



CERTIFICATION TEST REPORT

Report Number. : 12607346-E3V2

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

Model : A2160, A2216, AND A2217

FCC ID : BCG-E3305A

IC : 579C-E3305A

EUT Description : SMARTPHONE

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

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REPORT REVISION HISTORY

Rev.	Issue Date	Revisions	Revised By
V1	7/30/2019	Initial Issue	Chris Xiong
V2	8/6/2019	Address TCB Questions	Chris Xiong

REPORT REVISION HISTORY	2
1. ATTESTATION OF TEST RESULTS	5
2. TEST METHODOLOGY	6
3. FACILITIES AND ACCREDITATION	6
4. CALIBRATION AND UNCERTAINTY	6
4.1. <i>MEASURING INSTRUMENT CALIBRATION</i>	6
4.2. <i>SAMPLE CALCULATION</i>	6
4.3. <i>MEASUREMENT UNCERTAINTY</i>	7
5. EQUIPMENT UNDER TEST	8
5.1. <i>EUT DESCRIPTION</i>	8
5.2. <i>DIFFERENCE IN MODEL NUMBER</i>	8
5.3. <i>MAXIMUM OUTPUT POWER</i>	8
5.4. <i>DESCRIPTION OF AVAILABLE ANTENNAS</i>	8
5.5. <i>SOFTWARE AND FIRMWARE</i>	8
5.6. <i>WORST-CASE CONFIGURATION AND MODE</i>	9
5.7. <i>DESCRIPTION OF TEST SETUP</i>	10
6. MEASUREMENT METHOD.....	14
7. TEST AND MEASUREMENT EQUIPMENT	15
8. ANTENNA PORT TEST RESULTS	17
8.1. <i>ON TIME AND DUTY CYCLE</i>	17
8.2. <i>99% BANDWIDTH</i>	20
8.2.1. 802.11b MODE	21
8.2.2. 802.11n HT20 MODE	25
8.2.3. 802.11ax HE20 MODE	35
8.2.4. 802.11ax HE20 OFDMA MODE 2TX	59
8.3. <i>6 dB BANDWIDTH</i>	79
8.3.1. 802.11b MODE	80
8.3.2. 802.11n HT20 MODE	84
8.3.3. 802.11ax HE20 MODE	94
8.3.4. 802.11ax HE20 OFDMA MODE 2TX	118
8.4. <i>OUTPUT POWER</i>	138
8.4.1. 802.11b MODE	139
8.4.2. 802.11n HT20 MODE	141
8.4.3. 802.11ax HE20 MODE	144
8.4.4. 802.11ax HE20 OFDMA MODE 2TX	152
8.5. <i>POWER SPECTRAL DENSITY</i>	156
8.5.1. 802.11b MODE	157
8.5.2. 802.11n HT20 MODE	161

8.5.3. 802.11ax HE20 MODE	171
8.5.4. 802.11ax HE20 OFDMA MODE 2TX	195
8.6. CONDUCTED SPURIOUS EMISSIONS.....	215
8.6.1. 802.11b MODE	216
8.6.2. 802.11n HT20 MODE	220
8.6.3. 802.11ax HE20 MODE	232
8.6.4. 802.11ax HE20 OFDMA MODE 2TX	256
9. RADIATED TEST RESULTS.....	284
9.1. TRANSMITTER ABOVE 1 GHz	286
9.1.1. TX ABOVE 1 GHz 802.11b MODE IN THE 2.4 GHz BAND	286
9.1.2. TX ABOVE 1 GHz 802.11n HT20 MODE IN THE 2.4 GHz	302
9.1.3. TX ABOVE 1 GHz 802.11ax HE20 MODE IN THE 2.4 GHz BAND.....	356
9.1.4. TX ABOVE 1 GHz 802.11ax HE20 OFDMA MODE IN THE 2.4 GHz BAND	420
9.2. WORST CASE BELOW 1 GHz.....	468
9.3. WORST CASE 18-26 GHZ.....	470
10. AC POWER LINE CONDUCTED EMISSIONS.....	472
10.1.1. AC Power Line Host.....	473
10.1.2. AC Power Line Norm	475
11. SETUP PHOTOS.....	477

1. ATTESTATION OF TEST RESULTS

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

EUT DESCRIPTION: SMARTPHONE

MODEL: A2160, A2216, AND A2217

SERIAL NUMBER: Radiated & Conducted
C39YT03DN2R0, C39YT042N2R0, C39YT03GN2R0,
C39T04GN2R0

DATE TESTED: APRIL 4, 2019 – JULY 18, 2019

APPLICABLE STANDARDS	
STANDARD	TEST RESULTS
CFR 47 Part 15 Subpart C	Complies
ISED RSS-247 Issue 2	Complies
ISED RSS-GEN Issue 5	Complies

UL Verification Services Inc. tested the above equipment in accordance with the requirements set forth in the above standards. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. It is the manufacturer's responsibility to assure that additional production units of this model are manufactured with identical electrical and mechanical components. All samples tested were in good operating condition throughout the entire test program. Measurement Uncertainties are published for informational purposes only and were not taken into account unless noted otherwise.

This document may not be altered or revised in any way unless done so by UL Verification Services Inc. and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by UL Verification Services Inc. will constitute fraud and shall nullify the document. This report must not be used by the client to claim product certification, approval, or endorsement by NVLAP, NIST, any agency of the Federal Government, or any agency of the U.S. government.

Approved & Released For
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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, 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 (IC:2324B-1)	<input checked="" type="checkbox"/> Chamber D (IC:22541-1)	<input type="checkbox"/> Chamber I (IC: 2324A-5)
<input checked="" type="checkbox"/> Chamber B (IC:2324B-2)	<input checked="" type="checkbox"/> Chamber E (IC:22541-2)	<input type="checkbox"/> Chamber J (IC: 2324A-6)
<input type="checkbox"/> Chamber C (IC:2324B-3)	<input type="checkbox"/> Chamber F (IC:22541-3)	<input type="checkbox"/> Chamber K (IC: 2324A-1)
	<input checked="" type="checkbox"/> Chamber G (IC:22541-4)	<input type="checkbox"/> Chamber L (IC: 2324A-3)
	<input checked="" type="checkbox"/> Chamber H (IC:22541-5)	

The above test sites and facilities are covered under FCC Test Firm Registration # 208313. Chambers above are covered under Industry Canada company address and respective code

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

4. CALIBRATION AND UNCERTAINTY

4.1. MEASURING INSTRUMENT CALIBRATION

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

4.2. SAMPLE CALCULATION

RADIATED EMISSIONS

Where relevant, the following sample calculation is provided:

Field Strength (dB_{uV/m}) = Measured Voltage (dB_{uV}) + 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 (dB_{uV}) = Measured Voltage (dB_{uV}) + Cable Loss (dB) + Limiter Factor (dB) + LISN Insertion Loss.

$$36.5 \text{ dBuV} + 0 \text{ dB} + 10.1 \text{ dB} + 0 \text{ dB} = 46.6 \text{ dBuV}$$

4.3. MEASUREMENT UNCERTAINTY

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

PARAMETER	UNCERTAINTY
Worst Case Conducted Disturbance, 9KHz to 0.15 MHz	3.84 dB
Worst Case Conducted Disturbance, 0.15 to 30 MHz	3.65 dB
Worst Case Radiated Disturbance, 9KHz to 30 MHz	2.52 dB
Worst Case Radiated Disturbance, 30 to 1000 MHz	4.88 dB
Worst Case Radiated Disturbance, 1000 to 18000 MHz	4.24 dB
Worst Case Radiated Disturbance, 18000 to 26000 MHz	4.37 dB
Worst Case Radiated Disturbance, 26000 to 40000 MHz	5.17 dB

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

5. EQUIPMENT UNDER TEST

5.1. EUT DESCRIPTION

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

5.2. DIFFERENCE IN MODEL NUMBER

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

5.3. MAXIMUM OUTPUT POWER

The transmitter has a maximum conducted output power as follows:

2.4GHz BAND

Frequency Range (MHz)	Mode	Output Power (dBm)	Output Power (mW)
1Tx			
2412 - 2472	802.11b	21.12	129.42
2412 - 2472	802.11g	Covered by 802.11n HT20 1TX	
2412 - 2472	802.11n HT20	21.22	132.43
2412 - 2472	802.11ax HE20, 242-Tones	21.21	132.13
2412 - 2472	802.11ax HE20, 26-Tones	21.2	131.83

2Tx			
2412 - 2472	802.11n HT20 CDD	23.07	202.77
2412 - 2472	802.11g SDM/STBC	Covered by 802.11n HT20 2TX CDD	
2412 - 2472	802.11ax HE20, 242-Tones	23.05	201.84
2412 - 2472	802.11ax HE20, 26-Tones	22.14	163.68

5.4. DESCRIPTION OF AVAILABLE ANTENNAS

Frequency Range	Antenna 4	Antenna ANT 3
2400-2480	-1.7	-1.9

5.5. SOFTWARE AND FIRMWARE

The EUT firmware installed during testing was v1.29.99992

5.6. WORST-CASE CONFIGURATION AND MODE

EUT was investigated in three orthogonal orientations X, Y and Z on ANT 4 (Antenna 4) and ANT 3 (Antenna 3). It was determined that Y (Landscape) orientation was worst-case orientation for ANT 4. For ANT 3 and 2Tx, X (Flatbed) orientation was the worst case for 2Tx.

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 radiated harmonics spurious below 1GHz, 1-18GHz L/M/H channels, 18-26GHz, and power line conducted emissions were performed with the EUT set at the 2Tx CDD mode among the CDD/SDM modes and 2Tx HE mode with power setting equal or higher than SISO modes as worst-case scenario. G mode covered by HT20 mode since it has the same power as HT20.

Below 1GHz tests were performed with EUT connected to AC power adapter as the worst case; and for above 1GHz tests, the worst-case configuration reported was with EUT only. For AC line conducted emission, test was investigated with AC power adapter and with laptop. There were no emissions found below 30MHz within 20dB of the limit.

The output power and psd for the 802.11 ax mode were investigated between all different tones, and we found that the highest tone had the highest output power and PSD readings, the lowest tone had the highest PSD readings. Therefore, full testing was performed on both the highest and lowest tones.

The peak PSD were performed as worst case mode.

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

802.11b mode: 1 Mbps
802.11n HT20mode: MCS0
802.11ax HE20mode: MCS0

There are two vendors of the WiFi/Bluetooth radio modules: variant 1 and variant 2. The WiFi/Bluetooth radio modules have the same mechanical outline (e.g., the same package dimension and pin-out layout), use the same on-board antenna matching circuit, have an identical antenna structure, and are built and tested to conform to the same specifications and to operate within the same tolerances.

Baseline testing was performed on the two variants to determine the worst case on all conducted power and radiated emissions.

5.7. DESCRIPTION OF TEST SETUP

SUPPORT EQUIPMENT

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

I/O CABLES

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

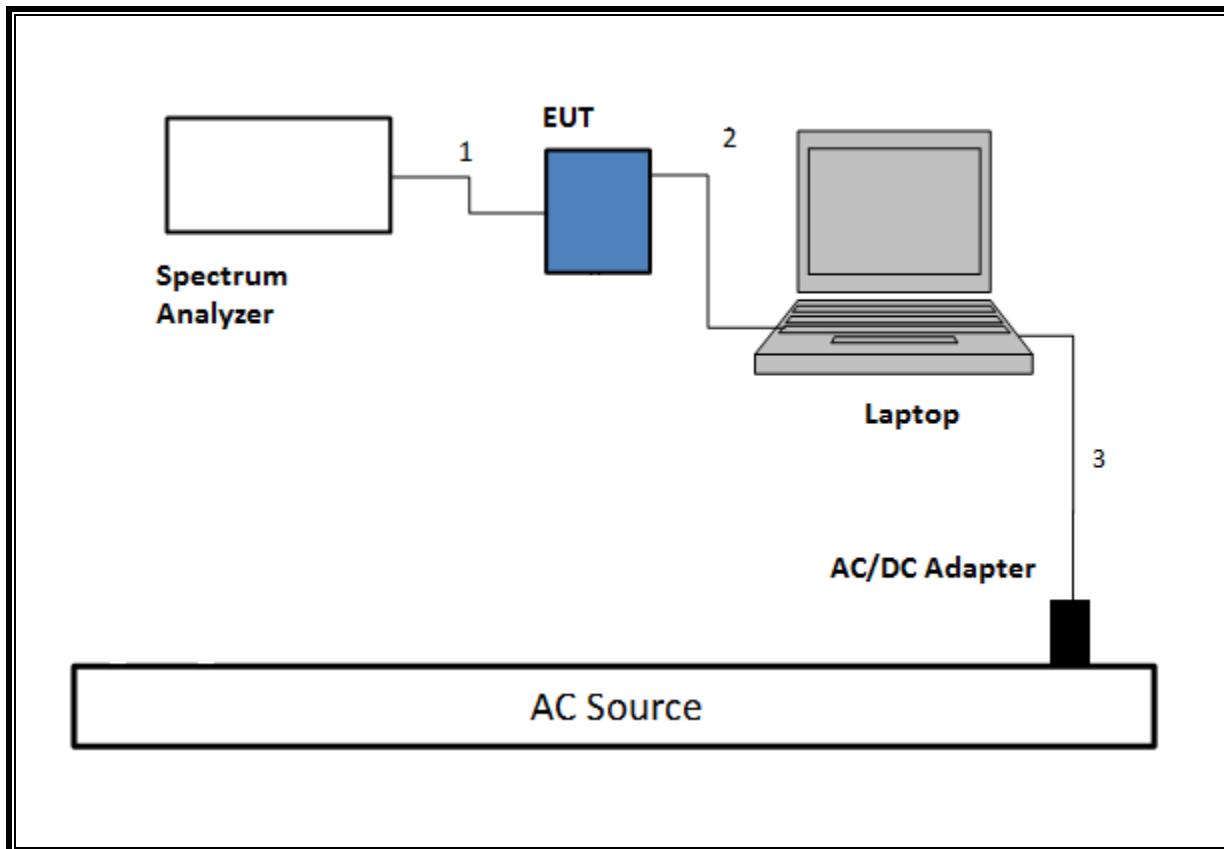
I/O CABLES (BELOW 1GHz AND AC POWER LINE TEST WITH ADAPTER AND LAPTOP)

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

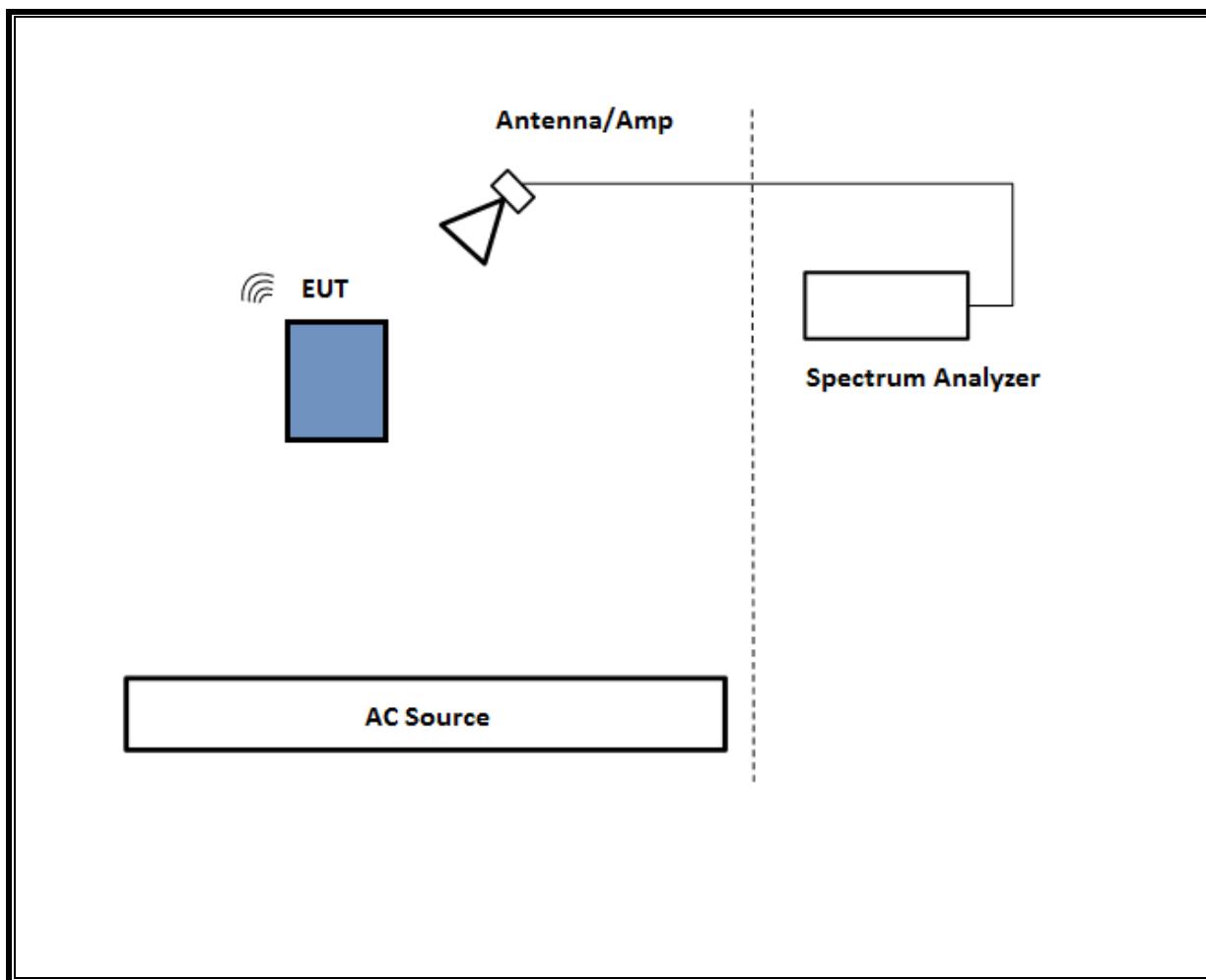
TEST SETUP

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

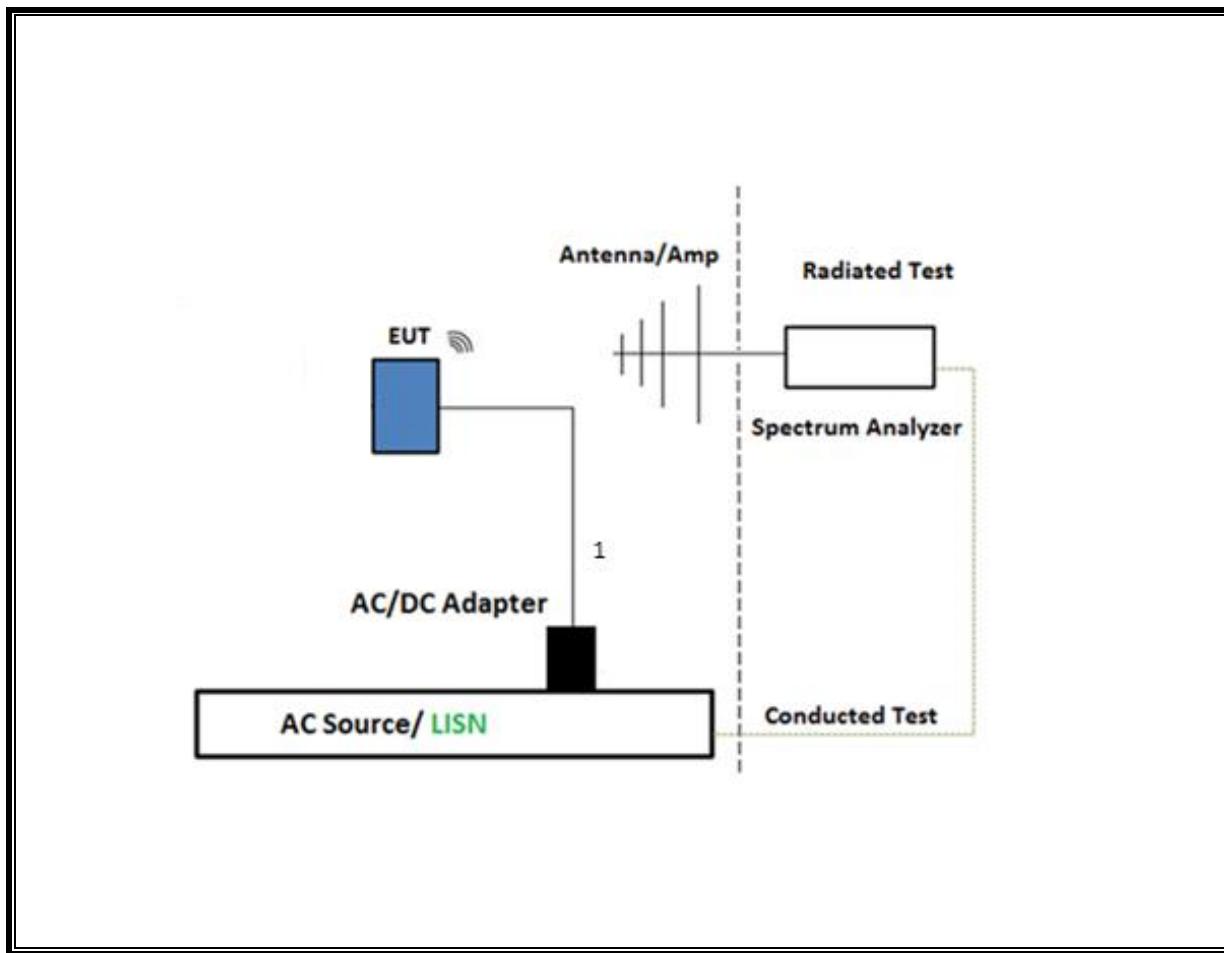
SETUP DIAGRAM FOR CONDUCTED TESTS



SETUP DIAGRAM FOR RADIATED TESTS Above 1GHz



SETUP DIAGRAM FOR Below 1GHz and AC LINE CONDUCTED TEST



6. MEASUREMENT METHOD

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

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

Output Power: ANSI C63.10 Subclause -11.9.2.3.1 Method AVGPM (Measurement using an RF average-reading power meter)

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

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

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

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

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

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

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

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

7. TEST AND MEASUREMENT EQUIPMENT

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

TEST EQUIPMENT LIST					
Description	Manufacturer	Model	ID Num	Cal Due	Last Cal
Antenna, Horn 1-18GHz	ETS-Lindgren	3117	T119	03/22/2020	03/22/2019
Amplifier, 1 to 18GHz. 35dB	AMPLICAL	AMP1G18-35	138301	09/15/2019	09/15/2018
Antenna, Horn 1-18GHz	ETS-Lindgren	3117	T344	05/07/2020	05/07/2019
Amplifier, 1 to 18GHz	MITEQ	AFS42-00101800-25-S-42	T931	05/11/2020	05/11/2019
Antenna, Horn 1-18GHz	ETS Lindgren	3117	T712	02/08/2020	02/08/2019
Amplifier, 1 to 18GHz	MITEQ	AFS42-00101800-25-S-42	T742	05/31/2020	05/31/2019
Antenna, Horn 1-18GHz	ETS Lindgren	3117	T136	07/02/2020	07/02/2019
Amplifier, 1 to 18GHz, 35dB	Amplical	AFS42-00101800-25-S-42	T1567	01/26/2020	01/26/2019
Antenna, Broadband Hybrid, 30MHz to 2000MHz w. 4dB Pad	Sunol Sciences Corp	JB3	T477	07/24/2019	07/24/2018
Amplifier, 10KHz to 1GHz, 32dB	SONOMA INSTRUMENT	310N	T834	6/01/2020	06/01/2019
Spectrum Analyzer, PXA 3Hz to 44GHz	Agilent (Keysight) Technologies	N9030A	T1466	01/23/2020	01/23/2019
Spectrum Analyzer, PXA 3Hz to 44GHz	Agilent (Keysight) Technologies	N9030A	T906	01/22/2020	01/22/2019
Spectrum Analyzer, PXA 3Hz to 44GHz	Agilent (Keysight) Technologies	N9030A	T340	01/22/2020	01/22/2019
Spectrum Analyzer, PXA 3Hz to 44GHz	Agilent (Keysight) Technologies	N9030A-544	T1113	01/22/2020	01/22/2019
Spectrum Analyzer, PXA, 3Hz to 44GHz	Agilent (Keysight) Technologies	N9030A	T908	01/23/2020	01/23/2019
Antenna, Active Loop 9KHz to 30MHz	ETS-Lindgren	6502	T1616	10/18/2019	10/18/2018
*Antenna Horn, 18 to 26GHz	ARA	MWH-1826	T447	06/16/2019	06/16/2018
Pre-Amp 18-26GHz	Agilent Technology	8449B	T404	03/23/2020	03/23/2019
Power Meter, P-series single channel	Agilent (Keysight) Technologies	N1911A	T227	10/29/2019	10/29/2018
Power Sensor	Keysight	N1921A	T1228	03/01/2020	03/01/2019
Thermometer	Control Company	14-650-118, 15557603	T1816	01/11/2019	01/11/2018

*Testing is completed before equipment expiration date.

AC Line Conducted					
Description	Manufacturer	Model	ID Num	Cal Due	Last Cal
*EMI Test Receiver 9Khz-7GHz	Rohde & Schwarz	ESCI7	T1436	02/14/2020	02/14/2019
Power Cable, Line Conducted Emissions	UL	PG1	T861	08/31/2019	08/31/2018
*LISN for Conducted Emissions CISPR-16	Fischer	50/250-25-2-01	T1310	06/19/2019	06/19/2018
UL AUTOMATION SOFTWARE					
Radiated Software	UL	UL EMC	Ver 9.5, April 26, 2016		
Conducted Software	UL	UL EMC	Ver 5.4, October 13, 2016		
AC Line Conducted Software	UL	UL EMC	Ver 9.5, May 26, 2015		

*Testing is completed before equipment expiration date.

8. ANTENNA PORT TEST RESULTS

8.1. ON TIME AND DUTY CYCLE

LIMITS

None; for reporting purposes only.

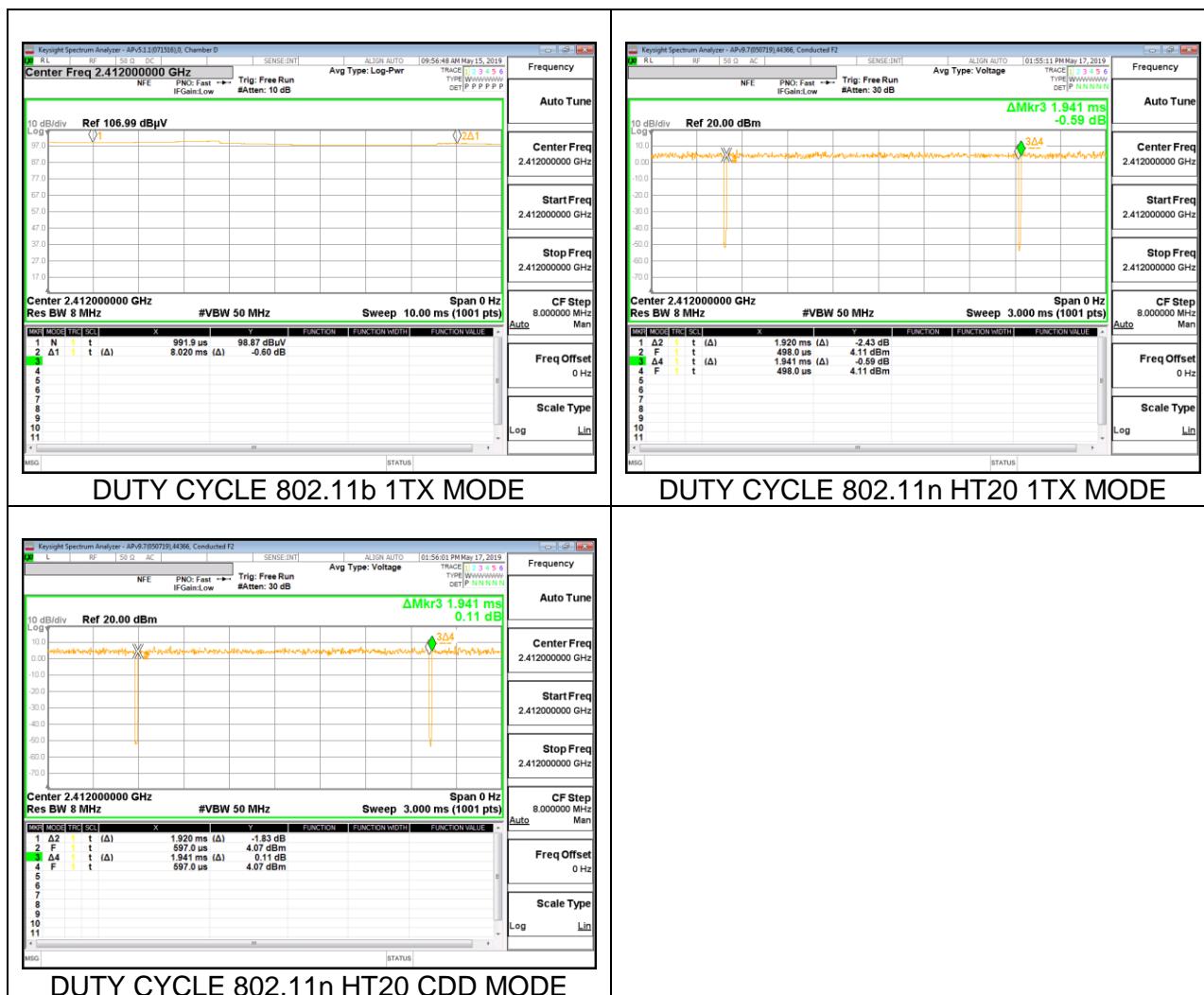
PROCEDURE

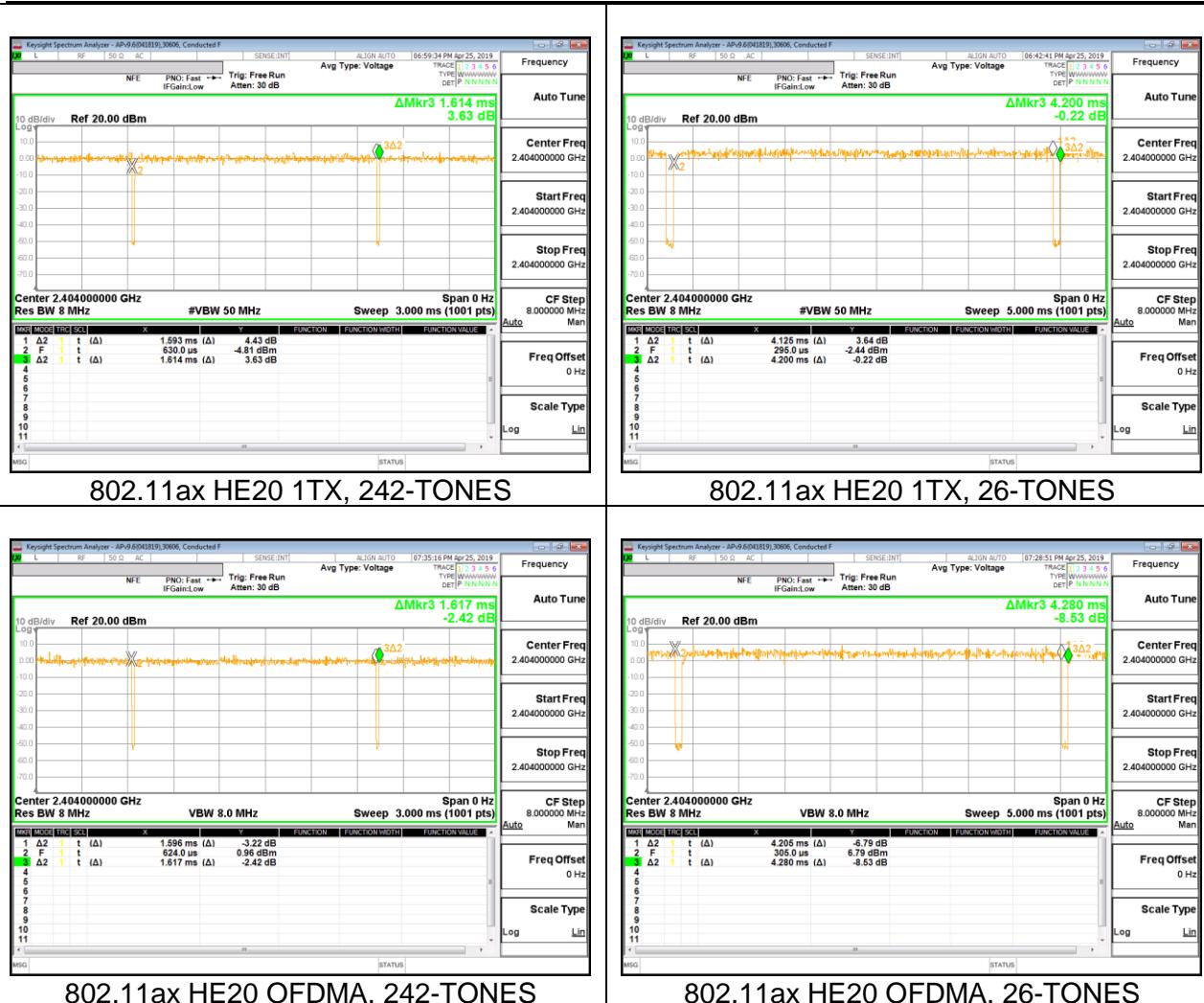
KDB 558074 Zero-Span Spectrum Analyzer Method.

ON TIME AND DUTY CYCLE 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	8.020	8.020	1.000	100.00%	0.00	0.010
802.11n HT20 1TX	1.920	1.941	0.989	98.92%	0.00	0.010
802.11n HT20 2TX CDD	1.920	1.941	0.989	98.92%	0.00	0.010
802.11ax HE20 1Tx, 242-Tones	1.593	1.614	0.987	98.70%	0.00	0.010
802.11ax HE20 1Tx, 26-Tones	4.125	4.200	0.982	98.21%	0.00	0.010
802.11ax HE20 OFDMA, 242-Tones	1.596	1.617	0.987	98.70%	0.00	0.010
802.11ax HE20 OFDMA, 26-Tones	4.205	4.280	0.982	98.25%	0.00	0.010

DUTY CYCLE PLOTS





8.2. 99% BANDWIDTH

LIMITS

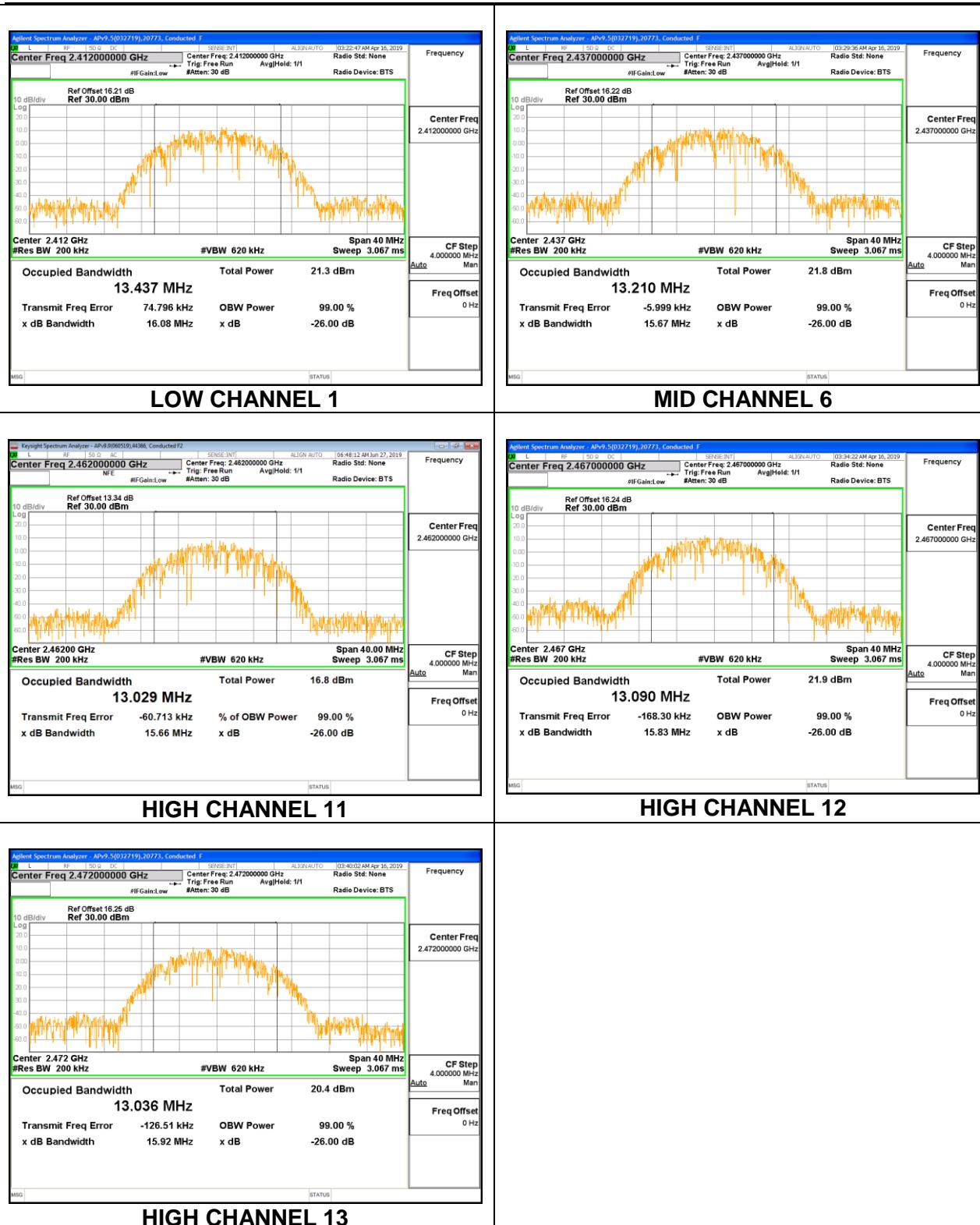
None; for reporting purposes only.

RESULTS

8.2.1. 802.11b MODE

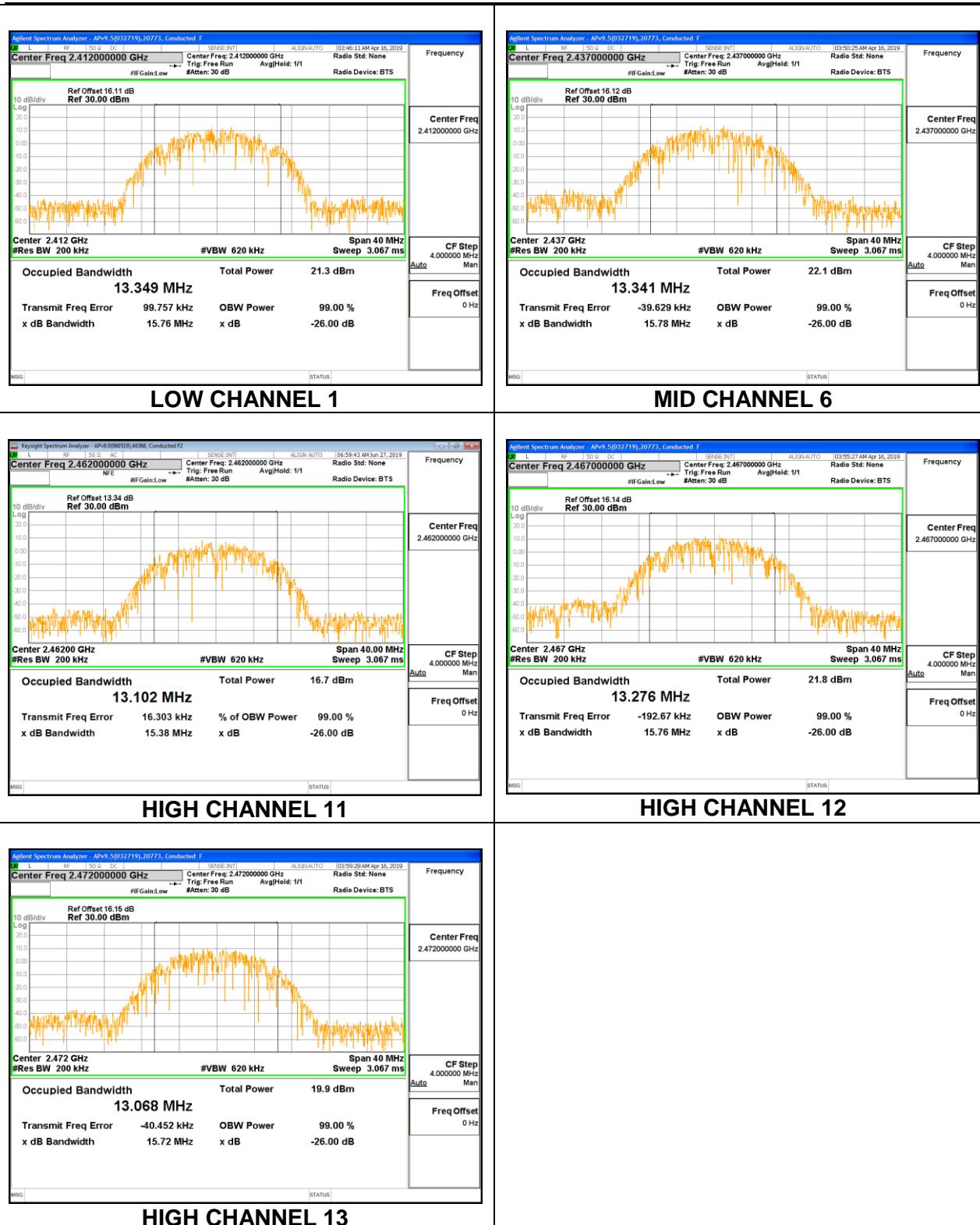
1TX Antenna 4 MODE

Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low 1	2412	13.4370
Mid 6	2437	13.2100
High 11	2462	13.0290
High 12	2467	13.0900
High 13	2472	13.0360



1TX Antenna 3 MODE

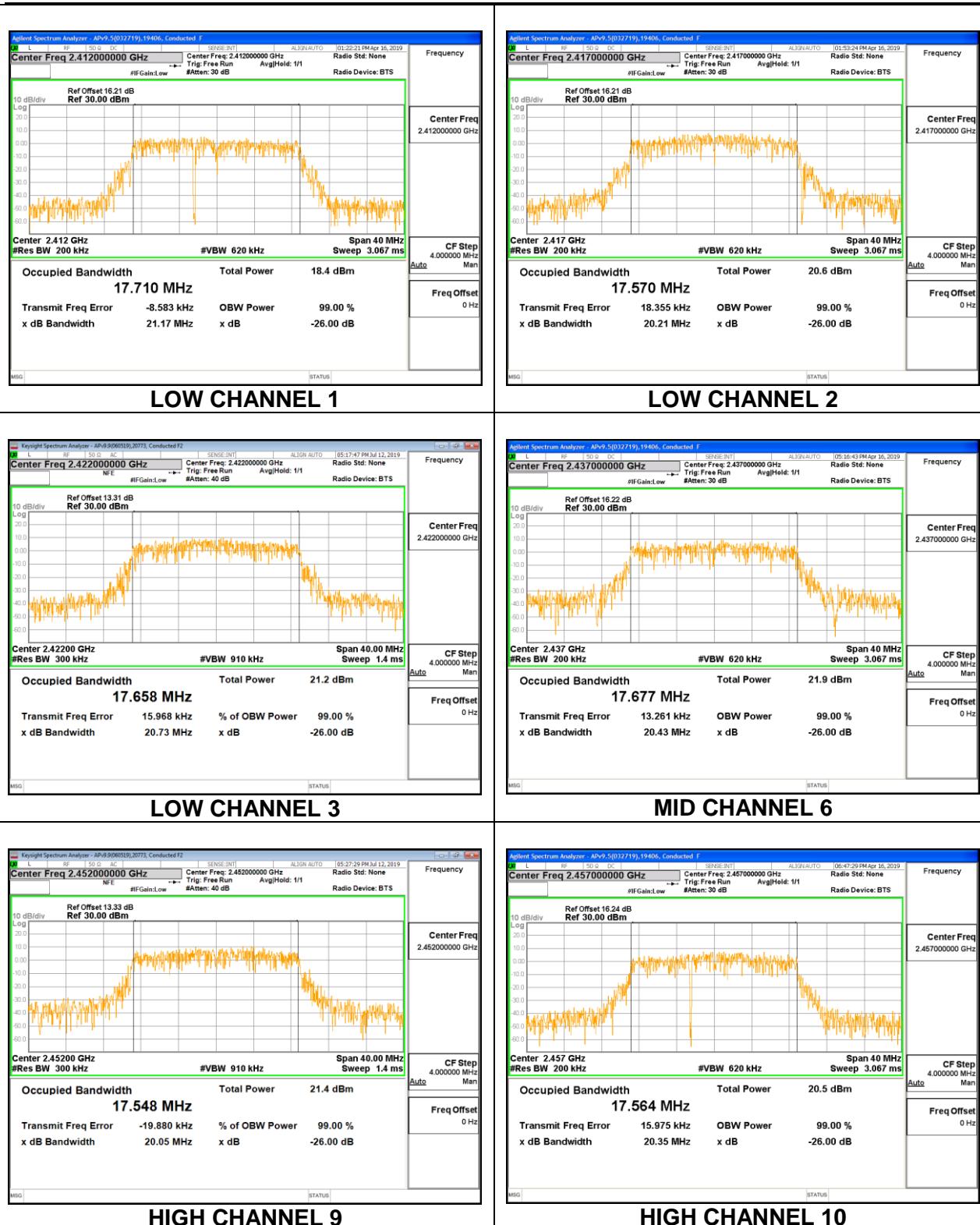
Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low 1	2412	13.3490
Mid 6	2437	13.3410
High 11	2462	13.1020
High 12	2467	13.2760
High 13	2472	13.0680

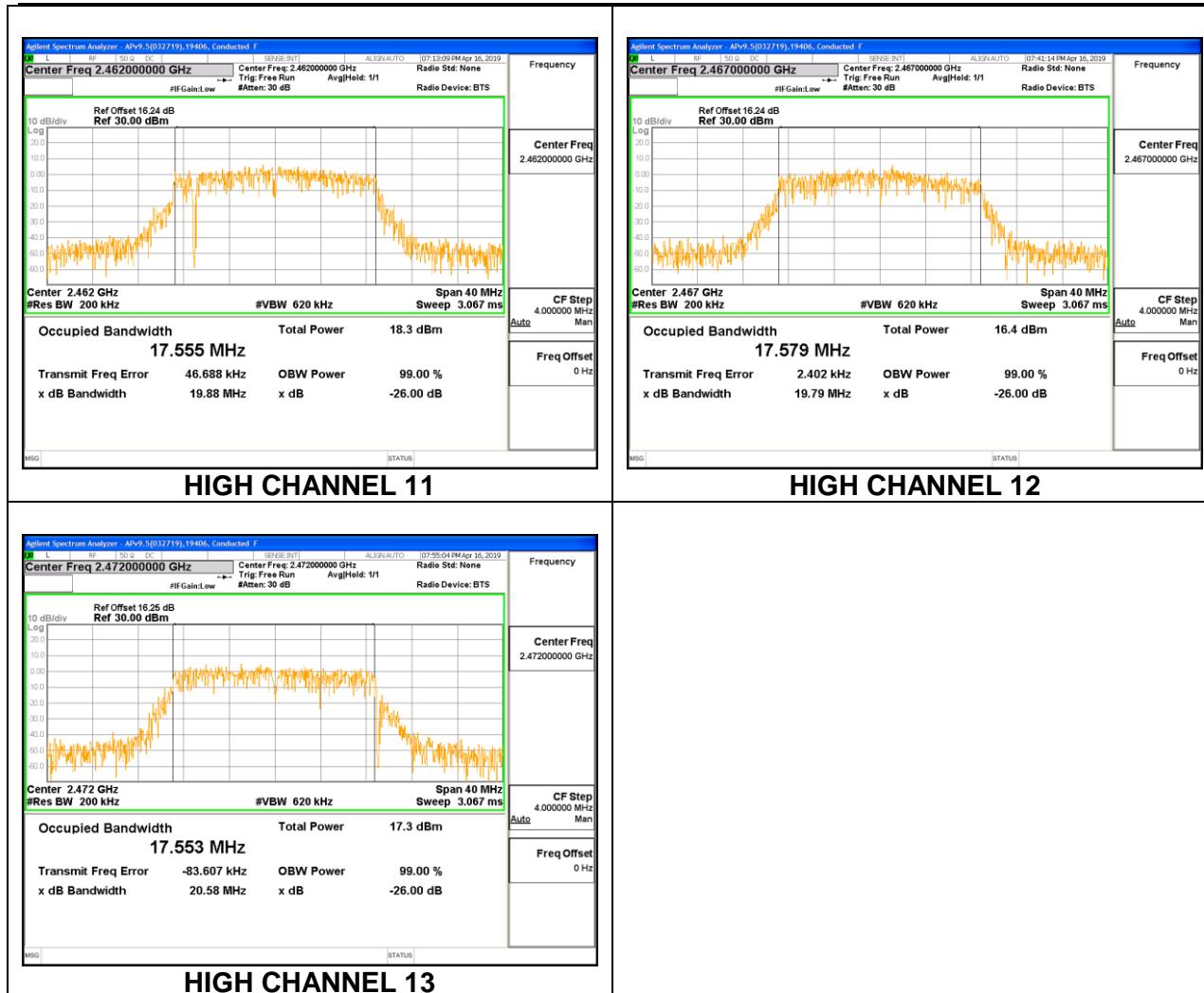


8.2.2. 802.11n HT20 MODE

1TX Antenna 4 MODE

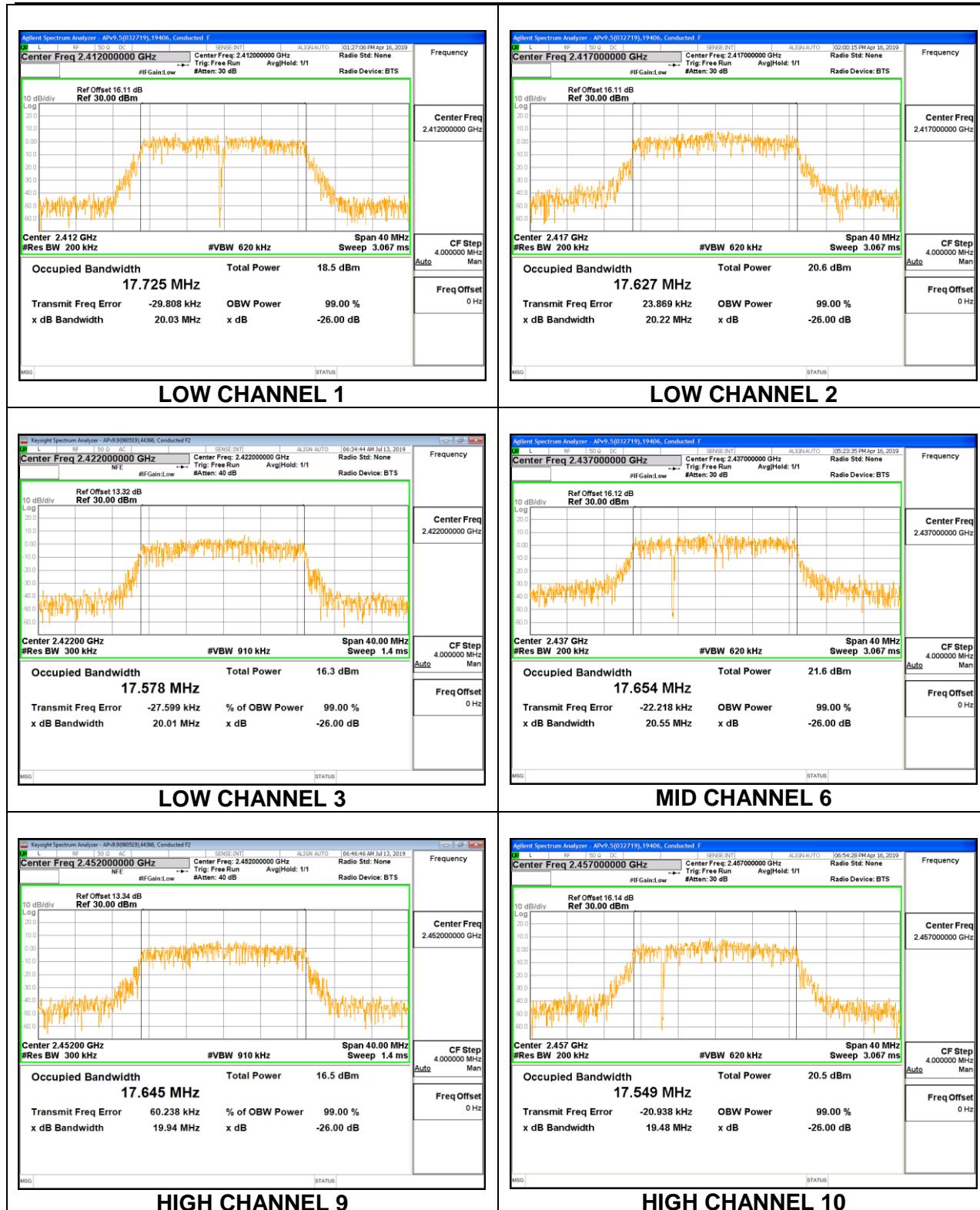
Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low 1	2412	17.7100
Low 2	2417	17.5700
Low 3	2422	17.6580
Mid 6	2437	17.6770
High 9	2452	17.5480
High 10	2457	17.5640
High 11	2462	17.5550
High 12	2467	17.5790
High 13	2472	17.5530

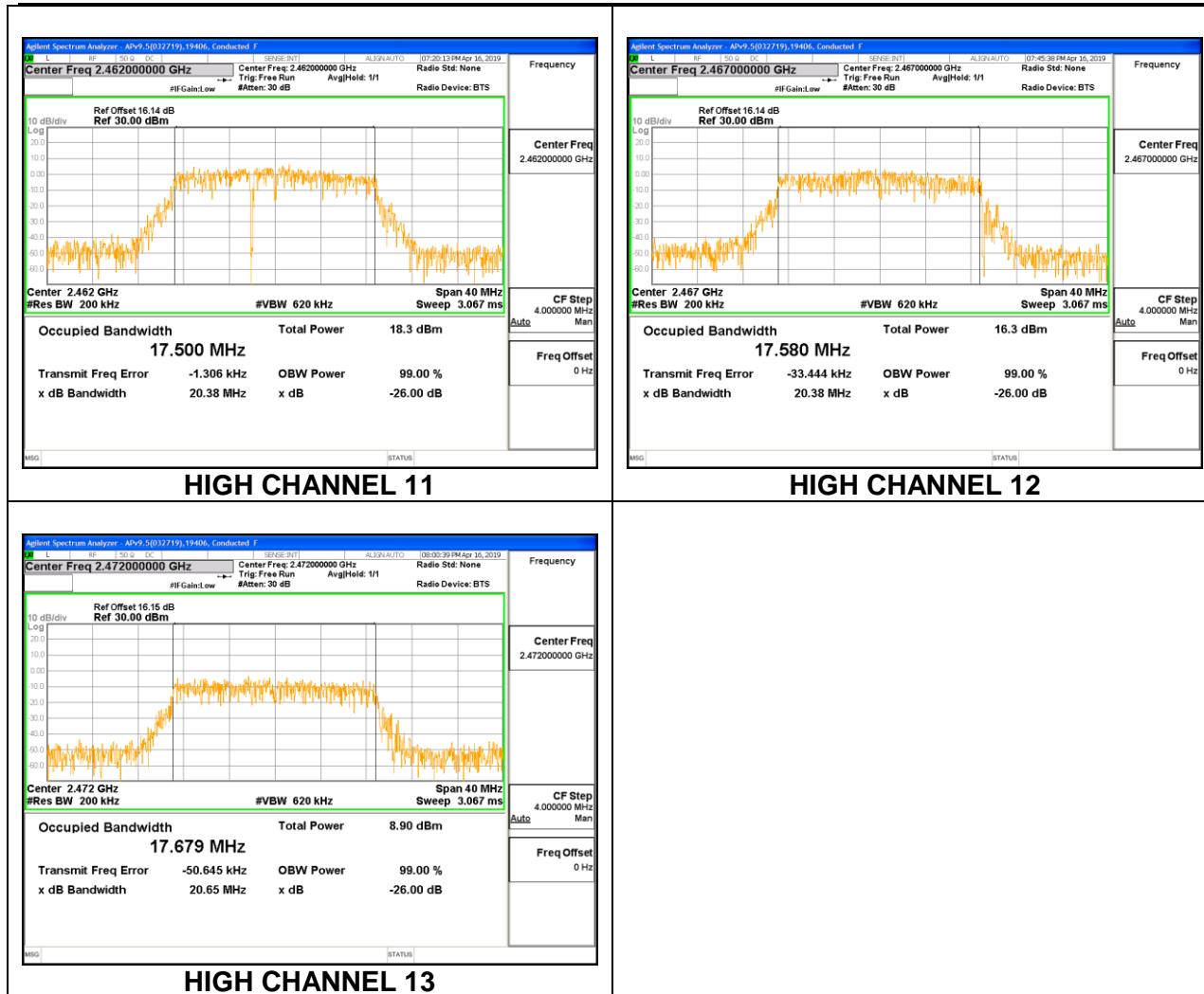




1TX Antenna 3 MODE

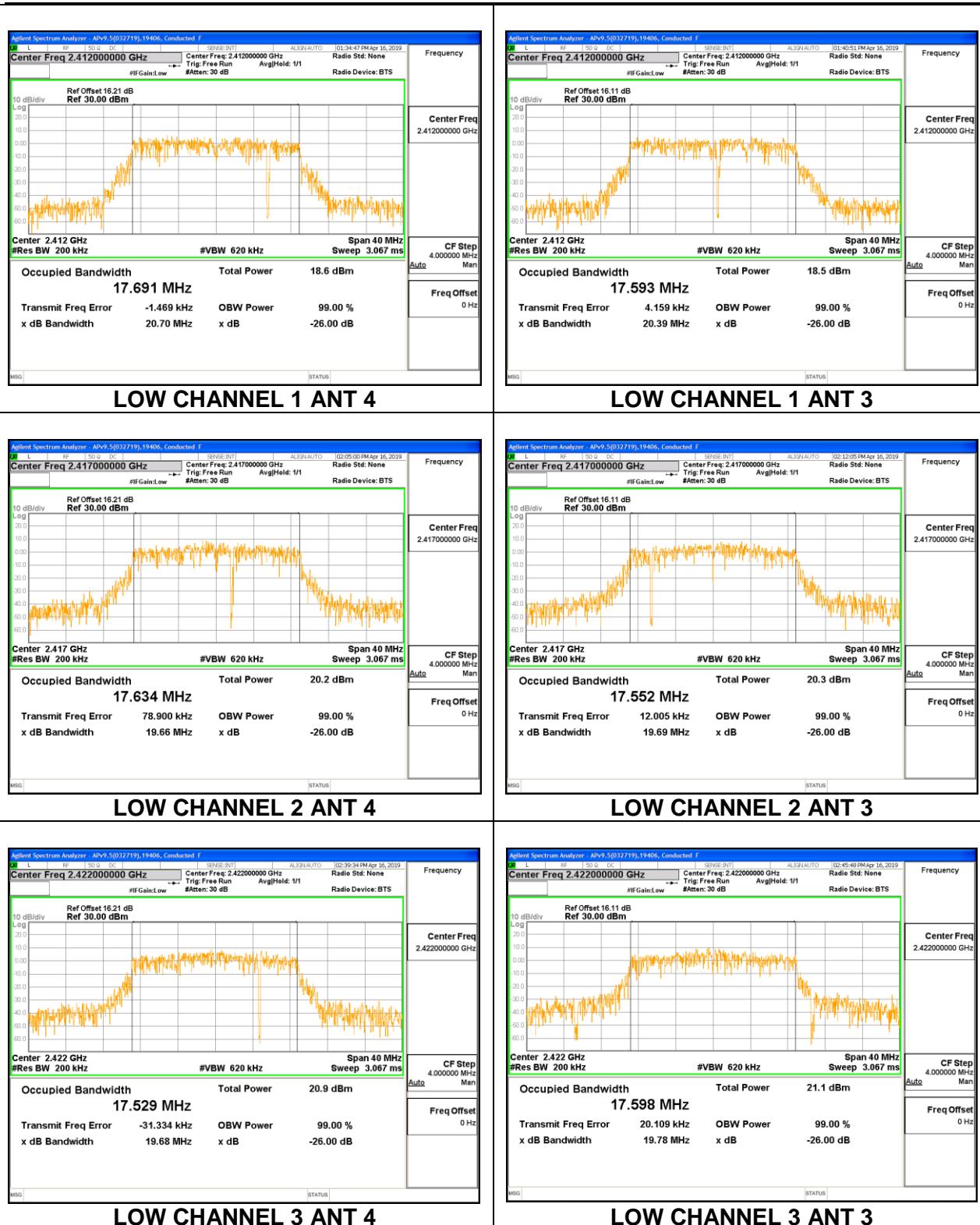
Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low 1	2412	17.7250
Low 2	2417	17.6270
Low 3	2422	17.5780
Mid 6	2437	17.6540
High 9	2452	17.6450
High 10	2457	17.5490
High 11	2462	17.5000
High 12	2467	17.5800
High 13	2472	17.6790

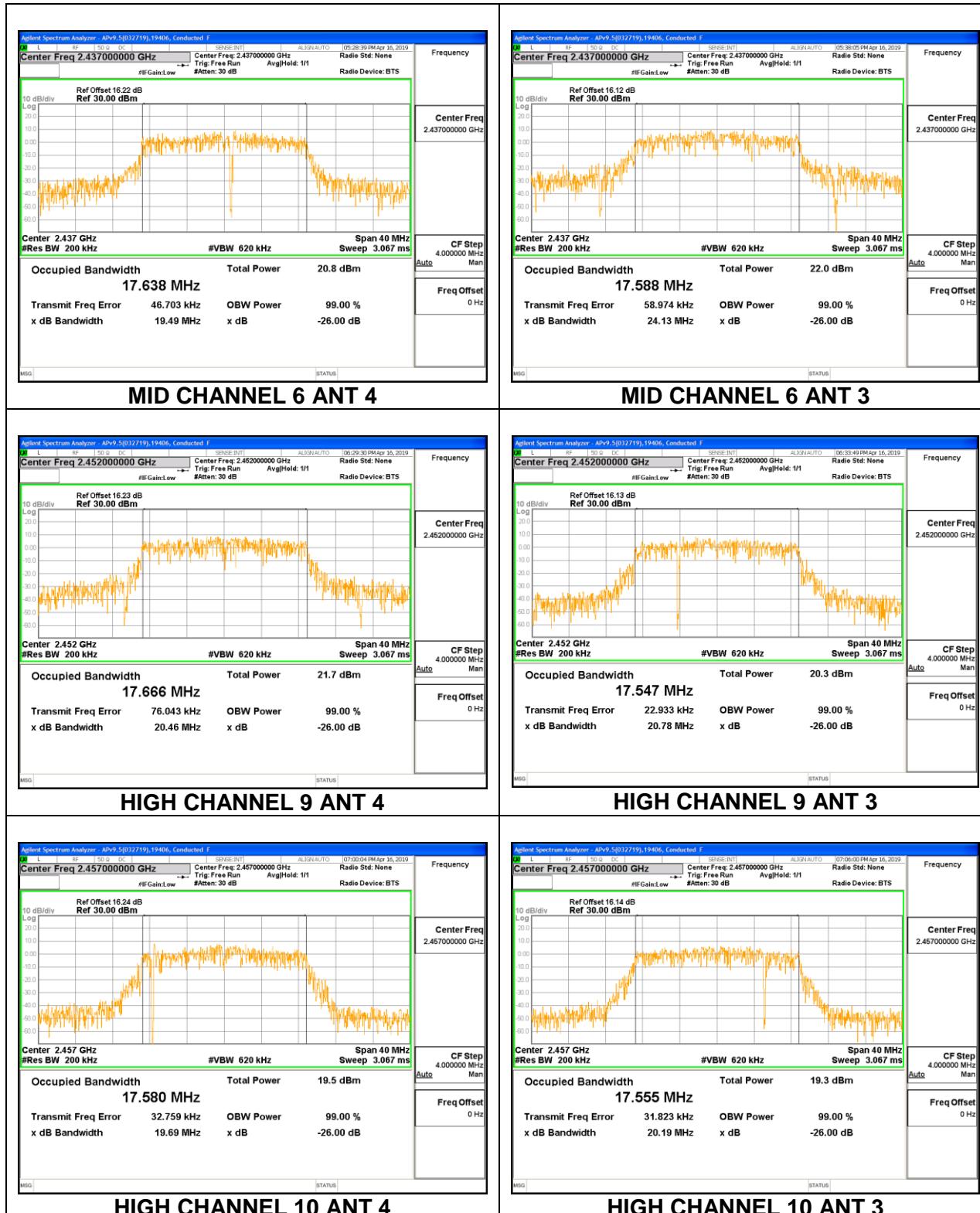


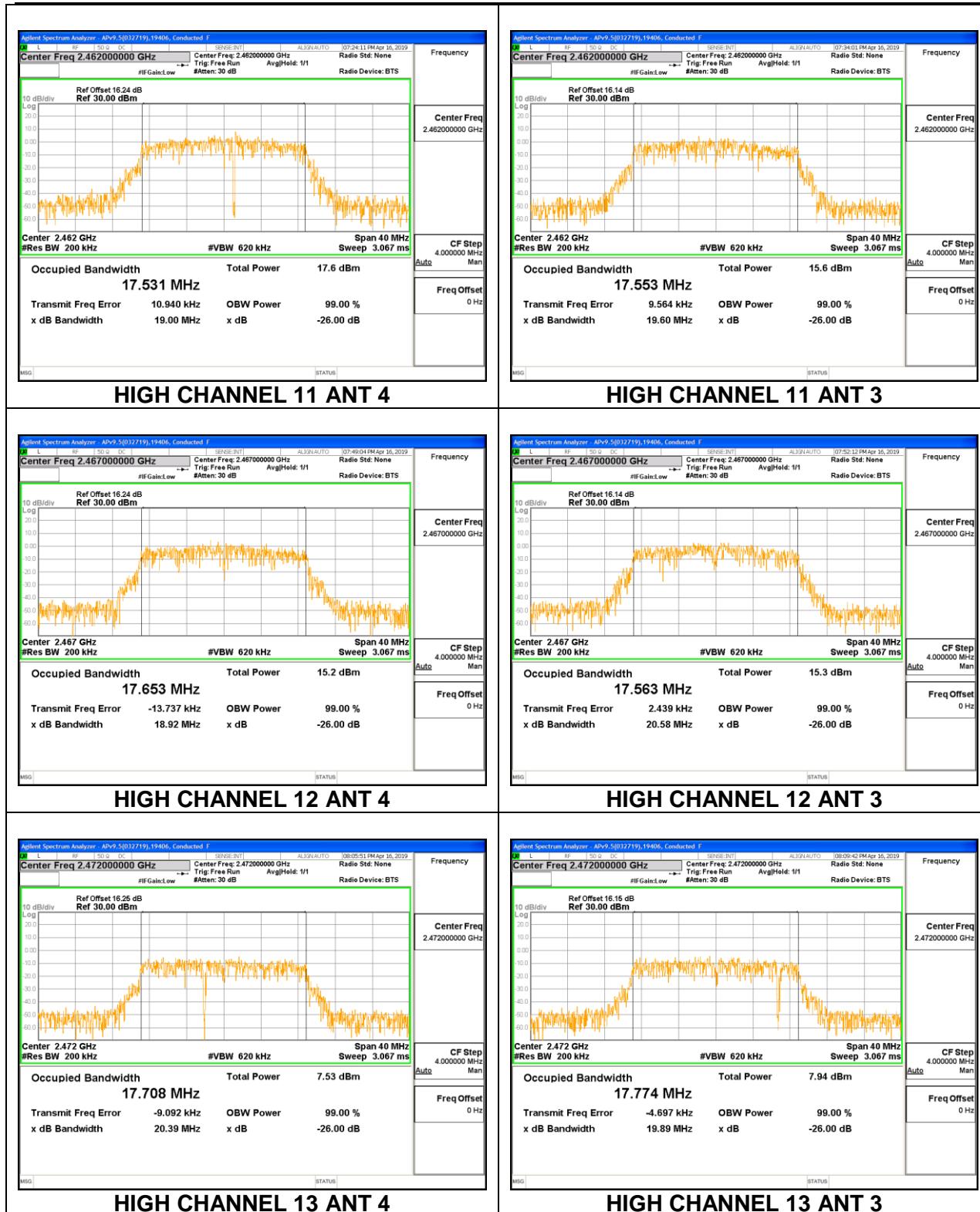


2TX Antenna 4 + Antenna 3 CDD MODE

Channel	Frequency (MHz)	99% Bandwidth Ant 4 (MHz)	99% Bandwidth Ant 3 (MHz)
Low 1	2412	17.6910	17.5930
Low 2	2417	17.6340	17.5520
Low 3	2422	17.5290	17.5980
Mid 6	2437	17.6380	17.5880
High 9	2452	17.6660	17.5470
High 10	2457	17.5800	17.5550
High 11	2462	17.5310	17.5530
High 12	2467	17.6530	17.5630
High 13	2472	17.7080	17.7740



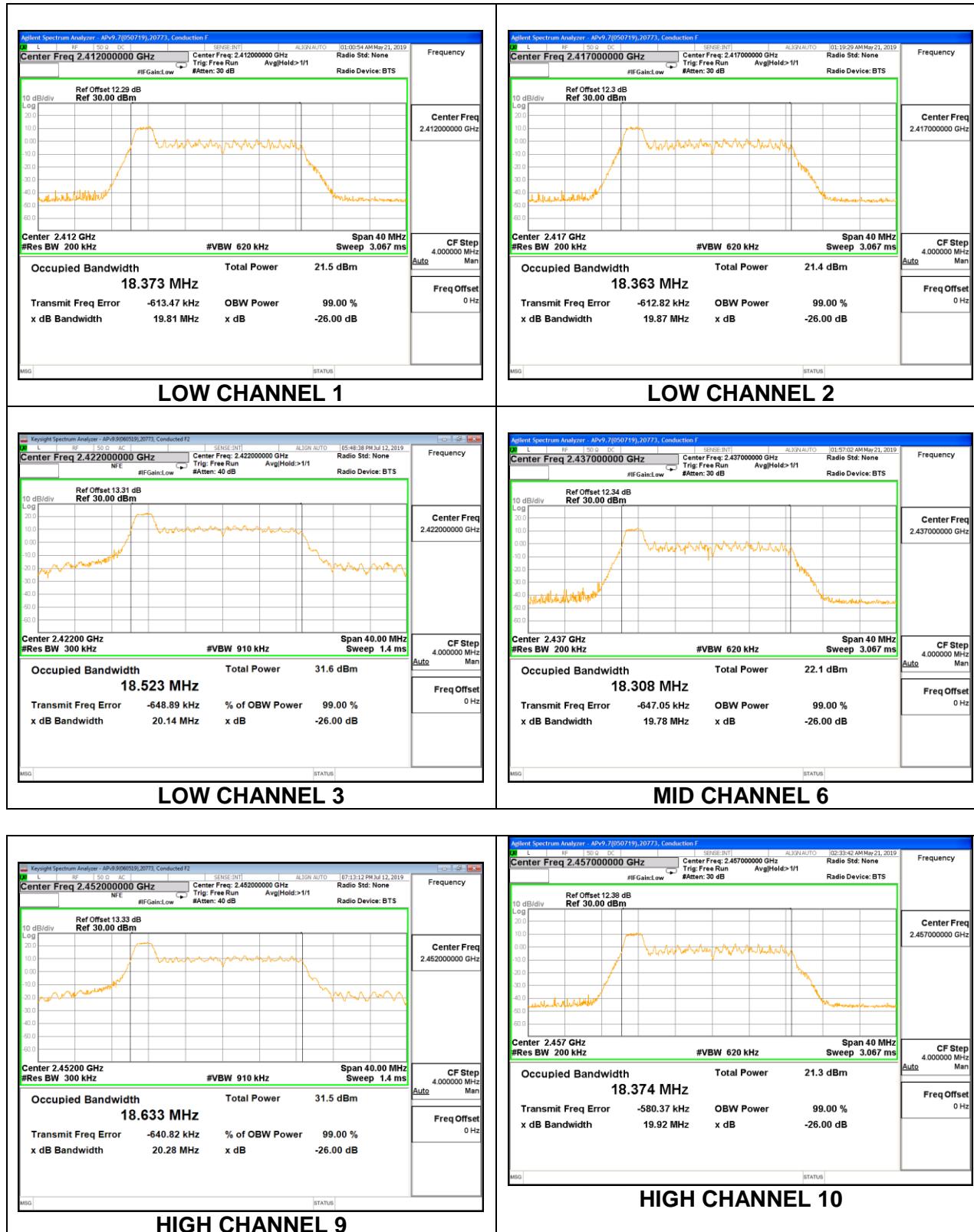


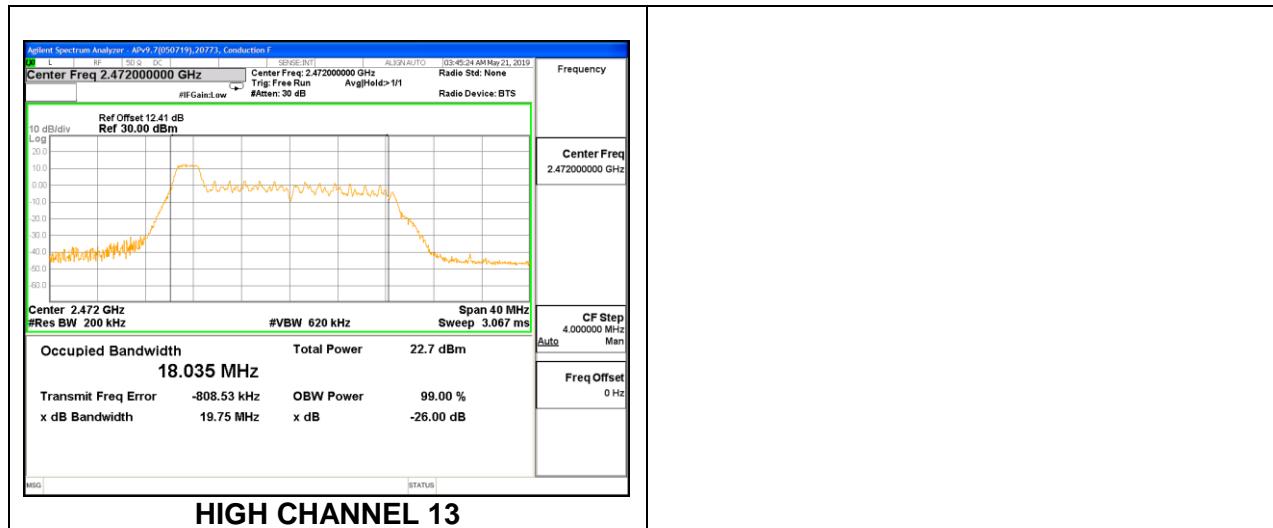
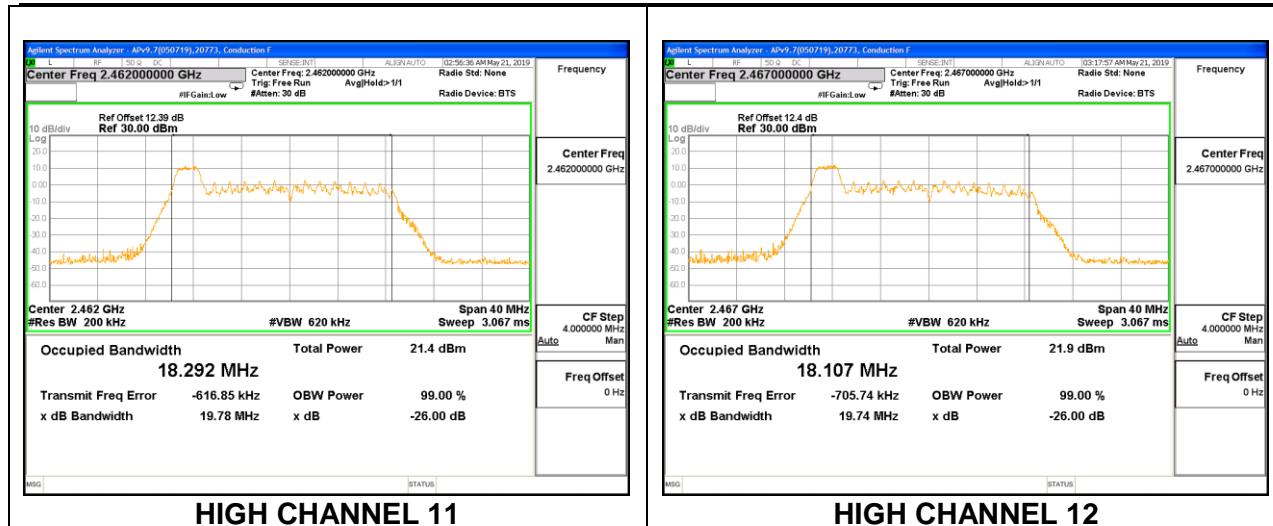


8.2.3. 802.11ax HE20 MODE

Antenna 4, LEGACY SISO MODE: 26-Tones, RU index 0

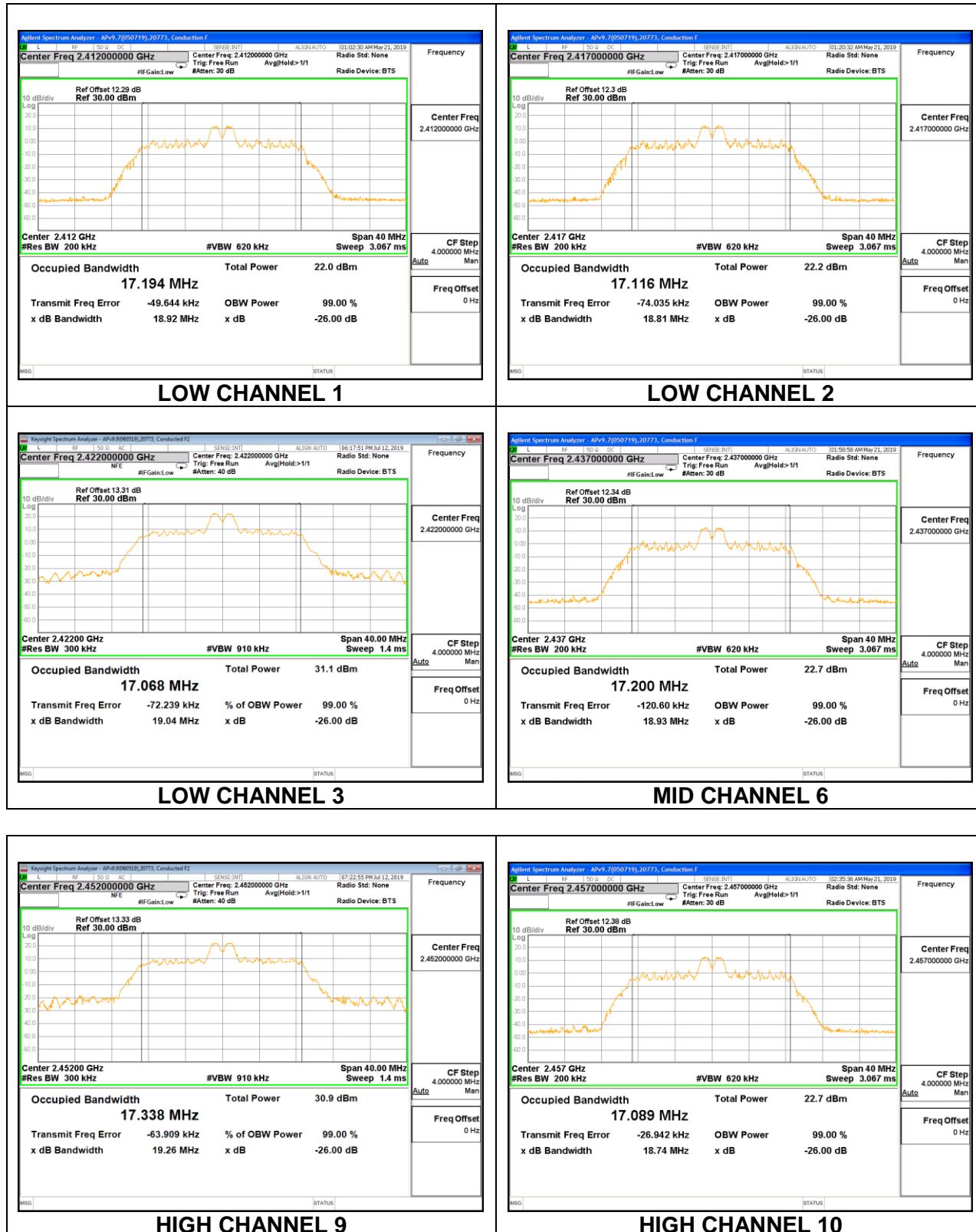
Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low 1	2412	18.3730
Low 2	2417	18.3630
Low 3	2422	18.5230
Mid 6	2437	18.3080
High 9	2452	18.6330
High 10	2457	18.3740
High 11	2462	18.2920
High 12	2467	18.1070
High 13	2472	18.0350

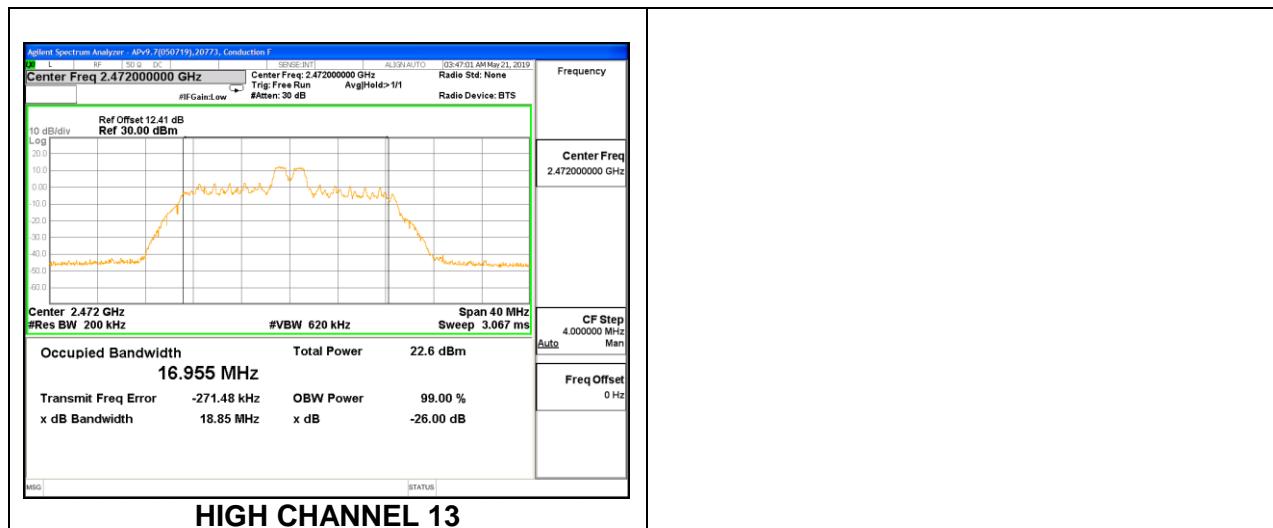
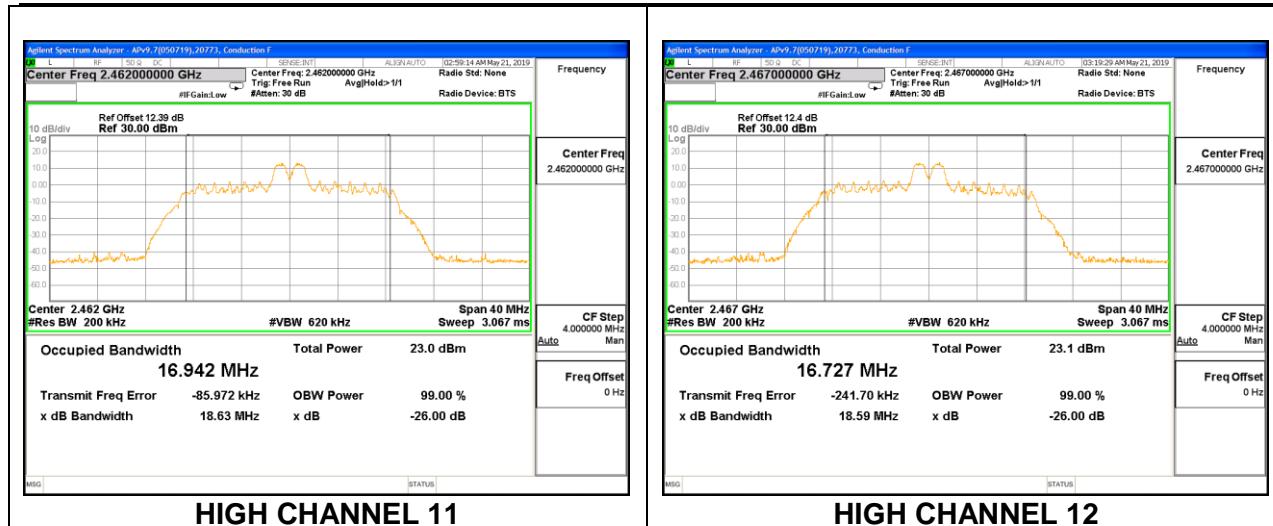




Antenna 4, LEGACY SISO MODE: 26-Tones, RU index 4

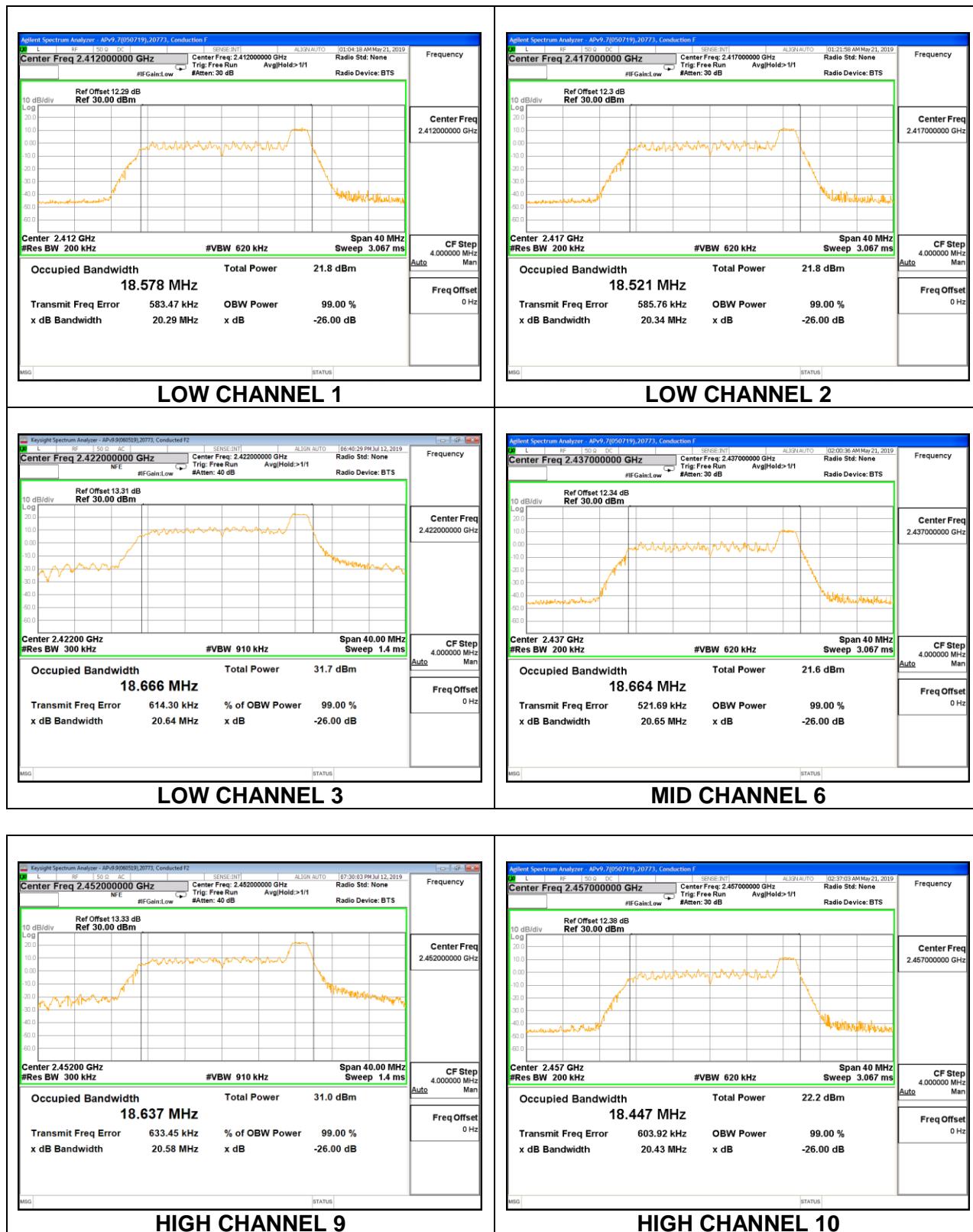
Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low 1	2412	17.1940
Low 2	2417	17.1160
Low 3	2422	17.0680
Mid 6	2437	17.2000
High 9	2452	17.3380
High 10	2457	17.0890
High 11	2462	16.9420
High 12	2467	16.7270
High 13	2472	16.9550

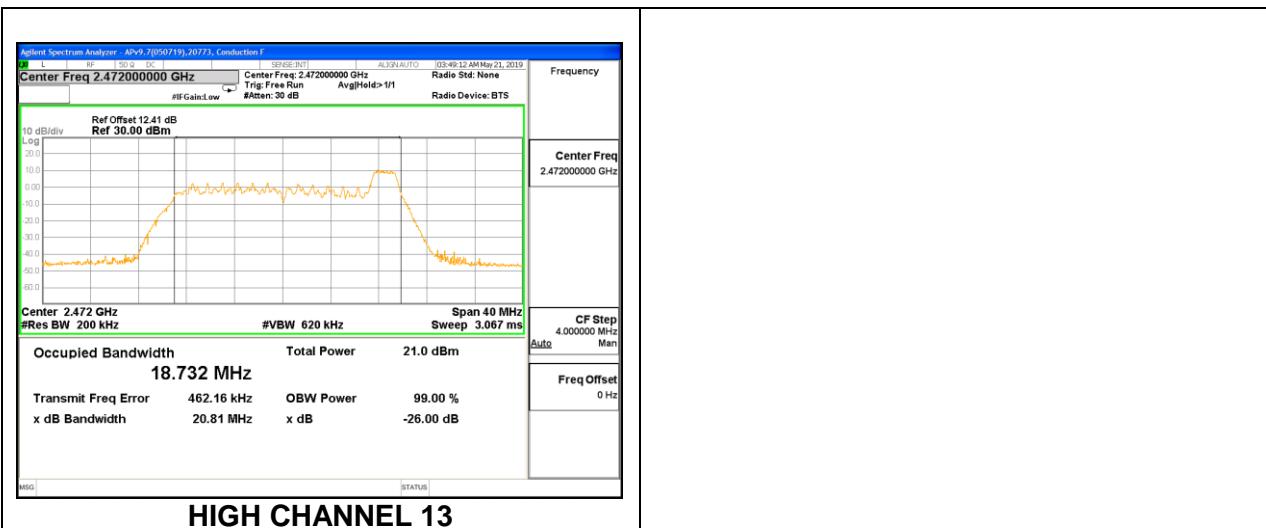
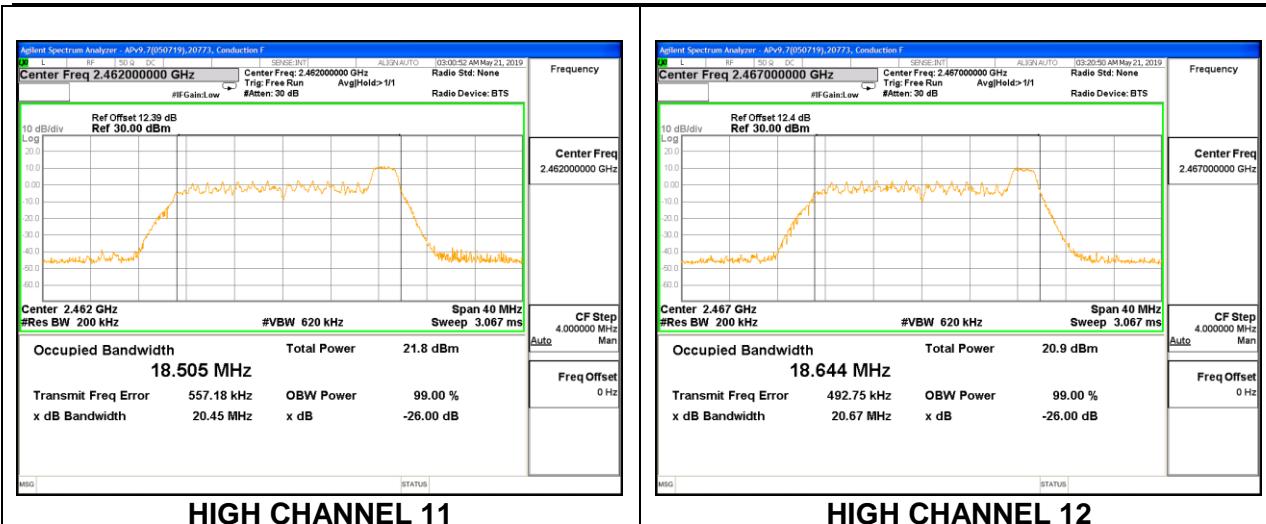




Antenna 4, LEGACY SISO MODE: 26-Tones, RU index 8

Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low 1	2412	18.5780
Low 2	2417	18.5210
Low 3	2422	18.6660
Mid 6	2437	18.6440
High 9	2452	18.6370
High 10	2457	18.4470
High 11	2462	18.5050
High 12	2467	18.6440
High 13	2472	18.7320





Antenna 4, LEGACY SISO MODE: 242-Tones, RU index 61

Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low 1	2412	18.8620
Low 2	2417	18.8720
Low 3	2422	18.9530
Mid 6	2437	18.9440
High 9	2452	19.1110
High 10	2457	18.9230
High 11	2462	19.0070
High 12	2467	18.8380
High 13	2472	18.8820