TEST REPORT

Report Number: 13259310-E2V2

Applicant	:	APPLE, INC. 1 APPLE PARK WAY CUPERTINO, CA 95014, U.S.A
Model	:	A2403, A2404, A2405
FCC ID	:	BCG-E3544A
IC	:	579C-E3544A
EUT Description	:	SMARTPHONE
Test Standard(s)	:	FCC 47 CFR PART 15 SUBPART C ISED RSS-247 ISSUE 2 ISED RSS-GEN ISSUE 5

Date of Issue:
September 15, 2020

Prepared by:
UL Verification Services Inc.
47173 Benicia Street
Fremont, CA 94538 U.S.A.
TEL: (510) 319-4000
FAX: (510) 661-0888

NVLAP TESTING

NVLAP Lab code: 200065-0

REPORT REVISION HISTORY

Rev.	Issue Date	Revisions	Revised By
V1	8/27/2020	Initial Issue	Chin Pang
V2	9/15/2020	Address TCB Questions	Francisco Guarnero

UL VERIFICATION SERVICES INC.
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TABLE OF CONTENTS

UL VERIFICATION SERVICES INC.
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1. ATTESTATION OF TEST RESULTS

COMPANY NAME: APPLE INC.
1 APPLE PARK WAY
CUPERTINO, CA 95014, U.S.A

EUT DESCRIPTION: SMARTPHONE

MODEL: A2403, A2404, A2405

SERIAL NUMBER: (Original): G6TCN05SQ5HH, G6TCN01JQ5HL
(Spot Check): G6TCM00ZQ5LL, G6TD204J04DG

DATE TESTED: JULY 29-30, 2020

APPLICAB ☐ LE STANDARDS	
STANDARD	**TEST RESULTS**
CFR 47 Part 15 Subpart C	Complies
ISED RSS-247 Issue 2	Complies
ISED RSS-GEN Issue 5	Complies

UL Verification Services Inc. tested the above equipment in accordance with the requirements set forth in the above standards. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. It is the manufacturer's responsibility to assure that additional production units of this model are manufactured with identical electrical and mechanical components. All samples tested were in good operating condition throughout the entire test program. Measurement Uncertainties are published for informational purposes only and were not taken into account unless noted otherwise.

This document may not be altered or revised in any way unless done so by UL Verification Services Inc. and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by UL Verification Services Inc. will constitute fraud and shall nullify the document. This report must not be used by the client to claim product certification, approval, or endorsement by NVLAP, NIST, any agency of the Federal Government, or any agency of the U.S. government.

Approved & Released For
UL Verification Services Inc. By:

Chin Pang
Senior Engineer
Consumer Technology Division
UL Verification Services Inc.

Prepared By:

Jingang Li
Test Engineer
Consumer Technology Division
UL Verification Services Inc.

2. TEST SUMMARY

FCC Clause	ISED Clause	Requirement	Result	Comment
15.209, 15.205	RSS-GEN 8.9, 8.10	Radiated Emissions	Complies	None.

3. TEST METHODOLOGY

The tests documented in this report were performed in accordance with FCC CFR 47 Part 2, FCC CFR 47 Part 15, ANSI C63.10-2013, KDB 558074 D01 15.247 Meas Guidance v05r02, KDB 662911, RSS-GEN Issue 5, and RSS-247 Issue 2.

4. FACILITIES AND ACCREDITATION

The test sites and measurement facilities used to collect data are located at 47173 and 47266 Benicia Street, and 47658 Kato Road, Fremont, California, USA. Line conducted emissions are measured only at the 47173 address. The following table identifies which facilities were utilized for radiated emission measurements documented in this report. Specific facilities are also identified in the test results sections.

47173 Benicia Street	47266 Benicia Street	47658 Kato Road
☐ Chamber A	☐ Chamber D	☒ Chamber I
☐ Chamber B	☐ Chamber E	☐ Chamber J
☐ Chamber C	☐ Chamber F	☐ Chamber K
	☐ Chamber G	☐ Chamber L
	Chamber H	☐ Chamber M

The above test sites and facilities are covered under FCC Test Firm Registration # 208313. Chambers above are covered under Industry Canada company address and respective code: 2324A.
UL Verification Services Inc. is accredited by NVLAP, Laboratory Code 200065-0

UL VERIFICATION SERVICES INC.
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5. DECISION RULES AND MEASUREMENT UNCERTAINTY

5.1. METROLOGICAL TRACEABILITY

All test and measuring equipment utilized to perform the tests documented in this report are calibrated on a regular basis, with a maximum time between calibrations of one year or the manufacturers' recommendation, whichever is less, and where applicable is traceable to recognized national standards.

5.2. DECISION RULES

The Decision Rule is based on Simple Acceptance in accordance with ISO Guide 98-4:2012 Clause 8.2. (Measurement uncertainty is not taken into account when stating conformity with a specified requirement.)

5.3. MEASUREMENT UNCERTAINTY

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the apparatus:

PARAMETER	U_{LAB}
Worst Case Conducted Disturbance, 9KHz to 0.15 MHz	3.39 dB
Worst Case Conducted Disturbance, 0.15 to 30 MHz	3.07 dB
Worst Case Radiated Disturbance, 9KHz to 30 MHz	2.52 dB
Worst Case Radiated Disturbance, 30 to 1000 MHz	4.88 dB
Worst Case Radiated Disturbance, 1000 to 18000 MHz	4.24 dB
Worst Case Radiated Disturbance, 18000 to 26000 MHz	4.37 dB
Worst Case Radiated Disturbance, 26000 to 40000 MHz	5.17 dB

Uncertainty figures are valid to a confidence level of 95%.

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6. INTRODUCTION OF TEST DATA REUSE

6.1. EUT DESCRIPTION

The Apple iPhone is a smartphone with multimedia functions (music, application support, and video), cellular GSM, GPRS, EGPRS, UMTS, LTE, 5G, CDMA, IEEE 802.11a/b/g/n/ac/ax, Bluetooth, Ultra-Wideband, GPS, NFC and WPT. All models support at least one UICC based SIM. The second SIM is either an UICC based p-SIM (physical SIM) or e-SIM (electronic SIM). The device supports a built-in inductive charging transmitter and receiver. The rechargeable battery is not user accessible.

6.2. INTRODUCTION

This application for certification is leveraging the data reuse procedures from KDB 484596 D01 based on reference FCC ID: BCG-E3542A, IC: 579C-E3542A to cover variant model BCG-E3544A, 579C-3544A. The major difference between the parent/reference model and the variant model is the depopulation in the variant model of the mmWave transmitter. All other circuitry and features are identical. The data reuse test plan was approved via manufacturer KDB inquiry.

6.3. DIFFERENCE IN MODEL NUMBER

Models A2403, A2404, and A2405 are electrically identical and the model numbers are allocated for marketing and logistic purposes only. Model A2403 was used for the spot check testing described in this report

6.4. SPOT CHECK VERIFICATION RESULTS SUMMARY

Spot check verification has been done on device model A2403, FCC ID: BCG-E3544A, IC: 579C-3544A for radiated spurious and radiated band-edge in accordance with the Test Plan that was approved via KDB inquiry.

BCG-E3544A / 579C-E3544A SPOT CHECK RESULTS										
Technology	Mode	Test Item	Channel	Measured	Original model		Spot check model		Delta (dB)	
					A2172		A2403, A2404, A2405			
					BCG-E3542A 579C-E3542A		BCG-E3544A 579C-E3544A			
				Frequency	Peak	Ave	Peak	Ave	Peak	Ave
BLE	TXBF 1Mbps	RBE	Low	2389.05MHz	54.05	42.14	53.65	42.69	-0.40	0.55
		RBE	High	2560.04MHz	54.90	43.15	52.34	39.94	-2.56	-3.21
	TXBF 2Mbps	RSE	Mid	12.19909GHz	56.30	46.18	52.05	43.53	-4.24	-2.65

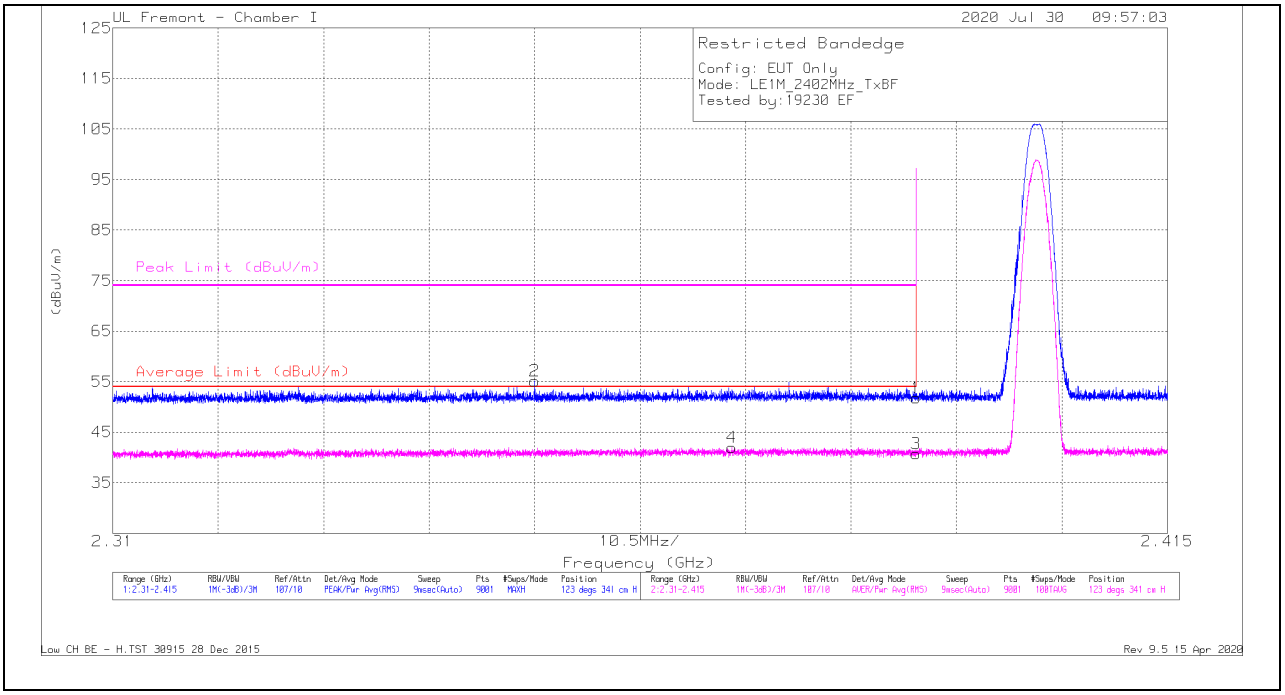
Comparison of the models, upper deviation is within 3dB range and all tests are under FCC Technical Limits. The test report for FCC ID: BCG-E3542A, IC: 579C-E3542A is therefore being used to support the application for certification for FCC ID: BCG-E3544A, IC: 579C-E3544A.

Note: The output powers were verified on model A2404 to match with model A2172 before radiated emissions spot check was performed.

SPOT CHECK DATA

BANDEDGE (LOW CHANNEL)

HORIZONTAL RESULT



Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF T862 (dB/m)	Amp/Cbl/Fltr/Pad (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* 2.38999	37.14	Pk	31.9	-17.3	51.74	-	-	74	-22.26	123	341	H
2	* 2.35201	40.62	Pk	31.7	-17.2	55.12	-	-	74	-18.88	123	341	H
3	* 2.38999	26.14	RMS	31.9	-17.3	40.74	54	-13.26	-	-	123	341	H
4	* 2.37164	27.41	RMS	31.9	-17.3	42.01	54	-11.99	-	-	123	341	H

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
Pk - Peak detector
RMS - RMS detection

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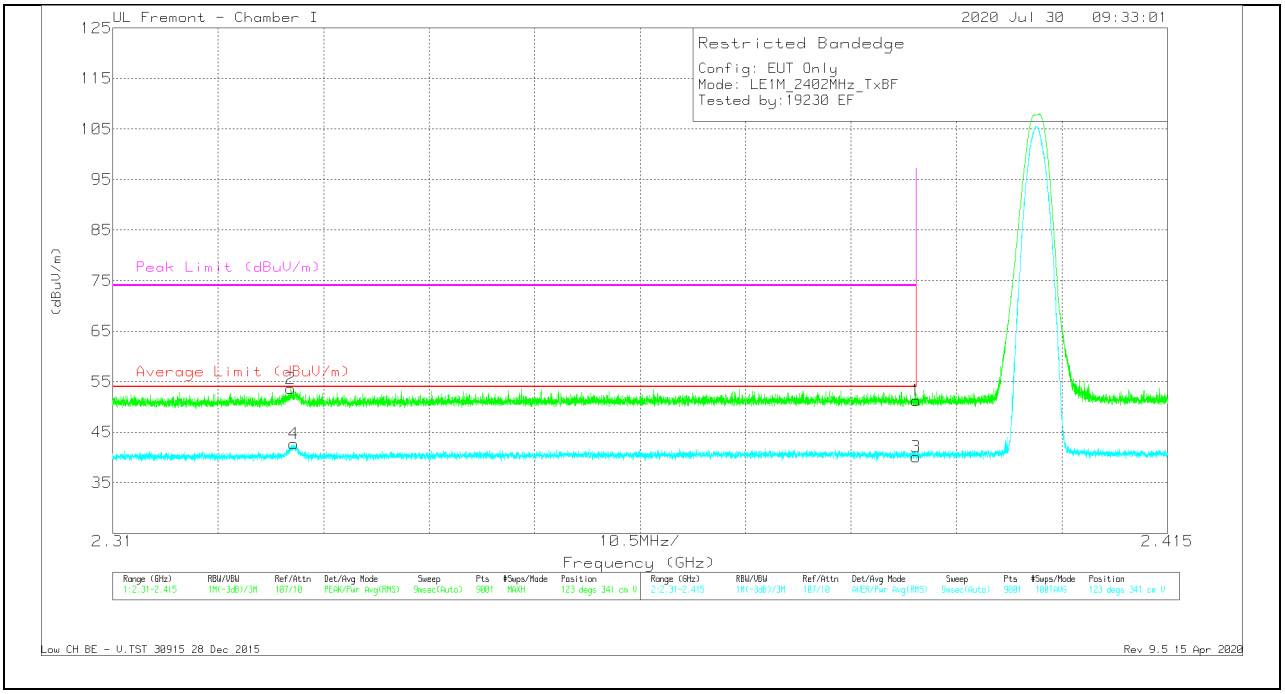
VERTICAL RESULT

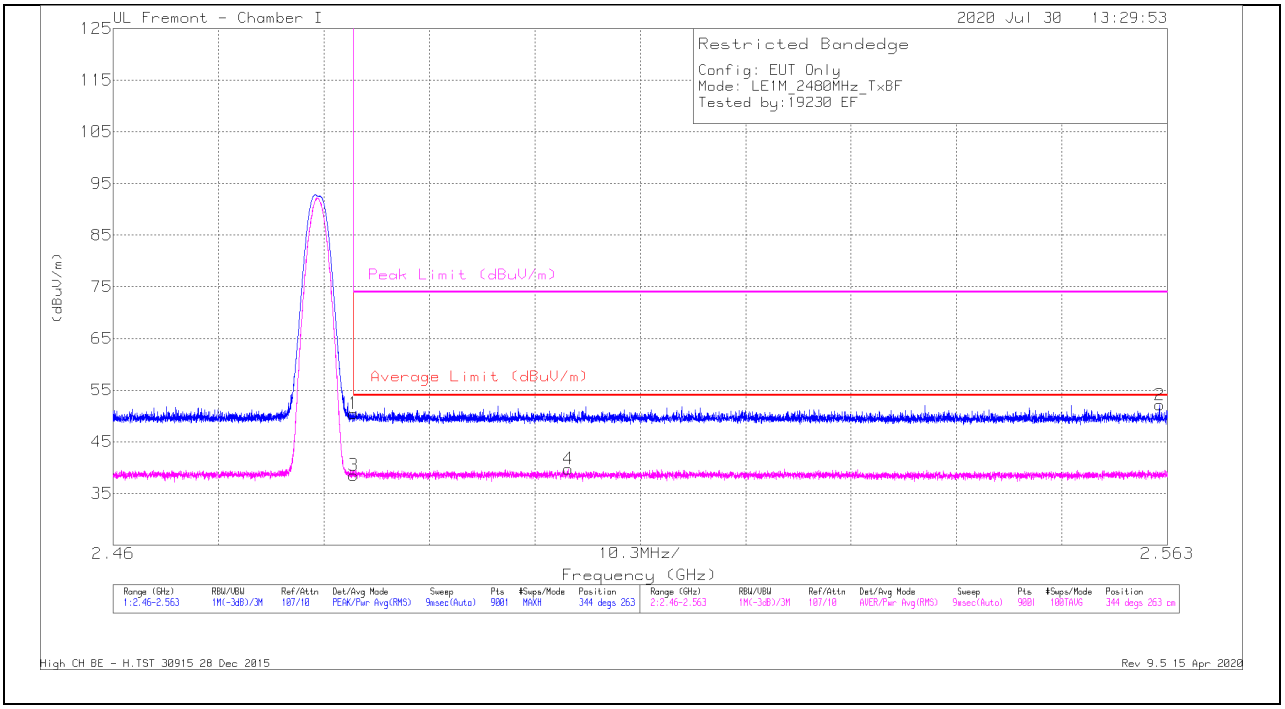


Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF T862 (dB/m)	Amp/Cbl/Fltr/Pad (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* 2.38999	36.73	Pk	31.9	-17.3	51.33	-	-	74	-22.67	123	341	V
2	* 2.32772	39.35	Pk	31.5	-17.2	53.65	-	-	74	-20.35	123	341	V
3	* 2.38999	25.46	RMS	31.9	-17.3	40.06	54	-13.94	-	-	123	341	V
4	* 2.328	28.39	RMS	31.5	-17.2	42.69	54	-11.31	-	-	123	341	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
Pk - Peak detector
RMS - RMS detection

BANDEDGE (HIGH CHANNEL)

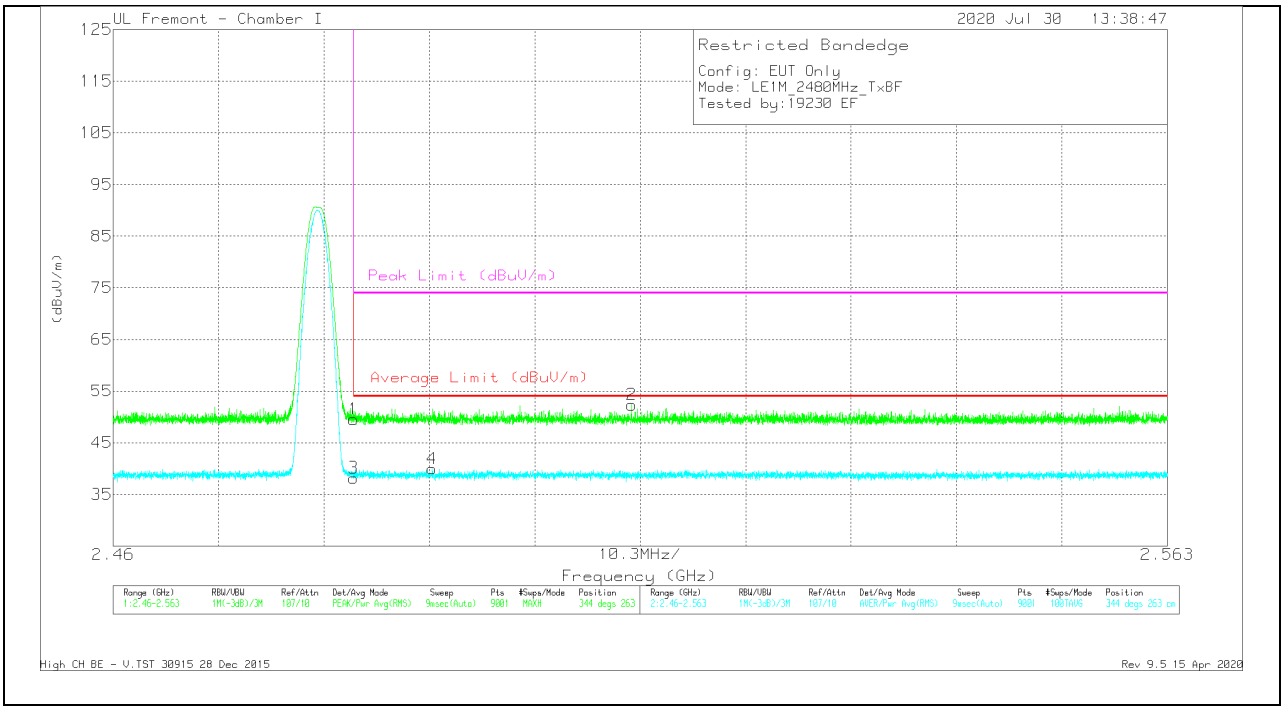
HORIZONTAL RESULT



Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF T862 (dB/m)	Amp/Cbl/Fltr/Pad (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* 2.48351	35.77	Pk	32.4	-17.7	50.47	-	-	74	-23.53	344	263	H
2	2.56226	37.62	Pk	32.3	-17.8	52.12	-	-	74	-21.88	344	263	H
3	* 2.48351	23.82	RMS	32.4	-17.7	38.52	54	-15.48	-	-	344	263	H
4	2.50446	25.23	RMS	32.3	-17.8	39.73	54	-14.27	-	-	344	263	H

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
Pk - Peak detector
RMS - RMS detection

VERTICAL RESULT

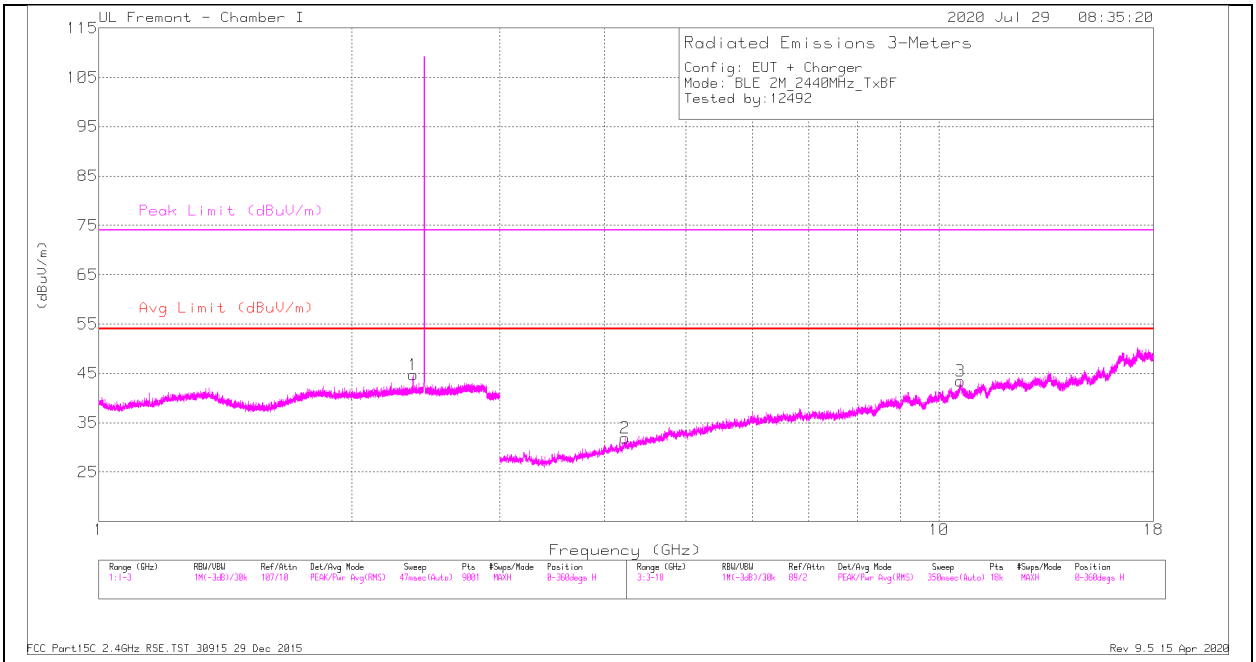


Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF T862 (dB/m)	Amp/Cbl/Fltr/Pad (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* 2.48351	34.84	Pk	32.4	-17.7	49.54	-	-	74	-24.46	344	263	V
2	2.51067	37.84	Pk	32.3	-17.8	52.34	-	-	74	-21.66	344	263	V
3	* 2.48351	23.46	RMS	32.4	-17.7	38.16	54	-15.84	-	-	344	263	V
4	* 2.49117	25.44	RMS	32.3	-17.8	39.94	54	-14.06	-	-	344	263	V

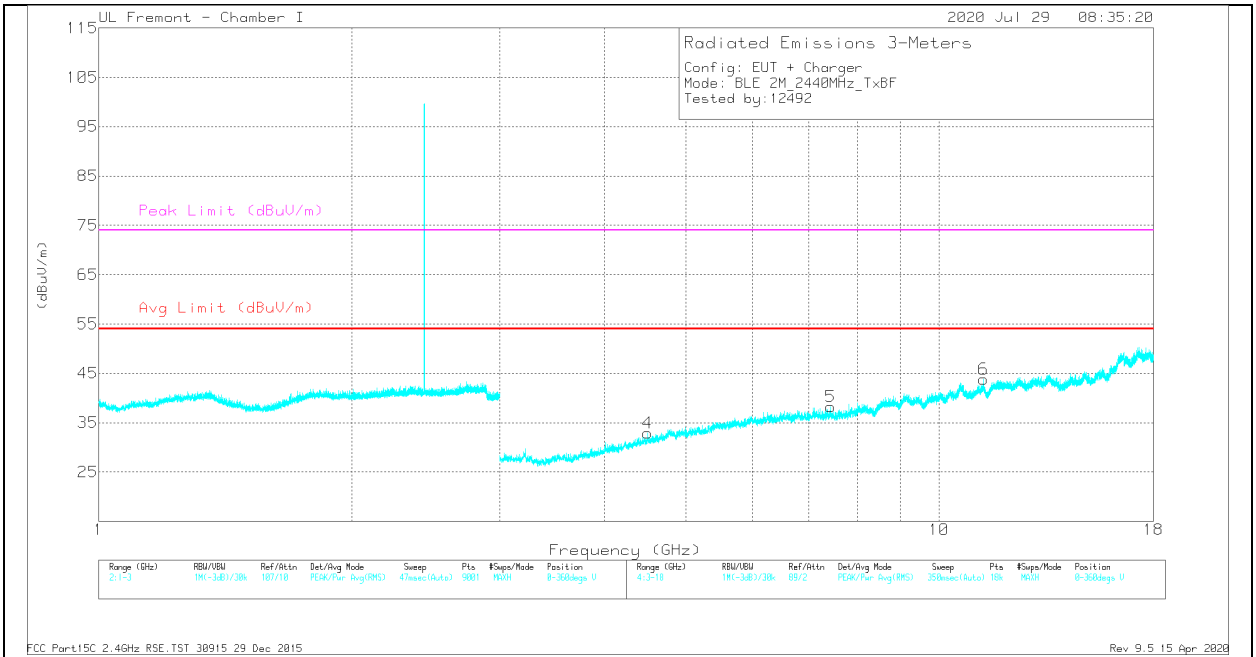
* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
Pk - Peak detector
RMS - RMS detection

HARMONICS AND SPURIOUS EMISSIONS

MID CHANNEL RESULTS



HORIZONTAL



VERTICAL

RADIATED EMISSIONS

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF T862 (dB/m)	Amp/Cbl/Fltr/Pad (dB)	Corrected Reading (dBuV/m)	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* 2.3655	37.55	PK2	31.8	-17.3	52.05	-	-	74	-21.95	127	103	H
	* 2.3658	29.03	MAv1	31.8	-17.3	43.53	54	-10.47	-	-	127	103	H
2	* 4.23347	35.99	PK2	33.4	-24.3	45.09	-	-	74	-28.91	32	399	H
	* 4.2347	24.66	MAv1	33.4	-24.3	33.76	54	-20.24	-	-	32	399	H
3	* 10.6111	30.18	PK2	37.9	-17.2	50.88	-	-	74	-23.12	178	232	H
	* 10.61304	19.4	MAv1	37.8	-17.2	40	54	-14	-	-	178	232	H
4	* 4.50332	34.89	PK2	33.7	-24.3	44.29	-	-	74	-29.71	43	396	V
	* 4.50267	24.39	MAv1	33.7	-24.3	33.79	54	-20.21	-	-	43	396	V
5	* 7.42492	30.57	PK2	35.5	-21	45.07	-	-	74	-28.93	224	171	V
	* 7.42629	20.27	MAv1	35.5	-21	34.77	54	-19.23	-	-	224	171	V
6	* 11.29912	31.26	PK2	38.1	-17.8	51.56	-	-	74	-22.44	207	200	V
	* 11.29773	20.34	MAv1	38.1	-17.8	40.64	54	-13.36	-	-	207	200	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
PK2 - KDB558074 Method: Maximum Peak
MAv1 - KDB558074 Option 1 Maximum RMS Average

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6.5. REFERENCE DETAIL

Reference application that contains the reused reference data which is attached to this report in Appendix A.

Equipment Class	Reference FCC ID / IC	Reference Report Number	Report Title/Section
DTS	BCG-E3542A 579C-E3542A	13179116-E2	FCC IC BLE Report / All sections

6.6. DESCRIPTION OF AVAILABLE ANTENNAS

Frequency Range (GHz)	ANT 4 (dBi)	ANT 3 (dBi)
2.4	-2.1	-0.3

6.7. SOFTWARE AND FIRMWARE

The EUT firmware installed during testing was 18.1.148.558

6.8. WORST-CASE CONFIGURATION AND MODE

Radiated band edge and spurious emissions from 1GHz to 18GHz were performed based on the Model A2172 worst case with the EUT set at highest power at Low/Middle/High channels.

There are two vendors of the WiFi/Bluetooth radio modules: variant 1 and variant 2. The Wi-Fi/Bluetooth radio modules have the same mechanical outline (e.g., the same package dimension and pin-out layout), use the same on-board antenna matching circuit, have an identical antenna structure, and are built and tested to conform to the same specifications and to operate within the same tolerances.

Baseline testing was performed on the two variants to determine the worst case on all conducted power and radiated emissions.

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6.9. DESCRIPTION OF TEST SETUP

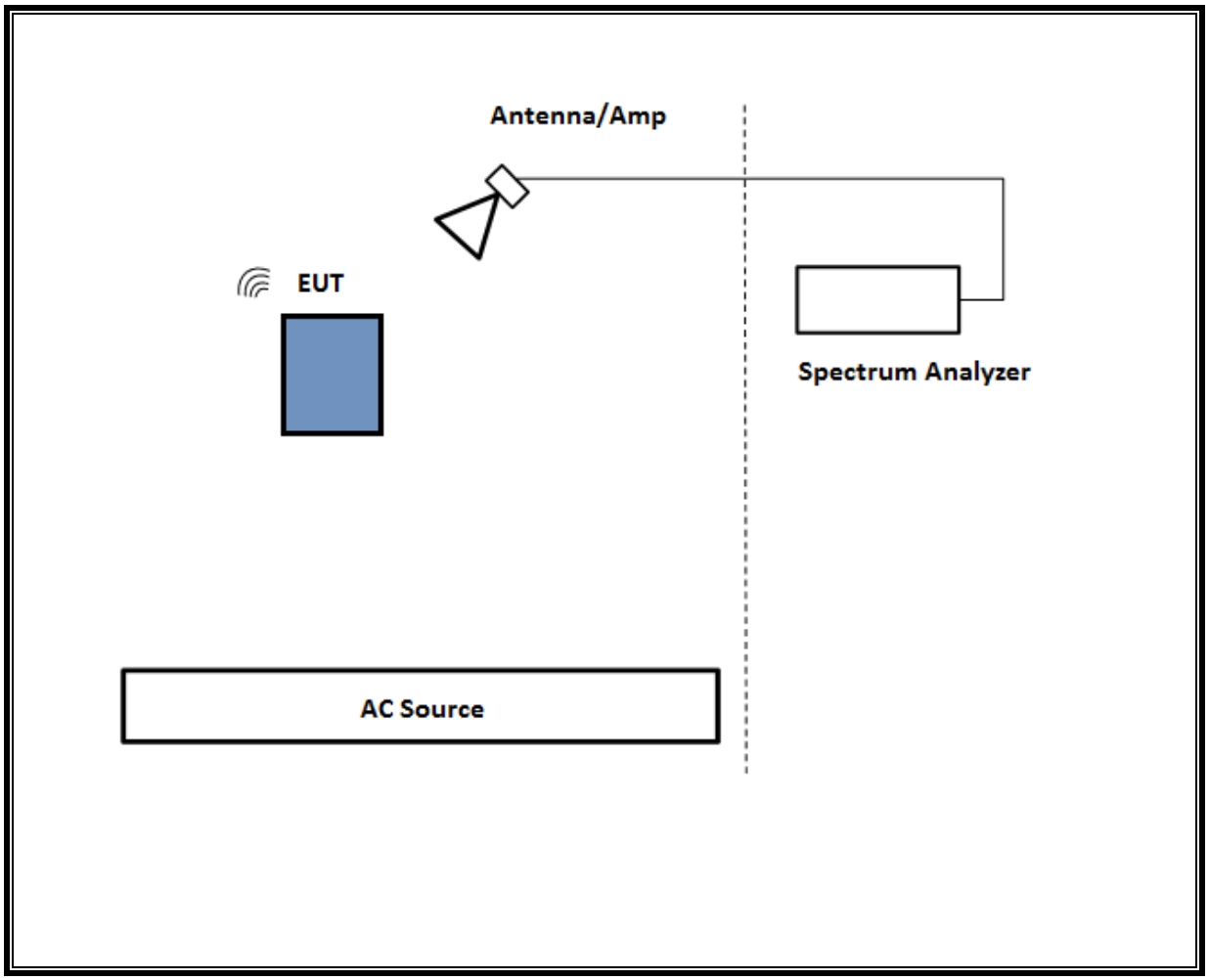
SUPPORT TEST EQUIPMENT				
Description	Manufacturer	Model	Serial Number	FCC ID/ DoC
Laptop	Apple	A1398	C02PM012G3QD	QDS-BRCM1069
Laptop AC/DC adapter	Liteon Technology	PA-1450-BA1	B123	N/A
EUT AC/DC adapter	Apple	A1385	D29325SM03XDHLHC9	N/A

I/O CABLES (RF RADIATED TEST)						
Cable No.	Port	# of Identical Ports	Connector Type	Cable Type	Cable Length (m)	Remarks
1	AC	1	AC	Un-shielded	2	N/A
2	USB	1	USB	Un-shielded	1	N/A

TEST SETUP

The EUT is connected to a test laptop during the tests. Test software exercised the radio card.

SETUP DIAGRAM FOR RADIATED TESTS Above 1 GHz



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7. MEASUREMENT METHOD

Output Power: ANSI C63.10 Subclause -11.9.1.3 Method PKPM1 Peak-reading power meter

Output Power: ANSI C63.10 Subclause -11.9.2.3.2 Measurement using gated average power meter.

Radiated emissions restricted frequency bands: ANSI C63.10 Subclause -11.12.1 & Clause 13

Band-edge: ANSI C63.10 Subclause -11.13.3.3 & Clause 13: Integration method -Trace averaging with continuous transmission at full power

Radiated emissions non-restricted frequency bands ANSI C63.10 Subclause -11.11 & Clause 13

NOTE: All conducted antenna port tests for Beamforming applied the same test procedures as BLE 1Mbps and BLE 2Mbps normal modes.

8. TEST AND MEASUREMENT EQUIPMENT

The following test and measurement equipment were utilized for the tests documented in this report:

Description	Manufacturer	Model	ID Num	Cal Due	Last Cal
*Antenna, Horn 1-18GHz	ETS Lindgren	3117	T862	08/20/2020	08/20/2019
Amplifier, 1 to 18GHz, 35dB	Amplical	AFS42-00101800-25-S-42	T1567	01/24/2021	01/24/2020
EMI Test Receiver	Rohde & Schwarz	ESW44	Pre0179522	02/20/2021	02/20/2020
Power Meter, P-series single channel	Keysight	N1911A	PRE0177682	01/21/2021	01/21/2020
Power Sensor	Keysight	N1921A	T1226	02/13/2021	02/13/2020

*Testing is completed before equipment expiration date.

9. SETUP PHOTOS

Please refer to 13179116-EP1 for setup photos

UL VERIFICATION SERVICES INC.
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Appendix A - Reference Test Report

Attached is the test report (13179116-E2) containing the reference data form the parent model as detailed in section 6.5.

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888

TEST REPORT

Report Number : 13179116-E2V2

Applicant	:	APPLE, INC. 1 APPLE PARK WAY CUPERTINO, CA 95014, U.S.A
Model	:	A2172
FCC ID	:	BCG-E3542A
IC	:	579C-E3542A
EUT Description	:	SMARTPHONE
Test Standard(s)	:	FCC 47 CFR PART 15 SUBPART C ISED RSS-247 ISSUE 2 ISED RSS-GEN ISSUE 5

Date Of Issue:
September 08, 2020

Prepared by:
UL Verification Services Inc.
47173 Benicia Street
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TEL: (510) 319-4000
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NVLAP TESTING
NVLAP Lab code: 200065-0

REPORT REVISION HISTORY

Rev.	Issue Date	Revisions	Revised By
V1	8/26/2020	Initial Issue	Chin Pang
V2	09/08/2020	Address TCB's Questions	Chin Pang

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TABLE OF CONTENTS

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UL VERIFICATION SERVICES INC.
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1. ATTESTATION OF TEST RESULTS

COMPANY NAME: APPLE INC.
1 APPLE PARK WAY
CUPERTINO, CA 95014, U.S.A

EUT DESCRIPTION: SMARTPHONE

MODEL: A2172

SERIAL NUMBER: G6TCN05SQ5HH, G6TCN01JQ5HL

DATE TESTED: FEBRUARY 25, 2020 – AUGUST 17, 2020

APPLICABLE STANDARDS	
STANDARD	**TEST RESULTS**
CFR 47 Part 15 Subpart C	Complies
ISED RSS-247 Issue 2	Complies
ISED RSS-GEN Issue 5	Complies

UL Verification Services Inc. tested the above equipment in accordance with the requirements set forth in the above standards. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

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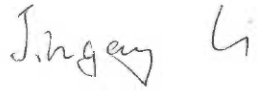
Approved & Released For
UL Verification Services Inc. By:

Chin Pang
Senior Engineer
Consumer Technology Division
UL Verification Services Inc.

Prepared By:



Jingang Li
Test Engineer
Consumer Technology Division
UL Verification Services Inc.

2. TEST SUMMARY

FCC Clause	ISED Clause	Requirement	Result	Comment
See Comment		Duty Cycle	Reporting purposes only	ANSI C63.10 Section 11.6.
-	RSS-GEN 6.7	99% OBW	Reporting purposes only	ANSI C63.10 Section 6.9.3.
15.247 (a) (2)	RSS-247 5.2 (a)	6dB BW	Complies	None.
15.247 (b) (3)	RSS-247 5.4 (d)	Output Power	Complies	None.
See Comment		Average power	Reporting purposes only	Per ANSI C63.10, Section 11.9.2.3.2.
15.247 (e)	RSS-247 5.2 (b)	PSD	Complies	None.
15.247 (d)	RSS-247 5.5	Conducted Spurious Emissions	Complies	None.
15.209, 15.205	RSS-GEN 8.9, 8.10	Radiated Emissions	Complies	None.
15.207	RSS-Gen 8.8	AC Mains Conducted Emissions	Complies	None.

3. TEST METHODOLOGY

The tests documented in this report were performed in accordance with FCC CFR 47 Part 2, FCC CFR 47 Part 15, ANSI C63.10-2013, KDB 558074 D01 15.247 Meas Guidance v05r02, KDB 662911, RSS-GEN Issue 5, and RSS-247 Issue 2.

4. FACILITIES AND ACCREDITATION

The test sites and measurement facilities used to collect data are located at 47173 and 47266 Benicia Street, and 47658 Kato Road, Fremont, California, USA. Line conducted emissions are measured only at the 47173 address. The following table identifies which facilities were utilized for radiated emission measurements documented in this report. Specific facilities are also identified in the test results sections.

47173 Benicia Street	47266 Benicia Street	47658 Kato Rd.
☐ Chamber A (IC:2324B-1)	☐ Chamber D (IC:22541-1)	☐ Chamber I (IC: 2324A-5)
☐ Chamber B (IC:2324B-2)	☐ Chamber E (IC:22541-2)	☐ Chamber J (IC: 2324A-6)
☐ Chamber C (IC:2324B-3)	☐ Chamber F (IC:22541-3)	☐ Chamber K (IC: 2324A-1)
	☒ Chamber G (IC:22541-4)	☒ Chamber L (IC: 2324A-3)
	☒ Chamber H (IC:22541-5)	☐ Chamber M (IC: 2324A-2)

The above test sites and facilities are covered under FCC Test Firm Registration # 208313. Chambers above are covered under Industry Canada company address and respective code: 2324A.
UL Verification Services Inc. is accredited by NVLAP, Laboratory Code 200065-0

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5. DECISION RULES AND MEASUREMENT UNCERTAINTY

5.1. METROLOGICAL TRACEABILITY

All test and measuring equipment utilized to perform the tests documented in this report are calibrated on a regular basis, with a maximum time between calibrations of one year or the manufacturers' recommendation, whichever is less, and where applicable is traceable to recognized national standards.

5.2. DECISION RULES

The Decision Rule is based on Simple Acceptance in accordance with ISO Guide 98-4:2012 Clause 8.2. (Measurement uncertainty is not taken into account when stating conformity with a specified requirement.)

5.3. MEASUREMENT UNCERTAINTY

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the apparatus:

PARAMETER	U_{LAB}
Worst Case Conducted Disturbance, 9KHz to 0.15 MHz	3.39 dB
Worst Case Conducted Disturbance, 0.15 to 30 MHz	3.07 dB
Worst Case Radiated Disturbance, 9KHz to 30 MHz	2.52 dB
Worst Case Radiated Disturbance, 30 to 1000 MHz	4.88 dB
Worst Case Radiated Disturbance, 1000 to 18000 MHz	4.24 dB
Worst Case Radiated Disturbance, 18000 to 26000 MHz	4.37 dB
Worst Case Radiated Disturbance, 26000 to 40000 MHz	5.17 dB

Uncertainty figures are valid to a confidence level of 95%.

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6. EQUIPMENT UNDER TEST

6.1. EUT DESCRIPTION

The Apple iPhone is a smartphone with multimedia functions (music, application support, and video), cellular GSM, GPRS, EGPRS, UMTS, LTE, 5G, CDMA, IEEE 802.11a/b/g/n/ac/ax, Bluetooth, Ultra-Wideband, GPS, NFC and WPT. All models support at least one UICC based SIM. The second SIM is either an UICC based p-SIM (physical SIM) or e-SIM (electronic SIM). The device supports a built-in inductive charging transmitter and receiver. The rechargeable battery is not user accessible.

6.2. MAXIMUM OUTPUT POWER

The transmitter has a maximum peak conducted output power as follows:

Antenna	Configuration	Frequency Range (MHz)	Mode	Output Power (dBm)	Output Power (mW)
Ant 4	High Power	2402 - 2480	BLE 1M	20.26	106.17
	Low Power			12.75	18.84
	High Power	2404 - 2478	BLE 2M	20.22	105.20
	Low Power			12.82	19.14
Ant 3	High Power	2402 - 2480	BLE 1M	20.25	105.93
	Low Power			12.71	18.66
	High Power	2404 - 2478	BLE 2M	20.21	104.95
	Low Power			12.79	19.01
BF, ANT 4 + ANT 3	High Power	2402 - 2480	BLE 1M	20.76	119.12
	Low Power			15.79	37.93
	High Power	2404 - 2478	BLE 2M	20.77	119.40
	Low Power			15.85	38.46

6.3. DESCRIPTION OF AVAILABLE ANTENNAS

Frequency Range (GHz)	ANT 4 (dBi)	ANT 3 (dBi)
2.4	-2.1	-0.3

6.4. SOFTWARE AND FIRMWARE

The EUT firmware installed during testing was 18.1.148.558

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6.5. WORST-CASE CONFIGURATION AND MODE

The EUT was investigated in three orthogonal orientations X, Y and Z on ANT 4 and ANT 3, it was determined that X (Flatbed) was the worst-case orientation for ANT 4 and 2TX Beamforming. The Y (Landscape) orientation for ANT 3.

Radiated band edge, harmonic, and spurious emissions from 1GHz to 18GHz were performed with the EUT was set to transmit at highest power on Low/Middle/High channels.

Radiated emissions below 1GHz, 18-26GHz and power line conducted emissions were performed with the EUT transmits at the channel with the highest output power as worst-case scenario.

For below 1GHz tests were performed with EUT connected to AC power adapter as the worst case; and for above 1GHz, the worst-case configuration reported was tested with EUT only. For AC line conducted emission, test was investigated with AC power adapter and with laptop. There were no emissions found below 30MHz within 20dB of the limit.

For simultaneous transmission of multiple channels in the 2.4GHz BLE and 5GHz bands. No noticeable emission was found.

There are two vendors of the WiFi/Bluetooth radio modules: variant 1 and variant 2. The Wi-Fi/Bluetooth radio modules have the same mechanical outline (e.g., the same package dimension and pin-out layout), use the same on-board antenna matching circuit, have an identical antenna structure, and are built and tested to conform to the same specifications and to operate within the same tolerances.

Baseline testing was performed on the two variants to determine the worst case on all conducted power and radiated emissions.

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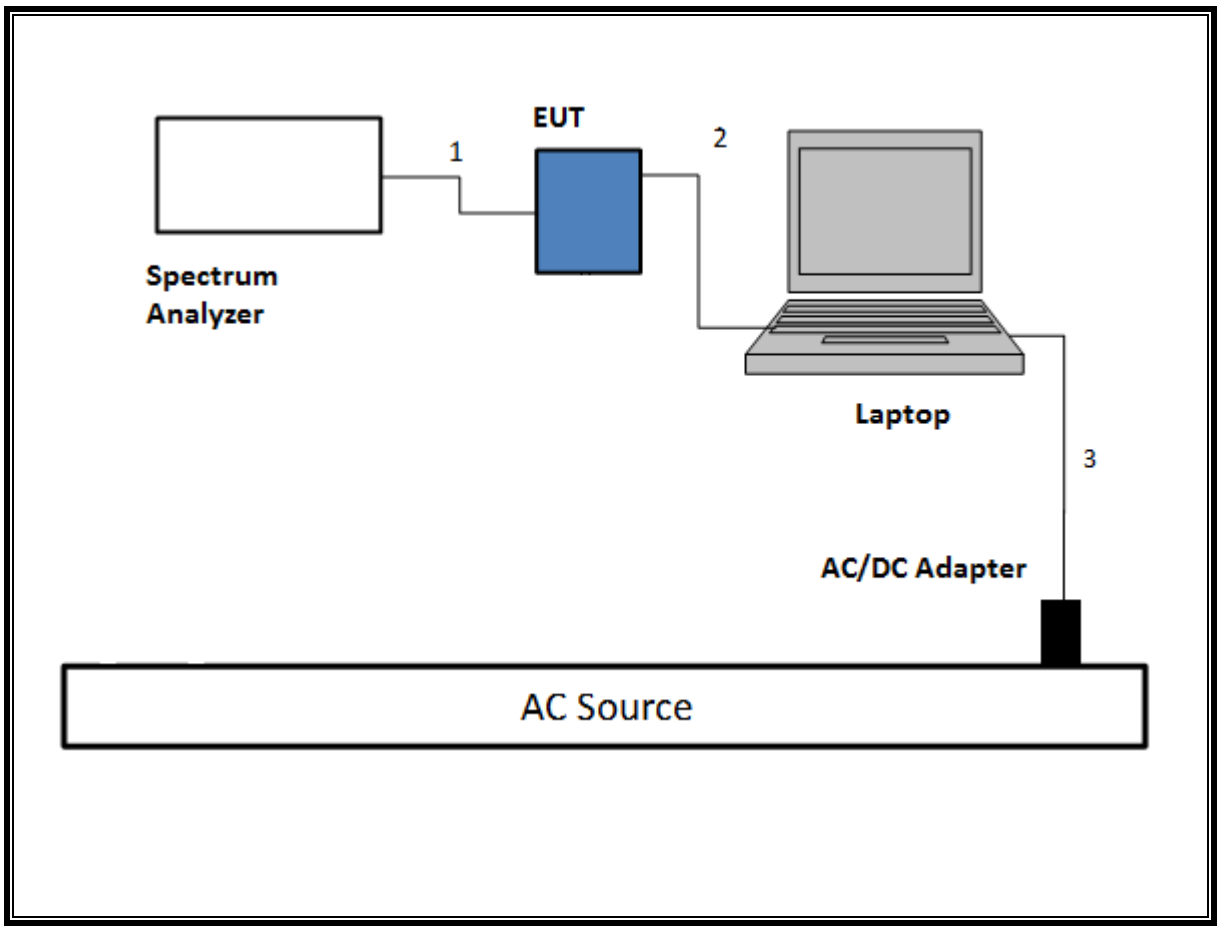
6.6. DESCRIPTION OF TEST SETUP

SUPPORT TEST EQUIPMENT						
Description		**Manufacturer**	**Model**	**Serial Number**		**FCC ID/ DoC**
Laptop		Apple	A1398	C02PM012G3QD		QDS-BRCM1069
Laptop AC/DC adapter		Liteon Technology	PA-1450-BA1	B123		N/A
EUT AC/DC adapter		Apple	A1385	D29325SM03XDHLHC9		N/A
I/O CABLES (RF CONDUCTED TEST)						
Cable No.	**Port**	**# of Identical Ports**	**Connector Type**	**Cable Type**	**Cable Length (m)**	**Remarks**
1	Antenna	1	SMA	Un-shielded	0.2	To spectrum Analyzer
2	USB	1	USB	Shielded	1.0	N/A
3	AC	1	AC	Un-shielded	2	N/A
I/O CABLES (RF RADIATED TEST)						
Cable No.	**Port**	**# of Identical Ports**	**Connector Type**	**Cable Type**	**Cable Length (m)**	**Remarks**
1	AC	1	AC	Un-shielded	2	N/A
2	USB	1	USB	Un-shielded	1	N/A

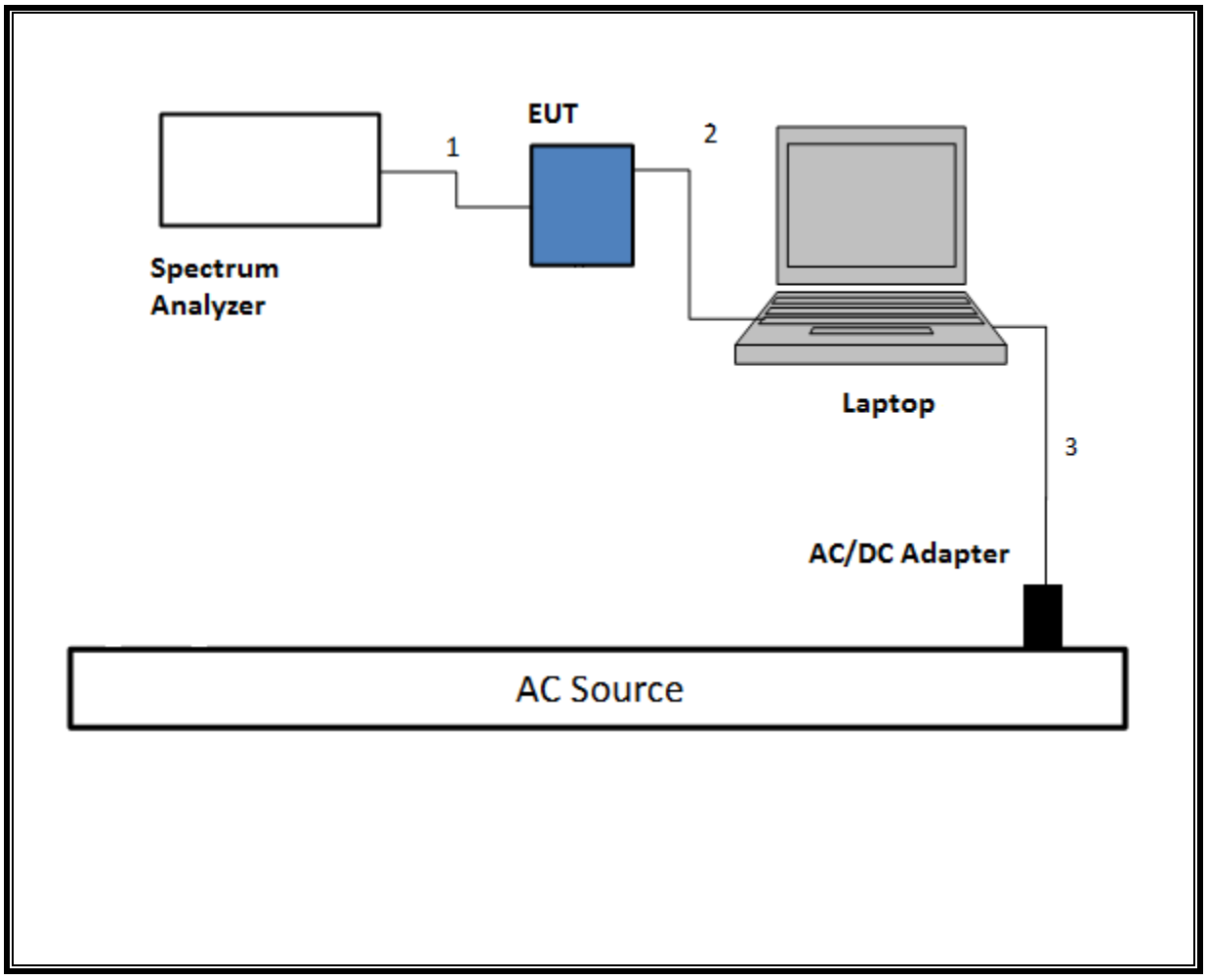
TEST SETUP

The EUT is connected to a test laptop during the tests. Test software exercised the radio card.

SETUP DIAGRAM FOR CONDUCTED TESTS



SETUP DIAGRAM FOR RADIATED TESTS Above 1 GHz



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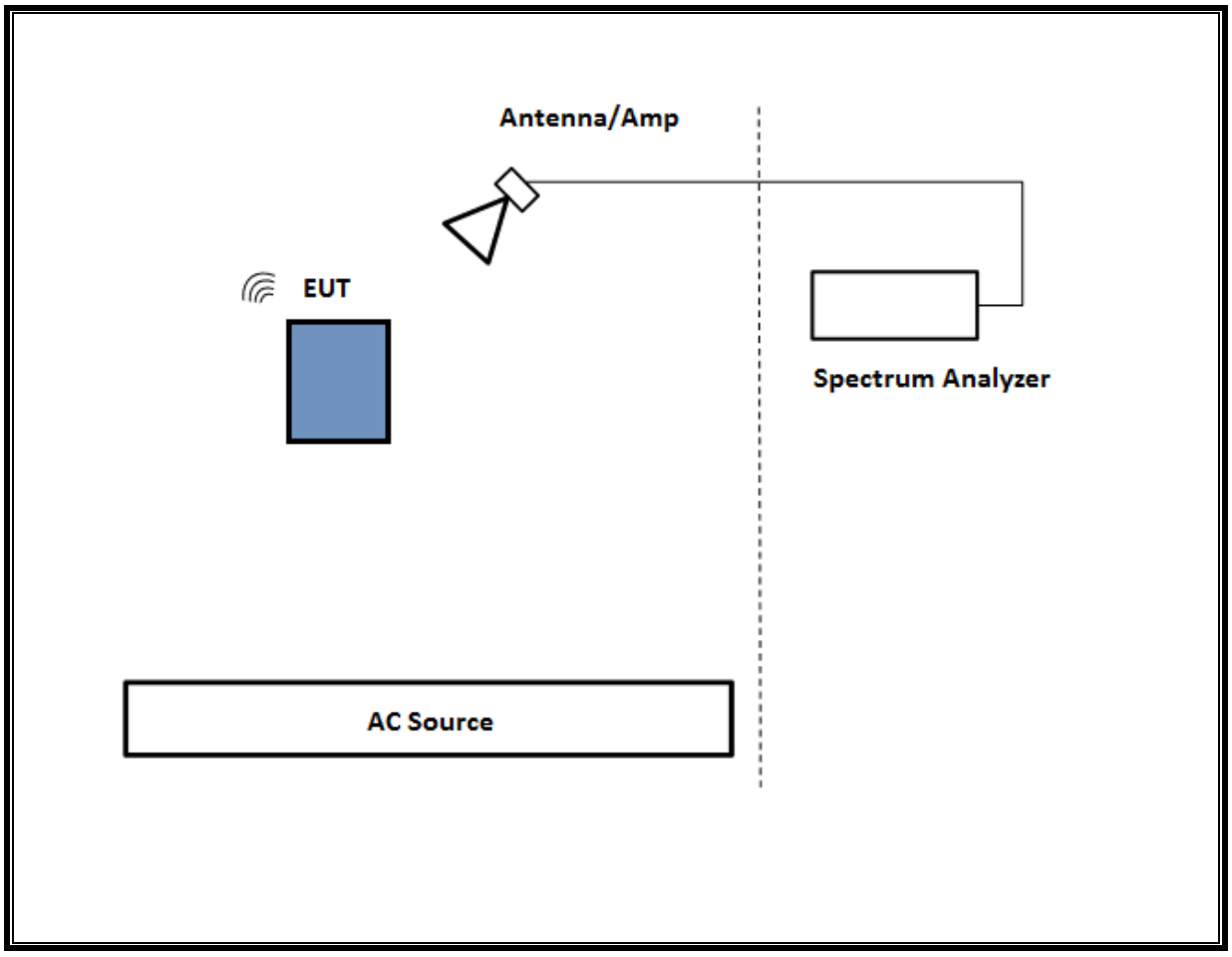
SETUP DIAGRAM FOR Below 1GHz and AC LINE CONDUCTED TEST



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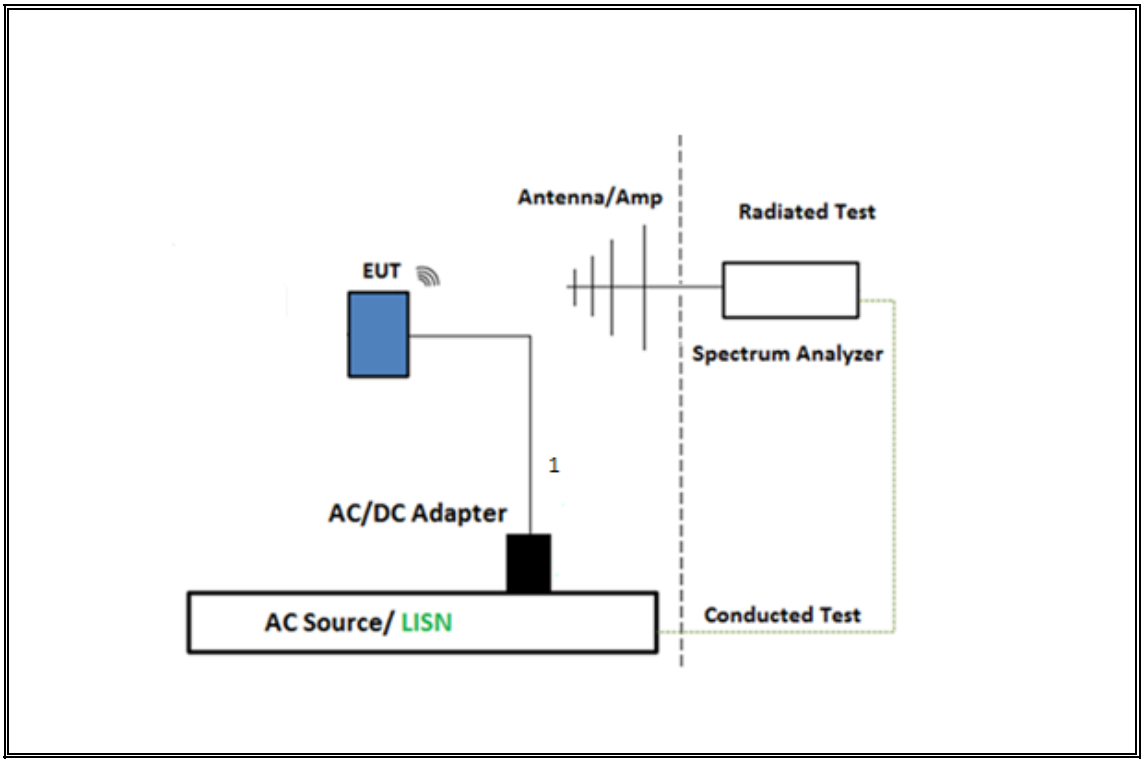
TEST SETUP- AC LINE CONDUCTED: LAPTOP CONFIGURATION



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7. MEASUREMENT METHOD

On Time and Duty Cycle: KDB 558074 D01 v05r02, Section 6.

6 dB BW: ANSI C63.10 Subclause -11.8.1 RBW ≥ DTS BW

Occupied BW (99%): ANSI C63.10-2013 Section 6.9.3

Output Power: ANSI C63.10 Subclause -11.9.1.3 Method PKPM1 Peak-reading power meter

Output Power: ANSI C63.10 Subclause -11.9.2.3.2 Measurement using gated average power meter.

PSD: ANSI C63.10 Subclause -11.10.2 Method PKPSD (peak PSD)

Radiated emissions restricted frequency bands: ANSI C63.10 Subclause -11.12.1 & Clause 13

Conducted emissions in restricted frequency bands: ANSI C63.10 Subclause -11.12.2

Band-edge: ANSI C63.10 Subclause -11.13.3.2 & Clause 13: Integration method -Peak detection

Band-edge: ANSI C63.10 Subclause -11.13.3.3 & Clause 13: Integration method -Trace averaging with continuous transmission at full power

AC Power Line Conducted Emissions: ANSI C63.10-2013, Section 6.2.

Radiated emissions non-restricted frequency bands ANSI C63.10 Subclause -11.11 & Clause 13

Radiated Spurious Emissions Below 30MHz: ANSI C63.10-2013 Section 6.4 & 13

NOTE: All conducted antenna port tests for Beamforming applied the same test procedures as BLE 1Mbps and BLE 2Mbps normal modes.

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8. TEST AND MEASUREMENT EQUIPMENT

The following test and measurement equipment was utilized for the tests documented in this report:

TEST EQUIPMENT LIST					
Description	**Manufacturer**	**Model**	**ID Num**	**Cal Due**	**Last Cal**
Antenna, Horn 1-18GHz	ETS-Lindgren	3117	T863	11/01/2020	11/01/2019
Amplifier, 1 to 18GHz, 35dB	Amplical	AFS42-00101800-25-S-42	T1567	01/24/2021	01/24/2020
*Antenna, Horn 1-18GHz	ETS Lindgren	3117	T136	06/14/2020	06/14/2019
Amplifier, 1 to 18GHz	Miteq	AFS42-00101800-25-S-42	T491	06/12/2021	06/12/2020
Antenna, Horn 1-18GHz	ETS-Lindgren	3117	T344	05/26/2021	05/26/2020
Amplifier, 1 to 18GHz	Miteq	AFS42-00101800-25-S-42	T1165	05/18/2021	05/18/2020
Spectrum Analyzer, PXA, 3Hz to 44GHz	Agilent (Keysight) Technologies	N9030A	T1210	01/21/2021	01/21/2020
Spectrum Analyzer, PXA, 3Hz to 44GHz	Agilent (Keysight) Technologies	N9030A	T1210	01/21/2021	01/21/2020
*Antenna, Broadband Hybrid, 30MHz to 2000MHz	Sunol Sciences Corp.	JB3	T900	08/09/2020	08/09/2019
Antenna Horn, 18 to 26GHz	ARA	SWH-28	T125	04/17/2021	04/17/2020
Pre-Amp 18-26GHz	Agilent Technology	8449B	T404	04/8/2021	04/08/2020
EMI Test Receiver	Rohde & Schwarz	ESW44	PRE0179522	02/20/2021	02/20/2020
EMI Test Receiver	Rohde & Schwarz	ESW44	PRE0179376	04/03/2021	04/03/2020
Power Meter, P-series single channel	Keysight	N1911A	PRE0177682	01/21/2021	01/21/2020
Power Sensor	Keysight	N1921A	T1226	02/13/2021	02/13/2020
Antenna, Active Loop 9KHz to 30MHz	ETS-Lindgren	6502	T757	10/01/2020	10/01/2020

AC Line Conducted					
Description	**Manufacturer**	**Model**	**ID Num**	**Cal Due**	**Last Cal**
EMI Test Receiver 9Khz-7GHz	Rohde & Schwarz	ESCI7	T1436	02/20/2021	02/20/2020
Power Cable, Line Conducted Emissions	UL	PG1	T861	10/27/2020	10/27/2019
LISN for Conducted Emissions CISPR-16	Fischer	50/250-25-2-01	PRE0186446	01/23/2021	01/23/2020
UL AUTOMATION SOFTWARE					
Radiated Software	UL	UL EMC	Rev 9.5, 30 Apr, 2020		
Conducted Software	UL	UL EMC	AP2020.8.6		
AC Line Conducted Software	UL	UL EMC	Rev 9.5, 21 Feb 2020		

*Testing is completed before equipment expiration date.

9. ANTENNA PORT TEST RESULTS

9.1. ON TIME AND DUTY CYCLE

LIMITS

None; for reporting purposes only.

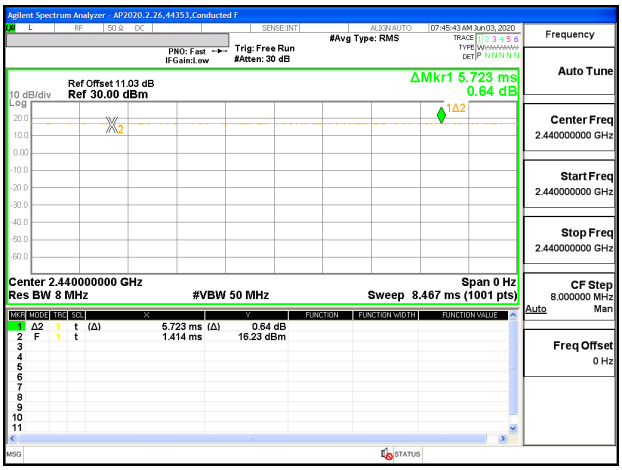
PROCEDURE

KDB 558074 Zero-Span Spectrum Analyzer Method.

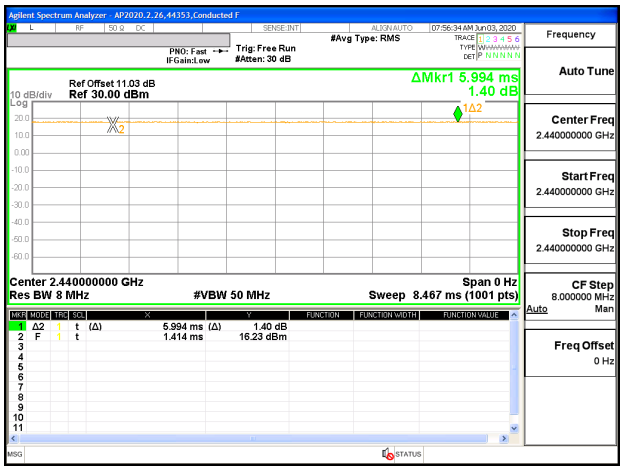
ON TIME AND DUTY CYCLE RESULTS

Mode	ON Time B (msec)	Period (msec)	Duty Cycle x (linear)	Duty Cycle (%)	Duty Cycle Correction Factor (dB)	1/B Minimum VBW (kHz)
2.4GHz Band						
BLE, 1Mbps	5.72	5.72	1.000	100.00%	0.00	0.010
BLE, 2Mbps	5.99	5.99	1.000	100.00%	0.00	0.010
BLE, TXBF, 1Mbps	5.49	5.49	1.000	100.00%	0.00	0.010
BLE, TXBF, 2Mbps	5.12	5.12	1.000	100.00%	0.00	0.010

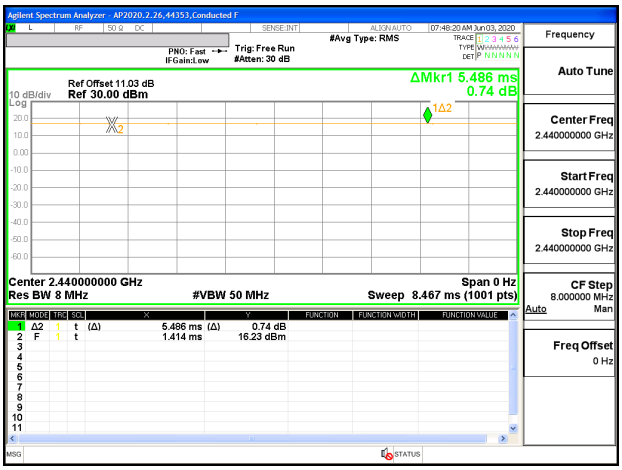
DUTY CYCLE PLOTS



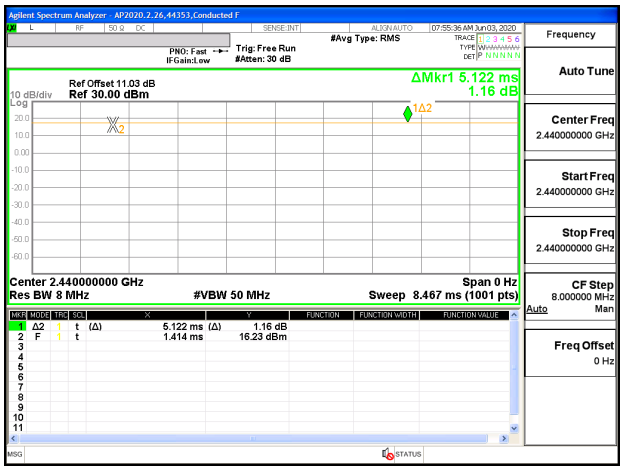
BLE 1Mbps



BLE 2Mbps



BLE TXBF 1Mbps



BLE TXBF 2Mbps

9.2. 99% BANDWIDTH

LIMITS

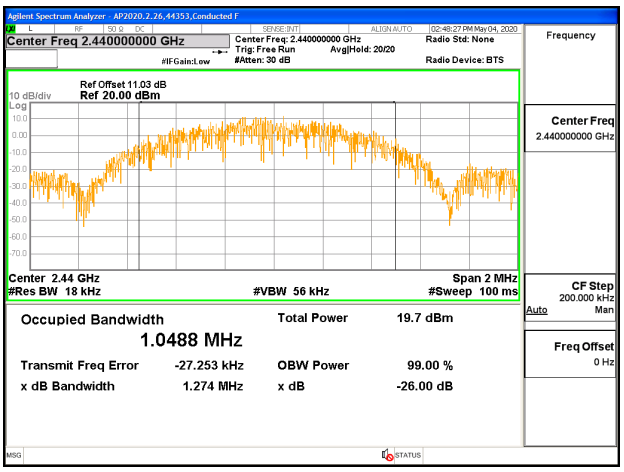
None; for reporting purposes only.

RESULTS

9.2.1. HIGH POWER BLE (1Mbps)

ANT 4

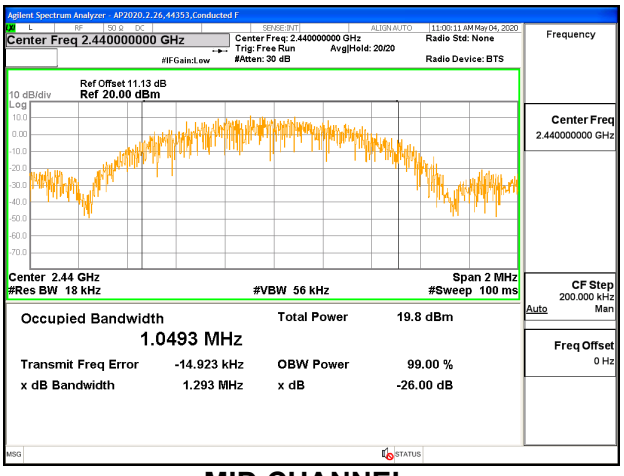
Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low	2402	1.057
Middle	2440	1.049
High	2480	1.053



MID CHANNEL

ANT 3

Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low	2402	1.056
Middle	2440	1.049
High	2480	1.040

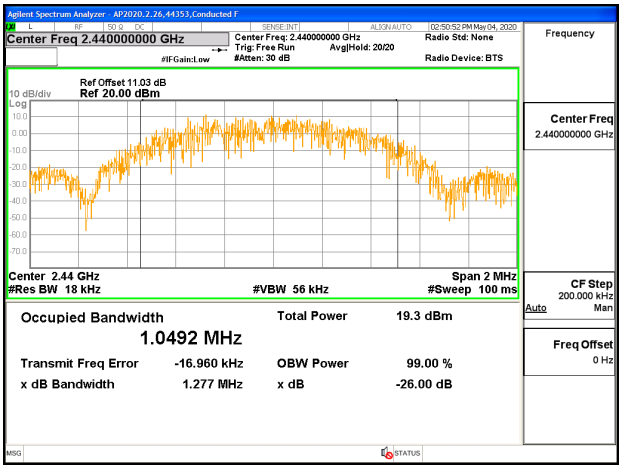


MID CHANNEL

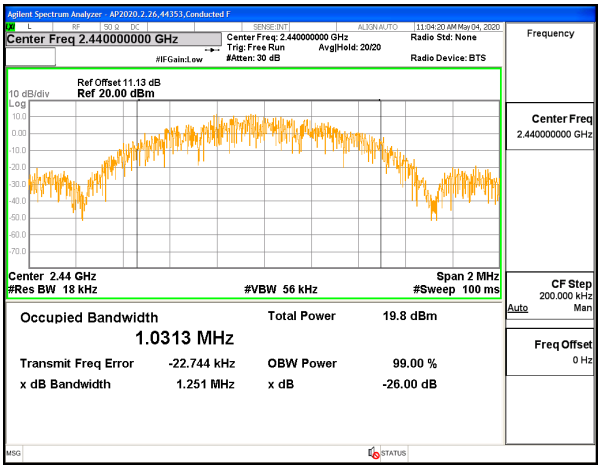
9.2.2. **HIGH POWER BLE TXBF (1Mbps)**

Channel	Frequency (MHz)	99% Bandwidth ANT 4 (MHz)	99% Bandwidth ANT 3 (MHz)
Low	2402	1.035	1.052
Mid	2440	1.049	1.031
High	2480	1.047	1.043

Note: Test procedures and setting are same as BLE normal mode.



MID CHANNEL ANT 4

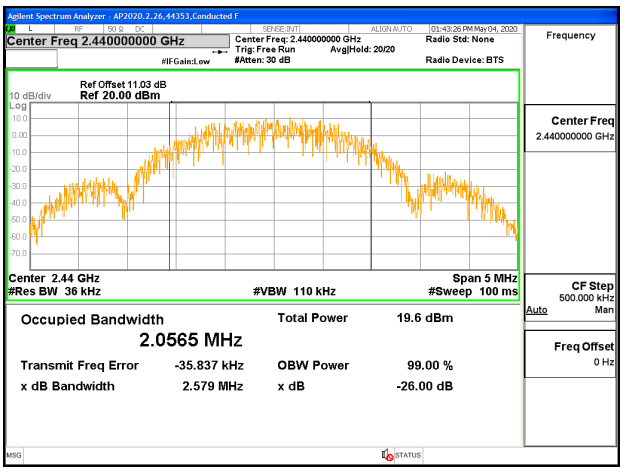


MID CHANNEL ANT 3

9.2.3. **HIGH POWER BLE (2Mbps)**

ANT 4

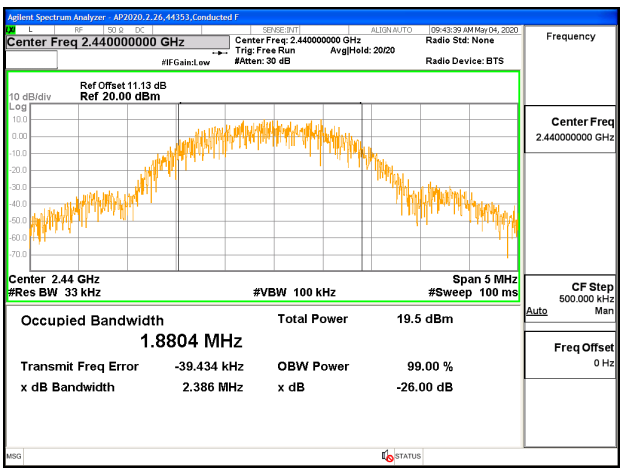
Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low	2404	2.026
Middle	2440	2.057
High	2478	2.056



MID CHANNEL

ANT 3

Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low	2404	1.908
Middle	2440	1.880
High	2478	1.914

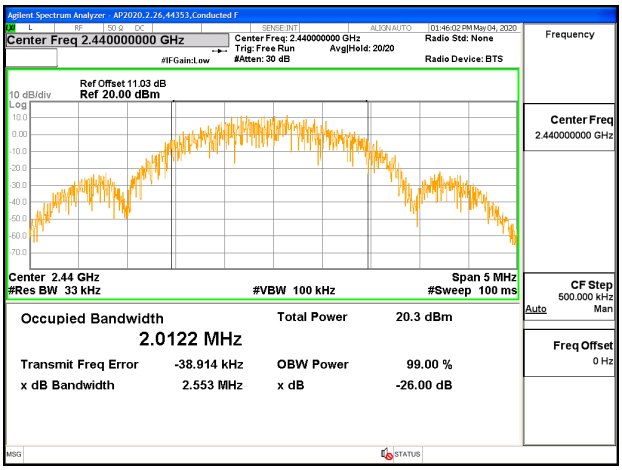


MID CHANNEL

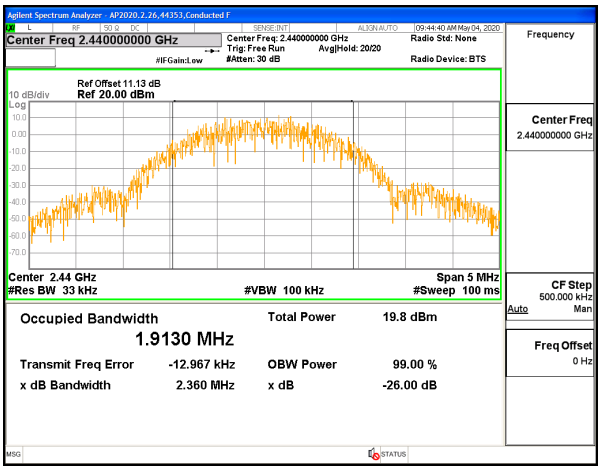
9.2.4. **HIGH POWER BLE TXBF (2Mbps)**

Channel	Frequency (MHz)	99% Bandwidth ANT 4 (MHz)	99% Bandwidth ANT 3 (MHz)
Low	2404	2.060	1.915
Mid	2440	2.012	1.913
High	2478	2.010	1.902

Note: Test procedures and setting are same as BLE normal mode.



MID CHANNEL ANT 4

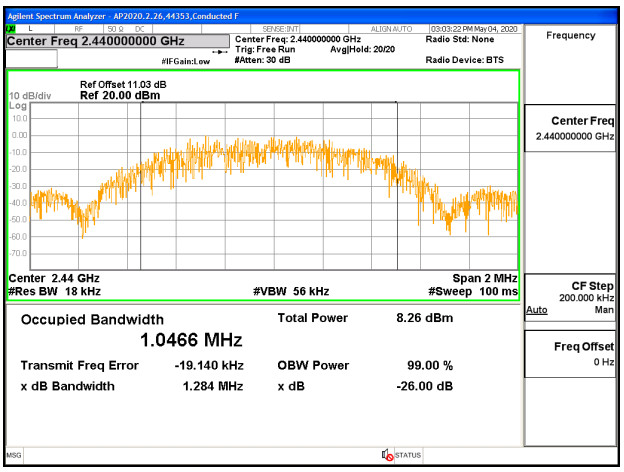


MID CHANNEL ANT 3

9.2.5. **LOW POWER BLE (1Mbps)**

ANT 4

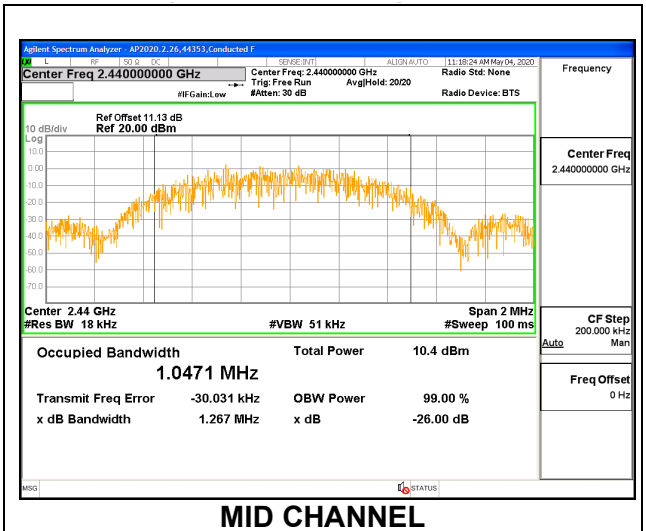
Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low	2402	1.066
Middle	2440	1.047
High	2480	1.060



MID CHANNEL

ANT 3

Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low	2402	1.065
Middle	2440	1.047
High	2480	1.049

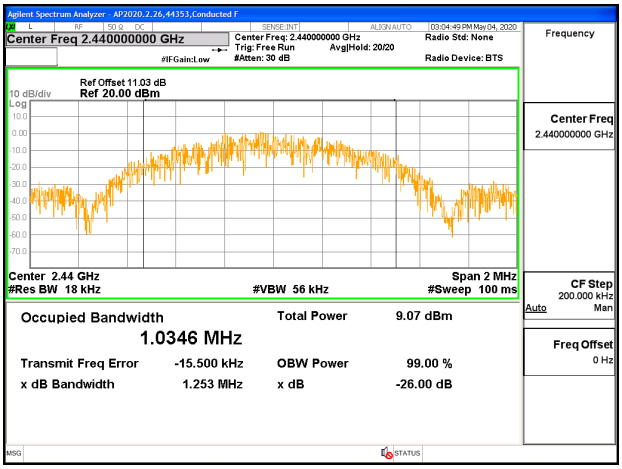


MID CHANNEL

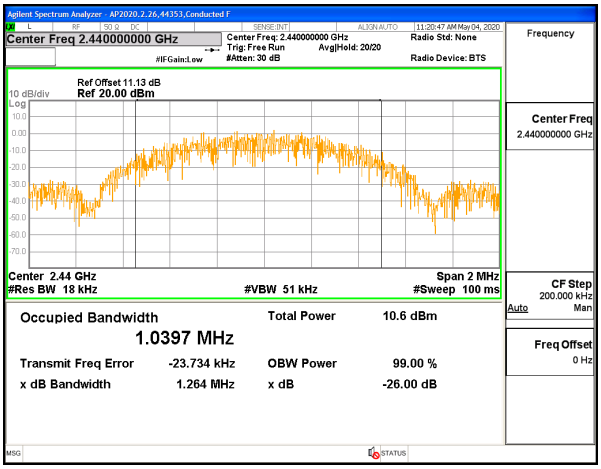
9.2.6. **LOW POWER BLE TXBF (1Mbps)**

Channel	Frequency (MHz)	99% Bandwidth ANT 4 (MHz)	99% Bandwidth ANT 3 (MHz)
Low	2402	1.060	1.059
Mid	2440	1.035	1.040
High	2480	1.059	1.061

Note: Test procedures and setting are same as BLE normal mode.



MID CHANNEL ANT 4

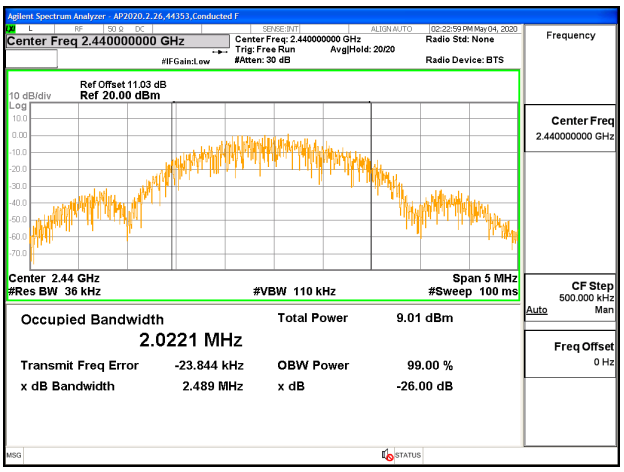


MID CHANNEL ANT 3

9.2.7. **LOW POWER BLE (2Mbps)**

ANT 4

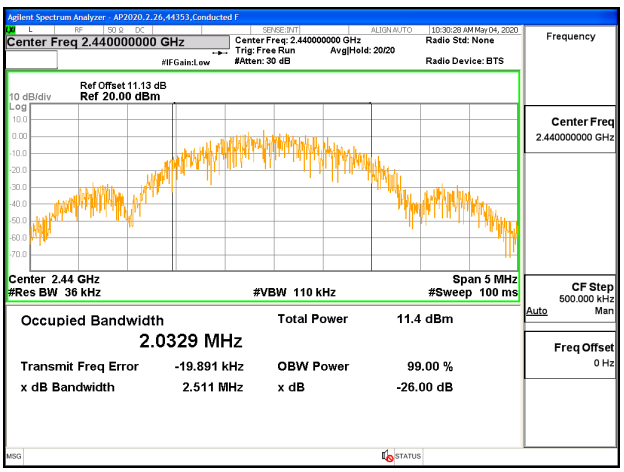
Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low	2404	2.016
Middle	2440	2.022
High	2478	2.018



MID CHANNEL

ANT 3

Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low	2404	2.022
Middle	2440	2.033
High	2478	2.021

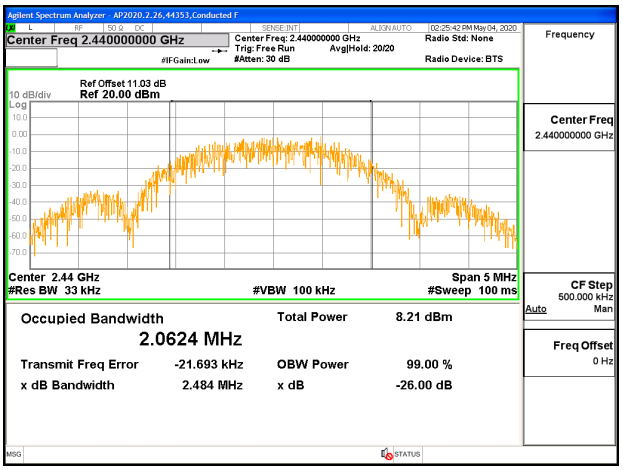


MID CHANNEL

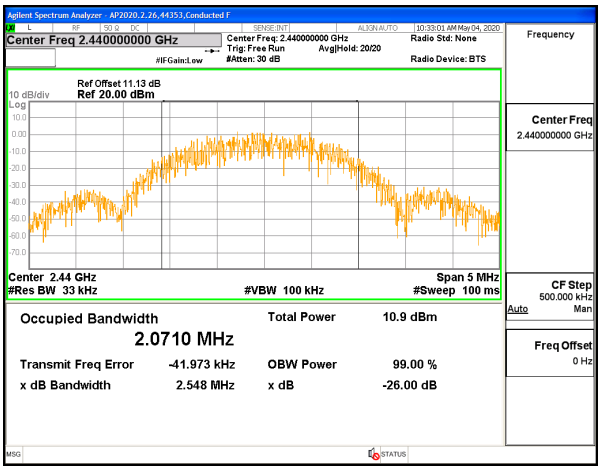
9.2.8. **LOW POWER BLE TXBF (2Mbps)**

Channel	Frequency (MHz)	99% Bandwidth ANT 4 (MHz)	99% Bandwidth ANT 3 (MHz)
Low	2404	2.048	2.074
Mid	2440	2.062	2.071
High	2478	2.044	2.068

Note: Test procedures and setting are same as BLE normal mode.



MID CHANNEL ANT 4



MID CHANNEL ANT 3

9.3. 6 dB BANDWIDTH

LIMITS

FCC §15.407 (e)

RSS-247 5.2 (a)

The minimum 6 dB bandwidth shall be at least 500 kHz.

RESULTS

The 6dB bandwidth was measured for the 1Mbps mode to demonstrate compliance with the minimum required bandwidth of 500 kHz. Other modes were not tested as their bandwidth is greater than the 2Mbps mode, as demonstrated by the 99% bandwidth measurements performed on all modes.

UL VERIFICATION SERVICES INC.
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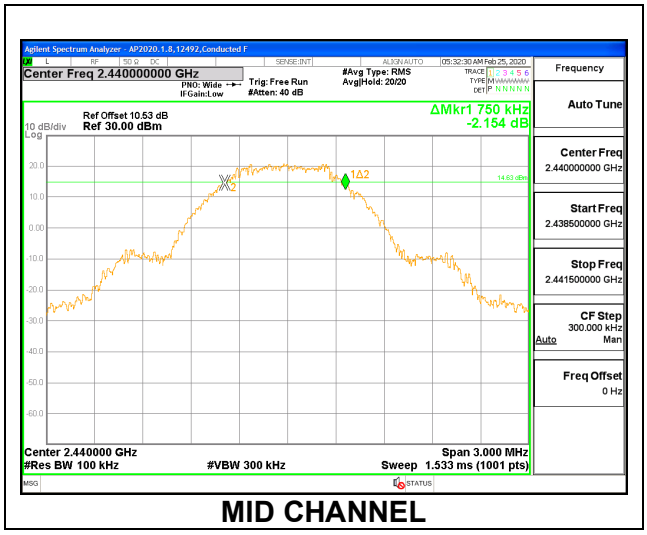
9.3.1. **HIGH POWER BLE (1Mbps)**

ANT 4

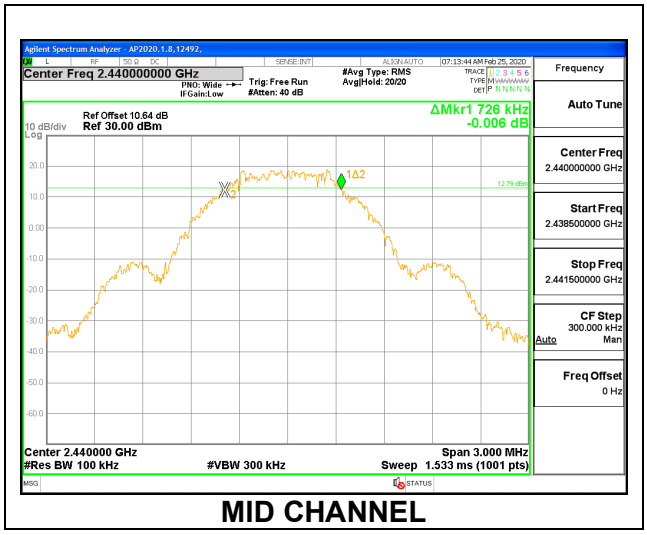
Channel	Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum Limit (MHz)
Low	2402	0.735	0.5
Middle	2440	0.750	0.5
High	2480	0.756	0.5



MID CHANNEL

ANT 3

Channel	Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum Limit (MHz)
Low	2402	0.744	0.5
Middle	2440	0.726	0.5
High	2480	0.720	0.5



MID CHANNEL

9.4. OUTPUT POWER

LIMITS

FCC §15.247 (b) (3)

RSS-247 5.4 (d)

The maximum antenna gain is less than or equal to 6 dBi, therefore the limit is 30 dBm.

TEST PROCEDURE

The transmitter output is connected to a power meter.

The cable assembly insertion loss of 11.03 dB (including 10 dB pad and 1.03 dB cable) was entered as an offset in the power meter to allow for a gated peak reading of power.

DIRECTIONAL ANTENNA GAIN

For 1 TX:
There is only one transmitter output therefore the directional gain is equal to the antenna gain.

For 2TX:

Tx chains are correlated for power and PSD due to the device supporting Beamforming mode
The directional gains are as follows:

Band (GHz)	ANT 4 Antenna Gain (dBi)	ANT 3 Antenna Gain (dBi)	Uncorrelated Chains Directional Gain (dBi)	Correlated Chains Directional Gain (dBi)
2.4	-2.10	-0.30	-1.11	1.86

RESULTS

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9.4.1. **HIGH POWER BLE (1Mbps)**

ANT 4

Tested By:	44353
Date:	7/29/2020

Channel	Frequency (MHz)	Peak Power Reading (dBm)	Limit (dBm)	Margin (dB)
Low	2402	20.17	30	-9.83
Middle	2440	20.26	30	-9.74
High	2480	20.14	30	-9.86

ANT 3

Tested By:	44353
Date:	7/29/2020

Channel	Frequency (MHz)	Peak Power Reading (dBm)	Limit (dBm)	Margin (dB)
Low	2402	20.06	30	-9.94
Middle	2440	20.25	30	-9.75
High	2480	20.00	30	-10.00

9.4.2. **HIGH POWER BLE TXBF (1Mbps)**

ANT 4 + ANT 3

Tested By:	4353
Date:	7/29/2020

Channel	Frequency (MHz)	Output Power ANT 4 (dBm)	Output Power ANT 3 (dBm)	Total Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	17.75	17.72	20.75	30	-9.25
Middle	2440	17.77	17.73	20.76	30	-9.24
High	2480	17.69	17.68	20.70	30	-9.30

9.4.3. HIGH POWER BLE (2Mbps)

ANT 4

Tested By:	44353
Date:	7/29/2020

Channel	Frequency (MHz)	Peak Power Reading (dBm)	Limit (dBm)	Margin (dB)
Low	2404	20.16	30	-9.84
Middle	2440	20.22	30	-9.78
High	2478	20.18	30	-9.82

ANT 3

Tested By:	44353
Date:	7/29/2020

Channel	Frequency (MHz)	Peak Power Reading (dBm)	Limit (dBm)	Margin (dB)
Low	2404	20.15	30	-9.85
Middle	2440	20.21	30	-9.79
High	2478	20.18	30	-9.82

9.4.4. HIGH POWER BLE TXBF (2Mbps)

ANT 4 + ANT 3

Tested By:	44353
Date:	7/29/2020

Channel	Frequency (MHz)	Output Power ANT 4 (dBm)	Output Power ANT 3 (dBm)	Total Power (dBm)	Limit (dBm)	Margin (dB)
Low	2404	17.70	17.68	20.70	30	-9.30
Middle	2440	17.78	17.74	20.77	30	-9.23
High	2478	17.73	17.65	20.70	30	-9.30

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9.4.5. **LOW POWER BLE (1Mbps)**

ANT 4

Tested By:	44353
Date:	7/29/2020

Channel	Frequency (MHz)	Peak Power Reading (dBm)	Limit (dBm)	Margin (dB)
Low	2402	12.67	30	-17.33
Middle	2440	12.75	30	-17.25
High	2480	12.62	30	-17.38

ANT 3

Tested By:	44353
Date:	7/29/2020

Channel	Frequency (MHz)	Peak Power Reading (dBm)	Limit (dBm)	Margin (dB)
Low	2402	12.64	30	-17.36
Middle	2440	12.71	30	-17.29
High	2480	12.66	30	-17.34

9.4.6. **LOW POWER BLE TXBF (1Mbps)**

ANT 4 + ANT 3

Tested By:	44353
Date:	7/29/2020

Channel	Frequency (MHz)	Output Power ANT 4 (dBm)	Output Power ANT 3 (dBm)	Total Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	12.75	12.72	15.75	30	-14.25
Middle	2440	12.78	12.77	15.79	30	-14.21
High	2480	12.69	12.67	15.69	30	-14.31

9.4.7. **LOW POWER BLE (2Mbps)**

ANT 4

Tested By:	44353
Date:	7/29/2020

Channel	Frequency (MHz)	Peak Power Reading (dBm)	Limit (dBm)	Margin (dB)
Low	2404	12.78	30	-17.22
Middle	2440	12.82	30	-17.18
High	2478	12.77	30	-17.23

ANT 3

Tested By:	44353
Date:	7/29/2020

Channel	Frequency (MHz)	Peak Power Reading (dBm)	Limit (dBm)	Margin (dB)
Low	2404	12.76	30	-17.24
Middle	2440	12.79	30	-17.21
High	2478	12.75	30	-17.25

9.4.8. **LOW POWER BLE TXBF (2Mbps)**

ANT 4 + ANT 3

Tested By:	44353
Date:	7/29/2020

Channel	Frequency (MHz)	Output Power ANT 4 (dBm)	Output Power ANT 3 (dBm)	Total Power (dBm)	Limit (dBm)	Margin (dB)
Low	2404	12.71	12.72	15.73	30	-14.27
Middle	2440	12.84	12.83	15.85	30	-14.15
High	2478	12.72	12.70	15.72	30	-14.28

9.5. AVERAGE POWER

LIMITS

None; for reporting purposes only.

TEST PROCEDURE

The transmitter output is connected to a power meter.

The cable assembly insertion loss of 10.5 dB (including 10 dB pad and 0.5 dB cable) was entered as an offset in the power meter to allow for a gated average reading of power.

RESULTS

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9.5.1. **HIGH POWER BLE (1Mbps)**

ANT 4

Tested By:	44353
Date:	7/29/2020

Channel	Frequency (MHz)	AV power (dBm)
Low	2402	19.90
Middle	2440	19.98
High	2480	19.88

ANT 3

Tested By:	44353
Date:	7/29/2020

Channel	Frequency (MHz)	AV power (dBm)
Low	2402	19.79
Middle	2440	19.99
High	2480	19.74

9.5.2. **HIGH POWER BLE TXBF (1Mbps)**

ANT 4 + ANT 3

Tested By:	44353
Date:	7/29/2020

Channel	Frequency (MHz)	Average Power ANT 4 (dBm)	Average Power ANT 3 (dBm)	Total Power (dBm)
Low	2402	17.45	17.41	20.44
Middle	2440	17.46	17.42	20.45
High	2480	17.40	17.39	20.41

9.5.3. **HIGH POWER BLE (2Mbps)**

ANT 4

Tested By:	44353
Date:	7/29/2020

Channel	Frequency (MHz)	AV power (dBm)
Low	2404	19.90
Middle	2440	19.95
High	2478	19.91

ANT 3

Tested By:	44353
Date:	7/29/2020

Channel	Frequency (MHz)	AV power (dBm)
Low	2404	19.87
Middle	2440	19.94
High	2478	19.92

9.5.4. **HIGH POWER BLE TXBF (2Mbps)**

ANT 4 + ANT 3

Tested By:	44353
Date:	7/29/2020

Channel	Frequency (MHz)	Average Power ANT 4 (dBm)	Average Power ANT 3 (dBm)	Total Power (dBm)
Low	2404	17.40	17.41	20.42
Middle	2440	17.47	17.43	20.46
High	2478	17.43	17.39	20.42

9.5.5. **LOW POWER BLE (1Mbps)**

ANT 4

Tested By:	44353
Date:	7/29/2020

Channel	Frequency (MHz)	AV power (dBm)
Low	2402	12.43
Middle	2440	12.47
High	2480	12.39

ANT 3

Tested By:	44353
Date:	7/29/2020

Channel	Frequency (MHz)	AV power (dBm)
Low	2402	12.41
Middle	2440	12.47
High	2480	12.42

9.5.6. **LOW POWER BLE TXBF (1Mbps)**

ANT 4 + ANT 3

Tested By:	44353
Date:	7/29/2020

Channel	Frequency (MHz)	Average Power ANT 4 (dBm)	Average Power ANT 3 (dBm)	Total Power (dBm)
Low	2402	12.47	12.44	15.47
Middle	2440	12.49	12.47	15.49
High	2480	12.43	12.40	15.43

9.5.7. **LOW POWER BLE (2Mbps)**

ANT 4

Tested By:	44353
Date:	7/29/2020

Channel	Frequency (MHz)	AV power (dBm)
Low	2404	12.43
Middle	2440	12.49
High	2478	12.42

ANT 3

Tested By:	44353
Date:	7/29/2020

Channel	Frequency (MHz)	AV power (dBm)
Low	2404	12.44
Middle	2440	12.48
High	2478	12.43

9.5.8. **LOW POWER BLE TXBF (2Mbps)**

ANT 4 + ANT 3

Tested By:	44353
Date:	7/29/2020

Channel	Frequency (MHz)	Average Power ANT 4 (dBm)	Average Power ANT 3 (dBm)	Total Power (dBm)
Low	2404	12.41	12.42	15.43
Middle	2440	12.47	12.46	15.48
High	2478	12.42	12.41	15.43

9.6. POWER SPECTRAL DENSITY

LIMITS

FCC §15.247 (e)

RSS-247 (5.2) (b)

The 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.

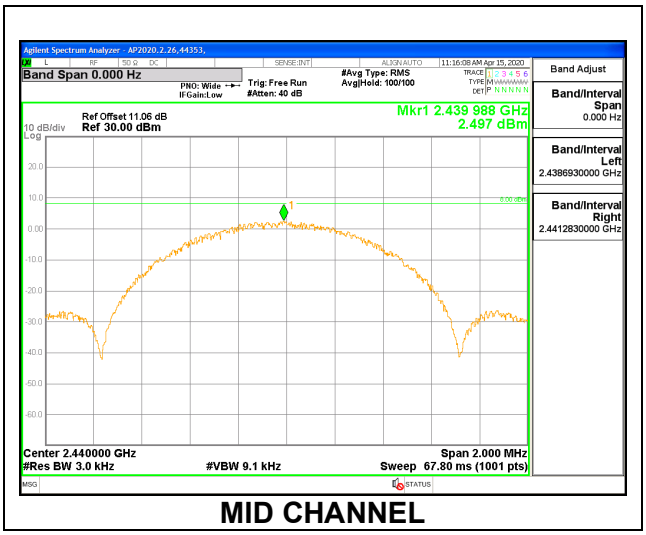
RESULTS

Power spectral density was measured on the low, mid and high channels for all supported modes. Additional measurements on adjacent channels to the low and/or high channels were limited to cases where the edge channels have a significantly lower rated power than the adjacent channels.

9.6.1. **HIGH POWER BLE (1Mbps)**

ANT 4

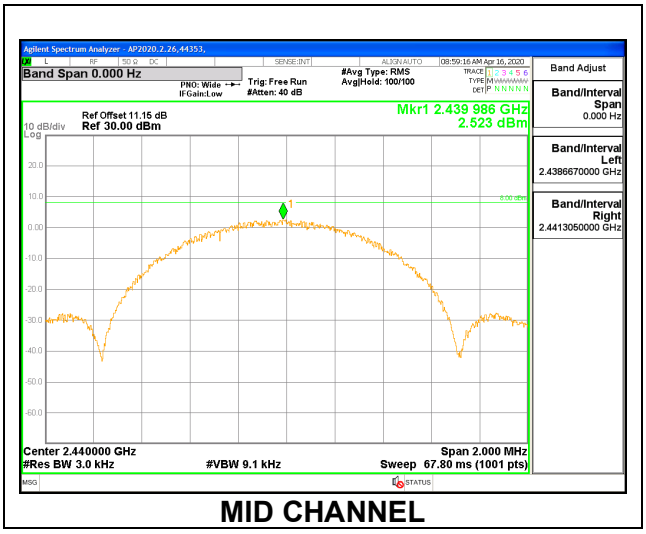
Channel	Frequency (MHz)	PSD (dBm/3kHz)	Limit (dBm/3kHz)	Margin (dB)
Low	2402	2.200	8	-5.80
Middle	2440	2.497	8	-5.50
High	2480	2.134	8	-5.87



MID CHANNEL

ANT 3

Channel	Frequency (MHz)	PSD (dBm/3kHz)	Limit (dBm/3kHz)	Margin (dB)
Low	2402	1.649	8	-6.35
Middle	2440	2.523	8	-5.48
High	2480	1.144	8	-6.86



MID CHANNEL

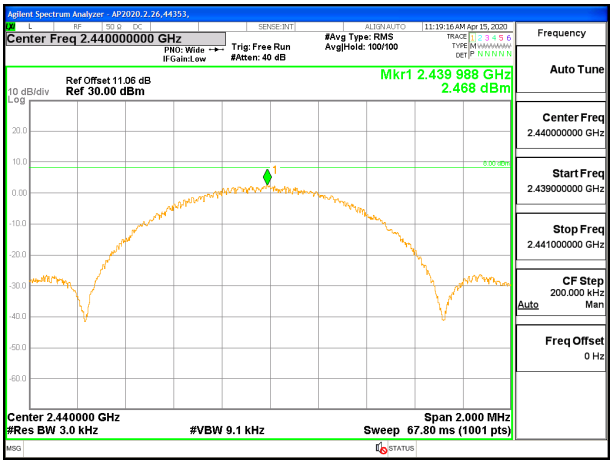
9.6.2. HIGH POWER BLE TXBF (1Mbps)

Duty Cycle CF (dB)	0.00	Included in Calculations of Corr'd PSD

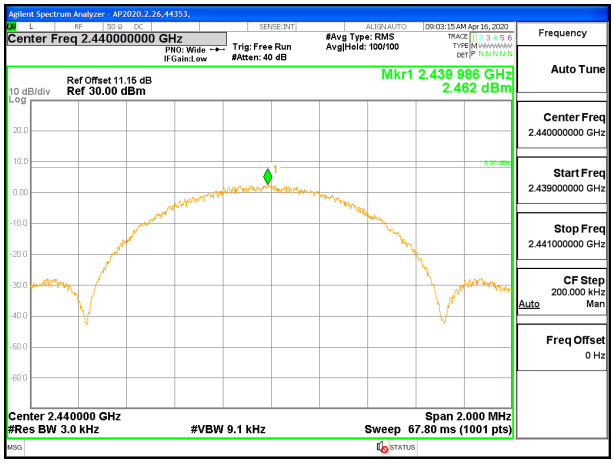
PSD Results

Channel	Frequency (MHz)	ANT 4 Meas (dBm/ 3kHz)	ANT 3 Meas (dBm/ 3kHz)	Total Corr'd PSD (dBm/ 3kHz)	Limit (dBm/ 3kHz)	Margin (dB)
Low	2402	2.198	2.129	5.17	8.0	-2.8
Mid	2440	2.468	2.462	5.48	8.0	-2.5
Hjigh	2480	2.088	1.521	4.82	8.0	-3.2

Note: Test procedures and setting are same as BLE normal mode.



MID CHANNEL ANT 4

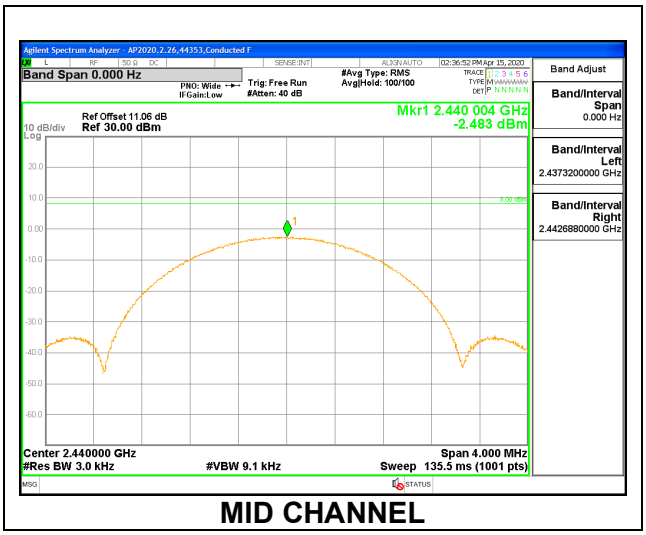


MID CHANNEL ANT 3

9.6.3. HIGH POWER BLE (2Mbps)

ANT 4

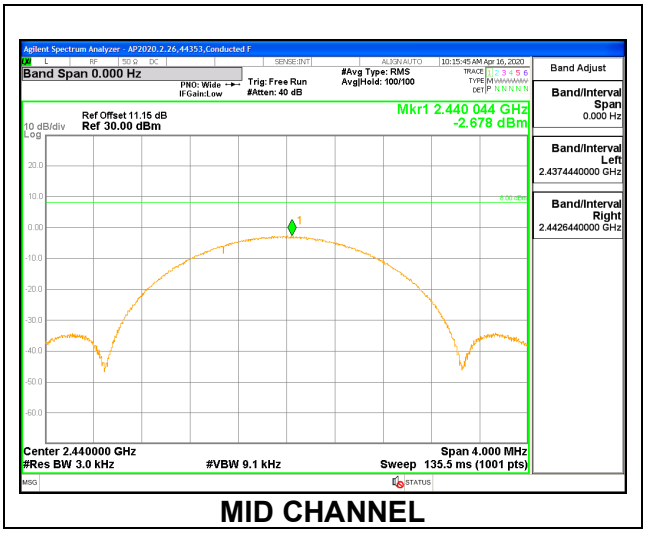
Channel	Frequency (MHz)	PSD (dBm/3kHz)	Limit (dBm/3kHz)	Margin (dB)
Low	2404	-2.990	8	-10.99
Middle	2440	-2.483	8	-10.48
High	2478	-2.863	8	-10.86



MID CHANNEL

ANT 3

Channel	Frequency (MHz)	PSD (dBm/3kHz)	Limit (dBm/3kHz)	Margin (dB)
Low	2404	-2.597	8	-10.60
Middle	2440	-2.678	8	-10.68
High	2478	-2.835	8	-10.84



MID CHANNEL

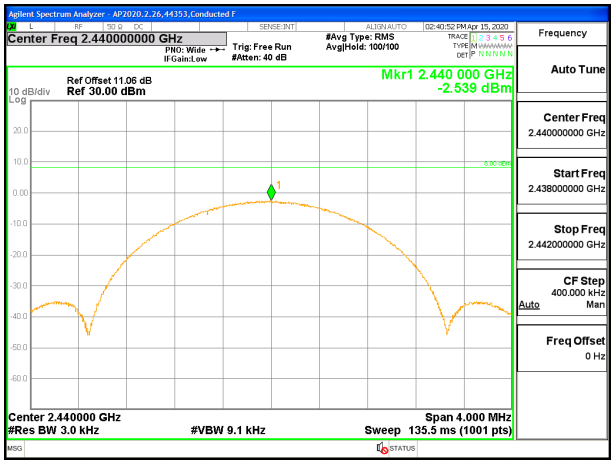
9.6.4. HIGH POWER BLE TXBF (2Mbps)

Duty Cycle CF (dB)	0.00	Included in Calculations of Corr'd PSD

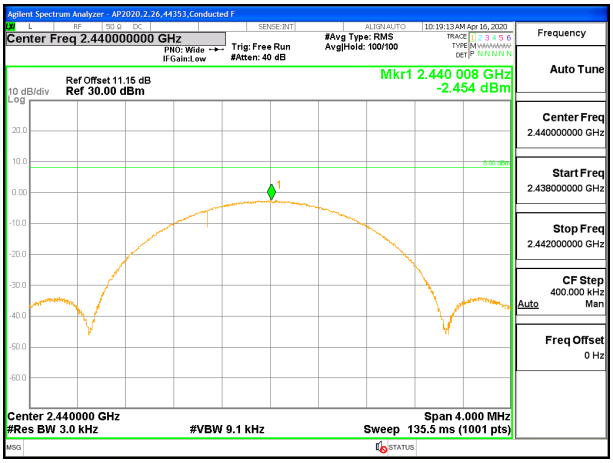
PSD Results

Channel	Frequency (MHz)	ANT 4 Meas (dBm/ 3kHz)	ANT 3 Meas (dBm/ 3kHz)	Total Corr'd PSD (dBm/ 3kHz)	Limit (dBm/ 3kHz)	Margin (dB)
Low	2404	-3.028	-2.660	0.17	8.0	-7.8
Mid	2440	-2.539	-2.454	0.51	8.0	-7.5
Hjigh	2478	-2.831	-2.903	0.14	8.0	-7.9

Note: Test procedures and setting are same as BLE normal mode.



MID CHANNEL ANT 4

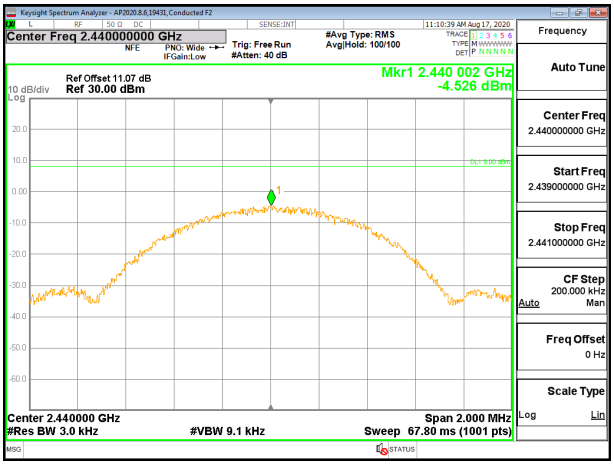


MID CHANNEL ANT 3

9.6.5. **LOW POWER BLE (1Mbps)**

ANT 4

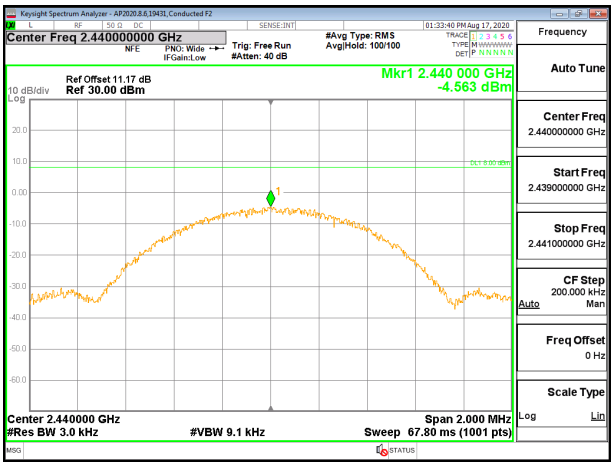
Channel	Frequency (MHz)	PSD (dBm/3kHz)	Limit (dBm/3kHz)	Margin (dB)
Low	2402	-5.280	8	-13.28
Middle	2440	-4.526	8	-12.53
High	2480	-6.734	8	-14.73



MID CHANNEL

ANT 3

Channel	Frequency (MHz)	PSD (dBm/3kHz)	Limit (dBm/3kHz)	Margin (dB)
Low	2402	-5.235	8	-13.24
Middle	2440	-4.563	8	-12.56
High	2480	-6.843	8	-14.84



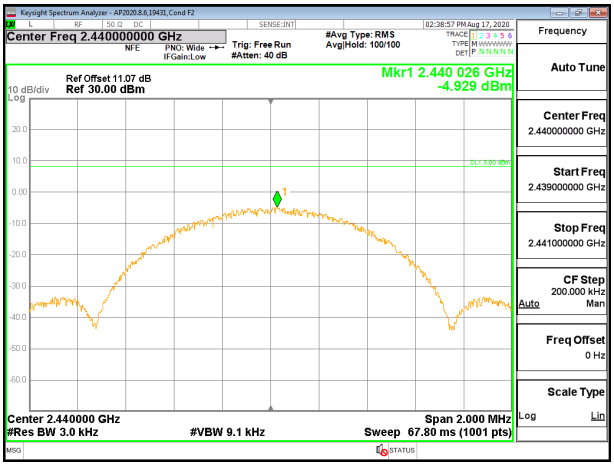
MID CHANNEL

9.6.6. **LOW POWER BLE TXBF (1Mbps)**

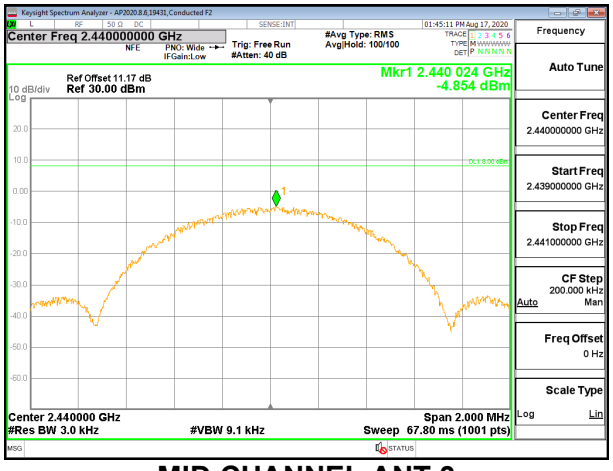
PSD Results

Channel	Frequency (MHz)	ANT 4 Meas (dBm/ 3kHz)	ANT 3 Meas (dBm/ 3kHz)	Total Corr'd PSD (dBm/ 3kHz)	Limit (dBm/ 3kHz)	Margin (dB)
Low	2402	-5.499	-5.533	-2.51	8.0	-10.5
Mid	2440	-4.929	-4.854	-1.88	8.0	-9.9
Hjigh	2480	-7.101	-7.290	-4.18	8.0	-12.2

Note: Test procedures and setting are same as BLE normal mode.



MID CHANNEL ANT 4

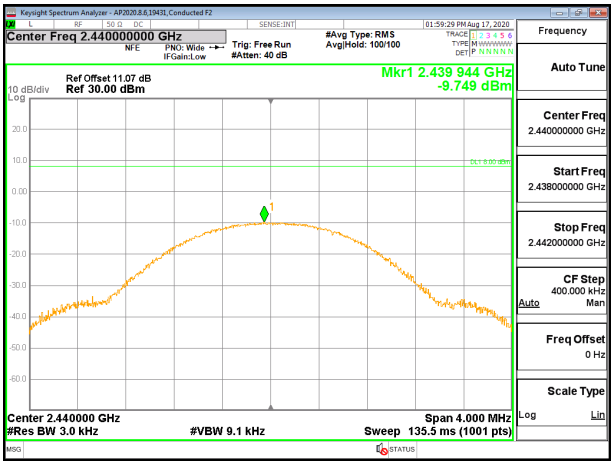


MID CHANNEL ANT 3

9.6.7. **LOW POWER BLE (2Mbps)**

ANT 4

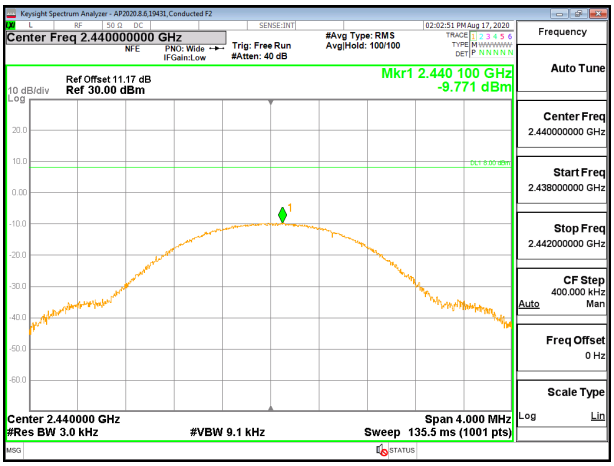
Channel	Frequency (MHz)	PSD (dBm/3kHz)	Limit (dBm/3kHz)	Margin (dB)
Low	2404	-10.603	8	-18.60
Middle	2440	-9.749	8	-17.75
High	2478	-11.998	8	-20.00



MID CHANNEL

ANT 3

Channel	Frequency (MHz)	PSD (dBm/3kHz)	Limit (dBm/3kHz)	Margin (dB)
Low	2404	-10.500	8	-18.50
Middle	2440	-9.771	8	-17.77
High	2478	-11.929	8	-19.93



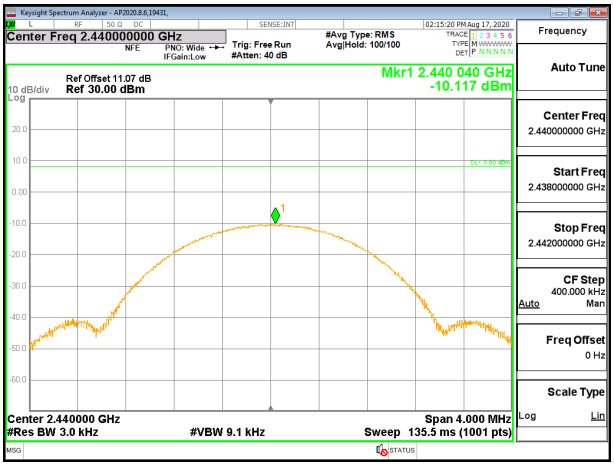
MID CHANNEL

9.6.8. **LOW POWER BLE TXBF (2Mbps)**

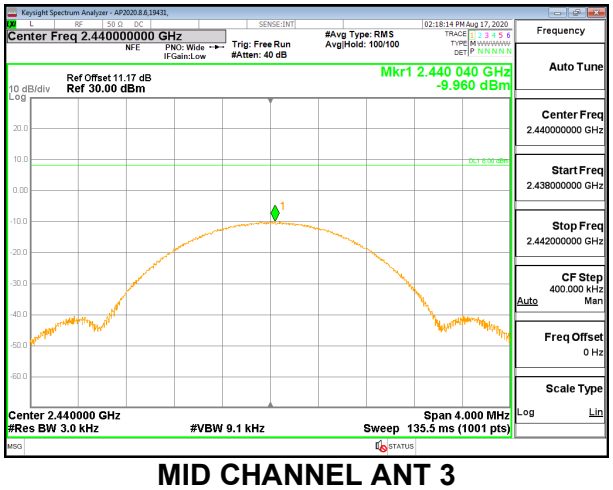
PSD Results

Channel	Frequency (MHz)	ANT 4 Meas (dBm/ 3kHz)	ANT 3 Meas (dBm/ 3kHz)	Total Corr'd PSD (dBm/ 3kHz)	Limit (dBm/ 3kHz)	Margin (dB)
Low	2404	-10.727	-10.590	-7.65	8.0	-15.6
Mid	2440	-10.117	-9.960	-7.03	8.0	-15.0
Hjigh	2478	-12.145	-12.202	-9.16	8.0	-17.2

Note: Test procedures and setting are same as BLE normal mode.



MID CHANNEL ANT 4



MID CHANNEL ANT 3

9.7. CONDUCTED SPURIOUS EMISSIONS

LIMITS

FCC §15.247 (d)

RSS-247 5.5

Output power was measured based on the use of a peak measurement, therefore the required attenuation is 20 dB.

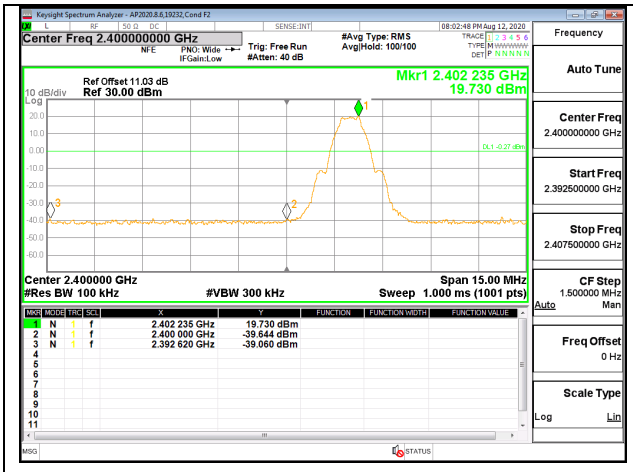
Note: Test procedures and setting are same as BLE normal mode.

RESULTS

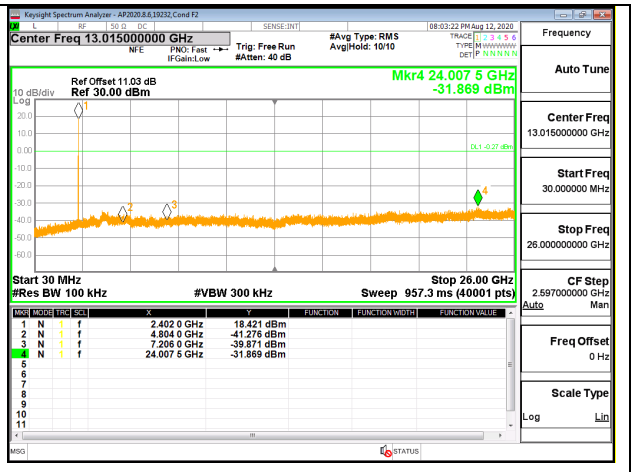
UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888

9.7.1. HIGH POWER BLE (1Mbps)

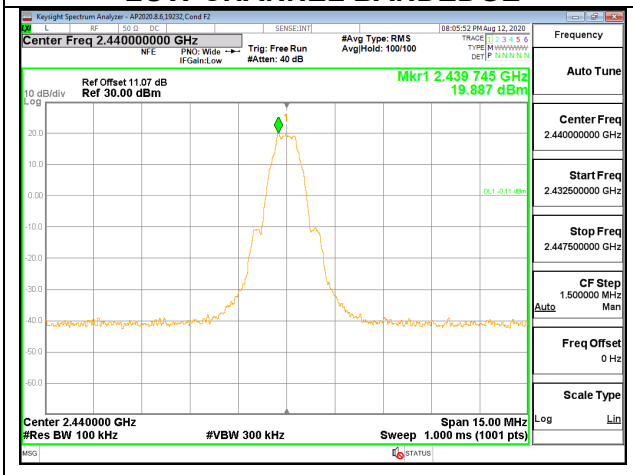
ANT 4



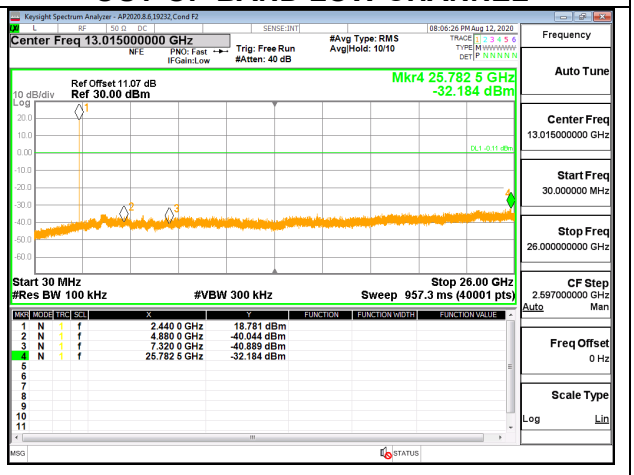
LOW CHANNEL BANDEDGE



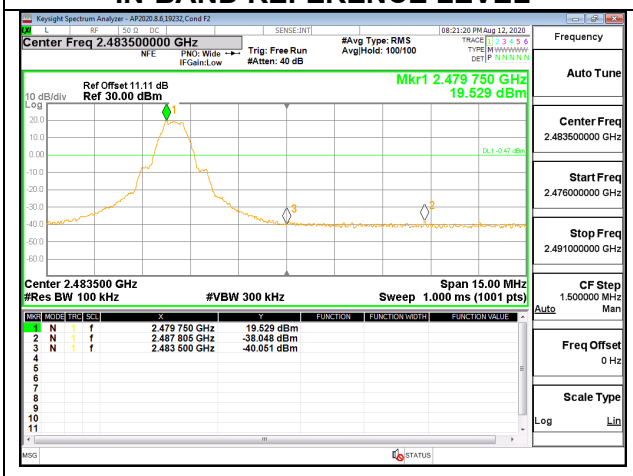
OUT-OF-BAND LOW CHANNEL



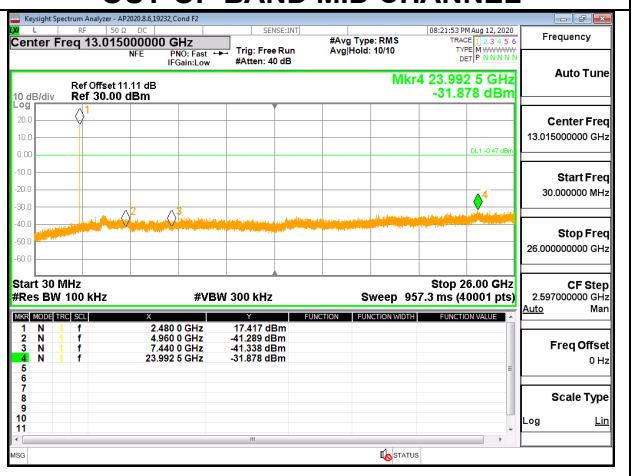
IN-BAND REFERENCE LEVEL



OUT-OF-BAND MID CHANNEL



HIGH CHANNEL BANDEDGE



OUT-OF-BAND HIGH CHANNEL

UL VERIFICATION SERVICES INC.
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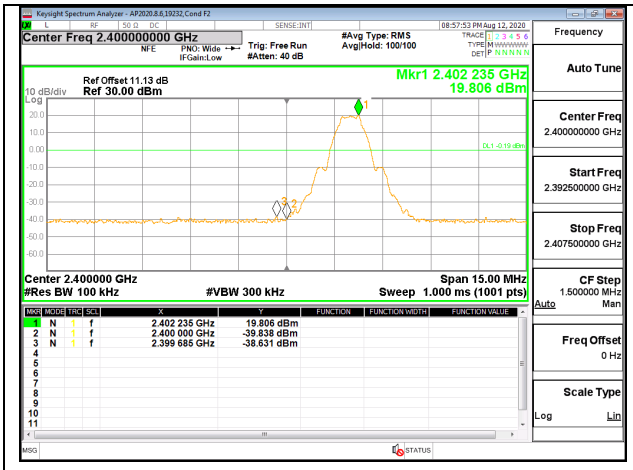
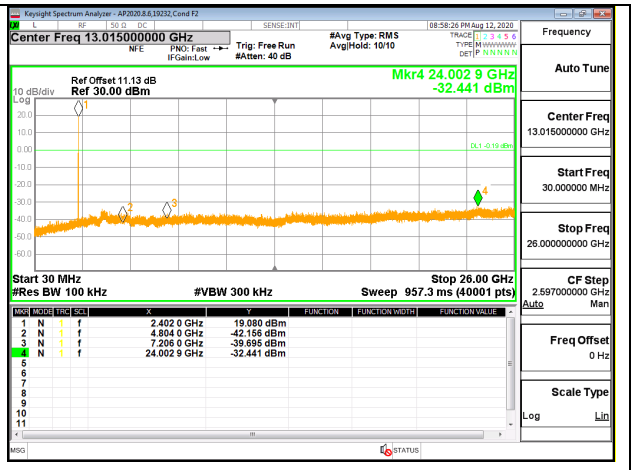
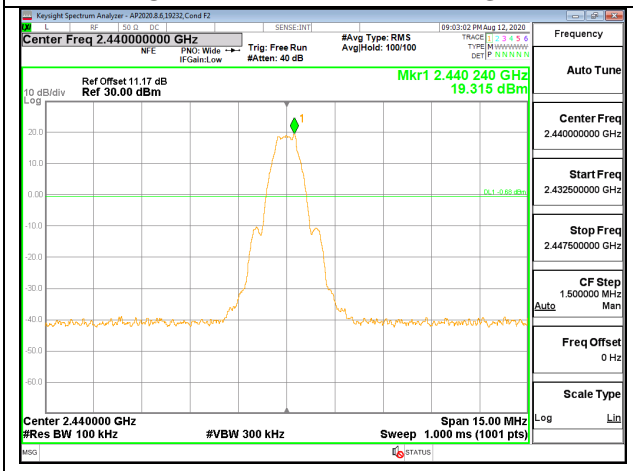
ANT 3



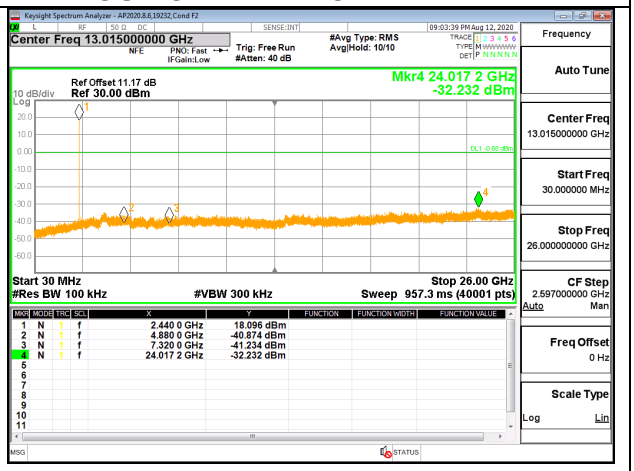
LOW CHANNEL BANDEDGE



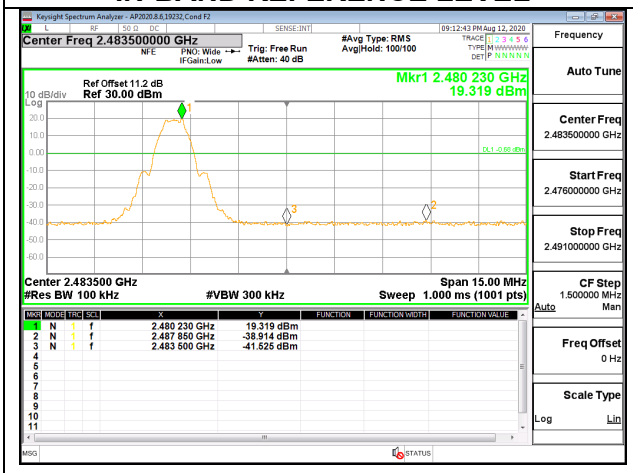
OUT-OF-BAND LOW CHANNEL



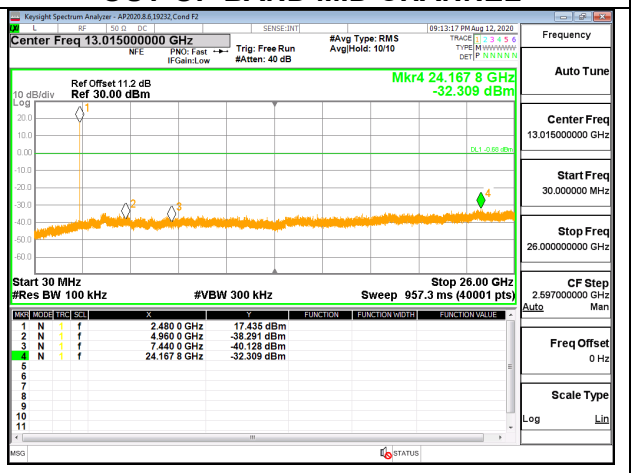
IN-BAND REFERENCE LEVEL



OUT-OF-BAND MID CHANNEL



HIGH CHANNEL BANDEDGE

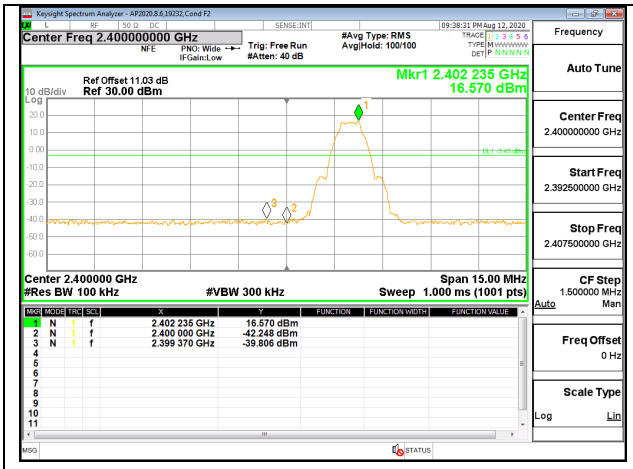


OUT-OF-BAND HIGH CHANNEL

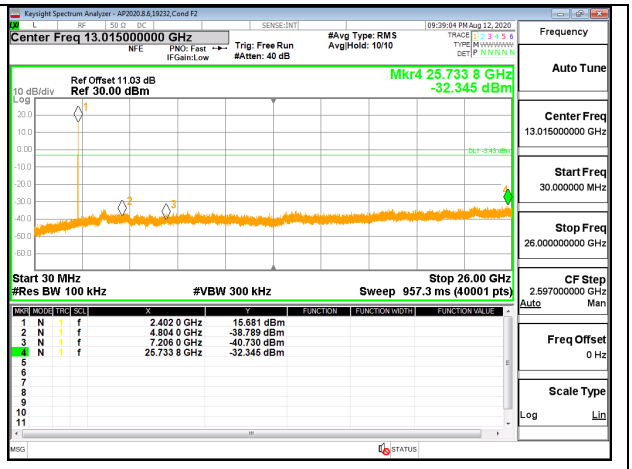
9.7.2. HIGH POWER BLE TXBF (1Mbps)

Note: Test procedures and setting are same as BLE normal mode.

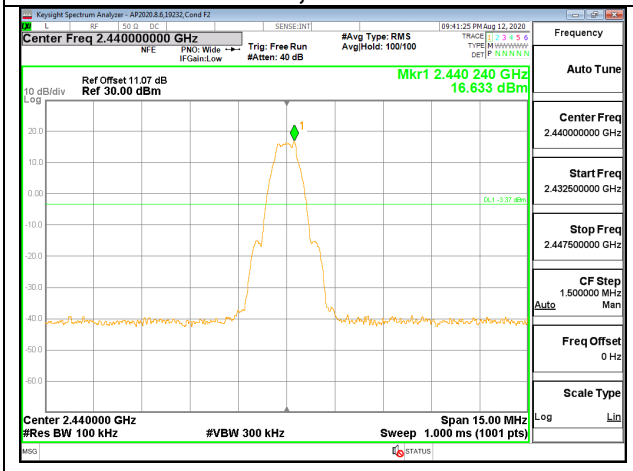
ANT 4



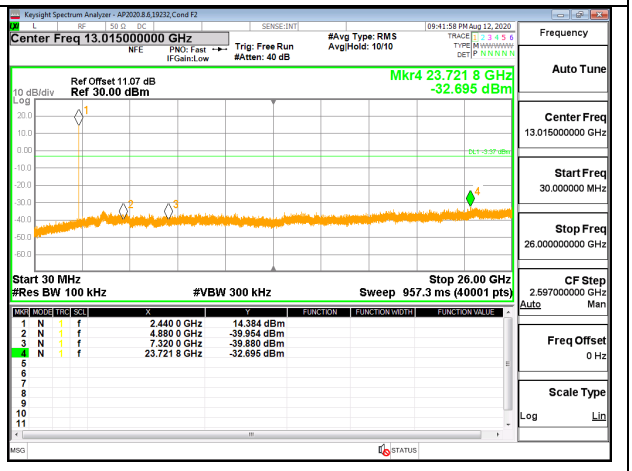
LOW CHANNEL , BANDEDGE ANT 4



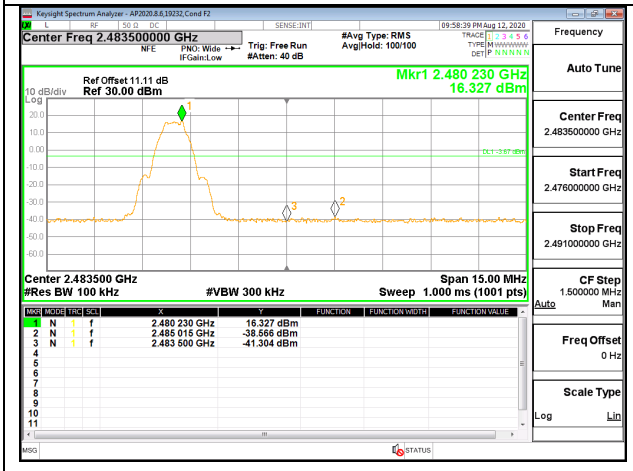
LOW CHANNEL OUT-OF-BAND ANT 4



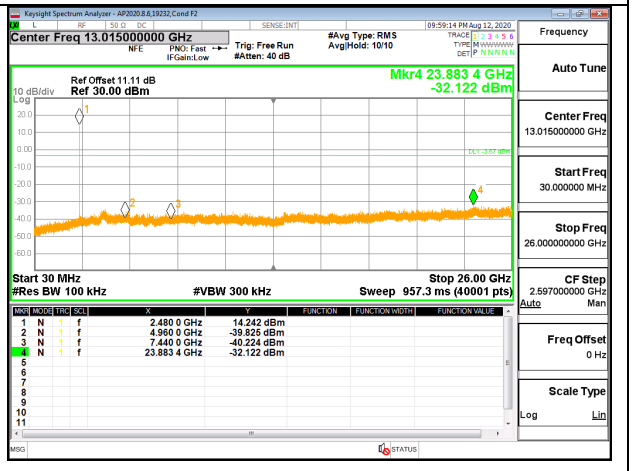
MID CHANNEL REFERENCE ANT 4



MID CHANNEL OUT-OF-BAND ANT 4

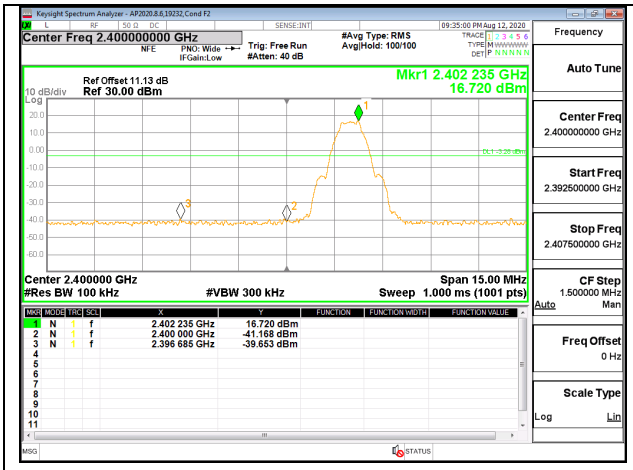


HIGH CHANNEL BANDEDGE ANT 4

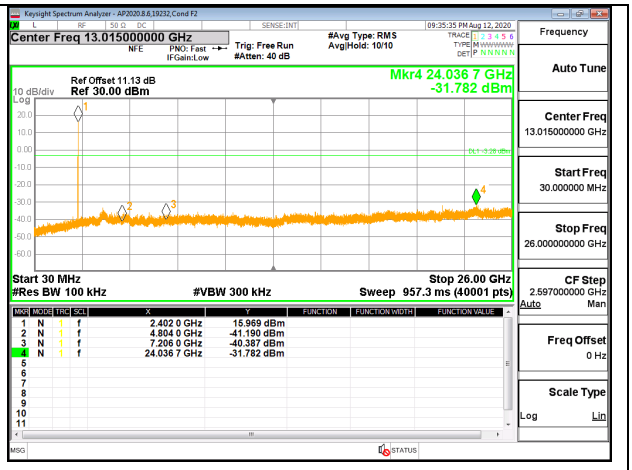


HIGH CHANNEL OUT-OF-BAND ANT 4

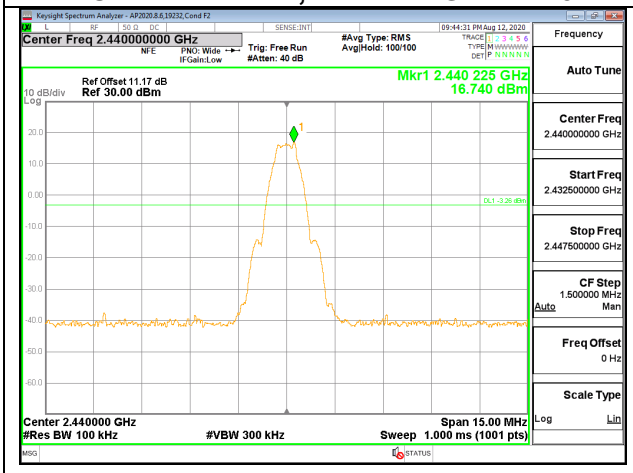
ANT 3



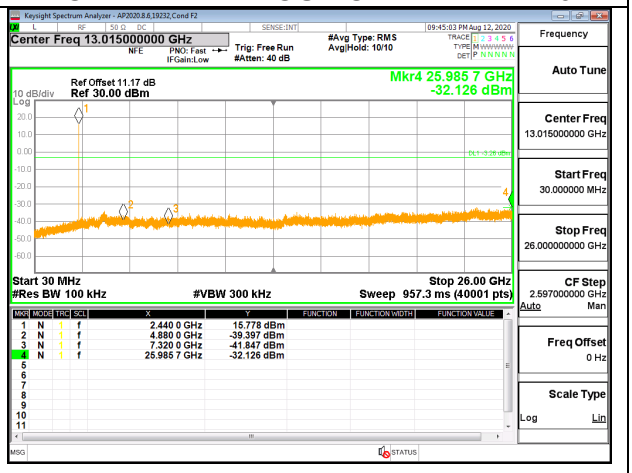
LOW CHANNEL , BANDEDGE ANT 3



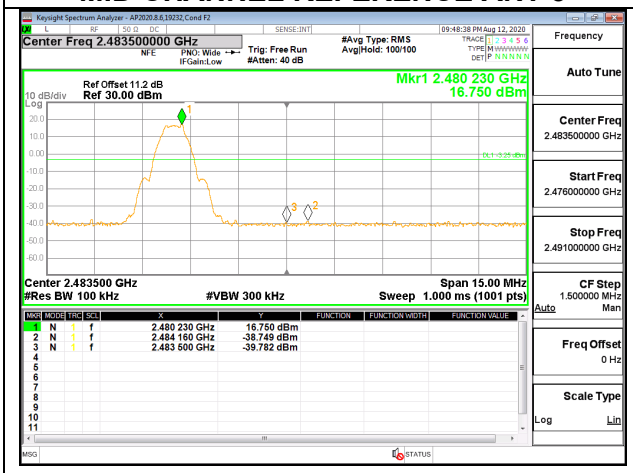
LOW CHANNEL OUT-OF-BAND ANT 3



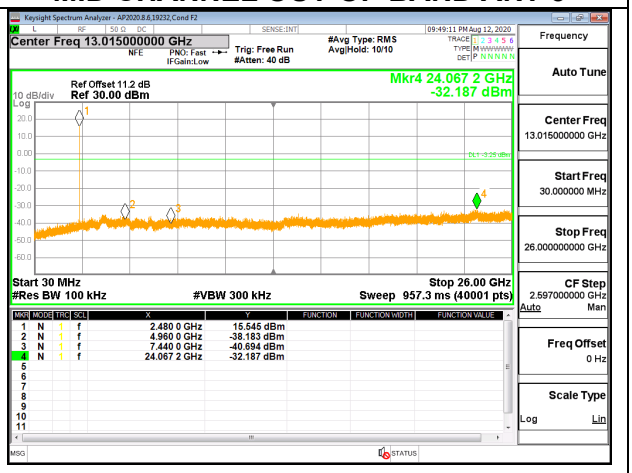
MID CHANNEL REFERENCE ANT 3



MID CHANNEL OUT-OF-BAND ANT 3



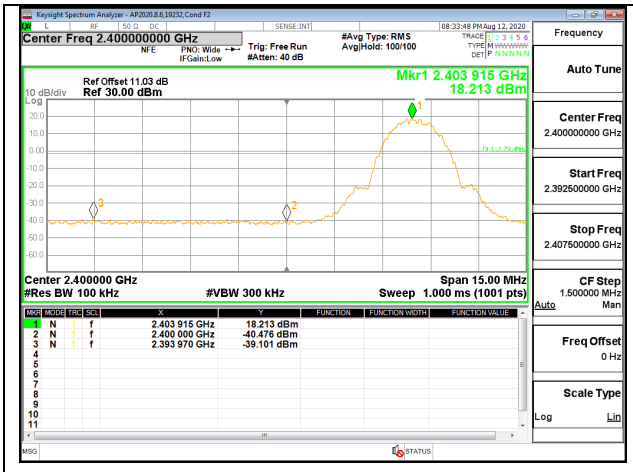
HIGH CHANNEL REFERENCE ANT 3



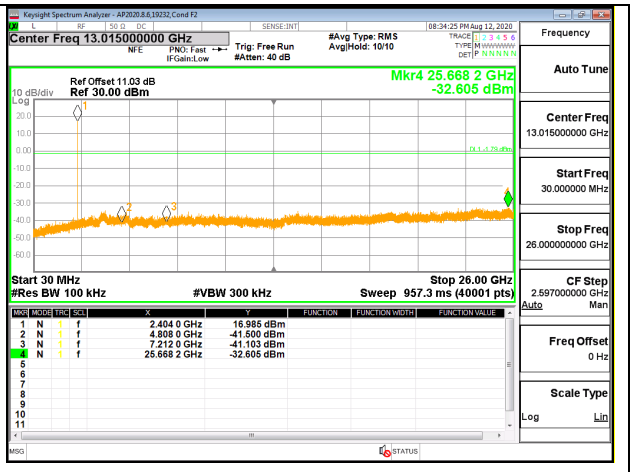
HIGH CHANNEL OUT-OF-BAND ANT 3

9.7.3. HIGH POWER BLE (2Mbps)

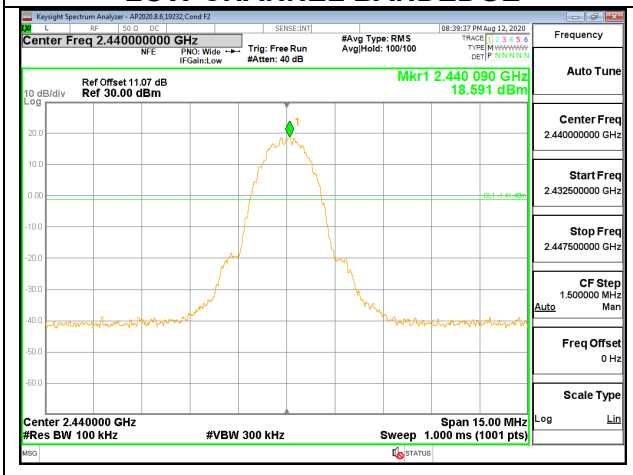
ANT 4



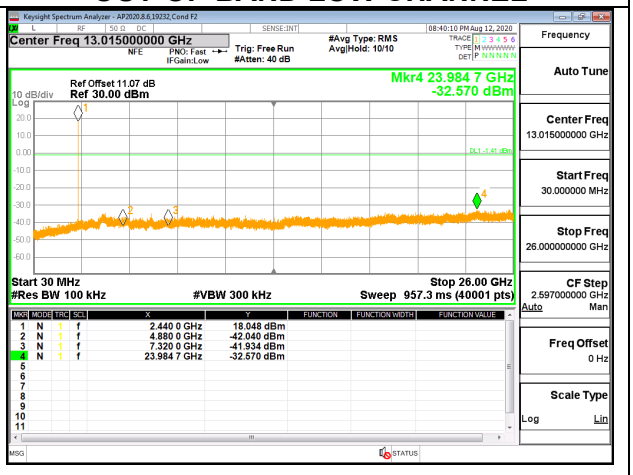
LOW CHANNEL BANDEDGE



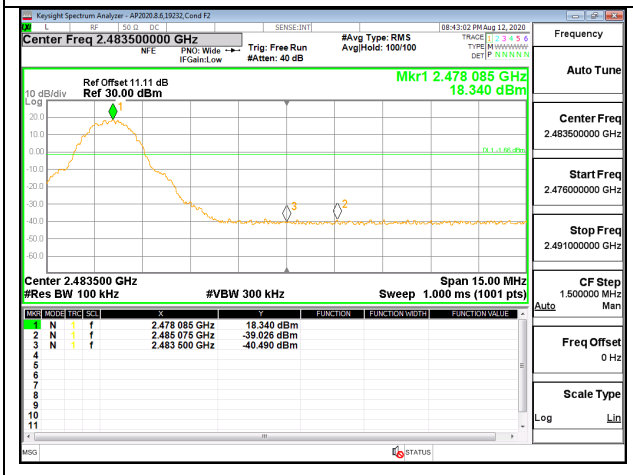
OUT-OF-BAND LOW CHANNEL



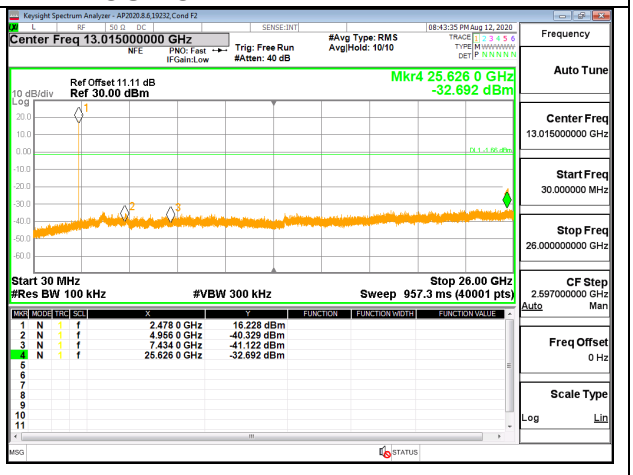
IN-BAND REFERENCE LEVEL



OUT-OF-BAND MID CHANNEL

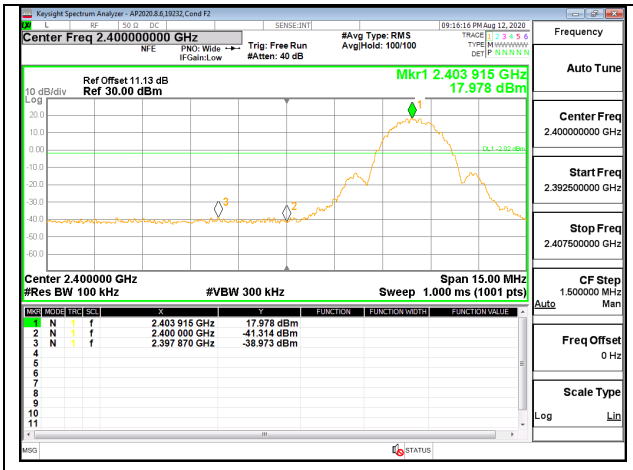


HIGH CHANNEL BANDEDGE

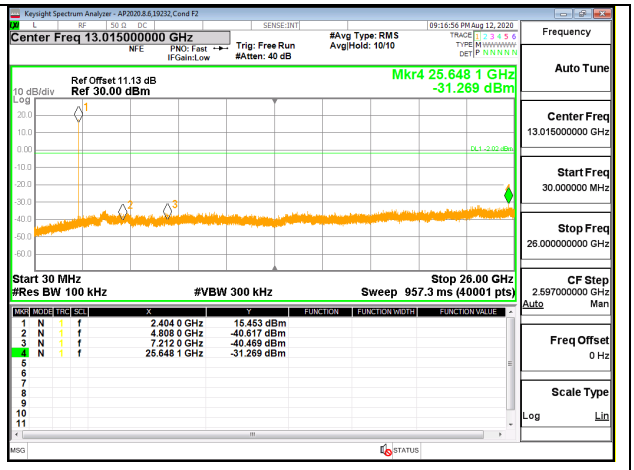


OUT-OF-BAND HIGH CHANNEL

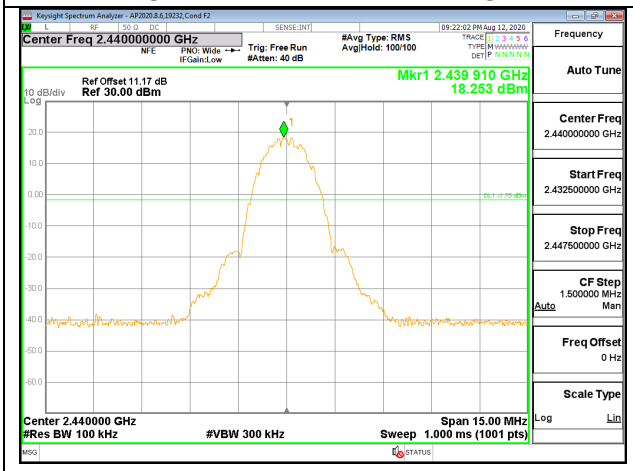
ANT 3



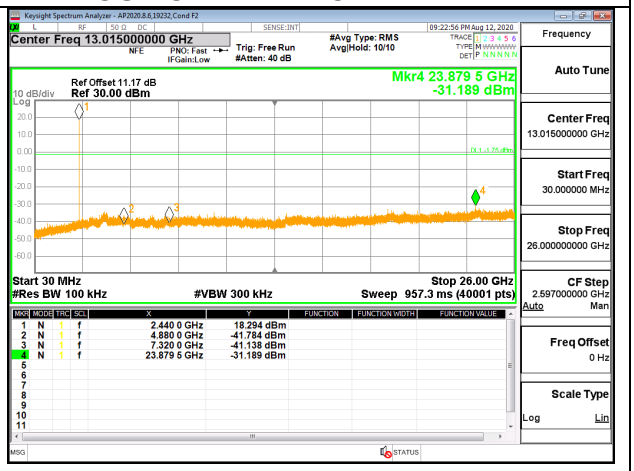
LOW CHANNEL BANDEDGE



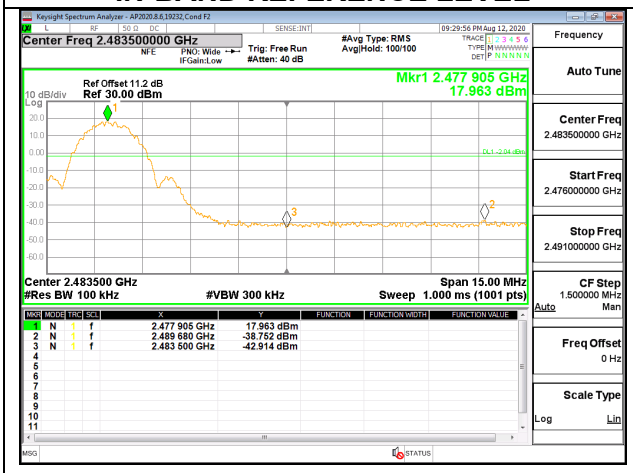
OUT-OF-BAND LOW CHANNEL



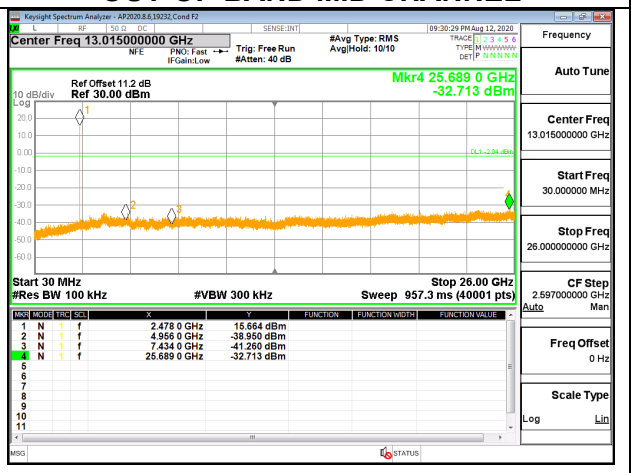
IN-BAND REFERENCE LEVEL



OUT-OF-BAND MID CHANNEL



HIGH CHANNEL BANDEDGE

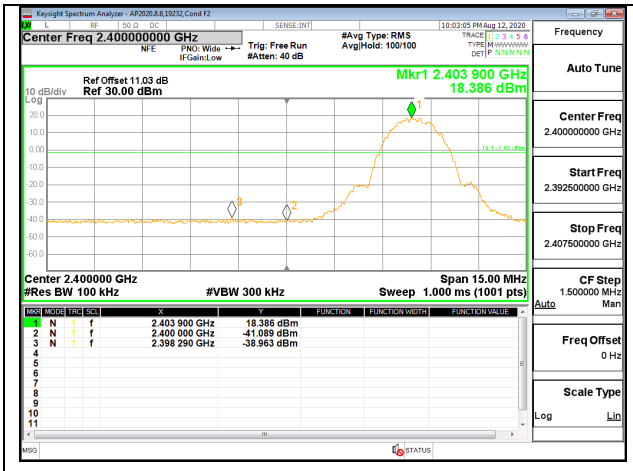


OUT-OF-BAND HIGH CHANNEL

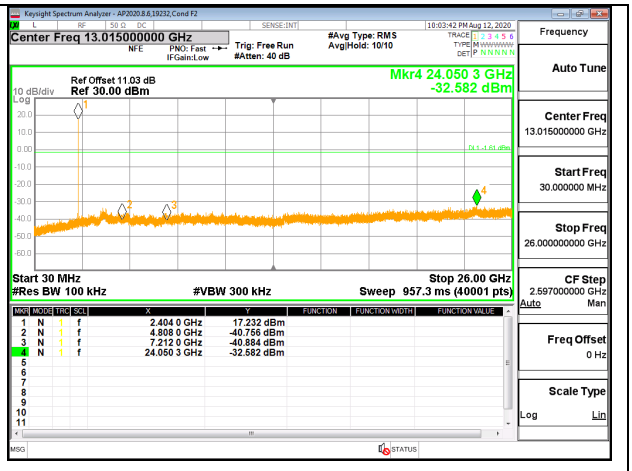
9.7.4. HIGH POWER BLE TXBF (2Mbps)

Note: Test procedures and setting are same as BLE normal mode.

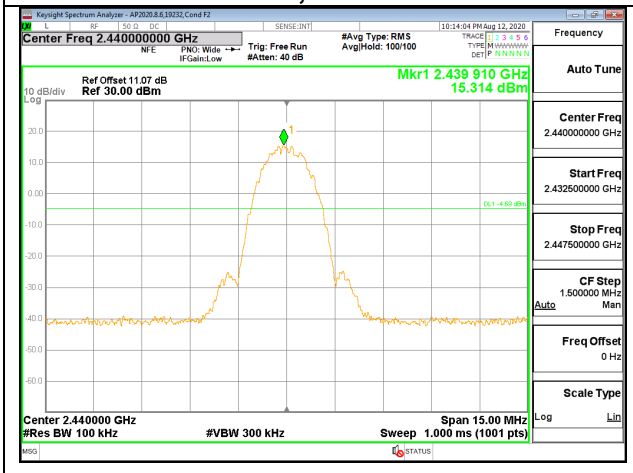
ANT 4



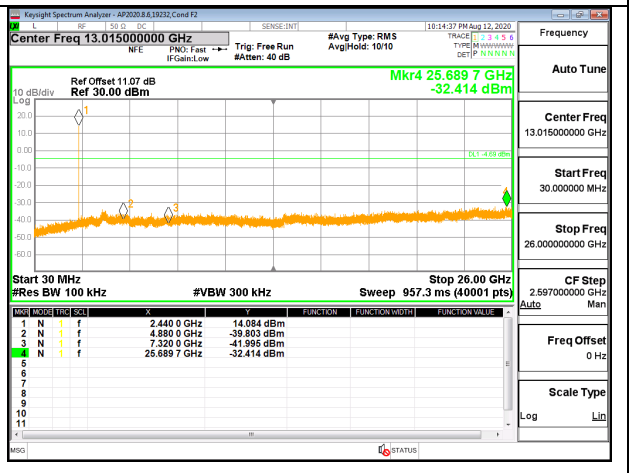
LOW CHANNEL , BANDEDGE ANT 4



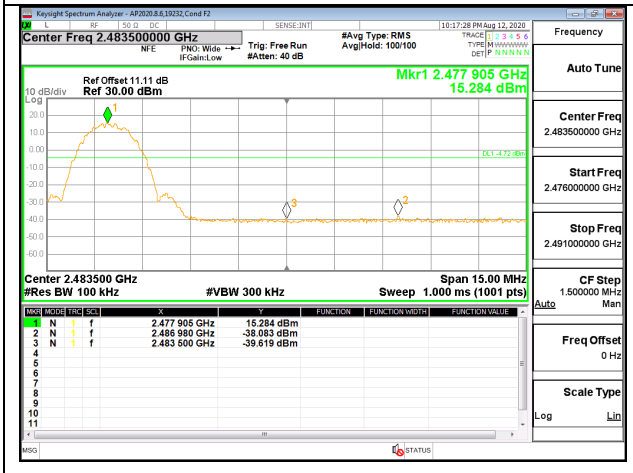
LOW CHANNEL OUT-OF-BAND ANT 4



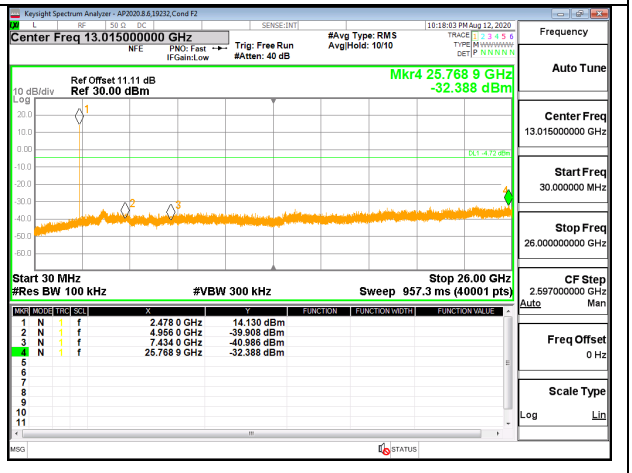
MID CHANNEL REFERENCE ANT 4



MID CHANNEL OUT-OF-BAND ANT 4

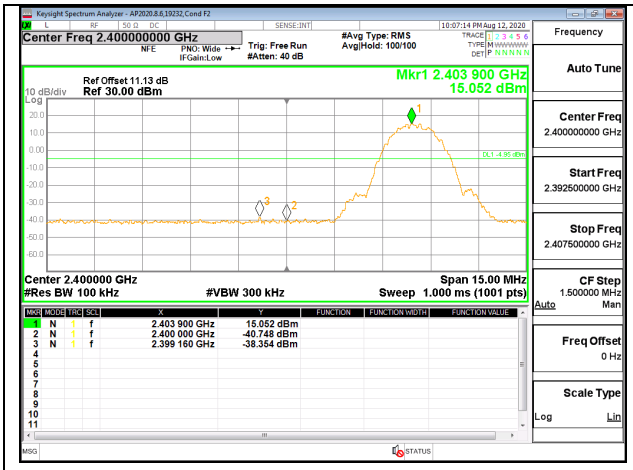


HIGH CHANNEL BANDEDGE ANT 4

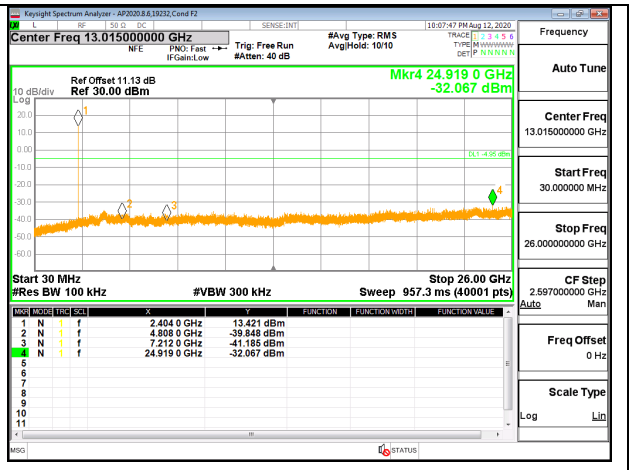


HIGH CHANNEL OUT-OF-BAND ANT 4

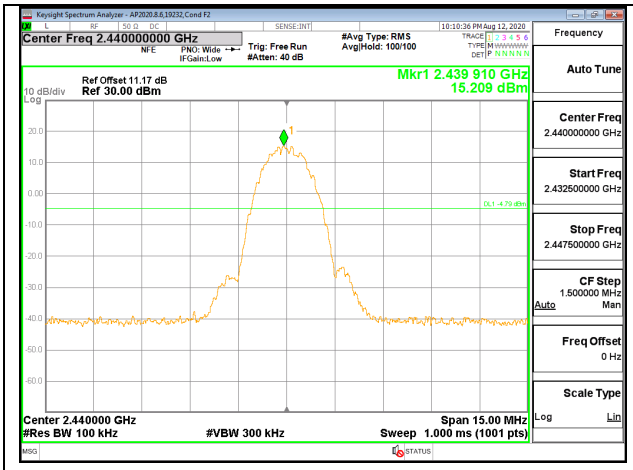
ANT 3



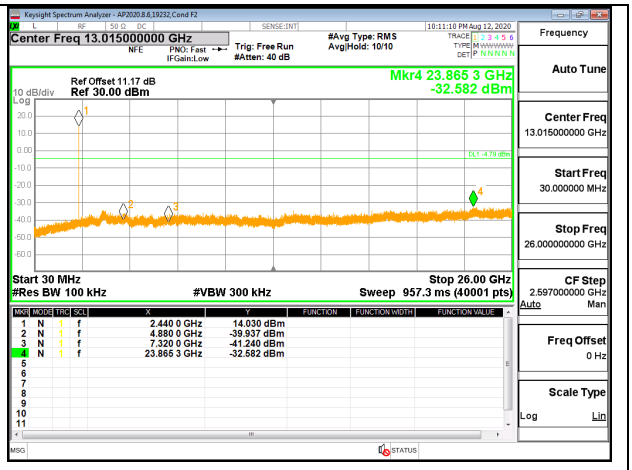
LOW CHANNEL , BANDEDGE ANT 3



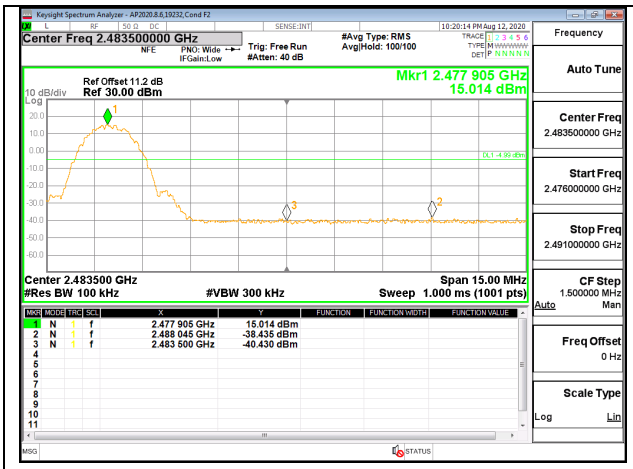
LOW CHANNEL OUT-OF-BAND ANT 3



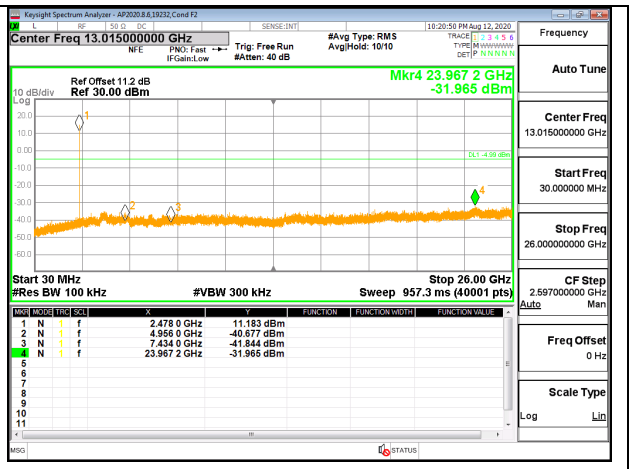
MID CHANNEL REFERENCE ANT 3



MID CHANNEL OUT-OF-BAND ANT 3



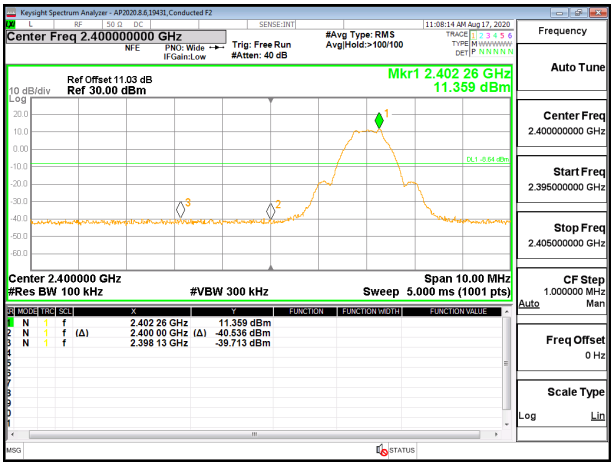
HIGH CHANNEL REFERENCE ANT 3



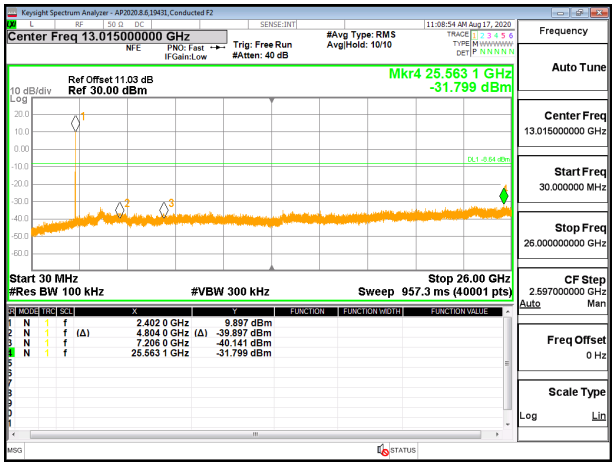
HIGH CHANNEL OUT-OF-BAND ANT 3

9.7.5. **LOW POWER BLE (1Mbps)**

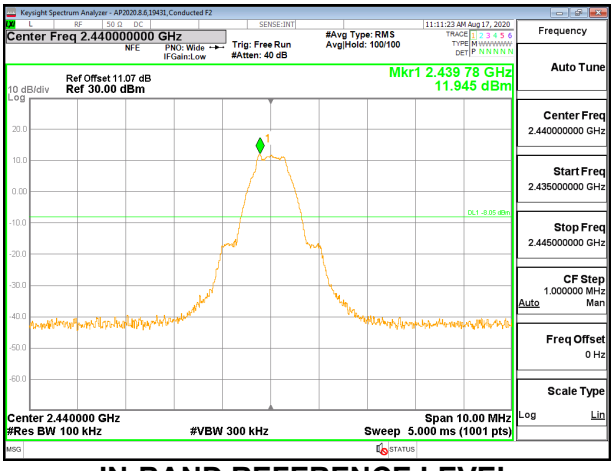
ANT 4



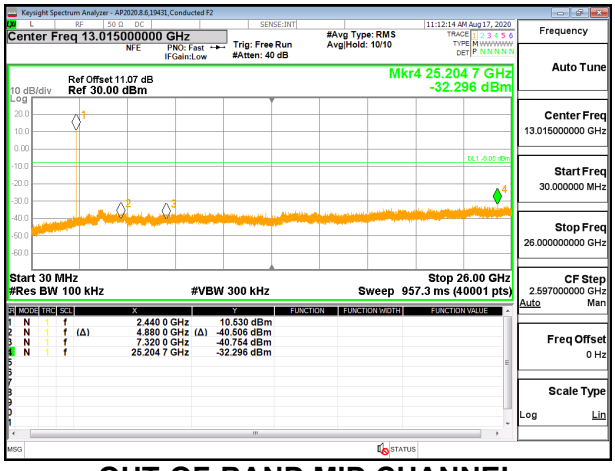
LOW CHANNEL BANDEDGE



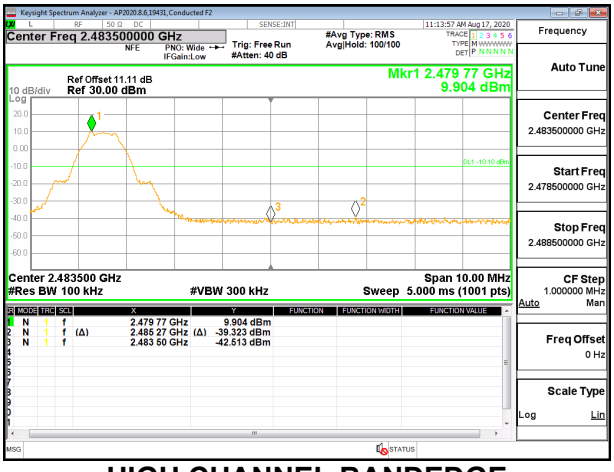
OUT-OF-BAND LOW CHANNEL



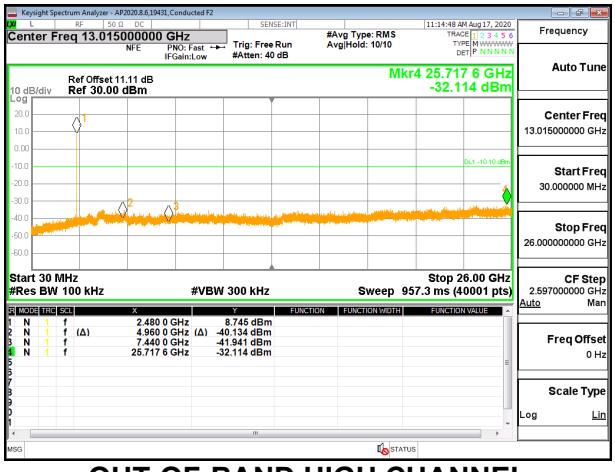
IN-BAND REFERENCE LEVEL



OUT-OF-BAND MID CHANNEL



HIGH CHANNEL BANDEDGE



OUT-OF-BAND HIGH CHANNEL