



# **CERTIFICATION TEST REPORT**

**Report Number. :** 11526444-E2V4

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

**Model :** S13

**FCC ID :** SBVRM012

**EUT Description :** 802.11 a/b/g/n (HT20) Client Device

**Test Standard(s) :** FCC 47 CFR PART 15 SUBPART E (Except DFS)

**Date Of Issue:**

July 31, 2017

**Prepared by:**

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NVLAP LAB CODE 200065-0

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Revision History

| Rev. | Issue Date | Revisions                                                    | Revised By |
|------|------------|--------------------------------------------------------------|------------|
| V1   | 06/30/17   | Initial Issue                                                | D. Corona  |
| V2   | 07/18/17   | Updated Section 6 & 9.3.3 (updated PSD limit)                | D. Corona  |
| V3   | 07/24/17   | Updated Section 6 & 10.2                                     | D. Corona  |
| V4   | 07/31/17   | Updated Section 9.3.3, 9.9.4, 10.1 & remove below 30MHz data | D. Corona  |

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## 1. ATTESTATION OF TEST RESULTS

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

**EUT DESCRIPTION:** 802.11 a/b/g/n (HT20) Client Device

**MODEL:** S13

**SERIAL NUMBER:** 170378-28-CA-10-05-CC-2, 170378-28-CA-10-05-CC-0, 170378-28-CA-00-07-80-E

**DATE TESTED:** MARCH 27 TO MAY 16, 2017

| APPLICABLE STANDARDS                  |              |
|---------------------------------------|--------------|
| STANDARD                              | TEST RESULTS |
| CFR 47 Part 15 Subpart E (Except DFS) | 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.

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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 14-30, FCC KDB 662911 D01 v02r01, FCC KDB 905462 D02 v01r02/D03 v01r01/D06 v01, FCC KDB 789033 D02 v01r01, FCC KDB 644545 D03 v01, ANSI C63.10-2013.

## 3. FACILITIES AND ACCREDITATION

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

| 47173 Benicia Street                |                        | 47266 Benicia Street     |                        |
|-------------------------------------|------------------------|--------------------------|------------------------|
| <input checked="" type="checkbox"/> | Chamber A (IC:2324B-1) | <input type="checkbox"/> | Chamber D (IC:22541-1) |
| <input type="checkbox"/>            | Chamber B (IC:2324B-2) | <input type="checkbox"/> | Chamber E (IC:22541-2) |
| <input type="checkbox"/>            | Chamber C (IC:2324B-3) | <input type="checkbox"/> | Chamber F (IC:22541-3) |
|                                     |                        | <input type="checkbox"/> | Chamber G (IC:22541-4) |
|                                     |                        | <input type="checkbox"/> | Chamber H (IC:22541-5) |

The above test sites and facilities are covered under FCC Test Firm Registration # 208313.

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>.

## 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:

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

### 4.3. MEASUREMENT UNCERTAINTY

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

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. DESCRIPTION OF EUT

The EUT is 802.11 a/b/g/n (HT20) Client Device. Product model S13 is a high-performance all-in-one wireless smart speaker and part of Sonos' home sound system. S13 adds integrated voice control functionality with far field microphones. Moreover, the device will support multiple voice platforms and music services, allowing customers to effortlessly control their music on Sonos.

### 5.2. MAXIMUM OUTPUT POWER

The transmitter has a maximum conducted output power as follows:

**2x2:**

| Frequency Range (MHz) | Mode                 | Output Power (dBm) | Output Power (mW) |
|-----------------------|----------------------|--------------------|-------------------|
| 5180 - 5240           | 802.11n HT20 CDD 2TX | 19.38              | 86.70             |
| 5260 - 5320           | 802.11n HT20 CDD 2TX | 20.48              | 111.69            |
| 5500 - 5700           | 802.11n HT20 CDD 2TX | 20.16              | 103.75            |
| 5745 - 5825           | 802.11n HT20 CDD 2TX | 20.90              | 123.03            |

**3x3:**

| Frequency Range (MHz) | Mode                 | Output Power (dBm) | Output Power (mW) |
|-----------------------|----------------------|--------------------|-------------------|
| 5180 - 5240           | 802.11n HT20 CDD 3TX | 21.55              | 142.89            |
| 5260 - 5320           | 802.11n HT20 CDD 3TX | 20.14              | 103.28            |
| 5500 - 5700           | 802.11n HT20 CDD 3TX | 19.90              | 97.72             |
| 5745 - 5825           | 802.11n HT20 CDD 3TX | 21.94              | 156.31            |

NOTE: Covered modes are test reduction modes. The output powers on the covered modes are equal to or less than the mode referenced and use the same modulation.

### 5.3. DESCRIPTION OF AVAILABLE ANTENNAS

The radio utilizes an integrated antenna, with a maximum gain as follows:

| Frequency (GHz) | Peak Antenna Gain (dBi) |         |         |
|-----------------|-------------------------|---------|---------|
|                 | Chain 0                 | Chain 1 | Chain 2 |
| 5180 - 5825     | 3.41                    | 2.26    | 4.22    |

### 5.4. SOFTWARE AND FIRMWARE

The test utility software used during testing was Atheros Radio Test 2 (ART2-GUI).

## **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 was: 802.11n HT20 mode: 26 Mbps (MCS3)

## 5.6. DESCRIPTION OF TEST SETUP

### SUPPORT EQUIPMENT

| Support Equipment List |              |         |                        |        |
|------------------------|--------------|---------|------------------------|--------|
| Description            | Manufacturer | Model   | Serial Number          | FCC ID |
| Laptop                 | Lenovo       | X230    | PK1D7EM                |        |
| AC Adapter             | Lenovo       | 42T4418 | 11S42T4418Z1ZF3B048J2Z |        |

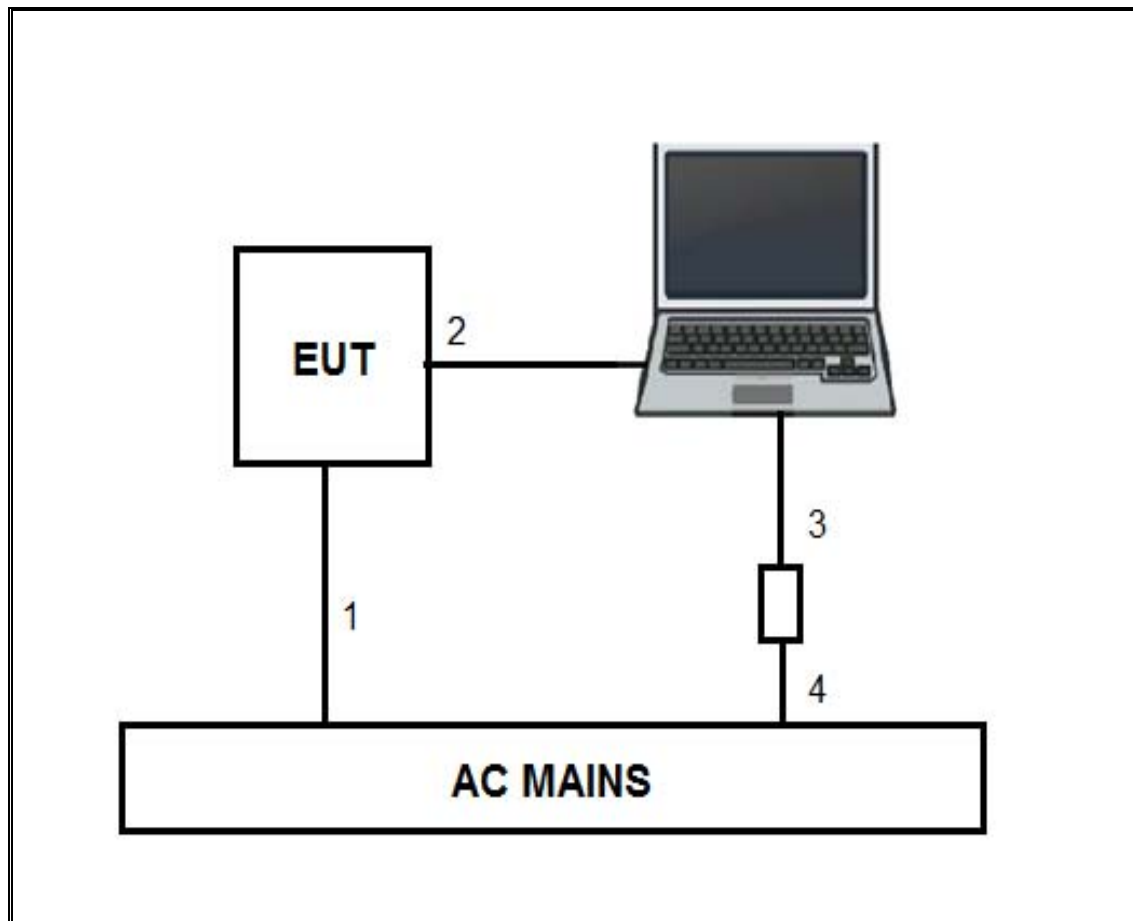
### I/O CABLES

| I/O Cable List |          |                      |                |            |                  |                           |
|----------------|----------|----------------------|----------------|------------|------------------|---------------------------|
| Cable No       | Port     | # of identical ports | Connector Type | Cable Type | Cable Length (m) | Remarks                   |
| 1              | AC Power | 1                    | AC             | Unshielded | 1                | 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 connected to support laptop via Ethernet cable.  
The Atheros Radio Test 2 (ART2-GUI) test software is exercising the EUT during testing.

**SETUP DIAGRAM**



## 6. 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                   | T No. | Cal Date | Cal Due  |
| Amplifier, 1 - 18GHz                       | Miteq         | AFS42                   | 1165  | 08/01/16 | 08/01/17 |
| Amplifier, 1-26.5GHz                       | Agilent       | 8449B                   | 404   | 07/05/16 | 07/05/17 |
| Amplifier, 26-40GHz                        | Miteq         | NSP 4000 SP2            | 88    | 04/29/17 | 04/29/18 |
| Amplifier, 10KHz to 1GHz, 32dB             | Keysight      | 8447D                   | 10    | 02/01/17 | 02/01/18 |
| Antenna, Broadband Hybrid 30MHz to 2000MHz | Sunol Science | JB1                     | 130   | 09/01/16 | 09/01/17 |
| Antenna, Horn 1-18GHz                      | ETS-Lindgren  | 3117                    | 711   | 01/30/17 | 01/30/18 |
| Antenna, Horn 18-26.5GHz                   | ARA           | MWH-2640/B              | 449   | 07/08/16 | 07/08/17 |
| Antenna, Horn 26.5-40GHz                   | ARA           | MWH-2640/B              | 446   | 06/12/16 | 06/12/17 |
| Power Meter                                | Keysight      | N1911A                  | 1269  | 03/29/17 | 03/29/18 |
| Wideband Power Sensor                      | Keysight      | N1921A                  | 1224  | 03/29/17 | 03/29/18 |
| USB RF Power Sensor 10Mhz-6Ghz             | ETS-LINDGREN  | 7002-006                | 1081  | 11/18/16 | 11/18/17 |
| Spectrum Analyzer, PXA, 3Hz to 44GHz       | Agilent       | N9030A                  | 1210  | 06/30/16 | 06/30/17 |
| Spectrum Analyzer, PXA, 3Hz to 44GHz       | Agilent       | N9030A                  | 907   | 01/23/17 | 01/23/18 |
| Spectrum Analyzer, PXA, 3Hz to 44GHz       | Agilent       | N9030A                  | 146   | 07/13/16 | 07/13/17 |
| LISN                                       | FISCHER       | FCC-LISN-50/250-25-2-01 | T1310 | 06/08/16 | 06/08/17 |

| Test Software List    |              |        |                       |
|-----------------------|--------------|--------|-----------------------|
| Description           | Manufacturer | Model  | Version               |
| Radiated Software     | UL           | UL EMC | Ver 9.5, Apr 26, 2016 |
| Conducted Software    | UL           | UL EMC | Ver 9.5, May 26, 2015 |
| Antenna Port Software | UL           | UL RF  | Ver 6.0, Jan 19, 2017 |

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

NOTE: \*testing is completed before equipment calibration expiration date.

## 7. SUMMARY TABLE

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

## 8. MEASUREMENT METHODS

On Time and Duty Cycle: KDB 789033 D02 v01r03, Section B.

6 dB Emission BW: KDB 789033 D02 v01r03, Section C.2.1

26 dB Emission BW: KDB 789033 D02 v01r03, Section C.

99% Occupied BW: KDB 789033 D02 v01r03, Section D.

Conducted Output Power: KDB 789033 D02 v01r03, Section E.3.b (Method PM-G) and KDB 662911 D01 v02r01.

Power Spectral Density: KDB 789033 D02 v01r03, Section F and KDB 662911 D01 v02r01.

Unwanted emissions in restricted bands: KDB 789033 D02 v01r03, Sections G.3, G.4, G.5, and G.6.

Unwanted emissions in non-restricted bands: KDB 789033 D02 v01r03, Sections G.3, G.4, and G.5.

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

## 9. ANTENNA PORT TEST RESULTS

### 9.1. ON TIME, DUTY CYCLE

#### LIMITS

None; for reporting purposes only.

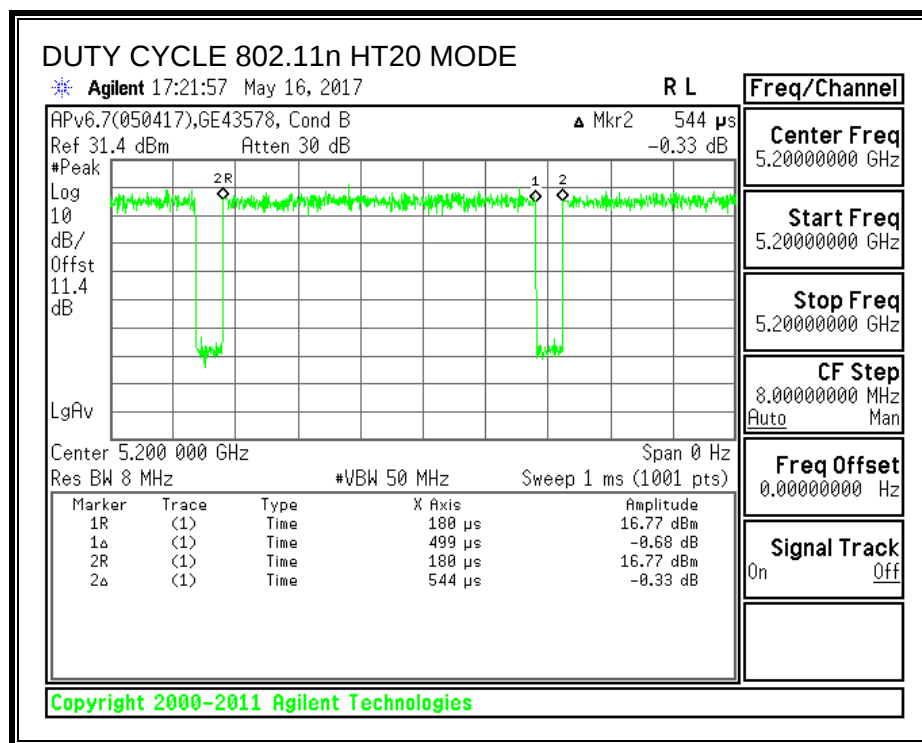
#### PROCEDURE

KDB 789033 Zero-Span Spectrum Analyzer Method.

#### RESULTS

| Mode         | ON Time<br>B<br>(msec) | Period<br>(msec) | Duty Cycle<br>x<br>(linear) | Duty<br>Cycle<br>(%) | Duty Cycle<br>Correction Factor<br>(dB) | 1/T<br>Minimum VBW<br>(kHz) |
|--------------|------------------------|------------------|-----------------------------|----------------------|-----------------------------------------|-----------------------------|
| 802.11n HT20 | 0.499                  | 0.544            | 0.917                       | 91.7%                | 0.37                                    | 2.004                       |

#### DUTY CYCLE PLOTS



## 9.2. 11n HT20 2TX CDD MIMO MODE IN THE 5.2GHz BAND

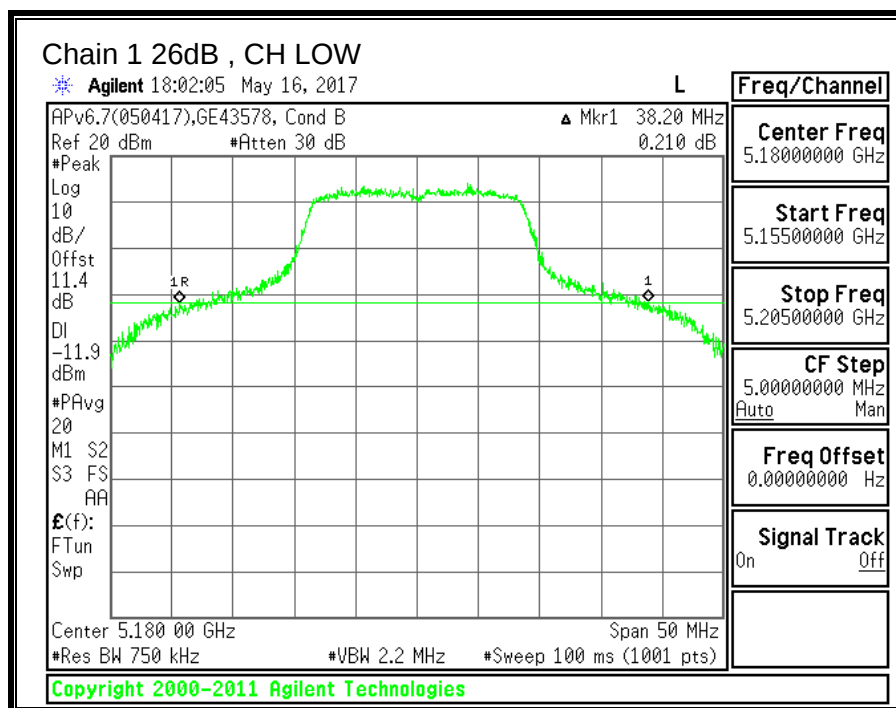
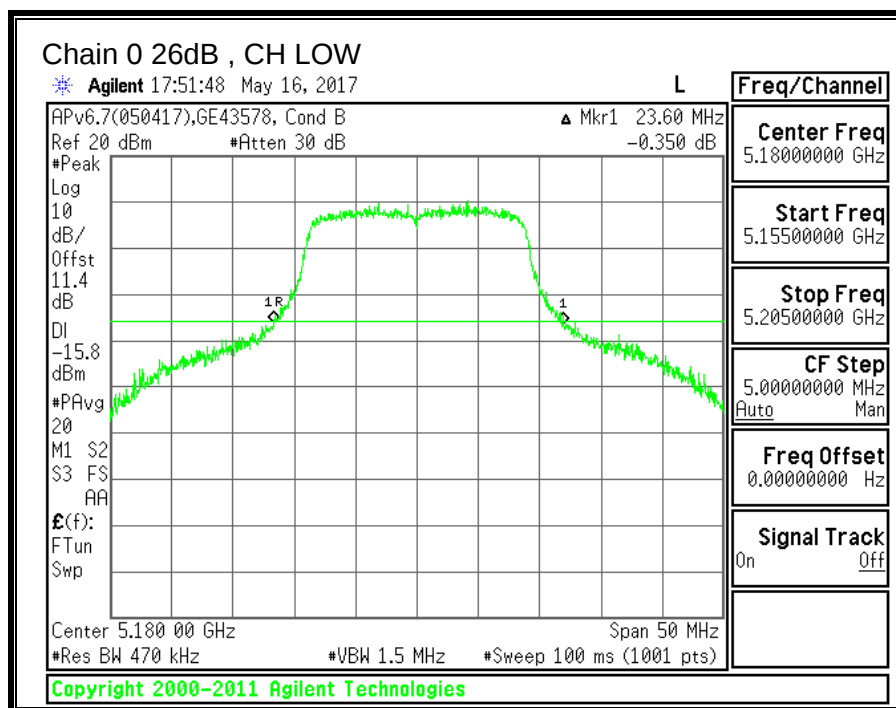
### 9.2.1. 26 dB BANDWIDTH

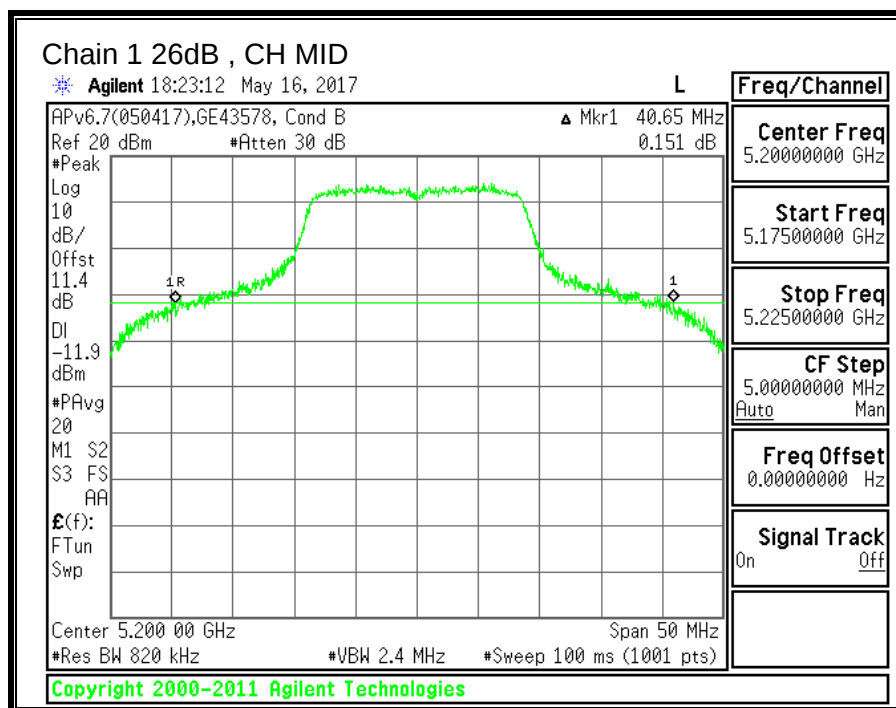
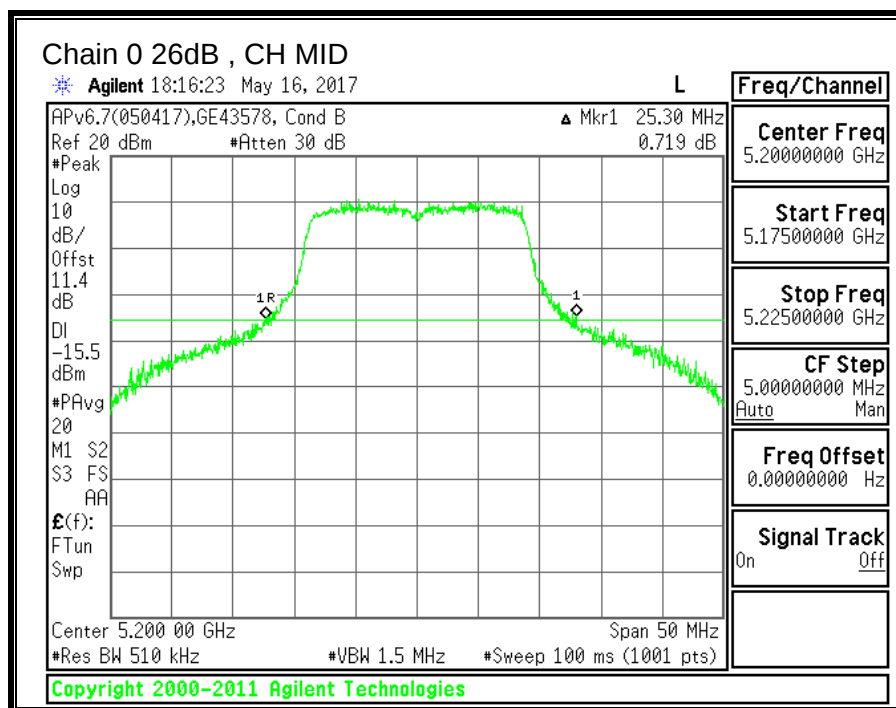
#### LIMITS

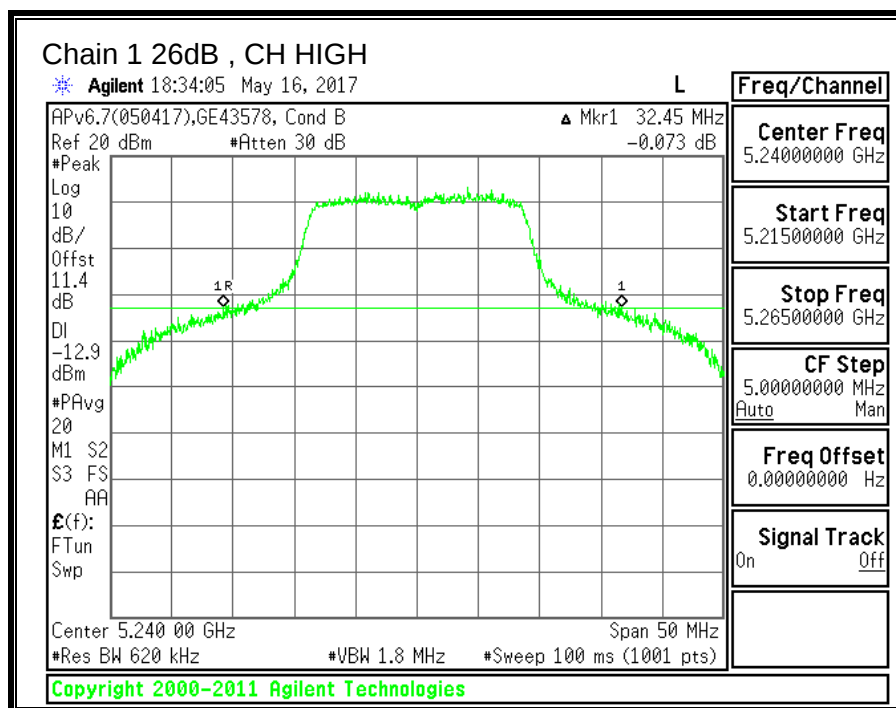
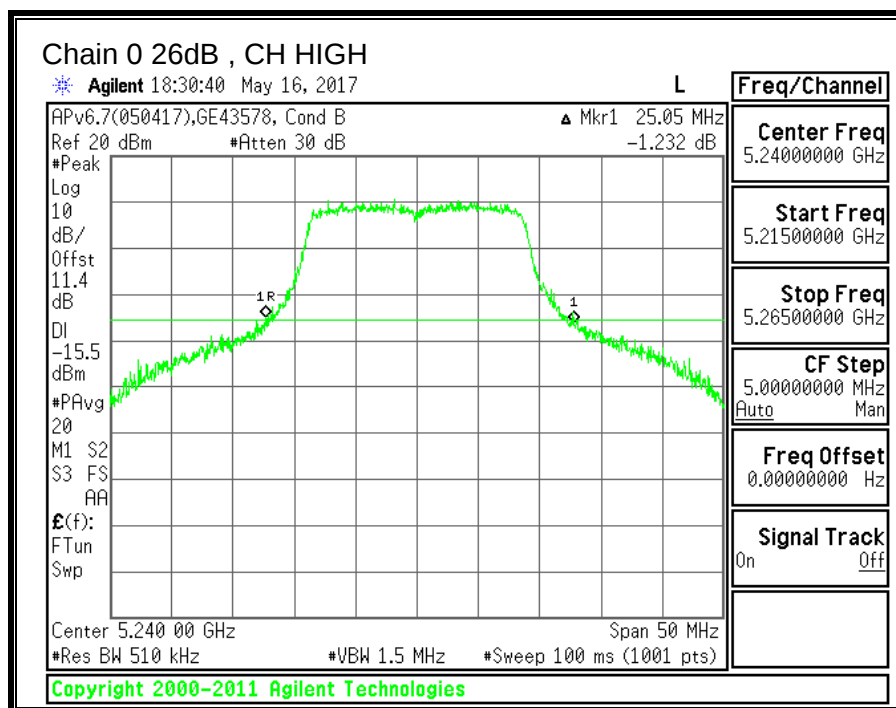
None; for reporting purposes only.

#### RESULTS

| Channel | Frequency | 26 dB BW<br>Chain 0<br>(MHz) | 26 dB BW<br>Chain 1<br>(MHz) |
|---------|-----------|------------------------------|------------------------------|
| Low     | 5180      | 23.60                        | 38.20                        |
| Mid     | 5200      | 25.30                        | 40.65                        |
| High    | 5240      | 25.05                        | 32.45                        |







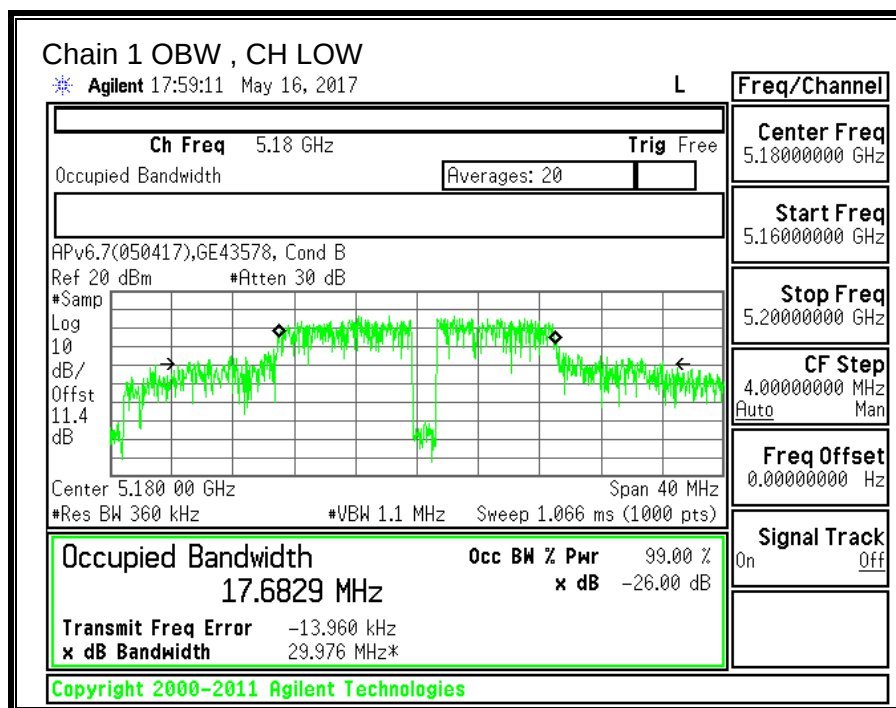
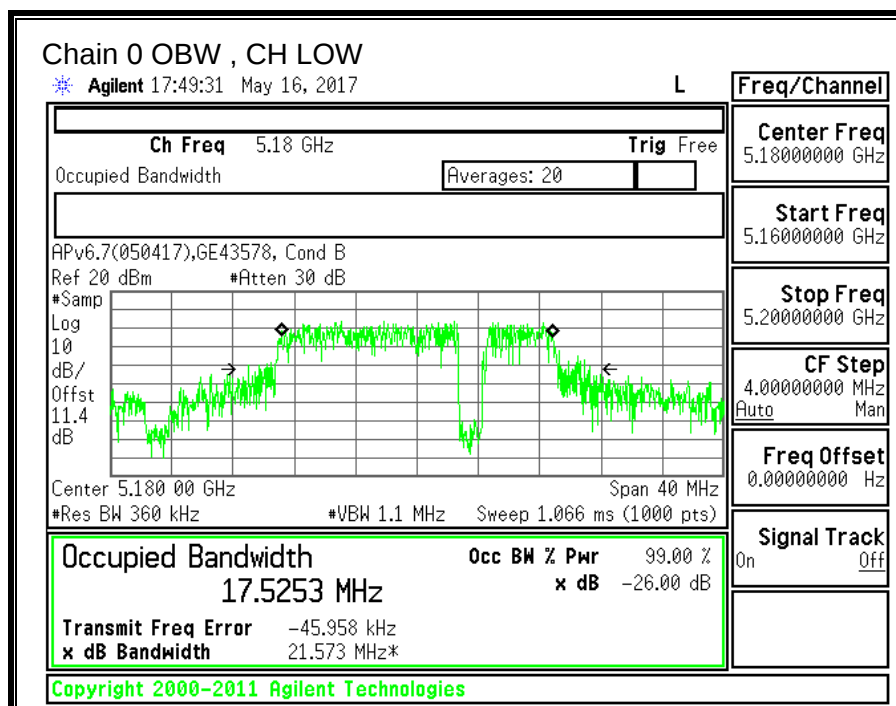
### 9.2.2. 99% BANDWIDTH

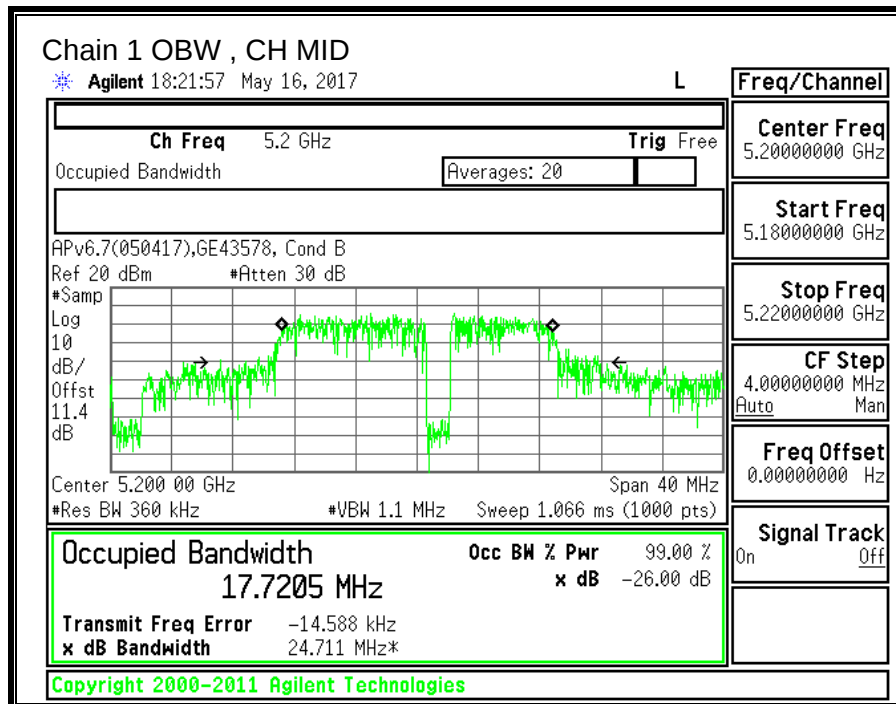
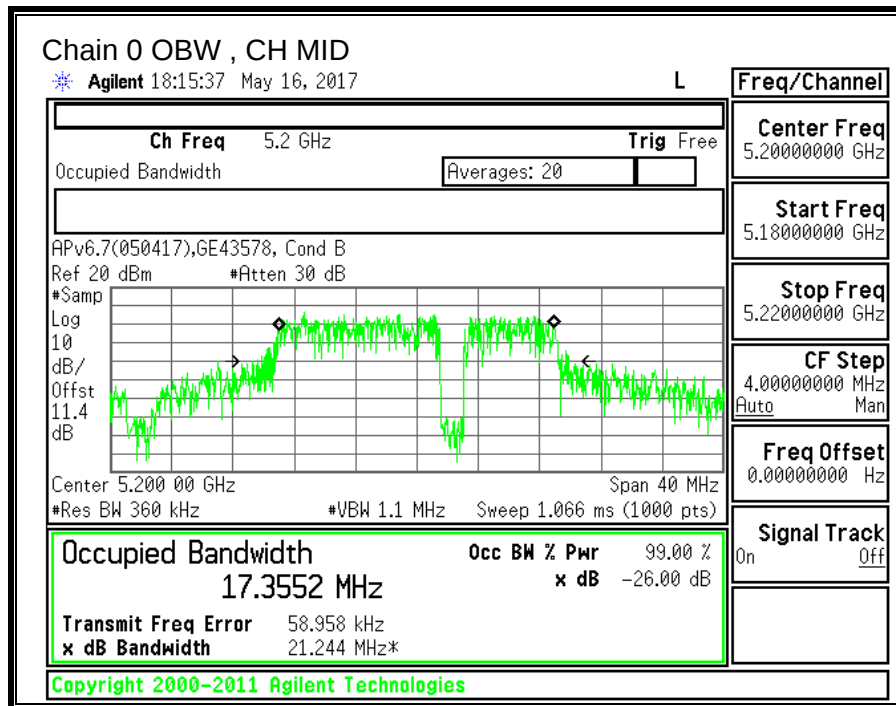
#### LIMITS

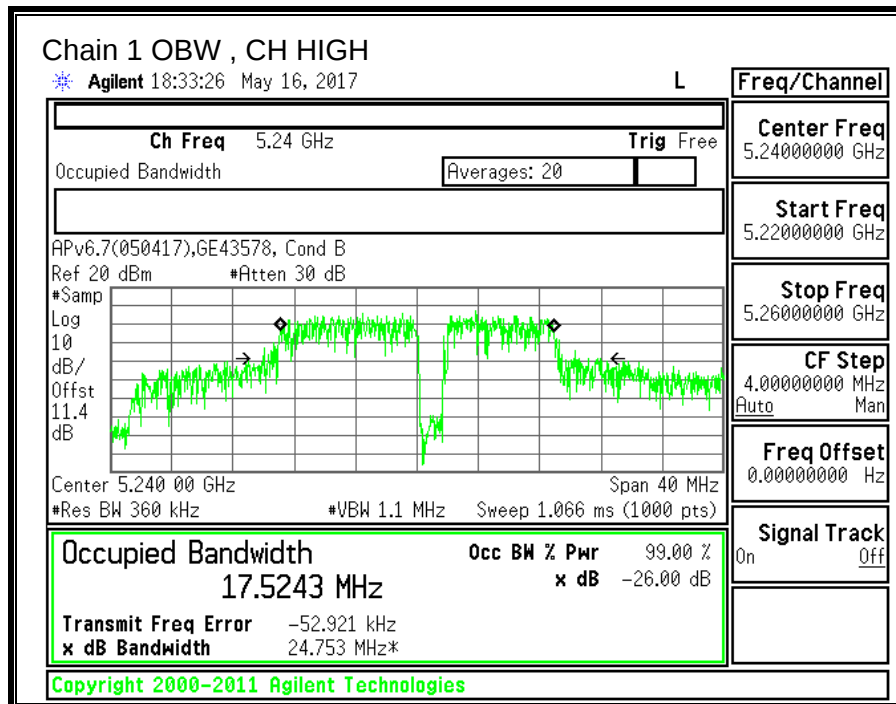
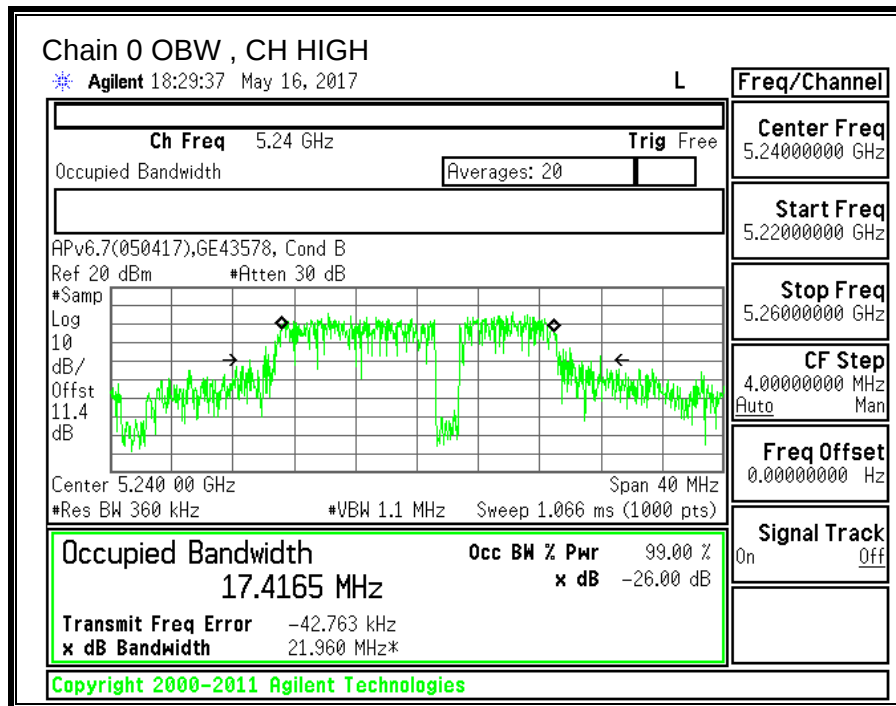
None; for reporting purposes only.

#### RESULTS

| Channel | Frequency | 99% BW<br>Chain 0<br>(MHz) | 99% BW<br>Chain 1<br>(MHz) |
|---------|-----------|----------------------------|----------------------------|
| Low     | 5180      | 17.5253                    | 17.6829                    |
| Mid     | 5200      | 17.3552                    | 17.7205                    |
| High    | 5240      | 17.4165                    | 17.5243                    |







### 9.2.3. OUTPUT POWER AND PPSD

#### LIMITS

FCC §15.407 (a) (1)

(i) For an outdoor access point operating in the band 5.15-5.25 GHz, the maximum conducted output power over the frequency band of operation shall not exceed 1 W provided the maximum antenna gain does not exceed 6 dBi. In addition, the maximum power spectral density shall not exceed 17 dBm in any 1 megahertz band. If transmitting antennas of directional gain greater than 6 dBi are used, both the maximum conducted output power and the maximum power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi. The maximum e.i.r.p. at any elevation angle above 30 degrees as measured from the horizon must not exceed 125 mW (21 dBm).

(ii) For an indoor access point operating in the band 5.15-5.25 GHz, the maximum conducted output power over the frequency band of operation shall not exceed 1 W provided the maximum antenna gain does not exceed 6 dBi. In addition, the maximum power spectral density shall not exceed 17 dBm in any 1 megahertz band. If transmitting antennas of directional gain greater than 6 dBi are used, both the maximum conducted output power and the maximum power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

(iii) For fixed point-to-point access points operating in the band 5.15-5.25 GHz, the maximum conducted output power over the frequency band of operation shall not exceed 1 W. Fixed point-to-point U-NII devices may employ antennas with directional gain up to 23 dBi without any corresponding reduction in the maximum conducted output power or maximum power spectral density. For fixed point-to-point transmitters that employ a directional antenna gain greater than 23 dBi, a 1 dB reduction in maximum conducted output power and maximum power spectral density is required for each 1 dB of antenna gain in excess of 23 dBi. Fixed, point-to-point operations exclude the use of point-to-multipoint systems, omnidirectional applications, and multiple collocated transmitters transmitting the same information. The operator of the U-NII device, or if the equipment is professionally installed, the installer, is responsible for ensuring that systems employing high gain directional antennas are used exclusively for fixed, point-to-point operations.

(iv) For mobile and portable client devices in the 5.15-5.25 GHz band, the maximum conducted output power over the frequency band of operation shall not exceed 250 mW provided the maximum antenna gain does not exceed 6 dBi. In addition, the maximum power spectral density shall not exceed 11 dBm in any 1 megahertz band. If transmitting antennas of directional gain greater than 6 dBi are used, both the maximum conducted output power and the maximum power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

## **TEST PROCEDURE**

Measurements perform using a wideband gated RF power meter provided that the gate parameters are adjusted such that the power is measured only when the EUT is transmitting at its maximum power control level. Since the measurement is made only during the ON time of the transmitter, no duty cycle correction factor is required.

## **DIRECTIONAL ANTENNA GAIN**

For Power, the TX chains are uncorrelated and the antenna gain is unequal among the chains. The directional gain is:

| <b>Chain 0<br/>Antenna<br/>Gain<br/>(dBi)</b> | <b>Chain 1<br/>Antenna<br/>Gain<br/>(dBi)</b> | <b>Uncorrelated Chains<br/>Directional<br/>Gain<br/>(dBi)</b> |
|-----------------------------------------------|-----------------------------------------------|---------------------------------------------------------------|
| 3.41                                          | 2.26                                          | 2.87                                                          |

For PSD, The TX chains are correlated and the antenna gain is unequal among the chains. The directional gain is:

| <b>Chain 0<br/>Antenna<br/>Gain<br/>(dBi)</b> | <b>Chain 1<br/>Antenna<br/>Gain<br/>(dBi)</b> | <b>Correlated Chains<br/>Directional<br/>Gain<br/>(dBi)</b> |
|-----------------------------------------------|-----------------------------------------------|-------------------------------------------------------------|
| 3.41                                          | 2.26                                          | 5.86                                                        |

## RESULTS

|            |         |              |         |
|------------|---------|--------------|---------|
| <b>ID:</b> | GE43578 | <b>Date:</b> | 5/16/17 |
|------------|---------|--------------|---------|

### Antenna Gain and Limits

| Channel | Frequency<br>(MHz) | Directional<br>Gain<br>for Power<br>(dBi) | Directional<br>Gain<br>for PSD<br>(dBi) | Power<br>Limit<br>(dBm) | PSD<br>Limit<br>(dBm) |
|---------|--------------------|-------------------------------------------|-----------------------------------------|-------------------------|-----------------------|
| Low     | 5180               | 2.87                                      | 5.86                                    | 24.00                   | 11.00                 |
| Mid     | 5200               | 2.87                                      | 5.86                                    | 24.00                   | 11.00                 |
| High    | 5240               | 2.87                                      | 5.86                                    | 24.00                   | 11.00                 |

|                           |      |                                               |
|---------------------------|------|-----------------------------------------------|
| <b>Duty Cycle CF (dB)</b> | 0.37 | <b>Included in Calculations of Corr'd PSD</b> |
|---------------------------|------|-----------------------------------------------|

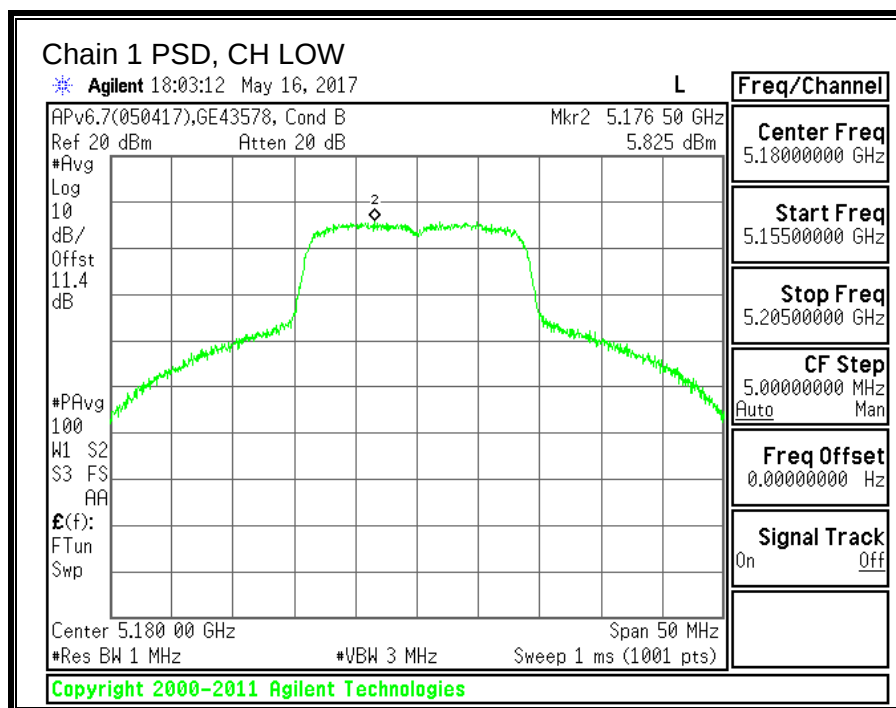
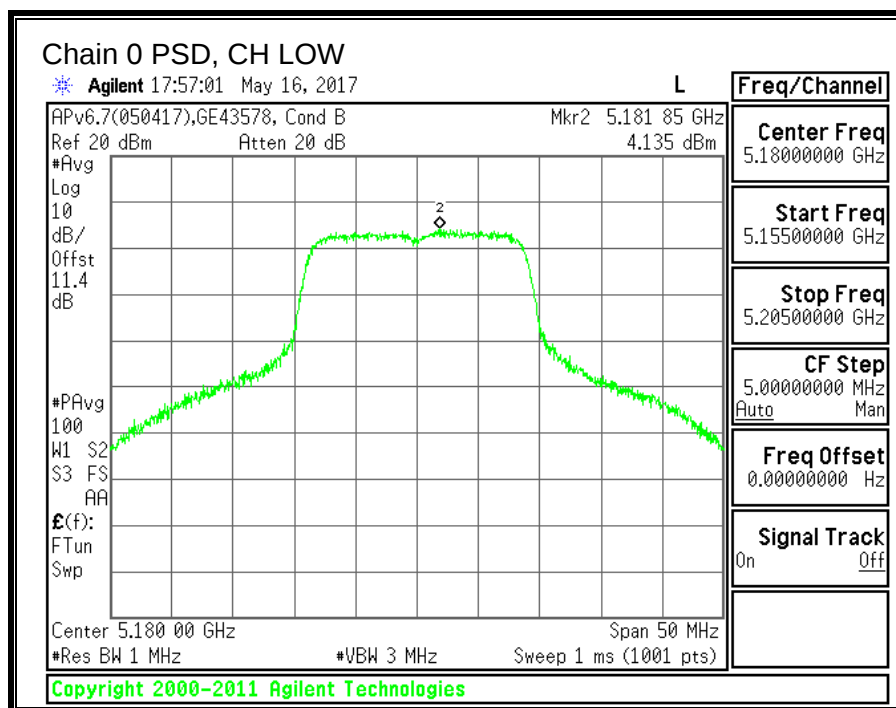
### Output Power Results

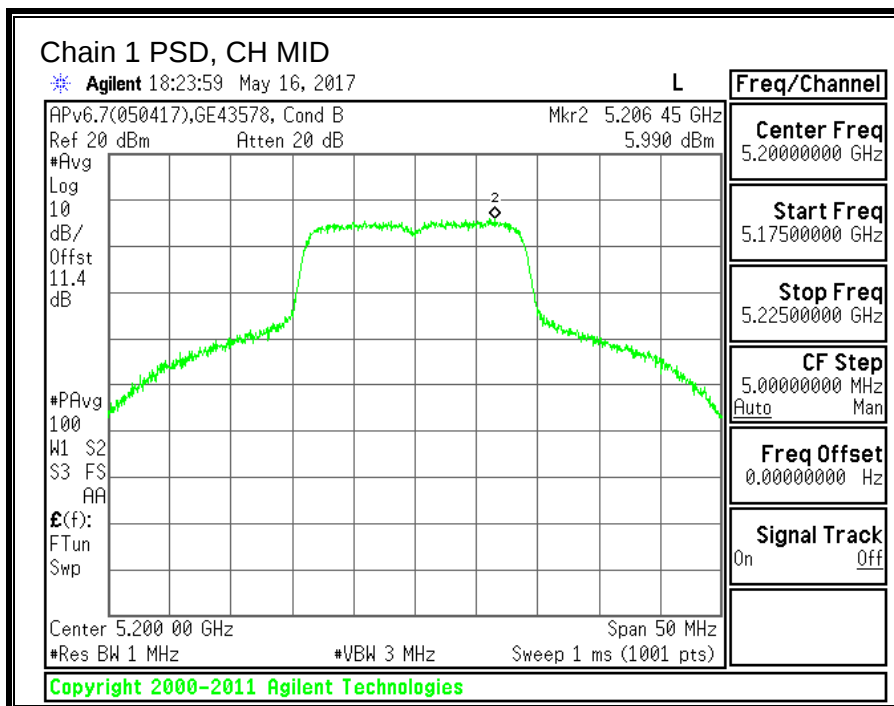
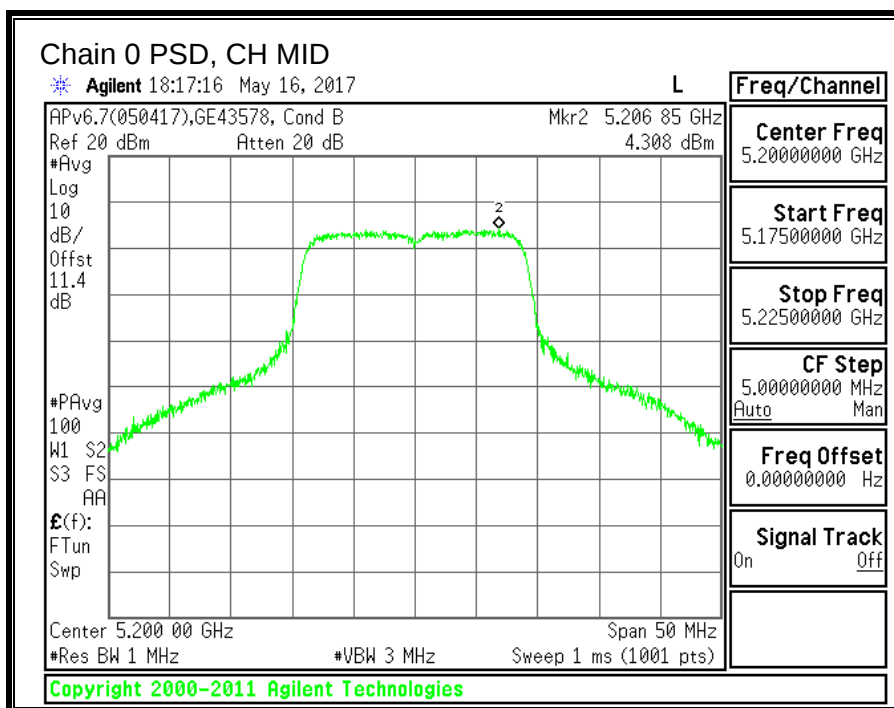
| Channel | Frequency<br>(MHz) | Chain 0<br>Meas<br>Power<br>(dBm) | Chain 1<br>Meas<br>Power<br>(dBm) | Total<br>Corr'd<br>Power<br>(dBm) | Power<br>Limit<br>(dBm) | Power<br>Margin<br>(dB) |
|---------|--------------------|-----------------------------------|-----------------------------------|-----------------------------------|-------------------------|-------------------------|
| Low     | 5180               | 15.39                             | 17.04                             | 19.30                             | 24.00                   | -4.70                   |
| Mid     | 5200               | 15.46                             | 17.12                             | 19.38                             | 24.00                   | -4.62                   |
| High    | 5240               | 15.42                             | 17.08                             | 19.34                             | 24.00                   | -4.66                   |

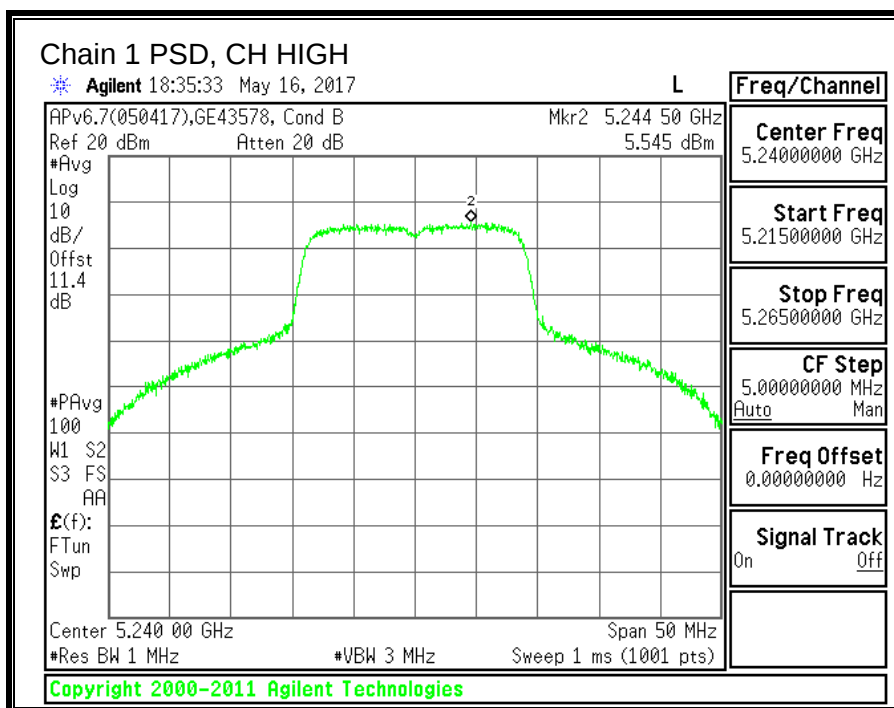
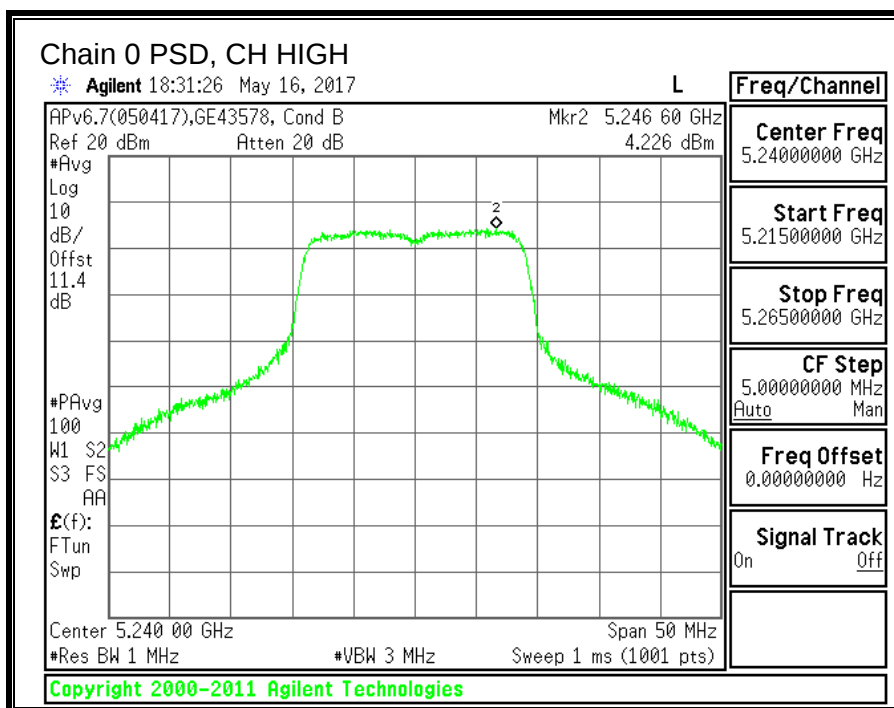
### PSD Results

| Channel | Frequency<br>(MHz) | Chain 0<br>Meas<br>PSD<br>(dBm) | Chain 1<br>Meas<br>PSD<br>(dBm) | Total<br>Corr'd<br>PSD<br>(dBm) | PSD<br>Limit<br>(dBm) | PSD<br>Margin<br>(dB) |
|---------|--------------------|---------------------------------|---------------------------------|---------------------------------|-----------------------|-----------------------|
| Low     | 5180               | 4.135                           | 5.825                           | 8.44                            | 11.00                 | -2.56                 |
| Mid     | 5200               | 4.308                           | 5.990                           | 8.61                            | 11.00                 | -2.39                 |
| High    | 5240               | 4.226                           | 5.545                           | 8.32                            | 11.00                 | -2.68                 |

**Note:** the power readings above were measured with gated method, and the measurement was taken only during the ON time. No duty cycle correction was necessary.







### 9.3. 11n HT20 3TX CDD MIMO MODE IN THE 5.2GHz BAND

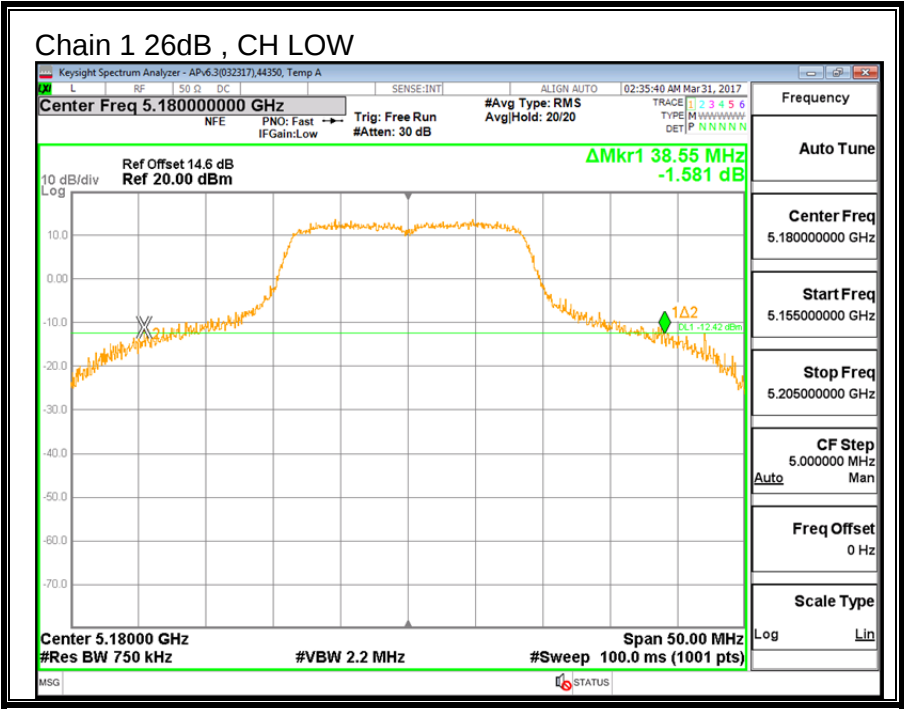
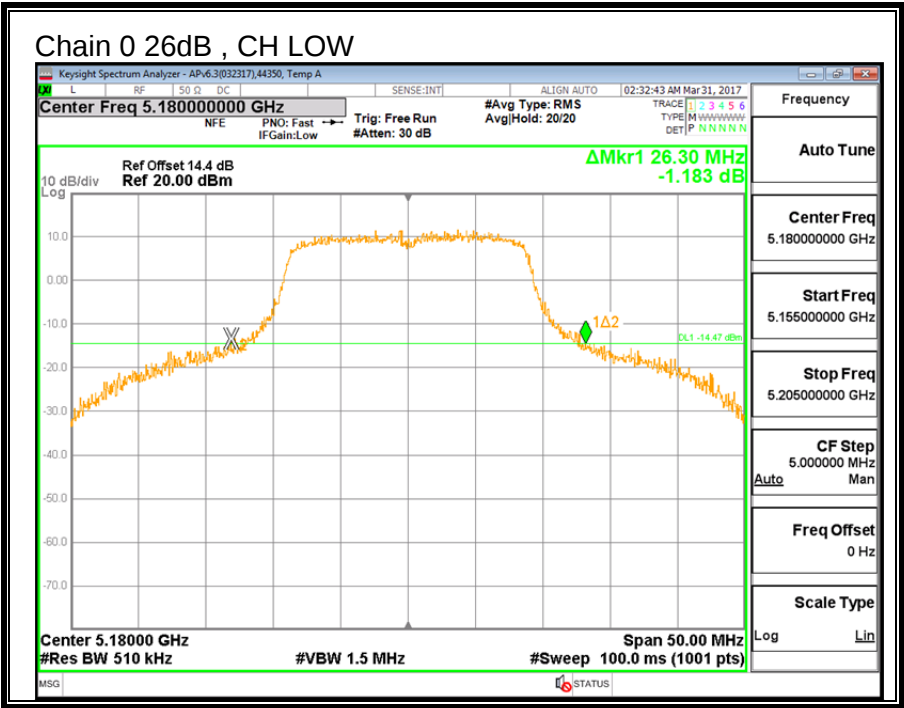
#### 9.3.1. 26 dB BANDWIDTH

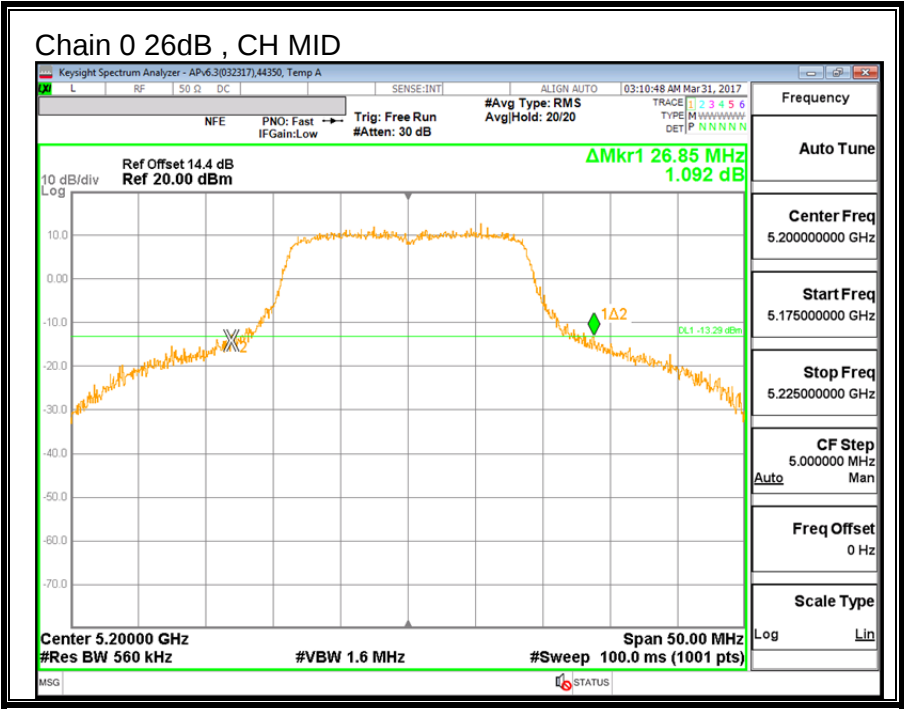
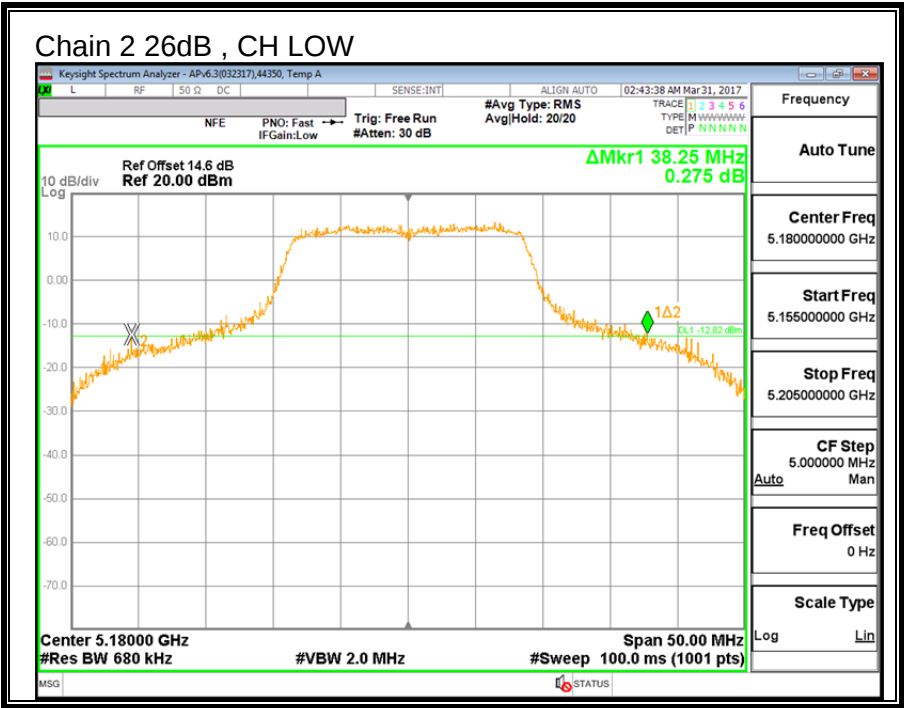
##### LIMITS

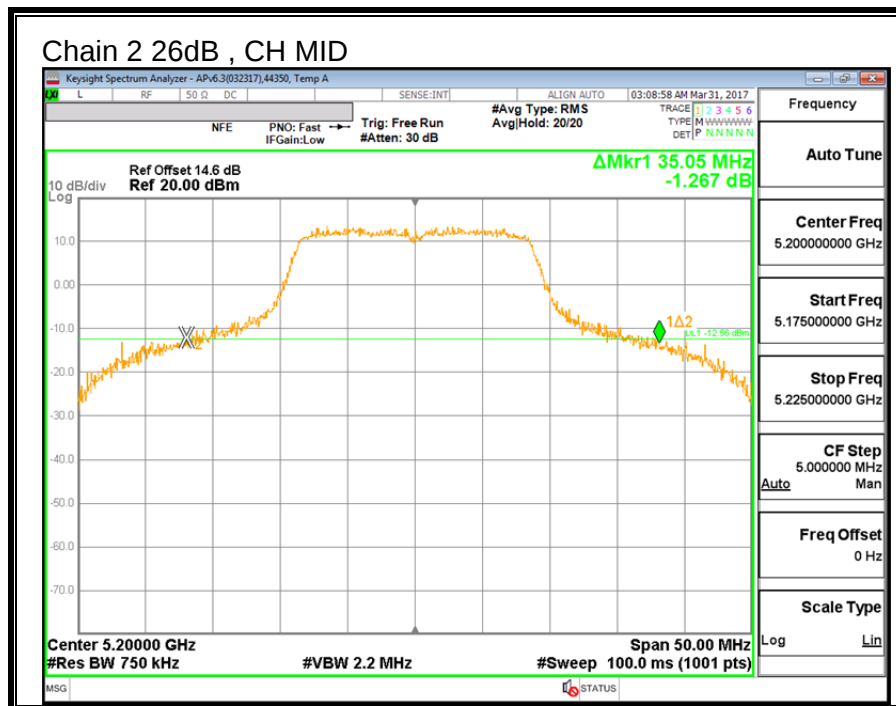
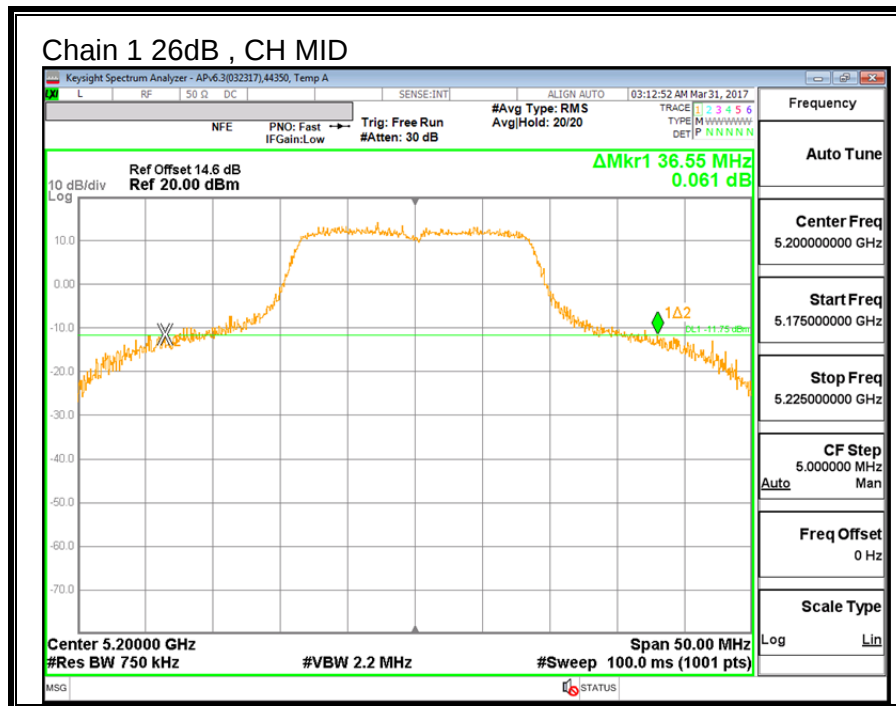
None; for reporting purposes only.

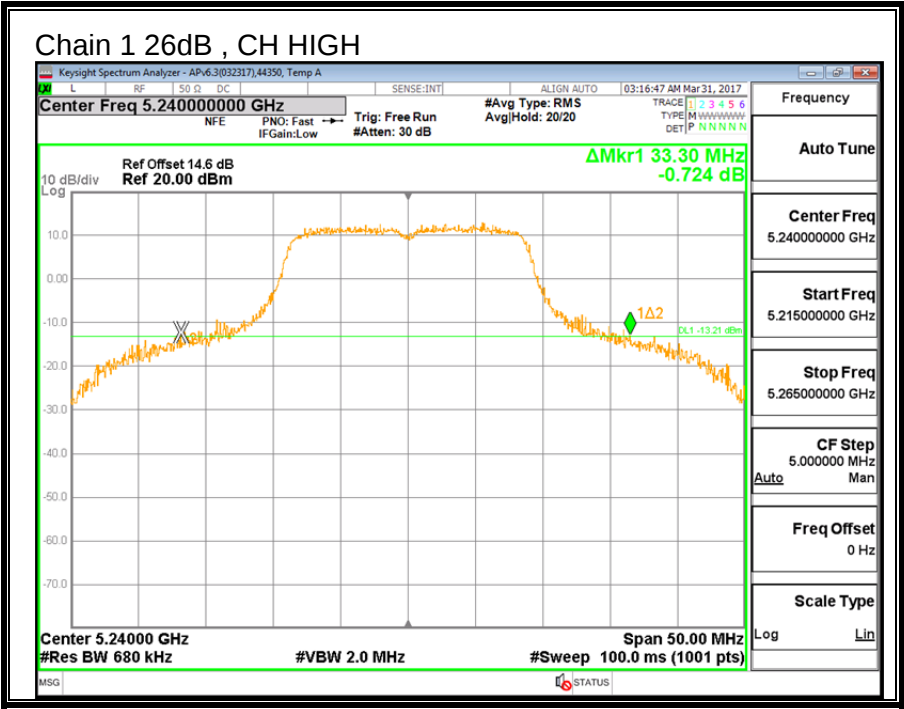
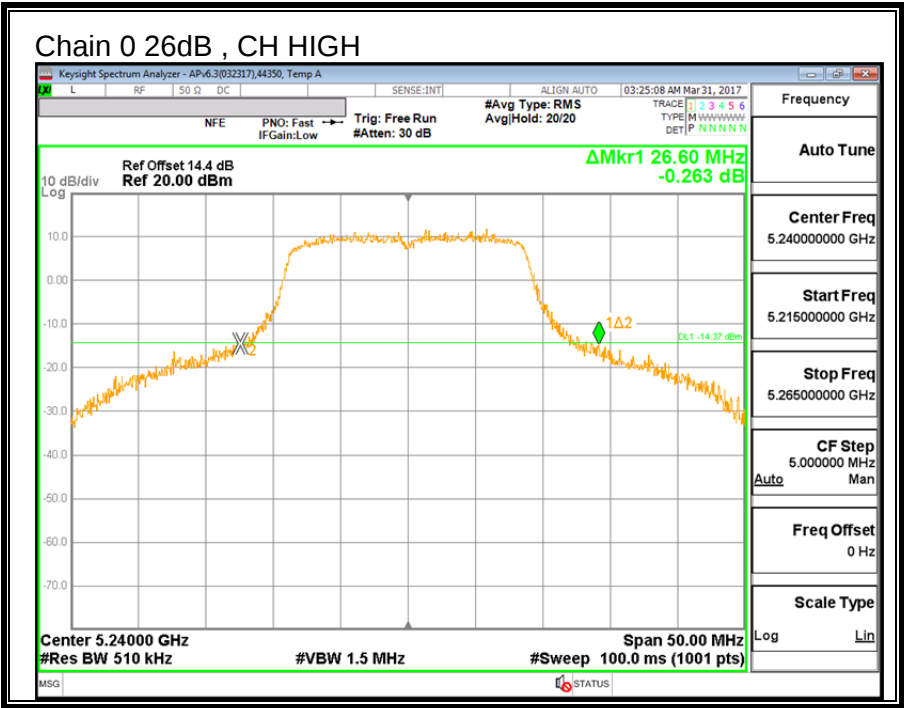
##### RESULTS

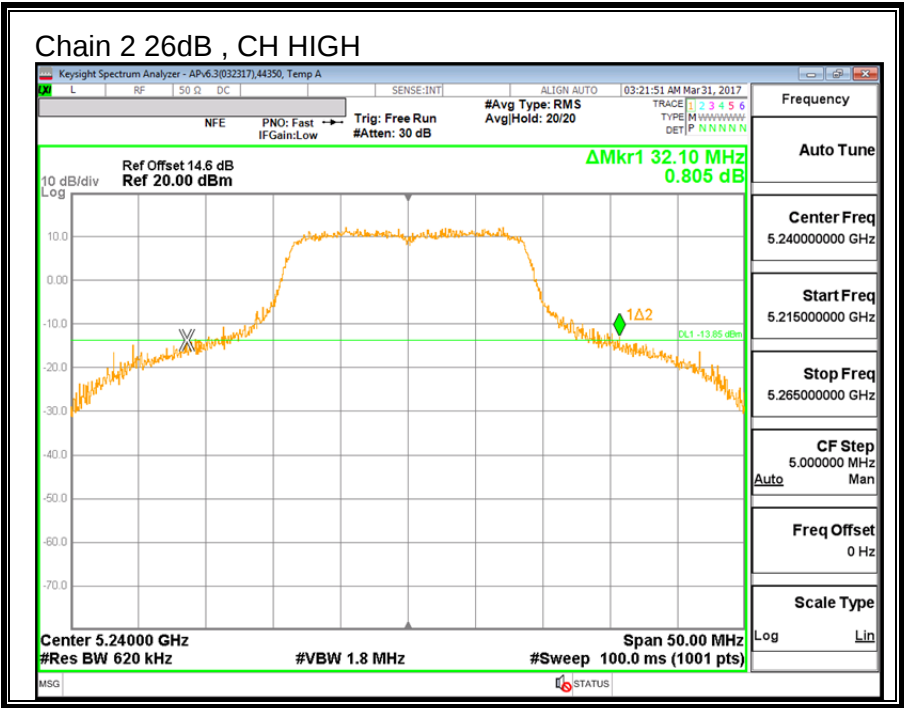
| Channel | Frequency | 26 dB BW<br>Chain 0<br>(MHz) | 26 dB BW<br>Chain 1<br>(MHz) | 26 dB BW<br>Chain 2<br>(MHz) |
|---------|-----------|------------------------------|------------------------------|------------------------------|
| Low     | 5180      | 26.30                        | 38.55                        | 38.25                        |
| Mid     | 5200      | 26.85                        | 36.55                        | 35.05                        |
| High    | 5240      | 26.60                        | 33.30                        | 32.10                        |











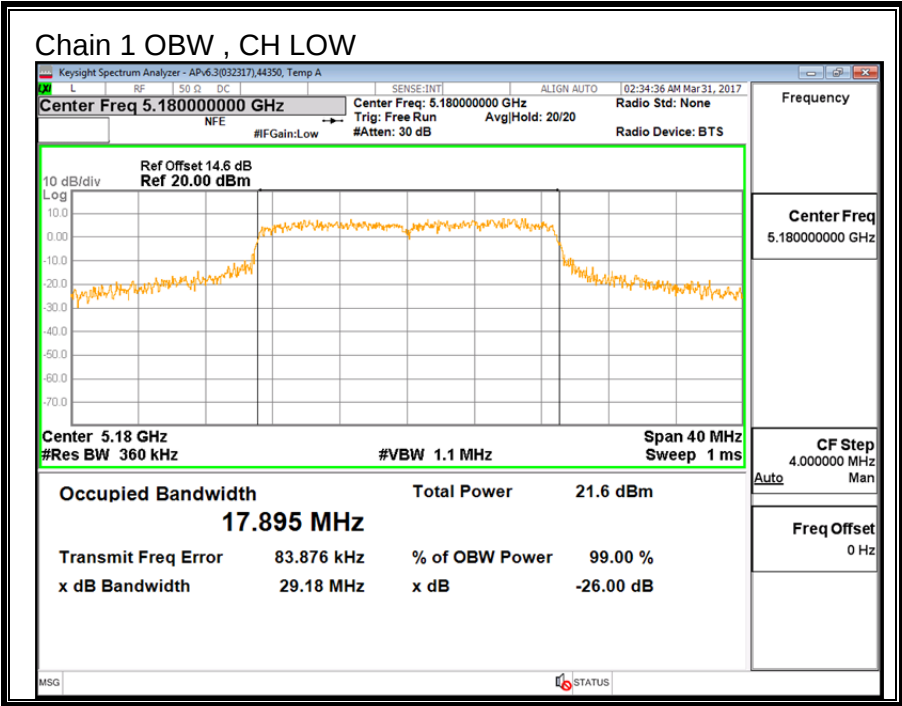
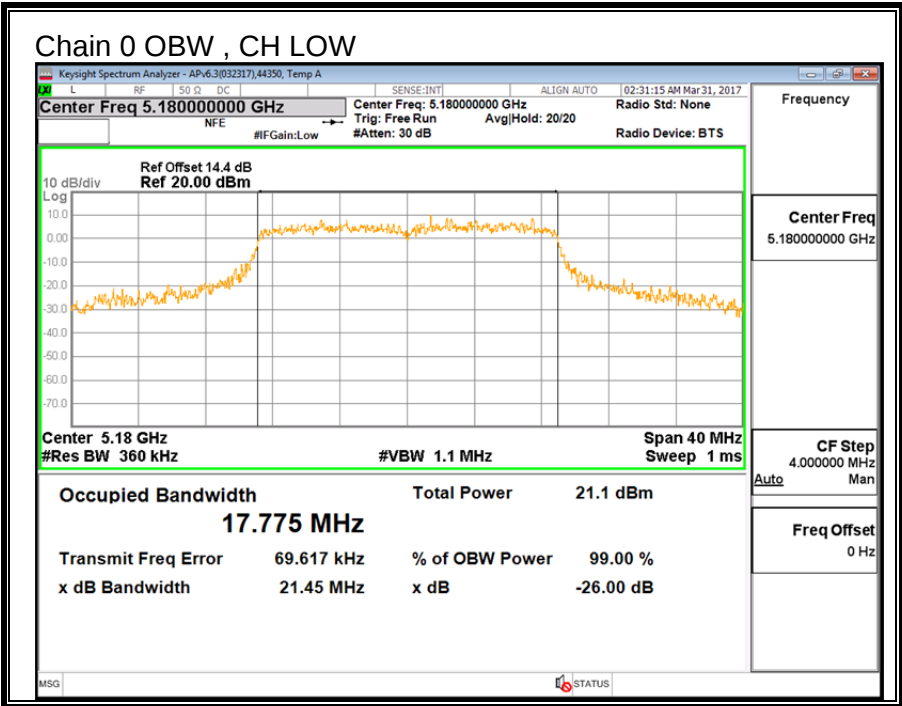
### 9.3.2. 99% BANDWIDTH

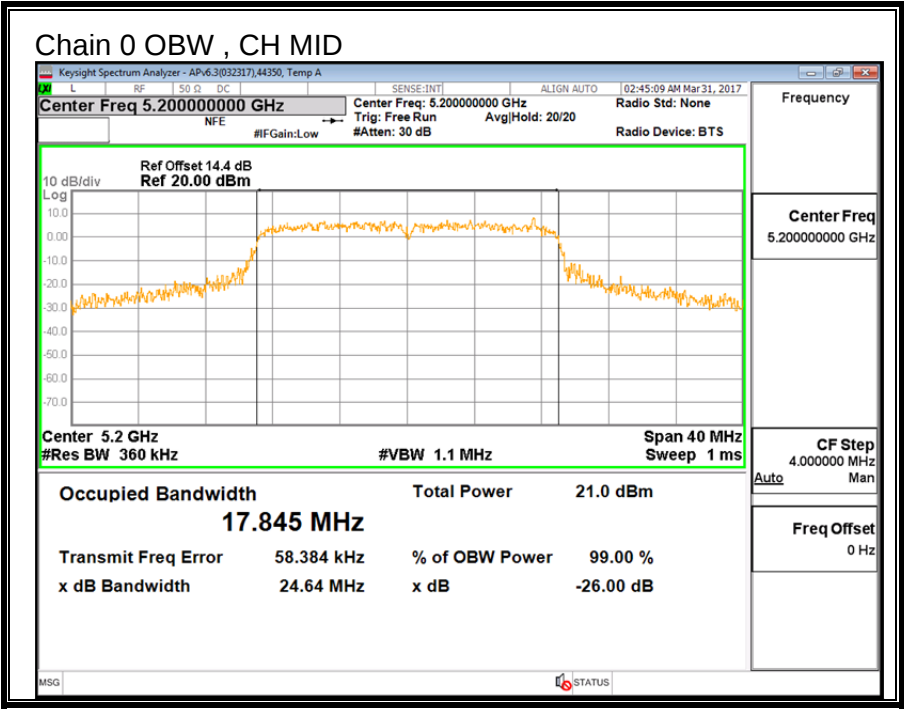
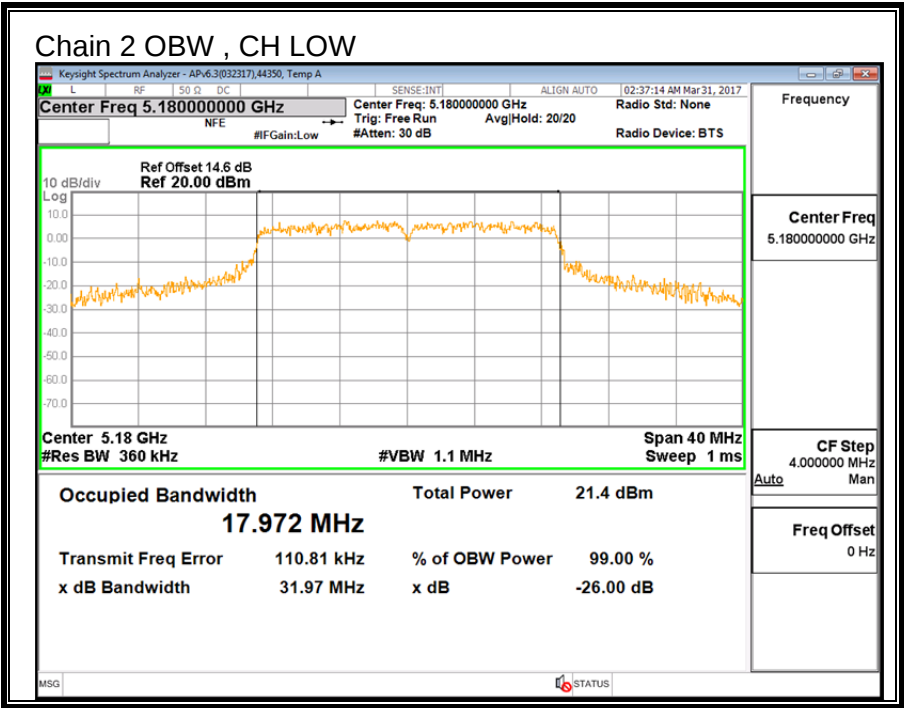
#### LIMITS

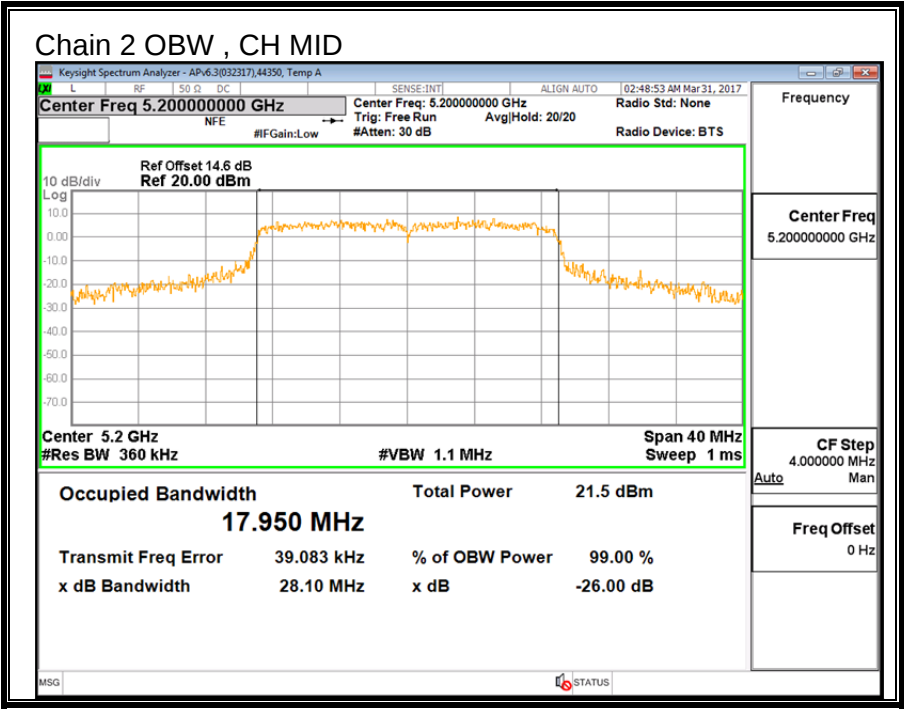
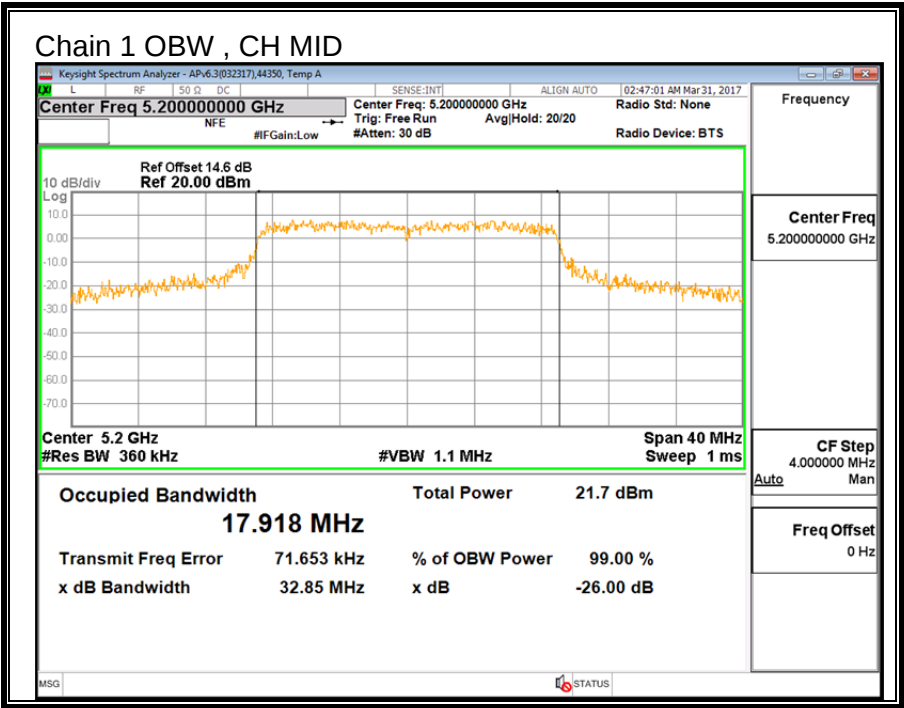
None; for reporting purposes only.

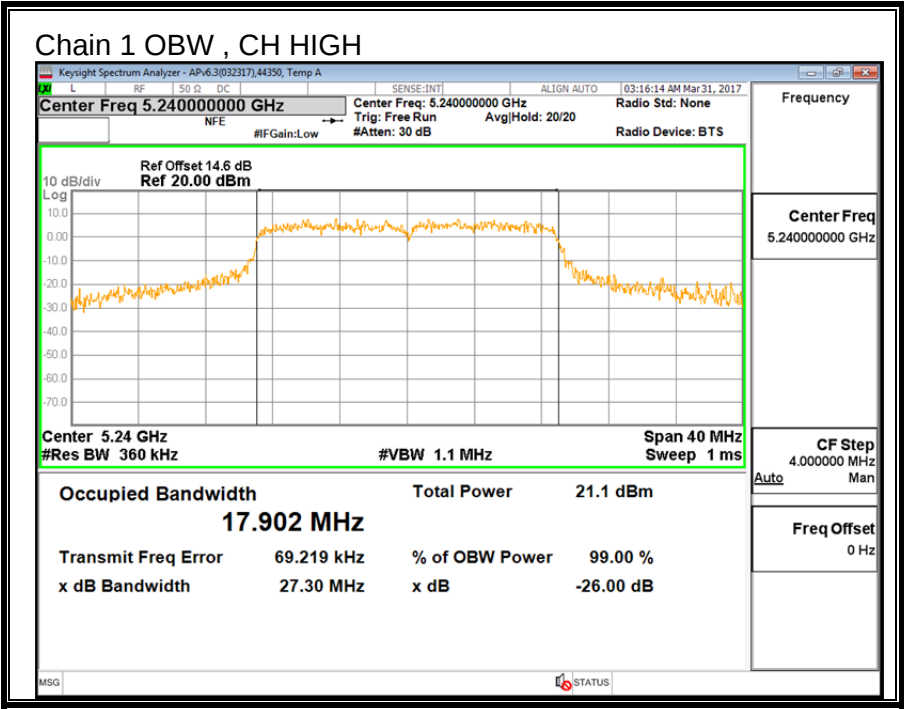
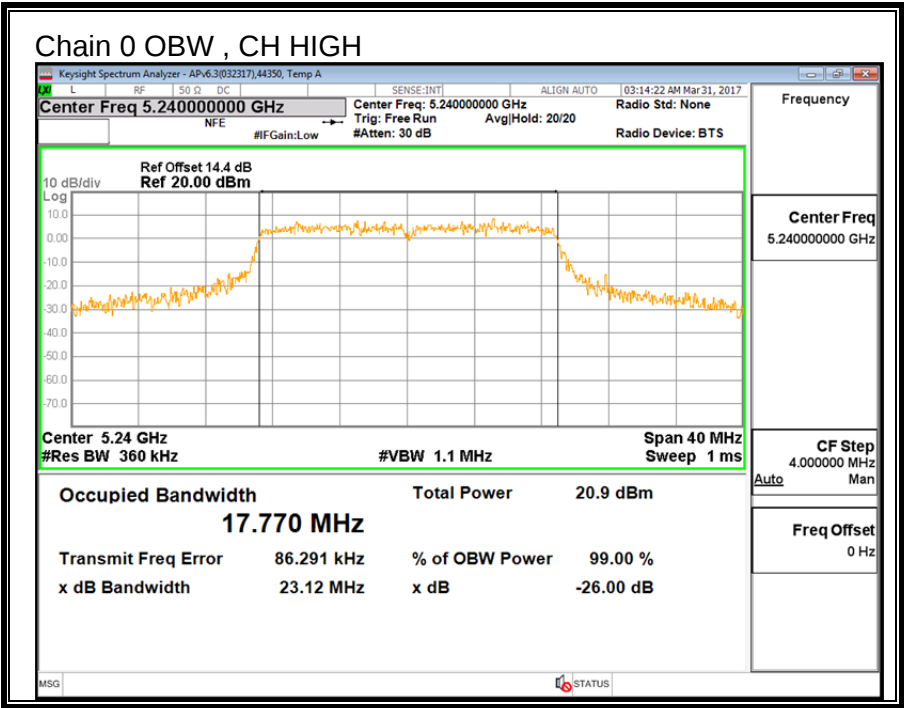
#### RESULTS

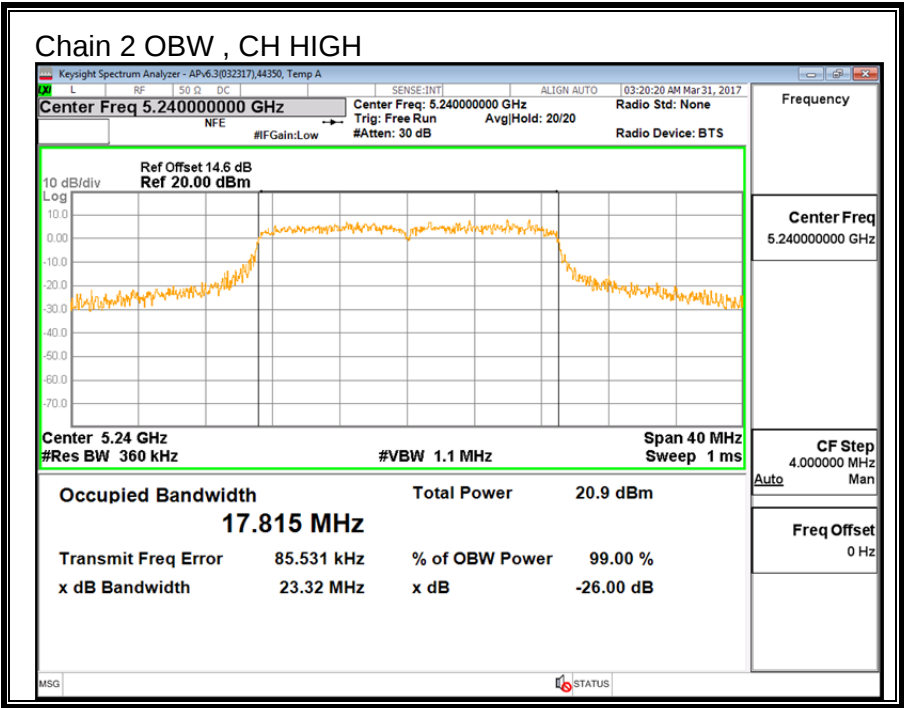
| Channel | Frequency | 99% BW<br>Chain 0<br>(MHz) | 99% BW<br>Chain 1<br>(MHz) | 99% BW<br>Chain 2<br>(MHz) |
|---------|-----------|----------------------------|----------------------------|----------------------------|
| Low     | 5180      | 17.775                     | 17.895                     | 17.972                     |
| Mid     | 5200      | 17.845                     | 17.918                     | 17.950                     |
| High    | 5240      | 17.770                     | 17.902                     | 17.815                     |











### 9.3.3. OUTPUT POWER AND PPSD

#### LIMITS

FCC §15.407 (a) (1)

(i) For an outdoor access point operating in the band 5.15-5.25 GHz, the maximum conducted output power over the frequency band of operation shall not exceed 1 W provided the maximum antenna gain does not exceed 6 dBi. In addition, the maximum power spectral density shall not exceed 17 dBm in any 1 megahertz band. If transmitting antennas of directional gain greater than 6 dBi are used, both the maximum conducted output power and the maximum power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi. The maximum e.i.r.p. at any elevation angle above 30 degrees as measured from the horizon must not exceed 125 mW (21 dBm).

(ii) For an indoor access point operating in the band 5.15-5.25 GHz, the maximum conducted output power over the frequency band of operation shall not exceed 1 W provided the maximum antenna gain does not exceed 6 dBi. In addition, the maximum power spectral density shall not exceed 17 dBm in any 1 megahertz band. If transmitting antennas of directional gain greater than 6 dBi are used, both the maximum conducted output power and the maximum power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

(iii) For fixed point-to-point access points operating in the band 5.15-5.25 GHz, the maximum conducted output power over the frequency band of operation shall not exceed 1 W. Fixed point-to-point U-NII devices may employ antennas with directional gain up to 23 dBi without any corresponding reduction in the maximum conducted output power or maximum power spectral density. For fixed point-to-point transmitters that employ a directional antenna gain greater than 23 dBi, a 1 dB reduction in maximum conducted output power and maximum power spectral density is required for each 1 dB of antenna gain in excess of 23 dBi. Fixed, point-to-point operations exclude the use of point-to-multipoint systems, omnidirectional applications, and multiple collocated transmitters transmitting the same information. The operator of the U-NII device, or if the equipment is professionally installed, the installer, is responsible for ensuring that systems employing high gain directional antennas are used exclusively for fixed, point-to-point operations.

(iv) For mobile and portable client devices in the 5.15-5.25 GHz band, the maximum conducted output power over the frequency band of operation shall not exceed 250 mW provided the maximum antenna gain does not exceed 6 dBi. In addition, the maximum power spectral density shall not exceed 11 dBm in any 1 megahertz band. If transmitting antennas of directional gain greater than 6 dBi are used, both the maximum conducted output power and the maximum power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

## **TEST PROCEDURE**

Measurements perform using a wideband gated RF power meter provided that the gate parameters are adjusted such that the power is measured only when the EUT is transmitting at its maximum power control level. Since the measurement is made only during the ON time of the transmitter, no duty cycle correction factor is required.

## **DIRECTIONAL ANTENNA GAIN**

For Power, the TX chains are uncorrelated and the antenna gain is unequal among the chains. The directional gain is:

| <b>Chain 0<br/>Antenna<br/>Gain<br/>(dBi)</b> | <b>Chain 1<br/>Antenna<br/>Gain<br/>(dBi)</b> | <b>Chain 2<br/>Antenna<br/>Gain<br/>(dBi)</b> | <b>Uncorrelated Chains<br/>Directional<br/>Gain<br/>(dBi)</b> |
|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|---------------------------------------------------------------|
| 3.41                                          | 2.26                                          | 4.22                                          | 3.37                                                          |

For PSD, The TX chains are correlated and the antenna gain is unequal among the chains. The directional gain is:

| <b>Chain 0<br/>Antenna<br/>Gain<br/>(dBi)</b> | <b>Chain 1<br/>Antenna<br/>Gain<br/>(dBi)</b> | <b>Chain 2<br/>Antenna<br/>Gain<br/>(dBi)</b> | <b>Correlated Chains<br/>Directional<br/>Gain<br/>(dBi)</b> |
|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|-------------------------------------------------------------|
| 3.41                                          | 2.26                                          | 4.22                                          | 8.10                                                        |

## RESULTS

|            |         |              |         |
|------------|---------|--------------|---------|
| <b>ID:</b> | GE43578 | <b>Date:</b> | 5/16/17 |
|------------|---------|--------------|---------|

### Antenna Gain and Limits

| Channel | Frequency<br>(MHz) | Directional<br>Gain<br>for Power<br>(dBi) | Directional<br>Gain<br>for PSD<br>(dBi) | Power<br>Limit<br>(dBm) | PSD<br>Limit<br>(dBm) |
|---------|--------------------|-------------------------------------------|-----------------------------------------|-------------------------|-----------------------|
| Low     | 5180               | 3.37                                      | 8.10                                    | 24.00                   | 8.90                  |
| Mid     | 5200               | 3.37                                      | 8.10                                    | 24.00                   | 8.90                  |
| High    | 5240               | 3.37                                      | 8.10                                    | 24.00                   | 8.90                  |

|                           |      |                                                           |
|---------------------------|------|-----------------------------------------------------------|
| <b>Duty Cycle CF (dB)</b> | 0.37 | <b>Included in Calculations of Corr'd Power &amp; PSD</b> |
|---------------------------|------|-----------------------------------------------------------|

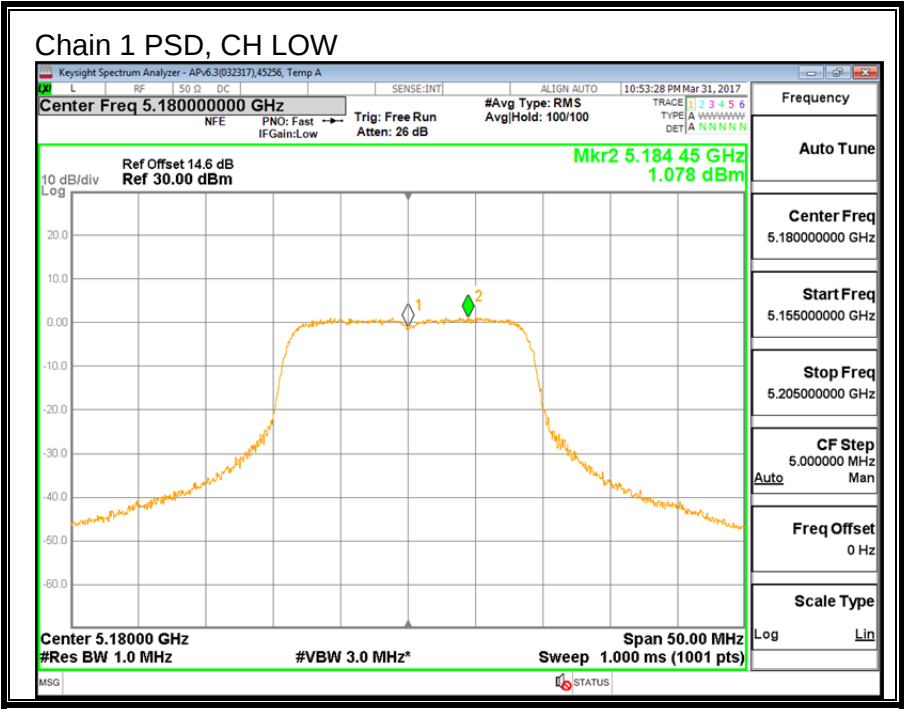
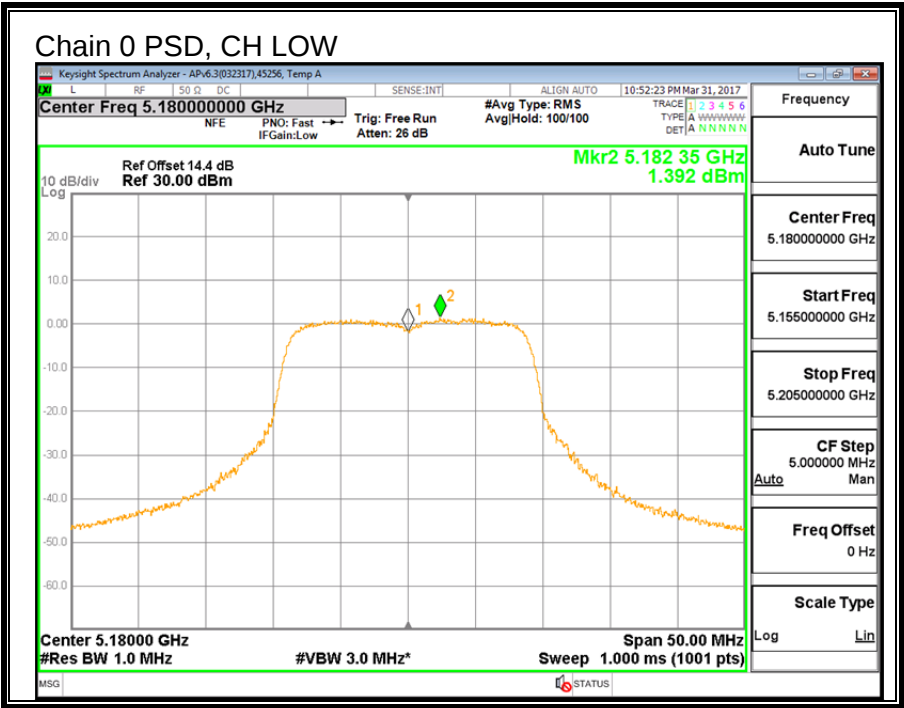
### Output Power Results

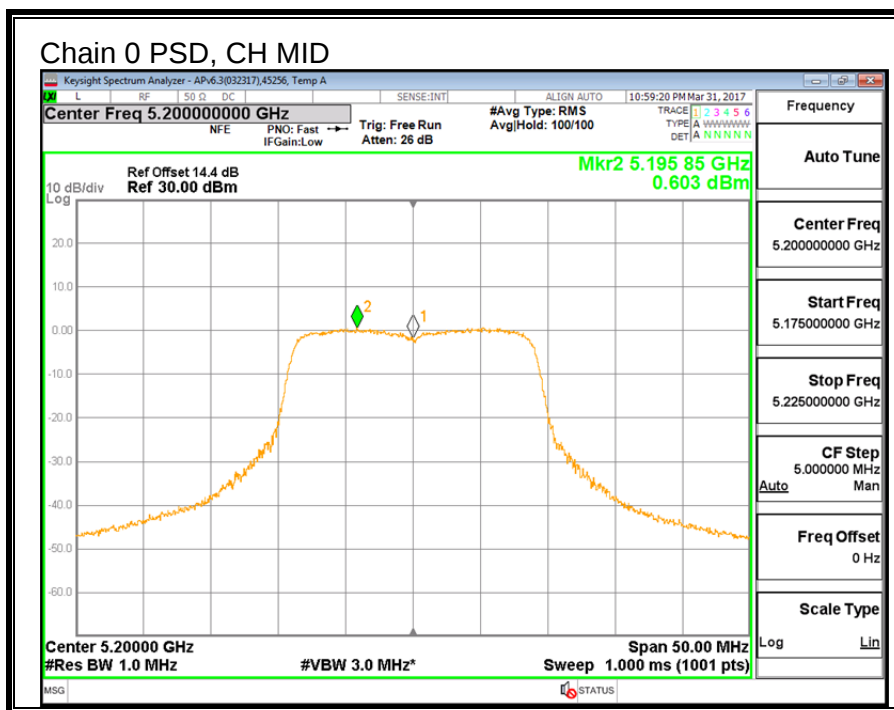
| Channel | Frequency<br>(MHz) | Chain 0<br>Meas<br>Power<br>(dBm) | Chain 1<br>Meas<br>Power<br>(dBm) | Chain 2<br>Meas<br>Power<br>(dBm) | Total<br>Corr'd<br>Power<br>(dBm) | Power<br>Limit<br>(dBm) | Power<br>Margin<br>(dB) |
|---------|--------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-------------------------|-------------------------|
| Low     | 5180               | 16.41                             | 16.52                             | 16.30                             | 21.55                             | 24.00                   | -2.45                   |
| Mid     | 5200               | 16.31                             | 16.49                             | 16.22                             | 21.48                             | 24.00                   | -2.52                   |
| High    | 5240               | 15.90                             | 15.96                             | 15.61                             | 20.97                             | 24.00                   | -3.03                   |

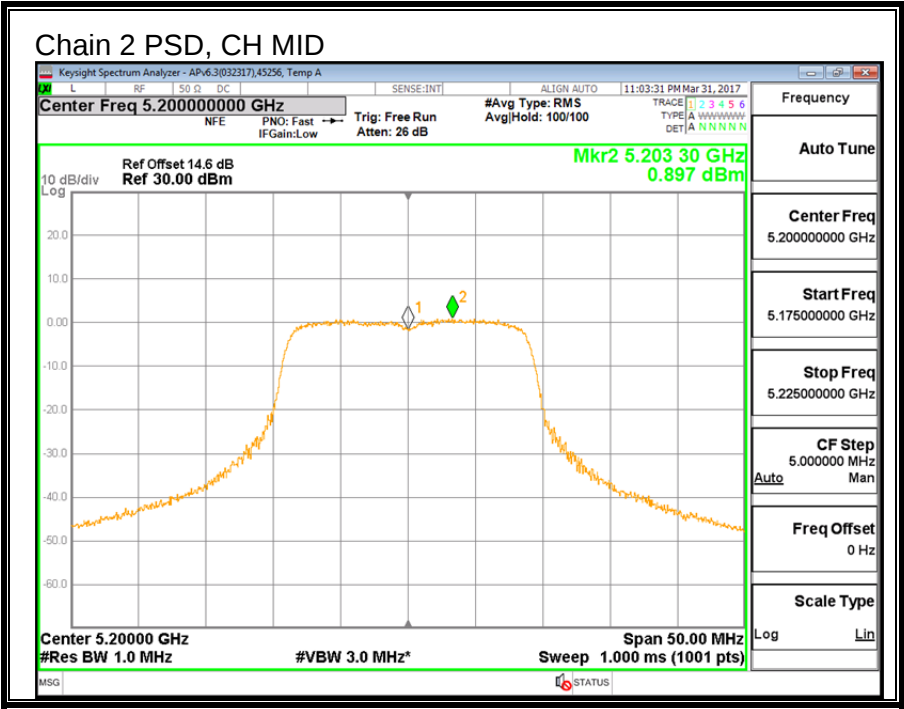
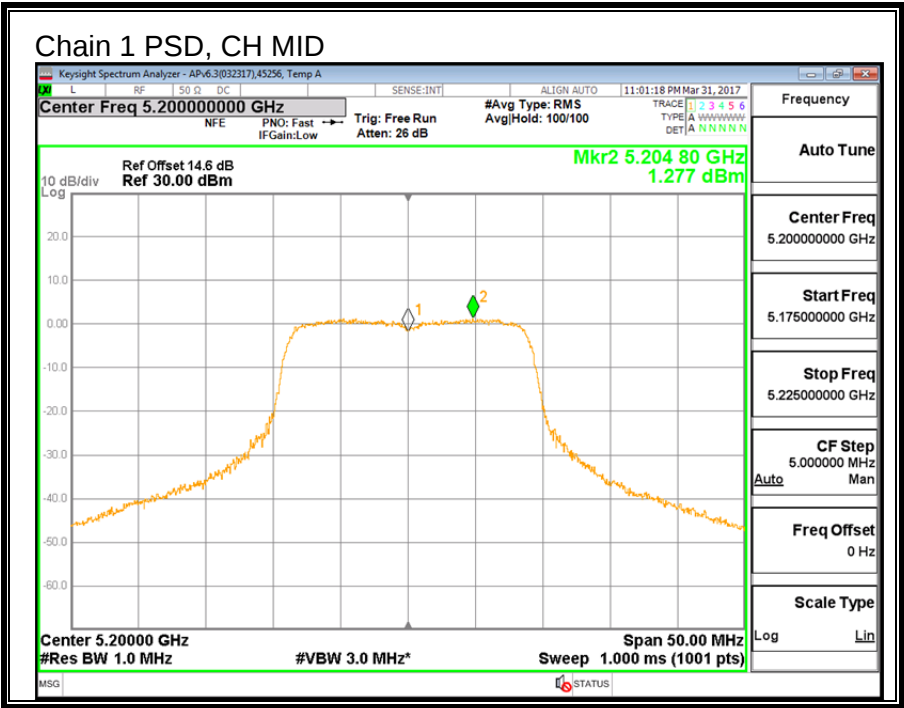
### PSD Results

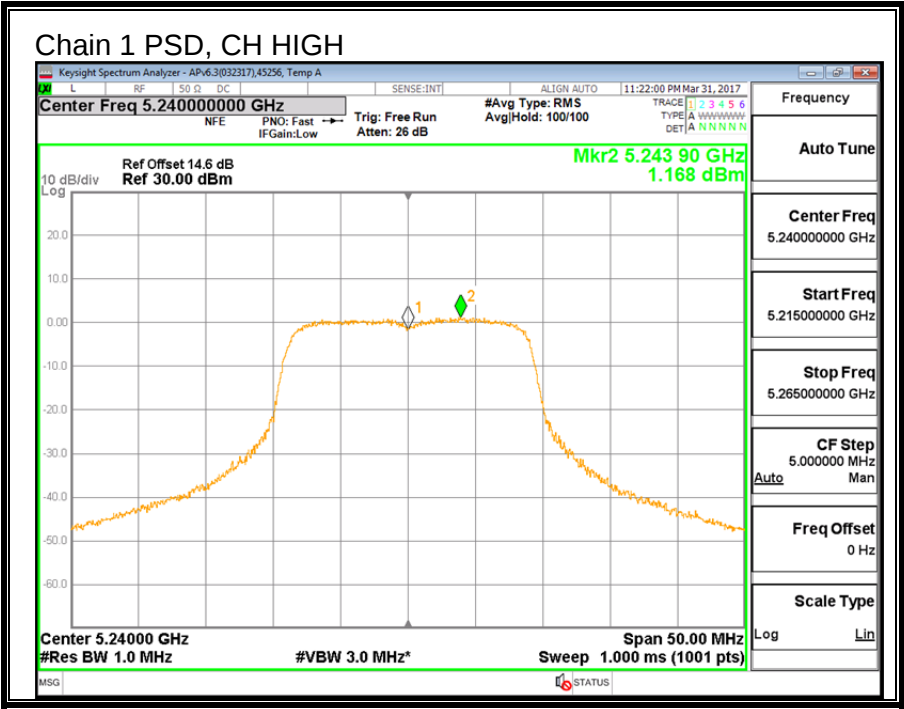
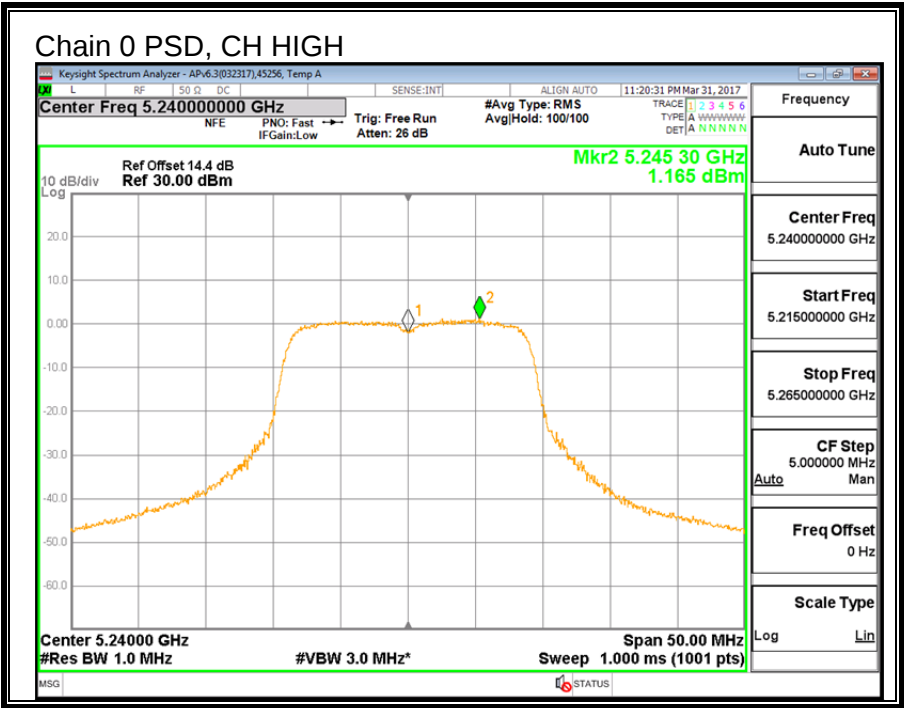
| Channel | Frequency<br>(MHz) | Chain 0<br>Meas<br>PSD<br>(dBm) | Chain 1<br>Meas<br>PSD<br>(dBm) | Chain 2<br>Meas<br>PSD<br>(dBm) | Total<br>Corr'd<br>PSD<br>(dBm) | PSD<br>Limit<br>(dBm) | PSD<br>Margin<br>(dB) |
|---------|--------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|-----------------------|-----------------------|
| Low     | 5180               | 1.392                           | 1.078                           | 0.955                           | 6.29                            | 8.90                  | -2.61                 |
| Mid     | 5200               | 0.603                           | 1.277                           | 0.897                           | 6.08                            | 8.90                  | -2.82                 |
| High    | 5240               | 1.165                           | 1.168                           | 0.833                           | 6.20                            | 8.90                  | -2.70                 |

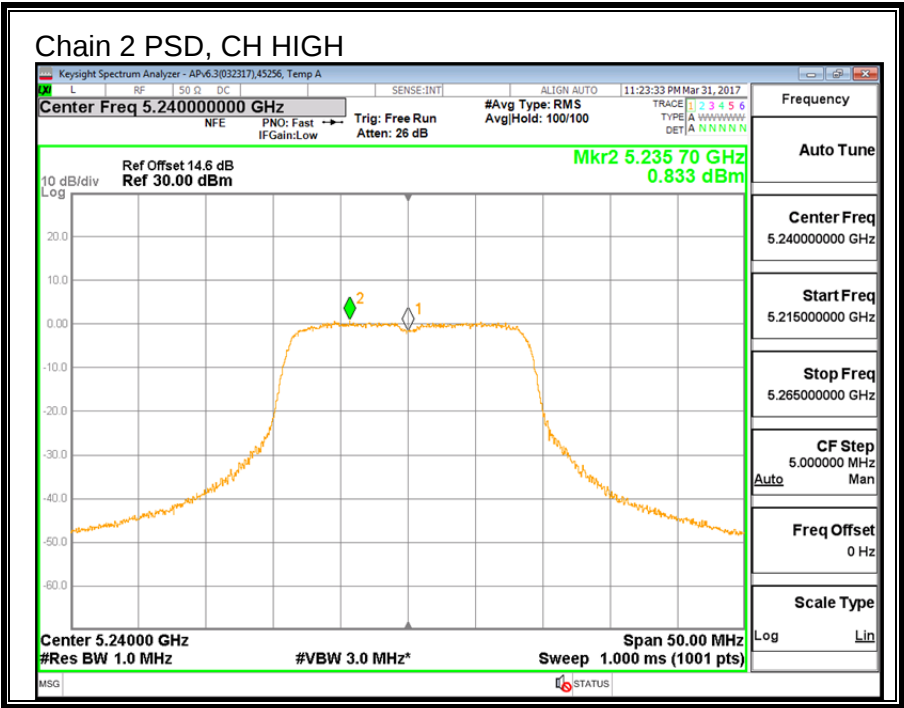
**Note:** the power readings above were measured with gated method, and the measurement was taken only during the ON time. No duty cycle correction was necessary.











## 9.4. 11n HT20 2TX CDD MIMO MODE IN THE 5.3GHz BAND

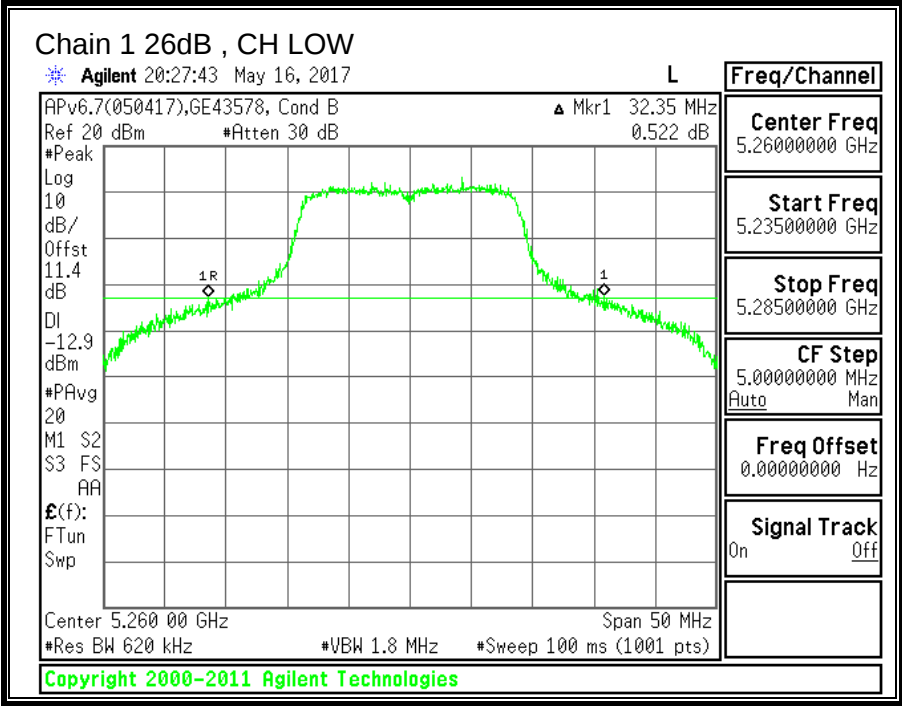
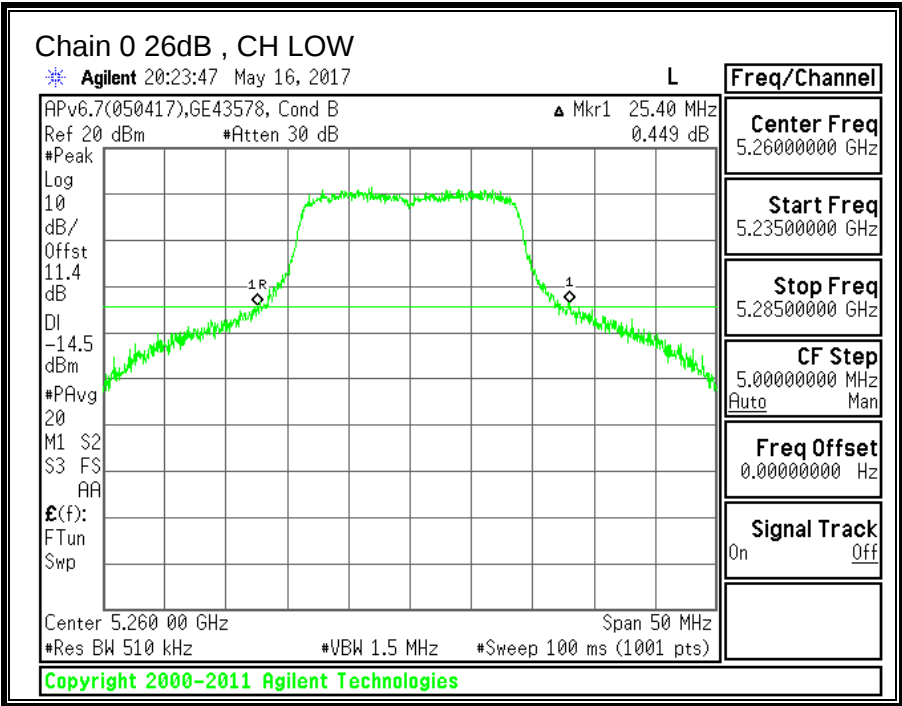
### 9.4.1. 26 dB BANDWIDTH

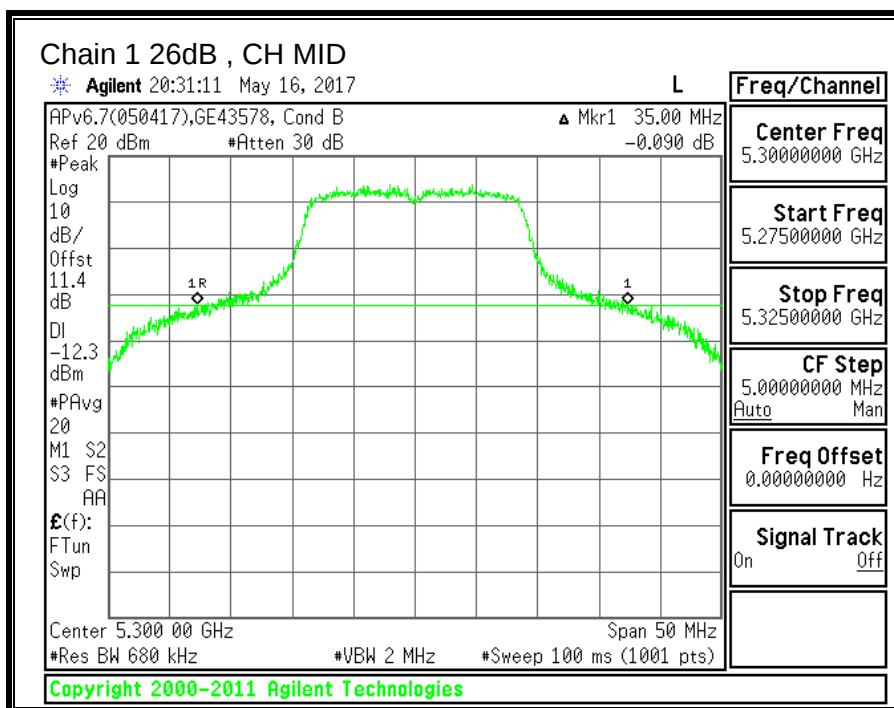
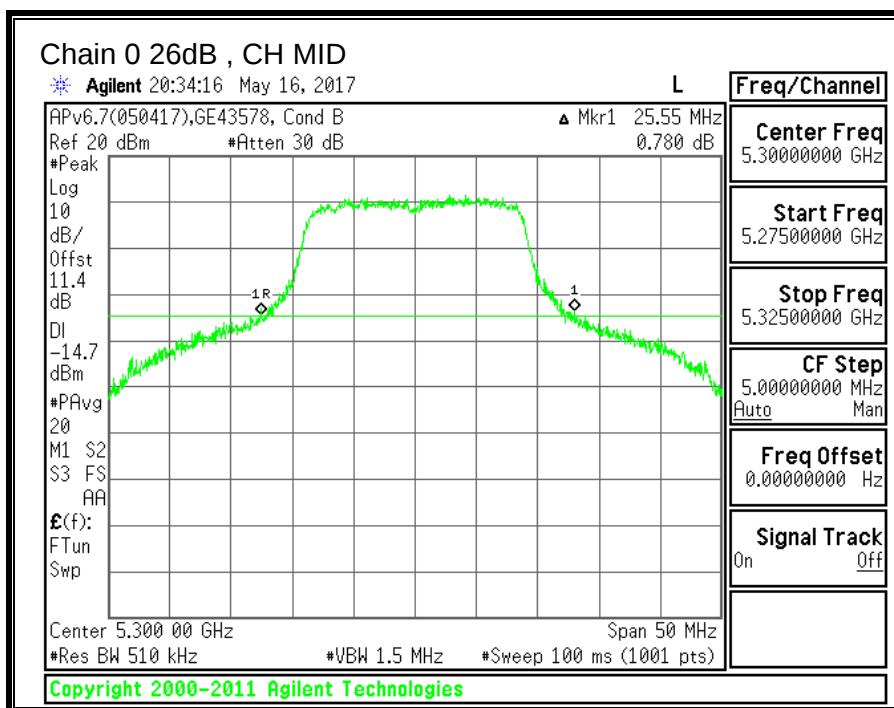
#### LIMITS

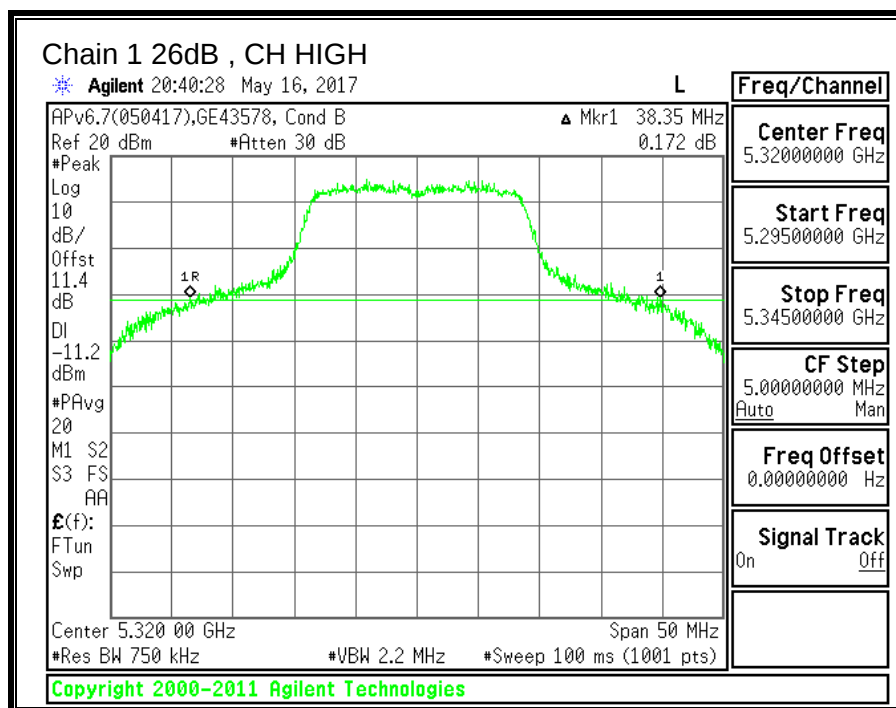
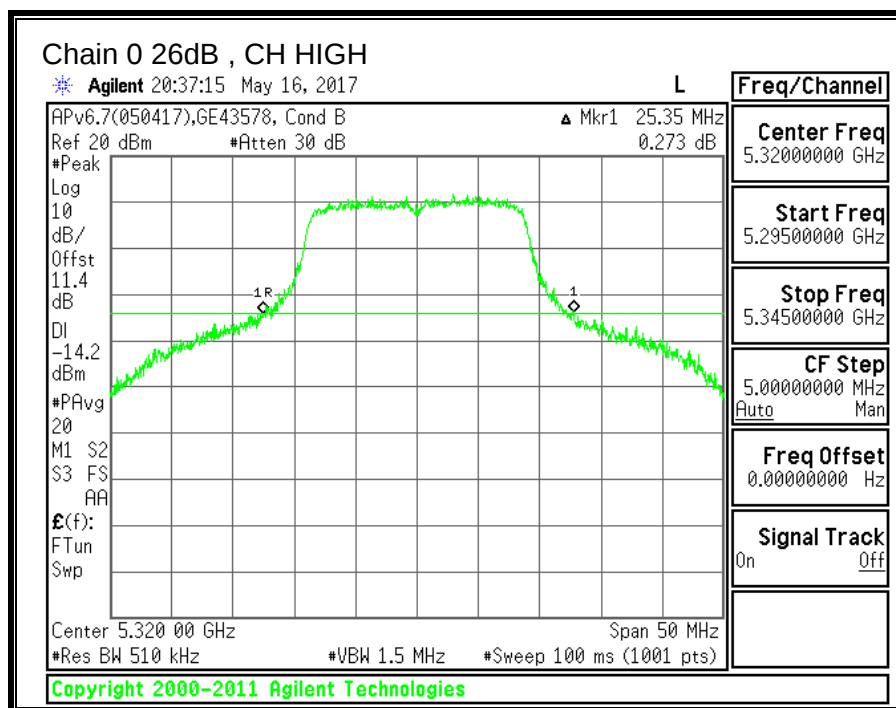
None; for reporting purposes only.

#### RESULTS

| Channel | Frequency | 26 dB BW<br>Chain 0<br>(MHz) | 26 dB BW<br>Chain 1<br>(MHz) |
|---------|-----------|------------------------------|------------------------------|
| Low     | 5260      | 25.40                        | 32.35                        |
| Mid     | 5300      | 25.55                        | 35.00                        |
| High    | 5320      | 25.35                        | 38.35                        |







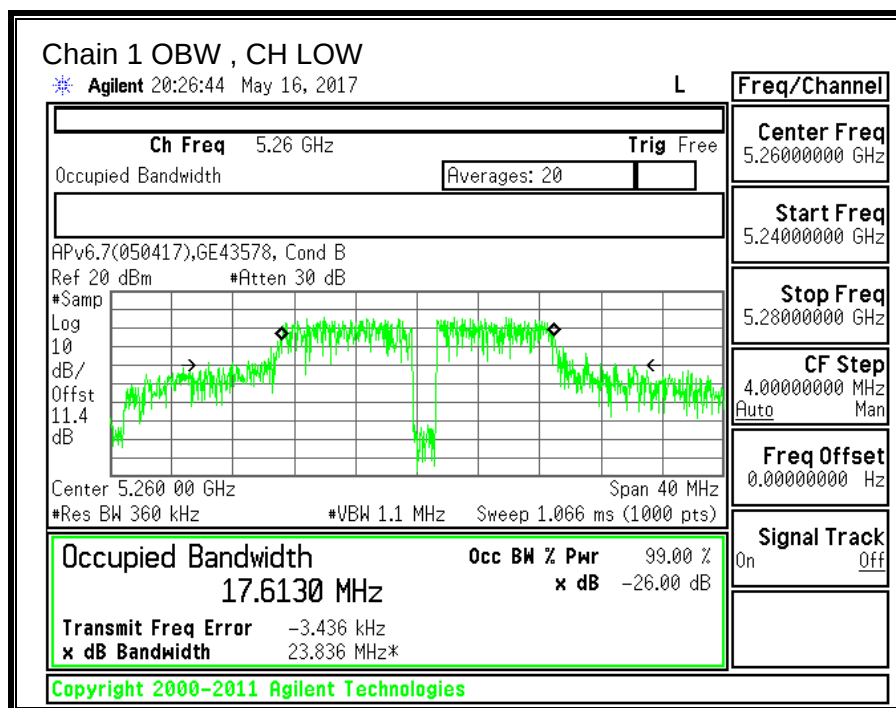
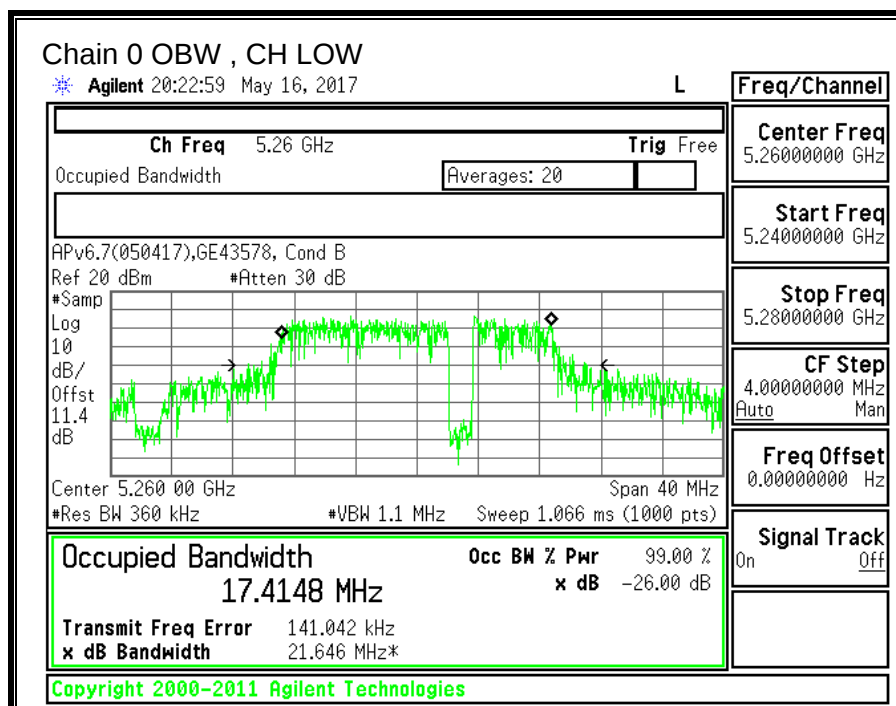
### 9.4.2. 99% BANDWIDTH

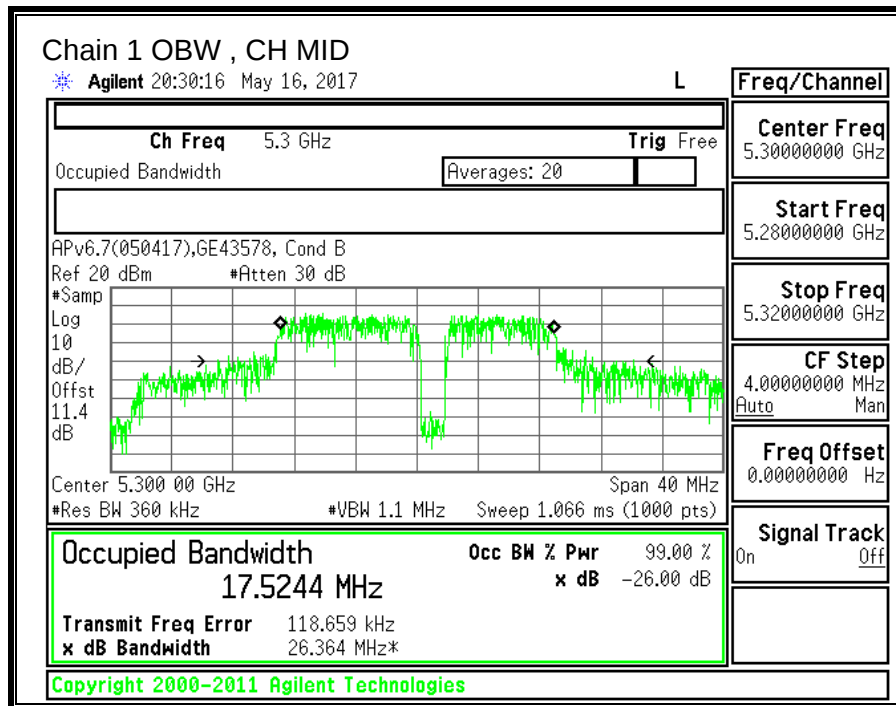
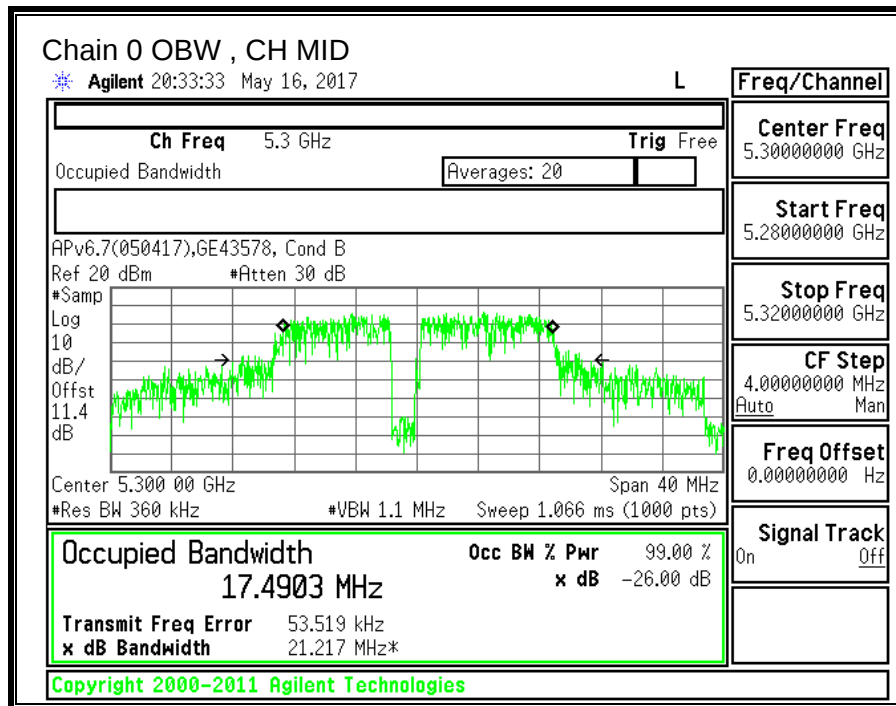
#### LIMITS

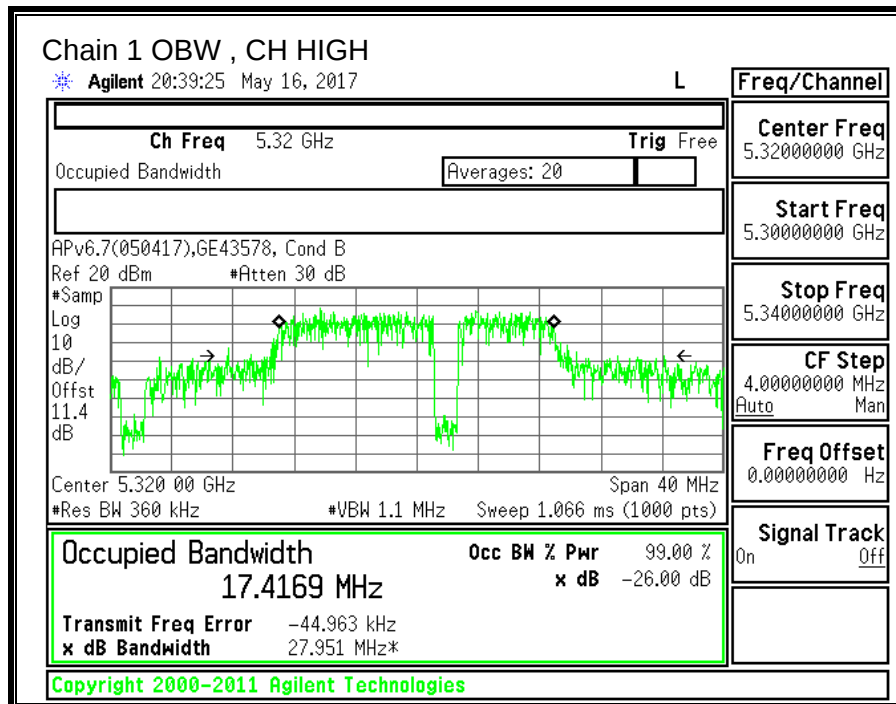
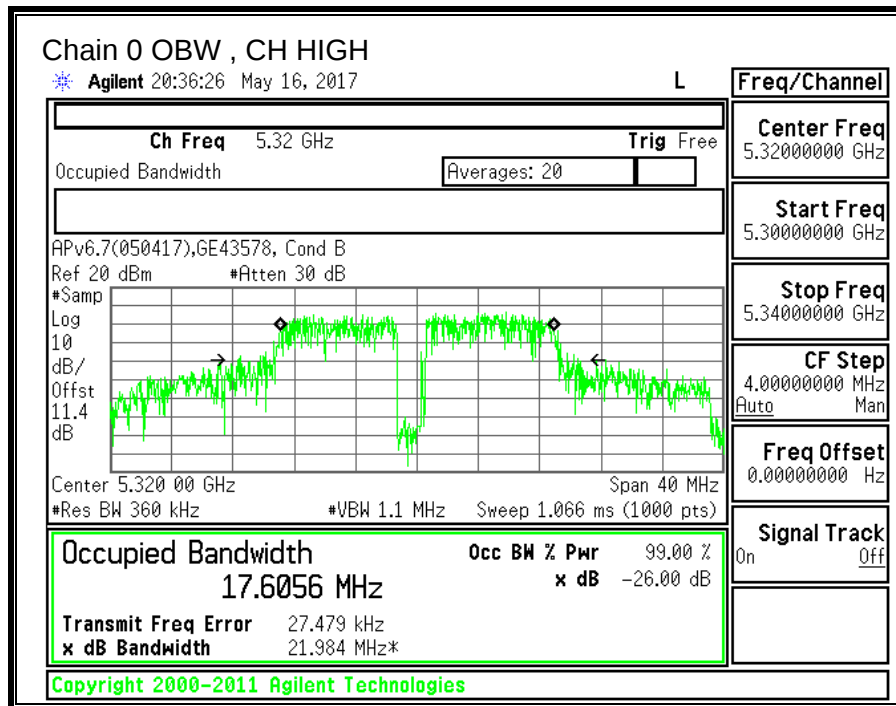
None; for reporting purposes only.

#### RESULTS

| Channel | Frequency | 99% BW<br>Chain 0<br>(MHz) | 99% BW<br>Chain 1<br>(MHz) |
|---------|-----------|----------------------------|----------------------------|
| Low     | 5260      | 17.4148                    | 17.6130                    |
| Mid     | 5300      | 17.4903                    | 17.5244                    |
| High    | 5320      | 17.6056                    | 17.4169                    |







### 9.4.3. OUTPUT POWER AND PPSD

#### **LIMITS**

FCC §15.407 (a) (2)

For the band 5.25–5.35 GHz, the maximum conducted output power over the frequency band of operation shall not exceed the lesser of 250 mW or  $11 \text{ dBm} + 10 \log B$ , where B is the 26–dB emission bandwidth in MHz. In addition, the maximum power spectral density shall not exceed 11 dBm in any 1–MHz band. If transmitting antennas of directional gain greater than 6 dBi are used, both the maximum conducted output power and the peak power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

#### **TEST PROCEDURE**

Measurements perform using a wideband gated RF power meter provided that the gate parameters are adjusted such that the power is measured only when the EUT is transmitting at its maximum power control level. Since the measurement is made only during the ON time of the transmitter, no duty cycle correction factor is required.

#### **DIRECTIONAL ANTENNA GAIN**

For Power, the TX chains are uncorrelated and the antenna gain is unequal among the chains. The directional gain is:

| Chain 0<br>Antenna<br>Gain<br>(dBi) | Chain 1<br>Antenna<br>Gain<br>(dBi) | Uncorrelated Chains<br>Directional<br>Gain<br>(dBi) |
|-------------------------------------|-------------------------------------|-----------------------------------------------------|
| 3.41                                | 2.26                                | 2.87                                                |

For PSD, The TX chains are correlated and the antenna gain is unequal among the chains. The directional gain is:

| Chain 0<br>Antenna<br>Gain<br>(dBi) | Chain 1<br>Antenna<br>Gain<br>(dBi) | Correlated Chains<br>Directional<br>Gain<br>(dBi) |
|-------------------------------------|-------------------------------------|---------------------------------------------------|
| 3.41                                | 2.26                                | 5.86                                              |

## RESULTS

|            |         |              |         |
|------------|---------|--------------|---------|
| <b>ID:</b> | GE43578 | <b>Date:</b> | 5/16/17 |
|------------|---------|--------------|---------|

### Bandwidth, Antenna Gain and Limits

| Channel | Frequency<br>(MHz) | Min<br>26 dB<br>BW<br>(MHz) | Directional<br>Gain<br>for Power<br>(dBi) | Directional<br>Gain<br>for PSD<br>(dBi) | Power<br>Limit<br>(dBm) | PSD<br>Limit<br>(dBm) |
|---------|--------------------|-----------------------------|-------------------------------------------|-----------------------------------------|-------------------------|-----------------------|
| Low     | 5260               | 32.35                       | 2.87                                      | 5.86                                    | 24.00                   | 11.00                 |
| Mid     | 5300               | 35.00                       | 2.87                                      | 5.86                                    | 24.00                   | 11.00                 |
| High    | 5320               | 38.35                       | 2.87                                      | 5.86                                    | 24.00                   | 11.00                 |

|                           |      |                                               |
|---------------------------|------|-----------------------------------------------|
| <b>Duty Cycle CF (dB)</b> | 0.37 | <b>Included in Calculations of Corr'd PSD</b> |
|---------------------------|------|-----------------------------------------------|

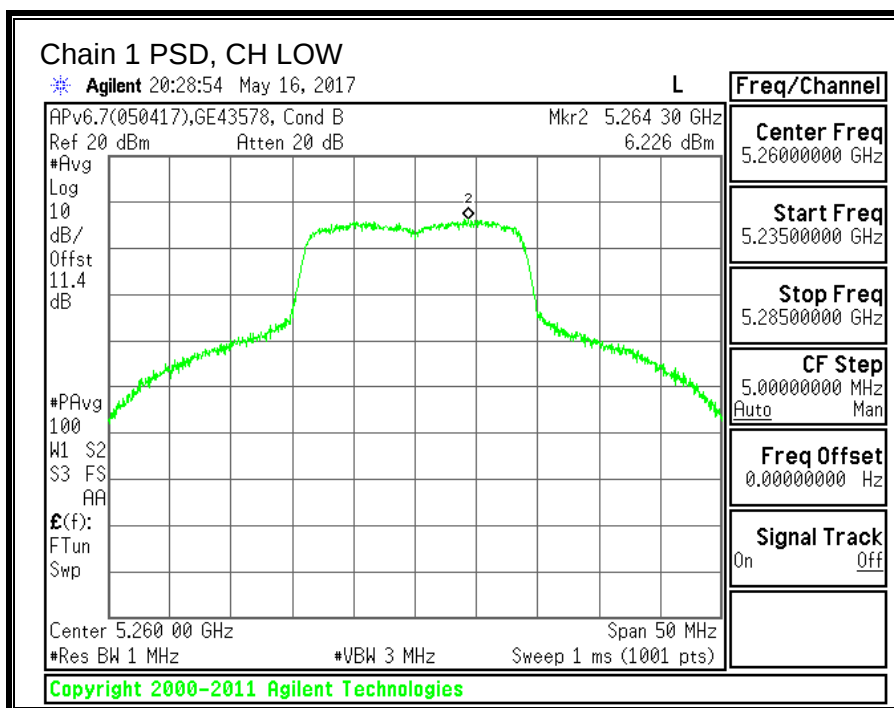
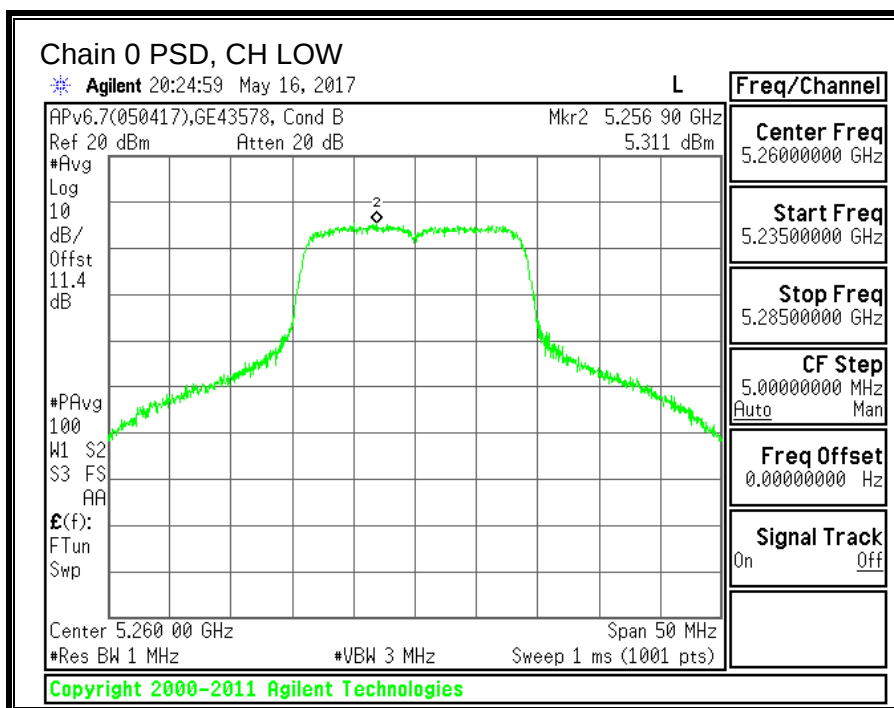
### Output Power Results

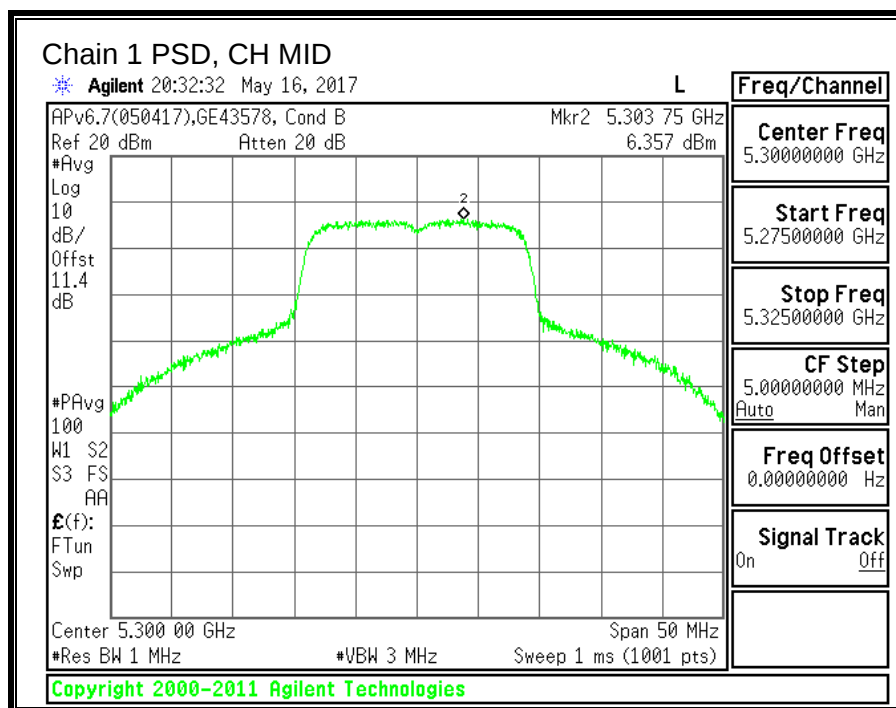
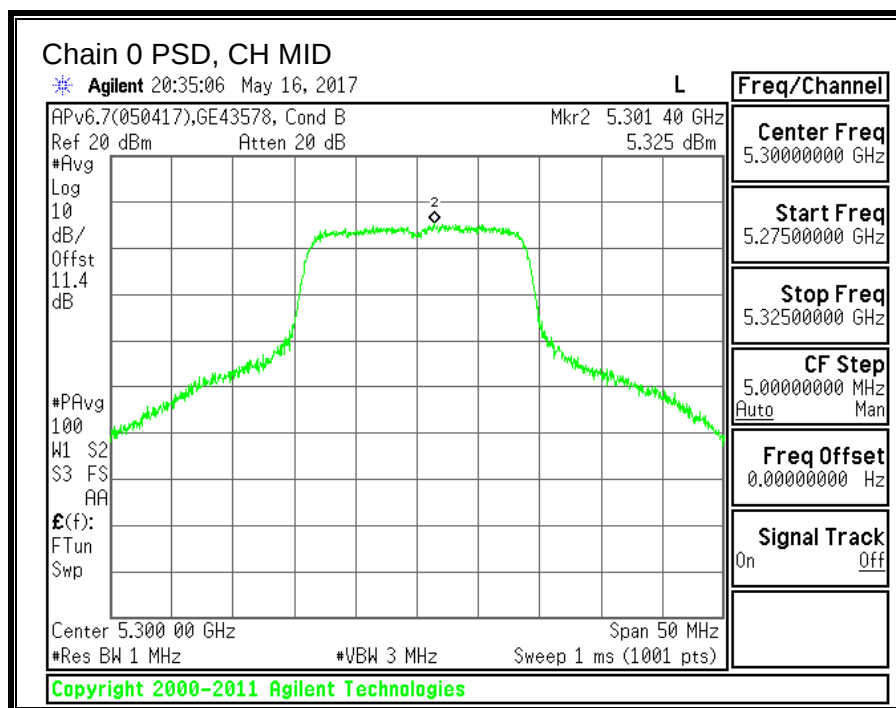
| Channel | Frequency<br>(MHz) | Chain 0<br>Meas<br>Power<br>(dBm) | Chain 1<br>Meas<br>Power<br>(dBm) | Total<br>Corr'd<br>Power<br>(dBm) | Power<br>Limit<br>(dBm) | Power<br>Margin<br>(dB) |
|---------|--------------------|-----------------------------------|-----------------------------------|-----------------------------------|-------------------------|-------------------------|
| Low     | 5260               | 16.45                             | 17.91                             | 20.25                             | 24.00                   | -3.75                   |
| Mid     | 5300               | 16.61                             | 18.12                             | 20.44                             | 24.00                   | -3.56                   |
| High    | 5320               | 16.74                             | 18.09                             | 20.48                             | 24.00                   | -3.52                   |

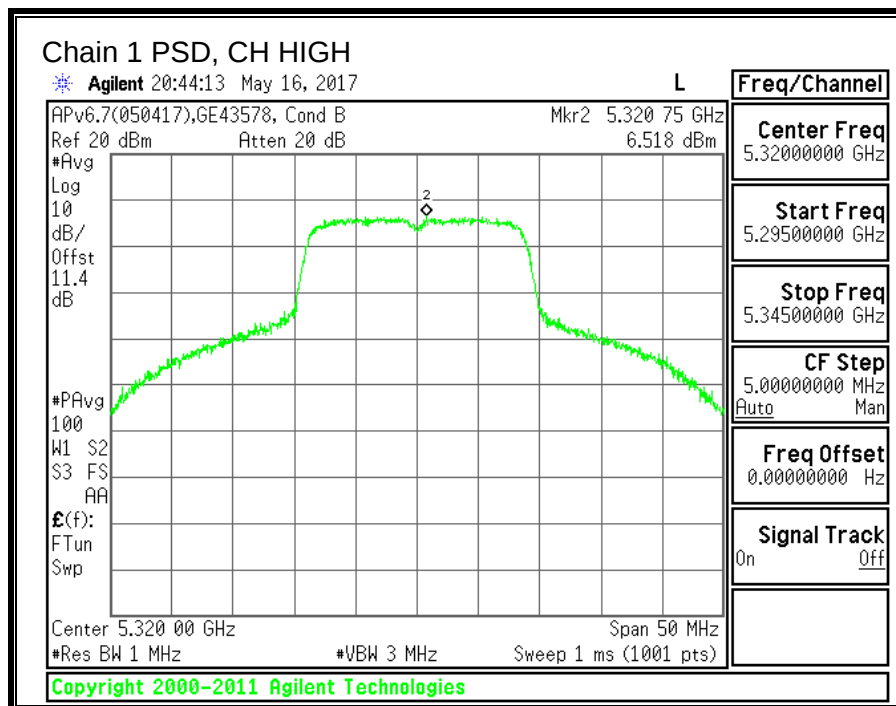
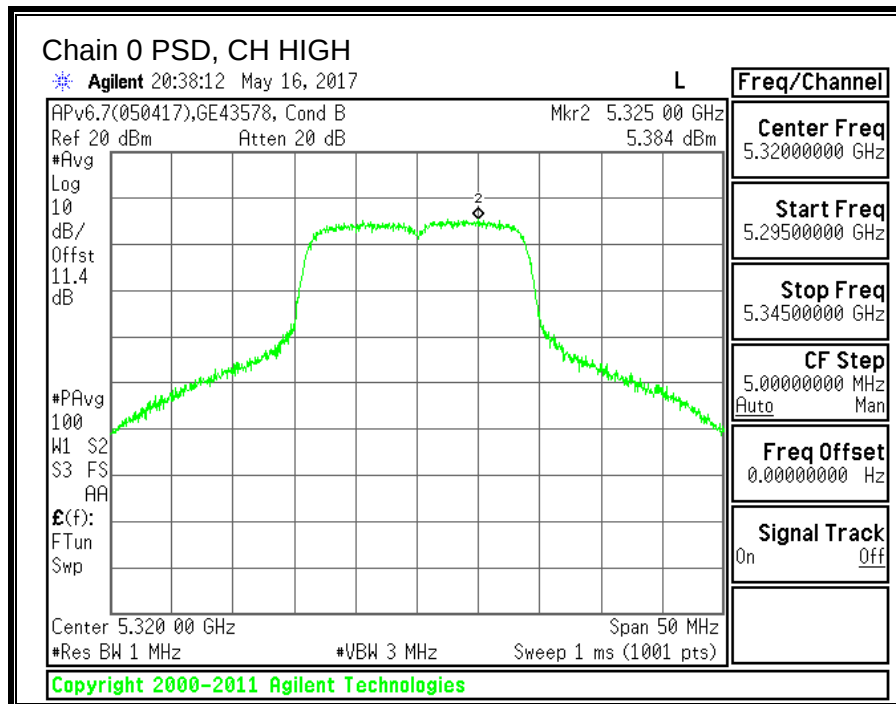
### PSD Results

| Channel | Frequency<br>(MHz) | Chain 0<br>Meas<br>PSD<br>(dBm) | Chain 1<br>Meas<br>PSD<br>(dBm) | Total<br>Corr'd<br>PSD<br>(dBm) | PSD<br>Limit<br>(dBm) | PSD<br>Margin<br>(dB) |
|---------|--------------------|---------------------------------|---------------------------------|---------------------------------|-----------------------|-----------------------|
| Low     | 5260               | 5.311                           | 6.226                           | 9.17                            | 11.00                 | -1.83                 |
| Mid     | 5300               | 5.325                           | 6.357                           | 9.25                            | 11.00                 | -1.75                 |
| High    | 5320               | 5.384                           | 6.518                           | 9.37                            | 11.00                 | -1.63                 |

**Note:** the power readings above were measured with gated method, and the measurement was taken only during the ON time. No duty cycle correction was necessary.







## 9.5. 11n HT20 3TX CDD MIMO MODE IN THE 5.3GHz BAND

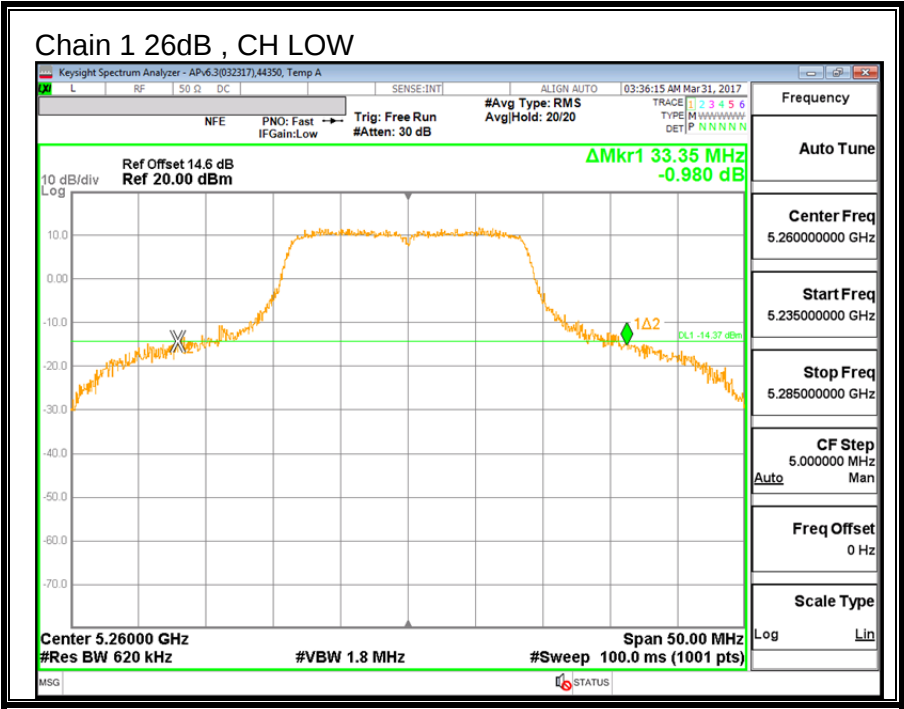
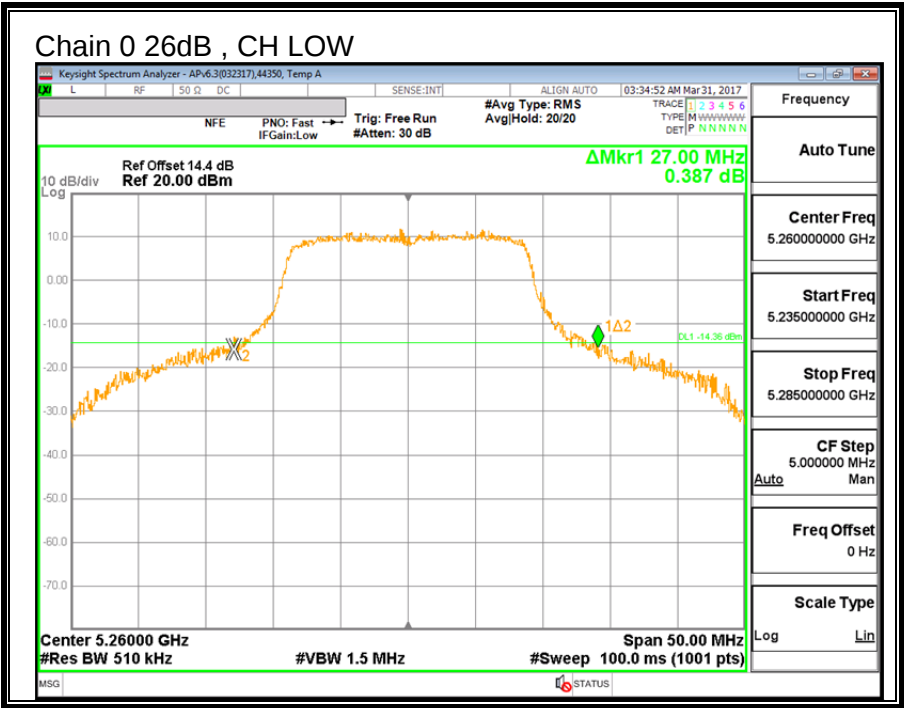
### 9.5.1. 26 dB BANDWIDTH

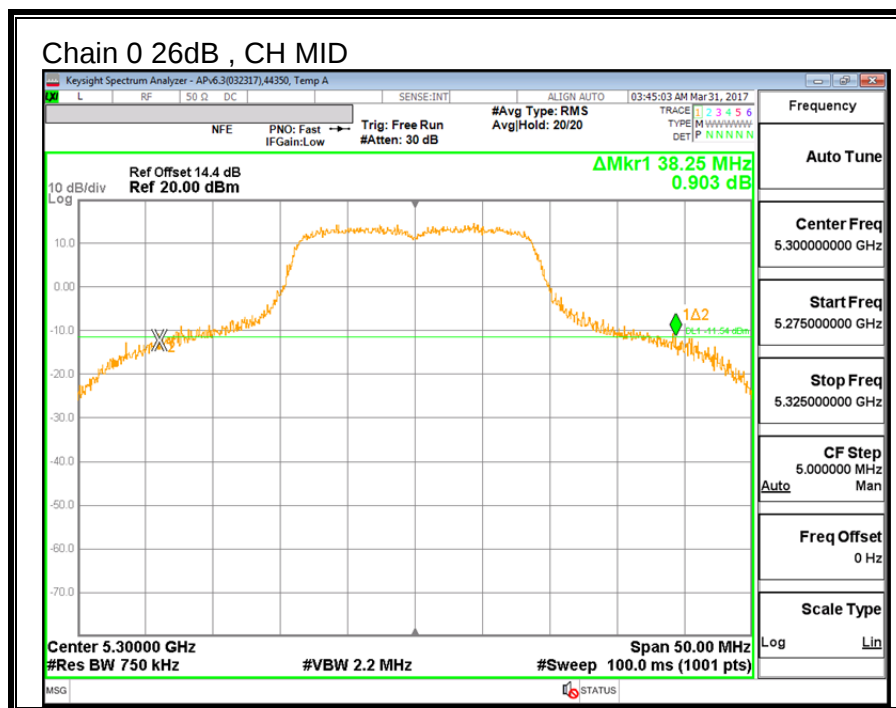
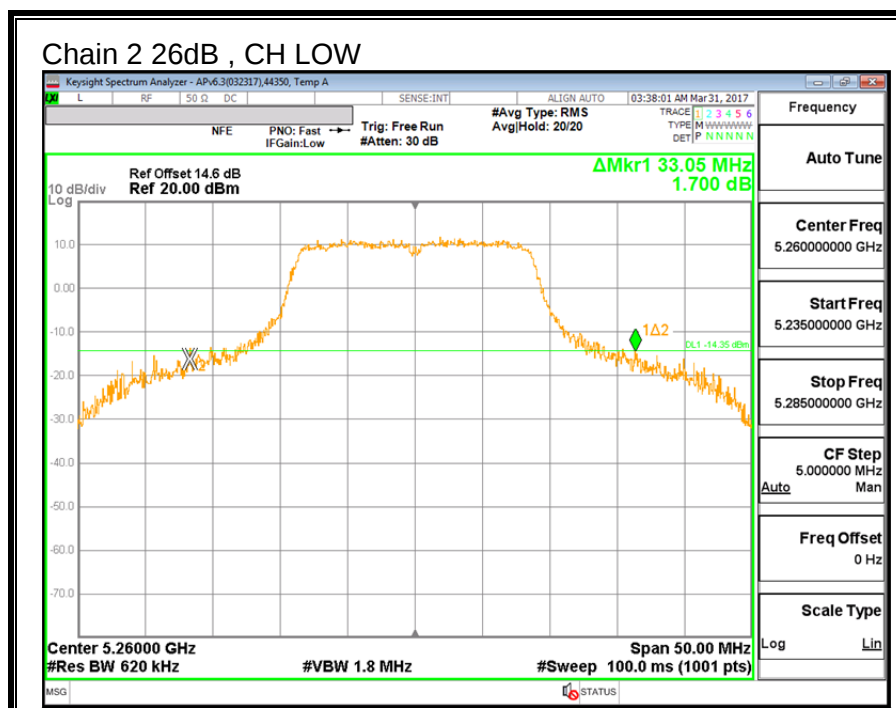
#### LIMITS

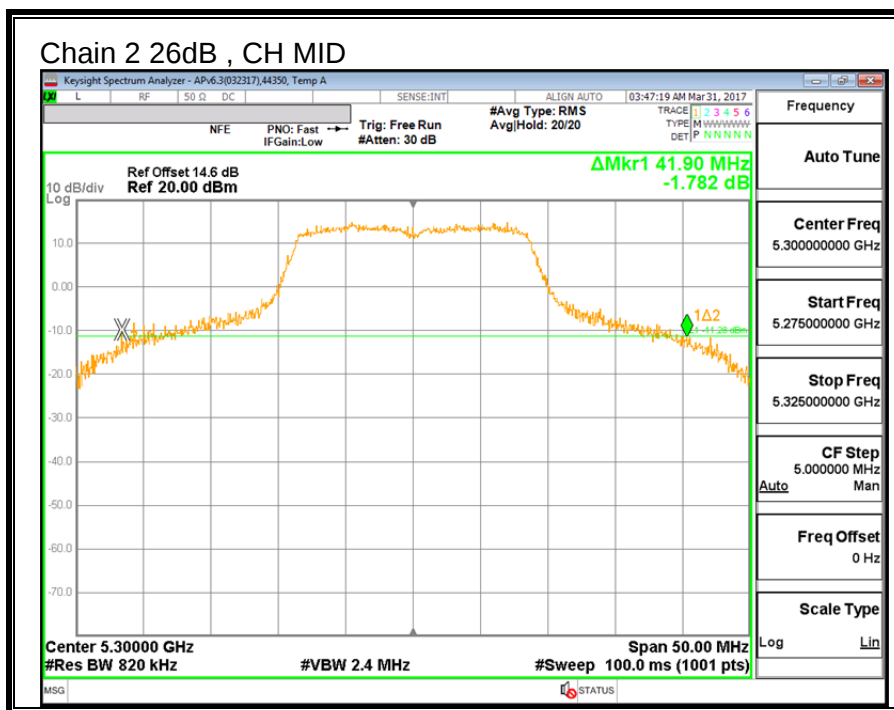
None; for reporting purposes only.

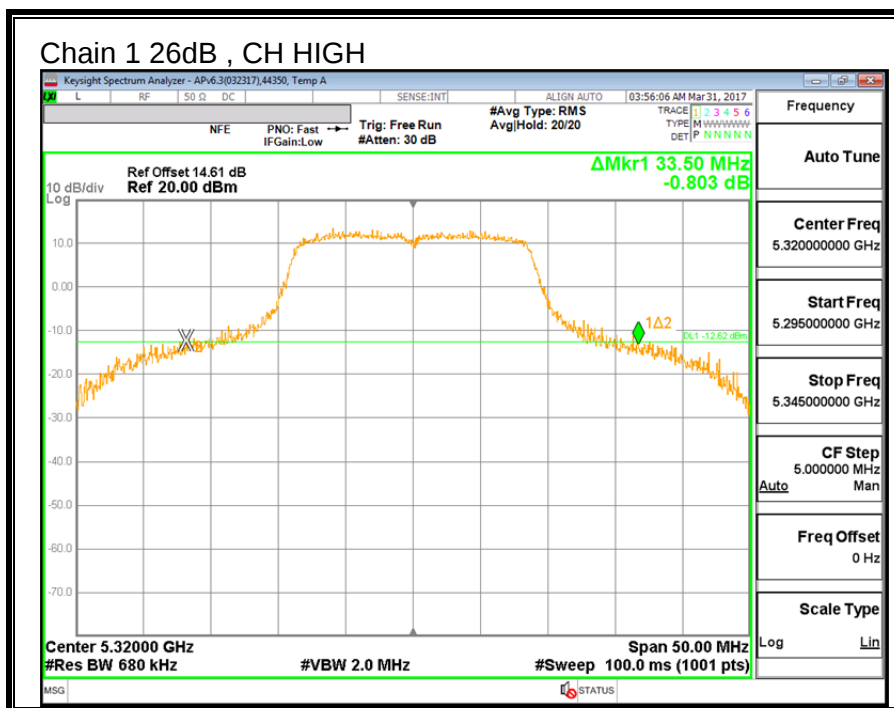
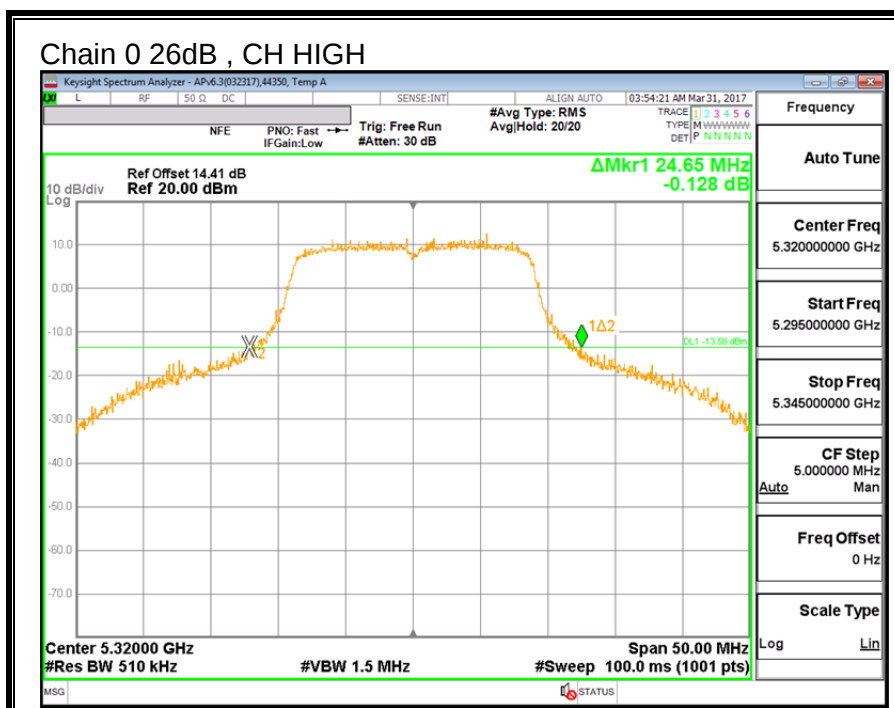
#### RESULTS

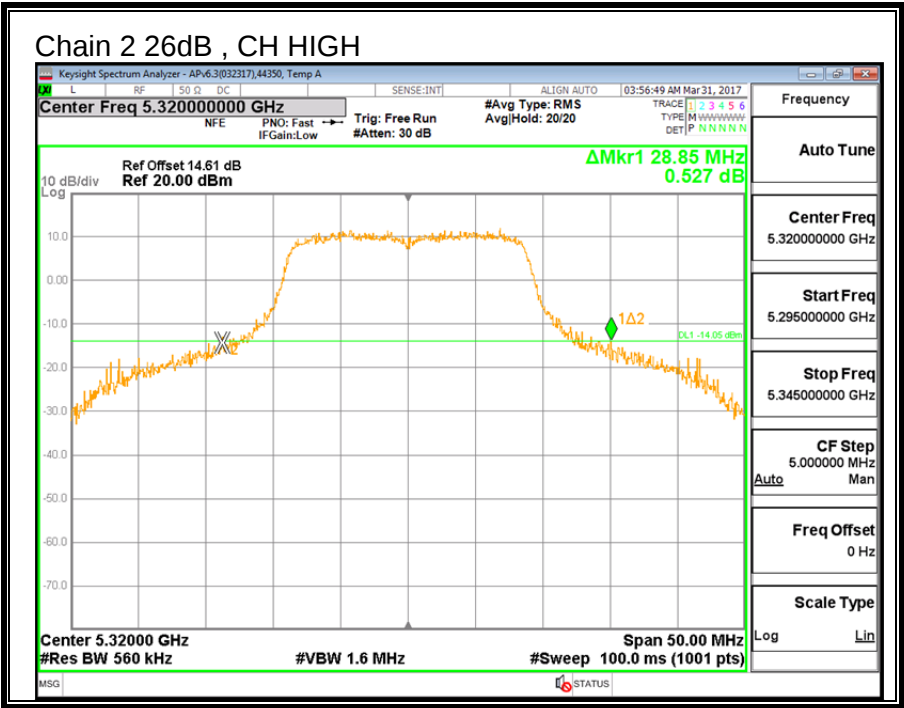
| Channel | Frequency | 26 dB BW<br>Chain 0<br>(MHz) | 26 dB BW<br>Chain 1<br>(MHz) | 26 dB BW<br>Chain 2<br>(MHz) |
|---------|-----------|------------------------------|------------------------------|------------------------------|
| Low     | 5260      | 27.00                        | 33.35                        | 33.05                        |
| Mid     | 5300      | 38.25                        | 42.75                        | 41.90                        |
| High    | 5320      | 24.65                        | 33.50                        | 28.85                        |











### 9.5.2. 99% BANDWIDTH

#### LIMITS

None; for reporting purposes only.

#### RESULTS

| Channel | Frequency | 99% BW<br>Chain 0<br>(MHz) | 99% BW<br>Chain 1<br>(MHz) | 99% BW<br>Chain 2<br>(MHz) |
|---------|-----------|----------------------------|----------------------------|----------------------------|
| Low     | 5260      | 17.850                     | 17.900                     | 17.840                     |
| Mid     | 5300      | 17.989                     | 18.360                     | 17.990                     |
| High    | 5320      | 17.849                     | 17.910                     | 17.839                     |

