



CERTIFICATION TEST REPORT

Report Number. : 13018918-E1V2

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

Model : A2296

FCC ID : BCG-E3501A

IC : 579C-E3501A

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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NVLAP Lab code: 200065-0

REPORT REVISION HISTORY

Rev.	Issue Date	Revisions	Revised By
V1	3/21/2020	Initial Issue	Chris Xiong
V2	3/25/2020	Address TCB's Questions	Chris Xiong

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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: A2296

SERIAL NUMBER: FFMZW00APM7C, FFMZW06XPM62

DATE TESTED: AUGUST 29, 2019 – NOVEMBER 18, 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.

Approved & Released For
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UL Verification Services Inc.

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, KDB 662911, 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)	☐ 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.

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

4. DECISION RULES AND MEASUREMENT UNCERTAINTY

4.1 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.

4.2 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.)

4.3 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%.

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, 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. MAXIMUM OUTPUT POWER

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

Antenna	Frequency Range (MHz)	Mode	Configuration	Output Power (dBm)	Output Power (mW)
UAT 1	2402 - 2480	BLE 1M	High Power	19.03	79.98
			Low Power	12.56	18.03
		BLE 2M	High Power	19.12	81.66
			Low Power	12.70	18.62
LAT 3	2402 - 2480	BLE 1M	High Power	20.03	100.69
			Low Power	12.59	18.16
		BLE 2M	High Power	20.10	102.33
			Low Power	12.68	18.54
BF, UAT 1 + LAT 3	2402 - 2480	BLE 1M	High Power	20.10	102.33
			Low Power	15.65	36.73
		BLE 2M	High Power	20.12	102.80
			Low Power	15.61	36.39

5.3. DESCRIPTION OF AVAILABLE ANTENNAS

Frequency Range (GHz)	LAT 3 (Core 1) (dBi)	UAT 1 (Core 0) (dBi)
2.4	-0.40	-2.20

5.4. SOFTWARE AND FIRMWARE

The EUT firmware installed during testing was BT FW Version: 17.1.210.2193.

5.5. WORST-CASE CONFIGURATION AND MODE

The EUT was investigated in three orthogonal orientations X (Flatbed), Y (Landscape) and Z (Portrait) on UAT 1 (Core 0), LAT 3 (Core 1) and 2TX beamforming (UAT 1 + LAT 3). It was determined that Y orientation was the worst-case for LAT 3 and X (Flatbed) was the worst-case orientation for UAT 1 and 2TX BF.

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

Radiated emissions below 30MHz, below 1GHz, 18-26GHz and AC power line conducted emissions were performed with the EUT transmitting 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, tests were performed with EUT only. There were no emissions found below 30MHz within 20dB of the limit. For AC power line conducted emission, tests were 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.

5.6. 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

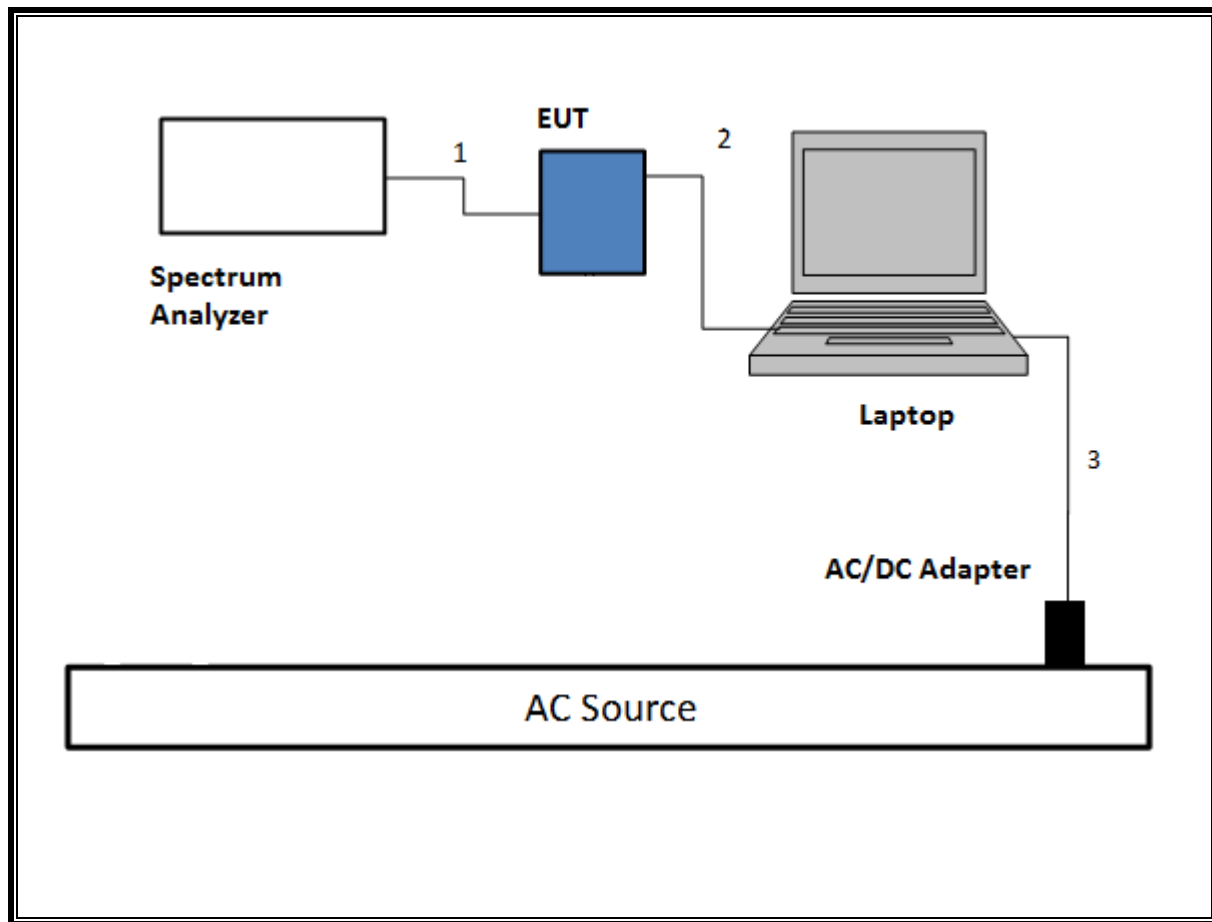
I/O CABLES (BELOW 1GHz AND AC POWER LINE TEST WITH ADAPTER AND LAPTOP)

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

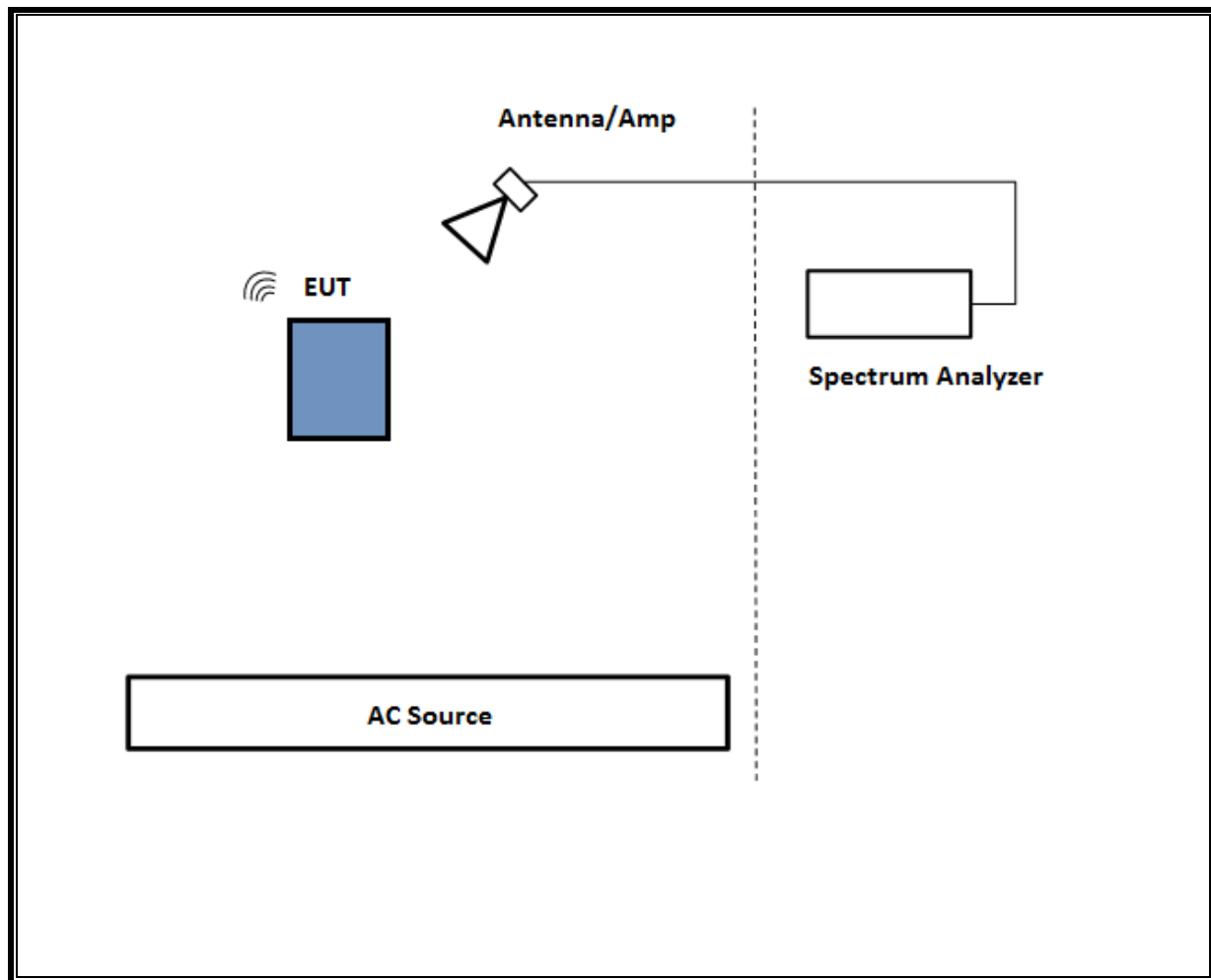
TEST SETUP

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

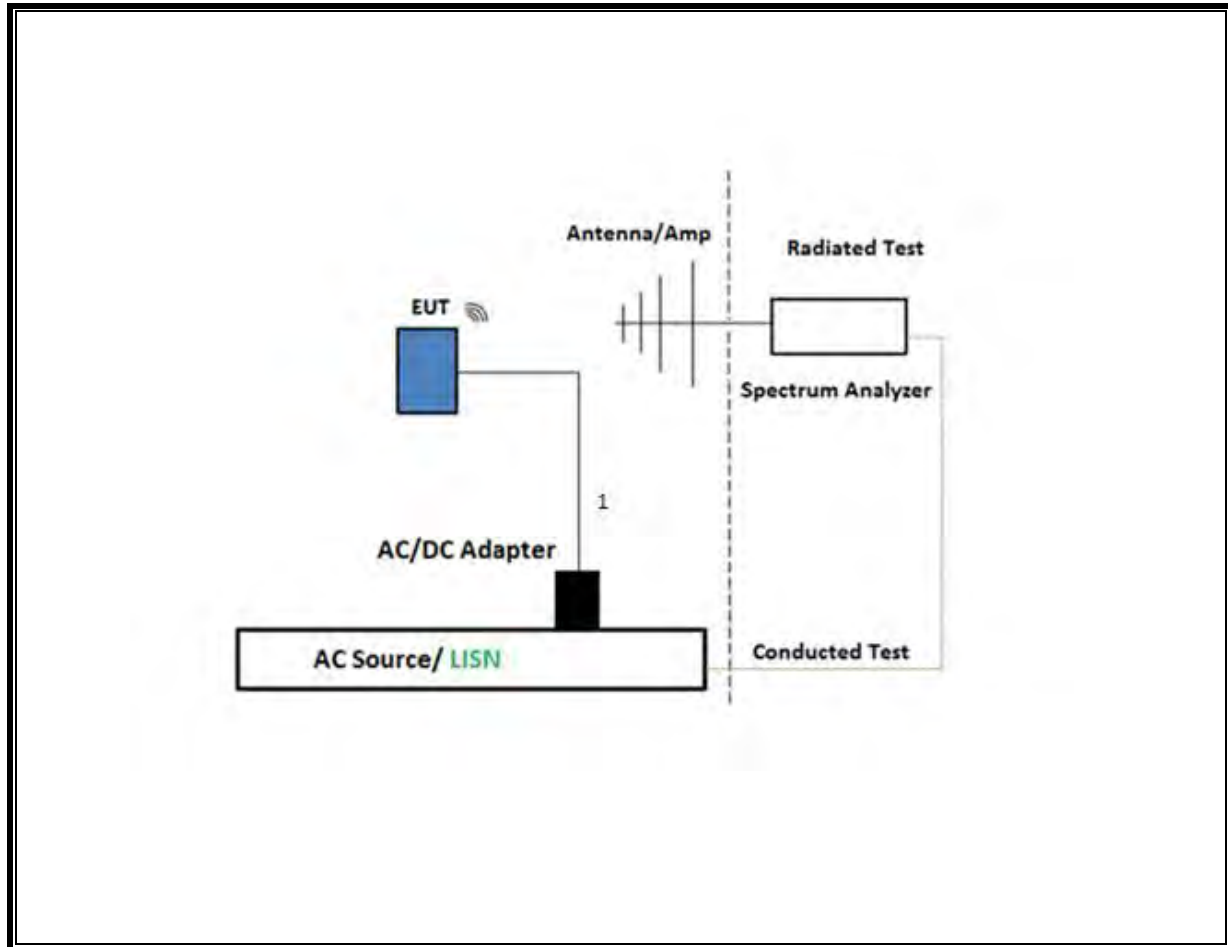
SETUP DIAGRAM FOR CONDUCTED TESTS



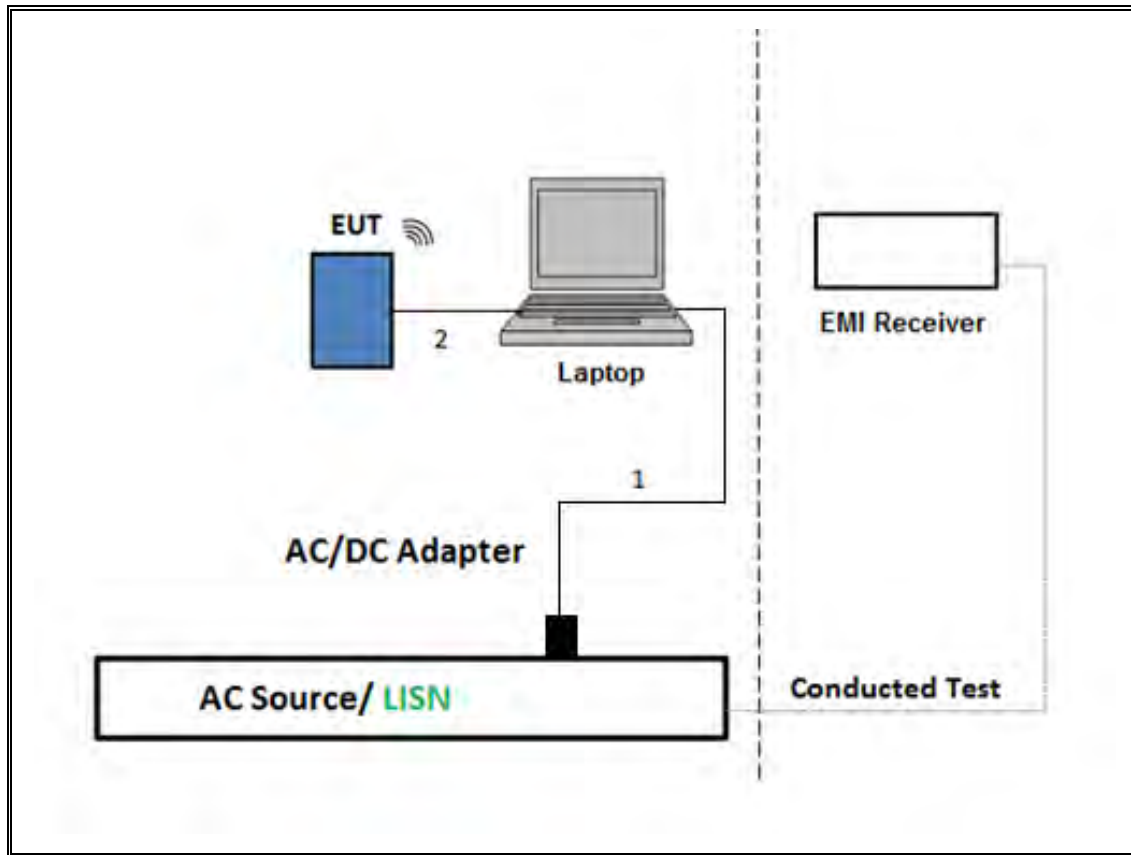
SETUP DIAGRAM FOR RADIATED TESTS Above 1 GHz



SETUP DIAGRAM FOR Below 1GHz and AC LINE CONDUCTED TEST



TEST SETUP- AC LINE CONDUCTED: LAPTOP CONFIGURATION



6. MEASUREMENT METHOD

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

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 -11.9.2.3.2 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

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.

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
*Spectrum Analyzer, PXA, 3Hz to 44GHz	Keysight Technologies	N9030A	T908	01/23/2020	01/13/2019
Antenna, Horn 1 to 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
Antenna, Horn 1-18GHz	ETS Lindgren	3117	T712	02/26/2020	02/26/2019
Amplifier, 1 to 18GHz	Miteq	AFS42-00101800-25-S-42	T740	07/31/2020	07/31/2019
*Spectrum Analyzer, PXA, 3Hz to 50GHz	Keysight Technologies	N9030A	T342	01/23/2020	01/23/2019
Antenna, Horn 1 to 18GHz	ETS-Lindgren	3117	T345	04/20/2020	05/07/2019
RF Amplifier, 1 to 18GHz, 45dB Min	AMPLICAL	AMP0.1G18-47-20	PRE0181907	07/15/2020	08/15/2019
Antenna, Broadband Hybrid, 30MHz to 2000MHz	Sunol Sciences Corp.	JB3	T407	05/11/2020	06/11/2019
Amplifier, 10KHz to 1GHz, 32dB	Sonoma Instrument	310	T173	06/06/2020	07/06/2019
*Spectrum Analyzer, PXA, 3Hz to 44GHz	Keysight Technologies	N9030A	T340	01/22/2020	01/22/2019
*Amplifier, 1 to 8GHz, 30dB Gain	L3 Narda	AMF-4D-01000800-30-29P	PRE0176601	01/26/2020	01/26/2019
*Spectrum Analyzer, PXA, 3Hz to 44GHz	Keysight Technologies	N9030A	T905	01/24/2020	01/24/2019
Antenna, Horn 1-18GHz	ETS-Lindgren	3117	T863	05/30/2020	05/30/2019
*Amplifier, 1 to 18GHz, 35dB	Amplical	AFS42-00101800-25-S-42	T1567	01/26/2020	01/26/2019
Antenna, Horn 18 to 26.5GHz	ARA	MWH-1826/B	T448	03/26/2020	03/26/2019
Amplifier, 1 to 26.5GHz, 23.5dB Gain	Keysight Technologies	8449B	T404	03/23/2020	03/23/2019
*Spectrum Analyzer, PXA, 3Hz to 44GHz	Keysight Technologies	N9030A	T339	01/23/2020	01/23/2019
Antenna Horn, 18 to 26GHz	ARA	MWH-1826	T447	08/13/2020	08/13/2019
Pre-Amp 18-26GHz	Agilent Technology	8449B	T404	03/23/2020	03/23/2019
EMI Test Receiver 9KHz - 7GHz	Rohde & Schwarz	ESR	T1436	02/14/2020	02/14/2019
*Conducted Emissions	UL	PR1	T861	10/19/2019	10/19/2018
*LISN	Fischer Custom Communications	FCC-LISN-50/250-25-2-01	T1310	01/24/2020	01/24/2019
Antenna, Active Loop 9KHz to 30MHz	EMCO	6502	T35	06/06/2020	06/06/2019
*Power Meter, P-series single channel	Keysight Technologies	N1912A	T1244	01/30/2020	01/30/2019
Power Sensor, P - series, 50MHz to 18GHz, Wideband	Keysight Technologies	N1921A	T1224	02/22/2020	02/22/2019

TEST SOFTWARE LIST			
Description	Manufacturer	Model	ID Num
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 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/2Mbps	1.000	1.000	1.000	100.00%	0.00	0.010
BLE TxBF, 1Mbps/2Mbps	1.000	1.000	1.000	100.00%	0.00	0.010

DUTY CYCLE PLOTS



8.2. 99% BANDWIDTH

LIMITS

None; for reporting purposes only.

RESULTS

8.2.1. HIGH POWER BLE (1Mbps)

UAT 1

Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low	2402	1.054
Middle	2440	1.045
High	2480	1.051



LAT 3

Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low	2402	1.050
Middle	2440	1.053
High	2480	1.045



8.2.2. HIGH POWER BLE (2Mbps)

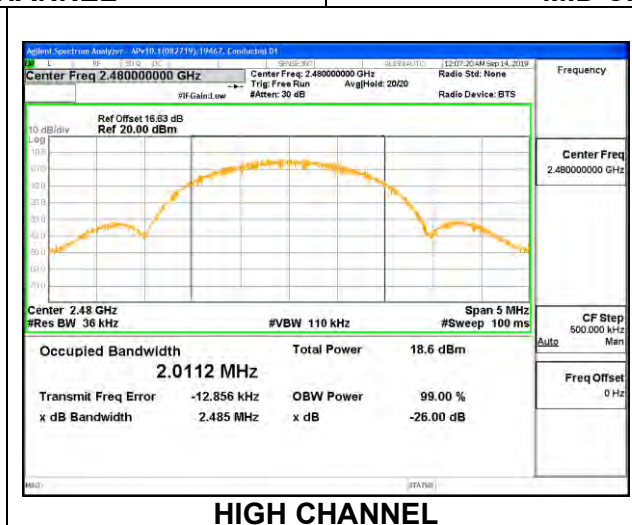
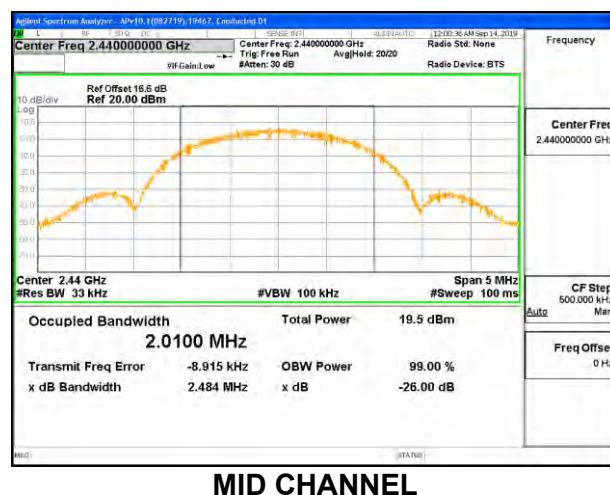
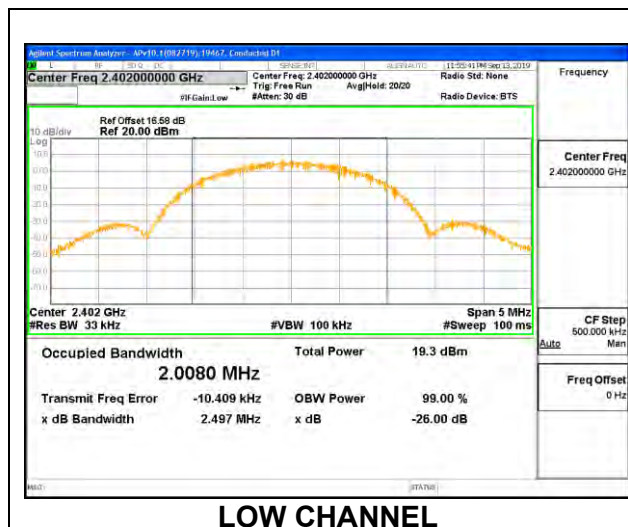
UAT 1

Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low	2402	2.007
Middle	2440	2.007
High	2480	2.005



LAT 3

Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low	2402	2.008
Middle	2440	2.010
High	2480	2.011



8.2.3. LOW POWER BLE (1Mbps)

UAT 1

Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low	2402	1.057
Middle	2440	1.048
High	2480	1.041



LAT 3

Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low	2402	1.052
Middle	2440	1.053
High	2480	1.053



8.2.4. LOW POWER BLE (2Mbps)

UAT 1

Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low	2402	2.015
Middle	2440	2.011
High	2480	2.019



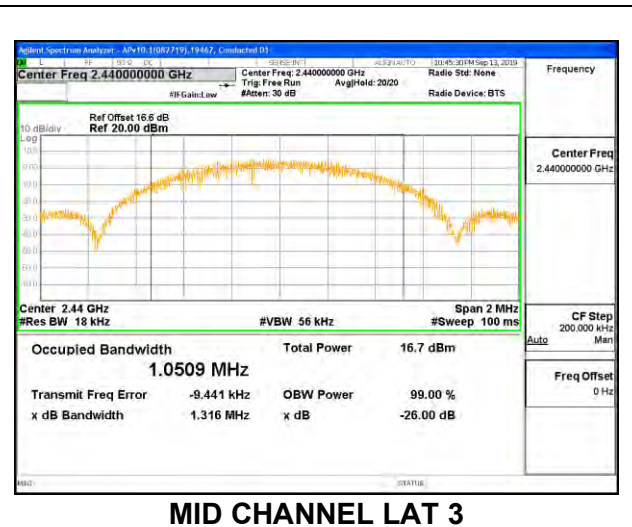
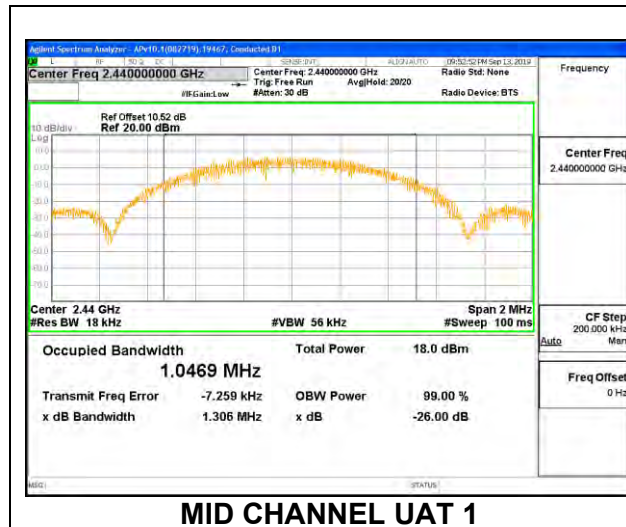
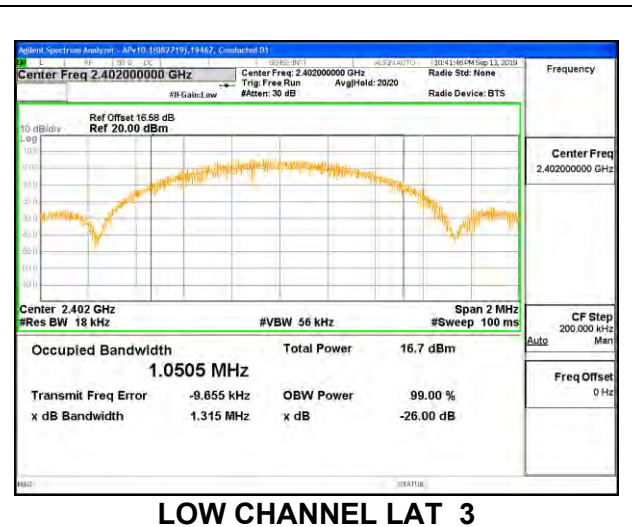
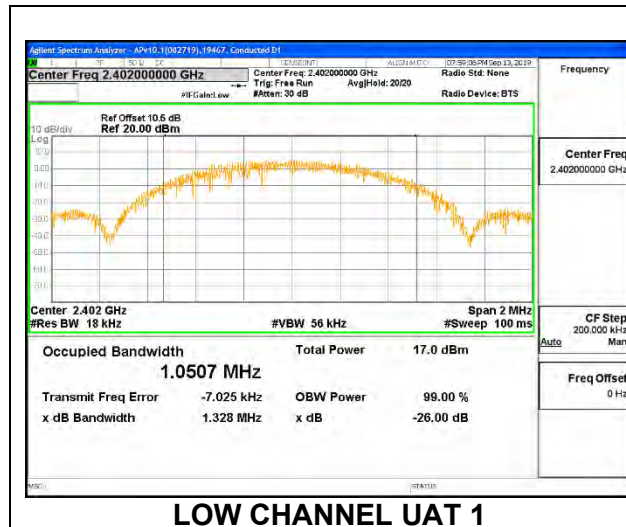
LAT 3

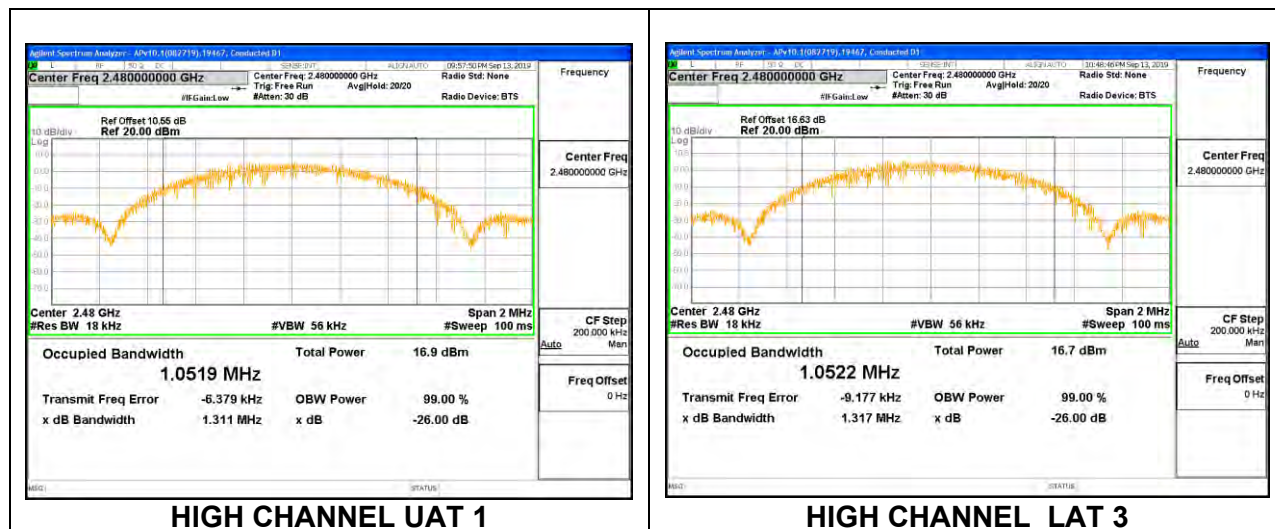
Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low	2402	2.003
Middle	2440	2.021
High	2480	2.007



8.2.5. BEAMFORMING HIGH POWER BLE (1Mbps)

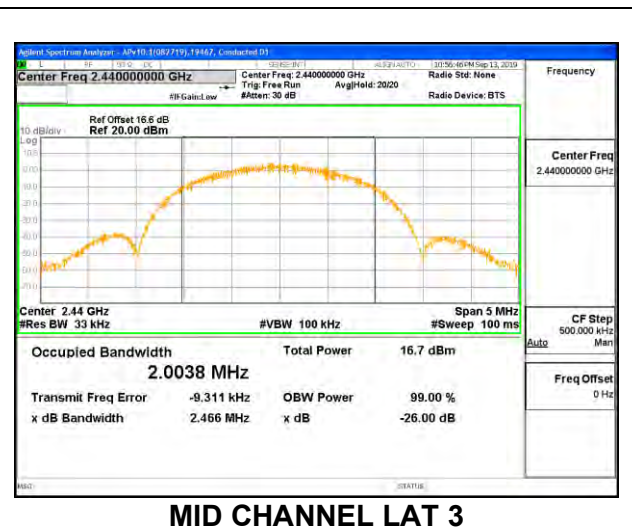
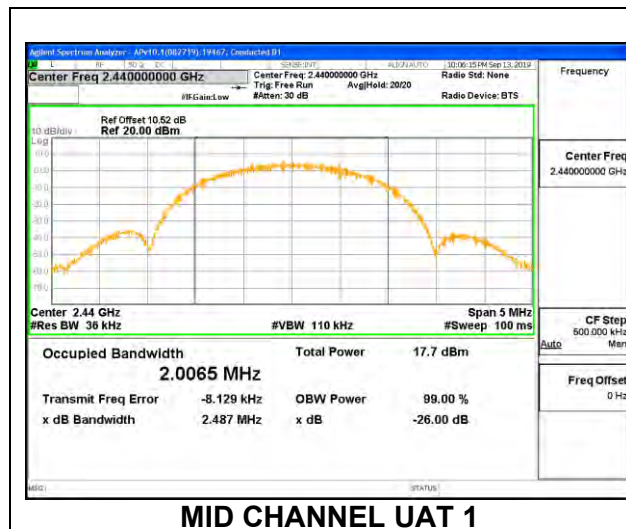
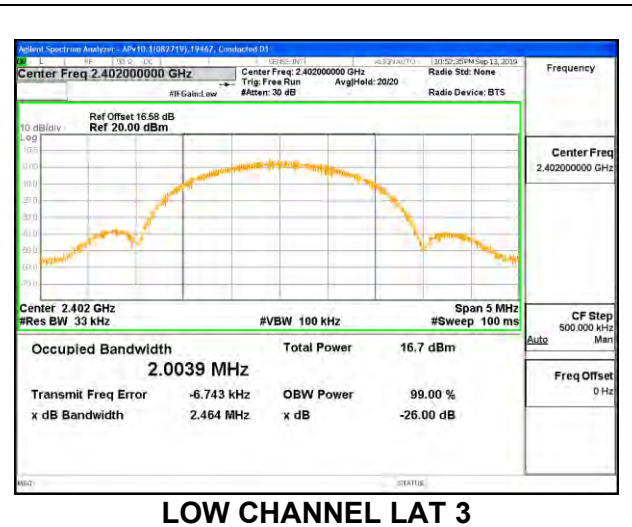
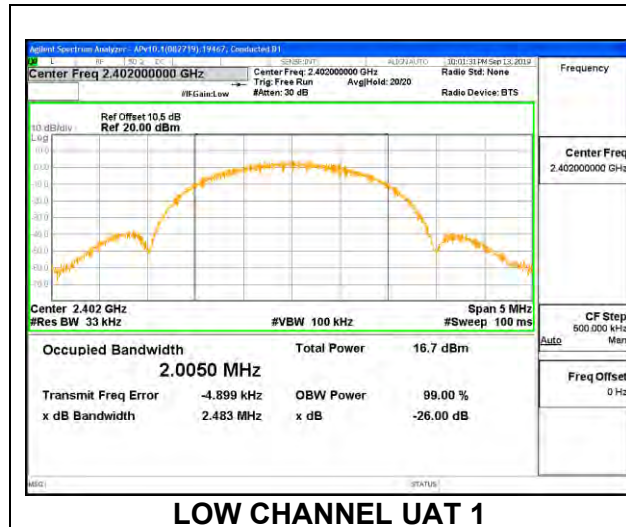
Channel	Frequency (MHz)	99% Bandwidth UAT 1 (MHz)	99% Bandwidth LAT 3 (MHz)
Low	2402	1.051	1.051
Mid	2440	1.047	1.051
High	2480	1.052	1.052

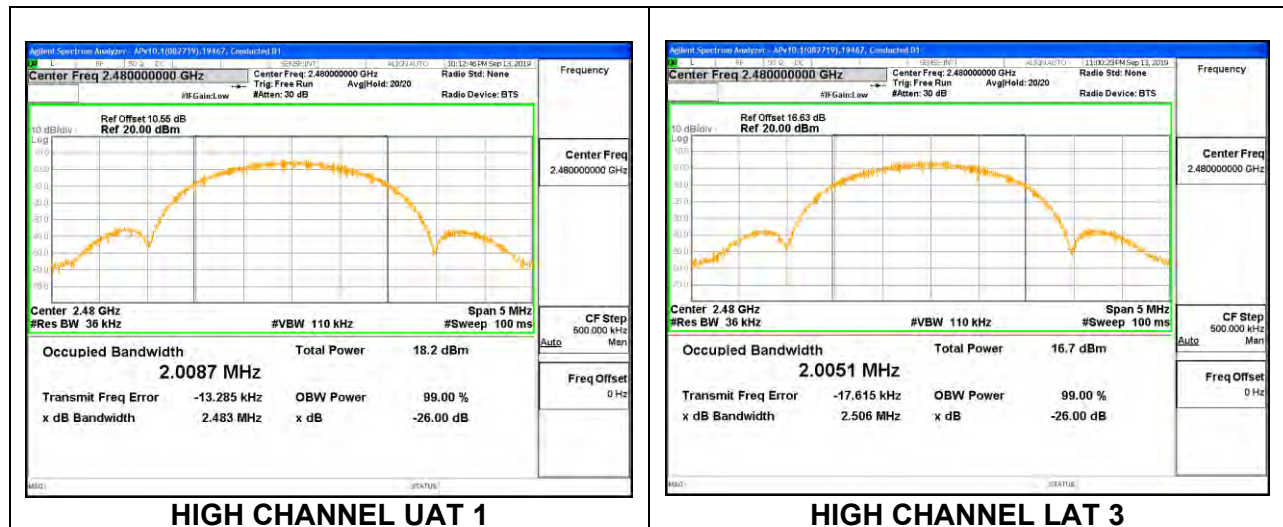




8.2.6. BEAMFORMING HIGH POWER BLE (2Mbps)

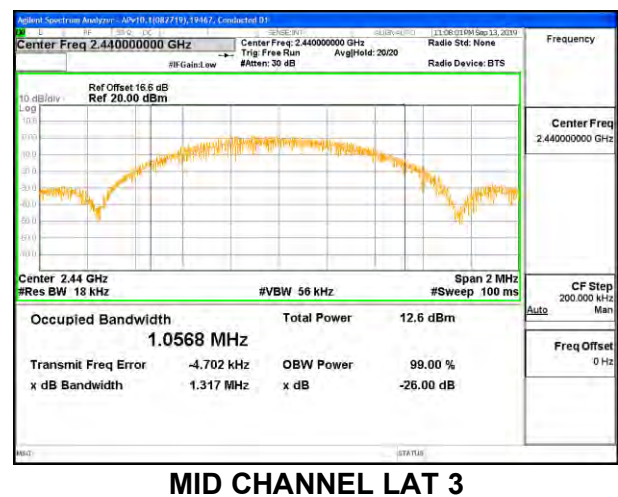
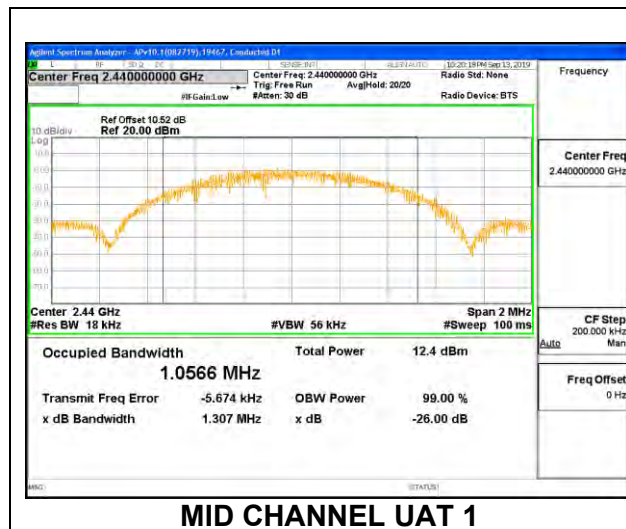
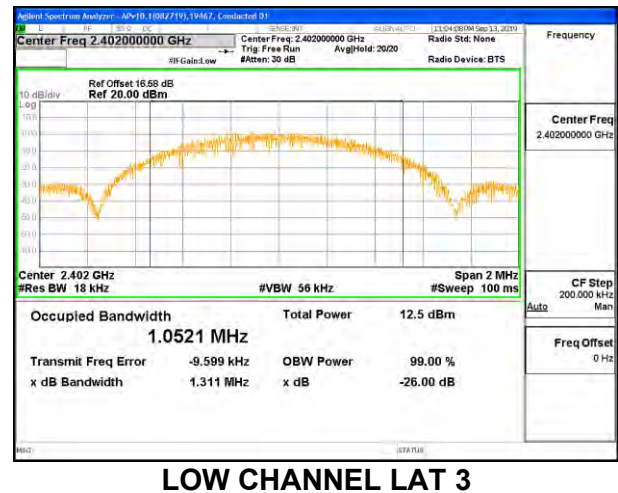
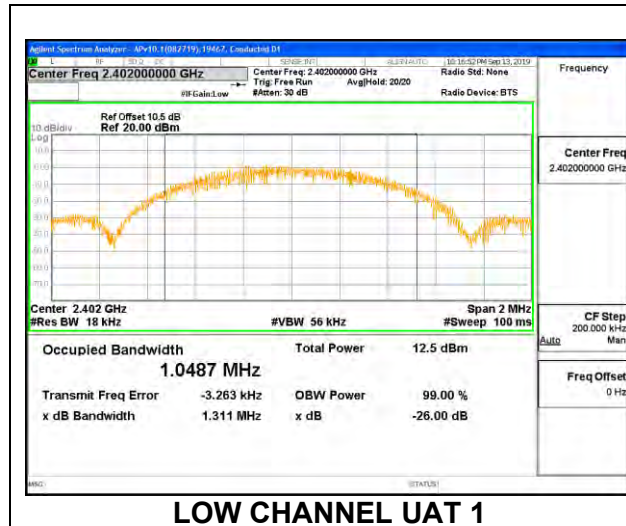
Channel	Frequency (MHz)	99% Bandwidth UAT 1 (MHz)	99% Bandwidth LAT 3 (MHz)
Low	2402	2.005	2.004
Mid	2440	2.007	2.004
High	2480	2.009	2.005

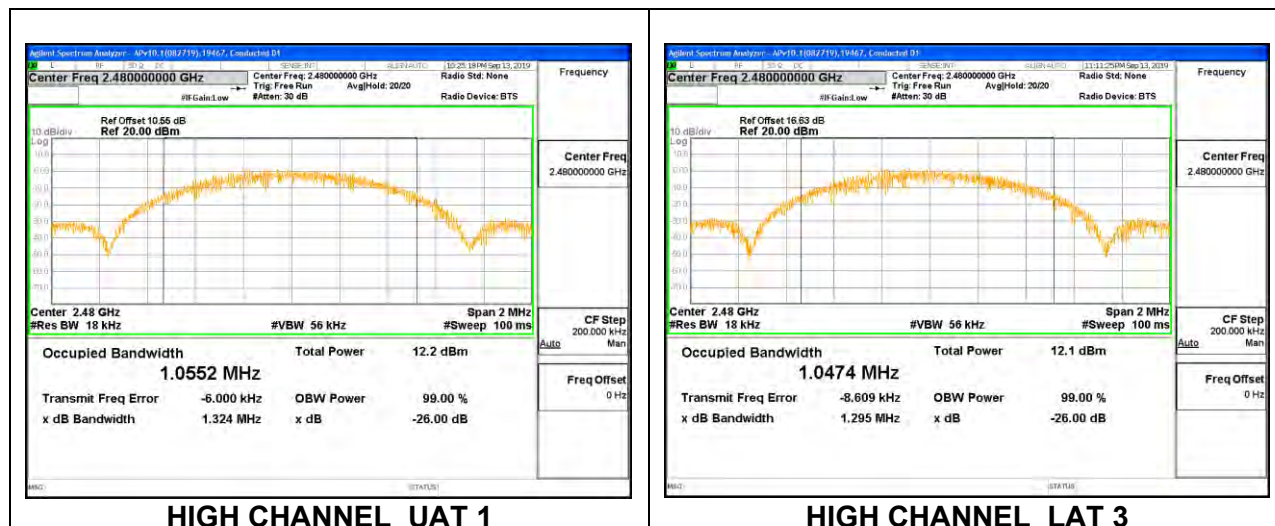




8.2.7. BEAMFORMING LOW POWER BLE (1Mbps)

Channel	Frequency (MHz)	99% Bandwidth UAT 1 (MHz)	99% Bandwidth LAT 3 (MHz)
Low	2402	1.049	1.052
Mid	2440	1.057	1.057
High	2480	1.055	1.047



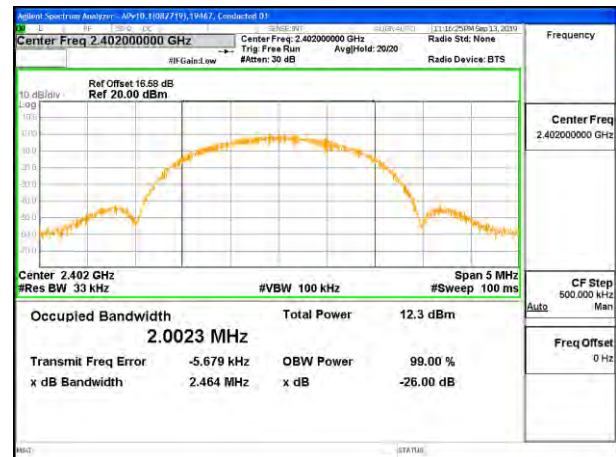


8.2.8. BEAMFORMING LOW POWER BLE (2Mbps)

Channel	Frequency (MHz)	99% Bandwidth UAT 1 (MHz)	99% Bandwidth LAT 3 (MHz)
Low	2402	2.016	2.002
Mid	2440	2.015	2.018
High	2480	2.013	2.003



LOW CHANNEL UAT 1



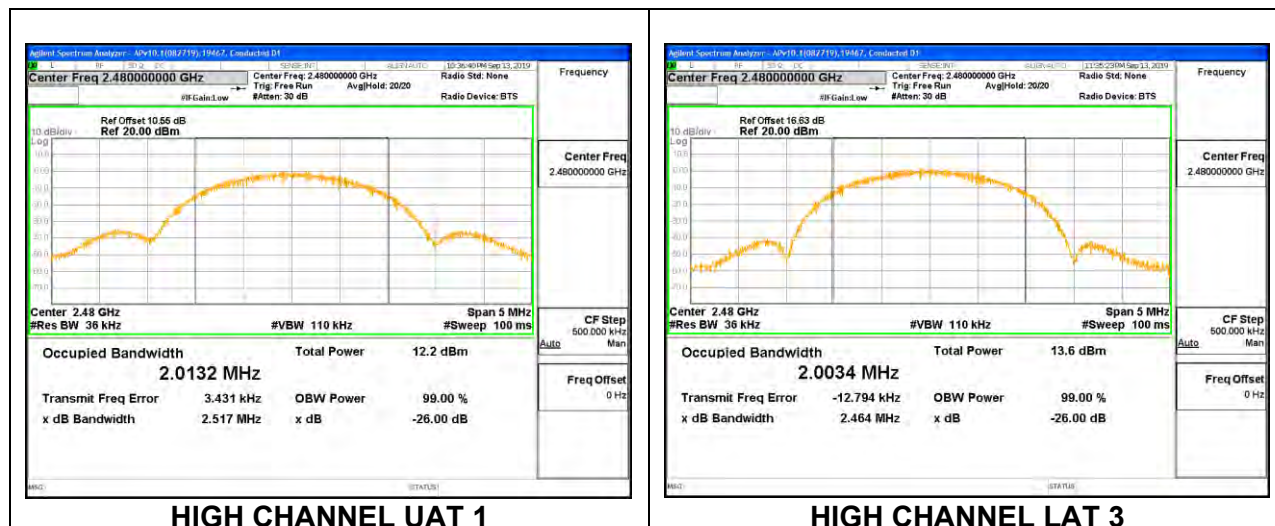
LOW CHANNEL LAT 3



MID CHANNEL UAT 1



MID CHANNEL LAT 3



8.3. 6 dB BANDWIDTH

LIMITS

FCC §15.247 (a) (2)

RSS-247 5.2 (a)

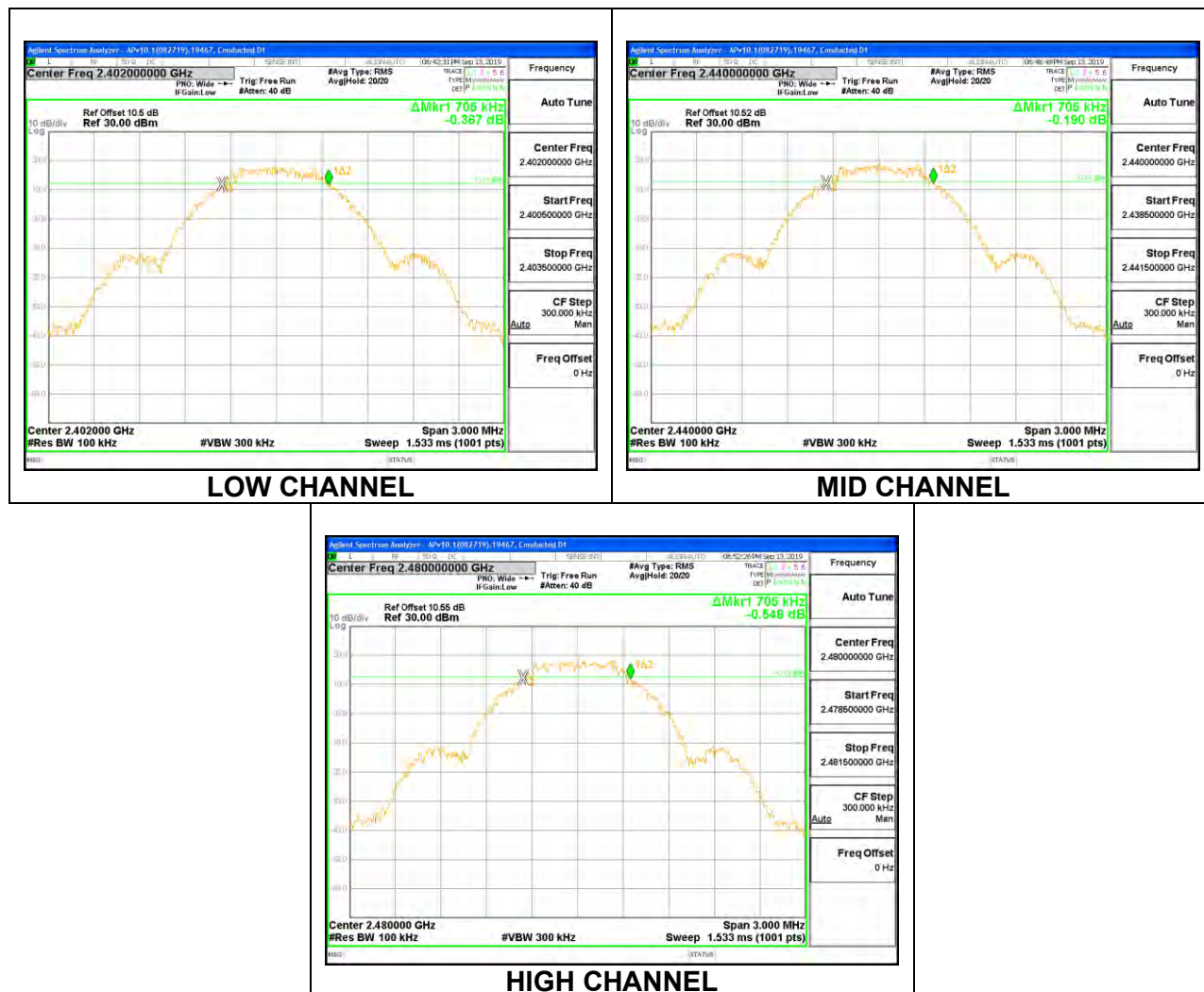
The minimum 6 dB bandwidth shall be at least 500 kHz.

RESULTS

8.3.1. HIGH POWER BLE (1Mbps)

UAT 1

Channel	Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum Limit (MHz)
Low	2402	0.705	0.5
Middle	2440	0.705	0.5
High	2480	0.705	0.5



LAT 3

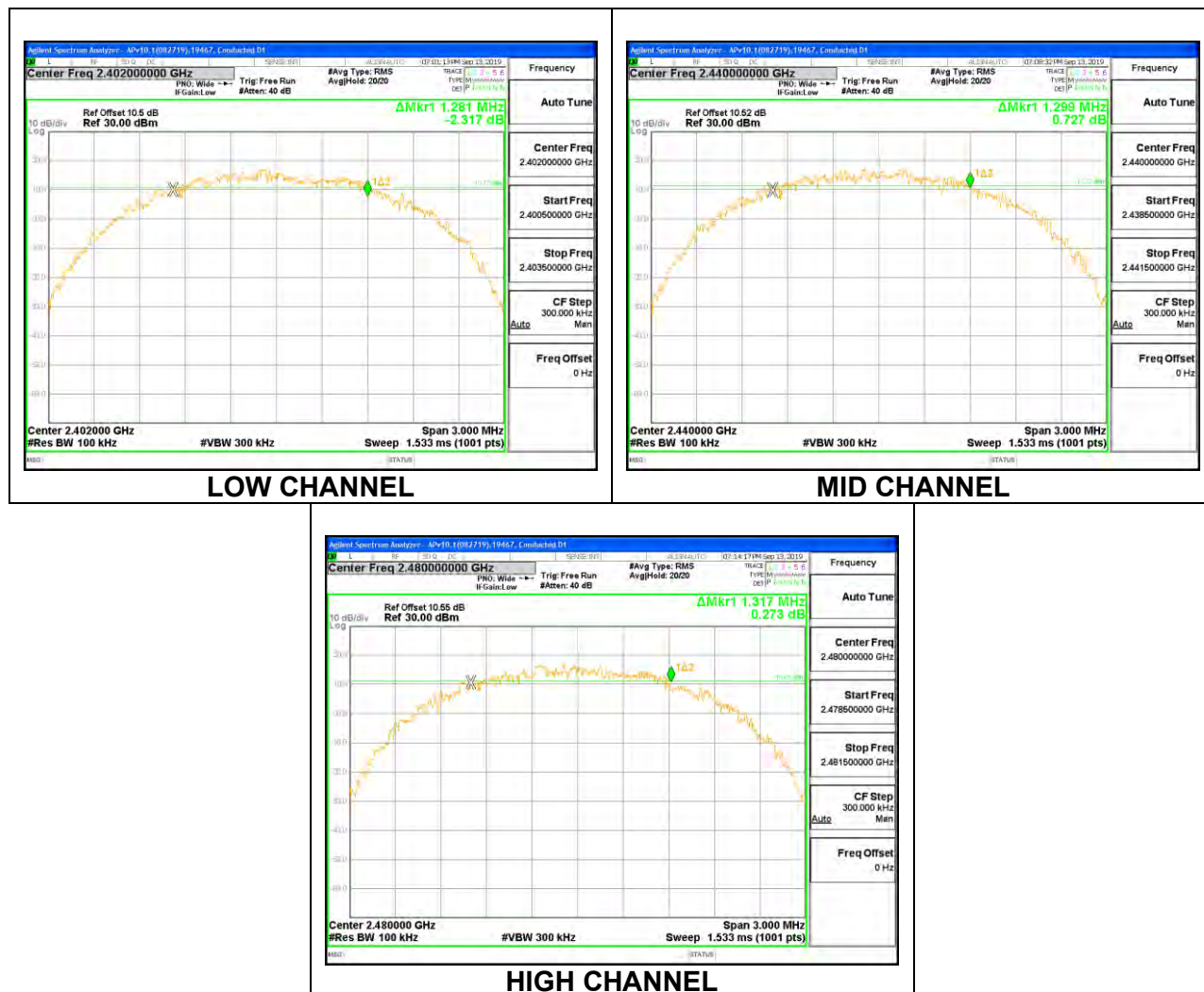
Channel	Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum Limit (MHz)
Low	2402	0.732	0.5
Middle	2440	0.681	0.5
High	2480	0.720	0.5



8.3.2. HIGH POWER BLE (2Mbps)

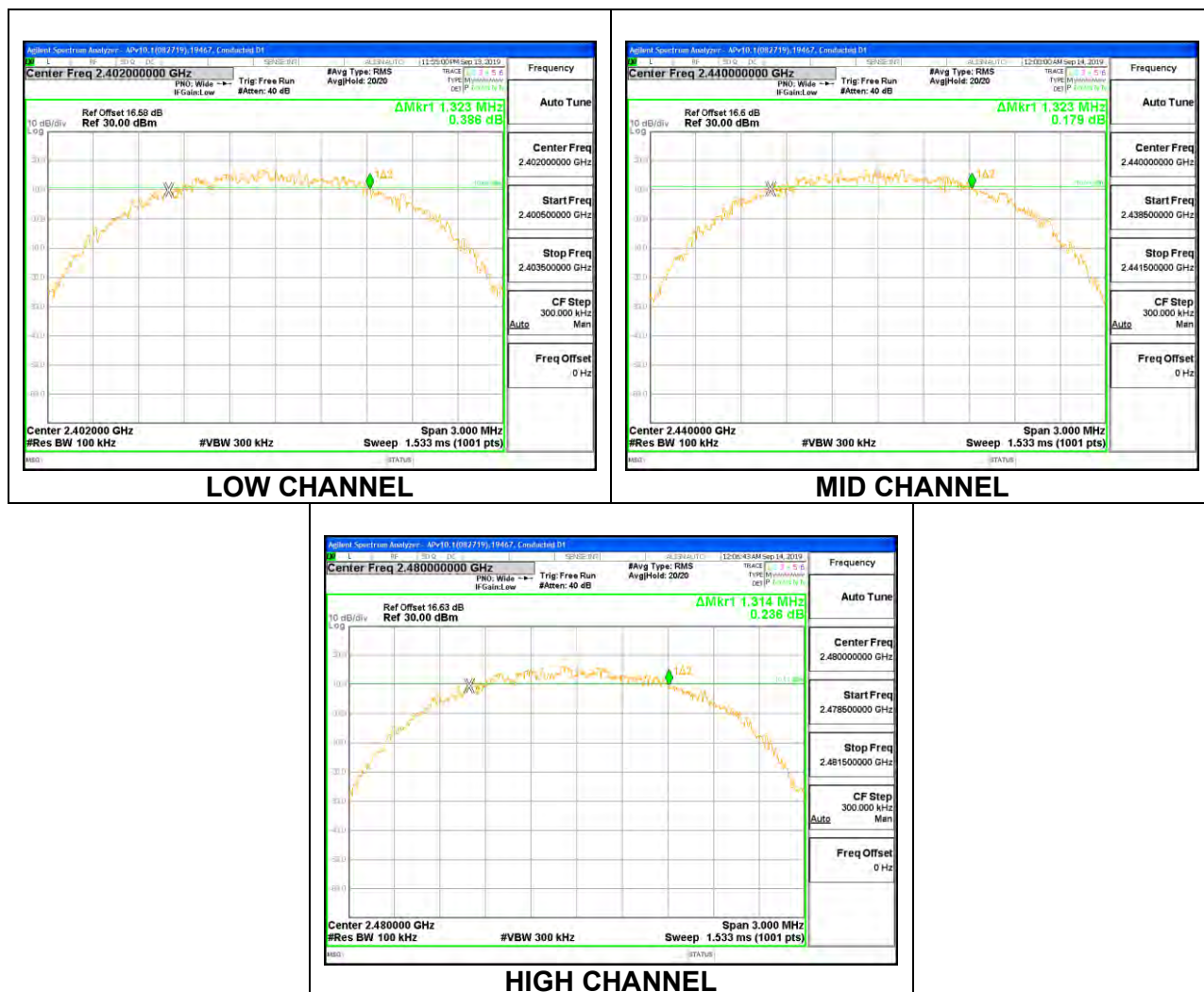
UAT 1

Channel	Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum Limit (MHz)
Low	2402	1.281	0.5
Middle	2440	1.299	0.5
High	2480	1.317	0.5



LAT 3

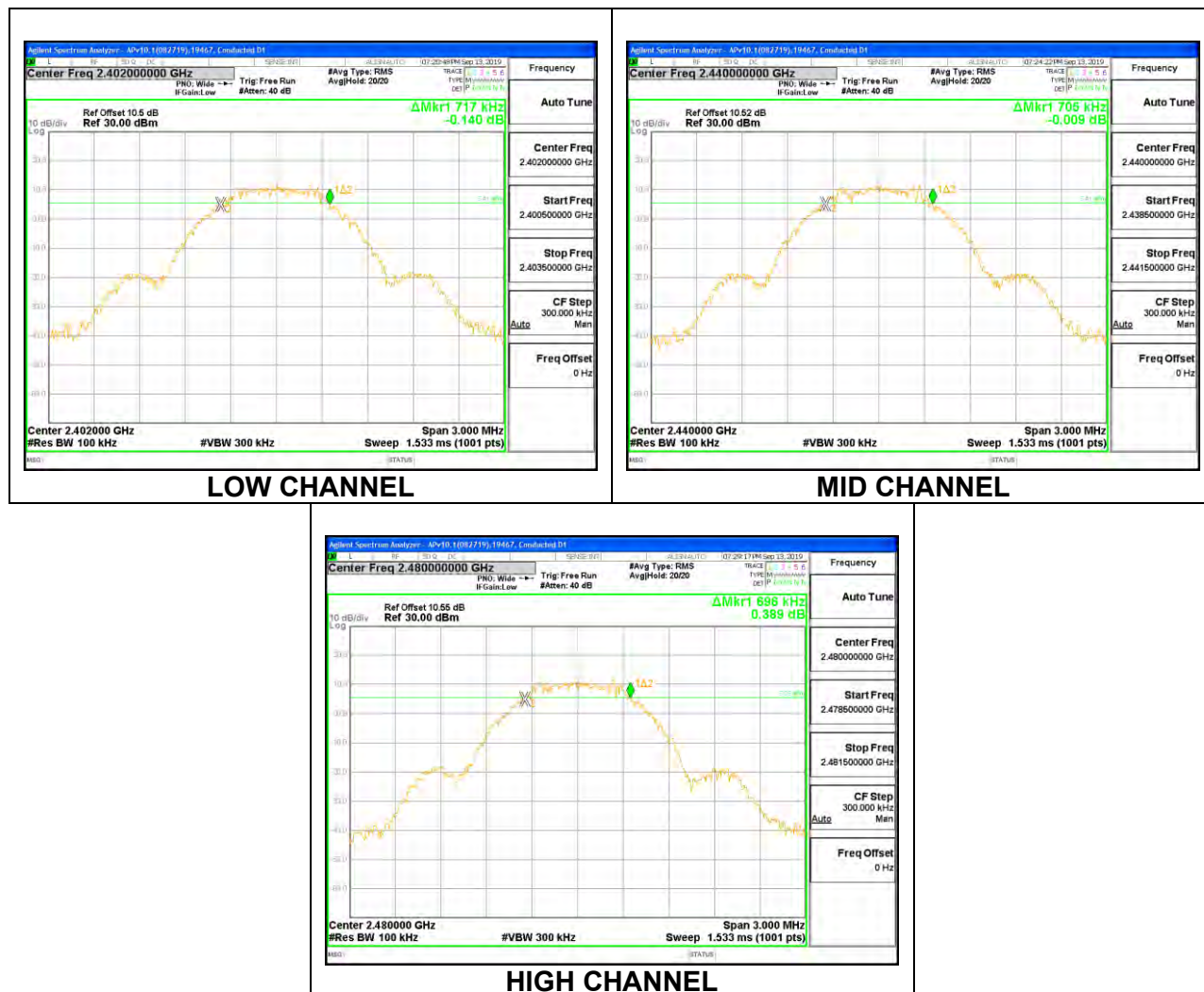
Channel	Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum Limit (MHz)
Low	2402	1.323	0.5
Middle	2440	1.323	0.5
High	2480	1.314	0.5



8.3.3. LOW POWER BLE (1Mbps)

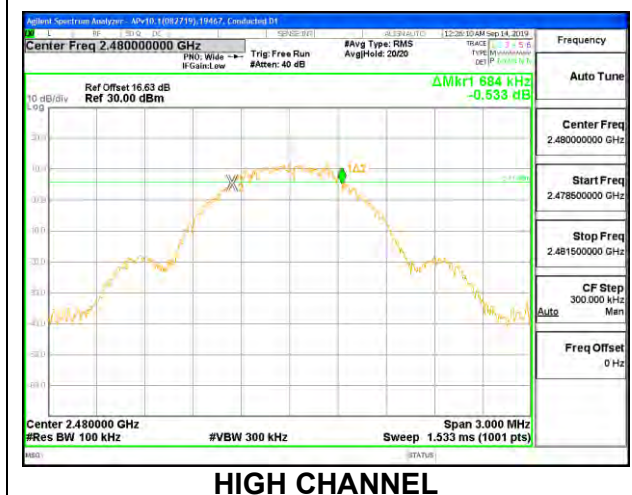
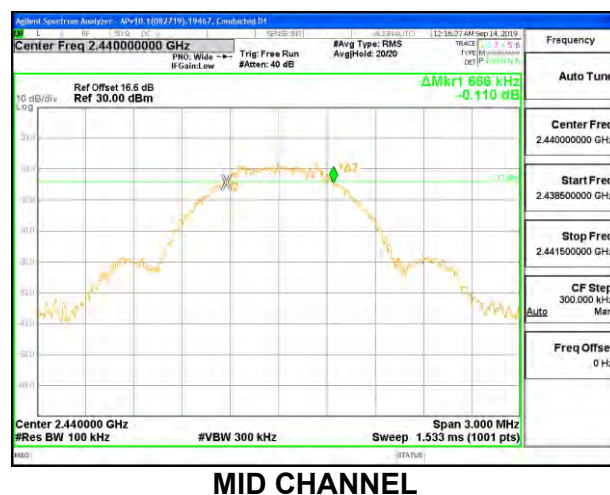
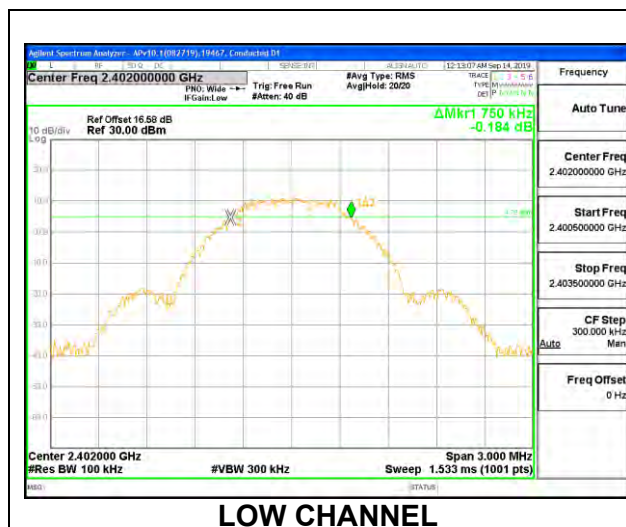
UAT 1

Channel	Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum Limit (MHz)
Low	2402	0.717	0.5
Middle	2440	0.705	0.5
High	2480	0.696	0.5



LAT 3

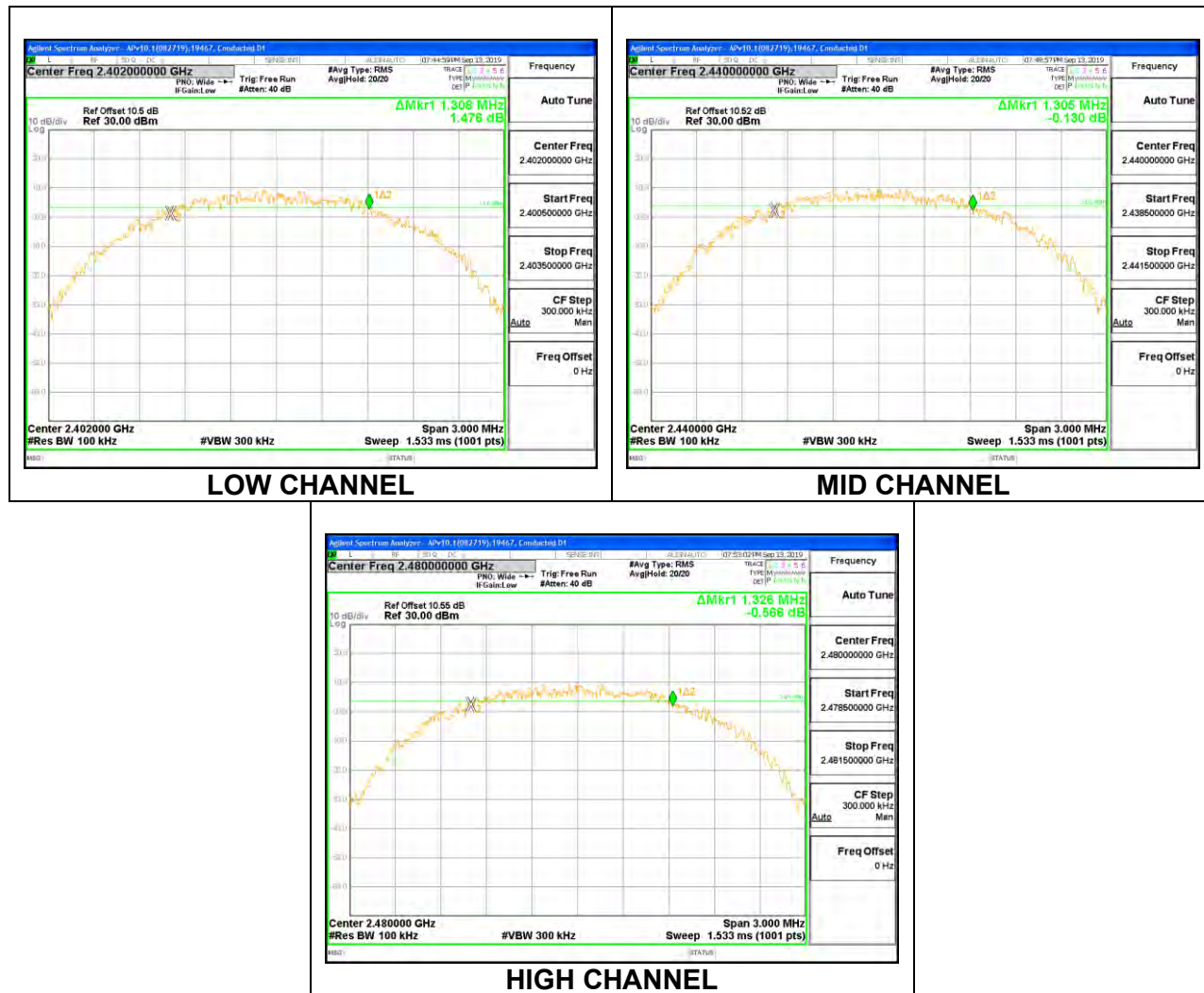
Channel	Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum Limit (MHz)
Low	2402	0.750	0.5
Middle	2440	0.666	0.5
High	2480	0.684	0.5



8.3.4. LOW POWER BLE (2Mbps)

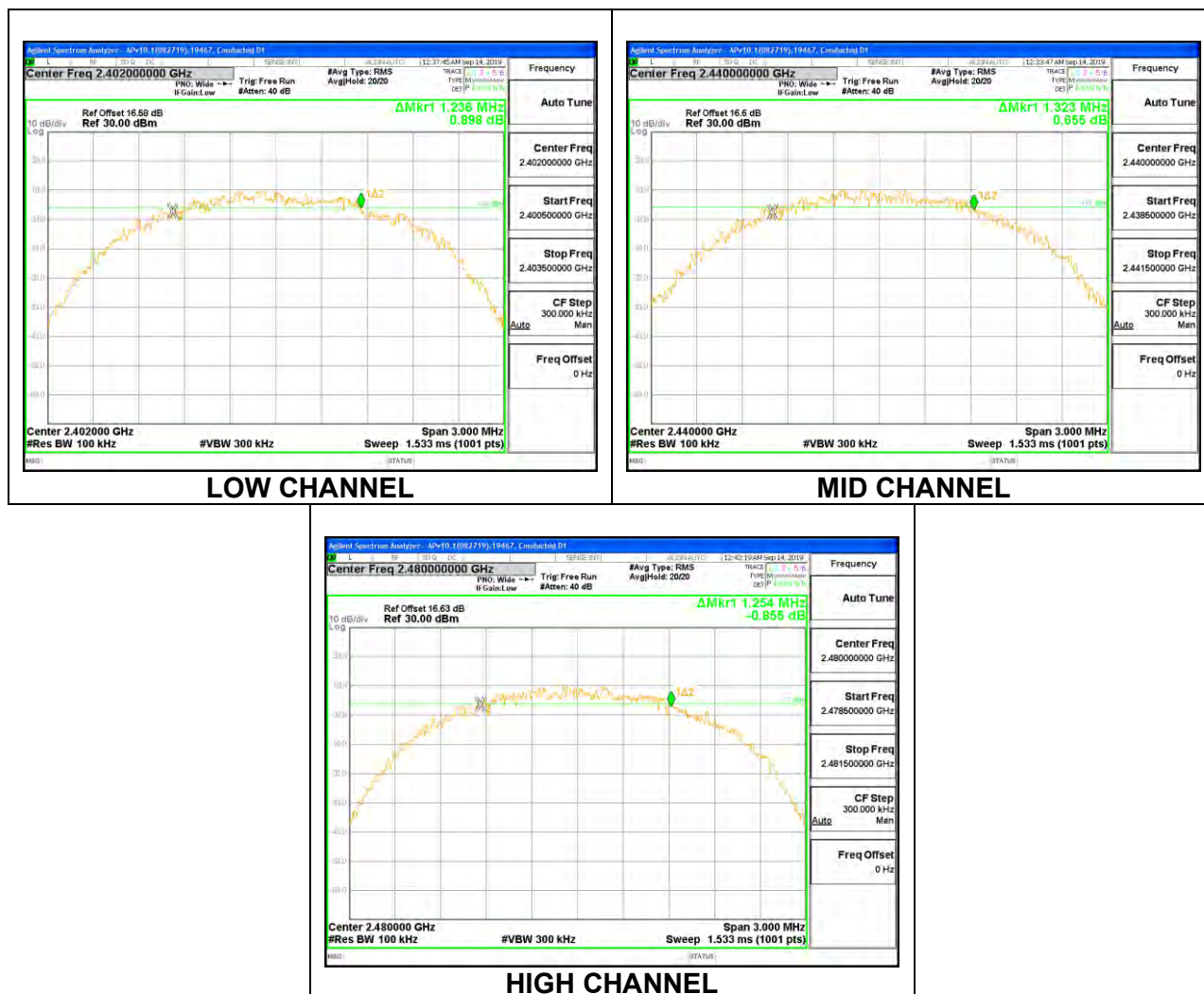
UAT 1

Channel	Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum Limit (MHz)
Low	2402	1.308	0.5
Middle	2440	1.305	0.5
High	2480	1.326	0.5



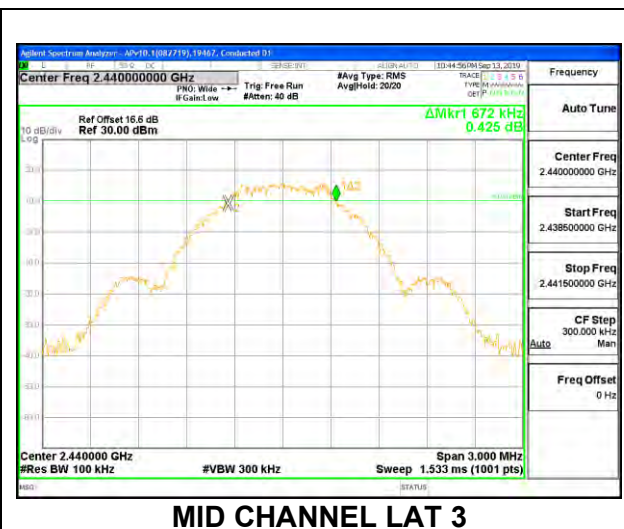
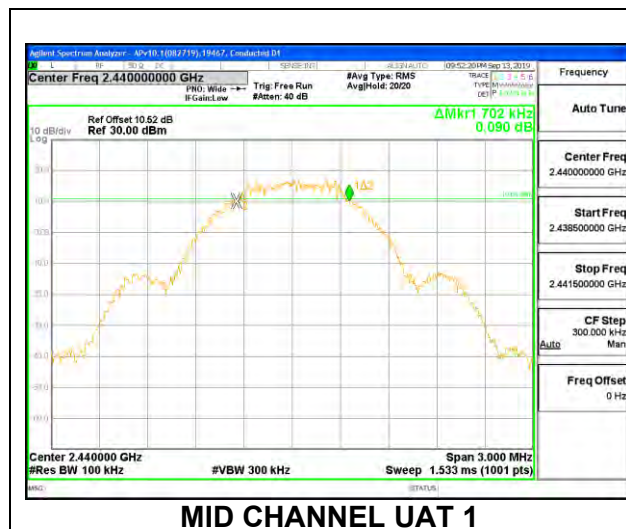
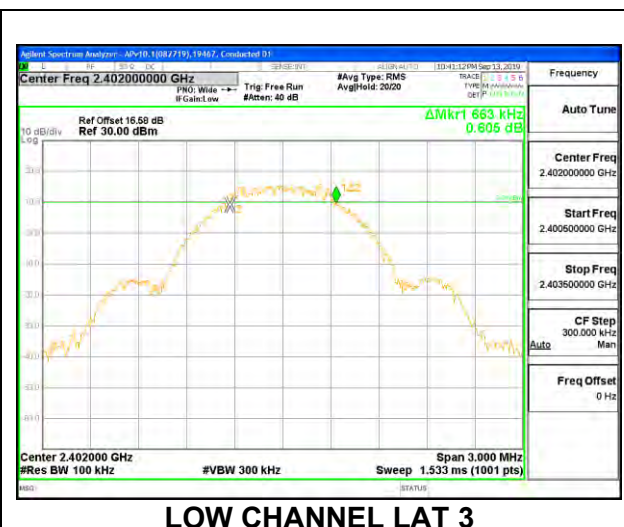
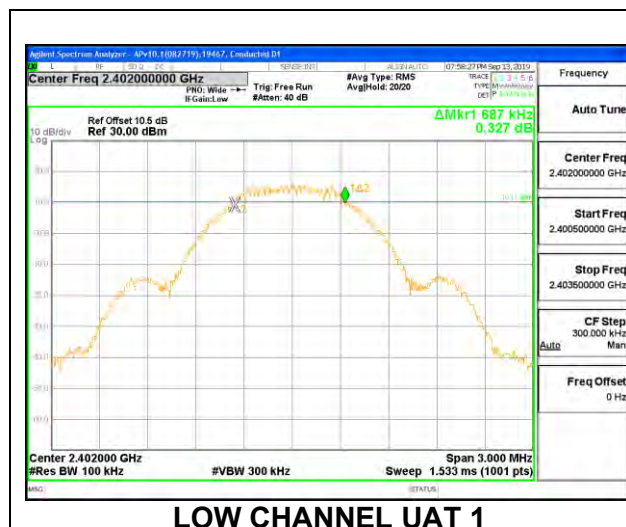
LAT 3

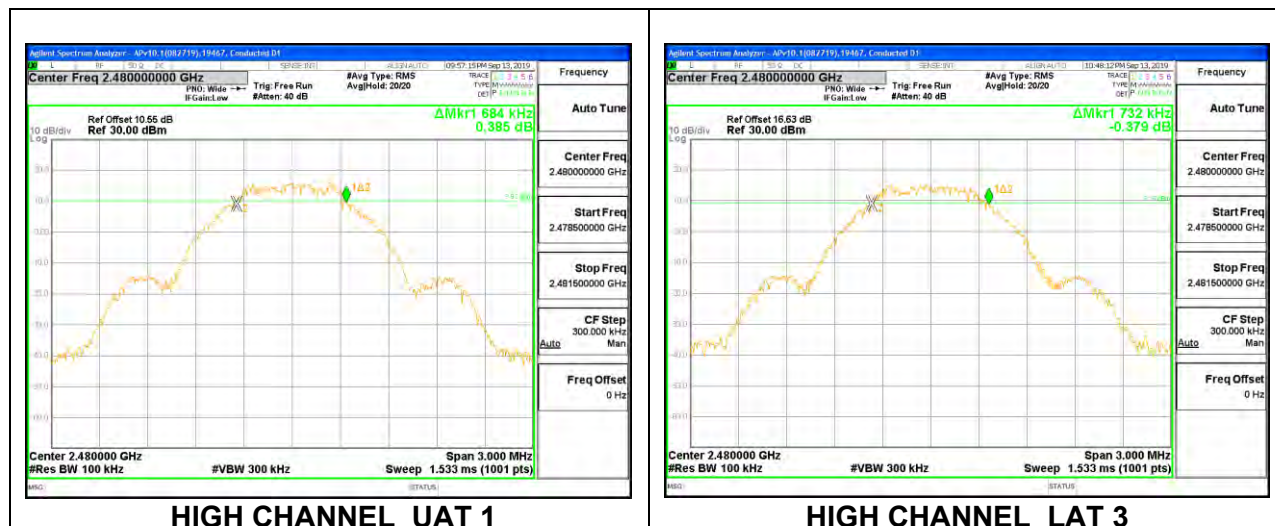
Channel	Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum Limit (MHz)
Low	2402	1.236	0.5
Middle	2440	1.323	0.5
High	2480	1.254	0.5



8.3.5. BEAMFORMING HIGH POWER BLE (1Mbps)

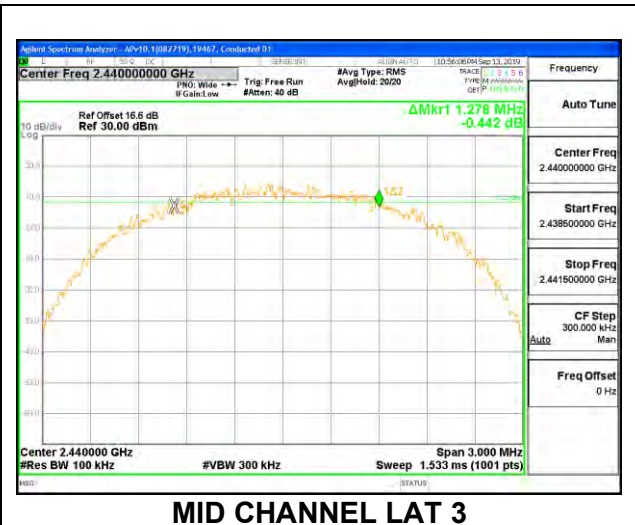
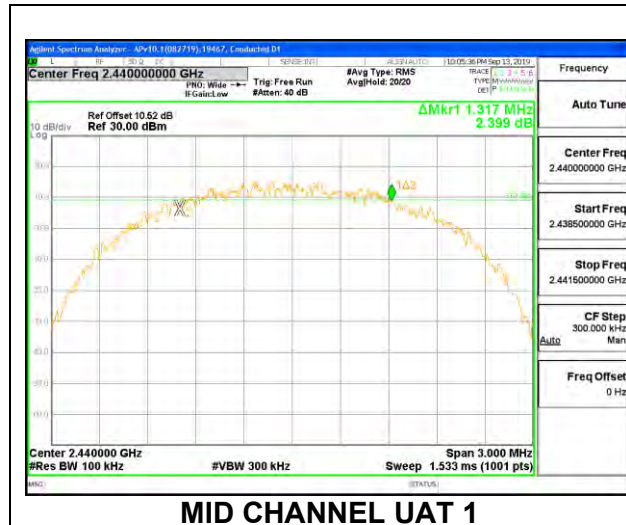
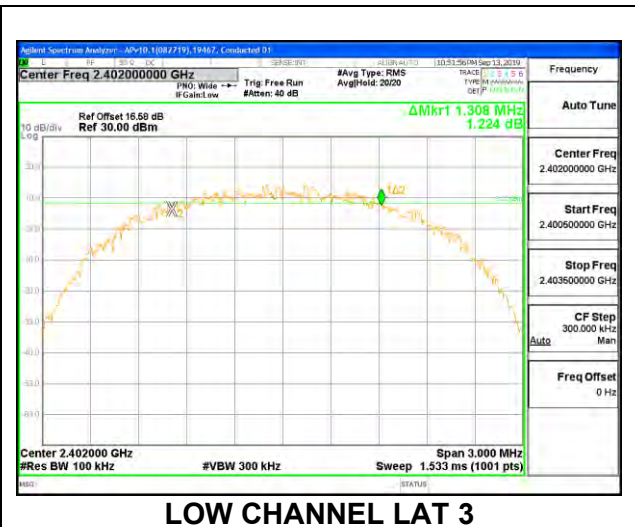
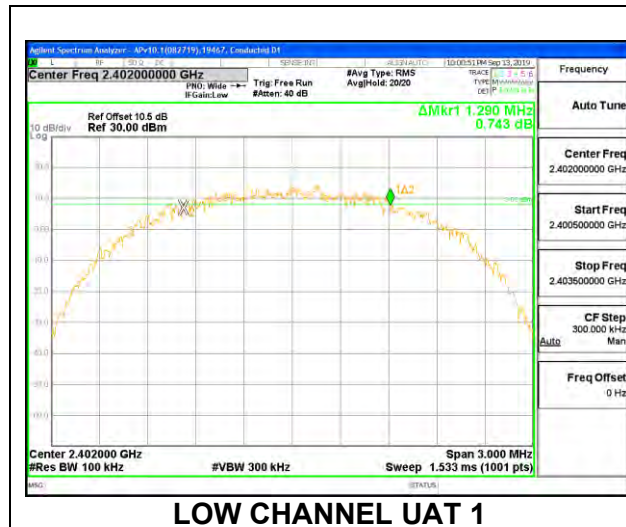
Channel	Frequency (MHz)	6dB Bandwidth UAT 1 (MHz)	6dB Bandwidth LAT 3 (MHz)
Low	2402	0.687	0.6630
Mid	2440	0.702	0.6720
High	2480	0.684	0.7320

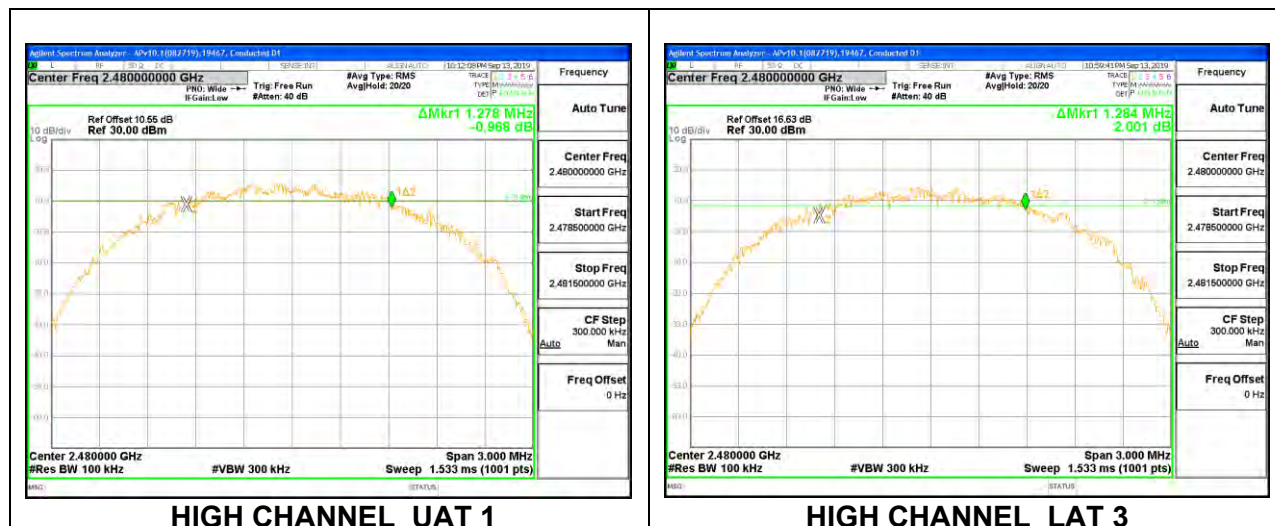




8.3.6. BEAMFORMING HIGH POWER BLE (2Mbps)

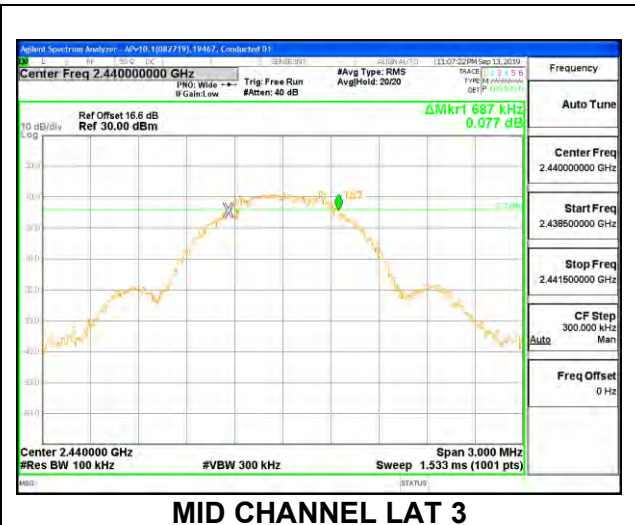
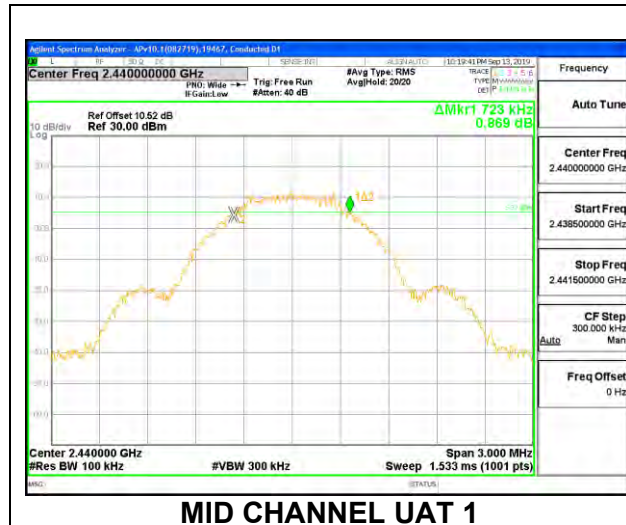
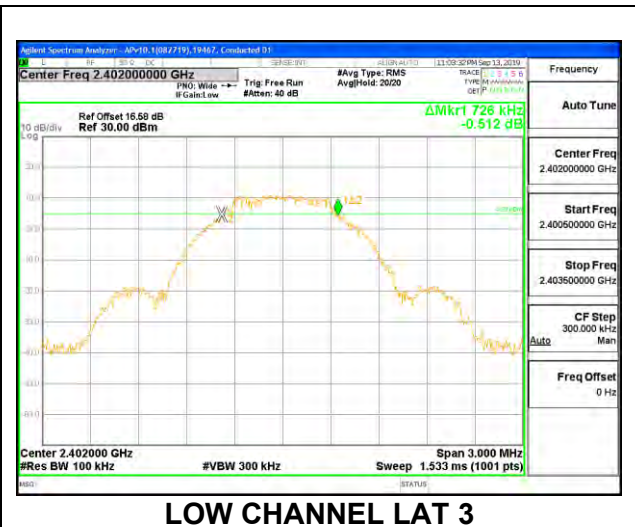
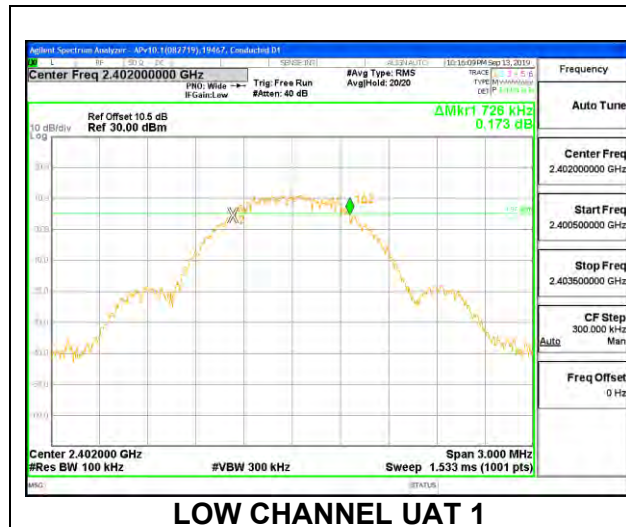
Channel	Frequency (MHz)	6dB Bandwidth UAT 1 (MHz)	6dB Bandwidth LAT 3 (MHz)
Low	2402	1.290	1.308
Mid	2440	1.317	1.278
High	2480	1.278	1.284

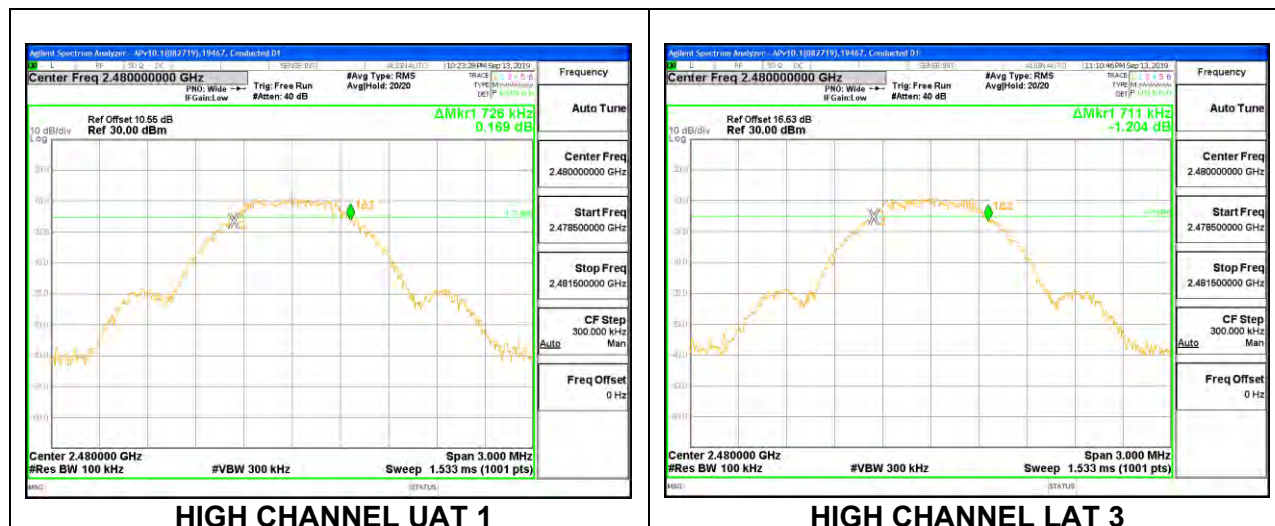




8.3.7. BEAMFORMING LOW POWER BLE (1Mbps)

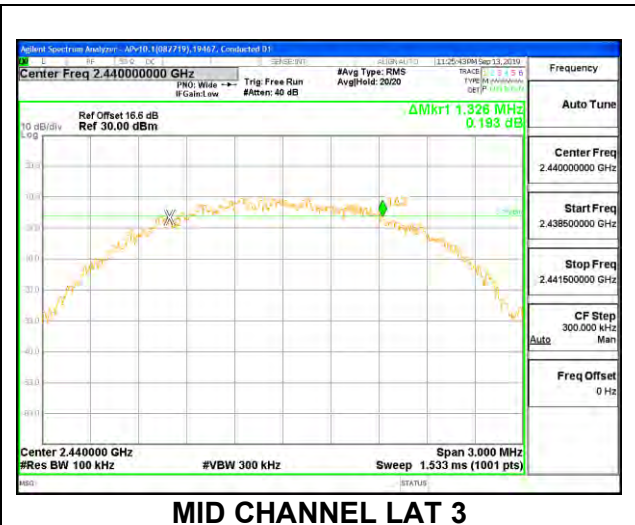
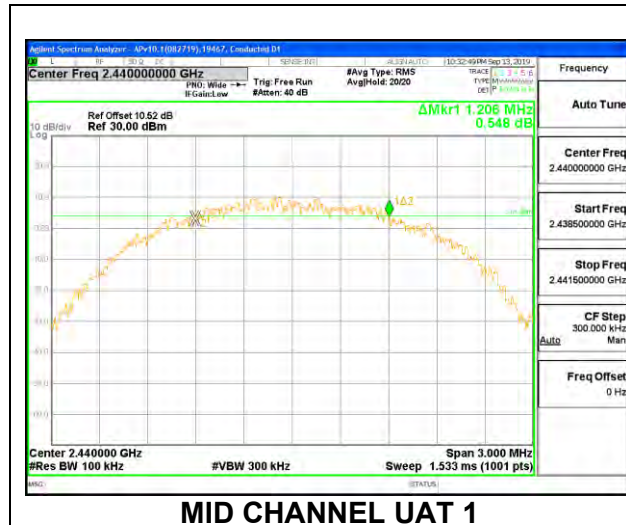
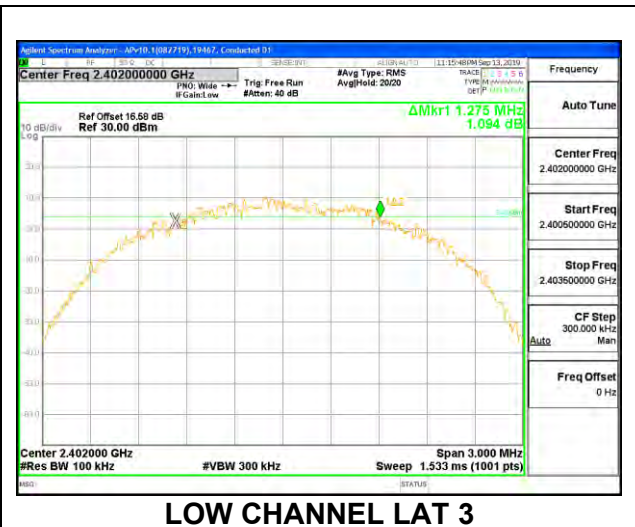
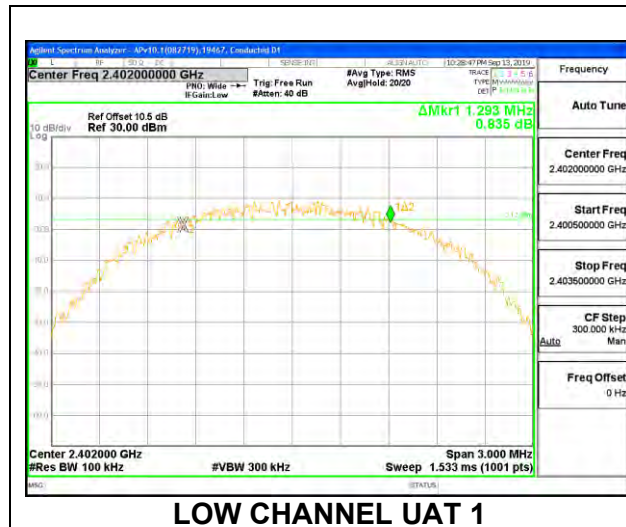
Channel	Frequency (MHz)	6dB Bandwidth UAT 1 (MHz)	6dB Bandwidth LAT 3 (MHz)
Low	2402	0.726	0.726
Mid	2440	0.723	0.687
High	2480	0.726	0.711

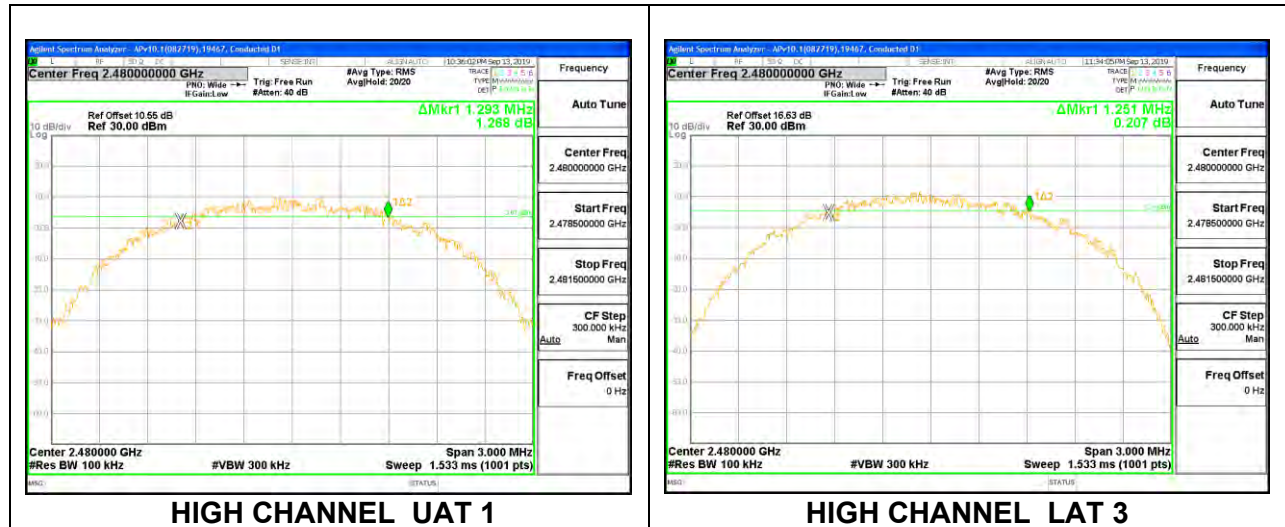




8.3.8. BEAMFORMING LOW POWER BLE (2Mbps)

Channel	Frequency (MHz)	6dB Bandwidth UAT 1 (MHz)	6dB Bandwidth LAT 3 (MHz)
Low	2402	1.293	1.275
Mid	2440	1.206	1.326
High	2480	1.293	1.251





8.4. 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 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 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 2 TX:

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

Band (GHz)	UAT 1 Antenna Gain (dBi)	LAT 3 Antenna Gain (dBi)	Uncorrelated Chains Directional Gain (dBi)	Correlated Chains Directional Gain (dBi)
2.4	-2.2	-0.4	-1.21	1.76

RESULTS

8.4.1. HIGH POWER BLE (1Mbps)

UAT 1

Tested By:	20773
Date:	12/12/2019

Channel	Frequency (MHz)	Peak Power Reading (dBm)	Limit (dBm)	Margin (dB)
Low	2402	18.98	30	-11.02
Middle	2440	19.03	30	-10.97
High	2480	19.01	30	-10.99

LAT 3

Tested By:	20773
Date:	12/12/2019

Channel	Frequency (MHz)	Peak Power Reading (dBm)	Limit (dBm)	Margin (dB)
Low	2402	19.98	30	-10.02
Middle	2440	20.01	30	-9.99
High	2480	20.03	30	-9.97

8.4.2. HIGH POWER BLE (2Mbps)

UAT 1

Tested By:	20773
Date:	12/12/2019

Channel	Frequency (MHz)	Peak Power Reading (dBm)	Limit (dBm)	Margin (dB)
Low	2402	19.06	30	-10.94
Middle	2440	19.12	30	-10.88
High	2480	19.09	30	-10.91

LAT 3

Tested By:	20773
Date:	12/12/2019

Channel	Frequency (MHz)	Peak Power Reading (dBm)	Limit (dBm)	Margin (dB)
Low	2402	20.06	30	-9.94
Middle	2440	20.10	30	-9.90
High	2480	20.03	30	-9.97

8.4.3. LOW POWER BLE (1Mbps)

UAT 1

Tested By:	20773
Date:	12/12/2019

Channel	Frequency (MHz)	Peak Power Reading (dBm)	Limit (dBm)	Margin (dB)
Low	2402	12.52	30	-17.48
Middle	2440	12.56	30	-17.44
High	2480	12.53	30	-17.47

LAT 3

Tested By:	20773
Date:	12/12/2019

Channel	Frequency (MHz)	Peak Power Reading (dBm)	Limit (dBm)	Margin (dB)
Low	2402	12.58	30	-17.42
Middle	2440	12.59	30	-17.41
High	2480	12.56	30	-17.44

8.4.4. LOW POWER BLE (2Mbps)

UAT 1

Tested By:	20773
Date:	12/12/2019

Channel	Frequency (MHz)	Peak Power Reading (dBm)	Limit (dBm)	Margin (dB)
Low	2402	12.61	30	-17.39
Middle	2440	12.70	30	-17.30
High	2480	12.66	30	-17.34

LAT 3

Tested By:	20773
Date:	12/12/2019

Channel	Frequency (MHz)	Peak Power Reading (dBm)	Limit (dBm)	Margin (dB)
Low	2402	12.68	30	-17.32
Middle	2440	12.68	30	-17.32
High	2480	12.64	30	-17.36

8.4.5. BEAMFORMING HIGH POWER BLE (1Mbps)

UAT 1 + LAT 3

Tested By:	20773
Date:	12/12/2019

Channel	Frequency (MHz)	Output Power UAT 1 (dBm)	Output Power LAT 3 (dBm)	Total Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	17.03	17.12	20.09	30	-9.91
Middle	2440	17.01	17.16	20.10	30	-9.90
High	2480	17.01	17.11	20.07	30	-9.93

8.4.6. BEAMFORMING HIGH POWER BLE (2Mbps)

UAT 1 + LAT 3

Tested By:	20773
Date:	12/12/2019

Channel	Frequency (MHz)	Output Power UAT 1 (dBm)	Output Power LAT 3 (dBm)	Total Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	17.07	17.14	20.12	30	-9.88
Middle	2440	17.06	17.11	20.10	30	-9.90
High	2480	17.13	17.05	20.10	30	-9.90

8.4.7. BEAMFORMING LOW POWER BLE (1Mbps)

UAT 1 + LAT 3

Tested By:	20773
Date:	12/12/2019

Channel	Frequency (MHz)	Output Power UAT 1 (dBm)	Output Power LAT 3 (dBm)	Total Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	12.58	12.62	15.61	30	-14.39
Middle	2440	12.63	12.64	15.65	30	-14.35
High	2480	12.58	12.6	15.60	30	-14.40

8.4.8. BEAMFORMING LOW POWER BLE (2Mbps)

UAT 1 + LAT 3

Tested By:	20773
Date:	12/12/2019

Channel	Frequency (MHz)	Output Power UAT 1 (dBm)	Output Power LAT 3 (dBm)	Total Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	12.6	12.59	15.61	30	-14.39
Middle	2440	12.57	12.61	15.60	30	-14.40
High	2480	12.59	12.59	15.60	30	-14.40

8.5. 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

8.5.1. HIGH POWER BLE (1Mbps)

UAT 1

Tested By:	20773
Date:	12/12/2019

Channel	Frequency (MHz)	AV power (dBm)
Low	2402	18.67
Middle	2440	18.71
High	2480	18.72

LAT 3

Tested By:	20773
Date:	12/12/2019

Channel	Frequency (MHz)	AV power (dBm)
Low	2402	19.65
Middle	2440	19.71
High	2480	19.74

8.5.2. HIGH POWER BLE (2Mbps)

UAT 1

Tested By:	20773
Date:	12/12/2019

Channel	Frequency (MHz)	AV power (dBm)
Low	2402	18.64
Middle	2440	18.74
High	2480	18.68

LAT 3

Tested By:	20773
Date:	12/12/2019

Channel	Frequency (MHz)	AV power (dBm)
Low	2402	19.67
Middle	2440	19.72
High	2480	19.61

8.5.3. LOW POWER BLE (1Mbps)

UAT 1

Tested By:	20773
Date:	12/12/2019

Channel	Frequency (MHz)	AV power (dBm)
Low	2402	12.17
Middle	2440	12.21
High	2480	12.15

LAT 3

Tested By:	20773
Date:	12/12/2019

Channel	Frequency (MHz)	AV power (dBm)
Low	2402	12.21
Middle	2440	12.23
High	2480	12.16

8.5.4. LOW POWER BLE (2Mbps)

UAT 1

Tested By:	20773
Date:	12/12/2019

Channel	Frequency (MHz)	AV power (dBm)
Low	2402	12.16
Middle	2440	12.25
High	2480	12.22

LAT 3

Tested By:	20773
Date:	12/12/2019

Channel	Frequency (MHz)	AV power (dBm)
Low	2402	12.23
Middle	2440	12.25
High	2480	12.18

8.5.5. BEAMFORMING HIGH POWER BLE (1Mbps)

UAT 1 + LAT 3

Tested By:	20773
Date:	12/12/2019

Channel	Frequency (MHz)	Average Power UAT 1 (dBm)	Average Power LAT 3 (dBm)	Total Power (dBm)
Low	2402	16.64	16.71	19.69
Middle	2440	16.61	16.74	19.69
High	2480	16.62	16.70	19.67

8.5.6. BEAMFORMING HIGH POWER BLE (2Mbps)

UAT 1 + LAT 3

Tested By:	20773
Date:	12/12/2019

Channel	Frequency (MHz)	Average Power UAT 1 (dBm)	Average Power LAT 3 (dBm)	Total Power (dBm)
Low	2402	16.68	16.73	19.72
Middle	2440	16.66	16.70	19.69
High	2480	16.74	16.61	19.69

8.5.7. BEAMFORMING LOW POWER BLE (1Mbps)

UAT 1 + LAT 3

Tested By:	20773
Date:	12/12/2019

Channel	Frequency (MHz)	Average Power UAT 1 (dBm)	Average Power LAT 3 (dBm)	Total Power (dBm)
Low	2402	12.21	12.23	15.23
Middle	2440	12.25	12.24	15.26
High	2480	12.19	12.22	15.22

8.5.8. BEAMFORMING LOW POWER BLE (2Mbps)

UAT 1 + LAT 3

Tested By:	20773
Date:	12/12/2019

Channel	Frequency (MHz)	Average Power UAT 1 (dBm)	Average Power LAT 3 (dBm)	Total Power (dBm)
Low	2402	12.24	12.21	15.24
Middle	2440	12.19	12.24	15.23
High	2480	12.20	12.22	15.22

8.6. POWER SPECTRAL DENSITY

LIMITS

FCC §15.247 (e)

RSS-247 (5.2) (b)

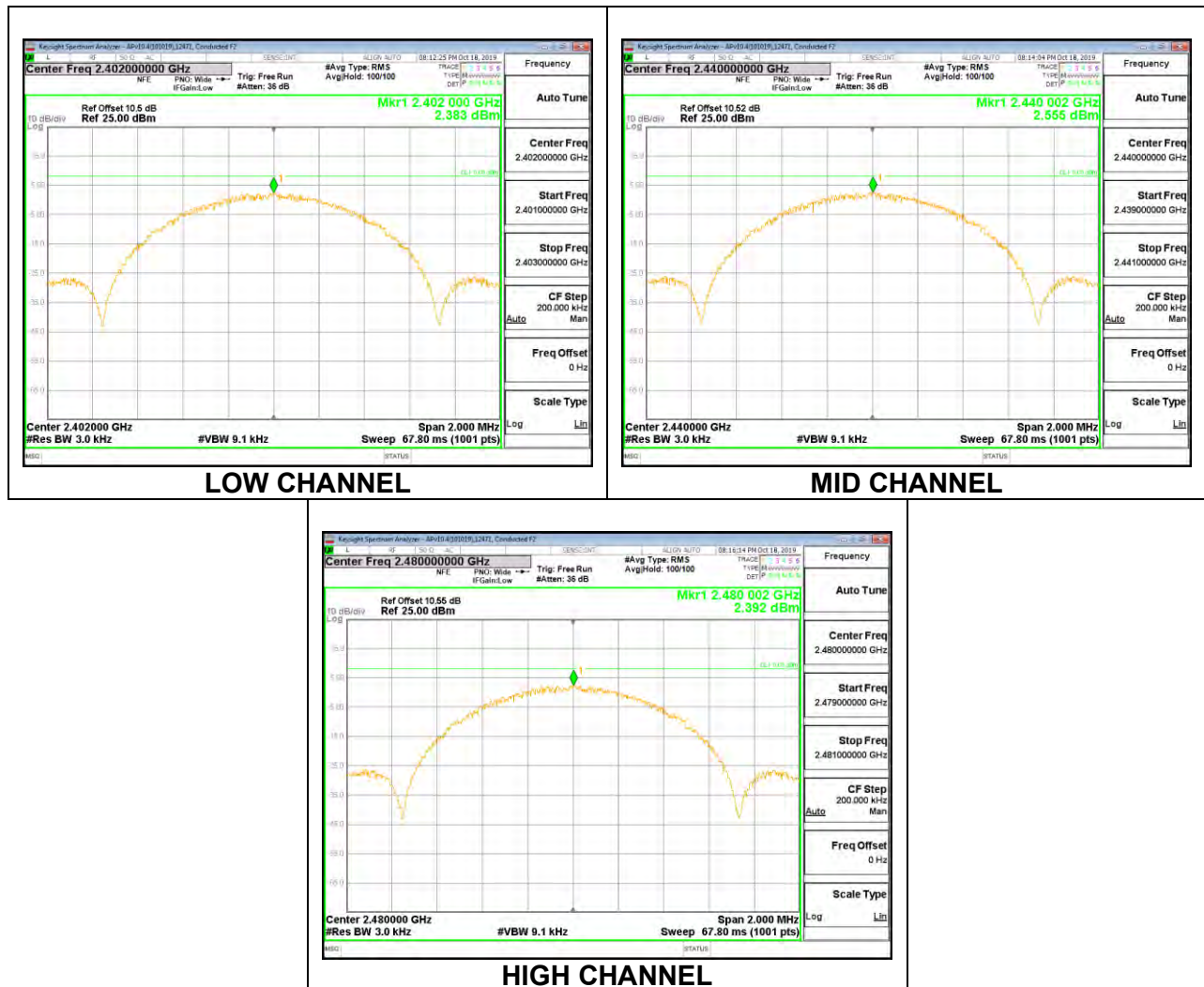
The power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

RESULTS

8.6.1. HIGH POWER BLE (1Mbps)

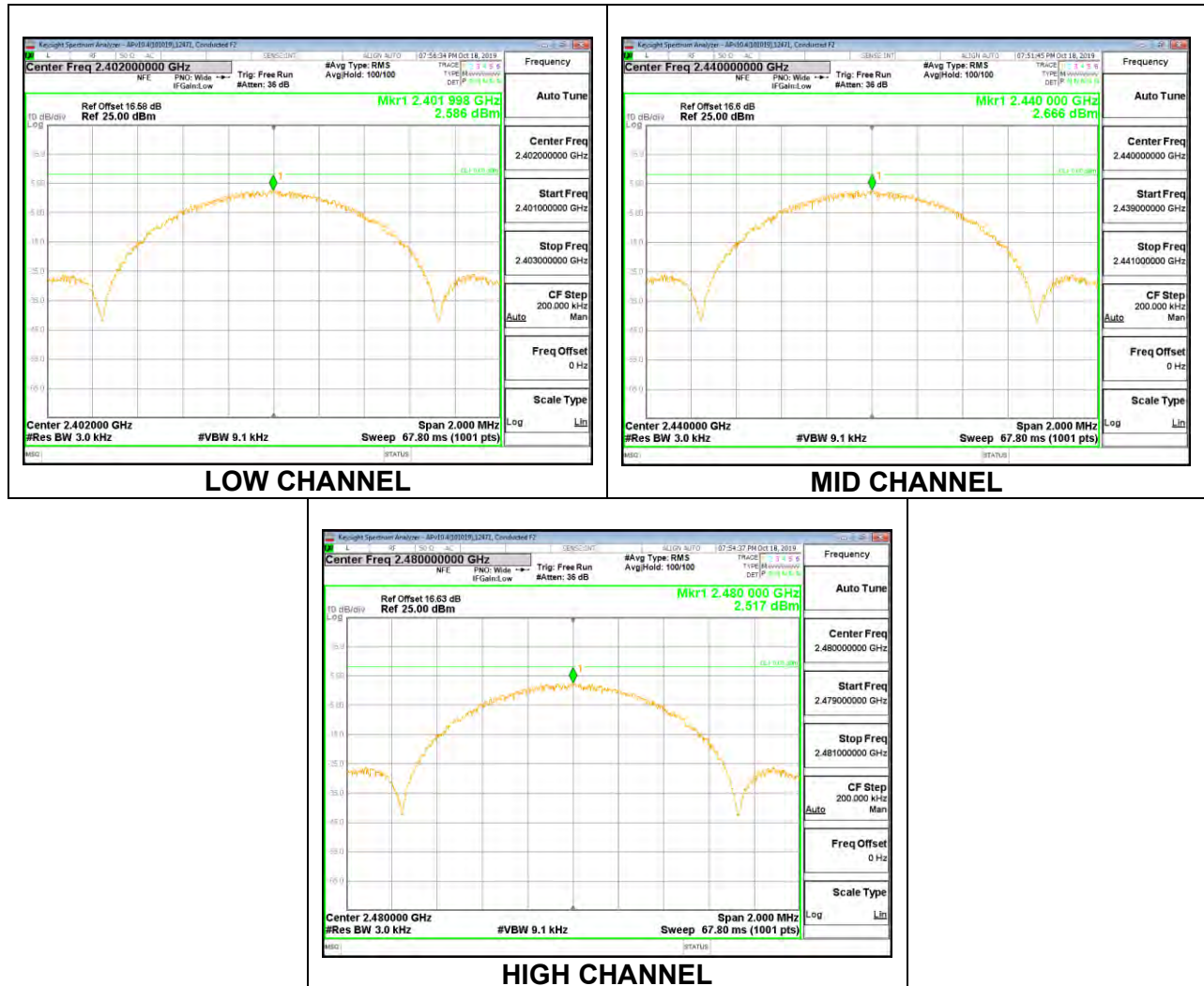
UAT 1

Channel	Frequency (MHz)	PSD (dBm/3kHz)	Limit (dBm/3kHz)	Margin (dB)
Low	2402	2.38	8	-5.62
Middle	2440	2.56	8	-5.45
High	2480	2.39	8	-5.61



LAT 3

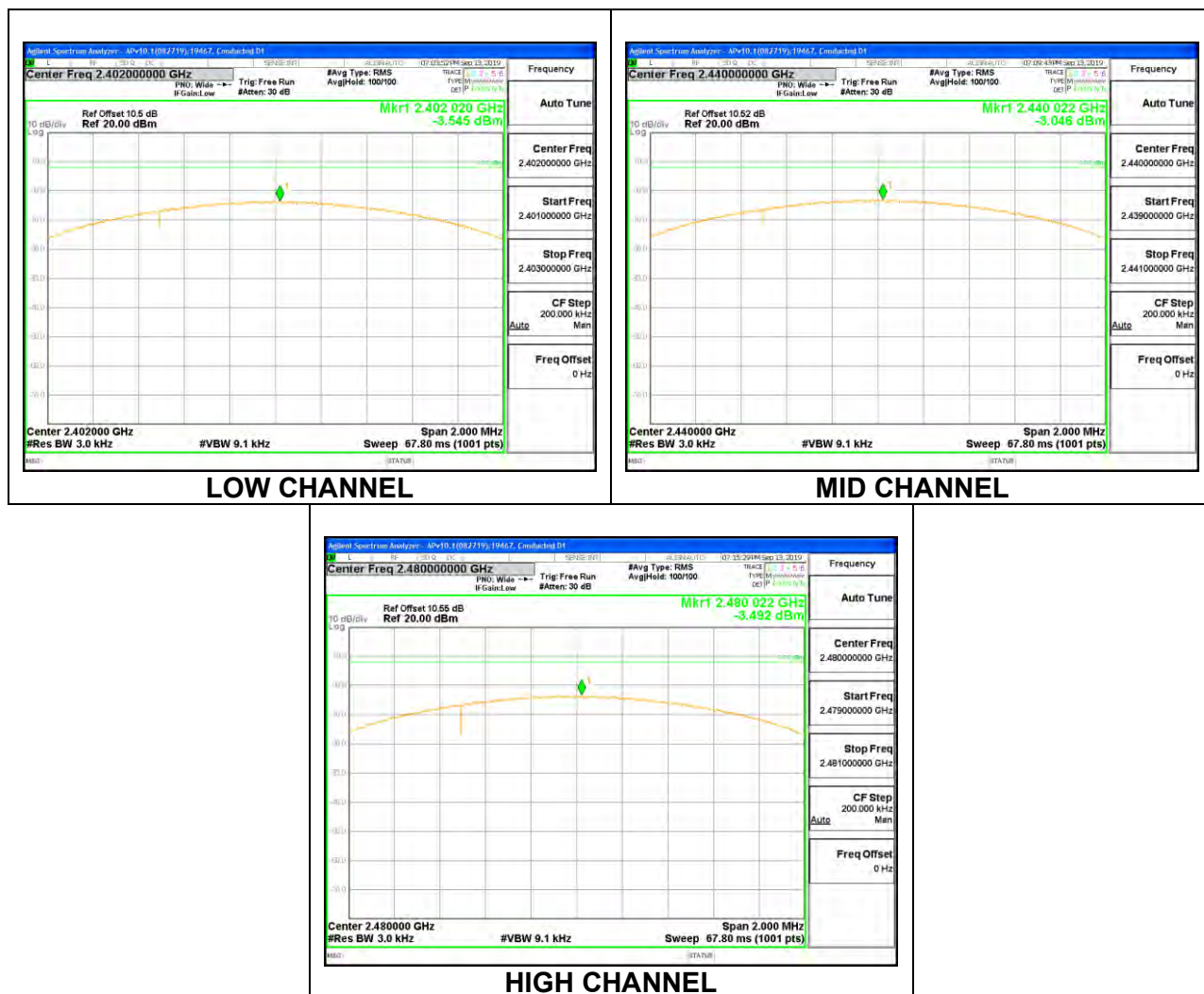
Channel	Frequency (MHz)	PSD (dBm/3kHz)	Limit (dBm/3kHz)	Margin (dB)
Low	2402	2.59	8	-5.41
Middle	2440	2.67	8	-5.33
High	2480	2.52	8	-5.48



8.6.2. HIGH POWER BLE (2Mbps)

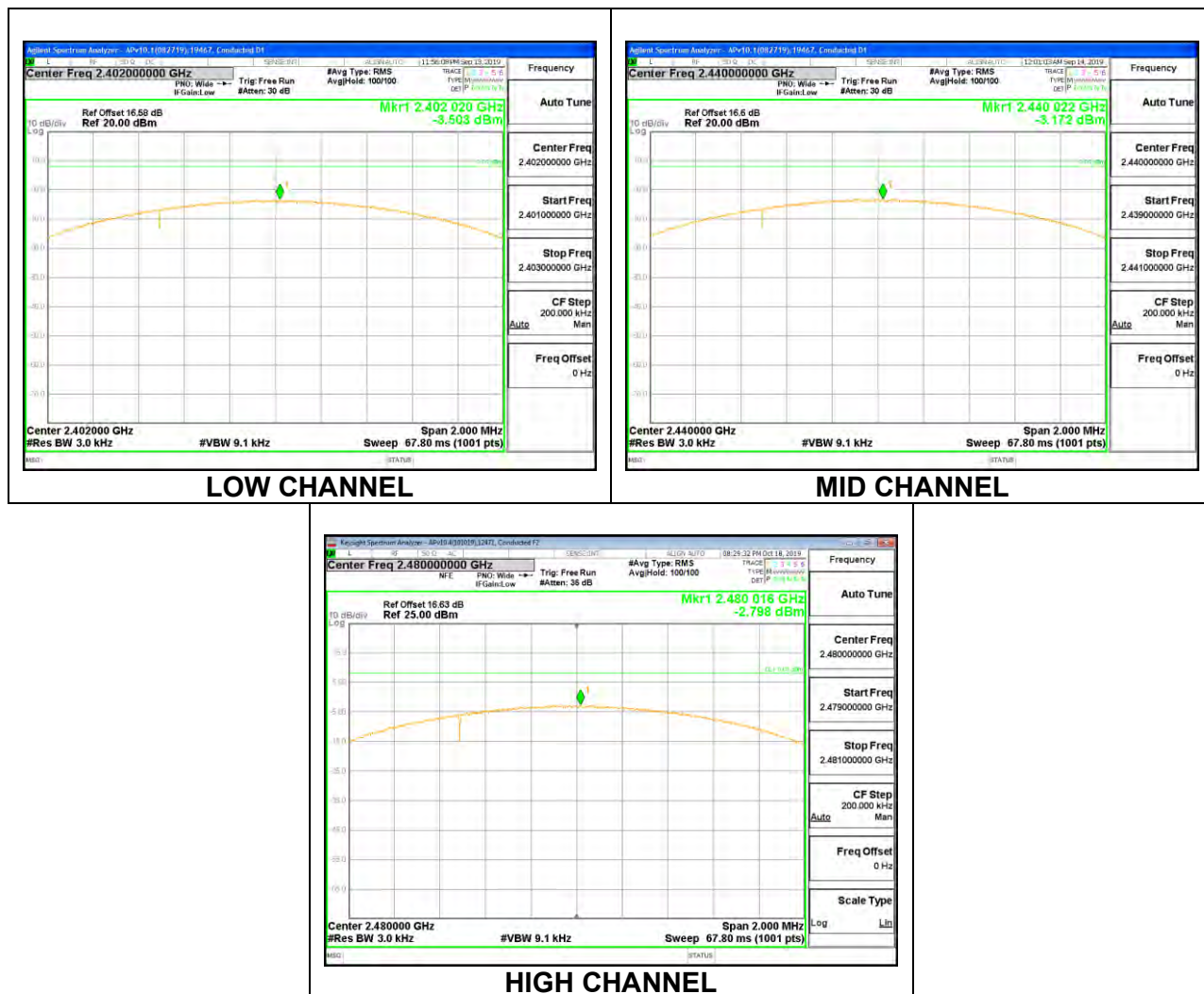
UAT 1

Channel	Frequency (MHz)	PSD (dBm/3kHz)	Limit (dBm/3kHz)	Margin (dB)
Low	2402	-3.54	8	-11.54
Middle	2440	-3.05	8	-11.05
High	2480	-3.49	8	-11.49



LAT 3

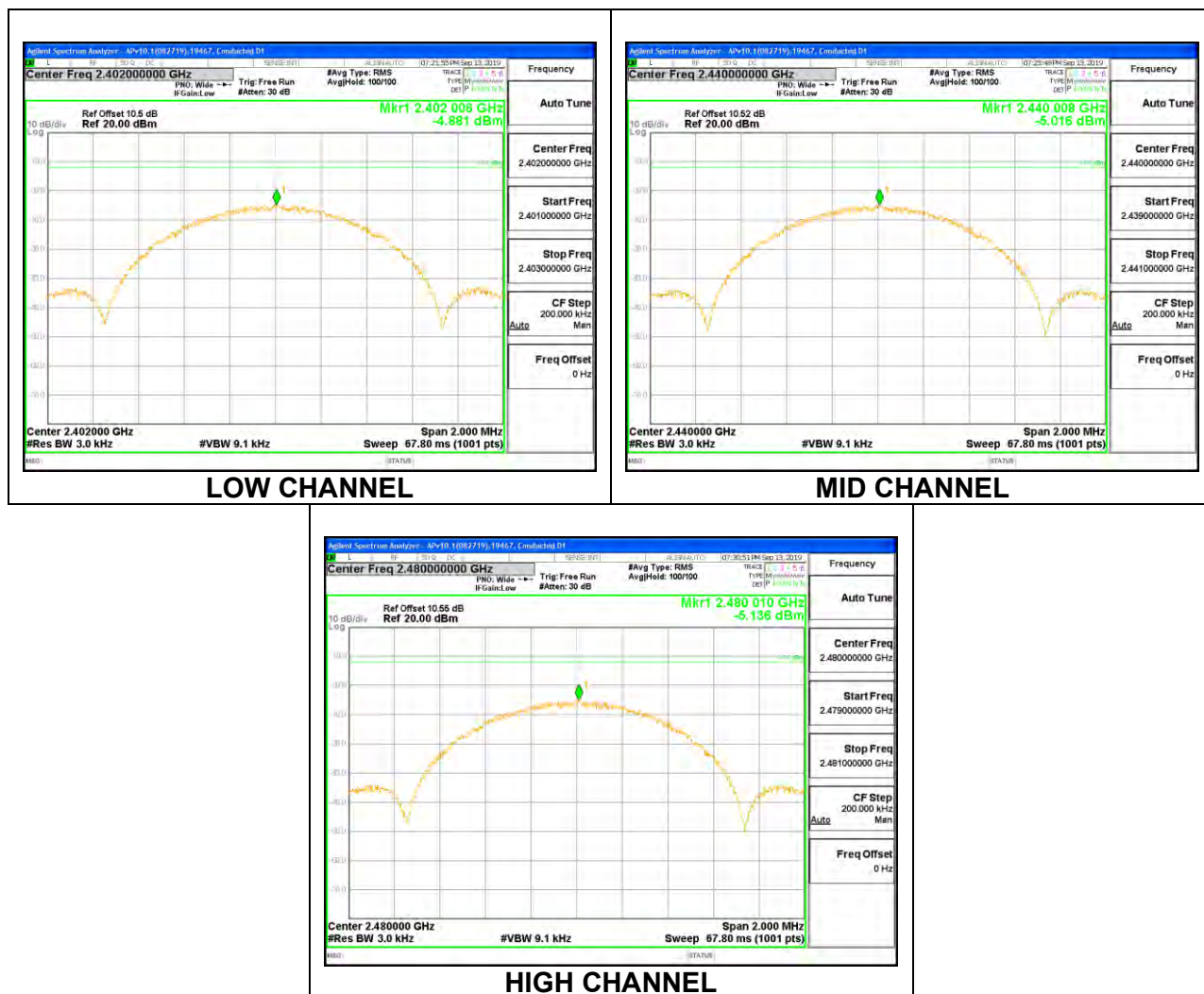
Channel	Frequency (MHz)	PSD (dBm/3kHz)	Limit (dBm/3kHz)	Margin (dB)
Low	2402	-3.50	8	-11.50
Middle	2440	-3.17	8	-11.17
High	2480	-2.80	8	-10.80



8.6.3. LOW POWER BLE (1Mbps)

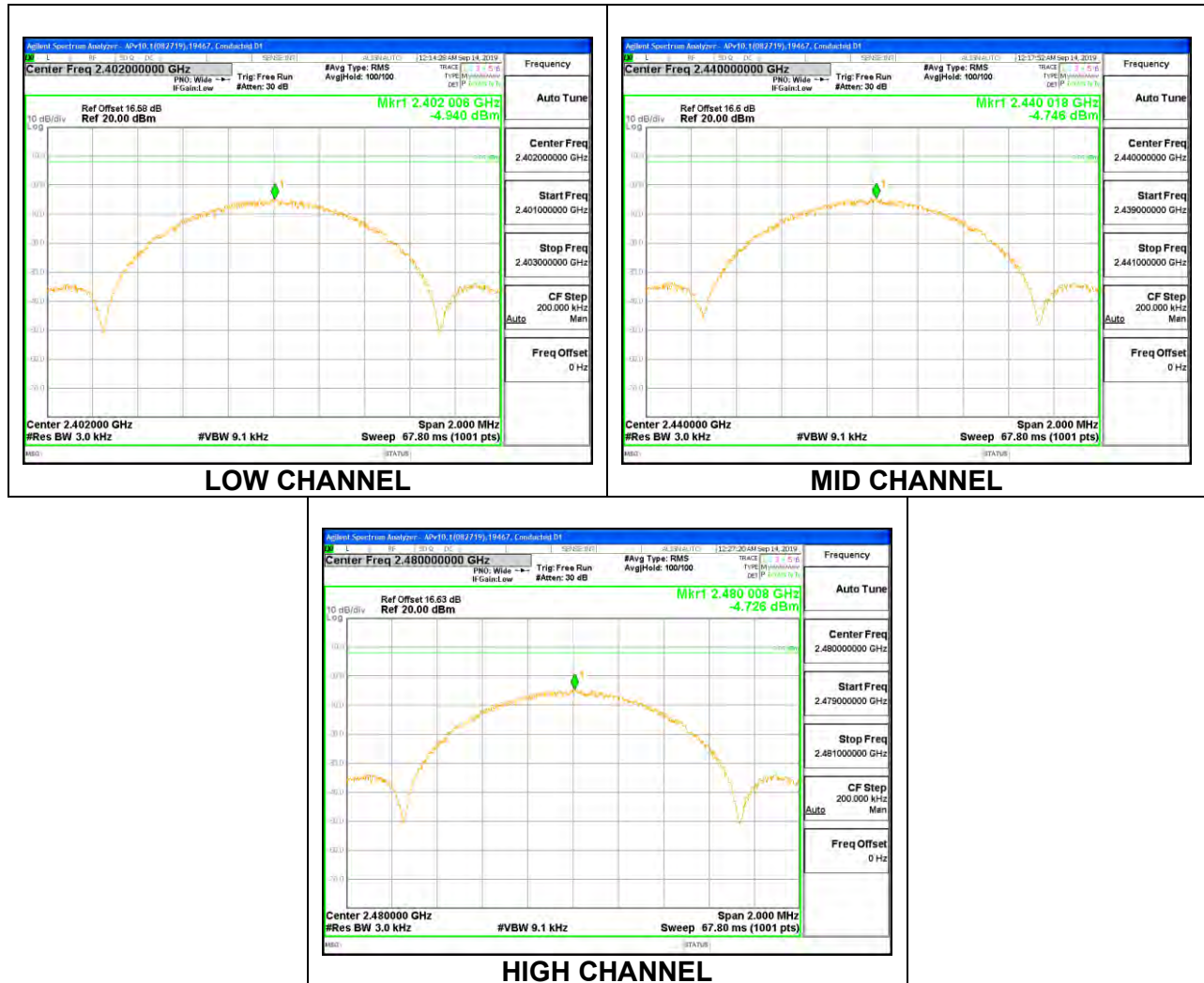
UAT 1

Channel	Frequency (MHz)	PSD (dBm/3kHz)	Limit (dBm/3kHz)	Margin (dB)
Low	2402	-4.88	8	-12.88
Middle	2440	-5.02	8	-13.02
High	2480	-5.14	8	-13.14



LAT 3

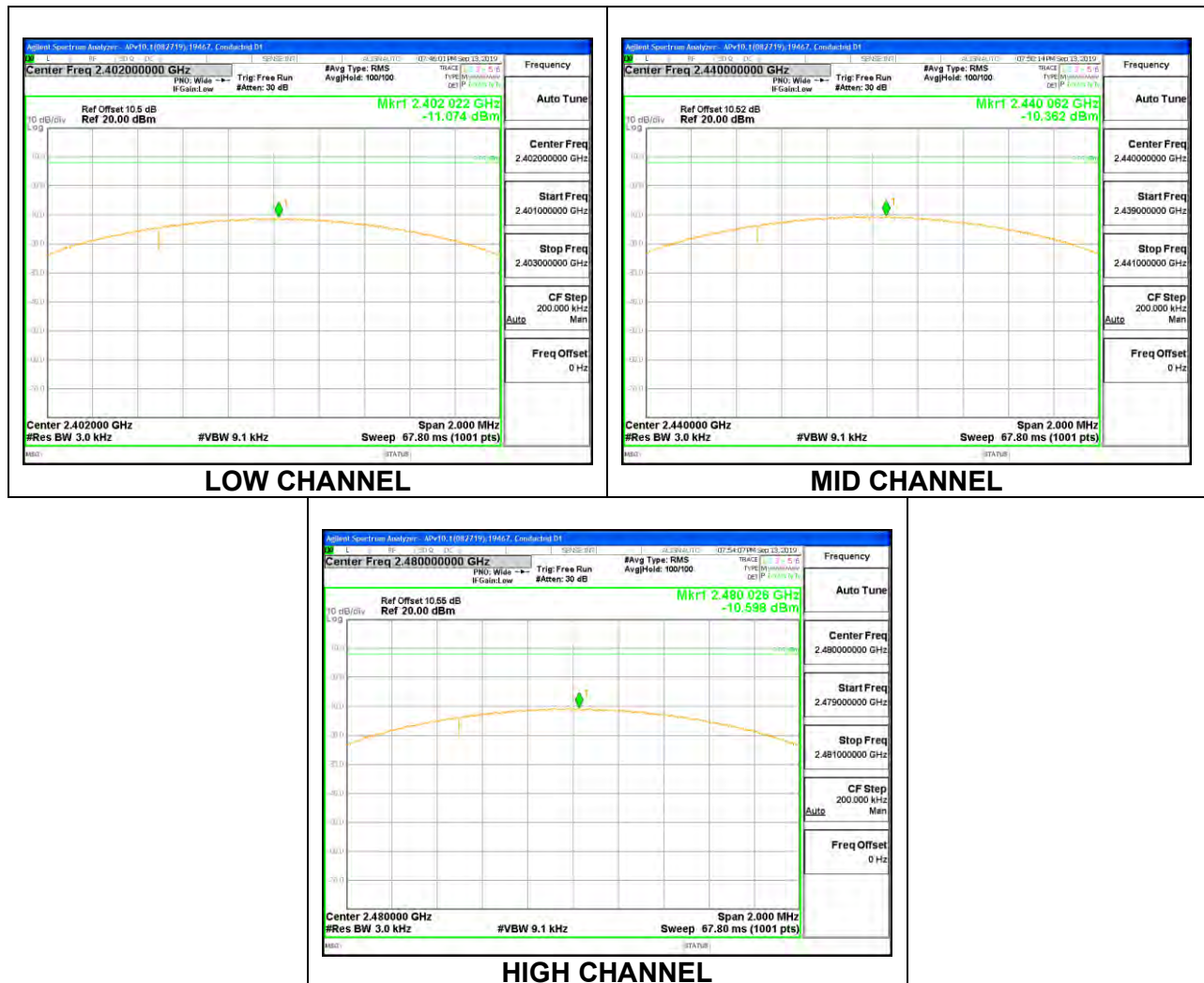
Channel	Frequency (MHz)	PSD (dBm/3kHz)	Limit (dBm/3kHz)	Margin (dB)
Low	2402	-4.94	8	-12.94
Middle	2440	-4.75	8	-12.75
High	2480	-4.73	8	-12.73



8.6.4. LOW POWER BLE (2Mbps)

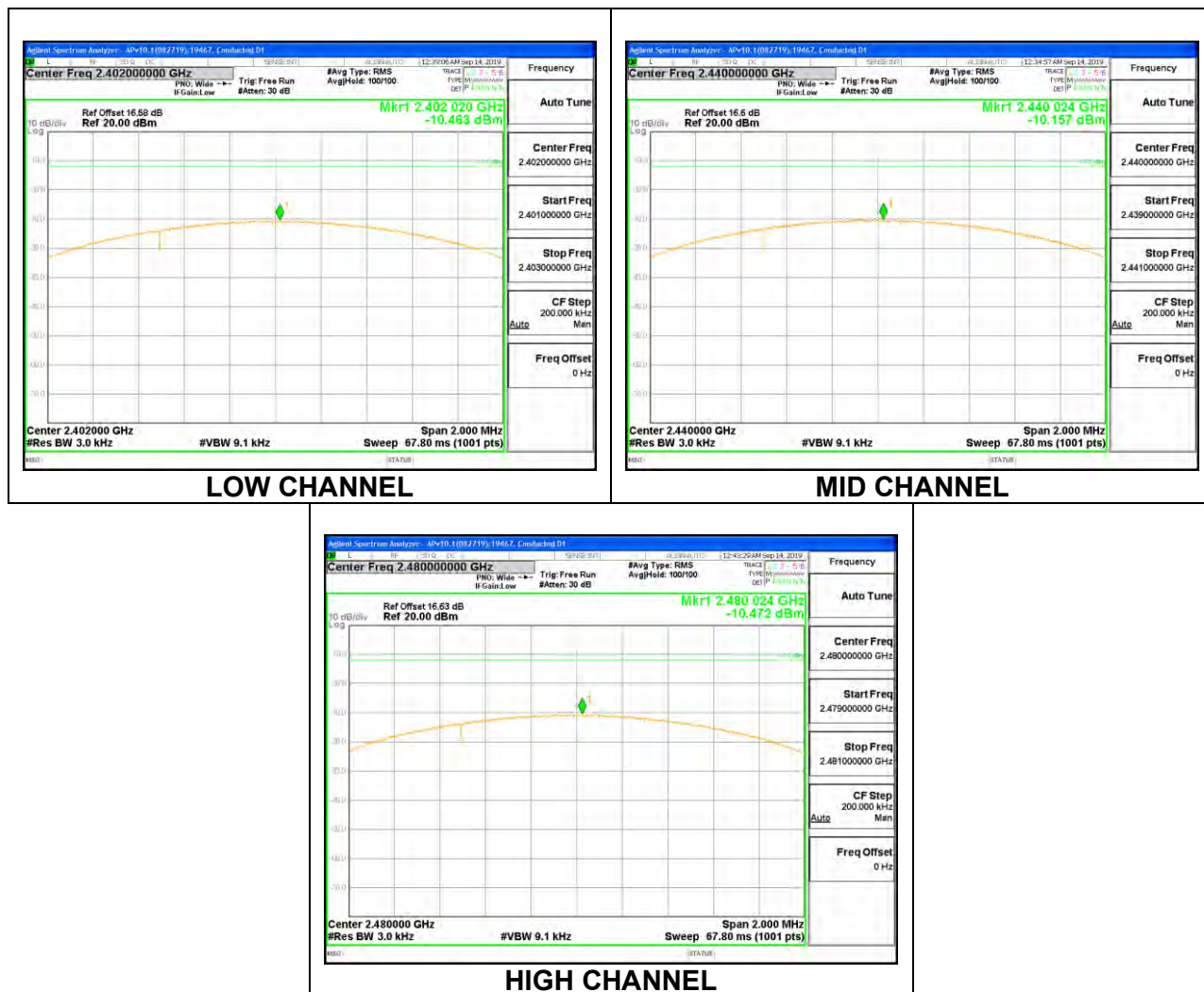
UAT 1

Channel	Frequency (MHz)	PSD (dBm/3kHz)	Limit (dBm/3kHz)	Margin (dB)
Low	2402	-11.07	8	-19.07
Middle	2440	-10.36	8	-18.36
High	2480	-10.60	8	-18.60



LAT 3

Channel	Frequency (MHz)	PSD (dBm/3kHz)	Limit (dBm/3kHz)	Margin (dB)
Low	2402	-10.46	8	-18.46
Middle	2440	-10.16	8	-18.16
High	2480	-10.47	8	-18.47

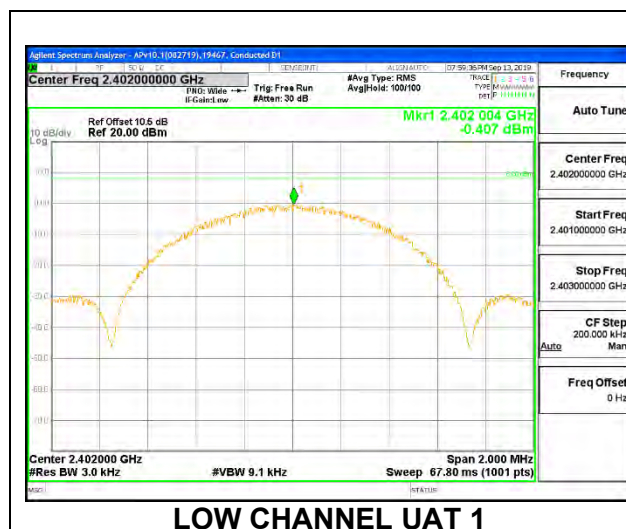


8.6.5. BEAMFORMING HIGH POWER BLE (1Mbps)

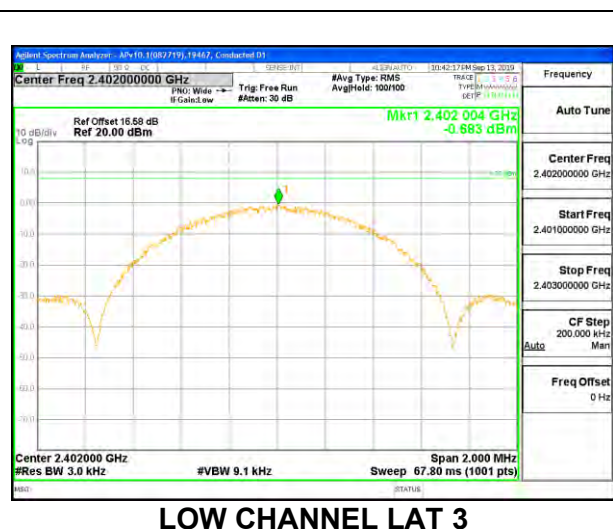
Duty Cycle CF (dB)	0.00	Included in Calculations of Corr'd PSD
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PSD Results

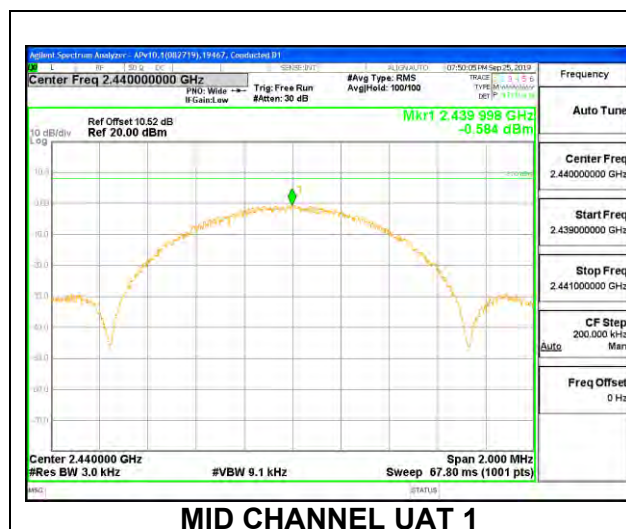
Channel	Frequency (MHz)	UAT 1 Meas (dBm/ 3kHz)	LAT 3 Meas (dBm/ 3kHz)	Total Corr'd PSD (dBm/ 3kHz)	Limit (dBm/ 3kHz)	Margin (dB)
Low	2402	-0.41	-0.68	2.47	8.0	-5.5
Mid	2440	-0.58	-0.57	2.43	8.0	-5.6
Hjigh	2480	-0.59	-0.68	2.38	8.0	-5.6



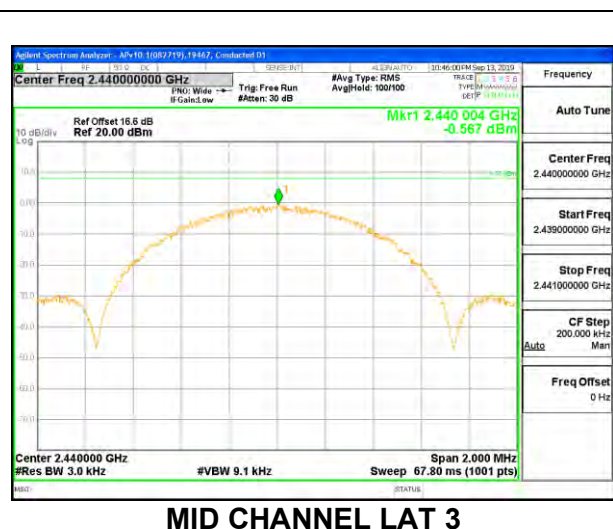
LOW CHANNEL UAT 1



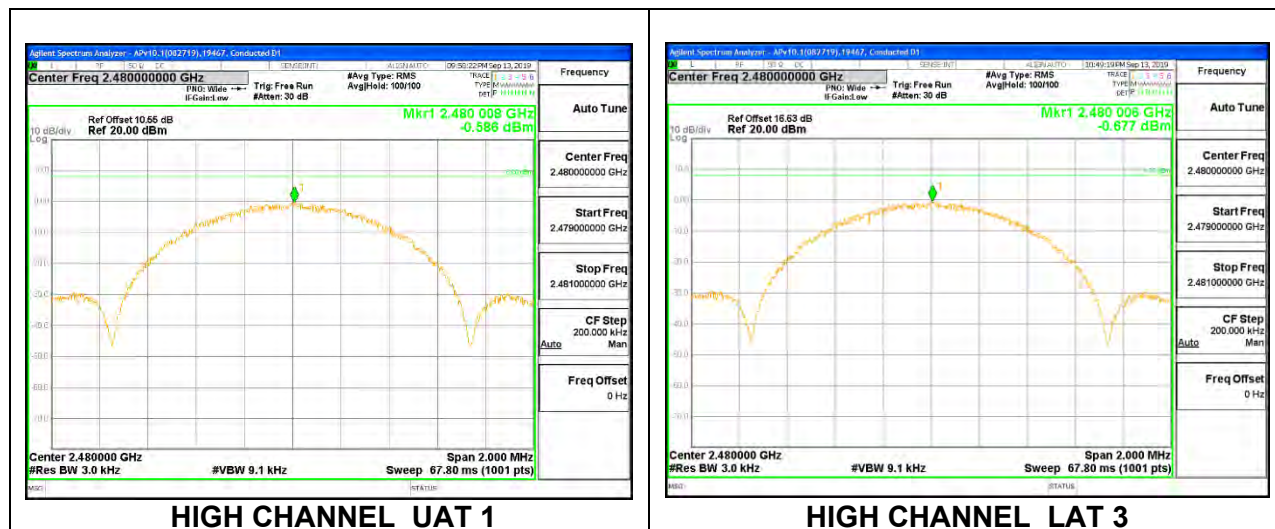
LOW CHANNEL LAT 3



MID CHANNEL UAT 1



MID CHANNEL LAT 3

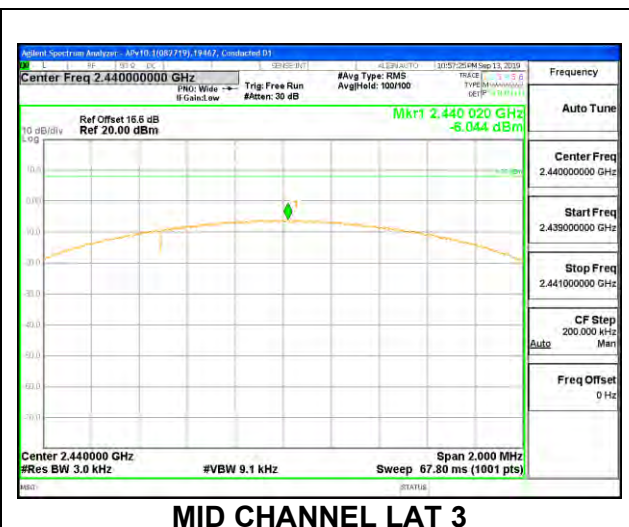
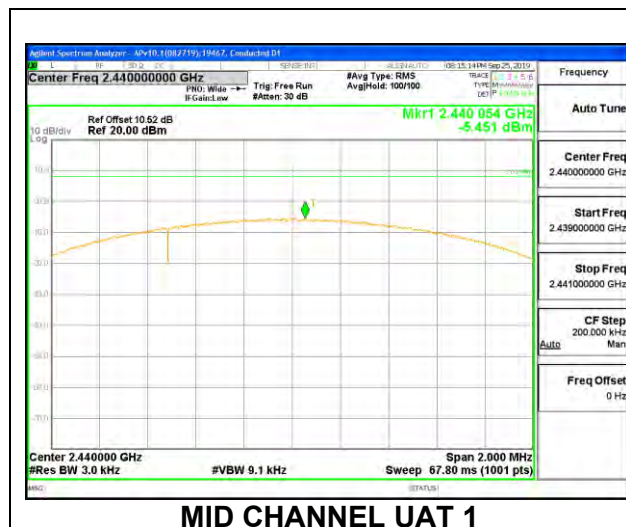
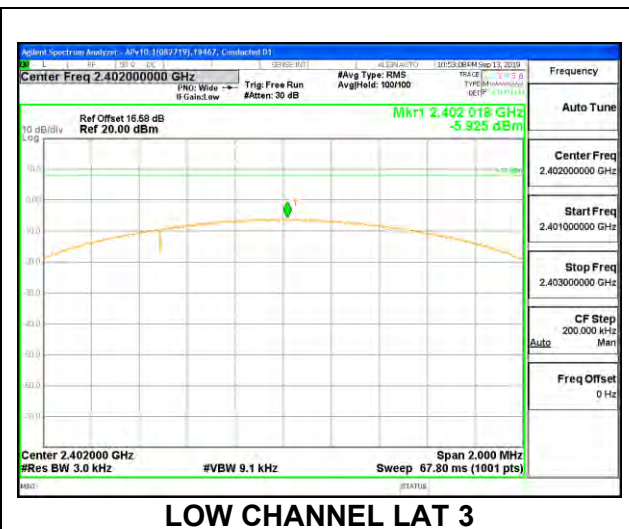
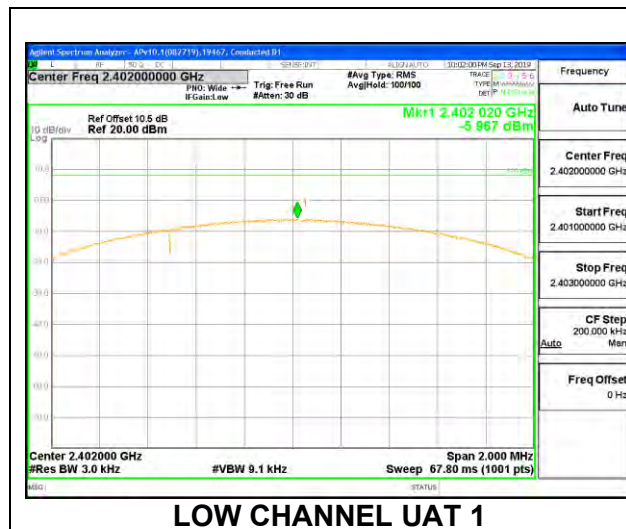


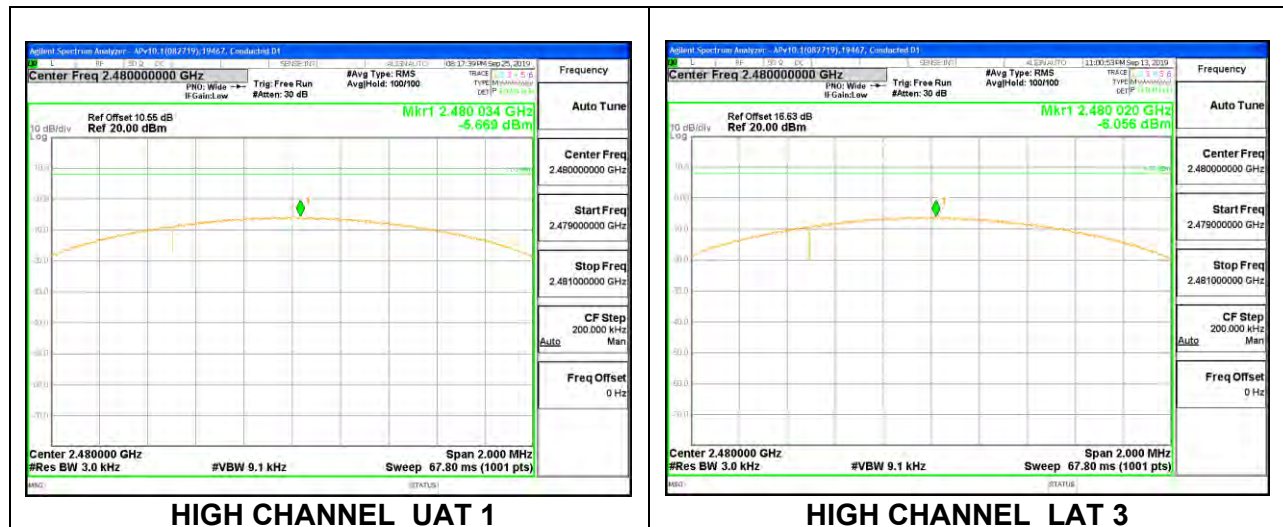
8.6.6. BEAMFORMING HIGH POWER BLE (2Mbps)

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

Channel	Frequency (MHz)	UAT 1 Meas (dBm/ 3kHz)	LAT 3 Meas (dBm/ 3kHz)	Total Corr'd PSD (dBm/ 3kHz)	Limit (dBm/ 3kHz)	Margin (dB)
Low	2402	-5.97	-5.93	-2.94	8.0	-10.9
Mid	2440	-5.45	-6.04	-2.73	8.0	-10.7
Hjigh	2480	-5.67	-6.06	-2.85	8.0	-10.8



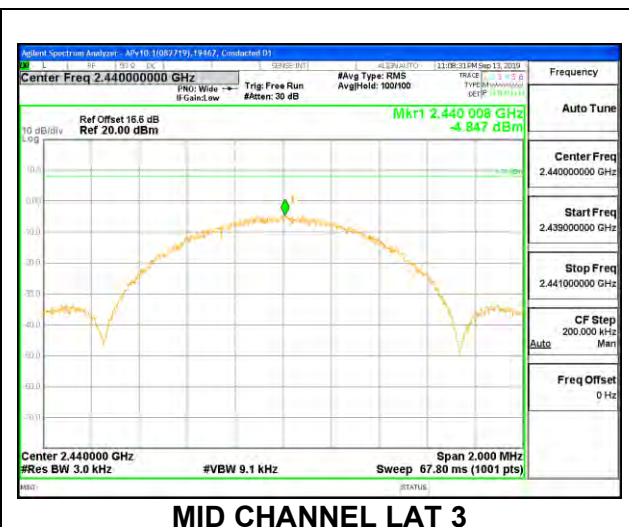
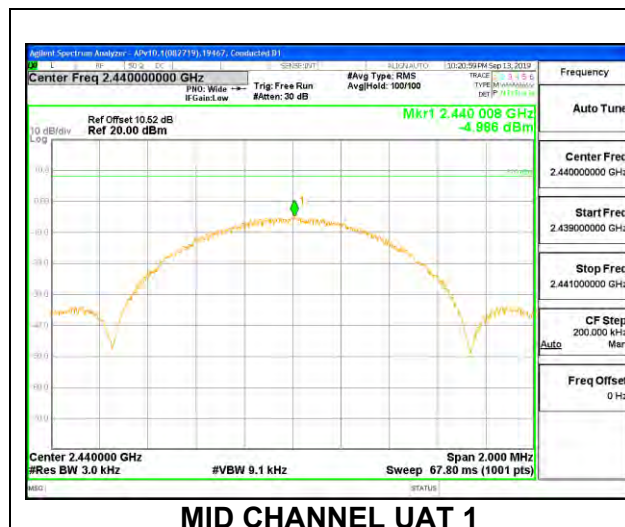
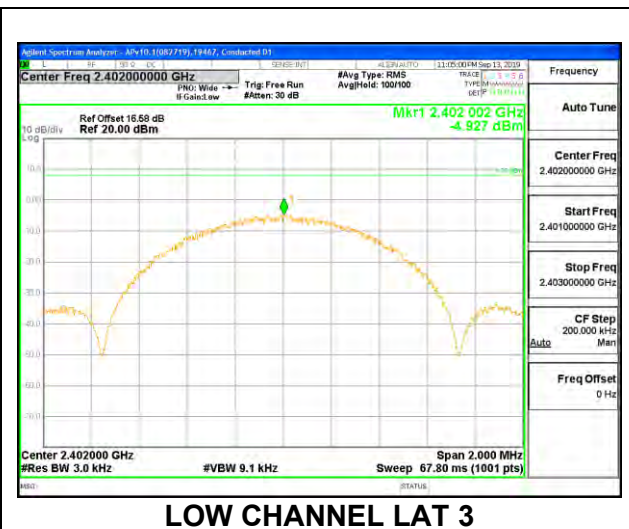
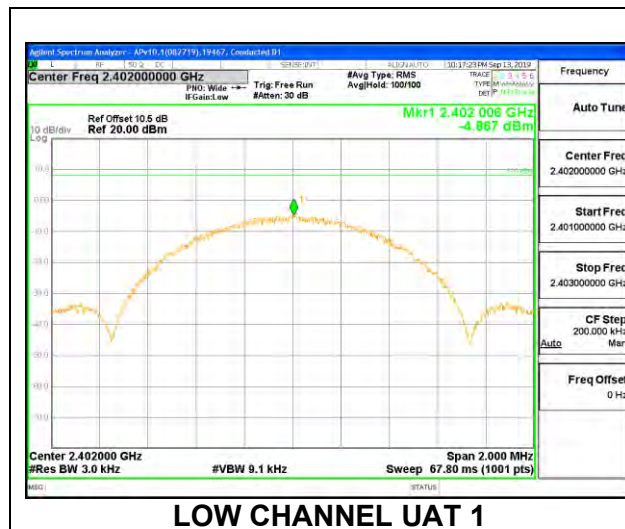


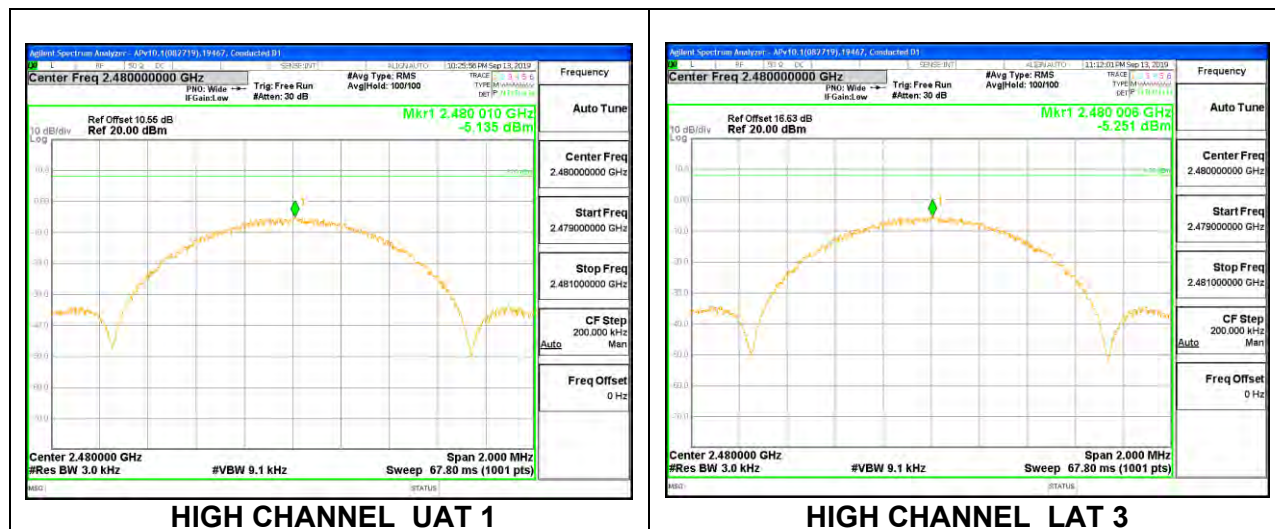
8.6.7. BEAMFORMING LOW POWER BLE (1Mbps)

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

Channel	Frequency (MHz)	UAT 1 Meas (dBm/ 3kHz)	LAT 3 Meas (dBm/ 3kHz)	Total Corr'd PSD (dBm/ 3kHz)	Limit (dBm/ 3kHz)	Margin (dB)
Low	2402	-4.87	-4.93	-1.89	8.0	-9.9
Mid	2440	-4.99	-4.85	-1.91	8.0	-9.9
Hjigh	2480	-5.14	-5.25	-2.18	8.0	-10.2



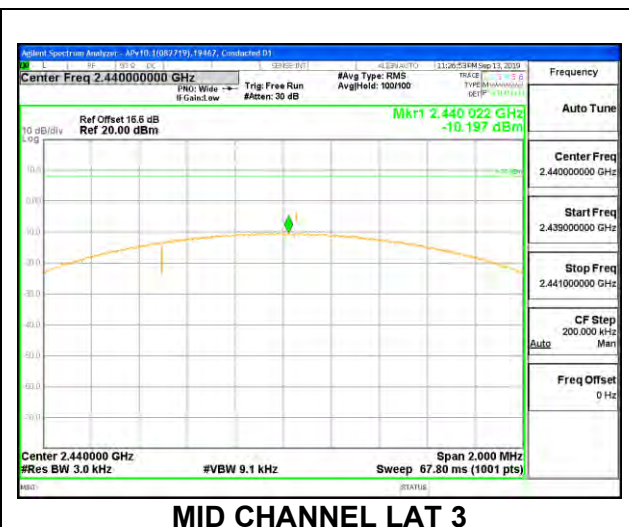
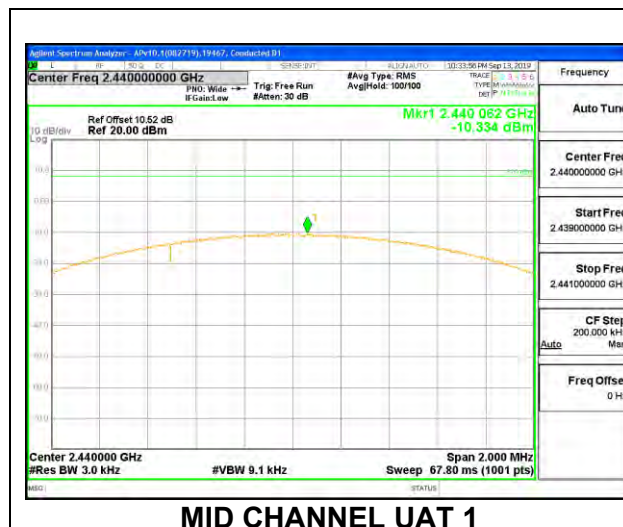
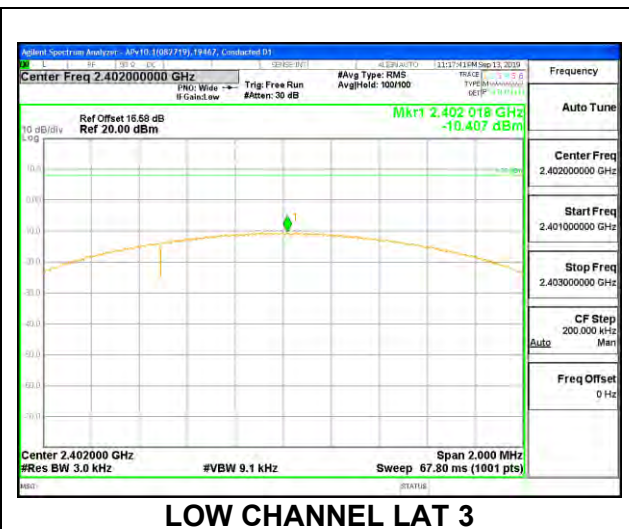
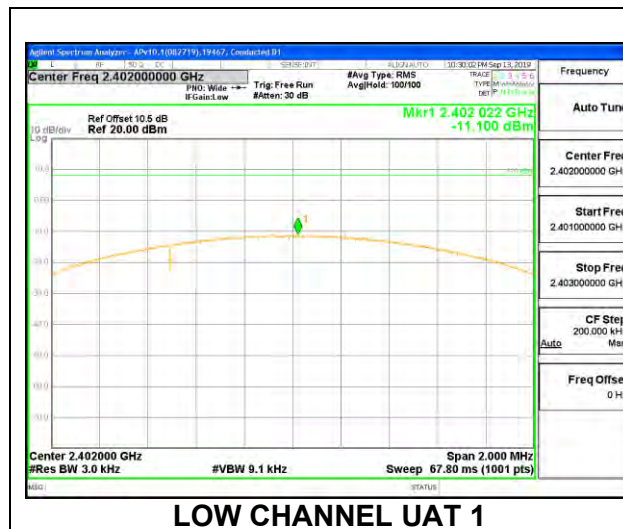


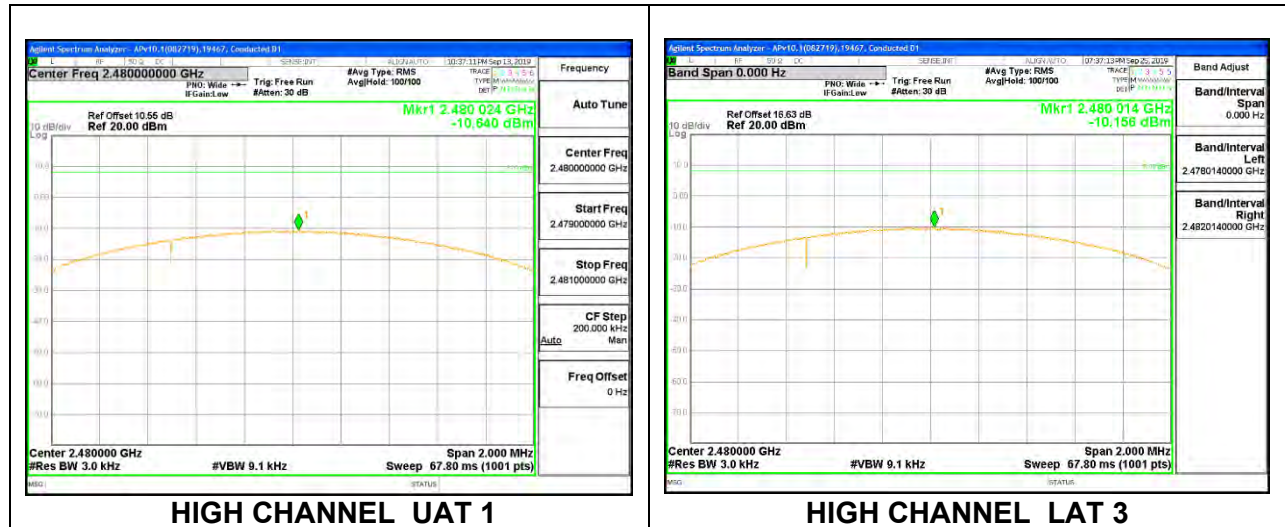
8.6.8. BEAMFORMING LOW POWER BLE (2Mbps)

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

Channel	Frequency (MHz)	UAT 1 Meas (dBm/ 3kHz)	LAT 3 Meas (dBm/ 3kHz)	Total Corr'd PSD (dBm/ 3kHz)	Limit (dBm/ 3kHz)	Margin (dB)
Low	2402	-11.10	-10.41	-7.73	8.0	-15.7
Mid	2440	-10.33	-10.20	-7.25	8.0	-15.3
Hjigh	2480	-10.64	-10.16	-7.38	8.0	-15.4





8.7. CONDUCTED SPURIOUS EMISSIONS

LIMITS

FCC §15.247 (d)

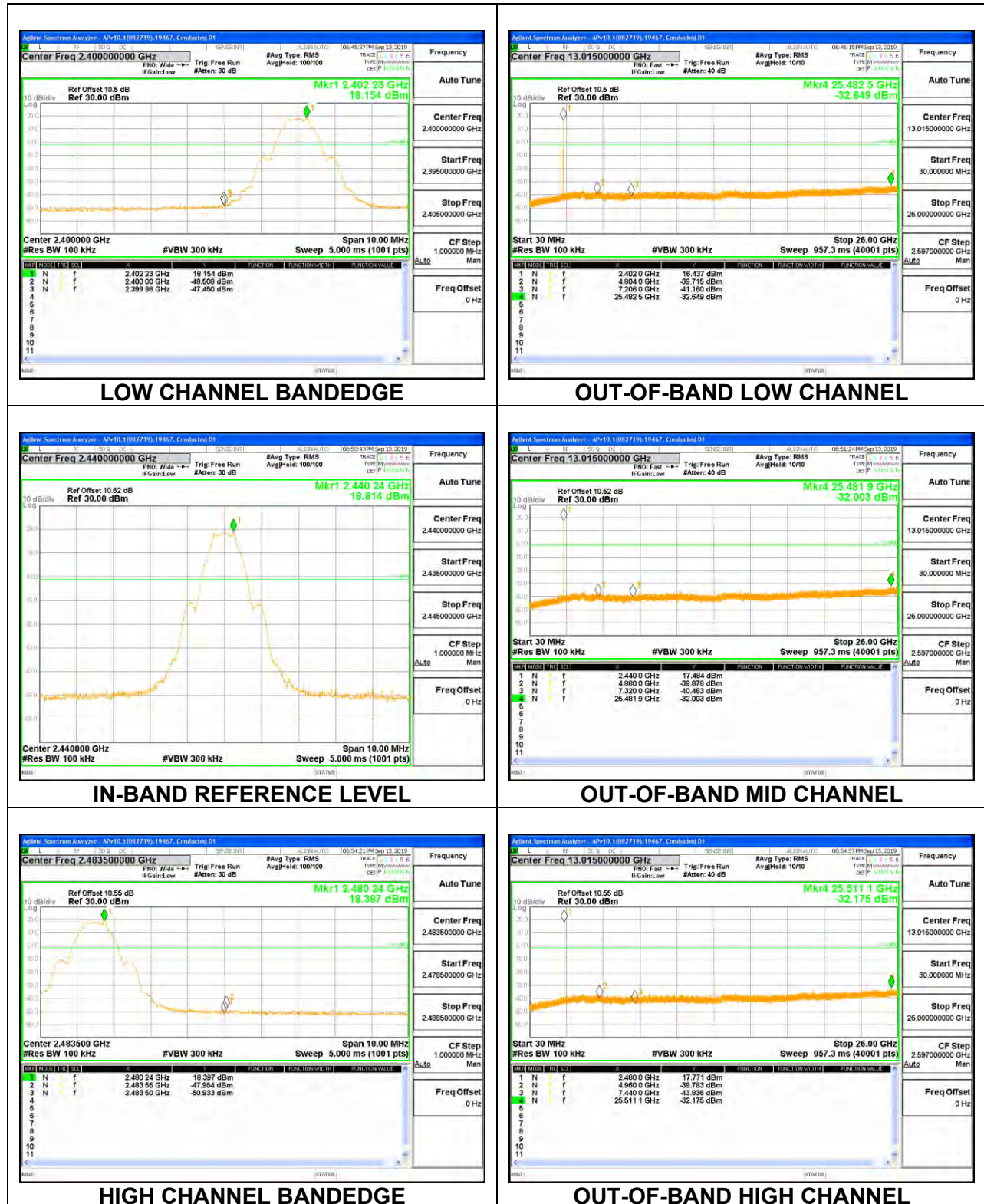
RSS-247 5.5

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

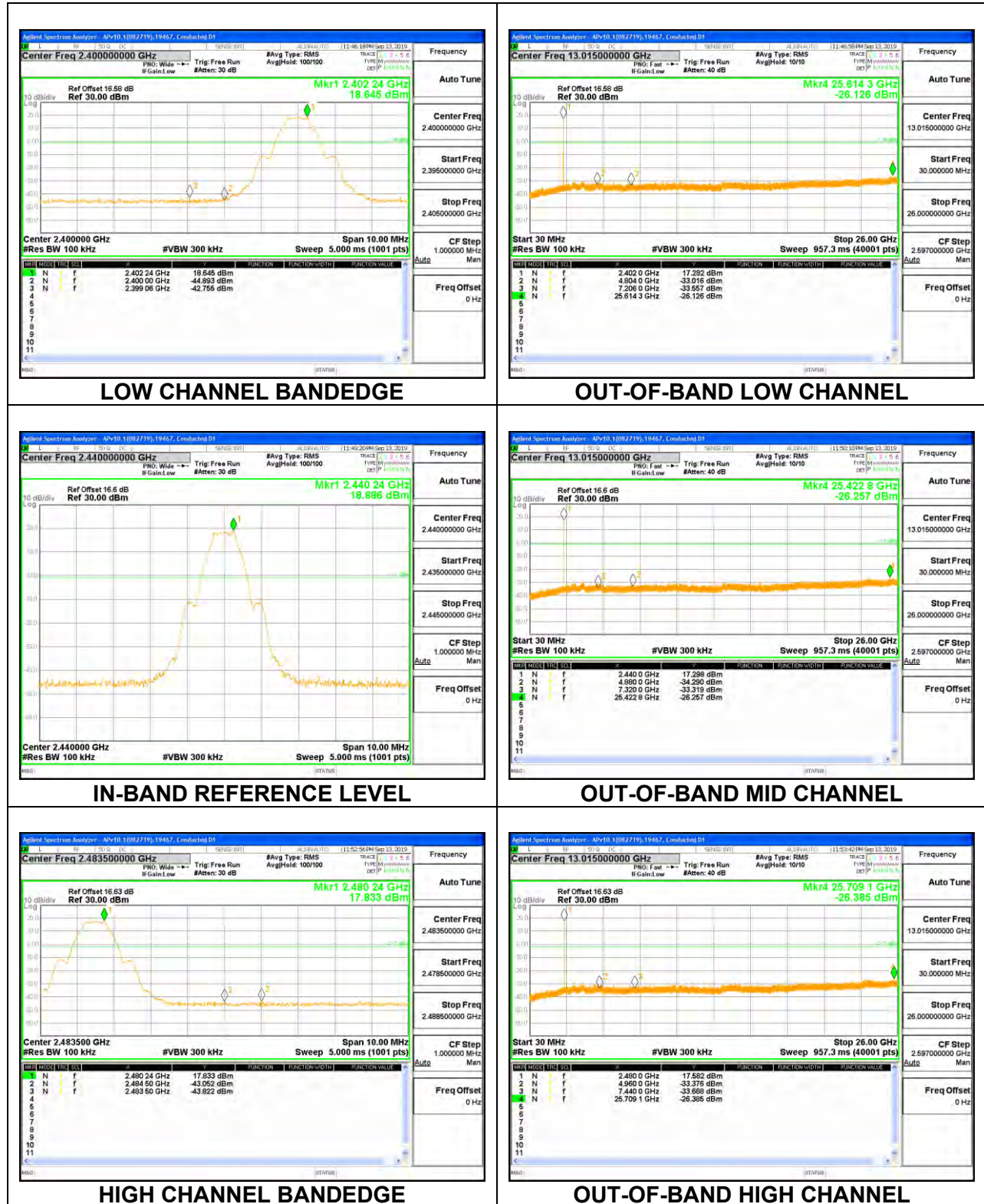
RESULTS

8.7.1. HIGH POWER BLE (1Mbps)

UAT 1

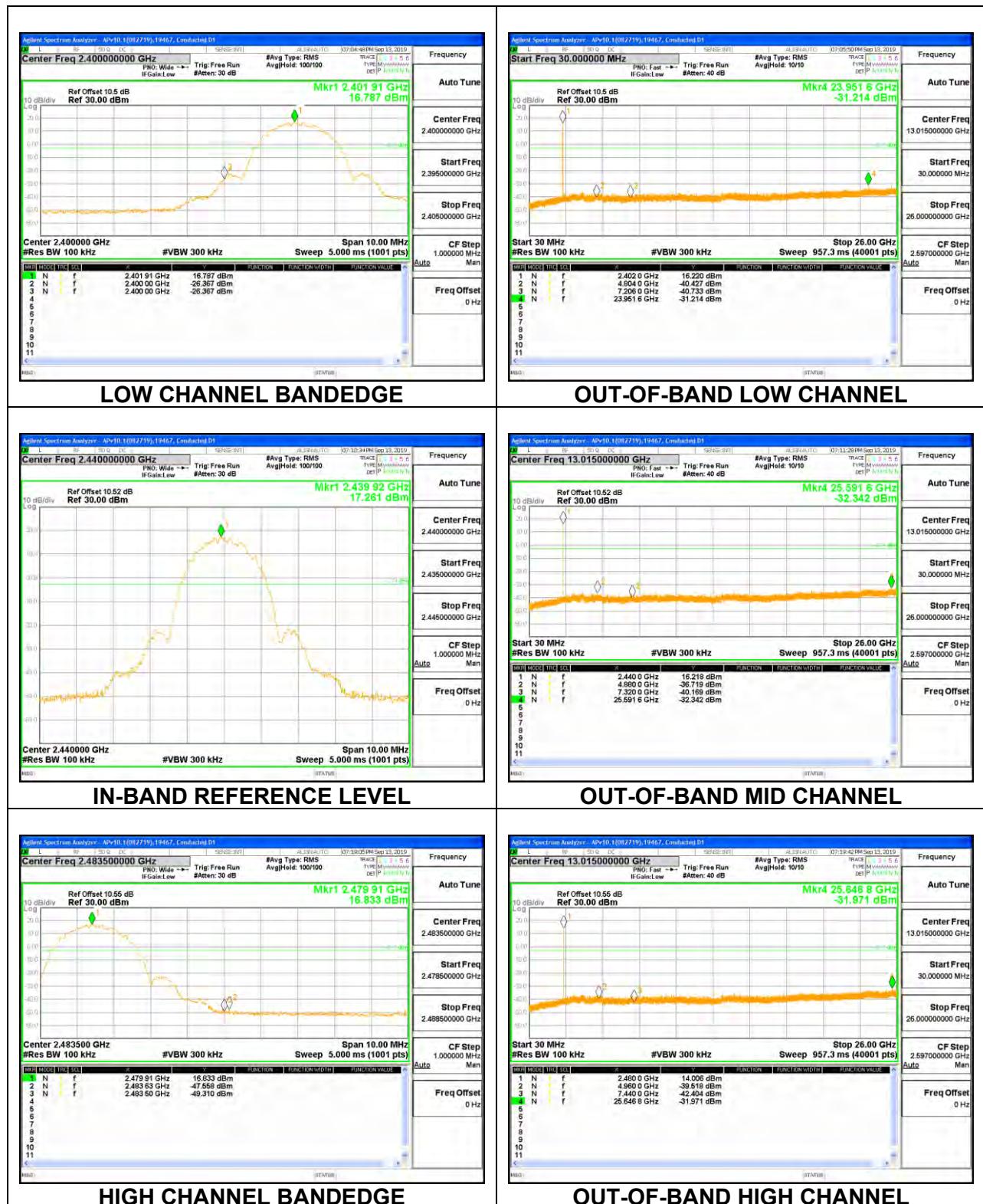


LAT 3

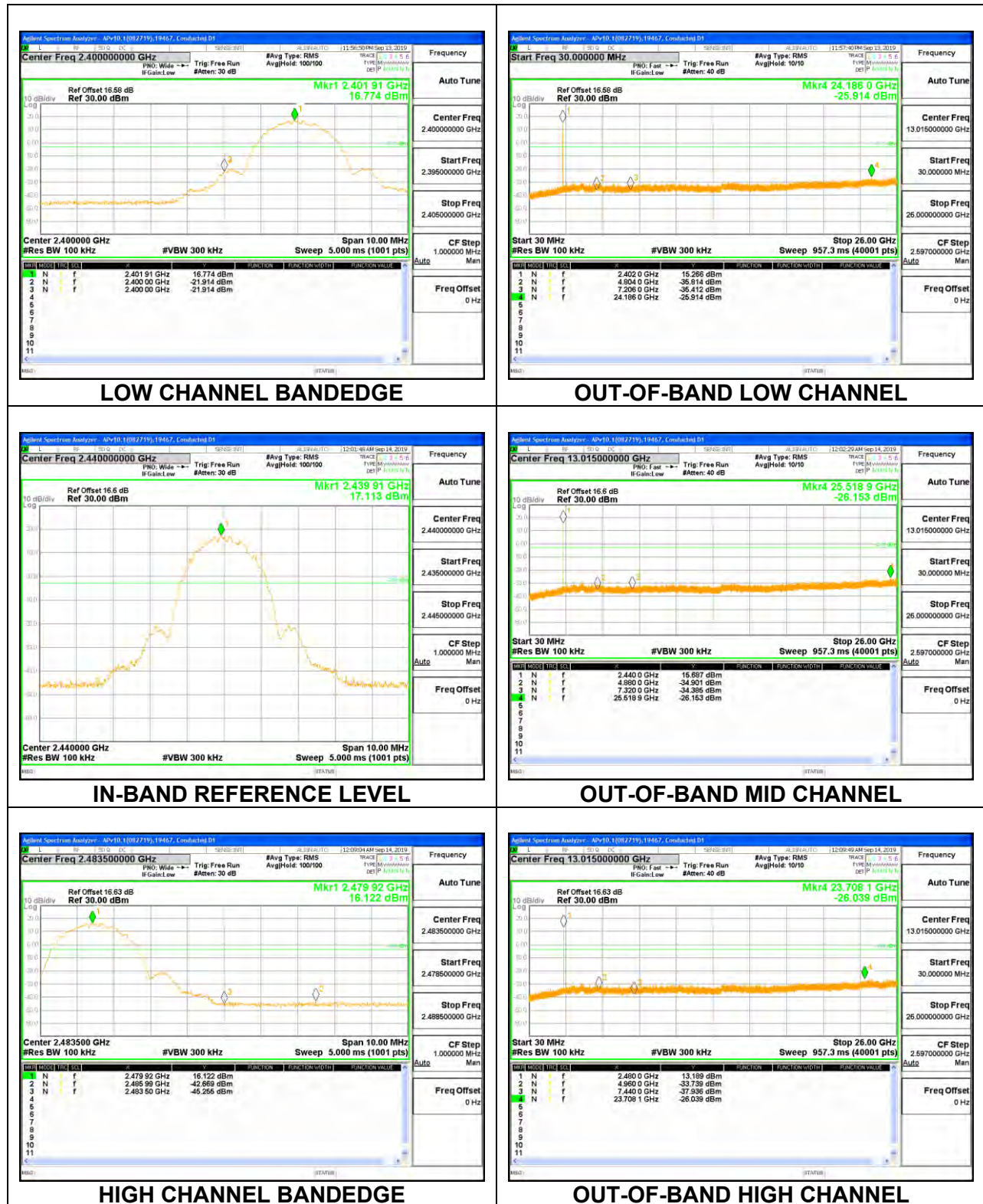


8.7.2. HIGH POWER BLE (2Mbps)

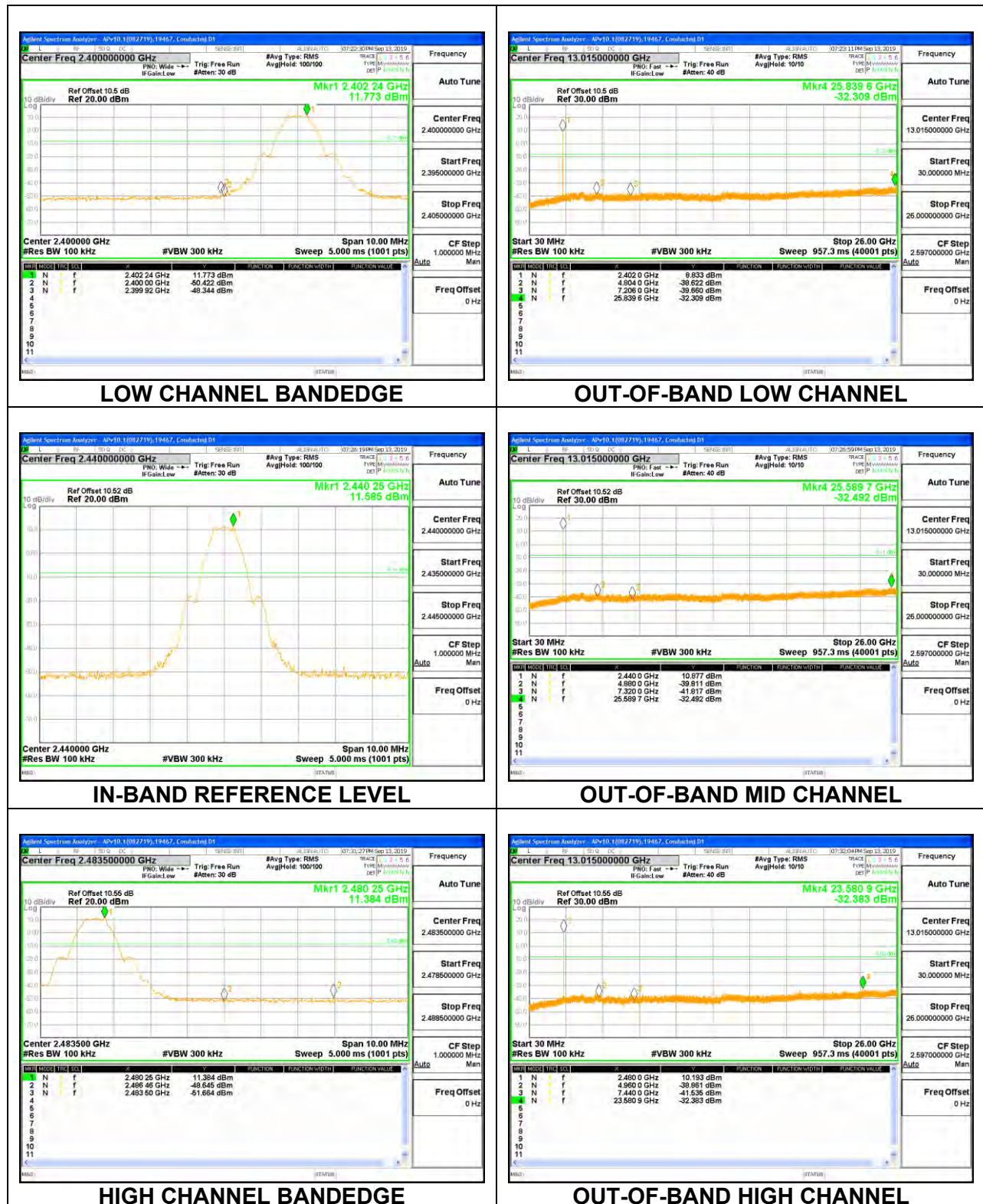
UAT 1



LAT 3



8.7.3. LOW POWER BLE (1Mbps) UAT 1



LAT 3

