



CERTIFICATION TEST REPORT

Report Number. : 12166253-E3V4

Applicant : SONOS INC.
614 CHAPALA STREET
SANTA BARBARA, CA 93101, U.S.A

Model : S18

FCC ID : SBVRM016

IC : 5373A-RM016

EUT Description : 802.11a/b/g/n HT20 CLIENT DEVICE

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

Date Of Issue:
January 23, 2019

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NVLAP Lab code: 200065-0

REPORT REVISION HISTORY

Rev.	Issue Date	Revisions	Revised By
V1	9/13/2018	Initial Issue	-
V2	10/4/2018	Updated Section 5.2, 5.5, 8.1, 8.3 & 8..5.8	K.Kedida
V3	10/10/2018	Updated Section 9.2	K.Kedida
V4	1/23/2019	Updated Section 5.3 (Changed antenna polarization from Horizontal to Vertical)	K.Kedida

TABLE OF CONTENTS

REPORT REVISION HISTORY	2
TABLE OF CONTENTS	3
1. ATTESTATION OF TEST RESULTS	5
2. TEST METHODOLOGY	6
3. FACILITIES AND ACCREDITATION	6
4. CALIBRATION AND UNCERTAINTY	7
4.1. MEASURING INSTRUMENT CALIBRATION	7
4.2. SAMPLE CALCULATION	7
4.3. MEASUREMENT UNCERTAINTY.....	7
5. EQUIPMENT UNDER TEST	8
5.1. EUT DESCRIPTION	8
5.2. MAXIMUM OUTPUT POWER.....	8
5.3. DESCRIPTION OF AVAILABLE ANTENNAS	8
5.4. SOFTWARE AND FIRMWARE.....	8
5.5. WORST-CASE CONFIGURATION AND MODE	9
5.6. DESCRIPTION OF TEST SETUP.....	10
6. MEASUREMENT METHOD.....	12
7. TEST AND MEASUREMENT EQUIPMENT	13
8. ANTENNA PORT TEST RESULTS	14
8.1. ON TIME AND DUTY CYCLE.....	14
8.2. 26 dB BANDWIDTH.....	16
8.2.1. 802.11a MODE IN THE 5.2 GHz BAND	17
8.2.1. 802.11a MODE IN THE 5.3 GHz BAND	19
8.2.2. 802.11a MODE IN THE 5.6 GHz BAND	21
8.2.3. 802.11a MODE IN THE 5.8 GHz BAND	23
8.2.4. 802.11n HT20 MODE IN THE 5.2 GHz BAND	25
8.2.5. 802.11n HT20 MODE IN THE 5.3 GHz BAND	27
8.2.6. 802.11n HT20 MODE IN THE 5.6 GHz BAND	29
8.2.7. 802.11n HT20 MODE IN THE 5.8 GHz BAND	31
8.3. 99% BANDWIDTH.....	33
8.3.1. 802.11a MODE IN THE 5.2 GHz BAND	34
8.3.2. 802.11a MODE IN THE 5.3 GHz BAND	36
8.3.3. 802.11a MODE IN THE 5.6 GHz BAND	38
8.3.4. 802.11a MODE IN THE 5.8 GHz BAND	40
8.3.5. 802.11n HT20 MODE IN THE 5.2 GHz BAND	42

8.3.6.	802.11n HT20 MODE IN THE 5.3 GHz BAND	44
8.3.7.	802.11n HT20 MODE IN THE 5.6 GHz BAND	46
8.3.8.	802.11n HT20 MODE IN THE 5.8 GHz BAND	48
8.4.	6 dB BANDWIDTH.....	50
8.4.1.	802.11a MODE IN THE 5.8 GHz BAND	51
8.4.2.	802.11n HT20 MODE IN THE 5.8 GHz BAND	53
8.5.	OUTPUT POWER AND PSD.....	55
8.5.1.	802.11a MODE IN THE 5.2 GHz BAND	59
8.5.2.	802.11a MODE IN THE 5.3 GHz BAND	61
8.5.3.	802.11a MODE IN THE 5.6 GHz BAND	65
8.5.4.	802.11a MODE IN THE 5.8 GHz BAND	67
8.5.5.	802.11n HT20 MODE IN THE 5.2 GHz BAND	69
8.5.6.	802.11n HT20 MODE IN THE 5.3 GHz BAND	71
8.5.7.	802.11n HT20 MODE IN THE 5.6 GHz BAND	75
8.5.8.	802.11n HT20 MODE IN THE 5.8 GHz BAND	77
9.	RADIATED TEST RESULTS.....	79
9.1.	TRANSMITTER ABOVE 1 GHz	80
9.1.1.	TX ABOVE 1 GHz 802.11a MODE IN THE 5.2 GHz BAND	80
9.1.2.	TX ABOVE 1 GHz 802.11a MODE IN THE 5.3 GHz BAND	88
9.1.3.	TX ABOVE 1 GHz 802.11a MODE IN THE 5.6 GHz BAND	96
9.1.4.	TX ABOVE 1 GHz 802.11a MODE IN THE 5.8 GHz BAND	106
9.1.5.	TX ABOVE 1 GHz 802.11n HT20 MODE IN THE 5.2 GHz BAND.....	116
9.1.6.	TX ABOVE 1 GHz 802.11n HT20 MODE IN THE 5.3 GHz BAND.....	124
9.1.7.	TX ABOVE 1 GHz 802.11n HT20 MODE IN THE 5.6 GHz BAND.....	132
9.1.8.	TX ABOVE 1 GHz 802.11n HT20 MODE IN THE 5.8 GHz BAND.....	136
9.2.	Worst Case Below 30 MHz	146
9.3.	Worst Case Below 1 GHz	147
9.4.	Worst Case 18-26 GHz.....	149
9.5.	Worst Case 26-40 GHz.....	151
10.	AC POWER LINE CONDUCTED EMISSIONS.....	153
11.	SETUP PHOTOS.....	156

1. ATTESTATION OF TEST RESULTS

COMPANY NAME: SONOS INC.
614 CHAPALA STREET
SANTA BARBARA, CA 93101, U.S.A.

EUT DESCRIPTION: 802.11a/b/g/n HT20 CLIENT DEVICE

MODEL: S18

SERIAL NUMBER: 78-28-CA-F0-00-2E-C (Radiated Sample)
78-28-CA-F0-00-14 (Conducted Sample)

DATE TESTED: July 23 – 30, 2018

APPLICABLE STANDARDS	
STANDARD	TEST RESULTS
CFR 47 Part 15 Subpart E	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. 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 the U.S. government.

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2. TEST METHODOLOGY

The tests documented in this report were performed in accordance with FCC CFR 47 Part 2, FCC CFR 47 Part 15, FCC KDB 662911 D01 Multiple Transmitter Output v02r01, FCC KDB 789033 D02 v02r01, ANSI C63.10-2013, RSS-GEN Issue 5, and RSS-247 Issue 2.

3. FACILITIES AND ACCREDITATION

The test sites and measurement facilities used to collect data are located at 47173 and 47266 Benicia Street, and 47658 Kato Road, Fremont, California, USA. Line conducted emissions are measured only at the 47173 address. The following table identifies which facilities were utilized for radiated emission measurements documented in this report. Specific facilities are also identified in the test results sections.

47173 Benicia Street	47266 Benicia Street	47658 Kato Rd.
☒ Chamber A (ISED:2324B-1)	☐ Chamber D (ISED:22541-1)	☒ Chamber K (ISED: 2324A-1)
☒ Chamber B (ISED:2324B-2)	☐ Chamber E (ISED:22541-2)	☐ Chamber L (ISED: 2324A-3)
☐ 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. Chambers K and L are covered under ISED company address code 2324A with site numbers 2324A-1 and 2324A-3, respectively.

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

Where relevant, the following sample calculation is provided:

$$\begin{aligned} \text{Field Strength (dBuV/m)} &= \text{Measured Voltage (dBuV)} + \text{Antenna Factor (dB/m)} + \\ &\text{Cable Loss (dB)} - \text{Preamp Gain (dB)} \\ 36.5 \text{ dBuV} + 18.7 \text{ dB/m} + 0.6 \text{ dB} - 26.9 \text{ dB} &= 28.9 \text{ dBuV/m} \end{aligned}$$

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%.

5. EQUIPMENT UNDER TEST

5.1. EUT DESCRIPTION

The EUT is 802.11 a/b/g/n HT20 CLINET DEVICE.

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)
5.2 GHz band, 2TX			
5180-5240	802.11a	16.06	40.36
5180-5240	802.11n HT20	16.20	41.69
5.3 GHz band, 2TX			
5260-5320	802.11a	19.19	82.99
5260-5320	802.11n HT20	20.44	110.66
5.6 GHz band, 2TX			
5500-5700	802.11a	19.52	89.54
5500-5700	802.11n HT20	20.72	118.03
5.8 GHz band, 2TX			
5745-5825	802.11a	19.33	85.70
5745-5825	802.11n HT20	20.80	120.23

5.3. DESCRIPTION OF AVAILABLE ANTENNAS

Frequency (MHz)	5GHz Max Antenna Gain dBi	
	Chain 0 / (Vertical Polarization)	Chain 1 (Vertical Polarization)
5180 - 5850	0.6	2.6

5.4. SOFTWARE AND FIRMWARE

The EUT software ware installed during testing was 44.2-53220-RF-Compliance_20180523.

The test utility software used during testing was Sonos Compliance GUI V2.2.

5.5. WORST-CASE CONFIGURATION AND MODE

Radiated bandage, harmonics, and spurious emissions from 1 GHz to 18GHz were performed. The EUT was set to transmit at the Low/Middle/High channels with designed (target) output powers.

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

The EUT can only be setup in desktop orientation; therefore, all radiated testing was performed with the EUT in desktop orientation.

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

802.11a: 6Mbps

802.11n HT20mode: MCS3

5.6. DESCRIPTION OF TEST SETUP

SUPPORT EQUIPMENT

Support Equipment List				
Description	Manufacturer	Model	Serial Number	FCC ID
Laptop	Lenovo	X201	SON-00000964	N/A
AC Adapter	Lenovo	ADLX65NLT2A	11S36200291ZZ200315AJU	N/A
Charging Base	Lenovo	X200	1S43R8781R934HPB	N/A

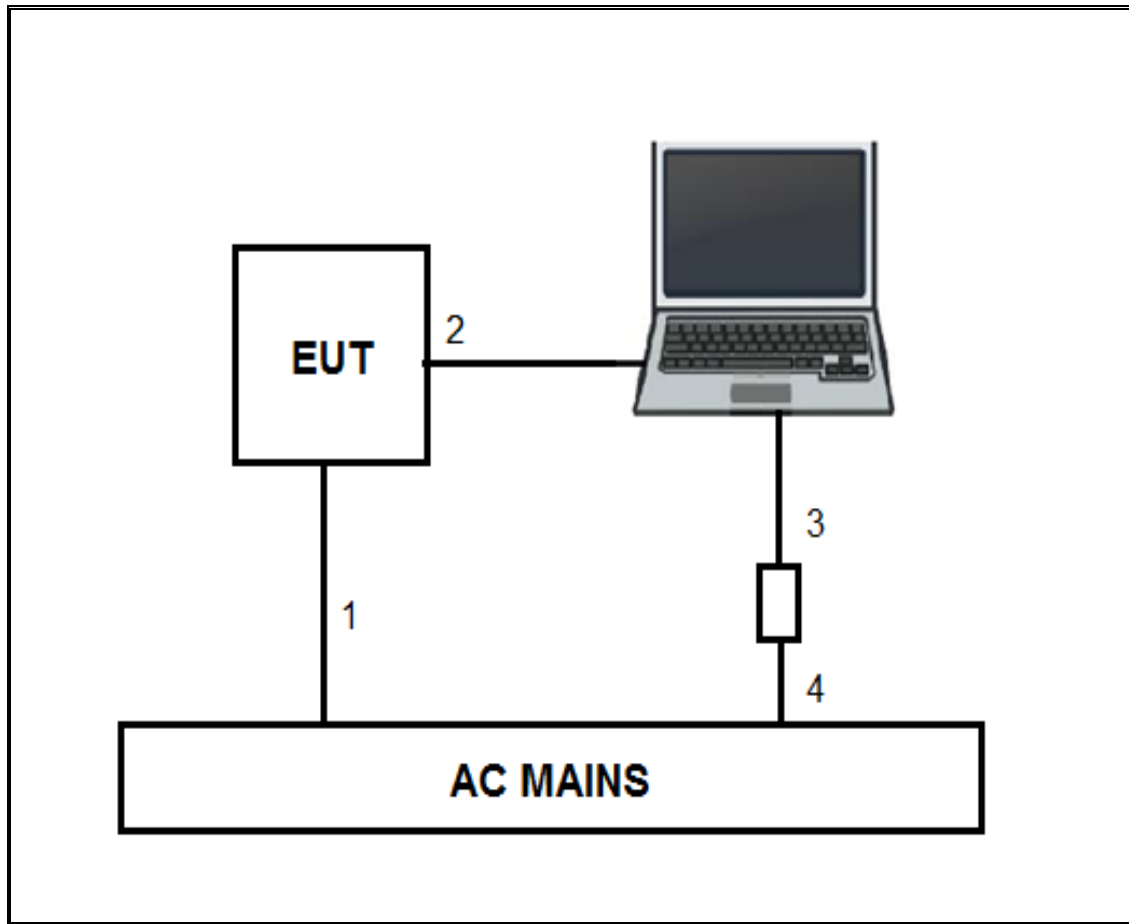
I/O CABLES

I/O Cable List						
Cable No	Port	# of identical ports	Connector Type	Cable Type	Cable Length (m)	Remarks
1	AC Power	1	AC	Unshielded	2	AC Mains to EUT
2	Ethernet	1	RJ45	Unshielded	10	EUT to Laptop
3	DC Power	1	DC	Shielded	1.2	AC/DC Adapter to Laptop
4	AC Power	1	AC	Unshielded	1	AC Mains to AC/DC Adapter

TEST SETUP

The EUT is a stand-alone unit, and the radio is exercised by Sonos Compliance GUI V2.2 test utility software via Ethernet.

SETUP DIAGRAMS



6. MEASUREMENT METHOD

On Time and Duty Cycle: KDB 789033 D02 v02r01, Section B.

6 dB Emission BW: KDB 789033 D02 v02r01, Section C.2

26 dB Emission BW: KDB 789033 D02 v02r01, Section C.1

99% Occupied BW: KDB 789033 D02 v02r01, Section D.

Conducted Output Power: KDB 789033 D02 v02r01, Section E.3.b (Method PM-G) and KDB 789033 D02 v02r01, Section E.2.b (Method SA-1)

Power Spectral Density: KDB 789033 D02 v02r01, Section F

Unwanted emissions in restricted bands: KDB 789033 D02 v02r01, Sections G.3, G.4, G.5, and G.6.

Unwanted emissions in non-restricted bands: KDB 789033 D02 v02r01, Sections G.3, G.4, and G.5.

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	ID Num	Cal Due
Amplifier, 100kHz to 1GHz, 32dB	Hewlet Packard	8447D	T15	08/14/2018
Antenna, Broadband Hybrid, 30MHz to 2000MHz	Sunol Sciences Corp.	JB1	T407	05/10/2019
Antenna, Horn 1-18GHz	ETS-Lindgren	3117	T863	06/21/2019
Antenna, Horn 1-18GHz	ETS-Lindgren	3117	T862	05/24/2019
Antenna, Horn 1-18GHz	ETS-Lindgren	3117	T344	04/30/2019
RF Amplifier	MITEQ	AFS42-00101800-25-S-42	T1165	04/23/2019
Amplifier, 1 to 8GHz, 35dB	Miteq Inc.	AMF-4D-01000800-30-29P	T1573	04/03/2019
Spectrum Analyzer, PXA, 3Hz to 44GHz	Agilent (Keysight) Technologies	N9030A	T1450	02/05/2019
Spectrum Analyzer, PXA, 3Hz to 44GHz	Agilent (Keysight) Technologies	N9030A	T1113	12/21/2018
Spectrum Analyzer, PSA, 3Hz to 44GHz	Agilent (Keysight) Technologies	N9030A	T1466	04/16/2019
Power Meter, P-series single channel	Agilent (Keysight) Technologies	N1911A	T1271	07/17/2019
Power Sensor, P-series, 50MHz to 18GHz, Wideband	Agilent (Keysight) Technologies	N1921A	T1225	04/10/2019
Antenna, Active Loop 9kHz-30MHz	Com-Power Corp.	AL-130R	T1866	10/10/2018
18 - 26.5 GHz Horn Antenna	Seavey Division	MWH-1826/B	T89	01/18/2019
Pre-Amp 1-26.5 GHz	Agilent	8449B	T404	03/09/2019
EMI Reciever	Rohde & Schwarz	ESR	T1436	02/21/2019
L.I.S.N.	FCC INC.	FCC LISN 50/250	T1310	06/15/2019

Test Software List			
Description	Manufacturer	Model	Version
Radiated Software	UL	UL EMC	Ver 9.5, June 22, 2018
Antenna Port Software	UL	UL RF	Ver 8.4, June 12, 2018

8. ANTENNA PORT TEST RESULTS

8.1. ON TIME AND DUTY CYCLE

LIMITS

None; for reporting purposes only.

PROCEDURE

KDB 789033 Zero-Span Spectrum Analyzer Method.

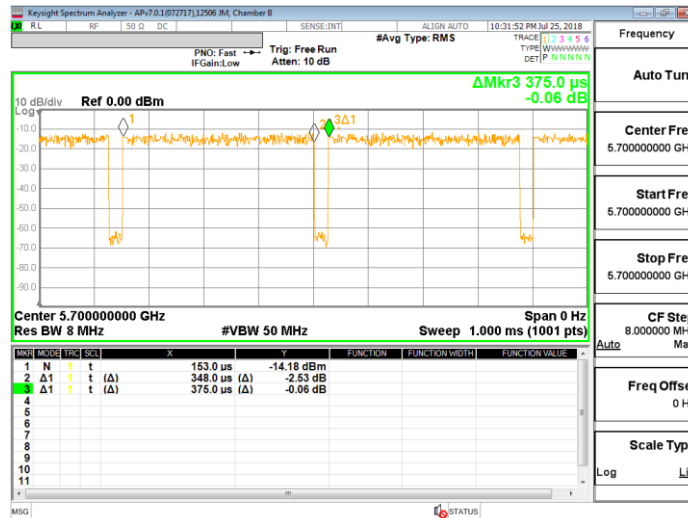
ON TIME AND DUTY CYCLE RESULTS

Mode	ON Time B (msec)	Period (msec)	Duty Cycle x (linear)	Duty Cycle (%)	Duty Cycle Correction Factor (dB)	1/B Minimum VBW (kHz)
802.11a	1.361	1.392	0.978	97.77%	0.10	0.735
802.11n HT20	0.348	0.375	0.928	92.80%	0.32	2.874

DUTY CYCLE PLOTS



802.11a HT20



802.11n HT20

8.2. 26 dB BANDWIDTH

LIMITS

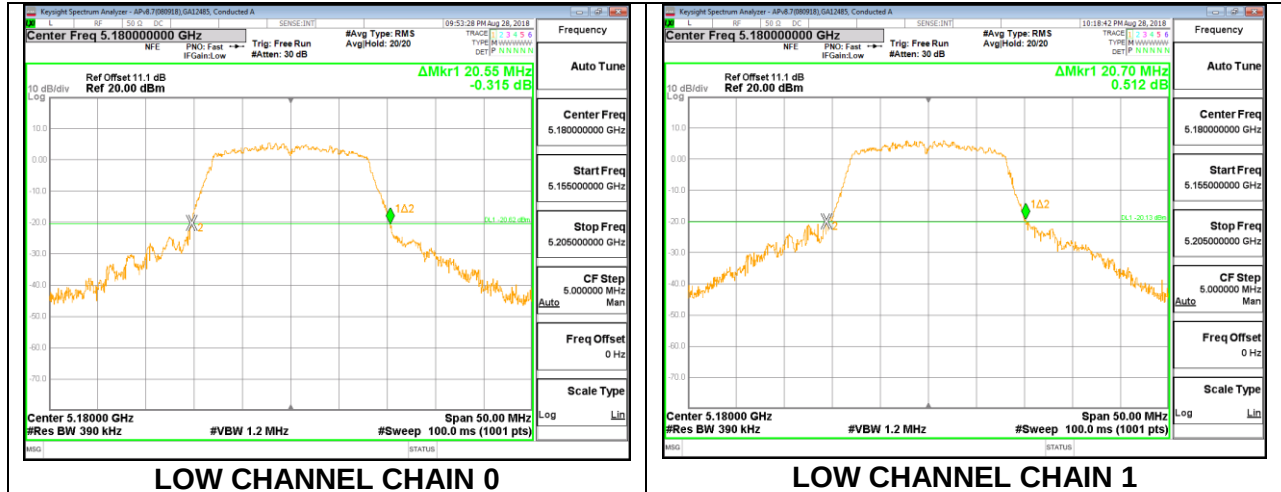
None; for reporting purposes only.

RESULTS

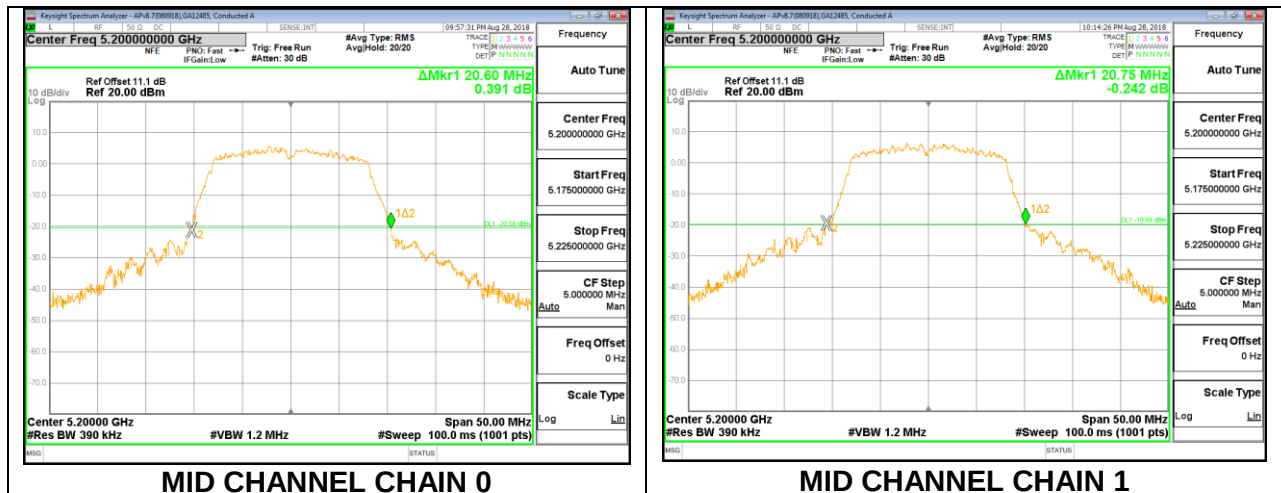
8.2.1. 802.11a MODE IN THE 5.2 GHz BAND

Channel	Frequency (MHz)	26 dB Bandwidth Chain 0 (MHz)	26 dB Bandwidth Chain 1 (MHz)
Low	5180	20.55	20.70
Mid	5200	20.60	20.75
High	5240	20.55	20.65

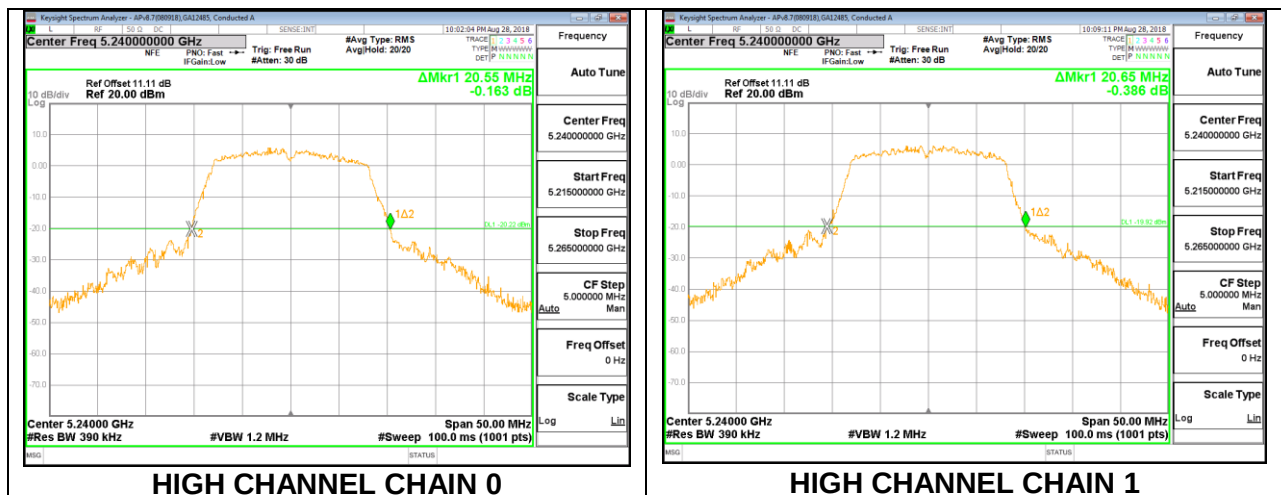
LOW CHANNEL



MID CHANNEL



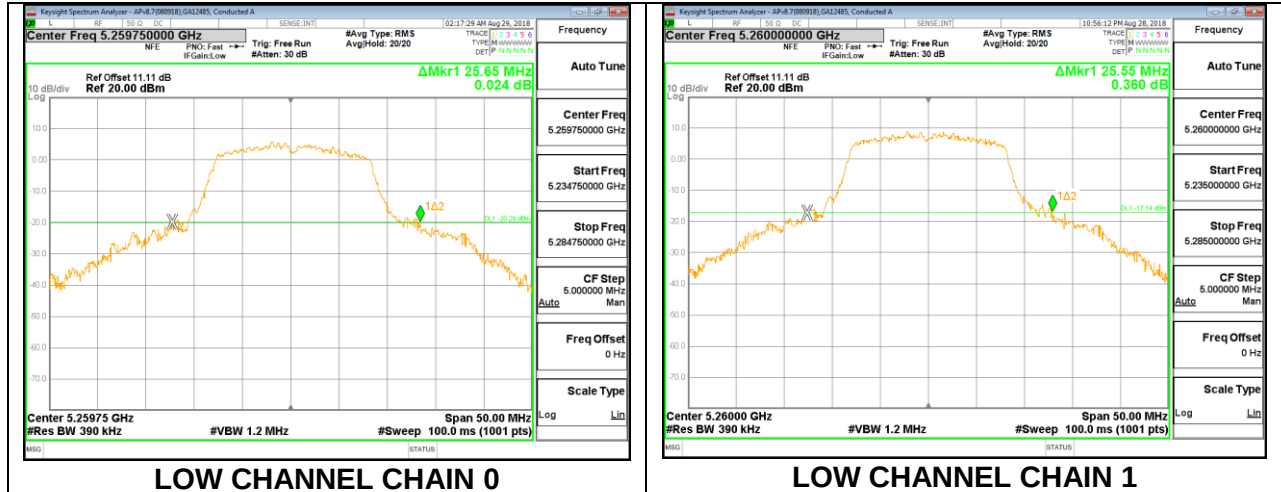
HIGH CHANNEL



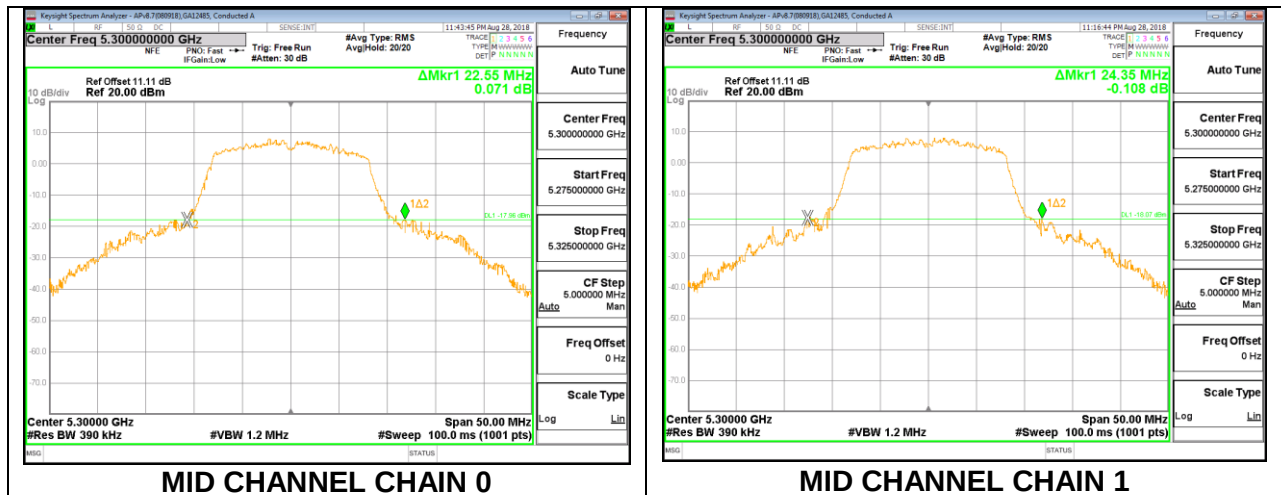
8.2.1. 802.11a MODE IN THE 5.3 GHz BAND

Channel	Frequency (MHz)	26 dB Bandwidth Chain 0 (MHz)	26 dB Bandwidth Chain 1 (MHz)
Low	5260	25.65	25.55
Mid	5300	22.55	24.35
High	5320	21.55	20.85

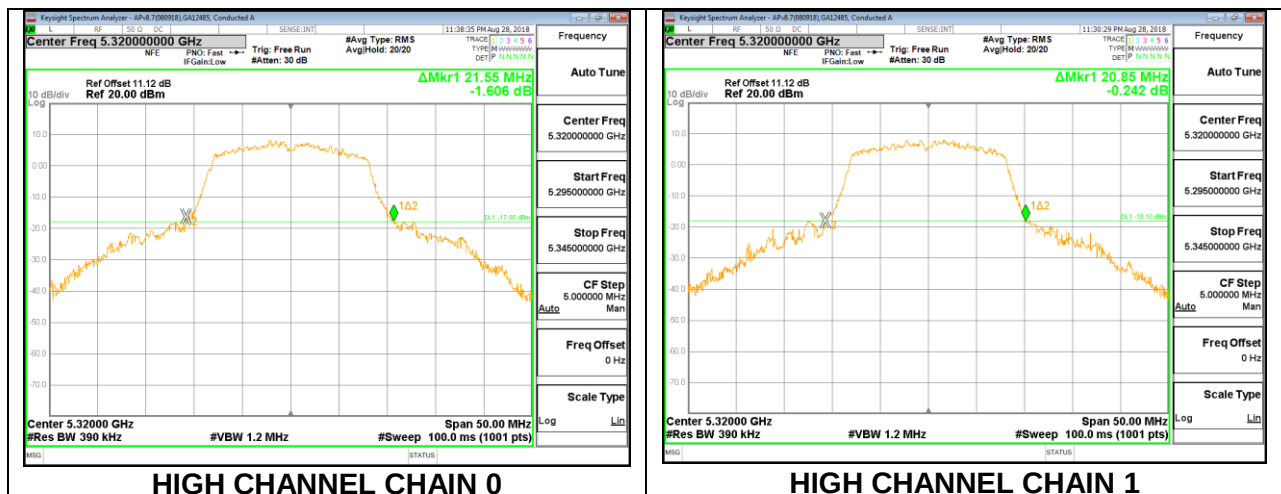
LOW CHANNEL



MID CHANNEL



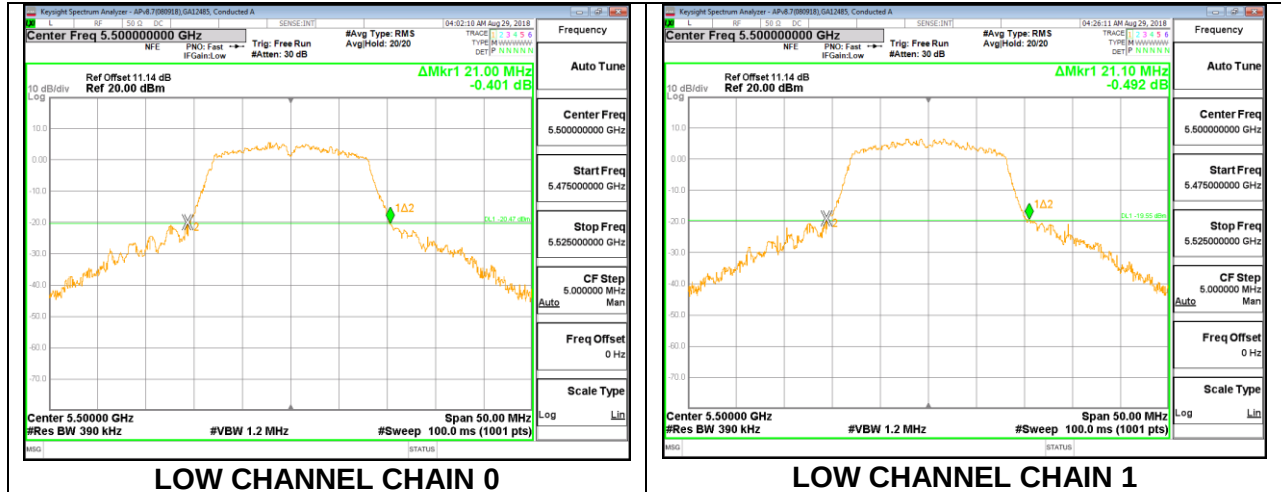
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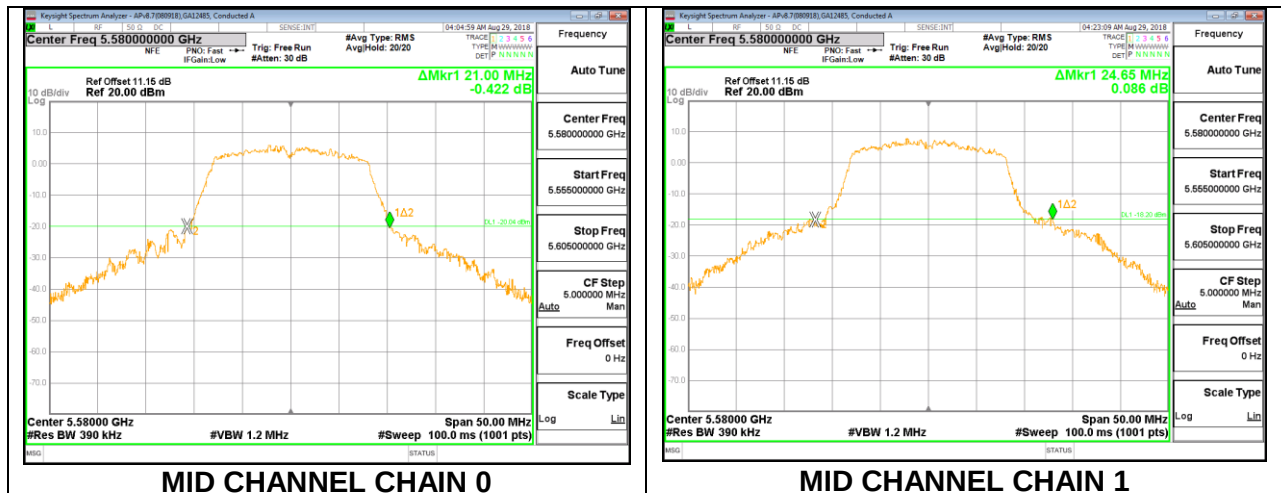
8.2.2. 802.11a MODE IN THE 5.6 GHz BAND

Channel	Frequency (MHz)	26 dB Bandwidth Chain 0 (MHz)	26 dB Bandwidth Chain 1 (MHz)
Low	5500	21.00	21.10
Mid	5580	21.00	24.65
High	5700	20.75	25.45

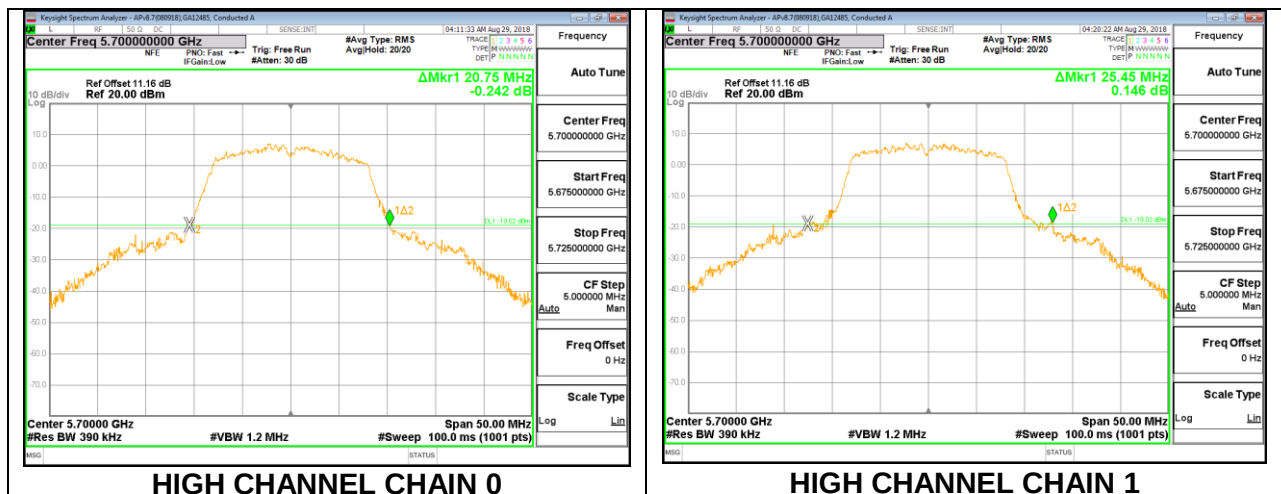
LOW CHANNEL



MID CHANNEL



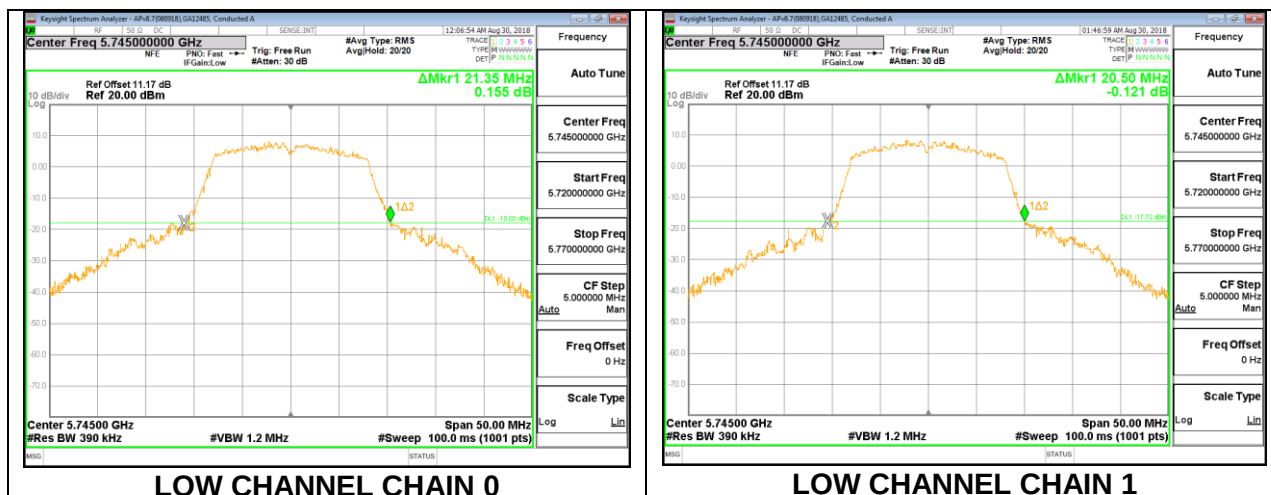
HIGH CHANNEL



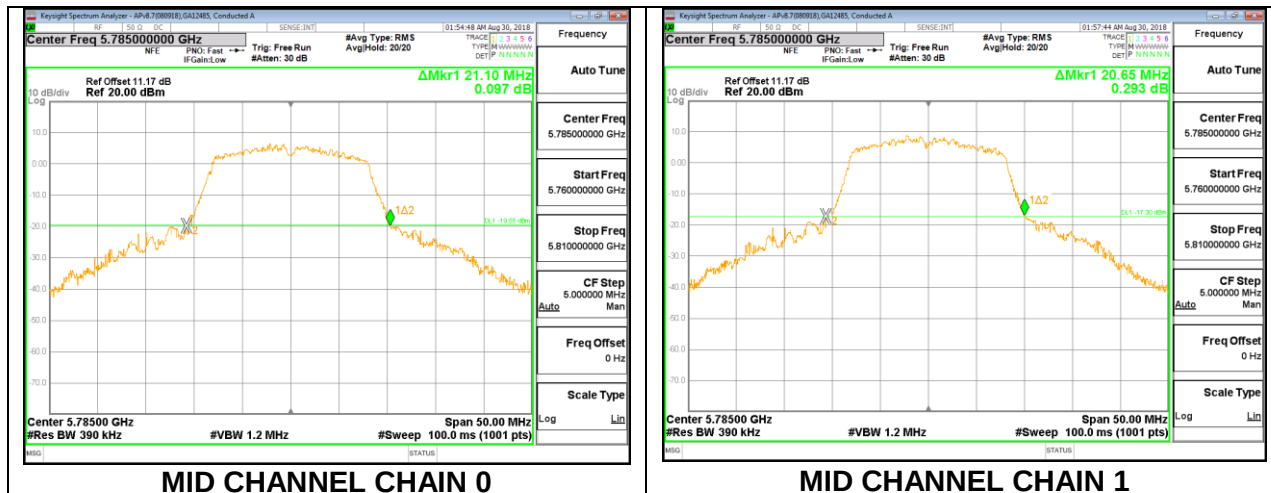
8.2.3. 802.11a MODE IN THE 5.8 GHz BAND

Channel	Frequency (MHz)	26 dB Bandwidth Chain 0 (MHz)	26 dB Bandwidth Chain 1 (MHz)
Low	5745	21.65	20.50
Mid	5785	21.10	20.65
High	5825	20.85	20.80

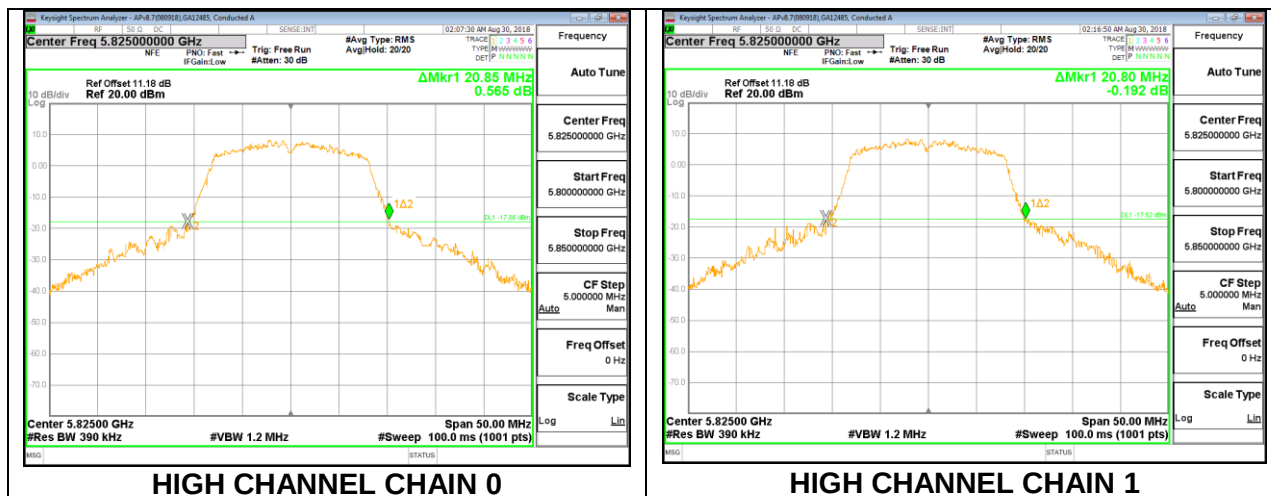
LOW CHANNEL



MID CHANNEL



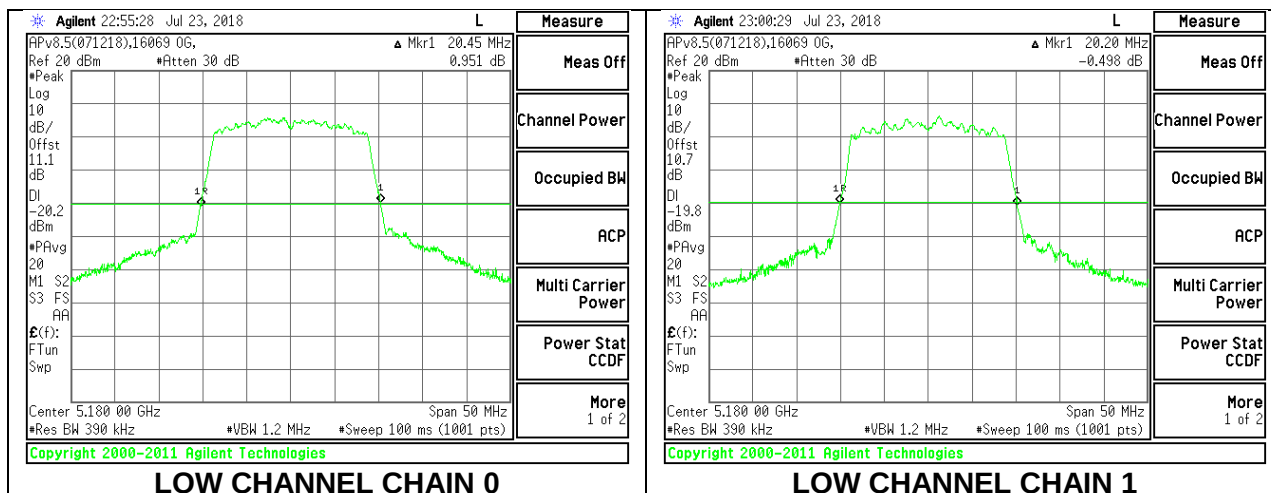
HIGH CHANNEL



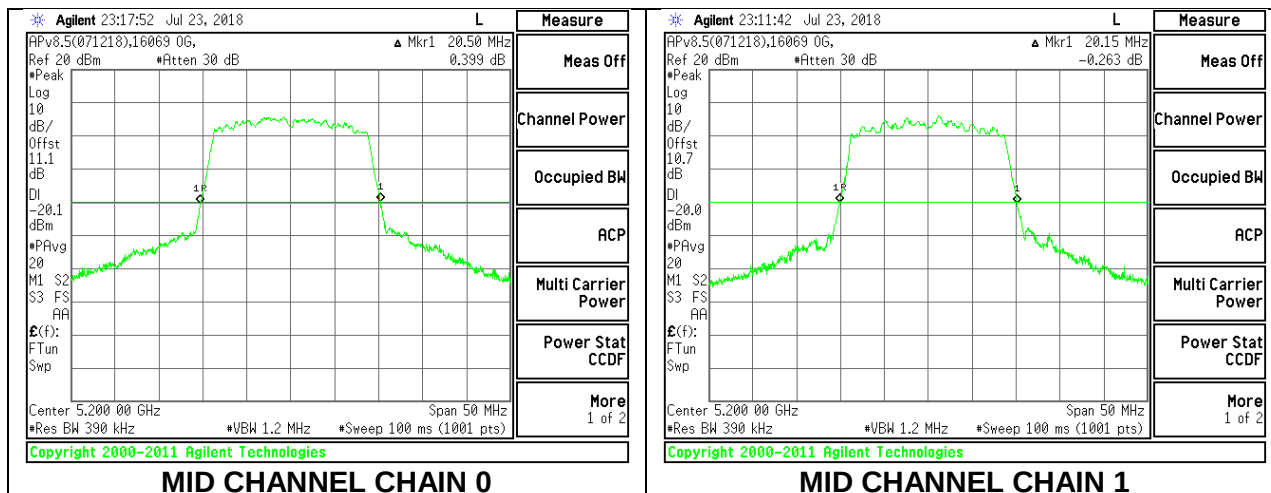
8.2.4. 802.11n HT20 MODE IN THE 5.2 GHz BAND

Channel	Frequency (MHz)	26 dB Bandwidth Chain 0 (MHz)	26 dB Bandwidth Chain 1 (MHz)
Low	5180	20.45	20.20
Mid	5200	20.50	20.15
High	5240	20.45	20.30

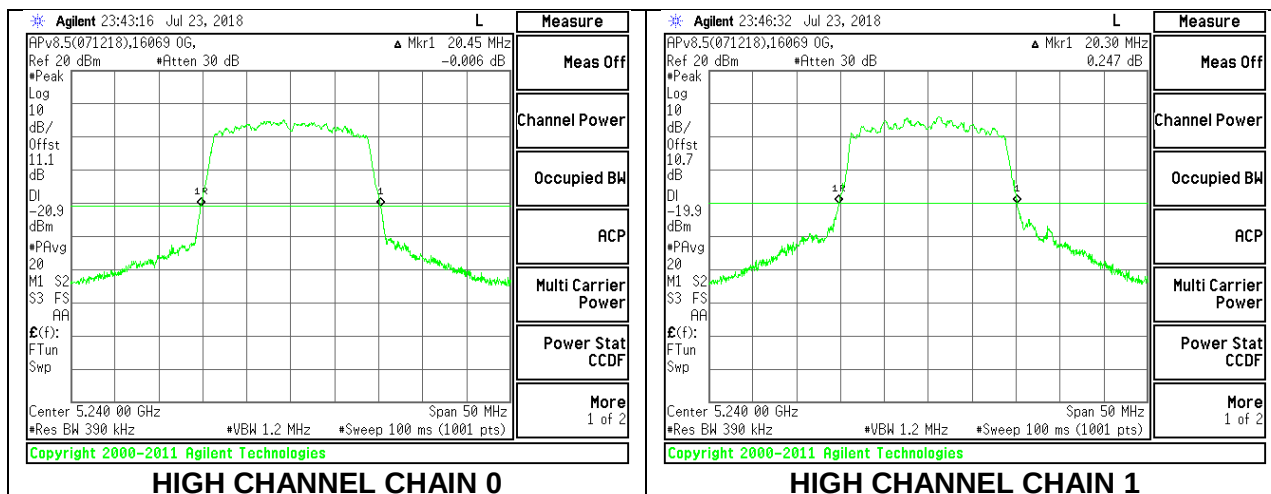
LOW CHANNEL



MID CHANNEL



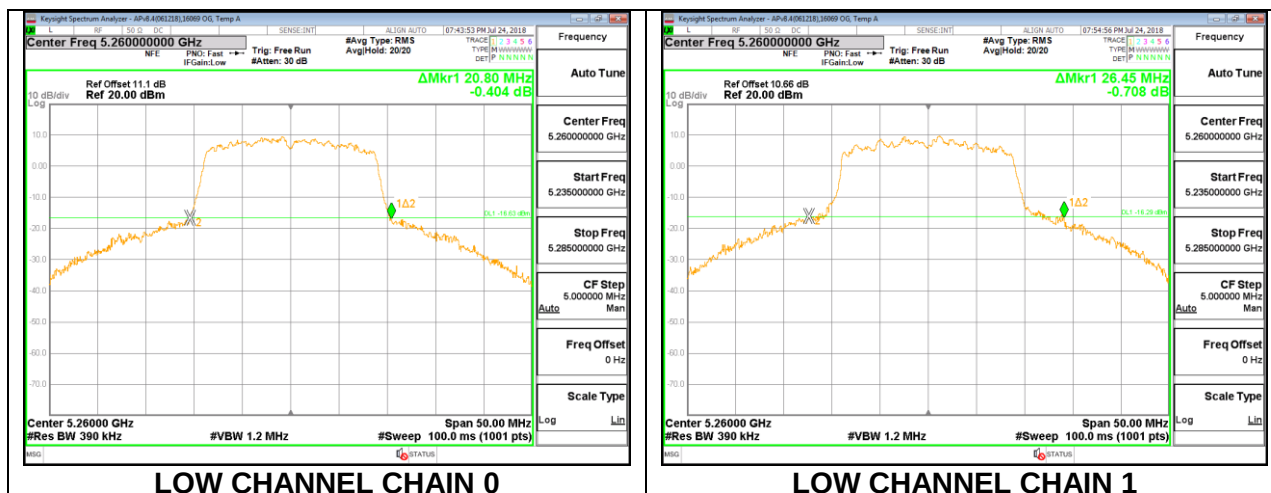
HIGH CHANNEL



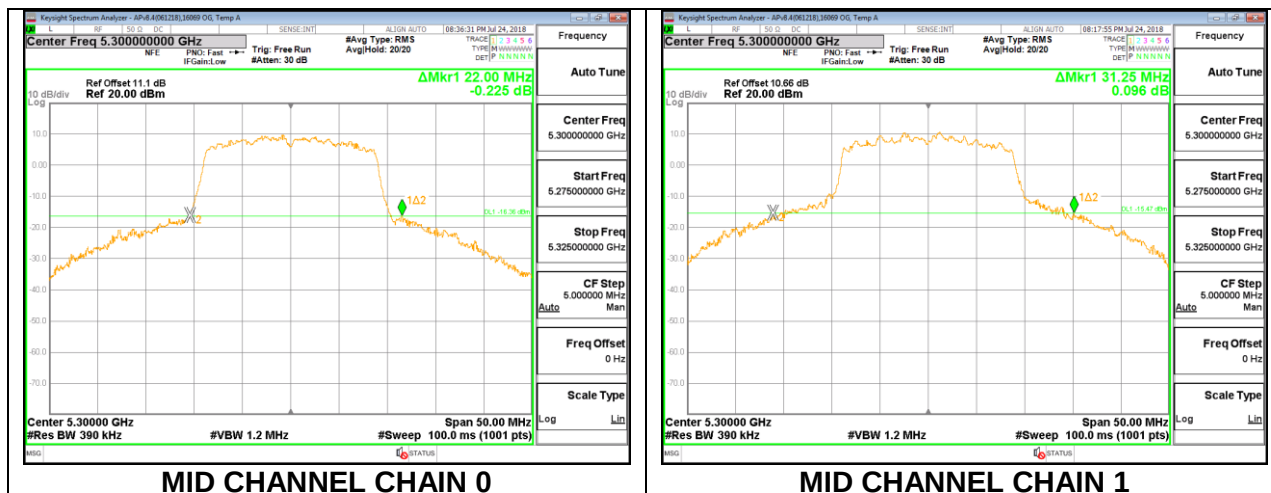
8.2.5. 802.11n HT20 MODE IN THE 5.3 GHz BAND

Channel	Frequency (MHz)	26 dB Bandwidth Chain 0 (MHz)	26 dB Bandwidth Chain 1 (MHz)
Low	5260	20.80	26.45
Mid	5300	22.00	31.25
High	5320	20.80	30.05

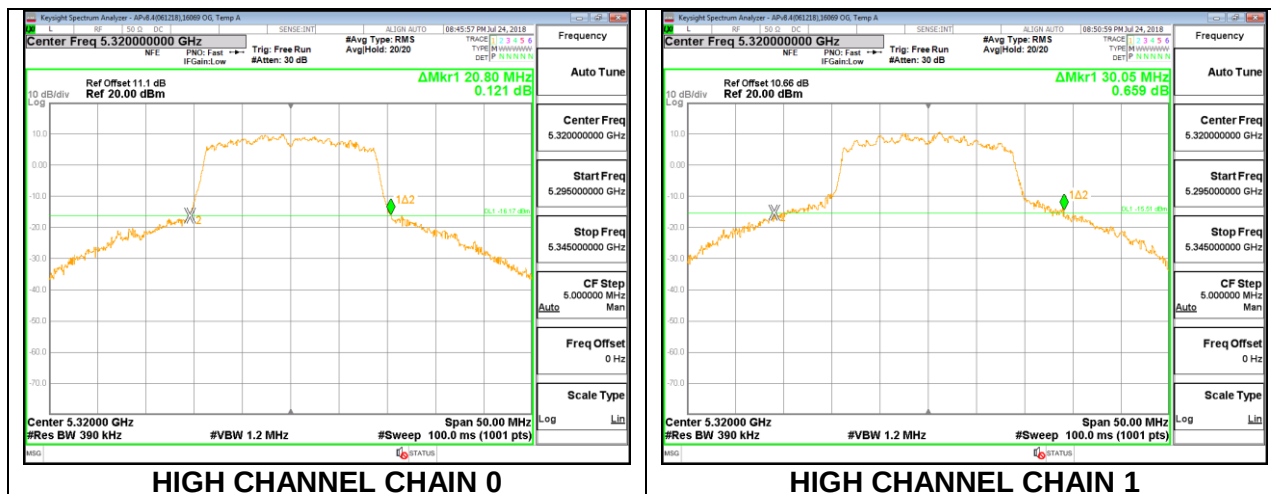
LOW CHANNEL



MID CHANNEL



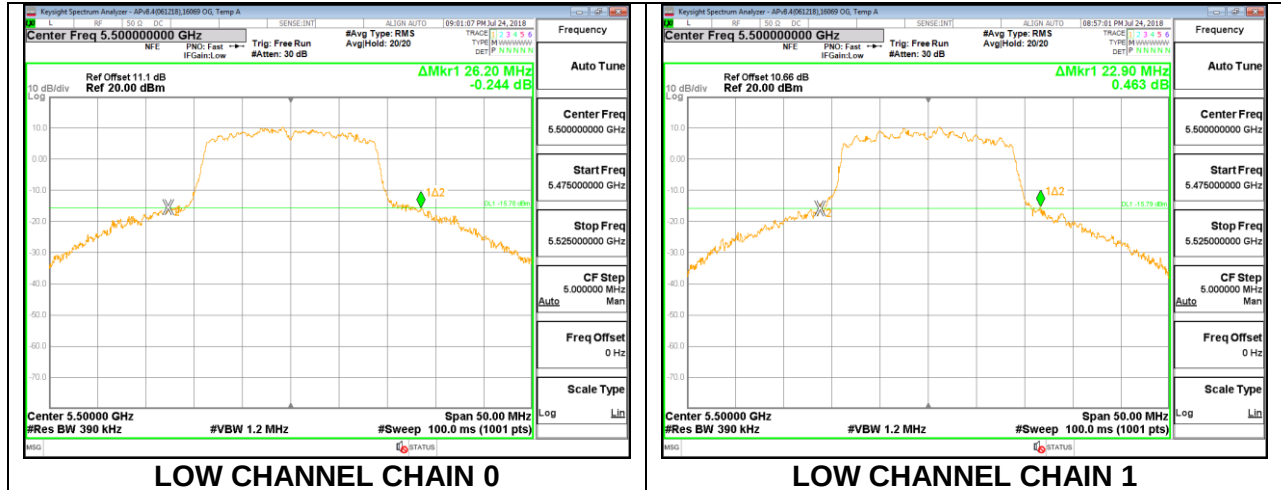
HIGH CHANNEL



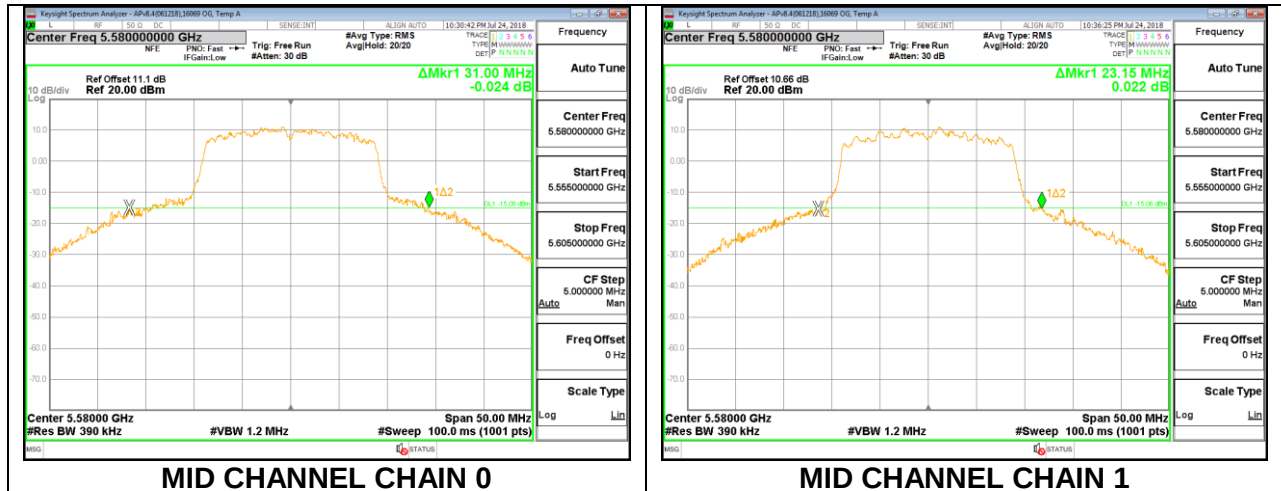
8.2.6. 802.11n HT20 MODE IN THE 5.6 GHz BAND

Channel	Frequency (MHz)	26 dB Bandwidth	
		Chain 0 (MHz)	Chain 1 (MHz)
Low	5500	26.20	22.90
Mid	5580	31.00	23.15
High	5700	31.05	28.95

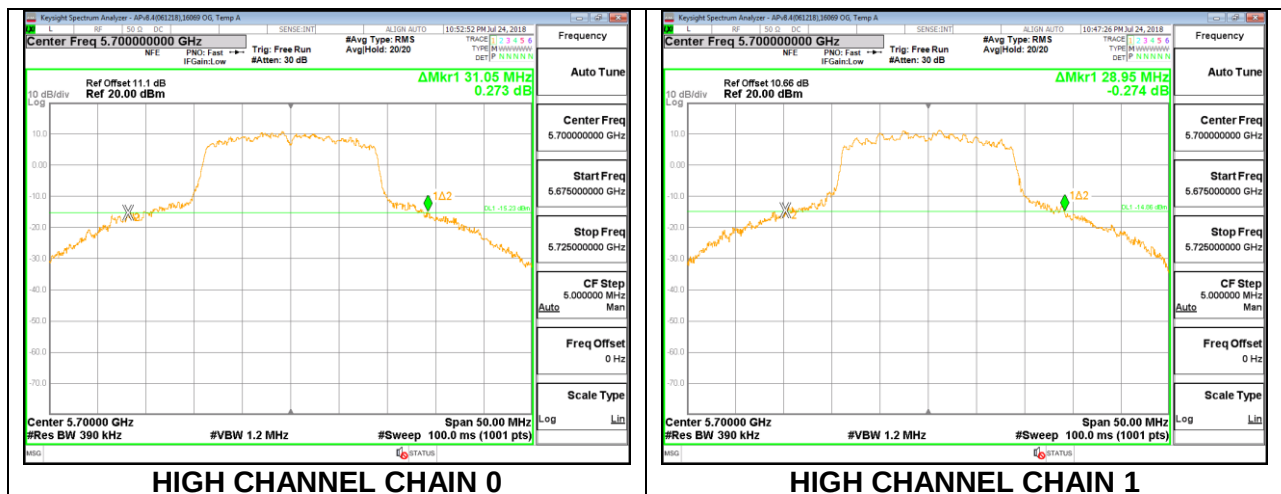
LOW CHANNEL



MID CHANNEL



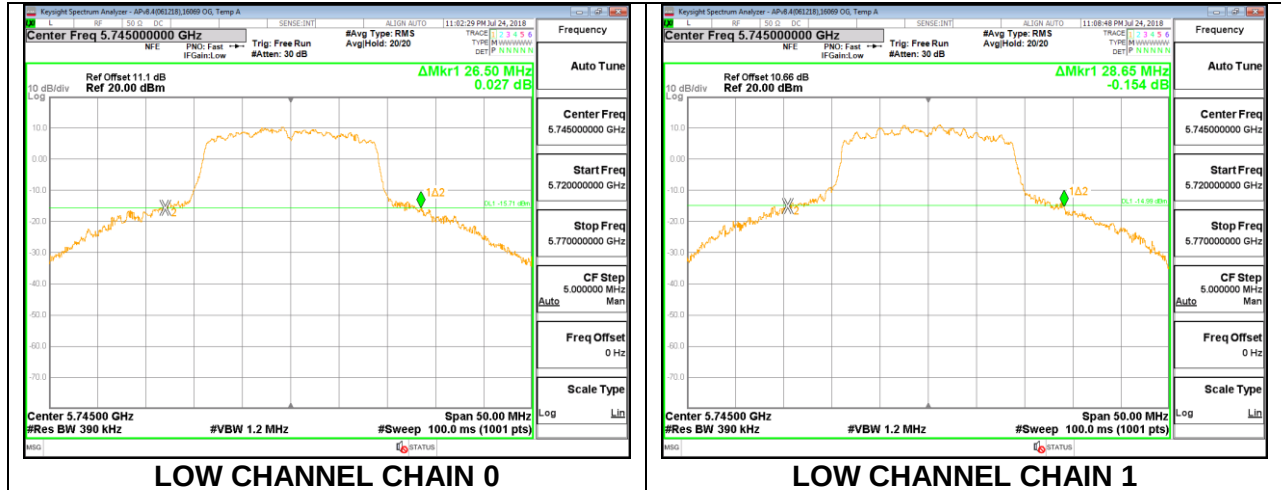
HIGH CHANNEL



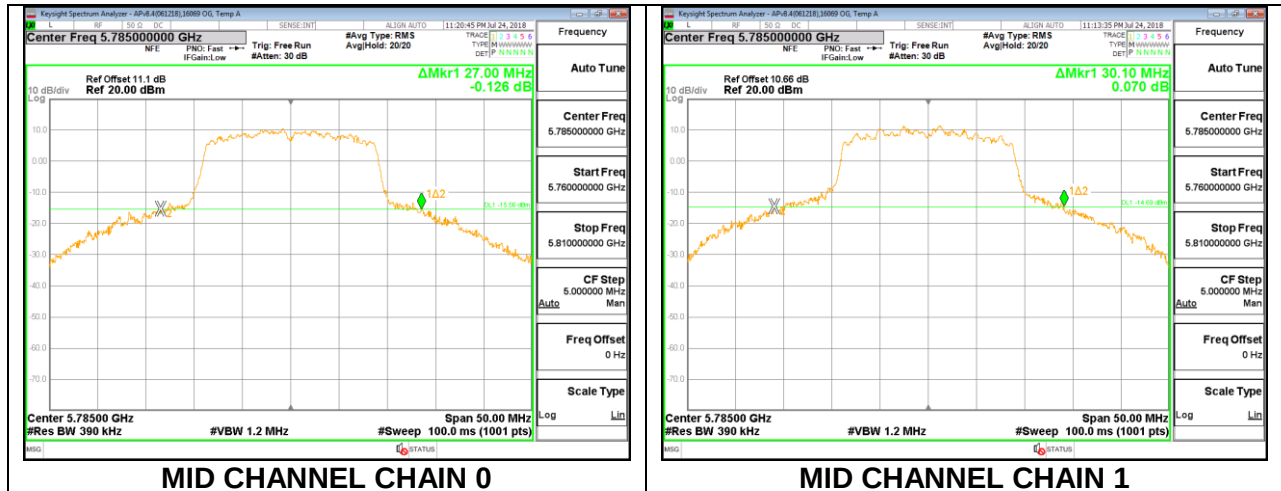
8.2.7. 802.11n HT20 MODE IN THE 5.8 GHz BAND

Channel	Frequency (MHz)	26 dB Bandwidth Chain 0 (MHz)	26 dB Bandwidth Chain 1 (MHz)
Low	5745	26.50	28.65
Mid	5785	27.00	30.10
High	5825	34.85	34.50

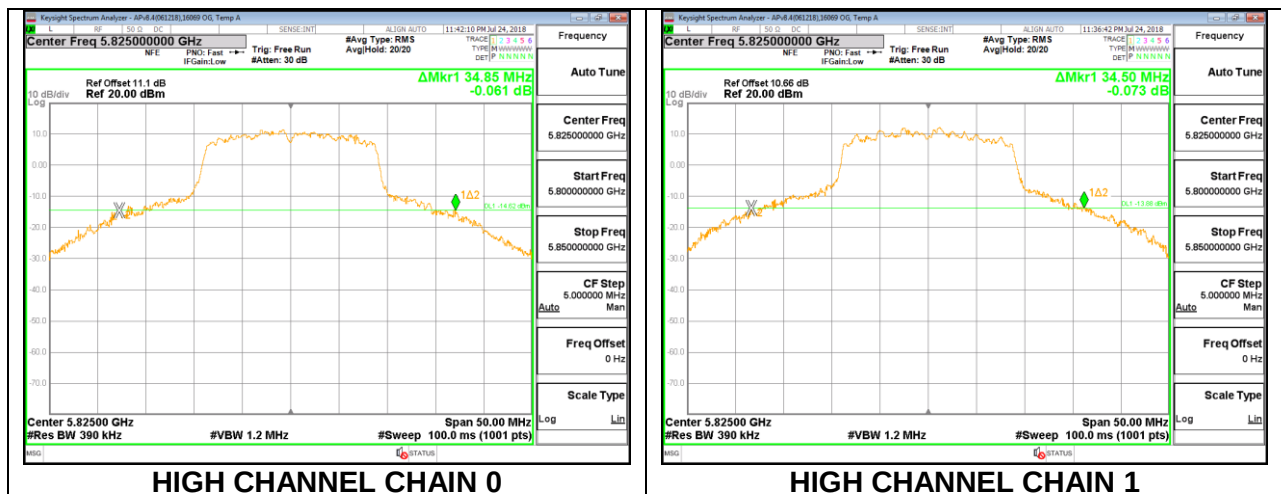
LOW CHANNEL



MID CHANNEL



HIGH CHANNEL



8.3. 99% BANDWIDTH

LIMITS

None; for reporting purposes only.

RESULTS

8.3.1. 802.11a MODE IN THE 5.2 GHz BAND

Channel	Frequency (MHz)	99% Bandwidth Chain 0 (MHz)	99% Bandwidth Chain 1 (MHz)
Low	5180	16.50	16.39
Mid	5200	16.39	16.46
High	5240	16.42	16.46

The figure displays two side-by-side screenshots of a Keysight Spectrum Analyzer, showing the frequency response of two different channel chains, Chain 0 and Chain 1. Both plots show a flat response with a slight dip around 5.18 GHz. The Chain 0 plot shows a total power of 11.7 dBm and an occupied bandwidth of 16.501 MHz. The Chain 1 plot shows a total power of 12.3 dBm and an occupied bandwidth of 16.392 MHz. Both plots have a center frequency of 5.18 GHz and a span of 40 MHz.

Left Plot (Chain 0):

- Center Freq: 5.18000000 GHz
- Ref Offset: 11.1 dB
- Ref: 30.00 dBm
- Center Freq: 5.18000000 GHz
- Radio Std: None
- Trig: Free Run
- AVG Hold: 1/1
- Radio Device: BTS
- Center: 5.18 GHz
- #Res BW: 330 kHz
- #VBW: 1 MHz
- Span: 40 MHz
- Sweep: 1.133 ms
- CF Step: 4.000000 MHz
- Auto: Man
- Occupied Bandwidth: 16.501 MHz
- Total Power: 11.7 dBm
- Transmit Freq Error: 684 Hz
- % of OBW Power: 99.00 %
- x dB Bandwidth: 18.96 MHz
- x dB: -26.00 dB

Right Plot (Chain 1):

- Center Freq: 5.18000000 GHz
- Ref Offset: 11.1 dB
- Ref: 30.00 dBm
- Center Freq: 5.18000000 GHz
- Radio Std: None
- Trig: Free Run
- AVG Hold: 1/1
- Radio Device: BTS
- Center: 5.18 GHz
- #Res BW: 330 kHz
- #VBW: 1 MHz
- Span: 40 MHz
- Sweep: 1.133 ms
- CF Step: 4.000000 MHz
- Auto: Man
- Occupied Bandwidth: 16.392 MHz
- Total Power: 12.3 dBm
- Transmit Freq Error: -40.964 kHz
- % of OBW Power: 99.00 %
- x dB Bandwidth: 19.40 MHz
- x dB: -26.00 dB

Left Screenshot (MID CHANNEL CHAIN 0):

- Center Freq: 5.200000000 GHz
- Ref Offset: 11.1 dB, Ref: 30.00 dBm
- Occupied Bandwidth: 16.388 MHz
- Total Power: 12.0 dBm
- Transmit Freq Error: -12.070 kHz
- % of OBW Power: 99.00 %
- x dB Bandwidth: 18.99 MHz
- x dB: -26.00 dB

Right Screenshot (MID CHANNEL CHAIN 1):

- Center Freq: 5.200000000 GHz
- Ref Offset: 11.1 dB, Ref: 30.00 dBm
- Occupied Bandwidth: 16.459 MHz
- Total Power: 12.8 dBm
- Transmit Freq Error: -1.094 kHz
- % of OBW Power: 99.00 %
- x dB Bandwidth: 19.36 MHz
- x dB: -26.00 dB

High Channel Chain 0

Center Freq: 5.240000000 GHz
 Ref Offset: 11.11 dB
 Ref: 30.00 dBm
 Span: 40 MHz
 Sweep: 1.133 ms
 Occupied Bandwidth: 16.417 MHz
 Total Power: 11.8 dBm
 Transmit Freq Error: -9.806 kHz
 % of OBW Power: 99.00 %
 x dB Bandwidth: 20.48 MHz
 x dB: -26.00 dB

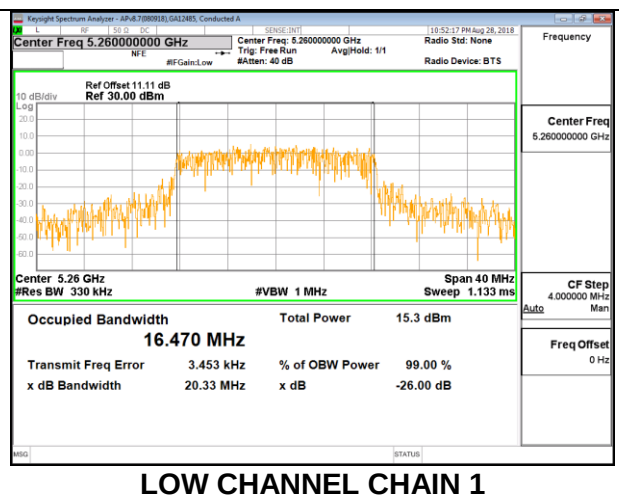
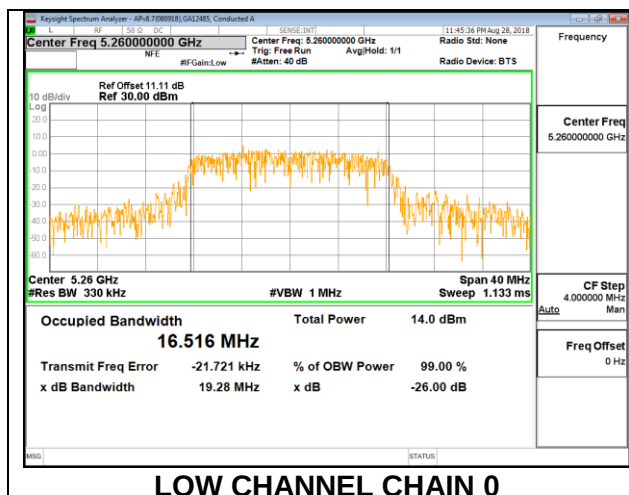
High Channel Chain 1

Center Freq: 5.240000000 GHz
 Ref Offset: 11.11 dB
 Ref: 30.00 dBm
 Span: 40 MHz
 Sweep: 1.133 ms
 Occupied Bandwidth: 16.455 MHz
 Total Power: 12.5 dBm
 Transmit Freq Error: -3.751 kHz
 % of OBW Power: 99.00 %
 x dB Bandwidth: 19.52 MHz
 x dB: -26.00 dB

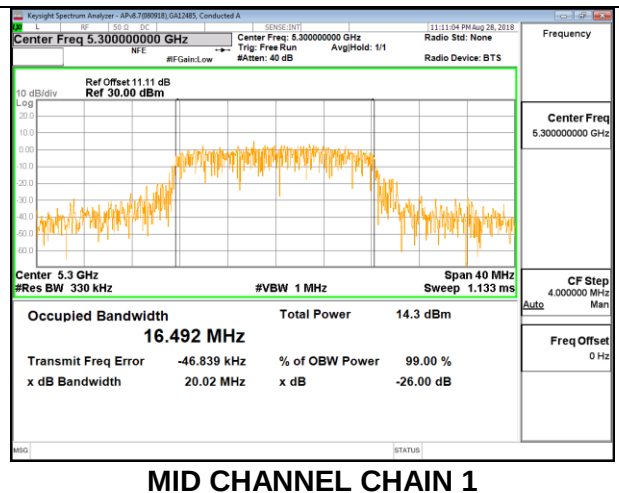
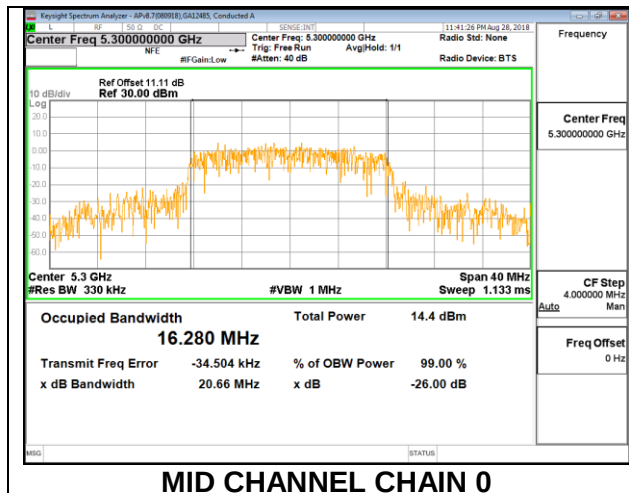
8.3.2. 802.11a MODE IN THE 5.3 GHz BAND

Channel	Frequency (MHz)	99% Bandwidth Chain 0 (MHz)	99% Bandwidth Chain 1 (MHz)
Low	5260	16.52	16.47
Mid	5300	16.28	16.49
High	5320	16.31	16.34

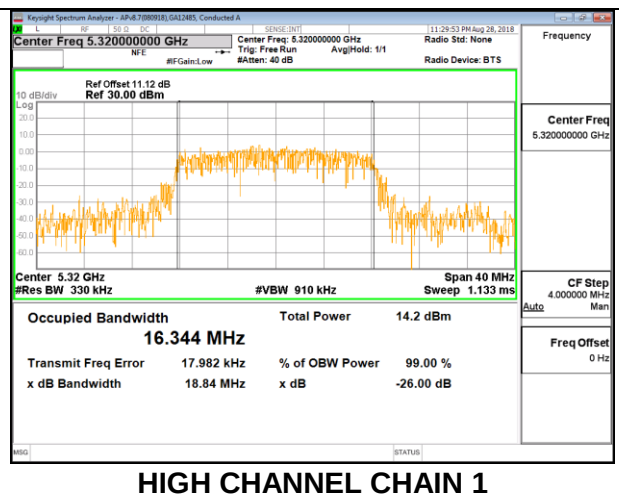
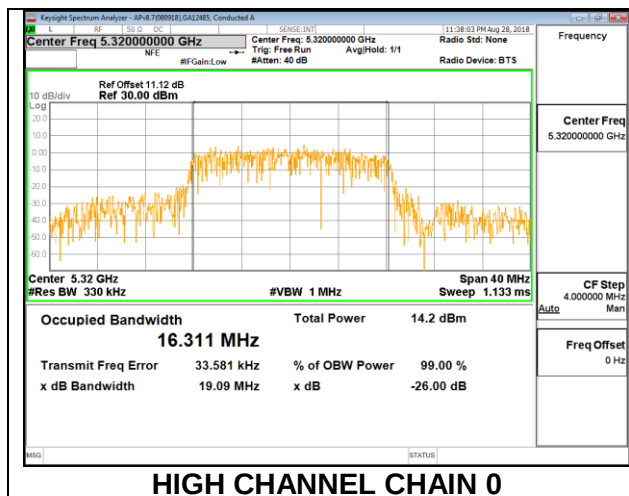
LOW CHANNEL



MID CHANNEL



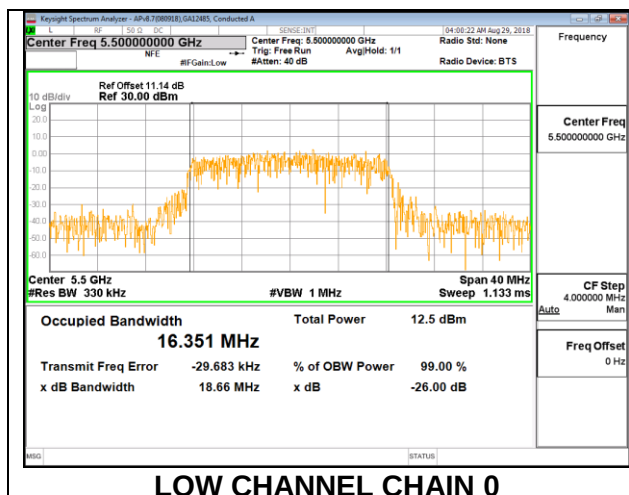
HIGH CHANNEL



8.3.3. 802.11a MODE IN THE 5.6 GHz BAND

Channel	Frequency (MHz)	99% Bandwidth Chain 0 (MHz)	99% Bandwidth Chain 1 (MHz)
Low	5500	16.35	16.42
Mid	5580	16.47	16.47
High	5700	16.30	16.42

LOW CHANNEL



8.3.4. 802.11a MODE IN THE 5.8 GHz BAND

Channel	Frequency (MHz)	99% Bandwidth Chain 0 (MHz)	99% Bandwidth Chain 1 (MHz)
Low	5745	16.36	16.35
Mid	5785	16.40	16.36
High	5825	16.31	16.41