

TEST REPORT

Applicant Name : Therabody, Inc.
Address : FCC: 6100 Wilshire Blvd. Suite 200 Los Angeles, CA 90048-5107, United States
IC: 6100 Wilshire Blvd., Suite 200 Los Angeles CA 90048-5107 United States Of America (Excluding The States Of Alaska)
Report Number : RA230329-15467E-RF
FCC ID: 2AU6TTSE
IC: 25672-TSE

Test Standard (s)

FCC PART 15.247; RSS-GEN ISSUE 5, FEBRUARY 2021 AMENDMENT 2; RSS-247, ISSUE 2, FEBRUARY 2017

Sample Description

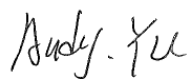
Product Type: Theragun SENSE
Model No.: Theragun SENSE
Multiple Model(s) No.: N/A
Trade Mark: Therabody
Date Received: 2023/03/29
Report Date: 2023/05/15

Test Result:	Pass*
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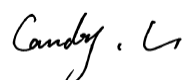
* In the configuration tested, the EUT complied with the standards above.

Prepared and Checked By:

Approved By:



Andy Yu
EMC Engineer



Candy Li
EMC Engineer

Note: This report may contain data that are not covered by the A2LA accreditation and are marked with an asterisk "★".

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DOCUMENT REVISION HISTORY

Revision Number	Report Number	Description of Revision	Date of Revision
0	RA230329-15467E-RF	Original Report	2023/05/15

GENERAL INFORMATION

Product Description for Equipment under Test (EUT)

HVIN	Theragun SENSE
FVIN	1.0.0
Frequency Range	BLE: 2402-2480MHz
Maximum Conducted Peak Output Power	BLE: 1.04dBm
Modulation Technique	BLE: GFSK
Antenna Specification*	2.71dBi (provided by the applicant)
Voltage Range	DC 10.8V from battery or DC 5V-15V from USB port
Sample serial number	24ZO_2 (RF Conducted Test) 24ZO_3 (RF Radiated Test) (Assigned by ATC)
Sample/EUT Status	Good condition

Objective

This report is in accordance with FCC Part 15, Subpart C, and section 15.203, 15.205, 15.209, 15.247 rules and RSS-GEN Issue 5, February 2021 Amendment 2 and RSS-247, Issue 2, February 2017 of the Innovation, Science and Economic Development Canada rules.

Test Methodology

All tests and measurements indicated in this document were performed in accordance ANSI C63.10-2013, RSS-GEN Issue 5, February 2021 Amendment 2 and RSS-247, Issue 2, February 2017.

And KDB 558074 D01 15.247 Meas Guidance v05r02.

All emissions measurement was performed at Shenzhen Accurate Technology Co., Ltd. The radiated testing was performed at an antenna-to-EUT distance of 3 meters.

Measurement Uncertainty

Parameter		Uncertainty
Harmonic Current		0.512%, k=2
Occupied Channel Bandwidth		5%
RF Frequency		0.082×10^{-7}
RF output power, conducted		0.71dB
Unwanted Emission, conducted		1.6dB
AC Power Lines Conducted Emissions	9k-30MHz	2.74dB, k=2
	150kHz-30MHz	2.92dB, k=2
Audio Frequency Response		0.1dB
Low Pass Filter Response		1.2dB
Modulation Limiting		1%
Emissions, Radiated	9kHz - 30MHz	2.06dB
	30MHz - 1GHz	5.08dB
	1GHz - 18GHz	4.96dB
	18GHz - 26.5GHz	5.16dB
	26.5GHz - 40GHz	4.64dB
Temperature		1 °C
Humidity		6%
Supply voltages		0.4%

Note: The extended uncertainty given in this report is obtained by combining the standard uncertainty times the coverage factor K with the 95% confidence interval. Otherwise required by the applicant or Product Regulations, Decision Rule in this report did not consider the uncertainty.

Test Facility

The test site used by Shenzhen Accurate Technology Co., Ltd. to collect test data is located on the Floor 1, KuMaKe Building, Dongzhou Community, Guangming Street, Guangming District, Shenzhen, Guangdong, China.

The test site has been approved by the FCC under the KDB 974614 D01 and is listed in the FCC Public Access Link (PAL) database, FCC Registration No.: 708358, the FCC Designation No.: CN1189. Accredited by American Association for Laboratory Accreditation (A2LA) The Certificate Number is 429 7.01.

The lab has been recognized by Innovation, Science and Economic Development Canada to test to Canadian radio equipment requirements, the CAB identifier: CN0016. The Registration Number is 30241.

SYSTEM TEST CONFIGURATION

Description of Test Configuration

For BLE mode, 40 channels are provided to testing:

Channel	Frequency (MHz)	Channel	Frequency (MHz)
0	2402	20	2442
1	2404	21	2444
2	2406	22	2446
3	2408	23	2448
4	2410	24	2450
5	2412	25	2452
6	2414	26	2454
7	2416	27	2456
8	2418	28	2458
9	2420	29	2460
10	2422	30	2462
11	2424	31	2464
12	2426	32	2466
13	2428	33	2468
14	2430	34	2470
15	2432	35	2472
16	2434	36	2474
17	2436	37	2476
18	2438	38	2478
19	2440	39	2480

EUT was tested with Channel 0, 19 and 39.

Equipment Modifications

No modification was made to the EUT tested.

EUT Exercise Software

“SSCOM5.13.1” software was used to test and power level as below:

Mode	Data rate	Power Level*		
		Low Channel	Middle Channel	High Channel
BLE	1Mbps	0F	0F	0F
	2Mbps	0F	0F	0F

The software and power level was provided by the applicant.

Duty cycle

Test Result: Compliant. Please refer to the Appendix

Support Equipment List and Details

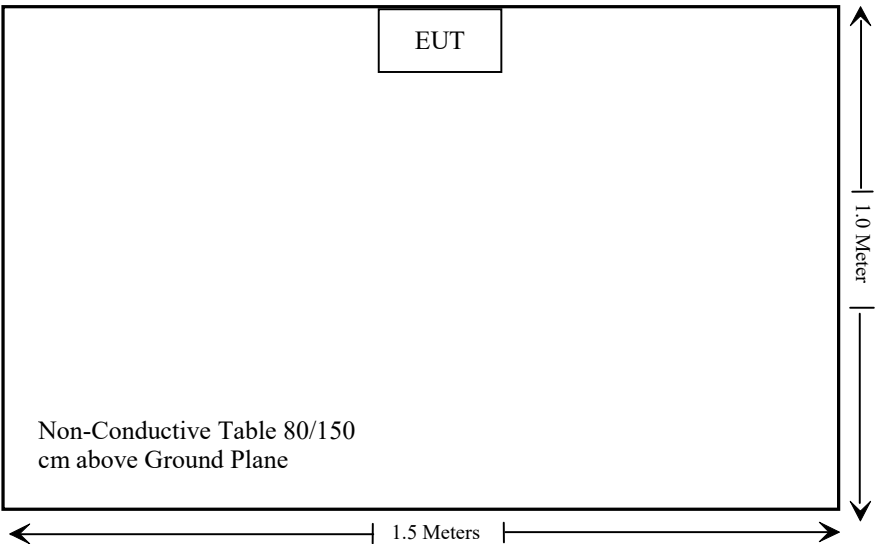
Manufacturer	Description	Model	Serial Number
/	/	/	/

External I/O Cable

Cable Description	Length (m)	From Port	To
/	/	/	/

Block Diagram of Test Setup

For Radiated Emissions:



Note: the support table edge was flushed with the center of turntable.

SUMMARY OF TEST RESULTS

FCC Rules	RSS Rules	Description of Test	Result
FCC §15.247 (i) & §1.1307 (b) (3) & §2.1093	RSS-102 § 2.5.1	RF Exposure & Exemption Limits For Routine Evaluation-SAR Evaluation	Compliant
§15.203	RSS-Gen §6.8	Antenna Requirement	Compliant
§15.207 (a)	RSS-Gen §8.8	AC Line Conducted Emissions	Not Applicable
§15.205, §15.209, §15.247(d)	RSS-GEN § 8.10 & RSS-247 § 5.5	Spurious Emissions	Compliant
§15.247 (a)(2)	RSS- Gen§6.7 RSS-247 § 5.2 (a)	99% Occupied Bandwidth & 6 dB Emission Bandwidth	Compliant
§15.247(b)(3)	RSS-247 § 5.4(d)	Maximum Conducted Output Power	Compliant
§15.247(e)	RSS-247 § 5.2 (b)	Power Spectral Density	Compliant
§15.247(d)	RSS-247 § 5.5	100 kHz Bandwidth of Frequency Band Edge	Compliant

Not Applicable: the EUT powered by battery when operating.

TEST EQUIPMENT LIST

Manufacturer	Description	Model	Serial Number	Calibration Date	Calibration Due Date
Radiated emission test					
Rohde& Schwarz	Test Receiver	ESR	102725	2022/11/25	2023/11/24
Rohde&Schwarz	Spectrum Analyzer	FSV40	101949	2022/11/25	2023/11/24
SONOMA INSTRUMENT	Amplifier	310 N	186131	2022/11/08	2023/11/07
A.H. Systems, inc.	Preamplifier	PAM-0118P	135	2022/11/08	2023/11/07
Quinstar	Amplifier	QLW-18405536-J0	15964001002	2022/11/08	2023/11/07
Schwarzbeck	Bilog Antenna	VULB9163	9163-323	2021/07/06	2024/07/05
Schwarzbeck	Horn Antenna	BBHA9120D	9120D-1067	2022/11/30	2025/11/29
Schwarzbeck	HORN ANTENNA	BBHA9170	9170-359	2022/12/26	2025/12/25
Radiated Emission Test Software: e3 19821b (V9)					
Unknown	RF Coaxial Cable	No.10	N050	2022/11/25	2023/11/24
Unknown	RF Coaxial Cable	No.11	N1000	2022/11/25	2023/11/24
Unknown	RF Coaxial Cable	No.12	N040	2022/11/25	2023/11/24
Unknown	RF Coaxial Cable	No.13	N300	2022/11/25	2023/11/24
Unknown	RF Coaxial Cable	No.14	N800	2022/11/25	2023/11/24
Unknown	RF Coaxial Cable	No.15	N600	2022/11/25	2023/11/24
Unknown	RF Coaxial Cable	No.16	N650	2022/11/25	2023/11/24
RF conducted test					
Rohde&Schwarz	Spectrum Analyzer	FSV-40	101948	2022/11/25	2023/11/24
WEINSCHHEL	3dB Attenuator	Unknown	F-03-EM121	2022/11/25	2023/11/24
Unknown	RF Coaxial Cable	No.31	RF-01	Each time	

* **Statement of Traceability:** Shenzhen Accurate Technology Co., Ltd. attests that all calibrations have been performed in accordance to requirements that traceable to National Primary Standards and International System of Units (SI).

FCC§15.247 (i), §1.1307 (b) (3) &§2.1093 – RF EXPOSURE

Applicable Standard

According to FCC §2.1093 and §1.1307(b) (3), systems operating under the provisions of this section shall be operated in a manner that ensure that the public is not exposed to radio frequency energy level in excess of the Commission's guideline.

According to KDB 447498 D04 Interim General RF Exposure Guidance

SAR-Based Exemption:

SAR-based thresholds are derived based on frequency, power, and separation distance of the RF source. The formula defines the thresholds in general for either available maximum timeaveraged power or maximum time-averaged ERP, whichever is greater.

Per § 1.1307(b)(3)(i)(B), for single RF sources (i.e., any single fixed RF source, mobile device, or portable device, as defined in paragraph (b)(2) of this section): A single RF source is exempt if:

the available maximum time-averaged power or effective radiated power (ERP), whichever is greater, is less than or equal to the threshold P_{th} (mW) described in the following formula. This method shall only be used at separation distances (cm) from 0.5 centimeters to 40 centimeters and at frequencies from 0.3 GHz to 6 GHz (inclusive). P_{th} is given by:

$$P_{th} \text{ (mW)} = \begin{cases} ERP_{20 \text{ cm}} (d/20 \text{ cm})^x & d \leq 20 \text{ cm} \\ ERP_{20 \text{ cm}} & 20 \text{ cm} < d \leq 40 \text{ cm} \end{cases}$$

Where

$$x = -\log_{10} \left(\frac{60}{ERP_{20 \text{ cm}} \sqrt{f}} \right) \text{ and } f \text{ is in GHz;}$$

and

$$ERP_{20 \text{ cm}} \text{ (mW)} = \begin{cases} 2040f & 0.3 \text{ GHz} \leq f < 1.5 \text{ GHz} \\ 3060 & 1.5 \text{ GHz} \leq f \leq 6 \text{ GHz} \end{cases}$$

d = the separation distance (cm);

For worst case:

Exemption limit:

For $f=2.48\text{GHz}$, $d=0.5\text{cm}$, the $P_{th}=2.72\text{mW}$

The higher of the available maximum time-averaged power or effective radiated power (ERP):

The antenna gain is 2.71dBi (0.56dBd), 0dBd=2.15dBi

The maximum tune up conducted power is 1.5dBm

The maximum tune-up ERP is 2.06dBm (1.61mW), which less than 2.72 mW@2480MHz exemption limit

So the stand-alone SAR test can be exempted.

RSS-102 § 2.5.1 - EXEMPTION LIMITS FOR ROUTINE EVALUATION – SAR EVALUATION

Applicable Standard

According to RSS-102 Issue 5 § (2.5.1), SAR evaluation is required if the separation distance between the user and/or bystander and the antenna and/or radiating element of the device is less than or equal to 20 cm, except when the device operates at or below the applicable output power level (adjusted for tune-up tolerance) for the specified separation distance defined in Table 1.

Table 1: SAR evaluation – Exemption limits for routine evaluation based on frequency and separation distance^{4,5}

Frequency (MHz)	Exemption Limits (mW)				
	At separation distance of ≤5 mm	At separation distance of 10 mm	At separation distance of 15 mm	At separation distance of 20 mm	At separation distance of 25 mm
≤300	71 mW	101 mW	132 mW	162 mW	193 mW
450	52 mW	70 mW	88 mW	106 mW	123 mW
835	17 mW	30 mW	42 mW	55 mW	67 mW
1900	7 mW	10 mW	18 mW	34 mW	60 mW
2450	4 mW	7 mW	15 mW	30 mW	52 mW
3500	2 mW	6 mW	16 mW	32 mW	55 mW
5800	1 mW	6 mW	15 mW	27 mW	41 mW

Frequency (MHz)	Exemption Limits (mW)				
	At separation distance of 30 mm	At separation distance of 35 mm	At separation distance of 40 mm	At separation distance of 45 mm	At separation distance of ≥50 mm
≤300	223 mW	254 mW	284 mW	315 mW	345 mW
450	141 mW	159 mW	177 mW	195 mW	213 mW
835	80 mW	92 mW	105 mW	117 mW	130 mW
1900	99 mW	153 mW	225 mW	316 mW	431 mW
2450	83 mW	123 mW	173 mW	235 mW	309 mW
3500	86 mW	124 mW	170 mW	225 mW	290 mW
5800	56 mW	71 mW	85 mW	97 mW	106 mW

Output power level shall be the higher of the maximum conducted or equivalent isotropically radiated power (e.i.r.p.) source-based, time-averaged output power. For controlled use devices where the 8 W/kg for 1 gram of tissue applies, the exemption limits for routine evaluation in Table 1 are multiplied by a factor of 5. For limb-worn devices where the 10 gram value applies, the exemption limits for routine evaluation in Table 1 are multiplied by a factor of 2.5. If the operating frequency of the device is between two frequencies located in Table 1, linear interpolation shall be applied for the applicable separation distance. For test separation distance less than 5 mm, the exemption limits for a separation distance of 5 mm can be applied to determine if a routine evaluation is required.

For medical implants devices, the exemption limit for routine evaluation is set at 1 mW. The output power of a medical implants device is defined as the higher of the conducted or e.i.r.p to determine whether the device is exempt from the SAR evaluation.

Test Result:

For worst case:

The higher of the conducted or equivalent isotropically radiated power (e.i.r.p.) source-based, time-averaged output power:

$$(2480-2450)/(3500-2450) = (4-P)/(4-2)$$

The exemption limit of 2480MHz is $P = 3.94\text{mW}$

The antenna gain is 2.71dBi, the maximum tune up conducted power is 1.5dBm

The maximum tune up conducted power is 4.21dBm (2.64mW), which less than 3.94mW@2480MHz exemption limit

So the stand-alone SAR evaluation can be compliance.

FCC §15.203 & RSS-GEN §6.8 – ANTENNA REQUIREMENT

Applicable Standard

According to FCC § 15.203, an intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this Section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited.

According to FCC § 15.203, the applicant for equipment certification shall provide a list of all antenna types that may be used with the transmitter, where applicable (i.e. for transmitters with detachable antenna), indicating the maximum permissible antenna gain (in dBi) and the required impedance for each antenna. The test report shall demonstrate the compliance of the transmitter with the limit for maximum equivalent isotropically radiated power (e.i.r.p.) specified in the applicable RSS, when the transmitter is equipped with any antenna type, selected from this list.

For expediting the testing, measurements may be performed using only the antenna with highest gain of each combination of transmitter and antenna type, with the transmitter output power set at the maximum level. However, the transmitter shall comply with the applicable requirements under all operational conditions and when in combination with any type of antenna from the list provided in the test report (and in the notice to be included in the user manual, provided below).

When measurements at the antenna port are used to determine the RF output power, the effective gain of the device's antenna shall be stated, based on a measurement or on data from the antenna's manufacturer.

The test report shall state the RF power, output power setting and spurious emission measurements with each antenna type that is used with the transmitter being tested.

For licence-exempt equipment with detachable antennas, the user manual shall also contain the following notice in a conspicuous location:

This radio transmitter [enter the device's ISED certification number] has been approved by Innovation, Science and Economic Development Canada to operate with the antenna types listed below, with the maximum permissible gain indicated. Antenna types not included in this list that have a gain greater than the maximum gain indicated for any type listed are strictly prohibited for use with this device. Immediately following the above notice, the manufacturer shall provide a list of all antenna types which can be used with the transmitter, indicating the maximum permissible antenna gain (in dBi) and the required impedance for each antenna type.

Antenna Connector Construction

The EUT has one internal antenna arrangement which was permanently attached and the maximum antenna gain is 2.71dBi, fulfill the requirement of this section. Please refer to the EUT photos.

Antenna type	Antenna Gain	Impedance	Frequency Range
Chip	2.71dBi	50 Ω	2400-2483.5MHz

Result: Compliance

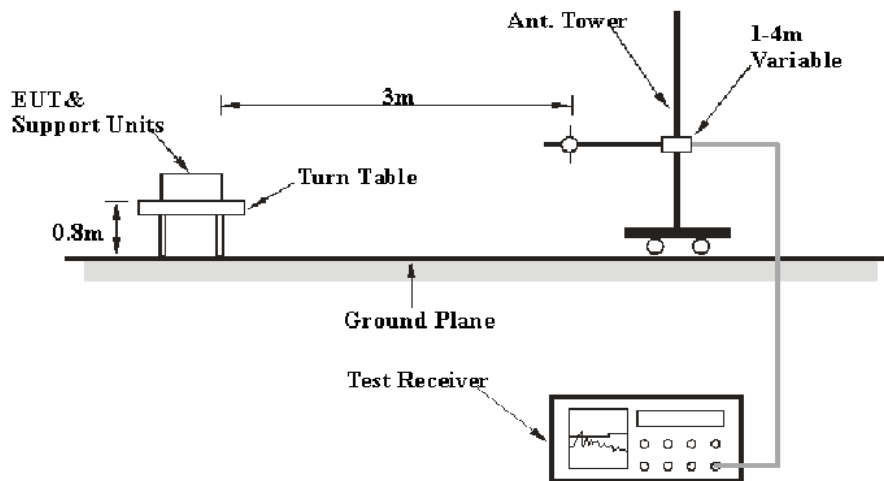
FCC §15.209, §15.205 & §15.247(D), RSS-GEN § 8.10 & RSS-247 § 5.5 – UNWANTED EMISSION FREQUENCIES AND RESTRICTED BANDS

Applicable Standard

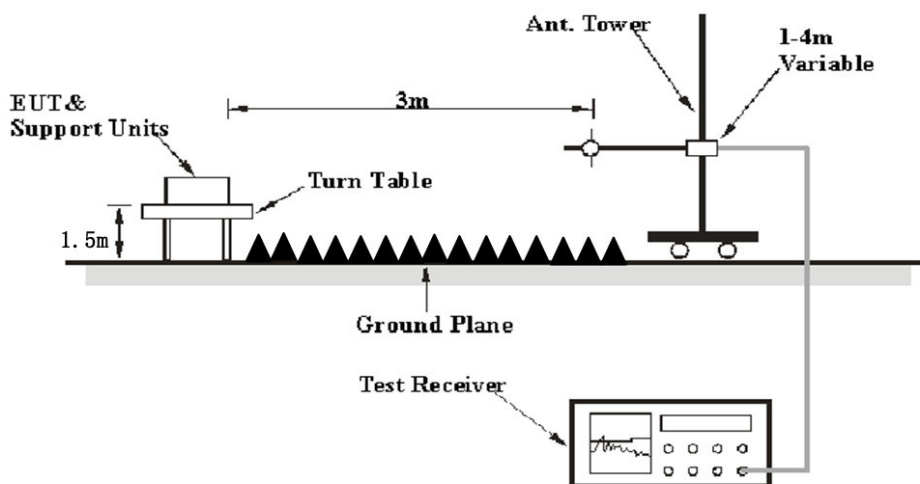
FCC §15.247 (d); §15.209; §15.205; RSS-247 §5.5, RSS-GEN §8.10.

EUT Setup

Below 1 GHz:



Above 1GHz:



The radiated emission tests were performed in the 3meters test site, using the setup accordance with the ANSI C63.10-2013. The specification used was the FCC 15.205, FCC 15.209, FCC 15.247, RSS-Gen and RSS-247 limits.

The external I/O cables were draped along the test table and formed a bundle 30 to 40 cm long in the middle.

EMI Test Receiver & Spectrum Analyzer Setup

The system was investigated from 30 MHz to 25 GHz.

During the radiated emission test, the EMI test receiver & Spectrum Analyzer Setup were set with the following configurations:

Frequency Range	RBW	Video B/W	IF B/W	Measurement
30MHz – 1000 MHz	100 kHz	300 kHz	120kHz	QP
Above 1 GHz	1MHz	3 MHz	/	PK
	1MHz	10 Hz ^{Note 1}	/	Average
	1MHz	> 1/T ^{Note 2}	/	Average

Note 1: when duty cycle is no less than 98%

Note 2: when duty cycle is less than 98%

Test Procedure

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

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

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.

Repeat above procedures until all measured frequencies were complete.

Factor & Margin Calculation

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

$$\text{Factor} = \text{Antenna Factor} + \text{Cable Loss} - \text{Amplifier Gain}$$

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

$$\begin{aligned} \text{Over Limit/Margin} &= \text{Level} / \text{Corrected Amplitude} - \text{Limit} \\ \text{Level} / \text{Corrected Amplitude} &= \text{Read Level} + \text{Factor} \end{aligned}$$

Test Results Summary

According to the data in the following table, the EUT complied with the FCC 15.205, FCC 15.209, FCC 15.247, RSS-Gen and RSS-247.

Test Data**Environmental Conditions**

Temperature:	24 °C
Relative Humidity:	56 %
ATM Pressure:	101.0 kPa

The testing was performed by Jimi Zheng on 2023-05-12 for below 1GHz and on 2023-04-15 for above 1GHz.

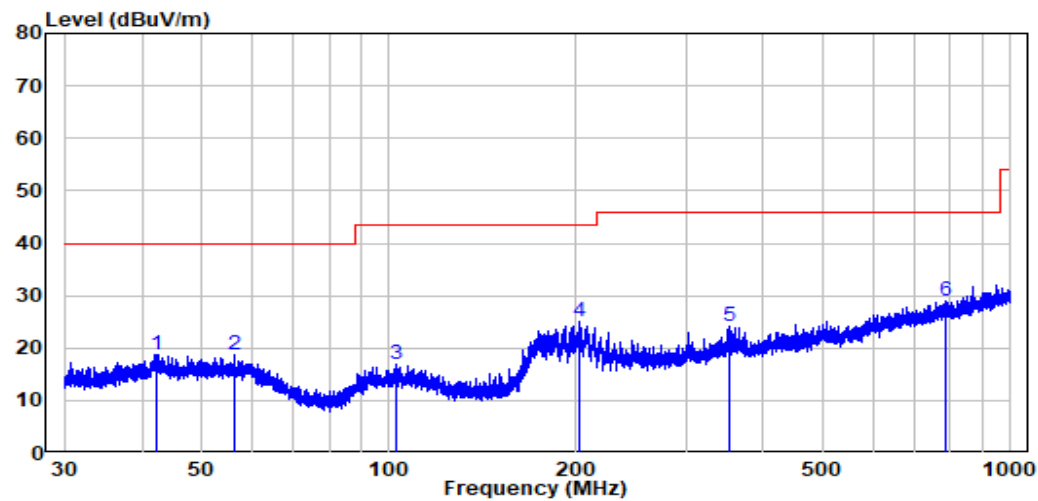
EUT operation mode: Transmitting

Note: Pre-scan in the X, Y and Z axes of orientation, the worst case X-axis of orientation was recorded

30MHz-1GHz: (Worst case is BLE 1M middle channel)

Note: When the test result of peak was less than the limit of QP more than 6dB, just peak value were recorded.

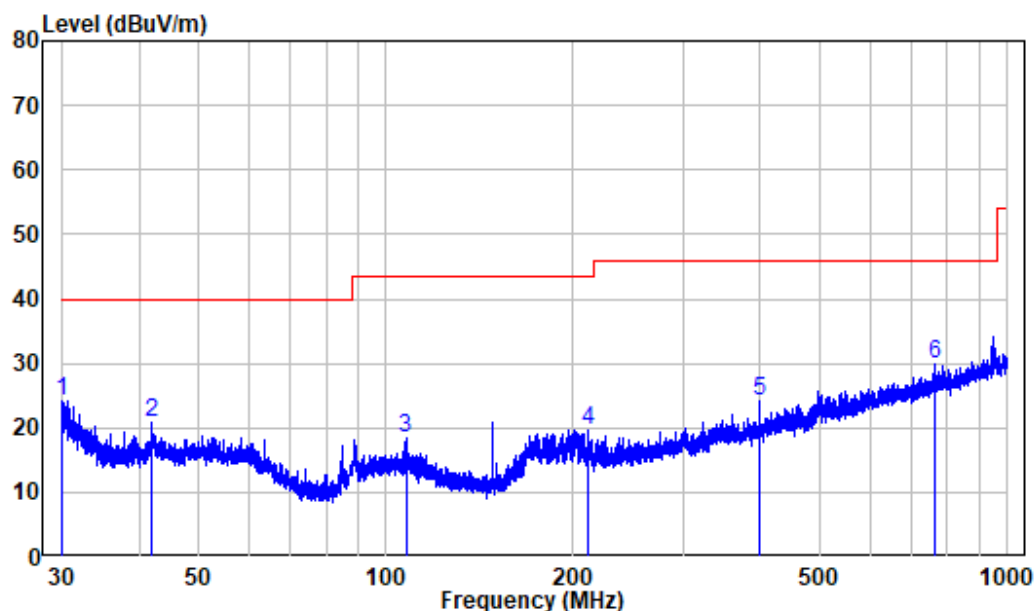
Horizontal



Site : chamber
Condition: 3m HORIZONTAL
Job No. : RA230329-15467E-RF
Test Mode: Transmitting

	Freq	Factor	Read Level	Level	Limit Line	Over Limit	Remark
	MHz	dB/m	dBuV	dBuV/m	dBuV/m	dB	
1	42.339	-10.00	28.74	18.74	40.00	-21.26	Peak
2	56.222	-10.16	28.75	18.59	40.00	-21.41	Peak
3	102.900	-11.65	28.59	16.94	43.50	-26.56	Peak
4	202.544	-11.61	36.76	25.15	43.50	-18.35	Peak
5	353.563	-7.44	31.56	24.12	46.00	-21.88	Peak
6	788.542	-0.11	29.04	28.93	46.00	-17.07	Peak

Vertical



Site : chamber
 Condition: 3m VERTICAL
 Job No. : RA230329-15467E-RF
 Test Mode: Transmitting

	Freq	Factor	Read Level	Level	Limit Line	Over Limit	Remark
	MHz	dB/m	dBuV	dBuV/m	dBuV/m	dB	
1	30.119	-12.39	36.48	24.09	40.00	-15.91	Peak
2	42.025	-10.02	30.81	20.79	40.00	-19.21	Peak
3	107.557	-11.98	30.30	18.32	43.50	-25.18	Peak
4	211.156	-11.81	31.52	19.71	43.50	-23.79	Peak
5	400.081	-6.73	30.88	24.15	46.00	-21.85	Peak
6	765.051	-0.41	30.43	30.02	46.00	-15.98	Peak

1-25 GHz:

BLE 1M

Frequency (MHz)	Receiver		Turntable Angle Degree	Rx Antenna		Factor (dB/m)	Absolute Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)
	Reading (dBμV)	PK/Ave		Height (m)	Polar (H/V)				
Low Channel(2402MHz)									
2311.2	54.09	PK	108	1.9	H	-10.38	43.71	74	-30.29
2311.2	39.91	AV	108	1.9	H	-10.38	29.53	54	-24.47
2366	55.05	PK	250	2.3	V	-10.75	44.30	74	-29.70
2366	41.00	AV	250	2.3	V	-10.75	30.25	54	-23.75
2390	53.86	PK	296	1.1	H	-10.70	43.16	74	-30.84
2390	40.94	AV	296	1.1	H	-10.70	30.24	54	-23.76
2390	52.69	PK	163	2.3	V	-10.70	41.99	74	-32.01
2390	40.86	AV	163	2.3	V	-10.70	30.16	54	-23.84
4804	57.75	PK	74	2.4	H	-6.11	51.64	74	-22.36
4804	45.40	AV	74	2.4	H	-6.11	39.29	54	-14.71
4804	57.86	PK	63	2.5	V	-6.11	51.75	74	-22.25
4804	47.19	AV	63	2.5	V	-6.11	41.08	54	-12.92
Middle Channel(2440MHz)									
4880	57.10	PK	124	1.4	H	-5.91	51.19	74	-22.81
4880	48.82	AV	124	1.4	H	-5.91	42.91	54	-11.09
4880	57.80	PK	155	1.6	V	-5.91	51.89	74	-22.11
4880	50.01	AV	155	1.6	V	-5.91	44.1	54	-9.90
High Channel(2480 MHz)									
2483.5	54.08	PK	255	1.8	H	-10.55	43.53	74	-30.47
2483.5	40.90	AV	255	1.8	H	-10.55	30.35	54	-23.65
2483.5	65.66	PK	315	1.2	V	-10.55	55.11	74	-18.89
2483.5	52.75	AV	315	1.2	V	-10.55	42.2	54	-11.80
2488.84	55.40	PK	266	1.8	H	-10.51	44.89	74	-29.11
2488.84	41.01	AV	266	1.8	H	-10.51	30.5	54	-23.50
2493.67	66.87	PK	115	1	V	-10.47	56.4	74	-17.60
2493.67	52.79	AV	115	1	V	-10.47	42.32	54	-11.68
4960	59.52	PK	152	1.9	H	-5.47	54.05	74	-19.95
4960	50.43	AV	152	1.9	H	-5.47	44.96	54	-9.04
4960	59.73	PK	317	1.3	V	-5.47	54.26	74	-19.74
4960	53.46	AV	317	1.3	V	-5.47	47.99	54	-6.01

BLE 2M

Frequency (MHz)	Receiver		Turntable Angle Degree	Rx Antenna		Factor (dB/m)	Absolute Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)
	Reading (dBμV)	PK/Ave		Height (m)	Polar (H/V)				
Low Channel(2402MHz)									
2338.5	65.28	PK	205	1.3	H	-10.67	54.61	74	-19.39
2338.5	51.34	AV	205	1.3	H	-10.67	40.67	54	-13.33
2389.5	66.35	PK	103	1.6	V	-10.70	55.65	74	-18.35
2389.5	52.48	AV	103	1.6	V	-10.70	41.78	54	-12.22
2390	63.63	PK	37	2.1	H	-10.70	52.93	74	-21.07
2390	51.94	AV	37	2.1	H	-10.70	41.24	54	-12.76
2390	65.20	PK	343	2.5	V	-10.70	54.50	74	-19.50
2390	52.45	AV	343	2.5	V	-10.70	41.75	54	-12.25
4804	56.98	PK	98	2.1	H	-6.11	50.87	74	-23.13
4804	44.85	AV	98	2.1	H	-6.11	38.74	54	-15.26
4804	57.61	PK	155	2.5	V	-6.11	51.50	74	-22.50
4804	45.21	AV	155	2.5	V	-6.11	39.10	54	-14.90
Middle Channel(2440MHz)									
4880	58.42	PK	247	1.2	H	-5.91	52.51	74	-21.49
4880	45.85	AV	247	1.2	H	-5.91	39.94	54	-14.06
4880	58.41	PK	267	1.2	V	-5.91	52.5	74	-21.50
4880	45.97	AV	267	1.2	V	-5.91	40.06	54	-13.94
High Channel(2480 MHz)									
2483.5	53.27	PK	3	2	H	-10.55	42.72	74	-31.28
2483.5	41.47	AV	3	2	H	-10.55	30.92	54	-23.08
2483.5	53.26	PK	329	1.8	V	-10.55	42.71	74	-31.29
2483.5	41.48	AV	329	1.8	V	-10.55	30.93	54	-23.07
2489.41	55.74	PK	331	1.8	H	-10.50	45.24	74	-28.76
2489.41	41.53	AV	331	1.8	H	-10.50	31.03	54	-22.97
2492.44	55.36	PK	169	2.2	V	-10.48	44.88	74	-29.12
2492.44	41.47	AV	169	2.2	V	-10.48	30.99	54	-23.01
4960	58.53	PK	87	2.1	H	-5.47	53.06	74	-20.94
4960	45.18	AV	87	2.1	H	-5.47	39.71	54	-14.29
4960	58.96	PK	2	1.4	V	-5.47	53.49	74	-20.51
4960	45.80	AV	2	1.4	V	-5.47	40.33	54	-13.67

Note:

Corrected Factor = Antenna factor (RX) + Cable Loss – Amplifier Factor

Corrected Amplitude = Corrected Factor + Reading

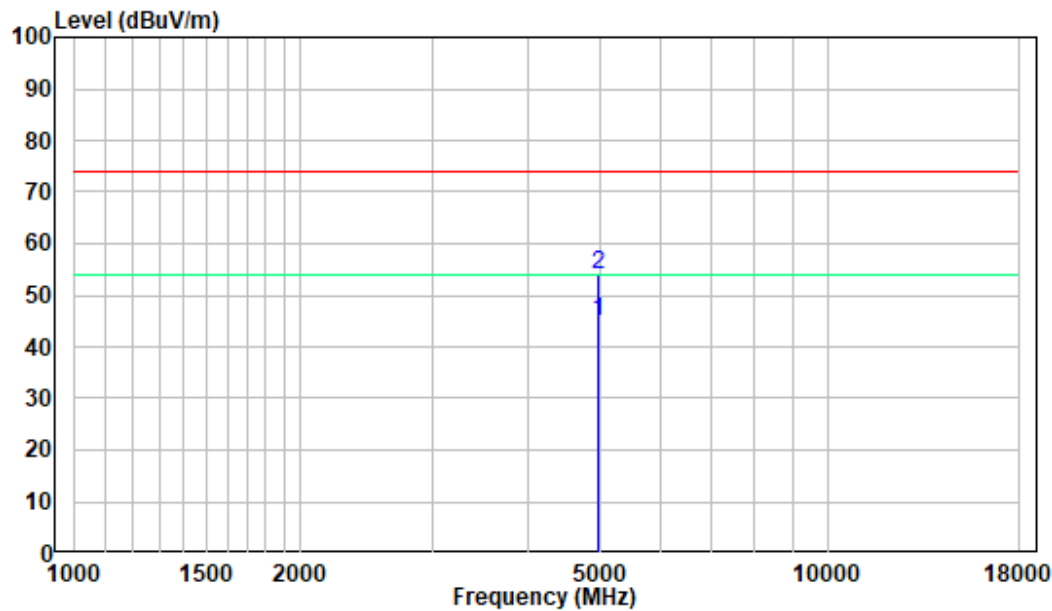
Margin = Corrected. Amplitude - Limit

The other spurious emission which is in the noise floor level was not recorded.

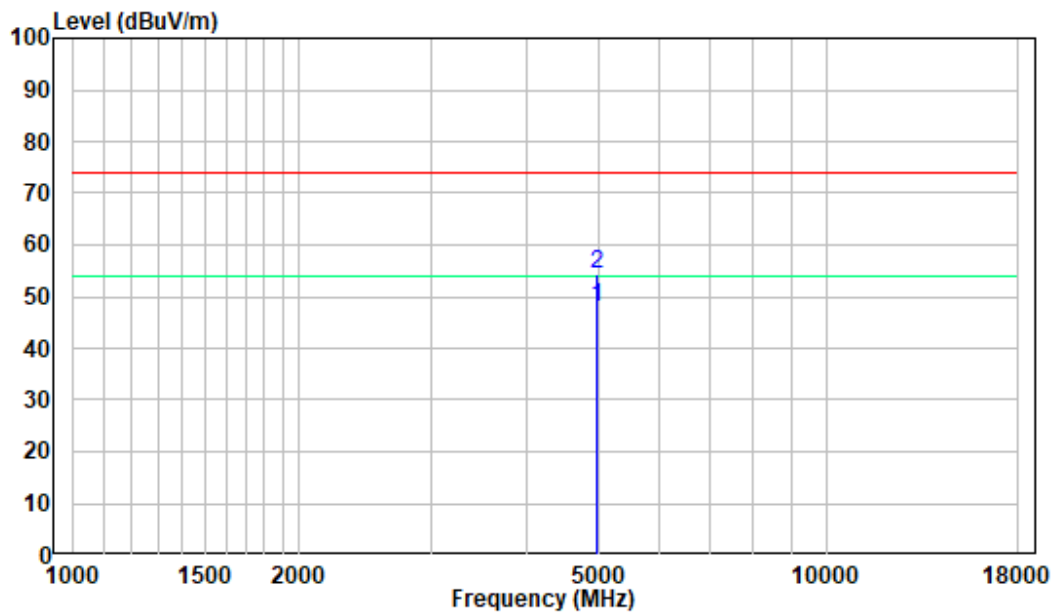
1-18 GHz:

Pre-scan for BLE 1M Low Channel

Horizontal



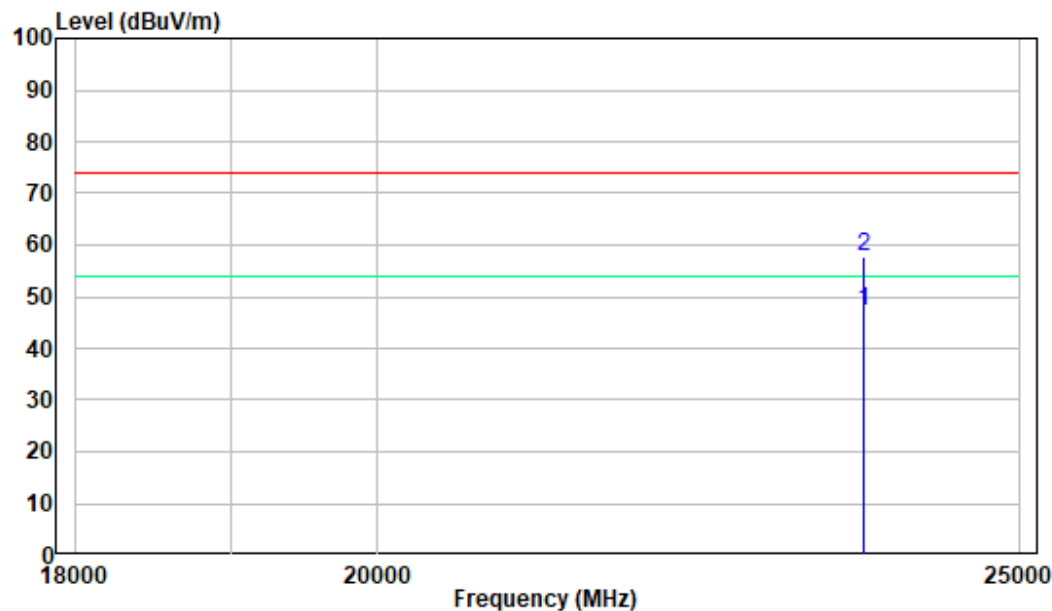
Vertical



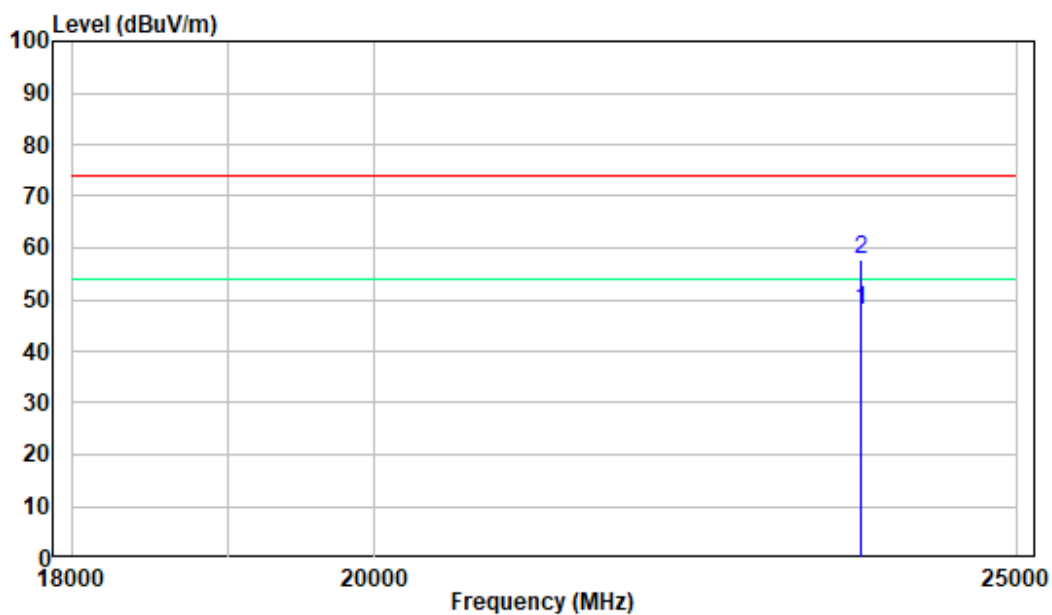
18 -25GHz:

Pre-scan for BLE 1M Low Channel

Horizontal



Vertical



FCC §15.247(a) (2), RSS-GEN § 6.7 & RSS-247 § 5.2 (a) – 99% OCCUPIED BANDWIDTH & 6 dB EMISSION BANDWIDTH

Standard Applicable

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.

According to RSS-247 §5.2 a)

The minimum 6 dB bandwidth shall be 500 kHz.

According to RSS-Gen §6.7

The occupied bandwidth or the “99% emission bandwidth” is defined as the frequency range between two points, one above and the other below the carrier frequency, within which 99% of the total transmitted power of the fundamental transmitted emission is contained. The occupied bandwidth shall be reported for all equipment in addition to the specified bandwidth required in the applicable RSSs.

In some cases, the “x dB bandwidth” is required, which is defined as the frequency range between two points, one at the lowest frequency below and one at the highest frequency above the carrier frequency, at which the maximum power level of the transmitted emission is attenuated x dB below the maximum in-band power level of the modulated signal, where the two points are on the outskirts of the in-band emission.

The following conditions shall be observed for measuring the occupied bandwidth and x dB bandwidth:

- The transmitter shall be operated at its maximum carrier power measured under normal test conditions.
- The span of the spectrum analyzer shall be set large enough to capture all products of the modulation process, including the emission skirts, around the carrier frequency, but small enough to avoid having other emissions (e.g. on adjacent channels) within the span.
- The detector of the spectrum analyzer shall be set to “Sample”. However, a peak, or peak hold, may be used in place of the sampling detector since this usually produces a wider bandwidth than the actual bandwidth (worst-case measurement). Use of a peak hold (or “Max Hold”) may be necessary to determine the occupied / x dB bandwidth if the device is not transmitting continuously.
- The resolution bandwidth (RBW) shall be in the range of 1% to 5% of the actual occupied / x dB bandwidth and the video bandwidth (VBW) shall not be smaller than three times the RBW value. Video averaging is not permitted.

Note: It may be necessary to repeat the measurement a few times until the RBW and VBW are in compliance with the above requirement.

For the 99% emission bandwidth, the trace data points are recovered and directly summed in linear power level terms. The recovered amplitude data points, beginning at the lowest frequency, are placed in a running sum until 0.5% of the total is reached, and that frequency recorded. The process is repeated for the highest frequency data points (starting at the highest frequency, at the right side of the span, and going down in frequency). This frequency is then recorded. The difference between the two recorded frequencies is the occupied bandwidth (or the 99% emission bandwidth).

Test Procedure

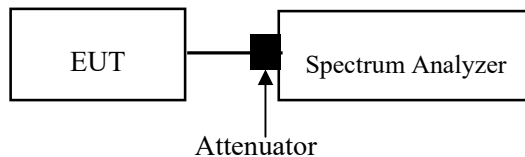
Test Method: ANSI C63.10-2013 Clause 11.8.1 & Clause 6.9.3

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 it to measurement instrument. Then set it to any one convenient frequency within its operating range. Set a reference level on the measuring instrument equal to the highest peak value.
3. Measure the frequency difference of two frequencies that were attenuated 6 dB from the reference level. Record the frequency difference as the emission bandwidth.
4. Repeat above procedures until all frequencies measured were complete.

99% Occupied bandwidth test:

Use Occupied bandwidth test function, measure the 99% Occupied bandwidth.

Repeat above procedures until all frequencies measured were complete.



Test Data

Environmental Conditions

Temperature:	27 °C
Relative Humidity:	52 %
ATM Pressure:	101.0 kPa

The testing was performed by Jacob Huang on 2023-04-28

EUT operation mode: Transmitting

Test Result: Compliant. Please refer to the Appendix.

FCC §15.247(b) (3), RSS-247 §5.4 (d) - PEAK OUTPUT POWER MEASUREMENT

Applicable Standard

According to FCC §15.247(b) (3), for 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.

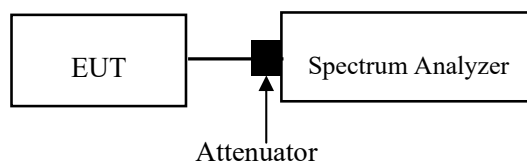
According to RSS-247§5.4 d) For DTSs employing digital modulation techniques operating in the bands 902-928 MHz and 2400-2483.5 MHz, the maximum peak conducted output power shall not exceed 1 W. Except as provided in Section 5.4(e), the e.i.r.p. shall not exceed 4 W.

As an alternative to a peak power measurement, compliance can be based on a measurement of the maximum conducted output power. The maximum conducted output power is the total transmit power delivered to all antennas and antenna elements, averaged across all symbols in the signalling 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 transmitting at a reduced power level. If multiple modes of operation are implemented, the maximum conducted output power is the highest total transmit power occurring in any mode.

Test Procedure

Test Method: ANSI C63.10-2013 Clause 11.9.1.1

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 one test equipment.
3. Add a correction factor to the display.



Test Data**Environmental Conditions**

Temperature:	27 °C
Relative Humidity:	52 %
ATM Pressure:	101.0 kPa

The testing was performed by Jacob Huang on 2023-04-28

EUT operation mode: Transmitting

Test Result: Compliant. Please refer to the Appendix.

FCC §15.247(e), RSS-247 §5.2 (b) – POWER SPECTRAL DENSITY

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.

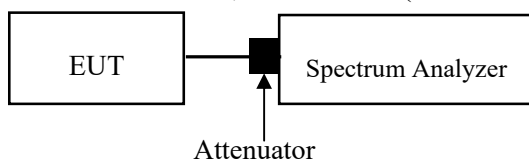
According to RSS-247 §5.2 b):

- b) The transmitter power spectral density conducted from the transmitter 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 section 5.4(d), (i.e. the power spectral density shall be determined using the same method as is used to determine the conducted output power).

Test Procedure

Test Method: ANSI C63.10-2013 Clause 11.10.2

1. Use this procedure when the maximum peak conducted output power in the fundamental emission is used to demonstrate compliance.
2. Set the RBW to: $3\text{kHz} \leq \text{RBW} \leq 100\text{ kHz}$.
3. Set the VBW $\geq 3 \times \text{RBW}$.
4. Set the span to 1.5 times the DTS bandwidth.
5. Detector = peak.
6. Sweep time = auto couple.
7. Trace mode = max hold.
8. Allow trace to fully stabilize.
9. Use the peak marker function to determine the maximum amplitude level within the RBW.
10. If measured value exceeds limit, reduce RBW (no less than 3 kHz) and repeat.



Test Data

Environmental Conditions

Temperature:	27 °C
Relative Humidity:	52 %
ATM Pressure:	101.0 kPa

The testing was performed by Jacob Huang on 2023-04-28

Test Mode: Transmitting

Test Result: Compliant. Please refer to the Appendix.

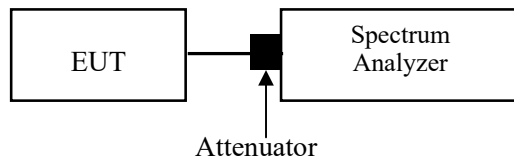
FCC §15.247(d) & RSS-247 §5.5 – 100 kHz BANDWIDTH OF FREQUENCY BAND EDGE

Applicable Standard

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)).

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced 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 that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under section 5.4(d), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required

Test Procedure



Test Method: ANSI C63.10-2013 Clause 11.11

1. Set the RBW =100 kHz.
2. Set the VBW $\geq 3 \times$ RBW.
3. Detector = peak
4. Sweep time = auto couple.
5. Trace mode=max hold
6. All trace to fully stabilize
7. Use the peak marker function to determine the maximum amplitude level.
Ensure that amplitude of all unwanted emissions outside of the authorized frequency band(excluding restricted frequency bands) is attenuated by at least the minimum requirement specified in 11.11.
Report the three highest emissions relative to the limit.

Test Data**Environmental Conditions**

Temperature:	27 °C
Relative Humidity:	52 %
ATM Pressure:	101.0 kPa

The testing was performed by Jacob Huang on 2023-04-28

EUT operation mode: Transmitting

Test Result: Compliant. Please refer to the Appendix.

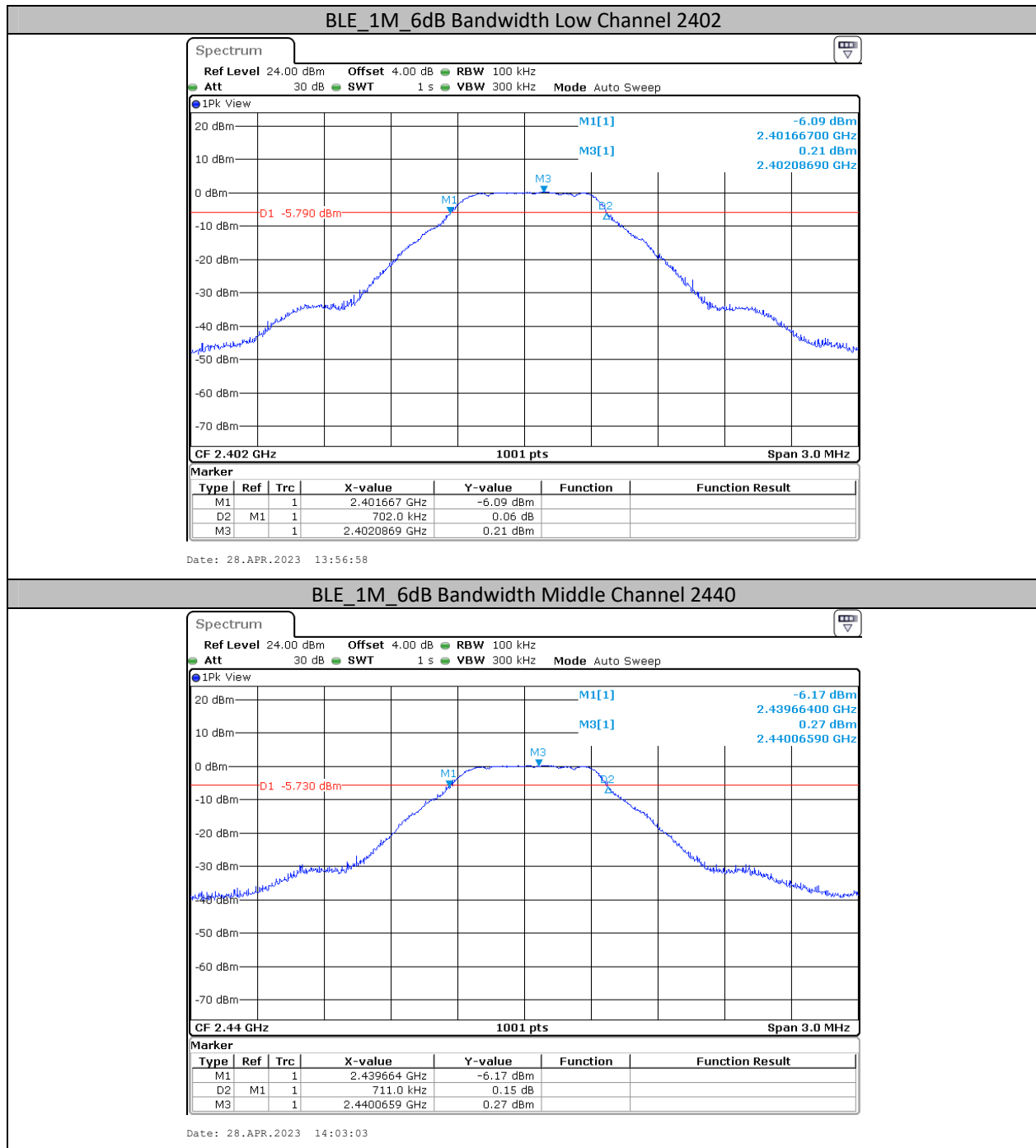
APPENDIX

Appendix A: 99% OCCUPIED BANDWIDTH & 6 dB EMISSION BANDWIDTH

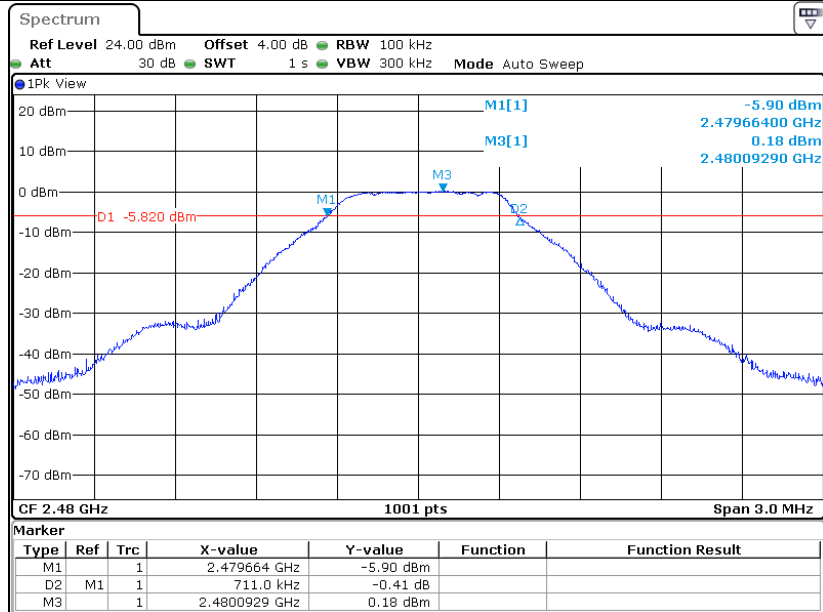
Test Result

Channel	Frequency (MHz)	6 dB Emission Bandwidth (MHz)	99% Emission Bandwidth (MHz)	Limit (kHz)
BLE 1M				
Low	2402	0.702	0.986	≥ 500
Middle	2440	0.711	1.004	≥ 500
High	2480	0.711	0.998	≥ 500
BLE 2M				
Low	2402	1.110	1.882	≥ 500
Middle	2440	1.116	1.888	≥ 500
High	2480	1.206	1.906	≥ 500

Test Graphs

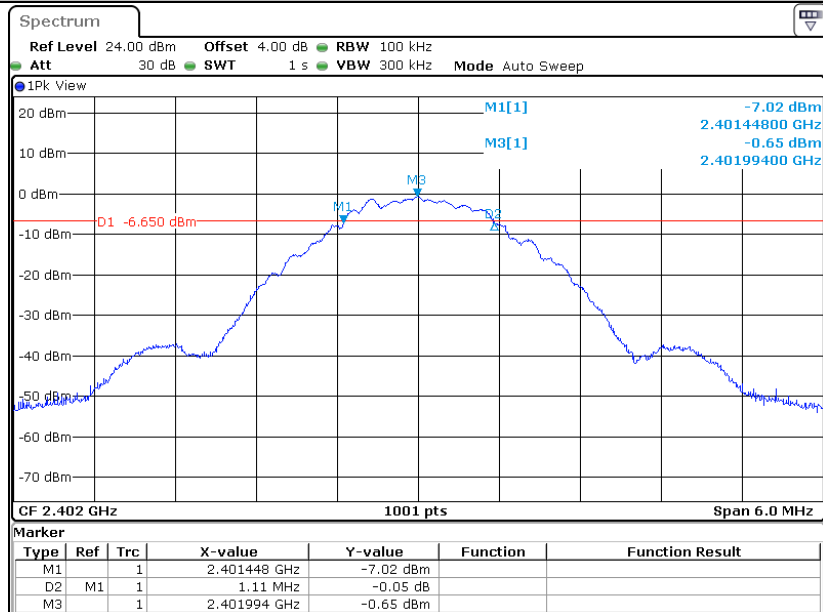


BLE_1M_6dB Bandwidth High Channel 2480



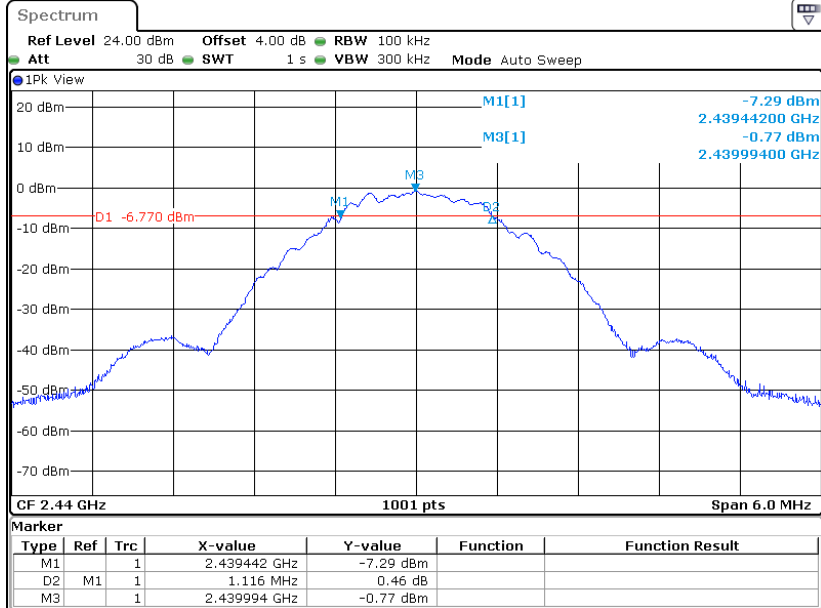
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BLE_2M_6dB Bandwidth Low Channel 2402



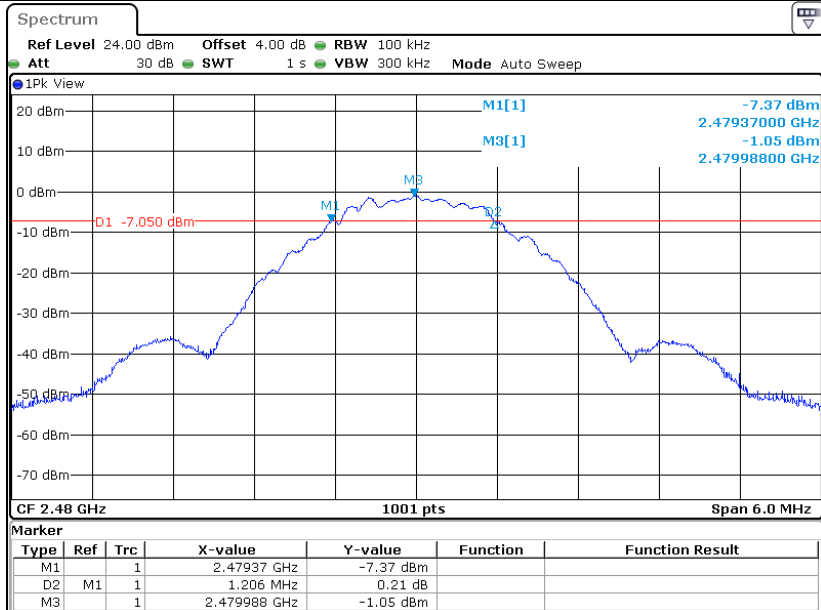
Date: 28.APR.2023 14:10:55

BLE_2M_6dB Bandwidth Middle Channel 2440

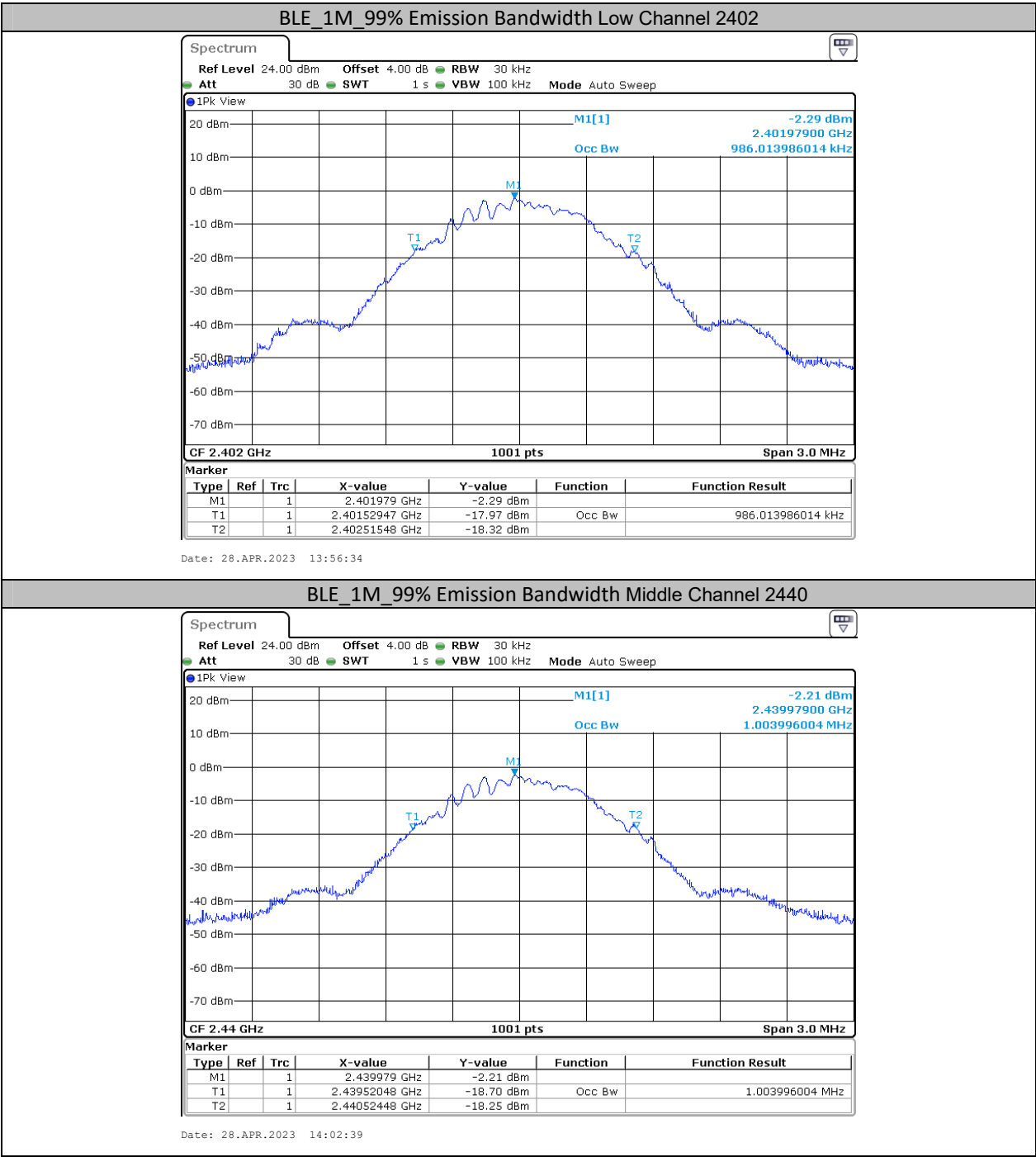


Date: 28.APR.2023 14:13:56

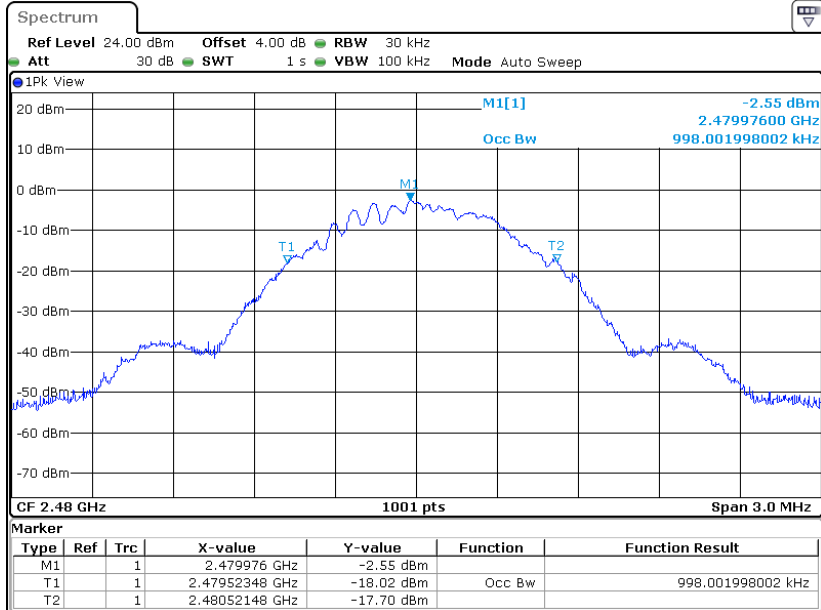
BLE_2M_6dB Bandwidth High Channel 2480



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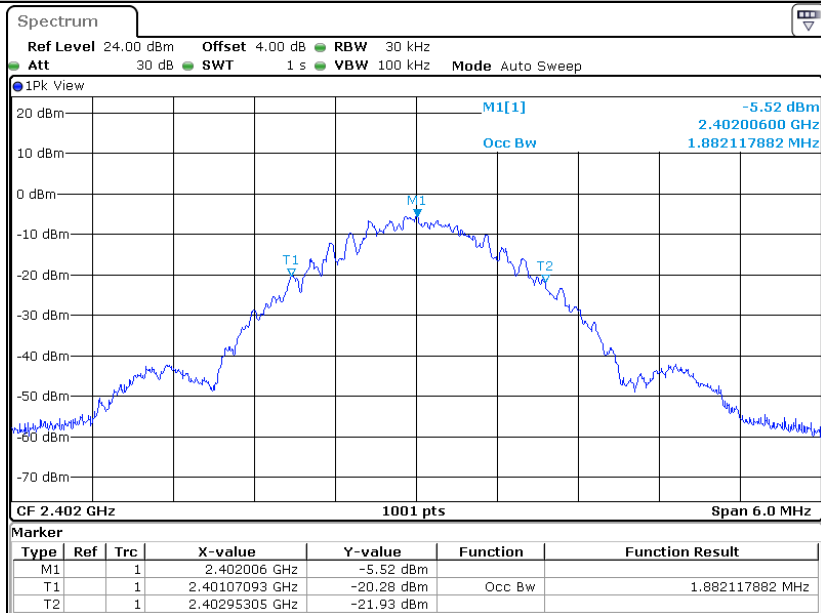


BLE_1M_99% Emission Bandwidth High Channel 2480



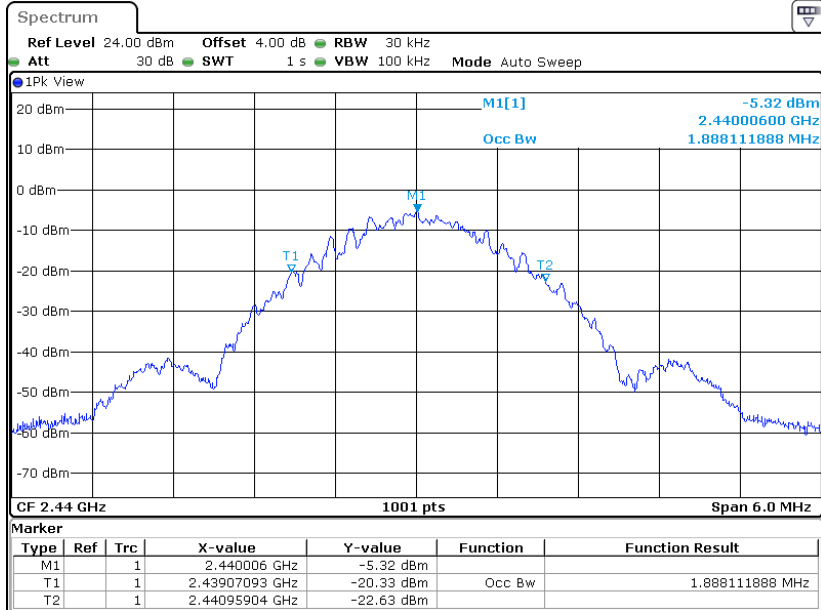
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BLE_2M_99% Emission Bandwidth Low Channel 2402



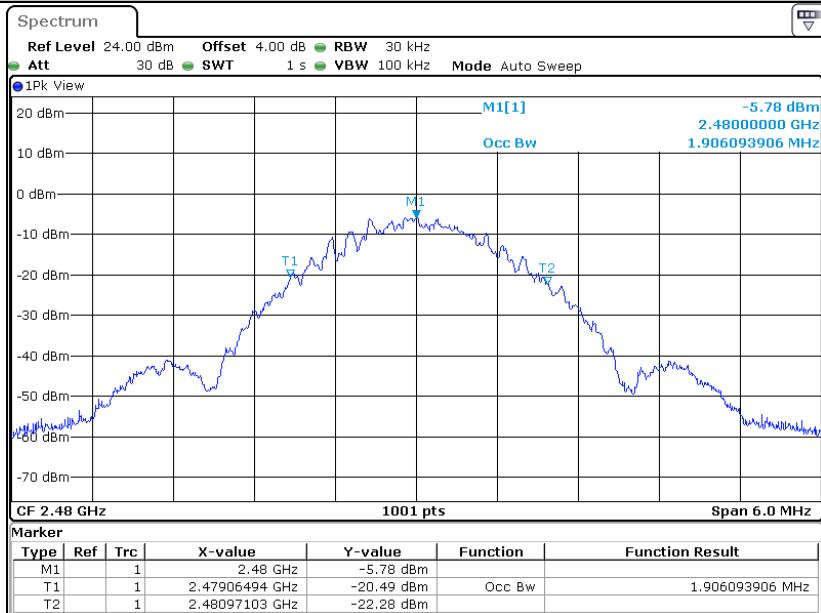
Date: 28.APR.2023 14:10:31

BLE_2M_99% Emission Bandwidth Middle Channel 2440



Date: 28.APR.2023 14:13:32

BLE_2M_99% Emission Bandwidth High Channel 2480

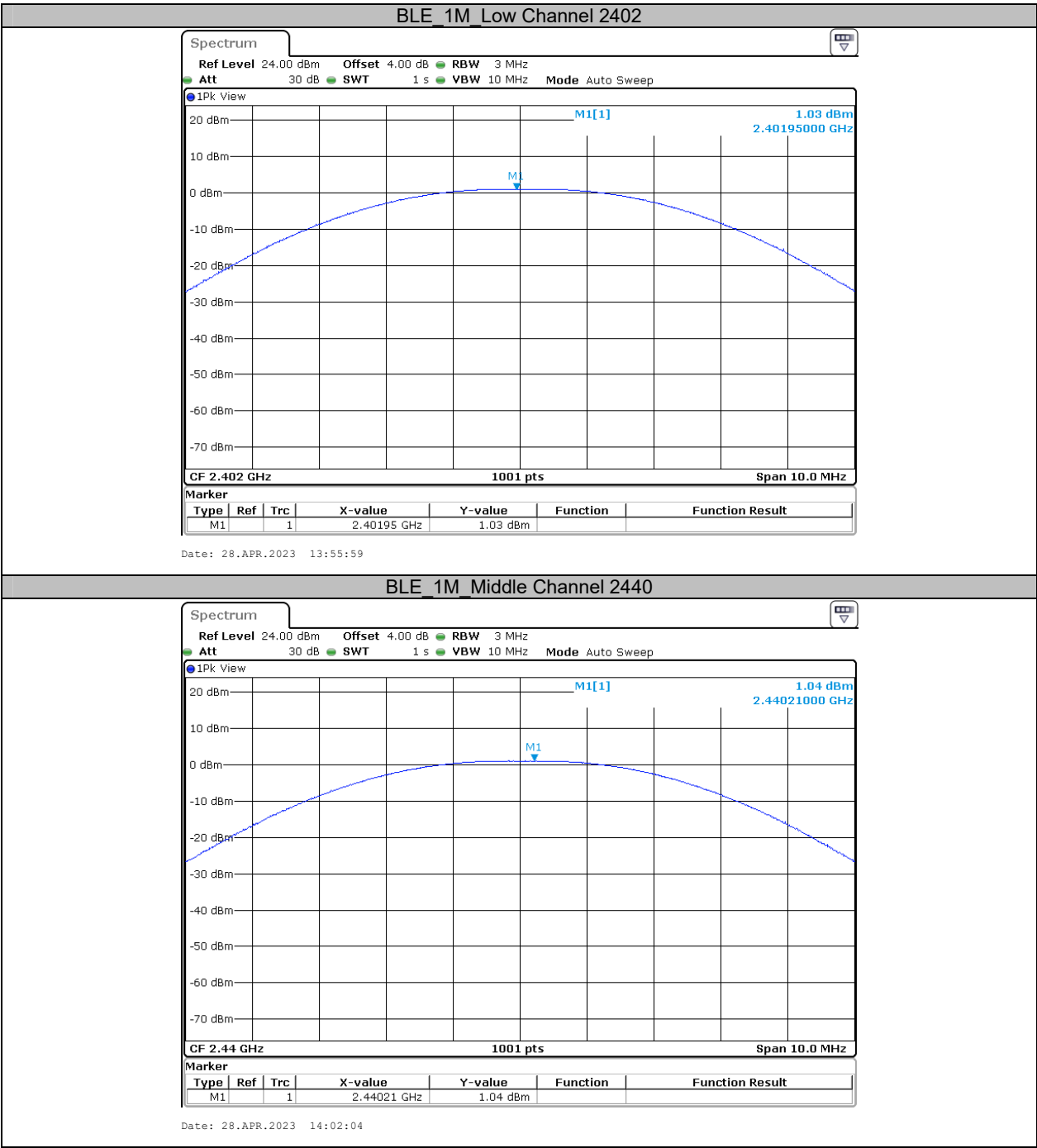


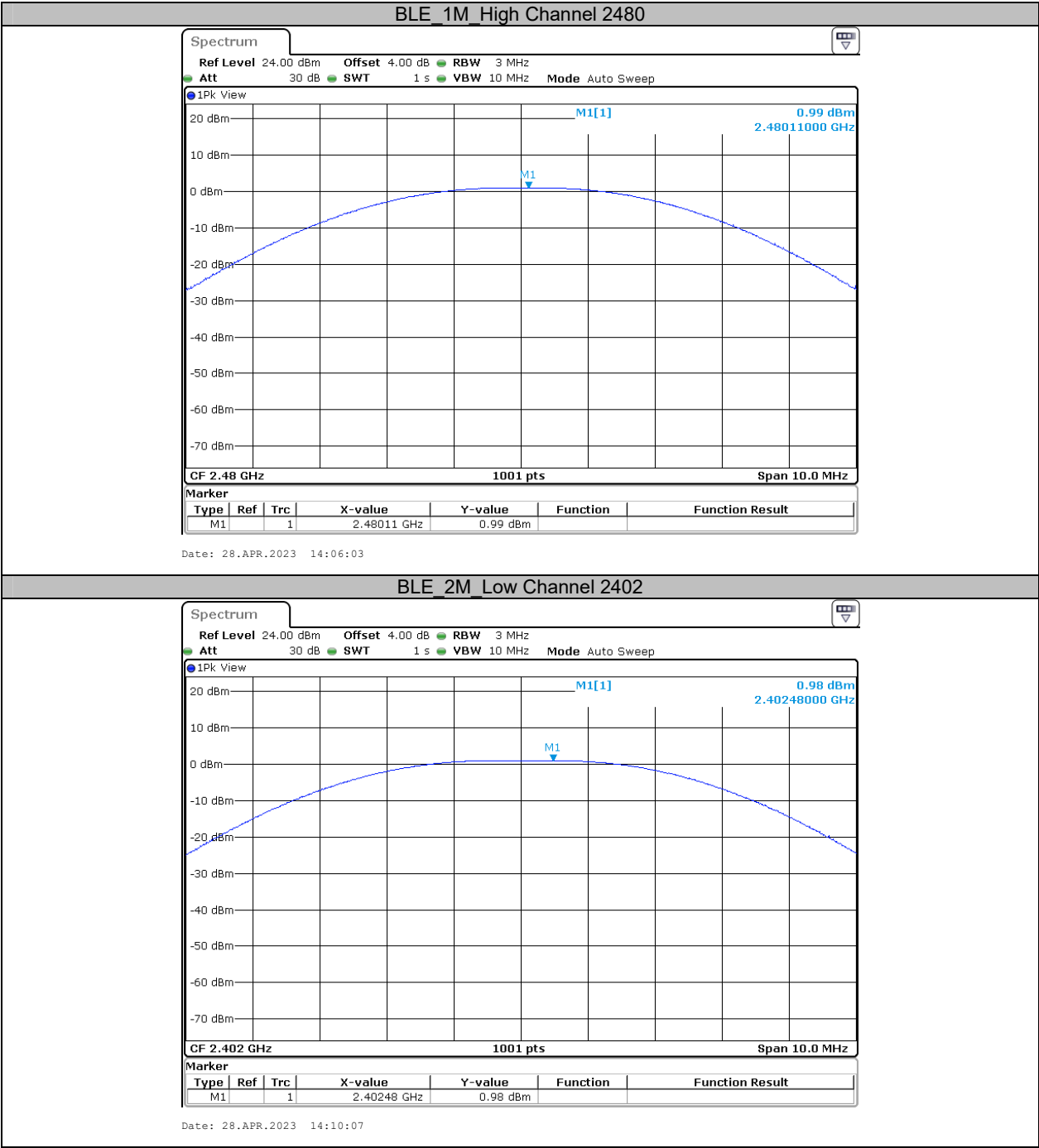
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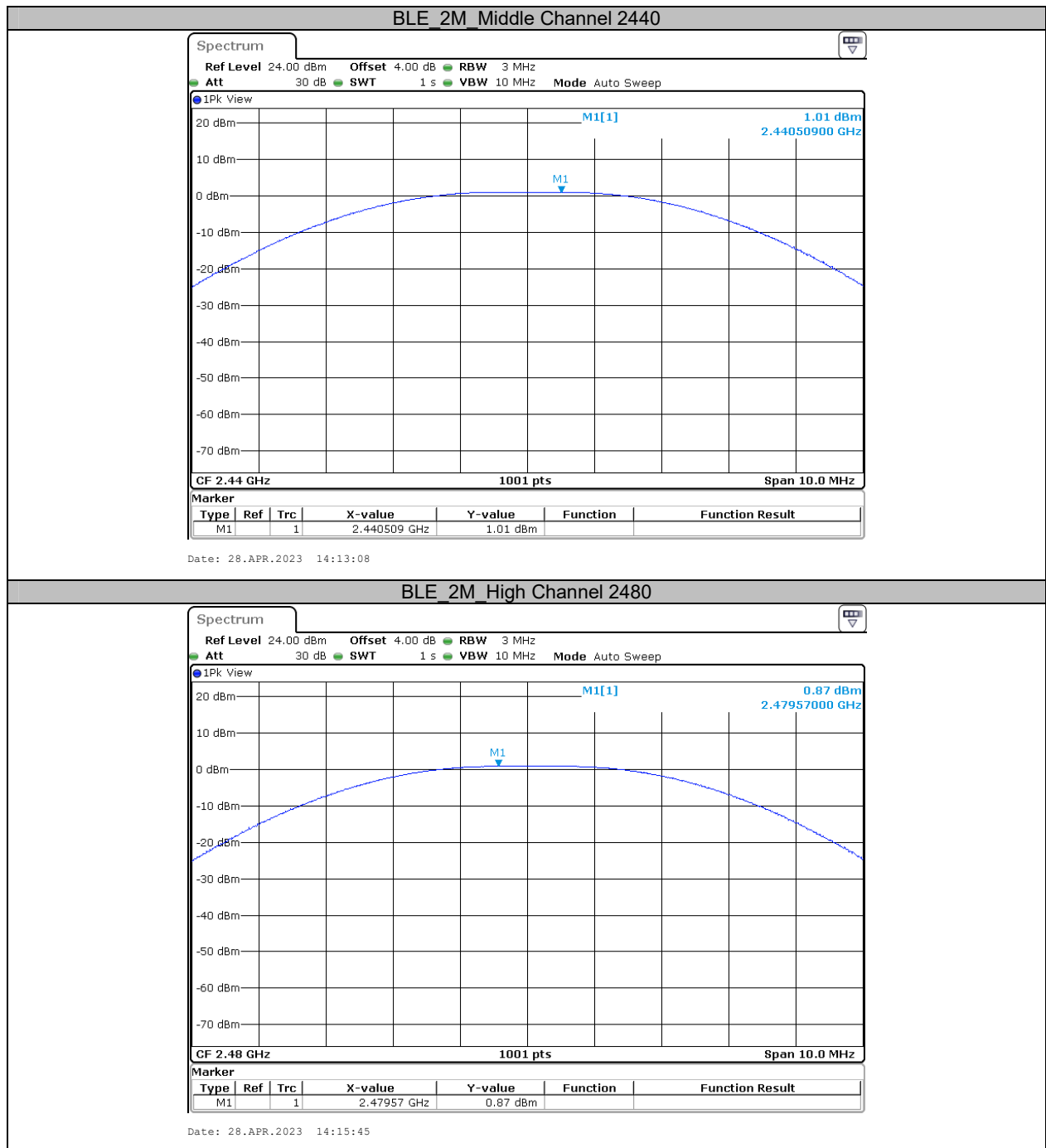
Appendix B: PEAK OUTPUT POWER MEASUREMENT**Test Result**

Channel	Frequency (MHz)	Max Conducted Peak Output Power (dBm)	Limit (dBm)
BLE 1M			
Low	2402	1.03	30
Middle	2440	1.04	30
High	2480	0.99	30
BLE 2M			
Low	2402	0.98	30
Middle	2440	1.01	30
High	2480	0.87	30
Note: antenna gain=2.71dBi, maximum EIRP=3.75dBm<36dBm			

Test Graphs



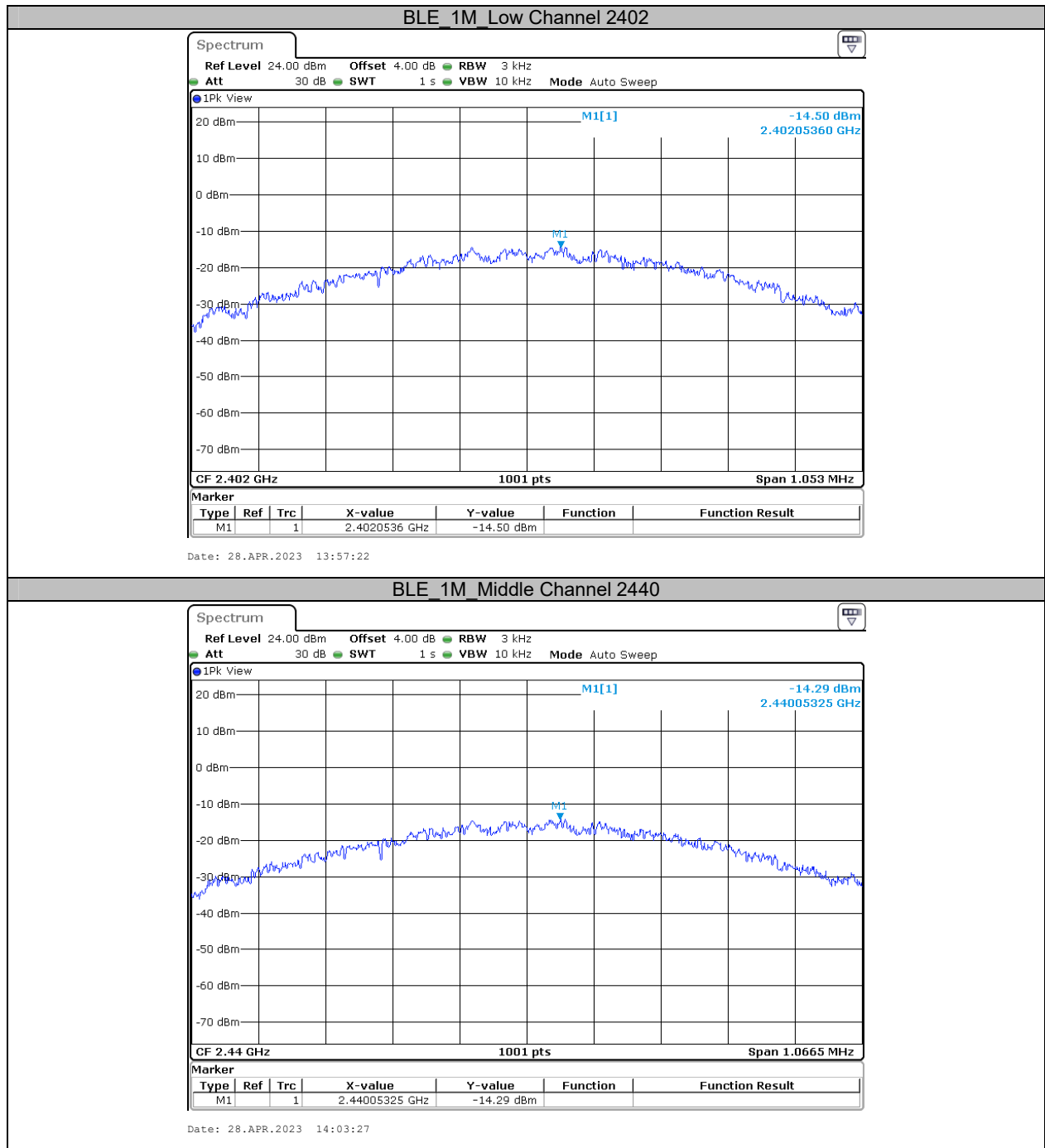


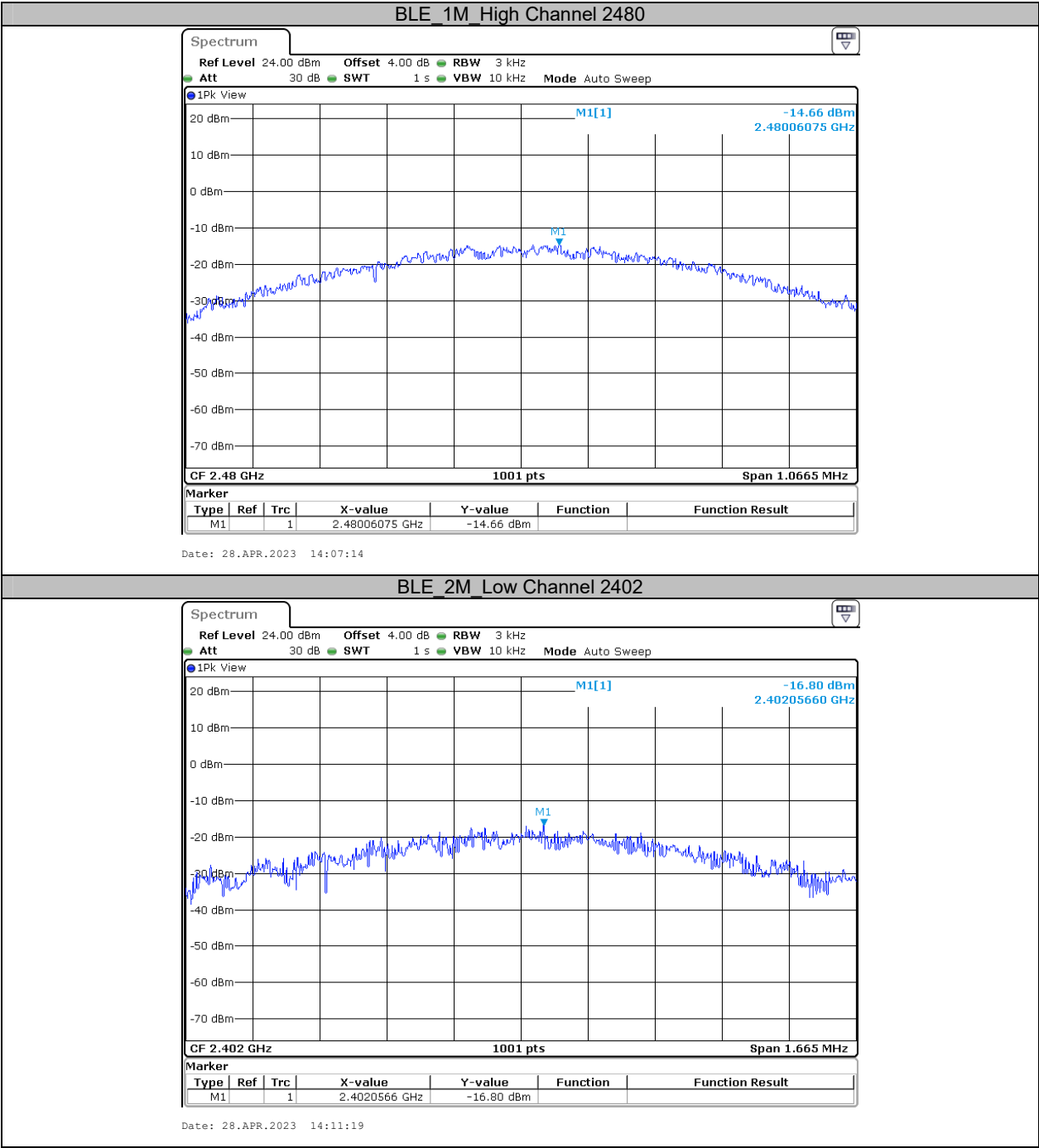


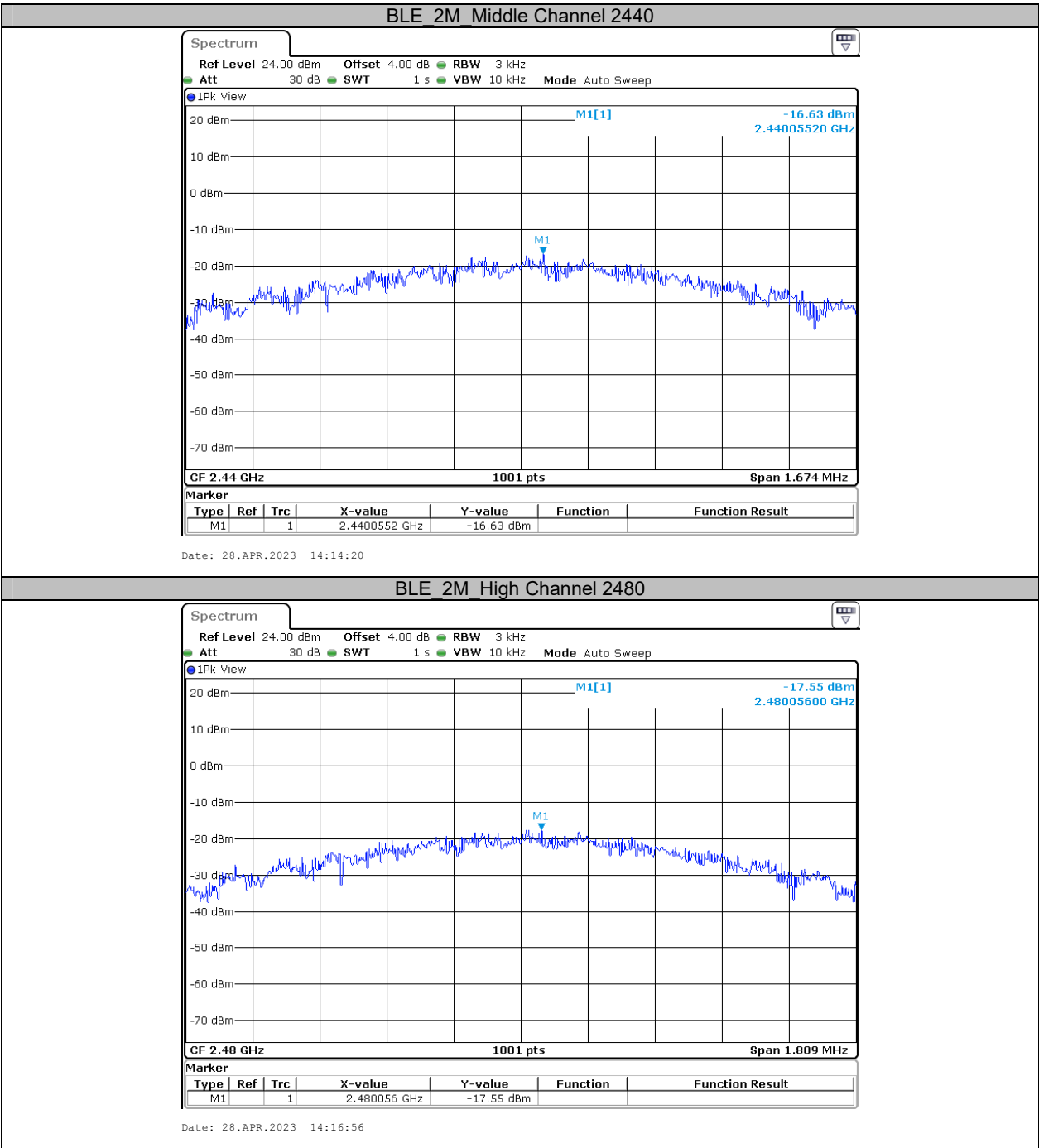
Appendix C: Power Spectral Density**Test Result**

Channel	Frequency (MHz)	PSD (dBm/3kHz)	Limit (dBm/3kHz)
BLE 1M			
Low	2402	-14.50	≤ 8
Middle	2440	-14.29	≤ 8
High	2480	-14.66	≤ 8
BLE 2M			
Low	2402	-16.80	≤ 8
Middle	2440	-16.63	≤ 8
High	2480	-17.55	≤ 8

Test Graphs

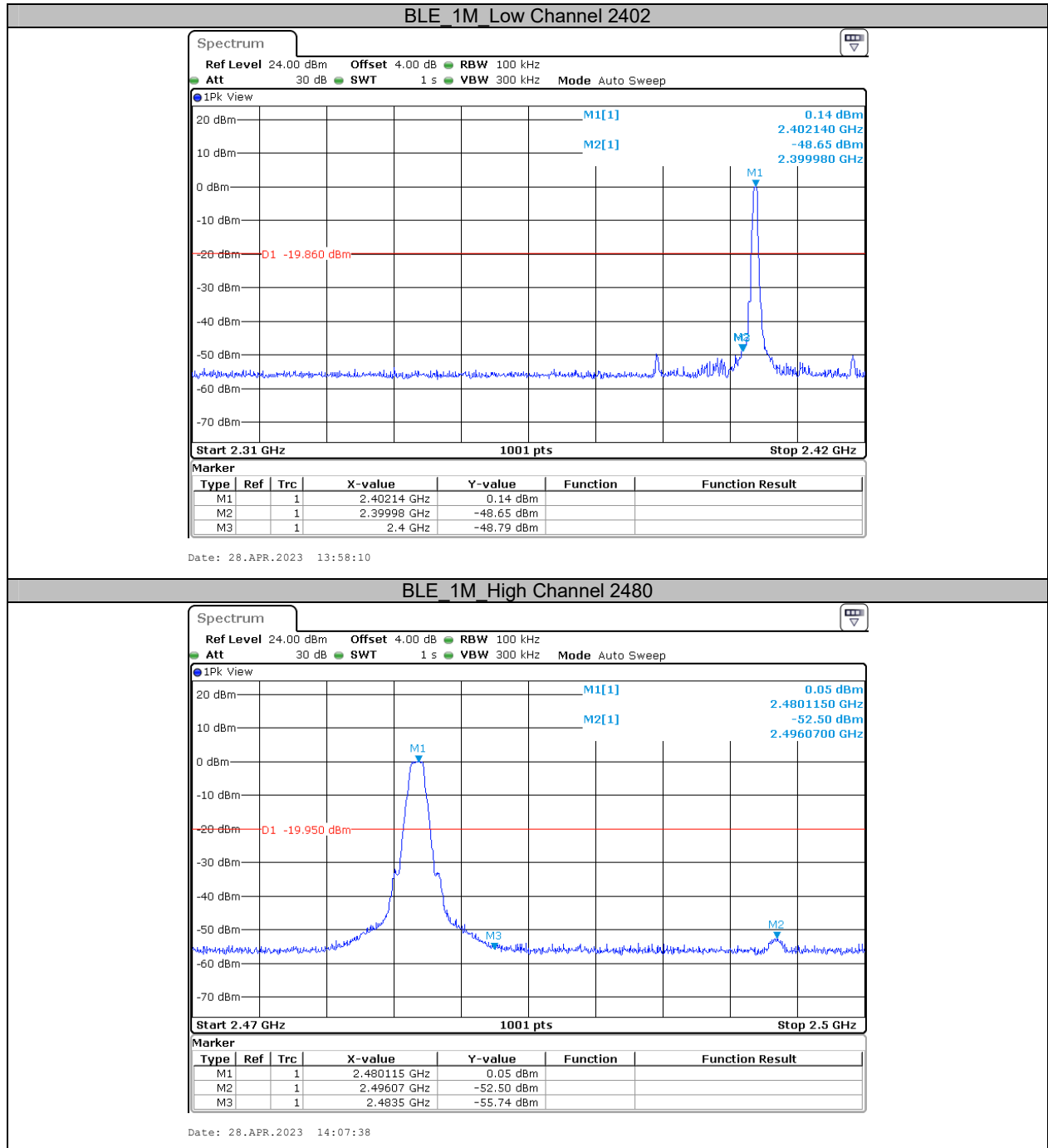


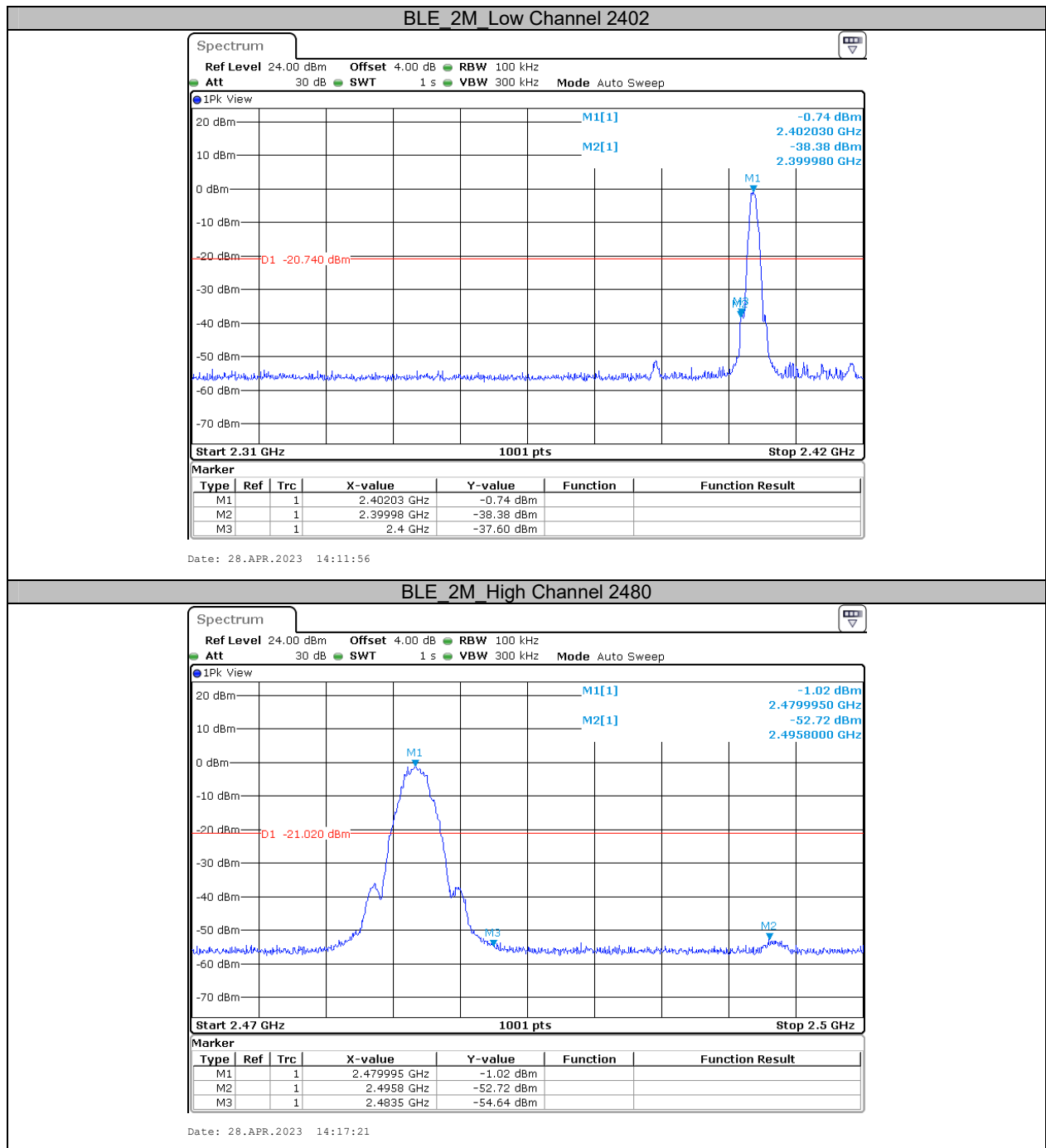




Appendix D: Bandwidth of Frequency Band Edge

Test Graphs



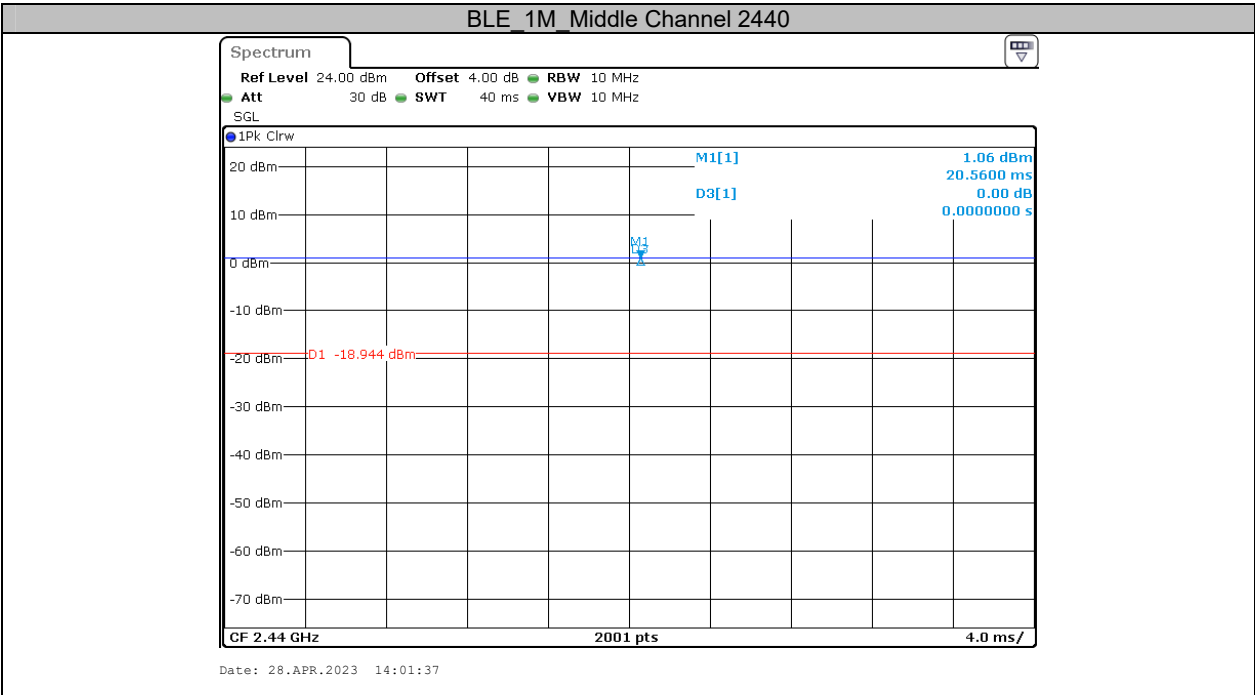


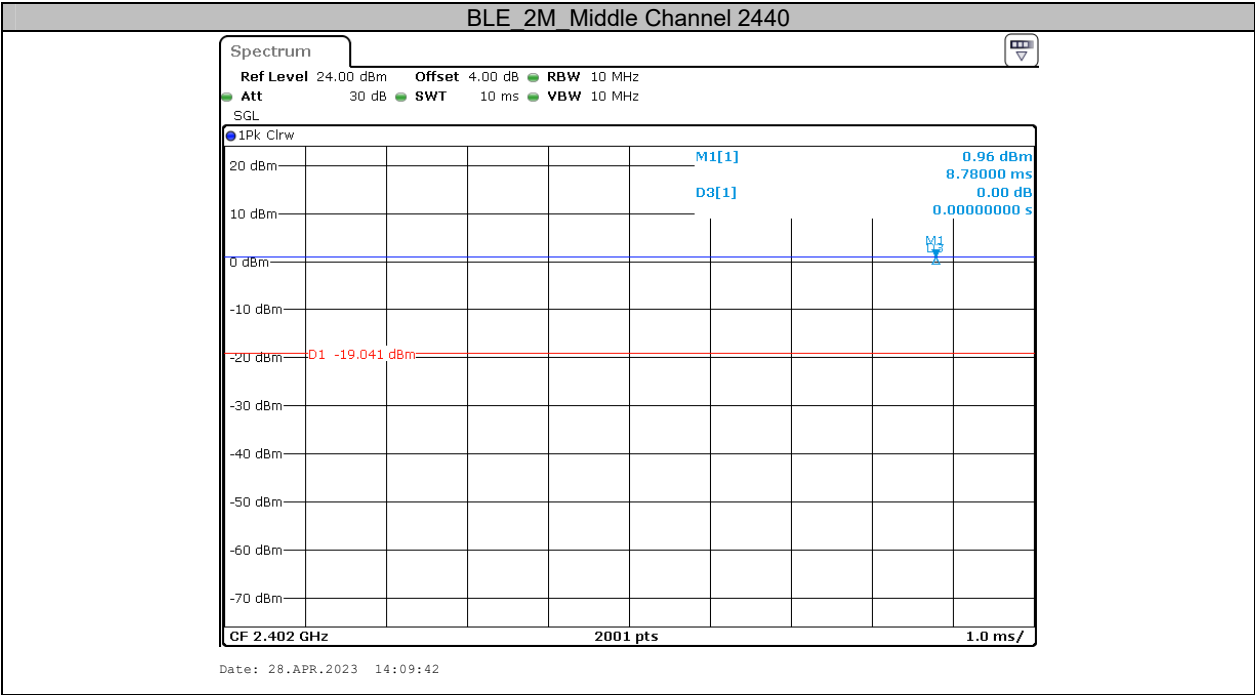
Appendix E: Duty Cycle

Test Result

Mode	T _{on} (ms)	T _{on+off} (ms)	Duty Cycle (%)
BLE 1M	40	40	100
BLE 2M	10	10	100

Test Graphs





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