



CERTIFICATION TEST REPORT

Report Number. : 12607346-E2V2

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

Model : A2160, A2216, AND A2217

FCC ID : BCG-E3305A

IC : 579C-E3305A

EUT Description : SMARTPHONE

Test Standard(s) : FCC 47 CFR PART 15 SUBPART C
ISED RSS-247 ISSUE 2
ISED RSS-GEN ISSUE 5

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REPORT REVISION HISTORY

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TABLE OF CONTENTS

REPORT REVISION HISTORY	2
TABLE OF CONTENTS	3
1. ATTESTATION OF TEST RESULTS	6
2. TEST METHODOLOGY	7
3. FACILITIES AND ACCREDITATION	7
4. CALIBRATION AND UNCERTAINTY	8
4.1. MEASURING INSTRUMENT CALIBRATION	8
4.2. SAMPLE CALCULATION	8
4.3. MEASUREMENT UNCERTAINTY	8
5. EQUIPMENT UNDER TEST	9
5.1. EUT DESCRIPTION	9
5.2. DIFFERENCE IN MODEL NUMBER	9
5.3. MAXIMUM OUTPUT POWER	9
5.4. DESCRIPTION OF AVAILABLE ANTENNAS	9
5.5. SOFTWARE AND FIRMWARE	9
5.6. WORST-CASE CONFIGURATION AND MODE	10
5.7. DESCRIPTION OF TEST SETUP	11
6. MEASUREMENT METHOD	16
7. TEST AND MEASUREMENT EQUIPMENT	17
8. ANTENNA PORT TEST RESULTS	18
8.1. ON TIME AND DUTY CYCLE	18
8.2. 99% BANDWIDTH	20
8.2.1. HIGH POWER BLE (1Mbps)	21
8.2.2. HIGH POWER BLE (2Mbps)	23
8.2.3. LOW POWER BLE (1Mbps)	25
8.2.4. LOW POWER BLE (2Mbps)	27
8.3. BEAMFORMING, 99% BANDWIDTH	29
8.3.1. HIGH POWER BLE (1Mbps)	29
8.3.2. HIGH POWER BLE (2Mbps)	31
8.3.3. LOW POWER BLE (1Mbps)	33
8.3.4. LOW POWER BLE (2Mbps)	35
8.4. 6 dB BANDWIDTH	37
8.4.1. HIGH POWER BLE (1Mbps)	38
8.4.2. HIGH POWER BLE (2Mbps)	40
8.4.3. LOW POWER BLE (1Mbps)	42

8.4.4.	LOW POWER BLE (2Mbps)	44
8.5.	<i>BEAMFORMING, 6dB BANDWIDTH</i>	46
8.5.1.	HIGH POWER BLE (1Mbps).....	46
8.5.2.	HIGH POWER BLE (2Mbps).....	48
8.5.3.	LOW POWER BLE (1Mbps)	50
8.5.4.	LOW POWER BLE (2Mbps)	52
8.6.	<i>OUTPUT POWER</i>	54
8.6.1.	HIGH POWER BLE (1Mbps).....	55
8.6.2.	HIGH POWER BLE (2Mbps).....	56
8.6.3.	LOW POWER BLE (1Mbps)	57
8.6.4.	LOW POWER BLE (2Mbps)	58
8.7.	<i>BEAMFORMING OUTPUT POWER</i>	59
1.1.1.	HIGH POWER BLE (1Mbps).....	59
1.1.2.	HIGH POWER BLE (2Mbps).....	59
1.1.3.	LOW POWER BLE (1Mbps)	60
1.1.4.	LOW POWER BLE (2Mbps)	60
8.8.	<i>AVERAGE POWER</i>	61
8.8.1.	HIGH POWER BLE (1Mbps).....	62
8.8.2.	HIGH POWER BLE (2Mbps).....	63
8.8.3.	LOW POWER BLE (1Mbps)	64
8.8.4.	LOW POWER BLE (2Mbps)	65
8.9.	<i>BEAMFORMING AVERAGE POWER</i>	66
8.9.1.	HIGH POWER BLE (1Mbps).....	66
8.9.2.	HIGH POWER BLE (2Mbps).....	66
8.9.3.	LOW POWER BLE (1Mbps)	67
8.9.4.	LOW POWER BLE (2Mbps)	67
8.10.	<i>POWER SPECTRAL DENSITY</i>	68
8.10.1.	HIGH POWER BLE (1Mbps)	69
8.10.2.	HIGH POWER BLE (2Mbps)	71
8.10.3.	LOW POWER BLE (1Mbps).....	73
8.10.4.	LOW POWER BLE (2Mbps).....	75
8.11.	<i>BEAMFORMING, POWER SPECTRAL DENSITY</i>	77
8.11.1.	HIGH POWER BLE (1Mbps)	77
8.11.2.	HIGH POWER BLE (2Mbps)	79
8.11.3.	LOW POWER BLE (1Mbps).....	81
8.11.4.	LOW POWER BLE (2Mbps).....	83
8.12.	<i>CONDUCTED SPURIOUS EMISSIONS</i>	85
8.12.1.	HIGH POWER BLE (1Mbps)	86
8.12.2.	HIGH POWER BLE (2Mbps)	88
8.12.3.	LOW POWER BLE (1Mbps).....	90
8.12.4.	LOW POWER BLE (2Mbps).....	92
8.13.	<i>BEAMFORMING, CONDUCTED SPURIOUS</i>	94
8.13.1.	HIGH POWER BLE (1Mbps)	94
8.13.2.	HIGH POWER BLE (2Mbps)	96
8.13.3.	LOW POWER BLE (1Mbps).....	98
8.13.4.	LOW POWER BLE (2Mbps).....	100
9.	RADIATED TEST RESULTS.....	102

9.1.	LIMITS AND PROCEDURE	102
9.2.	TRANSMITTER ABOVE 1 GHz	104
9.2.1.	HIGH POWER BLE (1Mbps)	104
9.2.2.	HIGH POWER BLE (2Mbps)	124
9.2.3.	LOW POWER BLE (1Mbps)	144
9.2.4.	LOW POWER BLE (2Mbps)	164
9.2.5.	BEAMFORMING, HIGH POWER BLE (1Mbps)	184
9.2.6.	BEAMFORMING, HIGH POWER BLE (2Mbps)	194
9.2.7.	BEAMFORMING, LOW POWER BLE (1Mbps)	204
9.2.8.	BEAMFORMING, LOW POWER BLE (2Mbps)	214
9.3.	WORST CASE BELOW 1 GHz	224
9.4.	WORST CASE ABOVE 18 GHz	226
10.	AC POWER LINE CONDUCTED EMISSIONS	228
10.1.	AC Power Line Host	229
10.2.	AC Power Line Norm	231
11.	SETUP PHOTOS	233

1. ATTESTATION OF TEST RESULTS

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

EUT DESCRIPTION: SMARTPHONE

MODEL: A2160, A2216, AND A2217

SERIAL NUMBER: C39YV06TN2R5, C39YT06WN2R0

DATE TESTED: APRIL 17, 2019 – AUGUST 01, 2019

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.

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.

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2. 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, RSS-GEN Issue 5, and RSS-247 Issue 2.

3. 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)	

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

UL Verification Services Inc. is accredited by NVLAP, Laboratory Code 200065-0

4. CALIBRATION AND UNCERTAINTY

4.1. MEASURING INSTRUMENT CALIBRATION

The measuring equipment utilized to perform the tests documented in this report has been calibrated in accordance with the manufacturer's recommendations, and is traceable to recognized national standards.

4.2. SAMPLE CALCULATION

RADIATED EMISSIONS

Where relevant, the following sample calculation is provided:

Field Strength (dBuV/m) = Measured Voltage (dBuV) + Antenna Factor (dB/m) + Cable Loss (dB) – Preamp Gain (dB)
 $36.5 \text{ dBuV} + 18.7 \text{ dB/m} + 0.6 \text{ dB} - 26.9 \text{ dB} = 28.9 \text{ dBuV/m}$

MAINS CONDUCTED EMISSIONS

Where relevant, the following sample calculation is provided:

Final Voltage (dBuV) = Measured Voltage (dBuV) + Cable Loss (dB) + Limiter Factor (dB) + LISN Insertion Loss.
 $36.5 \text{ dBuV} + 0 \text{ dB} + 10.1 \text{ dB} + 0 \text{ dB} = 46.6 \text{ dBuV}$

4.3. MEASUREMENT UNCERTAINTY

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

PARAMETER	UNCERTAINTY
Worst Case Conducted Disturbance, 9KHz to 0.15 MHz	3.84 dB
Worst Case Conducted Disturbance, 0.15 to 30 MHz	3.65 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%.

5. EQUIPMENT UNDER TEST

5.1. EUT DESCRIPTION

EUT is a smartphone with multimedia functions (music, application support, and video), cellular GSM, GPRS, EGPRS, UMTS, LTE, TD-SCDMA, CDMA, IEEE 802.11a/b/g/n/ac/ax, Bluetooth, Ultra-Wide band, GPS and NFC. All models support at least one UICC based SIM. The second SIM, if present, is either UICC based pSIM (physical SIM) or e-SIM (electronic SIM). The device has a built-in inductive charging receiver. The rechargeable battery is also not user accessible.

5.2. DIFFERENCE IN MODEL NUMBER

Model A2160, A2216 and A2217 is electrically identical to Model A2160. Three model numbers are allocated for marketing and logistic purposes only. A2160 was used to perform all final tests.

5.3. 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)
Antenna 4	High Power	2402 - 2480	BLE 1M	16.57	45.39
	Low Power			12.64	18.37
	High Power		BLE 2M	16.70	46.77
	Low Power			12.71	18.66
Antenna 3	High Power	2402 - 2480	BLE 1M	19.55	90.16
	Low Power			12.61	18.24
	High Power		BLE 2M	19.64	92.04
	Low Power			12.65	18.41
BF, Antenna 3 + Antenna 4	High Power	2402 - 2480	BLE 1M	19.94	98.63
	Low Power			15.61	36.39
	High Power		BLE 2M	19.85	96.61
	Low Power			15.64	36.64

5.4. DESCRIPTION OF AVAILABLE ANTENNAS

Frequency Range (GHz)	Ant. 4 (Core 0) (dBi)	Ant. 3 (Core 1) (dBi)
2.4	-1.7	-1.9

5.5. SOFTWARE AND FIRMWARE

The EUT firmware installed during testing was 17.1.140.1283

5.6. WORST-CASE CONFIGURATION AND MODE

The EUT was investigated in three orthogonal orientations X, Y and Z on Ant 4 (Core 0) and Ant 3 (Core 1), it was determined that X(Flatbed) orientation was the worst-case orientation for Ant 4, Ant 3 and 2TX beamforming mode.

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 30MHz, 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. There were no emissions found below 30MHz within 20dB of the limit. For AC line conducted emission, test was investigated with AC power adapter and with laptop.

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.

5.7. DESCRIPTION OF TEST SETUP

SUPPORT EQUIPMENT

Support Equipment List				
Description	Manufacturer	Model	Serial Number	FCC ID
laptop	Apple	A1502	HRP003436	QDS-BRCM1080
Laptop AC/DC adapter	Liteon Technology	PA-1450-BA1	B123	NA
EUT AC Adapter	Apple	A1385	D29325SM03XDHLHC9	NA

I/O CABLES

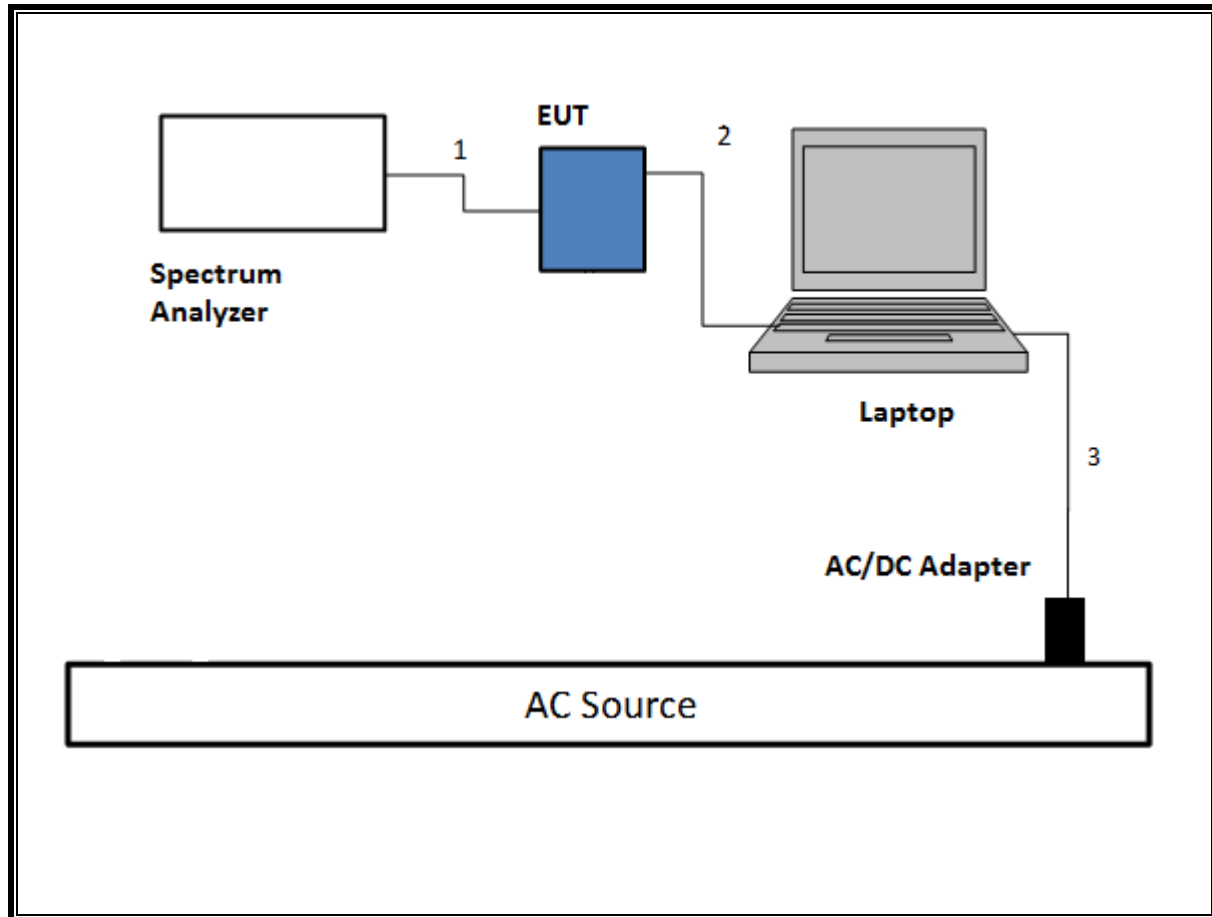
I/O Cable List						
Cable No	Port	# of identical ports	Connector Type	Cable Type	Cable Length (m)	Remarks
1	Antenna	1	SMA	Un-Shielded	0.2	To spectrum Analyzer
2	USB	1	USB	Shielded	1	N/A
3	AC	1	AC	Un-shielded	2	N/A

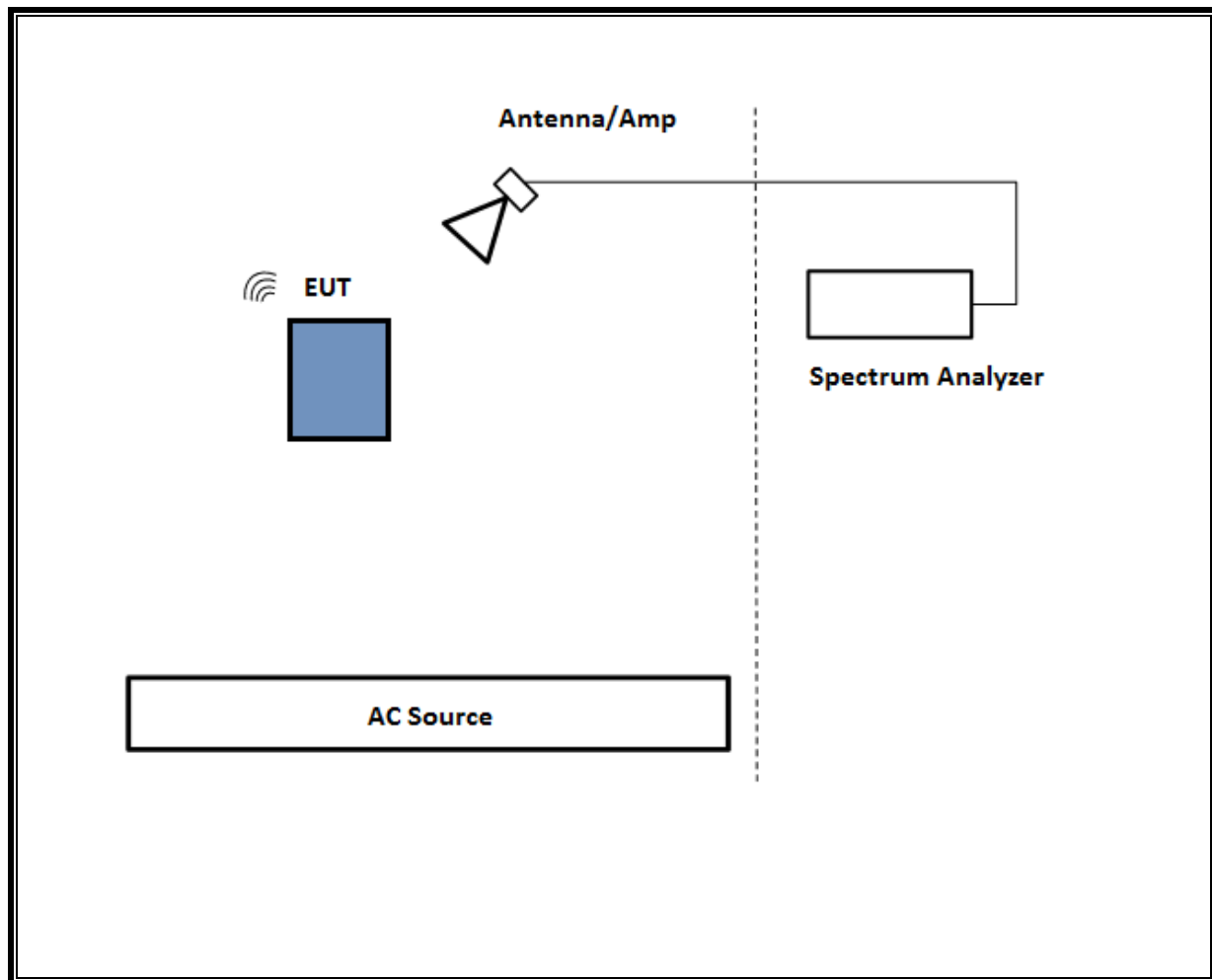
I/O CABLES (BELOW 1GHz AND AC POWER LINE TEST WITH ADAPTER AND LAPTOP)

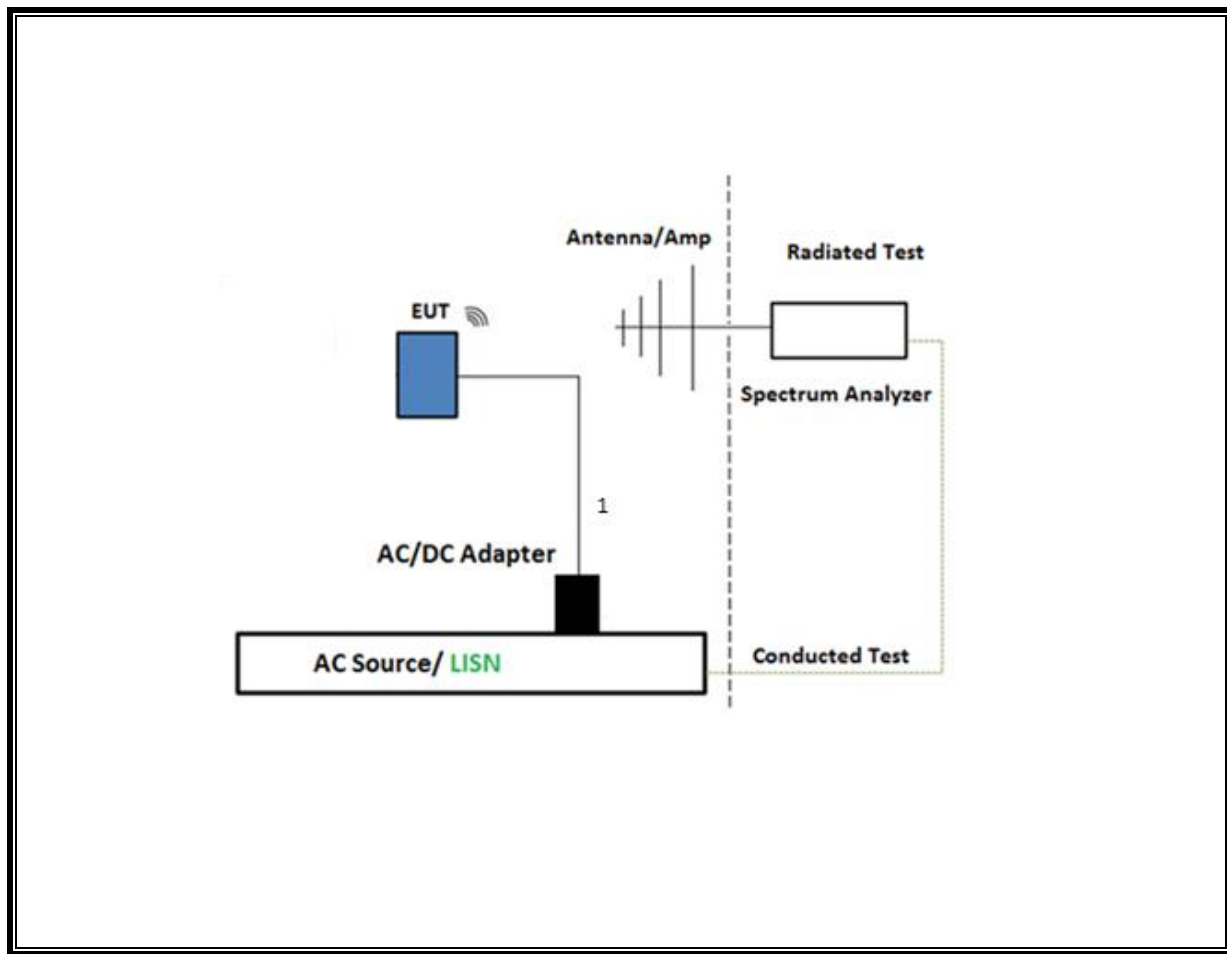
I/O Cable List						
Cable No	Port	# of identical	Connector Type	Cable Type	Cable Length (m)	Remarks
1	AC	1	AC	Un-shielded	2	N/A
2	USB	1	USB	Un-shielded	1	N/A

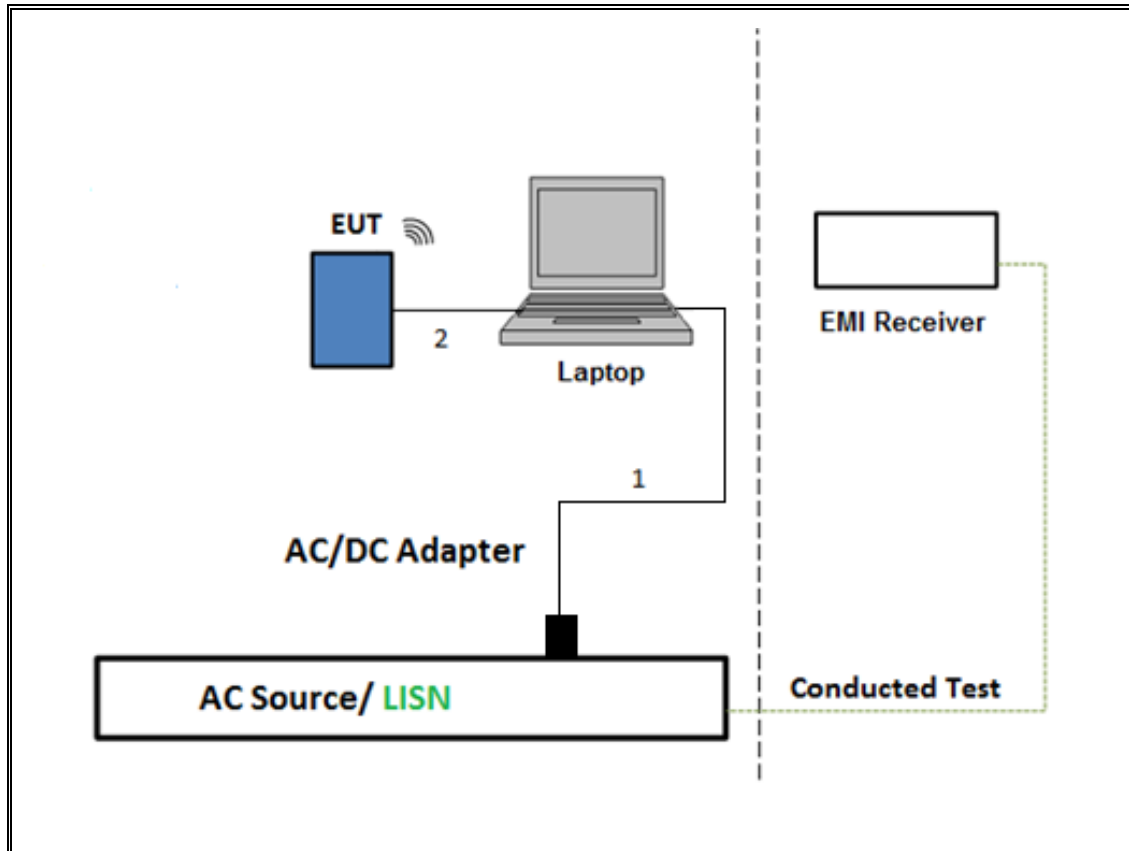
TEST SETUP

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

SETUP DIAGRAM FOR Below 1GHz and AC LINE CONDUCTED TEST

TEST SETUP- AC LINE CONDUCTED: LAPTOP CONFIGURATION

6. MEASUREMENT METHOD

6 dB BW: ANSI C63.10 Subclause -11.8.1 RBW $\geq$ 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 -11.9.2.3.1 Measurement using average power meter

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

Radiated emissions non-restricted frequency bands: ANSI C63.10 Subclause -11.11

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

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

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

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

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

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

7. 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	T119	03/22/2020	03/22/2019
Amplifier, 1 to 18GHz	Miteq	AFS42-00101800-25-S-42	T740	10/06/2019	10/06/2018
Antenna, Broadband Hybrid, 30MHz to 3GHz	SunAR rf motion	JB3	PRE0184052	10/24/2019	10/24/2018
Amplifier, 10KHz to 1GHz, 32dB	Sonoma	310N	T15	08/15/2019	08/15/2018
*Antenna, Horn 1-18GHz	ETS Lindgren	3117	T120	07/02/2019	07/02/2018
Antenna, Horn 1-18GHz	ETS Lindgren	3117	T712	02/26/2020	02/26/2018
Amplifier, 1 to 18GHz	Miteq	AFS42-00101800-25-S-42	138301	09/15/2019	09/15/2019
Amplifier, 1 to 18GHz	Miteq	AFS42-00101800-25-S-42	T491	05/30/2020	05/30/2019
Antenna, Horn 1-18GHz	ETS Lindgren	3117	T346	05/14/2020	05/14/2019
Amplifier, 1 to 18GHz	Miteq	AFS42-00101800-25-S-42	T931	05/11/2020	05/11/2019
Spectrum Analyzer, PXA 3Hz to 44GHz	Keysight	N9030A	T1454	01/23/2020	01/23/2019
Spectrum Analyzer, PXA, 3Hz to 44GHz	Agilent (Keysight) Technologies	N9030A	T340	01/22/2020	01/22/2019
Spectrum Analyzer, PXA 3Hz to 44GHz	Keysight	N9030A-544	T1210	08/06/2019	08/06/2018
*Antenna Horn, 18 to 26GHz	ARA	MWH-1826	T447	06/16/2019	06/16/2018
Pre-Amp 18-26GHz	Agilent Technology	8449B	T404	03/23/2020	03/23/2019
Spectrum Analyzer, PXA, 3Hz to 44GHz	Agilent (Keysight) Technologies	N9030A	T342	01/23/2020	01/23/2019
Power Meter, P-series single channel	Keysight	N1912A	T1244	01/30/2020	01/30/2019
Power Sensor	Keysight	N1921A	T1224	02/22/2020	02/22/2019
Antenna, Active Loop 9KHz to 30MHz	EMCO	6502	T35	06/06/2020	06/06/2019

AC Line Conducted					
EMI Test Receiver 9KHz-7GHz	Rohde & Schwarz	ESCi7	T1436	02/14/2020	02/14/2019
Power Cable, Line Conducted Emissions	UL	PG1	T861	08/31/2019	08/31/2018
*LISN for Conducted Emissions CISPR-16	Fischer	50/250-25-2-01	T1310	06/19/2019	06/19/2018
UL AUTOMATION SOFTWARE					
Radiated Software	UL	UL EMC	Ver 9.5, April 26, 2016		
Conducted Software	UL	UL EMC	Ver 5.4, October 13, 2016		
AC Line Conducted Software	UL	UL EMC	Ver 9.5, May 26, 2015		

*Testing is completed before equipment expiration date.

8. ANTENNA PORT TEST RESULTS

8.1. ON TIME AND DUTY CYCLE

LIMITS

None; for reporting purposes only.

PROCEDURE

KDB 558074 Zero-Span Spectrum Analyzer Method.

ON TIME AND DUTY CYCLE WITH HIGH POWER 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	1.000	1.000	1.000	100.00%	0.00	0.010
BLE, 2Mbps	1.000	1.000	1.000	100.00%	0.00	0.010
BLE TxBF, 1Mbps	1.000	1.000	1.000	100.00%	0.00	0.010
BLE TxBF, 2Mbps	1.000	1.000	1.000	100.00%	0.00	0.010

Note: Low power duty cycle is same as higher power

DUTY CYCLE PLOTS

8.2. 99% BANDWIDTH

LIMITS

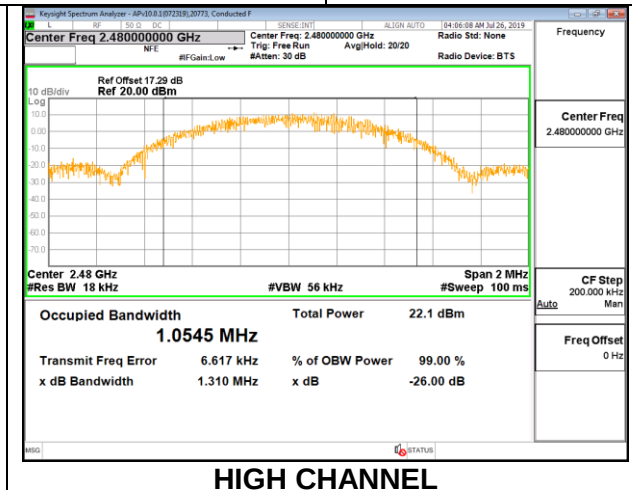
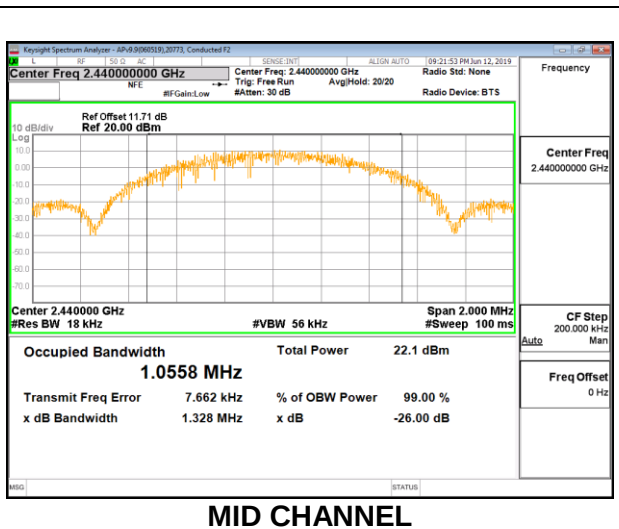
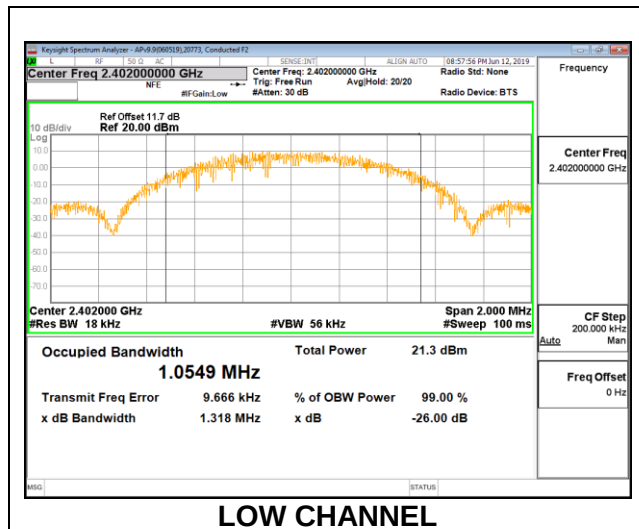
None; for reporting purposes only.

RESULTS

8.2.1. HIGH POWER BLE (1Mbps)

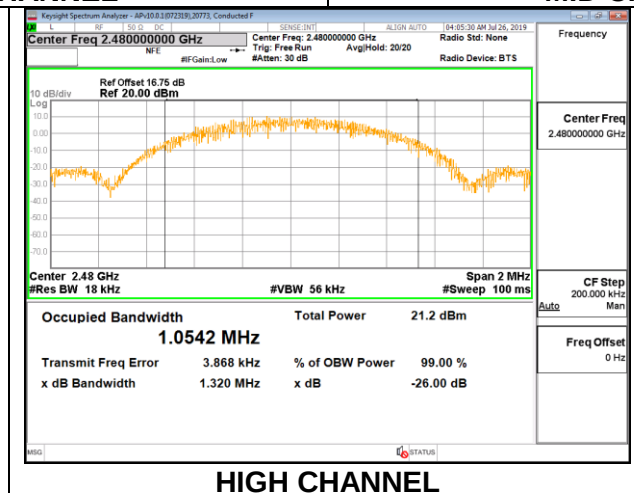
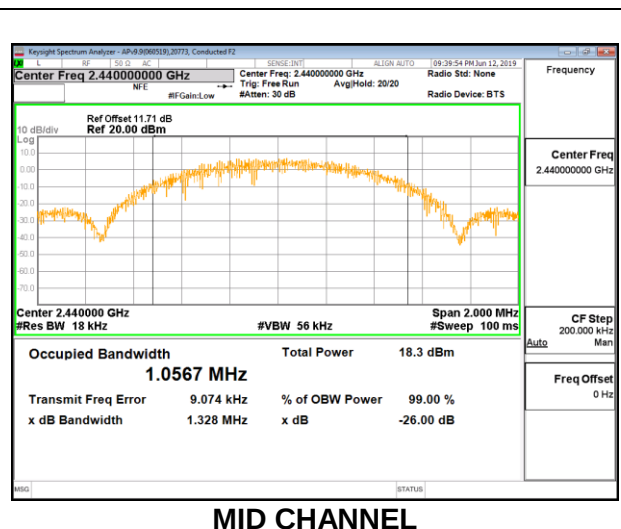
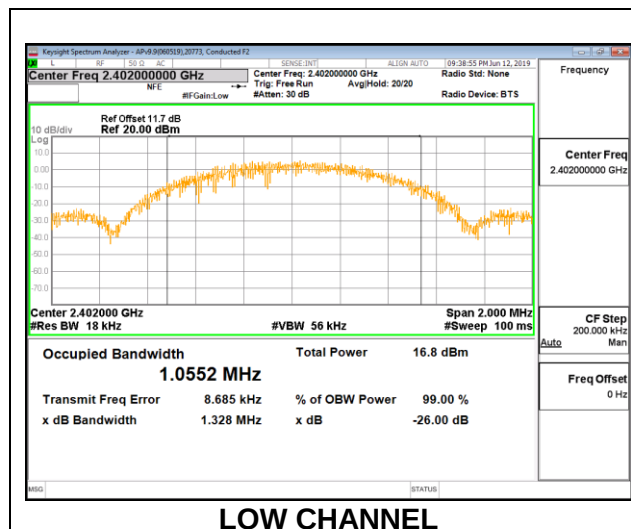
Antenna 4

Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low	2402	1.0549
Middle	2440	1.0558
High	2480	1.0545



Antenna 3

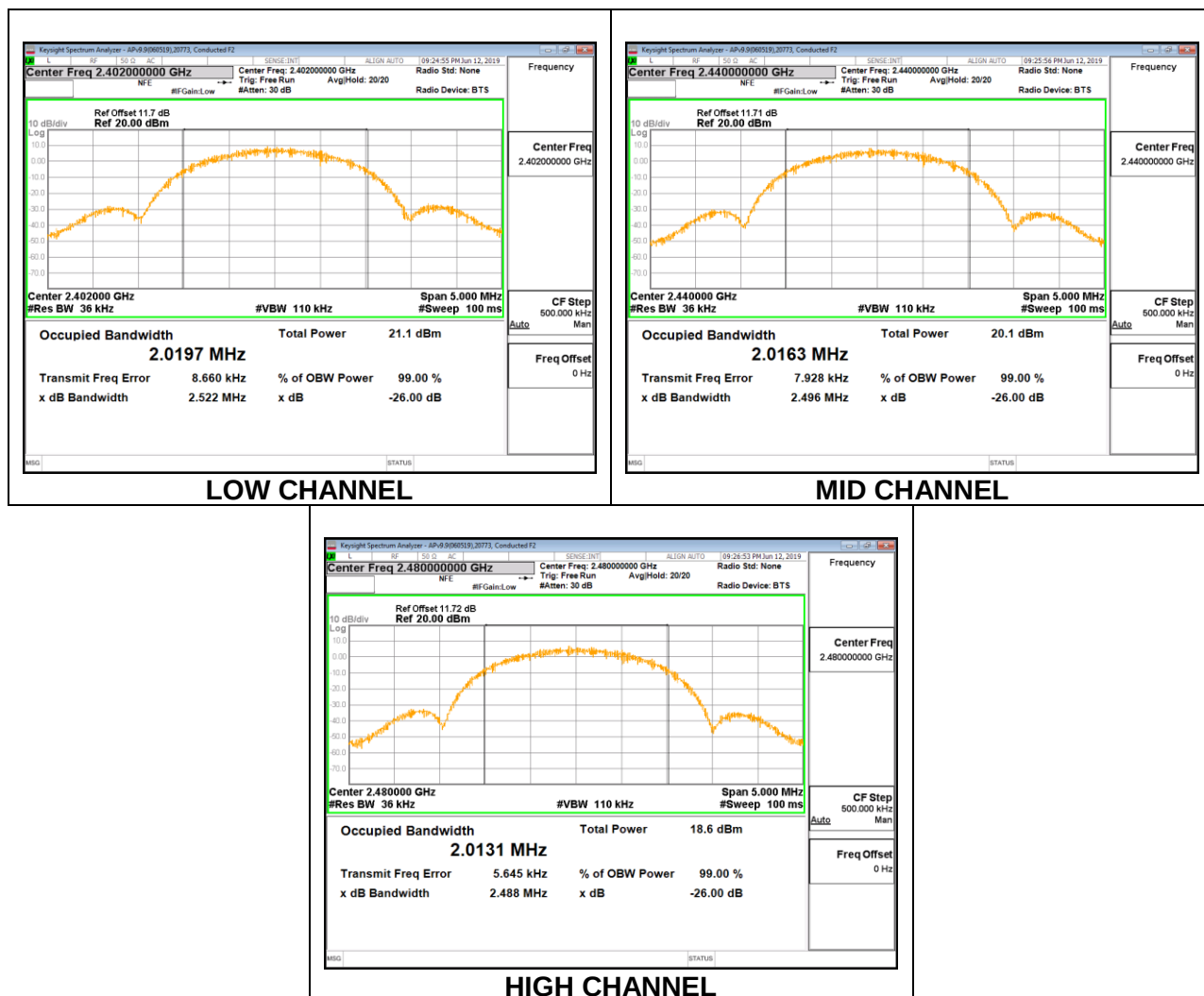
Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low	2402	1.0552
Middle	2440	1.0567
High	2480	1.0542



8.2.2. HIGH POWER BLE (2Mbps)

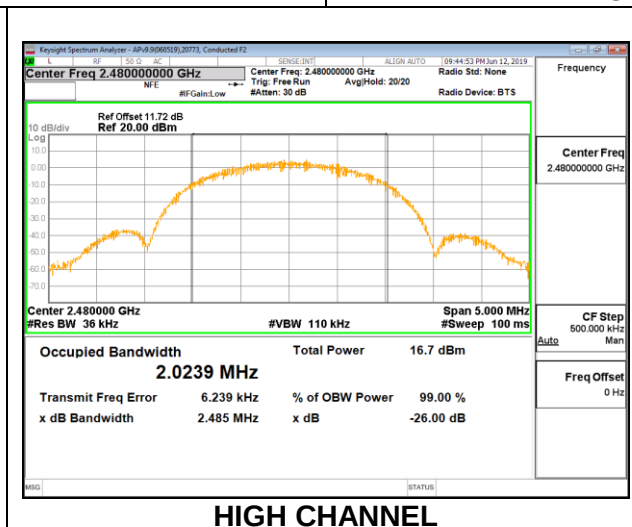
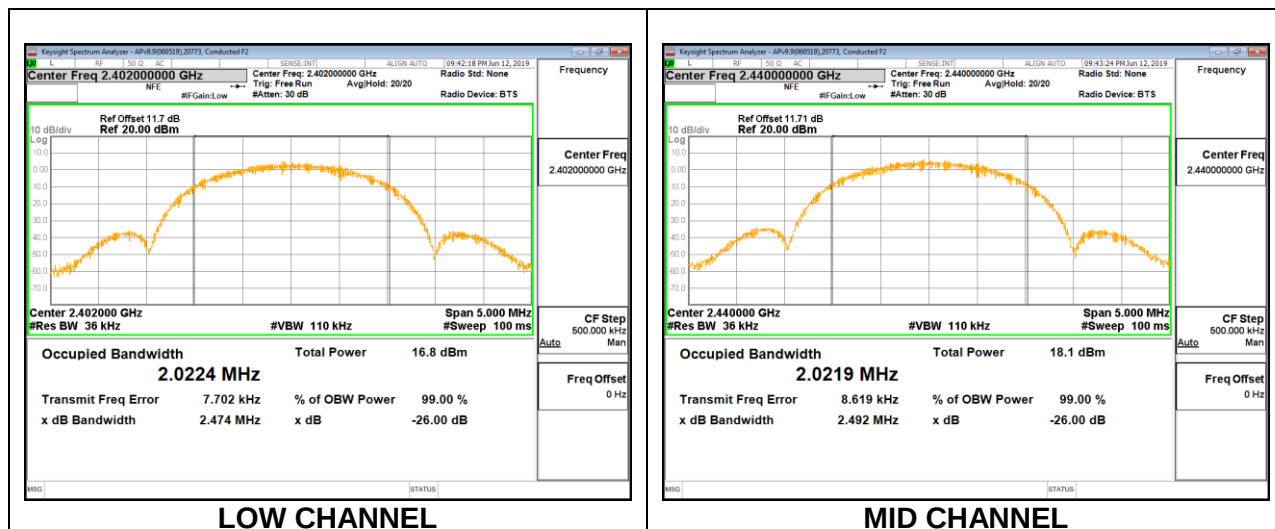
Antenna 4

Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low	2402	2.0197
Middle	2440	2.0163
High	2480	2.0131



Antenna 3

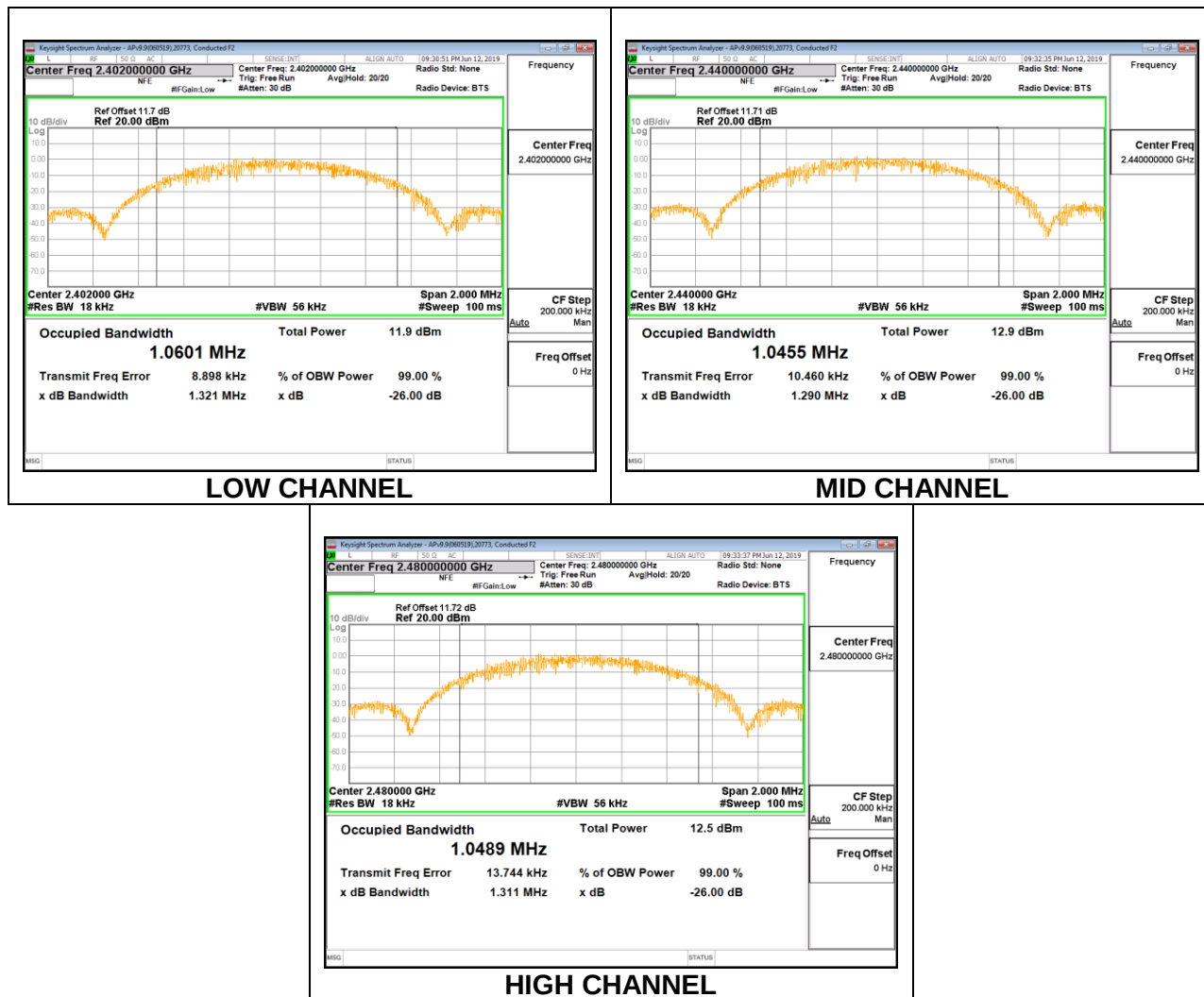
Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low	2402	2.0224
Middle	2440	2.0219
High	2480	2.0239



8.2.3. LOW POWER BLE (1Mbps)

Antenna 4

Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low	2402	1.0601
Middle	2440	1.0455
High	2480	1.0489



Antenna 3

Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low	2402	1.0656
Middle	2440	1.0618
High	2480	1.0641



8.2.4. LOW POWER BLE (2Mbps)

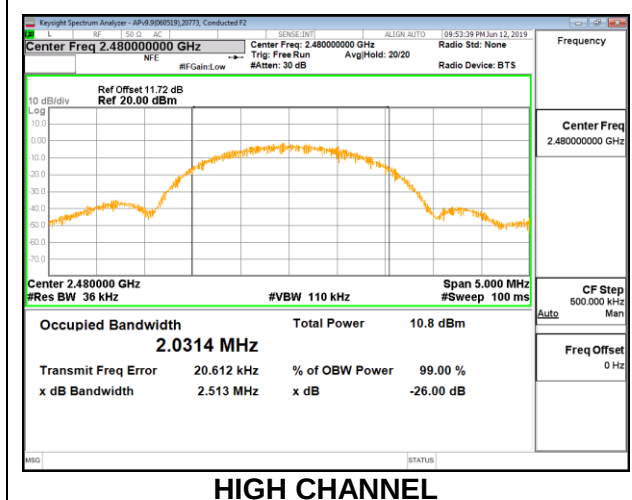
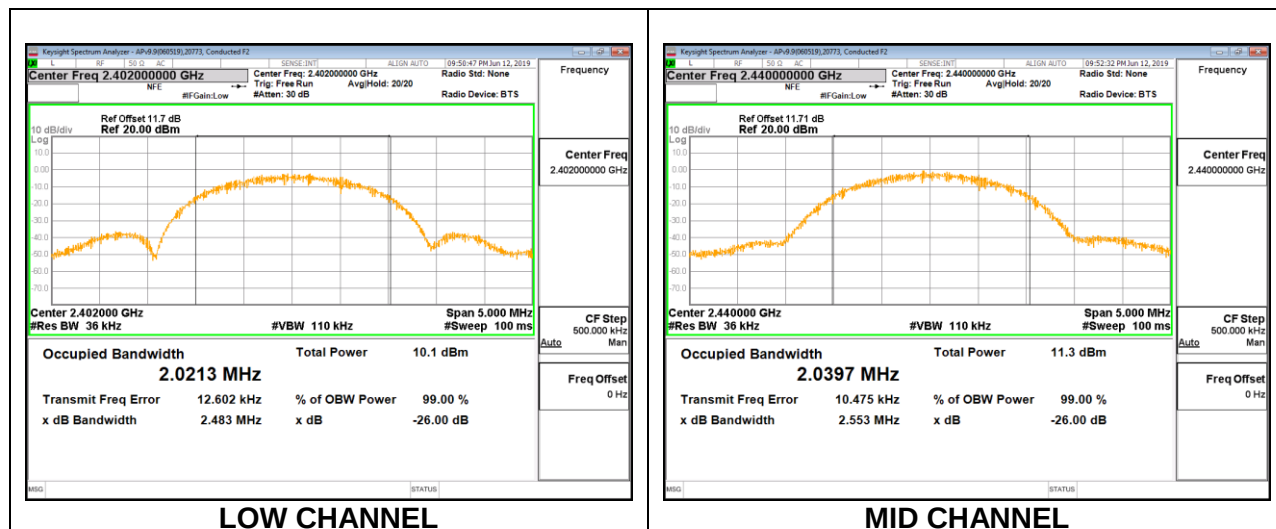
Antenna 4

Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low	2402	2.0296
Middle	2440	2.0247
High	2480	2.0254



Antenna 3

Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low	2402	2.0213
Middle	2440	2.0397
High	2480	2.0314

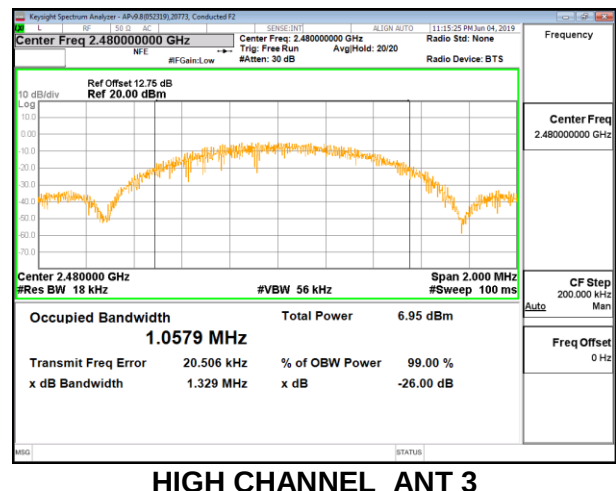
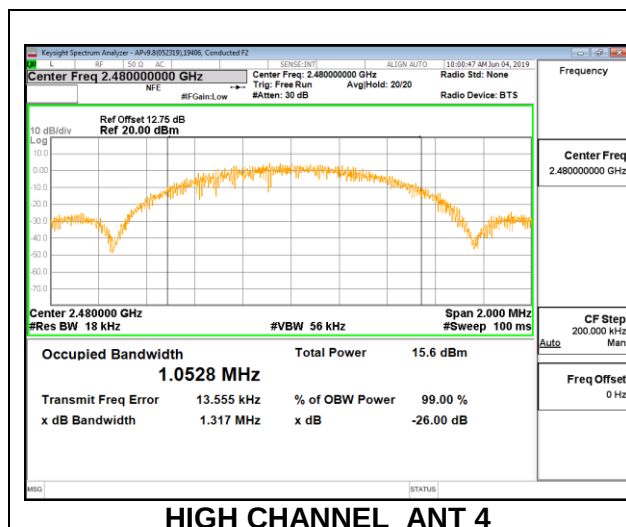
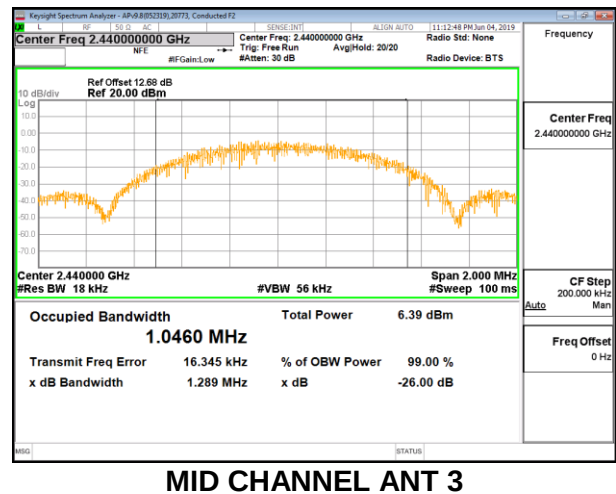
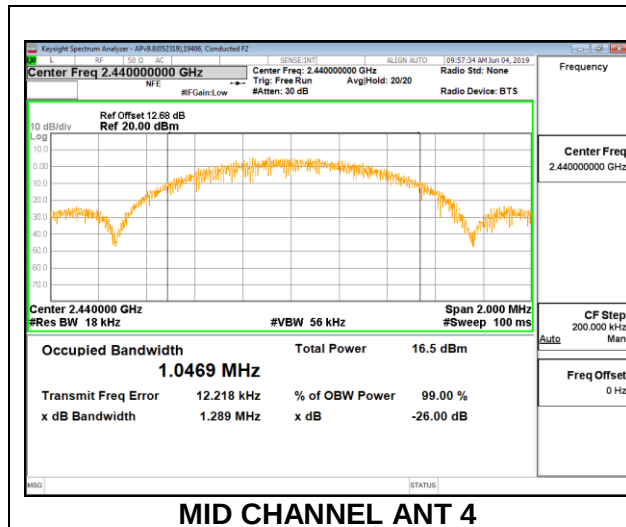
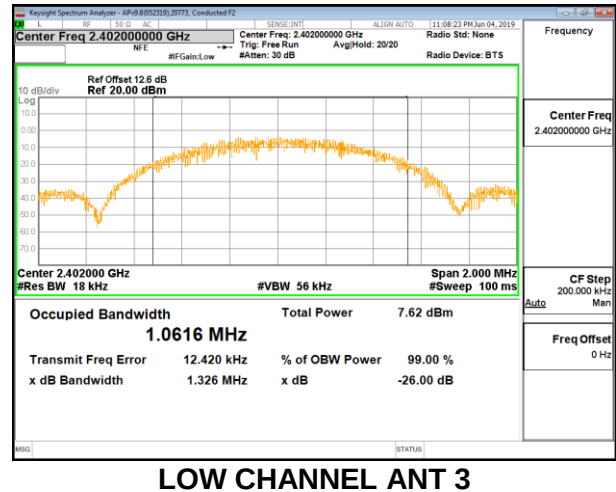
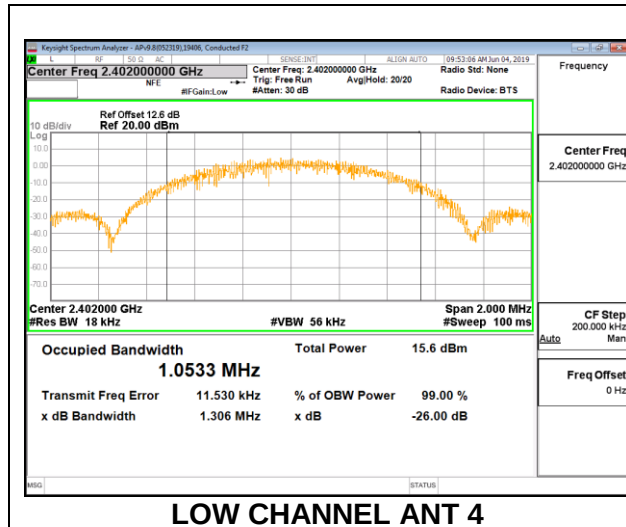


8.3. BEAMFORMING, 99% BANDWIDTH

8.3.1. HIGH POWER BLE (1Mbps)

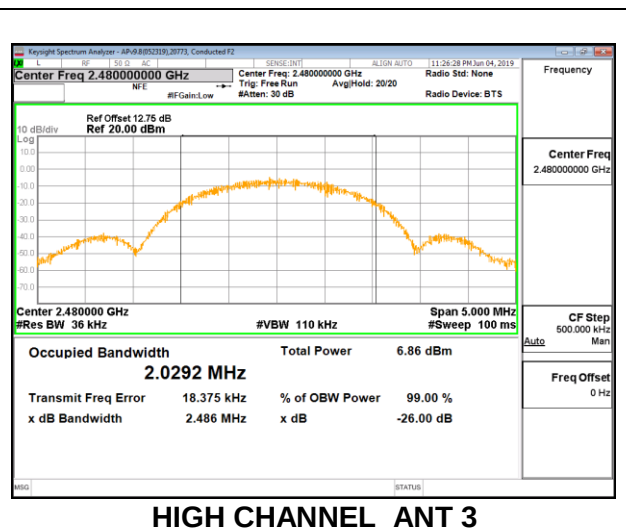
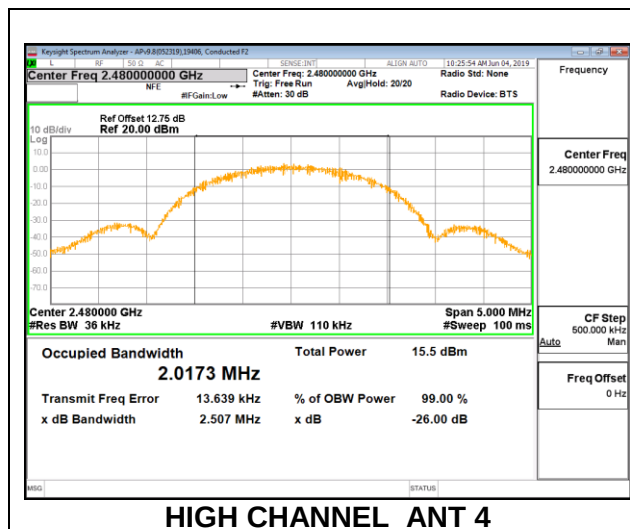
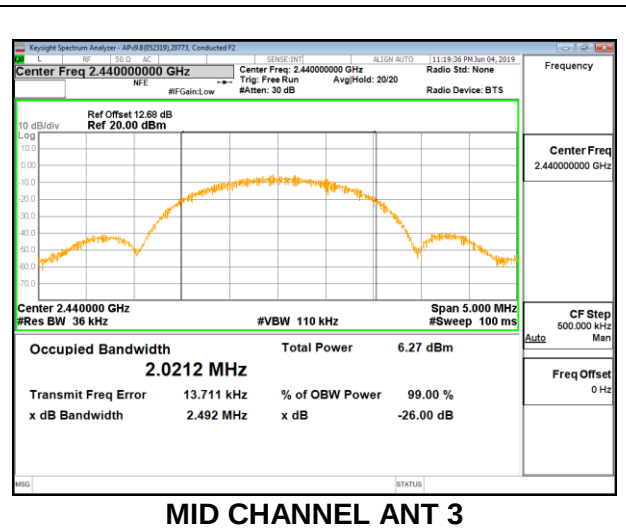
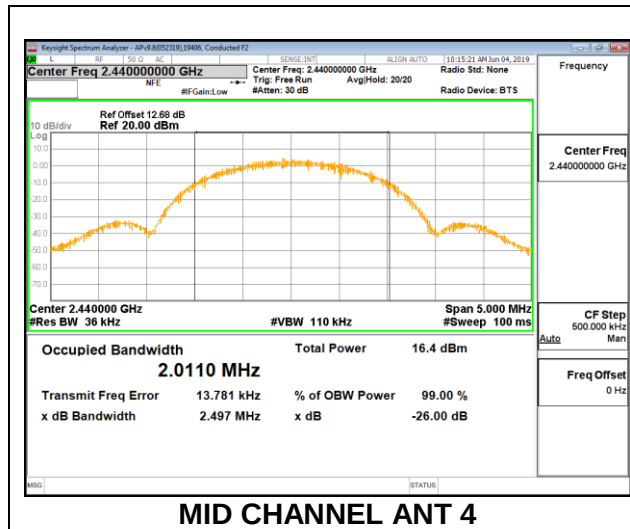
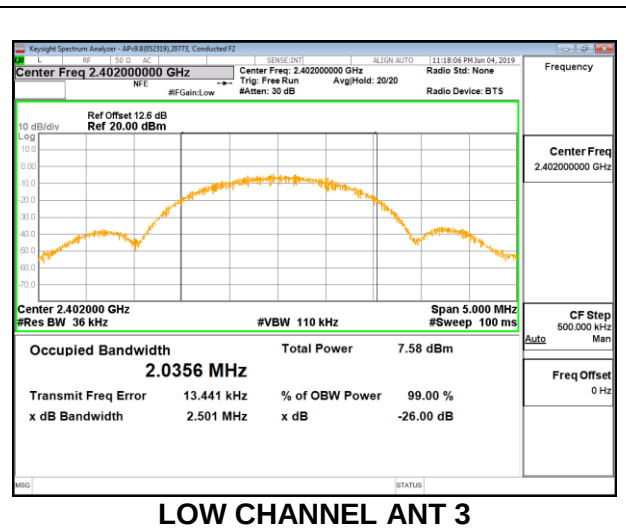
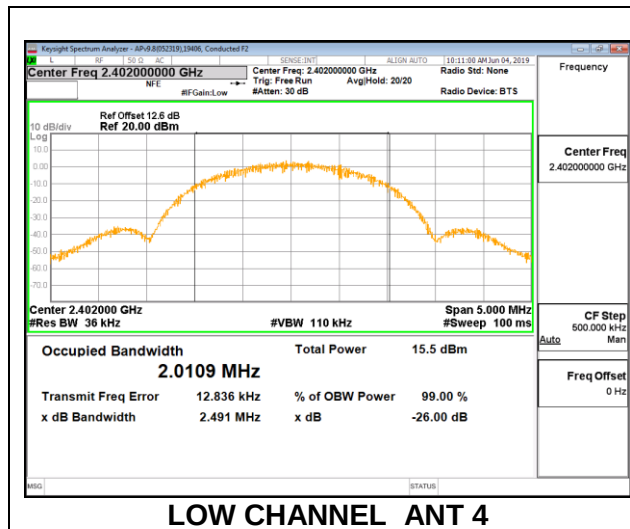
Channel	Frequency (MHz)	99% Bandwidth ANT 4 (MHz)	99% Bandwidth ANT 3 (MHz)
Low	2402	1.0533	1.0616
Mid	2440	1.0469	1.0460
High	2480	1.0528	1.0579

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



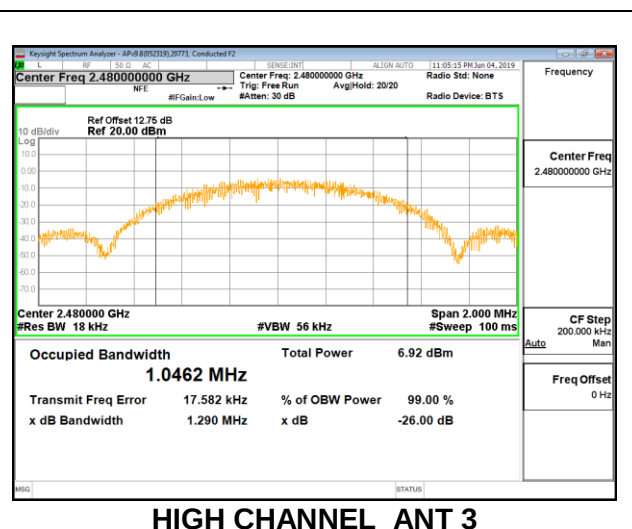
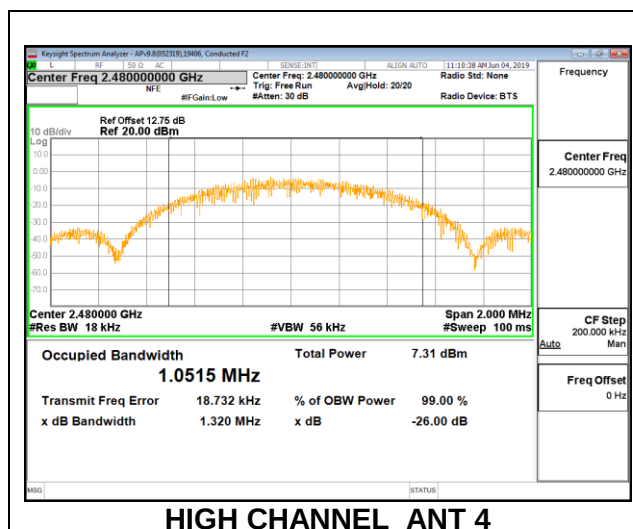
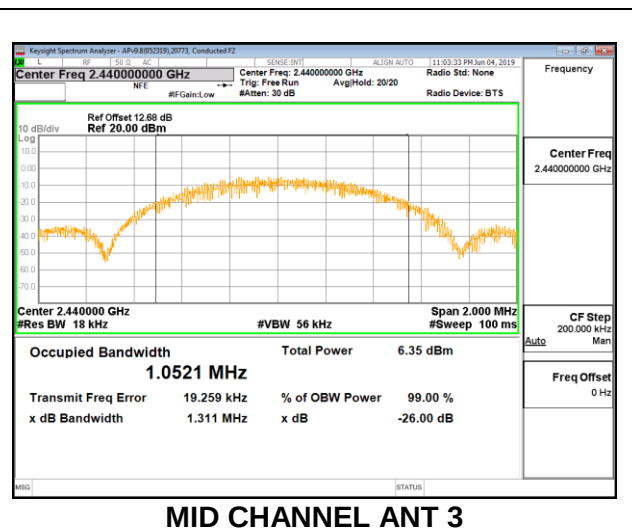
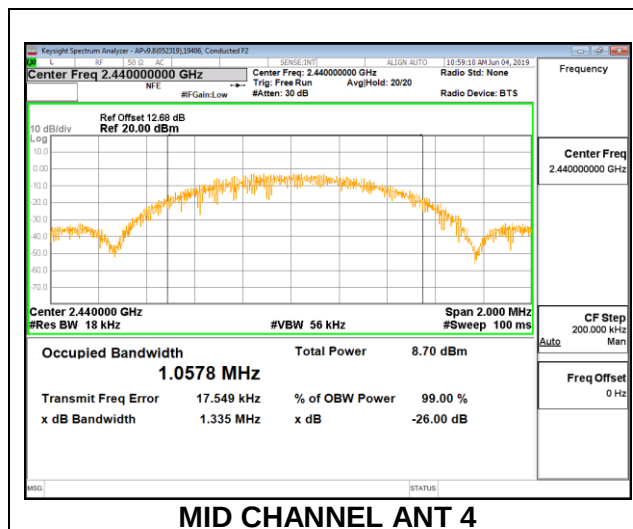
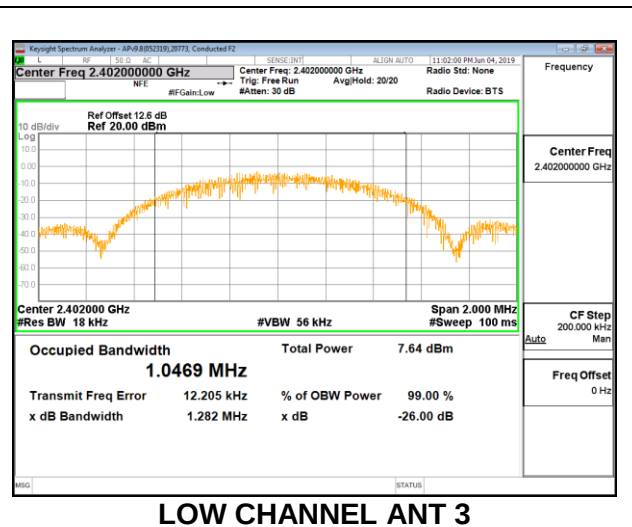
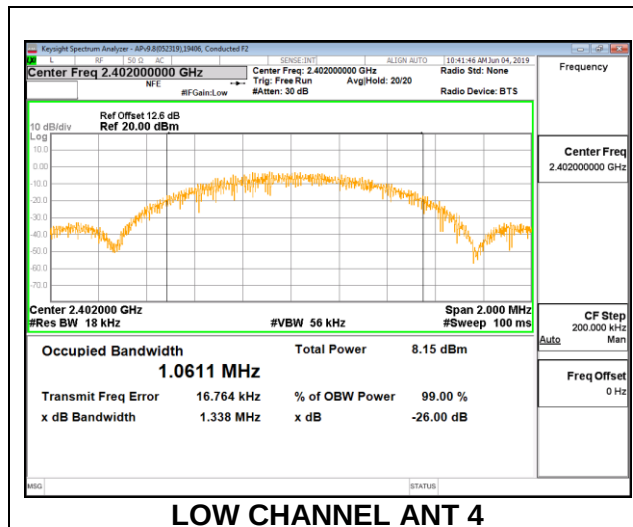
8.3.2. HIGH POWER BLE (2Mbps)

Channel	Frequency (MHz)	99% Bandwidth ANT 4 (MHz)	99% Bandwidth ANT 3 (MHz)
Low	2402	2.0109	2.0356
Mid	2440	2.0110	2.0212
High	2480	2.0173	2.0292



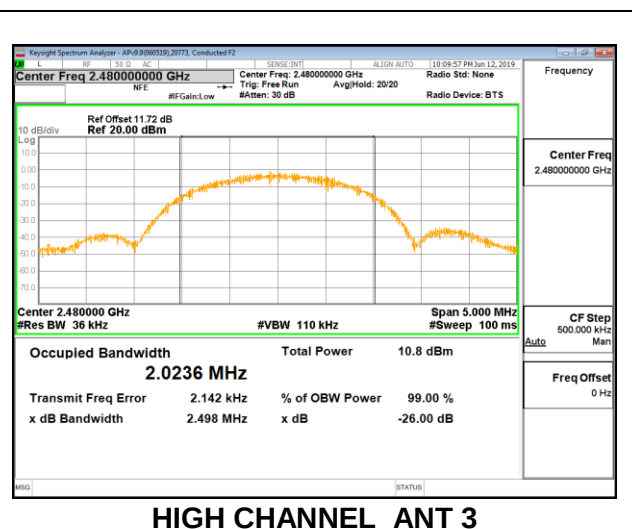
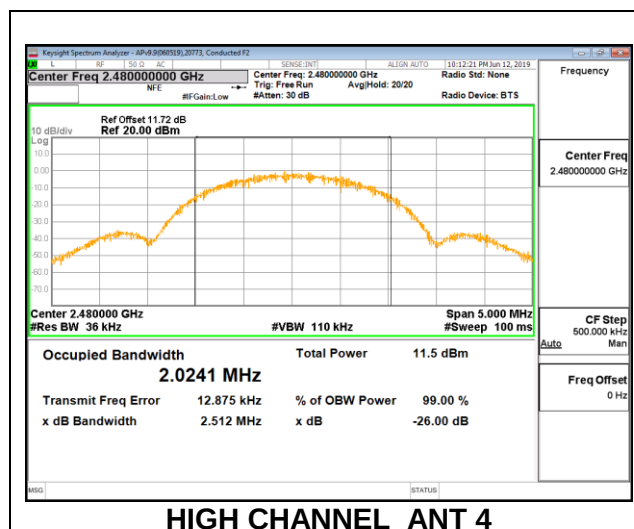
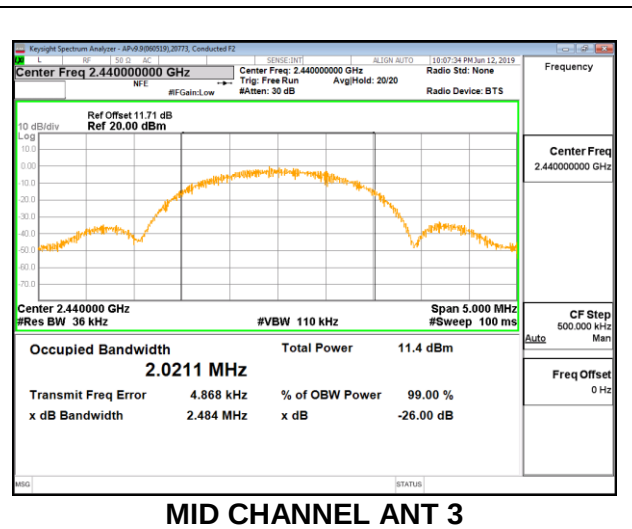
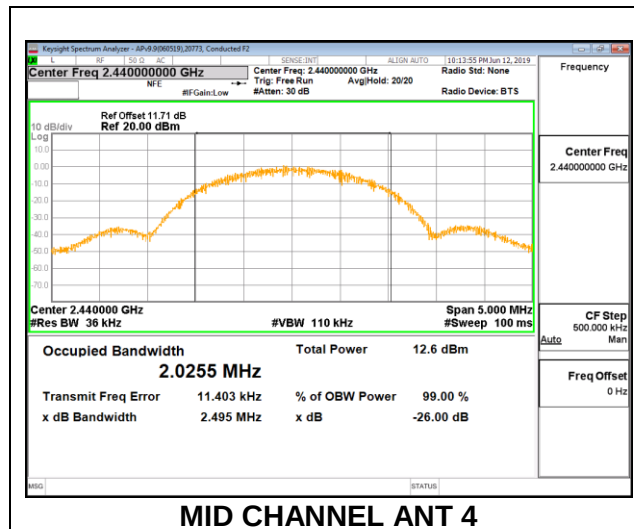
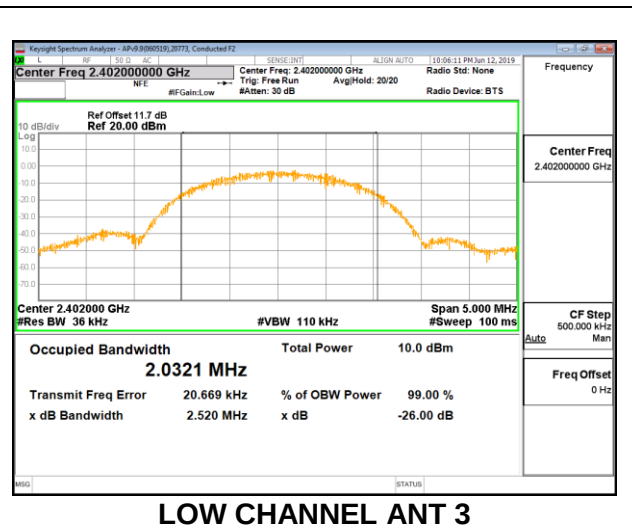
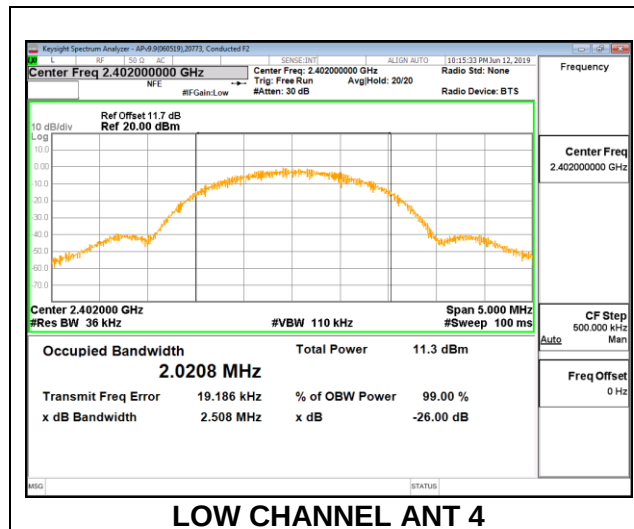
8.3.3. LOW POWER BLE (1Mbps)

Channel	Frequency (MHz)	99% Bandwidth ANT 4 (MHz)	99% Bandwidth ANT 3 (MHz)
Low	2402	1.0611	1.0469
Mid	2440	1.0578	1.0521
High	2480	1.0515	1.0462



8.3.4. LOW POWER BLE (2Mbps)

Channel	Frequency (MHz)	99% Bandwidth ANT 4 (MHz)	99% Bandwidth ANT 3 (MHz)
Low	2402	2.0208	2.0321
Mid	2440	2.0255	2.0211
High	2480	2.0241	2.0236



8.4. 6 dB BANDWIDTH

LIMITS

FCC §15.247 (a) (2)

RSS-247 5.2 (a)

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

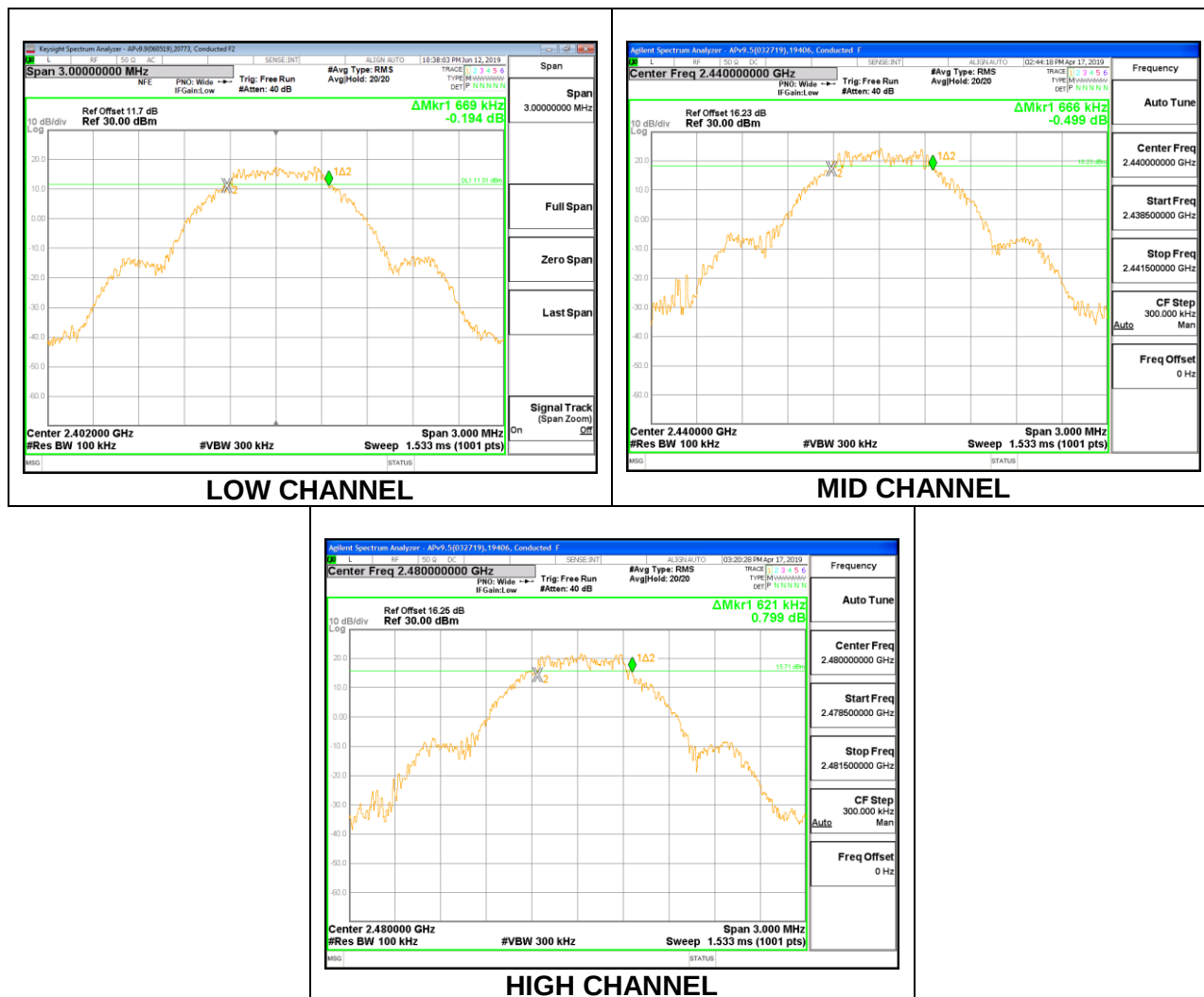
Note: Test procedures and setting are same as BLE normal mode.

RESULTS

8.4.1. HIGH POWER BLE (1Mbps)

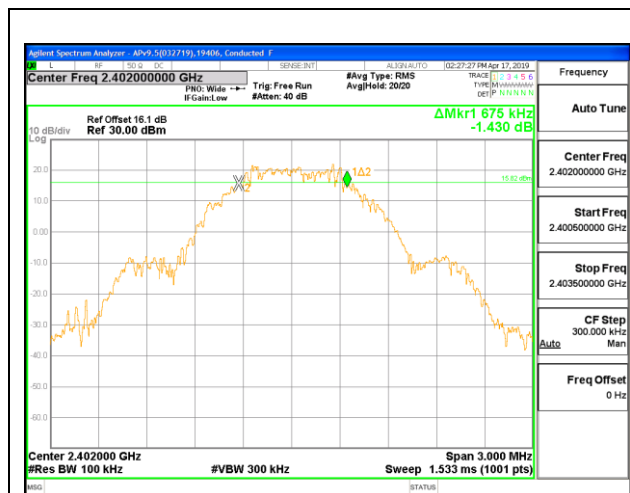
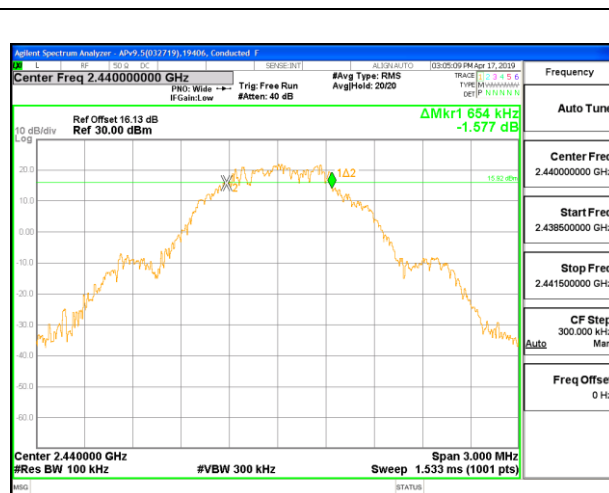
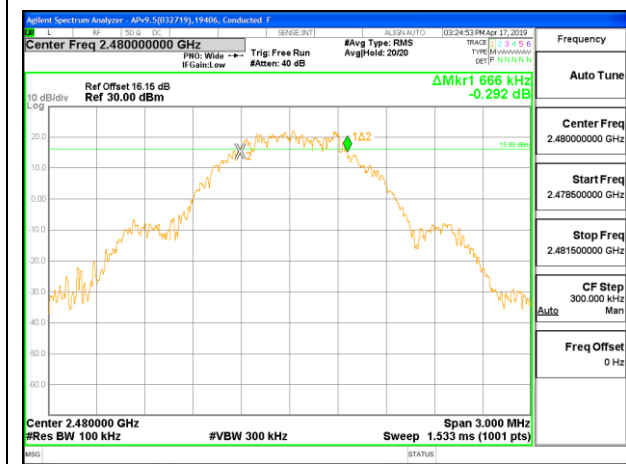
Antenna 4

Channel	Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum Limit (MHz)
Low	2402	0.6690	0.5
Middle	2440	0.6660	0.5
High	2480	0.6210	0.5



Antenna 3

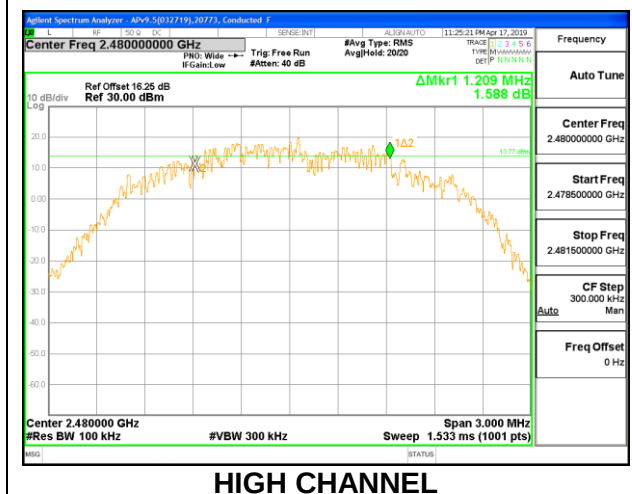
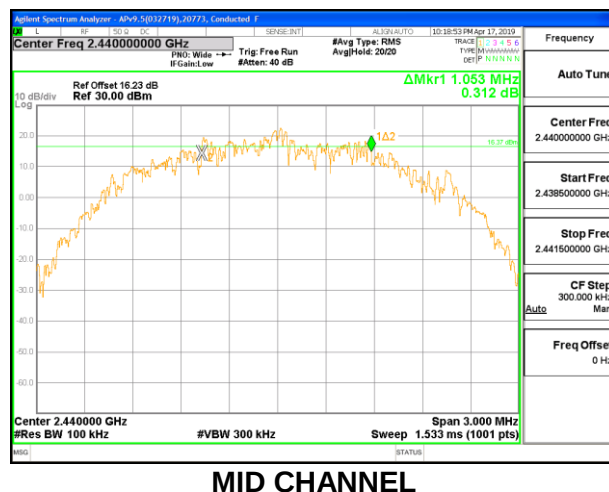
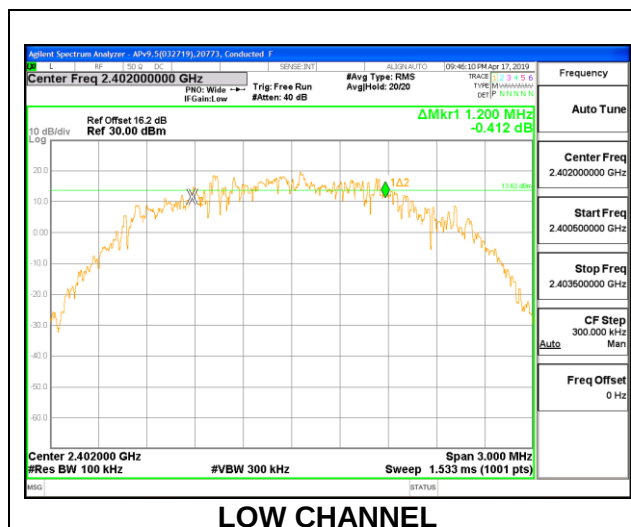
Channel	Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum Limit (MHz)
Low	2402	0.6750	0.5
Middle	2440	0.6540	0.5
High	2480	0.6660	0.5

**LOW CHANNEL****MID CHANNEL****HIGH CHANNEL**

8.4.2. HIGH POWER BLE (2Mbps)

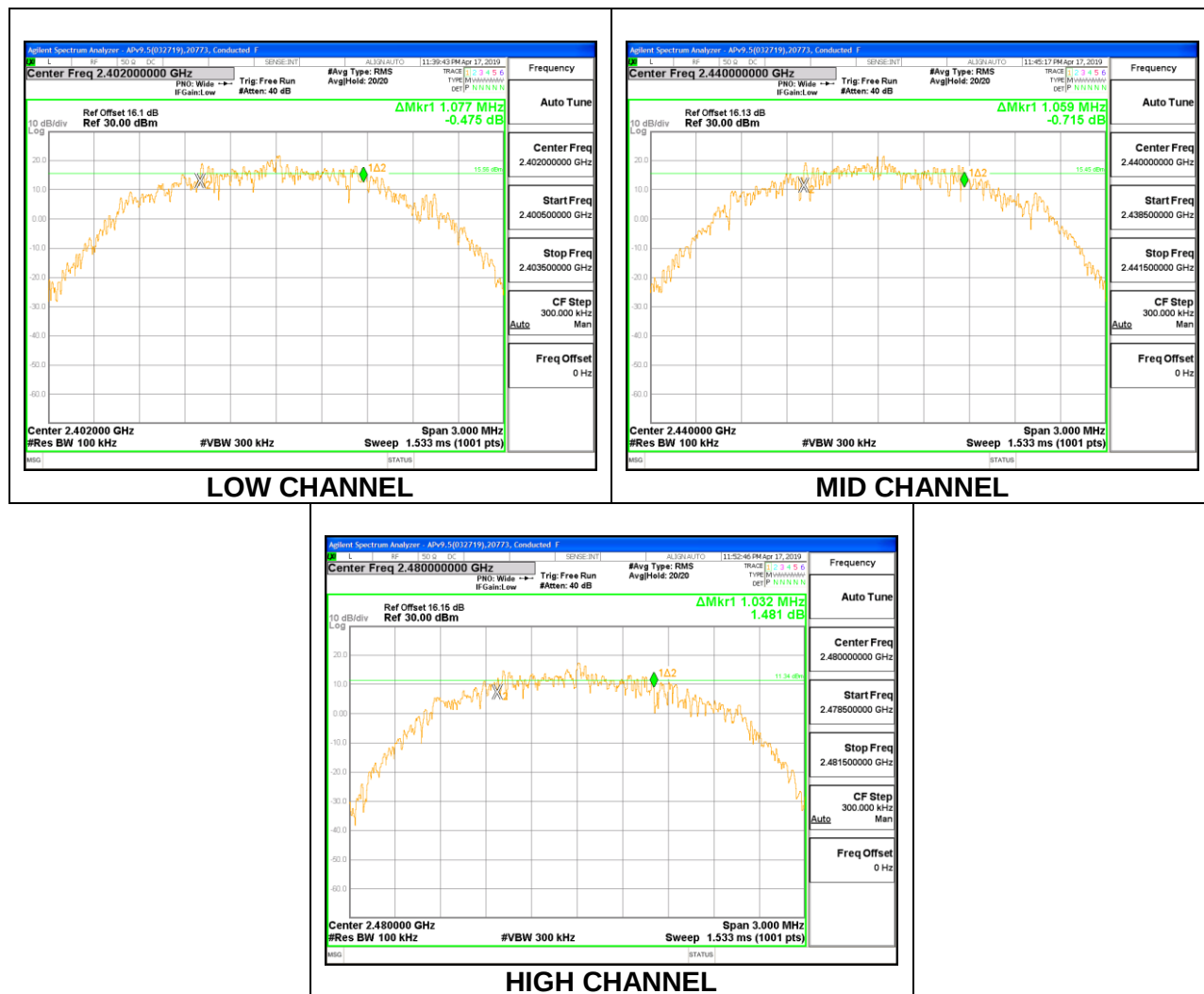
Antenna 4

Channel	Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum Limit (MHz)
Low	2402	1.2000	0.5
Middle	2440	1.0530	0.5
High	2480	1.2090	0.5



Antenna 3

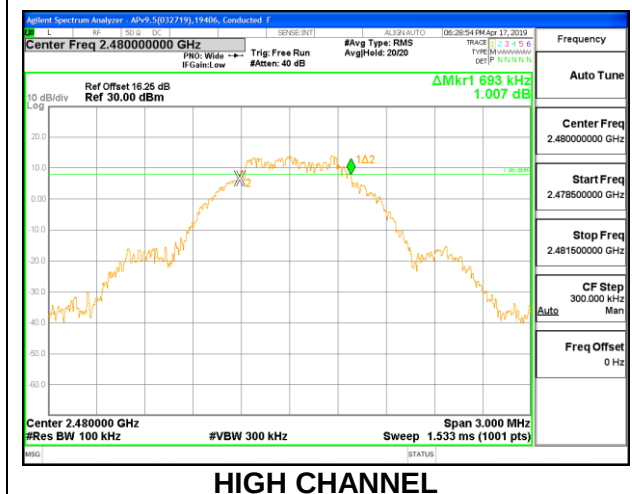
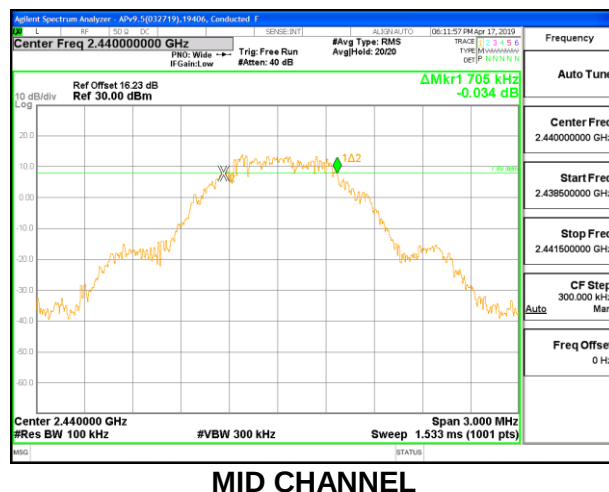
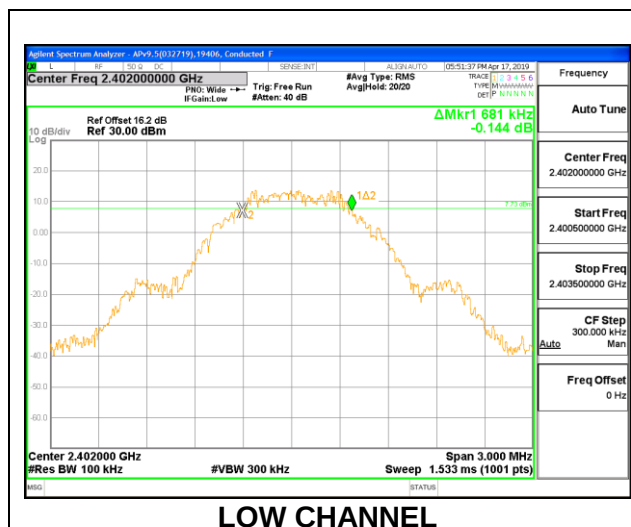
Channel	Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum Limit (MHz)
Low	2402	1.0770	0.5
Middle	2440	1.0590	0.5
High	2480	1.0320	0.5



8.4.3. LOW POWER BLE (1Mbps)

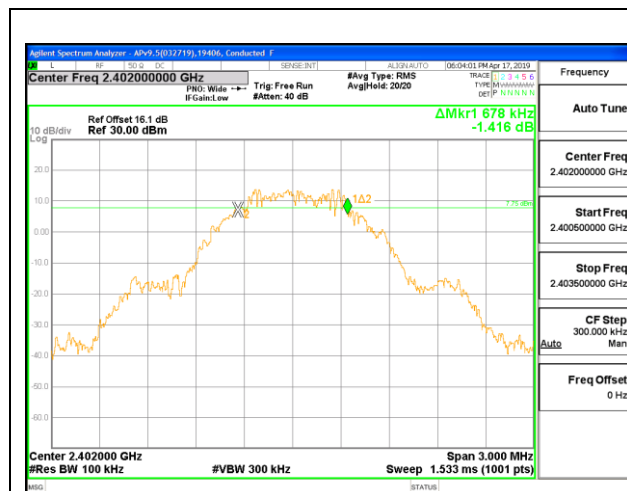
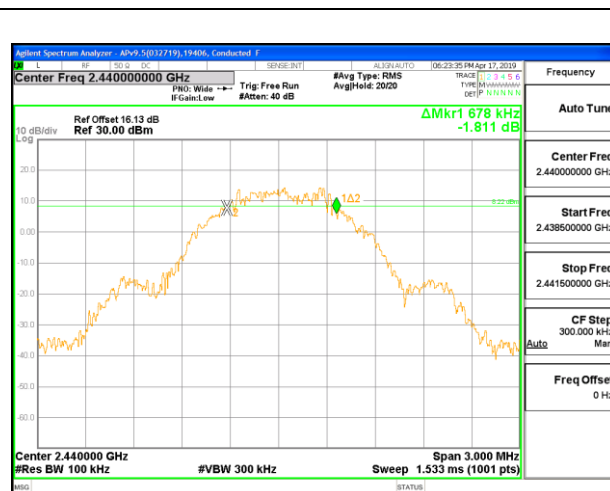
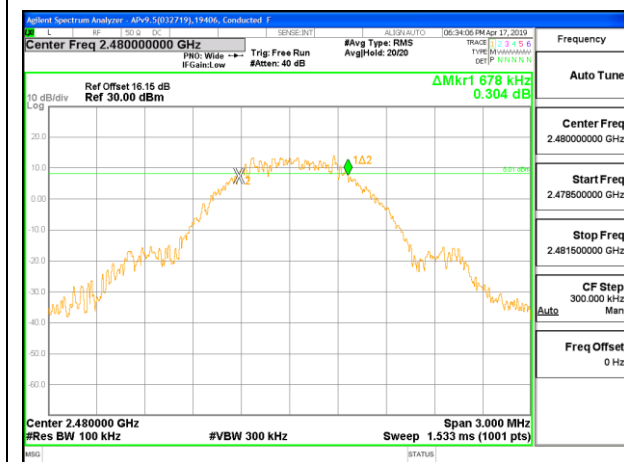
Antenna 4

Channel	Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum Limit (MHz)
Low	2402	0.6810	0.5
Middle	2440	0.7050	0.5
High	2480	0.6930	0.5



Antenna 3

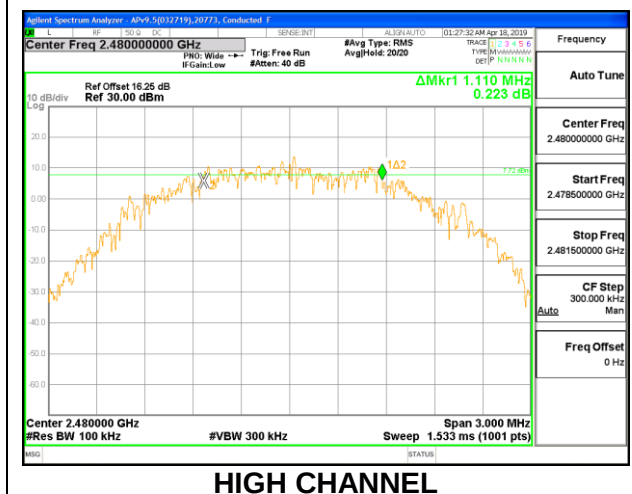
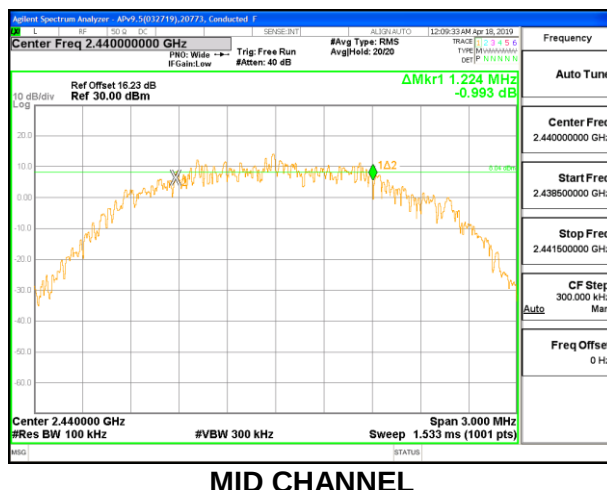
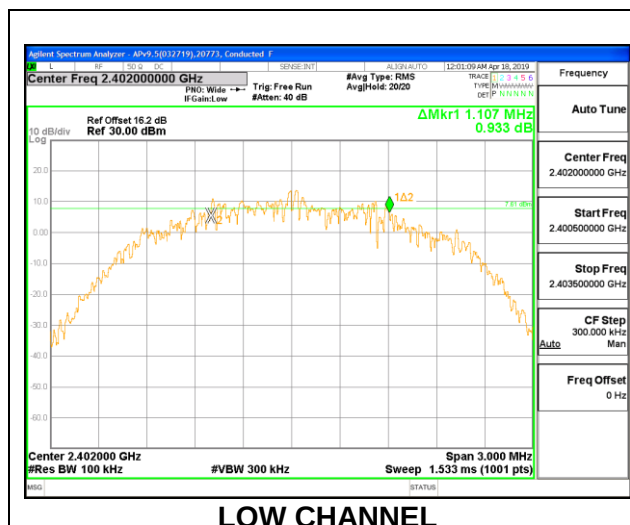
Channel	Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum Limit (MHz)
Low	2402	0.6780	0.5
Middle	2440	0.6780	0.5
High	2480	0.6780	0.5

**LOW CHANNEL****MID CHANNEL****HIGH CHANNEL**

8.4.4. LOW POWER BLE (2Mbps)

Antenna

Channel	Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum Limit (MHz)
Low	2402	1.1070	0.5
Middle	2440	1.2240	0.5
High	2480	1.1100	0.5



Antenna 3

Channel	Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum Limit (MHz)
Low	2402	1.0980	0.5
Middle	2440	1.1550	0.5
High	2480	1.1130	0.5

