CERTIFICATION TEST REPORT

Report Number. : 12229692-E2V2

Applicant	:	MASIMO CORPORATION 52 Discovery Irvine, CA 92618-1604 USA
Model	:	Radical-7
FCC ID	:	VKF-RAD7B
IC	:	7362A-RAD7B
EUT Description	:	Pulse CO-Oximeter
Test Standard(s)	:	FCC 47 CFR PART 15 SUBPART C ISED RSS-247 ISSUE 2 ISED RSS-GEN ISSUE 5

Date Of Issue:
February 24, 2019

Prepared by:
UL Verification Services Inc.
47173 Benicia Street
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NVLAP TESTING
NVLAP LAB CODE 200065-0

REPORT REVISION HISTORY

Rev.	Issue Date	Revisions	Revised By
V1	5/2/2018	Initial Issue	
V2	2/25/2019	Updated per TCB reviewer's comments	Vien Tran

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1. ATTESTATION OF TEST RESULTS

COMPANY NAME: MASIMO CORPORATION
52 Discovery
Irvine, CA 92618-1604 USA

EUT DESCRIPTION: Pulse CO-Oximeter

MODEL: Radical-7

SERIAL NUMBER: 1000117295 (Radiated) & 1000117068 (Conducted)

DATE TESTED: April 09 –April 27, 2018

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
UL Verification Services Inc. By:

DAN CORONIA
CONSUMER TECHNOLOGY DIVISION
OPERATION LEADER
UL Verification Services Inc.

Prepared By:

ERIC YU
CONSUMER TECHNOLOGY DIVISION
TEST ENGINEER
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 v05, and 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, 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
☒ Chamber A (ISED:2324B-1)	☐ Chamber D (ISED:22541-1)
☒ Chamber B (ISED:2324B-2)	☐ Chamber E (ISED:22541-2)
☐ Chamber C (ISED:2324B-3)	☐ Chamber F (ISED:22541-3)
	☐ Chamber G (ISED:22541-4)
	☐ Chamber H (ISED:22541-5)

The above test sites and facilities are covered under FCC Test Firm Registration # 208313. Chambers A through C are covered under ISED company address code 2324B with site numbers 2324B -1 through 2324B-3, respectively. Chambers D through H are covered under ISED company address code 22541 with site numbers 22541 -1 through 22541-5, respectively.

UL Verification Services Inc. is accredited by NVLAP, Laboratory Code 200065-0. The full scope of accreditation can be viewed at http://nist.gov/standards/scopes/2000650.htm.

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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

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 dBuV + 18.7 dB/m + 0.6 dB – 26.9 dB = 28.9 dBuV/m

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	3.15 dB
Worst Case Radiated Disturbance, 30 to 1000 MHz	5.36 dB
Worst Case Radiated Disturbance, 1000 to 18000 MHz	4.32 dB
Worst Case Radiated Disturbance, 18000 to 26000 MHz	4.45 dB
Worst Case Radiated Disturbance, 26000 to 40000 MHz	5.24 dB

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

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5. EQUIPMENT UNDER TEST

5.1. EUT DESCRIPTION

The EUT is a pulse CO-Oximeter

5.2. MAXIMUM OUTPUT POWER

The transmitter has a maximum conducted output power as follows:

Frequency Range (MHz)	Mode	Output Power (dBm)	Output Power (mW)
2412 - 2472	802.11b	16.83	48.19
2412 - 2472	802.11g	15.32	34.04
2412 - 2472	802.11n HT20	13.68	23.33
2422 - 2452	802.11n HT40	13.12	20.51

5.3. DESCRIPTION OF AVAILABLE ANTENNAS

The radio utilizes an Ethertronics (P/N- 18046) with gain as specified in table below:

Frequency	Peak Gain
2.390-2.490GHz	2dB
5.150-5.350GHz	5dB
5.35-5.90GHz	6dB

5.4. SOFTWARE AND FIRMWARE

The test utility software used during testing was the following: iMX: E0847, MCU: 1064, MX: 7e23, WiFi: 7.45.100.7, Bluetooth:003.001.025.0143.0000.

5.5. WORST-CASE CONFIGURATION AND MODE

Radiated emissions below 1GHz, above 18GHz, and power line conducted emission were performed with the EUT set to transmit at the channel with highest output power as worst-case scenario.

Band edge and radiated emissions between 1GHz and 18GHz were performed with the EUT set to transmit at the highest power on low, middle and high channels.

The fundamental of the EUT was investigated in three orthogonal orientations X,Y,Z, it was determined that Y orientation was worst-case orientation; therefore, all final radiated testing was performed with the EUT in Y orientation.

Worst-case data rates as provided by the client were:

802.11b mode: 1 Mbps
802.11g mode: 6 Mbps
802.11n HT20mode: MCS0
802.11n HT40mode: MCS0

5.6. DESCRIPTION OF TEST SETUP

SUPPORT EQUIPMENT

Support Equipment List				
Description	**Manufacturer**	**Model**	**Serial Number**	**FCC ID**
Chaging Base	Masimo	RDS-1	291175	N/A
Debug Board	Masinmo	82444 REV A	1447700018	N/A
Laptop	Lenovo	T460	PC0C3DUA	N/A
AC Adaptor	Lenovo	ADLX65NCCZA	11S45N0263ZS9957G6W	N/A

I/O CABLES

I/O Cable List						
Cable No	**Port**	**# of identical ports**	**Connector Type**	**Cable Type**	**Cable Length (m)**	**Remarks**
1	AC	1	AC	AC	0.3	
2	AC	1	AC	AC	0.8	
3	USB	1	USB	unshielded	1.0	
4	Antenna	1	RF	Shielded	0.5	To spectrum Analyzer

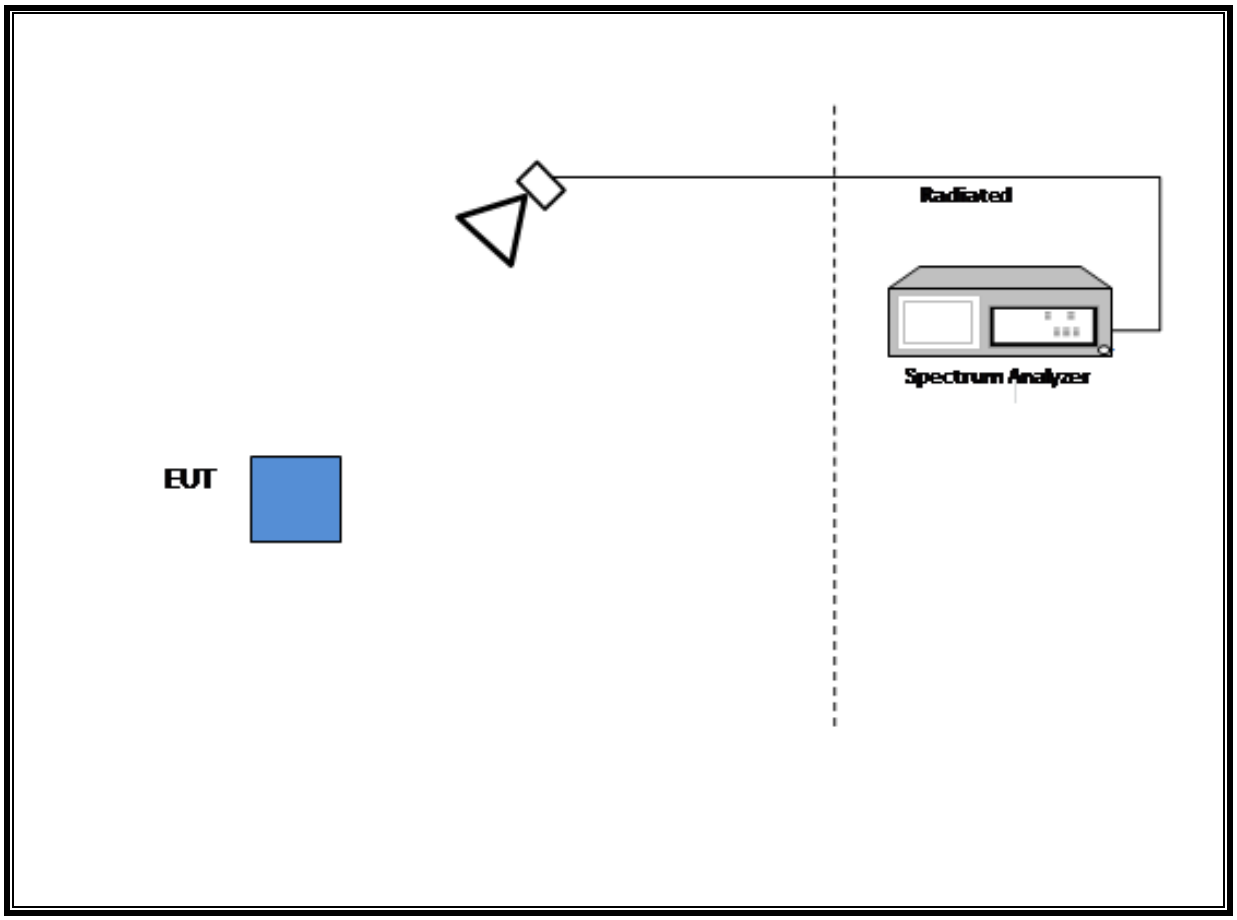
TEST SETUP

For conducted and AC Line tests: the EUT was docked on the charging base and connected to a host laptop via an USB cable, and a debug board for parameter setting purpose such as channel, output power...etc.

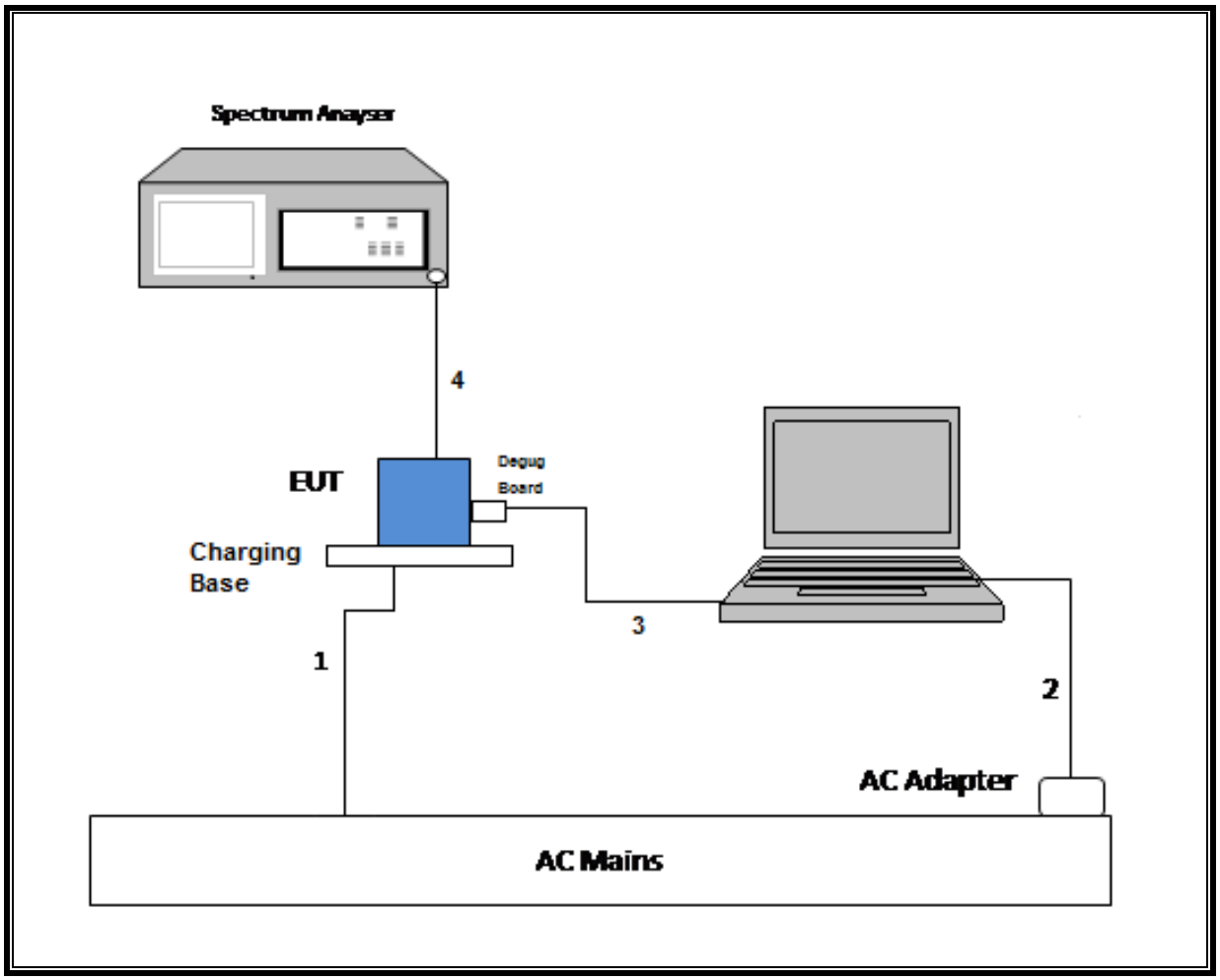
For radiated tests: All support equipment (charging base, host laptop, USB cable, and debug board) were removed after the EUT programmed.
The EUT was operated as stand-alone unit by 3.7VDC battery pack.

The test software exercises the radio.

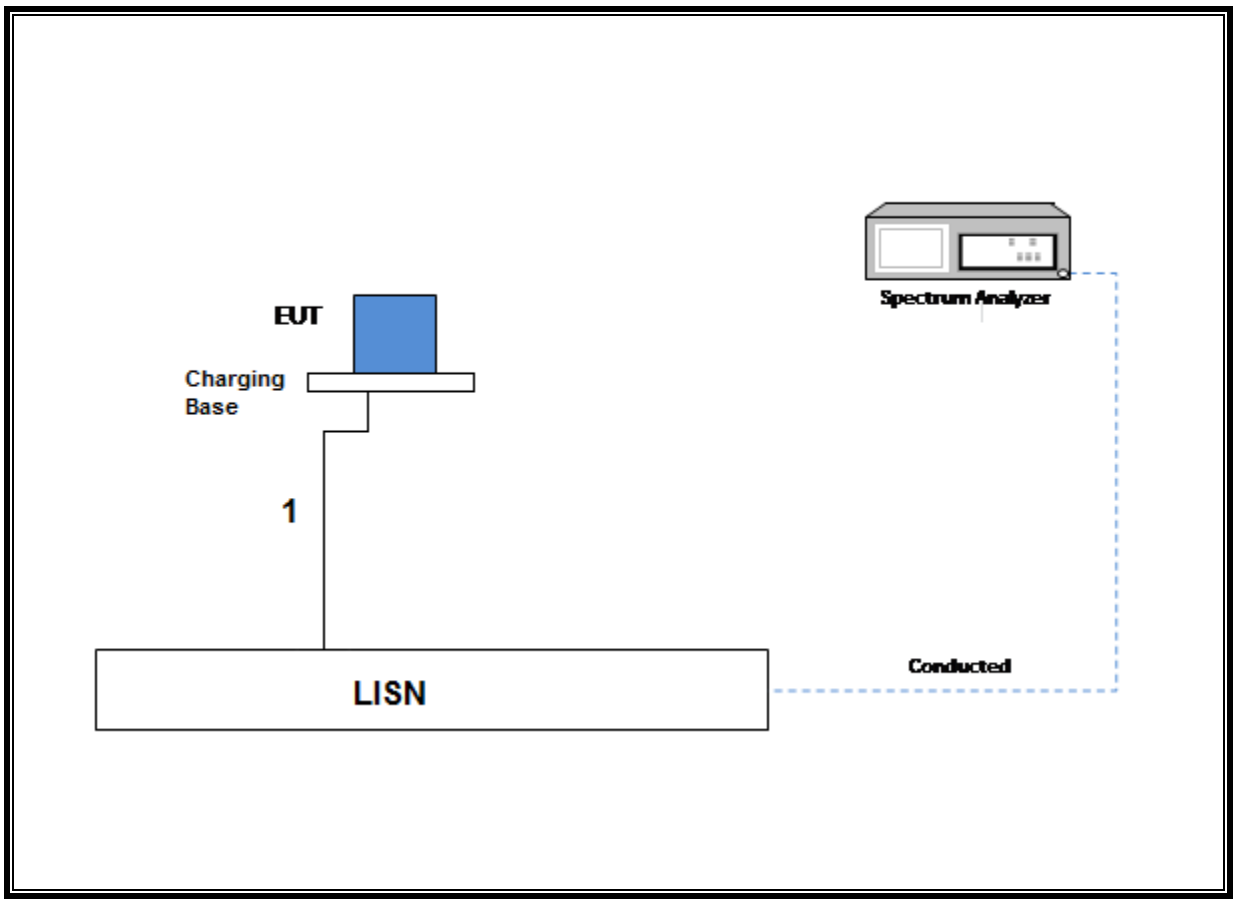
SETUP DIAGRAM FOR RADIATED



SETUP DIAGRAM FOR CONDUCTED TESTS



SETUP DIAGRAM FOR AC LC TESTS



6. MEASUREMENT METHOD

On Time and Duty Cycle: ANSI C63.10 Subclause -11.6

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

99% BW: ANSI C63.10-2013, Section 6.9.3.

Output Power: ANSI C63.10 Subclause -11.9.2.3.2 Method AVGPM-G (Measurement using a gated RF average-reading power meter)

PSD: ANSI C63.10 Subclause -11.10.3 Method AVGPSD-1

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 -11.13.3.4 Integration method -Trace averaging across ON and OFF times DC correction

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

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**	**Asset**	**Cal Due**
Amplifier, 10KHz to 1GHz, 32dB	Agilent (Keysight) Technologies	8447D	T15	08/14/2018
Amplifier, 1 - 18GHz	MITEQ	AFS42-00101800-25-S-42	T931	09/20/2018
RF Preamplifier, 1 - 26GHz	Agilent	8449B	T404	07/23/2018
Antenna, Broadband Hybrid, 30MHz to 2000MHz	Sunol Sciences Corp.	JB3	T130	06/15/2018
Antenna, Horn 1-18GHz	ETS-Lindgren	3117	T863	06/09/2018
Antenna Horn, 18 to 26GHz	ARA	MWH-1826/B	T449	06/12/2018
Power Meter, P-series single channel	Keysight	N1912A	T1245	05/12/2018
Power Sensor	Keysight	N1921A	T413	06/22/2018
Spectrum Analyzer, PXA, 3Hz to 44GHz	Agilent (Keysight) Technologies	N9030A	T1466	04/16/2019
Spectrum Analyzer, PXA, 3Hz to 44GHz	Agilent (Keysight) Technologies	N9030A	T1454	01/08/2019
Spectrum Analyzer, PXA, 3Hz to 44GHz	Agilent (Keysight) Technologies	N9030A	T1113	12/21/2018
AC Line Conducted				
EMI Test Receiver 9Khz-7GHz	Rohde & Schwarz	ESCI7	T1124	11/07/2018
LISN for Conducted Emissions CISPR-16	Fischer	50/250-25-2-01	T1310	06/15/2018
Power Cable, Line Conducted Emissions	UL	PG1	T861	08/31/2018
UL AUTOMATION SOFTWARE				
Radiated Software	UL	UL EMC	Ver 9.5, Dec 01, 2016	
Antenna Port Software	UL	UL EMC	Ver 7.9, Jan 24, 2018	
AC Line Conducted Software	UL	UL EMC	Ver 9.5, May 26, 2015	

NOTES:

1. Equipment listed above that calibrated during the testing period was set for test after the calibration.
2. Equipment listed above that has a calibration due date during the testing period, the testing is completed before equipment expiration date.

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8. ANTENNA PORT TEST RESULTS

8.1. ON TIME AND DUTY CYCLE

LIMITS

None; for reporting purposes only.

PROCEDURE

ANSI C63.10, Section 11.6 : Zero-Span Spectrum Analyzer Method.

ON TIME AND DUTY CYCLE RESULTS

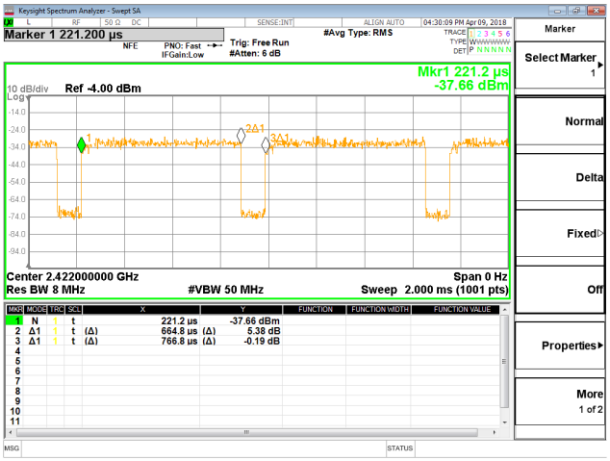
Mode	ON Time B (msec)	Period (msec)	Duty Cycle x (linear)	Duty Cycle (%)	Duty Cycle Correction Factor (dB)	1/B Minimum VBW (kHz)
2.4GHz Band						
802.11b 1TX	8.604	8.717	0.987	98.70%	0.00	0.010
802.11g 1TX	1.429	1.529	0.935	93.46%	0.29	0.700
802.11n HT20 1TX	1.336	1.436	0.930	93.04%	0.31	0.749
802.11n HT40 1TX	0.665	0.767	0.867	86.70%	0.62	1.504

DUTY CYCLE PLOTS

802.11b MODE

802.11g MODE

802.11n HT20 MODE



802.11n HT40 MODE

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8.2. 99% BANDWIDTH

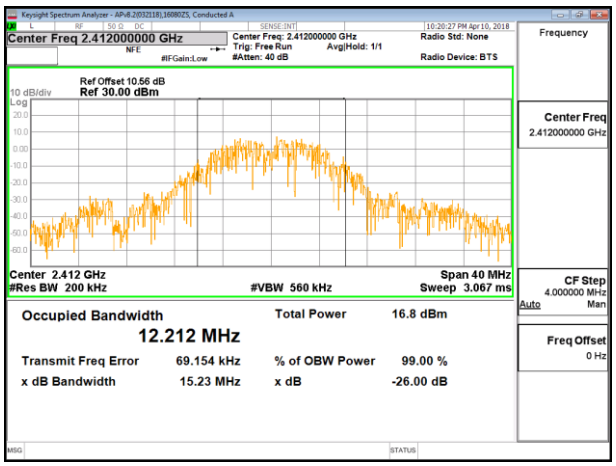
LIMITS

None; for reporting purposes only.

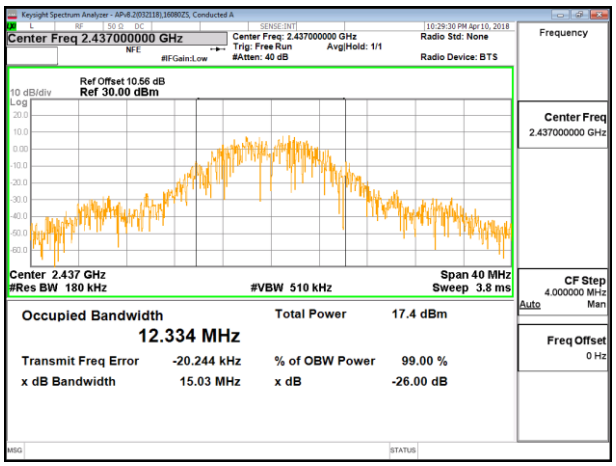
RESULTS

8.2.1. 802.11b MODE

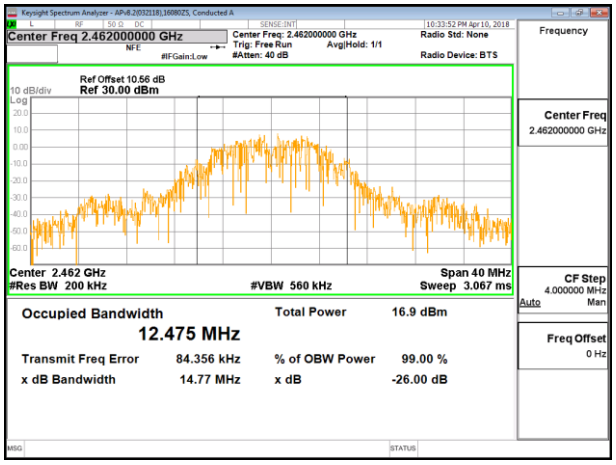
Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low 1	2412	12.212
Mid 6	2437	12.334
High 11	2462	12.475
High 12	2467	12.474
High 13	2472	12.184



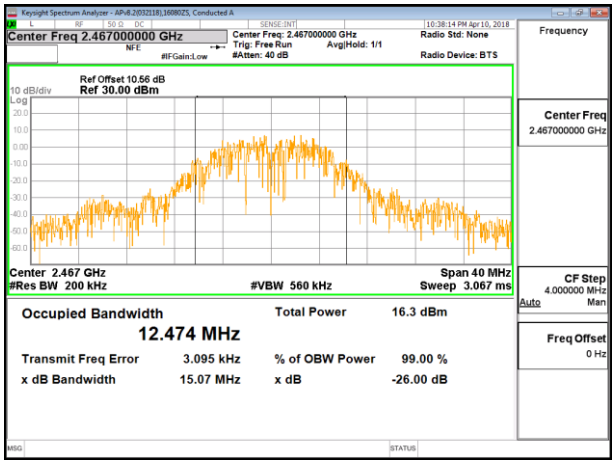
LOW CHANNEL 1



MID CHANNEL 6



HIGH CHANNEL 11



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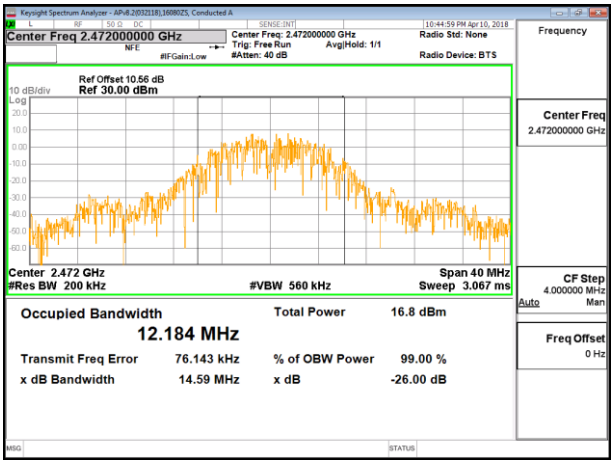
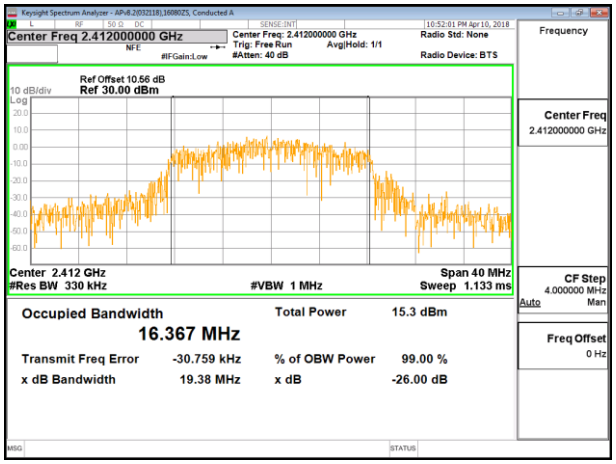


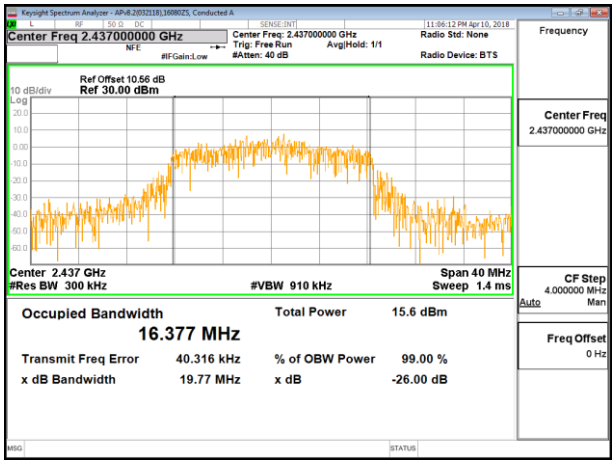
HIGH CHANNEL 13

8.2.2. 802.11g MODE

Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low 1	2412	16.367
Mid 6	2437	16.377
High 11	2462	16.349
High 12	2467	16.390
High 13	2472	16.396



LOW CHANNEL 1



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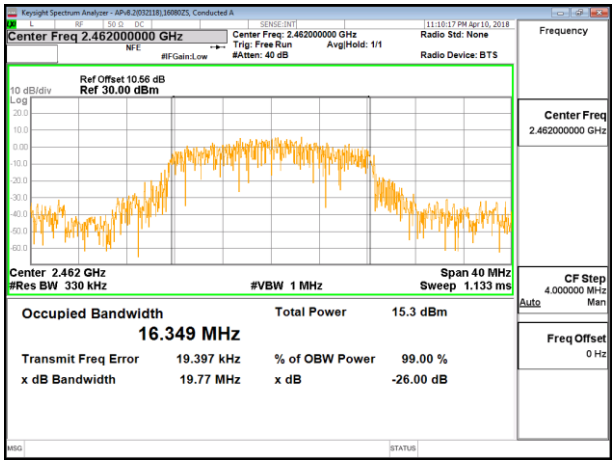

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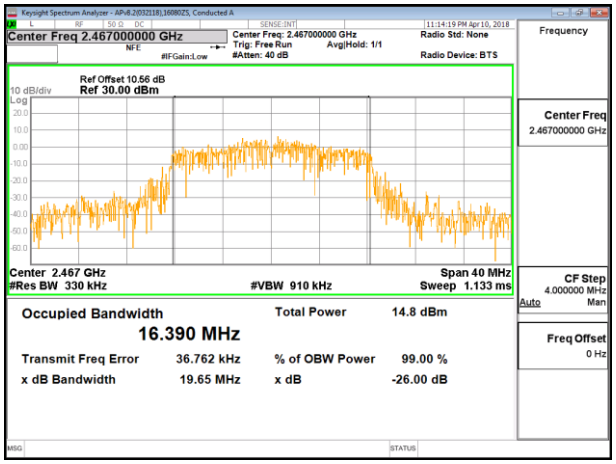

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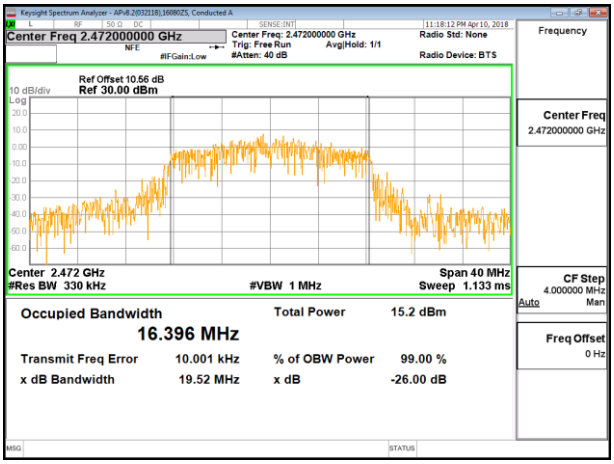
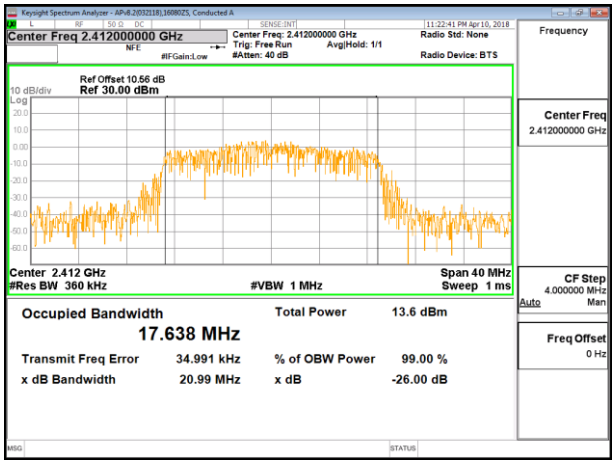


HIGH CHANNEL 13

8.2.3. 802.11n HT20 MODE

Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low 1	2412	17.638
Mid 6	2437	17.569
High 11	2462	17.685
High 12	2467	17.526
High 13	2472	17.564



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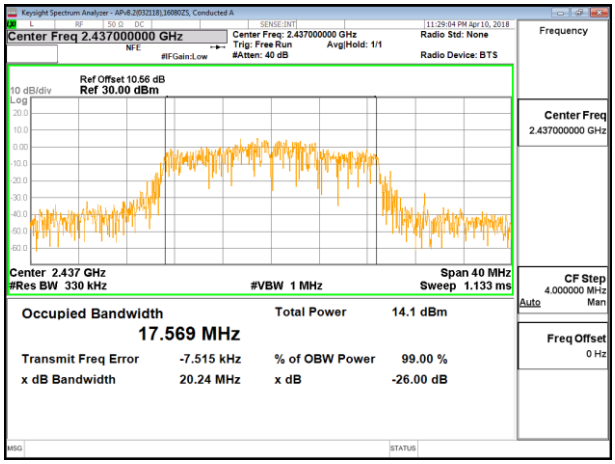

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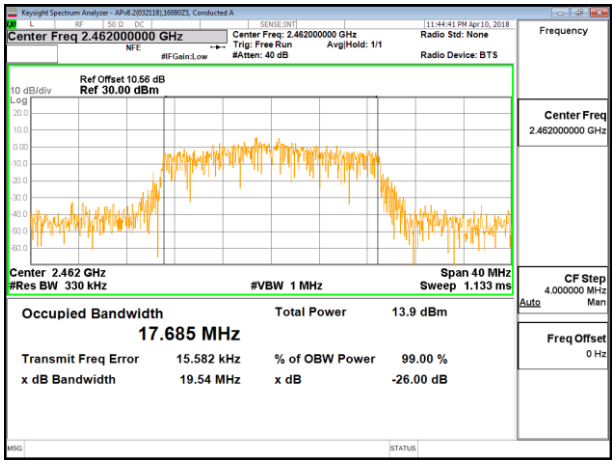

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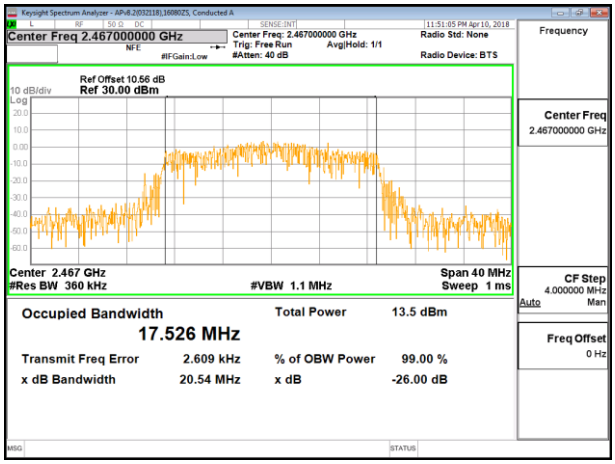

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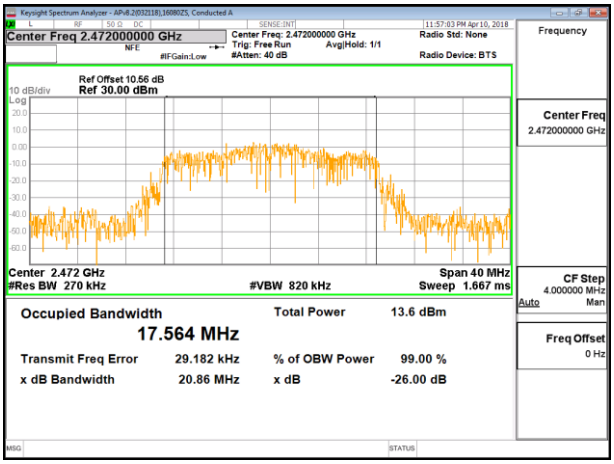
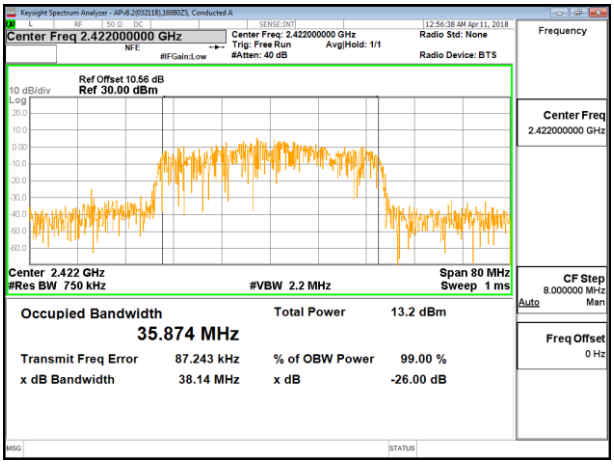


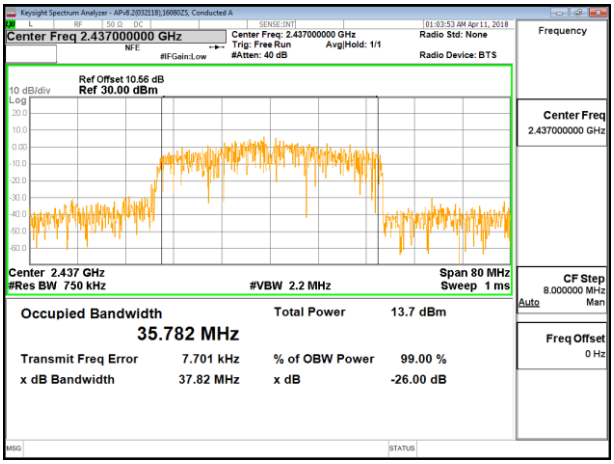
HIGH CHANNEL 13

8.2.4. 802.11n HT40 MODE

Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low 3	2422	35.874
Mid 6	2437	35.782
High 9	2452	35.968



LOW CHANNEL 3



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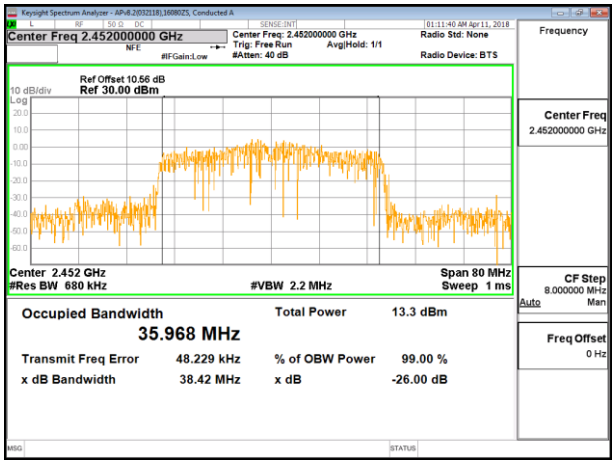


HIGH CHANNEL 9

8.3. 6 dB BANDWIDTH

LIMITS

FCC §15.247 (a) (2)

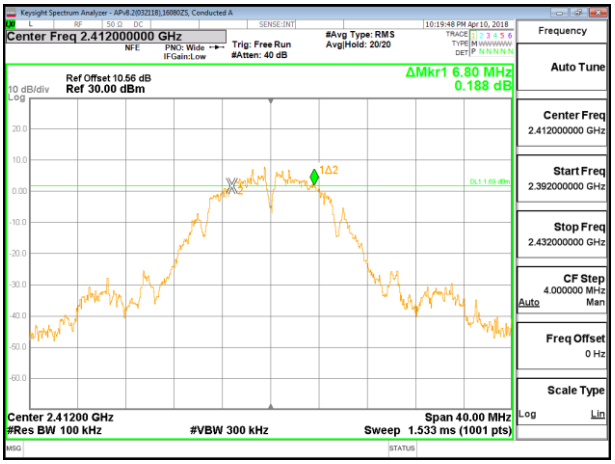
RSS-247 5.2 (a)

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

RESULTS

8.3.1. 802.11b MODE

Channel	Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum Limit (MHz)
Low 1	2412	6.80	0.5
Mid 6	2437	7.16	0.5
High 11	2462	8.56	0.5
High 12	2467	7.92	0.5
High 13	2472	7.64	0.5



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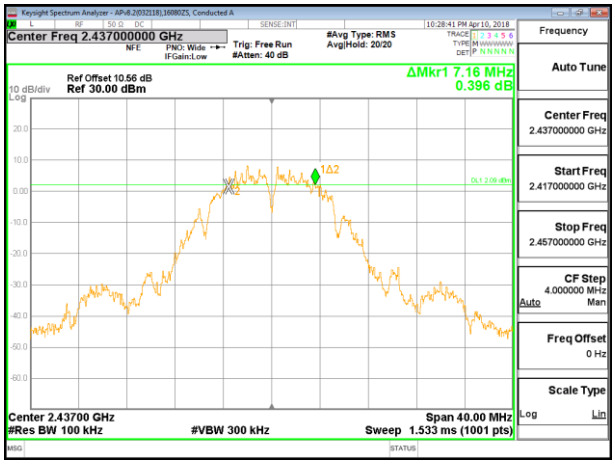

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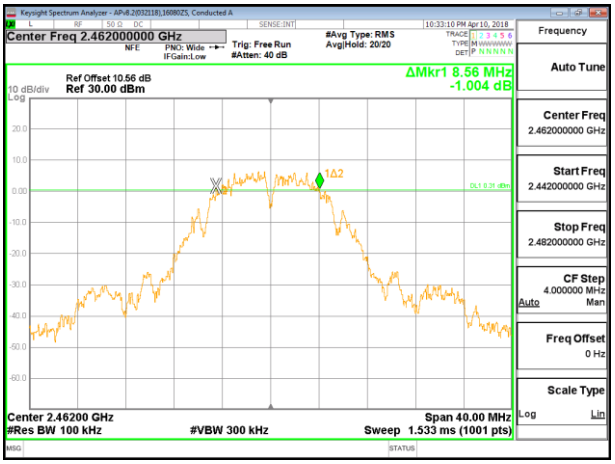

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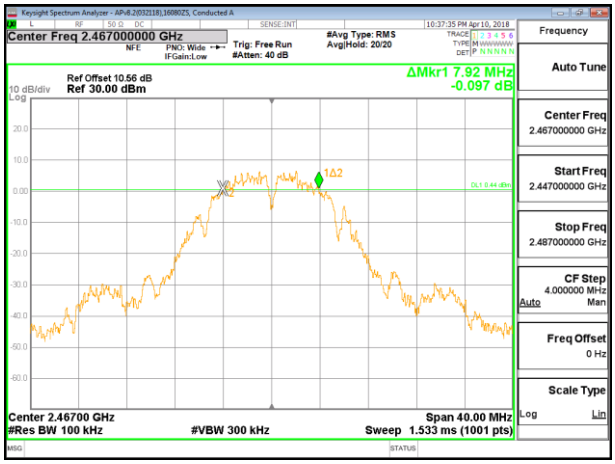
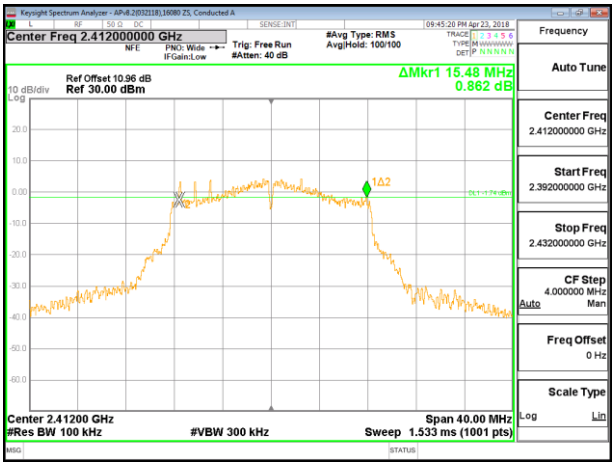


HIGH CHANNEL 12

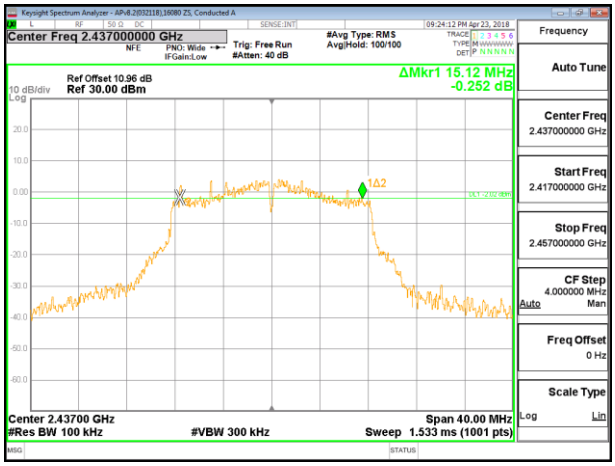
HIGH CHANNEL 13

8.3.2. 802.11g MODE

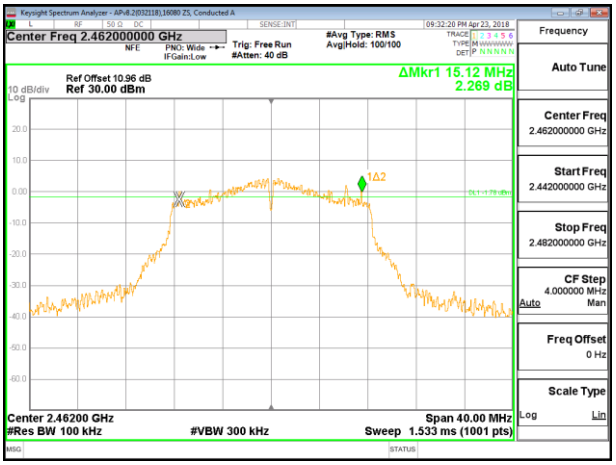
Channel	Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum Limit (MHz)
Low 1	2412	15.48	0.5
Mid 6	2437	15.12	0.5
High 11	2462	15.12	0.5
High 12	2467	15.04	0.5
High 13	2472	15.12	0.5



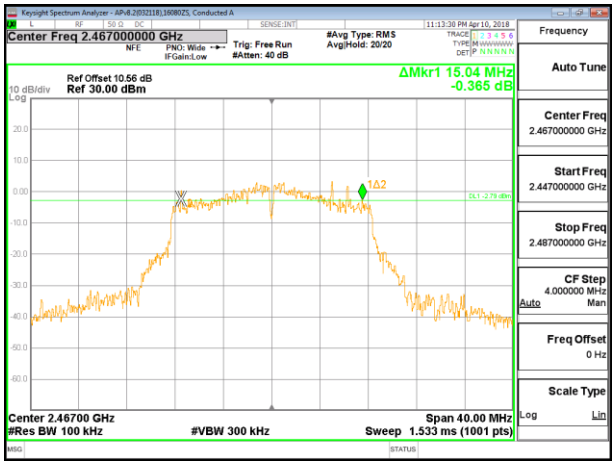
LOW CHANNEL 1



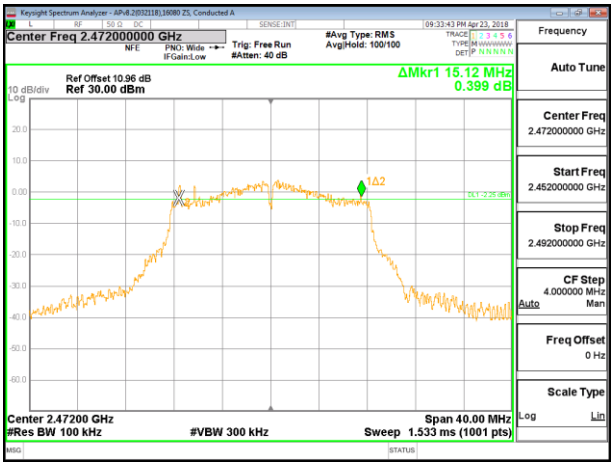
MID CHANNEL 6



HIGH CHANNEL 11



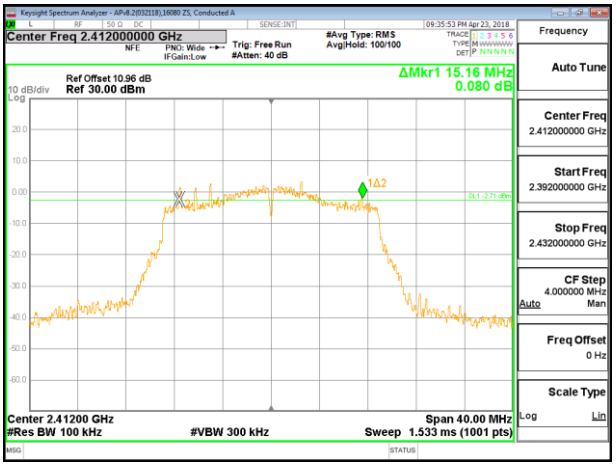
HIGH CHANNEL 12



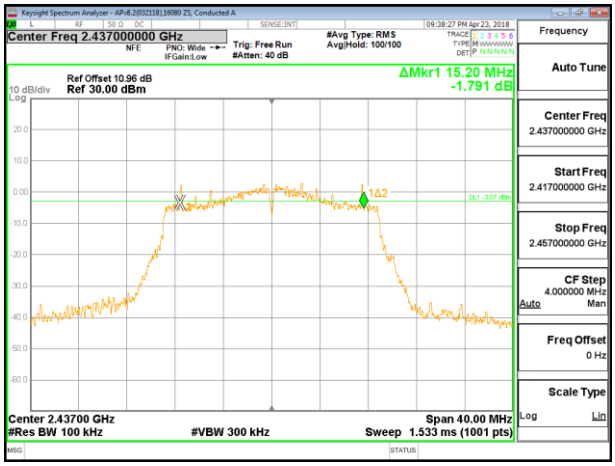
HIGH CHANNEL 13

8.3.3. 802.11n HT20 MODE

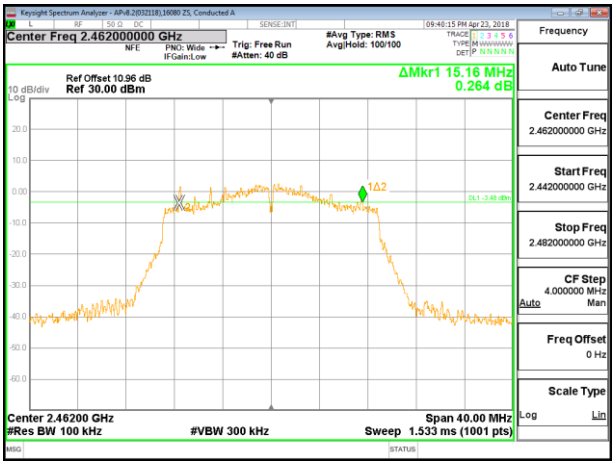
Channel	Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum Limit (MHz)
Low 1	2412	15.1600	0.5
Mid 6	2437	15.2000	0.5
High 11	2462	15.1600	0.5
High 12	2467	15.9200	0.5
High 13	2472	15.3600	0.5



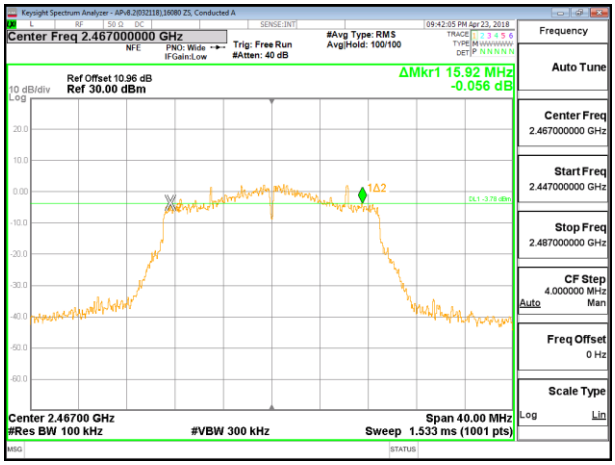
LOW CHANNEL 1



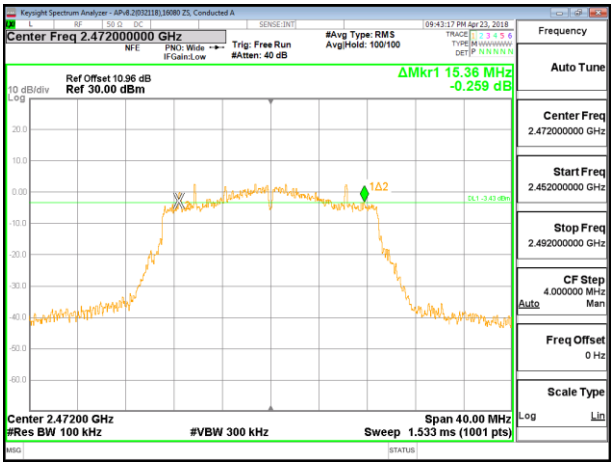
MID CHANNEL 6



HIGH CHANNEL 11



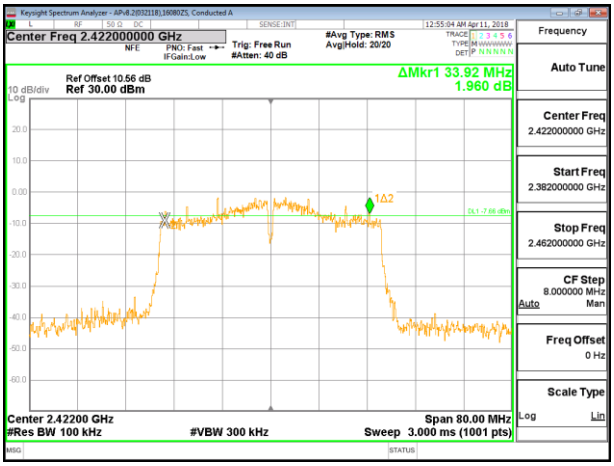
HIGH CHANNEL 12



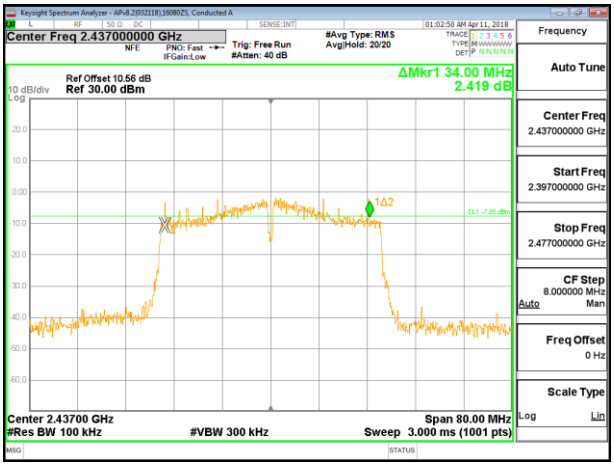
HIGH CHANNEL 13

8.3.4. 802.11n HT40 MODE

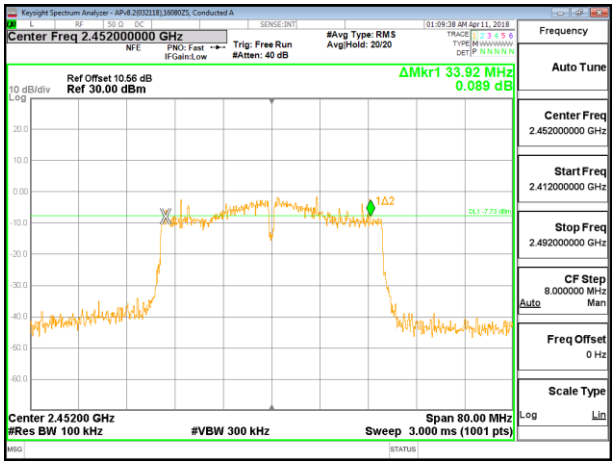
Channel	Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum Limit (MHz)
Low 3	2422	33.92	0.5
Mid 6	2437	34.00	0.5
High 9	2452	33.92	0.5



LOW CHANNEL 3



MID CHANNEL 6



HIGH CHANNEL 9

8.4. OUTPUT POWER

LIMITS

FCC §15.247 (b) (3)

RSS-247 5.4 (d)

For systems using digital modulation in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands: 1 Watt, based on the use of antennas with directional gains that do not exceed 6 dBi. If transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

TEST PROCEDURE

The transmitter output is connected to a power meter.

The cable assembly insertion loss of 10.96 dB (including 10 dB pad and 0.96 dB cable) was entered as an offset in the power meter to allow for a gated average reading of power.

RESULTS

8.4.1. 802.11b MODE

Limits

Channel	Frequency (MHz)	Directional Gain (dBi)	FCC Power Limit (dBm)	ISED Power Limit (dBm)	ISED EIRP Limit (dBm)	Max Power (dBm)
Low 1	2412	2.00	30.00	30	36	30.00
Mid 6	2437	2.00	30.00	30	36	30.00
High 11	2462	2.00	30.00	30	36	30.00
High 12	2467	2.00	30.00	30	36	30.00
High 13	2472	2.00	30.00	30	36	30.00

Results

Channel	Frequency (MHz)	Meas Power (dBm)	Total Corr'd Power (dBm)	Power Limit (dBm)	Margin (dB)
Low 1	2412	16.81	16.81	30.00	-13.19
Mid 6	2437	16.83	16.83	30.00	-13.17
High 11	2462	16.67	16.67	30.00	-13.33
High 12	2467	16.47	16.47	30.00	-13.53
High 13	2472	15.66	15.66	30.00	-14.34

8.4.2. 802.11g MODE

Limits

Channel	Frequency (MHz)	Directional Gain (dBi)	FCC Power Limit (dBm)	ISED Power Limit (dBm)	ISED EIRP Limit (dBm)	Max Power (dBm)
Low 1	2412	2.00	30.00	30	36	30.00
Mid 6	2437	2.00	30.00	30	36	30.00
High 11	2462	2.00	30.00	30	36	30.00
High 12	2467	2.00	30.00	30	36	30.00
High 13	2472	2.00	30.00	30	36	30.00

Results

Channel	Frequency (MHz)	Meas Power (dBm)	Total Corr'd Power (dBm)	Power Limit (dBm)	Margin (dB)
Low 1	2412	15.32	15.32	30.00	-14.68
Mid 6	2437	15.17	15.17	30.00	-14.83
High 11	2462	15.07	15.07	30.00	-14.93
High 12	2467	14.88	14.88	30.00	-15.12
High 13	2472	14.16	14.16	30.00	-15.84

8.4.3. 802.11n HT20 MODE

Limits

Channel	Frequency (MHz)	Directional Gain (dBi)	FCC Power Limit (dBm)	ISED Power Limit (dBm)	ISED EIRP Limit (dBm)	Max Power (dBm)
Low 1	2412	2.00	30.00	30	36	30.00
Mid 6	2437	2.00	30.00	30	36	30.00
High 11	2462	2.00	30.00	30	36	30.00
High 12	2467	2.00	30.00	30	36	30.00
High 13	2472	2.00	30.00	30	36	30.00

Results

Channel	Frequency (MHz)	Meas Power (dBm)	Total Corr'd Power (dBm)	Power Limit (dBm)	Margin (dB)
Low 1	2412	13.68	13.68	30.00	-16.32
Mid 6	2437	13.56	13.56	30.00	-16.44
High 11	2462	13.37	13.37	30.00	-16.63
High 12	2467	13.49	13.49	30.00	-16.51
High 13	2472	13.38	13.38	30.00	-16.62

8.4.4. 802.11n HT40 MODE

Limits

Channel	Frequency (MHz)	Directional Gain (dBi)	FCC Power Limit (dBm)	ISED Power Limit (dBm)	ISED EIRP Limit (dBm)	Max Power (dBm)
Low 3	2422	2.00	30.00	30	36	30.00
Mid 6	2437	2.00	30.00	30	36	30.00
High 9	2452	2.00	30.00	30	36	30.00

Results

Channel	Frequency (MHz)	Meas Power (dBm)	Total Corr'd Power (dBm)	Power Limit (dBm)	Margin (dB)
Low 3	2422	12.88	12.88	30.00	-17.12
Mid 6	2437	13.12	13.12	30.00	-16.88
High 9	2452	12.82	12.82	30.00	-17.18