CERTIFICATION TEST REPORT

Report Number. : 11949808-E4V4

Applicant	:	APPLE, INC. 1 INFINITE LOOP CUPERTINO, CA 95014, U.S.A.
Model	:	A1639
FCC ID	:	BCG-A1639
EUT Description	:	WIRELESS SPEAKER
Test Standard(s)	:	FCC 47 CFR PART 15 SUBPART C

Date Of Issue:
November 08, 2017

Prepared by:
UL Verification Services Inc.
47173 Benicia Street
Fremont, CA 94538, U.S.A.
TEL: (510) 771-1000
FAX: (510) 661-0888

NVLAP LAB CODE 200065-0

REPORT REVISION HISTORY

Rev.	Issue Date	Revisions	Revised By
V1	10/9/2017	Initial Issue	--
V2	10/11/2017	Updated Straddle channels	Tri Pham
V3	10/16/2017	Address TCB questions	Jin Li
V4	11/08/2017	Address TCB questions	Chin Pang

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

TABLE OF CONTENTS

REPORT REVISION HISTORY 2

TABLE OF CONTENTS 3

1. ATTESTATION OF TEST RESULTS 7

2. FACILITIES AND ACCREDITATION 8

3. TEST METHODOLOGY 8

4. CALIBRATION AND UNCERTAINTY 8

4.1. MEASURING INSTRUMENT CALIBRATION 8

4.2. SAMPLE CALCULATION 8

4.3. MEASUREMENT UNCERTAINTY 9

5. SUMMARY OF TESTING 9

6. MEASUREMENT METHOD 10

7. TEST AND MEASUREMENT EQUIPMENT 11

8. EQUIPMENT UNDER TEST 12

8.1. DESCRIPTION OF EUT 12

8.2. MAXIMUM OUTPUT POWER 12

8.3. SOFTWARE AND FIRMWARE 15

8.4. DESCRIPTION OF AVAILABLE ANTENNAS 15

8.5. WORST-CASE CONFIGURATION AND MODE 16

8.6. DESCRIPTION OF TEST SETUP 17

10. ANTENNA PORT TEST RESULTS 27

10.1. 26 dB BANDWIDTH 27

10.1.1. 802.11n HT20 MODE IN THE 5.2 GHz BAND 27
10.1.2. 802.11n HT40 MODE IN THE 5.2 GHz BAND 32
10.1.3. 802.11ac VHT80 MODE IN THE 5.2 GHz BAND 35
10.1.4. 802.11n HT20 MODE IN THE 5.3 GHz BAND 37
10.1.5. 802.11n HT40 MODE IN THE 5.3 GHz BAND 42
10.1.6. 802.11ac VHT80 MODE IN THE 5.3 GHz BAND 46
10.1.7. 802.11n HT20 MODE IN THE 5.6 GHz BAND 48
10.1.8. 802.11n HT40 MODE IN THE 5.6 GHz BAND 53
10.1.9. 802.11ac VHT80 MODE IN THE 5.6 GHz BAND 58
10.1.10. 802.11n HT20 MODE IN THE 5.8 GHz BAND 62
10.1.11. 802.11n HT40 MODE IN THE 5.8 GHz BAND 66
10.1.12. 802.11ac VHT80 MODE IN THE 5.8 GHz BAND 68

10.2. 99% BANDWIDTH 70

10.2.1. 802.11n HT20 MODE IN THE 5.2 GHz BAND 70
10.2.2. 802.11n HT40 MODE IN THE 5.2 GHz BAND 75

UL VERIFICATION SERVICES INC. FORM NO: CCSUP4701J
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

10.2.3. 802.11ac VHT80 MODE IN THE 5.2 GHz BAND 78
10.2.4. 802.11n HT20 MODE IN THE 5.3 GHz BAND 80
10.2.5. 802.11n HT40 MODE IN THE 5.3 GHz BAND 85
10.2.6. 802.11ac VHT80 MODE IN THE 5.3 GHz BAND 88
10.2.7. 802.11n HT20 MODE IN THE 5.6 GHz BAND 90
10.2.8. 802.11n HT40 MODE IN THE 5.6 GHz BAND 95
10.2.9. 802.11ac VHT80 MODE IN THE 5.6 GHz BAND 100
10.2.10. 802.11n HT20 MODE IN THE 5.8 GHz BAND 104
10.2.11. 802.11n HT40 MODE IN THE 5.8 GHz BAND 108
10.2.12. 802.11ac VHT80 MODE IN THE 5.8 GHz BAND 110

10.3. 6 dB BANDWIDTH 112
10.3.1. 802.11n HT20 MODE IN THE 5.8 GHz BAND 113
10.3.2. 802.11n HT40 MODE IN THE 5.8 GHz BAND 117
10.3.3. 802.11ac VHT80 MODE IN THE 5.8 GHz BAND 121

10.4. OUTPUT POWER AND PSD 123
10.4.1. 802.11n HT20 MODE IN THE 5.2 GHz BAND 125
10.4.2. 802.11n HT40 MODE IN THE 5.2 GHz BAND 133
10.4.3. 802.11ac VHT80 MODE IN THE 5.2 GHz BAND 141
10.4.4. 802.11n HT20 MODE IN THE 5.3 GHz BAND 147
10.4.5. 802.11n HT40 MODE IN THE 5.3 GHz BAND 155
10.4.6. 802.11ac VHT80 MODE IN THE 5.3 GHz BAND 163
10.4.7. 802.11n HT20 MODE IN THE 5.6 GHz BAND 169
10.4.8. 802.11n HT40 MODE IN THE 5.6 GHz BAND 178
10.4.9. 802.11ac VHT80 MODE IN THE 5.6 GHz BAND 187
10.4.10. 802.11n HT20 MODE IN THE 5.8 GHz BAND 193
10.4.11. 802.11n HT40 MODE IN THE 5.8 GHz BAND 202
10.4.12. 802.11ac VHT80 MODE IN THE 5.8 GHz BAND 211

10.5. TPC POWER 217
10.5.1. 802.11n HT20 TPC POWER, ANTENNA A, 1TX 217
10.5.2. 802.11n HT20 TPC POWER, ANTENNA B, 1TX 218
10.5.3. 802.11n HT20 TPC POWER, 2TX ANTENNA A + ANTENNA B CDD 219
10.5.4. 802.11n HT20 TPC POWER, 2TX ANTENNA A + ANTENNA B STBC 221
10.5.5. 802.11n HT40 TPC POWER, ANTENNA A, 1TX 223
10.5.6. 802.11n HT40 TPC POWER, ANTENNA B, 1TX 224
10.5.7. 802.11n HT40 TPC POWER, 2TX ANTENNA A + ANTENNA B, CDD 225
10.5.8. 802.11n HT40 TPC POWER, 2TX ANTENNA A + ANTENNA B, STBC 227
10.5.9. 802.11ac VHT80 TPC POWER, ANTENNA A, 1TX 229
10.5.10. 802.11ac VHT80 TPC POWER, ANTENNA B, 1TX 230
10.5.11. 802.11ac VHT80 TPC POWER, 2TX ANTENNA A + ANTENNA B, CDD 231

11. RADIATED TEST RESULTS 233

11.1. TRANSMITTER ABOVE 1 GHz 234
11.1.1. TX ABOVE 1 GHz 802.11n HT20 MODE IN THE 5.2 GHz BAND 234
11.1.2. TX ABOVE 1 GHz 802.11n HT40 MODE IN THE 5.2 GHz BAND 246
11.1.3. TX ABOVE 1 GHz 802.11ac VHT80 MODE IN THE 5.2 GHz BAND 256
11.1.4. TX ABOVE 1 GHz 802.11n HT20 MODE IN THE 5.3 GHz BAND 264
11.1.5. TX ABOVE 1 GHz 802.11n HT40 MODE IN THE 5.3 GHz BAND 276
11.1.6. TX ABOVE 1 GHz 802.11ac VHT80 MODE IN THE 5.3 GHz BAND 280
11.1.7. TX ABOVE 1 GHz 802.11n HT20 MODE IN THE 5.6 GHz BAND 288
11.1.8. TX ABOVE 1 GHz 802.11n HT40 MODE IN THE 5.6 GHz BAND 308
11.1.9. TX ABOVE 1 GHz 802.11ac VHT80 MODE IN THE 5.6 GHz BAND 328

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

11.1.10. TX ABOVE 1 GHz 802.11n HT20 MODE IN THE 5.8 GHz BAND.....346
11.1.11. TX ABOVE 1 GHz 802.11n HT40 MODE IN THE 5.8 GHz BAND.....364
11.1.12. TX ABOVE 1 GHz 802.11ac VHT80 MODE IN THE 5.8 GHz BAND 380

11.2. Worst Case Below 1 GHz.....394

11.3. Worst Case 18-26 GHz 396

11.4. Worst Case 26-40 GHz 398

12. AC POWER LINE CONDUCTED EMISSIONS.....400

13. DYNAMIC FREQUENCY SELECTION.....403

13.1. OVERVIEW.....403
13.1.1. LIMITS.....403
13.1.2. TEST AND MEASUREMENT SYSTEM.....407
13.1.3. TEST AND MEASUREMENT SOFTWARE 409
13.1.4. TEST ROOM ENVIRONMENT 409
13.1.5. SETUP OF EUT (CLIENT MODE) 410
13.1.6. SETUP OF EUT (CLIENT TO CLIENT MODE).....411
13.1.7. SETUP OF EUT (PEER TO PEER MODE).....411
13.1.8. DESCRIPTION OF EUT 413

13.2. CLIENT MODE RESULTS FOR 20 MHz BANDWIDTH.....415
13.2.1. TEST CHANNEL 415
13.2.2. RADAR WAVEFORM AND TRAFFIC.....415
13.2.3. OVERLAPPING CHANNEL TESTS.....418
13.2.4. MOVE AND CLOSING TIME 418

13.3. CLIENT MODE RESULTS FOR 40 MHz BANDWIDTH.....422
13.3.1. TEST CHANNEL 422
13.3.2. RADAR WAVEFORM AND TRAFFIC.....422
13.3.3. OVERLAPPING CHANNEL TESTS.....425
13.3.4. MOVE AND CLOSING TIME 425

13.4. CLIENT MODE RESULTS FOR 80 MHz BANDWIDTH.....429
13.4.1. TEST CHANNEL 429
13.4.2. RADAR WAVEFORM AND TRAFFIC.....429
13.4.3. OVERLAPPING CHANNEL TESTS.....432
13.4.4. MOVE AND CLOSING TIME 432
13.4.5. 30-MINUTE NON-OCCUPANCY PERIOD.....436

13.5. CLIENT-TO-CLIENT COMMUNICATIONS MODE RESULTS FOR 20 MHz BANDWIDTH.....437
13.5.1. TEST CHANNEL 437
13.5.2. RADAR WAVEFORM AND TRAFFIC.....437
13.5.3. OVERLAPPING CHANNEL TESTS.....440
13.5.4. MOVE AND CLOSING TIME 440

13.6. CLIENT-TO-CLIENT COMMUNICATIONS MODE RESULTS FOR 40 MHz BANDWIDTH.....444
13.6.1. TEST CHANNEL 444
13.6.2. RADAR WAVEFORM AND TRAFFIC.....444
13.6.3. OVERLAPPING CHANNEL TESTS.....447
13.6.4. MOVE AND CLOSING TIME 447

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

13.7. CLIENT-TO-CLIENT COMMUNICATIONS MODE RESULTS FOR 80 MHz BANDWIDTH....451
13.7.1. TEST CHANNEL 451
13.7.2. RADAR WAVEFORM AND TRAFFIC....451
13.7.3. OVERLAPPING CHANNEL TESTS....454
13.7.4. MOVE AND CLOSING TIME 454
13.7.5. 30-MINUTE NON-OCCUPANCY PERIOD....458

13.8. PEER TO PEER MODE EUT RESULTS FOR 20 MHz BANDWIDTH....459
13.8.1. TEST CHANNEL 459
13.8.2. RADAR WAVEFORM AND TRAFFIC....459
13.8.3. OVERLAPPING CHANNEL TESTS....462
13.8.4. MOVE AND CLOSING TIME 462

13.9. PEER TO PEER MODE EUT RESULTS FOR 40 MHz BANDWIDTH....466
13.9.1. TEST CHANNEL 466
13.9.2. RADAR WAVEFORM AND TRAFFIC....466
13.9.3. OVERLAPPING CHANNEL TESTS....469
13.9.4. MOVE AND CLOSING TIME 469

13.10. PEER TO PEER MODE EUT RESULTS FOR 80 MHz BANDWIDTH....473
13.10.1. TEST CHANNEL 473
13.10.2. RADAR WAVEFORM AND TRAFFIC....473
13.10.3. OVERLAPPING CHANNEL TESTS....476
13.10.4. MOVE AND CLOSING TIME 476
13.10.5. 30-MINUTE NON-OCCUPANCY PERIOD....480

13.11. PEER TO PEER MODE PEER SLAVE DEVICE RESULTS FOR 20 MHz BANDWIDTH....481
13.11.1. TEST CHANNEL 481
13.11.2. RADAR WAVEFORM AND TRAFFIC....481
13.11.3. OVERLAPPING CHANNEL TESTS....484
13.11.4. MOVE AND CLOSING TIME 484

13.12. PEER TO PEER MODE PEER SLAVE DEVICE RESULTS FOR 40 MHz BANDWIDTH....488
13.12.1. TEST CHANNEL 488
13.12.2. RADAR WAVEFORM AND TRAFFIC....488
13.12.3. OVERLAPPING CHANNEL TESTS....491
13.12.4. MOVE AND CLOSING TIME 491

13.13. PEER TO PEER MODE PEER SLAVE DEVICE RESULTS FOR 80 MHz BANDWIDTH....495
13.13.1. TEST CHANNEL 495
13.13.2. RADAR WAVEFORM AND TRAFFIC....495
13.13.3. OVERLAPPING CHANNEL TESTS....498
13.13.4. MOVE AND CLOSING TIME 498
13.13.5. 30-MINUTE NON-OCCUPANCY PERIOD....502

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

1. ATTESTATION OF TEST RESULTS

COMPANY NAME: APPLE, INC.
1 INFINITE LOOP
CUPERTINO, CA 95014, U.S.A.

EUT DESCRIPTION: WIRELESS SPEAKER

MODEL: A1639

SERIAL NUMBER: CC4V228DJ5Y3

DATE TESTED: AUGUST 10, 2017 – OCTOBER 03, 2017

APPLICABLE STANDARDS	
STANDARD	**TEST RESULTS**
CFR 47 Part 15 Subpart E	Pass
INDUSTRY CANADA RSS-247 Issue 1	Pass
INDUSTRY CANADA RSS-GEN Issue 4	Pass

UL Verification Services Inc. tested the above equipment in accordance with the requirements set forth in the above standards. All indications of Pass/Fail in this report are opinions expressed by UL Verification Services Inc. based on interpretations and/or observations of test results. Measurement Uncertainties were not taken into account and are published for informational purposes only. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

Note: The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. 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 any government.

Approved & Released For
UL Verification Services Inc. By:

Chin Pang
CONSUMER TECHNOLOGY DIVISION
Senior Engineer
UL Verification Services Inc.

Prepared By:

Tri Phan
CONSUMER TECHNOLOGY DIVISION
TEST ENGINEER
UL Verification Services Inc.

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

2. 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 (IC:2324B-1)	☐ Chamber D (IC:22541-1)
☐ Chamber B (IC:2324B-2)	☐ Chamber E (IC:22541-2)
☐ Chamber C (IC:2324B-3)	☒ Chamber F (IC:22541-3)
	☐ Chamber G (IC:22541-4)
	☐ Chamber H (IC:22541-5)

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

3. TEST METHODOLOGY

FCC: The tests documented in this report were performed in accordance with FCC CFR 47 Part 2, FCC CFR 47 Part 15, FCC 14-30, FCC KDB 662911 D01 v02r01, FCC KDB 905462 D02 v02/D03 v01r02/D06 v02/ D07 v02, FCC KDB 789033 D02 v01r04, FCC KDB 644545 D03 v01, ANSI C63.10-2013.
The tests documented in this report were performed in accordance with the DFS portion of FCC CFR 47 Part 2, FCC CFR 47 Part 15, FCC 06-96, FCC KDB 789033, KDB 905462 D02 and D03 and RSS-247 Issue 2

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

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

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
Occupied Channel Bandwidth	±0.39 %
Time	±0.02 %

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

5. SUMMARY OF TESTING

SUMMARY TABLE

FCC Part Section	RSS Section	Test Description	Test Limit	Test Condition	Test Result
§15.407 (a)	RSS-247	Occupied Band width (26dB)	N/A	Conducted	Pass
§15.407	RSS-247 6.2.4	6dB Band width (5.8Ghz)	>500KHz		Pass
§15.407 (a)(1)	RSS-247 6.2	TX Cond. Power5.15-5.25 GHz	<24dBm (FCC) / <23 dBm EIRP or <10+10Log(99% BW) EIRP (IC)		Pass
§15.407 (a)(2)	RSS-247 6.2	TX Cond. Power 5.25-5.35 & 5.47-5.725 GHz	<24dBm or <11+10log (OBW) (FCC) / <24 dBm or <11+10Log(99% BW) (IC)		Pass
§15.407 (a)(3)	RSS-247 6.2.4	TX Cond. Power 5.725-5.850 GHz	<30dBm		Pass
§15.407 (a)(1)	RSS-247 6.2	PSD (5.15-5.25 GHz)	<11dBm/MHz (FCC) <10 dBm/MHz EIRP (IC)		Pass
§15.407 (a)(2)	RSS-247 6.2	PSD (5.3,5.5GHz)	<11dBm/MHz		Pass
§15.407 (a)(3)	RSS-247 6.2.4	PSD (5.8GHz)	<30dBm per 500kHz		
§15.207 (a) §15.407(b) (6)	RSS-GEN 8.8	AC Power Line conducted emissions	Section 10		Pass
§15.407 (b) & 15.209	RSS-GEN 8.9/7	Radiated Spurious Emission	<54dBuV/m	Radiated	Pass
§15.407 (h)(2)	RSS-247 6.3	Dynamic Frequency Selection	N/A	Radiated / Condcuted	Pass

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

6. MEASUREMENT METHOD

6 dB Emission BW: KDB 789033 D02 v01r04, Section C.

26 dB Emission BW: KDB 789033 D02 v01r04, Section C.

99% Occupied BW: KDB 789033 D02 v01r04, Section D.

Conducted Output Power: KDB 789033 D02 v01r04, Section E.3.b (Method PM-G).

Power Spectral Density: KDB 789033 D02 v01r04, Section F (Method SA-2).

Unwanted emissions in restricted bands: KDB 789033 D02 v01r04, Sections G.3, G.4, G.5, and G.6.
Unwanted emissions in non-restricted bands: KDB 789033 D02 v01r04, Sections G.3, G.4, and G.5.
AC Power-line conducted emissions: ANSI C63.10-2013, Section 6.2.

UL VERIFICATION SERVICES INC. FORM NO: CCSUP4701J
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

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**
Antenna, Horn 1-18GHz	ETS Lindgren	3117	T711	1/30/2018
Amplifier, 1 to 18GHz	Miteq	AFS42-00101800-25-S-42	T740	11/29/17
Spectrum Analyzer, PXA 3Hz to 44GHz	Keysight	N9030A	T340	12/14/2017
Antenna, Horn 1-18GHz	ETS Lindgren	3117	T346	3/28/2018
Amplifier, 1 to 18GHz	Miteq	AFS42-00101800-25-S-42	T741	11/29/2017
Spectrum Analyzer, PXA 3Hz to 44GHz	Keysight	N9030A	T906	2/14/2018
Antenna, Horn 1-18GHz	ETS Lindgren	3117	T119	3/28/2018
Antenna, Broadband Hybrid, 30MHz to 2000MHz	Sunol Sciences	JB1	T122	1/31/2018
Amplifier, 1 to 18GHz	Miteq	AFS42-00101800-25-S-42	T742	11/29/2017
Amplifier, 10KHz to 1GHz, 32dB	Sonoma	310N	T173	6/24/2018
Spectrum Analyzer, PSA, 3Hz to 44GHz	Agilent (Keysight) Technologies	E4446A	T177	03/20/2018
Spectrum Analyzer, PXA 3Hz to 44GHz	Keysight	N9030A	T1613	12/2/2017
Antenna Horn, 18 to 26GHz	ARA	MWH-1826	T89	1/04/2018
Antenna, Horn 26.5GHz to 40GHz	ARA	MWH-2640/B	T90	8/25/2018
Amplifier 26-40Ghz	Miteq	NSP 4000 SP2	T88	4/29/2018
Pre-Amp 18-26GHz	Agilent Technology	8449B	T404	7/23/2018
Power Meter, P-series single channel	Keysight	N1912A	T1245	1/05/2018
Power Sensor	Keysight	N1921A	T1224	1/31/2018
AC Line Conducted				
EMI Test Receiver 9Khz-7GHz	Rohde & Schwarz	ESCI7	T1436	01/06/2018
LISN for Conducted Emissions CISPR-16	Fischer	50/250-25-2-01	T1310	06/15/2018
Power Cable, Line Conducted Emissions	UL	PG1	T861	8/31/2018
UL AUTOMATION SOFTWARE				
Radiated Software	UL	UL EMC	Ver 9.5, April 26, 2016	
Conducted Software	UL	UL EMC	Ver 5.4, October 13, 2016	
AC Line Conducted Software	UL	UL EMC	Ver 9.5, May 26, 2015	

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

8. EQUIPMENT UNDER TEST

8.1. DESCRIPTION OF EUT

The EUT is a wireless speaker with multimedia function, IEEE 802.11a/b/g/n/ac radio and Bluetooth radio. It has no rechargeable battery. It is powered by 100-240V 50-60Hz, 1A AC supply line.

8.2. MAXIMUM OUTPUT POWER

The transmitter has a maximum conducted output power as follows:

5.2GHz Band

Frequency Range (MHz)	Mode	Output Power (dBm)	Output Power (mW)
5180 - 5240	802.11a	Covered by 802.11n HT20 SISO	
	802.11n HT20 SISO	19.99	99.77
	802.11n VHT20 1TX	Covered by 802.11n HT20 SISO	
	802.11n HT20 CDD 2TX	18.92	77.98
	802.11n HT20 STBC 2TX	19.96	99.08
	802.11ac VHT20 SDM 2TX	Covered by 802.11n HT20 2TX CDD	
5190 - 5230	802.11n HT40 SISO	20.95	124.45
	802.11n VHT40 1TX	Covered by 802.11n HT20 SISO	
	802.11n HT40 CDD 2TX	21.43	139.00
	802.11n HT40 STBC 2TX	22.42	174.58
	802.11ac VHT40 SDM 2TX	Covered by 802.11n HT40 2TX CDD	
5210	802.11ac VHT80 SISO	13.99	25.06
	802.11ac VHT80 CDD 2TX	16.44	44.06
	802.11ac VHT80 STBC/SDM 2TX	Covered by 802.11ac VHT80 2TX CDD	

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

5.3GHz Band

Frequency Range (MHz)	Mode	Output Power (dBm)	Output Power (mW)
5260 - 5320	802.11a	Covered by 802.11n HT20 SISO	
	802.11n HT20 SISO	19.88	97.27
	802.11n VHT20 1TX	Covered by 802.11n HT20 SISO	
	802.11n HT20 CDD 2TX	18.78	75.51
	802.11n HT20 STBC 2TX	19.91	97.95
	802.11ac VHT20 SDM 2TX	Covered by 802.11n HT20 2TX CDD	
5270 - 5310	802.11n HT40 SISO	20.85	121.62
	802.11n VHT40 1TX	Covered by 802.11n HT40 SISO	
	802.11n HT40 CDD 2TX	21.46	139.96
	802.11n HT40 STBC 2TX	22.46	176.20
	802.11ac VHT40 SDM 2TX	Covered by 802.11n HT40 2TX CDD	
5290	802.11ac VHT80 SISO	14.92	31.05
	802.11ac VHT80 CDD 2TX	16.90	48.98
	802.11ac VHT80 STBC/SDM 2TX	Covered by 802.11ac HT80 2TX CDD	

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

5.6GHz Band

Frequency Range (MHz)	Mode	Output Power (dBm)	Output Power (mW)
5500 - 5700	802.11a	Covered by 802.11n HT20 SISO	
5500 - 5700	802.11n HT20 SISO	19.88	97.27
	802.11n VHT20 1TX	Covered by 802.11n HT20 SISO	
5720	802.11ac VHT20 SISO (based on UNII-2C band output power)	19.89	97.57
5500 - 5700	802.11n HT20 CDD 2TX	18.84	76.56
	802.11n HT20 STBC 2TX	19.90	97.72
	802.11ac VHT20 SDM 2TX	Covered by 802.11n HT20 CDD 2TX	
5720	802.11ac VHT20 CDD 2TX (based on UNII-2C band output power)	18.94	78.34
	802.11ac VHT20 STBC 2TX (based on UNII-2C band output power)	16.82	48.08
5510 - 5670	802.11n HT40 SISO	20.88	122.46
	802.11n HT40 1TX	Covered by 802.11n HT40 SISO	
5710	802.11ac VHT40 SISO (based on UNII-2C band output power)	20.68	116.90
5510 - 5670	802.11n HT40 CDD 2TX	21.44	139.32
	802.11n HT40 STBC 2TX	22.48	177.01
	802.11ac VHT40 SDM 2TX	Covered by 802.11n HT40 CDD 2TX	
5710	802.11ac VHT40 CDD 2TX (based on UNII-2C band output power)	18.36	68.55
	802.11ac VHT40 STBC 2TX (based on UNII-2C band output power)	19.40	87.10
5530-5610	802.11ac VHT80 SISO	18.89	77.45
5690	802.11ac VHT80 SISO (based on UNII-2C band output power)	20.76	119.12
5530-5610	802.11ac VHT80 CDD 2TX	20.77	119.40
	802.11ac VHT80 STBC/SDM 2TX	Covered by 802.11ac VHT80 CDD 2TX	
5690	802.11ac VHT80 CDD 2TX (based on UNII-2C band output power)	23.73	236.05
	802.11ac VHT80 STBC/SDM 2TX	Covered by 802.11ac VHT80 CDD 2TX	

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

5.8GHz Band

Frequency Range (MHz)	Mode	Output Power (dBm)	Output Power (mW)
5745 - 5825	802.11a	Covered by 802.11n HT20 SISO	
	802.11n HT20 SISO	20.93	123.88
	802.11n VHT20 1TX	Covered by 802.11n HT20 SISO	
	802.11n HT20 CDD 2TX	23.71	234.96
	802.11n HT20 STBC/SDM 2TX, 802.11ac VHT20 STBC/SDM 2TX	Covered by 802.11n HT20 CDD 2TX	
5755 - 5795	802.11n HT40 SISO	19.83	96.16
	802.11n VHT40 1TX	Covered by 802.11n HT40 SISO	
	802.11n HT40 CDD 2TX	22.38	172.98
	802.11n HT40 STBC/SDM 2TX, 802.11ac VHT40 STBC/SDM 2TX	Covered by 802.11n HT40 CDD 2TX	
5775	802.11ac VHT80 SISO	18.93	78.16
	802.11ac VHT80 CDD 2TX	20.65	116.14
	802.11ac VHT80 STBC/SDM 2TX	Covered by 802.11ac VHT80 CDD 2TX	

8.3. SOFTWARE AND FIRMWARE

The firmware installed in the EUT during testing was version 15A420.

8.4. DESCRIPTION OF AVAILABLE ANTENNAS

The radio utilizes an FPCB antenna, with a maximum gains are as follows.

Antenna Num	Peak Gain (dBi) 5150-5250 MHz	Peak Gain (dBi) 5250-5350 MHz	Peak Gain (dBi) 5470-5725 MHz	Peak Gain (dBi) 5725-5850 MHz
A	3.6	3.1	2.7	2.7
B	1.8	2.8	4.0	4.8

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

8.5. WORST-CASE CONFIGURATION AND MODE

For radiated harmonics spurious below 1GHz, 1-18GHz L/M/H channels, 18-40GHz, and power line conducted emissions were performed with the EUT set at the CDD mode among the CDD/STBC/SDM modes with power setting equal or higher than SISO modes as worst-case scenario.

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

For SISO modes, there are two transmission antennas. The antenna used in any given time can be either Ant A or Ant B. Both antenna ports have the same power; output power and PSD measurement for SISO modes on both antennas are reported. For MIMO modes, both Ant A and Ant B used at the same time.

EUT was tested at normal operating standup Y-axis position.

Worst-case data rates as provided by the client were:
Based on the baseline scan, the worst-case data rates were:

802.11a mode: 6 Mbps
802.11n HT20mode: MCS0
802.11n HT40mode: MCS0
802.11ac VHT80 mode: MCS0

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.

For simultaneous transmission of multiple channels from the same antenna in the 2.4GHz and 5GHz bands, tests were conducted for various configurations having the highest power. No noticeable new emission was found.

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

8.6. DESCRIPTION OF TEST SETUP

SUPPORT EQUIPMENT

Support Equipment List				
Description	Manufacturer	Model	Serial Number	FCC ID
Laptop AC/DC adapter	Liteon Technology	PA-1450-BA1	B123	NA
Laptop	Apple	MackBook Air 4	NA	NA
Dongle	N/A	N/A	HDG1409226823	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	3	N/A

I/O CABLES (RADIATED ABOVE 1 GHZ)

I/O Cable List						
Cable No	Port	# of identical ports	Connector Type	Cable Type	Cable Length (m)	Remarks
1	AC	1	AC	Un-shielded	3	N/A

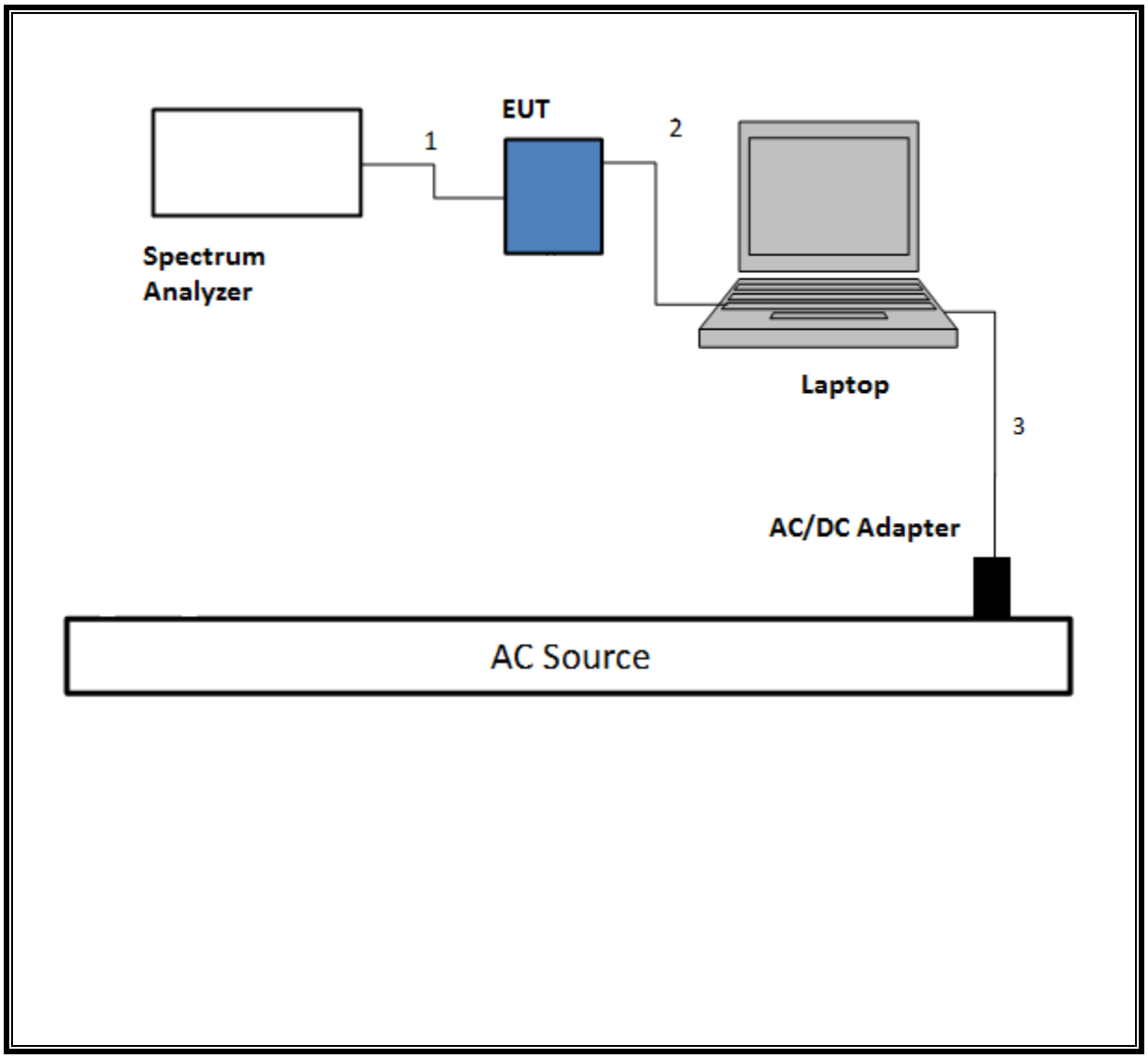
I/O CABLES (AC POWER CONDUCTED TEST AND BELOW 1 GHZ)

I/O Cable List						
Cable No	Port	# of identical ports	Connector Type	Cable Type	Cable Length (m)	Remarks
1	AC	1	AC	Un-shielded	3	N/A

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

TEST SETUP FOR CONDUCTED TESTS

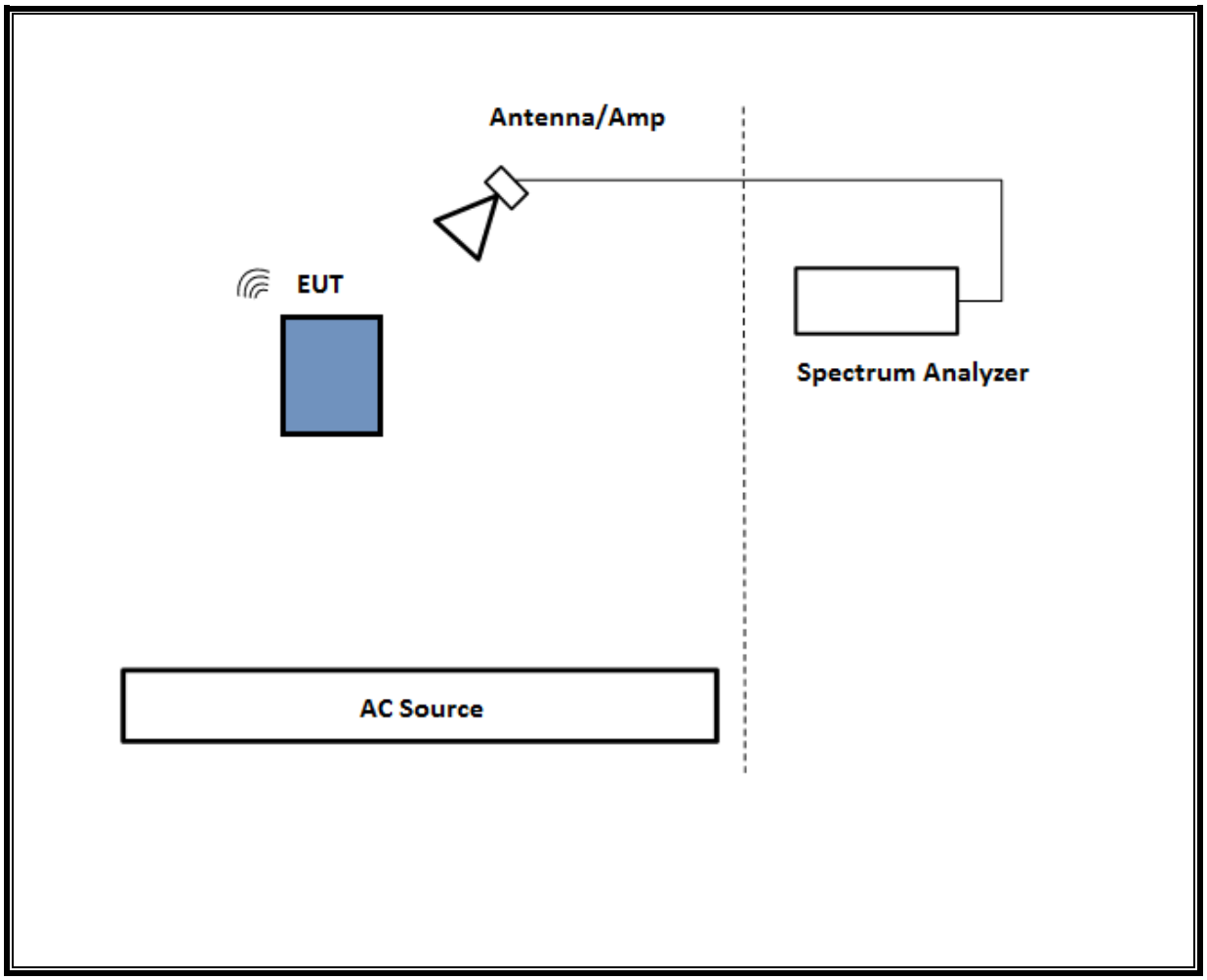
The EUT was tested connected to a host Laptop via USB cable adapter and spectrum analyzer to antenna port. Test software exercised the EUT.



This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

TEST SETUP FOR RADIATED TESTS

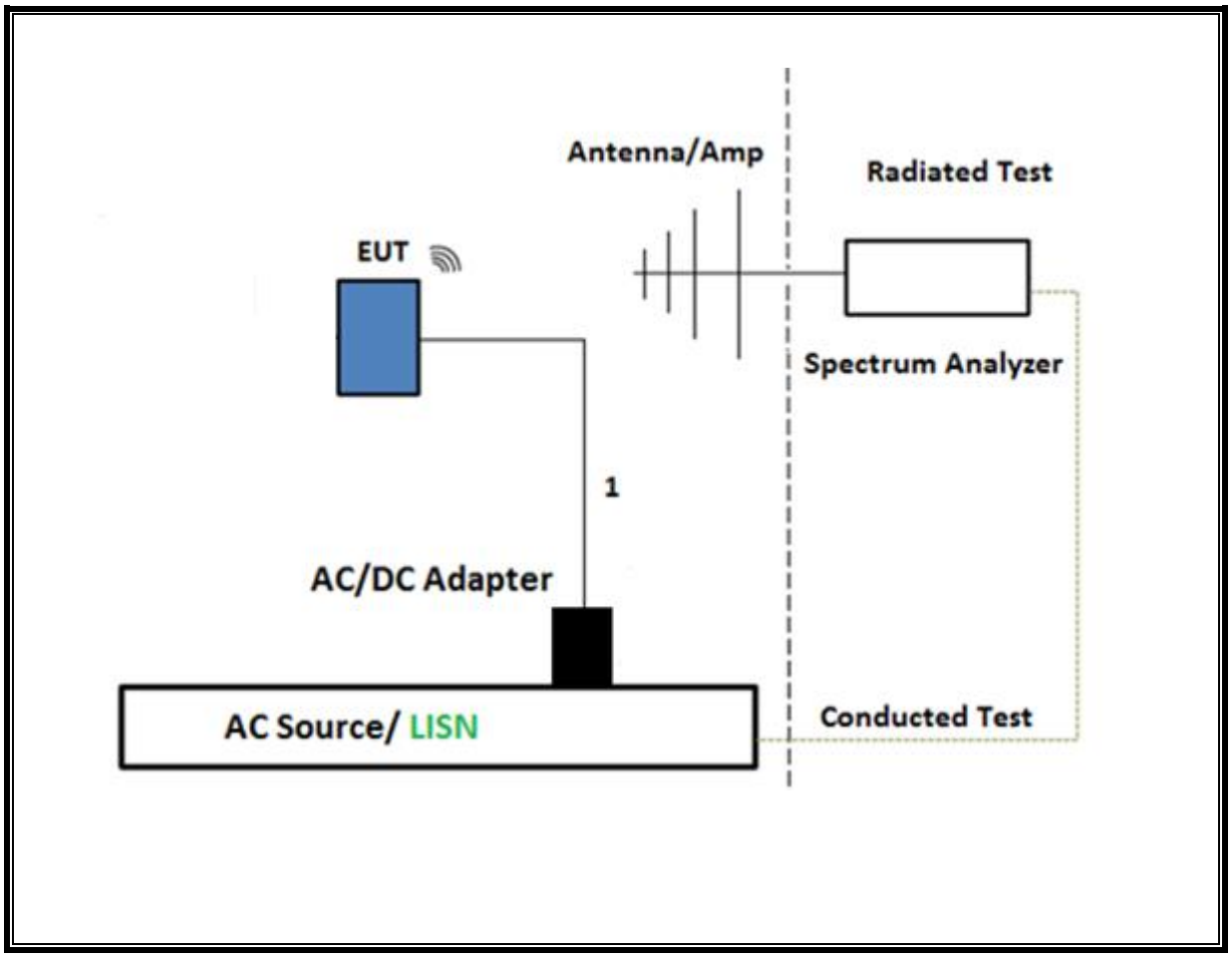
The EUT was powered by AC cord. Test software exercised the EUT.



This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

TEST SETUP FOR LINE CONDUCTED TEST

The EUT was powered by AC cord. Test software exercised the EUT.



This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

9. ON TIME, DUTY CYCLE AND MEASUREMENT METHODS

ON TIME AND DUTY CYCLE

LIMITS

None; for reporting purposes only.

PROCEDURE

KDB 789033 Zero-Span Spectrum Analyzer Method.

RESULTS

Mode	ON Time B (msec)	Period (msec)	Duty Cycle x (linear)	Duty Cycle (%)	Duty Cycle Correction Factor (dB)	1/B Minimum VBW (kHz)
802.11n HT20 1TX	1.920	1.942	0.989	98.87%	0.00	0.010
802.11n HT20 CDD 2TX	1.920	1.941	0.989	98.92%	0.00	0.010
802.11n HT20 STBC 2TX	1.913	1.935	0.989	98.86%	0.00	0.010
802.11n HT40 1TX	0.944	0.965	0.978	97.78%	0.10	1.060
802.11n HT40 CDD 2TX	0.944	0.966	0.977	97.72%	0.10	1.059
802.11n HT40 STBC 2TX	0.937	0.960	0.976	97.63%	0.10	1.067
802.11ac VHT80 1TX	0.461	0.481	0.958	95.78%	0.19	2.169
802.11ac VHT80 CDD 2TX	0.460	0.481	0.956	95.63%	0.19	2.174

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

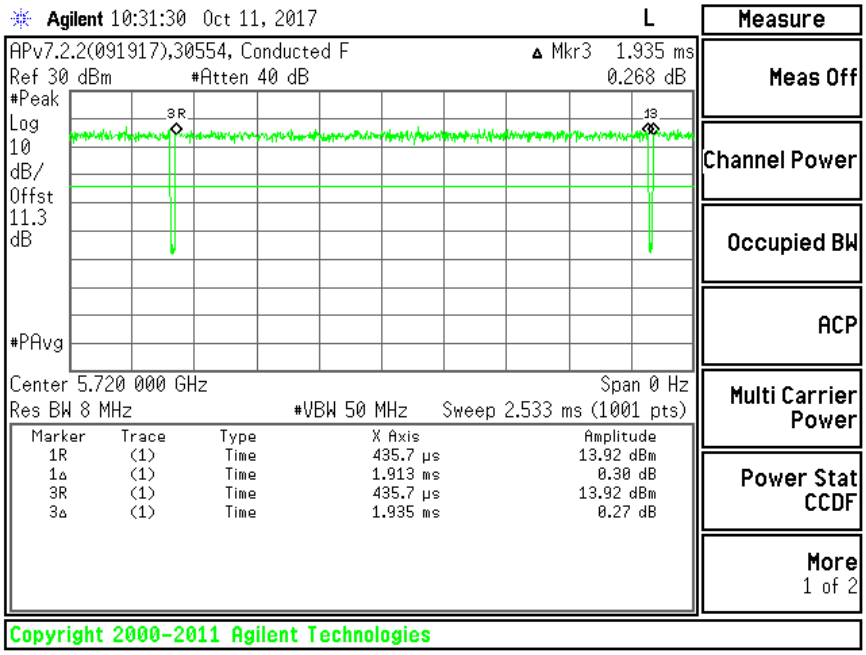
DUTY CYCLE PLOTS

DUTY CYCLE 802.11n HT20 1TX MODE

DUTY CYCLE 802.11n HT20 CDD MODE

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

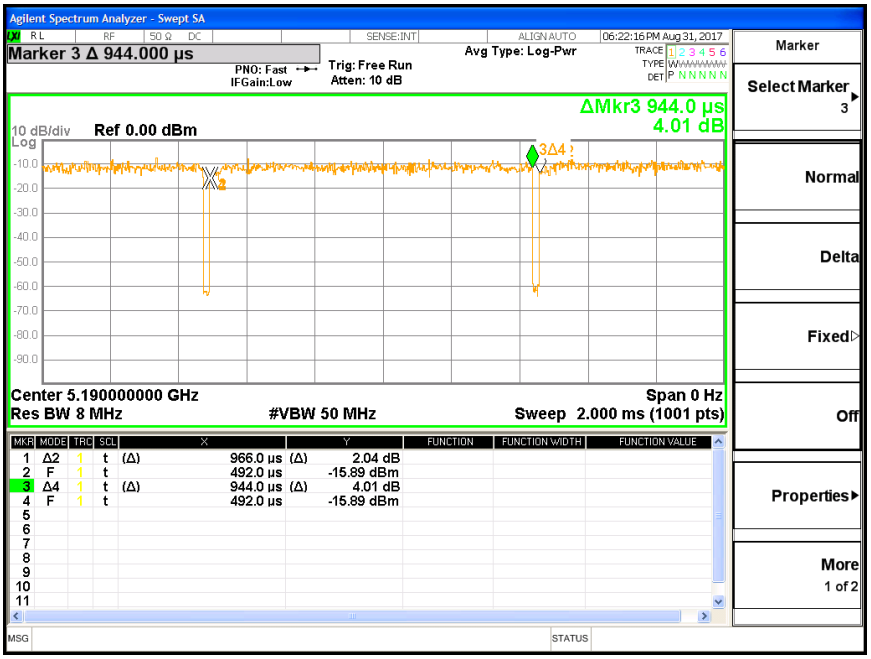
DUTY CYCLE 802.11n HT20 STBC MODE



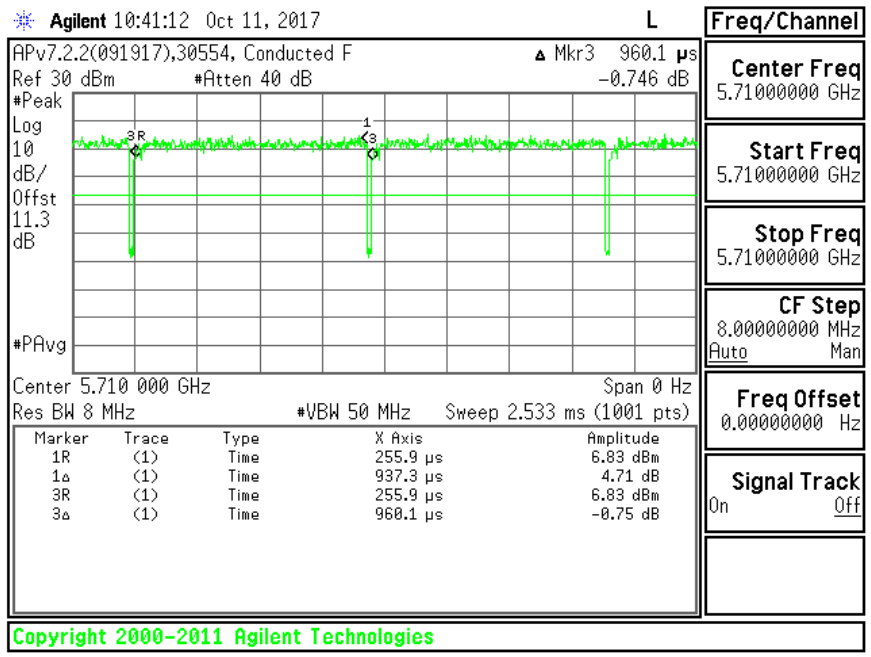
DUTY CYCLE 802.11n HT40 1TX MODE

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

DUTY CYCLE 802.11n HT40 CDD MODE

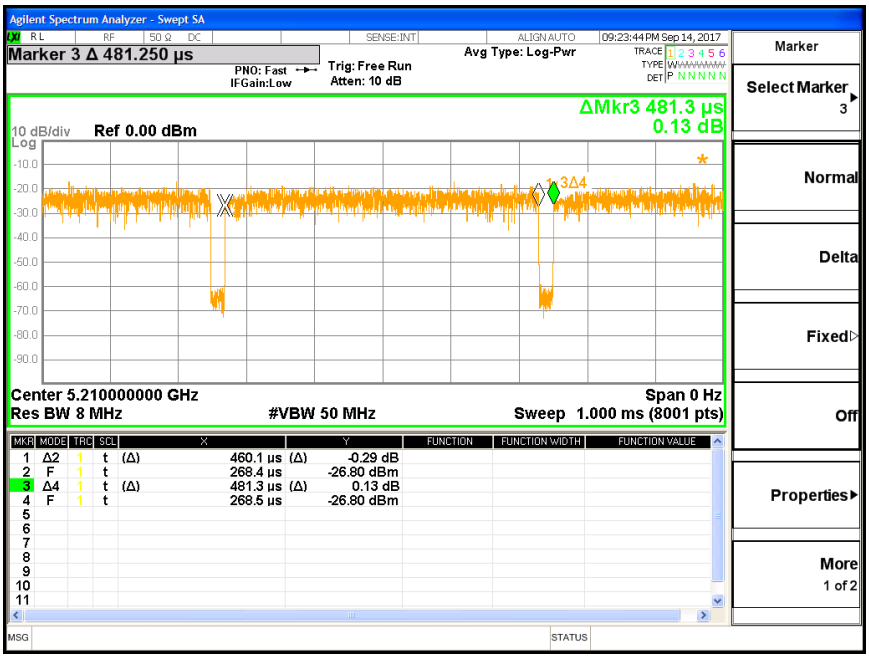


DUTY CYCLE 802.11n HT40 STBC MODE

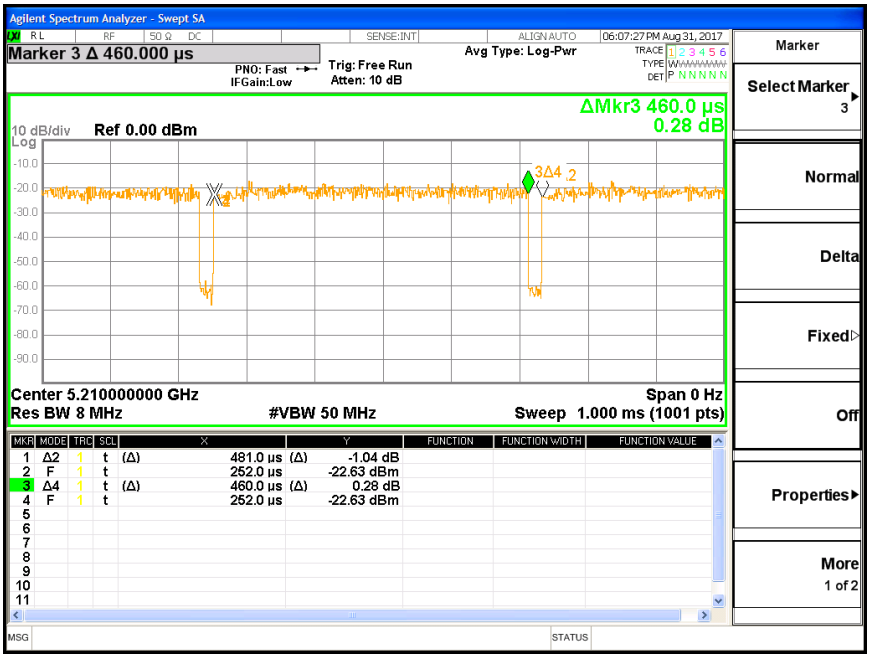


This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

DUTY CYCLE 802.11n HT80 1TX MODE



DUTY CYCLE 802.11n HT80 CDD MODE



This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

9.1. MEASUREMENT METHODS

6 dB Emission BW: KDB 789033 D02 v01r04, Section C.

26 dB Emission BW: KDB 789033 D02 v01r04, Section C.

99% Occupied BW: KDB 789033 D02 v01r04, Section D.

Conducted Output Power: KDB 789033 D02 v01r04, Section E.3.b (Method PM-G).

Power Spectral Density: KDB 789033 D02 v01r04, Section F (Method SA-2).

Unwanted emissions in restricted bands: KDB 789033 D02 v01r04, Sections G.3, G.4, G.5, and G.6.

Unwanted emissions in non-restricted bands: KDB 789033 D02 v01r04, Sections G.3, G.4, and G.5.

AC Power-line conducted emissions: ANSI C63.10-2013, Section 6.2.

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

10. ANTENNA PORT TEST RESULTS

10.1. 26 dB BANDWIDTH

LIMITS

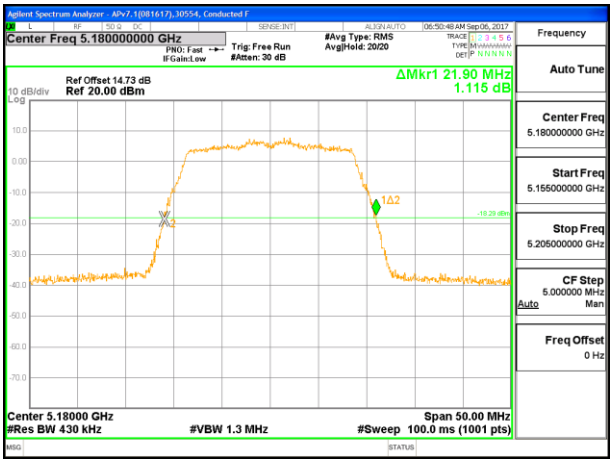
None; for reporting purposes only.

RESULTS

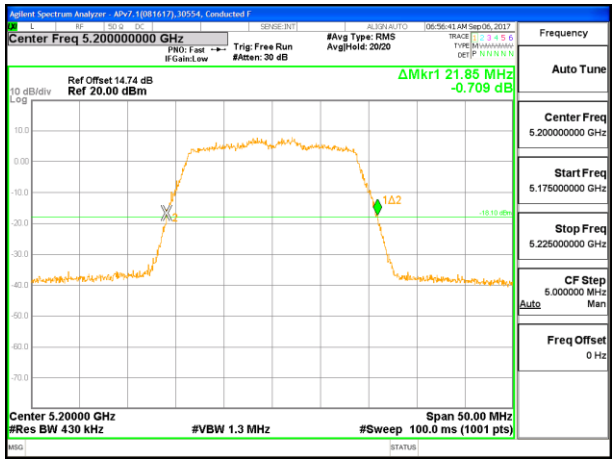
10.1.1. 802.11n HT20 MODE IN THE 5.2 GHz BAND

1TX Antenna A

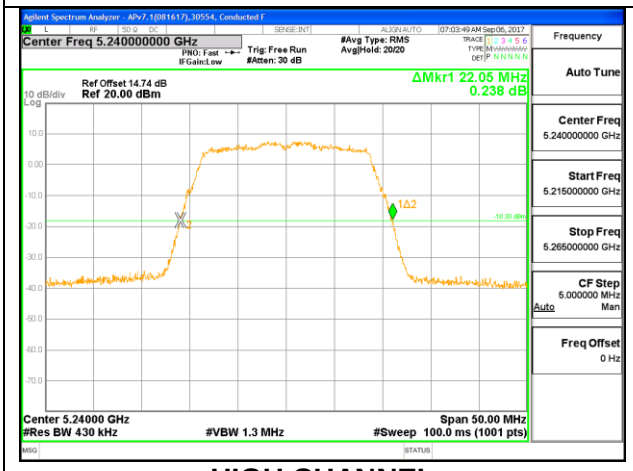
Channel	Frequency (MHz)	26 dB Bandwidth (MHz)
Low	5180	21.90
Mid	5200	21.85
High	5240	22.05



LOW CHANNEL



MID CHANNEL

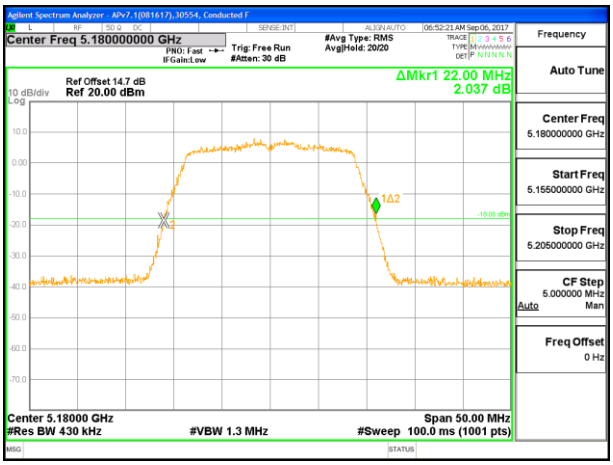


HIGH CHANNEL

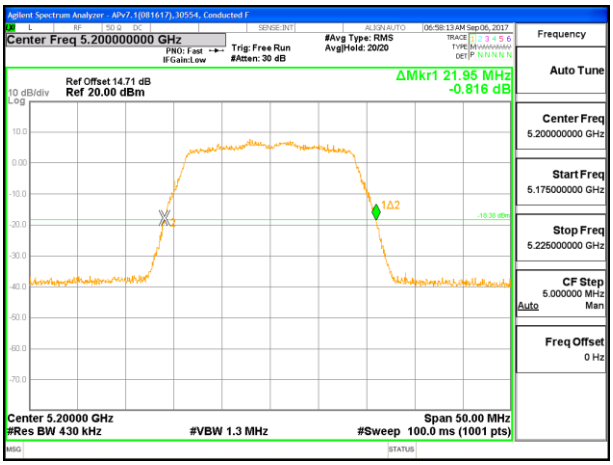
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

1TX Antenna B

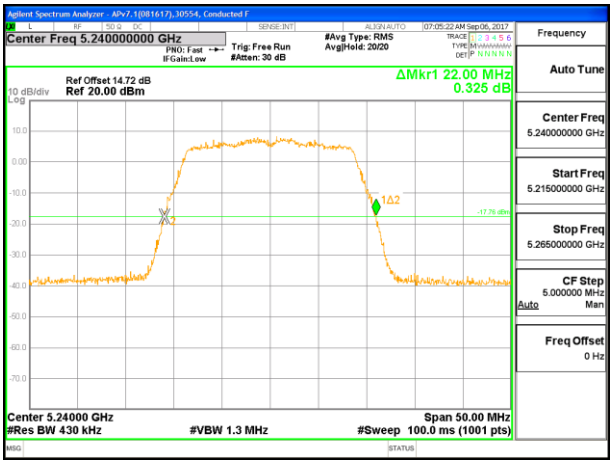
Channel	Frequency (MHz)	26 dB Bandwidth (MHz)
Low	5180	22.00
Mid	5200	21.95
High	5240	22.00



LOW CHANNEL



MID CHANNEL



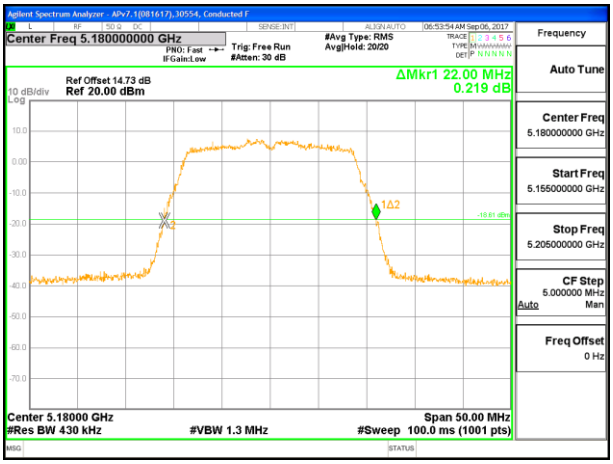
HIGH CHANNEL

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

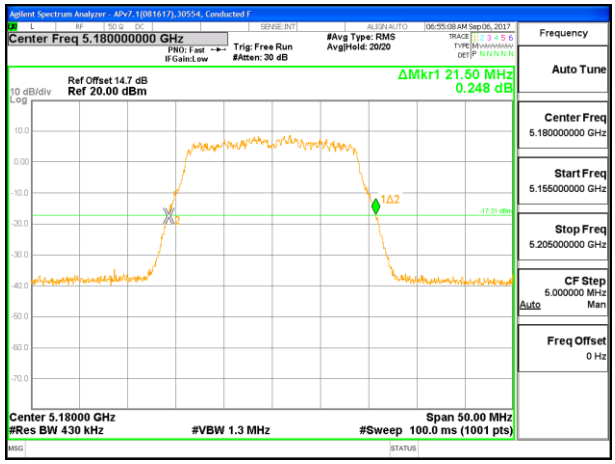
2TX Antenna A + Antenna B CDD MODE

Channel	Frequency (MHz)	26 dB Bandwidth Ant A (MHz)	26 dB Bandwidth Ant B (MHz)
Low	5180	22.00	21.50
Mid	5200	21.95	21.55
High	5240	21.85	21.55

LOW CHANNEL

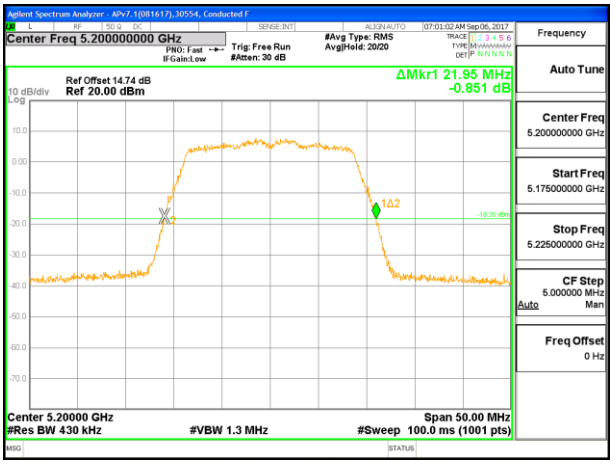


LOW CHANNEL ANT A

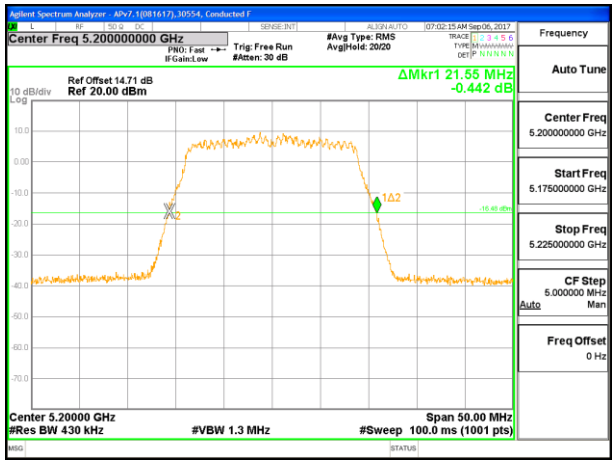


LOW CHANNEL ANT B

MID CHANNEL



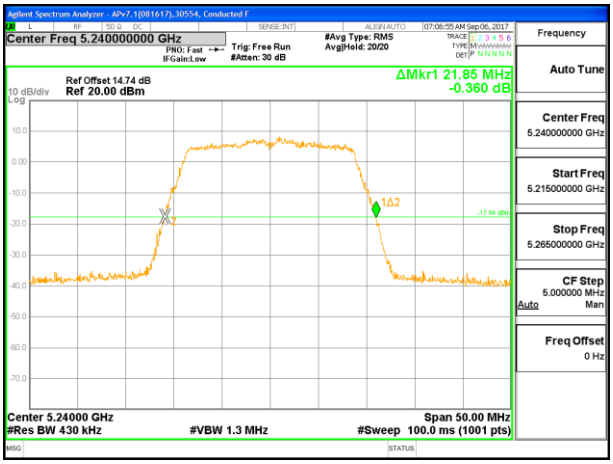
MID CHANNEL ANT A



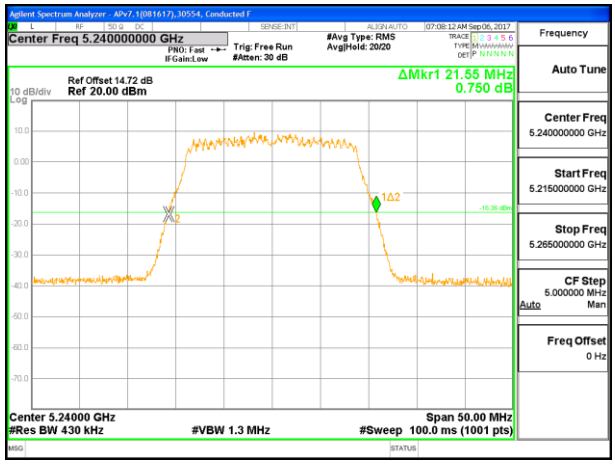
MID CHANNEL ANT B

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

HIGH CHANNEL



HIGH CHANNEL ANT A



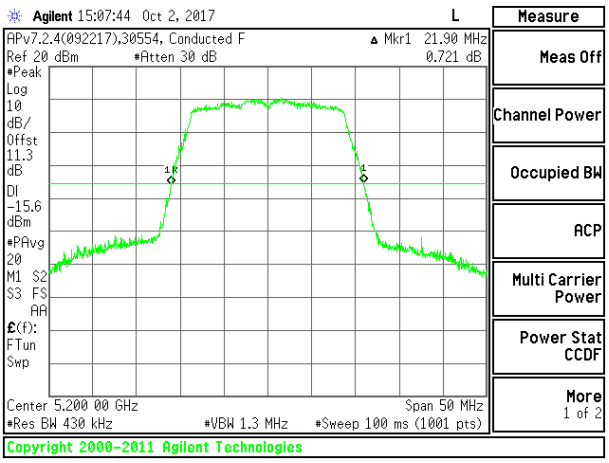
HIGH CHANNEL ANT B

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

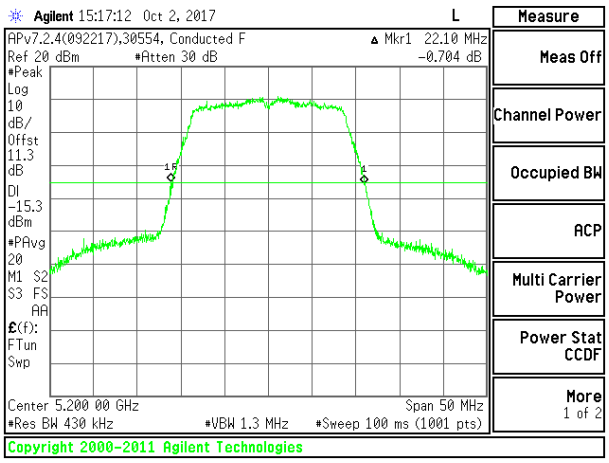
2TX Antenna A + Antenna B STBC MODE

Channel	Frequency (MHz)	26 dB Bandwidth Ant A (MHz)	26 dB Bandwidth Ant B (MHz)
Mid	5200	21.90	22.10
High	5240	21.90	22.15

MID CHANNEL

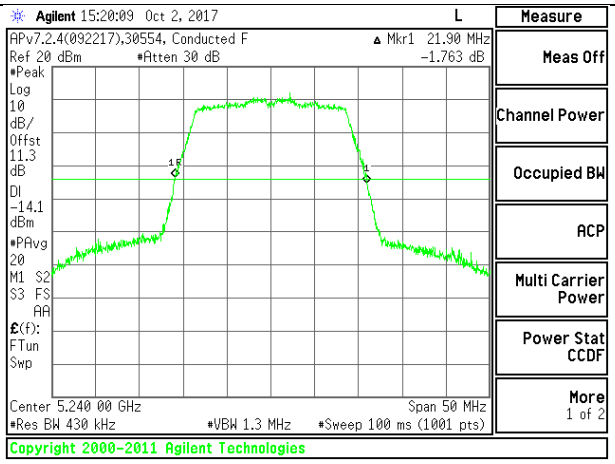


MID CHANNEL ANT A

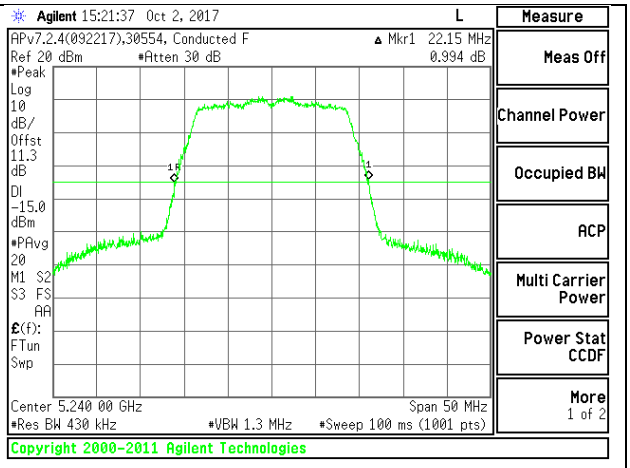


MID CHANNEL ANT B

HIGH CHANNEL



HIGH CHANNEL ANT A



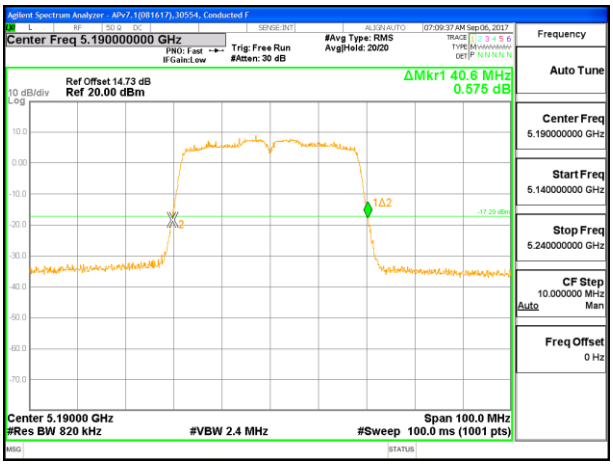
HIGH CHANNEL ANT B

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

10.1.2. 802.11n HT40 MODE IN THE 5.2 GHz BAND

1TX Antenna A

Channel	Frequency (MHz)	26dB Bandwidth (MHz)
Low	5190	40.60
High	5230	40.60

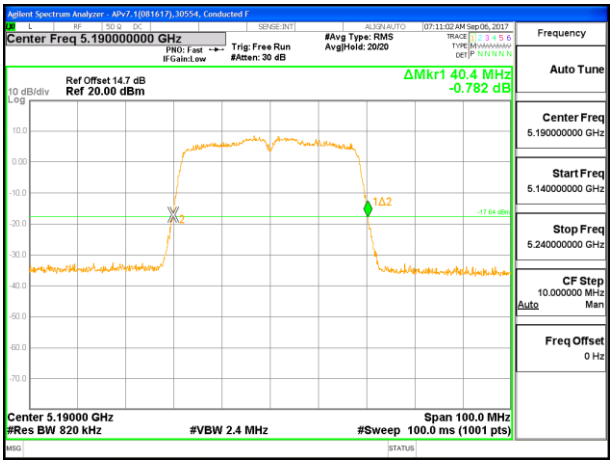


LOW CHANNEL

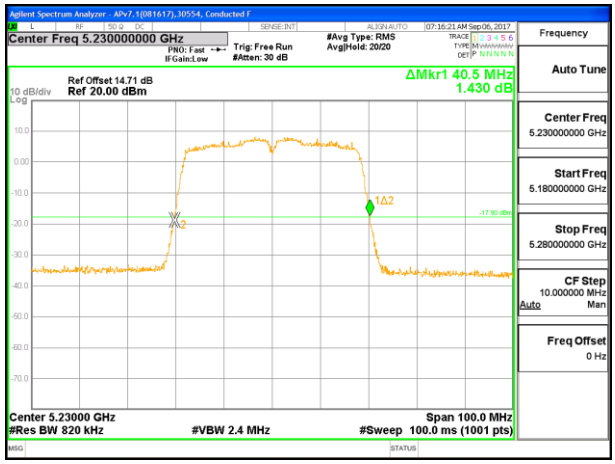
HIGH CHANNEL

1TX Antenna B

Channel	Frequency (MHz)	26dB Bandwidth (MHz)
Low	5190	40.40
High	5230	40.50



LOW CHANNEL



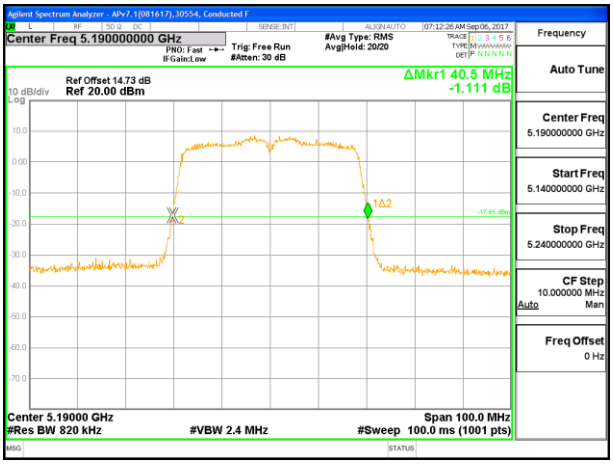
HIGH CHANNEL

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

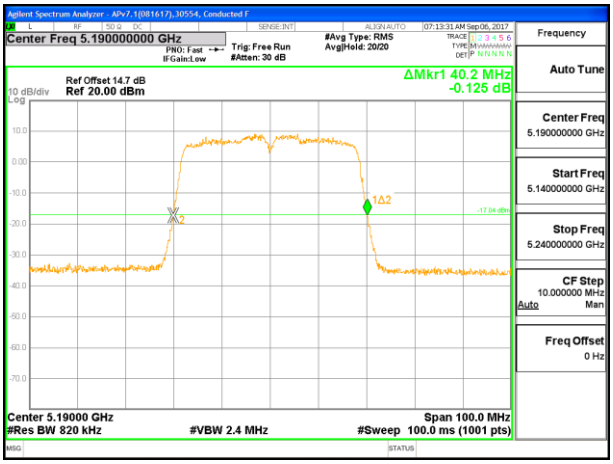
2TX Antenna A + Antenna B CDD MODE

Channel	Frequency (MHz)	26 dB Bandwidth Ant A (MHz)	26 dB Bandwidth Ant B (MHz)
Low	5190	40.50	40.20
High	5230	40.40	40.20

LOW CHANNEL

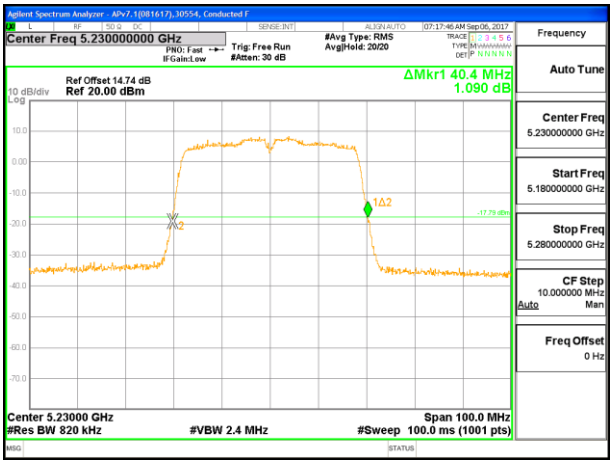


LOW CHANNEL ANT A

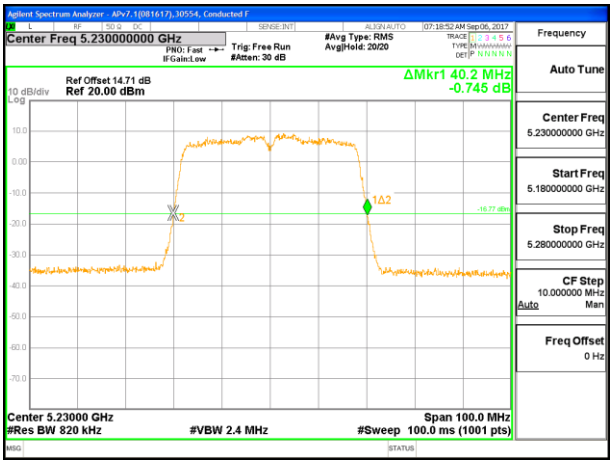


LOW CHANNEL ANT B

HIGH CHANNEL



HIGH CHANNEL ANT A



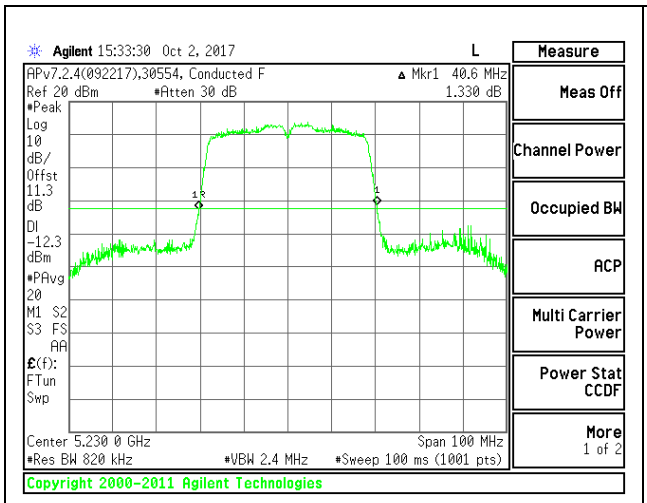
HIGH CHANNEL ANT B

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

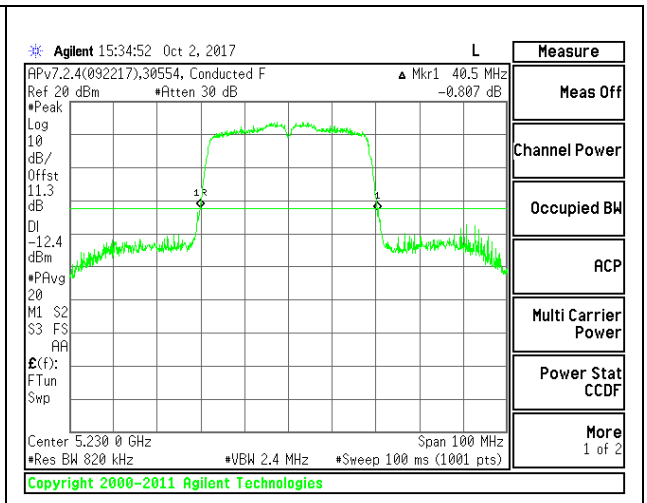
2TX Antenna A + Antenna B STBC MODE

Channel	Frequency (MHz)	26 dB Bandwidth Ant A (MHz)	26 dB Bandwidth Ant B (MHz)
High	5230	40.69	40.50

HIGH CHANNEL



HIGH CHANNEL ANT A



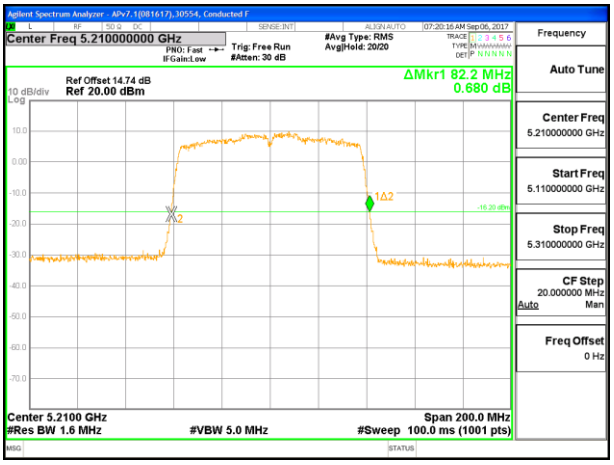
HIGH CHANNEL ANT B

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

10.1.3. 802.11ac VHT80 MODE IN THE 5.2 GHz BAND

1TX Antenna A

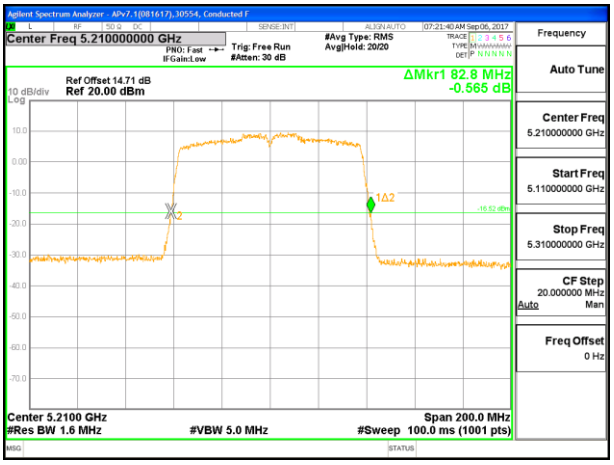
Channel	Frequency (MHz)	26 dB Bandwidth (MHz)
Mid	5210	82.20



MID CHANNEL

1TX Antenna B

Channel	Frequency (MHz)	26 dB Bandwidth (MHz)
Mid	5210	82.80



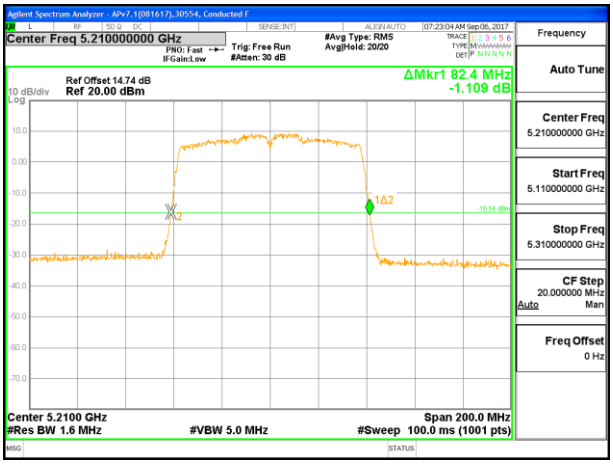
MID CHANNEL

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

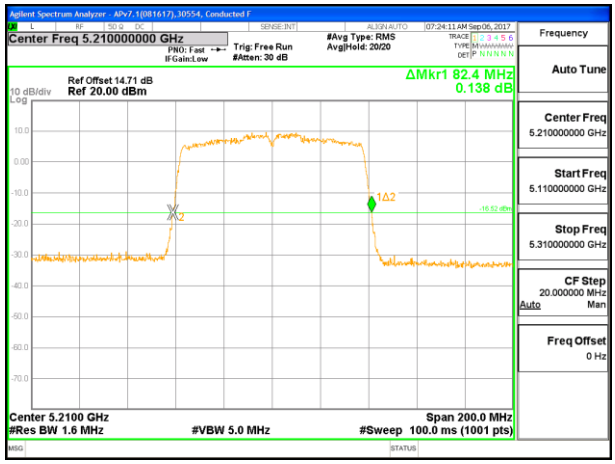
2TX Antenna A + Antenna B CDD MODE

Channel	Frequency (MHz)	26 dB Bandwidth Ant A (MHz)	26 dB Bandwidth Ant B (MHz)
Mid	5210	82.40	82.40

MID CHANNEL



MID CHANNEL ANT A



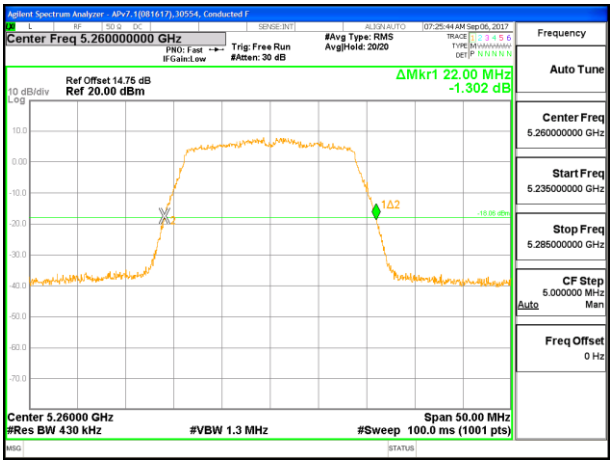
MID CHANNEL ANT B

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

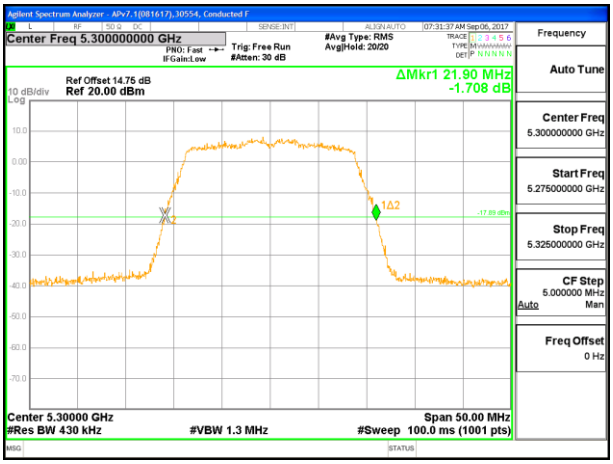
10.1.4. 802.11n HT20 MODE IN THE 5.3 GHz BAND

1TX Antenna A

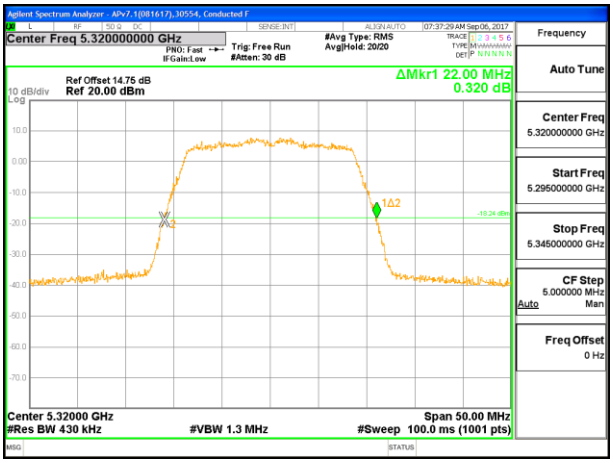
Channel	Frequency (MHz)	26 dB Bandwidth (MHz)
Low	5260	22.00
Mid	5300	21.90
High	5320	22.00



LOW CHANNEL



MID CHANNEL

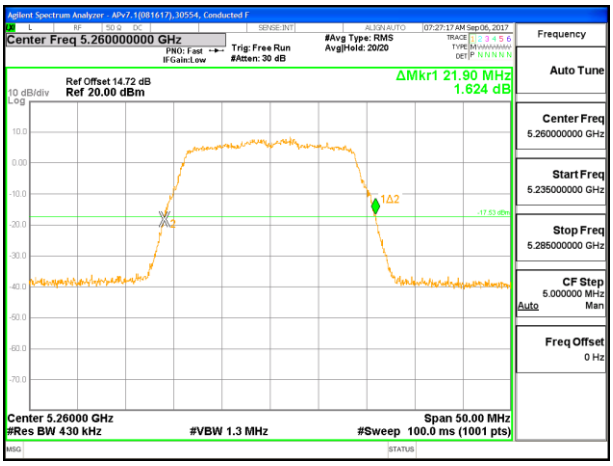


HIGH CHANNEL

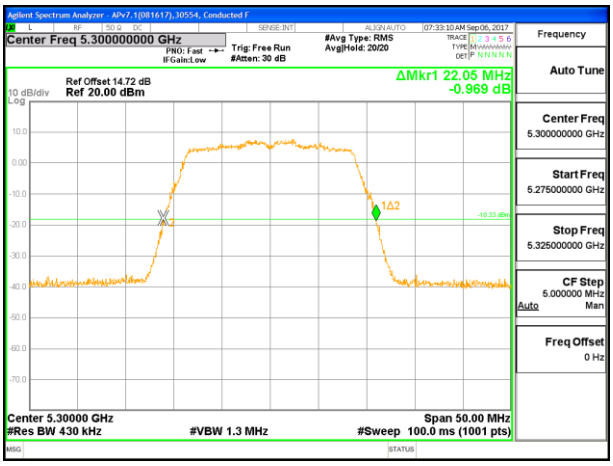
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

1TX Antenna B

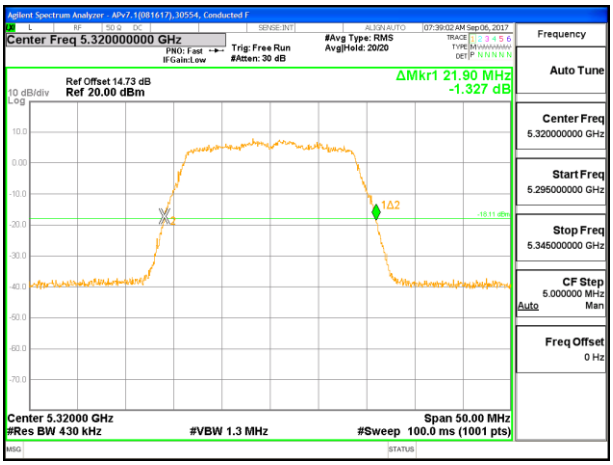
Channel	Frequency (MHz)	26 dB Bandwidth (MHz)
Low	5260	21.90
Mid	5300	22.05
High	5320	21.90



LOW CHANNEL



MID CHANNEL



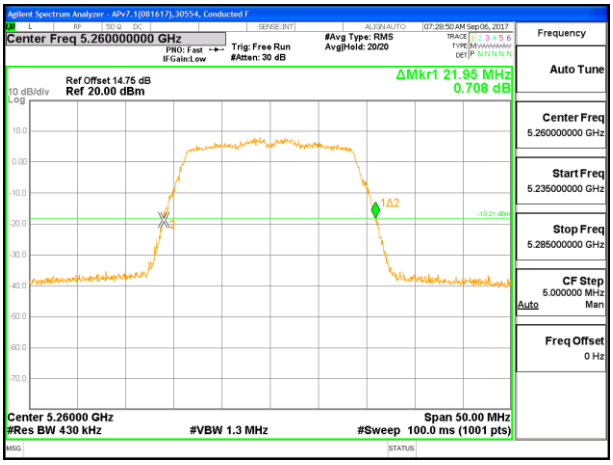
HIGH CHANNEL

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

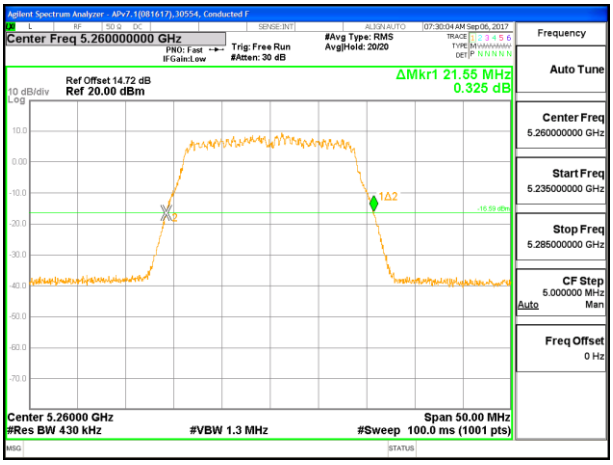
2TX Antenna A + Antenna B CDD MODE

Channel	Frequency (MHz)	26 dB Bandwidth Ant A (MHz)	26 dB Bandwidth Ant B (MHz)
Low	5260	21.95	21.55
Mid	5300	21.90	21.65
High	5320	21.95	21.60

LOW CHANNEL

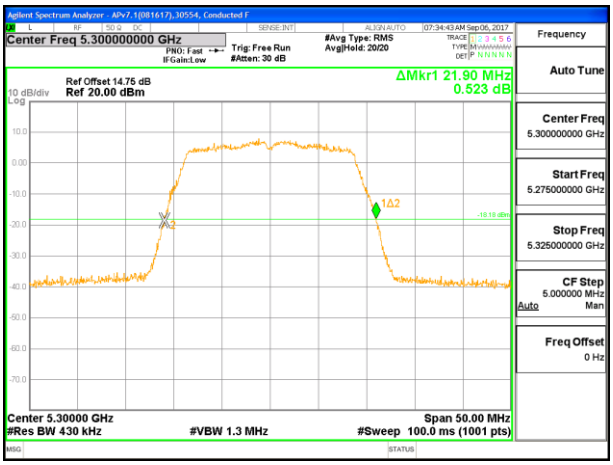


LOW CHANNEL ANT A

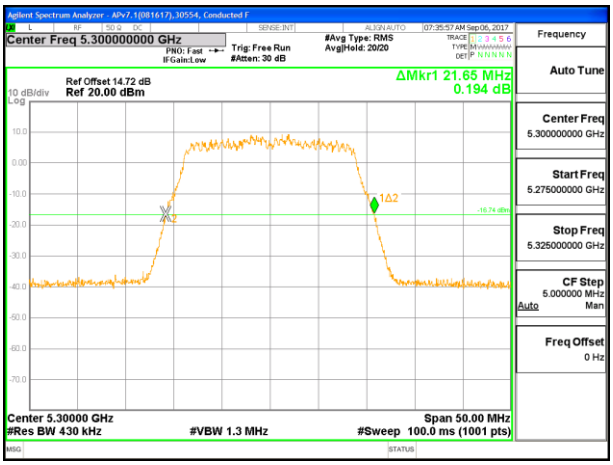


LOW CHANNEL ANT B

MID CHANNEL



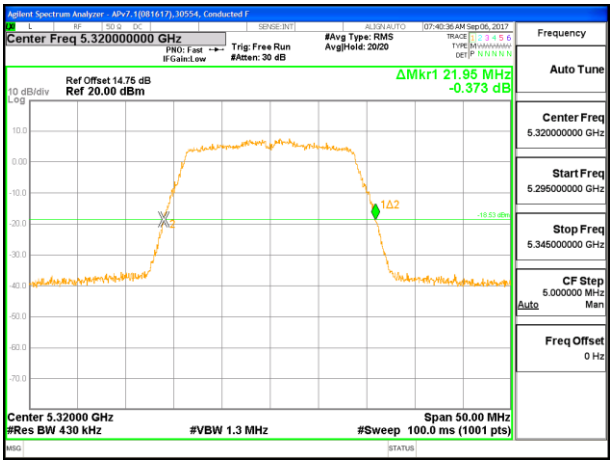
MID CHANNEL ANT A



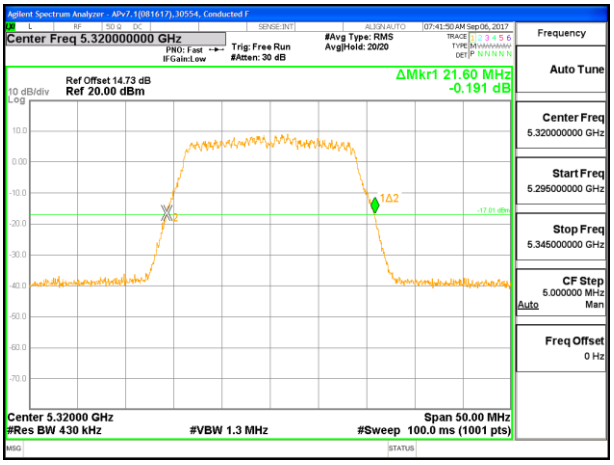
MID CHANNEL ANT B

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

HIGH CHANNEL



HIGH CHANNEL ANT A



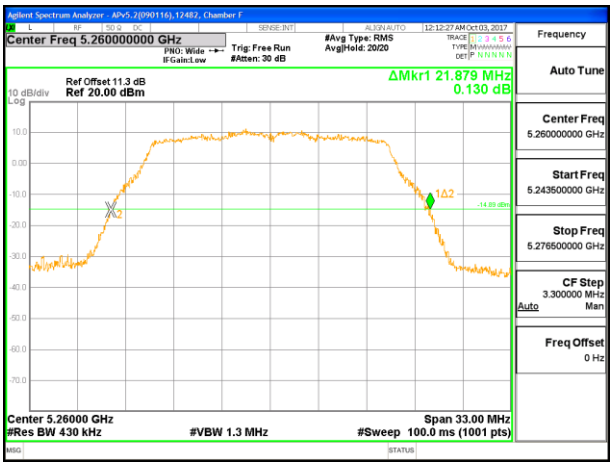
HIGH CHANNEL ANT B

UL VERIFICATION SERVICES INC. FORM NO: CCSUP4701J
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

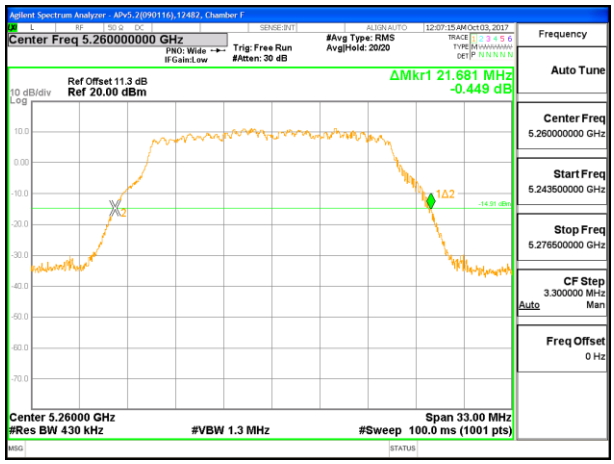
2TX Antenna A + Antenna B STBC MODE

Channel	Frequency (MHz)	26 dB Bandwidth Ant A (MHz)	26 dB Bandwidth Ant B (MHz)
Low	5260	21.88	21.69
Mid	5300	21.75	22.00

LOW CHANNEL

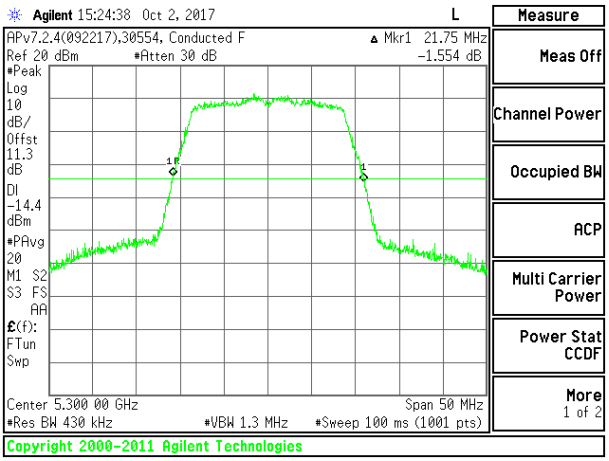


LOW CHANNEL ANT A

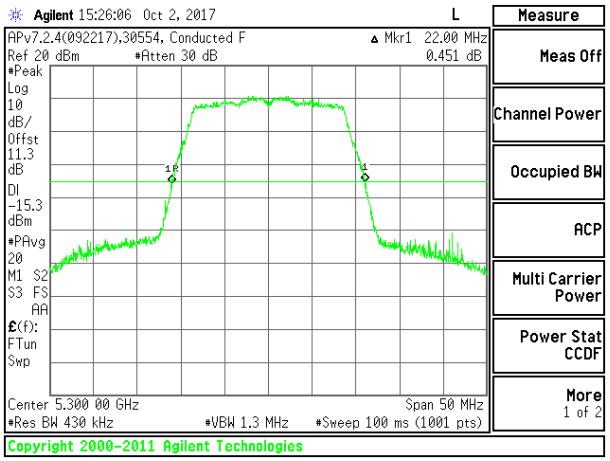


LOW CHANNEL ANT B

MID CHANNEL



MID CHANNEL ANT A



MID CHANNEL ANT B

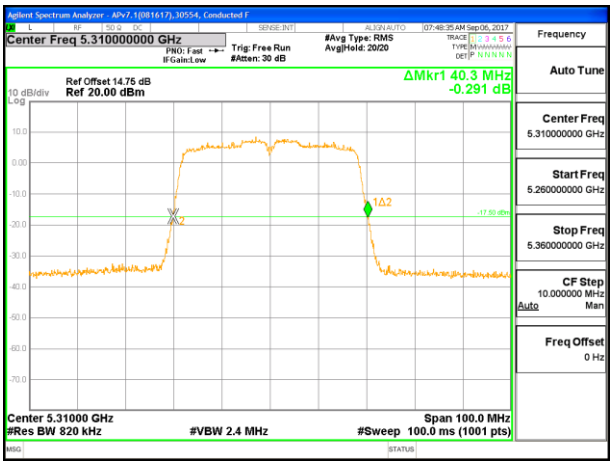
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

10.1.5. 802.11n HT40 MODE IN THE 5.3 GHz BAND

1TX Antenna A

Channel	Frequency (MHz)	26dB Bandwidth (MHz)
Low	5270	40.40
High	5310	40.30

LOW CHANNEL

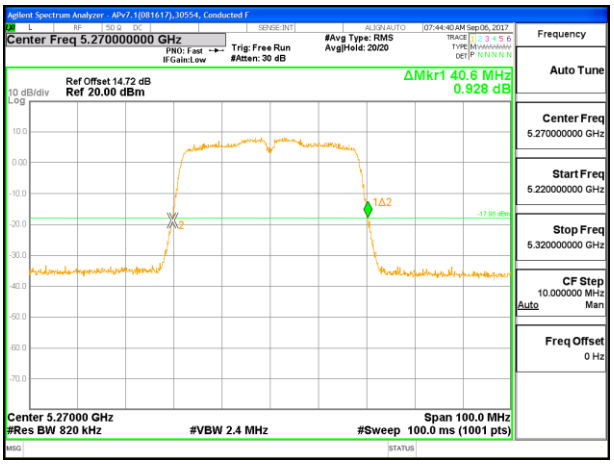


HIGH CHANNEL

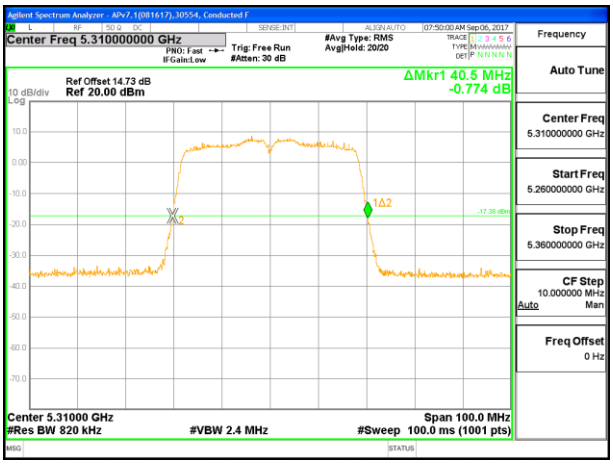
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

1TX Antenna B

Channel	Frequency (MHz)	26dB Bandwidth (MHz)
Low	5270	40.60
High	5310	40.50



LOW CHANNEL



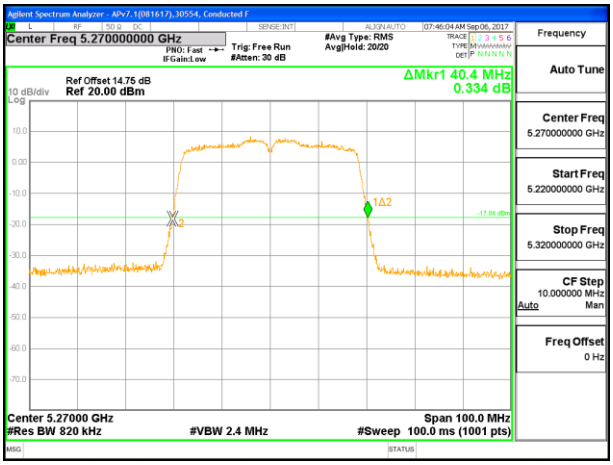
HIGH CHANNEL

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

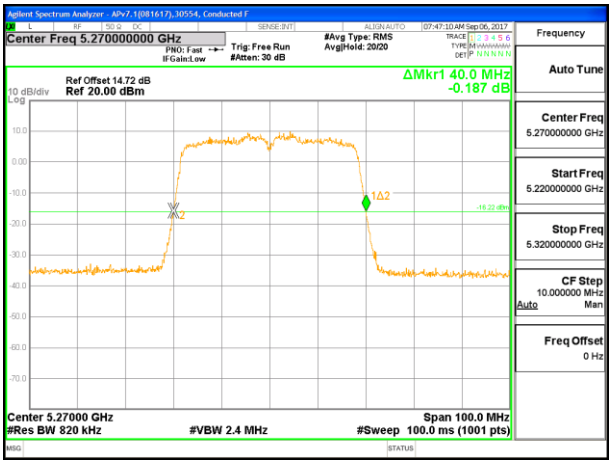
2TX Antenna A + Antenna B CDD MODE

Channel	Frequency (MHz)	26 dB Bandwidth Ant A (MHz)	26 dB Bandwidth Ant B (MHz)
Low	5270	40.40	40.00
High	5310	40.40	40.00

LOW CHANNEL



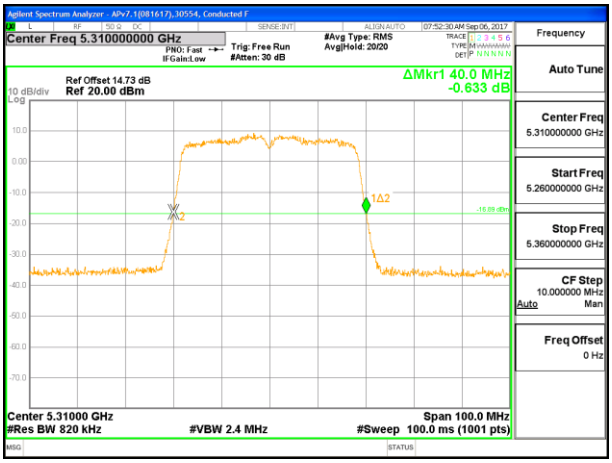
LOW CHANNEL ANT A



LOW CHANNEL ANT B

HIGH CHANNEL

HIGH CHANNEL ANT A



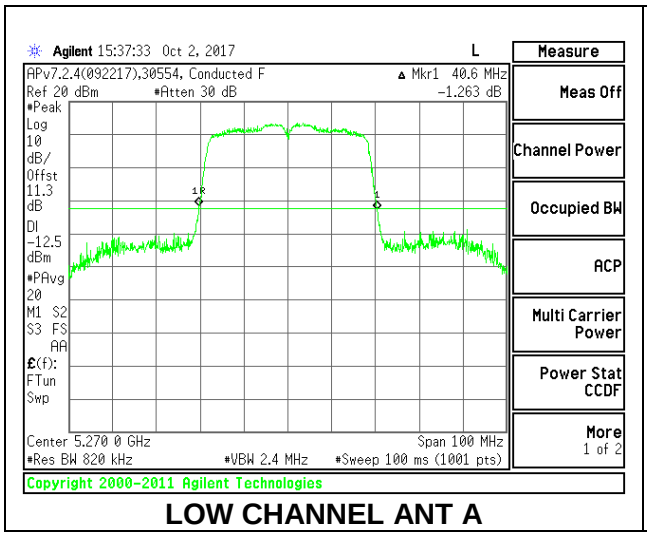
HIGH CHANNEL ANT B

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

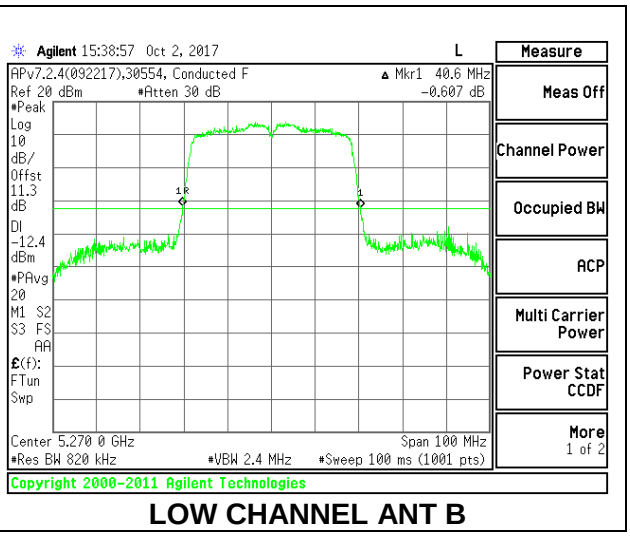
2TX Antenna A + Antenna B STBC MODE

Channel	Frequency (MHz)	26 dB Bandwidth Ant A (MHz)	26 dB Bandwidth Ant B (MHz)
Low	5270	40.60	40.60

LOW CHANNEL



LOW CHANNEL ANT A



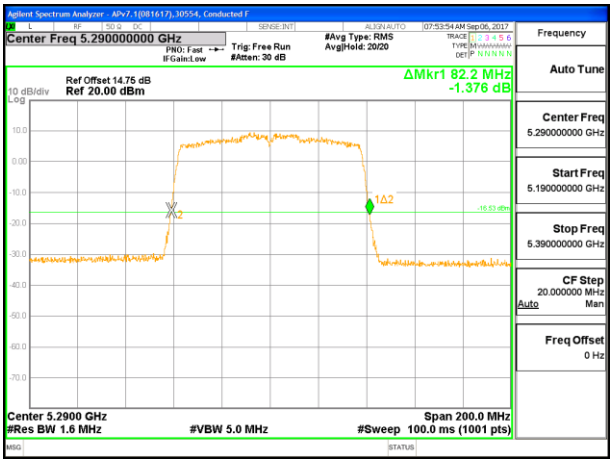
LOW CHANNEL ANT B

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

10.1.6. 802.11ac VHT80 MODE IN THE 5.3 GHz BAND

1TX Antenna A

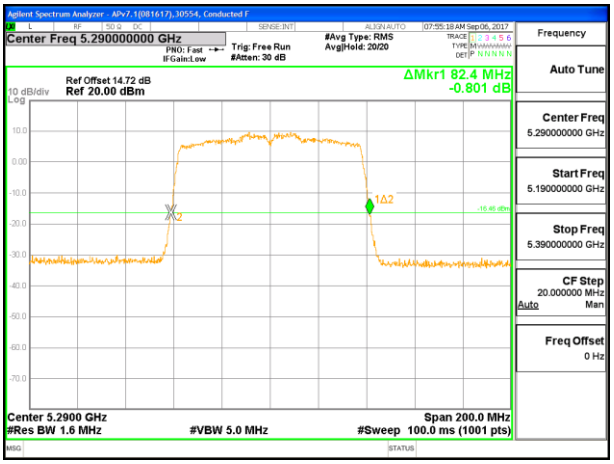
Channel	Frequency (MHz)	26 dB Bandwidth (MHz)
Mid	5290	82.20



MID CHANNEL

1TX Antenna B

Channel	Frequency (MHz)	26 dB Bandwidth (MHz)
Mid	5290	82.40



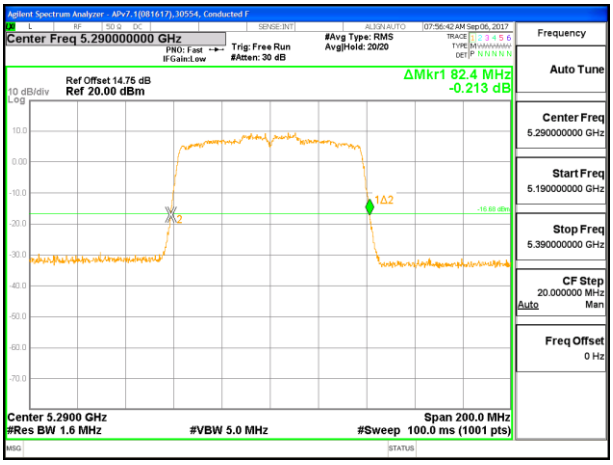
MID CHANNEL

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

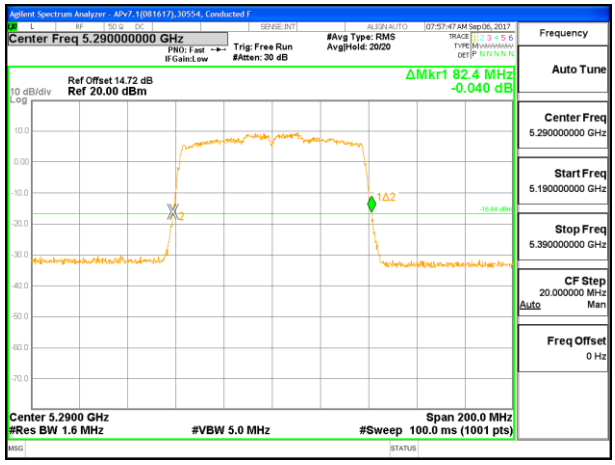
2TX Antenna A + Antenna B CDD MODE

Channel	Frequency (MHz)	26 dB Bandwidth Ant A (MHz)	26 dB Bandwidth Ant B (MHz)
Mid	5290	82.40	82.40

MID CHANNEL



MID CHANNEL ANT A



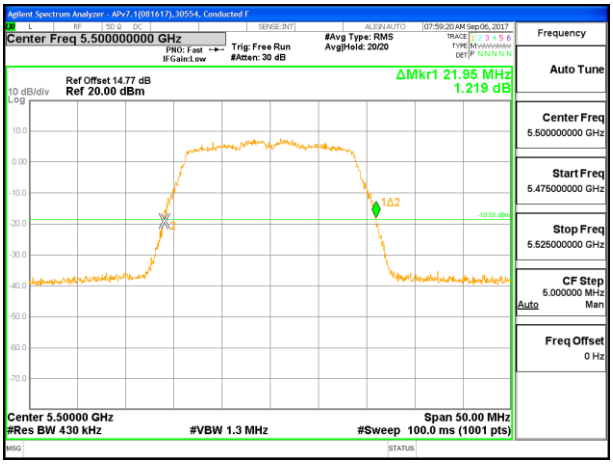
MID CHANNEL ANT B

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

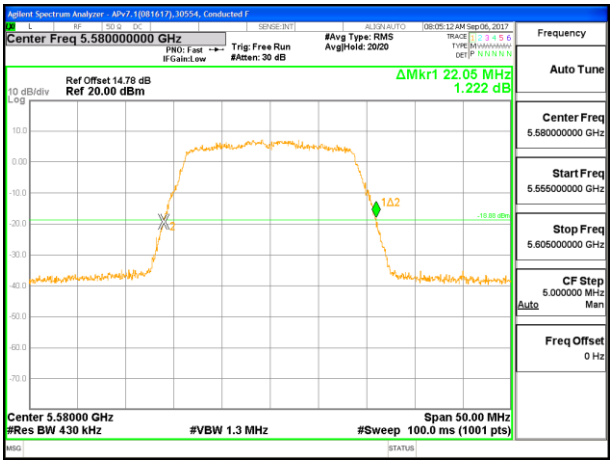
10.1.7. 802.11n HT20 MODE IN THE 5.6 GHz BAND

1TX Antenna A

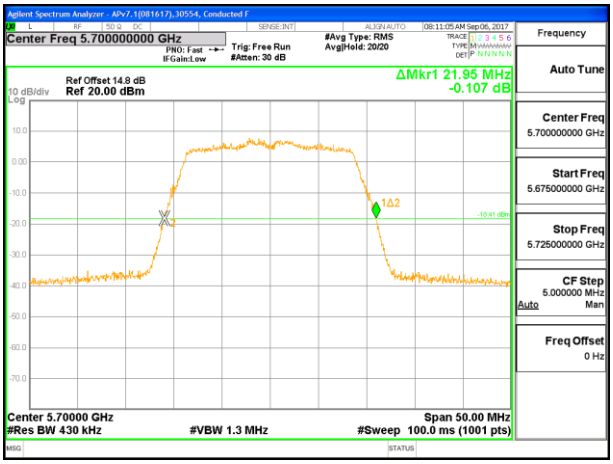
Channel	Frequency (MHz)	26 dB Bandwidth (MHz)
Low	5500	21.95
Mid	5580	22.05
High	5700	21.95
144	5720	21.90



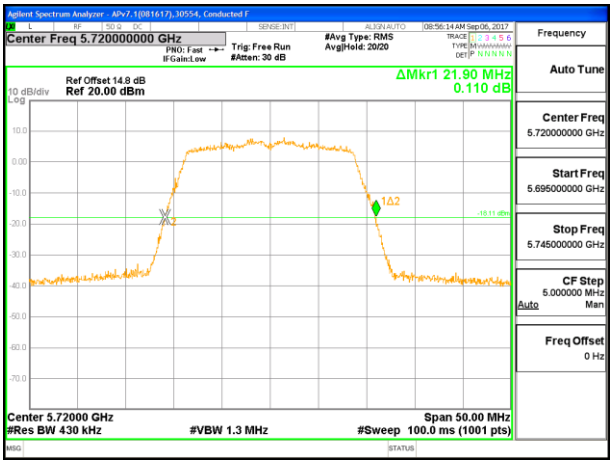
LOW CHANNEL



MID CHANNEL



HIGH CHANNEL

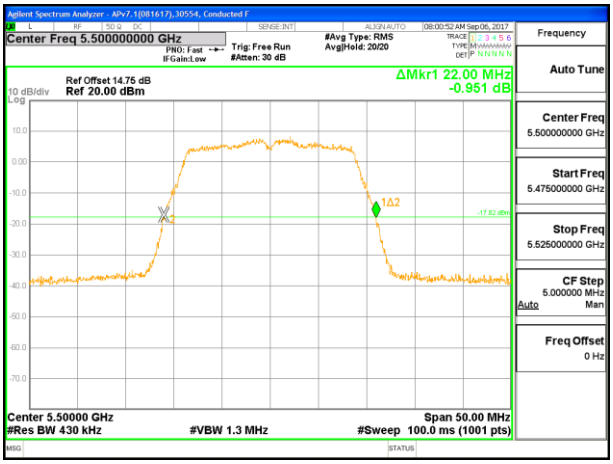


CHANNEL 144

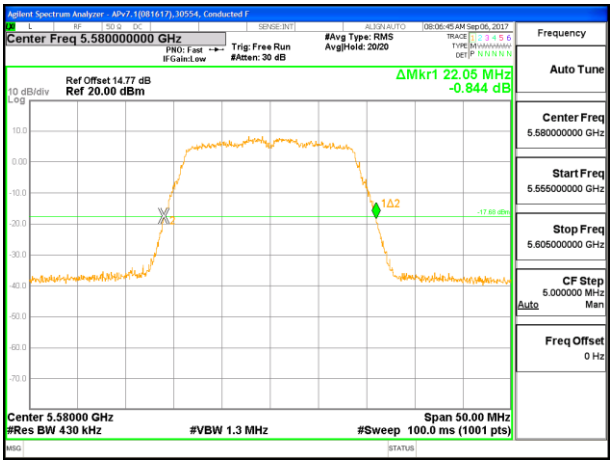
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

1TX Antenna B

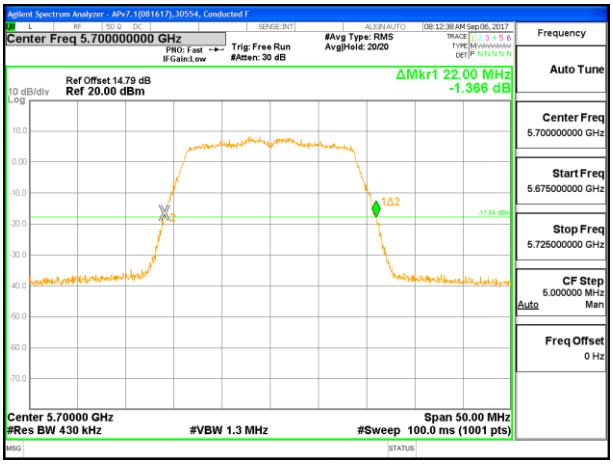
Channel	Frequency (MHz)	26 dB Bandwidth (MHz)
Low	5500	22.00
Mid	5580	22.05
High	5700	22.00
144	5720	21.90



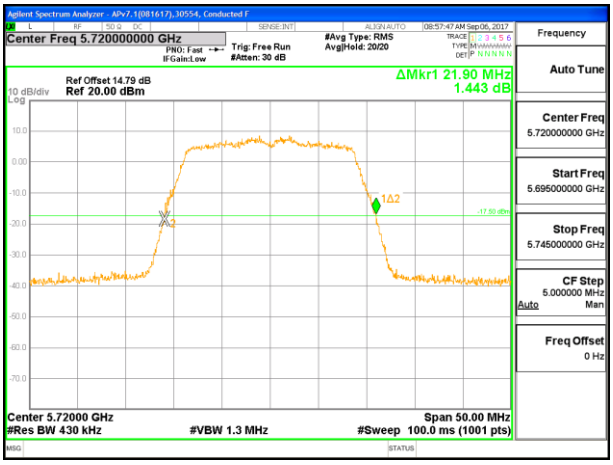
LOW CHANNEL



MID CHANNEL



HIGH CHANNEL



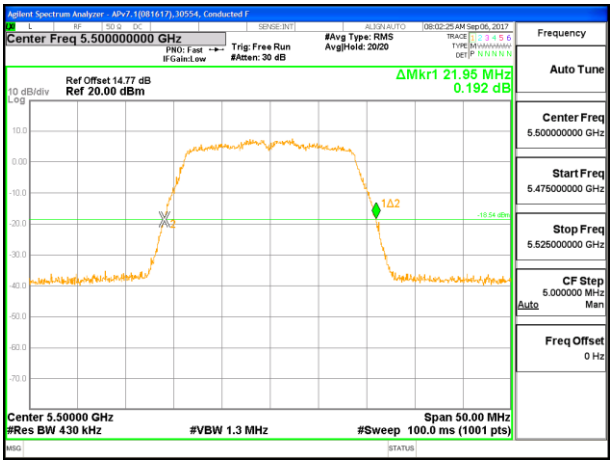
CHANNEL 144

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

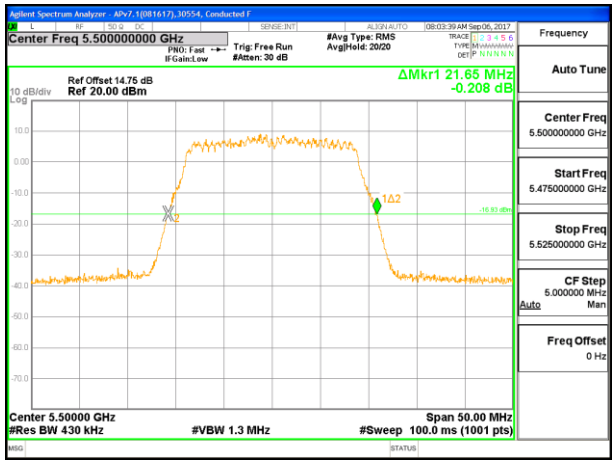
2TX Antenna A + Antenna B CDD MODE

Channel	Frequency (MHz)	26 dB Bandwidth Chain 0 (MHz)	26 dB Bandwidth Chain 1 (MHz)
Low	5500	21.95	21.65
Mid	5580	22.00	21.70
High	5700	22.00	21.65
144	5720	21.90	21.50

LOW CHANNEL

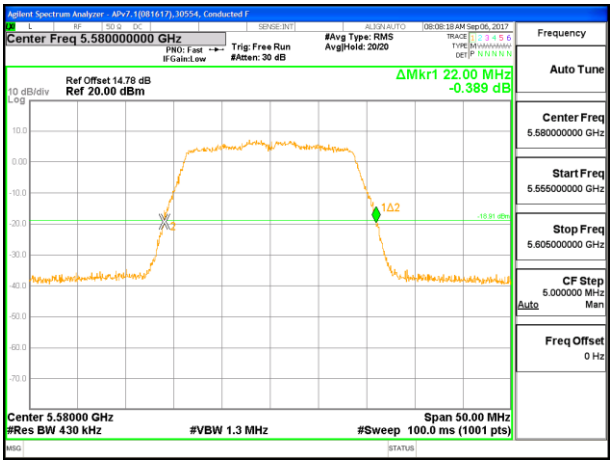


LOW CHANNEL ANT A

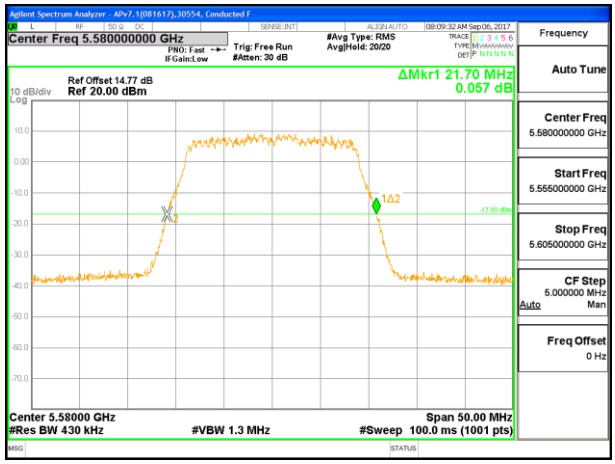


LOW CHANNEL ANT B

MID CHANNEL



MID CHANNEL ANT A



MID CHANNEL ANT B

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.