



CERTIFICATION TEST REPORT

Report Number. : 12696946-E12V2

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

Model : A2111, A2222 AND A2223

FCC ID : BCG-E3309A

IC : 579C-E3309A

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:

July 25, 2019

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REPORT REVISION HISTORY

Rev.	Issue Date	Revisions	Revised By
V1	7/18/2019	Initial Issue	Chris Xiong
V1	7/25/2019	Address TCB's Questions	Chin Pang

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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: A2111, A2222 AND A2223

SERIAL NUMBER: C7CYQ004MT74, C7CYP0L2MT5Q

DATE TESTED: FEBRUARY 21, 2019 – JUNE 30, 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
<input checked="" type="checkbox"/> Chamber A (ISED:2324B-1)	<input type="checkbox"/> Chamber D (ISED:22541-1)	<input type="checkbox"/> Chamber I (ISED:2324A-5)
<input type="checkbox"/> Chamber B (ISED:2324B-2)	<input type="checkbox"/> Chamber E (ISED:22541-2)	<input type="checkbox"/> Chamber J (ISED:2324A-6)
<input type="checkbox"/> Chamber C (ISED:2324B-3)	<input checked="" type="checkbox"/> Chamber F (ISED:22541-3)	<input type="checkbox"/> Chamber K (ISED:2324A-1)
	<input checked="" type="checkbox"/> Chamber G (ISED:22541-4)	<input type="checkbox"/> Chamber L (ISED:2324A-3)
	<input checked="" type="checkbox"/> Chamber H (ISED: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

The Apple iPhone 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 A2111, A2222 and A2223 is electrically identical to Model A2111. Three model numbers are allocated for marketing and logistic purposes only. A2111 was used to perform all final tests.

5.3. DESCRIPTION OF AVAILABLE ANTENNAS

Frequency Range (GHz)	Ant. 2 (dBi)	Ant. 5 (dBi)
2.4	-4.5	-2.6

5.4. 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 2	High Power	2404 - 2478	HDR4	14.72	29.65
	Low Power			8.94	7.83
	High Power		HDR8	15.26	33.57
	Low Power			9.44	8.79
Ant 5	High Power	2404 - 2478	HDR4	14.73	29.72
	Low Power			8.86	7.69
	High Power		HDR8	15.45	35.08
	Low Power			9.69	9.31
BF, Ant 2 + Ant 5	High Power	2404 - 2478	HDR4	17.86	61.09
	Low Power			11.97	15.74
	High Power		HDR8	18.07	64.12
	Low Power			12.63	18.32

5.5. SOFTWARE AND FIRMWARE

The EUT firmware installed during testing was FW Version: 17.1.140.1283.

5.6. WORST-CASE CONFIGURATION AND MODE

The EUT was investigated in three orthogonal orientations X, Y and Z on both Ant 2 (Core 0) and Ant 5 (Core 1), it was determined that Y (Landscape) orientation was the worst-case orientation for Ant 2 and X (Flatbed) for Ant 5 and beamforming 2TX mode.

Radiated band edge, 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 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.

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

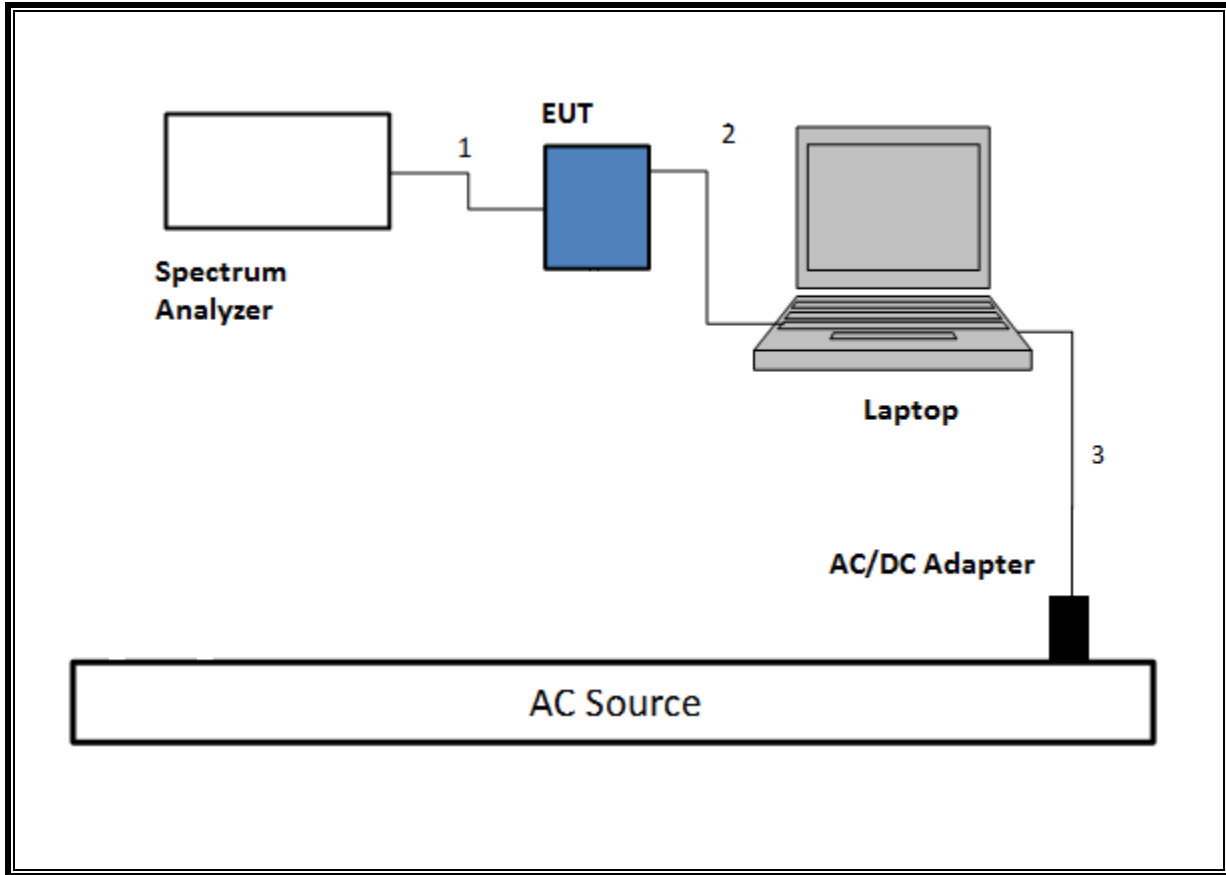
I/O CABLES (BELOW 1GHz AND AC POWER LINE TEST WITH ADAPTER AND LAPTOP)

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

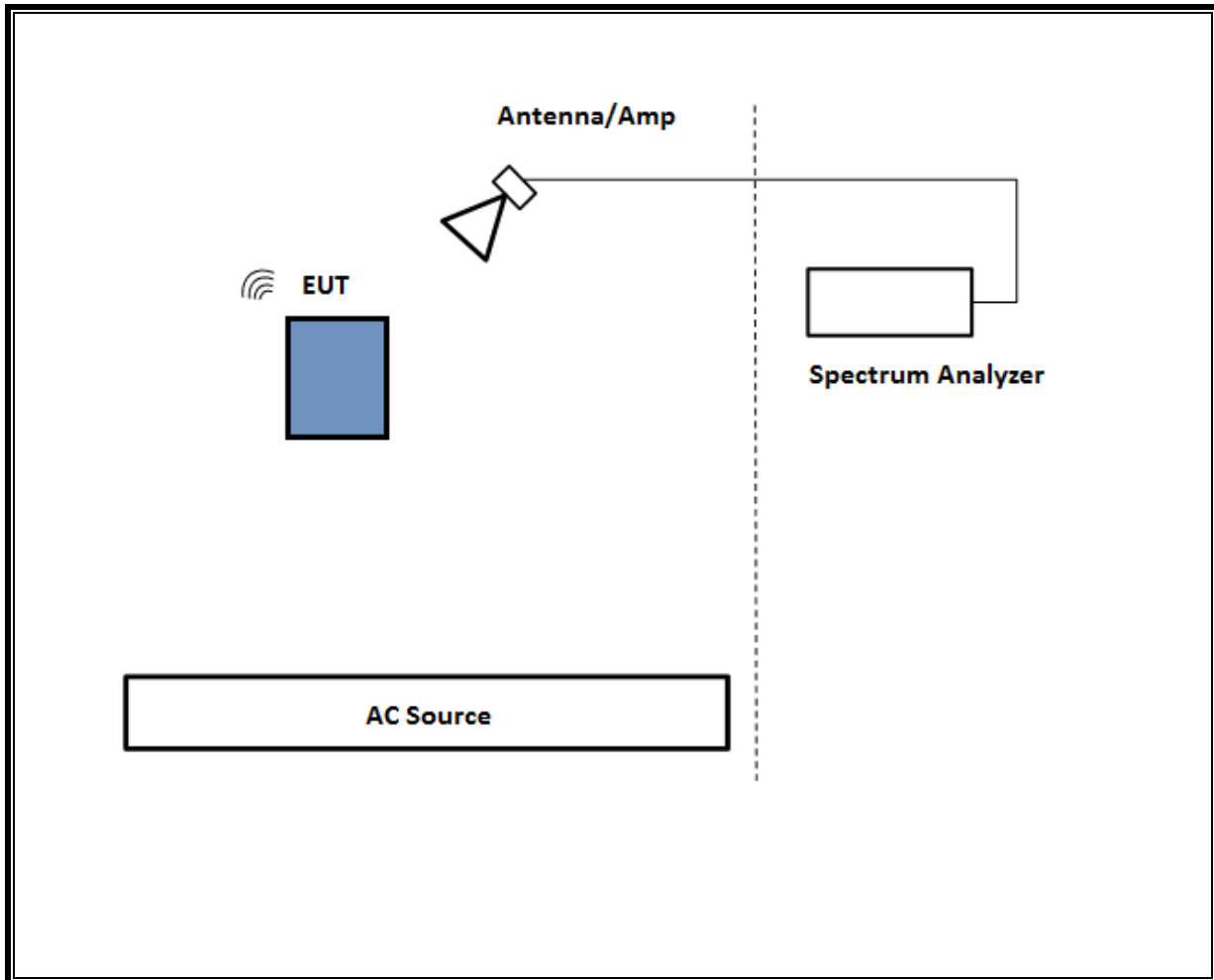
TEST SETUP

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

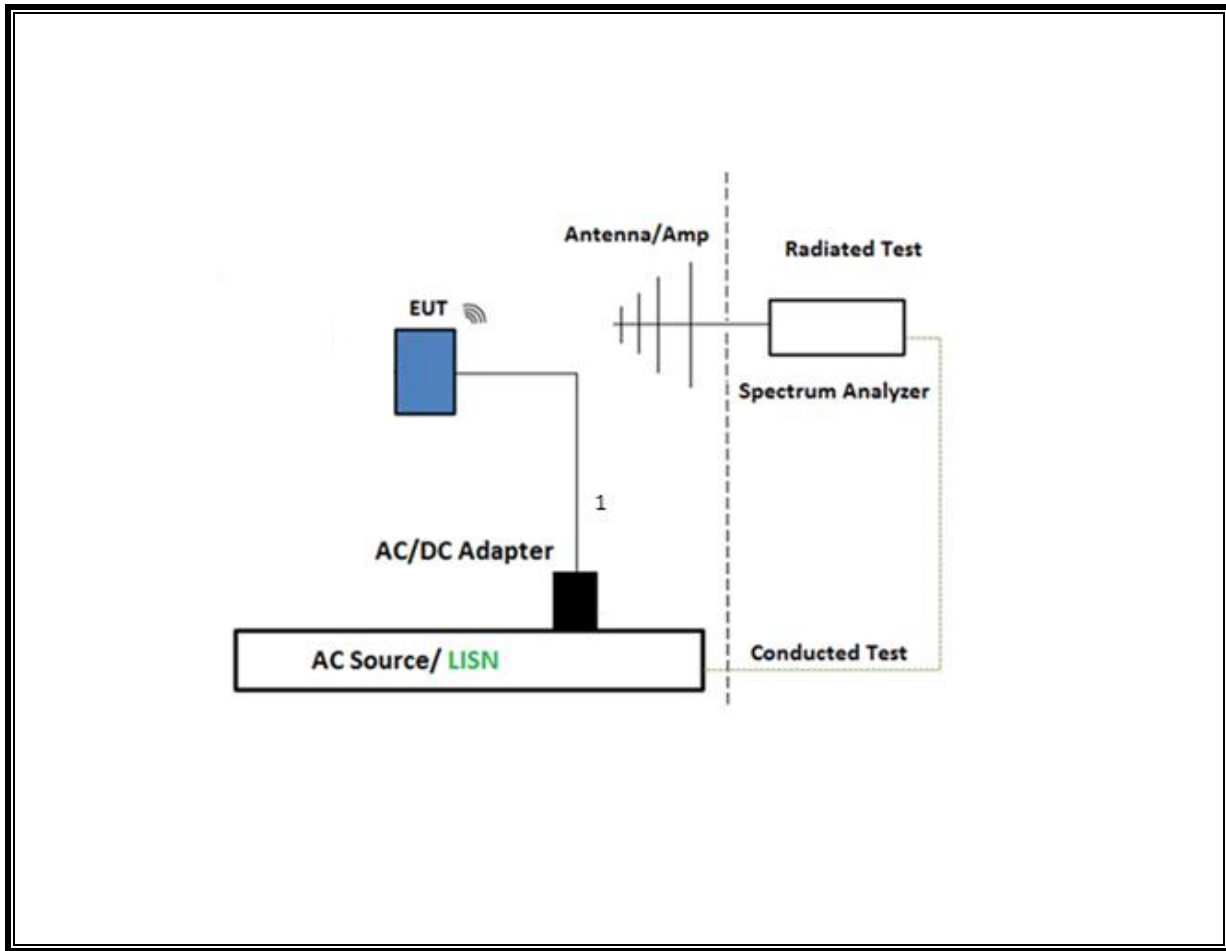
SETUP DIAGRAM FOR CONDUCTED TESTS



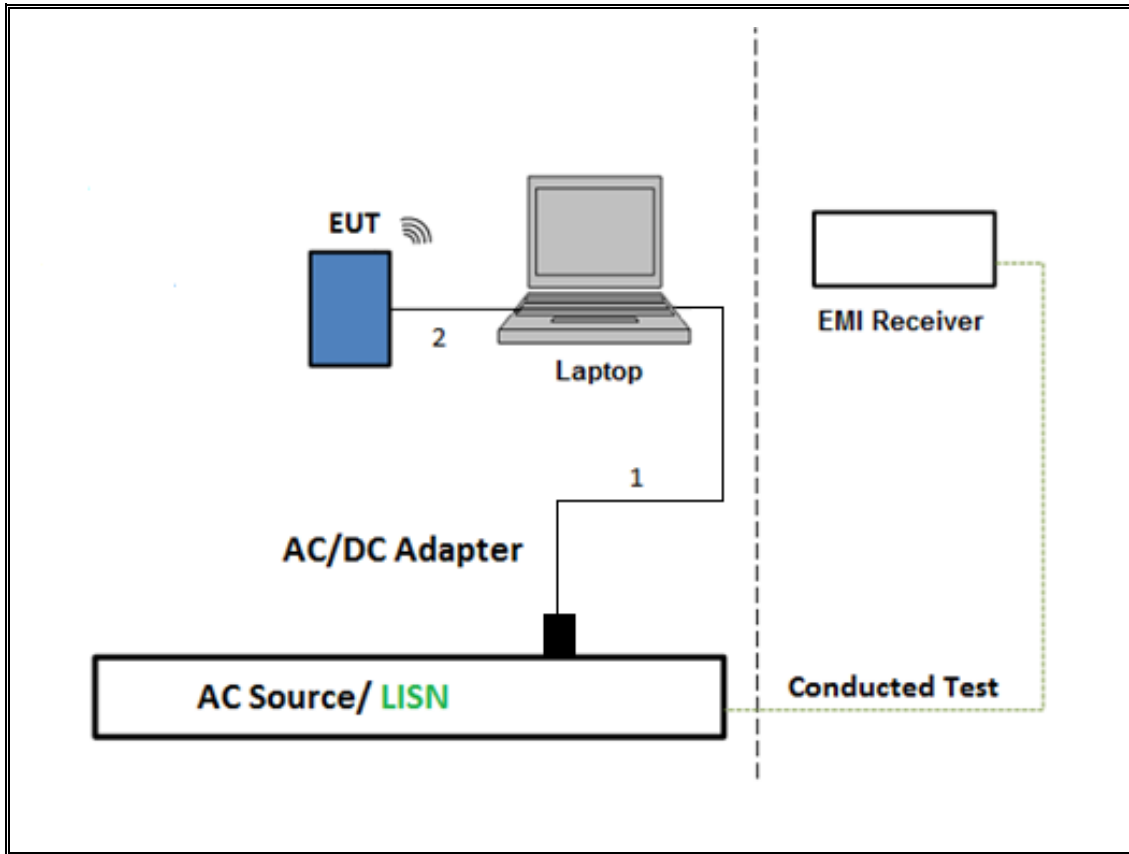
SETUP DIAGRAM FOR RADIATED TESTS Above 1 GHz



SETUP DIAGRAM FOR Below 1GHz and AC LINE CONDUCTED TEST



TEST SETUP- AC LINE CONDUCTED: LAPTOP CONFIGURATION



6. MEASUREMENT METHOD

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

6 dB BW: KDB 558074 D01 v05r02, Section 2.1

Output Power (Peak): KDB 558074 D01 v05r02, Section 8.3.1, ANSI C63.10 Subclause 11.9.1

Output Power (Average): KDB 558074 D01 v05r02, Section 8.3.1, ANSI C63.10 Subclause 11.9.2

Power Spectral Density: KDB 558074 D01 v05r02, Section 8.4

Out-of-band emissions in non-restricted bands: KDB 558074 D01 v05r02, Section 8.1. ANSI C63.10 Subclause 11.11

Out-of-band emissions in restricted bands: KDB 558074 D01 v05r02, Section 8.1, ANSI C63.10 Subclause 11.12

Band-edge: KDB 558074 D01 v05r02, Section 8.6

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

NOTE: All conducted testing for Beamforming applied same test procedures as BT HDR normal modes.

7. TEST AND MEASUREMENT EQUIPMENT

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

Description	Manufacturer	Model	ID Num	Cal Due
Antenna, Horn 1-18GHz	ETS Lindgren	3117	T136	07/02/2019
Spectrum Analyzer, PXA, 3Hz to 44GHz	Agilent (Keysight) Technologies	N9030A	T342	01/23/2020
Amplifier, 1 to 18GHz, 35dB	Amplical	AFS42-00101800-25-S-42	T1567	01/26/2020
Amplifier, 10KHz to 1GHz, 32dB	Sonoma	310N	T835	01/02/2020
Antenna, Horn 1-18GHz	ETS Lindgren	3117	T120	07/02/2019
Amplifier, 1 to 18GHz	Miteq	AFS42-00101800-25-S-42	T491	05/30/2020
Antenna, Horn 1-18GHz	ETS Lindgren	3117	T120	07/02/2019
Antenna, Horn 1-18GHz	ETS-Lindgren	3117	T345	04/20/2020
*Amplifier, 1 to 18GHz	Miteq	AFS42-00101800-25-S-42	T1165	06/12/2019
Antenna, Active Loop 9KHz to 30MHz	EMCO	6502	T35	06/06/2020
Hybrid Antenna, 30-3GHz	SunAR rf Motion	JB3	PRE0181574	08/01/2019
Thermometer - Digital	Control Company	14-650-118	PRE0177862	02/22/2020
*Antenna Horn, 18 to 26GHz	ARA	MWH-1826	T447	06/16/2019
Pre-Amp 18-26GHz	Agilent Technology	8449B	T404	03/23/2020
Spectrum Analyzer, PXA, 3Hz to 44GHz	Agilent (Keysight) Technologies	N9030A	T459	07/25/2019
AC Line Conducted				
EMI Test Receiver 9KHz-7GHz	Rohde & Schwarz	ESC17	T1436	02/14/2020
Power Cable, Line Conducted Emissions	UL	PG1	T861	08/31/2019
*LISN for Conducted Emissions CISPR-16	Fischer	50/250-25-2-01	T1310	06/19/2019
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.

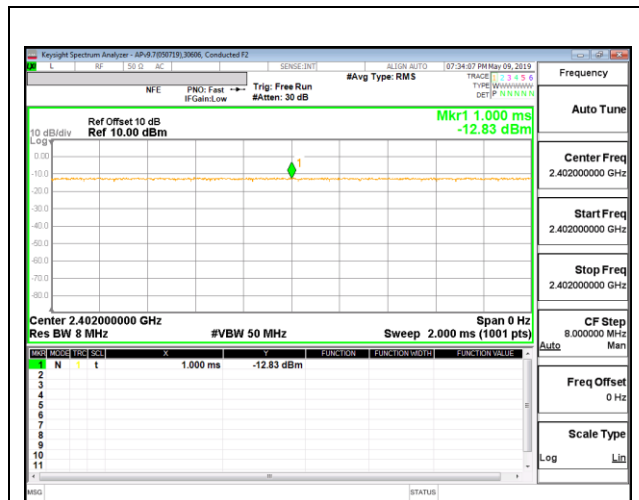
PROCEDURE

KDB 558074 Zero-Span Spectrum Analyzer Method.

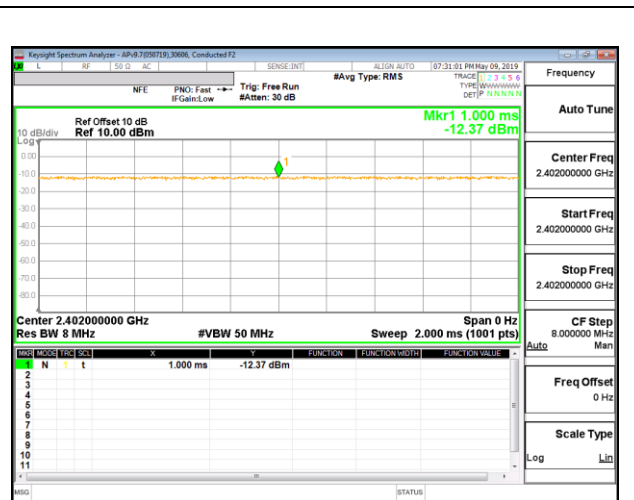
ON TIME AND DUTY CYCLE RESULTS

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						
HDR4	1.000	1.000	1.000	100.00%	0.00	0.010
HDR8	1.000	1.000	1.000	100.00%	0.00	0.010
HDR4, TxBF	1.000	1.000	1.000	100.00%	0.00	0.010
HDR8, TxBF	1.000	1.000	1.000	100.00%	0.00	0.010

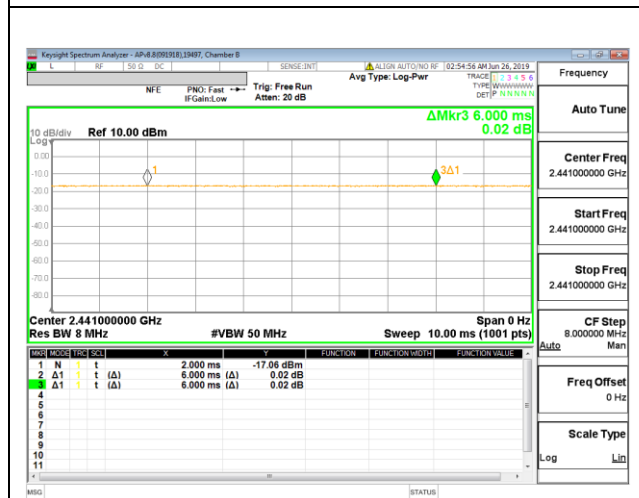
DUTY CYCLE PLOTS



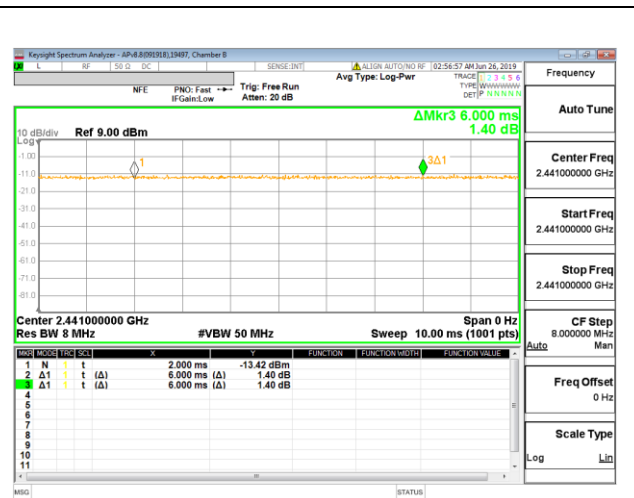
HDR 4



HDR 8



HDR 4 TxBF



HDR 8 TxBF

8.2. 99% BANDWIDTH

LIMITS

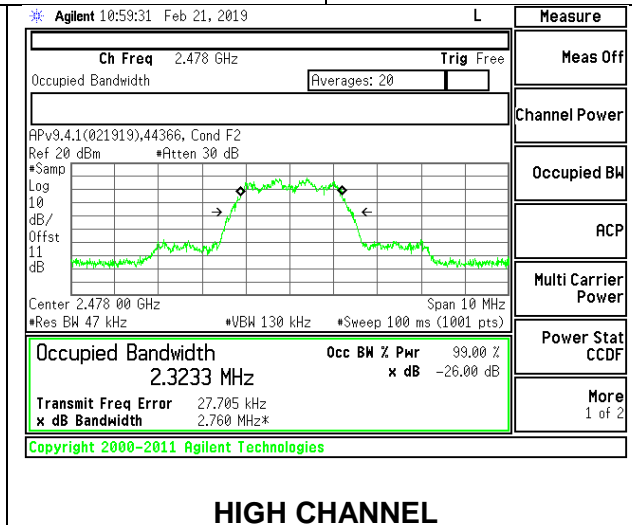
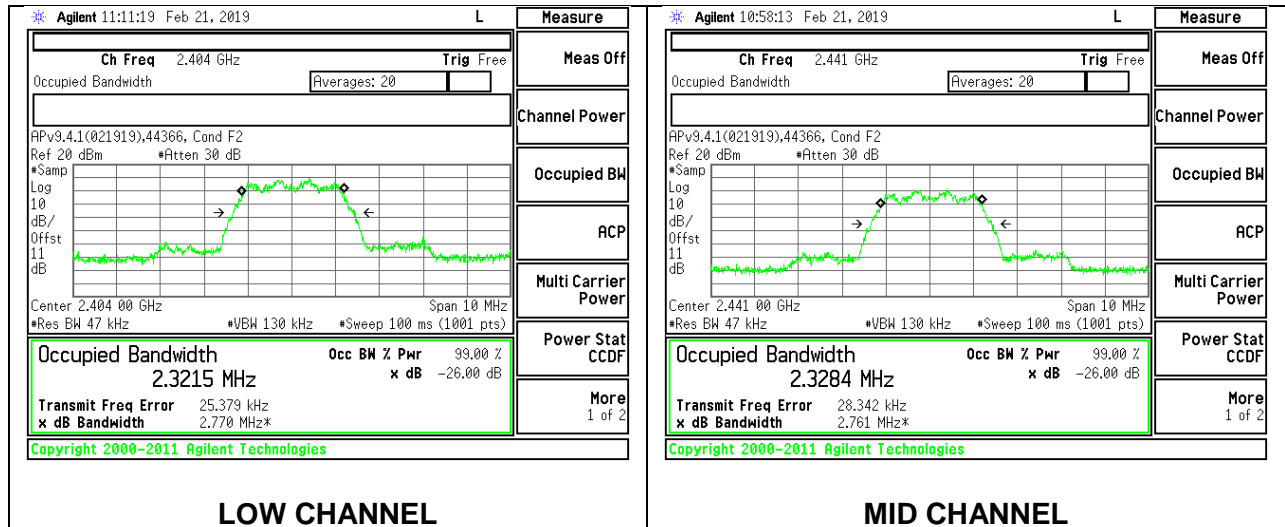
None; for reporting purposes only.

RESULTS

8.2.1. HIGH POWER HDR (HDR4)

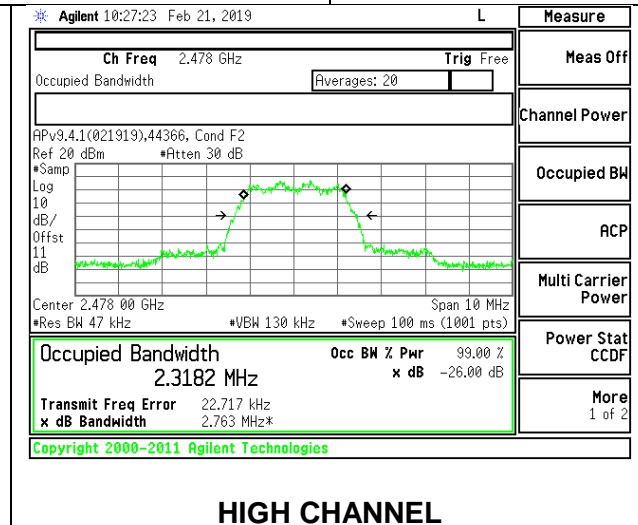
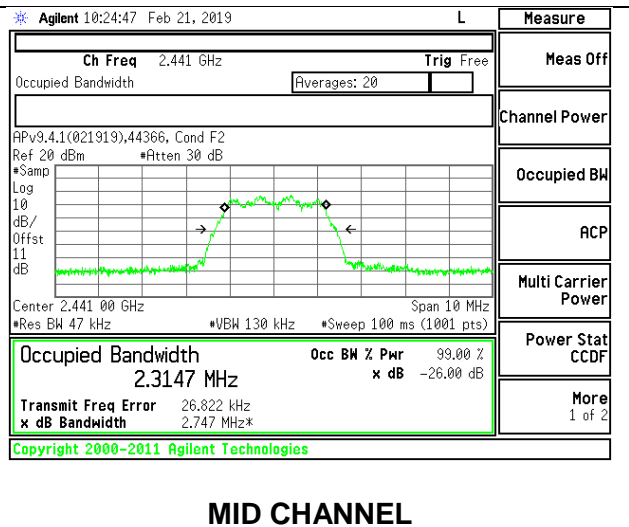
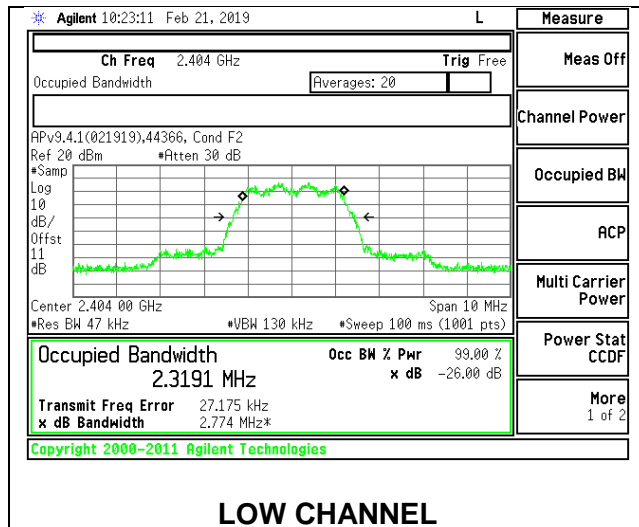
Antenna 2

Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low	2404	2.3215
Middle	2441	2.3284
High	2478	2.3233



Antenna 5

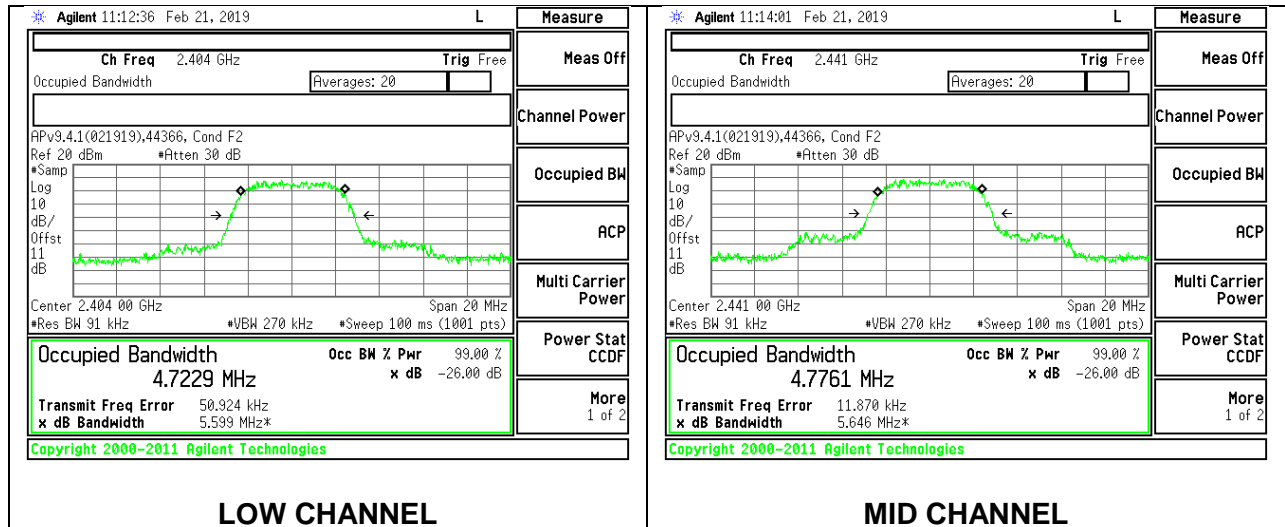
Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low	2404	2.3191
Middle	2441	2.3147
High	2478	2.3182



8.2.2. HIGH POWER HDR (HDR8)

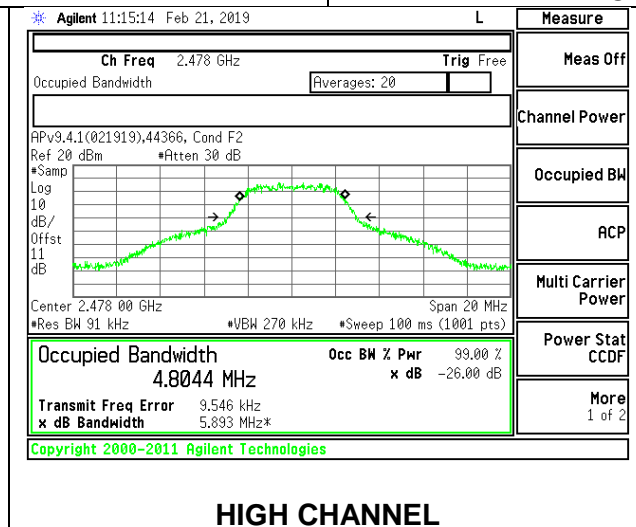
Antenna 2

Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low	2404	4.7229
Middle	2441	4.7761
High	2478	4.8044



LOW CHANNEL

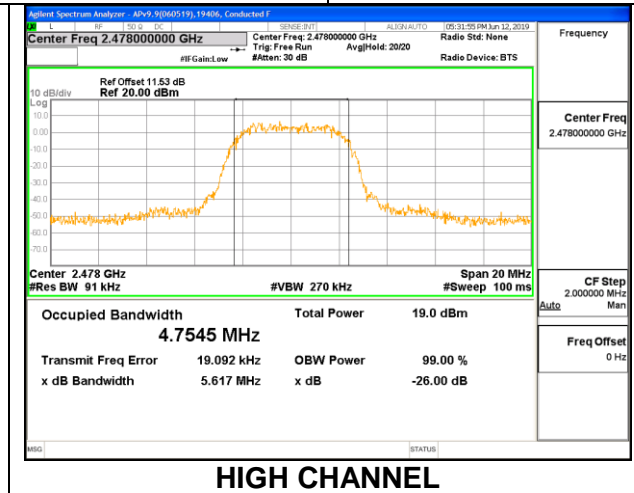
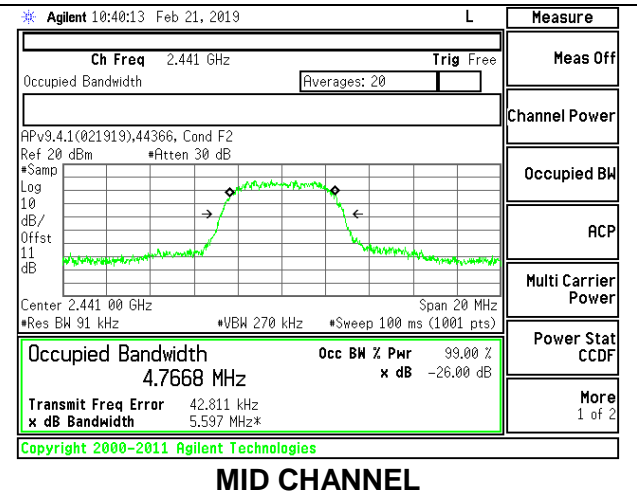
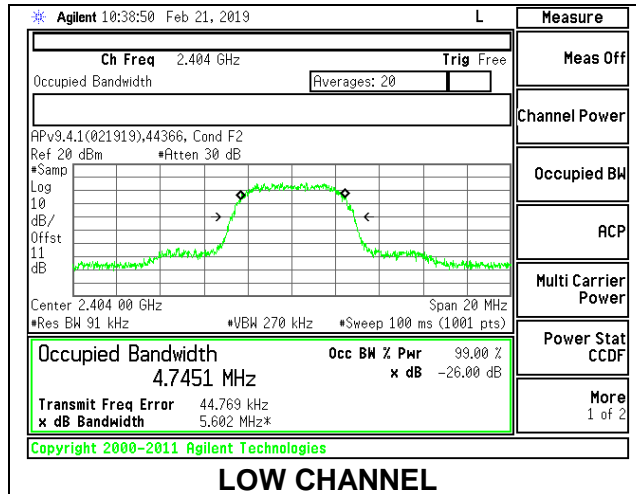
MID CHANNEL



HIGH CHANNEL

Antenna 5

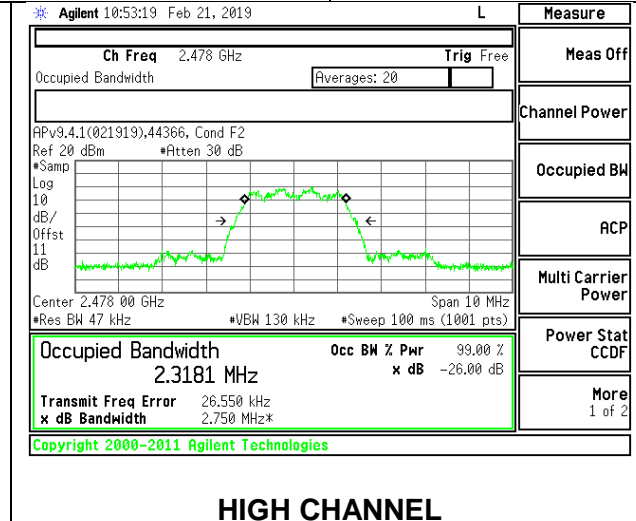
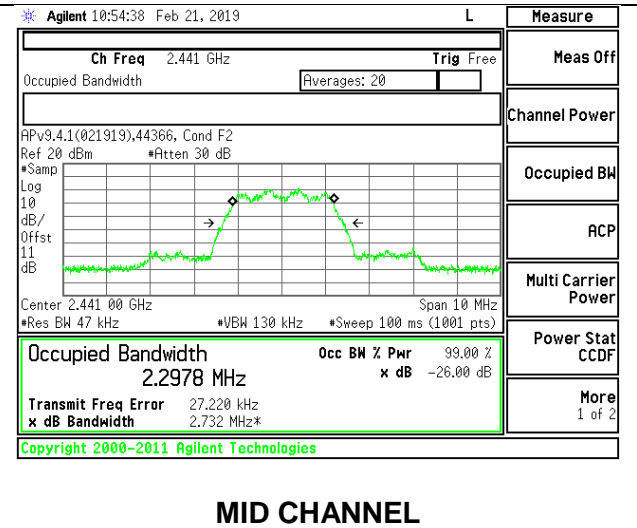
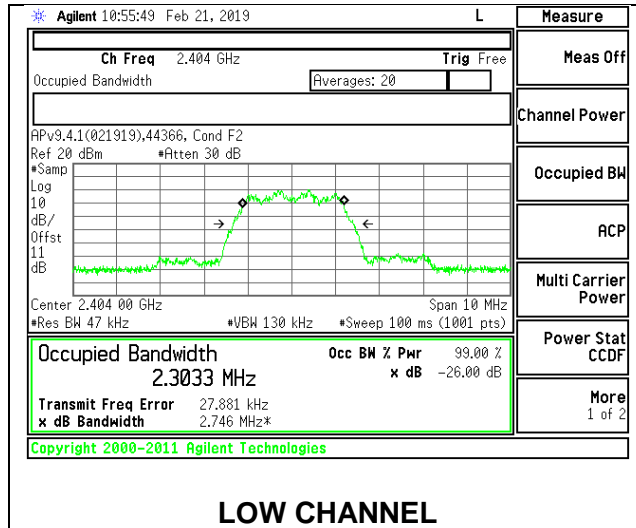
Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low	2404	4.7451
Middle	2441	4.7668
High	2478	4.7545



8.2.3. LOW POWER HDR (HDR4)

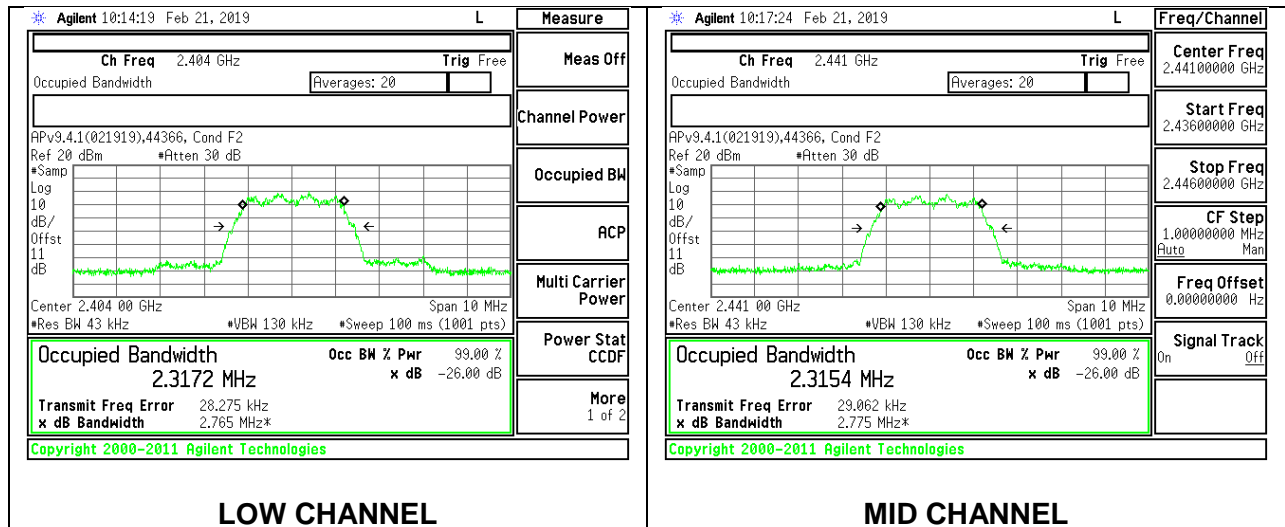
Antenna 2

Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low	2404	2.3033
Middle	2441	2.2978
High	2478	2.3181



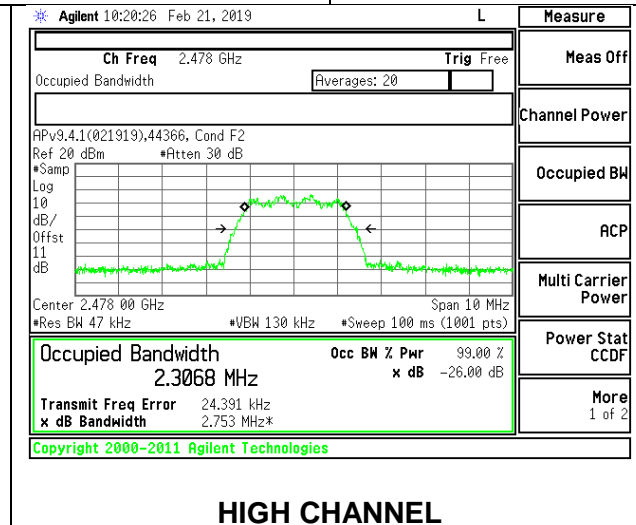
Antenna 5

Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low	2404	2.3172
Middle	2441	2.3154
High	2478	2.3068



LOW CHANNEL

MID CHANNEL

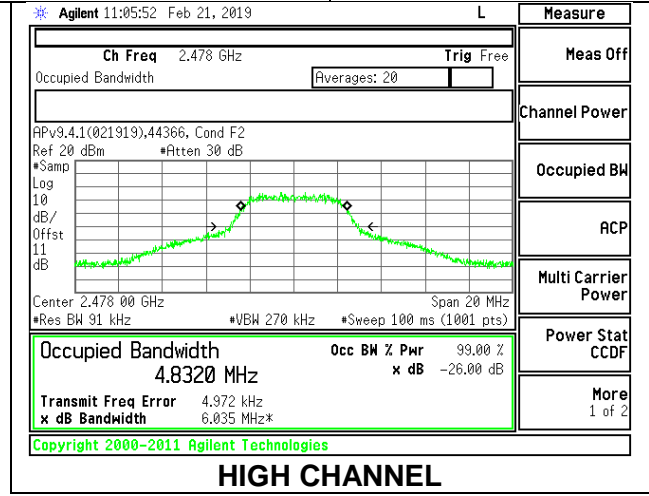
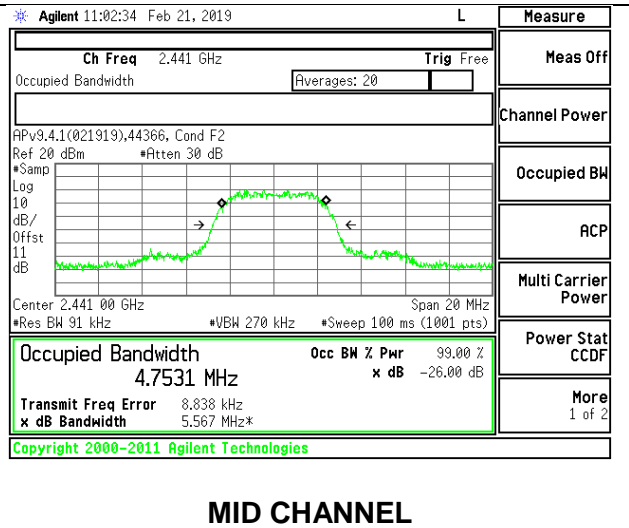
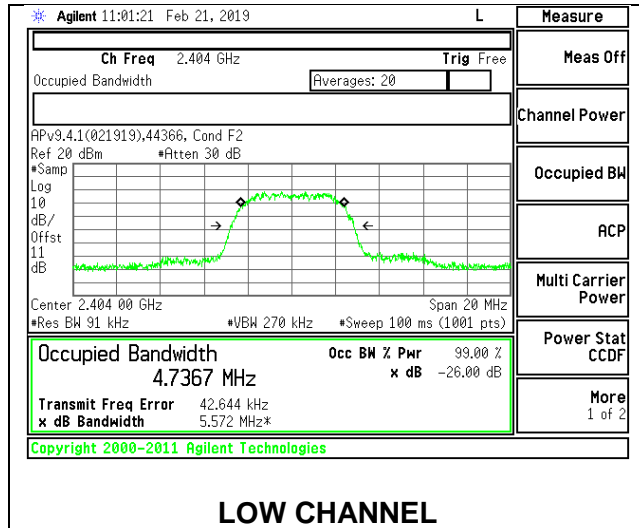


HIGH CHANNEL

8.2.4. LOW POWER HDR (HDR8)

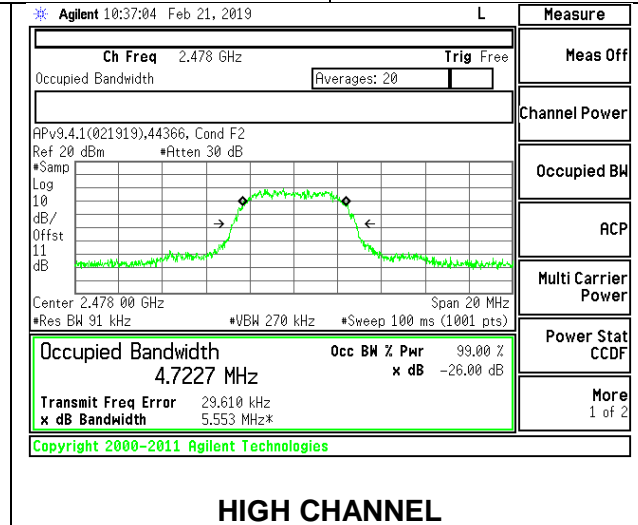
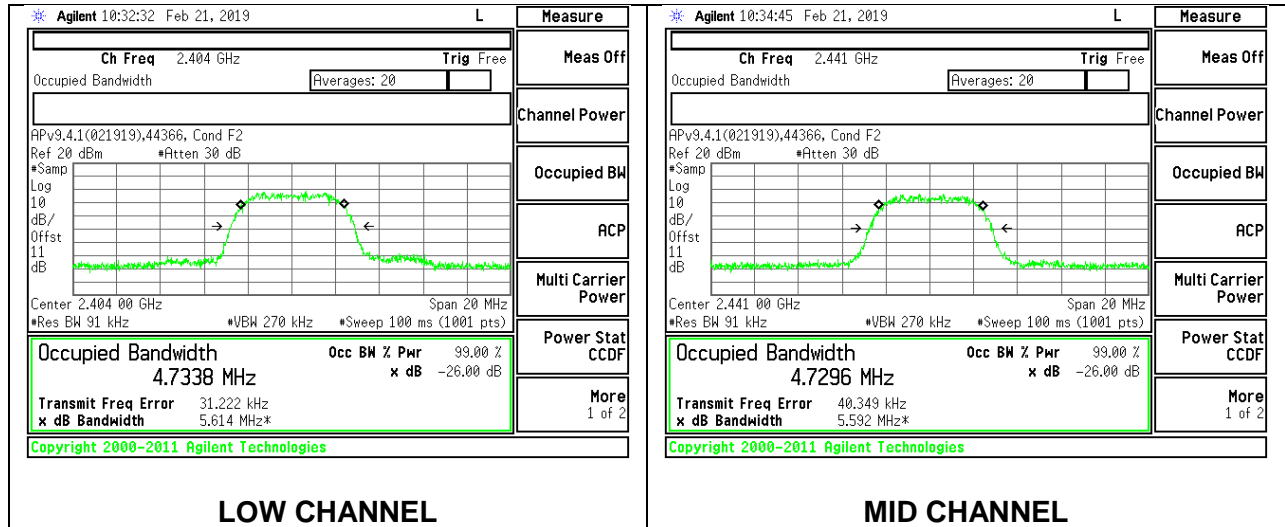
Antenna 2

Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low	2404	4.7367
Middle	2441	4.7531
High	2478	4.8320



Antenna 5

Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low	2404	4.7338
Middle	2441	4.7296
High	2478	4.7227



8.3. 6 dB BANDWIDTH

LIMITS

FCC §15.407 (e)

RSS-247 5.2 (a)

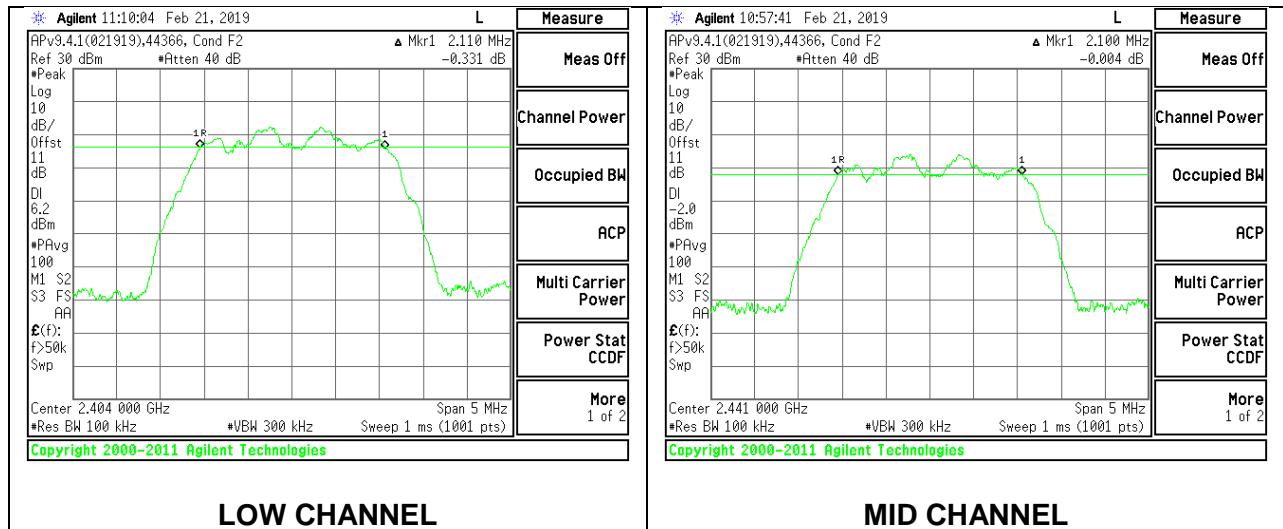
The minimum 6 dB bandwidth shall be at least 500 kHz.

RESULTS

8.3.1. HIGH POWER HDR (HDR4)

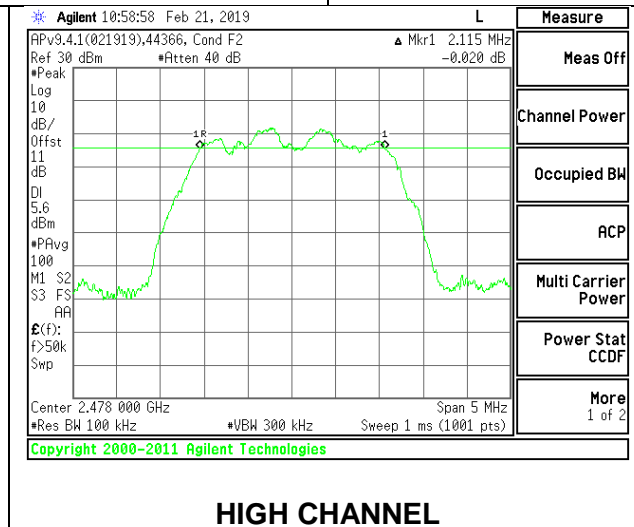
Antenna 2

Channel	Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum Limit (MHz)
Low	2404	2.1100	0.5
Middle	2441	2.1000	0.5
High	2478	2.1150	0.5



LOW CHANNEL

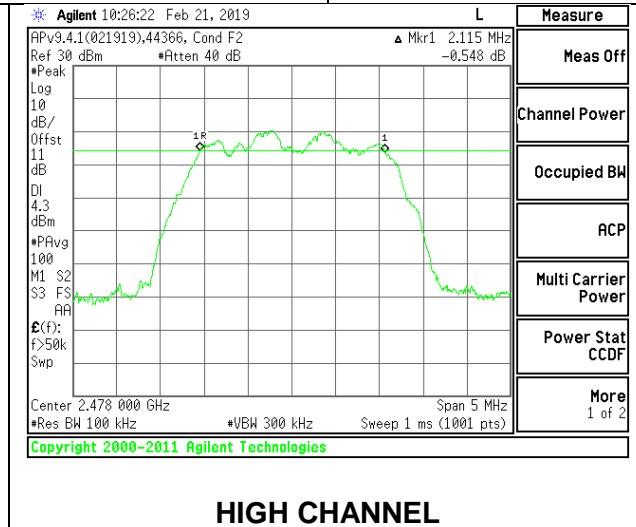
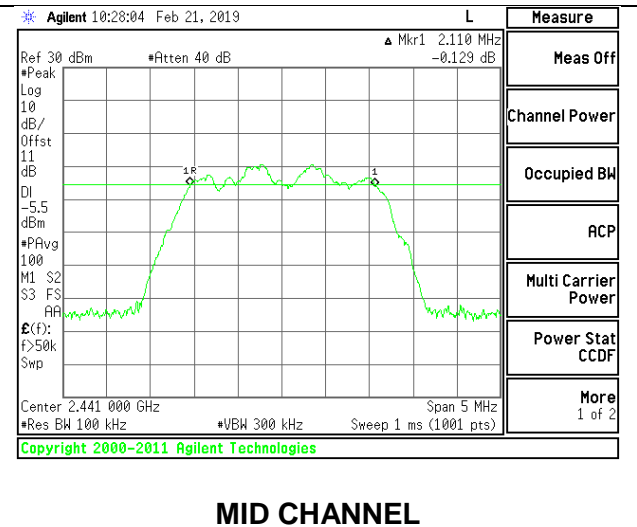
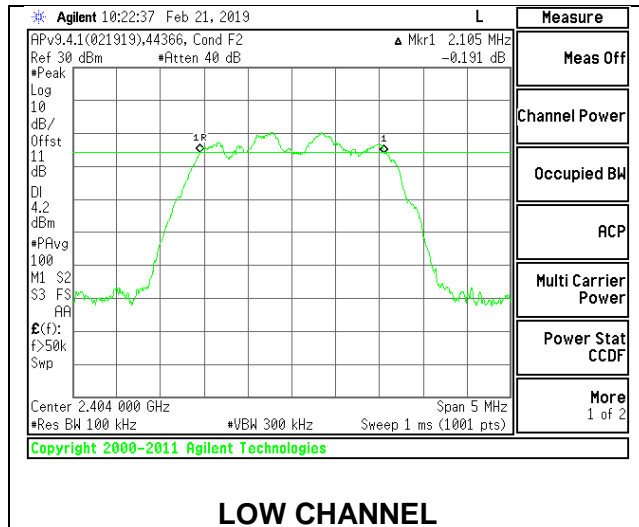
MID CHANNEL



HIGH CHANNEL

Antenna 5

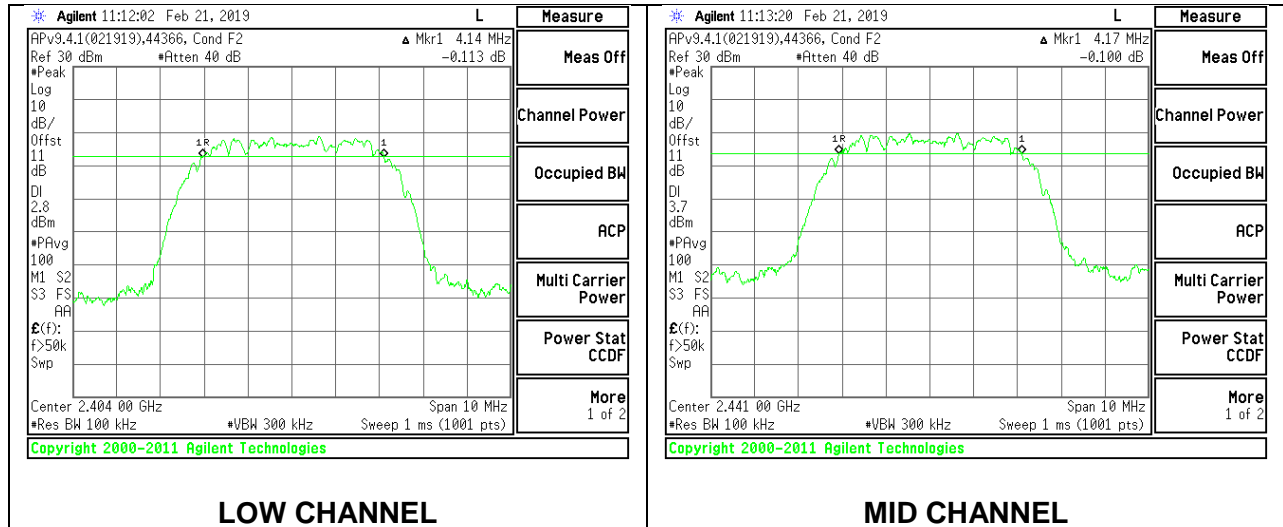
Channel	Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum Limit (MHz)
Low	2404	2.1050	0.5
Middle	2441	2.1100	0.5
High	2478	2.1150	0.5



8.3.2. HIGH POWER HDR (HDR8)

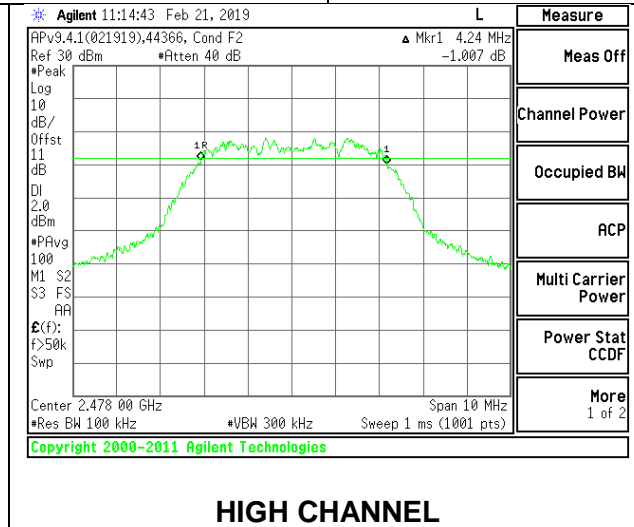
Antenna 2

Channel	Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum Limit (MHz)
Low	2404	4.140	0.5
Middle	2441	4.170	0.5
High	2478	4.240	0.5



LOW CHANNEL

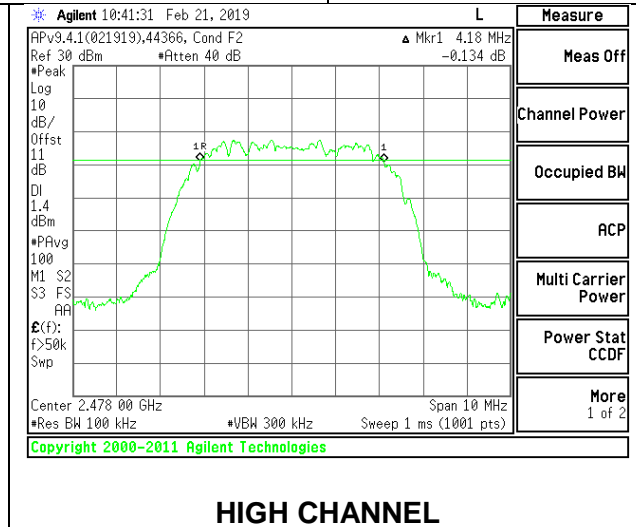
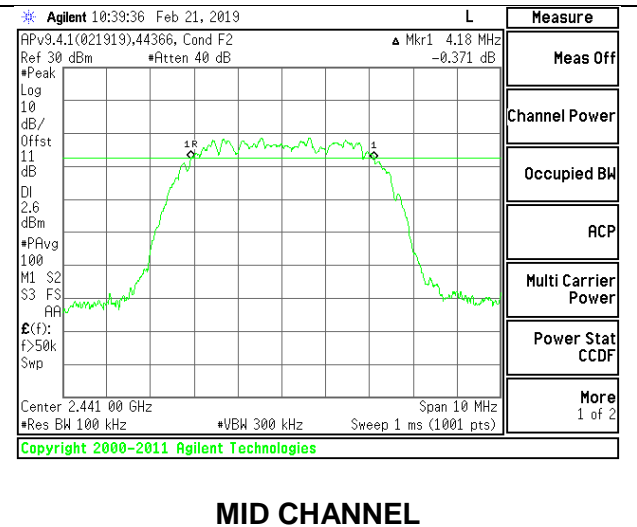
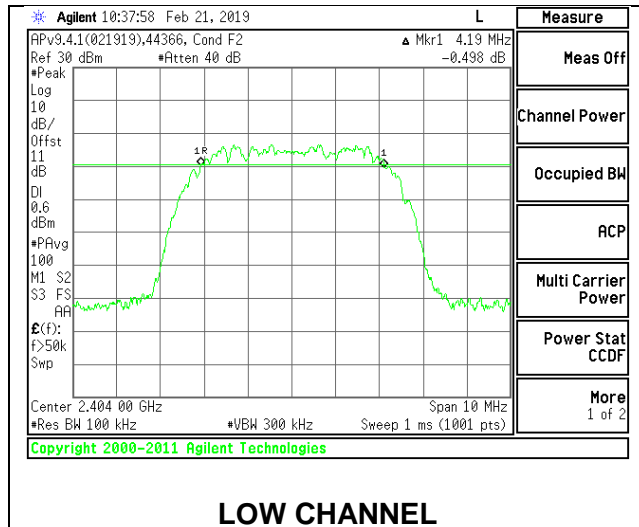
MID CHANNEL



HIGH CHANNEL

Antenna 5

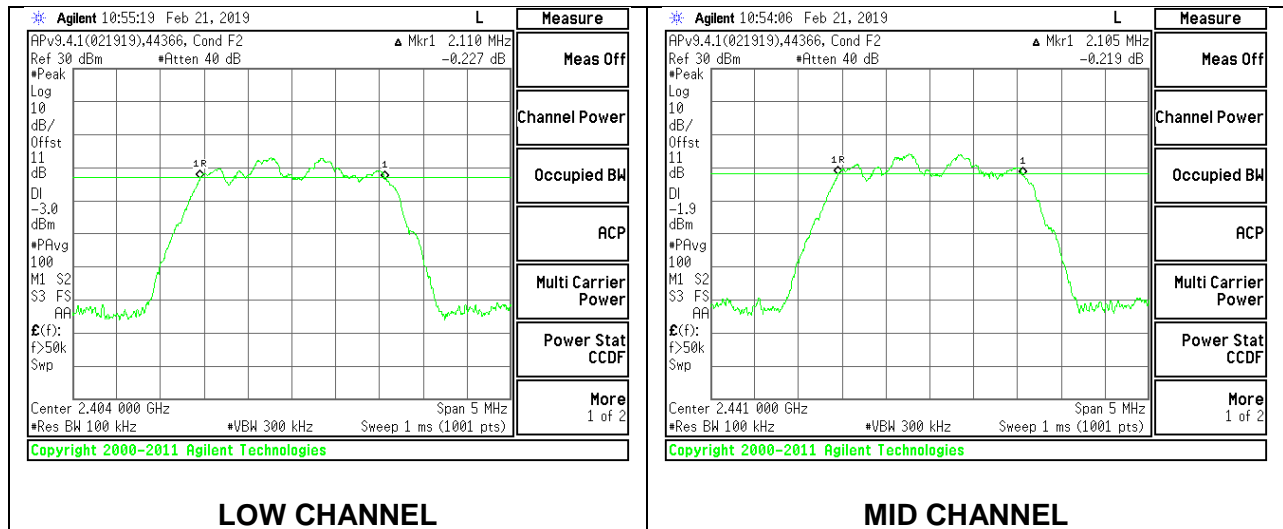
Channel	Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum Limit (MHz)
Low	2404	4.190	0.5
Middle	2441	4.180	0.5
High	2478	4.180	0.5



8.3.3. LOW POWER HDR (HDR4)

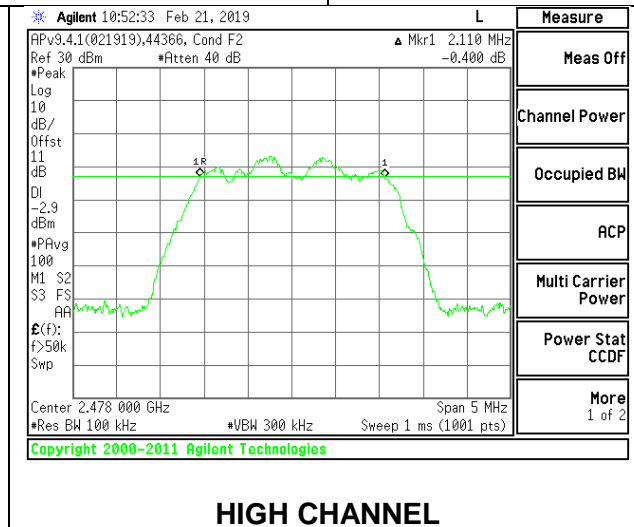
Antenna 2

Channel	Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum Limit (MHz)
Low	2404	2.110	0.5
Middle	2441	2.105	0.5
High	2478	2.110	0.5



LOW CHANNEL

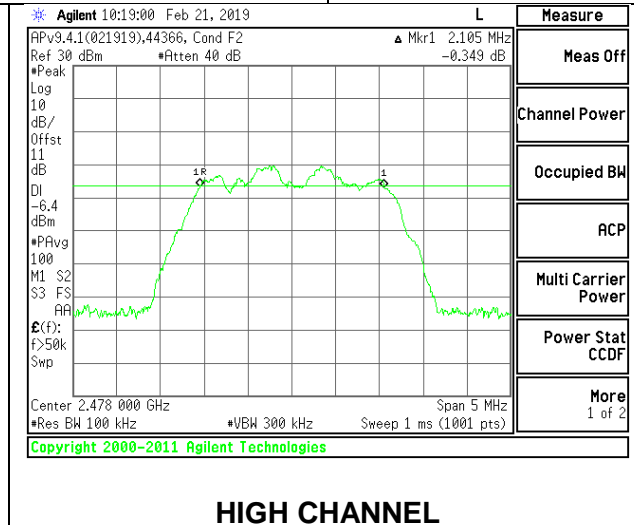
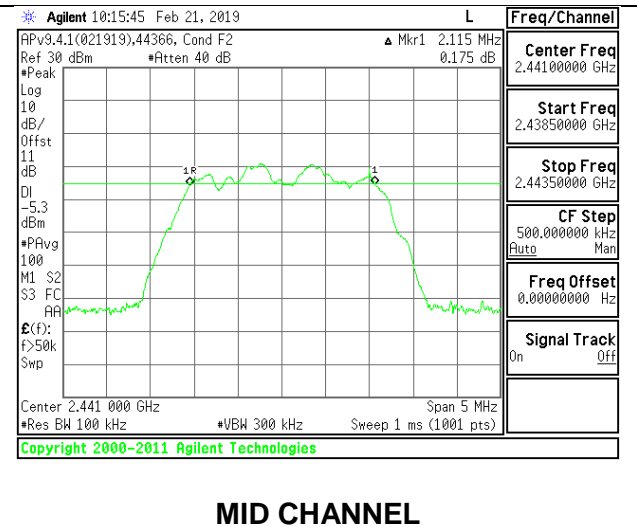
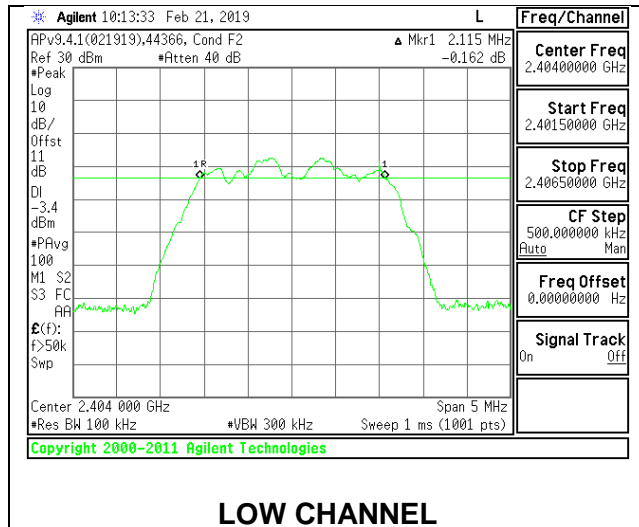
MID CHANNEL



HIGH CHANNEL

Antenna 5

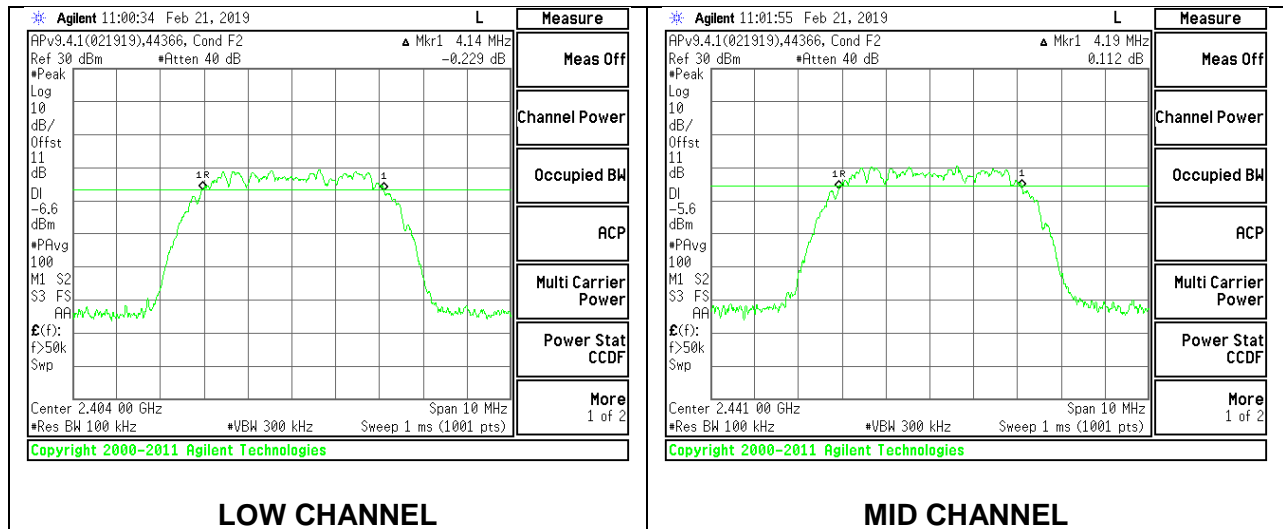
Channel	Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum Limit (MHz)
Low	2404	2.115	0.5
Middle	2441	2.115	0.5
High	2478	2.105	0.5



8.3.4. LOW POWER HDR (HDR8)

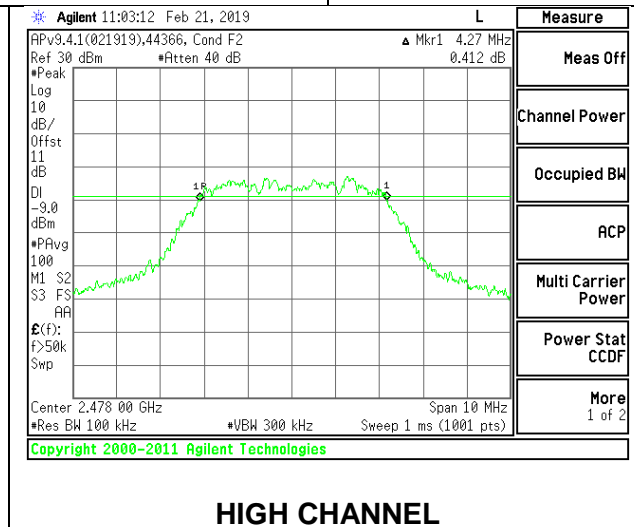
Antenna 2

Channel	Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum Limit (MHz)
Low	2404	4.140	0.5
Middle	2441	4.190	0.5
High	2478	4.270	0.5



LOW CHANNEL

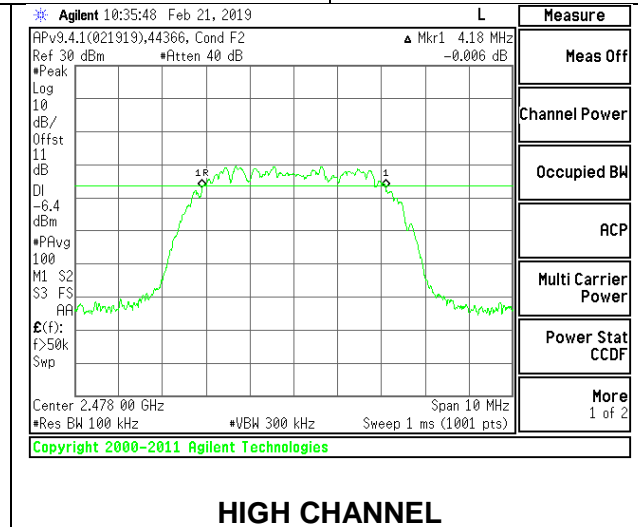
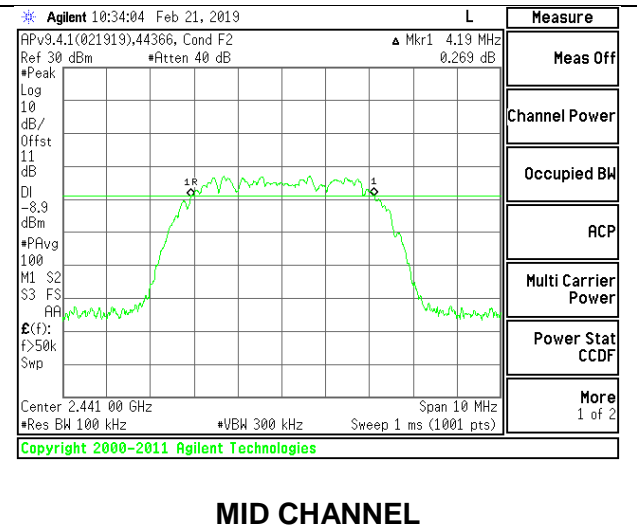
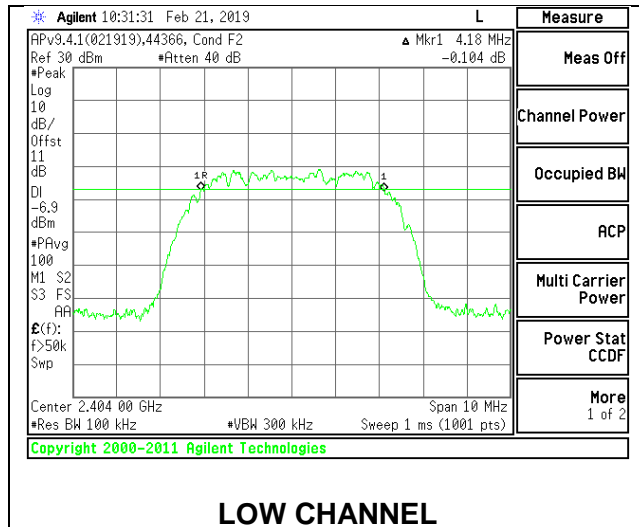
MID CHANNEL



HIGH CHANNEL

Antenna 5

Channel	Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum Limit (MHz)
Low	2404	4.180	0.5
Middle	2441	4.190	0.5
High	2478	4.180	0.5



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.

RESULTS

8.4.1. HIGH POWER HDR (HDR4)**Antenna 2**

Tested By:	39316
Date:	6/28/2019

Channel	Frequency (MHz)	Peak Power Reading (dBm)	Limit (dBm)	Margin (dB)
Low	2404	14.70	30	-15.30
Middle	2441	14.72	30	-15.28
High	2478	14.68	30	-15.32

Antenna 5

Tested By:	39316
Date:	6/28/2019

Channel	Frequency (MHz)	Peak Power Reading (dBm)	Limit (dBm)	Margin (dB)
Low	2404	14.71	30	-15.29
Middle	2441	14.73	30	-15.27
High	2478	14.69	30	-15.31

8.4.2. HIGH POWER HDR (HDR8)

Antenna 2

Tested By:	39316
Date:	6/28/2019

Channel	Frequency (MHz)	Peak Power Reading (dBm)	Limit (dBm)	Margin (dB)
Low	2404	15.25	30	-14.76
Middle	2441	15.26	30	-14.74
High	2478	15.23	30	-14.77

Antenna 5

Tested By:	39316
Date:	6/28/2019

Channel	Frequency (MHz)	Peak Power Reading (dBm)	Limit (dBm)	Margin (dB)
Low	2404	15.43	30	-14.57
Middle	2441	15.45	30	-14.55
High	2478	15.36	30	-14.64

8.4.3. LOW POWER HDR (HDR4)

Antenna 2

Tested By:	39316
Date:	6/28/2019

Channel	Frequency (MHz)	Peak Power Reading (dBm)	Limit (dBm)	Margin (dB)
Low	2404	8.67	30	-21.33
Middle	2441	8.94	30	-21.06
High	2478	9.01	30	-20.99

Antenna 5

Tested By:	39316
Date:	6/28/2019

Channel	Frequency (MHz)	Peak Power Reading (dBm)	Limit (dBm)	Margin (dB)
Low	2404	8.86	30	-21.14
Middle	2441	8.55	30	-21.45
High	2478	8.78	30	-21.22

8.4.4. LOW POWER HDR (HDR8)**Antenna 2**

Tested By:	39316
Date:	6/28/2019

Channel	Frequency (MHz)	Peak Power Reading (dBm)	Limit (dBm)	Margin (dB)
Low	2404	9.44	30	-20.56
Middle	2441	9.39	30	-20.61
High	2478	9.40	30	-20.60

Antenna 5

Tested By:	39316
Date:	6/28/2019

Channel	Frequency (MHz)	Peak Power Reading (dBm)	Limit (dBm)	Margin (dB)
Low	2404	9.69	30	-20.31
Middle	2441	9.34	30	-20.66
High	2478	9.43	30	-20.57

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