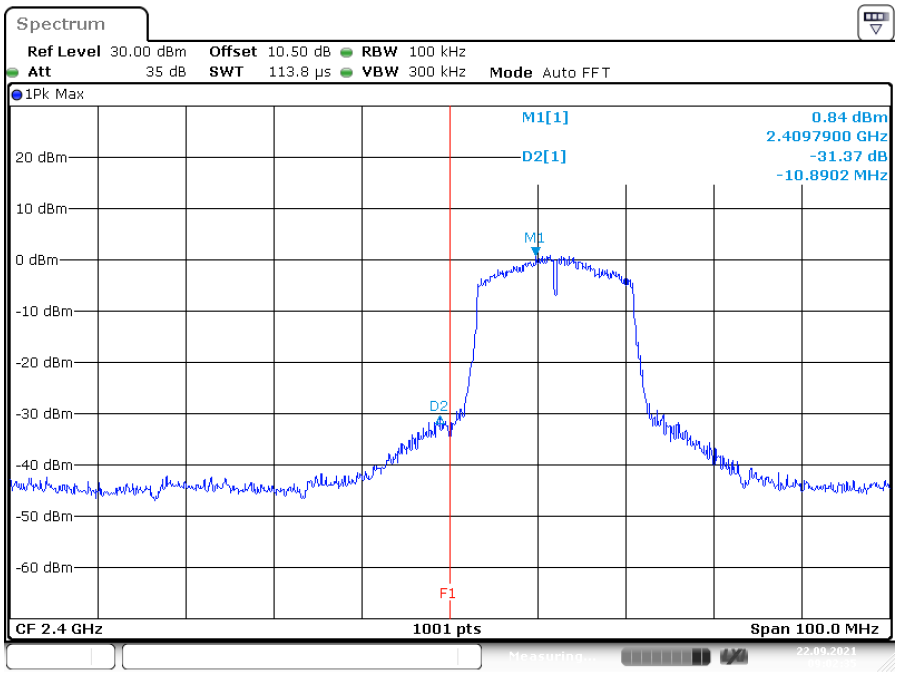
Band Edge, Right Side



Date: 22.SEP.2021 08:58:12

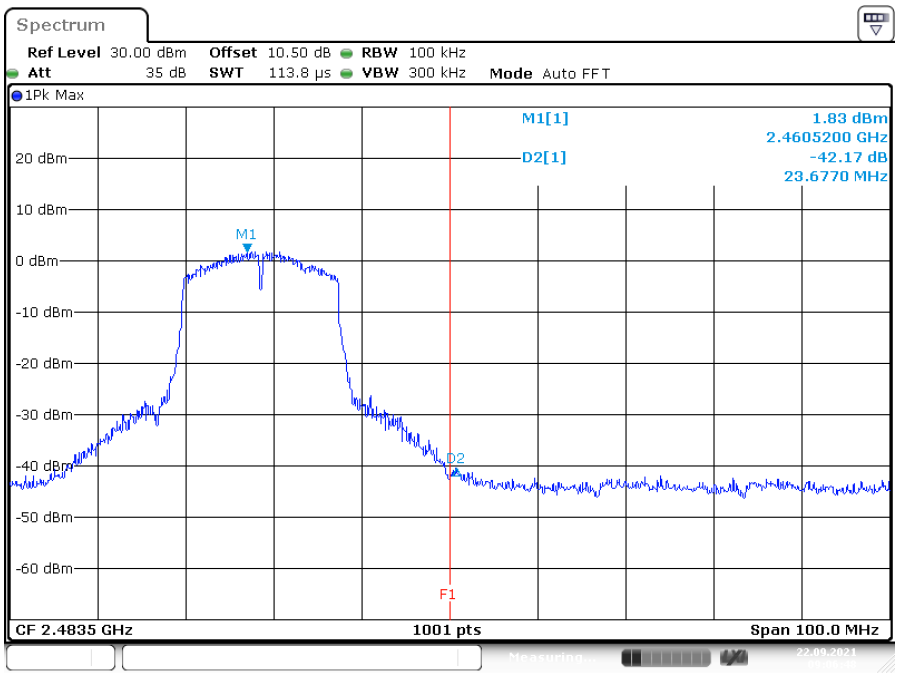
N20 Mode

Band Edge, Left Side



Date: 22.SEP.2021 09:02:36

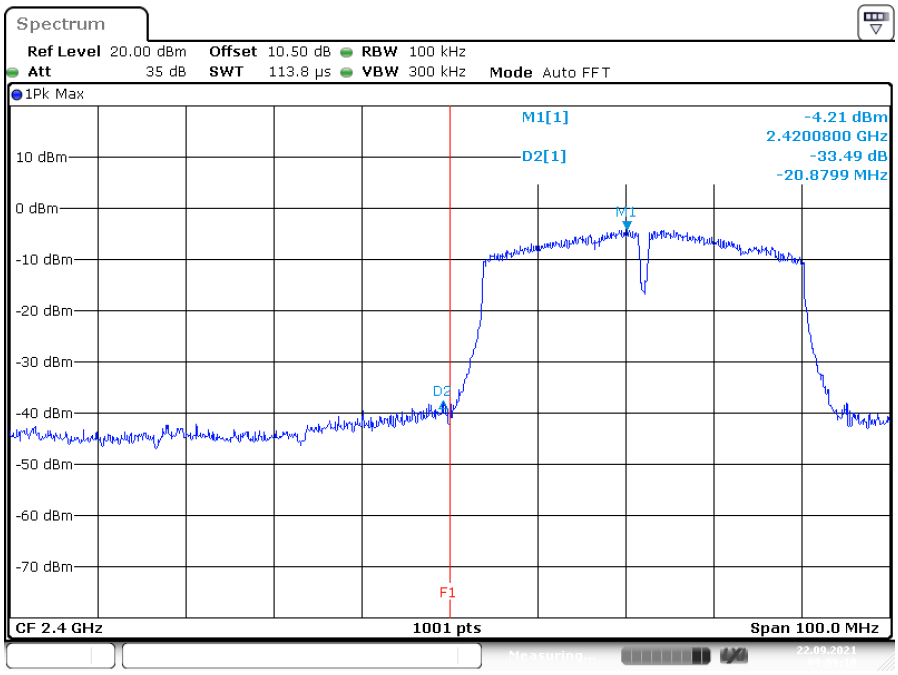
Band Edge, Right Side



Date: 22.SEP.2021 09:06:49

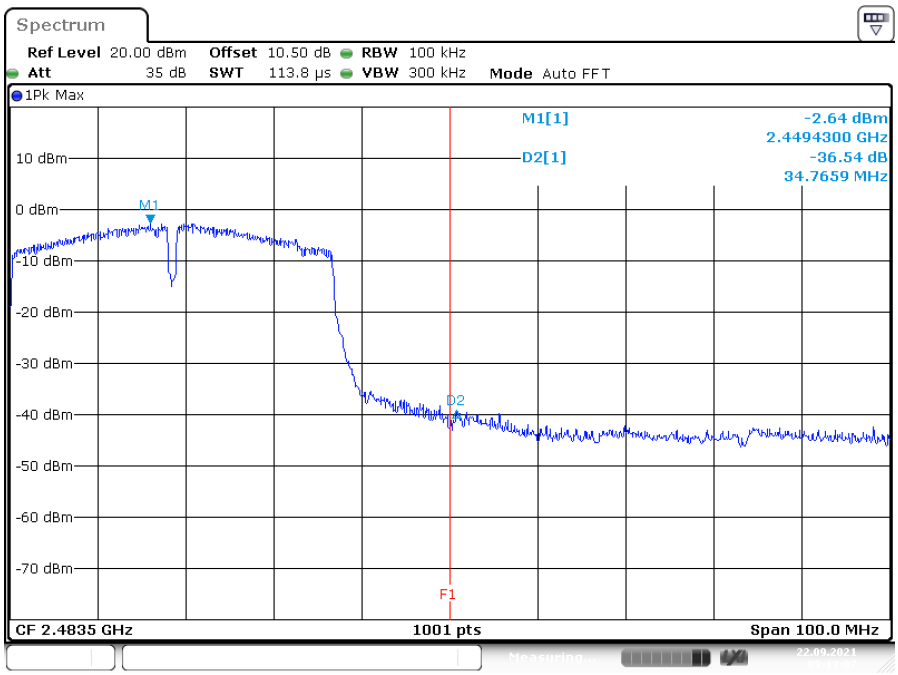
N40 Mode

Band Edge, Left Side



Date: 22.SEP.2021 09:09:11

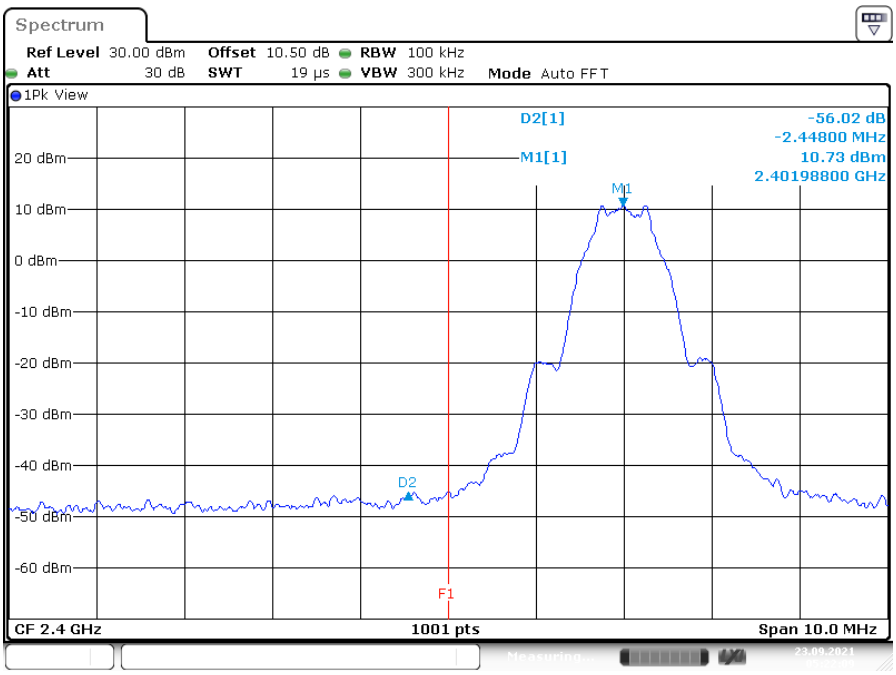
Band Edge, Right Side



Date: 22.SEP.2021 09:13:08

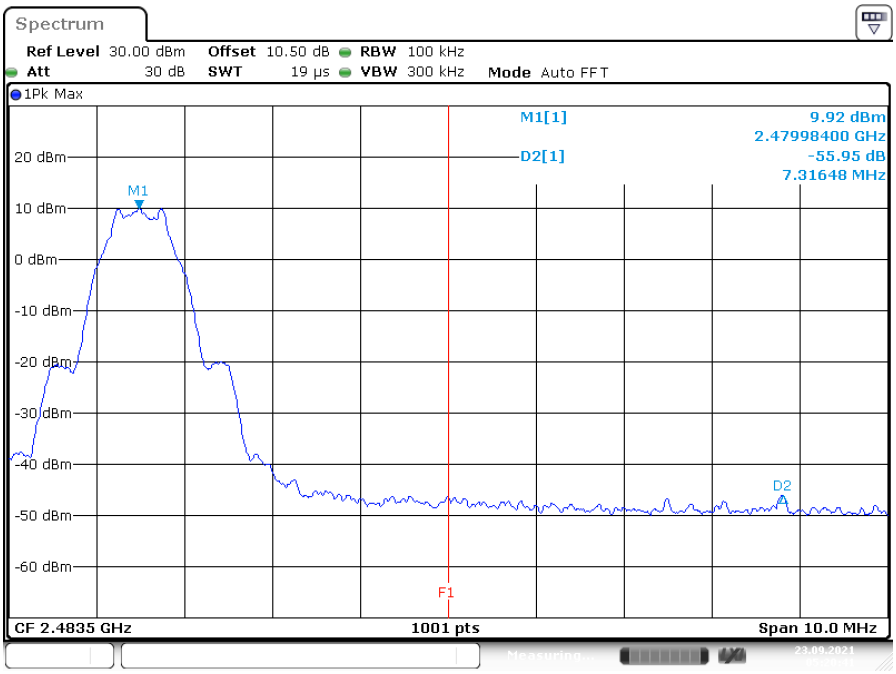
BLE(1M) Mode

Band Edge, Low Channel



Date: 23.SEP.2021 05:22:09

Band Edge, High Channel



Date: 23.SEP.2021 05:20:42

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

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

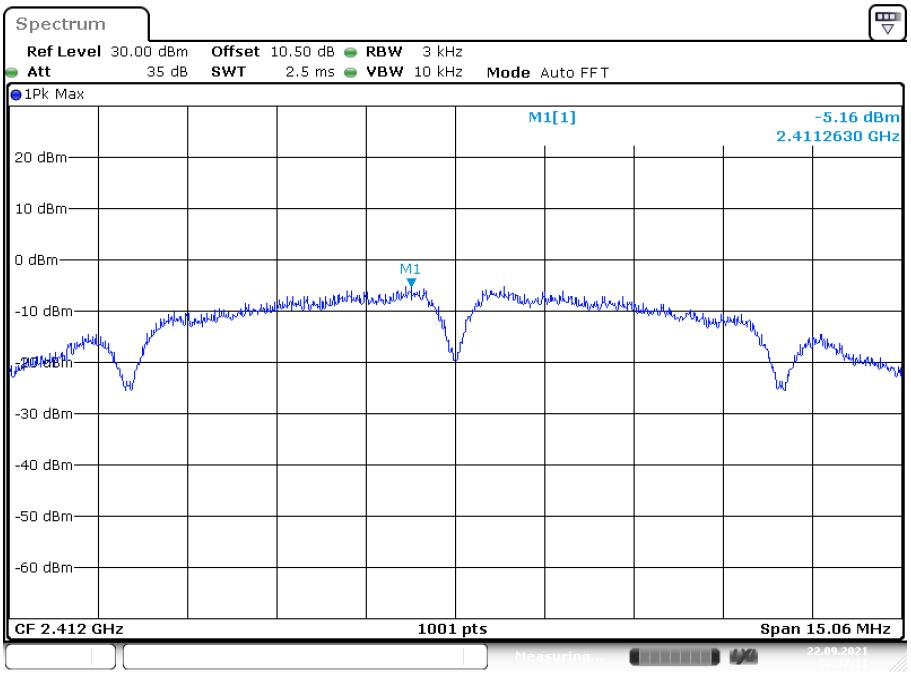
12.3 Test Results

Channel	Frequency (MHz)	Power Spectral Density (dBm/3 kHz)	Limit (dBm/3 kHz)	Result
B Mode				
Low	2412	-5.16	8	PASS
Middle	2437	-4.93	8	PASS
High	2462	-3.20	8	PASS
G Mode				
Low	2412	-5.23	8	PASS
Middle	2437	-4.68	8	PASS
High	2462	-5.98	8	PASS
N20 Mode				
Low	2412	-9.47	8	PASS
Middle	2437	-5.91	8	PASS
High	2462	-8.25	8	PASS
N40 Mode				
Low	2422	-14.58	8	PASS
Middle	2437	-9.62	8	PASS
High	2452	-13.37	8	PASS
BLE(1M) Mode				
Low	2402	-4.14	8	PASS
Middle	2440	-4.22	8	PASS
High	2480	-4.91	8	PASS

Please refer to the following plots

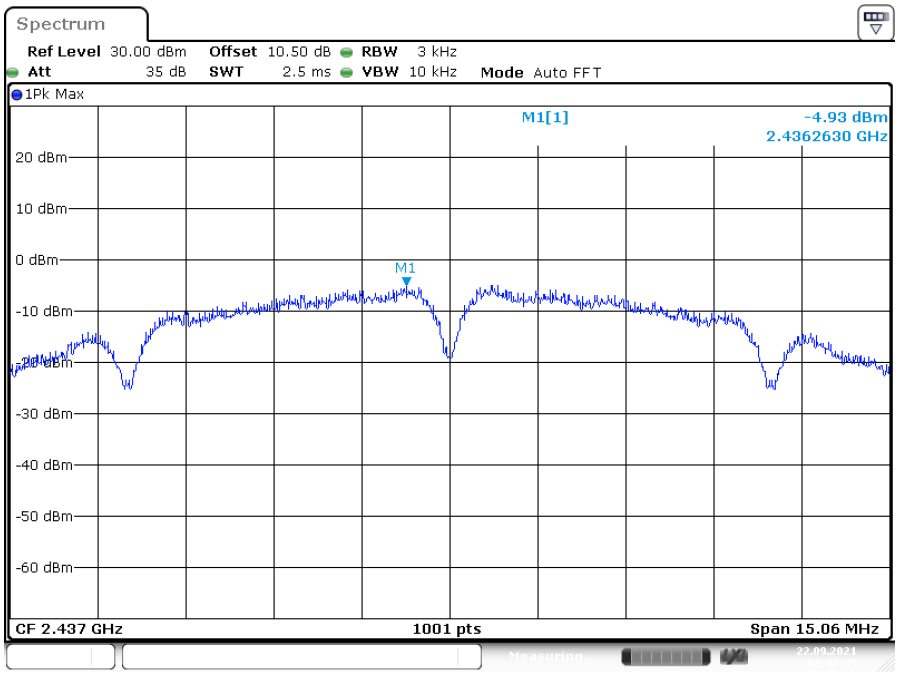
B Mode

Low Channel



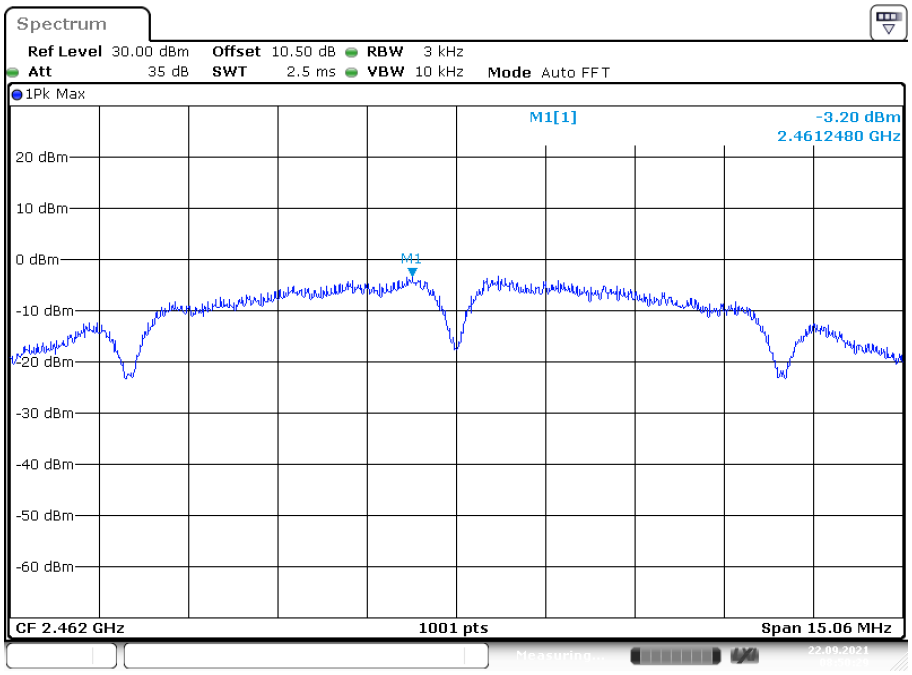
Date: 22.SEP.2021 08:37:12

Middle Channel



Date: 22.SEP.2021 08:47:45

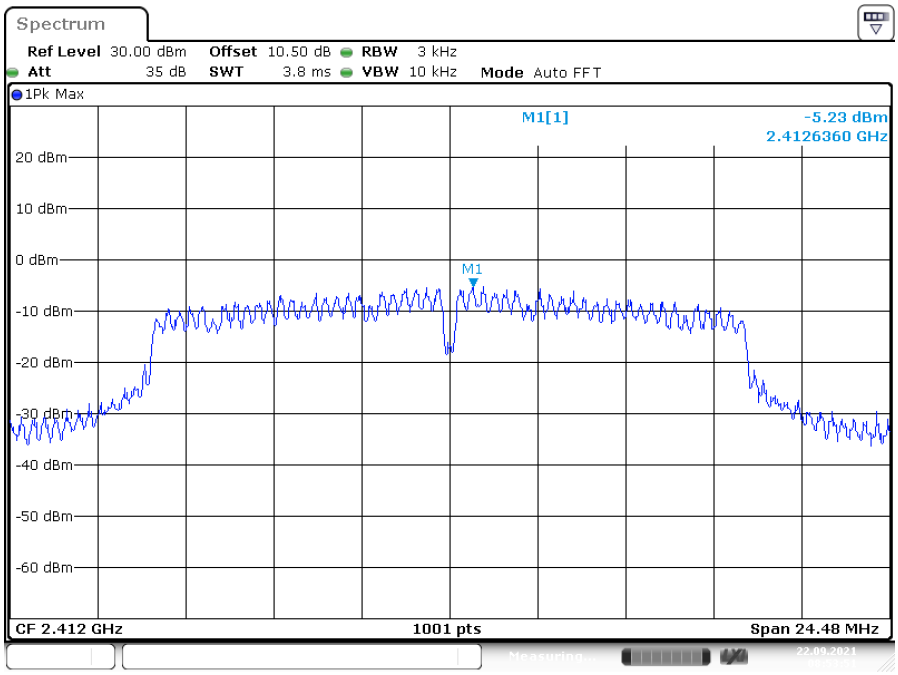
High Channel



Date: 22.SEP.2021 08:50:29

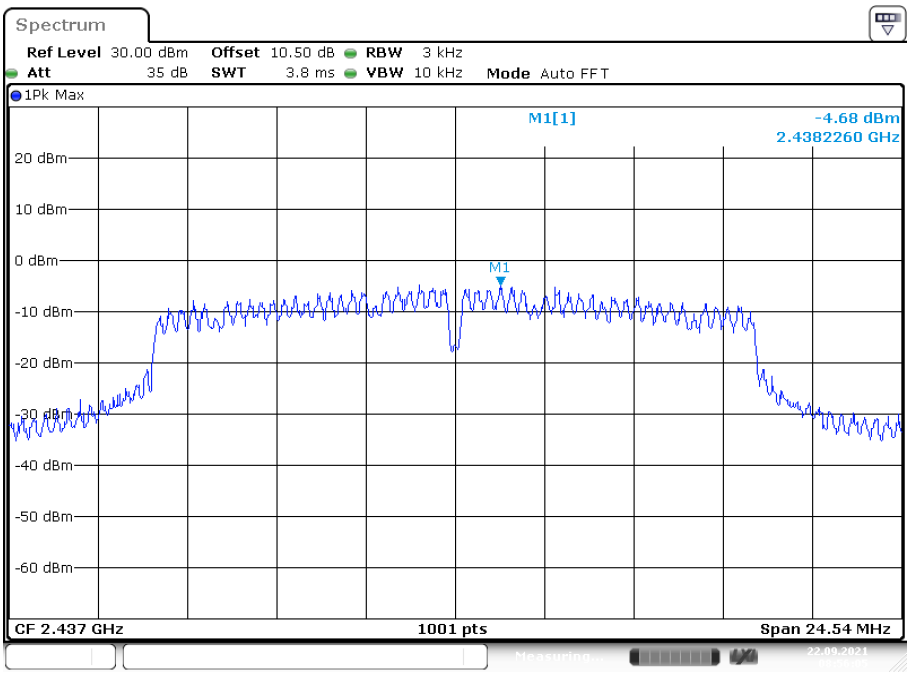
G Mode

Low Channel



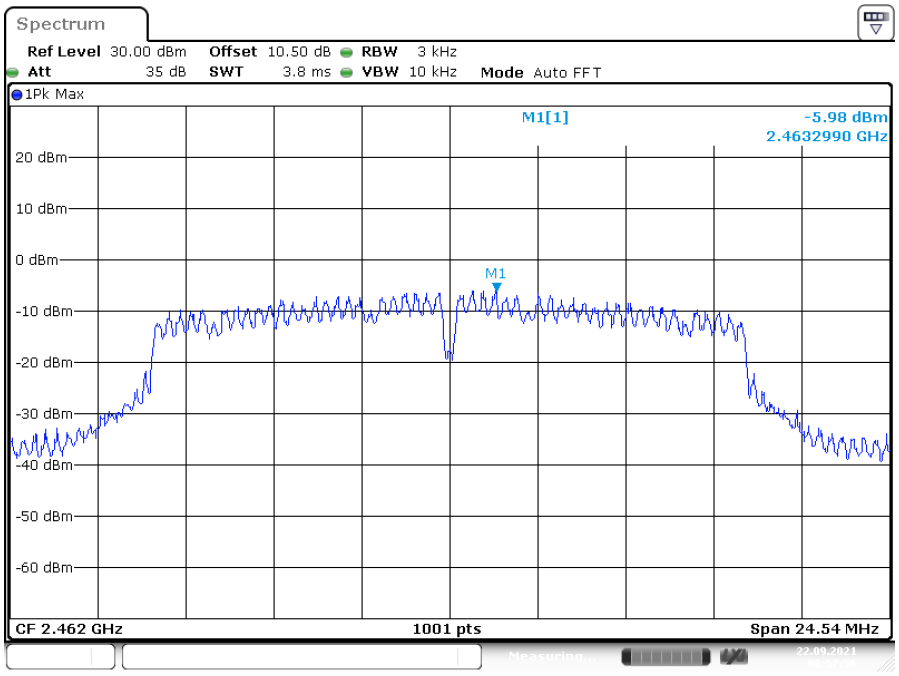
Date: 22.SEP.2021 08:53:52

Middle Channel



Date: 22.SEP.2021 08:56:05

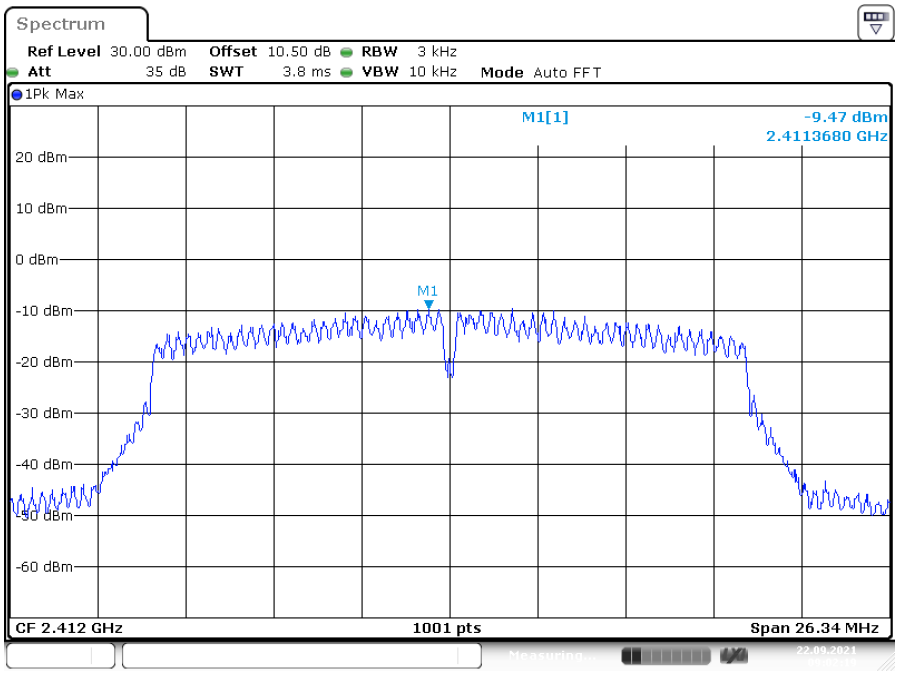
High Channel



Date: 22.SEP.2021 08:57:56

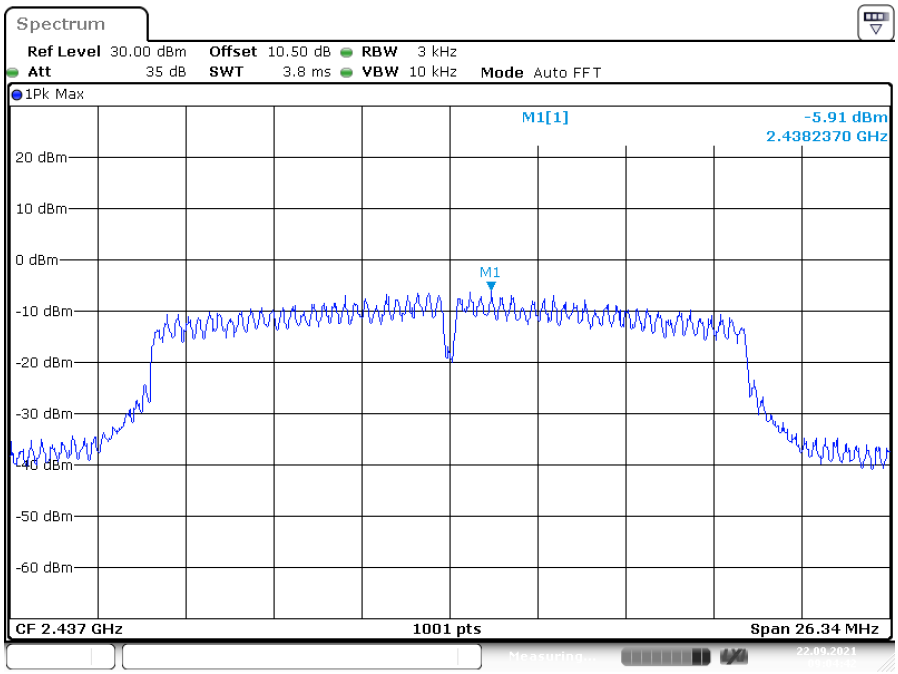
N20 Mode

Low Channel



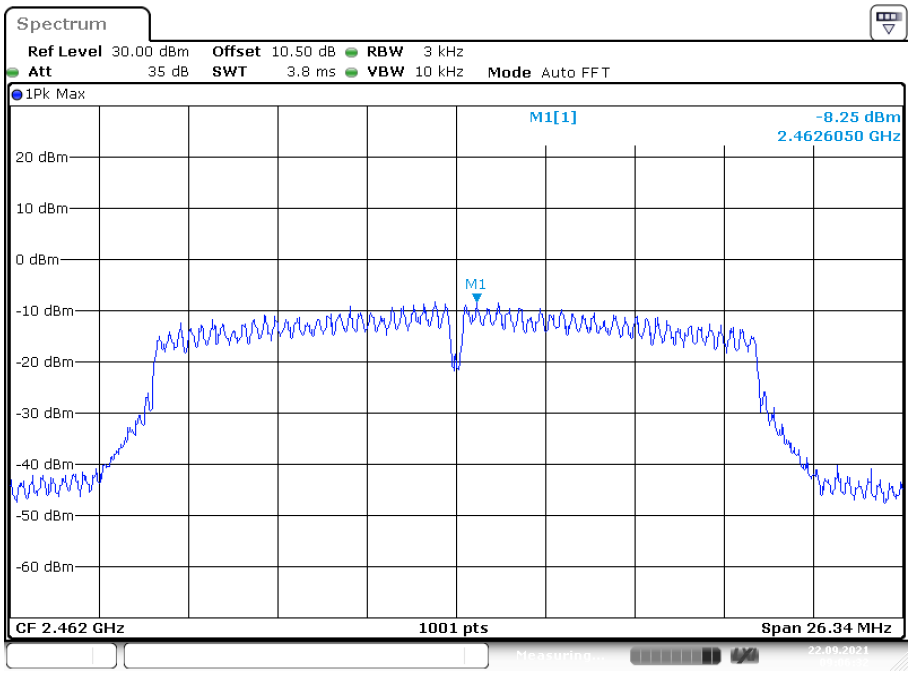
Date: 22.SEP.2021 09:02:20

Middle Channel



Date: 22.SEP.2021 09:04:43

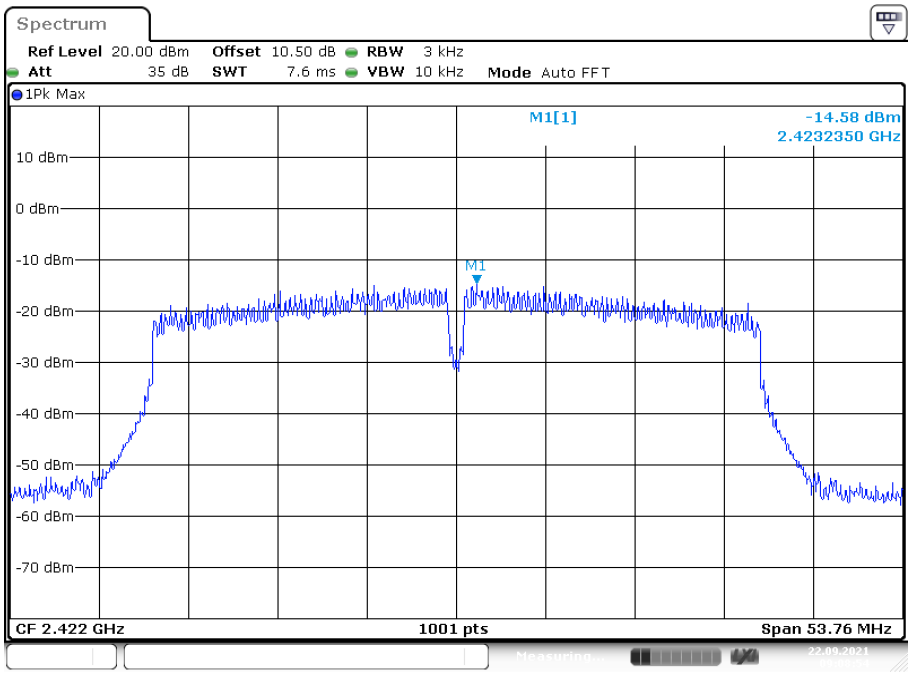
High Channel



Date: 22.SEP.2021 09:06:33

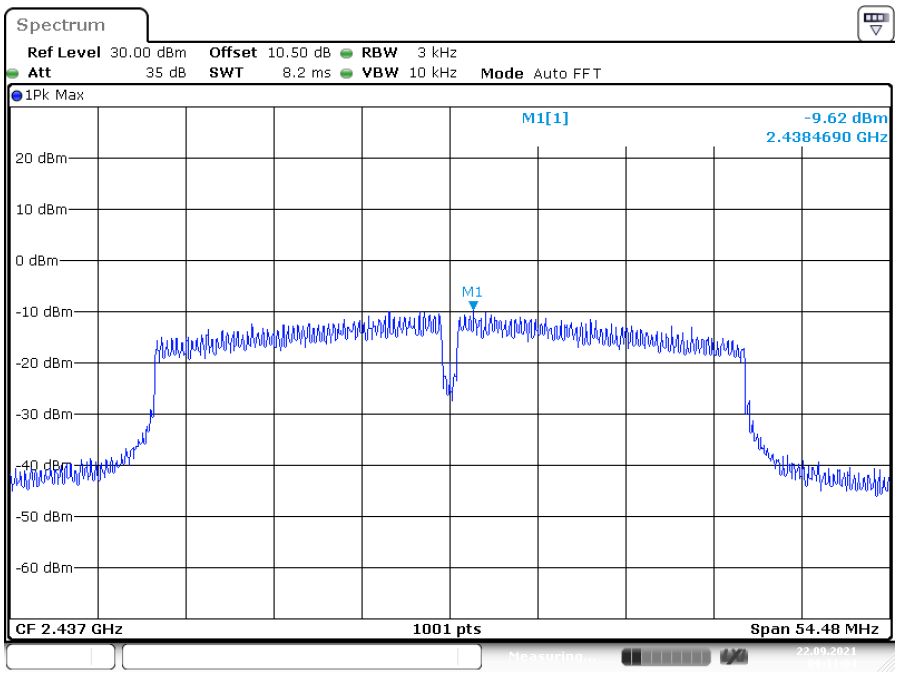
N40 Mode

Low Channel



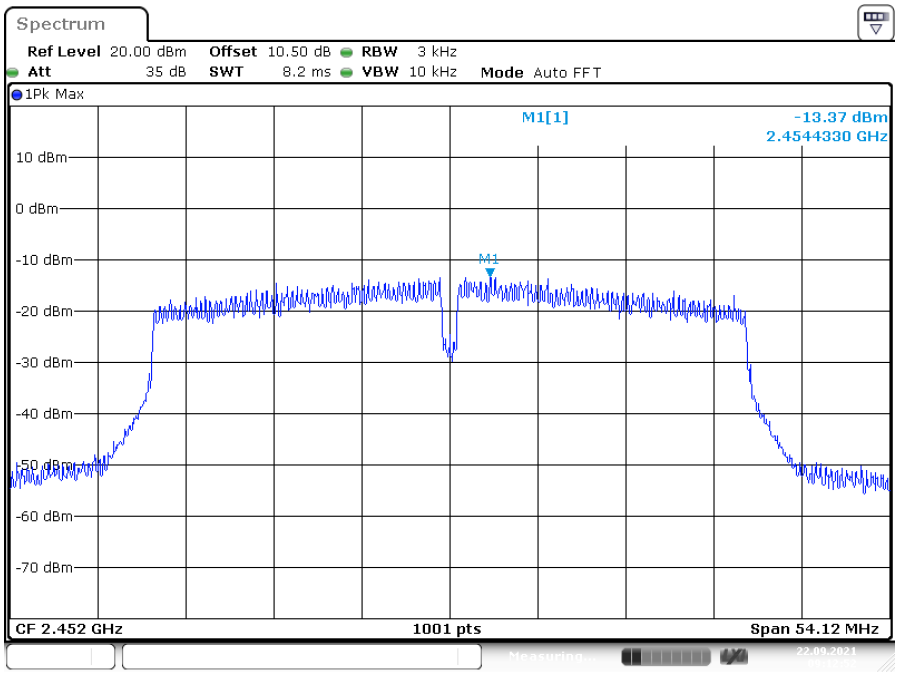
Date: 22.SEP.2021 09:08:55

Middle Channel



Date: 22.SEP.2021 09:11:04

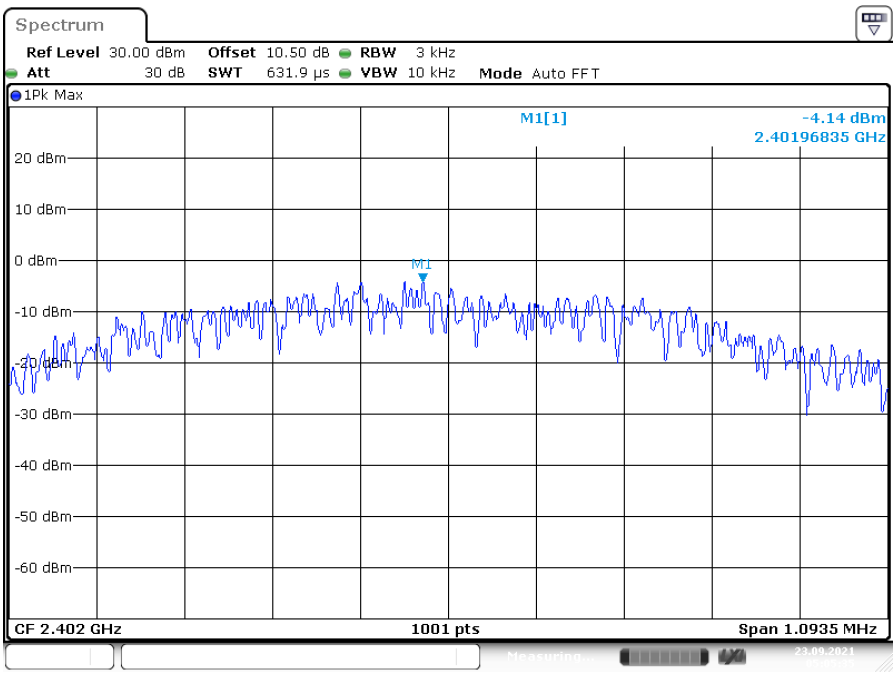
High Channel



Date: 22.SEP.2021 09:12:52

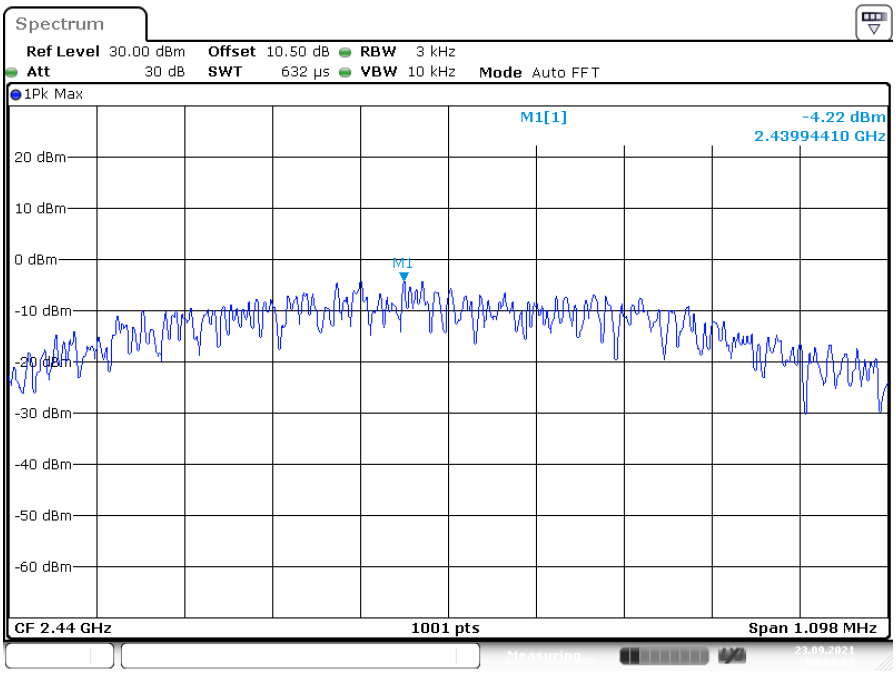
BLE(1M) Mode

Low Channel



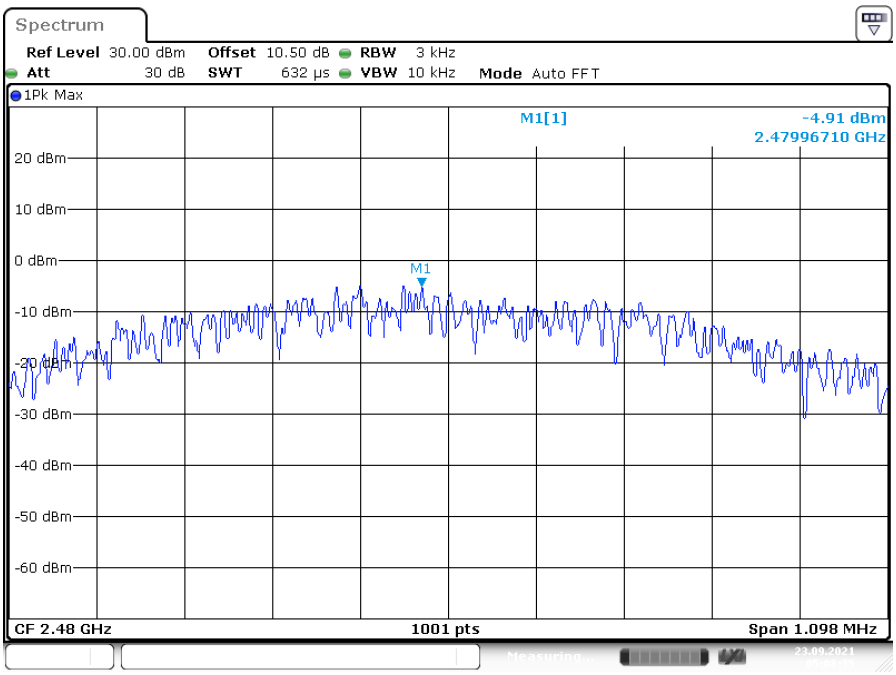
Date: 23.SEP.2021 05:05:36

Middle Channel



Date: 23.SEP.2021 05:07:23

High Channel



Date: 23.SEP.2021 05:08:36

******* END OF REPORT *******